TECHNICAL MANUAL

OPERATOR'S, ORGANIZATIONAL, DIRECT SUPPORT AND GENERAL SUPPORT MAINTENANCE MANUAL [INCLUDING REPAIR PARTS AND SPECIAL TOOLS LIST]

FOR

TRUCK, FIREFIGHTIN6, DRY CHEMICAL AFFF

NSN 4210-00-484-5729

VOLUME II

HEADQUARTERS, DEPARTMENT OF THE ARMY

14 APRIL 1986

TECHNICAL MANUAL
No. 5-4210-222-14&P-2

HEADQUARTERS
DEPARTMENT OF THE ARMY
WASHINGTON, D.C., 14 April 1986

Operator's, Organizational, Direct Support,
and General Support Maintenance Manual
(Including Repair Parts and Special Tools List)

for

TRUCK, FIREFIGHTING, DRY CHEMICAL AFFF
NSN 4210-00-484-5729

This manual consists of 3 volumes.
Each volume has its own table of contents. The index found in Volume I pertains only to Volume I.

VOLUME I is the Illustrated Parts Breakdown for the entire truck.

VOLUME II contains the Operation, Maintenance, and Repair Manual for:
ENGINE, TRANSMISSION, CHASSIS, CAB and RELATED ITEMS

VOLUME III contains the Operation, Maintenance and Repair Manual for:
TWIN AGENT UNIT, INVERTER, HYDRAULIC RESCUE TOOL (Jaws of Life),
POWER UNIT, RESCUE SAW 10 TON HYDRAULIC RESCUE KIT,
ELECTRONIC SIREN

NOTE: Throughout these manuals, information has been deleted which is not pertinent.

REPORTING ERRORS AND RECOMMENDING IMPROVEMENTS

You can help improve this manual. If you find any mistake or if you know of a way to improve the procedures, please let us know. Mail your letter, DA Form 2028 (Recommended Changes to Publications and Blank Forms), or DA Form 2028-2 located in the back of this manual directly to: Commander, U.S. Army Troop Support Command, ATTN: AMSTR-MCTS, 4300 Goodfellow Boulevard, St. Louis, MO 63120-1798. A reply will be furnished directly to you.

REPORTING EQUIPMENT IMPROVEMENT RECOIMMENDATIONS (EIR)

If your fire truck needs improvement, let us know. Send us an EIR. You, the user, are the only one who can tell us what you don't like about your equipment. Let us know why you don't like the design. Put it on an SF 368 (Quality Deficiency Report). Mail it to us at Commander, U.S. Army Troop Support Command, ATTN: AMSTR-QX, 4300 Goodfellow Boulevard, St. Louis, MO 63120-1798. A reply will be furnished to you.

INTRODUCTION

a. **Purpose and Function.**

This manual covers a commercial, diesel-engine-driven 4x4 truck cab and chassis, equipped with a dual agent fire extinguisher system, a remote controlled roof mounted twinned turret and hose reel for dispensing aqueous film forming foam (AFFF) and dry chemical, with equipment cabinets.

b. **Capabilities**

The commercial diesel-engine-driven 4x4 truck firefighting vehicle is capable of discharging an AFFF action solution through 100 feet of hose or twinned turret ambient temperature at a minimum-maximum range of 45 to 60 gallons per minute at 100 pounds per square inch gage pressure, with a nozzle ground pattern reach of 50 feet with a minimum width of 14 feet. It is also capable of discharging a dry chemical P-K-P, at normal ambient temperature within a minimum-maximum range of 5.0 to 8.0 pounds per second at 100 psig pressure, with a ground pattern reach of 35 to 40 feet. The combined agent fire extinguisher system is also capable of operating in any normal ambient temperature above 32° F.

c. **Performance Characteristics**

The fully equipped commercial, diesel-engine-driven 4x4 truck firefighting vehicle is capable of performing the following:

1. Attaining a maximum speed of not less than 65 mph on dry, level, paved roadway.

2. Accelerating on a level road from a standing start to a speed of 50 mph in 30 seconds.

3. Negotiating a 50 percent grade traveling both up and down the hill in a low speed range.

4. Operating on a 20 percent side slope in two directions.

5. Stopping within a braking distance of 30 feet from a speed of 20 mph on a dry, smooth, level surface free from loose material using service brakes.

6. Holding the truck on a 30 percent grade in both ascending and descending positions using the parking brake and repeating the operation using the service brake.

d. **<u>Table of Specifications, Dimensions and Weights.</u>**

CHASSIS TYPE	International Harvester
	1854 (4x4) S-Series
OVERALL DIMENSIONS	
Length	19’-0"
Width	97"
Height	131"
GROSS VEHICLE WEIGHT	
Loaded	19,446 lbs.
Unloaded	15,960 lbs.
WHEEL BASE (INCHES) 152 Inches	
ENGINE TYPE	International Harvester 9.0 Liter
Number of Cylinders	8
Horsepower	165
Bore	114.6 mm (4.51 IN)
Stroke	109.5 mm (4.31 IN)
Displacement	9000 cm3 (551.1 IN3)
Idle Speed (No Load)	625-675 rpm
Governed Speed	
No Load	3025-3125 rpm
Full Load	2800 rpm
Firing Order	1-8-7-3-6-5-4-2
Engine Weight (Dry)	576.6 kg (1270 lbs)
Cooling System Capacity	19.5 US Quarts
Lubricating System Capacity (Including Filters)	14 US Quarts
TRANSMISSION TYPE	Detroit Allison, GM, AT545
	4 Speed Automatic
Rating	
Input Torque	385 lbs. ft. (max)
Input Speed	3200 rpm (max) (diesel)
Input Horsepower	235 hp (175 kw) (max)
Drive	Flexplate
Rotation	(Viewed from Input)
Input	Clockwise
Output	Clockwise
Output Location	In Line with Input
Dry Weight	275 lbs. (125 kg)
Clutches	Oil Wet, Hydraulic Actuated,
	Spring Released, Self Compensating for Wear
Gearing	Planetary, Straight-Cut Spur, Constant Mesh
Oil Filter and Sump	Integral
Fluid	GM Dexron II or Dexron Transmission Fluids
Fluid Capacity	16 US Quarts
TRANSFER CASE	
Manufacturer	Rockwell
Model	T-223H

AIR COMPRESSOR

Manufacturer .... Midland Ross
Model. .... EL 740

AIR DRYER

Manufacturer .... Brakemaster
Model 62

POWER STEERING PUMP

Manufacturer .... Eaton
Model 781

STEERING GEAR

Manufacturer .... Ross
Model .... HFB 64

STARTING MOTOR

Manufacturer .... Delco
Model 1114 120
Volts 12

WHEELS, FRONT 6 SPOKE

Manufacturer .... International Harvester
Model 465 525 C91

WHEELS, REAR, 5 SPOKE

Manufacturer .... International Harvester
Model 595 989 C91

FUEL TANK

Manufacturer .... International Harvester
Model 509 045 C1
Capacity 30 .... US Gallons
Fuel .... Diesel Fuel

ALTERNATOR

Manufacturer .... Leece-Neville
Model 4725
Volts 130
AMP Rating .... 55 at 14 Volts DC

SIREN, ELECTRONIC

Manufacturer .... Federal Signal Corporation
Model PA300*
Frequency Range .... 300-10,000 Hz
Input Voltage .... 11 V.D.C. - 16 V.D.C.
Operating Current .... 10 Amperes Max.

SPOTLIGHT

Manufacturer .... Unity Manufacturing Company
Model S-6/225-V

LAMP, QUARTZ (FRONT)

Manufacturer	Havis Shields
Model	605-500
Watts	500

LAMP, QUARTZ (TELESCOPING)

Manufacturer	Havis Shields
Model	305-500
Watts	500

SKID UNIT

Manufacturer	Rockwood Systems Corporation
Model	RTS 1500/250
Capacity	
AFFF	250 Gallons
Dry Chemical	1400 lbs. PKP ((70) 50 lb. cans)
Size	621" W x 121" L x 731" H
Weight (With Full Nitrogen Tanks)	
Empty	2,900 lbs.
Full	6,500 lbs.
Propellant	Nitrogen Gas (5) Cylinders @ 2400 PSIG

TWIN AGENT HOSE REEL (12V DC Explosion Proof 1/2 HP Motor)

Manufacturer	Clifford B. Hannay & Sons, Inc.
Model	7000 Series
Size	28" W x 44" L x 24" H
Hose	100 Ft., 1" Non-Collapsible Twin Hose

TWIN AGENT HANDLINE

Manufacturer	Rockwood Systems Corporation
Model	510-1678
Discharge Rate	
AFFF	60 gpm @ 100 psi
Dry Chemical	5-8 lbs./ sec. @ 100 psi
Effective Range	
AFFF	
Solid Stream	60 ft.
Fully Dispersed Stream	15 ft. wide at 26 ft. range
Dry Chemical	25-40 ft.
AFFF Quality	
Expansion	8 (Minimum)
One Quarter Drainage Time	3 Minutes (Minimum)
	per NFPA 412

TWIN AGENT TURRET

Manufacturer	Rockwood Systems Corporation
Model	510-1679
Discharge Rate	
AFFF	100-400 gpm - 100 ft. minimum far point
	17 ft. minimum full width
Dry Chemical	10-25 lbs./sec-90 ft. minimum far point
	15 ft minimum full width
Rotation	180° minimum
Elevation	80°
Depression	20°

POWER RESCUE TOOL (JAWS OF LIFE)

Manufacturer	Hurst Performance, Inc.
Model	32b
Capacity	10 Tons
Size	14" H x 16" W x 291" L

POWER UNIT, POWER RESCUE TOOL

Manufacturer	Hurst Performance, Inc.
Model	4 Cycle
Size	14+" W x 18+" L x 231" H

RESCUE SAW

Manufacturer	Partner
Model	K 1200-12"
Engine	100cc Air Cooled, Two Cycle
Fuel Partner	Oil/Gasoline
	1:50 Ratio or other quality 2 stroke oil
	@ 1:25 ratio

HYDRAULIC RESCUE KIT

Manufacturer	Black Hawk
Model	65066
Capacity	10 Tons
Size	8" H x 15" W x 36" L

AIRCRAFT RESCUE TOOL KIT

Manufacturer	Halprin Supply Company
Model	CRK5 Sierra
Size	6" W x 6" H x 28" L
Weight	8 lbs.

INVERTER

Manufacturer	Dynamote
Model	A30 - 70D
Size	141" L x 12 3/4" W x 10" H
Input	12V DC
Output	120V 60 Hz AC

TIRES

Manufacturer	Good Year
Model Super	Single/Traction Road Lug, Tubeless
Size	16.5-22.5
Load Range	H
Plies	
Tread	11 Plies Nylon Cord
Sidewalls	10 Plies Nylon Cord
Maximum Load	9230 lbs. @ 90 psi (cold)

e. **Environmental Requirements**

The commercial, diesel-engine-driven 4x4 firefighting truck is in compliance with current Department of Transportation Federal Motor Vehicle Safety Standards and Regulations and Environmental Protection Agency Regulations regarding air pollution and noise levels.

f. **List of Items Furnished.**

1. Truck, firefighting, dry chemical, AFFF, 4x4 commercial NSN 4210-00-484-5729

2. Rescue saw, Partner-model K 1200-12"

3. Hydraulic rescue kit, 10 ton capacity, Blackhawk - Model 65066

4. Aircraft crash rescue tool kit, Halprin Supply Co. - Model CRK - Sierra

5. Hydraulic - powered rescue tool (Jaws of Life), Hurst - Model 32b

6. Power unit, hydraulic - powered rescue tool, Hurst - 4 cycle

g. **List of Items Required**

The following related manuals contain operation, maintenance and overhaul instructions, with an illustrated parts breakdown required for the complete operation and maintenance of the commercial diesel-engine-driven 4x4 firefighting truck.

1. The illustrated Parts Breakdown manual lists and describes the parts necessary for identifying each part and also for identifying each individual assembly and sub-assembly.

2. The Operation and Maintenance manual lists and details all phases of operation, maintenance, overhaul and trouble-shooting procedures for the commercial, diesel-engine-driven 4x4 firefighting truck.

h. **Warranty Information.**

Data required in this section consists of basic procedures found in each section of the Operation and Maintenance manual. Individual procedures which include required tools and test equipment should be adhered to for proper operation of the vehicle.

Vendor warranty information is found at the beginning of each major component section and covers the vehicle as designed. The contractor warrants that vehicle is manufactured to conform to the performance requirements, special contract requirements, and other supplementary agreements entered into by the United States and the Kovatch Corporation.

MANUFACTURER'S CODE. The following is a listing of vendor codes with names and addresses of suppliers. They are arranged in alphabetical order.

70418 Arrow Safety Device Company
Georgetown, DE 19947

04009 Crouse-Hinds Company
103 Hawthorn Street
Hartford, CT 06101

73342 Detroit Diesel Allison
Division of General Motors
1100 Main Street Plant
P.O. Box 894
Indianapolis, IN 46206

60481 DEV-TEC
2323 New Hyde Park Road
New Hyde Park, NY 11042

57054 Dynamote Corporation
1200 West Nickerson Street
Seattle, WA 98119

98905 Federal Signal Corporation
2645 Federal Signal Drive
Park Forest South, IL 60466

12183 Halprin Supply Company
3804-T South Broadway P1.
Los Angeles, CA 90037

7F200 Havis Shields Equipment Corp.
P.O. Box 533
538 Davisville Road
Willow Grove, PA 19090

98903 Hurst Performance, Inc.
50 West Street Road
Warminster, PA 18974

31007 International Harvester
4370 West 109th Street
Suite 150
Overland Park, KS 66211

59556 Kovatch Corporation
500 West Catawissa Street
Nesquehoning, PA 18240

33510 Leece-Neville
Division of Sheller-Globe
1374 East 51st Street
Cleveland, OH 44103

75582 Leviton Manufacturing, Inc.
Department TRA
59-25 Little Neck Parkway
Little Neck, NY 11362

76123 Mars Signal Light Company
1224 Industrial Boulevard
Naples, FL 33942

30978 Partner/Paratech
1025 Lambrecht Road
Frankfort, IL 60423

12662 Peterson Manufacturing
4200 East 135th Street
Grandview, MO 64030

52659 Rockwood Systems Corporation
640 East Main Street
Lancaster, TX 75146

77977 Signal-Stat
65 Veronica Avenue
P.O. Box 438
Sommerset, NJ 08873

78977 Unity Manufacturing Company
1260 North Claybourn Avenue
Chicago, IL 60610

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VEHICLE REPAIR PROCEDURES - CONTINUED

INTERNATIONAL

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WARNING

Proper service techniques and repair procedures are necessary for reliable and safe operation of all vehicles as well as the safety of the personnel performing the work. This service manual provides normal and effective methods for accomplishing repair and service work.

With the many variations In procedures and techniques, and the skill level of the individual doing the work, the service manual cannot anticipate all variations and furnish cautions and directions.

The following list contains some general precautions the technician should follow when servicing a vehicle, to avoid the possibility of personal Injury or property damage:

- Always wear safety glasses for eye protection from caustic chemicals, burns, and foreign objects.
- Use floor stands whenever a procedure requires the technician to be under a raised vehicle.
- Be sure the Ignition switch is always In the OFF position, unless otherwise required by the procedure. Disconnect the battery ground cable when servicing the electrical system to avoid electrical burns and damage to the vehicle.
- Always set the parking brake when working on a vehicle. Leave the transmission gear selector in NEUTRAL with the parking brake applied (engine ON or OFF) unless instructed otherwise for a specific operation. Place wood blocks (4”x4" or larger) against the front and rear surfaces of the tire to provide additional restraint from Inadvertent vehicle movement.
- Operate the engine only In a well-ventilated area to avoid the danger of carbon monoxide poisoning.
- Keep hands (feet, face, etc.) and other objects away from moving parts, especially fan blades and belts when the engine is running. Remove rings, watches, loose hanging jewelry, and loose clothing before beginning to work on a vehicle to avoid Injury.
- Do not smoke while working on a vehicle. Volatile gases or vapors are produced In the service area during certain procedures, and an explosion may result, causing serious bodily Injury.

IMPORTANT

Your vehicle may utilize parts which have either metric and/or conventional English unit dimensions.

In some Instances, fasteners In metric are almost Identical in dimension to the English Inch systems; therefore any new part must be of the same measurement and strength as that replaced. Numbers on the head of metric bolts and on surfaces of metric nuts indicate their strength. English unit bolts use radial lines for this Identification, while most English unit nuts do not have strength markings.

Mismatched or Incorrect fastener can result In vehicle damage, malfunction or possibly personal Injury. Whenever possible, fasteners removed from a specific location should be reused In that same location. If this is not possible, new fasteners selected must match those replaced.

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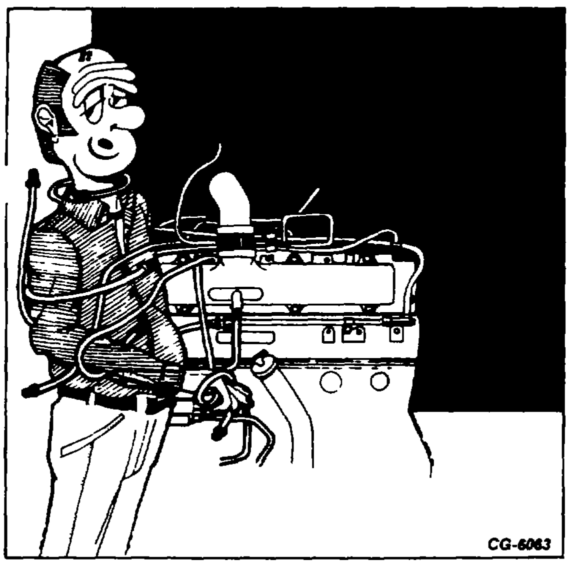
SAFETY SUGGESTIONS

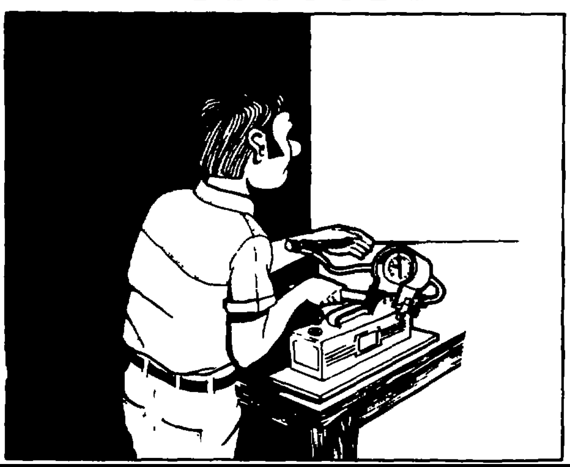
Be careful when using compressed air. Never apply compressed air to any part of the body or clothing, injury or death can occur.

Use approved air blow guns, do not exceed 30 psi, wear safety glasses or goggles and use proper shielding to protect everyone in the work area.



When removing fuel lines remove them as an assembly, not individually.

Avoid getting fuel injection lines mixed up as our friend has.



Be extremely careful when dealing with fluids under pressure.

Fluid under pressure can have enough force to penetrate the skin. These fluids may also infect a minor cut or opening in the skin. If injured by escaping fluid, see a doctor at once. Serious infection or reaction can result if medical treatment is not given immediately.

Never put your hands in front of fluid under pressure.

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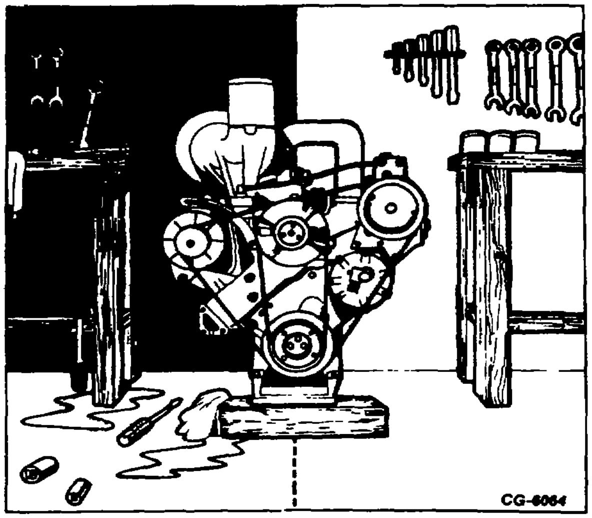
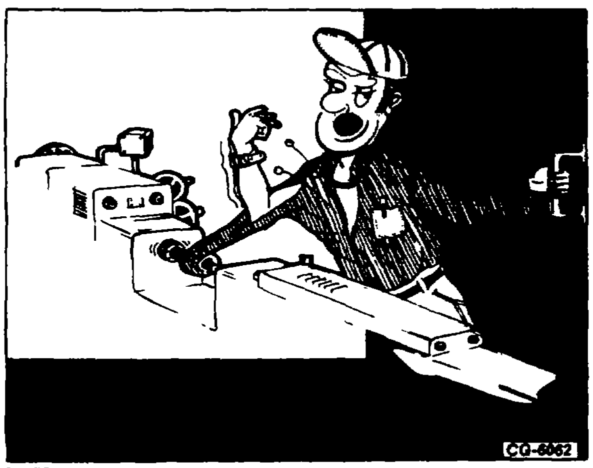
2003



Keep work area organized and clean. Wipe up oil spills of any kind. Keep tools and parts off floor. Eliminate the possibility of a fall which could result in a serious injury.

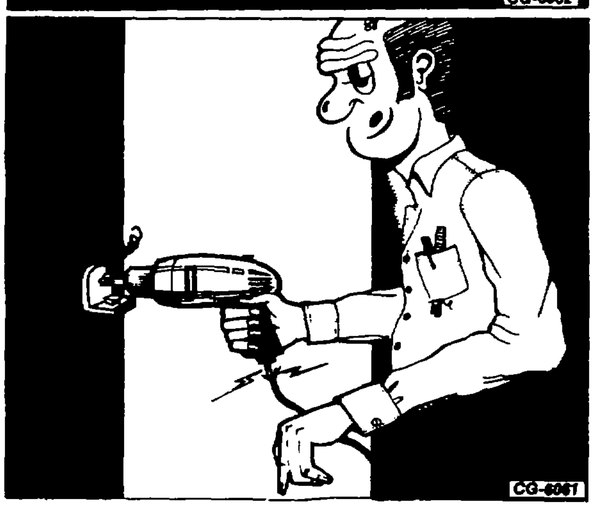
Be sure to reinstall safety devices, guards or shields after adjusting and/or servicing the machine.

After servicing, be sure all tools, parts, or servicing equipment are removed from the machine.

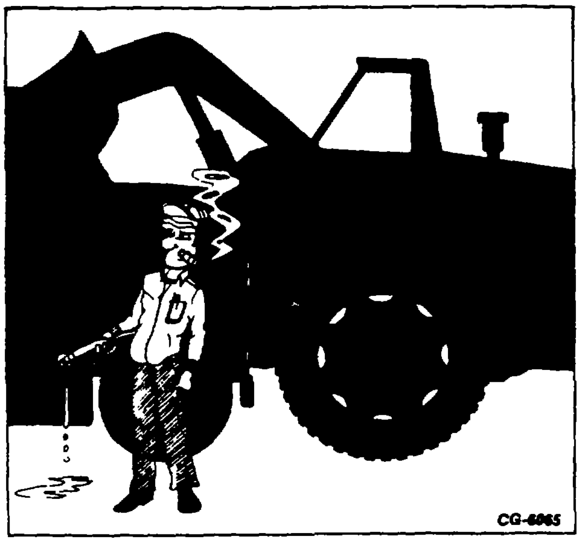


Be sure to wear safe work clothing. It sho be well fitted and in good repair.

Do not wear rings, wrist watches or loose fitting clothing, when working on machinery, they could catch on moving parts causing serious injury. Wear sturdy, rough-soled work shoes. Never adjust and/or service a machine in bare feet, sandals or sneakers.



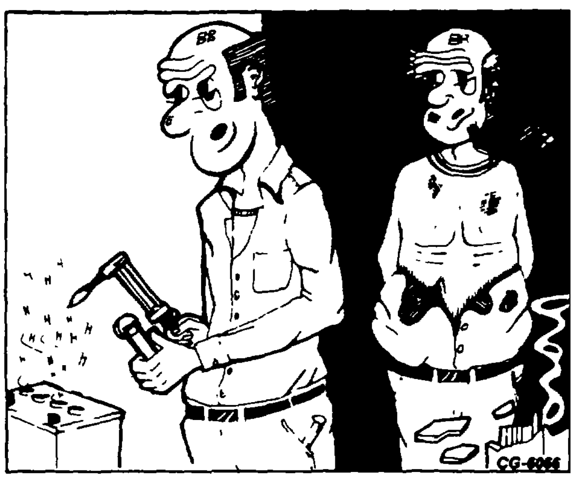
Do not use defective portable power tools. Check for frayed cords prior to using the tool. Be sure all electric tools are grounded.



When refueling, keep the hose and nozzle or the funnel and container In contact with the metal of the fuel tank to avoid the possibility of an electric spark igniting the fuel.

Do not over fill the fuel tank overflow creates a fire hazard.

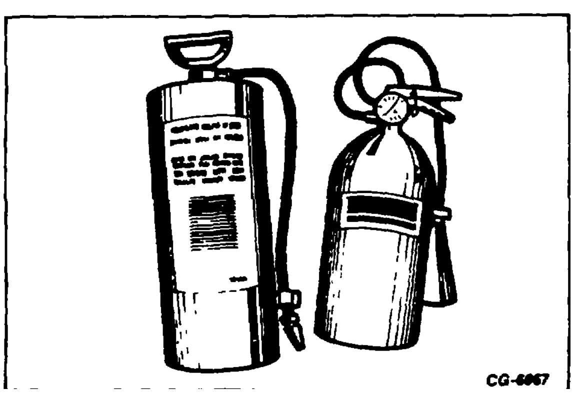
Do not smoke when refueling and never refuel when the engine Is hot or running.



Electrical storage batteries give off highly inflammable hydrogen gas when charging and continue to do so for some time after receiving a steady charge.

Do not under any circumstances allow an electric spark or open flame near the battery or explosion may occur.

Always disconnect a battery cable before working on the electrical system.



Keep a "charged" fire extinguisher within reach whenever you work in an area where fire may occur.

Also, be sure you have the correct type of extinguisher for the situation: Type A: Wood, Paper, Textile and Rubbish Type B: Flammable Liquids Type C: Electrical Equipment

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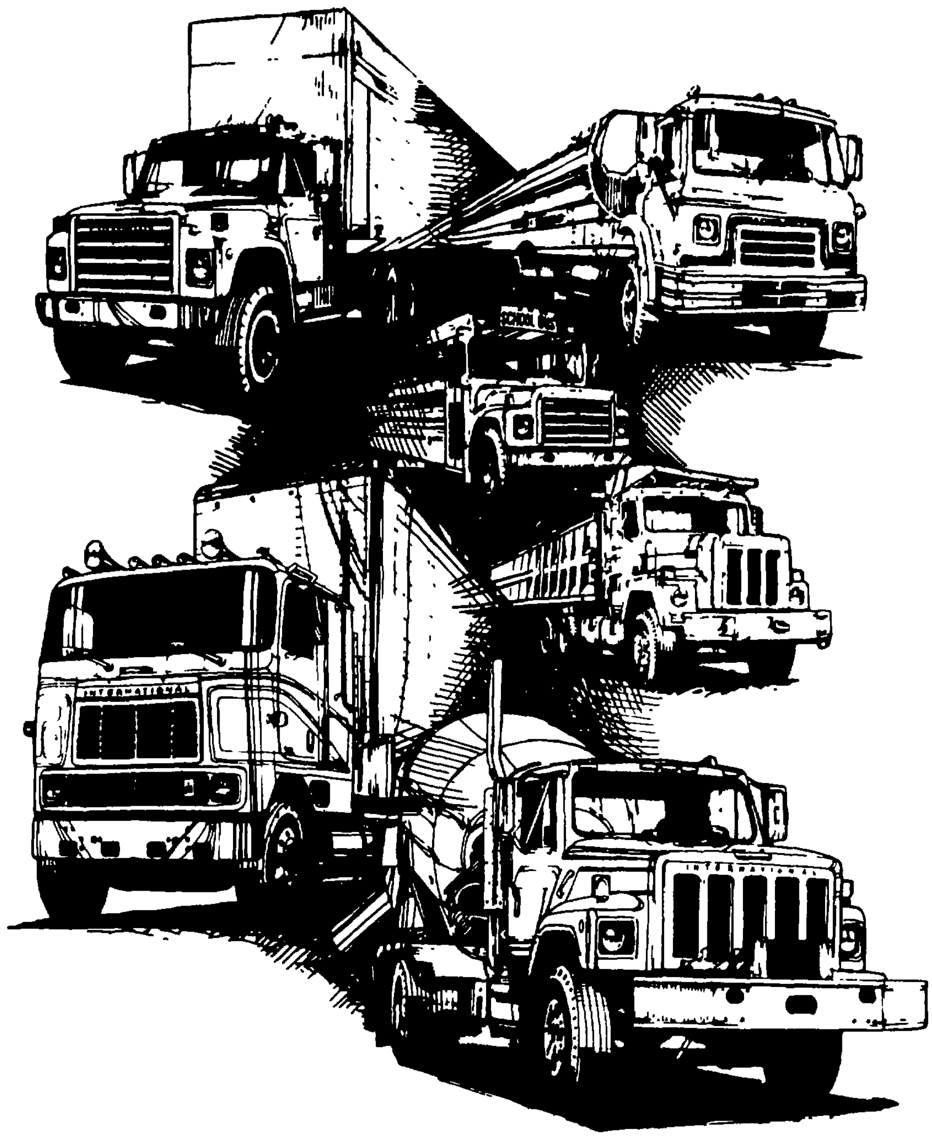

OPERATOR'S MANUAL
(Maintenance)

• S-SERIES • •

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DO NOT REMOVE FROM VEHICLE

2007

IMPORTANT
IT IS IMPORTANT THAT VEHICLE IDENTIFICATION NUMBER (VIN), COMPONENT CODE AND SERIAL NUMBERS BE RECORDED. THESE NUMBERS ARE REQUIRED TO OBTAIN INFORMATION PERTINENT TO THIS VEHICLE.

VEHICLE IDENTIFICATION NUMBER (VIN) IH

CARGOSTAR, S-SERIES:

Stamped on plate cab door Inner panel, left side.

COMPONENT IDENTIFICATION NUMBERS

Component codes appear on the vehicle line setting ticket (see page A-1). Component serial numbers appear on the components.

FRONT AXLE

CODE # SERIAL # ____________

REAR AXLE

CODE # SERIAL # ____________

TRANSMISSION

CODE # SERIAL # ____________

ENGINE IDENTIFICATION NUMBERS

Engine code appears on vehicle Line Setting Ticket (see page A-1).

CODE # SERIAL # ____________

ENGINE SERIAL NUMBER LOCATION

IH 9.0 LITER: Stamped on crankcase front corner right bank.

SALES REGIONS

EASTERN

International Harvester Company
Two Echelon Plaza - Suite 150
Voorhees Township, New Jersey 08043
(609) 772-1400

SOUTHEAST

International Harvester Company
1726 Montreal Circle - Suite 18
Tucker, Georgia 30084
(404) 934-0660

MIDWEST

International Harvester Company
4400 W. 109th Street
Overland Park, Kansas 66211
(913) 383-5600

SOUTHWEST

International Harvester Company
1850 N. Greenville Ave.
Suite 150
Richardson, Texas 75081
(214) 238-3504

WESTERN

International Harvester Company
2682 Bishop Drive, Suite 101
San Ramon, California 94583
(415) 830-2200

CANADA

International Harvester Company
3390 S. Service Rd.
Burlington, Ontario L7N3J5
(416) 681-1311

NOTICE
Those instructions, illustrations and specifications comprising this Manual were compiled from latest information available at publication time.

The International Harvester Company reserves the right to make changes or improvements without notification or applying these changes or improvements to vehicles previously manufactured.

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ASSISTANCE GUIDE

The manual will familiarize you with your vehicle and provide sufficient information to perform minor services necessary for continued efficient operation. **Study this manual carefully before you operate the vehicle.**

When parts are required, always provide the unit code number, vehicle model and vehicle serial number. Request the salesman to assist you in obtaining this information upon delivery.

For information not given in this manual, or if you require services of a trained serviceman, we urge you to contact a nearby IH dealer.

IH believes that every customer is entitled to the best service, both from the product itself and from the firm who sells and services that product.

If, for any reason, you do not feel you are receiving these services in connection with the operation of your vehicle or the sales transaction, you should return to your selling dealer so that these matters can be corrected to your satisfaction. If the matter is not resolved at that time, it is suggested that the following steps be taken:

A. CONTACT A MEMBER OF MANAGEMENT AT THE DEALER

Discuss the details of the difficulty. In most instances any problem can be resolved to your satisfaction by the owner or manager in charge.

B. CONTACT CLOSEST INTERNATIONAL SALES REGION OFFICE

Addresses of Region Sales Offices are found on the inside front cover of this manual. Should you desire to contact any of these offices, it is important to include the following information in your communication.

1. Name under which new vehicle was purchased, address and telephone number of purchaser.
2. Vehicle model, year vehicle identification number, component code and serial numbers.
3. Vehicle delivery date and present mileage.
4. Location where purchased.
5. Details of the problem.

We sincerely appreciate your purchase of an INTERNATIONAL vehicle. Remember, you are entitled to and shall receive every consideration and complete service involving your vehicle. Thank you for favoring us with your business.

COMPONENT CODE NUMBERS

Codes are the basis for identifying the components used on IH Trucks. They are used by sales personnel ordering the truck, by manufacturing to build that truck and by parts personnel to service the truck. Many items in this manual are identified by codes or by IH model. Therefore, it is important to understand their meaning. The code structure is explained on page A-2.

Page 2010
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THE CODE STRUCTURE IS AS FOLLOWS:

00 000 0000

GROUP NUMBER

All International truck parts are divided into 17 groups, numbered from 01 to 17 Code sheets in some instances show group numbers 17 through 22 for wheels, rims and related items.

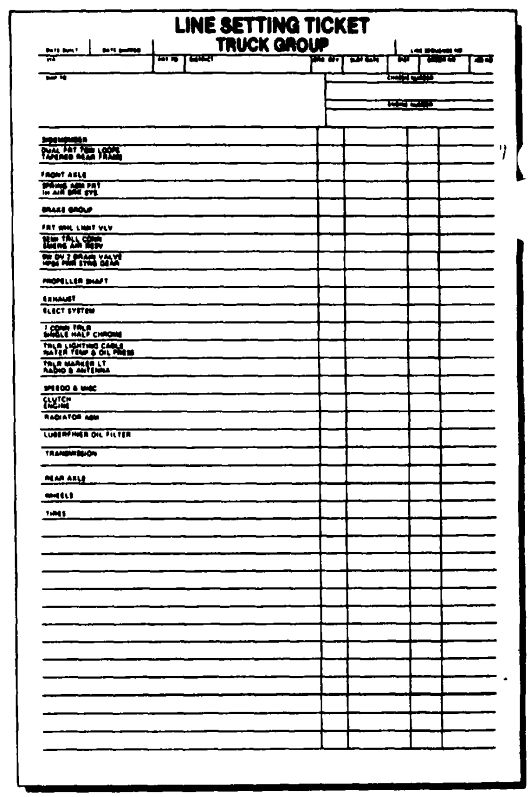
UNIT NUMBER

Unit numbers identify the various components within a group. These unit numbers are also used as IH model numbers. They are sometimes directly significant, as in rear axles, where the first digit of the unit number indicates the type of axle: 0 for single reduction, 1 for two-speed, 2 for a double reduction and 3 or 4 for a tandem.

ASSIGNMENT NUMBER

This number may indicate model differences, different sources of supply, manufacture at different facilities, different equipment applications or design changes. You will need this assignment number only in the few cases where the service parts catalog listings are broken down by assignment numbers. In all other cases you can ignore these last four digits.

LINE SETTING TICKET


LINE SETTING TICKET
TRUCK GROUP

Each vehicle is provided with a Line Setting Ticket (code sheet) which lists identification code numbers of component units used to build the vehicle.

One copy of the line setting ticket Is included in the literature provided with the vehicle. When replacement parts are required, take this copy with you to positively identify vehicle components to be sure of getting the correct parts.

BE SURE TO RETURN LINE SETTING TICKET TO VEHICLE AFTER OBTAINING PARTS.

A second copy of the Line Setting Ticket is permanently attached to the vehicle. (Location will vary with vehicle model.) **THIS TICKET MUST NOT BE REMOVED.**

Locations of permanently-attached Line Setting Tickets are:

Vehicle	Location
S-Series	
Regular Cab	Headliner above driver's sun visor.

VEHICLE STORAGE INSTRUCTIONS

When a vehicle is not used for an extended period of time, certain precautions must be taken to prevent deterioration of some components. Contact your dealer for advice on vehicle storage, as well as proper procedures to follow when you return the vehicle to service.

EXTERIOR NOISE EMISSIONS

THE WARRANTY

International Harvester warrants to the first person who purchases this vehicle for purposes other than resale and to each subsequent purchaser that this vehicle, as manufactured by International Harvester, was designed, built and equipped to conform at the time it left International Harvester's control with all applicable U.S. EPA Noise Control Regulations.

This warranty covers this vehicle as designed, built and equipped by International Harvester, and is not limited to any particular part, component or system of the vehicle manufactured by International Harvester. Defects in design, assembly or in any part, component or system of the vehicle as manufactured by International Harvester, which at the time it left International Harvester's control, cause noise emissions to exceed Federal standards, are covered by this warranty for the life of the vehicle.

TAMPERING WITH NOISE CONTROL SYSTEM PROHIBITED

Federal law prohibits the following acts or the causing thereof: (1) The removal or rendering inoperative by any person other than for purposes of maintenance, repair, or replacement, of any device or element of design incorporated into any new vehicle for the purpose of noise control prior to its sale or delivery to the ultimate purchaser or while it is in use, or (2) The use of the vehicle after such device or element of design has been removed or rendered inoperative by any person. Among those acts presumed to constitute tampering are the acts listed as follows: A. Air Intake System: Removal of air cleaner, intake silencer or piping. B. Acoustical Shielding (Body): Removal of wheel well splash shields, cab shields or acoustical (underhood) insulation. C. Cooling System: 1. Removal or rendering inoperative the fan clutch. 2. Removal of fan shrouds. D. Engine and Drive Line System: 1. Removal or rendering engine speed governor inoperative so as to allow engine speed to exceed manufacturer specifications. 2. Removal of engine block shield, oil sump shield or transmission enclosures. E. Exhaust System: Removal or rendering inoperative exhaust system components including muffler, resonator or tailpipe.

INSTRUCTIONS FOR PROPER MAINTENANCE

In order to comply with federal exterior noise regulations, your vehicle may be equipped with the following noise items. Depending upon the vehicle configuration, it may incorporate all or some of the following five groups.

To avoid abnormal changes in vehicle sound level, it is necessary for the owner to perform inspections and necessary maintenance at the intervals shown in the following maintenance schedules, and record on the inspection verification forms provided.

AIR INTAKE SYSTEM:

A. Air Intake Silencer a metal ring or canister mounted between the air cleaner and the engine air intake should be checked for proper installation.

B. Air Cleaner if remote mounted to dash panel, should be inspected and its location should not be altered. Do not alter inlet and outlet piping.

BODY:

A. Wheel Well splash shields, cab shields and underhood insulation should be inspected for deterioration, dislocation and orientation.

COOLING SYSTEM:

A. Check fan for damage to blades; replace if damaged with manufacturer recommended parts. Inspect for fan to shroud interference, and any damage to shroud such as cracks, holes and buckling of metal.

B. Fan ratio should not be changed and fan spacer dimensions and position should not be altered.

EXTERIOR NOISE EMISSIONS (Continued)

C. Inspect for proper operation of fan clutch making sure that the fan is disengaged when cooling of engine is not required.

D. Check for proper operation of radiator shutters, if provided. Shutters should be open during normal operating temperatures

ENGINE AND DRIVELINE SYSTEM:

A. Engine sump cover Inspect for cracks, holes and visible signs of deterioration. Sump cover should be mechanically isolated to be effective. Check for grounding Maintain exact location of sump cover and check sealing at edges.

B. Transmission enclosure inspect for cracks, holes and tears. Clean any deposits such as oil, dirt and stones.

C. Throttle delay devices should be checked and, if necessary, adjust as per manufacturers' recommendations.

D. Engine valve covers and block covers are made to damp out engine mechanical noise and, If needed to be replaced, should be replaced by recommended parts. Check for mechanical Isolations.

EXHAUST SYSTEM:

A. Inspect for leaks at various joint connections and tighten clamps. Make visual inspection for cracks or holes in muffler and tailpipe. Always replace with manufacturer recommended parts. Tailpipe elbow orientation must not be changed from standard position as originally received.

EXTERIOR NOISE EMISSIONS (Continued)

MAINTENANCE INTERVALS

KILOMETERS, MILEAGE, MONTHS or OPERATION HOURS, WHICHEVER OCCURS FIRST
(Kilometers and Mileage in Thousands)

MAINTENANCE INSPECTIONS	KM	6	13	19	38	58	77	96
	MILES	4	8	12	24	36	48	60
	MOS.	5	10	15	30	45	60	75
	HOURS	125	250	375	750	1125	1500	1875
AIR INTAKE SYSTEM:								
Silencer					X		X	
Piping					X		X	
Clamps					X		X	
BODY:								
Splash Shields				X	X	X	X	X
Cab Shields			X	X	X	X	X	X
Under Hood Insulation				X	X	X	X	X
COOLING SYSTEM:								
Fan Damage		X		X	X	X	X	X
Fan Clutch Operation		X		X	X	X	X	X
Shroud Damage		X		X	X	X	X	X
Shroud Interference		X		X	X	X	X	X
Shutter Operation		X		X	X	X	X	X
ENGINE and DRIVELINE:								
Oil Sump Cover		X			X		X	
Valve Covers		X			X		X	
Block Covers		X			X		X	
Throttle Delays		X			X		X	
Governor		X			X		X	
Manifold Condition		X			X		X	
Manifold Gaskets		X			X		X	
Transmission Enclosure		X			X	X	X	X
EXHAUST SYSTEM:								
Exhaust Flange Bolts		X			X		X	
Exhaust Flange Gaskets		X			X		X	
Exhaust Pipe Condition		X			X		X	
Muffler Condition						X		
Resonator Condition		X				X		
Tailpipe Condition		X				X		
Tailpipe Orientation		X			X		X	
Flexpipe Condition		X				X		
Clamps		X			X		X	

EXTERIOR NOISE EMISSIONS (Continued)

VERIFICATION OF INSPECTIONS

CHASSIS MODEL ___________________________ VEHICLE IDENTIFICATION NO. _____________________________

FIRST INSPECTION

MILES _________________ Km _______________ Hours ____________________ Months _____________________

PERFORMED BY: _________________ _____________ ___________ _________________ ___________
SERVICE MANAGER DEALER DATE CITY STATE

APPROVED BY: _________________ _____________ ___________ _________________ ___________
OWNER DATE STREET CITY STATE

SECOND INSPECTION

MILES _________________ Km _______________ Hours ____________________ Months _____________________

PERFORMED BY: _________________ _____________ ___________ _________________ ___________
SERVICE MANAGER DEALER DATE CITY STATE

APPROVED BY: _________________ _____________ ___________ _________________ ___________
OWNER DATE STREET CITY STATE

THIRD INSPECTION

MILES _________________ Km _______________ Hours ____________________ Months _____________________

PERFORMED BY: _________________ _____________ ___________ _________________ ___________
SERVICE MANAGER DEALER DATE CITY STATE

APPROVED BY: _________________ _____________ ___________ _________________ ___________
OWNER DATE STREET CITY STATE

FOURTH INSPECTION

MILES _________________ Km _______________ Hours ____________________ Months _____________________

PERFORMED BY: _________________ _____________ ___________ _________________ ___________
SERVICE MANAGER DEALER DATE CITY STATE

APPROVED BY: _________________ _____________ ___________ _________________ ___________
OWNER DATE STREET CITY STATE

FIFTH INSPECTION

MILES _________________ Km _______________ Hours ____________________ Months _____________________

PERFORMED BY: _________________ _____________ ___________ _________________ ___________
SERVICE MANAGER DEALER DATE CITY STATE

APPROVED BY: _________________ _____________ ___________ _________________ ___________
OWNER DATE STREET CITY STATE

SIXTH INSPECTION

MILES _________________ Km _______________ Hours ____________________ Months _____________________

PERFORMED BY: _________________ _____________ ___________ _________________ ___________
SERVICE MANAGER DEALER DATE CITY STATE

APPROVED BY: _________________ _____________ ___________ _________________ ___________
OWNER DATE STREET CITY STATE

SEVENTH INSPECTION

MILES _________________ Km _______________ Hours ____________________ Months _____________________

PERFORMED BY: _________________ _____________ ___________ _________________ ___________
SERVICE MANAGER DEALER DATE CITY STATE

APPROVED BY: _________________ _____________ ___________ _________________ ___________
OWNER DATE STREET CITY STATE

DIESEL ENGINES EMISSION CONTROL SYSTEMS

EMISSION CONTROL SYSTEMS WARRANTY HEAVY-DUTY CALIFORNIA AND FEDERAL EMISSION CLASS ENGINES

International Harvester Company warrants to the owner of any IH manufactured diesel engine, applicable at the time of manufacture, that the engine's emission control system:

1. All diesel engines are designed, built and equipped so as to conform at the time of sale with all regulations of the U.S. Environmental Protection Agency and of the California Air Resources Board, if vehicle/engine is so ordered, applicable at the time of manufacture.

2. 9.0 Liter Engines-

   Will conform with those regulations as may be applicable for a period of use of 5 years or 160 000 km (100, 000 miles) or 3000 hours of engine operation, whichever occurs first. Engine Emission Control System parts which are proved defective during normal use, will be repaired or replaced during this period.

The warranty period shall begin on the date the vehicle is delivered to the first retail purchaser or, if the vehicle is first placed in service as a demonstrator or company vehicle prior to sale at retail on the date the vehicle is first placed in service.
The emission control systems of your new IH manufactured engine were designed, built and tested using genuine IH parts, and the engine is certified as being in conformity with Federal and California emission control regulations. Accordingly, it is recommended that any replacement parts used for maintenance, repair or replacement of emission control systems be IH Service Parts or IH ReNEWed Parts. The owner may elect to have maintenance, replacement or repair of the emission control devices and systems performed by any vehicle repair establishment or individual and may elect to use parts other than IH Service or ReNEWed Parts for such maintenance, replacement or repair without invalidating this warranty; the cost of such service or parts, however, will not be covered under the warranty.

Use of replacement parts which are not of equivalent quality may impair the effectiveness of emission control systems. If other than IH Service Parts or ReNEWed Parts are used for maintenance, owner shall obtain assurances that such parts are warranted by their manufacturer to be equivalent to genuine IH parts in this warranty with respect to a part other than IH Service Parts or ReNEWed Parts. However, the use of non-IH replacement parts does not invalidate the warranty on other components unless non-IH parts cause damage to warranted parts.

Repairs and service covered by this warranty will be performed by an authorized IH dealer at his place of business with no charge for parts or labor (including diagnosis), using IH Service parts or ReNEWed parts for any part of the emission control system covered by this warranty and found defective. In case of an emergency where an authorized IH dealer is not available, repairs may be performed at any available service establishment. IH will reimburse the owner for such repairs (including labor in most cases) that are covered under this warranty. Replaced parts and paid invoices must be presented at an IH dealership as a condition of reimbursement for emergency repairs not performed by an IH dealer.
The emission control parts covered by this Emission Control System Warranty are listed under "What Is Covered By The Emission Warranty." You are advised to perform all recommended maintenance including severe operating condition maintenance or repairs on your new IH vehicle engine. IH will not deny a warranty claim solely because you have no record of maintenance; however, IH may deny a warranty claim If your failure to perform maintenance resulted in the failure of a warranted part. Receipts covering the performance of regular maintenance should be retained in the event questions arise concerning maintenance The receipts should be transferred to each subsequent owner of the vehicle with the emission warranted engine.

CUSTOMER ASSISTANCE

IH wishes to help assure that the Emission Control Systems Warranty Is properly administered. In the event that you do not receive the warranty service to which you believe you are entitled under the Emission Control Systems Warranty, you should contact the nearest IH Regional Office for assistance. The address and telephone number of each Regional Office is in your vehicle owner's manual. If you need additional assistance or information concerning the Emission Control Systems Warranty, contact:
Manager, Customer Relations, Truck Group
International Harvester Company
401 North Michigan Avenue
Chicago, Illinois 60611

WHAT IS NOT COVERED BY THE EMISSION WARRANTY

The warranty does not cover:

1. Malfunctions in any part caused by any of the following: misuse, abuse, improper adjustments, modification, alteration, tampering, disconnection, improper or inadequate maintenance, or use of fuels not recommended for the engine.

2. Damage resulting from accident, acts of nature or other events beyond the control of IH.

3. The replacement of expendable maintenance items such as positive crankcase ventilation valve, flame arrestor, exhaust system, filters, hoses, belts, oil, thermostat and coolant made in connection with scheduled emission control maintenance services.

4. A warranted part requiring replacement at an inspection or adjustment maintenance interval for reasons other than being defective.

5. Replacement items which are not IH Service parts or ReNEWed parts.

6. Loss of time, inconvenience, loss of use of vehicle/ engine or commercial loss.

7. Any vehicle on which the odometer or hourmeter has been disconnected or the mileage (or hours) has been altered so the actual engine usage cannot be readily determined.

8. Any vehicle registered and normally operated outside the United States.

WHAT IS COVERED BY THE EMISSION WARRANTY

The following is a list of items that are considered a part of the Emission Control Systems and are covered by the Emission Warranty when installed as original equipment by IH on vehicles which were built to conform to California Air Resources Board regulations.

IMPORTANT - This does not Include expendable maintenance Items made In connection with scheduled emission control maintenance services.

I. Fuel Injection System
II. Air Induction System
  A. Intake manifold
  B. Turbocharger system
III. Positive Crankcase Ventilation (PCV) System (if applicable)
  A. PCV valve
  B. Oil filler cap
IV. Exhaust Manifold
V. Miscellaneous Items Used in Above Systems
  A. Hoses, clamps, fittings and tubing
  B. Pulleys, belts and idlers
  C. Vacuum, temperature and time sensitive valves and switches

Date vehicle delivered to first retail purchaser or first placed in service ________________________19 _____ odometer and hourmeter reading at time of purchase. Odometer reading _______________________hourmeter reading ____ .

DIESEL ENGINE MAINTENANCE

Refer to the Engine section of this manual for maintenance interval information.

CONTENTS

VEHICLE ENTRY AND EXIT

The following are procedures for entering and exiting the cab on various IH vehicles. These procedures apply to typical vehicle designs. On special vehicles or vehicles with special equipment, entry/exit procedures may differ from those listed here.

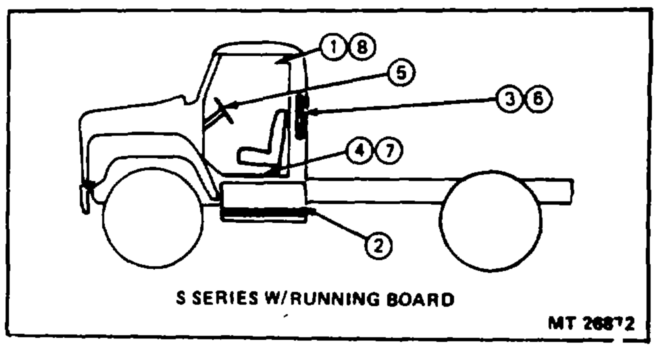
The numbers in circles on the various vehicle illustrations correspond to the step numbers of procedures for entering the vehicles.

For the majority of vehicles, the movements to exit the vehicle will be in reverse order of entry movements.

S-SERIES WITH RUNNING BOARD,

ENTRY (DRIVER'S SIDE)

1. Open door.



2. Place left foot on step (running board).
3. On S-Series grasp grab handle (if so equipped) behind door opening with right hand.

   Pull body upward.
4. Place right foot on cab floor.

5. Grasp steering wheel with left hand
6. Release right hand. Move body Into seat.
7. Move left foot into cab.
8. Close door.

EXIT (DRIVER'S SIDE)

1. Open door
2. Grasp steering wheel with left hand.
3. Move body outward so you are facing into the cab and grasp grab handle (if so equipped) behind door opening with right hand.

4. Place left foot on step (running board).
5. Lower body. Place right foot on ground Release right hand.
6. Move left foot to ground. Release left hand.
7. Close door.

ENTRY (PASSENGER SIDE)
(NOT ILLUSTRATED)

1. Open door
2. Place right foot on step (running board).
3. On S-Series grasp grab handle behind door opening with left hand.

Pull body upward.

4. Grasp arm rest on door* with right hand.
5. Place left foot on cab floor.
6. Release left hand. Move body into seat.
7. Move right foot into cab.
8. Close door.

EXIT (PASSENGER SIDE)
(NOT ILLUSTRATED)

1. Open door
2. Grasp arm rest on door* with right hand.
3. Move body outward (so that you are facing into the cab).
4. Grasp grab handle behind door* with left hand.
5. Place right foot on step (running board).
6. Lower body. Move left foot to ground.
7. Move right foot to ground. Release hand holds.
8. Close door

DOOR CONTROL AND LOCK

TO LOCK-UNLOCK FROM INSIDE (ALL MODELS)

To lock doors, push door lock control downward. To unlock doors, pull control upward.

TO LOCK-UNLOCK FROM OUTSIDE (ALL MODELS)

To lock doors, turn key clockwise and remove. To unlock, turn key counterclockwise and remove.

TO OPEN FROM INSIDE-OUTSIDE S-SERIES;

To open door from inside, pull upward on handle.

To open door from outside, insert fingertip into door control recess and pull handle outward.

WARNING - KEEP DOORS LOCKED WHEN VEHICLE IS IN MOTION.

DOOR WINDOW REGULATOR

To lower door glass (left door), turn window regular handle clockwise. To raise glass, turn handle counterclockwise. Reverse this procedure for opposite door

SEAT ADJUSTMENT (FULL WIDTH)

Position yourself behind the steering wheel and push the seat adjustment lever toward the rear of cab to release the locking mechanism. Then move the seat forward or backward to desired position.

Adjustment instructions for optional seats may be found on seat base.

SEAT BELTS

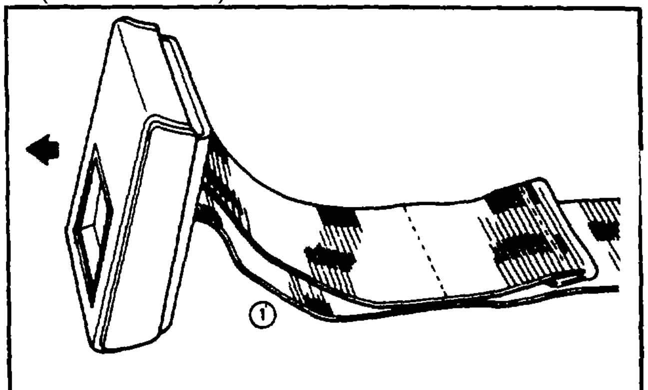
Seat belts should be worn at all times. Before fastening a front seat belt, always adjust the driver's seat to the position in which you will drive. Seat belts should be worn across the hips and adjusted snugly. Never adjust a seat belt across the abdomen.

TO LENGTHEN

Tip the buckle end downward, and pull the buckle until the ends can be joined. Insert tongue into open end of buckle and snap together. The belt can be shortened after it is connected by pulling on the loose end until the belt Is snug and comfortable (see illustration).

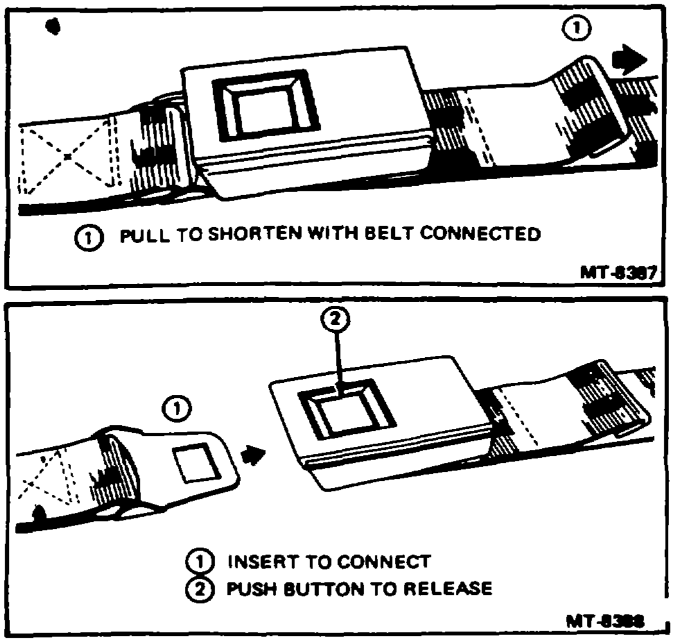
TO RELEASE

Push in on the button release latch to release the seat belt (see illustration).



(1) PULL TO LENGTHEN WITH BUCKLE IN VERTICAL POSITION

MT-8386



INSTRUMENT PANEL AND CONTROLS

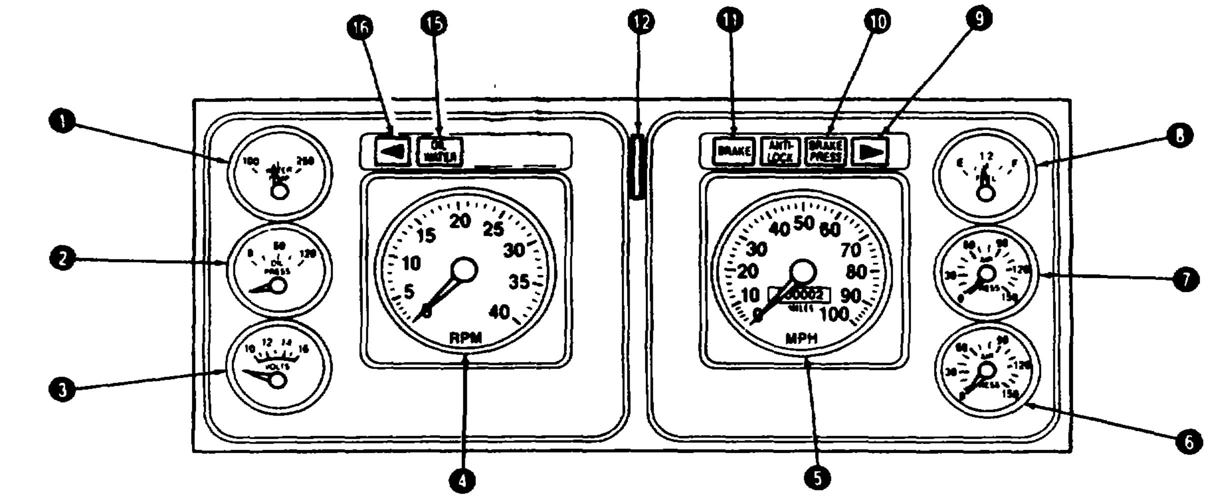
CARE OF SEAT

Clean the belts occasionally with mild soap; do not use cleaning solvents or abrasives.

CAUTION - DO NOT BLEACH OR RE-DYE COLOR WEBBING. BLEACHING OR RE-DYEING MAY SEVERE LOSS OF BELT STRENGTH. THIS LOSS OF STRENGTH COULD ALLOW THE SEAT BELT TO BREAK UNDER STRESS, THUS RESULTING IN PERSONAL INJURY.

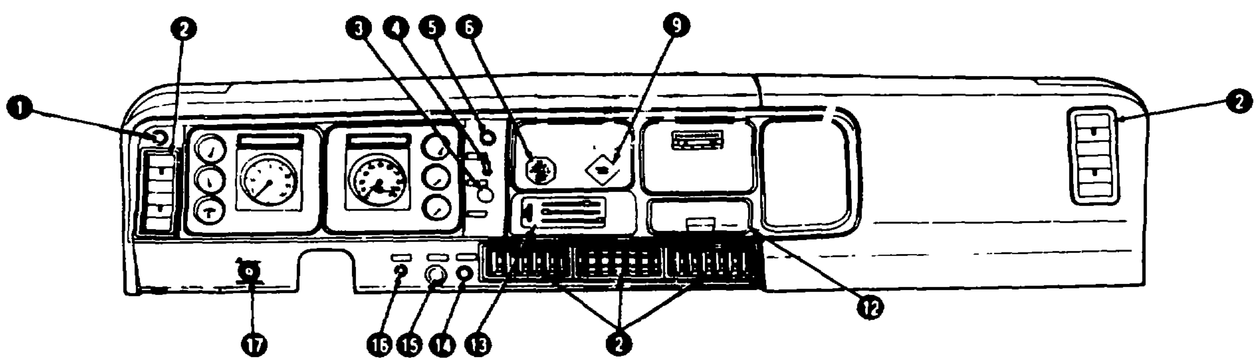
The entire seat belt assembly Should be inspected for corrosion, wear, fraying or weak spots. The seat belt mounting bolts should be tight at all times. Any seat belt severely strained in an accident should be replaced immediately. All belts should be replaced at least every five years.

S-SERIES



1. WATER TEMPERATURE GAUGE
2. OIL PRESSURE GAUGE
3. BATTERY — GENERATING SYSTEM GAUGE
4. TACHOMETER
5. SPEEDOMETER
6. AIR PRESSURE GAUGE OR VACUUM GAUGE
7. AIR PRESSURE GAUGE OR VACUUM GAUGE
8. FUEL GAUGE
9. RIGHT HAND TURN SIGNAL INDICATOR
10. BRAKE AIR PRESSURE INDICATOR
11. PARKING BRAKE INDICATOR
12. HIGH BEAM INDICATOR
15. OIL PRESSURE/WATER TEMPERATURE INDICATOR
16. LEFT HAND TURN SIGNAL INDICATOR

MT-28245A

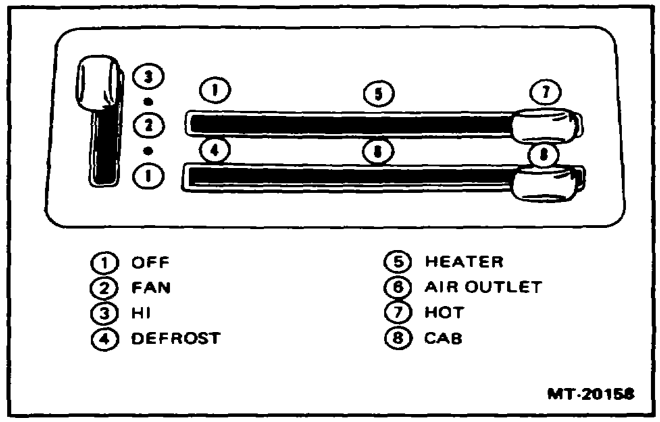


1. VENT CONTROL
2. HEATER OUTLET
3. WIPER WASHER CONTROL
4. CLEARANCE-IDENTIFICATION LIGHT CONTROL
5. HEAD LIGHT CONTROL
6. TRUCK-TRACTOR PROTECTION VALVE CONTROL
9. PARKING BRAKE CONTROL
12. ASH RECEPTACLE
13. HEATER CONTROLS
14. VENT CONTROL
15. THROTTLE CONTROL
16. ENGINE STOP CONTROL
17. IGNITION SWITCH

HEATING - DEFROSTING - VENTILATION (S-SERIES)

HEATING

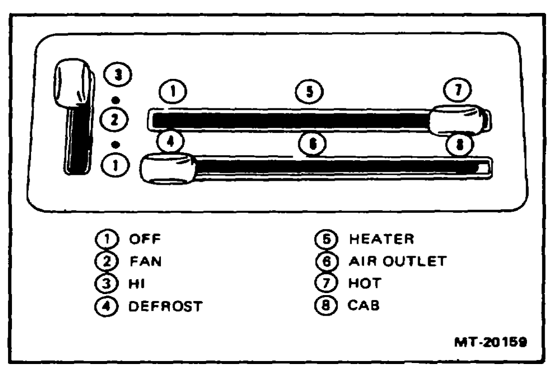
For proper cold weather operation the heat should be directed toward the floor level. Therefore, close all instrument panel outlets and fully open driver floor dump outlet. The driver floor dump is cable operated from a push-pull control at the instrument panel's upper left-hand side.



Adjust the temperature 'HTR" (heat) lever as required to give the desired degree of heat. The full right HOT" position provides the maximum heat. Move the "AIR OUTLET" control lever to whichever position provides the desired air flow distribution between heat and defrost. For the maximum air flow, move the fan switch to the "HI" position. The heater will also operate with the fan "OFF" due to the ram air produced by vehicle motion.

DEFROSTING

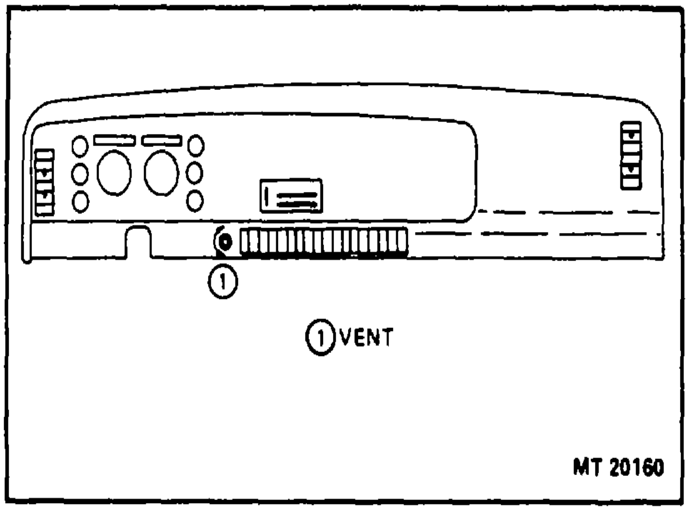
To obtain maximum defrosting, place the "AIR OUTLET" lever on "DEF" and adjust the OHTR" lever for the desired degree of heat. Adjust the fan speed to provide the desired air flow (see illustration).



FRESH AIR VENTILATION

Fresh air enters the cab either through an independent ventilation system or through the heater system itself. The ventilation system is controlled by rotating the vent knob located just left of the center Instrument panel outlets (see illustration). When the knob is turned counterclockwise, air flows through the instrument panel outlets and floor dump. For all other modes of operation, the knob should be rotated fully clockwise (vent door closed).

The fan may be used to increase the quantity of air entering the cab during ventilation. Adjust the fan speed and air outlets as desired.



(Pages 2029 through 2034 DELETED

HOOD
S-SERIES,

RAISING THE HOOD

1. Release latches on both sides of cowl.

2. With foot positioned on bumper step, grasp hood assist handle.

3. Pull hood forward and over center. Gently rest hood on stop cables.

LOWERING THE HOOD

1. Grasp hood assist handle. With foot in bumper step, slowly lower hood to closed position.

2. Engage latches at both sides of cowl.

CARE

Frequent and regular washing will lengthen the life of your new vehicle's painted finish and bright metal trim.

WASHING

Wash your vehicle often with warm or cold water to remove dirt and preserve the original luster of the paint Never wash the vehicle in the direct rays of the hot sun or when the sheet metal is hot to the touch, as this may cause streaks on the finish. Do not use hot water or strong soaps or detergents or wipe off dirt when the surface is dry as this will scratch the paint.

WAXING OR POLISHING NEW VEHICLES

Prior to use of any wax or polish, vehicle must be thoroughly washed.

BRIGHT METAL CARE

To preserve the bright look of your vehicle's anodized aluminum trim (grilles, bumpers, etc.) use only mild detergents and lukewarm water for cleaning Damage to these parts can occur If cleaning solutions having excessive acidity or alkalinity (pH) are used. Also, the higher the solution temperature ranges, the more caustic the cleaner's chemical compounds become. However, if high pressure washing equipment and washing compounds are used, satisfactory results can be achieved if the solution has a pH value between 4 and 8, and the temperature does not exceed 71°C (160°F). Solutions that are more acid or more alkaline will attack the anodic coating. If you are having difficulty with your washing compound, contact your local supplier for the acidity/alkalinity (pH) specification A nonabrasive chrome cleaner may be used sparingly to clean the bright metal. Do not use steel wool Use of automobile wax or polish on bright metal usually will restore the original brightness.

UPHOLSTERY CARE

Use a whisk broom and vacuum cleaner to remove loose dust and dirt from upholstery and floor Vinyl and woven plastic upholstery can be washed with warm water and mild soap Wipe dry. If commercial cleaners are used, follow instructions supplied with cleaner.

(Pages 2036 through 2040 DELETED

CONTENTS

ALTERNATOR

IMPORTANT - Before connecting a fast charger, booster battery or installing a new battery, make sure that the ground polarities of the fast charger, booster battery or alternator (when installing a battery) are matched to the ground polarity of the vehicle battery. Improper usage of fast charger, hookup of booster battery or installing battery can cause damage to the electrical system or to the alternator. Do not attempt to polarize the alternator.

AMMETER

The ammeter indicates the rate of charge of electric current supplied by the alternator to the battery, or the rate of discharge from the battery. At low engine speeds the ammeter indicator may show a negative or discharge reading. When the battery is fully charged, a very slight charge is indicated during normal vehicle operation.

BATTERY

WARNING TO PREVENT SEVERE INJURY TO THE EYES, FACE, LIMBS AND BODY, IT IS IMPERATIVE THAT LIGHTED TOBACCO, FLAMES OR SPARKS BE KEPT AWAY FROM THE VENT OPENINGS OF THE BATTERY. THE GAS MIXTURE IN THE BATTERY CELLS, WHICH ESCAPES THROUGH THE VENTS, COULD IGNITE AND/OR CAUSE AN EXPLOSION. THIS IS PARTICULARLY TRUE WHEN JUMPER CABLES ARE BEING USED.

IN ADDITION, INHALING OF HYDROGEN GAS PRODUCED IN THE NORMAL OPERATION OF THE BATTERY COULD RESULT IN PARTIAL OR PERMANENT DAMAGE TO THE RESPIRATORY SYSTEM.

WHENEVER DISCONNECTING BATTERY TERMINALS, ALWAYS DISCONNECT GROUND TERMINAL FIRST. WHEN RECONNECTING, ALWAYS CONNECT GROUND TERMINAL LAST.

ALWAYS WEAR EYE PROTECTION WHEN WORKING AROUND BATTERIES. DO NOT ATTEMPT TO JUMP START A VEHICLE HAVING A FROZEN BATTERY, BECAUSE THE BATTERY MAY RUPTURE OR EXPLODE. IF A FROZEN BATTERY IS SUSPECTED, EXAMINE ALL FILL VENTS ON THE BATTERY. IF ICE CAN BE SEEN, DO NOT ATTEMPT TO START WITH JUMPER CABLES AS LONG AS THE BATTERY REMAINS FROZEN. THAW OUT BATTERY, FILL WITH WATER AND RECHARGE.

FAILURE TO OBSERVE THESE INSTRUCTIONS COULD RESULT IN PERSONAL INJURY AND/OR DAMAGE TO THE VEHICLE.

The solution in each cell should be to the indicator level. When the solution is below this level, add distilled water, using a clean syringe. Acid or electrolyte should never be added except by persons skilled in working with these materials. Some maintenance free batteries do not have removable caps for adding distilled water.

Never add special battery "dopes", solutions or powders.

Battery cable terminals must be clean and tight. Use hot water and common baking soda for removing terminal corrosion and for cleaning the top of the battery. Brighten the contact surface with steel wool, apply a light coat of Grafo Grease or chassis lubricant and reassemble. Be sure the terminals are clamped tightly and that the battery Is clamped securely in the battery box.

When working around the terminals and battery, use extra care to avoid shorting. A good practice is to insulate pliers and screwdrivers. DO NOT CHECK BATTERY CONDITION BY SHORTING (FLASHING) ACROSS TERMINALS.

BATTERY/GENERATING SYSTEM GAUGE (VOLTMETER)

The battery, generating system indicator gauge indicates the condition of the battery.

The gauge is divided Into two sections, red and green.

With ignition switch "ON" (before starting engine) the gauge will show the condition of the battery.

GREEN - A well-charged battery.
RED - Very low battery charge.

With the engine running at operating speeds the gauge will show the condition of the generating system.

GREEN - generating system working properly.
RED - voltage output too high.

Constant reading in either RED area indicates the need for a complete check of the battery and generating system.

CIRCUIT BREAKERS, AND FUSIBLE LINKS

Electrical circuits are protected either by circuit breakers, fuses or fusible links. Refer to Circuit Breakers in the following text for location. Type and size of circuit breakers and fuses will be found in the circuit diagram manual supplied with each vehicle. Fusible links consist of a length of lighter gauge wire in a circuit. In case of a short or overload, the fusible link opens (bums out) to protect the remainder of the circuit. Repair consists of splicing in a new piece of same gauge wire (a new link). Wire sizes are called out in the circuit diagram manual.

S-SERIES

The various electrical units are protected by either fuses or circuit breakers located under the instrument panel to the left of the driver.

A fuse panel for trailer connections is located on the cab behind the driver.

HORN

Some areas have local Noise Control Laws regulating horn use. If your vehicle has both an electric and an air horn system, use the electric horn within city limits and the air horn outside city limits.

The electric horn control (city horn) Is normally located In the steering wheel. Push down to operate.

The air horn control (country horn) is normally located forward of the left door opening above the driver's head. Pull down to operate.

HOUR METER

The hour meter records the number of hours that the engine has operated. Never leave starting switch in the "Run" position while the engine is not operating. The hour meter will operate when start switch is in the "Run" position even though engine is not running.

In certain types of operations such as stationary use of engine during power take-off use or short hauls Involving extensive use of reverse gear, the odometer reading is not an accurate guide for engine or chassis lubrication intervals. The hour meter reading can be used as a guide in determining lubrication and maintenance intervals.

LIGHTING SWITCHES

S-SERIES

When the lighting switch is pulled out halfway, the parking, side marker and taillights are "ON". When the lighting switch is pulled out all the way, the headlights, side marker lights and taillights are "ON". To light the instrument panel, turn the light switch control to the left; a built-in rheostat controls the intensity of the panel light from "OFF" to full "ON". To turn the cab interior light on, turn the lighting switch control counterclockwise to the extreme left position.

SPEEDOMETER AND ODOMETER

The speedometer Indicates the vehicle speed in miles or kilometers, per hour. The odometer records the total of numbers of miles traveled.

TACHOMETER

The tachometer Indicates engine RPM. The engine can be operated between rated speed and high idle without damage but should not be allowed to overspeed (such as when going downhill). Refer to ENGINE section of this manual for vehicle operation engine speeds.

TURN SIGNAL SWITCH

The turn signal switch is mounted on the left side of the steering column below the steering wheel. Green directional indicator lights are located on the instrument panel.

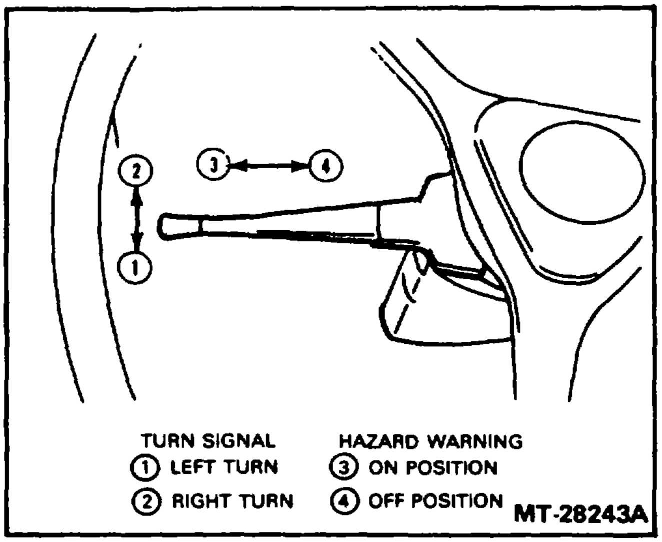
IMPORTANT The turn signal system on some models Is not self-canceling. After a turn is completed, the driver must manually shut the system off by returning the switch to the "OFF" position.

TRAFFIC HAZARD WARNING LIGHT SWITCH

The traffic hazard warning flasher system will operate with the key switch in the “ON' or "OFF” position. Use the warning system any time your vehicle becomes a traffic hazard, day or night.

S-SERIES, CARGOSTAR

The traffic hazard warning switch is located within the steering column. To activate the hazard warning lights, pull turn signal switch lever "outward." To cancel hazard warning lights, push turn signal switch lever In towards steering column.



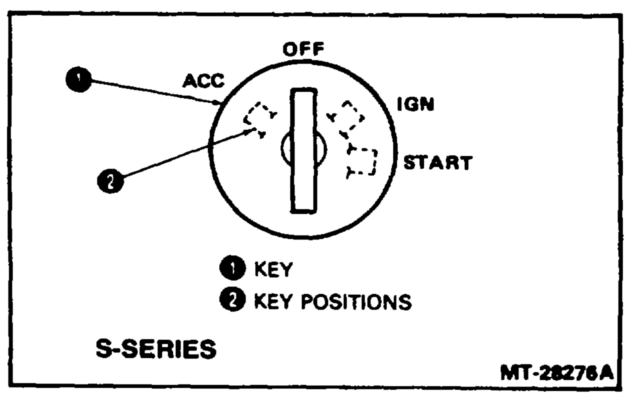
COOLANT TEMPERATURE WARNING LIGHT

This light will glow when the engine coolant has overheated.

STARTING SWITCHES

S-SERIES

Place transmission control in the neutral position. With ignition key in switch, rotate switch clockwise to the first position, marked IGN. The ignition system is now activated. Continued clockwise rotation of the switch will activate the starting system causing the engine to turn over. As soon as the engine starts release switch and the switch will return to the IGN position. Engine will continue to run with switch in IGN position. To stop the engine rotate the switch counter-clockwise to the vertical position, marked OFF, and remove key from switch. There is also an ACC (Accessory) position on the switch, allowing use of accessories during periods when engine operation is not desired. With ignition key in switch, rotate switch counter-clockwise from the OFF position. Switch will stop at the ACC position. To terminate accessory operation rotate switch clockwise to the OFF position and remove key.



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WARNING-FAILURE TO MAINTAIN BRAKES IN PROPER CONDITION AND ADJUSTMENT COULD RESULT IN REDUCED BRAKING ABILITY, PROPERTY DAMAGE AND/OR PERSONAL INJURY.

DOWNHILL OPERATION

Always descend hills with extreme care, relying on the braking effect of the engine to control vehicle speed. Heed warning signs posted for any grade. Before Pages 2045 through 2046 DELETED starting a descent, (if a safe area is available) stop and check the brakes.

Observe the following precautions:

Service brakes alone should not be used to control speed on major downgrades. Brakes will fade from overuse.

Operating engine with closed throttle and transmission in reduced gear is the method that should be used

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to control downhill speed. If the transmission gear selection will not hold the desired speed without overuse of the brakes, an Improper gear selection was made.

Make a full stop (if possible). Let the brakes cool, then continue down grade in a lower gear range.

DO NOT ATTEMPT to gear down if the engine has reached maximum speed (RPM) in any transmission gear range and the brakes have faded. It will be impossible to shift into a lower gear.

The common rule to follow in using the engine and transmission to control vehicle speed is to select the same gear going down the hill that would be required to ascend the hill. There are some exceptions such as going down a short hill with good visibility and no hazards.

The service brakes should be used to supplement available vehicle retardation. When descending long grades requiring use of the brakes, snub applications (5 to 10 seconds duration) should be made rather than long, continuous applications. This minimizes temperature rise, brake fade and air consumption of air brake system.

WARNING - NEVER COAST DOWNHILL.

AIR BRAKES

All air brake-equipped vehicles have a split brake system.

The purpose of this split system is to provide a means of stopping the vehicle should a failure occur in either the primary or secondary brake system. In the event air pressure loss occurs in one system, the remaining system continues to provide braking action.

Even though there will be enough braking capability for emergency stopping, the vehicle must not be operated when a failure is indicated, as there is no capability for replenishing air pressure.

If vehicle has been parked for an extended period in cold weather, always check to be sure all wheels are rolling free (brakes are not frozen) when starting out. Always clean accumulated ice and snow from brake linkage.

AIR GAUGE LOW AIR PRESSURE BUZZER AND INDICATOR LIGHT

Should air pressure in either section of the dual air brake system be reduced to 483 ± 41 kPa **(**70 ± 6psi) the warning buzzer will sound and a red light on the instrument panel will glow. Also, the air gauge/gauges will indicate low air pressure in at least one of the Independent systems.

The warning buzzer and red light will automatically shut off when the air pressure in both systems is sufficient (approximately 483 kPa/70 psi) to operate the vehicle.

Should the red light and buzzer not shut off soon after startup, the air pressure gauge/gauges should indicate at least one section of the dual system has low ail pressure.

If the red light, buzzer and gauge indicate a loss of pressure while driving, the vehicle still has a portion of the braking capability, in that either one-half of the dual system or the spring brake system braking capability is retained. However, the distance required to stop the vehicle will be increased.

WARNING - NEVER OPERATE THE VEHICLE WHEN INSUFFICIENT AIR PRESSURE (LESS THAN 483 KPA/70 PSI) IS INDICATED FOR EITHER SYSTEM. HAVE THE BRAKE SYSTEM CHECKED AND REPAIRED BEFORE RETURNING THE VEHICLE TO SERVICE.

BRAKE APPLICATION

Rapid successive brake applications and release, sometimes referred to as “fanning the pedal," should be avoided. This is an inefficient way of slowing or stopping a vehicle and inefficient use of air pressure.

BRAKE INSPECTION AND ADJUSTMENT

A regular schedule for periodic cleaning, lubrication, adjustment and inspection should be established, based on the type of vehicle operation It is difficult to predetermine an exact maintenance interval (time or mileage), since vehicles will be used in a wide variety of applications and conditions If you are uncertain of the proper schedule and procedures for your vehicle, contact your IH dealer.

Periodic checking of push rod travel or brake adjustment is essential for good braking. Push rod travel should be checked every 3 000 km (2, 000 miles) to determine if adjustment is necessary. Vehicles with automatic slack adjusters should also be checked to ensure proper operation of the adjuster mechanism at the 3 000 km (2, 000 mi.) interval. Push rod travel should be kept at a minimum without brakes dragging.

Inspect brake lining every 19 000 km (12, 000 miles) or every 12 months, whichever occurs first. Inspect more often during periods of severe service operation or considerable stop-and-go operation. When brake lining or blocks are worn to within 1.6mm (1/16 inch) of rivets, brake lining must be replaced.

This inspection or adjustment should only be performed by qualified service personnel and must be in accordance with instructions provided by International Harvester Company.

Do not back off front brakes so that they are not as aggressive, letting the rear brakes do all the stopping of the vehicle. Do not overlook the brakes on the trailer either. Brake balance on trucks and tractor trailers is essential for good braking.

PARKING BRAKE

All vehicles with air brakes are equipped with spring brakes for parking. The parking system is operated manually by a single valve, which in the case of a tractor also controls the parking system on the towed unit.

The purposes of this brake are to hold the vehicle In a parked position and to assist in bringing it to an emergency stop. The parking brake should not be used to brake the vehicle during normal driving.

To apply the parking brake, pull out control. To release the parking brake, push in on control.

If air pressure is reduced to approximately 69 kPa (10 psi) in both the Primary and Secondary systems, the parking brakes will automatically apply on single unit trucks and tractors with independent parking and trailer controls.

If air pressure is reduced to approximately 207 ± 27.6 kPa (30 ± 5 psi) in both the primary and secondary systems, the parking brake control will automatically apply on tractors with the modular control system.

It should be noted that partial spring brake application will occur prior to automatic application of the control valve in either system described above.

To release, recharge system to 483 kPa (70 psi). If the system cannot be recharged and the vehicle must be moved, the spring brake must be manually released.

WARNING - TO AVOID PERSONAL INJURY OR PROPERTY DAMAGE, WHEN MANUALLY RELEASING THE SPRING BRAKES, BE SURE TO BLOCK THE WHEELS SO THAT VEHICLE CANNOT MOVE WHEN THE BRAKES ARE RELEASED.

FOR TOWING, MAKE SURE THE VEHICLE IS SECURELY CONNECTED TO TOW VEHICLE BEFORE RELEASING THE SPRING BRAKES.

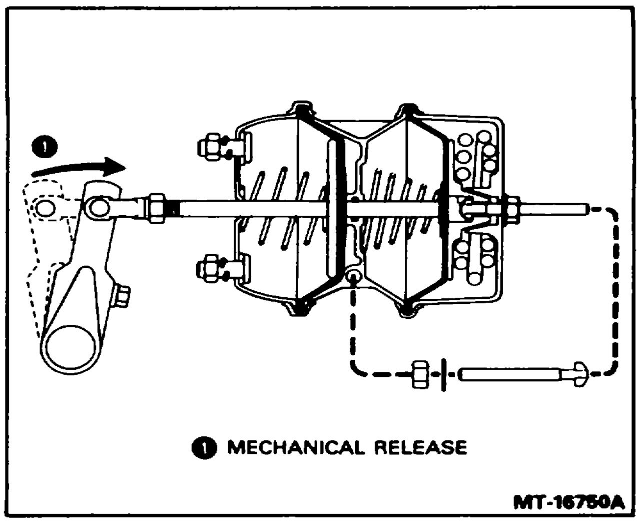
PARKING BRAKE RELEASE

In the event it is necessary to move the vehicle after an emergency application (before air pressure can be restored), the emergency parking spring can be compressed mechanically to release the brake. A release stud "spring caging tool" is furnished with the brake chamber assembly. The release stud engages In the spring pressure plate and Its nut is tightened to compress "cage" the spring and release the brake.

Remove release stud assembly from carrying pocket.

Apply a light coat of Never Seeze to the threads of the release stud to avoid any unnecessary wear of the threads. Remove the access plug from the end of the spring chamber. Insert the release stud through the opening in the chamber and into the spring pressure plate.

Turn the release stud 1/4 turn to engage the tangs on the release stud into the slot In the pressure plate. Install the nut on the release stud. Be sure tang on release stud stays engaged with slot on pressure plate while installing the nut. Tighten the nut with a wrench to compress the spring.



PARKING BRAKE RESET

Charge spring brake chambers with air pressure. Remove the release stud and nut from the spring housing and reinstall the access plug in the housing opening. Reinstall the release stud and nut in the carrying pocket on the brake chamber housing.

RESERVOIR MOISTURE DRAINING

Moisture taken in with the air through the compressor inlet valves collects in the reservoirs and necessitates draining each reservoir daily in cold weather and once a week in warm weather by opening the drain cock located either on the bottom of the tank or in the end of the tank. If in the end of the tank, there must be some air pressure in the system to assure proper drainage. Be sure to close the drain cocks after all moisture has been expelled.

On vehicles so equipped, the Automatic Reservoir Drain Valve ejects moisture and contaminants from the reservoir in which it is connected. It operates automatically and requires no manual assistance or control lines from the other sources. The reservoir should be drained and the valve should be examined periodically to ensure that the drain passage is not obstructed.

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VACUUM GAUGE AND LOW VACUUM INDICATOR LIGHT

(Vehicles with Dual Power Brake and Reserve Tank)

The vacuum gauge registers the amount of vacuum In the brake system. If vacuum falls below 20.3 cm (8 inches) a warning light on the instrument panel will glow The warning light will go out when vacuum in the system is sufficient to operate vehicle.

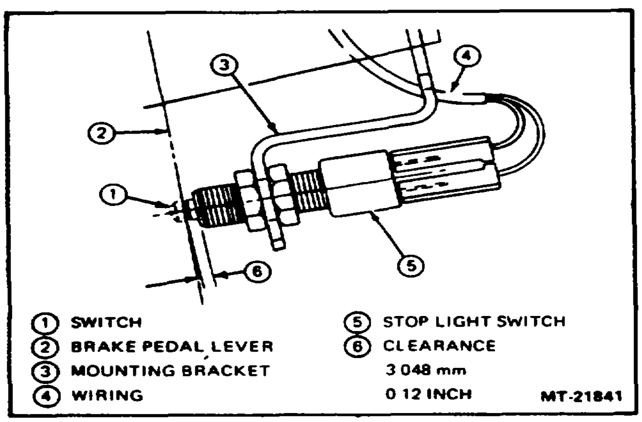
PEDAL ADJUSTMENT

When adjustment of the pedal free travel is necessary, it is extremely important that the work be property performed.

To avoid needless delay and expense, allow only competent and experienced servicemen to perform these operations.

STOPLIGHT SWITCH ADJUSTMENT

The stoplight switch should be adjusted so that the clearance between the switch body (not plunger) and pedal lever is 3.048mm (0.12 inch), when the brake pedal has been property adjusted.



PARKING BRAKE INDICATOR LIGHT

The "PARK BRAKE" indicator is operated in conjunction with the parking brake. During engine cranking period the "PARK BRAKE" indicator should illuminate.

This light will go out after engine is started providing the parking brake is not applied. If parking brake i;/ applied, this light will remain on after engine has start ed. If light does not illuminate during cranking period the light bulb may be defective.

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AIR RESTRICTION GAUGE

The air restriction gauge indicates how much engine air cleaner filter capacity has been used and how much filter capacity remains. It measures maximum restriction of the filter element when the engine is operated at full load and locks at that point. This feature gives the operator the capability of reading maximum restriction with the engine shut down.

The gauge will be mounted on the air cleaner

Air Cleaner Mounted

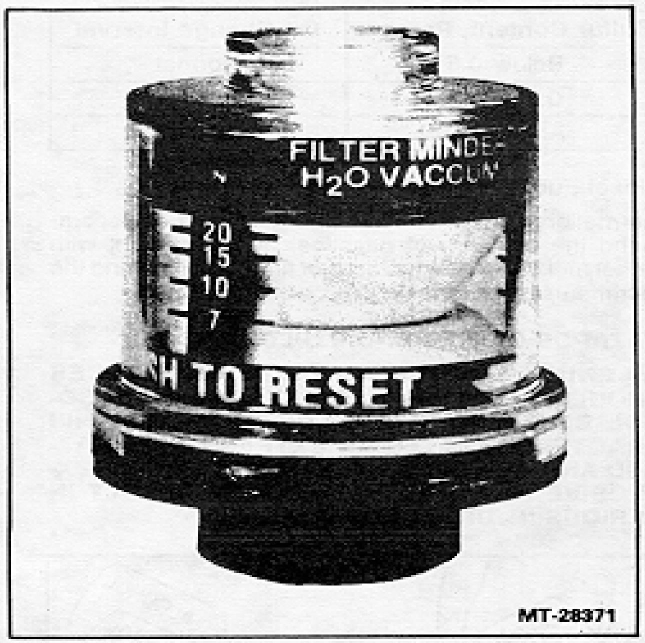
It is recommended that the operator NOT reset gauge until it has been determined if air cleaner service required.

NOTE:: It is not necessary that the engine be shut down when the yellow indicator in gauge reaches the maximum restriction (red) but indicates air cleaner service is required (refer to Troubleshooting).

The initial restriction with a new air filter element will vary with air cleaner design and installation.

Normal Clean Filter. (3-15 inches)
(Varies With Each System)

DO NOT open air cleaner, disturb seals or element until gauge registers maximum restriction (refer to Engine Air Restriction Limit Chart). Replacement of air cleaner element Is not to be judged by appearance. Air cleaner element may look dirty but still be In satisfactory condition.



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Filter Life Used Up. Refer To Engine Air Restriction Limit Chart. Continued Operation May Damage Engine.

ENGINE AIR RESTRICTION LIMIT CHART	
Maximum Inches of Water Vacuum (H_2O)	Engine Application
20" 500 mm	IH 9 Liter Detroit Diesel

TROUBLESHOOTING

No flea lotion Reading

POSSIBLE CAUSES:	HOW TO CHECK:
Plugged fitting or vacuum line.	Apply vacuum to gauge until locked up at red zone. Reconnect line and *hod in* reset button. Indicator will fully return unless line or fitting is plugged. A slow return is normal due to safety filter in fitting.
Leak in vacuum line.	Apply vacuum to gauge until locked up at red zone. Reconnect gauge and close end of line air tight. Hold In reset button. Indicator will drop slightly and then not move unless vacuum line has a leak.
Leak in gauge.	Repeat above except close gauge connection air tight.
Engine air flow too low to generate a restricting reading.	Turbocharged engines must be at full load to pull full engine air flow. (N.A. engines at full RPM)

High Restriction Reading

POSSIBLE CAUSES:	EXPLANATION:
Plugged or poorly cleaned elements.	Ultra fine particles are difficult to remove and cleaning may not sufficiently lower restriction.
Plugged Inner element (If equipped).	Replace inner element.
Plugged inlet screens or ducts.	Check system upstream from restriction tap for debris, damage, or improper installation.
Heavy snow or rain.	Temporary high restriction can occur during a rain or snowstorm and it disappears after drying out. COLD AIR MAYBE SO DENSE THAT HIGH RESTRICTION MAY NOT REDUCE ENGINE POWER BEFORE ELEMENTS ARE DAMAGED FROM HIGH VACUUM. If gauge is locked up at red zone check elements for damage.

DIESEL ENGINES
9 LITER

FUEL REQUIREMENTS (DIESEL)

For engines not manufactured by IH, refer to separate manual provided with vehicle.

RECOMMENDED FUEL FOR IH DIESELS:

This fuel information will help the operator obtain maximum performance at the least cost when using an International diesel engine. The specifications are broad enough to permit the use of low cost fuels yet are restrictive enough to prevent use of low quality fuels which could lead to frequent overhauls.

Fuel Grade: Use only Grade No. 1-D or Grade No. 2-D diesel fuels. Specifications for these fuels are listed in ASTM D975 or Federal Specification VV-F-800. Do not use fuels sold only as heating or furnace oil. Choose the proper fuel grade as follows:

Expected Temperature	Preferred Fuel Grade
Above −7°C (+20°F)	Grade No. 2-D
Below −7°C (+20°F)	Grade No. 1-D

NOTE: If Grade No. 1-D is not available, use a "winterized" or "climatized" Grade No. 2-D fuel, made by blending No. 1-D with No. 2-D fuel to match the temperature conditions In your area.

If your engine suddenly becomes noisy after a fuel fill, you possibly received substandard fuel with a low cetane rating. Whenever feasible, buy diesel fuel from a reputable supplier who sells a large amount of diesel fuel.

Sulfur Content: Diesel fuels with a maximum sulfur content of 0.5 percent are recommended. Know your fuel sulfur content. (Ask your supplier, or have fuel analyzed.) If fuel contains more than 0.5 percent sulfur, reduce the oil-change interval as follows:

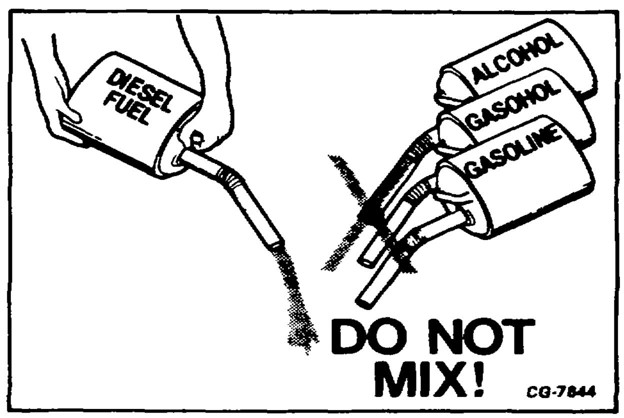
Sulfur Content, Percent	Oil-Change Interval
Below 0.5	Normal
0.5 to 1.0	1/2 Normal
Above 1.0	1/4 Normal

Diesel Fuel/Gasoline Blends

International Harvester Company does not recommend the blending of gasoline, and/or alcohol with diesel fuel due to the hazards of fire/explosion and the detrimental effects on engine performance.

HAZARDS OF FIRE AND EXPLOSION:

WARNING - UNDER NO CIRCUMSTANCES SHOULD GASOLINE, GASOHOL AND/OR ALCOHOL BE BLENDED WITH DIESEL FUEL. THIS PRACTICE CREATES AN EXTREME FIRE HAZARD AND UNDER CERTAIN CONDITIONS AN EXPLOSIVE HAZARD WHICH COULD RESULT IN SERIOUS INJURY OR DEATH.



- As little as two volume percent gasoline mixed with diesel fuel will create a flammable/explosive mixture in the fuel tank vapor space, which will pose an extreme fire/explosion hazard during refueling or engine operation.

ENGINE PERFORMANCE PROBLEMS

- Lower fuel viscosity could reduce engine power and fuel economy, and increases the possibility of excessive fuel system wear or failure.

- Lower cetane number could cause hard starting and slower warmup, and could increase engine noise and exhaust emissions.

  IMPORTANT - Excessive cetane number reduction can lead to engine damage or failure.

WARNING - ANY VOLUME OF GASOLINE IN DIESEL FUEL IS EXTREMELY DANGEROUS AND IS NOT RECOMMENDED BY INTERNATIONAL HARVESTER COMPANY.

WARNING - DO NOT START OR RUN AN ENGINE WITHOUT VEHICLE BEING COMPLETELY VENTILATED AT ALL TIMES. EXHAUST GAS FROM ALL INTERNAL COMBUSTION ENGINES CONTAINS POISONOUS CARBON MONOXIDE WHICH IS ODORLESS, TASTELESS, AND COLORLESS. WHEN VEHICLE IS STARTED INSIDE, KEEP GARAGE DOORS WIDE OPEN. THIS POISONOUS CARBON MONOXIDE GAS WILL NOT ONLY CAUSE DROWSINESS, BUT COULD BE FATAL. ALWAYS PROVIDE PROPER VENTILATION WHILE OPERATING THE VEHICLE.

STARTING - DIESEL ENGINES

BEFORE STARTING ENGINE

The following checks should be made before starting the engine:

1. Check the cooling system level and fill if necessary. For specifications refer to Cooling System of this section in this manual.

2. Check engine oil level for proper level. Refer to Lubrication in Section N of this manual if addition is necessary.

3. Check diesel fuel recommendations.

CAUTION - DO NOT INCREASE ENGINE SPEED UNTIL OIL PRESSURE GAUGE INDICATES NORMAL. SHUT ENGINE DOWN IF OIL PRESSURE DOES NOT REGISTER ON GAUGE WITHIN 20 SECONDS.

WARNING EXPLOSION HAZARD. DO NOT USE VOLATILE STARTING AIDS, SUCH AS ETHER, PROPANE OR GASOLINE IN THE ENGINE AIR INTAKE SYSTEM. GLOW PLUGS WILL IGNITE VAPORS AND CAUSE SEVERE ENGINE DAMAGE AND PERSONAL INJURY.

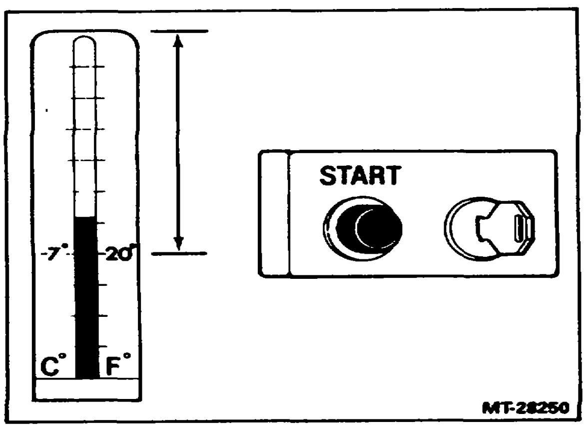
CAUTION DO NOT JUMP START VEHICLE WITH AUXILIARY SOURCE OF MORE THAN 12 VOLTS. DO NOT BYPASS OR ALTER GLOW PLUG CIRCUITS IN ANY WAY. FAILURE TO COMPLY WILL DESTROY GLOW PLUGS AND CAN LEAD TO SEVERE ENGINE DAMAGE.

9.0 LITER, ENGINE

Engine starting can be divided into starts with or without the use of an ether starting aid. Ether will not be required with ambient temperatures above -7°C (20°F), provided engine and starting system are In good condition. The following procedures should be used.

Starting procedures may vary slightly dependent upon accessory package.

STARTS AT -7° (20°F) AND ABOVE



1. Set parking brake, place transmission in neutral and fully depress clutch pedal.

2. Place engine shut-off in RUN or ON position.

3. Depress accelerator fully and engage starter to start engine.

4. When engine starts, release starter switch immediately and reduce engine speed to less than 1,000 RPM. Warm engine 3 to 5 minutes or until all systems reach operating temperatures. Check all gauges during warm-up.

If engine starts and then stops, it is necessary to release accelerator pedal allowing return to low idle, and then press to full speed to ensure that the Injection pump has excess fuel for starting. Investigate the cause of non-starting if more than three attempts are required to start engine.

CAUTION DO NOT INCREASE ENGINE SPEED UNTIL OIL PRESSURE GAUGE INDICATES NORMAL. SHUT ENGINE DOWN IF OIL PRESSURE DOES NOT REGISTER ON GAUGE WITHIN 20 TO 30 SECONDS AFTER START.

NOTE - An engine at or near operating temperature may be started with accelerator pedal at low Idle or partially depressed.

9.0 LITER ENGINES ONLY

1. Set parking brake and place transmission control in the neutral position. Depress clutch pedal, if applicable.

2. Place engine shutoff in RUN or ON position, for either option of manual or electrical shutoff control.

3. Depress accelerator pedal to full speed position, push and release other injection switch button once.

4. Crank engine.

CAUTION -DO NOT RELEASE ETHER INTO THE CYLINDERS UNTIL JUST PRIOR TO **CRANKING THE ENGINE. INTRODUCTION OF ETHER AT AN APPRECIABLE TIME BEFORE CRANKING MAY DAMAGE PISTONS AND RINGS.**

5. When engine starts, release starter switch immediately and reduce engine speed to 1,000 RPM or less. Monitor gauges and warm up engine until all systems reach operating temperature.

CAUTION IF IN EXTREMELY COLD AMBIENT TEMPERATURE, INITIAL ENGINE OPERATION IS ROUGH OR DIES, INJECT ETHER SHOT TO FACILITATE SMOOTH OPERATION.

6. If engine fails to start, repeat above procedure.

CAUTION - SHUT DOWN ENGINE IF OIL PRESSURE IS NOT REGISTERED ON GAUGE WITHIN 30 SECONDS.

ALL DIESEL ENGINES

CAUTION - IF ENGINE FAILS TO START WITHIN 30 SECONDS, RELEASE STARTER SWITCH AND WAIT 2 TO 3 MINUTES TO ALLOW STARTER MOTOR TO COOL. REPEAT ABOVE PROCEDURE. IF AFTER THREE (3) REPEAT OPERATIONS ENGINE DOES NOT START, INVESTIGATE AND DETERMINE CAUSE FOR ENGINE NOT STARTING. STARTER MOTOR DAMAGE MAY RESULT IF STARTING OPERATION IS CONTINUED.

NOTE: Ether capsule starting aids are not recommended.

IMPORTANT - Cold ambient engine warm-up time can be reduced by operating vehicle under load at reduced engine speed. Commence normal driving when systems reach operating temperatures.

EMERGENCY STARTING

WARNING - THE PROCEDURES BELOW MUST BE PERFORMED EXACTLY AS OUTLINED. OTHERWISE INJURY TO THE FACE, EYES, BODY, UMBS, AND RESPIRATORY SYSTEM COULD RESULT FROM FIRE OR ACID DUE TO BATTERY EXPLOSION. PROPERTY DAMAGE COULD ALSO RESULT.

1. To prevent shorting of the system, remove metal rings or watches and do not allow metal tools to contact positive terminal of battery.
2. Place transmission in NEUTRAL and set parking brake in both vehicles.
3. Shut off lights, heater, air conditioner and any other electrical loads in both vehicles.
4. Eye protection should be worn if available. If not available, shield eyes when near either battery.
5. Vehicle bodies or bumpers must not be in contact.
6. Connect one end of the first jumper cable to positive (+) terminal of the dead battery and then the other end to the positive (+) terminal of the booster battery.
7. Connect one end of the second jumper cable to negative (-) terminal of the booster battery, and the other end to an engine bolthead or good metallic contact spot on the engine of the vehicle to be started. Do not attach the other end to the negative (-) battery terminal, because a spark could occur and cause explosion of gases normally present around the battery.
8. Reverse above procedure when removing the jumper cables.

IMPORTANT - If the battery is a Delco maintenance free-type, do not attempt to Jump-start the vehicle, charge or test the battery If the Indicator in the battery is bright or light yellow. Install a new battery.

WARM UP

It is very important that any engine be warmed up before applying load.

The warm-up period provides time for the lubricating oil to establish a film between moving parts.

In colder areas where temperature is often below 0°C (32°F), the warm-up period for turbocharged engines is especially important. The cold external oil lines leading to the turbocharger will tend to slow oil flow until the oil warms up.

Slow oil flow to the turbocharger reduces the oil available for the bearing; therefore, before applying load or speed above 1000 RPM to the engine make sure to warm up the engine for a minimum of five minutes at or below 1000 RPM.

OPERATING INSTRUCTIONS

Start vehicle in motion by utilizing the highest gear speed in the transmission that will enable the engine to easily start the load without slipping the clutch. Accelerate smoothly and evenly to engine rated speed. Rapid acceleration will result in high fuel consumption with no increase in performance.

When approaching a hill, depress accelerator smoothly to start the upgrade at full power, then shift down as needed to maintain vehicle speed.

Prevent overspeeding of the engine when going down long and steep grades. The governor has no control over engine speed when it is being pushed by the loaded vehicle. Operate in a gear that will permit an engine speed not in excess of the MAXIMUM GOVERNED SPEED or HI-IDLE RPM (no load). Operating an engine beyond the maximum governed speed can cause severe damage.

COLD WEATHER OPERATION

In order to operate engine in temperatures of 0°C (32°F) or lower, observe the following instructions:

1. Make certain that battery is of sufficient size and is in fully-charged condition. Check that all other electrical equipment is in optimum condition.
2. Use permanent-type anti-freeze solution to protect against damage by freezing.
3. At the end of each daily operation, drain water from water separator. Fill fuel tank at end of daily operation to prevent condensation.
4. Be sure to use proper cold weather lubricating oil, and be sure crankcase contains a sufficient amount.
5. At temperatures of -20°C (-4°F) and below, it is recommended that you use a crankcase-mounted coolant heater to improve cold starting.
6. If operating in arctic temperatures of -29°C (-20°F) or lower, consult your International Harvester dealer for information about special cold weather equipment and precautions.

HOT WEATHER OPERATION

1. Make sure that battery has proper amount of electrolyte.
2. Keep cooling system filled with clean permanent anti-freeze solution to protect against damage by overheating.
3. Fill fuel tank at end of daily operation to prevent condensation in tank.
4. Keep external surface of engine, radiator and accessories clean to avoid dirt build-up.

THE PROPER PROCEDURE SHOULD BE:

Set the trailer brakes, bring the RPM up slightly and begin to engage the clutch while, at the same time, releasing the trailer brakes.

As the RPM begins to fall off, DO NOT disengage the clutch. The RPM will quickly come back and the vehicle will rapidly accelerate up the grade.

SHUTDOWN

Idle the engine for three to five minutes before shutting down. This few minutes idling allows the lubricating oil and water to carry heat away from the iron masses.

The larger the engine, the greater the need for this idling period and of course, the length of the idling period should somewhat follow the size of the engine in order to avoid seals or like features of an engine being damaged by rising heat.

PARKING

WARNING WHEN PARKING YOUR DIESEL VEHICLE, DO NOT LEAVE TRANSMISSION IN GEAR; IF VEHICLE ROLLS, ENGINE COULD START BY HEAT OF COMPRESSION. USE HAND BRAKE FOR PARKING. WHEN PARKING ON A GRADE BLOCK WHEELS OR TURN WHEELS TO CURB.

FAILURE TO FOLLOW THESE PROCEDURES COULD RESULT IN AN UNATTENDED VEHICLE MOVING, THUS RESULTING IN PERSONAL INJURY OR PROPERTY DAMAGE.

COOLING SYSTEM

ANTI-FREEZE

The cooling system of your new vehicle is filled at the factory with IH permanent-type anti-freeze. IH permanent-type anti-freeze may be added undiluted if protection below -29°C (-20°F) is required.

Maintaining Required Conditioner Concentration
All cooling system conditioners, including those In anti-freeze solutions, become depleted through normal operation. If conditioners in anti-freeze are allowed to become depleted, the anti-freeze becomes corrosive and attacks and coats metallic surfaces of the cooling system, which reduces heat transfer. To maintain an acceptable conditioner concentration, additional chemicals must be supplied to the cooling system. Your IH Dealer can assist you with cooling system conditioner service Information.

CLEANING
Once a year the cooling system should be drained and thoroughly flushed. (Flush with cooling system conditioner every 24 months.)

Unless the cooling system is treated with a corrosion preventative, rust and scale will eventually clog up passages in the radiator and water jackets. This condition is aggravated in some localities by formation of insoluble salts from the water used.

IH cleaning solutions are available which have proven very successful in removing accumulation of rust, scale, sludge and grease. This solution should be used according to the recommendation on the container.

IMPORTANT Do not use chemical mixtures to stop radiator leaks except in an emergency. Never use such solutions Instead of needed radiator repair. Do not use soluble oil.

When draining the cooling solution, disconnect the radiator outlet hose, as large particles of sediment will not pass through the drain.

WARNING - USE ONLY THE FOLLOWING PROCEDURE TO REMOVE THE PRESSURE TYPE CAP FROM THE RADIATOR. ALWAYS ALLOW THE ENGINE TO COOL FIRST. WRAP A THICK, HEAVY CLOTH AROUND THE CAP. PUSH DOWN, LOOSEN CAP SLOWLY TO ITS FIRST NOTCH POSITION; THEN PAUSE A MOMENT. THIS WILL AVOID POSSIBLE SCALDING BY HOT WATER OR STEAM. CONTINUE TO TURN CAP TO THE LEFT AND REMOVE.

CAUTION - IF THE COOLANT SHOULD GET EXTREMELY LOW AND THE ENGINE VERY HOT, LET

THE ENGINE COOL FOR APPROXIMATELY'15 MINUTES BEFORE ADDING COOLANT; THEN, WITH THE ENGINE RUNNING, ADD COOLANT SLOWLY. ADDING COLD WATER TO A HOT ENGINE MAY CRACK THE CYLINDER HEAD OR CRANKCASE. NEVER USE WATER ALONE.

RADIATOR FINS

Check the radiator fins periodically to make sure they are free of bugs, leaves and other debris, and that they are not bent or damaged. Clogged or damaged fins prohibit the flow of outside air to the radiator and hamper efficient cooling system operation.

COOLANT HOSES

The only coolants which are recommended for use in IH cooling systems are those which contain an ethylene glycol base. Other base coolants may damage rubber hoses, especially those made of silicone rubber. Type of rubber can usually be determined by color. Silicone hoses are made in "COLOR" while other rubber hoses are "BLACK." If coolants used are not of ethylene glycol base, this may affect your engine warranty.

IMPORTANT - Anti-freeze made with methoxy propanol or propylene glycol Is not recommended for use with IH engines. These types of anti-freeze can damage engine Internal seals and coolant hoses and create a potential fire hazard due to lower flash points than ethylene glycol type anti-freeze.

THERMOSTAT
Your new truck Is equipped at the factory with a high temperature thermostat.

Permanent type anti-freeze must be used with high temperature thermostats.

ENGINE OIL
Keep oil level as near the high level mark as possible. Never operate an engine with oil level below low level mark.

When checking the oil level, the dipstick must be withdrawn and wiped clean, then inserted all the way and again withdrawn for a true reading.

Never check the oil level with engine running or immediately after engine shutdown as an inaccurate reading will be obtained.

Most engines require a 15 to 20 minute waiting period. The 6.9 Liter requires a 20 to 30 minute shutdown prior to an oil level check.

Use only a good grade and proper viscosity engine oil. Refer to LUBRICATION - SECTION N for engine oil specifications.

The lubricating oil in a diesel engine becomes dark In color after short periods of engine operation. This discoloration Is not harmful to engine parts as long as the oil and oil filter element change periods are performed at **regular Intervals**.

FUEL AND LUBRICANT ADDITIVES

The following is the International Harvester Truck Group's policy on the use of fuel and lubricant additives.

"It is the International Harvester Truck Group's policy to develop and build trucks that will operate satisfactorily on fuels and lubricants of good quality marketed by the petroleum industry. The Truck Group does not recommend the use of any supplementary fuel or lubricant additives. The vehicle warranty shall not apply to any unit which has been subjected to misuse, negligence or accident. Malfunctions attributable to neglect or failure to follow manufacturer's fuel or lubricating recommendations may not be within the coverage of the warranty."

FAN AND ACCESSORY BELT ADJUSTMENT

FAN AND ACCESSORY DRIVE BELTS

Replace belt(s) if worn, cracked or grease and oil soaked. Replace worn pulleys.

New belts have a break-in period and lose tension during groove seating.

IMPORTANT New belt Initial Installation tension is higher than the re-tension value applied to a used belt (run five minutes or longer). This Is done to minimize number of belt adjustments and prevent belt operation under low tension during break-in period.

Belt tension checks should be performed using a Belt Tension Gauge, such as a Howard KRIKIT Gauge, tool number 7401-0071. This tool is available from:

Howard Manufacturing Company
59996 South Crocker
Little Town, Colorado 80120
Phone (303) 794-2510

IMPORTANT - Use of the KRIKIT Gauge is restricted to SAE 3/8, 1/2 and 11/16 inch belts. Check tension on the midpoint range of the longest span of belt. New belts should be checked at 483 km (300 miles) or 10 hours, then checked again after 2 414 km (1, 500 miles) or 50 hours. The second service adjustment of belts establishes tension stabilization.

Before adjusting belt tension, check the tension several times. Use an average of the readings.

Belt tension checks must be made at midpoint between pulleys at the longest belt span. Refer to Belt Tension Chart.

The 9.0 liter fan and water pump drive belts have an idler pulley with spring tension. No adjustment is needed.

In multi-belt drives, the belt tension readings taken on the same span may vary considerably between belts. When this occurs, average readings to establish applied tension, except in the application of the DT/DTI 466 engines' power steering pump (Vickers), where the values stated are for each belt.

Belt Tension Chart

Tension Condition	Belt Tension
New Belt Installation	423-444 N (95-100 lbf)*
Re-tension New truck upon delivery After 10 hours (or 300 miles) After 50 hours (or 1,500 miles) —At intervals of 200 hours (or 6,000 miles)	356-378 N (80-85 lbf)*
Minimum Permissible Tension	267 N (60 lbf)*

*DT/DTI 466 Engine Power Steering (Vickers) Pump
New Belt - 356 N (80 Ibf) per belt
Re-tension - 222N (50 Ibf) per belt
Minimum Permissible Tension - 222 N
(50 Ibf) per belt

CHECKING BELT TENSION BY DEFLECTION METHOD

Belt tension may also be checked by using a straight edge and scale.

Approximately 12.7 mm (1/2 inch) deflection should be measured. The deflection measurement should be made between pulleys at midpoint of longest belt span.

IMPORTANT - Operating engine with below minimum tension will result In excessive belt and groove deterioration.

MAINTENANCE INSTRUCTIONS

GENERAL

For effective emission control and low operating cost, It is important that maintenance operations listed on the following pages be performed at the specified periods or mileage intervals indicated (kilometers, miles, hours or months, whichever occurs first).

Service intervals are based upon average operating conditions. Where dusty, frequent start and stop or heavily laden operations are encountered, more frequent servicing will be required.

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As the vehicle (engine) owner, you are responsible for the performance of all scheduled maintenance. The required maintenance operations may be performed by the owner at a service establishment of the owner's choosing. Any replacement parts used for required maintenance services or repairs should be genuine IH parts or equivalent in quality and performance to genuine IH parts. Use of inferior replacement parts hinders operations of engine and emission controls.

Receipts covering the performance of regular maintenance should be retained in the event questions arise concerning maintenance. The receipts should be transferred to each subsequent owner of the engine (vehicle).

MAINTENANCE ICHEDULE CHART
(9.0 LITER ENGINES)

Maintenance Operations⑤	Daily	Inspection Interval			
		Every 9 600 km, 6,000 Miles 200 Hours or 3 Months	Every 19 200 km 12,000 Miles, 400 Hours or 6 Months	Every 38 400 km 24,000 Miles, 800 Hours or 12 Months	Every 96 000 km 60,000 Miles, 2000 Hours or 30 Months
Inspect Coolant and Oil Levels	X				
Inspect Low Oil Pressure Alarm (if equipped)	X				
Inspect Air Cleaner Restriction Indicator①	X				
Drain Water Separator (Fuel System) (If Equipped)	X				
Inspect for External Leakage	X				
Inspect and Adjust Belts		X			
Change Engine Oil and Oil Filter③		X			
Change Fuel Filters			X		
Clean or Replace Air Filter	← ① →				
Valve Lash Adjustment②⑥⑦					X
Check Low Idle Speed④⑥				X	
Check High Idle Speed④⑥				X	
Check Accelerator Linkage⑥				X	
Test Injection Nozzle⑥⑧					X
Check Transfer Pump Pressure⑥				X	

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SERVICE RECORDS

EMISSION MAINTENANCE SERVICE RECORD

This chart provides space for recording the dates and mileage (odometer readings) when the required emission control maintenance operations were performed

To prove proper maintenance of the vehicle record- work orders and receipts should be retained shoe that scheduled maintenance has been perform, Failure to maintain such records may affect your warranty coverage

9.0 Liter And DT/DTI 466 Engines

Service Interval	Performed
3 Months	Date
200 Hours	Hours
6,000 Miles	Miles
9 600 Km	Km
6 Months	Date
400 Hours	Hours
12,000 Miles	Miles
19,200 Km	Km
9 Months	Date
600 Hours	Hours
18,000 Miles	Miles
28 800 Km	Km
12 Months	Date
800 Hours	Hours
24,000 Miles	Miles
38,400 Km	Km
15 Months	Date
1000 Hours	Hours
30,000 Miles	Miles
48 000 Km	Km
18 Months	Date
1200 Hours	Hours
36,000 Miles	Miles
57 600 Km	Km
21 Months	Date
1400 Hours	Hours
42,000 Miles	Miles
67 200 Km	Km
24 Months	Date
1600 Hours	Hours
48,000 Miles	Miles
76 800 Km	Km

Service Interval	Performed
27 Months	Date
1800 Hours	Hours
54,000 Miles	Miles
86 400 Km	Km
30 Months	Date
2000 Hours	Hours
60,000 Miles	Miles
96 000 Km	Km
33 Months	Date
2200 Hours	Hours
66,000 Miles	Miles
105 600 Km	Km
36 Months	Date
2400 Hours	Hours
72,000 Miles	Miles
115 200 Km	Km
39 Months	Date
2600 Hours	Hours
78,000 Miles	Miles
124 800 Km	Km
42 Months	Date
2800 Hours	Hours
84,000 Miles	Miles
134 400 Km	Km
45 Months	Date
3000 Hours	Hours
90,000 Miles	Miles
144 000 Km	Km
48 Months	Date
3200 Hours	Hours
96,000 Miles	Miles
153 600 Km	Km

DAILY MAINTENANCE REPORT

DAILY CARE AND REPORT

A daily check of the engine should be made to prevent premature engine failure. If corrective steps are taken immediately upon discovery of loose or worn parts, fewer forced stops and a more economical operation will result. If any substandard readings or observations are found, be sure to report it to proper authorities. Points to be checked daily are as follows:

1. Oil, air, water or fuel leaks.
2. Cooling system, clean radiator core, add coolant or anti-freeze as necessary Be sure filler cap seal is in good condition and the cap is Installed tightly.
3. Unusual engine noise.
4 Excessive use of crankcase lubricating oil, coolant, battery fluid or fuel.
5. Fuel pressure gauge - check with engine running, change fuel filter if indicator is in red range.
6. Air cleaner indicator, if so equipped - inspect with engine running. Service air cleaner when red piston remains in up position or when vacuum gauge reaches allowable restriction.
7. Dirt should not be allowed to accumulate on the engine. A few minutes spent daily in keeping it clean are well repaid in improved appearance, and greater ease and safety in operation and maintenance.

Date	Miles	Fuel		Lube Oil	Parts		Labor		Down Time	Service Performed
		Quan.	Cost		Part	Cost	Time	Cost		

(Continued on next page)

DAILY MAINTENANCE REPORT

DAILY CARE AND REPORT (Continued)

Date	Miles	Fuel		Lube Oil	Parts		Labor		Down Time	Service Performed
		Quan.	Cost		Part	Cost	Time	Cost		

CONTENTS

F

FRONT AXLE (4x4)

With different configurations of transfer cases and types of controls, such as manually-operated or air- operated, it is Important that the FRONT AXLE control Instructions provided on the vehicle be followed. Some vehicles have a front axle Indicator light to alert the driver that the front axle is engaged.

WARNING - TO AVOID PERSONAL INJURY OR PROPERTY DAMAGE PAY STRICT ATTENTION TO THE FOLLOWING:
SHOULD IT BE NECESSARY TO OPERATE THE REAR WHEELS (WITH ENGINE POWER) WITH THE VEHICLE STATIONARY AND THE REAR WHEELS RAISED FROM THE GROUND, FIRST DISENGAGE THE FRONT AXLE; OTHERWISE THE DRIVING FRONT AXLE WILL PULL THE VEHICLE OFF ITS SUPPORT.
PARKING BRAKES SHOULD BE APPLIED WHEN THE TRANSMISSION AND THE TRANSFER CASE HAVE BEEN LEFT IN THE NEUTRAL POSITION WITH THE ENGINE RUNNING OR NOT RUNNING.
IMPORTANT-- Do not keep the front axle engaged when operating on dry, hard surfaced roads except where It Is absolutely necessary to operate with the transfer case In low range. Os orating on had, dry surface with both the front and rear axle engaged creates a buildup of torque between the axles resulting in excessive tire wear and strain on the entire drive unit.

When necessary to operate with the transfer case In low range, the front axle drive must be engaged to avoid excessive torque load on the rear axle.

FRONT AXLE DISENGAGEMENT (4x4)

The torque buildup between the front and rear axles sometimes make it difficult to disengage the front axle while the vehicle is in motion.

To disengage the front axle with the vehicle In motion, slack off abruptly on the accelerator and/or release the clutch while pressure Is applied to the front axle control.

In some instances it may be necessary to stop the vehicle and move it slightly In the reverse direction to complete disengagement of the front axle.

REAR AXLE (WITH LOCKING
DIFFERENTIAL)

WARNING - TO AVOID PERSONAL INJURY OR PROPERTY DAMAGE, PAY STRICT ATTENTION TO THE FOLLOWING:

'YOUR VEHICLE IS EQUIPPED WITH A LOCKING DIFFERENTIAL, POWER WILL BE TRANSMITTED, TO THE OPPOSITE WHEEL SHOULD ONE OF THE WHEELS SLIP. BOTH WHEELS MUST BE RAISED FREE OF THE GROUND SHOULD IT BE NECESSARY TO OPERATE ONE WHEEL WITH THE VEHICLE STATIONARY; OTHERWISE THE WHEEL THAT IS NOT RAISED WILL PULL THE VEHICLE OFF ITS SUPPORTS.

AS WITH ANY VEHICLE, CARE SHOULD BE TAKEN TO AVOID SUDDEN ACCELERATIONS WHEN BOTH DRIVE WHEELS ARE ON A SLIPPERY SURFACE. THIS COULD CAUSE BOTH DRIVE WHEELS TO SPIN, AND ALLOW THE VEHICLE TO SLIDE SIDEWAYS ON THE CROWNED SURFACE OF A ROAD OR IN A TURN.

NO SPIN DETROIT LOCKER POSITIVE LOCKING DIFFERENTIAL

The NoSPIN positive-locking differential is designed to deliver 100 percent of the available power to both drive wheels, yet "unlock" as required to allow wheel speed differentiation . automatically.

The performance of a vehicle equipped with a NoSPIN differential is somewhat different from that of a vehicle equipped with a conventional differential. For example:

When turning a corner, the sound of gear disengagement and reengagement may be audible, and the transfer of driving torque from both wheels to one wheel may be noticeable.

When going from drive (acceleration) to coast (deceleration) in a turn, a "metallic" sound may be heard as torque flow is reversed (inside wheel engaged during acceleration; outside wheel engaged during deceleration).

These characteristics are normal because of backlash designed into the NoSPIN differential, which is of a fixed amount (1 to 2 inches or rotation at the tire tread).

Anything that improperly causes a difference in individual wheel speeds, such as mismatched tire diameters due to differences in tire wear or tire pressure, or unbalanced loading of the vehicle, or vehicle operated on a side slope, can cause the NoSPIN differential to deliver power to only one side of the vehicle affecting vehicle controllability. Always maintain matched tire sizes and pressures and balanced loads and avoid operation on side slopes.

When negotiating a turn under conditions of poor traction, the inside wheel may receive excessive torque which will cause it to break traction. This will cause the inside tire to slip until the turn is completed or until the inside wheel catches up with the outside wheel. This condition is most noticeable with lightly loaded drive axles.

Certain vehicles equipped with NoSPIN differentials, such as short wheelbase trucks (e.g. under 120" wheelbase) and tour-wheel drive trucks with a NoSPIN differential in the front steering axle, can experience "understeer' when negotiating a turn under power. Re-leasing the accelerator will reduce the torque thus reducing understeer.

Use extreme caution when accelerating or decelerating on slippery or unstable surfaces. Vehicles/axles equipped with traction differentials are inherently more sensitive to side-slip than vehicles equipped with con-ventional differentials. Stability can be retained If side-slip occurs. It can be reduced by decelerating (letting off accelerator).

CAUTION - IF SIDE SLIP OCCURS, APPLYING THE BRAKES CAN INCREASE SIDE SLIP CAUS- ING LOSS OF VEHICLE CONTROL. UNDER THESE CONDITIONS BRAKING SHOULD BE AVOIDED UNLESS NECESSARY TO MAKE AN EMERGENCY STOP.

Braking capacity is reduced when a NoSPIN differential-equipped vehicle makes a turn while coasting downhill in that the inside wheel is then disconnected from the driveline. Operating in low gear will allow the engine to act as a retarder and will improve braking capacity.

When NoSPIN differentials are used in four-wheel drive articulated vehicles, steering may be difficult when the vehicle is stationary (especially on hard surfaces). This condition can be corrected by moving the vehicle slightly In either forward or reverse. (Assure that proper steering pressure is maintained.)

WARNING - RE-READ THE FOLLOWING NOTICES REFERENCED IN ADDITION TO THE CONSEQUENCES NOTED. FAILURE TO OBSERVE ANY OR ALL OF THESE MEASURES CAN CAUSE PART FAILURE OR RESULT IN A MISHAP WHICH CAN CAUSE PROPERTY DAMAGE, PERSONAL INJURY, AND EVEN DEATH.

DO NOT OPERATE THE VEHICLE IF BOTH WHEELS OF A NoSPIN/DETROIT LOCKER DIF- FERENTIAL EQUIPPED AXLE ARE NOT DRIVING (SEE OPERATION TEST IN THIS SECTION). POWER TO ONLY ONE WHEEL CAN EFFECT CON-TROLLABILITY. REPAIR AS REQUIRED AND PER-FORM THE OPERATION TESTS BEFORE PUTTING THE VEHICLE INTO SERVICE.

USE EXTREME CAUTION WHEN ACCELERATING OR DECELERATING ON SLIPPERY OR UNSTA- BLE SURFACES. VEHICLESI/AXLES EQUIPPED WITH TRACTION DIFFERENTIALS ARE INHER- ENTLY MORE SENSITIVE TO SIDE-SLIP THAN VEHICLES EQUIPPED WITH CONVENTIONAL DIFFERENTIALS.

DISTRIBUTE THE LOAD EVENLY SIDE-TO-SIDE; DO NOT EXCEED THE VEHICLE'S RATED PAYLOAD CAPACITY; KEEP THE DIAMETER OF THE TIRES EQUAL. FAILURE TO OBSERVE, THESE MEASURES CAN CREATE A DIFFERENCE IN INDIVIDUAL WHEEL SPEEDS WHICH CAN CAUSE THE NoSPIN/DETROIT LOCKER DIFFER- ENTIAL TO DELIVER POWER TO ONLY ONE SIDE OF THE VEHICLE AFFECTING CONTROL-LABILITY.

TURN THE ENGINE OFF AND RAISE ALL DRIVING WHEELS OF A NoSPIN/DETROIT LOCKER DIF-FERENTIAL-EQUIPPED AXLE WHEN CHANGING TIRES TO PREVENT THE VEHICLE FROM MOV- ING. AXLES EQUIPPED WITH NoSPIN/DETROIT LOCKER DIFFERENTIALS DELIVER POWER TO BOTH WHEELS EVEN WHEN ONLY ONE WHEEL IS ON THE GROUND.

OPERATION TEST

Check to see that both wheels of each NoSPIN differ-ential-equipped axle are driving. Make this test under load, so that engine torque is applied through the NoSPIN differential with the wheels on the ground. One way to achieve this load is to block vehicle with one side on loose dirt or gravel, and attempt to spin both wheels together. Perform this test in forward and reverse, and by blocking each side of vehicle.

Check Camming Action On a flat surface, with good traction, drive the vehicle in a tight circle in forward and reverse to be sure that the outside wheel is free to overrun (i.e that the outside tire does not scuff). A clicking or indexing sound may be heard. The sound of gear reengagement may also be heard upon completion of the turn. This is normal.

AXLE AND SUSPENSION CONVERSIONS

International Harvester is aware that on occasion after-market add-on axles and suspensions are installed by others on IH chassis which allow operator control for weight transfer from other axles (i e. air lift axles).

When operating a loaded vehicle, the driver must keep all adjustable axles on the ground at all times, support-ing their share of the load. Failure to do so can overload other axles, tires, wheels, springs, steering, brakes and frames, resulting in early component failure and personal injury accidents.

This statement is not to be construed that International Harvester is in agreement with or approves of such aftermarket conversions.

CONTENTS

WHEEL AND TIRE BALANCING

Front wheel and tire assemblies must be balanced to prevent wheel vibration and bounce While the correct front wheel alignment is necessary for easy steering and maximum tire life, unstable steering is frequently caused by improper balance of front wheels. When this condition exists, the wheel and tire assembly should be properly balanced.

A vulcanized or retreaded tire, or a tire that has a boot in it, may cause an unbalanced condition that cannot be corrected by balancing. In such cases the tire should be replaced before attempting to balance the assembly.

International Harvester strongly recommends that re-treaded or recapped tires not be used on front axles.

STATIC BALANCING

A wheel out of balance statically has a tendency to bounce up and down, resulting In rapid tire wear In round or oblong spots.

Static balancing is performed while the wheel is stationary by attaching weights to the rim flange to offset an opposite heavy point.

Static balancing may be sufficient in some instances where vehicle is operated only at slow speeds. However, dynamic balancing (in motion) balances the wheel and tire assembly statically as well as dynamically, thereby eliminating vibrations and wheel bounce at both low and high speeds.

A wheel may be perfectly balanced statically (not in motion) but may still vibrate and bounce at high speed rotation because of its being out of balance dynamically.

DYNAMIC BALANCING

Dynamic balancing (in motion) takes into consideration the distribution of weight to be added to the w[illegible]his is accomplished by rapidly rotating (norm[illegible]uck operating speed) the wheel and tire assembly either on the vehicle or with the wheel assembly removed and placed on a dynamic balancing machine. This determines the heavy point on the wheel.

When the amount of weight required to offset a heavy part In a wheel assembly is known, it is sometimes necessary to attach one-half of the weight to the outside rim flange and the remaining half to the inside rim flange.

With the weight properly distributed on the wheel assembly, the wheel should be in balance both statically and dynamically and should rotate free of vibration and bounce at normal truck operating speeds.

TIRE CARE

Proper tire inflation, loads, and road speeds are important factors governing tire mileage, steering ease and maneuverability. How these three factors affect tire wear is described in the following paragraphs.

INFLATION

Tire pressures should be checked at regular and frequent intervals and the pressures maintained to specifications. Use an accurate tire pressure gauge and check when tires are cool.

Over inflated or under inflated tires will reduce the service life of the tire.

Never "bleed" air from hot tire, The pressure will be reduced but an increase In temperature will result as soon as driving continues.

LOADS

Loading tires beyond their rated capacity decreases tire life, and can cause tire failure resulting In personal injury and property damage.

TIRE MATCHING

4x4,

Replacement tires must have same rolling radius as original equipment tires in order to avoid damage to the drive train components. Refer to line setting ticket for original equipment tire size.

TIRE MIXING

RADIAL AND BIAS PLY TIRES

It is recommended that for best overall performance that only bias or only radial tires be used on a vehicle. However, different heavy truck tires may be used under the following conditions:

- Bias or radial tires may be used on either axle of two-axle vehicles if the vehicle has dual rear wheels, or is equipped with wide base single tires.
- Either bias or radial tires may be used on the steering axle of vehicles with three more axles.
- Never mix different tire sizes or constructions on the same axle.
- Never mix bias and radial tires in a tandem drive axle combination.

TIRE ROTATION

ROTATION IS ALWAYS ADVISABLE:

1 If front (steering) axle tires become irregularly worn, move to rear or trailer position.
2. In a dual assembly, if one tire wears much faster than Its mate, reverse position of tires.

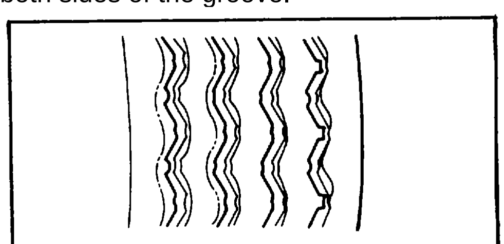
ROTATION MAY BE ADVISABLE:

1. If rib-type tires are used In all wheel positions: Front (Steering) Axle - Install new tires in front wheel positions. When worn to no less than 3.175mm (1/8") remaining groove depth, move to any other position.
   Rear and Trailer Axles - Tires must be removed when worn to no less than 1.588mm (1/16") remainlng original groove depth However, tires identified by the word "regroovable" molded on the side wall can be regrooved.
2 If rib type tire is used on front axle and lug type on rear axle positions:

   Front (Steering Axle) - Install new tires In front wheel positions. When worn to 3.175mm (1/8") remaining groove depth, they must be removed and can be moved to trailer positions.

   Rear and Trailer Axles - Tires must be removed when worn to 1 588mm (1/16") remaining original groove depth. However, tires Identified with the word "regroovable" molded on the sidewall can be regrooved

A type of Irregular wear which can occur on any tire but which is more prevalent on radial tires, is sometimes called "erosion wear, " "f'ree-rolling wear" or “river wear." It is characterized by a fast-wearing channel adjacent to one or both sides of the groove.



CIRCUMFERENTIAL TREAD CHANNELING

This type of wear is found most typically on any free-rolling position. Tires on drive positions can also generate this condition, but due to the faster rate of wear and the torque being transmitted through these tires, the wear is worn away as fast as it develops and is very rarely observed.

Wear of this type will generally not decrease the overall mileage that the tire can give, if it is found and corrected early. Tires with this condition should be moved to drive positions where they can be smoothed out.

BIAS AND RADIAL TIRE LOAD AND INFLATION CHART (NOT MICHELIN)

(FOR TRUCKS, BUSES AND TRAILERS IN NORMAL HIGHWAY SERVICE)

Tire Size Designations		*	TIRE LOAD LIMITS AT VARIOUS COLD INFLATION PRESSURES (PSI)															
Tube	Tubeless	**	40 45	45 50	50 55	55 60	60 65	65 70	70 75	75 80	80 85	85 90	90 95	95 100	100 105	105 110	110 115	115 120
	16 5-22.5	D		5800	6170	6520	6860	7190	7520	7820	8120H							
		S				6590	7010	7410	7790	8170	8540	8890	9230H	9570	9890	10210J		

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Letters listed with weight are the maximum load for load range of tire
Do not exceed rim loads and/or inflation limits.
For applicable load limits for other than normal highway service, for other size designations and for size designations with suffixes such as "ML" (mining and logging) consult the tire manufacturer

* Cold Inflation Pressure for Bias Tires.

** Cold Inflation Pressure for Radial Tires Radial Tires have an "R" in the Size Designation, example 10 00R20

D = Dual Tire Usage
S = Single Tire Usage

TIRE AND RIM COMBINATIONS

TIRES DESIGNED FOR NORMAL HIGHWAY SERVICE

Tube Type		Tubeless	
Tire Size	Rim Width	Tire Size	Rim Width
		16.5-22.5	12.25, 13.00

CAUTION: ALWAYS USE APPROVED TIRE AND RIM COMBINATIONS FOR DIAMETERS AND CONTOURS. AFTER MOUNTING DUAL TIRES, INSURE TIRES DO NOT CONTACT EACH OTHER UNDER A LOADED CONDITION.

CAUTION: NOT APPLICABLE FOR ML (MINING & LOGGING) TIRES.

CONVERSION OF PLY RATING TO LOAD RANGE DESIGNATION

Load Range	Replaces Ply Rating
D	8
E	10
F	12
G	14
H	16
J	18
L	20
M	22
N	24

CONTENTS

INSTALLATION, TIGHTENING AND ALIGNMENT

When Installing disc wheels or demountable rims with cast spoke wheels, be certain that the threads on studs and nuts are clean to permit correct torquing of nuts. The mounting surfaces of rims, wheels, spacer rings and clamps must be free of dirt, rust or damage

Use a wire brush to clean mounting contact surfaces Do not use lubricant on threads

After rim or wheel has been properly torqued, it should be checked for alignment. Rotate the wheel with a piece of chalk attached to a steady, firm surface and placed to just barely clear outside surface of tire bead seat. This procedure will point out the "high spot." Keep in mind, however, that a "high spot" does not necessarily mean that lug nuts have been unevenly tightened. This condition or misalignment could be caused by a bent wheel.

Checking the alignment of the wheel/rim installation is more important on cast spoke rims since the rims can be drawn out of alignment when improperly tightened. Use the following installation procedures

CAST SPOKE WHEELS

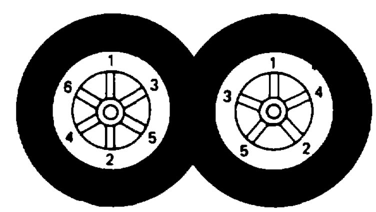
1. Slide inner rear or front tire and rim assembly over the cast spoke wheel and push It back into position against tapered mounting surface. Be sure valve stem faces out and is centered between two spokes.

2. Slide spacer ring over wheel. Check spacer ring for concentricity by rotating spacer ring around cast spoke wheel.

3 Slide the outside rear tire and rim assembly on the wheel, making sure the valve stem faces inboard and is located in same relative position as Inner valve stem.

4. Assemble all rim clamps and nuts. Turn nuts on studs until each nut is flush with end of stud. (Refer to illustration for steps five through eight.)

5. Turn top nut "1" until it is snug.



CAST SPOKE WHEEL TIGHTENING SEQUENCE MT-26738

6. Rotate wheel and rim until nut "2" is at top position and snug nut.

7. Rotate wheel and rim until nut "3" is at top position and snug nut.

8. Rotate wheel and rim until nuts "4, " "5" and "6" are respectively at top and snug these nuts. Since the entire weight of tire and rim assembly is on top spoke, the foregoing procedure (criss-cross sequence) will assure even application of force at all points on the rim, keeping the rim in proper alignment.

9. Repeat the sequence of tightening the nuts to torque value listed in Torque Chart.

10. After operating the vehicle approximately 80 km (50 miles) check the stud nuts for tightness in same sequence shown. Once each week inspect and retorque wheel stud nuts.

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PRECAUTIONS

Always loosen rim clamps before complete removal of nut from stud (cast spoke wheels). With loosened nuts on stud, strike clamps with a heavy hammer and be sure each clamp is loose.

Always deflate tires completely before removing locks or side rings.

Always inspect and clean all parts before assembly.

Always inflate tires in a safety cage.

Always use a 'clip-on" air chuck with remote control valve to inflate tires.

Never strike cast spokes of wheel assembly when loosening rim clamps.

Never mix rim side rings or lock rings of different types or size.

Never use cracked, bent or badly rusted parts.

Never reinflate flat tires on vehicle. Use the spare.

Never add air until each side or lock ring is fully seated.

Never hammer side or lock ring on a partially or fully inflated tire.

When installing the tire and rim assembly on disc-braked axles, make sure the tire valve stem clears the brake caliper. The use of an IH valve stem retainer or a tire manufacturer's stem forming tool are the only acceptable methods of obtaining clearance when necessary.

PROPER TORQUE

It Is important to tighten and maintain wheel and rim mounting nuts to the proper torque. Loose nuts or overtightened nuts can lead to premature wear and possible failure of the wheel, rim and/or mounting hardware

CHANGING WHEEL TYPES

Changing from one type of wheel to another (steel to aluminum) requires changing the mounting hardware Consult a Service Parts catalog or your IH dealer prior to attempting these changes

TORQUE CHART

CAST WHEELS			
5/8"	Rim Clamp Nut	217-237	160-175
3/4"	Rim Clamp Nut	258-285	190-210

DRY THREADS - NO LUBRICATION

Where excessive corrosion exists, a light coat of lubricant on first three threads of stud on bolt is permitted. Keep lubricant away from cap nut ball faces, or ball seats of disc wheels and rim clamps of cast wheels.

TOWING INSTRUCTIONS

Before moving the towed vehicle, check for adequate road clearance of vehicle components.

IH recommends unloading the towed vehicle prior to towing to reduce any abnormal loads to the vehicle components resulting from the towing procedures.

Before towing, be sure to fully release the parking brake vehicle is equipped with spring actuated type parking brake, the brake must be released manually in the event of air failure. The spring actuated type park- ing brake can also be reset by recharging the air system with at least 441 kPa (64 lbs.) of air. See Parking Brakes.

CAUTION - TO AVOID PERSONAL INJURY OR PROPERTY DAMAGE WHEN MANUALLY RELEASING THE SPRING BRAKES, BE SURE TO BLOCK THE WHEELS SO THAT VEHICLE CANNOT MOVE WHEN THE BRAKES ARE RELEASED.

FOR TOWING, MAKE SURE THE VEHICLE IS SECURELY CONNECTED TO TOW VEHICLE BEFORE RELEASING THE SPRING BRAKES.

TOWING VEHICLE WITH FRONT WHEELS SUSPENDED

When it is necessary to tow a vehicle with the front wheels suspended, extra precautions must be taken to avoid transmission or differential damage Proceed as follows.

Remove axle shafts from axle assembly. This will leave wheels in contact with the ground and will prevent any movement of differential or transmission components. Refer to Full Floating Axles

Vehicles with automatic transmissions should not be towed even short distances without suspending rear wheels or removing the axle shafts or propeller shaft.

FULL FLOATING AXLES

Full Floating axles are axles where the axle shafts may be removed without disturbing the wheel and hub assemblies. On chassis with full floating axles, remove the axle shafts from all axles that will be in contact with the road surface while towing. The wheel hub ends must be covered to prevent loss of axle lubricant and entrance of contaminants.

If axle shafts are not removed, removal of propeller shafts at rear axle will be required.

TOWING VEHICLE WITH REAR WHEELS SUSPENDED

Whenever possible, it is preferable to tow a disabled vehicle from the rear by raising the rear of the chassis.

When towing a vehicle with rear of the chassis suspended, the front wheels must be locked in the straight ahead position.’

Towing the vehicle with the front wheels on the ground also eliminates possible damage to the front bumper

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SPRINGS

U-BOLTS

1. After the chassis has been operating under load for 1 600 km (1000 miles) or six months, which-ever comes first, the U-Bolt nuts must be retorqued.

2. The U-Bolt nuts thereafter should then be retorqued every 57 936 km (36, 000 miles).

3. The U-Bolt (joint) should be cleaned and free of corrosion as in a new or as-new condition.

U-BOLT NUTS

U-BOLT DIA. (NOM)	TORQUE	
	N•m	Ft.-Lbs.
1/2	88-109	65-80
5/8	176-217	130-160
3/4	271-325	200-240
3/4 Flanged Nut①	350-380	260-300
7/8	305-373	225-275
1	441-543	325-400

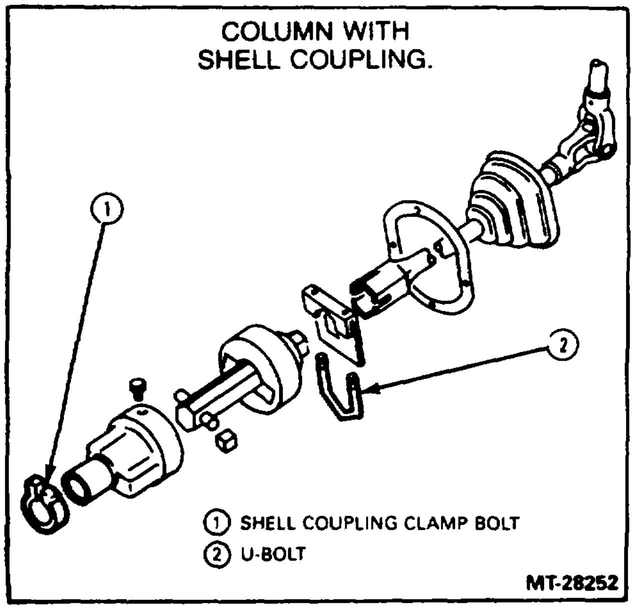
①On IH Four Spring and Air Suspensions

STEERING

TIGHTENING STEERING COLUMN JOINT BOLTS

WARNING - FAILURE TO MAINTAIN THE STEERING SYSTEM IN PROPER CONDITION CAN CAUSE REDUCED STEERING ABILITY RESULTING IN PERSONAL INJURY AND PROPERTY DAMAGE.

As a good maintenance practice, it is recommended that steering column joint bolts be checked for tightness every 80 000 km (50, 000 miles) or annually, whichever occurs first. Tighten bolts to torque specified in table below. DO NOT OVERTIGHTEN.



Bolt Location	Specified Torque
Clamp or Yoke Bolt:	
3/8-24 (Shell Coupling)	41-47 N•m (30-35 ft.-lbs.)
3/8-24 (Yoke or U-Joint)	47-54 N•m (35-40 ft.-lbs..)
7/16-20 S-Series	81-89 N•m (60-66 ft.-lbs..)
7/16-20 All except S-Series	95-102 N•m (70-75 ft.-lbs..)
U-Bolt on Steering	
Column Clamp	14-16 N•m (10-12 ft.-lbs..) DO NOT OVERTIGHTEN

CONTENTS

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As with any machine, care should be taken when making any check, doing any maintenance, or making any repair to avoid being injured. Improper or incomplete service could also lead to the vehicle itself not working properly which may result in personal injury or damage to the vehicle or its equipment. If you have any question about carrying out some service, have the service done by a skilled mechanic.

Your vehicle has been engineered and manufactured according to strict standards so that it can provide continued, trouble-free service. However, it Is the owner's responsibility to see that the vehicle receives proper care and maintenance.

Modifications made to various parts, components and systems of your vehicle, such as brake and steering systems, can adversely affect the quality and reliability of your vehicle. Such modifications must be avoided.

Follow the periodic lubrication procedures and regular inspection intervals outlined in this guide. Have your IH dealer or service center inspect your vehicle at least once a year. Remember that regular maintenance and replacement of worn parts will usually prevent serious problems from developing later.

The lubrication intervals present a good opportunity to inspect the vehicle. We suggest that the following points be checked at these intervals.

WARNING - ASBESTOS DUST DURING BRAKE SERVICING

1. Because studies have Indicated that exposure to excessive amounts of asbestos dust may be a potential health hazard, the Occupational Safety and Health Administration (OSHA) has set maximum limits of levels of airborne asbestos dust to which workers may be exposed. Since most automotive friction materials normally contain a sizeable amount of asbestos, it is important that people who handle brake linings be aware of the problem and know the precautions to be taken.

2. Areas where brake work is done should be set aside, if possible, and should be posted with an asbestos exposure sign as follows:

ASBESTOS DUST HAZARD
AVOID BREATHING DUST
WEAR ASSIGNED PROTECTIVE EQUIPMENT
DO NOT REMAIN IN AREA UNLESS YOUR WORK REQUIRES IT
BREATHING ASBESTOS DUST MAY BE HAZARDOUS TO YOUR HEALTH

3. OSHA standards should be consulted with respect to mandatory requirements as well as for suggested procedures to minimize exposure. (Reference: Title 29, Code of Federal Regulations, Section 1910.1001.)

AXLE-FRONT

Maintaining front axle alignment to specifications is very important and should only be performed by a qualified mechanic.

Check to assure that axle mounting U-bolt nuts, attaching or mounting bolts and nuts are securely tightened.

Regularly check front axle for damaged, binding or worn parts, and adequate lubrication.

AXLE-REAR

Check to assure that axle mounting U-bolt nuts, attaching or mounting bolts and nuts are securely tightened.

Regularly check rear axle for damaged, binding or worn parts.

BRAKE SYSTEM

Brake Lining Adjustment: Always maintain proper lining adjustment.

Brake Lining Inspection: Every 19 000 km (12,000 miles), or 12 months, whichever occurs first, have brake linings inspected for wear.

Where vehicles are used in severe service or in considerable stop-and-go service, Inspect more often.

Periodically, or at least once a year, inspect entire brake system for:
1. Brake controls (refer to Rubber Parts)
2. Condition of drums, discs, brake chambers and slack adjusters.
3. Air or fluid leaks.
4. Hose or pipes for rust, damage, deterioration.
5. Operation of service and parking brake.

Some parts, such as air brake chamber diaphragm, should be inspected once a year or every 80 000 km (50,000 miles) and replaced if considered unserviceable for further use.

CAB

DEFROSTERS: Operate defroster controls to determine if sufficient air is being directed against windshield.

DOOR LATCHES: Check latches for positive closing, latching and locking GLASS: Check for cracked, broken, scratched or dirty glass including rear view mirrors.

SEATS: Be sure manually operated seats are firmly engaged to avoid forward or rearward movement when starting or stopping.

SEAT BELTS: Check entire seat belt assembly for wear and proper operation. Make certain anchor mountings are tight.

In addition to the above, check condition of cab mounting brackets, sheet metal, rubber mountings and safety prop when equipped.

SMOKING IN CAB AREA

Always use the ashtray(s) provided for disposing of cigar, cigarette, or pipe ashes and tobacco.

The hazard associated with smoking in the cab is that smoke or toxic gases emitted from a fire may promote confusion and disorientation, which could result in an accident, fatality, or serious injury.

CARGO AREA OCCUPANCY

Do not ride in the cargo area. To avoid possible injury or fatality do not ride in this area.

GROSS WEIGHT (AXLE-VEHICLE)

Your IH truck has gross axle weight and gross vehicle weight ratings. Do not exceed these ratings. Exceeding these ratings by overloading can cause early component failure resulting in personal injury and property damage.

FRAME

Because International chassis are manufactured with frame rails of either cold rolled steel, heat-treated steel or aluminum alloy, each must be handled in a specific manner to assure maximum service life.

Specific instructions are published concerning proper repair of frame rails. See your nearest IH Dealer.

FUEL SYSTEM

Frequently check throttle linkage for proper operation. Inspect condition of fuel tanks, fuel lines, clips and routing.

PROPELLER SHAFT

At the regular lubrication interval, check universal joints for wear.

Should propeller shaft vibrations occur, stop the vehicle immediately to avoid possible hazardous consequences or damage to other components.

RUBBER PARTS

Rubber may deteriorate wherever it is used. Brake cylinder parts should be Inspected periodically by a competent mechanic and replaced as necessary. Replacement intervals will vary according to the severity and length of service.

SPRINGS

Maintain specified torque on spring U-bolt nuts. Periodically check condition of spring leaves for evidence of fatigue, bending or breakage.

STEERING

Be alert to any change (feel) in steering when driving. This change or feel would include increased steering efforts, unusual sounds when turning, excessive wheel play or pulling to either side.

Check tie rod and drag link end clamp bolts. They must be tight. Ask your service mechanic to examine the steering mechanism. Minor adjustments could head off further problems.

Check power steering system for leaks or hose chafing. Repair at once.

Maintain proper steering gear and power steering pump lubricant levels.

Regularly inspect steering column joint bolts and steering linkage, particularly for body-to-chassis clearance.

IMPORTANT Have any steering problems corrected at once by a qualified mechanic.

SUSPENSIONS

Check condition of suspension mounting brackets or bushings.

Suspension alignment must be maintained at all times.

TOW HOOKS

Front and rear tow hooks should be inspected for damage or a loose mounting. This is of great importance, particularly on vehicles where the tow hooks are used frequently.

TRANSMISSION

Check fluid level and shift linkage for proper operation.

IMPORTANT- vehicle Is equipped with an automatic transmission, have a qualified mechanic occasionally check operation of starter safety switch.

TRANSFER CASE

When parking your 4 x 4 vehicle, certain procedures must be followed. Refer to the TRANSMISSION Section of this manual.

Failure to follow these procedures could result in an unattended vehicle moving, thus resulting in personal injury or property damage.

WHEELS

Check condition of and maintain recommended torque on wheel and rim mounting bolts and nuts.

Check condition of tires for abnormal wear patterns, and proper inflation pressures. Cut or broken tire casing must be repaired.

CAUTION - ALWAYS USE PROPER EQUIPMENT AND FOLLOW CORRECT PROCEDURES WHEN MOUNTING OR DEMOUNTING TIRES.

Wheel bearings should be inspected, lubricated and adjusted at regular intervals. This is especially important if operating in deep sand, mud, or water.

CAB ENTRY AND EXIT

Refer to Cab section pertaining to entry and exit to avoid personal injury or accidents.

DOWNHILL OPERATION

For precautions to be followed when operating vehicle on downgrades, refer to the BRAKE Section of this manual.

CONTENTS

GENERAL INSTRUCTIONS

New vehicles are properly lubricated at the factory and before they are delivered. After the vehicle Is placed in operation, regular lubrication intervals, as outlined, should be followed. Thorough lubrication at these intervals will add to the Low Cost of Ownership (LCO) and will reduce overall operating expense.

The interval between lubrication periods and oil changes depends entirely upon operating conditions, loads carried, speeds and road and weather conditions. Where operating conditions are extremely severe, such as in deep water, mud, or unusually dusty conditions, the vehicle may require lubrication after every twenty-four hours of operation.

Only lubricants of the best quality, having proper body or viscosity, should be used. The use of inferior products will reduce the service life of the vehicle or result In failure of its components.

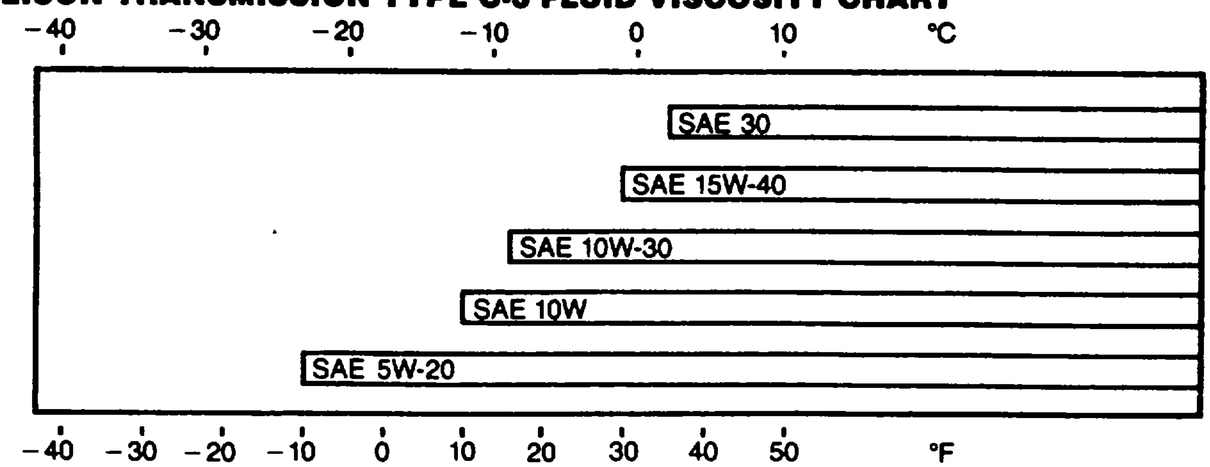
The International Harvester Company Truck Group recommends the use of its regular IH oil and lubricants available through your IH truck dealer.

The lubrication specifications refer only to the viscosity (SAE) and type to be applied. The viscosity limbers have been adopted by the Society of Automotive Engineers to classify lubricants according to 'body or 'thickness' and do not cover any other properties.

Unless otherwise specified, never add lubricant unless it is the same grade as that which is already in use. f the grade is unknown or is not available, drain, flush and refill with new lubricant.

The Lubrication Intervals specified should be performed at whatever interval occurs first, whether it is months, miles or kilometers.

ALLISON TRANSMISSION TYPE C-3 FLUID VISCOSITY CHART



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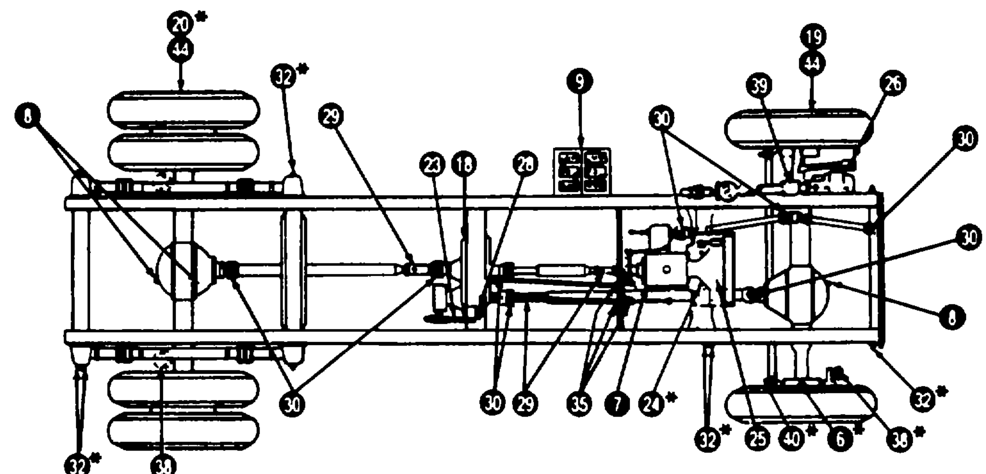

TYPICAL 4 × 4 VEHICLE

* THESE POINTS SYMMETRICAL
BOTH SIDES OF VEHICLE

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LUBRICATION - MAINTENANCE GUIDE INTERVALS

KEY NO.	DESCRIPTION	OPERATION	USE OR REMARKS①
DAILY INSPECTION			
1	Engine Crankcase Level Change Interval	Check and Correct	A (See also Engine Section)
2	Coolant Level	Check and Correct on each Fuel Stop	Refer to Cooling System in this Section
NI	Low 011 Pressure Alarm	Correct as Necessary Lubricant	Refer to Lubrication Chart for Specified
NI	External Leakage	Correct as Necessary	
NI	Air Cleaner Restriction Indicator	Correct as Necessary	Refer to 'Special Instructions' B
3	Fuel/Water Separator	Drain and Replace Element as Necessary	
AS REQUIRED			
NI	Air Cleaner (Engine)	Clean or Replace	B
NI	Speedometer, Tachometer Cable	Lubricate	IH251 H EP Grease or equivalent NLGI #2 Multi-purpose Lithium Grease. (Electronic Speedometer or Tachometer Not Required)
NI	Speedometer, Tachometer Head	Lubricate	Light Weight oil (Not Required w/ Electronic Speedometer or Tachometer)
3	Fuel Filters	Replace	Refer to Engine Maintenance Charts found in this Manual or Separate
4	Engine Oil Filter	Replace	Engine Supplements.
5	Throttle Linkage	Lubricate	Light Engine oil
6	Trunnion Bearing and Axle Shaft U-Joint-Dana Axles	Lubricate	O
NI	Seat Adjuster Slides		IH251 H EP Grease or Equivalent NLGI #2 Multi-Purpose Lithium Grease.
NI	Manifold Heat Control Valve	Lubricate	Penetrating Oil

4,000 MILES, 8000 KILOMETERS OR MONTHLY			
8	Differential (Front or Rear Axles) Dana	Change Initial Fill	Mileage Interval Only. Q C
8	Differential (Front or Rear Axles)	Check Level and Correct as Required	C, Q
9	Battery (With Caps)	Check Water Level	Distilled Water
9	Battery Posts	Clean	Grease After Cleaning
10	Brake Master Cylinder S-Series,	Check Level and Correct as Required	Super Heavy Duty -DOT 3" Brake Fluid.

*Registered Trademark of General Motors Corporation NI = Not Illustrated NA = Not Applicable
①Letters indicate additional requirements of Special Instructions following this chart.

LUBRICATION - MAINTENANCE GUIDE INTERVALS

KEY NO.	DESCRIPTION	OPERATION	USE OR REMARKS➀
4,000 MILES, 6000 KILOMETERS OR MONTHLY (CONTINUED)			
17	Power Steering	Check Level and Correct as Required	F
18	Transfer Case	Check Level and Correct as Required	H
7	Transmissions Automatic	Check Level and Correct as Required	M
23	Parking Brake Linkage S-Series,	Lubricate	Light Weight Engine Oil
NI	Door Check, Hinges, Latches, Strikers, S-Series,	Lubricate	Light Weight Engine Oil
NI	Hood Linkage	Lubricate	Light Weight Engine Oil
26	Drag Line S-Series	Lubricate	IH 251 H EP Grease or Equivalent NLGI. #2 Multi-Purpose Lithium Grease
NI	Hood Tilt Linkage	Lubricate	IH 251 H EP Grease or Equivalent NLGI #2 Muldti-Purpose Lithium Grease
NI	Power Divider Lock Yoke Pin	Lubricate	IH 251 H EP Grease or Equivalent NLGI. #2 Muldti-Purpose Lithium Grease
27	Prop Shaft Center Bearing	Lubricate	IH 251 H EP Grease or Equivalent NLGI. #2 Muldti-Purpose Lithium Grease

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➀Letters indicate additional requirements of Special Instructions following this chart.

LUBRICATION - MAINTENANCE GUIDE INTERVALS

KEY NO.	DESCRIPTION	OPERATION	USE OR REMARKS①
4,000 MILES, 6000 KILOMETERS OR MONTHLY (CONTINUED)			
28	Parking Brake Relay Lever	Lubncate	IH 251 H EP Grease or Equivalent NLGI #2 Multi-Purpose Lithium Grease
29	Prop Shaft Slip Joint	Lubricate	IH 251 H EP Grease or Equivalent NLGI #2 Multi-Purpose Uthium Grease
30	Prop Shaft U-Joint	Lubricate	IH 251 H EP Grease or Equivalent NLGI, #2 Multi-Purpose Lithium Grease
31	Power Take Off Shift Control	Lubricate	IH 251 H EP Grease or Equivalent NLGI #2 Multi-Purpose Uthium Grease
32	Spring Pins	Lubricate	IH 251 H EP Grease or Equivalent NLGI #2 Multi-Purpose Uthium Grease
33	Steering Gear Relay Lever	Lubricate	IH 251 H EP Grease or Equivalent NLGI #2 Multi-Purpose Uthium Grease
34	Suspension Connecting Tube Bearing	Lubricate	IH 251 H EP Grease or Equivalent NLGI #2 Multi-Purpose LithIum Grease
35	Transfer Case Shift Linkage	Lubricate	IH 251 H EP Grease or Equivalent NLGI #2 Multi-Purpose Uthium Grease

16,000 MILES, 26 000 KILOMETERS OR 5 MONTHS			
NI	Air Cleaner (Air Compressor)	Clean or Replace	
38	Brake Camshafts and Manual Slack Adjusters	Lubricate	
39	Steering Column U-Joints, Slip Joint	Lubricate	
40	Tie Rod Ends	Lubricate	N IH 251 H EP Grease or Equivalent NLGI #2 Multi-Purpose Uthium Grease
41	Transmission Air and Oil Filter	Replace	
18	Transfer Case	Change Lubricant	H
7	Transmission (Automatic)	Change Lubricant	M

*Registered Trademark of General Motors Corporation NI = Not Illustrated NA = Not Applicable
①Letters indicate additional requirements of Special Instructions following this chart.

LUBRICATION -- MAINTENANCE GUIDE INTERVALS

KEY NO.	DESCRIPTION	OPERATION	USE OR REMARKS①
20,000 MILES, 32,000 KILOMETERS OR MONTHLY (CONTINUED)			
20,000 MILES, 32 000 KILOMETERS OR 20 MONTHS			
43	Power Steering Pump Fiter Element		Replace
24,000 MILES, 38 000 KILOMETERS OR 5 MONTHS			
38	Brake Automatic Slack Adjusters	Lubrlcate	IH 251 H EP Grease or Equivalent NLGI #2 Multi-Purpose ULthlum Grease
NI	Brake Pedal to Brake Valve Linkage	Lubricate	Light Weight Engine Oil
32,000 MILES OR 51 000 KILOMETERS			
32,000 MILES, 51 000 KILOMETERS OR ANNUALLY			
44	Wheel Bearings (Grease)	Repack	IH 251 H EP Grease or Equivalent NLGI #2 Mult-Purpose Uthlum Grease
52,000 MILES, 84 000 KILOMETERS OR 6 MONTHS			

ANNUALLY, 100,000 MILES OR 160 000 KILOMETERS			
8	Differential (Front or Rear) Dana	Change Lubricant	C After Intial Change, Change Annually
NI	Door Lock Cylinders	Lubricate	Lock Oil
OVERHAUL			
45	Altemator	Lubricate	Cam and Ball Bearing Lubricant (Delco-Remy #1948791)
NI	Brake Caliper & Anchor Plate	Lubricate	NLGI #1-1/2 (Part No. 990647CI)
NI	Brake Shoe Anchor Pins	Lubricate	IH 251 H EP Grease or Equivalent NLGI #2 Multi-Purpose Uthium Grease

*Registered Trademark of General Motors Corporation NI = Not Illustrated NA = Not Applicable
①Letters indicate additional requirements of Special Instructions following this chart.

SPECIAL INSTRUCTIONS

A. For Engine Oil Specifications refer to Engine Oil Specifications in this section (except gas engines and Diesel Engines not manufactured by IH. This information will be found in separate engine supplements furnished with vehicle.

Recommended Engine Oil Filter Service Intervals will be located in Engine Section of this manual (Maintenance Charts) or separate manuals furnished with vehicle.

B. Diesel Engines: When air restriction reading (in inches of water vacuum) reaches the following, clean or replace engine air cleaner. Refer to engine section of this manual.

Engine	Inches of Water Vacuum
IH 9.0 Liter	20 in. H20 or 500 mm Hg

Washing Procedure: (Not Donaldson Konepac Element). Filter element can be washed with any good non- sudslng, household detergent. Use warm water 49-60"C (120-140°F). Flush filter with gentle stream until drain water is clean. Air dry element before using. Also inspect after every cleaning for damage or rupture. Wipe all internal parts clean before reassembling. Replace gasket regularly.

D. Rockwell front or rear axle lubricant change after initial fill lubricant change is as follows: Vehicles operated less than 60,000 miles or 97 000 kilometers change lubricant twice a year.

Vehicles operated more than 60,000 miles or 97 000 kilometers change lubricant every 25,000 to 30,000 miles or every 40,000 to 48 000 kilometers.

Refer to Note "C” for lubricant.

E. SAE-10OW Engine Oil for temperatures 18°C (0°F) and up. For temperatures below 18°C (0OF) use three parts SAE-1OW engine oil to one part kerosene. The mixture can safely be used in temperatures up to OOC (32'F).

F.

Roes Gears: 10W-40 Engine Oil Only.

SPECIAL INSTRUCTIONS (CONTINUED)

G. Lubrication Procedure: With chassis load on axle, force grease through thrust bearings. Then with axle lifted clear of floor, force grease between king pin and bushing surfaces. Use IH 251 H EP grease. Except Rockwell front axles with permanently sealed king pins and permanently lubricated tie rod ends. Do not raise wheel end off ground when greasing.

H. Use straight mineral oil SAE 90 for temperatures 180C (0°F) and up. Use SAE 80 for temperatures below 18°C (0(F). Special Recommendations: Where temperature is consistently below -18°C (0°F) and where parked vehicles are exposed to unusual cold for long periods, use SAE 75. Where temperatures are consistently above 32°C (90°F) or unusually hot, use SAE 140 straight mineral oil.

K. Spicer

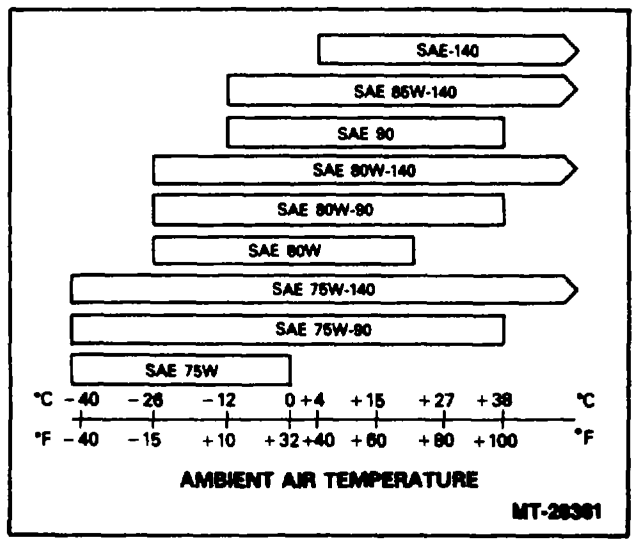
Engine oil (SF, CC or CD)	SAE-30	Below - 18° (0°F)
	SAE-30, 40, 50	Above - 18°C (0°F)
Mineral Oil (Rust and Oxidation Inhibited)	SAE 80	Below - 18°C (0°F)
	SAE 90	Above -18°C (0°F)

SPECIAL INSTRUCTIONS (CONTINUED)

O. FA64 (Dana) and Front Driving Axles only - Lubricate with IH 251 H EP Grease. Lube axle shaft U-joint whenever axle shafts are removed. Lube trunnion bearings when bearing caps are removed for service. No periodic lubrication is required.

P. Use RHEOLUBE '362w or equivalent. RHEOLUBE 362 is available from Eaton Corporation under Part Number 113741. RHEOLUBE 362 Is manufactured by NYE Specialists Lubricants, New Bedford, Mass.

Q. Dana-Spicer axles use SP type lubricant of API GL 5quality inspecting MIL-L-2105 B, C or better specifications including synthetic lubricants. For abnormally high temperatures, severe service (hot climate prolonged periods), use SAE 140. Refer to table at right.



ENGINE OIL SPECIFICATIONS - IH ENGINES

Choosing an engine oil of correct quality and proper viscosity and following recommended oil-change intervals are essential to Low Cost of Ownership (LCO). Using the recommended oil and change Interval will result In good engine starting, performance and long-term durability. The responsibility for obtaining the proper oil rests with the engine owner/operator. He should have his lubricant supplier confirm that the products being provided meet specific engine recommendations.

Failure to use the proper lubricants and to follow recommended oil-change intervals could result In Warranty denial.

SUPPLEMENTARY ADDITIVES

There are many supplementary fuel and oil additives for sale. If the lubricant and oil-change interval recommendations are followed, the engine will not require these additives.

OIL QUALITY

Oil quality Is described by API (American Petroleum Institute) engine service categories. API categories are defined by oil performance (deposits and wear) measured in standardized engine tests. API US" categories (SC, SE, SF) describe oils for spark Ignition (gasoline) engines, while "C" categories (CC, CD) describe oils for diesel engines. Oils with both 'S" and “C" categories (such as SF/CD) are suitable for both spark ignition and diesel engines. Sometimes, the 'S" and NC" categories are reversed (such as CD/SF).

Oil quality Is also described by two current U.S. Military Specifications, MIL-L-46152B and MIL-L-2104D. (MIL-L-2104D recently superseded MIL-L-2104C, which is now obsolete but which may still be widely used.)

The oil quality recommended depends upon engine type and engine design (6.9 liter, 9.0 liter, or DT/DTI-466C). Find type and design of your engine in the following section, and then choose the correct oil quality.

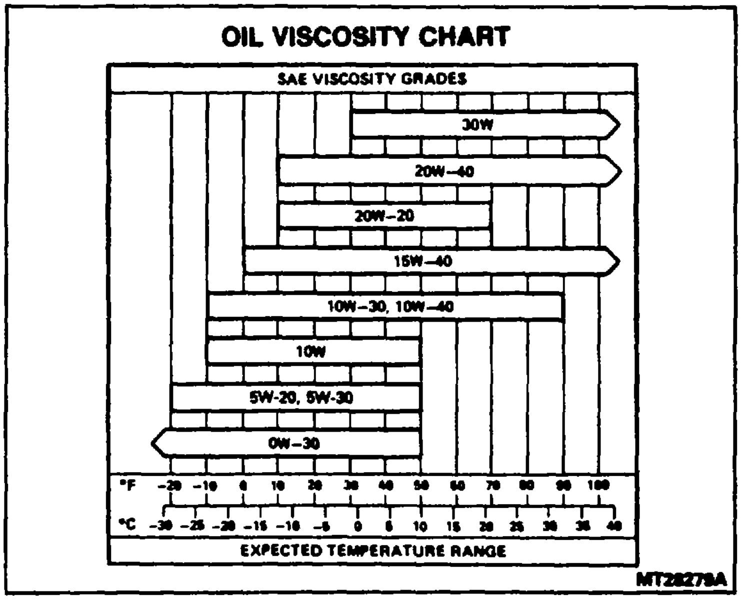
NOTE: - Do NOT use oils specifically marketed by suppliers for stationary, marine, or railroad diesel engines, or for stationary natural gas engines, even though they are marked API category CD. Such oils can cause excessive valve train wear and combustion chamber deposits. (These oils are sold only in drums or bulk.)

9.0 LITER DIESEL ENGINES

Use oils meeting API categories SE/CC, SF/CC, CD, SC/CD, SE/CD, or SF/CD, or Military Specifications MIL-L46152B, MIL-L-2104D, or MIL-L-2104C. IH No. 1 Engine Oil meets these requirements.

OIL VISCOSITY

011 viscosity (thickness) is described by SAE (Society of Automotive Engineers) Viscosity Grade. Colder temperatures require lower viscosity oils to ensure good flow during starting, while hotter temperatures require higher viscosity oils for satisfactory lubrication. Based upon the temperature range you expect before your next oil change, use the oil viscosity chart and the notes below to choose the proper viscosity grade. Using other viscosity grades, or using viscosity grades at temperatures outside the recommended ranges could result in engine damage.



NOTES:

1. SAE 30 IS THE PREFERRED VISCOSITY GRADE FOR 6.
LITER DIESEL - ENGINES FOR ALL OPERATING CONDITIONS WHERE THE TEMPERATURE WILL NOT BE COLD
ER THAN -1°C (+30°F.

2. SOME INCREASE IN OIL CONSUMPTION MAY BE EXPECTED WHEN SAE 0W-30, 5W-20, 5W-30 AND 10W-40 OILS ARE USED. CHECK OIL LEVELS MORE FREQUENTLY.

3. SAE 5W-20 OILS ARE NOT RECOMMENDED FOR CONTINUOUS HIGH SPEED OPERATION.

OIL-CHANGE INTERVAL

Refer to ENGINE-SECTION E of this manual (IH Diesel Engines) or Engine Supplements supplied with vehicles for the recommended oil-change interval for your engine. Use of oils exceeding the required quality level, synthetic oils, or other oils claiming longer service intervals does not justify extending oil-change intervals beyond those recommended.

For diesel engines, the recommended oil-change intervals are based on the use of diesel fuels with a maximum sulfur content of 0.5 percent. Know your fuel sulfur content. (Ask your supplier, or have fuel analyzed). if fuel contains more than 0.5 percent sulfur, reduce the oil-change interval as follows:

Sulfur Content, Percent	Oil-Change Interval
Below 0.5	Normal
0.5 to 1.0	1/2 Normal
Above 1.0	1/4 Normal

ENERGY CONSERVING OILS

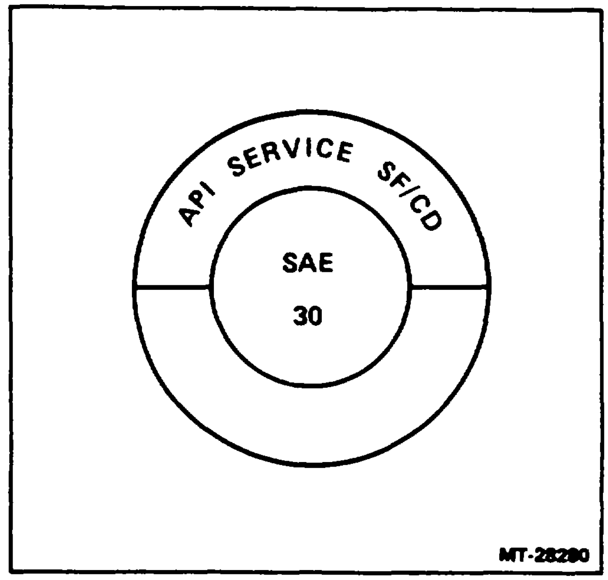
Oils marketed as *Energy Conserving" are intended to Improve fuel economy in passenger car engines. Some of these oil contain friction modifier chemical additives. One additive, molybdenum dithiophosphate, has been implicated in copper corrosion problems in some heavy duty diesel engines. Therefore, until further information is available, do not use an "Energy Conserving" oil containing molybdenum dithiophosphate in any IH-built engine. In addition, some "Energy Conserving" oils meet only API category SF for spark Ignition engines, and do not meet the oil quality requirements for diesel engines.

OIL IDENTIFICATION SYMBOL

An oil container symbol system has been developed to help you choose the proper oil. The top portion of the symbol shows the oil quality, such as API Service SF/CD in the example. The symbol may show additional categories, such as API Service SE, SF/CC, CD. The center portion will probably show the SAE viscosity grade, such as SAE 30 in the example. If the lower portion shows "Energy Conserving," be sure the upper and center portions show correct API service category and proper SAE viscosity grade recommended for your engine.

ADDITIONAL INFORMATION

Additional information may be obtained from: SAE, 400 Commonwealth Drive, Warrendale, PA 15096 API, 2101 L Street NW, Washington, DC 20037



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UNIT REFILL CAPACITIES

CONTENTS

Subject	Page

ABBREVIATIONS OF METRIC TERMS

Volume
cm3 = cubic centimeter
l = liter
Length
m = meter
mm = millimeter
cm = centimeter
km = kilometer
Pressure
kPa = kilopascal

Velocity
km/h = kilometers per hour
Power
kw = kilowatts
Mass
g = gram
kg = kilogram
gpl = grams per liter
gpg = grams per gallon

Torque
N ·m = Newton Meter
Temperature
c = celsius

O

AXLE FRONT

Model	Code	Liter	Pints
FA64	02064	8.42	17-3/4

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AXLE REAR

Model	Code	Forward		Rear		Notes
		Liters	Pints	Liters	Pints	
RA-39	14039	11.35	24			

AXLE REAR (Continued)

Model	Code	Forward		Rear		Notes
		Liters	Pints	Liters	Pints	

NOTES

1. Add .946 liter, (2 pints) of forward Rear Axle Total at inner axle differential.
2. Add an additional .946 liter (2 pints) of gear lubricant to inner axle differential forward rear axle.
3. Add .47 liter (1 pint) of this total at pinion cage plug on single or tandem rear axles.
4. Fill forward rear and rear axle through fill hole located on side of carrier housing.
5. Add 1.892 liter (4 pints) of forward rear axle differential capacity total to inner axle differential.
6. Friction Modifiers .02 liter (.042 pt.)/.473 liter (.999 pt.) of axle lube.
7. Fill forward rear axle through fill hole located on side of carrier housing.

COOLING SYSTEM

NOTE: Some cooling system capacity charts list optional radiators by the radiator frontage area (square inches).

S-SERIES COOLING SYSTEMS CAPACITIES		
Engine	**Liters**	**Quarts**
9.0 Liter	**40**	**42**
Capacities listed above are for standard cooling radiators (with heater, add 1.9 Liters [2 Qts.]). Trucks with increased capacity radiators add additional coolant to bring level about one inch below top of the radiator surge tank.		

Capacities listed are for standard cooling radiators with heater and air compressor (without air compressor subtract 1.9 liters [2 quarts]). Trucks with increased capacity radiators need to add additional coolant to bring level about one inch below top of radiator surge tank.

COOLING SYSTEM (Continued)

CRANKCASE AND OIL FILTERS

IH ENGINES

S-SERIES				
			With 011 Filter Element Change	
Engine	Liters	Quarts	Liters	Quarts
9.0 Liter	11	12	13	14

9.0 LITER ENGINE SPECIFICATIONS

Engine Specifications	165 HP		
Number of Cylinders	8		
Bore	114.6mm (4.51 in.)		
Stroke	109.5mm (4.31 in.)		
Displacement	9000cm3 (551.1 in.^{3})		
Brake Hp @ 2800 rpm	165 BHP (123 kW)		
Torque	483 N-m (355 lb-ft) @ 1680 rpm		
Idle Speed (No Load)	625-675 rpm		
Governed Speed (No Load)	3050-3150 rpm		
Governed Speed (Full Load)	2800 rpm		
Compression Ratio	19.1:1		
Firing Order	1-8-7-3-6-5-4-2		
Valve Tappet Clearance (Cold): Intake Exhaust	 0.30mm (.012 in.) 0.41mm (.061 in.)		
Engine Weight: Dry	 576.6 kg (1270 lbs.)		
Engine Lube Oil Pressure (Engine at Operating Temperature) Low Idle High Idle	 82-172 kPa (12-25 psi) 310-414 kPa (45-65 psi)		

*Power based on J270 standards 152.4 meters (500 ft.) altitude and 29.4°C (85°F) ambient.

POWER RATINGS AND SPEED SETTINGS

	FEDERAL
Brake Horsepower @ RPM	165 2400
HI Idle RPM (No Load)	2730 ± 25
Low Idle RPM	650 ± 25
Governed Speed Full Load RPM	2400
Brake Horsepower @ RPM	195 2600
HI Idle RPM (No Load)	2925 ± 25
Low Idle RPM	650 ± 25
Governed Speed Full Load RPM	2600

NOTE: Horsepower based on J-270 standards 152.4 meters (500 ft.) altitude and 29.5°C (85°F) ambient. No deration required up to 3048 meters (10, 000 ft.).

CERTIFIED SERVICE AGREEMENT

- Contracted service over an established time period.
- Covers all specified major and minor parts, labor, preventive maintenance inspections, and lubrications.
- Allows you to prorate service on a fixed-cost basis.
- Reduces your investment in service facilities, parts inventory, and personnel.
- Permits you to redirect a greater portion of time to other areas of your business.
- You benefit from IH's nationwide parts and service availability.

PREVENTIVE MAINTENANCE

- Service is performed on a "per job" basis.
- Routine scheduling of service inspections.
- Uses three levels of inspections.
- Completely tailored to fit into your operations and meet your needs.
- You benefit from IH's nationwide parts and service availability.

Both plans have been designed to save you maintenance expense and to increase truck life. Don’t spend more than you have to!

Send for more Information today!

SEE YOUR LOCAL
INTERNATIONAL HARVESTER
TRUCK DEALER

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INTERNATIONAL HARVESTER DEALERS are located throughout the world to provide you with quality parts and service.

INTERNATIONAL HARVESTER DEALERS SERVICE DEPARTMENTS have access to the most up-to-date service techniques and procedures.

"INTERNATIONAL HAS IT!"

Quality parts available to **INTERNATIONAL HARVESTER DEALERS** from Regional Depots throughout the United States.

TRUCK GROUP
INTERNATIONAL HARVESTER COMPANY
401 NORTH MICHIGAN AVE. CHICAGO, ILLINOIS 60611, U.S.A.

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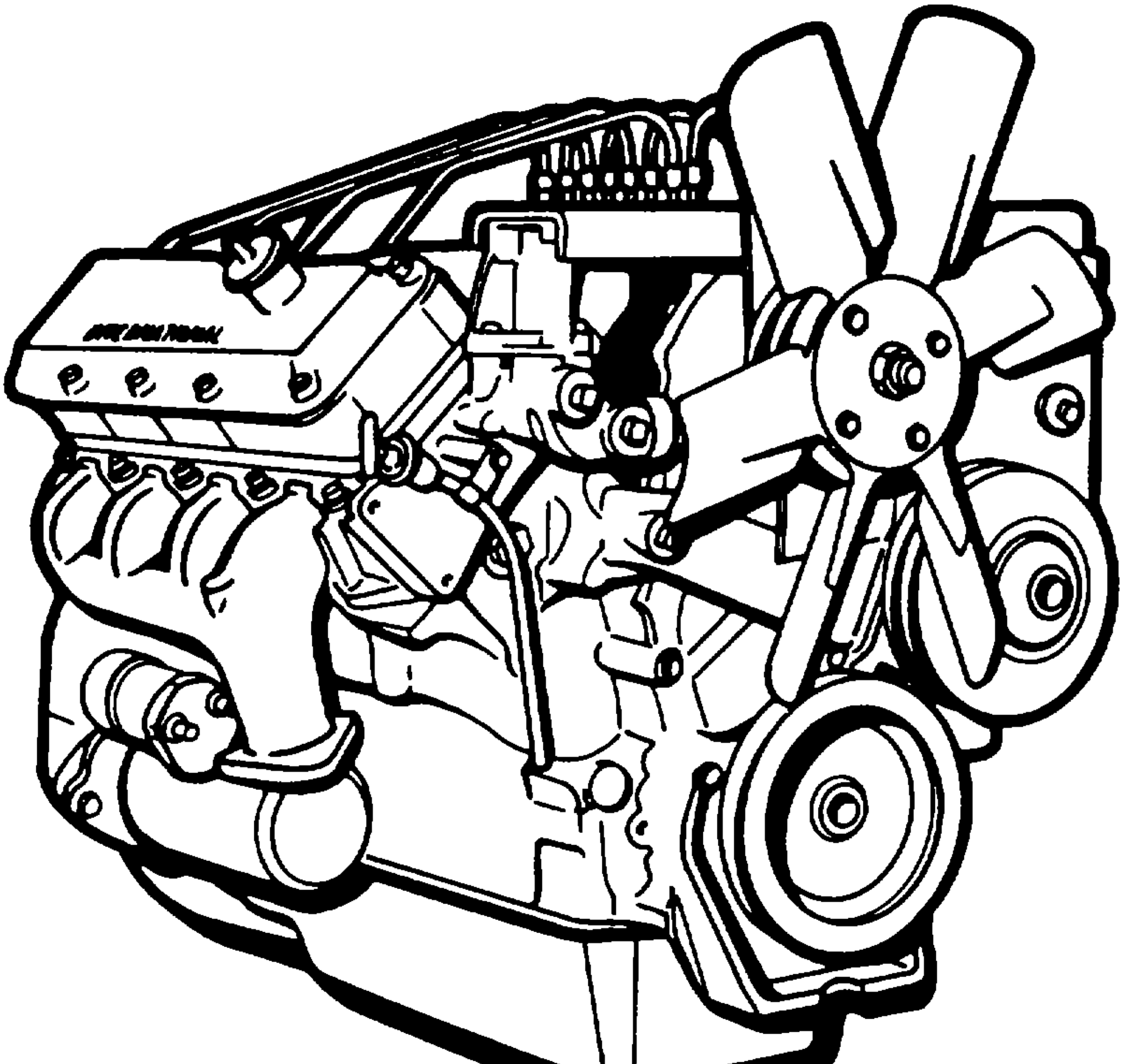
VEHICLE OPERATION PROCEDURES

FOR TRUCK AND TRUCK DERIVATIVE VEHICLE APPLICATIONS ALL MODEL YEARS



IH ENGINES

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CONTENT
INDEX TABS

Instructions for operation, instrumentation, specifications, maintenance, records and trouble shooting are covered by this manual. The instructions are divided into 10 sections to simplify reference to the most important information. The manual must be read completely prior to operating the engine to gain full knowledge of the engine and its correct normal maintenance and operation.

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GENERAL INFORMATION

INTRODUCTION

9.0 Liter Engine

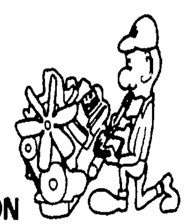
The information in this manual will familiarize you with your 9.0 liter diesel engine and provide sufficient information to enable you to perform services necessary for efficient operation.

The 9.0 liter diesel engine has been designed to operate, when properly maintained, within the permissible emission limits established by the United States Clean Air Act.

Because permissible smoke levels depend on proper engine operation, engine must be correctly adjusted and maintained. This manual lists the schedule of maintenance operations required to assure optimum emission control and service from the engine.

As the owner, it is your responsibility to be certain that maintenance operations are performed at specified mileage or intervals. In addition to controlling required emission levels, proper maintenance pays off in improved vehicle performance and more economical operations.

Remember, clean air and energy conservation is everybody's responsibility.



IDENTIFICATION

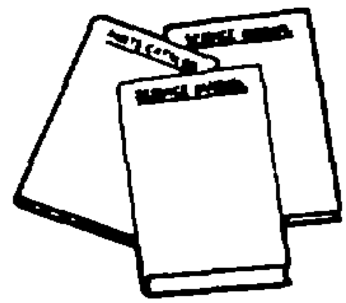
We suggest you fill in the engine identification information indicated below for quick reference when parts or service are required.

9.0 Liter Engine

ENGINE MODEL ________________________________
(Punch out on emission label located on a flat section of the rocker cover pan).

ENGINE SERIAL NUMBER ________________________
(Stamped on crankcase front corner right bank)
INJECTION PUMP
SERIAL NUMBER ______________________________
(Plate on injection pump left side center)

INJECTION PUMP
PART NUMBER ________________________________
(Plate on injection pump rear of governor housing)



SERVICE LITERATURE

If additional service information is required for your 9.0 liter diesel engine, the following manuals may be ordered through your local IH deal or branch.

Form No.	Description
CGES-205U	Engine Service Manual
CGES-220U	Injection Pump Service Manual
CGES-225U	Injection Nozzle Service Manual
CGED-335	Diagnostic Form
CGES-240-2	Diesel Engine Diagnostic Manual

For proper parts information, refer to the appropriate Truck Group catalog.

EMISSION CONTROL SYSTEMS WARRANTY HEAVY-DUTY CALIFORNIA AND FEDERAL EMISSION CLASS ENGINES

International Harvester Company warrants to the owner of any I.H. manufactured diesel engine applicable at the time of manufacture that the engine's emission control system:

1. Was designed, built and equipped so as to conform at the time of sale with all regulations of the U.S. Environmental Protection Agency and of the California Air Resources Board, if engine is so ordered, applicable at the time of manufacture.

GENERAL INFORMATION

2. Is free from defects in material and workmanship which cause it to fail to conform with those regulations as may be applicable for a period of use of 5 years, or 160, 000 km (100, 000 miles) or 3, 000 hours of engine operation, whichever occurs first.

The warranty period shall begin on the date the vehicle with the new engine is delivered to the first retail purchaser or, if the vehicle is first placed in service as a demonstrator or company vehicle prior to sale at retail on the date the vehicle is first placed in service.

The emission control systems of your new I.H. manufactured engine were designed, built and tested using genuine I.H. parts, and the engine is certified as being in conformity with Federal and California Emission control regulations. Accordingly, it is recommended that any replacement parts used for maintenance, repair or replacement of emission control systems be I.H. Service Parts or I.H. ReNEWed Parts. The owner may elect to have maintenance, replacement or repair of the emission control devices and systems performed by any vehicle repair establishment or individual and may elect to use parts other than I.H. Service or ReNEWed Parts for such maintenance, replacement or repair without invalidating this warranty. The cost and performance of such non I.H. approved service or parts, however, will not be covered under the warranty.

If other than I.H. Service Parts or ReNEWed Parts are used for maintenance, the owner shall obtain assurances that such parts are warranted by their manufacturer to be equivalent to the genuine I.H. parts covered by this warranty with respect to a part other than I.H. Service Parts or ReNEWed Parts. However, the use of non-I.H. replacement parts does not invalidate the warranty on the other I.H. engine components unless non-I.H. approved parts cause damage to warranted parts.

Repairs and service covered by this warranty will be performed by an authorized I.H. dealer at his place of business with no charge for parts or labor (including diagnosis), using I.H. Service or ReNEWed parts for any part of the emission control system covered by this warranty and found defective. In case of an emergency where an authorized I.H. dealer is not available, repairs may be performed at any available service establishment qualified and equipped to perform diesel service. I.H. will reimburse the owner for such repairs (including labor in most cases) that are covered under this warranty. Replaced parts and paid invoices must be presented at an I.H. dealership as a condition of reimbursement for emergency repairs not performed by an I.H. dealer.

The emission control parts covered by this emission control system warranty are listed under "WHAT IS COVERED BY THE EMISSION WARRANTY." You are advised to perform all recommended maintenance including severe operating condition, maintenance or repairs on your new I.H. vehicle engine. I.H. will not deny a warranty claim solely because you have no record of maintenance; however, I.H. may deny a warranty claim if your failure to perform maintenance resulted in the failure of a warranted part. Receipts covering the performance of regular maintenance should be retained in the event questions arise concerning maintenance. The receipts should be transferred to each subsequent owner of the vehicle with the emission warranted engine.

Customer Assistance

I.H. wishes to help assure that the Emission Control Systems Warranty is properly administered. In the event that you do not receive the warranty service to which you believe you are entitled under the Emission Control Systems Warranty, you should contact:

Manager, Engine Reliability and Field Service
International Harvester Company
10400 West North Avenue
Melrose Park, IL 60160

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GENERAL INFORMATION

What Is Not Covered By The Emission Warranty

The warranty does not cover:

1. Malfunctions in any part caused by any of the following: Improper engine installation, misuse, abuse, improper adjustments, modification, alteration, tampering, disconnection, improper or inadequate maintenance, or use of fuels or lubricating oils not recommended for this engine.
2. Damage resulting from accident, acts of nature or other events beyond the control of the engine manufacturer.
3. The replacement of expendable maintenance items such as positive crankcase ventilation valve, exhaust system, filters, hoses, belts, oil, thermostat and coolant made in connection with scheduled emission control maintenance services.
4. A warranted part requiring replacement at an inspection or adjustment maintenance interval for reasons other than being defective.
5. Replacement items which are not I.H. Service Parts or ReNEWed Parts.
6. Loss of time, inconvenience, loss of use of vehicle/engine or commercial loss.
7. Any vehicle on which the odometer or hourmeter has been disconnected or the mileage (or hours) has been altered so the actual engine usage cannot be readily determined.
8. Any vehicle registered and normally operated outside the United States.

What Is Covered By The Emission Warranty

The following is a list of items that are considered a part of the Emission Control Systems and are covered by the Emission Warranty when installed as original equipment by I.H. on vehicles which were built to conform to California Air Resources Board regulations.

IMPORTANT:

This does not include expendable maintenance items made in connection with scheduled emission control maintenance services.

I. Fuel Injection System

II. Air Induction System
   A. Intake manifold
   B. Turbocharger system

III. Positive Crankcase Ventilation (PCV) System (if applicable)
   A. PCV valve
   B. Oil filler cap

IV. Exhaust Manifold

V. Miscellaneous Items Used in Above Systems
   A. Hoses, clamps, fitting and tubing
   B. Pulleys, belts and idlers
   C. Vacuum, temperature and time sensitive valves and switches

Date vehicle engine delivered to first retail purchaser or first placed in service:______________________________
Month Day Year

Vehicle Odometer and hourmeter reading at time of installation are: Odometer reading _________________ .
hourmeter reading _______________________________ .

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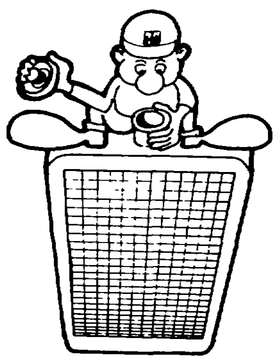
OPERATING INSTRUCTIONS

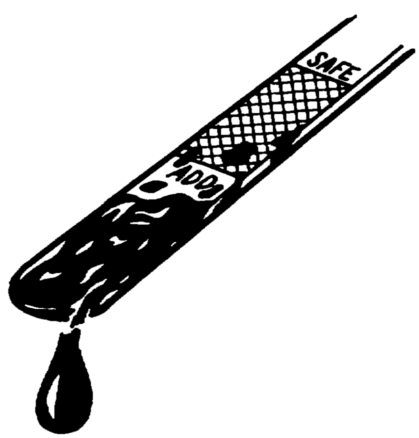
BEFORE STARTING ENGINE

The following checks should be made before starting the engine.

1. Check the cooling system level and fill if necessary. For coolant specifications see section 5 of this manual, or refer to vehicle Operator's Manual for a service replacement engine or to your selling dealer for a repower engine.



2. Check engine oil level for proper level. Refer to lubrication specifications in Section 5 of this manual, if addition is necessary. DO NOT OVERFILLI



ENGINE STARTING AND WARM-UP

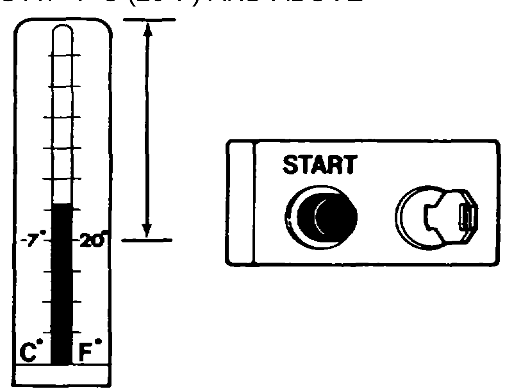
Starting Temperature	Starting Aid	Accelerator Position
--7°C (20°F) and Above	None	Depress Fully
Below -7°C (20°F)	Ether	Depress Fully

Engine starting can be divided into starts with or without the use of an ether starting aid. Ether will not be required with ambient temperatures above -7°C (20°F), provided engine and starting system are in good condition. The following procedures should be used.

Starting procedures may vary slightly dependent upon accessory package.

If engine fails to start after following the starting procedures, refer to Starting Problems Section of this book.

STARTS AT -7°C (20°F) AND ABOVE



1. Set parking brake and place transmission in neutral and fully depress clutch pedal.

2. Push in fuel shut-off control to "ON" position.

3. Depress accelerator FULLY and engage starter to start engine.

OPERATING INSTRUCTIONS

Engine Starting and Warmup-Continued

CAUTION - DO NOT INCREASE ENGINE SPEED UNTIL OIL PRESSURE GAUGE INDICATES NORMAL. SHUT ENGINE DOWN IF OIL PRESSURE DOES NOT REGISTER ON GAUGE WITHIN 20 SECONDS AFTER START.

4. When engine starts, release starter switch immediately and reduce gnine speed to less than 1000 RPM. Warm up engine 3 to 5 minutes or until all systems reach operating temperatures. Check all gauges during warm-up period.

IMPORTANT

Engine warm-up time can be reduced by operating vehicle under load at partial throttle. Commence normal driving when systems reach operating temperatures.

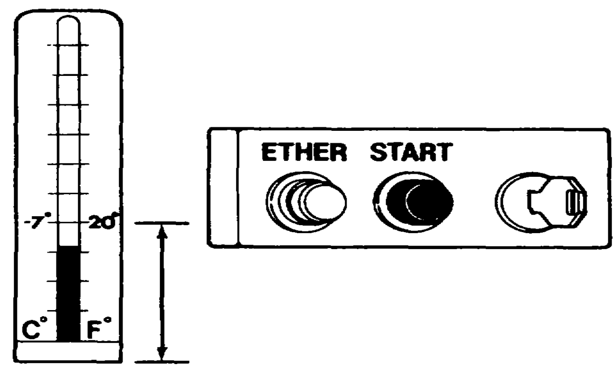
NOTE: An engine at or near operating temperature may be started with accelerator pedal at low idle or partial depression.

IMPORTANT

If engine starts and then stops, it is necessary to release accelerator pedal allowing return to low idle, and then press to full speed to ensure that the injection pump has excess fuel for starting. Investigate the cause of non-starting if more than three attempts are required to start engine.

STARTS BELOW -7°C (20°F)

With Ether Injection



Before any starting attempt, check the ether container to insure that a supply of starting fluid is available under pressure.

IMPORTANT

Ether injector valve inlet must be sealed against dirt entry at all times by having ether container installed or by installing the dust cap provided.

WARNING: ETHER STARTING FLUID IS HIGHLY FLAMMABLE AND TOXIC. Observe the precautions printed on the container when using or storing this fluid and when discarding the empty containers.

1. Set parking brake, put transmission in neutral and depress clutch, if applicable.

2. Place engine shutoff in "RUN" or "ON" position, for either option of manual or electrical shutoff control.

3. Depress accelerator pedal to full speed position.

OPERATING INSTRUCTIONS

4. Simultaneously crank engine and press ether injection switch button. Allow 1 to 2 seconds for ether injector to fill; then with the engine cranking, release ether injector switch button to release a measured shot of ether into the engine.

CAUTION RELEASE OF ETHER INTO CYLINDER PRIOR TO ENGINE BEING CRANKED MAY DAMAGE THE PISTONS AND RINGS.

5. When engine starts, release starter switch immediately and reduce engine speed to between 800-1200 RPM. Monitor gauges and warm up engine 3-5 minutes or until all systems reach operating temperature.

CAUTION IF IN EXTREMELY COLD AMBIENT TEMPERATURE, INITIAL ENGINE OPERATION IS ROUGH OR DIES, INJECT ETHER SHOT TO FACILITATE SMOOTH OPERATION. DO NOT INJECT ETHER INTO A WARM ENGINE.

6. If engine fails to start, repeat above procedures.

IMPORTANT

Shutdown engine if oil pressure is not registered on gauge within 20 seconds.

CAUTION: If engine fails to start within 30 seconds, release starter switch and wait 2 to 3 minutes to allow starter motor to cool. Repeat above procedure. If after three (3) repeat operations engine does not start, investigate and determine cause for engine not starting. STARTER MOTOR DAMAGE MAY RESULT IF STARTING OPERATION IS CONTINUED.

NOTE: Ether capsule starting aids are not recommended.

WARM UP

It is very important that any engine be warmed up before applying load.

The warm-up period provides time for the lubricating oil to establish a film between moving parts.

IMPORTANT

Cold ambient engine warm-up time can be reduced by operating vehicle under load at reduced engine speed. Commence normal driving when systems reach operating temperatures.

Before applying load or speed above 1000 RPM to the engine make sure to warm up the engine for a minimum of five minutes at or below 1000 RPM.

EMERGENCY STARTING

WARNING: THE PROCEDURES BELOW MUST BE PERFORMED EXACTLY AS OUTLINED. OTHERWISE INJURY TO THE FACE, EYES, BODY, LIMBS, AND RESPIRATORY SYSTEM COULD RESULT FROM FIRE OR ACID DUE TO BATTERY EXPLOSION. PROPERTY DAMAGE COULD ALSO RESULT.

1. To prevent shorting of the system, remove metal rings or watches and do not allow metal tools to contact positive terminal of battery.

2. Place transmission in PARK or NEUTRAL and set parking brake in both vehicles.

3. Shut off lights, heater, air conditioner and any other electrical loads in both vehicles.

4. Eye protection should be worn if available. If not available, shield eyes when near either battery.

5. Vehicle bodies or bumpers must not be in contact.

OPERATING INSTRUCTIONS

6. Connect one end of the first jumper cable to positive (+) terminal of the dead battery and then the other end to the positive (+) terminal of the booster battery.

7. Connect one end of the second jumper cable to negative (-) terminal of the booster battery, and the other end to an engine bolthead or good metallic contact spot on the engine of the vehicle to be started. Do not attach the other end to the negative (-) battery terminal, because a spark could occur and cause explosion of gases normally present around the battery.

8. Reverse above procedure when removing the jumper cables.

IMPORTANT

If the battery is a maintenance free type, do not attempt to jump-start the vehicle, charge or test the battery if the indicator in the battery is bright or light yellow. Install a new battery.

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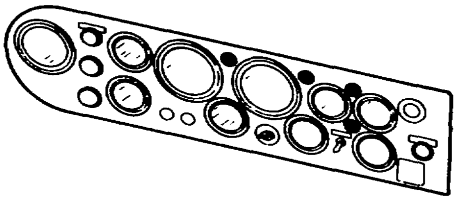
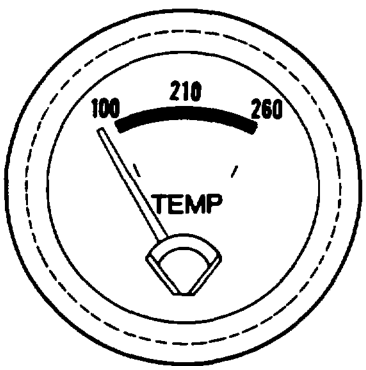
GAUGES



After the engine starts and at frequent intervals while engine is operating, all gauges should be observed for proper readings. This engine operators manual describes gauges in general terms as gauge type may vary with vehicle application. Refer to vehicle operator's manual for vehicle orientation. **PAGE 2024**

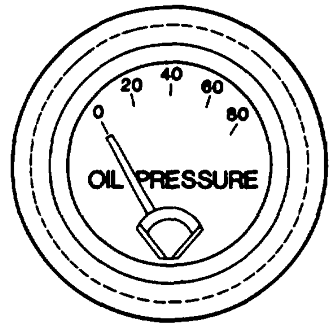
Water Temperature Gauge



The temperature gauge indicates the temperature of the coolant in the cooling system. The gauge should operate only when the ignition switch is turned to the "ON" position or is turned to the accessory position. If indicator suddenly rises, engine should be stopped and the cause of overheating determined. Normal engine operating temperature is between 77° to 93°(170°F to 200°F).

NOTE: Operation of engine above 100°C (212°F) may cause internal engine damage.

Oil Pressure Gauge



The engine oil pressure gauge indicates the operating oil pressure of the engine. At engine idle speed and using SAE 30 oil, the pressure should be approximately 82-172 kPa (12-25 psi); at normal operation speeds, 310-448 kPa (45-65 psi)*

If gauge fluctuates or does not register when the engine is operating, stop the engine immediately and correct cause.

*Engine at normal operating temperature with SAE 30 oil.

Air Cleaner Restriction Gauge and Indicator

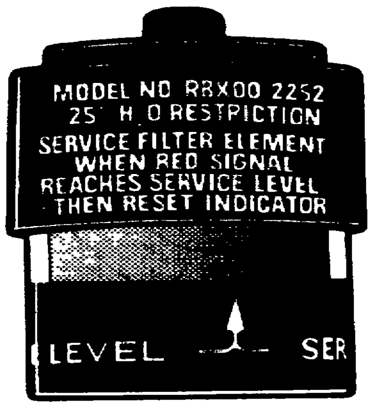
The amount of air cleaner restriction may be detected by either an air cleaner indicator and/or a vacuum gauge.

The vacuum gauge and/or indicator should be checked periodically to insure proper indication. This can be accomplished with a master gauge.

The filter in the air cleaner restriction line should be cleaned when servicing air cleaner filter element.

GAUGES

Air Cleaner Restriction Gauge and Indicator - Continued



CG-7340

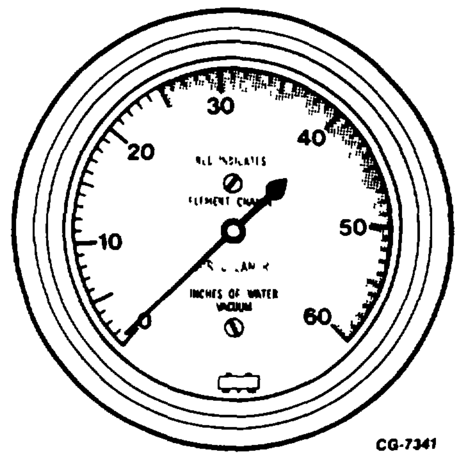
Restriction Indicator

An air cleaner restriction indicator operates from a signal actuated directly by a pressure drop between air cleaner and engine. During operation a red band will gradually rise in window as dust particles accumulate in filter element.

When the filter element reaches the maximum allowable restriction of 4.96 kPa (20 in H_2O), the red band reaches top of window and automatically locks in this position. The red band remains fully exposed even after engine shutdown. The filter element must be properly serviced or replaced at this time to prevent drop in engine performance.

After servicing filter element release the red band by pressing the reset button. The red indicator signal band should drop below window.

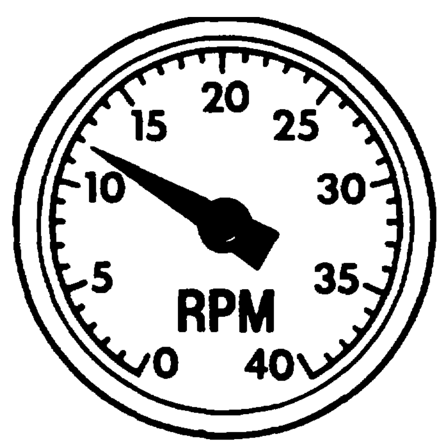
> **IMPORTANT**
>
> After starting engine, band may be seen in lower part of window. This is normal and should not be mistaken as a signal for element service.



Restriction Gauge

The air cleaner restriction gauge (vacuum gauge) may be connected at air cleaner. When reading the vacuum gauge maximum allowable restriction is 4.96 k)a (20 in H_2O). Check the accuracy of the restriction gauge (vacuum gauge) periodically against a master gauge.

Tachometer



The tachometer indicates engine RPM. The engine can be operated between rated speed and high idle without damage but should not be allowed to overspeed (such as when going downhill).

PRECAUTIONS AND RECOMMENDATIONS

OPERATING INSTRUCTIONS

Prevent overspeeding of the engine when going down long and steep grades. The governor has no control over engine speed when it is being pushed by the loaded vehicle. Operate in a gear that will permit an engine speed not in excess of high idle RPM. Operating engine beyond high idle speed can cause severe damage.

COLD WEATHER OPERATION

In order to operate engine In temperatures of 0°C (32°F) or lower, observe the following instructions:

1. Make certain that battery is of sufficient size and is in fully-charged condition. Check that all other electrical equipment is in optimum condition.
2. Use permanent-type anti-freeze solution to protect against damage by freezing.
3. At the end of each daily operation, drain water from water separator, if equipped. Fill fuel tank at end of daily operation to prevent condensation.
4. Be sure to use proper cold weather lubricating oil, and be sure crankcase contains a sufficient amount.
5. At temperatures of -20°C (-4°F) and below, it is recommended that you use a crankcase mounted coolant heater to improve cold starting.
6. If operating in arctic temperatures of -29°C (-20°F) or lower, consult your International Harvester dealer for information about special cold weather equipment and precautions.

HOT WEATHER OPERATION

1. Make sure that battery has proper amount of electrolyte.
2. Keep cooling system filled with clean permanent anti-freeze solution to protect against damage by overheating.
3. Fill fuel tank at end of daily operation to prevent condensation in tank.
4. Keep external surface of engine, radiator and accessories clean to avoid dirt build-up.

SHUTDOWN

Idle the engine for three to five minutes before shutting down. This few minutes idling allows the lubricating oil and water to carry heat away from the iron masses.

The larger the engine, the greater the need for this idling period and of course, the length of the idling period should somewhat follow the size of the engine in order to avoid seals or like features of an engine being damaged by rising heat.

SHUTDOWN WARNING LIGHT

A warning light on the instrument panel will indicate high coolant temperature or low oil pressure.

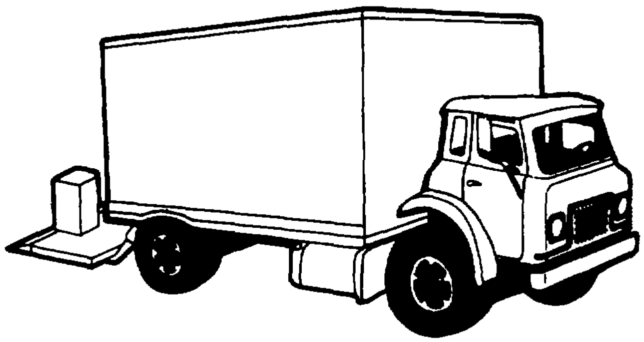
PARKING

WARNING: WHEN PARKING YOUR DIESEL VEHICLE, DO NOT LEAVE TRANSMISSION IN GEAR; IF VEHICLE ROLLS, ENGINE COULD START BY HEAT OF COMPRESSION. USE HAND BRAKE FOR PARKING ON A GRADE, BLOCK WHEELS OR TURN TO CURB.

FAILURE TO FOLLOW THESE PROCEDURES COULD RESULT IN AN UNATTENDED VEHICLE MOVING, THUS RESULTING IN PERSONAL INJURY OR PROPERTY DAMAGE.

PRECAUTIONS AND RECOMMENDATIONS

IDLE SPEEDS



Low idle speed for the 9.0 liter engine is 625-675 RPM. automatic transmission in gear. If engine operation includes extended periods of idling, low idle speed should be temporarily increased by adjusting throttle to 1200 RPM during these periods.

Return engine to specified low idle speed before normal operation is resumed.

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SPECIFICATIONS

9.0 LITER ENGINE SPECIFICATIONS

Engine Specifications	165 HP		
Number of Cylinders	8		
Bore	114.6 mm (4.51 in.)		
Stroke	109.5 mm (4.31 in.)		
Displacement	9000cm³ (551.1 in.³)		
Brake HP @ 2800 rpm	165 BHP (123 kW)		
Torque	483 N•m (355 lb-ft) @ 1680 rpm		
Idle Speed (No Load)	625-675 rpm		
Governed Speed (No Load)	3025-3125 rpm		
Governed Speed (Full Load)	2800 rpm		
Compression Ratio	19.1:1		
Firing Order	1-8-7-3-6-5-4-2		
Timing (Static)	15°± 1° BTDC		
Valve Tappet Clearance (Cold) Intake Exhaust	 0.30 mm (.012 in.) 0.41 mm (.016 in.)		
Engine Weight: Dry	 576.6 kg (1270 lbs.)		
Engine Lube Oil Pressure (Engine at Operating Temperature with SAE 30 oil) Low Idle High Idle	 82-172 kPa (12-25 psi) 310-414 kPa (45-65 psi)		

*Power based on J270 standards 152.4 meters (500 ft.) altitude and 29.4eC (85’F) ambient.

SPECIFICATIONS

FUEL REQUIREMENTS

Recommended Fuel for IH Diesels

This fuel information will help the operator obtain maximum performance at the least cost when using an International diesel engine. The specifications are broad enough to permit the use of low cost fuels yet are restrictive enough to prevent use of low quality fuels which could lead to frequent overhauls.

Fuel Grade: Use only Grade No. 1-D or Grade 2-D diesel fuels. Specifications for these fuels are listed in ASTM D975 or Federal Specification VV-F-800. Do not use fuels sold only as heating or furnace oil. Choose the proper fuel grade as follows:

Expected Temperature	Preferred Fuel Grade
Above 7°C (+20°F)	Grade No. 2-D
Below -7°C (+20°F)	Grade No. 1-D

NOTE: If Grade No. 1-D is not available, use a "winterized" or "climatized" Grade No. 2-D fuel, made by blending No. 1-D with No. 2-D fuel to match the temperature conditions in your area.

If your engine suddenly becomes noisy after a fuel fill, you possibly received substandard fuel with a low cetane rating. Whenever feasible, buy diesel fuel from a reputable supplier who sells a large amount of diesel fuel.

Sulfur Content: Diesel fuels with a maximum sulfur content of 0.5 percent are recommended. Know your fuel sulfur content. (Ask your supplier, or have fuel analyzed.) If fuel contains more than 0.5 percent sulfur, reduce the oil change interval as follows:

Sulfur Content, Percent	Oil-Change Interval
Below 0.5	Normal
0.5 to 1.0	1/2 Normal
Above 1.0	1/4 Normal

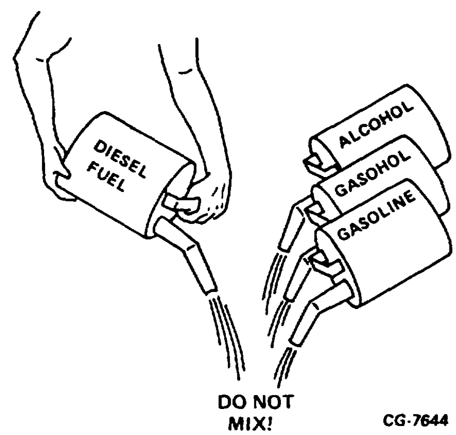
NOTE: It is not necessary to reduce filter change intervals when oil change intervals are reduced.

Diesel Fuel/Gasoline Blends

International Harvester Company does not recommend the blending of gasoline, and/or alcohol with diesel fuel due to the hazards of fire/explosion and the detrimental effects on engine performance.

HAZARDS OF FIRE AND EXPLOSION:

WARNING: UNDER NO CIRCUMSTANCES SHOULD GASOLINE, GASOHOL AND OR ALCOHOL BE BLENDED WITH DIESEL FUEL. THIS PRACTICE CREATES AN EXTREME FIRE HAZARD AND UNDER CERTAIN CONDITIONS AN EXPLOSIVE HAZARD WHICH COULD RESULT IN SERIOUS INJURY OR DEATH.



- As little as two volume percent gasoline mixed with diesel fuel will create a flammable/explosive hazard during refueling or engine operation.

ENGINE PERFORMANCE PROBLEMS:

- Lower fuel viscosity could reduce engine power and fuel economy, and increases the possibility of excessive fuel system wear or failure.
- Lower cetane number could cause hard starting and slower warmup, and could increase engine noise and exhaust emissions.

SPECIFICATIONS

IMPORTANT

Excessive cetane number reduction can lead to engine damage or failure.

WARNING: ANY VOLUME OF GASOLINE IN DIESEL FUEL IS EXTREMELY DANGEROUS AND IS NOT RECOMMENDED BY INTERNATIONAL HARVESTER COMPANY.

WARNING: DO NOT START OR RUN AN ENGINE WITHOUT VEHICLE BEING COMPLETELY VENTILATED AT ALL TIMES. EXHAUST GAS FROM ALL INTERNAL COMBUSTION ENGINES CONTAINS POISONOUS CARBON MONOXIDE WHICH IS ODORLESS, TASTELESS, AND COLORLESS. WHEN VEHICLE IS STARTED INSIDE, KEEP GARAGE DOORS WIDE OPEN.THIS POISONOUS CARBON MONOXIDE GAS WILL NOT ONLY CAUSE DROWSINESS, BUT COULD BE FATAL. ALWAYS PROVIDE PROPER VENTILATION WHILE OPERATING THE VEHICLE.

Antifreeze

IH Antifreeze and Coolant is recommended. It contains all necessary conditioners to prevent corrosion (but not cavitation erosion) and has been tested for use in International Harvester products. It is an ethylene glycol type antifreeze and compatible with chromate and non-chromate type coolant filters. Current antifreeze part numbers are displayed in Chart 1.

CHART 1

IH Antifreeze and Coolant Part Numbers	
Quart	996722R2
Gallon	996723R2
55-Gallon Drum	996900R2

Coolant Conditioner

Selection and maintenance of engine coolant is as important to long engine life as is selection and changing of engine lubricating oil and oil filters.

IH coolant conditioner is a complete conditioning system of a non-chromate type which is compatible with both water and IH Antifreeze and Coolant. Approved Cooling System Conditioner part numbers are displayed in Chart 2.

CHART 2

IH Coolant Conditioner and Coolant Filter Part Numbers		
	Cooling System Conditioner	Coolant Filter/ Conditioner
Pint	690126C1	
Quart	690127C1	
Gallon	———	
55-Gallon Drum	690128C1	
Spin-On Filter		690171C1 or 462816C2
Spin-On Filter		690124C1

Maintaining Required Conditioner Concentration

Cooling system conditioner concentration is controlled by the amount of liquid conditioner in the system. Cooling systems filled with plain water and those filled with an I H Antifreeze mixture are both treated the same.

All cooling system conditioners, including those in antifreeze solutions, become depleted through normal operation. If conditioners in antifreeze are allowed to become depleted, the antifreeze becomes corrosive and attacks and coats metallic surfaces of the cooling system which reduces heat transfer. To maintain an acceptable conditioner concentration, additional chemicals must be supplied to the cooling system.

SPECIFICATIONS

Maintenance of Vehicles Using IH Liquid Conditioner (Chart 3).

Vehicles in high-hour and low-mileage applications, such as refuse packers and transmit mixers, which operate frequently at low engine speeds and engine temperatures, are best maintained according to hour intervals rather than mileage intervals.

"Initial Treatment" Column is used to bring a previously unconditioned vehicle conditioner concentration up to recommended levels. All service after the initial treatment should be per Columns 1 and 2.

At the interval specified in Column 2 of Chart 3, the coolant should be drained and the cooling system chemically flushed with IH Cooling System Cleaner and Neutralizer (995007R1). After flushing and refilling the system, add specified quantity of liquid IH Cooling System Conditioner to the radiator top tank. Operate engine until it is warmed up enough to open thermostat and circulate conditioner through the cooling system.

Anytime make-up coolant is added, liquid I H Cooling System Conditioner should be added at a rate of 4 ounces per one gallon of make-up coolant.

CHART 3

TOTAL COOLING SYSTEM CAPACITY (Gallons)	INITIAL TREATMENT	COLUMN 1	COLUMN 2
		Every 18,000 Miles (600 Engine Hours)	Every 72,000 Miles, 2,400 Engine Hours or 2 Year's Services (whichever comes first) and After Any Complete Drain
	Drain and Flush with IH Cooling System Cleaner and Neutralizer and Service With	Service With	Drain and Flush with IH Cooling System Cleaner and Neutralizer and Service With
	The following quantity of IH Cooling System Conditioner*#		
6.00 thru 7.25	2 Pints	1 Pint	2 Pints
7.50 thru 11.00	4 Pints		4 Pints
11.25 thru 15.00	5 Pints	2 Pints	5 Pints
15.25 thru 18.00	6 Pints		6 Pints

*See Chart 2 for part numbers. Additional IH Cooling System Conditioner is added at initial treatment or after any complete drain to bring concentration up to the required level.

IMPORTANT: It is vital that above change intervals and amount of coolant system conditioner be followed precisely. If not, the concentration of conditioners in the coolant may become depleted or overconcentrated, both of which can be detrimental to the cooling system and engine. Cooling system conditioners other than those recommended in this report may not provide proper concentration of conditioners and may not be compatible with the cooling system.

#NOTE: Do not follow the time intervals and quantities specified on the liquid conditioner bottles. Follow the maintenance schedule specified above.

SPECIFICATIONS

COOLING SYSTEMS SPECIFICATIONS - Continued

Coolant Testing for Conditioner Concentration

When the cooling system is maintained as recommended, the conditioner concentration should be satisfactory. An IH Coolant Test Kit (690 125 C91) is available to determine the chemical concentration level. The test kit measures the amount of cylinder sleeve cavitation erosion protection in a coolant sample. In general, a good reading indicates that the conditioner contained in the coolant is sufficient to insure cooling system protection. It is recommended that the conditioner concentration be checked with the test kit every four months.

CLEANING THE COOLING SYSTEM

Once a year the cooling system should be drained and thoroughly flushed.

NOTE: Every two (2) years with coolant conditioner element.

Unless the cooling system is treated with a corrosion preventative, rust and scale will eventually clog up passages in the radiator and water jackets. This condition is aggravated in some localities by formation of insoluble salts from the water used.

IH cleaning solutions are available which have proven very successful in removing accumulation of rust, scale, sludge and grease. This solution should be used according to the recommendation on the container.

IMPORTANT

Do not use chemical mixtures to stop radiator leaks except in an emergency. Never use such solutions instead of needed radiator repair. DO NOT USE SOLUBLE OIL.

When draining the cooling solution, disconnect the radiator outlet hose as large particles of sediment will not pass through the drain.

WARNING: USE ONLY THE FOLLOWING PROCEDURE TO REMOVE THE PRESSURE TYPE CAP FROM THE RADIATOR. ALWAYS ALLOW THE ENGINE TO COOL FIRST. WRAP A THICK, HEAVY CLOTH AROUND THE CAP. PUSH DOWN, LOOSEN CAP SLOWLY TO ITS FIRST NOTCH POSITION; THEN PAUSE A MOMENT. THIS WILL AVOID POSSIBLE SCALDING BY HOT WATER OR STEAM. CONTINUE TO TURN CAP TO THE LEFT AND REMOVE.

CAUTION: IF THE COOLANT SHOULD GET EXTREMELY LOW AND THE ENGINE VERY HOT, LET THE ENGINE COOL FOR APPROX-, IMATELY 15 MINUTES BEFORE ADDING COOLANT; THEN, WITH THE ENGINE RUNNING, ADD COOLANT SLOWLY. ADDING COLD WATER TO A HOT ENGINE MAY CRACK THE CYLINDER HEAD OR CRANKCASE. NEVER USE WATER ALONEI

RADIATOR FINS

Check the radiator fins periodically to make sue' they are free of bugs, leaves and other debris, and that they are not bent or damaged. Clogged or damaged fins prohibit the flow of outside air to the radiator and hamper efficient cooling system operation.

COOLANT HOSES

The only coolants which are recommended for use in IH cooling systems are those which contain an ethylene glycol base. Other base coolants may damage rubber hoses, especially those made of silicone rubber. Type of rubber can usually be determined by color. Silicone hoses are made in "COLOR" while other rubber hoses are "B LACK." If coolants used are not of ethylene glycol base, this may affect your engine warranty.

SPECIFICATIONS

IMPORTANT

Antifreeze made with methoxy propanol or propylene glycol is not recommended for use with IH engines. These types of antifreeze can damage engine internal seals and coolant hoses and create a potential fire hazard due to lower flash points than ethylene glycol type antifreeze.

THERMOSTAT

Your new truck is equipped at the factory with a high temperature thermostat.

Permanent type antifreeze must be used with high temperature thermostats.

ENGINE LUBRICATION

Oil Quality

Oil quality is described by API (American Petroleum Institute) engine service categories. API categories are defined by oil performance (deposits and wear) measured in standardized engine tests. API "S" categories (SC, SE, SF) describe oils for spark ignition (gasoline) engines, while "C" categories (CC, CD) describe oils for diesel engines. Oils with both "S" and "C" categories (such as SF/CD) are suitable for both spark ignition and diesel engines. Sometimes, the "S" and "C" categories are reversed (such as CD/SF).

Oil quality is also described by two current U.S. Military Specifications, MIL-L-46152B and MILL-2104D. (MIL-L-2104D recently superseded MIL-L-2104C, which is now obsolete but which may still be widely used.)

The oil quality recommended depends upon engine type and engine design. The recommended 9.0L diesel engine oil quality is:

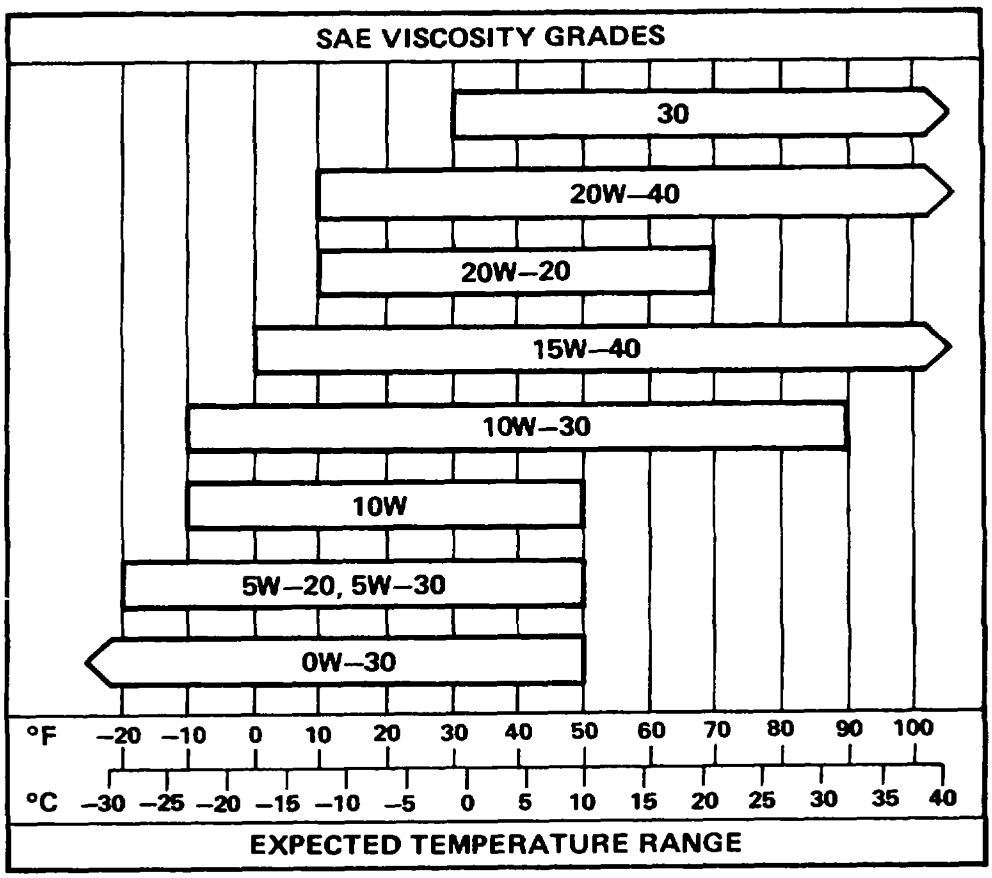
Oils meeting API categories SE/CC, SF/CC, CD, SC/CD, SE/CD, or SF/CD, or Military Specifications MIL-L-46152B, MIL-L-2104D, or MIL-L2104C. IH No. 1 Engine Oil meets these requirements.

NOTE: Do not use oils specifically marketed by suppliers for stationary, marine, or railroad diesel engines, or for stationary natural gas engines, even though they are marked API category CD. Such oils can cause excessive valve train wear and combustion chamber deposits. (Such oils are sold only in drums and in bulk quantities).

SPECIFICATIONS

OIL VISCOSITY

Oil viscosity (thickness) is described by SAE (Society of Automotive Engineers) Viscosity Grade. Colder temperatures require lower viscosity oils to ensure good flow during starting, while hotter temperatures require higher viscosity oils for satisfactory lubrication. Based upon the temperature range you expect before your next oil change, use chart and the notes below to choose the proper viscosity grade. Using other viscosity grades, or using viscosity grades at temperatures outside the recommended ranges could cause engine damage.



CG-9893

NOTE: Some increase in oil consumption may be expected when SAE OW-30, 5W-20, 5W-30, 10 W, and 10W-30 oils are used. Check oil level more frequently.

SPECIFICATIONS

OIL-CHANGE INTERVAL

Refer to Maintenance Instructions for the recommended oil-change interval for your engine. Use of oils exceeding the required quality level, synthetic oils, ore other oils claiming longer service intervals does not justify extending oil-change intervals beyond those recommended.

For diesel engines, the recommended oil-change intervals are based on the use of diesel fuels with a maximum sulfur content of 0.5 percent. Know your fuel sulfur content. (Ask your supplier, or have fuel analyzed). If fuel contains more than 0.5 percent sulfur, reduce the oil-change interval as follows:

Sulfur Content, Percent	Oil-Change Interval
Below 0.5	Normal
0.5 to 1.0	1/2 Normal
Above 1.0	1/4 Normal

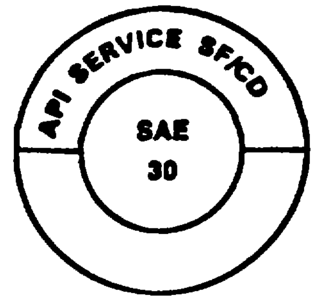
NOTE: It is not necessary to reduce filter change intervals when oil change intervals are reduced.

ENERGY CONSERVING OILS

Oils marketed as "Energy Conserving" are intended to improve fuel economy in passenger car engines. Some of these oils contain friction modifier chemical additives. One additive, molybdenum dithiophosphate, has been implicated in copper corrosion problems, in some heavy duty diesel engines. Therefore, until further information is available, do not use an "Energy Conserving" oil containing molybdenum dithiophosphate in any IH-built engine. In addition, some "Energy Conserving" oils meet only API category SF for spark ignition engines, and do not meet the oil quality requirements for diesel engines.

IDENTIFICATION SYMBOL

An oil container symbol system has been developed to help you choose the proper oil. The top portion of the symbol shows the oil quality, such as API Service SF/CD in the example. The symbol may show additional categories, such as API Service SE,SF/CC,CD. The center portion will probably show the SAE viscosity grade, such as SAE 30 in the example. If the lower portion shows "Energy Conserving", be sure the upper and center portions show correct API service category and proper SAE viscosity grade recommended for your engine.



CRANKCASE OIL SPECIFICATIONS

For specific information on most commercial oil brand names, write for the booklet entitled:

"LUBRICATING OIL DATA BOOK FOR HEAVY-DUTY AUTOMOTIVE AND INDUSTRIAL ENGINES"

Engine Manufacturers Association
111 East Wacker Drive
Chicago, IL 60601
(312) 644-6610

CHECKING ENGINE OIL LEVEL

Keep oil level as near the high level mark as possible. Never operate an engine with oil level below low level mark. DO NOT OVERFILL!

When checking the oil level, the dipstick must be withdrawn and wiped clean, then inserted all the way and again withdrawn for a true reading.

Never check the oil level with engine running or immediately after engine shutdown as an inaccurate reading will be obtained.

9.0 Liter Diesel Crankcase Refill Capacities*

11.3L (12 Qts.)
+ 2L (2 Qts.) with Filter Change

*Engine equipped with auxiliary filtering system require additional oil.

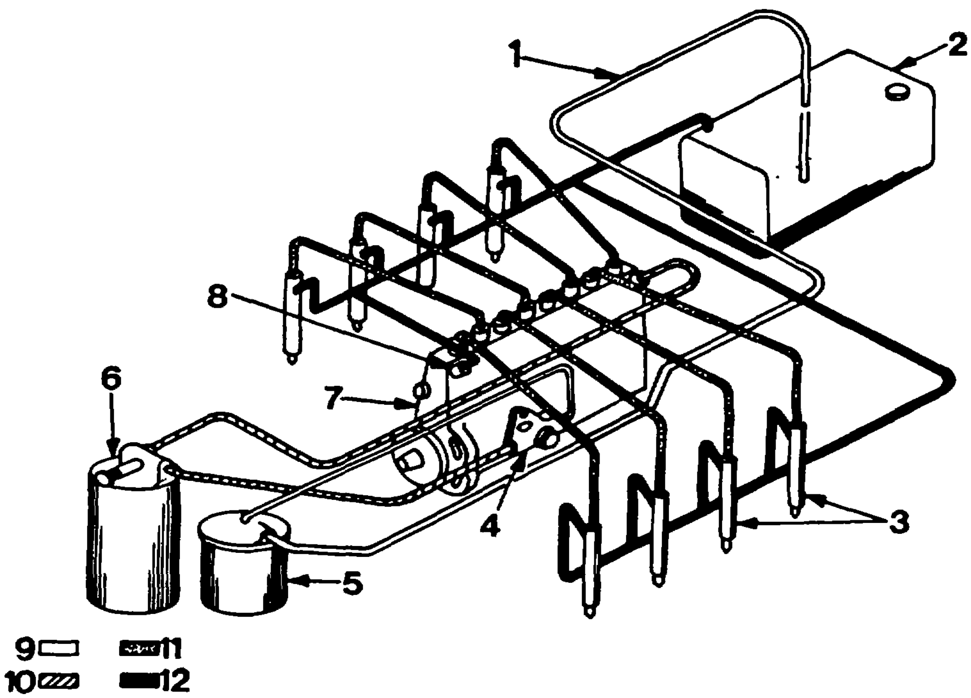
The major systems in the 9.0 liter engine are as follows:

FUEL SYSTEM
LUBRICATION SYSTEM
COOLING SYSTEM
EXHAUST SYSTEM
AIR INDUCTION SYSTEM

The objective of this section is to briefly describe each system in the engine.

FUEL SYSTEM

(Refer to Illustration)



Legend

1. Fuel Line From Tank to Primary Filter
2. Fuel Tank
3. Nozzle and Holder Assembly
4. Transfer Pump
5. Primary Filter
6. Final Filter With Hand Primer
7. Fuel Injection Pump
8. Damper Valve (Fuel Return)
9. Transfer Pump Suction
10. Transfer Pump Discharge
11. Injection Pump Discharge (HP)
12. Fuel Return

FUEL SYSTEM - Continued

Fuel is drawn from the tank(s) through the primary fuel filter and is then passed through the transfer pump to the final fuel filter. The final fuel filter is located on the left or right front side of the engine depending upon application. Filtered fuel is then directed to the fuel injection pump located between the cylinder heads. The pump meters and delivers fuel under high pressure to injection nozzles located at each cylinder.

The injection pump is the in-line, single action plunger type with individual plunger and barrel for each cylinder. Pump plunger stroke is constant but effective pumping (metering) stroke Is variable and controlled by position of a common control rack operated by the governor and the accelerator pedal. The governor is integral with the fuel injection pump assembly.

Operating and service instructions for the fuel system are given in separate sections of the service manual. Fuel System Manual CGES-220U covers the fuel injection pump and governor. Fuel System Manual CGES-225U covers the fuel injection nozzles.

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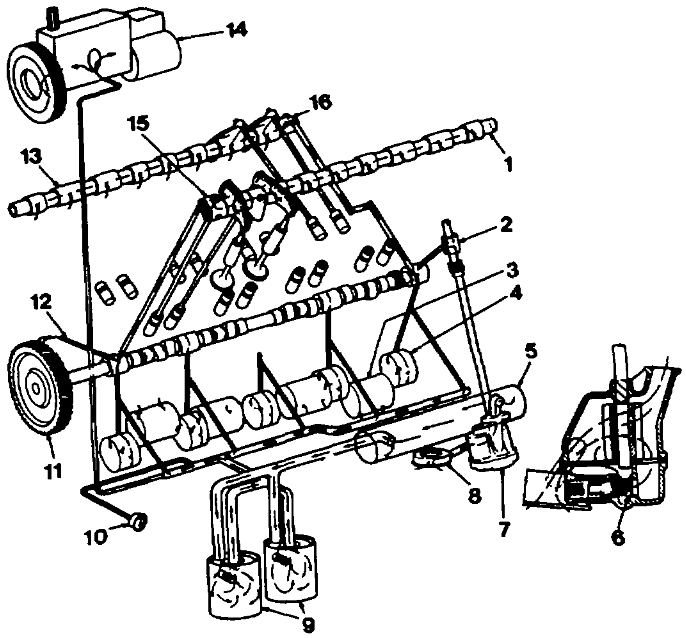
LUBRICATION SYSTEM



Legend

1. Rocker Arm Shaft Left Bank
2. Oil Pump and Tachometer Shaft Upper Bushing
3. Connecting Rod Bearing 4
4. Main Bearing
5. Oil Cooler
6. Pressure Relief Valve (2 used) Opens at 75 P.S.I.
7. Oil Pump
8. Oil Pump Screen
9. Full Flow Oil Filter with By-Pass Valve
10. Oil Pressure Gauge
11. Camshaft Gear
12. Oil Feed to Gears
13. Rocker Arm Shaft Right Bank
14. Injection Pump
15. Oil Feed Bracket Front Left Bank
16. Oil Feed Bracket Rear Right Bank

Engine lubrication is provided by a system of galleries and drilled passages running through the various engine castings and moving parts. This design eliminates external or internal oil lines and assures trouble-free, efficient engine lubrication.

In operation, oil is forced through the engine by an internally mounted gear type oil pump which is driven through gears at the engine camshaft. Oil enters the pump through a stationary screen assembly located under the surface of the oil in the oil pan and above the bottom of the oil pan and attached to the oil pump body. Because of the reserve oil delivery capacity of the oil pump, the two regulator valves are required. Oil relieved by the pressure regulator valves is recirculated within the pump. This feature eliminates oil aeration, which is often caused by oil returning to the pan from the pump.

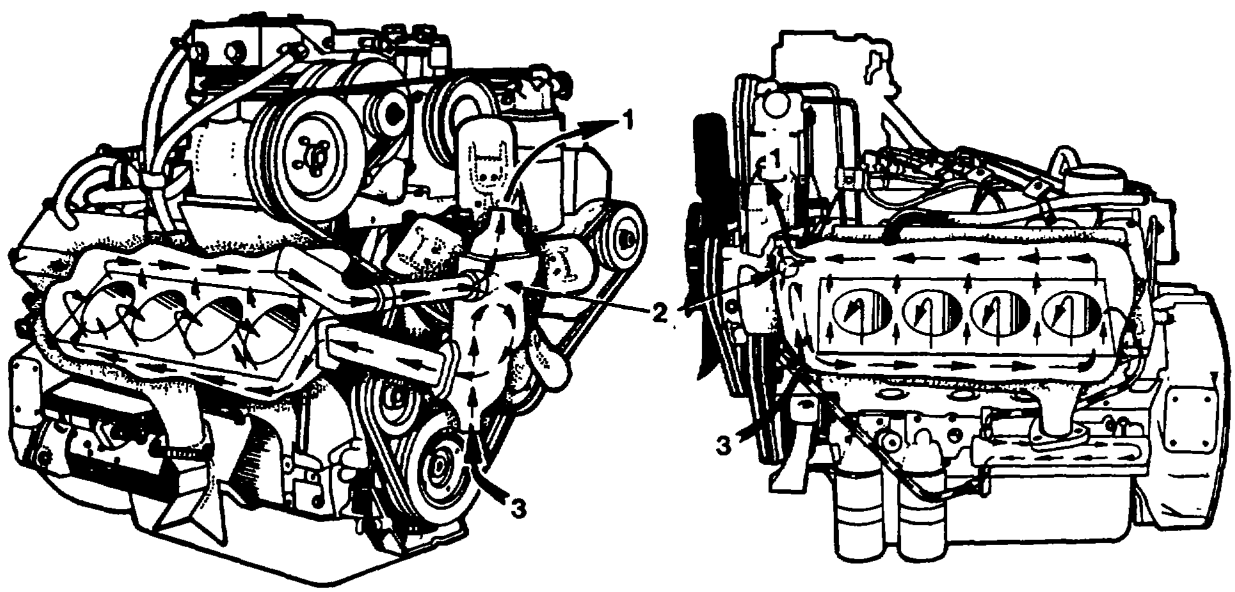
Oil leaving the oil pump passes through the oil cooler where heat from the oil is removed by the engine coolant and dissipated through the engine cooling system. From the oil cooler, the oil enters full-flow oil filters. Each spin-on type filter has a bypass valve which permits oil to flow to the engine if the filter becomes clogged.

After passing through the cooler and filters, oil enters the main engine oil galleries which supply oil through drilled passages to the crankshaft, main and connecting rod bearings, as well as the camshaft and bearing.

The hollow rocker arm shafts are drilled to feed oil to each rocker arm bearing as well as the rocker arms. The rocker arms are drilled to feed oil in channels or grooves to the valve stems and push rods.

A tap is provided in the engine crankcase to deliver engine oil to lubricate bearings in the fuel injection pump. The air compressor receives lubrication from this same source.

COOLING SYSTEM



Legend

1. Water Outlet 2. Water Pump 3. Water Inlet

Coolant is circulated through the engine by a belt driven water pump located on the left front of the engine.

The pump directs coolant to the oil cooler, crankcase and cylinder heads. Dual thermostats in a housing at the front of the engine provide for quick engine warm-up, and allows free circulation of coolant after operating temperature has been reached. A modulated fan drive is used to provide for a more efficient and quieter engine, as fan speed is reduced when cooling requirements are low.

EXHAUST SYSTEM

The exhaust system is used to carry away exhaust heat and gases from the engine. Smoke and back pressure tests can be performed on the system for indications of engine conditions.

AIR INDUCTION SYSTEM

The 9.0 liter diesel engine is naturally aspirated. Air travels through the air cleaner and intake manifold to the combustion chamber.

GENERAL

For effective emission control and low operating cost, it is important that maintenance operations listed on the following pages be performed at the specified periods or mileage intervals indicated.

Service intervals are based upon average operating conditions. Where dusty, frequent start and stop or heavily laden operations are encountered, more frequent servicing will be required.

As the vehicle (engine) owner, you are responsible for the performance of all scheduled maintenance. The required maintenance operations may be performed by the owner at a service establishment of the owner's choosing. Any replacement parts used for required maintenance services or repairs should be genuine I H parts or equivalent in quality and performance to genuine I H parts. Use of inferior replacement parts hinders operations of engine and emission controls.

Receipts covering the performance of regular maintenance should be retained in the event questions arise concerning maintenance. The receipts should be transferred to each subsequent owner of the engine (vehicle).

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MAINTENANCE SCHEDULE CHART
(9.0 LITER ENGINES)

	Maintenance Operations	Daily	Inspection Interval: Every 9,600 km, 6,000 Miles, 200 Hours or 3 Months	Every 19,200 km, 12,000 Miles, 400 Hours or 6 Months	Every 38,400 km, 24,000 Miles, 800 Hours or 12 Months	Every 96,000 km, 60,000 Miles, 2000 Hours or 30 Months
1	Inspect Coolant and Oil Levels (5)	X				
2	Inspect Low Oil Pressure Alarm (if equipped) (9)	X				
3	Inspect Air Cleaner Restriction Indicator (1) (5)	X				
4	Inspect for External Leakage (9)	X				
5	Inspect and Adjust Belts (5)		X			
6	Change Engine Oil and Oil Filter (3) (5)		X			
7	Change Fuel Filters (5)			X		
8	Clean or Replace Air Filter (1) (5)			X		
9	Check Low Idle Speed (4) (6)				X	
10	Check High Idle Speed (4) (6)				X	
11	Check Accelerator Linkage (5) (6)				X	
12	Check Transfer Pump Pressure (6)				X	
13	Test Injection Nozzle (6) (8)					X
14	Valve Lash Adjustment (2) (6) (7)					X

(1) Indicator will signal when air filter element should be replaced or cleaned.
(2) New or rebuilt engine after 6,000 miles, 9,600 km, 200 hours or 3 months, then every 60,000 miles, 98,000 km, 2,000 hours or 30 months
(3) If fuel contains more than 0.5 percent sulfur, reduce oil-change interval as follows:

Sulfur Content, Percent	Oil-Change Interval
Below 0.5	Normal
0.5 to 1.0	1/2 Normal
Above 1.0	1/4 Normal

NOTE: It is not necessary to reduce filter change intervals when oil change intervals are reduced.

(4) New or rebuilt engine after 6,000 miles, 9,600 km, 200 hours or 3 months, then every 24,000 miles, 38,400 km, 800 hours or 12 months
(5) Refer to Maintenance Instructions on the following pages.
(6) Service instructions will be found in CGES-240, Diesel Engine Diagnostic Manual.
(7) Adjustment procedure can be found in CG ES-205, 9.0 Liter Engine Service Manual.
(8) Test procedure can be found in CGES225, Injection Nozzle Service Manual.

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OPERATIONS 14 are performed Daily

OPERATION 1

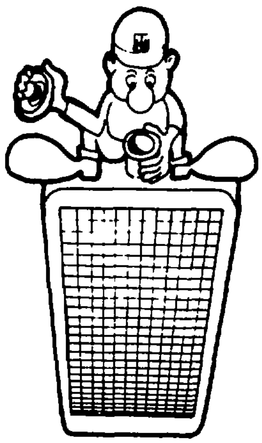

Figure 1.

Inspect Coolant and Oil Level (Daily)

Inspect coolant level (Engine cold - Not Running) as follows:

1. Use coolant level sight gauge to determine appropriate coolant level.

2. check coolant level at fill cap.

CAUTION! When removing the pressure type cap from the radiator, perform the operation in three steps:

1. Push down, loosen cap slowly to its first notch position.
2. Pause a moment to allow pressure and/or steam to escape. (This will avoid possible scalding by hot water or steam.)
3. Continue to turn cap to the left and remove.

IMPORTANT

If the coolant should get extremely low and the engine very hot, let the engine cool for approximately 15 minutes before adding coolant; then, with the engine running, add coolant slowly. Adding cold water to a hot engine may crack the cylinder head or crankcase.

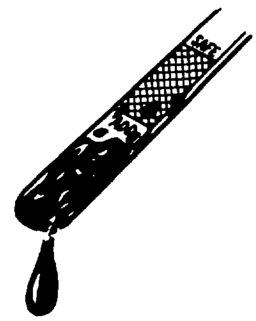

Figure 2.

Inspect oil level as follows:

1. Let engine run until operating temperature is reached.

2. Stop engine. Check oil level gauge 15 minutes after engine shut-off.

3. Inspect oil level gauge to insure engine crankcase oil level is at least up to the low mark on gauge to avoid engine damage.

If required, add oil as follows:

1. When oil level is at or below low mark with engine at operating temperature (as above) add oil.

2. Do not "overfill" past full mark on oil level gauge.

NOTE: Refer to Section 5 for Crankcase Refill Capacities.

MAINTENANCE OPERATIONS (Continued)

OPERATION 2

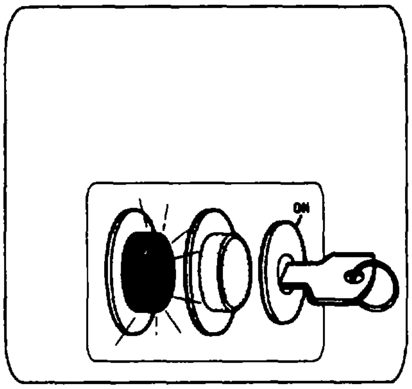

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Figure 3.

Inspect Low Oil Pressure Alarm (Daily)

Inspect low oil pressure alarm (if equipped) as follows:

1. Turn electrical switch key to "on" position with engine stopped.

2. If oil pressure is low, red light and buzzer alarm will operate.

OPERATION 3

Inspect Air Cleaner Restriction Indicator (Daily)

Refer to Section 3, "Instruments and Indicators" for indication operation.

Refer to CGES-2402, Diesel Engine Diagnostic Manual for measuring air intake restriction.

MAINTENANCE OPERATIONS (Continued)

OPERATION 4

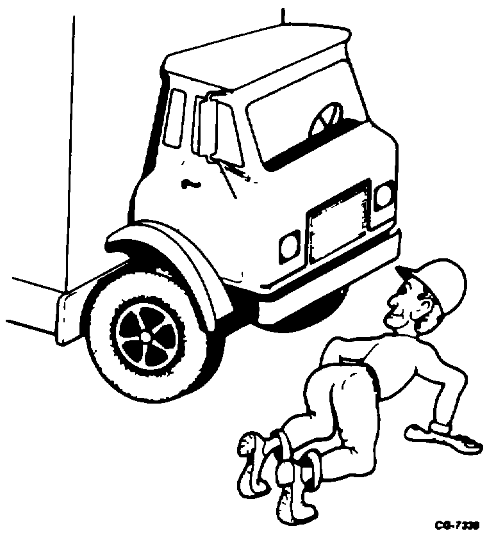

Figure 4.

Inspect for External Leakage (Daily)

Inspect external leakage as follows:

Visually inspect:

1. Hoses
2. Water stains
3. Oil stains
4. Wetness at water pump

Operations 5 and 6 are performed every 9,600 km, 6,000 miles, 200 hours or 3 months, whichever occurs first.

OPERATION 5

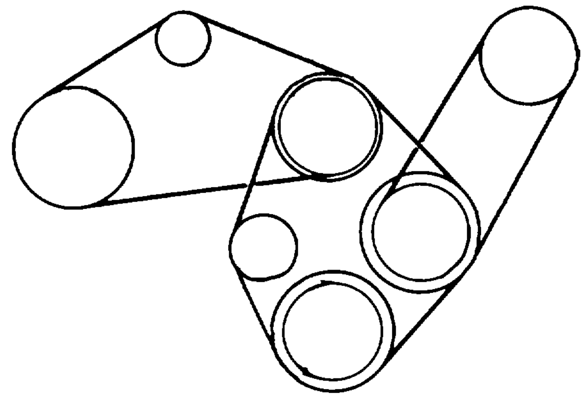

Figure 5.

Inspect and Adjust Belts

FAN AND ACCESSORY DRIVE BELTS

New belts have a break-in period and lose tension during groove seating.

IMPORTANT

New belt initial installation tension is higher than the re-tension value applied to a used belt (run five minutes or longer). This is done to minimize number of belt adjustments and prevent belt operation under low tension during break-in period.

MAINTENANCE OPERATIONS (Continued)

IMPORTANT

The 9.0 liter fan and water pump drive belts have a idler pulley with spring tension. No adjustment is needed.

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OPERATION 6

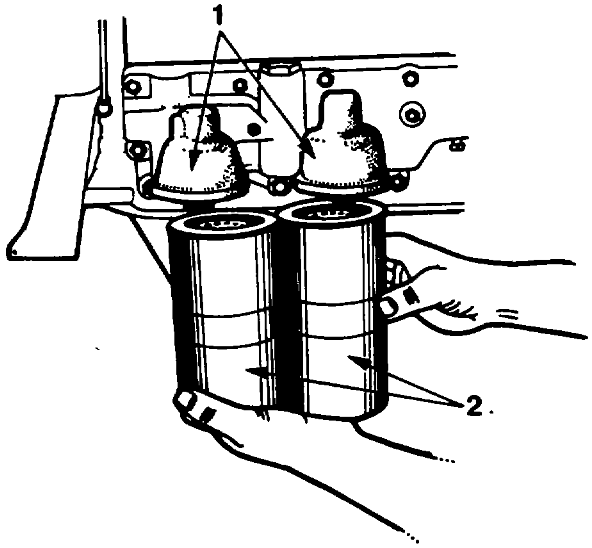

Figure 12.

Legend

1. Header
2. Filters

Change Engine Oil and Filters

Change engine oil and oil filters as follows:

IMPORTANT
Use ONLY authorized IH filters containing check valve in filter.

1. Remove oil drain plug from bottom of oil pan and drain oil.

2. Replace oil drain plug.

3. Service of filters as follows:

   a. Remove spin-on filter assemblies by turning counterclockwise with the hands or a suitable tool.

   b. Clean filter mounting pad.

   c. Coat gasket on new filter with a film of oil.

   d. Place new filter in position on center tube.

   e. Hand tighten 1/2 to 3/4 of a turn after gasket first contacts base of mounting pad. DO NOT OVERTIGHTEN.

   f. Fill with oil of specified quantity and grade, start engine and check for oil leaks. Shut-down engine.

4. Recheck oil level and add sufficient oil to bring the level between "ADD" and "FULL" mark on oil level gauge.

OPERATIONS 7 AND 8

Perform every 19,200 km, 12,000 miles, 400 hours or 6 months, whichever occurs first.

OPERATION 7

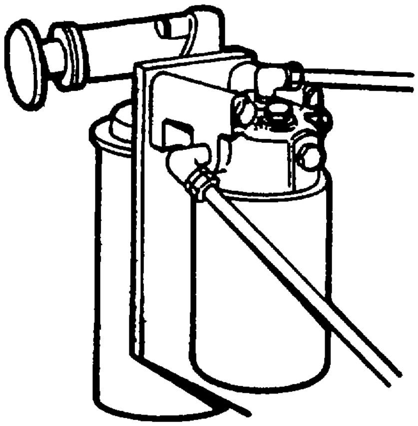

Figure 13.

Change Fuel Filters

1. Remove fuel filter assemblies by turning counterclockwise by hand or a suitable tool.

2. Clean filter mounting pad.

3. Lubricate the gasket sealing surface on the new filter with a film of oil or grease.

4. Place new filter in position on center tube. DO NOT pour fuel in new filter element.

5. Hand tighten 1/4 to 1/2 of a turn after gasket first contacts base of mounting pad. DO NOT OVERTIGHTEN.

6. Start the engine and run at low idle for several minutes and check for leaks. If the engine fails to start, prime the fuel system.

7. If air is trapped in the fuel system, the engine will either not start or misfire and it is necessary to prime the system. The fuel priming pump is located on the fuel filter base. When fuel filters are serviced or if the engine has run out of fuel, prime the fuel system as follows:

   a. Be sure the fuel line valve is open and the engine shut-off control is off. Unlock fuel priming pump.

   b. Loosen priming vent located on right front of the injection pump or fuel filter.

   c. Operate priming pump until clear fuel flows from fuel vent plug. Tighten vent plug.

   d. Lock fuel priming pump.

IMPORTANT

Ensure priming pump plunger is in locked position during engine operation or damage to the priming pump may result.

   e. If engine continues to misfire or smoke, further bleeding is necessary. With engine running, loosen fuel line nuts at injector one at a time, and allow fuel to run until free of air bubbles. Tighten fuel line nuts.

OPERATION 8

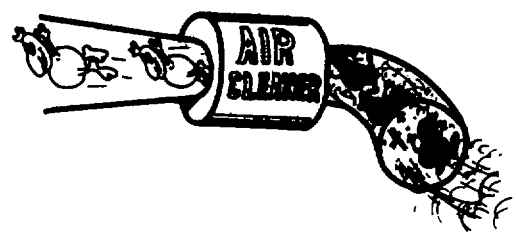

Figure 14.

Clean or Replace Air Cleaner

Clean or replace air cleaner element(s) when red band reaches top of window in air cleaner restriction indicator or restriction reads 4.96 kPa (20" H20) on vacuum gauge.

IMPORTANT

The vacuum gauge and/or indicator should be checked with a master gauge periodically to insure proper indication.

Procedure for servicing the air cleaner is as follows:

1. Remove air cleaner element.

2. Clean any accumulation of dirt from air cleaner housing. DO NOT USE AIR FOR THIS CLEANING.

3. Clean element using low pressure air from center of element directed outward (see Figure 15.

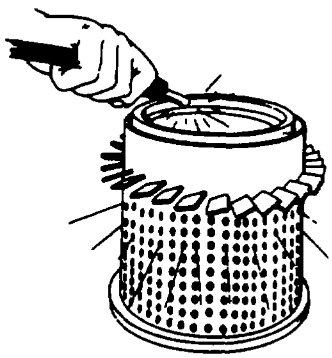

Figure 15.

IMPORTANT

Maximum air pressure should not exceed 207 kPa (30 psi).

4. Check element for punctures or splits by looking through filter paper toward light held in center of the element.

5. The primary element must be replaced after six cleanings or annually, whichever occurs first. The secondary element must be replaced, if after servicing the primary, the air cleaner continues to have a high restriction. It should be replaced whenever the primary is changed or annually, whichever occurs first. The secondary element cannot be cleaned. Operations 9-12 perform every 38,400 km, 24,000 miles, 800 hours or 12 months, whichever comes first.

OPERATION 9

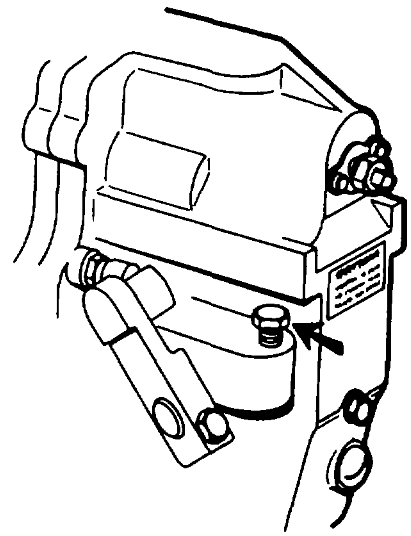

Figure 16.

Check Low Idle Speed

IMPORTANT

This interval is after the initial 9,600 km (6,000 mile), 200 hour or 3 month dealer inspection.

Check and adjust low idle speed as follows:

1. Locate adjustment screw at rear of injection pump.

2. Start engine and operate until temperature is up to normal operating range.

3. Release throttle cable completely, allow engine to idle. Engine speed on tachometer should read between 625-675 RPM.
automatic in gear.

4. If low idle speed is not within specifications, adjust as follows:

   a. Loosen lock nut.

   b. Turn adjusting screw to obtain correct idle speed. Turn screw clockwise to reduce engine RPM. Turn screw counterclockwise to increase engine RPM.

   c. Tighten lock nut, recheck low idle speed.

OPERATION 10

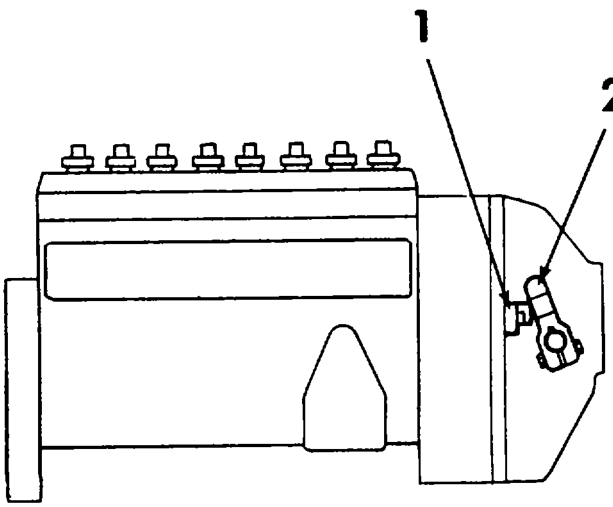

Figure 17.

Legend

1. High Idle Stop Screw 2. Throttle Lever

Check High Idle Speed

IMPORTANT

This interval is after the initial 9,600 km (6,000 miles), 200 hour or 3 month dealer inspection.

Check idle speed as follows:

1. Start engine and operate until temperature is up to normal operating range.

2. Push throttle lever to its full forward position - lever against its stop.

3. Observe engine speed. See Specifications for proper reading.

4. If high idle speed does not reach specified limit, check throttle linkages to make sure pump lever is not restricted. Adjust linkage as required. If this does not correct situation, see your authorized IH dealer!

IMPORTANT

High idle speed is the maximum no load speed the governor will permit. Engine must never be allowed to exceed this speed such as when vehicle is on downhill operations.

OPERATION 11

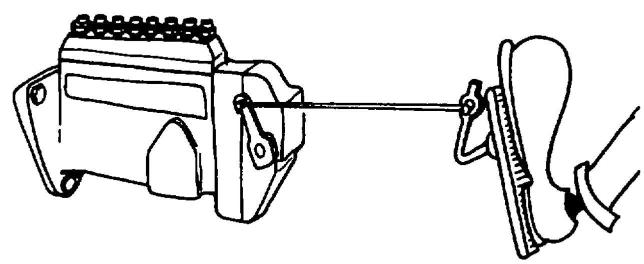

Figure 18.

Check Accelerator Linkage

1. Inspect all accelerator controls for proper connection and free operation. Replace or repair controls as needed.

2. With accelerator pedal fully depressed, insure rack control lever is against high idle stop screw and override system on accelerator control lever is partially engaged.

OPERATION 11 - Continued

Adjust as follows:

a. Attach cable assembly to accelerator pedal rod.

b. Secure pedal to full throttle position.

c. Adjust ball joint position at engine throttle (inner control lever just contacts the high idle stop screw) without activating override.

d. Tighten ball joint 3 full turns onto cable. This will give proper override.

e. Tighten jam nut.

A complete depressed override lever condition can cause severe damage to injection pump assembly. Replace or repair controls as needed.

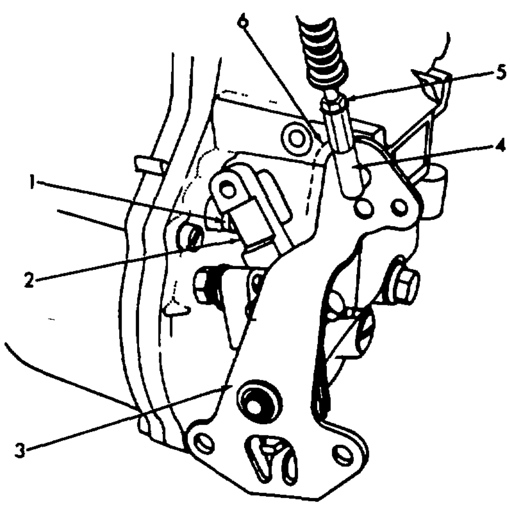

Figure 19. Checking Override Position

1. High Idle Stop Screw
2. Inner Control Lever
3. Outer Control Lever
4. Ball Joint
5. Jam Nut
6. Override Position

OPERATION 12

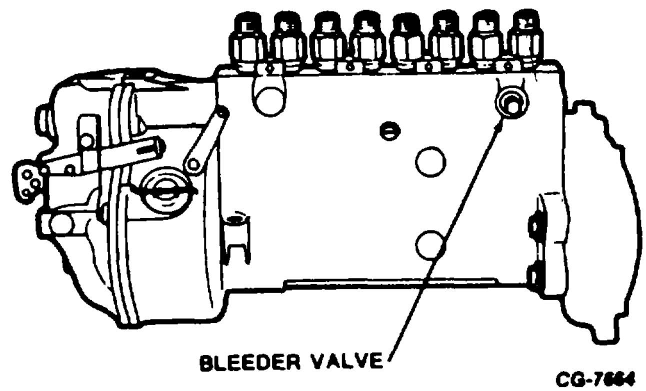

Figure 20.
Right Side View of Injection Pump

Check Transfer Pump Pressure

Check transfer pump pressure as follows:

1. Install an adapter injection pump bleeder valve.

2. Connect hose to test gauge SE-2239 in cab, or 160 psi range pressure gauge.

3. Operate engine at High Idle (RPM); observe reading.

4. Pressure should be as follows:

   Minimum - 172 kPa (25 psi)

5. If reading is below minimum reading:

   a. Replace both fuel filters

   b. Prime system with hand pump.

   c. Repeat test

6. If installation of new filters does not correct pressure, refer to Section 5, CGES-240-2 Diesel Engine Diagnostic Manual for detailed information on checking inlet restriction.

NOTE: Low transfer pump pressure will result in low fuel delivery, low power.

Operations t3 and 14 perform every 96,000 km, 60,000 miles, 2000 hours or30 months, whichever occurs first.

OPERATION 13

Test Injection Nozzles

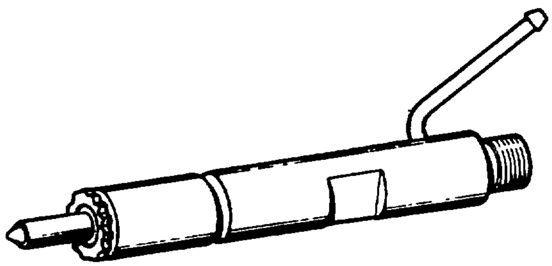

Figure 21.

IMPORTANT

In outlining the procedure for inspection of injection nozzles, the necessity of cleanliness cannot be over-emphasized. A clean work-bench, clean washing fluid and clean tools are all essential to produce satisfactory results. The use of suitable tools for this type of work is equally important.

1. Injection Nozzle Removal:

   a. Detach high-pressure tubing and leak-off lines, covering their opening ends with plastic, cloth or paper caps to protect against the entrance of dirt.

   b. Remove mounting bolt and clamp. Pull nozzle assembly from the cylinder head being careful not to strike the end of the nozzle against any hard surface. If the assembly seems to be stuck, rotate slightly to break it loose from carbon deposits within the cylinder head recess. See Service Manual.

   c. Cover nozzle openings with plastic, cloth or paper cap to prevent the entrance of dirt. Also protect nozzle tip.

   d. Remove injector nozzle gasket from nozzle bore with suitable tool.

2. Injection Nozzle Testing

The prime requirements for a satisfactory nozzle assembly are: pressure tight seats; no excessive valve stem leakage; satisfactory spray and atomization characteristics.

   a. After removal from engine test nozzles for spray condition, opening pressure and leakage on a hand test pump SE-2002.

   Illustration shows an injection nozzle mounted for testing on theSE-2002 pump.

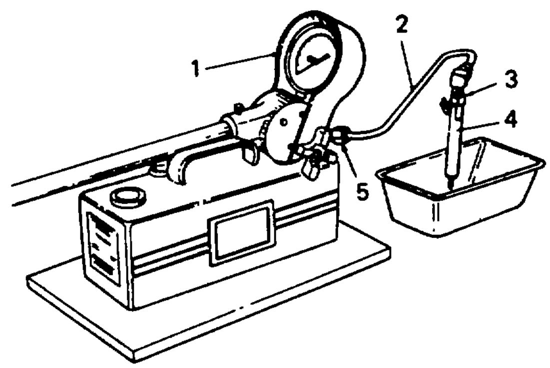

Figure 22.
Nozzle Assembly Mounted in Test Pump

Legend

1. Pressure Gauge
2. SE-2004-13 Nozzle Tube Assembly
3. SE-2004-3 Adapter
4. Nozzle Assemblies
5. SE-2004-4 Adapter

IMPORTANT

It is advisable to test nozzles before cleaning them After testing, place nozzles in a cold decarbonizing solution for at least one hour. After removing nozzles from solution, wash off the outside surfaces.

OPERATION 13 - Continued

b. Prepare pump for making tests. Fill pump reservoir with clean No. 2 diesel fuel. Open pump valve slightly and operate pump handle to expel air from pump and outlet pipe. Operate pump until solid fuel (without air bubbles) flows from end of outlet pipe. Close pump valve.

c. Connect injection nozzle to test pump. Avoid "cross-threading." Tighten connector nut securely with end wrench.

d. Bleed air from nozzle. Open pump valve and operate pump for several quick strokes to expel (bleed) air from injection nozzle. Fuel should spray from the spray holes in nozzle tip.

IMPORTANT

Keep hands away from nozzle spray. Fuel spraying from the nozzle under high pressure can penetrate the skin and cause infection. Medical attention should be provided immediately in the event of skin penetration.

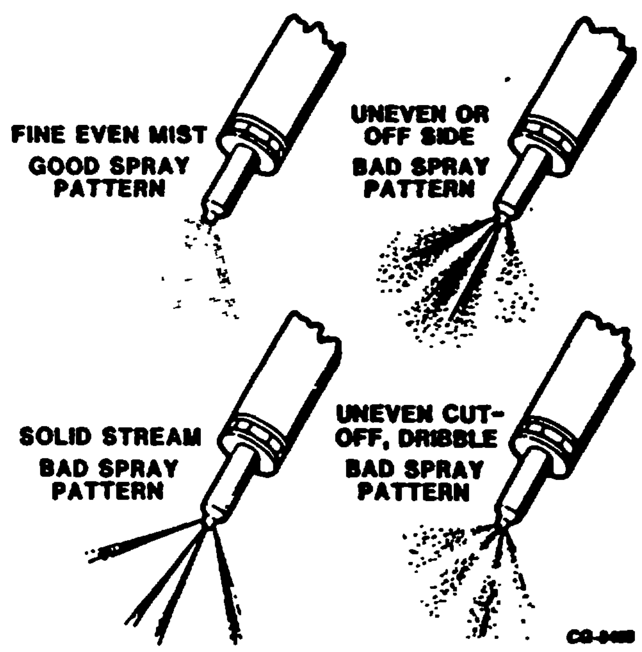

Figure 23.
Typical Nozzle Spray Patterns

e. Check spray pattern. Operate test pump in smooth, even strokes and observe pattern of fuel spraying from nozzle tip spray holes. The spray should be finely atomized in an even pattern, free from irregular streaks and dribbling. Examples of good and bad spray patters are shown in illustration.

f. Check nozzle opening pressure. Open gauge valve, operate test pump in smooth, even strokes and observe pressure gauge to determine pressure at which nozzle opens (sprays fuel). Nozzle should operate within specified opening pressure range. The proper specification for nozzle opening pressure is as follows:

New or Rebuilt
21718 kPa ± 517 kPa
(3150 psi ± 75 psi)
Minimum Permissible (Used)
18960 kPa
(2750 psi)

g. Check for tip leakage. Wipe nozzle tip dry. Operate test pump to maintain pressure at about 3450 kPa (500 psi) below opening pressure. Nozzle tip should remain dry without an accumulation of fuel drops at spray holes. A slight wetting after about 5 seconds is permissible if no drop lets am formed.

IMPORTANT

Do not wipe tip with fingers as this will tend to draw the fuel present in the sac hole through the orifices and falsely indicate a leak and rejection of a good valve.

OPERATION 13 - Continued

h. Check fuel leak-off. Operate test pump in quick strokes and observe for flow of fuel from leak-off part of nozzle. A very slight leak-off is normal. If an excessive amount of fuel is expelled or If fuel surges from leak-off port when test pump Is operated, nozzle is faulty.

If nozzle passes above tests, it is suitable for further service in the engine following external cleaning and removal of accumulated carbon. Nozzles showing irregular spray pattern, leakage at nozzle tip spray holes, excessive fuel leak-off or opening pressure below minimum permissible limit should be replaced or serviced (disassembled, cleaned and rebuilt).

3. Injection Nozzle Installation

a. Thoroughly clean nozzle bore in cylinder head before reinserting nozzle holder assembly. Pay particular attention to seating surfaces, in order that no small particles or carbon will cause assembly to be cocked or permit blow-by of combustion gases Don't use hard or sharp tools for cleaning. A round piece of brass properly shaped or a round steel bristle brush is permitted if used with care.

b. Install injection nozzle washer, seal and gasket on injection assembly. Use new mounting gasket every time injector nozzle is removed.

c. Install nozzle assembly carefully into its bore so that nozzle tip does not strike against recess wall.

d. Install clamp, mounting bolt and attach high pressure tubing and leak-off lines.

OPERATION 14

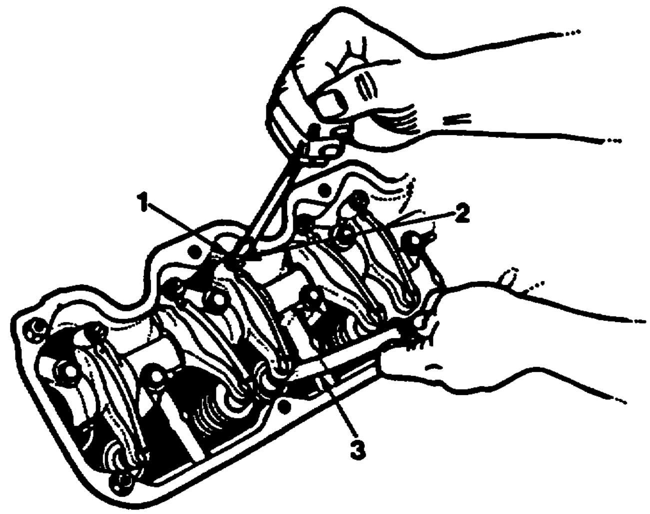

Figure 24.
Legend

1. Locknut
2. Adjusting Screw
3. Feeler Gauge

Valve Lash Adjustment

IMPORTANT
The initial interval s 9600 km (6,000 miles), 200 hours or 3 month dealer inspection on new or rebuilt engines.

1. Remove valve covers.

IMPORTANT
Insure shut-off switch is pulled to "Off" position.

OPERATION 14 - Continued

2. Rotate the engine in operating direction to TDC for No. 1 cylinder (on compression stroke). Adjust the following valves:

No. 1 Int and Exh	No. 2 Int
No. 3 Exh	No. 4 Int
No. 5 Int	No. 8 Exh
No. 7 Exh	

   b. Turn adjusting screw to allow 0.30 mm (.012 in.) clearance gauge to pass between valve cap and rocker arm for intake valves or 0.41 mm (.016 in.) clearance gauge for exhaust valves. ADJUST WITH ENGINE COLD.

   c. Tighten adjusting screw lock nut, and check lash clearance.

3. Rotate the engine 360' to TDC for No. 6 cylinder (on compression stroke). Adjust the following valves:

No. 3 Int	No. 2 Exh
No. 5 Exh	No. 4 Exh
No. 7 Int	No. 6 Int and Exh
No. 8 Int	

4. Replace valve cover gaskets and install valve covers.

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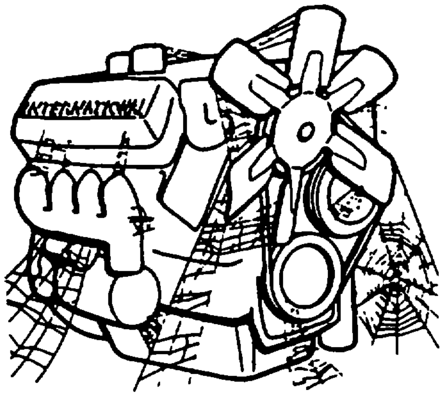

When a truck is taken out of service and stored for a period of time that exceeds 30 days, steps must be taken to protect the engine. Recommended procedures to prepare an engine for storage, to maintain the level of protection throughout the storage interval, and to prepare the engine for operation at the end of the storage period am provided as follows:

PREPARING ENGINE FOR PLACING VEHICLE IN STORAGE:

A. General:
1. Visually inspect engine and radiator(s) for leakage and other defects.
2. Steam-clean engine.
3. Correct any defects found per instructions in appropriate section of "Engine Service Manual," CGES-205U. PAGE 2655

B. Cooling System:
1. Completely drain and chemically flush the cooling system per instructions in Section 5.

3. Fill cooling system with a conditioned water/antifreeze solution suitable for the lowest temperature anticipated. See cooling system specifications in Section 5 for proper antifreeze and coolant conditioner concentrations.

IMPORTANT
Under no circumstances should the vehicle be stored with a dry cooling system.

C. Air Intake Systems: Clean or replace air cleaner elements per instructions in Section 6.

D. Fuel System:
1. Drain the fuel tank.
2. Remove, empty, and reinstall fuel filters (Primary and final).
3. Put approximately 12 gallons of approved diesel fuel in the fuel tank. Refer to Section 5 for designation of approved fuels.
4. Put approximately 2 oz of a fuel stabilizer in the fuel tank.

Fuel Stabilizer

5. Put 1.5 oz of volatile corrosion inhibitor ("VCI") in the fuel tank for each 10 gal- Ions of fuel tank capacity. (EX)AMPLE: For 100 gallon fuel tank use 15 oz of ("VCI"). Volatile corrosion inhibitor (VCI)

CAUTION! DUE TO THE VOLATILE NATURE OF 'VCI', IRRITATION OF EYES MAY OCCUR AND PROLONGED EXPOSURE TO THE VAPORS SHOULD BE AVOIDED.

6. Bleed the fuel filters.

7. Start engine and run at 14001600 rpm, no load, for approximately 4 minutes

PREPARING ENGINE FOR PLACING VEHICLE IN STORAGE (Continued)

E. Lubrication

1. Oil or grease all linkage connections, joints, nuts, pins, shafts, and bushings.

2. Drain lube oil from engine crankcase.

3. Change the engine lube oil filters.

4. Fill with proper engine lube oil per specifications in Section 5.

5. Add 0.5 oz of "VCI" for each quart of engine lube oil capacity. Add through the oil filler.

CAUTION! DUE TO THE VOLATILE NATURE OF "VCI", IRRITATION OF EYES MAY OCCUR AND PROLONGED EXPOSURE TO THE VAPORS SHOULD BE AVOIDED.

6. Start engine and run at 1400-1600 rpm, no load, for approximately 30 seconds.

F. Sealing the Engine:

1. Remove the air intake cap.

2. Seal the engine air intake, the crankcase breather tube, the engine exhaust outlet, and the fuel tank vent line.

3. Pour 4 oz of "VCI" through a tapped hole in the intake manifold.

CAUTION! DUE TO THE VOLATILE NATURE OF "VCI", IRRITATION OF EYES MAY OCCUR AND PROLONGED EXPOSURE TO THE VAPORS SHOULD BE AVOIDED.

G. Batteries: Remove the batteries and store in a cool, dry place 0' to 10'C (32' to 50F) to minimize discharge. Be sure batteries are fully charged before storing.

SERVICING ENGINE WHILE VEHICLE IS IN STORAGE:

A. Every month: Check batteries for water level and specific gravity. Charge if needed. Never allow level of charge in stored batteries to drop below 3/4 full charge.

B. Every six months:

1. GENERAL:

   a. Visually inspect engine and radiator for leakage and other defects.

   b. Correct any defects found per instructions in appropriate section of "Service Manual."

2. REMOVE SEALS FROM ENGINE: Remove seals from the engine air intake, the crankcase breather tube, the engine exhaust outlet, and the fuel tank vent line.

3. BATTERIES: Install fully charged batteries.

4. COOLING SYSTEM: Check level of coolant in radiator and add coolant if needed. Be sure any added coolant contains proper concentrations of antifreeze and coolant conditioners.

5. FUEL SYSTEM:

   a. Drain fuel tank.

   b. Remove, empty, and reinstall fuel filters (Primary and Final).

   c. Put approximately 12 gallons of approved diesel fuel in the fuel tank. Refer to Section 5 for designation of approved fuel.

   d. Put approximately 2 oz of a "Fuel Stabilizer" in the fuel tank.

   e. Put 1-1/2 oz of "VCI" in the fuel tank for each 10 gallons of fuel tank capacity.

CAUTION! DUE TO THE VOLATILE NATURE OF "VCI", IRRITATION OF EYES MAY OCCUR AND PROLONGED EXPOSURE TO THE VAPORS SHOULD BE AVOIDED.

f. Bleed the fuel filters.

g. Start engine and run at 1400-1600 rpm, no load, for approximately 4 minutes.

6. LUBRICATION:

a. Oil or grease all linkage connections, joints, nuts, pins, shaft, and bushings.

b. Add 0.5 oz of "VCI" for each quart of engine lube oil capacity. Add through the oil filler.

CAUTION! DUE TO THE VOLATILE NATURE OF "VCI", IRRITATION OF EYES MAY OCCUR AND PROLONGED EXPOSURE TO THE VAPORS SHOULD BE AVOIDED.

c. Start engine and run at 1400-1600 rpm, no load, for approximately 30 seconds.

7. SEALING THE ENGINE:

a. Seal the engine air intake, the crankcase breather tube, the engine exhaust outlet, and the fuel tank vent line.

b. Pour 4 oz of "VCI" through a tapped hole in the intake manifold.

CAUTION! DUE TO THE VOLATILE NATURE OF "VCI", IRRITATION OF EYES MAY OCCUR AND PROLONGED EXPOSURE TO THE VAPORS SHOULD BE AVOIDED.

8. BATTERIES: Remove batteries and return to storage.

PREPARING STORED VEHICLE ENGINE FOR RETURN TO WORKING CONDITION

A. General:

1. Visually inspect engine and radiator for leakage and other defects.

2. Correct any defects found per instructions in appropriate section of "Service Manual."

3. Check radiator and clean if needed. For instructions see Section 5.

B. Remove Seals from Engine: Remove seals from the engine air intake, the crankcase breather tube, the engine exhaust outlet, and the fuel tank vent line.

C. Batteries: Install fully charged batteries.

D. Cooling System: Check level of coolant in radiator and add coolant if needed. Be sure any added coolant contains proper concentrations of antifreeze and coolant conditioners.

E. Air Intake System:

1. Clean or replace air cleaner elements per instructions in Section 7, "Maintenance Operation 12."

2. Install air intake cap.

F. Fuel System:

1. Drain the fuel tank.

2. Remove and discard fuel filters.

3. Install new fuel filters.

4. Fill tank with approved diesel fuel.

5. Bleed fuel filters.

G. Lubrication:

1. Oil or grease all linkage connections, joints, nuts, pins, shafts, and bushings.

2. Drain lube oil from engine crankcase.

3. Change the engine lube oil filters.

4. Fill with proper engine lube oil per instructions in Section 5.

5. Crank the engine until pressure is indicated on the oil pressure gauge.

EMISSION MAINTENANCE SERVICE RECORD

This chart provides space for recording the dates and mileage (odometer readings) when the required emission control maintenance operations were performed.

To prove proper maintenance of the vehicle records, work orders and receipts should be retained showing that scheduled maintenance has been performed. Failure to maintain such records may affect your warranty coverage.

SERVICE INTERVAL	PERFORMED
3 Months 200 Hours 6,000 Miles 9,600 Km	Date Hours Miles Km
6 Months 400 Hours 12,000 Miles 19,200 Km	Date Hours Miles Km
9 Months 600 Hours 18,000 Miles 28,800 Km	Date Hours Miles Km
12 Months 800 Hours 24,000 Miles 38,400 Km	Date Hours Miles Km
15 Months 1000 Hours 30,000 Miles 48,000 Km	Date Hours Miles Km
18 Months 1200 Hours 36,000 Miles 57,600 Km	Date Hours Miles Km
21 Months 1400 Hours 42,000 Miles 67,200 Km	Date Hours Miles Km
24 Months 1600 Hours 48,000 Miles 76,800 Km	Date Hours Miles Km

SERVICE INTERVAL	PERFORMED
27 Months 1800 Hours 54,000 Miles 86,400 Km	Date Hours Miles Km
30 Months 2000 Hours 60,000 Miles 96,000 Km	Date Hours Miles Km
33 Months 2200 Hours 66,000 Miles 105,600 Km	Date Hours Miles Km
36 Months 2400 Hours 72,000 Miles 115,200 Km	Date Hours Miles Km
39 Months 2600 Hours 78,000 Miles 124,800 Km	Date Hours Miles Km
42 Months 2800 Hours 84,000 Miles 134,400 Km	Date Hours Miles Km
45 Months 3000 Hours 90,000 Miles 144,000 Km	Date Hours Miles Km
48 Months 3200 Hours 96,000 Miles 153,600 Km	Date Hours Miles Km

DAILY CARE AND REPORT

A daily check of the engine should be made to prevent premature engine failure. If corrective steps are taken immediately on discovery of loose or worn parts, fewer forced stops and a more economical operation will result. If any sub- standard readings or observations are found, be sure to report it to proper authorities. Points to be checked daily are as follows:

1. Oil, air, water or fuel leaks.

2. Cooling system, clean radiator core, add coolant or antifreeze as necessary. Be sure filler cap seal is in good condition and the cap is installed tightly.

3. Unusual engine noise.

4. Excessive use of crankcase lubricating oil, coolant, battery fluid or fuel.

5. Fuel pressure gauge - check with engine running, change fuel filter if indicator is in red range.

6. Air cleaner indicator, if so equipped - inspect with engine running. Service air cleaner when red piston remains in up position.

7. Dirt should not be allowed to accumulate on the engine. A few minutes spent daily in keeping it clean are well repaid in improved appearance, and greater ease and safety in operation and maintenance.

MODEL__________________________ SERIAL NO. ____________________

DATE	MILES	FUEL QUAN.	FUEL COST	LUBE OIL	PARTS PART	PARTS COST	LABOR TIME	LABOR COST	DOWN TIME	SERVICE PERFORMED

FORM NO. 1 171 576 RI e
PRINTED IN UNITED STATES OF AMERICA 2197
Pages 2186, 2188 and2189 DELETED

SCHEDULED (NORMAL) MAINTENANCE WILL
"Protect Your Investment"

THROUGH INCREASED EQUIPMENT RELIABILITY AND AVAILABILITY

This vehicle is your INVESTMENT - NOW - let's use it to make all the PROFIT possible.

Normal maintenance is necessary to protect the long life built into your vehicle engine. International Harvester Company has designed a program to assist you in restricting delays and keep costly repairs to a minimum. This program consists of normal maintenance; scheduled interval lubrication, adjustments, and inspections. This program when used, will result in reduced "down-time" and minimum repairs. The systematic procedure of lubrication, adjustments and inspection is outlined in the "SCHEDULED MAINTENANCE" section of this manual.

FORM NO. 1 171 576 R1
PRINTED IN UNITED STATES OF AMERICA

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VEHICLE REPAIR PROCEDURES
FRAME

CONTENTS

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GENERAL

Since the frame is depended upon to keep the major components of a vehicle in their relative positions, it is highly important that the frame be kept in good condition at all times.

Because International chassis are manufactured with frame rails of either cold rolled steel, heat treated steel. or aluminum alloy, each must be handled in a specific manner to assure maximum service life.

IDENTIFICATION

No unusual difficulty should be encountered in identifying aluminum alloy frames. These side rails and crossmembers are made of thicker material than are the components of a comparative size steel frame. If there is any doubt, use a file to expose the material hardness or color. There are several methods of identifying heat treated frame rails, the most-common of which is a stencil marking on the inside middle section of the rail or a stencil mark on one of the crossmembers. The stencil notes that the rail is heat treated and rail flanges must not be drilled or welded. This is to caution against the welding of additional brackets or crossmembers of the welding of full length reinforcement rails. Minor repairs as indicated in later paragraphs are acceptable.

A number of the heat treated frame rails have small patches covering "Brinell" test, mark along the inside (web) of the rail. These patches are at about three or four foot intervals. The patch can be removed to expose the "Brinells marking.

Some rails are starpped "H" for heat treated, on the upper face of the rail flange about three inches from the rail end.

ALIGNMENT
METHOD OF CHECKING

A satisfactory method of checking the frame and axle alignment, particularly when a body and cab is on a chassis, is to mark on a level floor all points at which measurements are to be taken. Tack or tape pieces of paper to the floor directly under each point of measurement on the chassis as indicated by the letter "K" in Figs. 1 and 2. Use a plumb bob since the points of measurement must be accurately marked in relation to the frame in order to obtain a satisfactory alignment check.

After each measurement point has been carefully marked on the floor, proceed as follows:

1. Locate center line of chassis by measuring front and rear end widths, using marks on floor. If frame widths check, draw center line on floor, full length of chassis. If frame widths do not check, lay out center line as follows:

2. Center line can be drawn through the into section of any one pair of equal diagonals (A-A, B-B, C-C, D-D) and center point to one end of frame or through points of intersection of any two pairs of equal diagonals.

3. Measure distance from center line to opposite points marked over entire length of frame: Measurements should not vary more than 1/8" at any point.
4. Measure diagonals (A-A, B-B, C-C, D-D) will indicate point where misalignment occurs. If diagonals in each pair check within 1/8", that part of frame included between points of measurement may be considered in satisfactory alignment. These diagonals should intersect within 1/8" of center line.

AXLE ALIGNMENT WITH FRAME

After determining that the frame is properly aligned, the axle alignment with the frame should be checked by comparing diagonals.

Dimensions for side elevation of frame should be checked at the points indicated and should not vary more than 1/8".

REPAIR AND REINFORCEMENTS

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HEAT TREATED FRAMES

With the use of heat treated frame rails in International vehicles, it becomes advisable to outline some of the procedures to be followed whenever these frames require repair.

Heat treated frame rails must not, of course, be intermixed with non-heat treated rails. If one side rail is to be replaced, the new rail material must match the old frame rail.

Preparation of Frame for Repair

A good method to follow when repairing a cracked frame where the crack is accessible from both sides is as follows:

a. Grind a V notch or groove extending along the full length of the crack and slightly beyond each end of the crack.

   A, heavy copper strip or "chill" should be clamped to the rail side away from the groove to help control the temperature and cooling rate. See Fig. 7. Discarded short lengths of heavy copper electrical bus bars make suitable chills.

   Preheat the frame rail along the crack area to 500-600 degrees to burn off excess oil or paint then permit heated area to cool to 200 degrees or below before welding is started. Under no circumstances should the roil be heated to a temperature exceeding 900-950 degrees F. since this is the tempering ’temperature of the rail.

   Either alternating’ current or direct current reversed polarity, combined with a short **arc** and a beading or narrow weave technique may be used. Direct current reversed polarity is recommended or pre, ferred.

   Slag should be removed after each pass and an interpass or constant temperature of 200 degrees should be maintained.

   When sufficient metal has been deposi-ted, the weld bead should be ground flush, Fig. 7, with the surface being repaired.

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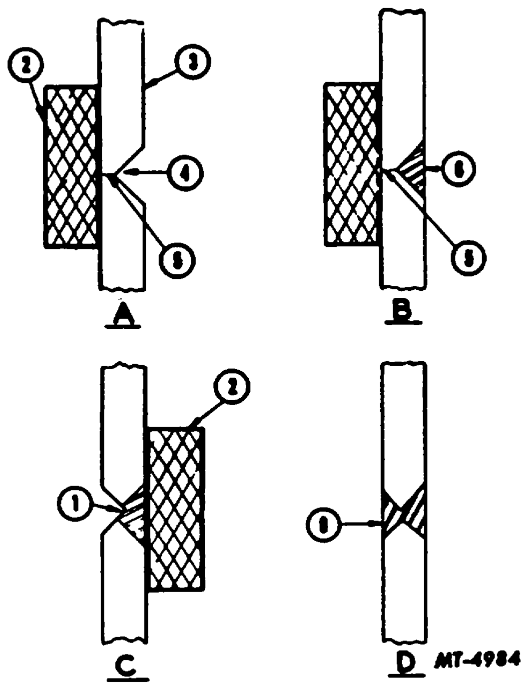

Fig. 7.

1. V-Groove into Sound Metal
2. Copper Chill Strip
3. Frame Rail
4. V-Groove
5. Crack
6. Weld-Ground Flush With Frame

f. Where both sides of the frame rail are accessible, a V-groove is ground from the side opposite the repair and the procedure outlined above repeated. Dependent upon accessibility, 'child strips should be used wherever possible. The V-groove ground on the opposite side of the repair should be deep enough to enter the sound metal of the first weld repair "C" of Fig. 7.

Welds on heat treated material tend to reduce physical properties in the weld heat-affected zone. Because of this, it is recommended that all reinforcements be designed so that all welds are parallel, rather than perpendicular to the frame rail edges. Welds perpendicular to the flange edges will reduce the carrying capacity of the rail, Fig 8 and 9.

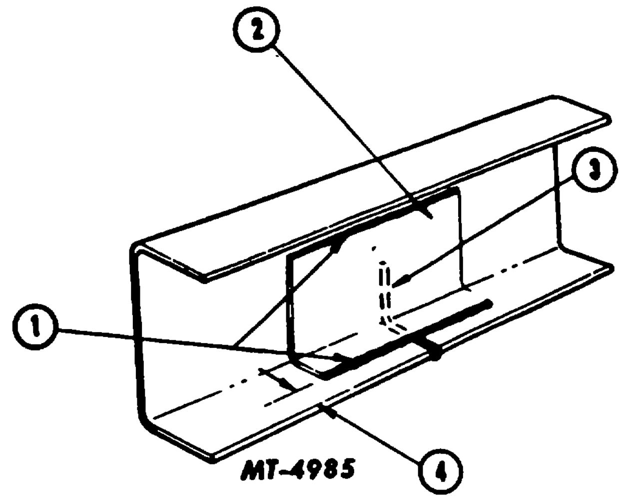

Fig. 8. Method of Reinforcing Crack In Frame

1. Welds Parallel to Frame Rail Edges
2. Reinforcement Extends at Least 4" Each Side of Crack
3. Crack-Notched Out Filled With Weld and Ground Flush
4. ¾" Min.

The edge of the reinforcement flange to the edge of side rail flange dimension should be held to a minimum of three quarters of an inch to keep the heat-affected zone from ex- tending to the sidemember flange edge. Wherever possible, it is recommended that plug welds of the type shown in Fig. 9, be substituted for edge welds when assembling the rei forcement to the side rail. Plug welds offer the advantages of a reduced heat-affected zone plus increased flexibility and reduced stress concentrations. When using this method, one half inch (minimum) diameter holes should be drilled and chamfered in the reinforcement on 2' center to center distances. At no time should these holes be drilled in the frame ri being repaired. The reinforcement should then be installed in its proper position on the sidemember and the holes filled with weld material.

Again a minimum dimension of 3/4" should be maintained between the weld and the edge of the sidemember flange. The voltage, amperage and pre-heat specifications listed be- low should be followed.

Welding

Position	Amperes	Voltage
Downhand	130/140	21/23
Overhead	130/140	21/23
Vertical Up	110/120	22/24

Use low hydrogen electrodes which have superior crack resistance and notch toughness similar to AWS-E-11018. This type electrode should be stored in a moisture-free container to avoid porosity during welding.

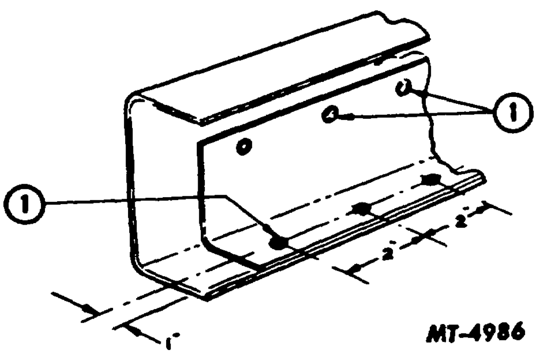

Fig. 9

1. Plug Welds

Fig. 9.

Full Length Reinforcement

When heat treated frames are to be rein- forced over a greater portion of their length, frame channel reinforcements should be in- stalled using bolts. Bolts of high strength material conforming to SAE grade 5 or better should be used. The bolts and nuts should be inspected periodically and kept tight, since the strength of the reinforcement depends some- what on the maximum clamping force between the members.

Drilling

The drilling of heat treated frame rails presents no unusual difficulty. Standard high speed drills of good quality will serve provided they are sharpened properly and not overheated during sharpening or use. There are. however, special high speed twist drills available having special materials which will hold a cutting edge longer. These drills are expensive and require especially rigid support, otherwise drill breakage will result.

When drilling heat treated rails, like in any other drilling operation, sufficient pressure must be applied to the drill bit to maintain continuous cutting. The drill point should frequently be drenched with cutting oil (soluble oil) to help cool the drill. Avoid letting a drill bit turn in the work without cutting. To do so will usually overheat and ruin the drill.

The drill must be held steady during the drilling operation. Avoid wobble or change of drill angle during the drilling operation.

Frame Straightening

When heat treated frame rails have been bent or twisted, they should not be heated for straightening. This work should be done with the frame rails cold. Heating for straightening purposes is likely to destroy the rail temper in localized areas, which will bring about rail failures.

Replace old Section with this revised Section In your CTS-4001 Manual

AXLE-FRONT

IH MODEL	IH CODE
FA-64	02064

CONTENTS

(1) Lubrication, see Service Manual Section CTS-4033

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DESCRIPTION

The axle covered in this manual is a front driving unit incorporating hypoid gears and spherical steering knuckles. Driving torque from the axle shaft to the wheels it transmitted by a drive flange bolted to the axle shaft.

COMPLETE OVERHAUL

1. Jack up truck until load is removed from the springs and place floor Jack under frame to safely secure truck weight off axle.
2. Drain lubricant from housing.
3. Disconnect brakes.
4. Disconnect drag link from ball stud bracket.
5. Disconnect propeller shaft from pinion shaft yoke.
6. Support axle on portable floor Jack and remove spring bolts.
7. Roll axle out from truck and position on stationary floor jacks.
8. Remove tires and rims or disc wheels as appropriate.

DISASSEMBLY

DIFFERENTIAL

1. To remove differential carrier from axle housing remove mounting nuts from carrier to axle housing flange.
2. Use puller screws provided in carrier mounting flange to start carrier from housing.
3. Support eight of carrier safely on roller type floor Jack or portable floor lift and roll Jack and carrier out from under truck.
4. Mount differential carrier in rebuild stand.
5. Remove cotter pins from bearing adjuster locks and remove locks from bearing caps.
6. Match mark one differential bearing cap and leg of carrier with punch or chisel to identify each for correct reassembly.
7. Remove bearing cap bolts and take off the bearing caps and bearing adjusters (Fig. 1).

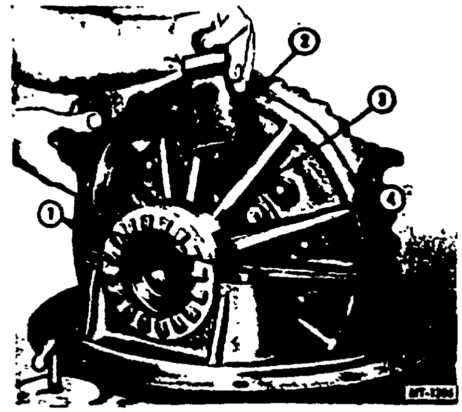

Fig. 1 Removing Differential Bearing Caps

1 Pilot Rings
2 Differential Bearing Cap
3 Differential Bearing Cup
4 Bearing Adjuster

Attach chain sling from overhead hoist and lift differential and drive gear assembly from the differential carrier.(Fig. 2). Tilt either the carrier or differential assembly to allow drive gear to pass pinion radial bearing. Place differential assembly on beach.

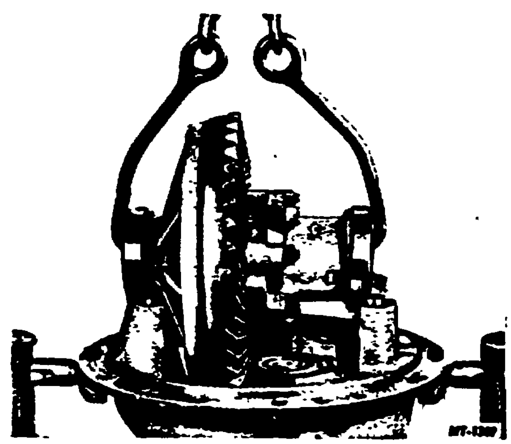

Fig.2 Lifting Differential from Carrier

8. Match mark differential case halves with a punch or chisel to assure correct alignment on reassembling.

9. Remove self-locking nuts from differential case bolts and separate the case halves.

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10. Remove differential spider, spider gears, side gears and thrust washers from differential case halves.

11. If necessary to remove drive gear, carefully center punch each rivet head on drive gear side and drill through the rivet head with a drill .79 mm (1/32) smaller than rivet body (Fig. 3). Use a punch to press out remaining portion of rivet. Never use chisel to cut off rivet heads or damage to case might result.

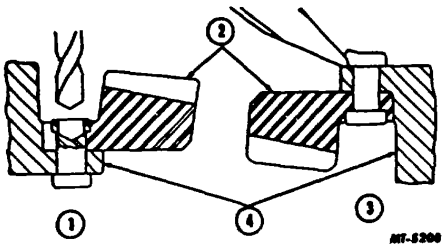


Fig. 3. Drive Gear Rivet Removal

1 Right
2 Drive Gear
3 Wrong
4 Differential Case

12 Take out pinion cage bolts which hold the cage to differential carrier.

13 Obtain a brass drift and hammer and strike against rear face of pinion shaft (Fig. 4) to start pinion and cage out of carrier.

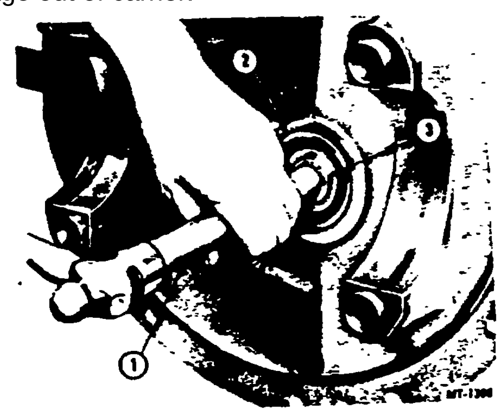


Fig. 4 Loosening Pinion and Cage from Carrier

1 Brass Drift
2 Pinion Shaft Radial Bearing
3 Pinion Shaft Face

14. Remove the pinion and cage assembly from the carrier (Fig. 5). Because of the weight of the pinion and cage assembly make sure that parts are secured safely while removing. Pinion and cage might be damaged if allowed to fail.

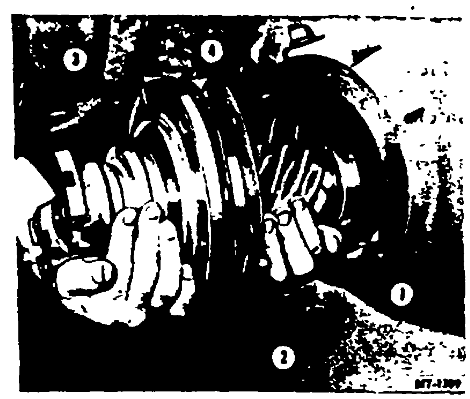


Fig. 5. Removing Pinion and Cage Assembly

1 Radial Bearing
2 Shims
3 Oil Seal Retainer
4 Pinion Cage

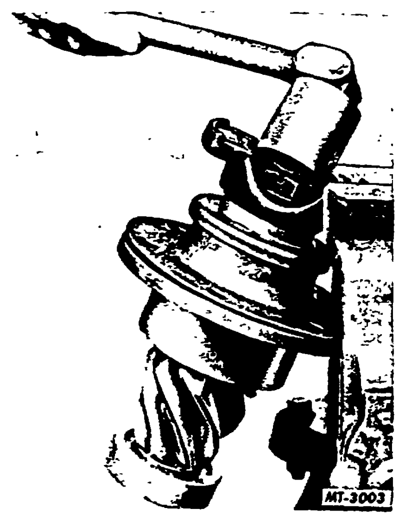


Fig. 6. Removing Pinion End Nut

15. Mount the pinion and cage assembly in **a** heavy duty vise and remove the pinion end nut as shown in Fig. *6.*

16. Drive the pinion assembly from the companion flange with &-soft hammer. Do not allow pinion assembly to fall.

17. Remove pinion cage "O" ring type seal (Fig. 7).

18. Tap pinion from cage and remove forward thrust bearing.

19. Remove the thrust bearing spacer from the pinion shaft.

20. If it is necessary to remove the rear thrust bearing or the radial bearing from the pinion shaft, remove these bearings with a suitable puller.

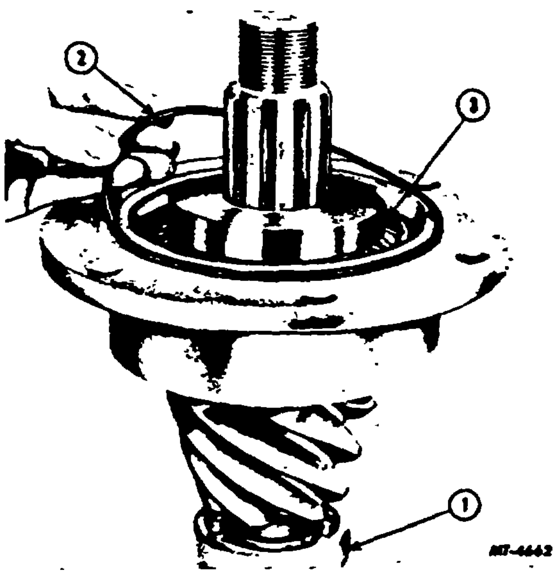


Fig. 7 Removing Pinion Cage Oil Seal

1 Pinion Shaft Radial Bearing
2 Pinion Cage Oil Seal
3 Pinion Shaft Thrust Bearing (Front)

CLEANING, INSPECTION AND REPAIR

Remove all dirt, old lubricant and gasket material from components of the front axle**.** Immerse in cleaning solvent and use a stiff brush if necessary. Bearings should be cleaned separately in clean solvent and special efforts taken to protect their finely machined surfaces. If compressed air is used for drying, do not spin bearings while drying .

Never use anything but brake fluid to clean hydraulic brake cylinders.

Examine all bearings for roughness, damage to wear by rotating each bearing slowly in the hand. If in doubt as to bearing condition. replace. Ring gear, drive pinion differential pinions and any other gears should be checked for damaged teeth, worn spots, or distortion. Inspect differential case assembly for cracks, damage or distortion. Make sure splined ends of axle shafts are neither twisted or cracked. Shim packs should be of uniform thickness. Discard thrust washers and obtain new even when only slight wear is indicated. Always use new gaskets. Hex nuts and capscrews with rounded corners. all lockwashers, seals, pins and bushings should be replaced.

REASSEMBLY

DIFFERENTIAL

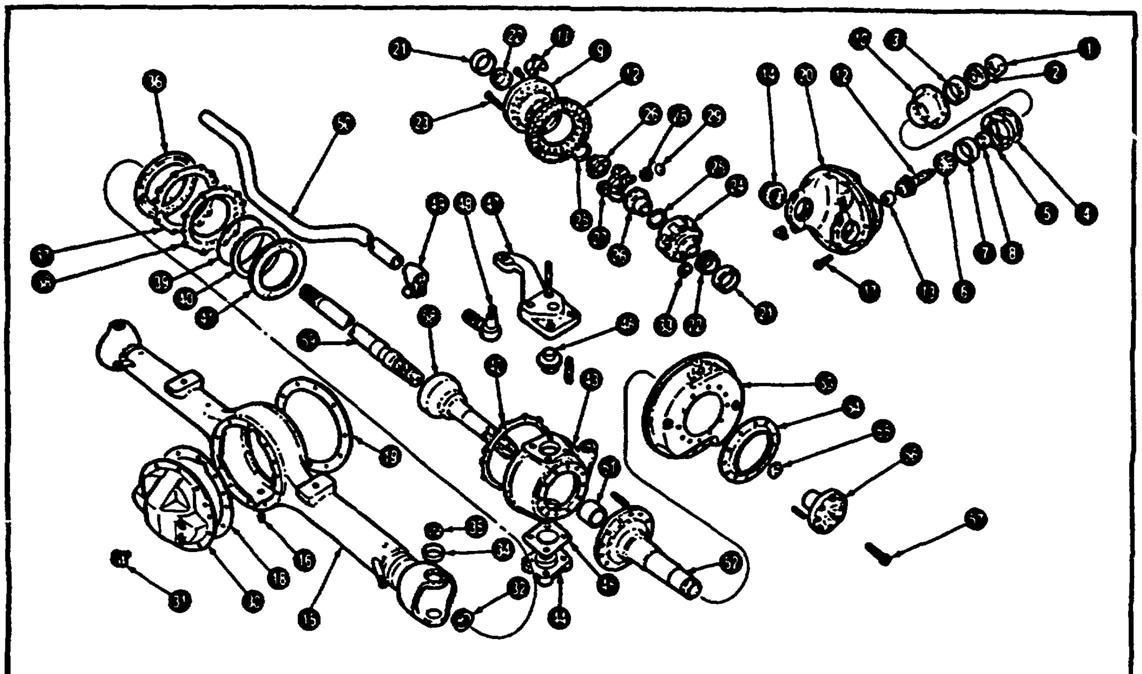
The principal adjustments made on the differential carrier assembly are devised for establishing the proper gear tooth contact and thereby obtaining a long wearing, quiet running front axle. Fundamentally. There are five adjustments to be covered and these are accomplished as the differential carrier assembly is assembled. To emphasize their importance these five steps or adjustments are listed here as well as in the actual assembly procedure. These adjustments are:

1. Preload the pinion bearings.
2. Establish the pinion nominal dimension.
3. Set **gear** lash.
4. Preloed the differential bearings.
5. Check the gear tooth contact.

Refer to the exploded view (Fig. 8) and reassembly differential carrier as follows.

1. Press rear thrust bearings (6) firmly against shoulder of pinion shaft (12).

2. Press radial bearing (13) on stub end of pinion shaft (12) and against pinion. Stake face of pinion evenly in six places to secure radial bearings in place (Fig. 9).



1. PINION OIL SEAL
2. FRONT PINION LOWER BEARING
3. FRONT PINION BEARING CUP
4. CAGE SHIM
5. CAGE SHIM
6. REAR PINION ROLLER BEARING
7. REAR PINION BEARING CUP
8. SPACER BEARING (SELECTED THICKNESS)
9. DIFFERENTIAL CASE, FLANGED HALF
10. PINION BEARING CAGE
11. OIL SCOOP
12. PINION SHAFT AND RING GEAR SET
13. PINION REAR (RADIAL) BEARING
14. BEARING ADJUSTER
15. AXLE HOUSING
16. MAGNETIC DRAIN PLUG
17. BOLT
18. LIQUID GASKET (IN TUBE)
19. DIFFERENTIAL HOUSING GASKET
20. DIFFERENTIAL CARRIER
21. BEARING CUP
22. ROLLER BEARING
23. BOLT-DIFF. CASE
24. DIFFERENTIAL CASE, PLAIN HALF
25. SIDE GEAR THRUST WASHER
26. SIDE GEAR
27. SPIDER
28. DIFFERENTIAL PINION GEAR
29. DIFFERENTIAL GEAR THRUST WASHER
30. AXLE HOUSING COVER
31. FILL PLUG
32. OIL SEAL
33. NUT-DIFF. CASE
34. BEARING CUP
35. ROLLER BEARING
36. SPLIT RING RETAINER
37. HALF RING RETAINER
38. STEERING KNUCKLE RETAINER
39. OIL SEAL SPRING
40. OIL SEAL, STEERING KNUCKLE
41. DUST SEAL
42. KNUCKLE RETAINER GASKET
43. STEERING KNUCKLE
44. KING PIN CAP
45. SHIM
46. TRUNION PIN
47. STEERING ARM
48. VERTICAL BALL JOINT (SOCKET)
49. CLAMP
50. SHAFT (LINK)
51. SPINDLE BUSHING
52. SPINDLE
53. BACKING PLATE
54. OIL DEFLECTOR
55. RETAINER WASHER
56. DRIVING FLANGE
57. CLEARANCE ADJUSTMENT BOLT
58. SHAFT AND JOINT
59. INNER AXLE SHAFT

MT-28380

Fig. 8. Front Drive Axle and Differential –Exploded View

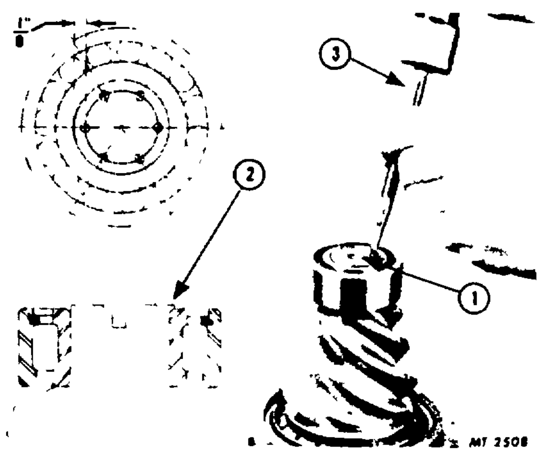


Fig. 9 Skating Pinion Straddle Bearing

1 Ground Face of Pinion
2 Metal Displaced to Secure Bearing
3 Blunt Point Punch

It is suggested that for locating punch positions for staking, the end of the pinion be painted with Prussian Blue and a circle be scribed on end of pinion about 3.17 mm (1/8") in from the pinion circumference. When staking the bearings be careful to make the depth of the indentations or stake points uniform, otherwise bearing may be damaged. Deep punch or stake marks are not necessary. Apply the staking operation at opposite sides of the pinion end until all stake points are obtained. Where special staking tools are available, they can be used, otherwise the use of a blunt or round nosed punch is satisfactory.

3. If bearing cups (7) have been replaced, press new cups firmly against shoulders of pinion cage (10).

4. Prelubricate the bearings with gear lubricant.

5. Position spacer (8) on pinion shaft and against rear thrust bearing.

6. Insert pinion and rear thrust bearing (6) in pinion cage.

7. Mount pinion and cage in arbor press and place pre-lubricated front thrust beazling (6) on pinion shaft. Press bearing firmly and squarely against spacer.

PINION BEARING PRELOAD

Pinion bearing preload is established by selecting the correct size spacer (8) located between the two pinion thrust bearings and tightening pinion end nut to the specified torque (see "TORQUE CHART").

8. Temporarily assembly the pinion, cage and flange assembly, less oil seal and retainer Clamp the assembly in a vise to hold the come panion flange. Tighten end nut to specified torque.

9. The pinion cage should be rotated while tightening the pinion to seat and align the bearings. Rotation of the pinion is important Otherwise a false condition of bearing load could exist. The bearing rollers must be seated against the face of the bearing cone (Fig. 10).

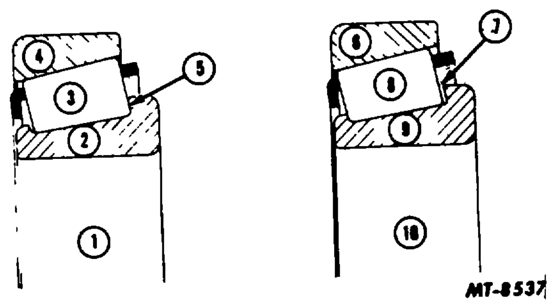


Fig. 10 Pinion Bearing Roller Position

1 Correct
2 Cone
3 Roller
4 Cup
5 Roller Against Face of Cone
6 Cup
7 Clearance
8 Roller
9 Cone
10 Incorrect

10. To measure bearing preload, wrap a strong cord or soft wire about the pinion cage and attach end to spring scale (Fig. 1x). Read scale only while cage is rotating. Compare this scale reading with the figure shown in "SPECIFICATIONS".

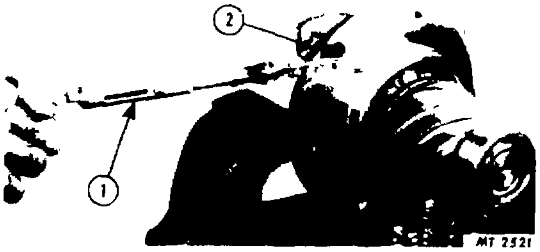


Fig. 11. Measuring Pinion Bearing Preload

1 Spring Scale
2 Cord or Soft Wire Wrapped Around Pinion Cage

11. When preload does not agree with "SPECIFICATIONS", bearing load may be increased by installing a thinner spacer or decreased by using a thicker spacer. Determine spacer thickness using a micrometer (Fig. 12) and make a new selection accordingly. Closer adjustment may be obtained by working spacer to desired thickness, using emery cloth on a flat surface.

12. Wash spacer clean of emery cuttings before installing on pinion.

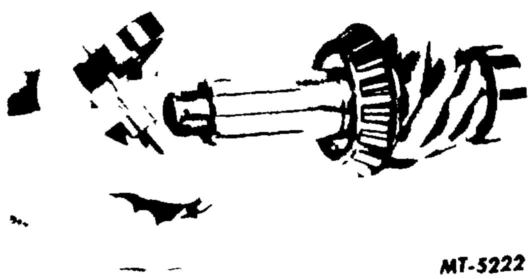


Fig. 12. Measuring Spacer Thickness

13. After pinion bearing preload is established good practice would be to check bearing roller ends to see whether they are in contact with bearing cone face. Use a feeler gauge ribbon. There must be no clearance at ends of rollers (Fig. 10).

Check pinion end nut for correct torque and install cotter pin.

PINION NOMINAL DIMENSION

To establish pinion nominal dimension which is the distance from the face or finished end of the installed pinion to the centerline of the ring gear or cross shaft, proceed as ' lows.

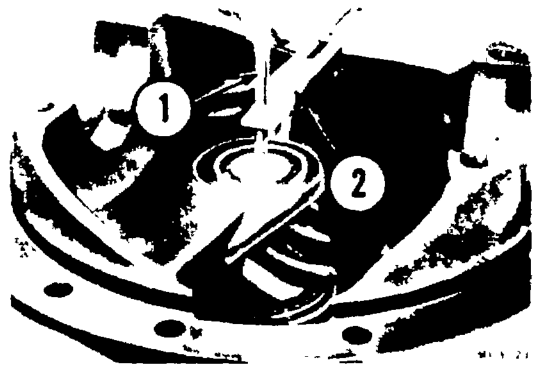


Fig. 13. Locating Step Plate Clamp

1 Step Plate Clamp Screw
2 Step Plate Clamp Assembly

14. Install pinion, cage and bearing assembly in differential carrier. Obtain step plate clamp assembly from SE-1065 Pinion Setting Gauge set and attach it to differential carrier flange, locating step plate clamp screw over center of pinion (Fig. 13).

15. Install step plate under clamp screw and tighten screw to hold step plate securely in position (Fig. 14).

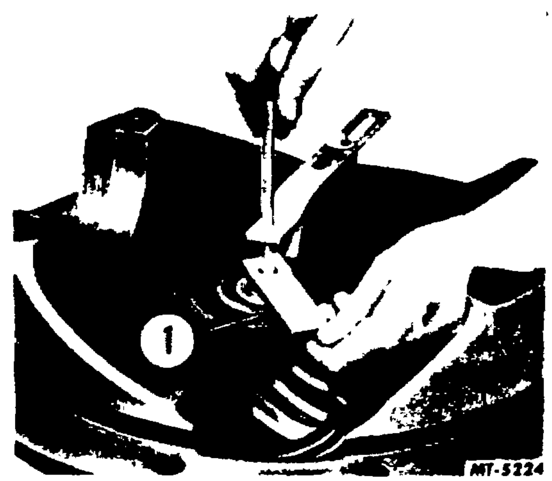


Fig. 14. Installing Step Plate

1 Step Plate

16. The step plate is necessary to project the face of the pinion where it can be measured by the gauge which is on the centerline of the drive gear.

Be certain lugs on step plate straddle the bearing staking indentations on end of pinion.

17. Mount assembled SE-1065 gauge in bearing bores of carrier (Fig. 15). See "SPECIFICATIONS" for correct disc size.

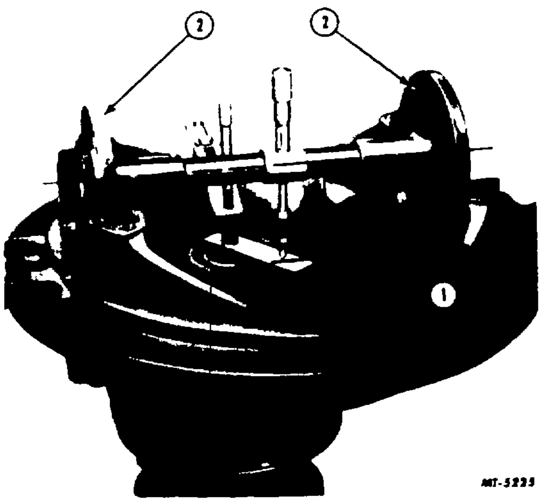


Fig. 15. Assembled Gauge in Position

1 Nominal Dimension Measured Here
2 Adapter Discs

18. Make certain that bearing bores are clean and free of nicks and burrs. Adjust micrometer so it is directly over end at a 90 degree angle to step plate,.

19. Run micrometer thimble down to measure distance between Center of ring gear and step plate. Make a note of this reading along with the nominal dimension given in "SPECIFICATIONS". Locate oh pinion the etched marking which indicates variation from zero cone setting. If it is a minus figure, subtract it from specified dimension, and if a plus figure, add it to specified dimension. Results of calculation will provide the corrected pinion nominal dimension to which pinion must be set. Comparison of corrected nominal dimension with the actual or measured dimension indicates amount of change necessary for correct pinion position. It may be necessary to add or remove shims between cage and differential carrier to provide correct pinion nominal dimension.

20. Remove gauge and prepare to install ring gear and differential carrier in differential housing.

21. If drive gear was removed from case, rivet gear to case flanged half.

When reinstalling ring gear, it is suggested that Riveting Jig SE-1575 be used. This special tool is designed for use with either hydraulic or mechanical press equipment. Rivet pressures for ring gear installation should be in accordance with those given in "SPECIFICATIONS".

22. Apply axle lubricant to differential case inner walls and all other component parts.

23. Place thrust washer (25) and side gear (26) in flanged half of case together with spider (27), pinion gears (28) and thrust washers (29).

24. Install opposite side gear and thrust washer in differential case plain half (24).

25. Align the match marks and join the two differential case halves. Draw assembly together with four equally spaced bolts (23) and nuts (33).

26. Check assembly for free rotation of side gears and pinions and if satisfactory, install remaining differential case bolts. Tighten to torque specified in "TORQUE CHART".

27. Differential bearings (22) are installed by pressing them squarely onto differential case halves.

28. Prelubricate differential bearings with axle lube and place bearing cups (21) over bearings. Attach chain sling to differential assembly and install in carrier.

29. Place bearing adjusters (14) in carrier and turn hand tight against bearing cups (21).

30. Observe match marks on bearing caps and install caps onto legs of differential carrier (20).

31. Install bearing cap bolts(17) and washers. Tighten to specified torque. (See "TORQUE CHART".)

32. Tighten bearing adjusters (14) alternately until all end play is eliminated. Rotate differential while tightening.

GEARLASH

33. A special effort should be made to set the backlash between pinion and ring gear to the same amount as was originally built into them .15-.30 mm (.006" to .012"). Generally the amount of backlash is stamped or etched on the ring gear. When installing new gears, backlash is measured with a dial indicator mounted on differential housing (Fig. 16).
To adjust the backlash move the ring gear toward or away from the pinion. This is done by backing off one adjusting ring and advancing the opposite ring the same amount.

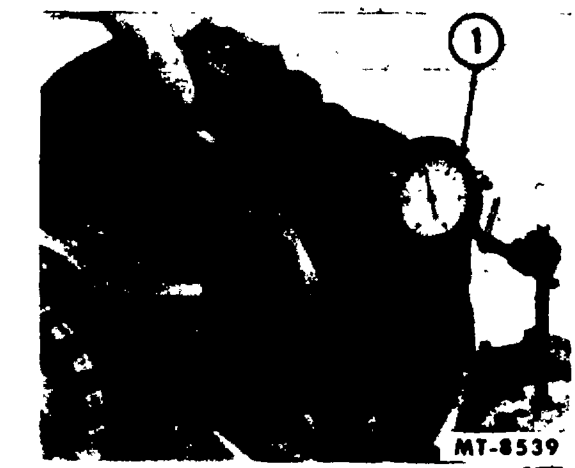


Fig. 16. Setting Correct Backlash

1 Dial Indicator

34. When original gear and pinion sets are being reinstalled, the wear pattern of the gear teeth must be considered in the backlash adjustment. Gears that have been in service for long periods form running contacts which should not be greatly changed. If, in checking backlash, the amount measured is in excess of the amount shown on the ring gear, the lash may be reduced only in the amount that will avoid overlap of the worn tooth section (Fig. 17). A slight overlap at the worn section will cause gear operation to be noisy and rough.

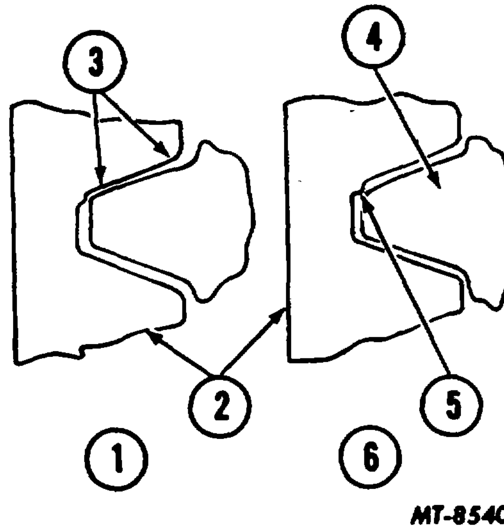


Fig. 17. Correct and incorrect Lash Adjustment where worn Gears Reinstalled

1 Correct
2 Ring Gear
3 Worn Section of Ring Gear
4 Pinion Too Deep in Ring Gear
5 Overlap
6 Incorrect

DIFFERENTIAL BEARING PRELOAD

35. To set the bearing preload, mount dial indicator at side of ring gear (Fig. 18). With the bearing capscrews loosened to permit bearing movement, loosen adjusting nuts only enough to notice end play on indicator.

36. While gear is held in .000" end play and before loading bearings, check gear for runout by revolving ring gear. If runout exceeds 20 mm (.008"), remove differential and check for case.

37. Tighten both adjusting nuts from .000" end play to preload the differential bearings (see "SPECIFICATIONS(").

38. Tighten bearing cap, capscrews or stud nuts to specified torque (see "TORQUE CHART").

39. Recheck gear lash to make certain that the lash setting has not been changed.

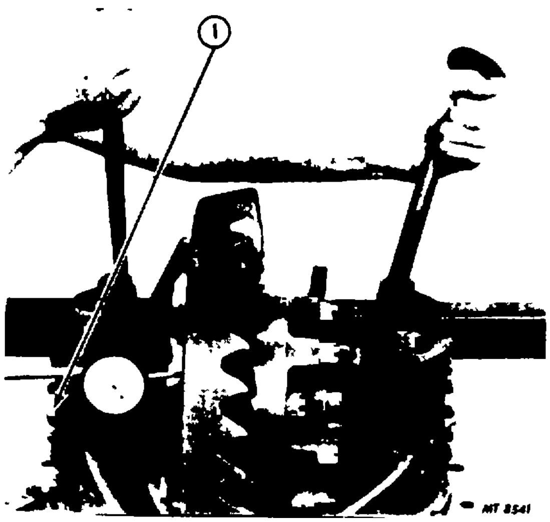


Fig. 14. Adjusting Bearing Preload

1 Bearing Adjuster

40. Install adjusting rings locks and cotter pins.

GEAR TOOTH CONTACT

41. Apply oiled red lead lightly to the hypoid gear teeth (Fig. 19).

Fig. 19. Painting Gear Teeth for Obtaining Tooth Contact Impressions

1 Bevel Gear
2 Coat With Red Lead

42. When the pinion is rotated, the red lead is squeezed away by the contact of the teeth, leaving bare areas the exact size, shape and location of the contacts (Fig. 20).

43. Sharper impressions may be obtained by applying a small amount of resistance to the gear with a flat steel bar and using a wrench to rotate the pinion. When making adjustments, check the drive side of the gear teeth. Coast side should be correct when drive side is correct. Generally, coating approximately twelve teeth is sufficient for checking purposes.

44. With adjustments properly made, a correct tooth contact similar to that shown in Fig. 20,' will be secured. The area of contact starts near the toe of the gear and extends about 62 1/2 per cent of the tooth length. This adjustment results in a quiet running gear and pinion set which, because the load is distributed over the teeth within the proper area, will deliver all the long service built into it.

45. When checking paint impressions on gear teeth of an axle under heavy load, the impressions usually spread out somewhat longer than the patterns obtained from a bench test. This can be considered as normal. Ring gears when mounted should show a bearing toward the toe or small end of the tooth, but never at the heel or large end. The reason being that it is practically impossible to make gears and gear mounting so rigid that no deflection will occur when full torque is applied. This deflection causes the bearing to approach the heel of the tooth. When gears are adjusted so that the bearing is toward the heel of the tooth, it results in a concentration of load on the top corner of the heel and breakage will follow.

INSTALLATION

DIFFERENTIAL CARRIER

46. Using chain sling and overhead hoist, move differential carrier assembly from rebuild stand to roller type floor jack.

47. Place a new carrier to housing gasket (19) on differential carrier (20) and roll carrier into position on the axle housing. Install the housing bolts and lockwashers and tighten to specified torque (See "TORQUE CHART").

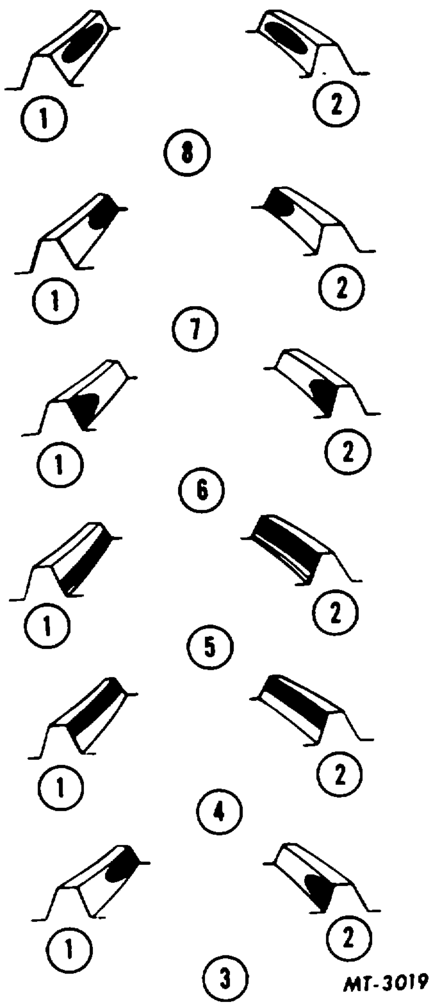


Fig. 20. Tooth Contact Impressions

1 Drive
2 Coast
3 Cross Bearing
4 Bearing Too High
5 Bearing Too Low
6 Too Much Heel Bearing
7 Too Much Toe Bearing
8 Proper Tooth Contact

AXLE END DISASSEMBLY (WHEEL, HUB, DRUM AND BRAKE GROUP REMOVED)

TRUNNION HOUSING DISASSEMBLY

1. Slide spindle off Trunnion Housing Studs, (retaining nuts removed when disassembling brake group). See Fig. 1.

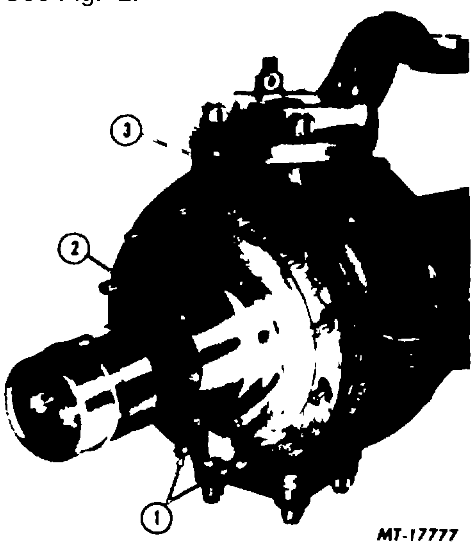


Fig. 1. Removing Spindle

1 Trunnion Housing Studs
2 Spindle
3 Trunnion Housing

2. Remove axle shaft and universal joint assembly from axle housing (Fig. 2).

Care should be taken not to damage axle shaft oil seal in end of axle housing when removing axle shaft.

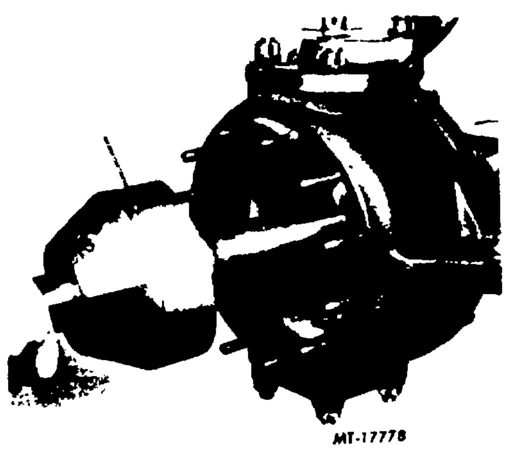


Fig. 2. Removing Axle Shaft and Universal Joint Assembly

3. Remove retaining ring half (halves) mounting bolts and lockwashers from back side of trunnion housing (Fig. 3).

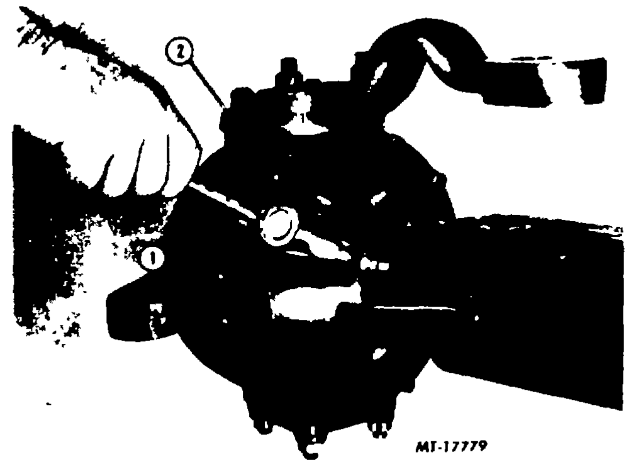


Fig. 3. Removing Retaining Ring Half (Halves) Mounting Bolts

1 Retaining Ring Bolts
2 Retainer Ring Half

4. Remove retaining ring halves, split ring retainer, seal with spring, steering ball felt, flange and gasket from back side of trunnion housing (Fig. 4).

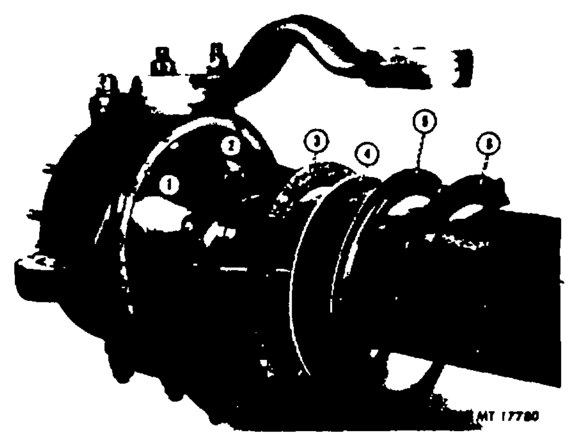


Fig. 4. Trunnion Housing Seals and Retainers

1 Gasket
2 Flange
3 Steering Ball Felt
4 Seal W/Spring
5 Split Retainer Ring
6 Retaining Ring Half

5. Loosen both upper and lower trunnion cap retaining nuts. Remove bottom cap mounting nuts and lockwashers only at this time.

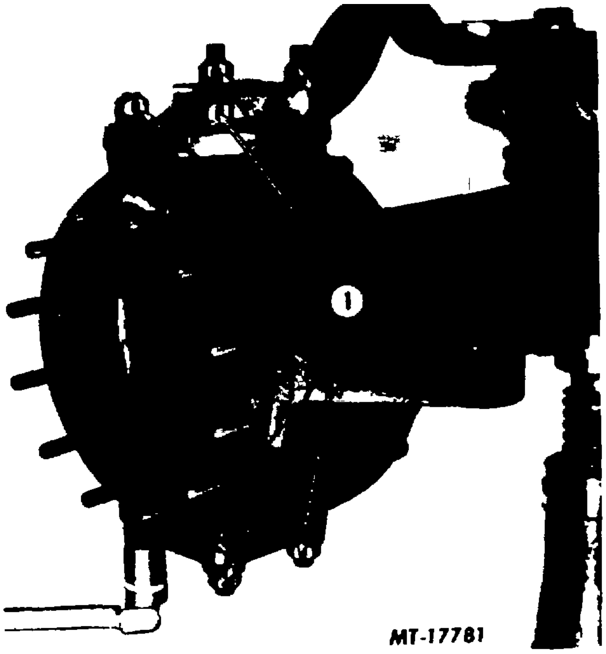


Fig. 5. Trunnion Cop Retaining Nuts

6. Remove lower trunnion cap and shim pack (Fig. 6). Retain and mark shim pack for reassembly.

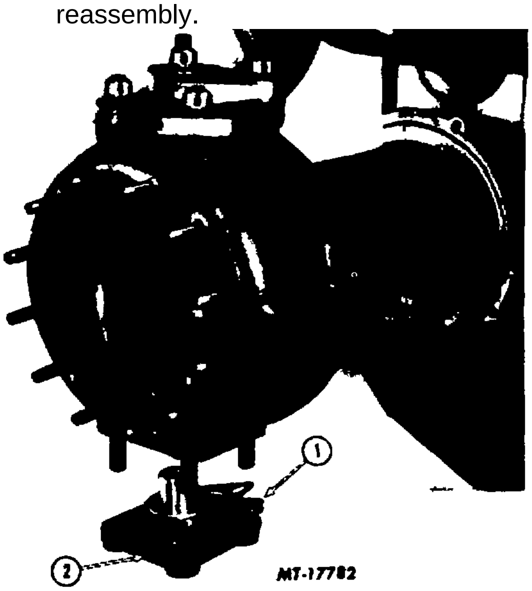


Fig. 6. Trunnion Cop and Shim Pack

1 Shim Pack
2 Lower Trunnion Cap

The lower trunnion bearing will lay loose on bottom of trunnion housing when lower trunnion cap is removed. Remove lower trunnion bearing by pulling trunnion housing away from axle housing to provide access to bearing as shown in F1gure 7.

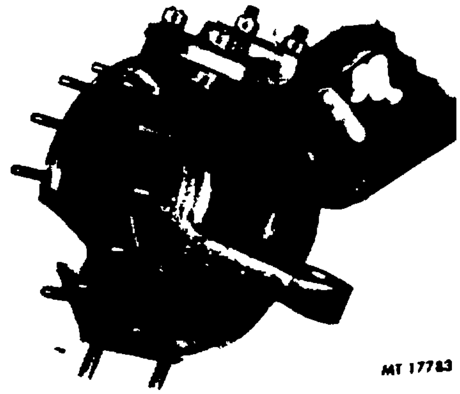


Fig. 7. Removing Trunnion Housing

7. Remove trunnion housing from axle housing by tilting bottom of trunnion housing out and pulling housing upward (Fig. 7).

   The upper trunnion housing bearing will lay loose on upper bearing race of axle housing end when trunnion housing is removed. Remove upper trunnion bearing.

8. Place trunnion housing on workbench and remove upper trunnion cap retaining nuts (previously loosened), lockwashers, trunnion cap and shim pack.

   On trunnion housings equipped with steering arms, remove steering arm retaining nuts exposing tapered dowels shown in Figure 8. Tapered dowels will be used with steering arms only.

9. To remove tapered dowels, work the steering arm back and forth until enough of the dowels are exposed to allow dowels to be gripped with a pliers or other suitable tool.

10. With tapered dowels removed, pull steering arm off of mounting studs and upper trunnion pin (Fig. 9).

    Remove upper trunnion cap shim pack. Retain and mark shim pack for reassembly.

    It is not necessary to remove the upper trunnion pin upon trunnion housing disassembly. However, if so desired the upper trunnion pin may be tapped from its bore by working through the trunnion housing rear opening.

Fig. 8. Tapered Dowels

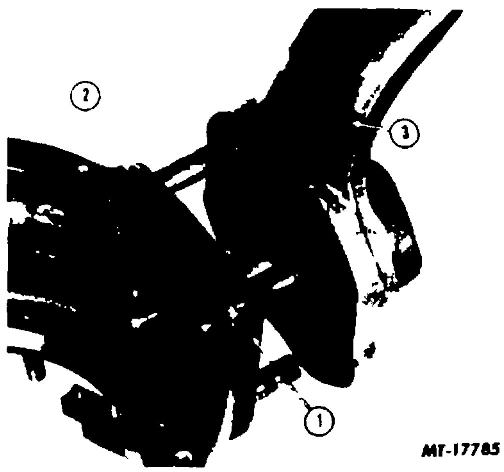


Fig. 9. Steering Arm Removal

1 Shim Pack
2 Upper Trunnion Pin
3 Steering Arm

AXLE SHAFT AND UNIVERSAL JOINT ASSEMBLY

1. Place axle shaft in a vise equipped with soft jaws. Grasp shaft end of universal joint and pull while rapping back side of joint with a soft faced hammer (see Fig. 10).

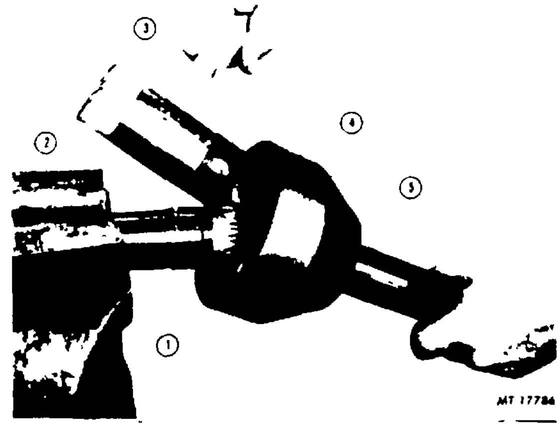


Fig. 10. Axle Shaft and Universal Joint Disassembly

1 Axle Shaft
2 Vise With Soft Jaws
3 Soft Faced Hammer
4 Universal Joint
5 Universal Joint Shaft

Remove lock ring from axle shaft end and discard. A new lock ring should always be used on reassembly.

2. Place universal joint in a vise equipped with soft jaws with outer race bell upward.

   Tilt inner race in outer race until one ball can be removed, continue this procedure until all balls are removed. A soft faced hammer may be used to aid inner race movement. See Fig. 11.

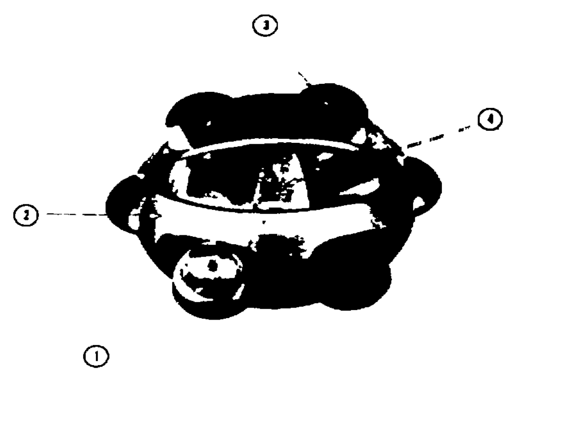


Fig. 11. Removing Universal Joint Balls

1 Universal Joint Ball
2 Universal Joint Cage
3 Universal Joint Outer Race Bell
4 Universal Joint Inner Race

3. Roll universal joint cage at a right angle to universal joint outer race bell with the two elongated openings in cage aligned with opposite teeth of outer race bell (Fig. 12) Lift cage and inner race from outer race bell.

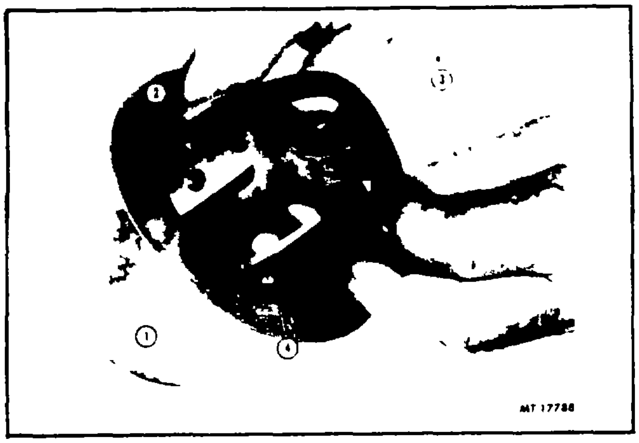


Fig. 12. Removing sage an Inner Race

1 Outer Race Bell
2 Elongated Opening In Cage
3 Universal Joint Cage
4 Universal Joint Inner Race

4. To separate inner race from cage turn inner race at right angle to cage, align notched tooth of inner race with elongated opening in cage, and roll inner race out of cage.

CLEANING AND INSPECTION

Remove all dirt, old lubricant and gasket material from all components Immerse In cleaning solvent and use a stiff brush if necessary. Bearings should be cleaned separately in clean solvent and special efforts taken to protect their finely machined surfaces. If compressed air is used for drying, do not spin bearings while drying.

Examine all bearings for roughness, damage or wear by rotating each bearing slowly in the hand. If in doubt as to bearing condition, replace.

Inspect axle shaft and universal joint assembly for seizure, broken or chipped balls, broken splines or other damage

Inspect spindle bushing for out of round condition caused by wear or corrosion, scoring or roughness in spots.

Inspect axle shaft oil seal for evidence of wear or damage.

Inspect for evidence of wear due to improper drive flange shim size. Wear on the interior surface of ball end of axle housing and on edge of ball joint bell housing indicates the use of too thin a shim, allowing contact between the two. If shim is too thick, the spindle bushing will show excessive wear.

OIL SEAL AND BEARING REPLACEMENT

1. To replace axle shaft oil seal (Fig. 13) pry out old seal from bore of axle housing and discard. Install new seal. Seal must contact counterbore.

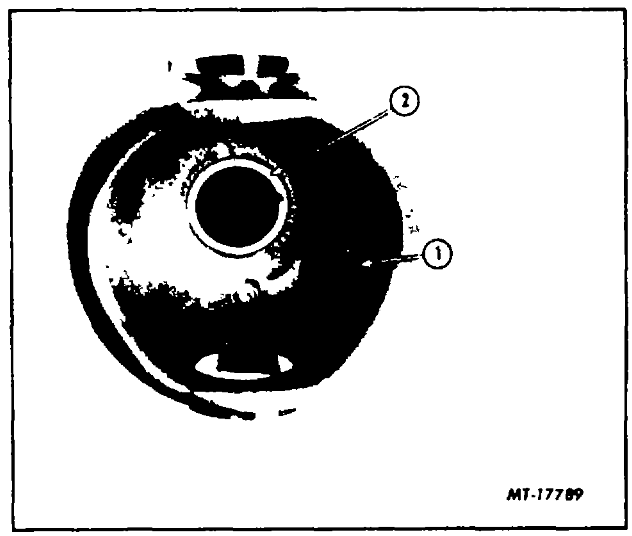


Fig. 13. Axle Shaft Oil Seal

1 Axle Housing End (Steering Ball)
2 Axle Shaft 011 Seal

2. To remove upper and lower trunnion bearing cups, drive cups out of axle housing bores with a driver and brass drift inserted through the opposite bore (Fig 14)

When installing new trunnion bearing cups care should be taken not to nick or scar bearing mating surface of cup.

Cups and bearings should be replaced as a matched set.

3. To remove spindle bushing (Fig. 15) insert puller in bushing bore and extract old bushing and discard.

   Install new bushing In bore. Bushing must contact counter bore.

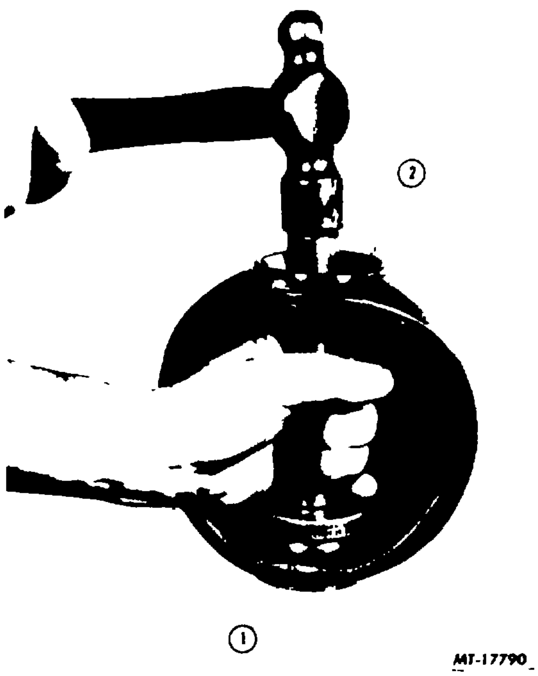


Fig. 14. Removing Trunnion Bearing Cup

1 Lower Trunnion Bearing Cup
2 Upper Trunnion Bearing Cup

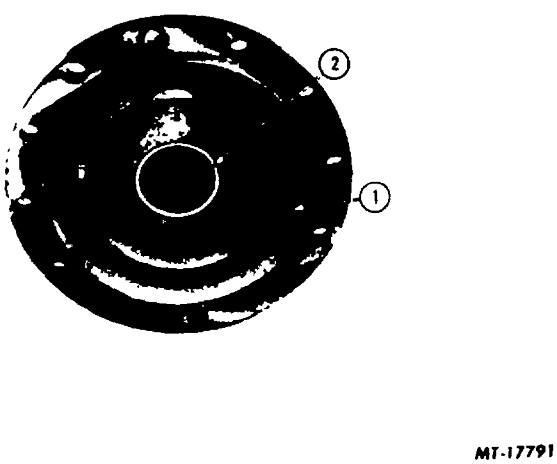


Fig. 15. Spindle Bushing

1 Spindle
2 Spindle Bushing

AXLE SHAFT AND UNIVERSAL JOINT ASSEMBLY

1. Assemble Inner race and cage by indexing notched tooth of inner race with elongated opening in cage and rolling Inner race into cage. See Fig. 16.

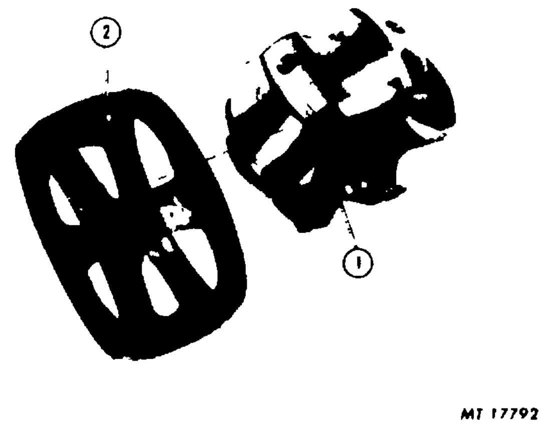


Fig. 16. Assembling Inner Race and Cage

1 Notched Tooth of Inner Race
2 Elongated Opening in Cage

2. Align elongated openings of cage with opposite teeth of outer race bell and lower inner race and cage assembly into outer race bell (Fig. 17).

Fig. 17. Assembling Inner Race. Cage and Outer Race Bell

1 Outer Race Bell
2 Opening in Cage
3 Universal Joint Cage
4 Universal Joint Inner Race

3. Tilt inner race in outer race until one ball can be inserted, continue this procedure until all balls are inserted. Prelubrication of components and a soft faced hammer may be used to aid inner race movement.

4. Install new lock ring on axle shaft end and place axle shaft in a vise equipped with soft jaws. See Fig 18.

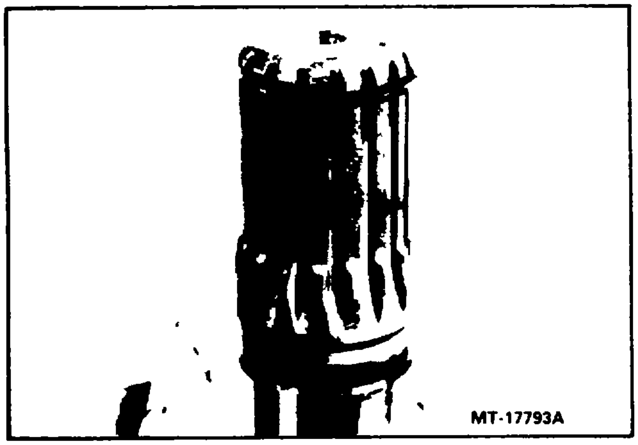


Fig. 18. Axle Shaft Lock Ring

5. Place universal joint on top of axle shaft index end of axle shaft in splined inner race, Tap end of universal joint shaft with a soft faced hammer to collapse lock ring, securing assembly See Fig. 19.

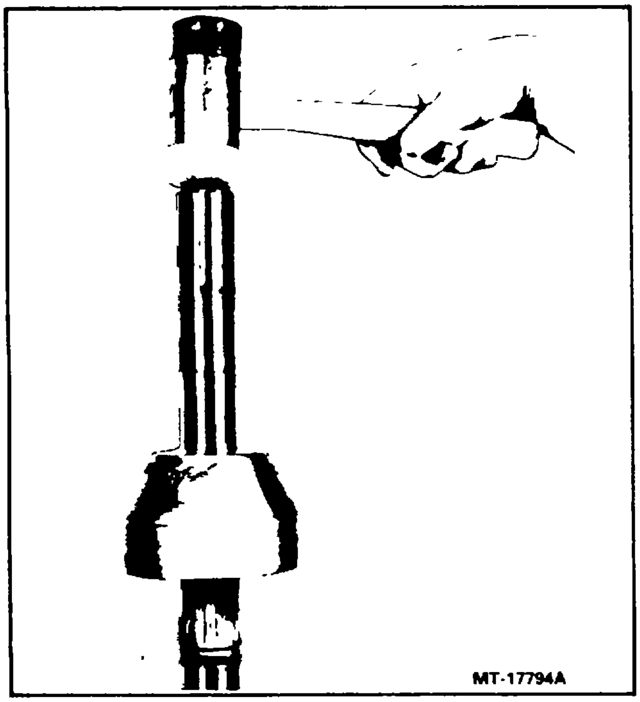


Fig. 19. Assembling Axle Shaft and Universal Joint

6. Pack universal joint bell with lubricant.

TRUNNION HOUSING ASSEMBLY

1. Using original shim pack Install upper trunnion cap Torque retaining nuts to 81 to 95 Newton Meters (60 to 70 ft lbs) On trunnion housings equipped with steering arms, install tapered dowels before Installing lockwashers and retaining nuts Torque retaining nuts to 81 to 95 Newton Meters (60 to 70 ft lbs) Refer to Fig 20

2. Lubricate trunnion bearings thoroughly Place a trunnion bearing on upper trunnion bearing cup of axle housing end Lower trunnion housing into place on axle housing end indexing upper trunnion pin with upper trunnion bearing

3 Place lower trunnion bearing in bottom of trunnion housing and align with lower bearing cup Using original shim pack Install lower trunnion cap Torque retaining nuts to 81 to 95 Newton Meters (60 to 70 ft lbs.)

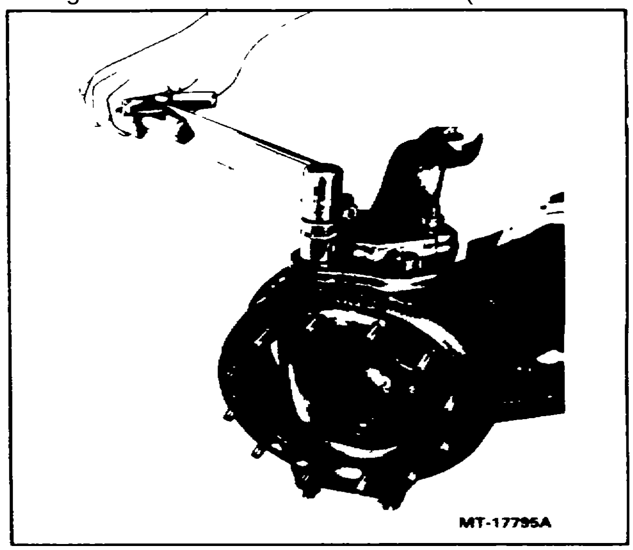


Fig. 20. Checking Bearing Adjustment

4. Check trunnion bearing adjustment by placing a torque wrench on trunnion cap or steering arm retaining nut and swinging trunnion housing Torque should be 11 to 20 Newton Meters (8 to 15 ft lbs) To increase torque, remove shims, to decrease torque, add shims See Fig 20

5. Install gasket, flange, steering ball felt, seal with spring, split retainer ring and retaining ring halves on rear of trunnion housing See Fig 21 for correct order of component installation

   Install retaining half (halves) lockwashers and mounting bolts Torque mounting bolts to 14 to 20 Newton Meters (10 to 15ft lbs)

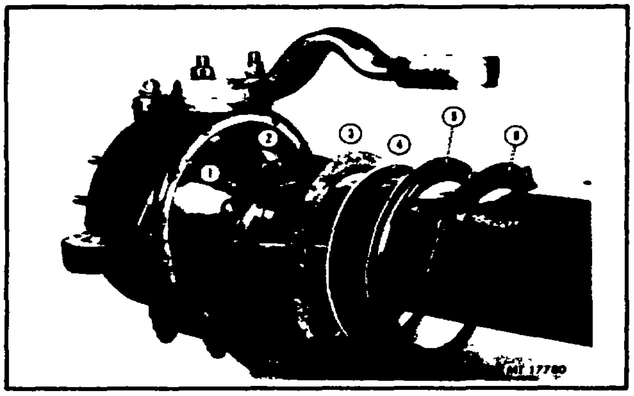


Fig. 21. Trunnion Housing Seals and Retainers

1 Gasket
2 Flange
3 Steering Ball Felt
4 Seal w/Spring
5 Split Retainer Ring
6 Retaining Ring Half

6. Install axle shaft and universal joint assembly In axle housing Indexing splined end of axle shaft with side gear of center unit (Fig. 22).
   When installing axle shaft and universal joint assembly, care should be taken not to damage axle shaft oil seal.
7. Slide spindle over universal joint shaft and on to trunnion housing studs.
8. Axle end assembly is now complete. Spindle is retained to trunnion housing by brake group retaining nuts upon brake group assembly

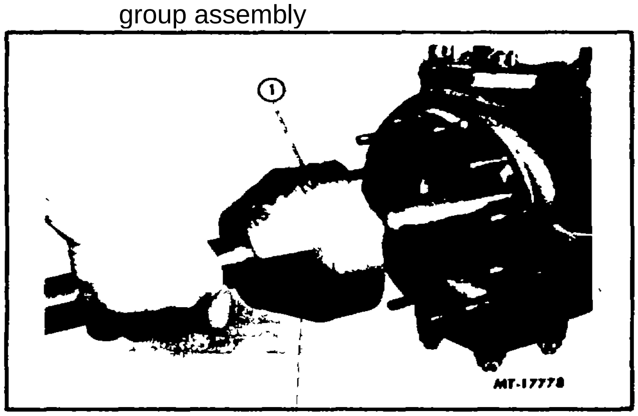


Fig. 22. Axle Shaft and Universal Joint Assembly

1 Axle Shaft and Universal Joint Assembly

The driving flange assembly located on both wheel ends of these axles has a bolt that goes in the center of the flange (Figure 8, item 57). The purpose of this bolt is to adjust the working clearance of the constant velocity U-joint to allow it to float during turns. This bolt is to be drawn up tight and then backed off one full turn.

TIE RODS

The tie rods are of three-piece construction, consisting of a tie rod and two rod end assemblies. The ends are threaded to the rod and locked with clamp bolts. Right and left hand threads are provided for toe-in adjustment. Tension on ball stud n the rod ends is self--adjusting and require no attention in service other than periodic Inspection to see that the ball studs are tight in th steering knuckle arms.

Fittings are proved for periodic lubrication n some types of tie rod end. Where no fittings are used, the tie rods have been lubricated at assembly and no further lubrication Is necessary.

If the tie rod taper joint is loose or the cotter pin is missing, remove, inspect and replace the tie rod end if the contact surfaces are worn.

Replace the tie rod end if looseness is found in the ball socket: With the tie rod stud clamped firmly, the socket should move no more than .762 mm (.030 inch) when the tie rod is grasped and shaken by hand. With the tie rod end removed from the arm, torque to rotate the stud should be .565 N•m (5 in lbs) or greater.

At assembly, insure that the slotted nut is torqued to the minimum value specified in the torque chart. If cotter pin cannot be installed, tightened nut to the next slot. **Do not back off** once minimum torque is reached.

CAUTION - WHEN TIE ROD, DRAG UNK OR POWER STEERING LINKAGE ENDS ARE REPLACED, THEY MUST BE THREADED INTO THE TIE ROD SUFFICIENTLY SO THAT WHEN THE CLAMP 18 APPLIED, THE CLAMPING ACTION WILL BE DIRECTLY OVER THE THREADS ON THE BALL JOINT END. BE SURE THAT THE END 18 IN FAR ENOUGH (PAST THE CLAMP) TO PROVIDE ADEOUATE CLAMPING AND THE BOLT IN THE CLAMP IS INSTALLED NEXT (OVER) THE SLOT IN THE TIE ROD. FIGURE 23 ILLUSTRAES A TYPICAL TIE ROD DESIGN FOR THESE AXLES.

DRAG LINK

Most installations have vertical socket type drag links which are similar in construction to the tie rod shown in Figure 23

Tension on ball stud In the drag link ends In self-adjusting and
requires no service other than periodic inspection to see that the ball studs are tight in the steering arms. Fittings are provided for periodic lubrication.

Replace the drag link end f looseness is found in the ball socket. With the stud clamped firmly, the socket should move no more than 762 mm (.030 Inch) when the drag link is grasped and shaken by hand. With the end removed from the link, torque to rotate th stud should be .585 N•m (5 in- lbs) or greater.

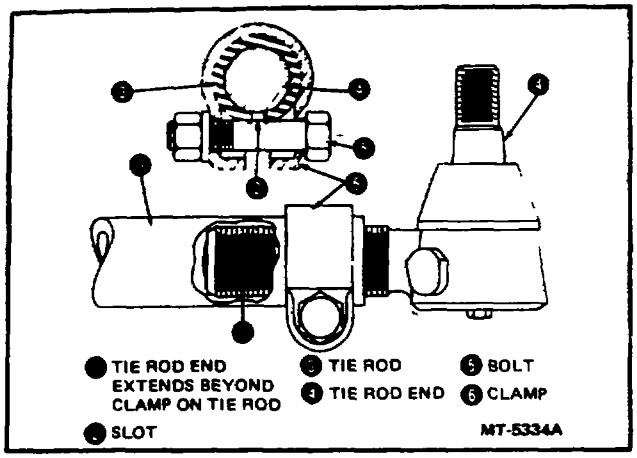


Fig. 23. Typical Tie Rod End

A limited number of vehicles have the horizontal socket type drag link shown In Figure 24. This type of drag link requires very little care other than periodic lubrication and occasional inspection to make sure that It is properly adjusted.

Adjustment is made by removing cotter pin and turning adjusting plug in the desired direction. To adjust for wear, turn adjusting plug in until it is tight, then back off to first cotter pin hole. Insert a new cotter pin of the correct size and bend ends over securely. Drag link should not be adjusted too tightly, otherwise steering will be affected. The spring Is merely to accommodate wear and is not intended to act as a cushion against shock.

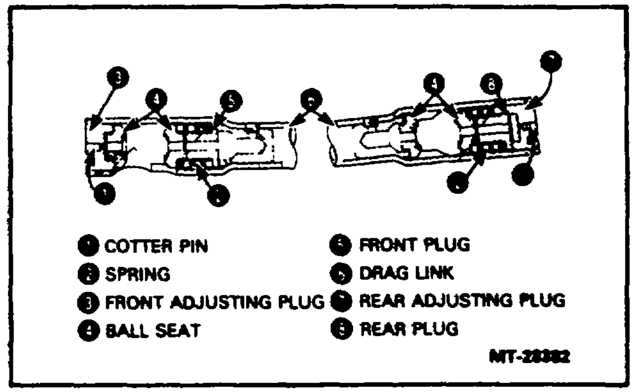


Fig. 24. Cross Section of Horizontal Type Drag Link

LUBRICATION AXLE ENDS

Pack upper and lower trunnion bearings and axle universal joint liberally with IH 251 HEP grease or an equivalent NLGI #2 multipurpose lithium grease. Lubricate universal joints when axle shafts are removed for service. Lubricate trunnion bearings whenever the bearing caps are removed for service. No periodic lubrication is required.

SPECIFICATIONS	
IH Model	**IH Model**
FA-64	02064
Pinion:	
Drive	Hypoid
Nominal Dimension	82.6 mm (3.2530”)
SE-1065-9 Disc	D (2)
Cage Rotating Torque (lbs.)	2.7-7.7 Kg (6-17 lbs.)
Differential:	
Bearing Preload	1 Notch Each Side
Housing	
Lubricant Capacity	8.2 Liters (17.8 Pints)
Serial Number Location	On Bolt Circle of Differential

TORQUE CHART

(Torque figures based on bolts and nuts that are cleaned and oiled.)

	Newton Meters	(Ft. Lbs.)
Pinion Shaft End Nut	441 N-m	(325 ft. lbs.)
Pinion Cage to Carrier Bolt	136 to 163 N-m	(100 to 120 ft. lbs.)
Carrier to Housing Bolt	47 to 61 N-m	(35 to 45 ft. lbs.)
Differential Case Bolts	109 to 122 N-m	(80 to 90 ft. lbs.)
Bearing Cap to Carrier	203 to 217 N-m	(150 to 160 ft. lbs.)
Trunnion Cap and Steering Arm to Trunnion Housing Stud	95 to 109 N-m	(70 to 80 ft. lbs.)
Trunnion Cap and Steering Arm to Trunnion Housing Stud Nut	81 to 95 N-m	(60 to 70 ft. lbs.)
Seal Retainer Half to Trunnion Housing Bolt	14 to 20 N-m	(10 to 15 ft. lbs.)
Spindle to Trunnion Housing Stud	41 to 54 N-m	(30 to 40 ft. lbs.)
Spindle to Trunnion Housing Stud Nut	34 to 47 N-m	(25 to 35 ft. lbs.)
Drive Flange to Hub Assy. Stud Nut	68 to 81 N-m	(50 to 60 ft. lbs.)
Tie Rod Clamp Bolt	88 to 109 N-m	(65 to 80 ft. lbs.)
Wheel Bearing Adjusting Nut	Tighten inner adjusting nut to 271 to 339 N-m (200 to 250 ft. lbs.) then back off 1/8 to 1/6 turn and bend tab to lock nut in place. Install outer locknut and tighten to 271 to 339 N-m (200 to 250 ft. lbs.) and bend tab to lock nut in place.	

RIVET PRESSURES

Millimeter	(Inch)	Megagrams	(Tons)
11 mm	(7/16 in.) Rivet	16 to 18 Mg	(18 to 20 tons)
13 mm	(1/2 in.) Rivet	18 to 23 Mg	(20 to 25 tons)
16 mm	(5/8 in.) Rivet	41 to 45 Mg	(45 to 50 tons)

LUBRICATION

For type of lubricant, refer to LUBRICATION CTS-4033.

Page 2220 DELETED

AXLE- FRONT

Replaced old Section with this revised Section in your CTS-4001 Manual.

FRONT WHEEL ALIGNMENT

CONTENTS

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INTRODUCTION

Outlined herein are Front Wheel Alignment Specifications pertaining to "Caster," "Camber," "Toe-In" and "Kingpin Inclination."

Kingpin inclination is not required for any of the front end alignment checking machines as a means of obtaining caster or camber. A check of kingpin Inclination can be used as an Indicator of damaged kingpins, knuckles or spindles.

FRONT WHEEL ALIGNMENT

The alignment of chassis according to the specifications should prevent misadjustment, which can affect tire wear, directional stability and steering wheel alignment. Check alignment at regular intervals and particularly after front suspension has been subjected to extremely heavy service or severe Impact loads Before checking and adjusting alignment, components such as wheel bearings, tie rods, steering gear, shock absorbers and tire inflation should be inspected and corrected where necessary.

The procedure for checking and adjusting alignment should be followed; namely, checking kingpin inclination, camber, caster and toe-in, in the order named. A slight modification in obtaining the proper caster and toe-in has been made and is outlined.

The caster, camber and toe-in dimensions are for vehicles at design load (no payload) If frame is not level with vehicle on alignment equipment, the frame angle must be considered This Is especially Important when making caster check, for the frame angle must be added to or subtracted from the caster angle to obtain a true setting.

CASTER ANGLE

Caster is the amount In degrees the top of the kingpin is inclined toward the front or rear of the truck, as viewed from the side of the truck The caster angle can range from a positive angle to a negative angle.

Positive caster, Figure 1, is the tilting of the top of the kingpin toward the rear of the truck, while negative, or reverse caster, is the tilting of the top of the kingpin toward the front of the truck.

Positive caster imparts a trailing action to the front wheels, while negative, or reverse caster, causes a leading action. The correct amount of caster helps to keep the front wheels in the straight-ahead position When In a turn, caster acts as a lever, assisting the driver to return the front wheels to the straight-ahead position.

Caster specifications are based on vehicle design load (no payload) which will usually result in a level frame. If the frame is not level when alignment checks are made, this must be considered in determining whether the caster setting is correct

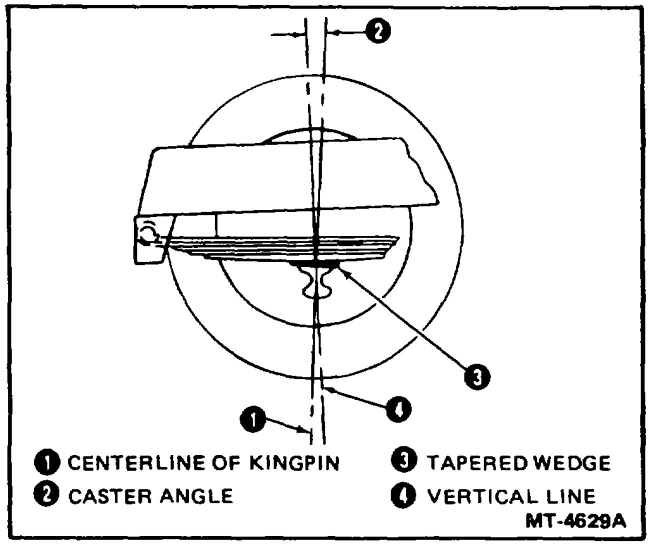


Figure 1 - Positive Caster

With the vehicle on a smooth, level surface, frame angle should be measured with a bubble protractor placed on the frame rail, Figure 2 The degree of tilt from the level frame position is the angle that must be used In determining a correcting caster setting. Positive frame angle is defined as forward tilt (front end down) and negative angle as tilt to rear (front end high).

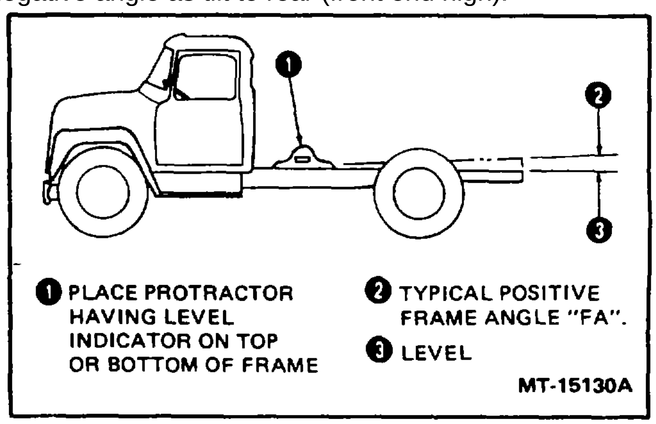


Figure 2 - Measuring Frame Angle

The measured frame angle should be added or subtracted, as required, from the specified level frame caster setting to obtain the caster that should actually be measured on vehicle 1. Positive frame angle should be subtracted from specified setting 2. Negative frame angle should be added to specified setting.

As an example, if the specified caster setting is a positive 1° and it is found that the vehicle has a positive 1° frame angle, then the measured caster should be 0 ± 1/2° This would result in the desired 1° ± 1/2° caster angle when the chassis settled to level frame under load.

Possible causes of incorrect caster are sagging springs, bent or twisted axle, or unequally tightened spring U-bolts. In most cases a twisted axle would be the cause if caster varies more than the specified 1/2° between left and right side.

If caster must be corrected, taper shims can be used as required between the springs and axle. Spring U-bolts should be tightened evenly and to specified torque after the addition or removal of shims.

NOTE: Be sure spring center bolt drops into I-beam pilot. Also, when tightening U-bolt nuts, be sure at least one full thread of U-bolt Is visible when nut Is tightened to specified torque. If not visible, use longer U-bolts.

CAUTION: WHEN U-BOLTS ARE REPLACED, THE NEW MUST BE GRADE 5 MINIMUM INCORPORATING ROLLED THREADS.

U-BOLT NUTS ARE TO BE FLANGED HEAD TYPE OR THOSE HAVING A NYLON INSERT LOCKING FEATURE.

Caster adjustment is made by inserting a wedge between the spring and axle, Figure 1.

To **increase** caster, insert the wedge so the thick parts face the rear of the truck (to front for underslung axles).

To **decrease** caster, place the wedge so that the thick end is toward the front of the truck (to rear for underslung axles).

If an excessively thick wedge Is required for a truck that has high mileage, check the contour of the springs and replace springs if necessary Be sure center bolt drops into I-beam.

The truck will lead to the side that has the most negative caster.

CAMBER ANGLE

Camber is the amount in degrees that the wheel inclines away from the vertical at the top, as viewed from the front of the truck, Figure 3.

"Positive" camber is an **outward** tilt or inclination of the wheel at the top.

"Negative" or reverse camber is an **Inward** tilt of the wheel at the top.

The amount of camber used depends on the amount in degrees the kingpin is inclined. An incorrect camber angle causes the side of the tread to wear, resulting in abnormal tire wear.

Unequal camber in the front wheels will cause the truck to lead to the right or left. The truck will lead to the side which has the most positive camber.

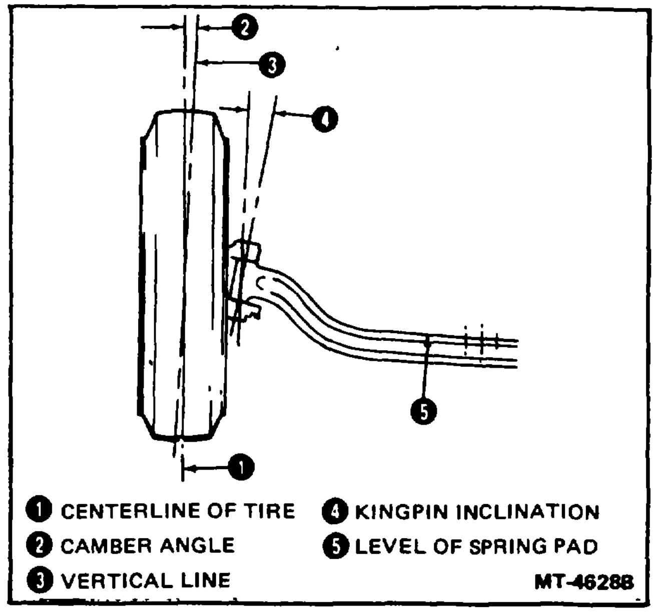


Figure 3 - Kingpin Inclination and Camber Angles

KINGPIN ANGLE (INCLINATION)

Kingpin inclination (angle) is the amount in degrees that the top of the kingpin inclines away from the vertical toward the center of the truck as viewed from the front of the truck, Figure 3.

Kingpin inclination working together with the camber angle puts the approximate center of the tire tread in contact with the road. Kingpin inclination has the effect of reducing steering efforts and improves directional stability in the vehicle.

There is no means of adjusting this angle; therefore, it will not change unless the front axle has been bent. Corrections or changes to this angle are accomplished by replacement of broken, bent or worn parts.

TOE-IN

Toe-in is the amount in fractions of a mm (inch) that the front wheels are closer together at the front than at the back as viewed from the top of the truck, Figure 4. With the camber on the front wheels, the left front wheel tries to steer to the left and right front wheel tries to steer to the right. This is due to the wheels wanting to turn in the same direction each wheel leans. To overcome this condition, the wheels are given a certain amount of toe-in.

Another reason for toe-in and the most familiar, is that when the vehicle is being driven, the forces acting on the front wheels tend to make the wheels toe-out.

Incorrect toe-in will result in rapid tire wear. Excessive **toe-in** will produce a scuffing or 'feather-edge" at the inside edge of the tire tread. **Toe-out** will produce a like wear but at the outside of the tire tread.

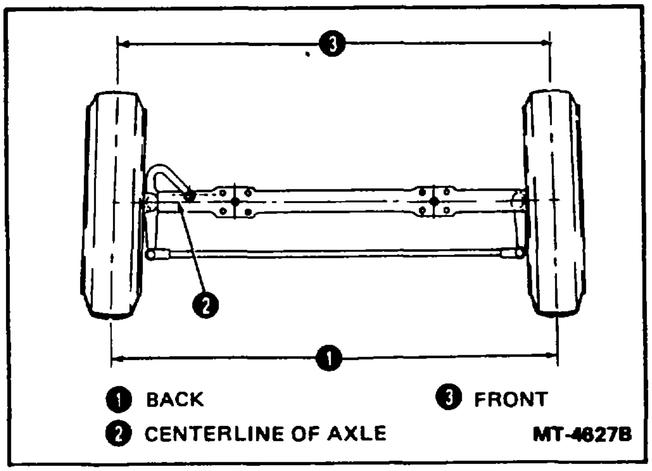


Figure 4 Toe-in Measurement

When attempting to determine the causes of excessive tire wear, first check kingpin inclination, camber and caster and correct, if necessary, in the order named.

No change should be made in toe-in until the other factors of front wheel alignment are known to be within specifications.

Turn the front wheels to the exact straight-ahead position.

When setting toe-in adjustment, the front suspension must be neutralized; that is, all component parts must be In the same relative position when making the adjustment as they will be in operation. To neutralize the suspension, the vehicle must be rolled forward 3.65 to 4.57m (12 to 15 feet). By rolling the vehicle forward, all tolerances in the front suspension are taken up and the suspension is then in normal operating position. Neutralizing the front suspension is extremely important, especially if the vehicle has been jacked up in order to scribe the tires; otherwise, the front wheels will not return to the normal operating position due to the tires gripping the floor surface when the vehicle is lowered.

Actual toe-in measurements should be taken at hub height between the two points on the center of the tread at the rear of the tires, Figure 4.

Mark the point and roll the truck ahead so that the points are in the front at hub height and measure the distance between the same two points on the tire treads.

The difference in the two measurements is the actual toe-in or toe-out.

1. To adjust the toe-in, turn the steering wheel so that the gear is in the mid-position.
2. Loosen the clamping bolts on the tie rod.
3. Turn the tie rod in the direction necessary to bring toe-in within the specified limits.
4 Tighten the clamping bolts on the tie rod.

Always recheck toe-in after any change in caster or camber angles or after any alteration in tie rod adjustment.

WARNING - WHEN TIE ROD, DRAG LINK OR POWER STEERING LINKAGE ENDS ARE REPLACED, THEY MUST BE THREADED INTO THE TIE ROD SUFFICIENTLY SO THAT WHEN THE CLAMP IS APPLIED, THE CLAMPING ACTION WILL BE DIRECTLY OVER THE THREADS ON THE BALL JOINT END. BE SURE THAT THE END IS IN FAR ENOUGH (PAST THE CLAMP) TO PROVIDE ADEQUATE CLAMPING, AND THE BOLT IN THE CLAMP IS INSTALLED NEXT TO (OVER) THE SLOT IN THE TIE ROD.

TURNING ANGLE

Turning angle is the degree of movement from a straight-ahead position of the front wheels to either an extreme right or left position. Two factors of major Importance when adjusting the angle are: tire interference with chassis and steering gear travel.

To avoid tire interference or bottoming of the steering gear, adjustable stop screws are located on the steering knuckles.

To adjust the turning angle, loosen the jam nuts and turn the steering knuckle stop screws in. Position support stands under the front axle so that the wheels are off the floor. Turn the wheels to extreme right turn until the steering gear bottoms or contact of the tire to chassis is made. Then back off the steering wheel 1/4 turn or back off the steering wheel until 12.7 to 25.4mm (1/2 to 1 inch) clearance is obtained between the tire and chassis. Be sure to check both front tires for clearance. When the proper clearance is determined, back the wheel stop screw out and tighten the jam nut.

Repeat the same procedure on the left extreme turn also and adjust the left steering knuckle stop screw.

NOTE: If vehicle Is equipped with power steering, adjust the steering gear relief valve to relieve pressure before contact Is made with the knuckle stop screw.

Refer to appropriate Steering Gear Service Manual for details.

The adjustment of both axle steering stop" and power steering unit should be periodically checked and corrected If necessary.

TURNING RADIUS ANGLE (TOE-OUT ON TURN)

Turning radius angle is measured in degrees and is the amount one front wheel turns sharper than the other on a turn.

When a vehicle is turned either to the right or left, the Inner wheel is required to turn in a smaller circle than the outside wheel, Figure 5.

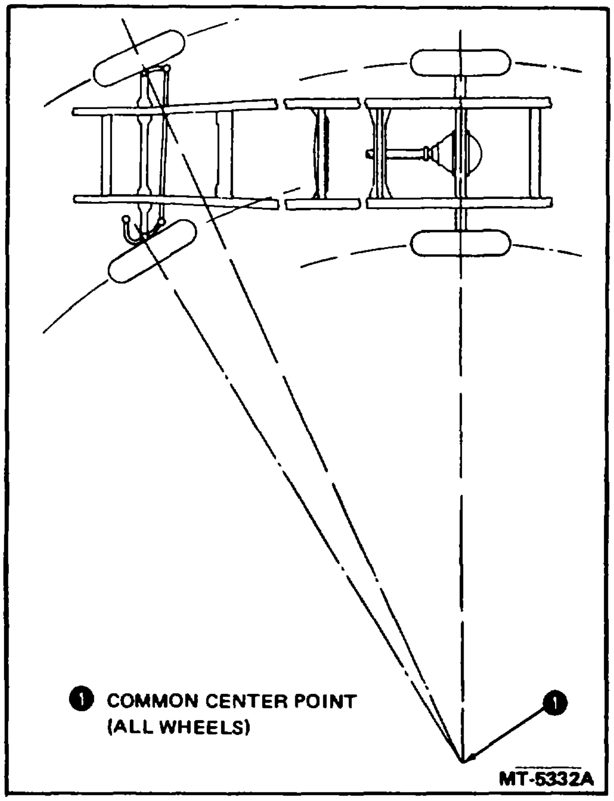


Figure 5- Inner Wheel Turns In a Smaller Circle Than Outside Wheel

If the inner wheel is not permitted to turn in a smaller circle or greater angle, tire scuffing will result. Therefore, it is necessary for the front wheels to assume a toed-out position during a turn.

Toe-out on turns is accomplished by having the ends of the steering arms (end at tie rod) closer together than the kingpins as shown in Figure 6. The amount of toe-out depends on the length and angle of the steering arms.

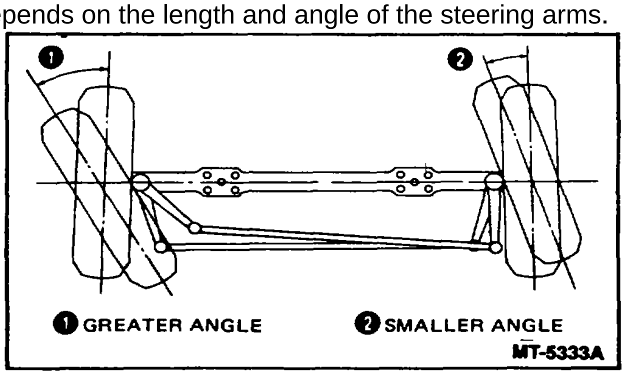


Figure 6 -- Inside Wheel Turns at Greater Angle

Even though the toe-in with the wheels in the straight ahead position may be adjusted correctly, a bent steering arm may cause the toe-out on a turn to be incorrect, causing scuffing of tires.

The turning radius angle is checked using turning radius plates SE-1447-2 or equivalent.

To check the turning radius angle, position the front wheels on the plates and in the straight-ahead position. After removing the locking pins from each plate, adjust the scale on the edge of the plates so that the pointers read 'zero." Turn the wheels to the right until the gauge at the left wheel reads 200. Then read the angle of the right wheel. The right wheel should then be turned to an angle of 20°. The left wheel should be at the same angle as was the right wheel when the wheels were turned to the left.

STEERING KNUCKLE STOP SCREWS

DRIVING FRONT AXLES

There is a stop screw located on each end of the axle housing for the purpose of limiting the amount of the turning angle of the wheels. These screws are not adjusted in accordance with the frame and tire interference as in conventional front axles. Instead, these screws are provided to limit the turning angle of the universal joints in the axles.

TROUBLESHOOTING

For Troubleshooting Guide, refer to FRONT AXLE GENERAL SERVICE Section, page 2229, in the Service Manual.

SPECIFICATIONS

When performing front wheel alignment procedures, observe the following rules:

A. Caster angles are for an unladen (no payload) vehicle. If frame is not level, a positive (+) frame rake must be added to caster measurement and a negative ( ) frame rake must be subtracted from caster measurement to obtain true caster reading.

B. Caster angle difference between left and right wheel not to exceed 0° 30 minutes.

C. Toe-in dimension may be measured from center of tread, or from inside of tire.

D. Tolerance unless otherwise noted:
   1. Caster - plus or minus 0° 30 minutes except Cargostar which is plus or minus 1° 0 minutes.
   2. Toe-in plus or minus 1.59mm (1/16 inch).
   3. Camber - plus or minus 0° 30 minutes.

SPECIFICATIONS

FRONT ALIGNMENT SPECIFICATIONS (LEFT HAND DRIVE)

PS = Power Steering
MS = Manual Steering

Chassis Model	Axle Model	Caster		Toe In		Camber	
S-Series	FA-64	2	30	.00-.19	.00-4.8	0	45

FRONT AUGNMENT SPECIFICATIONS (RIGHT HAND DRIVE)

CAUTION - THE CAMBER SETTING FOR RIGHT HAND DRIVE VEHICLES IS THE SAME AS LEFT HAND DRIVE EXCEPT THOSE LISTED BELOW. ALL OTHER SPECIFICATIONS ARE THE SAME WHETHER RIGHT OR LEFT HAND DRIVE.

Chassis Model	Axle Model	Camber (+)	
		Degree	Minutes
S-Series	FA-109,	LT 0 RT 0	15 30

KINGPIN INCUNATION

Axle Model	Kingpin Inclination (Degree)	
	Left	Right
FA-64,	0	0

*Top of Kingpin Hole tilted outboard in I-Beam.

AXLE - FRONT

Replace old Section with this revised Section in your CTS-4001 Manual.

FRONT AXLE GENERAL SERVICE

CONTENTS

CLEANING

Clean parts having ground and polished surfaces, such as knuckle pins, knuckle pin sleeves, bearings and spindles, with solvent type cleaners such as emulsion cleaners, or petroleum solvents excluding gasoline. Do not clean these parts in a hot solution tank or with water and alkaline solutions such as sodium hydroxide, orthoslicates or phosphates.

DRYING

Parts should be thoroughly dried Immediately after cleaning. Use soft, clean, lintless, absorbent paper towels or wiping rags free d abrasive material, such as lapping compound, metal filings or contaminated oil. Bearings should never be dried by spinning with compressed air.

INSPECTION

It is impossible to overstress the importance o careful and thorough Inspection of steering knuckle components prior to reassembly. Thorough visual inspection for indications of wear or stress and the replacement of such parts as are necessary will eliminate costly and avoidable front end difficulties.

1. Inspect the steering knuckle thrust bearing, wheel bearing cones and cups. Replace if rollers or cups are worn, pitted or damaged In any way.
2. If wheel bearing cups are to be replaced, remove from hubs with a suitable puller. Avoid the use of drift and hammers as they may easily mutilate cup bores.
3. Inspect the steering knuckles and replace if indications of weakness or excessive wear is found.
4. Check wear of the knuckle pins; compare with correct specification.
5. Check kingpin bushing wear.
6. Check the tightness of the steering connections such as tie rod arms, steering arm, etc.

CORROSION PREVENTION

Parts that have been cleaned, dried, inspected and are to be Immediately reassembled should be coated with light oil to prevent corrosion. Spindles, knuckle pins or sleeves that are to be stored for any length of time should be treated with a good rust preventative and wrapped in oiled paper and boxed to keep dry and clean.

REPAIR OF FORGED PARTS

In deciding whether to repair or scrap a damaged part, always keep in mind that we, as manufacturers, never hesitate to scrap any part which is in any way doubtful. Do not attempt to straighten bent steering arms, knuckles or aluminum I-beams. These parts must be replaced.

TROUBLESHOOTING

Remember that all alignment angles are so closely related that any change of one will automatically change the others. Because of this fact, it will probably be found that there is more than one cause for the complaint. The troubleshooting guide (next page) is not all-encompassing but is representative of the more common causes of difficulty encountered in wheel and axle alignment and should also prove of value in locating and correcting complaints on steering or tire wear.

TROUBLESHOOTING GUIDE

Complaint	Possible Cause
Shimmy (generally exists at speeds below 30 miles per hour)	a. Tire pressure incorrect. b. Tires of unequal size or weight. c. Wheel bearings loose. d. Steering arms loose. e. Steering gear loose. f. Too much caster. g. Drag link ends loose. h. Drag link springs weak or broken. i. Spring shackles loose. j. Kingpins and bushings worn. k. Tie rod ends loose. l. Kingpins loose in I-beam.
High-Speed Wheel Tramp (generally exists at speeds above 35 miles per hour)	a. Tire and wheel assemblies out of balance. b. Shock absorbers ineffective.
Wander or Weave	a. Tire pressure incorrect. b. Tires of unequal size. c. Bent spindle. d. Wheel bearings loose. e. Kingpins and bushings worn. f. Kingpins bent. g. Kingpins tight in knuckle. h. Pitman arm loose. i. Steering gear assembly too tight or too loose. j. Too little caster. k. Too much or too little camber. l. Too much or too little toe-in. m. Drag link ends tight. n. Drag link springs weak or broken. o. Tie rod ends too tight or too loose. p. Front axle bent. q. Front axle shifted. r. Springs broken. s. Rear axle shifted. t. Rear axle housing bent. u. Frame diamond shaped.
Hard Steering	a. Tire pressure low. b. Wheel spindle bent. c. Kingpin assembly poor fit. d. Steering assembly too tight. e. Tie rod ends tight. f. Caster excessive. g. Lack of lubrication.
Uneven Tire Wear	a. Tire pressure low. b. Excessive camber. c. Wheels out of balance. d. Tires overloaded. e. Eccentric wheels or rims. f. Caster incorrect. g. Toe-in incorrect.

Insert this new Section in your CTS-4001 Service Manual.

SPRINGS

SPRING ASSEMBLIES AND SHOCK ABSORBERS

CONTENTS

SPRING ASSEMBLIES-DESCRIPTION

Various types of spring assemblies used on IH vehicles are described below.

Constant Rate

Constant rate springs are leaf-type spring assemblies that have a constant rate of deflection. For example, if 227 Kg (500 pounds) deflect the spring assembly 2.54 cm (1 inch), then 454 Kg (1000 pounds) would deflect the same spring assembly 5.08 cm (2 inches). Thus, the rate of deflection is constant.

Constant rate springs are mounted to the axle with U-bolts and lock washers. The front end of the spring Is mounted to stationary bracket. The rear end of the spring is mounted to a spring shackle. The shackle allows for variations in spring length during compression and rebound.

This type of spring assembly is used in both front and rear axle applications on IH vehicles.

Figures 1 and 2 show typical views of constant rate spring assembly applications.

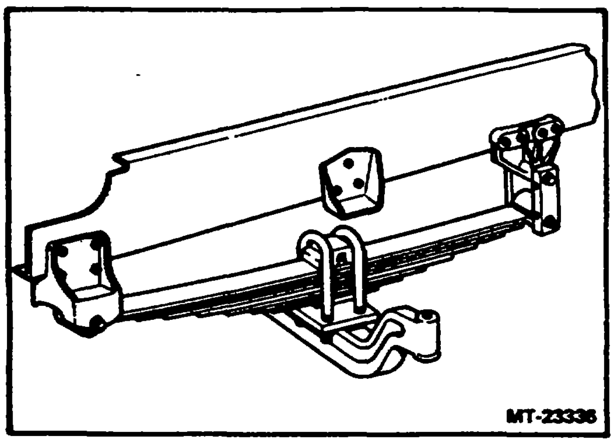


Figure 1. - Front Axle Application (Constant Rate)

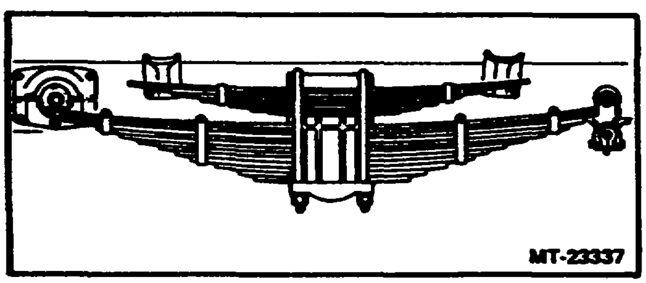


Figure 2. - Rear Axle Application (Constant Rate)

MAINTENANCE

Lubrication

For lubrication intervals, refer to Operator's Manual, page 2097.

Retightening U-Bolt Nuts

U-bolt nuts must be retightened at the intervals listed below. This applies to both new vehicles and to vehicles on which spring service has been performed.

1. The U-bolt nuts must be retightened after the vehicle has operated under load for 1 600 kilometers (1, 000 miles) or six months, whichever occurs first.

2. Thereafter, the spring U-bolt nuts should be retightened every 58, 000 kilometers (36, 000 miles)

   CAUTION WHEN CHECKING U-BOLTS TO DETERMINE IF LOOSENESS HAS OCCURRED, TORQUE VALUES OF 40% OF THE SPECIFICATIONS WOULD ASSURE JOINT INTEGRITY, PROVIDED THE U-BOLTS AND NUTS WERE IN LIKE-NEW CONDITION. HOWEVER, *ALWAYS TIGHTEN TO ORIGINAL SPECIFICATIONS.* RUSTY JOINTS MUST BE DISASSEMBLED, CLEANED AND LUBRICATED TO ASSURE A LIKE-NEW CONDITION PRIOR TO TIGHTENING.

SERVICING

Although the exact servicing procedures are different for each type of spring assembly and application, the basic procedures are similar. The following is a general outline for servicing all spring assemblies.

Removal

1. Place floor jack under truck frame and raise truck sufficiently to relieve weight from spring to be removed.
2. Remove shock absorbers where used.
3. Remove U-bolts, spring bumper and retainer or U-bolts seat.
4. Remove lubricators (not used on springs equipped with rubber bushings).
5. Remove nuts from spring shackle pins or bracket.
6. Slide spring off bracket pin and shackle pin.

Disassembly

1. Clamp spring end in vise and remove old bushing from spring eye.
2. Reposition spring in vise so that assembly will be damped near center.
3. If bolted-type rebound dips are used, remove nuts, bolts and spacers. Where clinch type rebound dips are used, bend tabs of dips up, being careful not to break them. Heating dips with torch will help avoid breakage.
4. Remove nut from spring center bolt.
5. Release vise to permit spring leaves to separate. Remove spring from vise and separate leaves from center bolt.

Cleaning, Inspection and Repair

1. Wash all parts in cleaning solvent or use steam cleaning equipment to remove grease and scale. Use a wire brush to hasten dirt removal.
   Do not immerse rubber spring bushings in cleaning solvent use a non-petroleum base type rubber lubricant on a dean cloth to wipe these parts dean.
2. Inspect all spring leaves for breakage and cracks. Also compare arch of leaves with new leaves. If leaves are flattened out, replace.
3. Spring pins must be replaced if they are worn, corroded or cracked.
4. Spring eye bushing and spring shackle bushing must also be replaced if defective.
5. Check spring brackets for cracks or for wear around mounting bolt or rivet holes. Replace bracket if damaged.
6. Always use new center bolts at each overhaul.

Assembly

1. Lightly lubricate spring leaves with a thin coat of graphite grease. Place spring leaves in proper order and align center bolt hole with a long drift.

2. Compress spring leaves sufficiently for installing center bolt and nut.

3. Place spring assembly In vise and compress spring leaves fully.

   WARNING - WHEN ASSEMBLING SPRING LEAVES, BE CAREFUL TO PREVENT PHYSICAL INJURY TO PERSONNEL THE USE OF SPECIAL HOLDING FIXTURES OR "C" CLAMPS FOR HOLDING SPRING LEAVES IN PLACE DURING ASSEMBLY IS STRONGLY RECOMMENDED.

4. Align spring leaves by tapping with a hammer and position rebound dips on spring. N bolted type clips are used, install spacers, bolts and nuts. Tighten enough to hold leaves in alignment but not enough to restrict free movement. If clinch type clips are used, bend ends of clips down on top leaf. Heat dips with torch to help avoid breakage.

Installation

Before reassembly, all shackle bolts, U-bolts, etc. should be cleaned and lubricated.

While the actual installation procedures will vary with each spring type, the pivot end d spring is usually fastened to frame bracket first. Shackle end can then be fastened by aligning shackle to other frame bracket. When installing U-bolts for securing axles, do not final tighten until springs have been placed under normal load. See SPECIFICATIONS for U-bolt torque, page 2238.

Spring failures may occur at the center bolt hole if U-bolts become loosened. These bolts must be retightened at the intervals specified under MAINTENANCE, page 2235.

SHOCK ABSORBERS

DESCRIPTION

Shock absorbers are provided to control body sway, to eliminate excessive tire wear, front wheel shimmy, and spring breakage. They also improve the riding qualities of the truck and are especially useful when the truck is empty or only partly loaded.

The direct-acting type shock absorber (Figure 6), sometimes called airplane type, has a sealed construction and requires no periodic maintenance. Shock absorbers d this type should be checked every 16, 000 km (10,000 miles). Make sure they are functioning satisfactorily, that bushings are not worn, and that outer jacket has not been damaged by flying stones or debris from the road. If a shock absorber is leaking, fails to operate, or develops unusual noises, the complete unit should be replaced. Direct acting shock absorbers are nonrefillable and service is limited to unit replacement.

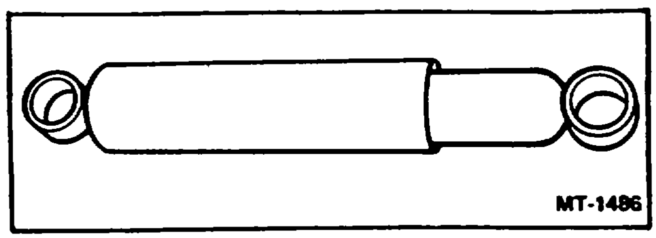


Figure 6. - Direct Acting Shock Absorber

MOUNTING AND LINKAGE

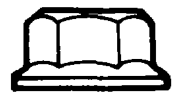
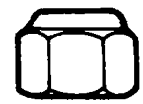
Check for and correct loose, bent or broken shock absorber mountings and linkage when servicing the suspension system. Inspect all rubber bushings and grommets to see that they effectively keep metal from striking metal. Link or bushing wear can be checked by twisting link with pliers or by prying link connection with screwdriver or small pry bar. Outward appearance will usually reveal excessive wear.

TROUBLESHOOTING

The following list covers the most frequent causes for troubles which may occur in the suspension system. However, several items may overlap similar complaints and causes that are common to axle and wheel alignment troubleshooting. For additional information on these or related items of troubleshooting, see AXLE-FRONT, CTS-4013, page 2229.

Complaint	Possible Cause
1. Truck wanders.	a. Front axle shifted on springs. b. Broken spring. c. Out of alignment.
2 Truck bottoms.	a. Overloading. b. Broken spring leaves. c. Defective shock absorbers. d. Weak spring
3. Truck lopsided	a. Broken spring leaves. b. Wrong spring installed. c Weak spring.
4. Frequent spring breakage.	a Overloading or severe operation. b. Loose U-bolts. c Defective shock absorbers. d. Tight spring shackle.
5. Noisy springs.	a. Loose U-bolts. b. Loose rebound clips. c. Loose shackles. d. Worn shackle bushings. e Loose, bent or broken spring brackets. f. Worn spring pins.
6. Erratic steering when braking.	Loose U-bolts

SPECIFICATIONS
TORQUE CHART
FOR ASSEMBLY OF SUSPENSION U-BOLTS

	Recommended Wrench Torque					
U-Bolt Diameter and Thread	All Steel Locknut 		All Steel Flange Nut 		Nylon Insert Nut 	
	Cut Thread U-Bolts (Prior to July 1974)					
	Newton Meters	Foot Pounds	Newton Meters	Foot Pounds	Newton Meters	Foot Pounds
7/16" - 20	68 - 81	50 - 60	—	—	79 - 92	58 - 68
1/2" - 20	88 - 102	65 - 75	—	—	104 - 118	77 - 87
9/16" - 18	109 - 129	80 - 95	—	—	130 - 151	96 - 111
5/8" - 18	163 - 190	120 - 140	—	—	197 - 224	145 - 165
3/4" - 16	197 - 224	145 - 165	—	—	339 - 407	250 - 300
7/8" - 14	258 - 312	190 - 230	—	—	448 - 502	330 - 370
1" - 14	298 - 353	220 - 260	—	—	651 - 786	480 - 560
—	—	—	—	—	—	—
	Rolled Thread U-Bolts					
	Newton Meters	Foot Pounds	Newton Meters	Foot Pounds	Newton Meters	Foot Pounds
1/2"- 2 0	68 - 81	50 - 60	88 - 109	65 - 80	—	—
5/8" - 18	142 - 170	105 - 125	176 - 217	130 - 160	—	—
3/4" - 16	237 - 292	175 - 215	298 - 325	220 - 240	—	—
7/8" - 14	—	—	—	—	305 - 373	225 - 275
1" - 14	—	—	—	—	441 - 543	325 - 400

SPECIAL TOOLS

SE-2189 Torque Indicator Wrench (100-600 lb.-ft.)
SE-2221 Torque Indicator Wrench (0-150 lb.-ft.)

BRAKES, AIR
AIR COMPRESSOR
MIDLAND BRAKE MODEL EL-740
CONTENTS

Printed in United States of America

CONTENTS (Continued)

DESCRIPTION

The Midland Brake EL-740 air compressor is a two-cylinder, air or water-cooled compressor, driven and lubricated by the engine. It can be either base or flange-mounted. Its rated capacity is .21 cubic meters per minute (7.4 cubic feet per minute) at 1250 rpm.

The crankshaft is a one-piece assembly supported with ball bearings at the front and a sleeve type rear bearing. Some models have ball bearings at front and rear.

The pistons are of aluminum alloy and have three compression rings each. One compression ring is located in the top groove and the other two in the second groove. There is also an expander ring along with two oil rails or rings in the oil rail groove below the piston pin. Thrust buttons are used at each end of the piston pin to retain the pin in the connecting rod.

The connecting rod bearings are the replaceable insert type.

All valve components are installed within the head. The exhaust valves are screw-in, spring loaded, disc type assemblies located in the bottom of the head. The inlet valve guard and valve are pressed into the inlet cavity In the bottom of the head.

The unloader mechanism components are housed in the unloader assembly, which Is bolted to the top of the head. The unloader pins extend from the unloader assembly, through the cylinder head to the inlet valve cavity. There they hold the Inlet valves open when the air system is at maximum pressure.

OPERATION

COMPRESSION

During the down stroke of each piston, air is drawn into the cylinder bore through the Inlet valve in the cylinder head. As each piston begins its upward stroke, the inlet valve closes and the air above the piston is compressed. When the pressure in the cylinder block becomes greater than the air pressure In the cylinder head above the exhaust valve, the exhaust valve is forced off its seat. Air is then allowed to pass through the exhaust port into the head cavity, and from there into the air line leading to the air reservoir. When the piston starts a downward stroke, the exhaust valve returns to its seat and the compressed air will not return to the cylinder block. The intake and compression cycle is then repeated.

UNLOADING (NOT COMPRESSING)

When air pressure in the system reaches the maximum governor pressure setting, the governor is actuated, causing the unloader pins to hold the inlet valves off their seats (open). With the inlet valves open, air passes freely back and forth between the cylinder bores, through the intake cavity in the cylinder head, to the Intake air cleaner. This suspends the compression of air until the pressure In the system is reduced to the governor cut-in pressure setting. The governor then exhausts the air pressure to the unloader mechanism, releasing the unloader pins. This allows the inlet valves to function normally and the resumption of air compression.

MAINTENANCE

Air cleaners should be cleaned or replaced when the vacuum exceeds 508.0mm (20 inches) of water at compression. The governor settings and unloader operation should be checked regularly. Maximum desirable reservoir pressure is 826 $\pm$ 27.6 kPa (125 $\pm$ 5 psi).

Type of air cleaner, operating conditions and experience may dictate additional service activity.

Check compressor mounting to be sure it is tight. Be sure the drive pulleys are in proper alignment and belt tension is properly adjusted. Make sure the oil supply and coolant lines are in good condition and not restricted.

If the air compressor should fail to maintain sufficient pressure or supply excessive air pressure, the unloader mechanism pins or seals could be defective.

The unloader components can be serviced or replaced without removing the compressor from the vehicle's engine.

Refer to disassembly procedures for unloader on page 2288
and assembly procedures for unloader on page 2296.

DIAGNOSIS AND TESTING

In order to properly test a compressor under simulated operating conditions, a test rack providing correct mounting, cooling, lubricating and driving of the compressor is necessary. Such tests are not compulsory if the unit has been carefully rebuilt by an experienced technician. A compressor efficiency or build-up test can be run which is not too difficult.

NOTE - If the compressor is belt-driven, and the drive pulley is removed or replaced during the overhaul, it must be replaced with the same size pulley. A different size pulley will affect compressor output, and would also require a different size drive belt.

Install a governor assembly to the compressor if one has not been installed previously. Connect an oil supply line having at least 9.1 kg (20 lbs.) of oil pressure at the rear bearing cap Provisions must be made for unrestricted oil drainage from the crankcase during the test. The oil return line must be 12.7mm (1/2 in.) minimum inside diameter.

If the compressor is water-cooled, connect a water supply line which will permit a flow of 5.7 liters (1.5 gallons) of water per minute at the compressor.

Connect the discharge port to an air tank with a known - volume, using 12.7mm (1/2 In.) outside diameter copper me or equivalent. The tank should have a quick-opening v b to exhaust air pressure. Connect a line from the air tank to the reservoir port and to the governor.

If tests are being made in a dusty atmosphere, connect a suitable air cleaner to the compressor air Inlet opening. Connect the compressor to a source of power (minimum two horse, power) to run at 1250 rpm.

Run the compressor at 1250 rpm pumping against a 689.5 kPa (100 psi) pressure for five minutes. This time should be used to adjust and test the governor. During this test, check for oil and air leakage, overheating and excessive noise. Decrease the pressure in the air tank to zero. Close the quick opening valve and check the build. up time from zero to 689.5 kPa (100 psi) in the air tank.

The build-up time must not exceed 55.0 seconds per 16, 387 cubic centimeters (1000 cubic-inches) o tank volume for the EL-740 air compressor. To determine the allowable build-up time, use the following formula:

EL-740 allowable build-up time (seconds) - air tank volume in cubic centimeters (cubic inches) x .055.

TROUBLESHOOTING GUIDE

CONDITION	POSSIBLE CAUSE	RESOLUTION
Compressor fails to maintain sufficient pressure or adequate air supply.	Dirty intake cleaner.	Clean or replace element as necessary.
	Restriction in compressor cylinder head intake, discharge cavities or line.	Repair or replace as necessary.
	Leaking or broken inlet or exhaust valves.	Repair or replace valves as necessary.
	Excessive wear.	Repair or replace compressor as necessary.
	Drive belt slipping.	Adjust or replace belt.
	Excessive system leakage.	Check all fittings and connections.
	Defective governor.	Repair or replace governor as necessary.
	Governor with improper setting.	Adjust governor as necessary.
	Gauge defective.	Replace gauge as necessary.
Noisy operation.	Loose drive pulley.	Tighten repair, or replace pulley as necessary.
	Restrictions in cylinder head or discharge line.	Repair or replace as necessary.
	Worn or burned out bearings.	Replace bearings as necessary.
	Compressor not getting proper lubrication.	Service lubrication system as necessary.
	Excessive wear.	Overhaul or replace compressor as necessary.
Compressor not unloading (excessive pressure.)	Defective unloader pins or seals.	Replace pins/seals as necessary.
	Defective governor.	Repair or replace governor as necessary.
	Reservoir line to governor restricted.	Repair or replace line as necessary.
	Unloader mechanism binding or stuck.	Repair unloader as necessary.
	Gauge defective.	Replace gauge as necessary.

TROUBLESHOOTING GUIDE (Continued)

CONDITION	POSSIBLE CAUSE	RESOLUTION
Compressor passes excessive oil	Excessive wear.	Overhaul or replace compressor as necessary.
	Dirty air cleaner.	Clean or replace element as necessary.
	High inlet vacuum (obstructed intake).	Service intake as necessary.
	Small or restricted oil return line flooding compressor.	Repair or replace return line as necessary.
	Excessive oil pressure.	Service lubrication system as necessary.
	Defective or worn oil seal in rear bearing cap.	Replace seal as necessary.
	Piston rings improperly installed.	Remove and reinstall as necessary.
	Back pressure from engine crankcase	Check engine ventilation system, excessive engine blow by (piston rings).
	Intake pipe restricted, too long or too small.	Repair or replace pipe as necessary.

REMOVAL AND INSTALLATION

WARNING WHEN ANY COMPONENT IS SERVICED OR REMOVED FROM THE AIR SYSTEM, BE SURE TO SET THE PARKING BRAKE AND/OR BLOCK THE VEHICLE TO PREVENT IT FROM MOVING WHILE ANY SERVICE IS BEING PERFORMED.

REMOVAL

1. Drain air pressure from main reservoir.
2. Drain engine cooling system and cylinder head of compressor if compressor is water-cooled.
3. Disconnect all air, water and oil lines leading to and from the compressor.
4. Remove compressor mounting bolts and drive belts as required.
5. Remove compressor from engine.
6. Use suitable puller to remove pulley or gear from compressor crankshaft after removing crankshaft nut.
7. Inspect pulley or gear and associated parts for wear or damage. If any parts are found worn or damaged, they must be replaced.

INSTALLATION

Installation of compressor Is performed by reversing the removal procedures. Items to be observed when re-installing compressor are:

Clean oil supply line so that oil will flow freely through the line.

Be sure oil return line or passages through brackets are clean and unrestricted so that oil can return to engine. Always use a new mounting gasket and be sure oil holes in gasket and compressor are properly aligned with oil supply line.

Inspect drive pulley or gear for wear or damage. It should fit securely on the crankshaft, contacting the shaft only, not riding the key. Tighten drive pulley nut to recommended torque listed in Torque Chart in this Section, page 2298.

Insure that the air cleaner is clean and properly installed. If air intake is connected to the engine air cleaner, connections should be tight with no leakage.

Clean or replace any dirty, corroded, or damaged air or water lines before connecting them to the compressor. Use a new discharge fitting gasket.

Align compressor drive and adjust to proper belt tension. Tighten mounting bolts to recommended torque listed in Torque Chart in this Section. Page 2298.

After compressor is installed, operate It and check for air, oil or water leaks at connections. Be sure to check for noisy operation.

DISASSEMBLY

Before disassembly, clean the compressor's exterior using solvent and a stiff brush.

Mark the head, block and crankcase as shown in Figure 1 to insure the components are reassembled correctly. EL-740 compressors with a flanged intake port on the block and a flanged exhaust port on the head must be reassembled with both ports on the same side of the compressor.

NOTE -- If the compressor is belt-driven, and the drive pulley is removed or replaced during an overhaul, it must be replaced with the same size pulley. A different size pulley will affect compressor output, and also require a different size drive belt.

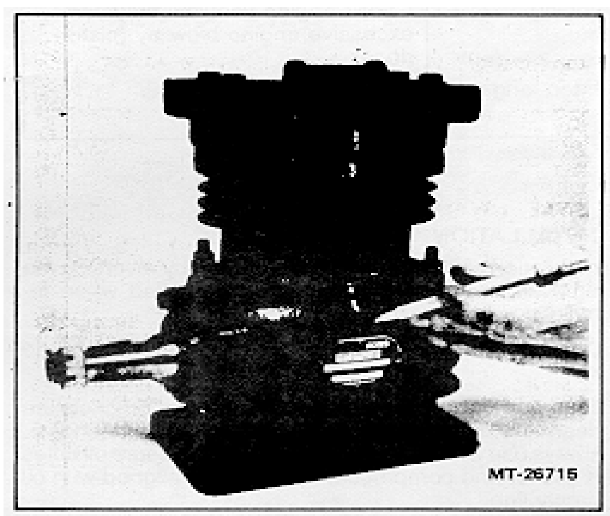


Figure 1. - Alignment Marks

GOVERNOR

The governor may be mounted to the head, block or end cap by means of a bracket, or It may be remote mounted.

1. Disconnect the unloader tube leading from the unloader assembly to the governor.
2. Remove the two bolts retaining the governor to the mounting bracket. The bracket for a head-mounted governor is removed when the head is removed from the block. The bracket for the block-mounted governor is removed when the block is removed from the crankcase.

AIR CLEANER

1. Remove the two bolts holding the air cleaner to the cylinder block.

2. Remove the air cleaner and discard gasket. Clean gasket surfaces. Do not damage machined surfaces.

Some compressors do not have an air cleaner attached to the compressor. These models are hose connected to the engine air cleaner. With this type application, the intake (air) manifold should be removed from the cylinder block by removing two bolts.

UNLOADER

1. Bleed off, main air reservoir below 552 kPa (80 psi). (For on vehicle maintenance only.)

2. Disconnect air line from governor to unloader assembly. (For on vehicle maintenance only.)

3. Remove two hex-head bolts from unloader (Figure 2) and lift unloader body from compressor.

Figure 2. - Removing Unloader Body

4. Unloader pins and springs will protrude from head. Remove pins from their bores (Figure 3).
5. Remove unloader springs and discard.
6. Remove bushings (Item 3, Figure 3). Some un-loader assemblies will have snap rings retaining the bushings in place. Use snap ring pliers to remove the ring.
7. Remove the valve discs and diaphragms from un- loader body.
8. Discard diaphragms and springs.

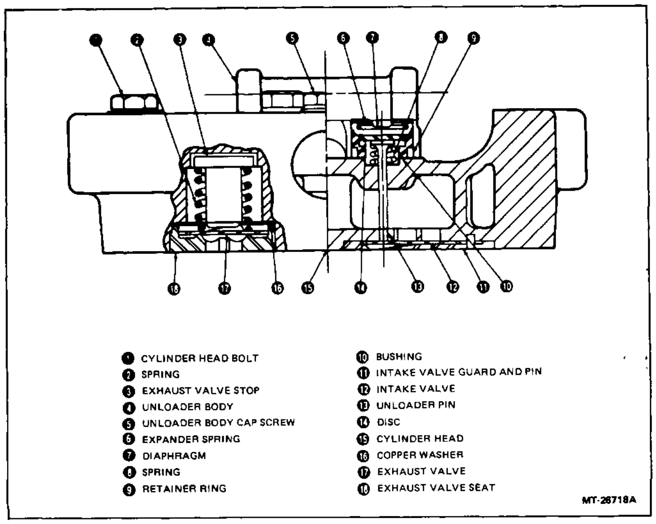


Figure 3 - Unloader Components

CYLINDER HEAD

1. Remove six cylinder head bolts (Figure 4).

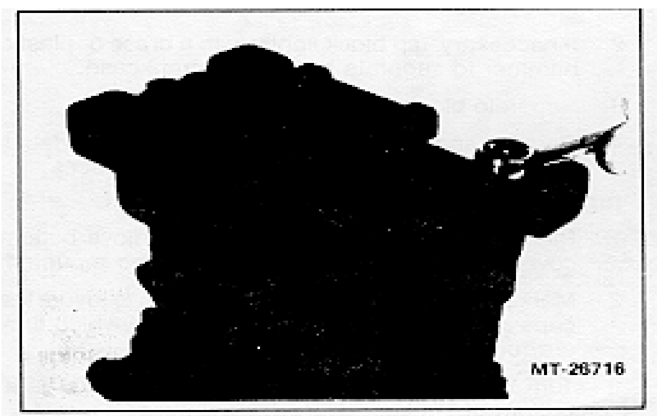


Figure 4 - Removing Cylinder Head

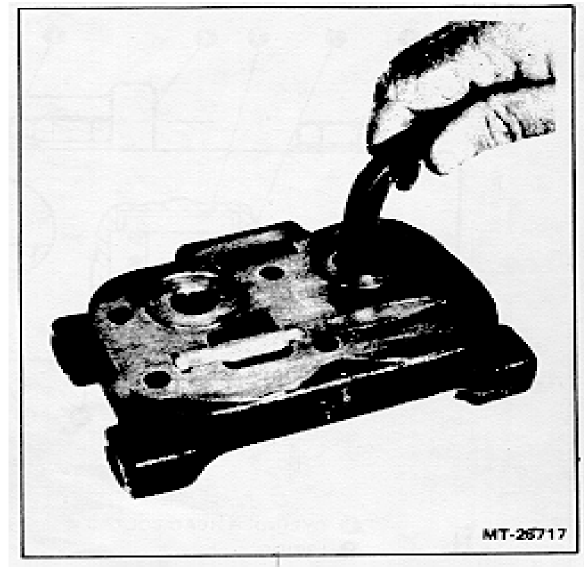


Figure 5 - Removing Exhaust Valve Seats

2. If necessary, tap the head lightly with a brass or plastic hammer to loosen it.

3. Remove head from block.

4. Discard head gasket and clean gasket surfaces. Do not damage machined surfaces.

5. If necessary, position cylinder head in a soft-jawed vise with block mating surface up

6 Use a 14mm (9/16 in) alien wrench and loosen exhaust valve seats (Figure 5).

NOTE - Refer to Figure 6 during steps 7, 8 and 9.

7. Remove the exhaust valve seats (Item 18), exhaust valve springs (Item 2), copper washers (Item 16) and exhaust valve stops (Item 3).

8. Discard the exhaust valve springs, exhaust valves, and copper washers.

9 Use a screwdriver and carefully pry the intake valve guards (Item 11) and intake valves (Item 12) from their cavities. (This is illustrated in Figure 7) Discard the valves.

If valve guard is damaged during removal, replace with new part The valve guards are staked to keep them in place for assembly purposes.

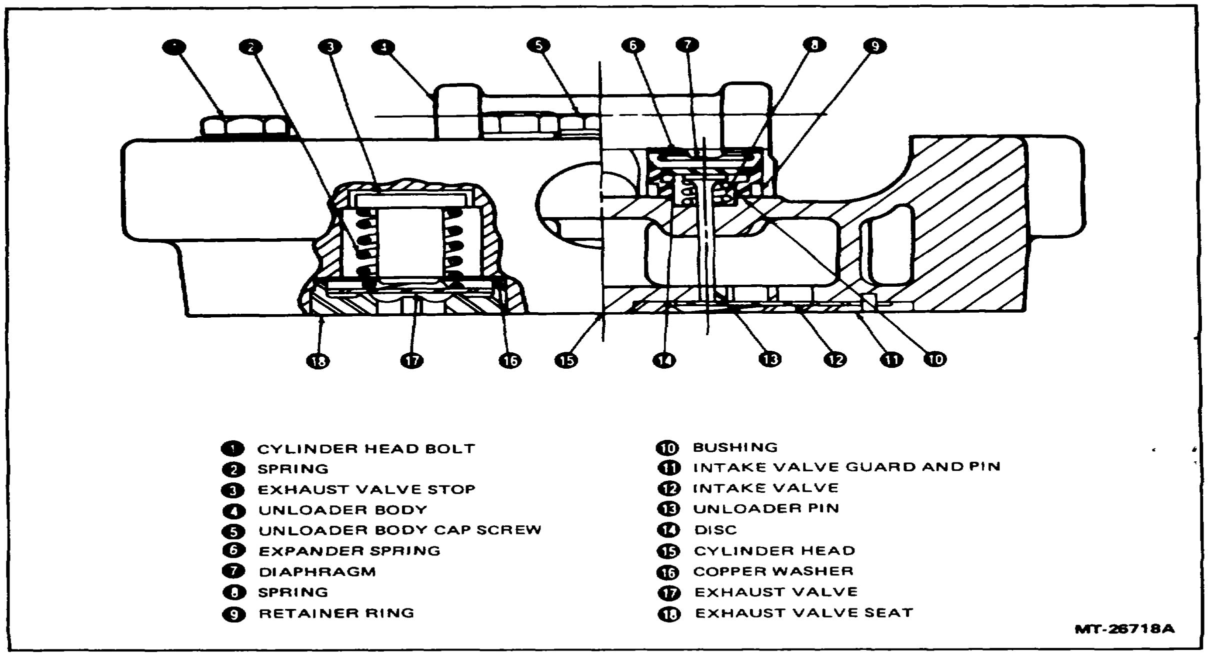


Figure 6 - Cross Section of Cylinder Head

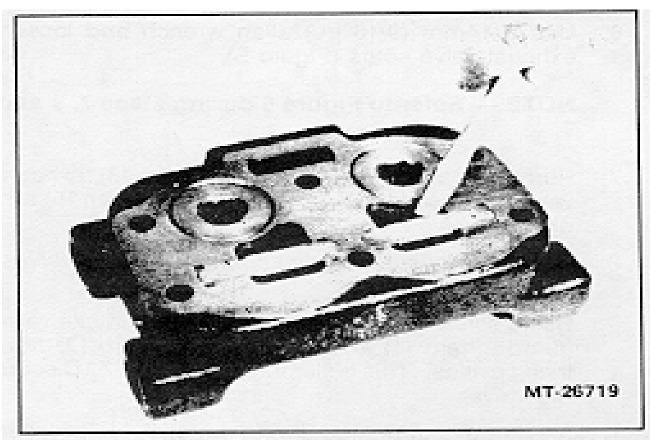


Figure 7 - Removing Intake Valve Guard

CYLINDER BLOCK

1. Remove the six nuts and lock washers which retain the cylinder block to crankcase.

2. If necessary, tap block lightly with a brass or plastic hammer to separate block from crankcase.

3 Separate block from crankcase and pistons.

4 Remove and discard gasket. Clean gasket surfaces using care not to damage machined surfaces.

PISTONS AND CONNECTING RODS

1. Place the compressor on its side. Remove bottom cover plate if the compressor is flange mounted.

2. Mark the connecting rods and rod caps to insure the caps are returned to the same rod from which they are removed.

3. Turn crankshaft so that one connecting rod is at bottom of stroke.

4. With a 7/16-inch socket remove the rod nuts (Figure 8).

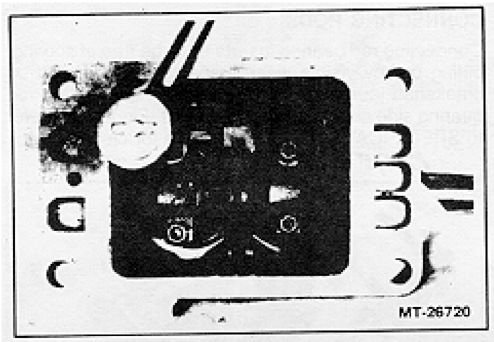


Figure 8 - Removing Connecting Rod Cap Nuts

5. Remove the rod cap.

6. Lift the piston and connecting rod through the top of the crankcase.

7. Repeat steps 2 through 6 on the remaining rod.

Each rod cap must be installed on the same rod from which it was removed.

8. Use a screwdriver to remove piston pin thrust buttons. Use care so that the piston is not damaged. Some compressors may use a wire pin instead of the thrust buttons. The wire pin is removed by prying the pin out of the retaining hole with a small screwdriver. Discard this wire pin and replace with thrust buttons.

9. Press piston pin out of the piston using care not to damage the piston. Application of some heat to piston will ease pin removal.

10. Remove piston rings from pistons (Figure 9) using piston ring expander.

11. Discard all rings.

CRANKSHAFT BEARING CAPS

1. Remove four bolts securing the bearing cap (flange mount) or caps (base mount) to crankcase.

2. Tap bearing caps with a soft hammer to loosen and remove them. Do not pry caps from crankcase Discard gaskets and clean gasket surfaces.

3. Compressors which are bottom lubricated have a tube insert or crossover between the crankcase and rear bearing cap. This insert is a lubricant passage between the two pieces The insert has two O-rings which are to be replaced.

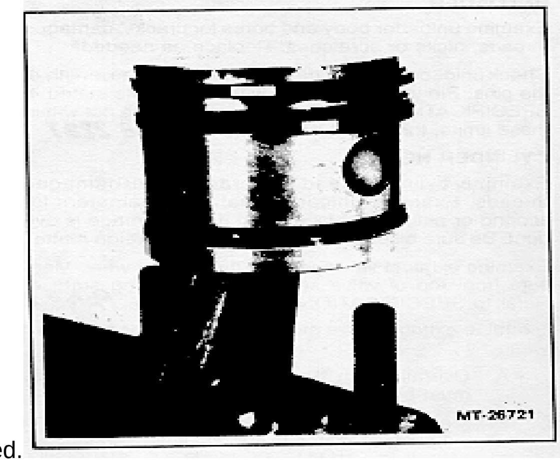


Figure 9 - Piston Assembly

4. Remove oil seal from front bearing cap and discard it.

CRANKSHAFT

Do not remove crankshaft and bearing from crankcase unless an inspection reveals necessity for removal.

If the compressor has tachometer drive, the drive must be removed before removing the crankshaft.

Use a soft-faced hammer, tap rear of crankshaft until bearing is free from supporting bore. Use a bearing puller to remove the front bearing from crankshaft.

The crankshaft can then be removed from the crankcase.

CLEANING, INSPECTION AND REPAIR

Wash all parts thoroughly in clean solvent. Make sure all carbon deposits are removed from pistons and cylinder head Be sure all drilled oil passages in crankshaft are open. Clean all carbon from piston ring grooves In piston. Remove old gasket material from gasket mounting surfaces

If any of the components are not within the specified limits listed in SPECIFICATIONS in this Section, that particular part must be replaced. PAGE2297

UNLOADER

Examine unloader body and bores for cracks, damaged threads, nicks or scratches. Replace as needed.

Check unloader pins for damage Measure the length of the pins. Pin length must be within the limits stated In SPECIFICATIONS in this Section. If pins are not within these limits, they must be replaced. **PAGE 2297**

CYLINDER HEAD

Examine cylinder head for cracks and damaged threads. Examine unloader seal bore diameters for scoring or pitting. Replace head if any damage is evident. Be sure all passages are free from foreign matter.

Examine exhaust valve seat for damage or wear. Measure from top of valve seat to valve seating surface, Refer to SPECIFICATIONS in this Section. **PAGE 2297**

Examine exhaust valve stops for damage or excessive wear.

A Overall length If parts are not within limits, they must be replaced with new.

B Measure the distance from tip (valve end) of exhaust valve stop to surface where spring sets (this distance is to include any wear caused by the spring)

Examine inlet valve guard for nicks, burrs or deformity If damaged, it must be replaced

CYLINDER BLOCK

Check cylinder block for cracks and check inside of cylinder bores for scratches, scoring, pitting, out-of-round and taper.

Out-of-round should not exceed more than 0 0127 mm (.0005 in.) or taper not more than 0.025 mm (.001 in) from top to bottom of bore If excessive taper or out of round is found, the cylinder must be rebored and honed oversize or replaced with a new cylinder block Service pistons and rings are available In 0.51 mm (.020 in) oversize.

PISTONS

Pistons must be Inspected for damage, such as cracks or scoring. Measure outside diameter of both pistons just below the compression ring grooves, then compare this diameter with inside diameter of respective cylinder bore. Be sure to measure the piston at 90 degree angle to piston pin bore to obtain correct measurement.

If piston diameter is more than 0.20 mm (.008 in) smaller than cylinder bore, the piston must be replaced Service pistons are available in 0.51 mm (.020 in) oversize.

Be sure to re-hone cylinder bores.

Piston pins must have a light interference fit In piston and a slip fit In the rod Check fit of compression and oil rings in grooves of pistons and measure clearance. Position each ring in its respective cylinder bore and measure ring gap. Refer to SPECIFICATIONS in this Section for ring gap limits and ring groove clearance. Rings must be replaced if not within specified limits. **PAGE 2297**

CONNECTING RODS

Connecting rod bearing inserts must be free of scoring, pitting or any visible wear. Inspect rod bearing fit on crankshaft journals Be sure to check connecting rod bearing side clearance on crankshaft (Figure 10). Refer to SPECIFICATIONS in this Section for clearance. **PAGE 2297**

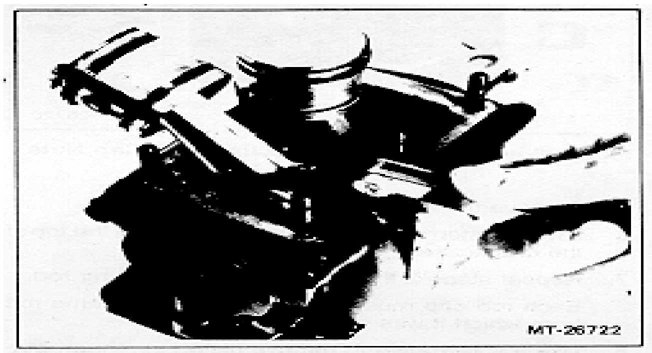


Figure 10 - Checking Connecting Rod Side Clearance

If connecting rod bearing-to-crankshaft clearance is excessive, new Inserts must be Installed If connecting rod side clearance is excessive, a new rod and bearing cap must be Installed

CRANKSHAFT BEARING CAPS

Examine crankshaft front and rear bearing caps and replace If cracked Check inside diameter of rear bearing sleeve.

If the bearing's dimensional limits exceed that listed In SPECIFICATIONS In this Section, or is damaged, the bearing cap must be replaced. **PAGE 2297**

CRANKSHAFT

Bent or twisted crankshaft cannot be repaired If rod journals are scored beyond repair or worn more than limits listed In SPECIFICATIONS, replace the crankshaft or regrind journals New insert bearings are available in 0.254 mm (.010 in), and 0.51 mm (.020 in) undersize

If a main bearing journal has a sleeve and the journal is scored beyond repair or worn more than the limits, listed in SPECIFICATIONS, the crankshaft must be replaced. **PAGE 2297**

Threads, keyway, and all ground and machined surfaces must not be mutilated or worn. Crankshaft oil passages must be clean to insure oil flow.

Examine ball bearing for worn or damaged balls; rotate bearing by hand to detect roughness. If wear, roughness, or damage is evident bearing must be replaced.

CRANKCASE

Inspect crankcase for damage and replace if any damage is noted. Inspect studs in the crankcase and replace any which are bent or have distorted threads. The oil passage on bottom lubricated crankcase must be thoroughly cleaning to assure oil flow.

Clean all gasket surfaces and make sure all gasket surfaces are free of nicks, scratches or burrs which would affect a good gasket seal.

SEALS AND GASKETS

Replace all seals and gaskets. Never re-use any gaskets or seals.

ASSEMBLY

Apply a coat of engine oil to crankshaft, bearings, connecting rod bearing, piston and cylinder block bore.

CRANKSHAFT

1. Position crankshaft in arbor press, supporting crankshaft rear. Place bearing over crankshaft and use a bearing adapter similar to that shown in figure 11. Press bearing on crankshaft until inner race is seated firmly against crankshaft shoulder.

2. Position crankshaft in crankcase. The crankshaft bearing may either be worked into the crankcase or pressed into the crankcase sing the adapter shown in figure 11. Position the crankcase in an arbor press so that the crankshaft will not be obstructed at rear of the crankcase. Press bearing and crankshaft into the crankshaft with bearing flush with inside of crankcase.

CRANKSHAFT BEARING CAPS

1. Apply a thin coat of Loctite Gasket Eliminator (purple) around the perimeter of the front bearing cap oil seal. The coating must be light, yet cover the seal fit area.
2. Press the new seal into the front bearing cap. The spring or lip of seal must face the crankcase when installed. The seal case should be flush to .15 mm (.005 in.) below the front surface of the bearing cap.

3. Apply a small amount of engine oil to lip of the sea.

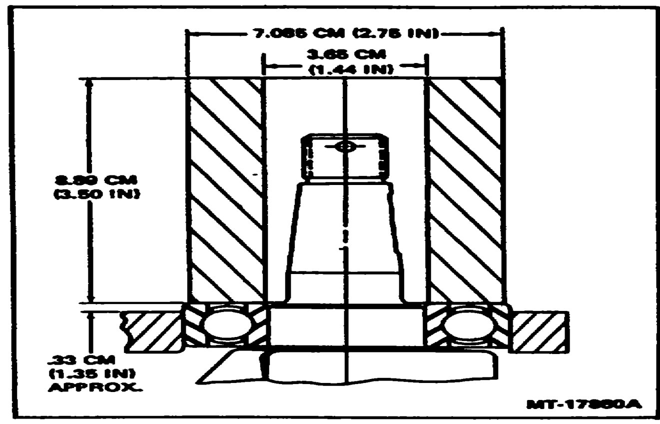


Figure 11 - Crankshaft Bearing Adapter

4. Assembly new gasket and bearing cap to crankcase using care so that the oil seal is not damaged,. Install the four cap screws tightening them alternately. Refer to Torque Chart in this Section.

5. Lubricate rear bearing cap sleeve with a light film of engine oil and place a new gasket on the rear bearing cap.

6. On compressors with bottom lubricating provision, position two new O-rings on the tube insert and lubricate insert with a film of engine oil. Position the tube insert in the rear of the crankcase.

7. Slide the rear bearing cap over the crankshaft end. Align the crankshaft and bearing cap so that the cap fits evenly in the crankcase bore. Install the four bearing cap screws tightening them alternately. Refer to Torque Chart in this Section. **PAGE 2298**

PISTONS AND CONNECTING RODS

1. Lubricate piston pin, piston pin bores and piston pin bore in connecting rod, with engine oil.

2. Position the connecting rod in piston and press piston pin into place.

3. Install thrust buttons in ends of piston pins.

4. Install piston rings. One compression ring is installed in top groove and two compression rings in

the second or middle groove (Figure 12). Install two oil ring with oil ring expander between the two oil rings in the bottom groove of pistons (Figure 12).

Compression rings must be installed with surface marked “TOP” facing top of piston. Some compression rings may have dots to indicate top of ring.

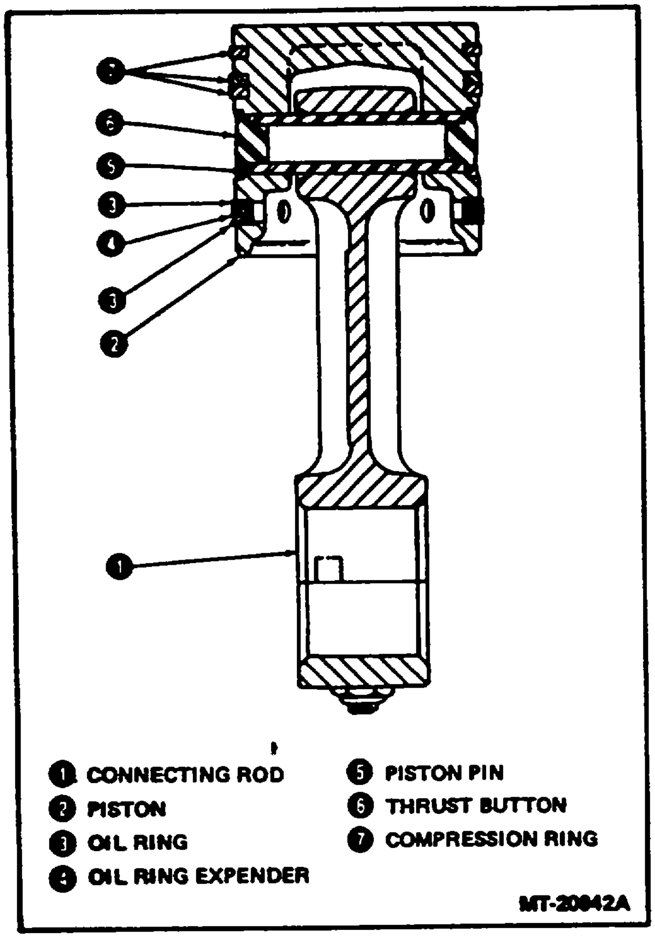


Figure12 - Cross Section of Piston and Connecting Rod

5, Position connecting rod bearing inserts in rod and bearing cap, making sure that the locating lips on inserts engage the locking notches in rod and cap. Make sure that the rod cap is installed on rod from which it was removed.

PISTONS AND CONNECTING RODS TO CRANKSHAFT

1. Position crankcase assembly on its side.
2. Remove bearing cap and insert from connecting rod.
3. Lubricate connecting rod bearing Inserts and crankshaft journals with engine oil.
4. Insert the connecting rod assemblies through the top of the crankcase and position rods on crankshaft
5. Install connecting rod bearing cap to its mating rod. Tighten rod nuts o recommended torque valve listed in Torque Chart in this Section. **PAGE 2298**
6. Be sure each connecting rod moves freely on the crankshaft.

CYLINDER BLOCK TO CRANKCASE

1. Position crankcase so that pistons are up (Figure 10).
2. Lubricate cylinder block bores, pistons and piston rings with engine oil.
3. Rotate crankshaft so that one piston and rod assembly is at bottom dead center and the other at top dead center.
4. Place a new gasket over the crankcase studs.
5. Position the piston ring gaps so that they are staggered in each ring groove about 180°.
6. Place cylinder block over crankcase making sure that the air intake is on the proper side of the crankcase.
7. Lower the cylinder block assembly over the pistons. The piston bores have a taper so that the piston rings will be compressed as the cylinder block is pushed down on the crankcase. A downward pressure will be required since it Is necessary to compress the piston rings as the pistons slide in their respective bores.
8. Tighten the cylinder block to crankcase nuts in two steps. Refer to Torque Chart in this Section.
   A. Tighten two center nuts then the four end nuts to torque value in first step.
   B. Increase the torque values starting with the two center nuts, then the four end nuts. Final torque value is listed in Torque Chart in this Section.
9. If governor mounting bracket was removed for the disassembly, it can now be installed.

CYLINDER HEAD

Refer to Figures 6 and 13.

1. Position cylinder head, bottom side up, In a soft-Jawed vise.
2. Place new exhaust valve stops in exhaust cavities. Then install new exhaust valve springs on exhaust valve stops.
3. Exhaust valves are placed in cavities followed by new copper washers. The exhaust valve will rest on the valve spring.

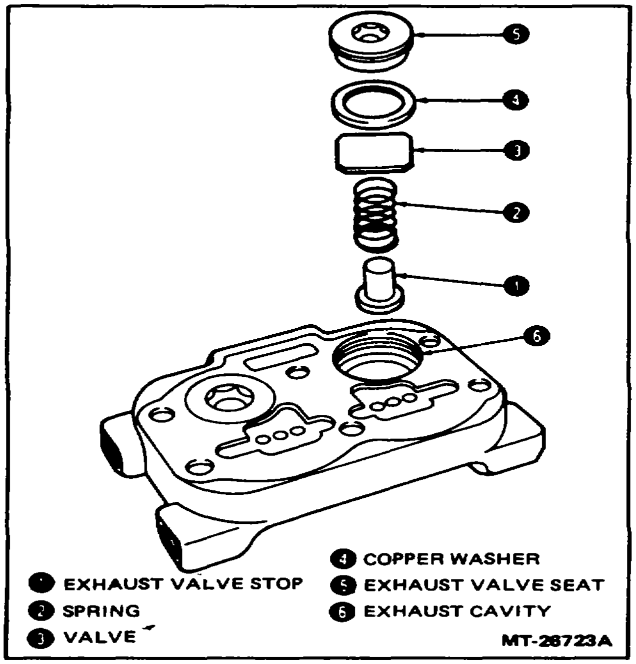


Figure 13 - Exploded View of Exhaust Valve Components

4. Install exhaust valve seats using a 14 mm (9/16 In.) allen wrench and tighten to recommended torque value listed in Torque Chart in this Section.

5. Position new intake valve on the intake valve guard pin and place both guard and valve In the cylinder head cavity (Figure 14). Use a punch and stake the guard assembly into the cavity. Repeat the procedure for the second intake valve assembly. The intake valve guard should not extend more than .1778 mm (.007 in.) above the cylinder head surface.

CYLINDER HEAD TO CYLINDER BLOCK

1. Position new cylinder head gasket on cylinder block and align. Then place the cylinder head on the block over new gasket. If the governor bracket is mounted on the head, replace it in its proper position.

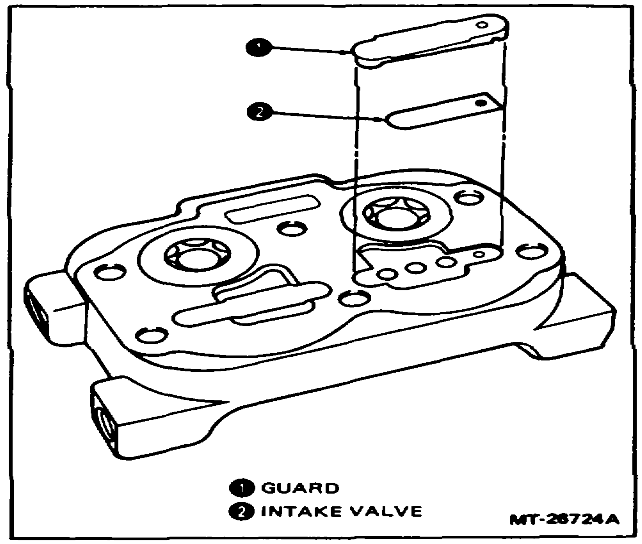


Figure 14 - Intake Valve Assembly

2. Assemble the six cylinder head bolts and tighten them In sequence shown in Figure 15. Head bolts are to be tightened In two steps according to Torque Chart in this Section. **PAGE 2298**

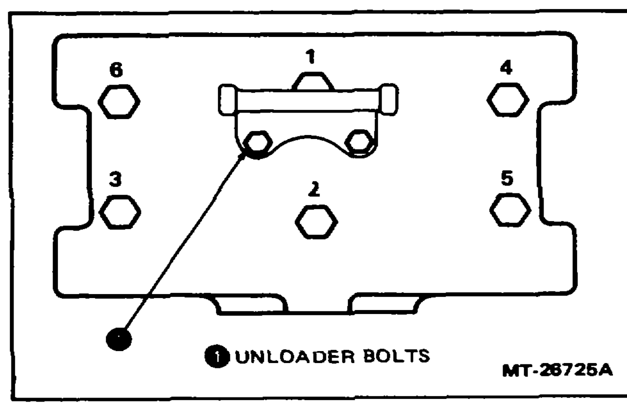


Figure 15 - Cylinder Head Bolt-Tightening Sequence

UNLOADER

Refer to Figure 16.

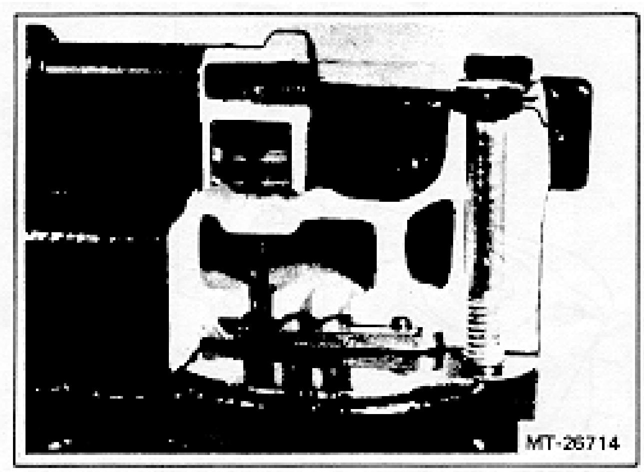


Figure 16 - Cross Section View of Unloader Assembly

1. Lubricate unloader body bores. Use a silicone lubricant meeting Mil-L-434A requirements Intended for dynamic lubrication between oil resistant rubber seals and metal parts. Dow-Coming Corporation No. 33 medium weight grease is suggested (For optional lubricant refer to COMPONENTS Section, General Lubrication Specifications, Item 3. **PAGE 2285**

2. Insert new expander springs in new diaphragm cups and position cups in bores of unloader body with springs facing inside of the body.

3. Position valve discs and bushings In the unloader bores with the discs next to the diaphragm cups. Some unloader assemblies use snap rings to retain the bushings In the unloader body. When a snap ring is used, snap ring pliers will be required to install the snap ring.

4. Position new unloader springs on unloader pins. Use new unloader pins if original pins did not meet specifications.

5. Insert unloader pin and spring assemblies into unloader pin holes in cylinder head.

6. Position unloader assembly over unloader pins on the cylinder head.

7. Install the unloader cover bolts Refer to Torque Chart In this Section.

8. Connect air line to governor.*

9. Replenish air supply and check operation to maintain sufficient air pressure or correction of excessive air pressure.*

AIR CLEANER

1. Assemble lock washers and bolts in air cleaner bolt holes, then place a new gasket on bolts.

2. Secure air cleaner assembly on cylinder head and tighten bolts to recommended torque value listed in Torque Chart in this Section. PAGE 2298

Compressors which use the engine air cleaner as a source for air have a manifold for the air hose connection This manifold is secured to the cylinder head in same manner as the air cleaner.

GOVERNOR

If the governor is secured to a bracket mounted on the compressor cylinder block, tighten the 5/1618 bolts to recommended torque value listed in Torque Chart in this Section Then reassemble the tube between the unloader and governor assembly.

*Steps 8 and 9 apply to on vehicle maintenance only. If governor was removed during service, it must be replaced prior to connecting governor/unloader air line and unit operation.

SPECIFICATIONS

GENERAL	
Model	EL740
Type	2 Cylinder
Capacity at 1250 RPM	.21 m^3/min 7.4 cfm
Lubrication	Engine Lubricated
Cooling	Air or Water
Drive	Belt or gear
CYLINDER HEAD COMPONENTS	
Unloader Pin Length	32.7660-32.5120mm (1.290-1.280 in.)
Exhaust Valve Seat (Top of Valve Seat to Seating Surface)	3.2512-3.1750mm (.128-.125 in.)
Exhaust Valve Stop	
Overall Length	22.7584-22.6568mm (.896-.892 in.)
Valve Stop Surface to Spring Seat Surface	18.7960-18.2880mm (.740-.720 in.)
PISTONS AND CONNECTING ROD COMPONENTS	
Pistons	
Standard	50.6807-50.6603mm (1.9955-1.9945 in.)
Oversize (.51mm-.020 in.)	51.1937-51.1683mm (2.0155-2.0145 in.)
Pin Hole	12.6949-12.5857mm (.4998-.4955 in.)
Pin Diameter	12.700-12.6949mm (.5000-.4998 in.)
Piston Rings	
Compression Ring Gap	.1270-.2540mm (.005-.010 in.)
Oil Ring Gap	.2540-1.0160mm (.010-.040 in.)
Ring Groove Clearance	
Compression Rings	.1270-.0762mm (.005-.003 in.)
Oil Rings	.01270-.1270mm (.0005-.005 in.)
Connecting Rod	
Piston Pin Hole Diameter	12.71016-.12.70508mm (.5004-.5002 in.)
Bearing Clearance to Crankshaft	.01270-0.05334mm (.0005-.00021 in.)
Side Clearance to Crankshaft	.2540mm (.010 in.)
CYLINDER BLOCK	
Cylinder Bore	
Standard	50.800-50.7863 (2.000-1.9995 in.)
Oversize (.51mm-.020 in.)	51.308-51.2953 (2.020-2.0195 in.)
CRANKSHAFT	
Connecting Rod Journal Diameter	
Standard	28.5369-28.5242mm (1.1235-1.1230 in.)
Undersize (.51mm-.020 in.)	28.0289-28.0162mm (1.1035-1.1030 in.)
Connecting Rod Journal Width	25.4508-25.400mm (1.002-1.000 in.)
Main Bearing Journal Diameter	35.01136-34.99866mm (1.3784-1.3779 in.)

SPECIFICATIONS (Continued)

CRANKCASE AND BEARING CAP	
Bearing Bore Diameter	
Cast Iron	72.0090-71.9938mm (2.8350-2.8344 in.)
Aluminum	71.9785-71.9607mm (2.8338-2.8331 in.)
Bearing Cap Bore Diameter (Sleeve Type)	35.0825-35.0444mm (1.3812-1.3797 in.)
Ball Bearing	
Outside Diameter	71.9861-71.9968mm (2.8341-2.8346 in.)
Inside Diameter	34.9885-35.0012mm (1.3775-1.3780 in.)

TORQUE CHART

LOCATION	RECOMMENDED TORQUE	
Air Cleaner Mounting to Cylinder Head	12.43-16.95 N•m	110-150 lb-in
Unloader Bolts	8.47-11.86 N•m	75-105 lb-in
Governor Mounting Bolts	12.43-16.95 N•m	110-150 lb-in
Compressor Mounting Bolts	46.10-56.94 N•m	34-42 lb-ft
Exhaust Valve Seats	94.91-122.02 N•m	70-90 lb-ft
Bearing Cap Bolts	13.6-18.1 N•m	120-160 lb-in
Connecting Rod Bolts	11.30-15.82 N•m	100-140 lb-in
Cylinder Block to Crankcase First Step Second Step	6.78-9.04 N•m 13.6-18.1 N•m	60-80 lb-in 120-160 lb-in
Cylinder Head Bolts First Step Second Step	14.12-18.1 N•m 20.9-27.68 N•m	125-160 lb-in 185-245 lb-in
Pulley Drive Nut (With Slot Aligned)	101.7-135.6 N•m	75-100 lb-ft

ENGINES

SERVICE MANUAL

GROUP 04, COMPONENTS revised pages, to be inserted in your CTS 4001 Manual as follows:
Replace COMPONENTS, CONTENTS page 1&2.
Replace CHAPTER I pages 3-4 with new.
Replace CHAPTER V complete.

BRAKES-AIR

COMPONENTS

CONTENTS

ENGINES

SERVICE MANUAL

BRAKES-AIR

GENERAL

CONTENTS

PRINTED IN UNITED STATES OF AMERICA

GENERAL INSTRUCTIONS

Air brake equipment on trucks and truck-tractors provides a means of controlling the brakes through the medium of compressed air. Air brake equipment consists of a group of devices; some maintain a supply of compressed air, some direct and control the flow of compressed air and others transfer the energy of compressed air into the mechanical force and motion necessary to apply the brakes. Different types and sizes of devices are in use on different types of vehicles to meet operating requirements.

The components used to make up a typical dual air system on a chassis are listed in this section with a brief description, operation, service checks and maintenance procedures. Disassembly and reassembly instructions are provided for some components.

CAUTION

Whenever any component is serviced or removed from the air system, be sure to set the parking brake and/or block the vehicle to prevent it from moving while the service is being performed.

The various components which apply directly to the Antilock System, as well as trouble shooting the system, will be found in ANTILOCK section.

LUBRICANT SPECIFICATIONS

Throughout the text whenever reference is made to a particular lubrication note or a particular item number, refer to the following list of item numbers and use the lubricant specified.

Item 1

IH 251H EP grease or equivalent to NLGI #2 multi-purpose lithium grease (same as BW 226M and 204M lubricant).

Item 2

Bendix 239277 (57 g 20o) molybdenum disulfide lubricant in liquid carrier. A lubricant suited for O-ring powder suspended in synthetic lubricant (polyalkylene glycol derivative) and rubber parts as well as metal lubrication, especially at low temperatures.

Item 3

Bendix 291126 (7.08 g 1/4 oz) or BW 291127 (57 g 2 oz) silicone grease intended primarily for dynamic lubrication between oil resistant rubber seals and metal parts. Meets MIL-L-4343A requirements. Can be used in serviceable range of -54 C (-65 F) to +426 C (+800 F). Causes less swelling and hardness change of rubber parts than normally encountered with petroleum based lubricants (approved source: Dow Corning Corporation -DC-55 pneumatic grease).

LEAKAGE TESTS

In some cases where leakage tests are performed on various components, a soap bubble test can be made to determine if the items need repairs. However, to assist in locating any leakage at connections or at any components, we suggest that a Leak Detector Tester (SE-2326) be used to locate any air leaks.

With special attachments contained in the tester a very small air leak can be detected easily; for example, in a confined area where a brush with soap is obstructed.

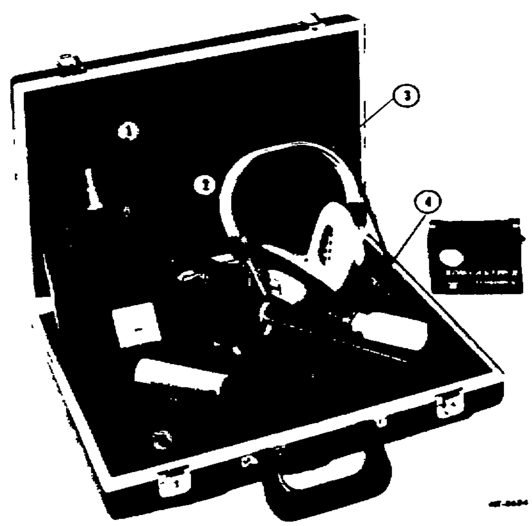


Fig. 1 Leak Defector Tester (SE-2326)

1	Amplifier	4	Sound Concentrator
2	Contact Probe	5	Hand Probe
3	Headphone		

BRAKES-AIR

GOVERNOR

CONTENTS

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BENDIX D-2 TYPE

DESCRIPTION

The air compressor governor along with the compressor unloader mechanism automatically limits system pressure to a predetermined range by opening unloading valves and stopping compression when system pressure has been built up to maximum pressure limit and by closing unloading valves and starting compression when system pressure has dropped to minimum pressure limit.

The D-2 governor has a piston upon which air pressure acts to overcome the pressure setting spring and control the inlet and exhaust valve to either admit or exhaust air to or from the compressor unloading mechanism.

Type D-2 governors can be attached to the compressor or mounted remotely. They are adaptable to either mounting. Connections in this system are to the reservoir and compressor unloading ports. They also have an exhaust port.

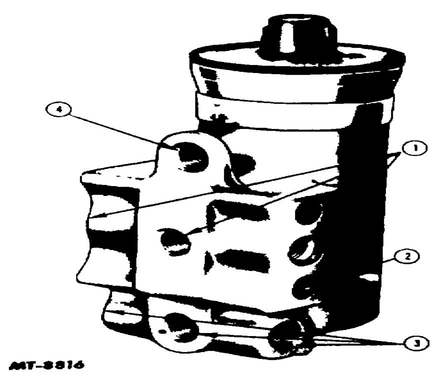

Fig. 1 Type D-2 Governor

1	Unloader Ports	3	Reservoir Ports
2	Mounting Holes	4	Exhaust Port

OPERATION (Fig. 2)

Reservoir air pressure enters the governor at one of its reservoir ports and acts on the area of the piston and beneath the inlet and exhaust valve. As the air pressure builds up, the piston moves against the resistance of the pressure setting spring. The piston and Inlet and exhaust valve move up when the reservoir air pressure reaches the cut-out setting of the governor.

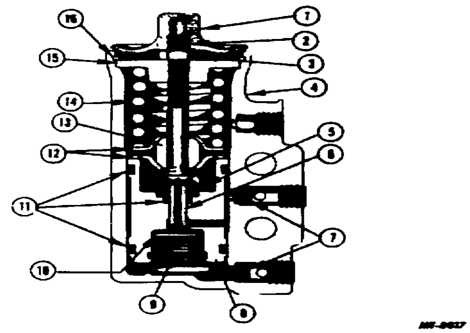

Fig. 2 Sectional View of Type D-2 Governor

1 Cover
2 Adjusting Screw
3 Lock Nut
4 Body
5 Exhaust Stem Spring
6 Exhaust Stem
7 Filters
8 Piston
9 Inlet-Exhaust Valve Spring
10 Inlet and Exhaust Valve
11 Grommets
12 Lower Spring Seats
13 Spring Guide
14 Pressure Setting Spring
15 Upper Spring Seat
16 Retaining Ring

The exhaust stem seats on the inlet and exhaust valve and then the inlet passage opens. Reservoir air pressure then flows by the open inlet valve, through the passage in the piston and out the unloader port to the compressor unloading mechanism. The air, besides flowing to the compressor unloading mechanism, also flows around the piston and acts on the additional area of the piston, assuring positive action and fully opening the inlet valve.

As the system reservoir air pressure drops to the cut-in setting of the governor, the force exerted by the air pressure on the piston will be reduced so that the pressure setting spring will move the piston down. The inlet valve will close and the exhaust will open. With the exhaust open the air in the unloader line will escape back through the piston, through the exhaust stem and out the exhaust port.

SERVICE CHECKS

Operating Tests

Start the vehicle engine and build up air pressure in the air brake system and check the pressure registered by a dash or test gauge at the time the governor cuts out, stopping the compression of air by the compressor. The cut-out pressure should be in accordance with the piece number of the governor. The more common cut-out pressure is 862 ± 35 kPa (125 ± 5psi).

With the engine still running make a series of brake applications to reduce the air pressure and observe at which pressure the governor cuts in the compressor. As in the case of the cut-out pressure, the it-in pressure should be in accordance with the governor piece number. Common cut-in pressure is 690 to 717 kPa (100 to 105 psi). Never condemn or adjust the governor pressure settings unless they are checked with an accurate test gauge or a dash gauge that is registering accurately. If the pressure settings of the governor are inaccurate or it is necessary that they be changed, procedure is as follows.

First, unscrew the cover at the top of the governor. Next, loosen the adjusting screw lock nut. With a screwdriver the adjusting screw is turned counterclockwise to raise the pressure setting and the screw is turned clockwise to lower the pressure setting. After the adjustment is completed, the adjusting screw lock nut should be tightened to lock adjustment.

NOTE: 1/4 turn will change the setting approximately 28 kPa (4 psi). Any governor requiring more than a 360° adjustment should be cleaned and inspected.

LEAKAGE TESTS

Leakage checks on the D-2 governor are made t its exhaust port in both cut-in and cut-out positions. In the cut-in position check exhaust port for inlet valve leakage by applying a soap solution at the port. Leakage could also be past the bottom piston grommet. In the cut-out position check the exhaust port to determine leakage at the exhaust valve seat or stem grommet. In this position leakage could also be past the upper piston grommet.

Leakage in excess of 25 mm (1 in.) soap bubble in 3 seconds is not permissible in either of the foregoing tests. If excess leakage is found, the governor must be repaired or replaced.

REMOVE

Apply parking brakes or block wheels to prevent vehicle from moving.

Drain air brake system.

If governor is compressor-mounted type, disconnect reservoir air line. If remote-mounted governor, disconnect both the unloader and reservoir air lines.

Remove governor mounting bolts, then governor.

INSTALL

If compressor-mounted type governor, clean mounting pad on both compressor and governor block. Clean connecting line or lines. Also be sure compressor unloading port is clear and clean.

If the governor is being mounted remotely, it should be positioned so that its exhaust port points down. It should be mounted higher than the compressor so that its connecting lines will drain away from the governor.

Install governor.

If compressor-mounted type, use a new governor mounting gasket.

Connect air lines to governor. Test governor as outlined under SERVICE CHECKS. **PAGE 2304**

DISASSEMBLY

Clean governor exterior of road dirt. and grease using a good cleaning solvent and brush.

Unscrew the top cover.

With a pair of retaining ring pliers remove the spring assembly retaining ring.

Remove the adjusting screw and spring assembly.

Remove the lock nut, then the hex-shaped upper spring seat from the adjusting screw.

Remove the pressure setting spring, lower spring seat, spring guide and the other lower spring seat from the adjusting screw.

Remove the exhaust stem and its spring from the top of the piston.

With the body in the inverted position tap it lightly and the piston should fall out.

Remove the inlet and exhaust valve spring and the valve from the piston.

Remove the two piston grommets and with a hooked wire remove the exhaust stem grommet.

Clean or remove the unloader and reservoir port filters.

CLEANING AND INSPECTION

Clean all metal parts in a good cleaning solvent.

Wipe rubber parts dry.

Inspect body for cracks or other damage. Be particularly careful that the body air passages, the filters, exhaust stem and piston are not obstructed.

Check springs for cracks, distortion or corrosion.

Replace all parts not considered serviceable during these inspections.

REASSEMBLY, ADJUST AND TEST

Prior to assembly, lubricate the lower body bore, the top of the piston, the piston grooves, piston grommets, a piston setting spring guide and adjust screw.

Install the exhaust stem grommet in its groove in the stem bore of the piston.

Drop the inlet and exhaust valve into place at the bottom of the piston.

Install the inlet valve spring with its narrow end against the valve. Press the spring down until the large coiled end snaps into the groove inside the piston.

Position the exhaust stem spring over the exhaust stem. Then carefully press the stem into the stem bore of the piston.

Install the piston in the body.

Install one lower spring seat, spring guide, the other lower spring seat, pressure setting spring and the hex-shaped upper spring seat on the adjusting screw, in that order. Screw the upper spring seat down until the dimension from the top of the seat to the bottom of the stem head is approximately 47.6 mm (1-7/8 in).

Install the lock nut.

Before placing the adjusting screw and stem assembly in the governor body, check to be sure the exhaust stem and its spring are in place in the piston.

Install the adjusting screw and spring assembly retaining ring.

At this point make the adjustment a outlined under SERVICE CHECKS. **PAGE 2304**

After the adjustment is made, the top cover should be screwed on tightly until it seals the body against the entrance of any foreign matter.

If necessary, install new filters in the reservoir and unloader ports. These cup-shaped filters can be installed with head of a pencil.

Perform operating and leakage tests as outlined in SERVICE CHECKS section when checking rebuilt governor. **PAGE 2304**

MAINTENANCE

40,000 km or 25,000 MILES

Clean or replace governor filters. If cleaning use a cleaning solvent which is known to have no detrimental effect on metal or rubber material.

160, 000 km or 100,000 MILES

Disassemble the governor and clean and inspect all parts and replace as necessary.

BRAKES-AIR

RESERVOIR, DRAIN COCK, SAFETY VALVE, PRESSURE GAUGE, LOW PRESSURE INDICATOR, STOP LIGHT SWITCH, RESERVOIR AUTOMATIC DRAIN VALVE

CONTENTS

Page 2308 DELETED

RESERVOIR

DESCRIPTION

The air reservoir (air tank) function is to provide a volume of compressed air used in braking the vehicle.

There are three reservoirs on the brake system. These tanks are supply reservoir and secondary and primary reservoirs. The primary reservoir is the air source for the rear brakes and the front brakes are supplied by the secondary air tank. In some instances, the supply reservoir and secondary reservoir may be in the same tank with a separation inside the tank (Fig. 1).

Another function of a reservoir is to provide a place where the air, heated during compression, may cool and cause the oil and water vapors to condense.

The combined volume of all service reservoirs and supply reservoirs are 12 times the combined volume of all service brake chambers at maximum travel of the pistons or diaphragms. The size of air tanks should never be altered without IH Engineering approval.

The reservoirs should be completely drained daily. If an automatic drain device is used, as shown in Fig. 1, the automatic drain should be checked periodically to determine if it is functioning properly. When manually draining tanks, satisfactory draining is only accomplished by leaving the drain cocks open after all air has escaped and all drainage has stopped.

Reservoirs are tested against a 2068 kPa (300 psi) and treated on the inside with a rust preventive.

SERVICE CHECKS

Leakage Tests

With the air brake system charged, use Leak Detector Tester (SE-2326) to check for leakage on outside surfaces of reservoirs. If any leakage is found, replace the reservoir.

Inspection

Inspect inside and outside surfaces for damage or corrosion. A small flashlight is helpful when inspecting the interior. If damage or corrosion is found that would weaken the reservoir, replace the reservoir.

Moisture taken in with the air through the compressor Inlet valve collects in the reservoirs and necessitates draining the reservoirs daily in cold weather and every week in warm weather by opening the drain cock located on the bottom. Be sure to close-the drain cocks after all moisture has been removed.

MAINTENANCE

Drain air reservoirs regularly as required. Local conditions govern frequency. In dry climates, for example, once a month may be sufficient, while in humid areas it may be necessary to drain reservoirs daily.

When draining the air reservoirs, open the drain cock and let the air bleed off. Be sure to leave the cock open until all drainage stops.

DRAIN COCK

DESCRIPTION

Drain cocks have a brass body fitted with a tapered brass key. The drain cock is open when the handle is parallel to the body and closed when the handle is at right angles to the body. Drain cocks are installed In the bottom of each reservoir (Fig. 1) in the air brake system to provide a convenient means of draining the condensation which normally collects In the reservoirs.

Always open a drain cock by hand. Never strike the handle with a hammer or any other instrument, as the cock will be damaged and leakage will develop.

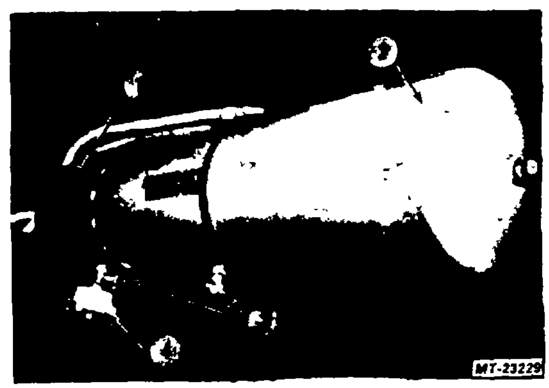

Fig. 1 Two Compartment Reservoir and Drain Cocks

1 Supply Reservoir
2 Secondary Reservoir
3 Drain Cocks
4 Automatic Drain Valve

SERVICE CHECKS

1. With air brake system charged, test with soap suds for leakage past the key. Also check for leakage through the body by coating the outside of the drain cock with soap

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suds. Leakage in excess of a 77 mm (3") soap bubble in 3 seconds is not permissible.

2. Leakage is caused by dirty or scored key or body. Leakage due to dirt is corrected by cleaning parts and applying a thin coating of LUBRICANT.

Leakage due to a scored key or body cannot be repaired and the drain cock must be replaced.

SAFETY VALVE

DESCRIPTION

The purpose of the safety valve is to protect the air brake system against excessive air pressure. Should the air pressure in the air brake system rise above the setting of the safety valve at 934 kPa (150 psi), the valve opens and permits pressure above 934 kPa (150 psi) to be exhausted. It is located on the supply reservoir.

The safety valve is a piston type valve (Fig. 2). The piston is equipped with an O-ring type seal which seats in the body of the valve.

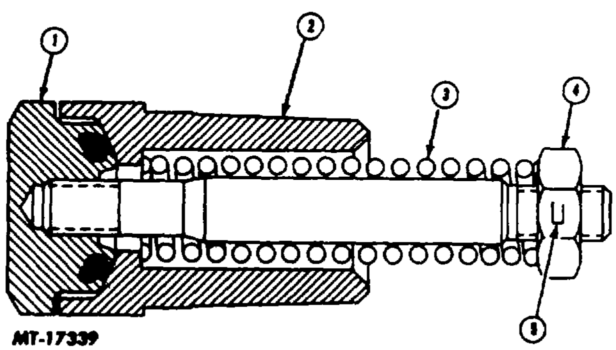

Fig. 2 Sectional View of Piston Type Safety Valve

1	Piston and Shaft Assembly	3	Spring
		4	Nut
2	Body	5	Stake Lock

MAINTENANCE

Once each year or every 160,000 km (100,000 miles). the safety valve should be removed and thoroughly cleaned.

SERVICE CHECK
Leakage Test

Leakage at the piston in the body should not exceed a 77 mm (3 in.) soap bubble in 3 seconds. If air leakage is excessive the valve must be replaced since it is only serviced as a complete component.

The safety valve is preset to "blow off" at approximately 934 kPa (150 psi).

Since the safety valve must be removed to perform any adjustments, it is suggested that the valve be replaced when any defect is detected.

CAUTION

When replacing the safety valve be sure to drain all air from the supply reservoir, to prevent bodily injury when the valve is removed. Draining of the primary and secondary reservoirs is not required since they are protected by check valves.

AIR PRESSURE GAUGE

DESCRIPTION

The purpose of the air pressure gauge is to register the amount of reservoir air pressure in the air system. While air pressure gauges of this type are commercially accurate, they must never be confused with or substituted for test air gauges, which are intended primarily for accurately checking air pressure in the air brake system.

The air pressure gauge may be either two gauges or a single gauge with two indicators as Illustrated (Fig. 3).

An air pressure gauge is located in both the primary and secondary brake systems so that the actual air pressure in both systems is indicated to the operator of the vehicle.

Fig. 3 Air Pressure Gauge

Only test gauges known to be accurate are to be used for checking brake valve delivery pressures, governor pressure settings and other tests. Test gauges differ from ordinary dash gauges in respect to material and workmanship. Due to these differences they are more accurate over entire range and maintain their accuracy over longer periods.

After initial starting of engine, if air gauge shows that one circuit has no air pressure nor a noticeable increase in air pressure within a reasonable length of time (30 to 60 seconds) and the low pressure switch and low pressure light will not shut off, this indicates an open drain cock or a failure in the brake system.

It is not compulsory but it is advisable that vehicles be inspected to be sure that the air gauges are properly connected. The primary system should be connected to the green needle and secondary system to red needle. This can easily be checked by charging the air system, bleeding off the primary system (rear brake reservoir) and the green needle should drop. If the green needle does not drop the air lines on the gauge should be changed. All chassis would be assured that they are connected in the same manner and identification of both systems will be uniform.

SERVICE CHECKS

1. Check the air gauge for accuracy. The simplest way do do this is to compare the pressures registered by the gauge over its normal pressure range with the pressure registered by a test gauge known to be accurate.

2. A gauge which loses its accuracy must be replaced. The continued use of a dash gauge showing an error of more than 35 kPa (5 psi) is not recommended.

LOW PRESSURE INDICATOR(LP-3 TYPE)

DESCRIPTION

The low pressure indicator (Fig. 4) is a safety device designed to give an automatic warning whenever the air pressure in the primary or secondary air brake system is below approximately 483 kPa (70 psi). Operating as an air-controlled switch of an electrical circuit, the low pressure indicator automatically sounds a buzzer when the air pressure drops too low. The warning will be both visible (light) and audible (buzzer).

The nominal pressure setting of 483 kPa (70 psi) is subject to a tolerance of plus or minus 41 kPa (6 psi) so that the actual operating pressure of the low pressure indicator may vary between 524 kPa (76 psi) maximum to 441 kPa (64 psi) minimum.

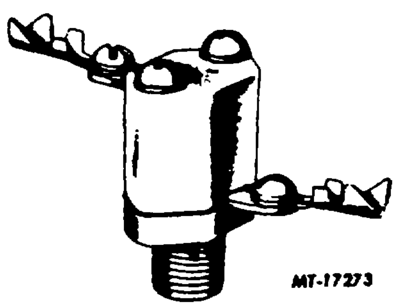

Fig. 4 Exterior View of Low Pressure Indicator

OPERATION (Fig. 5)

To describe the operation, we shall assume Low Pressure Indicator is set for 483 kPa (70 psi). Setting of indicator is marked on a label on valve body. When air pressure at supply port and under the diaphragm is above 483 kP (70 psi), electrical contacts remain open because the force exerted by air pressure underneath the diaphragm overcomes force exerted the spring above the diaphragm.

When air pressure below the diaphragm drop below 483 kPa (70 psi), the spring exerts a for which is greater than the force exerted by the air pressure below the diaphragm. This cause the piston to move and allow the electrical contacts to close. This completes or closes electrical circuit to warning device, warning drive of low air pressure in the system.

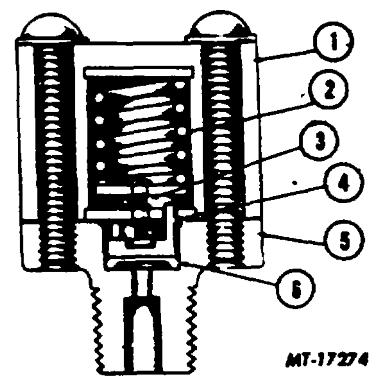

Fig. 5 Cross Sectional View of Low Pressure Indicator

1	Cover	4	Piston
2	Spring	5	Body
3	Contact Points	6	O-Ring Diaphragm

MAINTENANCE

Every three months or after 40,000 km (25,000 miles), check electrical connections.

Every year or 160,000 km (100,000 miles), perform SERVICE CHECKS. If diaphragm is ruptured, replace complete assembly.

SERVICE CHECKS

Operating Test

Operation of the low pressure indicator may be checked with ignition switch on, then by reducing the reservoir pressure and being sure that the contacts close when the reservoir pressure

BRAKES-AIR

CHECK VALVES,

CONTENTS

Pages 2312 through 2316 DELETED
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Page 2316 DELETED

ONE WAY CHECK VALVE

DESCRIPTION

The one-way check valves (Fig. 1 and 2) are used to permit passage of air pressure through the valve in one direction only as indicated by the arrow on the side of the valve. They are installed in both primary and secondary reservoirs to maintain the air supply in both reservoirs if an air loss should occur ahead of the valve.

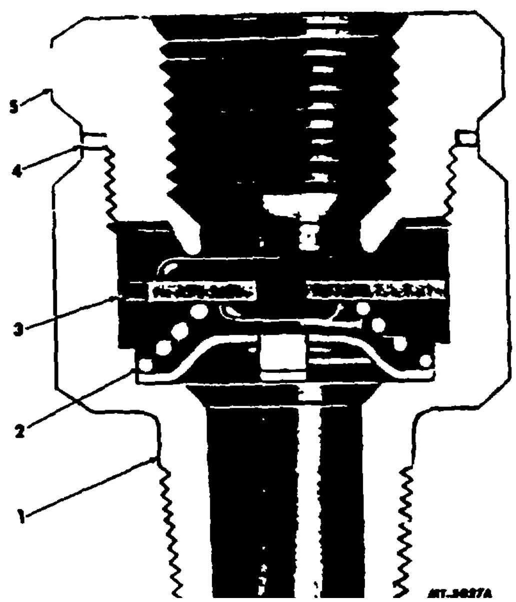

Fig. 1 Cross Sectional View of One-Way Check Valve

1	BODY, Valve	4	WASHER, Cap-to-Body
2	SPRING	5	CAP, Valve
3	SEAL, Assembly		

The 90° angle check valve shown in Fig. 2 is used in applications where clearance conditions exist on various chassis.

OPERATION

Air flow in direction of arrow moves the seal from its seat and the air flow is unobstructed. Flow in reverse direction is prevented by seating of the seal by the upstream air pressure and assistance of spring.

MAINTENANCE

Once each. year or every 160,000 km (100,000 miles) check operation (see SERVICE CHECKS).

SERVICE CHECKS

Depending upon installation, it may be easier or necessary to completely remove check valve so that the following checks may be made. If checking valves at primary and secondary reservoirs, bleed air supply reservoir and disconnect air inlet to valve and proceed a follows.

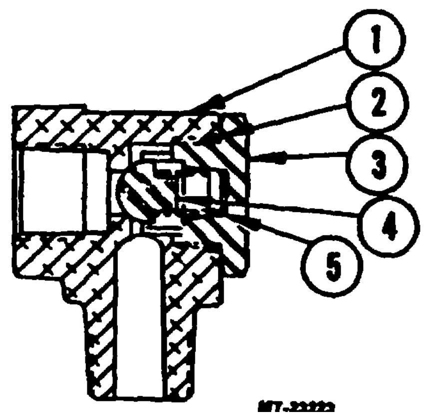

Fig. 290° Angle Check Valve

1	Body	4	Valve
2	"O" Ring	S	Spring
3	Cap		

> **CAUTION**
> Be sure to set parking brake or block wheels to prevent vehicle from moving.

With air pressure present at outlet side of check valve and inlet open to atmosphere, use leak detector tester to test for leakage. Leakage should not exceed 25.4 mm (1 in.) soap bubble in S seconds, slight leakage is permitted. However, if valve leaks excessively, the valve should be repaired or replaced.

REMOVE

1. Apply parking brake or block wheels to prevent vehicle from moving.
2. Drain all air reservoirs.
3. Disconnect air lines and remove check valve.

REINSTALL

1. Check and if required, clean or replace air line to valve.

2. Install valve making certain that it is installed correctly. Arrow on outside of body indicates direction of air flow through valve.

3. Check valve for leakage.

DOUBLE CHECK VALVE

DESCRIPTION

Double check valves or two-way check valves (Fig. 3) are used in an air brake system where it is necessary to automatically direct the flow of air pressure into a common line from either of two other lines.

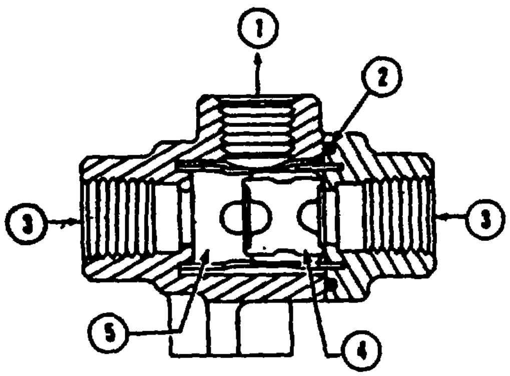

Fig. 3 Sectional View of Double Check Valve Shuttle Type

1	Delivery	4	Shuttle Valve
2	"O" Ring	5	Shuttle Guide
3	Supply		

OPERATION

As air pressure enters either end of the double check valve (inlet port) the movable shuttle responds to the air pressure and seals the line on opposite inlet port, but permitting air pressure to flew out the delivery (outlet) port. The same action takes place if air pressure on one side of shuttle is higher 'than that on the other side. It is not necessary for the -cavity of one side of shuttle to be exhausted for valve to operate. Double check valves are designed so it is impossible for shuttle to block outlet port.

MAINTENANCE

Once each year or every 160,000 km (100,000 miles) remove, disassemble, clean and inspect all parts. Install new parts if signs of wear or deterioration are apparent.

SERVICE CHECKS

Due to the various applications of double check valves it is best to bench test the valve using two separately controlled air supplies and connected to inlet pots.

1. Install an accurate test gauge in outlet port or in a line from outlet port.

2. Apply and release air to one inlet port and note that gauge registers application and release.

3. Repeat application and release of air to other inlet port.

4. Leakage check is performed at inlet p orts by:

   a. Disconnecting line from one inlet port.
   b. Applying air to other inlet port. If soap solution is used to check leakage, leakage should not exceed 25.4 mm (1 in.) bubble in S seconds.

   c. Repeat step "b" by applying air to other inlet port while checking opposite inlet port for leakage.

5. If check valve does not meet requirements, it should-either be replaced or disassembled and repaired using new parts.

DISASSEMBLY

1. Remove end cap from valve.

2. Remove O-ring.

3. Remove shuttle (piston) and guide.

CLEANING AND INSPECTION

1. Clean all metal parts in cleaning solvent.

2. Inspect all parts for signs of wear or deterioration. Replace all parts not considered serviceable.

3. Replace all rubber parts.

REASSEMBLY

1. Install shuttle guide and shuttle.

2. Position new O-ring in end cap.

3. Install end cap.

4. Perform operating and leakage as described in SERVICE CHECKS.

BRAKES-AIR

BRAKE VALVE

CONTENTS

Pages 2321 through 2326 and 2328 DELETED

BENDIX TYPE E7

DESCRIPTION

The brake valve is the control unit of the air brake system. It provides the operator of the vehicle a means of applying or releasing the vehicle brakes. The brake valve can either be treadle operated or fitted with a suspended pedal lever.

Brake valves are equipped with two separate supply and delivery circuits for service and emergency braking, providing the driver with a graduated control for applying and releasing the vehicle brakes.

The primary circuit is that portion of the valve between the spring seat which contacts the plunger and the relay piston. The secondary circuit is that portion between the relay piston and exhaust cavity.

The primary circuit is similar in operation to a standard single circuit air brake valve and under normal operating conditions the secondary circuit portion is similar in operation to the relay valve.

Both the primary and secondary circuits of the brake valve use a common exhaust check valve.

OPERATION

The text and illustrations contained herein actually pertain to the treadle type brake valve. The treadle and suspended type valves differ in that the suspended pedal valve is turned over and the valve body is equipped with an exhaust port at a 90 degree angle at the top to exhaust air out the side of the cab.

Applying Normal Operation - Primary Circuit Portion of Bake Volvo (Fig. 3)

When the brake pedal is depressed, the plunger exerts force on the spring seat, rubber graduating spring and primary piston. The primary piston which contains the exhaust valve seat, closes the primary exhaust valve. As the exhaust valve closes, the primary inlet valve is moved off its seat allowing primary air pressure to flow out the primary delivery port.

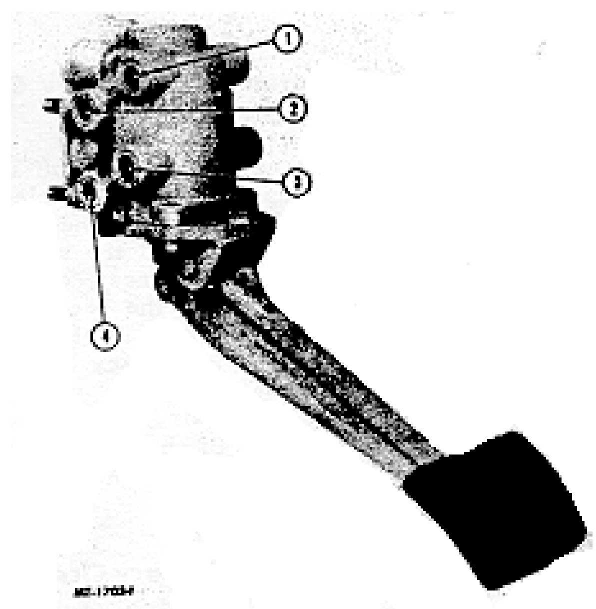

Fig. 2 Suspended Type Brake Valve

1. Primary Delivery
2. Secondary Delivery
3 Secondary Supply
4 Primary Supply

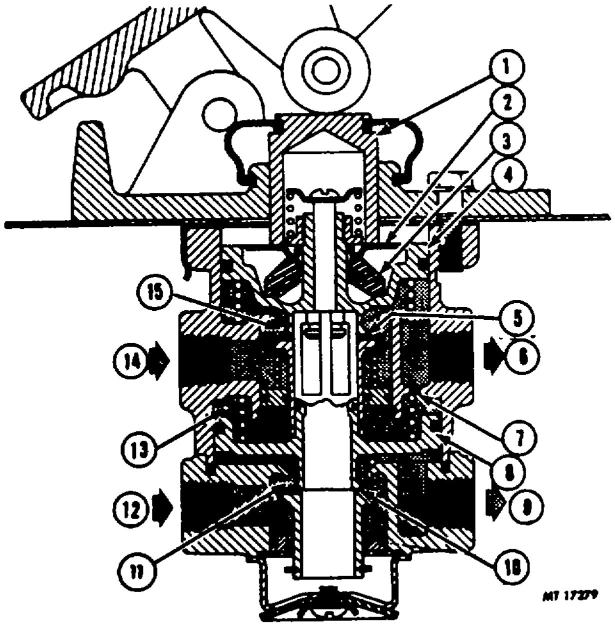

Fig. 3 Brake Valve Applied - Normal Operation

1 Plunger
2 Spring Seat
3 Rubber Graduating Spring
4 Primary Piston
5 Primary Exhaust Valve Closed
6 Primary Delivery
7 Two Bleed Passages
8 Relay Piston
9 Secondary Delivery
10 Secondary Exhaust Valve Closed
11 Secondary Inlet Valve Open
12 Secondary Supply
13 Relay Cavity
14 Primary Supply
15 Primary Inlet Valve Open

Applying Normal Operation - Secondary Circuit Portion of Bake Valve (Fig. 3)

When the primary inlet valve is moved off its seat, air is permitted to pass through the bleed passage and enters the relay cavity. The air pressure moves the relay piston and the relay piston, which contains the exhaust seat, closes the secondary exhaust valve. As the secondary exhaust valve closes, the secondary inlet valve is moved off its seat allowing secondary air pressure to flow out the secondary delivery port. Because of the small volume of air required to move the relay piston, action of the secondary circuit portion of the valve is almost simultaneous with the primary circuit.

Application - Loss of Air In Secondary Circuit

Should air be lost in the secondary circuit, the primary circuit portion will continue to function as described under "Normal Operation
- Primary Circuit."

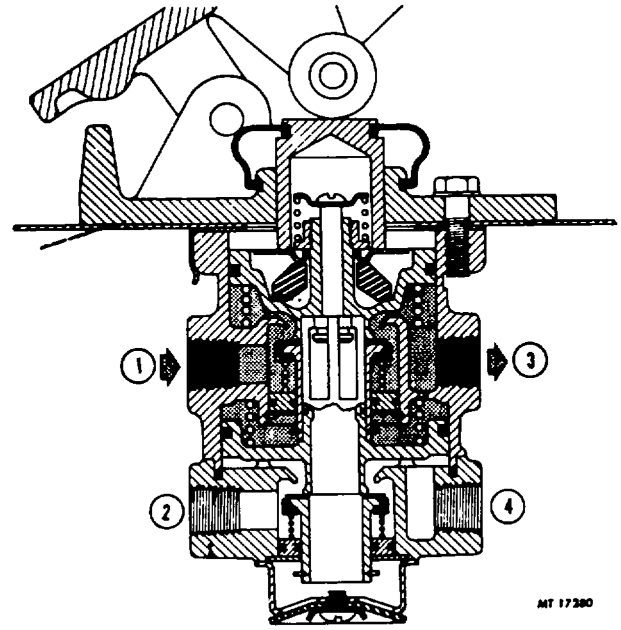

Fig. 4 Brake Valve Applied - Los of Air In Secondary Circuit

1 Primary Supply
2 No Air In Secondary Circuit
3 Primary Delivery
4 Secondary Delivery

Application - Loss of Air In Primary Circuit (Fig. 5)

Should air be lost in the primary circuit, the function will be as follows. As the brake pedal is depressed and no air pressure is present in the primary circuit supply and delivery ports, the primary piston will mechanically move the relay piston allowing the piston to close the secondary exhaust valve and open the secondary inlet valve and allow air pressure to flow out the secondary delivery port.

Balanced - Primary Circuit of Brake Valve (Fig. 6)

When air pressure delivered to the brake actuators and air pressure in the cavity of the delivery side of the primary piston equals the mechanical force of the brake pedal application, the primary piston will move and the primary inlet valve will close, stopping the further flow of air from the primary supply line through the valve. The exhaust valve remains closed preventing any escape of air through the exhaust port.

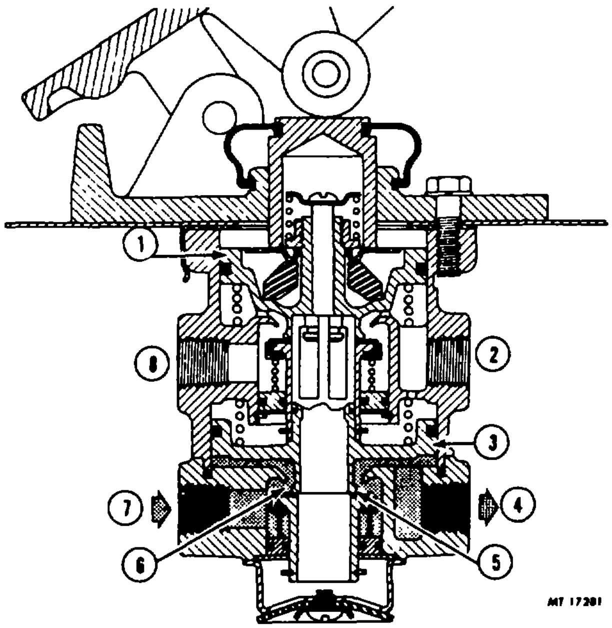

Fig. 5 Brake Valve Applied - Loss of Air In Primary Circuit

1 Primary Piston
2 Primary Delivery
3 Relay Piston
4 Secondary Delivery
5 Secondary Exhaust Valve Closed
6 Secondary Inlet Valve Open
7 Secondary Supply
8 No Air in Primary Circuit

Balanced - Secondary Circuit of Broke Valve (Fig. 6)

When the air pressure on the secondary side of the relay piston approaches that being delivered on the primary side of the relay piston, the relay piston moves closing the secondary inlet valve and stopping further flow of air pressure from the supply line through the valve. The exhaust remains closed as the secondary supply pressure balances the secondary delivery pressure.

When applications in the graduating range are made, a balanced position in the primary portion is reached as the air pressure on the delivery side of the primary piston equals the effort exerted by the driver’s foot on the pedal or treadle.

A balanced position in the secondary portion is reached when air pressure on the secondary side of the relay piston closely approaches the air pressure on the primary side of the relay piston.

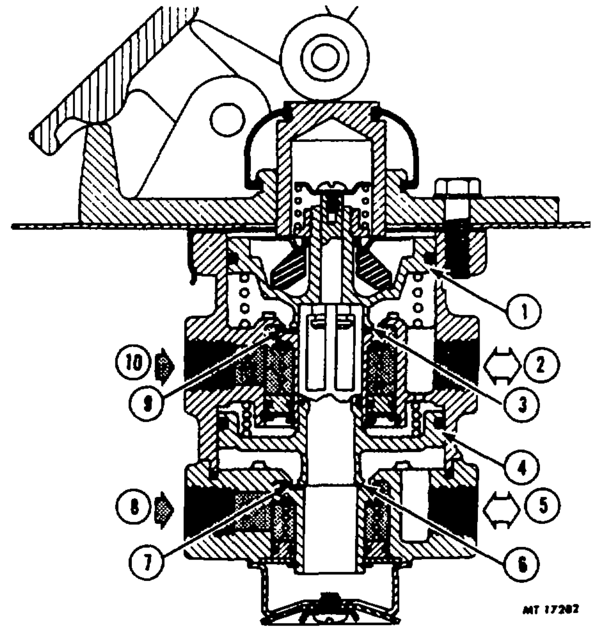

Fig. 6 Brake - Valve In Balanced Position

1 Primary Piston
2 Primary Delivery
3 Primary Exhaust Valve Closed
4 Relay Piston
5 Secondary Delivery
6 Secondary Exhaust Valve Closed
7 Secondary Inlet Valve Closed
8 Secondary Supply
9 Primary Inlet Valve Closed
10 Primary Supply

When the brake pedal or treadle is fully depressed, both primary and secondary inlet valves remain open and full reservoir pressure is delivered to the actuators.

Releasing - Primary Circuit of Broke Valve (Fig. 7)

With the brake pedal released, mechanical force is removed from the spring seat, rubber graduating spring and primary piston. Air pressure and spring load move the primary piston, opening the primary exhaust valve, allowing air pressure in the primary delivery line to exhaust out the exhaust port.

Releasing - Secondary Circuit of Brake Valve (Fig. 7)

With the brake pedal released, air is exhausted from the primary side of the relay piston. Air pressure and spring load move the relay piston, opening the secondary exhaust valve, allowing air pressure in the secondary delivery line to exhaust out the exhaust port.

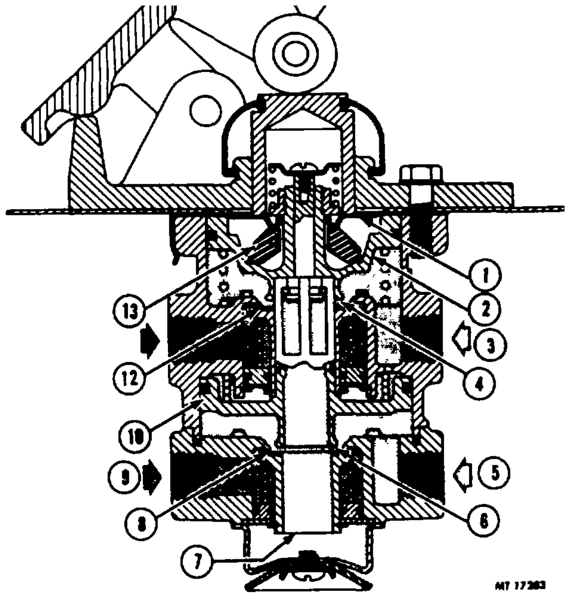

Fig. 7 Brake Valve Releasing

1 Spring Seat
2 Primary Piston
3 Primary Delivery
4 Primary Exhaust Valve Open
5 Secondary Delivery
6 Secondary Exhaust Valve Open
7 Exhaust Port
8 Secondary Inlet Valve Closed
9 Secondary Supply
10 Relay Piston
11 Primary Inlet Valve Closed
12 Primary Supply
13 Rubber Graduating Spring

MAINTENANCE

Every Three Months or 32,000 km (20,000 Miles)

Clean any accumulated dirt, gravel or foreign matter away from heel of treadle, plunger boot and mounting plate.

Lubricate plunger, roller, roller pin and hinge pin using Item 1 in LUBRICANT SPECIFICATIONS. Check rubber plunger boot for cracks, holes or deterioration and replace If required. Check mounting plate for integrity.

Free pedal travel should be checked as follows. Be sure plunger is in contact with spring seat. The stop button should be adjusted so that the roller and plunger just contact.

Clean exhaust port.

Every Year or 160,000 km (100,000 Miles)

Disassemble brake valve; clean and inspect all parts. Install new parts where they are found to be worn or damaged.

SERVICE CHECKS

Operations

Check delivery pressure of both primary and secondary systems using test gauges known to be accurate. Depress pedal or treadle to several positions between the fully released and fully applied positions and check the delivered pressure on the test gauges to see that it varies proportionately with the movement of the brake pedal.

After a full application is released, the reading on test gauges should fall off to zero promptly. It should be noted that the primary system delivery pressure will be about 14 kPa (2 psi) greater than the secondary system delivery pressure with both supply reservoirs at the same pressure. This is normal for these valves.

IMPORTANT

A change in vehicle braking characteristics or a low pressure warning may indicate a malfunction in one or the other brake systems and, although vehicle should not be operated until necessary repairs have been made and both braking systems, including pneumatic and mechanical devices, are operating normally. Always check vehicle brakes after performing brake work and before returning the vehicle to service.

Leakage Test

Make and hold a high pressure application. Check the exhaust port for leakage. Using a soap solution , a 25 mm (1") soap bubble in 3 seconds is permitted.

If the brake valve does not function as described, the valve should either be replaced or repaired.

REMOVE

1. Apply parking brake or block wheels to prevent vehicle from moving.

2. Drain all air from all reservoirs.

3. Disconnect all supply and delivery lines at brake valve. Mark all air lines in relation to valve to assist reconnecting lines.

4. Remove fittings from valve. Mark these fittings also.

5. Remove valve from chassis.

   a. Suspended Pedal Valves

      Remove nuts on exterior side of dash and remove valve assembly.

   b. Treadle Type Valves

      Remove brake valve and treadle assembly by removing three capscrews on outer bolt circle of mounting plate. Basic valve alone may be removed by removing three capscrews on inner bolt circle.

REINSTALL

Installation of brake valve is basically the reverse of removal. Be sure to make service checks before returning vehicle to service.

DISASSEMBLY

Treadle Type Brake Valve (E6)

Refer to Fig. 8 for numbers in parenthesis.

1. If the entire brake valve and treadle assembly was removed from the vehicle, remove the three capscrews securing the treadle assembly to the basic brake valve.

2. Remove screw (1) securing the exhaust diaphragm (3) and washer (2) to exhaust cover (4).

3. Remove four screws that secure exhaust cover (4) to lower body (10).

4. Remove secondary inlet and exhaust valve assembly (items 5 through 9) from lower body. Disassembly of secondary inlet and exhaust valve assembly is not required since it is only serviced as an assembly.

5. Remove four hex head capscrews securing the lower body (10) to upper body (11) and separate the bodies.

6. Remove the rubber seal ring (12) from the lower body.

7. Apply thumb pressure to primary piston (16), lift out and up on the three lock tabs of primary piston retainer (19).

8. Using a 10 mm (3/8") wrench, hold ENSA nut on threaded end of stem on top of primary piston. Insert a screwdriver in exhaust passage through center of valve and engage slotted head of the stem (23).

CAUTION

Before proceeding with the disassembly (refer to Fig. 8), note the ESNA nut and stem are used to contain primary piston return spring (17), stem spring (21) and relay piston spring (14). Combined force of these springs is approximately 222 N (50 lbf) and care must be taken when removing the ESNA nut as the spring forces will be released. It is recommended that primary piston and relay piston be manually or mechanically contained while nut and stem are being removed to prevent bodily injury.

9. Rotate the screwdriver counterclockwise and remove stem (23), stem spring (21), spring guide (22) and ESNA nut.

10. Remove relay piston (13), relay piston spring (14), primary piston and primary piston return spring from the upper body.

11. Disassemble primary piston by rotating the spring seat nut (24) counterclockwise. Separate spring seat nut, spring seat (20), rubber spring (18) and remove piston O-ring.

12. Remove large and small O-rings from relay piston.

13. Remove retaining ring securing primary inlet and exhaust valve assembly (15) in upper body and remove valve assembly. Do not disassemble primary inlet as it is only serviced as an assembly.

CLEANING AND INSPECTION

Wash all metal parts in cleaning solvent and dry them. Inspect all parts for excessive wear or deterioration. Inspect valve seats for nicks or burrs. Check springs for cracks or corrosion. Replace all rubber parts and any part not found to be serviceable during inspeciton.

DISASSEMBLY

Suspended Pedal Type Valve (E7)

Refer to Fig. 9 for numbers in parenthesis.

1. Remove three capscrews and pedal assembly.

2. Apply force on retainer, disengage locking tabs from body and remove retainer (7).

3. Grasp lock nut (S) of lower static piston assembly (10) with pliers and pull piston assembly from body (12).

4. Fasten a hook from a 152 mm (6") piece of .125 mm (1/8') diameter wire (approx.), bending one end 90 degrees at a length 12.7 to 19.mm (1/2' to 3/4') from end of wire. Insert hook end in bore of body and through secondary inlet valve exhaust bore hooking onto valve. Pull firmly and remove upper static piston (15) assembly with secondary inlet and exhaust valve (16).

5. Apply firm pressure on spring seat (6) which will compress primary piston spring (11). Locking groove (20) in piston is now accessible through rectangular opening in body. Insert wire on screwdriver into locking groove, thus holding primary piston spring (11) in compressed position.

6. Inert blade of screwdriver through exhaust passage of secondary and primary pistons and into slot of stem (1). Back off locking nut (5).

7. Remove locking nut (5), spring stem guide (4) and stem spring (3).

8. Remove spring seat nut (2) spring- seat (6) and rubber spring (9) using same type procedure as item 6.

9. Removal of screwdriver or wire from locking groove will permit spring load to push out primary piston (8) and relay piston (13). Care should be used when removing tool from locking ring because of spring load.

10. Remove primary piston (8) and return spring (11), and relay piston (13) and return spring (14).

11. Remove stem (1) and O-rings from relay and primary pistons.

12. Remove O-rings from upper static piston (15) and lower static piston (10).

13. Remove large retaining ring (17) from lower static piston and remove primary inlet/exhaust valve assembly (18). Disassembly of inlet and exhaust valve is not required since it is only serviced as an assembly.

14. Remove large retaining ring (19) from upper static piston assembly (15) and remove secondary inlet/exhaust valve assembly (16).

CLEANING AND INSPECTION

Wash all metal parts in cleaning solvent and dry them. Inspect all parts for excessive wear or deterioration. Inspect valve seats for nicks or burrs. Check springs for cracks or corrosion. Replace all rubber parts and any part not considered to be serviceable.

REASSEMBLY

Suspended Pedal Type Valve (7)

Before starting to reassemble brake valve lubricate all O-rings, O-ring grooves, piston bores and metal moving parts with Item 1 in LUBRICANT SPECIFICATIONS.

Refer to Fig. 9 for numbers in parenthesis.

1. Install new secondary inlet/exhaust valve assembly (16) in upper static piston (15) and secure with retainer ring (19) making certain retaining ring is engaged in groove of upper static piston bore.

2. Install O-ring on upper static piston assembly and install in body of valve.

3. Install primary inlet/exhaust valve assembly (18) in lower static piston (10) and secure with retainer ring (17) making certain retaining ring is engaged in groove in lower static piston (10).

4. Install three O-rings in grooves of lower static piston assembly (10).

   The larger diameter 0-ring is installed in groove nearest to bottom of piston assembly.

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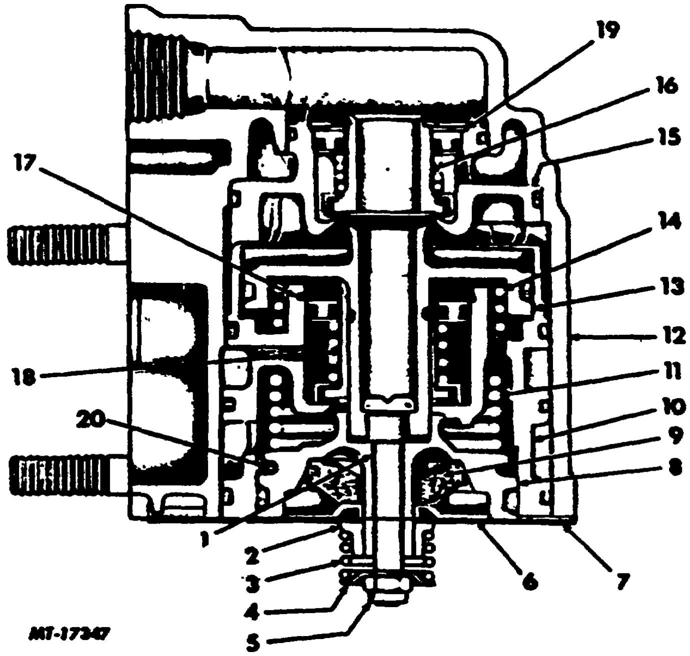

1	STEM	11	SPRING. Primary Piston Return
2	NUT, Spring Seat	12	BODY
3	SPRING, Stem	13	PISTON, Relay
4	GUIDE, Stem Spring	14	SPRING, Relay Piston Return
S	NUT, Lock 15	15	PISTON, Upper Static
6	SEAT. Spring	16	VALVE, Secondary Inlet & Exhaust
7	RETAINER	17	RING, Retaining
8	PISTON Primary	18	VALVE, Primary Inlet & Exhaust
9	SPRING, Rubber	19	RING, Retaining
10	PISTON, Lower Static	20	GROOVE, Locking

5. Install O'rings on relay piston (13) and primary piston (8).

6. Position rubber spring (9), concave side down, in primary piston (8) and place spring seat (6), flat side up, over rubber spring.

7. Install spring seat nut (2) on primary piston with hex head closest to spring seat and rotate nut clockwise until top surface of spring seat is even with top surface of piston (8).

8. Position relay piston spring (14), which is lighter of the two piston return springs, relay piston (13), primary piston spring (11) and primary piston (8) in lower static piston (10). Compress both primary and secondary pistons in lower static piston. Hold them manually or mechanically.

   A screwdriver may be used by inserting it through a rectangular opening in static piston into locking groove (20) in primary piston.

9. Insert stem (1) through exhaust passage of relay and primary pistons and engage a screwdriver with slot in head of stem; then position stem spring (3), spring guide (4) on spring seat nut (2).

10. Compress guide spring assembly and install lock nut (5) on stem. Torque nut to 2.3 3.4 N.m (20 30 in lbs).

    Torque is a specified value for assembly; after assembly, torque value will fall off. Do not retorque nut.

11. Remove screwdriver from lower static piston assembly.

12. Install lower static piston assembly in valve body. Then install retainer (7) making certain locking tabs engage on valve body bosses.

13. Install pedal assembly using three capscrews. Check to be certain plunger is in contact with spring seat. The stop button should be adjusted so that the roller and plunger contact after adjustment; roller should be able to be turned freely by thumb.

14. Test rebuilt brake valve by performing operation and leakage tests as outlined in SERVICE CHECKS.

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BRAKES - AIR

QUICK RELEASE VALVES
AND
DIFFERENTIAL QUICK RELEASE VALVE

CONTENTS

Pages 2338 through 2342 DELETED

DESCRIPTION

Quick release valves are used to release air from air brakes at the brake chamber. This makes the release of brakes quicker than a system where the chamber air has to flow back through the brake piping to the foot valve. There are two types of quick release valves, the basic type and the differential type.

These valves are usually mounted on the frame close to the brake chambers they control. The line connected to the top port is the delivery line from the brake valve. The ·to side ports are the brake chamber connections, and the bottom port is the exhaust. In most cases it also functions as a tee and connects two air brake chambers to the line from the foot valve.

The valves that are used by International Harvester are supplied by Bendix and by Midland.

MIDLAND TYPE QUICK RELEASE VALVE

The Midland valve can be distinguished by having a cast or plastic body and stamped cover (Figure 2 and 5). The brake foot valve port and the brake chamber ports are in the body. The exhaust port is a set of holes pierced in the center of the stamped cover.

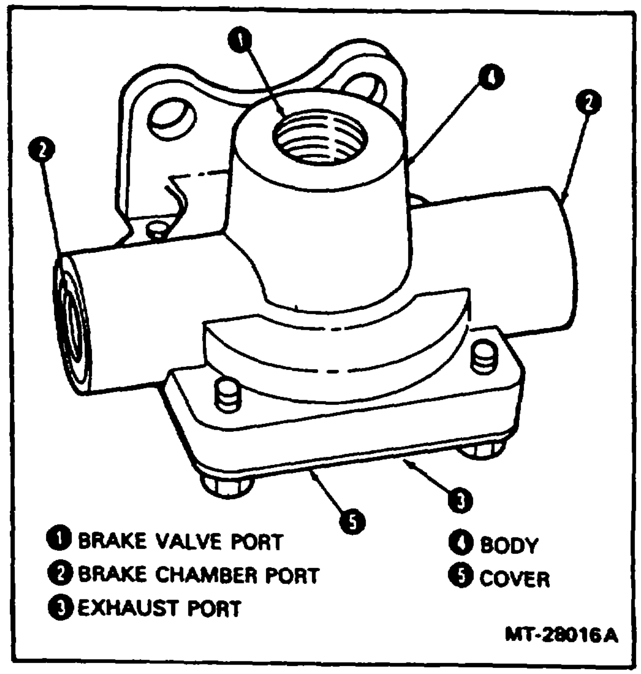

Figure 2 - Midland Quick Release Valve

OPERATION
QUICK RELEASE VALVE

When a brake valve application Is made, air pressure enters the top (brake valve) port of the valve (Figure 5). This will move the diaphragm down closing me exhaust port At the same time, the air pressure forces the edges of the diaphragm down. The air will then flow to the brake chambers.

When the brake chamber pressure beneath the di- aphragm equals the air pressure being delivered in the brake valve, the outer edges of the diaphragm will seal against the cover seat. The exhaust port is still sealed by the center portion of the diaphragm.

When the brake valve is released, air pressure above the diaphragm is exhausted. This will allow the di- aphragm to raise, opening the exhaust port. t will then allow the brake chamber pressure to release through the exhaust port.

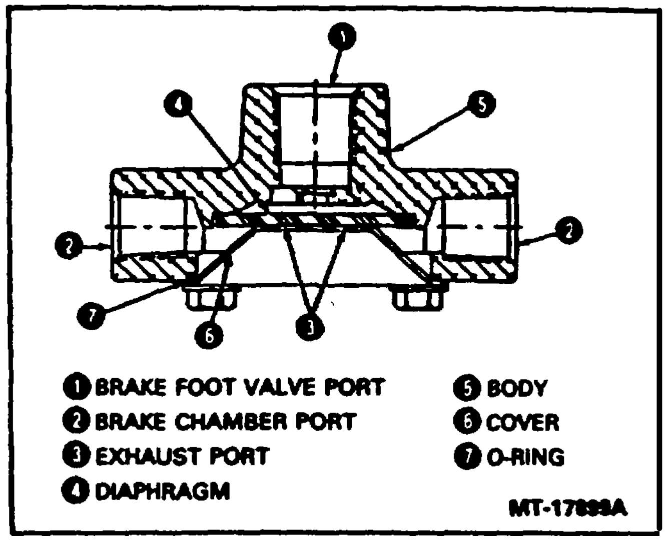

Figure 5 - Quick Release Valve (Basic) (Midland)

SERVICE CHECKS

OPERATION TEST

Apply the brakes and observe that when the brakes are released, air pressure is quickly exhausted through the exhaust port of the valve. Be sure the exhaust port is not restricted.

Pressure Test-Differential Quick Release Valve

Install pressure ages on the air line from the brake foot valve and on one of the lines to the brake chamber. Both gages should have the same scale. The IH special service equipment duplex gage (SE-2325) or gages reading from 900 kPa (125 psi) to 1400 kPa (200 psi) may be used. The most convenient places to connect are at he quick release coupling (glad hand) of the trailer serve bake for the foot valve pressure and the airline port on the brake chamber for Its pressure. Apply the brakes. Read both gages with the brakes applied. Subtract the brake chamber reading from the foot valve reading. To eliminate gage error, switch the gages and repeat the procedure. Add the results of the two subtractions and divide by 2 The answer should be 41 kPa (6 psi): 14 kPa (2 psi). If the results are outside that range check for leaks and/or repair or replace the differential quick release valve.

Leakage Test

Leak Detector Tester (SE-2326) may be used to deter- mine if air Is leaking through the exhaust port when the brakes are applied. When the brakes are released, be sure the valve releases immediately with the corresponding return movement of foot pedal, Leakage could be caused by dirt on valve seat or a defective diaphragm. Leakage in excess of a 25 mm (1") soap bubble in 6 seconds is not permissible. Repair or re-place valve if excessive leakage is found.

REMOVAL

1. Disconnect air lines from quick r elease valve or differential quick release valve.

2. Remove mounting bolts and valve.

INSTALLATION

1. Mount quick release valve or differential quick release valve with mounting bolts and lockwashers. Make sure that its exhaust port is pointing down.

2. Connect the brake valve line to the top port and the brake chamber lines to the side ports.

3. Make sure that the exhaust port is not restricted.

4. After the valve (new or rebuilt) is installed, perform tests as outlined under OPERATION TESTS.

DISASSEMBLY

1. Remove four capscrews and valve cover.

2. Remove diaphragm (and spring and baffle of differential quick release valve).

3. Remove cover O-ring.

CLEANING AND INSPECTION

1. Clean all parts in good cleaning solvent.

2. Inspect diaphragm, especially the lower part that contacts the exhaust seat and cover O-ring, for wear or deterioration. Replace f necessary.

3. Check the cover exhaust seat for pitting or nicks. This seat should be smooth and sharp. f not, use a fine piece of emery cloth to dress the seat

4. Clean or replace as necessary.

The diaphragm should be replaced if worn or deteriorated. There are some valves for which service repair kits are not available. If inspection of a valve reveals worn parts, the valve will have to be replaced as a unit.

REASSEMBLY

1. Position diaphragm in valve body. (On differential quick release valve, first assemble baffle to diaphragm and install spring on top of baffle.)

2. Place O-ring in groove in valve body.

3. Assemble valve cover on body.

4. Install capscrews and tighten to 5.7-6.8 N-m (50-60 in. lbs.).

MAINTENANCE

Every year or 160, 000 km (100, 000 miles), remove the quick release valve or differential quick release valve, disassemble it and dean all parts.

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BRAKES-AIR

INVERSION VALVE

CONTENTS

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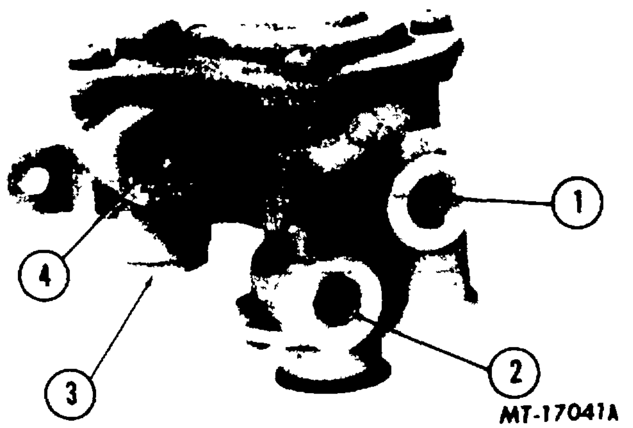

Fig. 1 Inversion Valve, Type SR-1

1 Delivery Port
2 Supply Port
3 Control Port
4 Reservoir Port

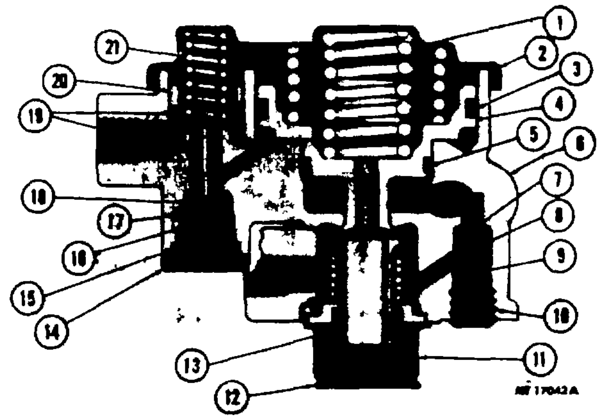

Fig. 2 Sectional View of Inversion Valve

1 Piston Spring
2 Cover
3 Large O-Ring
4 Piston
5 Small O-Ring
6 Body
7 Check Valve
8 Check Valve Spring Guide
9 Check Valve Spring
10 Pipe Plug
11 Exhaust Cover
12 Diaphragm
13 Inlet & Exhaust Valve
14 Cap Nut
15 O-Ring
16 Valve Stop
17 Valve Spring
18 Valve
19 O-Rings
20 Piston
21 Piston Spring

BENDIX SR-1 TYPE

DESCRIPTION

The inversion valve is used only on a straight truck with dual air brake system. Its purpose is to allow a modulated spring brake application if air loss should occur in the primary (rear) portion of the air system.

The secondary (front) brakes cannot supply enough braking effort alone to stop the vehicle quickly to meet the FMVSS 121 requirements for emergency stopping.

The inversion valve senses the loss of air in the primary system, allowing the spring brakes on the rear axle to be applied or released in a modulated manner at the same time the front service brakes are applied or released by the operator. The inversion valve also permits air pressure to enter the parking brake chamber releasing the spring brakes.

The inversion valve is not required on tractor applications due to the fact the trailer brakes, being supplied with air from both the primary and secondary tractor systems, provide necessary braking required to meet FMVSS 121 emergency stopping requirements.

OPERATION

Initial Air Charge (Fig. 3)

Initial air charge from the primary and secondary reservoirs flows through the spring brake control valve and enters the supply port of the inversion valve. Air entering the support port flows past inlet and exhaust valve "B" to the underside of piston "B" and out de- livery port to the emergency air connection on the spring brake chamber. Note that the springs above piston "B" force it into contact with inlet and exhaust valve "B." In the position shown the exhaust is closed and the inlet is open.

Only air flowing from the primary reservoir enters the reservoir port on the inversion valve. This air remains under piston "A" as system pressure builds up. With primary reservoir pressure approximately below 379 kPa (55 psi) the spring above piston "A"' forces it into contact with inlet exhaust valve "A" causing the exhaust to seal and inlet to open.

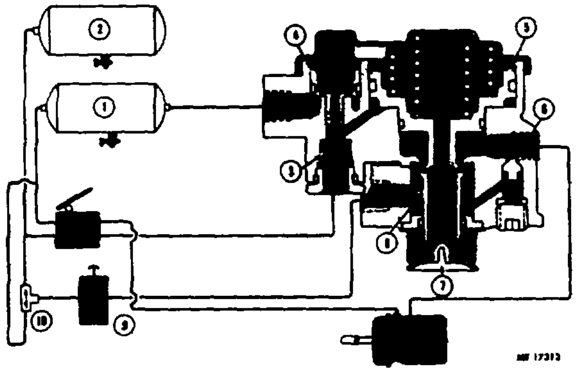

Fig.. 3 Initial Air System Charge Below 55 PSI

1 Primary Reservoir
2 Secondary Reservoir
3 Inlet & Exhaust A
4 Piston A
5 Piston B
6 Check Valve
7 Exhaust
8 Inlet & Exhaust B
9 Spring Brake Control Valve
10 Double Check Valve

System Fully Charged (Fig. 4)

When the air pressure builds up past the approximate 379 kPa (55 psi) in both the primary and secondary reservoirs, piston "A" has moved against the force of the spring above it permitting the inlet of valve "A" to close and open the hollow exhaust passage through piston "A."

When air pressure under piston "B" is about 655 kPa (95 psi), piston "B" raises slightly against the force of springs above it allowing the inlet of valve "B" to close. The exhaust through valve "B" remains closed. The closing of inlet portion of valve "B" traps about 655 kPa (95 psi) in the hold-off cavity of the spring brake actuators while allowing full air system pressure to build elsewhere.

Normal Brake Application with Primary and Secondary Reservoirs Charged (Fig. 5)

When the service brakes are applied by actuating the dual brake valve, air from the secondary system is delivered from the brake valve to the control port where it is stopped at the closed inlet valve "A." No further movement of internal components of the inversion valve takes place. Air from the primary de- livery system of the brake valve actuates the service brakes of the spring brake chambers.

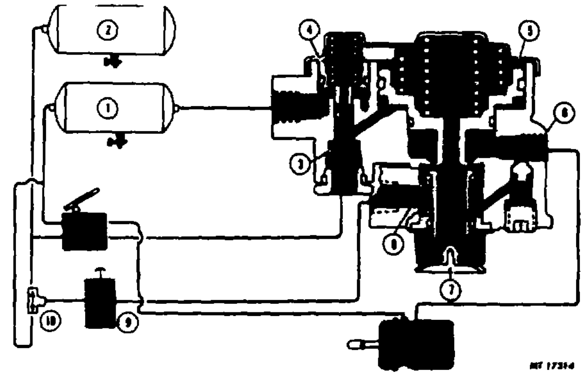

Fig. 4 Air System Fully Charged

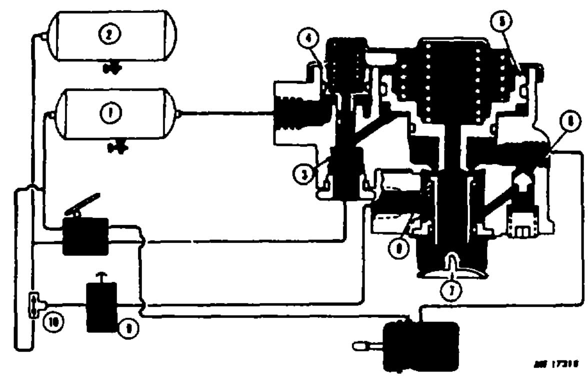

Fig. 5 Normal Brake Application, Primary and Secondary Systems Charged

1 Primary Reservoir
2 Secondary Reservoir
3 Inlet & Exhaust A
4 Piston A
5 Piston B
6 Check Valve
7 Exhaust
8 Inlet & Exhaust B
9 Spring Brake Control Valve
10 Double Check Valve

Brake Application with Loss of Air In Secondary System (Fig. 6)

If air pressure is lost in the secondary reservoir, the primary reservoir as well as the spring brake control valve is protected against air loss through action of single check valve (air source to primary reservoir) and double check valve (Fig. 6). A brake application at brake valve in this situation results in little or no air being delivered from the secondary system to the control port of inversion valve. No movement of the internal components of the valve takes place. Braking is assured since the primary reservoir is protected and the primary de- livery system of the brake valve will apply the service brake portion of the spring brake chambers.

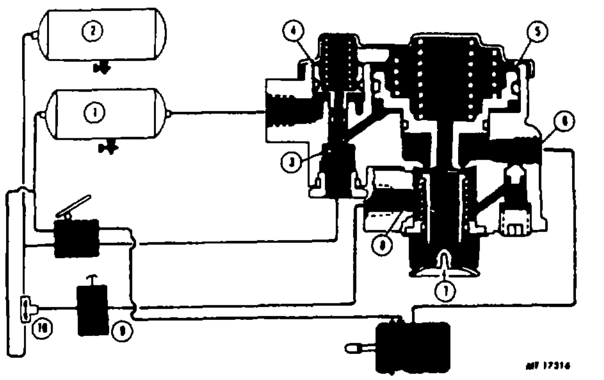

Fig. 6 Brake Application, Loss of Air In Secondary System

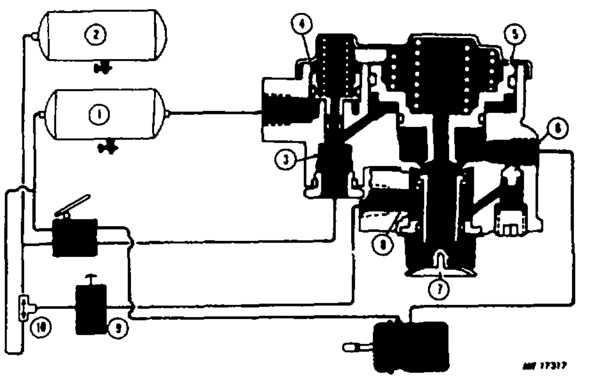

Fig. 7 Brake Application, Loss of Air In Primary System

1 Primary Reservoir
2 Secondary Reservoir
3 Inlet & Exhaust A
4 Piston A
5 Piston B
6 Check Valve
7 xhaust
8 Inlet & Exhaust B
9 Spring Brake Control Valve
10 Double Check Valve

Brake Application with Loss of Air In Primary System (Fig. 7)

If air pressure In the primary reservoir should fall below approximately 379 kPa (55 psi), the pressure below piston "A" is insufficient to resist spring force above and piston "A" moves in- to contact with valve "A". Initial contact between piston "A" and valve "A" closes the hollow exhaust passage of piston "A". Continued movement of piston opens the Inlet valve "A".

The secondary reservoir and spring brake control valve is protected from air pressure loss by action of check valve.

When brake application is made through the brake valve, air delivered from the secondary system of the brake valve enters the inversion valve control port. Air enters control port, moves past the inlet of valve "A" and is con- ducted through a passage in the body to the underside of piston "B." The added force of air pressure below piston "B" moves up, opening the exhaust valve "B." When exhaust of valve "B" opens, air pressure trapped in the emergency section of the spring brake chamber is allowed to escape resulting In a brake application by emergency section. The amount of air pressure released from spring brake is proportional to the amount of air pressure delivered to the control port of the inversion valve by de- livery of brake valve secondary system.

Parking (Spring) Brake Application (Fig. 8)

When both primary and secondary systems are charged with air and spring brake control valve is placed in "apply" or exhaust position, the in- version valve air supply and air pressure in the spring brake chambers will be exhausted. The single check valve in the inversion valve assists the exhaust of air from the spring brake by al- lowing air below piston "B" to flow back out the open exhaust of spring brake control valve. When air pressure below piston "B" has dropped enough, piston "B" moves down opening the inlet of valve "B" thus providing an additional exhaust passage for air exhausting through the inversion valve from spring brakes.

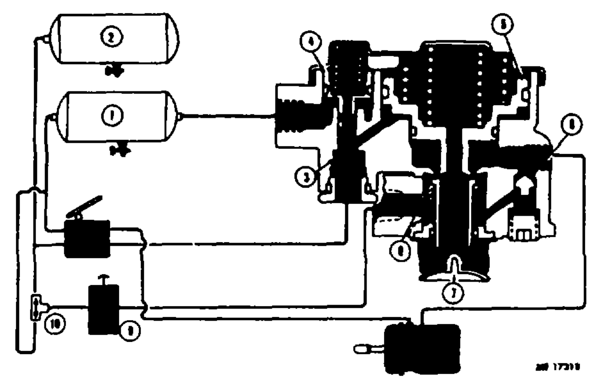

Fig. 8 Parking Broke Application

1 Primary Reservoir
2 Secondary Reservoir
3 Inlet & Exhaust A
4 Piston A
5 Piston B
6 Check Valve
7 Exhaust
8 Inlet & Exhaust B
9 Spring Brake Control Valve
10 Double Check Valve

MAINTENANCE

Every 160, 000 km (100, 000 miles) or every year, remove, disassemble, clean and inspect all parts. If signs or wear or deterioration are found, install new parts. It is recommended all rubber parts be replaced.

SERVICE CHECKS

Operation Test

Block vehicle and hold by means other than vehicle brakes. Charge air brake system to governor cut-out pressure.

1. Place parking control valve in the "apply" position. Observe that the spring brake actuators apply promptly. In the delivery port of the inversion valve install a test gauge known to be accurate. Place the parking control valve in the "release" position. Observe that the spring brake actuators release fully.

2. With the parking control valve in the "release" position, note the gauge pressure read- mg (should be approximately the same as gauge on instrument panel). If the pressure reading is incorrect, the valve must be re- paired or replaced.

3. Place the parking control valve in the "apply" position, the gauge reading should drop to zero promptly. A slow release of pressure could indicate faulty operation of the single check valve (within the Modulating Valve). At approximately 48-241 kpa (7-35 psi) the spring parking brakes should be fully applied.

4. Place the parking control valve in the "re- lease" position. Locate the number one service reservoir and drain it completely.

5. Apply the foot brake valve several times and note that the pressure reading on the gauge decreases each time the foot brake valve is applied. After the foot brake valve has been applied several times, pressure on the gauge will drop to the point where release of the spring brake actuators will no longer occur.

Leakage Test

With air system fully charged and parking brake control valve in "release" position, use the Leak Detector Tester around valve cover and exhaust port to detect air leakage. A slight leak- age is permitted.

If inversion valve does not function as described above or leakage is excessive, it is recommended that the valve either be replaced or repaired.

REMOVE

1. Apply parking brakes and drain all air reservoirs.

2. Mark or identify all air lines before disconnecting from inversion valve. Then disconnect air lines.

3. Remove the two mounting bolts from valve and remove valve.

INSTALL

1. Install inversion valve using the two mounting bolts.

2. Connect air lines. Make sure they are installed at the same ports.

3. Before releasing vehicle for service, perform SERVICE CHECKS as outlined.

DISASSEMBLY (Refer to Fig. 2)

1. Remove socket head pipe plug at check valve.

2. Remove check valve spring, spring guide and check valve.

3. Remove two Phillips screws and remove exhaust cover.

4. Separate exhaust diaphragm from cover.

5. Remove inlet and exhaust valve assembly.

6. Remove inlet and exhaust valve cap nut and separate cap nut O-ring.

7. Remove valve stop, valve spring and inlet and exhaust valve.

8. Remove four Phillips head screws and lockwashers that secure cover to the body.

> CAUTION
>
> Cover is under a spring load and should be held while removing screws to prevent bodily injury.

9. Remove cover and three piston springs.

10. Remove small piston and small and large O-rings.

11. Remove large piston and large and small O-rings from it.

CLEANING AND INSPECTION

Wash all metal parts in cleaning solvent and dry them. Inspect all parts for excessive wear or deterioration. Inspect the valve seats for nicks or burrs. Check the springs for cracks or corrosion. Replace all rubber parts and any part not found to be serviceable during inspection.

ASSEMBLY

Prior to reassembly of the SR-1 Spring Brake Valve, lubricate all O-rings, O-ring grooves, piston bores and metal-to-metal moving surfaces with the silicone base lubricant packaged in the repair kit or Item 3 in LUBRICANT SPECIFICATIONS.

The torque values listed in assembly procedure are assembly torque values and can be expected to fall off after assembly. Do not retorque after initial assembly torques fall.

1. Assemble check valve, valve spring guide and valve spring and insert them in body.

2. Apply a pipe sealant to the socket head pipe plug and install it in body. Tighten to 15-19 Nm (130-170 inch-pounds) of torque.

3. Place inlet and exhaust valve assembly into valve body.

4. Install exhaust diaphragm in exhaust cover

5. Position exhaust cover on body and secure cover with two Phillips screws. Tighten screws to 2.3-3.4 Nm (20-30 inch-pounds) of torque.

6. Place inlet exhaust valve in body and install valve spring and valve stop.

7. Install O-ring on the cap nut and install the cap nut in body. Tighten to 12-13 Nm (100-125 inch-pounds) of torque.

8. Position small and large O-rings on small diameter piston and insert piston in body.

9. Install large and small O-rings on large diameter piston and insert the piston in body.

10. Position piston springs in their respective pistons.

11. Secure cover to body using four 1/4" - 20 Phillips head screws and lockwashers. Tighten four screws to 5.7-9 Nm (50-80 inch-pounds).

Be sure inversion valve is checked as outlined in SERVICE CHECKS before chassis is returned to service.

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BRAKES AIR

AIR CONTROL VALVE

CONTENTS

Page 2358 DELETED

KELSEY HAYES
DESCRIPTION

An air control valve or modulator valve (Fig. 1) is part of the antilock system. There is one valve mounted on the chassis per axle with anti- lock. As the wheel rotates, an electrical signal proportional to wheel speed is generated which a computer module records the rate of impulses. There is one computer module per axle with anti- lock. During a brake application the computer sends an electrical signal to the air control valve when wheel lock-up is about to occur, the air chambers on the axle involved dump a controlled amount of air and as the wheel or wheels speed up, air is automatically reapplied.

OPERATION (Fig. 2)

The modulator valves are basically connected in series in the air system between the brake valve and air chambers. However, there will also be a quick release valve or a relay quick release valve located in the air system. There is one modulator valve per axle.

During a normal brake application, the poppet at the electric solenoid is open and air passes by the poppet closing the upper diaphragm and at the same time opening the lower diaphragm. Air from brake valve is then permitted to pass through the modulator valve onto brake chambers.

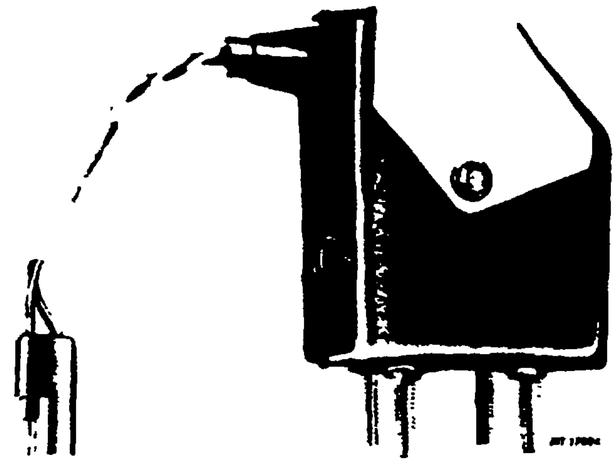

Fig. 1 Modulator Valve

If one or both brakes on an axle that the modulator valve controls are about to lock up, the computer module sends an electrical signal to the solenoid on the modulator valve, the poppet closes and the valve is then in operating position.

In operating position the poppet is closed, air from the brake valve is also closed off at the lower diaphragm since air passes through the outer edge of the diaphragm forcing it up and sealing the inlet seat. At the same time the upper valve is moved up permitting air from brake side of valve to exhaust out the exhaust ports.

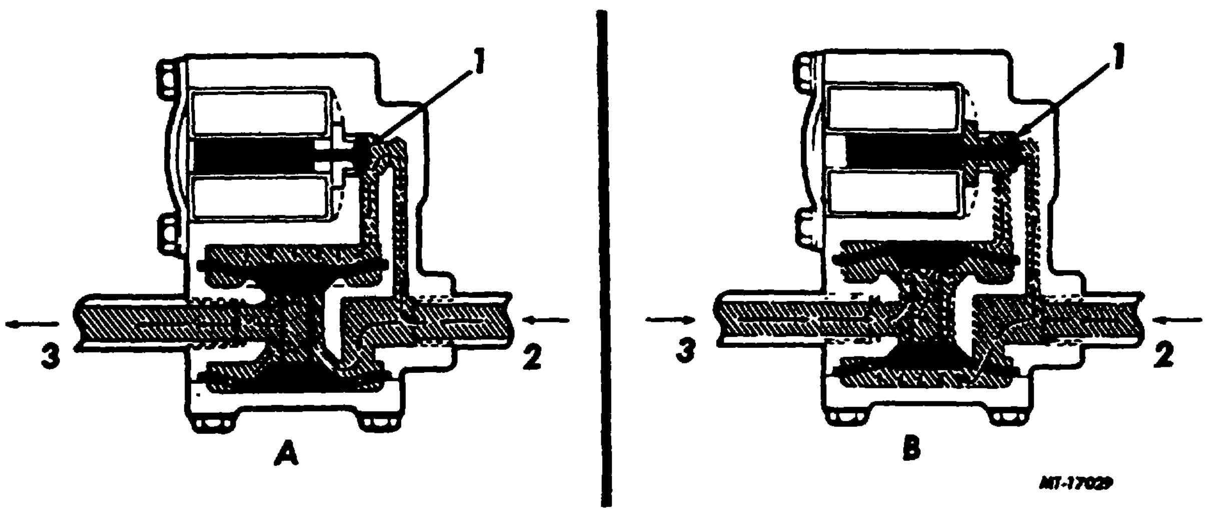

Fig. 2 Modulator Valve Operation

A Normal Braking Position

1 Poppet Open
2 Air Supply
3 Brake Chamber

B Operating Position

1 Poppet Closed
2 Air Supply
3 Brake Chamber

MAINTENANCE

Once each year or every 160, 000 km (100, 000 miles) valve should be removed and diaphragms replaced.

SERVICE CHECKS

Leakage and Operation Tests

Apply air brake system and check control valve for leaks using Leak Detector Tester (SE-2326). If any air leaks are detected re- place valve or repair it.

If any air leaks are detected in the solenoid area, remove computer module cover for valve in question. Disconnect valve "Hi" wire from computer module. Apply vehicle brakes. Connect a jumper wire from hot connection on computer to air "Hi" wire which was removed.
This will operate control valve solenoid. Then check for air leaks. If any air leakage is detected using the leak detector tester either repair or replace valve.

For detailed information pertaining to the antilock system refer to ANTILOCK.

REMOVE

1. Apply parking brakes or block wheels to prevent vehicle from moving.
2. Tag or identify air line before disconnecting; then disconnect air lines.
3. Disconnect wiring to solenoid.
4. Remove mounting nuts and then remove control valve.

   In some instances it may be necessary to remove the air control valve and relay quick release valve mounting bracket as an assembly to gain access to air control valve mounting nuts.

INSTALL

1. If mounting bracket was removed from frame, assemble control valve to bracket tighten nuts.
2. Assemble hoses to air control valve.
3. Install air control valve to frame or mounting bracket to frame.
4. Connect wiring.
5. Prior to returning vehicle to service, perform SERVICE CHECKS as outlined in ANTILOCK Service Manual Section.

DISASSEMBLY

Refer to Fig. 3 and proceed as follows.

1. Remove two valve cover bolts.
2. Remove valve cover.
3. Remove valve boot. Slide solenoid wires through boot neck; then slide boot from the valve.
4. Remove four hex mounting bolts; this will allow removal of the valve assembly from the solenoid assembly.
5. Remove small O-ring.
6. Remove lower diaphragm from connecting rod. This will allow removal of upper diaphragm, connecting rod and spacer from the valve body.
7. Slide diaphragm spacer off connecting rod.
8. Remove upper diaphragm from connecting rod.

CLEANING AND INSPECTION

Wash all metal parts in cleaning solvent. Inspect all parts for excessive wear or deterioration. Inspect valve seats for nicks or burrs. Replace all rubber parts.

ASSEMBLY

1. Coat diaphragm liberally with Item 3 of LUBRICANT SPECIFICATIONS and assemble upper diaphragm (solid diaphragm) to the connecting rod.
2. Position diaphragm spacer (large end up) over connecting rod and push into the valve body .
3. Assemble lower diaphragm (diaphragm with 6 equally spaced holes) onto other end of connecting rod.

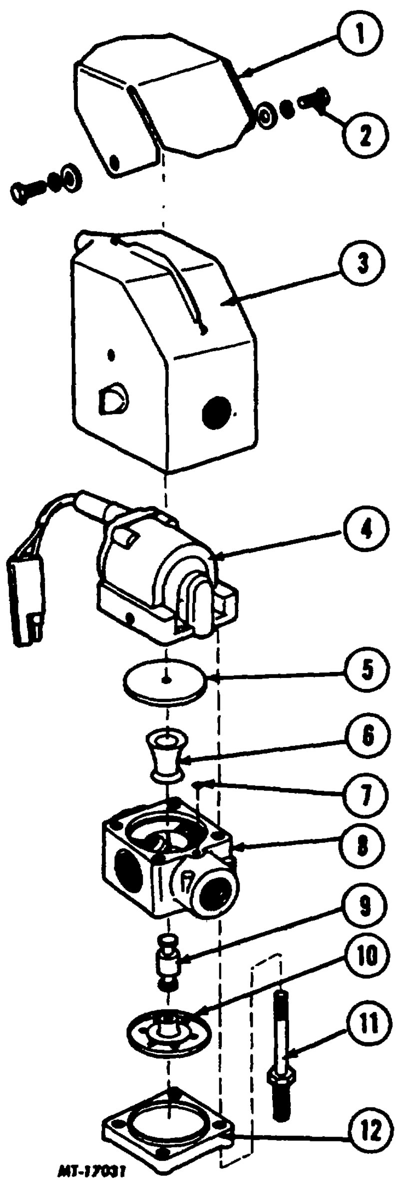

Fig. 3 Exploded View of Modulator Valve

1 Valve Cover
2 Valve Cover Bolts
3 Valve Boot
4 Solenoid Assembly
5 Upper Diaphragm
6 Diaphragm Spacer
7 '0" Ring
8 Valve Body
9 Connecting Rod
10 Lower Diaphragm
11 Mounting Stud
12 Base Plate

4. Install small O-ring into solenoid body.

5. Position lower diaphragm so one of the holes is in line with "air in" port.

6. Reassemble the valve body to the solenoid assembly being sure that the small O-ring lines up with solenoid air inlet.

7. Assemble base plate to bottom of valve assembly and install four mounting bolts. Tighten mounting bolts to 7.9 - 9.3 Nm (70 - 84 in lbs) torque.

8. Install the valve boot, valve boot cover 'and valve boot bolts.

BRAKES-AIR

SPRING BRAKE,
CONTROL VALVES

CONTENTS

SPRING BRAKE CONTROL VALVE (MIDLAND ROSS)

DESCRIPTION

The spring brake control valve is a manually operated valve of push-pull type. When the valve is pushed "in" the valve is open to supply air. The "out" position closes off supply air and allows delivered air to exhaust to atmosphere, applying the spring brakes. Valve also features a plunger pressure sensing arrangement which provides automatic return to "out" position when brake system air pressure approaches low energy levels.

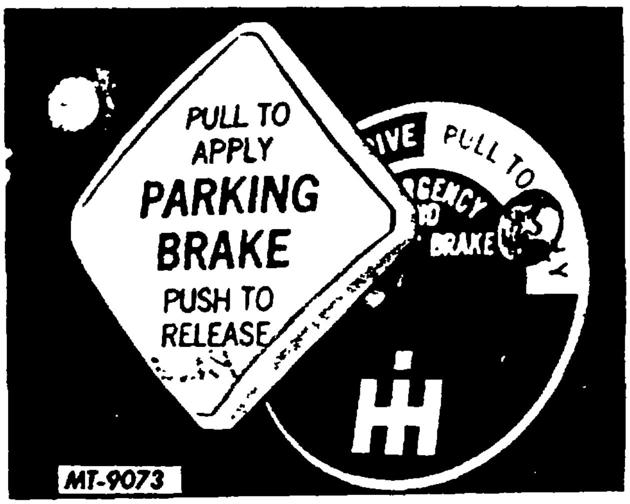

Fig. 1 Spring Broke Control Valve

OPERATION

The spring brake control valve serves to apply and release the spring actuated parking brakes. The valve is in the "in" position under normal operation on either a straight truck or tractor-trailer. Air supply passes through the valve delivering system pressure to retract and hold parking brakes in released position. Manual pull "out" closes off air supply and vents delivered air to atmosphere, applying the parking brakes.

When valve is pushed "in, " it will remain in as long as supply line is 48-241 kPa (7-35 psi) or more. During normal operation the air control valve will automatically apply, moving "out, " if air pressure should drop to 48-241 kPa (7-35 psi). The automatic application will result when both primary and secondary systems have depleted air supply to 48-241 kPa (7-35 psi).

Refer to Fig. 2 for following operational description. Fig. 2 illustrates valve in applied (out) position.

Pushing piston in moves valve assembly off body seat until contacting end cap seat. Air pressure at inlet has free passage to outlet and is blocked from exhausting to atmosphere. Pulling piston out moves valve assembly away from end cap seat and contacts body seat. Air pressure at inlet is blocked from entering either outlet or exhaust passages. Air pressure in outlet has free passage to exhaust to atmosphere. The spring in the valve assists to move piston out automatically if inlet pressure drops and effective opposing force across the valve seat is overcome.

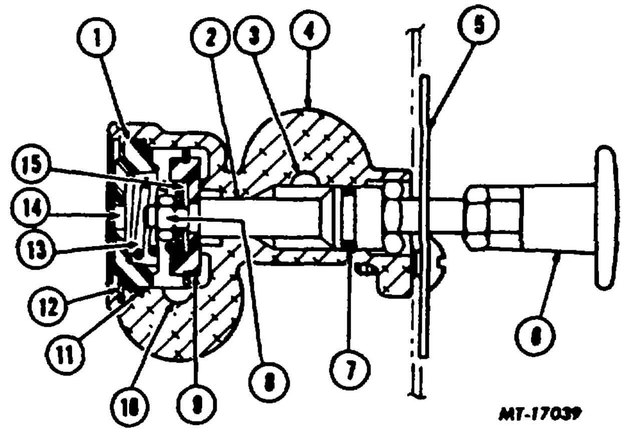

Fig. 2 Crow Section of Spring Brake Control Valve

1	End Cap	9	Valve Assembly
2	Piston	10	Outlet
3	Inlet	11	"O" Ring
4	Body	12	Snap Ring
5	Name Plate	13	Spring
6	Knob	14	Exhaust
7	"O" Ring	15	Washer
8	Torque Nut to 12 to 17 Inch Lbs.		

MAINTENANCE

Once each year or every 160, 000 km (100, 000 miles) the valve should be removed, disassembled and a repair kit installed.

SERVICE CHECKS

Leakage Test

Use air pressure source equipped with in-line manual shut-off valve, air gauge known to be accurate and connection. Connect air source to inlet port. Also connect a manifold with an air gauge and close manual shut-off valve to outlet. With air control valve in "out" position, open manual valve to build up 689-861 kPa (100-125 psi) to inlet port. Shut off manual valve. No air leakage is allowed around piston or through casting surfaces. Permissible leakage at exhaust port is a 25 mm (1") soap bubble in six seconds.

Push control valve in and build up 689-861 kPa (100-125 psi) pressure at both inlet and outlet. Shut off manual manual valve and repeat above leakage test.

Pull control valve out. Outlet port pressure should exhaust to zero through valve.

Operation Test

Begin with zero pressure at inlet and outlet. Hold control valve 'in' and open manual valve to allow 48-241 kPa (7-35 psi) pressure to build up at both inlet and outlet. Control of valve should remain "in" at 48-241 kPa (7-35 psi) and above.

Second check is accomplished with 689-861 kPa (100-125 psi) in both inlet and outlet ports and both manual shut-off valves closed. Slowly open manual valve at outlet to bleed down pressure. The spring brake control should automatically move "out" when air pressure at inlet port reaches 48-241 kPa (7-35 psi).

If spring brake control valve does not per- form as described it should be repaired or replaced.

DISASSEMBLY (Fig. 2)

Before moving spring brake control valve from vehicle, drain all air from all reservoirs.

1. After valve is removed from vehicle, inspect it for damage. If casting is broken or shows fractures replace valve assembly.

2. Carefully remove end cap snap ring.

3. End cap, O-ring and spring can be removed now.

4. Remove nut, washer and valve assembly.

5. Pull piston with the knob out end of body and remove O-ring from piston.

CLEANING AND INSPECTION

Wash all metal parts in cleaning solvent. Inspect body and end cap seats. Face of seats must be flat and smooth with no cracks or nicks.

Use new parts supplied in repair kit.

REASSEMBLY (Fig. 2)

Lubricate O-rings, O-ring sealing surfaces and piston-to-body surfaces with Item 3 of LUBRICANT SPECIFICATIONS.

1. Install O-ring on piston and insert piston into body, aligning hex on piston to hex on body.

2. Position valve assembly over end of piston, then position washer over piston stud end against metal face of valve.

3. Install nut and torque as specified on Fig. 2. Piston should move smoothly back and forth in body.

4. Install spring with small end against valve disc.

5. Position O-ring over end cap. Align end cap over spring and push end cap into body. Hold end cap to prevent spring pushing end cap out.

6. Install snap ring in valve body groove. Plunger should move in and out by applying force to move plunger in and releasing it.]

Before releasing vehicle for service perform SERVICE CHECKS as outlined. Page 2365

REASSEMBLY

Lubricate O-rings, O-ring sealing surfaces and stem with Item 3 of LUBRICANT SPECIFICATIONS (refer to Fig. 4 for numbers in parenthesis).

1. Install new O-rings on stem (10) and piston (5).

2. Insert stem in valve body; then position piston (5) in valve body over stem.

3. Install stem nut (3).

4. Install valve end cap (1) and new gasket (2).

Before vehicle is returned to service, perform SERVICE CHECKS on valve as outlined.

Pages 2367 through 2392 DELETED

BRAKES-AIR

FLEXIBLE HOSE, NYLON TUBING, RIGID PIPING AND FITTINGS, TRAILER BRAKE HOSE AND COUPLINGS

CONTENTS

Pages 2367 through 2392 DELETED
Page 2394 DELETED

DESCRIPTION

Rigid (copper) tubing and fittings of different sizes have been used to connect different air devices in the air system. However, flexible hoses and nylon tubing is gaining increasingly wide usage in place of copper piping on IH vehicles.

FLEXIBLE HOSE

Any size or length of hose can now be made locally for service requirements.

The hose is constructed of a seamless synthetic rubber lining or tube reinforced with one fabric braid of high tensile steel wire which is covered with a synthetic rubber-impregnated oil-resistant fabric braid.

These hoses can be used for air systems and air brake systems, except air line from air compressor to air reservoir, where the temperature will exceed 167 degrees C (300 degrees F).

The fittings used at the ends of the flexible hose are of the swivel type, such as that shown in Fig. 1. The swivel end permits one end of the hose to be disconnected and not disturb the complete hose.

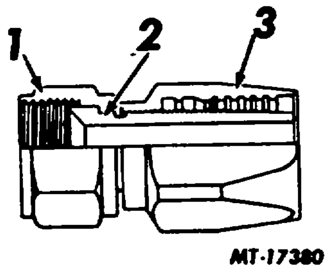

Fig. 1 Flexible Hose Fitting

1 Nut
2 Fitting
3 Hose Socket

CAUTION

Do not try to mix different type hoses and hose fittings. In some cases the hose and hose fittings may seem to fit, but the ends may not hold up under pressure which could result in loss of air while vehicle is being operated. <u>If in doubt as to the identification of the hose and/or fittings which are being repaired, use new IH components to make up a new hose assembly.</u>

HOSE ASSEMBLY INSTRUCTION

When the assembly procedure in making up a hose is being performed, each step should be finished carefully to assure proper connections at the hose ends.

1. Remove the hose fitting and nut from socket and hose. Fig. 1 illustrates the swivel hose fitting. So that the swivel nut and fitting can be removed from the hose and socket assembly, install a pipe adapter in the swivel nut and tighten it, locking the swivel joint assembly (nut and fitting). The swivel nut and fitting can now be turned out of the hose using a wrench.
2. Separate the hose from the socket.
3. Repeat steps 1 and 2 for the removal of second end.
4. Use a fine-tooth hack saw to cut hose to desired length (Fig. 2). Use care in supporting the hose so as not to crush or damage the hose during the cutting operation.

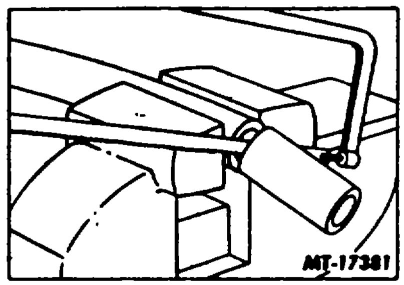

Fig. 2

5. Lightly clamp the hose socket in a vise.
6. Screw end of new hose into socket until hose bottoms in fitting (turn hose counterclockwise). Then back off hose 1/4 turn (Fig. 3).

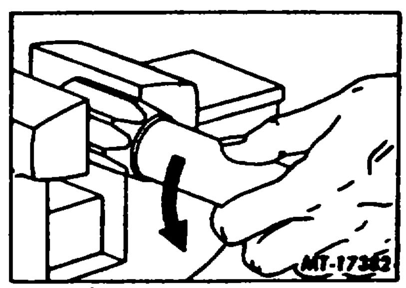

Fig. 3

7. Reposition hose and socket in the vise as shown in Fig. 4. Lubricate hose socket and fitting threads.

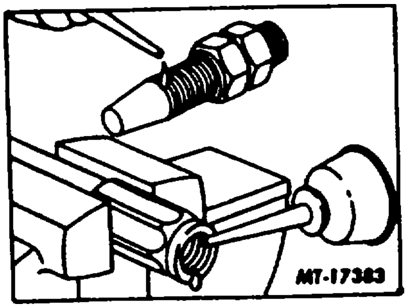

Fig. 4

8. Position hose socket in swivel nut and reassemble pipe adapter (if removed) to lock swivel nut on the fitting. Thread the fitting and swivel nut (with pipe adapter) assembly into the hose as shown in Fig. 5 leaving .793-1.59 mm (1/32 inch to 1/16 inch) clearance between nut and socket so that the nut can swivel freely.

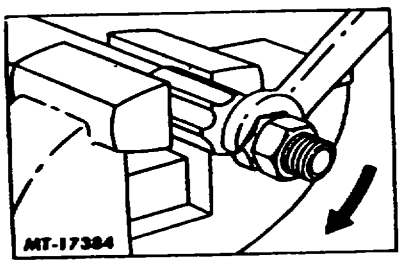

Fig. 5

9. Repeat steps 5, 6, 7 and 8 on opposite end of hose to install the remaining nut and fitting.
10. Lubricate the threads of the hose assembly when connecting the lines (use light engine oil sparingly).
11. When installing the new hose assembly on the vehicle be sure to check for possible leakage and correct any leaks if leaks are present.

HOSE ASSEMBLY SPECIAL INSTRUCTIONS

Installation and routing of these hoses is just as important as special attention given to the installation of the ends. Common problems encountered with installation and routing which will result in short service life of these hoses are:

1. High external temperatures will shorten the life of a hose. Route hoses away from hot manifolds and exhaust systems.
2. Abrasion of hoses will cause outer surfaces to wear and weaken the hose. When installing these flexible hoses avoid contact or crisscrossing, sharp surfaces and contact of moving parts (shift levers and pedals). Clip hoses in place to prevent vibration, abrasion; route hoses together and parallel. If the hose cannot be clipped adequately, the hose must be equipped with a protective conduit (cover). If the hose being replaced has a protective conduit, be sure to use a cover on new hose.
3. Flexing of short hoses should not be allowed, since this will tend to wear the hoses at the fittings. If the hose must move, do not permit the hose to twist; keep the bend in the hose in the same plane as the movement where the hose is connected. Provide enough hose to permit any movement which may be required. Avoid sharp bends or turns in the hoses.

NYLON TUBING

NYLON TUBING ASSEMBLY INSTRUCTIONS

For the most part nylon tubing in air brake systems is assembled much like copper tubing. The same fittings, sleeves and nuts used with copper tubing can be used with nylon tubing. Long or short tube nuts may be found on chassis in service with nylon tubing (Fig. 6). Either nut may be satisfactorily used on the nylon lines.

If copper tubing is being substituted for nylon tubing, the short tube nut must not be used. Either the short tube nut or the long tube nut may be used satisfactorily with nylon tubing.

A tube support or insert will be used in all applications of the nylon tubing in air brake systems. The insert provides a stiff or rigid area for the sleeve to be crimped or compressed on the tubing and prevents collapsing the tubing when the nut is tightened. The parts listing notes that there are some sizes of tubing that are used only in accessory piping systems. In repairing accessory piping systems tube supports are needed with all sizes of tubing except 1/8" O.D. if compression-type fittings are used.

Once the tubing has been connected and tightened the sleeve has been crimped on the tubing and insert. Since the sleeve has been compressed and distortion of the insert may have resulted. the sleeve and inserts should never be used the second time.

To assemble tubing ends for use with compression-type fittings, the following steps should be followed carefully.

1. Loosen and remove nut from fitting.
2. Pull tubing from fitting.
3. Repeat the same operations at other end of tubing. If only one end of line needs repairing, second end need not be disconnected if line is long enough to permit repairing.
4. Cut the selected size of tubing to length. Be sure to make smooth, square cuts. Either a sharp knife or hack saw may be used.
5. Position nut on tube.
6. Position compression sleeve on tube.

*7. Insert tube support into tube.

*8. Position the tube, support and sleeve in the fitting. Push tube in fitting until it bottoms.

9. Then install and tighten tube nut to secure sleeve on tubing.
10. Inspect tubing connections for air leakage. With the tubing and associated fittings charged to full system air pressure coat tubing lines and fittings with soap suds to check for leakage. No leakage is permissible. Leakage at a tubing fitting is sometimes corrected by tightening the tubing fitting nut. If this fails to correct the leakage, replace the tubing fitting, tubing, or both.

* No tube support is used with 1/8" O.D. tubing. Certain fittings used in accessory piping systems have the tube support as an integral part of the fitting body. These fittings may be reused if no distortion of the tube support has occurred.

NYLON TUBING SPECIAL INSTRUCTIONS

For the present this nylon tubing should not be substituted in the field for any metallic tubing. In addition, the following precautions must be taken in the use of nylon tubing.

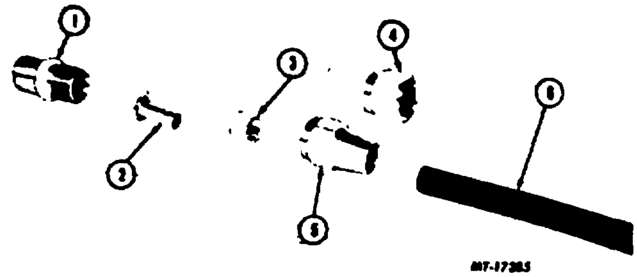

Fig. 6 Nylon Tubing Assembly

1 Fitting
2 Tube Support or Insert
3 Sleeve
4 Short Nut
5 Long Nut
6 Nylon Tubing

1. Do not use nylon tubing for any application which would cause it to be exposed to temperatures below -40 degrees C or +111 degrees C (-40 degrees YF or above +200 degrees P).
2. Do not subject nylon tubing to working pressure in excess of 1034 kpa (150 psi).
3. Do not use nylon tubing for frame-to-axle, tractor-to-trailer or any similar line where a high degree of flexibility is required.
4. Observe extreme care when welding near nylon tubing. Hot slag or spark will damage the tubing.
5. Protect nylon tubing from battery acid.

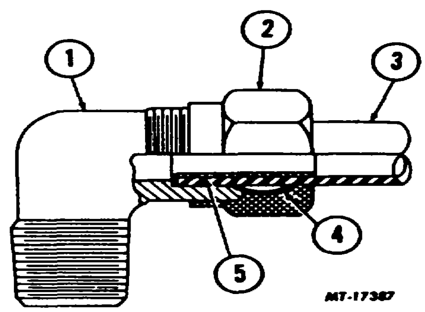

Fig. 7 Nylon Tubing Assembly Cross Section

1 Fitting
2 Short Nut
3 Nylon Tubing
4 Sleeve
5 Tube Insert or Support

The service nylon tubing will be marked at regular intervals with name, number, type, size and manufacturing code designations. This marking is intended to positively identify the tubing and prevent substitution of inferior quality tubing.

Test

1. If a line is suspected of being restricted, remove and blow air through it in both directions. Air passage through hose must not be obstructed in any way.
2 To check for leaks, apply the brakes and coat hose and connections with soap suds. No leaks are permitted. Leakage at hose connectors is

sometimes corrected by tightening the connector nut, but if this fails, replace the connectors or hose, or both.

MAINTENANCE

Every six months all air connections should be checked and tightened if leaking (refer to SERVICE CHECKS). Once each year all tubing and hoses should be inspected for dents, kinks, swelling, chafing or crimping. Replace tubing if these conditions are found.

Be sure to inspect trailer brake hoses and hose coupling packing rings and replace if necessary.

SERVICE CHECKS

Operating Tests

If any evidence is found that an air line is restricted, remove and blow out through it in both directions to be sure the passage through the tubing is not obstructed in any way. Inspect piping for partial restrictions such as may be caused by dents or kinks. Damaged pipes must be replaced.

Leakage Tests

With the air system fully charged, the governor cut out and brakes applied, use SE-2326 Leak Detector Tester at air lines, hoses and fittings to check for leakage. No leakage is permissible. Leakage at a tubing fitting is sometimes corrected by tightening the fitting nut. If this fails to correct the leakage, replace the tubing, sleeve or fitting, the tubing or hose.

Pages 2400 through 2408
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BRAKES-AIR

AIR DRYER

CONTENTS

CONTENTS (Continued)

Pages 2411 through 2419 DELETED

CR BRAKEMASTER 62

DESCRIPTION

The CR Brakemaster units (Figs. 21 & 22) are actually heat exchangers since the compressed air from the air compressor is cooled.

When the compressed air leaves the air compressor, it is about 149° C (300° F) and by the time it reaches the Brakemaster unit, the temperature will drop to about 60° C (140° F).

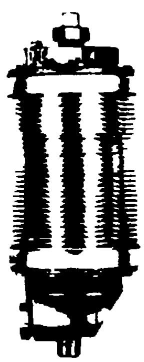
MT-23508

Fig. 21 CR Brakemaster Model 62

The hot compressed air enters the expansion chamber where the sudden drop in pressure cools it off. The heat is carried away through the external fins which are an integral part of the one piece aluminum body.

As the air cools in the expansion chamber, both water and oil vapors are condensed out. This condensation collects on the walls of the expansion chamber and runs down into the collection area where it is automatically discharged by a specially designed unloader valve.

The heat exchanger has a permanent air filter element which traps carbon particles that can harm other components in the air system. Every time the unloader operates (each time the compressor completes a cycle) there is a back rush of air through the filter, so that any carbon trapped in the filter element is flushed out and ejected through the unloader valve.

In an air system where the compressor is in good condition, the filter will require little or no maintenance. If the filter should require servicing, it should only need a bath in cleaning solvent. Replacement should be unnecessary.

MAINTENANCE

Periodic or scheduled maintenance is not required. However, for trouble free operation, the following items should be checked.

1. Steam clean cooling fins to remove accumulated road grime.
2. Check to be sure cooling fins have not been painted.
3. Check air lines to be sure they have not become kinked, cracked, broken or chafed.
4. Perform the Service Checks.

Pages 2411 through 2419 DELETED

SERVICE CHECKS

1. Build up pressure in air system using the air compressor. Bleed off air to cause the compressor to cycle several times.

2. Check and compare the temperature at the inlet and outlet ports. This check can be accomplished by holding your hand on each of the port areas.

CAUTION

The inlet port may be very warm and a burn could result.

The inlet port should be warmer than the outlet port; the outlet port should be at or slightly above ambient temperature. Since the vehicle is stationary, the unit will become warmer than normally experienced during over the road operation. If both inlet and outlet temperatures are high or at the same temperature (about 660 C or 150° F) the deflector will need servicing.

3. Hold a clean shop towel under the unloader (exhaust) port and make the air compressor go through several "unload" cycles. Catch water from the unloader port. If water is oily, the compressor should be checked. If water is "brownish" or if brown particles are expelled, the deflector requires servicing.
4. After the heat exchanger has "exhausted" and while the air compressor is in "stand-by" mode, hold your hand under the unloader port. If air flows out the port, the check valve at the top (outlet port) of the heat exchanger is stuck open and requires service, or the compressor inlet is connected to the outlet side of the turbocharger.
5. If air leaks past the exhaust port while the compressor is building up pressure, the unloader valve is stuck open and requires attention.
6. While the air compressor is building up pressure, it is normal for the check valve to produce a rattling sound through rapid opening and closing.
7. When the air compressor is rebuilt or replaced or if the heat exchanger is moved from one vehicle to another it is recommended that the heat exchanger unit be completely disassembled and cleaned.

If the unloader valve should stick in the open position while the vehicle is on the road, the air system can be restored by threading a 1/2" pipe plug into the exhaust port. By doing this, the air system pressure can be restored but moisture. etc. cannot be exhausted from the air dryer. The unit should be serviced as soon as possible by repairing the unloader valve.

DISASSEMBLY AND REASSEMBLY

General Instructions

Before any work is accomplished, it is important for your safety and the cleanliness of your system to adhere to the following:

1. The area surrounding the unit, and the unit itself, should be thoroughly cleaned to remove dirt, oil and other road grime.
2. Set parking brake.
3. Relieve ALL AIR from vehicle's air system.
4. Relieve pressure in line from "UNL" port of compressor governor to unloader port in the center of the large nut on the bottom of the unit.

Each part of the heat exchanger can be serviced by means of using the various service and replacement kits available.

Servicing Unloader Valve

There are several indications which may mean that the unloader valve of your heat exchanger unit needs servicing:

The compressor goes into "stand-by" mode but cycles rapidly.

Air flows from the exhaust port when compressor is attempting to build up pressure in the air system.

The unit does not "unload" when compressor goes into stand-by mode.

These situations can be caused by several conditions. Check the TROUBLE SHOOTING GUIDE to make sure that the probable cause is a malfunctioning unloader valve on the CR BRAKEMASTER unit. If the probable cause is the unloader valve, it could mean that a piece of debris is clogging this valve, and it only needs to be cleaned, or that the valve assembly itself has been worn and needs to be replaced. In either case, the following steps should be taken.

Refer to Fig. 24 for numbers in parenthesis.

1. Disconnect electrical wire to heater.
2. Disconnect inlet air line from bottom cap.

3. Remove governor control line from UNL port.

4. Remove large unloader nut from UNL port.

CAUTION

Use care in removing the nut to prevent bodily injury since nut is spring loaded.

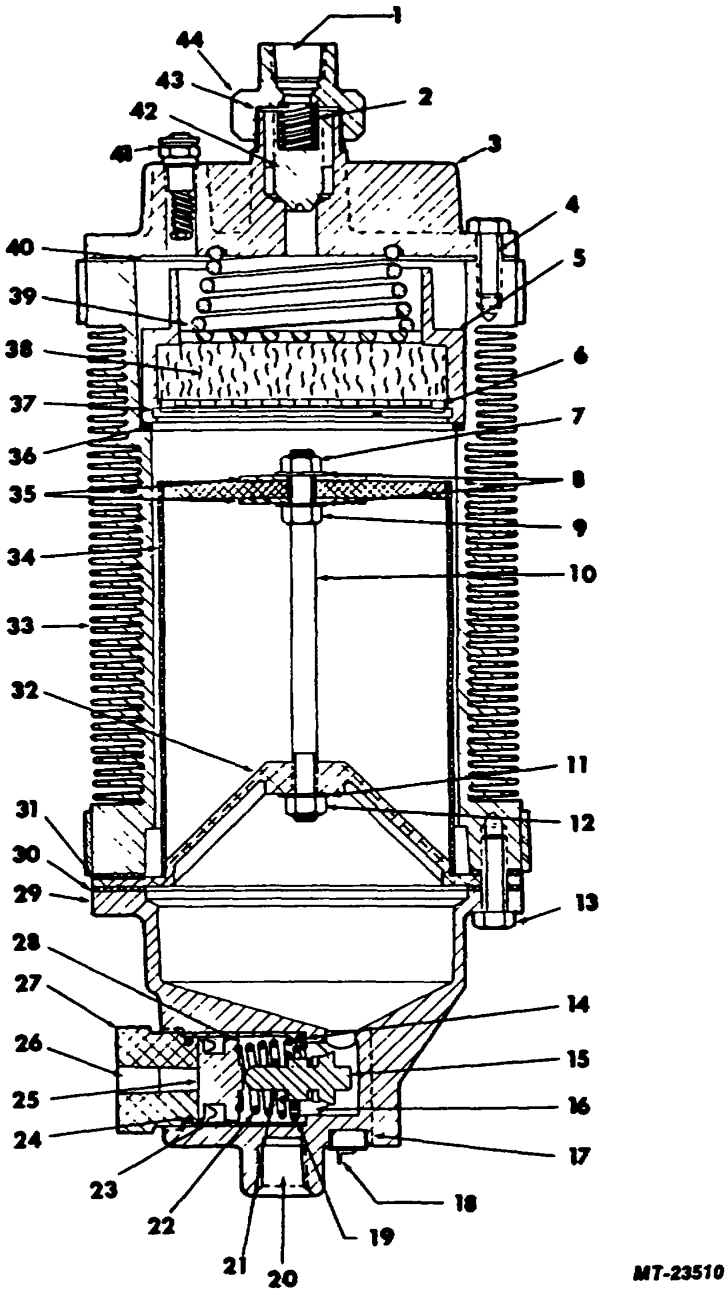

Fig. 23 Cross Section of CR Brakemaster Heat Exchange

Legend for Fig. 23

1 Outlet Port
2 Spring
3 Cap. Top
4 Screw. Cap 3/8"-16x1"
5 Cup. Filter
6 Strainer
7 Nut, 3/8"-16
8 Washer, Lock 3/8"-ext. tooth
9 Nut, 3/8"-16
10 Rod. Support
11 Washer, Lock 3/8"-ext. tooth
12 Nut, 3/8"-16
13 Screw, Cap Socket hd. 3/81-16xl1"
14 Gasket
15 Spindle
16 Seat, Ring
17 Heater
18 Thermostat
19 Spring
20 Port. Exhaust
21 Ring, Retaining
22 Spring
23 Cup. U
24 Ring. O
25 Piston
26 Port (UNL) Unloader
27 Nut, Unloader
28 Sleeve
29 Cap, Bottom
30 Gasket
31 Gasket
32 Plate, Support
33 Body
34 Deflector
35 Washer
36 Ring. Packing
37 Spring, V
38 Filter
39 Spring
40 Gasket
41 Valve, Safety
42 Spindle
43 Gasket
44 Nut

5. Remove complete unloader valve assembly including copper gaskets (10).
Excessive accumulation of oil in the unloader assembly indicates that the air compressor requires attention.

6. Examine unloader valve assembly. If the unloader sleeve (5) is nicked, wrinkled or has axial scratches, the unloader valve assembly should be replaced. The unloader valve assembly if clogged should be cleaned with a' good cleansing solvent.

7. Do not remove retaining ring (7) from unloader spindle (9) since they are serviced as an assembly with spring (8) and seat ring (1).

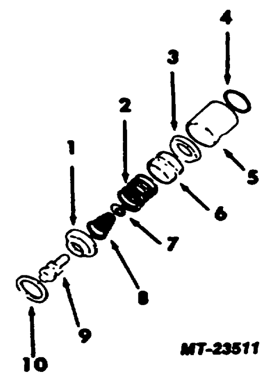

Fig. 24 Contents of Unloader Valve Kit

1	Ring Seat	6	Piston
2	Spring. Large	7	Ring, Retaining
3	Cup, U	8	Spring. Small
4	Ring, 0	9	Spindle, Unloader
5	Sleeve	10	Gasket (2 Req'd.)

8. Install new BU" cup (3) in groove of unloader piston. Lips of *U cup should face away from spring seat. Do not use sharp tools that may mar or score parts.

9. Apply a light film of Item 1 in LUBRICANT SPECIFICATIONS to O-ring (4) and position on unloader nut.

10. Position the two copper gaskets (10) together and lightly coat exposed surfaces with Item 1 of LUBRICANT SPECIFICATIONS. Then position lubricated gaskets on shoulder of ring seat (1). Gaskets should be on face opposite the spring (8).

11. Place gaskets (10) followed by seat ring assembly into bottom cap (Item 29 of Fig. 23).

12. Install unloader sleeve (5) in unloader port against the seat ring. Be sure the 12.7 mm (1/2") diameter cross hole is next to the seat ring.

13. Position large spring (2) in the sleeve (5) with large diameter coil against seat ring.

14. Insert unloader piston (6) into unloader sleeve. Lips of U-cup (3) must face out with spring seat toward spring. The unloader spindle K9) and seat ring (1) is a mated assembly and should not be disassembled. If either the ring seat or spindle is nicked, the entire mated assembly must be replaced as an assembly.

15. Insert a 12.7 mm (1/2") diameter rod or equivalent through the exhaust port in the bottom cap (Item 29 of Fig. 23) and into the cross hole of sleeve (5) to maintain alignment. If the cross holes are not aligned, the unit will not operate.
16. Apply a non-hardening sealing compound to thread of the unloader valve nut (Item 27 of Fig. 23) and install the nut. Tighten nut to 81 Nm (60 ft. lbs.) maintaining the alignment of the cross holes of sleeve (5). Overtightening of the unloader nut will result in damage to the unloader assembly.
17. Remove the alignment rod inserted in step 15.
18. Reinstall the governor control line to UNL port in center of unloader nut.
19. Reinstall in air input line from the air compressor.
20. Connect electrical lead for the heater.
21. Test unit using the instructions listed in SERVICE CHECKS.

Servicing Deflector Assembly

There are several indications which may mean that the deflector assembly needs servicing:

Compressed air was cooled by the unit but no longer is cooled properly.

Water exhausted by the CR BRAKEMASTER is brownish or brown particles are exhausted.

A piece of the deflector is caught in the unloader valve assembly causing it not to operate properly.

These situations can be caused by several conditions. Check the TROUBLE SHOOTING GUIDE to make sure that the probable cause is a malfunctioning deflector assembly. If it is a malfunctioning deflector assembly, the following are the instructions for replacing this deflector assembly.

Refer to Fig. 25 for numbers in parenthesis.

1. Refer to General Instructions.
2. Disconnect air compressor service line at inlet port.
3. Disconnect governor control line from unloader nut (Item 27 of Fig. 23).
4. Disconnect wire from heater assembly.

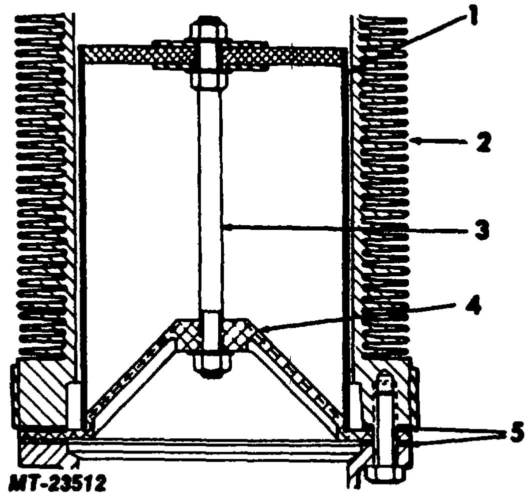

Fig. 25 Contents of Deflector Kit

1 Deflector
2 Body Tube
3 Rod, Support Assy. (Refer to Fig. 23 for detail)
4 Plate, Mounting 5 Gaskets

5. Remove the eight cap screws (Item 13 of Fig. 23) retaining bottom cap to body (2).
6. Remove bottom cap and deflector assembly. On older units the deflector is secured to the bottom cap. If this is the case, the deflector should be removed from the bottom cap by means of removing the four screws holding the deflector to the bottom cap. The feet of the bottom cap (to which the deflector was attached) must be removed.
7. Remove all traces of old gasket(s) material from gasket surfaces of bottom cap and body. Discard old gaskets. Be careful not to scratch or mar gasket surfaces.
8. Wash bottom cap and inside of unit with cleaning solvent.
9. Position new gasket (5) on top of surface of deflector mounting plate (4).
10. Position second new gasket (5) on gasket surface of bottom cap.
11. Align bolt holes and position assembly against bottom gasket surface of body tube (2). Use of gasket sealant is NOT recommended.

12. Insert eight cap screws to attach bottom cap to body tube and deflector assembly. Tighten alternately and evenly to 20.3 Nm (15 ft. lbs.). If unit previously had old style deflector attached to bottom cap, use the eight longer cap screws contained in the deflector replacement kit.
13. Reconnect the air line to the inlet port (this line leads from the compressor service port).
14. Reconnect the governor control line to the unloader port in unloader nut (Item 27 of Fig. 23).
15. Reconnect the wire to the heater.
16. Test the unit following the instructions listed in SERVICE CHECKS.

Servicing Check Valve Assembly

There are several indications which may mean that the check valve needs servicing:

Air is exhausted from exhaust port when compressor is in stand-by mode.

System air pressure bleeds off rapidly when air using equipment is not being operated.

Compressor goes into stand by mode but cycles rapidly.

Compressor attempts to build pressure but system pressure will not build up.

Safety valve opens.

• These situations can be caused by several conditions. Check the TROUBLE SHOOTING GUIDE to make sure that the probable cause is a defective assembly. The following is the procedure for servicing and replacing the check valve assembly.

Refer to Fig. 26 for numbers in parenthesis.

1. Refer to the General Instructions.
2. Disconnect air line at outlet port at top of unit.
3. Remove top nut (4). This nut is spring loaded.
4. Remove copper gaskets (3). spring (1), and check valve spindle (2).
5. Clean and dry entire check valve area and top nut (4).
6. Position new check valve spindle (2) in top cap with tapered end down.

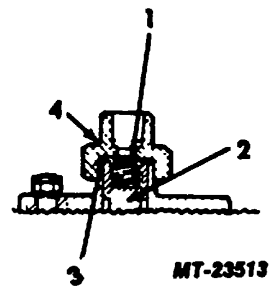

Fig. 26 Check Valve Assembly

1	Spring	3	Gaskets
2	Spindle	4	Nut

7. Install spring (1) in check valve spindle.
8. Position new copper gaskets (3) in nut (4) and rub a small quantity of grimes on the gaskets to help them keep their position in the top nut.
9. Thread nut on to top cap and torque to 81 *Nm* (60 ft. lbs.). Top nut (4) is not included in check valve replacement kit.
10. Reconnect the air line to the outlet port. The safety valve (Item 41 of Fig. 23) cannot be serviced and it is recommended that it <u>not</u> <u>be</u> removed from the top cap. If the set valve was removed, apply non-hardening sealant to threads of top cap.
11. Test the unit following the instructions listed in SERVICE CHECKS.

Servicing Filter Assembly

Although the filter assembly of the unit is designed to require little or no servicing, it is a good practice to service the filter assembly when performing service on the other filters located on' the vehicle. This servicing can be accomplished in one of two ways, either replacing the entire filter assembly, or by servicing the filter assembly. In most cases, simply servicing will only be necessary. The following are the steps for servicing the filter assembly. If the entire filter assembly is being replaced, those steps preceded by an asterisk (*) can be eliminated.

Refer to Fig. 27 for numbers in parenthesis.

1. Refer to the General Instructions.
2. Remove air line at outlet port.

3. Remove eight cap screws holding top cap (2) to body (8).

CAUTION
Use care in removing top cap bolts to prevent bodily injury because the cap is spring loaded with approximately 178 Nm (40 ft. lbs.).

4. Remove spring (Item 39 in Fig. 23).
5. Remove all traces of gasket material from top cap and body gasket surfaces (2 & 7). Discard gasket. Be careful not to scratch or score gasket surfaces and wash top cap in cleaning solvent.
6. Remove complete filter assembly.
7. Remove rubber packing ring (7) and discard.
8. Discard old stainless steel filter. If you are replacing entire filter assembly, the entire filter assembly including filter cup (3), strainer (5) and V-spring (4) may also be discarded.
9. Wash strainer (5) and filter cup (3) in cleaning solvent.
10. Assemble stainless steel filter (6) in filter cup (3). Filter should be stretched slightly to fill the space in filter cup.
11. Reinstall strainer (5) with flat face of strainer towards stainless steel filter.
12. Install V-spring (4) holding filter assembly together ,.
13. Install new packing ring (7) on ledge of body.
14. Position filter assembly into body with large end down. The filter must set on packing ring.
15. Install heavy spring (39, Fig. 23) with larger r4-metir coil against top of filter assembly.
16. Position new gasket (I) on body. Do not use gasket cement.
17. Position top cap and spring so that the ,small diameter coil on spring fits groove in top cap.
18. Compress a spring and install four 3/8 cap screws (4, Fig. 23) into body. Each of these four (4) screws should be engaged at let three full turns before load on cap is removed. Cap screws should be equally spaced. Then thread remaining screws into place.

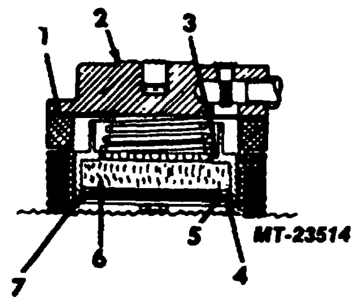

Fig. 27 Servicing Filter Assembly

1	Gasket	5	Strainer
2	Top Cap	6	Filter 3 Filter Cup
7	Packing Ring	4	V Spring

19. Tighten all top cap bolts alternately and evenly to 20.4 Nm (15 ft. lbs.).
20. Reconnect air line to outlet port.
21. Test unit operation following instructions outlined in SERVICE CHECKS.

Servicing Thermostatically Controlled Cartridge Type Heater

The current heat exchanger units contain a 12 volt 50 watt heater as standard equipment. This heater requires a newly designed bottom cap which is completely interchangeable with those in use previously. Use of this new cap may. however, necessitate a change of the deflector assembly if your present bottom cap has the deflector attached to it by screws. Wrap around strap type heaters, which are NOT thermostatically controlled are available for this old style bottom cap. Refer to Servicing Wrap Around Strap Type Heater.

There are two kits used in servicing the thermostatically controlled cartridge type heater assembly. Heater is 50 watt, 12 volt.

Instructions for installing either of the kits are as follows.

1. Refer to the General Instructions.
2. Disconnect the electrical line from the CR BRAKEMASTER heater.
3. Remove old cartridge type heater by loosening set screw for heater on bottom cap.

4. Remove old thermostat from bottom cap by removing the two small screws which retain

the thermostat on the bottom cap. Discard entire heater/thermostat assembly.

5. Install new heater by inserting it into hole from which old heater was removed and re-tighten set screw.
6. Install new thermostat by inserting it into the hole from which old thermostat was removed and attach by means of the two screws provided.
7. Attach the lead from the thermostat to the electrical system. Even though the heater is thermostatically controlled, it is recommended that the heater be hooked up through a control switch.
8. Be sure the unit is grounded to the chassis.

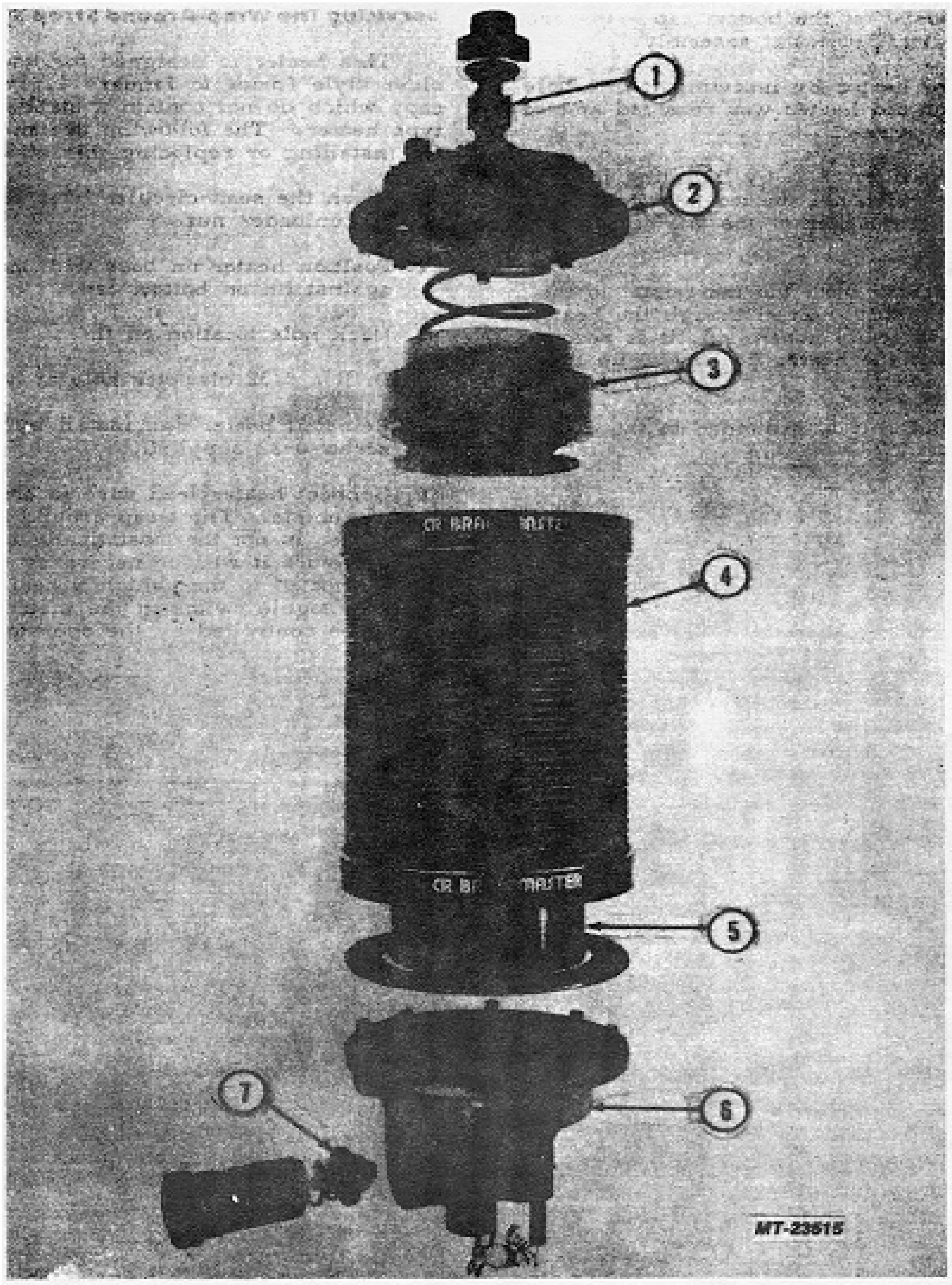

Fig. 28 Exploded View of CR Brakemaster Heat Exchanger

1	Check Valve Assembly	5	Deflector Assembly
2	Top Cap	6	Bottom Cap
3	Filter Assembly	7	Unloader Valve Assembly
4	Body		

SYMPTOM	PROBABLE CAUSE	REMEDY
Air is exhausted from exhaust port when compressor is in the stand-by mode.	1. Inlet side of compressor connected to outlet side of turbocharger.	Consider changing compressor inlet connection. Consult vehicle manufacturer.
	2. Check valve at outlet port stuck open.	Clean or replace check valve assembly.
System air pressure bleeds off rapidly when air using equipment is not being operated.	1. Leak in air line connection(s).	Tighten or replace fittings.
	2. Leak in air line or reservoir.	Repair or replace faulty item(s).
	3. Check valve at outlet port stuck open.	Clean or replace check valve assembly.
Compressor runs continuously (will not go into stand-by mode).	1. Leak in air line connections.	Tighten or replace fittings.
	2. Leak in air line or reservoir.	Repair or replace faulty item(s).
	3. Compressor defective.	Rebuild or replace compressor.
	4. Unloader valve stuck open.	Clean or replace unloader valve assembly.
	5. Compressor capacity too low for vehicle.	Install larger compressor.
Compressor goes into "stand-by" mode but cycles rapidly.	1. Leak in air system.	Correct leak.
	2. Check valve in CR Brakemaster outlet port stuck open.	Clean or replace check valve assembly.
	3. Defective seal in unloader.	Repair unloader valve.
	4. Unloader sleeve defective.	Replace sleeve.
Air flows from exhaust port when compressor is attempting to build up pressure in air system.	1. Unloader valve stuck open.	Rebuild unloader valve.
	2. Seat of unloader valve chipped or nicked.	Replace seat assembly.
	3. Piece of dirt or foreign material stuck in unloader valve.	Replace seat assembly.
Compressor attempts to build pressure but system pressure will not build up.	1. Refer to "Compressor runs continuously" of Trouble Shooting Guide.	
	2. Line between compressor and exchanger blocked.	Replace line or remove blockage.
	3. Check valve in outlet port stuck closed.	Clean outlet and replace check valve.
	4. Pressure sensing device defective.	Replace
	5. Blockage in air line between compresor and sensing device (Note: If safety valve of exchanger opens, blockage is after unit).	Remove blockage.

SYMPTOM	PROBABLE CAUSE	REMEDY
Does not cool air (initial installation).	1. Mounted in location where it cannot be cooled by ambient air.	Relocate unit.
	2. Mounted too near heat producing equipment or too near other heat dissipating equipment.	Relocate unit.
	3. Copper tubing from compressor to inlet too short.	Increase length of copper tubing.
Does not "unload" when compressor goes into stand-by mode.	1. UNL port of governor not connected to unloader port or line broken.	Connect or repair line.
	2. Components of unloader valve worn.	Rebuild unloader valve.
	3. Ice formed in area of unloader valve.	Shorten line (24" min. allowable length) and/or install heater.
	4. Heater inoperative.	Replace heater or check electrical connections.
Safety valve opens.	1. Check valve in outlet stuck closed.	Clean outlet and replace check valve assembly.
	2. Obstruction in air line beyond heat exchanger.	Remove obstruction.
	3. Compressor governor valve defective.	Replace.
	4. Safety valve defective.	Replace.
Water exhausted by unit contains excessive oil and/or soot.	1. Compressor rings defective.	Rebuild or replace compressor.
No water exhausted during unloading cycle.	1. Insufficient water in ambient (inlet) air.	
	2. Not cooling air sufficiently to condense water.	Lengthen copper line from compressor to heat exchanger (36" max. length allowable). Relocate heat exchanger to area of greater ambient air flow.
Compressed air was cooled by unit but no longer is cooled properly.	1. Covered with dirt or paint.	Steam clean and/or remove paint.
	2. Deflector damaged or broken.	Replace deflector assembly.
Water exhausted is brownish or brown particles are exhausted.	1. Broken or damaged deflector.	Replace deflector assembly.

BRAKES- AIR

FOUNDATION BRAKE - AIR

CAM-ACTUATED TYPE

CONTENTS

CONTENTS (Continued)

DESCRIPTION

The term "foundation brake" is given to those components at wheels which actually do the braking. This includes such items as brake shoes, lining, anchors, drums and spider or backing plate. Although the slack adjusters, cam and followers are not directly known as components of the foundation brakes, they will be covered herein.

MAINTENANCE

A regular schedule for periodic cleaning, lubrication, adjustment and inspection should be established, usually based on past experience and type of vehicle operation. It is difficult to determine an exact maintenance interval (time or mileage) since vehicles will be used in a wide variety of operational applications and conditions.

To compensate for lining wear, brakes should be adjusted frequently to maintain satisfactory operation and efficient brakes.

Refer to BRAKE ADJUSTENT for detailed adjustment procedures.

Drain air reservoirs regularly as required. Local conditions govern frequency. Dry climates require less attention than humid areas, where it may be necessary to drain reservoirs daily.

When draining air reservoirs, let all air bleed off and be sure all drainage stops.

For details for the air system, refer to the appropriate air brake system section.

BRAKE ADJUSTMENT

Brake adjustment can be a contributing factor of brake complaints. Proper brake adjustment must be maintained. Do not overlook brake adjustment on the trailer either. Brake balance on trucks and tractor trailers is essential for good braking.

Periodic checking of push rod travel or brake adjustment is essential for good braking. Push rod travel should be checked every 6, 000 km (4,000 miles) to determine if adjustment is necessary. Push rod travel should be kept at a minimum without brakes dragging.

Inspect brake lining every 19, 000 km (12, 000 miles) or every 12 months, whichever occurs first. When brake lining or blocks are worn to within 1.6 mm (1/16") of rivets, brake lining must be replaced.

If brake lining is satisfactory, adjust brakes in the following manner making brake adjustment, one wheel at a time, with all drums in place and all slack adjusters connected to chambers.

<u>These instructions apply to manual adjustment type slack adjusters.</u>

1. With wheels raised and parking brake released so that wheels will rotate freely, check each brake chamber push rod to make certain that it is in fully released position. To do this, disconnect push rod at slack adjuster. If push rod moves toward (released) brake chamber, turn worm shaft and rotate slack adjuster toward push rod until clevis pin can be reinstalled.
2. Disengage locking sleeve on worm shaft or adjusting screw by depressing spring loaded sleeve with a wrench (Fig. 1).

   Fig. 1 illustrates the locking sleeve in its disengaged position. Be sure sleeve is <u>held in</u>, disengaging the adjusting screw when making adjustments.

   Use either an open or socket wrench when making adjustment. Make certain locking sleeve is <u>held in</u>, thereby disengaging the locking mechanism. <u>Never use a wrench on the sleeve portion</u>.

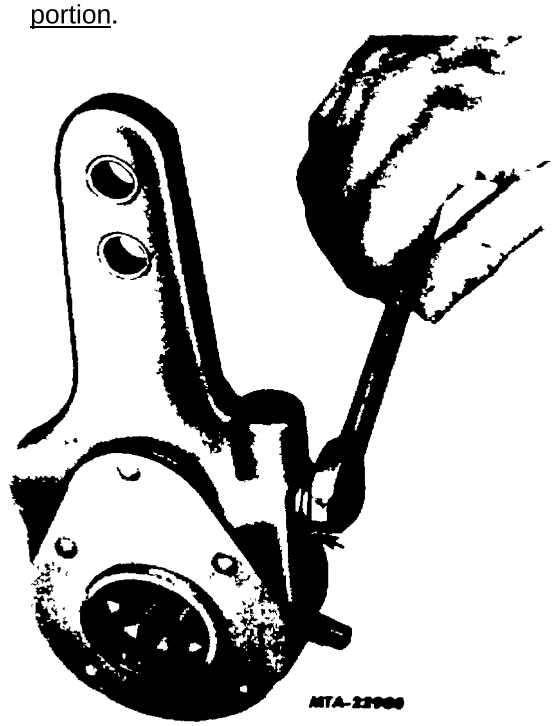

Fig. 1. Slack Adjuster Locking Sleeve on Adjusting Nut

3. Turn vehicle wheel and at the same time rotate adjusting screw until brake shoes are tight against drum.
4. Back off adjusting screw just enough to eliminate drag.
5. Make and hold full brake application to fully seat brake shoes against drum and note the angle between slack adjust and push rod. This angle should be a minimum of 90 degrees or more.

If the foregoing adjustment or relining of brake shoes does not establish an angle of near 90 degrees between push rod and slack adjuster with brakes applied (Fig. 2), then maximum force against slack adjuster cannot be obtained. Readjust push rod as follows:

1. Disconnect slack adjuster and push rod. Do this carefully because slack adjuster may be turned toward brake chamber with considerable pressure.

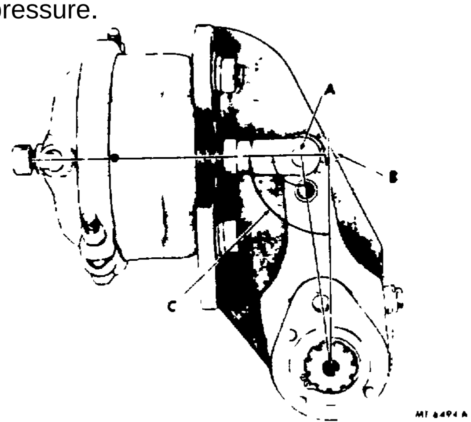

Fig. 2. Brake Chamber and Slack Adjuster

A Slack Adjuster More Than 900 in Released Position
B Applied Position
C Angle Should be 900 in Applied Position

2. Loosen lock nut on clevis and thread clevis onto push rod toward brake chamber for several turns.
3. Reconnect slack adjuster and push rod with clevis pin.
4. Make a full brake application and check angle between slack adjuster and push rod. If 90 degrees or slightly more is not obtained with brakes applied, repeat adjustment until angle is satisfactory.

The desirable situation is to bring brake shoes against drum just as the slack adjuster attains the near 90 degree position (Fig. 2).

MANUAL SLACK ADJUSTER OPERATION TEST

Slack adjusters should rotate freely without binding when the brakes are applied and when the brakes are released, all slack adjusters must return to the released position freely and without binding. The slack adjusters must be adjusted so that the angles formed by brake chamber push rod and center of slack are near 90 degrees as described in BRAKE ADJUST.

BRAKE CHAMBER SERVICE TEBT

Operational Test

Apply and release the brakes, observing the brake chamber push rod. The chamber push rod should move out promptly and return to the released position freely without binding.

Leakage Test

1. Apply the service brakes and apply soap solution to the chamber clamping area. If leakage is noted, tighten the clamp ring bolts and if leakage does not stop, the chamber must either be reconditioned or replaced.
2. With the service brakes applied, check for leakage through the diaphragm by applying a soap solution to the push rod opening and drain holes on non-pressured side of chamber. No leakage is permissible. If leakage is evident, the chamber diaphragm must either be replaced or complete chamber replaced.

LUBRICATION

Brake camshafts and slack adjusters should be lubricated every five months or 26,000 km (16, 000 miles). Refer to ILBRICATION Section for type of lubricant. Do not overlubricate. Slack adjusters without fittings require no lubrication. The provision for lubrication may differ on slack adjusters. Some have zerk fittings while others utilize pipe plugs or snap-in type plugs or covers.

When brake linings are replaced, apply a thin coat of the same lubricant to brake shoe anchor pins and camshafts. Do not overlubricate.

FOUNDATION BRAKE GROUP

DISASSEMBLY

Variations in disassembly procedure may be required as different types of brakes have been used on IH vehicles. Some typical brakes used are single and double anchor cam actuated types as well as wedge type actuated brakes. Refer to the particular Service Manual section for complete details pertaining to wedge-type brakes.

The disassembly instructions contained herein have been arranged as follows:

Remove Wheel, Hub and Drum

Brake Groups with Backing Plate

Brake Groups with Spider (Cast Type Mounting Bracket)

Detailed information covering disassembly and reassembly of various components such as slack adjusters, brake chambers and brake shoes will be found elsewhere in this section.

Remove Wheel, Hub and Drum

1. Position vehicle on floor stands.
2. Release parking brake. If vehicle is equipped with spring brake chambers, chambers should be manually released or "caged" to avoid an automatic application of spring brake chambers while vehicle is being serviced. Refer to proper Parking Brake, Spring Brake Chamber section for detailed instructions covering manual release of spring brake.
3. It may be necessary to back off brake adjustment to obtain enough clearance for drum removal (Fig. 3).
4. Remove brake drum assembly as determined by the type of drum mounting. Two variations will be found in drum-to-hub mounting.
   a. Inboard mounted drum will be secured to the hub assembly on the brake group side of hub. This type of mounting will apply to all cast wheels and some disc wheels. With this type of drum mounting, the wheel, hub and drum is removed as one assembly (Fig. 4).
   b. Outboard mounted drums will be secured between the wheel and hub. This mounting will only apply to some disc wheel installations.

   When outboard mounted drum brake groups are serviced, the wheels are removed, then the drum can be removed without disturbing the hub assembly (Fig. 5). This will eliminate wheel bearing repacking and adjustment.

Further identification and service procedures will be found in the Wheels, Rims and Tires section.

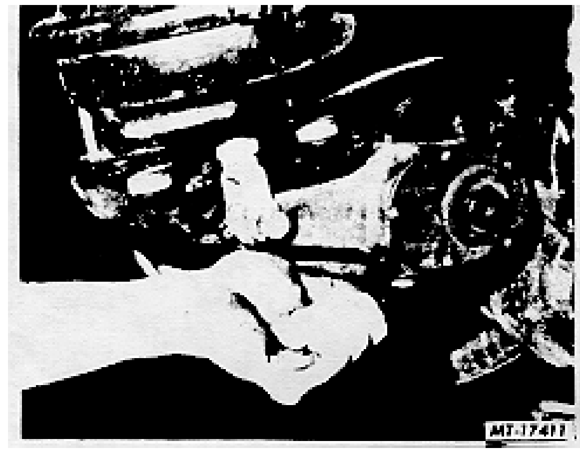

Fig. 3. Backing Off Brake Adjustment

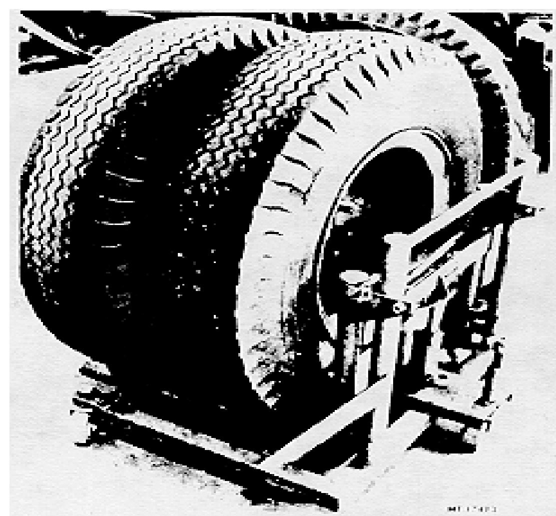

Fig. 4. Using Wheel Dolly to Remove Wheel, Hub and Drum Assembly

Rockwell "Q" Series Brake Group (Fig. 10)

Remove brake shoes as follows:

1. Disconnect lower and upper cam roller retainers (Fig. 11).

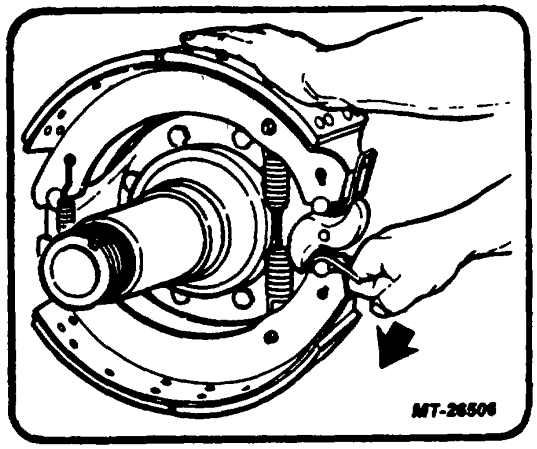

Fig. 10. Disconnecting Roller Retainer

2. Press down on the lower brake shoe and remove the lower cam roller (Fig. 12).

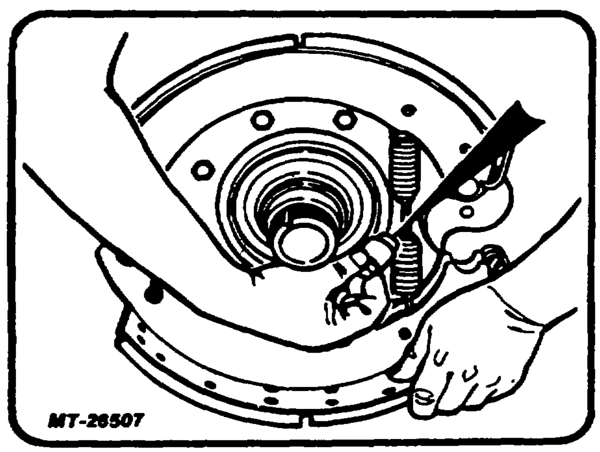

Fig. 11. Removing Lower Cam Roller

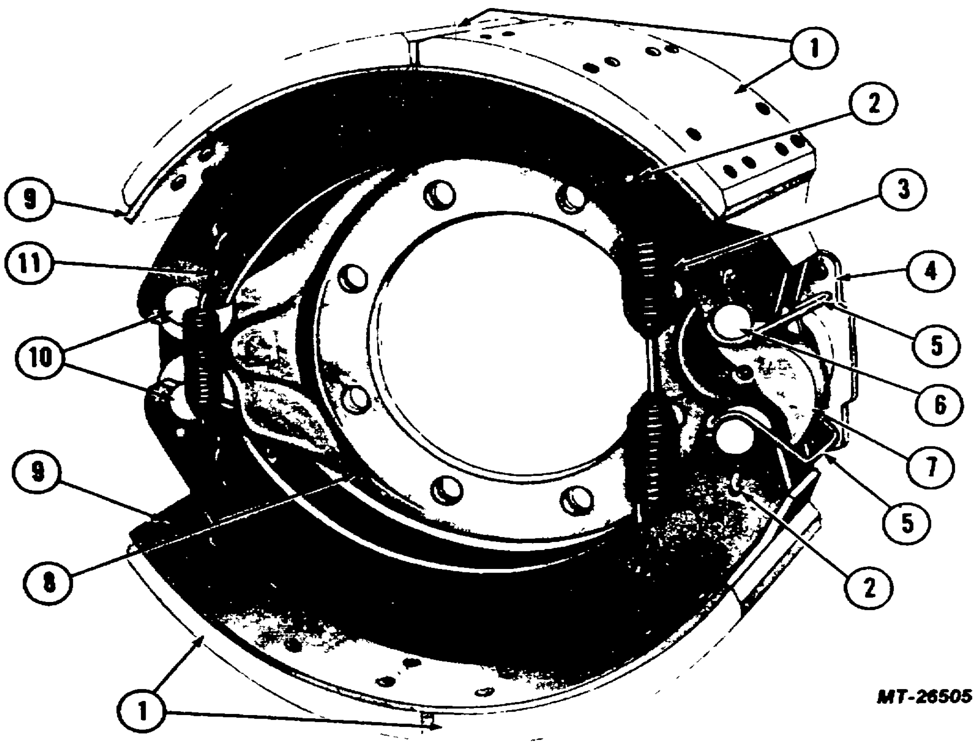

Fig. 12. Typical Broke Group with Removable Anchor Pine

1	Lining (Blocks)	5	Roller Retainer	9	Shoe
2	Link	6	Roller Assembly	10	Anchor Pins
3	Return Spring	7	Camshaft Assembly	11	Shoe Retaining Spring
4	Camshaft Bracket	8	Spider		

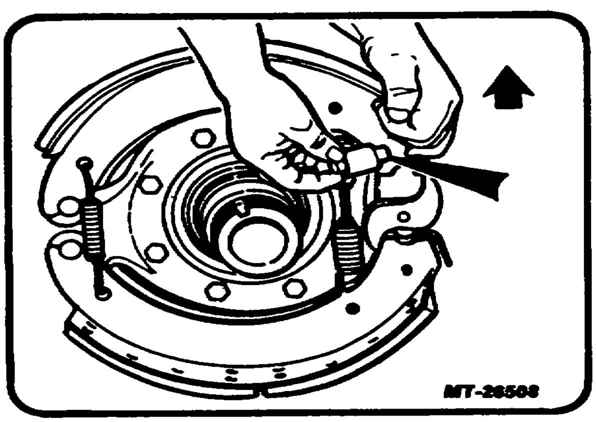

Fig. 13. Removing Upper Cam Roller

3. Lift top shoe and remove the remaining can roller assembly (Fig. 13).
4. After removing roller assemblies, the shoe return spring will be loose and can be slipped from the links between shoe webs (Fig. 14).
5. Swing lower shoe back about 1800 to relieve the tension on the retainer springs (Fig. 15). Then remove the inboard and outboard retainer springs (Fig. 16).
6. Remove lower shoe (Fig. 17). Then remove upper shoe.
7. Mark position manual of slack adjuster to camshaft also noting position of adjusting screw. The adjuster screw may be facing toward or away from brake chamber mounting surface.
8. Remove clevis pin connecting the brake chamber push rod to slack adjuster.

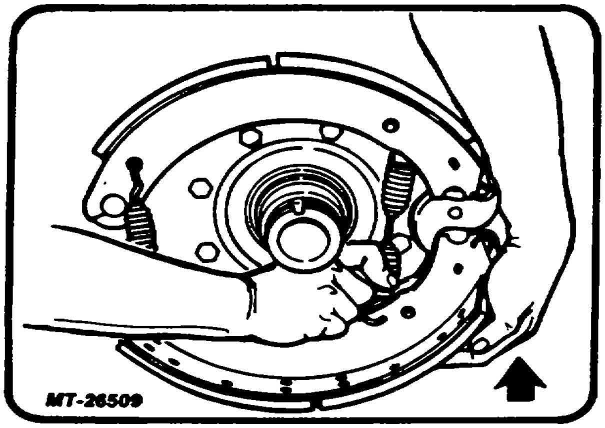

Fig. 14. Remove Shoe Return Spring

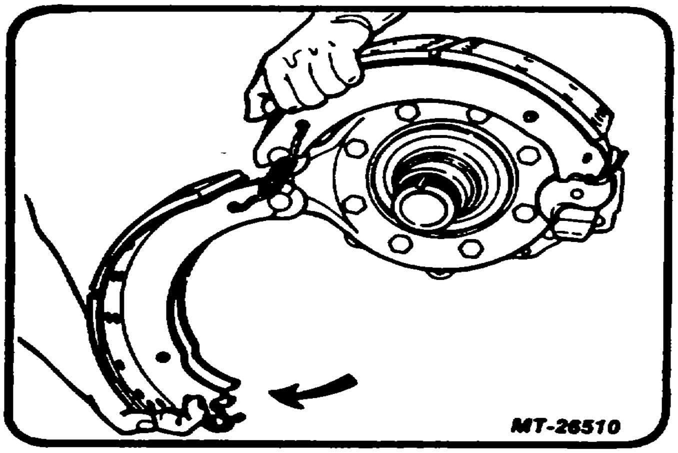

Fig. 15. Rotate Lower Shoe Approximately 180°

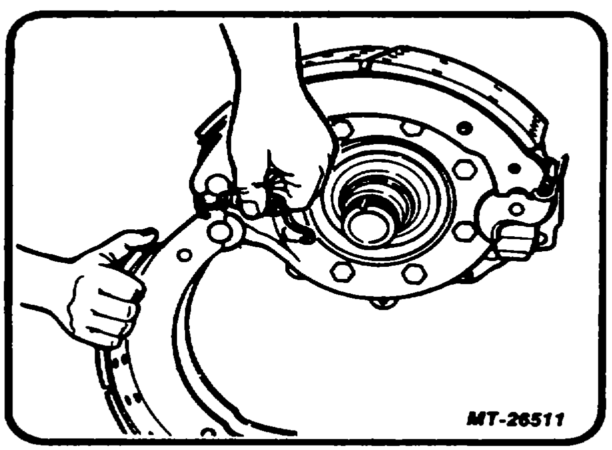

Fig. 16. Removing Retainer Springs

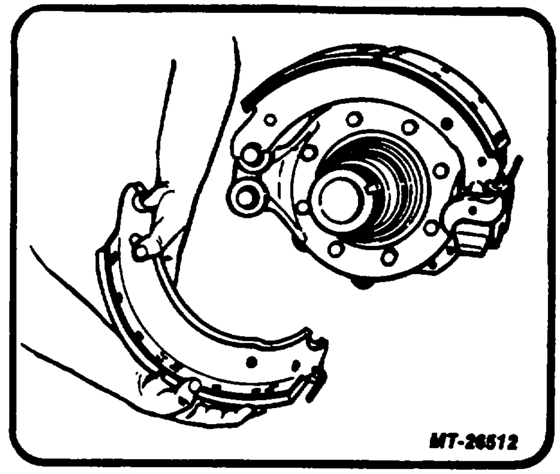

Fig. 17. Removing Lower Shoe

9 Remove lock ring from end of camshaft. Note location of spacer washers for reassembly purposes.

10. Remove slack adjuster from camshaft.

11. Push or tap camshaft from spider and camshaft bracket.

CLEANING AND INSPECTION

Thoroughly clean all parts except drums and brake lining material in cleaning fluid and wipe dry. Grease and solvents which leave an oil residue will affect brake performance.

CAUTION

Because studies have indicated that exposure to excessive amounts of asbestos dust may be a potential health hazard, OSHA has set maximum limits of levels of airborne asbestos dust to which workers may be exposed. Since most automotive friction materials normally contain a sizable amount of asbestos, it is important that people who handle brake linings be aware of the problem and know the precautions to be taken.

OSHA standards should be consulted with respect to mandatory requirements as well as for suggested procedures to minimize exposure.

Drum, Shoe and Lining

Refer to the service manual section pertaining to reconditioning drums and shoes.

Anchor Pins

The anchors should be inspected for signs of wear. In most cases, rust will be the factor in servicing brake anchors. Clean all dirt and rust from anchors and coat then with a very light coat of lubricant. Refer to LUBRICATION, section, Brakes, for type of lubricant.

If anchor pins are worn, they must be replaced. Anchor pins may be replaced on all brake groups except Eaton (Fig. 18). Eaton anchor pins are staked in place and are replaced with spider.

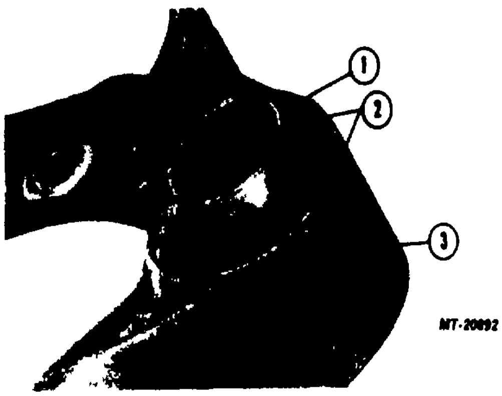

Fig. 18. Brake Spider with Fixed Anchor

Brake Shoe Return Spring

Inspect brake shoe return springs for distortion, such as nicks, twisted shanks or spread coils. Damaged springs must be replaced. It is suggested that shoe return sprigs be replaced when shoes or shoe lining are replaced.

Spider

Inspect spider fore. If any cracks are found, the spider must be replaced.

Camshaft Bushings and Rollers

Clean all dirt and rust from rollers and cam shaft. In mot cases, rust will be the factor in servicing rollers. Check for dirt in splines on camshaft. Remove any mall burrs from camshaft assembly to avoid damage to seals when shaft is reinstalled.

Inspect camshaft, camshaft bushings or bearings and brake shoe rollers. If noticeable signs of wear exist, replace worn parts.

Do not remove camshaft bushings from spider and/or mounting bracket unless replacement is necessary.

Apply a very light coat of lubricant to camshaft assembly and rollers. Refer to LUBRICATION section for type of lubricant.

For detailed servicing instructions pertaining to camshaft and bushings, refer to SERVICING BRAKE GROUP COMPONENTS in this section.

REASSEMBLY

The reassembly instructions contained herein have been arranged as follows:

Install Wheel, Hub and Drum

Brake Groups with Spiders

Install Wheel, Hub and Drum

After various components of the brake assemblies have been serviced, brakes are reassembled by reversing the disassembly procedure.

It is recommended that newly installed brake lining be circle ground before installing brake drums. Circle grinding lining to fit drum assures full contact between lining and drum. Refer to RECONDITIONING BRAKE DRUMS AND SHOES section.

When reassembling various components which are secured with bolts and/or nuts such as backing plates, spiders, camshaft brackets or anchor pins, refer to applicable TORQUE CHART.

Brake shoes must be properly located to provide designed efficiency of brake group. The primary (forward) shoe is the first shoe just past the cam in forward direction of wheel rotation.

Brake shoes with combination brake blocks sets of semi-metallic and organic lining must be installed as shown in Figures 19 and 20.

The brake blocks on each shoe consist of one semi-metallic material (shaded area) and one block of organic material (unshaded area).

The semi-metallic material is identified by the metal particles embedded in the brake block. The organic material will not have the visible metal particles.

Brake Groups with Spider

Rockwell "Q" Series (Fig. 12) with two removable anchor pins and open ends on shoes.

1. Lubricate camshaft bushings with lubricant listed in LUBRICATION section, Brakes.
2. Install camshaft assembly being sure spacer washers are assembled in reverse sequence when removed.
3. Install anchor pins if removed (Rockwell "Q" Series brake groups).

"Q" Series - Anchor pins are held in place by the shoes, eliminating snap rings, felts and set screws.

4. On brake groups with open end anchor ends on shoes, position shoes on anchors and install shoe retaining springs at anchor end of shoes.
5. Install brake shoe return springs.
6. Pry each shoe (one at a time) away from cam and install rollers. If rollers have retainers, be sure they are hooked on the roller assemblies.
7. Reassemble slack adjusters on camshaft aligning scribe marks and repositioning spacer washers to the same location when removed.
   a. Spacer washers are to be positioned to provide a maximum end play of 1.59 mm (.062") with retaining ring installed.
   b. Adjuster screw may be either facing toward or away from brake chamber mounting flange to provide accessibility. In most instances, the adjuster screw will be facing away from brake chamber mounting surface.
8. Install slack adjuster retaining ring. Make sure that the retaining ring is of correct thickness. Two variations of ring grooves will be found; namely 1.5875 m(1/16") and 3.1750 mm (1/8"). The proper ring thickness must be used in the camshaft groove.
9. Install brake chamber if removed.
10. Reinstall wheel and drum assembly and adjust wheel bearings.
11. Adjust brakes as outlined in BRAKE -ADUS-NT instructions.

SERVICING FOUNDATION BRAKE COMPONENTS

DRUMS AND SHOES

For complete details covering servicing of brake drums and shoes, refer to the section covering RECINDITIONING DM AND SHOES.

ANCHOR PINS

Anchor pins provide a point where shoes can be secured to backing plate or spider and also permit positioning shoe in respect to drum.

Anchor pins are designed to withstand all braking force of slowing or stopping the vehicle.

Anchor pins which are secured to the backing late with a lock washer and nut are replaced y using two wrenches; one wrench is positioned on the nut while the second wrench is positioned over the flats on threaded area on anchor pin. Refer to TORQUE CHART for specified torque value.

If fixed anchor pins (Fig. 18) become worn, the complete spider replacement will be necessary.

Anchor pins in spiders which are removable (similar to that shown in Fig. 9) will be equipped with bushings which are serviceable. Replaced bushings are to have a clearance of .076-.127 Um (.003-.005 in.) between bushing and pin.

CAMSHAFT, BUSHINGS AND SEALS

The camshaft is actuated by movement of slack adjuster. The rotating movement of can forces shoe rollers away from cam, thus forcing shoes into contact with drum.

Removal procedure for camshaft assembly is covered in Brake Disassembly procedure. When removing camshaft' from backing plate or spider, note position of spacing washers to assure correct reinstallation.

Do not remove camshaft bushings from spider and/or mounting bracket unless replacement is necessary.

Do not interchange right and left hand camshafts.

Removal of brake chamber bracket will be required to replace the bushings in sane instances.

To check bushings to determine if replacement is required, insert the camshaft in the bushing and check side play. If more than .5080 mm (.020") on Wagner or Eaton brakes or .7620 mm (.030") on Rockwell brakes, the bushings need replacing.

Install new bushings with a suitable tool like that shown in Fig. 21.

Apply IH 251 HEP grease or equivalent NLGI #2 multi-purpose lithium grease to outside diameter of bushings to assist in pushing them into position.

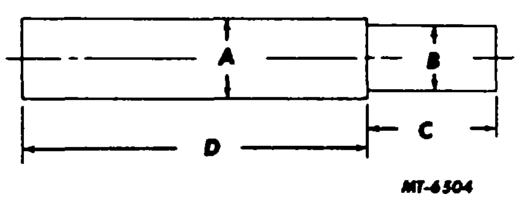

Fig. 21. Recommended Type of Camshaft Bushing Removing Tool

A Bushing Outside Diameter
B Bushing Inside Diameter
C Bushing Length
D Suitable Length

Install new seals with lip of seal toward slack adjuster (Fig. 22).

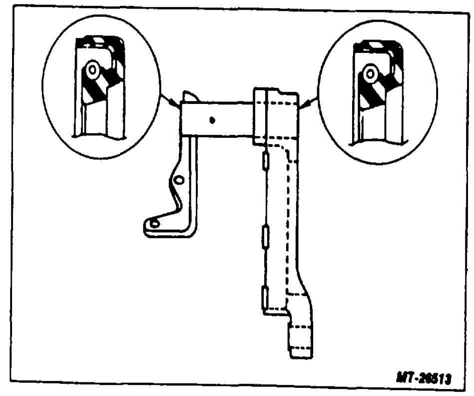

Fig. 22. Brake Chamber Bracket Seal Installation

BRAKE CHAMBERS

Brake chambers (Fig. 23) transform energy of compressed air into mechanical force and motion to apply brakes. One chamber is used at each wheel to operate brakes.

Air pressure entering the brake chamber (Fig. 23) behind the diaphragm forces the diaphragm and push rod outward, rotating slack adjuster, brake camshaft and cam applying the brakes. The higher the air pressure admitted to chamber, the greater the force pushing brake shoes against drum.

When air pressure is released from brake chamber, brake shoe return springs and brake chamber release spring return shoes, can, slack adjuster and brake chamber back to the released position.

The brake chamber consists of two dished metal sections; namely, pressure plate assembly and non-pressure plate, separated by a rubber diaphragm, all of which are held together by a metal two-segment clamp. In front of the diaphragm are the push rod, push rod spring and retainer (Fig. 23).

Several types of spring actuated type parking brakes are used in conjunction with or are attached to brake chambers while others replace the entire brake chamber.

The purpose of auxiliary spring brakes is to provide an emergency brake which will stop the vehicle if air pressure drops.

These spring brake systems are covered in PARKING BRAKE section of the Service Manual. Refer to the respective section pertaining to

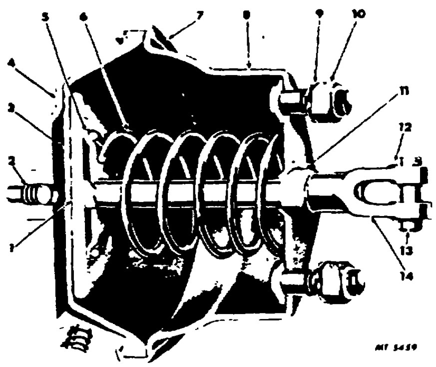

Fig. 23. Brake Chamber (Cross Sectional View)

1	Rod, Push	8	Plate, Nonpressure
2	Plug	9	Washer, Lock
3	Diaphragm	10	Nut
4	Plate, Pressure	11	Nut, Lock
5	Retainer, Spring	12	Pin, Cotter
6	Spring	13	Pin, Clevis
7	Clamp	14	Yoke, Clevis

particular spring brake chamber involved.

Remove

Disconnect air line and push rod yoke. Remove nuts from mounting studs and remove chamber.

Install

Position brake chamber on mounting bracket and install nuts on mounting studs. Install lock nut and yoke on push rod. Connect air line. Adjust yoke to slack adjuster (see ADJUSTMENT) . Be sure end of push rod does not bind with slack adjuster when brakes are applied.

Disassemble

To disassemble the brake chamber (numbers in parenthesis) refer to Fig. 23.

1. Mark non-pressure plate (8), pressure plate (4) and clamp (7). This will make it easier to reassemble air chamber in its original position and avoid installation interference.

2. Remove yoke (14) and lock nut (10) from nut rod (1).

3. Remove nuts and bolts from clamp ring. Separate plates carefully since return spring inside brake chamber is under tension.
4. With two sections of brake chamber separated remove push rod, spring retainer (5) and spring (6) from non-pressure plate.

Cleaning and Inspection

After brake chamber has been disassembled, proceed as follows:

1. Using a suitable cleaning solvent, clean all metal parts thoroughly.

2. Examine diaphragm. If any signs of damage or deterioration are evident, replace diaphragm. When one diaphragm requires replacement, it is good practice to replace all brake chamber diaphragms in the system while vehicle is out of service. Brake chamber diaphragms 'must be replaced once each year or every 160, 000 km (100, 000 miles) regardless of condition.

3. Inspect push rod, spring and spring retainer. If parts are damaged, they should be replaced. Check return springs. If a load scale is available, compare their tension with new spring. Matching an old spring with a new spring will indicate condition of old part.

4. Check condition of non-pressure plate. If clamping flanges on plates are dented or damaged, replace plates.

Reassemble

1. Install nuts (10) on mounting studs and clamp non-pressure plate (8) in vise with inside of plate facing up.
2. Install spring (6) in spring retainer (5).
3. Install push rod assembly in body, press assembly down (brake applied position) to compress spring and use vise grip pliers on outside of push rod to hold spring compressed.
4. Install diaphragm (3) in pressure plate (4).
5. Position brake chamber plates matching up etch marks made prior to disassembly.
6. Install clamp (7) with bolts and nuts and tighten nuts to 17 N•m (150 in. lbs.) torque. Remove vise grip pliers.

7. Install lock nut (11), yoke (14), pin (13) and cotter pins (12).
8. Assemble yoke and lock nut to push rod.

Test

To check for leaks, coat brake chamber around clamp with soapsuds and apply air pressure to port in pressure plate (4).No leakage allowed.

Preventive Maintenance

Every month, or every 6, 000 km (4,000 miles), brake chamber push rod travel should be checked. Push rod travel should be kept at a minimum without brakes dragging. Excessive travel of brake chamber push rod shortens the life of the diaphragm. Over travel also slows braking response.

Once each year, or every 160,000 (100,000 miles), brake chamber should be disassembled and cleaned. New diaphragms must be installed. Be sure to use correct diaphragm return springs when reassembling chamber or uneven braking may result.

Adjustment

After brake chamber is installed, the brakes must be adjusted and checks made to be sure linkage does not bind. Adjustment of push rod length may be accomplished by altering the location of yoke. With brakes applied, the angle formed by the push rod and slack adjuster must be 90 degrees and all slack adjusters should be set at the same angle. With brakes applied, after being adjusted, this angle should still be no greater than 90 degrees. In other words, slack adjuster should not go "over center" when brakes are applied (Fig. 2).

SLACK ADJUSTERS

Slack adjusters provide a method of adjusting brakes to compensate for brake lining wear and also serve as a lever during braking operation (Fig. 24).

Slack adjusters were designed to conform to the development of heavy duty, two-shoe foundation brakes.

During brake operation, the entire slack adjuster rotates bodily with camshaft. When adjusting brakes, the worm moves the gear so as to change position of lever arms in relation to brake camshaft.

Information pertaining to automatic slack adjusters will be found elsewhere in the BRAKE section of the Service Manual.

Remove

1. Remove cotter key and clevis pin from slack adjuster and push rod clevis.

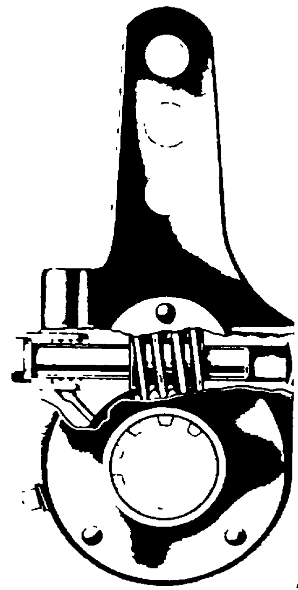

Fig. 24. Section View of Slack Adjuster

2. Remove snap ring from camshaft.
3. Slide slack adjuster from end of brake camshaft.

Install

Slack adjuster installation is the reverse procedure of removal.

Be sure that the spacer washers are installed to provide a maximum end play of 1.59 mm (.062") with retaining ring installed.

TORQUE CHARTS

BRAKE GROUP MOUNTING BOLT-NUT

Tighten brake group mounting bolts to the torque values listed from the nut side. Since some mounting holes in the steering knuckles are of conical design, the knuckle bolts must utilize conical mounting nuts to coincide with mounting holes in the knuckle. These conical nuts have a smooth cone surface and the torque values are considerably higher than the torque values for regular nuts or prevailing type lock nuts.

FRONT AXLE BRAKE GROUP MOUNTING BOLTS WITH CONICAL TYPE NUTS

	TORQUE	
Bolt Size	Newton-meters (N.m)	Foot Pounds (ft. lbs.)
1/2"	149-163	110-120
5/8"	298-325	220-240
3/4"	373-407	275-300

FRONT & REAR AXLE BRAKE GROUP MOUNTING BOLTS WITH REGULAR NUTS OR PREVAILING TORQUE TYPE LOCK NUTS

	TORQUE	
Bolt Size	Newton-meters (N.m)	Foot Pounds (ft. lbs.)
1/2"	102-115	75-85
9/16"	156-170	115-125
5/8"	217-237	160-175
3/4"	373-407	275-300

BRAKE CHAMBER MOUNTING NUTS

	TORQUE	
Bolt Size	Newton-meters (N.m)	Foot Pounds (ft. lbs.)
7/16"	45-56	34-42
5/8"	142-170	105-125

ANCHOR PIN LOCK BOLT (Fig. 9)

	TORQUE	
Bolt Size	Newton-meters (N.m)	Foot Pounds (ft. lbs.)
3/8"	26-37	19-27

ANCHOR PIN

	TORQUE	
Bolt Size	Newton-meters (N.m)	Foot Pounds (ft. lbs.)
3/4" UNF (Rockwell)	251-475	185-350

CAMSHAFT BRACKET MOUNTING

	TORQUE	
Bolt Size	Newton-meters (N.m)	Foot Pounds (ft. lbs.)
1/2"	88-115	65-85

BRAKES AIR

RECONDITIONING BRAKE DRUMS AND SHOES

The text herein is to provide the actual reconditioning of brake drums and shoes. For the disassembly and reassembly of brake groups and servicing of other particular components, refer to appropriate section of the Service Manual, page 2431.

CONTENTS

DRUM BRAKES

INSPECTION OF DRUMS

The friction surface of brake drums must be smooth, true and concentric. Make certain with a visual check that drums are not barrel shaped, bell-mouthed, scored or eccentric.

Hard or chill spots, Fig. 1, in brake drum may produce pedal pulsation and roughness or brake surge. If these effects are present, drum should be replaced.

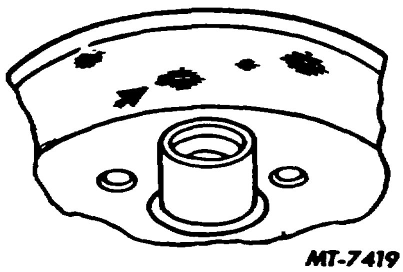

Fig. 1 Hard or Chili Spotted Drum

A barrel shaped drum (Fig. 2) results from overheating. If this barrel shaped condition is not corrected, the braking surface is reduced and uneven lining wear results.

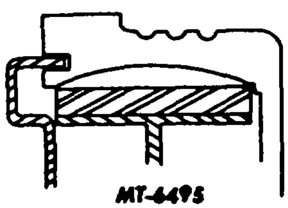

Fig. 2 Barrel Shaped Drum

Extreme pressure which over a period of time will create a bell-mouthed drum as shown in Fig. 3. Brake linings on a bell-mouthed brake drum will make contact only on the inner surface of the drum. In addition to cutting the braking surface to a minimum, it will also cause uneven and rapid wear.

Scored drums are the result of worn linings to the point where the drum-to-shoe contact is made or an accumulation of small steel particles imbed themselves in the brake lining (Fig. 4). The steel particles form a tough scale which is sometimes harder than the drum. As a result deep grooves are formed in friction surface of drum.

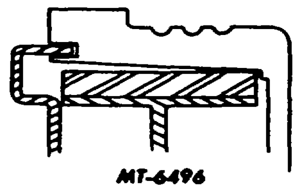

Fig. 3 Bell-mouthed Drum

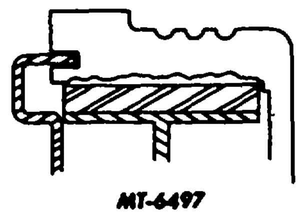

Fig. 4 Scored Drum

Brake drum scoring never improves but continually gets worse until both lining and brake drum are useless. Attempting to reline brakes without turning scored brake drum surface will quickly destroy new lining and make effective braking impossible.

Brake lining in an eccentric or out-of-round drum cannot make full contact with the drum resulting in rapid or uneven lining wear and could even cause brakes to seize or chatter. Maximum allowable out-of-round or eccentricity should be .25 mm (.010 in.).

If inspection shows that any of the preceding conditions exist, brake drum should be either turned or replaced. To assure a balanced braking system, always install turned or new brake drums in pairs on each axle.

Any time a new brake drum is to be installed on a vehicle, the runout should be checked as follows. Place the new brake drum with hub and wheel assembled in brake drum lathe making certain drum is centered. Mount Dial Indicator SE-1848 on lathe and check runout about 12.7 mm (.5") in from edge of drum (on braking surface) as shown in Fig. 5. Runout must not exceed .25 mm (.010").

Before assembling drum, hub and wheel, all parts must be clean and free of foreign matter.

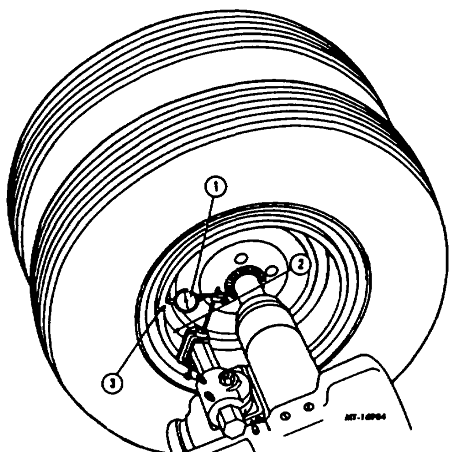

Fig. 5 Checking Drum Runout On Brake Drum Lathe

1. Dial Indicator
2. Braking Surface
3. .5 inch from Edge of Brake Drum

Special attention to the installation of all wheel and drum assemblies must be adhered to on vehicles with antilock.

Refer to Antilock Section for installation of exciter ring and checking runout, also installation of wheel and drums.

REFINISHING BRAKE DRUMS

On brake drums manufactured after January 1, 1971, the maximum diameter to which drum can be worn is stamped or cast into drum. Drum should be discarded if worn beyond this limit.

Minor scores on brake drum can be removed with fine emery cloth or steel wool, but always clean emery or steel wool particles from drum after this operation. More heavily damaged or out-of-round drums should be ground or turned on brake drum lathe.

If depth of scoring, bellmouth or barrel shaping exceeds .13 mm (.005"), measured with micrometer across part or all of brake surface, drum should be refinished. Reboring limits (see drum) must not be exceeded and no heat checks, cracks or bluing is evident.

Use a micrometer also to check for an out-of-round drum. Make check by measuring drum brake surface diameter at various points 450 apart around circumference. Eccentricity (out-of-round) should not exceed .25 mm (.010") on diameter.

Remember that each time brake drums are turned, less metal remains to absorb the heat developed by braking action. Brake drums containing less metal will operate at a higher temperature. As a result, brake fade, slow recovery and erratic wear will be more noticeable. Also, extremely high temperatures shorten lining life and cause heat checks and cracks (Fig. 6) to form on inner surface of drums. These conditions will become progressively worse until drums fail.

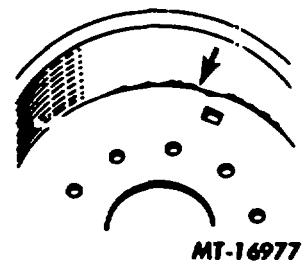

Fig. 6 Cracked Drum

REMACHINING DRUMS

Brake drums that are otherwise in good condition can be turned in a lathe. However, it must be remembered that the recommended remachining or rebore limit for brake drums with a diameter over 355 mm (14") may not be increased more than 2.03 mm (.080") diameter (total cut) and discarded at 3.05 mm (.120") over normal diameter.

IMPORTANT
The dimension located on the drum is discard dimension. Never remachine drums to maximum wear or discard diameter.

To recondition a brake drum in a lathe (Fig. 7), the drum must be mounted so that it is centered. Use proper size cone to provide accurate centering. Turn drum, taking only light cuts and remove just enough material to clean up drum. Then grind the finished surface if grinder is available or use emery cloth on a straight piece of wood and polish the drum friction surface.

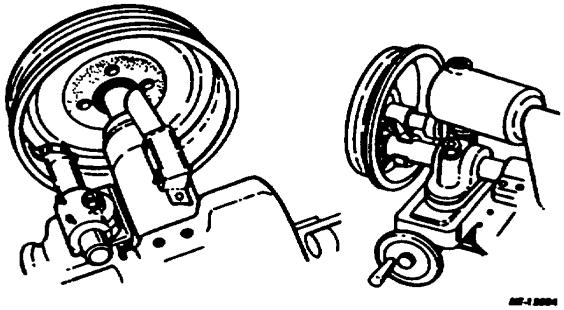

Fig. 7 Reconditioning Drum on Brake Drum Lathe

Brake drums should be cleaned thoroughly with a steam cleaner or hot water. Do not use a solvent which leaves an oily residue. If inspection shows the drums may be used without remachining, rub friction surface with fine emery cloth or sandpaper to remove any foreign deposits. If drum has been reconditioned, clean friction surface with fine emery cloth or sandpaper and wash. Next examine very carefully to see that no metal chips remain in drum.

INSPECTION OF SHOES

When brake linings or blocks are worn to within 1.6 mm (1/16") of rivets, the brake shoes must be removed and relined. It is recommended that all the brakes be relined at the same time since this will maintain balanced braking on the vehicle. If complete replacement is not desirable or necessary, be sure that all lining on one axle (both sides) is replaced at the same time.

Examine shoes carefully and discard those which have any defects as shown in Fig. 8.

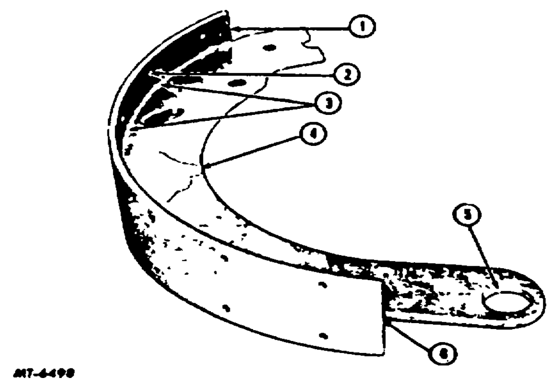

Fig. 8 Defects to be Looked for Brake Shoe

1. Table Twisted or Distorted
2. Oversize Rivet Holes
3. Broken Weld
4. Cracks in Table or Web
5. Oversize Anchor Pin Hole
6. Table Not Square with Web

REPLACING LINING ON SHOES

When removing worn lining from shoes, drill out old rivets if possible to prevent distorting shoe table. After the old linings are removed from the shoes, the shoes should be cleaned and buffed to remove all dirt and grease. Grease is one of the greatest deteriorating agents of lining.

Discard used lock washers after removing lining bolts. Use new washers when installing new lining. Replace bolts and nuts if signs of distortion or wear are Present.

Do not handle new brake linings or relined shoes with greasy hands or allow linings to come in contact with mineral oil or grease.

Care should be used in selecting the correct thickness of lining for each brake shoe and drum. Usually the standard thickness will be used. If the drum has been turned or become worn, increasing the diameter, oversize lining may be required.

If it is not known how much material has been removed from the drum during the turning operation, the following simple test may be used to help select the proper lining.

Hold standard size lining snugly to the shoe, position it against the inner surface of the drum, forcing it into contact with the drum surface. The lining is now in the same position as during a brake application. If space is noted at the ends of the shoe (shoe can be rocked), oversize lining is required (Fig. 9). If lining selected is too thick, only the ends of the lining will contact the drum. See Fig. 10.

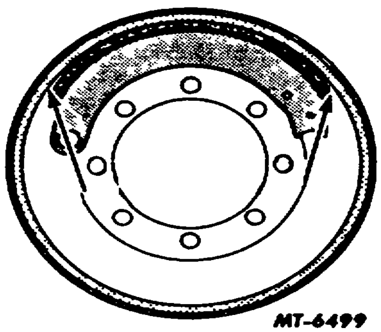

Fig. 9 Space At End Of Shoe Lining Selected Too Thin

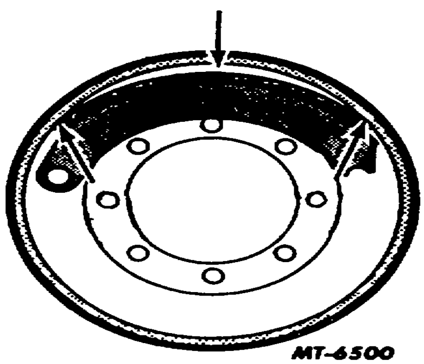

Fig. 10 Space At Center Of Shoe And Lining Contacting Ends, Lining Selected Too Thick

The lining must be installed on the shoe so that it fits smoothly and evenly, contacting the shoe throughout the entire radius. If gaps occur between the rivets, difficulty will be met in adjusting the brakes in that "spongy" or rubbery pedal may occur which makes satisfactory brake application impossible.

To insure complete contact and avoid gaps between lining and shoe, secure lining to shoe with "C" clamp so that rivet or bolt holes are in alignment. Position NC" clamp as close to the holes as possible, clamping the lining firmly in place.

When securing brake lining to shoes, start with the center rivet or bolt and work toward the ends as shown in Fig. 11. When securing brake block lining to shoe, use the sequence as shown in Fig. 12. Always use new lock washers when installing bolt on lining and tighten nuts to 89-111 Nm (20-25 ft. lbs.) torque.

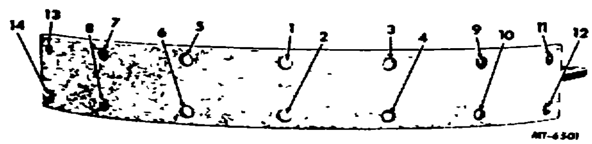

Fig. 11 Sequence In Securing Brake lining to Shoe

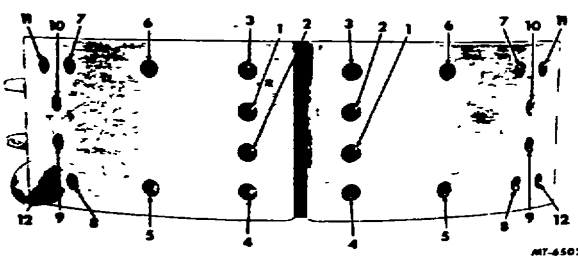

Fig. 12 Sequence In Securing Brake Block lining to Shoe

When riveting linings, use a roll set to upset the rivets. A star set may split the tubular end of rivet and prevent a tight fit.

After the lining is installed, check tightness of lining to shoe, (Fig. 13) with a .203 mm (.008 in.) feeler gauge at any point along the arc of shoe and lining.

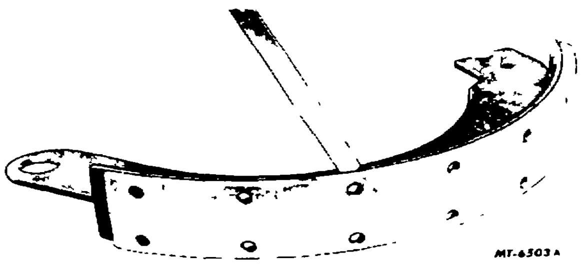

Fig. 13 Checking Tightness of Lining Using A Feeler Gauge

After installing the new lining on the shoes, the lining should be ground in a true radius to fit the drum diameter. A brake shoe grinder is provided on brake reliner (SE-1272) which is designed to dress the lining in a true radius and fit the drum diameter. This grinder swings the shoe in an arc across the surface of an abrasive wheel.

A brake shoe grinder which mounts on the spindle may be used after installing shoes with new lining. The grinder rotates about on its axis and the grinding head equalizes the distance between the two brake shoe lining surfaces and drum surface. Grind new lining approximately 1.78 mm (.070 in.) less than the inside diameter of brake drum. Make certain that the brake is fully released before grinding.

DRUM REPLACEMENT
MEDIUM AND HEAVY DUTY VEHICLES

Drum replacement on medium and heavy duty vehicles requires the removal of nuts from bolts securing hub and drum together. The hub and drum can then be separated.

MOUNTING NEW DRUM TO HUB

Clean exposed hub or axle mounting flange with wire brush or coarse file.

Use straight edge across surface of flange to make sure it is not bent. Remove excess paint from edge of drum hub hole and wash rust preventive sealer from drum with solvent.

Before installing a replacement drum wash the drum thoroughly with high grade denatured alcohol to remove all protective grease, oil or other residue DO NOT use gasoline, mineral spirits or oil.

When assembling hub and drum together, pay special attention to the bolt heads so that they are aligned properly in the drum (Fig. 14).

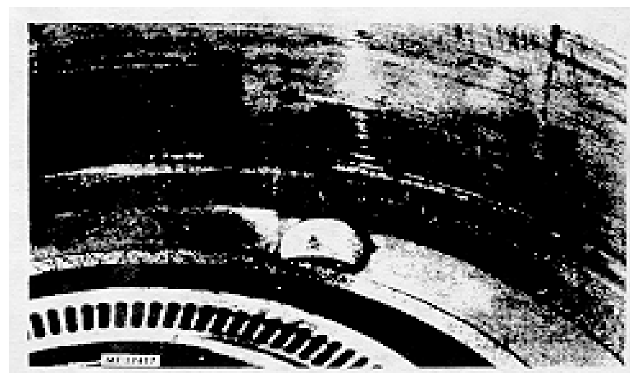

Fig. 14 Drum Bolt Alignment

Refer to Torque Chart for bolt tightening sequence and proper torque values of hub to drum mounting bolts as well as rim and wheel mountings.

IMPORTANT

Special attention must be given to vehicles with Antilock, where the exciter ring runout must be checked. Refer to the ANTILOCK Section of Service Manual.

TORQUE CHART

HUB TO DRUM

Nominal Size	TORQUE N.m	TORQUE Ft Lbs
1/2"	95 - 115	70 - 85
9/16"	144 - 170	105 - 125
5/8"	194 - 237	145 - 175
3/4"	346 - 407	250 - 300

Tighten hub-to-drum bolts alternately, across from each other.

RIM AND WHEEL MOUNTINGS

Size	Mounting	N.m	Ft Lbs
Cast Wheels (Rim Clamp)			
5/8"		217 - 237	160 - 157
3/4"		237 - 271	175 - 200
Disc Wheels-Standard Mounting			
11/16"	Flanged Nut Mounting	475 - 542	350 - 400
3/4"	Standard Square Cap Nut Mounting (13/16" Across Flats)	610 - 678	450 - 500
3/4"	Standard Hex Cap Nut Mounting (1-1/2" Across Flats)	610 - 678	450 - 500
1-1/8"	Standard Hex Cap Nut Mounting (1-1/2" Across Flats)	610 - 678	450 - 500
Disc Wheel Heavy Duty Mounting			
1-1/8"	HD Hex Cap Nut Mounting (1-3/4" Across Flats)	882 - 949	650 - 700
15/16"	HD Square Cap Nut Mounting (15/16" Across Flats)	1017 - 1220	750 - 900
1-5/16"	HD Hex Cap Nut Mounting (1-3/4" Across Flats)	1017 - 1220	750 - 900

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STEERING

POWER STEERING PUMP
EATON
HEAVY DUTY ROLL VANE-TYPE
PUMP WITH INTEGRAL RESERVOIR

CONTENTS

CONTENTS (Cont'd.)

DESCRIPTION

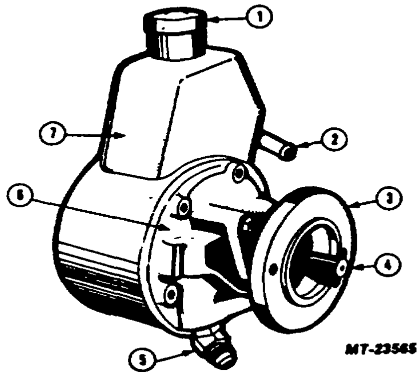

Fig. 1 Eaton Heavy Duty Roll Vane Pump

1 Reservoir Cap
2 Oil Return Inlet
3 Pump Mounting Flange
4 Pump Shaft
5 High Pressure Line Fitting
6 Pump Housing
7 Reservoir

The housing and internal pump parts are located inside the reservoir so that the pump parts operate submerged in oil. The reservoir is sealed against the pump housing, leaving the housing face and shaft hub exposed. A shaft seal and non-replaceable bushing are pressed into the housing from the front. The drive shaft is inserted through this seal and bushing. A large cavity in the rear of the housing contains the rotating pump parts. A smaller cavity contains the flow control valve and spring.

MAINTENANCE

FLUID LEVEL

1. Run engine until power steering fluid reaches normal operating temperature, approximately 800C (170°F), then shut engine off. Remove reservoir filler cap and check oil level on dipstick.
2. If oil level is low, add power steering fluid to proper level and replace filler cap. For lubrication intervals, refer to Operator's Manual. For types of lubricant recommended refer to Lubrication Section CTS-4033.
3. When checking fluid level after the steering system has been serviced, air must be bled from the system. Proceed as follows:

   a. With wheels turned all the way to the left add power steering fluid to level indicated on dipstick.
   b. Start engine, and running at idle, recheck fluid level. Add fluid if necessary.
   c. Bleed system by turning wheels from side to side without hitting stops. Maintain fluid level so it is just visible in the reservoir. Fluid with air in it will have a light tan or milky appearance. This air must be eliminated from fluid before normal steering action can be obtained.
   d. Return wheels to center position and continue to run engine for two or three minutes, then shut engine off.
   e. Road-test vehicle to make sure steering functions normally and is free from noise.
   f. Recheck fluid level as described in Steps 1 and 2.

BELT TENSION

A belt that has been previously tensioned is considered to be a used belt and should be tightened to from 245 to 311 Newtons (55 to 70 lbs.). A belt that has never been tensioned is considered to be a new belt and should be tightened to 445 Newtons (100 lbs.).

Place Belt Tension Gage SE-2312, or equivalent, midway between the pulleys on drive belt being checked.

BELT ADJUSTMENT

When adjusting a power steering pump belt, never pry against the pump reservoir or pull against the filler neck. To increase belt tension move the pump outward by prying against the bracket pry lugs or against the pump housing casting extension directly behind the pump drive pulley.

1. When power steering pump is driven by a single belt:

   a. Loosen the pump attaching bolts and adjust the belt to correct tension by moving the pump outward, away from the engine.
   b. Snug all pump mounting bolts and remove pry bar.

c. Tighten all pump mounting bolts to specified torque.
d. Check belt tension.

2. When the power steering pump is driven by two belts in a matched set:

   a. Follow same checking and adjusting procedure as 1 above, but if it is necessary to replace one belt, both must be replaced by a new matched set to equalize belt tension in both belts. Check tension in both belts.

3. When the power steering pump pulley is driven by one primary belt and is used as an idler for a second belt driving some other accessory:

   a. Follow same checking and adjusting procedure for the primary power steering pump drive belt as for above.
   b. Recheck and adjust as necessary the pump belt tension after adjusting tension on belt driving the other accessory.

DIAGNOSTIC INFORMATION

GENERAL INFORMATION

Complaints of faulty steering are frequently the result of problems other than the pump. Those areas of the steering system which can be easily checked and quickly corrected without disassembly and overhaul of any major components should be attempted first.

Conditions such as hard or loose steering, road shock or vibrations are not always due to the steering gear or pump, but are often related instead to such factors as low tire pressure and front end alignment. These factors should be checked and corrected before any adjustment or disassembly of the power steering pump is attempted.

Many factors affect proper operation of the steering system, of which the most common are:

1. Fluid level and condition.
2. Drive belt tension.
3. Loose component mountings.
4. Loose pump pulley nut.

These factors must be checked and corrected before making any further diagnosis of the steering system. The need for proper diagnosis cannot be overemphasized.

After the source of the problem has been found, determine the cause. For example, if the oil level in the reservoir is found to be low, refill and check the entire hydraulic system for oil leaks. Refilling the reservoir will not necessarily correct the problem.

When reference is made to power steering gear components in the following charts, it will be necessary to determine which gear the vehicle is equipped with, and then refer to the appropriate manual in your CTS-4001 Truck Service Manual for gear adjustment and repair procedures.

DIAGNOSTIC CHARTS

CONDITION	POSSIBLE CAUSE	CORRECTION
Chirp noise in steering pump	1. Loose belt	1. Adjust belt tension to specification
Belt squeal (particularly noticeable during steering at full wheel travel and -standstill parking)	1. Loose belt	1. Adjust belt tension to specification
Growl noise in steering pump	1. Excessive back-pressure in hoses or steering gear caused by restriction	1. Locate restriction and correct. Replace part if necessary.
Growl noise in steering pump (particularly noticeable at standstill parking)	1. Scored pressure plates or carrier 2. Extreme wear of cam ring and rolls	1. Replace parts and flush system. 2. Replace parts.

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CONDITION	POSSIBLE CAUSE	CORRECTION
Groan noise in steering pump	1. Low oil level	1. Fill reservoir to proper level and check for leaks.
	2. Air in the oil. Poor pressure hose connection	2. Tighten connector to specified torque. Bleed system by operating steering from right to left - full turn.
Rattle or knock noise in steer-ing pump	1. Loose pump pulley nut	1. Tighten nut to specified torque. If pulley is still loose, both the pulley and pump shaft must be replaced.
Momentary increase in effort when turning wheel fast to right or left	1. Low oil level. and check for leaks.	1. Fill reservoir to proper level
	2. Loose belt.	2. Adjust belt tension to specification
	3. High internal leakage	3. Check pump flow and pressure. (See Power Steering System Test Procedure)
Steering wheel surges or jerks when turning with engine run-ning especially during parking	1. Low oil level	1. Fill reservoir to proper level and check for leaks.
	2. Loose belt	2. Adjust belt tension to specification
	3. Insufficient pump pressure	3. Check pump pressure. (See Power Steering System Test Procedure). Replace relief valve if defective. Replace pumping elements if excessively worn.
	4. Sticky flow control valve	4. Inspect for varnish and small nicks or damage on valve. Replace if necessary
Foaming milky power steering fluid	1. Low oil level.	1. Fill reservoir to proper level and check for leaks.
	2. Air in the fluid.	2. Bleed air from system.
	3. Hard shaft seal	3. If oil level is correct and pump still foams, check shaft seal for excessive hardening or wear. Extremely cold temperatures will cause system aeration with these conditions. Replace shaft if ex- cessively worn at seal area.
Low pressure to steering gear	1. Flow-control valve stuck or inoperative	1. Remove burrs or dirt; replace.
	2. Pressure plate not flat against cam ring	2. Correct.
	3. Extreme wear of cam ring and rolls	3. Replace parts. Flush system.
	4. Scored pressure plate or carrier	4. Replace parts. Flush system.
	5. Cracked or broken thrust or pressure plate	5. Replace part.

CONDITION	POSSIBLE CAUSE	CORRECTION
Low pressure to steering gear (Cont'd.)	6. Low oil level 7. Loose belt	6. Fill reservoir to proper level and check for leaks. 7. Adjust belt tension to specification
Hard steering or lack of assist especially in parking	1. Loose belt 2. Low oil level 3. Steering gear to column misalignment 4. Lower coupling flange rubbing against steering gear 5. Tires not properly inflated 6. Cracked or broken pressure plate or cam ring 7. Missing housing ball plug or cracked housing	1. Adjust belt tension to specification 2. Fill reservoir to proper level and check for leaks. 3. Align steering column 4. Loosen pinch bolt and assemble properly. 5. Inflate to recommended pressure 6. Replace parts. 7. Replace part.
Note: If checks 1 through 7 do not reveal cause of hard steering. refer to Power Steering System Test Procedure	Further possible causes could be: 8. Sticky flow control valve 9. Insufficient pump pressure output 10. Excessive internal pump leakage 11. Excessive internal system leakage	In order to diagnose conditions such as listed in 8, 9, 10 and 11, a test of the entire power steering system is required.

POWER STEERING SYSTEM TEST PROCEDURE

This section presents a systematic method of diagnosing and trouble shooting the power steering hydraulic system. Start with Step 1 and move consecutively through the remaining steps completing every procedure and if necessary, the correction described before moving on.

1. Disconnect pressure, hose at pump or gear and connect power steering analyzer SE-2780 (Fig. 2) in series with the pressure hose.
2. Open valve on analyzer and start engine. Allow power steering system oil to reach normal operating temperature and check analyzer connections for leaks. Correct if necessary.
3. Check fluid level in system and add fluid as required.
4. With engine at idle, record flow and pressure. If pressure is in excess of 517 kilopascals (75 PSI), check hoses for restrictions and correct as required.
5. With engine at idle, partially close valve on analyzer to build 4826 kilopascals (700 PSI) and record flow. Subtract this flow from the flow recorded in Step 4. Flow should not drop more than 3.8 1/MIN (1 GPM). If flow drops more than 3.8 1/MIN (1 GPM), check rotating group (cam ring, rolls and carrier) in pump and correct as required.
6. Close and partially open analyzer valve three times. Record the highest pressure each time the valve is closed.

IMPORTANT
Do not leave valve fully closed for more than five seconds as the pump could be damaged.

All three readings must be within the listed specifications and must not vary more than 345 kilopascals (50 PSI). If readings do not meet this criteria, check for loose belt. If no problem exists with belt, replace pump flow control valve.

7. Increase engine speed to 1500 RPM and record flow. Subtract this flow from the flow recorded in Step 2. Flow should not vary more than 3.8 1/MIN (1 GPM). If flow does vary more than 3.8 1/MIN (1 GPM), remove flow control valve and clean. Check oil condition. If oil is dirty, disassemble pump and gear, clean and reassemble.
8. With engine idling, turn wheel slightly in both directions and observe pressure readings. Release wheel quickly; if pressure does not snap-back, disassemble and clean gear hydraulic control valve. If oil is dirty, disassemble and clean gear and pump.
9. With engine idling, turn and hold wheel against wheel stops in both directions. A noticeable drop in pressure should occur as the wheel hits the stops. If no drop, or a rise in pressure occurs, adjust steering gear relief plungers (if so equipped) or replace steering gear relief valve (if so equipped) to correct.

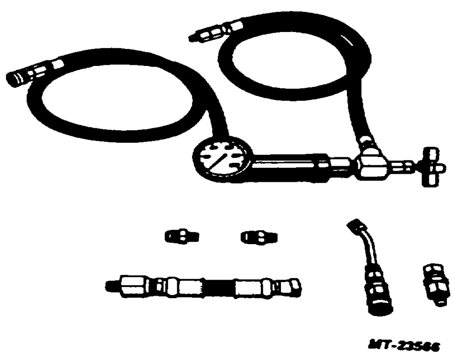

Fig. 2 SE-27U0 Power Steering Analyzer

EXTERNAL LEAKAGE DIAGNOSIS

The adjacent diagram has been prepared to show the potential areas of leakage. If leakage occurs in the areas shown, perform the operation described.

When diagnosing external leakage, always check for the possibility of system overheating. An indication of overheating is when the majority of the pump gaskets become hard and brittle within 48,000 kilometers (30,000 miles) of vehicle operation. Some gaskets normally harden during routine operation, therefore it is important to determine if the majority of the gaskets are hard and brittle. Another indication of overheating is when the power steering fluid has decomposed and significantly darkened interior pump surfaces. Occasionally a "burnt" oil odor will be noticeable with overheated systems. Overheating is normally caused by restricted lines causing excessive back pressure or by severe operating conditions. A complete gasket overhaul and/or addition of a cooler may be required.

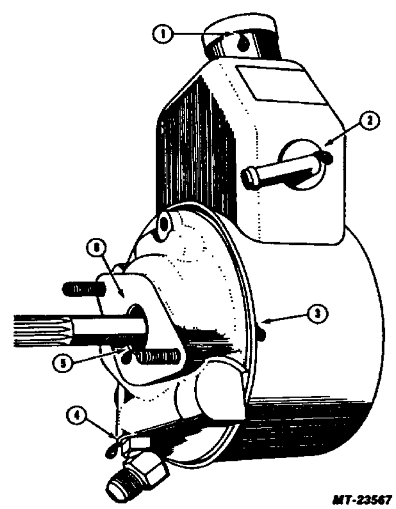

Fig. 3 Suspected Leakage Areas

1. Check oil level. An overfilled pump reservoir can be a cause for leakage. The oil in the steering system expands as heated during normal usage. If overfilled the excess is forced through the reservoir cap vent. Operate the engine and steering system until normal operating temperature is obtained. Remove the reservoir cap and check level. Adjust the oil level as required.

   If leakage persists with the oil level correct and the cap tight, replace the cap.

All three readings must be within the listed specifications and must not vary more than 345 kilopascals (50 PSI). If readings do not meet this criteria, check for loose belt. If no problem exists with belt, replace pump flow control valve.

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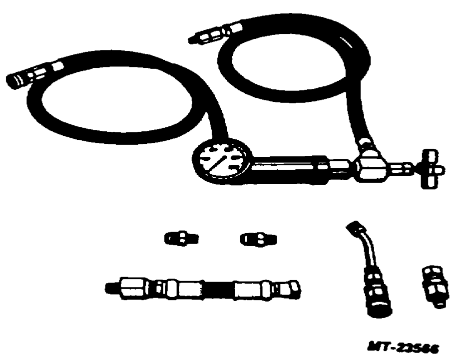

Fig. 2 SE-27U0 Power Steering Analyzer

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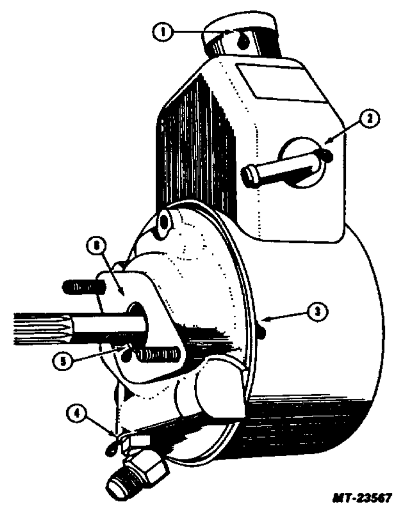

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   If leakage persists with the oil level correct and the cap tight, replace the cap.

Air in the system can also cause fluid level to rise, especially after system repair. Bleed the system as described in the MAINTENANCE section of this chapter.

2. Replace reservoir.
3. Replace reservoir gasket seal.
4. Tighten fitting to specified torque. If leakage persists, replace O-ring seal. If either the return hose or the pressure hose leaks, other than at the nut connections, replace the hose.
5. Replace drive shaft seal after inspecting and thoroughly cleaning the sealing surface. Replace drive shaft if severe wear is found at sealing locations. If the corrosion in the lip seal contact zone is slight, clean the surface of the shaft with crocus cloth. Always replace the seal if the shaft is replaced.
   On certain Cummins direct drive applications, leaks in this area will cause migration of engine oil into the pump. If the seal does not appear excessively hardened, correct excessive pressure condition in the engine pump mounting area cavity. Modification to the engine is required.
6. Clean all gasket surfaces removing old gasket material and replace with new O-ring seal.

INSTALLATION AND REMOVAL

INSTALLATION

Belt Driven Pump

1. If removed, reinstall pump mounting bracket. Tighten mounting bolts to specified torque.
2. Position pump assembly on engine with holes lined up and install bolts loosely.
3. Install pulley. Insure that key remains in groove to avoid seal damage. Install pulley retaining bolt finger tight.
4. Connect and tighten hose fittings to specified torque.
5. Fill reservoir. Bleed pump by turning pulley backward (counter-clockwise as viewed from front) until air bubbles cease to appear.
6. Install pump belt over pulley.
7. Adjust belt tension and tighten pump mounting bolts to specified torque. See BELT TENSION and BELT ADJUSTMENT.
8. Tighten pulley retaining bolt to specified torque.
9. Bleed system per FLUID LEVEL section of this manual.

REMOVAL

Belt Driven Pump

1. Disconnect both hoses at pump, taking care not to bend hoses any more than absolutely necessary. (With time and temperature exposure, hoses may take a "sets and will not have the flexibility of a new hose). When both hoses are disconnected. secure ends in raised position to prevent drainage of oil. Protect hose ends to avoid contamination of system.
2. Install caps at both pump fittings to prevent drainage of oil from pump.
3. Loosen pulley retaining bolt. Then loosen bracket mounting bolts to relieve belt tension.
4. Remove belt and pulley.
5. If pump is to be disassembled. remove pump and mounting bracket as an assembly. If pump is not to be disassembled, the mounting bracket may remain attached to the engine.

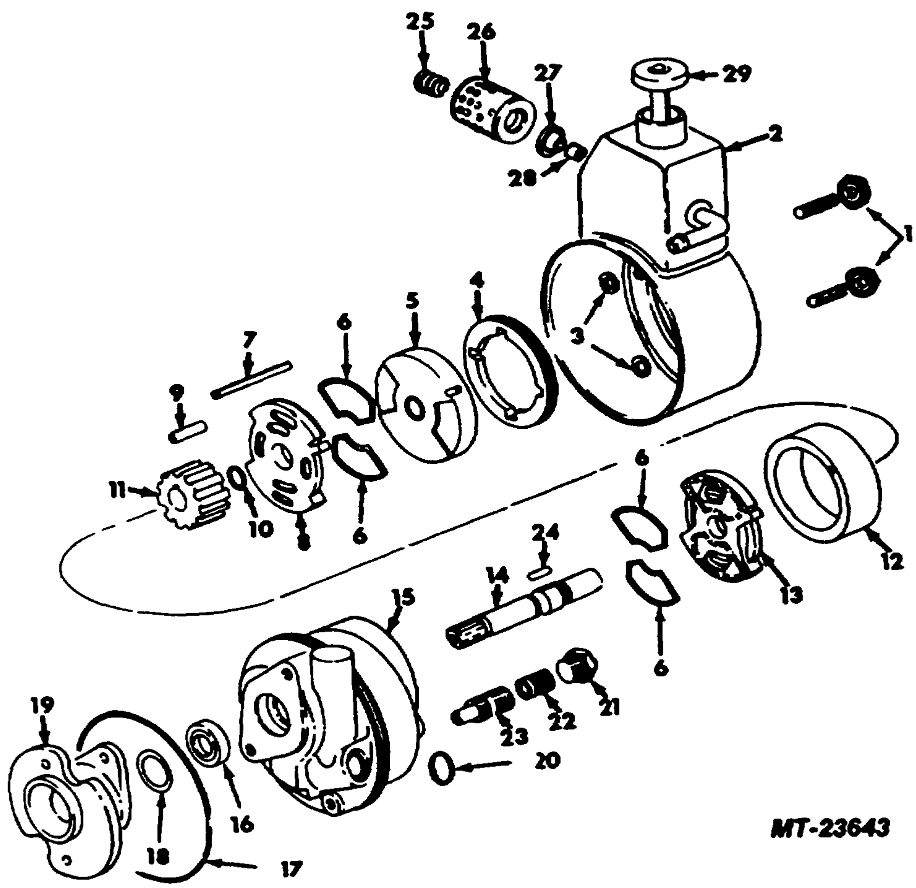

Fig. 4 Pump Components

1 Reservoir Retaining Nuts
2 Reservoir
3 Sealing Washers
4 Threaded Retainer Ring
5 Pump Cover
6 Gasket
7 Locating Pin
8 Rear End Plate
9 Roll
10 Snap Ring
11 Carrier
12 Cam Ring
13 Front End Plate
14 Pump Shaft
15 Pump Housing
16 Shaft Oil Seal
17 Reservoir Gasket
18 Mounting Flange O-Ring
19 Mounting Flange
20 Discharge Fitting O-Ring
21 Valve Cap
22 Valve Spring
23 Flow Control ,Valve
24 Pump Shaft Key
25 Filter Element Spring
26 Filter Element
27 Filter Element Guide
28 Spacer (Some Pumps)
29 Reservoir Cap

SERVICE

Refer to Figure 4 to aid service procedures.

OIL FILTER REPLACEMENT

1. Remove pump from vehicle. See INSTALLATION AND REMOVAL section of this manual. Drain oil from reservoir.
2. Place pump in a bench vise using the mounting flange (gear driven pump) or mounting bracket (belt driven pump) to hold pump.

IMPORTANT
Do not clamp vise on pump housing or reservoir.

3. Mark position of reservoir on pump housing to provide proper location during reassembly.
4. Remove reservoir retaining nuts, Figure 5.

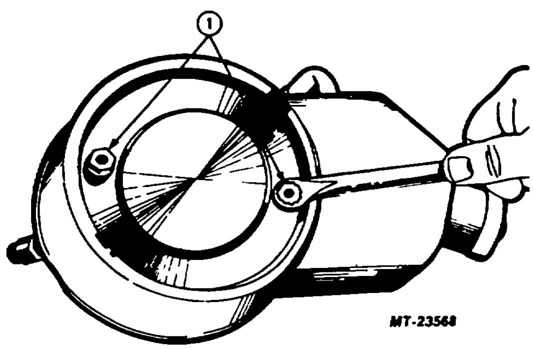

Fig. 5 Remove Retaining Nuts

1 Reservoir Retaining Nuts

5. Remove reservoir by rapping the side of the reservoir with the hand until the reservoir rotates slightly on the pump housing.

IMPORTANT
Do not pry on reservoir flange to remove reservoir

6. To remove filter element, insert a screw-driver behind the spring and pry the spring out. The filter element can then be removed. There is also a loose filter element guide that fits over the end of the return tube on the inside of the reservoir, Figures 6 and 7. Clean interior of reservoir and components with clean solvent and air dry.
7. To install filter element, slide the-guide over the end of the return tube with the long end of guide toward reservoir wall. Some units are equipped with a spacer which should be placed over the return tube prior to installing the guide.

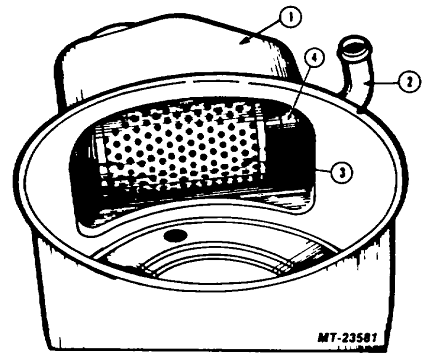

Fig. 6 Filter Location

1 Reservoir
2 Oil Return Inlet Tube
3 Filter Element
4 Filter Guide

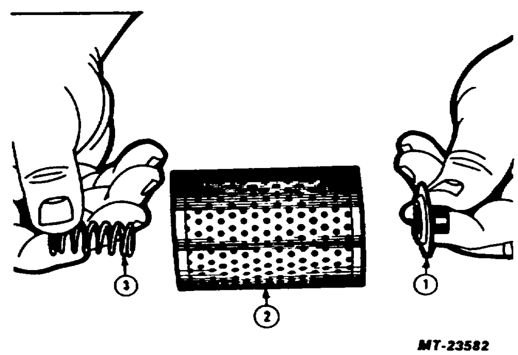

Fig. 7 Filter Components

1 Filter Guide
2 Filter
3 Spring

Insert the spring into the cupped or closed end of the filter element. Position the open end of the filter element over the guide and force the spring into place in the recessed area of the reservoir neck.

8. Replace reservoir gasket and sealing washers on inside of reservoir (Figure 8) and install reservoir. Seat reservoir by placing a wood block against rear of reservoir and rapping block with a hammer.

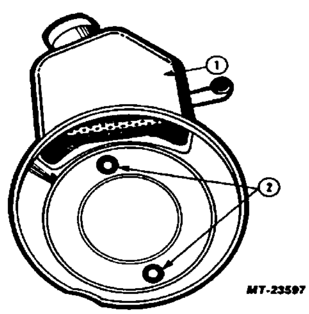

Fig. 8 Sealing Washer Location

1 Reservoir
2 Sealing Washers

9. Install reservoir retaining nuts and tighten to specified torque.
10. Reinstall pump assembly on vehicle. See INSTALLATION AND REMOVAL section of this manual.

PUMP SHAFT OIL SEAL REPLACEMENT (PUMP ASSEMBLID)

1. Remove pump assembly from vehicle. See INSTALLATION AND REMOVAL section of this manual. Remove mounting flange (gear driven pump only) and coupling (if equipped).
2. Place Seal Remover SE-2839 over pump shaft. Apply downward pressure on top of tool and screw tool into seal material until firmly seated, Figure 9.
3. Thread tool bolt into tool and against top of pump shaft until tool and seal are drawn out of pump housing, Figure 10.

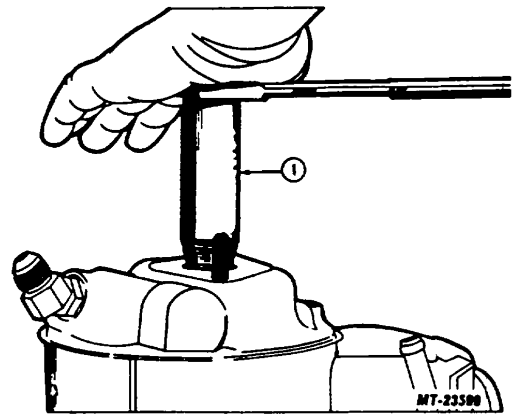

Fig. 9 Setting Seal Remover Tool

1 Seal Remover SE-2839

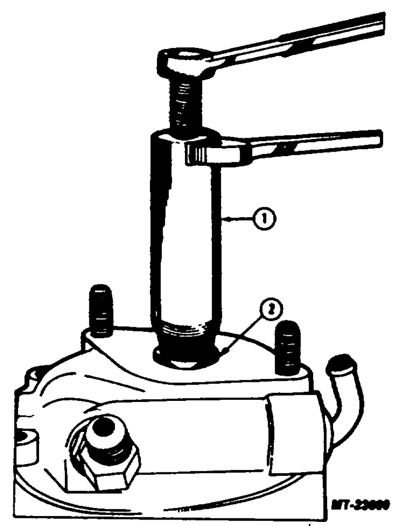

Fig. 10 Removing Shaft Seal

1 Seal Remover SE-2839
2 Pump Shaft Oil Seal

4. Lubricate new shaft seal with same type of fluid as used in pump, then slide seal over shaft with metal side of seal upward.

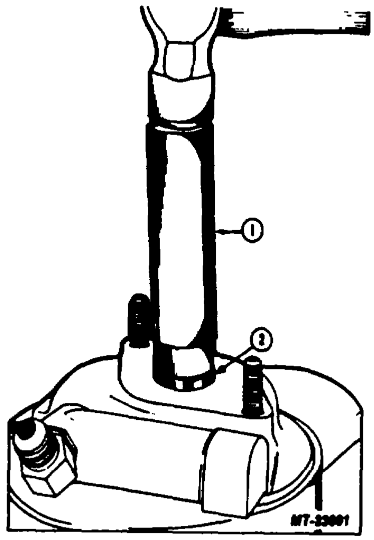

Fig. 11 Installing Shaft Seal

1 Seal Installer SE-2840
2 Pump Shaft Oil Seal

5. Install new seal using Seal Installer SE-2840, Figure 11. Seal should be bottomed in seal bore but be careful not to crush seal cage.
6. After cleaning flange to pump mating surfaces, reinstall pump mounting flange (gear driven pumps only) using a new O-ring. Tighten mounting bolts to specified torque.
   Reinstall drive coupling and nut (some units also have a washer) if so equipped and tighten to specified torque.
7. Reinstall pump on vehicle. See INSTALLATION AND REMOVAL section of this manual.

DISASSEMBLY

Before disassembly of pump, remove reservoir filler cap and drain oil from reservoir by inverting the pump so oil may drain out the filler neck.

After oil is drained from reservoir, cap should be replaced and the entire pump assembly washed in a non-toxic solvent to remove all dirt and prevent any foreign matter from contaminating pump components.

IMPORTANT

Examine exposed part of drive shaft. If it is corroded, use crocus cloth to remove corrosion before disassembling pump. This will prevent damage to the shaft bushing which might require replacement of the entire housing.

1. Place pump in a bench vise using the mounting flange (gear driven pump) or mounting bracket (belt driven pump) to hold pump.

IMPORTANT

Do not clamp vise on pump housing or reservoir.

2. Mark location of reservoir on pump housing to provide proper location during reassembly.
3. Remove reservoir retaining nuts, Figure 12.

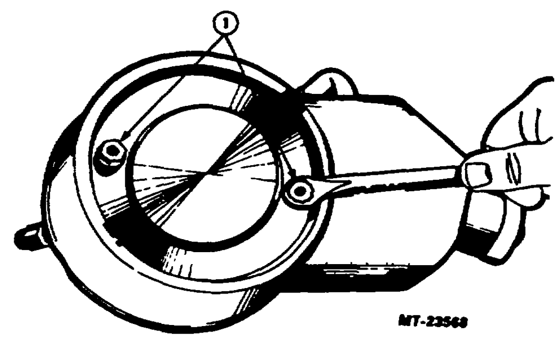

Fig. 12 Remove Retaining Nuts

1 Reservoir Retaining Nuts

4. Remove reservoir by rapping the side of the reservoir with the hand until the reservoir rotates slightly on the pump housing.

IMPORTANT

Do not pry on reservoir flange to remove reservoir.

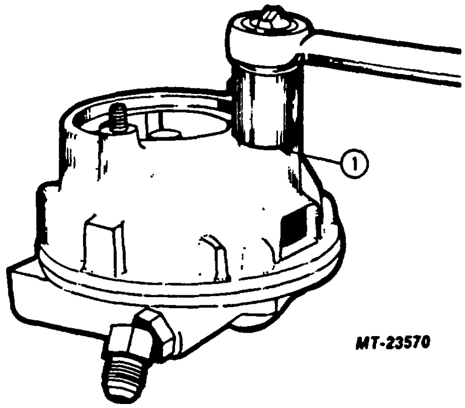

Fig. 13 Remove Valve Cop

1 Flow Control Valve Cap

5. Loosen but do not remove flow control valve cap, Figure 13.
6. Mark position of discharge fitting in housing to provide proper positioning during reassembly, Figure 14. Loosen but do not remove discharge fitting.

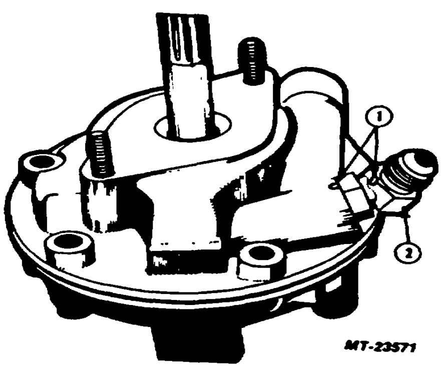

Fig. 14 Mark Fitting Location

1 Alignment Marks
2 Discharge Fitting

7. Loosen but do not remove the large threaded retaining ring in the center of the pump body Figure 15.

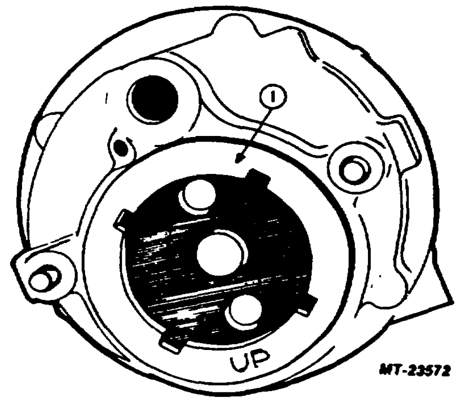

Fig. 15 Ring Location

1 Threaded Retaining Ring

8. Use tool SE-2838 to loosen retainer ring.

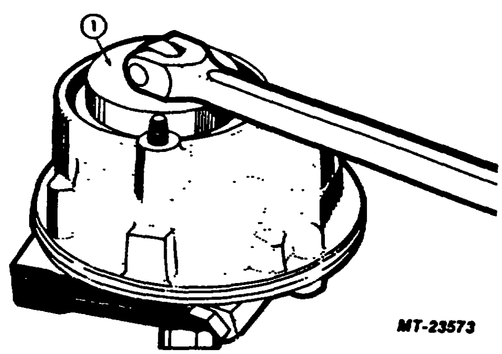

Fig. 16 Removing Retainer Ring

1 SE-2838

9. At this point, the pump may be removed from the vise for the remaining disassembly procedures.
10. Remove mounting flange (gear driven pumps) and coupling (if equipped) or mounting bracket (belt driven pumps).

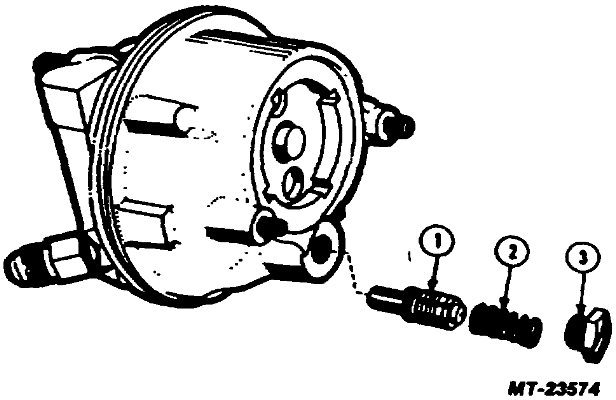

Fig. 17 Valve Components

1 Flow Control Valve
2 Spring
3 Valve Cap

11. Remove flow control valve cap and flow control valve components, Figure 17.
12. Remove discharge fitting and discard O-ring, Figure 18.

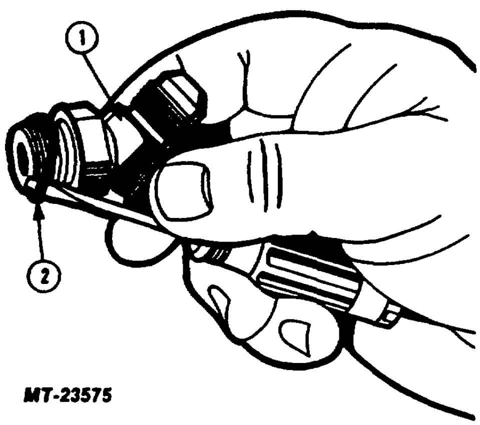

Fig. 18 Remove O-Ring

1 Discharge Fitting
2 O-Ring

13. Remove threaded retainer ring.
14. Remove pump cover. Tap end of drive shaft lightly to aid removal if necessary.

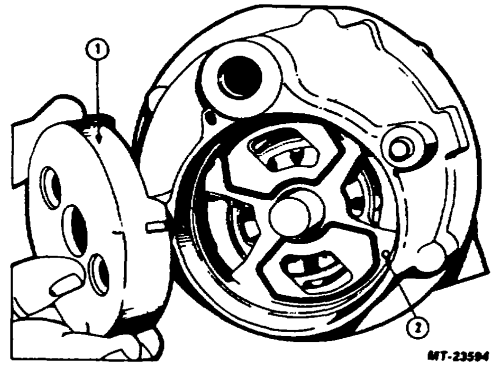

Fig. 19 Pin Location

1 Pump Cover
2 Locating Pin

IMPORTANT

Some pump housing will be drilled with two locating pin holes. Note position of pin for proper location during reassembly, Figure 19.

15. Remove rear end plate and discard O-rings.
16. Remove the shaft and carrier assembly, roll vanes and then the cam ring, Figure 20.

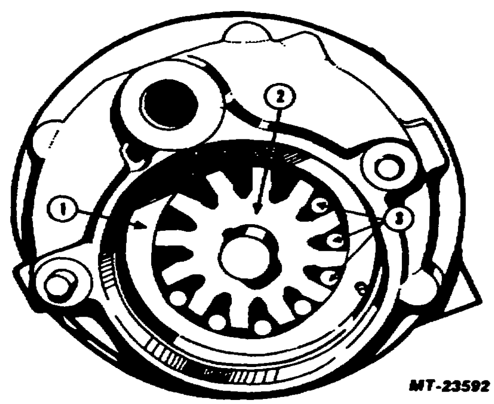

Fig. 20 Remove Components

1 Cam Ring
2 Shaft and Carrier Assembly
3 Roll Vanes

The cam ring can develop sharp edges from wear. Use a clean shop cloth to remove cam ring to avoid cuts. Remove ring by lifting straight up.

17. Remove front end plate and discard gaskets. Remove locating pin.
18. Remove housing-to-reservoir sealing gasket. Figure 21.

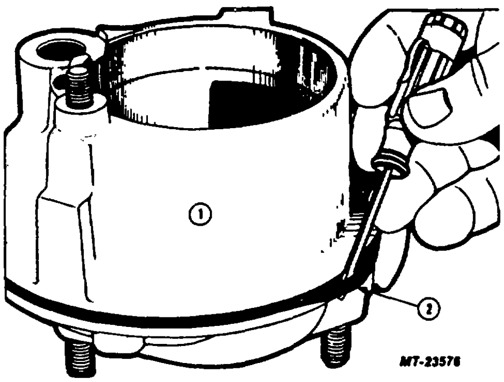

Fig. 21 Remove Gasket

1 Housing
2 Gasket

19. Remove shaft oil seal with a screwdriver being careful not to scratch seal bore or housing bushing, Figure 22.

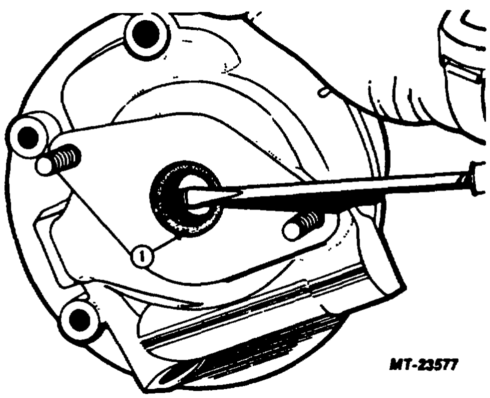

Fig. 22 Remove Seal

1 Shaft Seal

CLEANING, INSPECTION AND REPAIR

Wash all components in a non-toxic solvent, air dry and inspect individually as outlined below.

Component Inspection

Housing - Inspect drive shaft bushing in housing for burning, scoring or oversize condition. The bushing is not serviceable. If bushing is damaged, the housing must be replaced.

Inspect ball plug located near the valve cap. If plug has blown out, it can be driven back in to a depth approximately 6.35 mm (1/4 inch) below the cast surface.

Pump Cover - Inspect drive shaft bushing in cover for burning, scoring or oversize condition. The bushing is not serviceable. If bushing is damaged, replace cover.

Cam Ring - Inspect internal surface of cam ring for wear or scoring. Polish in some are is normal, but any wear severe enough to raise a noticeable burr on the edge of the cam ring I.D. indicates replacement is necessary.

Shaft and Carrier Assembly - Inspect carrier on the ends of drive tooth faces for excessive wear or scoring. If ends are worn or scored or wear pattern on any of the roll drive faces is greater than 2.3 mm (.09 in.) in width, the carrier must be replaced. Carriers are not serviced alone, but can be replaced as part of a pumping element kit.

Inspect the shaft for any excessive wear, burning, or scoring in the areas of the two bushings and the oil seal. If any of these conditions exist, replacement is required.

Rolls - Inspect each of the twelve rolls for burning, scoring, or wear on the O.D. surface.

End Plates - Inspect both end plates for wear, cracks or scoring on the surface opposite the sealing O-rings. Any scoring indicates replacement is required.

Flow Control Valve Assembly - It is difficult to visually determine if a valve is defective. If the pump problem was diagnosed as low pressure, and the pumping element shows no sign of excessive wear, it is probable that the valve needs replaced. The valve must fit and move smoothly in the valve bore.

Pump Shaft Seal Installation

1. Lubricate new shaft seal with same type of fluid as used in pump. Place seal on top of seal bore with-metal side of seal upward.

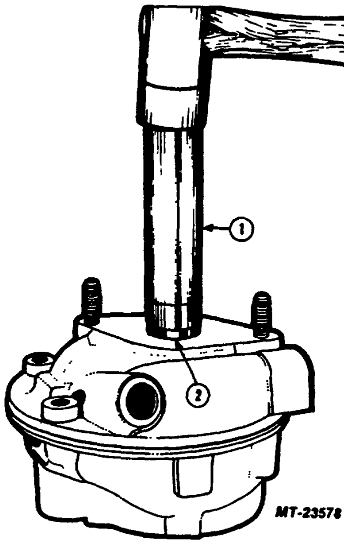

Fig. 23 Installing Shaft Seal

1 Seal Installer SE-2840
2 Shaft Seal

2. Install seal using Seal Installer SE-2840, Figure 23. Seal should be bottomed in seal bore but be careful not to crush seal cage.

ASSEMBLY

IMPORTANT
The figures in this manual section illustrate assembly of a clockwise rotation pump. Certain pumping elements are installed differently for counter clock-wise rotation pumps. Where those differences occur, they will be noted in the text but not illustrated.

Internal pump components will be assembled in pump housing as shown in Figure 24.

1. Install new pre-formed gaskets into front end plate, Figure 25. Use a small amount of multi-purpose grease to hold gaskets in place during assembly.

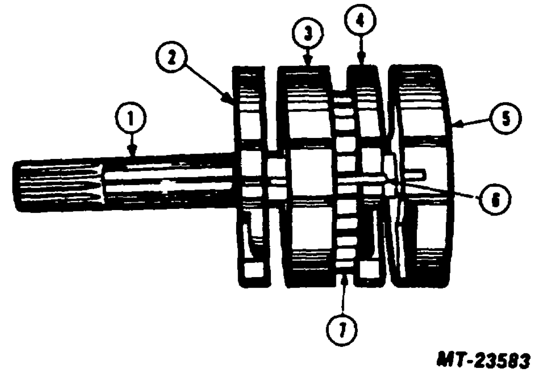

Fig. 24 Internal Pump Components

1 Pump Shaft
2 Front End Plate
3 Cam Ring
4 Rear End Plate
5 Pump Cover
6 Locating Pin
7 Carrier with Rolls

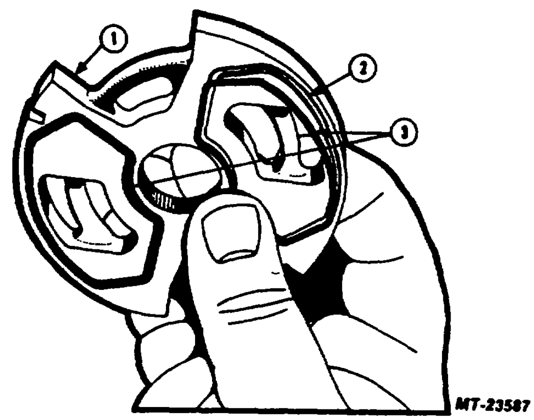

Fig. 25 Installing Pre-formed Gaskets

1 Front End Plate
2 Gasket Grooves
3 Pre-formed Gaskets

IMPORTANT

The front and rear end plates are different and must be assembled in their proper locations for the pump to function correctly.

As shown in Figure 26, the front end plate for clockwise rotation pumps contains the oil grooves. For counter clock- wise pumps, the end plate without the oil grooves is the front end plate. A correct assembly will align the end plate O.D. large open slots with the large shallow pump housing pocket ports. The end plate gasket side will be away from the pumping elements.

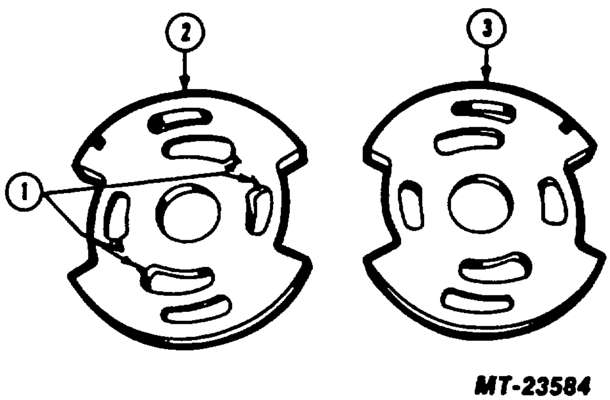

Fig. 26 End Plate Identification

1 Oil Grooves
2 Grooved End Plate
3 No Groove End Plate

IMPORTANT

Two different types of end plates and gaskets are used in this pump assembly. They may be identified by the shape of the gasket grooves in the end plate surface. As illustrated in Figure 27, one type of end plate uses a circular gasket which must be formed into the end plate grooves. The other type uses a pre-formed gasket moulded in the shape of the end plate grooves.

Determine which type of end plate is used in the pump being serviced. <u>The different types of gaskets are not interchangeable.</u>

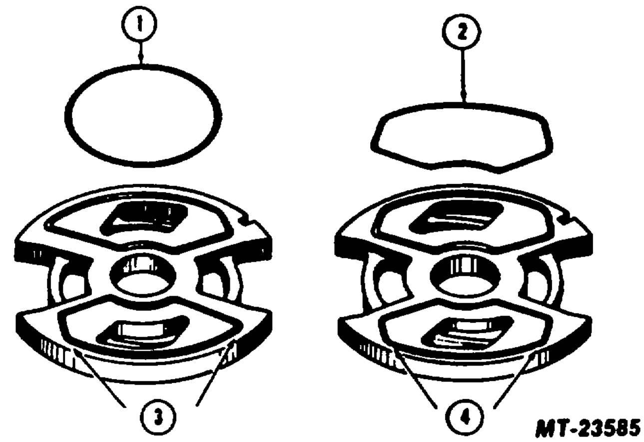

Fig. 27 End Plate and Gasket Identification

1 Circular Gasket
2 Pre-formed Gasket
3 Different on Each Side
4 Same on Both Sides

2. Install locating pin in pump housing, Figure 28. If housing is drilled to accept two pins, install pin in original location as marked during disassembly.

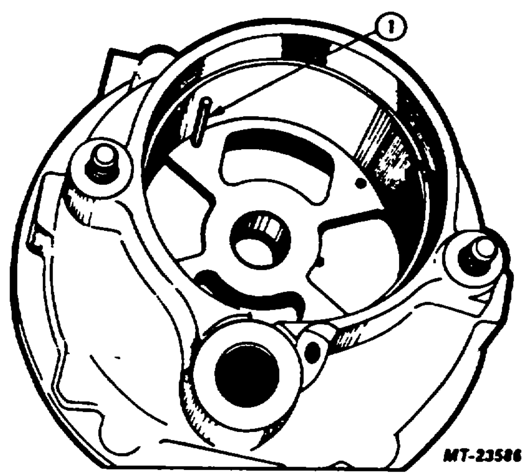

Fig. 28 Locating Pin in Housing

1 Locating Pin

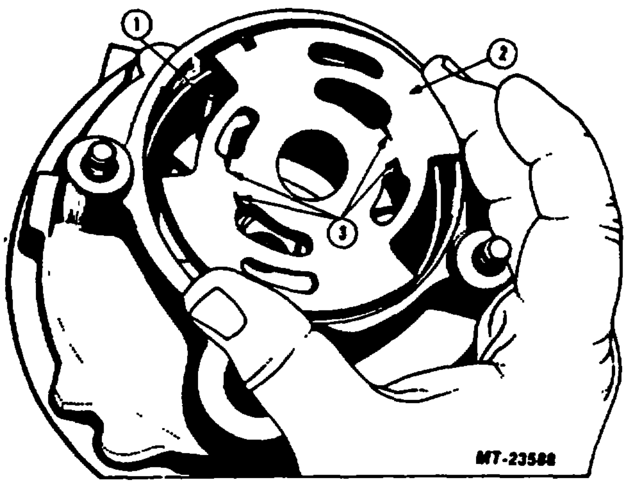

Fig. 2 Installing Front End Plto

1 Locating Pin
2 Front End Plate
3 Oil Grooves

3. Install front end plate in housing with O-ring side down, Figure 29 (CW pump assembly illustrated).

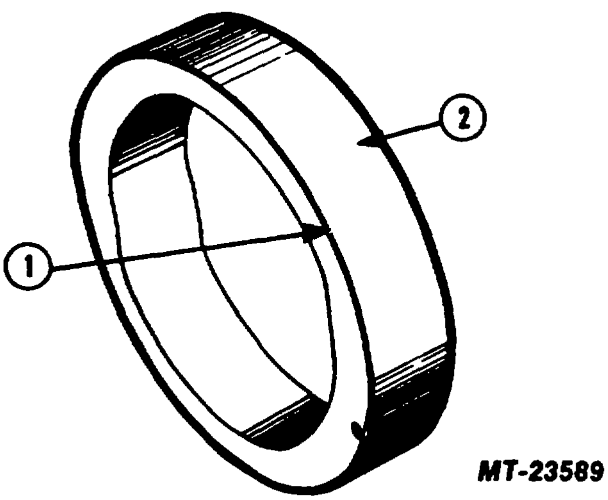

Fig. 30 Chamfered Edge of Cam Ring

1 Chamfered Edge
2 Cam Ring

4. Install cam ring into the pump housing positioning it over the locating pin, Figure 31. If pump assembly being serviced is equipped with two locating pins, install second pin at this time.

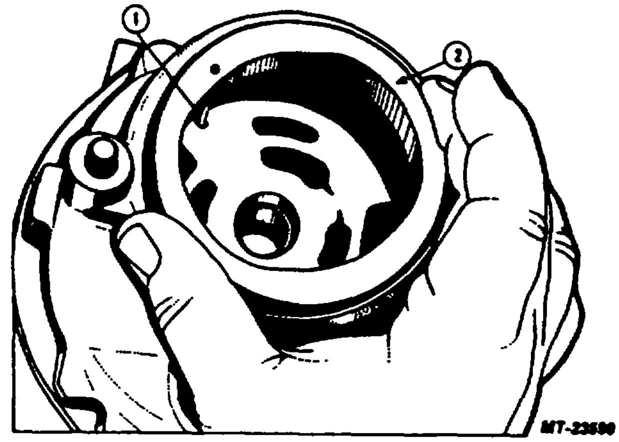

Fig. 31 Installing Cam Ring

1 Locating Pin
2 Cam Ring

IMPORTANT

The cam ring has a chamfer on one edge of the ring O.D., Figure 30. Install cam ring with chamfered edge down for clockwise pumps and chamfered edge up for counter clockwise pumps.

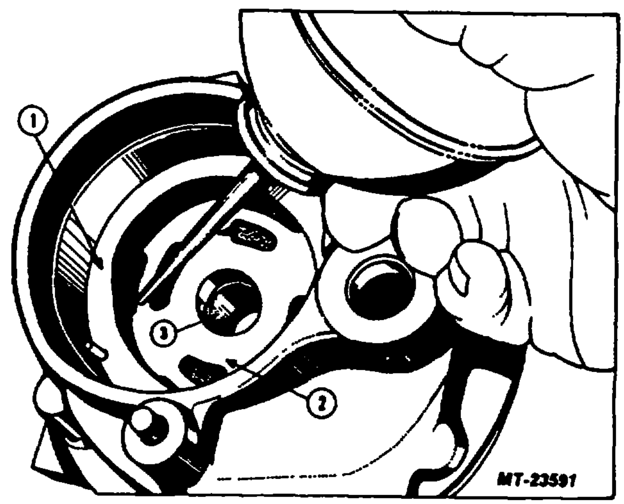

Fig. 32 Lubricate Pump Components

1 Cam Ring
2 Front End Plate
3 Housing Bushing

5. Lubricate the face of the front end plate, shaft bushing and I.D. wall of the cam ring with the same type of fluid as used in the pump, Fig. 32.

6. If shaft and carrier assembly or any of the individual components of the shaft and carrier assembly are being replaced, check orientation of the carrier on the shaft. Looking at the rear of the shaft (opposite driven end). the carrier teeth should be angled to the left as shown in Figure 33 for clockwise pumps and to the right for counter clockwise pumps. Two snap rings are used to hold the carrier to the shaft. Snap rings must be assembled in the grooves closest to each carrier end.

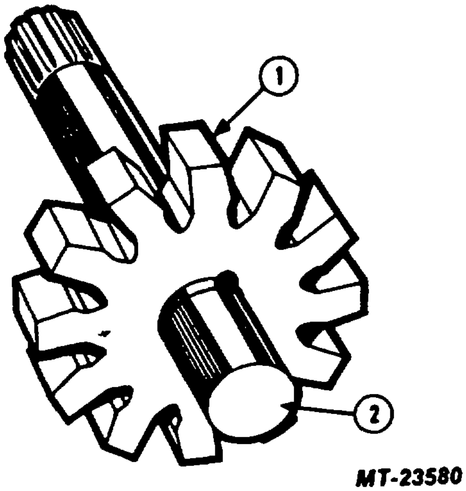

Fig. 33 Proper Carrier Orientation
1 Carrier Teeth
2 Rear of Shaft

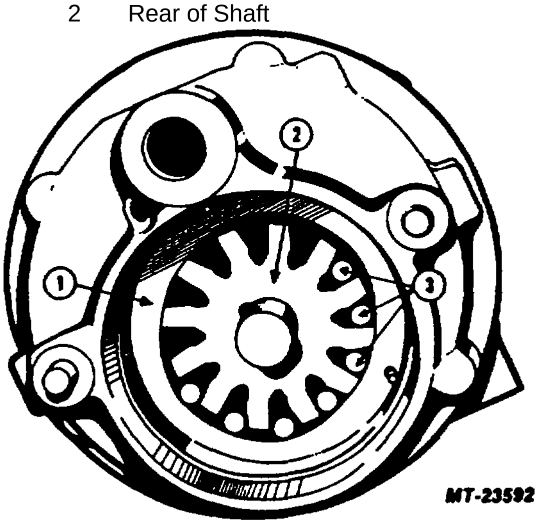

Fig. 34 Inserting Rolls
1 Cam Ring
2 Carrier
3 Rolls

7. Lubricate shaft seal I.D. with a generous amount of multi-purpose grease and install shaft and carrier assembly into pump housing.
8. Insert rolls into carrier and lubricate carrier face and shaft with same type of lubricant as used in pump, Figure 34.
9. Install new pre-formed gaskets into rear end plate. See IMPORTANT notes in Step 1 of assembly procedure.
10. Install rear end plate over locating pin in pump housing with gasket side up, Figure 35.
11. Install cover over the shaft and onto the locating pin, Figure 36. If properly assembled, open slots of body, end plates and cover should align.

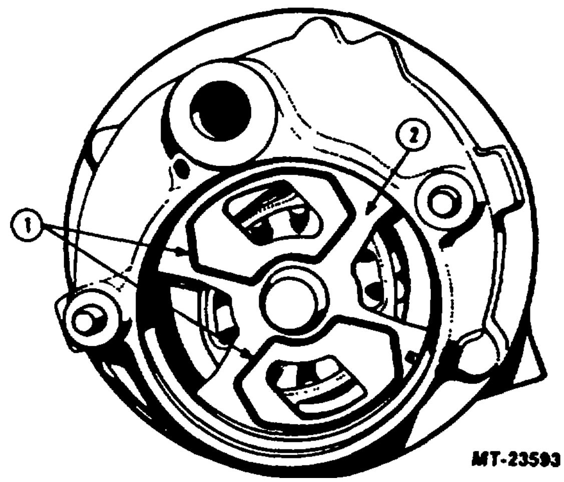

Fig. 35 Installing Rear End Plate
1 Pre-formed Gaskets
2 Rear End Plate

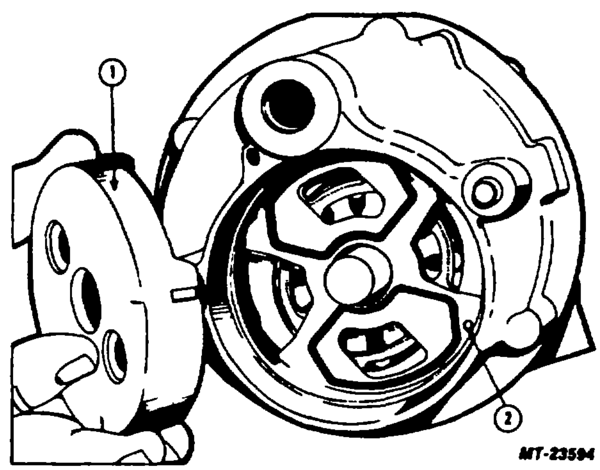

Fig. 36 Installing Cover
1 Pump Cover
2 Locating Pin

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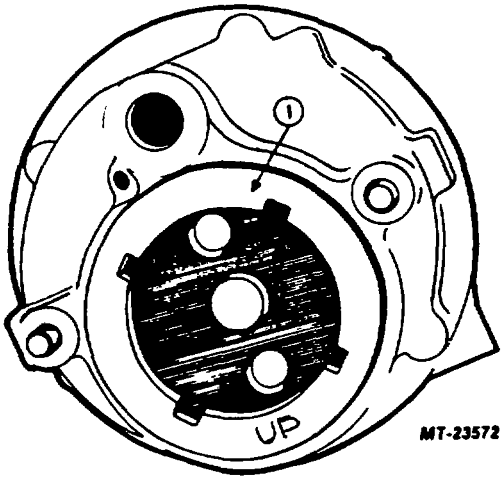

Fig. 37 Retainer Ring In Housing

1 Retainer Ring

12. Thread the retainer ring into pump body finger tight. Install the "UP" side of the ring up, Figure 37.

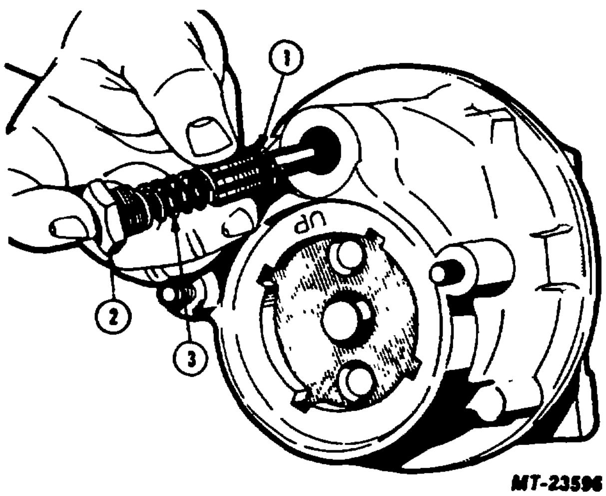

Fig. 38 Installing Flow Control Valve

1 Flow Control Valve
2 Valve Cap
3 Valve Spring

13. Lubricate the flow control valve bore with the same type of lubricant as used in pump. Insert the valve assembly into the bore with the long small diameter end in first, Figure 38. The valve must slide smoothly in the bore. Place the flow control valve spring in the valve bore and install the valve cap finger tight.
14. Install new O-ring on discharge fitting (Figure 39) and install fitting in housing finger tight.
15. Clean mating surfaces and install the pump mounting flange using a new O-ring (gear driven pump) or mounting bracket (pulley driven pump) and tighten mounting nuts to specified torque.
16. Place pump in a bench vise using the mounting flange (gear driven pump) or mounting bracket (pulley driven pump) to hold pump.

IMPORTANT
Do not clamp vise on pump housing.

17. Tighten valve cap to specified torque.

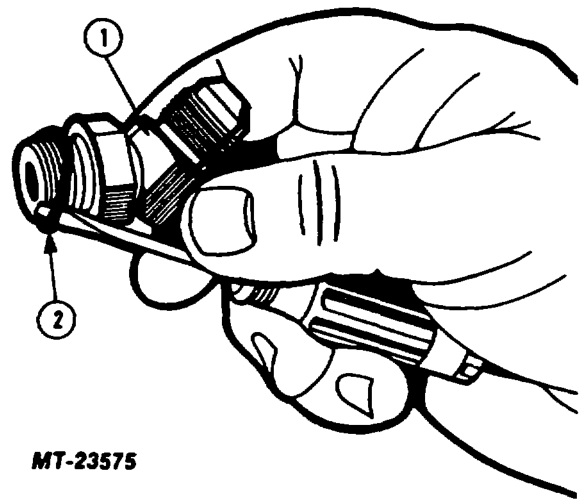

Fig. 39 Discharge Fitting O-Ring

1 Discharge Fitting
2 O-Ring

18. Locate discharge fitting in its original position as marked during disassembly (Figure 40), and tighten jam nut to specified torque.

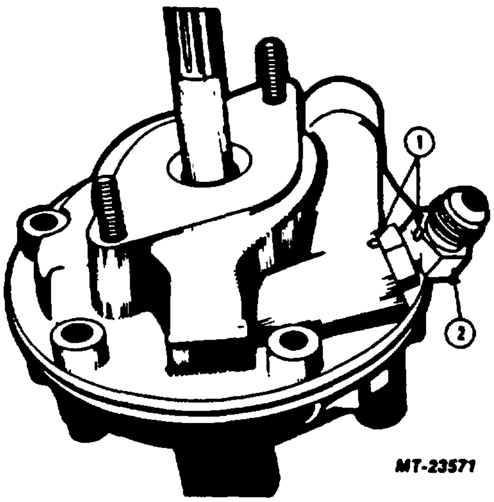

Fig. 40 Positioning Discharge Fitting

1 Alignment Marks
2 Discharge Fitting

19. Using tool SE-2838, tighten retainer ring to the specified torque, Figure 41.

20. The base pump is now assembled. Check the shaft to insure that it rotates freely and smoothly.

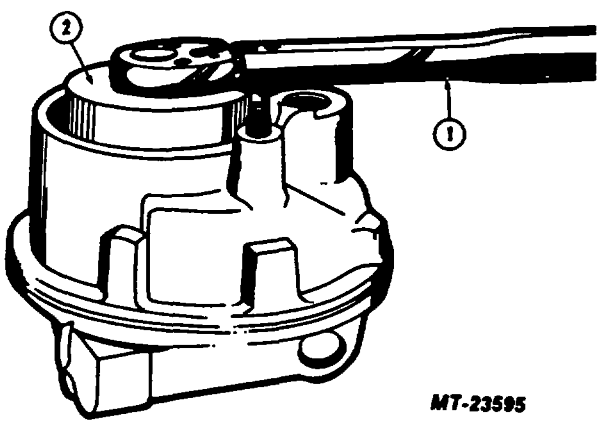

Fig. 41 Tightening Retainer Ring

1 Torque Wrench
2 SE-2838

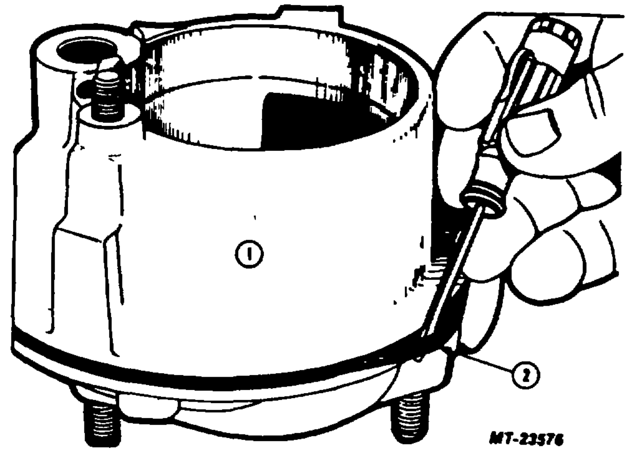

Fig. 42 Housing-to-Reservoir Gasket

1 Housing
2 Gasket

21. Install a new pump housing-to-reservoir 0-ring in the pump housing groove, Figure 42. Gasket should be installed with color side out.

22. Prior to assembling reservoir on pump, install a new filter element. The filter element is located in the expansion neck of the reservoir, Figure 43.

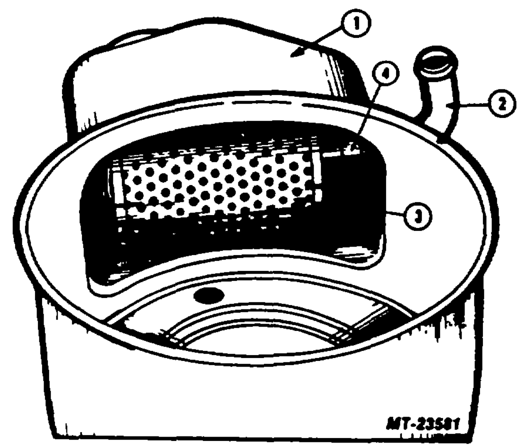

Fig. 43 Filter Element Location

1 Reservoir Expansion Neck
2 Oil Return Inlet Tube
3 Filter Element
4 Filter Guide

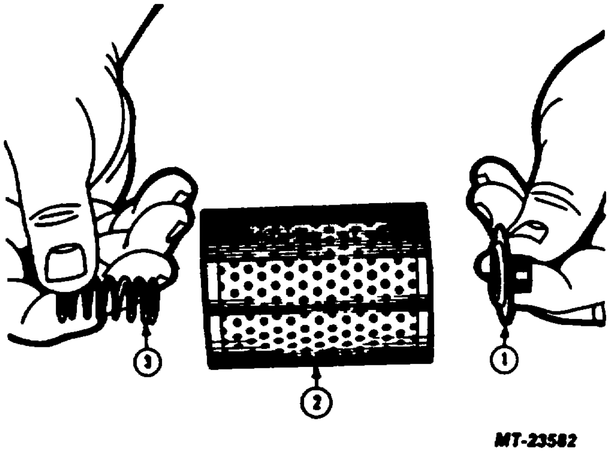

Fig. 44 Filter Element Components

1 Filter Guide
2 Filter
3 Spring

23. To remove filter element, insert a screwdriver behind the spring and pry the spring out. The filter element can then be removed. There is also a loose filter element guide that fits over the end of the return tube on the inside of the reservoir, Figure 44.

24. To install filter element, slide the guide over the end of the return tube with long end of guide toward reservoir wall. Some units are equipped with a spacer which should be placed over the return tube prior to installing the guide.

    Insert the spring into the cupped or closed end of the filter element. Position the open end of the filter element over the guide and force the spring into place in the recessed area of the reservoir neck.

25. If removed, install reservoir mounting studs in pump housing and place sealing washers over studs.

26. Install reservoir on pump housing in original position by indexing alignment marks made during disassembly.

27. Seat reservoir by placing a wood block against rear of reservoir and rapping block with a hammer. Install reservoir retaining nuts and tighten to specified torque.

28. Reinstall pump assembly on vehicle. See INSTALLATION AND REMOVAL section of this manual.

TORQUE CHART

FASTENER LOCATION	NEWTON METERS	FT. LBS.
Flow Control Valve Cap	54-75	40-55
Discharge Fitting Jam Nut	41-61	30-45
Threaded Retainer Ring	122-149	90-110
Reservoir Retaining Nuts	34-41	25-30
Pulley Retaining Bolt	20-27	15-20
Drive Coupling Nut	34-47	25-35
Mounting Flange Studs	1.4-14	1-10
Mounting Flange-to-Pump Nut	46-52	34-38
Mounting Flange-to-Engine Bolt (All except Detroit Diesel)	46-52	34-38
Mounting Flange-to-Engine Bolt (Detroit Diesel Only)	61-68	45-50
Mounting Bracket Hardware 3/8 Inch	41-52	30-38
Mounting Bracket Hardware 7/16 Inch	68-81	50-60
Mounting Bracket Hardware 1/2 Inch	95-115	70-85

SPECIAL TOOLS

SE-2050 Torque Indicator Wrench (0-150 ft. lbs.)
SE-2780 Power Steering System Analyzer
SE-2838 Power Steering Pump Retainer Ring Spanner Wrench
SE-2839 Power Steering Pump Shaft Oil Seal Remover
SE-2840 Power Steering Pump Shaft Oil Seal Installer

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STEERING

Replace old Section with this revised Section in your CTS-4001 Manual.

STEERING COLUMN ASSEMBLY

S-SERIES

CONTENTS

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DESCRIPTION

The steering column assemblies used on S-Series Regular Cab are constructed with a few minor differences; however, the overall design and function are similar.

The steering wheel, containing the horn switch mechanism, is connected to the upper steering column shaft. On conventional cab models, the upper steering column shaft passes through the steering column housing assembly and connects with the lower steering column shaft at a double-yoke assembly with the aid of a spider-type universal joint. The steering column housing is fastened to the dash panel via two support bracket assemblies.

On all S-Series chassis, the lower steering column shaft is joined to the steering gear by a shell coupling assembly.

The stationary (fixed) steering column cannot be repositioned

CAUTION - ALWAYS LOCK COLUMN IN POSITION BEFORE MOVING VEHICLE.

MAINTENANCE

STEERING COLUMN SHAFT BOLTS

The steering column end yoke pinch bolt assembly, or the column shaft mounting and shell coupling clamp nuts should be checked for tightness annually or every 80 000 kilometers (50, 000 miles), whichever comes first. All bolts and nuts should be tightened to torque recommended in SPECIFICATIONS. **Do not over-tighten.**

Bolts affected are:

Item 22, Figures 2 and 3.

Items 24 and 28, Figure 4.

Items 18 and 26, Figure 5.

Item 18, Figure 6.

REMOVAL AND INSTALLATION

STEERING WHEEL

Procedures for steering wheel removal and installation are common to all S-Series models.

Removal

1. Position front wheels in a straight ahead position.
2. Remove negative battery terminal.
3. Pry up horn button cap evenly, disconnect horn wire, and remove the horn button.
4. Remove the retainer ring.
5. Remove the slip ring retainer screws.
6. Remove the steering wheel mounting nut.
7. Remove steering wheel using steering wheel puller SE-1821 (Figure 1).

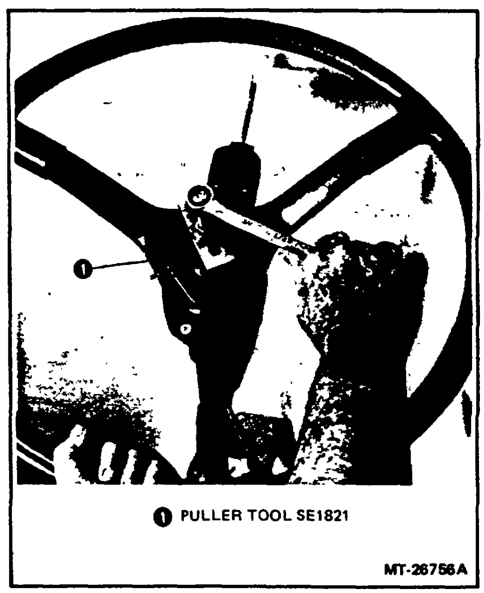


Figure 1 - Removing Steering Wheel

Installation

1. With front wheels in a straight ahead position, install the steering wheel with the narrow spoke (with the word 'top") at the 12 o'clock position. Install the steering wheel mounting nut and tighten to recommended torque (see SPECIFICATIONS).

2. Install the slip ring retainer screws.

3. Install the retainer ring.

4. Connect the horn wire to the horn button and install the horn button.

5. Connect the negative battery terminal.

STEERING COLUMN - CONVENTIONAL CAB
Removal

(Refer to Figure4).

1. Disconnect the negative battery terminal cable.

2. On vehicles with the shell coupling steering shaft assembly, remove the U-bolt clamp and separate the steering column assembly from the lower steering column shaft (Figure 4).

3. Remove the steering wheel as previously outlined and install the steering wheel mounting nut to prevent the steering column from sliding out of the steering column housing.
4. Remove the steering column trim cover.

5. Remove the electrical connectors and wiring from the steering column housing.

6. Remove the screws attaching the steering column rubber seal to the dash panel.

7. Remove the bolts attaching the steering column housing to the steering column support bracket. Tilt the steering column assembly to the side and remove it from the vehicle.

8. Remove the steering wheel mounting nut, and remove the steering shaft assembly, bushing, washer, flatwasher and spring.

Installation

1. Assemble the steering shaft assembly, spring, flatwasher, washer and bushing and Install in the steering column housing. Install the steering wheel mounting nut temporarily.

2. Guide the lower portion of the steering column assembly through the opening in the dash panel. On vehicles with the shell coupling steering shaft assembly, position the shaft assembly on the lower steering column shaft.

3. Install the bolts attaching the steering column housing to the steering column support bracket and tighten to recommended torque (see SPECIFICATIONS).

4. Install the screws attaching the steering column rubber seal to the dash panel.

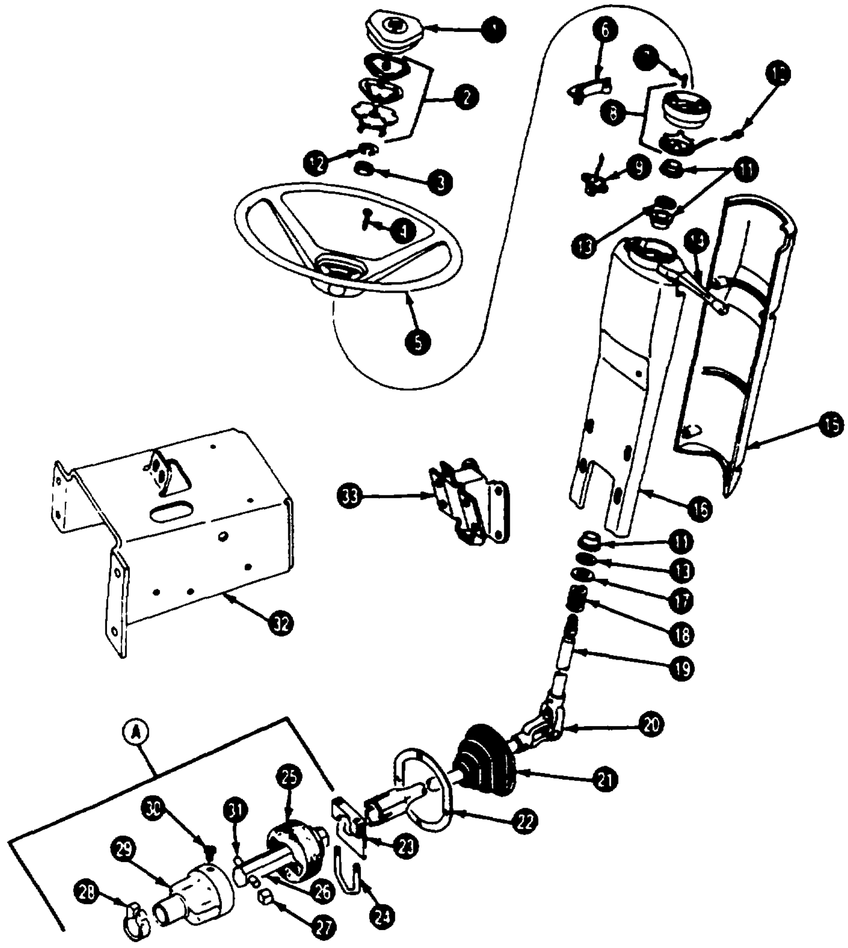
5. Install the electrical connectors and wiring in the steering column housing.

6. Install the steering column trim cover

7. Install the steering wheel as previously outlined

8. On vehicles with the shell coupling steering shaft, install the U-bolt and clamp and tighten the attaching nuts to recommended torque. Refer to Lower Column Shell Coupling Adjustment and SPECIFICATIONS in this Section.

9. Install the battery negative terminal and close the hood.



Ⓐ LOWER STEERING COLUMN SHAFT

1. HORN BUTTON
2. HORN BASE PLATE ASSEMBLY
3. STEERING WHEEL MOUNTING NUT*
4. PAN SCREW
5. STEERING WHEEL ASSEMBLY WITH PIN
6. STEERING COLUMN HOUSING COVER (WITHOUT AIR BRAKE HAND CONTROL)
7. CANCELLING PIN
8. RETAINER WITH SLIP RING
9. HORN CONTACT BRUSH ASSEMBLY PAN SCREW PLAIN WASHER
10. HORN CABLE
11. STEERING COLUMN BUSHING
12. RETAINER RING
13. STEERING COLUMN WASHER
14. TURN SIGNAL AND HAZARD SWITCH
15. STEERING COLUMN HOUSING
16. STEERING COLUMN HOUSING
17. HARDENED FLAT WASHER 7/8
18. STEERING COLUMN SHAFT SPRING
19. STEERING COLUMN SHAFT WITH U-JOINT
20. U-JOINT
21. STEERING COLUMN SEAL
22. STEERING COLUMN SEAL RETAINER
23. COLUMN SHAFT MOUNTING CLAMP
24. COLUMN SHAFT MOUNTING U-BOLT HEX NUT 3/8NF* LOCKWASHER 3/8 REGULAR
25. SHELL COUPLING BOOT
26. LOWER STEERING COLUMN SHAFT WITH PIN
27. SHELL COUPLING BUTTON AND WASHER
28. SHELL COUPLING CLAMP BOLT, HEX-HD 3/8NC X 1-3/4 LOCK NUT 3/8NC*
29. STEERING SHELL ASSEMBLY *EXPANSION PLUG*
30. BOLT, HEX-HD 1/4NF X 3/8 STAR LOCKWASHER, 3/8
31. STEERING COLUMN SHAFT PIN
32. STEERING COLUMN SUPPORT BRACKET ASSEMBLY
33. STEERING COLUMN SUPPORT BRACKET ASSEMBLY

*REFER TO TORQUE CHART IN THIS SECTION

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Figure 4 - Stationary Steering Column with Shell Coupling - Conventional Cab

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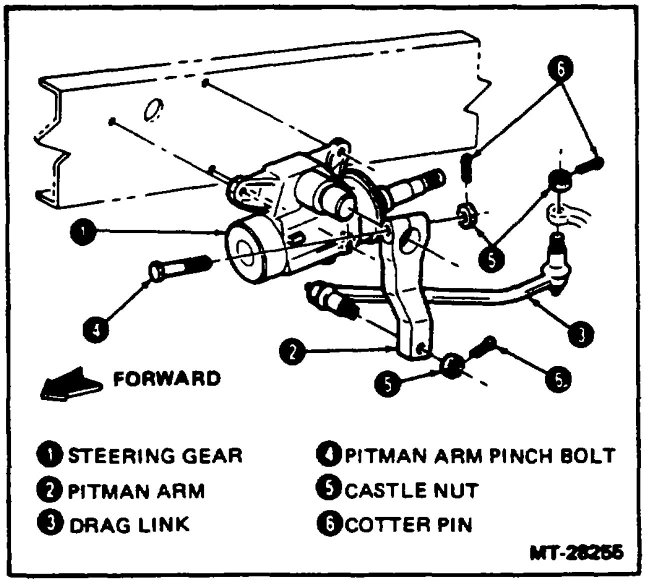

Figure 8 -- Pltman Arm and Drag Link Installation

4. Drive wedge into slot in Pitman arm (Figure 9). Remove Pitman arm.

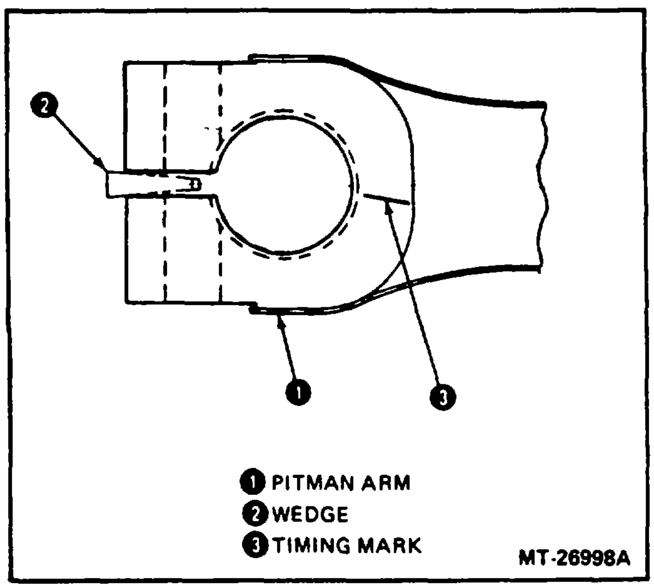

Figure 9 - Pitman Arm Removal

Installation

1. Position the Pitman arm on the sector shaft, aligning the timing mark on the sector shaft to the timing mark on the Pitman arm. Use the pinch bolt to align the groove on the sector shaft and the bolt hole in the Pitman arm.

2. Remove the wedge, making certain that the Pitman arm stays aligned to the sector shaft.

3. Install the nut and lockwasher and tighten to recommended torque (see SPECIFICATIONS).
4. Install the drag link ball stud in the Pitman arm and tighten the nut to recommended torque. If the cotter **pin** cannot be Installed after **obtaining minimum torque, do not back off nut. Tighten to next castellatlon. Refer to SPECIFICATIONS.**

DRAG LINK
Removal
Refer to Figure 8.
1. Remove cotter pins from the attaching nuts.
2. Remove the nuts.
3. Remove the ball studs from the Pitman arm and steering linkage.

Installation
1. Install ball studs in the Pitman arm and steering linkage holes.
2. Install nuts and tighten to recommended torque (see SPECIFICATIONS).
3. Install cotter pins. **If cotter pin cannot be Installed after obtaining minimum torque, do not back off nut. Tighten to next castellation.**

DISASSEMBLY AND ASSEMBLY

UNIVERSAL JOINT

Columns equipped with the lower steering shaft shell coupling utilize a standard spider-type universal joint for connecting the upper and lower steering column shafts. To service the universal joint on these models, it is first necessary to remove the steering column from the vehicle.

CAUTION - USE EXTREME CARE NOT TO DAMAGE BEARING SURFACES.

Disassembly

1. Place the universal joint in a vise as shown in Figure 10. Remove the snap rings retaining the bearings In the yoke

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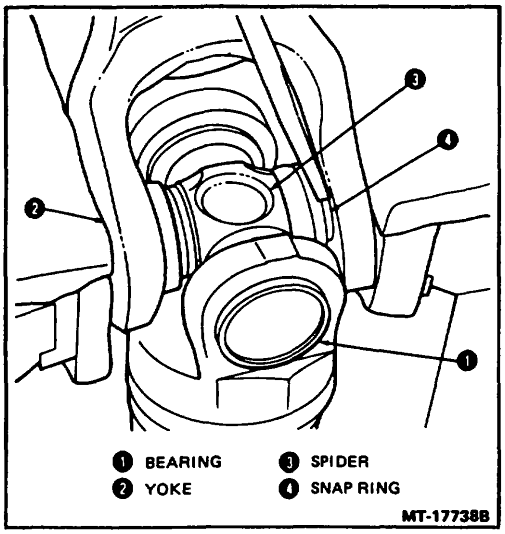

Figure 10 - Snap Ring Removal

2. Place the shaft assembly in a vise as shown in Figure 11. Tap the yoke with a soft hammer beside the bearing that is being removed. The bearing should come out. if the bearing does not come out, place the bearing in a vise. Use copper jaw covers on vise. Tap the yoke away from the bearing as shown in Figure 12.

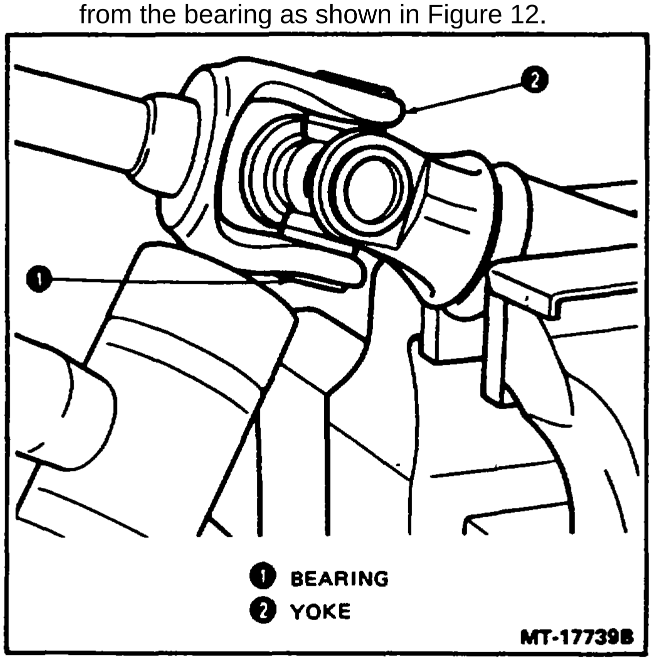

Figure 11 - Bearing Removal

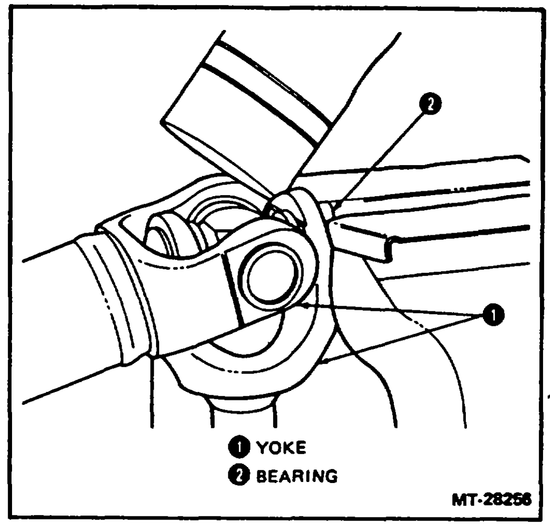

Figure 12 -- Bearing Removal

3. Remove the spider after the bearings have been removed.

Assembly

1. Make certain parts are clean before assembly.
2. Rest yoke on hard surface. Tap one bearing part way into yoke with a soft hammer (Figure 13).' Be certain bearings are straight in yoke.

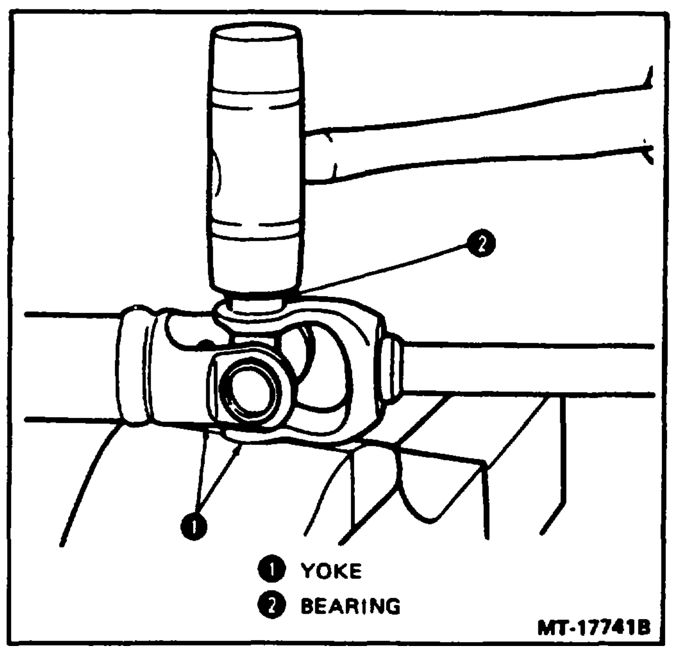

Figure 13 -- Install Bearing Part Way Into Yoke

3. Insert spider through the opposite hole, without bearing, and swing it into place and down into the partially installed bearing.
4. Turn assembly over and tap the opposite bearing part way into the yoke. Be certain to start bearing straight in yoke.
5. Place yoke in vise with bearings against jaws of vise. Tighten vise slowly and the bearings will be pressed into the yoke as shown in Figure 14.

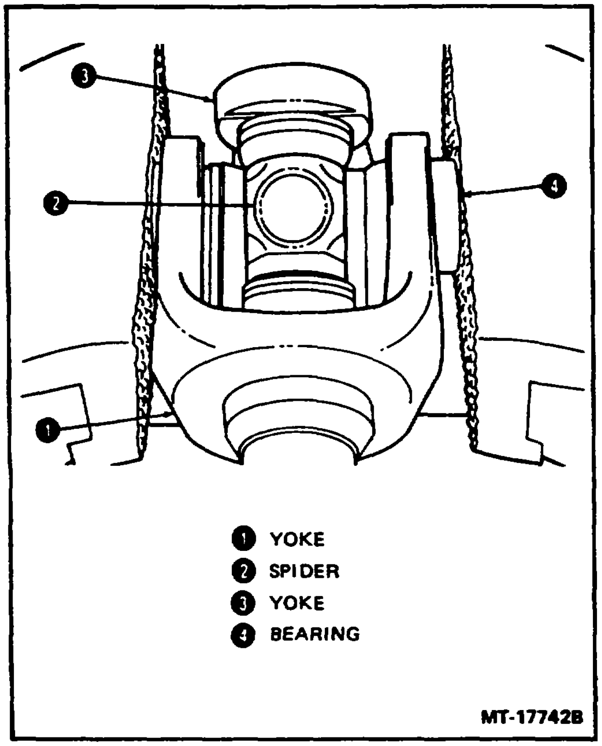

Figure 14 - Press Bearings Into Yoke

6. After pressing bearing into yoke, the spider may be off center in yoke. This is desirable because it permits installation of snap ring on the side with the most clearance. Refer to Figure 15 and install snap ring.

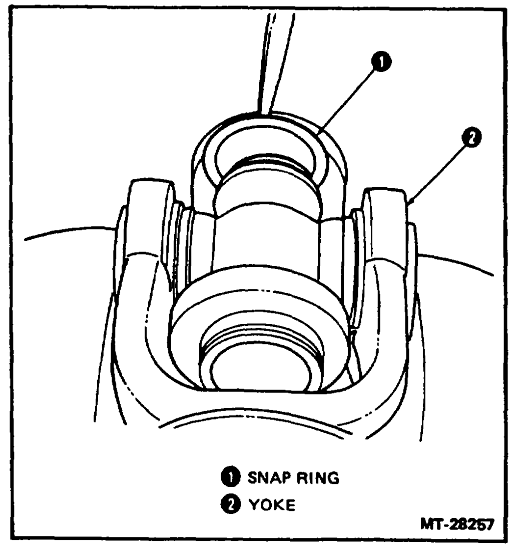

Figure 15 - Snap Ring Installation

7. After the first snap ring is in place, turn assembly over. The bearing with snap ring installed should be on the bottom. Rest yoke on vise and strike bearing which is on top. This will seat both bearings. Snap rings should rest against inside milled surface of yoke. Install remaining snap ring.
8. Bearings must move freely. If tight, tap yoke until free.

STEERING WHEEL ALIGNMENT

1. Position front wheels in a straight ahead position. The narrow spoke of the steering wheel (marked 'top') should be pointed to the front of the vehicle.
2. if the narrow spoke of the steering wheel Is off center, remove the steering wheel and install it with the narrow spoke centered. Refer to Steering Wheel in this section for removal and installation procedures.

SPECIFICATIONS
TORQUE CHART

LOCATION	RECOMMENDED TORQUE
Steering Wheel Mounting Nut	102-108 N•m (75-80 lb-ft)
Steering Column End Yoke Pinch Bolt	
3/8 Bolt	47-54 N•m (35-40 lb-ft)
7/16 Bolt	81-89 N•m (60-66 lb-ft)
Shell Coupling Clamp Bolt	41-47 N•m (30-35 lb-ft)
Column Shaft Mounting U-Bolt (Shell Coupling)	14-16 N•m (10-12 lb-ft)
Drag Link Locking Clamp	68-81 N•m (50-60 lb-ft)
Drag Link to Pitman Arm Nut	149-169 N•m (110-125 lb-ft)*
Steering Column to Support Bracket	31-36 N•m (23-27 lb-ft)
Pitman Arm Pinch Bolt	
1/2" Bolt (Sector Shaft Diameter 1-3/8")	149-163 N•m (110-120 lb-ft)
5/8" Bolt (Sector Shaft Diameter 1-1/2" to 1-3/4")	298-325 N•m (220-240 lb-ft)
3/4" Bolt (Sector Shaft Diameter 1-15/16")	447-502 N•m (330-370 lb-ft)

*If a castle nut and cotter pin are used, and the cotter pin cannot be inserted after attaining minimum torque, tighten to next castellation and insert cotter pin. Do not back nut off to insert cotter pin.

***Castle nut only with drag link studs**

SPECIAL TOOLS

SE-1821 Puller
SE-2221 Torque Indicator Wrench (0-150 lb-ft)
SE-2189 Torque Indicator Wrench (100-600 lb-ft)

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PROPELLER SHAFT

CONTENTS

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FORWARD

This manual Is presented as a guide In solving problems associated with drive shafts. No attempt has been made to discuss technical consideration of design or theory of vibrating systems.

In discussing installation of drive shafts, no hard and fast rule or fine dividing line has been drawn between satisfactory and unsatisfactory operation.

The limits set forth in this manual correspond with our own standards. Our long experience in the installation of drive shafts has proven these standards to be accurate.

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FUNCTION

In examining the drive line, it would be well to start with a review of drive shaft operation. A critical examination of why it is there and what it must do may be helpful in analyzing its effect on the entire drive line system. A driveshaft's functions can be briefly described as follows:

1. It must transmit torque from the transmission to the axle. This requirement makes it necessary that the driveshaft be capable of transmitting the maximum low gear torque developed by the engine and transmission ratio and any shock loads which may develop. It must also be capable of rotating at the maximum speed required for vehicle operation. This speed is often engine speed increased by an overdrive ratio in the transmission.
2. The driveshaft must operate through constantly changing relative angles between transmission driveshaft and axle.
3. The length of the driveshaft must be capable of changing while transmitting torque. Length changes are caused by necessary axle movement due to torque reaction, road deflections, braking loads, etc.

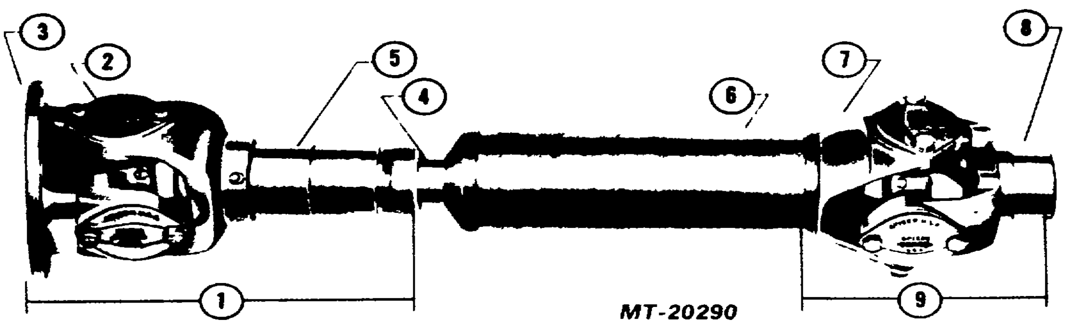

Fig. 1 Typical Parts Identification

1 Slip Joint
2 Journal and Bearing Kit
3 Flange Yoke
4 Slip Stub Shaft
5 Sleeve Yoke Assembly
6 Tubing
7 Stub Yoke
8 End Yoke
9 Permanent Joint

CONSTRUCTION

The basic functions having been designated, let's look at conventional universal joint and driveshaft construction.

To transmit required loads, the driveshaft must possess high strength. Forged steel, or high strength cast yokes are generally used to provide necessary strength and the rigidity required to maintain bearing alignment under torque loads and during high speed operation. Special high-strength tubing is used to provide, maximum torque carrying capacity at minimum practical weight. This tubing must be securely welded to its end members, to provide the necessary torque capacity.

High quality anti-friction bearings are used to withstand required loads while oscillating at high speeds. These bearings on the journal cross carry very high loads for their size. The full complement. roller-type (needle) bearings are generally used because of their high capacity in a limited space. Bearings are individually sealed to provide retention of required lubricants as well as to prevent the entry of foreign material. If lubricants become contaminated with water or abrasive material, needle bearing life is seriously affected.

Abrasive material is a major problem where a vehicle operates under conditions of extreme moisture and dirt. Off-highway installations are especially critical in this respect. Military trucks represent the-extreme in this direction and were the first to show the shortcomings in the conventional cork seals used in universal joint bearings. It was found that an improved seal was required for this type of operation. Synthetic rubber-type seals were developed for these installations. These seals have been in use for many years on military vehicles and are now used in most commercial installations. The improved sealing shows increased life and a less critical re-lubrication cycle.

The sliding splines between slip joint and permanent joint must support the driveshaft and be capable of sliding under full torque loads. To provide adequate strength and wear resistance, hardened and ground splines are used. These splines are phosphate or nylon coated to resist galling and to reduce sliding friction.

COMPONENTS

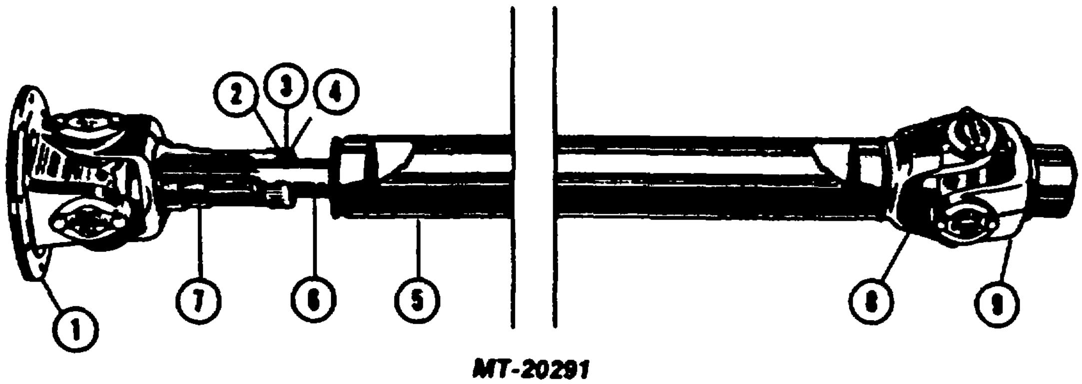

Fig. 2 Slip Joint Permanent Joint

1 Flange Yoke
2 Cork Washer
3 Steel Washer
4 Dust Cap
5 Tubing
6 Slip Stub Shaft, Center Bearing
7 Sleeve Yoke Assembly
8 Stub Yoke
9 End Yoke

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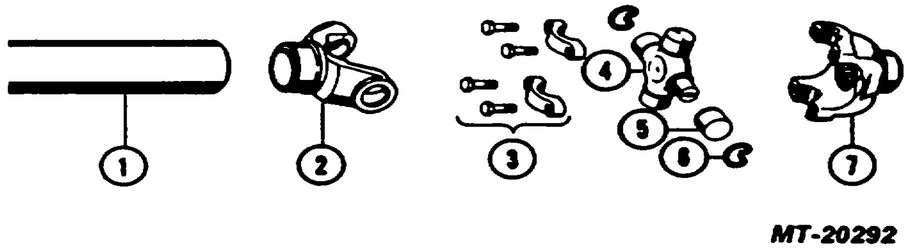

Fig. 3 Permanent Joint

1 Tubing
2 Stub Yoke
3 Cap and Bolt
4 Journal Assembly
S Bearing Assembly
6 Snap Ring
7 End Yoke

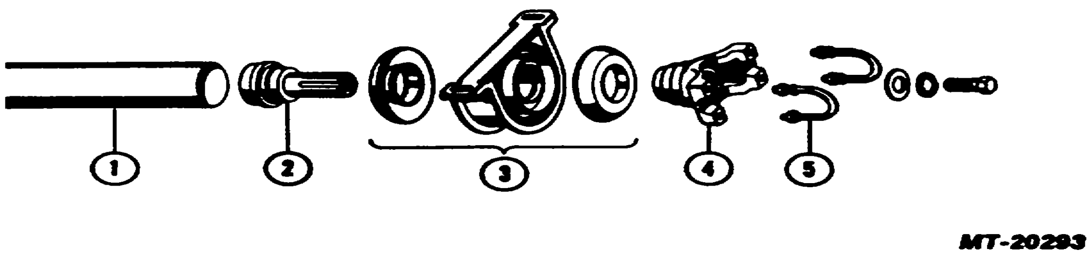

Fig. 4 Center Bearing Assembly

1 Tubing
2 Midship Stub Shaft
3 Center Bearing
4 End Yoke
5 U-Bolt

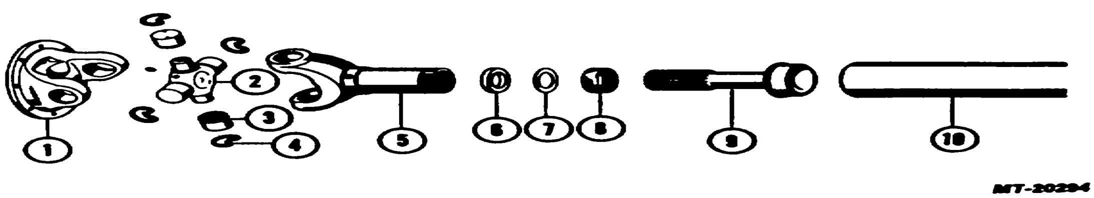

Fig. 5 Slip Joint

1 Flange Yoke
2 Journal Assembly
3 Bearing Assembly
4 Snap Ring
5 Sleeve Yoke
6 Cork Washer — or one piece
7 Steel Washer — neoprene seal
8 Dust Cap
9 Slip Stub Shaft
10 Tubing

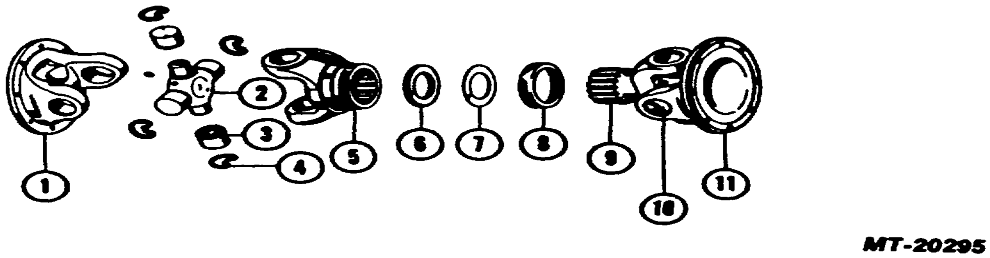

Fig. Short Coupe Joint

1 Flange Yoke
2 Journal Assembly
3 Bearing Assembly
4 Snap Ring
5 Sleeve Yoke
6 Cork Washer
7 Steel Washer or one piece
8 Dust Cap neoprene seal
9 Yoke Shaft
10 Journal and Bearing
11 Flange Yoke

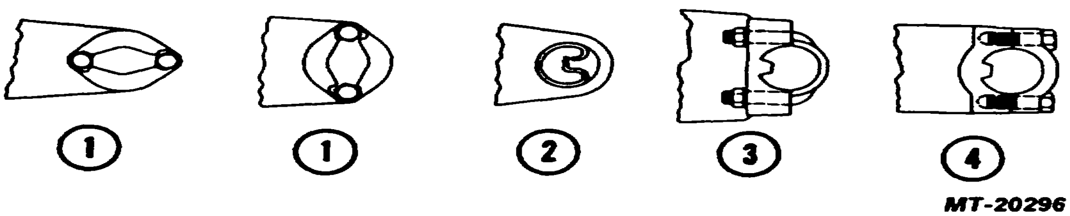

Fig. 7 Alternate Yoke Constructions

1 Bearing Cap
2 Snap Ring
3 U-Bolt
4 Cap and Bolt

Fig. 8 Alternate Companion flange - Flange Yoke

1 Circular Type
2 Rectangular Type

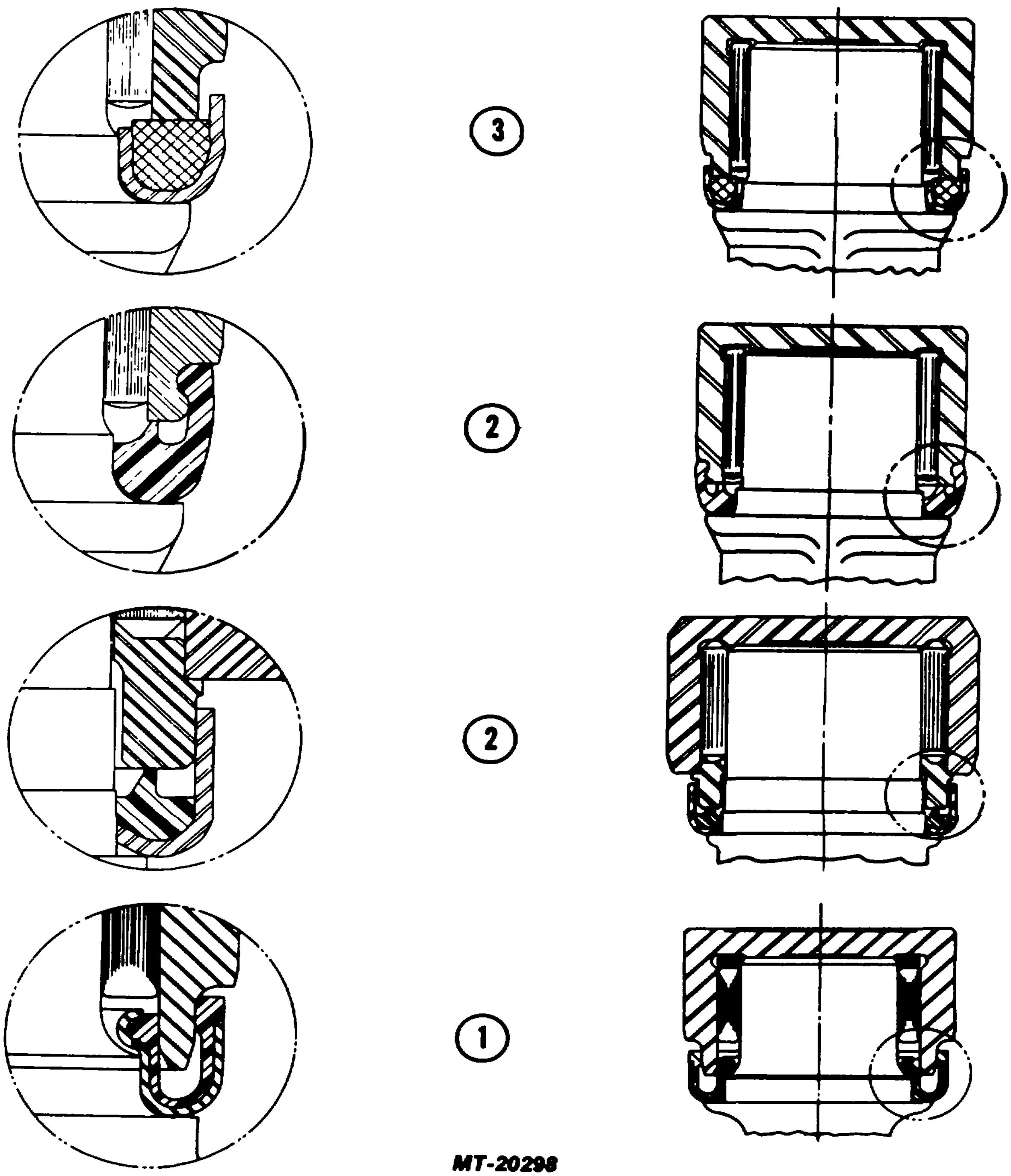

Fig. 9 Universal Joint Seal

1 Extended Life Seal
2 Rubber Seal
3 Cork Seal

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LUBRICATION

DON'T NEGLECT DRIVE SHAFT LUBRICATION!

Lack of adequate or proper lubrication is among the most common causes of U-Joint and drive shaft failure!

Proper servicing of the drive shaft is an essential part of vehicle maintenance and should not be overlooked in routine shop procedure.

UNIVERSAL JOINTS

IN THE VEHICL OR APPLICATION

To insure proper lubrication of all four bearing assemblies on universal joints, it is essential that mechanics add lubricant until it appears at all journal cross bearing seals (Fig. 10). This assures removal of dirt particles and other contaminants that may find their way into the bearings and indicates to the mechanic that the bearings are fully lubricated.

Do not assume that bearing cavities have been filled with new lubricant unless flow is noticed around all four bearing seals!

Journal cross seals are designed to relieve. However, if all the seals do not "pop" when being lubed, move the driveshaft laterally in all four directions and pull or push on the drive shaft in the direction opposite to the journal cross seal not relieving while lube gun pressure is being applied to the alemite fitting. An increase in line pressure may also be necessary.

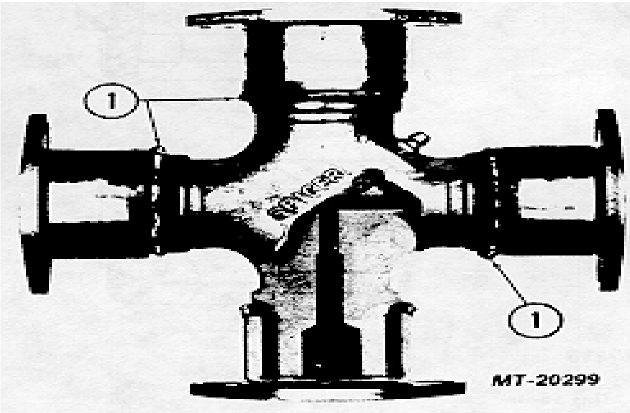

Fig. 10

1 Lube

DRIVE SHAFT ASSEMBLY

Factory assembled drive shafts are lubricated at the plant prior to shipment. However, shipping, handling and installation of the drive shaft assembly into the vehicle usually results in some loss of lube. Therefore, it is recommended that all universal joints be relubricated after installation of the drive shaft prior to putting vehicle in service.

JOURNAL AND BEARING KITS

Replacement universal joint kits contain only enough grease to provide needle bearing protection during storage. It is therefore necessary to completely lubricate each replacement kit prior to assembly into the drive shaft yokes. Each journal cross lube reservoir should be fully packed with a recommended grease and each bearing assembly should also be wiped with the same grease; filling all the cavities between the rollers and applying a liberal grease coating on the bottom of each race. After the kits are installed into the driveshaft yokes and prior to placing into service, they should be relubed, through the zerks, using the same grease.

RECOMMENDED LUBRICANTS

For center bearings, slip joints and universal joints use IH 251 HEP grease or equivalent NLGI #2 multi-purpose grease.

RELUBE CYCLES

Relubrication cycles for driveshaft universal joints and slip splines will vary with service requirements and operating conditions. Refer to Operator's Manual.

SLIP JOINT LUBRICATION

Relube spline at intervals prescribed in Operator's Manual. Apply grease gun pressure to lubrication zerk until lubricant appears at pressure relief hole in welch plug at sleeve yoke end of spline (Fig. 11). At this point, cover pressure relief hole with finger and continue to apply pressure until grease appears at sleeve yoke seal (Fig. 12). This will insure complete lubrication of spline.

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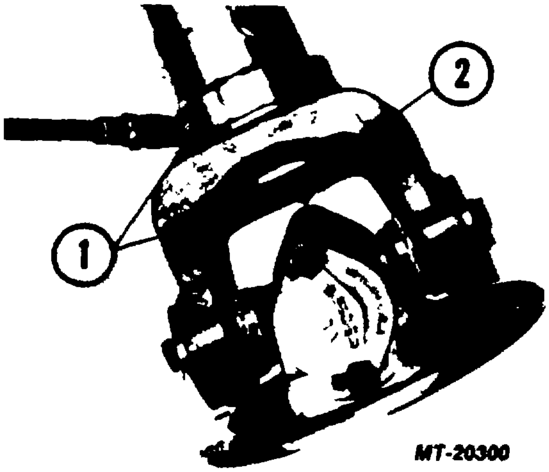

Fig. 11

1 Lube
2 Pressure Relief Hole

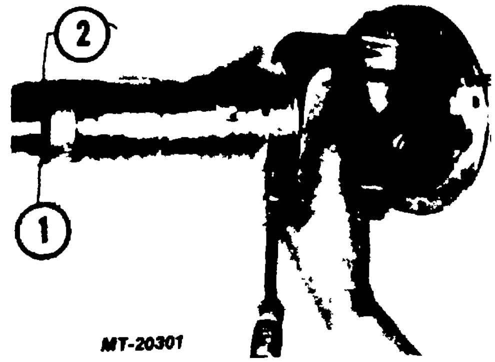

Fig. 12

1 Lube
2 Sleeve Yoke Seal

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SERVICE INSTRUCTIONS

Needle bearing joints are simple in construction, easily removed from the vehicle and readily disassembled and reassembled without the use of any special tools or any special mechanical knowledge.

REMOVAL FROM THE VEHICLE

Fig. 14

Double End, Yoke Type (U-Bolt Construction) (Fig. 14)

Fig. 15

Remove the U-Bolts, Nuts, and Lockwashers from the End Yokes. Slide the Sleeve Yoke toward the shaft to free the Bearings from their seats between the shoulders in the End Yokes (Fig. 15). Care should be taken not to drop the two Bearings from the trunnion ends of the Journal Cross at both ends of the driveshaft. The End Yokes remain on the vehicle.

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SERVICE INSTRUCTIONS

DISASSEMBLING UNIVERSAL JOINT

1. SNAP RING Remove by pinching the ends together with a pair of pliers. If a ring does not readily snap out of the groove in the yoke, tap the end of the bearing cap lightly to relieve the pressure against the ring (Fig 24).

2. THRUST PLATE CONSTRUCTION (Fig. 25) Remove capscrews and plate. The balance of the disassembly and assembly Instructions are the same as those for snap ring joints.

3. NEEDLE BEARING CAP Remove by driving on the end of one bearing cap until the opposite bearing cap comes out. Turn the joint over and tap the exposed end of the journal cross until the opposite needle bearing cap is free. Use a soft round drift with flat face about .79 mm (1/32") smaller than the hole diameter in the yoke, otherwise, there is danger of damaging the bearing.

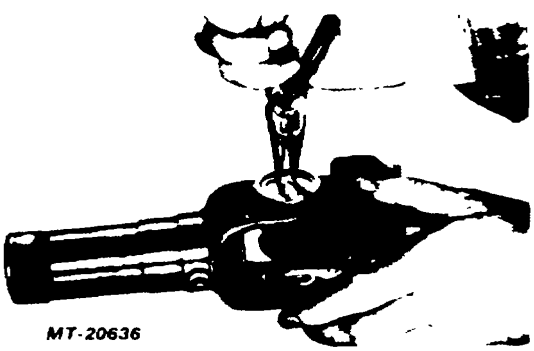

Fig. 24

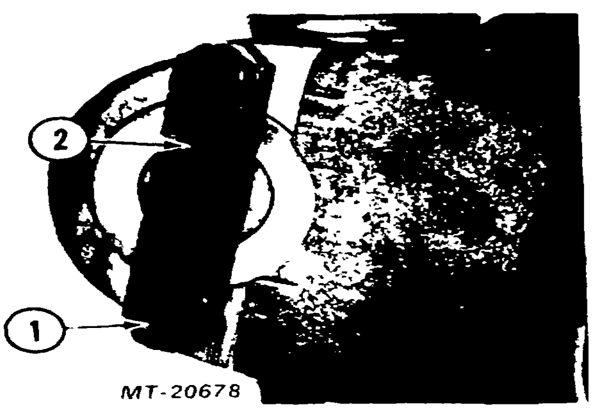

Fig. 25

4. JOURNAL CROSS - Remove by sliding it to the side of the yoke and tilting it over the top of the yoke lug (Fig. 26).

Fig. 26

ASSEMBLING UNIVERSAL JOINT

Reassembly is merely reverse order of the above operations. On joints without a lubrication fitting, repack reservoirs In the journal cross ends with the recommended lubricant. Make sure the reservoir in each trunnion is filled. With the rollers in the race, fill the race about 1/2 full (Fig. 27).

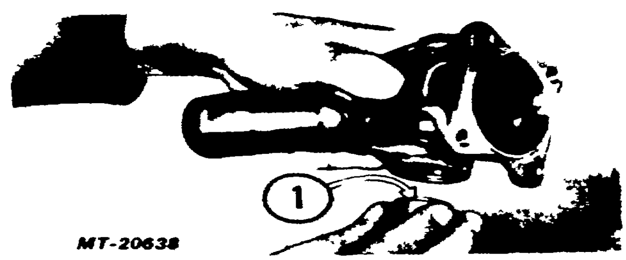

Fig. 27

1 Fill Race 1/2 Full With Lube

U-BOLT CONSTRUCTION

U-Bolt joints are a combination of U-Bolt and snap ring construction (Fig. 28). Except that the U-Bolts are disassembled when the complete propeller shaft is removed from the vehicle, the balance of disassembly and assembly instructions are the same as those for snap ring joints.

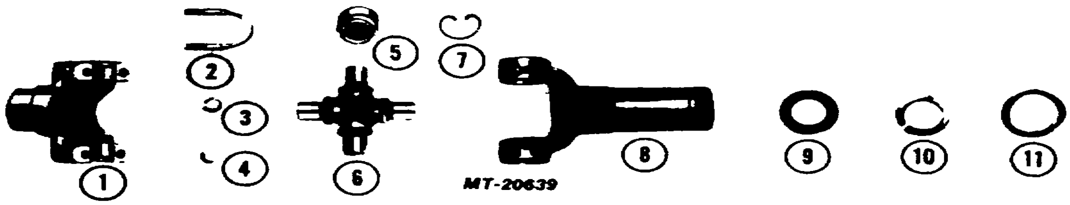

Fig. 28

1 End Yoke
2 U-Bolt
3 Nut
4 Lock Washer
5 Bearing Assembly
6 Journal Assembly
7 Snap Ring
8 Sleeve Yoke
9 Cork Washer
10 Steel Washer
11 Dust Cap

CLEANING AND INSPECTION

1. Clean All Parts Use a suitable cleaning fluid. Allow the parts to remain in the cleaner for some time to loosen up any particles of grease or foreign matter. Remove any burrs or rough spots from any machined surfaces.

2. Needle Bearings Do not disassemble. Clean with short stiff brush and blow out with compressed air. Work a small quantity of lubricant into each bearing cap and turn the needle bearing on the trunnion to check wear. Replace if worn.

3. Journal Cross Because worn needle bearings used with a new journal cross or new needle bearings used with a worn journal cross will wear more rapidly making another replacement necessary in a short time, always replace the journal cross and four needle bearing caps as a unit.

4. Journal and Bearing Kit (Figs. 29 and 30) To facilitate the replacement of journals and bearings, a Journal and Bearing Kit is available. The use of the Kit insures having the correct individual parts when required and saves valuable time.

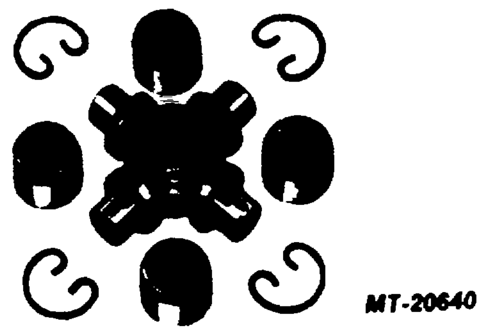

Fig. 29

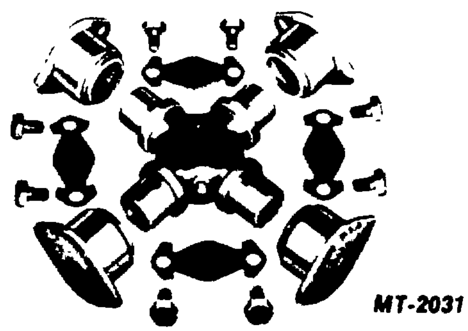

Fig. 30

Fig. 31 Lack of Lubrication

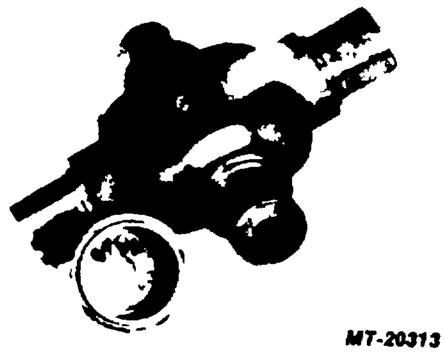

Fig. 32 End Galling

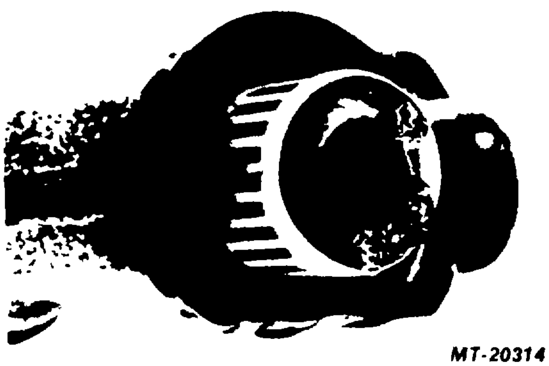

Fig. 33 Brinnelling

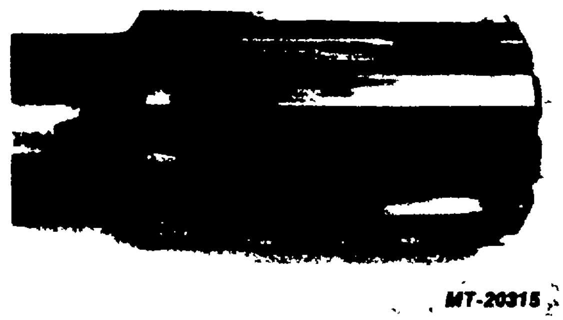

Fig. 34 Slip Spline Galling

REBUILDING DRIVESHAFTS

BALANCING

The rebuilding of a driveshaft assembly usually consists of replacing worn journal cross and bearings with a new kit. These kits replace the part of a driveshaft most subject to wear in operation. The slight off-center condition present in the journal cross assemblies makes it desirable to balance the assembly after installing new journal and bearing kits.

Generally, unbalance resulting after installation of a journal and bearing kit is equivalent to the unbalance existing after straightening the shaft. If balancing cannot be done, it is advisable to check assembly for smooth operation In vehicle before it is put into operation.

It is sometimes necessary to revise driveshaft lengths when rebuilding a vehicle. This job requires proper facilities to produce a quality assembly. It is necessary to properly assemble fittings into the tube and straighten, before welding, to be sure parts are centralized. This can be done by mounting shaft assembly on center and straightening at fittings until ends of tube run concentric within about .12 mm (.005") TIR. The welding of the tube in the fittings must provide for adequate strength and prevent distortion which could cause excessive runout. It is often desirable to tack weld and recheck for runout before proceeding with final weld. After welding, the entire driveshaft should be straightened to the following limits (See Fig. 35)

.12 mm (.005") TIR	On shaft neck
.25 mm (.010") TIR	On ends of tubing 38.1 mm (1-1/2") from welds
.38 mm (.015") TIR	In center of tube

These runouts should be taken with entire driveshaft assembly mounted on master attaching flanges or yokes, selected for dynamic balance to eliminate as much unbalance as possible During balancing, the driveshaft again should be mounted on these selected flanges or yokes.

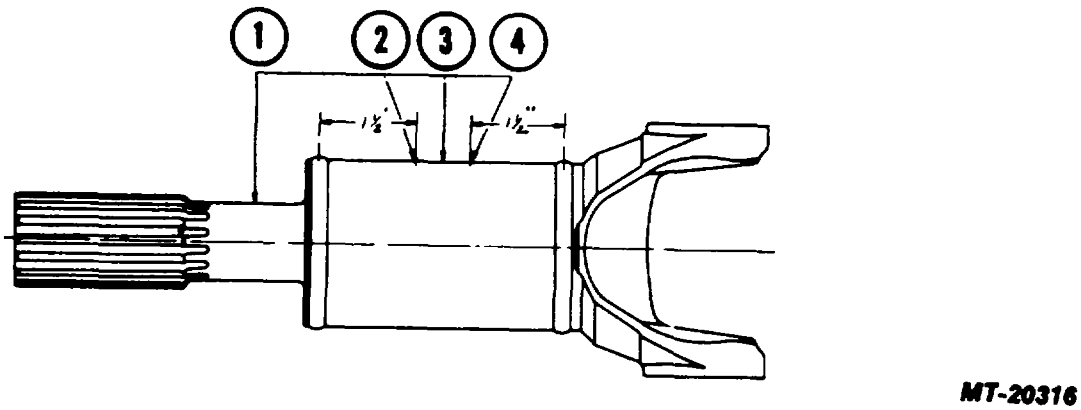

Fig. 35 Check Straightness of Shaft With Dial Indicator At Points - 2 - 3 - 4.

1 - .005"	3 - .015"
2 - .010"	4 - .010"

INSTALLATION

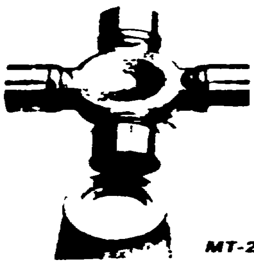

Fig. 36

JOURNAL CAPS WITH LOCK FLATS (Fig. 36) - When installing new journal kit caps into yoke ear holes, the lock flat on two of the journal caps must be kept in alignment with the locking flats near the front of the yoke ears. Proper location of locking flats will assure that the journal cap will not rotate.

The installation of a driveshaft into the vehicle does not present any unusual mechanical difficulties. Before actual installation, the driveshaft should be checked for the following items:

1. No damage or dents on driveshaft tubing which could cause unbalance. If the dents are severe enough they can weaken the tube and a failure might occur under torque load.

2. Splines should slide freely with slight drag from spline seal.

3. Bearings should flex and be free from excessive bind. A slight drag is the most desirable condition on a new universal joint. This drag is from the bearing seals. When rotating, yoke lug deflections cause some additional clearance. Excessive looseness is not desirable due to the resulting unbalance.

4. Mounting flanges and pilots should be free from burrs, paint and foreign substances which would not allow proper seating at assembly.

The driveshaft is mounted using flange bolts, bearing capscrews, or "U" bolts depending upon the size and construction. These bolts must carry high torque loads and should be of quality material and properly torqued. The following reviews requirements on these bolts.

1. Flange Bolts: Flange bolts should be alloy steel equivalent to SAE Grade 8, high-strength bolts. These bolts used with spring lockwashers and nuts provide the capacity required. The nuts should be torqued to the following specifications:

	N.m	Ft. Lbs.
5/16"-24 Thread	29.8-32. 5	22-24
3/8"-24 Thread	54.2-59.6	40-44
7/16"-20 Thread	85. 4-94.9	63-70
1/2"-20 Thread	132.9-146.4	98-108

IMPORTANT

In cap and bolt construction joints (Fig. 7), be sure to torque the capscrews to 135.6 N.m (100 ft. lbs.). These joints are usually In the inter-axle assemblies.

2. U-Bolt Style Yokes: On smaller size universal joints, a "U" bolt style end yoke is used. This construction permits easier assembly where the smaller size bearings allow its use. The bearing race is seated in a half round hole and under locating ears. Be sure that mounting faces are cleaned of rust, paint and other foreign material. The "U" bolts are assembled over the bearing races to retain them in the end yokes. Spring lockwashers and nuts should be used with these "U" bolts at assembly. The following torque loads are suggested for use with these parts:

	N.m	Ft. Lbs.
5/16"-24 Thread	18.9-23.0	14-17
3/8"-24 Thread	27.1-32. 5	20-24
7/16"-20 Thread	43.3-50.1	32-37

These torque loads are somewhat lighter than normally used with these thread sizes, however, the lower torques are required to prevent bearing race distortion.

ASSEMBLING SLIP JOINT ON SHAFT

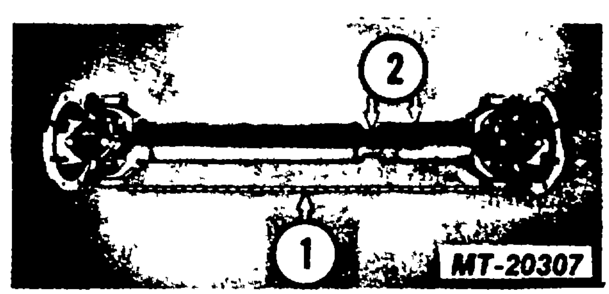

Fig. 37

1 Yoke Lugs in Line
2 Line Up Arrows

INSTALLATION

Lubricate the splines thoroughly (refer to page 10) and assemble on the shaft. BE SURE that the arrows or marks on the shaft and slip Joint are in line, since the sleeve yoke lugs must be in the same plane as the stud ball yoke lugs to prevent excessive vibration (Fig. 37).

The cork washer should be replaced if necessary before assembling with the dust cap and steel washer on the sleeve yoke.

INSTALLING PROPELLER SHAFT

1. Propeller Shaft Assembly Place in a pair of centers and check the shaft for runout if not previously done during assembly. The runout on the tube should not be more than .38 mm (.015") indicator reading, and on the neck of the slip stub shaft the runout should not be more than .12 mm (.005") indicator reading. Mark the high and low points on the shaft with chalk and straighten if necessary. Install with the slip joint nearest the source of power. Tighten the flange bolts evenly after the nuts and NEW lockwashers are in place.

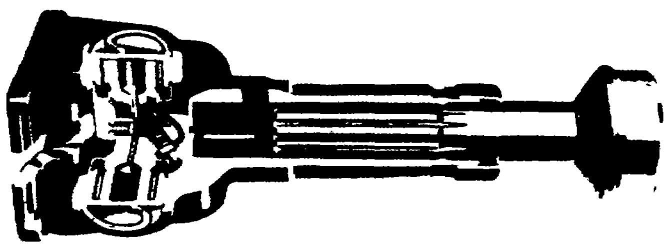

Fig. 38

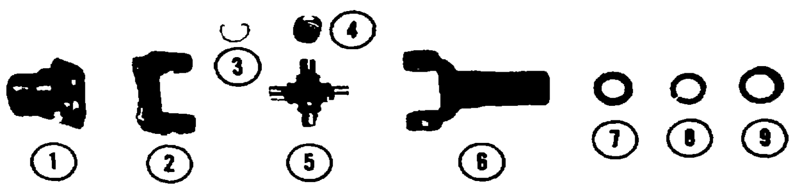

Fig. 39

1 Flange Yoke
2 Flange Yoke
3 Snap Ring
4 Bearing Assembly
5 Journal Assembly
6 Sleeve Yoke
7 Cork Washer
8 Steel Washer
9 Dust Cap

TWO-JOINT PROPELLER SHAFT

It is of primary importance that universal joints of sufficient capacity be used. When assembling the slip joint on the shaft, care must be taken to place the sleeve yoke lugs (12) in the same plane as the shaft yoke lugs (13). Arrows will be found stamped on the sleeve and shaft for this purpose.

Install transmission so that the transmission mainshaft and axle pinion shaft are parallel or nearly so, in order to keep the angles (X) on both joints as nearly equal as possible. See Fig. 40. If this method results in angles (X) of more than 12 deg., use the method shown in Fig. 41, where the axle pinion shaft is tilted upward to enable the centerlines to intersect at a point midway between the joint centers, thus giving equal angles (Y).

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INSTALLATION

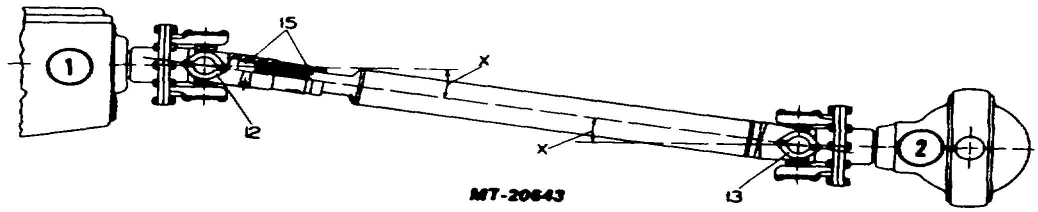

Fig. 40

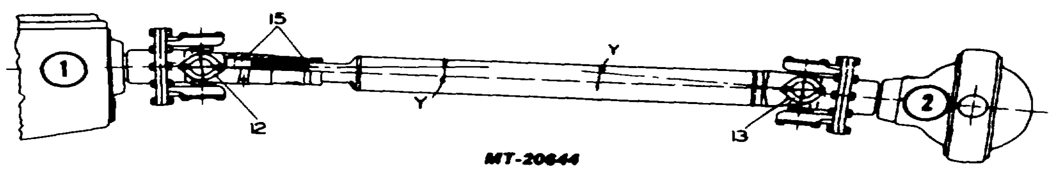

Fig. 41

1 Transmission   2 Axle

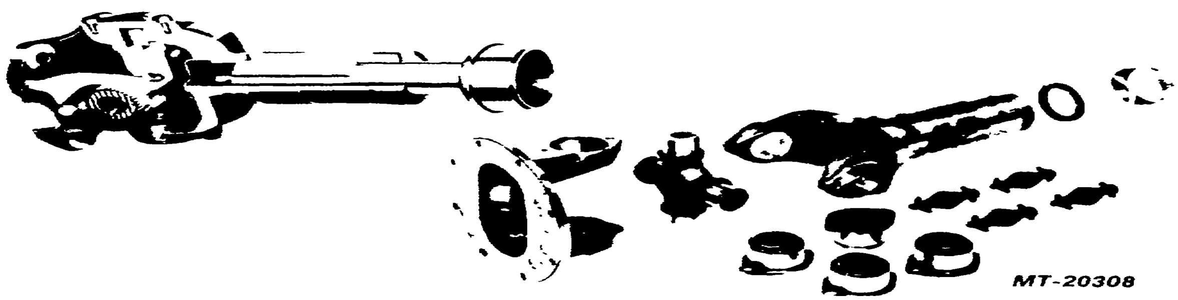

Fig. 42

UNIVERSAL JOINT PHASING (See Fig. 37)

When U-joints or yokes are assembled to their shafts in the same plane, they are in phase. When they are assembled to the shaft in different planes, they are out of phase. To obtain vibration free operation, check the following.

1. Yokes or flanges between the main and auxiliary transmission must be "In Phase".

2. In the case of a two-piece driveshaft assembly, between the transmission (Main or Auxiliary) and the forward rear axle, the joints on this shaft should be assembled "In Phase", unless otherwise specified by the manufacturer of the vehicle.

3. The inter-axle driveshaft yokes must be "In Phase".

4. If a vehicle has driveshafts that do not have intersecting angles but parallel angles throughout the drive line system, the yokes or flanges must be held parallel to within 1 deg. of each other.

INSTALLATION

INSTALLING DRIVESHAFT

Drive Shaft Assembly Place in a pair of centers and check the shaft for runout if not previously done during assembly. The runout on the tube should not be more than .38 mm (.015") indicator reading, and on the neck of the slip stub shaft the runout should not be more than .12 mm (.005") indicator reading. Mark the high and low points on the shaft with chalk and straighten if necessary. Install with the slip joint nearest the source of power. Tighten the flange bolts evenly after the nuts and NEW lockwashers are in place.

CHECKING DRIVESHAFT ANGLES

The procedure to check driveshaft angles for proper universal joint operating angles follows:

1. Remember to check driveshaft angles both with the tractor fifth wheel unloaded, and loaded with a trailer.

2. To determine driveshaft angles, a spirit level protractor is required (Fig. 43). When angles are read from the 0 deg. mark (for example, measuring inter-axle shaft angle 5 deg.), record and use the angle shown on the protractor. When angles are read from either of the 90 deg. marks (vertically) for example, measuring yoke angles, do not record the angle shown on the protractor since the 90 deg. marks must be understood to be the same as 0 deg. on the horizontal plane. Thus, if a vertical reading is 85 deg., the angle being measured Is 5 deg.

3. All angles should be read within 1/4 deg. (15 minutes) and they should be measured with the protractor held plumb on a clean, flat surface.

4. Inflate all tires to the pressure at which they are normally operated. Park the tractor on a surface which is as nearly level as possible both from front-to-rear and from side-to-side.

5. The tractor must be in its normal operating position. Do not attempt to level the truck by jacking up the front or rear axles to obtain a level condition.

6. Check and record the angle on the engine and main transmission. This reading can be taken at the rear of the main transmission on the output yoke or flange. Record this reading on a sketch similar to Fig. 44 (Example on Fig. 45, -1 deg. down).

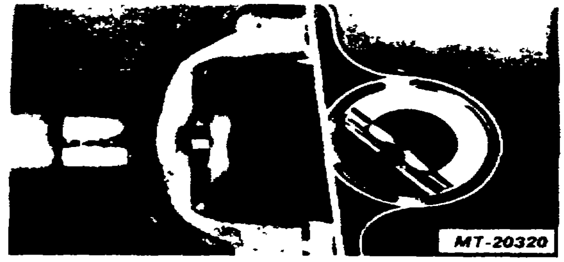

Fig. 43

7. Move protractor to the 0 deg. reading and check driveshaft angle between transmission and forward axle (Example 4 deg. 30 sec. down).

8. Check front axle input yoke angle with protractor (Example angle up 2 deg. 30 sec.), also check front axle output yoke (Example angle down 2 deg. 20 sec.).

9. Measure the angle of the tandem driveshaft between the front axle and first rear axle (Example 5 deg. down).

10. Measure the rear axle input yoke angle (Example 12 deg. up).

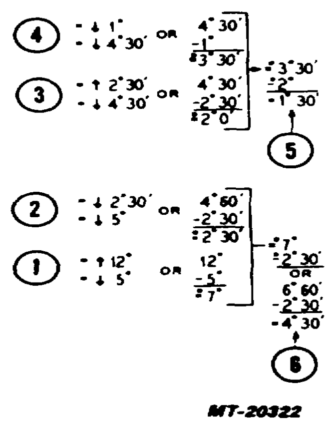

Fig. 44

See Page 23 for legend.

Legend for Fig. 44

1	Rear Axle Yoke	=	12°
	Interaxle Drive Shaft	=	5°
2	Forward Axle Output Yoke	=	2° 30"
	Interaxle Drive Shaft	=	5°
3	Forward Axle Input Yoke	=	2° 30'
	Front Drive Shaft	=	4° 30"
4	Transmission Output Yoke	=	1°
	Front Drive Shaft	=	4° 30'
5	Good Cancellation of Journal Operating Angles		
6	Improper Cancellation of Journal Operating Angles		

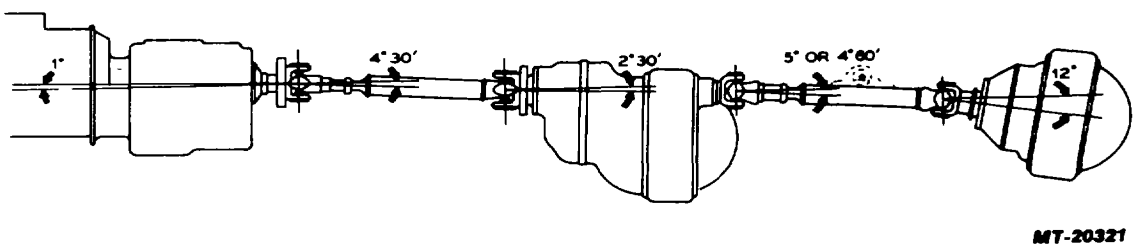

Fig. 45

11. With all the above angles recorded, these values are checked to obtain the journal cross operating angles of each driveshaft set to determine if they are operating to within a 3 deg. maximum of each other. If the operating angles or journals exceed 3 deg., it will cause early wear, and possible seizure of the journal to the needle bearing in the journal cap.

TORQUE ARM SHIMMING

The adding or removing of shims from the rear torque arm will change the angle of the inter-axle driveshaft. Therefore, it is necessary to take the inter-axle driveshaft angle and the rear axle yoke angle after each adjustment is made, to determine the journal operating angle.

SHORT COUPLED JOINTS

Short coupled joints must be installed so that the front and rear joints will have equal angles which should not exceed 3 deg.

CENTER BEARING

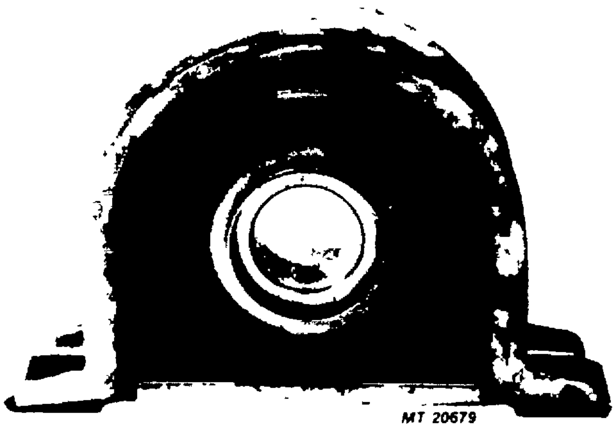

Fig. 46

GENERAL

Center bearings (Fig. 46) are provided to support the propeller shaft assembly and to smooth out the power delivered to the rear axle assembly.

Loose center bearing assembly mounting bolts should be tightened. Deteriorated or oil soaked center bearing insulators should be replaced. These conditions can cause excessive drive line vibration if not corrected.

BALL BEARING TYPE

Description

The center bearing used on some vehicles utilizes a ball bearing with the bearing housing enclosed in rubber

No lubrication for this center bearing is provided as the bearing is filled with a waterproof grease for life of bearing.

REMOVE

1. Set parking brake.
2. Disconnect rear propeller shaft assembly (universal joint) at center bearing.
3. Remove companion flange nut, then remove the yoke assembly.
4. Remove the center bearing bracket mounting bolts and separate center bearing mounting bracket with bearing from center bearing bracket (on frame cross member).
5. Remove center bearing assembly and both slingers from stud shaft.
6. The center bearing is serviced as a complete assembly, therefore separating the "U" shape bracket from rubber cushion is not required.

REASSEMBLY

The reassembly procedure is the reverse of the disassembly procedure. Be sure to inspect the center bearing bracket (on frame cross-member) for damage.

Replace old section with this revised section in your CTS-4001 Manual

ELECTRICAL

BATTERY

MAINTENANCE-FREE

CONTENTS

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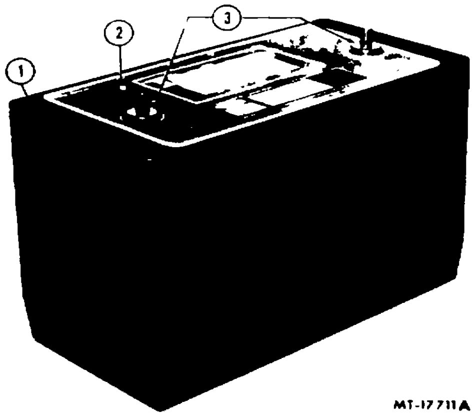


Fig. 1 Heavy Duty, Maintenance Free Battery

1 Finger Grip Handles 3 Terminals
2 Test Indicator

DESCRIPTION

The top terminal type maintenance-free battery shown In Figure 1 is designed for use in trucks and other heavy duty applications.

Water never needs to be added to the maintenance-free battery. There are no vent plugs in the cover. The battery Is completely sealed except for a small vent hole on the side. This vent hole allows what small amount of gases that are produced in the battery to escape. The special chemical composition inside the battery reduces the production of gas to an extremely small amount at normal charging voltages.

The maintenance-free battery has a strong ability to withstand damaging effects of overcharge. Also, the terminals are sealed tightly to retard leakage.

A test indicator in the battery cover can be used to determine if the battery can be tested in case of a cranking complaint. This feature Is explained below.

SAFETY PRECAUTIONS

Wear safety glasses when working near batteries.

All automotive batteries generate hydrogen gas which is highly flammable. If ignited by a spark or flame, the gas may explode violently causing spraying of acid, fragmentation of the battery, and possible severe personal injuries, particularly to the eyes.

Avoid battery acid. In case of contact, flush immediately with water.

Charge batteries only in a well-ventilated area. Always be sure battery chargers are "OFF" when connecting to or disconnecting from batteries.

TEST INDICATOR

The test indicator (Figure 1) is to be used with accepted diagnostic procedures only. It is not to be used to determine if battery is good or bad. The test indicator is a built-in hydrometer in one cell and provides visual information for battery testing.

It is important when observing the test indicator that the battery be level and have a clean top to see the correct indication. A light may be required in some poorly-lit areas.

Under normal operation, two indications can be observed:

1. GREEN DOT VISIBLE (Figure 2)

   Any green appearance is interpreted as a "green dot", and the battery is ready for testing .

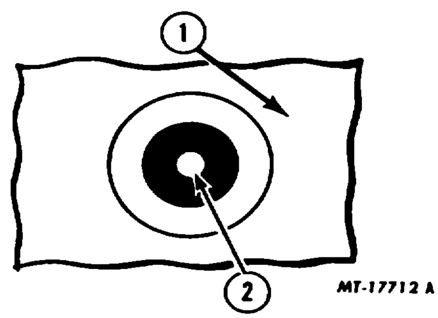


Fig. 2 Test Indicator Green Dot Visible

1 Battery Top
2 Green Dot

If there is a cranking complaint, the battery should be tested as instructed under "TESTING" and the vehicle's charging system should be checked for proper operation and adjustment.

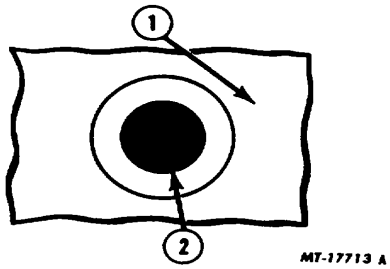


Fig. 3 Test Indicator Dark (Green Dot Not Visible)

1 Battery Top
2 All Dark

On occasion, the test indicator may turn light yellow. This indicates a low electrolyte level. Loss of electrolyte level could result from excessive over-charging, a broken case or tipping the battery over 450 on its side.

If test indicator shows light yellow, inspect battery and check charging system. Although the battery may be capable of further service, if a cranking complaint has been reported, replace the battery. DO NOT CHARGE, TEST OR JUMP START!

TESTING

1. VISUAL INSPECTION

   Check for obvious damage, such as a cracked or broken case or cover that could permit loss of electrolyte. If obvious physical damage is noted, replace battery. Determine cause of damage and correct as needed.

2. OBSERVE TEST INDICATOR

   a. Green Dot Visible (Figure 2)

   Proceed to Step 3.

   On occasion, after prolonged cranking the green dot may still be visible with the battery discharged. Should this occur, charge the battery as instructed under "CHARGING".

   b. Dark (Green Dot Not Visible) (Figure 3)

   Charge the battery as instructed under "CHARGING" and proceed to Step 3.

   c. On occasion, the test indicator may appear light yellow. In this instance, the battery should NOT be tested. Replace the battery.

3. REMOVE SURFACE CHARGE

   Disconnect battery cables and connect a 300 ampere load across terminals for 15 seconds to remove surface charge from battery. (Attach load clamps to contact lead terminal pads as instructed under "CHARGING AND TESTING ADAPTERS").

4. LOAD TEST

   a. Connect voltmeter and test load across terminals (see "CHARGING AND TESTING ADAPTERS") .

   b. Apply specified load (See "SPECIFI-CATIONS"). Read voltage after 15 seconds with load connected; then disconnect load.

   c. If minimum voltage is 9.6* or more, battery is good.

   d. If minimum voltage is less than 9.6*, replace battery.

* This voltage Is to be used for battery ambient temperature of 21 deg. C (70 deg. F) and above. For temperatures below 21 deg. C (70 deg. F), refer to Table 1. TABLE I

Table I

Ambient Temperature	21 C (70 F) & Above	16 C (60 F)	10 C (50 F)	4 C (40 F)	-1 C (30 F)	-7 C (20 F)	-12 C (10 F)	-18 C (0 F)
Minimum Voltage	9.6	9.5	9.4	9.3	9.1	8.9	8.7	8.5

CHARGING

Charging equipment for ordinary batteries is suitable for maintenance-free batteries.

DO NOT charge a battery if the green dot is visible in the test indicator.

On occasion, following prolonged cranking, the green dot may still be visible with the battery discharged. Should this occur, a booster charge of 20 ampere-hours is recommended.

DO NOT charge a battery if the test indicator is light yellow.

When charging battery, disconnect battery cables and connect charger to battery terminals as instructed under "CHARGING AND TESTING ADAPTERS". For typical charging rates, refer to Table 2. Note that this table recommends a maximum charge input of 75-80 ampere-hours.

To AVOID DAMAGE, charging rate must be reduced or temporarily halted if:

1. Battery case feels hot (51 deg. C/125 deg. F).

TABLE 2

BATTERY CHARGING GUIDE

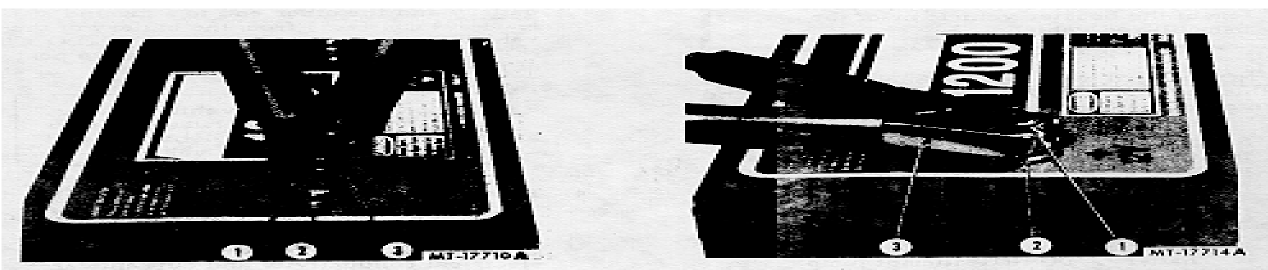
Heavy Duty Maintenance-Free

Stop charging when the green dot appears or when the maximum charge shown below is reached.

Slow Charging Rate	Fast Charging Rate
15 Hours @ 5 A 7 1/2 Hours @ 10 A	3 3/4 Hours @ 20 A 2 1/2 Hours @ 30 A 2 Hours @ 40 A 1 1/2 Hours @ 50 A

2. Violent gassing or spewing of electrolyte occurs.

After charging in accordance with Table 2, even though the green dot does not appear, the battery is still sufficiently charged for testing.



Figs. 4 end 5 Alligator Clamps Contacting Lead Pad For Battery Testing end Charging

1 Hex Nut
2 Lead Pad
3 Alligator Clamp

CHARGING AND TESTING ADAPTERS

Heavy duty maintenance-free batteries may be charged or tested either on or off the vehicle. However, the battery terminal hex nuts (ACDelco part number 7802) are required for testing and charging.

It is important that the alligator clamps of the tester or charger be placed between the terminal nuts and the lead pads of the terminal studs after the vehicle battery cables are detached, as shown in Figures 4 and 5. The clamps must touch the lead pads.

If this connection cannot be made because of alligator clamp design, the load for testing must be reduced as indicated in "SPECIFICATIONS".

EMERGENCY (JUMPER) STARTING

Both booster and discharged battery should be treated carefully when using jumper cables. Be careful not to cause sparks. Follow exactly the procedure outlined below.

CAUTION

Any procedure other than the following could result in: 1) personal injury caused by electrolyte squirting out the battery vent, 2) personal injury or property damage due to battery explosion, 3) damage to the charging system of the booster vehicle or of the immobilized vehicle.

DO NOT permit vehicles to touch each other as this could establish a ground connection and counteract the benefits of this procedure.

1. Set parking brake and place automatic transmission in "PARK" (neutral for manual transmission). Turn off lights, heater and other electrical loads.

   Observe test indicator:

   If indicator is light yellow, replace battery. DO NOT attempt jump starting when indicator is light yellow.

   If test indicator is dark, with or without a green dot in the center, proceed as follows: 2. Attach one end of one jumper cable to the positive (+) terminal of the booster battery and the other end of same cable to positive (+) terminal of discharged battery (Figure 6).

   On positive ground vehicles, connect jumper cable between negative (-) battery terminals.

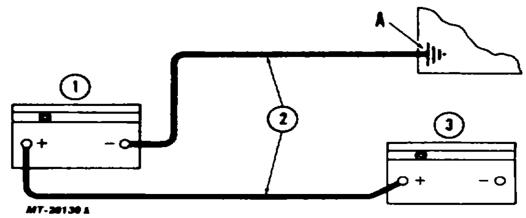


Fig. 6 Proper Jumper Cable Connections (Negative Ground Vehicles Shown)

1 Booster Battery
2 Jumper Cables
3 Discharged Battery A Ground at least 30 cm (12") from battery

3. Attach one end of the remaining jumper cable to the negative terminal of the booster battery and the other end to a ground at least 304 mm (12") from the battery of the vehicle being started (Figure 6). (DO NOT connect directly to the negative post of the dead battery.)

On positive ground vehicles, connect jumper cable between positive (+) terminal of booster battery and ground on the stalled vehicle.

4. Take care that the clamps from one cable do not inadvertently touch the clamps on the other cable. DO NOT lean over the battery when making connections. The ground connection must provide good electrical conductivity and current carrying capacity. Avoid moving, hot or electrical hazards such as fans, manifolds and spark plug terminals.

5. Reverse this sequence exactly when removing the jumper cables.

INSTALLATION PROCEDURE

1. Be sure there are no foreign objects in the carrier so that the battery will rest properly in the bottom of the carrier. Hold-downs should be functional and properly tightened.

2. Cable terminals should be securely tightened, but not over 20 N.m (15 lb. ft.).

3. Connect grounded terminal of battery last to avoid short circuits or grounds which may damage the electrical system.

4. Remove circles from "service date" label to certify date.

5. If installation is performed in sub-zero temperature, it is beneficial to boost charge for 15 minutes in order to achieve maximum battery performance.

6. If engine does not crank satisfactorily--

   a. and green dot is not visible in test indicator, battery should be recharged as instructed under "CHARGING".

   b. and green dot is visible, battery should be checked as instructed under "TESTING".

   A battery that passes the test procedure indicates a need for further checking of the vehicle’s fuel, ignition, cranking and charging systems.

SPECIFICATIONS

BATTERY MODEL	VOLTS	AMPS FOR LOAD TEST	RESERVE CAPACITY (MINUTES)	COLD CRANKING CURRENT (AMPS)		MAXIMUM DIMENSIONS			APPROX. WEIGHT
				At -18°C (0°F)	At -29°C (-20°F)	LENGTH	WIDTH	HEIGHT (INCL. POSTS)	
1110	12	310*	160	625	490	330 mm (13 in.)	172 mm (6-3/4 in.)	239 mm (9-7/16 in.)	26.8 Kg. (59.2 lbs.)

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ELECTRICAL

REGULAR CAB

CONTENTS

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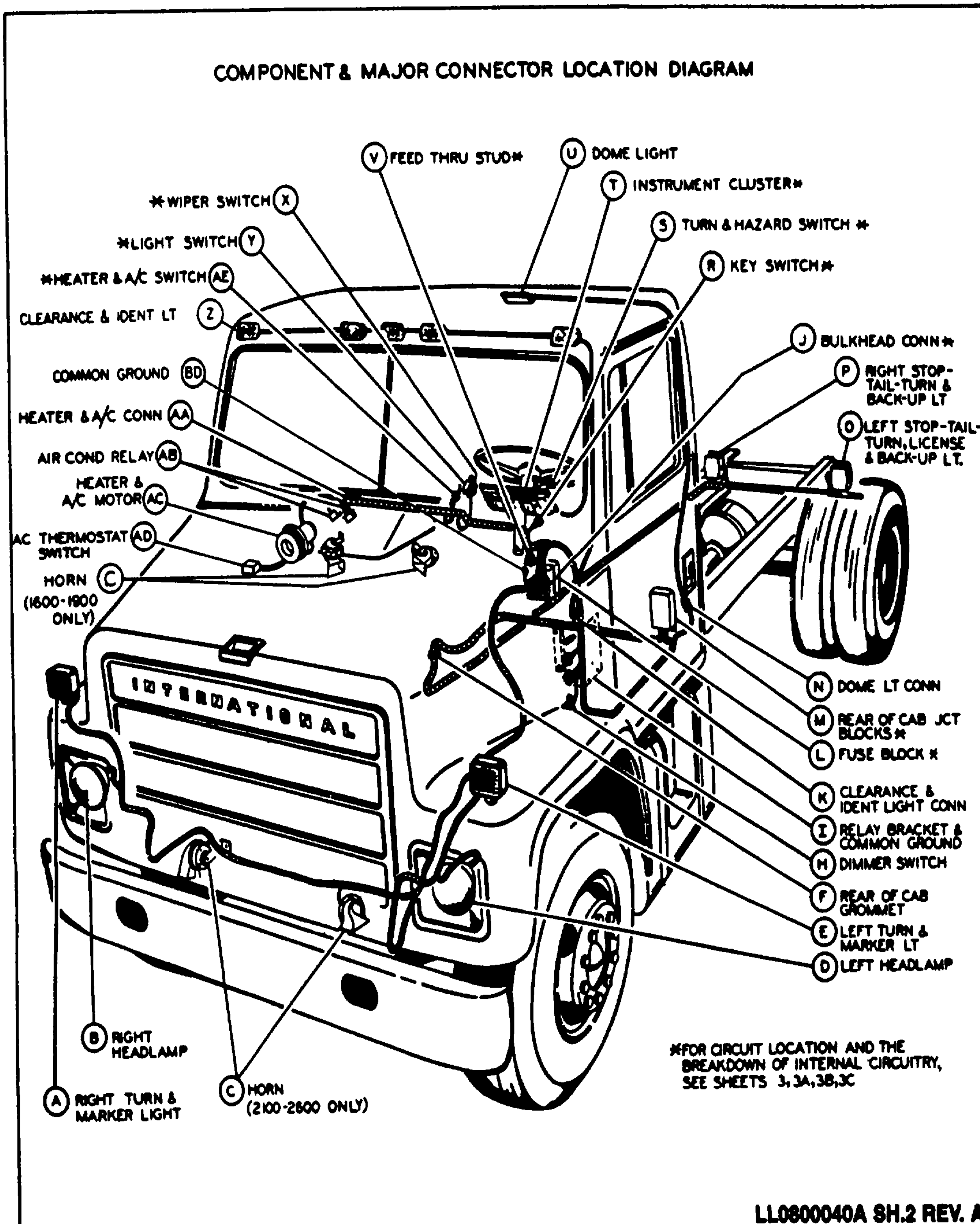
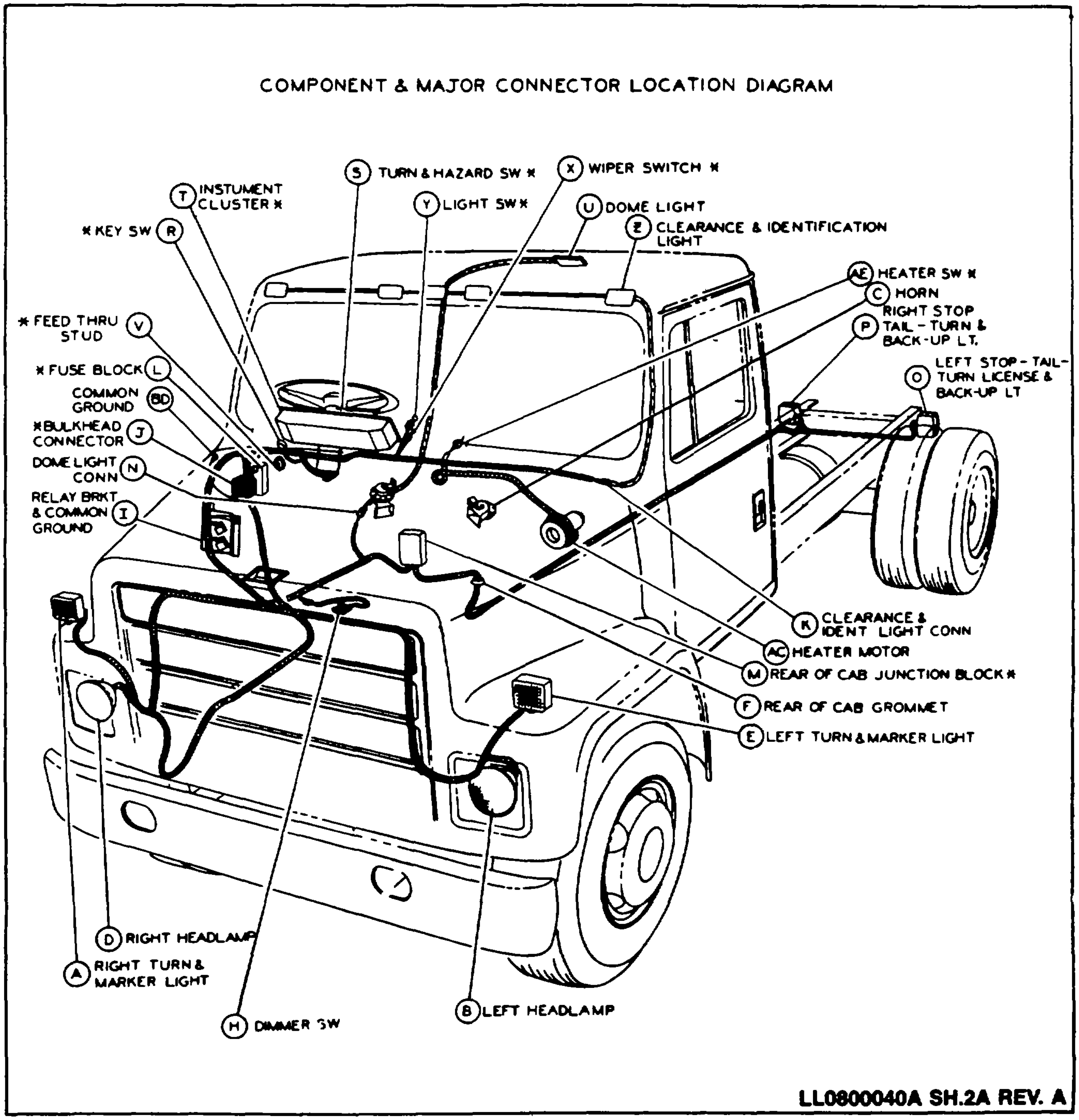
CONTENTS (Continued)

CONTENTS (Continued)



NOTE: THE CIRCLED COMPONENT LETTERS FOUND IN EACH OF THE INDIVIDUAL CIRCUIT DIAGRAMS EXAMPLE: ())REFER TO THE CORRESPONDING ITEMS IN THE COMPONENT AND MAJOR CONNECTOR LOCATION DIAGRAMS, THIS PAGE THROUGH PAGE 7.



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CIRCUIT NUMBERS & DESCRIPTION

1 GENERATOR (FIELD)
2 GENERATOR (CHARGE)
7 REGULATOR,VOLT (CHARGE)
11 GROUND
14 MAIN FEED
15 KEY SWITCH
16 IGNITION
17 STARTING CONTROL
19 FUEL SHUT-OFF
21 ETHER
23 MAGNETIC FAN
24 EXHAUST BRAKE
28 INSTRUMENT
29 ENG WATER TEMP
30 ENG OIL TEMP
31 TRANS OIL TEMP
35 ENG OIL PRESS
36 FUEL LEVEL
37 FUEL PUMP
43 P.D.L. WARNING
44 BRAKE SYSTEM WARNING
48 TACHOMETER
50 LIGHT SWITCH
51 DIMMER SWITCH
52 HEADLIGHT - HI BEAM
53 HEADLIGHT - LOW BEAM
55 DIR. SIGNAL SWITCH
56 DIR. SIGNAL LIGHTS - LEFT
57 DIR. SIGNAL LIGHTS - RIGHT
58 CLEAR, IDENT, & MARKER LIGHTS
60 HAZARD SWITCH
62 PANEL LIGHTS
63 DOME &/OR COURTESY LIGHTS
68 TAIL LIGHT
70 STOP LIGHT
71 BACK-UP LIGHT
72 TRAILER
75 HEATER
77 AIR CONDITIONER
80 ACCESSORY FEED
82 WINDSHIELD WIPER
84 CIGAR LIGHTER
85 HORN
86 RADIO
87 WINDSHIELD WASHER
90 HY-POWER BRAKES
93 AXLE SHIFT
94 WHEELLOCK (ANTI SKID BRAKES)
95 EXHAUST EMISSION

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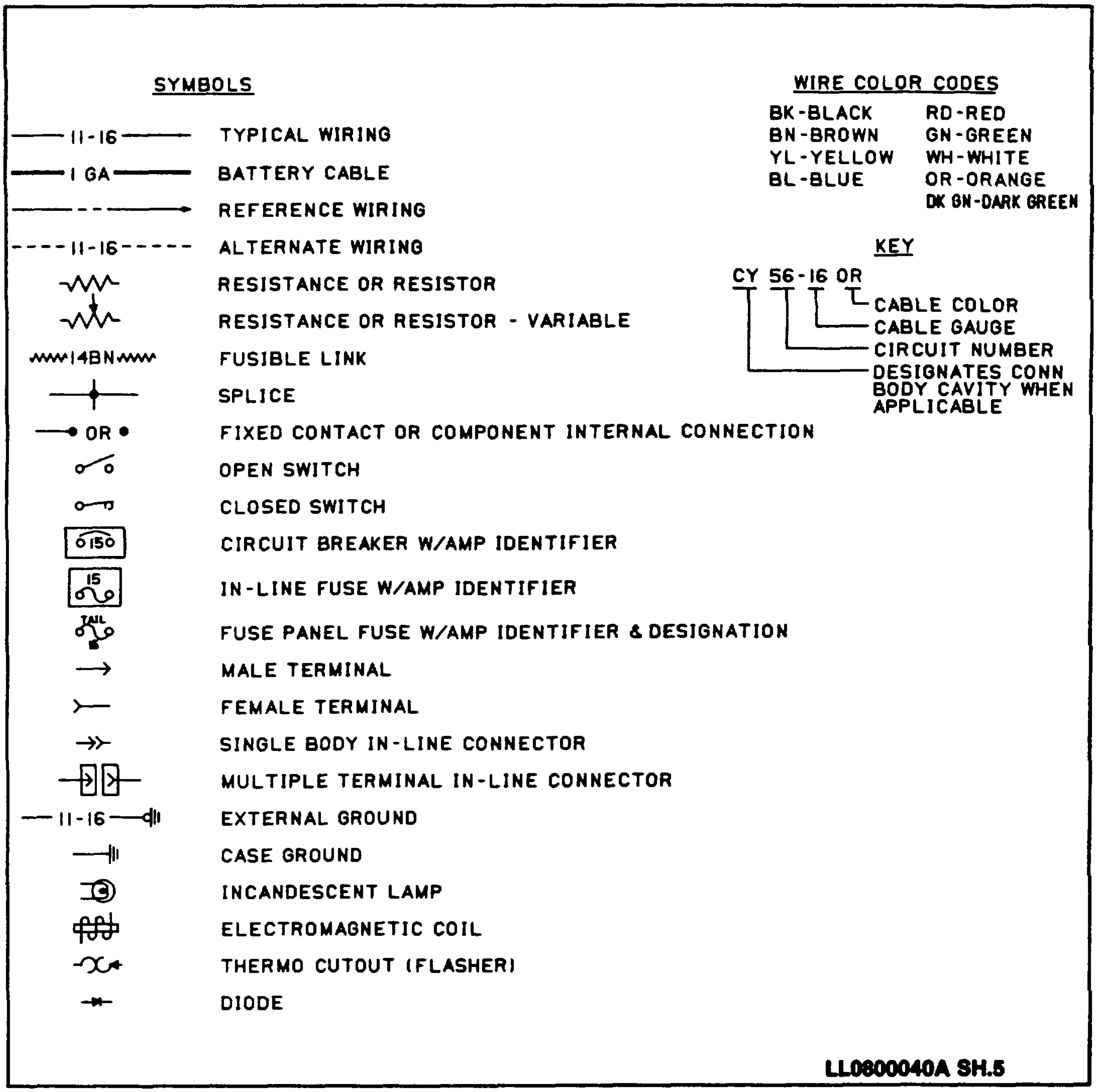

SYMBOLS
11-16
TYPICAL WIRING
1 GA
BATTERY CABLE
REFERENCE WIRING
11-16
ALTERNATE WIRING
RESISTANCE OR RESISTOR
RESISTANCE OR RESISTOR - VARIABLE
14BN
FUSIBLE LINK
SPLICE
OR
FIXED CONTACT OR COMPONENT INTERNAL CONNECTION
OPEN SWITCH
CLOSED SWITCH
150
CIRCUIT BREAKER W/AMP IDENTIFIER
15
IN-LINE FUSE W/AMP IDENTIFIER
TAIL
FUSE PANEL FUSE W/AMP IDENTIFIER & DESIGNATION
MALE TERMINAL
FEMALE TERMINAL
SINGLE BODY IN-LINE CONNECTOR
MULTIPLE TERMINAL IN-LINE CONNECTOR
11-16
EXTERNAL GROUND
CASE GROUND
INCANDESCENT LAMP
ELECTROMAGNETIC COIL
THERMO CUTOUT (FLASHER)
DIODE
WIRE COLOR CODES
BK-BLACK
BN-BROWN
YL-YELLOW
BL-BLUE
RD-RED
GN-GREEN
WH-WHITE
OR-ORANGE
DK GN-DARK GREEN
KEY
CY 56-16 OR
CABLE COLOR
CABLE GAUGE
CIRCUIT NUMBER
DESIGNATES CONN BODY CAVITY WHEN APPLICABLE
LL0800040A SH.5

FUSE CHART

DESCRIPTION	SIZE	TYPE	LOCATION
HAZARD LIGHTS TURN LIGHTS CIGAR LIGHTER	20A	FUSE	TURN/HAZARD
HORN DOME	15A	FUSE *	HORN/DOME
STOP LIGHTS TRAILER MARKER FLOOD LIGHTS	30A	FUSE *	STOP/TRL MKR
TAIL LIGHTS CL/ID LIGHTS PARK & MKR LIGHTS MIRROR LIGHTS	20A	FUSE *	TAIL/CAB MKR
TRL MKR LT REL	20A	FUSE *	MARKER
INSTR PANEL LIGHTS CLUSTER PANEL ASHTRAY LIGHTS HTR & A/C COND ILLUM XMSN & ENG OIL TEMP GAUGE ILLUM	4A	FUSE *	PANEL
RADIO	4A	FUSE *	RADIO
HEATER ONLY OR HTR & A/C - EXCEPT HIGH POSITION	20A	FUSE *	HEATER & A/C
2-SPD AXLE ELECT PDL	20A	FUSE *	2-SPD
SUBMERGED FUEL PUMP FRONT AXLE WARN LT	4A	FUSE *	FUEL PUMP
BACK-UP LIGHTS FUEL TANK SEL VALVE ANTI-LOCK SYSTEMS	15A	FUSE *	B/U - ANTILOCK

FUSE IDENT SHOWN AS ON FUSE BLOCK
FUSE BLOCK MTG ON INSIDE CAB - UPPER LEFT SIDE OF DASH - LH DR
FUSE BLOCK MTG ON INSIDE CAB - UPPER RIGHT SIDE OF DASH - RH DR

DESCRIPTION	SIZE	TYPE	LOCATION
GLOW PLUG SYSTEM 6.9L ENGINE	7.5A	IN-LINE FUSE	ENGINE COMPARTMENT AT BULKHEAD CONNECTOR
FUEL SHUT-OFF DT466 ENGINE	15A	IN-LINE FUSE	ENGINE COMPARTMENT AT BULKHEAD CONNECTOR
TRAILER AUX	--	-----	
TRAILER MARKER	15A	FUSE *	FUSE BLOCK
TRAILER STOP	20A	FUSE *	AT REAR
TRAILER TAIL	15A	FUSE *	CAB
TRAILER RT TURN	10A	FUSE *	JUNCTION BLOCKS
TRAILER L TURN	10A	FUSE *	
HOURMETER INSTR CLUST GAUGES & CLUST WARN LTS	5A	IN-LINE FUSE	FUSE BLOCK
ETHER START	15A	IN-LINE FUSE	LWR L EDGE INST PNL
KYSOR ENG SHUT-ON 2 FUSES	10A 6A	IN-LINE FUSE IN-LINE FUSE	ABOVE KYSOR SW, LWR FRT L SIDE OF CAB
EXHAUST BRAKE	10A	IN-LINE FUSE	FUSE BLOCK
ENG STOP CAT-3406	30A	IN-LINE FUSE	FUSE BLOCK
HY-POWER BRAKES	5A	IN-LINE FUSE	FUSE BLOCK

CIRCUIT BREAKER & FUSIBLE LINK CHART

DESCRIPTION	SIZE	TYPE	LOCATION
HTR & A/C HIGH POSITION	30A	CIR BRKR	FUSE BLOCK (HEATER & A/C)
HEADLIGHTS	15A	CIR BRKR	INSIDE LIGHT SW
WSHLD WIPER & WASH	8A	CIR BRKR	REAR OF WIPER SW
HI-POWER BRK PUMP	50A	CIR BRKR	RELAY MTG BRKT
LIGHT SW FEED (HEADLIGHT)	100A	DK GN FUS LINK	DASH FEED STUD IN CAB
LIGHT SW FEED (TAIL,CLEARANCE AND IDENT)	100A	DK GN FUS LINK	DASH FEED STUD IN CAB

NOTE: * CIRCUIT BREAKER OPTIONAL

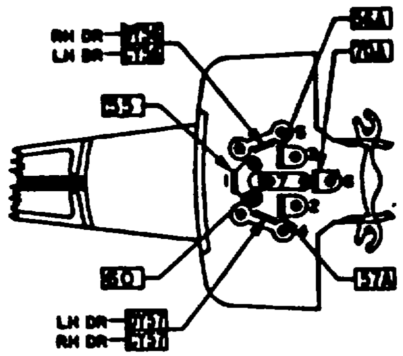
LL0800040A SH.4A REV. D

BULB CHART

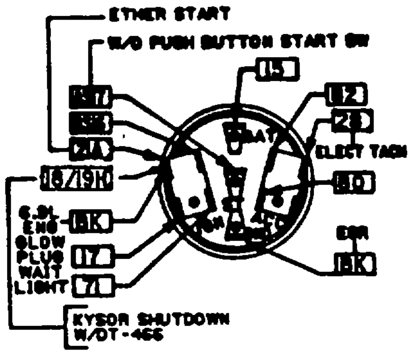
BULB APPLICATION	WATTS OR CANDLE POWER	TRADE NO.
HEADLIGHT:		7002 RH DR 6014 LH DR
UPPER BEAM	60 WATTS	
LOWER BEAM	45 WATTS RH DR 50 WATTS LH DR	
FRONT TURN	32	1156
SIDE MARKER	2	1895
PARK	3	181
STOP-TURN/TAIL-LICENSE	32/3	1157
BACK-UP	.32	1156
IDENTIFICATION-CLEARANCE	3	168
FLOOD LIGHT	12	561
MIRROR LIGHT	2	1895
INSTRUMENT CLUSTER:		
ILLUMINATION	3	168
INDICATOR	2	194
WARNING	2	194
INFORMATION	2	194
CONTROL IDENTIFICATION OR WARNING LIGHT:		
ENGINE STOP	0 50	**
FRONT AXLE	0.50	**
GAUGE ILLUMINATION:		
ENGINE OIL TEMPERATURE	1	53
XMSN OIL TEMPERATURE	1	53
INSTRUMENT PANEL CONTROLS	0.50	**
ASH TRAY	0.50	**
DOME	12	211-2
RADIO	0.75	1892
HEATER & A/C CONTROLS	3	168
AUTOMATIC XMSN CONTROLS	1	53
GLOW PLUG WAIT LIGHT	2	57

**-PURCHASED LIGHT ASSEMBLY
(REF G.E. BULB NO.2162D)

LL0800040A SH.4 REV. B

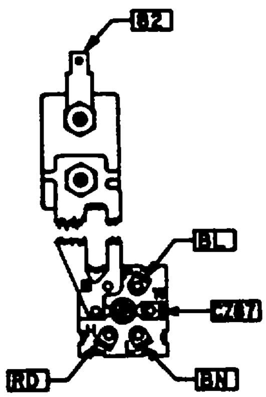


TURN SIGNAL SWITCH
LOCATION - S
VIEWED FROM TERMINAL SIDE

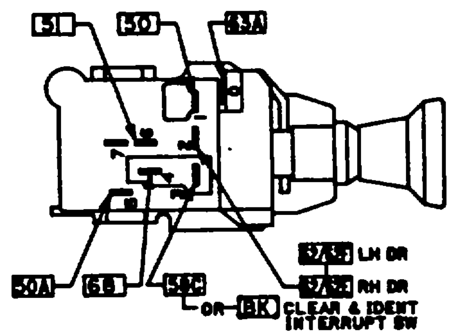


KEY SWITCH
LOCATION - R
VIEWED FROM TERMINAL SIDE

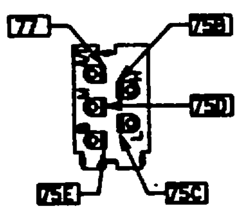
SWITCH	POSITION	CONTACTS CLOSED	CONTACTS OPEN
TURN SIGNAL & HAZARD	OFF (NORMAL)	2,3 & 6	1,4,5 & 7
	LEFT TURN & LANE CHANGE	1,3 & 5 / 2 & 6	4 & 7
	RIGHT TURN & LANE CHANGE	1,2 & 4 / 3 & 6	5 & 7
	HAZARD	2,3,4,5 & 7	1 & 6
HEAD LIGHT	OFF-(KNOB IN & TURNED C.W.)	2,3 & 4	0,1,5,6 & 7
	PARK LIGHTS (KNOB IN 1ST POS)	1 & 7 / 2,3,4 & 5	0 & 6
	HEADLIGHTS (KNOB IN 2ND POS)	1 & 6 / 2,3,4 & 5	0 & 7
	DOME-(KNOB IN & TURN C.C.W.)	0 TO GND / 3,4 & 2	1,5,6 & 7
	PANEL-(2ND POS TURN C.C.W. TO LOCK)	0 TO GND / 1 & 6 / 2,3,4 & 5	7
KEY	OFF	NONE	ALL
	START	BAT-ST-IGN / GND-CASE	ACC
	IGNITION	BAT-IGN-ACC	ST-GND
	ACCESSORY	BAT-ACC	ST-IGN-GND
HEATER & A/C	OFF	NONE	ALL
	LOW	BAT-L-A/C	M-H
	MED	BAT-M-A/C	L-H
	HIGH	BAT-H-A/C	L-M
WIPER/ WASHER	PARK	BAT-P	W-L-H
	LOW	BAT-L	W-P-H
	HIGH	BAT-H	W-P-L
	WASHER (KNOB IN)	BAT-W	L-M-H
SHUT-DOWN TEMP	NORMAL (BELOW 204°)	C-NC	C-NO
	ALARM (204°-210°)	C-NC C-NO	NONE
	SHUT-DOWN (ABOVE 210°)	C-NO	C-NC
SHUT-DOWN PRESS	ENG OFF	C-NC	C-NO
	NORMAL	C-NO	C-NC
	ALARM (7 OR 11 PSI)	C-NO C-NC	NONE
	SHUT-DOWN (3 OR 6 PSI)	C-NC	C-NO



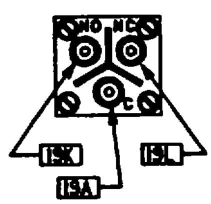
WIPER/WASHER SWITCH
LOCATION - X
VIEWED FROM TERMINAL SIDE



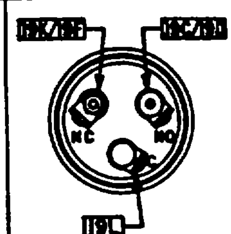
LIGHT SWITCH
LOCATION - Y
VIEWED FROM TERMINAL SIDE



HEATER/A-C SWITCH
LOCATION-AE
VIEWED FROM TERMINAL SIDE

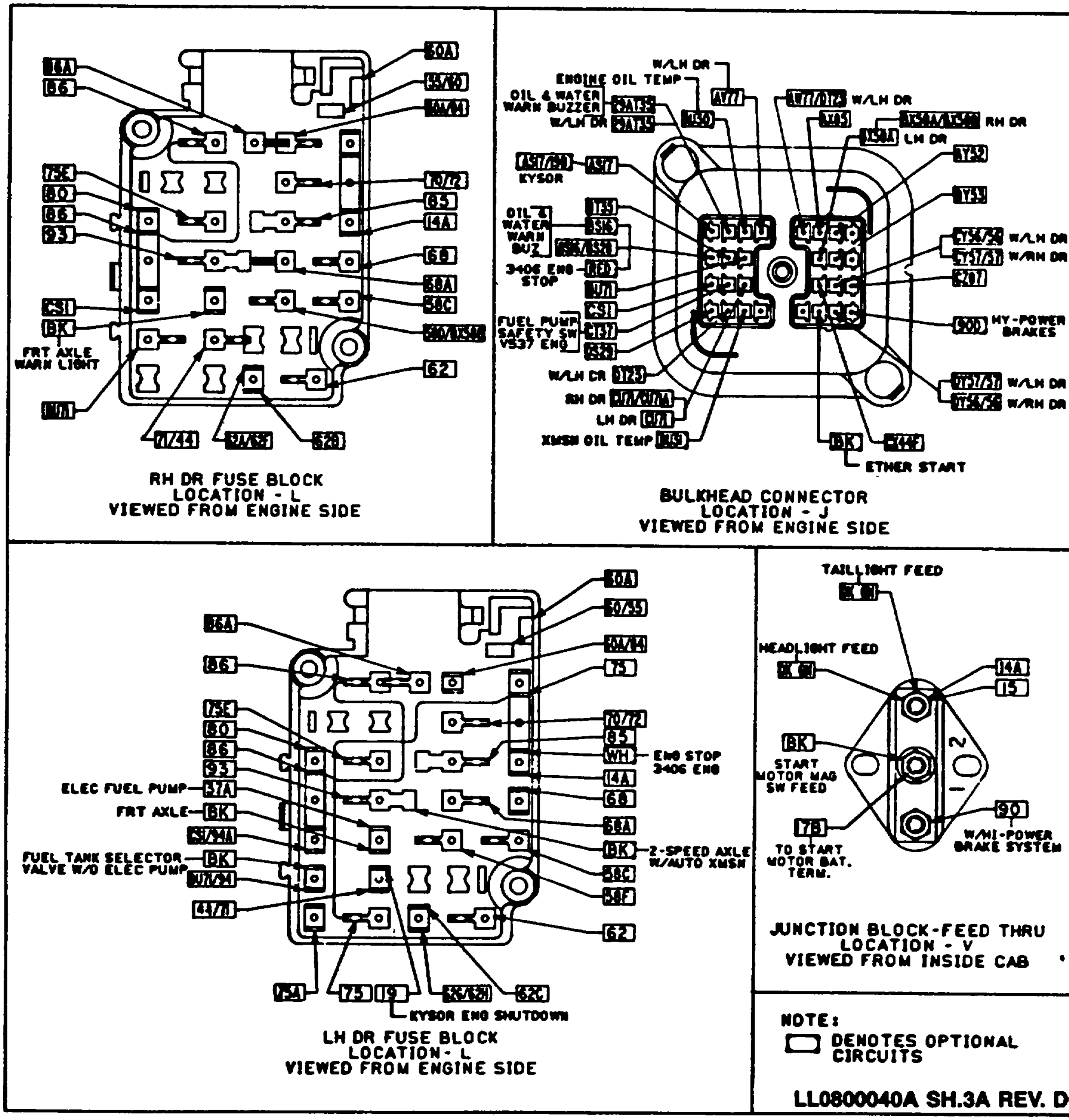


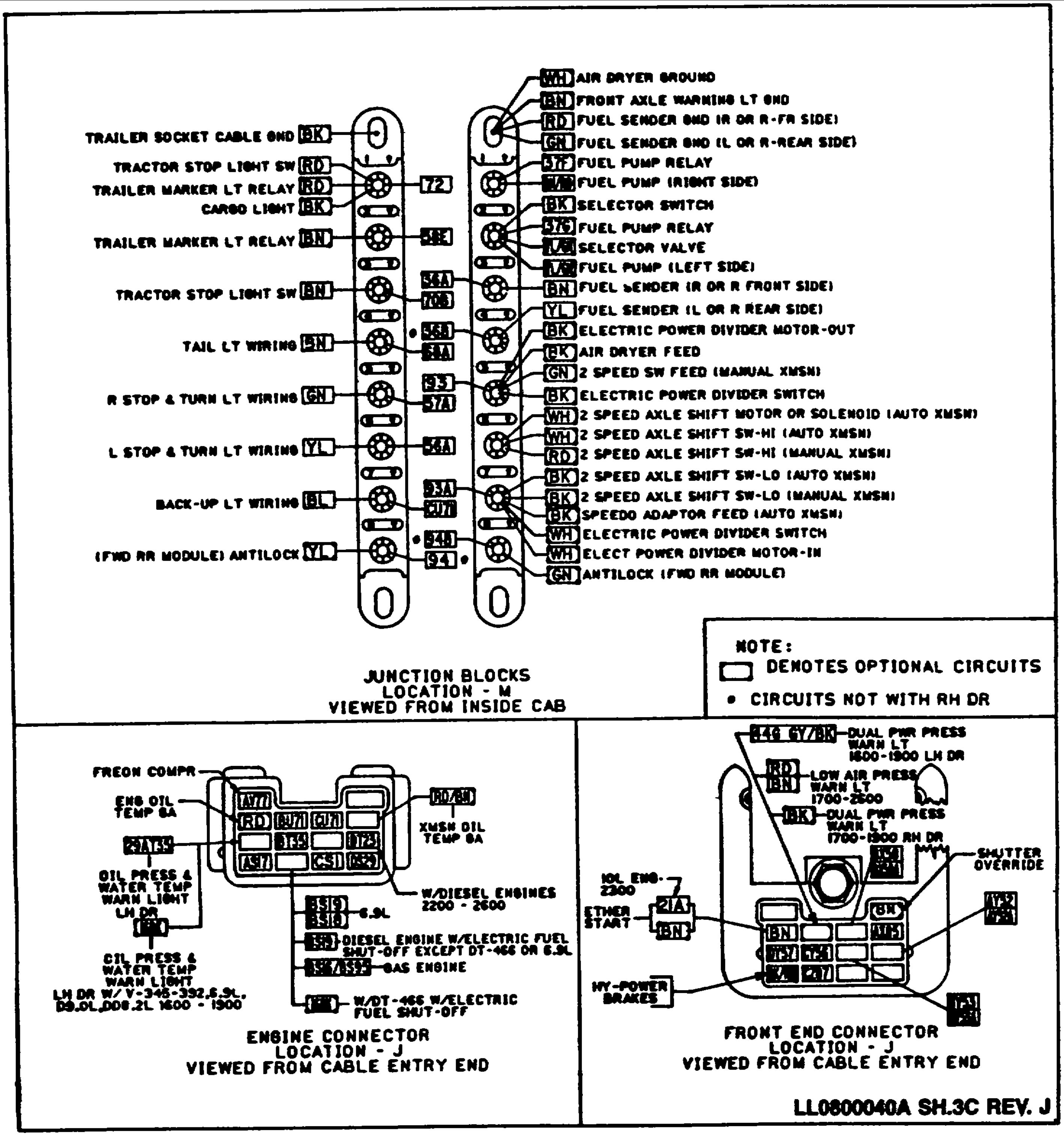
SHUT-DOWN
TEMP SW

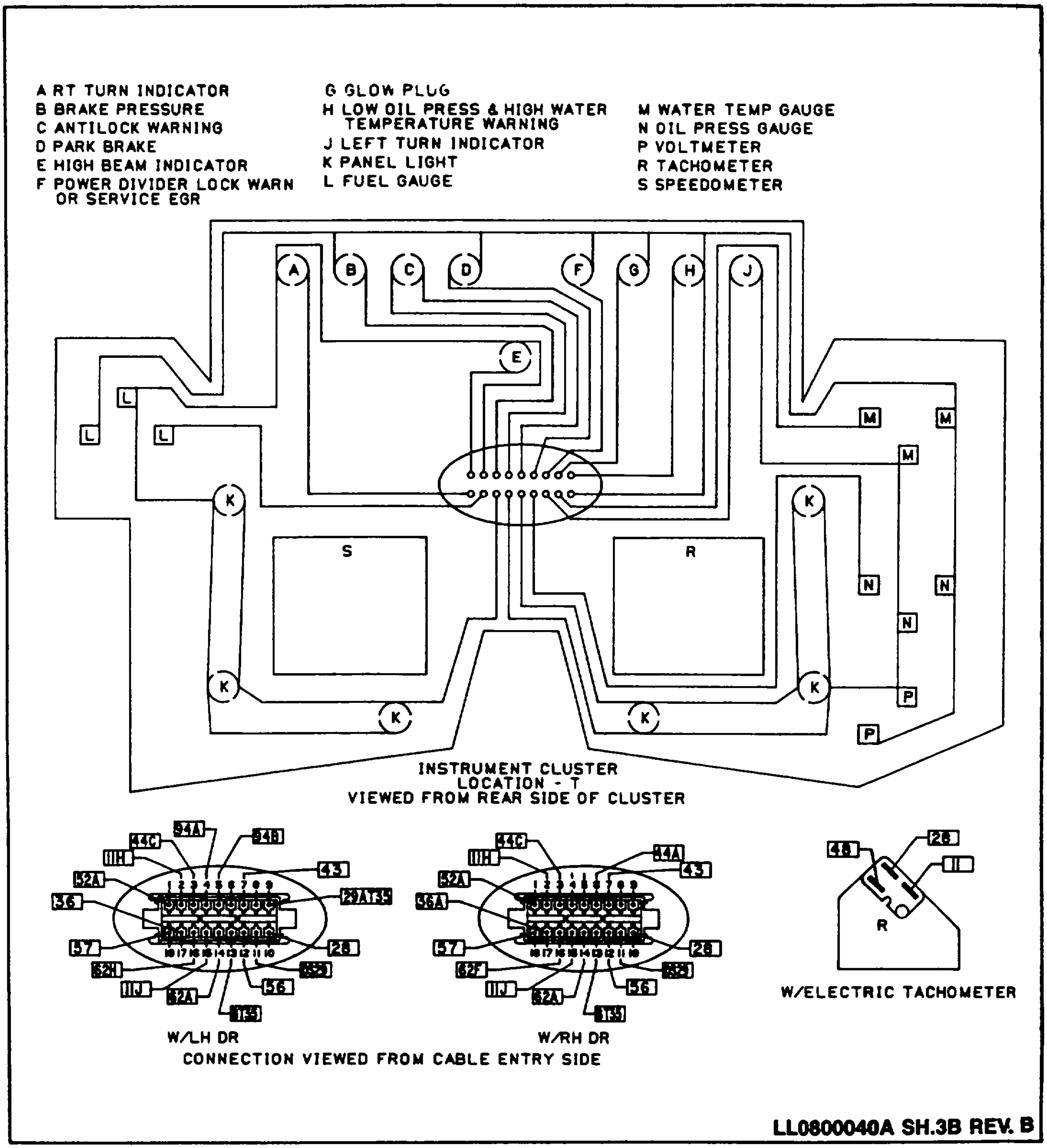


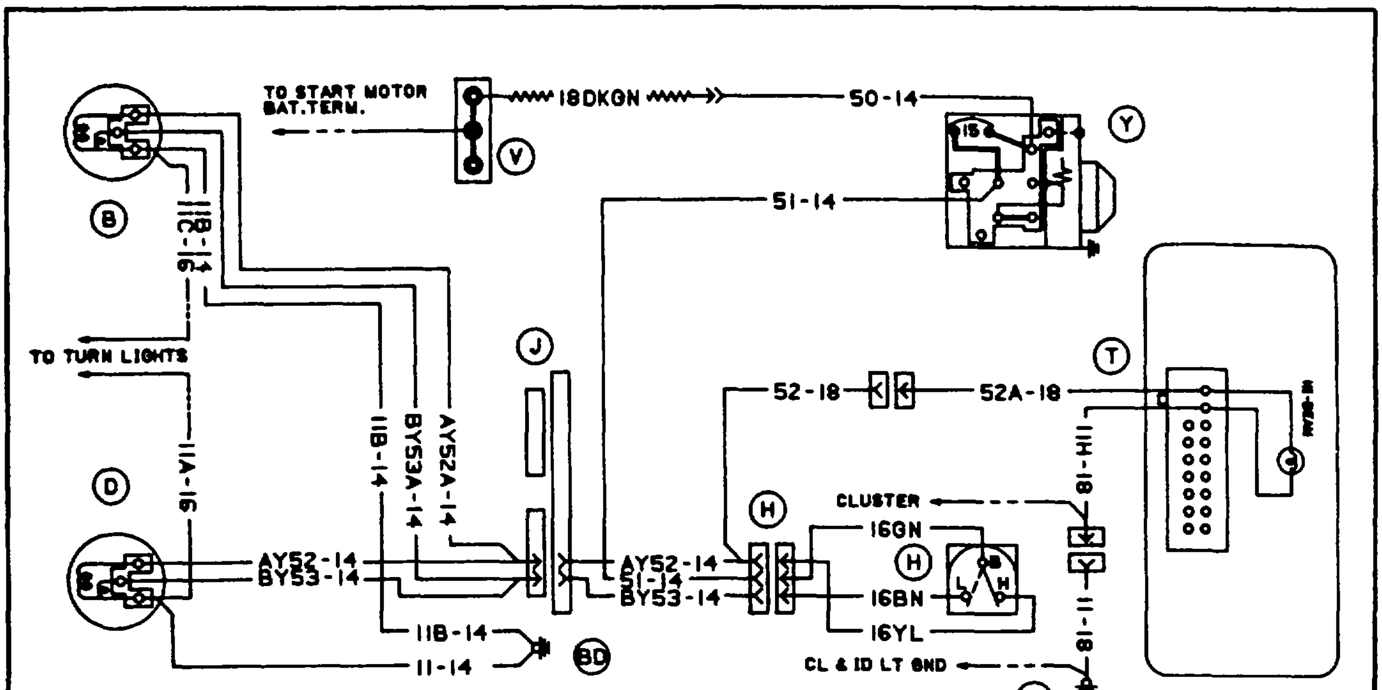
SHUT-DOWN
PRESS SW

LL0800040A SH.3 REV. D


RH DR FUSE BLOCK
LOCATION - L
VIEWED FROM ENGINE SIDE
FRT AXLE WARN LIGHT
W/LH DR
ENGINE OIL TEMP
OIL & WATER WARN BUZZER
KYSOR
3406 ENG STOP
FUEL PUMP SAFETY SW V537 ENG
RH DR
LH DR
XMSN OIL TEMP
HY-POWER BRAKES
W/RH DR
ETHER START
BULKHEAD CONNECTOR
LOCATION - J
VIEWED FROM ENGINE SIDE
ELEC FUEL PUMP
FRT AXLE
FUEL TANK SELECTOR VALVE W/O ELEC PUMP
ENG STOP 3406 ENG
2-SPEED AXLE W/AUTO XMSN
KYSOR ENG SHUTDOWN
LH DR FUSE BLOCK
LOCATION - L
VIEWED FROM ENGINE SIDE
TAILLIGHT FEED
HEADLIGHT FEED
START MOTOR MAG SW FEED
TO START MOTOR BAT. TERM.
W/HI-POWER BRAKE SYSTEM
JUNCTION BLOCK-FEED THRU
LOCATION - V
VIEWED FROM INSIDE CAB
NOTE:
DENOTES OPTIONAL CIRCUITS
LL0800040A SH.3A REV. D

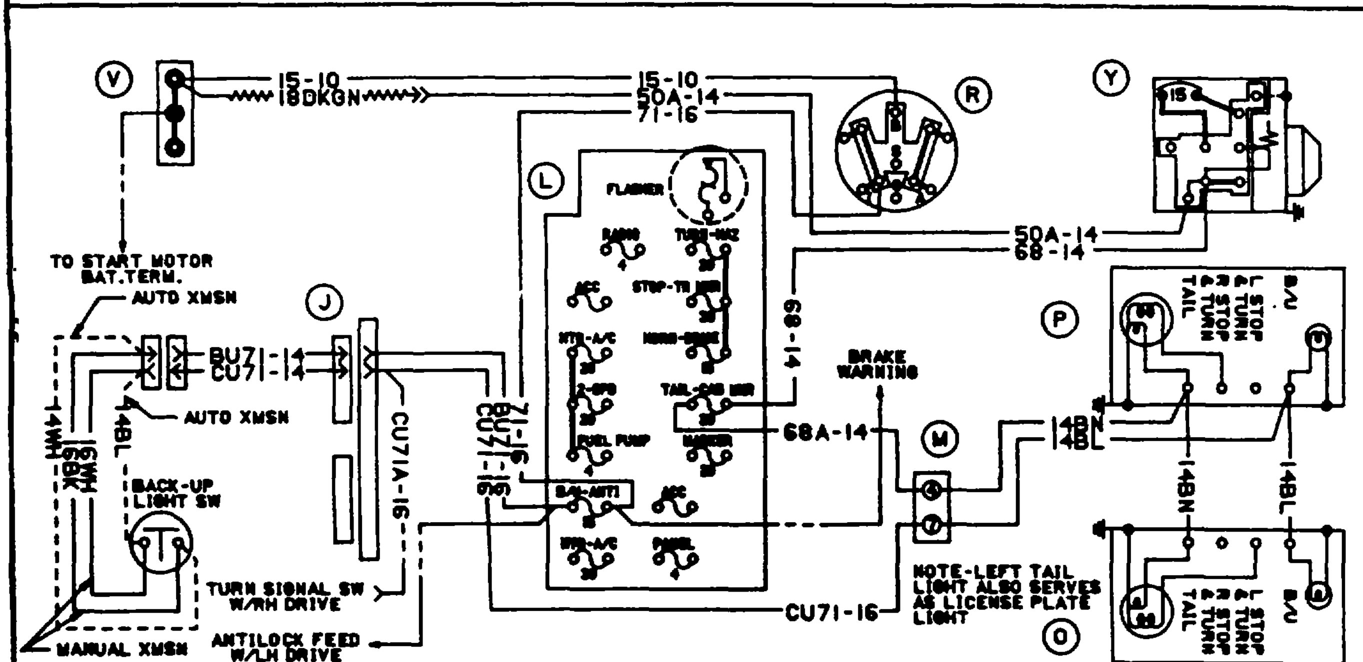

TRAILER SOCKET CABLE GND BK
TRACTOR STOP LIGHT SW RD
TRAILER MARKER LT RELAY RD
CARGO LIGHT BK
TRAILER MARKER LT RELAY BN
TRACTOR STOP LIGHT SW BN
TAIL LT WIRING BN
R STOP & TURN LT WIRING GN
L STOP & TURN LT WIRING YL
BACK-UP LT WIRING BL
(FWD RR MODULE) ANTILOCK YL
72
58E
56A
70B
56B
58A
93
57A
56A
93A
CU7
94B
94
WH AIR DRYER GROUND
BN FRONT AXLE WARNING LT GND
RD FUEL SENDER GND (R OR R-FR SIDE)
GN FUEL SENDER GND (L OR R-REAR SIDE)
57F FUEL PUMP RELAY
FUEL PUMP (RIGHT SIDE)
BK SELECTOR SWITCH
57G FUEL PUMP RELAY
SELECTOR VALVE
FUEL PUMP (LEFT SIDE)
BN FUEL SENDER (R OR R FRONT SIDE)
YL FUEL SENDER (L OR R REAR SIDE)
BK ELECTRIC POWER DIVIDER MOTOR-OUT
BK AIR DRYER FEED
GN 2 SPEED SW FEED (MANUAL XMSN)
BK ELECTRIC POWER DIVIDER SWITCH
WH 2 SPEED AXLE SHIFT MOTOR OR SOLENOID (AUTO XMSN)
WH 2 SPEED AXLE SHIFT SW-HI (AUTO XMSN)
RD 2 SPEED AXLE SHIFT SW-HI (MANUAL XMSN)
BK 2 SPEED AXLE SHIFT SW-LO (AUTO XMSN)
BK 2 SPEED AXLE SHIFT SW-LO (MANUAL XMSN)
BK SPEEDO ADAPTOR FEED (AUTO XMSN)
WH ELECTRIC POWER DIVIDER SWITCH
WH ELECT POWER DIVIDER MOTOR-IN
GN ANTILOCK (FWD RR MODULE)
JUNCTION BLOCKS
LOCATION - M
VIEWED FROM INSIDE CAB
NOTE:
DENOTES OPTIONAL CIRCUITS
• CIRCUITS NOT WITH RH DR
FREON COMPR
ENG OIL TEMP GA
29A T35
OIL PRESS & WATER TEMP WARN LIGHT LH DR
OIL PRESS & WATER TEMP WARN LIGHT LH DR W/ V-345-392,6.9L, D9.0L,DD8.2L 1600 - 1900
AV77
RD
BU71
CU71
BT55
D73
A97
CS1
RD/BN
XMSN OIL TEMP GA
W/DIESEL ENGINES 2200 - 2600
BS19
BS18
6.9L
DIESEL ENGINE W/ELECTRIC FUEL SHUT-OFF EXCEPT DT-466 OR 6.9L
BS97/BS95
GAS ENGINE
W/DT-466 W/ELECTRIC FUEL SHUT-OFF
ENGINE CONNECTOR
LOCATION - J
VIEWED FROM CABLE ENTRY END
44G GY/BK
DUAL PWR PRESS WARN LT 1600-1900 LH DR
RD
BN
LOW AIR PRESS WARN LT 1700-2600
BK
DUAL PWR PRESS WARN LT 1700-1900 RH DR
SHUTTER OVERRIDE
IDL ENG. 2300
ETHER START
21A
BN
BN
BN
HY-POWER BRAKES
FRONT END CONNECTOR
LOCATION - J
VIEWED FROM CABLE ENTRY END
LL0800040A SH.3C REV. J


A RT TURN INDICATOR
B BRAKE PRESSURE
C ANTILOCK WARNING
D PARK BRAKE
E HIGH BEAM INDICATOR
F POWER DIVIDER LOCK WARN OR SERVICE EGR
G GLOW PLUG
H LOW OIL PRESS & HIGH WATER TEMPERATURE WARNING
J LEFT TURN INDICATOR
K PANEL LIGHT
L FUEL GAUGE
M WATER TEMP GAUGE
N OIL PRESS GAUGE
P VOLTMETER
R TACHOMETER
S SPEEDOMETER
INSTRUMENT CLUSTER
LOCATION - T
VIEWED FROM REAR SIDE OF CLUSTER
W/LH DR
W/RH DR
CONNECTION VIEWED FROM CABLE ENTRY SIDE
W/ELECTRIC TACHOMETER
LL0800040A SH.3B REV. B



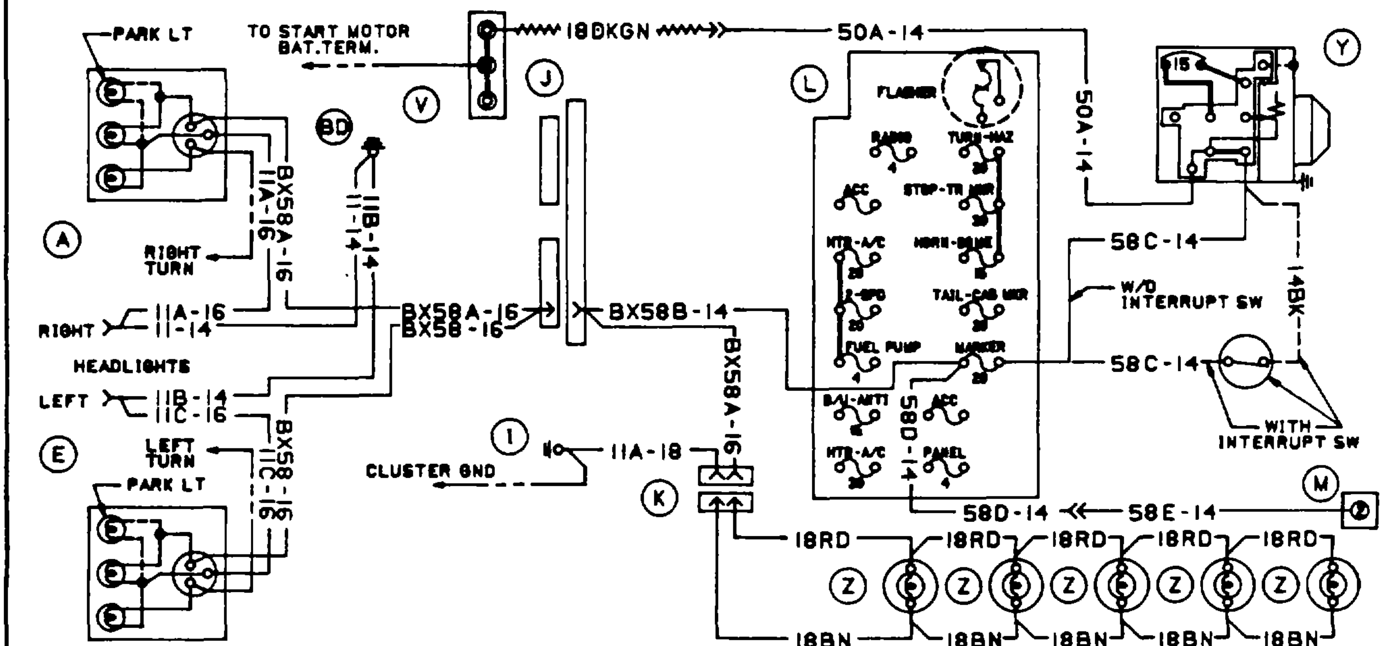
HEADLIGHT WIRING

LL0800040A SH.6 REV. B



TAIL,BACK-UP & LICENSE PLATE LIGHT WIRING

LL0800040A SH.6B REV. B



CLEARANCE-IDENTIFICATION-PARK & MARKER LT WIRING 1700-1900 RH DR

LL0800040A SH.6A REV. B

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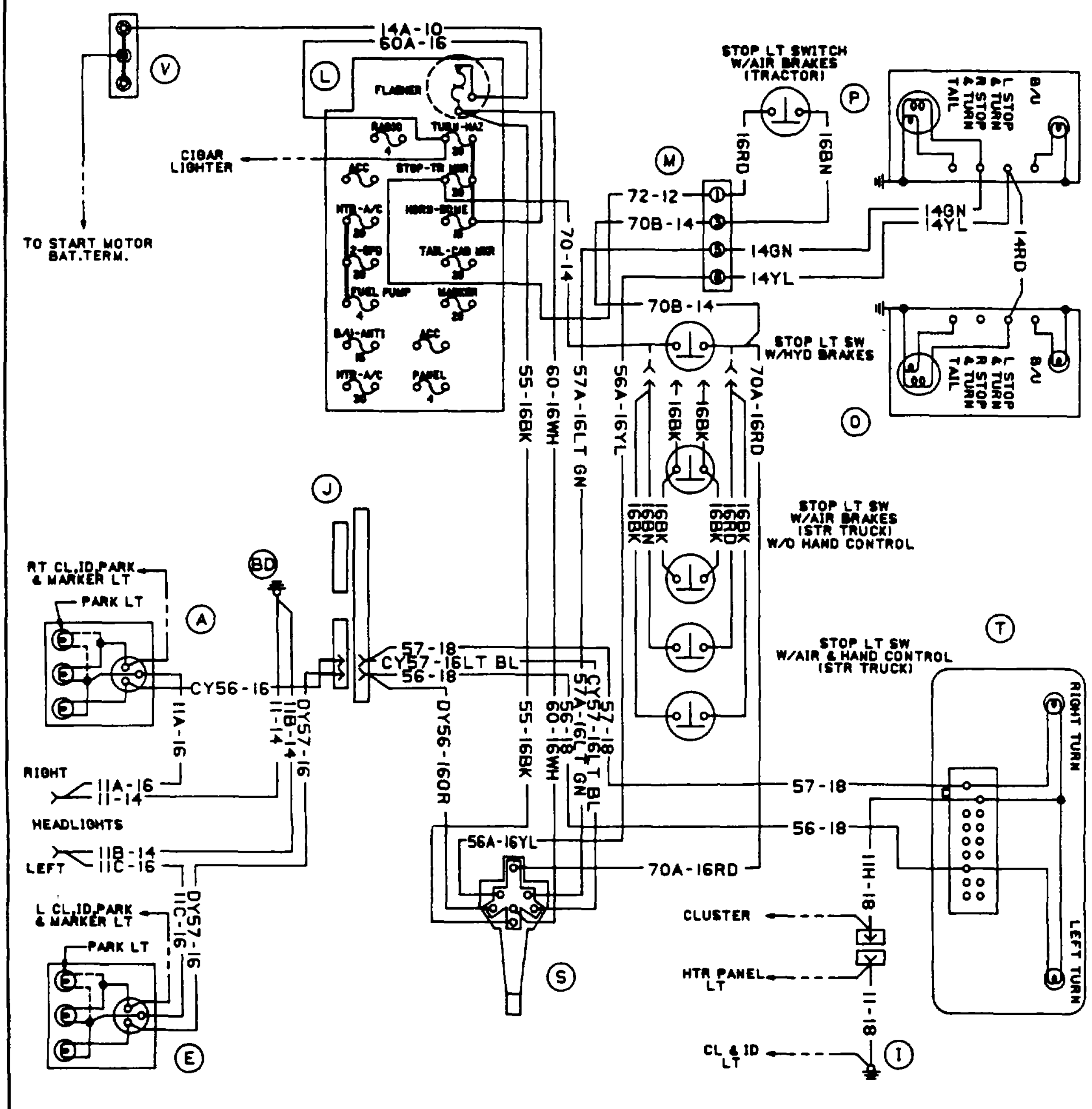

TURN HAZARD & STOP LIGHT WIRING 1700 THRU 1900

LL0800040A SH.7B REV. B

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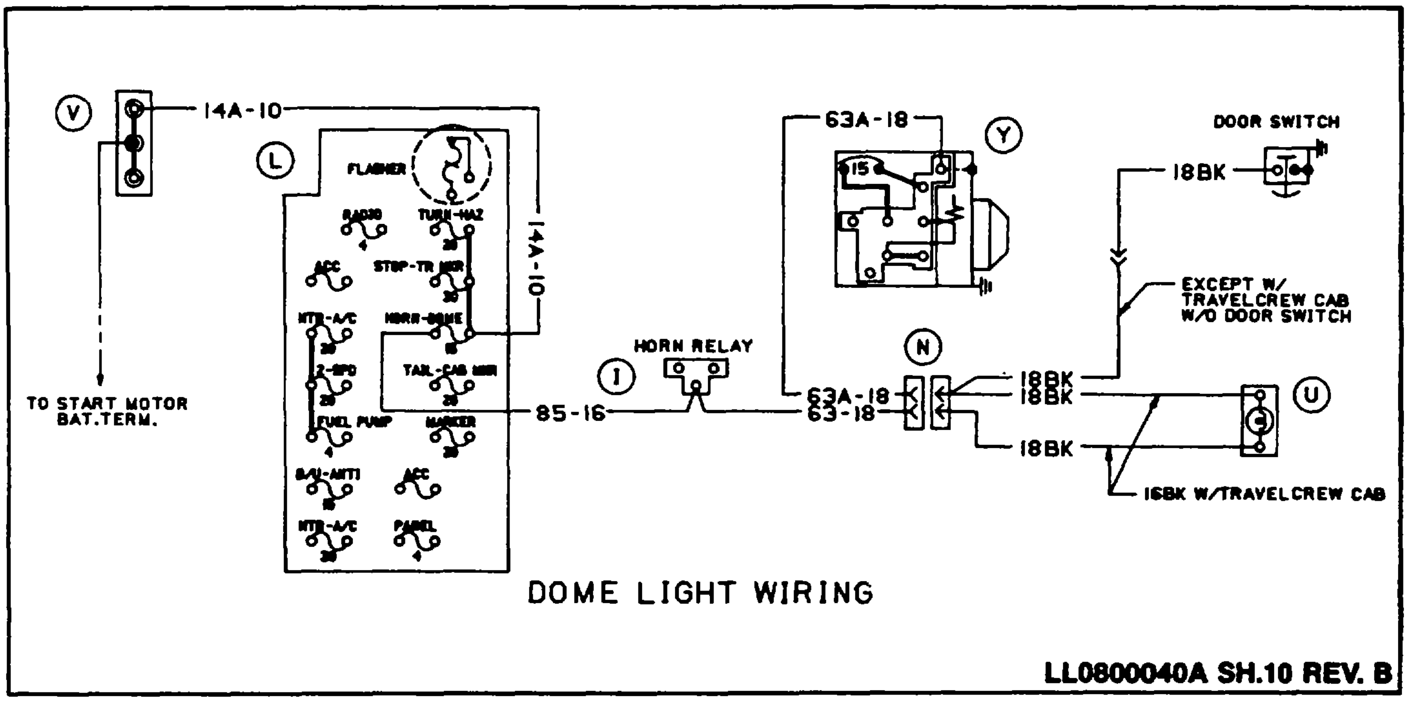
Pages 2549 and 2550 DELETED



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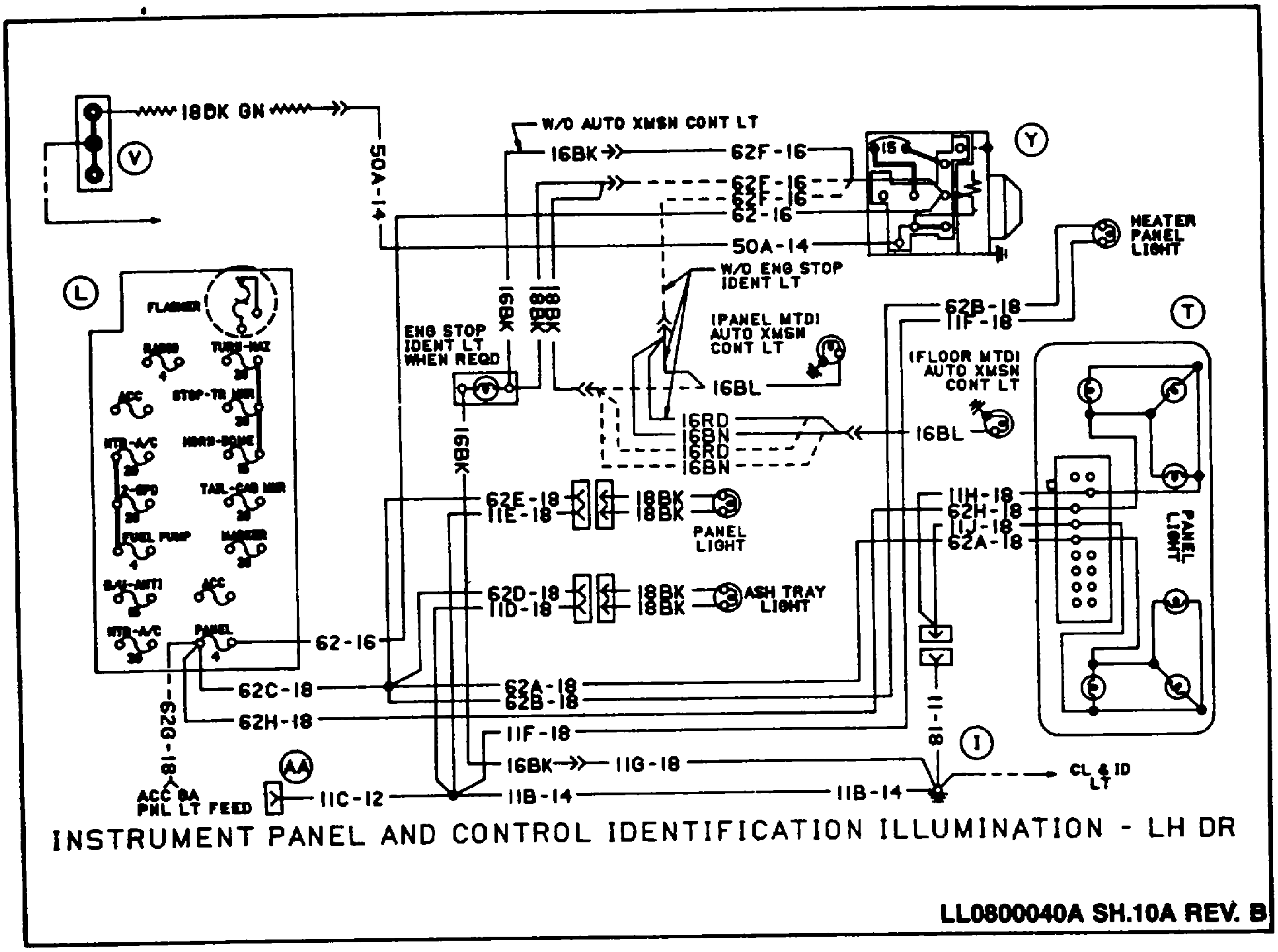
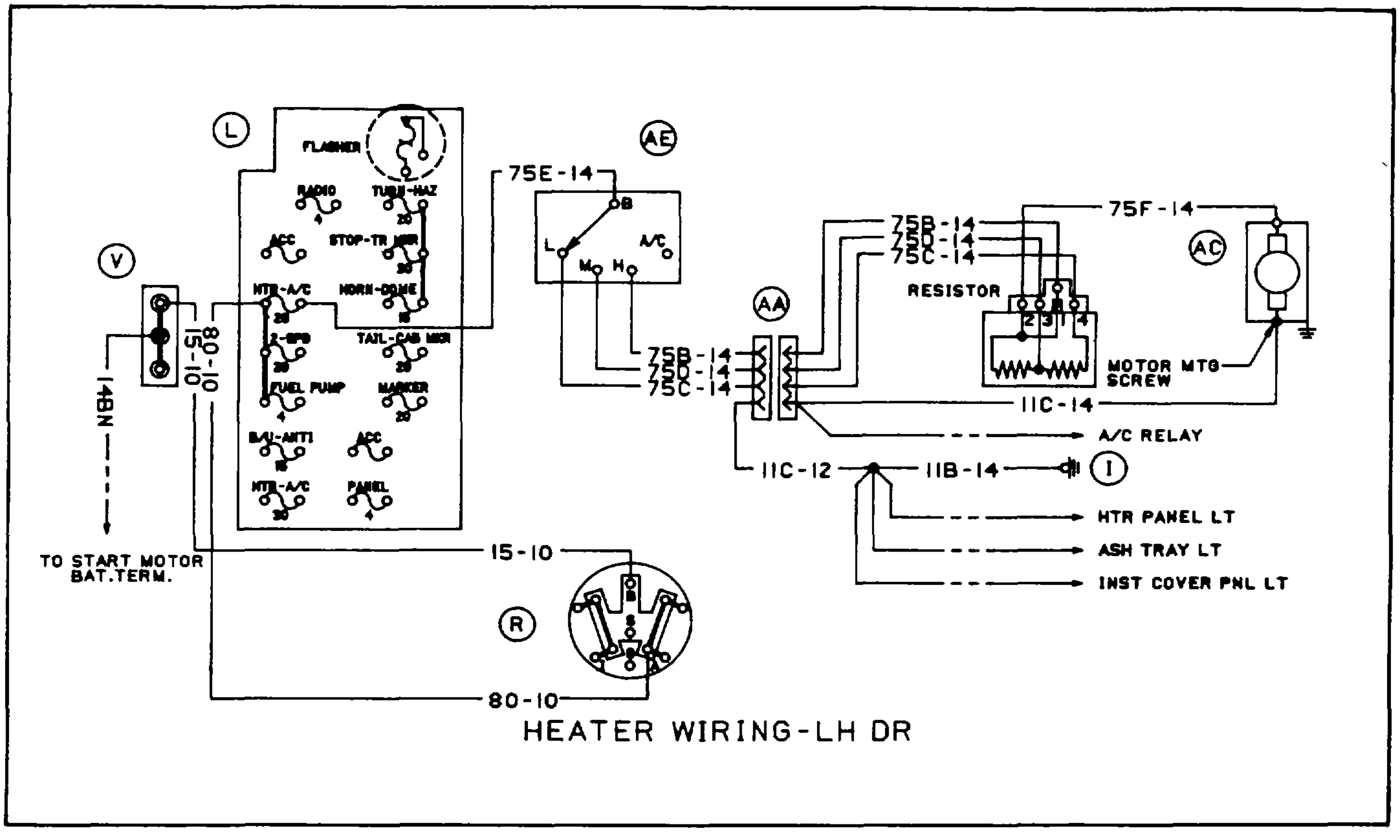
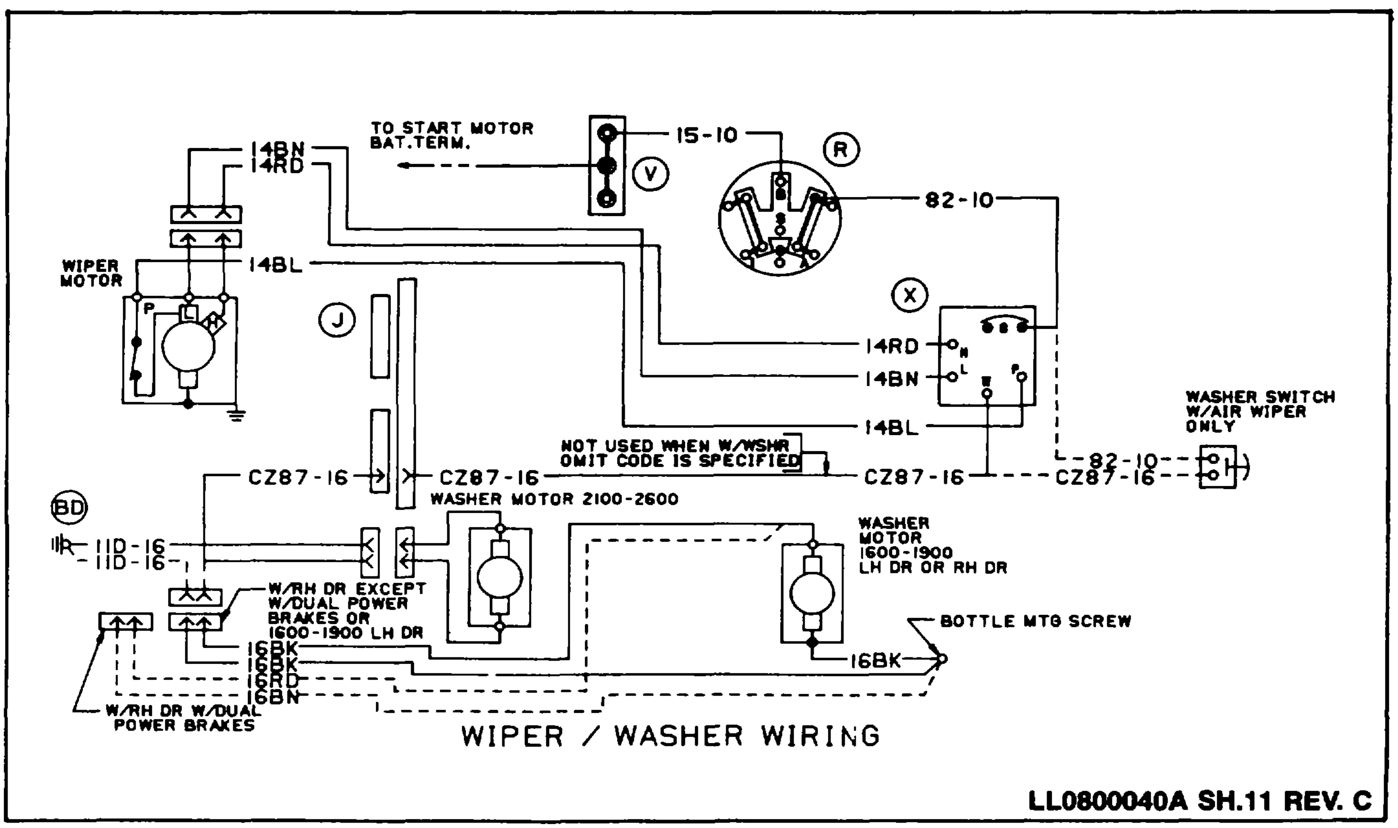

18DK GN
50A-14
W/O AUTO XMSN CONT LT
16BK
62F-16
62F-16
62F-16
62-16
50A-14
HEATER
PANEL
LIGHT
FLASHER
RADIO
TURN-HAZ
ACC
STOP-TR MIR
HTR-A/C
HORN-DOME
2-SPD
TAIL-CAB MIR
FUEL PUMP
MARKER
S/U-ANTI
ACC
HTR-A/C
PANEL
16BK
18BK
ENG STOP
IDENT LT
WHEN REQD
W/O ENG STOP
IDENT LT
(PANEL MTD)
AUTO XMSN
CONT LT
16BL
62B-18
11F-18
(FLOOR MTD)
AUTO XMSN
CONT LT
16RD
16BN
16RD
16BN
16BL
16BK
62E-18
11E-18
18BK
18BK
PANEL
LIGHT
11H-18
62H-18
11J-18
62A-18
PANEL
LIGHT
62D-18
11D-18
18BK
18BK
ASH TRAY
LIGHT
62-16
62C-18
62A-18
62B-18
62H-18
62G-18
11F-18
11-18
16BK
11G-18
ACC BA
PNL LT FEED
11C-12
11B-14
11B-14
CL & ID
LT
INSTRUMENT PANEL AND CONTROL IDENTIFICATION ILLUMINATION - LH DR
LL0800040A SH.10A REV. B





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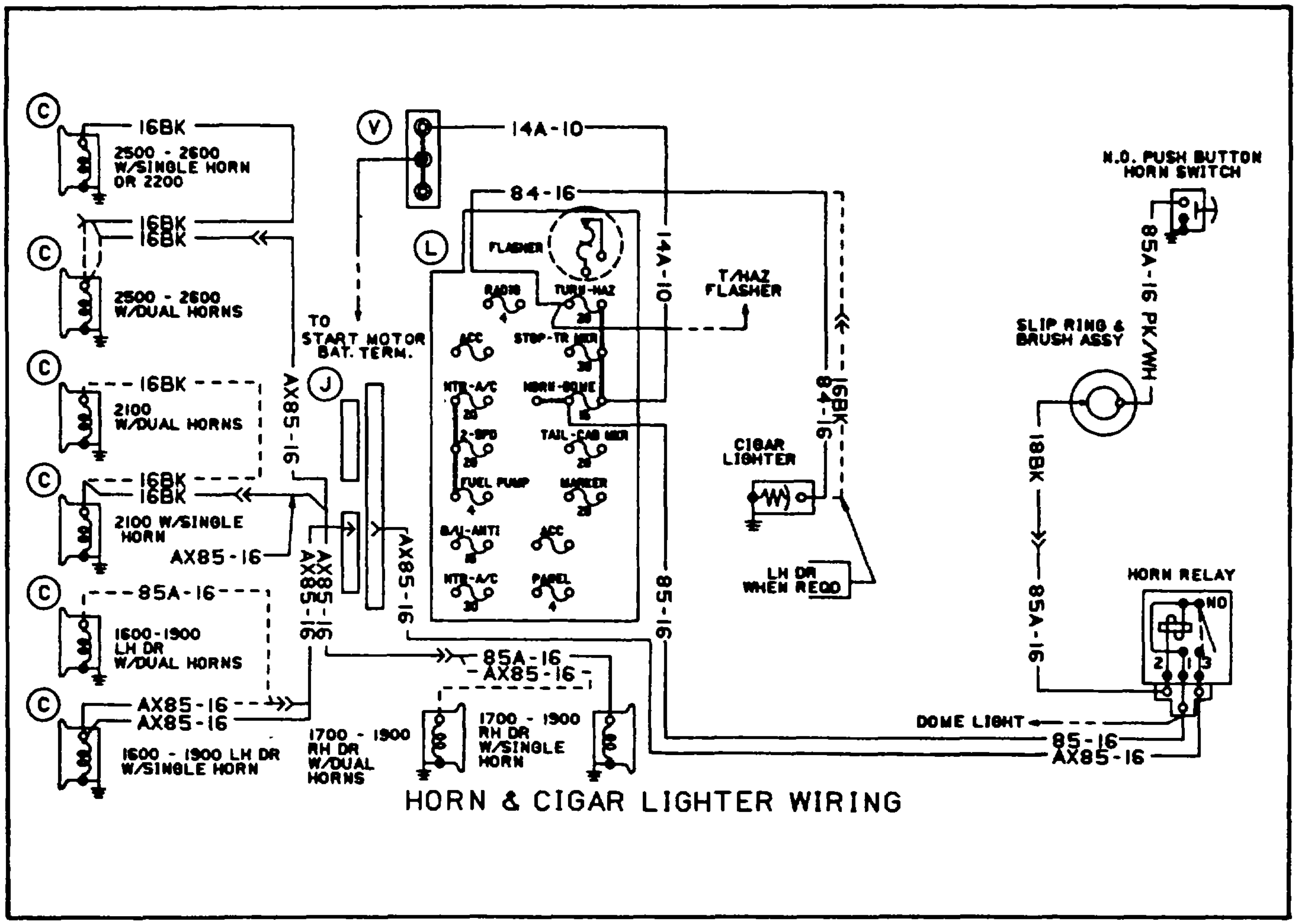

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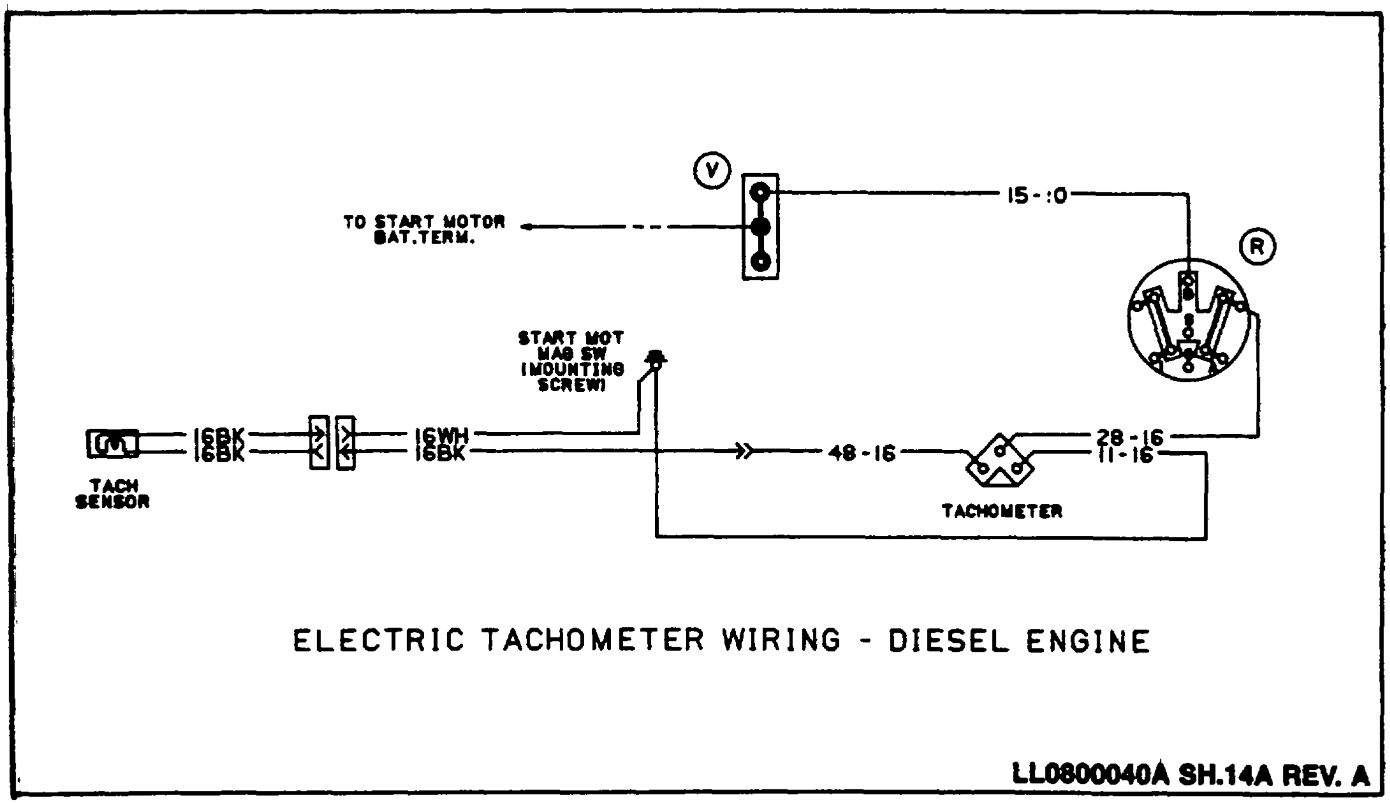
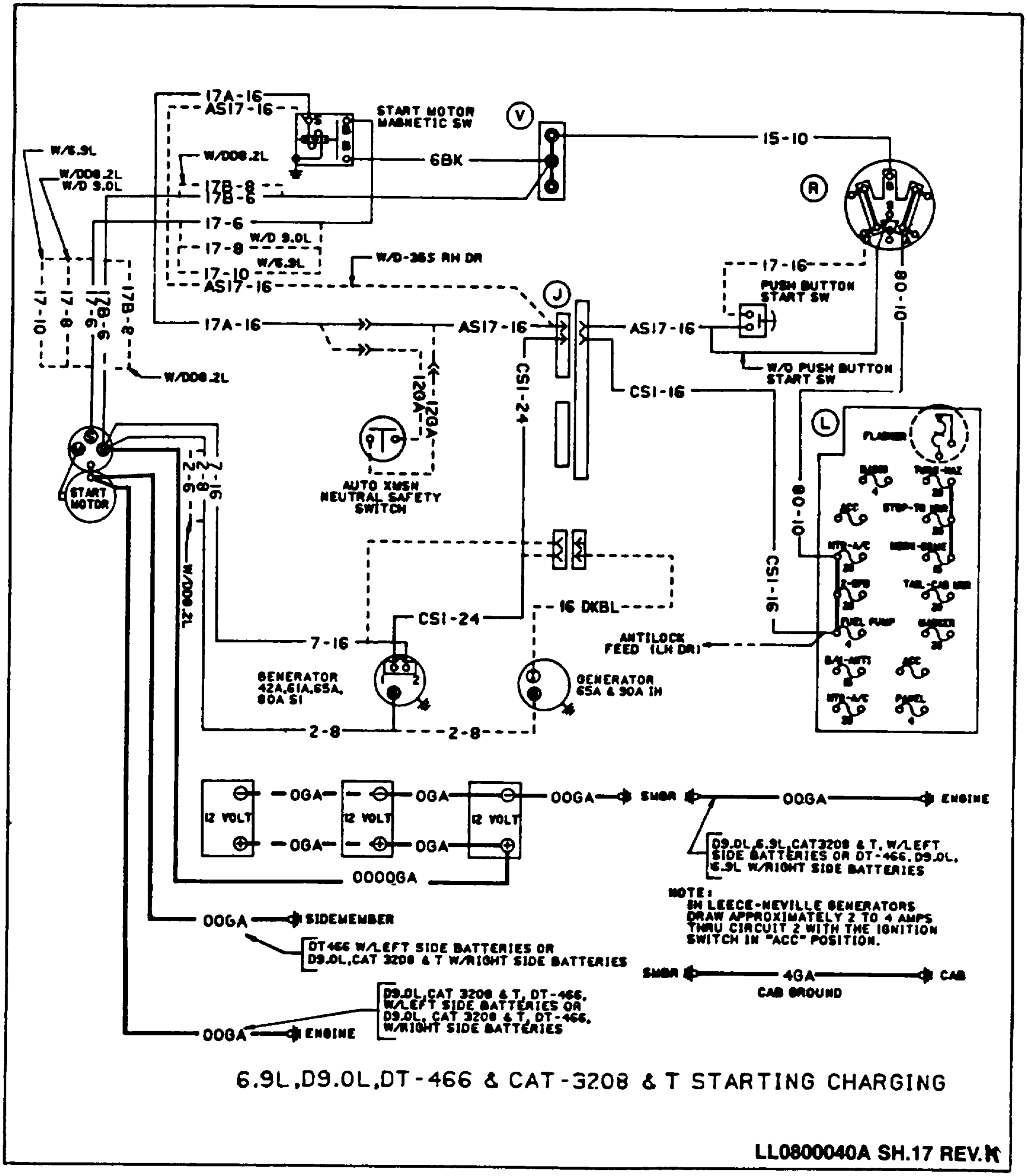


ELECTRIC TACHOMETER WIRING - DIESEL ENGINE



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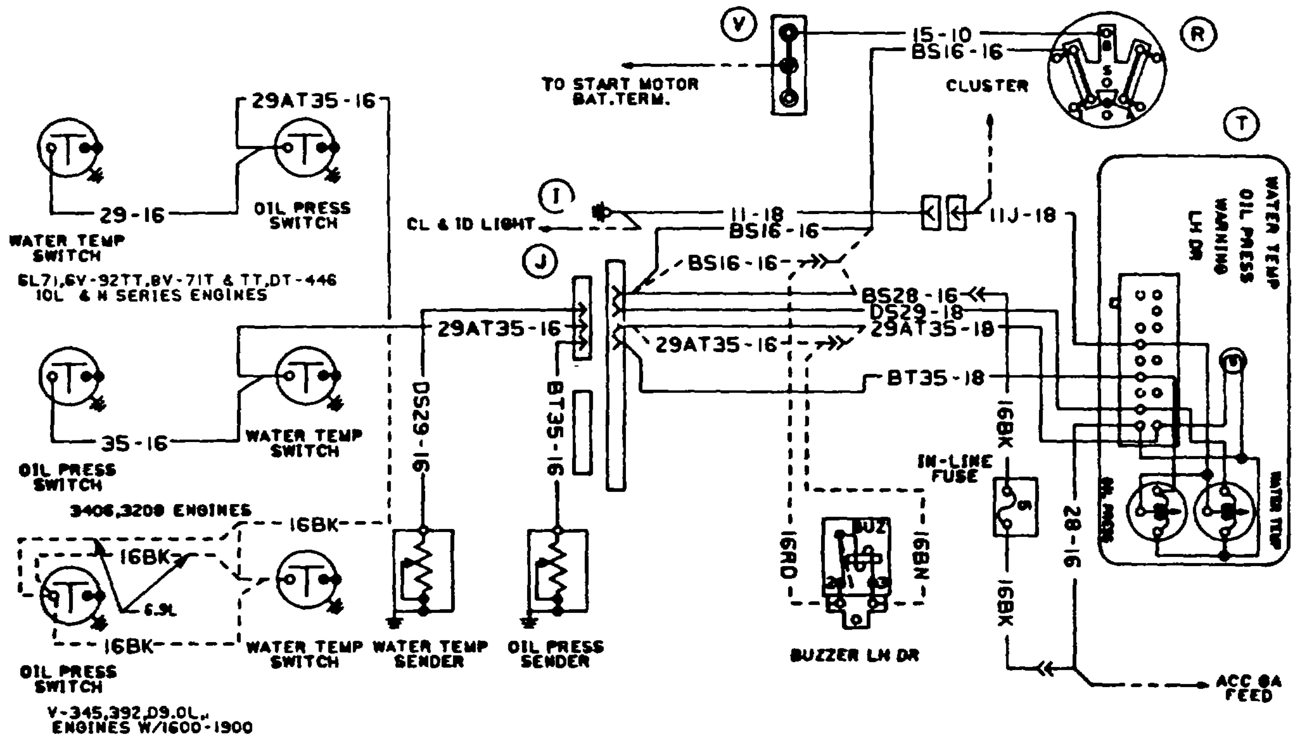
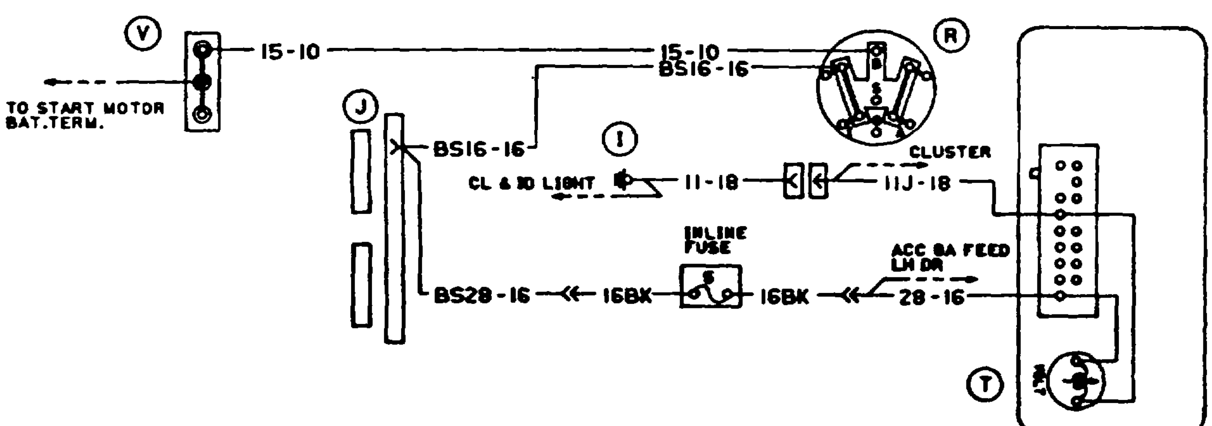


OIL PRESSURE & WATER TEMP GAUGE & OIL/WATER WARNING LIGHT WIRING & BUZZER



VOLTMETER WIRING

LL0800040A SH.20 REV. G

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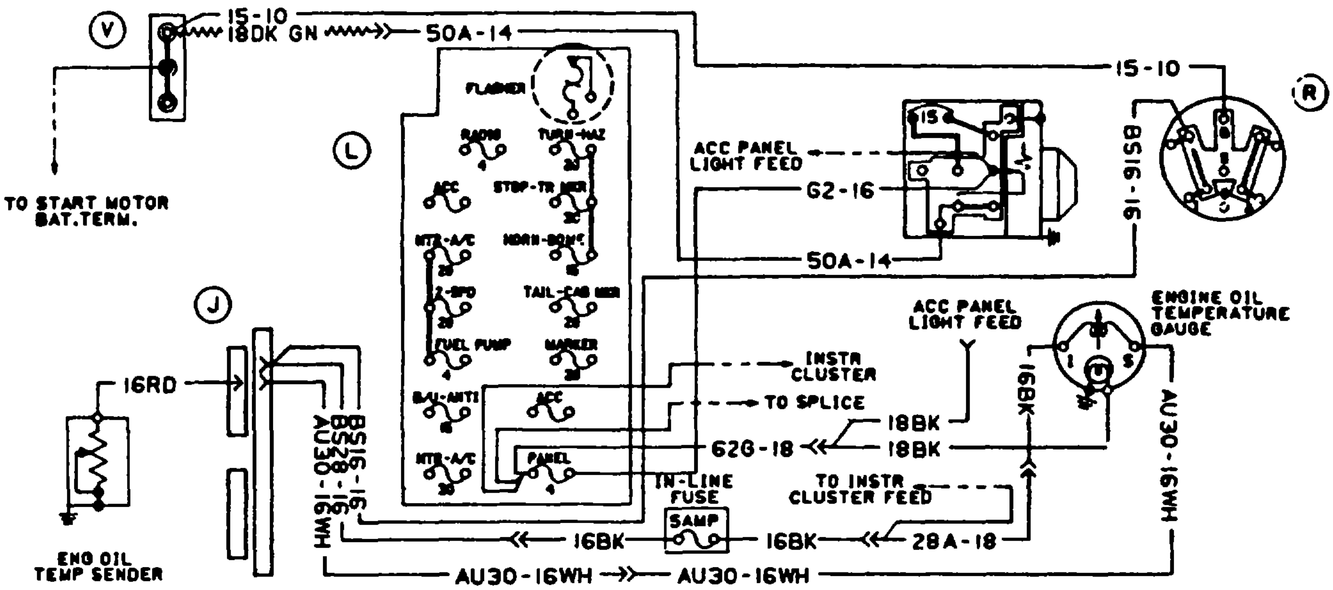
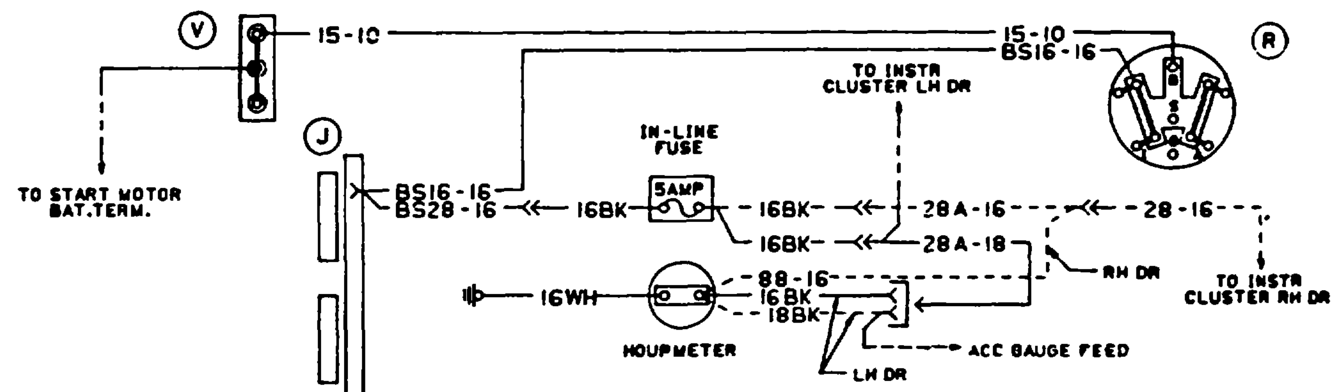
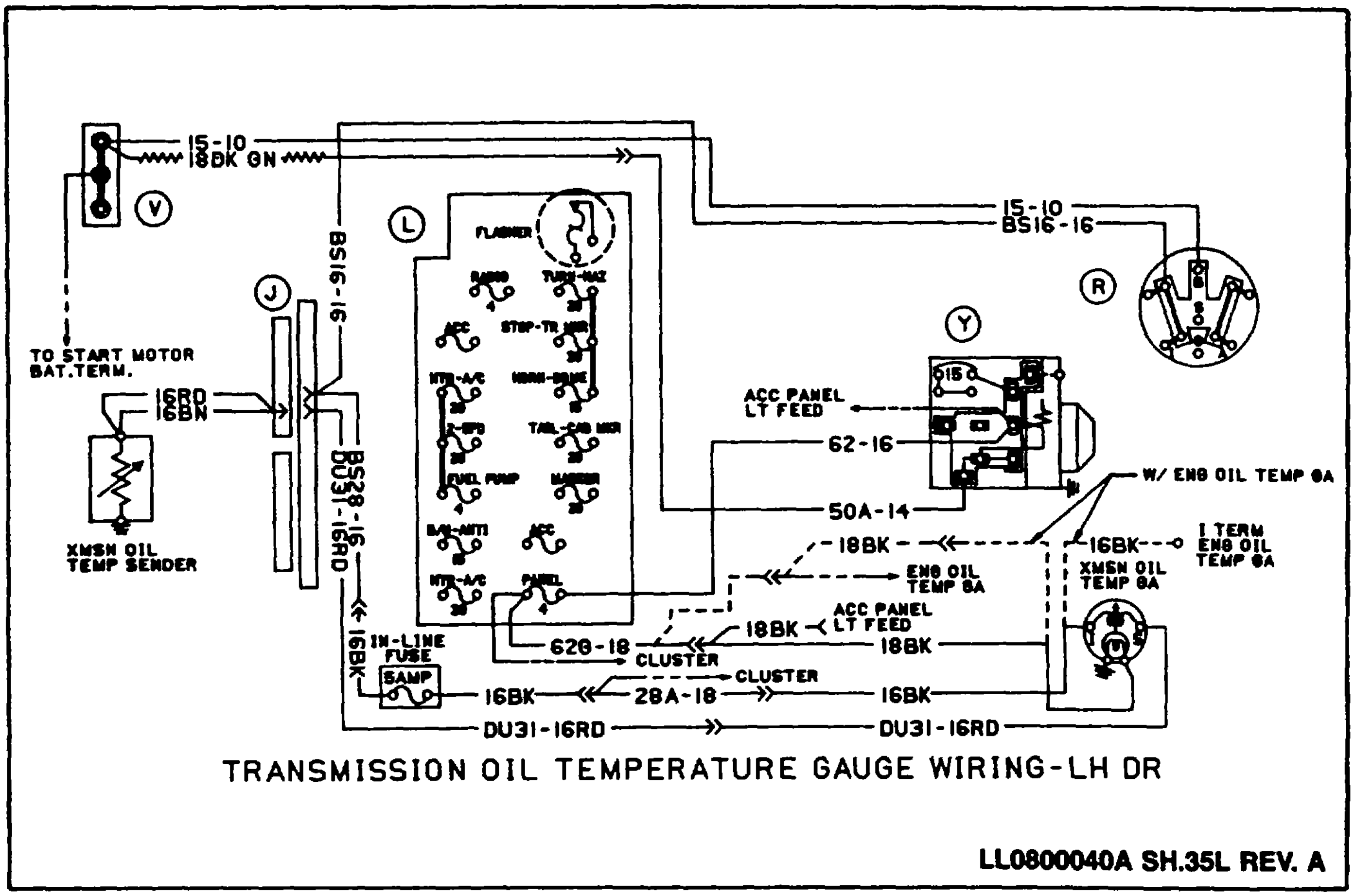


ENGINE OIL TEMPERATURE GAUGE WIRING



HOURMETER WIRING



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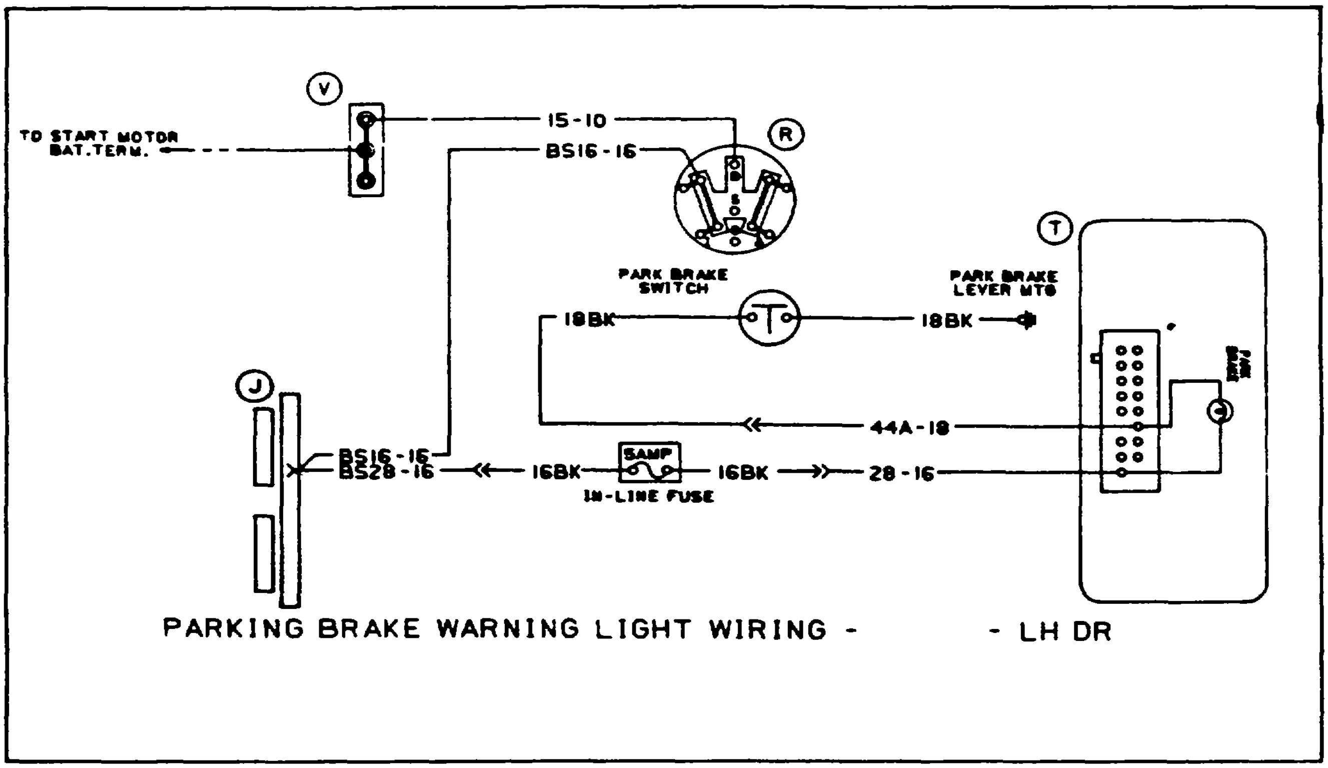

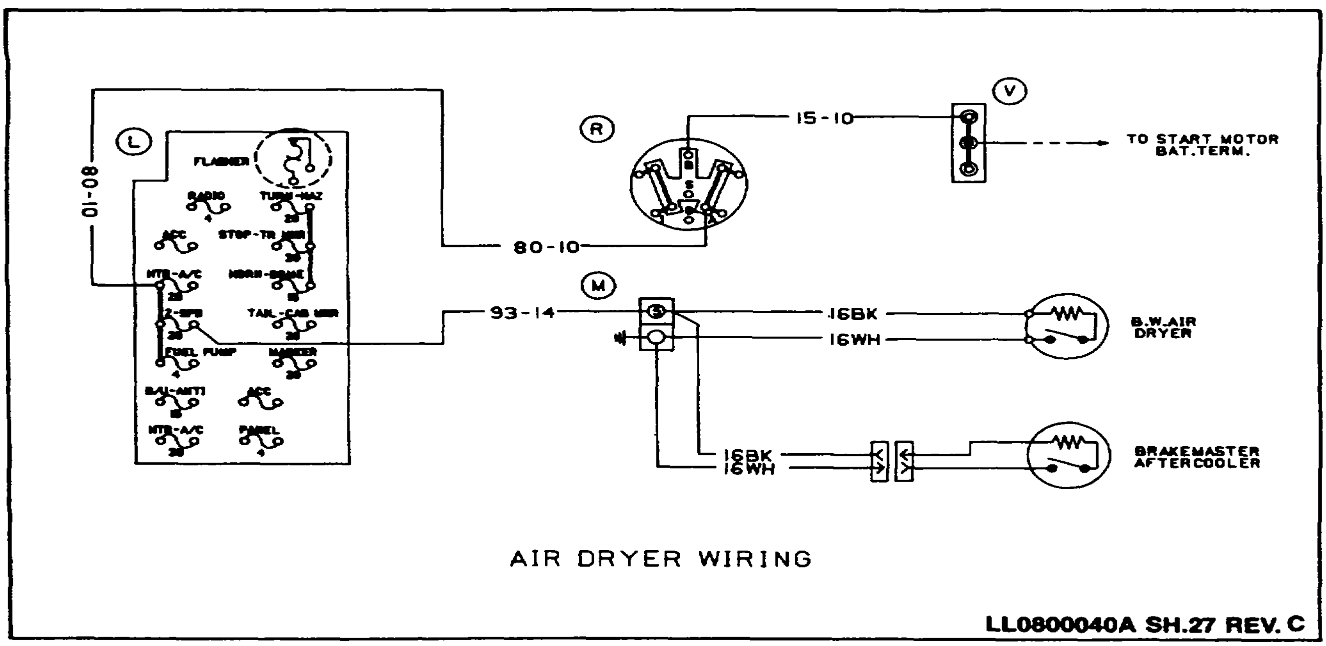

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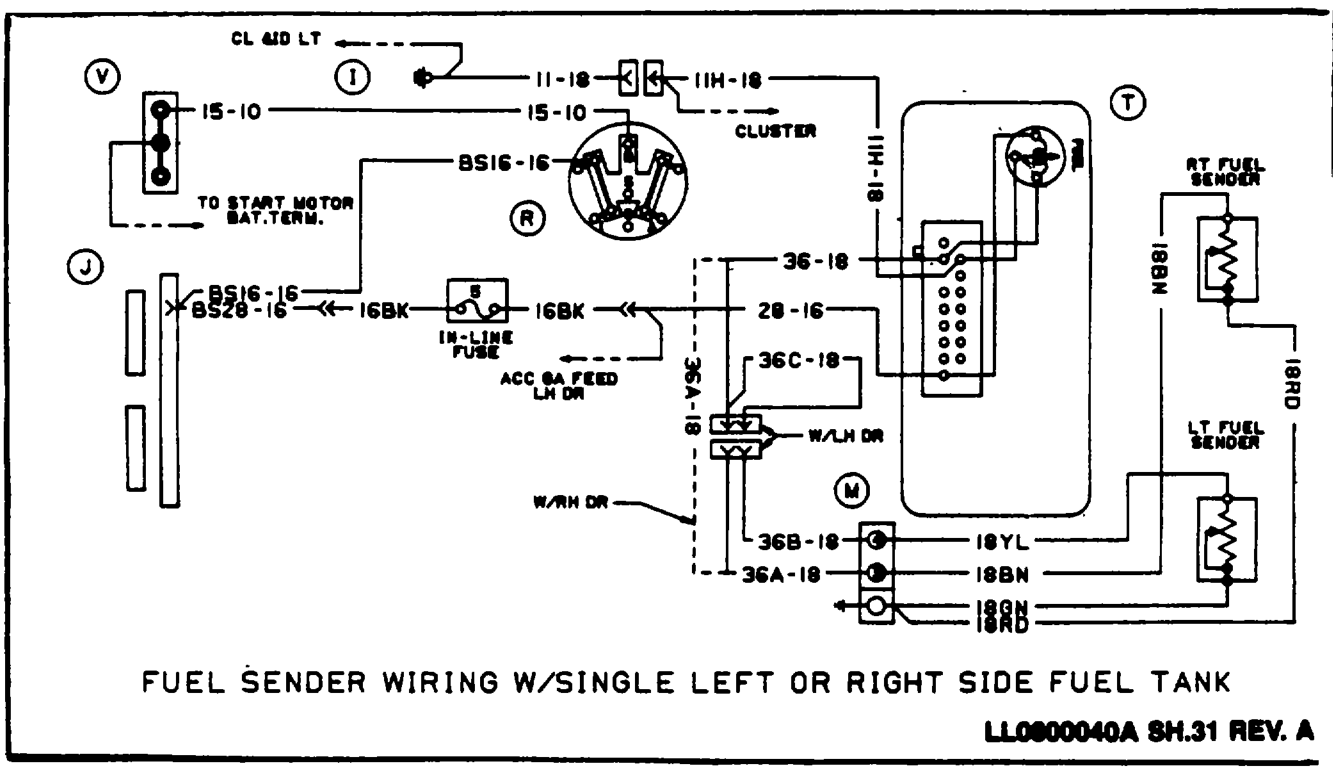
Pages 2577 and 2578 DELETED



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ELECTRICAL

FUSES AND CIRCUIT BREAKERS

S-SERIES

CONTENTS

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Page 2582 DELETED

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INTRODUCTION

All chassis Incorporate safety devices to protect electrical wiring and equipment from short circuits or electrical overloads. These protective devices may be fuses, circuit breakers or fusible links.

CIRCUIT BREAKERS

Circuit breakers are designed to open the circuit any time current demand exceeds the capacity of the breaker. In the event of short or overload, the circuit breaker will open due to excessive heat developed by the higher amperage passing through it. When the heat dissipates, the breaker will close allowing current flow again.

If the cause of the short or overload has not been removed, the circuit breaker will open again to protect the circuit. The current flow limit is indicated by the rating (capacity) of the circuit breaker--15 amperes, 20 amperes, etc. Do not replace a circuit breaker with one of a higher capacity.

Circuit breakers for vehicle wiring circuits are generally grouped together in a circuit breaker panel. Most circuit breaker panels provide space for installing additional circuit breakers if needed for installation of accessory circuits.

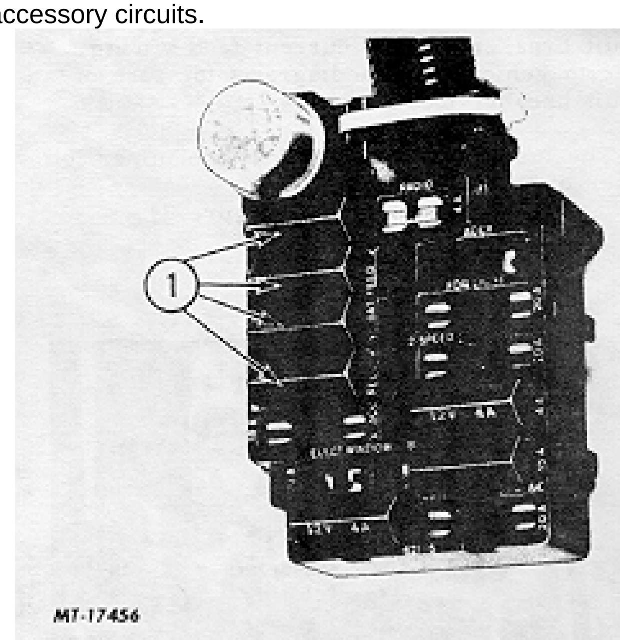

Fig. 2 Fuse Panel With Fuse Replacement Type Circuit Breakers Installed

1 Circuit Breakers

Figure 2 illustrates circuit breakers which can be used to replace fuses in the fuse panel.

FUSIBLE LINKS

Another type of protective device is the fusible link. Fusible links are used to protect the wiring harness m the event of a short in an unfused circuit.

The fusible link consists of a length of light gauge wire. In case of a short or overload, the fusible link opens ("burns out") to protect the rest of the circuit. Repair consists of splicing a new fusible link into the circuit.

Locations of fusible links, where used, are shown on the wiring circuit diagram covering the vehicle involved.

FUSE PANEL LOCATIONS

Illustrated below are locations of fuse panels.

Vehicles may have additional secondary or accessory circuits not routed through the fuse or circuit breaker panel. Such circuits are protected by "in line" fuses or remote mounted circuit breakers in the current feed wiring. Refer to vehicle circuit diagrams for fuse or circuit breaker locations.

The fuse panel is located at the upper left corner of the dash panel on S-Series vehicles (Figure 3).

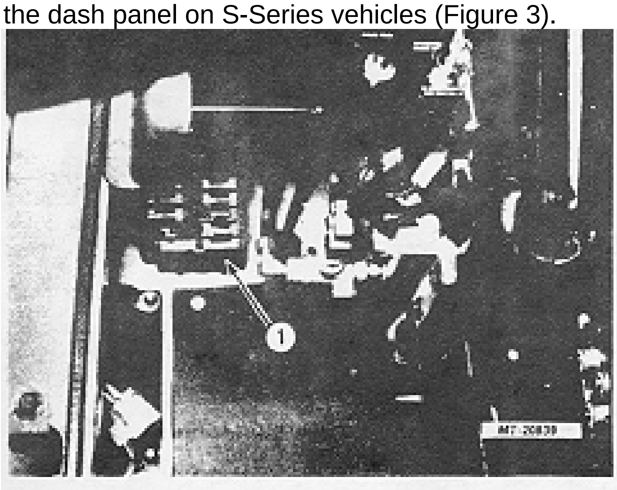

Fig. 3 Fuse Panel Location -- S-Series Vehicles

ELECTRICAL

LIGHTS

S-SERIES VEHICLES

CONTENTS

Page 2586 DELETED

INTRODUCTION

Outlined below are service procedures covering lights used on typical S-Series vehicles. Some vehicles may be equipped with additional accessory lights which are not covered herein.

When diagnosing light failure, first check for a "blown" fuse or tripped circuit breaker. Fuse sizes and locations are listed in the circuit diagram section of the Truck Service Manual. Refer to the appropriate section covering the model year of the vehicle being serviced. If a "blown" fuse or tripped circuit breaker is found, inspect wiring circuit for cause of overload and make necessary repairs.

If fuse or circuit breaker is satisfactory, check for "burned out" light bulb and replace if necessary. Light bulb types used in various lights are listed in the LIGHT BULB CHART in this section.

If light bulb is good, check wiring and connectors for an "open" circuit. A 12-volt test light can be used to check circuit continuity. Refer to the appropriate wiring circuit diagram.

HEADLIGHTS

HEADLIGHT AIMING

Various types of headlight aiming equipment are available commercially. When using aiming equipment, follow instructions provided by the equipment manufacturer.

Where headlight aiming equipment is not available, headlight aiming can be checked by projecting the upper beam of each light upon a screen or chart at a distance of about 25 feet ahead of the headlights. The truck should be exactly perpendicular to the chart.

The vertical lines on the chart (Figure 1) mark the distance between the vertical center lines of the headlights and are equally spaced from the center line of the chart.

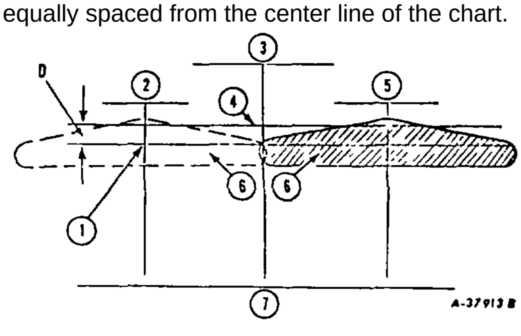

Fig. 1 Headlight Aiming Pattern

1 Projected Beam Center Height
2 Left Light
3 Center of Truck
4 Headlamp Center Height
5 Right Light
6 Projected Beam Pattern (Upper Beam)
7 Floor Line

A horizontal line should be placed on the chart at a level of two (2) inches below the height of the headlight centers above the floor.

With headlights on "HIGH" beam, the "hot spot" of each projected beam pattern should be centered over the point of intersection of the vertical and horizontal lines on the chart, as shown in Figure 1.

If necessary, adjust headlights vertically and/or laterally to obtain proper aim. (See HEADLIGHT ADJUSTMENT).

> IMPORTANT
>
> Headlight aim should always be checked on a level floor with the vehicle unloaded.
>
> In some states, the above instructions may conflict with existing laws and regulations. Where this is the case, legal requirements must be met.
>
> Modify the instructions accordingly.

HEADLIGHT ADJUSTMENT

Adjusting screws are provided to move the headlight assembly in relation to the hood (fender) to obtain correct headlight aim.

Lateral or side-to-side adjustment is accomplished by turning adjusting screw at side of headlight (Figure 2).

Vertical or up-and-down adjustment is accomplished by turning adjusting screw at top of headlight (Figure 2).

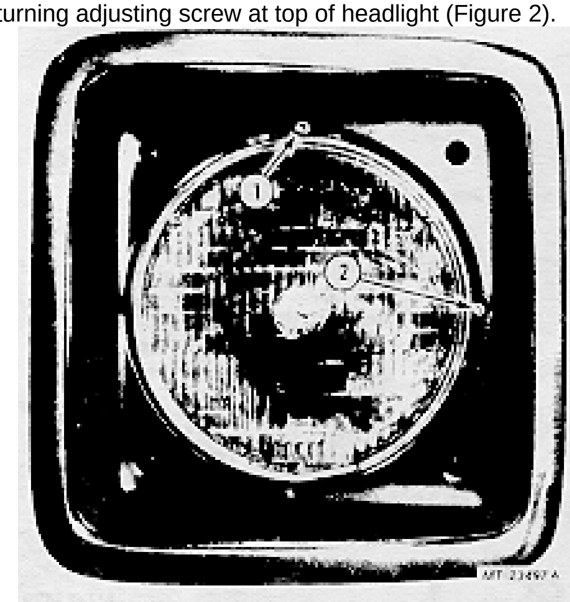

Fig. 2 Headlight Adjusting Screws

1 Vertical Adjustment
2 Lateral Adjustment

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To adjust headlight aim, turn adjusting screws as required to position headlight beam pattern as shown under HEADLIGHT AIMING. Adjustments can be made without removing headlight bezels.

SEALED BEAM UNIT REPLACEMENT

1. Remove four (4) retaining screws (Figure 3) and remove headlight bezel.

Fig. 3 Removing Headlight Bezel

2. Remove three (3) retaining screws and remove sealed beam unit retaining ring (Figure 4).

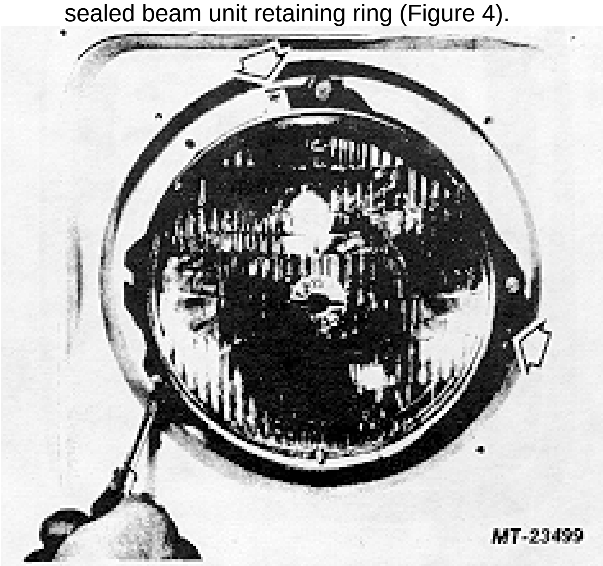

Fig. 4 Removing Sealed Beam Unit Retaining Ring

3. Pull sealed beam unit from headlight assembly. Disconnect three-way wiring connector from rear of sealed beam unit (Figure 5) and remove sealed beam unit.

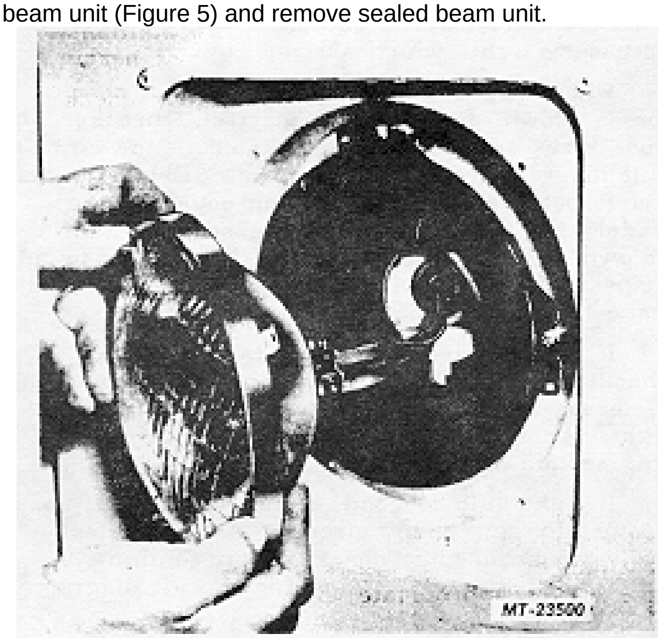

Fig. 5 Removing Sealed Beam Unit

4. Connect three-way wiring connector to new sealed beam unit.

5. Position sealed beam unit in mounting ring. Install retaining ring and secure with screws.

6. Install headlight bezel and secure with screws.

CAUTION

DO NOT overtighten bezel retaining screws. Overtightening could cause damage (stripping) of threads in hood (fender).

7. Check light operation.

HEADLIGHT ASSEMBLY REPLACEMENT

1. Remove four (4) retaining screws and remove headlight bezel (Figure 3).

2. Disconnect headlight retaining spring from headlight assembly (Figure 6).

3. Disengage headlight assembly from adjustment screws. DO NOT turn adjustment screws.

Fig. 6 Disconnecting Headlight Retainer Spring

4. Disconnect three-way wiring connector from rear of sealed beam unit and remove headlight assembly (Figure 7).

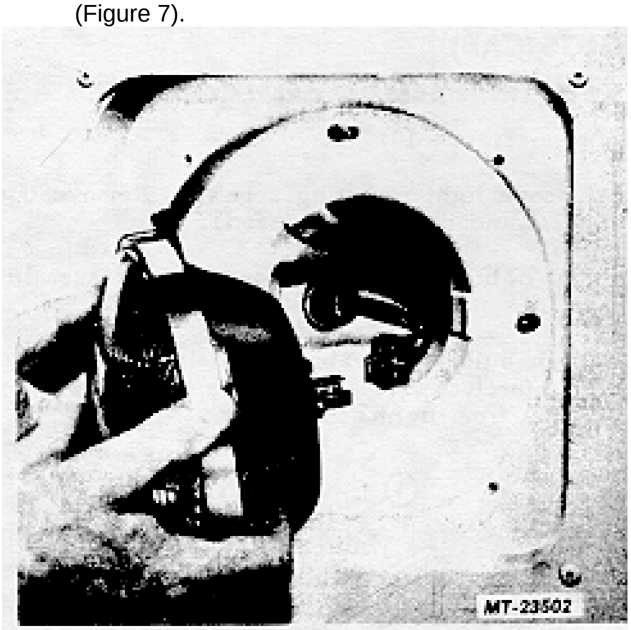

Fig. 7 Removing Headlight Assembly

5. To remove sealed beam assembly from mounting ring (if necessary):

   a. Remove three (3) retaining screws and remove sealed beam retaining ring (Figure 4).

   b. Remove sealed beam unit from mounting ring.

6. If replacement of headlight retaining spring is required:

   a. Remove spring retaining screw and remove spring from hood (fender).

   b. Position new spring on hood (fender) and secure with retaining screw.

7. If required, replace headlight adjusting screw(s) as follows: (Refer to Fig. 8).

   a. While pushing screw inward (toward rear of vehicle) rotate grommet (nut) ninety degrees (900) clockwise until front tangs of grommet align with slot in hood (fender).

   b. Extract screw (with grommet) working from wheel side of hood (fender).

   c. Position new screw and grommet assembly in hood (fender). Align front retaining tangs on grommet with slot in hood and push screw assembly forward as far as possible.

   d. Rotate grommet ninety degrees (90°) counterclockwise until retainer tabs .on rear tangs engage with slot in hood (fender) and front tangs are perpendicular to slot.

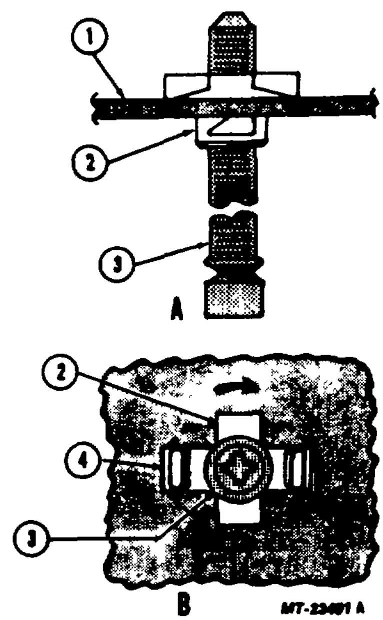

Fig. Adjusting Screw Mounting Details

A	Top View	2	Grommet
B	Front View	3	Screw
1	Hood (Fender)	4	Slot in Hood

8. If necessary, position sealed beam unit in headlight mounting ring and secure with retaining ring and screws.

9. Connect three-way wiring connector to rear of sealed beam unit.

10. Engage mounting slots in headlight mounting ring into collar grooves of adjustment screws. Connect headlight retaining spring to headlight mounting ring.

11. Install headlight bezel and secure with screws.

CAUTION

DO NOT overtighten bezel retaining screws. Overtightening could cause damage (stripping) of threads in hood (fender).

12. Check light operation.
13. Check headlight aim. (See HEADLIGHT AIMING)

FRONT TURN SIGNAL/MARKER LIGHTS BULB REPLACEMENT

Procedure applies to either turn signal or side marker bulbs. Refer to Figure 9.

1. Remove lens mounting screws and remove lens.

2. Press bulb inward and turn counterclockwise to remove bulb from socket.

3. Inspect bulb socket. If rusty or corroded, replace place light assembly. Inspect lens gasket and replace if damaged.

4. Insert new bulb in socket, press inward and turn clockwise to lock in place.

5. Position lens and gasket on light body and install lens mounting screws.

6. Check light operation.

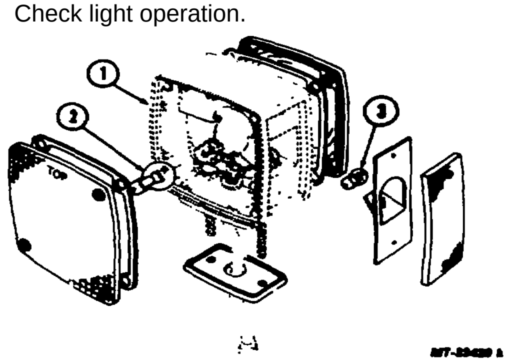

Fig. 9 Front Turn Signal/Marker Light

1 Light Assembly
2 Bulb (Turn Signal)
3 Bulb (Marker)

LIGHT ASSEMBLY REPLACEMENT

1. Disconnect wiring cable from base of light assembly.

2. Remove nuts, washers and wiring cable clip (where used) from light mounting studs. Remove nuts and washers from light guard mounting bolts (if equipped).

3. Remove light assembly (and light guard) from fender.

4. Inspect light mounting pad and replace if damaged or deteriorated.

5. Position mounting pad, light assembly (and light guard) on fender.

6. Install washers and nuts (and cable clip, where used) on light mounting studs. Install light guard mounting bolts, washers and nuts (if equipped).

7. Plug wiring cable connector into light assembly .

8. Tighten light (and light guard) mounting nuts.

9. Check light operation.

CLEARANCE AND IDENTIFICATION LIGHTS (CAB)

BULB OR LIGHT ASSEMBLY REPLACEMENT

(Refer to Figure 10).

1. Remove light mounting screws. Remove trim bezel and seal (where used).

2. Pry light assembly from mounting recess in cab.

3. Turn bulb socket about one-eighth turn counterclockwise and remove socket (with bulb) from light assembly.

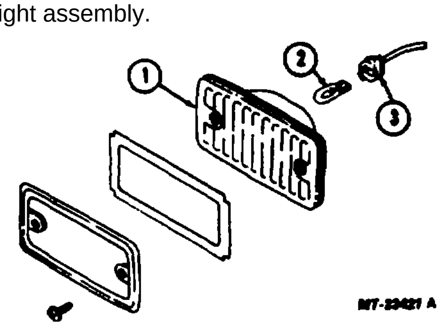

Fig. 10 Clearance Light

1 Light Assembly
2 Bulb
3 Socket

4. Grasp bulb and pull straight out to remove plug-in type bulb from socket.

5. Inspect light assembly and gasket and replace if damaged.

6. Push new bulb into socket.

7. Position socket (with bulb) into light assembly and turn socket one-eighth turn clockwise to secure.

8. Position light assembly (with seal and trim bezel where used) into mounting recess in cab. Secure with mounting screws.

9. Check light operation.

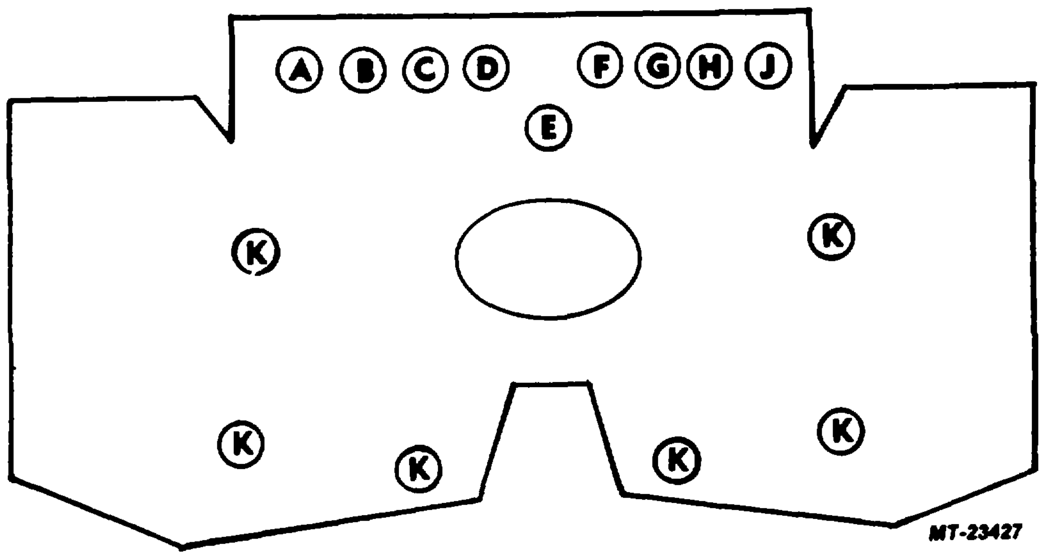

Fig. 11 Instrument Cluster Light Locations (As viewed from front of vehicle)

Legend

A. Right Turn Indicator

B. Low Air Pressure Warning

C. Antilock Warning (Some Models)

D. Park/Hydr. Brake Warning

E. High Beam Indicator

F. Power Divider Lock Warning or EGR Service Indicator

G. Antilock Warning (Some Models)

H. Low Oil Pressure/High Water Temperature Warning

J. Left Turn Indicator

K. Panel Illumination

INSTRUMENT CLUSTER LIGHTS

Locations of instrument cluster illumination, indicator and warning lights are shown in Figure 11.

BULB REPLACEMENT

Procedures for replacing bulbs in instrument cluster lights are as follows:

Indicator and Warning Lights (A thru J, Figure 11)

1. Remove instrument cluster cover screws (5) and remove cover to expose warning and indicator lights.

2. Grasp bulb and pull straight outward to remove plug-in type bulb from socket (Figure 12).

In some cases it may be necessary to remove socket from instrument cluster to remove bulb. See "Cluster Illumination Lights" below.

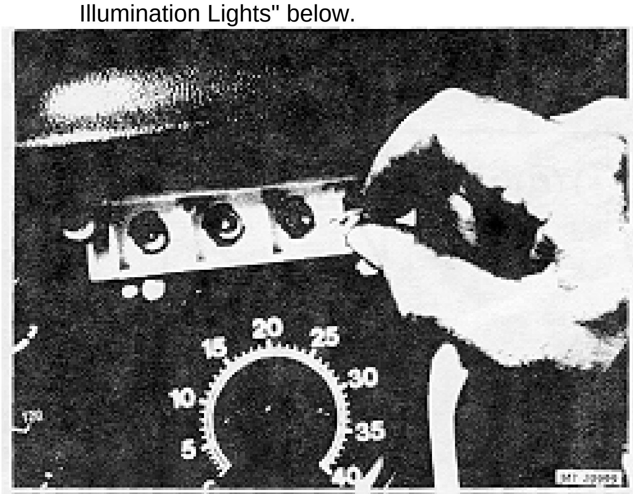

Fig. 12 Removing Bulb from Face of Cluster

3. Insert new bulb into socket.

4. Install instrument cluster cover and screws.

5. Check light operation.

Cluster Illumination Lights:
(K, Figure 11)

1. Reaching up in front of instrument cluster, grasp light socket.

2. Turn bulb socket about one-eighth turn clock wise (as viewed from front of vehicle). Pull socket (with bulb) from instrument cluster (Figure 13).

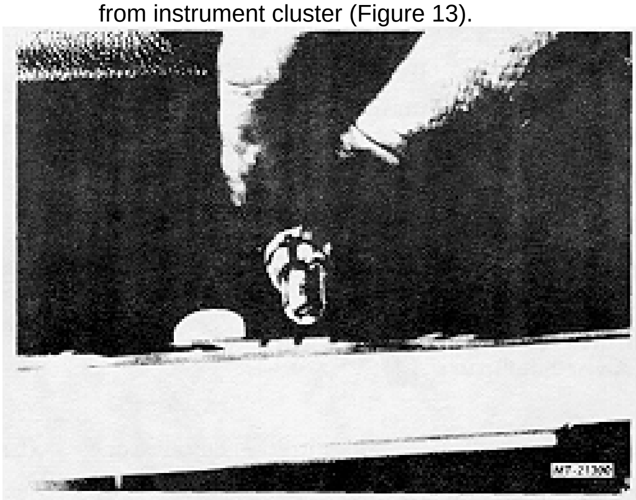

Fig. 13 Removing Bulb and Bulb Socket from Cluster

3. Grasp bulb and pull straight out to remove bulb from socket.

4. Install new bulb in socket.

5. Position socket (with bulb) into instrument cluster and turn socket one-eighth turn counterclockwise (as viewed from front of vehicle) to secure.

6. Check light operation.

DOME LIGHT

BULB REPLACEMENT

(Refer to Figure 14).

1. Pry edge of lens inward to disengage retaining clips. Remove lens.

2. Disengage bulb from terminals.

3. Position new bulb in terminals.

4. Position lens in light assembly and engage retaining clips.

5. Check light operation

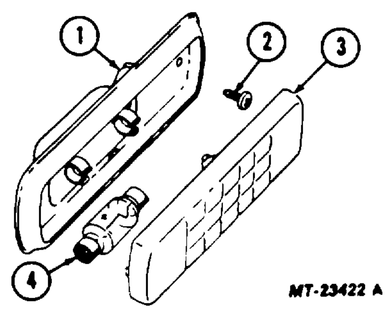

Fig. 14 Dome Light

1	Light Assembly	3	Lens
2	Screw (2)	4	Bulb

LIGHT ASSEMBLY REPLACEMENT

1. Pry edge of lens inward to disengage retaining clips. Remove lens.

2. Remove light mounting screws.

3. Pull light assembly away from cab panel to expose wiring cable connector.

4. Disconnect wiring cable from light assembly. Remove light assembly.

5. Connect wiring cable to new light assembly.

6. Position light assembly on cab panel and secure with mounting screws.

7. Check light operation.

TAIL, STOP, REAR TURN SIGNAL, BACK-UP LIGHTS BULB REPLACEMENT

(Refer to Figure 16)

1. Remove lens mounting screws (4).

2. Pry lens from light assembly.

3. Press bulb in lightly and turn counterclockwise to disengage retaining pins.

4. Pull bulb from socket.

5. Inspect lens and gasket and replace if damaged.

6. Install new bulb as follows:

   a. Align retaining pins with slots in socket. Stop, tail, turn signal bulb has staggered retaining pins to assure correct positioning in socket.

   b. Push bulb into socket and turn clockwise to secure retaining pins.

7. Position gasket and lens in light assembly and secure with screws.

8. Check light operation.

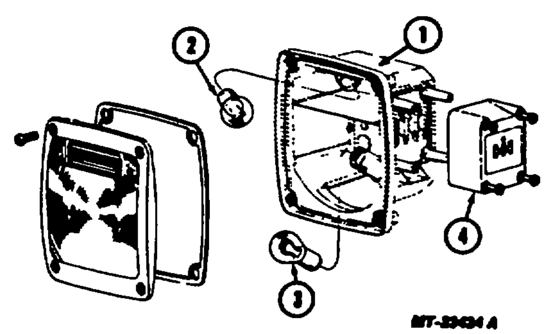

Fig. 16 Tail, Stop, Rear Turn Signal, Back-Up Light

1 Light Assembly
2 Bulb (Back-up)
3 Bulb (Tail, Stop, T-Sig.)
4 Terminal Cover

LIGHT ASSEMBLY REPLACEMENT

1. If necessary, clean dirt from threads of light assembly mounting studs.

2. Remove nuts and washers (3 each) securing light assembly to mounting bracket.

3. Remove mounting screws (4) securing terminal cover to light assembly.

4. Disconnect wiring harness connector from light assembly.

5. Inspect and clean wiring harness connector terminals. If terminals are badly corroded or damaged, replace connector.

6. To retard corrosion, coat terminals of new lamp assembly and wiring harness with grease.

7. Connect wiring harness terminal connector to light assembly.

8. Install terminal cover on light assembly and secure with mounting screws.

9. Position light assembly on mounting bracket and secure with lock washers and nuts.

10. Check light operation.

INSTRUMENT PANEL CONTROL LIGHT

(Located above headlight switch)

If bulb fails, it will be necessary to replace the light assembly as follows:

1. Remove nine (9) screws and remove instrument panel top cover.

2. If necessary pull light wiring up through hole in top of instrument panel to expose wiring connector.

3. Disconnect light assembly wiring connector from wiring harness connector (Figure 17).

4. Disengage slot of light assembly from lens to remove light assembly (Figure 17).

   Do not lose lens which can fall out of instrument panel when light is removed.

5. Discard old light assembly.

6. Hold lens into hole in instrument panel and snap new light assembly over lens to retain lens and light assembly.

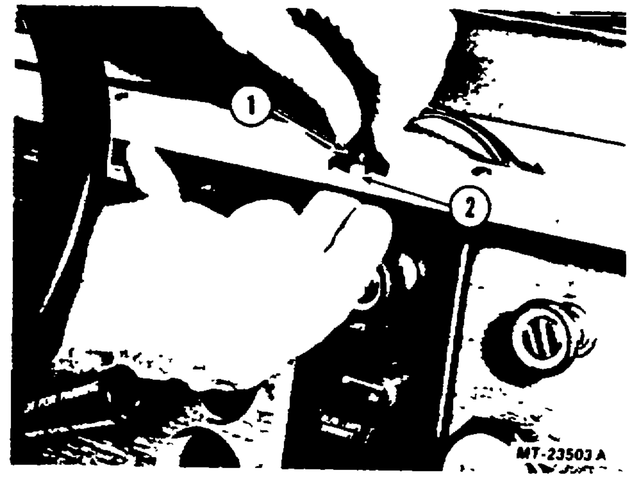

Fig. 17 Instrument Panel Control Light

1 Light Assembly
2 Lens

7. Connect light assembly wiring connector to wiring harness connector.

8. Check light operations

9. Install instrument panel top cover and retaining screws.

HEATER CONTROL LIGHT BULB REPLACEMENT

1. Remove control assembly mounting screws. Remove trim plate. Pull control assembly outward. It may be necessary to remove ashtray to allow movement of control assembly.

2. Rotate light socket (Figure 19) clockwise (as viewed from rear of vehicle). Pull light socket (with bulb) from control assembly.

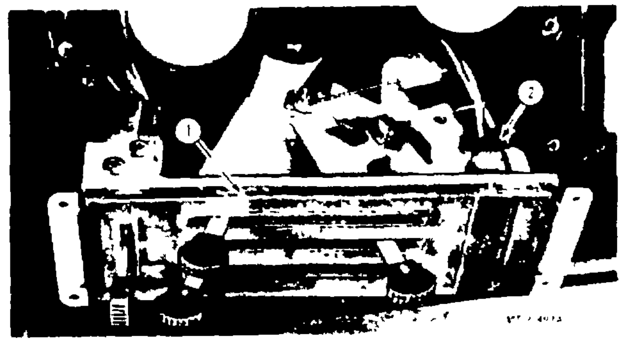

Fig. 19 Heater

1. Control Assembly
2. Light Socket

3. Grasp bulb and pull straight outward to remove plug-in type bulb from socket.

4. Insert new bulb into socket.

5. Insert light socket into control assembly. Turn light socket to secure in position.

6. Position control assembly in instrument panel and install trim plate and mounting screws.

7. Check light operation.

AUTOMATIC TRANSMISSION CONTROL LIGHT BULB REPLACEMENT

1. Grasp light socket and disengage socket from hole in control housing. DO NOT pull on wire to remove socket. (Se- Figure 20).

   In some cases it may be necessary to loosen control assembly left support bracket bolts to permit removal of light socket.

2. Press bulb in lightly and turn counterclockwise to disengage retaining pins.

3. Pull bulb from socket.

4. Install new bulb as follows:

   a. Align retaining pins with slots in socket.

   b. Push bulb into socket and turn clockwise to secure retaining pins.

5. Insert light socket into hole in control housing and push inward until retaining clips "snap" into position securing socket.

6. Tighten support bracket bolts (if loosened to permit light removal).

7. Check light operation.

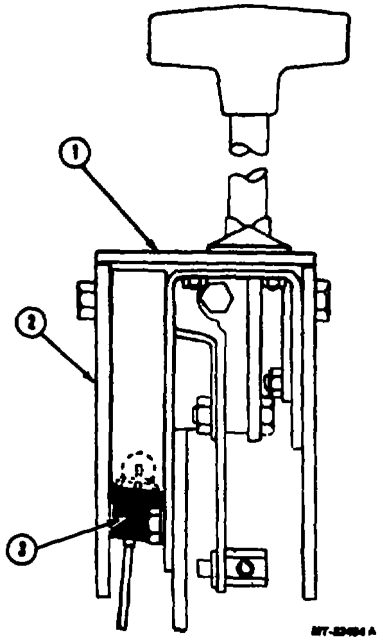

Fig. 20 Automatic Transmission Control Light (As viewed from lower rear)

1 Auto. Trans. Control Assembly
2 Support Bracket (Left)
3 Light Socket

CONTROL IDENTIFICATION OR WARNING LIGHTS

(Engine Stop, Front Axle)

If bulb fails, it will be necessary to replace the light assembly as follows:

1. Pry old light assembly out of slot in instrument panel. Be careful not to scratch finish of instrument panel.

2. Disconnect light assembly from wiring harness.

3. Discard old light assembly.

4. Connect new light assembly to wiring harness
5. Position light assembly into slot in instrument panel. Push light assembly inward until retaining tangs "snap" into position securing light to instrument panel.

6. Check light operation.

AUXILIARY GAUGE ILLUMINATION LIGHT

(Engine Oil Temperature, Transmission Oil Temperature)

BULB REPLACEMENT

1. Remove mounting screws* from cluster panel holding radio, ashtray and auxiliary gauge(s).

> * 6 without radio; 8 with radio. On 2200 series vehicles, 8 without radio; 10 with radio.

2. Tip panel outward to gain access to instrument (Figure 21).

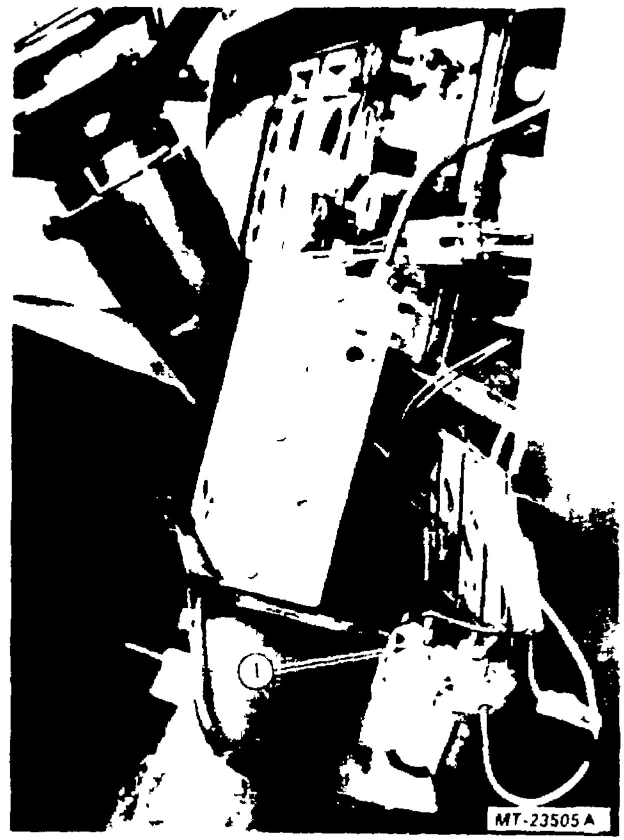

Fig. 21 Auxiliary Gouge Illumination Light (Typical)

1. Light Socket

3. Disconnect light socket from instrument.

4. Press bulb in lightly and turn counterclockwise to disengage retaining pins.

5. Pull bulb from socket.

6. Install new bulb as follows:
   a. Align retaining pins with slots in socket

   b. Push bulb into socket and turn clockwise to secure retaining pins.

7. Insert light socket (with bulb) into instrument.

8. Position cluster panel, with radio, ashtray, and gauge(s) on instrument panel and secure with screws.

LIGHT BULB CHART

APPLICATION	CANDLE POWER	TRADE NO.
Headlight	60 Watt (Upper Beam)	6014 (L.H. Dr.) 7002 (R.H. Dr.)
Front Turn Signal	32	1156
Side Marker	2	1895
Clearance - Identification	3	168
Instrument Cluster	2	194
Dome	12	211
Tail - Stop - Turn - License	32/3	1157
Back-Up	32	1156
Instrument Panel Controls	0.5	*
Heater	3	168
Auto. Trans. Control	3	168
Control Identification or Warning Lights	0.5	*
Auxiliary Gauge Illumination	1	53

* Replace light assembly.

SERVICE MANUAL

ELECTRICAL

Replace old Section with this revised Section in your CTS-4001 Service Manual.

INSTRUMENTS

S-SERIES
CONTENTS

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INTRODUCTION

Instruments used on S-Series trucks include voltmeter, fuel gauge, oil pressure gauge, water temperature gauge, speedometer, tachometer and air or vacuum gauges, plus oil, water, brake and power divider lock warning lights.

All of these instruments are located on the instrument panel in a demountable instrument cluster (Figure 1) directly in front of the driver. Gauges and panel lights of the cluster are connected to the vehicle electrical system by a flexible printed circuit.

Optional gauges for such other items as engine oil temperature, transmission oil temperature, hour meter, etc. are located to the right of heater controls in a separate panel. Optional gauges are wired independent of the printed circuit.

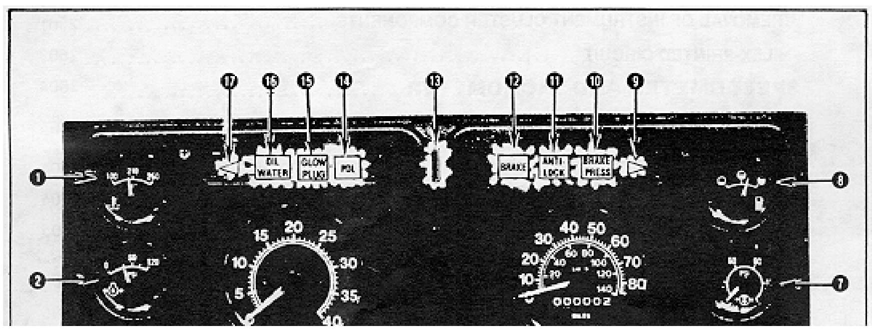
INSTRUMENT CLUSTER

The instrument cluster is a reliable, quick-disconnect package for the most commonly used instruments. Should the need arise, cluster body can be quickly detached from the instrument panel for quick access to any of its components Either the complete cluster assembly or its components can be replaced.

CAUTION - ALWAYS DISCONNECT BATTERY NEGATIVE (GROUND) CABLE BEFORE SERVICING INSTRUMENT CLUSTER OR ITS COMPONENTS.

REMOVAL OF COMPLETE CLUSTER

1. Unscrew the four cluster mounting screws.
2. Tilt or lift out cluster assembly from instrument panel (Figure 2).



1. WATER TEMPERATURE GAUGE
2. OIL PRESSURE GAUGE
3. VOLTMETER
4. TACHOMETER
5. SPEEDOMETER
6. AIR PRESSURE GAUGE
7. AIR PRESSURE GAUGE
8. FUEL LEVEL GAUGE
9. RIGHT TURN SIGNAL INDICATOR
10. BRAKE AIR PRESSURE INDICATOR
11. ANTILOCK WARNING INDICATOR
12. PARKING BRAKE INDICATOR
13. HIGH BEAM INDICATOR'
14. POWER DIVIDER LOCK INDICATOR
15. GLOW PLUG INDICATOR
16. OIL PRESSURE WATER TEMPERATURE INDICATOR
17. LEFT TURN SIGNAL INDICATOR

MT-21397A

Figure 1 -- S-Series Instruments (Typical)
Gauges which read totally metric are also available.

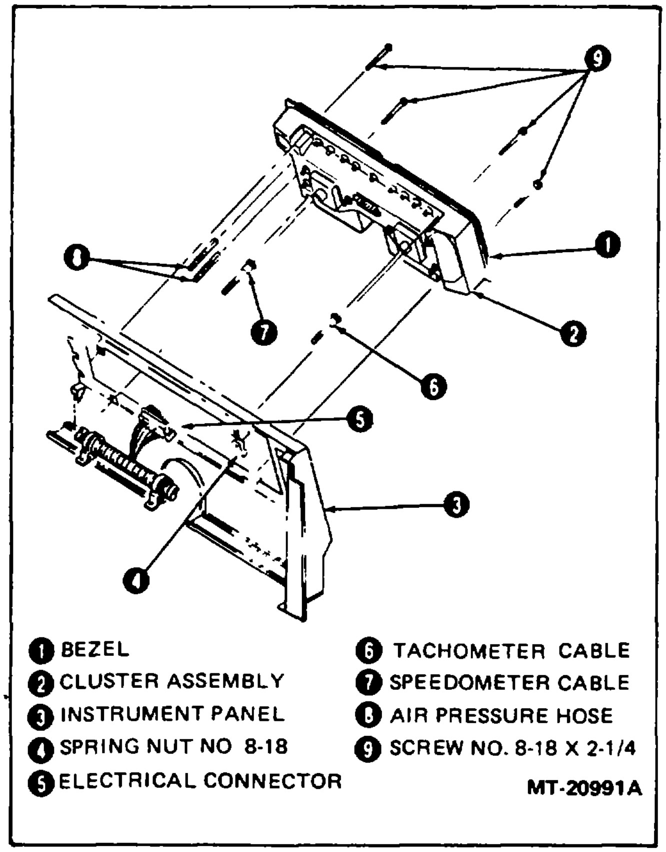


Figure 2 - Removing Instrument Cluster

3. Disconnect wiring harness connector from printed circuit on back of cluster assembly (Figure 3).

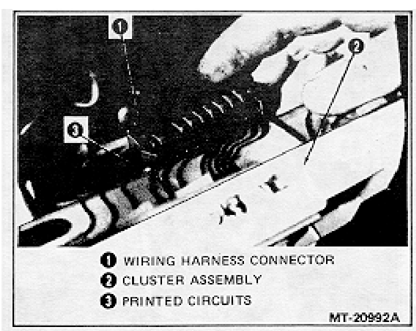


Figure 3 - Removing Wiring Harness Connector

4. Disconnect flexible cables from back of speedometer and tachometer by pressing down on quick-connect spring clasp (Figure 4).

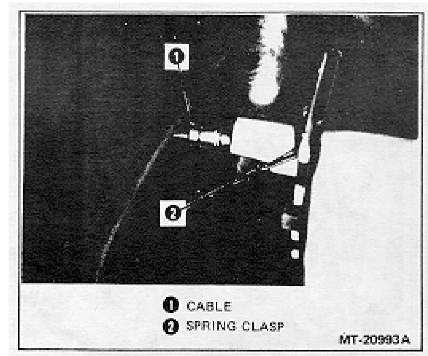


Figure 4 - Releasing Speedometer or Tachometer Cable

5. Disconnect air or vacuum lines from fittings (Figure 5) on back of air or vacuum gauges. Two air pressure gauges are used on vehicles with air brakes. One vacuum gauge is used on vehicles with vacuum boosted hydraulic brakes.

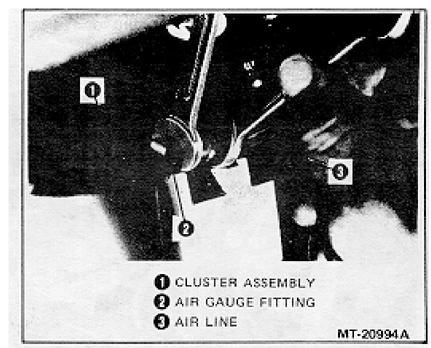


Figure 5 - Removing Air or Vacuum Lines

6. Instrument cluster assembly is now free to be removed from Instrument panel.

REMOVAL OF INSTRUMENT CLUSTER COMPONENTS

If it is desired that Individual components are to be removed, procedure IS as follows:

1 With the four cluster mounting screws removed, remove a fifth mounting screw from center of cluster bezel and detach bezel (Figure 6) Figure 6 - Removing Instrument Cluster Bezel

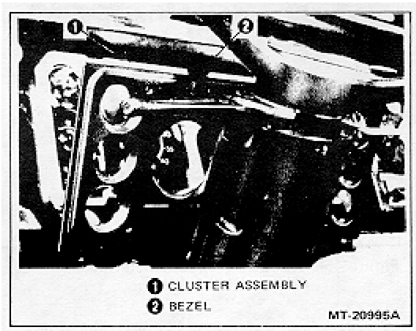


Fig 6 - Removing Instrument Cluster Bezel

2 Individual gauges can now be removed by loosening gauge mounting screws as required All electrically actuated gauges (Figure 7) are removed from front and have plug-in spring loaded connections.

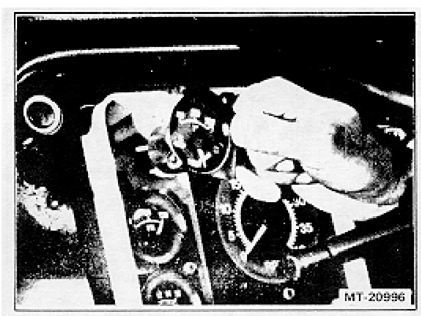


Figure 7 - Removing Electrically Actuated Water Temperature Gauge

3. Speedometer and tachometer (Figure 8) are also front serviceable and can be removed from cluster without disconnecting cables. (If cables are to be removed, these are quick-disconnect from rear of cluster, Figure 4)

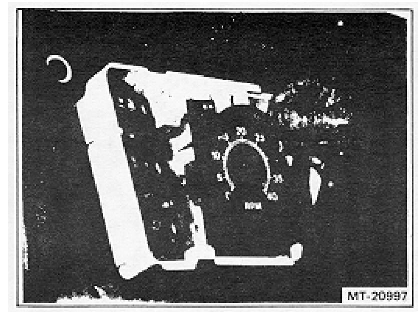


Figure 8 - Removing Tachometer

4. Mechanical type air gauges (Figure 9) are front serviceable after removing air line fittings from rear of cluster (Figure 5).

NOTE - Air gauges are mounted to a common bracket and are Installed or removed as a pair from the cluster body. Also, when reinstalling air lines and fittings, use a non-hardening type sealant on fitting threads.

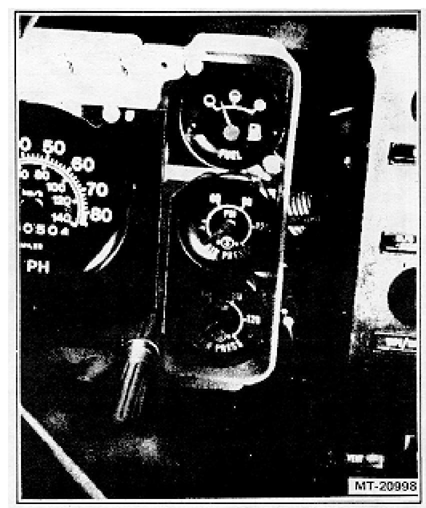


Figure 9 - Removing Air Gauges

5 Light bulbs are plug-in type and are serviceable from either front or rear of instrument cluster (Figures 10 and 11).

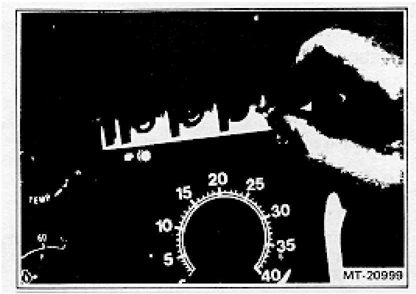


Figure 10 Removing Bulb From Front of Cluster

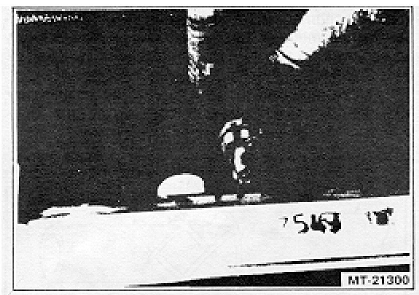


Figure 11 - Removing Bulb and Bulb Socket From Rear of Cluster

FLEX-PRINTED CIRCUIT

One component of instrument cluster which is integral with cluster body itself is the flex-printed circuit This tough flexible plastic film is cemented to cluster body to simplify instrument wiring (25 electrical connections are replaced by one). However, If the need should arise for electrical troubleshooting, Individual circuits on the printed circuit are easily checked This Is accomplished with cluster removed (Figure 12)

Circuit Testing

Obtain low voltage (battery powered) test light or circuit tester. Position test probes on a selected circuit In a manner similar to that shown in Figure 12. If test light illuminates, circuit is unbroken, or if test light fails to illuminate circuit is broken. Check each circuit in turn and if a broken circuit is found, instrument cluster body must be replaced.

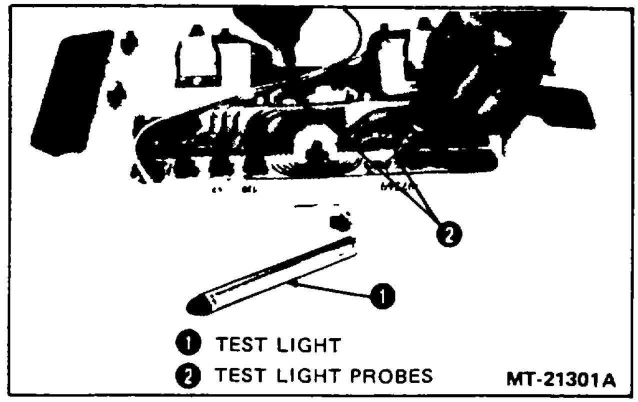


Figure 12 - Checked Printed Circuit Continuity

Replacement

Since printed circuit is cemented to and integral with instrument cluster body, the printed circuit and cluster body are available for replacement as a complete assembly only. Where replacement is required, obtain new instrument cluster body assembly and transfer all gauges and light bulbs from old cluster body to new Individual parts of the instrument cluster, available for service, are shown in Figure 13.

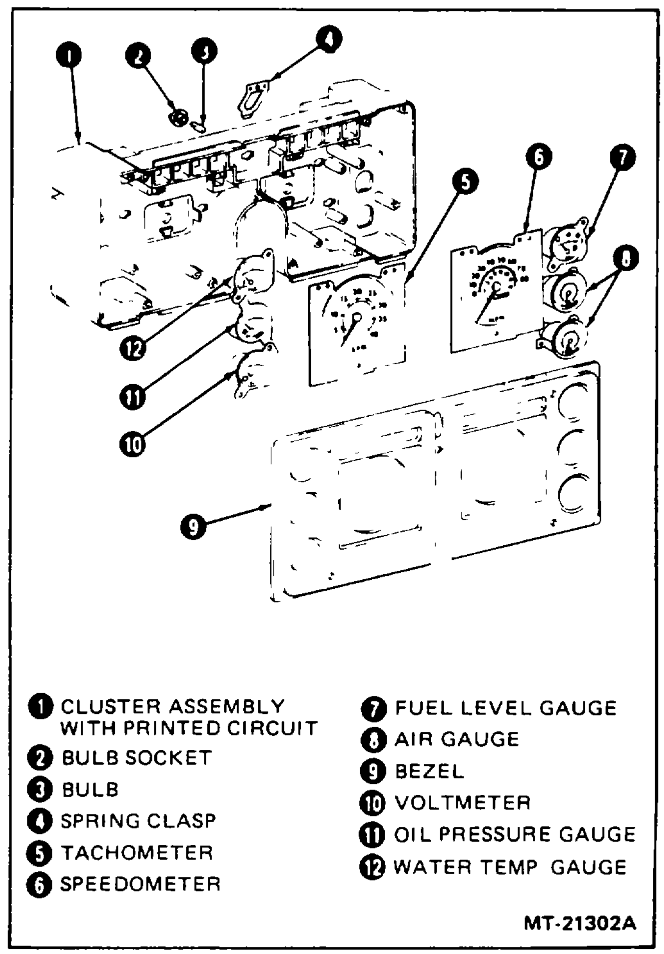


Figure 13 - Components of Instrument Cluster

SPEEDOMETER AND TACHOMETER

SPEEDOMETER

The speedometer used on this vehicle indicates miles and kilometers per hour. Distance traveled is recorded (in miles*) on an odometer. Speedometer is driven by a semi-rigid cable connected to a set of gears in vehicle transmission. Specified gears match the particular truck model and take into consideration such other factors as tire size and rear axle ratio. The semi-rigid cable which connects transmission driven gear to the speedometer head consists of an outer case and an inner core. Odometer records up to 999,999 miles* and returns to zero. School bus models record 99,999.9 miles.* (*Total metric speedometers record kilometers.)

Speedometer Adapter

Should the need arise for changing a truck axle ratio or tire size, a corresponding change must also be made to the speedometer drive. This Is accomplished by changing the speedometer adapter and in some instances the driven gear In the truck transmission. Information for finding the correct adapter and driven gear can be found in the Speedometer Section of the Parts Catalog.

TACHOMETER

An electrical or mechanical tachometer (not standard for all vehicles) is also located In the instrument cluster to record engine RPM (Revolutions Per Minute). This Instrument enables driver to keep engine speed within an efficient operating range.

The mechanical tachometer is driven by a flexible shaft connected to an adapter or driving unit located on engine (distributor shaft for gasoline engines or air compressor injection pump, auxiliary shaft, etc. for diesel engines).

The electric tachometer reads the same as the mechanical unit but receives electrical impulses by wire instead of rotating cable. These impulses are received from a sender unit mounted on the engine and using the mechanical tachometer drive take off.

SPEEDOMETER AND TACHOMETER CABLES

A semi-rigid type cable is used for both speedometer and mechanical tachometer on S-Series trucks.

This cable consists of two segments:

(1) An outer case assembly with nut and ferrule at lower end and a quick -disconnect ferrule at upper end.

(2) A wire-wound flexible inner core assembly with squared drive at upper end and floating tip (Figure 14) at lower end.

The floating tip-which is detachable from cable allows core to float and thereby minimize thrust on speedometer or tachometer head. (Speedometer cable assemblies are sometimes made in two sections for assembly purposes.)

The cable outer case is formed from an inner nylon liner, an intermediate ply of wire braid and an outer polypropylene or polyethylene case (Figure 15).

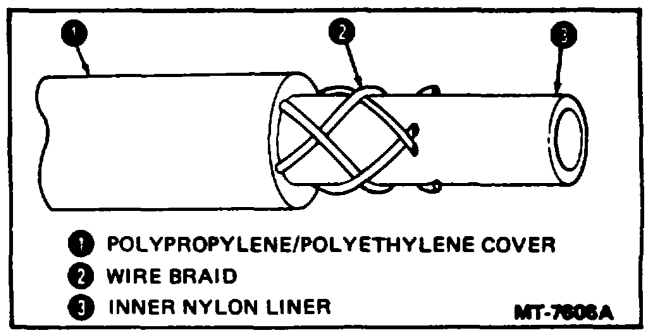


Figure 15 - Semi-Rigid Cable Outer Case

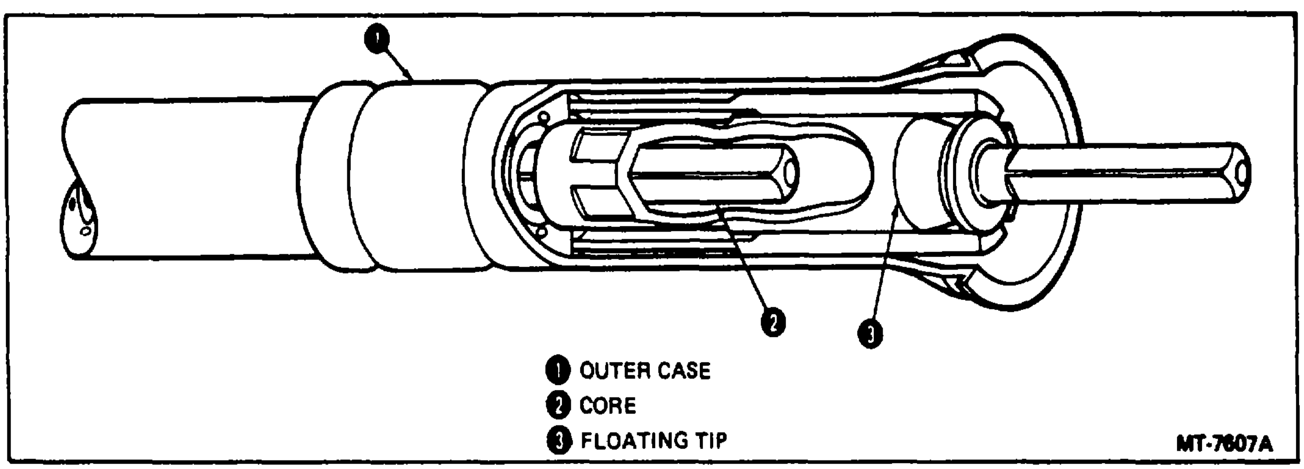


Figure 14 - Semi-Rigid Cable End Details

CABLE SERVICE

Removal

1. Disconnect upper end of speedometer or tachometer cable by removing four mounting screws from instrument cluster and detaching cluster enough to expose back of cluster.

2. Depress spring clasp on back of speedometer or tachometer and release cable (Figure 4).

3. Unscrew cable lower or drive end from adapter at either transmission or engine component.

4. Unfasten cable from any ties or slips and remove complete cable assembly from chassis.

Inspection

1. Pull the flexible core out of case.

2. Check for kinks by rolling core on a flat surface. A core kink will show up as a hop at kinked point.

3. Check for frayed spots by running core loosely through fingers.

Core Replacement

Never reuse a kinked or frayed core. A kinked core will cause a fluctuation of speedometer or tachometer reading and a frayed core will fail completely a sort time after being returned to service.

NOTE - When replacing core, be sure core not too long. A long core will cause a damaging thrust to head of speedometer or tachometer when installed.

Installation

Apply a thin coat of lubricant (IH #251H EP) to core at reassembly as follows:

1. Place approximately 1 teaspoon of lube in one hand.

2. Feed the core (lower end first) through the lube and Into casing.

3. Keep last four inches of cable free of lube to prevent lube from entering the instrument head.

4. Install complete cable assembly in chassis and connect in reverse order of "Removal procedure.

IMPORTANT - Avoid sharp bends when installing speedometer or tachometer cables. Under no circumstance should a casing have less than a six inch radius bend. Route tachometer cable away from compressor discharge line and strap to stay rod to avoid cable damage.

SPEEDOMETER, TACHOMETER AND CABLE TROUBLESHOOTING GUIDE

PROBLEM	PROBABLE CAUSE	SOLUTION
Inoperative	1. Cable disconnected. 2. Broken core. 3. Damaged speedometer or tachometer.	1. Connect cable. 2. Repair or replace. 3. Replace.
Indicator pointer fluctuates	1. Kinked core. 2. Cable Improperly routed. 3. Cable Improperly Installed in speedometer or tachometer head.	1. Repair or replace. 2. Route cable correctly. 3. Install cable correctly.
Noisy, clicking or squealing	1. Damaged or worn parts In speedometer or tachometer. 2. Damaged core. 3. Cable improperly routed.	1. Replace. 2. Repair or replace. 3. Route cable correctly.
Reads incorrectly	1. Wrong adapter. 2. Cable Improperly Installed. 3. Speedometer or tachometer not calibrated.	1. Install correct adapter. 2. Install cable cow6,,y. 3. Replace.

GAUGES

Except for air pressure and other optional gauges which are mechanical – Bourdon tube of diaphragm-type – all gauges are of the electromagnetic air core-type. In each system to be monitored (Fuel Level, Oil Pressure, Water Temperature, etc.), a sender uses a variable resistance to control current from the battery through a coil or coils in the gauge.

GAUGE TESTER

To assist in checking the electrical indicating-type gauges, use of a universal-type Gauge Tester SE-2781 (Figure 16) is suggested. This test eliminates time-consuming trial and error methods of checking out the gauges.

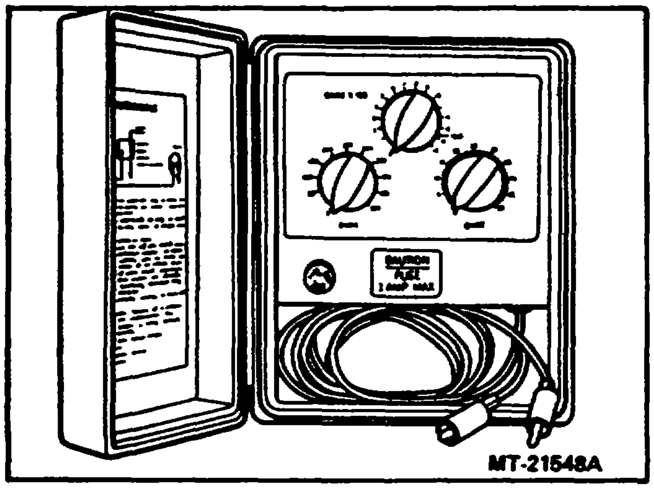


Figure 16 -- Gauge Tester (E-2781)

To test gauge operation, the sender wire is disconnected from the sender unit and the tester is connected between the sender wire and ground. The tester substitutes for the sender unit as shown in Figure 17.

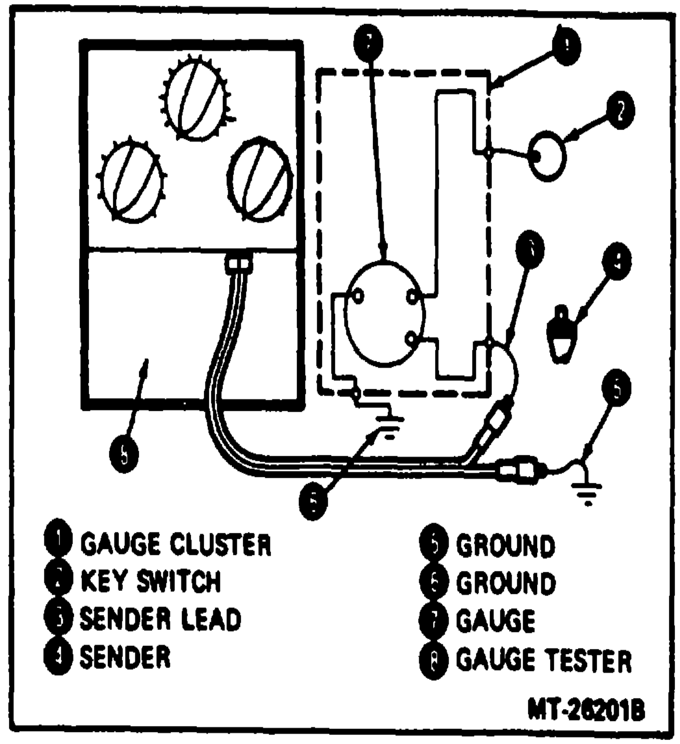


Figure 17 - Gauge Tester Connections

Procedures for testing temperature fuel level, and oil pressure gauges with e gauge tester are given later in this section. Tester setting and gauge reading specifications are, in Table 1.

NOTE - To ensure full power to all instruments in cluster, connector lock tabs on both sides of harness connector must be solidly engaged with cluster socket.

TABLE 1

GAUGE TESTER RESISTANCE SETTINGS (Ohms)
(For Use With SE-2781 Gauge Tester)

Type of Gauge	Low scale	Gauge Reading, Half Scale	Full Scale
Water Temperature:			
With 260° gauge	1365	113	55
With 220° gauge	1365	212	99
Fuel Level	1	44	88
Oil Pressure	1	47	88
Oil Temperature:			
Engine	1365	63	28
Transmission	1365	63	28
Rear Axle	1365	63	28

Proper connector Insertion and power to cluster Is assured If the following Indicators react when key switch is turned on:

1. Voltmeter pointer moves up scale.

2. Some warning lights come on (depends on Installation).

3. Electric gauges Indicate zero.

With power to cluster off, electric gauge pointers may move to any point on gauge scale. This is a characteristic of this type of gauge and does not Indicate a faulty part.

GAUGE QUICK CHECKS

If a universal gauge tester is not available, electrical gauges can also be 'quick-checked* to determine if they are functioning by a simple Sender Disconnect and Ground Test" (Table 2). While this a quick test, it does have two disadvantages.

1. The test tells only that gauge is functioning. It does not determine if gauge is accurate.
2. The grounding of sender wire test for a temperature gauge will damage that unit.

FUEL LEVEL GAUGE

Operation

The electric fuel gauge system consists of two basic components - the instrument cluster mounted gauge and the fuel tank sending unit. The tank unit controls the gauge and the gauge registers the quantity of fuel in the tank. The two units are connected electrically as shown in Figure 18.

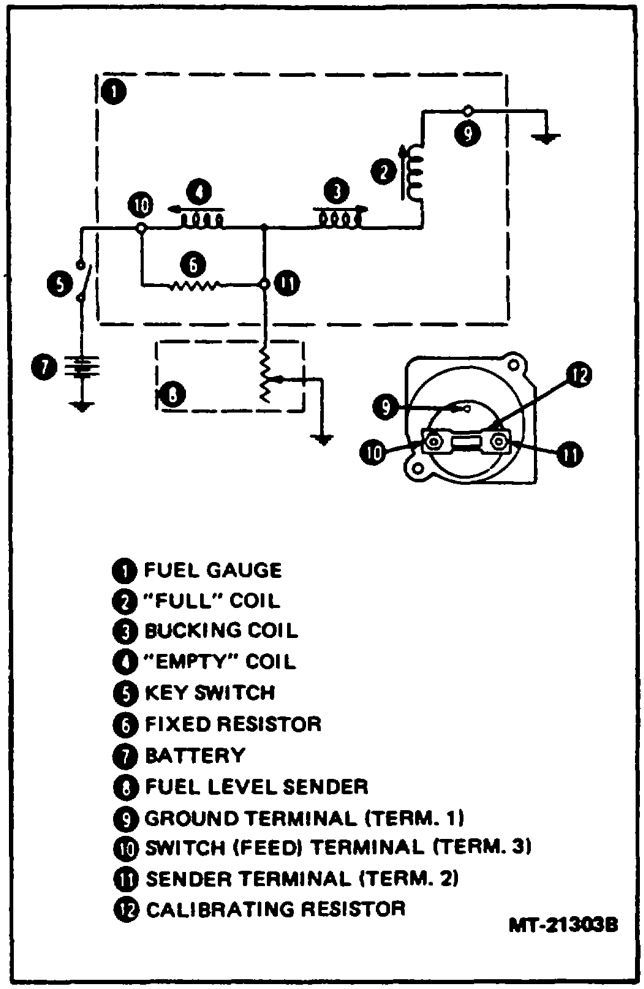


Figure 18 - Fuel Gauge Circuit Diagram

TABLE 2

GAUGE QUICK CHECK (Sender Wire Disconnect and Ground Test)		
	Gauge Reading (With Key Switch "ON")	
Type of Gauge	With Sender Wire Disconnected	With Sender Wire Grounded
Fuel Level	Above Full Scale	Below Low Scale
Oil Pressure	Above Full Scale	Below Low Scale
Water Temperature	Below Low Scale	Do Not Ground'
Oil Temperature:		
Engine	Below Low Scale	Do Not Ground*
Transmission	Below Low Scale	Do Not Ground*
Rear Axle	Below Low Scale	Do Not Ground*
*Grounding temperature sender wire will bum out gauge.		

This air core type fuel gauge consists of three (3) copper wire coils wound around a plastic bobbin containing a magnet and spindle assembly. Attached to the magnet and spindle assembly Is a pointer which indicates fuel level. The fuel gauge requires a 0 to 90 ohm resistance sender to operate. The sender Is the tank unit and consists of a float and arm assembly and a variable resistor. The sender's resistance is controlled by the position of float and arm assembly. A full fuel tank raises float to its highest position. At this position the variable resistor has a resistance of 88 ohms. With an empty fuel tank the float assumes its lowest position, creating a sender resistance of less than 1 ohm.

The fuel gauge circuit diagram (Figure 18) shows that with key switch "ON," current flows from the battery through a parallel circuit consisting of the empty coil and the fixed resistor and thence through another circuit composed of:

- The variable resistance fuel level sender, and the bucking coil and the full coil.
- The fuel sender only when in its empty position.

Variations In the position of the fuel level sender contact will vary the active portion of resistance element and thus control the amount of current flowing in the bucking and full coils. Maximum current in the bucking and full coils occurs with the tank unit in the full 'F position. Under this condition, the magnetic field of the bucking and full coils Is at maximum and the pointer and armature assembly will align itself with the resultant magnetic field of the three coils the 'Full' position. As the fuel is used, the fuel level sender contact position changes to reduce the current in the bucking and full coils and increases the current in the empty coil. This variation In current reduces the magnetic field strength of the bucking and full coils from a maximum at 'full' to zero at the empty or 'E' position at which time the armature and pointer assembly is aligned with the magnetic field of the empty coil. Thus, the interaction of the magnetic field of the three coils produces a resultant magnetic field which controls the rotation and position of the armature and pointer assembly.

The sender and key switch terminals are connected by a calibrating resistor (Figure 18). The other terminal is the ground terminal.

The sender terminal is the first terminal clockwise from ground terminal when viewed from back side of gauge.

NOTE - The gauge Is grounded to chassis through the ground terminal when plugged Into Instrument cluster printed circuit.

When the key switch is turned off, pointer will not necessarily return to the empty position. This is inherent in the instrument and does not Indicate a faulty part.

Testing

1. Disconnect wire at fuel tank sender unit.
2. Connect one lead of Gauge Tester to end of sender wire. Connect second lead to ground. (Gauge tester now substitutes for sender unit.)
3. Turn key switch "ON." (Be sure there is power to cluster.)
4. Set tester for 88 ohms. Fuel gauge should read at full. (Pointer within boundaries of ball.)
5. Set tester for 44 ohms. Fuel gauge should read at half scale. (Pointer within boundaries of ball.)
6. Set tester at 1 ohm. Fuel gauge should read at empty. (Pointer within boundaries of ball.) If fuel gauge responds correctly to various tester settings, gauge and wiring between gauge and sender unit are OK. Trouble Is in sender unit or sender unit is not grounded.
    a. Check sender unit ground circuit. Make sure circuit is grounded.
    b. If ground circuit is OK, replace sender unit.

If gauge does not respond to tester:

a. Check continuity of gauge wiring circuits. Make sure connector terminals are clean and tight.
b. Check gauge cluster ground circuit. Make sure circuit is grounded.
c. If wiring is OK, replace gauge.

WATER TEMPERATURE GAUGE

Operation The water temperature gauge circuit consists of two basic components the cluster-mounted gauge and the thermistor sending unit. The sender controls the gauge reading which indicates the water temperature. The two units are connected electrically as shown in Figure 19.

The operating principle of the temperature indicating system can be understood by reference to the temperature gauge circuit diagram (Figure 19). With the ignition switch closed, current will flow from the battery through the bucking and "cold" coils and the fixed resistor to ground, and through the 'Hot' coil and the variable resistance temperature sender to ground.

The temperature sender consists of a thermistor enclosed in a sealed threaded shell containing a heat transfer medium and equipped with an insulated terminal. With the temperature sender immersed in a cold liquid (100"F), its resistance is high and the current flowing through the 'hot' coil is small; therefore, the magnetic field produced by the "hot" coil is negligible. At this time the pointer and armature assembly will align itself with the resultant magnetic field produced by the 'cold" and bucking coils at the 1 00°F position. The magnetic field of the 'cold" and bucking coils is always a constant and serves as a reference. As the temperature of the liquid increases, the resistance of the sender decreases since the thermistor has a negative temperature coefficient. The decrease in sender resistance increases the current flowing in the 'hot" coil, reaching a maximum at the full-scale position. Thus, the interaction of the magnetic fields of the three coils produces a resultant magnetic field which controls the rotation and position of the armature and pointer assembly.

NOTE - The gauge Is grounded to chassis through the ground terminal when plugged Into the Instrument cluster printed circuit.

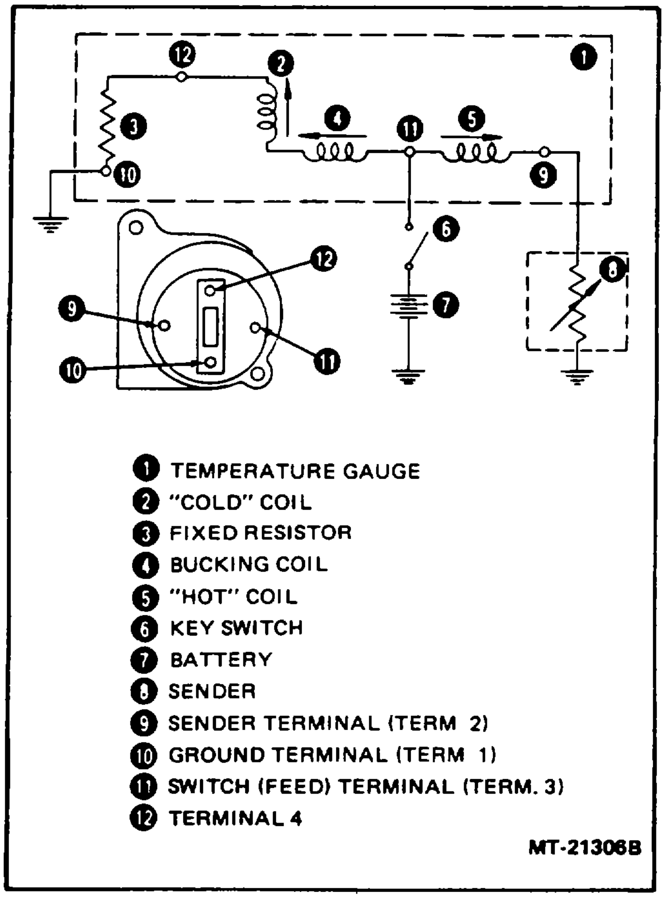


Figure 19 - Water Temperature Gauge Circuit Diagram

The sender terminal is the first terminal clockwise from ground terminal (when viewed from back side). The ignition terminal is directly opposite from sender terminal.

Testing

1. Disconnect sender wire from water temperature sender unit.
2. Connect one lead of gauge tester to sender wire. Connect other lead of tester to a good vehicle ground. (Gauge tester now substitutes for sender unit.)
3. Turn key switch 'ON." (Be sure there is power to cluster.)
4. Set tester: For 260° gauges, use 55 ohms. For 2200 gauges, use 99 ohms. Temperature gauge should read at full scale (HOT). (Pointer within 2 pointer widths of hash mark.)
5. Set tester: For 260° gauges, use 113 ohms. For 2200 gauges, use 212 ohms. Gauge should read at half scale. (Pointer within 2 pointer widths of hash mark.)
6. Set tester to 1365 ohms. Gauge should read at low scale (COLD). (Pointer within 2 pointer widths of hash mark.)

If temperature gauge responds correctly to various tester settings, gauge and wiring between gauge and sender unit are OK. Trouble is in sender unit or sender unit is not grounded.

NOTE - Sealant or dirt on threads of sender unit or engine cylinder head may prevent a good electrical ground. Check for this condition before replacing sender unit.

If gauge does not respond to tester:

a. Check continuity of gauge wiring circuits. Make sure connectors' terminals are clean and tight
b. Check gauge cluster ground circuit Make sure circuit is grounded.
c. If wiring Is OK, replace gauge.

A similar procedure is used to test engine, transmission and rear axle oil temperature gauges Refer to Table 1 for tester settings.

AUXILIARY TEMPERATURE GAUGES

The auxiliary (optional) temperature gauges are also electromagnetic type and are actuated by sending units (variable resistance thermistors). Sending units are located in the component on which temperature monitoring is desired (engine oil, transmission, rear axles, etc.)

Operating principles and testing of auxiliary temperature gauges are similar to the water temperature gauge previously described. Refer to Table 1 for tester settings for checking these gauges.

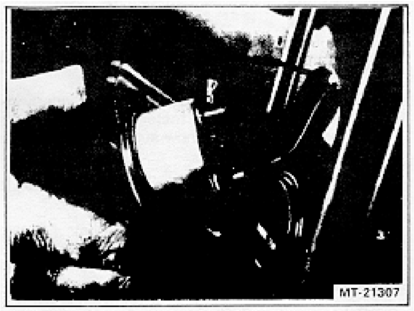


Figure 20 - Servicing Auxiliary Gauge

OIL PRESSURE GAUGE

Operation

The oil pressure gauge circuit (Figure 21) consists of two basic components the cluster-mounted gauge and the sending unit. The sending unit senses the pressure of oil In the oil gallery during engine operation and registers the pressure on the gauge.

Operation of the oil pressure gauge system is similar to the fuel level gauge except that the sending unit resistance is controlled by a diaphragm instead of a float.

Testing

1. Disconnect wire at oil pressure sender unit (located under cab floor on driver's side).
2. Connect one lead of gauge tester to end of sender wire Connect second lead to ground (Gauge tester now substitutes for sender unit.)
3. Turn key switch "ON " (Be sure there is power to cluster)
4. Set tester for 88 ohms (O11 pressure gauge should read at full scale)
5. Set tester for 47 ohms Oil pressure gauge should read at half scale (Pointer within 2 pointer widths of hash mark.)
6. Set tester at 1 ohm O11 pressure gauge should read at low scale (Pointer within 2 pointer widths of hash mark)

If oil pressure gauge responds correctly to various tester settings, gauge and wiring between gauge and sender unit are OK. Trouble Is in the sender unit or the sender unit is not grounded

NOTE - Sealant or dirt on threads of sender unit or engine oil gallery may prevent a good electrical ground. Check for this condition before replacing sender unit.

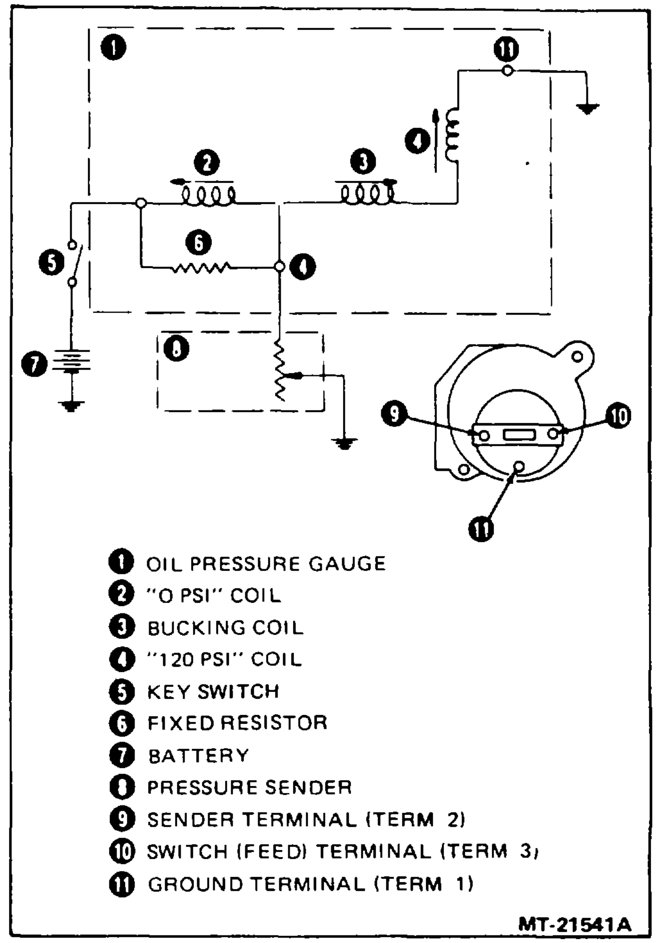


Figure 21 - Oil Pressure Gauge Circuit Diagram

If gauge does not respond to tester

a. Check continuity of gauge wiring circuit Make sure connector terminals are clean and tight.

b. Check gauge cluster ground circuit Make sure circuit is grounded.

c. If wiring is OK, replace gauge.

OIL PRESSURE WARNING LAMP

A second or back-up oil pressure warning system is also used. This system uses a second oil pressure warning switch mounted on the engine.

When engine oil pressure Is In its normal operating range (high) the pressure switch is held In Its off position and no current is sent to warning light In the instrument cluster.

When engine oil pressure is below Its normal operating range (low) the pressure switch will close to its "on" position and deliver current to warning light In instrument cluster and cause warning lamp to light

AIR PRESSURE GAUGE

Operation

The air pressure gauges are the mechanical type and operate on the Bourdon tube principle.

When air system is pressurized, air enters the air pressure gauge and exerts pressure on the Bourdon tube. As pressure increases, the Bourdon tube tends to straighten out and thus actuate the sector and pinion gear (Figure 22) to which it is attached. This causes Indicator to move across dial In an upscale direction When pressure decreases, the Bourdon tube relaxes and pointer moves In a down scale direction. A steadily applied air pressure holds the Bourdon tube and pointer at a fixed scale reading corresponding to applied pressure.

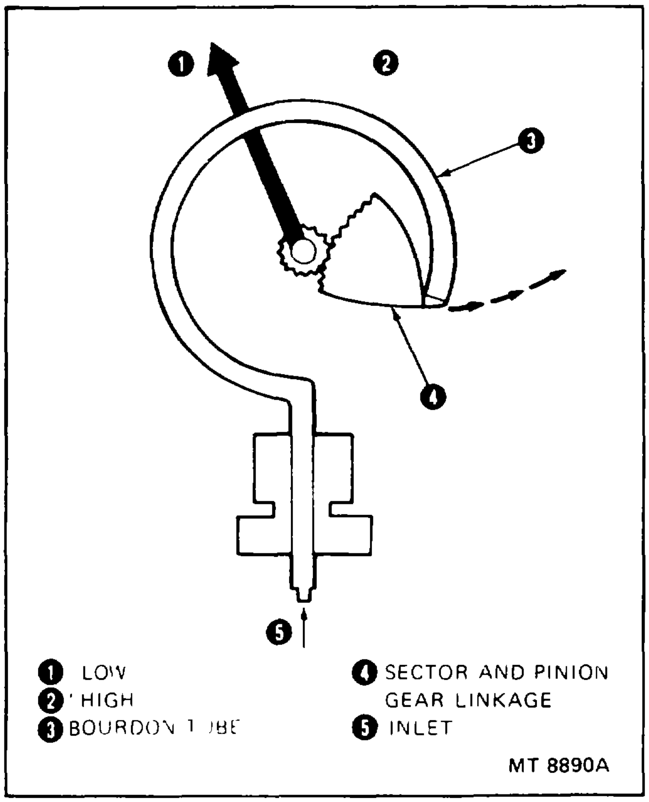


Figure 22 - Air Pressure Gauge Details

Removal

1. Detach Instrument cluster and cluster bezel
2. Unscrew air lines from fittings on rear of the two air gauge Inlets on back of Instrument cluster
3. Remove gauge mounting screws and demount gauges from instrument cluster (Figure 23)
4. Separate Individual gauges from bracket

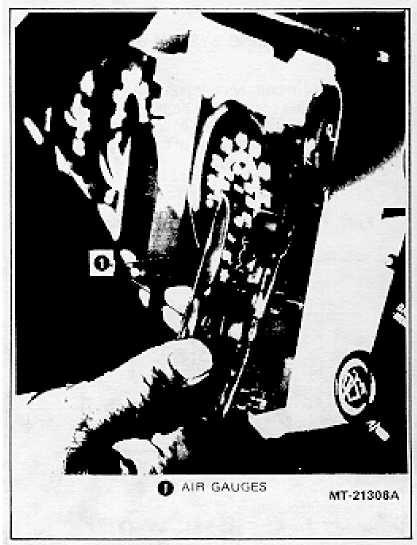


Figure 23 - Removing Air Pressure Gauges

Testing

1. If a suspected gauge has been reading high and does not return to-zero when disconnected, Bourdon tube has been damaged. Service by replacing with a new gauge

2. If gauge has been reading low or does not read at all examine the inlet connection for dirt which might restrict air from entering gauge. Make a trial connection and If gauge still does not register correctly, replace gauge.

NOTE - Always make a comparison test with a gauge known to be reading correctly before discarding a questionable gauge.

Installation

Installation of air gauges is the reverse of removal procedure Be sure to use non-hardening sealing compound on fitting threads to prevent leaks Check installation so as to prevent kinks In air lines

VOLTMETER (BATTERY/CHARGING SYSTEM GAUGE)

Operation

The voltmeter or battery/charging system gauge (Figure 24) indicates the condition of battery and charging system. This gauge will monitor a voltage range between 10 and 16 volts. Color segments of this range also indicate system condition as follows:

GREEN - A well-charged battery.
FIRE ORANGE - Either a too high or too low charged battery.

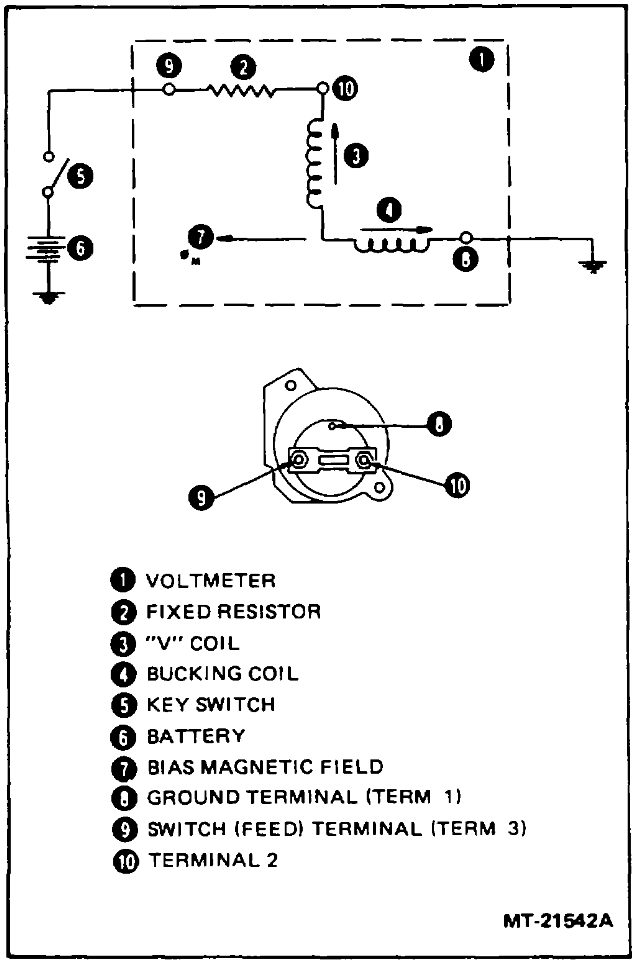


Figure 24 --Voltmeter Circuit Diagram

With key switch "on" but before starting engine, the voltmeter will show condition of battery. While starting engine, indicator will temporarily descend to "Fire Orange" segment but immediately return to "Green" segment when engine is operating. With engine running at operating speeds, the voltmeter indicator should remain in the "Green" segment This is charging system’s normal operating range and indicates alternator Is charging.

If Indicator ascends to "Fire Orange" segment, alternator voltage output is too high.

Constant reading in either high or low "Fire Orange" segments of the voltmeter indicates a complete check of battery and charging system is required. See appropriate alternator section of the Service Manual.

Testing

Operation of voltmeter can be checked by removing voltmeter from cluster and connecting voltmeter terminals to an independent voltage source (12 V battery). The voltmeter should indicate battery voltage + 0.5 volt.

If voltmeter reads properly, voltmeter is OK and problem is in vehicle wiring. Check continuity with test light.

If voltmeter does not read properly, replace voltmeter.

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SUPPLEMENT NO.

Replace old section with this Revised Section In your CTS2001 Manual.

STARTING MOTOR

ENCLOSED SHIFT LEVER TYPE

HEAVY DUTY

CONTENTS

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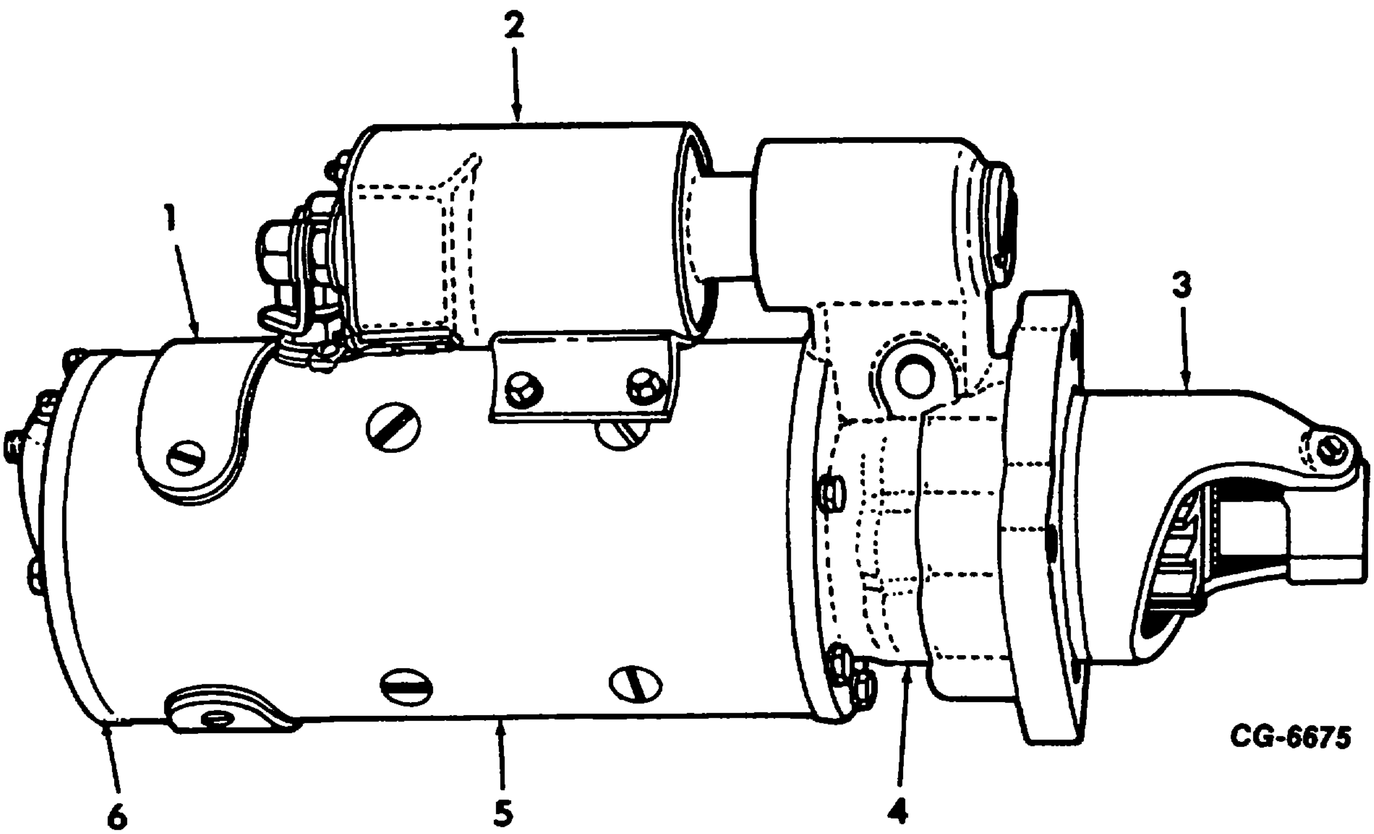

Fig. 1 Heavy Duty Stating Motor with Enclosed Shift Lever

1. Cover Plate
2. Solenoid
3. Nose housing
4. Lever housing
5. Field frame
6. Commutator end

DESCRIPTION

Heavy duty, enclosed shift lever type starting motors are designed to protect the shift lever and solenoid plunger from dirt, road splash and icing conditions.

The nose housing can be rotated to obtain a number of different solenoid positions with respect to the mounting flange, which permits a variety of mounting applications.

NOTE: Be sure to mark the location of the nose housing in some manner to assure proper location of nose housing to lever housing upon reassembly of starting motor.

Either the intermediate duty or the heavy duty overrunning type sprag clutches may be used on the heavy duty starting motors with the enclosed shift lever. Both types of clutches are shifted into mesh with the flywheel ring gear by action of the solenoid. When the drive pinion is engaged with the flywheel, the pinion will not be permitted to disengage until the engine has started and the solenoid circuit is interrupted.

Some of the heavy duty starting motors feature a seal between the shaft and lever housing, and all of the heavy duty starting motors with the enclosed shift lever have a rubber boot or linkage seal over the solenoid plunger. These seals prevent the entry of dirt and oil into the motor main frame.

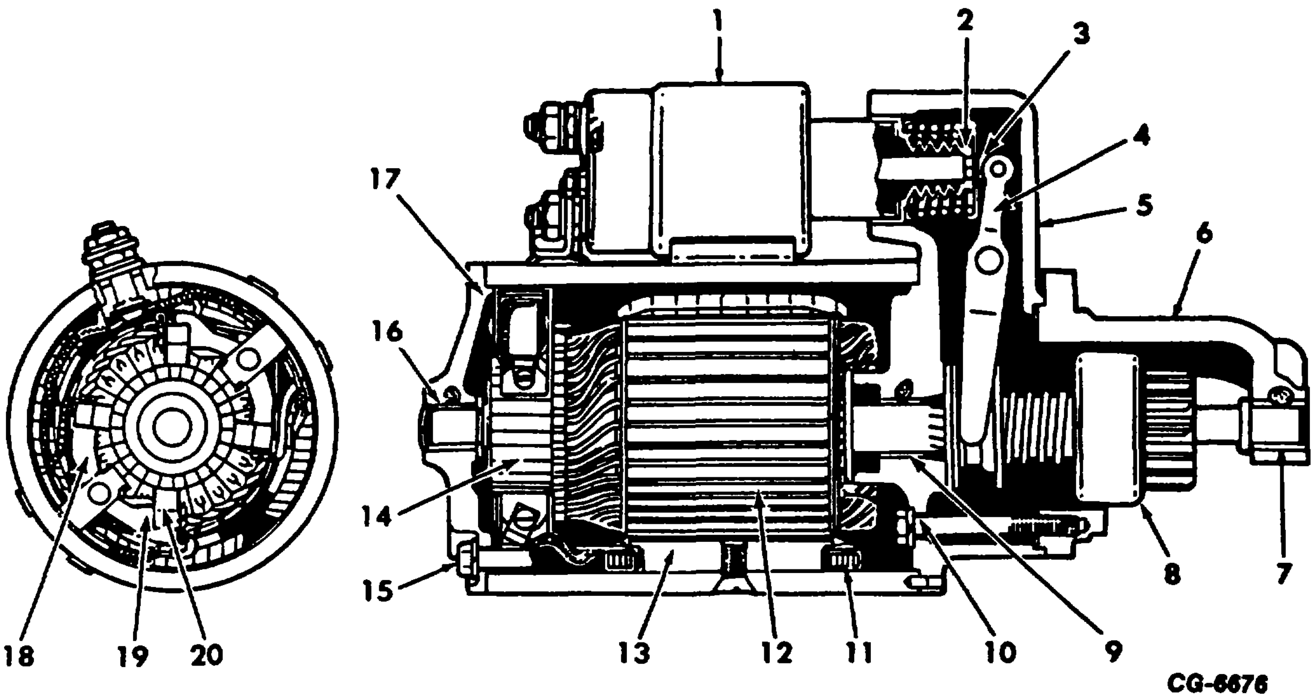

Fig. 2 Sectional View of Starting Motor with International Duty Clutch

1. Solenoid
2. Linkage seal
3. Linkage
4. Shift Lever
5. Lever housing
6. Nose housing
7. Bronze bushing
8. Intermediate duty clutch
9. Bronze bushing
10. Attaching bolt
11. Field coil
12. Armature
13. Pole shoe
14. Commutator
15. Thru bolt
16. Bronze bushing
17. Commutator end frame
18. Grounded brush holder
19. Insulated brush holder
20. Brush

LUBRICATION

Lubrication is provided for the bronze bushings located in the commutator end frame, lever housing and the nose housing, by an oil saturated wick that projects through each bushing and contacts the armature shaft. Oil can be added to the wicks by removing the pipe plugs.

The starting motor should be lubricated whenever it is disassembled with SAE-10 oil. All the wicks should be saturated, reservoirs filled and the splines underneath the clutch should be lubricated with a light coat of oil.

Some of the starting motors are equipped with a large oil reservoir for each wick, also “0” rings are used at various locations to resist entry of dirt and moisture. The starting motors which utilize the large oil reservoirs and the "0" ring are called 'long life motors".

MAINTENANCE

On chassis operating under normal conditions no maintenance to these starting motors will be required. When the engine is overhauled the starting motor should be disassembled, inspected, cleaned, tested and any repairs made.

TROUBLE SHOOTING THE STARTING CIRCUIT

When trouble develops in the starting motor system, and the starter motor cranks the engine slowly or not at all, several preliminary checks can be made to determine whether the trouble is in the battery, starting motor, wiring circuit between them, or elsewhere. Many conditions besides defects in the motor can result in poor cranking performance.

To obtain full performance from a starting motor or to determine the cause of abnormal operation, the motor should be subjected to one or more of the following tests. These tests are performed with the starter motor removed from the engine. Failure of the motor to perform according to the specifications will require disassembly and further checks or adjustments to be made.

NOTE: All starting motor tots should be made with engine and battery at room temperature (not cold).

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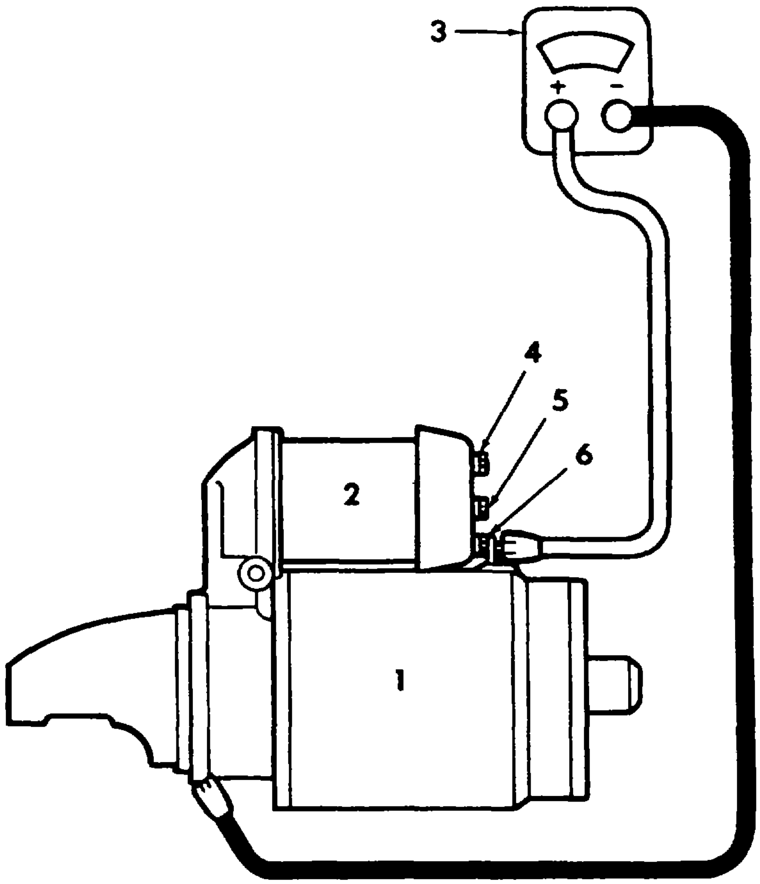

Fig. 5 Cranking Voltage Test

1. **Starting motor**
2. **Solenoid**
3. **Voltmeter**
4. **Battery Terminal (Batt.)**
5. **Solenoid Terminal (S)**
6. **Motor Terminal (M)**

Test No. 2 - Battery Capacity Test

The battery capacity test is per- formed to determine if the battery is in satisfactory condition. See "Battery" Section. B. If the battery passes this test, continue the next test.

Test No. 3 - Voltage Drop Test

Generally, the starting or cranking circuit is a series circuit from the battery insulated post to the starting motor solenoid, to the motor, to ground (chassis) and return to the battery ground post, Fig, , h

In the cranking circuit we also have a cranking control circuit, Fig. 6. In this circuit the solenoid is controlled or operated by closing an ignition switch or push button starting switch at the instrument panel. In this cranking control circuit there are frequently some safety switches such as transmission "neutral safety switch" and/or vacuum-operated cutout switch.

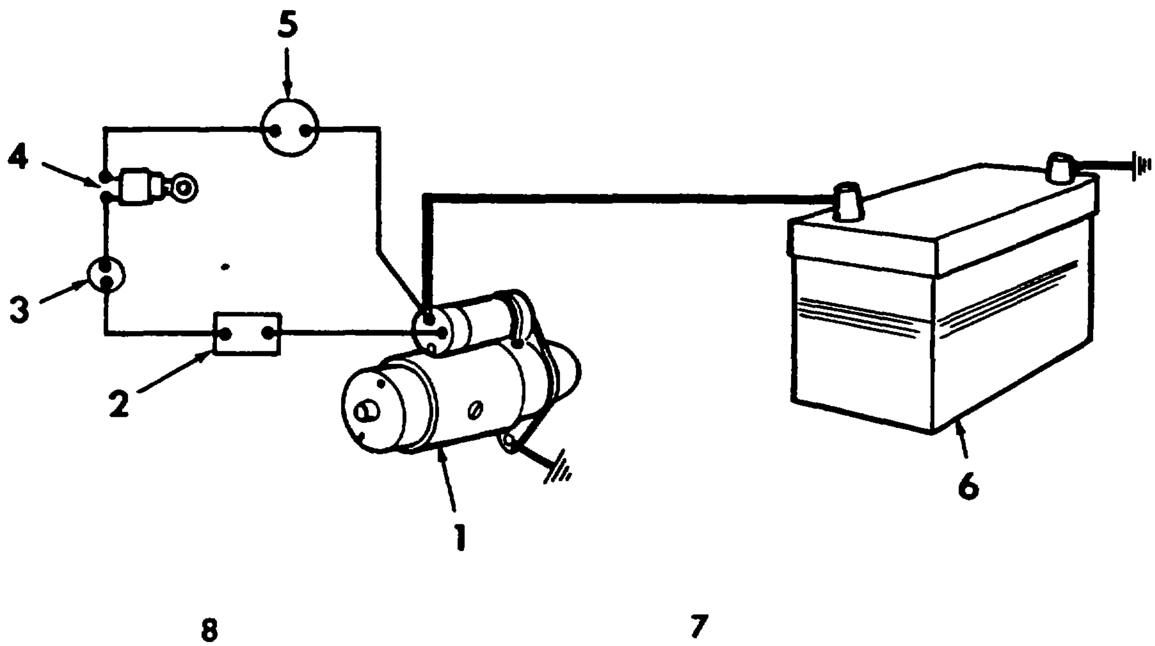

Fig. 6 Starting Motor Circuit

1. **Starting motor**
2. **Vacuum switch**
3. **Neutral safety twitch**
4. **Ignition switch**
5. **Ammeter**
6. **Battery**
7. **Cranking circuit (cable)**
8. **Control circuit (wire)**

Excessive resistance in the starting or cranking system circuit will cause slow cranking speeds and hard starting. The starting system will function properly only when the 'cranking circuit' and 'control circuit' with the components are in satisfactory condition. Corrosion, loose terminal, damaged or undersized cables (wires) will cause cranking problems. In addition, the switches involved must make good electrical connections when closed.

The voltage drop test will be performed in three steps: cranking circuit, control circuit and grounded side.

Cranking Circuit: Voltage drops are measured by connecting a voltmeter in parallel across the circuit or section of a circuit being inspected, then reading the voltmeter while circuit is in operation. To test voltage drop in the cranking circuit from battery to starter, connect the voltmeter (observing the polarity and voltage rating of meter) to battery post (not clamp) to starter motor terminal as shown in Fig. 7. Prevent engine from starting during test. Crank engine and observe voltmeter reading.

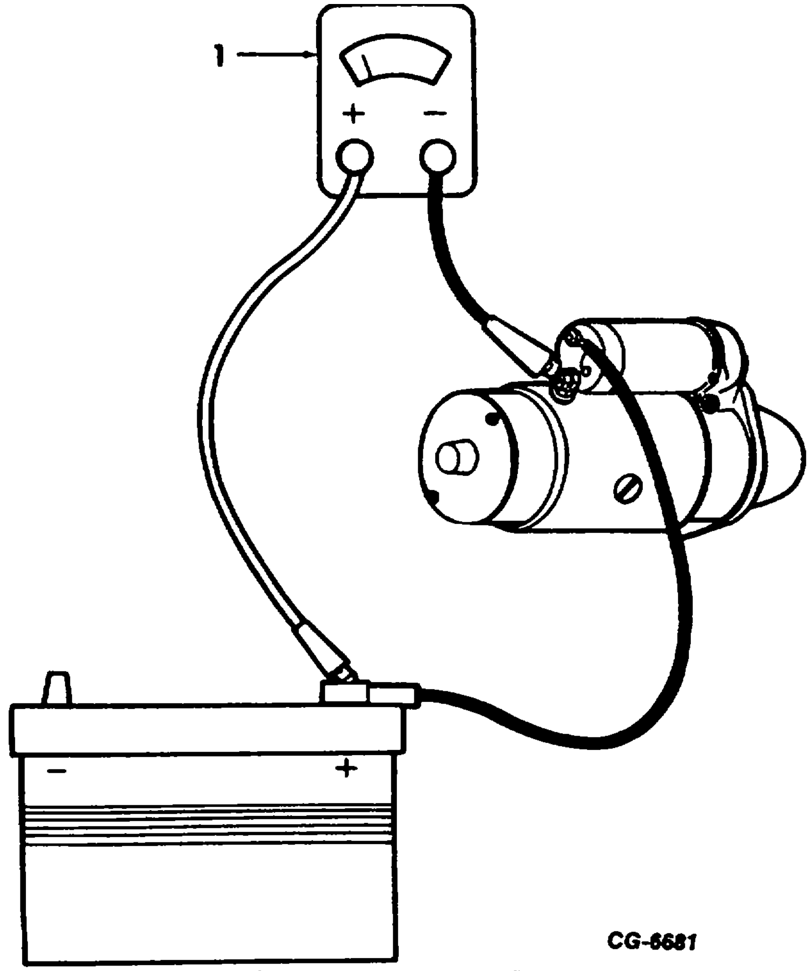

Fig. 7 Cranking Circuit Test
1. Voltmeter

Values of maximum voltage drops for a standard 12-volt cranking circuit are as follows:

	Volt
Cable Under Three (3) Feet	.1
Cable Over Three (3) to Six (6) Feet	.2
Mechanical Switch	.1
Solenoid Switch	.2
Magnetic Switch	.3
Each Connection	.0

Add these values together. For ex- ample, you have a total of .5 volt and you have less than .5 volt drop, continue to grounded side test.

However, if you have more than .5 volt drop, you have an excessive voltage drop. This must be located by moving test lead from starting motor and working toward the battery. Crank engine and each move. When a noticeable decrease in the voltage reading is obtained, the trouble will be located between that point and the preceding point checked.

Items which could be at fault can either be a damaged cable or poor connection, an undersized wire or possibly a bad solenoid (contact within the solenoid).Repair the fault.

Grounded Size: High resistance in ground circuit of starting motor system will result in hard starting and may affect the charging circuit as well.

Connect voltmeter leads to ground on starting motor and to ground post of battery. The allowable voltage drop of .2 volt is permissible. If more than .2 volt is obtained, a poor ground is pre- sent, such as a loose starting motor mounting bolt, bad battery ground connector or ground connection to engine or frame, depending upon the battery installation. The excessive voltage drop is located in much the same manner as in the preceding test working toward the battery.

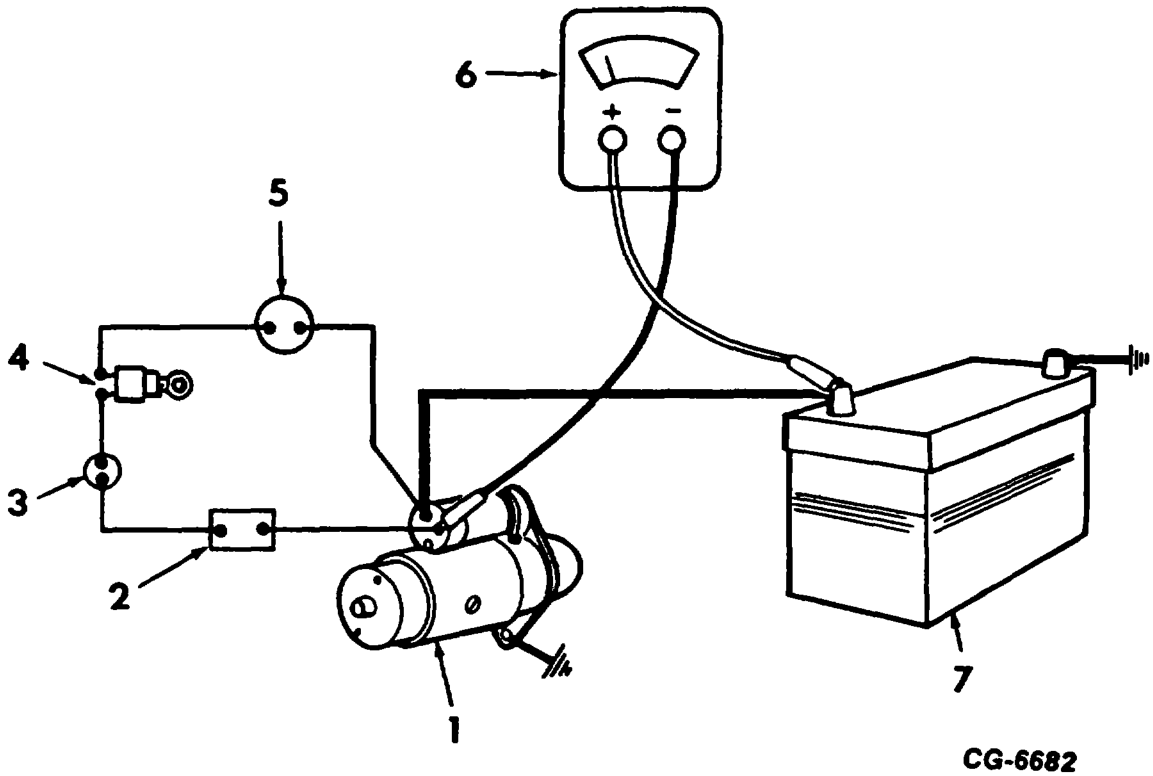

Fig. 8 Control Circuit Test

1. **Starting motor**
2. **Vacuum switch**
3. **Neutral safety switch**
4. **Ignition switch**
5. **Ammeter**
6. **Voltmeter**
7. **Battery**

Control Circuit: High resistance in the control circuit will reduce the cur- rent flow through the solenoid windings, which can cause improper function of solenoid or not at all. Improper functioning of the solenoid could result in burning of contacts in the solenoid causing high resistance in the starting motor circuit.

To complete control circuit test, check the vehicle circuit diagram to assist in locating the wires and particular switches involved in the chassis. Observe polarity of voltmeter and connect leads to battery post and solenoid switch terminal as shown in Fig. 8. Crank engine using the vehicle ignition switch or push button if equipped, observing the voltmeter reading. If the voltmeter shows less than .5 volt, the circuit is in good condition. If more than .5 volt, this is an indication of excessive resistance. Note: Occasionally a slightly higher voltage will be found in the circuit and the circuit still be normal.

Isolate the point of high resistance by placing the voltmeter leads across each component in the circuit in turn. A reading of more than .1 volt across any one wire or switch is usually an indication of the trouble.

After completing the cranking volt- age test, battery capacity test and the voltage drop tests, and the starting motor still fails to function, remove the motor and make the no load test as follows.

Note that the preceding tests were made in the particular order to make certain the starting motor circuit is in good condition before needless starter motor removal.

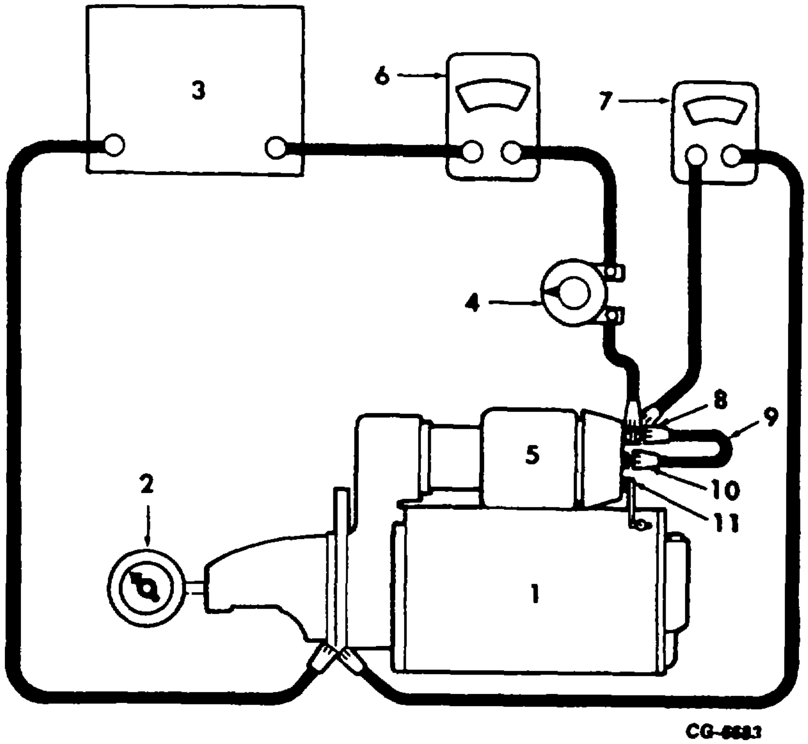

Fig. 9 No Load Test Hookup

1. **Starting motor**
2 **RPM indicator**
3. **Battery**
4. **Variable resistance**
5. **Solenoid**
6. **Ammeter**
7. **Voltmeter**
8. **Batter Terminal (Batt.)**
9. **Jumper lead**
10. **Solenoid Terminal (S)**
11. **Motor Terminal (M)**

<u>Test No. 4 - No Load Test</u>

Before performing the "No Load Test" look the motor over. The pinion should be checked to be sure it is free by turning it on the screw shaft. The armature should be checked so that it is free to rotate by prying the pinion with a screw driver. Tight bearing, bent armature shaft or loose pole shoe

screws could cause the armature not to turn freely. The motor should be disassembled if the armature does not turn freely. However, if the armature will rotate freely, the next step is to give the motor a no load test before disassembly.

Connect the starting motor in series with a fully charged battery of the specified voltage, an ammeter capable of reading several hundred amperes, and a variable resistance. Also connect a voltmeter as illustrated in Fig. 9 from the motor terminal to the motor frame. An R.P.M. indicator is necessary to measure armature speed. Obtain the specified voltage by varying the re- sistance unit, then read the current draw and the armature speed and compare these readings with the values listed in the specifications.

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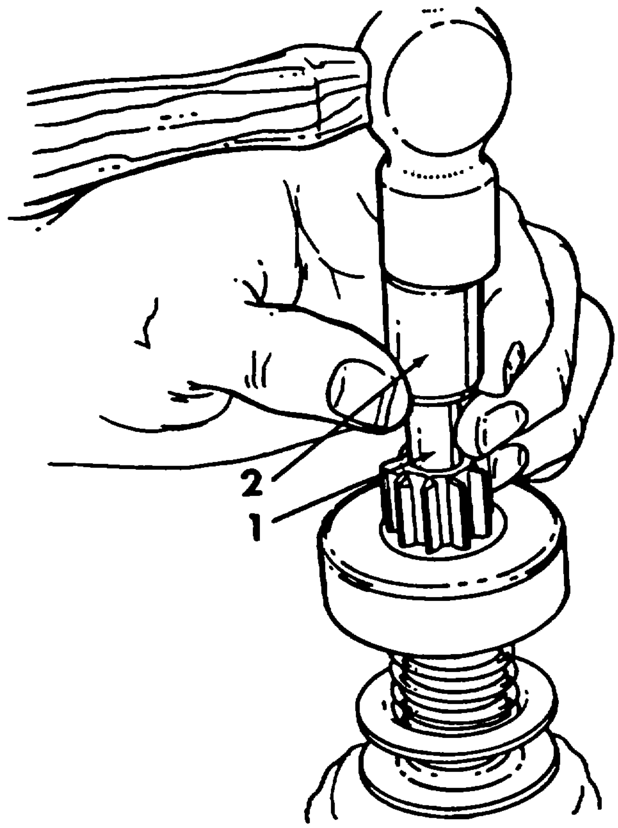


CG-6684

Fig. 10 Removing Retainer from Snap Ring

1. Retainer **2. Cylinder**

DISASSEMBLY

If the starting motor does not per- form according to the specifications it will be necessary to disassemble it for further tests of the components.

NOTE: Before starting to disassemble the starting motor etch mark the field frame, lever housing and the nose housing so they may be reassembled in the same position.

Intermediate Duty Drive Clutch Motor

1. Disconnect field coil connector from solenoid motor terminal and remove solenoid mounting screws.
2. Remove the through bolts.
3. Remove commutator end frame from field frame and frame from lever housing.
4. Remove the nose housing bolts and separate the lever housing and nose housing .
5. Remove the pinion from the armature by sliding a metal cylinder onto the shaft. With a hammer. strike the metal cylinder against the retainer, drive the retainer towards the armature core and off the snap ring, Fig. 10.
6. Remove the snap ring from the groove in the armature shaft. If snap ring is too badly distorted during removal, it must be replaced.
7. Remove the armature and clutch assemblies from the lever housing.
8. Separate the solenoid from the lever housing.

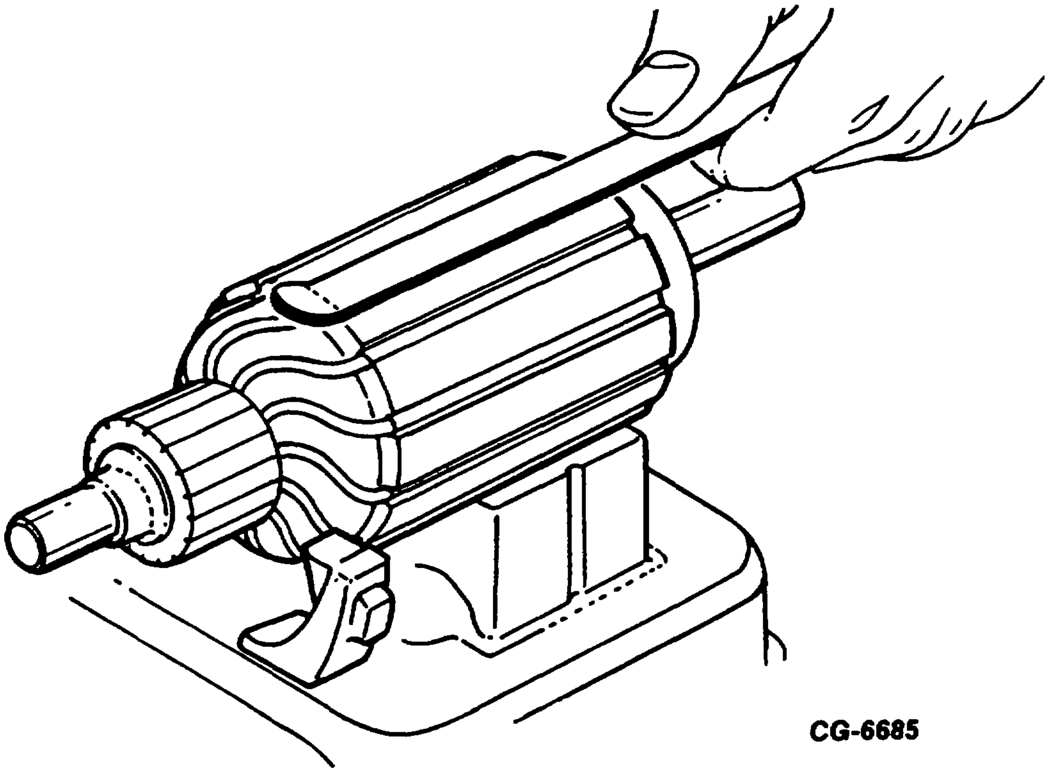


Fig. 11 Testing Armature for CG-6685 Short Circuits

Heavy Duty Drive Clutch Motor

1. Disconnect field coil connector from solenoid motor terminal and lead from solenoid ground terminal.
2. Motors which have brush inspection plates, remove the plates, then remove the brush lead screws which disconnect the field leads from the brush holders.
3. Separate the commutator end frame from the field frame.
4. Separate the nose housing and field frame from the lever housing.
5. Remove the armature and clutch assembly from lever housing.
6. Separate solenoid from lever housing by pulling apart.

INSPECTION AND REPAIR

1. Brushes, and Brush Holders - Inspect the brushes for wear. If they are worn down to one-half their original length, when compared with a new brush, they should be replaced. Clean brush holders and be sure that the brushes will not bind in the holders. The full length of the brush surface should ride on the commutator with spring tension to provide a good contact. Inspect the brush leads and screws to be sure they are tight and clean.

2. Armature - Inspect the armature to be sure there are no short circuits, open or grounds.

   a. Short circuits are located by turning the armature in a growler while holding a steel strip on the armature. The steel strip will vibrate on the area of the short circuit, see Fig. 11.

   b. Opens are usually found where the conductors are joined to the commutator. Loose or poor connections will cause arcing and burning of the commutator. If the bars are not burned too bad, resolder the leads in the riser bars and turn the commutator down in a lathe. Then under cut the insulation between the commutator bars 1/32!.

   c. Grounds in the armature can be founds using a test lamp and prods, see Fig. 12. If the lamp lights when one prod is positioned on the commutator and the other prod on the armature core or shaft the armature is groun4

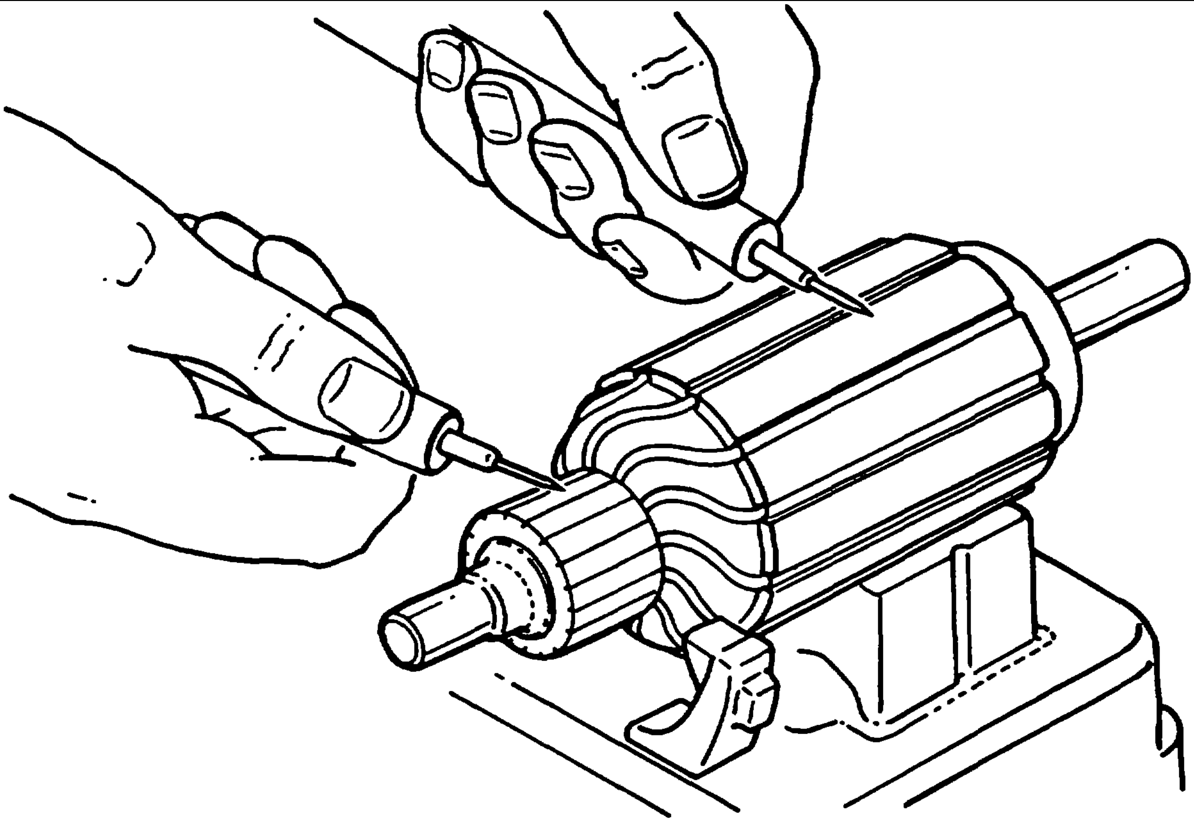


Fig. 12 Testing Armature for GroundsCG-6686

If the commutator is worn, dirty or out-of-round or the insulation is high, the commutator should be turned down and under cut.

3. Field Coils - Check field coils for ground and opens with a test lamp.
   a. Grounds - With the field coil ground disconnected, position one test prod on the field frame and the other to the field connector. If the lamp lights the field coils are grounded and must either be replaced or repaired.
   b. Opens - If the test lamp does not light when the prods are connected to the ends of coil leads, the field coils are open.

A pole shoe spreader and pole shoe screw driver should be used if the field coils are to be removed. Extra caution should be taken in replacing the field coils to prevent grounding or shorting when they are tightened in place. If the pole shoe has a long lip on one side, it should be assembled in the direction of armature rotation.

CLUTCH ASSEMBLIES

Four kinds of clutches or motor drives (a heavy duty sprag, a Positork drive, an intermediate duty type and a splined drive) may be used on the enclosed shift lever heavy duty motors.

The intermediate clutch may be either the sprag type or the four roll type. All four types are moved into mesh with the flywheel ring gear by action of the solenoid. The pinion will remain engaged until starting is assured and the solenoid is interrupted.

Intermediate Duty Sprag Clutch

1. Remove the lock wire, collar and spring from sleeve assembly. Early design type cluthes are equipped with a spring stop and a second lock wire which must be removed after removing the spring.
2. Remove the retainer ring and large washers. DO NOT remove sleeve assembly or sprags from shell-assembly.
3. Lubricate the sprags and saturate the felt washer with No. 5W-20 oil. Heavier oil must not be used.
4. Reassembly is the reverse of the disassembly.

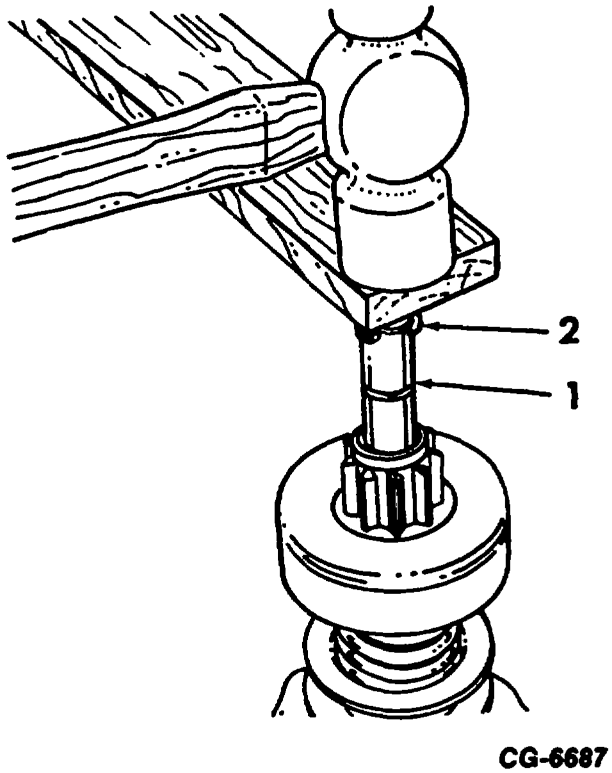


Fig 13 Installing Snap Ring

1. Groove **2 Snap ring**

Heavy Duty Sprag Clutch and DR-250 Drive

1. Remove the cupped pinion stop and split washer. When removing the cupped pinion stop it will probably be damaged. A new one will be required at time of reassembly.
2. Remove remaining parts such as pinion washer or retainer cups and baffle if equipped. The splined drive will have a spring cup (spring inside cup).
3. DO NOT lubricate the sprags on heavy duty clutches as they are lubricated for life with a special lubricant.
4. Reassembly is the reverse of the disassembly.

Spline Drive and Positork Drive

These types of drives are serviced by complete replacement only.

REASSEMBLY

The reassembly procedure for the most part is the reverse of the disassembly.

Motors using the snap ring and retainer on the armature shaft as the pinion stop are re-assembled as follows:

1. Place the clutch assembly on the armature shaft.
2. To aid in reinstalling the snap ring and retainer on the armature shaft observe the following:
   a. Place the retainer on the armature shaft with the cupped surface facing the snap ring groove.
   b. Place the snap ring on the end of the shaft. With a piece of wood on top of ring, force the ring over the shaft with a light hammer blow, Fig. 13. Then slide the ring down into the groove.
   c. To force the retainer over the snap ring, place a suitable washer over the shaft and squeeze the retainer and washer together with pliers, Fig. 14.
   d. Remove the washer.

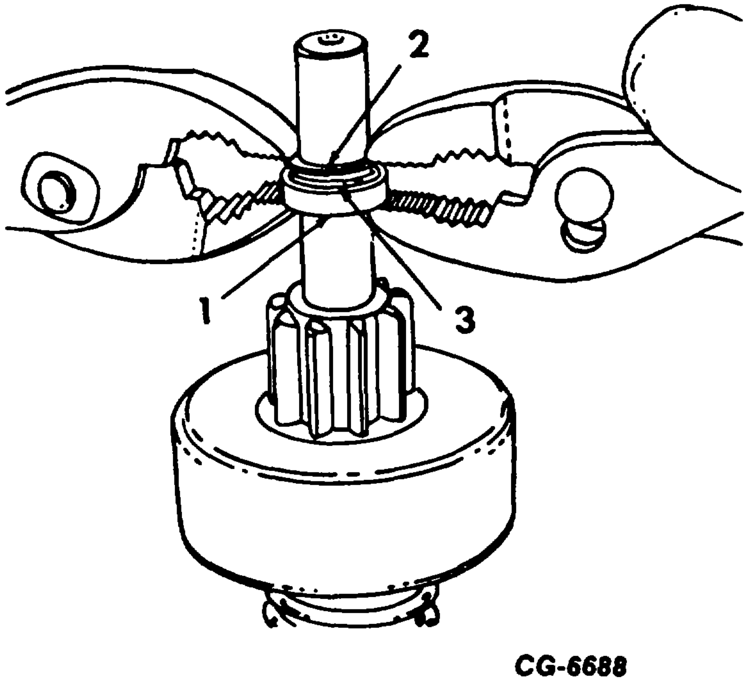


Fig. 14 Installation of Retainer

1. Retainer **2. Washer** **3. Snap Ring**

3. When reinstalling the field frame lever housing and nose housing align the etch marks scribed when the motor was disassembled.

4. Starting motors with the end frame which utilize eight brushes --

   a. Pull the armature out of the field frame just enough to permit the brushes to be positioned over the commutator.

   b. Push the commutator end frame and armature back against the field frame.

5. On intermediate duty clutch motors, be sure to assemble all brushes to the brush arms so the long side of the brush is toward the commutator end frame (the brush holes are off-set). Otherwise, the brushes may contact the riser bars.

6. Be sure all wicks and oil reservoirs are saturated with SAE-10 oil and the splines were coated with a light coat of SAE-10 oil also. Lever housings having a bearing and seal should have the grease cavity between the bearing and seal .filled with Delco-Remy Lubricant No. 1960954 or equivalent (Fig. 3 and Fig. 4).

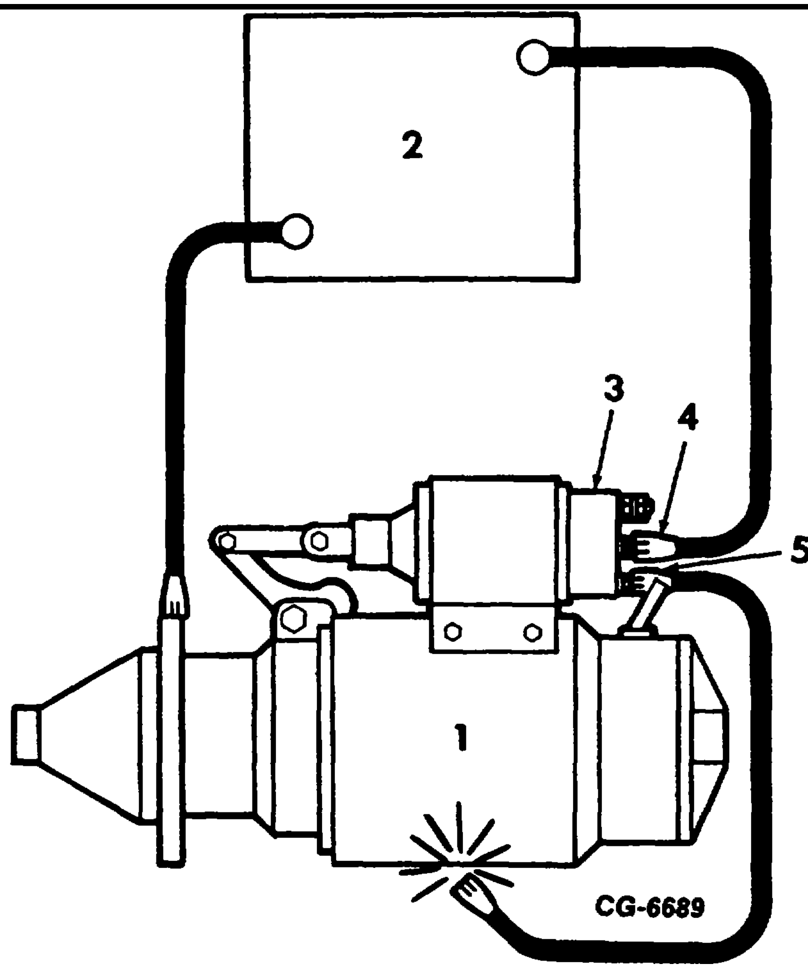


Fig. 15 Pinion Drive Clearance Check Hookup

1. Starting Motor
2. Battery
3. Battery Terminal (Batt.)
4. Solenoid Terminal (S)
5. Motor Terminal (M)

PINION CLEARANCE

There are no provisions for adjusting the pinion clearance on motors using the intermediate duty clutch, Fig. 2. However, the pinion clearance should be checked on all motors after reassembly to insure proper clearance. Check the pinion clearance as follows:

1. Disconnect the motor field coil connector from the solenoid motor terminal. CAREFULLY INSULATE IT.

2. Connect a battery, of the same voltage as the solenoid, one lead to solenoid switch terminal and the other to the starter or solenoid frame, Fig. 15.

3. Connect a jumper wire to the starting motor terminal on the solenoid, then touch the second end to the motor frame. This will shift the pinion into cranking position and will remain until the battery is disconnected.

CAUTION: Do not keep the jumper wire connected too long as overheating of the solenoid may result.

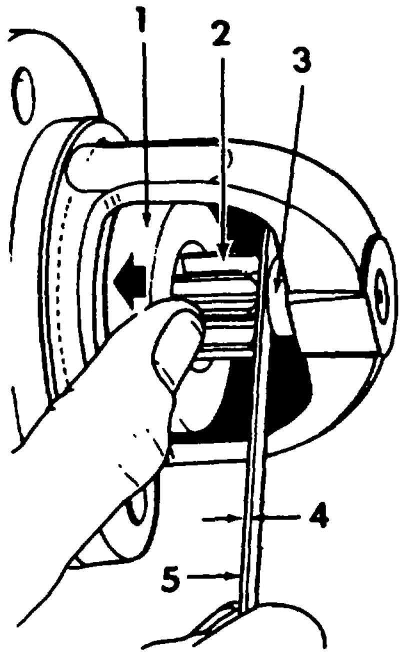


Fig. 16 Checking Pinion Clearance on Motors with the Intermediate Duty Clutch

1. Press on clutch as shown to take up movement
2. Pinion
3. Retainer
4. .010" to .140" pinion clearance
5. Feeler gauge

4. Push the pinion back towards the commutator end to eliminate any overtravel. Measure the distance between the pinion stop and pinion. The clearance should be:

   a. Intermediate Duty Clutch -- .010 to .140 inch, Fig. 16.

   b. Heavy Duty Clutch -- 23/64 inch, Fig. 16 and Fig. 17.

   c. Motors with Spline Drive -- .010 to .070 inch between spline and retainer.

5. Clearance is adjusted by removing plug and gasket on rear housing and turning the adjustment nut, Fig. 17 and Fig. 18.

Model Numbers	System Voltage	NO LOAD TEST					
		Volts	Amperes* Minimum	Amperes* Maximum	RPM Minimum	RPM Maximum
1114120	12	9	140	190	4000	7000

LUBRICATION

Replace old Section with this revised Section in your CTS-4001 Manual.

CONTENTS

GENERAL

New vehicles are lubricated before they are delivered. After the vehicle is placed in operation, regular lubrication Intervals, based on the type of service and road conditions, should be established. Thorough lubrication at definite intervals will add greatly to the service life of the vehicle and will reduce the overall operating expense.

The interval between lubrication periods, oil changes, etc., depends entirely upon operating conditions. The loads carried, speed, road and weather conditions all contribute to the frequency of lubrication periods.

In some types of operation, and where operating conditions are extremely severe (such as In deep water, mud, or unusually dusty conditions), the vehicle may require lubrication after every twenty-four (24) hours of operation.

Only lubricants of the best quality such as IH oil and lubricants, having proper body or viscosity, should be used. The use of inferior products will reduce the service life of the vehicle or result In failure of its components.

The International Harvester Company Truck Group recommends the use of its regular IH oil and lubricants available through your IH truck dealer.

The lubrication specifications refer only to the viscosity (SAE) and type to be applied. The viscosity numbers have been adopted by the Society of Automotive Engineers to classify lubricants according to "body or "lme4ss" land do not cover any other properties.

Unless otherwise specified, never add lubricant unless it is the same grade as that which is already in use. ithe grade is unknown or not available, drain flush and refill with new lubricant

The Lubrication Intervals specified should be performed at whatever interval occurs first, whether It is months or miles (kilometers).

ENGINE OIL

Keep oil level as near the high level mark as possible. Never operate an engine with oil level below low level mark.

When checking the oil level, the dipstick must be withdrawn and wiped clean, then Inserted all the way and withdrawn again for a true reading.

Never check the oil level with the engine running or immediately after engine shutdown as an inaccurate reading will be obtained.

ENGINE OIL SPECIFICATIONS
OIL QUALITY

Oil quality is described by API (American Petroleum Institute) engine service categories. API categories are defined by oil performance (deposits and wear) measured In standardized engine tests. API *So categories (SC, SE, SF) describe oils for spark ignition (gasoline) engines, while 'C' categories (CC, CD) describe oils for diesel engines. Oils with both 'Sw and *C' categories (such as SF/CD) are suitable for both spark ignition and diesel engines. Sometimes, the "S and C" categories are reversed (such as CD/SF).

Oil quality Is also described by two current U.S. Military Specifications, MIL-L-46152B and MIL-L-2104D. (MIL-L-2104D recently superseded MIL-L-2104C, which is now obsolete but which may still be widely used.)

The oil quality recommended depends upon engine type (diesel or spark ignition) and engine design. There are many supplementary fuel and oil additives for sale. if you follow the lubricant and oil-change Interval recommendations, your engine will not require these additives.

NOTE: Do NOT use oils specifically marketed by suppliers for stationary, marine, or railroad diesel engines, or for stationary natural gas engines, even though they are marked API category CD. Such oils can cause excessive valve train wear and combustion chamber deposits. (These oils are sold only In drums or bulk.)

9.0 LITER DIESEL ENGINES

Use oils meeting API categories SE/CC, SF/CC, CD, SC/CD, SE, CD, or SF/CD, or Military Specifications MIL-L-46152B, MIL-L-2104D, or MIL-L-2104C. IH No. 1 Engine Oil meets these requirements.

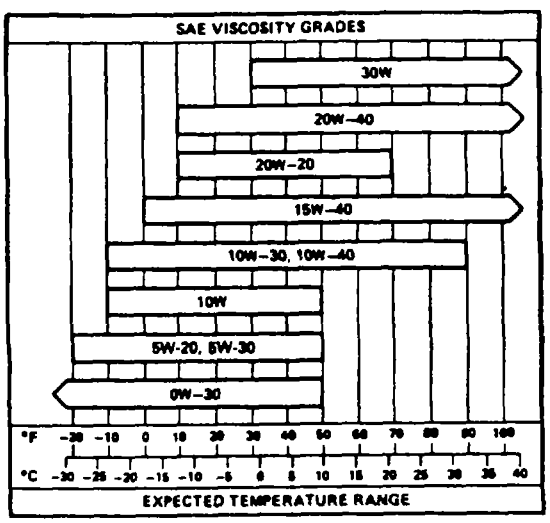
OIL VISCOSITY

Oil viscosity (thickness) is described by SAE (Society of Automotive Engineers) Viscosity Grade. Colder temperatures require lower viscosity oils to ensure good flow during starting, while hotter temperatures require higher viscosity oils for satisfactory lubrication. Based upon the temperature range you expect before your next oil change, use oil viscosity chart and the notes below to choose the proper viscosity grade. Using other viscosity grades, or using viscosity grades at temperatures outside the recommended ranges could result in engine damage.

ENERGY CONSERVING OILS

Oils marketed as 'Energy Conserving' are Intended to improve fuel economy in passenger car engines. Some of these oils contain friction modifier chemical additives. One additive, molybdenum dithiophosphate, has been implicated in copper corrosion problems in some heavy duty diesel engines. Therefore, until further information is available, do not use an 'Energy Conserving' oil containing molybdenum dithiophosphate in any IH-built engine. In addition, some 'Energy Conserving' oils meet only API category SF for spark ignition engines, and do not meet the oil quality requirements for diesel engines.

OIL VISCOSITY CHART



MT28279A

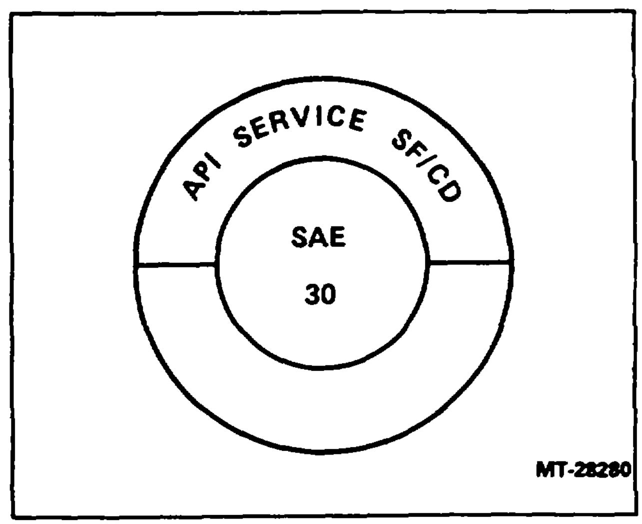
1. SAE 30 is the preferred viscosity grade for 6.9 liter diesel engines for all operating conditions where the temperature will not be colder than - 1°C **(+30(F).**

2. Some Increase In oil consumption may be expected when SAE OW-30, 5W-20, 5W-30, 10W, 10W-30, and 10W-40 oils are used. Check oil level more frequently.

3. SAE 5W-20 oils are not recommended for continuous, high speed operation.

OIL IDENTIFICATION SYMBOL

An oil container symbol system has been developed to help you choose the proper oil. The top portion of the symbol shows the oil quality, such as API Service SF/ CD in the example. The symbol may show additional categories, such as API Service SE, SF/CC, CD. The center portion will probably show the SAE viscosity grade, such as SAE 30 in the example. If the lower portion shows 'Energy Conserving, " be sure the upper and center portions show correct API service category and proper SAE viscosity grade recommended for your engine.



ADDITIONAL INFORMATION

Additional Information may be obtained from: SAE, 400 Commonwealth Drive, Warrendale, PA 15096 API, 2101 L Street NW, Washington, DC 20037

ENGINE MAINTENANCE SCHEDULE CHARTS (CONTINUED)
9.0 LITER ENGINES

Maintenance Operations ⑤	Daily	Inspection Interval				
		Every 9 600 km, 6,000 Miles 200 Hours or 3 Months	Every 19 200 km 12,000 Miles, 400 Hours or 6 Months	Every 38 400 km 24,000 Miles, 800 Hours or 12 Months	Every 96 000 km 60,000 Miles, 2000 Hours or 30 Months	Every 241 500 to 322 000 km, 150,000 to 200,000 Miles, or 5,000 to 6,700 Hours
Inspect Coolant and Oil Levels	X					
Inspect Low Oil Pressure Alarm (If Equipped).	X					
Inspect Air Cleaner Restriction Indicator ①	X					
Drain Water Separator (Fuel System) (If Equipped)	X					
Inspect for External Leakage	X					
Inspect and Adjust Belts		X				
Change Engine Oil and Oil Filter ③		X				
Change Fuel Filters			X			
Clean or Replace Air Filter	←		①			→
Valve Lash Adjustment ②⑥⑦					X	
Check Low Idle Speed ④⑥				X		
Check High Idle Speed ④⑥				X		
Check Accelerator Linkage ⑥				X		
Test Injection Nozzle ⑥						X
Check Transfer Pump Pressure ⑥				X		

1 Indicator will signal when air filter element should be replaced or cleaned.
2 New or rebuilt engine every 60,000 miles, 96 000 km, 2,000 hours or 30 months.
3 If fuel contains more than 0.5 percent sulfur, reduce oil change intervals as follows’

Sulfur Content, Percent	Oil-Change Interval
Below 0.5	Normal
0.5 to 1.0	1/2 Normal
Above 1.0	1/4 Normal

4 New or rebuilt engine after 6,000 miles, 9 600 km, 200 hours or 3 months, then every 24,000 miles, 38 400 km, 800 hours or 12 months.
5 Service Instructions will be found in 1171563R1, 9.0 Liter Engine Operation and Maintenance Manual.
6 Service Instructions will be found in CGES-240-3, Diesel Engine Diagnostic Manual.
7 Adjustment procedure can be found in CGES-205, 9 0 Liter Engine Service Manual.

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COOLING SYSTEM

ANTI-FREEZE

The cooling system of your new vehicle is filled at the factory with IH permanent-type anti-freeze. IH permanent-type anti-freeze may be added undiluted if protection below **-2C** (-2F) is required.

CLEANING

Once a year the cooling system should be drained and thoroughly flushed.

Unless the cooling system is treated with a corrosion preventative, rust and scale will eventually clog up passages in the radiator and water jackets. This condition is aggravated in some localities by formation of insoluble salts from the water used.

IH cleaning solutions are available which have proven very successful in removing accumulation of rust, scale, sludge and grease. This solution should be used according to the recommendation on the container.

CAUTION - DO NOT USE CHEMICAL MIXTURES TO STOP RADIATOR LEAKS EXCEPT IN AN EMERGENCY. NEVER USE SUCH SOLUTIONS INSTEAD OF NEEDED RADIATOR REPAIR.

When draining e cooling solution., disconnect the radiator outlet hose, as large particles of sediment will not pass through the drain.

WARNING - USE ONLY THE FOLLOWING PROCEDURE TO REMOVE THE PRESSURE TYPE CAP FROM THE RADIATOR. ALWAYS ALLOW THE ENGINE TO COOL FIRST. WRAP A THICK, HEAVY CLOTH AROUND THE CAP. PUSH DOWN, LOOSEN CAP SLOWLY TO ITS FIRST NOTCH POSITION; THEN PAUSE A MOMENT. THIS WILL AVOID POSSIBLE SCALDING BY HOT WATER OR STEAM. CONTINUE TO TURN CAP TO THE LEFT AND REMOVE.

CAUTION - IF THE COOLANT SHOULD GET EXTREMELY LOW AND THE ENGINE VERY HOT, LET THE ENGINE COOL FOR APPROXIMATELY 15 MINUTES BEFORE ADDING COOLANT; THEN, WITH THE ENGINE RUNNING, ADD COOLANT SLOWLY. ADDING COLD WATER TO A HOT ENGINE MAY CRACK THE CYUNDER HEAD OR CRANKCASE.

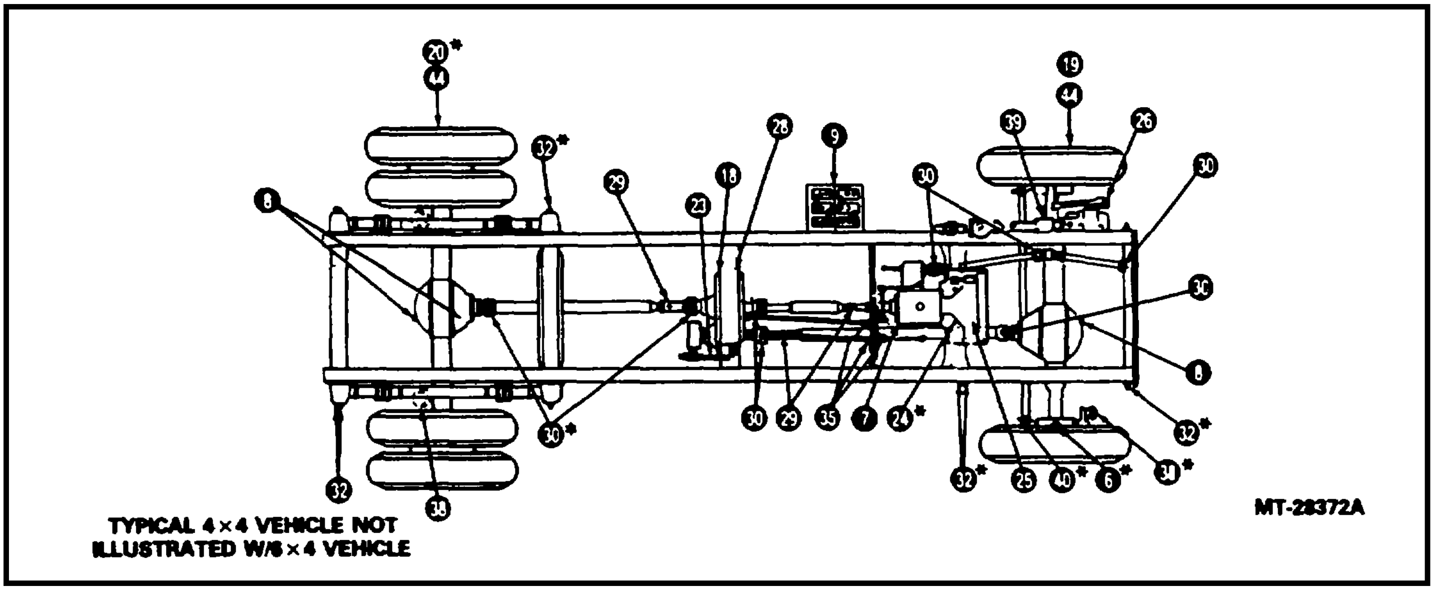

Figure 2- Lubrication Points- Typical 4x4

Page 2643 DELETED

LUBRICATION - MAINTENANCE GUIDE INTERVALS

KEY NO.	DESCRIPTION	OPERATION	USE OR REMARKS①
DAILY INSPECTION			
1	Engine Crankcase Level Change Interval	Check and Correct	A Refer to Engine Oil Specifications and Engine Maintenance Charts
2	Coolant Level	Check and Correct on each Fuel Stop	Refer to Cooling System in this Section
NI	Low Oil Pressure Alarm	Correct as Necessary	Refer to Engine Oil Specifications
NI	External Leakage	Correct as Necessary	
NI	Air Cleaner Restriction Indicator	Correct as Necessary	B
3	Fuel/Water Separator	Drain and Replace Element as Necessary	
AS REQUIRED			
NI	Air Cleaner (Engine)	Clean or Replace	B
NI	Speedometer, Tachometer Cable	Lubricate	IH251 H EP Grease or equivalent NLGI #2 Multi-purpose Lithium Grease. (Electronic Speedometer or Tachometer Not Required)
NI	Speedometer, Tachometer Head	Lubricate	Light Weight Oil (Not Required w/ Electronic Speedometer or Tachometer)
3	Fuel Filters	Replace	Refer to Engine Maintenance Charts found in this Manual or Separate Engine Supplements.
4	Engine Oil Filter	Replace	
5	Throttle Linkage	Lubricate	Light Engine Oil
6	Trunnion Bearing and Axle Shaft U-Joint-Dana Axles	Lubricate	O
NI	Seat Adjuster Slides		IH251 H EP Grease or Equivalent NLGI #2 Multi-Purpose Lithium Grease.
NI	Manifold Heat Control Valve	Lubricate	Penetrating Oil
4,000 MILES, 6000 KILOMETERS OR MONTHLY			
8	Differential (Front or Rear Axles) Dana	Change Initial Fill	Mileage Interval Only. Q C
8	Differential (Front or Rear Axles)	Check Level and Correct as Required	C, Q
9	Battery (With Caps)	Check Water Level	Distilled Water
9	Battery Posts	Clean	Grease After Cleaning
10	Brake Master Cylinder S-Series,	Check Level and Correct as Required	Super Heavy Duty "DOT 3" Brake Fluid.

•Registered Trademark of General Motors Corporation NI = Not Illustrated NA = Not Applicable
①Letters indicate additional requirements of Special Instructions following this chart.

LUBRICATION - MAINTENANCE CUIDE INTERVALS

KEY NO.	DESCRIPTION	OPERATION	USE OR REMARKS①
4,000 MILES, 6000 KILOMETERS OR MONTHLY (CONTINUED)			
17	Power Steering Pump	Check Level and Correct as Required	F
18	Transfer Case	Check Level and Correct as Required	H
7	Transmissions	Check Level and Correct as Required	
	Automatic		M
23	Parking Brake Linkage S-Series, Cargostar	Lubricate	Light Weight Engine Oil
NI	Door Check, Hinges, Latches, Strikers, S-Series, Cargostar	Lubricate	Light Weight Engine Oil
NI	Hood Linkage	Lubricate	Light Weight Engine Oil
NI	Cab Latch and Lock Levers, Cargostar, CO9670 & CO5870	Lubricate	Mobil SHC 32 Low Temp Lubricant or Equivalent
26	Drag Link S-Series	Lubricate	IH 251 H EP Grease or Equivalent NLGI #2 Multi-Purpose Lithium Grease
NI	Hood Tilt Linkage	Lubricate	IH 251 H EP Grease or Equivalent NLGI #2 Multi-Purpose Lithium Grease
NI	Power Divider Lock Yoke Pin	Lubricate	IH 251 H EP Grease or Equivalent NLGI #2 Multi-Purpose Lithium Grease
27	Prop Shaft Center Bearing	Lubricate	IH 251 H EP Grease or Equivalent NLGI #2 Multi-Purpose Lithium Grease

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LUBRICATION - MAINTENANCE GUIDE INTERVALS

KEY NO.	DESCRIPTION	OPERATION	USE OR REMARKS①
4,000 MILES, 6000 KILOMETERS OR MONTHLY (CONTINUED)			
28	Parking Brake Relay Lever	Lubricate	IH 251 H EP Grease or Equivalent NLGI #2 Multi-Purpose Lithium Grease
29	Prop Shaft Slip Joint	Lubricate	IH 251 H EP Grease or Equivalent NLGI #2 Multi-Purpose Lithium Grease
30	Prop Shaft U-Joint	Lubricate	IH 251 H EP Grease or Equivalent NLGI #2 Multi-Purpose Lithium Grease
31	Power Take Off Shift Control	Lubricate	IH 251 H EP Grease or Equivalent NLGI #2 Multi-Purpose Lithium Grease
32	Spring Pins	Lubricate	IH 251 H EP Grease or Equivalent NLGI #2 Multi-Purpose Lithium Grease
33	Steering Gear Relay Lever Cargostar	Lubricate	IH 251 H EP Grease or Equivalent NLGI #2 Multi-Purpose Lithium Grease
34	Suspension Connecting Tube Bearing	Lubricate	IH 251 H EP Grease or Equivalent NLGI #2 Multi-Purpose Lithium Grease
35	Transfer Case Shift Linkage	Lubricate	IH 251 H EP Grease or Equivalent NLGI #2 Multi-Purpose Lithium Grease
16,000 MILES, 26 000 KILOMETERS OR 5 MONTHS			
NI	Air Cleaner (Air Compressor)	Clean or Replace	
38	Brake Camshafts and Manual Slack Adjusters	Lubricate	
39	Steering Column U-Joints, Slip Joint	Lubricate	
40	Tie Rod Ends	Lubricate	N IH 251 H EP Grease or Equivalent NLGI #2 Multi-Purpose Lithium Grease
41	Transmission Air and Oil Filter	Replace	
18	Transfer Case	Change Lubricant	H
7	Transmission (Automatic)	Change Lubricant	M

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①Letters indicate additional requirements of Special Instructions following this chart.

LUBRICATION - MAINTENANCE GUIDE INTERVALS

KEY NO.	DESCRIPTION	OPERATION	USE OR REMARKS①
20,000 MILES, 32 000 KILOMETERS OR MONTHLY			
20,000 MILES, 32 000 KILOMETERS OR 20 MONTHS			
43	Power Steering Pump Filter Element	Replace	
24,000 MILES, 38 000 KILOMETERS OR 5 MONTHS			
38	Brake Automatic Slack Adjusters	Lubricate	IH 251 H EP Grease or Equivalent NLGI #2 Multi-Purpose Lithium Grease
NI	Brake Pedal to Brake Valve Linkage	Lubricate	Light Weight Engine Oil
32,000 MILES OR 51 000 KILOMETERS			
7	Transmission (Fuller) Main & Aux.	Change Lubricant	J After Initial Fill Lubricant Change
32,000 MILES, 51 000 KILOMETERS OR ANNUALLY			
44	Wheel Bearings (Grease)	Repack	IH 251 H EP Grease or Equivalent NLGI #2 Multi-Purpose Lithium Grease
52,000 MILES, 84 000 KILOMETERS OR 6 MONTHS			
ANNUALLY, 100,000 MILES OR 160 000 KILOMETERS			
8	Differential (Front or Rear) Dana	Change Lubricant	Q After Initial Change, Change Annually
NI	Door Lock Cylinders	Lubricate	Lock Oil
OVERHAUL			
45	Alternator	Lubricate	Cam and Ball Bearing Lubricant (Delco-Remy #1948791)
NI	Brake Caliper & Anchor Plate	Lubricate	NLGI #1-1/2 (Part No. 990647Cl)
NI	Brake Shoe Anchor Pins	Lubricate	IH 251 H EP Grease or Equivalent NLGI #2 Multi-Purpose Lithium Grease

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①Letters indicate additional requirements of Special Instructions following this chart.

SPECIAL INSTRUCTIONS

A. For Engine Oil Specifications refer to Engine Oil Specifications in this Section (except Diesel Engines not manufactured by IH. This information will be found in separate engine supplements furnished with vehicle).

Recommended Engine Oil and Oil Filter Service Intervals will be located in operator's manual (Maintenance Charts) or separate manuals furnished with vehicle.

B. Diesel Engines: When air restriction reading (In Inches of water vacuum) reaches the following, clean or replace engine air cleaner. Refer to Restriction Gauge Instructions in operator's manual.

Engine	Inches of Water Vacuum
IH 9.0 Liter & Detroit Diesel Turbocharged	20 in. $_{H20}$ or 500mm

Washing Procedure: (Not Donaldson Konepac Element). Filter element can be washed with any good non-sudsing, household detergent. Use warm water 49-60'C (120-140°F). Flush filter with gentle stream until drain water Is clean. Air dry element before using. Also Inspect after every cleaning for damage or rupture. Wipe all Internal parts clean before reassembling. Replace gasket regularly.

D. Rockwell front or rear axle lubricant change after initial fill lubricant change is as follows:
Vehicles operated less than 60,000 miles or 97,000 kilometers - change lubricant twice a year.
Vehicles operated more than 60,000 miles or 97,000 kilometers - change lubricant every 25,000 to 30,000 miles or every 40,000 to 48,000 kilometers.

Refer to Note 'C" for lubricant.

E. SAE-10OW Engine Oil for temperatures - 18*C (0°F) and up. For temperatures below - 18"C (OOF) use three parts SAE-10OW engine oil to one part kerosene. The mixture can safely be used In temperatures up to O°C (32*F).

Ross Gears: 10W-40 Engine Oil Only.

G. Lubrication Procedures:
With chassis load on axle, force grease through thrust bearings. Then with axle lifted clear of floor, force grease between king pin and bushing surfaces. Use IH 251H EP grease. Except Rockwell front axles with permanently sealed king pins and permanently lubricated tie rod ends. Do not raise wheel end off ground when greasing.

H. Use straight mineral oil SAE 90 for temperatures - 18"C (O"F) and up. Use SAE 80 for temperatures below - 18"C (OF). D,=-I Recommendations: Where temperature is consistently below -18°C (0.F) and where parked vehicles are exposed to unusual cold for long periods, use SAE 75. Where temperatures are consistently above 32'C (90"F) or unusually hot, use SAE 140 straight mineral oil.

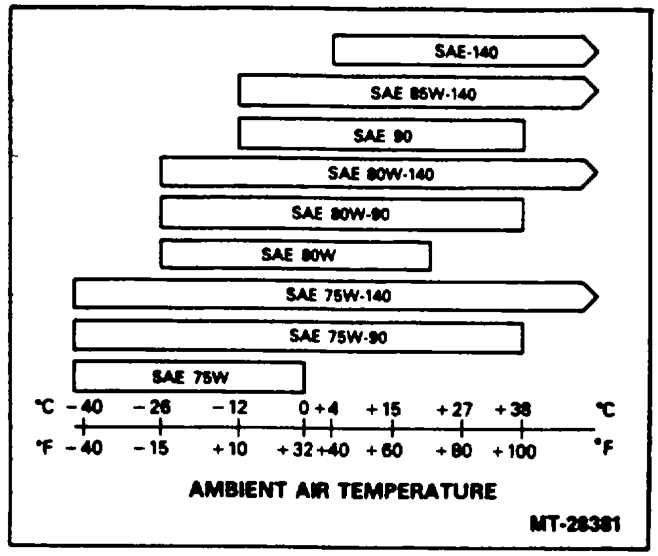
K. Spicer

Engine Oil (SF, CC or CD)	SAE 30	Below -18°C (0°F)
	SAE 30, 40, 50	Above -18°C (0°F)
Mineral Oil (Rust and Oxidation Inhibited)	SAE 80	Below -18°C (0°F)
	SAE 90	Above -18°C (0°F)

O. FA6 (Dana) and Front Driving Axles only - Lubricate with IH 251H EP Grease. Lube axle shaft U-Joint whenever axle shaft are removed. Lube trunnion bearings when bearing caps are removed for service. No periodic lubrication is required.

P. Use RHEOLUBE '362' or equivalent. RHEOLUBE 362 is available from Eaton Corporation under part number 113741. RHEOLUBE 362 is manufactured by NYE Specialists Lubricants, New Bedford, Mass.

Q. Dana-Spicer axles use SP type lubricant of API GL 5quality inspecting MIL-L-2105 B, C or better specifications including synthetic lubricants. For abnormally high temperatures, severe service (hot climate prolonged periods), use SAE 140. Refer to table at right.



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TO THE OWNER

This Service Manual is published to assist the reader in overhaul and maintenance instructions on the 9.0 Liter Diesel Engine. The manual is divided into two basic parts which are:

- Introductory Section
- Component Sections

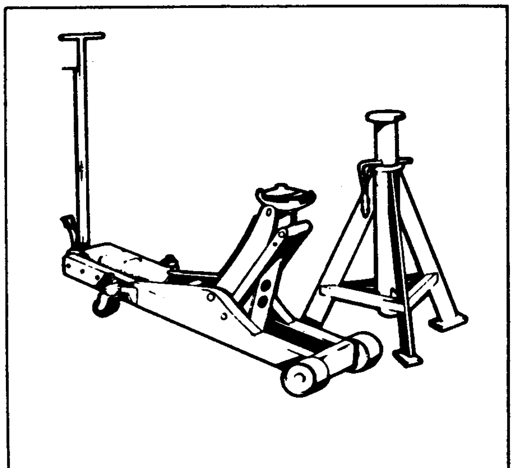
Introductory Section:

This part of the manual covers general areas which should be read before engine disassembly. It will also be used for reference during disassembly, repair and reassembly operations. The introductory section covers the following areas:

- Engine Features (General)
- Mounting Engine on Stand

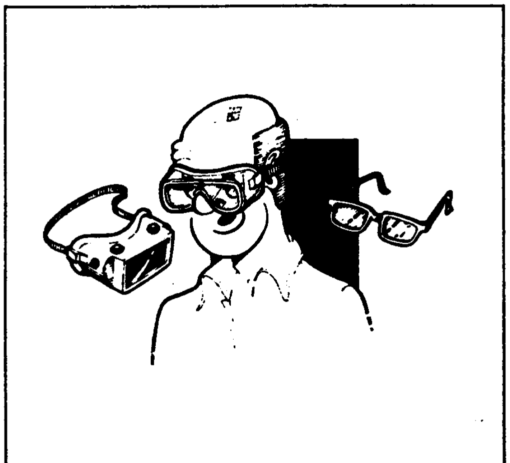
Component Sections:

This part of the manual covers each component of the engine providing the following exploded diagram, specifications, special torques, removal procedure, inspection and repair of the component and reassembly procedure.



CG-6057

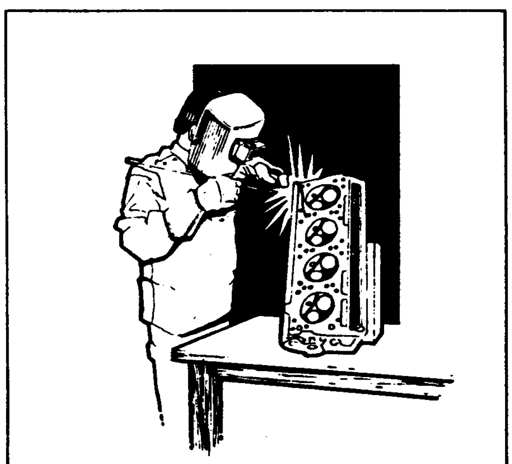
Always use safety stands in conjunction with hydraulic jacks or hoists. Do not rely on jack or hoist alone to carry the load. They can fail.



CG-6058

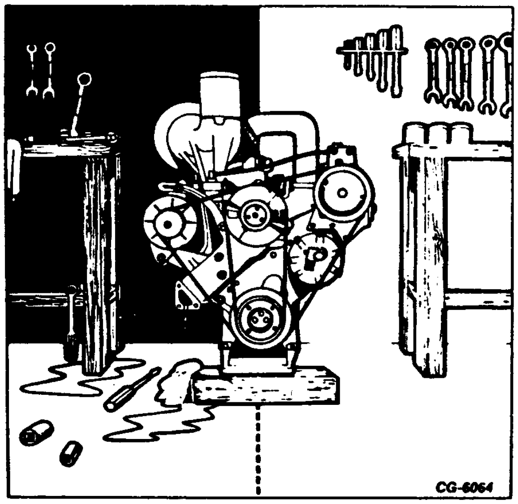
To prevent injury always select appropriates type safety glasses for the job.

It is especially important to wear safety glasses when using tools such as hammers, chisels, pullers and punches.



CG-6059

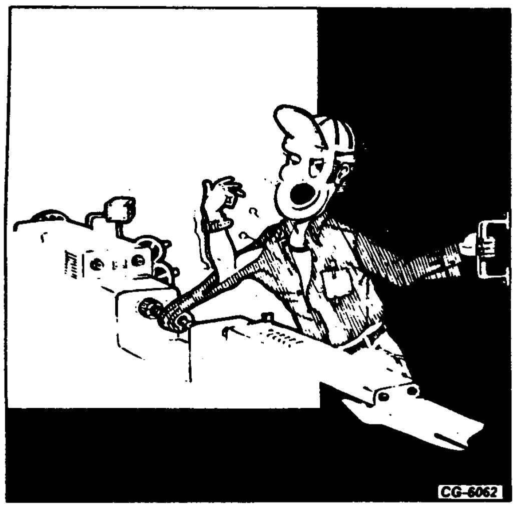
When welding or using an acetylene torch, always wear welding goggles and gloves. Insure acetylene and oxygen tanks are separated by a metal shields and are chained to a cart. Do not weld or heat area as near fuel tanks or fuel liens and utilize proper shielding around hydraulic lines.



Keep work area organized and clean. Wipe up oil spills of any kind. Keep tools and parts off floor. Eliminate the possibility of a fall which could result in a serious injury.

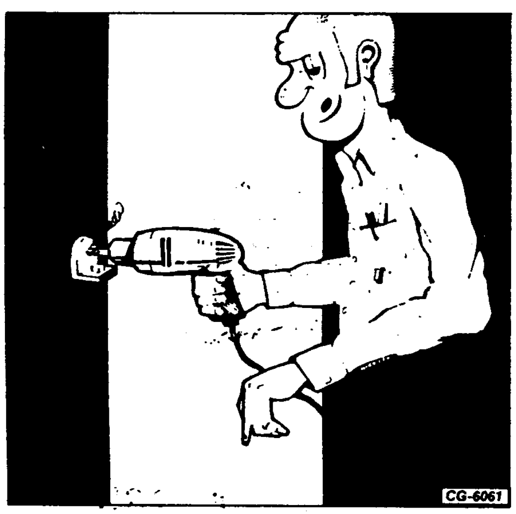
Be sure to reinstall safety devices, guards or shields after adjusting and/or servicing the machine.

After servicing, be sure all tools, parts, or servicing are removed from the machine.



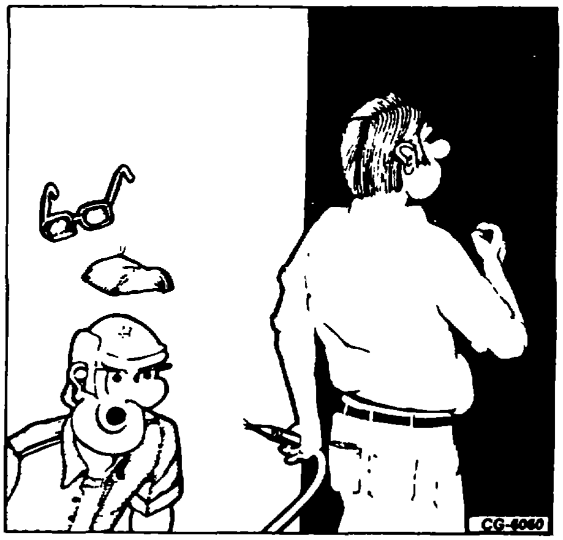
Be sure to wear safe work clothing. It should be well fitted and in good repair.

Do not wear rings, wrist watches or loose fitting clothing, when working on machinery, they could catch on moving parts causing serious injury. Wear sturdy, rough-soled work shoes. Never adjust and/or service a machine in bare feet, sandals or sneakers.



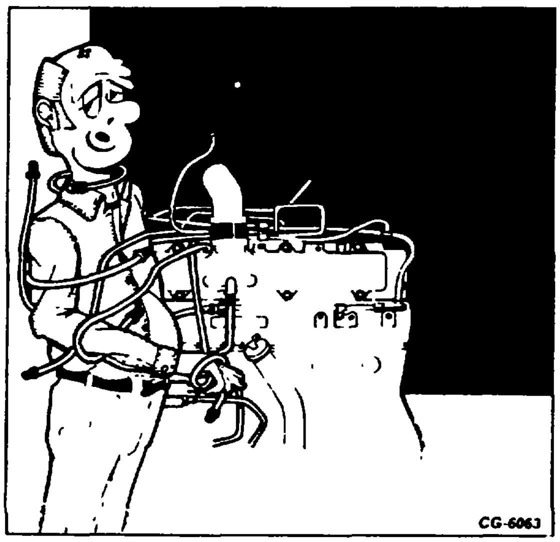
Do not use defective portable power tools. Check for frayed cords prior to using the tool. Be sure all electric tools are grounded.

SAFETY SUGGESTIONS



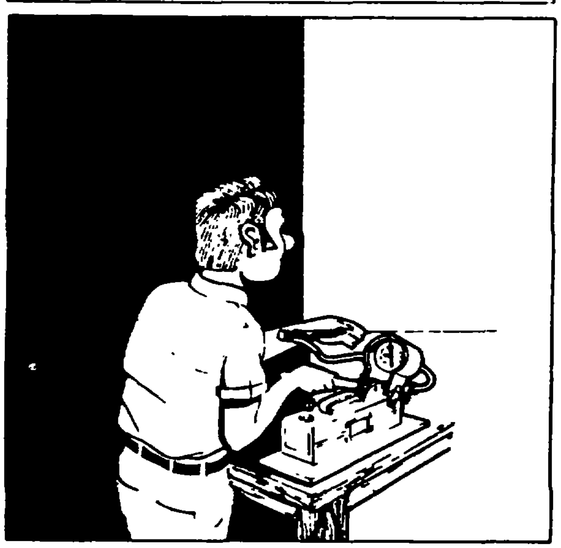
Be careful when using compressed air. Never apply compressed air to any part of the body or clothing, injury or death can occur.

Use approved air blow guns, do not exceed 30 psi, wear safety glasses or goggles and use proper shielding to protect everyone in the work area.



When removing fuel lines remove them as an assembly, not individually.

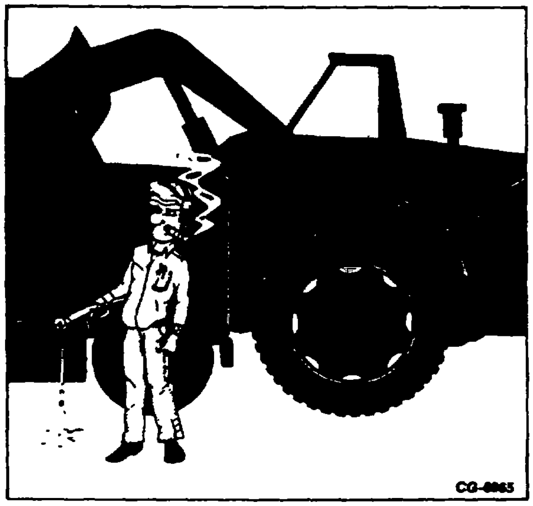
Avoid getting fuel injection lines mixed up as our friend has.



Be extremely careful when dealing with fluids under pressure.

Fluid under pressure can have enough force to penetrate the skin. These fluids may also infect a minor cut or opening in the skin. If injured by escaping fluid, see a doctor at once. Serious infection or reaction can result if medical treatment is not given immediately.

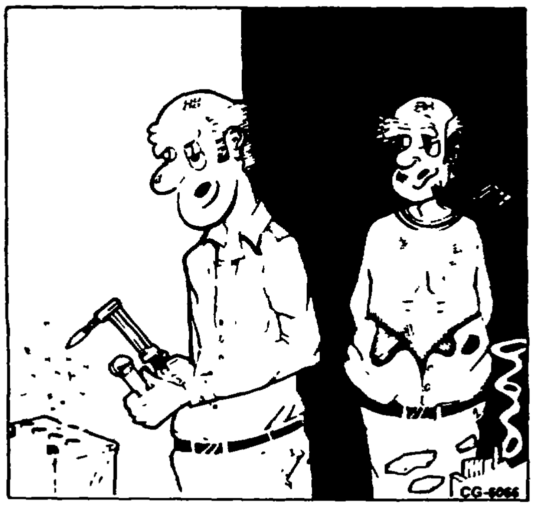
Never put your hands in front of fluid under pressure.



When refueling, keep the hose and nozzle or the funnel and container in contact with the metal of the fuel tank to avoid the possibility of an electric spark igniting the fuel.

Do not over fill the fuel tank overflow creates a fire hazard.

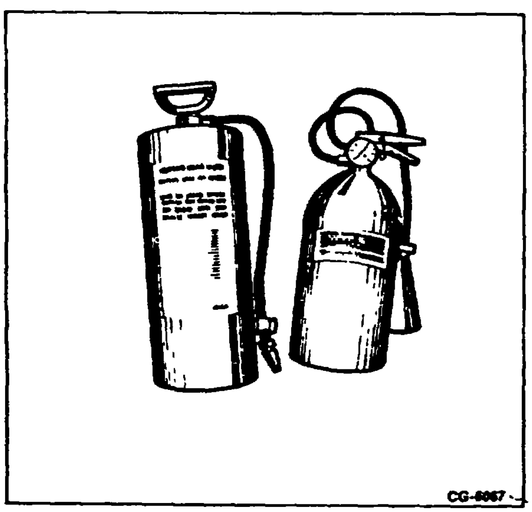
Do not smoke when refueling and never refuel when the engine is hot or running.



Electrical storage batteries give off highly inflammable hydrogen gas when charging and continue to do so for some time after receiving a steady charge.

Do not under any circumstances allow an electric spark or open flame near the battery or explosion may occur.

Always disconnect a battery cable before working on the electrical system.



Keep a "charged" fire extinguisher within reach whenever you work in an area where fire may occur.

Also, be sure you have the correct type of extinguisher for the situation:

Type A: Wood, Paper, Textile and Rubbish

Type B: Flammable Liquids

Type C: Electrical Equipment

CONVERSION TABLE

CONVERSION TABLE – INCH FRACTIONS AND DECIMALS TO MILLIMETER EQUIVALENTS											
INCHES		mm	INCHES		mm	INCHES		mm	INCHES		mm
Fract	Dec		Fract	Dec		Fract	Dec		Fract	Dec	
–	0004	01	–	3	7 620	–	7874	20	–	1 969	50
–	001	0250	5/16	.3125	7 938	51/64	.7969	20 241	2	2 000	50 8
–	0039	10	–	3150	8	13/16	8125	20 638	2 1/8	2 125	54
–	.005	127	21/64	3281	8.334	–	8268	21	–	2 165	55
–	0079	2	–	3346	8 5	53/64	8281	21 034	2 1/4	2 250	57 2
–	0098	25	11/32	.3438	8.731	27/32	.8438	21 431	–	2 362	60
–	01	254	–	3543	9	55/64	8594	21 828	2 3/8	2 375	60.3
–	0118	.3	23/64	.3594	9128	–	.8662	22	2 1/2	2 500	63.5
1/64	0156	397	–	3740	9 5	7/8	8750	22 225	–	2 559	65
–	0157	4	3/8	375	9 525	57/64	8906	22 622	2 5/8	2 625	66.7
–	0197	5	25/64	3906	9 922	–	9	22 860	2 3/4	2 750	69 9
–	0236	.6	–	3937	10	–	9055	23	–	2 756	70
–	025	635	–	4	10 160	29/32	9063	23.019	2 7/8	2 875	73
–	0276	7	13/32	4062	10 319	59/64	9219	23 416	–	2.953	75
–	0295	75	–	4134	10 5	15/16	9375	23 813	3	3.000	76 2
1/32	0313	794	27/64	4219	10 716	–	9449	24	–	3.150	80
–	0315	8	–	4331	11	61/64	9531	24 209	3 1/4	3 250	82 6
–	0354	9	7/16	4375	11 113	31/32	9688	24 606	–	3 346	85
–	0394	1	29/64	4531	11 509	–	9843	25	3 1/2	3.500	88 9
3/64	0469	1 191	15/32	4688	11 906	1	1 000	25 400	–	3.543	90
–	0472	1 2	–	4724	12	–	1 024	26	–	3 740	95
–	05	1.270	31/64	4844	12 303	1 1/16	1 062	26 988	3 3/4	3.750	95 3
–	0551	1.4	–	4921	12 5	–	1 063	27	–	3.937	100
–	0591	1 5	1/2	5	12 700	–	1 102	28	4	4 000	101 6
1/16	0625	1 588	–	5118	13	1 1/8	1 125	28 575	–	4 331	110
–	.0669	1 7	33/64	5156	13 097	–	1 142	29	4 1/2	4 500	114 3
–	075	1 905	17/32	5328	13 494	–	1 181	30	–	4 724	120
5/64	0781	1 984	–	5315	13 5	1 3/16	1 188	30 16	5	5.000	127
–	0787	2	35/64	5469	13.891	–	1 221	31	–	5.118	130
–	0906	2 3	–	5512	14	1 1/4	1 250	31 75	5 1/2	5 500	139 7
3/32	0938	2 381	9/16	5625	14 288	–	1 260	32	–	5 512	140
–	0984	2 5	–	571	14 5	–	1 299	33	–	5 906	150
–	1	2 540	37/64	5781	14 684	1 5/16	1 312	33 34	6	6.000	152.4
–	1024	2.6	–	5906	15	–	1 339	34	–	6.299	160
7/64	1093	2 776	19/32	5938	15 081	1 3/8	1 375	34 93	6 1/2	6 500	165 1
–	1181	3	–	.6	15 240	–	1 378	35	7	7.000	177 8
1/8	125	3 175	39/64	6094	15 478	–	1 417	36	–	7.087	180
–	1378	3.5	–	.6103	15 5	1 7/16	1 438	36 51	7 1/2	7 500	190 5
9/64	1406	3 572	5/8	6250	15 875	–	1 457	37	–	7 874	200
5/32	1563	3 969	–	6299	16	–	1 496	38	8	8.000	203 2
–	.1575	4	41/64	6406	16 272	1 1/2	1 500	38.10	8 1/2	8.500	215 9
11/64	1719	4 366	–	6496	16 5	–	1 535	39	–	8.661	220
–	1772	4.5	21/32	6563	16 669	1 9/16	1 562	39 69	9	9 000	228 6
3/16	1875	4 763	–	.6693	17	–	1 575	40	–	9 449	240
–	1969	5	43/64	6719	17 066	–	1 614	41	9 1/2	9 500	241.3
–	2	5 080	11/16	.6875	17 463	1 5/8	1 625	41 28	–	9 843	250
13/64	.2031	5.159	–	6890	17 5	–	1 654	42	10	10 000	254
–	2165	5.5	–	7	17 780	1 11/16	1 688	42 86	–	10 236	260
7/32	2188	5 556	45/64	.7031	17 859	–	1.693	43	11	11 000	279 4
15/64	2344	5.953	–	.7087	18	–	1 732	44	–	11 024	280
–	.2362	6	23/32	7188	18 256	1 3/4	1.750	44.45	–	11 811	300
1/4	25	6.350	–	.7283	18.5	–	1 772	45	12	12 000	304 8
–	2559	6.5	47/64	.7344	18 653	–	1 811	46	13	13.000	330.2
17/64	.2656	6.747	–	.7480	19	1 13/16	1 813	46 04	–	13.780	350
–	2756	7	3/4	.75	19 050	–	1 850	47	14	14 000	355 6
9/32	.2813	7.144	49/64	.7656	19 447	1 7/8	1 875	47 63	15	15.000	381
–	2953	7.5	–	.7677	19 5	–	1 890	48	–	15.748	400
19/64	2969	7.541	25/32	.7813	19 844	–	1.929	49	16	16.000	406.4

ENGINES **SERVICE MANUAL**

STANDARD TORQUE DATA FOR NUTS AND BOLTS - FOOT POUNDS

Recommended torque for all Standard Application Nuts and Bolts, provided:

A. All thread surfaces are clean and lubricated with SAE-30 engine oil. (See NOTE.)

B. Joints are rigid, that is, no gaskets or compressible materials are used.

C. When reusing nuts or bolts use minimum torque values.

NOTE: Multiply the standard torque by:

.65 When finished jam nuts are used.
.70 When Molykote, white lead or similar mixtures are used as lubricants.
.75 When parkerized bolts or nuts are used.
.85 When cadmium plated bolts or nuts and zinc bolts w/waxed zinc nuts are used.
.90 When hardened surfaces are used under the nut or bolt head.

1 FOOT POUND = 1.355 NEWTON METERS

Bolt or stud Diameter		Type 1 Studs Only		Type 1 Bolts 6" length or less		Type 1 Bolts longer than 6"		Type 5 (all lengths)		Type 8 (all lengths)			
										Only when used† in cast (gray) iron		All other applications	
Inches	MM	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
1/4	6.4	5	6	5	6	3	3	9	10	11	13	12	14
5/16	8.0	12	13	12	13	6	7	19	21	24	27	27	30
3/8	9.5	21	24	21	24	11	13	33	37	43	47	45	50
7/16	11.1	35	38	35	38	19	21	53	60	69	76	75	85
1/2	12.7	52	58	52	58	29	32	80	90	104	117	115	130
9/16	14.3	70	80	70	80	41	46	115	130	150	170	165	185
5/8	15.9	98	110	98	110	57	63	160	180	210	230	220	250
3/4	19.0	174	195	174	195	100	112	290	320	350	390	400	450
7/8	22.2	300	330	162	181	162	181	420	470	570	630	650	730
1	25.4	420	470	250	270	250	270	630	710	850	950	970	1090
1-1/8	28.6	600	660	350	380	350	380	850	950	1200	1350	1380	1550
1-1/4	31.8	840	940	490	540	490	540	1200	1350	1700	1900	1940	2180
1-3/8	34.9	1100	1230	640	710	640	710	1570	1760	2300	2500	2600	2800
1-1/2	38.1	1470	1640	850	940	850	940	2000	2300	3000	3300	3300	3700
1-3/4	44.5	2350	2450	1330	1490	1330	1490	3300	3700	4700	5200	5300	6000
2	50.8	3500	3900	2000	2200	2000	2200	5000	5500	7000	7800	8000	9000

† When bolt penetration is 1-1/2 times the diameter of the bolt.

STANDARD TORQUE DATA FOR NUTS AND BOLTS - NEWTON METERS

Recommended torque for all Standard Application Nuts and Bolts, provided:

A. All thread surfaces are clean and lubricated with SAE-30 engine oil. (See NOTE.)

B. Joints are rigid, that Is, no gaskets or compressible materials are used.

C. When reusing nuts or bolts use minimum torque values.

NOTE: Multiply the standard torque by:

.65 When finished Jam nuts are used.
.70 When Molykote, white lead or similar mixtures are used as lubricants.
.75 When parkerized bolts or nuts are used.
.85 When cadmium plated bolts or nuts and zinc bolts w/waxed zinc nuts are used.
.90 When hardened surfaces are used under the nut or bolt head.

1 NEWTON METER = 0.738 FOOT POUND

Bolt or stud Diameter		Type 1 Studs Only		Type 1 Bolts 6" length or less		Type 1 Bolts longer than 6"		Type 5 (all lengths)		Type 8 (all lengths) Only when usedt in cast (gray) iron		Type 8 (all lengths) All other applications	
Inches	MM	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
1/4	6 4	7	8	7	8	4	4	12	14	15	18	16	19
5/16	8 0	17	18	17	18	8	10	26	29	33	37	37	41
3/8	9 5	29	33	29	33	15	18	45	50	58	64	61	68
7/16	11.1	48	52	48	52	26	29	72	81	94	103	102	115
1/2	12.7	F71	79	71	79	39	43	108	122	141	159	156	176
9/16	14 3	95	108	95	108	56	62	156	176	205	230	225	250
5/8	15 9	133	149	133	133	77	85	220	245	285	310	300	340
3/4	19.0	240	265	240	265	136	152	390	430	470	530	540	610
7/8	22 2	400	450	220	245	220	245	570	640	770	850	880	990
1	25.4	570	640	340	365	340	365	850	960	1150	1290	1300	1480
1-1/8	28 6	810	900	470	510	470	510	1150	1290	1630	1830	1870	2100
1-1/4	31.8	1140	1270	660	730	660	730	1600	1830	2300	2600	2600	3000
1-3/8	34.9	1490	1670	870	960	870	960	2100	2400	3100	3400	3500	3800
1-1/2	38.1	2000	2200	1150	1270	1150	1270	2700	3100	4100	4600	4500	6000
1-3/4	44.5	3200	3300	1800	2000	1800	2000	4500	5000	6400	7000	7100	8100
2	50 8	4750	5300	2700	3000	2700	3000	6800	7500	9500	10500	10800	12200

When bolt penetration is 1-1/2 times the diameter of the bolt.

BOLT TYPE IDENTIFICATION CHART

IH Type	S.A.E. Grade	Description	Bolt Head Marking*
1	Equivalent 1 OR 2	WILL HAVE A STANDARD MONOGRAM IN THE CENTER OF THE HEAD Low or Medium Carbon Steel Not Heat Treated	
5	5	WILL HAVE A AND 3 RADIAL LINES Quenched and Tempered Medium Carbon Steel	
8	8	WILL HAVE A AND 6 RADIAL LINES Quenched and Tempered Special Carbon or Alloy Steel	

*The center marking identifies the bolt manufacturer. The monogram is currently used. Some bolts may still have an IH or a raised dot which previously identified IH bolts.

TORQUE - TENSION VALUES FOR STANDARD FASTENERS

This chart provides tightening torque for general purpose applications using original equipment standard hardware as listed in the Parts Catalog for the application Involved. DO NOT SUBSTITUTE. Original equipment standard hardware Is defined as IH Type 8, coarse thread bolts and nuts and thru hardened flat washers (Rockwell "C" 38-45), all phosphate coated and assembled without supplemental lubrication (as received condition).

The torques shown below also apply to the following:

1. Phosphate coated bolts used in tapped holes In steel or gray iron.
2. Phosphate coated bolts used with phosphate coated prevailing torque nuts (nuts with distorted threads or plastic Inserts).
3. Phosphate coated bolts used with copper plated weld nuts.

Markings on bolt heads or nuts indicate material grade ONLY and are NOT to be used to determine required torque.

Nominal Thread Diameter	Standard Torque 10%	
	N·m	lbf-ft
1/4	10	7
5/16	19	14
3/8	32	24
7/16	51	38
1/2	80	60
9/16	110	80
5/8	155	115
3/4	270	200
7/8	440	320
1	650	480
1-1/8	800	590
1-1/4	1100	830
1-3/8	1500	1100
1-1/2	1900	1400
1-3/4	3100	2300
2	4600	3400

SERVICE TOOL APPLICATION CHART

CYLINDER HEAD

1	Cylinder Head Lifting Sling	SE-1896
2	Cylinder Head Holding Fixture	SE-2104 - Valves at approximately 7 degree angle in head.
3	Valve Spring Compressor	SE-1846
4	Valve Spring Tester	SE-2241
5	Valve Stem Checking Gauge	SE-2614
6	Valve Guide Bore Gauge	SE-1826 (Adjustable Gauge Type) SE-2506 (Sunnen Indicator Type)
7	Valve Guide Cleaner	SE-1300
8	Valve Guide Remover	SE-1722
9	Valve Guide Installer	SE-1943
10	Valve Seat Insert Peening Tool	SE-2094 Inserts not peened in production.
11	Valve (intake) Seat Insert Remover	HC-104A
12	Valve Recession Checking Gauge	SE-2515 Depth Gauge.
13	Valve Seat Counterbore Cutters	SE-1797
14	Valve Seat Grinder:	
	a. Stones	Stones presently included in both SE-1631 and SE-1804 sets - requirements as follows: Exhaust Valve Seat (45°) SE-1631 = 1-3/4" O.D x 45° SE-1804 = K-87 rough; K-17 finish Intake Valve Seat (45°) SE-1631 = 2-1/8" O.D x 45° SE-1804 = K-98 rough; K-28 finish
	b. Tapered Pilots	Tapered pilots presently in both SE-1631 and SE-1804 sets requirement for both intake and exhaust valve guides as follows: SE-1631 = 3/8" minus.001", Standard 3/8", 3/8" plus .001", .002", .003" and .004" SE-1804 = T-374, T-375, T-376, T-377, T-378.
15	Reamer, Valve Guide I.D	SE-2215 - Service guide pre-reamed. Use reamer after installation in cylinder to clean up guide bore.
16	Rocker Arm Bushing Remover	Not required - Bushing not used. Arm machined to size.
17	Hydraulic Lifter Remover	SE-2097 - Lifters of the solid mechanical type. Tool has application with cylinder heads removed only.

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SERVICE TOOL APPLICATION CHART

CAMSHAFT

1	Bushing Remover and Installer	SE-1897 - Adapters SE-1897-3, -4, -5 and -6 applicable.
2	Camshaft Gear Remover	SE-1368 Gear employs two (2) 3/8"-16 UNC (2B) tapped holes for applying puller. Use 3-1/2" long hex bolts with flat washers.
3	Camshaft Gear Installer	SE-1900 Set. SE-1900-2 adapter (1" .20 Thd) will work on external threads of camshaft.
4	Camshaft Remover and Installer	SE-1880
5	Gear Backlash Check	SE-1848
6	Camshaft End Play Check	SE-1848

CRANKSHAFT

1	Crankshaft Pulley Puller	SE-1368 - Pulley employs four (4) 3/8"-16 UNC (2B) tapped holes equally spaced for applying puller.
2	Crankshaft Pulley Installer	SE-1900 - Use SE-19004 adaper. SE-1900-6 sleeve, SE-1900-8 screw, SE-1900-9 forcing nut and SE-1900-10 thrust washer.
3	Crankshaft Pulley Wear Sleeve Remover	Use small ball peen hammer tapping gently around circumference of wear sleeve to expand sleeve for removal.
4	Crankshaft Pulley Wear Sleeve	SE-1905 - Sleeve pressed on pulley flush with end of hub.
5	Crankshaft Gear Remover	SE-1368 - Gear includes two (2) 3/8"-16 UNC (28) tapped holes for applying puller. Also puller set includes suitable pulling arms to pick up at back face of gear.
6	Crankshaft Gear Installer	SE-1900 - Use SE-1900-4 adapter to apply installer.
7	Rear Main Bearing Cap Remover	SE-1719 - Use SE-17193 adapter to apply puller. Also SE-2093 remover used with SE-1746 slide hammer applicable.
8	Rear Main Bearing Cap Side Seal Installer	Suitable installer tool can be made locally from 1/8" diameter welding rod Service Manual to include instructions for making locally.
9	Main Bearing Cap Remover	SE-2093 - Use with SE-1746 slide hammer puller.
10	Crankshaft Rear Oil Seal Remover	SE-2091
11	Crankshaft Rear Oil Seal Installer	SE-2092 - Production seal installed flush with rear face of crankcase Service seal installed .085" below crankcase rear face.
12	Crankshaft Rear Oil Seal Wear Sleeve Remover removed	Use blunt chisel to mark sleeve several places; then tap with flat hammer until sleeve expands sufficiently to be Service Manual to include instructions
13	Crankshaft Rear Oil Seal Wear Sleeve Installer	SE-2092
14	Crankshaft End Play	SE-1848
15	Clutch Pilot Bearing Remover	SE-1746

SERVICE TOOL APPLICATION CHART

PISTON AND CONNECTING RODS

1	Piston Pin Retaining Ring Remover	SE-1884 Snap Ring Pliers.
2	Piston Pin Bushing Remover and Installer	SE-2417 - Used with SE-1033 support plate.
3	Piston Pin Bushing Burnisher	SE-2218 - Sunnen Hone - Service bushing requires burnishing .001" to .003" on diameter after installation in connecting rod. Use AL-1400 Expansion Manual to burnishing bushing.
4	Piston Pin Bushing Reamer	SE-2218 Sunnen Hone - Service bushing requires sizing after installation in connecting rod. Use SL-1500 mandrel and ST-1500 truing sleeve for sizing bushing to 1.50091.5011".
5	Piston Ring Expander	Standard automotive expander available locally applicable.
6	Piston Ring Compressor	SE-1610
7	Connecting Rod Aligner	SE-1099 -- Check for bent rods only. Rods incorporate special hardening process called “Tufftride" and rod straightening is not permitted.
8	Connecting Rod-Out-of-Roundness Bore Gauge	SE-2331 or AG-300 gauge supplied with SE-2218 Wet Hone.
9	Connecting Rod Side Play Check	Use feeler gauge.
10	Piston Fitting	Use micrometer to measure piston O.D. Measure bore I.D. using SE-2331 or SE-686 bore gauge.

CRANKCASE

1	Engine Lifting Eyes	SE-2721 or SE-2722 Load Positioning Sling.
2	Engine Overhaul Stand	SE-1962 -- Use No. 975 adapter with stand.
3	Cylinder Honing Equipment	SE-784
4	Cylinder Bore Gauge	SE-2331;SE-686
5	Cylinder Boring Equipment	SE-1399
6	Cylinder Glaze Breaker	SE-2314 Silicone Brush Type.
7	Front Cover Oil Seal Installer	SE-2096 - Production engines have oil seal installed .052" below front face in cover. Service oil seal to be installed .190" below front face in cover.
8	Front Cover Oil Seal Remover	SE-2091
9	Cylinder Compression Indicator	SE-2482 and SE-2482-6 adapter.
10	Clutch Pilot Bearing Remover	SE-1746
11	Bellhousing Aligner Fixture	SE-1834 - Used with SE-1848 Dial Indicator.
12	Flywheel Housing-to-Crankcase Dowel Reamer	Use standard tapered reamer to size holes for 112" diameter service replacement roll pins.
13	Core Plug Installer	Oval type expansion plugs used. Install plugs with ball peen hammer.

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SERVICE TOOL APPLICATION CHART

INJECTOR NOZZLE AND LINES

1	Nozzle Remover	Suitable adapter can be made locally from line nut for use with SE-1746 slide hammer to extract nozzle assembly from cylinder. Using nut from a discarded high pressure line, drill and tap nut with 1/2 13 NC thread to receive slide hammer. Service manual to include instructions for making adapter locally.
2	Wrench, High Pressure Line Nut	Obtain locally. Snap-On AN-8508-11 11/16" crow foot wrench (3/8" drive) or similar wrench.

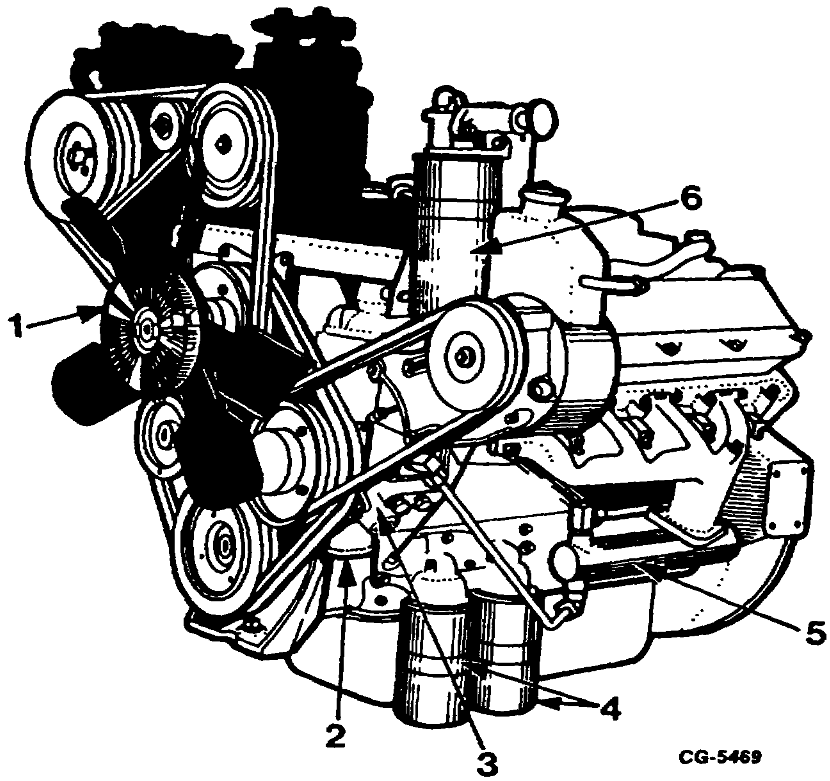

Figure 1. Left Front View of Engine

1. Fan Modulator
2. Water Inlet
3. Water Pump
4. Oil Filters
5. Oil Cooler
6. Fuel Filter

DESCRIPTION

The International 9.0 liter diesel engine is a four cycle naturally aspirated V-8 with overhead valves. It has a displacement of 9.0 liter (551 cu. in.).

When viewing the engine from the rear, the right bank of cylinders are numbered 2, 4, 6 and 8 with 2 being at the front. Similar, the left bank of cylinders are numbered 1, 3, 5 and 7 with No. 1 being at the front The firing order is 18-7-3-6-542.

The crankcase has been especially developed to withstand the loads of diesel operation and utilizes tie bolts at each main bearing to assure a rigid, inflexible support for the rotating parts. Oil galleries traverse the crankcase to deliver oil to all moving parts.

The crankshaft is a five main bearing unit with fore and aft thrust controlled at the center (No. 3) bearing. Precision steel backed main and connecting rod bearings are utilized. Connecting rods are of heavy-duty construction and are attached to the crankshaft, two to each bearing throw with the piston pin being of free floating type permitting the pin to move or float freely in piston and rod. The pin is held in place with pin retaining rings.

The intake and exhaust valves are both provided with inserts at the cylinder head and valve rotators are used at both intake and exhaust valves. The rotators are seated on the cylinder head. Valve dampers are used with each valve spring.

The engine is equipped with a fully closed crank-case ventilating system. The crankcase ventilation fittings are located in the cylinder head covers and are connected by hose to the intake manifolds crossover.

The fuel injection pump is located between the cylinder heads and intake manifolds at the top of the engine. The engine governor is integral with the fuel injection pump. Operating principles and service instructions for the fuel system components are given in separate sections of the service manual. Fuel System, Section CGES-220 covers the fuel injection pump and governor. Fuel System, Section CGES-225 covers the fuel injection nozzle.

The air cleaner is remote mounted and is connected via piping to a crossover adapter mounted on the intake manifolds.

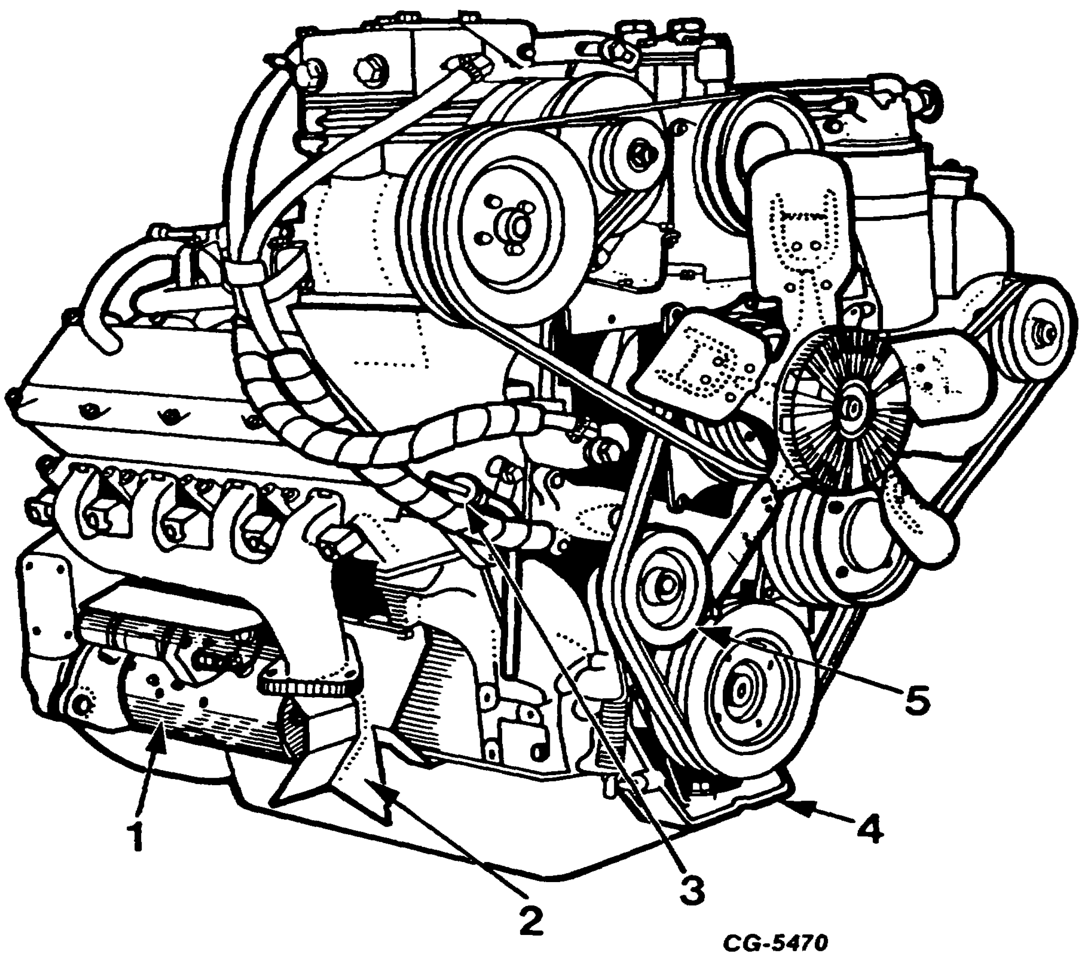

Figure 2. Right Front View of Engine

1. Starting Motor
2. Heat Shield
3. Oil Level Dipstick
4. Front Engine Mount
5. Idler Pulley

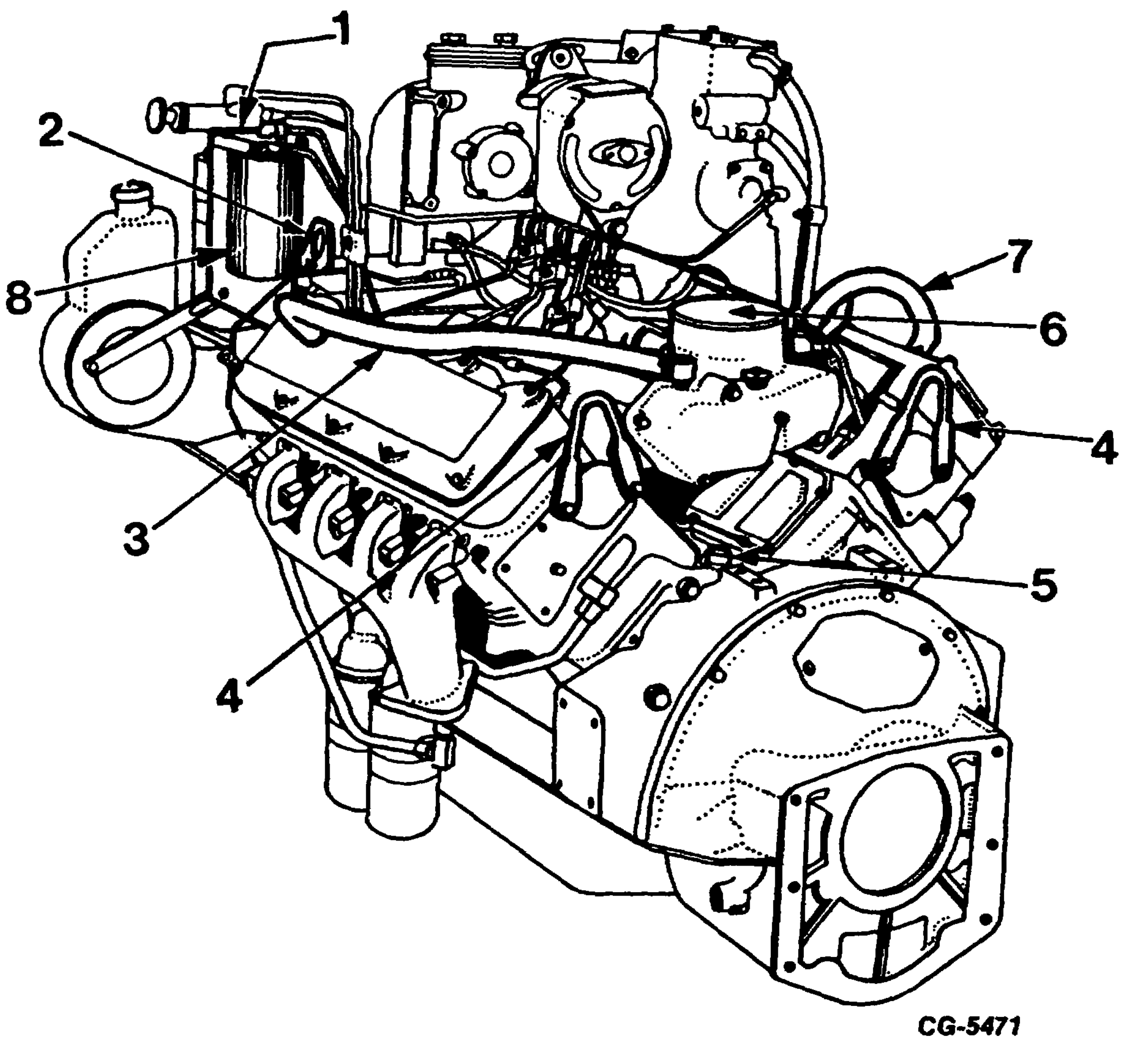

Figure 3. Left Rear View of Engine

1. Fuel Filter Assembly Mounting Bracket
2. Lifting Eye
3. Ventilator Hose
4. Lifting Loop
5. Tachometer Drive
6. Air Intake
7. Ventilator Hose
8. Fuel Filter

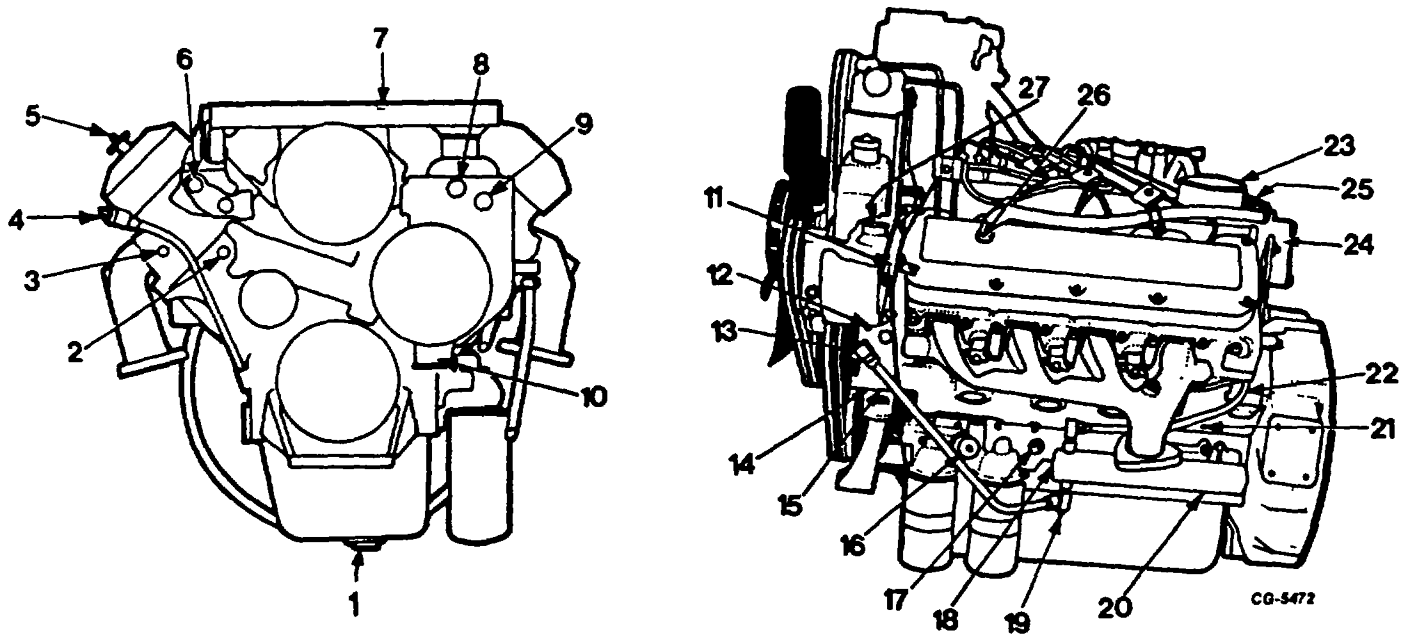

Figure 4. Engine Showing Coolant, Oil and Air Connecting Location

1. Oil Drain
2. Air Compressor Water Supply .500" NPTF (Note: Air compressor water supply should not be "Teed" under any circumstances)
3. Air Compressor Oil Return .250" NPTF
4. Oil Level Gauge
5. Engine Oil Fill
6. Air Compressor Water Return .500" NTPF
7. Air Compressor Oil Supply
8. Engine Cooling System Air Vent .375" NPTF
9. Water Temperature Sender Switch .500" NPTF (Light)
10. Water Inlet (2.5" ID hose)
11. Water Temperature Sender .500" NPTF (Gauge)
12. Heater Return .500" NPTF
13. Oil Cooler Water Return
14. Heater Supply .500" NPTF
15. Surge Tank (Engine Fill) .750" NPTF
16. Oil Pressure Sender.125" NPTF
17. Low Oil Pressure Engine Shutoff Safety Switch .125" NPTF
18. Auxiliary Oil Filter Supply (Filter Hose) .250" NPTF
19. Oil Cooler, Coolant Drain
20. Auxiliary Oil Filter Return (Crankcase) .250" NPTF
21. Coolant Drain both sides of Crankcase .250" NPTF
22. Oil Cooler coolant supply (Note: Oil cooler should not be used to accommodate other needs)
23. Air Inlet
24. Ventilator Hose connecting location on air inlet manifold crossover (either side .500" NPTF)
25. Pipe Plug .500" NPTF
26. Ventilator Hose connecting location on Cylinder Head Cover
27. Water Outlet 2.0" ID hose

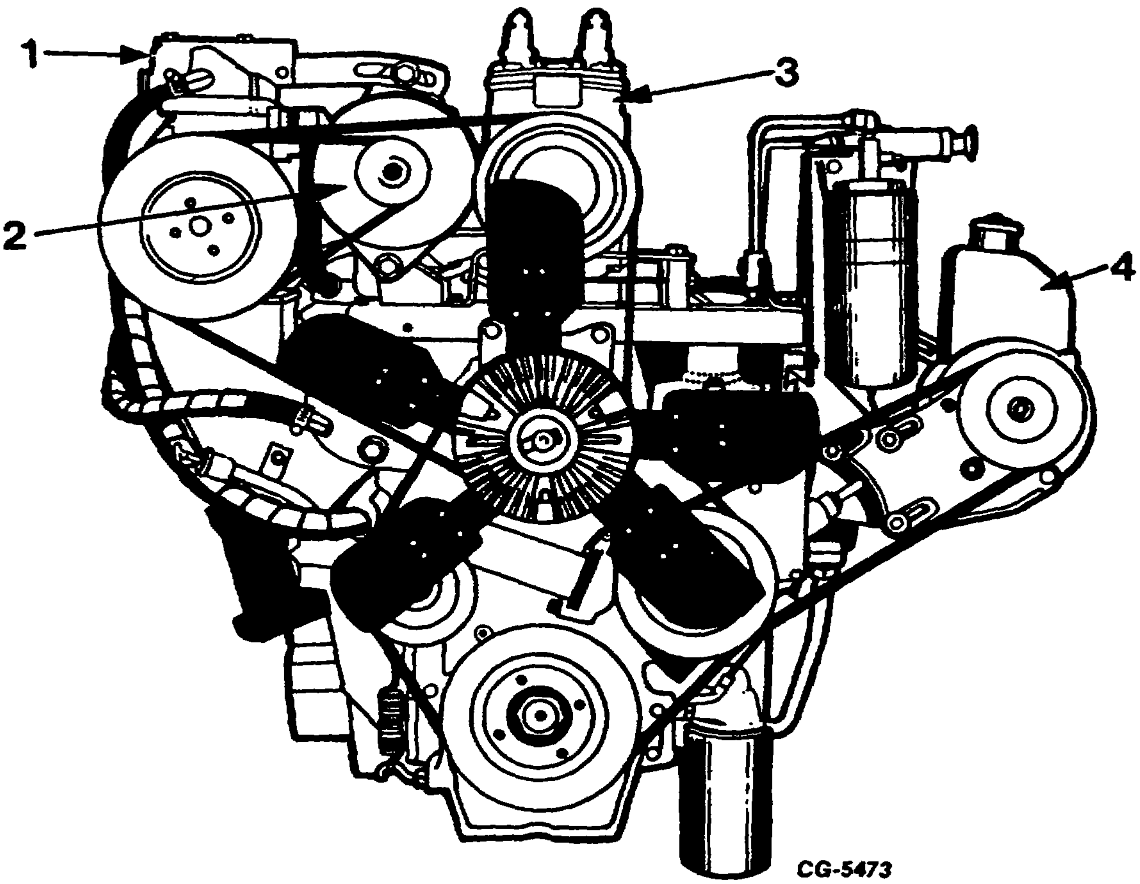

Figure 5. Typical Accessory Location S-Series Models

1. Air Compressor
2. Alternator
3. Freon Compressor
4. Power Steering Pump

ENGINE ACCESSORIES

Typical truck application engine accessories are shown in Figure 5. The accessories shown or their location may vary between truck models or engine application.

Dual main drive belts driven by the crankshaft pulley drive the water pump and automatic temperature modulated fan. The main drive belts are held in correct tension by a spring loaded idler pulley.

The idler pulley, is held in position by a pivoted idler arm to which the tension spring is attached. The idler pulley runs on a double row ball bearing, prelubricated and sealed so that further lubrication is not required. The idler arm pivots on a bushing which is oil impregnated and utilizes seals at both ends. No further lubrication of this bushing is required. The air compressor and alternator are driven by dual belts from the fan pulley. The power steering pump is driven by dual belts from the water pump pulley.

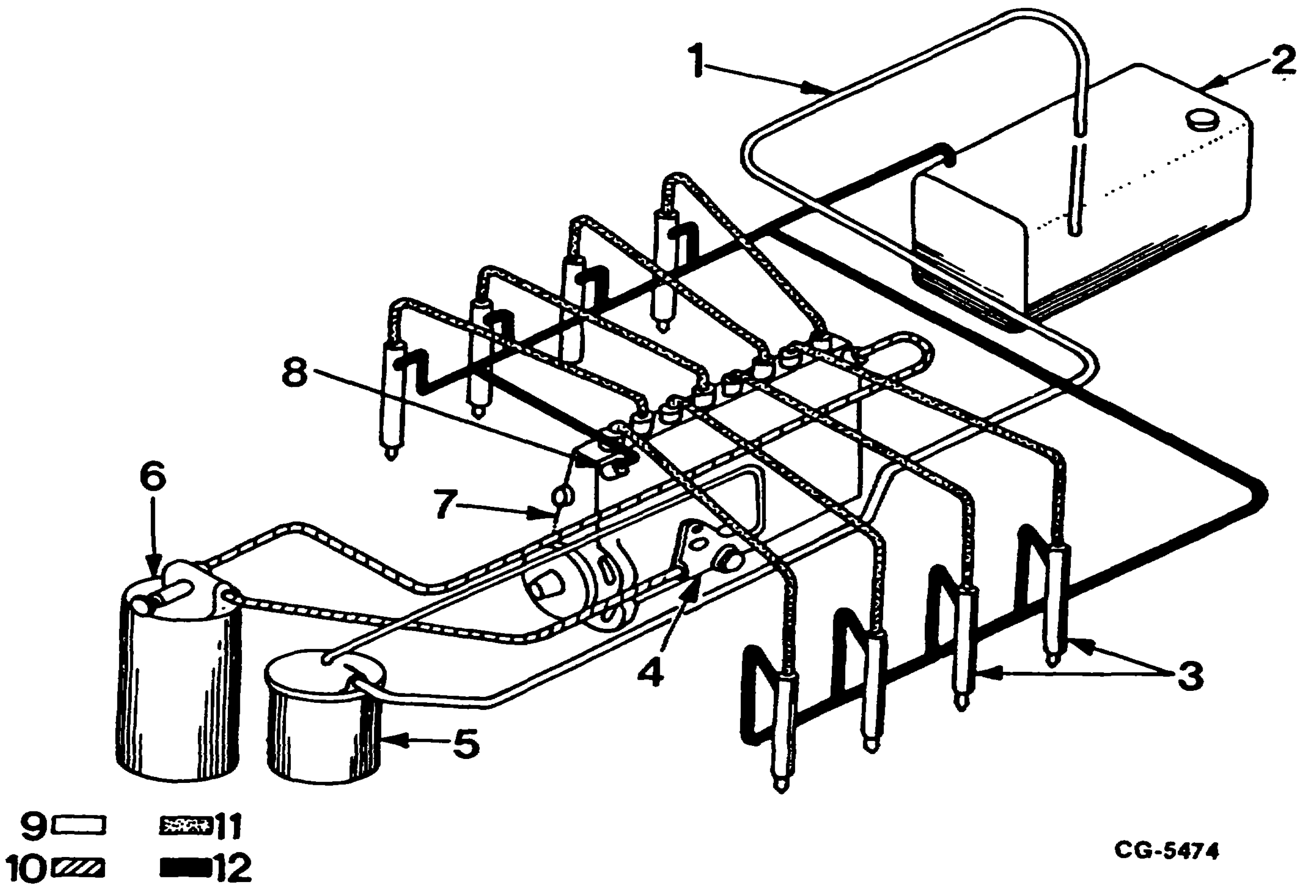

Figure 6. Fuel System

1. Fuel Supply Line
2. Fuel Tank
3. Nozzle and Holder Assembly
4. Transfer Pump
5. Primary Filter
6. Final Filter with Primer
7. Injection Pump
8. Pressure Regulator Valve
9. Fuel Tank to Primary Filter
10. Transfer Pump to Final Filter to Injection Pump
11. Injection Lines
12. Leak-Off and Return to Tank Lines

FUEL SYSTEM

Fuel is pumped from the fuel tank through the primary filter by the transfer pump, then through the final filter.

Filtered fuel is then directed to the fuel injection pump located between cylinder banks where it is metered and delivered under high pressure to the hydraulic type injection nozzles located at each combustion chamber in the cylinder heads.

MODULATED FAN DRIVE ASSEMBLY

Torque is supplied to the input shaft of the modulated fan assembly from the fan drive hub. The input shaft transmits torque to the fan by the movement of silicon fluid between the input and output plates in the fluid filling housing The fan drive is actuated by the positioning of a slide valve plate which controls the amount of fluid from the forward supply chamber and the rear drive chamber. Close clearance between the driving and driven CGES-205 members causes the driven plate to turn. The volume of fluid in the drive chambers regulates the fan speed.

The valve plate is actuated by the control element, which is a bimetal coil and reacts to the air temperatures behind the radiator core operating temperature 52°C to 68°C (125°F to 155°F). When the coil is cooled by the air temperature, the coil will close the slide valve plate, restricting the flow of the silicon fluid. Through centrifugal force the fluid is allowed to re-enter the forward supply chamber through a small hole. The fan will turn at a reduced speed due to a smaller volume of fluid between the driving and driven member.

The modulated fan assembly should not be disassembled, as it is only a unit replacement item.

COOLANT FLOW

The right bank coolant is drawn from the radiator through the water pump in to the right lower crankcase via the water manifold, circulated through the crankcase and cylinder head and returned to thermostat housing through the coolant return tube.

The left bank is cooled by coolant flow from the radiator through the water pump and into the lower crankcase through a port in the back of the water pump housing, through the crankcase and cylinder head and back to the thermostat housing located on top of the water pump housing.

Coolant is piped to the oil cooler from the rear of the left cylinder head and back to the water pump housing

LUBRICATING SYSTEM
Engine lubrication is provided by a system of galleries and drilled passages running through various engine castings and moving parts. This design eliminates external or internal oil lines and assures trouble-free, efficient engine lubrication.

Figure 10 illustrates a flow diagram of the engine lubricating system.

In operation oil is forced through the engine by an internally mounted gear type oil pump which is driven through gears at the engine camshaft. Oil enters the pump through a stationary screen assembly located under the surface of the oil in the pan and above the bottom of the oil pan and attached to the oil pump body. Dual spring-loaded pressure relief valves are located in the oil pump which limit the maximum oil pressure in the system. Because of the reserve oil delivery capacity of the oil pump, the two regulator valves are required. Oil relieved by the pressure regulator valves is recirculated within the pump. This feature eliminates oil aeration, which is often caused by oil returning to the pan from the pump.

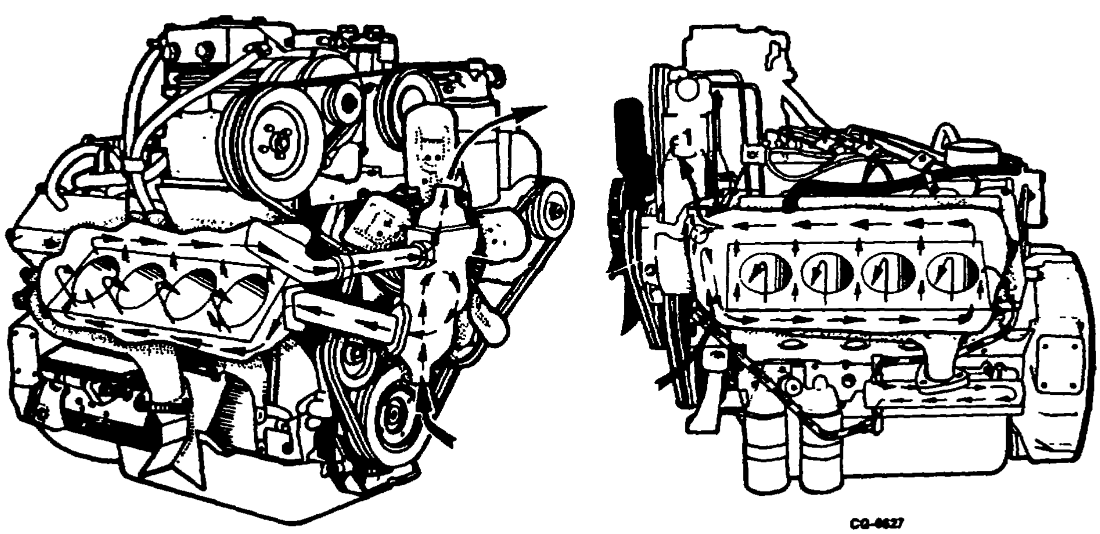

Figure 7. Engine Coolant Flow Diagram

Oil leaving the oil pump passes through the oil cooler where heat from the oil is removed by the engine coolant and dissipated through the engine cooling system. From the oil cooler, the oil enters the full-flow oil filters. Each spin-on type filter has a by-pass valve which permits oil to flow to the engine in case the filter becomes clogged.

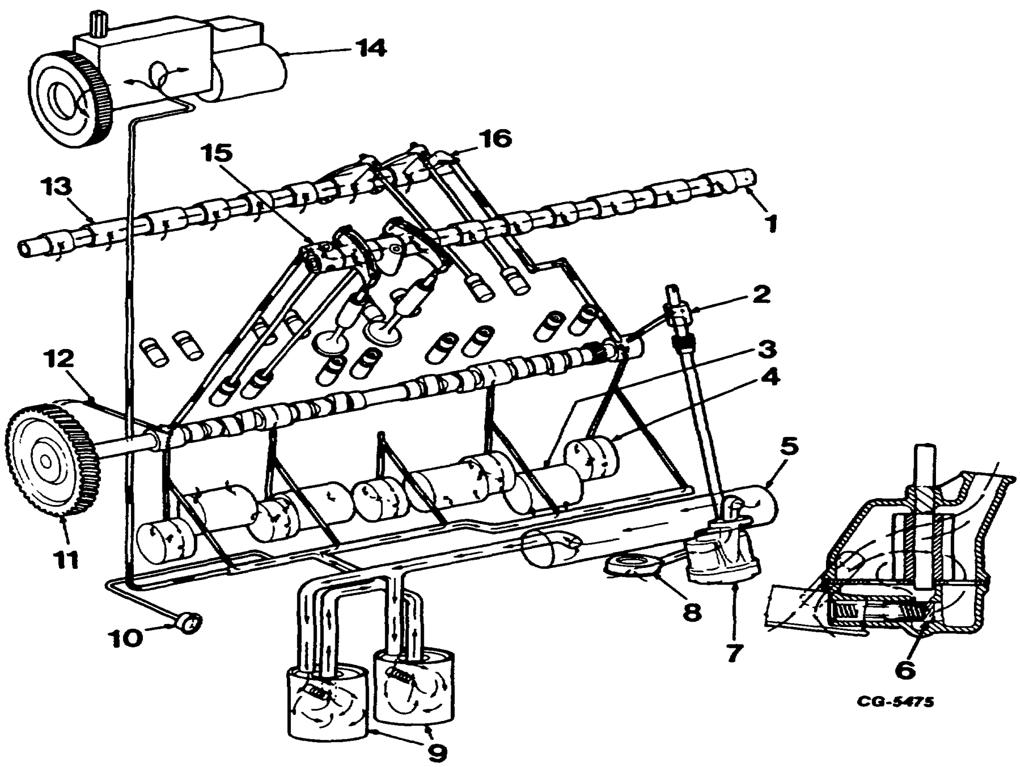

Figure 8. Engine Lubrication System

1. Rocker Arm Shaft Left Bank
2. Oil Pump and Tachometer Shaft Upper Bushing
3. Connecting Rod Bearing
4. Main Bearing
5. Oil Cooler
6. Pressure Relief Valve
7. Oil Pump
8. Oil Pump Screen
9. Full Flow Oil Filter with By-Pass Valve
10. Oil Pressure Gauge
11. Camshaft Gear
12. Oil Feed to Gears
13. Rocker Arm Shaft Right Bank
14. Injection Pump
15. Oil Feed Bracket Front Left Bank
16. Oil Feed Bracket Rear Right Bank

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ACCESSORIES

TORQUE CHART

Air Compressor Pulley Nut:	N•m	LBS.-FT.
3/4" Thread Size	54 Min. (*)	(40 Min.) (*)
7/8" Thread Size	68 Min. (*)	(50 Min,) (*)

(*) Plus additional tightening to align key slot.

For all other fasteners in this section refer to General Torque Chart.

This section only describes removal and installation of the accessories from the engine, for detailed testing and repair procedures refer to appropriate CGES or CTS Service Manual.

ENGINE DISASSEMBLY

The disassembly sequence outlined below is intended as a guide since the actual disassembly procedure will depend upon the extent of service required and the accessory components mounted on the individual engine being serviced.

Engine disassembly can best be accomplished by mounting the engine in a rotating engine stand such as stand SE-1962.

1. Mount engine in overhaul stand as follows:

   Overhaul Stand SE-1962

   a. Remove right exhaust manifold.

   b. Remove exhaust manifold heat shield (Figure 9).

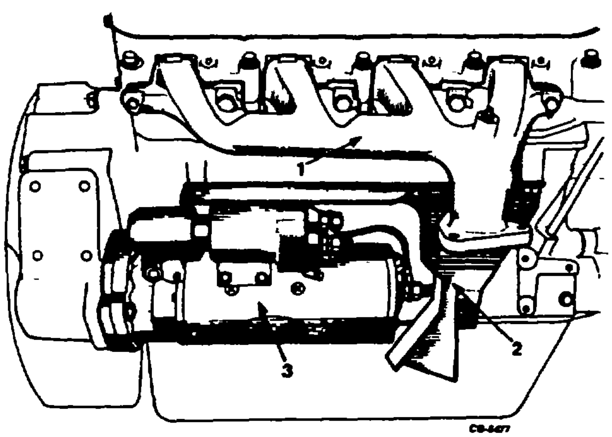


Figure 9. Remove Exhaust Manifold, Heat Shield and Starting Motor

1. Exhaust Manifold
2. Heat Shield
3. Starting Motor

   c. Remove starting motor and adapter from flywheel housing,

   d. Install overhaul stand adapter No. 975 to engine block.

   e. Mount engine, with adapter, in overhaul stand (Figure 10).

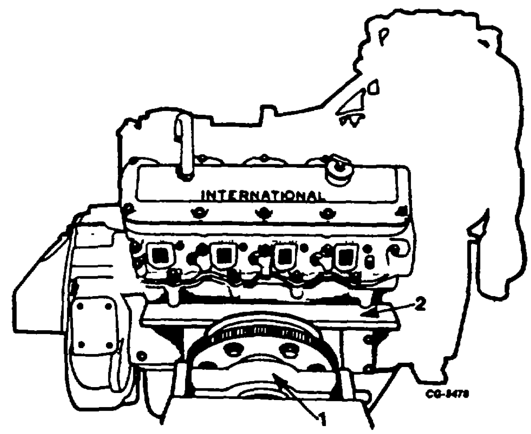


Figure 10. Engine Mounted on Overhaul Stand

1. Overhaul Stand SE-1962 with Adapter
2. Adapter

2. Loosen alternator adjusting strap bolt and two mounting bolts, push alternator towards air compressor to loosen alternator drive belts (Figure 11).

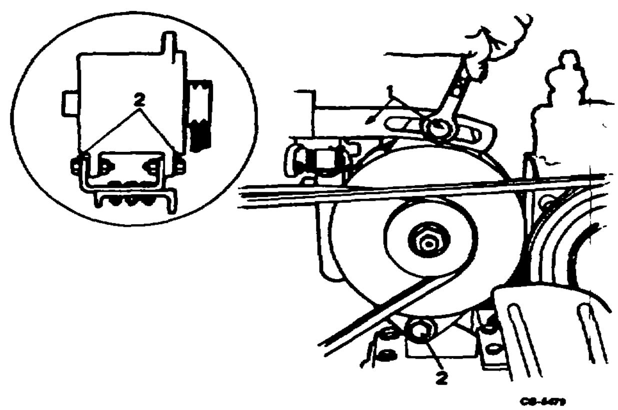


Figure 11. Alternator Adjusting Bolt Location

1. Adjusting Strap and Bolt
2. Mounting Bolts Both Ends

4. Remove air compressor and alternator drive belts.

5. Remove air compressor water supply hose, water return hose and oil supply pipe (Figure 13).

6. Remove air compressor. The air compressor and mounting bracket may be removed as an assembly by removing three bolts located at the bottom of the bracket or by removing the air compressor from the bracket and then the bracket from the cylinder head (Figure 13).

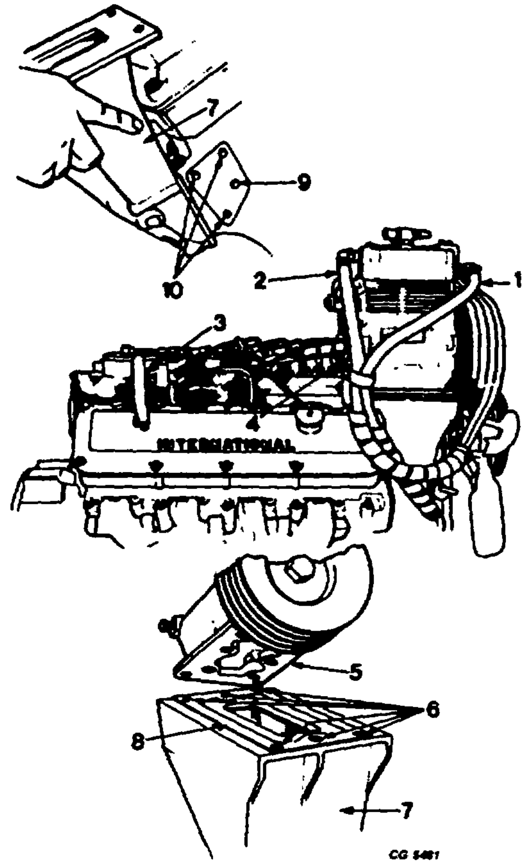


Figure 13. Removing Air Compressor

1. Water Supply Hose
2. Water Return Hose
3. Ventilator Hose
4. Oil Supply Pipe
5. Air Compressor
6. Mounting Hole Location (Air Compressor to Mounting Brkt.
7. Air Compressor Mounting Brkt.
8. Gasket
9. Oil Return Hole
10. Mounting Hole Location (Bracket Cylinder Head)

8. Remove two alternator to mounting bracket bolts. Remove alternator. Remove four mounting bracket bolts and remove bracket (Figure 14).

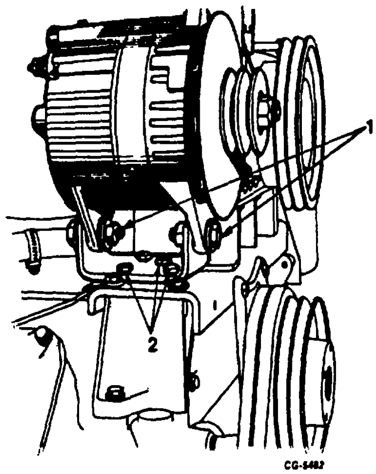


Figure 14. Remove Alternator

1. Alternator to Mounting Bracket Bolts
2. Bracket Mounting Bolts

10. Loosen the power steering pump adjusting bolt locknut, three bracket bolts and adjusting strap bolt at the rear of pump. Push mounting bracket inward to remove power steering pump drive belts (Figure 16).

11. The power steering pump and mounting bracket may be removed from the engine as an assembly by removing the adjusting strap bolts and three pump brackets to engine mounting bolts (Figure 16).

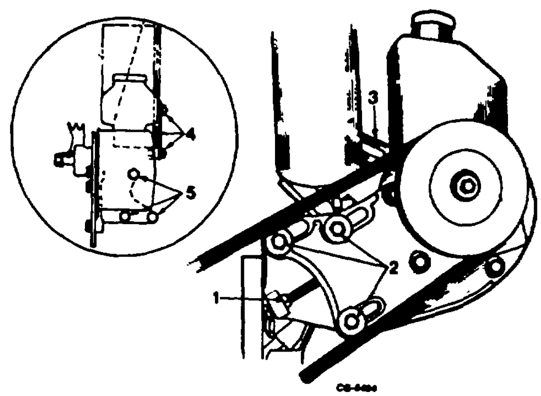


Figure 16. Removing Power Steering Pump

1. Adjusting Bolt and Locknut
2. Bracket Bolts
3. Adjusting Strap
4. Adjusting Strap and Bolts
5. Pump Bracket to Engine Mounting Bolts

REASSEMBLY

1. Install power steering pump and mounting bracket assembly (Figure 16).

3. Install alternator mounting bracket to accessory channel and mount alternator to bracket (Figure 14).

4. If air compressor was removed from it's mounting bracket, replace mounting gasket and mount air compressor to bracket. Mount bracket to cylinder head (Figure 13).

5. Connect water supply hose, water return hose and oil supply pipe to air compressor (Figure 13).

6. Install accessory drive belts: Power steering pump is driven from front pulley of water pump.

   Alternator is driven from rear pulley of air compressor.

   Air compressor driven from front fan pulley.

7. Adjust accessory drive belts (Figure 17 and 18).

   Accessory drive belts require correct installation, tension, alignment and maintenance. Neglect of these factors causes short belt and pulley life, cooling problems and bearing failures.

   New belts, including replacement, experience a break-in period and initially loose tension during groove seating. New belt initial installation tension is higher than the retension value applied to a used belt (run five minutes or longer) This is done to minimize the number of belt adjustments and prevent belt operation under low tension during the break-in period.

   Check for proper belt tension with belt: Tension Gauge SE-2312.

   Belt tension must be made at midpoint between pulleys at the longest belt span.

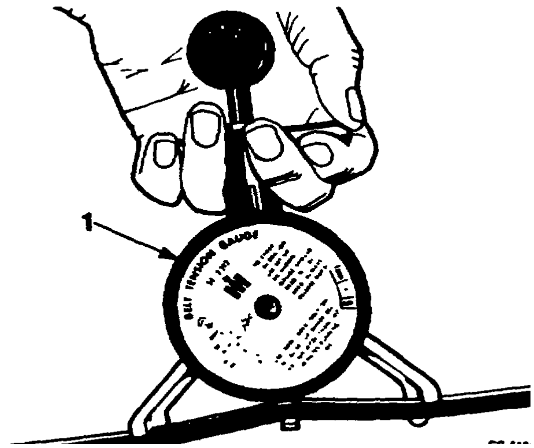


Figure 17. Checking Belt Tension with Belt Tension Gauge SE-2312

1. Belt Tension Gauge SE-2312

8. Grasp gauge and depress ball handle all the way down. Make certain hook extends beyond legs to pick up the belt.

   a. Apply gauge to belt. Be sure belt is positioned between nose piece and hook and that the nose piece is centered on belt.

   b. Release ball handle quickly. A slow release may prevent full return of hook, thus giving a false reading.

   c. Observe the area of gauge face indicated at the index mark. If index mark does not indicate a NEW reading on a used belt, it will be necessary to increase or decrease belt tension as required.

   d. Before changing belt tension, repeat several times to become familiar with gauge operation. Observe gauge reading each time operation is repeated. Check tension of both belts when so equipped.

To establish tension of a loose belt, apply SE-2312 gauge to the belt and make the adjustment. Tighten belt until proper tension area is indicated on gauge. Lock adjustment and recheck belt tension. Readjust if necessary.

When using SE-2312 belt tension gauge, remember to set new belts (belt with less than five minutes running time) to the NEW area on gauge face and used belts (with more than five minutes running time) to USED area on gauge.

Belt tension may also be checked by using a straightedge and scale as illustrated (Figure 18).

Approximately 12.7 mm (1/2 inch) deflection should be measured. The deflection measurement should be made between pulleys at midpoint of longest belt span.

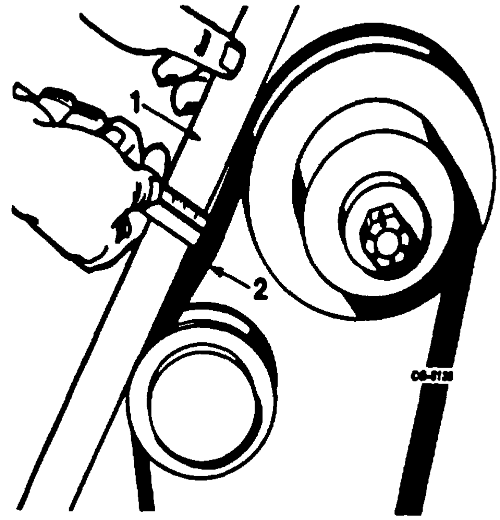


Figure 18. Measuring Belt Tension

1. Straight Edge 2. Belt

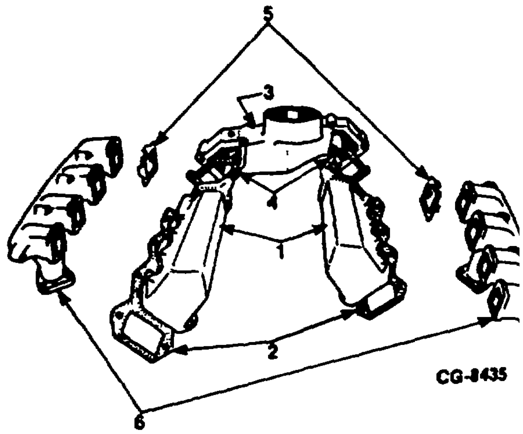


Figure 19. Intake and Exhaust Manifold

1. Intake Manifold
2. Intake Manifold Gasket
3. Intake Manifold Crossover
4. Crossover Gasket
5. Exhaust Manifold Gasket
6. Exhaust Manifold

SPECIFICATIONS

Intake Manifold Torque	41 N•m 30 Lb-Ft
Crossover Manifold Torque	20 N•m 15 Lb-Ft
Exhaust Manifold Torque	3/8 NC 41 N•m 30 Lb-Ft
	1/2 NC 108 N•m 80 Lb-Ft

For all other fasteners in this section refer to General Torque Chart.

DISASSEMBLY

EXHAUST MANIFOLD REMOVAL

1. Remove exhaust manifold by removing five mounting bolts, remove manifold gaskets.

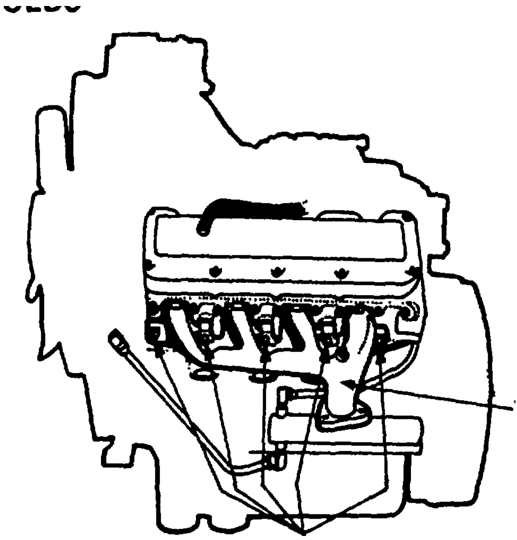


Figure 20. Removing Exhaust Manifold Left Side of Engine

1. Exhaust Manifold 2. Mounting Bolt

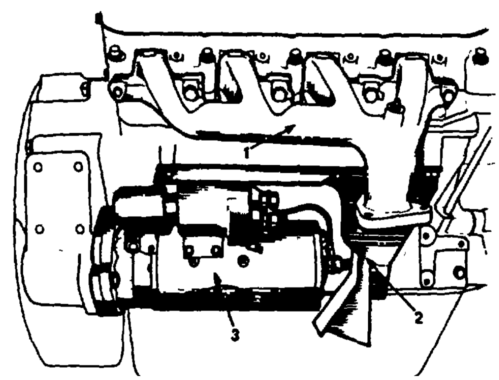


Figure 21. Remove Exhaust Manifold, Heat Shield and Starting Motor

1. Exhaust Manifold 3. Starting Motor
2. Heat Shield

INTAKE MANIFOLD REMOVAL

2. Disconnect fuel injection lines from injection pump and injection nozzles, remove line (Figure 22).

IMPORTANT

WHEN REMOVING FUEL LINES, THE LINES SHOULD HAVE DUST CAPS INSTALLED OVER BOTH ENDS AS WELL AS THE FITTINGS WHERE THE LINESWERE REMOVED. THIS PROCEDURE IS TO PROTECT AGAINST ENTRY OF FOREIGN MATTER IN THE FUEL SYSTEM. THE DUST CAPS COME IN VARIOUS SIZES AND CAN BE PROCURED LOCALLY.

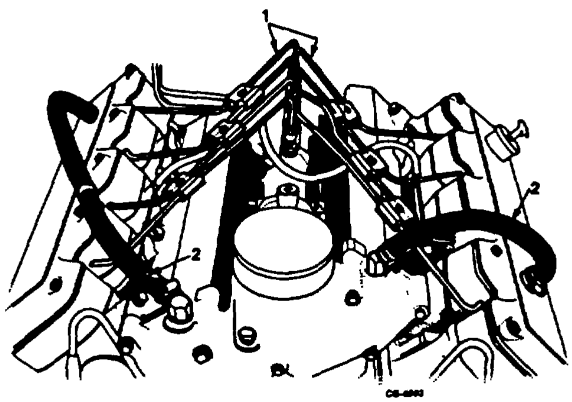


Figure 22. Removing Injection Lines and Ventilator Hoses

1. Fuel Injection Lines
2. Ventilator Hose

3. Disconnect left and right bank ventilator hose from air intake manifold crossover (Figure 22).

4. Disconnect ventilator hose from left valve cover (Figure 22).

5. Remove six manifold crossover mounting bolts and remove crossover from intake manifold (Figure 23).

6. Disconnect leak off return hose from leak-off manifold and injection pump valve, remove hose (Figure 39).

7. Remove leak off manifold with support clips from intake manifold and disconnect from nozzle coupling hoses, remove leak off manifold (Figure 24).

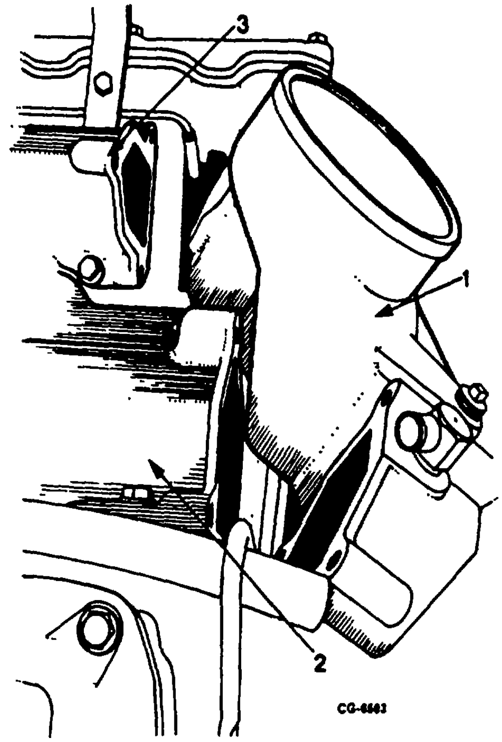


Figure 23. Removing Intake Manifold Crossover

1. Intake Manifold Crossover
2. Left Intake Manifold
3. Right Intake Manifold

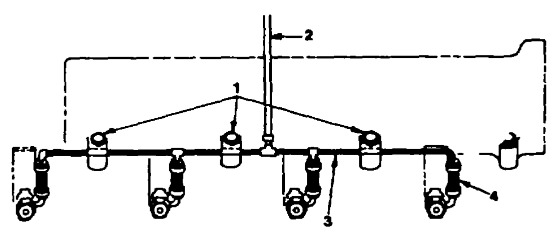


Figure 24. Removal of Leak-Off Manifold

1. Mounting Bolts
2. Leak-Off Hose
3. Nozzle Fuel Leak-Off Manifold with Support Clips
4. Nozzle Coupling Hoses

8. Remove left intake manifold (Figure 25).

NOTE : Left and right intake manifold can be interchanged.

9. Remove eight mounting bolts from the left bank intake manifold (Figure 25).

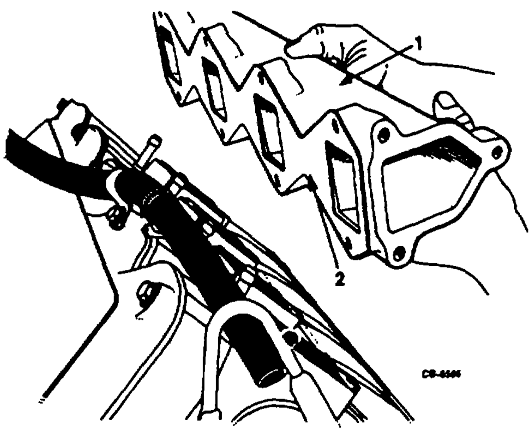


Figure 25. Left Intake Manifold Removal

1. Intake Manifold 2. Gasket

10. Disconnect fuel supply line from transfer pump and remove.

11. Disconnect fuel line from transfer pump and fuel filter, remove line.

CLEANING, INSPECTION AND REPAIR

1. Intake manifolds should be thoroughly cleaned and examined for cracks. Place mounting surface (outlets) of manifold on a smooth flat surface and check for warpage. Replace manifold if cracked or warped.

NOTE: Do not surface grind intake manifold to correct warpage. Any attempt to resurface intake manifolds will create misalignment of ports to cylinder heads and air cleaner mounting.

Exhaust manifolds are cast in one piece. Examine exhaust manifolds for cracks or burning and check for warping by placing inlet ports on a flat surface. Minor warpage can be corrected by surface grinding. If warpage is extreme, replace manifold.

REASSEMBLY

1. Install intake and crossover manifolds with new gaskets. Be sure manifold bolts are properly aligned with each gasket bolt hole.

2. Tighten bolts to proper torque. See specifications.

3. Install exhaust manifolds with new gaskets. Tighten bolts to proper torque. See specifications

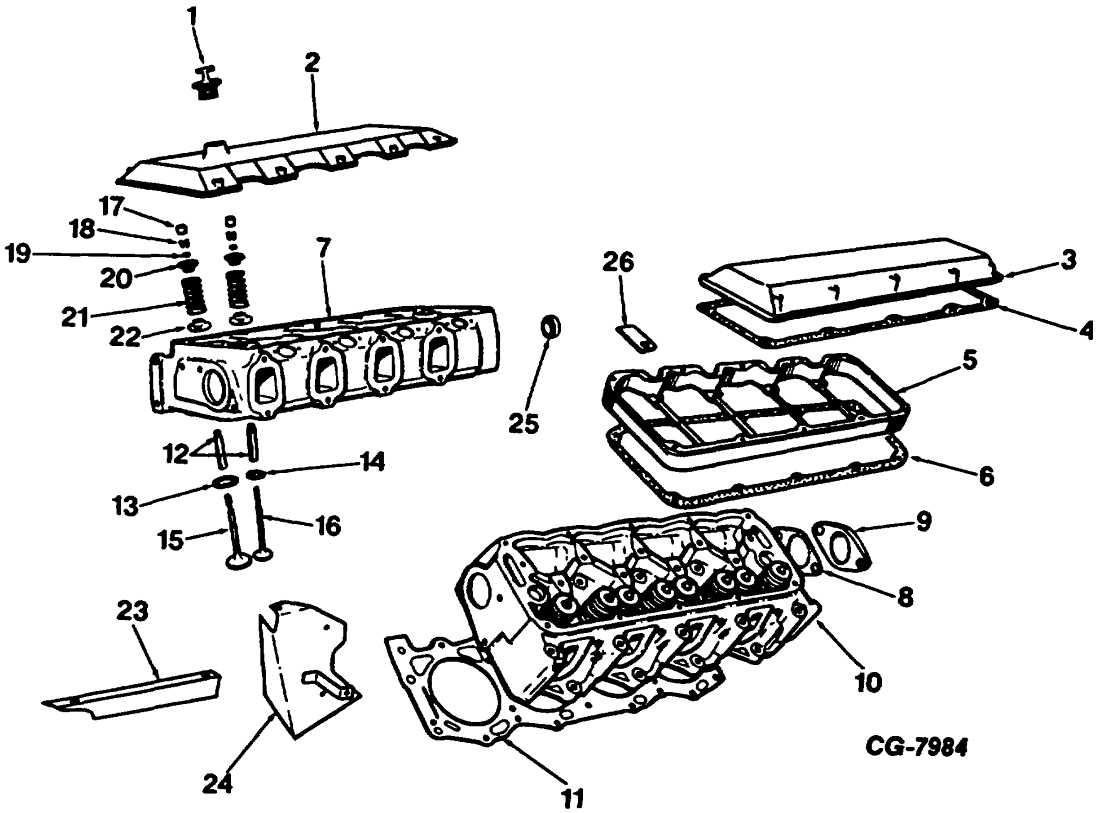


Figure 26. Cylinder Head and Valves

1. Oil Filler Cap
2. Right Valve Cover
3. Left Valve Cover
4. Cylinder Head Cover Gasket
5. Cylinder Head Extension
6. Extension Gasket
7. Cylinder Head
8. Thermostat Cover
9. Thermostat Cover Gasket
10. Cylinder Head
11. Cylinder Head Gasket
12. Valve Guide
13. Intake Valve Seat
14. Exhaust Valve Seat
15. Intake Valve
16. Exhaust Valve
17. Valve Cap
18. Valve Spring Retainer
19. Valve Stem Seal
20. Valve Stem Cup
21. Valve Spring
22. Valve Rotator
23. Heat Shield
24. Rear Heat Shield

SPECIFICATIONS

EXHAUST VALVES

Exhaust Valves:	
Valve Lift	12.014 mm (.473")
Stem Diameter	9.449 - 9.462 mm ('3720 - .3725")
Clearance in Guides	.033- .071 mm (.0013- .0028")
Face Angle	45°
Seat Angle	45°
Seat Width	2.032 - 2.286 mm (.080- .090")
Maximum Allowable Seat Run-Out	.051 mm (.002")
Maximum Allowable Face Run-Out	.038 mm (.0015")
Seat Insert and Counterbore Data:	
Standard	
Insert O.D.	45.060 - 45.085 mm (1.7740 - 1.7750")
Counterbore Diameter	44.958 - 45.009 (1.770 - 1.772")
.05 mm (.002") Oversize	
±Insert O.D.	45.085 - 45.110 mm (1.7750 - 1.7760")
Counterbore Diameter	45.009 - 45.060 mm (1.7720 - 1.7740")
.381 mm (.015") Oversize	
Insert O.D.	45.441 - 45.466 mm (1.7890 - 1.7900")
Counterbore Diameter	45.339 - 45.390 mm (1.7850 - 1.7870")
.762 mm (.030") Oversize	
Insert O.D.	45.822 - 45.847 mm (1.8040 - 1.8050")
Counterbore Diameter	45.720 - 45.771 (1.800 - 1.802")

Valve Head and Valve Head Protrusion Relative to Deck (Head Gasket) Surface on Cylinder Head.

Maximum	.89 mm (.035")
Minimum	.48 mm (.019")
Valve Tip to Rocker Arm Clearance (Hot or Cold)	.407 mm (.016")
Valve Guides:	
Overall Length	
Intake	75.413 mm (2.969")
Exhaust	75.413 mm (2.969")
Bore Diameter	9.495 - 9.520 mm (.3738- .3748")
Height Above Top of Cylinder Head	33.02 mm (1.30")

SPECIFICATIONS

INTAKE VALVES

Intake Valves:	
Valve Lift	11.760 mm (.463")
Stem Diameter	9.4615 - 9.4742 mm (.3725 - .3730")
Clearance in Guide	.020- .058 mm (.0008 - .0023")
Face Angle	45°
Seat Angle	45°
Seat Width	2.032 - 2.286 mm (.080 - .090")
Maximum Allowable Seat Run-Out	.051 mm (.002")
Maximum Allowable Face Run-Out	.038 mm (.0015")
Seat Insert and Counterbore Data:	
Standard	
Insert O.D.	50.089 - 50.114 mm (1.9720 - 1.9730")
Counterbore Diameter	49.987 - 50.038 mm (1.968 - 1.970")
.05 mm (.002") Oversize	
Insert O.D.	50.114 - 50.140 mm (1.9730 - 1.9740")
Counterbore Diameter	50.038 - 50.089 mm (1.970 - 1.972")
.762 (.030") Oversize	
Insert O.D.	50.851 - 5a876 mm (2.0020- 2.0030")
Counterbore Diameter	50.749 - 50.800 mm (1.998 - 2.000")

Valve Head Protrusion Relative to Deck or Cylinder Head (Head Gasket Surface)	
Maximum	1.372 mm (.054")
Minimum	.813 mm (.032")

Valve Tip to Rocker Arm Clearance	.407 mm (.016")

TORQUE CHART	
Cylinder Head Mounting Bolts	149 N•m (110 Ft-Lbs)
Valve Cover 5/16" Bolts	14-20 N•m (10-15 Ft-Lbs.)
Cylinder Head Extension Housing	
Mounting Bolts	
3/8 Bolts	16-23 N•m (12-17 Ft-Lbs)
5/16 Bolts	13-20 N•m (10-15 Ft-Lbs.)
For All Other Fasteners Refer to General Torque Chart.	

• Three steps in proper sequence, Step 1. 68 N•m (50 Ft-Lbs.), Step 2. 122 Norm (100 Ft-Lbs.), Step 3. Final

DISASSEMBLY

Refer to unit section for detailed disassembly procedures.

1. Drain cooling system.

2. Remove the following:
   Fuel Injection Lines
   Fuel Injection Nozzles
   Intake and Exhaust Manifolds

The following steps 3 thru 8 pertain to disassembly of both cylinder heads:

3. Remove ten cylinder head cover bolts and flat washers, remove cover from cylinder head extension.

4. Remove five rocker arm shaft assembly mounting bolts and flat washers, remove four cylinder head extension bolts and flat washers, remove rocker arm shaft assembly (Figure 27).

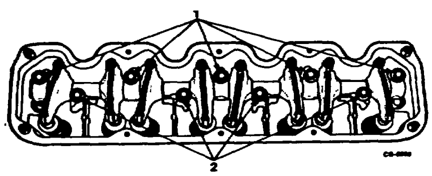


Figure 27. Removing Rocker Arm Shaft Assembly

1. Rocker Arm Shaft Assembly Mounting Bolts
2. Cylinder Head Extension Mounting Bolts

5. Remove four comer cylinder head extension mounting bolts and remove extension.

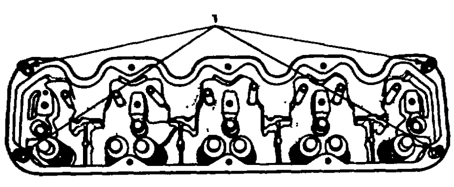


Figure 28. Removing Cylinder Head Extension

1. Cylinder Head Extension Comer Mounting Bolts

6. Remove valve tips from ends of valves. Withdraw push rods from engine (Figure 29).

7. Remove fourteen cylinder head to crankcase mounting bolts (Figure 29).

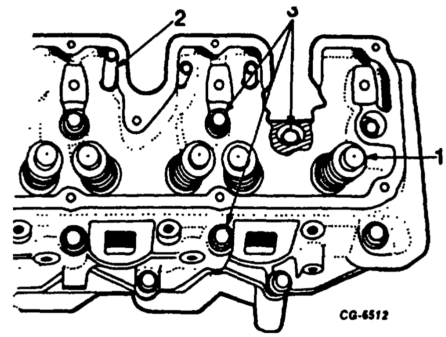


Figure 29. Removing Valve Caps, Push Rods and Head Mounting Bolts

1. Valve Cap
2. Push Rod
3. Cylinder Head Mounting Bolts

8. Attach cylinder head lifting sling SE-1896 to cylinder head. Remove head and gasket, being careful not to damage location dowel sleeves (Figure 30).

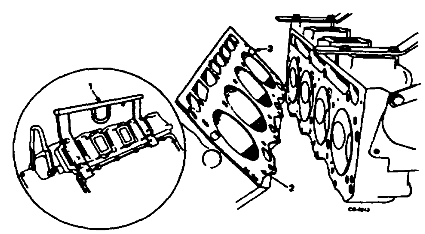


Figure 30. Removing Cylinder Head

1. Lifting Sling SE-1896
2. Gasket
3. Dowell Sleeve

CLEANING, INSPECTION AND REPAIR

Cylinder Heads

The cylinder head assemblies are interchangeable from one cylinder bank to another. Cylinder head gasket is also interchangeable.

SE-1896 Cylinder head sling can be used as a holding fixture to protect machined surfaces during cleaning and miscellaneous disassembly operations.

1. With valves in place to protect seats, clean carbon deposits from combustion chambers and valve heads with a wire brush and scraper. Wash cylinder head in cleaning solvent to remove dirt and grease from all surfaces and dry thoroughly. Check all water passages to make sure they are clean and open.

   Remove valves from cylinder head as follows:

   a. Place head assembly in vertical position. Apply valve spring compressor and remove valve keepers or locks (Figure 31). It may be necessary to strike valve ends with a light, soft hammer to loosen valve keepers.

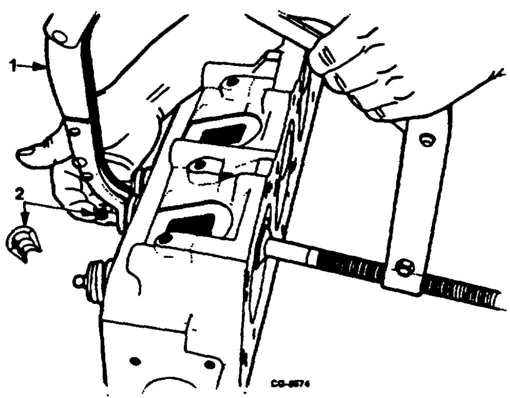


Figure 31. Removing Valve Keepers

1. Valve Spring Compressor
2. Valve Keeper

   b. Release spring compressor and remove spring retainer, valve spring and damper assembly, valve stem seal and Rotocoil assembly (Figure 32).

NOTE: Keep valves and their related parts together so they may be reinstalled in their respective positions.

2. After removing valves, examine cylinder heads for waterleaks or cracks in combustion chambers, exhaust ports, or around valve seats. Inspect machined or gasket surfaces for scratches or mars which may cause leakage after assembly.

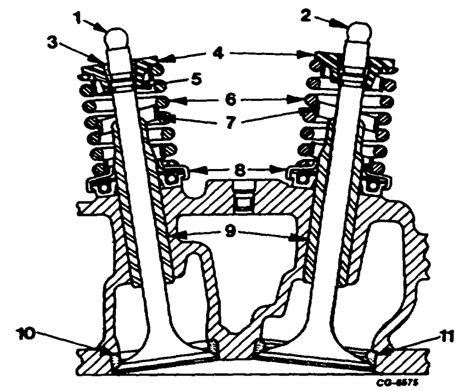


Figure 32. Sectional View of Valve Installation

1. Exhaust Valve	7. Damper
2. Intake Valve	8. Rotor Coil
3. Valve Keeper	9. Valve Guide
4. Retainer	10. Exhaust Seat
5. Oil Seal	11. Intake Seat
6. Spring	

3. Check gasket surface of cylinder head for trueness with a straightedge. Test by attempting to insert a .006" feeler gauge ribbon between straightedge and cylinder head. If this is possible, replace cylinder head.

   NOTE: Cylinder heads are not to be resurfaced. Valves

4. Remove all carbon from valve stems and valve heads using a fine wire brush or buffing wheel.

5. Inspect each valve, discarding any that show evidence of burned, warped or bent condition. Measure each valve stem for wear. If worn

beyond specified limits (see SPECI FICATIONS) Replace valve. Check fit of valve stems in valve guides for proper running clearance. (See SPECIFICATIONS). Replace valve guides if needed.

6. If valves are in serviceable condition, reface as needed. See specifications for valve face dimensions. Grinding wheels of refacing equipment should be carefully dressed to specified valve angle. During grinding, remove only the minimum amount of material necessary to true up the valve face.

IMPORTANT
NEW VALVES NEED NOT BE REFACED; HOWEVER, ALL VALVES SHOULD BE CAREFULLY INSPECTED FOR DAMAGED SEAT FACES OR FOR A RUN-OUT CONDITION DUE TO A BENT VALVE STEM. USE TOOL SE-2614 FOR CHECKING VALVE STEM RUN-OUT.

7. Inspect valve keepers for excessive wear and replace in pairs as required. When installing a new valve, always use new valve keepers.

Valve Guides

Using appropriate size brush (SE-1300) clean valve guide bores (Figure 33).

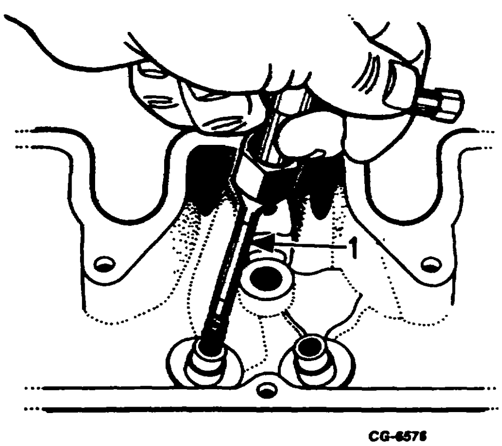


Figure 33. Cleaning Valve Guide Bore

1. Cleaning Tool

8. Using equipment such as SE-1826 small bore gauge (and micrometer) or SE-2506valve guide gauge, check valve guide bores (Figure34). (See SPECIFICATIONS for proper guide bore diameter.) Replace guides having bore diameters outside recommended limits, are bellmouthed more than .0005" or which show egg-shaped wear.

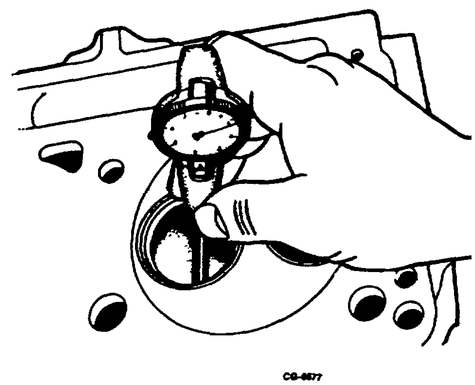


Figure 34. Checking Valve Guide Bore

Excessive guide clearance prevents adequate cooling of the valve through the guide and allows valve to tilt or tip which may cause valve breakage at high engine speed. These conditions prevent good seating and promote leakage past valve face.

Replace valve guides as follows:

9. Remove cylinder head sling and position cylinder head (combustion chamber side up), on support fixture SE-2104 in press bed (Figure 35). Support fixture is designed to position valve guides vertically under press ram.

10. Using remover tool SE-1722 (Figure 35) press valve guide from cylinder head. All guides must be pressed out from the combustion chamber side through the top of the head.

11. Turn cylinder head over (top side up) on support stand in press bed.

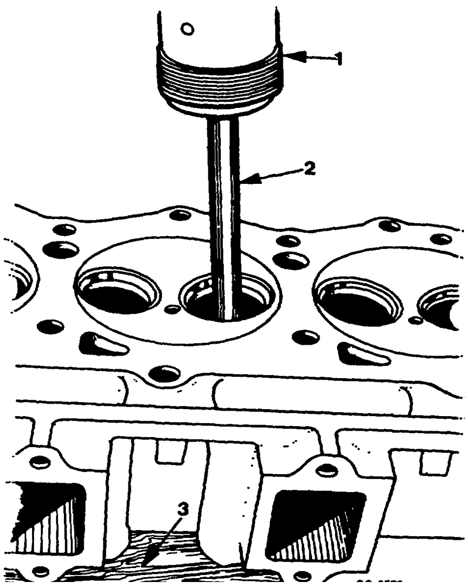


Figure 35. Removing Valve Guide

1. Press Ram
2. Remover Tool SE-1722
3. Support Fixture SE-2104

12. Adjust valve guide installer tool SE-1943 (Figure 36) for specified valve guide height above cylinder head. (See SPECIFICATIONS).Tool is designed to install both intake and exhaust guides.

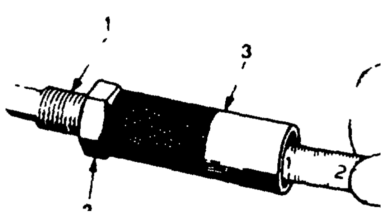


Figure 36. Adjusting Valve Guide Installer for Proper Height

1. Adjusting Screw 3. Body
2. Lock Nut

13. Insert top end of valve guide into staller tool. Lubricate O.D. of valve guide with a commercial press-fit lubricant. Press valve guide into cylinder head (Figure 37) until installer tool rests firmly on top of head, thus obtaining proper valve guide height.

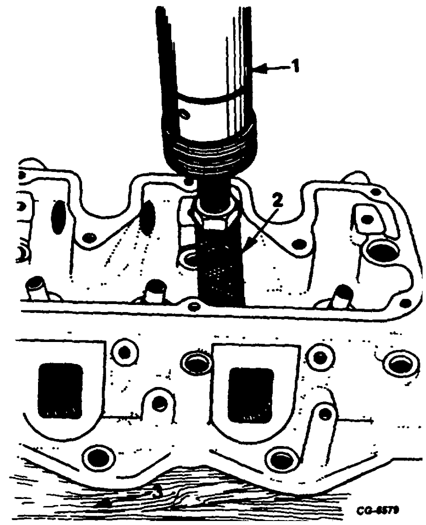


Figure 37. Installing Valve Guide

1. Press Ram
2. Installer
3. Support Fixture SE-2104

14. Replacement guides are designed to give proper clearance when installed in the cylinder head. Reaming is not required, but care must be taken to insure the ends of the guides are not burred during installation. After guides are installed, insert SE-2215 Reamer to insure guides have not been distorted during installation and to remove any burrs.

Valve Inserts

Inspect valve seat inserts for looseness, burned or cracked condition. Replace inserts showing indications of damage or excessive grinding.

Replace valve seat inserts as follows:

15. Using remover tool HC1044 (Figure 38) to remove intake valve inserts. ,osi3ion remover collet to insert and turn coned screw out to

expand collet jaws, providing a firm grip under insert ring. Use a slide hammer to remove insert.

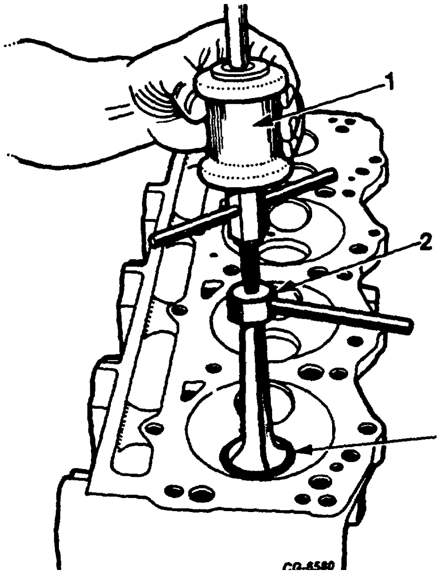


Figure 38. Removing valve Seat Insert

1. Slide Hammer
2. Remover Tool
3. Intake Valve Seat Insert

NOTE:

Model HC-104A Universal

Valve Seat Puller may be used for 9.0 liter engine exhaust valve seat removal. This tool can be ordered from:

Winona Tool Manufacturing Company
4730 West Highway 61
Winona, Minnesota 55987

16. Select inserts of proper size O.D. (Inserts are provided in oversizes for use in previously .serviced heads.)

17. Use counterbore tool such as SE-1797 (Figure 39) to clean up (or machine to desired oversize) the valve seat insert counterbores in cylinder head. Follow equipment manufacturer's instructions.

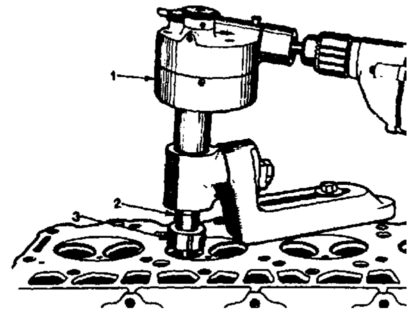


Figure 39. Machining Valve Seat Insert Counterbore

1. Cutter Drive Unit SE-1797
2. Drive Shaft
3. Cutter

18. Using insert installer tool from counterbore tool set SE-1797 (Figure 40) install valve seat inserts. Chill inserts thoroughly with dry ice or other means. Position insert on installer tool and drive into cylinder head counterbore until firmly seated.

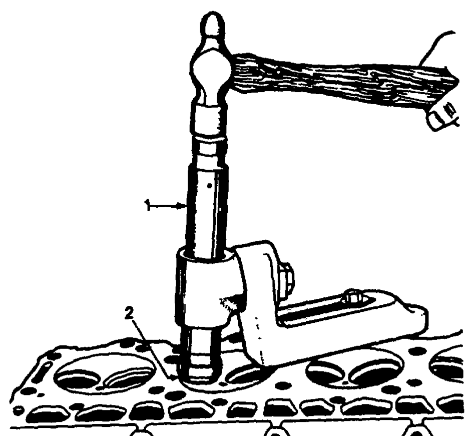


Figure 40. Installing Valve Seat Insert

1. Driver 2. Seat

19. Stake valve seat inserts securely in place. Use peening tool SE-2094 or a dull pointed chisel 6.35 mm (1/4") wide to peen cylinder head metal over outer edge of insert. Peen material all the way around insert except injection nozzle area on intake valve insert.

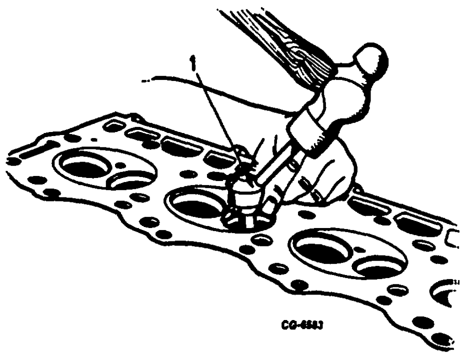


Figure 41. Staking Valve Seat Insert in Cylinder Head with Peening Tool

1. Peening Tool SE-2094

20. To insure a good compression - tight fit with valves, reface valve seats with precision equipment such as the SE-1631 or SE-1804 valve seat grinder (Figure 42). Grind seats to specified angle and seat width (See SPECIFICATIONS)

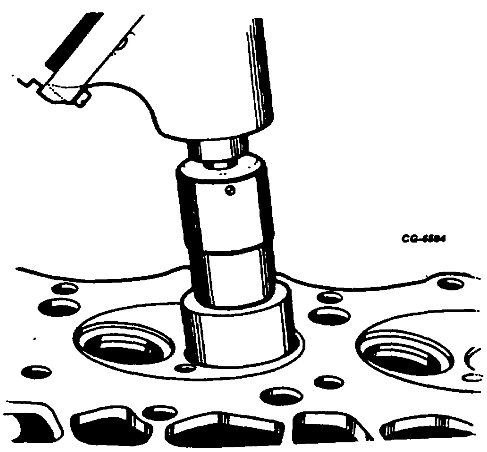


Figure 42. Grinding Valve Seat

21. During grinding operation remove only the minimum amount of material necessary to true up the seat. If the seat is wider than specified, it will be necessary to grind from the top of the seat until the proper seat width is obtained.

22. After grinding seats, check each seat for run-out using dial indicator or run-out gauge from SE-1631 seat grinder set (Figure 43). Seat run-out should not exceed specified limits (see SPECIFICATIONS).

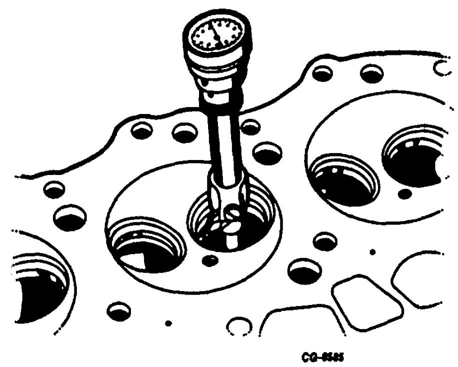


Figure 43. Checking Seat Run-Out

It is important to have the finished seat face contact the approximate center of the valve face. To check face contact, place a thin coat of Prussian Blue on valve face. Position valve in cylinder head and tap valve lightly to its seat Inspect each valve for seat dimensions as outlined in specifications and make any necessary corrections. Corrections should always be made on seat and not valve face. When seat contact is satisfactory, mark each valve for installation in its respective seat.

NOTE: This test is merely for proof of re- suits of defacing and reseating operations. Do not attempt to lap valves and seats. A poor grind job cannot be corrected by lapping A nearly perfect seat is often destroyed by attempting to lap the valves to their seats.

After valve grinding operation has been performed, check valve protrusion above cylinder head. Valve recession Is the distance valve head is located from cylinder head gasket surface. (See SPECIFICATIONS.) To check the minimum and maximum recession, the valves should be positioned in their respective ports to which they-were ground. Check valve recession by placing depth gauge SE-2515 on the valve edge and "O" gauge as illustrated (Figure 44). Then move depth gauge to gasket surface of cylinder head and compare reading with specification (Figure 44). This check must be made to assure clearance between top of piston and head of valves. If protrusion does not meet the minimum specified clearance, valve insert will have to be re-ground starting from the top of seat until proper clearance is obtained. However, if clearance is larger than specified, valve insert must be replaced and a grinding operation performed.

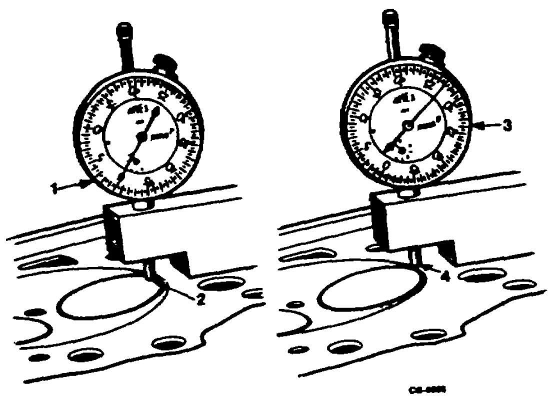


Figure 44. Checking valve Protrusion

1. Depth Gauge Set at Zero
2. Valve Edge
3. Depth Gauge Reading Recession
4. Cylinder Head Gasket Surface

Valve Springs

23. Inspect valve spring and dampers for wear or fatigue marks. Spring ends must be flat and square to prevent lateral loads on valve stem. Out-of-square springs place a side force on the stem causing rapid guide wear.

24. Using spring tester such as SE-2241 (Figure 45) check springs for proper tension (See SPECIFICATIONS). Weak valve spring tension can result in valve "float" (unsatisfactory closing) and valve bounce, which is common cause of seat pounding and valve breakage.

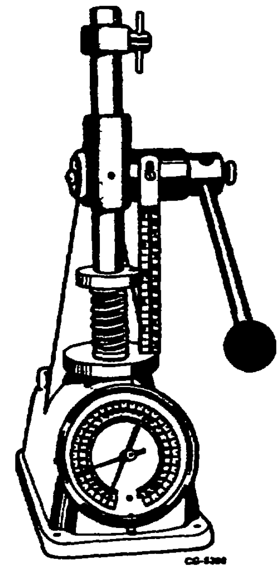


Figure 45. Checking Valve Spring Tension

25. Replace valve springs and dampers showing evidence of wear, cracks or improper tension, pits or rust.

    NOTE: Because of the possibility of fatigue cracks, valve springs and dampers should be replaced on the same basis as recommended for valves which have been in service for long periods.

26. Inspect valve spring retainers and roto-coil assemblies for wear. Rotate Roto-coil assemblies by hand to check for rough or irregular operation. Replace if wear or roughness is indicated.

27. Reinstall valves in cylinder head as follows: Wipe valve faces and seats with cleaning solvent to remove all dirt or foreign material. Coat valve stems and faces with oil and install valves in the seats to which they were checked. Install Roto-coil assembly, valve spring and damper assembly, valve stem seal and spring retainer (Figure 32). Compress valve spring with valve spring compressor and install valve spring retainer locks. Be sure retainer and locks are correctly seated on all valves.

REASSEMBLY

1. Install cylinder heads as follows:

   a. Position new cylinder head gaskets over the aligning dowel sleeve of each cylinder bank. Make sure all bolt holes in gaskets align with holes in crankcase.

   b. Using lifting sling SE-1896, place one cylinder head in the proper cylinder bank. Align head with dowel sleeves in crankcase. Loosely install all cylinder head bolts (Figure 46).

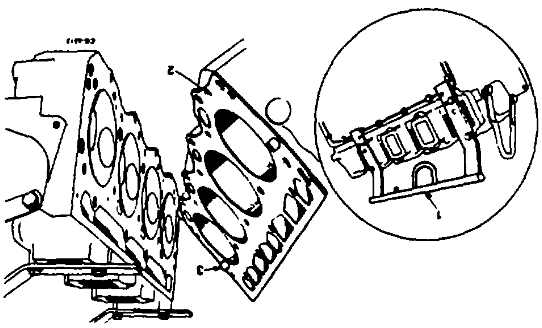


Figure 46. Installing Cylinder Head

1. Lifting Sling SE-1896
2. Gasket
3. Dowell Sleeve

IMPORTANT
LUBRICATE BOLT THREADS AND MATING SURFACES OF BOLT HEADS AND WASHERS WITH ENGINE OIL. REPEAT THESE OPERATIONS TO INSTALL OPPOSITE CYLINDER HEAD.

   c. Following sequence shown in (Figure 47) tighten cylinder head bolts the first two specified torques. Then for the final torque tighten the bolts in this sequence, 11, 3, 5, 13, 17, 9, 1, 7, 15, 16, 8, 2, 10, 18, 14, 6, 4 and 12. (See TORQUE CHART).

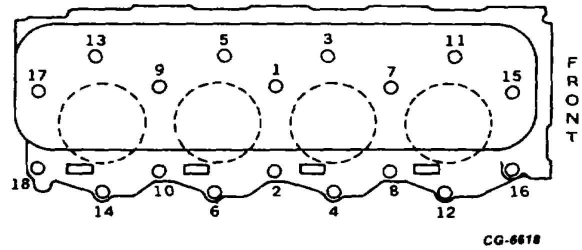


Figure 47. Cylinder Head Bolt Tightening Sequence

2. Place new extension gasket on each cylinder head and install extension (Figure 48). Tighten bolts to proper torque. See Figure 48).

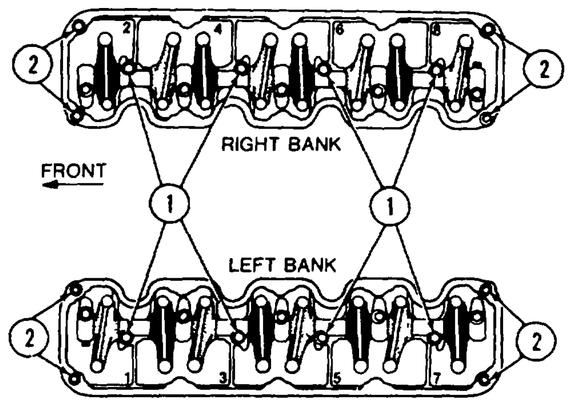


Figure 48.

1. 3/8 Bolts 16-23 N•m (12-17 ft-lbs)
2. 5/16 Bolts 13-20 N•m (10-15 ft-lbs) (Comer Mounting Bolts)

3. Insert valve lifter push rods in their respective positions.

4. Position a valve cap on each valve stem. Stick it on with grease.

   Install rocker arm assemblies as follows:

   a. Loosen rocker adjusting screw locknuts and back off adjusting screws.

   b. Position rocker arm assembly on extension, making sure rocker arms align with valve stems and rocker arm shaft spacer split is facing center extension mounting bolts. After torquing bolts make sure spacers have free movement.

c. Making sure there is no interference between rocker arms and push rods, tighten rocker arm support bolts to specified torque (see TORQUE CHART).

d. Position push rods under rocker arm adjusting screws and tighten screws until they just touch push rods with corresponding piston on compression stroke. It will be necessary to rotate the engine to accomplish this on all cylinders.

5. Adjust rocker arm to valve tip (tappet) clearance as follows: Figure 49

a. Remove valve covers.

IMPORTANT
INSURE SHUT-OFF SWITCH IS PULLED TO "OFF" POSITION.

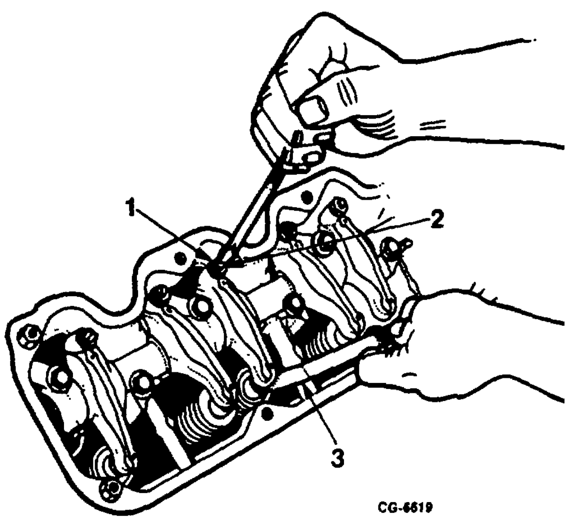


Figure 49. Valve Adjustment

1. Adjusting Screw Lock Nut	2. Adjusting Screw
	3. Feeler Gauge

6. Rotate the engine in operating direction to TDC for No. 1 cylinder (on compression stroke). Adjust the following valves:

No. 1 Int and Exh	No. 2 Int
No. 3 Exh	No. 4 Int
No. 5 Int	No. 8 Exh
No. 7 Exh	

a. With valve adjusting lock nut loose, position valve lifter rods under rocker arm adjusting screws, push rocker arm against rocker arm shaft mounting bracket and tighten screws until they just touch push rods.

b. Turn adjusting screw to allow 0.30 mm (0.12 in.) clearance gauge to pass between valve cap and rocker arm for intake valves or 0.41 mm (0.16 in.) clearance gauge for exhaust valves. MAY ADJUST WITH ENGINE HOT OR COLD.

c. Tighten adjusting screw lock nut, and check lash clearance.

7. Rotate the engine 360° to TDC for No. 6 cylinder (on compression stroke). Adjust the following valves:

No. 3 Int.	No. 2 Exh
No. 5 Exh	No. 4 Exh
No. 7 Int	No. 6 Int and Exh
	No. 8 Int

8. Inspect and replace valve cover gaskets as needed and install valve covers.

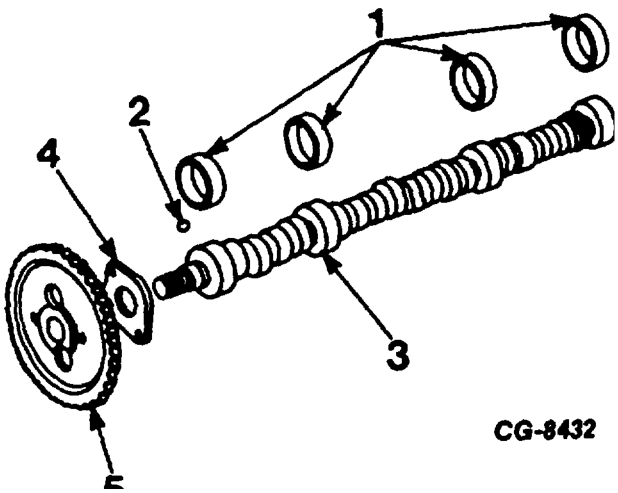


Figure 50

1. Camshaft Bearing
2. Woodruff Key
3. Camshaft
4. Thrust Flange
5. Camshaft Gear

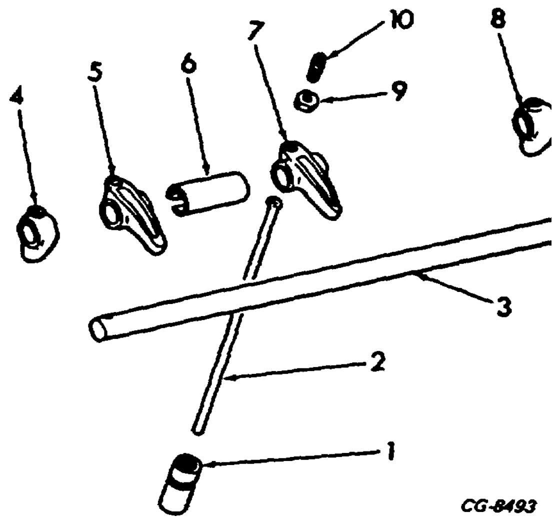


Figure 51.

1. Tappet
2. Push Rod
3. Rocker Arm Shaft
4. Oil Supply Bracket
5. Exhaust Rocker Arm
6. Spacer
7. Intake Rocker Arm
8. Shaft Bracket
9. Adjuster Nut
10. Adjuster Screw

VALVE TRAIN-CAMSHAFT, TAPPETS AND PUSH RODS
SPECIFICATIONS

CAMSHAFT

Bearing Journal Diameter	
Front	59.6011 - 59.6265 mm (2.3465 - 2.3475")
Second	58.8137 - 58.8391 mm (2.3155 - 2.3165")
Third	58.1533 - 58.1787 mm (2.2895- 2.2905")
Fourth	57.0611 - 57.0865 mm (2.2465 - 2.2475")
Bearing Clearance	.0381 - .0889 mm (.0015 - .0035")
Thrust Taken by	Thrust Flange
End Play	.0089 - .2921 mm (.0035 - .0115")
Timing Gear Backlash	.0127 - .1143 mm (.0005 - .0045")

ROCKER ARMS

Shaft Bore Diameter	21.905 - 21.968 mm (.8624 - .8649")
Clearance on Shaft	.028 - .114 mm (.0011 - .0045")
Rocker Arm To Valve Cap Clearance	
Intake	.305 mm (.012")
Exhaust	.407 mm (.016")

VALVE TAPPETS

Length	64.770- 65.786 mm (2.550 - 2.590")
Diameter	25.286 - 25.298 mm (.9955 - .9960")
Clearance in Block	.076 - .127 mm (.003 - .005")
Valve Tip to Rocker Arm Clearance	
(Hot or Cold)	.407 mm (.016")

SPECIAL TORQUES

Rocker Arm Support Bolts	42-47	(30-35)’
Rocker Arm (Valve) Adj. Nut	24,34	(18-25)

DISASSEMBLY

Refer to appropriate unit section to remove the following:
1. Injection Lines
2. Manifolds
3. Cylinder Head
4. Front Cover

NOTE: Rocker arm assembly is removed in the cylinder head repair section.

1. Remove tappets. Figure 52.

    NOTE: Mark tappets as to location in engine block so they can be returned to their original position.

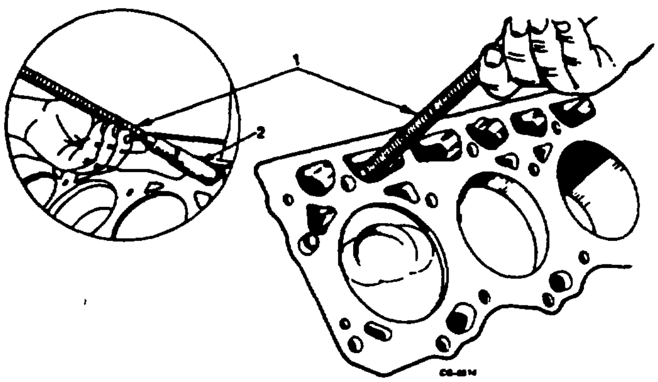


Figure 52. Tappet Removal
1. Remover Installer Tool SE-2097
2. Tappet

2. Mount dial indicator on front of engine and check and record camshaft gear-to-crankshaft gear backlash (Figure 53). If backlash exceeds specified limits (See SPECIFICATIONS), timing gears should be replaced.

3. Reposition dial indicator and check record camshaft end play (Figure 54). If end play exceeds specified limits (See SPECIFICATIONS) camshaft thrust plate should be replaced.

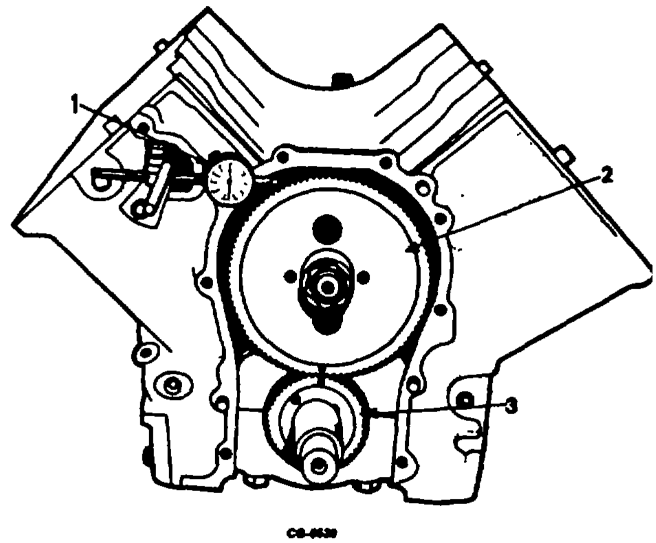


Figure 53. Checking Camshaft and Crankshaft Gear Backlash

1. Dial Indicator
2. Camshaft Gear
3. Crankshaft Gear

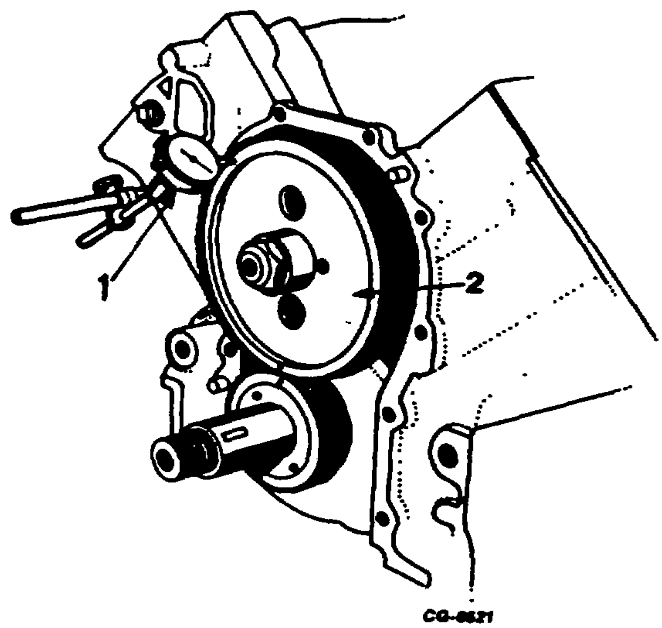


Figure 54. Checking Camshaft End Play

1. Dial Indicator.
2. Camshaft Gear

4. Remove camshaft thrust plate bolts (Figure 55).

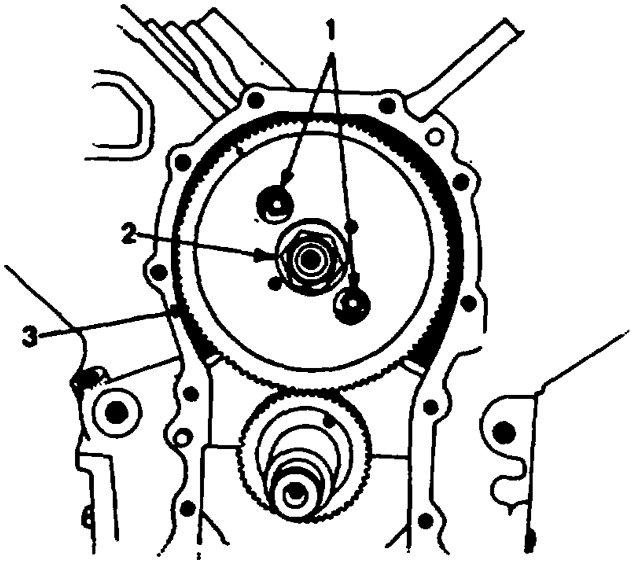


Figure 55. Camshaft Thrust Plate Mounting Bolts

1. Thrust Plate Mounting Bolts	2. Nut and Spacer 3. Camshaft Gear

5. Remove camshaft gear nut. Install removal tool SE-1880 on threads of camshaft and remove camshaft, gear and spacer as an assembly (Figure 56).

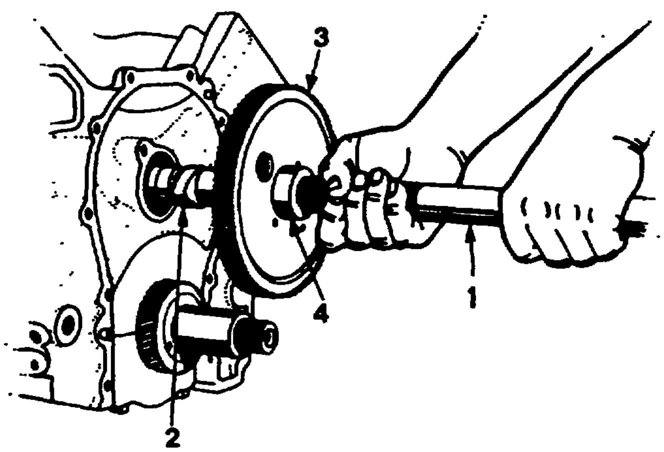


Figure 56. Removing Camshaft, Gear and Spacer as an Assembly

1. Remover SE-1880	3. Gear
2. Camshaft	4. Spacer

NOTE: Where desired, camshaft, gear and spacer can be removed individually as follows:

a. Remove camshaft nut and spacer. Using puller SE-1368, remove camshaft gear (Figure 57}.

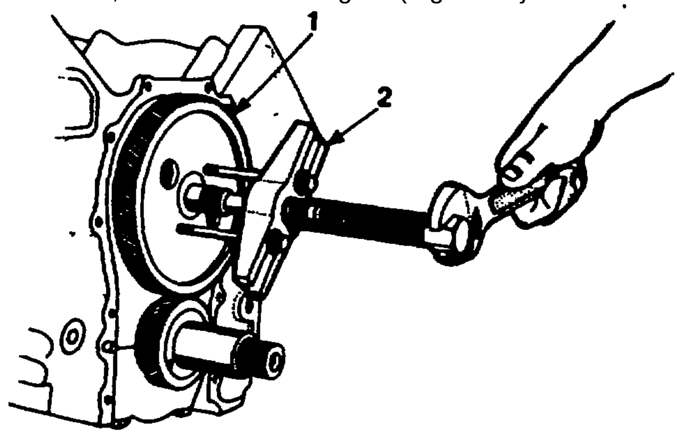


Figure 57. Removing Camshaft Gear

1. Camshaft Gear 2. Puller SE-1368

b. Remove camshaft thrust flange capscrews.

c. Install remover tool SE-1880 on threads of camshaft and remove camshaft (Figure 58).

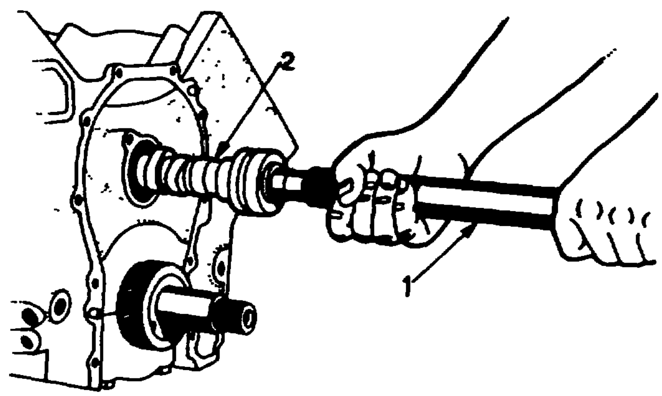


Figure 58. Removing Camshaft

1. Remover SE-1880 2. Camshaft

CAMSHAFT, ROCKER ARM AND RELATED COMPONENTS

Camshaft

1. Wash camshaft in cleaning solvent and remove all sludge or carbon deposits with a soft brush.

2. Check oil pump drive gear on rear of camshaft. If teeth are worn or damaged, camshaft must be replaced, as gear is integral with shaft.

3. Check camshaft gear and replace if teeth are nicked, worn or damaged.

NOTE: Camshaft gear, crankshaft gear and injection pump drive gear are provided in matched sets and should be installed only as sets.

4. Inspect spacer used on front of camshaft and replace if cracked or damaged.

CLEANING, INSPECTION AND REPAIR

Service rocker arm assemblies as follows:

1. Starting from end opposite oil feed support, slide supports and rocker arms from shaft. Keep parts in order so they may be replaced in their original position if in satisfactory condition.

2. Remove capscrew and lockwasher from oil feed support and press support from shaft.

3. Remove plugs from each end of shaft.

4. Clean all parts thoroughly, making sure all oil passages are open.

5. Inspect rocker arm shaft Check on a surface plate for signs of bending; check for wear from rocker arms. If a shaft is bent or shows excessive wear, it must be replaced.

6. Inspect valve stem cap and contact pad surface of rocker arm. If rocker arm pad wear is excessive, resurface pad but do not remove more than .010" of material from surface. If valve stem cap shows excessive wear, replace cap.

7. Check rocker arm bore for wear or scoring. Check the rocker arm-to-shaft running clearance. (See SPECIFICATIONS).

8. To assemble, align oil hole in oil feed support with cross hole in end of rocker arm shaft (Figure. 59). Then press oil feed support on shaft, indexing oil holes.

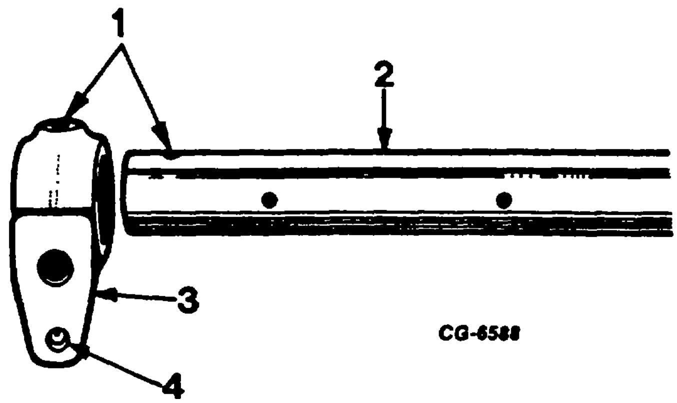


Figure 59. Aligning Holes in Rocker Arm Shaft and Support

1. Index Holes
2. Rocker Arm Shaft
3. Oil Feed Support
4. Oil Feed Orifice

NOTE: If oil holes are not indexed when performing pressing operation, they can be aligned by installing oil feed support in a vise (Figure 60) and using a drift punch rotate shaft to permit tightening support screw finger tight. Using this method will eliminate the possibility of bottoming bolt against shaft, which could result in stripping threads in support. After support has been secured to shaft use a fine oil stone to remove any burrs caused by using drift punch in hole to turn shaft.

9. Place rocker arms, rocker arm shaft spacers and remaining supports on shaft making sure rocker arm shaft-to-arm oil feed holes are in a downward position. This will properly position rocker arm shaft oil feed holes so that oil feed hole in right rocker arm shaft assembly will be toward the rear, while oil feed hole in left rocker arm shaft assembly will be toward the front. See Figure 60 for correct installation.

10. After rocker arm shaft has been completely assembled, a wire (Figure 63) can be used to hold assembly together for installation on cylinder head.

Clean and inspect all valve push rods Check push rods for straightness by rolling on a flat surface. Replace any that are bent or have loose ends.

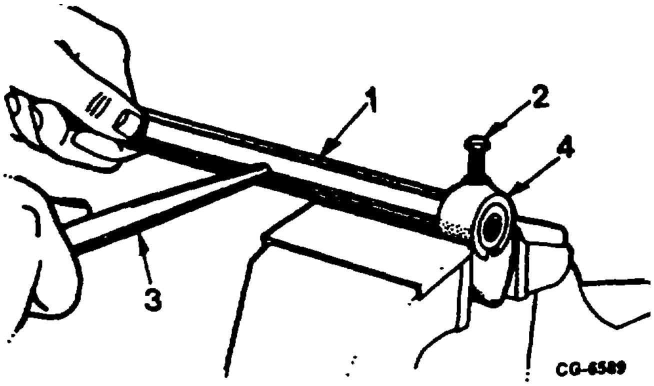


Figure 60. Turning Rocker Arm Shaft to Align Screw Holes

1. Rocker Arm Shaft
2. Bolt
3. Drift Punch
4. Oil Feed Support

REASSEMBLY

Camshaft

1. Coat camshaft lobes, bearing surfaces, camshaft bushings and camshaft gear teeth with heavy duty hypoid axle lubricant.

2. Insert camshaft (with gear and spacer into cylinder block).

3. Align timing marks on camshaft gear and crankshaft gear (Figure 61) and position camshaft into camshaft bushings. Remove installer tool.

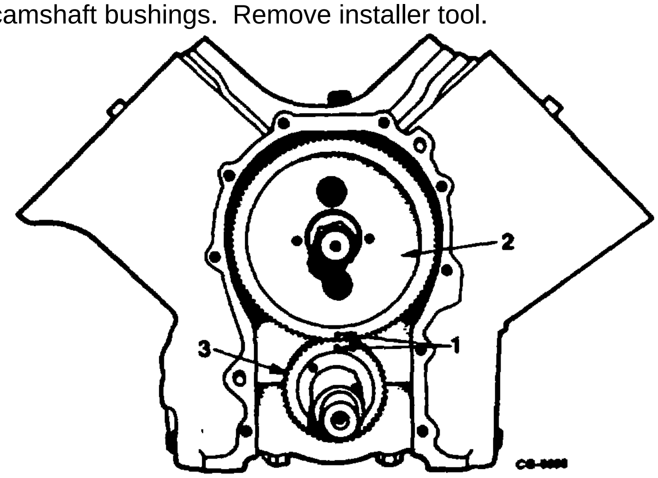


Figure 61. Aligning Timing Marks on Camshaft and Crankshaft Gears

1. Timing Marks
2. Camshaft Gear
3. Crankshaft Gear

4. Install camshaft thrust flange bolts and tighten to specified torque. (See TORQUE CHART).

5. Install camshaft gear nut and tighten to specified torque. (See TORQUE CHART).

6. Rotate crankshaft and camshaft to see that gears do not bind or interfere. Using dial indicator, check camshaft end play and camshaft gear-to-crankshaft gear backlash.

IMPORTANT

WHERE DESIRED, CAMSHAFT, THRUST PLATE AND CAMSHAFT GEAR CAN BE INSTALLED INDIVIDUALLY. USING INSTALLER TOOL SE-1880, INSTALL CAMSHAFT IN CYLINDER BLOCK (FIGURE 60). INSTALL CAMSHAFT THRUST FLANGE AND TIGHTEN BOLTS TO SPECIFIED TORQUE. USING SE-1900 INSTALLER AND SE-1900-2 ADAPTER, INSTALL CAMSHAFT GEAR ON CAMSHAFT (FIGURE 62).

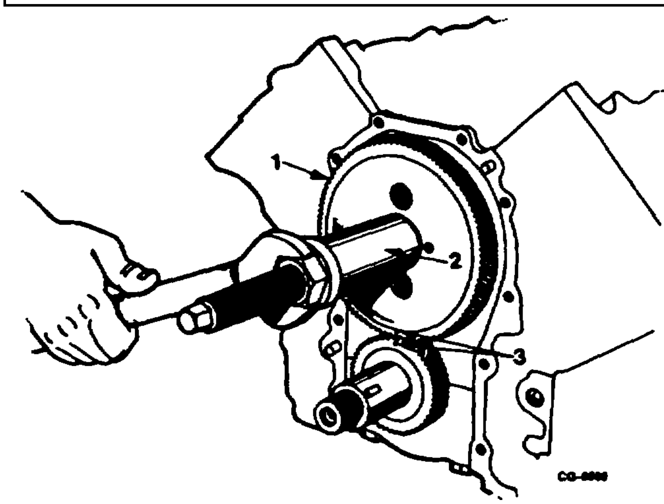


Figure 62. Installing Camshaft Gear

1. Camshaft Gear
2. Installer
3. Timing Marks

Rocker Arm Assembly

7. Place new extension gasket on each cylinder head and install extension.
8. Insert valve lifter push rods in their respective positions.

9. Position a valve cap on each valve stem.

10. Install rocker arm assemblies as follows:

11. Loosen rocker adjusting screw locknuts and back off adjusting screws.

12. Position rocker arm assembly on extension, making sure rocker arms align with valve stems and rocker arm shaft spacer split is facing center extension mounting bolts. After torquing bolts make sure spacers have free movement.

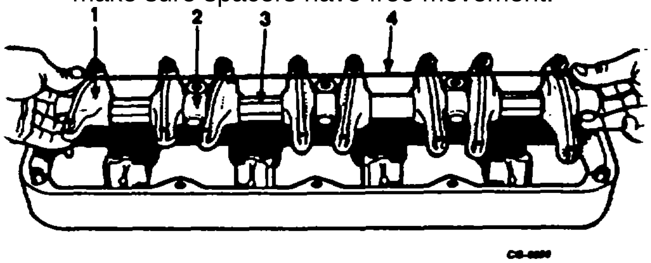


Figure 63. Method of Holding Rocker Arm Assembly Together for Installation

1. Rocker Arm
2. Support
3. Spacer
4. Temporary Assembly Holding Wire

13. Making sure there is no interference between rocker arms and push rods, tighten rocker arm support bolts to specified torque (see TORQUE CHART).

14. Position push rods under rocker arm adjusting screws and tighten screws until they just touch push rods with corresponding piston on compression stroke. It will be necessary to rotate the engine to accomplish this on all cylinder.

IMPORTANT

INSURE SHUT-OFF SWITCH IS PULLED TO "OFF" POSITION.

15. Rotate the engine in operating direction to TDC for No. 1 cylinder (on compression stroke). Adjust the following valves:

No. 1 Int and Exh — No. 2 Int
No. 3 Exh — No. 4 Int
No. 5 Int — No. 8 Exh
No. 7 Exh

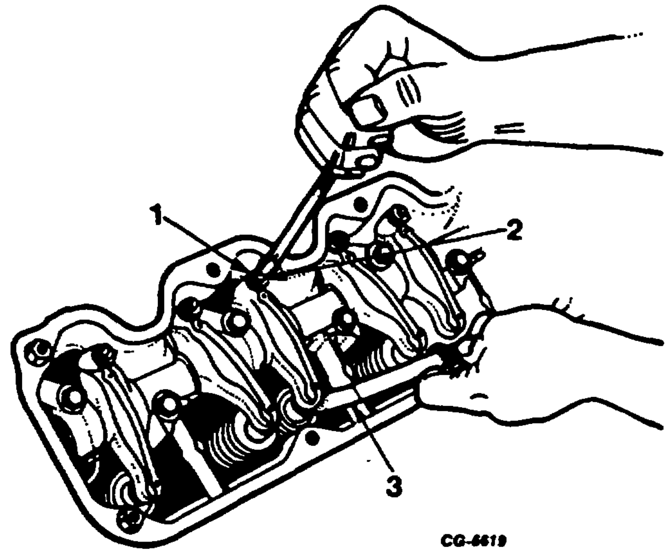


Figure 64. Valve Adjustment

1. Adjusting Screw Lock Nut
2. Adjusting Screw
3. Feeler Gauge

a. With valve adjusting lock nut loose, position valve lifter rods under rocker arm adjusting screws, *push rocker arm against rocker arm shaft mounting bracket* and tighten screws until they just touch push rods.

b. Turn adjusting screw to allow 0.30 mm (.012 in.) clearance gauge to pass between valve cap and rocker arm for intake valves or 0.41 mm (.016 in.) clearance gauge for exhaust valves. MAY ADJUST WITH ENGINE HOT OR COLD.

c. Tighten adjusting screw lock nut, and check lash clearance.

16. Rotate the engine 360^{O} to TDC for No. 6 cylinder (on compression stroke). Adjust the following valves:

No. 3 Int — No. 2 Exh
No. 5 Exh — No. 4 Exh
No. 7 Int — No. 6 Int and Exh
No. 8 Int

17. Inspect and replace valve cover gaskets as needed and install valve covers.

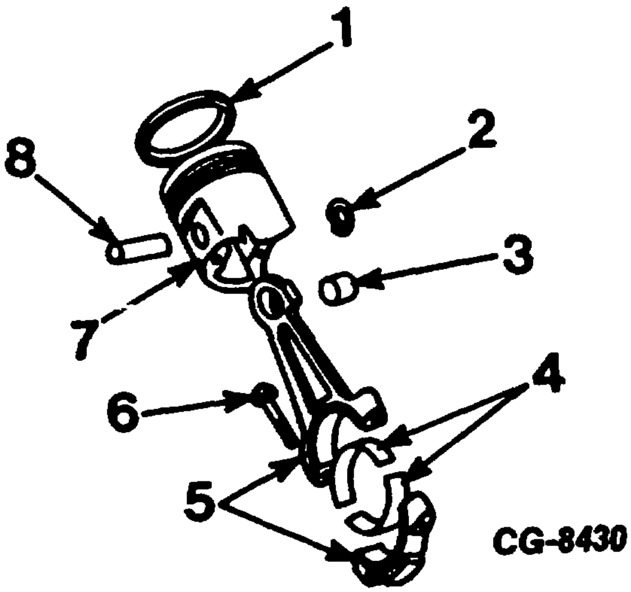


Figure 65

1. Piston Ring Set
2. Retainer Ring
3. Pin Bushing
4. Connecting Rod Bearings
5. Connecting Rod
6. Bearing Cap Bolt and Washer
7. Piston
8. Piston Pin

TORQUE CHART

	N•m	
Connecting Rod Cap Bolts	72[1]	55[1]

1. Plus an additional one sixth turn.

SPECIFICATIONS

Connecting Rods:	
Bearing Bore Diameter	74.8157 - 74.8284 mm (2.9455 - 2.9460")
Allowable Bore Out of Round	.0127 (.0005")
Allowable Bore Taper	.0127 (.0005")
Connecting Rod Bearing Clearance	.0483 - .1118 mm (.0019 - .0044")
Connecting Rod End Clearance	.2032 - .4572 mm (.008 - .018")
Bearing Insert Spread Dimensions:	
Main Bearing No. 1, 2, 4, 5	
Bearing O. D. Installed	84.226 - 84.252 mm (3.316 - 3.317)
Specified Spread	.762 mm Minimum (.030 Minimum)
Spread of Bearing	84.988 Minimum (3.346 Minimum)
Main Bearing No. 3 (Thrust):	
Bearing O. D. Installed	84.226 - 84.252 mm (3.316 - 3.317")
Specified Spread	.076 - .406 mm (.003 - .016")
Spread of Bearing	84.302 - 84.658 mm (3.319 - 3.332")

SPECIFICATIONS

Bearing Insert Spread Dimensions - Continued		
Connecting Rod Bearings:		
Bearing O.D. (Installed)	74.816 - 72.828 mm (2.9455 - 2.9460")	
Specified Spread	.762 mm Minimum (.030 Minimum)	
Spread of Bearing	75.578 mm Minimum (2.9755 Minimum)	
Pistons:		
Material	Aluminum Alloy	
Clearance in Cylinder Bore	.178 - .203 mm (.007 - .008")	
Standard Size Skirt Diameter	114.38 - 114.402 (4.503 - 4.504)	
Weight	1508 Grams (3.325 Lbs.)	
Piston Pins:		
Length	82.296 - 82.550 mm (3.240 - 3.250")	
Diameter	38.095 - 381 mm (1.4998 - 1.5000")	
Pin Fit: (Room Temperature 70°F)		
Clearance in Rod	.023 - .033 mm (.0009 - .0013")	
Clearance in Piston	.005 - .015 mm (.0002 - .0006")	
Piston Rings:		
Ring Diameter	114.55 mm (4.510")	
Compression Rings:		
Number Per Piston	2	
Size:		
Top	Tapered (Keystone Type)	
2nd	2.381 mm (.09375")	
Fit in Groove:	Upper Limit	Replacement Limit
Top (Diameter over Pins)	114.490 mm (4.5238)	114.132 (4.5934) - Standard
	115.158 mm (4.5338)	114.386 (4.5034) - (.010 O.S.)
	115.412 mm (4.5438)	114.640 (4.5134) - (.020 O.S.)
	115.566 mm (4.5538)	114.490 (4.5234) - (.030 O.S.)
2nd	.089 - .140 mm (.0035 - .0055")	
Gap	.330- .584 mm (.013- .023")	
Oil Control Rings:		
Number Per Piston	1	
Size	4.7625 mm (.1875")	
Fit in Groove	.038 - .076 mm (.0015 - .0030")	
Gap	.330- .711 mm (.013-.028")	

DISASSEMBLY

1. Remove the following:

   Cylinder Head
   Oil Pan

2. Refer to cylinder head and crankcase sections for detailed removal procedures.

3. To prepare for removal of piston and connecting rod assemblies, use ridge reamer tool to remove wear ridges from tops of cylinder bores.

4. Rotate crankshaft to position journals for removal of connecting rod and piston assemblies.

5. Remove each connecting rod bearing cap and push connecting rod and piston assembly from the cylinder bore (Figures 66 and 67). Replace cap and bearing inserts on rod so that identification numbers match.

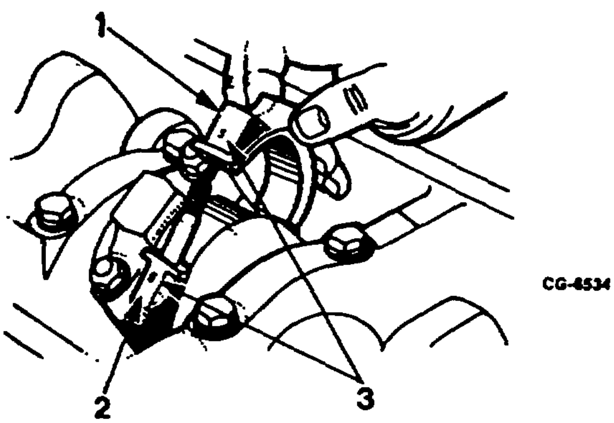


Figure 66. Removing Connecting Rod Cap

1. Connecting Rod Bearing Cap
2. Connecting Rod
3. Cap and Rod Identification

Pistons

To disassemble piston from connecting rod assembly remove piston pin retaining snap rings (one on each side of piston) by using snap ring removing pliers (Figure 68). Push piston pin out with thumb.
(It may be necessary to tap pin lightly to remove.) After the pin is removed, separate piston from connecting rod, taking precautions to see that parts are marked so they may be reinstalled in their respective cylinder.

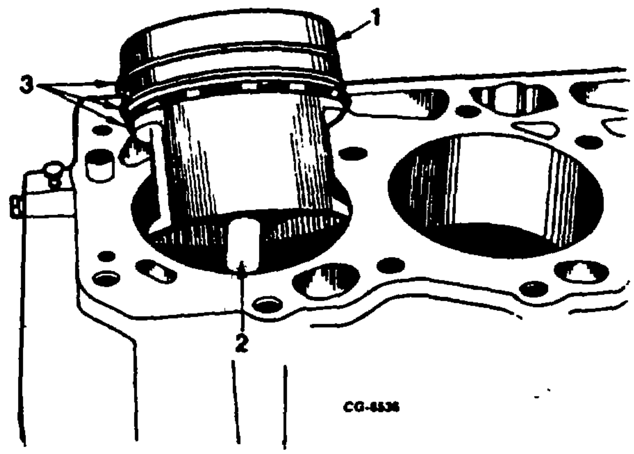


Figure 67. Removing Piston and Connecting Rod

1. Piston
2. Connecting Rod
3. Piston Ring

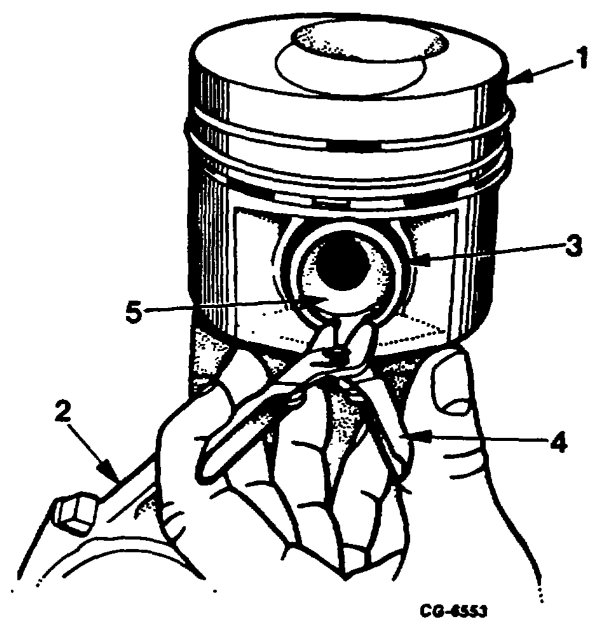


Figure 68. Piston Pin Removal

1. Piston
2. Connecting Rod
3. Piston Pin Retaining Snap Ring
4. Snap Ring Removing Pliers
5. Piston Pin

CLEANING, INSPECTION AND REPAIR

1. Remove all old piston rings. Immerse piston in cleaning solvent and clean thoroughly.

   NOTE: Never use a caustic solution for cleaning aluminum pistons.

2. Use a special ring groove cleaner or broken piston ring to clean all carbon from second compression ring groove and oil ring groove. Make sure that all oil holes are open.

3. The top (keystone type) groove cannot be cleaned with a ring groove cleaner or broken piston ring. It is suggested that piston be soaked in a carburetor type cleaning solution and softened deposits removed from top groove by running a heavy cord down in and around groove.

4. Inspect pistons for scuffed or scored skirts or cracked worn ring lands, discarding any showing such conditions.

5. Check fit of piston pins in pin bores of pistons. If pin bores are worn beyond specified limits, replace pistons.

6. To select correct size pistons for an engine overhaul, size of the cylinder bore diameters must be determined first. This can be accomplished with an inside reading micrometer or dial bore gauge. Each bore should be measured at top of ring travel and lower end of ring travel both parallel and at right angles to the crankshaft.

7. After cylinder bores have been measured and recorded, select a piston to fit a certain bore. This is accomplished by measuring the piston skirt at 90^{o} from the vertical center line of the piston pin bore along the horizontal center line of the piston pin bore. Figure 69. Piston size selected should be large enough to permit cleaning up cylinder bore and provide specified running clearance. See SPECIFICATIONS. Also, by making this check it can be determined if the engine has been rebuilt with oversize pistons. See SPECIFICATIONS.

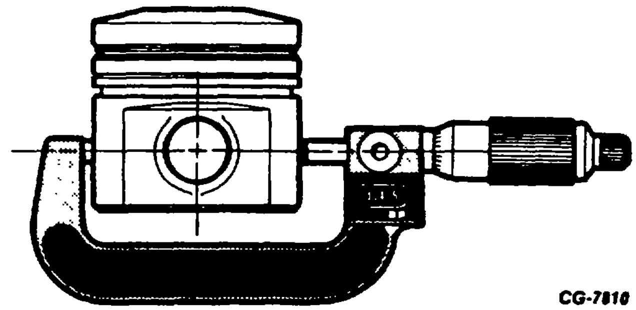


Figure 69.

Piston Pins

8. Inspect piston pins and replace any which show signs of corrosion or etching.

9. Using a micrometer, check piston pins for wear and out-of-round. Replace worn pins.

10. Check fit of piston pins in pistons and connecting rods. If piston pin bores of pistons are worn excessively, replace pistons. If piston pin bushings in connecting rods are worn or out-of-round, replace bushings. (See Connecting Rods.)

Piston Rings

11. The pistons have three piston rings located above the piston pin. The compression rings are located in the top grooves, while the lower groove accommodates the oil control ring Select the proper rings for the size of pistons to be used.

12. Prior to installing rings on pistons, each ring must be checked for proper ring gap. Push ring down into the cylinder bore, making sure ring is square with cylinder wall. Extreme care should be used during this operation. Check space or gap between the ends of ring with a feeler gauge (Figure 70). Ring gap should be within specified limits (See SPECIFICATIONS).

13. If gap is not within specified limits, try another ring for fit.

    NOTE: Do not attempt to alter gap of chrome-faced rings by filing ends of rings. This will damage the chrome plating.

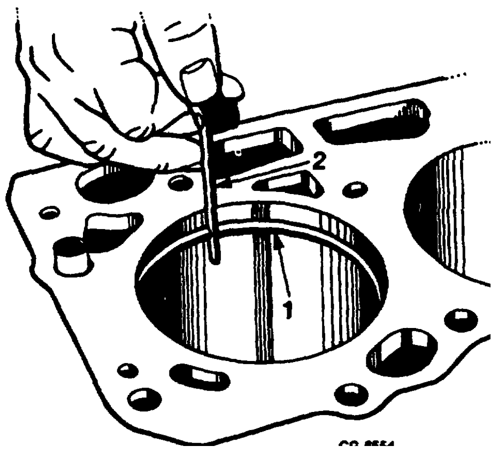


Figure 70. Checking Ring Gap

1. Piston Ring 2. Feeler Gauge

14. Each ring should be fitted and checked in the cylinder in which it is to be used and marked accordingly.

15. Second compression ring and oil control ring should be checked for side clearance in the groove of the piston on which they are to be installed. This is done by placing outer edge of ring in the piston groove, rolling ring entirely around piston to make sure there is no binding and ring is free in the groove. With a feeler gauge, check side clearance of each ring in its respective groove (Figure 71). See SPECIFICATIONS for proper clearance.

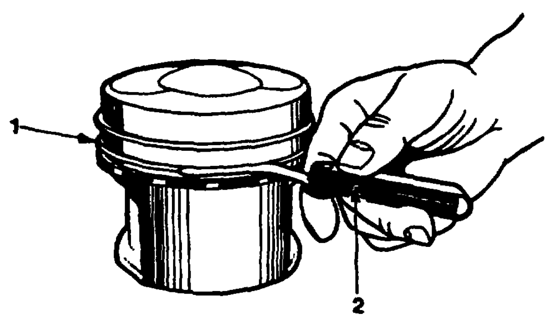


Figure 71. Checking Ring Side Clearance

1. Piston Ring 2. Feeler Gauge

16. Prior to installing keystone type top compression piston, top ring groove must be checked for wear.

    NOTE: A new piston groove measuring tool (No. 3020) has been developed to accommodate this.

17. The tool (No. 3020) consists of two 0.900 in. gauge pins and two 0.1150 in. gauge pins mounted on springs. The 0.900 in. gauge pins are not used for the 9.0 liter engine. The 0.1150 in. gauge pins-are used to measure the top piston groove wear.

18. If measurements over gauge pins are not within specifications, replace old piston and rings with new.

    a. After piston has been thoroughly cleaned place 0.1150 in. gauge pin and spring assembly in piston groove to be measured. Be sure that center of gauge pins align with center of piston so gauge pins are parallel.

    b. Place a 4-5 in. outside micrometer over gauge pins and take reading across the diameter the piston (widest point through piston center.) Figure 72.

    c. Record measurements and see SPECIFICATIONS.

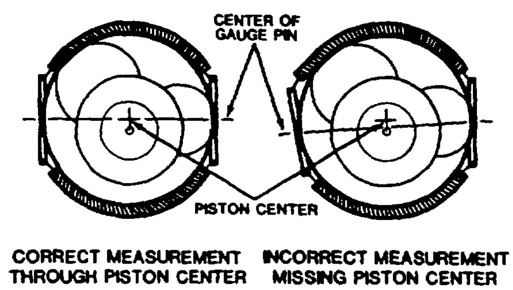


Figure 72.

19. Assemble rings on pistons to which they were fitted by using piston ring expander tool. This type of tool is recommended to avoid over-expanding and to avoid distortion (Figure 73). General practice when installing piston rings is to stagger the ring gaps. For further information refer to instructions furnished with service ring sets.

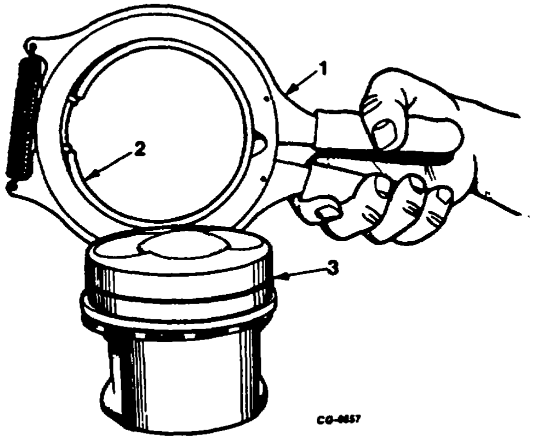


Figure 73. Installing Piston Ring

1. Piston Ring Expander Tool
2. Piston Ring
3. Piston Ring Groove

Connecting Rods

20. During manufacture, the connecting rods are subjected to a special heat-treating process known as "tuffride". The "tuffride" process is applied after the connecting rod has been finished machined and imparts a very hard surface to the rod.

Because of this special hardening of the connecting rod, no attempt is to be made to straighten or in any way bend the rod. To do so will cause minute fractures or cracks in hardened surfaces which will in turn lead to rod breakage.

When working with rods, use care to prevent rough handling, which could nick or notch rod surfaces and destroy the "tuffride" hardening. Rods must not be filed, ground or damaged in any way.

At the time of engine overhaul, connecting rods should be thoroughly cleaned and inspected for defects as outlined below.

21. Check connecting rod alignment on equipment such as the SE-1099 alignment checking fixture. Follow equipment manufacturer's instructions. Piston pin bore and connecting rod bearing bore must be parallel within .013 mm (.0005"). Replace rods that are bent. Do not attempt to straighten rods.

22. The connecting rod bearing plays a major role in distributing the proper amount of oil to piston pin, cylinder walls, piston and piston rings. This is known as oil throwoff, and the condition of the connecting rod bearing determines how well the lubrication operation is performed. Where bearing clearance is more than specified, an abnormal amount of oil is thrown onto cylinder walls, causing increased oil consumption and low oil pressure due to oil passing through the bearing surfaces too quickly. Where bearing clearances are less than the specified amount, oil flow through the bearing is insufficient to properly cool the bearing, resulting in short bearing life, improper oil throw-off and scoring of pistons and cylinder walls.

If connecting rod bearing bore is stretched or out-of-round beyond specified diameter, insert will be out-of-round and will not be held securely in connecting rod and bearing "crush" may be lost.

A very thorough inspection of the connecting rod bore is necessary. This inspection consists of the following:

Bore Size: With connecting rod cap installed and bolts tightened to specified torque, bearing bore (Figure 74) should be within specified limits (See SPECIFICATIONS).

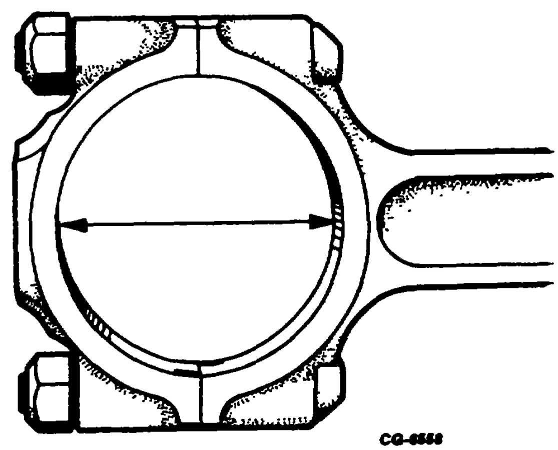


Figure 74. Connecting Rod Bearing Bore Measurement

Roundness: With connecting rod cap installed and bolts tightened to specified torque bearing bore out-of-round (Figure 75) should not exceed specified limits (See SPECIFI-CATIONS).

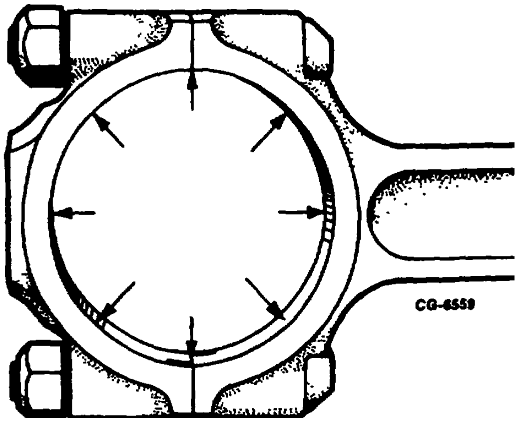


Figure 75. Connecting Rod Bearing Bore Out-of-Round Measurement

Straightness: Check for taper in bearing bore (Figure 76). Taper should not exceed limit given in SPECIFICATIONS.

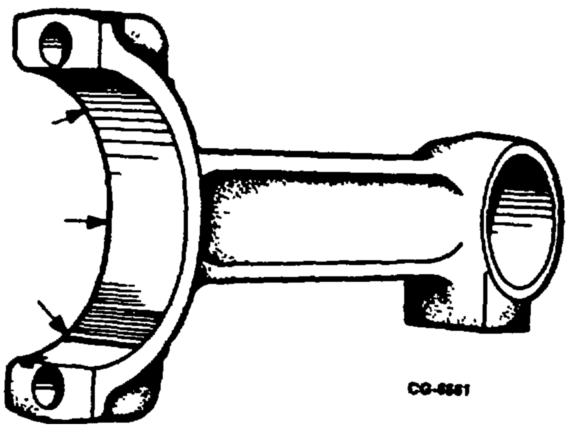


Figure 77. Connecting Rod Bearing Bore Surface Finish

The precision gauge furnished with honing machine SE-2218 or similar bore gauge as shown in Figure 78 can be used to inspect condition of connecting rod bearing bore.

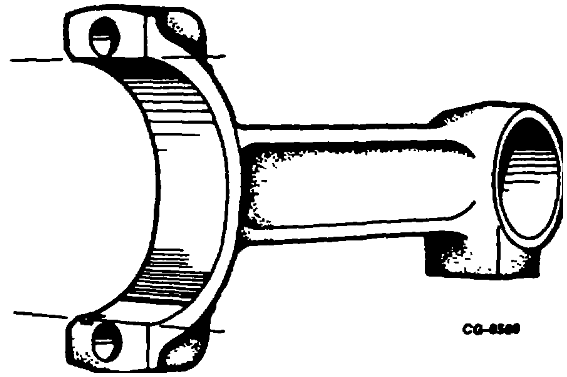


Figure 76. Connecting Rod Bearing Bore Taper Measurement

Surface Finish: The bearing insert contact surface must be smooth (Figure 77) without indication of uneven bearing contact or movement of bearing in bore.

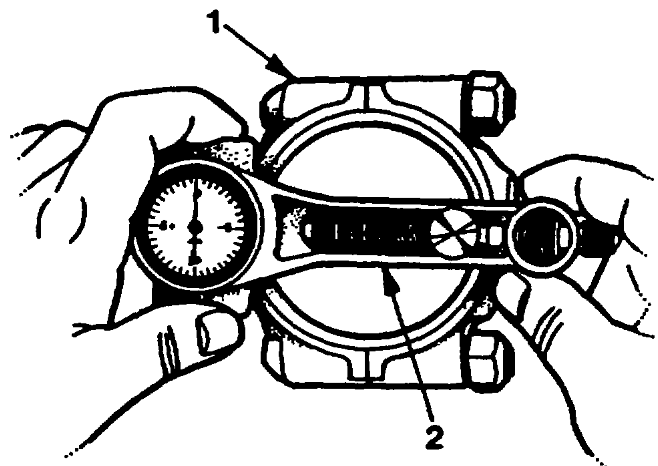


Figure 78. Checking Connecting Rod Bearing Bore

1. Connecting Rod 2. Bore Gauge

If connecting rod bearing bore does not pass the above inspection, connecting rod must be replaced.

NOTE: When replacing connecting rods, mark (number) new rods and caps to correspond with old parts being replaced.

23. Check fit of piston pin in connecting rod piston pin bushing. If bushing is worn or out-of-round, replace bushing as follows:

    a. Insert remover end of SE-2417 remover/ installer tool into bushing. Position tool and connecting rod in press using a piece of tubing 5.08 cm (2") O.D. x 4.4 cm (1.75") I.D. x 5.08 cm (2") long as a support (Figure 79). Press bushing out of rod.

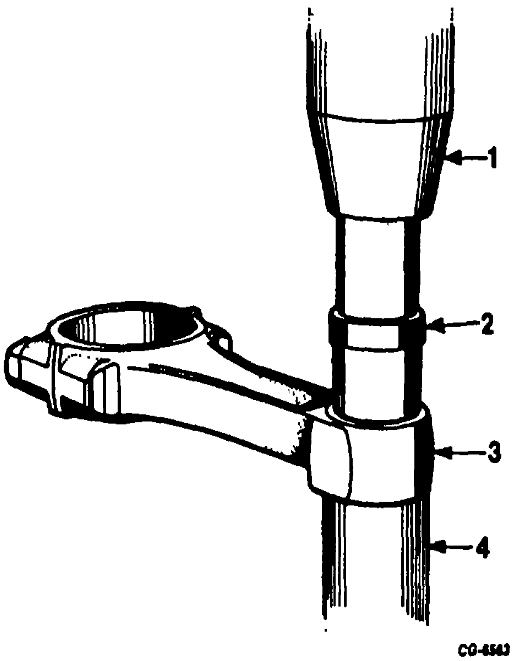


Figure 79. Removing Piston Pin Bushing from Connecting Rod

1. Press Ram
2. Remover
3. Connecting Rod
4. Tubing

    b. Place new bushing on installer end of SE2417 remover/installer tool. Using support plate SE-1033 position connecting rod in press with large chamfer side of connecting rod bearing bore down (Figure 81). Lubricate O.D. of bushing with a commercial press fit lubricant or engine oil. Align split of bushing on a horizontal plane with balance boss of rod (Figure 80) and press bushing into rod until shoulder of installer tool is firmly seated against rod.

    c. Ream or hone new piston pin bushing to provide a hand push piston pin fit.

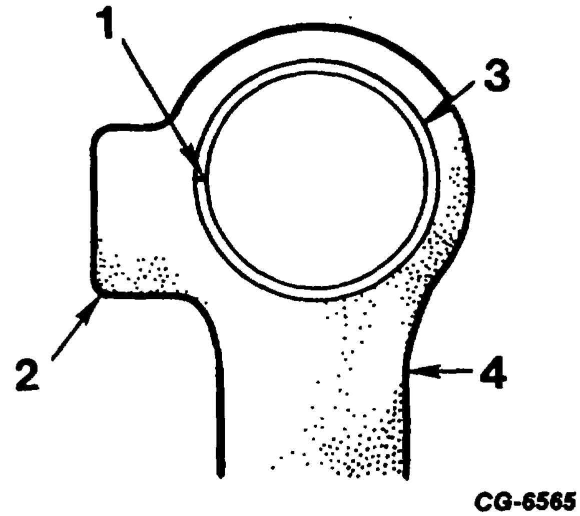


Figure 80. Installing Piston Pin Bushing in Connecting Rod

1. Location of Bushing
2. Balance Boss
3. Bushing
4. Connecting Rod

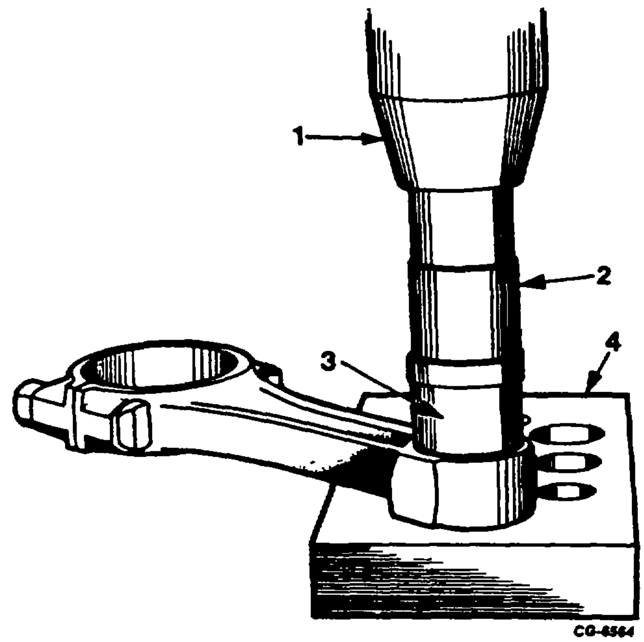


Figure 81. Proper Location of Bushing Split When Installed in Connecting Rod

1. Press Ram
2. Installer
3. Bushing
4. Support Plate

24. To assemble piston to connecting rod, position rod into piston so that connecting rod bearing locators (tangs) will be toward the side marked "top" of piston or the side where the combustion cavity is close to the edge of the piston (Figure 82). Lubricate piston pin with clean engine oil. Align rod bore and piston bore and insert piston pin. Push piston pin into place with thumb and install retainer snap rings.

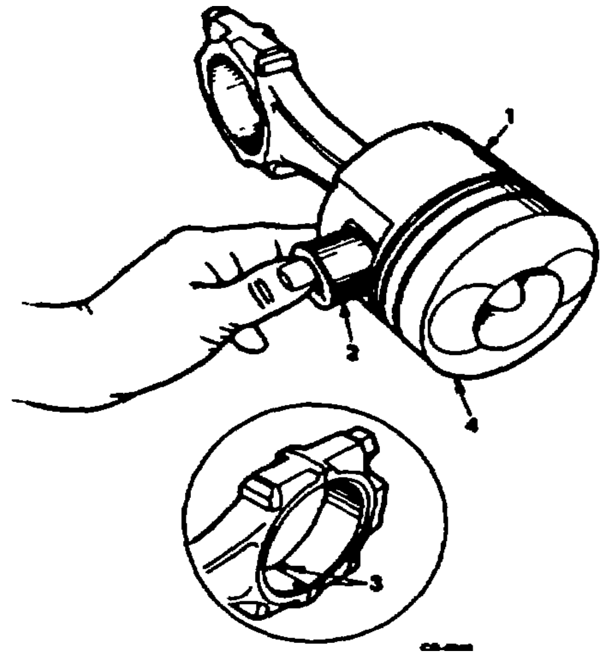


Figure 82. Installing Piston Pin

1. Piston
2. Piston Pin
3. Bearing Locators (Tang)
4. Marked Top

25. It is important, that rod and piston be assembled correctly, so that when piston is installed In engine, the large, chamfered side of each rod is located against crankshaft face. The chamfer provides clearance for the crankshaft fillet (Figure 83).

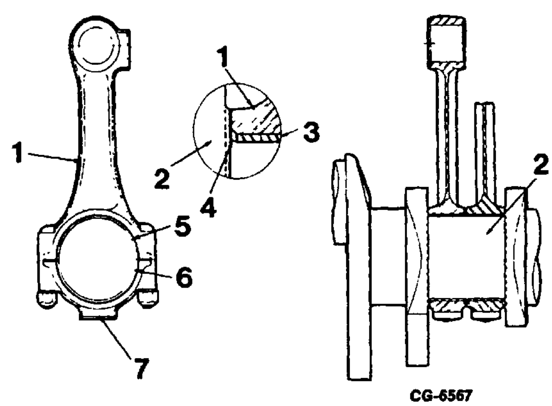


Figure 83. Proper Installation of Connection Rod to Crankshaft

1. Connecting Rod
2. Crankshaft
3. Bearing
4. Crankshaft Fillet
5. Connecting Rod Bearing - Upper
6. Connecting Rod Bearing - Lower
7. Connecting Rod Bearing Cap

Connecting Rod Bolt Tightening

Correct fastening of connecting rods to the engine crankshaft is extremely important.

The major purpose of tightening connecting rod bolts and nuts to a specified torque is to obtain tension in the bolt (Figure 84) which in turn develops a clamping load or preload that exceeds any possible loading imposed on connecting rod parts during engine operation. The connecting rod must "hang on" to crankshaft and suffer all the strains of inertia and cylinder combustion impulse without permitting the least movement or flexing of the rod cap, bolts or nuts. Torque applied must be within the capacity of parts (bolt, nut, caps, connecting rods) to withstand these loads. Especially designed bolts, nuts and washers manufactured from selected materials permit application of this loading without undue stretching of bolts.

There is a relationship between torque applied and clamping effect obtained. For proper clamping, connecting rod bolts and nuts must be cleaned of all foreign matter including the anti-rust materials that may be in the threads. It is recommended that new connecting rod bolts, nuts and washers be used during reassembly.

Threads that are dry, excessively rough, battered or that are filled with dirt require considerable effort just to rotate the nut. When bolts are tightened, torque reading mounts rapidly (due to thread friction) to specified figure without approaching desired bolt tension and clamping effect. Under these conditions specified torque reading is obtained, but clamping effect might be far below requirements, leading to bearing failure or to connecting rod bolt breakage.

Proper bolt tension and clamping effect cannot be attained if bolt threads are dry. Threads of nut and bolt and contact surfaces of nut and washer should be lubricated with engine oil at installation.

Tighten connecting rod bolt nuts alternately and finish tightening with torque wrench to specified torque, then release torque load to zero and re-torque to specified torque. (See Torque Chart.) After rod bolts have been torqued, turn nut an additional one-sixth turn or one flat of the nut. If nut is inadvertently overtightened enough to stretch the bolt, it must be replaced with a new bolt and nut In major engine overhaul use new rod bolts, nuts and flat washers throughout.

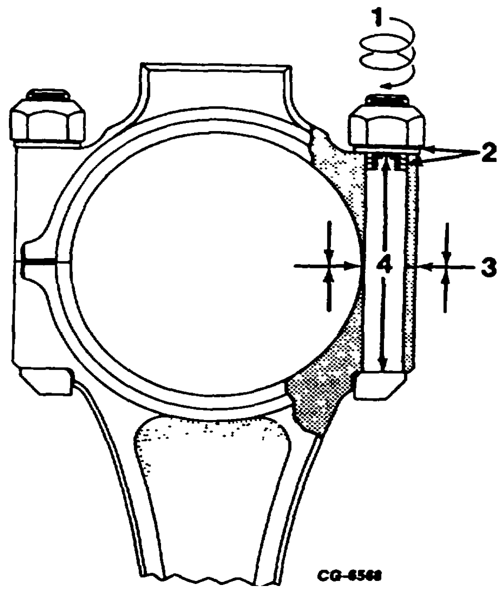


Figure 84. Connecting Rod Cap Bolt and Nut Details

1. Torque
2. Friction
3. Clamped
4. Tension

To torque connecting rod bolt nuts, use a torque wrench known to be accurately calibrated.

CAUTION! Do not use a power wrench for removing or installing connecting rod bolts, nuts and washers. Such practice will cause seizure of the connecting rod bolt or nut threads.

26. When installing precision-type connecting rod or main bearings, it is important that bearing shells fit tightly in bearing bore. To accomplish this, the bearing manufacturer makes the diameter at right angles to the parting line slightly larger than the actual diameter of the bore into which they are assembled. When the assembly is drawn up tight, bearings are compressed, assuring a positive contact between bearing back and bore. This increased diameter is referred to as bearing "crush." (See Figure 85).

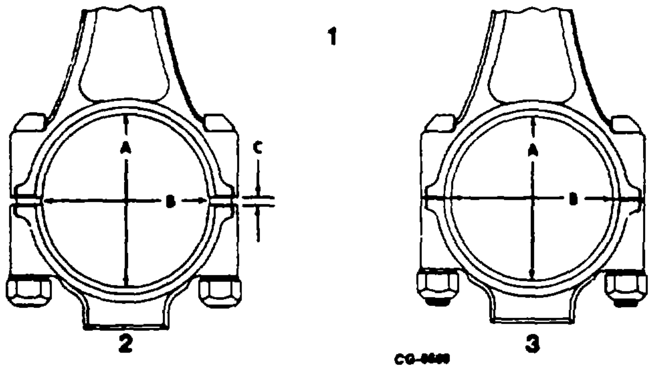


Figure 85. Illustration of Bearing "Crush"

1. Difference between diameters (A) and (B) is bearing crush (C).

2. Diameter (A) at right angles to parting lines greater than diameter (B).

3. With bearing cap drawn up tight, diameter (A) and (B) are equal.

Fitting Connecting Rod Bearings

27. The following procedure can be used to check connecting rod bearing clearance, using Plastigage, and connecting rod end clearance.

    NOTE: To obtain an accurate reading using Plastigage, both connecting rods (right bank and left bank) must be in place on each crankshaft rod journal and torqued to specifications.

    a. Remove bearing cap and wipe oil from face of bearing insert and exposed portion of crankshaft journal.

    b. Place a piece of Plastigage on bearing surface the full width of bearing about 1/4" off center.

    c. Install cap and tighten bolts and nuts to 68 N•m (50 lb.-ft.) torque.

    NOTE: Do not turn crankshaft while Plastigage is in place.

    d. Remove bearing cap and use Plastigage scale to measure widest point of Plastigage (Figure 86). This reading indicates bearing clearance in thousandths of an inch.

    e. It bearing clearance (with new bearing inserts) is not within specified limits (see SPECIFI-CATIONS), the crankshaft must be replaced.

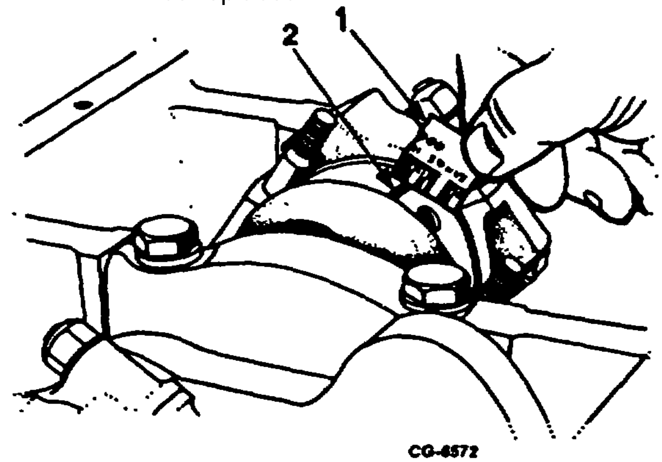


Figure 86. Checking Connecting Rod Bearing Clearance

1. Gauge 2. Plastigage Flattened

28. Check connecting rod end clearance using a feeler gauge as shown in Figure 87. End clearance should be within specified limits. (See SPECIFICATIONS.)

    Excessive clearance may require replacement of rods or shaft Lack of clearance could indicate a damaged rod or perhaps a rod bearing out of position.

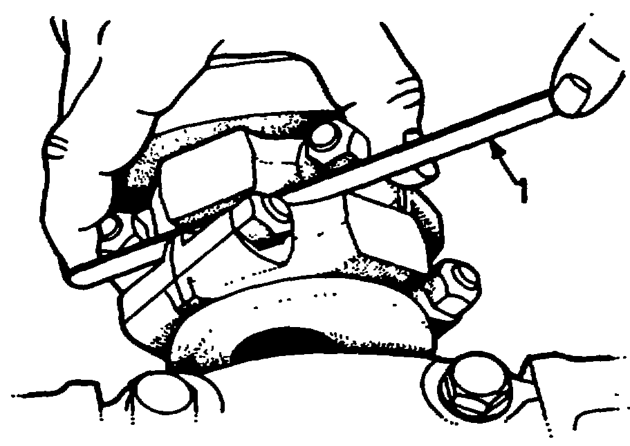


Fig. 109. Checking Connecting Rod End Clearance
Figure 87. Checking Connecting Rod End Clearance

1. Feeler Gauge

REASSEMBLY

1. Install piston and connecting rod assemblies as follows:

   a. Turn cylinder block to vertical position with front end facing upward. Turn No. 1 crankpin to the top of its stroke.

   b. Coat No. 1 piston and piston rings with clean engine oil and install piston ring compressor on piston.

   c. Coat No. 1 cylinder bore with clean engine oil. Position piston and rod assembly in cylinder bore with word "TOP" marked on piston toward centerline of engine block. Carefully push piston and rod assembly through ring compressor (Figure 88) until piston is in cylinder bore. Avoid striking cylinder bore with connecting rod.

   d. Coat crankshaft journal and connecting rod bearings with clean engine oil. Pull connecting rod down onto crankshaft journal. Install connecting rod cap to rod with marked sides matching.

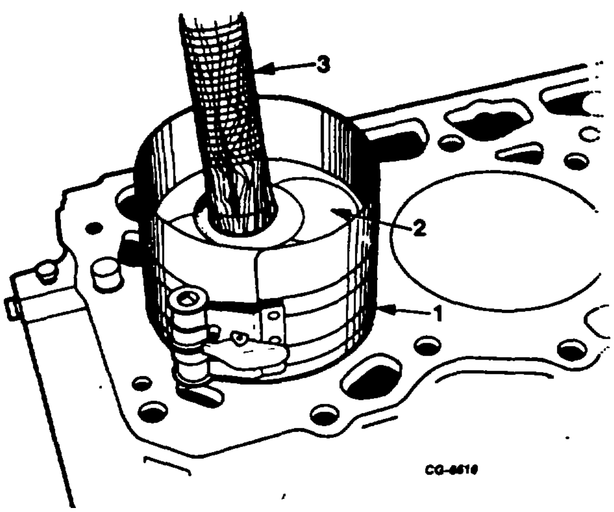


Figure 88. Installing Piston and Connecting Rod Assembly

1. Ring Compressor
2. Piston
3. Hammer Handle

   e. Install new bearing cap bolts, nuts and flat washers. Lubricate bolt threads and mating surfaces of bolt heads and washers with engine oil and install bolts.

IMPORTANT

WHEN INSTALLED PROPERLY, THE LARGE CHAMFERED SIDE OF THE ROD AND CAP WILL BE ON THE FILLET SIDE OF THE CRANKPIN (FIGURE 89).TIGHTEN BOLTS TO SPECIFIED TORQUE SHOWN IN TORQUE CHART, THEN RELEASE TORQUE LOAD TO ZERO AND RETIGHTEN TO SPECIFIED TORQUE. AFTER BOLTS HAVE BEEN TORQUED, TURN EACH NUT AN ADDITIONAL ONE-SIXTH TURN OR ONE FLAT OF THE NUT.

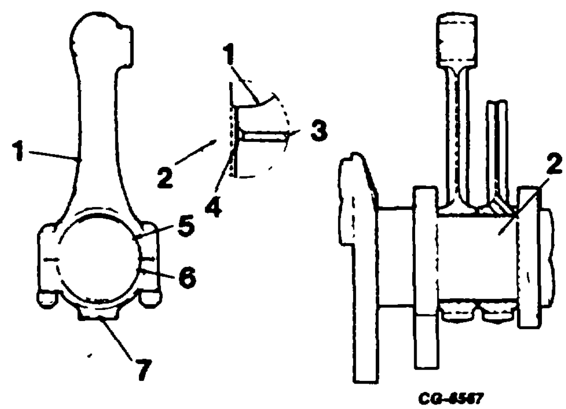


Figure 89. Proper Installation of Connection Rod to Crankshaft

1. Connecting Rod
2. Crankshaft
3. Bearing
4. Crankshaft Fillet
5. Connecting Rod Bearing - Upper
6. Connecting Rod Bearing - Lower
7. Connecting Rod Bearing Cap

   f. Install remaining piston and connecting rod assemblies in the same manner.

   g. Recheck connecting rod end play.

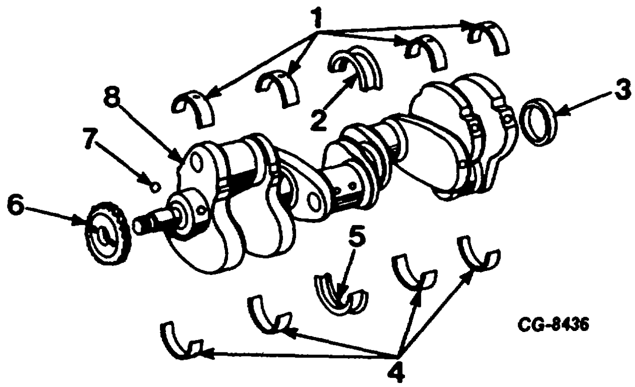


Figure 90. Crankshaft and Related Parts

1. Upper Bearing Inserts
2. Upper Thrust Bearings
3. Crankshaft Wear Sleeve
4. Lower Bearing Inserts
5. Lower Thrust Bearing
6. Crankshaft Gear
7. Woodruff Key
8. Crankshaft

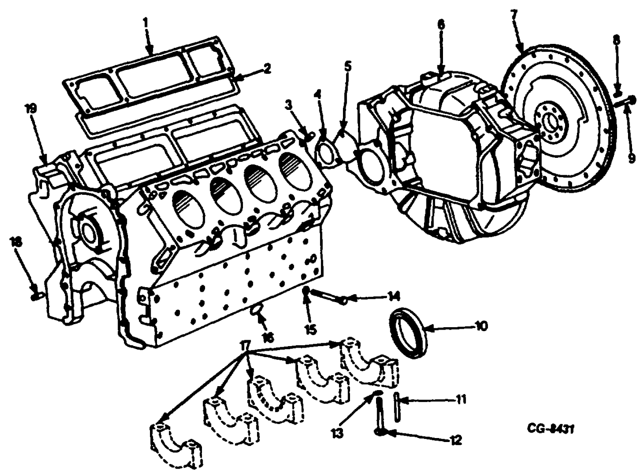


Figure 91. Crankcase and Related Parts

1. Tappet Cover
2. Tappet Cover Gasket
3. Cylinder Head Dowel
4. Cover Plate Gasket
5. Camshaft Cover Plate
6. Flywheel Housing
7. Flywheel
8. Dowel Pin
9. Flywheel
10. Rear Seal
11. Rear Bearing Cap Seal
12. Bolt
13. Washer
14. Tie Bolt
15. Washer
16. Expansion Plug
17. Main Bearing Caps
18. Dowel
19. Crankcase

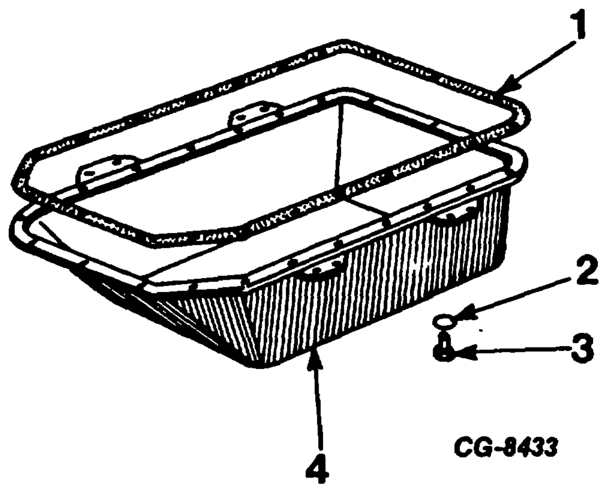


Figure 92.

1. Oil Pan Gasket
2. Washer
3. Drain Plug
4. Oil Pan

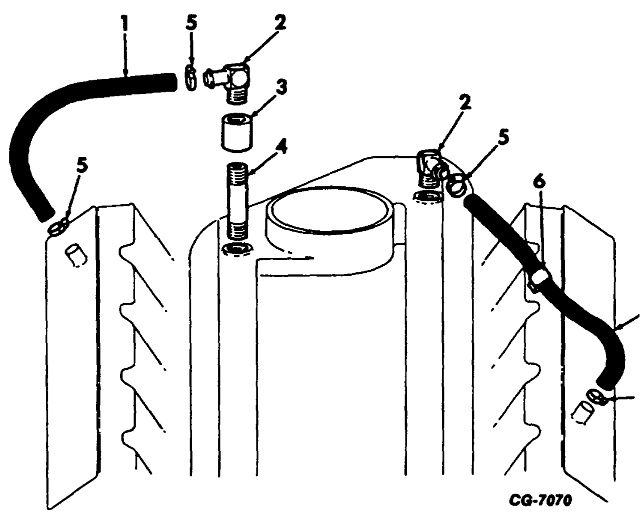


Figure 93. Crankcase Ventilation

1. Hose
2. Elbow, 90 Degree
3. Coupling, Pipe
4. Nipple, Pipe
5. Clamp, Hose
6. Clamp
7. Hose

CRANKSHAFT, MAIN BEARINGS, FLYWHEEL AND CRANKCASE SPECIFICATIONS

Crankshaft:	
Main Journal Diameter	416 - 677 - 2850 Missagua 79.324 - 79.350 mm (3.123 - 3.124")
Number of Main Bearings	5
Crankpin Diameter	69.926 - 69.952 mm (2.753 - 2.754")
Bearing Clearance	.0457 - .1219 mm (.0018 - .0048")
Crankshaft End Play	.1016 - .2540 mm (.004 - .010")
Thrust Taken By	Intermediate
Hardening Method	Elotherm (Induction Hardening)

Bearing Insert Spread Dimensions:	
Main Bearing No. 1, 2, 4, 5,:	
Bearing O.D. Installed	84.226 - 84.252 mm (3.316 - 3.317)
Specified Spread	.762 mm Minimum (.030 Minimum)
Spread of Bearing	84.988 Minimum (3.346 Minimum)
Main Bearing No. 3 (Thrust):	
Bearing O.D. Installed	84.226 - 84.252 mm (3.316 - 3.317")
Specified Spread	.076- .406 mm (.003- .016")
Spread of Bearing	84.302 - 84.658 mm (3.319 - 3.332")

Flywheel Runout	0.20 mm (.008")
Flywheel Concentricity	0.20 mm (.008")

TORQUE CHART

Location	Recommended Torque, Newton-meters	Ft. Lbs.
Main Bearing Cap Bolts	169183	(125-135) (*)
Main Bearing Tie Bolts (*)	54-61	(40-45) (*)
Crankshaft Pulley Nut	353-393	(260-290)
Flywheel to Crankshaft Bolts	149156	(110115)

All Other Fasteners Refer to General Torque Chart.

* Main bearing cap bolts must be torqued before tightening tie bolts

DISASSEMBLY

1. Remove the following:

   Cylinder Head
   Intake Manifolds
   Exhaust Manifolds
   Injection Pump
   Camshaft
   Pistons
   Front Cover

   Refer to the appropriate manual section for detailed removal procedures.

2. Disconnect left and right bank ventilator hose from air intake manifold crossover (Figure 94).

3. Disconnect ventilator hose from left valve cover (Figure 94).

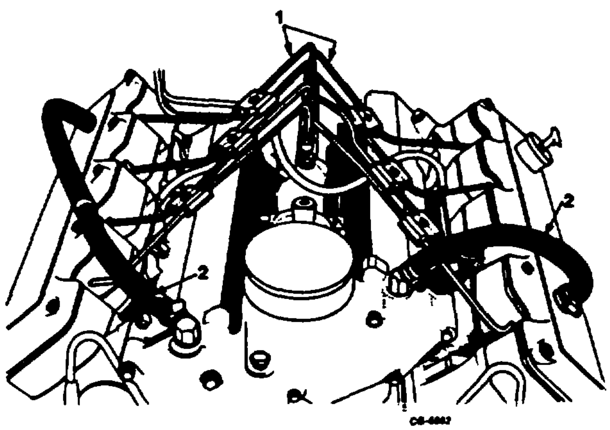


Figure 94. Removing Injection Lines and Ventilator Hoses

1. Fuel Injection Lines
2. Ventilator Hose

4. Prior to disassembly check crankshaft to camshaft gear backlash Figure 95.

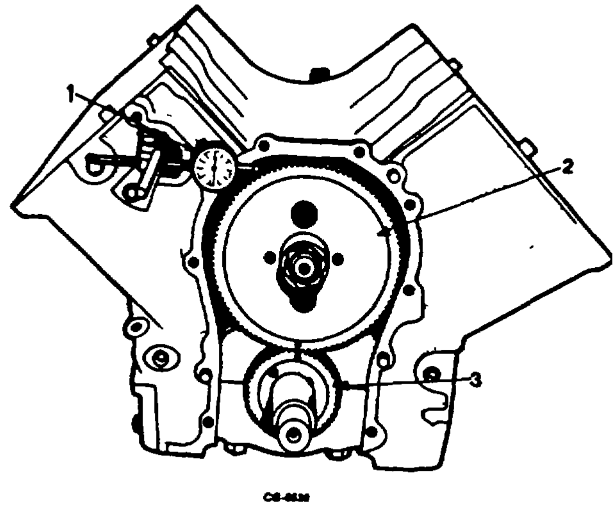


Figure 95. Checking Camshaft and Crankshaft Gear Backlash

1. Dial Indicator
2. Camshaft Gear
3. Crankshaft Gear

5. Check crankshaft end play. Figure 96.

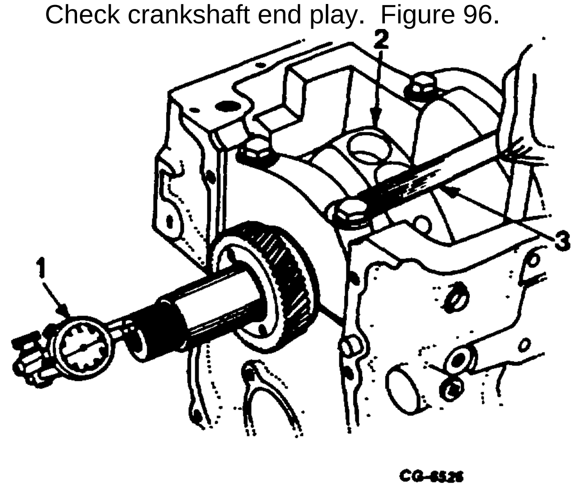


Figure 96. Checking Crankshaft End Play

1. Dial Indicator
2. Crankshaft
3. Pry Bar

Remove crankshaft gear using puller SE-1368 (Figure 97).

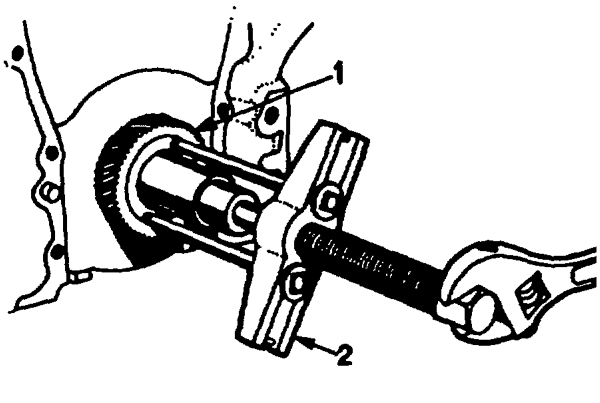


Figure 97. Removing Crankshaft Gear
1. Crankshaft Gear
2. Puller SE-1368

7. Remove clutch assembly from engine flywheel.

Clutch removal procedures vary between clutch types. On the clutch assembly shown in Figure 98, the clutch plate should be held compressed by the three spacers shown prior to removing mounting bolts from cover. Loosen clutch back plate-to-flywheel and remove the clutch assembly.

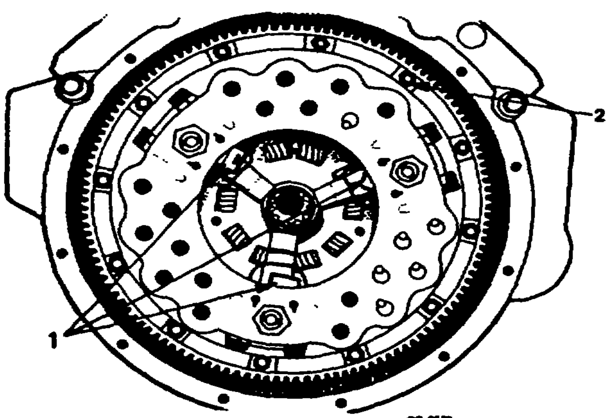


Figure 98. Clutch Removal
1. Spacers used when removing or installing Clutch Cover (must be removed after installing)
2. Cover Mounting Bolts

8. Using a slide hammer and puller SE-1746, remove clutch pilot bearing from flywheel (Figure 99).

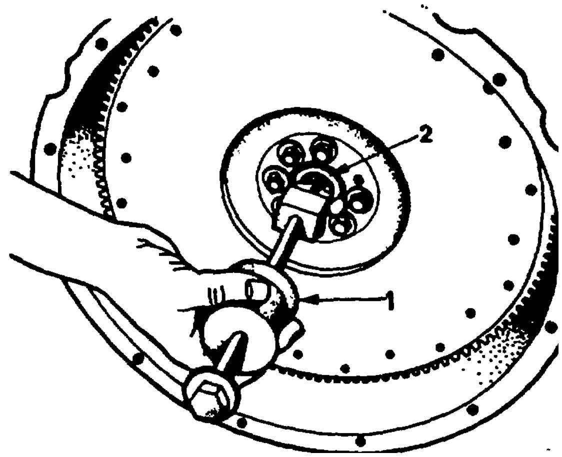


Figure 99. Removing Clutch Pilot Bearing
1. Puller SE-1746 2. Pilot Bearing

NOTE: It may be necessary to remove a small amount of material from the bottom of puller legs to permit installation of puller legs between flywheel and back side of pilot bearing.

9. Loosen flywheel mounting bolts and remove the flywheel assembly and roll pin from the crankshaft flange (Figure 100).
crankshaft flange (Figure 100).

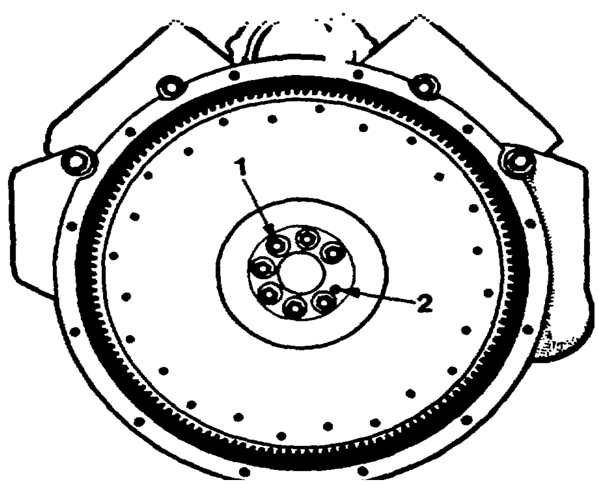


Figure 100. Flywheel Mounting Details
1. Mounting Bolts
2. Roll Pin

NOTE: Use extreme care when removing flywheel housing, to avoid damaging roll pins used to align housing to crankcase.

10. To remove, pierce seal retainer with point of screw on end of remover. Thread screw into seal. Apply slide hammer to pull seal from bearing cap. Figure 101.

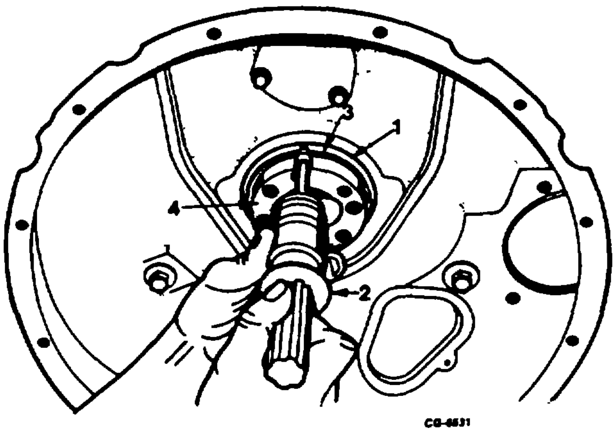


Figure 101. Removing Rear Main Oil Seal UsingSE-2091 Seal Remover

1. Rear Oil Seal
2. Seal Remover SE-2091
3. Wear Sleeve
4. Crankshaft

11. Remove six flywheel housing mounting bolts and flat washers and remove flywheel housing (Figure 102).

NOTE: When required, crankshaft rear main oil seal can be removed with engine in chassis by using SE-2091 oil sealer remover (Figure 101) or, during engine overhaul when the main bearing cap is removed (Figure 102).

12. Remove three camshaft cover plate mounting bolts and lockwashers, remove cover plate and gasket from end of block (Figure 103).

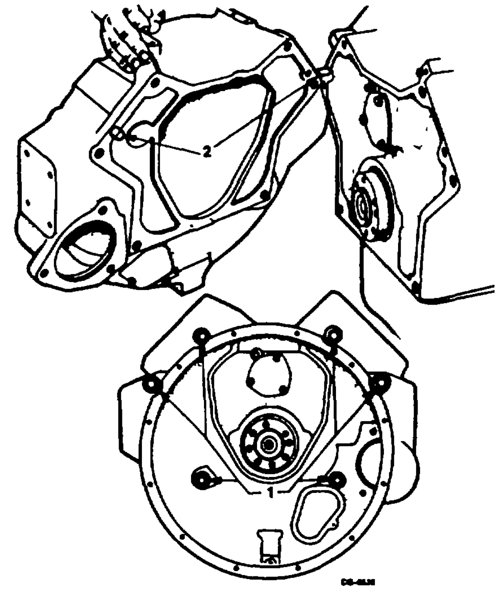


Figure 102. Flywheel Housing Mounting Details

1. Flywheel Housing Mounting Bolts
2. Roll Pins

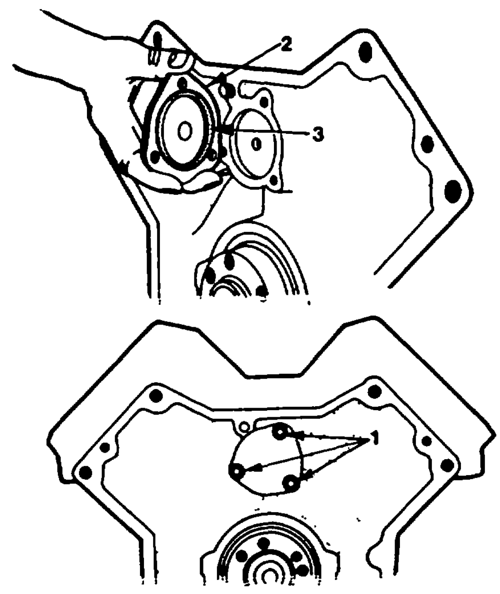


Figure 103. Removing Camshaft Cover Plate

1. Cover Mounting Bolts
2. Cover
3. Gasket

13. Remove twenty three oil pan to crankcase attaching bolts and remove oil pan.

14. Remove two oil pump mounting bolts and remove pump (Figure 104).

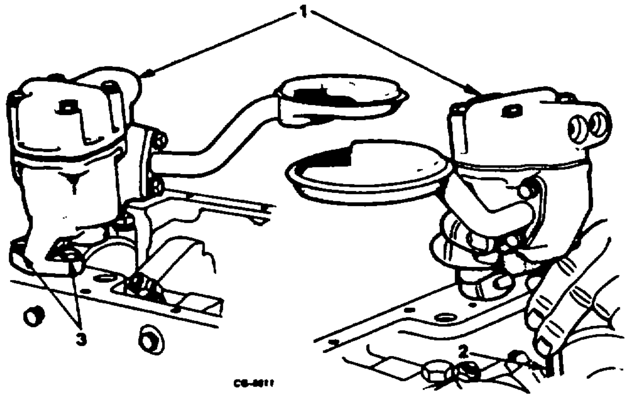


Figure 104. Installing Oil Pump

1. **Oil Pump**
2. **Checking Oil Pump Shaft Alignment to Block**
3. **Oil Pump Mounting Bolts**

15. Remove self-locking bolts, tie bolts and washers from each crankshaft main bearing cap (Figure 105).

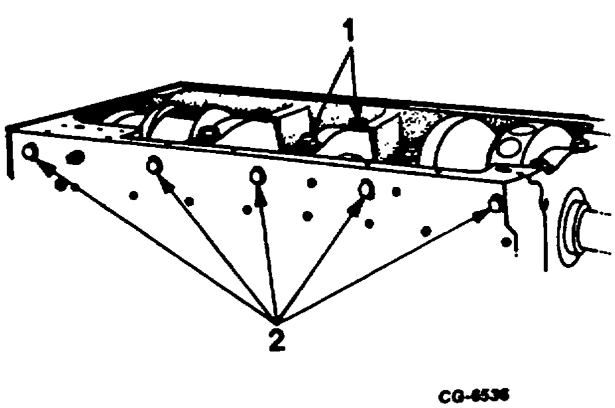


Figure 105. Main Bearing Cap Bolts, Tie Bolts and Washer

1. Self-Locking Bolts
2. Tie Bolts & Washers

16. Using remover tool SE-2093 and slide hammer SE-1746, remove main bearing caps (numbers 1, 2, 3 and 4) by inserting hook end of remover tool in horizontal hole and toward centerline of crankshaft (Figure 106).

17. The crankshaft bearing caps are numbered to identify their position, and they must be reinstalled in their respective positions.

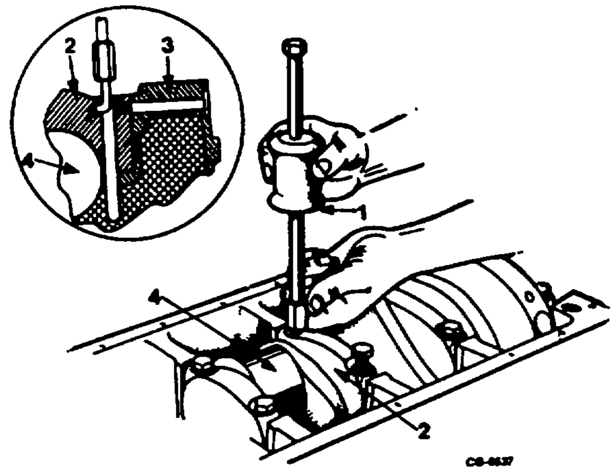


Figure 106. Removing Main Bearing Cap (Numbers 1, 2, 3, and 4)

1. Slide HammerSE-1746 with Remover Tool SE-2093
2. Bearing Cap
3. Crankshaft

18. The center (No. 3) main bearing cap accommodates a thrust flange to control crankshaft end play (Figure 107).

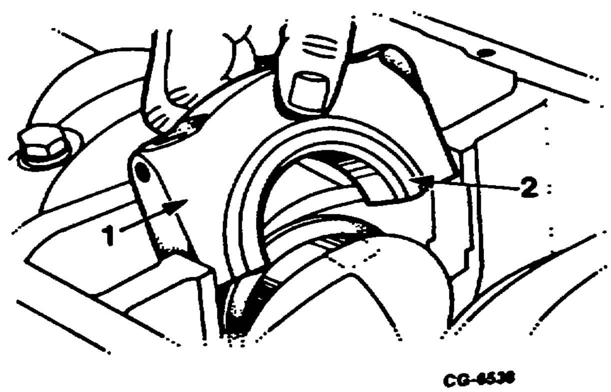


Figure 107. Main Bearing Cap with Thrust Flanges (No. 3)

1. Intermediate Main Bearing Cap
2. Thrust Flange

19. Use puller SE-1719 and adapter SE-1719-3 to remove rear (No. 5) main bearing cap (Figure 108). Slide hammer SE-1746 with remover tool SE-2093 may be used to remove rear bearing cap.

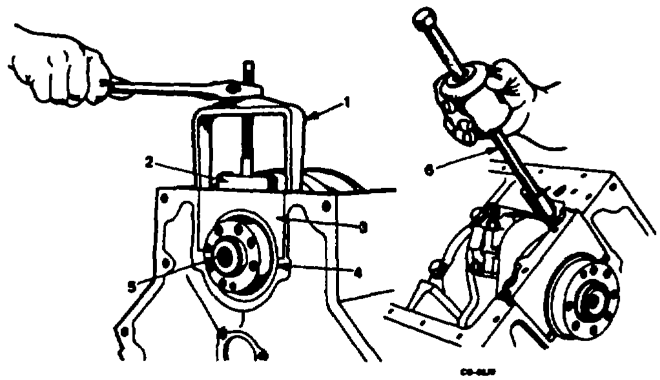


Figure 108. Pulley Rear Main Bearing Cap (No. 5)

1. Rear Main Bearing Cap Puller SE-1719
2. Adapter SE-1719-3
3. Rear Main Bearing Cap
4. Rear Seal
5. Crankshaft
6. Slide Hammer SE-1746 with Remover Tool SE-2093

20. Remove rear main bearing cap side seals and remove rear main bearing oil seal from crank-shaft (Figure 109).

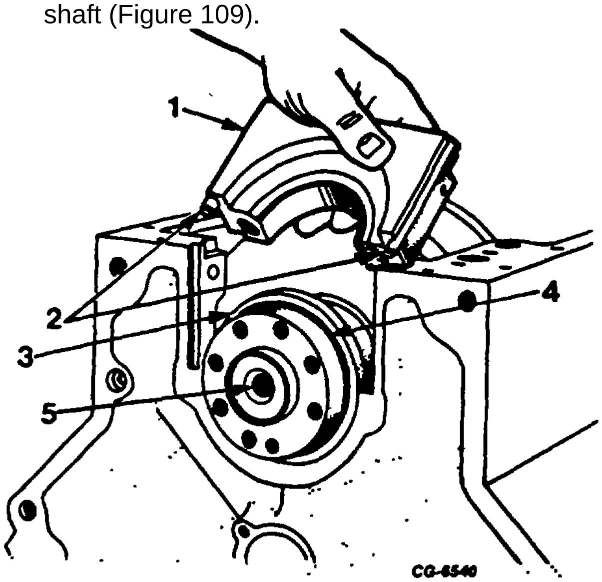


Figure 109. Removing Rear Main Bearing Cap and Oil Seals

1. Rear Main Bearing Cap
2. Side Seal
3 Rear Oil Seal
4. Wear Sleeve
5. Crankshaft

21 Using rope sling, lift crankshaft up and out oF engine crankcase.

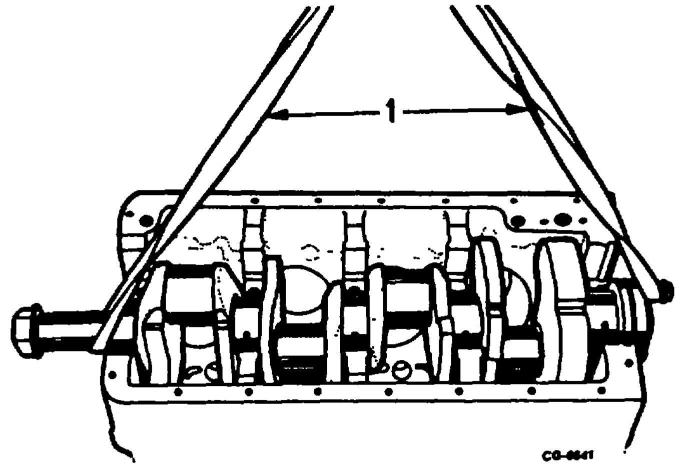


Figure 110. Removing Crankshaft from Crankcase

1. Rope Sling

CLEANING, INSPECTION AND REPAIR

Vibration Damper

1. Prior to vibration damper removal, check the following:

   a. Visually inspect for abrasion, cracking or tearing of rubber at the inner or outer diameter of the rubber diameter. Replace if cavity depth is 3 mm (0.12 in.) or more through 360'.

   b. Replace damper if voids 6.35 mm (0.25 in.) deep through 90' are found.

2. Inspect alignment of inertia member (outer iron ring) with hub Figure 111.

   a. Locate Alignment Marks.

   b. Measure movement between hub and inertia member.

   c. The marks fall on a radial line from the center of the damper hub. If more than 1.5 mm (0.06 in.) misalignment is found, replace damper.

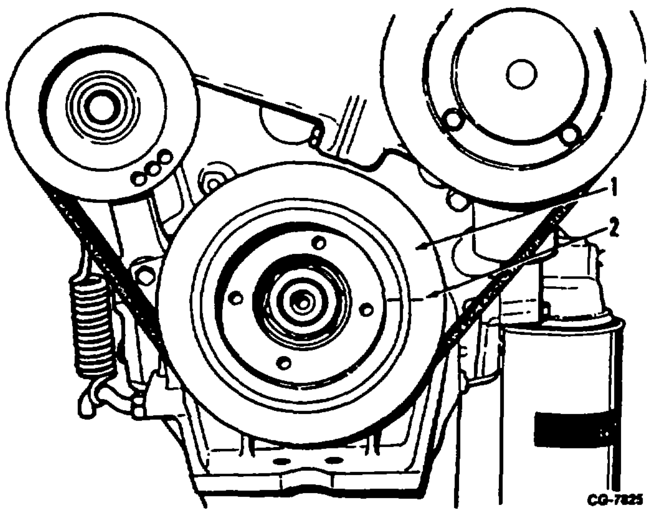


Figure 111.

1. Inertia Member
2. Alignment Marks

3. Measure wobble on front face of inertia member Figure 112.

a. Attach dial indicator to vibration damper.

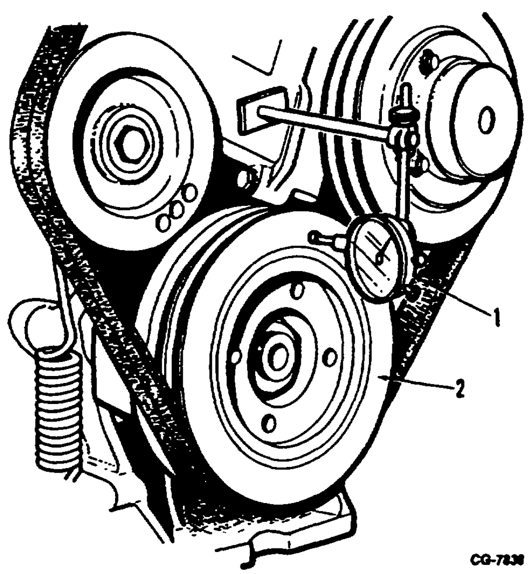


Figure 112.

1. Dial Indicator
2. Vibration Damper

b Check at least four points 90" apart.

c. Replace if wobble exceeds 1.5 mm (0.06 in.) total indicator reading.

Crankshaft

Clean all parts with cleaning solvent, dry with compressed air, and inspect the bearings for wear and evidence of uneven bearing support. If such evidence is present, examine bearing caps and sup- porting surfaces of the crankcase for high spots and burrs.

Inspect crankshaft journals for scoring and measure diameter of each journal, using a micrometer. Check the dimensions obtained against those listed in "SPECIFICATIONS." Measure each journal at two points, one at right angles to the other, in order to show any tendency to out-of-round. Move micrometer over entire width of journal.

Hardness must be checked on every journal which incurred a bearing failure or shows evidence of overheating. All crankshafts must be hardness checked before regrinding. Bearing failures can cause overheating of crankshaft journals and reduction of hardness. When such occurs, the crankshaft strength may be unacceptably reduced. Test crankshafts as follows:

a. Using a Rockwell Hardness Tester, check main journal in at least three locations.

b. Check rod journals at top, bottom and one other location. (Top and bottom determined with journal at TDC.) Top check should be made 12.7 mm (.50") from fillet (top of pin fillet is not hardened). The bottom should be checked as close to the fillet as possible.

c. Minimum hardness: 50-55 Rc. If any reading is below the minimum, the shaft must be scrapped.

NOTE: Elotherm crankshafts MUST NOT be straightened. Even slight straightening with complete absence of cracks will endanger the high strength built into the shaft.

Crankshaft Grinding

An induction-hardened fillet and journal crank- shaft (Elotherm) can be reground similar to any precision crankshafts. However, these shafts require special treatment when grinding. Before grinding, all crankshafts must be checked for hardness.

The superior strength of the fillet-hardened (Elotherm) shaft is due to the special process by which the bearing surfaces and fillets are hardened. This localized hardening greatly increases the bending strength of the crankshaft; in order to maintain this strength, special precautions must be taken when regrinding the Elotherm shaft. If special precautions are not taken, the crankshaft can be severely weakened. The metallurgical characteristics of the Elotherm shaft demand exacting standards and control when regrinding journals. For this reason, it is recommended that this work be done by l.H. ReNEWal stations. However, it can be reground locally where equipment and experience can produce quality standards outlined in the following instructions.

The most important consideration is to avoid any bums in the grinding operation. Refer to crankshaft Undersize Grinding Limits Chart.

The Elotherm crankshafts are reground similar to any precision crankshaft with the following precautions:

1. A mechanical or an automatic wheel dresser is mandatory to prevent chatter, burning and poor surface finish. A hand stone should NEVER be used to rough or fine dress the face or radii of the wheel. The radii should blend evenly into the journal.

2. The selection of the grinding wheel is important because too hard a wheel will increase the possibility of burning. An aluminum-oxide wheel with a grit size of approximately 50 and a maximum hardness of M will produce satisfactory results, with other conditions being suitable.

3. The coolant must be such that it minimizes burning. This requires a fluid with high lubricity properties. The straight-cutting oils appear to be the best for grinding Elotherm crankshafts and are strongly recommended.

4. A grinding wheel speed of 6500 surface feet per minute with a work spindle speed of approximately 40 to 45 revolutions per minute is usually satisfactory.

Grind all journals with crankshaft rotating in a counterclockwise direction (viewed from front of crankshaft), lap all journals and rear seal surface with crankshaft rotating in clockwise direction.

CAUTION! As a normal precaution, it is recommended that a C02 fire extinguisher be near the grinding machine, just in cam any excessive heat should ignite the oil. If a fire should start, it can be rapidly extinguished without causing any damage to the machine or surrounding area by following the normal fire-extinguishing procedure.

Feed rates should be slower than normal to prevent any burning.

Inspection of the crankshaft for dimensional tolerances is the same as for conventionally hardened crankshafts, except that extra care must be taken to be sure the shaft is cool before inspecting.

In addition to inspecting the dimensional tolerances, the Elotherm crankshaft must also be carefully checked for surface defects, particularly for grinding cracks and burns. Where equipment is available, it is advisable to magnaflux Elotherm crankshafts after grinding and lapping to insure that there is no surface cracking.

Crankshaft Undersize Grinding Limits

Grinding Limits:

Maximum allowable taper on crankpins (rod journals) and main journals 0.0038 mm per 25.4 mm of length (0.00015 per inch of length). Crankpins and journals must be polished to 20 Micro-inch maximum - to 5 Micro-inch minimum, and must not be over 0.003 mm (0.0003 inch) out of round.

The main journal fillet radii should be 3.810 - 3.048 mm (.150 - .120 in.) with the crankpins (rod journals) fillet radii held at 4.318 - 4.064 mm (.170 - .160 in.)

The third main journal controls crankshaft end thrust and provides initial location of crankshaft in relation to crankcase. For this reason the width of the third journal must be 34.620 - 34.544 mm (1.369 - 1.360 in.).

PRODUCTION SIZE	
Main Journal	79.350 - 79.502 mm (3.124 - 3.123 in.)
Crankpin (rod journal)	69.951 - 69.926 mm (2.754 - 2.753 in.)
.010 INCH UNDERSIZE	
Main Journal	79.095 - 79.070 mm (3.114 - 3.113 in.)
Crankpin (rod journal)	69.697 - 69.672 mm (2.744 - 2.743 in.)
.020 INCH UNDERSIZE	
Main Journal	78.841 - 78.816 mm (3.104 - 3.103 in)
Crankpin (rod journal)	69.444 - 69.672 mm (2.734 - 2.743 in.)
.030 INCH UNDERSIZE	
Main Journal	78.588 - 78.562 mm (3.094 - 3.093 in.)
Crankpin (rod journal)	69.189 - 69.164 mm (2.724 - 2.723 in.)

TARASOV ETCH: In order to establish the accept- ability of a regrind procedure, equipment and operator, the first reground crankshafts should be etched before lapping to determine whether, the crankshaft was burned during the regrinding cycle. The best etch to use is the Tarasov etch, which will show both the rehardened and the overtempered areas. The etching procedure is as follows:

CAUTION! Due to the sharp odor and flammability of the Tarasov etch, the etching should be done in a well-ventilated area, away from any open flame.

a. Clean surface with a scouring powder and water or a good solvent.

b. Wash thoroughly and rinse with alcohol.

c. Apply etchant No. 1 (4 parts nitric acid in 96 parts water) for approximately 16 seconds with a cotton swab.

d. Rinse with water and dry.

e. Apply etchant No. 2 (2 parts hydrochloric acid in 98 parts acetone) for approximately 15 seconds with a cotton swab.

CAUTION ! Acetone is highly flammable.

f. Rinse with alcohol and dry thoroughly with compressed air.

If the crankshaft has been burned, it will show up as a change of color after the etch. Areas re- hardened by excessive heat appear nearly white, while softened areas turn dark gray or black. Areas unaffected by the heat of grinding etch a light gray.

If any bums show up after the etch is used, the physical properties of the crankshaft will have been seriously reduced, and the crankshaft should be scrapped.

If burning becomes a serious problem, it can usually be elimimated by reducing the infeed rate, using a softer grade of wheel, or increasing the work spindle speed. Sometimes, a combination of these factors, along with the recommendations mentioned above, will be necessary to overcome the problem.

Examine crankshaft timing gear teeth and replace gear if teeth are worn or chipped.

NOTE: Crankshaft gear, camshaft gear and injection pump drive gear should only be replaced in matched sets.

To obtain proper bearing assembly with correct "crush, " care must be taken when tightening clamping bolts and nuts to make sure they are drawn down alternately and evenly using a torque wrench and tighten to specifications. Then back off nut and retighten to specified torque.

Rods, caps or bearing must not be lapped or reworked in any other manner in order to reduce clearance.

Premature bearing failure will result from attempts to reduce journal-to-bearing running clearance by reworking bearing caps, bearings, or both, because such reworking will result in an out-of-round bore, bearing shell distortion and destroy the specifically desired "crush."

Bearing inserts are designed with the "spread" (width across the open ends) slightly larger than the diameter of crankcase bore or connecting rod bore into which they are assembled (Figure 113).

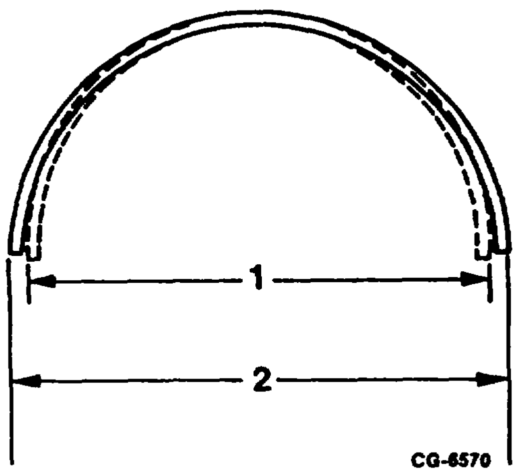


Figure 113. Illustration of Bearing "Spread"

1. O.D. of bearing when installed is the same as the diameter of the crankcase or connecting rod bore.

2. Spread of bearing before installation.

This condition causes the bearing to fit snugly in the rod bore, and the bearing must be "snapped" or lightly forced into its seat. Some of this "snap" may be lost in normal use, but the bearing need not be replaced because of a nominal loss of this condition. If bearing fits loosely in bore (does not "snap" into position), bearing should be replaced.

"Spread" is originally designed into the bearing to cause it to tend to spread outward at the parting line when "crush" load is applied by tightening bolts.

Specified spread for main and connecting rod bearing inserts is given in SPECIFICATIONS.

Fitting Main Bearings

Outlined below are procedures for checking main bearing clearance, using the Plastigage method, and crankshaft end play.

IMPORTANT
TO OBTAIN AN ACCURATE READING USING PLASTIGAGE, ALL MAIN BEARING CAPS MUST BE IN PLACE AND TORQUED TO SPECIFICATIONS.

1. Remove one bearing cap and bearing insert. Remaining caps are left tight while checking the fit of this bearing.

2. Wipe the oil from all contact surfaces such as crankshaft journal, bearing insert, bearing cap, etc.

3. Place a piece of Plastigage the full width of the bearing surface on the crankshaft journal (or bearing cap insert) approximately .63 mm (.25") off center. Tap bearing cap on with soft hammer until it just meets the mating surface of the crankcase. With the cap lined up with the back face of the crankcase, install cap bolts finger tight. Then install the tie bolts finger tight. Torque the cap bolts and tie bolts to proper torque according to notes on TORQUE CHART.

IMPORTANT
DO NOT TURN CRANKSHAFT WHILE MAKING CHECK WITH PLASTIGAGE.

4. Remove bearing cap bolts, then loosen tie bolts and remove bearing cap and insert.

Crankshaft Bearings

The bearing inserts used in these engines are selected fit and require no line reaming on installation. The bearings are available for service in standard sizes only.

If inspection reveals badly worn or scored bearings, replace bearings. Installation of new bearings must be closely checked to maintain proper clearance and between journals and bearing surface. A convenient and accurate method for checking clearance is with the use of Plastigage.

5. Do not disturb Plastigage. Using Plastigage envelope, measure widest point of Plastigage (Figure 114). This reading indicates bearing clearance in thousandths of an inch.

If bearing clearance (with new bearing inserts) is not within specified limits (see SPECIFICATION), the crankshaft must be replaced.

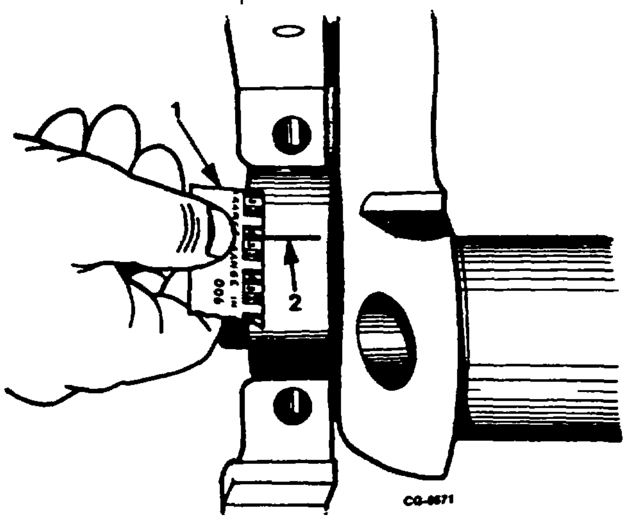


Figure 114. Checking Main Bearing Clearance

1. Gauge
2. Plastigage Flattened

The third (intermediate) main bearing also controls crankshaft end thrust and provides initial location of crankshaft in relation to crankcase. Use a dial indicator to check crank- shaft end play. (Figure 96).

If end play (with new intermediate bearing insert) is not within specified limits (see SPECIFICATIONS), the crankshaft must be replaced.

Crankcase

One of the most important phases of engine reconditioning is the thorough cleaning and inspection of the cylinder block.

Each machined surface of the cylinder block should be cleaned of all old gasket material. The pipe plugs which seal oil passages should be removed and all passages thoroughly cleaned.

Carefully inspect cylinder block for scoring of cylinder walls, damaged bearing bores, cracks or water leaks. Small cracks may be found by coating suspected areas with a mixture of light motor oil and kerosene. After wiping area dry, immediately apply a coat of quick-drying liquid such as zinc oxide powder mixed with wood alcohol. Wherever cracks are present, a brown discoloration will appear in the white coating.

If necessary to replace an expansion type plug due to water leaks, drill a 1/2" hole in center of plug and remove by prying with a screwdriver or suitable tool.

Coat edges of plug with a suitable non-hardening sealing compound and install with concave side of plug toward the interior of cylinder block. Drive plug into place with a ball peen hammer.

The oil pump and tachometer drive shaft upper bearing should be checked for correct size. Specifications of the lower portion of this bore is 12.357-12.382 mm (.4865-.4875") inside diameter. If diameter does not meet these specifications, bearing should be replaced as follows:

1. Using a drift, carefully drive bearing out of crankcase from underside.

2. Align punch mark on new bearing with rib on crankcase (Figure 115). This will index oil hole in bearing with oil passage in crankcase.

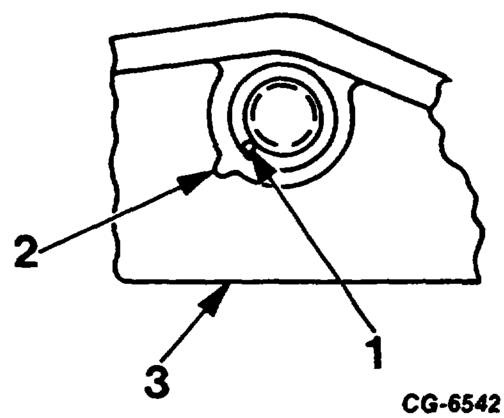


Figure 115. Installation of Oil Pump and Tachometer Drive Shaft Bearing in Crankcase

1. Punch Mark on Bearing
2. Rib on Crankcase
3. Crankcase

3. Press bearing in flush with top of crankcase.

Each cylinder bore should be checked for wear, out-of-round and taper using an inside reading micrometer SE-686 or dial bore gauge. SE-2331 Figure 116).

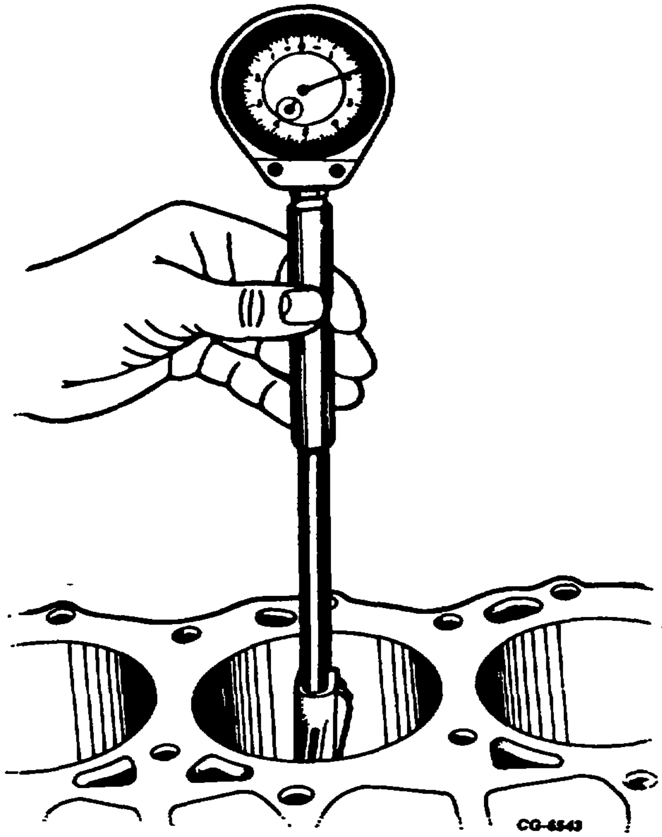


Figure 116. Checking Cylinder Bore with Dial Bore Gauge SE-2331

When measuring cylinder bores, main bearing caps must be in place with bearing cap and tie bolts tightened to specified torque. See "TORQUE CHART."

Measure diameter of each cylinder bore at top of ring travel at right angle to centerline of crankshaft ("A", Figure 117). Record readings.

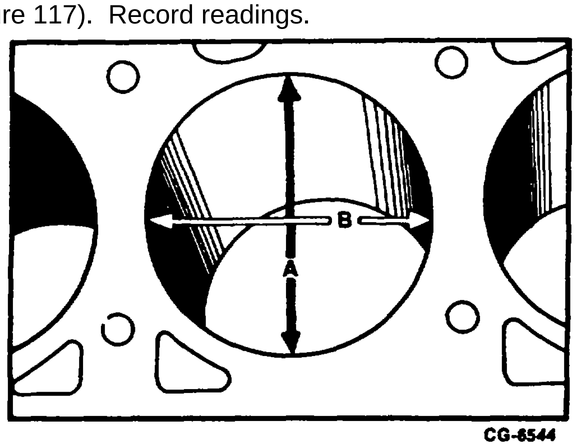


Figure 117. Measurements for Checking Cylinder Bore Out-of-Round

Next, measure each bore at top of ring travel with gauge aligned with centerline of crankshaft ("B", Figure 117). Record readings.

The difference between each corresponding "A" and "B" reading is the out-of-round condition at the top of the ring travel for that cylinder.

Repeat the same procedure to check for out-of- round at bottom of ring travel.

The difference between diameters (at right angle to centerline of crankshaft) at top of ring travel (A, Figure 118) and bottom of ring travel ("A", Figure 118) is the taper of the cylinder bore.

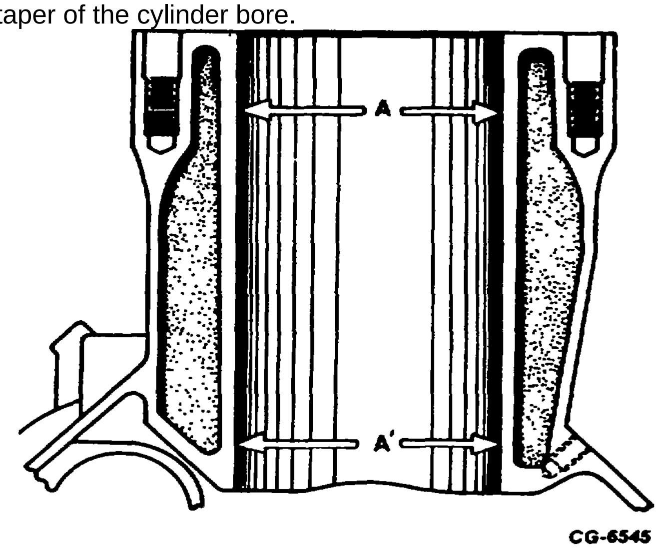


Figure 118. Measurements for Checking Cylinder Bore Taper

If cylinder bore wear does not exceed 0.05 mm (.002") out-of-round or 0.127 mm (.005") taper, new standard size service piston rings will give satisfactory performance, provided the piston clearance is not excessive. When standard size piston rings are to be installed, cylinder bore should be deglazed.

If cylinder bore wear exceeds specified limits or if cylinder bores are scored or damaged, it will be necessary to rebore the cylinders to oversize diameter. Oversize selected should be large enough to permit cleaning up the cylinder bore and provide proper piston running clearance. See specifications for running clearance.

Deglazing Cylinder Bores

Cylinder bores can be deglazed by using the proper size SE-2314 glaze breaker brush (Figure 119).

This silicone carbide-tipped nylon flexible brush quickly deglazes cylinder walls and produces a crosshatch pattern on the cylinder wall surface in a single operation. The brush contours itself to the cylinder wall and conditions the wall surface without altering cylinder bore. The glaze breaker brush is driven by a low speed (350-500 RPM) electric drill. Most 3/8 inch capacity drills are satisfactory.

The brush should be lubricated with SAE-30 engine oil to produce a desirable wall finish. The lubricant also controls airborne abrasive particles which can be easily wiped from cylinder bore with a cloth.

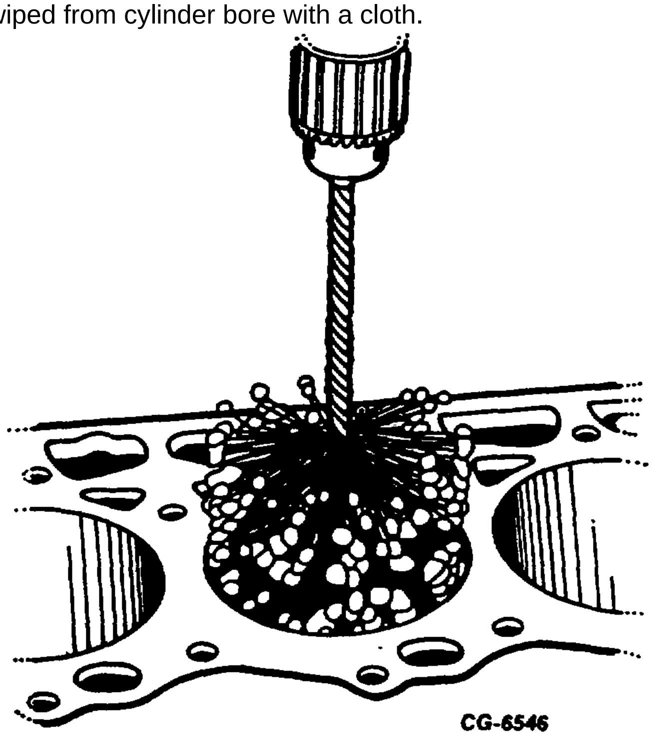


Figure 119. Deglazing Cylinder Walls

Stroke the brush up and down in the bore at a rate of 3040 strokes per minute for 15-20 seconds per cylinder bore. In most instances 20 seconds is adequate time for the brush to break cylinder wall glaze and produce a cross-hatch pattern on the cylinder wall surface.

Thoroughly clean cylinder bore walls after de- glazing. Wipe as much of the abrasive deposits from the wall as possible. Then swab out each abrasive-coated cylinder with SAE-10 oil and carefully wipe it out with a clean cloth. Continue cleaning until a clean, white cloth shows no evidence of discoloration when wiped through the cylinder bore. This usually requires three or more complete swabbing operations.

NOTE: Do not use gasoline, kerosene or commercial cleaner to clean cylinders. Solvents of this nature will not remove abrasives from the walls which can cause rapid engine wear and ring failure.

Reboring and Honing Cylinder Bores:

To avoid possible bore distortion, main bearing caps must be in place with bearing cap bolts and tie bolts tightened to specified torque when boring and honing cylinders.

Use boring equipment such as the SE-1399 boring machine (Figure 20) to enlarge cylinder bores. When oversizing cylinders, bore to within 0.07 mm (.003") of required oversize diameter. This will allow enough stock for final honing to obtain exact clearance for selected oversize pistons. Figure 120.

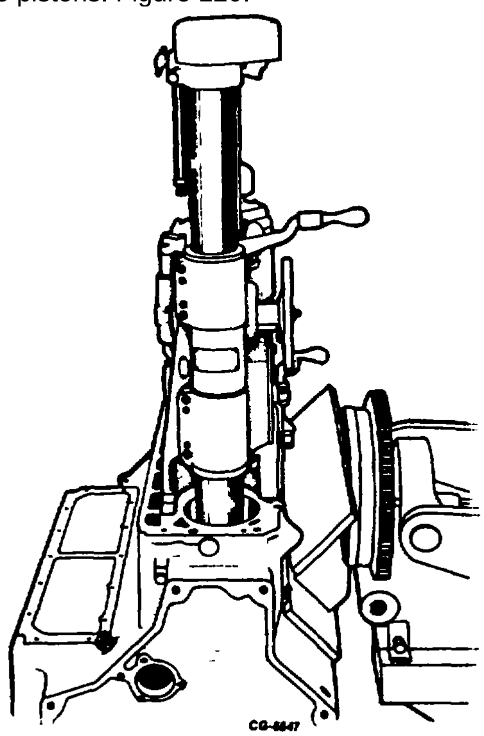


Figure 120. Reboring Cylinder

Hone cylinder bores as needed to obtain specified piston running clearance using honing equipment such as the SE-784 cylinder hone (Figure 121).

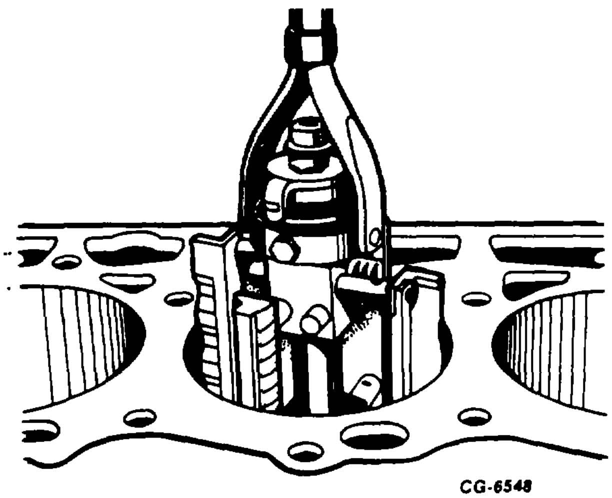


Figure 121. Honing Cylinder Bore

When performing honing operation, hone should be stroked up and down to produce a crosshatch pattern on cylinder wall surface (Figure 122). The faster hone rotates, the faster it must be stroked up and down to produce desired crosshatch pattern.

Figure 122. Crosshatch Finish on Cylinder Wall

NOTE: After the honing operation is completed, the sharp, burred edge that develops at the bottom of a new honed cylinder should be removed manually with emery cloth.

Thoroughly clean block and cylinder bores after honing. Wipe' as much of the abrasive deposits from the cylinder wall as possible. Then swab out each abrasive-coated cylinder with clean SAE-10 oil and carefully wipe it out with a clean cloth. Continue cleaning until a clean, white rag shows no evidence of discoloration when wiped through the cylinder bore. This usually requires three or more complete swabbing operations.

NOTE: DO NOT use gasoline, kerosene or com- mercial cleaner to clean cylinders. Solvents of this nature will not remove abrasives which can cause rapid engine wear and ring failure.

Camshaft Bearings

Using telescoping gauge and micrometer, check camshaft bearings for wear and proper running clearance. (See SPECIFICATIONS.) If bearing clearance exceeds specified limits, replace bearings. This can be accomplished using camshaft bearing remover and installer tool set SE-1897 with slide hammer and adapter from puller set SE-1879 as follows:

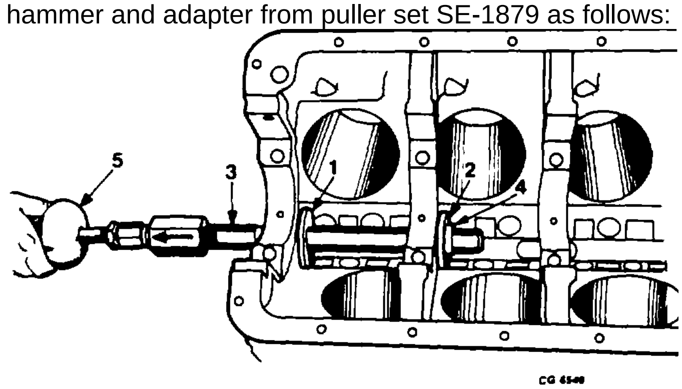


Figure 123. Removing Second Camshaft Bearing

1. Front Pilot Adapter SE-1897-3
2. Second Remover Adapter SE- 1897-4
3. Bar
4. "C" Washer
5. Slide Hammer

1. Position front adapter, SE-1897-3 in front bearing (Figure 123).

2. Position second adapter, SE-1897-1 in second bearing (Figure 123).

3. Install bar through adapters and lock second adapter on the bar with "C" washer SE-1897-2.

4. Using front adapter as a pilot, pull second bearing with slide hammer (Figure 123).

NOTE: Always hold adapter firmly against bearing being removed or installed to avoid damage.

5. Position new bearing on second adapter and "C" washer behind adapter (Figure 124). Align oil holes and pull in second bearing.

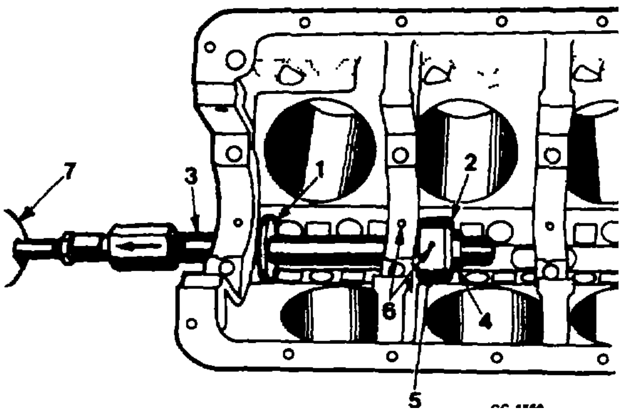


Figure 124. Installing Second Camshaft Bearing

1. Front Pilot Adapter SE-1 897-3
2. Second Adapter SE-1897-4
3. Bar
4. "C" Washer
5. Second Camshaft Bearing
6. Oil Holes Must Be Aligned

6. Remove "C" washer and use second adapter as a pilot. Remove front bearing by pulling bearing from case (Figure 125).

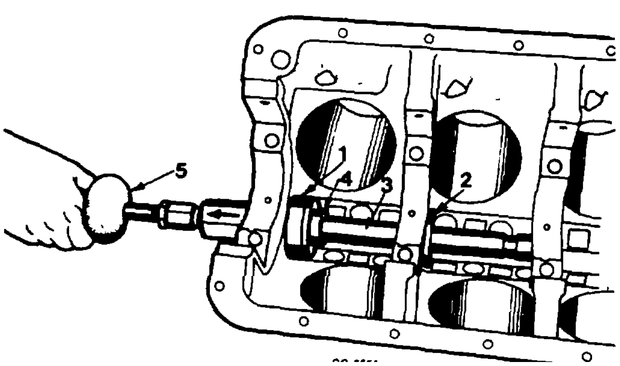


Figure 125. Removing Front Camshaft Bearing

1. Front Adapter SE-1897-3
2. Second Adapter SE-18P.L4
3. Bar
4. "C" Washer
5. Slide Hammer

7. Remove bar and front adapter. Position new bearing on front adapter with chamfered side toward case. Slide bar into case and through second adapter serving as a pilot (Figure 126).

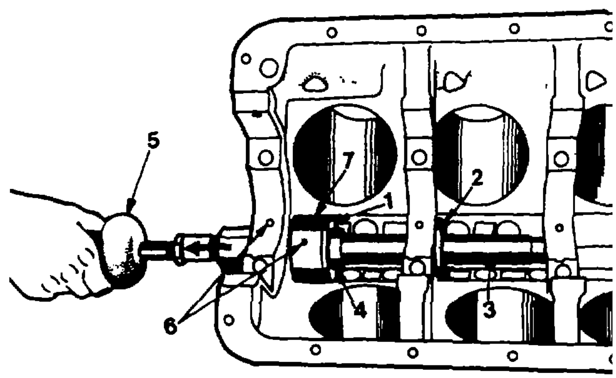


Figure 126. Installing Front Camshaft Bearing

1. Front Adapter SE-1897-3
2. Second Pilot Adapter SE-1897-4
3. Bar
4. "C" Washer
5. Slide Hammer
6. Oil Holes Must Be Aligned
7. Front Camshaft Bearing

8. Align oil holes and in front bearing (Figure 126).

NOTE: Oil hole drilled through groove in bearing must align with main bearing oil feed hole.

9. Using third adapter SE-1897-5 and rear adapter SE-1897- and working from rear of crankcase, install third and rear bearings in the same manner as described above for front and second bearings.

NOTE: Oil hole in groove of rear bearing must align with feeder hole in crankcase.

Rear Oil Seal

1. Check rear oil seal wear sleeve on crankshaft. If wear sleeve shows more than one wear path, it should be replaced. Wear sleeves with only one wear path can be reused by recessing oil seal into crankcase bore. (See ENGINE ASSEMBLY).

2. To remove wear sleeve, use a blunt chisel to mark wear sleeve surface in several places, then with a fiat hammer tap seal surface until sleeve expands sufficiently to be removed. Be careful when performing the cutting operation so not to nick, scuff or damage crankshaft flange surface.

3. After engine has been disassembled, all parts must be thoroughly cleaned, inspected for wear and damage and then reconditioned for further use or replaced as necessary.

ENGINE REASSEMBLY

NOTE: Throughout the engine assembly procedures outlined below, instructions are given for prelubricating bearings and other running parts with engine oil. This is important to assure initial lubrication of these parts when engine is started. If engine is to be stored before installation in a vehicle, it is recommended that these parts be pre- lubricated with a coat of waterproof grease (Lubri- plate 630AA or equivalent). The grease will not drain off parts during storage, will prevent rusting and provide initial lubrication.

1. Mount cylinder block in engine stand. Rotate engine stand so that bottom of cylinder block faces upward.

2. Install cylinder block drain plugs (or drain cocks) and tighten securely.

3. Wipe main bearing bores of cylinder block and main bearing caps to remove any dirt or dust. Make sure main bearing inserts are clean.

4. Lubricate upper (block) half of each bearing insert, on wear surfaces only, with clean engine oil and place in position in bearing bore of block. Make sure that bearing inserts are fully seated with oil holes in inserts aligned with oil passages in block and that locking tangs are engaged. Following the same procedure, place lower half of bearing inserts in bearing caps.

5. Wipe crankshaft main bearing journals. Lower crankshaft into place in cylinder block bearing inserts.

6. Place bearing caps (with inserts) over crank- shaft journals, making sure number on cap is toward right side of engine. Install new self- locking cap bolts and flat washers.

NOTE: Lubricate bolt threads and mating surfaces of bolt heads and washers with clean engine oil.

7. Tighten bearing cap bolts snugly (not to specified torque). Using a soft hammer, tap each bearing cap until rear machined face of cap is flush with machined face of cylinder block on both sides of crankshaft. Alignment of these machined faces assures proper cap location. Tighten bearing cap bolts to specified torque (see TORQUE CHART).

8. Install bearing cap tie bolts and special washers and tighten to specified torque. (See TORQUE CHART).

NOTE: Lubricate bolt threads and mating surfaces of bolt heads and washers with clean engine oil.

9. Using dial indicator check crankshaft end play (Figure 96).

10. If rear oil seal wear sleeve was removed from crankshaft at engine disassembly, install new wear sleeve as follows:

a. Install aligner studs SE-2092-3 into end of crankshaft flange (Figure 127).

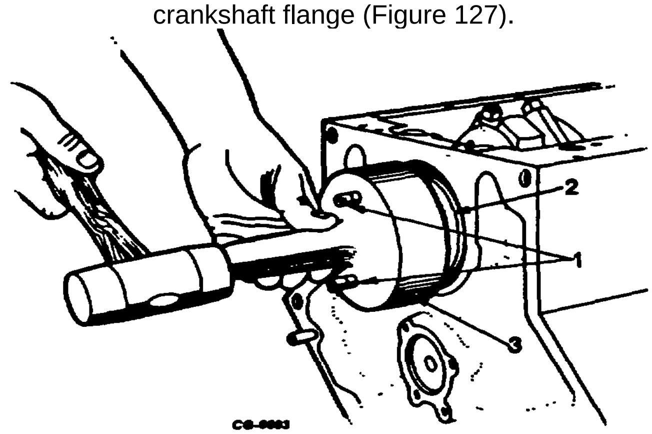


Figure 127. Installing Oil Seal Wear Sleeve
1. Aligner Studs
2. Wear Sleeve
3. Installer

b. Coat crankshaft flange with engine oil. Position wear sleeve on crankshaft flange with large chamfer toward rear of crankshaft.

c. Position installer tool SE-2092-1 over aligner studs (Figure 127) and drive wear sleeve onto crankshaft flange until installer tool seats against crankcase. This will correctly locate wear sleeve (Figure 129).

d. Remove installer tool and aligner studs.

11. Install rear oil seal as follows:

a. Install aligner studs SE-2092-1 into end of crankshaft flange (Figure 128).

b. Lubricate crankshaft flange and wear sleeve and seal bore of crankcase and bearing cap with engine oil.

c. Place new oil seal over crankshaft flange, aligning seal with crankcase bore.

d. Position installer tool SE-2092-1 over aligner studs (Figure 128) and drive oil seal into crankcase as follows:

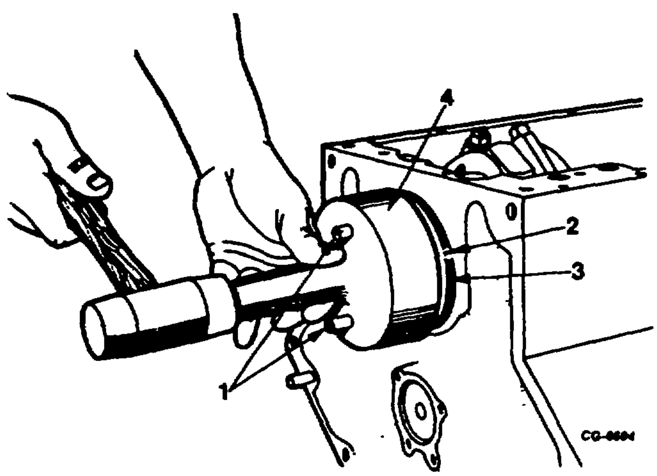


Figure 128. Installing Rear Oil Seal

1. Aligner Studs	3. Rear Oil Seal
2. Wear Sleeve	4. Installer

(1) Where a new seal is being installed against a new wear sleeve, place seal flush with rear of crankcase (Figure 129).

(2) Where a new seal is being installed against a used wear sleeve, recess seal into crankcase bore (Figure 129) to allow lip of seal to ride upon unworn surface of wear sleeve. (If wear sleeve shows more than one wear path, replace wear sleeve.)

e. Remove installer tool and aligner studs.

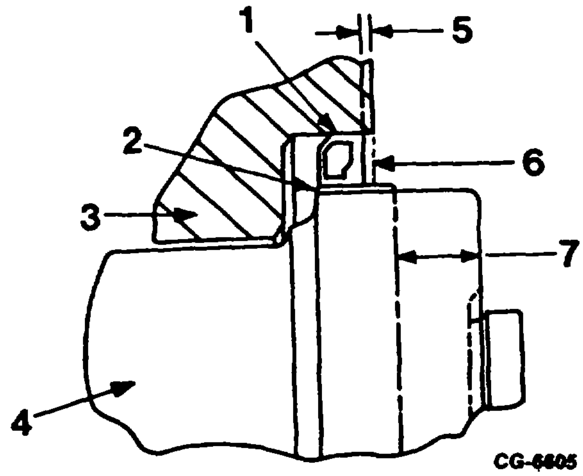


Figure 129. Sectional View Showing Proper Location of Wear Sleeve and Rear Oil Seal

1. Seal	6. With New Wear Sleeve Install Seal Flush with end of Crankcase.
2. Wear Sleeve	7. 16.65 mm (.656") Wear Sleeve to this Dimension
3. Crankcase	
4. Crankshaft	
5. 2.15 mm (.085") with used Wear Sleeve Recess Seal to this Dimension	

12. Install rear main bearing cap side oil seals (Figure 130). Use an installer made from 3.18 mm (1/8") welding rod. To make tool, puddle a ball on end of rod and file ball to approximately 3.97 mm (5/32") diameter. Lubricate seals with a light coat of engine oil.

13. Position gear key in keyway of crankshaft. Lubricate inside diameter of crankshaft gear with a commercial press-fit lubricant Install crankshaft gear using installer tool set SE- 1900 (Figure 131).

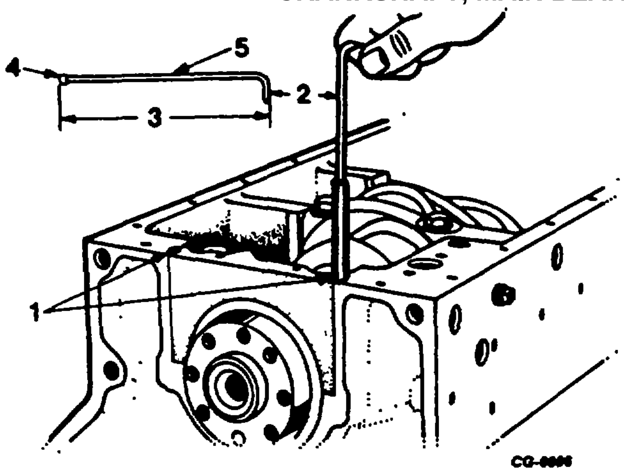


Figure 130. Installing Rear Main Bearing Cap Side Oil Seals

1. Bearing Cap Side Seals
2. Installer Tool
3. 203.2 mm (8") Long
4. 3.9687 mm (5/32") Diameter
5. 3.1750 mm (1/8") Welding Rod

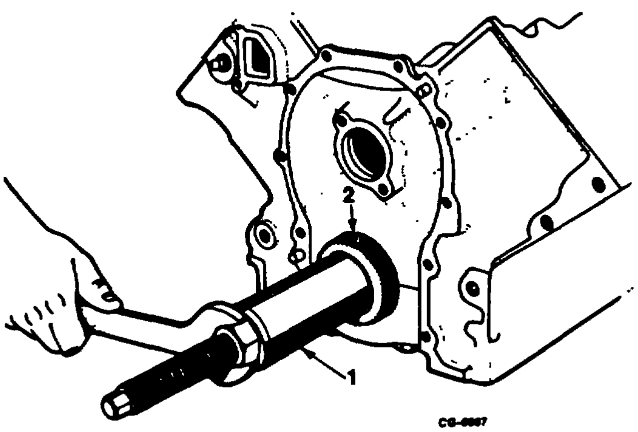


Figure 131. Installing Crankshaft Gear

1. Installer
2. Crankshaft Gear

14. Position camshaft thrust plate on camshaft. Position gear key in keyway of camshaft. Lubricate inside diameter of camshaft gear with press-fit lubricant and press gear on camshaft.

15. Install camshaft (with gear and spacer) as follows:

    a. Install installer tool SE-1880 on threads of camshaft (Figure 132).

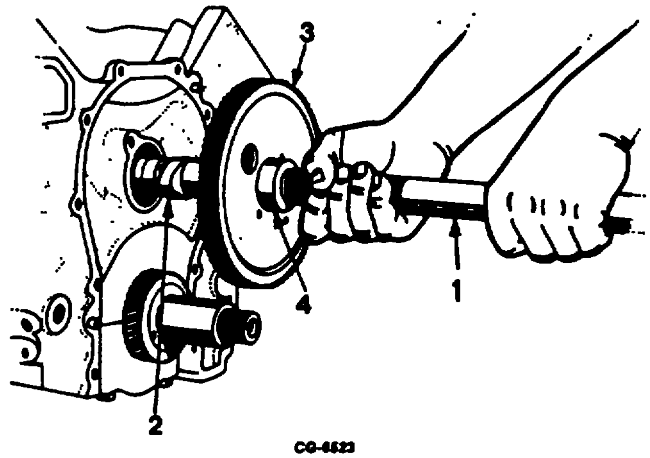


Figure 132. Installing Camshaft, Gear and Spacer as an Assembly

1. Remover SE-1880
2. Camshaft
3. Gear
4. Spacer

    b. Coat camshaft lobes, bearing surfaces camshaft bushings and camshaft gear teeth with heavy duty hypoid axle lubricant

    c. Insert camshaft (with gear and spacer into cylinder block (Figure 132).

    d. Align timing marks on camshaft gear and crankshaft gear (Figure 146) and position camshaft into camshaft bushings. Remove installer tool.

IMPORTANT

WHEN THE TIMING MARKS ARE ALIGNED THE ENGINE IS ON TDC FOR #1 CYLINDER ON THE EXHAUST STROKE.

a. Install camshaft thrust flange bolts (Figure 133) and tighten to specified torque. (See TORQUE CHART).

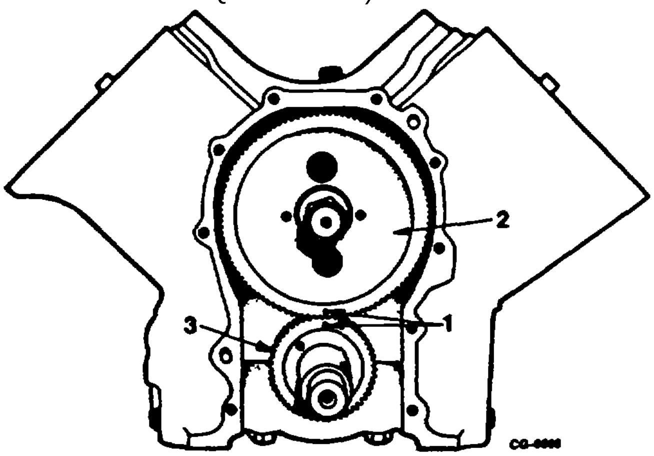


Figure 133. Aligning Timing Marks on Camshaft and Crankshaft Gears

1. Timing Marks
2. Camshaft Gear
3. Crankshaft Gear

f. Install camshaft gear nut and tighten to specified torque. (See TORQUE CHART).

g. Rotate crankshaft and camshaft to see that gears do not bind or interfere. Using dial indicator, check camshaft end play (Figure 134) and camshaft gear-to-crank- shaft gear backlash.

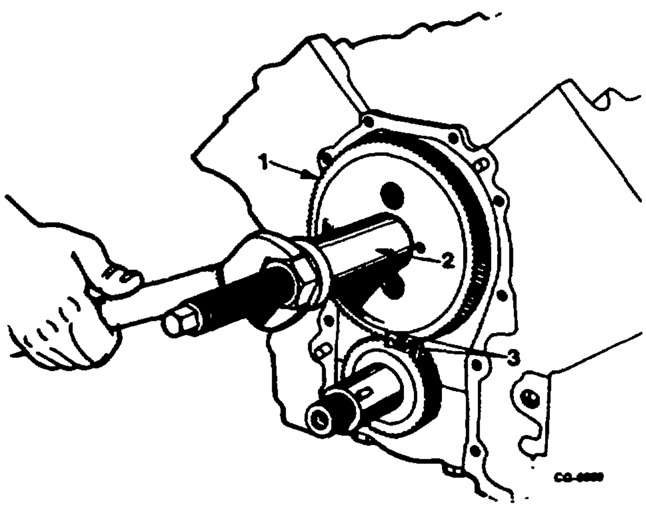


Figure 134. Installing Camshaft Gear

1. Camshaft Gear
2. Installer
3. Timing Marks

16. Install piston and connecting rod assemblies as follows:
    a. Turn cylinder block to vertical position with front end facing upward. Turn No. 1 crankpin to the top of its stroke.

    b. Coat-No. 1 piston and piston rings with clean engine oil and install piston ring compressor on piston.

    c. Coat No. 1 cylinder bore with clean engine oil. Position piston and rod assembly in cylinder bore with word "TOP" marked on piston toward centerline of engine block. Carefully push piston and rod assembly through ring compressor (Figure 135) until piston is in cylinder bore. Avoid striking cylinder bore with connecting rod.

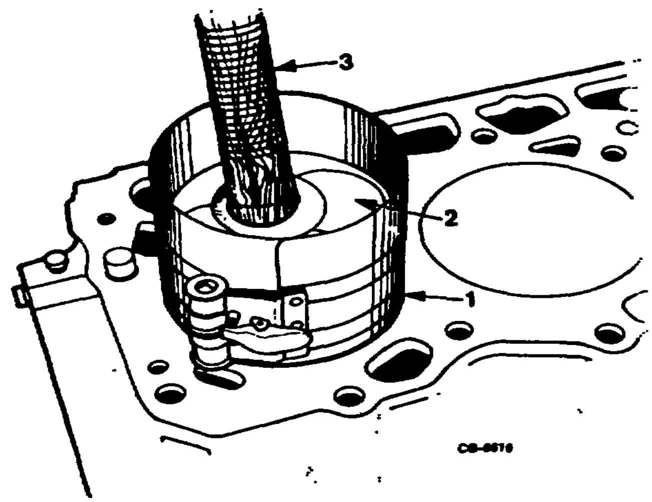


Figure 135. Installing Piston and Connecting Rod Assembly

1. Ring Compressor
2. Piston
3. Hammer Handle

    d. Coat crankshaft journal and connecting rod bearings with clean engine oil. Pull connecting rod down onto crankshaft journal. Install connecting rod cap to rod with marked sides matching.

    e. Install new bearing cap bolts, nuts and flat washers .Lubricate bolt threads and mating surfaces of bolt heads and washers with engine oil and install bolts.

IMPORTANT

WHEN INSTALLED PROPERLY, THE LARGE CHAMFERED SIDE OF THE ROD AND CAP WILL BE ON THE FILLET SIDE OF THE CRANKPIN (FIGURE 103). TIGHTEN BOLTS TO SPECIFIED TORQUE SHOWN IN TORQUE CHART, THEN RELEASE TORQUE LOAD TO ZERO AND RETIGHTEN TO SPECIFIED TORQUE. AFTER BOLTS HAVE BEEN TORQUED, TURN EACH NUT AN ADDITIONAL ONE-SIXTH TURN OR ONE FLAT OF THE NUT.

f. Install remaining piston and connecting rod assemblies in the same manner.

g. Recheck connecting rod end play.

17. Position oil pump in cylinder block and check for correct alignment. Pump shaft should rotate freely without binding (Figure 136).

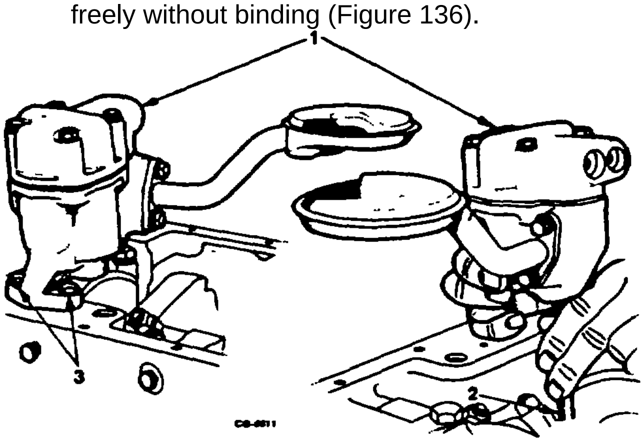


Figure 136. Installing Oil Pump

1. Oil Pump
2. Checking Oil Pump Shaft Alignment to Block
3. Oil Pump Mounting Bolts

18. Rotate cylinder block to horizontal position with top of block facing upward. Place flywheel housing in position over two aligning roll pins and tap into cap-screws (with flat washers) and tighten in sequence shown in Figure 137.

IMPORTANT

THE TWO LOWER MOUNTING BOLTS SHOULD BE WRAPPED WITH TWO TURNS OF TEFLON THREAD TAPE TO PREVENT OIL LEAKAGE.

19. Using aligner tool SE-1834 and dial indicator, check flywheel housing alignment (Figure 137). Run-out (out-of-round) should not exceed specified limits. (See SPECIFICATIONS).

IMPORTANT

IF FLYWHEEL HOUSING ALIGNMENT OUT-OF-ROUND EXCEEDS SPECIFIED LIMIT OR IF EITHER FLYWHEEL HOUSING OR CRANKCASE IS BEING REPLACED REMOVE ROLL PINS, ALIGN FLYWHEEL HOUSING WITH DIAL INDICATOR AND REAM ROLL PIN HOLES WITH STANDARD TAPERED REAMER, 12.7 MM (1/2 INCH) TO ACCOMMODATE OVERSIZE ROLL PINS (FIGURE 138).

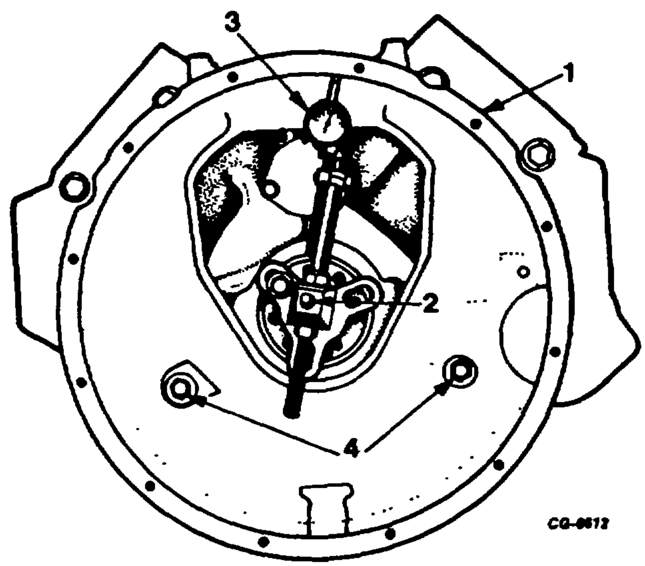


Figure 137. Checking Flywheel Housing Alignment

1. Flywheel Housing
2. Aligner
3. Dial Indicator
4. Wrap Bolt Thread

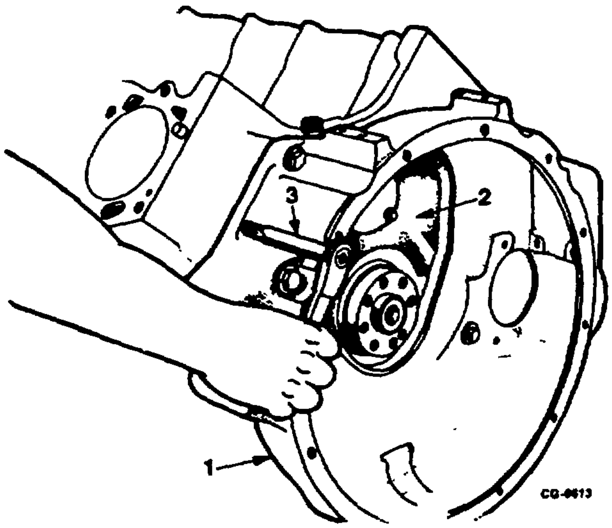


Figure 138. Reaming Flywheel Housing-to-Crankcase Roll Pin Holes

1. Flywheel Housing
2. Crankcase
3. Reamer

If possible, align flywheel housing while engine is in engine stand with cylinder block in vertical position (Flywheel housing facing up).

20. Position flywheel (with ring gear) on roll pin in crankshaft flange. Install flywheel mounting bolts in flywheel and crankshaft flange and tighten to specified torque. (See TORQUE CHART).

21. Coat the O.D. of the clutch pilot bearing and I.D. of flywheel bore with Loctite grade B. Then install clutch pilot bearing into the flywheel. Do not allow Loctite to contact inside of bearing or between flywheel and crank-shaft.

22. Install clutch assembly on engine flywheel. Clutch installation procedures vary between clutch types. With clutch assembly shown in Figure 139 proceed as follows:

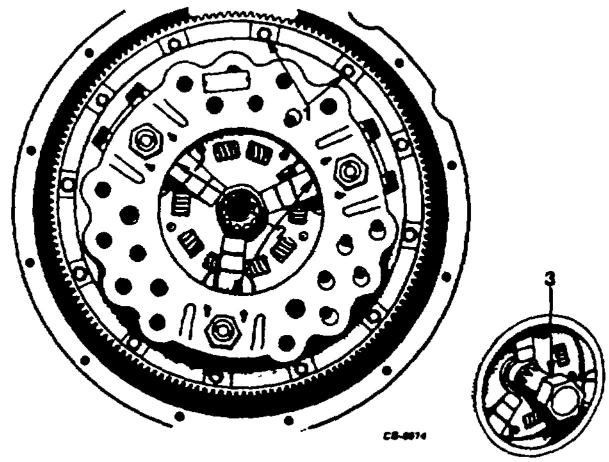


Figure 139. Clutch Installation

1. Cover Retaining Bolts
2. Spacer Block
3. Aligning Tool

a. Position clutch driven disc against flywheel so that long portion of hub is toward the rear. Place clutch in position on flywheel over clutch driven disc. Locate arrow or inspection mark (usually a dab of white paint) on flange of clutch backing plate or cover as near as possible to letter "L" on flywheel and install two or three mounting bolts and lockwashers loosely.

b. Insert a clutch aligning arbor or a transmission main drive gear shaft through clutch driven disc hub splines and into clutch pilot bearing. Hold clutch driven disc in position and install remaining mounting bolts and lockwashers in. The flange of clutch backing plate or cover.

c. Tighten all bolts alternately, evenly and securely. Remove three retaining bolts and flat washers, retaining clips or wood blocks which were installed to hold clutch compressed.

IMPORTANT

THE CLUTCH WILL NOT OPERATE PROPERLY UNLESS RETAINING BOLTS, CLIPS OR WOOD SPACER BLOCKS ARE REMOVED.

23. Position a new front cover gasket over dowel pins in crankcase. Install engine front cover.

24. Install front cover oil seal as follows:

    a. Position front cover oil seal on tool pilot (small diameter) of SE-2096 installer with wiping lip of seal toward outer end of pilot.

    b. Lubricate seal bore of front cover with engine oil.

    c. Place installer over end of crankshaft and drive seal into cover (Figure 140). Seal is properly located when inner shoulder on tool contacts machined surface of front cover.

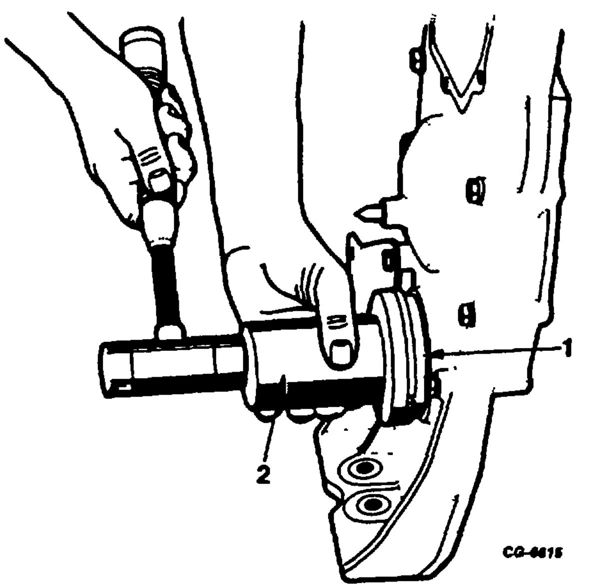


Figure 140. Installing Engine Front Cover Oil Seal

1. Oil Seal
2. Installer Tool SE-2096

IMPORTANT
TOOL CAN ALSO BE USED TO INSTALL OIL SEAL WHERE COVER IS REMOVED FROM ENGINE BY PLACING FRONT COVER IN A PRESS AND PRESS SEAL IN UNTIL FLANGE OF TOOL CONTACTS MACHINED SURFACE ON FRONT COVER.

25. If front oil seal wear sleeve was removed from crankshaft pulley at engine disassembly, install new wear sleeve as follows:

    a. Coat crankshaft pulley hub with a non-hardening sealer. Position pulley on press bed.

    b. Heat wear sleeve in boiling water and position on pulley hub. Using handle and 7.3 cm (2-7/8 inch) diameter adapter from SE-1905 tool set, press wear sleeve onto pulley hub until flush with end of hub (Figure 141).

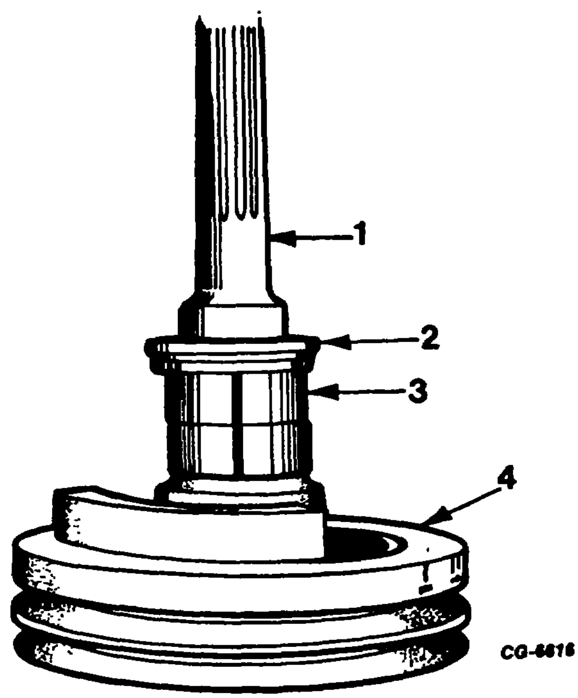


Figure 141. Installing Front Oil Seal Wear Sleeve

1. Handle
2. Adapter
3. Wear Sleeve
4. Crankshaft Pulley

26. Position pulley key in keyway of crankshaft. Lubricate inside diameter of crankshaft pulley with press-fit lubricant. Install crankshaft pulley using installer tool SE-1900 (Figure 142). Install crankshaft pulley nut and flat washer. Tighten pulley nut to specified torque. (See TORQUE CHART).

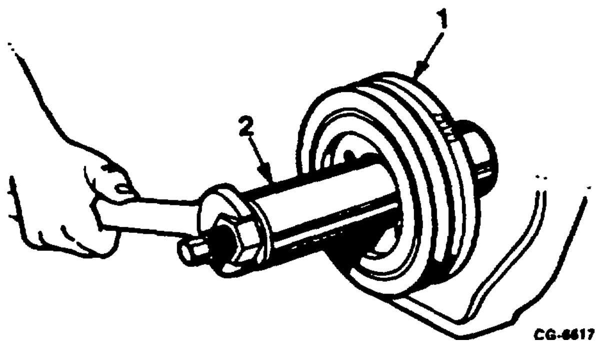


Figure 142. Installing Crankshaft Pulley

1. Crankshaft Pulley
2. Installer SE-1900

IMPORTANT
WEAR SLEEVE SURFACE ON CRANKSHAFT DAMPER SHOULD BE LUBRICATED WITH CLEAR ENGINE OIL TO PREVENT SEAL DAMAGE.

27. Turn engine with oil pan mounting surface up. Position new gasket on crankcase and install oil pan.

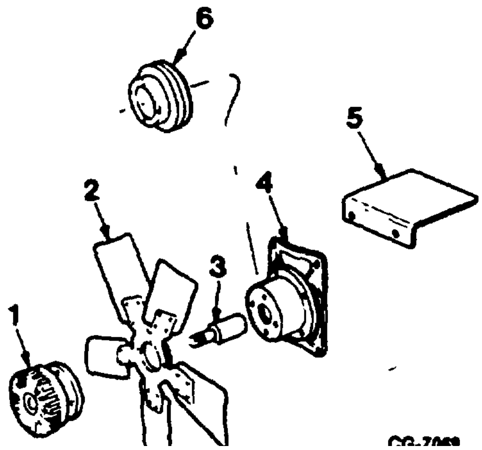


Figure 143.

1. Fan Drive
2. Fan
3. Fan Bearing
4. Fan Drive With Hub and Pulley
5. Fan Support Bracket
6. Fan Drive Pulley

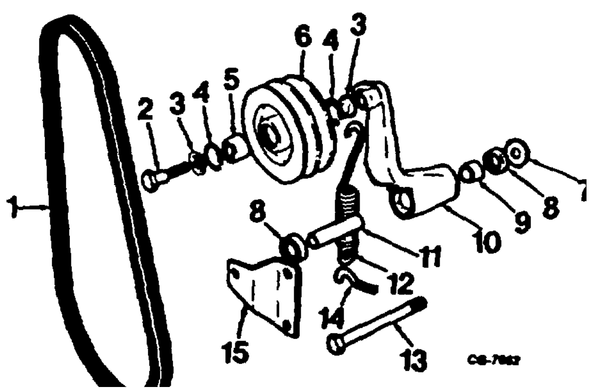


Figure 144.

1. Fan Drive Belt (Matched Set)
2. Idler Bearing Shaft
3. Dust Shield
4. Snap Ring
5. Idler Pulley Bearing
6. Idler Pulley
7. Thrust Washer
8. Idler Arm Oil Seal
9. Idler Arm Bushing
10. Idler Arm
11. Idler Arm Spacer
12. Spring
13. Bolt
14. Eye Bolt
15. Idler Arm Support Bracket

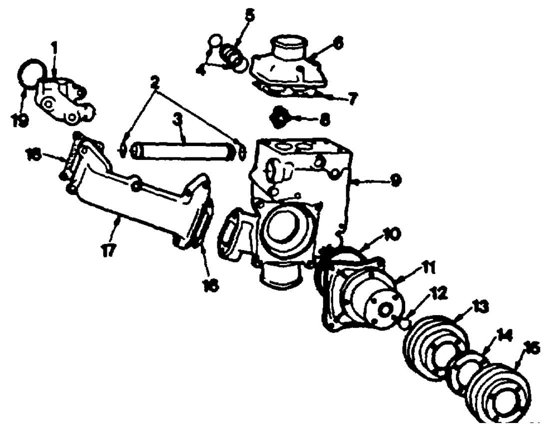


Figure 145. Water Pump Assembly

1. Water Outlet
2. O-Ring
3. Water Return Tube
4. O-Ring
5. Water Return Tube
6. Thermostat Housing
7. Thermostat Housing Gasket
8. Thermostat
9. Water Pump Housing
10. Water Pump Mounting Gasket
11. Water Pump Assembly
12. Not Used
13. Water Pump Drive Pulley
14. Not Used
15. Not Used
16. Gasket
17. Water Pump to Crankcase Manifold
18. Water Manifold Gasket

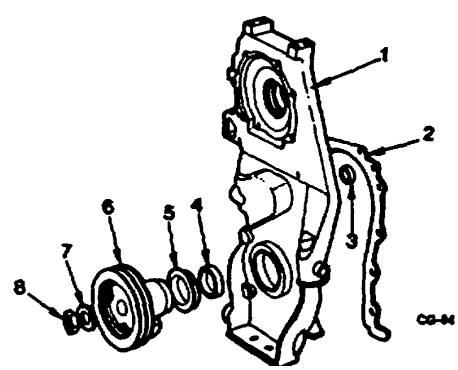


Figure 146. Front Cover Assembly

1. Front Cover
2. Front Cover Gasket
3. Jam Nut
4. Crankshaft Bearing Seal
5. Wear Sleeve
6. Crankshaft Pulley
7. Pulley Washer
8. Pulley Nut

DISASSEMBLY

Refer to unit section for detailed disassembly procedures.

1. Drain cooling system.

2. Remove the following (if equipped):

   Power Steering Pump
   Air Compressor

3. Remove modulated fan drive and fan assembly from the fan pulley hub by removing four bolts and lockwashers. Remove modulated fan drive and fan assembly (Figure 147). The fan may be removed from the modulated fan drive by removing four bolts and lockwashers (Figure 147).

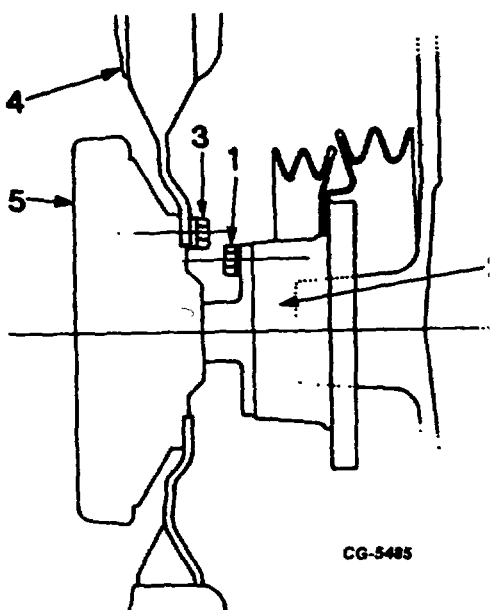


Figure 147. Modulated Fan Drive and Fan Removal

1. Mounting Bolts, Modulated Fan Drive to Pulley Hub
2. Fan Pulley Hub
3. Mounting Bolts, Fan to Drive
4. Fan
5. Modulated Fan Drive

4. Pry idler pulley toward center of engine and remove main drive belts (Figure 148).

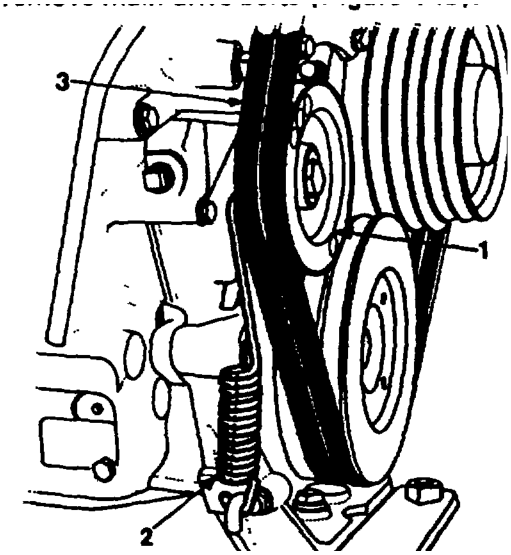


Figure 148. Removing Main Drive Belts

1. Idler Pulley
2. Idler Pulley Tension Spring
3. Main Drive Belts

5. Remove fuel filters and fuel pipes from primer pump assembly. Remove three bolts from primer pump mounting bracket and remove bracket with pump from engine. Figure 149.

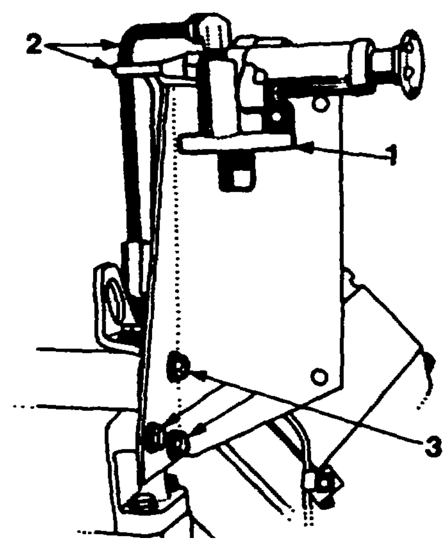


Figure 149. Removing Primer Pump and Filter Mounting Bracket Assembly

1. Fuel Filter Base and Primer Pump Assembly
2. Fuel Pipes
3. Bracket Mounting Bolts

6. Remove four fan hub assembly mounting bolts and remove assembly (Figure 150).

   The hub pulley may be removed before or after the assembly is removed from engine.

7. Remove accessory mounting channel by removing the remaining six bolts along with the engine lifting eye (Figure 150).

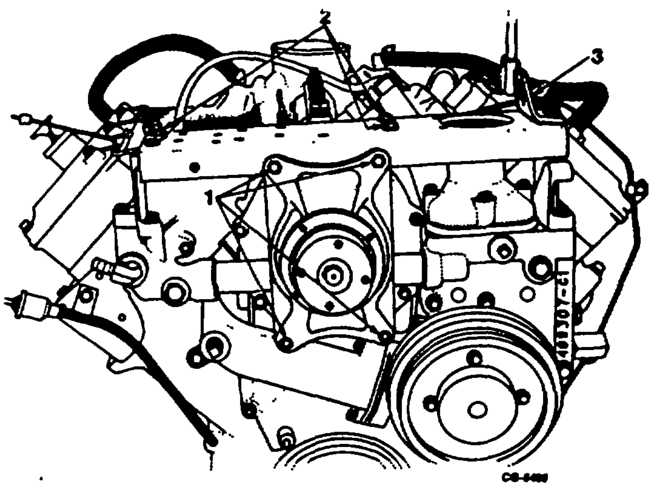


Figure 150. Removing Fan Hub Assembly

1. Fan Hub Assembly Mounting Bolts
2. Channel Mounting Bolts
3. Engine Lifting Eye & Mounting Bolts

8. Remove water pump pulleys by removing four mounting bolts, then slide the front pulley, the spacer and the rear pulley off the hub (Figure 151).

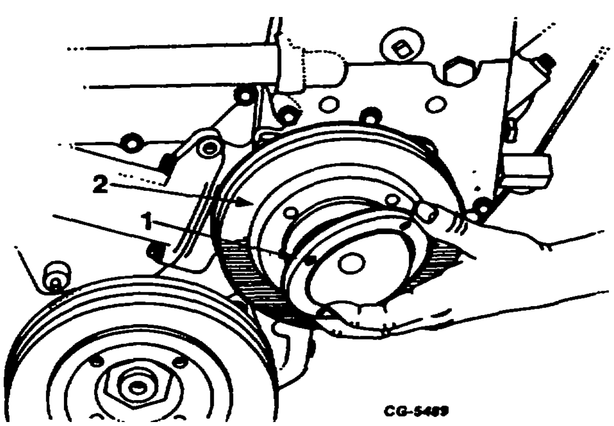


Figure 151. Water Pump Pulley Removal

1. Between Pulleys Spacer 2. Rear Pulley

9. The water pump assembly with hub can be removed at this time or on the bench after the complete water pump housing assembly has been removed. (The water pump assembly with hub is serviced as a complete assembly). To remove water pump assembly with hub, remove four bolts and remove assembly (Figure 152).

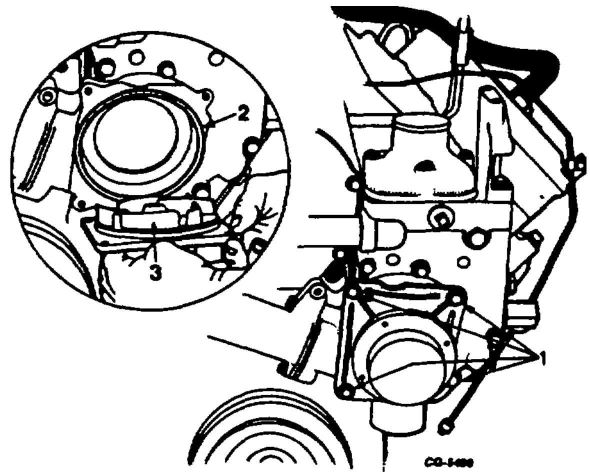


Figure 152. Removal of Water Pump Assembly

1. Water Pump Assembly Mounting Bolts
2. Gasket
3. Gasket Impeller

10. To remove water outlet and water return tube, remove two bolts from water outlet and remove assembly from cylinder head and water pump housing (Figure 153).

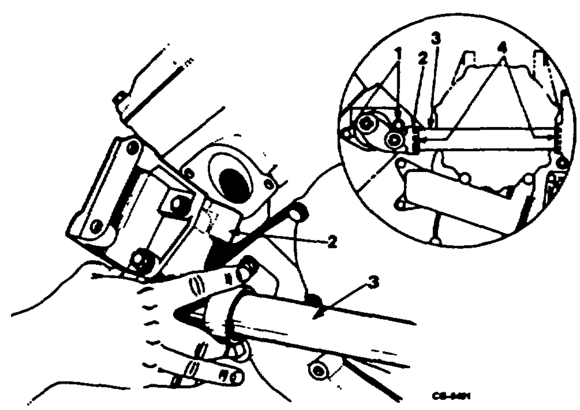


Figure 153. Removing Left Water Outlet and Return Tube

1. Mounting Bolts
2. Water Outlet
3. Return Tube
4. "O" Ring

11. Remove water pump to crankcase manifold by removing two bolts from manifold to crankcase and two bolts from manifold (Figure 154).

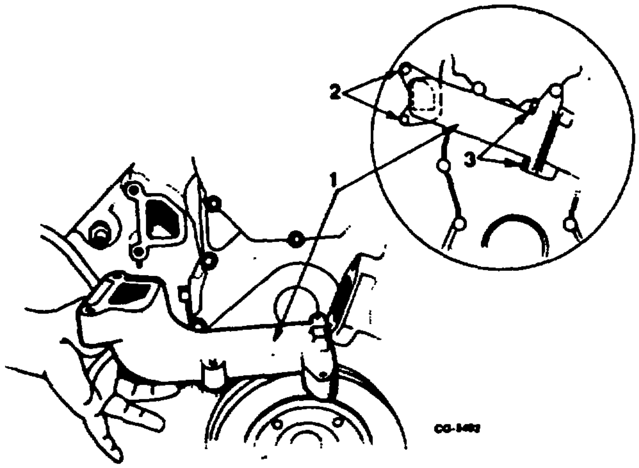


Figure 154. Removing Water Manifold

1. Water Manifold
2. Manifold to Crankcase Mounting Bolts
3. Manifold to Water Pump Mounting Bolts

12. Remove water pump housing with thermostat housing from crankcase by removing five bolts and oil cooler water return line, remove housing with water return tube (Figure 155).

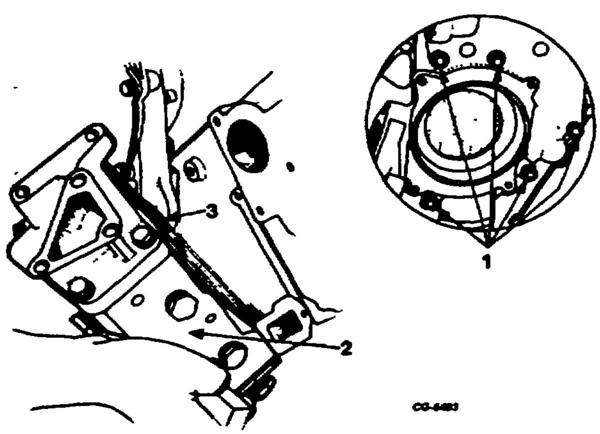


Figure 155. Water Pump Housing Removal

1. Mounting Bolts
2. Water Pump Housing
3. Water Return Tube and "O" Ring

13. Remove injection pump drive gear cover by removing seven bolts, then remove cover (Figure 156). Remove the oil level dipstick by turning back-and-forth and pulling at the same time.

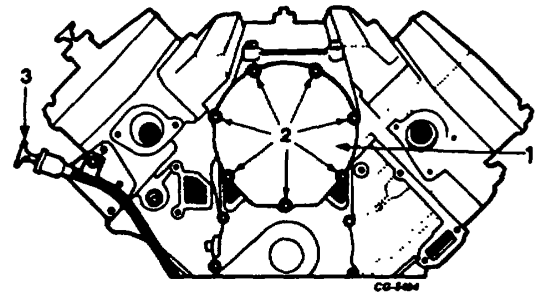


Figure 156. Removing Injection Pump Drive Gear Cover and Dipstick

1. Injection Pump Drive Gear Cover
2. Cover Bolts
3. Oil Level Dipstick Gauge

14. Remove four injection pump drive gear mounting bolts, remove gear (Figure 157).

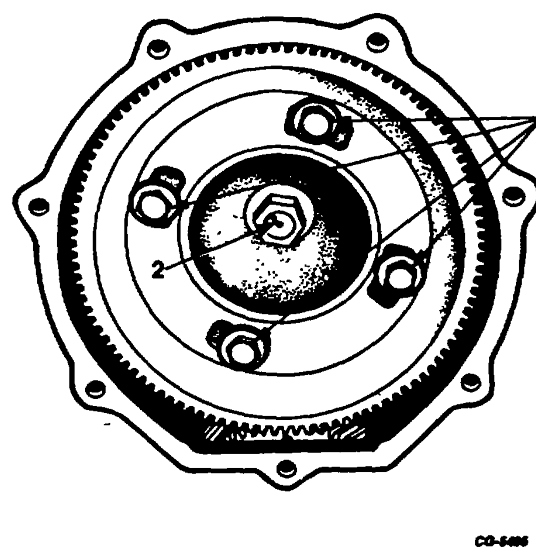


Figure 157. Removing Injection Pump Drive Gear

1. Injection Pump Drive Gear Mounting Bolts
2. Timing Mark

15. Disconnect idler arm spring from hook in front cover and remove spring from idler arm. Loosen idler arm bolt and remove idler arm and spacer from bracket (Figure 158).

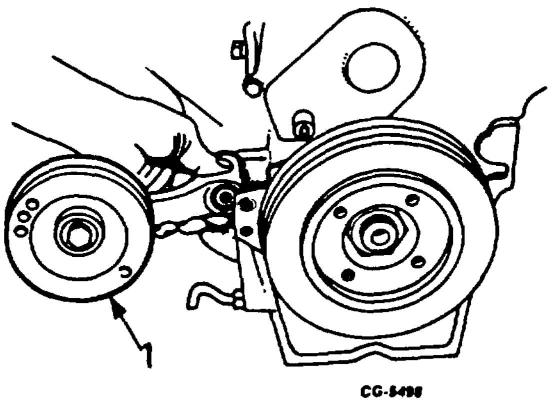


Figure 158. Removing Idler Arm Pulley Assembly

1. Idler Arm Pulley

See crankshaft repair section and remove the following:

Crankshaft Pulley
Front Cover Oil Seal
Crankshaft Pulley Wear Sleeve

16. Remove ten front cover to crankcase mounting bolts (two of the ten bolts are located on the back side of the front cover under the injection pump gear opening) and three oil pan to front cover mounting bolts (Figure 159).

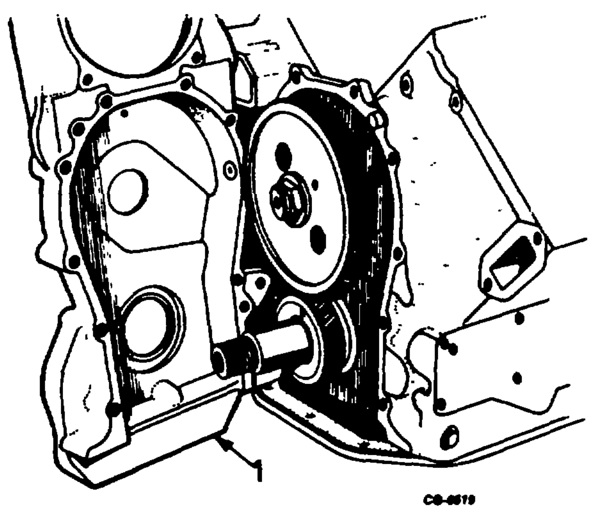


Figure 159. Removing Front Cover

1. Front Cover

CLEANING, INSPECTION AND REPAIR

Fan Mounting

The fan mounting assembly consists of fan mounting body, bearing and shaft assembly, snap ring and drive hub (Figure 160).

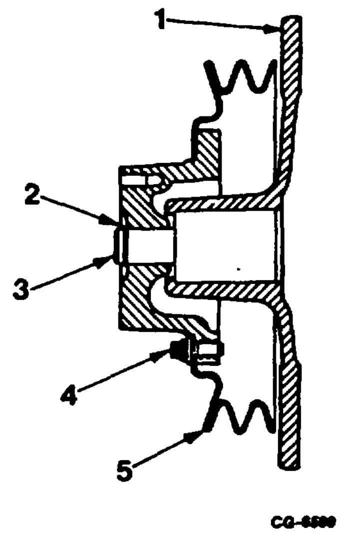


Figure 160. Fan Mounting Section View

1. Fan Mounting Body
2. Snap Ring
3. Bearing and Shaft Assembly
4. Pulley to Hub Mounting Bolt
5. Pulley

Fan mounting bearing must be replaced if looseness or wobble is indicated.

Drive hub and bearing removal:

1. Remove drive pulley mounting bolts and re move pulley.

2. Remove snap ring from shaft.

3. Using remover adapter tool press hub from shaft (Figure 161).

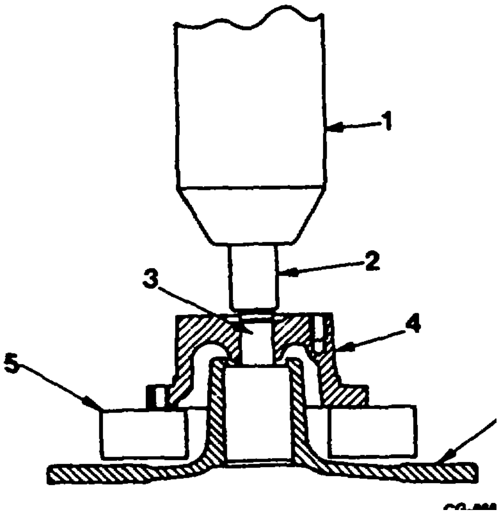


Figure 161. Fan Mounting Drive Hub Removal

1. Press Ram
2. Remover Adapter
3. Bearing and Shaft Assembly
4. Drive Hub
5. Support Block
6. Fan Mounting Body

4. Using remover adapter tool, press bearing and shaft assembly from fan mounting body (Figure 162).

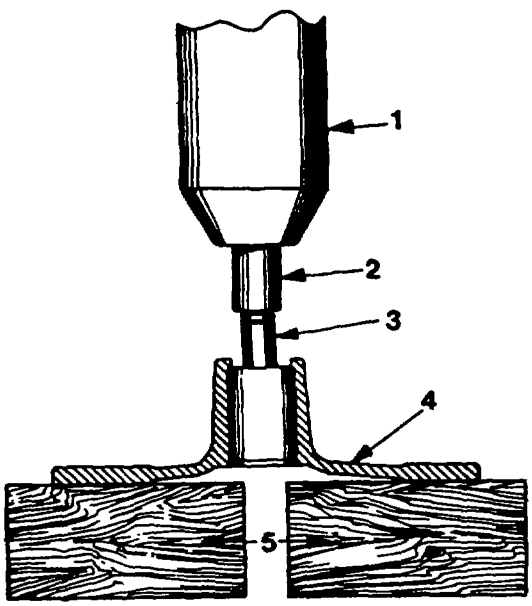


Figure 162. Removing Bearing and Shaft Assembly

1. Press Ram
2. Remover Adapter
3. Bearing and Shaft Assembly
4. Fan Mounting Body
5. Support Blocks

Drive hub and bearing installation:

1. Press new bearing and shaft assembly in fan mounting body.
2. Apply Locquic Primer T and Loctite AA to hub and bearing shaft.
3. Press on drive hub.
4. Reinstall snap ring.

Idler Pulley

Check idler pulley bearing for looseness (wear) or rough operation.

Check idler arm support bushing for looseness (wear).

If necessary, replace pulley bearing and/or support bushing (Figure 163) as outlined below.

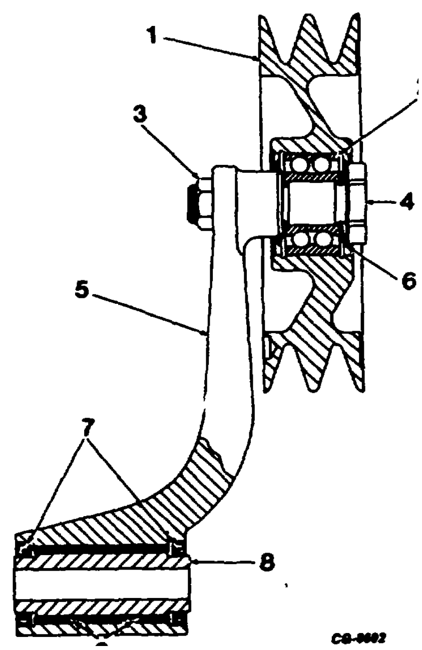


Figure 163. Sectional View of Idler Pulley Assembly

1. Pulley
2. Bearing
3. Nut
4. Bolt
5. Idler Arm
6. Shield
7. Seals
8. Spacer
9. Bushing

Pulley Bearing Replacement:

1. Remove nut from idler bearing shaft.

2. Remove idler pulley and shaft from idler arm.

3. Remove bearing shields and shaft from idler pulley bearing and remove two snap rings (one each side of bearings).

4. Using remover tool SE-1955-8 with a flat washer 15.875 mm (5/8"), I.D. x 23.813 mm (15/16") O.D. x 2.381 mm (3/32") thick, press bearing from pulley.

5. Clean pulley carefully. Inspect for cracks or other damage. Replace pulley if damaged.

6. Install one snap ring in bore of pulley. Make certain snap ring is seated securely. Support pulley on a press plate, then press new bearing into pulley bore until bearing seats against snap ring.

IMPORTANT
USE CARE NOT TO PRESS BEARING ASSEMBLY. PRESS ON BEARING OUTER RACE TO PREVENT DAMAGE TO BEARING. AFTER BEARING IS PRESSED INTO PLACE, INSTALL OTHER SNAP RING. THE NEW BEARING IS PRE-LUBRICATED AND REQUIRES NO FURTHER ATTENTION.

7. Place one bearing shield on shaft and insert shaft into bearing. Install other shield on opposite side of bearing.

8. Thread bearing shaft into idler arm and install nut on shaft and tighten securely. Support Bushing Replacement:

1. Press spacer from idler arm using remover tool SE-1722.

2. Remove both seals from Idler arm using remover SE-1746 and slide hammer.

3. With the use of remover tool SE-1036-1, remove bushing from idler arm.

4. Using installer tool SE-1946-1, press new bushing into Idler arm bore until it is just flush with edge of bore.

5. Place new seal in one counterbore of idler arm with lip of seal facing inward. Using 13/16" socket, press seal in until it bottoms in counterbore. Do not damage seal.

6. Install spacer in idler arm bushing.

7. Turn idler arm over and install opposite seal per Step 5.

Water Pump

The water pump assembly is composed of a pulley hub and a housing which accommodates a shaft and bearing assembly, seal and Impeller as shown in Figure 164. The water pump will be sold only as a complete assembly along with its mounting gasket.

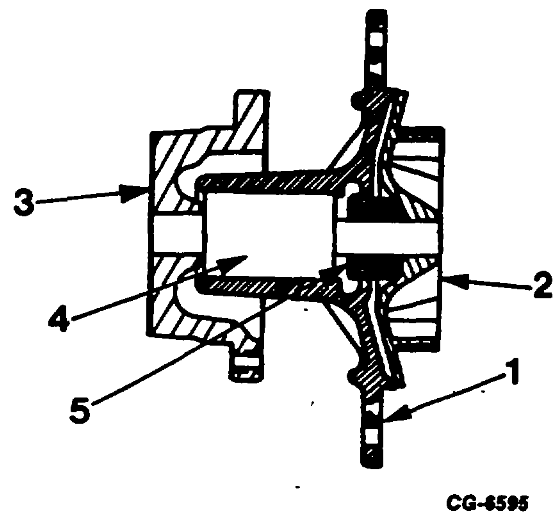


Figure 164. Sectional View of Water Pump Assembly

1. Water Pump Housing
2. Impeller
3. Hub
4. Bearing Assembly
5. Seal

1 When removing water pump all gasket material should be cleaned from the water pump. Inspect the water pump for damaged impeller, cracks and other faulty conditions. If-any defects are noted, the water pump must be replaced as an assembly.

2. If the pulley hub must be replaced, apply Locquic Primer T and Loctite AA to hub and bearing shaft assembly prior to assembly.

3. Press the hub on to the shaft using pulley hub installer SE-2085 as shown in Figure 165.

NOTE: When pressing the hub on the water pump assembly, special care must be taken, so as not to disturb the impeller's position on the shaft.

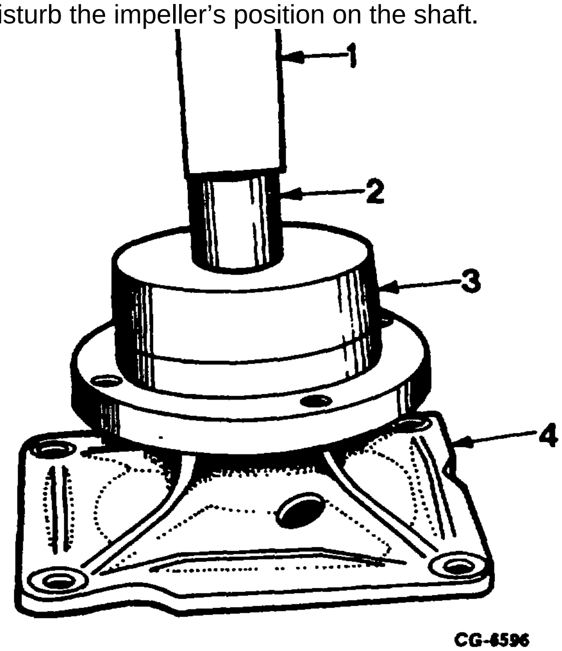


Figure 165. Installing Pulley Hub

1. Press Ram	3. Pulley Hub
2. Installer SE-2085	4. Housing

4. Check impeller running clearance as follows:

   a. Position suitable amount of moulding clay on two impeller vanes (Figure 166).

   b. Position gasket on water pump housing. Install pump assembly into pump body and tighten mounting screws.

IMPORTANT

BE CAREFUL NOT TO ROTATE IMPELLER OR HUB.

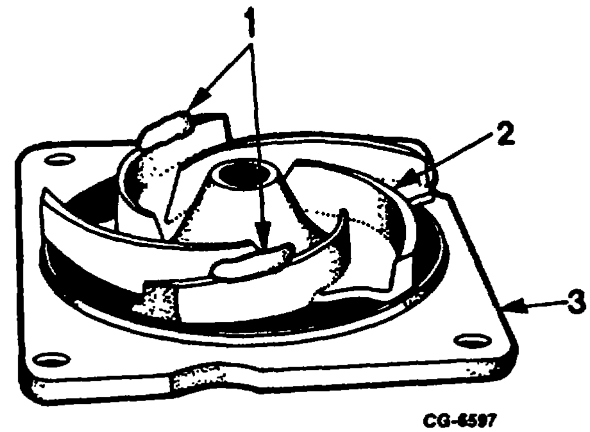


Figure 166. Moulding Clay Mounted on Impeller Vanes to Check Impeller Clearance

1. Moulding Clay
2. Impeller
3. Housing

   c. Remove pump assembly and check thickness of moulding clay (Figure 167). If clearance exceeds specifications, the water pump must be replaced.

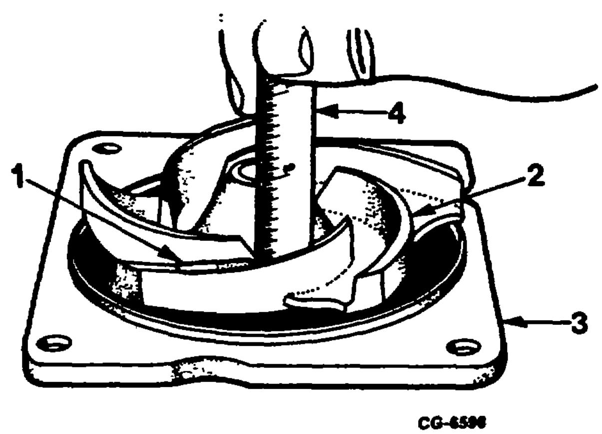


Figure 167. Measuring Thickness of Moulding Clay to Determine Impeller Clearance

1. Moulding Clay	3. Housing
2. Impeller	4. Scale

5. Position gasket on water pump housing. Install pump assembly into pump body and tighten mounting screws.

REASSEMBLY

1. Position a new front cover gasket over dowel pins in crankcase. Install engine front cover.

2. Install front cover oil seal as follows:

   a. Position front cover oil seal on tool pilot (small diameter) of SE-2096 installer with wiping lip of seal toward outer end of pilot.

   b. Lubricate seal bore of front cover with engine oil.

   c. Place installer over end of crankshaft and drive seal into cover (Figure 168). Seal is properly located when inner shoulder on tool contacts machined surface of front cover.

> IMPORTANT
> TOOL CAN ALSO BE USED TO INSTALL OIL SEAL WHERE COVER IS REMOVED FROM ENGINE BY PLACING FRONT COVER IN A PRESS AND PRESS SEAL IN UNTIL FLANGE OF TOOL CONTACTS MACHINED SURFACE ON FRONT COVER.

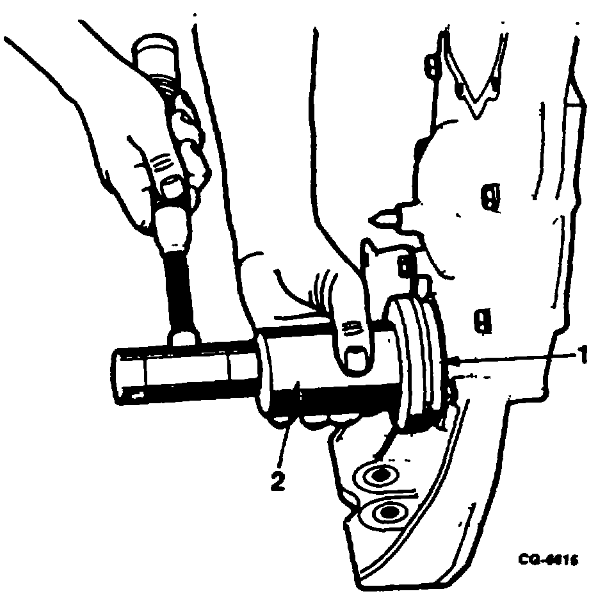


Figure 168. Installing Engine Front Cover Oil Seal

1. Oil Seal
2. Installer Tool SE-2096

3. If front oil seal wear sleeve was removed from crankshaft pulley at engine disassembly, install new wear sleeve as follows:

   a. Coat crankshaft pulley hub with a nonhardening sealer. Position pulley on press bed.

   b. Heat wear sleeve in boiling water and position on pulley hub. Using handle and 7.3 cm (2-7/8 inch) diameter adapter from SE-1905 tool set, press wear sleeve onto pulley hub until flush with end of hub (Figure 169).

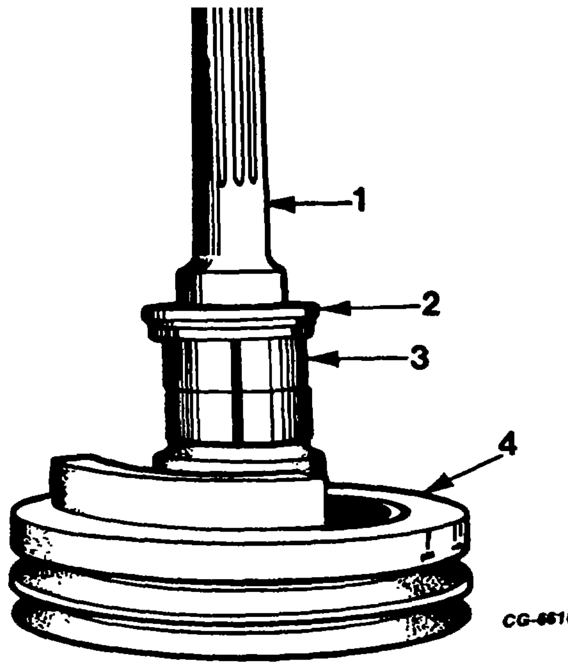


Figure 169. Installing Front Oil Seal Wear Sleeve

1. Handle	3. Wear Sleeve
2. Adapter	4. Crankshaft Pulley

4. Position pulley key in keyway of crankshaft. Lubricate inside diameter of crankshaft pulley with press-fit lubricant. Install crankshaft pulley using installer tool SE-1900 (Figure 170). Install crankshaft pulley nut and flat washer. Tighten pulley nut to specified torque. (See TORQUE CHART).

> IMPORTANT
> WEAR SLEEVE SURFACE ON CRANKSHAFT DAMPER SHOULD BE LUBRICATED WITH CLEAR ENGINE OIL TO PREVENT SEAL DAMAGE.

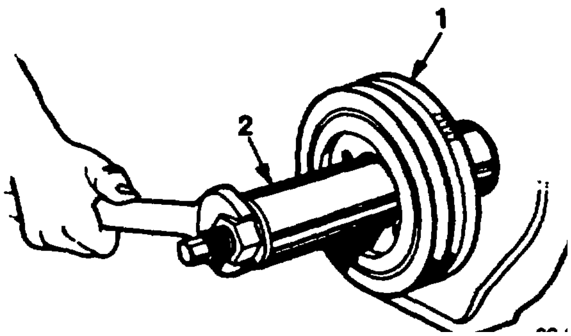


Figure 170. Installing Crankshaft Pulley

1. Crankshaft Pulley
2. Installer SE-1900

5. Position mounting gasket on injection pump adapter and mount injection pump-to front engine cover.

IMPORTANT
USE ONLY 9.53 MM X 25.4 MM (3/8 X 1"). PATCH BOLTS FOR MOUNTING INJECTION PUMP TO FRONT ENGINE COVER.

6. Place new "O" rings on water return tube, place tube in water pump housing as shown in Figure 155. Place the five mounting bolts in housing, position a service gasket over the two lower bolts and install water pump housing (Figure 155). Connect oil cooler water return pipe.

7. Position proper gasket on water manifold and attach manifold to crankcase and water pump housing (Figure 154).

8. Place new "O" rings on water return tube. Place end of tube in water outlet housing and the other end in the water pump housing, attach water outlet housing to cylinder head (Figure 153).

9. Position new gasket on water pump housing and install water pump assembly (Figure 152).

10. Place rear pulley, spacer and front pulley on water pump hub. Secure with four mounting bolts.

11. Install accessory mounting channel (Figure 151).

12. Install fan hub assembly as shown in Figure 151.

13. Install primer pump and filter mounting bracket assembly (Figure 149) and connect fuel lines (Figure 6).

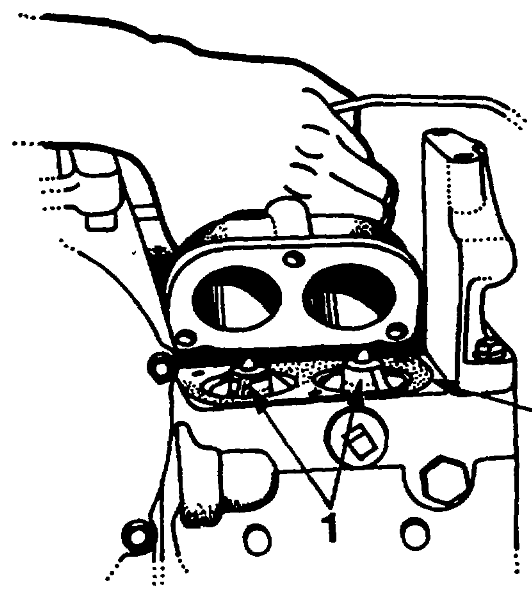
14. Install idler pulley arm and spring (Figure 158).

15. Push idler pulley toward center of engine and install main drive belts (Figure 148).

16. Install modulated fan drive and fan assembly to fan pulley hub (Figure 147). Secure with four mounting bolts and lockwashers.

17. Adjust accessory drive belts (Figure 17 and 18).

18. Check or install new thermostats (Figure 171).



CG-6622

Figure 171. Thermostat Installation

1. Thermostats
2. Gaskets

Since a low operating temperature will result in loss of power and economy, only specified temperature range thermostats should be used. The thermostats should not be removed in an attempt to lower operating temperature.

Thermostat operation should be checked at the time of engine overhaul or whenever faulty operation is suspected.

To check operation, place thermostat in a pan of water, heat water, and using an accurate thermometer, observe water temperature when thermostat starts to open. Thermostat should start to open at approximately 82 degrees C (180 degrees F). Replace thermostat if defective.

When installing, position thermostats correctly in housing per instructions stamped on thermostat. Make sure thermostats are seated in housing. Use new thermostat housing gasket.

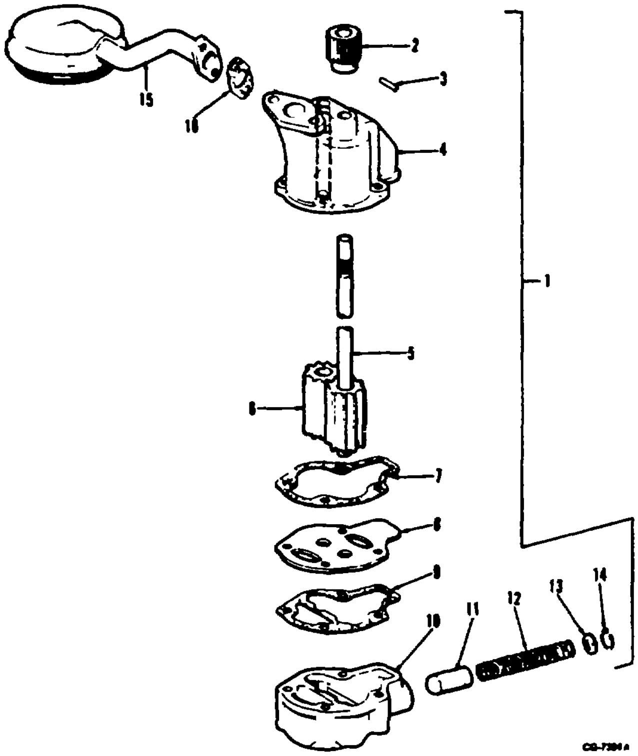


Figure 172. Oil Pump Assembly

1.	Oil Pump Assembly	9.	Gasket
2.	Drive Gear	10.	Base Cover
3.	Roll Pin	11.	Relief Valve
4.	Body with Shaft	12.	Spring
5.	Shaft	13.	Guide
6.	Gears	14.	Snap Ring
7.	Gasket	15.	Oil Pickup Screen
8.	Cover Plate	16.	Gasket

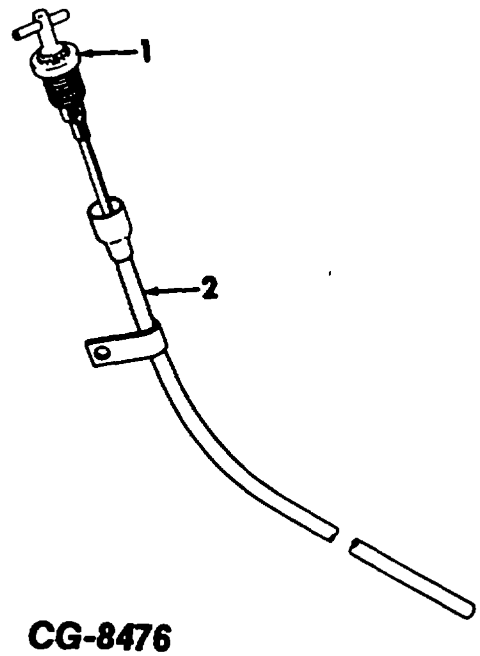


Figure 173. Oil Level Gauge Assembly

1. Oil Level Gauge
2. Oil Level Tube

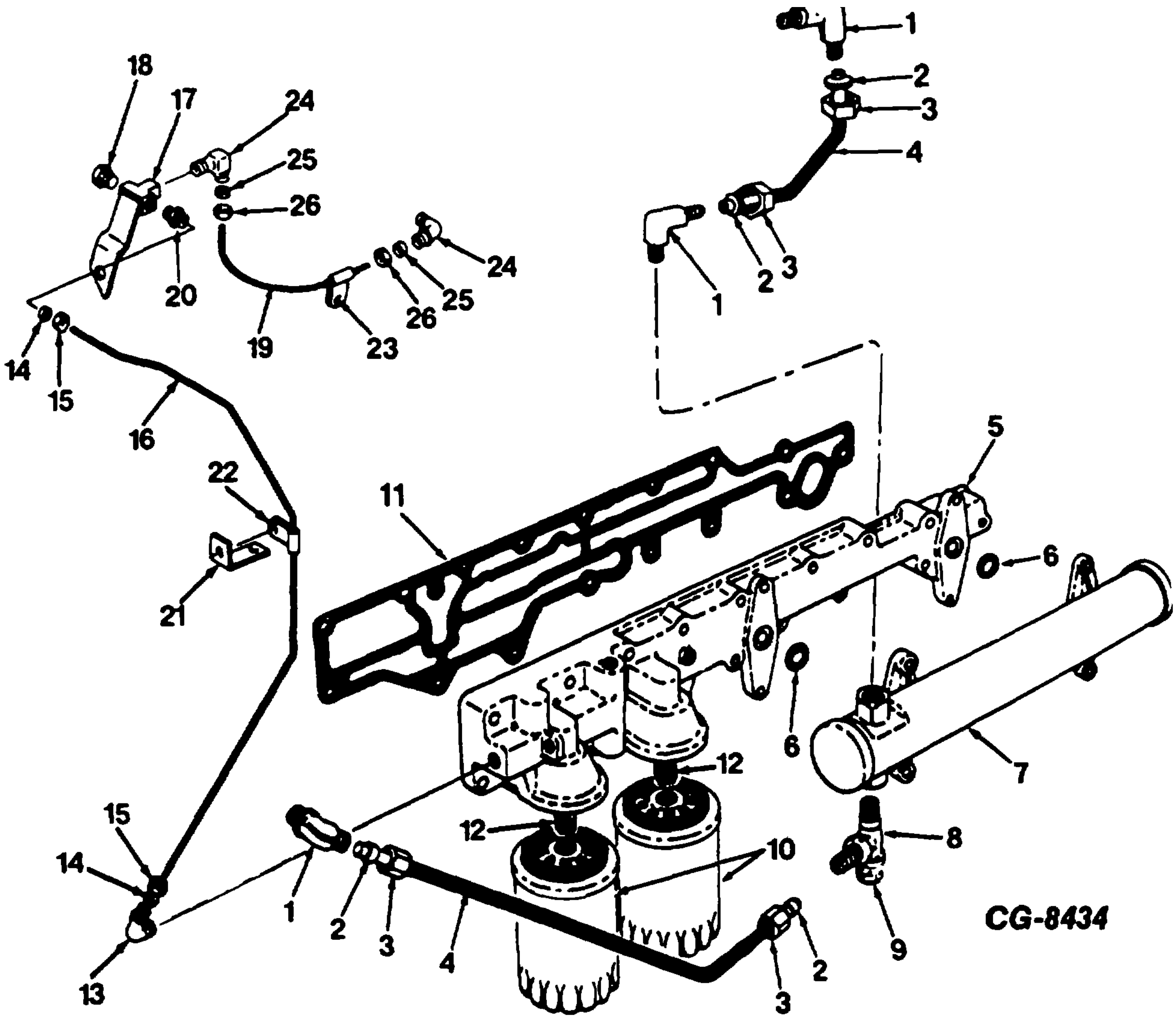


Figure 174. Oil Filter and Cooler Assembly

1. Elbow
2. Flex Sleeve
3. Nut
4. Tube
5. Oil Cooler Base
6. O-Ring
7. Oil Cooler
8. Tee Fitting
9. Plug
10. Oil Filters
11. Base Gasket
12. Adapter Fitting
13. Elbow
14. Sleeve
15. Nut
16. Tube
17. Tee Bracket
18. Plug
19. Tube
20. Connector
21. Clip
22. Clamp
23. Clip
24. Elbow
25. Sleeve
26. Nut

SPECIFICATIONS

Oil Pump:

Gear to Body End Clearance	.076 - .114 mm (.003 - .0045")
Gear to Body Side Clearance	.058 - .114 mm (.0023 - .0045")
Shaft Diameter	12.459 - 12.476 mm (.4905 - .4912")
Shaft Clearance in Bore	.033 - .076 mm (.0013 - .0030")
Body Gear Backlash	.013 - .165 mm (.0005 - .0065")

TORQUES

See General Torque Chart for all fasteners in this section.

DISASSEMBLY

Refer to unit sections for detailed disassembly procedures and remove the following:

Oil Pan

1. Remove two oil pump mounting bolts and remove pump (Figure 175).

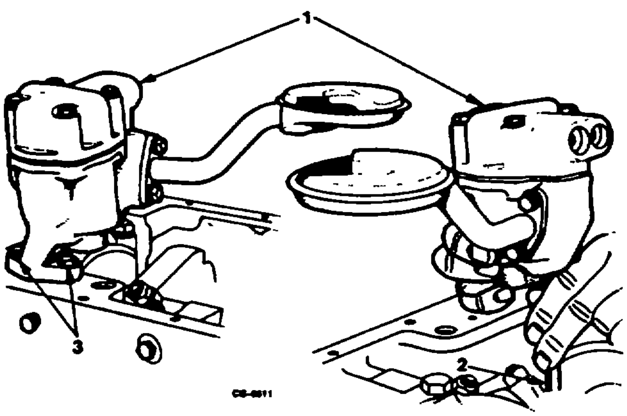


Figure 175. Installing Oil Pump

1. Oil Pump
2. Checking Oil Pump Shaft Alignment to Block
3. Oil Pump Mounting Bolts

2. Disconnect oil cooler water return line from oil cooler and remove return line. Disconnect oil cooler water inlet line from engine and oil cooler and remove water inlet line. Remove four oil cooler mounting bolts and remove oil cooler (Figure 176). The oil filters may be removed at this time.

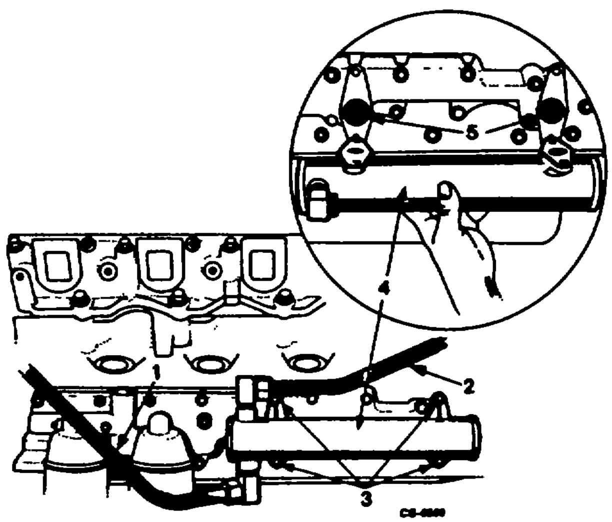


Figure 176. Removing Oil Cooler

1. Water Outlet Line
2. Water Inlet Line
3. Mounting Bolts
4. Oil Cooler
5. "O" Rings

NOTE: In the event of camshaft, crankshaft, connecting rod or main bearing failure, bearing debris may become lodged in the oil cooler assembly.

3. Cleaning or flushing of the oil cooler assembly is not adequate and the metal residue can cause a repeat engine bearing failure.

4. To prevent repeat engine failures it is recommended that the oil cooler core assembly be replaced whenever a bearing failure occurs or when an engine failure occurs that allows metal debris to circulate through the lubrication system.

5. Disconnect air compressor and injection pump oil line from oil filter base (Figure 177).

6. Remove sixteen mounting bolts from oil filter base and remove oil filter base (Figure 177).

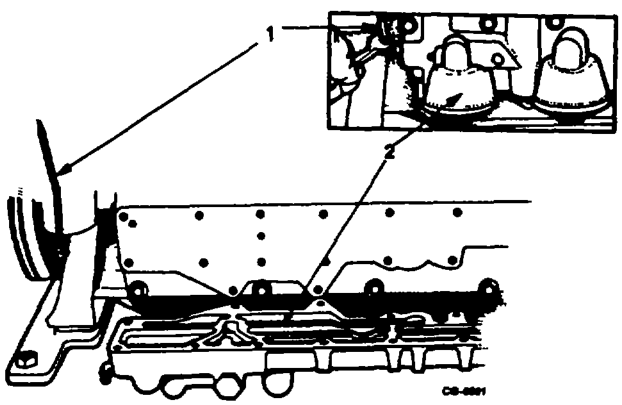


Figure 177. Removing Oil Filter Base

1. Air Compressor and Injection Pump Oil Feed Line

2. Oil Filter Base

CLEANING, INSPECTION AND REPAIR

Oil Pump

Recommended oil pump inspection and repair procedures are as follows:

1. Wash all pump parts and screen assembly in cleaning solvent.

2. With cover, plate and gaskets removed and gears and shaft in place, exert pressure against gears with thumb to push gears away from the outlet side of pump.

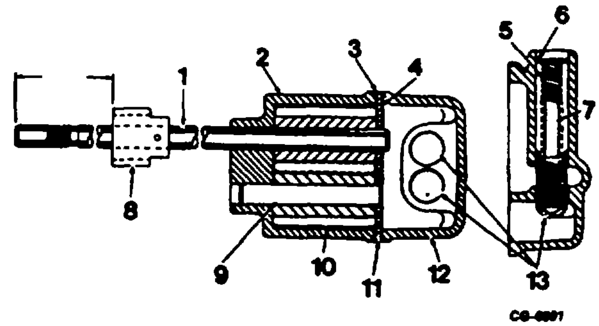


Figure 178. Sectional View of Oil Pump Assembly

1. Shaft
2. Body
3. Gasket-Use as Required to Provide Gear End Play
4. Gasket
5. Spring
6. Retaining Ring
7. Guide
8. Drive Gear
9. Idler Shaft
10. Idler Gear
11. Plate
12. Cover
13. Relief Valve (Two Used)

3. While holding gears in this manner, measure clearance between outside diameter of gear and bore of housing Figure 179).Clearance should be within limits given in SPECIFICATIONS.

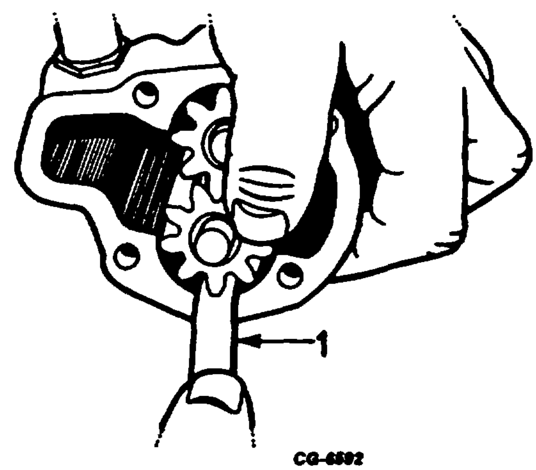


Figure 179. Measuring Pump Gear-to-Body Clearance

1. Feeler Gauge

4. If clearance is not within specified limits (See SPECIFICATIONS), obtain new pump.

5. Check pump shaft clearance in the bore. If worn beyond limits given in SPECIFICATIONS, replace pump assembly.

6. Check backlash between pump body gears. If this exceeds figure shown in SPECIFICATIONS, replace pump.

7. Establish body gear end clearance. Oil pump cover plate-to-body gaskets control clearance (end play) between pump body gears and pump cover plate. Add or remove gaskets to obtain specified clearance. (See SPECIFICATIONS).

8. Inspect relief valves and replace if worn or damaged.

9. Check relief valve springs for proper tension. (See SPECIFICATIONS). Replace springs if weak or damaged.

10. When installing pump gears and shaft, these parts should be oiled liberally with engine oil for initial lubrication.

11. When installing oil pump drive gear on shaft, gear should be pressed on to a 7.3 cm (2-7/8") dimension from top of gear to end of shaft (Figure 178).

12. Installation of pump screen must be made after pump assembly has been installed on engine. (See ENGINE ASSEMBLY).

Oil Filter and Cooler Base

At the time of engine overhaul, oil filter and cooler base should be serviced as follows:

1. Remove all gasket material from filter/cooler base. Wash base in cleaning solvent and dry carefully.

2. Inspect gasket surfaces of base for nicks or scratches which could cause leakage. Replace base If damaged (Figure 180).

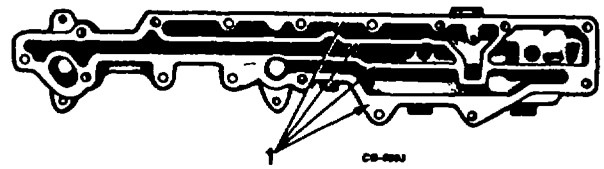


Figure 180. Oil Filter and Cooler Base

1. Gasket Surfaces

Oil Cooler

The following operations should be performed on the oil cooler during engine overhaul.

1. Remove fittings from coolant openings of cooler.

2. Looking through coolant openings, inspect coolant portion of cooler for deposits of lime or other contaminents and for evidence of oil leakage. Replace cooler if heavy deposits or oil leakage are found.

3. Pressure test cooler for leakage as follows (Figure 181):

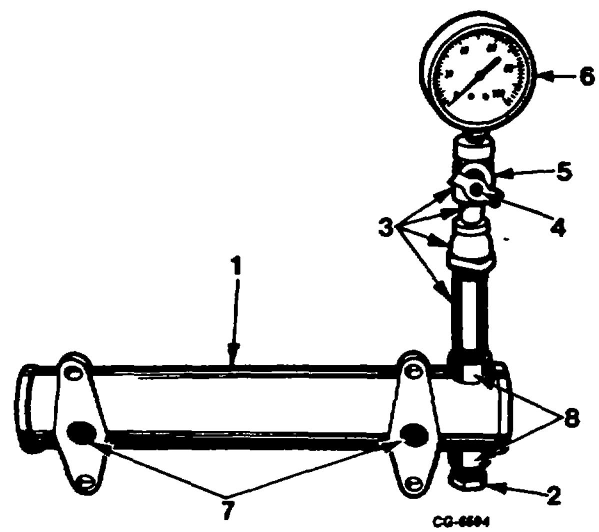


Figure 181. Oil Cooler Leakage

1. Oil Cooler Assembly
2. Plug
3. Necessary Adapter Fittings
4. Supply Air Input
5. Air Control Valve
6. Air Pressure Gauge
7. Oil Openings
8. Coolant Openings

a. Plug one coolant opening.

b. Using necessary adapter fittings and air control valve (Radiator drain valve will work) connect an air pressure gauge to the other coolant opening (Figure 132).

c. Pressurize coolant portion of cooler with air (Do Not exceed 517 kPa (75 psi) air pressure). Close air control valve, release supply air and check pressure gauge for leak-off.

d. Replace cooler if leakage is indicated.

Alternate Method:

a. Plug one coolant opening of oil cooler.

b. Using necessary adapter fittings connect other coolant opening to source of regulated air pressure.

c. Completely submerge oil cooler in a container of water, if leakage is observed, replace oil cooler.

REASSEMBLY

1. Position oil pump in cylinder block and check for correct alignment. Pump shaft should rotate freely without binding (Figure 182).

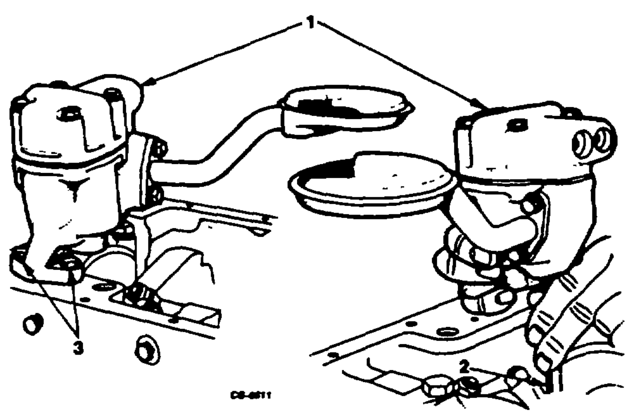


Figure 182. Installing Oil Pump

1. Oil Pump
2. Checking Oil Pump Shaft Alignment to Block
3. Oil Pump Mounting Bolts

. Connect oil line from oil feed line tee to injection pump (Figure 174).

3. Install oil filter and cooler base as follows:

   a. Insert two bolts in each end of base and in the middle of base.

   b. Position gasket against base and just start threads of bolts In gasket.

   c. Place base with gasket against crankcase and start bolts.

   d. Install remaining bolts and tighten all alternately and evenly.

4. Position new oil cooler gaskets on oil cooler base and install cooler (Figure 174).

5. Install oil cooler water inlet and return lines (Figure 174).

6. Install oil pressure sender unit to oil filter base.

7. Connect oil feed line from oil filter base to tee at injection pump.

8. Install new oil filters and fill crankcase with proper type and quantity of oil.

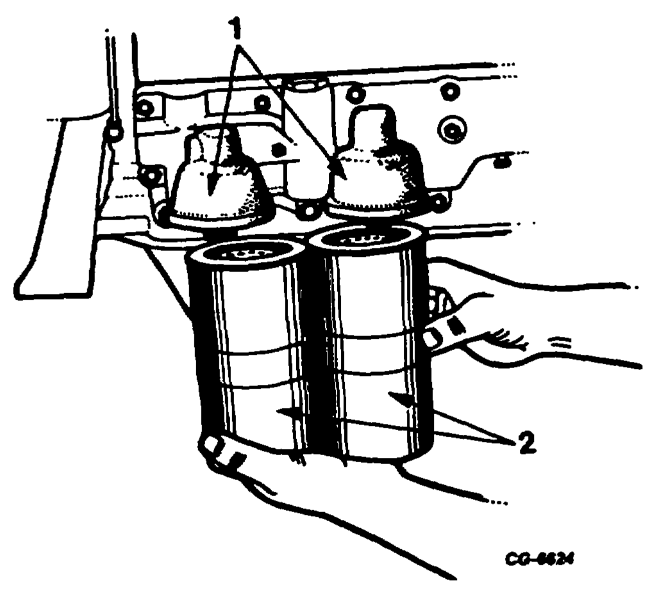


Figure 183. Oil Filter Installation

1. Oil Filter Base
2. Oil Filter

9. Prime lubricating system: When assembling the engine during overhaul it is important to prelubricate the running parts with clean engine oil to assure Initial lubrication when the engine is first started.

To further assure complete initial lubrication, the engine lubricating system should be pressure primed or charged with oil. Priming the lubricating system will minimize the possibility of scuffing or heat build-up during initial engine operation which could lead to immediate or low mileage failure.

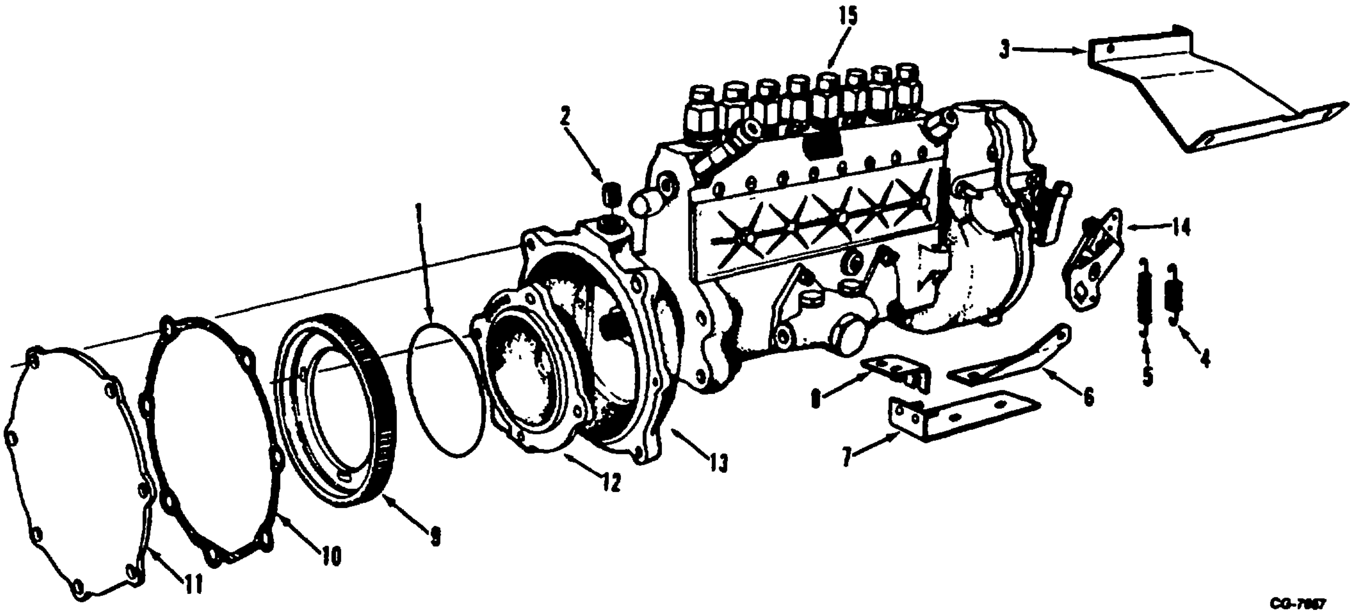


Figure 184. Fuel Injection Drive and Mounting

1. Gasket (Adapter to Crankcase Cover)
2. Pin Plug
3. Bracket
4. Outer Return Spring
5. Inner Return Spring
6. Spring Anchor Bracket
7. Support Bracket
8. Support Bracket
9. Drive Gear
10. Drive Cover Gasket
11. Drive Cover
12. Hub
13. Adapter
14. Lever
15. Injection Pump

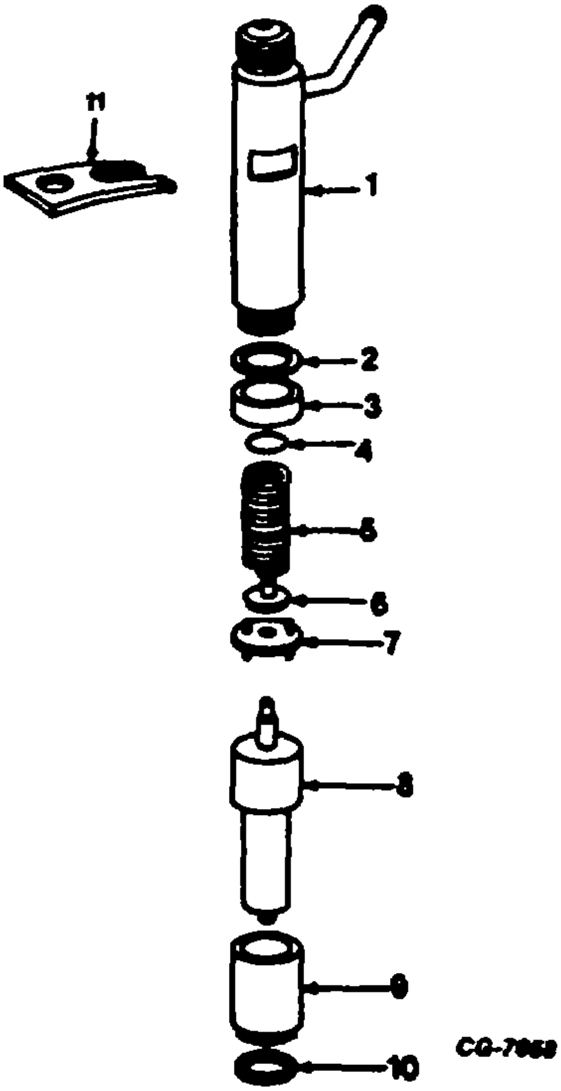


Figure 185.

1. Nozzle Holder Body
2. Injector Seal Washer
3. Injector Seal
4. Spring Spacer
5. Pressure Spring
6. Spring Seat Guide
7. Valve Stop Spacer
8. Injector Nozzle
9. Nozzle Cap Nut
10. Injector to Cylinder Head Gasket
11. Fuel Injector Clamp

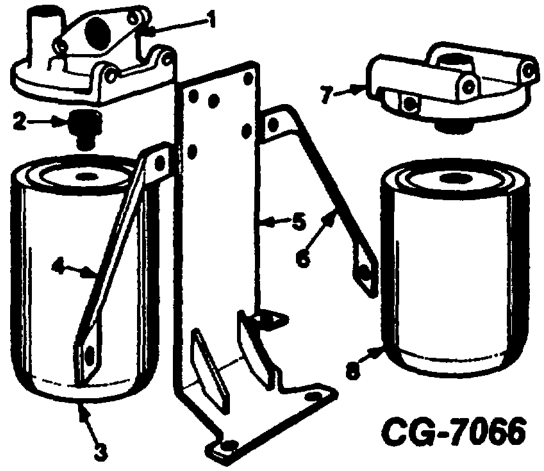


Figure 186. Fuel Filter Assembly

1. Final Fuel Filter Base
2. Fuel Filter Adapter
3. Final Fuel Filter
4. Brace
5. Fuel Filter Bracket
6. Brace
7. Primary Fuel Filter Base
8. Primary Fuel Filter

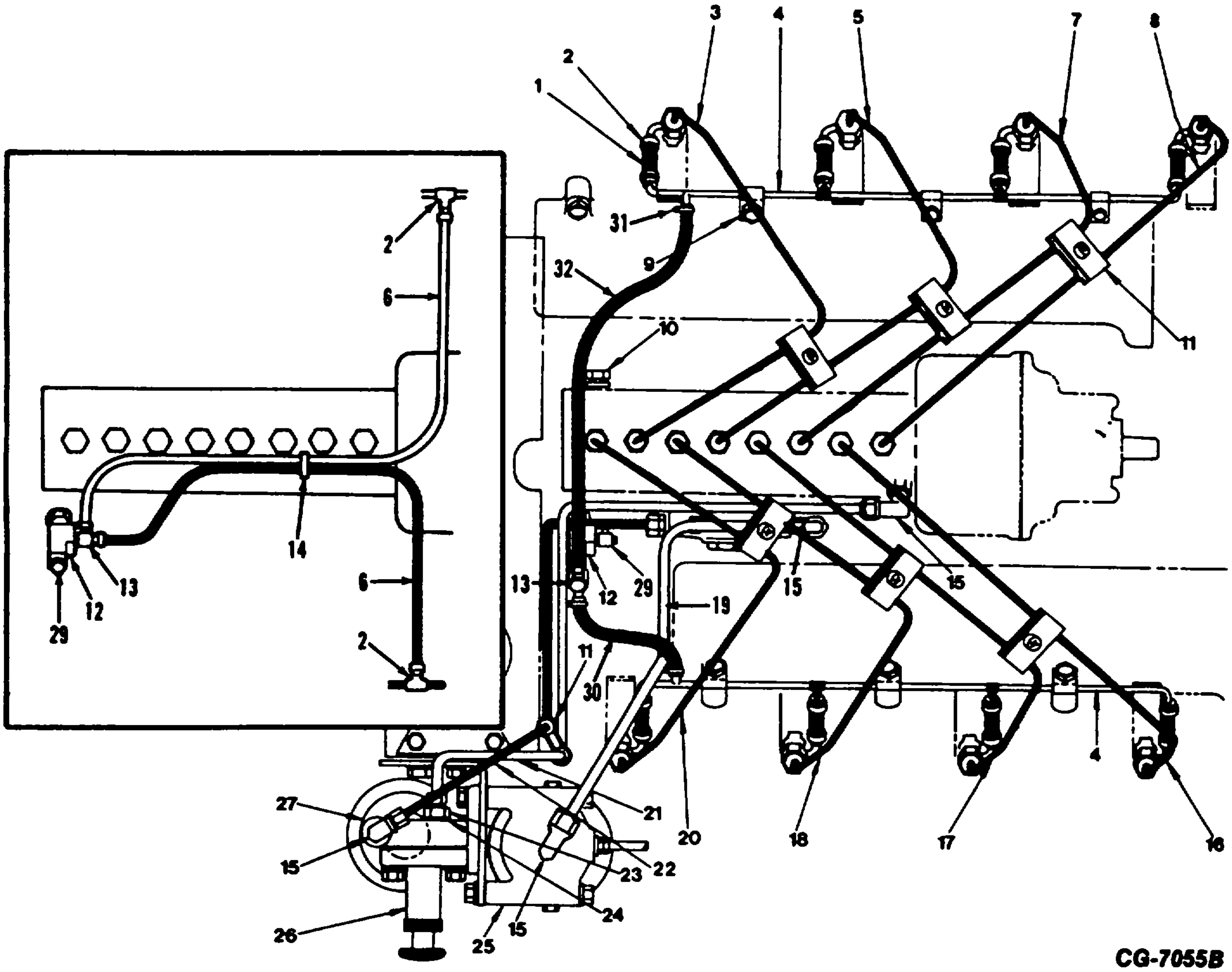


Figure 187

1. Leak Off Hose
2. Leak Off Hose Clamp
3. No. 2 Injection Pipe
4. No. 2 Leak Off Pipe
5. No. 4 Injection Pipe
6. Hose
7. No. 6 Injection Pipe
8. No. 8 Injection Pipe
9. Clamp
10. Air Bleed Valve
11. Clamp
12. Pipe Tee
13. Connector Tee
14. Strap
15. Elbow
16. No. 7 Injection Pipe
17. No. 5 Injection Pipe
18. No. 3 Injection Pipe
19. Pipe
20. No. 1 Injection Pipe
21. Final Filter Pipe
22. Transfer Pump Pipe
23. Connector
24. O-Ring
25. Filter Header
26. Fuel Priming Pump
27. Final Fuel Filter
28. Connector
29. Pipe Plug
30. Hose
31. Clamp
32. Hose

SPECIFICATIONS

Injection Pump Drive:

Drive Gear Backlash .013 - .114 mm (.0005 - .0045")

TORQUES

	N·m	Ft.-Lbs.
Injection Line Connectors	21-27	(16-20)
Injection Pump Drive Shaft Nut	95-108	(70-80)
Injection Pump Gear Bolts	27-34	(20-25)
Nozzle Hold-Down Clamp	19-22	(14-16)
Mtg. Bracket to Injection Pump Bolts	27-34	(20-25)

For all other fasteners refer to General Torque Chart.

DISASSEMBLY

Refer to unit sections for detailed disassembly procedures and remove the following:

Accessory Belts
Modulated Fan
Fan Hub
Fan Mounting Bracket
Left Water Outlet and Return Tube

1. Remove fuel filters and fuel pipes from primer pump assembly. Remove three bolts from primer pump mounting bracket and remove bracket with pump from engine. Figure 188.

2. Remove injection pump drive gear cover by removing seven bolts, then remove cover (Figure 189).

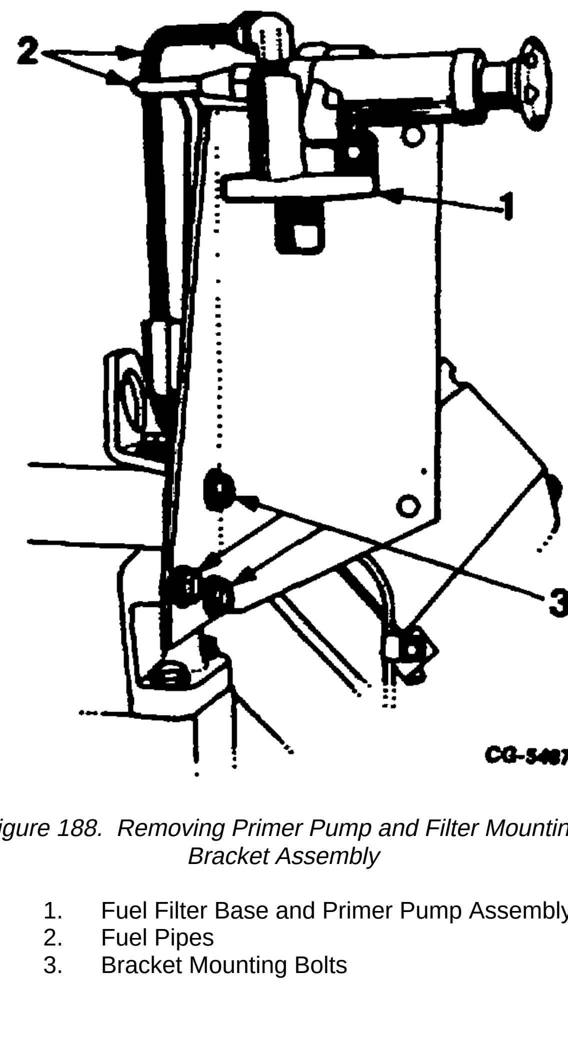


Figure 188. Removing Primer Pump and Filter Mounting Bracket Assembly

1. Fuel Filter Base and Primer Pump Assembly
2. Fuel Pipes
3. Bracket Mounting Bolts

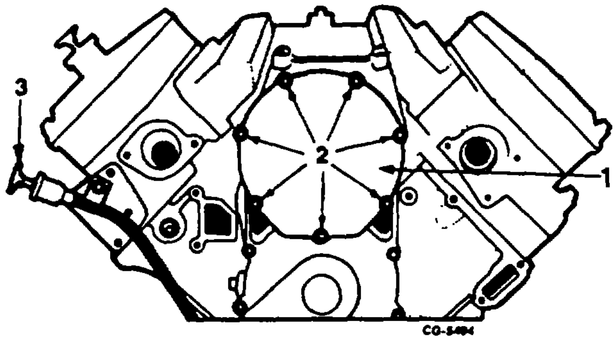


Figure 189. Removing Injection Pump Drive Gear Cover and Dipstick

1. Injection Pump Drive Gear Cover
2. Cover Bolts
3. Oil Level Dipstick Gauge

3. Remove four injection pump drive gear mounting bolts, remove gear (Figure 190).

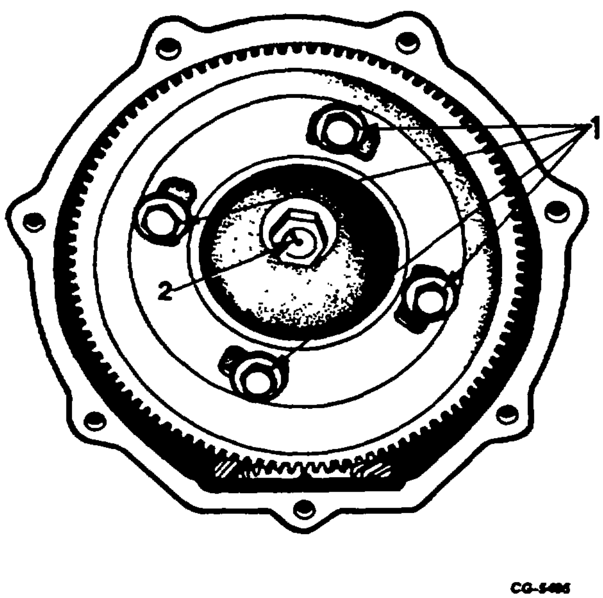


Figure 190. Removing Injection Pump Drive Gear

1. Injection Pump Drive Gear Mounting Bolts
2. Timing Mark

NOTE: The injection pump drive gear hub does not have to be removed at this time. It may be left on pump shaft until the pump is overhauled or set up for pump stand installation.

4. Remove injection pump drive gear hub retaining nut (Figure 191).

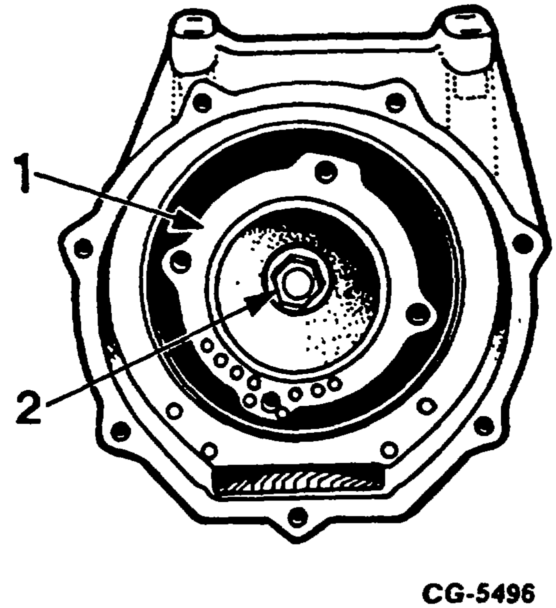


Figure 191. Removing Gear Hub Retaining Nut

1. Injection Pump Drive Gear Hub
2. Retaining Nut

5. Remove injection pump drive gear hub with puller SE-1368 (Figure 192).

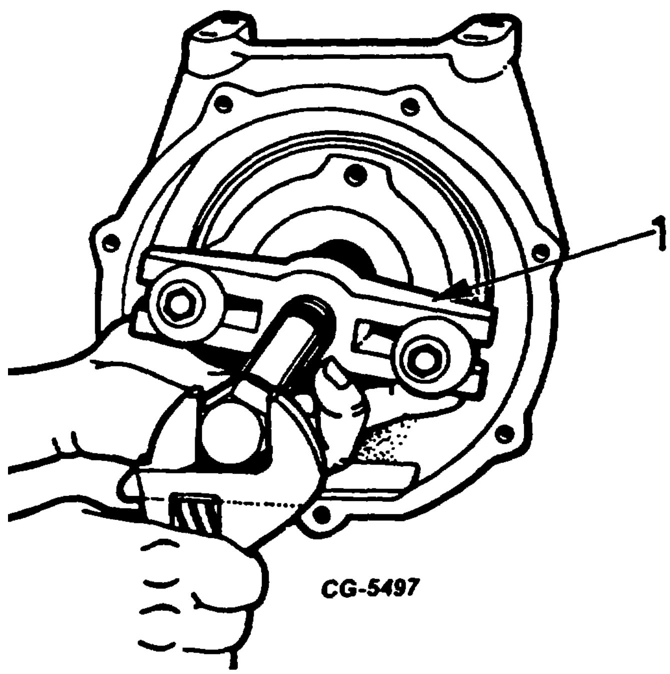


Figure 192. Removal of Gear Hub with Puller SE-1368

1. Puller SE-1368

6. Disconnect fuel injection lines from Injection pump and injection nozzles, remove lines (Figure 193).

IMPORTANT
WHEN REMOVING FUEL LINES, THE LINES SHOULD HAVE DUST SAPS INSTALLED OVER BOTH ENDS AS, WELL AS THE FITTINGS WHERE THE LINES WERE REMOVED. THIS PROCEDURE IS TO PROTECT AGAINST ENTRY OF FOREIGN MATTER IN THE FUEL SYSTEM. THE DUST CAPS COME IN VARIOUS SIZES AND CAN BE PROCURED LOCALLY.

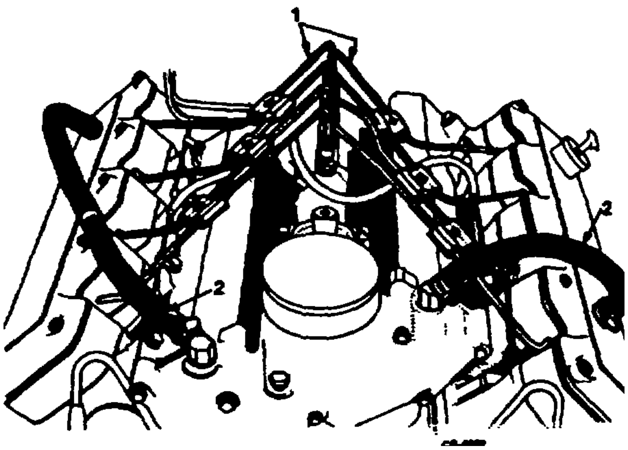


Figure 193. Removing Injection Lines and Ventilator Hoses

1. Fuel Injection Lines
2. Ventilator Hoses

7. Disconnect leak off return hose from leak-off manifold and injection pump valve, remove hose (Figure 194).

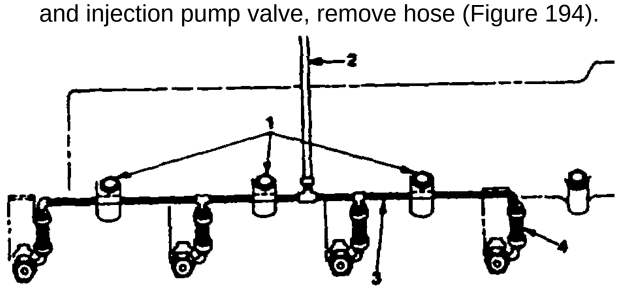


Figure 194. Removal of Leak-Off Manifold

1. Mounting Bolts
2. Leak-Off Hose
3. Nozzle Fuel Leak-Off Manifold with Support Clips
4. Nozzle Coupling Hoses

8. Remove leak-off manifold with support clips from intake manifold and disconnect from nozzle coupling hoses, remove leak off manifold (Figure 194).

9. Disconnect fuel supply line from transfer pump and remove (Figure 195).

10. Disconnect fuel line from transfer pump and fuel filter, remove line (Figure 195).

11. Disconnect fuel line from injection pump and primer pump, remove line (Figure 195).

12. Disconnect oil feed lines from tee fitting (line coming from oil filter base and oil feed line for air compressor or vacuum pump (Figure 195).

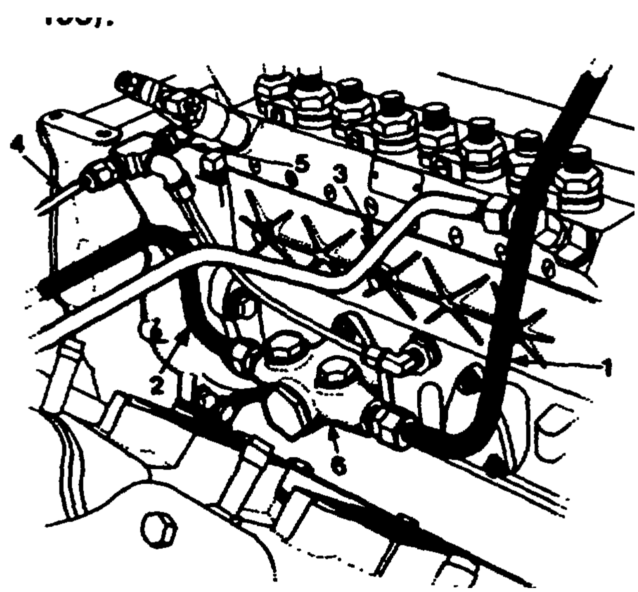


Figure 195. Removing Fuel and Oil Line From Injection Pump

1. Fuel Line From Primary Filter
2. Fuel Line to Final Filter
3. Fuel Line From Primer Pump
4. Oil Feed Line From Oil Filter Base
5. Oil Line to Air Compressor or Vac. Pump

13. Remove four injection pump adapter to engine front cover mounting bolts. Remove two support bracket bolts on right side of pump' and two mounting bracket nuts underneath injection pump, remove pump (Figure 196).

14. Remove two bolts from lower pump mounting bracket and remove bracket (Figure 196).

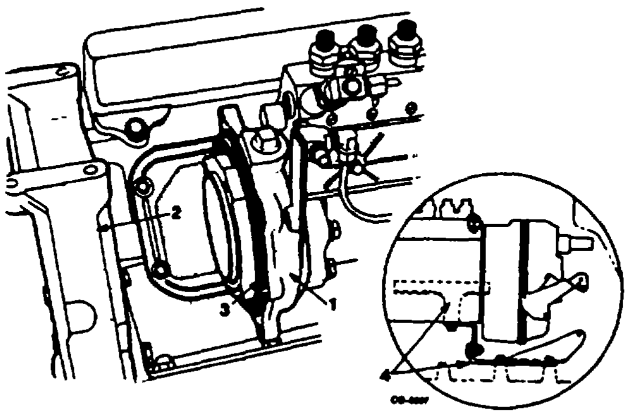


Figure 196. Removing Injection Pump

1. Injection Pump to Engine Front Cover Adapter
2. Engine Front Cover
3. Gasket
4. Injection Pump Mounting Bracket Locations

15. Remove injection nozzles by removing the nozzle hold-down bolt, flat washer and clamp, then with slide hammer remover tool SE-1746 equipped with adapter nut installed securely on nozzle, remove nozzle, washer, seal and gasket from cylinder head (Figure 197). Be careful not to strike nozzle tips against any hard surface during removal. Cover nozzle assembly fuel inlet and leak-off openings with plastic cap to prevent entry of dirt.

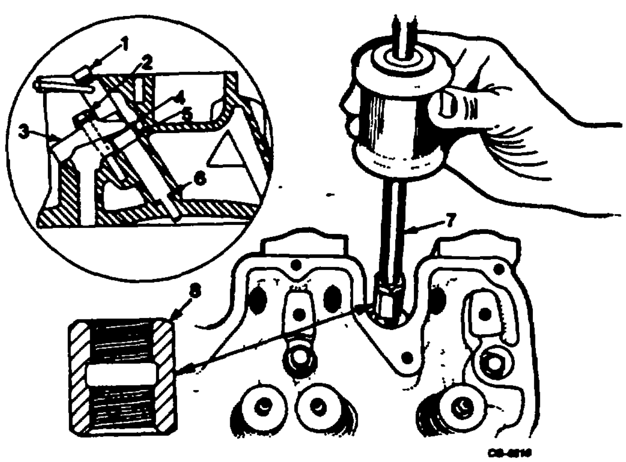


Figure 197. Removing Injection Nozzle

1. Nozzle
2. Hold-Down Bolt and Washer
3. Clamp
4. Washer
5. Seal
6. Gasket
7. Slide Hammer Remover SE-1746
8. Drill and Tap Nut (Part No. 1700462-Cl) to '½-13 UNC28 Thread

16. Place nozzle assemblies in a holding fixture (SE-2102) as they are removed from the heads. The fixture (Figure 198) is stamped with numbers corresponding to cylinder numbering of the engine. Use of this fixture permits replacing nozzles in their respective ports in the cylinder heads.

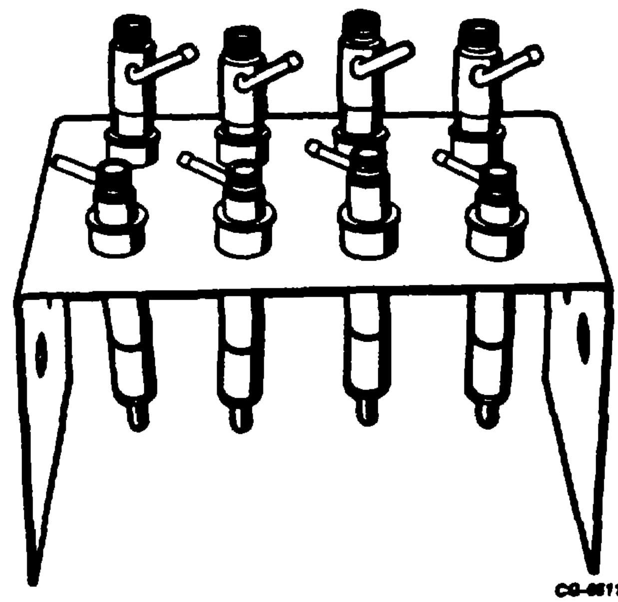


Figure 198. Nozzle Holding Fixture SE-2102

CLEANING, INSPECTION AND REPAIR

For detailed cleaning, inspection and repair of the R. Bosch fuel injection pump refer to CGES-220 Service Manual. For the nozzles refer to CGES- 225 Service Manual.

REASSEMBLY

1. Install injection nozzles as follows:

   a. Install injection nozzle washer, dirt seal and tip gasket on injector assembly. Use new gasket every time injector nozzles is removed.

   b. Install nozzle assembly carefully into its bore so that nozzle tip does not strike against recess: wall. (Leak-off tube to be positioned toward Intake manifold). Install clamp, mounting bolt and attach leak-off manifold.

2. Install injection pump mounting brackets to injection pump (Figure 196).

3. Position mounting gasket on injection pump adapter and mount injection pump to front engine cover.

IMPORTANT

USE ONLY 9.53 MM X 25.4 MM (3/8 X 1"). PATCH BOLTS FOR MOUNTING INJECTION PUMP TO FRONT ENGINE COVER.

4. Secure injection pump mounting brackets to crankcase (Figure 196).

5. If injection pump drive gear hub was removed during disassembly, it must be installed, and the pump timed.

   a. Install injection pump drive gear hub, by aligning keyway in hub with key on pump shaft, slide hub on shaft and install retaining nut.

   b. Remove sight plug on top of adapter. Rotate drive gear hub until scribed line on hub is aligned with pointer pin (Figure 199).

   c. Rotate engine until piston is at TDC of compression stroke and the engine timing pointer is aligned with the 16 degree mark on the crankshaft pulley. (Figure 199).

   d. Using care not to move drive gear hub, install drive gear on hub (Figure 190). Recheck hub scribed line and pointer pin alignment (Figure 199).

   The scribed line on injection pump camshaft should be at Eleven O'Clock as shown.

6. Attach Injection pump drive gear cover to engine front cover.

7. Connect primary filter output line to input side of transfer pump.

8. Connect fuel line to output side of transfer pump (line leading to primer pump).

9. Connect fuel line from final filter to injection pump.

10. Connect oil line from oil feed line tee to injec-

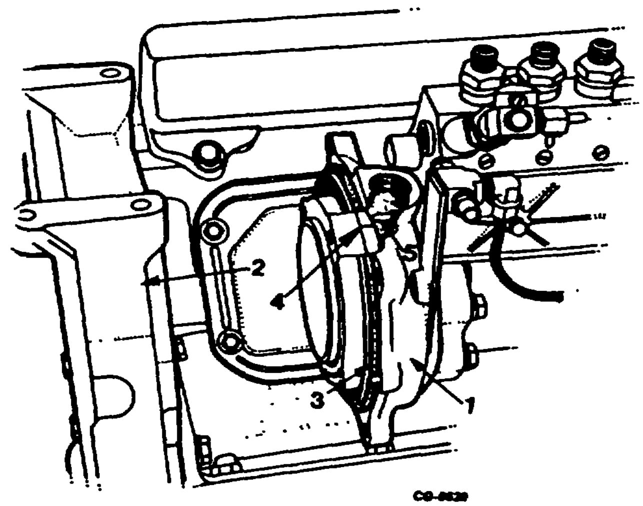


Figure 199. Timing Injection Pump to Engine

1. Injection Pump Adapter
2. Engine Front Cover
3. Gasket
4. Scribed Line On Hub
5. Pointer Pin

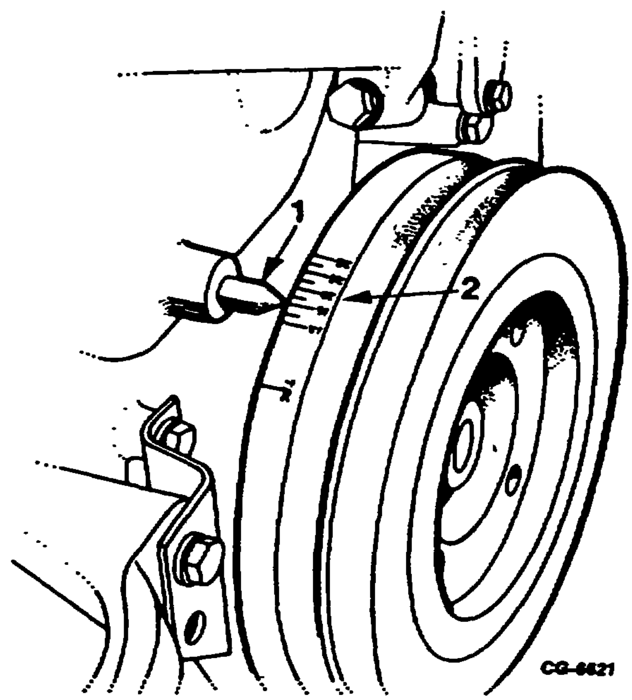


Figure 200. Engine Timing Marks and Pointer Location

1. Index Pointer
2. Timing Marks

FUEL INJECTION NOZZLES
FOR INTERNATIONAL
9.0 liter diesel engines

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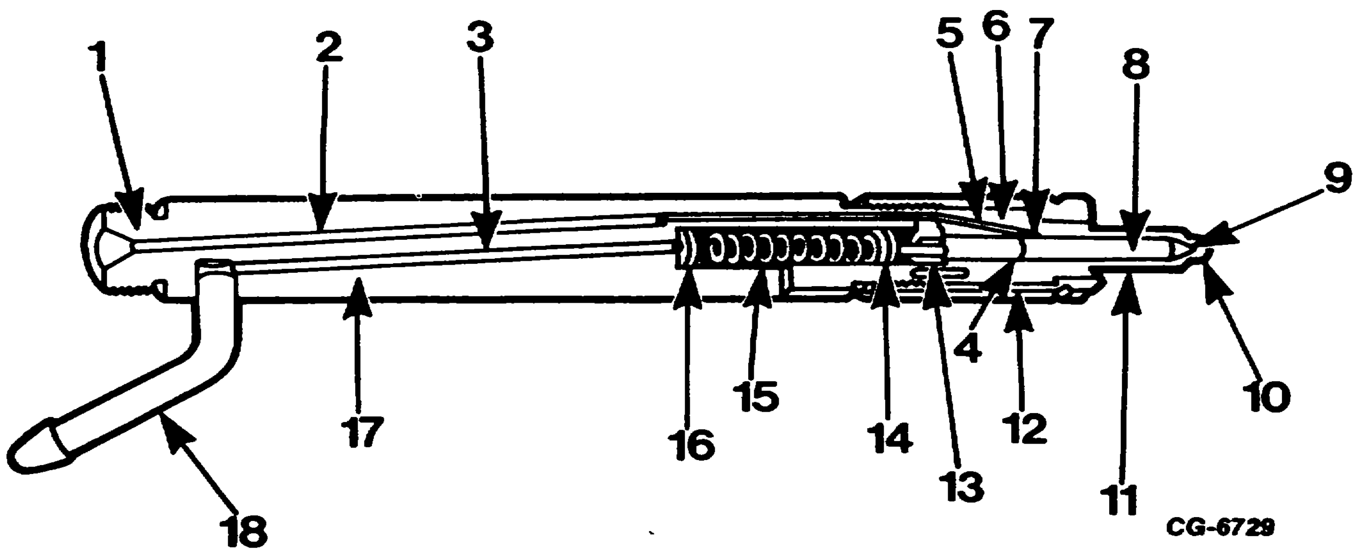


Fig. 1 Sectional View of Injection Nozzle Assembly

1. High Pressure Tubing Connection
2. High Pressure Fuel Duct
3. Low Pressure Leak-Off Duct
4. Differential Surface
5. Nozzle Fuel Duct
6. Nozzle Body
7. Pressure Chamber
8. Nozzle Valve
9. Nozzle Sac
10. Spray Holes (4)
11. Nozzle
12. Nozzle Cap Nut
13. Nozzle Spacer
14. Lower Spring Seat
15. Pressure Adjusting Spring
16. Pressure Adjusting Spacer
17. Nozzle Holder Body
18. Leak-Off Connecting

DESCRIPTION

The injection nozzles are of the inward opening, differential hydraulically operated, spray hole type. Their function is to direct a metered amount of fuel, under high pressure from the fuel injection pump, into the engine combustion chamber.

The injection nozzle assembly consists of two principal sub-assemblies, the nozzle and the nozzle holder. Fig. 1 illustrates a section view of the injection nozzle assembly.

Figure 2 shows an exploded view of the assembly.

Nozzle Holder

The nozzle holder is used to hold the nozzle in its correct position in the cylinder head and to provide channels for conducting fuel oil to the nozzle. The holder also contains the spring retainer (intermediate plate), spring and shims for adjusting the opening pressure of the nozzle valve. The lower end of the holder has an accurately ground and lapped surface which makes a leakproof and pressure-tight seal with the corresponding lapped surface at the upper end of the spring retainer (intermediate plate). The intermediate plate mates with the lapped surface of the upper end of the nozzle. The nozzle and intermediate plate are held in alignment by dowel pins and are secured to the nozzle holder by the nozzle retainer nut. The relationship of nozzle holder assembly components is shown in Fig. 1.

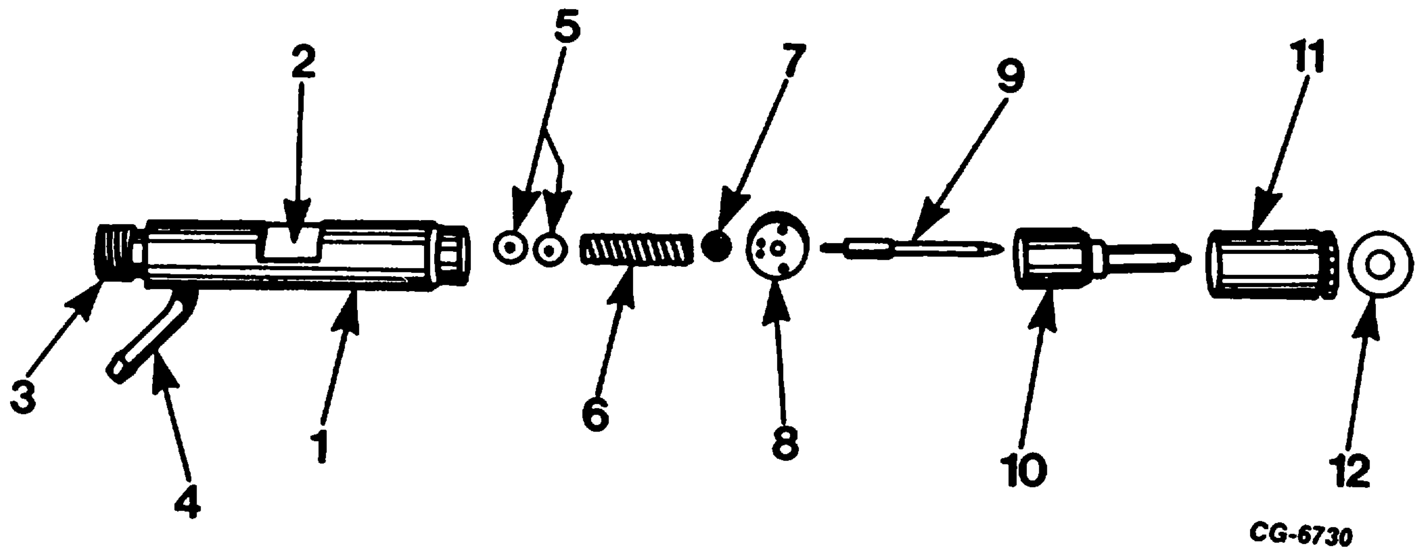


Fig. 2 Injection Nozzle Assembly Exploded View

1. Nozzle holder body
2. Mounting cutout
3. High pressure tubing connection
4. Leak-Off connection
5. Pressure adjusting 1pacrs
6. Pressure adjusting spring
7. Lower spring eat
8. Nozzle spacer
9. Nozzle valve
10. Nozzle
11. Nozzle cap nut
12. Gasket

OPERATION

Operation of the injection nozzle assembly is simple and positive. The metered quantity of fuel from the injection pump enters the nozzle holder through the inlet fitting and passes through connection ducts to the pressure chamber just above the nozzle valve seat. At the instant the pressure of fuel acting on the differential area of the valve exceeds a predetermined spring load, it lifts the valve from its seat and fuel flows from the nozzle until delivery from the injection pump ceases. Then a positive cut-off of fuel occurs as the valve is seated by the nozzle -spring. A certain amount of fuel seepage between lapped surfaces of nozzle valve and body-is necessary for lubrication. This leakage oil accumulates in the spring cavity and drains through to' the leak-off outlet provided for this purpose.

Nozzle

The nozzle, Fig. 3, consists of two parts; the nozzle body and the nozzle valve. These parts are lapped to form an extremely close-fitting matched set. (Body and valve cannot be exchanged singly but must be used together and replaced as an assembly.) The nozzle incorporates 4 spray holes (orifices) beneath the valve seat in the tip of the nozzle body. These spray holes are sized and located to provide a spray pattern of finely atomized fuel to produce the most efficient combustion and engine performance.

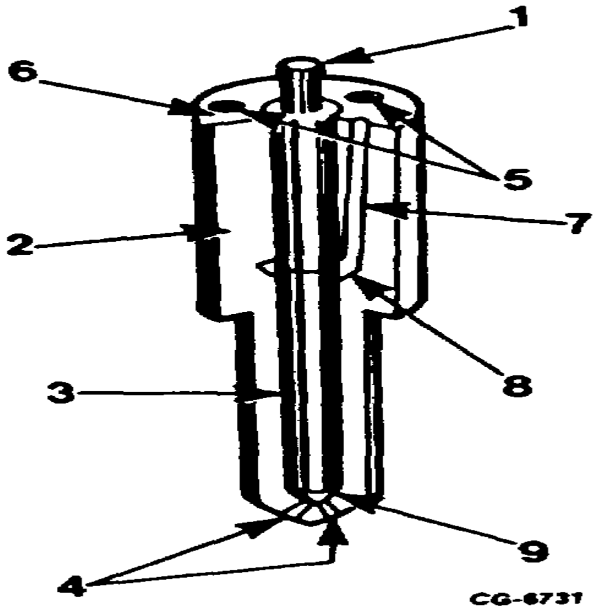


Fig. 3 Cut-Away View of Nozzle Valve And Body

1. Valve Stem
2. Nozzle Body
3. Valve
4. Spray Holes (4)
5. Dowel Holes
6. Lapped Face
7. Channel Duct
8. Pressure Chamber
9. Valve Seat

SERVICE INSTRUCTIONS

Where ideal conditions of good combustion, specified engine temperature control and absolutely clean fuel prevail, nozzles require little attention.

Nozzle trouble is usually indicated by one or more of the following symptoms:

1. Smoky exhaust (black)
2. Loss of power
3. Misfiring
4. Increased fuel consumption
5. Combustion knock
6. Engine overheating

While the above faults may be caused by defective nozzles, they may also be caused by other engine troubles such as wrong fuel, water in fuel, dirty or damaged filters, incorrect maximum fuel setting, faulty injection pump, defective engine lubrication, incorrect pump timing, or faulty engine valves.

Where faulty nozzle operation is suspected on an engine that is misfiring or puffing black smoke, a simple test can be made to determine which cylinder is causing the difficulty.

With the engine running at a speed that makes the defect most pronounced, momentarily loosen the high pressure fuel inlet connection on one nozzle assembly sufficiently to "cut out" the cylinder. Check each cylinder in the same manner. If one is found where loosening makes no difference in the irregular operation or causes puffing of black smoke to cease, the injection nozzle, for that cylinder should be tested.

Nozzle testing, disassembly, cleaning and reconditioning must be done only by an authorized IH Service Station or other diesel service outlet equipped and qualified to perform such services.

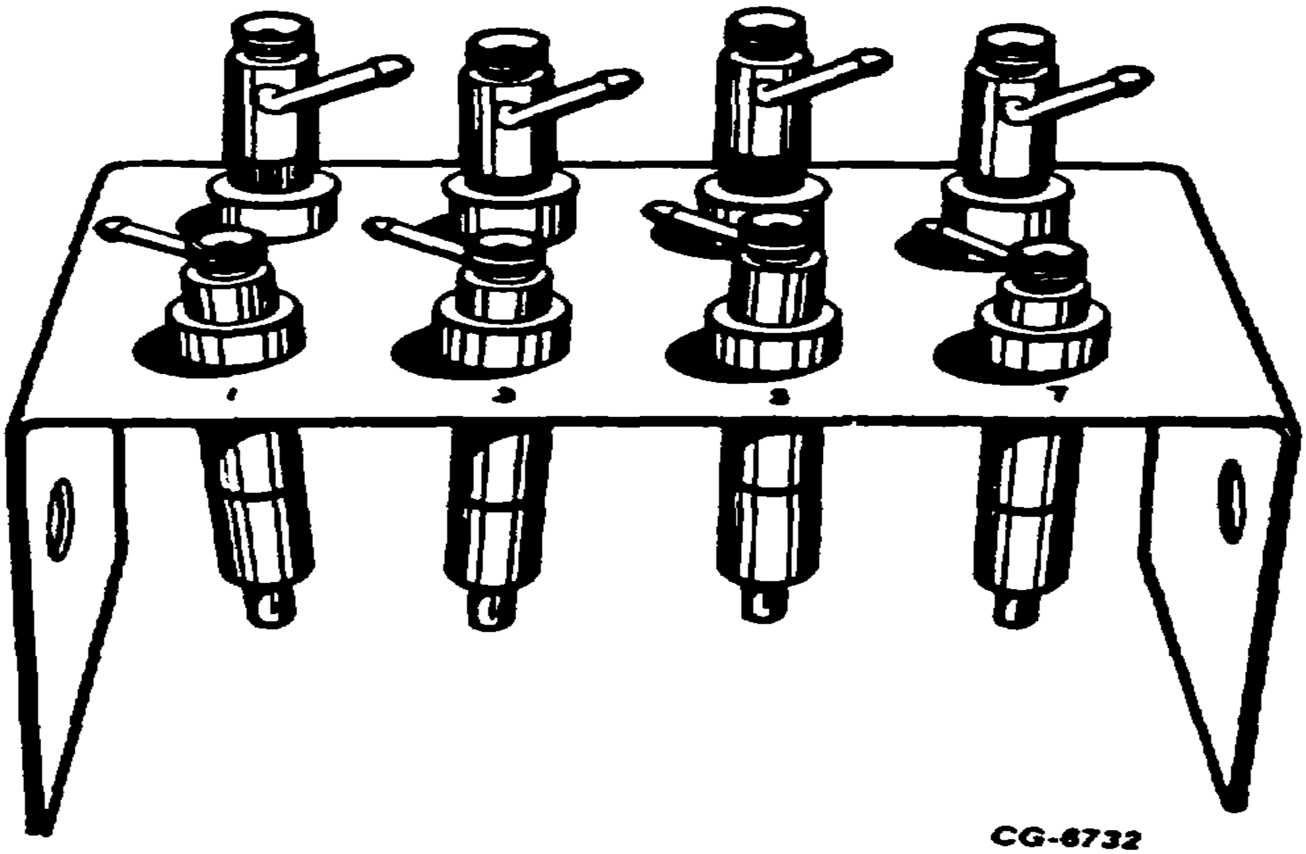


Fig. 4 Nozzle Holding Fixture SE-2102

When servicing injection nozzle assemblies, the necessity of cleanliness cannot be over-emphasized. A clean work-bench, clean washing fluid containers, clean tools and clean hands are all essential to produce satisfactory results.

Removal

1. Before removing nozzle assemblies, clean exterior of each nozzle assembly and the surrounding area with clean fuel oil or solvent to prevent entry of dirt into engine when nozzle assemblies are removed. Also, clean fuel inlet and fuel leak-off piping connections.

2. Disconnect fuel inlet (high pressure) and fuel-leak-off pipes from each nozzle assembly. Cover open ends of pipes to prevent entry of dirt.

3. Remove nozzle mounting bolt and hold down clamp. Pull nozzle assembly with washer and seal from engine. If assembly seems stuck, rotate it slightly to break it loose from carbon deposits in the cylinder head recess. Be careful not to strike the nozzle tip against any hard surface during removal.

   Cover nozzle assembly fuel inlet and leak-off openings with plastic caps to prevent entry of dirt. Also protect nozzle tip.

4. Place nozzle assemblies in a holding fixture SE-2102 as they are removed from the heads, Fig. 4. The fixture is stamped with numbers corresponding to the cylinder numbering of the engine. Use of this fixture permits replacing nozzles in their respective ports in the cylinder heads.

Operation Test

After removal from the engine, the nozzles should be tested for proper operation on a nozzle test pump. This test will give valuable information about the condition of the nozzles and indicate where service is required. Fig. 5 shows an injection nozzle mounted for testing on the SE2002 Hydraulic Test Pump. The nozzle test procedure is outlined below.

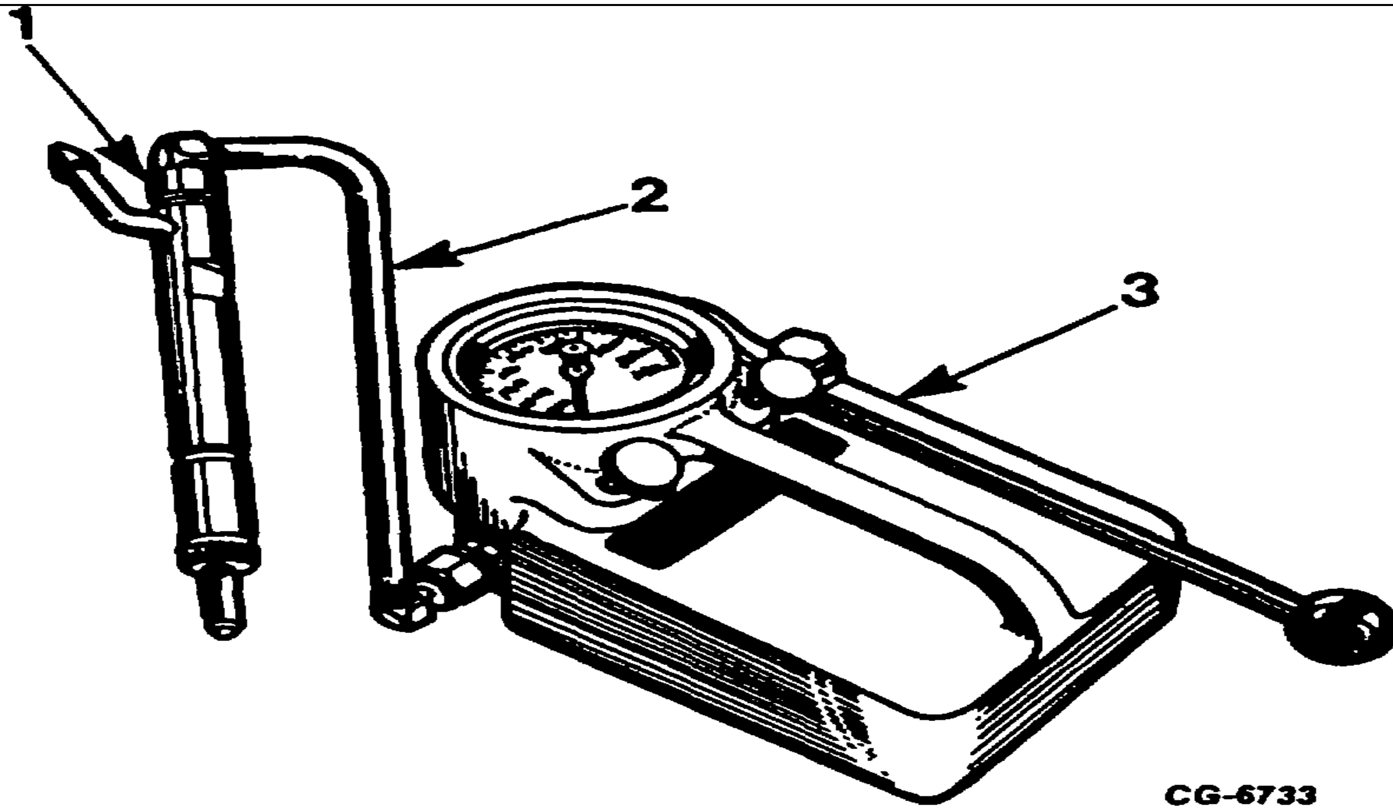


Fig. 5 Nozzle Assembly Mounted in Test Pump

1. Nut SE-20043
2. Rigid Connection SE-200413
3. Hydraulic Test Pump SE-2002

1. Prepare pump for making tests. Fill pump reservoir with clean No. 2 diesel fuel. Open pump valve slightly and operate pump handle to expel air from pump and outlet pipe. Operate pump until solid fuel (without air bubbles) flows from end of outlet pipe. Close pump valve.

2. Connect injection nozzle to test Pump. Care should be taken to avoid "cross-threading". Tighten connector nut securely with end wrench.

3. Bleed air from nozzle. Open pump valve and operate pump for several quick strokes to expel (bleed) air from injection nozzle. Fuel should spray from the spray holes in nozzle tip.

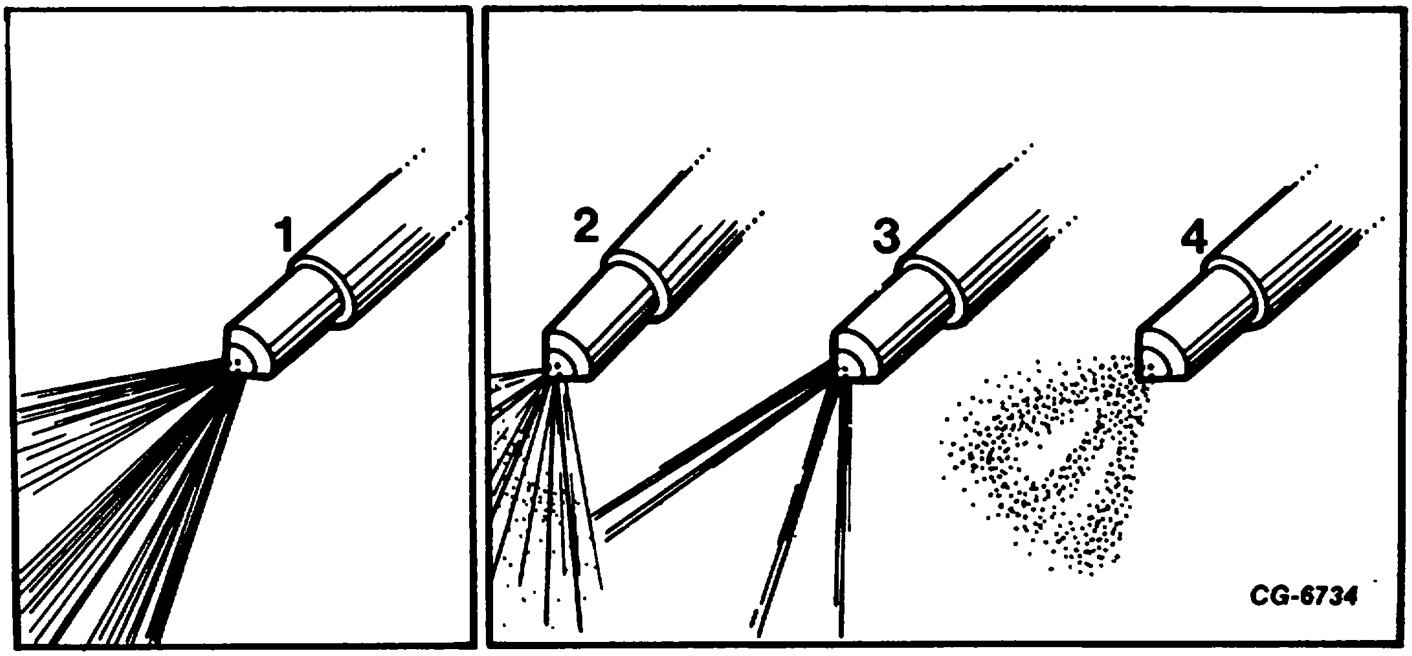
   CAUTION: Keep hands away from nozzle spray. Fuel spraying from the nozzle under high pressure can penetrate the skin and cause infection.

4. Check spray pattern. Operate test pump in smooth, even strokes and observe pattern of fuel spraying from nozzle tip spray holes. The spray should be finely atomized in an even pattern, free from irregular streaks and dribbling. Examples of good and bad spray patterns are shown in Fig. 6.

5. Check nozzle opening pressure. Open gauge valve, build up line pressure by slowly depressing handle until nozzle opens (sprays fuel). Observe gauge to determine pressure at which nozzle opens, then repeat operation until accurate opening pressure is established. (See Specifications).

6. Check for tip leakage. Wipe nozzle tip dry. Operate test pump to maintain pressure at-about 100 psi below opening pressure. Nozzle tip should remain dry without an accumulation of fuel drops at spray holes. A slight wetting after about 5 seconds is permissible if no droplets are formed.

7. Check fuel leak-off. Operate test pump in quick strokes and observe for flow of fuel from leak-off part of nozzle. A very slight leak-off is normal. If an excessive amount of fuel is expelled or if fuel surges from leak-off port when test pump is operated, nozzle is faulty.



Good nozzle spray pattern - Fig. 6 -- nozzle spray patterns

1. Fine Even Mist
2. Uneven or Off Side
3. Solid Stream
4. Uneven Cut-Off, Dribble

If nozzle passes above tests, it is suitable for further service in the engine following external cleaning and removal of accumulated carbon. Nozzles showing irregular spray pattern, leak- age at nozzle tip spray holes, excessive fuel leak-off or opening pressure below minimum permissible limit should be replaced or serviced (disassembled, cleaned and rebuilt).

Disassembly

Disassembly of the nozzle holder assembly for cleaning, inspection and service can be accomplished as follows:

1. Wash all external dirt, grease and carbon deposits from holder assembly with a suitable cleaning agent.

2. Remove nozzle gasket from nozzle.

3. A brass wire hand brush should be used to remove hardened deposits of dirt or carbon. DO NOT allow wire brush to come into contact with nozzle spray holes.

IMPORTANT: Soak nozzle holder assembly in a carbon removing cleaning agent ("GUNK", "BENDIX CLEANER", or equivalent) for at least 4 hours before removing nozzle cap nut; otherwise, the nozzle locating pins may be damaged.

4. Special tools SE-2'52 and SE-2753 are required when disassembling a nozzle holder assembly. Otherwise, the nozzle locating pins may be damaged (See Figure 7).

5. Injector nozzle holding fixture should be attached to a work bench to prevent fixture from moving.

6. Engage a 9/32" 12 point box wrench to nozzle cap nut.

7. Install nozzle holder assembly with wrench into nozzle holding fixture. With clamping plate in place, tighten clamping bolt until it touches nozzle tip. Then torque clamping bolt to 24-30 N·m (18-22 ft lbs). (Figure 8).

8. Loosen cap nut with box wrench until nut can be turned by hand.

NOTE: A sharp blow to end of wrench may be required to break carbon bond between nozzle and cap nut.

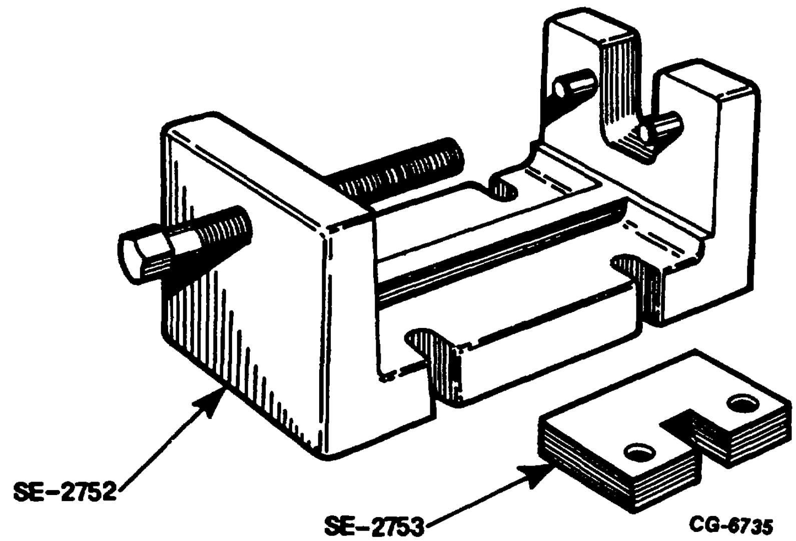


Figure 7. SE-2752 Injector Nozzle Holding Fixture

1. SE-2752
2. SE-2753

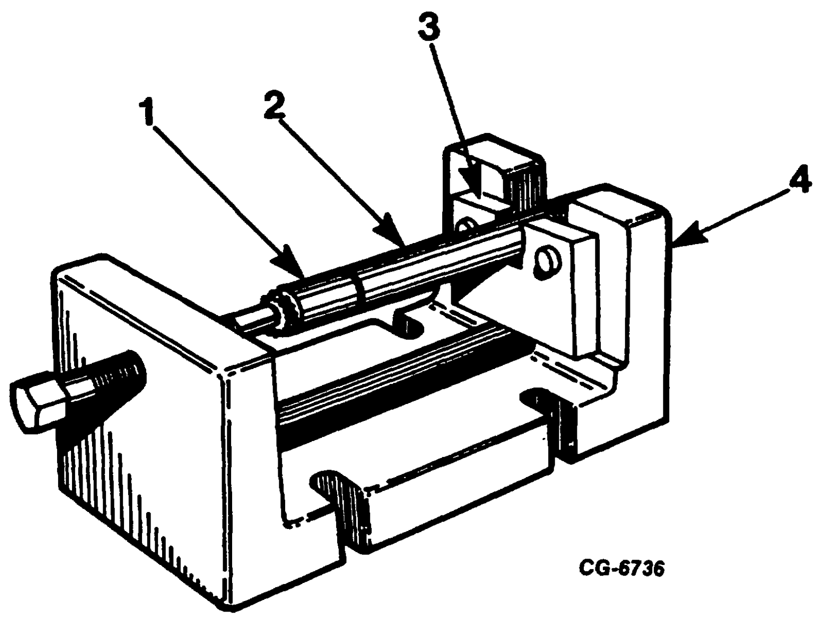


Figure 8. Holding fixture and clamping plate with nozzle installed.

1. Cap
2. Injector Holder
3. SE-2753
4. SE-2752

9. Loosen clamping bolt and remove nozzle holder assembly from holding fixture.

10. Remove cap nut, nozzle spacer and nozzle from holder body.

11. Remove spring seat, spring and spacers from holder body. (See Figure 2)

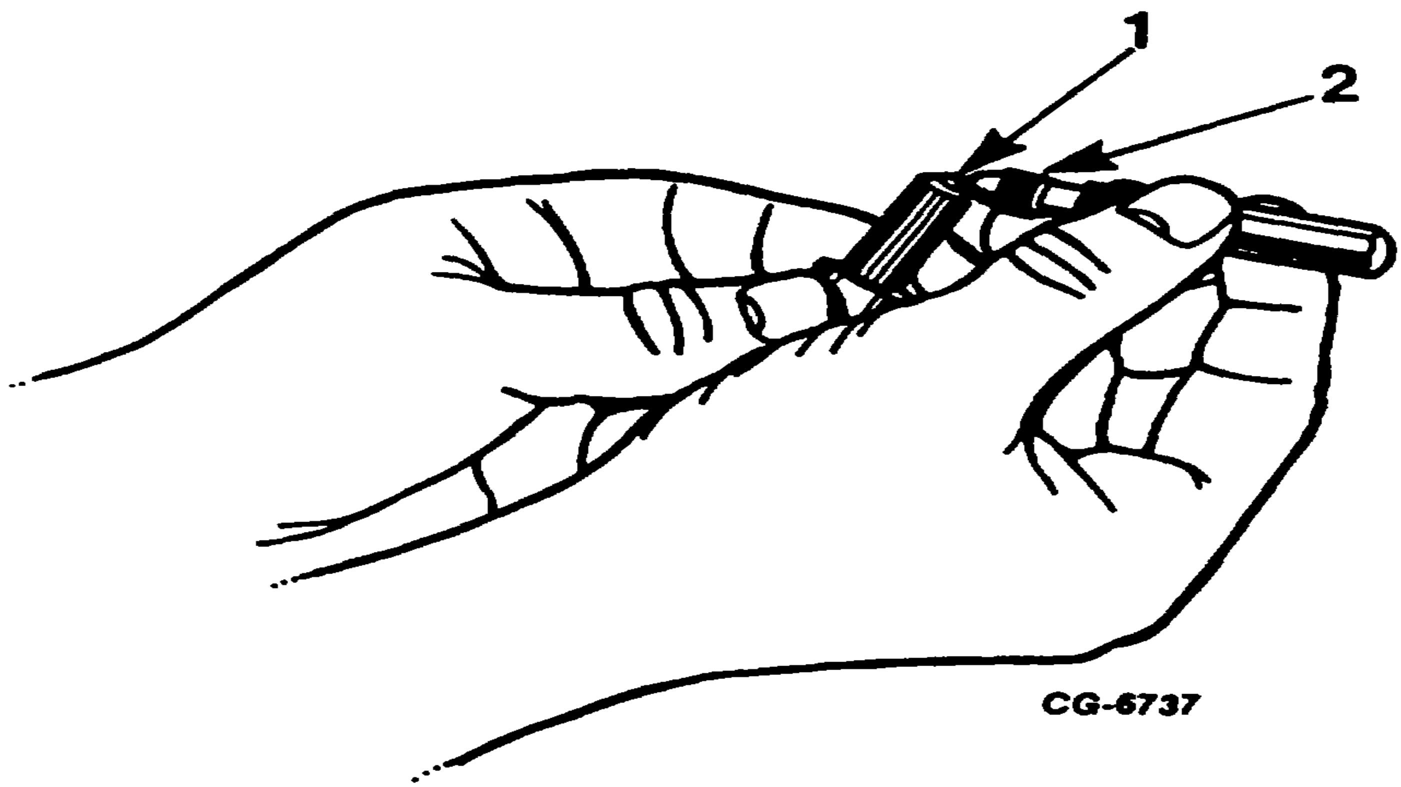


Fig. 9 Cleaning Spray Holes

1. Spray Hole
2. Pin Vise and Cleaning Needle

Cleaning and Inspection

All parts of the nozzle assembly should be thoroughly cleaned and inspected. Any parts showing damage or excessive wear should be replaced.

Special tools for performing nozzle cleaning operations are contained in SE2202 Nozzle Cleaning Set. Hard or sharp tools, emery cloth, crocus cloth, grinding compounds or abrasives of any kind should <u>never</u> be used in the cleaning of nozzles.

1. Wash all parts in Varsol or an equivalent cleaning agent.

   CAUTION: DO NOT inter-mix nozzle valves. Keep each valve with its original nozzle body.

2. Soak nozzle in a varnish removing cleaning agent.
3. Probe all nozzle spray holes with cleaning needle. .25mm(.011") diameter needle should be used and is part of special tools kit SE-2002.
4. Clean all ducts and nozzle spray holes with compressed air.
5. Thoroughly clean interior of nozzle cap nut. All carbon de- posits must be removed (soak to loosen - wire brush to clean).

Reassembly

After cleaning and parts replacement, assemble nozzle holder assemblies as follows:

1. Dip all parts in clean calibrating or lube oil.
2. Insert adjusting spring and spring seat into spring line.
3. Align nozzle spacer locating pins with pin holes in holder body and assemble spacer to body.

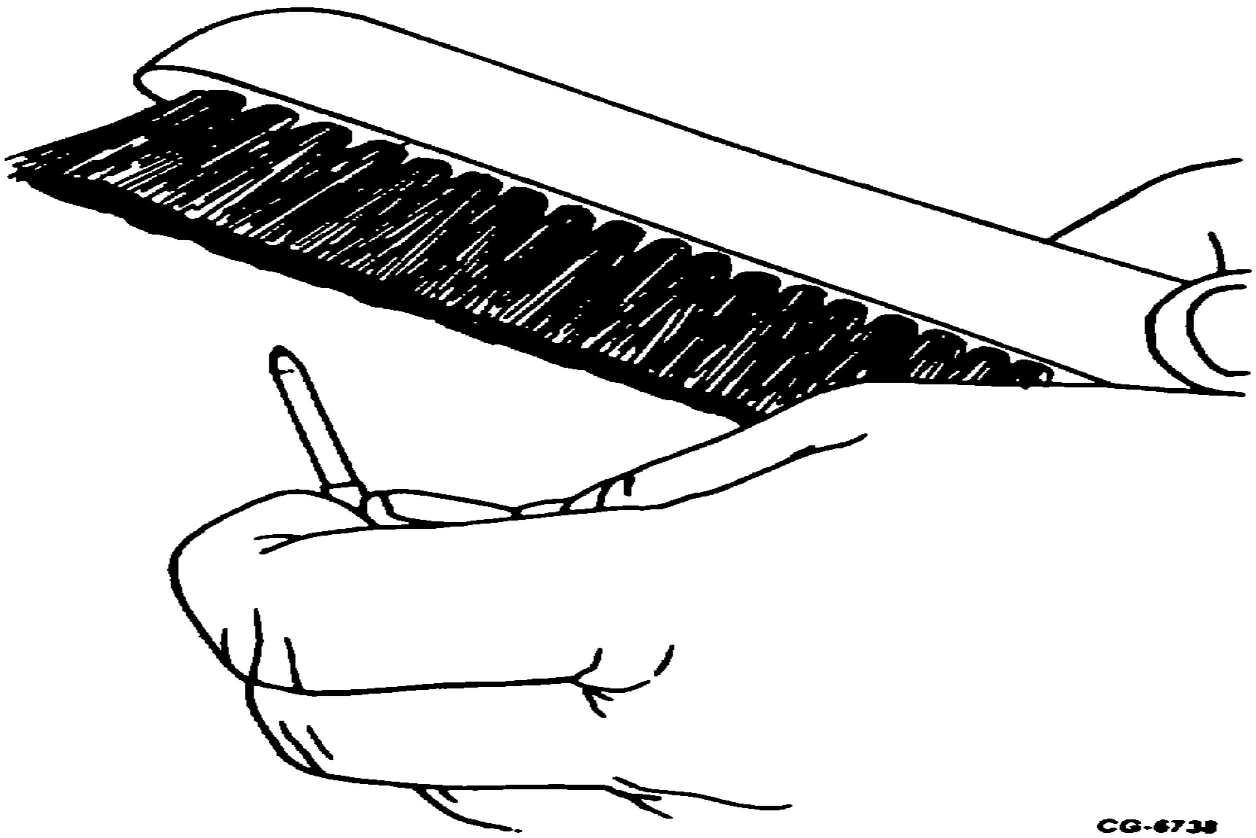


Fig. 10 Cleaning Nozzle Valve

4. Dip nozzle valve in clean calibrating or lube oil. Assemble valve into nozzle body and move valve up and down several times to make certain that valve does not stick.

5. Apply a thin, even coat of "Lubri-plate 130 AAA", or equivalent, to the nozzle body seating shoulder, align nozzle body locating pin holes with spacer pins and assemble nozzle to spacer.

6. Assemble cap nut over nozzle and tighten cap nut by hand.

7. Install nozzle holder assembly with box wrench on cap nut into holder fixture. (Figure 8)

8. Tighten cap nut to proper torque (see specifications).

9. Mount nozzle holder assembly in nozzle test pump and check nozzle operation. (See "Nozzle Operating Test").

10. If nozzle opening pressure is not within limits specified for new or rebuilt nozzles (See 'Specifications") adjust by adding or removing adjusting shims at top end of springs. Be sure hardened wear shim (darkest in color) is placed next to spring.

Check for leakage between lapped surfaces of nozzle body, intermediate plate and nozzle holder body. Leakage may be either internal or external. External leakage is visible at nozzle retainer nut, and internal leakage is visible at leak off outlet. Do not attempt to cover leakage by overtightening nozzle retainer nut. Remove nozzle and re-examine pressure faces for dirt or burrs on surface. Clean and retest.

Check spray pattern (Fig. 6). Fuel should be finely atomized and free .from streaks. If spray pattern is faulty check for dirty or damaged spray holes.

11. Cover fuel inlet and leak-off openings and protect nozzle tip.

Installation

1. Thoroughly clean nozzle bore in cylinder head before reinserting nozzle holder assembly. Pay particular attention to seating surfaces, in order that no small particles or carbon will cause assembly to be cocked or permit blow-by of combustion gases. Don't use hard or sharp tools for cleaning. A round piece of brass properly shaped or a round steel bristle brush is permitted if used with care.

2. Install a new seal and a new gasket on nozzle holder assembly.

   NOTE: Use new seal and gasket each time nozzle is installed.

3. Install nozzle holder assembly into cylinder head nozzle bore. Be careful that nozzle tip does not strike against recess wall.

4. Install clamp, bolt, flat washer, and crab washer. Tighten bolt to specified torque. (See Specifications)

5. Remove protective covers from nozzle holder parts and fuel pipes. Connect high pressure fuel inlet and leak-off pipes to nozzle holder.

6. Purge high pressure fuel pipes of air by loosening connector and cranking engine until solid fuel, free from air, flows from connection. Tighten connection.

7. Start engine and check for fuel leakage at high pressure connections.

INJECTION NOZZLE
TROUBLE SHOOTING GUIDE

FAULT	POSSIBLE CAUSE	REMEDY
Nozzle Blueing.	1. Faulty installing or tightening.	Replace nozzle.
	2. Insufficient cooling.	Correct cooling system
Spray pattern distorted.	1. Carbon deposit on tip of nozzle valve.	Clean nozzle.
	2. Nozzle holes partially blocked.	Clean nozzle.
	3. Defective nozzle.	Replace nozzle.
Nozzle opening pressure too high.	1. Incorrect shim adjustment	Readjust nozzle.
	2. Nozzle valve dirty or sticky or opening is clogged.	Clean nozzle.
	3. Seized nozzle.	Replace nozzle.
Nozzle opening pressure too low.	1. Incorrect shim adjustment.	Readjust nozzle.
	2. Nozzle valve spring broken.	Replace spring and readjust pressure.
	3. Nozzle seat worn.	Install new or reconditioned nozzle.
Nozzle drip.	1. Nozzle leaks because of carbon deposit or sticking nozzle valve.	Clean nozzle.
	2. Defective nozzle.	Replace nozzle.
Excessive leak-off.	1. Dirt between pressure face of nozzle, spring retainer or plate and nozzle holder.	Clean nozzle.
	2. Loose nozzle retainer nut.	Inspect lapped faces and tighten retainer nut.
	3. Defective nozzle.	Replace nozzle.

SPECIFICATIONS

Nozzle Holder Assembly:	
IH Part Number	489116C92
Manufacturer's Number	NHA 7817 1/1
Engine Model	9.0 liter
Nozzle Valve Seat Angle (Degrees)	60
Nozzle Spray Holes:	
Number of Holes	4
Hole Diameter:	0.29 mm
Nozzle Opening Pressure: (psi.)	
New or Rebuilt	3150 $\pm$ 75
Minimum Permissible (Used)	2750
Permissible Leakdown	See Text (1)
Nozzle Cap Nut Torque (lb. ft.)	40-48 Nm (30-35 Ft. lbs)
Nozzle Holder-to-Engine Mounting Bolt Torque (lb. ft.)	18 - 22 lb. ft

(1) Refer to "Nozzle Operation Test".

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TO THE OWNER

This Service Manual is published to assist the reader in overhaul of the Robert Bosch fuel injection pump for the IH 9.0 Liter Diesel Engine. The manual is divided into six sections which are:

Section and page numbers appear in the upper outside comer of each page for easy reference.

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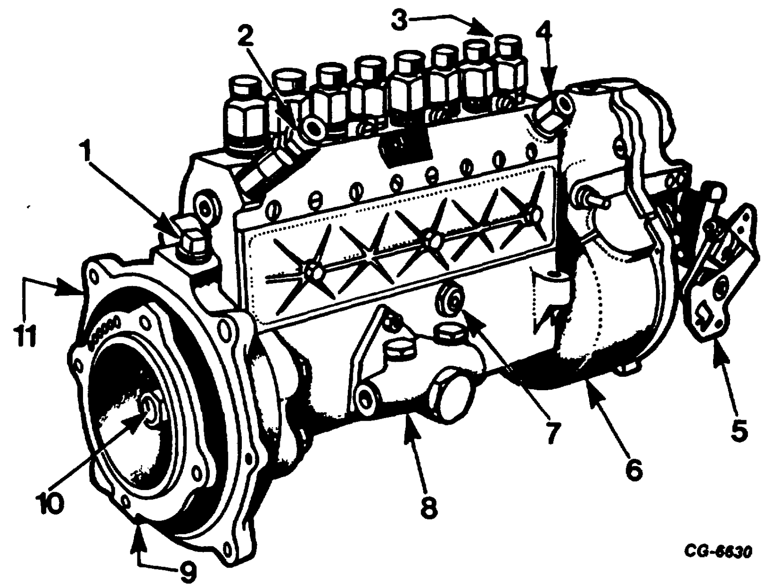

Figure 1. Left Side View of Injection Pump

1. Timing Sight Plug
2. Pressure Regulator Valve
3. Delivery Valve Holder
4. Fuel Inlet
5. Control Lever
6. Governor Housing
7. Lube Oil Inlet
8. Transfer Pump
9. Drive Hub
10. Timing Mark on Camshaft
11. Adapter Housing

DESCRIPTION

The Robert Bosch Model PES 8A95 Fuel Injection Pump is used on the International 9.0 liter diesel engine.

The injection pump is an in-line, single action plunger type, with individual plunger and barrel pumping elements for each engine cylinder. The injection sequence is 1, 8, 7, 3, 6, 5, 4, 2.

A snubber valve is staked in the upper part of each delivery valve holder and maintains residual pressure in the injection lines between pumping cycles. (Note California-emission pumps do not have a snubber valve.).

The injection pump assembly incorporates an integral mechanical flyweight type RQV all speed governor.

The pump control levers, including the lo-idle and hi-idle adjusting stop screws, are mounted on the left side of the governor assembly. The fuel shutoff lever and stop bracket are located on the right side of the governor.

The injection pump is located between the cylinder heads and intake manifolds at the top of the engine. High pressure lines connect the injection pump to the fuel injection nozzles.

Operating and service instructions for the fuel injection nozzles are given in Nozzle Service Manual CGES-225. Removal of the injection pump from the engine is detailed in Engine Service Manual CGES-2051.

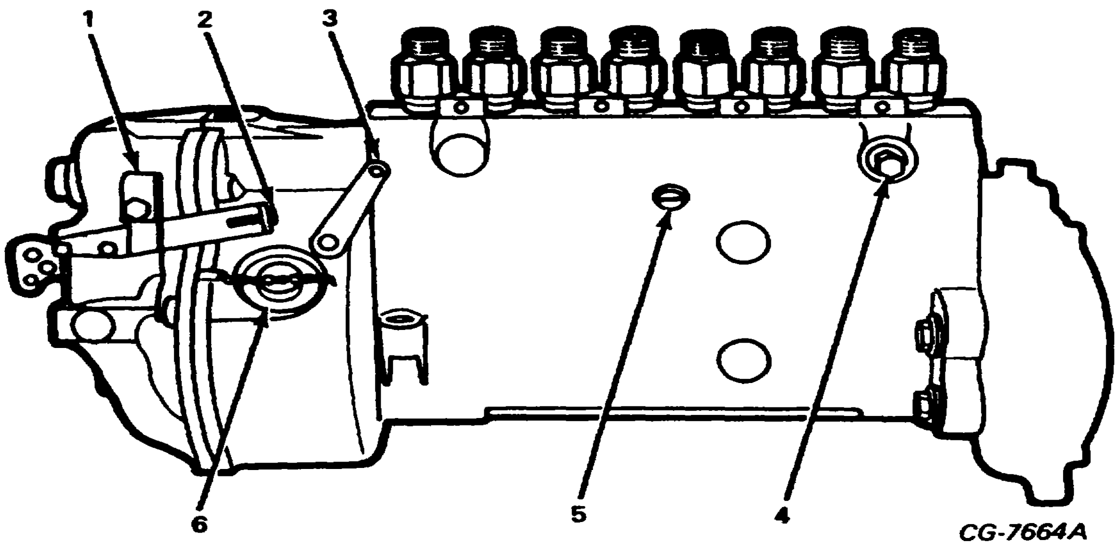

Figure 2. Right Side View of Injection Pump

1. Bracket, Shut-Off Cable
2. Stop, Shut-Off Lever
3. Shut-Off Lever
4. Bleeder Valve
5. Rack Position Screw
6. Governor Adjusting Plug

IDENTIFICATION

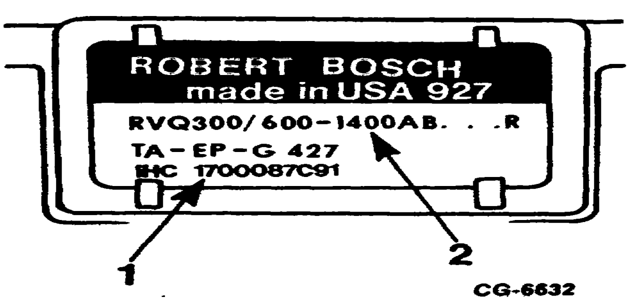

Figure 3. IH Part Number Plate (On Rear of Governor Housing)

1. IH Part Number
2. Governor Number, Size and Rating

Identification of injection pump and governor assemblies can be made by referring to name plates found on the injection pump - one on rear of governor housing and one on left side of injection pump housing. The nameplate on rear of governor (Figure 3) gives the IH part number of the complete pump and governor assembly and governor number, size and rating. The nameplate on side of the pump housing (Figure 4) gives tie serial number, model code and manufacturer's part number.

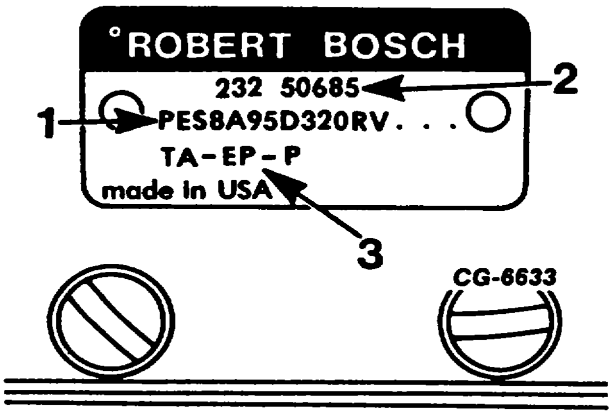

Figure 4. Injection Pump Serial Number Plate (On Left Side of Injection Pump)

1. Model Number
2. Serial Number
3. Robert Bosch Part Number

OPERATING PRINCIPLES

Injection Pump

The injection pump is the in-line, single action plunger type with individual plunger and barrel pumping elements for each engine cylinder. Pump plunger stroke is constant but effective pumping (metering) stroke is variable and controlled by position of a common plunger control rack operated by the governor and the vehicle accelerator pedal.

The individual plunger and barrel pumping elements (Figure 5) receive fuel under transfer pump pressure from the injection pump housing fuel gallery and force it under very high pressure through the injection nozzles into the engine combustion chambers.

The injection pump plungers are operated through tappet assemblies driven by the injection pump camshaft. The camshaft is timed to the engine to inject fuel into each cylinder at the proper time.

Each pumping element has a delivery valve above the plunger. The delivery valve which is held on its seat by spring pressure prevents fuel from draining out of the high pressure fuel line between pumping cycles.

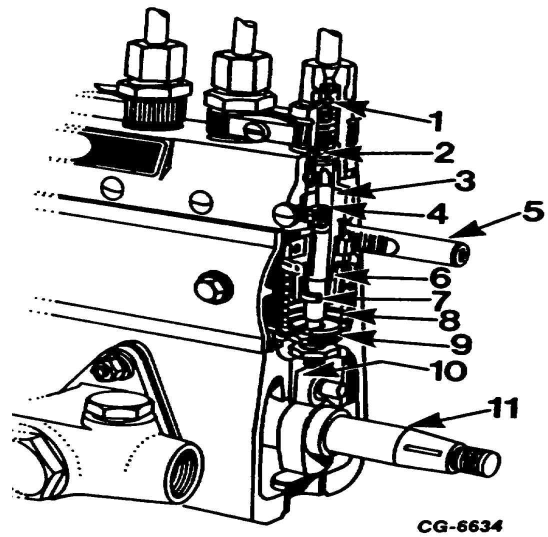

Figure 5. Sectional View of Plunger and Barrel Pumping Element

1. Snubber Valve
2. Delivery Valve
3. Barrel
4. Plunger
5. Control Rack
6. Control Sleeve
7. Plunger Vane
8. Plunger Spring
9. Spring Plate
10. Roller Tappet
11. Camshaft

Each delivery valve holder has a snubber valve assembly staked in the upper part (Figures 5 and 6). On the end of the pumping cycle the snubber orifice valve is closed by spring pressure. Fuel drains, through the orifice in the valve, into the cavity above the delivery valve and controls the residual pressure in the high pressure fuel line between pumping cycles.

The injection cycle can be described by observing the plunger in its four principal positions in the barrel. The four positions (shown in Figure 7) are:

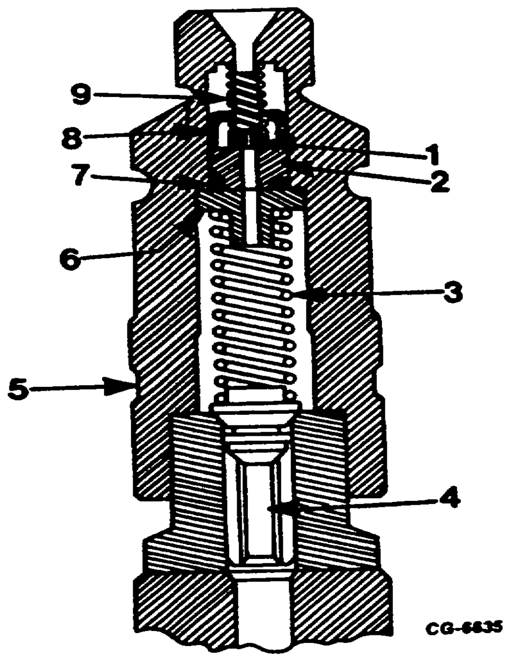

Figure 6. Sectional View of Snubber and Delivery Valve

1. Orifice Valve (if equipped).
2. Orifice Seat
3. Spring
4. Delivery Valve
5. Delivery Valve Holder
6. Spring Seat
7. Fill Washer
8. Spring Cap
9. Spring

Bottom Dead Center (BDC)

At bottom dead center plunger is held down on lowest point of cam lobe by plunger spring. Top of plunger is below barrel charging/high pressure spill port. Fuel at transfer pump pressure flows through from injection pump housing fuel gallery through the barrel charging/high pressure spill port to fill area above plunger.

Start of Injection (Start Inj.)

Injection begins when the rising plunger covers the charging/high pressure spill port and fuel is trapped above the plunger.

Injection (Inj.)

As plunger continues upward with charging ports covered, fuel above plunger is forced upward under high pressure, unseats delivery valve, unseats snubber valve, flows to nozzle, opens nozzle valve and is injected into the cylinder.

End of Injection (End Inj.)

When plunger moves up to the point where charging/high pressure spill port is again uncovered fuel pressure above plunger is relieved to the charging gallery. This pressure drop allows delivery valve, snubber valve, and injection nozzle valve to seat thus ending injection of fuel into cylinder.

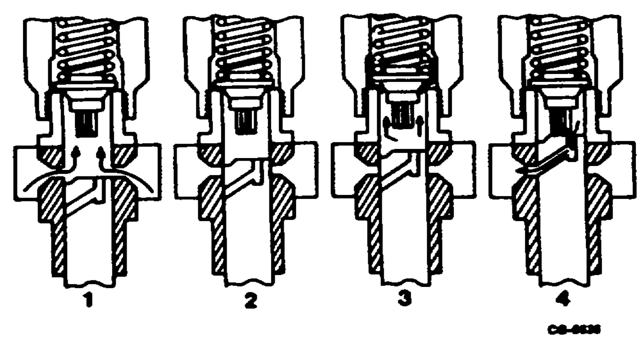

Figure 7. Four Principal Plunger Positions of Injection Cycle

1. Bottom Dead Center
2. Start of Injection (Port Closure)
3. Injection
4. End of injection

Metering (providing proper amount of fuel to meet engine requirements at various speeds and loads) is accomplished by rotating plungers in barrels to change the effective pumping stroke. The effective stroke is the distance traveled up- ward by the plunger from the time the charging port is covered until it is again uncovered. A short effective stoke means a small amount of fuel is injected. As effective stroke increases, amount of fuel injected increases

The metering function can be described by observing the relationships of plunger helix to barrel charging port under various metering positions as shown in Figure 9.

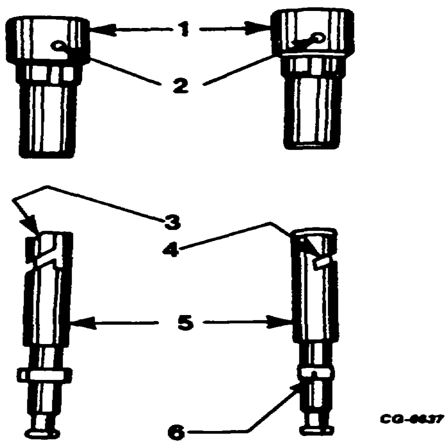

Figure 8. Details of Injection Pump Plunger and Barrel

1. Barrel
2. Charging Port
3. Upper Helix (early pumps only)
4. Lower Helix
5. Plunger
6. Installation Mark

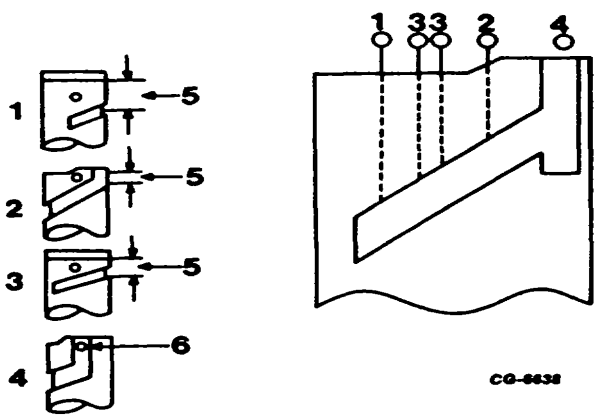

Figure 9. Helix and Charging Port Metering Positions

1. Start Position (Charging Port Closed)
2. Idle Position (Charging Port Closed)
3. Full Load Position (Charging Port Closed
4. Stop Position (Charging Port Open)
5. Effective Stroke

6. Charging Port Position

Starting (Excess Fuel)

For starting, plunger is rotated by control rack (accelerator pedal fully depressed) to a point where the maximum effective stroke (port closing to port opening) is obtained.

When engine starts, release accelerator pedal. This rotates plunger out of start fuel position to de crease fuel delivery.

Engine Operating (Metered Delivery)

At engine operating speeds from idle through maximum governed speed, the quantity of fuel delivered is determined by effective stroke (port closing to port opening) as controlled by the accelerator pedal and governor (by means of the control rack).

Engine Stop (No Delivery)

To stop the engine, plungers are rotated so that vertical slots (stop slots) are in line with barrel port. As plunger moves up and down fuel is transferred back and forth from top of plunger through vertical slots and into charging gallery. The ports do not close - thus, no delivery.

Plungers are rotated to the various metering positions by the control rack. Rack movement is controlled by the accelerator pedal, governor and engine shut off control.

GOVERNOR

The mechanical flyweight governor, which is integral with the injection pump, is the all-speed type, identified by the manufacturer as the RQV 325-1400. The 325-1400 designation refers to the injection pump speed range in which the governor functions As pump speed is one-half engine speed, this corresponds to engine speeds of 650 2800 rpm. Figure 10 illustrates a cut-away view of the governor assembly.

The functions of the governor are:

(1) limit minimum (lo-idle) engine speed,
(2) limit maximum engine speed and
(3) maintain smooth speed control within the limits of its regulation throughout the operating speed range of the engine.

The all-speed governor provides speed control at any fixed position of the control lever (accelerator pedal). This provides the vehicle operator with the most satisfactory driving characteristics The governor tends to keep engine speed constant at the level determined by position of the accelerator pedal and automatically increases or reduces fuel delivery in response to minute changes in engine speeds without a significant change in road speed and without the operator changing position of the accelerator pedal.

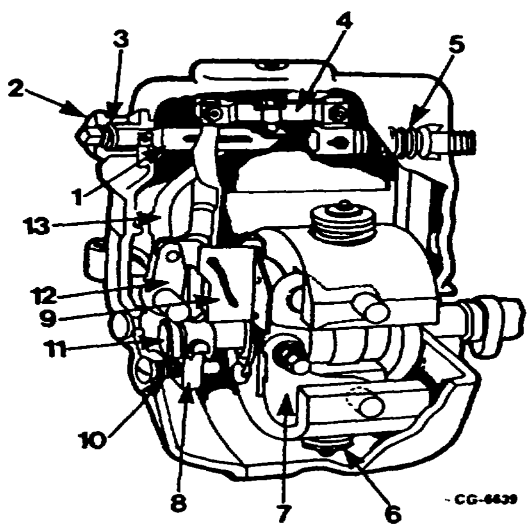

Figure 10. Cut-Away View of Governor Assembly

1.	Stop Shackle	7.	Bell Crank
2.	Lock Nut	8.	Sliding Block
3.	Control Rack Stop Assembly	9.	S-Plate
		10.	Guide Pin
4.	Rack Link	11.	Adjusting Pin
5.	Control Rack	12.	Guide Lever
6.	Governor Springs	13.	Rocker Arm

The transfer pump, a single action none positive displacement plunger type pump, is driven by the injection pump camshaft.

The transfer pump can supply more fuel than is required for injection. Excess fuel, utilized for cooling injection pump, is routed from the injection pump fuel gallery back to the fuel tank.

PRESSURE REGULATOR VALVE

A pressure regulator valve, located in the left front outlet of the injection pump housing fuel gallery (Figure 1) regulates the fuel pressure in the fuel gallery and dampens transfer pump fuel pulsations

INJECTION NOZZLES

The engine injection nozzles (Figure 11) are the inward opening differential needle type featuring sactype nozzle tips. The injection nozzles are mounted in the engine cylinder head and direct fuel under high pressure from the injection pump into the engine combustion chambers in the form of a fine mist.

The injection nozzle valve is held on its seat in the nozzle tip by a strong spring in the nozzle holder. When pressure of the fuel from the injection pump, acting upon the coned surface of the nozzle valve, exceeds spring pressure the valve is lifted off its seat and fuel is forced out of the four spray holes (orifices) in the nozzle tip. As pressure from the injection pump decreases, spring pressure re turns the nozzle valve to its seat ending fuel injection.

Nozzle opening pressure is determined by spring preload which can be adjusted by removing or adding shims between the spring and the nozzle holder body.

Leak-off of fuel past the lapped fit of the valve in the nozzle tip (used for lubrication of the parts) passes through the spring chamber, out the leak- off line, and is returned to the fuel tank.

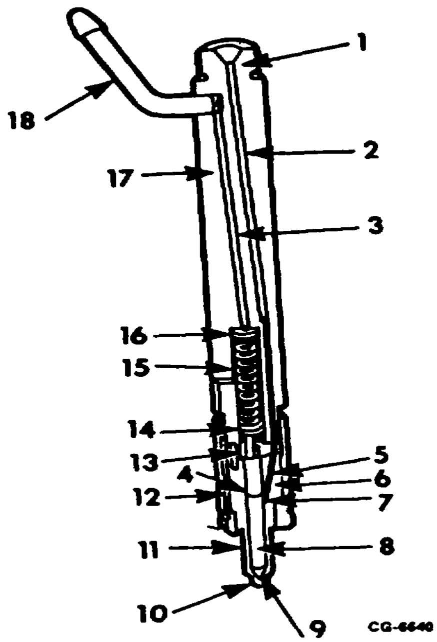

Figure 11. Sectional View of injection Nozzle Assembly

1. Fuel Inlet Connection
2. High Pressure Fuel Duct
3. Leak-Off Duct
4. Differential Surface
5. Nozzle Fuel Duct
6. Nozzle Body
7. Pressure Chamber
8. Nozzle Valve
9. Nozzle Sac
10. Spray Holes (4)
11. Nozzle
12. Nozzle Cap Nut
13. Nozzle Spacer
14. Spring Seat
15. Adjusting Spring
16. Adjusting Shims
17. Nozzle Holder Body
18. Leak-Off Connection

Service instructions for the injection nozzles are covered in Nozzle Service Manual CGES-225.

FUEL SYSTEM

The fuel system (Figure 12) consists of a primary fuel filter, a transfer pump, a final fuel filter with hand primer pump, an injection pump, injection nozzles, a pressure regulator valve and the connecting lines and fittings.

Fuel is pumped from the fuel tank through the primary filter by the transfer pump, then through the final filter.

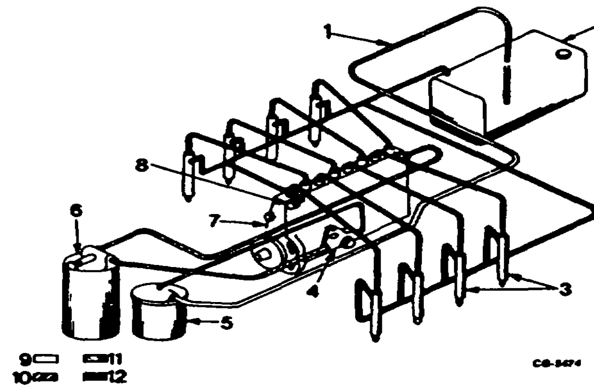

Figure 12. Fuel System

1. Fuel Line Supply
2. Fuel Tank
3. Nozzle Assembly
4. Transfer Pump
5. Primary Filter
6. Final Filter
7. Injection Pump
8. Pressure Regulator Valve
9. Primary Filter Transfer Pump Line
10. Transfer Pressure Line
11. Injection Lines
12. Leak-Off and Return to Tank Line

Filtered fuel is then directed to the fuel injection pump where it is metered and delivered under high pressure to the injection nozzles located at each combustion chamber in the cylinder heads Excess fuel from the injection pump and nozzles is directed through the leak-off and return lines to the fuel tank.

FUEL FILTERS

The primary fuel filters (Figure 13) filters large dirt particles and insoluble gums from the fuel.

The final fuel filter removes any minute particles that may pass through the primary filter.

Both primary and final fuel filters utilize "spin- on" type elements.

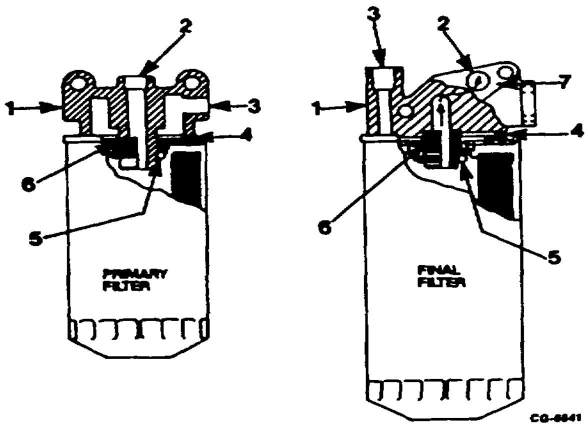

Figure 13. Fuel Filters

1. Filter Base
2. Outlet Port
3. Inlet Port
4. Outer Seal
5. O-Ring
6. Adapter
7. Mounting Pad Primer Pump

FUEL LINES (PIPES) AND FITTINGS

Low pressure lines used in the fuel system have either conventional or flex-tube type fittings (Figure 14). Flex-tube fittings consist of a fitting body, synthetic rubber sleeve and nut When installing flex-tube fittings be sure rubber sleeve is in good condition and line is inserted fully into fitting body. Tighten nut until it bottoms against fitting body.

High pressure lines connecting injection pump and injection nozzles are made from thick wall steel tubing with swaged ends (Figure 14). If a line must be removed, disconnect at both ends and remove brackets to prevent bending. If an injection line is damaged, use only Genuine I H replacement, since lines are of a specified length and a diameter. Always cap ends of lines when disconnected to prevent the entrance of dirt.

ENGINE TO INJECTION PUMP DRIVE

Camshaft of injection pump has a "keyed on" drive flange to which the drive gear is mounted.

Four oversize mounting holes in the injection pump drive gear provide adjustment for pump timing.

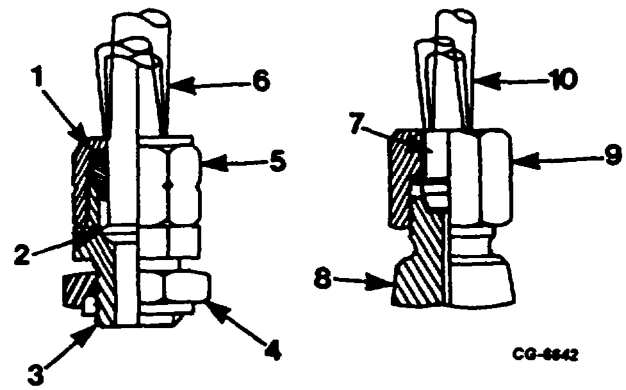

Figure 14. Low and High Pressure Fuel Line Fittings

1. Flex Sleeve Seal
2. 45 Degree Flare
3. Fitting Body
4. Seal Nut
5. Nut
6. Fuel Line (Low Pressure)
7. Sleeve
8. Nozzle Holder or Delivery Valve Holder
9. Connector Nut
10. Injection Line (High Pressure)

MAINTENANCE AND ON-ENGINE PERFORM-ANCE CHECKS

Refer to Diagnostic Manual CGES240-3 or Engine Manual CGES-2051.

TROUBLESHOOTING GUIDE

PROBLEM	POSSIBLE CAUSE	REMEDY
Fuel not reaching injection pump. Engine fails to start.	Tank empty.	Fill tank.
	Primary or secondary filter plugged.	Replace filters
	Fuel lines clogged or damaged. Defective pressure regulator valve.	Clean or replace fuel lines Replace pressure regulator valve.
	Defective transfer pump.	Replace transfer pump.
Fuel reaches injection pump but does not inject to nozzle.	One or more injection lines plugged or damaged.	Replace lines.
	Plunger seized or spring broken.	Repair or replace injection pump.
Fuel reaches nozzles but engine fails to start or starts hard.	Cranking speed too slow.	Recharge battery or correct faulty cranking motor system. Lube oil may be too heavy at low temperature.
	Accelerator not in start fuel position.	Correct accelerator linkage.
	Intake air temperature low. Improper fuel or water in fuel.	Use starting aids Check ether device for proper operation. (Check Operators Manual.) Drain system and pump housing; use specified fuel and prime system.
	Pump out of time with engine.	Correct timing.
	Poor compression.	Correct engine as required.
	Worn or scored plungers.	Repair or replace injection pump.
Engine starts and stops	Water or other contaminants in fuel.	Drain system and pump housing; use specified fuel and prime system.
	Air in fuel.	Prime system.
	Fuel filters clogged.	Replace filters
	Fuel tank vent plugged.	Clean vent.
	Waxed fuel filters	Replace filters; use specified fuel.
	Fuel lines clogged or damaged.	Clean or replace fuel lines

TROUBLESHOOTING GUIDE - Continued

PROBLEM	POSSIBLE CAUSE	REMEDY
Erratic engine operation (surging or misfiring).	Improper or contaminated fuel.	Drain system and pump housing; use specified fuel and prime system.
	Low transfer pressure	Change filters, check for fuel line restriction, replace pressure regulator valve or transfer pump.
	Injection pipes leaking.	Correct leaks.
	Pump out of time.	Correct timing.
	Nozzles faulty.	Repair or replace nozzles
	One or more injection lines plugged or damaged.	Replace lines.
	Poor compression.	Correct engine as required.
Engine idles poorly.	Improper lo-idle adjustment	Make lo-idle adjustment
	Water in fuel. use new fuel and prime.	Drain system and pump housing;
	Air in fuel.	Bleed system.
	Accelerator linkage incorrect	Correct linkage as required.
	Incorrect timing.	Check and correct timing.
	One or more injection lines damaged.	Replace lines
	Poor compression.	Correct engine as required.
	Defective lo-speed flyweight spring.	Calibrate injection pump.
	Plungers worn or scored.	Repair or replace injection pump.
Engine has low power but shows no increase in smoke.	Accelerator linkage restricted.	Adjust accelerator linkage.
	Improper hi-idle adjustment	Make hi-idle adjustment
	Low transfer pressure.	Change filters, check for fuel line restriction, replace pressure regulator valve or transfer pump.
	Loss of one cylinder.	Injection line plugged.
	Faulty maximum fuel setting.	Calibrate injection pump.
	Plungers worn or scored.	Repair or replace injection pump.
	Exhaust system restricted.	Check pipe diameter or muffler for damage.

TROUBLESHOOTING GUIDE - Continued

PROBLEM	POSSIBLE CAUSE	REMEDY
Engine has low power but shows no increase in smoke. (Continued)	Air cleaner restricted.	Check manifold vacuum. Service air cleaner if vacuum exceeds specified limits.
	Nozzles faulty.	Repair or replace nozzles.
	Pump out of time.	Correct timing.
High smoke - with no loss or with increase in power.	Increase in fuel delivery.	Check nozzles.
	Air cleaner restriction.	Service air cleaner.
Overall poor performance.	General mechanical condition of engine poor.	Correct as required before extensive repair to the fuel system.
High smoke at rapid acceleration.	Governor reaching into start fuel.	Calibrate governor.
Crankcase dilution (fuel in crankcase).	Nozzles faulty.	Check on nozzle tester; repair or replace.
	Transfer pump faulty.	Replace transfer pump.
	Injection pump faulty: a. Incorrect delivery valve holder torque.	Loosen holders and re-torque to specifications.
	b. Worn barrel and plunger.	Replace barrel and plunger.
	c. Leakage past rear fuel gallery plug.	Repair or replace pump housing.
	d. Damage to barrel seat	Repair or replace pump housing.
	e. Cracked housing.	Repair or replace pump housing.
High speed surge.	Injection pump faulty: a. Governor weight imbalance.	Calibrate governor.
	b. Damaged governor damper.	Replace governor buffer
	c. Too little spring pretension on governor weights or slider.	Calibrate governor.
	d. Sticking control rack.	Loosen delivery valve holders and retorque to specifications. Relieve bind in governor internal linkage. Clean dirt from housing.

TROUBLESHOOTING GUIDE - Continued

PROBLEM	POSSIBLE CAUSE	REMEDY
High speed surge. (Continued)	Injection pump faulty: (Continued)	
	e. Rack fails to go into start fuel position.	Replace stop shackle.
		Relieve governor spring pretenstion. Correct slider dimension.
Engine has low power and increased smoke.	Air cleaner restricted.	Service air cleaner.
	Nozzles faulty	Check on nozzle tester/repair or replace.
	Pump out of time.	Correct timing.
	Loss of one cylinder.	Check compression.
	Max fuel setting incorrect.	Calibrate injection pump.

SPECIFICATIONS

TORQUE CHART

Camshaft Nut (Drive End)	81.3 - 97.6 N·m (60-72 lb-ft)
Pump-to-Adapter Bolt	33.9 - 47.5 N·m (25-35 lb-ft)
Pump Bracket Bolts	21.1 - 33.9 N·m (20-25 lb-ft)
Delivery Valve Holder Nut	29.8 - 33.9 N·m (22-25 lb-ft) (*)
Injection Line Nut	21.7 - 27.1 N·m (16-20 lb-ft)
Governor Flyweight Assembly Nut	50.2 - 58.3 N·m (37-43 lb-ft)
Pressure Regulator Valve Fitting	24.4 - 33.9 N·m (18-25 lb-ft)
Governor Oil Fill Plug	9.5 - 12.2 N·m (7-9 lb-ft)
Control Rack Cap	9.5 - N·m (7 lb-ft)

(*) Tighten to specified torque and relieve twice before final torquing.

SPECIFICATIONS

9.0 Liter Diesel Engine Model Code	165F	
Injection Pump Part Number	1 701 171 C91**	
Engine Rating (Gross Power)†	165 BHP @ 2800 RPM	
Injection Pump Type	In-Line Plunger	
Drive	Timing Gear Train	
Pump Speed	One-Half Engine Speed	
Pump Rotation (Viewed From Drive End)	Clockwise	
Firing Order	1—8—7—3—6—5—4—2	
Camshaft End Play	.02 - .06 mm (.0008 - .0024 in.)	
Camshaft Protrusion	20.7 - 22.2 mm (.817 - .877 in.)	
"Slider-to-Housing" Distance	38.8 mm (1.524 ± .015 in.)	
Basic Setting of S-Plate	21.5 - 21.9 mm (.847 - .863 in.)	
Initial Timing ± 1° BTDC (Static) No. 1 Piston on Compression Stroke - Crankshaft Damper Timing Mark and Pointer Indexed	16° — Below S/N 2538 15° — Above S/N 2539	
Transfer Pump Vacuum (Maximum) (Between Primary Filter and Transfer Pump) Transfer Pump Pressure (Minimum) (Between Final Filter and Injection Pump)	35.6 cm (14 in.) Hg. @ Full Load and Rated Speed 172 kPa (25 psi) @ Full Load and Rated Speed	
Engine Compression Pressure @ 200 RPM	3100 - 3619 kPa (450-525 psi)	
Governor Type	All Speed	
Low Idle Speed RPM (No Load)	625-675	
High Idle Speed RPM (No Load)	3025-3125	
Manifold Vacuum (Air Cleaner Restriction)	50.8 cm (20 in.) H_2O or 3.73 cm (1.47 in.) Hg. (Max. Permissible @ Rated Speed)	
Exhaust Back Pressure (Exhaust Restriction)	11.4 cm (4.5 in.) Hg. or 155.2 cm (61.1 in.) H_2O at Exhaust Manifold Plug on Either Bank OR 7.6 cm (3.0 in.) Hg. or 103.4 cm (40.7 in.) H_2O at Tap 2 inches Below Exhaust Manifold on Either Bank (Max. Permissible @ Full Load and Rated Speed)	

**Engine S/N 12181 and later (w/Auto Trans.);

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Section 2
Page 1

REMOVAL OF INJECTION PUMP

Preparing for Removal

Truck model differences affect pump removal, but the following is always required:

1. Drain engine coolant from radiator and engine block.

2. Disconnect accelerator and shut off control cables from governor.

3. Before disconnecting fuel lines, clean pump and connections with clean diesel fuel.

4. Disconnect injection lines, low pressure lines and lube oil line from pump. Remove fuel line brackets as necessary. Use plastic caps or plugs to protect openings from dirt.

Removal

Remove fan drive, water outlet and return tube, injection pump drive gear cover and drive gear mounting bolts.

(For detailed removal procedure, see Engine Service Manual CGES-2051.)

NOTE: If injection pump has been operated on an engine in which water or anti-freeze has entered the crankcase, disassemble and clean the pump and governor immediately. Do not store pump before overhaul.

Special Tools

To overhaul the pump assembly, metric wrenches and sockets ranging in size from 8 mm through 19 mm will be required. Special rebuild tools (Figure 1) called out throughout the text will speed repair work and protect parts from damage.

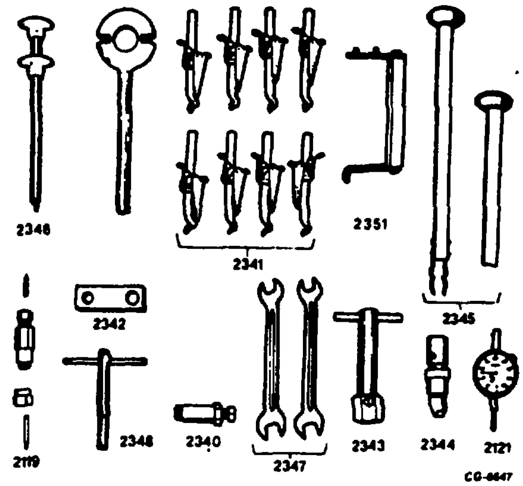

Figure 1. Special Tools for Pump Overhaul

SE-2119	Rack Gauge Holder
SE-2121	Dial Indicator
SE-2340	Remover, Governor Flyweight Damper
SE-2341	Holder, Tappet
SE-2342	Gauge, Camshaft Protrusion
SE-2343	Holder, Dial Indicator
SE-2344	Remover and Installer, Camshaft Cylindrical Nut
SE-2345	Remover and Installer, Tappet
SE-2346	Remover and Installer, Barrel Plunger
SE-2347	Wrench, Tappet Adjusting
SE-2348	Wrench, Governor Spring Adjusting
SE-2351	Fixture, Pump Holding

Preparation for Disassembly

Pump and governor overhaul should be performed in a clean area free from airborne dirt. A separate injection service room is preferred. Work bench, vise and tools should be clean. The use of trays for keeping injection pump parts in order is recommended. The pump assembly should be thoroughly cleaned externally before disassembly.

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Prepare the pump for disassembly as follows:

1. Drain fuel and lubricating oil from pump and governor housings.

2. Cap or plug fuel and lube oil openings after draining to prevent entry of dirt.

3. Use clean diesel fuel or kerosene to clean exterior of pump and governor assembly.

4. Clamp holding fixture SE-2351 (Figure 2) in vise. Remove two pump housing to adapter bolts. Secure injection pump assembly to holding fixture.

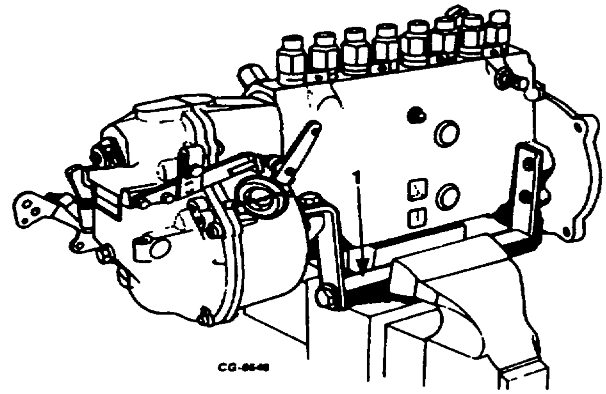

Figure 2. Injection Pump Mounted in Holding Fixture

1. Holding Fixture SE-2351

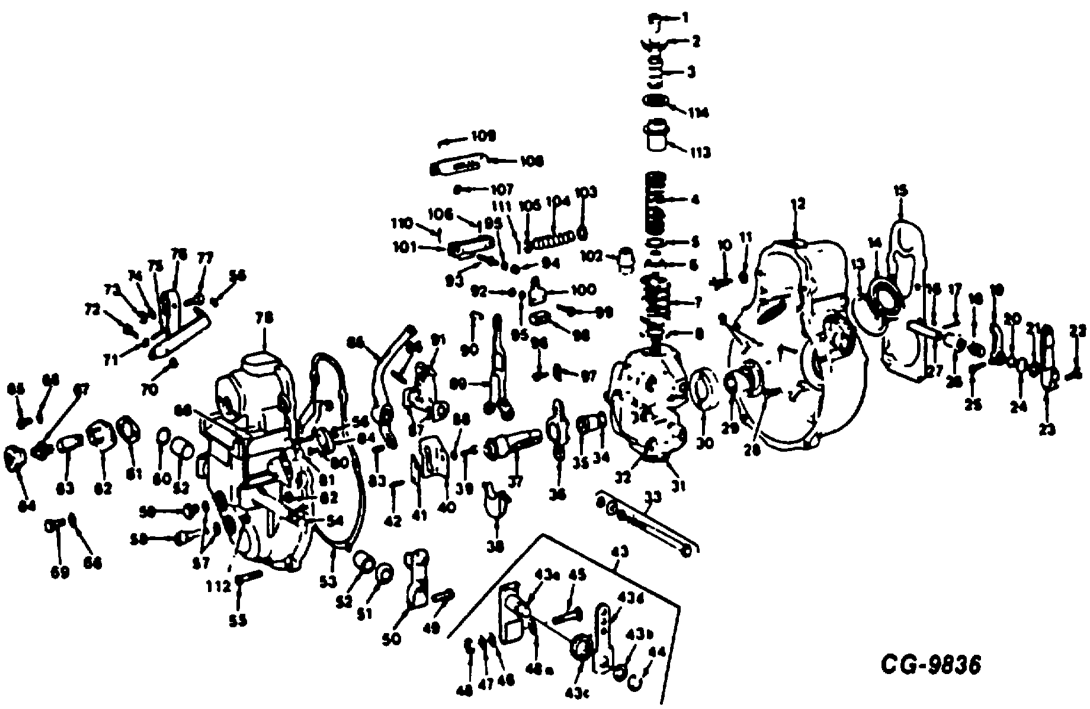

Figure 3. Exploded View of Governor

Legend for Figure 3

1. Nut, Cylinder
2. Seat, Spring Outer
3. Spring, Governor Maximum Speed
4. Spring, Governor Maximum Speed Center
5. Washer, Special
6. Seat, Governor Spring
7. Spring, Governor Idle
8. Shim, Governor Idle
9. Bumper, Governor Weight
10. Screw
11. Washer, Lock
12. Housing, Governor
13. Gasket, Governor Housing Plug
14. Plug, Governor Housing
15. Gasket, Governor to Pump
16. Key, Woodruff
17. Pin, Cotter
18. Spring, Governor Lever
19. Lever, Governor
20. O-Ring, Gover
21. Shim, Governor Lever
22. Bolt, Governor Lever Control
23. Lever, Governor Control
24. Washer, Spacing
25. Screw, Set
26. Bushing, Governor Shaft
27. Shaft, Governor
28. Screw, Governor Mounting
29. Hub, Governor
30. Retainer, Governor Weight
31. Weight, Governor Flywheel
32. Ring, Snap
33. Bolt, Governor
34. Washer, Governor Nut
35. Nut, Governor
36. Bushing, Governor
37. Pin, Governor Adjusting
38. Guide, Governor
39. Bolt, Governor
40. Bracket, Cam Mounting
41. Shim, Governor Bracket
42. Pin, Governor
43. Lever w/Clamp, Governor

43a. Clamp, Lever
43b. Shim
43c. Spring, Torsion
43d. Lever, Governor
44. Ring, Snap
45. Bolt, Hex-Hd
46. Washer, Flat
47. Washer, Lock
48. Nut, Hex
48a. Washer, Governor Lever
49. Bolt, Clamp
50. Lever, Governor
51. Seal, Governor Shaft Oil
52. Bushing, Governor Shaft
53. Gasket, Governor Housing
54. Shaft, Governor
55. Screw, Wt. Housing to Governor Housing
56. Nut, Hex
57. Gasket
58. Screw, Governor
59. Bushing or Plug (Depending on application)
60. Plug
61. Gasket, Control Rack Stop
62. Stop Assembly, Control Rack
63. Pin, Control Rack Stop
64. Nut, Control Rack Stop Adjusting Screw
65. Screw, Governor
66. Washer, Lock
67. Screw, Control Rack Stop Adjusting
68. Bolt, Governor
69. Screw
70. Washer, Spacing
71. Washer, Lock
72. Bolt, Mounting
73. Nut, Special
74. Washer, Lock Special
75. Screw, Set
76. Lever Assembly
77. Bolt, Mounting
114. Shim

78. Cover Assembly, Governor
79. Screw, Stop
80. Screw, Special
81. Seal, Bar Screw
82. Key, Woodruff
83. Spring, Lever
84. Cap, Protective
85. Lever, Governor Rocker
86. Pin, Governor Lever
87. Washer, Governor Lever
88. Washer, Lock
89. Lever, Governor
90. Pin, Link
91. Lever Assembly, Governor
92. Nut, Special
93. Pin, Governor or Stud, Threaded (Depending on application)
94. Nut, Hex
95. Washer, Lock
96. Bolt, Lock Plate
97. Plate, Lock
98. Bar, Spacer Bracket
99. Bolt, Bracket
100. Bracket, Governor
101. Link, Governor Control
102. Not Used
103. Ring, Governor Spring Guide
104. Spring, Governor
105. Seat, Governor Spring
106. Pin, Cotter
107. Pin, Guide
108. Link
109. Clip, Rack Stop
110. Pin, Cotter
111. Pin, Cotter
112. Screw or Nut (Depending on application)
113. Seat, Governor Spring Inner

Governor Disassembly

1. Using 10 mm Allen wrench, remove plug from rack link adjustment access hole in top of governor housing.

2. Remove seal wire and remove two rack stop assembly to governor housing screws.

3. Move control lever fully back against low idle stop screw.

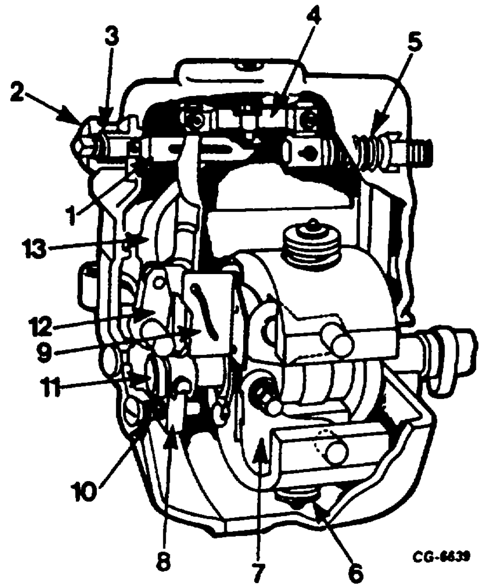

Figure 4. Cut-Away View of Governor Assembly

1. Stop Shackle	**7. Bell Crank**
2. Lock Nut	**8. Sliding Block**
3. Control Rack Stop Assembly	**9. S-Plate**
4. Rack Link	**10. Guide Pin**
5. Control Rack	**11. Adjusting Pin**
6. Governor Springs	**12. Guide Lever**
	13. Rocker Arms

4. Reaching down through rack link adjustment access hole with a small screwdriver (Figure 5), lightly pry stop shackle aside (to right as viewed from rear of pump) to disengage stop shackle from rocker arm pin. (See Figure 4 for relationship of parts)

NOTE: To ease this operation, interior of governor housing can be lighted by removing seal wire and plug from governor adjustment access cover on side of governor housing and inserting penlight through access hole.

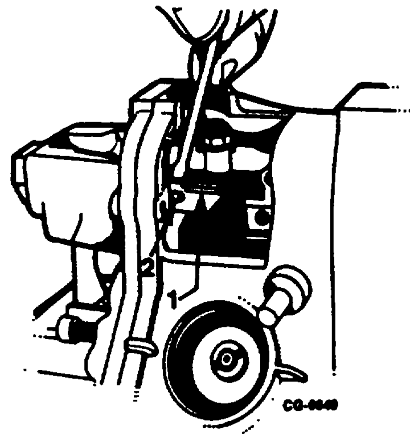

Figure 5. Disengaging Stop Shackle (Cut-Away View for Illustration)

1. Stop Shackle **2. Rocker Arm pin**

5. Pull control rack stop assembly to rear, then rotate approximately 45 degrees counterclockwise to permit stop shackle to pass governor levers and slide assembly from governor housing (See Figure 6).

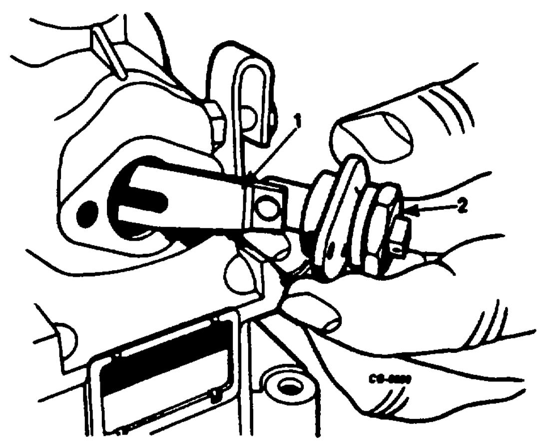

Figure 6. Removing Rack Stop Assembly

1. Stop Shackle **2. Rack Stop Assembly**

6. Remove slotted screw guide pin (Figure 7) from governor cover. Use large screwdriver to fit slot of this screw which has been sealed in place with Loctite hydraulic sealant

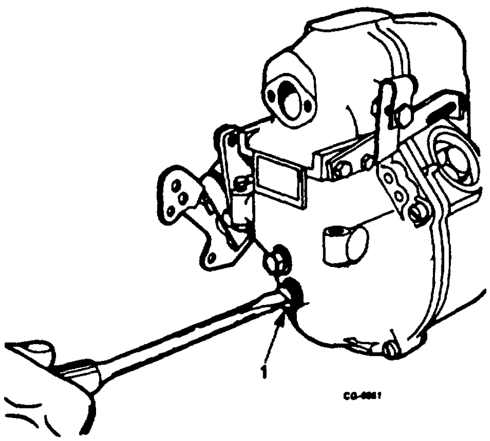

Figure 7. Removing Guide Pin

1. Slotted Screw Guide Pin

7. Remove six governor cover screws and take off governor cover (Figure 8). Lift cover up and operate control lever to release internal linkage.

8. Remove cotter pin and link pin and disconnect floating lever from rack link.

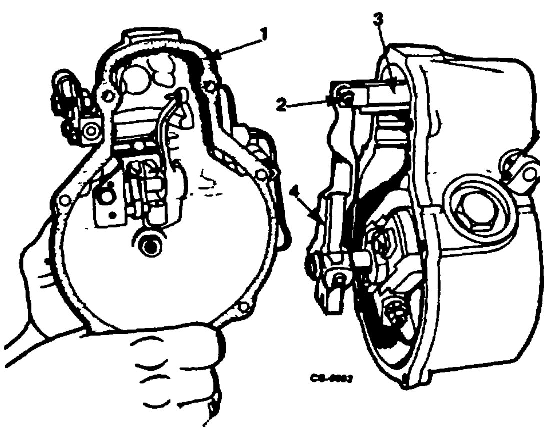

Figure 8. Removing Governor Cover

1. Cover	**3. Rack Link**
2. Link Pin	**4. Floating Lever**

9. Pull top of floating lever back and down to remove floating lever and slider (Figure 9) from guide pin.

NOTE: Secure rack link to delivery valve to prevent link damage.

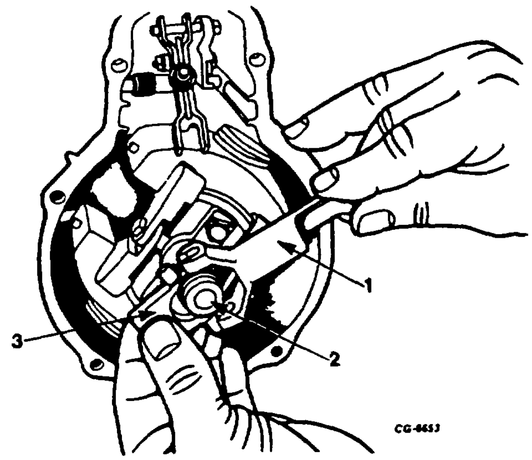

Figure 9. Removing Floating Lever and Slider

1. **Floating Lever3.Slider**
2. **Adjusting Pin**

10. Raise tabs on lock washer and remove double nutted thru-bolt and adjusting pin from governor flyweight assembly (Figure 10).

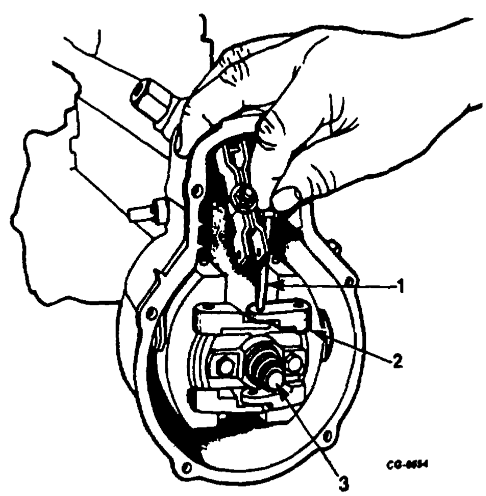

Figure 10. Removing Adjusting Pin from Flyweight Assembly

1. Thru-Bolt	**3. Adjusting Pin**
2. Flyweight Assembly	

11. Raise tabs on lock plates, remove two cap screws and take out adjusting pin guide bushing (Figure 11).

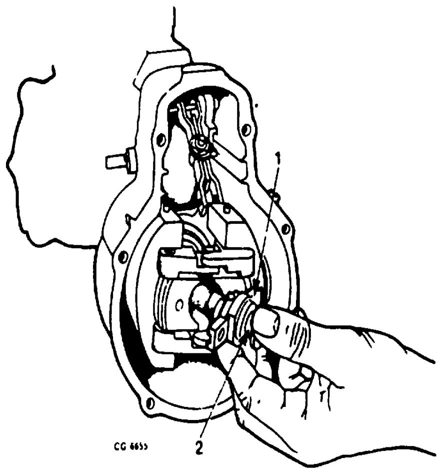

Figure 11. Removing Adjusting Pin Guide Bushing

1. **Adjusting Pin Guide Bushing**
2. **Adjusting Pin**

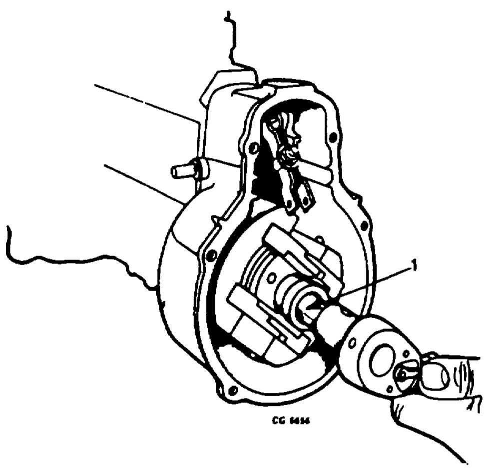

Figure 12. Removing Cylindrical Nut

1. Cylindrical Nut Remover SE-2344

12. Install two 3/8 NC x 3-1/2 bolts in the drive flange (Figure 17). Using SE-2344 remover tool on slotted cylindrical nut and holding bar between bolts to hold camshaft, remove the cylindrical nut (Figure 12) and spacer shim under the nut. It may be necessary to use small quantity of lube on nut to extract spacer shim.

13. Install SE-2340 governor flyweight remover tool (Figure 13) and remove flyweight assembly. Since governor weight assembly is serviced as a complete unit, no further disassembly is required until rebuild.

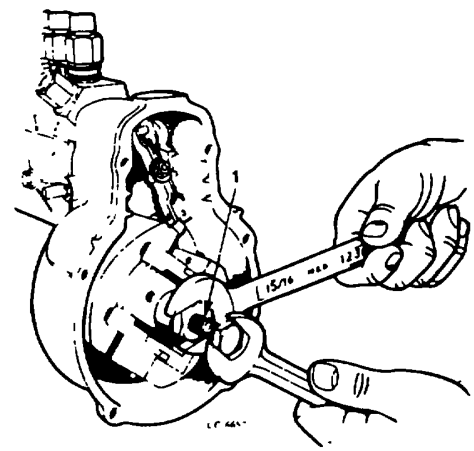

Figure 13. Removing Governor Flyweight Assembly

1. Governor Flyweight Remover Tool SE-2340

14. To remove governor housing, remove rack link, link bracket and spring from rear of control rack. Move tab of stop lever return spring aside and unscrew seven governor housing to pump housing mounting screws. Remove governor housing and bracket.

NOTE: Governor housing screws are staked. Governor - housing will not have to be removed from pump housing unless governor housing is damaged or cracked, fuel dilation is suspected, there are other leaks, or camshaft bearing damage is evident.

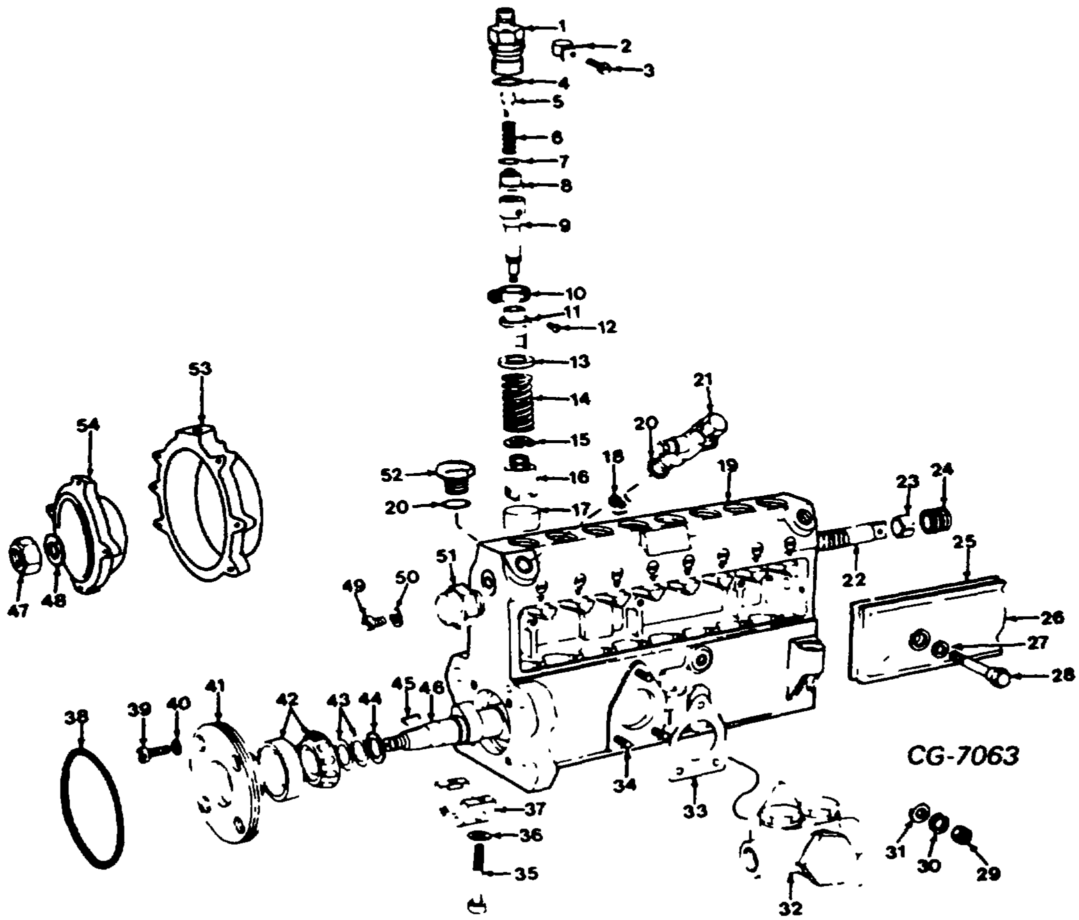

Figure 14. Exploded View of Pump

1. Retainer, Valve
2. Clamp
3. Screw, Clamp
4. Gasket, Valve Retainer
5. Spacer, Fuel Filter
6. Spring, Fuel Valve
7. Gasket, Fuel Valve
8. Valve, Delivery
9. Piston
10. Gear, Valve
11. Sleeve
12. Screw, Valve Gear
13. Seat, Spring Upper
14. Spring, Valve
15. Seat, Spring Lower
16. Sleeve, w/Roller, Lifter
17. Cover
18. Screw, Special
19. Housing, Pump
20. Gasket, Copper
21. Valve, Injection Pump Overflow
22. Rack, Control
23. Ring, Guide
24. Bushing, Guide
25. Gasket, Cover
26. Cover w/Gasket, Injection Pump
27. Gasket, Cover Bolt
28. Bolt, Cover
29. Nut, Hex
30. Washer, Lock
31. Washer, Flat
32. Pump, Supply
33. Gasket, Housing
34. Stud, Pump
35. Screw, Cam Bearing
36. Washer, Flat
37. Bearing, Camshaft
38. O-Ring, Bearing Retainer
39. Screw, Special
40. Washer, Lock
41. Retainer, Bearing
42. Bearing w/Cup, Camshaft Roller
43. Shim, Camshaft Bearing Drive End
44. Spacer
45. Key, Woodruff
46. Camshaft, Injection Pump
47. Nut, Camshaft
48. Washer, Lock Camshaft
49. Screw, Rack Adjustment
50. Shim, Rack Adjustment
51. Cap, Injection Pump Closing
52. Fitting, Pump
53. Housing, Adapter
54. Hub, Pump

Pump Disassembly

NOTE: The main body contains several fittings, bushings and plugs on which Loctite hydraulic sealant has been used. Do not remove these parts unless known to be leaking. Included among these are the inlet fuel adapter fitting, the fuel gallery plug, and lube oil inlet bushing and the bleeder valve bushing.

1. Remove three side cover bolts, remove side cover and gasket from pump housing.

2. Remove three transfer pump nuts and washers. Remove transfer pump and gasket from pump housing.

3. Install eight SE-2341 tappet holder tools (Figures 15 and 16) in side of pump to hold all tappets up from camshaft. To prevent tool breakage, lift each tappet by rotating camshaft before installing holder tool.

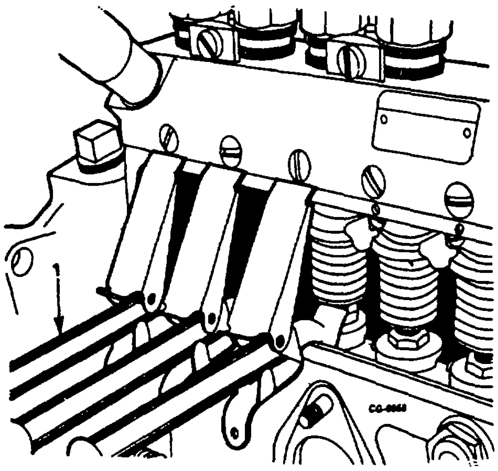

Figure 15. Installing Tappet Holder Tool

1. Tappet Holder SE-2341

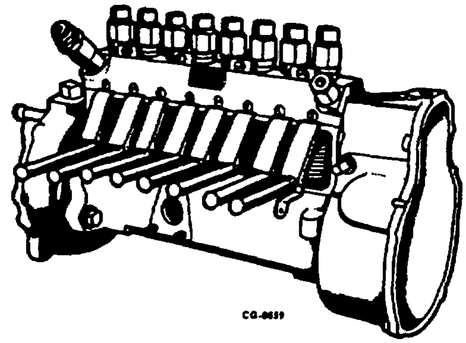

Figure 16. All Tappet Holder Tools in Place

4. Using holding bar to hold drive hub, remove camshaft nut and washer (Figure 17).

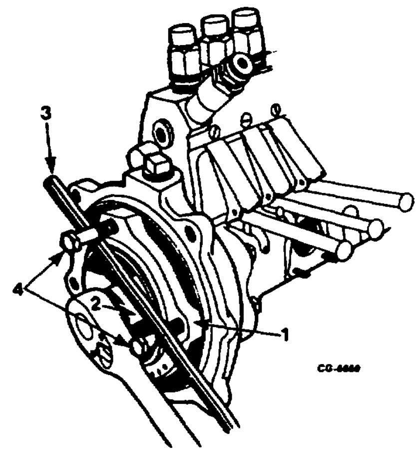

Figure 17. Removing Camshaft Nut

1. **Drive Hub**
2. **Socket Wrench**
3. **Holding Bar**
4. **Hub Holder Bolts**

5. Remove drive hub from camshaft by using a gear puller (Figure 18). Remove woodruff key from camshaft.

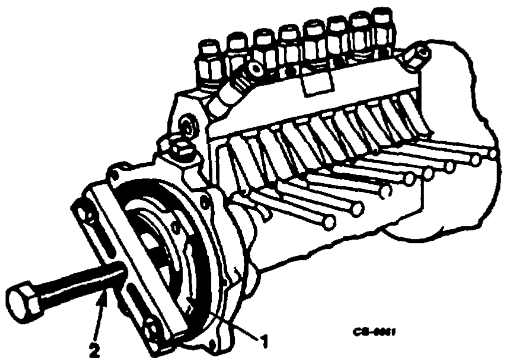

Figure 18. Removing Drive Hub

1. Drive Hub 2. Drive Hub Puller

6. Remove two remaining adapter to pump housing bolts and remove adapter housing (Figure 19).

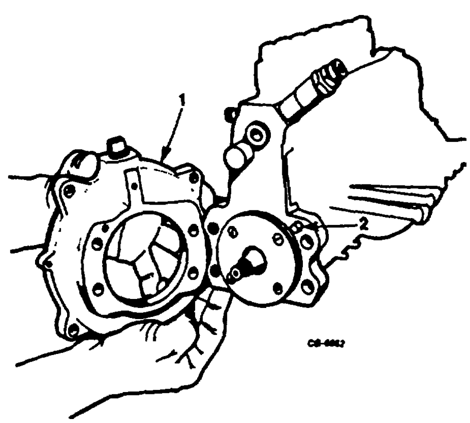

Figure 19. Removing Adapter Housing

1. Adapter Housing 2. Locating Pin

7. Loosen holding fixture clamp bolts. Reposition pump assembly on side (tappet holder tools pointing upward) and retighten fixture clamp bolts.

8. Remove the two camshaft center bearing screws from bottom of pump (Figure 201.

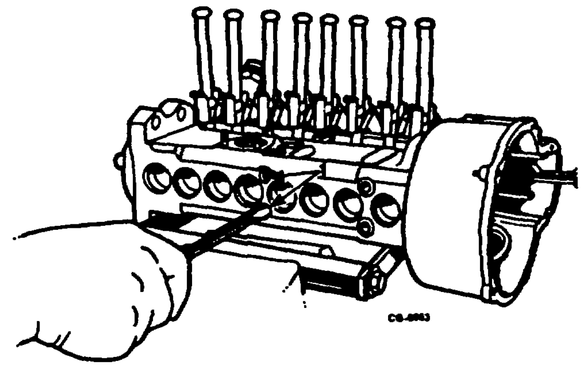

Figure 20. Removing Camshaft Center Bearing Screws

1. Center Bearing Screws

9. Using large screwdriver remove the four fiat head screws from camshaft front bearing retainer and remove retainer (Figure 21).

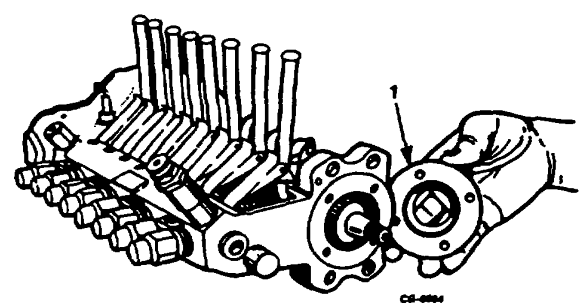

Figure 21. Removing Front Bearing Retainer

1. Front Bearing Retainer

10. Remove camshaft (Figure 22) with center bearing and both end bearings out front of pump. A slight tapping on rear of shaft with soft hammer is permitted.

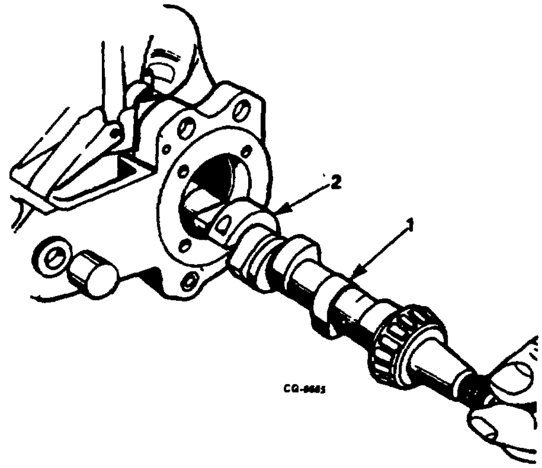

Figure 22. Removing Camshaft

1. Camshaft **2. Center Bearing**

11. Using a 5/8" or 11/16" socket or similar size wooden plug, drive the eight base plugs inside pump housing and remove (Figure 23).

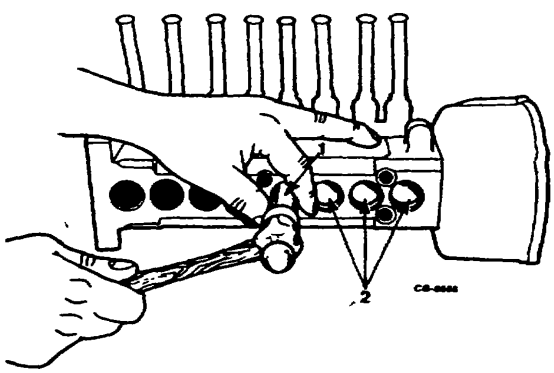

Figure 23. Removing Base Plugs

1. Plug **2. Bas Plug**

12. Using SE-2345 tappet remover tool, push roller tappet up so that SE-2341 tappet holder tool can be. removed (Figure 24). Clear holder tools from all eight tappets and remove roller tappet assemblies from pump housing. Keep parts in order so that tappets can be returned to their respective bores on reassembly.

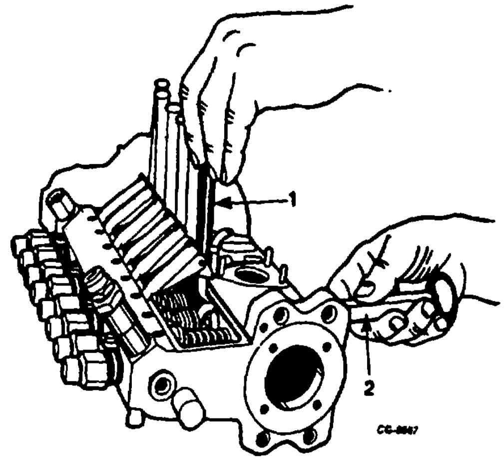

Figure 24. Removing Holder Tool and Tappet

1. Tappet Holder SE-2341
2. Tappet Remover SE-2345

13. Remove keepers, plunger springs, upper spring seats and plungers (Figure 25). Keep parts in order, don’t touch machined surfaces and keep surfaces wet with fuel oil while removed.

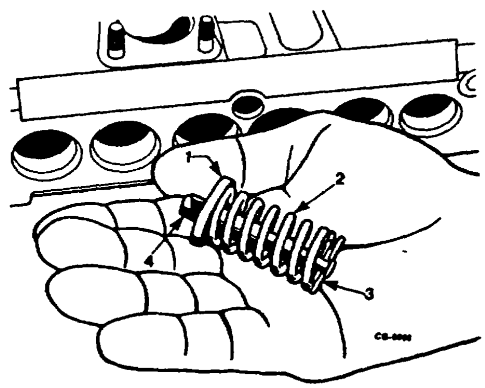

Figure 25. Removing Plungers

1. Seat	**3. Keeper**
2. Spring	**4. Plunger**

14. Remove control sleeves from barrels (Figure 26).

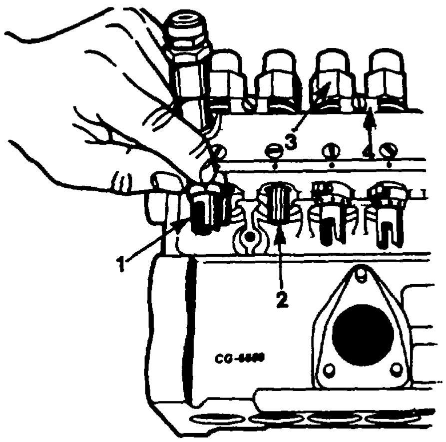

Figure 26. Removing Control Sleeves

1. Control Sleeve	**3. Delivery Valve Holder**
2. Barrel	**4. Clamps**

15. Remove delivery valve holder clamps and using a 7/8" socket, remove the holders (Figure 27).

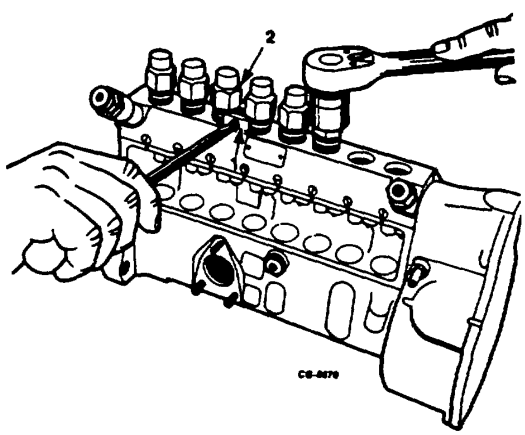

Figure 27. Removing Holder Clamps and Delivery Valve Holders

1. Holder Clamp	**2. Delivery Valve Holder**

16. Remove shims, springs, gaskets and delivery valve assemblies by lifting up on barrels from inside of pump housing (Figure 28). As soon as barrels are removed, keep barrels and plungers together. While these parts are mated at assembly, they have no mating marks. Be sure to keep parts in order.

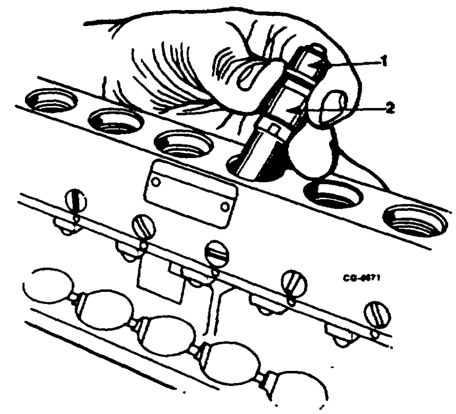

Figure 2& Removing Barrel and Delivery Valve

1. Delivery Valve	**2. Barrel**

17. Remove control rack positioning screw and control rack end plug (Figure 29).

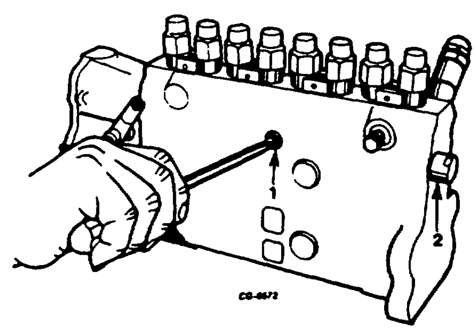

Figure 29. Removing Rack Position Screw

1. **Control Rack Positioning Screw**
2. **End Plug**

18. Remove control rack from pump housing (Figure 30).

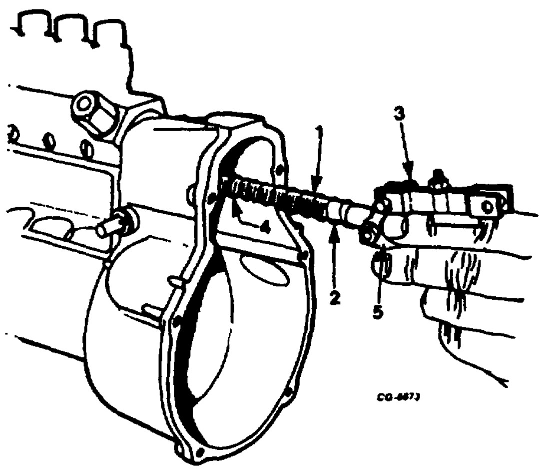

Figure 30. Removing Control Rack

1. Control Rack
2. Spring
3. Rack Link
4. Guide Ring
5. Bracket

CLEANING, INSPECTION AND RECONDITIONING

A thorough cleaning and inspection of all parts is important to reconditioning the injection pump and governor assembly.

Each machined surface should be cleaned of all old gasket material and wash all parts in clean fuel oil or calibrating oil.

When inspecting for damage or wear, it is a good practice to replace any part that is questionable.

Part	Inspect For Following Condition(s)	Corrective Action When Required
Injection Pump Housing	Cracks, chips, evidence of overtorque or stripping of screw threads, damage in roller tappet bores.	If damaged, replace.
	Damaged camshaft bearing cups located in governor housing, front bearing retainer and bearings on camshaft.	If damaged, replace bearing as follows: 1. Remove governor housing from pump housing (Governor Disassembly, step 14; Section 2, Page 7) 2. Remove bearing cup, item 42, (Figure 14, Section 2) and gasket material from governor and pump housings. Install new bearing cup. 3. Obtain new gasket and tap governor housing onto pump housing. Install mounting screws and restake to secure. Reposition stop lever spring end in hole provided. 4. Remove and replace bearing cup in front bearing retainer. 5. Remove and replace bearings on camshaft and use the same number of shims used under old bearing. See NOTE*
Camshaft	Deep wear or grooving on cams or bearing surfaces.	Replace camshaft.
Roller Tappets	Pressure marks or grooving.	Slight marks or grooving - smooth out with polishing cloth. More serious wear - replace parts.
Spring Keepers	Worn or bent.	Replace keepers.
Springs	Broken or rust coated.	Replace springs.
Barrels and Plungers	Damage (scratches, scoring, etc.) on lapped surfaces of plunger. See NOTE**	Replace barrel and plunger.
Control Sleeves	Slight damage. Severe damage.	Polish and reuse. Replace sleeves.

• **NOTE**: When installing a new camshaft, use the same number of shims as used on old shaft as a starting point for shim buildup to make end play adjustment

•• **NOTE**: Test the set by washing out with test oil and pulling plunger part way out of barrel. It must fall back slowly by its own weight.

Part	Inspect For Following Condition(s)	Corrective Action When Required
Control Rack	Burrs on gear teeth or scratches along sides.	Polish with crocus cloth. Replace if any binding with housing exists.
Delivery Valve Assembly	Damage at delivery valve seat or needle.	Replace complete assembly.
Base Plugs	Known to be leaking.	Replace.
Gaskets, Seats and O-Rings	ALWAYS REPLACE WHEN REBUILDING PUMP	
Transfer Pump	Fuel leakage past pump drive stem. See NOTE*	Replace as a complete unit only.
Governor Housing and Cover	Cracks, stripped screw threads, burrs on mating surfaces.	Replace.
Governor Weight Assembly	Worn bell cranks, damaged weights, stripped adjusting nut threads, worn or damaged springs.	Replace weight assembly as complete unit. Weight springs and shims may be replaced individually.
Governor	RECONDITION AS OUTLINED BELOW.	

• **NOTE**: Plug outlet side of transfer pump and pressurize inlet side with air to 103137 kPa (1520 psi). When submerged in fuel oil, no air leaks are permitted past pump drive assembly.

RECONDITIONING THE GOVERNOR

1. Perform a static check on balanced movement of governor weights by making a temporary buildup less springs but using spring seats, trial spacer bushings (obtained locally) and adjusting nuts (Figure 1) on each weight as follows:

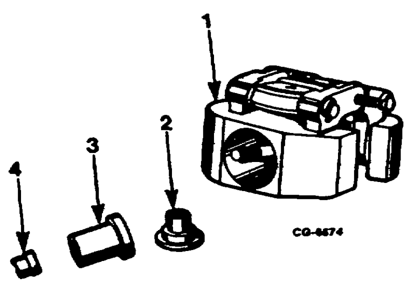

Figure 1. Details of Flyweight Assembly

1. **Governor Flyweight Assembly**
2. **Spring Seat**
3. **Trial Spacer Bushing**
4. **Adjusting Nut**

Install double-nutted thru-bolt in weight assembly. Apply slight pressure to center of bolt and check for excessive rocking movement in one or the other weights (Figure 2). When installing the three different size weight springs, remove the trial spacer bushing

2. Reinstall flyweight springs. Always start preliminary shim pack under governor shims as follows:

Outer spring: 1.0 mm (.040")
Intermediate Spring: 1.0 mm (.040")
Inner Spring: 1.5 mm (.060")

Install outer spring seat and adjusting nut When Installing adjusting nut, preload of governor springs should range from 2 to 3 180 degree clicks from flush nut position with threaded bolt. Preliminary adjustment should be equal on both spring sets.

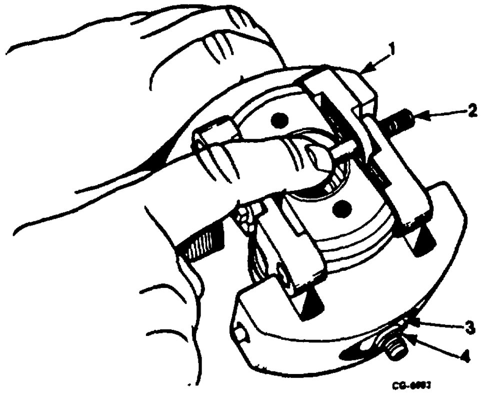

Figure 2. Checking Flyweight Trail Build-Up

1. **Rocking Movement**
2. **Through Bolt**
3. **Trial Spacer Bushing**
4. **Adjusting Nut**

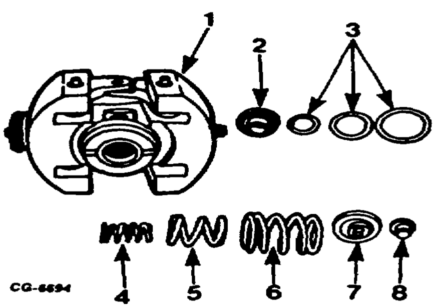

Figure 3. Exploded View of Flyweight Springs

1. **Flyweight Assembly**
2. **Lower Spring Seat**
3. **Adjusting Shims**
4. **Inner Spring (Hi-idle)**
5. **Intermediate Spring**
6. **Outer Spring (Lo-Idle)**
7. **Upper Spring Seat**
8. **Adjusting Nut**

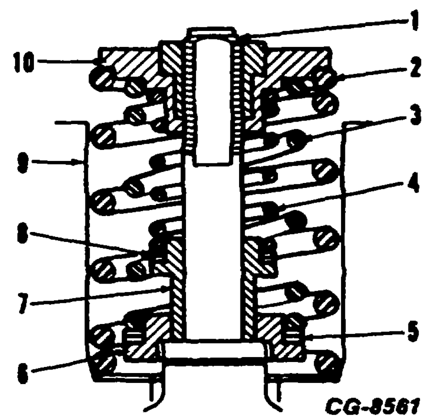

Figure 4. Sectional View of Flyweight Spring Installation

1. **Cylindrical Adjusting Nut**
2. **Lo-Idle Spring**
3. **Intermediate Spring**
4. **Hi-Idle Spring**
5. **Intermediate Adjusting Shim**
6. **Lower Spring Seat (Lower Half)**
7. **Lower Seat (Upper Half)**
8. **Inner Spring Shim**
9. **Flyweight Assembly**
10. **Upper spring Seat**

3. Inspect damper buffers for damage. Pry up hub to inspect. Replace buffers as a set if needed (Figure 5).

4. Assembly prelubricated buffers in damper retainer and place damper hub on weight assembly.

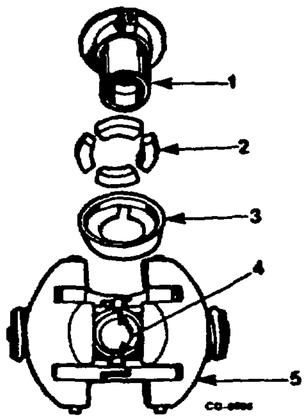

Figure 5. Exploded View of Damper Hub

1. **Damper Hub**
2. **Buffer**
3. **Retainer**
4. **Mounting Tang**
5. **Flyweight Assembly**

S-Plate: Sliding parts should operate free of bind; any grooves or pressure marks on curve should be smoothed with fine emery.

Adjusting Pin: If any parts of the adjusting pin are worn or damaged, replace the complete unit.

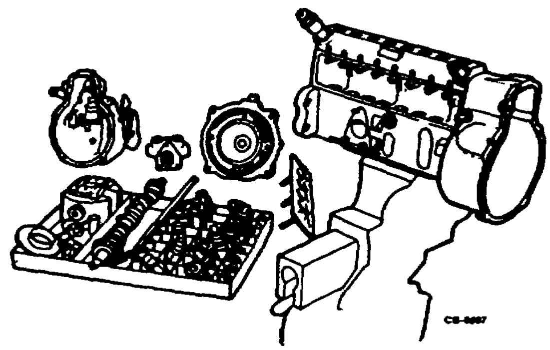

Figure 6. Disassembled Pump - Cleaned,, Inspected, Reconditioned and Ready for Reassembly

PUMP REASSEMBLY

1. Position pump body in SE-2351 holding fixture and clamp upright in vise.

2. Noting for correct order, Install the barrels, aligning guide slots with pins in pump housing. Pre-lubricate with fuel oil while Installing.

3. Install delivery valves and assemblies.

4. Install new delivery valve gaskets, springs, fillers and delivery valve holders. Use new O-rings and pre-lubricate with fuel oil. Install delivery valve holders finger tight. Do not torque until control rack and control sleeves have also been installed.

5. Attach rack link bracket and rack link to rack and with rack spring and washers in place on rack, install control rack through governor and into pump housing. The rack spring is important, since it functions to take up lost motion in the internal pump parts and serves to retract rack if other linkage should fail.

6. Secure control rack in pump with rack positioning screw. Be sure rack is free.

7. Reposition holding fixture to place pump tappet cover side up.

8. Install control sleeves on barrels (Figure 1) with all eight centered on rack segments. Check for binding by operating sleeves with control rack and replace any that do.

9. Starting at drive end, torque Nos. 1 through 8 delivery valve holders.

NOTE: Tighten holders to specified torque and relieve twice before final torquing. Operate rack between each sequence to be certain rack has no binding.

10. Install upper spring seats and springs

11. Using SE-2346 plunger installer tool, grasp plunger in tool and place spring keeper on tool. With marked tang of plunger toward side cover opening and open end of spring keeper away from side cover opening, install plungers and spring keepers in their respective barrels (Figure 2). Align plunger tang with control sleeve slot.

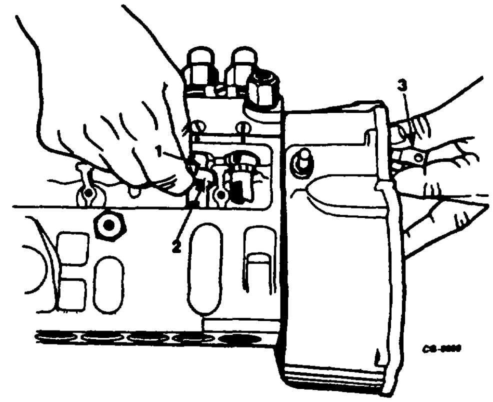

Figure 1. Installing Control Sleeves

1. Barrel **3. Rack Link**
2. Control Sleeves

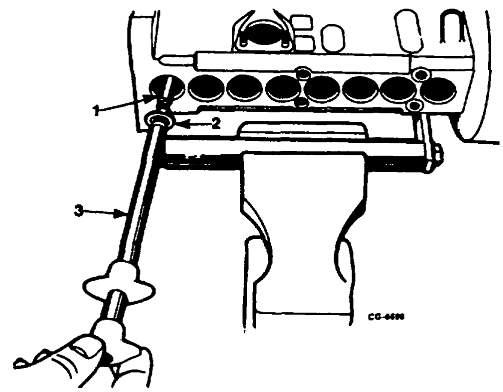

Figure 2. Installing Plungers

1. Plunger **3. Plunger Installer SE-2346**
2. Spring Keeper

12. Using SE-2345 tappet installer and noting guide slot, install tappets in their respective bores Keep roller pin flush with tappet It will be noted that lube oil supply port passes through number 5 tappet bore. The action of tappet aids oil circulation through pump housing.

13. Compress plunger springs with SE-2345 tappet installer tool and position the eight SE-2341 tappet holder tools on side of pump housing to hold all tappets in their raised position (Figure 3).

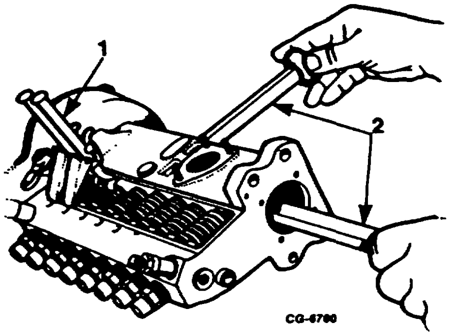

Figure 3. Installing Tappets

1. **Tappet Holder SE-2341**
2. **Tappet Installer SE-2345**

14. Place a small dab of lube on center bearing to hold it to camshaft and install camshaft into pump housing. Center bearing is positioned on bottom side of camshaft. Secure center bearing with two screws through bottom of pump housing.

NOTE: Install shoulder of center bearing towards front of injection pump.

15. Obtain new gasket and install front bearing retainer Use light lube on gasket Start all four screws to guide retainer into place, but do not use screws to draw down. Tap retainer into place while turning camshaft to assure alignment (Figure (4). Tighten mounting screw securely.

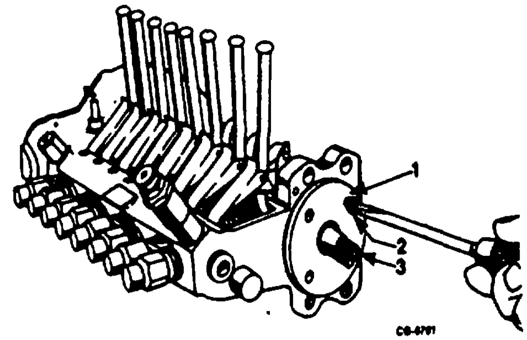

Figure 4. Installing Front Bearing Retainer.

1. **Front Bearing Retainer**
2. **Mounting Screw**
3. **Camshaft**

16. To *check camshaft end play*, screwSE-2343 holder tool onto front end of camshaft (Figure 5). Place SE-1848 dial indicator set in holder so indicator will read end play when tool handle is pulled and released. End play is .02 - .06 mm (.0008" - .0024"). Change end play by adding or removing shims behind front bearing.

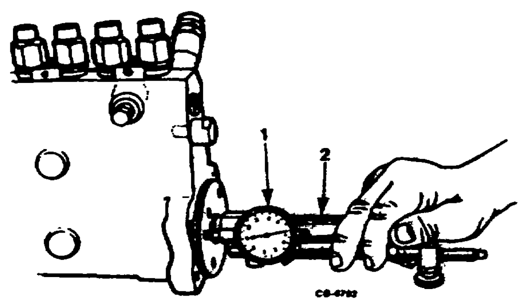

Figure 5. Checking Camshaft End Play

1. **Dial Indicator Set SE-1848**
2. **End Play Holder Tool SE-2343**

17. To check *camshaft protrusion* or space between drive coupling and main body (Figure 6), use SE-2342 protrusion gauge and depth micrometer. Place gauge over front end of camshaft and using micrometer, measure distance from surface of tool to machined surface of pump housing. Distance should be 20.7 -22.2 mm t.817" -.877"). Change camshaft protrusion by adding shims under bearing at governor end of camshaft to increase protrusion or removing shims to decrease protrusion. Maintain same thickness of shims at each end to hold correct end play.

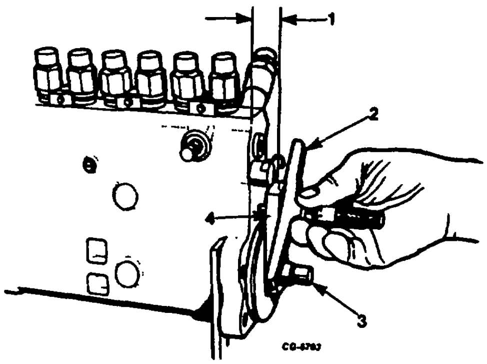

Figure 6. Checking Camshaft Protrusion

1. **Protrusion**
2. **Depth Micrometer**
3. **Camshaft**
4. **Protrusion Gauge 2342**

18. When satisfied that camshaft has sufficient end play and protrusion, recheck bearing retainer mounting screws for tightness.

19. After placing woodruff key in camshaft slot, temporarily install drive flange assembly (Figure 7), IH part number 406 419 C91. Install washer and nut, using wrench SE-2339, and tighten to 81.3 - 97.6 N-m (6072 lb-ft). Torque the socket head set screws in drive flange to 24.4 - 33.9 N-m (1&25 lb-ft).

NOTE: Temporary drive flange is used s an adapter between pump assembly and calibrating stand and will be replaced after pump has been calibrated.

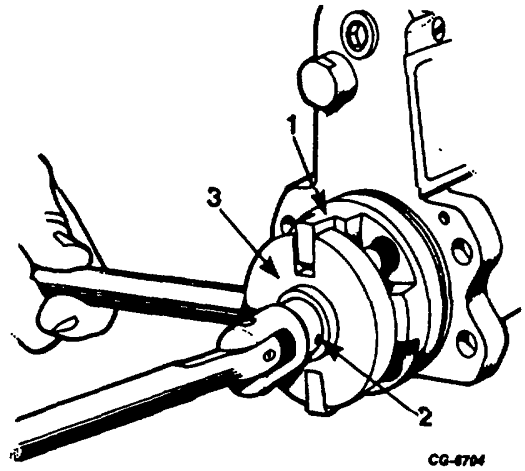

Figure 7. Installing Temporary Camshaft Flange

1. **Drive Flange**
2. **Socket Wrench**
3. **Wrench SE-2339**

20. Using camshaft cams to release pressure on the SE-2341 tappet holder tools, remove tools from side of housing.

21. Install base plugs in bottom of pump housing unit 5/8" or 11/16" socket or similar size wood dowel (Figure 8). Seat plugs so they are just past lower edge of chamfer in pump housing. To prevent leakage, install new plugs and apply thin coat of sealant to plug circumference.

22. Install new gasket and transfer pump to side of pump housing. Secure with three mounting nuts and lock washers.

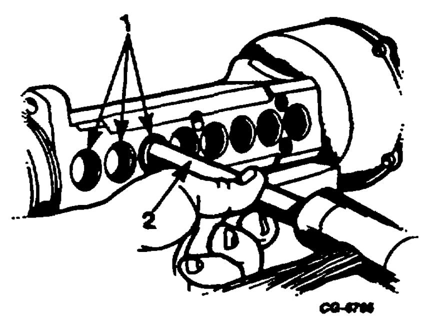

Figure 8. Installing Base Plugs

1. **Base Plugs**
2. **Wood Dowel**

GOVERNOR REASSEMBLY

1. Install reconditioned flyweight assembly to camshaft (Figure 9). Install spacer shim and secure to camshaft with slotted cylindrical nut. Use SE-2344 and SE-2339 rebuild tools. Torque nut to specifications.

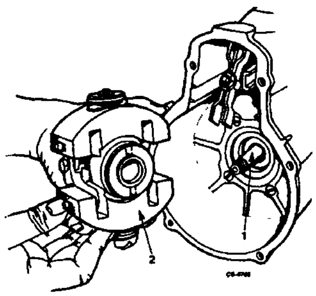

Figure 9. Installing Flyweight Assembly

1. Camshaft **2. Flyweight Assembly**

2. Check action of damper by holding camshaft, grasping weight assembly and twisting to note for slight movement Use thicker spacer shim to obtain more movement or thinner shim to decrease movement (varying spacer shim increases or decreases pressure on damper). Purpose of damper is to dampen out injection impulses from governor weights

3. Install adjusting pin guide bushing; secure bushing with two cap screws - lock screws in place with lock plate tabs

4. Install adjusting pin assembly; temporarily secure with thru-bolt at this time, since another measurement will be made later in procedure.

5. Install slider and floating lever - open slot of floating lever to right Pin floating lever to rack link to hold in place.

6. Measure "slider-to-housing" distance (Figure 10). This is made by measuring from back of slider to governor mating surface (no gasket) 38.8 mm (1.524" ± .015"). Change distance by turning screw inside of adjusting pin. One-half turn of adjusting screw moves sliding block approximately ,5 mm (.020"). Back screw out to increase distance or turn screw in to decrease distance.

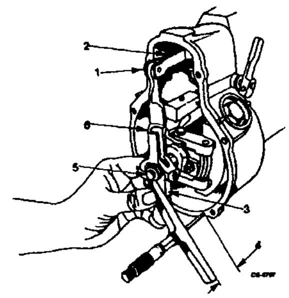

Figure 10. Measuring Slider-to-Housing Distance

1. Pin
2. Rack Link
3. Slider
4. Slider to Housing Distance
5. Adjusting Pin
6. Floating Lever

7. Secure double-nutted thru-bolt in governor weight assembly by installing lock washer and nut Bend over tabs of lock washer to secure. Operate rack back and forth to recheck all linkage for free movement

Remove seal cover from hi-idle adjusting screw locknut on governor cover and back out hi-idle adjusting screw. Hi-idle screw is removed so that control lever can be moved full forward for making next check.

Measure basic setting of S-plate (Figure 11). This is measured from governor cover surface (gasket in place) to guide pin shaft when guide pin is in maximum fuel position and bottomed in S-plate. Basic setting is 21.5 - 21.9 mm (.847" - .863").

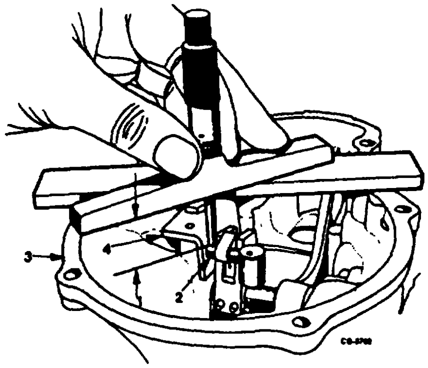

Figure 11. Measuring S-Plate Basic Setting

1. Basic Setting' Curve Plate 3. Gasket 2. Guide Pin 4.

8. Add shims under S-plate mounting to decrease basic setting or remove shims to increase basic setting (Figure 12). Check for free travel of guide pin shaft in S-plate after resetting. Check to be sure cotter pin has been used to secure pin between rack link and floating lever.

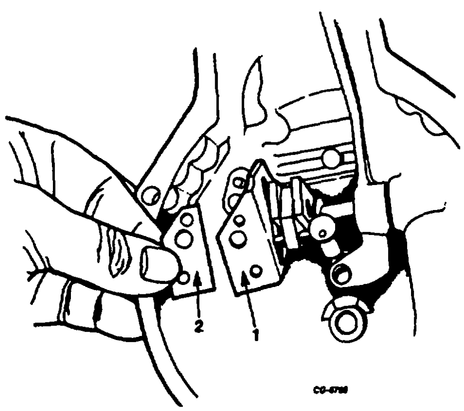

Figure 12 Locating for S-Plate Shim Adjustment

1. S-Plate 2. Shim

9. Install governor cover to housing. When installing, apply small dab of lube to floating block to hold hollow end up and note that floating block enters floating lever. Operate control lever to facilitate installation. Secure cover with six cover screws.

10. Install guide bolt in rear of governor cover. Apply Loctite hydraulic sealant to threads before installing.

11. If governor control lever and/or accelerator lever assembly were removed, reinstall at this time as follows:

a. Install woodruff key and governor control lever on shaft and tighten securely.

b. Install accelerator lever assembly on shaft (Figure 13) and tighten securely.

12. Position control lever fully back against lo-idle stop screw.

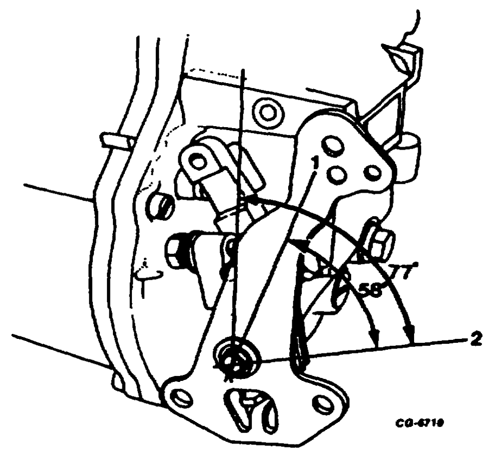

Figure 13. Location for Accelerator Lever Assembly

1. Full Load Position 2. Low Idle Position

13. Insert control rack stop assembly (with stop shackle) into governor housing. Rotate rack stop assembly approximately 45 degrees in the counter-clockwise direction (from installed position). Slide rack stop assembly into governor housing until stop shackle clears governor floating lever, then rotate rack stop assembly 45 degrees clockwise to the horizontal position.

14. Move control lever to the vertical position.

15. Using a hook made from light wire, reach down through adjustment access hole and lift stop shackle up to engage slot in stop shackle with .rocker arm pin. (See Figure 14). In some cases, it may be easier to lift stop shackle with hook engaged at rear of mating flange or in slot of stop shackle.

NOTE: To ease this operation, interior of governor housing can be lighted by removing seal wire and plug from governor adjustment access cover on side of governor housing and inserting penlight through access hole.

16. After stop shackle is engaged with rocker arm pin (Step 15), push rack stop assembly into position against governor housing and secure with two mounting screws.

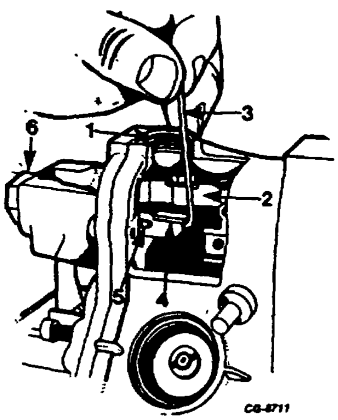

Figure 14. Engaging Stop Shackle to Rocker Arm Pin (Governor Housing Cut Away for Illustration)

1. Adjustment Access Hole
2. Rack Link
3. Wire Hook
4. Stop Shackle
5. Rocker Arm Pin
6. Rack Stop Assembly

Check rack stop assembly as follows:

a. Hold accelerator lever fully forward. This should place rack in excess fuel (starting) position with adjustment screw of rack link resting on top of mating flange on stop shackle. (See Figure 15).

b. Slowly move fuel shut-off lever to rear. If installation is correct, a distinct "click" will be heard as rack moves back from excess fuel position and adjustment screw on rack link engages with rear edge of mating flange on stop shackle. (See Figure 16).

c. If correct positions of parts (steps a and b) cannot be obtained ("click" is not heard), check for proper engagement of slot in stop shackle to rocker arm pin. If necessary, loosen rack stop assembly mounting screws and connect stop shackle to rocker arm pin per Step 15.

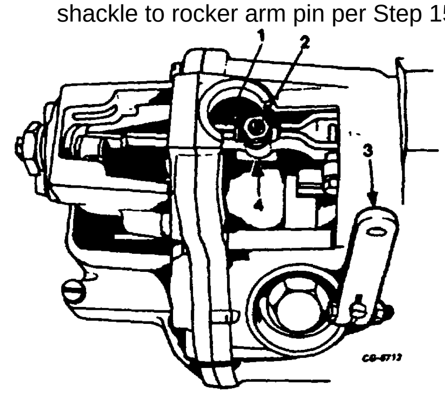

Figure 15. Rack Link and Stop Shackle in Excess Fuel (Starting) Position (Governor Housing Cut Away for Illustration)

1. Rack Link
2. Adjustment Screw Resting on Top of Mating Flange
3. Shut-Off Lever
4. Stop Shackle

NOTE: Confirmation of rack positions can be made by observing end of rack through plug hole in front (drive end) of pump housing. At maximum position, rack should extend approximately 9.5 mm (.375") forward of threaded guide bushing on front of pump housing. At full load fuel position, end of rack should lie approximately 3.2 mm (.125") inside of threaded guide bushing on pump housing. (See Figure 17).

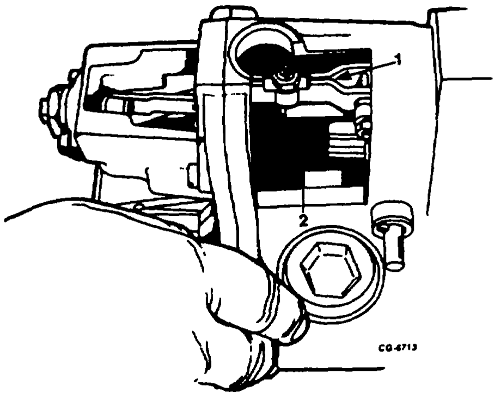

Figure 16. Rack Link and Stop Shackle in Full Load Fuel Position (Governor Housing Cut Away for Illustration)

1. Rack Link **2. Stop Shackle**

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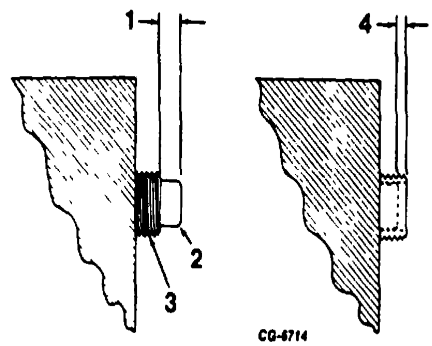

Figure 17. Rack Positions for Confirming Proper Stop Shackle Installation

1. **Rack in Maximum Position**
2. **Rack**
3. **Guide Bushing**
4. **Rack Position, Inside of Guide Bushing**

Further reassembly including side cover plate, hi idle adjusting screw and miscellaneous locks, seals, etc. cannot be completed until after pump is calibrated.

Pump is now ready for mounting to calibrating stand.

INJECTION PUMP CALIBRATION

Following injection pump or governor service and overhaul, the pump must be recalibrated to establish correct internal timing, fuel delivery and governor operation. It is also recommended that pump calibration be checked on a calibrating stand anytime the injection pump is removed to perform engine service operations.

> **IMPORTANT**
>
> **FOR PROPER INJECTION PUMP OPERATION IT IS NECESSARY THAT CALIBRATION AND ADJUSTMENT CHECKS ARE PERFORMED IN SEQUENCE, AS OUTLINED IN THIS SECTION.**

Calibrating Stand

Calibrating stands SF,414 (5.59 kW/7.5 hp) or SE-2333 (5.59 kW/7.5 hp) are recommended. Other stands can be used providing they can be adapted accordingly. (Calibrating stand SE-2414 is shown in Figure 1).

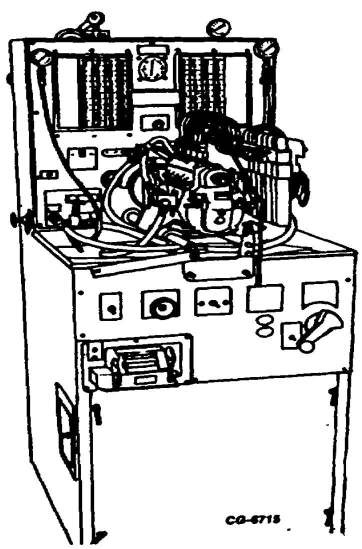

Figure 1 . Injection Pump Calibrating Stand (SE-2414)

Accessory set SE-2415 (Figure 2) and SE-2415-4 are required to adapt calibrating stands SE-2414 or SE-2333 for testing the model PES8A95 injection pump and ROV governor.

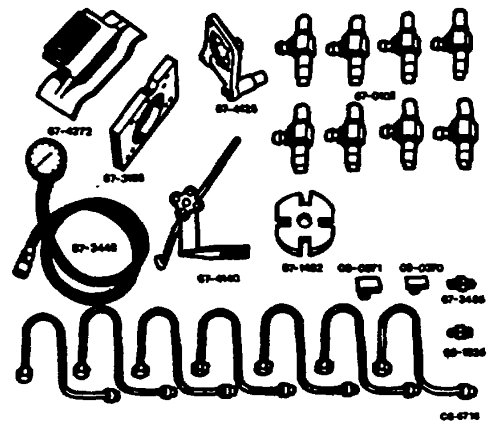

Figure 2. Calibrating Stand Accessory Set (Se-2415)

Legend for Figure 2

Code No.	Quantity	Description
67-4272	1	Bracket, Flange Mtg
67-3166	1	Plate, Adapter
67-4125	1	Bracket, Support
67-0102	1	Test Nozzle Set
67-3448	1	Gauge (0100 psi)
67-4140	1	Throttle Positioner
67-1462	1	Disc, Drive
67-0100	8	Tubes, Bleed Off
03-0371	1	Elbow
03-0370	1	Elbow
67-3456	1	Fitting, Disconnect
67-5650	8	Fuel Lines (SE-24154)
03-1535	1	Connector

Additional items required for mounting the injection pump on the calibrating stand are (1) transfer pump-to-injection pump fuel line and fittings made locally and (2) modified Injection pump-to-engine adapter (IH part number 391 983 C1) and (3) injection pump coupling IH part number 406 419 C91.

Calibrating Stand Maintenance

The calibrating stand must be kept in good operating condition. Maintenance checks and lubrication of test stand components must be performed periodically to assure satisfactory results.

Calibrating oil must be of the specified type. Calibrating oil and filters must be changed regularly. Transfer pump must maintain minimum specified pressure since injection pump calibration depends upon correct calibrating oil pressure.

To assure uniform delivery, calibrating stand test nozzles should be tested for balance (equal delivery) every six months or whenever 200 pumps have been tested. The method for balancing the test nozzles is as follows:

a. Adjust all test nozzles to specified test nozzle opening pressure. (See CALIBRATING CHART.)

b. Install an injection pump on calibrating stand.

c. Perform the "Maximum Fuel Delivery Check" and record amount of fuel obtained from No. 1 pumping element.

d. Install each of the remaining test nozzles in the No. 1 nozzle position and note delivery from each nozzle. If necessary, adjust nozzle opening pressure to obtain same flow as recorded for nozzle No. 1 (step c). Nozzles must be balanced to within 0.5 cm^3 per 1000 strokes.

e. After nozzle balance (uniform delivery) has been obtained, recheck opening pressure of all nozzles. If nozzle opening pressure is not within specified limits, nozzle should be repaired or replaced.

Mounting Pump On Calibrating Stand

Before mounting injection pump on calibrating stand, make sure pump can be rotated. This is especially important where pump has been overhauled, tappets replaced, etc. Tappet adjustment could be so high that control tangs on plunger will hit bottom of barrel.

a. Assemble flange mounting bracket and support bracket from accessory set to rails of calibrating stand.

b. Install pump-to-engine adapter on pump housing. Assemble adapter plate from accessory set to adapter on pump housing.

c. Place drive disc from accessory set on tangs of pump drive coupling.

d. Mount injection pump assembly on mounting brackets. Rotate test stand drive to align tangs on drive coupling with slots in drive disc.

Slide pump forward to engage drive tangs. Bolt adapter flange to flange mounting bracket, see Figure 3. After pump is mounted, rotate-test stand and pump two or three revolutions by hand to check for binding.

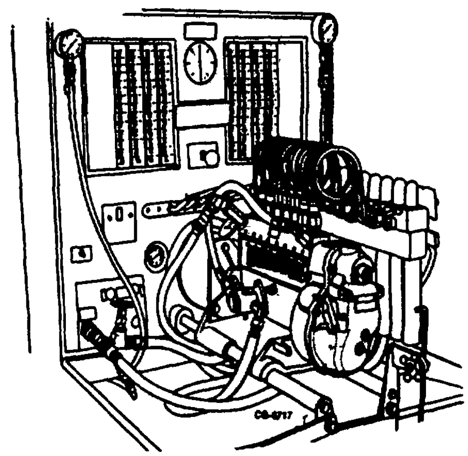

Figure 3. Injection Pump Mounted in Calibrating Stand

e. Attach supply and return (low pressure) lines between injection pump and calibrating stand (Figure 4). If possible use transparent hoses for both inlet and return lines so that condition of oil can be observed as it flows through pump. This will assure operator that pump is receiving a solid charge of calibrating oil.

f. Pre-lubricate' injection pump assembly by pouring 59.2 cc (2 oz.) of engine oil over tappets and 240.0 cc (8 oz.) into governor housing.

1. Install Dial Indicator

Remove rack end cap from front of pump and install rack gauge (dial indicator SE-2121) as shown in Figure 5.

Zero dial indicator as follows:

a. Loosen mounting bolts of external rack stop bracket and remove bracket

b. Use a pull back spring to hold fuel shut off lever to rear holding rack back against internal rack stop.

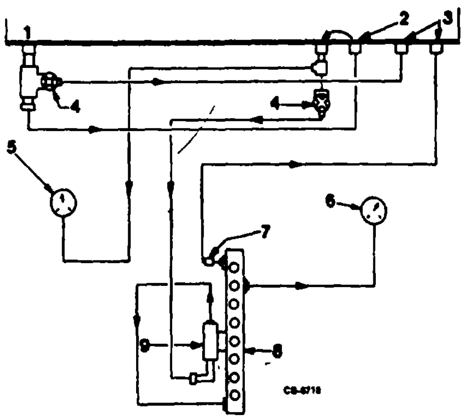

Figure 4. Calibrating Stand Low Pressure Plumbing

1. **Inlet**
2. **Final Filter**
3. **Outlet**
4. **Valve**
5. **Supply Pressure Gauge**
6. **Transfer Pressure Gauge**
7. **Pressure Regulator Valve**
8. **Injection Pump**
9. **Transfer Pump**

c. Zero dial indicator and secure in position.

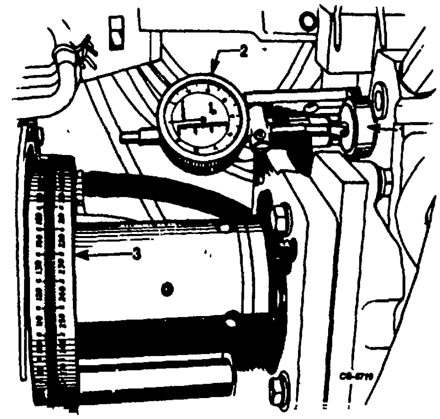

Figure 5. Installing Rack Gauge (Dial Indicator)

1. **Rack Gauge Holder SE-2119**
2. **Dial Indicator SE-2121**
3. **Degree Wheel Index**

Establishing Initial Plunger Lift (Pre-Stroke) For No. 1 Pumping Element

a. Remove delivery valve holder, filler, spring, gasket and delivery valve assembly from No. 1 pumping element.

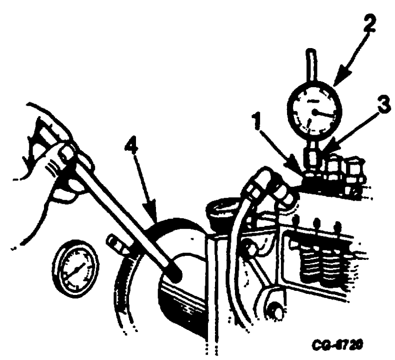

Figure 6. Establishing Initial Plunger Lift (No. 1 Pumping Element)

1. **Delivery Valve Holder (Modified Locally)**
2. **Dial IndicatorSE-2121**
3. **Fuel Line Nut (Modified Locally)**
4. **Degree Wheel Index**

b. Install dial indicator holder and SE-2121 indicator with 4.45 cm (1-3/4") stem extension in No. 1 bore (Figure 6). Extension should bear on top of plunger.

A satisfactory indicator holder can be made locally from an extra delivery valve holder (IH number 1 700 575 C1), a nut from injection line and an O-ring gasket to fit threaded bore of line nut. Drill a 8.0 mm (5/16") diameter hole in delivery valve holder to receive indicator stem extension. Also drill a 9.5 mm (3/8") diameter hole in line fitting nut to receive indicator shank. To assure tight grip on indicator, use two O-rings or countersink holder 6.5 mm (1/4") with 9.5 mm (3/8") drill.

When installing indicator, torque indicator holder into pump 29.8 33.9 N-m (22-25 lb. ft.) to prevent barrel from loosening.

c. Place control rack in start fuel position as follows: 1. Move control lever fully forward.

d. Move control lever forward until rack dial indicator reads 17.217.5 mm (.677".689") and secure lever. (Start fuel position).

e. Bar calibrating stand over by hand to rotate pump camshaft in normal direction of rotation (clockwise as viewed from drive end of pump) until No. 1 plunger is at bottom dead center (base circle of cam). Zero prestroke dial indicator.

f. Continue barring calibrating stand in direction of normal pump rotation until dial indicator reads specified plunger lift of 2.6 mm (.102").

g. Set calibrating stand degree wheel at zero.

h. Remove prestroke dial indicator and holder and reinstall delivery valve seat (without needle), gasket and delivery valve holder (without spring and filler) in No. 1 pumping element

2. Phasing the Pump (Low Pressure Method)

This is an actual fuel flow test performed on the injection pump to establish the precise start of injection for each of the eight plungers in firing order.

Check start of delivery (port closing) on No. 1 element as follows:

a. With rack at Start Fuel position and with delivery valve needle, spring and filler removed from No. 1 element, install drip spout (made from used injection line) in No.1 pumping element (Figure 7).

NOTE: Where high pressure delivery equipment is available on calibrating stand, the delivery valves do not have to be removed.

b. Install fuel supply and return lines to pump and turn on test stand fuel supply. Adjust supply pressure to obtain 35 kPa (5 psi) at fuel gallery. Check at bleeder valve' port on right front comer of pump housing.

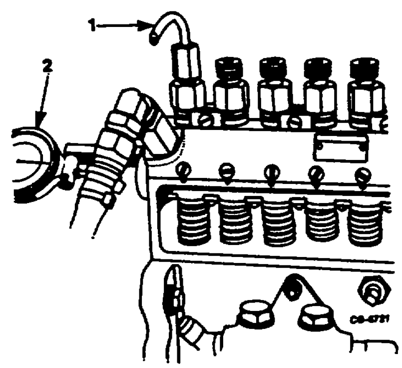

Figure 7. Checking Start of Delivery (No. 1 Pumping Element)

1. Drip Spout **2. Rack Gauge**

c. Turn pump camshaft (clockwise as viewed from drive end) until fuel flows freely from drip spout. Continue to rotate camshaft clockwise slowly until fuel flow from drip spout decreases to one drop every 3 to 5 seconds (This indicates port closing or start of delivery for No. 1 element)

d. If port closure or start of delivery does not occur at the degree wheel zero mark, adjust tappet screw so that port closing of No. 1 element and zero mark on degree wheel will coincide.

Using tappet adjusting wrenches (SE-2347) adjust tappet setting as follows: (Figure 8).

If port closing occurs before degree wheel zero mark, loosen locknut and turn tappet screw "in". If port closing occurs after zero, turn tappet screw "out". One flat of tappet screw equals approximately 2 degrees travel at degree wheel. Tighten locknut and repeat test after adjustment.

e. Turn off test stand fuel flow; remove drip spout and reinstall delivery valve needle, spring, filler and delivery valve holder to No. 1 element.

f. Remove delivery valve needle, spring and filler from No. 8 element and install drip spout.

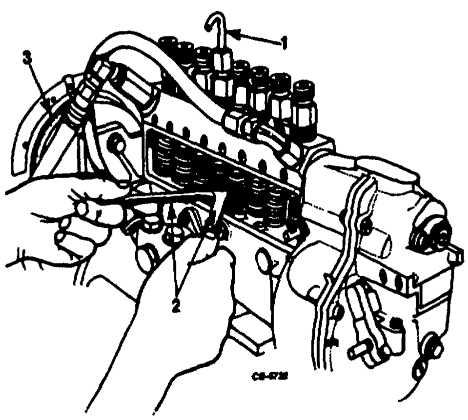

Figure 8. Adjusting Tappet Setting

1. **Drip Spout**
2. **Tappet Adjusting Wrenches (SE-2347)**
3. **Degree Wheel**

g. Turn test stand fuel on. Fuel should now flow from drip spout in No. 8 element.

h. Turn pump camshaft clockwise by hand and watch for port closing or start of delivery for No. 8 element (as indicated at drip spout) when camshaft has been turned to 45 degree mark. If it doesn't, tappet screw must be adjusted per step "d".

If port closing occurs early, turn tappet adjusting screw into roller tappet; if port closing occurs late, turn tappet adjusting screw "out".

i. Continuing in firing order, go on to No. 7 element and remaining elements in 45 degree increments on degree wheel and repeat the steps as covered above for No. 8 element. When all 8 elements have been similarly checked, the pump can be considered in phase

3. Pump-to-Calibrating Stand Installation Check

When all phasing and tappet setting has been completed and delivery valve assemblies, gaskets, springs, filters and delivery valve holders have been reinstalled and properly torqued, the pump can now be made ready for the operating tests (Figure 9).

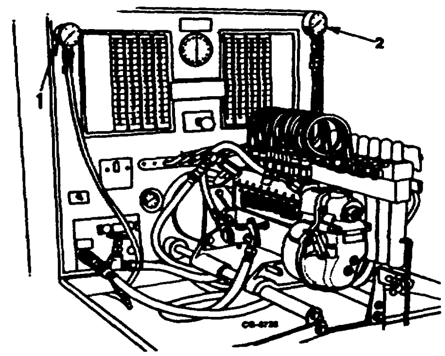

Figure 9. Calibration Stand and Injection Pump Ready for Operation

1. **Stop Shackle**
2. **Rocker Arm pin**

a. When sure test stand nozzles are set for correct opening pressure, install injection lines from accessory kit between injection pump and test nozzles and connect fuel supply lines.

b. Check governor assembly for correct installation of rack stop shackle as follows:

1. Place control lever in full forward position and lock in place.

2. Pull shutoff lever slowly to rear until click is heard. **NOTE**: Click indicates that rack link adjustment screw has engaged with stop shackle. If click is not heard, observe rack gauge for visible evidence of rack engagement.

3. Recheck rack stop shackle installation if rack is not engaged.

c. Start drive motor and operate stand at 1400 RPM.

d. Note that fuel is injecting to all eight injection assemblies.

e. Note that transfer pressure gauge shows gallery pressure being maintained to specifications. If not, check and correct as needed.

f. Should no adjustment be necessary, proceed to next step.

4. Check Governor Preliminary Cut-Off (Governor Internal Adjustment)

With control lever assembly in full forward position and hi-idle stop screw removed, rack position should be 20.0 - 21.0 mm (.787"- .827") as shown on dial indicator prior to start.

Operate calibrating stand at 1420 RPM and observe rack position. Rack position should be 15.2 - 17.8 mm (.599" - .700") as shown on dial indicator.

If preliminary governor cut off does not come into effect within specifications, corrective adjustments inside governor housing are made as follows:

a. Remove seal wire and governor access plug from side of governor housing.

b. Check control rack and governor assembly for binding and correct if needed.

c. Adjust cut-off by increasing or decreasing pretension of governor weight spring Use SE-2348 governor spring adjusting wrench on cylindrical nut to make this adjustment (Figure 10).

To raise governor cut-off, pre-tension is increased; to lower governor cut-off, pre-tension is decreased. "Cam" nut is self-locking but must be turned in 1/2 or 1/4 turns (see Note) to assure its being in locked position. Preload of governor springs should be one complete (360’) turn (optimum position) plus or minus one "click" from flush on eash side. Alter preload range as required.

NOTE: For older-type governors one "click" represents 180’ (1/2 turn). For newer-type governors one "click" represents 90’ (1/4 turn).

d. Spring set may be one-half turn out of balance with opposite set if necessary to obtain desired governor cut-off.

e. If specified governor cut-off can not be obtained by adjusting preload, remove adjusting nut, spring seat and intermediate spring. Add or remove intermediate spring shims on both sides to achieve specified control rack position and recheck.

f. If specified governor cut-off cannot be obtained by steps c, d or e, recheck "slider to housing" and "S-plate" basic dimensions

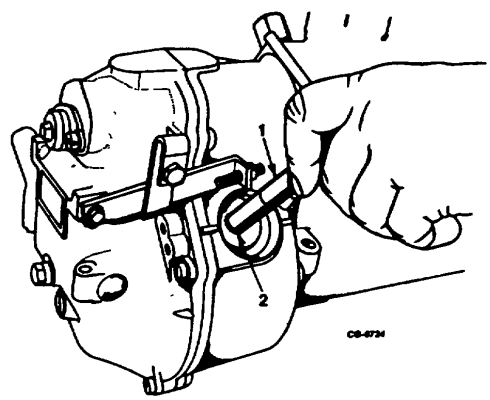

Figure 10. Making Preliminary Governor Cut-Off Adjustment

1. **Adjusting Wrench SE-2348**
2. **Governor Cut-Off Adjusting Nut**

5. Check Governor Cut-Off (Governor External Adjustment)

Install hi-idle stop screw and operate test stand, with control lever assembly in full load position (fully forward), at 1450-1460 RPM. Check rack setting on dial indicator and compare with specifications given on CALIBRATION CHART.

If rack is not positioned within specified limits, make hi-idle adjustments (Figure 11) as follows:

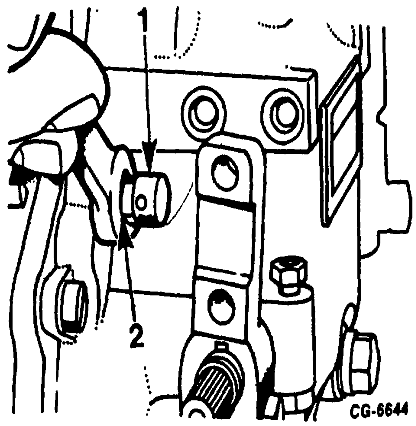

Figure 11. Adjusting Hi-Idle Rack Position

1. Hi-Idle Stop Screw 2. Lock Nut

a. Loosen locknut and turn hi-idle stop screw with wrench counterclockwise to decrease rack dimension, or clockwise to increase rack dimension.

b. Tighten locknut and recheck rack dimension.

6. Governor Performance at No-Load (Hi-Idle) Check

Operate test stand, with control lever assembly in full load position (fully forward), at specified RPM listed on CALIBRATION CHART and observe rack position. Rack position should be 4.0 t 0.1 mm (.157" t .003") as shown on dial indicator.

If specified rack position is unattainable, recheck governor cut-off (internal adjustment) and governor cut-off (external adjustment) calibrations

7. Governor End Regulation Check

Operate test stand at 1650 RPM with control lever assembly in full load position (fully forward) and observe rack position. Rack position should be 1.0 mm (.039") or less.

If specified rack position is unattainable, recheck governor cut-off internal adjustment and governor external adjustment calibration

8. Governor Lo-Idle Regulation Check

Operate test stand at 325 RPM with control lever assembly in lo-idle position (fully back). Adjust lo-idle stop screw (Figure 12) to a rack position of 7.0 7.3 mm (.275" .287") as shown on dial indicator.

Increase test stand speed to 670 750 RPM and observe rack position. Rack position should be 2.0 t 0.1 mm (.078" ± .004").If rack is not positioned within limits, make governor adjustments as follows:

a. Remove adjusting nut (count clicks to flush), spring seat and outer spring. Add or remove outer spring shims to achieve specified control rack position.

b. To increase rack position shims must be added and to decrease rack position shims must be removed. Add or remove same shim pack on both sides.

c. Install outer spring, spring seat, adjusting nut, preload governor springs to initial setting from flush position and recheck.

d. If specified rack position cannot be obtained by steps a, b and c, recheck ."slider to housing" and "S-plate" basic dimensions.

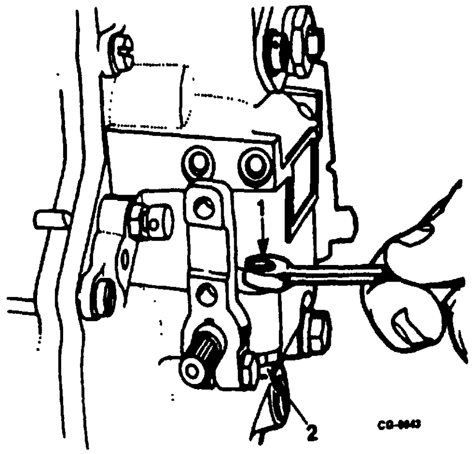

Figure 12. Adjusting Lo-Idle Position

1. Lo-Idle Stop Screw 2. Lock Nut

9. Lo-Idle Back-Up Check

Operate test stand at 325 RPM with control lever assembly in lo-idle position (fully back). If needed, adjust lo-idle stop screw to a rack position of 7.0-7.3 mm (.275" -.287") as shown on dial indicator.

Decrease test stand speed to 100 RPM. Rack position should be 8.9 mm (.350"') or *greater* as shown on dial indicator.

If rack is not positioned as specified, repeat governor low-idle regulation test and recheck lo-idle back-up.

10. Adjust Full Load Fuel Setting and Balance Delivery

This is an operating test to assure that the injection pump provides the proper quantity of fuel at full load setting and at the same time provides a balanced fuel delivery between pumping elements. Test and adjustment is made as follows:

a. Operate test stand at 1400 RPM with control lever in full load position (fully forward) and note rack position as shown on dial indicator.

b. Loosen rack stop assembly lock nut (Figure 13) and adjust control rack, with adjusting stud, to specified rack dimension (see CALIBRATION CHART).

c. Operate test stand for fuel delivery at 1400 RPM for 1000 strokes. Read and record flow to each of the eight graduates.

d. If average fuel delivery for all pumping elements and imbalance between individual pumping elements do not meet specifications (see CALIBRATION CHART), adjust affected elements (see Balanced Delivery Adjustment Procedure).

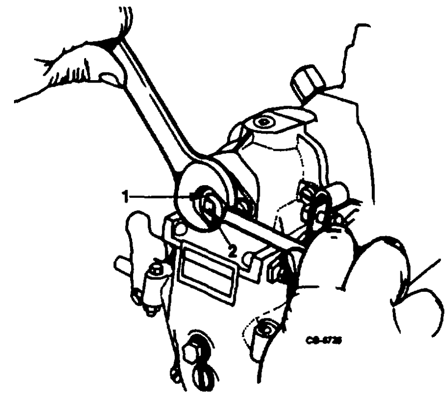

Figure 13. Adjusting Full Load Fuel Setting

1. Lock Nut 2. Adjusting Stand

Balanced Delivery Adjustment Procedure

If fuel flow of one or more pumping elements are not within specified balance limits given on CALIBRATION CHART, adjust affected *elements as* follows: (See Figure 14).

a. Loosen clamping screw of toothed quadrant.

b. Turn control sleeve and plunger with awl or small hex-key wrench.

c. To increase flow from element, turn control sleeve to rear (counterclockwise).

d. After checking balance and setting delivery quantity, the clamping screw of toothed quadrant on each element should be marked with a scribe. Mark each element once.

NOTE: Balance should be maintained to as close a tolerance as Is reasonably possible to prevent readjustment in later tests.

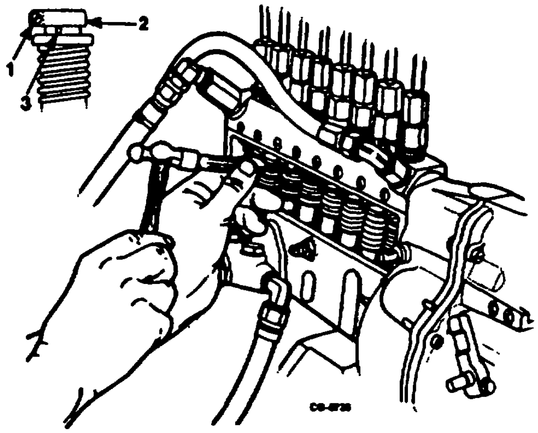

Figure 14. Adjusting for Balanced Delivery

1. **Clamping Screw**
2. **Delivery Control Sleeve**
3. **Control Sleeve Indent**

11. Fuel Delivery at Lo-Idle Check

This is an operating test to assure that the injection pump provides the proper quantity of fuel at lo-idle. Test and adjustment are made as follows:

a. Operate test stand at 325 RPM with control lever in lo-idle position (fully back) for 1000 strokes.

b. Record fuel delivery from elements and compare results with specifications given on CALIBRATION CHART.

c. Check balanced delivery between pumping elements and compare imbalance with specifications given on CALIBRATION CHART.

d. Adjust fuel delivery and imbalance at control sleeves (see Test 10).

12. Check Fuel Delivery at 800 RPM

This is an operating test to assure proper pump and governor operation. Perform the test as follows:

a. Operate stand at 800 RPM with control lever locked in full load (fully forward) position for 1000 strokes.

b. Record fuel delivery from elements and check for balanced delivery between pumping elements and compare with specifications given on CALIBRATION CHART.

c. If fuel delivery exceeds maximum specification, governor and/or injection pump is malfunctioning. Repair as required.

13. Check Fuel Shut-Off

This adjustment is made to protect pump internal stop and rack from damage. Adjustment is made by loosening stop bracket against which shut-off lever will strike (Figure 15). Operate shut-off lever to rear and hold in this position (rack against internal stop). Reposition external stop lever bracket so that shut-off lever will contact bracket stop screw just before rack would be stopped by the internal stop. , Rack setting (dial indicator reading) with rack against internal stop should be between 05 to 1 mm (.020" - .040").

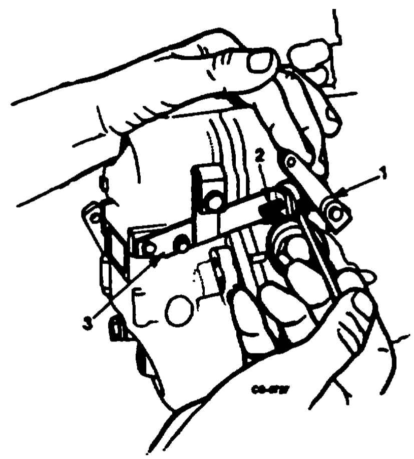

Figure 15. Adjusting External Stop Bracket

1. **Shut-Off Lever**
2. **Stop Screw**
3. **Stop Bracket**

14. Check Start Fuel Cut-Out

This is an operating test made to assure that control rack will move from start fuel to full load fuel position at specified pump speed. Adjustment is made by varying the height of the rack link adjustment screw.

Increase test stand speed slowly from 50 RPM and simultaneously operate control lever between lo-idle and hi-idle stops until cut-out occurs and observe test stand speed. Test stand speed should be between 205 - 265 RPM.

If specified test speed is not obtained, reposition rack link adjusting screw height as follows: (See Figure 16).

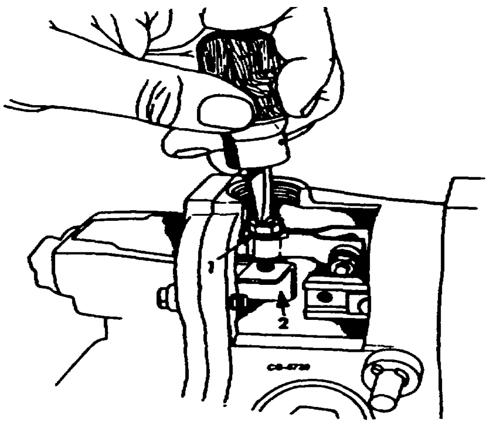

Figure 16. Adjusting Excess Fuel Rack Position
(Governor Housing Cut-Away for Illustration)

1. Adjustment Screw 2. Stop Shack

a. Using 10 mm Allen wrench, remove plug from adjustment access hole in top of governor housing

b. Loosen adjusting screw locknut (10 mm).

c. If cut-out occurred below specified speed, turn adjusting screw counterclockwise and if cut-out occurred above specified speed turn adjusting screw clockwise.

d. Tighten adjusting screw locknut and repeat test.

e. Reinstall plug in adjustment access hole.

15. Check Start Fuel Quantity

This is an operating test made to assure that the injection pump provides the proper quantity of fuel to start the engine. Test is made as follows:

a. Remove dial indicator from injection pump and install rack end cap.

b. Operate test stand at 100 RPM with control lever locked in start position (fully forward) for 1000 strokes.

c. Record fuel delivery from elements and compare with specifications given on CALIBRATION CHART.

d. If fuel delivery does not meet minimum specifications, remove shim(s) from under screw head located at the end of control rack. If fuel delivery exceeds maximum specification, add shim(s) under screw head.

e. Install rack end cap and recheck fuel delivery.

16. Pump Static Timing Check (Drip Spout Method)

The static timing check is made to assure precise positioning of the timing scribed line on the pump drive hub in relation to timing pointer in adapter housing. This check is made at port closing or start of delivery on No. 1 pumping element.

Check timing as follows:

a. Install side cover with new gasket Remove injection pump from test stand.

b. Remove test stand drive hub from injection pump.

c. Install injection pump adapter housing with 2 bolts on right side of pump, place pump in holding fixture and clamp in vise. Remove adapter housing sight plug.

d. Install woodruff key, drive hub and nut. Torque nut to specification.

e. Remove delivery valve needle, and filler from No. 1 pumping element and install drip spout. Make drip spout locally from extra injection line and connector nut. Place a paper cup under drip spout to collect fuel flow from spout (Figure 17).

f. Install adapter hose with small fuel container to fuel inlet and charge pump fuel gallery. (Figure 17).

g. Move control lever to full load (fully forward) position and lock in place. Slowly move shut-off lever to rear. A distinct "click" will be heard as the rack moves from the start fuel to the full load position.

Lock control lever in full load position.

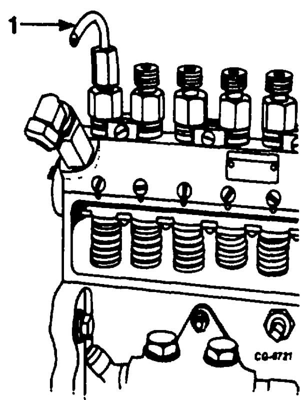

Figure 17. Checking Pump Timing

1. Drip Spout (Made Locally)

h. Rotate drive hub clockwise until fuel flow is reduced to drip at the rate of one drop every 3 to 5 seconds. This indicates port closure or start of delivery for No. 1 pumping element Check through sight hole and verify that timing pointer lines up with scribed line on hub (Figure 18). If new hub was installed, line should be scribed on hub at this time.

SEAL AND PROTECT PUMP

When injection pump overhaul and calibration have been completed, always perform the following:

1. Inspect pump for fuel and lube oil leaks and correct as necessary.

2. Be sure access plug in governor housing is tight and all other covers are in place.

3. Install anti-tamper seals on governor as required.

4. Install protective closures on both high and low pressure fuel and lube oil openings

5. Install delivery valve retainer clamp.

6. Remove pump from holding fixture and install remaining bolts in adapter housing.

Pump is now ready for installation on engine.

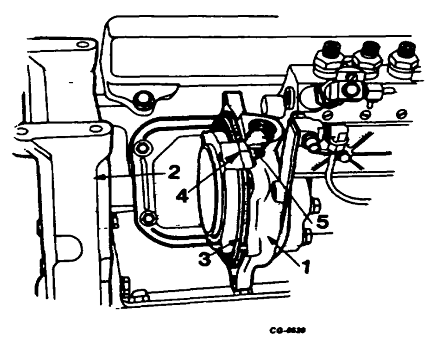

Figure 18. Timing Marks on Pump

1. Injection Pump Adapter	**3. Gasket**
2. Engine Front Cover	**4. Scribed Line On Hub**
	5. Pointer Pin

Model PES8A95 Injection Pump With RQV All-Speed Governor						
Calibrating Stand: SE-2414 or 2333				Calibrating Oil· SAE J 967D – ISO-4113		
Accessory Set. SE-2415 SE-2415-4				Test Nozzle Opening Pressure. 17235-17717 kPa (2500-2570 PSI) Balanced Flow		
Engine Model for Truck				165F		
Injection Pump Number (IH Part No.)				1 701 171 C91		
Fuel Pressure in Injection Pump Fuel Gallery				193 kPa (28 PSI) Minimum @ 2800 RPM and Full Load Rack Position		
	TEST SEQUENCE	INJECTION PUMP RPM	CONTROL LEVER ASSY. POSITION	CONTROL RACK POSITION MM (INCH)	FUEL DELIVERY CC/1000 STROKES	REMARKS AND SPECIFICATIONS
1	Zero Control Rack Position. Pre-stroke Setting	- -	Back Forward	0 17.2 - 17.5 (.677 - .689)	- -	2.6 ± 0.05 mm (.102" ± .002") Lift to port closure.
2.	Pump Camshaft Phasing	-	Forward	17.2 - 17.5 (.677 - .689)	-	45 ± 0.5° Firing Order 1-8-7-3-6-5-4-2
3.	Pump-to-Stand Check	1400	Forward	-	-	Check Fuel Flow.
4.	Preliminary Governor Cut-Off	1430	Forward (No Hi-Idle Stop)	15.2 - 17.8 (.599 - .700)	-	Rack position prior to start 20-21 mm (.787 - .827").
5	Governor Cut-Off 165 HP 180 HP	1440- 1450	Forward (Hi-Idle Screw Installed)	10.6 ± 0.1 (.417 ± .004) 11.5 ± 0.1 (.453 ± .004)		Rack position is 1 mm (.039") less than full-load rack position
6.	Governor Performance at No Load (Hi-Idle)	1545-1575	Forward	4.0 ± 0.1 (.157 ± .004)		-
7	Governor End Regulation	1640	Forward	1.0 or Less (.039 or Less)	-	
8	Lo-Idle Regulation 165 HP 180 HP	620-680 630-690	Back	2.0 ± 0.1 (0.78 ± .004)	-	Prior to test, adjust control rack to 7.0 - 7.2 mm (.275 - .283") at 325 RPM 7.3 - 7.5 mm (.287 - .295").
9	Lo-Idle Back-Up Check 165 HP (See Item 8 180 HP "Remarks")	100	Back	9.1 Min. (.358 Min.)	-	Same as Remarks in Item 8
10	Fuel Delivery at Full Load 165 HP 180 HP	1400	Forward	11.6 ± 0.1 (.456 ± .004) 12.5 ± 0.1 (.492 ± .004)	68.0 - 70.0 75.5 - 77.5	Maximum imbalance 3.0 cc/1000 strokes between pumping elements.
11	Fuel Delivery at Lo-Idle	325	Back	7.15 (Ref.) (.281)	9.0 - 15.0	Maximum imbalance 3.0 cc/1000 strokes between pumping elements.
12	Fuel Delivery Maximum Imbalance at 800 RPM 165 HP 180 HP	800	Forward	11.6 ± 0.1 (.456 ± .004) 12.5 ± 0.1 (.492 ± .004)	59.0 Maximum 69.0 Maximum	4.0 cc/1000 strokes between pumping elements.
13.	Fuel Shut-Off	-	-	.5 - 1.0 (.019 - .039)	-	Shut-off lever back against stop.
14.	Start Fuel Cut-Out	170 - 250	-	-	-	Operate lever from hi-idle to lo-idle
15	Fuel Delivery at Start	100	Forward	-	70.0 - 100.0	Rack end cap installed

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Preparation of Engine

Inspect pump mounting flange at rear of engine front cover. Also inspect injection pump stabilizer brackets and drive gear for damage or wear.

Installation Procedure

1. Secure mounting adapter and injection pump to rear of engine front cover with four mounting bolts.

2. Install stabilizing brackets to side at rear of pump housing.

3. Connect low pressure fuel inlet and return lines and lube oil line to injection pump.

4. Connect high pressure injection lines to injection pump and secure fuel line brackets.

5. Connect accelerator rod and stop control cable to governor levers.

6. Install air cleaner or manifold crossover adapter.

7. Prime fuel system.

8. Operate engine and check for fuel and lube oil leakage at injection pump.

Detailed installation instructions are covered in Engine Service Manual CGES-205-1. ***PAGE2655***

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Detroit Diesel Allison

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IMPORTANT SAFETY NOTICE

IT IS YOUR RESPONSIHILITY to be completely familiar with the warnings and cautions described in this service manual. These warnings and cautions advise against the use of specific service methods that can result in personal injury, damage to the equipment, or cause the equipment to be unsafe. It is, however, important to understand that these warnings and cautions are not exhaustive. Detroit Diesel Allison could not possible know, evaluate and advise the service trade of all conceivable ways in which service might be done or of the possible hazardous consequences of each way. Consequently, Detroit Diesel Allison has not undertaken any such broad evaluation. Accordingly, ANYONE WHO USES A SERVICE PROCEDURE OR TOOL WHICH IS NOT RECOMMENDED BY DETROIT DIESEL ALLISON MUST first be thoroughly satisfied that neither personal safety nor equipment safety will be jeopardized by the service methods selected.

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

WARNINGS, CAUTIONS, AND NOTES

Three types of headings are used in this manual to attract your attention.

WARNING is used when an operating procedure, practice, etc., which, if not correctly followed could result in personal injury or loss of life.

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

NOTE is used when an operating procedure, practice, etc., is essential to highlight.

LIST OF WARNINGS

This manual contains the following warnings. IT IS YOUR RESPONSIBILITY to be familiar with all of them.

Do not burn discarded Teflon seals; toxic gases are produced by burning.

Never dry bearings by spinning them with compressed air. A spinning bearing can disintegrate. Also, spinning a bearing without lubrication can damage the bearing.

When conducting a converter stall test, the vehicle must be prevented from moving. Both the parking and service brake must be applied and, if necessary, the vehicle should be blocked to prevent movement. Warn personnel to keep clear of the vehicle and its travel path.

Service Manual

Allison Transmissions AUTOMATIC MODELS

AT 545

1 FEBRUARY 1983

Detroit Diesel Allison
Division of General Motors Corporation
Indianapolis Indiana 46206

Printed in U.S.A.

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FOLDOUT ILLUSTRATIONS
(back of Service Manual)

Section 1. GENERAL INFORMATION

1-1. SCOPE OF MANUAL

a. Coverage. This Service Manual describes the operation, maintenance, and overhaul procedures for the AT 545 automatic transmissions. The major components of the transmissions are discussed and the function and operation of the hydraulic system and torque paths are explained. Assembly or disassembly procedures for the transmission and its components may be considered common, if not qualified. Figures 1-1, 1-2, 1-3, 1-4, 1-5, and 1-6 illustrate the transmissions.

b. Arrangement

(1) Eight sections. Eight sections are included in this manual Each paragraph and illustration number is prefixed with the applicable section number.

(2) Section content. Section 1 contains g e n e r a 1 information, specifications, and data. Section 2 describes the transmission components and explains their operation. Section 3 outlines maintenance procedures a n d includes troubleshooting data. Section 4 is general information required for overhaul Section 5 covers disassembly of the transmission into subassemblies. Section 6 covers rebuild of subassemblies. Section 7 covers assembly of the transmission from subassemblies. Section 8 covers wear limits and spring information.

(3) Foldout illustrations. Foldout illustrations at the end of this manual include across-section views of the transmissions, schematic views of the hydraulic systems, and exploded parts views which show all components in assembly relation.

c. Maintenance Information. Each task outlined in this Service Manual has been successfully accomplished by service organizations and individuals. It is not expected that every service organization or individual will possess the required special tooling, training, or experience to perform all the tasks outlined. However, any task outline herein may be performed if the following conditions are met:

(1) The organization or individual has the required knowledge of the task

(2) The work environment is suitable to prevent contamination or damage to transmission parts or assemblies.

(3) Required tools and fixtures are available as outlined in the Service Manual.

(4) Reasonable and prudent maintenance practices are utilized.

1-2. SUPPLEMENTARY INFORMATION

Supplementary information will b e issued, a s required, to cover changes made after publication of this manual.

1-3. ASSEMBLY DIFFERENCES

Assemblies within the AT Series differ slightly. Some AT 545 models include a power takeoff drive gear; some do not.

Control valves require a combination of calibrated

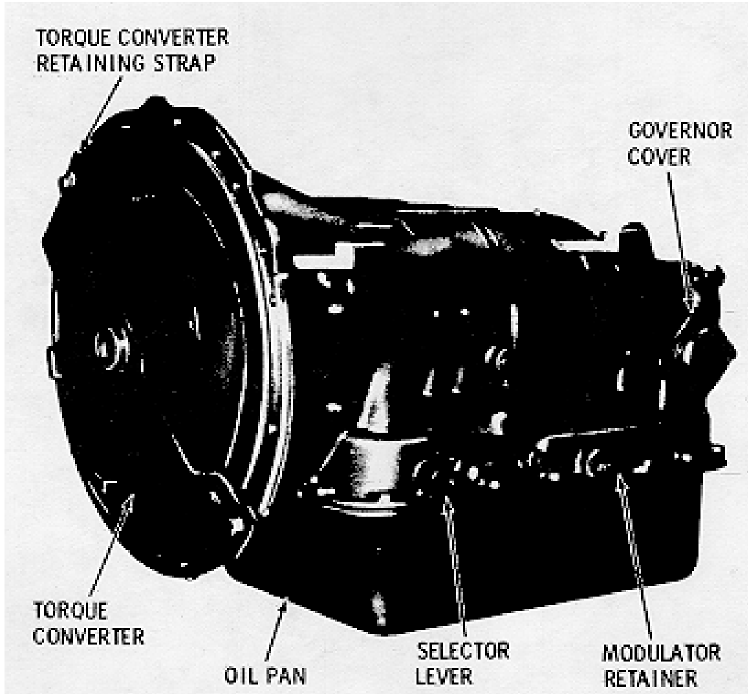

Fig. 1-5. AT 545 Automatic transmission-left-font view

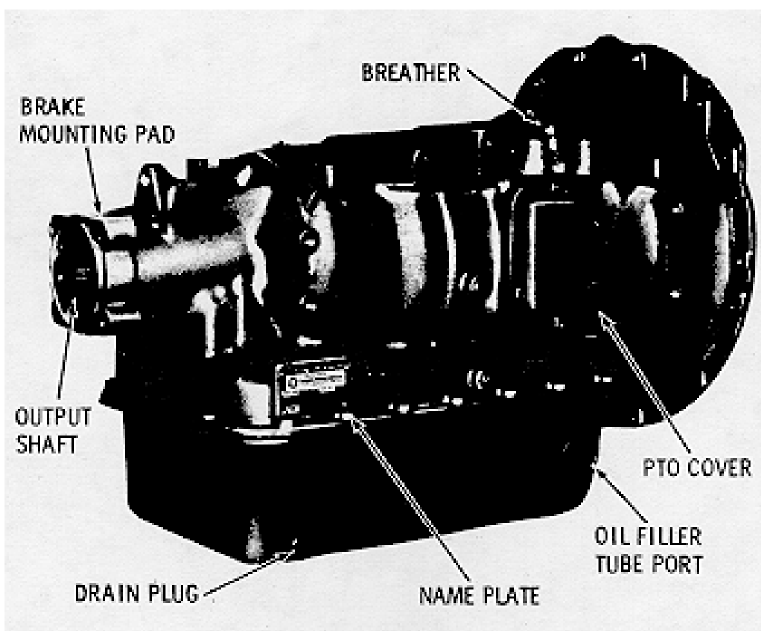

Fig. 1-6. AT 545 automatic transmission-right-rear view

springs to time the automatic shifts. Modulator valves require a mechanical actuator (diesel engine) to control modulator pressure. Explanations in Section 2 clarify the difference between a vacuum modulator and a mechanical actuator. Section 6 explains the power takeoff differences. A spring chart in Section 8 covers the selection of valve body springs.

1-4. ORDERING PARTS

a. Transmission Nameplate. The nameplate (fig. 1-7), located on the right-rear side of the transmission, includes the transmission serial number, assembly number, and model designation. All three of these must be supplied when ordering repair parts or requesting service information.

b. Parts Catalog. All replacement parts should be ordered from your dealer. These parts are listed in the current Parts Catalog (SA 1235). Do not order by illustration item numbers used in foldouts 5 through 9. Refer to Section 4 for further replacement parts information.

1-5. GENERAL DESCRIPTION OF TRANSMISSION

a. Automatic, Four Speeds. The AT 545 transmissions have four forward speeds and one reverse. Shifting within the forward ranges selected by the operator is fully automatic.

b. Torque Converter. A simple, 3-element torque converter transmits power from the engine to the transmission gearing. The torque converter serves as both a fluid coupling and a torque multiplier.

c. Planetary Gearing, Clutches. Ratios for four forward speeds and reverse are established by planetary gearing. The planetary gearing is controlled by multiple disc, hydraulic clutches. All gearing is in constant mesh.

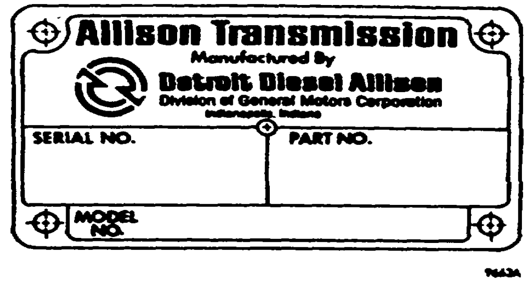

Fig. 1-7. Transmission nameplate

1-6. OPERATING INSTRUCTIONS

a. Vehicle-Related Controls. For information on controls which are related to the vehicle, refer to the vehicle service manual.

b. Neutral (N). Place the shift selector at the neutral position before starting the engine. A neutral safety switch on the transmission (or in the selector linkage) prevents starting the engine while the selector lever is not at neutral. Apply the parking brake and shift to neutral any time the engine is to be running while the operator is not at the controls.

c. Forward Drive Ranges

(1) Shifting from neutral. The engine should be at idle speed when any shift from neutral to a drive range is made.

(2) Drive (D). Drive (D) includes all four forward gears. By depressing the accelerator, the transmission will start in first gear and automatically upshift at the proper speeds through second, third, and fourth gears. Downshifts will also occur automatically in relation to speed.

(3) Drive 3 (3). In this range, the transmission will start in first gear and automatically upshift, at the proper speeds, to second and third gears.

(4) Drive 2 (2). In this range, the transmission will start in first gear and

automatically upshift, at the proper speed, to second gear.

(5) Drive 1 (1). In this range, the transmission will start in first gear. No automatic upshift will occur unless excessive speed is attained in first gear.

d. Reverse (R). To move the vehicle backward, idle the engine and shift the selector to the reverse position. Depressing the accelerator will then cause the vehicle to back up.

e. Towing. All lubricating and clutch oil is provided by the input oil pump. Because the pump location is in front of the transmission gearing and clutches, the pump cannot be motored by pushing or towing the vehicle. Therefore, any time the vehicle must be towed or pushed, the driveline must be disconnected or the driving wheels must be lifted off the ground.

f. Power Takeoff. A provision for attaching an SAE 6-bolt regular-duty power take-off is provided on the right side of the transmission main housing.

1-7. SPECIFICATIONS AND DATA

The specifications and data in the chart which follows are applicable to AT 545 transmissions.

GENERAL INFORMATION

SPECIFICATIONS AND DATA

Models	AT 545
Manufacturer	Detroit Diesel Allison Division, GM
Rating:	AT 545
input torque	385 lb ft (max)(522 N•m)
input speed	3200 rpm (max)
input horsepower (net installed)	235 hp (175 kW) (max)
Vehicle application:	
gross vehicle weight	30,000 lb (14 000 kg)
gross combined weight	30,000 lb (14 000 kg)
Mounting:	
engine	SAE 3 automotive housing
vehicle	Two side mounting pads (in addition, transmission may be overhung)
Drive	Flexplate
Rotation (viewed from input):	
input	clockwise
output (in forward ranges)	clockwise
Output location	In line with input
Dry weight (basic configuration)	275 lb (125 kg)-- AT 545
Parking brake provision	Mounting provided at rear of transmission case
Output flange	Supplied by installer
Oil capacity (less external system)	

AT 545 (deep oil pan)
20 U.S. qts (18.9 liters), initial fill as received from factory
22 U.S. qts (20.8 liters), initial fill when dry
16 U.S. qts (15 liters), refill

SPECIFICATIONS AND DATA (cont)

Temperatures:	
sump	250°F (121°C) max 100°F (38°C) min
to cooler--converter-out	300°'F (148°C) max
normal operation	160-200°F (71-98°C)
Clutches	Oil wet, hydraulic-actuated, spring-released, self-compensating for wear
Gearing	Planetary, straight-cut spur, constant mesh
Power takeoff (converter driven):	
mounting (one opening)	SAE 6-bolt regular duty
drive gear	6 pitch, 55 teeth, 20° pressure angle
location	right side, viewed from rear
rotation	same as engine
rating: (continuous)	200 lb ft (270 N•m)
(intermittent)	250 lb ft (340 N•m)
Oil filter	Integral (in sump)
Sump	Integral
Input pressure oil pump	Positive displacement
Oil type	Dexron® or Dexron® II Alternate: Type C-3
Oil pressure (Refer to paragraph 3-21)	
Converter:	
number of stages	1
number of elements	3
stall-torque multiplication:	
AT 545	2.0:1
Drive range and sequences	Reverse, N, 1-2-3-4, 1-2-3, 1-2, 1
Drive range and shift control (external)	Mechanical
Shifting mechanism (internal control)	Hydraulic

®Dexron is a registered trademark of General Motors Corporation.

SPECIFICATIONS AND DATA (cont)

Shift modulation. . . . . Vacuum or Mechanical

Neutral start and reverse signal switches . . . . Supplied by customer

Speedometer drive:

type. . . . . 13/16-20 UNEF thread for SAE regular duty -- thread type

drive gear data (cross axis). . 5 teeth, 29 normal pitch, 85°, 20', 30", left helix angle, 20° normal pressure angle

8 teeth, 20 normal pitch, 78°, 59', 42", left hand helix angle, 20° normal pressure angle

driven gear . . . . Supplied by customer

TRANSMISSION RATIOS (mechanical*)

Range	Clutch(es) Engaged	Ratio
Neutral	First	0
First	Forward and first	3.45:1
Second	Forward and second	2.25:1
Third	Forward and third	1.41:1
Fourth	Forward and fourth	1.00:1
Reverse	Fourth and first	5.02:1

*Overall torque multiplication ratio of transmission (output stalled) is the product of the converter torque multiplication ratio (see Converter, above) and the mechanical (gear) ratio.

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Section 2. DESCRIPTION AND OPERATION

2-1. SCOPE

This section describes transmission components and explains their function. The hydraulic system and torque paths through the transmission are explained.

2-2. MOUNTING

a. To Engine. The front of the transmission case is a SAE size 3 flange. This flange is bolted to the rear of the engine.

b. To Vehicle. Two 5/8-11 tapped holes in flat mounting pads at each side of the transmission, slightly behind t he engine- mounting flange provide for mounting support in the vehicle.

2-3. INPUT DRIVE

a. AT545. Six tapped lugs on the front of the torque converter provide for attachment of a flexible drive disk. The outer bolt circle of the disk is bolted to the lugs. The inner bolt circle is bolted to the engine crankshaft or crankshaft adapter hub.

2-4. TRANLSMISSION HOUSING

The transmission housing (B, foldout 8) is cast aluminum. It is machined to receive the clutches and gearing, oil pump, governor, control valve, and oil pan. A parking brake mounting surface is provided at the rear. A power takeoff mounting surface is provided on the right side.

2-5. TORQUE CONVERTER ASSEMBLY

a. AT 545. AT 545 torque converter is a closed, welded unit that cannot be disassembled (except by removing the weld metal).

c. Description. The 545 model torque converters include a pump, a turbine, and a stator. The pump is driven by the engine. The turbine drives the turbine shaft. T h e stator is mounted on a freewheel clutch, the hub of which is splined to a stationary ground sleeve. The hub of the pump drives the transmission input pressure pump.

d. Operation. (1) The torque converter assembly is continually filled with oil, which flows through the converter to cool and lubricate it. When the converter is driven by the engine, the pump vanes throw oil against the turbine vanes. The impact of the oil against the turbine vanes tends to rotate the turbine.

(2) The turbine, splined to the turbine shaft, transmits torque to the transmission gearing. At engine idle speed, the in- pact of oil against the turbine vanes is minimal At high engine speed, vehicle stationary, the impact is much greater, and high torque is produced by the turbine.

(3) Oil thrown into the turbine flows to the stator vanes. The stator vanes change the direction of oil flow (when the stator is locked against rotation), and directs the oil to the pump in a direction that assists the rotation of the pump. It is the

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redirection of the oil in a manner to assist the pump that enables the torque converter to multiply input torque.

(4) Greatest torque multiplication occurs when the turbine is stalled and the pump is rotating at its highest speed. Torque multiplication decreases as the turbine rotates and gains speed.

(5) When turbine speed approaches the speed of the pump, oil following to the stator begins striking the backs of the stator vanes. This rotates the stator in the same direction as the turbine and pump. At this point, torque multiplication stops and the converter becomes, in effect, a fluid coupling.

(6) Thus, as explained in (1) through (5) preceding, the torque converter accomplishes three main functions. It acts as a disconnect clutch because little torque is transmitted at engine idle speed. It multiplies torque at low turbine/high pump speed to g i v e greater starting or driving effort when needed. And it acts as a fluid coupling to efficiently transmit engine torque to the transmission gearing during drive, other than idle or starting.

2-6. OIL PUMP ASSEMBLY

a. Description (B, foldout 5)

(1) Oil pump assembly 2 includes, in addition to pump components, a front support assembly 17 and main-pressure regulator components 24 through 27.

(2) The oil pump consists mainly of an eccentric driven gear 9 and drive gear 10 which are located in pump body 8. Pump body 8 is bolted to front support and bearing assembly 16.

(3) The front support assembly includes stator shaft 19. Front support 21 is the member which closes the front of the transmission and supports the torque converter, input shaft, and forward clutch.

b. Operation (B, foldout 5)

(1) When the torque converter is rotating, its rear hub drives pump drive gear 10. Gear 10 is meshed with t h e internal teeth of driven gear 9. Gear 9 is eccentric from gear 10.

(2) A crescent-shaped projection in pump body 8 fills the space between the external teeth of drive gear 10 and the internal teeth of driven gear 9, opposite the point where the gears mesh. As the gears rotate, oil is drawn into a port near the unmeshing teeth and carried to a port near the remeshing teeth. The remeshing teeth force the oil out of the pump and into the hydraulic system.

(3) Refer to paragraph 2-18, following, for further explanation of the oil pump, in relation to the hydraulic system.

2-7. POWER TAKEOFF

NOTE

The power takeoff is converter driven. It can be operated while the vehicle is standing or moving.

a. Engagement. To e n g a g e the power takeoff, apply the vehicle brakes to prevent the vehicle moving and shift to any selector position other than neutral This stops the rotation of the PTO drive gear in the transmission. Then engage the power takeoff. If engagement is prevented by the gear teeth not meshing properly, release the brakes a n d allow the vehicle to creep slightly-or shift the selector to neutral and then back into gear.

CAUTION

The PTO unit should never be engaged by clashing the gear teeth. This may damage the PTO Unit and the transmission PTO drive gear teeth. This could result in further damage to the transmission and PTO.

b. Neutral operation. To operate the power takeoff while the vehicle is standing, shift the transmission to neutral after engagement of the power takeoff. Then, increase engine speed until the desired power takeoff operating speed is obtained.

c. Disengagement after neutral operation. To disengage the power takeoff after operation with the vehicle standing, release the throttle, allow the driven equipment to come to a stop, and then disengage the power takeoff.

d. Operation with vehicle in motion. To operate the power takeoff during movement of the vehicle (after engagement as described In a above), shift to the desired range and drive the vehicle. The speed of the power takeoff during this period of operation will always maintain a direct relation to vehicle speed. Power takeoff speed will decrease in relation to vehicle (transmission output) speed as shifts to higher ranges occur. The following chart shows these relations.

Gear	PTO DRIVE GEAR SPEED (X transmission output speed)
First	3.45
Second	2.25
Third	1.41
Fourth	1.00
Reverse	5.02

e. Disengagement after operation with vehicle in motion. When operating the power takeoff while the vehicle is moving, . the power takeoff may be disengaged whenever it is no longer required. When there is no load on the power takeoff gear, it can be pulled out of engagement.

2-8. FORWARD CLUTCH AND TURBINE SHAFT

a. Description (A, foldout 6) (1) The forward clutch and turbine shaft assembly connects the converter turbine to the other clutches and gearing in the transmission. T he output from the converter must be transmitted by the turbine shaft during every operational phase of the transmission, including PTO operation.

(2) The turbine s h a f t is splined to clutch housing 8. The external tangs of clutch plates 21 engage slots in housing 8. The internal splines of clutch plates 22 en- gage hub 20, that transmits torque to the gearing.

(3) Piston 13 is installed in a bore in housing 8 and is retained by sixteen release springs 14, retainer 15, and snapring 16. Clutch plates 21 and 22 are held in housing 8 by fourth clutch driving hub 23, retained by snapring 24.

(4) Transmissions are available with or without power takeoff drive gear 3 or 26. When used, gear 26 is splined to housing 8 a n d retained by one snapring 25. Earlier models use gear 3, splined to housing 8 and retained by snaprings 2 and 4.

b. Operation (A, foldout 6)

(1) The turbine shaft and housing 6 rotate when the torque converter turbine rotates. Fourth clutch driving hub 23 also rotates and rotates Internal-splined plates (B, foldout 6) of the fourth clutch. PTO drive gear 3 or 26 (A, foldout 6), when included, also rotates.

(2) When hydraulic pressure is directed to the piston bore in housing 8 (A, foldout S), piston 13 compresses clutch plates 21 and 22 against driving hub 23. This locks clutch hub 20 to housing 8. Hub 20 is splined to transmission main shaft 4 (B, foldout 7).

(3) When the converter turbine rotates and the forward clutch is applied, the transmission m a i n shaft is rotated. This drives the transmission gear set, and will drive the output shaft in any forward gear depending upon which additional clutch is engaged.

(4) The forward clutch is engaged only during operation in a forward gear, and is always paired with another clutch (either first, second, third, or fourth). It is released during neutral and reverse operation.

(5) In neutral, t h e forward clutch housing can rotate to drive the power take- off. In reverse. its housing can rotate to drive the fourth clutch (which is applied in combination with the first clutch to obtain reverse gear).

2-9. FOURTH CLUTCH

a. Description (B, foldout 6)

(1) The fourth clutch includes housing assembly 11, piston 8, five external-tanged clutch plates 4, five internal-splined plates 3, and backplate 2.

(2) Piston 8 is installed in a bore in housing 13, and retained by sixteen return springs 7, retainer 6, and snapring 5. External-tanged plates 4 engage slots in housing 13. Internal-splined plates 3 are splined to fourth clutch driving hub 23 (A, foldout 6). Plates 3 and 4 (B, foldout 6) are retained in housing 13 by clutch backplate 2 and snapring 1.

(3) The central hub of housing 13 is splined to sun gear shaft 3 (B, foldout 7). The outer splines on housing 13 (B, foldout 6) engages internal-splined plates 3 (A, foldout 7) of the third clutch.

b. Operation (B, foldout 6)

(1) When t h e fourth clutch is released, internal-splined plates 3 are free of external-tanged p1 a t e s 4. This permits plates 3 to rotate independent of housing 13, whether housing 13 is stopped or has a different speed or direction of rotation.

(2) When hydraulic pressure is directed to the piston cavity in housing 13, piston 8 compresses plates 3 and 4 against backplate 2. T h i s locks internal-splined plate.3 .to-external-tanged plates 4 and, in turn, to housing 13.

(3) Thus, when the fourth clutch is engaged, it is locked to fourth clutch driving hub 23 (A, foldout 6) and must rotate with the turbine shaft when the forward clutch is engaged. This condition exists only during fourth gear and reverse gear operations.

(4) In fourth gear, the purpose is to transmit turbine shaft rotation to sun gear shaft 3 (B, foldout 7) while the same rotation is being transmitted to transmission main shaft 4 by the engaged forward clutch. The result is direct drive to the output shaft. (5) In reverse gear, the purpose is to transmit turbine shaft rotation to sun gear shaft 3 (B, foldout 7) while the first clutch (A, foldout 8) is engaged. The result is re- verse rotation o f the transmission output shaft.

2-10. SECOND, THIRD CLUTCHES AND CENTER SUPPORT

a. Description (A, foldout 7)

(1) The second and third clutches are identical, and positioned back-to-back in the transmission housing. The third clutch is forward of the center support assembly. The second clutch is behind the center support assembly.

(2) The third clutch includes items 1 through 12 (A, foldout 7). The second clutch includes items 16 through 25. Center support assembly 13 serves the two clutches jointly. The front side of support 15 is bored to receive third clutch piston 9. The rear side of support 15 is bored to receive second clutch piston 18. Center support 15 includes passages which direct oil to both these clutches, as well as a passage to serve the fourth clutch. The fourth clutch passage directs oil to the support hub, where oil is directed to fourth clutch housing 13 (B, foldout 6) which rotates on the hub.

(3) External-tanged clutch plates 4 (A, foldout 7) and 23 engage slots in the transmission housing, and are always stationary. Internal-splined plates 3 of the third clutch engage housing 13 (B, foldout 6) of the

fourth clutch. Internal-splined plates 24 (A, foldout 7) of the second clutch engage external splines of front planetary assembly 8 (B, foldout 7).

b. Operation of Third Clutch (A, foldout 7)

(1) W hen the third clutch is released, internal-splined plates 3 can rotate freely. This permits fourth clutch housing 13 (B, foldout 6) to rotate. The third clutch is released in all gears except third.

(2) When hydraulic pressure is directed to t h e third clutch piston cavity (front) of center support 15 (A, foldout 7), piston 9 compresses plates 3 and 4 against backplate 2. This anchors clutch plates 2, 3, 4 and fourth clutch housing 13 (B, foldout 6) to the transmission housing, stopping rotation. Since housing 13 is splined to sun gear shaft 3 (B, foldout 7), the shaft is also held stationary. This provides a reaction for the gearing and causes the gears to produce third gear (input torque for the gearing comes through the engaged forward clutch and transmission main shaft).

c. Operation of Second Clutch (A, foldout 7)

(1) W he n the second clutch is re- leased, internal-splined plates 24 are free to rotate. Plates 24 are splined to front planetary carrier assembly 8 (B, foldout 7) that is, thus, also f re e to rotate. The second clutch i s released during operation in all gears except second.

(2) When hydraulic pressure is directed to the second clutch piston cavity (rear) of center support 15 (A, foldout 7), piston 18 compresses plates 23 and 24 against backplate 25. Backplate 25 reacts against the transmission housing. This anchors internal-splined plates 24, and external-tanged plates 23 to the transmission housing.

(3) The internal-splines of plates 24 are splined to front planetary carrier assembly 8 (B, foldout 7), holding the carrier stationary. A compound arrangement in the gearing produces second gear (input torque comes through the turbine shaft, the engaged forward clutch, and the transmission main shaft).

2-11. FIRST CLUTCH

a. Description (A, foldout 8)

(1) The first clutch includes piston 9, seven external-tanged clutch plates 4, seven internal-splined clutch plates 3, and back- plate 2.

(2) Piston 9 is positioned in a bore in the rear of the transmission housing. The external tangs of clutch plates 4 engage the slots in the transmission housing and are always stationary. Internal-splined plates 3 engage rear planetary ring gear 5 (or 53 in B, foldout 7 for earlier models).

(3) Piston 9 (A, foldout 8) is retained in the transmission housing by twenty-two return springs 8, retainer 7, and snapring 6. Backplate 2 and clutch plates 3 and 4 are retained in the transmission case by snapring 1.

b. Operation (A, foldout 8)

(1) When the first clutch is released, internal-splined plates 3 are free to rotate. This leaves rear planetary ring gear 5 free to rotate. The first clutch is released during operation in all gears except first and re- verse. It is engaged during operation in neutral, first gear, and reverse.

(2) When hydraulic pressure is directed to the first clutch piston cavity (in the transmission housing), piston 9 foldout 8) compresses clutch plates 3 and 4 against backplate2.Thislocks internal-splined plates 3 to external-tanged plates 4, which a reanchored to the transmission housing. Plates 3, splined to rear planetary ring gear 5, hold the ring gear stationary.

(3) The stationary ring gear provides a reaction for the planetary gearing to produce either first gear or reverse, depending

upon the driving member in the gear set. In first gear, the driving member is rear planetary sun gear 31 (B, foldout 7), which receives torque through the turbine shaft, the engaged forward clutch, and the transmission main shaft.

(4) In reverse gear, the driving member is center sun gear 19 (B, foldout 7), which receives torque through the turbine shaft, t he engaged fourth clutch, and sun gear shaft 3. First gear is a simple planetary action (involving only one planetary). Reverse gear is a compound planetary action (involving two planetary sets).

2-12. PLANETARY GEA R UNIT

a. Description (B, foldout 7)

(1) The planetary gear includes all of the gears and shafts in the transmission, except the turbine shaft and the rear planetary ring gear.

(2) Three planetary gear sets are in- c 1 u d e d in the assembly. These, because the in functions overlap, are called simply front planetary, center planetary, and rear planetary. The planetary sets are so designated because of their location in relation to the transmission and to each other.

(3) The front planetary includes sun gear 6, carrier assembly 8, and ring gear 18. The center planetary includes sun gear 19, carrier assembly 20, and ring gear 30. The rear planetary includes sun gear 31 and carrier assembly 36.

(4) The three planetary sets are interconnected by sun gear shaft 3, main shaft 4, and connecting drum 28. This interconnection of the planetary input, reaction, and output elements, and connection of clutches to the shafts and planetary elements, produces four forward speeds and reverse.

b. Operation (B, foldout 7)

(1) The front planetary, in conjunction w i t h the center planetary, produces second gear when the forward and second clutches are engaged (fig. 2-3).

(2) The center planetary is active in second, third, and reverse gears. In second gear it is compounded with the front planetary as described in (1), above.

(3) The center planetary produces third gear when the forward and third clutches are engaged (fig. 2-4).

(4) The center planetary is locked up along with the front and with the rear planetaries to produce fourth gear when the forward and fourth clutches are engaged (fig. 2-5).

(5) The center planetary is compounded with the rear planetary to produce reverse gear when the fourth and first clutches are engaged (fig. 2-6).

(6) The rear planetary is active in first and reverse gears.

(7) The rear planetary is locked up with the front and center planetaries to produce fourth gear as explained in (4), above.

(8) The rear planetary is compounded with the center planetary to produce reverse gear as explained in (5), above.

(9) The rear planetary acts alone to produce first gear when the forward and first clutches are engaged (fig. 2-2).

NOTE

In fourth gear, because both the forward and fourth clutches are engaged, all three planetaries rotate as a unit. This gives direct drive through the transmission.

2-13. SPEEDOMETER DRIVE

a. Description (B, foldout 9)

(1) The speedometer drive consists of drive gear 2, and provision for mounting

the driven gear assembly in the transmission case.

(2) Drive gear 2 is a worm type, with a left-hand helix. It is concentric with t h e transmission output shaft. Having no key or drive splines, the drive gear is clamped between adjacent components for rotational drive.

b. Operation (B, foldout 9). When the transmission output shaft rotates, drive gear 2 rotates. The driven gear, supplied by the vehicle manufacturer, rotates clockwise during forward operation (viewed at drive cable connection on transmission).

2-14. GOVERNOR

a. Description (B, foldout 8). Governor assembly 17 is a centrifugal (flyweight) governor, rotated by drive gear 1 (B, foldout 9), mounted on the transmission output shaft. It is retained in the transmission case by cover 21 (B, foldout 8).

b. Operation (B, foldout 8). When the governor rotates, centrifugal force causes t he governor weights to move outward. Their outward movement pushes a valve into the governor body. The valve admits oil to the governor circuit. When oil is admitted, governor pressure increases. In turn, when governor pressure increases, the governor valve is pushed back against the weights. Governor pressure is regulated when the push of the weights is balanced by the opposite push of governor pressure. Thus, governor pressure varies with transmission output speed, increasing as output speed in- creases. Governor pressure, in combination with modulator pressure (para 2-14, below) controls automatic shifting of the transmission gears. Refer also to paragraph 2-17g, h, **i,** k, and L

2-15. VACUUM AND MECHANICAL MODULATOR

a. Vacuum Modulator (B, foldout 8)

(1) Vacuum modulator 26 (B, foldout 8) is a unit assembly calibrated and sealed at the factory. It contains a spring and diaphragm which is responsive to vacuum. A vacuum line from the engine intake manifold is connected to the shell of the modulator. Evacuation of air causes the diaphragm to depress the diaphragm spring. Movement of the diaphragm actuates the modulator valve through an actuator pin in the control valve body assembly.

(2) Vacuum varies with vehicle speed, 1 o a d, and engine throttle opening. The position of the diaphragm in the modulator varies with vacuum. When the diaphragm moves, now in the modulator valve is affected, thereby affecting modulation pressure. Modulator and governor pressures control the automatic selection of transmission ranges Refer to paragraph 2-14, above, for the explanation of the governor. Refer to paragraphs 2-18 g, _h, _k, and L

b. Mechanical Modulation

(1) Mechanical modulation i s required when the transmission is coupled to a diesel engine. Mechanical modulation is used because the diesel engine is incapable of producing a suitable control vacuum. The modulator unit is attached to the transmission and activated by a cable.

(2) The cable is connected to the fuel control lever at one end and the modulator valve mechanical actuator at the other. With the actuation of the accelerator, the fuel control lever moves the cable, thereby mechanically controlling the modulator valve. The valve requires no force at engine idle and a 13.5 to 15.5 lb (60 to 69 N) force at full throttle.

2-16. CONTROL VALVE ASSEMBLY

a. Description (A, foldout 9). Control valve body assembly 1 includes the various valves, springs, and other components which c on t r o 1 the selection of ranges, and the automatic selection of gears. T h e valve body assembly is bolted to the bottom of the transmission housing, which is channeled to direct the now of oil between the valve body and clutches and other components.

b. Operation. Refer to paragraph 2-18 for operation of control valve body assembly.

2-17. OIL PAN AND OIL FILTER

a. Description (B, foldout 9)

(1) Oil pan 23 or 28 is a pressed steel assembly providing openings for draining oil and for mounting a combination oil filler tube and dipstick-type oil level checking gage. The oil pan is the oil sump for the transmission and bolts to the bottom of the transmission housing.

(2) Oil filter assembly 19 is a paper element retained by a steel casing. It maintains the same filtration as the earlier steel shelled, fine-mesh screen filter, but it has ten times the filter area. The new filter does not have an integral oil filter tube.

(3) Sump oil is drawn through the filter by the input oil pump and directed to the hydraulic system. A washer-head screw (shallow pan) or a bolt and washer (deep pan), attaches the oil filter to the valve body. Deep pan units also use spacer 18 and a longer intake pipe 17 between the filter and the valve body.

b. Function (B, foldout 9)

(1) Oil pan 23 or 28 holds the entire oil supply for the transmission and covers the control valve body assembly and the oil filter. The oil pan is removed to replace the oil filter.

(2) The oil filter assembly screens all oil entering the hydraulic system.

2-18. HYDRAULIC SYSTEM

a. System Functions. The hydraulic system generates, directs, a n d controls the pressure and f 1 o w of the hydraulic fluid within the transmission. The hydraulic fluid (transmission oil) is the power transmitting medium in the torque converter. Its velocity drives the torque converter turbine. Its flow cools and lubricates the transmission. Its pressure applies the clutches.

b. System Schematic Illustration (fold-outs4). A foldout illustration, representing the system in action, in neutral, with the engine idling, is presented at the back of this manual It may be folded o u t for reference in connection with the study of text covering the hydraulic system.

c. Oil Filter, Pump Circuit (foldouts 3, 4). Oils drawn from the sump (transmission oil pan) through a fine-mesh filter screen by the input-driven pressure pump. Oil, discharged by the pump, flows into t h e bore of the main-pressure regulator valve. A by pass returns oil to the pump intake when main pressure is excessive.

d. Main-Pressure Circuit (foldouts4)

(1) Main pressure is regulated by the main-pressure regulator valve. Oil from the pump flows into the bore surrounding the valve, into an internal passage of the valve, and to the upper end of the valve. Pressure at t he upper end of the valve forces the valve downward until oil flows to the torque converter and, if pump flow is of sufficient volume, to the bypass . Spring pressure, below the valve, balances oil pressure above it.

(2) The main oil passage to the remainder of the hydraulic system is connected to the main-pressure regulator valve bore at the same point as the pump outlet.

(3) Although main pressure is con- trolled primarily by the force of the spring below the regulator valve, two other factors influence main pressure. These are modulator pressure and neutral, for- ward regulator pressure The presence of either w ill 1 reduce main pressure. Further explanations of the effects of these two pressures are made in paragraphs covering the selector valve and the modulator pressure valve.

(4) Increased main pressure was introduced on the AT 545 by removing modulated pressure at the main regulator valve. With throttle modulated main pressure removed, a constant main pressure schedule is maintained throughout the entire throttle range of the transmission. This provides for increased clutch capacity resulting in less slippage and plate wear.

e. Converter, Cooler, Lubrication Circuit (foldouts 3, 4)

(1) This circuit originates at the main-pressure regulator valve. Converter-in flows to the torque converter. Oil must flow through the converter continuously to keep it filled, and to carry off the heat generated by the turbulence of the oil

(2) Converter-out oil, leaving the torque converter, flows to an external cooler (supplied by vehicle or power unit manufacturer). A flow of air or water over or through the cooler removes the heat from the transmission oil

(3) Lubrication oil leaving the cooler is returned to the transmission and directed to points requiring a continuous flow to lubricate components. Lubrication oil returns, finally, to the transmission sump.

f. Selector Valve; Neutral Forward Regulator Circuits (foldouts 3, 4)

(1) The selector valve is manually shifted to select the operating range de sired. It can be shifted to any of six positions These are: neutral (N), reverse (R), drive (D), drive 3, drive 2, and drive 1. At each of these positions, the selector valve establishes the hydraulic circuit for operation in the condition indicated.

(2) Drive 1, drive 2, drive 3, and drive are forward ranges, in which the highest gear attainable (by automatic up- shifts) is indicated by the number in the range The lowest gear attainable in each is first gear. Any time the vehicle starts off in any of these four ranges, it is in first gear. Shifting within any range is automatic, depending upon speed and throttle position.

(3) The neutral, forward regulator pressure is directed from the selector valve to the main-pressure regulator valve when the selector valve is at any position except reverse. In neutral, and all forward drive ranges, this pressure pushes downward on the main-pressure regulator valve, and reduces main pressure. In reverse, the regulator pressure is absent, permitting a higher main pressure.

g. Governor Valve, Governor Circuits (foldout 3, 4)

(1) Governor feed is merely main pressure directed to t he governor valve. A centrifugal-type governor, driven by the transmission output, controls the position of the governor valve. The position of the governor valve determines the pressure in the governor circuit). When the transmission output is not rotating, governor pressure is negligible. When the transmission output rotates, governor pressure varies with the speed of rotation. The greater the speed of rotation, the greater is governor pressure.

(2) Governor pressure
is directed to the 1-2, 2-3, and 3-4

shift valves. The action of governor pressure in automatic upshifts and downshifts is explained in., k, and below.

h. Modulator Pressure Valve Circuit (foldout4)

(1) Modulation pressure is, a regulated, -- reduced pressure de- rived from main pressure at the modulator pressure valve. The valve is moved right- ward by a spring at the left end of the valve when the actuator pin pressure is released. Pressure is applied by a mechanical actuator (diesel engine). At high vacuum, all pressure is removed from the actuator pin allowing the valve to move rightward. Low vacuum increases the pressure on the actuator pin, due to the overpowering spring in the vacuum modulator, forcing the valve leftward The actuator pin movement for the mechanical actuator fluctuates according to throttle position. Opening the throttle applies pressure to the actuator pin, and pushes the valve leftward (decreasing modulator pressure). Closing the throttle re- moves pressure from the actuator pin, and permits the valve to move rightward (in- creasing modulator pressure).

(2) Thus, when the modulator pressure valve moves to the left, modulator pressure is reduced; when it moves to the right, modulator pressure is increased. Since engine vacuum varies with load, throttle opening, and engine speed, the position of the modulator pressure valve and modulator pressure vary also. On the AT 545, this varying pressure is directed to the three shift signal valves, and to the trimmer regulator valve.

(3) At the 1-2, 2-3, and 3-4 shift signal valves, modulator and governor pressures act on calibrated areas to upshift the valves against calibrated springs. Each of the shift valves and springs are calibrated to ensure that the valves will shift in proper sequence. At a given governor pressure, an increase In modulator pressure will upshift a signal valve. A decrease in modulator pressure will cause a downshift if governor pressure alone will not hold the valve upward.

(4) At t h e main-pressure regulator valve, modulator pressure (foldout 3) exerts a downward force on the valve. An increase in modulator pressure causes a decrease in main pressure; a de- crease in modulator pressure causes an in- crease in main pressure. Thus, under full- throttle conditions, main pressure is higher to prevent clutch slippage.

(5) modulator pressure is directed to a calibrated area on the trimmer regulator valve, exerting an upward force against its spring. This causes a reduction in trimmer regulator pressure at -the trimmer valves. Refer to o, below, for explanation of the trimmer regulator valve.

i. Clutch Circuits Drive Ranges (foldout4)

(1) There are five clutches in the transmission. These are: first clutch, second clutch, third clutch, fourth clutch, and forward clutch. The clutches are applied for various conditions, as follows:

Condition	Clutch(es) applied
Neutral	First
First gear	First and forward
Second gear	Second and forward
Third gear	Third and forward
Fourth gear	Fourth and forward
Reverse	First and fourth

(2) Each of the five clutches has its own circuit. Each clutch except the forward clutch is connected to a relay valve and a trimmer valve. The forward clutch is connected directly to the selector valve and does not connect to a trimmer valve. It does dot require connection to a trimmer valve because its application (except In a

neutral-to-first gear shift) precedes the application of an additional clutch, which is trimmed.

(3) The first clutch circuit connects the clutch to the 1-2 relay valve and to the first clutch trimmer valve. In neutral, the 1-2 relay valve is held upward by spring pressure, and main pressure is directed to the clutch circuit. The 1-2 relay valve cannot move downward unless the 1-2 signal line is charged. This will not occur in neutral (vehicle standing) because there is no governor pressure to shift the 1-2 signal valve. Only the first clutch is applied, so the transmission output cannot locate since two clutches must be applied to transmit power (refer to fig. 2-1).

(4) The four trimmer valves all function in a similar manner. They differ only in calibration. Refer to m below, for explanation of the trimmer.

(5) The first clutch, in addition to being applied during neutral operation, is applied a 1s o in first and reverse gears. Shifting the selector valve from neutral (N) to drive (D4) or to any other drive range (D3, D2, or D1) charges the forward clutch circuit and applies the forward clutch. The first clutch remains charged. Shifting the selector valve f r o m neutral to reverse (R) charges the fourth clutch, while the first clutch remains applied.

(6) Movement of the selector valve determines the highest gear which will be normally reached automatically. In drive (D), automatic 1-2, 2-3, and 3-4, shifts can occur. In drive 3, automatic 1-2 and 2-3 shifts can occur. In drive 2, an automatic 1-2 shift can occur. In drive 1, no upshift can occur unless overspeed occurs. Automatic downshifts can occur within the selected ranges.

(7) The various drive ranges limit the highest gear attainable by introducing a pressure which prevents rear governor pressure from upshifting the signal valves (unless output shaft rpm exceeds full-load governed engine speed by approximately 7?%). This pressure is a regulated, reduced pressure derived from main pressure at the hold regulator valve. Main pressure is directed to the hold regulator valve through the hold feed line when the selector valve is at drive 3, drive 2, or drive 1 position. The pressure produced in the hold regulator valve is directed to the 3-4 shift signal valve when the selector valve is at drive 3. The hold pressure is directed to the 2-3 and 3-4 shift signal valves when the selector valve is at drive 2 position. The pressure is directed to all three shift signal valves (3-4, 2-3, and 1-2) when the selector valve is at drive I position.

(8) Hold regulator pressure at each shift signal valve will push the upper valve upward, and raise the pressure at which the lower valve will be pushed upward by rear governor pressure. Thus, when hold regulator pressure is present, an upshift can occur at that shift signal valve, but only at an elevated speed.

i. Automatic Upshifts (foldout ' 4)

(1) When the transmission is operating in first gear, with the selector valve at drive (D), a combination of governor pressure and modulator pressure, or governor pressure alone, will upshift the transmission to second gear. At closed, or part throttle, modulator pressure exists and will assist governor pressure. At full throttle, there is no modulator pressure. Thus, upshifts occur sooner when the throttle is closed or delayed by opening the throttle.

(2) Governor pressure i s dependent upon the rotational speed of the transmission output. The greater t h e output (vehicle) speed, the greater is governor pressure. When governor pressure is sufficient, the first upshift (1-2) will occur. A further increase in governor pressure (and vehicle speed) will cause a 2-3 upshift. A still further increase in governor pressure will cause a 3-4 upshift. Note that each of these upshifts will be either delayed or hastened by the decrease or increase, respectively, of modulator pressure.

(3) In other drive ranges, the same upshift sequence occurs until the highest gear attainable in that range is reached (i (6), (7), above).

(4) In a n y automatic upshift, the shift signal valve acts first. This directs a shift pressure to the relay valve. The relay valve shifts, exhausting the applied clutch and applying a clutch for a higher gear.

k. Automatic Downshifts (foldout4)

(1) Automatic downshifts, like up- shifts, are controlled by governor and modulator pressures. Downshifts occur in sequence as governor pressure and/or modulator pressures decrease. Low modulator pressure (open throttle) will h a s t e n the downshift; high modulator pressure (closed throttle) will delay downshifts.

(2) In any automatic downshift, the shift signal valve acts first. This exhausts the shift signal holding the relay valve downward. The relay valve then moves up- ward, exhausting the applied clutch and applying the clutch for the next lower gear.

L Downshift Inhibiting (foldout. , 4)

(1) Inherent in the system, as a result of valve areas and pressure calibrations, is a means for preventing downshifts at a too rapid rate. For example, if the vehicle is traveling at high speed in fourth gear (4) and the selector valve is inadvertently shifted to drive 1, the transmission will not immediately shift to first gear. Instead, it will shift 4-3-2-1 as speed decreases (it will remain in fourth gear if speed is not decreased sufficiently to require an automatic downshift).

(2) The progressive downshift occurs because the regulated hold pressure is calibrated, along with the valve areas, to shift the signal valves downward against governor pressure only when the governor pressure decreases to a value corresponding to a safe downshift speed. Thus, if speed is too great, governor pressure is sufficient to hold the shift signal valve upward against drive 3, drive 2, or drive 1 pressure (all of which are the regulated holding pressure originating in the hold regulator valve). As governor pressure decreases, shift signal valves (3-4, 2-3, 1-2) move downward in sequence.

m. Trimmer Valves (foldout.4)

(1) There are four trimmer valves in the hydraulic system. These are: first clutch trimmer, second-clutch trimmer, third-clutch trimmer, and fourth-clutch trimmer. The purpose of a trimmer is the initial application of a clutch at reduced pressure, followed by a gradual increase in apply pressure to maximum. This method of clutch application is necessary to avoid harsh shifts.

(2) All four trimmers function in the same manner. Each trimmer includes (from top to bottom) an orificed trimmer valve, a valve plug, a plug spring or springs, and a stop. The plug spring or springs (calibrated for each trimmer) push and hold the valve plug and trimmer valve to the top of the valve bore. With the exception of trimmer regulator pressure applied to the first and second clutch trimmer valves and the no trimmer action for reverse gear (AT 545), the function of the trimmer is as described in (3), below. The trim regulated first and second clutch trimmers and the no reverse trimmer action is an described in (4) and (5), below.

(3) When any clutch (except for- ward) is applied, apply pressure is sent also to the upper end of the trimmer valve. Initially, the valve and plug are forced downward against the plug spring until oil escapes to exhaust. This escape of oil, as long as it continues, reduces clutch apply pressure. However, oil flows through an orifice in the trimmer valve to the cavity between the trimmer valve and plug. Pressure in this cavity forces the plug farther downward, to the stop. The plug stops, and flow through the orifice in the trimmer valve stops. Pressures above and below t he trimmer valve equalize. The pressure below the trimmer valve, because it is acting upon a greater diameter, pushes the

trimmer valve to the top of the valve bore. This throttles, then stops, the escape of oil to exhaust. When escape of oil is throttled, clutch apply pressure rises When escape of oil stops, clutch apply pressure is at maximum value. The p 1 u g remains downward, against the stop, until the clutch is released.

(4) The second clutch trimmer valve is regulated by a calibrated spring and trimmer regulator pressure at the bottom of the valve bore. (Reference para 2-17, o.) The trimmer regulator pressure is directed to the bottom of the second clutch trimmer valve (foldout4). This regulated pressure at the bottom of the valve resists the clutch apply pressure at the top of the valve, holding the trimmer valve and valve plug at the top of the valve bore until increased clutch apply pressure moves the valve downward. This increased pressure shifts the clutch with a positive action, preventing clutch slippage and promoting longer plate life.

(5) The fourth clutch trimmer is utilized in two gears, fourth and reverse. In fourth gear, the clutch trimming procedure is explained in (3), above. In reverse gear, the fourth clutch trimming is explained as follows. Since reverse gear is usually applied when the vehicle is standing still, a trimming action is not required. Therefore, (AT 545 only) when the transmission is shifted into reverse gear, clutch apply pressure is directed to the top and bottom of the fourth-clutch trimmer valve (foldout 4). This application of oil equalizes the pressure on both ends of the valve holding the trimmer valve and valve plug at the top of the valve bore. With the valve and valve plug held at the top of the valve bore, no trimming action in reverse gear will occur.

(6) This action applies the clutch gently, preventing shift shock. When the clutch is released, the plug spring pushes the trimmer components to the top of the bore. In that position, the trimmer is reset, ready to repeat It s trimming action when the clutch is again engaged.

n. Priority Valve (foldout:4)

(1) The priority valve ensures that the control system upstream from the valve (governor, modulator, forward clutch) will retain sufficient pressure during shifts to perform its automatic functions.

(2) Without the priority valve, the filling of a clutch might require a greater volume of oil (momentarily) than the pump could supply and still maintain the necessary control pressures.

(3) main pressure is routed directly to the priority valve, thereby including the 1-2 signal valve in those receiving pressure priority.

o. Trimmer Regulator Valve (foldout4)

(1) The trimmer regulator valve reduces main pressure to a regulated pressure The regulated pressure, is raised or lowered by changes in modulator pressure

(2) Trimmer regulator pressure is directed to the lower sides of the first and second clutch trimmer valve plugs to vary the clutch apply pressure pat tern of the trimmer valves. A higher modulator pressure (closed throttle) will reduce trimmer regulator pressure. This results in lower initial clutch pressure. Conversely, a lower modulator pressure (open throttle) results in higher regulator pressure and a higher initial clutch pressure.

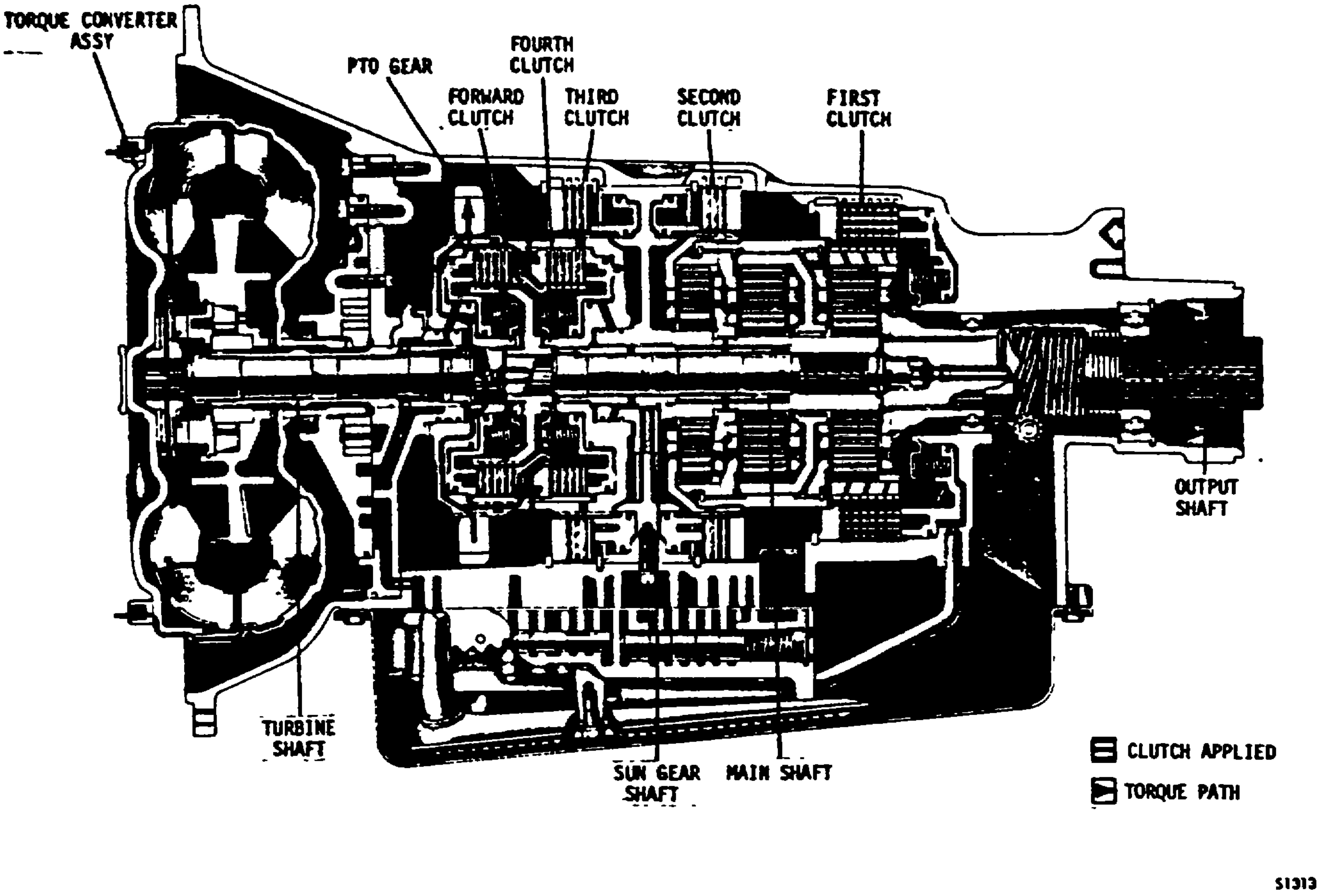

Fig. 2-1. Neutral power flow

2-19. TORQUE PATHS THROUGH TRA NSMISSION

a. Power is transmitted hydraulically through t h e torque converter. The engine drives the converter pump. The pump throws oil against the vanes of the turbine, imparting torque to the converter turbine shaft. From the turbine, oil flows between the vanes of the stator, and re-enters the converter pump where the cycle begins again.

b. The torque path through the torque converter is identical in all drive situations and in neutral When the engine is idling, impact of the oil upon the turbine vanes is negligible. When the engine is accelerated, the impact is increased and the torque produced in the converter turbine shaft can exceed the engine torque (by an amount equal to the torque ratio of the converter).

c. Because t o r q u e converter torque paths are identical in all situations, the torque paths described in paragraphs 2-19 through 2-24, below, all start at the converter turbine shaft which is also attached to the forward clutch housing.

2-20. NEUTRAL-TORQUE PATH (fig. 2-1)

Torque produced in the torque converter is not transmitted beyond the one-piece turbine shaft and forward clutch housing as the forward clutch is not applied. (The first clutch is applied, but two clutches must be applied to produce output shaft rotation in either forward or reverse.)

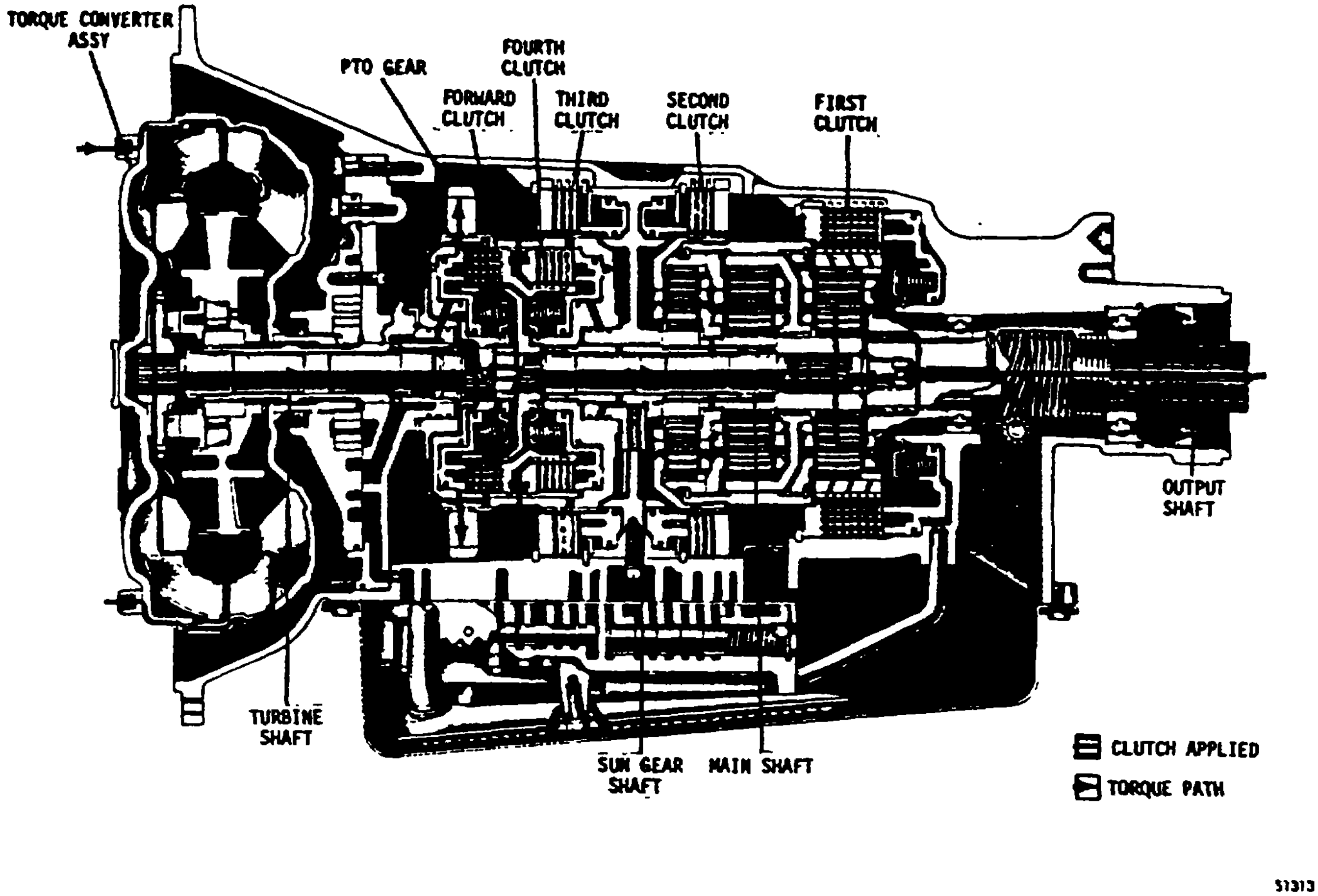

Fig. 2-2. First gear power flow

2-21. FIRST GEAR - TORQUE PATH (fig. 2-2)

The forward and first clutches are applied. The first clutch application anchors the rear planetary ring gear against rotation. The forward clutch application locks the turbine shaft and transmission main shaft together to rotate as a unit. The rear sun gear is splined to the main shaft and rotates with it and, in turn, it rotates the rear planetary pinions. The pinions are part of the carrier assembly which is splined to the transmission output shaft. With the rear ring gear held stationary by the applied first clutch and the rear sun gear rotating the pinions, the rear planetary carrier must rotate within the ring gear and drive the output shaft at a speed reduction of 3.45:1.

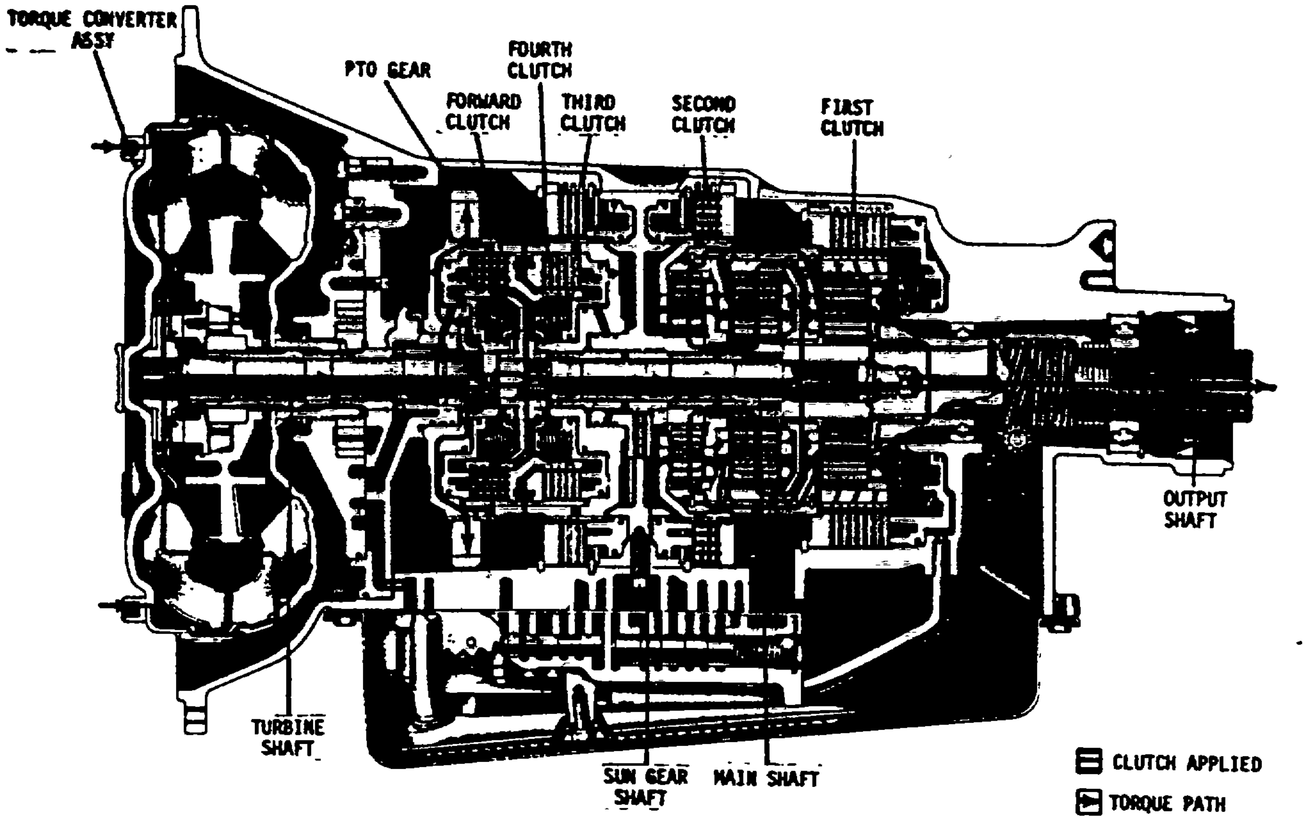

Fig. 2-3. Second gear power flow

2-22. SECOND GEAR - TORQUE PATH
(fig. 2-3)

The forward and the second clutches are applied. The second clutch application anchors the carrier of the front planetary carrier assembly against rotation. The forward clutch application locks the turbine shaft and main shaft together to rotate as a unit. The rear sun gear is splined to both the rotating main shaft and the center ring gear and all three parts rotate at turbine speed. !With the carrier of the front planetary carrier assembly anchored against rotation (by second clutch application), the rotating center ring gear, rotates the center sun gear via the planetary pinions. This sun gear is splined to the sun gear shaft assembly to which the front sun gear is also splined. The rotating front sun gear rotates the front carrier pinions whose carrier is anchored against rotating by the applied second clutch. In turn, the rotating front carrier pinions rotate the front ring gear, which, along with the center carrier, is splined, via the planetary connecting drum and rear carrier assembly, to the output shaft. Due to this compounding action of the front and center planetary gear sets, there is an output speed reduction of 2.25:1.

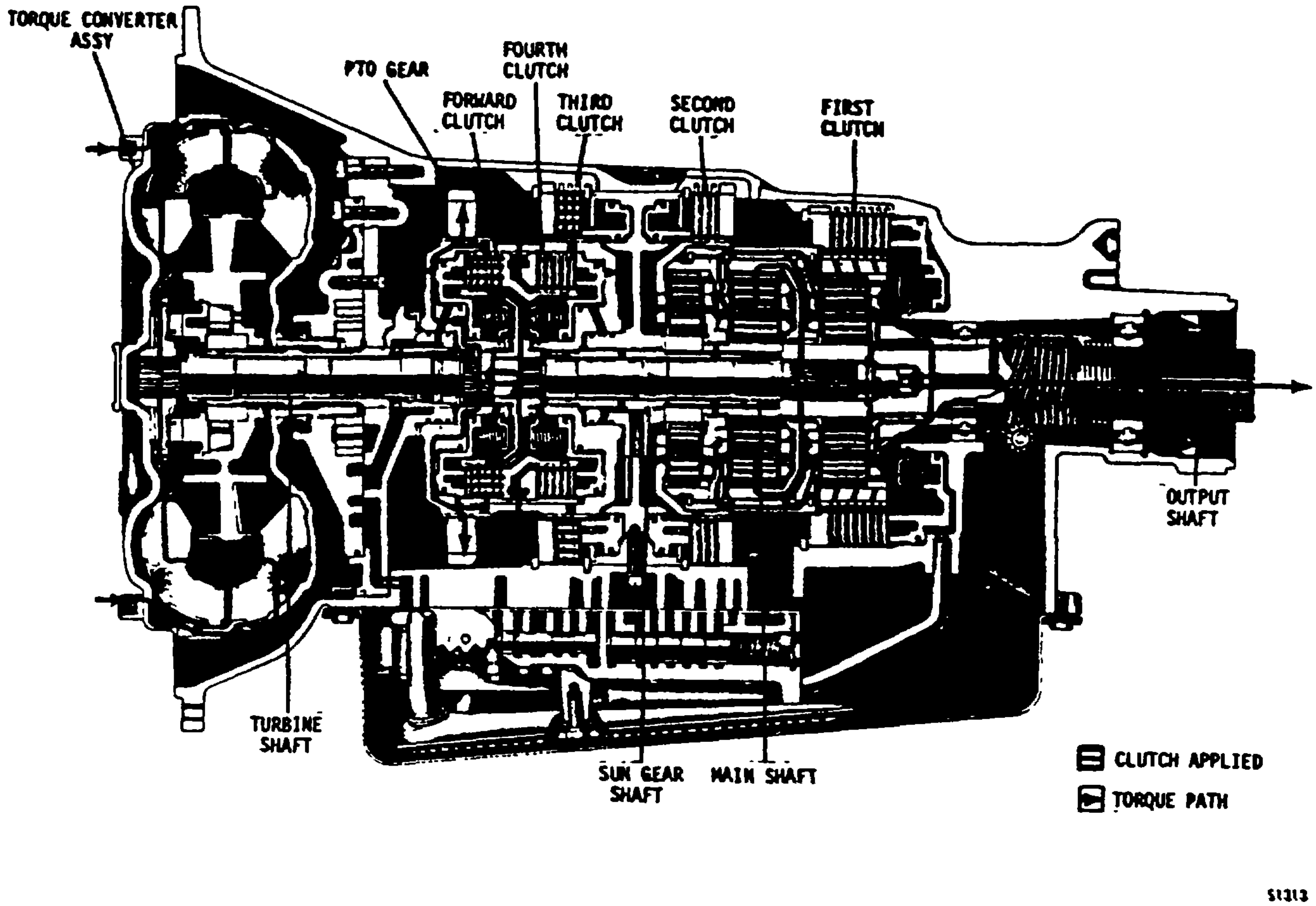

Fig. 2-4. Third gear power flow

2-23. THIRD GEAR - TORQUE PATH
(fig. 2-4)

The forward and the third clutches are applied. The third clutch application anchors the sun gear shaft against rotation, which, in turn, prevents the center sun gear (splined to rear of shaft) from rotating. The forward clutch application locks the turbine shaft and main shaft together, to rotate as a unit. The rear sun gear is splined to both the main shaft and the center ring gear and rotates at turbine speed. With the center sun gear stationary and the center ring gear rotating, the ring gear drives the center planetary carrier pinions. This rotates the center planetary carrier at a speed reduction of 1.41:1. T his carrier (and also the r e a r planetary carrier) is splined to the planetary connecting drum and rotates with it as a unit. The rear carrier is splined to the transmission output shaft which rotates with the rear carrier at the same speed as the center planetary carrier (1.41:1 speed reduction).

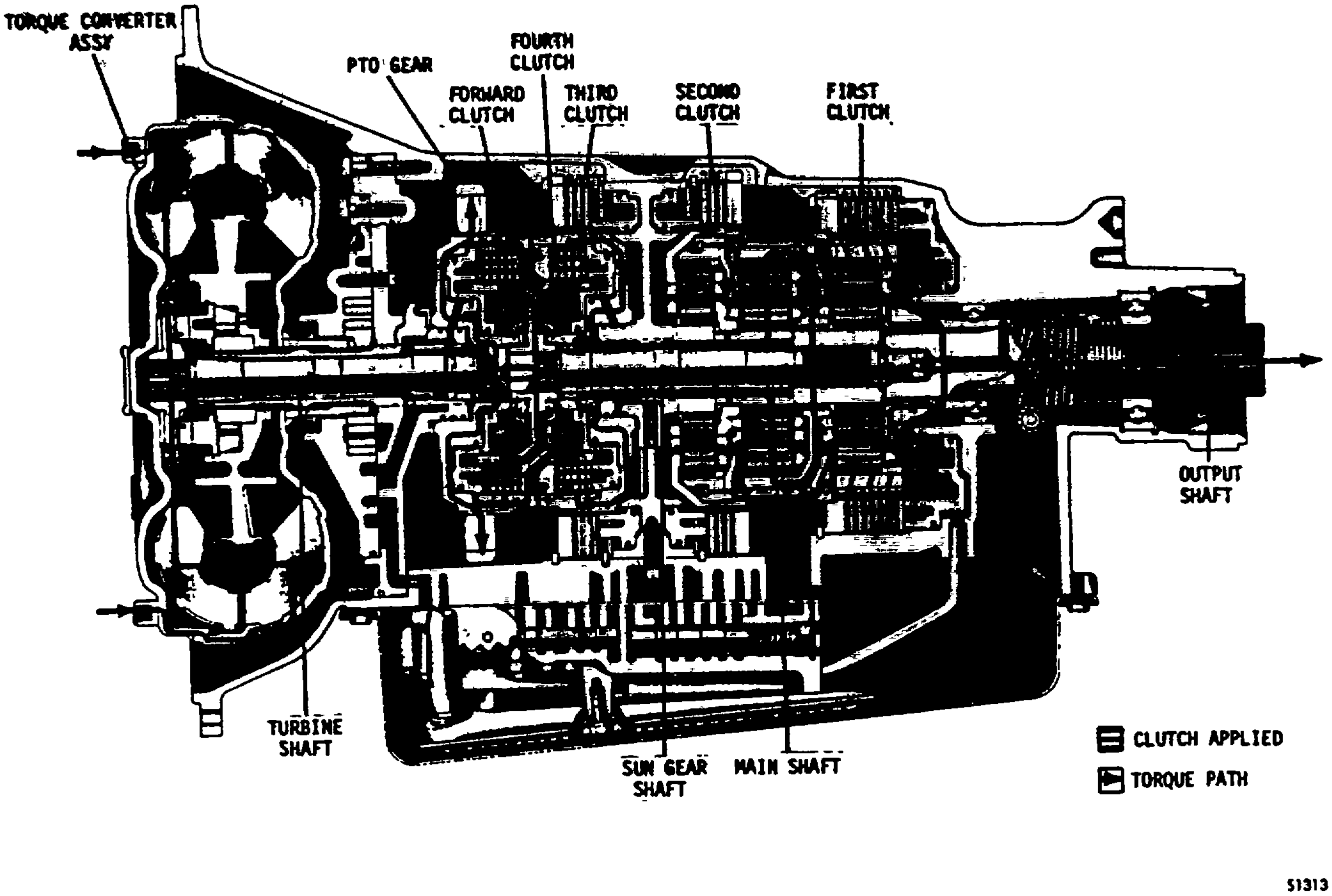

Fig. 2-5. Fourth gear power flow

2-24. FOURTH GEAR – TORQUE PATH (fig. 2-5)

The forward and fourth clutches are applied. With the clutches applied, the transmission main shaft and the sun gear shaft are locked together and rotate as a unit at turbine speed. With the center and rear sun gears rotating at the same speed (locked together) and their carriers splined to the planetary connecting drum, all components rotate at turbine output speed. The transmission output shaft is splined to the rear carrier and gives an output ratio of 1.00:1.

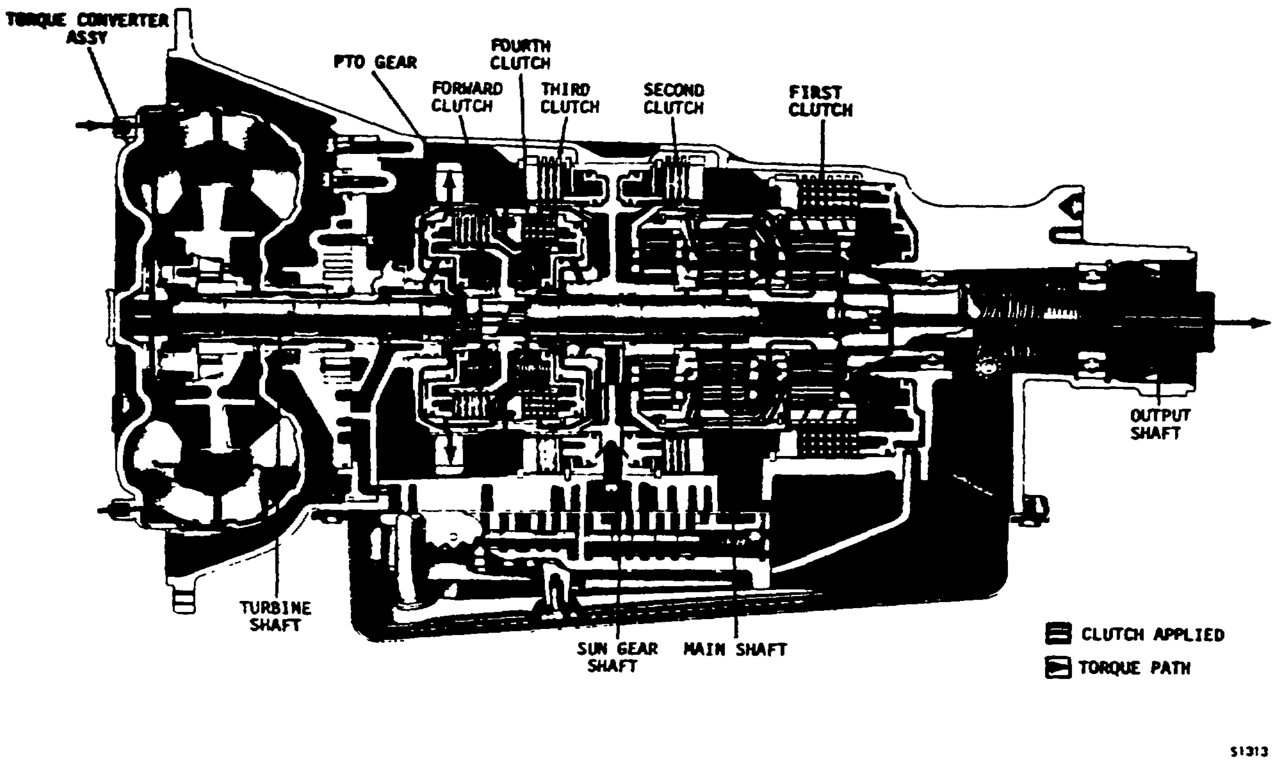

Fig. 2-6. Reverse gear power flow

2-25. REVERSE GEAR -- TORQUE PATH (fig. 2-6)

Reverse gear is the only gear in which the forward clutch is not engaged. In this gear, the fourth clutch is applied and this rotates the sun gear shaft assembly (with the front and center sun gears splined to it) at turbine speed. The first clutch is applied also, and anchors the rear ring gear against rotation. The center sun gear rotates the center carrier pinions, which, In turn, rotate the center r i n g gear in an opposite direction. The center carrier is splined to the planetary connecting drum, which is splined to the rear carrier. The reverse direction of rotation of the center ring gear rotates the rear sun gear. This causes the rear planetary pinions to drive the rear carrier, in a reverse direction, within the stationary ring gear. This compounding action of the center and rear planetaries gives a reverse rotation with 5.02:1 speed reduction, to the rear carrier, which is splined to t h e transmission output shaft.

3-1. SCOPE

This section outlines the routine and periodical procedures required to maintain the transmission in good operating condition. Included are instructions for inspection, for care o f the oil system and breather, for checking temperatures and pressures, for care of external cooler and piping, and explanations of operating characteristics and troubleshooting. Tabulated troubleshooting information is included at the back of this section.

3-2. INSPECTION AND CARE

The transmission should be kept clean. Check for loose bolts, loose or leaking oil lines, condition of control linkage and hose to vacuum modulator, and for oil leakage. Check the transmission oil level at the intervals specified in vehicle operator's manual (refer to para 3-3, below).

3-3. CHECKING OIL LEVEL

a. Importance of Proper Oil Level

(1) Maintaining the proper oil level is very important. The transmission oil is used to apply clutches and lubricate and cool the components. If the oil level is too low, the result can be poor performance (clutches will not receive adequate oil supply). If the oil level is too high, overheating results from the oil being churned and aerated. Add or drain enough oil to restore the proper level; refer to subparagraph e.

(2) Always check the oil level at least twice to ensure that an accurate check is obtained. If inconsistent dipstick readings occur, check for proper venting of the transmission breather and/or oil filler tube. A clogged breather can force oil up into the filler tube and cause an inaccurate reading. A dipstick that anchors inside the top end of an unvented filler tube can draw oil up into the tube during removal and give an inaccurate reading.

(3) Transmission input speed and oil temperature significantly affect the oil level An increase in Input speed lowers the oil level; an increase in oil temperature raises the oil level Thus, the oil level must always be checked with the engine at idle and the transmission in neutral. A final check of the oil level must be made when the transmission reaches normal operating temperature (160-200°F; 71-93°C).

b. Foaming and Aerating

(1) Transmission performance will be affected when the oil foams or aerates. The primary causes of aeration are low oil in the sump, too much oil in the sump, or a defective or missing sealring on the intake pipe.

(2) A low oil level (denoted on the dipstick) will not completely envelop the oil filter. Therefore oil and air are drawn in by the input pump and directed to the clutches and converter, causing converter cavitational noises and irregular shifting. The aeration also changes the viscosity and color of the oil to a thin milky liquid.

(3) At normal oil level, the oil is slightly below the planetary gear units. If the transmission is overfilled, the planetary units will run in the oil, causing it to become aerated. Overheating and irregular shift patterns can occur when the oil is aerated.

(4) A defective sealring 16 (B, fold- out 9) on t h e filter intake pipe will cause the input pump to draw air and oil from the sump, causing the oil to become aerated.

c. Protect Fill Pipe. When adding oil or checking oil level dirt or foreign material must not be allowed to enter the filler tube. Before removing the dipstick, clean around the end of filler tube.

d. Dipstick Markings

(1) Earlier models use a dipstick marked FULL and ADD (fig. 3-1). Later models use a dipstick marked COLD RUN

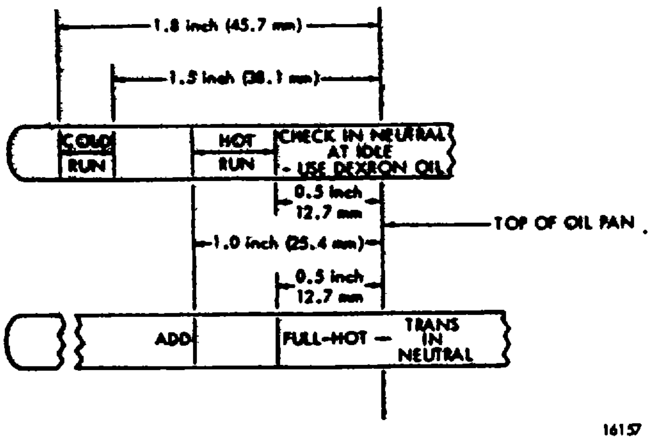

Fig. 3-1. Dipstick markings (AT , 545)

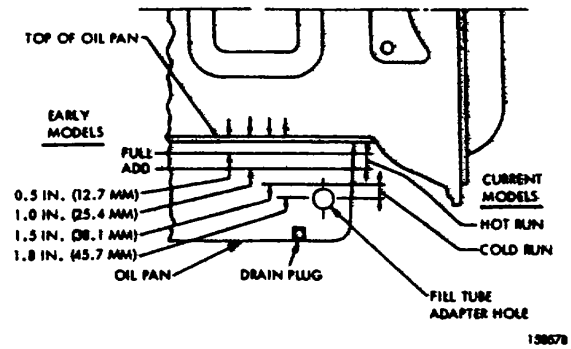

Fig. 3-2. How oil levels are established (AT 545)

and HOT RU N. Figure 3-2 illustrates the marks in relation to the transmission.

NOTE

The add and full dimensions on the early dipsticks coincide with the HOT RUN band dimensions on the later dipsticks.

(2) If desired, the early dipstick can be recalibrated to show HOT and COLD RUN bands.

e. Oil Level Check Procedure

(1) Two checks must be made to ensure proper oil level in the transmission-a Cold Check and a Hot Check. A Cold Check must be made when the transmission oil temperature is 60-120°F (16-49°C). This check is required to ensure that there is a sufficient quantity of oil in the transmission to operate the vehicle until normal operating temperature is reached. A Hot Check must be made when the transmission oil reaches normal operating temperature (160-200°F; 71-93°C). This check is required to ensure that the oil level is at the proper operating level

(2) Park the vehicle on a level surface. Apply the parking brake and operate the engine at 1000-1200 rpm for approximately one minute to purge air from the system. To fill clutch cavities and circuits, shift the transmission into Drive and then to Reverse. Allow the engine to idle and shift to neutral.

(3) Cold Check. Run the engine until the oil temperature reaches 60-120°F (16-49°C). With the engine idling and the transmission in neutral, wipe the dipstick clean and check the oil level If the oil level registers in the COLD RUN band, the quantity of oil in the transmission is operating temperature (160-2000F; 71-930C) is reached. (Refer to fig. 3-1 for dipstick markings.) If the oil level registers on or below the bottom line of the COLD RU N band, add oil to bring the level within the band. If the oil level registers above the COLD RUN band, drain oil to bring the level within the band. Then operate the vehicle and make a Hot Check when normal operating temperature is reached.

CAUTION

The oil level rises as oil temperature increases. Do not fill above the COLD RUN band before the transmission reaches normal operating temperature.

(4) Hot Cheek. Be sure the oil temperature is between 160-200°F (71- 93°C). With the engine idling and the trans-

mission in neutral, wipe the dipstick clean and check the oil level. If the oil level registers in the HOT RUN band or between ADD and FULL, the oil level is satisfactory to continue operation of the vehicle. (Refer to fig. 3-1 for dipstick markings.) If the oil level registers on or below the bottom line of the HOT RUN band or below the ADD line, add oil to bring the oil level within the band.

f. Adjusting Oil Level. About one U.S. quart (0.946 liter) of oil is required to raise the oil level from the bottom of the band to the top of the band (or from ADD to FULL). If a hot check shows the oil level is above the HOT RUN band or FULL line, drain oil until it is level with the top of the HOT RUN band or FULL line. The oil level should never be above the top of the COLD RUN band in a cold oil check. Drain oil to bring the oil level within the band.

3-4. KEEP OIL CLEAN

Oil must be handled in clean containers, fillers, etc., to prevent foreign material entering the transmission.

CAUTION

Containers or fillers that have been used for any antifreeze solution must not be used for oil that is to be used in the transmission.

Clean around oil filler tube before removing dipstick, and lay dipstick in a clean place while filling transmission. Grease used in- ternally must be nonfibrous, low temperature, and oil soluble.

3-5. OIL SPECIFICATIONS

a. Dexron ®. Dexron II or Dexron trans- mission fluids are the only fluids recommended for use in on-highway automatic transmissions.

b. Type C-3. T y p e C-3 oil is recommended for use in automatic transmissions used in off-highway applications, and must conform to the ambient temperature (see chart below), fluid viscosity grade, a n d dealer recommended specification for the area.

c. Ambient Temperatures, D e x r o n. When the ambient temperature for trans- missions using Dexron oil i s below -30°F (-34°C), auxiliary preheat is required. Raise the sump temperature above -30°F (-34°C) before operating the transmission.

d. Ambient Temperatures, C-3 Oil. The minimum ambient temperature for preheat requirements on transmissions using C-3 oil is shown below.

AMBIENT TEMPERATURE REQUIRING PREHEAT	VISCOSITY GRADE
35°F (2°C) and below	SAE 30
10°F (-12°C) and below	SAE 10W

e. Grease Used For Assembly. A low temperature grease should be for internal assembly. The grease must be soluble in Dexron or C-3 transmission fluid. High temperature grease having a good oxidation and water resistance should be used at the inside diameter of the output and input shaft oil seals. Petrolatum should be used for assembly purposes inside t h e transmission. Petrolatum normally has a melting point of 100-1400F (38600C) a n d is commercially available. Petrolatum equivalent to MIL-VV-P-236 or Amojell petrolatum (Amoco Oil Co.) is recommended.

3-6. OIL, GOVERNOR OIL SCREEN, AND OIL FILTER CHANGE INTERVALS

The oil and oil filter should be changed every 25,000 miles, 1000 hours, or 12 months, whichever occurs first. Also replace or clean the governor oil screen 11 (B, foldout 9).

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3-7. OIL CHANGE PROCEDURES

NOTE

The transmission should be at operating temperature (160°F, 71°C minimum) when the oil is drained. This will ensure quicker and m or e complete drainage.

a. Shift the transmission to neutral

b. Remove the oil pan drain plug and allow-the oil to drain. On earlier models, which do not have a drain plug, disconnect the oil filler tube at the pan and allow the oil to drain.

c. Disconnect the oil filler tube if not previously disconnected. Remove twenty-one washer-head screws 24 (B, foldout 9) that retain oil pan 23 or 28 to the transmission housing. Discard pan gasket 22. Clean pan 23 or 28 with mineral spirits.

d. Remove the screw or bolt and washer that retains internal oil filter 19. Pull out oil filter 19 and oil intake pipe 17. Remove sealring 16 and discard.

e. Clean or replace governor oil screen 11. The screen is located in the governor feed tube bore. Replacement of the screen can only be accomplished by removing governor feed tube 10. This tube and the two remaining tubes are held in place by the control valve body. Refer to paragraph 5-3 for valve body removal procedures and paragraph 7-9 for valve body installation.

f. Install a new sealring 16 onto the top end of oil intake pipe 17. Lubricate the sealring with transmission fluid.

g. Insert the intake pipe and sealring in- to the hole in the bottom of the transmission. Install new oil filter assembly 19 (includes grommet) onto the intake pipe.

h. deep oil pan 23 (B, foldout 9) is used retain the oil filter with one 5/16-18 x 2-1/4 inch bolt and one 5/16 inch washer. Install the bolt and washer as shown on B. foldout 9.

i. Place the oil pan gasket onto the oil pan. Do not use any substance as a gasket retainer.

CAUTION

Do not use gasket-type sealing compounds any place inside the transmission or where they might get washed into the transmission. Also, nonsoluble, vegetable base, cooking compounds, or fibrous greases must not be used inside the transmission.

j. Install the oil pan. Guide the pan and gasket carefully into place. Guard against dirt or foreign material entering the pan. Retain the pan to the housing with four 5/16-18 washer-head screws. Install each screw, by hand, one at a time, into each corner of the pan.

k. Install the remaining seventeen washer-head screws by hand, carefully threading each through the gasket and into the transmission. Bottom all of the screws before tightening any of them.

l. Tighten all twenty-one screws evenly to 10-13 lb ft (14-18 N•m). Check gasket fit while the screws are being tightened.

NOTE

The oil pan bolts must maintain a minimum of 5 lb ft (7 N-m) of torque after the oil pan gasket has taken a set.

m. Install the filler tube at the side of the pan. Tighten the tube fitting to 90-100 lb ft (122-136 N•m). Install the drain plug and gasket, if used. Tighten the plug 15-20 lb ft (20-27 N•m).

n. Remove the dipstick and refill the transmission with transmission fluid.

Transmissions with 5-inch deep pan will require about 16 quarts (15 liters) of fluid. Check oil level (refer to paragraph 3-3). Finish filling as required.

3-8. OIL CONTAIVINATION

a. Water Leakage

(1) Before changing the oil, increase the temperature of the oil to normal running level. Inspect the breather for oil spewing. Drain the oil from the oil pan. If the oil is gray or cloudy, the presence of water is indicated. Excessive quantities of water in the oil will cause rust and pitted trans- mission parts, reducing t h e life of the transmission.

(2) Remove the oil pan and clean thoroughly. Inspect the engine radiator for evidence of oil (this may also indicate engine oil leakage). During disassembly (Section 5) and rebuild (Section 6), inspect all gaskets and seals for blistering and wrinkling, indicating presence of water.

b. Metal Particles. Metal particles in the oil (except for t h e minute particles normally trapped in the oil filter) indicate damage has occurred in the transmission. When these particles are found in the sump, the transmission must be disassembled and closely inspected to find the source. Metal contamination will require complete disassembly of the transmission and cleaning of all internal and external circuits, cooler, filter, and all other areas where the particles could lodge.

c. Coolant Leakage

(1) The presence of ethylene glycol coolant in the transmission oil is detrimental to the reliability and durability of the internal components. Ethylene glycol has a deteriorating effect on nonmetallic components (seals, gasket, etc.) a n d on highly loaded steel parts, such as bearings and gears, due to reduced lubricity of the oil.

(2) Should the presence of ethylene glycol in the oil be suspected, an immediate verification test should be made. Gly-Tek-Test Kit is available and is a quick and easy method to determine the presence of glycol. If glycol is found, disassemble, inspect, and remove all traces of coolant and vanish deposits resulting from coolant contamination. Replace seals, gaskets, and fiber clutch plates.

d. Auxiliary Filter

(8) Filter elements should be re- placed after the first 5,000 miles (8000 km) and at normal oil change intervals there- after.

3-9. BREATHER

The transmission breather is pressed into the top of the transmission (fig. 1-6). This serves to prevent pressure within the trans- mission a n d relieve surges. The breather must be kept clean and the passage open.

3-10. LINKAGE

a. Installing Manual Selector Lever

CAUTION

Manual selector shafts that are center-drilled at their outer ends require an LM10 X 1.5-6G nut (metric thread). Shafts that are undrilled require a 3/8-16 n u t (standard inch series). Use of the wrong nut will damage both the shaft and the nut. Torque for either nut is 15-20 lb ft (20-27 N-m). Excessive torque applied to the nut, without holding the lever, can damage the internal lever.

(1) Rotate the selector shaft to a position that is at least two detent notches from either end of its travel.

(2) Install the lever, aligning the flats in the lever opening with the tapered flats on the selector shaft. Install the nut.

(3) Hold the lever to prevent rotation and tighten the nut to 15-20 lb ft (20-27) N•m).

b. Maintain Proper Adjustment. Proper adjustment of the manual selector valve linkage is important as the sift tower detents must correspond exactly to those in the transmission. Periodic inspections should be made for bent or worn parts, loose threaded connections, loose bolts and accumulation of grease and dirt. All moving joints must be kept clean and well lubricated.

c. Reference to Vehicle Manual. Refer to vehicle manual -Refer to vehicle manual for specific linkage adjustment procedures. The following general procedures are applicable to most vehicles.

(1) The manual selector lever should move easily and give a crisp detent feel in each position. The linkage should be adjusted so the stops in the shift tower match the detents in the transmission.

(2) When the linkage is correctly adjusted, the pin which engages the shift lever linkage at the transmission can be moved freely in each range.

d. Mechanical Actuator Adjustment

(1) It is imperative the mechanical linkage be properly adjusted f o r efficient performance.

(2) Place t h e fuel control lever on the engine at full throttle position.

(3) Place the mechanical actuator cable at full throttle position against the mechanical stop.

(4) Adjust the clevis at the fuel control lever so the pin fits freely through the hole in the clevis, making sure the lever is secure.

(5) Total cable control travel should not be less than 1.187 inches (30.14 mm) or more than 1.56 inches (39.6 mm).

(6) Refer to oil pressure checking procedures, paragraph 3-21.

3-11. SHIFT SPEED ADJUSTMENTS

NOTE

Transmission shift points can- not be satisfactorily adjusted if the transmission has the wrong governor installed. Check the two-digit code o n the head of the governor with the code shown in the current parts catalog (SA 1235) for the governor listed for your trans- mission assembly part number. If the letter "M" follows the two-digit code, the governor is a service replacement assembly. If the "M" is not included, the governor was installed at original factory build.

a. Calibrated on Test Stand or in Vehicle

(1) Proper timing of s hi ft speed points is necessary for maximum trans- mission performance. Shifts may be adjusted on the test stand when the transmission is rebuilt or overhauled, or during road testing of the vehicle.

(2) The Kent Moore Valve and Governor Test Stand (J-25000) is designed to check five principal transmission functions. It performs a checking procedure on the governor, modulator, hold regulator, shift points (up-down-inhibit), and a trimmer regulator check. If a test stand is not avail- able, satisfactory calibration of shift points may be made after road testing of the vehicle.

b. Location of Adjusting Components

(1) Shift speeds are changed by changing the positions of adjusting rings that determine the retaining force of certain valve springs in the valve body. Refer to items 5, 47, 54, 60, and 66 on A, foldout 9.

(2) A special tool (J24314 - see special tools table in Section 4) is used to depress and rotate the adjusting rings to the proper positions. Clockwise rotation in- creases spring force and will raise the shift point. Counterclockwise rotation will reduce spring force and lower the shift point.

NOTE

Each notch of adjustment will alter the shift point approximately 50 rpm.

e. Checks Before Adjusting Shift Points

(1) When calibration is to be made during a road test or on a test stand that simulates road operation, certain preparations must be made.

(2) Warm up the transmission or test stand setup to normal operating temperature of 160-200°F (71-93°C) for road test.

(3) Check the engine governor setting, and adjust if required, to conform to the transmission's engine speed requirements.

(4) Check the engine for satisfactory performance b e f o r e checking shift points.

(5) Check the linkage that controls the mechanical modulator valve actuator in the transmission (diesel) for proper travel, routing, and operation.

(6) Cheek the shift selector linkage for proper range selection.

(7) Provide Curate instrumentation required for observing speeds, temperatures, pressures, vacuum, etc.

d. Calibration by Road Test Method

(1) Note the governed speed of the engine (c (3), above). This is the base speed from which checks and adjustments are made.

(2) Automatic upshifts should occur as follows

1-2 -- within 400 rpm below engine governed speed.*
2-3 -- within 300 rpm below engine governed speed.*
3-4 -- within 200 rpm below engine governed speed.*

*Vehicle loaded.

NOTE

mately the same amount, check adjustment of the modulator external linkage

Before road test, determine the vehicle tachometer error with a test tachometer. Make corrections for error, as required, in subsequent tests.

(3) Drive the vehicle and check the engine speed (at full throttle) at which each upshift occurs. Each upshift should occur at the speed specified above.

(4) If an upshift speed does not reach that specified, the shift point may be raised by adjusting (increasing) the spring force on the 1-2, 2-3, or 3-4 shift signal valve. If the upshift speed exceeds the specified rpm, or if upshift does not occur at all, the spring force must be reduced. Adjust the force on only the springs for valves that do not upshift at the proper speed.

NOTE

If more than one shift signal valve spring requires adjustment in the same direction, it may be necessary to adjust the spring force on the modulator valve in the same direction. if not adjusted, the closed throttle downshifts may be abnormally high or low depending on
the direction the shift signal adjusting rings were rotated. If all full throttle upshift points are too low by approxi-

(5) Refer to sections 5, 6, and 7 for procedures covering removal and replacement of affected components.

e. Alternate Method Using Speedometer Readings

(1) When a tachometer is not avail- able for checking shift points, the vehicle speedometer can be used. Proceed as out- lined in (2) through (4), below.

(2) Check the top speed of the vehicle in each selector hold position (first, second, third gears). Record the top speed for each.

(3) For checking the shift points, place the selector at DRIVE (D) so that all automatic shifts can occur. Drive the vehicle at full throttle from a standing start until the 3-4 upshift occurs, recording the mph at which each upshift occurs.

(4) Compare the upshift speeds with the hold speeds recorded in (2), above. The 2-3 upshift should occur at approximately two mph below the top speed of second gear. The 3-4 upshift should occur at approximately two mph below the top speed for third gear. The 1-2 upshift is not be to adjusted relative to hold speed. The 2-1 downshift at closed throttle should occur at 3 to 5 mph (4.83 to 8.05 km/h).

f. Calibration by Test Stand Method

(1) The table be lo w provides detailed information required for adjusting shift points on transmissions matched to en-

			OUTPUT RPM AT START OF SHIFT							
ENGINE GOVERNED SPEED (RPM)			3800	3600	3400	3200	3000	2800	2600	2400
RANGE	THROTTLE SETTING	SHIFT								
DRIVE	FULL	1-2	900-960	900-960	770-830	770-830	710-770	595-655	595-655	580-640
		2-3	1490-1625	1400-1535	1310-1445	1220-1355	1130-1265	1045-1100	955-1090	865-1000
		3-4	2450-2590	2305-2445	2165-2305	2020-2160	1880-2020	1735-1875	1595-1735	1455-1595
	CLOSED	4-3*	300-700	150-600	675-970	530-750	410-680	490-485	350-610	305-555
		3-2*	455-765	405-720	620-875	590-810	550-760	520-665	465-630	400-560
		2-1	50-450	50-450	20-450	20-450	20-300	20-300	20-300	20-300
DR 3	FULL	4-3	2760-3240	2600-3050	2400-2890	2290-2770	2240-2690	2100-2370	1980-2280	1820-2120
DR 2		3-2	1700-2130	1570-1990	1470-1850	1380-1740	1330-1700	1270-1530	1200-1470	1060-1350
DR 1		2-1	1000-1450	900-1340	960-1200	930-1100	910-1080	770-1010	735-970	660-900

***4-2 DOWNSHIFT IS ACCEPTABLE**

FULL THROTTLE SETTING IS 0 IN. HG VACUUM
CLOSED THROTTLE SETTING IS 19-21 IN. HG VACUUM

gines having governed speeds from 2400 to 3800 rpm.

(2) The actual adjustment procedures are as outlined in d, above. However, the base for checks and adjustments is out- put shaft speed instead of engine governed speed. Individual output shaft speed ranges are given for each shift.

3-12. EXTERNAL LINES AND OIL COOLER

a. External Lines

(1) Inspect for loose or leaking connections, worn or damaged hoses, tubing and loose fastenings.

(2) Examine the radiator coolant for traces of transmission oil. This condition indicates a faulty heat exchanger.

b. Oil Cooler. Transmission operation at abnormally high temperatures can cause clogging of the oil cooler as well as trans- mission failure. It is suggested t h e oil cooler system be thoroughly cleaned after each major or minor rebuild. Failure to do so may cause poor performance, overheating, and transmission damage. For recommendations for cleaning or flushing the oil cooler, see the vehicle service manual

3-13. TRANSMISSION STALL TEST

a. Purpose. A stall test should be con- ducked when the power package (engine and transmission) is not performing satisfactorily. The purpose of the test is to determine if the transmission is the malfunctioning component.

WARNING

When conducting a converter stall test, the vehicle must be prevented from moving. Both the parking and service brakes must be applied and, if necessary, the vehicle should be blocked to prevent movement. Warn personnel to keep clear of the vehicle and its travel path.

CAUTION

Do not maintain t h e stalled condition longer than 30 seconds due to rapid heating of the transmission oil.

b. Overheating. If the temperature reaches 300°F (149°C) or if 30 seconds is insufficient time to complete the needed checks, the transmission temperature should be lowered as follows.

(1) With the transmission in neutral, run the engine at 1200 to 1500 rpm for 2 minutes to cool the oil.

(2) Maintain a constant check on converter-out oil temperature. It should not

exceed 300°F (149°C). Prolonged operation at 300°F (149°C) will reduce the lift of the transmission.

(3) Keep a close check on the engine cooling system to prevent overheating.

c. Procedure

(1) A torque converter stall test is performed by locking the transmission out- put, putting the transmission in gear, accelerating the engine to full throttle, and noting the maximum rpm the engine will attain. The speed attained is then compared to the speed specified by the vehicle manufacturer as normal for those conditions. An engine speed above or below the specified range may indicate a malfunction in the engine or transmission

NOTE

Engine power will decrease with an increase in elevation (altitude), becoming more pronounced at greater elevation. This will result in a lower engine speed under converter- stall conditions.

(2) After making allowances for elevation, a low engine speed may indicate the engine is not delivering full power. Refer to engine service manual for engine repair in- formation.

(3) If low engine speed persists after engine is tuned, refer to the troubleshooting procedures and chart in paragraph 3-20.

(4) If high engine speed is noted, refer to the troubleshooting chart in paragraph 3-20.

3-14. PRESERVATION AND STORAGE

b. Preservation Methods. When the transmission is to be stored or remain in- active f o r an extended period (one or more years), specific preservation methods are recommended to prevent damage due to rust, corrosion, and organic growth in the oil Preservation methods are presented for storage with and without transmission fluid.

c. Storage, One Year--Without Oil

(1) Drain the oil (para 3-7).

(2) Spray two ounces (60 milliliters) of VCI #10® through the fill tube.

(3) Seal all openings and the breather with moisture-proof tape.

(4) Coat all exposed, unpainted surfaces with preservative grease such as petrolatum (MIL-C-11796, Class 2).

(5) If additional storage time is required, repeat steps (2), (3), and (4) at yearly intervals.

d. Storage, One Year--With Oil
(normally in a vehicle)

(1) Drain the oil and replace the oil filter element(s) (para 3-7).

®VCI #10 is the registered trademark for a vapor phase rust preventive manufactured by the Daubert Chemical Company, Chicago, Illinois. VCI #10 is covered by Military Specifications MlI/L46002 (ORD) and MIL-I-23310 (WEP) under the designation of Nucle Oil.

(2) Fill the transmission to operating level with a mixture of one part VCI #10 (or equivalent) to 30 parts Dexron or Dexron II transmission fluid. Add 1/4 teaspoon of Biobor JF((or equivalent) for each 3 gallons (11 liters) of fluid in the system.

NOTE

When calculating the amount of Biobor JF required, use the total volume of t he system, not just the quantity required to fill the transmission. Include external lines, filters, and the cooler.

(3) Run the engine for approximately five minutes at 1500 rpm with the transmission in neutral.

(4) Drive the vehicle. Make sure the transmission shifts through all ranges. If it is equipped with a converter lockup clutch, make sure the lockup clutch is activated.

(5) Continue running the engine at 1500 rpm with the transmission in neutral until normal operating temperature is reached.

CAUTION

If the unit does not have a converter-out temperature gage, do not stall the converter.

(6) If normal operating temperature is less than 225° F (107°C), shift the transmission to the highest forward range and stall the converter. When converter-out temperature reaches 225°F (107° C), stop the engine. Do not exceed 225° F (107°C).

(7) As soon as the transmission is cool enough to touch, seal all openings and the breather with moisture-proof tape.

(8) Coat all exposed, unpainted surfaces with preservative grease such as petrolatum (MIL-C-11796, Class 2).

(9) If additional storage time is required, repeat steps (2) through (8) at yearly intervals; except, it is not necessary to drain the transmission each year. Just add Motor-stor and Biobor JF (or equivalents).

e. Restoring Transmission to Service

(1) Remove all tape from openings and the breather.

(2) Wash off all external grease with mineral spirits.

(3) If the transmission is new, drain the residual preservative oil Refill the transmission to the proper level (para 3-3) with Dexron or Dexron II transmission fluid.

(4) If the transmission was prepared for storage without oil, drain the residual oil and replace the oil filter element(s). Refill the transmission to the proper level (para 3-3) with Dexron or Dexron II transmission fluid.

(5) If the transmission was prepared for storage with oil, It is not necessary to drain and refill the transmission with new transmission fluid. Check for proper fluid level. Add or drain fluid as required to obtain the proper level

3-15. REPLACING OUTPUT SHAFT OIL SEAL, BEARING, SPEEDOMETER DRIVE GEAR (Transmission in Vehicle)

a. Removing Oil Seal Output Flange

(1) Disconnect the vehicle drive shaft from the transmission output shaft.

®Biobor JF is the registered trademark for a biological inhibitor manufactured by U.S. Borax and Chemical Corporation.

(2) Remove the flange retaining bolt, washer, and flange retainer washer. If a patch lock bolt was used, discard the bolt.

(3) Remove the transmission output flange from the output shaft. (Reference para 3-16.)

(4) Remove the oil seal from the rear of the transmission housing. Do not damage the oil seal bore.

b. Removing Bearing

(1) Remove internal snapring 5 (B, foldout 9) from the rear of the transmission housing.

(2) Remove output shaft bearing 4 (B, foldout 9) using tool J-24463. Place the foot of one J-24463-2 leg between two bearing balls. Twist the leg, forcing the foot under the inner and outer race of the bearing. Install the second leg 180 degree from the first leg, in the same manner. Adjust the center screw and each of the leg nuts until puller body J-24420 is perpendicular to the rear face of the transmission housing (fig. 3-3). Tighten the center screw and remove the output bearing.

c. Removing Speedometer Gear and Selective Spacer. Remove the selective spacer and speedometer drive from the output shaft. Note the number of grooves on the selective spacer for accurate replacement.

NOTE

If the selective spacer is lost or damaged beyond recognition, refer to paragraph 7-5a for replacement procedure.

d. Installing Speedometer Drive Gear and Selective Spacer

(1) Install speedometer drive gear 2 (B, foldout 9) onto the output shaft.

(2) Check selective spacer 3 (B, foldout 9) for damage. If replacement is required, select a spacer with the same number of external grooves as the one it

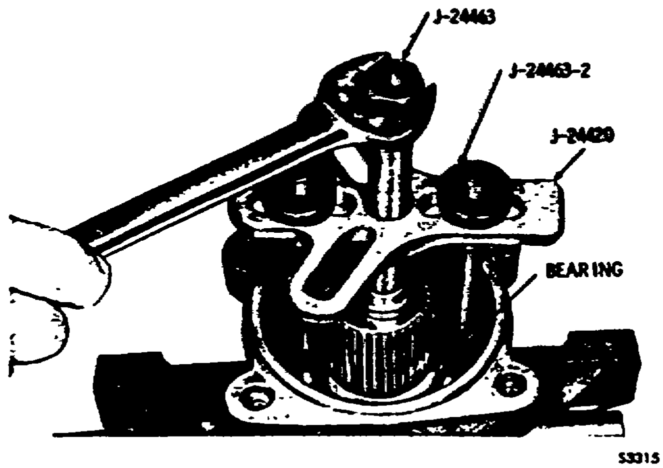

Figure 3-3. Removing output shaft rear bearing

replaced. If the spacer identification is impossible, refer to paragraph 7-5a for replacement procedure.

(3) Install selective spacer 3 onto the output shaft.

e. Installing Output Shaft Bearing and Snapring

(1) Inspect ball bearing 4 (B, foldout 9) for scratches, gouges, heat discoloration, etc. If damage is evident, replace the bearing.

(2) Clean the bearing bore. Make sure snapring 9 (B, foldout 8) is seated in its groove and is not damaged.

(3) Using tool J-24446, install bearing 4 (B, foldout 9) into the transmission housing. The tool will seat the bearing squarely against snapring 9 (B, foldout 8).

(4) Install snapring 5 (B, foldout 9), beveled side out, into its groove in the transmission housing. Be sure the snapring is fully expanded.

f. Installing Oil Seal, Output Flange

(1) Coat the lip of oil seal 6 (B, foldout 9) with high temperature grease (MIL-6-3545A or equivalent) to provide lubrication during initial operation.

(2) Coat the outside circumference of the oil seal with nonhardening sealer. Start the oil seal, lip first, squarely into the rear bore of the transmission housing.

(3) Using installer tool J-23631, drive the oil seal into the housing until the installer seats against the housing (fig. 7-29).

(4) Clean the splines on the output shaft and lubricate with transmission fluid.

(5) Install the output flange onto the output shaft. Retain the flange with a washer and a bolt. Refer to paragraph 3-16 for the flange retaining bolt installation procedure.

(6) Connect the vehicle drive shaft to the transmission output flange. (See vehicle installation manual for alignment procedure, if required.)

3-16. RETAINING OUTPUT FLANGE

a. Clean and inspect the splines and threads of the output shaft. If the splines are damaged, correct the damage or replace the output shaft. Reference paragraph 6-11.) If the bolt threads in the end of the shaft are damaged, retap the threads with a used tap.

b. Apply a lubricant (transmission fluid or equivalent) to the output shaft prior to the installation of the output flange and flange retainer bolt.

c. Clean and inspect the splines of the output flange. If the flange is damaged, correct the damage or replace the flange.

d. Lubricate the splines of the output flange and install it onto the output shaft.

CAUTION

Do not use a hammer or mallet to drive the flange onto the output shaft. Hammering the flange onto the shaft could damage the output bearing.

e. Install the flange retainer washer into the flange. Retain the flange to the output shaft with one 1/2-20 x 1 1/2-inch nylon patch lock bolt (23014159 or equivalent) and one 17/32-inch hardened plain washer (9411417 or equivalent). Tighten the bolt to 102-121 lb ft (138-164 N•m).

3-17. TROUBLESHOOTING - BEFORE REMOVAL OR OPERATION

a. Visual Inspection. Do not operate the vehicle prior to completing the procedures described in this paragraph. Inspect for oil leakage. Visually inspect all splitlines, connections, valve bodies, oil level indicator tube, and plugs for leaks. Oil leakage at splitlines may be caused by loose mounting bolts or defective gaskets. Tighten all bolts and plugs where leakage is found. If mounting bolts are tight and oil continues to leak, install a new gasket. Oil from the indicator tube may be caused from foaming and aerating. (Refer to para. 3-3 b.)

3-18. TROUBLESHOOTING - BEFORE REMOVAL AND DURING OPERATION

a. Determine Trouble Cause. If the inspection in paragraph 3-17, above, does not a reveal the cause of the failure and the vehicle is operable, further troubleshooting is necessary. Do not remove the transmission from the vehicle until the cause of the trouble listed in the troubleshooting chart is checked.

b. Proper Engine Tuning. In order to m a k e a thorough test of the transmission while it is mounted in the vehicle, be sure that the engine is properly tuned, and the oil level in the transmission is correct. Refer to paragraph 3-3 for checking oil level

3-19. TROUBLESHOOTING-TRANSMISSION REMOVED FROM VEHICLE

When the malfunction o f a transmission is not ascertained by tests or inspections before removal from the vehicle, the transmission may be mounted in a test stand and checked (if a test stand is available). Particular attention should be given to proper oil level and to correct linkage adjustment in every transmission test.

3-20. TROUBLESHOOTING CHART

The troubleshooting chart lists possible causes of transmission troubles and their remedies. Capital letters indicate the symptom; numerals following the symptom indicate several possible causes; corresponding numerals in the right column indicate remedies for the causes.

NOTE

The various oil pressure check points are shown in the top and bottom views of figure 3-4.

3-21. OIL PRESSURE CHECKING PROCEDURES

The troubleshooting chart lists oil pressure checks that can be used to troubleshoot the transmission. Two oil pressure checking procedure charts are provided at the end of this section to check main pressure. One chart is for checking main pressure on transmissions having modulated main pressure. The other is for checking main pressure on transmissions having demodulated main pressure. Each chart emphasizes the importance of safety during the checking procedure.

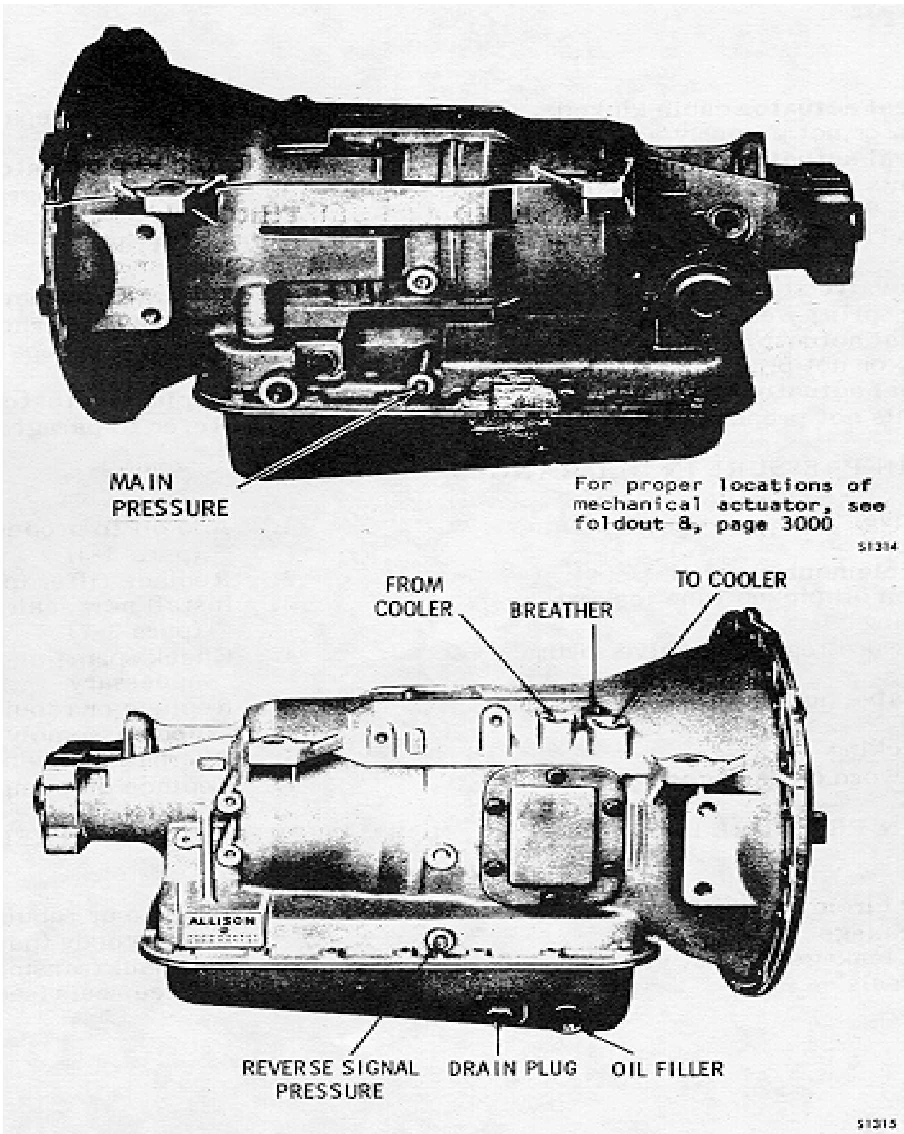

Fig. 3-5. Transmission check points

TROUBLESHOOTING CHART

	Cause		Remedy
A	AUTOMATIC SHIFTS AT TOO HIGH SPEED		
1.	Governor valve malfunctioning	1.	Clean or replace governor screen
4.	Mechanical actuator cable kinked, broken, or not properly adjusted	4.	Replace or repair cable
5.	Mechanical actuator malfunctioning	5.	Replace actuator
6.	Shift points not properly adjusted	6.	Refer to paragraph 3-11
B	AUTOMATIC SHIFTS AT TOO LOW SPEED AT FULL THROTTLE		
1.	Governor valve stuck	1.	Clean or replace governor
2.	Governor spring weak	2.	Replace governor
3.	Mechanical actuator cable kinked, broken, or not properly adjusted	3.	Replace or repair cable
4.	Mechanical actuator malfunctioning	4.	Replace actuator
5.	Shift points not properly adjusted	5.	Refer to paragraph 3-11
C	LOW MAIN PRESSURE IN ALL RANGES		
1.	Low oil level (para 3-3)	1.	Add oil to proper level
2.	Oil filter element clogged	2.	Replace filter (para 3-7)
3.	Sealring on oil pickup tube leaking or missing	3.	Install new sealring (para 3-7)
4.	Main-pressure regulator valve spring weak	4.	Check spring and replace if necessary
5.	Control valve body leakage body assembly	5.	Replace or rebuild valve
6.	Valves sticking	6.	Overhaul valve body assembly
7.	Oil pump worn or damaged	7.	Replace oil pump
D	LOW MAIN PRESSURE IN FIRST GEAR, NORMAL PRESSURE IN OTHER FORWARD RANGES		
1.	First gear circuit of control valve body, leakage	1.	Replace or rebuild control valve body (para 6-6)
2.	Excessive leakage at first clutch piston seals	2.	Overhaul transmission; replace seals (sect. 5 thru 7)

TROUBLESHOOTNG CHART (cont)

	Cause	Remedy
E	BUZZING NOISE OCCURRING INTERMITTENTLY	
1.	Low oil level (para 3-3)	1. Add oil to proper level
2.	Air leak at oil intake pipe	2. Replace intake pipe seal and filter (para 3-7)
3.	Clogged filter	3. Replace filter (para 3-7)
4.	Aerated oil	4a. Improper oil level (para 3-3) 4b. Improper or contaminated oil
F	EXCESSIVE CREEP IN FIRST AND REVERSE GEARS	
1.	Engine idle speed too high	1. Adjust to correct idle speed (refer to vehicle manual)
G	LOW LUBRICATION PRESSURE	
1.	Oil level low	1. Add oil to proper level (para 3-3)
2.	Excessive internal oil leakage	2. Check other pressures (refer to C and D, above); check valve body mounting bolts
3.	Cooler lines restricted or leaking	3. Check for kinks, leakage; replace lines if necessary
H	OIL LEAKING INTO CONVERTER HOUSING	
1.	Engine crankshaft rear oil seal, leakage	1. Refer to vehicle service manual
2.	Charging oil pump, lip-type seal at torque converter, leaking	2. Replace pump seal (para 6-7)
3.	Sealring around OD of oil pump leaking	3. Replace OD seal (para 6-7)
4.	Cracked weld in converter assembly leaking	4. Replace converter assembly (para 6-3)
I	TRANSMISSION HEATING UP IN ALL RANGES	
1.	Oil level low	1. Add oil to proper level (para 3-3)
2.	Oil level high*	2. Drain oil to proper level (para 3-3)
3.	Engine cooling system restricted	3. Refer to vehicle service manual
4.	Oil cooler lines restricted*	4. Clean or replace lines (refer to vehicle service manual)
5.	Broken parts in converter	5. Replace converter assembly (par 6-3)

*Can also result in excessive fuel consumption

TROUBLESHOOTING CHART (cont)

Cause		Remedy
J	NO RESPONSE TO MOVEMENT OF SHIFT LEVER	
1.	Range, selector linkage unhooked	1. Hook up linkage (refer to vehicle service manual)
2.	Range selector linkage defective or broken	2. Repair or replace linkage (refer to vehicle service
3.	Main pressure low	3. Refer to C, above
4.	Range selector not engaged at control valve	4. Install or replace parts involved (inside oil pan) (para 7-9)
K	HIGH STALL SPEED (refer to para 3-13)	
1.	Oil level low	1. Add oil to proper level (para 3-3)
2.	Clutch pressure low*	2. Refer to D, above
3.	Forward clutch slipping (forward)*	3. Rebuild forward clutch (para 6-8)
4.	First clutch slipping*	4. Rebuild first clutch Para 7-3)
L	LOW STALL SPEED (refer to para 3-13)	
1.	Engine not performing efficiently (may be due to high altitude)	1. Refer to engine manufacturer's manual or vehicle service manual
2.	Broken converter parts	2. Replace converter assembly (para 63)
M	ROUGH SHIFTING	
1.	Manual selector linkage out of adjustment	1. Adjust linkage (para 3-10)
2.	Control valves, sticking	2. Replace or rebuild control valve (para 6-6)
3.	Governor valve malfunctioning	3. Clean or replace governor and governor screen
6.	Mechanical actuator cable kinked, broken, or not property adjusted	6. Replace or repair cable
7.	Mechanical actuator malfunctioning	7. Replace actuator
8.	Engine idle speed too fast	8. Adjust engine idle sped screw

*Clutch slippage may be recognized by alternate racing and loading of the engine which is, at times, accompanied by a violent chatter.

TROUBLESHOOTING CHART (cont)

Cause		Remedy	
N	ENGINE OVERSPEEDS ON FULL THROTTLE UPSHIFT		
1.	Piston seals leaking or clutch plates slipping in range involved	1.	Overhaul transmission (Sect. 5 thru 7)
2.	Forward clutch piston seals or clutch plates slipping (all upshifts)	2.	Overhaul forward clutch and piston assembly (para 6-8)
3.	Broken sealrings on front support hub	3.	Replace rings (para 7-7b)
4.	Sticking governor valve	4.	Clean or replace governor
O	EXCESSIVE SLIPPAGE AND CLUTCH CHATTER IN ONLY ONE RANGE		
1.	Clutch slippage in that range clutch	1.	Overhaul clutch
2.	Excessive oil leakage in range piston seals	2.	Overhaul clutch and piston assembly
3.	Oil leakage in valve components for that particular range	3.	Overhaul control valve body assembly (para 6-6)
P	DIRTY OIL		
1.	Failure to change oil at proper Interval	1.	Change oil, install new filter (par* 3-7)
2.	Heat excessive	2.	Refer to I, 4, above
3.	Clutch failure	3.	Overhaul transmission
4.	Damaged oil filter	4.	Replace filter (para 3-7)
Q	OIL LEAK AT OUTPUT SHAFT		
1.	Faulty or missing seal at output flange	1.	Install new lip-type seal in rear of transmission housing (para 7-8)
R	SLIPPAGE IN ALL FORWARD GEARS		
1.	Oil level low	1.	Add oil to proper level (para 3-3)
2.	Clutch pressure low	2.	Refer to C, above
3.	Forward clutch slipping	3.	Rebuild forward clutch (para 6-8)
S	SLIPPAGE IN FOURTH AND REVERSE GEAR ONLY		
1.	Fourth clutch slipping	1.	Rebuild clutch and replace piston seals (para 6-9)
2.	Broken sealring on support assembly hub	2.	Replace sealrings (para 6-9)

TROUBLESHOOTING CHART (cont)

	Cause		Remedy
T	SLIPPAGE IN REVERSE AND FIRST GEAR: PROPER FUNCTION IN OTHER FORWARD GEARS		
1.	First clutch slipping	1.	Overhaul clutch and replace piston seals (para 7-3)
U	VEHICLE MOVES FORWARD IN NEUTRAL		
1.	Range selector linkage out of adjustment	1.	Adjust linkage properly
2.	Forward clutch failed and dragging	2.	Rebuild forward clutch (para 6-8)
V	VEHICLE MOVES BACKWARD IN NEUTRAL		
1.	Range selector linkage out of adjustment	1.	Adjust linkage properly
2.	Fourth clutch failed and dragging	2.	Rebuild clutch assembly (para 6-9)
W	THROWS OIL OUT OF TRANSMISSION FILLER TUBE		
1.	Dipstick loose	1.	Tighten cap; replace if necessary
2.	Oil level too high	2.	Drain oil to proper level (para 3-3); oil may also come out breather
3.	Oil level too low	3.	Fill oil to proper level
4.	Breather stopped up	4.	Clean or replace breather
5.	Water in oil	5.	Drain oil (para 3-8 a.)
X	VEHICLE WILL NOT PUSH START		
1.	Normal operation (no rear push-start pump)		

4-1. SCOPE

This section provides information required before proceeding with the overhaul of the transmission. Tools and equipment for overhaul are discussed. Replacement parts and service kit information is provided. The importance of cleanliness and careful handling is stressed. Helpful information on cleaning and inspection is given. General information on the removal and installation of the transmission is given. Torque specifications for bolts and nuts are tabulated. Information on wear limits and spring specifications are referenced.

4-2. TOOLS AND EQUIPMENT

a. Improvised Tools and Equipment. The following items may be improvised.

(1) Gage for comparing vacuum modulators (fig. 3-4).

(2) Work table (fig. 4-1).

NOTE

The transmission holding fixture (fig. 5-1) may be mounted on the work table.

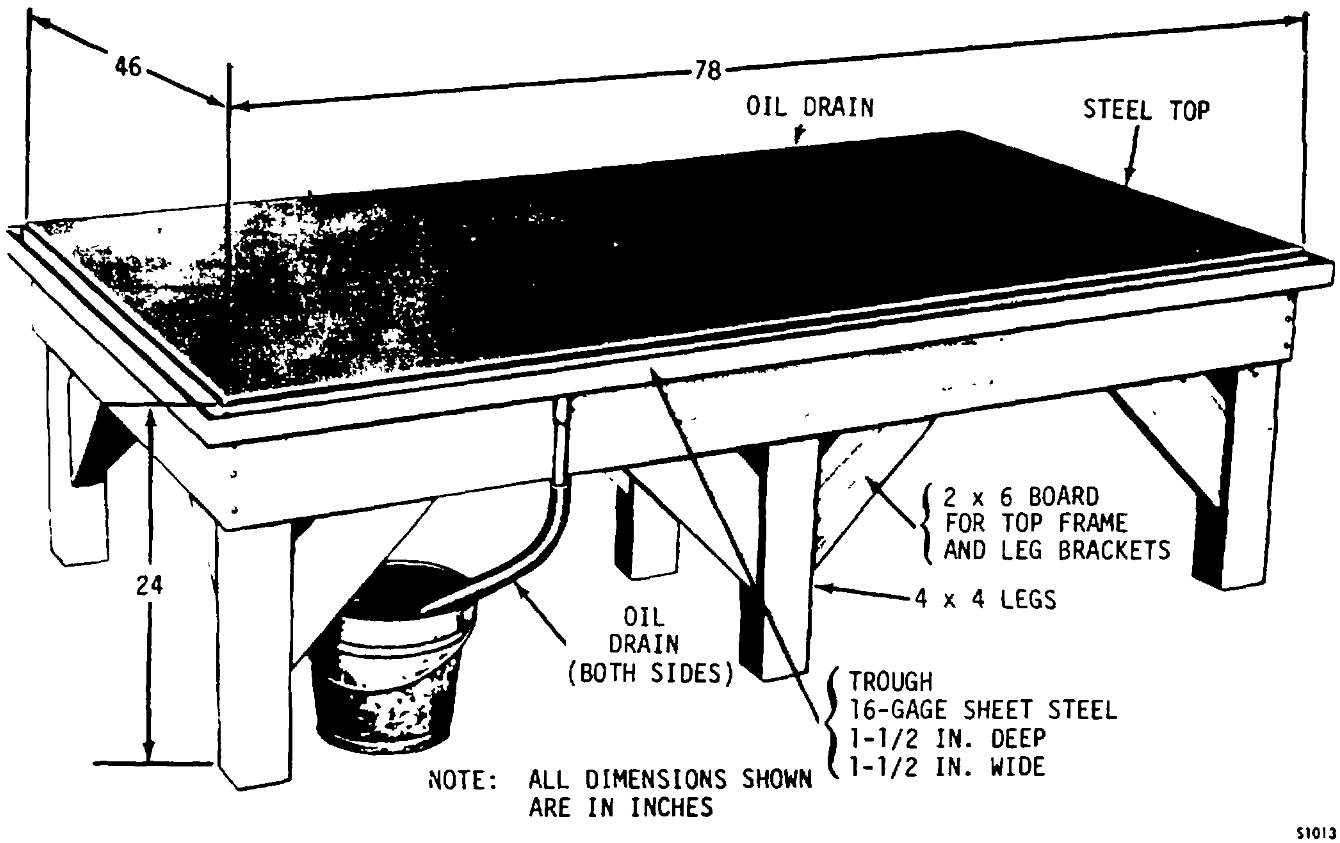

Fig. 4-1. Work table

b. Special Tools. Special tools are shown in figures 4-2, 4-3, 4-4, 4-5, and 4-6. These tools are identified in the special tools table, following.

SPECIAL TOOLS TABLE (cont)

Tool No.*	Fig.	Item	Description	Ref. Paragraph
J-3289-20	4-3	24	Transmission holding fixture base (used with J-23642)	5-2a(2)
J-5959-1	4-4	40	Dial indicator (used with J-7872-2, J-7872-3, J-5959-3, J-5959-7)	6-3b(4)
J-5959-3	4-4	42	Rod 1/4" x 10 1/2" (used with J-5959-1, J-5959-7, J-7872-2, J-7872-3	6-3b(4)
J-5959-7	4-4	44	Lug attachment (used with J-5959-1, J-5959-3, J-7872-2, J-7872-3)	6-3b(4),(5)
J-6125A	4-3	31	Front support slide hammer (2)	5-4a(3)
J-6125-2	4-3	32	Slide hammer adapter (2)	5-4a(3)
J-7872-2	4-4	45	Magnetic clamp (used with J-5959-1, J5-5959-3 J-5959-7, J-7872-3)	6-3b(4)
J-7872-3	4-4	46	Swivel adapter (used with J-5959-1, J-5959-3, J-5959-7, J-7872-2)	6-3b(4)
J-8092	4-2	5	Driver handle (used with J-23613-01, J-23615, J-24778, J-25356)	
J-21359	4-2	2	Oil pump seal installer	6-7b(9)
J-21362	4-4	36	Forward clutch inner seal protector	6-8b(3), (4)
J-21369	4-3	23	Converter leak test fixture	6-3c(2)
J-21795-4	4-2	12	Thumb screw for item 11	
J-23549	4-4	53	Stator thrust bearing-installer (used with J-8092)	6-4b(12)
J-23613-01	4-2	4	Output shaft bushing installer (used with J-8092)	6-11b(2)

* These tools are manufactured by Kent-Moore Tool Division, 29784 Little Mack, Roseville, Michigan'48066, and may be obtained through your local Detroit Diesel Allison dealer or distributor.

SPECIAL TOOLS TABLE (cont)

Tool No.*	Fig.	Item	Description	Ref. Paragraph
J-23614	4-2	6	Stator shaft front bushing installer (also front and rear sun gear shaft bushings)	6-7b(6) 6-11b(3)
J-23615	4-2	3	Stator shaft rear bearing installer (used with J-8092)	6-7b(5)
J-23616	4-2	9	Forward and fourth clutch spring compressor	6-8a(14), 6-8c(3), 6-9a(2), 6-9c3)
J-23619-01	4-3	19	Forward clutch clearance gage	6-8b(7)
J-23620	4-4	20	Fourth clutch clearance gage	6-9a(7)
J-23630-02	4-3	26	First clutch spring compressor assembly (includes J-23630-1, J-23630-2, J-23630-3)	7-5a(9)
J-23630-1	4-3	28	First clutch spring compressor	5-7b(5) 7-3a(7)
J-23630-2	4-3	27	First clutch spring compressor base (used separately to position components during thrust washer selection)	7-5a(9)
J-23630-3	4-3	29	Press bolt and nut	5-7b(5)
J-23631	4-2	1	Output shaft seal installer	7-7a(3), 3-15f(3)
J-23632-01	4-2	15	Spacer selection gage	7-5a(5)
J-23633	4-2	13	Thrust washer selection gage bar	7-7a(l)
J-23642-01	4-3	25	Transmission holding fixture (used with J-3289-20)	
J-23643	4-2	10	Center support lifting bracket	5-6a(2), 7-4b(2),(9)
J-23715	4-3	21	First clutch clearance gage	7-3a(13),(14)
J-23716	4-3	22	Third clutch clearance gage	7-6a(4)

* These tools are manufactured by Kent-Moore Tool Division, 29784 Little Mack, Roseville, Michigan'48066, and may be obtained through your local Detroit Diesel Allison dealer or distributor.

SPECIAL TOOLS TABLE (cont)

Tool No.*	Fig.	Item	Description	Ref. Paragraph
J-23717	4-3	34	Center support compressor assembly	7-4b(4)
J-23717-4	4-3	35	Snapring gage	7-4b(6)
J-23718-02	4-3	30	Output shaft positioning sleeve	6-11b(12),(22)
J-23779-01	4-4	38	Forward and fourth clutch outer seal protector	6-8b(3),(4) 6-9a(3),(4)
J-24202-4	4-4	41	Driver handle	
J-24216-01	4-4	37	First clutch inner seal protector	7-3a(2),(3)
J-24218-2	4-4	50	Stator roller retainer ring (2 13/16 OD)	6-4e(5)
J-24314	4-2	7	Shift valve adjusting ring tool	
J-24352	4-2	11	Sun gear shaft retainer assembly	7-5a(1),b,(1)
J-24420	4-4	48	Rear bearing puller body (used with J-24463-2)	3-15b(2)
J-24446	4-4	51	Rear bearing installer (with or without output shaft installed)	7-8a(2) 3-15e(3)
J-24453	4-4	39	Retainer ring installer	6-10b(4)
J-24463	4-4	47	Rear bearing puller assembly (in vehicle) (includes J-24420 and J-24463-2)	3-15b(2)
J-24463-2	4-4	49	Rear bearing puller legs (2) (used with J-24420)	3-15b(2)
J-24602	4-2	14	Converter end play gage	6-3b(2)
J-24778	4-4	52	Center support bushing installer	6-10b(1)
J-24787	4-4	54	Main regulator valve installer or remover	6-7a(9), 6-7b(4)
J-25356	4-4	55	Front pump bushing installer	6-7b(8)

* These tools are manufactured by Kent-Moore Tool Division, 29784 Little Mack, Roseville, Michigan'48066, and may be obtained through your local Detroit Diesel Allison dealer or distributor.

SPECIAL TOOLS TABLE (cont)

Tool No.*	Fig.	Item	Description	Ref. Paragraph
J-25587-01		**	Planetary Rebuilding Kit	6-13b, NOTE 6-13d, NOTE
J-25587-1	4-5	64	Swaging fixture	6-4e(5),(14), 6-13b(2)
J-25587-2	4-5	69	Pin remover and installer adapter	6-13d(4)
J-25587-3	4-5	73	Support block	6-13 Chart
J-25587-4	4-5	72	Support block	6-13 Chart
J-25587-6	4-5	74	Pin remover and installer "spacer	6-13 Chart
J-25587-10	4-5	66	Pin installer	6-13 Chart
J-25587-14	4-5	68	Pin installer	6-13 Chart
J-25587-16	4-5	65	Pin remover	6-13b(3)
J-25587-17	4-5	71	Bottom swaging tool holder	6-13d(8)
J-25587-20	4-5	70	5/8" loading pin	6-13 Chart
J-25587-22	4-5	67	1/2" load pin	6-13 Chart
J-25587-25	4-5	78	Swaging tool	6-13 Chart
J-25587-27	4-5	75	Swaging tool	6-13 Chart
J-25587-49	4-5	62	5/8" guide pin	6-13 Chart
J-25587-50	4-5	63	1/2" guide pin	6-13 Chart
J-26282	4-2	8	Selector shaft seal installer	6-12b(2)
J-26401	4-3	33	Shift lever seal remover	6-12a(2)
J-26558-601	NI		Sleeve retainer 601 (Loctite)	6-2g
J-26857	4-4	43	Pump gear gage set	6-7b(1 1)

* These tools are manufactured by Kent-Moore Tool Division, 29784 Little Mack, Roseville, Michigan 48066, and may be obtained through your local Detroit Diesel Allison dealer or distributor.

** All J-25587 numbers, above, are components of Planetary Rebuilding Kit J25587-01. Additional components of the kit are used in the rebuild of planetary assemblies in other Allison models

SPECIAL, TOOLS TABLE (cont)

Tool No.*	Fig.	Item	Description	Ref. Paragraph
J-28501	4-2	16	Front planetary bushing installer	6-13c(5)
J-28684	4-3	17	Governor pin installer	6-12b(5)
J-28708	4-3	18	Governor pin remover	6-12a(5)
J-29121-1	4-5	61	Rivet punch	6-4c(14)
J-29121-3	4-5	60	Rivet remover pin	6-4c(5)
J-29375	4-6	77	Turbine rivet tool set	
J-29375-1	4-6	78	Base plate	6-4d(2),(3),(15)
J-29375-2	4-6	79	Guide plate	6-4d(4),(7),(19)
J-29375-3	4-6	81	Staking tool	6-4d(19)
J-29375-4	4-6	82	Pin remover	6-4d(9)
J-29375-5	4-6	83	Drill guide bushing	6-4d(7)
J-29375-11	4-6	84	Adapter	6-4d(4),(16)
J-29521	4-5	56	Stator rivet set	NI
J-29521-1	4-5	57	Stator rivet base	6-4c(3),(13)
J-29521-2	4-5	58	Top plate	6-4c(3),(13)
	4-5	59	Bolt, 5/8-11 x 3.25	6-4c(4),(13)
	4-6	80	Bolt, 1/2-13 x 3 1/2	6-4d(5),(17)

* These tools are manufactured by Kent-Moore Tool Division, 29784 Little Mack, Roseville, Michigan 48066, and may be obtained through your local Detroit Diesel Allison dealer or distributor.
NI - Not illustrated

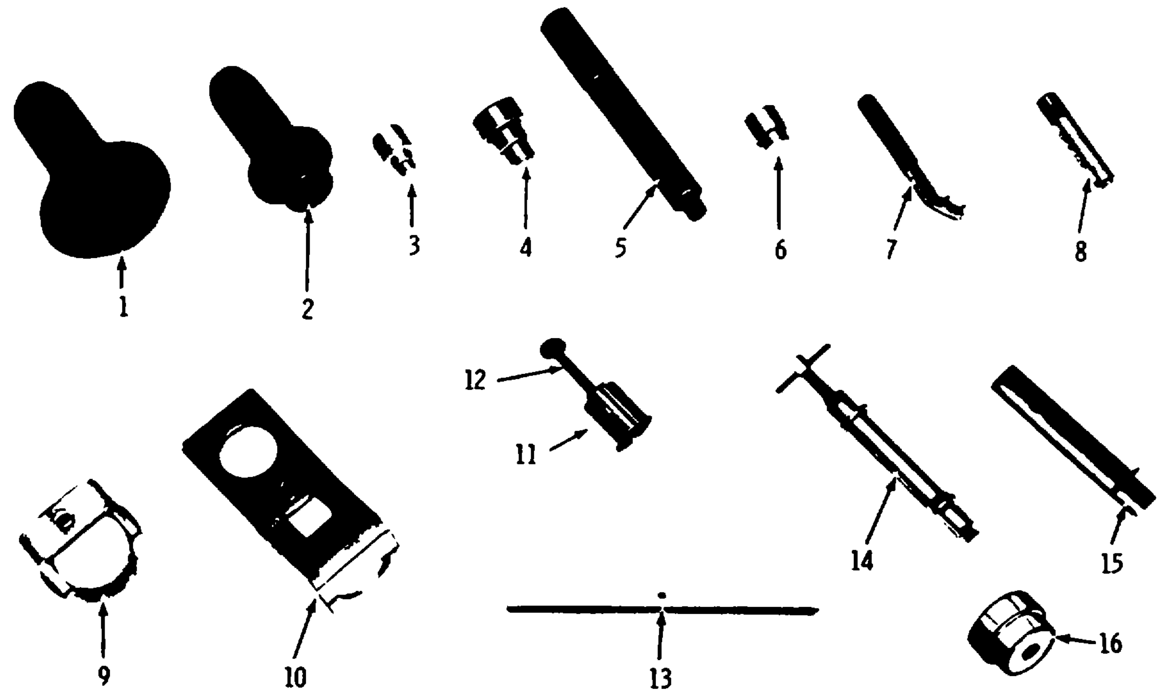

Fig. 4-2. Special tools (1 thru 16)

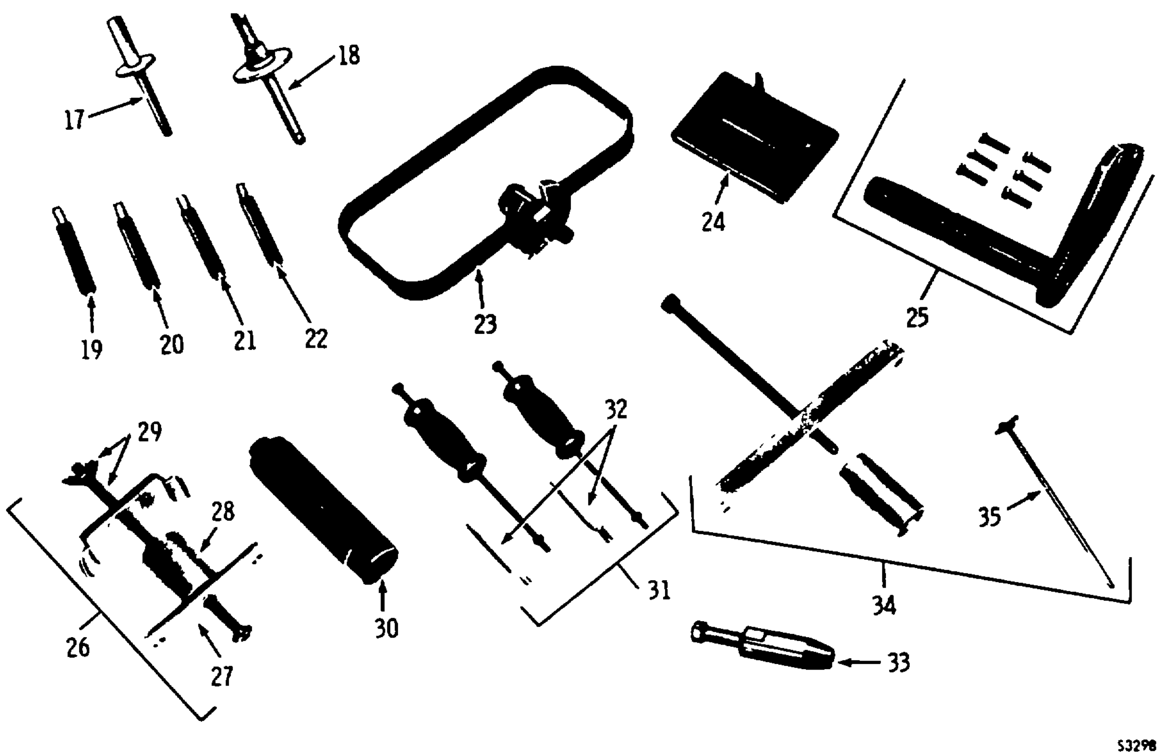

Fig. 4-3. Special tools (17 thru 35)

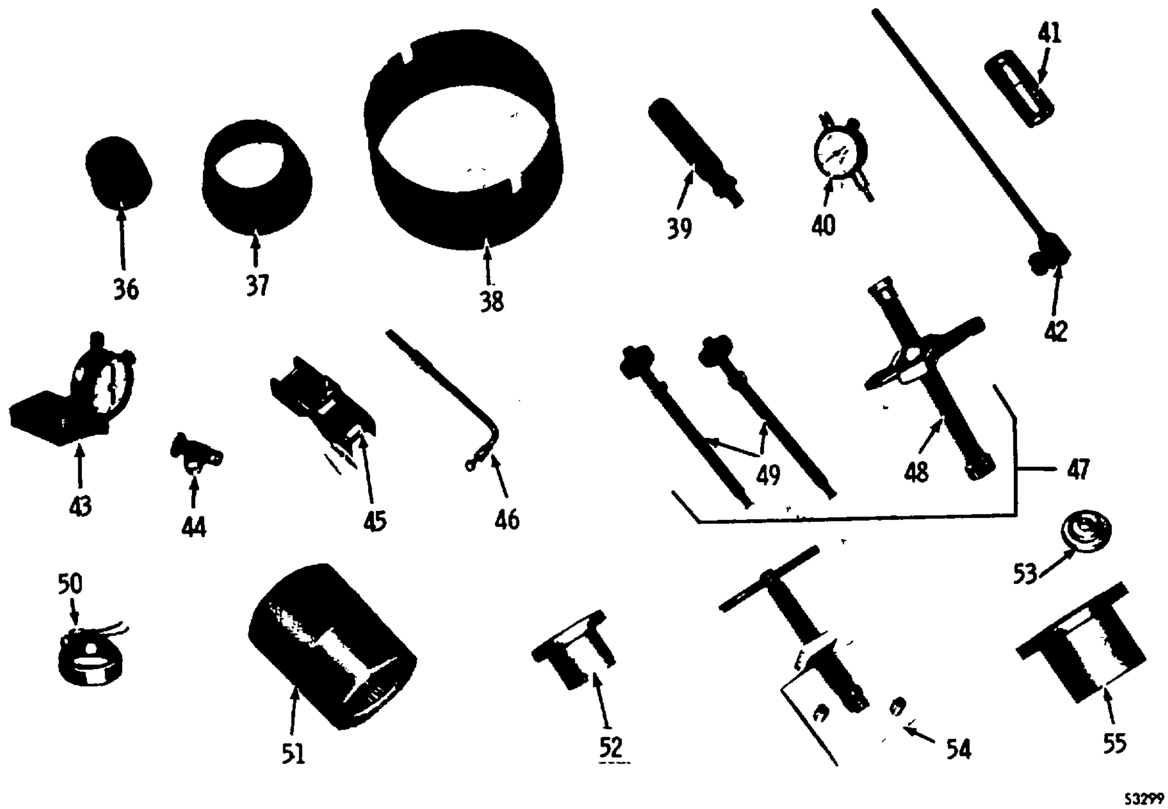

Fig. 4-4. Special tools (36 thru 55)

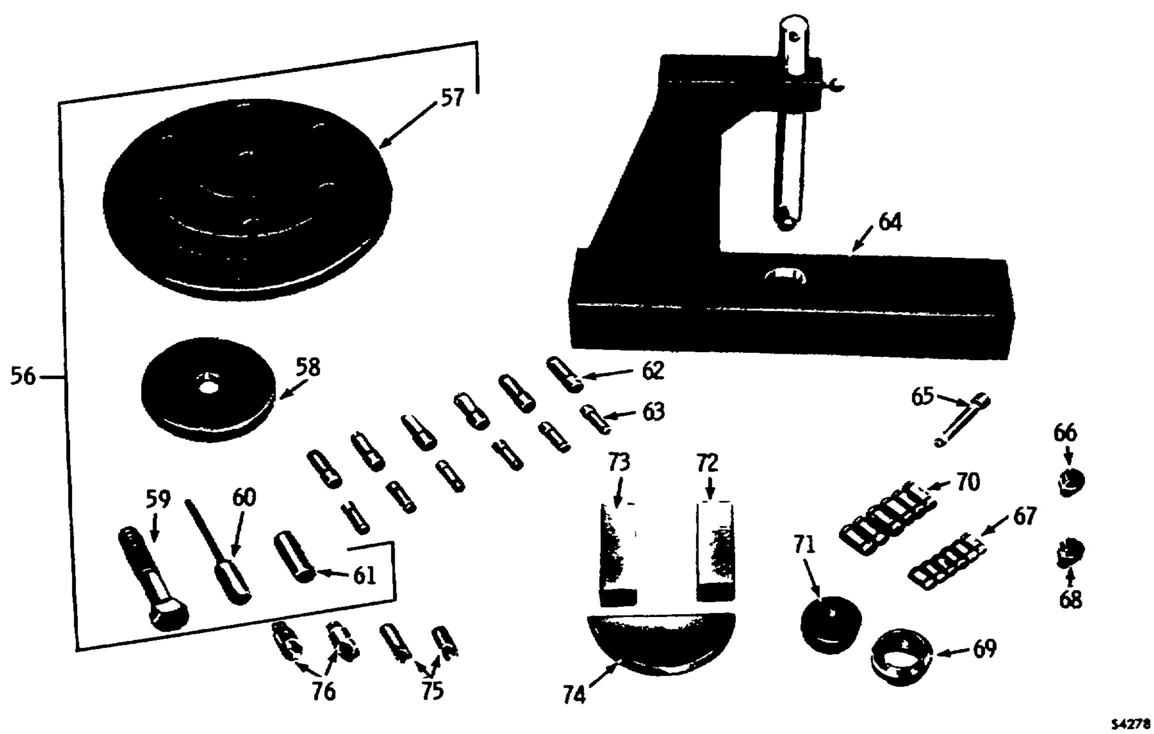

Fig. 4-5. Special tools (56 thru 76)

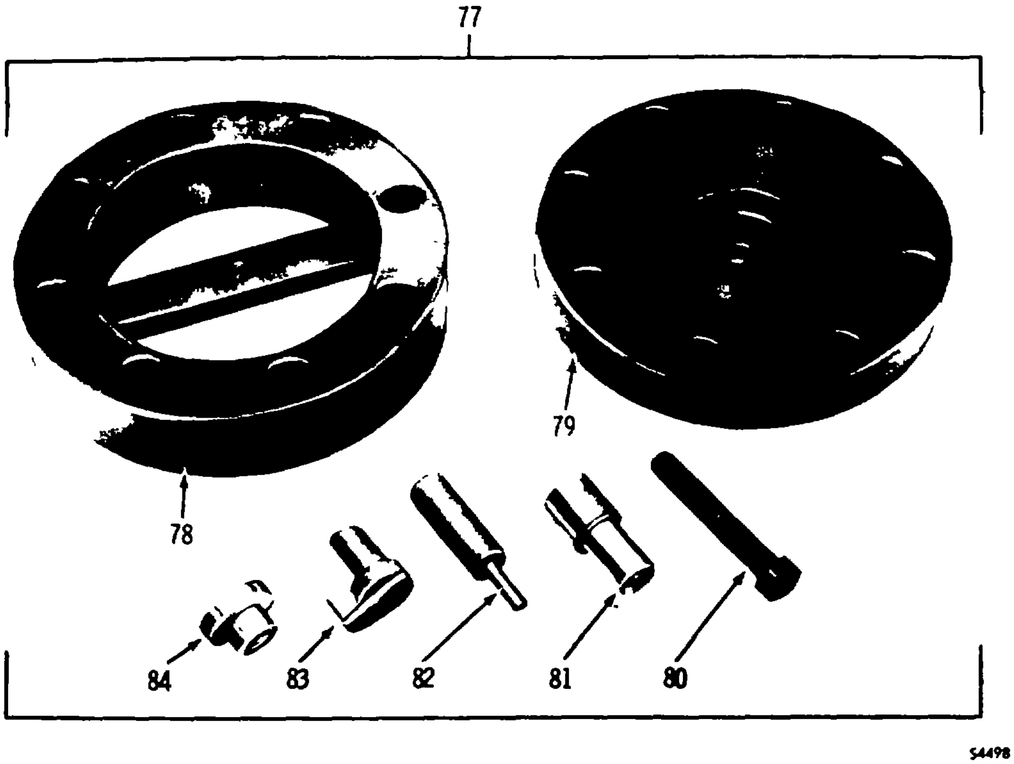

Fig. 4-6. Special tools (77 thru 84)

c. Mechanic's Tools, Shop Equipment

(1) The following tools, in addition to the common tools ordinarily required, should be available:

- Snapring pliers (fig. 5-19, 5-20)
- Depth micrometer (fig. 6-63, 6-62)
- Headless guide bolts, 5/16-18 x 4 (2) (fig. 7-27)
- Torque wrench (fig. 7-12)
- Dial indicator set (for checking end play, fig. 6-1)
- Gear and bearing pullers

(2) A press for disassembly and assembly of spring-loaded clutches, and for installation of press-fit parts, is required (fig. 6-39, 6-46).

(3) A suitable hoist of at least 1/4-ton capacity is required.

(4) A hot plate or heating equipment (for heating bearings or other interference-fit parts to aid assembly) is required.

(5) The following should be available:

- Clean shop cloths (do not use waste)
- Boxes, receptacles for parts
- Supply of wood blocks
- Oil-soluble grease (petrolatum)
- Cleaning supplies (brushes, solvents, etc.)
- Sealer - Perfect Sealer #4 or Permatex #2, or equivalent (for plugs, seals)

4-3. REPLACEMENT PARTS

a. Ordering Information. Refer to the current issue of Parts Catalog for parts information.

b. Parts Normally Replaced. The following parts are normally replaced at each transmission overhaul

(1) Gaskets

(2) Washers or snaprings damaged by removal

(3) Oil seals, piston sealrings

(4) Center support bolt

4-4. CAREFUL HANDLING

During all rebuild procedures, parts and subassemblies must be handled carefully to prevent nicking, scratching, a n d denting. Parts which have close operating clearance can bind if damaged. Parts which depend upon smooth surfaces f o r sealing may leak if scratched. This is very important concerning parts of the control valve body assembly (valves, when dry, must move freely by their own weight). Such parts should be carefully handled and protected during removal, cleaning, inspection, and installation as well as being kept clean while in containers awaiting installation.

4-5. CLEANING, INSPECTION

a. Dirt Causes Malfunction. All parts must be clean to permit effective inspection. At assembly, it is very important that no dirt or foreign material be allowed to enter the transmission. Even minute particles can cause the malfunction of close-fit parts, such as valves and bearings.

NOTE

It is recommended that all assembled bearings be replaced when any metal contamination is present.

b. Cleaning Parts

(1) All the metallic parts of the transmission except bearings should be cleaned thoroughly with volatile mineral spirits or by the steam-cleaning method. Do not use caustic so d a solution for steam cleaning.

(2) Parts should be dried with coin-pressed air. Steam-cleaned parts should be oiled immediately after drying.

(3) Clean oil passages by working a piece of soft wire back and forth through the passages and flushing with mineral spirits. Dry the passages with compressed air.

(4) Examine parts, especially oil passages, after cleaning, to make certain they are entirely clean. Reclean them if necessary.

c. Cleaning Bearings

(1) Bearings that have been in service should be thoroughly washed in volatile mineral spirits.

(2) If the bearings are particularly dirty or filled with hardened grease, soak then in the spirits before trying to clean them.

WARNING

Never dry bearings by spinning them with compressed air. A spinning bearing can disintegrate. Also, spinning a bearing without lubrication can damage the bearing.

(3) Before inspection, oil the bearings with the same type of oil that will be used in the transmission.

d. Inspecting Bearings

(1) Inspect bearings for roughness of rotation. Replace a bearing if its rotation is still rough after cleaning and oiling.

(2) Inspect bearings for scored, pitted, scratched, cracked, or chipped races, and for excessive wear of rollers or balls. If one of these defects is found, replace the bearing.

(3) Inspect a defective bearing's housing a n d shaft for grooved, burred, or galled conditions that would indicate that the bearing has been turning in its bore or on its shaft. If the damage cannot be repaired with crocus cloth, replace the defective part.

(4) When installing a bearing on a shaft, heat the bearing to 200°F (93°C) in an oil bath (approximately 30 minutes). Use t he proper size installation sleeve and a press to seat the bearing.

(5) If a bearing must be removed or installed without a sleeve, press only on the race which is adjacent to the mounting surface. If a press s not available, seat the bearing with a drift and hammer, driving against the supported race.

e. Keeping Bearings Clean. Since the presence of dirt or grit in ball bearings is usually responsible for bearing failures, it is important to keep bearings clean during removal and installation. Observance of the following rules will do much to ensure maximum bearing life.

(1) Do not remove the wrapper from new bearings until ready to install them.

(2) Do not remove the grease in which new bearings are packed.

(3) Do not lay bearings on a dirty bench; place them on clean, lint-free paper.

(4) If assembly is not to be completed at once, wrap or cover the exposed bearings with clean paper or lint-free cloth to keep out dust.

f. Inspecting Cast Parts, Machined Surfaces

(1) Inspect bores for wear, scratches, grooves, and dirt. Remove scratches and burrs with crocus cloth. Remove foreign matter. Replace parts that have scratches or grooves that cannot be removed with crocus cloth.

(2) Inspect all oil passages f or obstructions. If an obstruction is found, remove it with compressed air, or by working a soft wire back and forth through the passage and flushing it out with cleaning solvent.

(3) Inspect mounting faces for nicks, burrs, scratches, and foreign matter., Remove such defects with crocus cloth or a soft stone. If scratches cannot be removes with crocus cloth, replace the part.

(4) Inspect threaded openings for damaged threads. Chase damaged threads with the correct size used tap (a new tap can cut oversize). A thread insert may be used if the insert will not be subjected to high pressure oil Inserts used in high pressure areas will leak oil

(5) Replace housings or other cast parts that are cracked.

(6) Inspect all machined surfaces for damage that could cause oil leakage or other malfunction of the part. Rework or replace the defective parts.

(7) Inspect clutch housing sealing surfaces for nicks, burrs, dents, or displaced metal that could interfere with mating parts or damage the piston seal Remove .raised metal, sharp edges, burrs, or nicks with a soft stone- and crocus cloth. Thoroughly clean all residue from housing prior to assembly.

(8) Inspect sealring grooves for nicks, burrs, dents or displaced metal that could damage the seal. Remove raised metal, sharp edges, burrs, or nicks with a soft stone and crocus cloth. Thoroughly clean all residue from the part prior to assembly.

(9) Inspect the oil tracks in the valve body and main housing valve body mounting surface for porosity, broken lands, cracks, dirt, and land surface imperfections These distortions and imperfections will cause severe oil leakage leading to trans-

mission failure. The oil tracks identified in figure 4-7 will assist in locating troubled areas.

g. Inspecting Bushings, Thrust Washers

(1) Inspect bushings for scores, burrs, roundness, sharp edges, and evidence of overheating. Remove scores with crocus cloth. Remove burrs and sharp edges with a scraper or knife blade. If the bushing is out-of-round, deeply scored, or excessively worn, replace it, using the proper size replacer.

NOTE

Do not damage (scratch, score) the bushing bore when removing a defective bushing.

(2) Inspect thrust washers for distortion, scores, burrs, and wear. Replace the thrust washer if it is defective or worn.

h. Inspecting Lip-type Seals, Sealrings, and Gaskets

(1) Inspect all lip-type sealrings and lip-type (metal encased) seals for nicks, cuts, tears, splits, and pattern damage. Damage on a seal can indicate rough or sharp edges in the piston sealring grooves or on mating surfaces that could also damage the new seal.

(2) Replace all composition gaskets.

(3) Inspect clutch housing sealring surfaces for nicks, burrs, dents, or displaced metal that would damage new lip-type seals or sealrings. Remove raised metal, sharp.

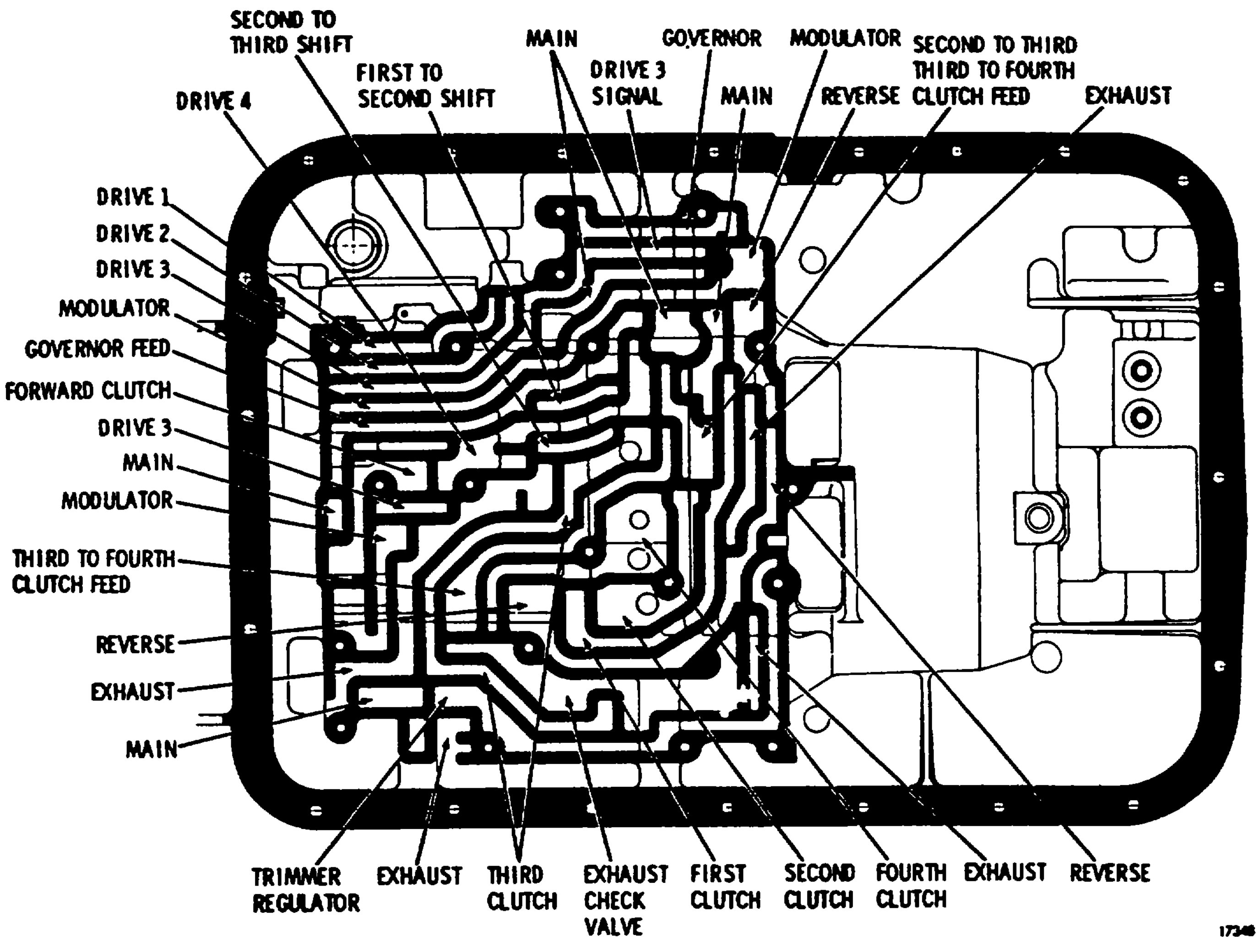

Fig. 4-7. Main housing valve body mounting surface tracks

edges, burrs, or nicks with a soft stone and crocus cloth. Thoroughly clean all residue from the housing prior to assembly.

(4) Install a new hook-type sealring if the ring shows any wear on the outside diameter, or if there is excessive side wear.

(5) The sides of the sealring must be smooth (0.005-inch (0.13 mm) maximum side wear). The sides of the shaft groove, or the bore, in which the sealring fits should be smooth, 50 microinches (1.27 micrometers) equivalent and square with the axis of rotation within 0.002 inch (0.05 mm). If the sides of the grooves have to be reworked, install a new sealring.

i. Inspecting Gears

(1) Inspect gears for scuffed, nicked, burred, or broken teeth. If the defect cannot be removed with a soft stone, replace the gear.

(2) Inspect gear teeth for wear that may have destroyed the original tooth shape. If this condition is found, replace the gear.

(3) Inspect the thrust face of gears for scores, scratches, and burrs. Remove such defects with a soft stone. If scratches and scores cannot be removed with a soft stone, replace the gear.

i. Inspecting Splined Parts. Inspect splined parts for stripped, twisted, chipped, or burred splines. Remove burrs with a soft stone. Replace the part if other defects are found. Spline wear is not considered detrimental except where it affects tightness of fit of the splined parts.

k. Inspecting Threaded Parts. Inspect parts for burred or damaged threads. Remove burrs with a soft stone or fine file. Replace damaged parts.

l. Inspecting Snaprings. Inspect all snaprings for nicks, distortion, and excessive wear. Replace snapring if any of those defects are found. The snapring must snap tight in its groove for proper functioning.

m. Inspecting Springs. Inspect springs for signs of overheating, permanent set, or wear due to rubbing adjacent parts. Replace the spring if any one of these defects are found. Refer to the spring chart at the end of Section 8.

n. Inspecting Clutch Plates

(1) Inspect friction-faced steel plates (internal-splined plates) for burrs, imbedded metal particles, severely pitted faces, excessive wear, cone, cracks, distortion, and damaged spline teeth. Remove burrs, using a soft honing stone. Replace plates which have other defects.

(2) Inspect steel plates (external-tanged plates) for burrs, scoring, excessive wear, cone, distortion, imbedded metal, galling, cracks, breaks, and damaged tangs. Remove burrs and minor surface irregularities, using a soft-honing stone. Replace plates which have other defects.

(3) The amount of cone in clutch plates is determined by measuring the distance between the inside diameter of the plate and a flat surface (fig. 4-8). If the cone exceeds the wear limits shown in the wear limits chart, replace the plate. Refer to wear limits chart, Section 8.

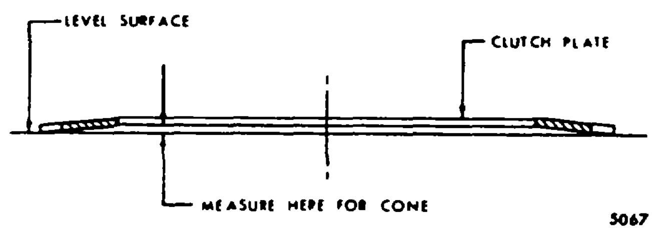

Fig. 4-8. Method of measuring clutch plate cone

4-6. GENERAL ASSEMBLY PROCEDURES

a. Clutches, Pistons

(1) Clutch pack clearances must be established prior to assembly. After clearances have been established, soak each friction-face clutch plate (2 minutes minimum) in transmission fluid prior to final assembly.

(2) Apply a generous amount of transmission fluid to the piston cavity prior to final assembly.

(3) Assemble clutch plates so that the cone of each plate faces the same direction as the cone of the adjacent plates.

b. Lubricants Used For Assembly. Use transmission fluid to lubricate splines, bearings, clutch plates, etc. during assembly. A low temperature grease, such as petrolatum shall be used for internal assembly where it is necessary to use a grease to hold parts in place for assembly. The grease shall have a melting point of 100-1400F (38-60°C) and must be completely soluble in the transmission fluid. Petrolatum equivalent toMIL-VV-236o r Amojell Petrolatum (Amoco Oil Co.) is recommended. High temperature grease having good oxidation and water resistance shall be used at the ID of input and output shaft oil seals. A high temperature grease equivalent to MILG-81322,Mobil greaseNo.28 (Mobil Oil Co.), or Aeroshell grease No. 22 (Shell Oil Co.) is recommended.

c. External Pipe Plugs, Hydraulic Fittings

(1) New Precoated Plugs. New Plugs that are precoated with Teflon need no preparation for assembly.

(2) Reused or Uncoated Plugs, Hydraulic Fittings. Prepare the threads with a small amount of nonhardening sealant, such as Loctite Pipe Sealant with Teflon, or equivalent. Do not use Teflon tape.

CAUTION

Inaccurate torque can cause leakage and cracked housings. Tighten all pipe plugs to the torque specified in the assembly step and on the exploded views.

d. Oil-Soluble Grease

CAUTION

Do not use oil-soluble grease to retain cork gaskets.

Use oil-soluble grease with a low melting point (petrolatum) to temporarily retain parts, step-joint sealrings, scarf-cut sealrings, and hook-type sealrings during assembly with mating parts.

e. Sealring Compounds, Nonsoluble Greases. Do not use gasket-type sealing compounds, fibrous greases, or nonsoluble, vegetable-base cooking compounds any place inside the transmission. Do not use them any place where they could be flushed into the transmission hydraulic system. However, if adhesvies or sealers are required for the oil pan gasket, they may be applied on the pan mounting flange, but only in the area outside of the flange bead.

f. Lip-type Oil Seals

(1) When replacing lip-type oil seals, make sure the spring-loaded lip side is toward the oil to be sealed in (toward the inside of the unit). Coat the ID of the seal with high temperature grease (MIL-G-81322 or equivalent) to protect t h e seal during shaft installation and to provide lubrication during initial operation.

(2) The circumference of some seals is precoated with a dry sealant. The sealant is usually colored for easy identification. The precoated seals do not require any additional sealant before installation.

(3) Seals which are not precoated must be coated with a nonhardening sealant. The sealant must be applied to the circumference of the seal prior to installation.

g. Interference-fit Parts. Assembly of interference-fit parts may be accomplished by heating and chilling the respective parts. The female part can be heated in an oven or oil bath to 3000F (149°C), and the male part can be chilled in dry ice. Either one or both parts may require a thermal process. However, if the chill process is used for a ferrous alloy part, coat the components with transmission fluid to prevent rust due to frost and moisture.

h. Sleeve-type Bearings and Bushings. The use of a locking compound is recommended to retain bushings and sleeve-type bearings that have press-fit tolerances. One such compound is Loctite 601 Sleeve Retainer. This compound or equivalent should be used.

i. Bearings (Ball or Roller)

(1) When installing a bearing on a shaft, heat the bearing to 200°F (93°C) on an electric hot plate or in an oil bath. Coat the mating surfaces with white lead and use the proper size installation sleeve and a press to seat the bearing.

NOTE

Bearings must be heated long enough for sufficient expansion. Heating -time is determined by the size of the bearing. Forty-five minutes is sufficient for the largest bearing in these transmissions.

(2) If a bearing must be removed or installed without a sleeve, b e careful to drive or press only on the race which is adjacent to the mounting surface. If a press is not available, seat the bearing with a drift and a hammer, driving against the supported race.

4-7. WEAR LIMITS

Refer to Section 8 for general and specific information covering parts fits, clearances, and wear limits.

4-8. SPRING SPECIFICATIONS

Refer to the spring chart in Section 8 for spring identification and specifications.

4-9. TORQUE SPECIFICATIONS

a. Location of Torques. Torque values are provided in chart form on the foldout illustrations at the rear of this manual. The chart is keyed by capital letters, to correspond with capital letters at the end of items in the legend. These same torque values are included in the assembly procedures.

b. Affects of Lubrication. All torque values are for dry assembly unless a specific lubricant is specified in the assembly procedures. However, the presence of transmission fluid on the threads will have little affect on the torque.

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5-1. SCOPE

This section covers disassembly of the AT545 transmissions

5-2. REMOVAL OF EXTERIOR PARTS

CAUTION

The torque converter must be held into the transmission by a retaining strap as shown in figure 1-3. Be sure the strap is in place before lifting the transmission.

a. Mounting in Holding Fixture

(1) Mount the transmission in holding fixture J-23642, figure 5-1. The holding fixture is bolted to the PTO opening after removing the PTO or the PTO cover. Refer to figure 5-1 for proper position of the fixture.

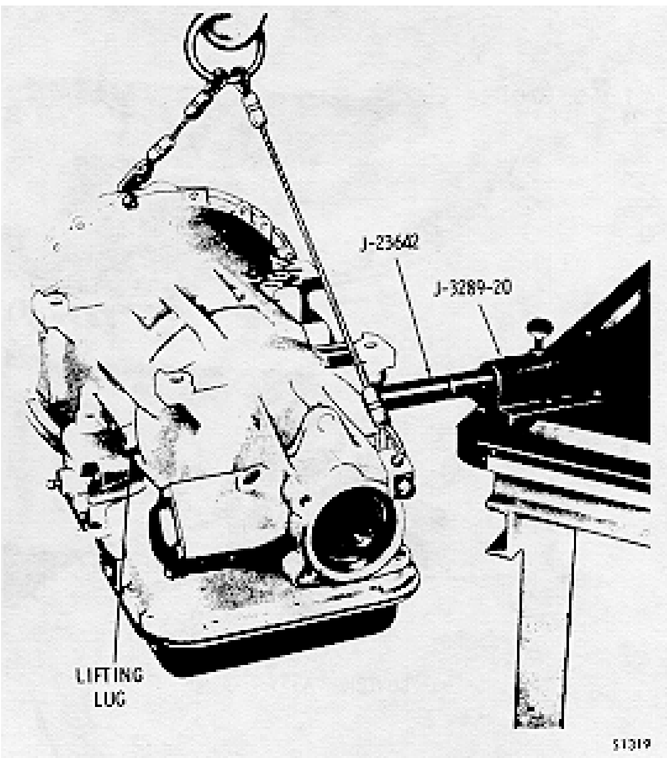

Fig. 5-1. Transmission in holding fixture

(2) The holding fixture is first attached to the transmission. Then the transmission and fixture are hoisted into position for attachment to fixture base J-3289-20 the work table.

b. Removing Torque Converter

(1) Rotate the fixture retained transmission housing until the torque converter located at the top (fig. 5-2).

(2) Remove the bolts and nuts that hold the converter retaining strap to the transmission housing.

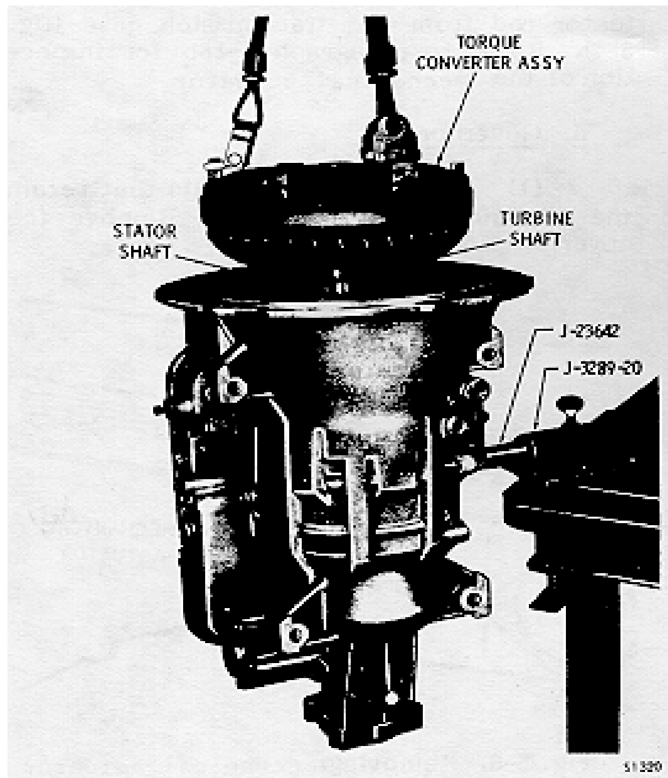

Fig. 5-2. Removing torque converter during overhaul

(3) Attach a three-strand sling to the torque converter. Lift the converter from the transmission housing and place it on a work table (fig. 5-2).

(4) Refertoparagraph6-3for inspection of the AT 545 torque converter assembly,

c. Mechanical Actuator

(1) Rotate the transmission, oil pan side upward.

(2) Remove the bolt and retainer from the transmission case (fig. 5-3).

(3) Remove the mechanical actuator (fig. 5-4). Remove t h e sealring from the mechanic-l actuator.

(4) Remove the mechanical actuator rod from the transmission case (fig. 5-4). Refer to paragraph 3-16b for inspection of the mechanical actuator.

d. Governor

(1) Remove the four bolts that retain the governor cover (fig. 5-4).Remove the cover.

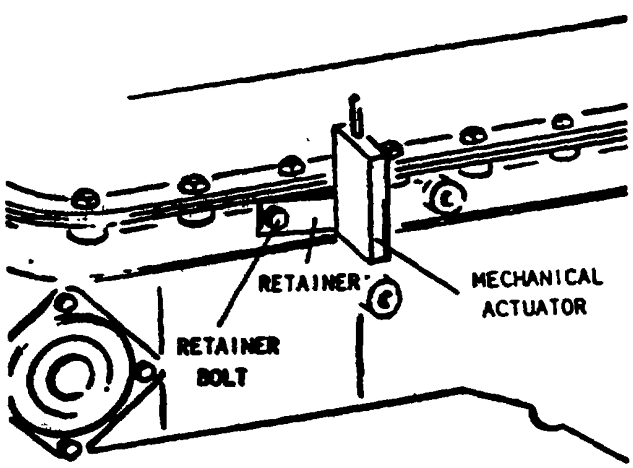

Fig. 5-3. Removing mechanical actuator retainer bolt

(2) Remove the governor assembly (fig. 5-5), rotating it clockwise to disengage the drive gears. Refer to paragraph 6-5 for inspection of the governor.

(3) Remove the governor cover gasket.

e. Oil Pan

(1) Remove the twenty-one screws that retain the oil pan (fig. 5-5).

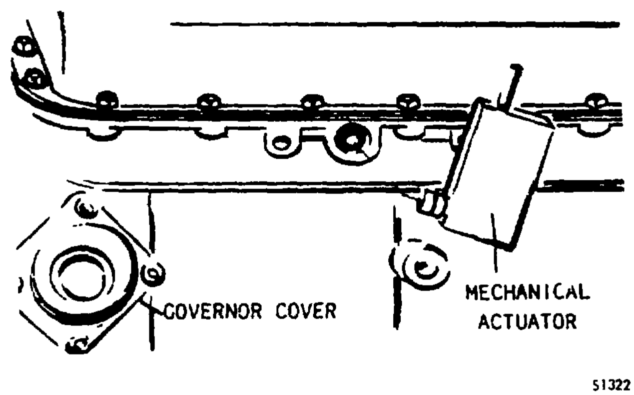

Fig. 5-4. Removing vacuum modulator

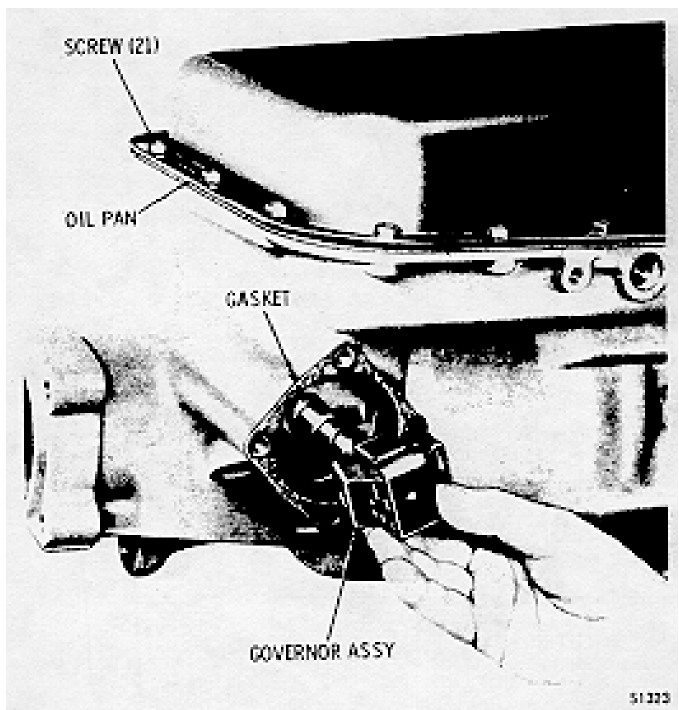

Fig. 5-5. Removing governor assembly

(2) Remove the oil pan (fig. 5-6). Remove the oil pan gasket.

f. Oil Filter

(1) Remove the screw that retains the oil filter (fig. 5-6). Remove the oil filter.

(2) Remove the oil intake pipe and seal ring (fig. 5-7).

5-3. REMOVAL OF CO N'T'ROL VALVE BODY

a. Remove the bolt that retains the detent spring (fig. 5-7). Remove the spring.

b. Remove the eighteen bolts that retain the valve body (fig. 5-7).

c. Remove the control valve body (fig. 5-7) by lifting upward on the body and the Fig. 5-6.

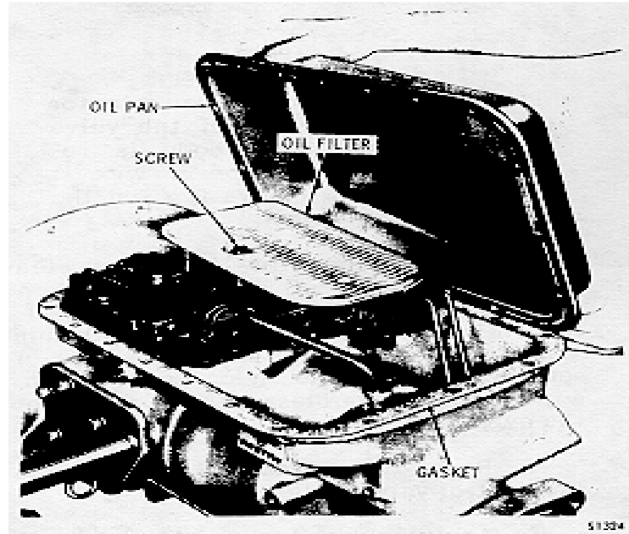

Fig. 5-6 Removing oil pan

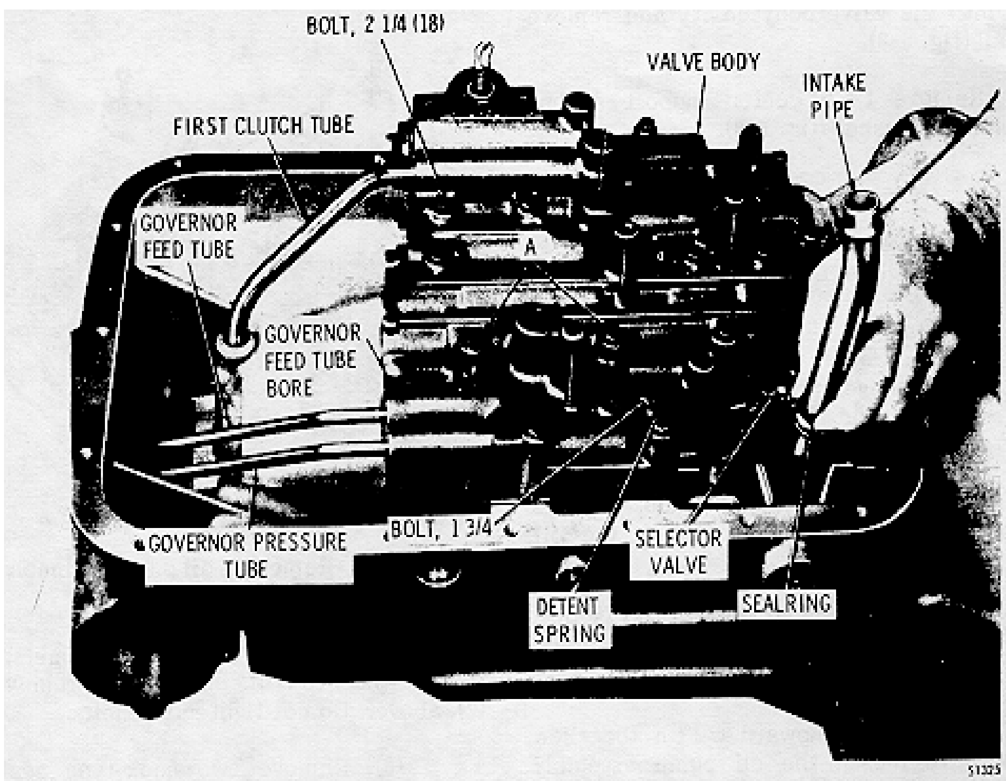

Fig. 5-7. Removing oil intake pipe

CAUTION

Do not allow the selector valve to drop out of the valve body when the body is removed. Either tape or wire it in place, or remove it from the front of the body.

d. Remove the three oil tubes. Remove the wire governor oil screen, located in the governor feed tube bore (fig. 5-7). If the screen is not damaged, clean it with mineral spirits. Some earlier models used a nylon screen Replace the nylon screen with the wire screen regardless of the condition of the nylon screen.

e. Refer to paragraph 6-6 for rebuild of the control valve body assembly.

f. Apply a small amount of oil-soluble grease to the end of a nonmagnetic rod (1/4- inch diameter). Insert the rod (greased end first) into the valve body cavity and remove the ball (fig. 5-8).

g. Remove t h e center support anchor bolt and flat washer (fig. 5-8).

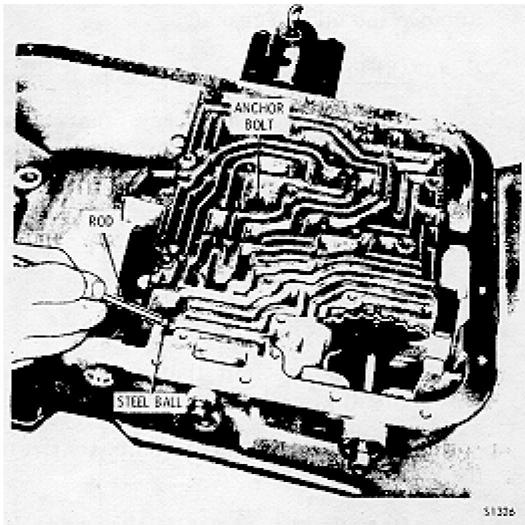

Fig. 5-8. Removing governor check ball

5-4. REMOVAL OF OIL PUMP AND FORWARD CLUTCH

a. Oil Pump

(1) Remove nine bolts and washers that retain the front support. Discard washers.

(2) Remove two bolts andwashers (approximately 1800 apart) from the oil pump body (fig. 5-9).

(3) Install slide hammers J-6125 into the holes from which the two bolts (step (2), above) were removed.

(4) Hammer upward w it h the slide hammers to loosen the oil pump assembly (fig. 5-9). When free, lift the oil pump assembly out of the transmission case.

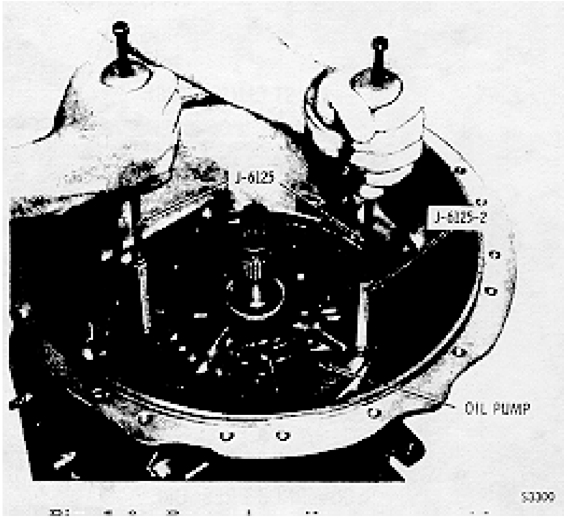

Fig. 5-9. Removing oil pump assembly

(5) Remove the slide hammers, and replace the two bolts and washers removed. in (2), above. Do not tighten the bolts.

(6) Remove two hook-type seal rings 34 (B, foldout 5) and thrust washer 33 from the oil pump assembly.

(7) Refer to paragraph 6-7 for rebuild of the oil pump assembly.

b. FORWARD CLUTCH AND TURBINE SHAFT

(1) Remove the front support gasket (fig. 5-10).

(2) Grasp the turbine shaft (fig. 5-10) and lift out the forward clutch and turbine shaft assembly.

(3) Remove thrust washer 29 (A, foldout 6) from the rear of the clutch assembly.

(4) Refer to paragraph 6-8 for rebuild Fig. 5-
build of the forward clutch and turbine shaft assembly.

5-5. REMOVAL OF FOURTH AND THIRD CLUTCHES

a. Fourth Clutch

(1) Grasp the spring retainer on the fourth clutch (fig. 5-11), and lift out the fourth clutch assembly.

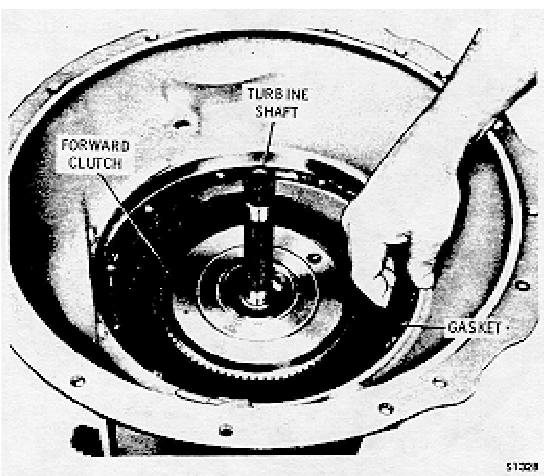

Fig. 5-12. Removing sun gear shaft assembly

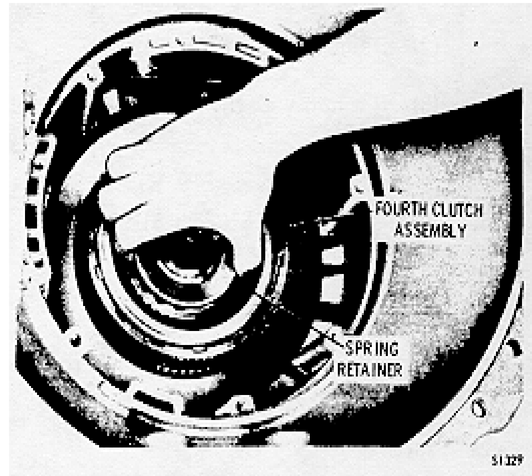

Fig. 5-11. Removing fourth-clutch assembly.

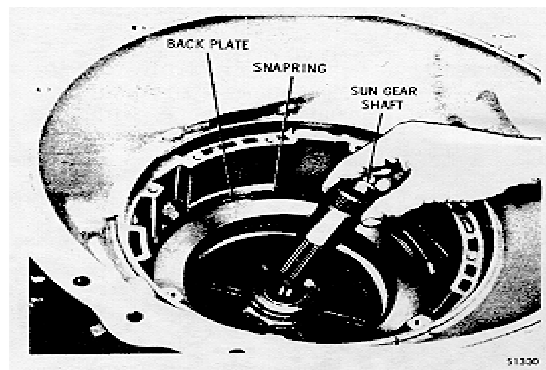

Fig. 5-12. Removing sun gear shaft assembly

(2) Refer to paragraph 6-9 for re-build of the fourth clutch assembly.

(3) Re move sun gear shaft (fig. 5-1 2).

b. Third Clutch

(1) Remove the snapring that retains gasket the third clutch backplate (fig. 5-12).

(2) Remove the backplate.

(3) Remove the six third clutch plates (fig. 5-13).

5-6. REMOVAL OF CENTER SUPPORT ASSEMBLY AND GEARING

a. Center Support Assembly

(1) Remove the snapring that retains the center support assembly (fig. 5-13). This is a selective thickness snapring (refer to para 7-2a(2)).

(2) Install the center support lifting bracket J-23643 into the recess between the hook-type sealrings on the center support hub (fig. 5-14).

CAUTION

The center support is fitted to the transmission case with very little clearance. It may bind In the case if the cases cold. Heat the case slightly, if necessary. Do not use a torch to heat the case. A sun lamp, or a current of warm air is sufficient. If the support assembly starts upward and then binds, tap It downward and lift again.

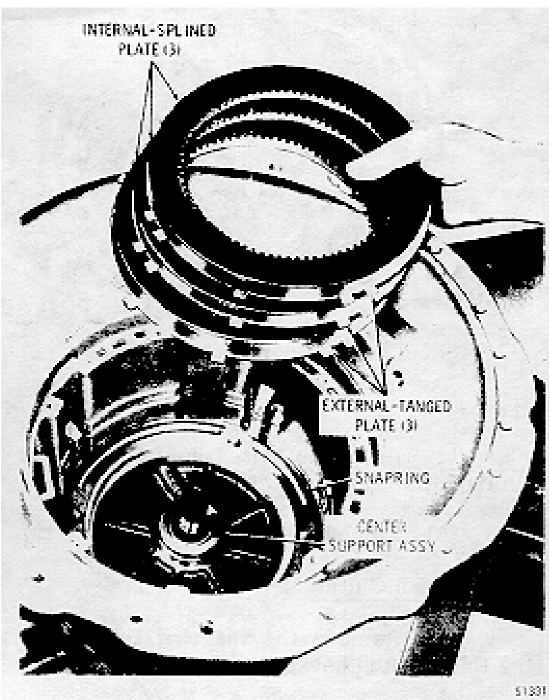

Fig. 5-13. Removing third clutch plates

(3) Lift carefully, straight upward, on the lifting bracket to remove the center support assembly.

(4) Refer to paragraph 6-10 for re- build of the center support assembly.

(5) Remove the thrust washer from the front planetary sun gear (fig. 5-15).

b. Gearing

NOTE

Before the planetary gear unit can be removed, the rear output flange must be removed.

(1) Grasp the transmission main shaft, and lift the planetary gear unit out of the transmission case (fig. 5-16).

Fig. 5-14. Removing center support assembly

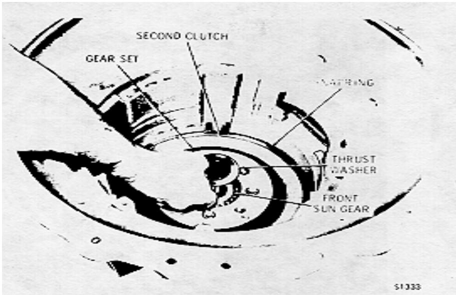

Fig. 5-15. Removing front sun gear thrust washer

NOTE

It may be necessary to tap upward on the output shaft with a soft-faced mallet while lifting on the gear unit.

(2) Refer to paragraph 6-11 for rebuild of the planetary gear unit.

(3) Governor drive gear 1 (B, foldout 9), speedometer drive gear 2, and spacer 3 may come out with the gear unit, or may stay in the transmission. Remove these parts.

5-7. REMOVAL OF SECOND AND FIRST CLUTCHES

a. Second Clutch

(1) Remove the snapring that retains the second clutch (fig. 5-17).

(2) Remove t h r e e external-tanged and three internal-splined, second clutch plates (fig. 5-17).

(3) Remove the second clutch backplate (fig. 5-18).

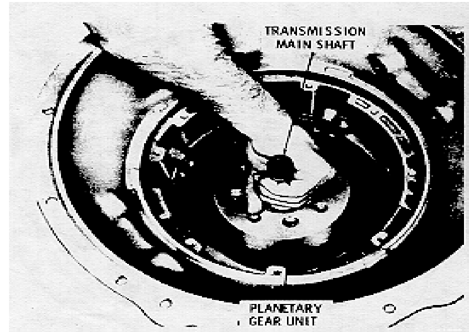

Fig. 5-16. Removing planetary gear unit

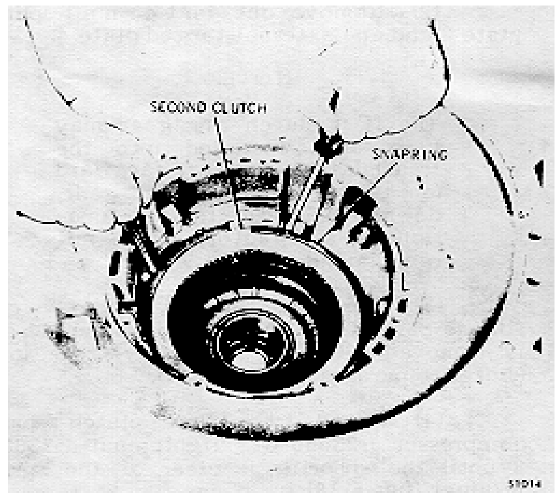

Fig. 5-17. Removing second clutch snapring

b. First Clutch

(1) Remove snapring 1 (A, foldout 8) that retains the first clutch backplate 2. Remove the backplate.

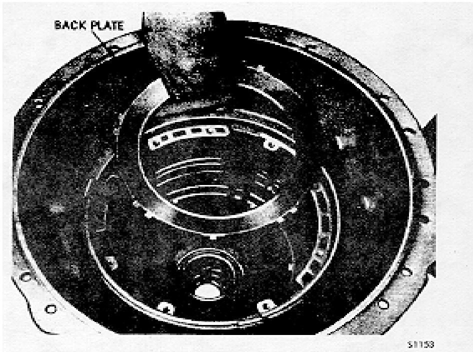

Fig. 5-18. Removing second clutch backplate

(2) Remove one interna1-splined plate 3 and one external-tanged plate 4.

NOTE

The first clutch ring gear may have been installed into the transmission housing backward (extended tooth on gear, down). Although this is functionally satisfactory, it is not recommended.

(3) On earlier models, the rear ring gear is part of the rear carrier assembly and is removed with the planetary gear unit. (Refer to paragraph 6-1 11<u>a</u>(12).)

(4) Install t h e first clutch spring compressor J-23630-01. Tighten nut J-23630-3 until the snapring is clear of the spring retainer (fig. 5-19).

(5) Remove t h e snapring. Remove the compressor.

(6) Remove t h e spring retainer and the twenty-two piston return springs.

(7) Remove t h e first clutch piston (fig. 5-20). Remove the two lip-type seal-rings from the piston.

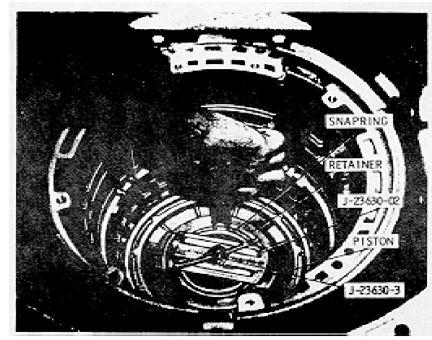

Fig. 5-19. Removing first clutch spring retainer snapring

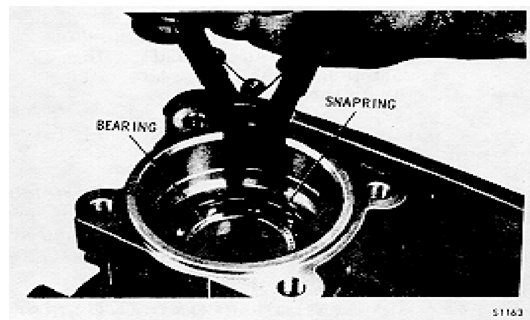

Fig. 5-20. Removing output shaft bearing snapring

5-8. REMOVAL OF OUTPUT SHAFT SEA[AND BEARING

<u>a</u>. <u>Output Shaft Seal</u>

(1) Remove oil seal 6 (B, foldout 9) from the rear of the transmission housing.

(2) Clean t h e bore from which the oil seal was removed.

b. Bearing

(1) Remove the snapring that retains the output shaft bearing (fig. 5-20).

(2) Remove the bearing f r o m its bore. (Refer to paragraph 3-15.)

(3) Remove the transmission housing, with its remaining attached parts, from the transmission holding fixture. Refer to paragraph 6-12 for rebuild of the trans- mission housing.

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Section 6. REBUILD OF SUBASSEMBLIES

6-1. SCOPE

This section describes the inspection of, or the disassembly and assembly of various subassemblies which were removed in Section 5. The rebuild procedures refer to exploded views (foldouts 5 through 9) located at the end of this manual. References are also made to line drawings and photographs within this section.

6-2. ENERAL INFORMATION FOR SUBASSEMBLY REBUILD

a. Tools, Parts, Methods. Refer to paragraphs 4-2, 4-3, and 4-4.

b. Cleaning, Inspection. Refer to paragraph 4-5.

c. Torque specifications. The specific torque value for each threaded fastener is stated at each assembly step. Torque values are also presented on the foldouts in the back of the manual.

d. Wear Limits, Spring Data. Refer to Section 8 for wear limits and spring data.

e. External Pipe Plugs, Hydraulic Fittings

(1) New Precoated Plugs. New plugs that are precoated with teflon need no preparation for assembly.

(2) Reused or Uncoated Plugs, Hydraulic Fittings. Prepare the threads with a small amount of nonhardening sealant, such as Loctite Pipe Sealant with Teflon, or equivalent. Do not use Teflon Tape.

CAUTION

Inaccurate torque can cause leakage and cracked housings. Tighten all pipe plugs to the torque specified in the assembly step and on the exploded view.

f. Clutch Pack Procedure. Soak the friction-faced clutch plates in transmission fluid for a minimum of 2 minutes prior to assembly.

g. Retaining Sleeve-Type Bearings. The use of a locking compound to retain bushings and sleeve-type bearings that are press fitted is recommended. One compound, LOCTITE 601 Sleeve Retainer J-26558-601 or an equivalent may be used.

6-3. TORQUE CONVERTER INSPECTION AT 545

a. Closed Unit Assembly. Because the torque converter assembly is closed and welded after assembly of the internal parts, no repairs can be made. The assembly can be tested, however, to determine its condition in two areas. End play of the internal elements can be measured, and the outer shell can be tested for leaks.

b. End Play Measurement

(1) Clear, the torque converter of oil Examine the oil for evidence of foreign matter or metal particles, indicating transmission or converter internal damage.

(2) Support the converter assembly on the converter cover (pump hub upward). Place the converter end play gage, J-24602, into the converter pump hub (fig. 6-1).

(3) Retain the body of the gage in the pump hub with one hand while rotating the center screw with the other hand, locking the gage to the turbine hub. Do not overtighten.

(4) Assemble J-5959-1, J-5959-3, J-5959-7, J-7872-2, J-7872-3 as shown in figure 6-1. Install the above items onto the converter pump hub as shown in figure 6-1.

(5) Adjust the lug attachment J-5959-7 so the dial will make firm contact with the top of the center screw (fig. 6-1).

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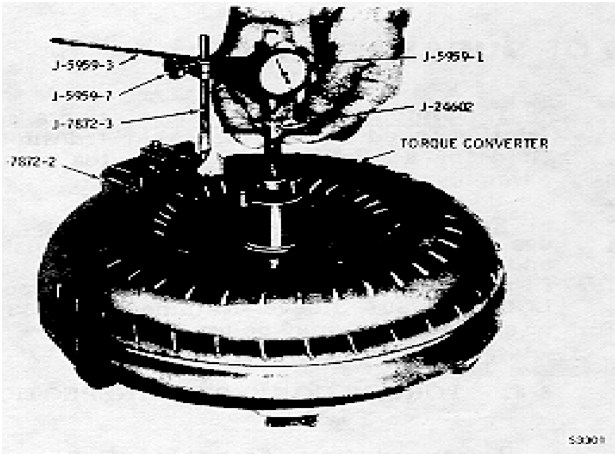

Fig. 6-1. Checking end play of torque converter elements

(6) Set the dial to read zero and lift the center screw (fig. 6-1) as far as possible. The dial indicator reading must not exceed the values listed below. If the converter end play exceeds the value listed, the torque converter assembly should be replaced.

CONVERTER TURBINE END PLAY CHART

Converter	Max End Play
New Converter	0.000-0.015 in. (0.00-0.38 mm)
Used Converter	0.000-0.037 in. (0.00-0.94 mm)

c. Leak Test

(1) Clear the torque converter of oil. Examine the oil for foreign matter or metal, indicating internal damage.

(2) Install the torque converter leak test fixture J-21369 onto the converter (fig. 6-2). The center body must be installed first, with its nut loosened (toward top of body).

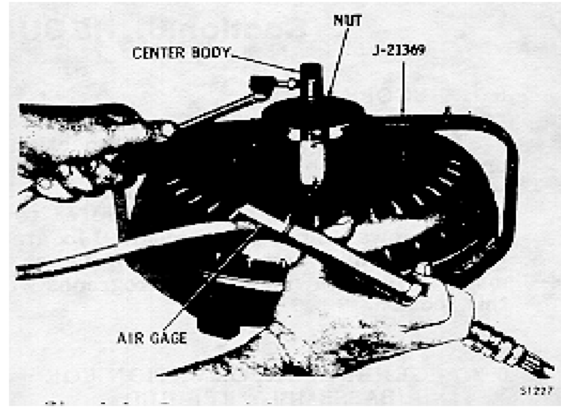

Fig. 6-2. Pressurizing torque converter for leak test

(3) Next, place the converter, and center body, in the fixture bracket. Tighten the nut firmly to seal the center body in the torque converter hub.

(4) Pressurize the converter to 75 psi maximum. Submerge the pressurized assembly in water, and observe closely for bubbles that indicate leakage. If the assembly leaks, it should be replaced.

WARNING

Be sure all pressure is exhausted from the converter before loosening the nut and removing the test fixture.

(5) Release the air from the torque converter by pushing on the valve stem in the air fitting on the center body.

Pages 2939 through 294
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6-7. OIL PUMP ASSEMBLY

a. Disassembly (B, foldout 5)

(1) Remove sealring 13 from front support 21.

(2) Remove six bolts 11 and washers 12 from the front of pump body 8. Discard washers.

(3) Remove three bolts 28 and two bolts 29 from front support and bearing assembly 16.

(4) Separate pump body and gear assembly 5 from front support and bearing assembly 16. Remove pump driven gear 9 and pump drive gear 10 from pump body 8.

(5) Remove sealring 4 from pump body 8.

(6) Remove oil seal 3 and, if parts replacement is necessary, bushing 7.

(7) If replacement is necessary, collapse bushing 18 and remove it from stator shaft 19. Do not damage the bearing bore in the stator shaft.

(8) If replacement is necessary, remove items 20, 22, and 23 from support assembly 17.

CAUTION

Do not attempt to remove stator shaft 19 from front support 21.

(9) Install main regulator valve remover tool J-24787. Compress spring stop 25 against main-pressure regulator valve spring 26 and remove retainer ring 24 as shown in figure 6-29.

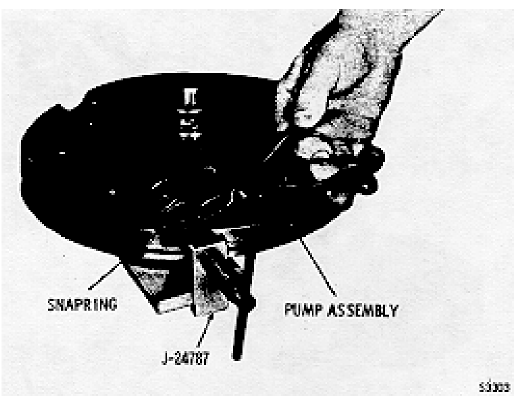

Fig. 6-29. Removing (or installing) main-pressure regulator valve

(10) Remove spring stop 25 and spring 26 from the valve bore of front support 21.

(11) Remove main-pressure regulator valve assembly 27 from the same bore.

(12) Turn the front support over, remove pin 15 from front support 21 and remove valve plug 14 from the smaller end of the main-pressure regulator valve bore.

NOTE

Refer to paragraph 6-2, above.

b. Assembly (B, foldout 5)

(1) Install valve plug 14 into the main-pressure regulator bore of front support 21. Install pin 15 into the pump body side of front support 21.

(2) Install main-pressure regulator valve assembly 27, smaller end first, into its valve bore.

(3) Install valve spring 26 and spring stop 25 (smaller end first) into the valve bore.

(4) Install main regulator valve installer tool J-24787. Compress spring stop 25 against main-pressure regulator valve spring 26 and install retainer ring 24 as shown in figure 6-29.

(5) If roller bearing 23 was removed, press a new bearing into the end of shaft 19 until the outer edge of the bearing measures 0.595-0.615 in. (15.11-15.62 mm) from the end of the shaft. Press on the lettered end of the bearing with installer J-23615. Figure 6-30 illustrates installation of the roller bearing.

(6) If bushing 18 (B, foldout 5) was removed, press a new bushing into the opposite end of shaft 19 until the outer end of the bushing is flush with, to 0.005 inch (0.127 mm) below, the end of the shaft. Figure 6-31 illustrates the installation of the bushing using installer tool J-23614.

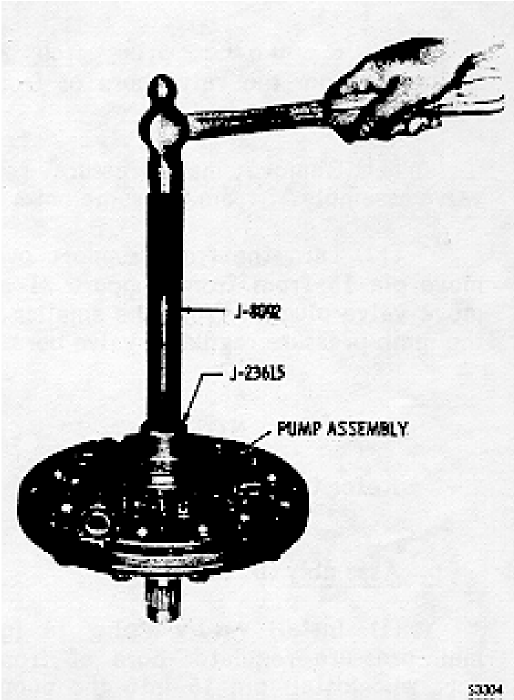

Fig. 6-30. Installing stator shaft rear bearing

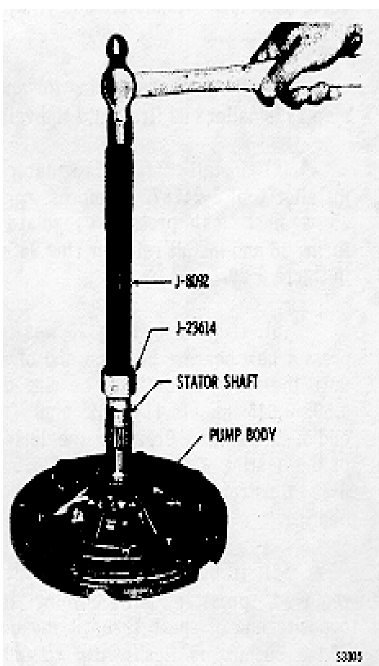

Fig. 6-31. Installing stator shaft front bushing

(7) If either plug 20 or 22 was removed, install a new plug. Press plug 20 into the support flush to 0.010 inch (0.25 mm) below the surface. Press plug 22 to the shoulder in the support.

(8) If bushing 7 (B, foldout 5) was removed, install a new bushing. The split in the bushing must be located within the 10 to 12 o'clock position in the pump body, when viewing the front of the body (within a 600 area immediately left of a vertical line extending upward from the pump body center). Use installer tool J-25356 to press the bushing into the front of the pump body. When installed, the front edge of the bushing should extend 0.010 to 0.020 inch (0.25 to 0.51 mm) above the surface.

(9) Coat the oil seal bore in pump body 8 (B, foldout 5) with Perfect Sealer #4 or an equivalent sealer and install oil seal 3, with the lip facing inward. Figure 6-32 shows the installation of the oil seal, using the special installer tool J-21359.

NOTE

Proper end play and side clearance of the oil pump gears must be established before the pump is assembled. Remove all nicks and burrs from pump and gear surfaces to facilitate accurate dial indicator readings.

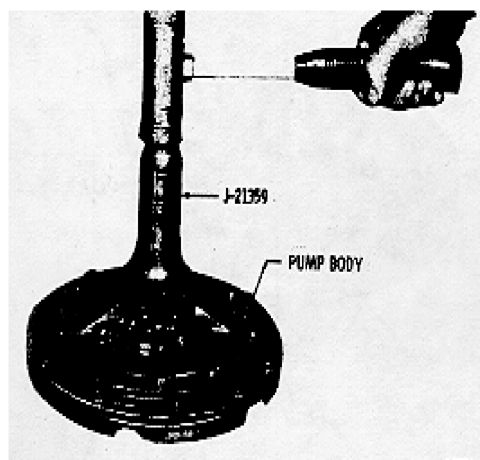

Fig. 6-32. Installing oil pump seal

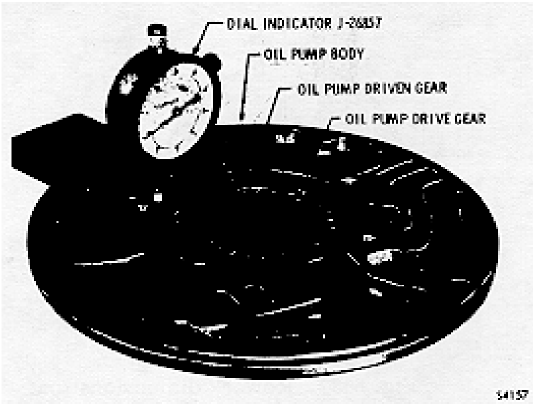

Fig. 6-33. Dial indicator check of oil pump body surface

(10) Position oil pump body assembly 6 (B, foldout 5), flat side upward. Install drive gear 10 into the pump body assembly 6, so the internal tangs of the gear are away from bushing 7. Locate diamond mark on the side of gear 9. Install gear 9, diamond side down, into pump body 6.

(11) Position dial indicator J-26857 on the pump body as shown in figure 6-33. Zero the dial while the stylus (plunger) is contacting body face.

(12) Without disturbing the dial setting, slide the indicator to the driven gear (fig. 6-34). While holding the indicator in position, rotate the gear 3600 and record the reading. Move the indicator 900 and record the second dial reading. Repeat the procedure and record the dial readings at each 900 point until four readings have been taken. If the clearance is not within 0.008-0.0022 in. (0.020-0.056 mm) on new gears or 0.0008-0.0026 in. (0.020-0.066 mm) on used gears, replace the gear and repeat steps (11) and (12).

(13) Slide the indicator to the drive gear (fig. 6-35). While holding the indicator in position, rotate the gear 3600 and record the reading. Move the indicator 900 and record the second dial reading. Repeat the procedure and record the dial readings at each 900 point until four readings have been taken.

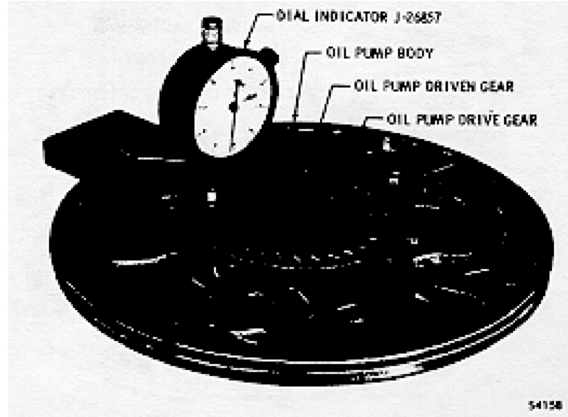

Fig. 6-34. Dial indicator check of oil pump driven gear end clearance

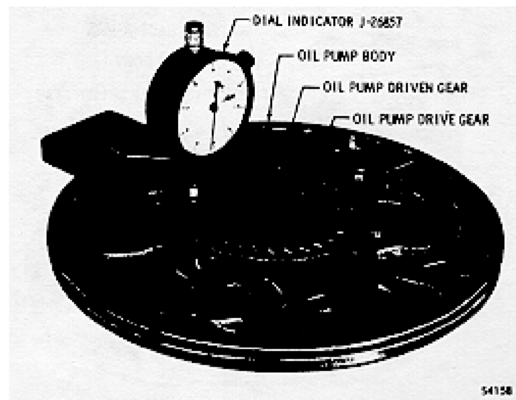

Fig. 6-35. Dial indicator check of oil pump drive gear end clearance

If the clearance is not within 0.008-0.0022 in. (0.020-0.056 mm) on new gears or 0.008-0.0026 in. (0.020-0.066 mm) on used gears, replace the gear and repeat steps(11) and (13).

NOTE

If the old pump and gears appear to be reusable, check their clearance using the "used gear" clearance for the maximum limit.

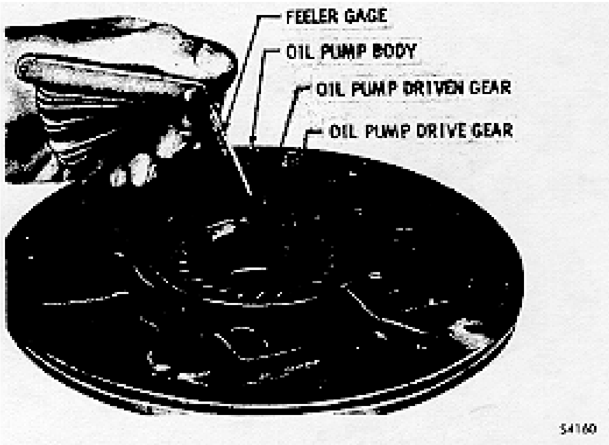

Fig. 6-36. Checking diameter clearance of oil pump driven gear

(14) Check the driven gear diametral clearance with a feeler gage as shown in figure 6-36. Replace the gear if the clearance is not within 0.0055 to 0.0085 inch (0.14-0.22 mm) on new gears or 0.0055-0.0089 inch (0.14-0.23 mm) on used gears.

(15) Grease and install sealring 4 onto pump body 8.

(16) Install front support assembly 17 onto pump body assembly 6, aligning the bolt holes.

(17) Install six 5/16-18 x l-inch bolts 11 (eight on earlier models) with new rubber coated washers 12 into the pump side of the oil pump assembly. Tighten the bolts finger tight.

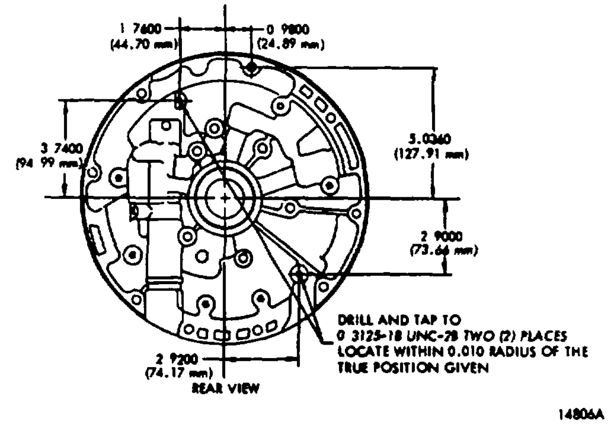

Fig. 6-37. Rework dimensions for front support

(18) Install three 5/16-18 x 1 3/4- inch self-locking bolts 28 and two 5/16-18 x 1-inch self-locking bolts 29.

(19) Tighten all bolts to 15-20 lb ft (20-27 N-m).

(20) Grease and install sealring 13 onto the outer diameter of front support 21.

6-8. FORWARD CLUTCH AND TURBINE SHAFT

a. <u>Disassembly</u> (A, foldout 6)

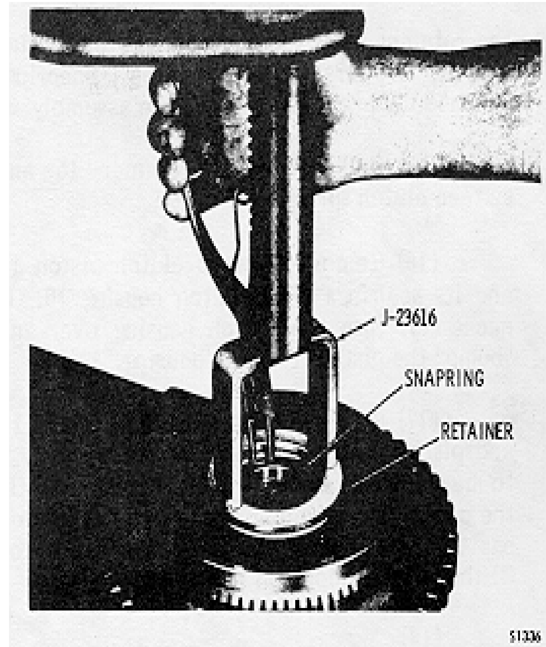

Fig. 6-39. Removing (or installing) forward clutch spring retainer snapring

(8) Remove hook-type sealring 1 from the turbine shaft. Turn the assembly over.

(9) Using a screwdriver, re m over snapring 24 from forward clutch housing 8. Remove fourth clutch driving hub 23 from the housing.

(10) Remove forward clutch hub 20 from the housing.

(11) Remove thrust bearing race 19, thrust needle bearing 18, and thrust bearing race 17 f r o m the hub of forward clutch housing 8.

(12) Remove five external-tanged clutch plates 21 and five internal-splined clutch plates 22 from clutch housing 8.

(13) Place the clutch assembly in a press with the spring retainer up (fig. 6-39).

(14) Place compressor tool J-23616 on the spring retainer (fig. 6-39). Compress

the retainer until the snapring is free. Using snapring pliers, remove the snapring. Release the press and remove the assembly.

(15) Remove spring retainer 15 and sixteen clutch springs 14.

(16) Remove forward clutch piston 13 and its sealrings from clutch housing 10. If necessary, turn the clutch housing over and "bump" the piston from the housing.

(17) Remove piston outer sealring 12 and piston inner sealring 11. Inspect ball 9 to make sure it moves freely in housing 8. If the piston is replaced, be sure the new piston has the same letter identification (A, B, or C) that was stamped on the replaced piston.

(18) On later models the sealring groove has been omitted from the forward clutch housing and turbine shaft assembly.

NOTE

Refer to paragraph 6-2, above.

b. Checking Clutch Pack Clearance (A, foldout 6)

NOTE

Two methods of establishing proper clutch clearance are explained and illustrated in steps (1) through (15). The first method is by direct measurement, steps (1) through (9); using a gono-go gage. The second method is by stack dimension computation, steps (10) through (15). This method may be more convenient when assembly line practices are used.

(1) Place forward clutch housing and turbine shaft assembly 6 (A, foldout 6) on the work table, with the shaft down.

(2) Place forward clutch piston 13 on the work table, with the return spring side upward, and install outer sealring 12, lip downward. Install inner sealring 11, lip downward, into the inner diameter of piston 13. Grease both seals and center each seal in its bore.

NOTE

If a new piston is used, refer to instructions in a(17), above.

(3) Apply lubricant to the outer surface of tool J-21362 and the inner surface of tool J-23779 to prevent the dislocation of the seals during tool removal. Place the sealring protector tools over the inner and outer sealring surfaces of the piston housing (fig. 6-40).

(4) Install piston 13, with sealrings, into forward clutch housing 8 until the piston bottoms against the housing. Remove tools J-21362 and J-23779 from the housing.

(5) Beginning with an external-tanged plate, alternately install five external-tanged 21 and five internal-splined 22 plates into forward clutch housing assembly 7.

(6) Install fourth clutch driving hub 25 into housing assembly 7, engaging the tangs in the slots. Install snapring 24 into housing assembly 7.

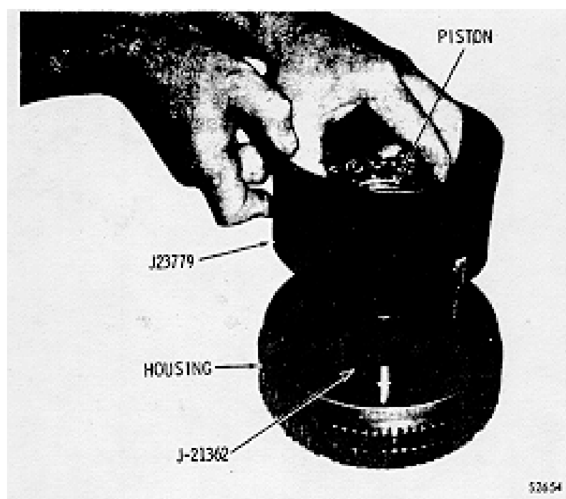

Fig. 6-40. Installing forward clutch housing piston, using sealring protector tool

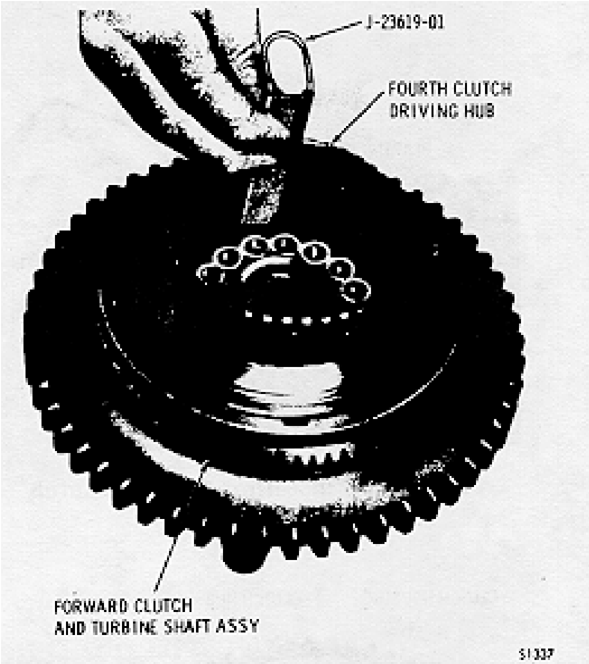

Fig. 6-4 1. Checking forward clutch clearance

(7) While holding clutch driving hub 23 firmly against snapring 24, use clearance gage J-23619-01 to measure the clutch running clearance (fig. 6-41). The smaller end of the gage must insert between the hub and the first plate. The larger end must not.

NOTE

If the J-23619-01 gage is not available, measure the clearance between the hub and the first plate. The clearance must be 0.077 (1.95 mm) minimum to 0.127 in. (3.22 mm) maximum.

(8) If the clutch running clearance is not within the specified limits, remove snapring 24 (A, foldout 6), fourth clutch driving hub 23, and clutch plates 22 and 21. Replace clutch plates 21 and 22 with new plates, as required, to obtain the desired running clearance. Refer to wear limits, Section 8, to determine the plates which should be replaced.

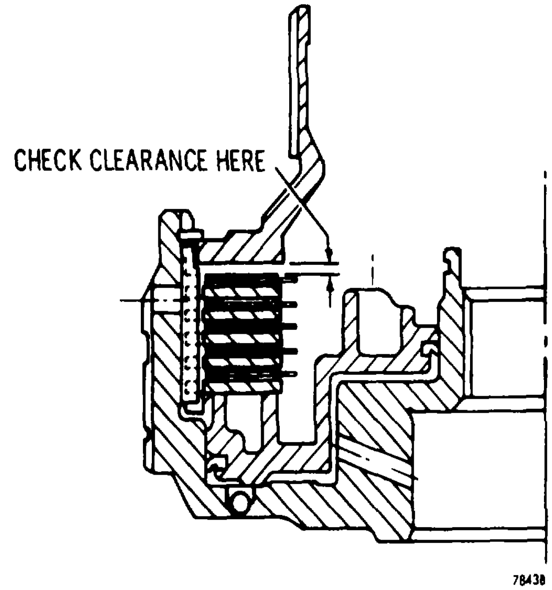

Fig. 6-42. Forward clutch clearance check point

(9) Repeat steps (5), (6), and (7) above. When the running clearance is within 0.077 to 0.127 (1.95 to 3.22 mm), remove snapring 24, clutch driving hub 23, and clutch plates 21 and 22. Retain the clutch plates as a package until required. Complete assembly procedures as outlined in c, below.

NOTE

Steps 10 through 15 establish the clutch clearance by using the stack dimension. computation method.

(10) Beginning with an external-tanged plate, alternately place five external-tanged plates 21 and five internal-splined plates 22 onto a press bed (fig. 6-43).

(11) Place the fourth clutch driving hub 23 on top of the clutch plates. Center the hub and plates in the press.

(12) Do not exert force on the hub extension. Install a sleeve and plate over the hub extension (fig. 6-43). Apply a compression load of 980-1020 lb (4537-4359 N).

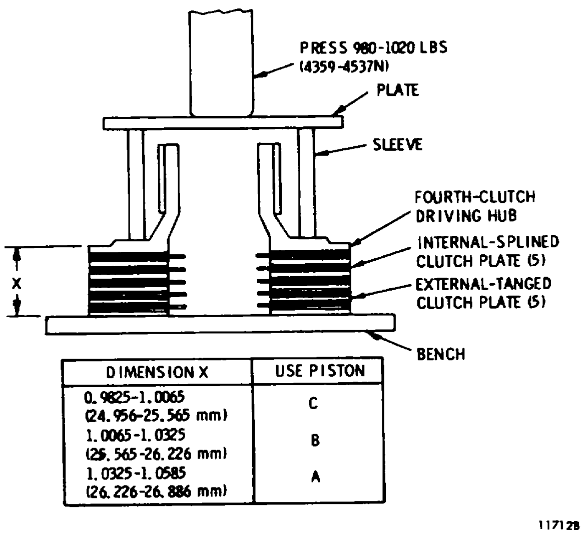

Fig. 6-43. Determining forward clutch piston thickness

(13) Measure the stack dimension (fig. 6-43), and select the proper piston A, B, or C (marked on piston).

(14) Remove the sleeve and plate from the fourth clutch driving hub and retain the clutch plate and hub package until required.

(15) Install the piston as outlined in steps (1) through (4), above.

c. Assembly (A, foldout 6)

(1) Install sixteen clutch springs 14 into their pockets on the piston. Install spring retainer 15, spring recess side first, onto the springs.

(2) Place the clutch assembly in a press, spring retainer upward. Lay snapring 15 in its approximate installed position on spring retainer 15.

(3) Using compressor tool J-23616, compress the spring retainer until it clears the snapring groove in the housing. Reference fig. 6-46. Install snapring 16 into the groove in the hub in clutch housing assembly 7. Release the press and remove the clutch assembly.

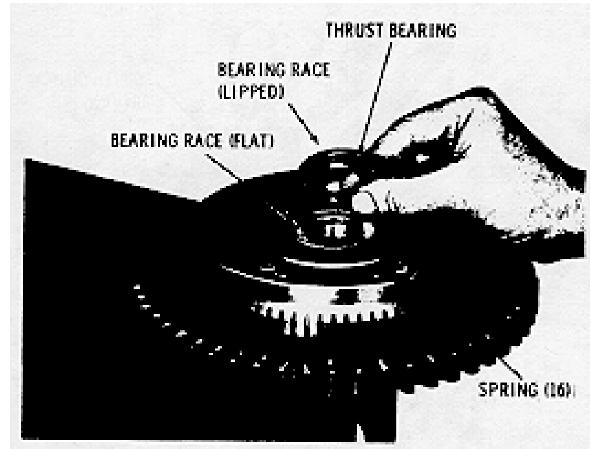

Fig. 6-44. Installing forward clutch thrust bearing

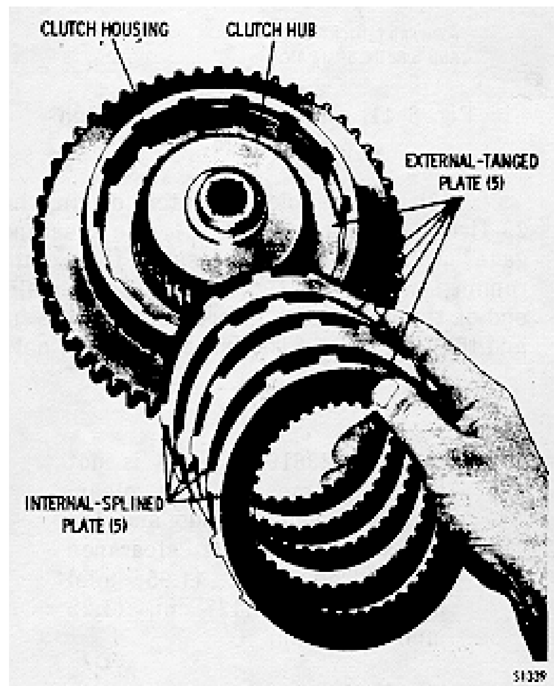

Fig. 6-45. Installing forward clutch plates

(4) Install the flat bearing race onto the hub of the forward clutch housing (fig. 6-44). Install the thrust needle bearing and the lipped bearing race so that it encloses the bearing. Retain the bearing and races with oil-soluble grease.

(5) Install the forward clutch hub into the clutch housing (fig. 6-45).

(6) Beginning with an external-tanged clutch plate, install the clutch package removed in b(9) or (14), above (fig. 6-45).

(7) Install fourth-clutch driving hub 23 (A, foldout 6) into housing assembly 7 and secure the hub with snapring 24.

(15) Install hook-type sealring 1 onto the turbine shaft.

6-9. FOURTH CLUTCH

a. Disassembly (B, foldout 6)

(1) Place the fourth clutch on the work table, with snapring 1 upward. Remove snapring 1, backplate 2, five internal-splined clutch plates 3, and five external-tanged clutch plates 4.

(2) Place fourth clutch housing assembly 11 in a press. Using spring compressor J-23616, depress piston return spring retainer 6 and remove snapring 5 and spring retainer 6 (fig. 6-46).

(3) Remove sixteen piston return springs 7 (B, foldout 6) and remove fourth clutch piston 8.

(4) Remove sealring 9 from the outside diameter of piston 8. Remove sealring 10 from the inside diameter of the piston bore in fourth clutch housing 13. Check the sealring groove thoroughly f o r burrs and rough spots.

NOTE
Refer to paragraph 6-2.

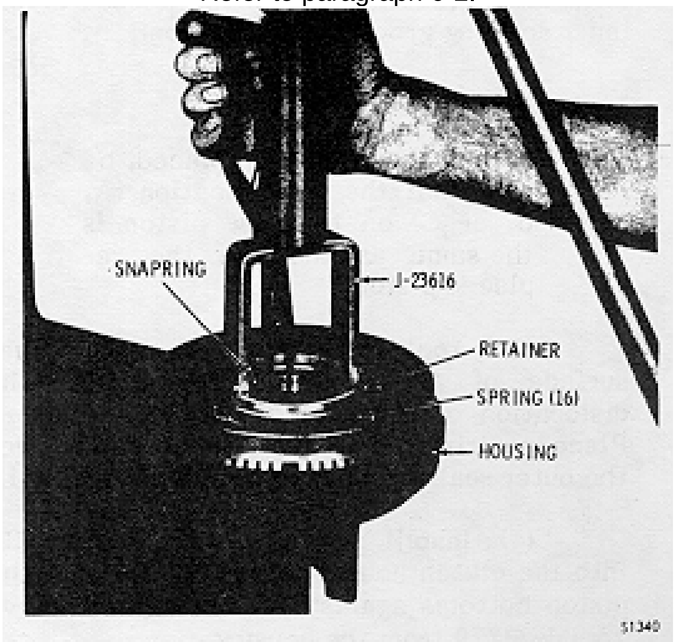

Fig. 6-46. Removing (or installing) fourth clutch spring retainer snapring

b. Checking Clutch Pack Clearance (B, foldout 6)

NOTE

Two methods of establishing proper clutch clearance are explained and illustrated in steps (1) through (15). The first method is by direct measurement, steps (1) through (9); using a go-no-go gage as shown in figure 6-41 and 6-42. The second method is by stack dimension computation, steps (10) through (15). This method may be more convenient when assembly line practices are used.

(1) Place fourth clutch housing assembly 11, open (front) side upward, on the work table. Install clutch housing sealring 10, lip downward, into the groove of the housing inner hub. Grease the sealring and center it in the groove.

(2) Place fourth clutch piston 8 on the work table, return spring side (front) upward and install outer sealring 9, lip downward. Lubricate the sealring with an oil-soluble grease. No sealring is used in the inner sealring groove of this piston.

NOTE

If piston 8 must be replaced, be sure that the identification (A, B, or C) on the new piston is the same as that on the re- placed piston.

(3) Apply lubricant to the inner surface of tool J-23779 to prevent the dislocation of the seal during tool removal. Place sealring protector tool J-23779 over the outer sealring surface of piston housing 13.

(4) Install piston 8, with sealring 9, into the clutch housing assembly 11 until the piston bottoms against the housing. Remove tool J-23779 from the housing.

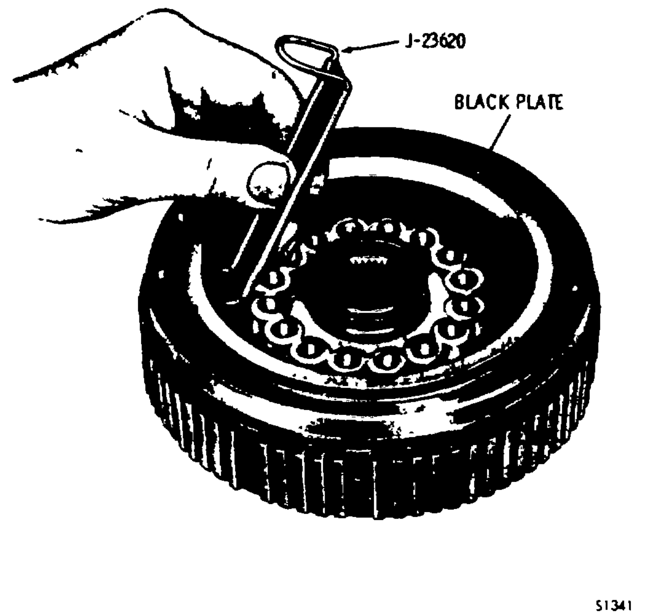

Fig. 6-47. Checking fourth clutch clearance

(5) Beginning with an external-tanged plate, alternately install five external-tanged 4 and five internal-splined 3 clutch plates onto piston 8.

(6) Install clutch backplate 2, flat side first, onto the last clutch plate 3 in- stalled. Install snapring 1 into housing 13.

(7) While holding backplate 2 firmly against snapring 1, use clutch clearance gage J-23620 to measure the clearance between the backplate and the clutch plate (fig. 6-47). The smaller end of the gage must insert between the backplate and the first clutch plate. The larger end must not.

NOTE

If the J-23620 gage is not available, measure the clearance between the backplate and the first clutch plate. The clearance must be 0.062 (1.57 mm) minimum to 0.112 (2.84 mm) maximum (fig. 648).

(8) If the clutch running clearance is not w it h i n the specified limits, remove

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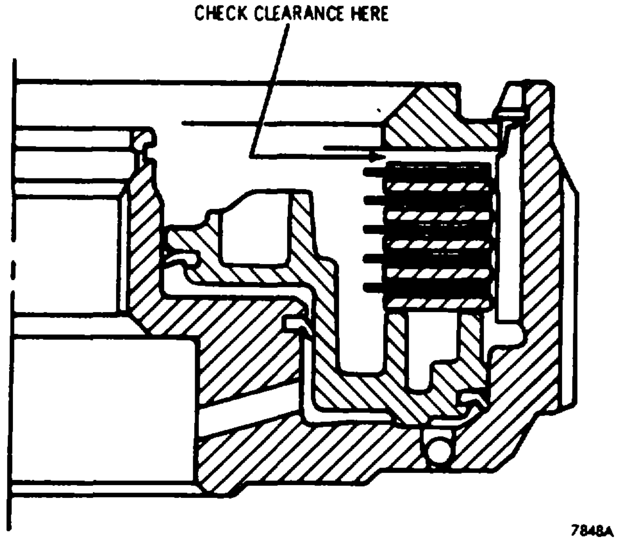


Fig. 6-48. Fourth clutch clearance check point

snapring 1 (B, foldout 6), backplate 2, and clutch plates 3 and 4. Replace clutch plates 3 and 4 with new plates, as required, to establish the proper running clearance. Refer to wear limits, Section 8, to determine the plates which should be replaced.

(9) Repeat steps (5), (6), and (7), above. When the running clearance is within 0.062 (1.57 mm) to 0.112 inch (2.84 mm), remove snapring 1, clutch backing plate 2, and clutch plate 3 and 4. Retain the clutch plates as a package until required. Complete assembly procedures as outlined in c, below.

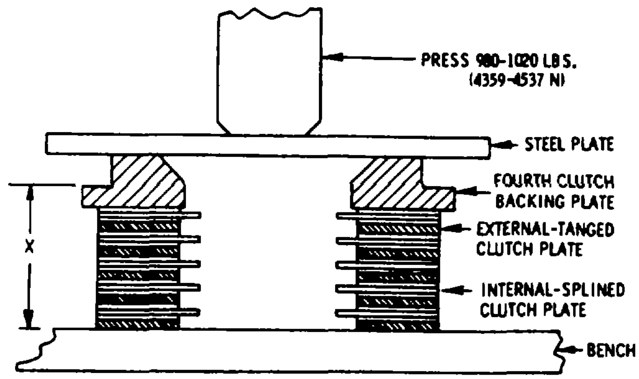
NOTE

Steps 10 through 15, below, establish the clutch clearances by using the stack dimension computation method.

(10) Beginning with an external- tanged plate 4, alternately install five external-tanged plates 4 and f i v e internal- splined plates 3 onto a press bed (fig. 6-49).

(11) Place fourth clutch backing plate 2 on top of clutch plates 3 and 4, flat side down. Center the plates on the bench.

(12) Place a steel plate on top of the backing plate, as shown in figure 6-49. Apply a compression load of 980-1020 lb (4359-4537 N).



DIMENSION X	USE PISTON
0.9965-1.0205 (25.311-25.921 mm)	C
1.0205-1.0465 (25.921-26.581 mm)	B
1.0465-1.0725 (26.581-27.242 mm)	A

11692B

Fig. 6-49. Determining fourth clutch piston thickness

(13) Measure t h e stack dimension (fig. 6-49), and select the proper piston A, B, or C (marked on piston).

(14) Remove t h e steel plate from the fourth clutch backing plate (fig. 6-49) and retain the clutch plate package until required.

(15) Install the piston as outlined in steps (1) through (4), above.

c. Assembly (B, foldout 6)

(1) Install sixteen return springs 7 into their pockets in piston 8. Install spring retainer 6, recess side first, onto the springs.

(2) Place the clutch assembly in a press, spring retainer upward. Lay snapring 5 in its approximate installed position, on spring retainer 6.

(3) Using compressor J-23616, compress the spring retainer until it clears the snapring groove in t h e housing hub (fig. 6-46). Install the snapring, and release the pressure f r o m the retainer. Remove the clutch assembly from the press.

(4) Beginning with an external- tanged plate, install the ten clutch plates from the pack removed in b (9) or (14), above.

(5) Install backplate 2 (B, foldout 6), flat side first, onto the clutch plates. Install snapring 1 to retain the backplate.

6-10. CENTER SUPPORT ASSEMBLY

a. Disassembly (A, foldout 7)

(1) Remove pistons 9 and 18 with attached parts, from center support assembly 13.

(2) Remove eight retainer washers 6 and 21. Cut the retainer washers to prevent damaging the piston projections (fig. 6-50).

(3) Remove spring retainers 7 a n d 20. Remove twenty-four piston return springs 8 and 19.

(4) Remove piston inner sealring 10 and 17 from pistons 9 and 18.

(5) Remove piston outer sealring 11 and 16 from piston 9 and 18.

(6) With the center support' and bushing assembly 13 standing upright, remove the two hook-type sealrings 12.

(7) If p a r t replacement is necessary, place support and bushing assembly 13 in a press, sealring grooves side up. Press bushing 14 out of the support, being careful not to damage bushing bore.

NOTE
Refer to paragraph 6-2, above.

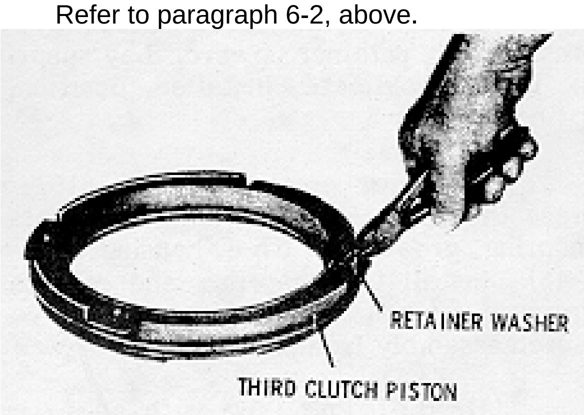


Fig. 6-50. Removing self-locking retainer washers

b. Assembly (A, foldout 7)

(1) Place center support 15 in a press, sealring grooves side up. Using bushing tool J-24778, install bushing 14 as shown in figure 6-51. Be sure the notch in bushing 14 is in proper alignment with the oil hole in support 15.

(2) If a special bushing tool is not available, press bushing 14 flush to 0.010 inch (0.25 mm) below the surface adjacent to the bore. The bushing must withstand 500 pounds (2224 N) of end load specified in the direction of arrow A in figure 6-52 after assembly. To ensure proper alignment of the oil hole in bushing 14 with the notch in support 15, t h e identifying notch of the bushing must lie in the area indicated in figure 6-52.

(3) Place pistons 9 and 18 (A, fold- out 7) on the work table, with the four ejector pin bosses upward. Install piston return springs 8 in the twelve holes in third clutch piston 9. Install piston return springs 19 in the twelve holes in second clutch piston 18.

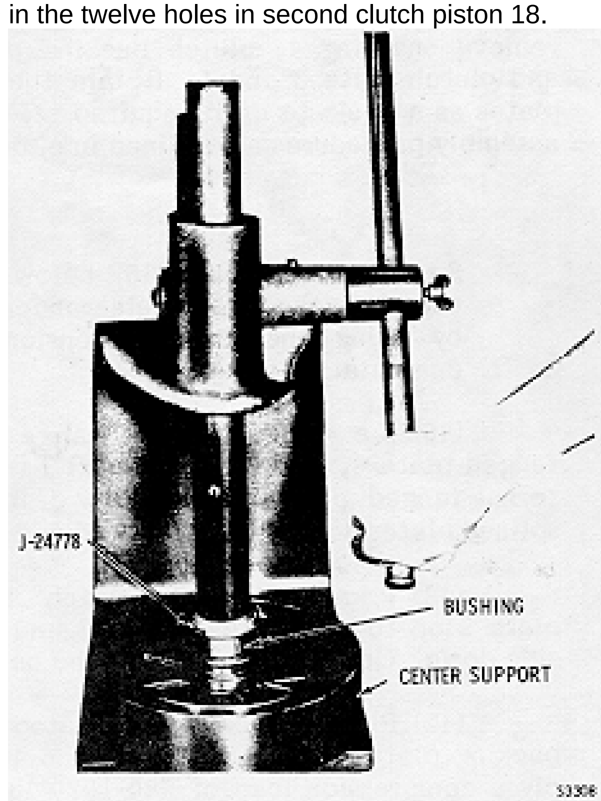


Fig. 6-51. Installing center support bushing

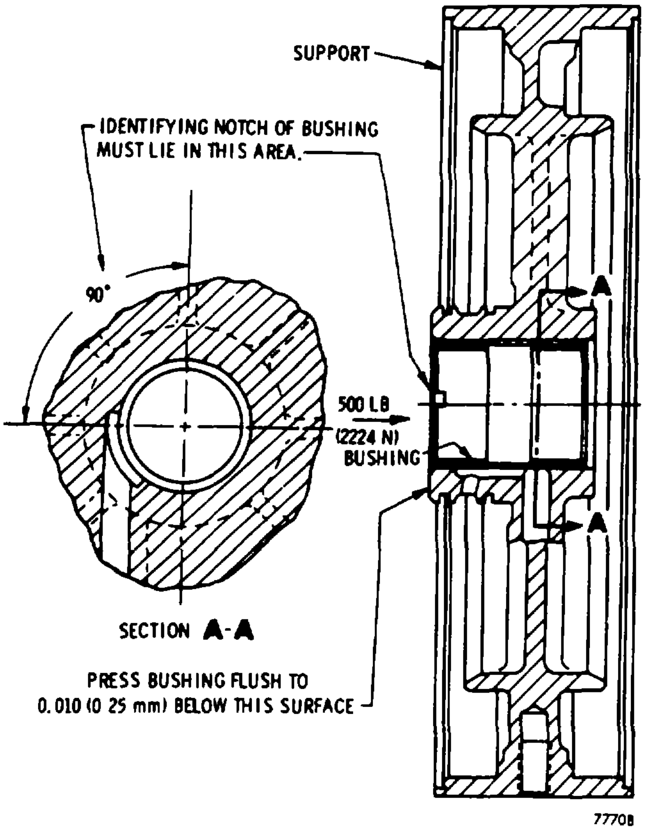


Fig. 6-52. Center support assembly

(4) Place spring retainers 7 and 20 on pistons 9 and 18, aligning the four holes in the retainer with the four ejector pin bosses on the pistons. Using tool J-24453, install eight new self-locking retainer washers 6 and 21 onto the eight ejector pin bosses (fig. 6-53). Do not force the retainer washers past the upper third of the ejector pin until the piston movement is properly located in its bore.

(5) Install the assembled piston, springs, and spring retainers into their piston bores in support assembly 13. Be sure the piston bottoms in its bore. Apply pressure to self-locking retainer washers 6 and 21 until spring retainer 7 and 20 are seated against the outer edge of the support assembly. Remove the pistons from the support assembly.

(6) Apply oil-soluble grease to the inner and outer diameter sealring grooves on pistons 9 and 18. Install sealrings 10 and 17 into the inside diameter groove of pistons 9 and 18. Install sealrings 11 and 16 into the

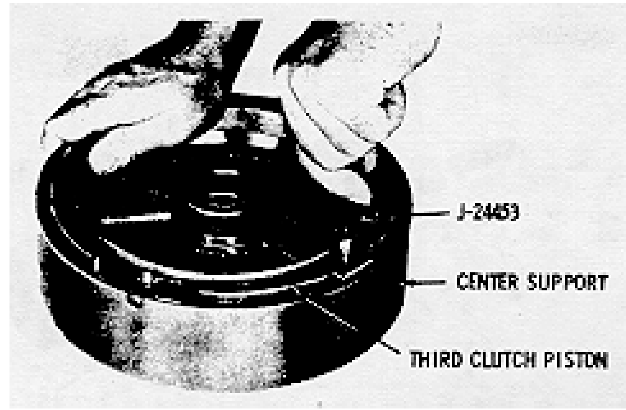


Fig. 6-53. Installing self-locking retainer washer

outside diameter grooves of pistons 9 and 18. Be sure the lips of the sealrings and the flat side of the piston face the same direction. Special care is required to prevent distortion, cutting, or stretching of the sealrings.

(7) Install two hook-type sealrings 12 onto the hub of center support 15.

NOTE

Do not install the piston assemblies until the second and third clutch plate clearance checks are made (para 7-4).

6-11. PLANETARY GEAR UNIT

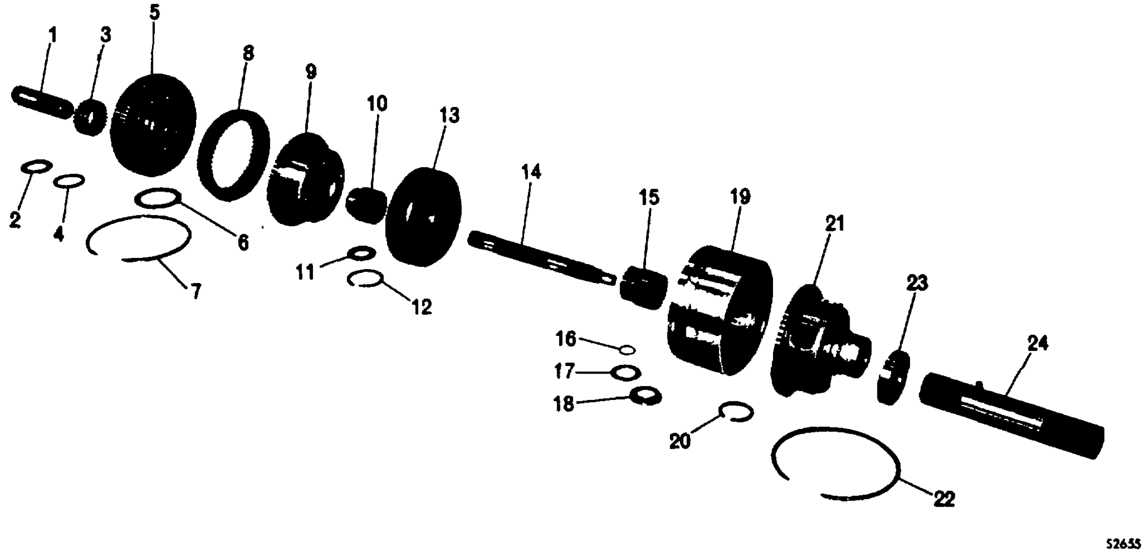
a. Disassembly (fig. 6-54)

(1) Place the planetary gear unit on its side on the worktable. Remove front planetary sun gear 3.

(2) Remove front planetary carrier assembly 5 from ring gear 8.

(3) Remove selective thrust washer 4 from front planetary carrier assembly 5, and thrust washer 6 from center planetary carrier assembly 9. Refer to paragraph 6-13
for rebuild of front planetary carrier assembly.

(4) Remove snapring 7 which retains front planetary ring gear 8 to planetary con-



1 - Sun gear shaft assembly
2 - Thrust washer
3 - Front planetary sun gear
4 - Selective thrust washer
5 - Front planetary carrier assembly
6 - Thrust washer
7 - Front planetary ring gear snapring
8 - Front planetary ring gear
9 - Center planetary carrier assembly
10 - Center planetary sun gear
11 - Thrust washer
12 - Center ring gear retaining snapring
13 - Center ring gear
14 - Transmission main shaft
15 - Rear sun gear
16 - Main shaft retaining ring
17 - Needle bearing assembly
18 - Needle bearing race
19 - Planetary connecting drum
20 - Rear planetary carrier retaining ring (output shaft to carrier)
21 - Rear planetary carrier assembly
22 - Rear planetary carrier retaining ring (connecting drum to carrier)
23 - Ball bearing assembly
24 - Transmission output shaft

Fig. 6-54. Planetary gear unit

necting drum 19. Remove ring gear 8 and center planetary carrier assembly 9 from drum 19. Refer to paragraph 6-13 for re- build of center planetary carrier assembly.

(5) Remove center planetary sun gear 10 and thrust washer 11.

(6) Remove main shaft assembly 14. Remove snapring 12, center ring gear 13, spiral retaining ring 16, and rear sun gear 15.

(7) Remove retaining ring 22 that holds rear planetary carrier assembly 21 to planetary connecting drum 19.

(8) Remove output s h a f t assembly 24

(9) Remove needle bearing assembly 17 and bearing race 18 located between output shaft 24 and rear sun gear 15.

(10) Place the output s ha f t on a work bench in a vertical position (rear planetary carrier up). If necessary force the planetary carrier down until retaining ring 20 is clear of the carrier. Remove the retaining ring and bearing 23.

(11) Remove r e a r carrier assembly 21 from the output shaft.

Refer to paragraph 6-13 for rebuild of the rear planetary carrier assembly.

(13) If parts replacement is necessary, remove spring pin 50 (B, foldout 7), bushing 47, and orifice plug 49 from output shaft 48 and two bushings 2 from sun gear shaft 3.

NOTE

Refer to paragraph 6-2, above.

b. Assembly (fig. 6-54)

NOTE

Items (1) through (5), below, explain the assembly of parts illustrated in B, foldout 7. Items (6) through (8) and (11) through (25) illustrate parts in figure 6-54. Items (9) and (10) illustrate parts in figure 6-56.

(1) If orifice plug 49 (B, foldout 7) was removed from output shaft 48, install a new plug. Press the plug clear of the chamfer.

(2) If bushing 47 was removed, in- stall a new bushing into output shaft 48, following t he specifications in figure 6-55. Bushing installer tool J-23613-01 can be used (fig. 6-56).

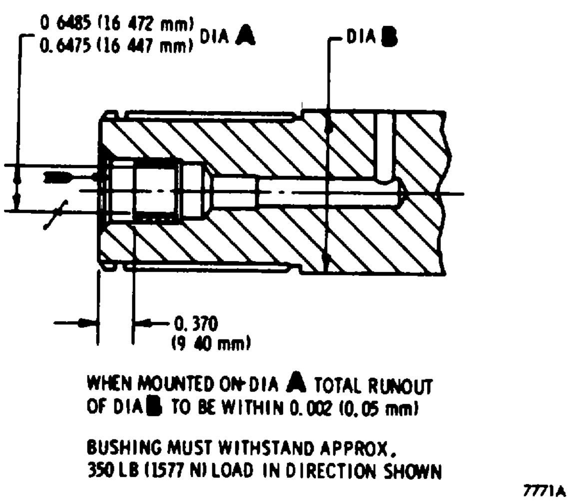


Fig. 6-55 Output shaft assembly

(3) If bushings 2 (B, foldout 7) were removed from sun gear shaft 3, install new bushings, following the specifications in figure 6-57. Bushing installer tool J-23614 can be used (fig, 6-58).

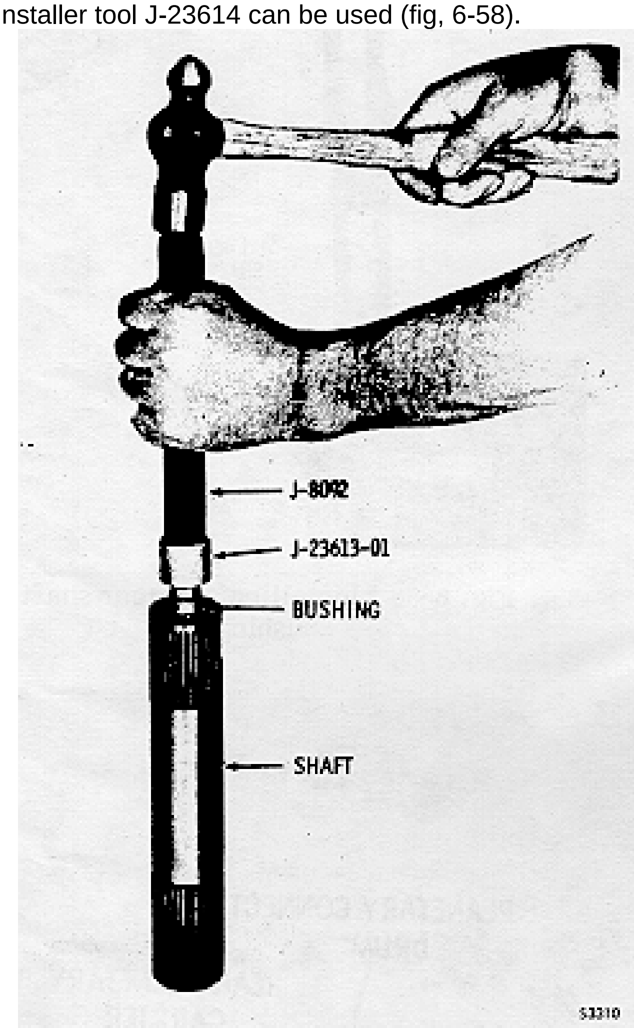


Fig. 6-56. Installing output shaft bushing

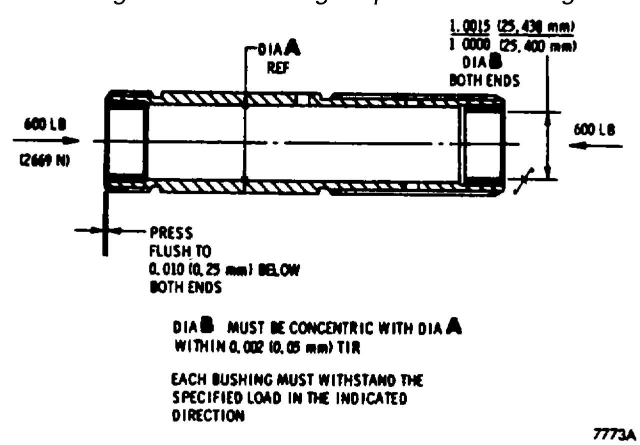


Fig. 6-57. Sun gear shaft and bushings

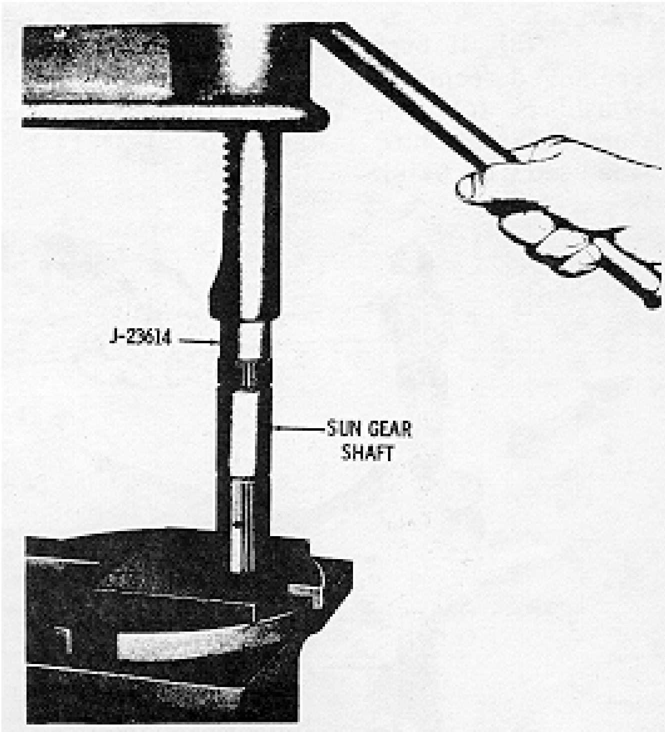


Fig. 6-58. Installing sun gear shaft bushing

(4) If bushing 15 (B, foldout 7) was damaged or distorted, replace the carrier assembly.

(5) If spring pin 50 w a s removed from output shaft 48, install a new pin. The pin must not extend beyond 0.160-inch (4.06 mm) from the shaft surface.

(6) Install rear planetary sun gear 15 (fig. 6-54) onto main shaft 14, smaller end first. Secure the sun gear to the main shaft with spiral retaining ring 16.

(7) Install center ring gear 13, concave side forward, onto the rear sun gear and secure with snapring 12.

(8) Install the rear planetary carrier assembly 21 into planetary carrier connecting drum 19 and secure the carrier with retaining ring 22. (Note the broad groove in the drum outer diameter is away from the

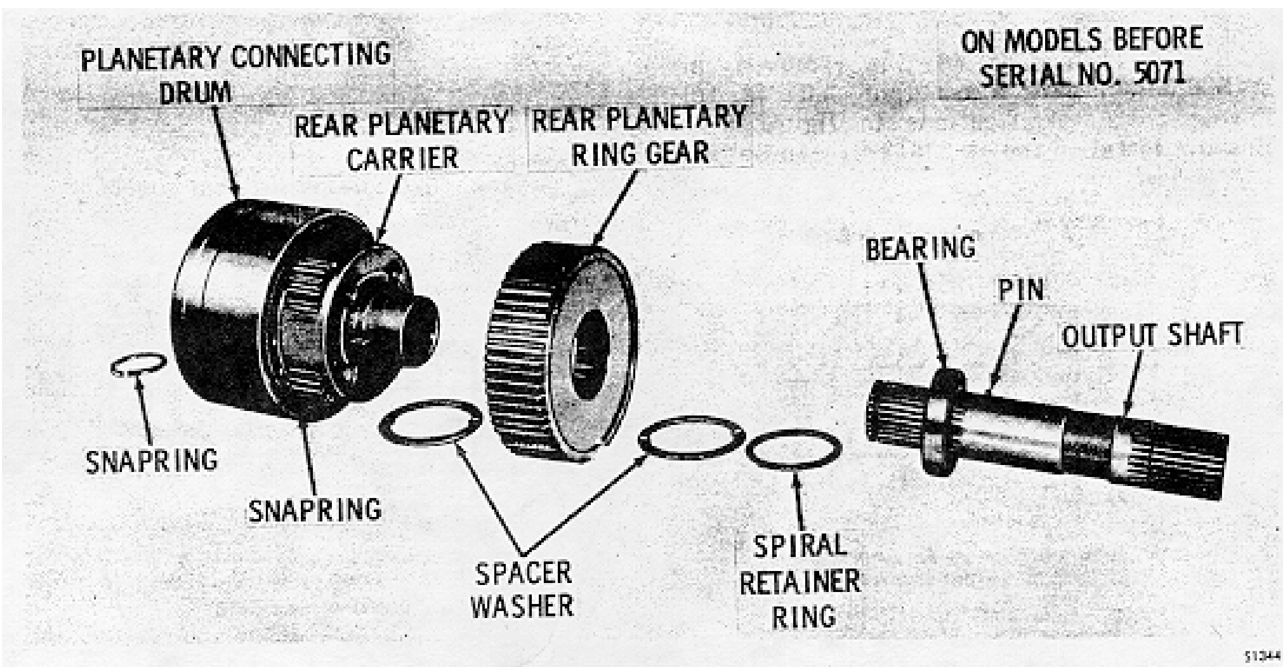


Fig. 6-59. Rear planetary (prior to S/N 5071)

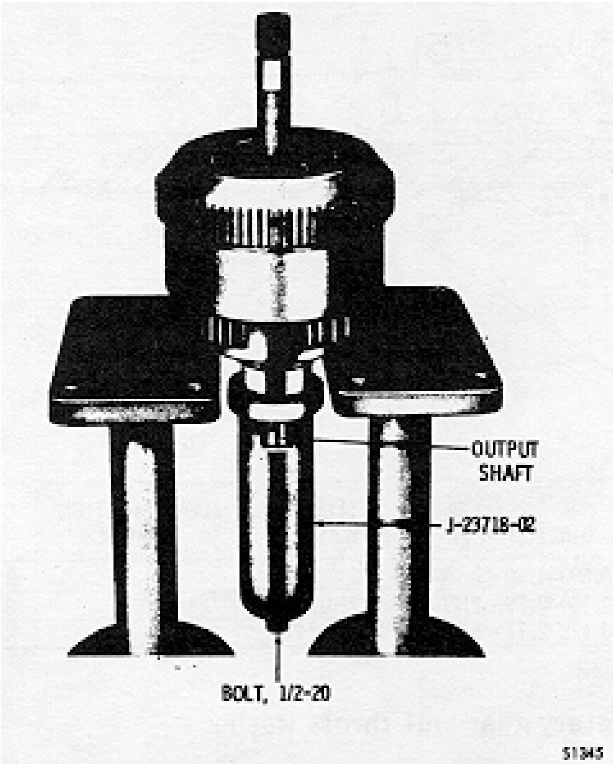


Fig. 6-60. Planetary gear unit assembled for measuring for selective thrust washer

(11) Install ball bearing assembly 23 (fig. 6-54) over the snapring groove end of output shaft 24. Install output shaft 24 (snapring groove first) into rear planetary carrier assembly 21. Secure it with retaining ring 20.

(12) Install positioning tool J-23718- 02 over the output shaft and retain with a 1/2-20 bolt (fig. 6-60). Tighten the bolt to 30 lb ft (40 N•m).

(13) Lubricate race 18 (fig. 6-54) and bearing assembly 17 with oil-soluble grease. Install the race and bearing onto the output shaft adjacent to the rear sun gear.

(14) Install main shaft assembly 14 into rear planetary carrier 21, Index sun gear 15 with the pinions of the rear planetary carrier.

(15) Install t h rust washer 11 (fig. 6-54) against the front side of the rear sun gear.

(16) Install center planetary carrier assembly 9, smaller diameter end first, into planetary connecting drum 19. Index the carrier splines with the splines in the connecting drum.

(17) Install center sun gear 10, larger end' first against thrust washer 11.

(18) Install front planetary ring gear 8, larger diameter end first, into planetary connecting drum 19 and secure with snapring 7.

(19) Lubricate and install thrust washer 6 onto the hub of front planetary carrier 5.

(20) Install front planetary carrier assembly 5 (fig. 6-54) onto center sun gear 10.

(21) Determine the measurement of dimension "A" (fig. 6-61) by using a depth micrometer. Take the measurements shown in figures 6-62 and 6-63. The difference between these two measurements is dimension "A". Select the correct thrust washer (fig. 6-61).

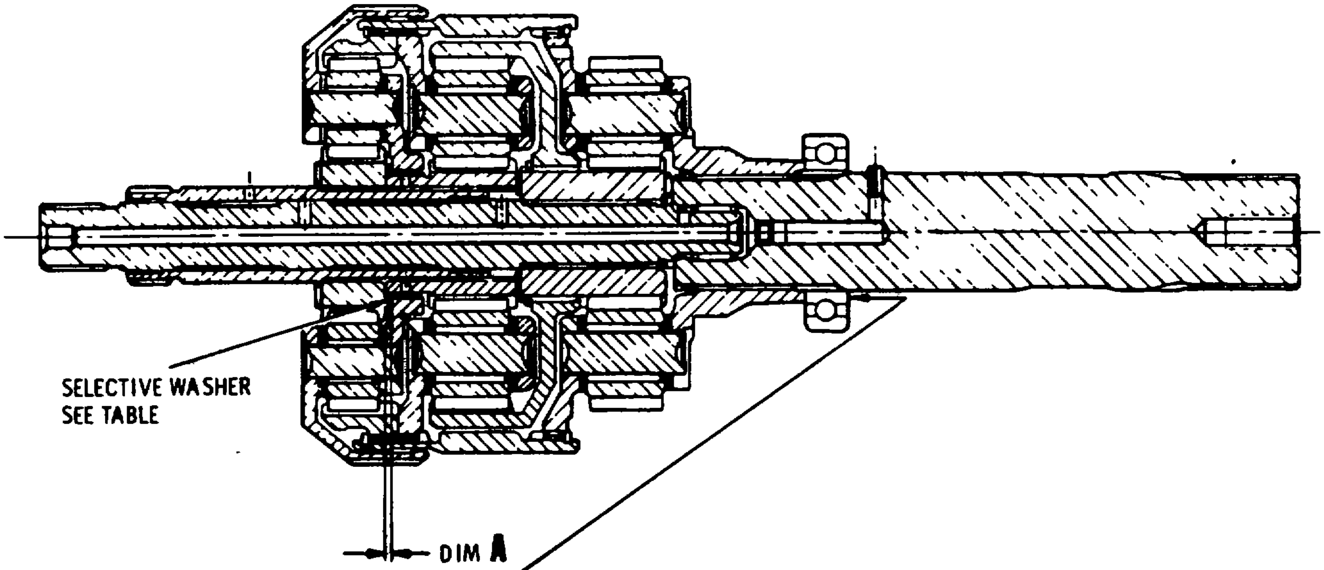
(22) Remove positioning tool J-23718-02 from output s h a f t installed in (12) above.

(23) Lubricate and i n s t a ll thrust washer 4 (selected in step (21), above) onto center sun gear 10 (fig. 6-49).

(24) Install front planetary sun gear 3, spline chamfer first, into front planetary carrier assembly.

NOTE

Thrust washer 2 (fig. 6-49) and sun gear shaft assembly 1 will be installed after the gear unit is installed into transmission.



DIMENSION A	SELECTIVE WASHER	IDENTIFICATION NUMBER	COLOR CODE
0.071 - 0.090 (1.80 - 2.29 mm)	23013451	1	RED
0.090 - 0.109 (2.29 - 2.77 mm)	23013452	2	GREEN
0.109 - 0.128 (2.77 - 3.25 mm)	23013453	3	NONE

7776C

Fig. 6-61. Selection of planetary gear unit thrust washer

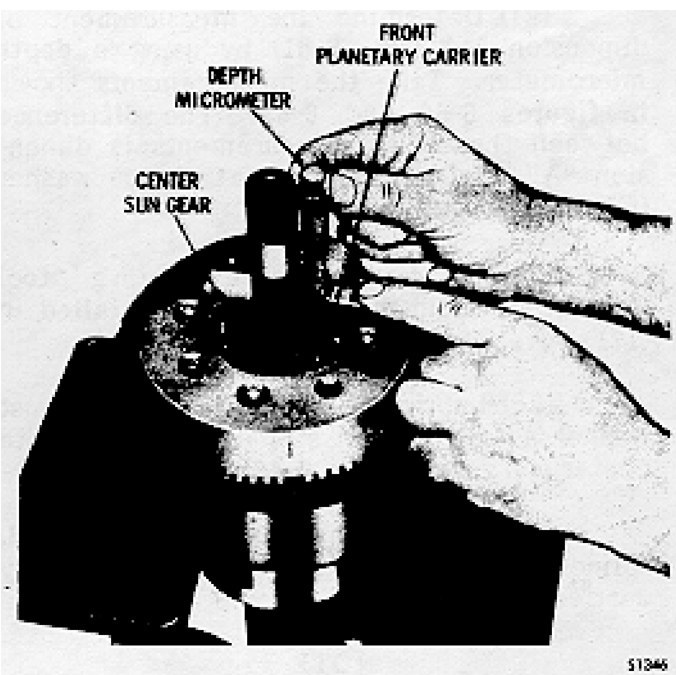


Fig. 6-62. Measuring depth of front planetary carrier

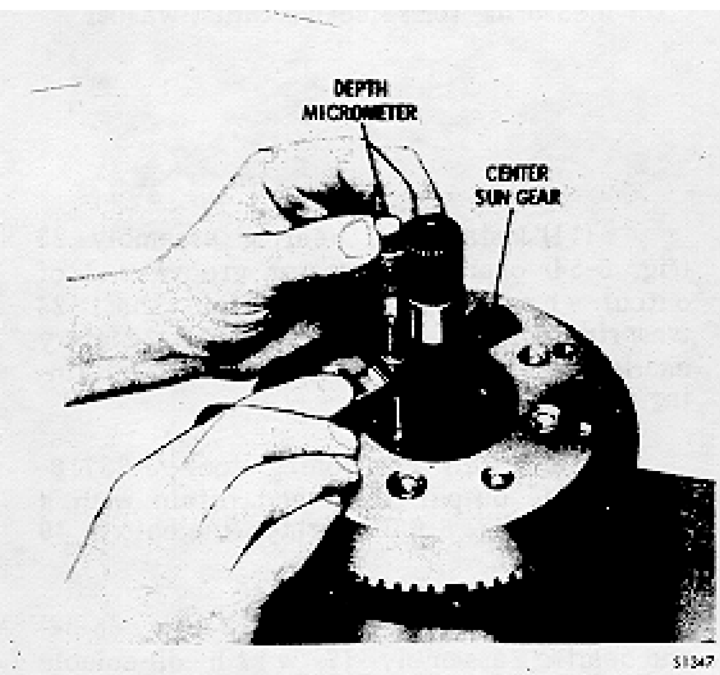


Fig. 6-63. Measuring to front of center-planetary sun gear

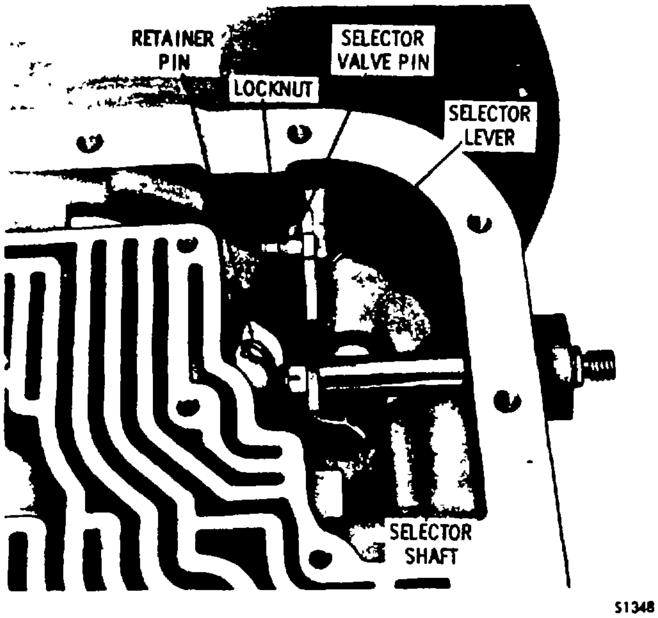


Fig. 6-64. Selector shaft components

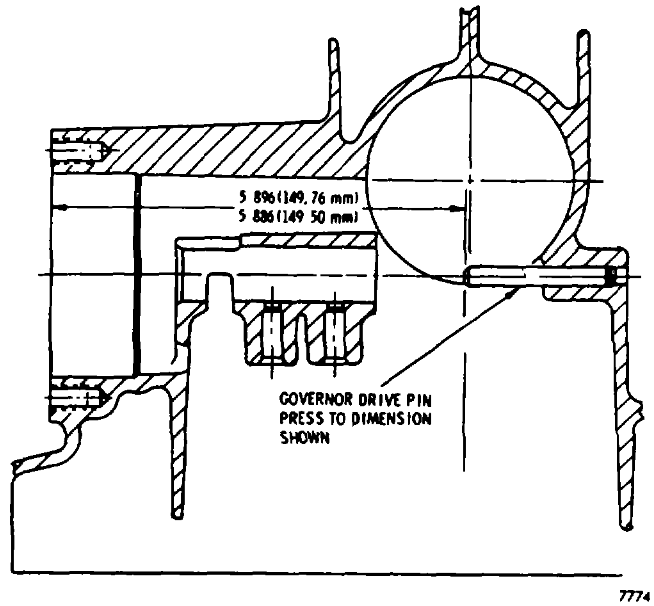


Fig. 6-65. Governor support pin location

6-12. TRANSMISSION HOUSING

a. Disassembly (B, foldout 9)

(1) To re move the manual shift lever, use the following procedure: Remove retainer pin 32 and locknut 33 (fig. 6-64). Hold selector lever 34 in one hand and re- move selector shaft through lip-type oil seal 37 in the case. Remove the selector lever.

(2) Remove seal 37 from the transmission housing using seal remover tool J-26401.

(3) Do not remove snapring 9 (B, foldout 8) unless replacement is necessary. Traces of aluminum on the outer race of bearing 4 (B, foldout 9) indicate rotation of the outer race within the transmission housing and possible damage to the snapring and to the bearing bore in the transmission housing.

(4) Do n o t remove breather 7 (B, foldout 8) from transmission housing 11. It is press fit and should be cleaned while in the housing.

(5) Check governor support pin 12 for evidence of wear. If damaged, remove the pin (fig. 6-65) using pin remover tool J-28708.

NOTE

The alignment of the governor pin with the governor bore in the transmission housing is critical The governor must rotate freely, without interference with either the case bore or the pin. Any interference will result in damage to the governor body, the bore in the housing, and/or the governor driven gear.

(6) Inspect test , plugs 8 and 13 (B, foldout 8). Replace if damaged.

(7) If it is necessary t o replace a damaged nameplate 4, remove o n e drive screw 5.

NOTE

All replacement parts ordered refer to the information on the nameplate. Therefore it is imperative that the new name-plate be stamped with identical information.

NOTE

Refer to paragraph 6-2 above.

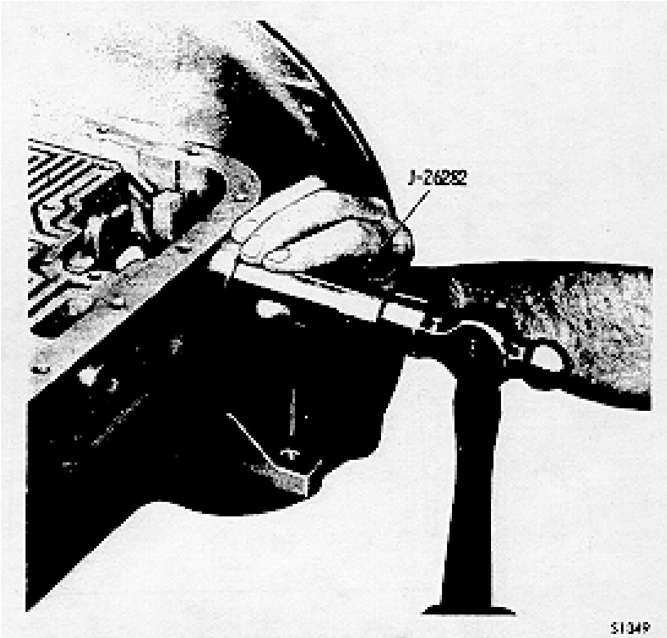


Fig. 6-66. Installing selector shaft oil seal

b. Assembly (B, foldout 8)

(1) It snapring 9 was removed, install a new snapring. Be sure to inspect the bore into which bearing 4 (B, foldout 9) fits for damage.

(2) Coat the inside diameter of lip-type oil seal 37 (B, foldout 9) with oil-soluble grease and coat the outside diameter of the seal with a nonhardening sealant. Install the seal, lip first, into transmission case 11 (B, foldout 8), using special installer J-26282. Figure 6-66 shows the installation.

(3) Hold selector lever 34 (B, foldout 9) so the selector valve pin is facing the inside of the case. Slide selector shaft 39 through the opening in case 11 (B, foldout 8), oil seal 37 (B, foldout 9), and the slot in selector lever 34. Attach locknut 33 and retainer pin 32 (fig. 6-59). Tighten the locknut to 15-20 lb ft (20-27 N-m).

(4) Replace breather 7 (B, foldout 8) if there is any evidence of damage. It is pressed into the housing.

(5) If governor support pin 12 was removed at disassembly, install a new pin using tool J-28684. If the tool is not available, install the pin to dimensions shown in figure 6-65. Refer to the note following a(5), above.

(6) Install test plugs 8 and' 13 (B, foldout 8) into housing 11. Tighten the plug 4 to 5 lb ft.

6-13. PLANETARY CARRIER ASSEMBLIES

NOTE

The disassembly and assembly procedures for all planetary carrier assemblies differ only in the proper tool selection for the specific application. The chart near the end of paragraph 6-13 shows the tool number required for a specific application and identifies the carrier involved (front, center, rear). If the tool is common to all the planetary carrier assemblies, its number will be listed in the text. If the tool is not common, the text will refer to the chart. For planetary carrier detailed information, refer to the exploded views at the back of this manual

a. Assembly Inspection

(1) Visually inspect planetary carrier assembly for evidence of excessive wear, indications of overheating, damage, or heavy metal contamination.

(2) Check end play of planetary carrier pinions. With washer held flat, insert feeler gage between the carrier and thrust washer. End play must be within 0.008 to 0.031 inch (0.20 to 0.79 mm).

NOTE

Do not disassemble carrier assembly unless parts replacement is necessary. Failure of one pinion requires replacement of the entire matched pinion gear set.

b. Removal of Pinion Components

NOTE

The hydraulic press, used with J-25587-01 Planetary Rebuilding Set, should have a five-ton capacity, an adjustable press bed of 25-inch (635 mm) minimum opening, and a pressure gage to assist in determining proper installation and staking of the pinion pins.

(1) Using a d r i 1l that is slightly smaller than the pinion pin diameter, drill into the swaged end on the pins (only one end required). Do not drill into the carrier. The rear ends of all pinion pins except those in the c e n t e r carrier assembly will be drilled. Drill the front ends of the center assembly pins.

(2) Place press fixture J-25587-1 in a hydraulic press. Select the proper spacer and adapter, if required, from the tool chart below. Position t h e s e parts (if used) to support the carrier assembly (drilled ends of pinion pins upward) solidly on the press fixture.

(3) Install p i n remover J-25587-16 into the ram of the press fixture. Press the pinion pins from the carrier assembly.

(4) Remove pinion groups, consisting of pinions, bearings, and thrust washers.

c. Replacing Bushing in Front Planetary Carrier

NOTE

Depending upon the amount of labor (machining bushing), time, part replacement, and extent of rework, complete replacement of the assembly may be warranted.

(1) Fabricate six dummy pins to dimensions shown in figure 6-67.

(2) Place the front carrier on a work table, rear downward.

(3) Press the bushing from the carrier. Do not scratch or score the bushing bore. [Refer to para 4-5f(l).]

(4) Place the carrier in a press, rear downward.

(5) Apply Loctite Sleeve Retainer No. 601 (or equivalent) to the outer diameter of a new bushing. Install the bushing using tool J-28501. Press the bushing flush to 0.010 inch (0.25 mm) below its adjacent surface (fig. 6-67).

(6) Using a lathe w it h a four jaw chuck, mount the carrier with surface (A) facing the chuck. Insert the six fabricated dummy pins (fig. 6-67) into the pinion pin
holes. Adjust the chuck, centering the car-

PLANETARY CARRIER ASSEMBLY REBUULD TOOL CHART

Note- All tools have a baseic number (J-25587) and a suffix.
Only the suffix is shown below. The figures In parentheses are quantities required.

Planetary Carrier Assy	Support Block	Pin Remover	Pin Remover & Installer Adapter	Pin Remover & Installer Spacer	Loading Pin	Guide Pin	Pin Installer	Swaging Tool Holder	Swaging Tool
Front	-4	-16			-22 (4)	-50 (4)	-14	-17	-27 (2)
Center	-1	-16			-20 (4)	-49 (4)	-10	-17	-25 (2)
Rear	-3	-16	-2	-6	-20 (4)	-49 (4)	-10	-17	-25 (2)

Tools in the chart above are components of planetary rebuilding kit J-25587-01. Refer to paragraph 4-2.

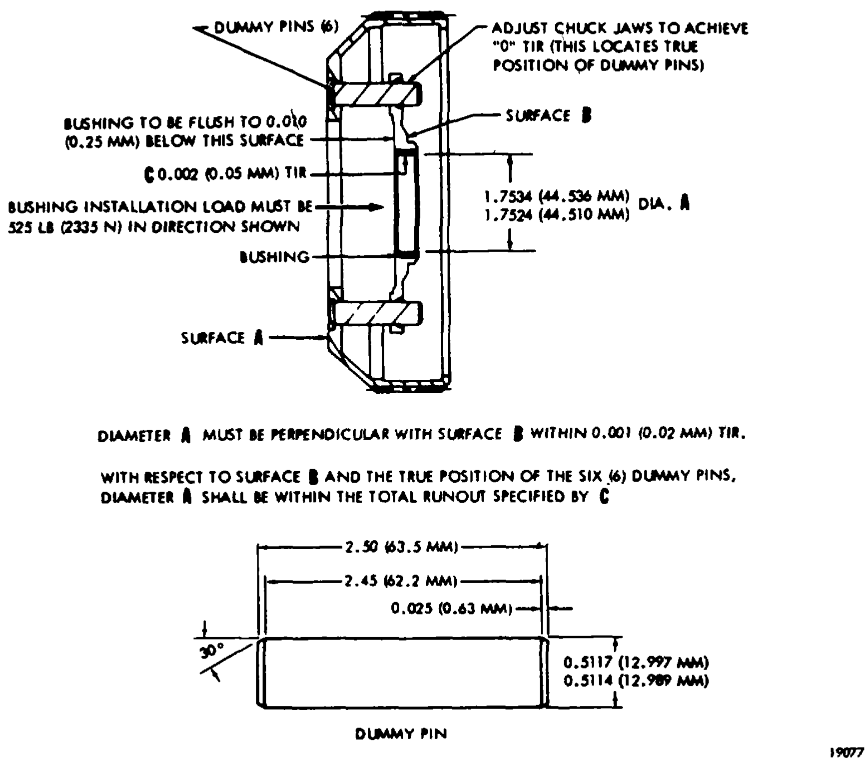


Fig. 6-67. Front carrier assembly bushing installation

rier based on surface (B) and the runout of the dummy pins.

(7) Tot a 1 runout of bushing after boring must not exceed 0.010 inch (0.25 mm). Use figure 6-67 as a guide.

d. Installation of Pinion Components

NOTE

The hydraulic press, used with J-25587-01 Planetary Rebuilding Set, should have a five-ton capacity, an adjustable press bed of 25-inch (635 mm) minimum opening, and a pressure gage to assist in determining proper installation and staking of the pinion pins

(1) Assemble all t h e pinion groups for the carrier assembly. Each group is assembled by inserting the proper loading pin into the bore of the pinion, installing the needle roller bearings around t h e loading pin, installing a steel thrust washer at each end of the pinion, and installing a bronze thrust washer onto each steel thrust washer.

NOTE

Lubricate needle rollers and thrust washers before assembling the pinion groups.

(2) Position t h e carrier assembly rear end upward except the center carrier. Install all pinion groups into the planetary carrier, aligning the loading pins with the pin bores in the carrier.

(3) Install t h e proper pinion guide pins, larger diameters first, into the pinion pin bores. Push the guide pins through the carrier until the loading pins drop out.

(4) Position the carrier assembly on the press fixture, using pin remover and installer adapter J-25587-2 (if required).

(5) Select the proper pin installer, and install it into the press fixture ram.

NOTE

Pin installers are shaped to avoid interference with bosses on the carrier assemblies. They must be installed in the ram so that the cutaway portion of the installer will clear the bosses when the pinion pin is pressed in.

(6) Place a pinion pin onto the pilot end of the pin guide located below the press fixture ram. Press the pinion pin into the carrier until the installer contacts the carrier.

CAUTION

Do not put pressure on the carrier. Distortion of the carrier will damage it.

(7) Install the remaining pinion pins as instructed in the preceding paragraph.

(8) R e m o v e the carrier assembly from the press fixture. Install swaging tool holder J-25587-17 into the opening of the press fixture bed. Install a swaging tool into the holder. Install another swaging tool into the press fixture rain. Lubricate both ends of the pinion pins with oil-soluble grease.

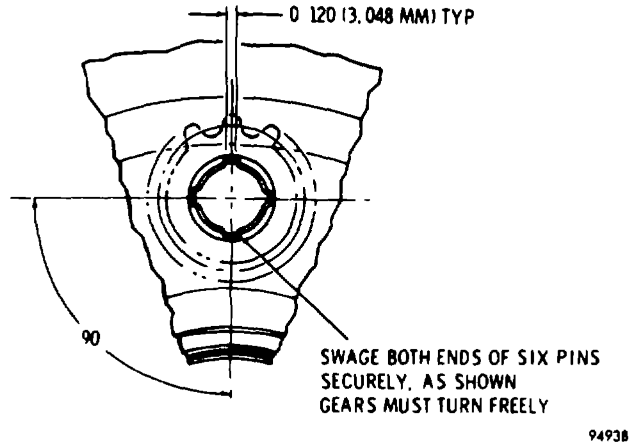


Fig. 6-68. Typical swaging pattern on pinion pin

(9) Position t h e carrier assembly, rear end upward (except the center carrier) on the press fixture. Use the proper support block to level the carrier while the lower swaging tool is supporting the lower end of one pinion pin.

(10) Apply sufficient pressure to the press fixture ram to firmly swage the ends of the pinion pins against the metal of the carrier. Figure 6-68 illustrates a typical swage pattern.

NOTE

Swaging pressure varies with the size of the pinion pins (approximately two tons for front carriers; three tons for center and rear carriers). While applying pressure, rotate t h e pinions and feel for reduction of end play. The pinions must rotate freely and have 0.008- 0.031 inch (0.20-0.79 mm) end play after swaging the pins.

(11) Swage the remaining pinion pin ends as instructed in (10), above.

7-1. SCOPE

This section covers assembly of the AT 545 transmissions.

7-2. SELECTIVE COMPONENTS

a. Establish Clearances

(1) Several components are available in graduated lengths or thicknesses to provide the proper running clearances. These components are selected by taking measurements at certain stages in the assembly of the transmission.

(2) Alternate methods for establishing clutch plate running clearances are introduced below. Their application simplifies assembly rebuild where production methods are used.

(3) The components which are selected during assembly of the transmission are tabulated below.

Item	Part Number	Illustration
Thrust washer	6831620 thru 6831625	33 (B, foldout 5)
Snapring	68365455 6836546 6884275 6836548	(A, foldout 7)
Second and third clutch backplate	6837603 and 6831644	2, 25 (A, fold-out 7)
First clutch backplate	6831707 thru 6831709	2 (A, foldout 8)
Spacer	6834648 thru 6834653	3 (B, foldout 9)

b. Clutch Plate Stack

(1) An initial clutch plate running clearance check may be in excess of the required dimension. Do not install a thicker backplate if excess clearance can be eliminated by installing new clutch plates.

(2) Refer to wear limits, Section 8 for clutch running clearance.

7-3. INSTALLATION OF FIRST CLUTCH AND GEARING

a. First Clutch

(1) Place the transmission housing assembly into the holding fixture (fig. 5-2), converter housing upward.

(2) Place inner seal protector tool J-24216-01 over the hub in the transmission housing (fig. 7-1).

(3) Install the inner and outer lip type sealrings into the grooves in the first

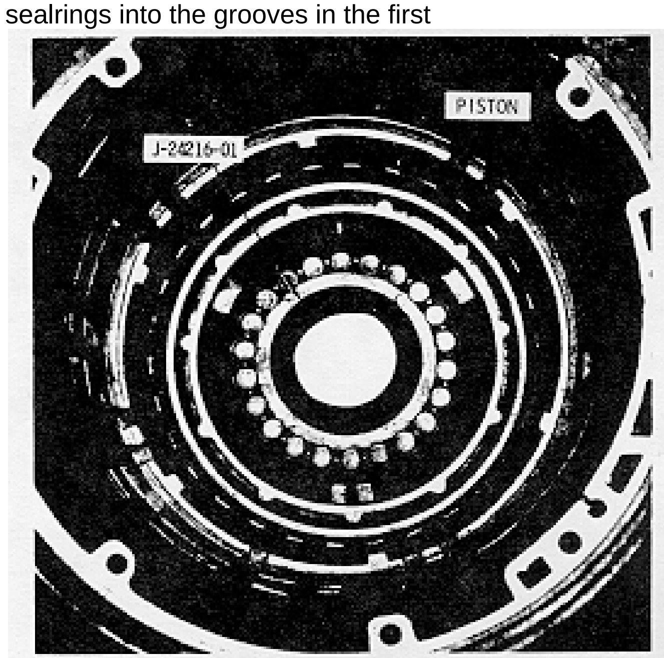


Fig. 7-1. Installing first clutch piston

clutch piston. A color-coded outer lip-type sealring (blue) is used on the piston after S/N 201937. The lips of both sealrings must face toward the rear of the transmission when the piston is installed. Lightly lubricate the surface of the piston bore and protector J-24216-01 with Dexron oil before installation.

(4) Install the piston and sealrings into the transmission housing rear bore, engaging the piston tang into the slot in the housing (fig. 7-1). Be sure the lip of the sealring on the outside diameter of the piston is not distorted. Remove the protector tool.

(5) Install twenty-two springs into the recesses in the piston. Install the spring retainer onto the springs (fig. 7-2).

(6) Lay the spring retainer snapring on the spring retainer (fig. 7-2).

(7) Install spring compressor assembly J-23630-1 into the rear bearing bore of the transmission housing (fig. 7-2). Check the springs for proper alignment.

(8) Tighten the wing-nut on the spring compressor until the spring retainer clears the snapring groove in the housing hub. Install the snapring into its groove. Remove the spring compressor.

(11) place the first ring gear on a work table, extended teeth down. Beginning with an internal-splined plate, alternately install six internal-splined and six external-tanged clutch plates onto the rear ring gear (fig. 7-3).

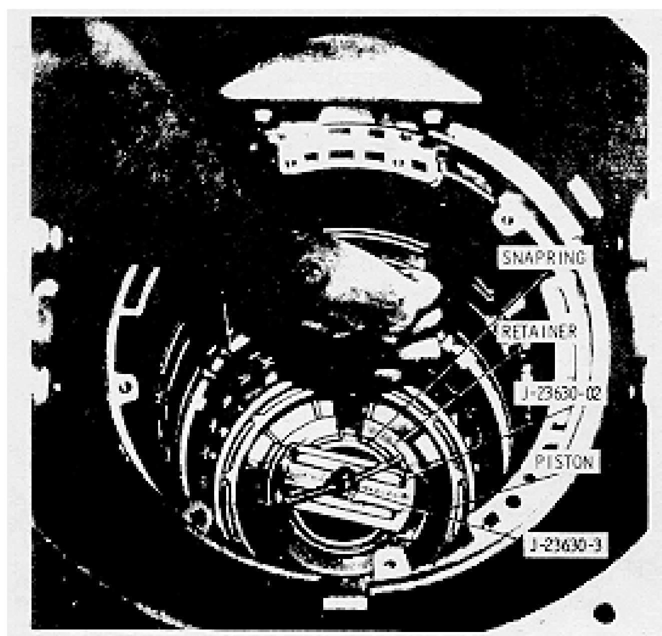


Fig. 7-2. Installing first clutch spring retainer snapring

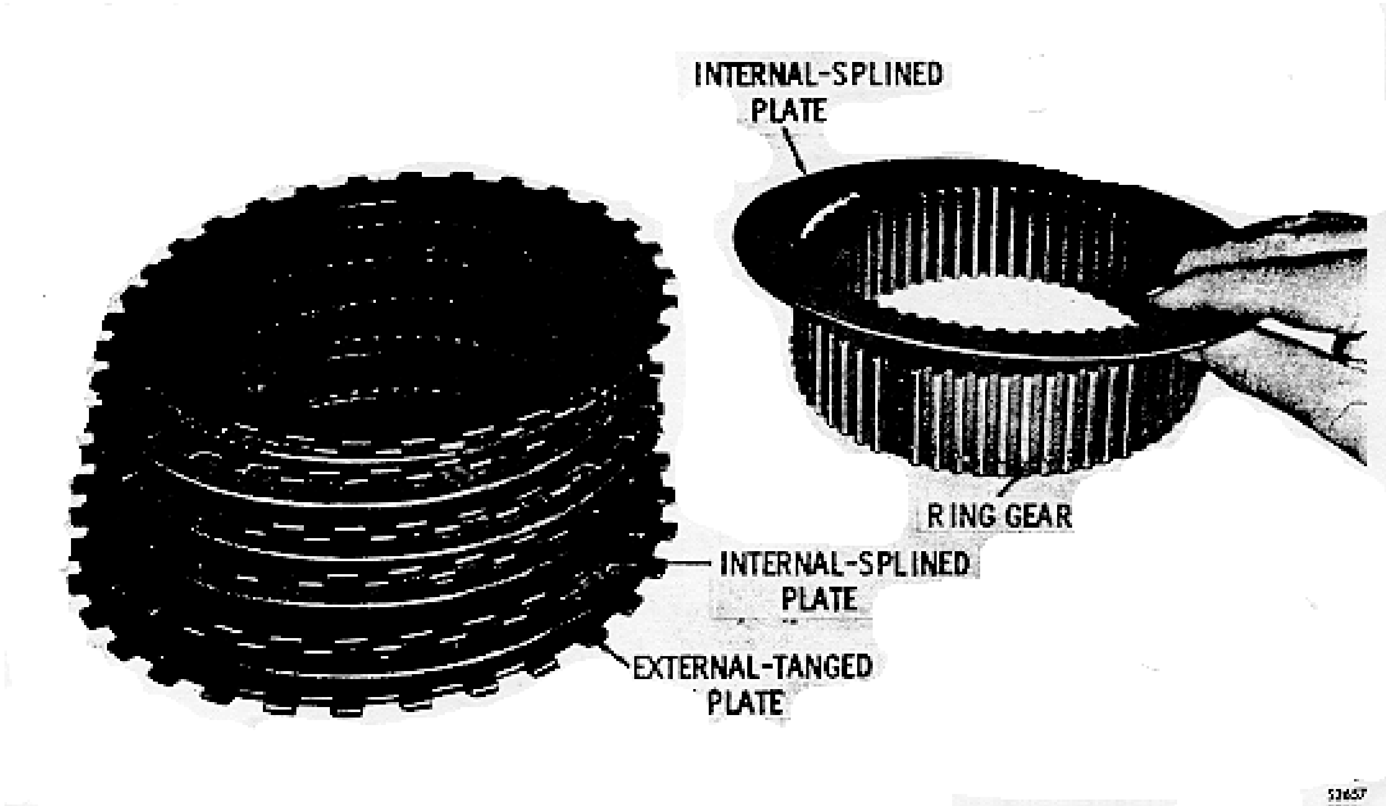


Fig. 7-3. Installing first clutch plates onto rear ring gear

(12) Pick up the gear and assembled plates. Invert the assembly. Align the tangs of the external clutch plates on the ring gear and install the gear and plates into the transmission as a package. Be sure the extended teeth on the ring gear are at the top of the gear after installation.

CAUTION

The first clutch plate retaining snapring must be installed with the snapring gap at t he 12 o'clock position, viewed from the front of the transmission housing. The snapring can become disengaged from its groove if the gap is not properly located.

(13) Install the two remaining clutch plates, external-tanged plate first. Install the clutch backplate (fig. 7-4) (wide surface down) and secure it with a snapring (fig. 7-5).

(14) Using clutch clearance gage J-23715, c h e c k the clearance between snapring and the backplate (fig. 7-5). The smaller end of the gage should go into the clearance while the larger end should not.

NOTE

If the J-23715 gage is not available, measure the clearance between the snapring and the backplate (fig. 7-5). The clearance must be 0.040 (1.02 mm) minimum to 0.100 (2.54 mm) maximum.

(15) If t h e clearance is excessive (larger end of gage will pass between the snapring and the backplate), new plates may be installed to reduce the clearance. If the clearance is still excessive after new internal-splined and external-tanged clutch plates are installed, a thicker backplate is required.

(16) If t h e clearance is insufficient (small end of gage will not enter), a thinner

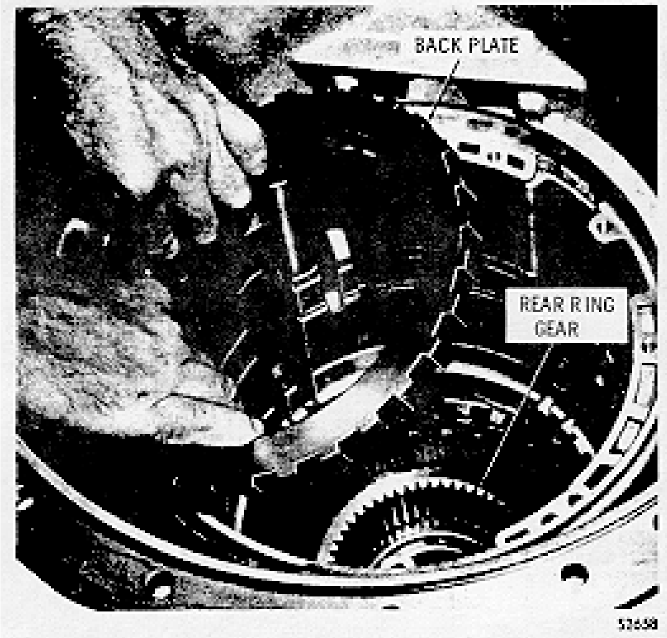


Fig. 7-4. Installing first clutch back plate

backplate is required. Backplates are stamped with identifying numbers (1, 2, or 3). Thicknesses are as follows:

Identification 1	0.683 to 0.693 in. thk (17.35 to 17.60 mm)
Identification 2	0.647 to 0.657 in. thk (16.43 to 16.69 mm)
Identification 3	0.611 to 0.621 in. thk (15.52 to 15.77 mm)

NOTE

Steps 17 through 21, below, explain an alternate method to establish clutch plate running clearance before the clutch is installed.

(17) Place first clutch piston 9 (A, foldout 8) on a press bed, spring pocket side up. Support the piston with a flat plate, placed between the press bed and the piston.

(18) Beginning with external-tanged plate 4, alternately place seven external plates and seven internal-splined plates 3 on

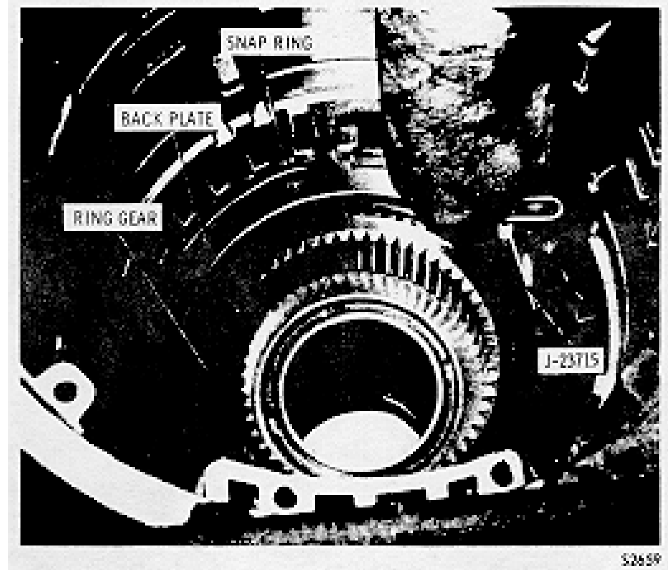


Fig. 7-5. Checking first clutch running clearance

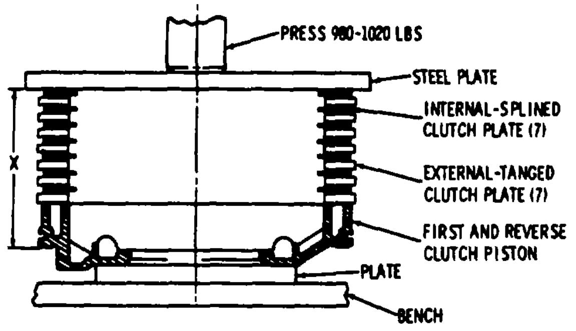
top of pistion 9. Place a flat steel plate on top of the clutch plates (fig. 7-6).

(19) Center the plates on the bench. Apply a compression load of 980 to 1020 lb (4359 to 4537 N).

(20) Measure the stack dimension. Refer to figure 7-6 and select the proper backplate 1, 2, or 3 (stamped on plate).

(21) Remove the steel plate from the top of the clutch plates. On models before S/N 5071, refer to items (2) through (10), below, for rebuild. On models after S/N 5070, refer to items (2) through (8), and (11) through (13).

b. Planetary Gear Unit



DIMENSION X	USE PLATE
2.2875 TO 2.3235	1
2.3235 TO 2.3595	2
2.3595 TO 2 3955	3

Fig. 7-6. Determining first clutch backplate thickness

(4) grasp the planetary gear unit by the main shaft and lower the unit into the transmission (Fig. 7-7). Mesh the internal teeth of the previously installed rear ring gear (para 7-3a(11) through (13)) with the rear planetary carrier pinion teeth. Be sure the unit bottoms.

(5) Install sun gear shaft assembly (long splines first) and front sun gear thrust washer (Fig. 7-8).

7-4. INSTALLATION OF SECOND CLUTCH AND CENTER SUPPORT

a. Second Clutch (A, foldout 7)

(1) Establish the proper clutch running clearance, as outlined in (2) through (6), below. If new clutch plates are used, see items (7) through (9), below.

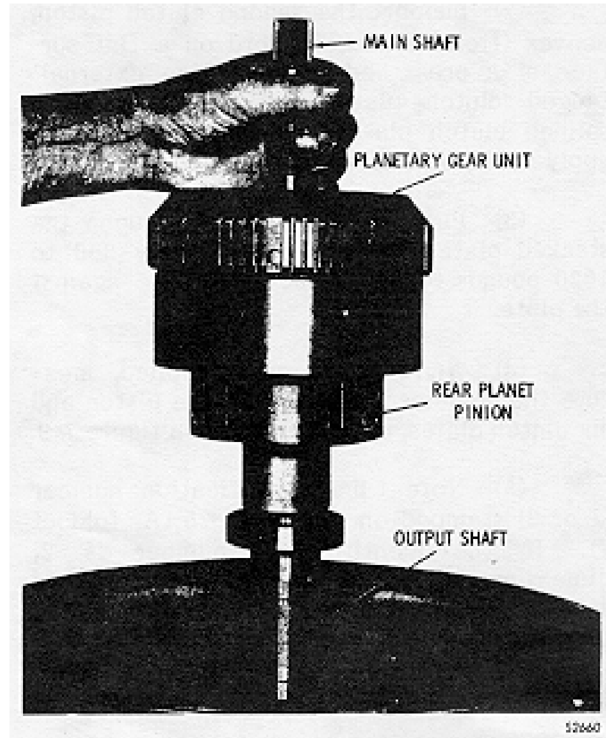


Fig. 7-7. Installing planetary gear unit

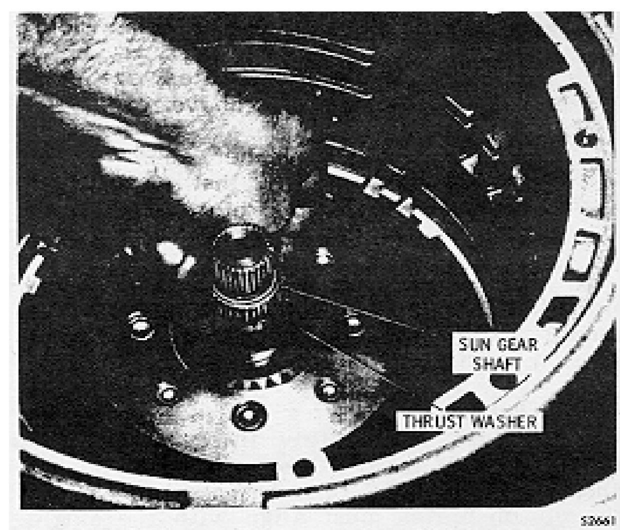


Fig. 7-8. Installing sun gear shaft assembly and thrust washer

(2) Support the second clutch piston, convex (front) side downward on a flat surface of a press bed. Stack three external-tanged clutch plates and three internal-splined clutch plates, alternately, onto the apply face of piston (Fig. 7-9).

(3) Place a flat steel plate upon the stacked plates. With a press, apply 980 to 1020 pounds (4359 to 4537 N) force against the plate.

(4) While the force is applied, measure the combined thickness of the piston and six clutch plates, designated "X" on figure 7-9.

(5) Note the identification number (1 or 2) stamped on backplate 25 (A, foldout 7). If the identification number is 2, dimension "X" must be within 1.5165 to 1.5425 inches (38.519-39.180 mm). If the identification number is 1, dimension "X"' must be within 1.4905-1.5165 inches (37.859-38.519 mm).

(6) If dimension "X" is not within limits, replace plates 23 (A, foldout 7) and/or 24 with new plates as required to obtain the required dimension "X". Refer to wear limits, Section 8, for clutch plate dimensions.

(7) If new clutch plates are used, repeat steps (2) through (6), above.

(8) Be sure the inner and outer lip type sealrings are properly installed into the piston. Install the second clutch piston into the rear bore of the center support assembly.

(9) Install the second clutch backplate (Fig. 7-10). Note the location of the single tang in the single slot in the transmission housing.

(10) Beginning with an internal-splined plate, alternately install three internal-splined and three external-tanged clutch plates (Fig. 7-10). The single tangs of the clutch plates must align with the single tang of the backplate.

(11) Install the 0.155 to 0.157 in. (3.94 to 3.99 mm) thick green snapring that retains the second clutch plates (Fig. 7-11). The snapring gap should be located at the 12 o'clock position of the transmission case.

b. Center Support Assembly

(1) Install the second clutch piston into the rear bore of center support assembly 13 (A, foldout 7). Be sure the piston sealring lips point to the bottom of the piston bore after installation.

(2) Install the center support with the second clutch piston into the transmission housing. Use center support lifting bracket J-23643 to lower the assembly into the transmission housing (reference figure 5-14). Be sure the tapped hole in the support is aligned with the anchor bolt hole in the bottom of the transmission housing.

(3) Remove the lifting bracket from the center support hub. Temporarily install the original 3/8-16 x 1-inch anchor bolt into the support. Tighten the bolt finger tight.

(4) Install center support compressor J-23717, as shown in figure 7-12. Use two of the 5/16-18 x 1 3/4-inch oil pump assembly retaining bolts to retain the compressor.

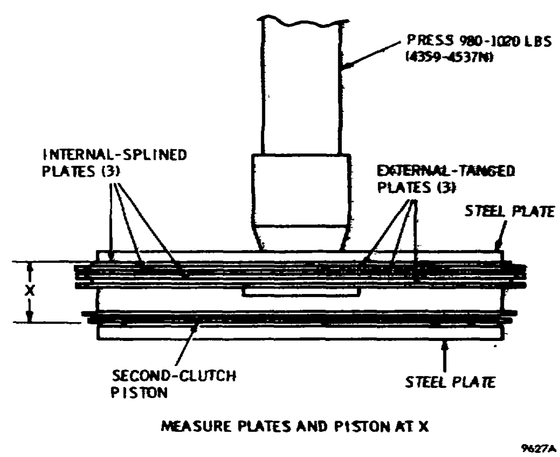


Fig. 7-9. Checking second clutch plate running clearance

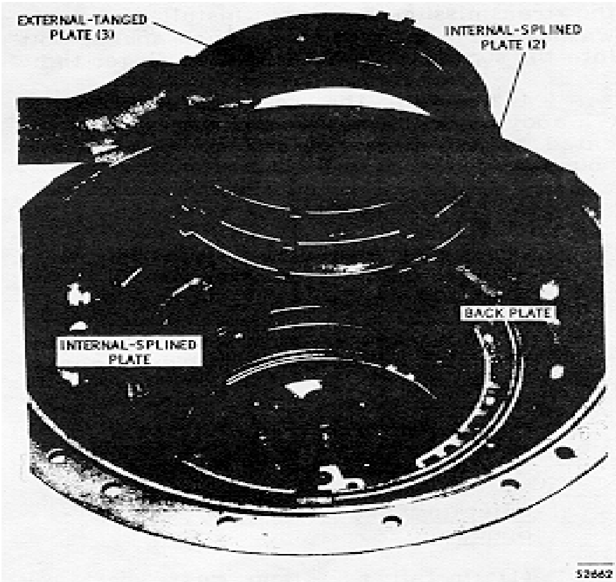


Fig. 7-10. Installing second clutch plates

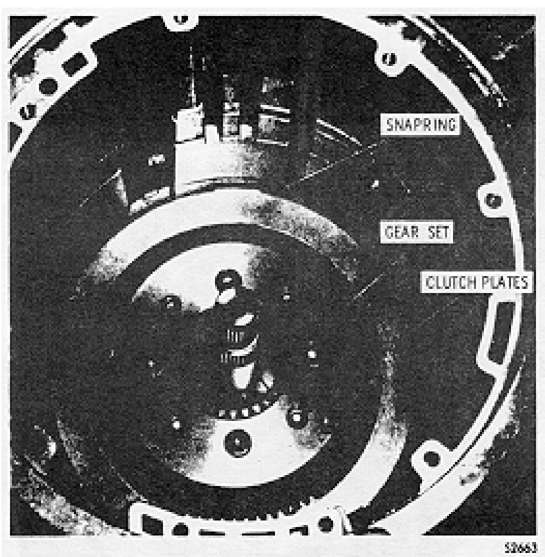


Fig. 7-11. Second-clutch snapring installed

(5) Tighten the compressor bolt to 5 lb ft (7 N-m) (Fig. 7-12).

(6) Using snapring gage J-23717-4, measure the snapring groove clearance (fig. 7-13). The gage has four lugs of different thicknesses. Try all four lugs into the groove. The thickest lug which will enter the groove indicates the thickness of the snapring required.

(7) Select a snapring, as shown below:

Gage lug	Snapring color	Snapring thickness
Blue	Blue	0.148 to 0.150 in. (3.76 to 3.81 mm)
Yellow	Yellow	0.152 to 0.154 in. (3.86 to 3.91 mm)
Green	Green	0.155 to 0.157 in. (3.94 to 3.99 mm)
Red	Red	0.158 to 0.160 in. (4.01 to 4.06 mm)

(8) Remove the center support compressor.

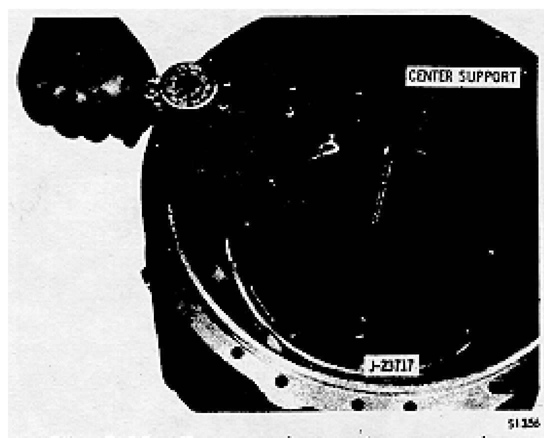


Fig. 7-12. Compressing center support for snapring measurement

(9) Attach center support lifting bracket J-23643 to the hub support. Remove the anchor bolt from the bottom of the transmission housing. Remove the center support. Place the center support on a work table and clean the piston bore of all foreign matter.

NOTE

Do not disturb the piston spring retainer lockrings when installing the piston into the piston bores in the center support. Both the second and third pistons have been preset in para 6-10b, (3) through (5).

(10) Lubricate the sealrings of the third clutch piston. Lubricate the piston bore in the center support. Install the piston and its attached parts, engaging the small lug on the third clutch spring retainer with the slot in the center support. Be sure the lips of the sealrings face the bottom of the piston cavity in the center support.

(11) Attach the center support lifting bracket to the center support and carefully lower the support into the transmission case, as shown in figure 5-14. During installation, align the threaded anchor bolt hole in the support with the hole in the bottom of the transmission housing. Install the plain

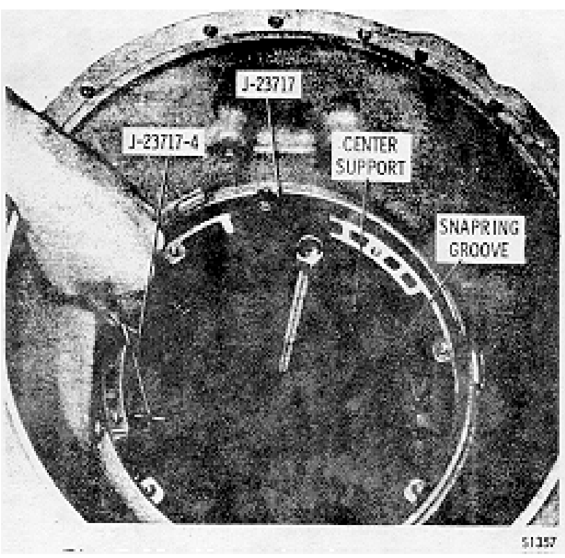


Fig. 7-13. Measuring for selection of center support snapring

washer and a new 3/8-16 x 1-inch anchor bolt into the support. Tighten the bolt finger tight.

(12) Install the snapring selected in (7), above. Be sure the snapring gap is located toward the top of the transmission housing.

NOTE

It may be necessary to use the center support compressor to install the snapring.

(13) Install two new hook-type sealrings 12 (A, foldout 5) onto the hub of center support assembly 13.

7-5. INSTALLATION OF REAR BEARING SPACER AND FOURTH CLUTCH

a. <u>Selecting, Installing Rear Bearing Spacer</u>

(1) Install the sun gear shaft retainer J-24352 onto the transmission main shaft (Fig. 7-14). Be sure retainer sleeve is seated on sun gear shaft while tightening thumb screw.

(2) Position the transmission, rear end upward. Install the governor drive gear, engaging its slot with the pin in the output shaft (Fig. 7-15).

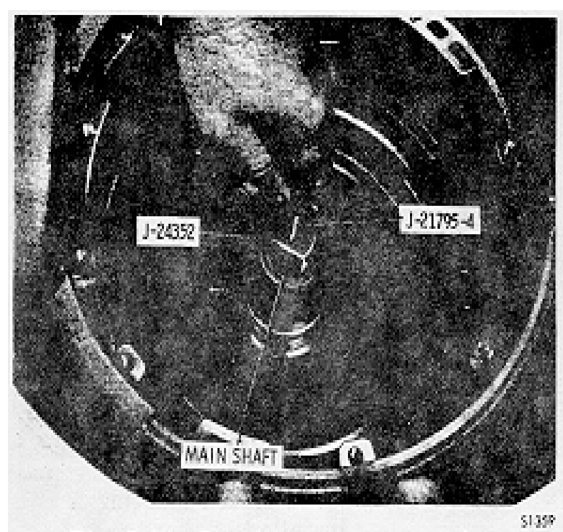


Fig. 7-14. Installing sun gear shaft of center support retainer

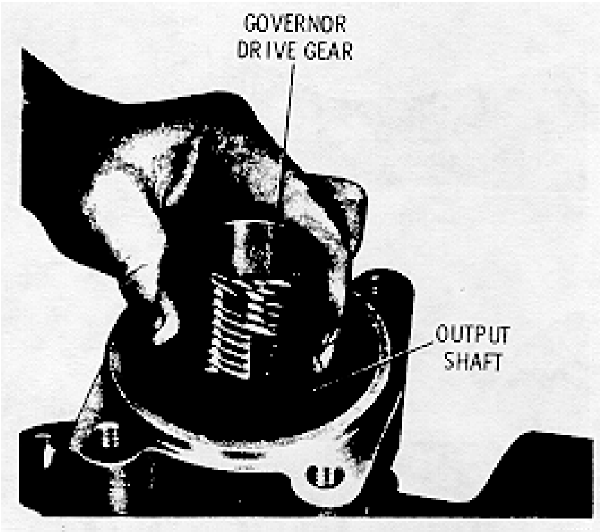


Fig. 7-15. Installing governor drive gear

(3) Install the speedometer drive gear onto the output shaft.

(4) Using a soft drift, tap against the speedometer drive gear to seat all the installed components.

(5) Loosen the thumbscrew on spacer selection gage J-23632-01 and position the gage against the output shaft (Fig. 7-16). Push the straight member of the gage against the rear of the speedometer drive gear. Push the lipped member against the rear bearing front snapring. When the gage is in firm contact with these parts, and the concave side of the straight member is firmly against the output shaft, tighten the thumbscrew.

(6) Remove the gage, and using a depth micrometer, measure the distance from the end of the straight member to the lip of the curved member. Use this dimension to select the proper rear spacer, as listed in the following chart. Install the spacer.

(7) Using bearing installer tool J-24446, install rear bearing 4 (B, foldout 9) numbered side out, as shown in figure 7-17. Install the beveled snapring, flat side down.

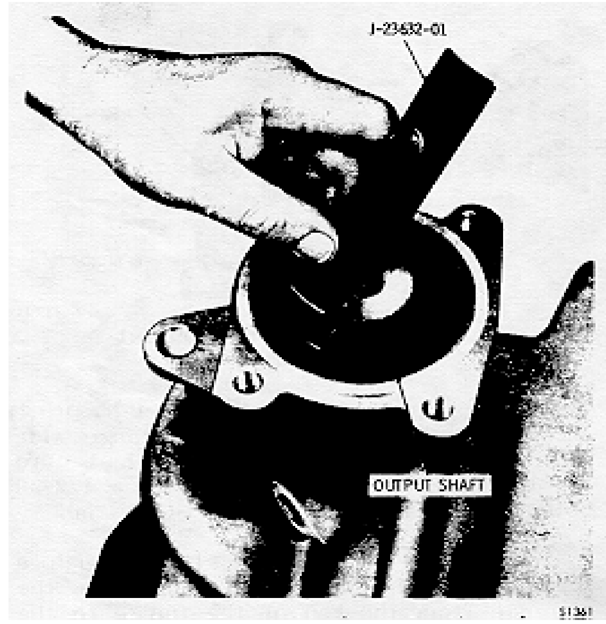


Fig. 7-16. Measuring for selection of rear bearing spacer

(8) Check the end play of the transmission output shaft as follows.

Micrometer* From	To	Use spacer	Marked
1.0003 (25.408)	1.0138 (25.750)	6834648	1 Groove
1.0138 (25.750)	1.0273 (26.093)	6834649	2 Grooves
1.0273 (26.093)	1.0408 (26.436)	6834650	3 Grooves
1.0408 (26.436)	1.0543 (26.779)	6834651	4 Grooves
1.0543 (26.779)	1.0678 (27.122)	6834652	5 Grooves
1.0678 (27.122)	1.0813 (27.465)	6834653	6 Grooves

*Dimensions are in inches (millimeters)

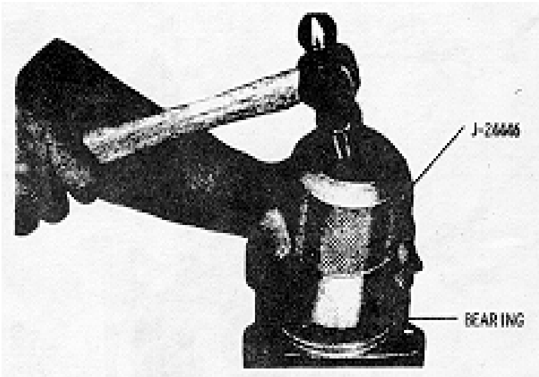


Fig. 7-17. Installing rear output shaft bearing

(9) Place the first clutch spring compressor b a s e J-23630-02, flange side down on the output shaft (Fig. 7-18). Secure the base to the output shaft with a 1/2-20 bolt. Tighten the bolt to 15 lb ft (20 N m).

(10) Lift the output s h aft with a screwdriver (Fig. 7-18) and measure the distance from the top of the flange to the rear of the transmission. Release the output shaft and repeat the measurement. A minimum of 0.015-inch (0.38 mm) and a maximum of 0.042-inch (1.07 mm) is acceptable.

NOTE

A dial indicator, shown in figure 7-18, or a depth micrometer may be used to establish minimum and maximum measurement.

(11) Remove the spring compressor base, turn it over, and reinstall it. Tighten the center bolt to 15 lb ft (20 N•m). Align the spring compressor base with the two parking brake mounting holes in the transmission housing (Fig. 7-19). Install two 1/2-13 bolts through the base and into the case. Tighten these bolts evenly to 5-8 lb ft (7-11 N•m). This positions the gear pack and all components for an accurate selective thrust washer measurement in paragraph 7-7.

b. Fourth Clutch

(1) Reposition the transmission, front upward. Carefully remove sun gear shaft retainer J-24352 (Fig. 7-14) without moving the sun gear shaft.

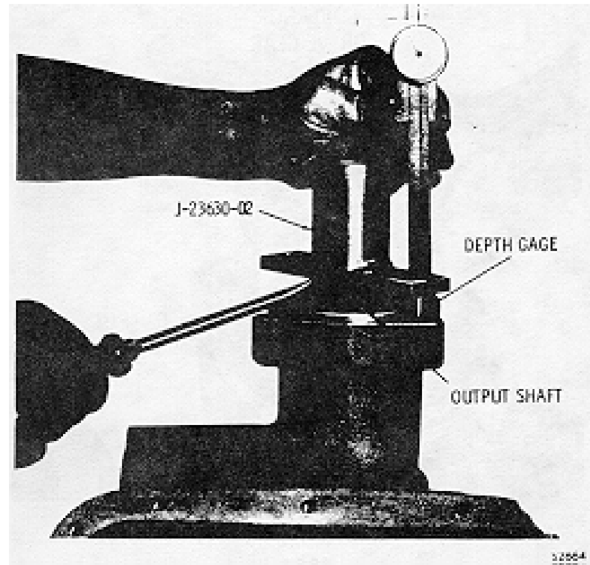


Fig. 7-18. Checking end play of output shaft S2665

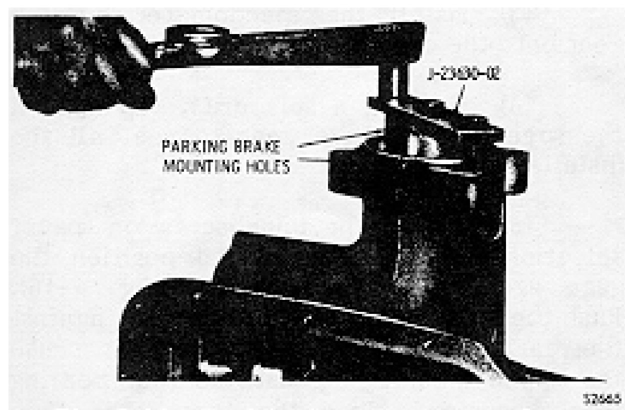


Fig. 7-19. Positioning components for front thrust washer measurements

CAUTION

Do not remove the sun gear shaft assembly before checking the required clearance shown on figure 7-20. If the clearance is less than 1/8 inch (3.18 mm), proceed with item (2). Otherwise omit item (2) and proceed with item (3).

(2) If the sun gear shaft assembly is properly seated, there should be approximately 1/8-inch (3.18 mm) distance from the end of the sun gear shaft assembly to the

shoulder on the main shaft shown in figure 7-20. If the shaft is not properly seated, a slow rotation with a slight up and down motion may seat it. If not, remove the shaft (noting its relative position to the main shaft) and center the front sun gear thrust washer so the sun gear shaft will bottom.

NOTE

The sun gear shaft assembly must be properly seated to establish a n accurate clearance between the forward clutch housing and the front support and bearing assembly. Reference paragraph 7-7.

(3) Install the fourth clutch assembly (as rebuilt in para 6-9) onto the splines of the sun gear shaft.

7-6. INSTALLATION OF THIRD AND FORWARD CLUTCHES

a. Third Clutch

NOTE

Establishing clutch clearances by a method other than explained below is not necessary. The clearance for this clutch is so tolerant it will accept all internal and external plates within their required wear limit. (Reference Section 8.)

(1) Beginning with an external-tanged clutch late, alternately install three external-tanged and three internal-splined plates (Fig. 7-21). Note the location of the three pairs of tangs and a single tang in relation to paired slots and a single slot. The plate will not have any rotational movement when properly installed.

(2) Install the third clutch backplate, aligning its tangs with those of the three clutch plates (Fig. 7-22). This plate is identified by the mark 2. Do not use a plate marked 1.

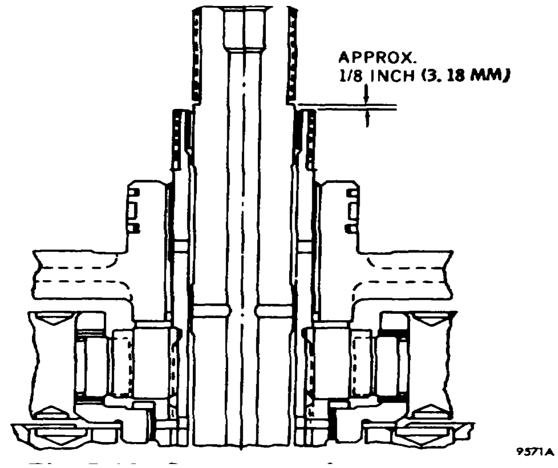


Fig. 7-20. Sun gear shaft clearance

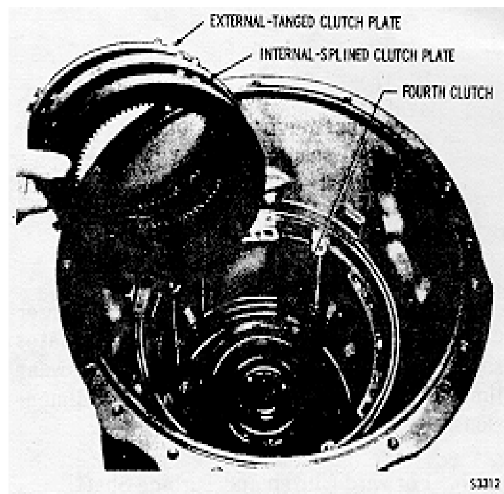


Fig. 7-21. Installing third clutch plates

(3) Install the snapring that retains the backplate (Fig. 7-22). The snapring is identified by a green mark and is 0.155 to 0.157 inch (3.94 to 3.99 mm) thick. Position the snapring gap toward t he top of the transmission housing.

(4) Using third clutch clearance gage J-23716, check t h e clutch running clearance. The thin end of the gage should pass between the snapring and the backplate; the thick end should not.

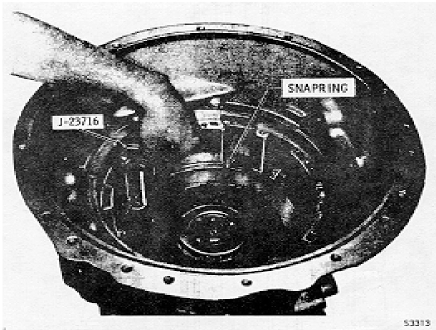


Fig. 7-22. Checking third clutch running clearance

NOTE

If the J-23716 gage is not available, measure the clearance between the backplate and the snapring. The clearance must be 0.029 (0.74 mm) minimum to 0.119 (3.02 mm) maximum.

(5) If clearance is excessive (larger end of gage enters plates), new clutch plates should replace worn plates. Refer to wear limits in Section 8 for clutch plate dimensions.

b. Forward Clutch and Turbine Shaft Assembly

(1) Install the thrust washer onto the hub of the forward clutch assembly, retaining it with oil-soluble grease (Fig. 7-23).

(2) Install forward clutch and turbine shaft assembly 5 (A, foldout 6). The hub splines engage the transmission main shaft. The splines on the fourth clutch drive hub engage the internal-splined plates of the fourth clutch.

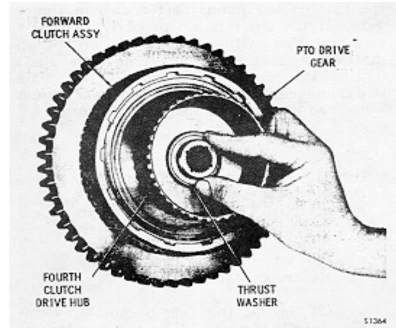


Fig. 7-23. installing thrust washer at rear of forward clutch hub

(3) Rotate the forward clutch assembly one or two revolutions, while pushing it downward. Make sure all the fourth clutch internal-splined plates are engaged.

7-7. INSTALLATION OF OIL PUMP ASSEMBLY

a. Selection of Front Thrust Washer

(1) Lay thrust washer selection gage bar J-23633 into the transmission housing, as shown in figure 7-24. Place the depth micrometer so that its stem passes through the center hole in the gage bar.

(2) Align the gage bar so that the micrometer stem is above the thrust washer surface of the forward clutch housing (Fig. 7-24).

(3) Measure the distance from the top of the gage bar to the thrust surface of the clutch housing (Fig. 7-24). Subtract 1.00 inch (25.4 mm) or the thickness of the gage bar and record the difference. Select the proper thrust washer from the following table.

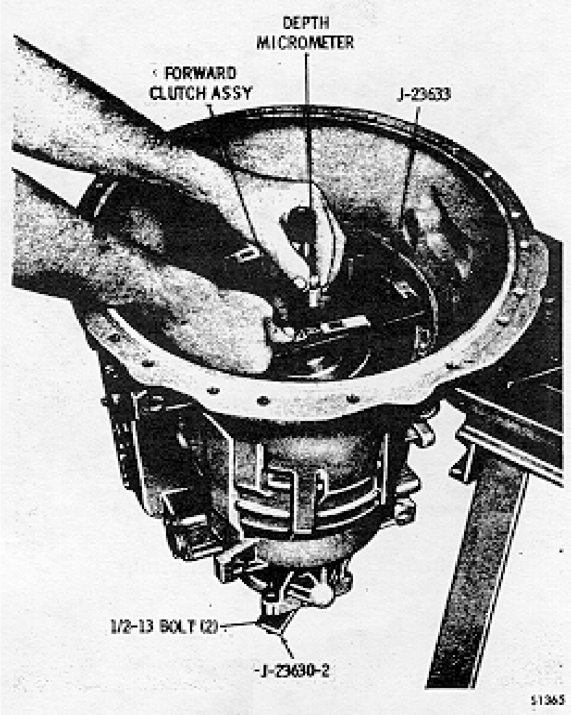


Fig. 7-24. Measuring for selection of front thrust washer

Dimension* From	To	Thrust washer number	Marked
0.7329 (18.616)	0.7493 (19.032)	6831620 No color	0
0.7493 (19.032)	0.7656 (19.446)	6831621 Red	1
0.7656 (19.446)	0.7820 (19.863)	6831622 Blue	2
0.7820 (19.863)	0.7983 (20.277)	6831623 Green	3
0.7983 (20.277)	0.8147 (20.693)	6831624 White	4
0.8147 (20.693)	0.8311 (21.110)	6831625 No color	5

*Dimensions are in inches (millimeters)

b. Oil Pump Assembly

(1) Using oil-soluble grease, install the thrust washer selected in a(3), above, onto the oil pump assembly (Fig. 7-25). The tab on the washer must engage the cast recess in the front support.

(2) Install two hook-type sealrings onto the hub of the front support (Fig. 7-25).

(3) Lubricate the sealrings and thrust washer with oil-soluble grease.

(4) Install the front support gasket, aligning the b o l t holes in the gasket with those in the transmission housing (Fig. 7-26).

(5) Install two 5/16-18 headless guide bolts into two opposite holes in the gasket and transmission housing (Fig. 7-27).

(6) Grasp the oil pump assembly by the stator shaft and lower it into the transmission housing (Fig. 7-27). Be sure the support bottoms.

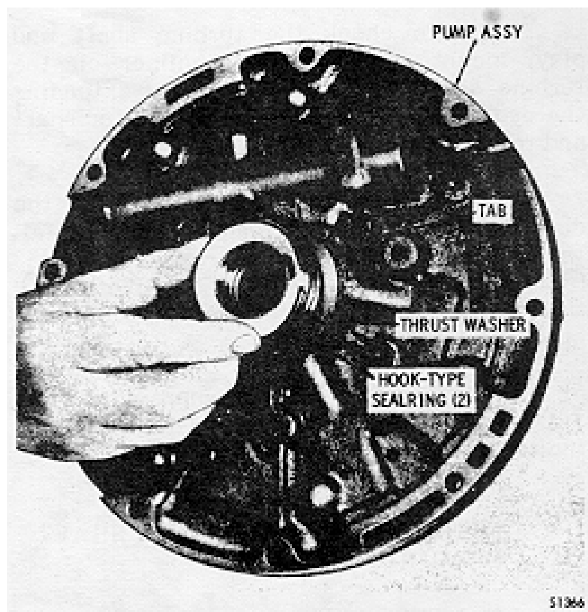


Fig. 7-25. Installing hook-type sealrings onto oil pump assembly

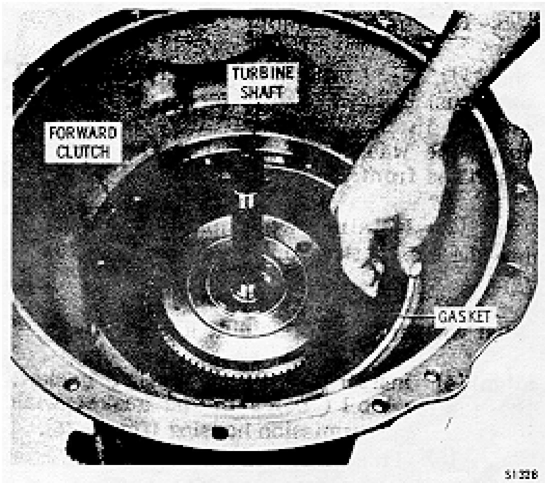


Fig. 7-26. Installing front support gasket

(7) Install nine 5/16-18 x 1 3/4-inch self-locking bolts, with nine new rubber coated washers, into the front support and transmission housing. Tighten the bolts to 13-16 lb ft (17-22 N•m).

(8) To check the turbine shaft end play, mount a vernier dial caliper on the turbine shaft. Raise t he shaft, extending the depth gage to bear upon the stator shaft and record the dial reading (Fig. 7-28).

(9) Release the shaft and record the dial reading. If the dial reading does not fall within the desired end play range of 0.0053 (min) to 0.0337 (max.) (0.135 to 0.856 mm), the thickness of the selective thrust washer must be recalculated.

(10 Remove the compressor base, J-23630-2, installed in para 7-5a(11), from the transmission housing and output shaft.

7-8. INSTALLATION OF OUTPUT SHAFT BEARING, OIL SEAL

a. Output Shaft Bearing

(1) Position the transmission housing rear end upward.

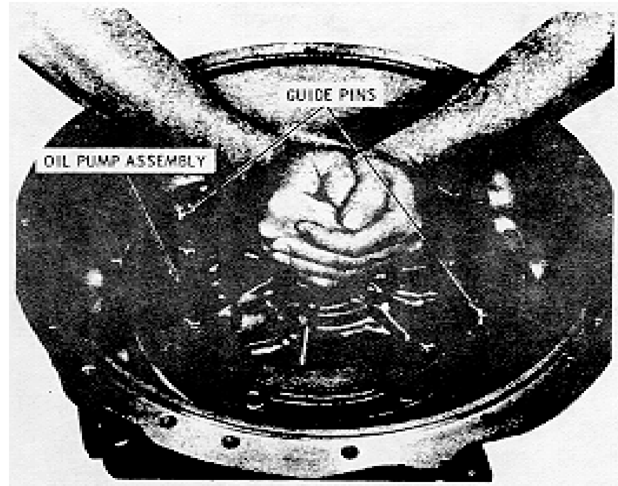


Fig. 7-27. Installing oil pump assembly

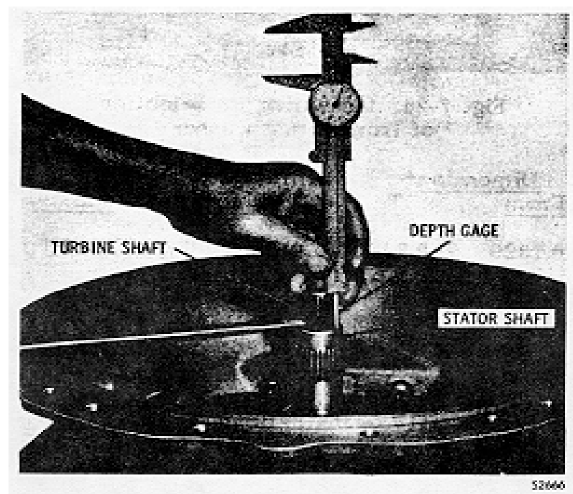


Fig. 7-28. Measuring turbine shaft end play

(2) Place output shaft bearing 4 (B, foldout 9) into its bore. Using installer tool J-24446, drive the bearing to the bottom of its bore, against snapring 9 (B, foldout 8). Remove the installer tool.

(3) Install snapring 5 (B, foldout 9), beveled side out, into its groove in the transmission housing.

b. Output Shaft Oil Seal

(1) Coat the lip of oil seal 6 (B, foldout 9) with high temperature grease (MIL-G-3545 A or equivalent).

(2) Coat the outside circumference of the oil seal with nonhardening sealer. Start the oil seal, lip first, squarely into the rear bore of the transmission housing.

(3) Using installer tool J-23631, drive the oil seal into the housing until the installer seats against the housing (Fig. 7-29).

NOTE

The rear of the oil seal should be 0.51 to 0.55 inch (13 to 14 mm) for w a r d of the brake mounting surface of the transmission housing.

(4) Install output flange components. Tighten the retaining bolt to 83-100 lb ft

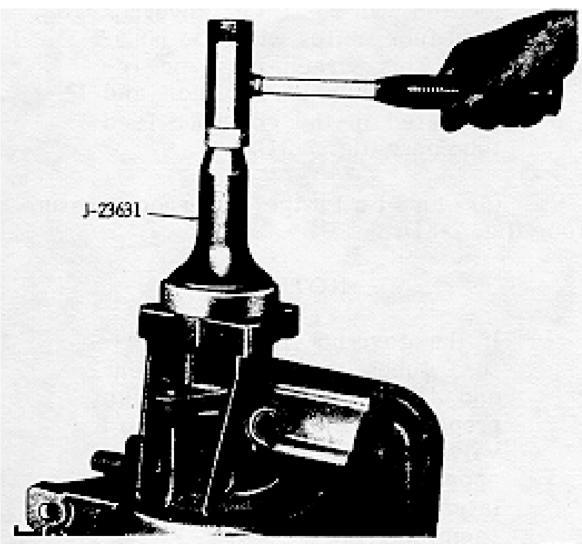


Fig. 7-29. Installing output shaft oil seal

(113-136 N-m) (Grade 5 bolt) or 96-115 lb ft (130-156 mm) (Grade 6 bolt). Stake the tab washer into the flange washer. Bend the tab washer against a flat of the bolt head.

7-9. INSTALLATION OF VALVE BODY, OIL FILTER, AND OIL PAN

NOTE

The control valve body assembly will perform properly only if it is functionally compatible with the main housing channeling. Refer to parts catalog.

a. Control Valve Body

(1) Position the transmission housing bottom side upward.

(2) Tighten the center support anchor bolt to 39-46 lb ft (53-62 N m) (Fig. 7-30).

(3) Install the governor check valve ball into t h e channel in the transmission housing (Fig. 7-30).

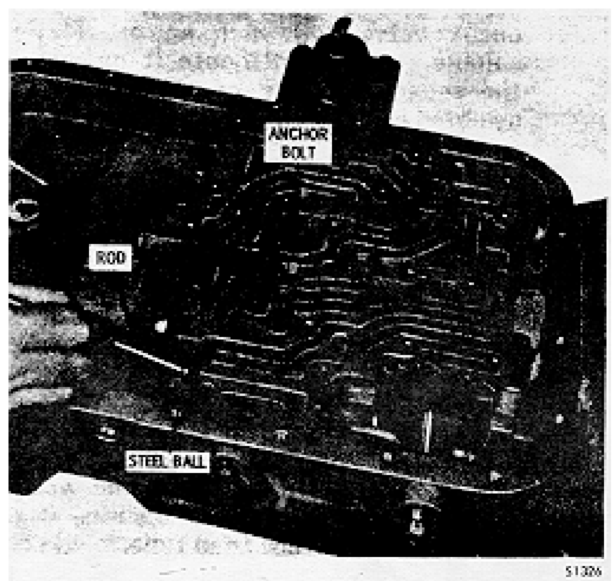


Fig. 7-30. Installing governor check oil seal ball

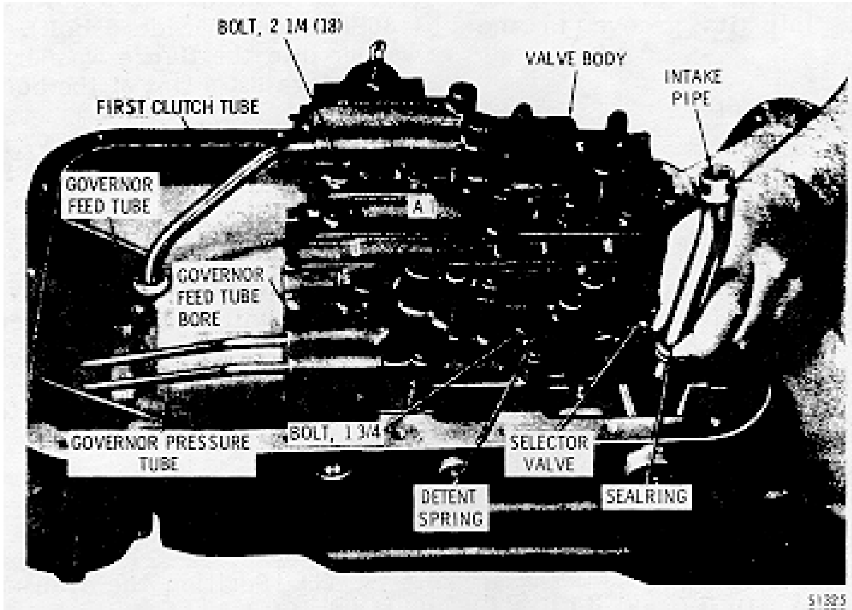


Fig. 7-31. Installing oil intake pipe

NOTE

If it is necessary to install the control valve assembly from a prone position (under the vehicle), grease the governor check valve ball with an oil soluble grease and locate it on the separator plate of the assembled control valve Fig. 6-23.

(4) Position the control valve body on the transmission housing in its approximate installed position (Fig. 7-31).

CAUTION

Do not allow the selector valve to fall out during handling of the assembly.

(5) Install governor oil screen 9 (B, foldout 9) closed end first, into the valve body, at the governor feed tube opening (fig.

NOTE

Inspect both ends of the governor feed tube. Some models contained a plastic oil screen located where the governor feed tube unites with the housing. This screen must be replaced with a wire screen and relocated in the governor feed tube bore (Fig. 7-31).

(6) Install the governor pressure tube (Fig. 7-31).

NOTE

If the governor feed and pressure tubes are installed, rear end first, they will not align properly when the control valve is installed. They may appear to align until installation of the valve body is attempted.

(7) Install first clutch tube (Fig. 7-31).

(8) Lift the valve body and swing the three tubes into proper position to enter their holes in the transmission case.

(9) Lower the valve body onto the case, while engaging the rear ends of the tubes in the case, and the selector valve on the selector lever (Fig. 7-31).

(10) Install the detent spring, with its roller over the selector lever, and its rear tab in the hole immediately behind the bolt hole (Fig. 7-31).

(11) Install a 1/4-20 x 1 3/4-inch bolt into the detent spring and valve body.

(12) Install eighteen valve body retaining bolts.

use eighteen 1/4-20 x 2 1/4-inch bolts (Fig. 7-31).

(13) install filter spacer 18 (B, foldout 9). Use valve body retaining bolts 'A' (Fig. 7-31) to retain the spacer.

(14) Shake the valve body slightly, and the ends of the bolts will start into the tapped holes in the transmission case.

NOTE

The detent spring must be held in alignment over the selector lever while the 1 3/4-inch bolt is tightened.

(15) Tighten the nineteen bolts evenly to 9-11 lb ft (12-15 N-m)

b. Oil Filter

(1) Install sealring onto the straighter end of the intake pipe (Fig. 7-31). Lubricate the sealring with oil-soluble grease.

CAUTION

Avoid twisting the intake pipe or filter when installing the oil filter, intake pipe, and sealring. The sealring may become pinched, cut, or deformed. An air-tight seal must be maintained.

(2) Install the intake pipe and sealring (Fig. 7-31).

(3) Install the oil filter onto the intake pipe, making sure the grommet in the filter fits the intake pipe snugly (Fig. 7-32).

NOTE

Turn the intake pipe until it enters the grommet squarely, if it appears to be misaligned.

(4) Retain the oil filter with one 5/16-18 x 5/8-inch, washer head screw (std. oil pan models) or one 5/16-inch plain washer and one 5/16-18 x 2 1/4-inch bolt (deep oil pan models). Tighten the bolt or screw to 10-15 lb ft (14-20 N•m).

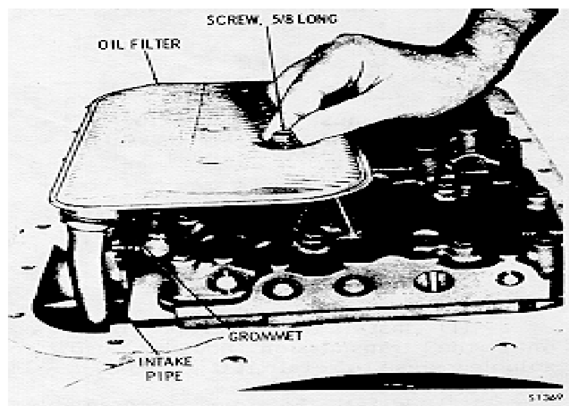


Fig. 7-32. Installing oil filter screw

c. Oil Pan

(1) Position the oil pan gasket on the transmission housing, aligning its bolt holes with those in the housing (Fig. 7-33).

(2) Position the oil pan on the transmission housing, as shown in B, foldout 9.

NOTE

If installation of the oil pan and gasket from a prone position is necessary, place the gasket on the oil pan aligning all bolt holes. (Do not use grease to retain the gasket to the oil pan.) Insert two washer-head screws (one on each side) through the oil pan and into the transmission housing. Tighten the screws two or three threads. Then, install the remaining screws, taking care not to damage the gasket.

(3) Retain the oil pan with twenty-one 5/16-18 x 5/8-inch washer-head screws (Fig. 7-33). Tighten the screws evenly to 10-13 lb ft (14-18 N•m).

NOTE

To prevent leakage, pan screws must retain a 5 lb ft (7 N•m) minimum torque after gasket set.

7-10. INSTALLATION OF GOVERNOR, MODULATOR, AND TORQUE CO N VERTER

a. Governor

(1) Install the governor cover gasket onto the transmission housing, using oil soluble grease to retain it (Fig. 7-34).

(2) Install the governor assembly by pushing it inward with a slight rotation counterclockwise (Fig. 7-34).

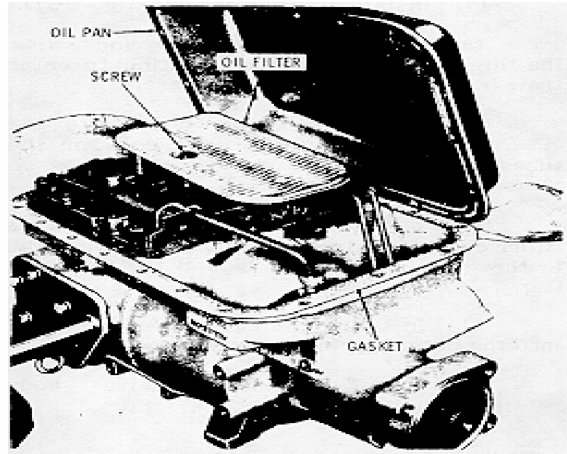


Fig. 7-33. Installing transmission oil pan

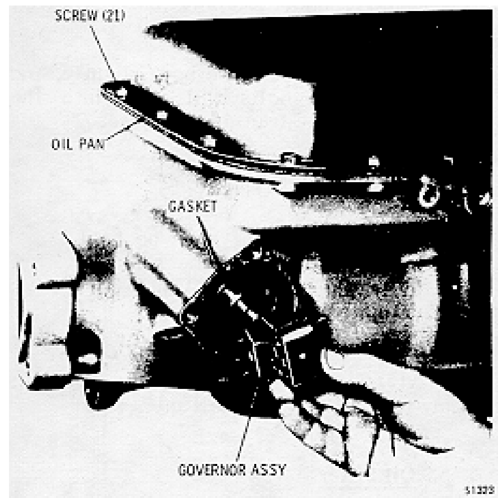


Fig. 7-34. Installing governor assembly

(3) Install the governor cover, and retain it with four 5/16-18 x 9/16-inch bolts (Fig. 7-35) Tighten the bolts to 15-20 lb ft (20-27 N-m).

u. Mechanical Actuator

(1) Install the mechanical actuator valve actuating rod, larger diameter end first (Fig. 7-35).

(4) Install the retainer, bent tabs toward transmission, a n d secure it with a 5/16-18 x 3/4-inch bolt (Fig. 7-36). Tighten the bolt to 15-20 lb ft (20-27 N-m).

c. Torque Converter Assembly

(1) Position the transmission housing front end upward. Install the torque converter assembly (as assembled in para 6-23 or 6-24) into the transmission housing (Fig. 7-37). Be sure the splines on the converter turbine shaft engage the splines in the converter turbine hub, and the tangs on the converter pump hub engage the input pump drive gear. (Reference foldout 1 and 2.) (2) Install the torque converter retaining strap before removing transmission from the holding fixture.

(3) Install the speedometer drive, or plug, as required.

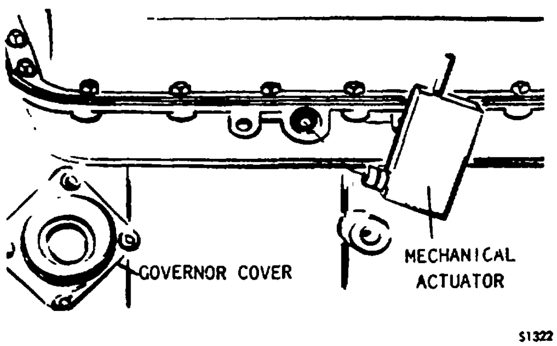


Fig. 7-35. Installing Mechanical Actuator

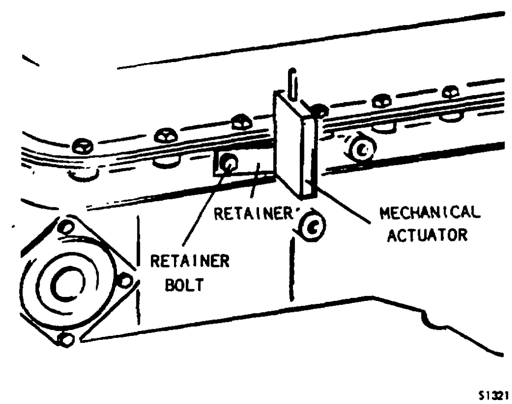


Fig. 7-36. Installing Mechanical Actuator retainer bolt

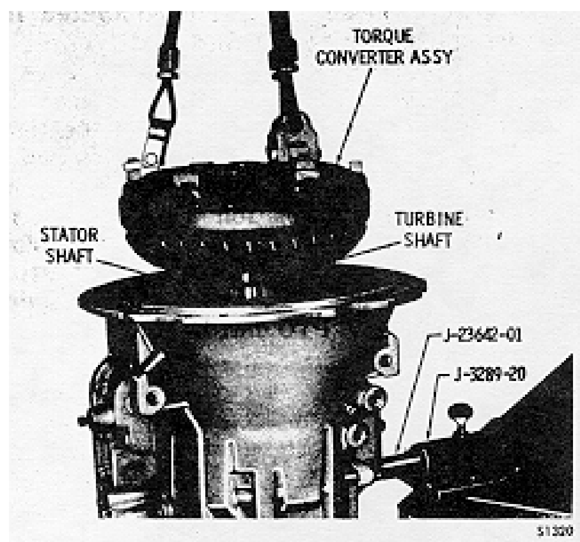


Fig. 7-37. Installing torque converter assembly

(4) Remove the transmission from the holding fixture.

7-12. INSTALLATION OF EXTERNAL SELECTOR LEVER

Before installing external selector lever, refer to paragraph 3-10 for procedure.

Section 8. WEAR LIMITS AND SPRING DATA

8-1. SCOPE

This section tabulates wear limits and spring data.

8-2. WEAR LIMIT DATA

a. Maximum Variations. Wear limit information in this section shows the maximum wear at which components are expected to function satisfactorily. Table 8-1 lists the wear limits data and is referenced to the exploded views (foldouts 5 through 9) in the back of this manual.

b. Cleaning, Inspection. Parts must be clean to permit effective inspection for wear or damage. Refer to paragraph 4-5.

c. Bearings, Bearing Journals, Bores. The application of bearings to any product is based on the recommendations of the bearing manufacturer and, therefore, no diametral dimensional deviation should be permitted in t he bearing or mated parts. Bearings should be carefully checked for signs of distress before reinstalling in the transmission.

d. Gears. Gears should be inspected for load pattern and signs of distress. Any distress indicates a possible future failure and the reuse of such gears should be the decision of the individual customer, based on experience. Backlash cannot be used to establish critical wear of a gear. The backlash tolerances are of such nature that a gear usually pits, scuffs, scores, or galls long before the gear wear becomes critical.

e. Splines. Severe spline wear is not considered detrimental except where it affects tightness of an assembly such as drive-line flanges. Here again, backlash cannot be used to establish critical wear because both mating parts must be concentrically located to obtain accurate measurement of backlash.

f. Hook-type Sealrings. Sides of the sealring should be smooth (maximum wear 0.005 inch; 0.13 mm). The sides of the groove into which the sealrings fit should be smooth (50 micro-inch; 1.27 micrometers or equivalent) and square with the axis of rotation within 0.002 inch (0.05 mm). A new sealring should be installed if grooves are reworked, or sealring outside diameter wear causes the possibility of a closed gap between sealring hooks when the ring is installed.

g. Oil Seals. Seals should be replaced if they show signs of excessive hardening, scoring, cracking or other indications of deterioration. (See Section 4.)

8-3. SPRING DATA

Springs must be clean to permit effective inspection. Springs should be replaced if there are signs of overheating, wear due to rubbing adjacent parts, or permanent set. Discard springs which do not meet the load-height specifications in the spring chart.

Inspection criteria (load vs height) and identification characteristics of the springs are presented in Table 8-2. The spring data is keyed to the exploded views (foldouts 5 through 9) in the back of this manual.

8-4. CLUTCH PLATE CONE

Inspect all steel plates for cone. The smallest conical distortion will affect clutch plate running clearance. To determine if a plate is coned, place the plate on a flat surface. If the cone exceeds the limit shown in the wear limit chart, replace the plate. Refer to paragraph 4-5 n (3).

TABLE 8-1. WEAR LIMITS

Illustration	Description	Wear Limit in.	(mm)
foldout 5, B	TORQUE CONVERTER, OIL PUMP ASSEMBLIES		
1, 7	Torque converter hub - clearance in bushing	0.005	0.127 max.
1	Torque converter assy - AT 540, 545 turbine end play	0.037	0.94
8, 9	Pump driven gear 9 - diametral clearance in body 8	Refer para 6-7	
10	Pump drive gear - side clearance	Refer para 6-7	
18	Stator shaft bushing - clearance on shaft 8, (A, foldout 6)	0.004	0.10 max.
foldout 6, A	FORWARD CLUTCH AND TURBINE SHAFT		
6	Turbine shaft - clearance in bushing 18 (B, foldout 5)	0.004	0.10 max.
21	External-tanged clutch plate - thickness	No visible wear or scoring permitted.	
	cone	0.004	0.10 max.
* 22	Internal-splined clutch plate - thickness	0.071	1.80 min
23	Fourth-clutch driving hub - thickness at friction face	No visible wear or	
	scoring permitted.		
	Forward clutch running clearance	Refer para 6-8b	
foldout 6, B	FOURTH CLUTCH		
2	Clutch back plate - thickness	No visible wear or scoring permitted.	
* 3	Internal-splined clutch plate - thickness	0.071	1.80 min
4	External-tanged clutch plate - thickness	No visible wear or scoring permitted.	
	cone	0.004	0.10 max.
	Fourth clutch running clearance	Refer-para 6-9b	
foldout 7, A	SECOND CLUTCH, THIRD CLUTCH, CENTER SUPPORT		
2	Third-clutch back plate - thickness	No visible wear or scoring permitted,	
* 3, 24	Internal-splined clutch plate - thickness	0.090	2.29 min

*Minimum depth of oil grooves, 0.008 in. (0.20 mm)

TABLE 8-1. WEAR LIMITS (Continued)

Illustration	Description	Wear Limit in.	(mm)
foldout 7, A (cont)			
4, 23	External-tanged clutch plate --		
	thickness	No visible wear or scoring permitted.	
	cone	0.010	0.25 max
14	Center support bushing-		
	clearance on shaft 3 (B, foldout 7)	0.005	0.13 max
25	Second-clutch back plate (indent 1 or 2) - thickness	No visible wear or scoring permitted.	
	Second clutch running clearance	Refer para 7-4a	
	Third clutch running clearance	Refer para 7-6a	
foldout 7, B	PLANETARY GEAR UNIT		
2	Sun gear shaft bushing - clearance on shaft 4	0.0075	0.191 max
3	Sun gear shaft -		
	clearance in bushing 14 (A, foldout 7)	0.005	0.13 max
4	Transmission main shaft --clearance in bushing 2	0.0075	0.191 max
15	Front planetary carrier bushing -		
	clearance on sun gear 19	0.005	0.13 max
47	Output shaft bushing - clearance on shaft 4	0.0065	0.165 max
foldout 8, A	FIRST CLUTCH		
2	Backplate (indent 1) -- thickness	No visible wear or	
2	Backplate (indent 2) - thickness	scoring permitted.	
2	Backplate (indent 3) - thickness		
* 3	Internal-splined clutch plate - thickness	0.090	2.29 max
4	External-tanged clutch plate -		
	thickness	No visible wear or scoring permitted.	
	cone	0.010	0.25 max
	First clutch running clearance	Refer para 7-3a	
foldout 8, B	TRANSMISSION HOUSING, GOVERNOR, AND VACUUM MODULATOR		
11	Transmission housing -		
	clearance of governor bore on governor 17	0.0035	0.089 max

*Minimum depth of oil grooves, 0.008 in (0.20 mm)

TABLE 8-2. SPRING DATA

Fold -out	Ref	Spring	Part No.	No. coils	Wire dia in. (mm)	Spring OD In. (mm)	Approx. Free Length In. (mm)	Length In. (mm)	Under load lb (N)
5, B	26	Main pressure regulator valve	6833294	14	0.126 (3.20)	1.6 (27.0)	4.19 (106.4)	2.01 (51.1)	74.15-78.76 (329.8-350.3)
6, A	14	Forward clutch piston release	8624073	10.5	0.055 (1.40)	0.45 (11.4)	1.31 (33.3)	0.88 (22.4)	12.22 max. (54.4)
6, B	7	Fourth clutch piston release	8624073	10.5	0.055 (1.40)	0.45 (11.4)	1.31 (33.3)	0.88 (22.4)	12.22 max. (54.4)
7, A	8	Third clutch piston release	6831656	11.5	0.041 (1.04)	0.38 (9.7)	1.29 (32.8)	0.82 (20.8)	5.7 max. (25)
7, A	19	Second clutch piston release	6831656	11.5	0.041 (1.04)	0.38 (9.7)	1.29 (32.8)	0.82 (20.8)	5.7 max. (25)
8, A	8	First clutch piston release	6831702	11.5	0.044 (1.12)	0.45 (11.4)	1.53 (38.9)	1.01 (25.7)	4.81 max. 21.4)
			6880251	10	0.063 (1.60)	0.45 (11.4)	1.28 (32.5)	0.95 (24.1)	13.6-16.4 (61-73)
9, A	8	Modulator valve	6833934	10	0.054 (1.37)	0.49 (12.5)	1.47 (37.3)	0.80 (20.3)	11.9-13.1 (53-58)
			23012948	10	0.054 (1.37)	0.49 (12.5)	1.47 (37.3)	0.80 (20.3)	11.9-13.1 (53-58)
9, A	14	Third clutch trimmer valve	6833945	7.4	0.092 (2.33)	0.93 (23.6)	2.27 (57.7)	1.94 (49.3)	9.4-11.4 (42-51)
			23012937	9	0.099 (2.52)	0.95 (24.1)	2.27 (57.7)	1.94 (49.3)	9.4-11.4 (42-51)
9, A	18	First clutch trimmer valve-outer	6833945	7.4	0.092 (2.33)	0.93 (23.6)	2.27 (57.7)	1.94 (49.3)	9.4-11.4 (42-51)
			6839271	10	0.103 (2.61)	0.94 (23.9)	2.56 (65.0)	1.94 (49.3)	20-22 (89.0-97.9)
			6880045	10	0.099 (2.52)	0.94 (23.9)	2.18 (55.4)	1.94 (49.3)	6.2-7.4 (28-33)

TABLE 8-2. SPRING DATA (cont)

Fold-out	Ref	Spring	Part no.	No. coils	Wire dia in. (mm)	Spring OD in. (mm)	Approx. Free Length in. (mm)	Length under load in. (mm)	Length under load lb (N)
9, A	19	First clutch trimmer valve-inner	6839102	8.5	0.092 (2.33)	0.72 (18.3)	1.68 (42.7)	1.10 (27.9)	32.6-39.8 (145-177)
			6880274	9.6	0.092 (2.33)	0.69 (17.5)	1.69 (42.9)	1.10 (27.9)	32.6-39.8 (145-177)
			6884701	9.6	0.092 (2.33)	0.69 (17.5)	1.69 (42.9)	1.10 (27.9)	32.6-39.8 (145-177)
			6885166	9.6	0.092 (2.33)	0.69 (17.5)	1.69 (42.9)	1.10 (27.9)	32.6-39.8 (145-177)
9, A	23	Second clutch trimmer valve	6833940	8.5	0.121 (3.07)	0.95 (24.1)	2.38 (60.5)	1.94 (49.3)	29.0-35.0 (129-156)
			6838532	8.5	0.121 (3.07)	0.95 (24.1)	2.10 (53.3)	1.94 (49.3)	10.5-15.5 (47-69)
			6839102	8.5	0.092 (2.33)	0.72 (18.3)	1.68 (42.7)	1.10 (27.9)	32.6-39.8 (145-177)
			6839271	10	0.103 (2.61)	0.94 (23.9)	2.56 (65.0)	1.94 (49.3)	20-22 (89-98)
			6885164	8.5	0.121 (3.07)	0.950 (24.13)	2.10 (53.3)	1.94 (49.3)	10.5-15.5 (47-69)
9, A	27	Fourth clutch trimmer valve-outer	6839271	10	0.103 (2.61)	0.94 (23.9)	2.56 (65.0)	1.95 (49.5)	20-22 (89-98)
9, A	28	Fourth clutch trimmer valve-inner	6880118	8.5	0.090 (2.29)	0.69 (17.5)	1.42 (36.1)	1.10 (27.9)	20.7-25.3 (92-113)
9, A	35	2-3 relay valve	6832462	11	0.072 (1.83)	0.69 (17.5)	2.18 (55.4)	1.20 (30.5)	16.2-19.8 (72-88)
9, A	38	1-2 relay valve	6834528	11	0.072 (1.83)	0.68 (17.3)	1.52 (38.6)	1.10 (27.9)	7.2-8.8 (32-39)
9, A	41	Priority valve	6835729	11	0.054 (1.37)	0.38 (9.7)	1.17 (29.7)	0.94 (23.9)	8.15-9.15 (36.3-40.7)
9, A	44	Hold regulator valve	6836784	13	0.041 (1.04)	0.40 (10.2)	1.90 (48.3)	1.15 (29.2)	5.93-6.17 (26.4-27.5)
			6836785	14	0.041 (1.04)	0.40 (10.2)	2.01 (51.1)	1.15 (29.2)	6.22-6.48 (27.7-28.8)

TABLE 8-2. SPRING DATA (cont)

Fold-out	Ref	Spring	Part no.	No. coils	Wire dia in. (mm)	Spring OD in. (mm)	Approx. Free Length in. (mm)	Length under load in. (mm)	lb (N)
9, A	44	Hold regulator valve (cont)	6836976	14	0.044 (1.12)	0.40 (10.2)	1.85 (47.0)	1.15 (29.2)	6.91-7.19 (30.7-32.0)
			6837539	11	0.041 (1.04)	0.40 (10.2)	1.72 (43.7)	1.15 (29.2)	5.44-5.66 (24.2-25.2)
			6837541	14	0.044 (1.12)	0.40 (10.2)	1.82 (46.3)	1.15 (29.2)	6.61-6.89 (29.4-30.7)
			6837952	14	0.044 (1.12)	0.40 (10.2)	1.87 (47.5)	1.15 (29.2)	7.10-7.40 (31.6-32.9)
			6837953	14	0.044 (1.12)	0.40 (10.2)	1.91 (48.5)	1.15 (29.2)	7.46-7.76 (33.2-34.5)
9, A	52	1-2 shift valve	6833935	9	0.054 (1.37)	0.64 (16.3)	2.17 (55.1)	1.15 (29.2)	8.6-9.1 (38-41)
			6833941	13.5	0.062 (1.57)	0.64 (16.3)	2.15 (54.6)	1.15 (29.2)	9.35-9.85 (41.6-43.8)
			6833942	12	0.054 (1.37)	0.64 (16.3)	2.50 (63.5)	1.15 (29.2)	7.85-8.35 (34.9-37.1)
			6834576	12	0.054 (1.37)	0.64 (16.3)	2.39 (60.7)	1.15 (29.2)	7.18-7.68 (31.9-34.2)
			6837454	10.8	0.062 (1.57)	0.67 (17.0)	1.98 (50.3)	1.15 (29.2)	8.22-8.72 (36.6-38.8)
			6881061	12	0.054 (1.37)	0.64 (16.3)	2.55 (64.8)	1.15 (29.2)	8.10-8.70 (36.0-38.7)
			23012946	12	0.054 (1.37)	0.64 (16.3)	2.39 (60.7)	1.15 (29.2)	7.18-7.68 (31.9-34.2)
			23013274	12	0.054 (1.37)	0.64 (16.3)	2.53 (64.3)	1.15 (29.2)	7.95-8.55 (35.4-38.0)
9, A	58	2-3 shift valve	6833935	9	0.054 (1.37)	0.64 (16.3)	2.17 (55.1)	1.15 (29.2)	8.6-9.1 (38-41)
			6833939	8.5	0.106 (2.68)	0.93 (23.6)	2.18 (55.4)	1.65 (41.9)	23.8-28.2 (106-125)
			6833941	13.5	0.062 (1.57)	0.64 (16.3)	2.15 (54.6)	1.15 (29.2)	9.35-9.85 (41.6-43.8)

TABLE 8-2. SPRING DATA (cont)

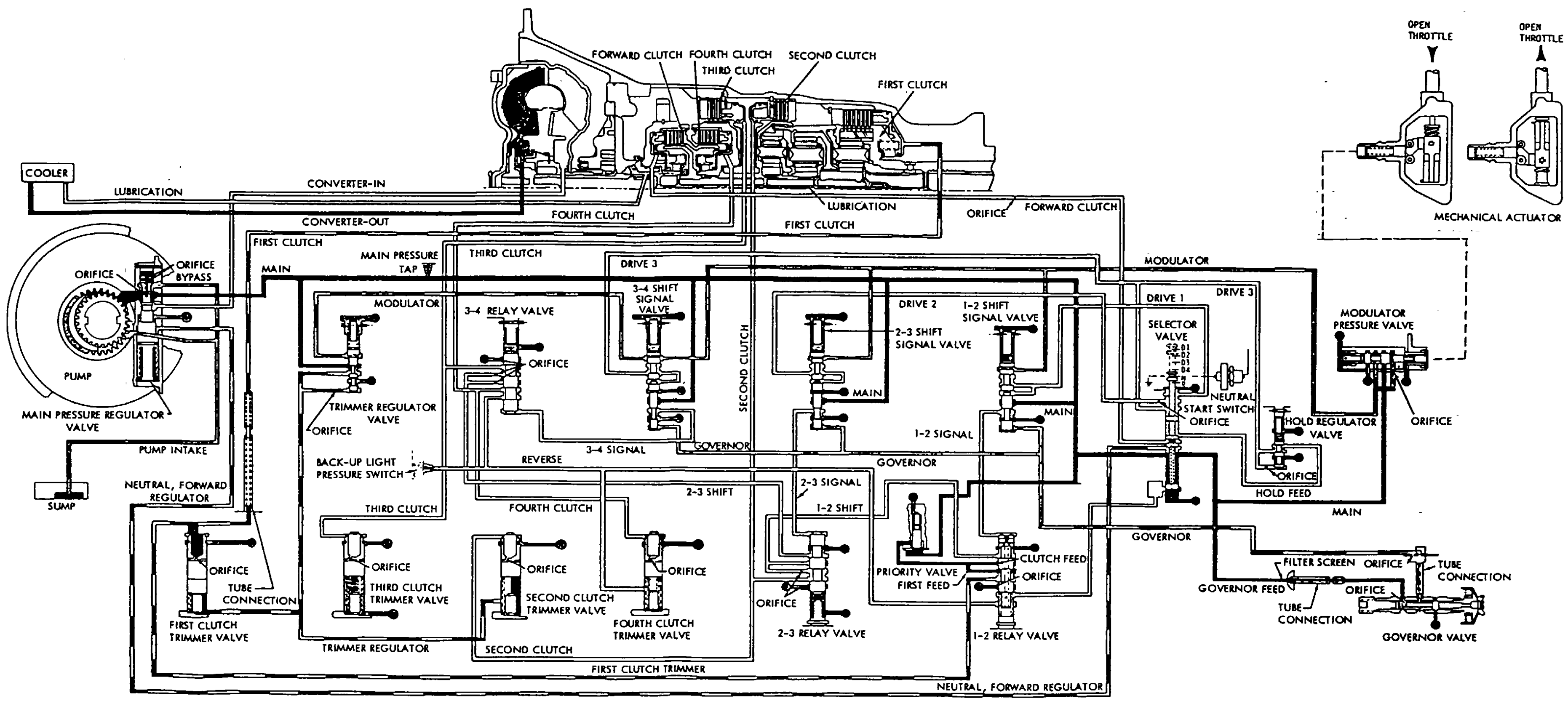
Fold-out	Ref	Spring	Part no.	No. coils	Wire dia in. (mm)	Spring OD in. (mm)	Approx. Free Length in. (mm)	Length under load in. (mm)	Length under load lb (N)
9, A	58	2-3 shift valve (cont)	6833942	12	0.054 (1.37)	0.64 (16.3)	2.50 (63.5)	1.15 (29.2)	7.85-8.35 (34.9-37.1)
			6834902	13	0.059 (1.50)	0.64 (16.3)	2.41 (61.2)	1.15 (29.2)	9.95-10.45 (44.3-46.5)
			6835310	13	0.059 (1.50)	0.64 (16.3)	2.51 (63.8)	1.15 (29.2)	10.75-11.25 (47.8-50.0)
			6837454	10.8	0.062 (1.57)	0.67 (17.0)	1.98 (50.3)	1.15 (29.2)	8.22-8.72 (36.6-38.8)
			6880991	12	0.054 (1.37)	0.64 (16.3)	2.75 (69.9)	1.15 (29.2)	9.25-9.95 (41.1-44.3)
			6880992	12	0.054 (1.37)	0.64 (16.3)	2.85 (72.4)	1.15 (29.2)	9.85-10.55 (43.8-46.9)
			6881061	12	0.054 (1.37)	0.64 (16.3)	2.55 (64.8)	1.15 (29.2)	8.10-8.70 36.0-38.7)
			23012950	12	0.054 (1.37)	0.64 (16.3)	2.90 (73.7)	1.15 (29.2)	10.15-10.85 (45.1-48.3)
			23012951	12	0.054 (1.37)	0.64 (16.3)	2.98 (75.7)	1.15 (29.2)	10.60-11.40 (47.1-50.7)
			23012952	9	0.054 (1.37)	0.64 (16.3)	2.17 (55.1)	1.15 (29.2)	8.6-9.1 (38-41)
			23012954	13	0.059 (1.50)	0.64 (16.3)	2.51 (63.8)	1.15 (29.2)	10.75-11.25 (47.8-50.0)
			23012955	13.5	0.062 (1.57)	0.64 (16.3)	2.15 (54.6)	1.15 (29.2)	9.35-9.85 (41.6-43.8)
			23012956	12	0.054 (1.37)	0.64 (16.3)	2.39 (60.7)	1.15 (29.2)	7.18-7.68 (31.9-34.1)
			23013274	12	0.054 (1.37)	0.64 (16.3)	2.53 (64.3)	1.15 (29.2)	7.95-8.55 (35.4-38.0)
9, A	64	3-4 shift valve	6833935	8	0.054 (1.37)	0.64 (16.3)	2.17 (55.1)	1.15 (29.2)	8.6-9.1 (38.3-40.5)
			6833941	13.5	0.062 (1.57)	0.64 (16.3)	2.15 (54.6)	1.15 (29.2)	9.35-9.85 (41.6-43.8)

TABLE 8-2. SPRING DATA (cont)

Fold-out	Ref	Spring	Part no.	No. coils	Wire dia in. (mm)	Spring OD in. (mm)	Approx. Free Length in. (mm)	Length under load in. (mm)	Length under load lb (N)
9, A	64	3-4 shift valve (cont)	6833942	12	0.054 (1.37)	0.64 (16.3)	2.50 (63.5)	1.15 (29.2)	7.85-8.35 (34.9-37.1)
			6834576	12	0.054 (1.37)	0.64 (16.3)	2.39 (60.7)	1.15 (29.2)	7.18-7.68 (31.9-34.1)
			6834902	13	0.059 (1.50)	0.64 (16.3)	2.41 (61.2)	1.15 (29.2)	9.95-10.45 (44.3-46.5)
			6837454	10.8	0.062 (1.57)	0.64 (16.3)	1.98 (50.3)	1.15 (29.2)	8.22-8.72 (36.6-38.8)
			6880991	12	0.054 (1.37)	0.64 (16.3)	2.75 (69.9)	1.15 (29.2)	9.25-9.95 (41.1-44.3)
			6880992	13	0.054 (1.37)	0.64 (16.3)	2.41 (61.2)	1.15 (29.2)	9.85-10.55 (43.8-46.9)
			6881061	12	0.054 (1.37)	0.64 (16.3)	2.55 (64.8)	1.15 (29.2)	8.10-8.70 (36.0-38.7)
			23012946	12	0.054 (1.37)	0.64 (16.3)	2.39 (60.7)	1.15 (29.2)	7.18-7.68 (31.9-34.1)
			23012952	9	0.054 (1.37)	0.64 (16.3)	2.17 (55.1)	1.15 (29.2)	8.6-9.1 (38-41)
			23012955	13.5	0.062 (1.57)	0.64 (16.3)	2.15 (54.6)	1.15 (29.2)	9.35-9.85 (41.6-43.8)
			23012956	12	0.054 (1.37)	0.64 (16.3)	2.39 (60.7)	1.15 (29.2)	7.18-7.68 (31.9-34.1)
			23013269	12	0.054 (1.37)	0.64 (16.3)	2.69 (68.3)	1.15 (29.2)	8.90-9.60 (39.6-42.7)
9, A	69	3-4 relay valve	6832462	11	0.072 (1.83)	0.69 (17.5)	2.18 (55.4)	1.20 (30.5)	16.2-19.8 (72-88)
9, A	73	Trimmer regulator valve	6834527	14	0.047 (1.19)	0.50 (12.7)	1.87 (47.5)	1.14 (29.0)	4.25-4.75 (18.9-21.1)

FOLDOUT 4

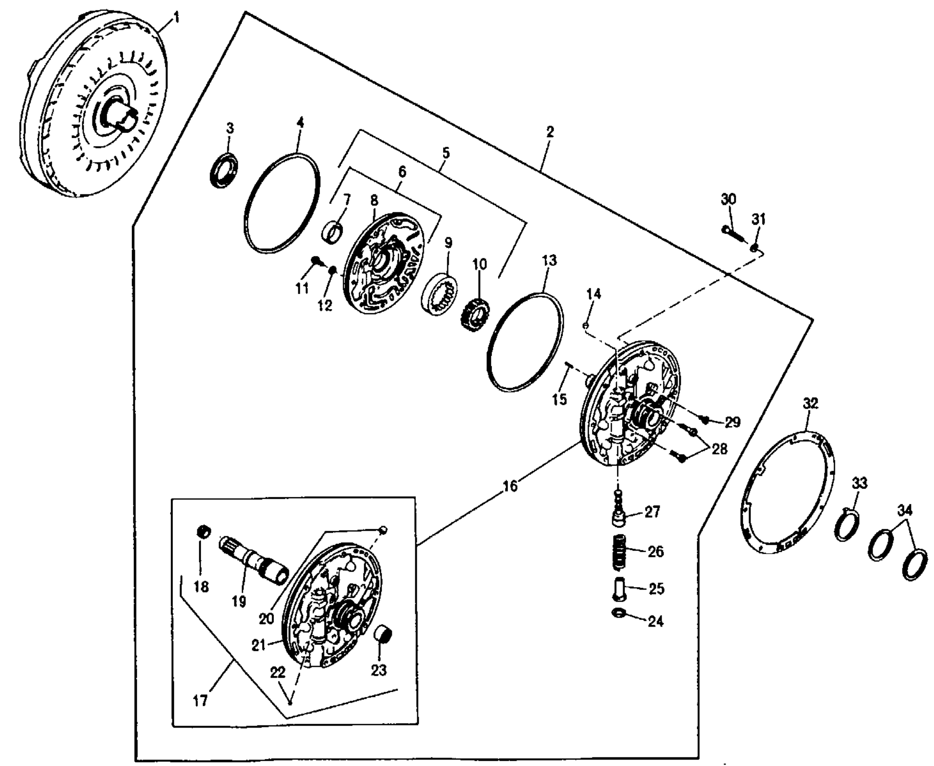
AT 545 AUTOMATIC TRANSMISSIONS



Foldout 4. Model AT 545 transmission hydraulic system - schematic view

AT 545 AUTOMATIC TRANSMISSIONS

B



B

1 - Torque converter assembly - AT 545
2 - Oil pump and front support assembly
3 - Oil seal
4 - Sealring
5 - Pump body and gear assembly
6 - Pump body assembly
7 - Bushing, (prebored)
8 - Pump body
9 - Pump driven gear
10 - Pump drive gear
11 - Bolt, 5/16-18 x 1 (6) A
12 - Rubber coated washer (6)
13 - Sealring
14 - Valve plug
15 - Pin
16 - Front support and bearing assembly
17 - Front support assembly
18 - Stator shaft bushing
19 - Stator shaft
20 - Lubrication plug
21 - Front support
22 - Plug
23 - Roller bearing
24 - Retainer ring
25 - Spring stop
26 - Valve spring
27 - Main pressure regulator valve
28 - Self-locking bolt, 5/16-18 x 1 3/4 (3) A
29 - Self-locking bolt, 5/16-18 x 1 (2) A
30 - Self-locking bolt, 5/16-18 x 1 3/4 (9) B
31 - Rubber coated washer, 5/16 (9)
32 - Gasket
33 - Thrust washer (selective)
34 - Hook-type sealring (2)

Torque	lb ft	N·m
A	15-20	20-27
B	13-16	18-22

B, foldout 5. Torque converter and oil pump assemblies - exploded view

AT 545 AUTOMATIC TRANSMISSIONS

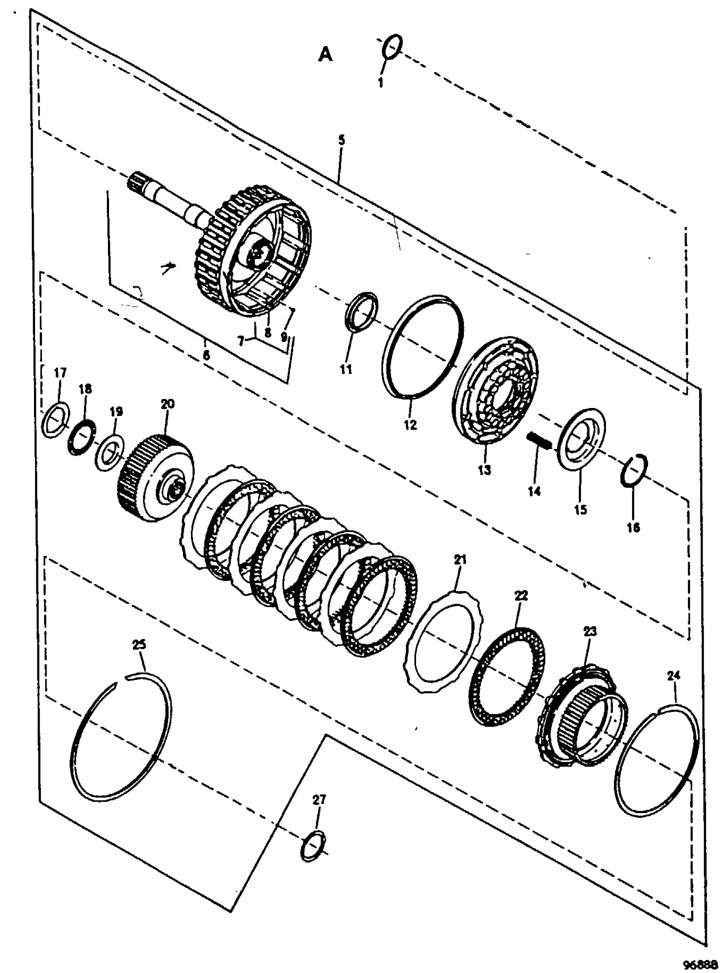
A

1 - Hook-type sealring
5 - Forward clutch and turbine shaft assembly
6 - Housing and shaft assembly
7 - Forward clutch housing assembly
8 - Forward clutch housing
9 - Ball
11 - Piston inner sealring
12 - Piston outer sealring
13 - Forward clutch piston (selective)
14 - Clutch release spring (16)
15 - Spring retainer
16 - Snapring
17 - Thrust bearing race
18 - Thrust needle bearing
19 - Thrust bearing race
20 - Forward clutch hub
21 - External-tanged clutch plate (5)
22 - Internal-splined clutch plate (5)
23 - Fourth clutch driving hub
24 - Snapring
25 - Snapring (later models)
27 - Thrust washer

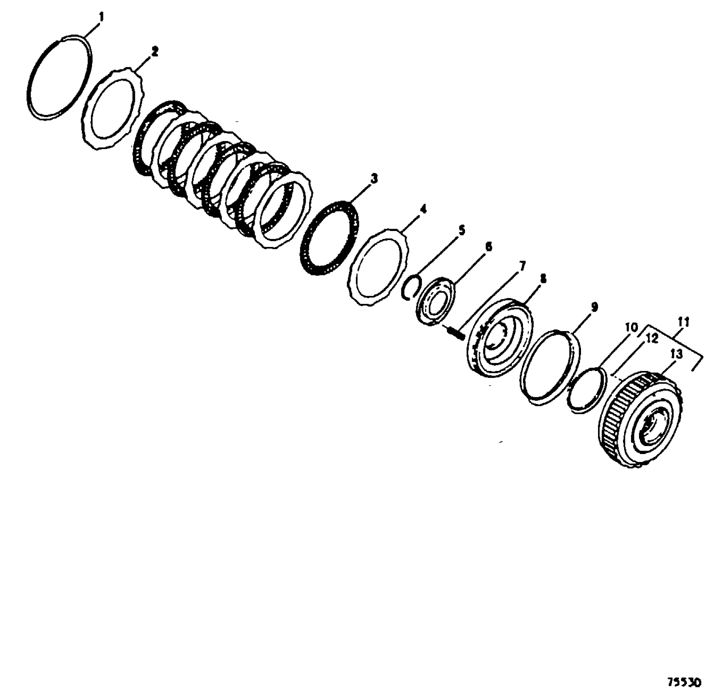
B

1 - Snapring
2 - Clutch backplate
3 - Internal-splined clutch plate (5)
4 - External-tanged clutch plate (5)
5 - Snapring
6 - Spring retainer
7 - Clutch return spring (16)
8 - Fourth clutch piston (selective)
9 - Piston outer sealring
10 - Clutch housing sealring
11 - Fourth clutch housing assembly
12 - Ball
13 - Fourth clutch housing

A



B



B, foldout 6, Fourth clutch - exploded view

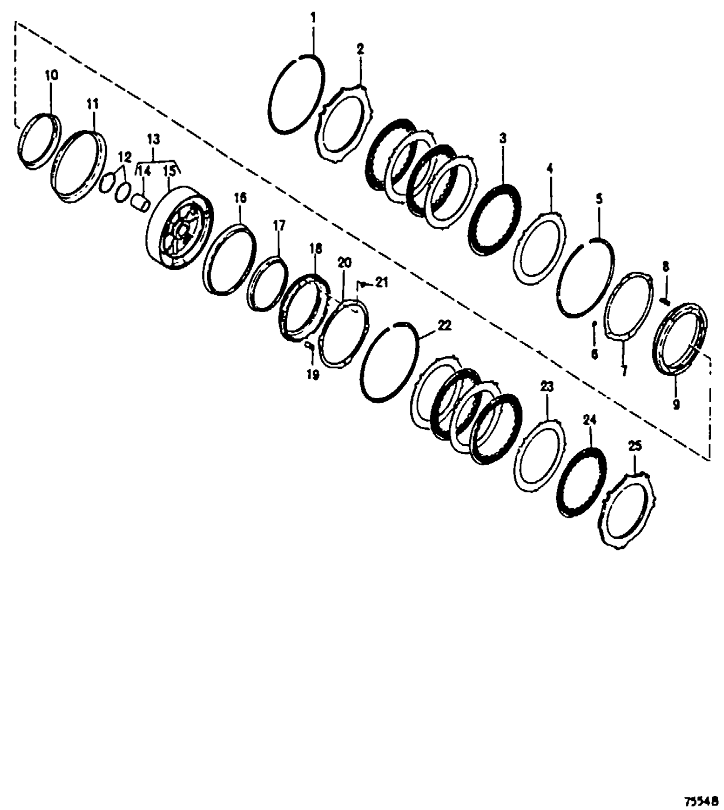
A

1 - Snapring
2 - Third clutch backplate (ident. 2)
3 - Internal-splined clutch plate (3)
4 - External-tanged clutch plate (3)
5 - Snapring (selective)
6 - Self-locking retainer washer (4)
7 - Spring retainer
8 - Piston return spring (12)
9 - Third clutch piston
10 - Piston inner sealring
11 - Piston outer sealring
12 - Hook-type sealring (2)
13 - Center support and bushing assembly
14 - Bushing
15 - Center support
16 - Piston outer sealring
17 - Piston inner sealring
18 - Second clutch piston
19 - Piston return spring (12)
20 - Spring retainer
21 - Self-locking retainer washer (4)
22 - Snapring
23 - External-tanged clutch plate (3)
24 - Internal-splined clutch plate (3)
25 - Second clutch backplate (selective)

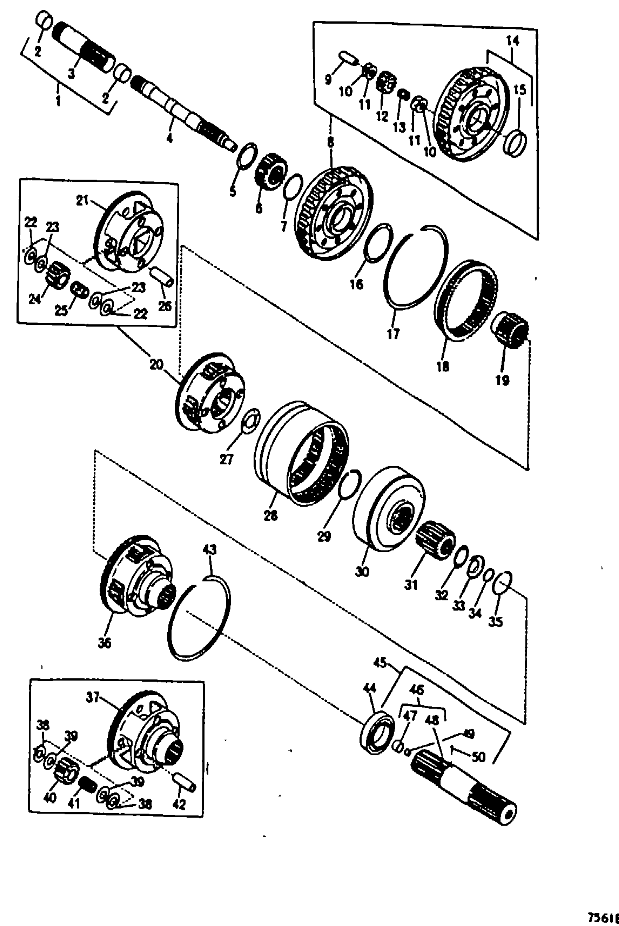
B

1 - Sun gear shaft assembly
2 - Bushing (2)
3 - Sun gear shaft
4 - Transmission main shaft
5 - Thrust washer
6 - Front planetary sun gear
7 - Thrust washer (selective)
8 - Front planetary carrier assembly
9 - Pinion pin (4)
10 - Bronze thrust washer (8)
11 - Steel thrust washer (8)
12 - Pinion (4)
13 - Needle roller bearing (80)
14 - Carrier and bushing assembly
15 - Bushing
16 - Thrust washer
17 - Snapring
18 - Front planetary ring gear
19 - Center sun gear
20 - Center planetary carrier assembly
21 - Center planetary carrier
22 - Bronze thrust washer (8)
23 - Steel thrust washer (8)
24 - Pinion (4)
25 - Needle roller bearing (76)
26 - Pinion pin (4)
27 - Thrust washer
28 - Planetary connecting drum
29 - Snapring
30 - Center planetary ring gear
31 - Rear planetary sun gear
32 - Needle thrust bearing
33 - Thrust bearing race
34 - Spiral retainer ring
35 - Snapring
36 - Rear planetary carrier assembly
37 - Rear planetary carrier
38 - Bronze thrust washer (8)
39 - Steel thrust washer (8)
40 - Pinion (4)
41 - Needle roller bearing (76)
42 - Pinion pin (4)
43 - Snapring
44 - Ball bearing
45 - Output shaft assembly
46 - Shaft and bushing assembly
47 - Bushing
48 - Output shaft
49 - Plug
50 - Governor drive spring pin

A



B



B, foldout 7. Planetary gear unit-exploded view

A

1 - Snapring
2 - Backplate (selective)
3 - Internal-splines clutch plate (7)
4 - External-tanged clutch plate (7)
5 - Rear planetary ring gear
6 - Snapring
7 - Spring retainer
8 - Piston return spring (22)
9 - First clutch piston
10 - Piston outer sealring
11 - Piston inner sealring

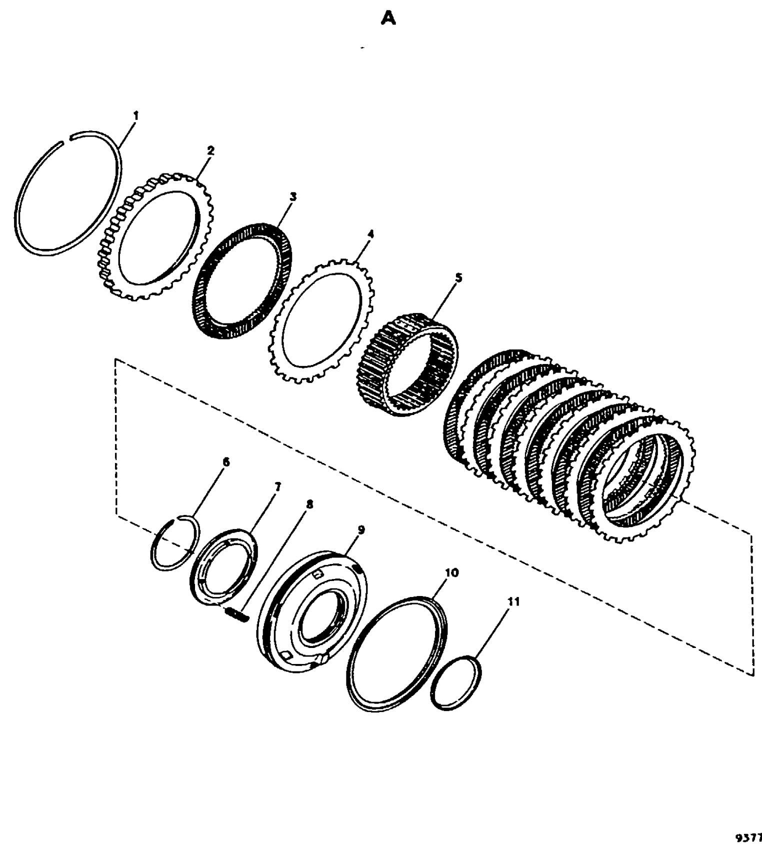
B

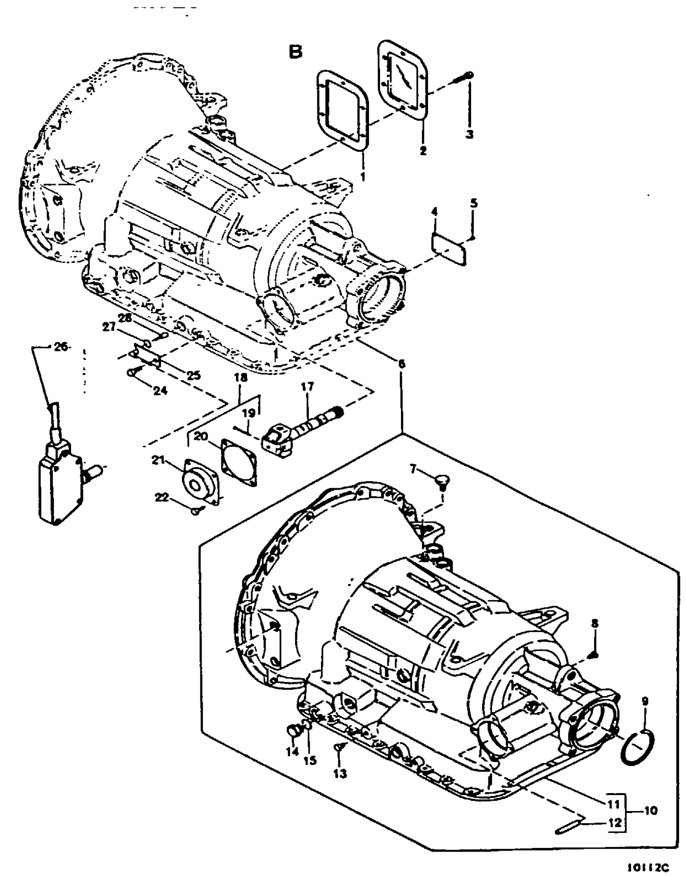
1 - Gasket
2 - Power takeoff cover
3 - Bolt, 3/8-16 x 1 (6) A
4 - Drive screw
5 - Name plate
6 - Transmission housing assembly
7 - Breather
8 - Pipe plug, 1/8 B
9 - Internal snapring
10 - Transmission housing and pin assembly
11 - Transmission housing
12 - Governor support pin
13 - Pipe plug, 1/8 B
14 - Neutral start switch plug, 3/4 C
15 - Gasket

17 - Governor assembly
18 - Governor service kit
19 - Governor weight pin (2)
20 - Cover gasket
21 - Governor cover
22 - Bolt, 5/16-18 x 9/16 (4) A

24 - Bolt, 5/16-18 x 9/16 A
25 - retainer
26 - mechanical actuator
27 - sealring
28 - valve actuating rod

Torque	lb ft	N·m
A	4-5	5-7
B	10-15	14-20
C	25-30	34-41





B, foldout 8. Transmission housing, governor, and vacuum modulator - exploded view

A

1 - Control valve body assembly
2 - Separator plate
3 - Bolt, 1/4-20 x 1-3/4 (3) A
4 - Retainer pin
5 - Adjusting ring
6 - Valve stop
7 - Washer
8 - Valve spring
9 - Modulator valve
10 - Modulator valve body
11 - Control valve body
12 - Third clutch trimmer valve
13 - Trimmer plug
14 - Trimmer spring
15 - Valve stop
16 - First clutch trimmer valve
17 - Trimmer plug
18 - Trimmer outer spring
19 - Trimmer inner spring

20 - Valve stop
21 - Second clutch trimmer valve
22 - Trimmer plug
23 - Trimmer spring
24 - Valve stop
25 - Fourth clutch trimmer valve
26 - Trimmer plug
27 - Trimmer outer spring
28 - Trimmer inner spring

29 - Valve stop
30 - Trimmer cover
31 - Bolt, 1/4-20 x 3/4 (8) A
32 - Retainer pin
33 - Retainer pin
34 - 2-3 relay valve
35 - Relay valve spring
36 - Valve stop
37 - 1-2 relay valve
38 - Relay valve spring
39 - Spring spacer
40 - Valve stop
41 - Priority valve spring
42 - Priority valve
43 - Hold regulator valve
44 - Valve spring
45 - Valve stoo
46 - Washer
47 - Adjusting ring

48 - Retainer pin
49 - Manual selector valve
50 - 1-2 shift signal valve
51 - Shift modulator valve
52 - Valve spring
53 - Valve stop
54 - Adjusting ring
55 - Retainer pin
56 - 2-3 shift signal valve
57 - Shift modulator valve
58 - Valve spring
59 - Valve stop
60 - Adjusting ring
61 - Retainer pin
62 - 3-4 shift signal valve
63 - Shift modulator valve
64 - Valve spring
65 - Valve stop
66 - Adjusting ring
67 - Retainer pin
68 - 3-4 relay valve
69 - Relay valve spring
70 - Valve stop
71 - Retainer pin
72 - Trimmer regulator valve
73 - Valve spring
74 - Valve stop
75 - Retainer pin

Torque	lb ft	N·m
A	9-11	12-15

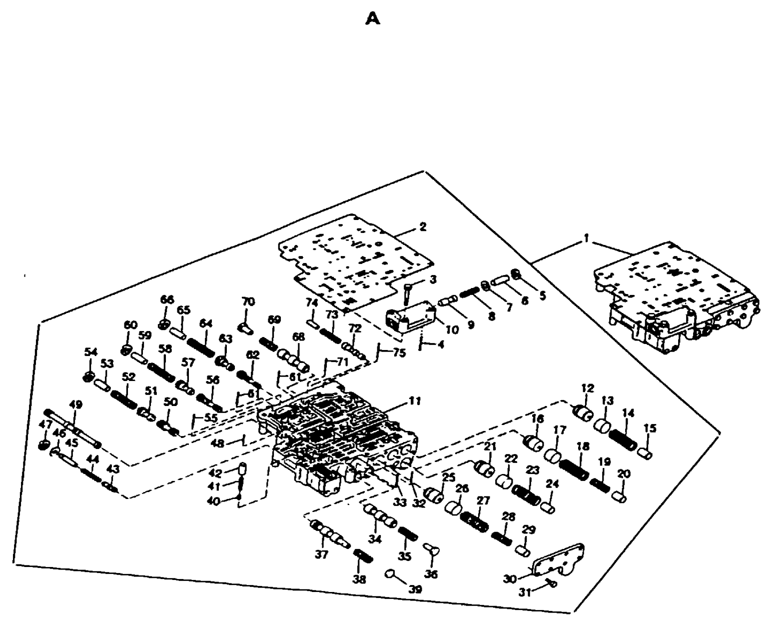
B

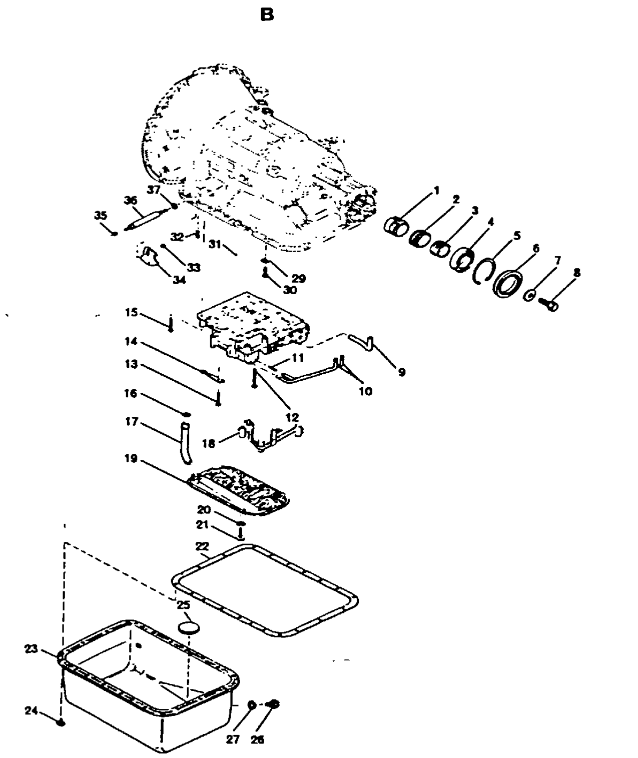
1 - Governor drive gear
2 - Speedometer drive gear
3 - Spacer (selective)
4 - Ball bearing
5 - Snapring
6 - Oil seal
7 - Output flange washer
8 - Bolt, 1/2-20 x 1-1/2 A
9 - First clutch tube
10 - Governor tube (2)
11 - Governor oil screen
12 - Bolt, 1/4-20 x 2-1/4 length) B
13 - Bolt, 1/4-20 x 1-3/4 B
14 - Detent roller and spring assembly
15 - Bolt, 1/4-20 x 2-1/4 (18)
16 - Sealring
17 - Intake pipe
18 - Spacer
19 - Oil filter assembly
20 - Washer
21 - Bolt, 5/16-18 x 2-1/4 C
- Washer-head screw, 5/16-18 x 5/8 C
22 - Oil pan gasket
23 - oil pan
24 - Washer-head screw, 5/16-18 x 5/8 (21) D
25 - Magnet
26 - Drain plug E
27 - Drain plug gasket

29 - Plain washer, 13/32
30 - Bolt, 3/8-16 x 1 F
31 - Steel ball, 1/4
32 - Selector shaft retainer pin
33 - Locknut, 3/8-24 E
34 - Selector lever
35 - Locknut, M 10 x 1.5-6G E
36 - Selector shaft
37 - Oil seal

Torque	lb ft	N·m
A	102-121	138-164
B	9 - 11	12 - 15
C	10 - 15	14 - 20
D	* 10 - 13	14 - 18
E	15 - 20	20 - 27
F	39 - 46	53 - 62

*5 lb ft (7 N·m) minimum after gasket sets.





A, Foldout 9. Control valve body assembly-exploded view

B, foldout 9. Oil pan oil filter, and governor and speedometer drives-exploded view

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AXLE-REAR

IH MODEL IH CODE
RA-39 14039

CONTENTS

LOCKING DIFFERENTIAL

Subject **Page**

DESCRIPTION

The axles contained In this section are full floating, single reduction units. Fig. 1 illustrates the single reduction differential assembly.

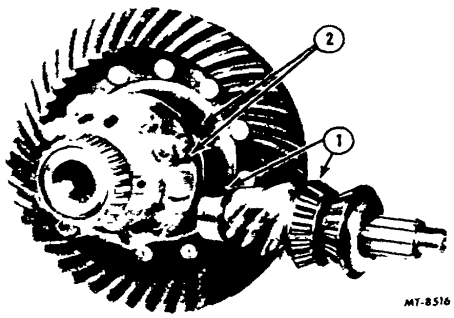

Fig. 1 Differential Assembly

1. Straddle Mounting For Pinion
2. Differential Case Halves

The construction of rear axles may vary as to design, but the fundamental components of the axles perform similarly regardless of the type. The basic parts of the axle with which the serviceman will be concerned are the drive gears, the differential assembly, the axle shafts, and the housing.

MAINTENANCE LUBRICATION

The most important item of axle maintenance about which the truck operator must be concerned is lubrication. For this reason factory recommendations on lubrication intervals, methods of filling, lubricant levels, draining and type of lubricant must be followed to assure long life and satisfactory performance. Inspect the axle frequently for lubricant leakage, especially around housing covers, pinion oil seal retainer and axle shaft flanges. When necessary, change gaskets or seals and keep nuts or bolts tight. See "Lubrication" section in the Operator's Manual provided with each truck.

AXLE HOUSING BREATHER VALVE

To prevent a pressure build-up in the axle housing when the axle becomes warm after a short period of operation, a breather valve, Fig. 2, is provided in rear axles. Without this valve the resulting pressure could force the axle lubricant past the rear wheel oil seals and damage the brake linings. The valve is so constructed that warm air may pass out of the axle to relieve built-up pressure, yet dirt and moisture are prevented from entering.

The breather valve should be kept open and clean. When the truck is operated off highway on unimproved roads or in ice and snow, dirt may sometimes be forced under the valve cap and cause the valve to become ineffective. Remove valve occasionally and clean thoroughly in a cleaning solution.

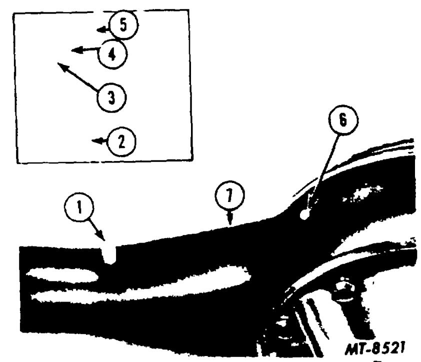

Fig. 2 Location of rather Valve in Axle Housing

1. Rear Axle Breather Valve
2. Valve Body
3. Sealing Washer
4. Spring
5. Cap
6. Location of Breather Valve on Heavy Duty Axles
7. Rear Axle Housing

ALIGNMENT

The rear axle should also be checked at regular intervals to determine if there is any misalignment of the axle with frame or drive line. Evidence of misalignment may some- times be noted at the U-bolts. To check for axle misalignment, lay a straightedge across and at right angles to the truck frame. The straightedge should be longer than the axle tread and clamped to the frame a short distance ahead of the rear axle. Measure the distance between the straightedge and identical points at each end of the axle assembly. When distances are not equal, misalignment is indicated, and rear springs and U-bolts must be checked for correct assembly.

DRIVE GEARS

These IH rear axles have the hypoid type of drive as illustrated In Fig. 3.

Because of the offset type of construction, hypoid rear axles actually have a greater torque capacity than do the spiral bevel type. This is possible because the hypoid pinion Is larger In diameter and has gear teeth that are larger than those of the spiral bevel pinion having the same number of teeth and same diameter ring gear. Hypoid pinions also have larger tooth areas and more teeth in longer contact with the ring gear. These design characteristics con- tribute to greater strength and quieter final drive operation. However, because of this greater tooth contact, more attention is required when securing a correct pinion setting at time of overhaul or when replacing differential bearings. Therefore, every effort must be made to be sure the final setting results In the best possible tooth contact.

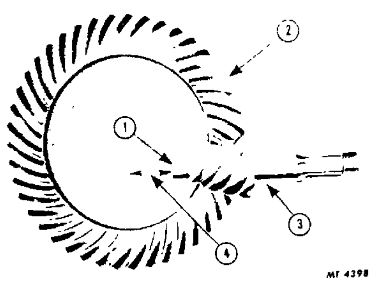

Fig. 3 Hypoid Type Drive

1. Ground Face of Pinion
2. Hypoid Ring Gear
3. Hypoid Pinion
4. Nominal Dimension

AXLE SHAM

Many axle failures can be attributed to the axle shafts; therefore, It is most important that shafts be installed correctly, be of correct size and length for splines to engage fully, have wheel bearings adjusted properly, and be kept free from runout or bends.

Fig. 4 illustrates the axle shaft and bearing arrangement on a full-floating rear axle.

AXLE HOUSING

In most cases the axle housing used for IH trucks is of one-piece construction with opening in center for mounting the differential and carrier. The outer ends of the axle housing are welded in place to provide mounting for the brake backing plates. A bent axle housing can be the cause of early axle failure, and whenever an axle is rebuilt, this condition should always be checked before going ahead with the assembly. Fig. 5 gives a quick way of checking for a bent housing.

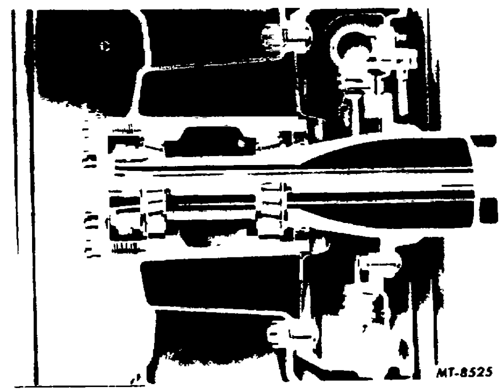

Fig. 4. Cross Section of Full-Floating Rear Axle

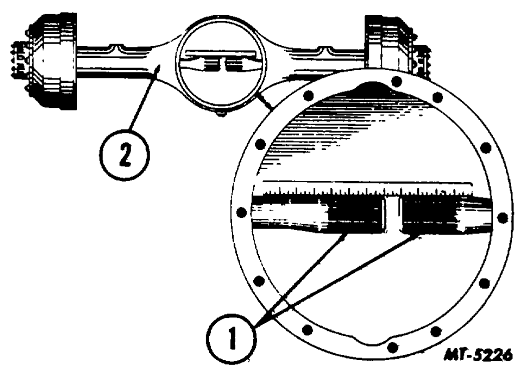

Fig. 5 Method of Checking For Bent Axle Housing

1. Check Alignment of Axle Shafts with a Straightedge
2. Rear Axle Housing with Axle Shafts and Wheels Hubs Installed

REMOVAL PROCEDURES

AXLE ASSEMBLY

Whether the complete axle assembly will have to be removed from the truck for over- haul is determined by the extent of the repairs required. For most axle repairs complete removal of the axle will not be necessary; but In the event that it is, removal procedure will be similar to the following:

1. Jack up truck until load is removed from springs and place blocks under frame to safety secure truck weight off of rear wheels.
2. Drain differential housing.
3. Disconnect brake lines.
4. Disconnect propeller shaft at rear axle companion flange.
5. Support differential on portable floor jack and take off U-bolts.
6. Roll out axle from under truck.

AXLE SHAFT

The axle shafts can be removed without taking off the wheels. To remove the shafts, first remove the axle shaft nuts from the studs in the wheel hub. Next install puller screws in the two tapped holes provided in the axle shaft flange. As puller screws are turned in, flange of shaft will be forced away from wheel hub and out from axle housing.

Another type of axle shaft removal procedure is required on full-floating axles where the tapered dowel is used in addition to the studs and nuts for securing axle shaft flange to wheel hub. This procedure will be similar to the following:

1. Remove flange nuts from studs of wheel hub.
2. Using a heavy hammer, strike sharply on the center of the flange of the axle shaft, Fig. 6. This will unseat and loosen the tapered dowels in each stud hole.
3. Remove the tapered dowels, Fig. 7. When dowels are installed, there must be a slight clearance between the lockwasher and axle shaft driving flange. See inset, Fig. 7. Lack of clearance at this point will cause excessive wear on studs, dowels or holes.

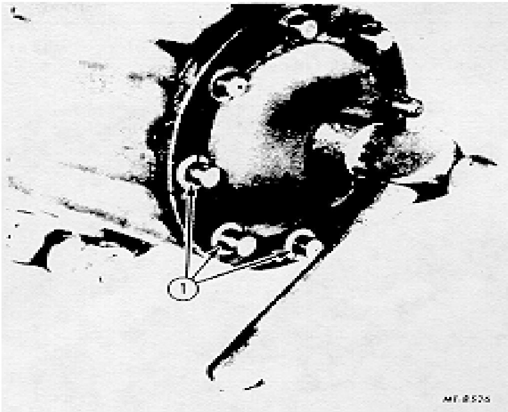

Fig. 6. Loosening Dowels in Axle Shaft

1. Tapered Dowels

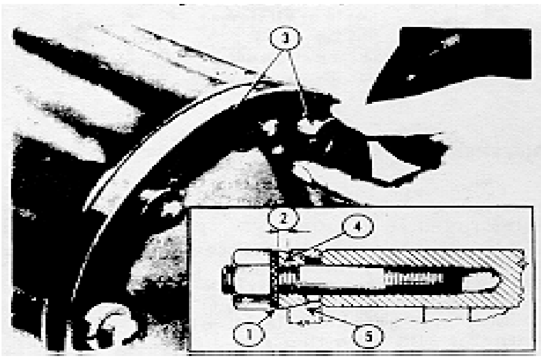

Fig. 7. Details of Taper Dowels

1 Lock Washer
2. Clearance
3. Tapered Dowels
4. Tapered Dowels
5. Axle Flange

4. After all dowels have been removed, push the axle shaft flange back into position against the wheel hub and again strike a sharp blow in the center of the flange as shown in Fig. 6. This will cause the axle shaft to spring away from the wheel hub and allow removal of the axle shaft without re- sorting to the use of a pry bar or screwdriver. Any prying between axle shaft flange and wheel hub may damage the seal

assembly or machined surfaces of the wheel hub or axle shaft flange.

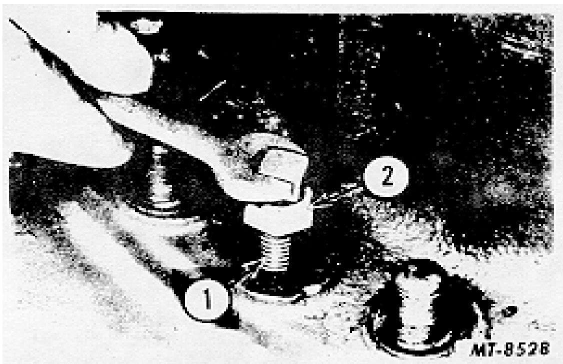

Fig. 8. Puller Screw Installation (Locknut is used if puller screw is to be kept with axle at all times.)

1. Puller Screw
2. Lock Nut

DIFFERENTIAL

To remove the differential it may be necessary to use the two extra tapped holes found in the differential housing. These are for Installing puller screws, Fig. 8. To force carrier from housing, in some Instances it may be necessary to break carrier loose from axle housing by striking the carrier with a heavy soft hammer (lead, plastic, rubber or leather). Be sure that the differential is securely supported on a portable floor lift before It is separated from the housing.

DISASSEMBLY

Mount differential assembly In a suitable holding fixture.

REMOVE DIFFERENTIAL AND DRIVE GEAR ASSEMLY

1. Remove cotter pins from bearing adjuster locks and remove locks from bearing caps, Fig. 9.

2. Match mark one differential bearing cap and leg of carrier with punch or chisel, Fig. 10, to identify each for correct reassembly.

3. Remove bearing cap stud nuts or cap screws and take off the bearing caps and adjusting nuts.

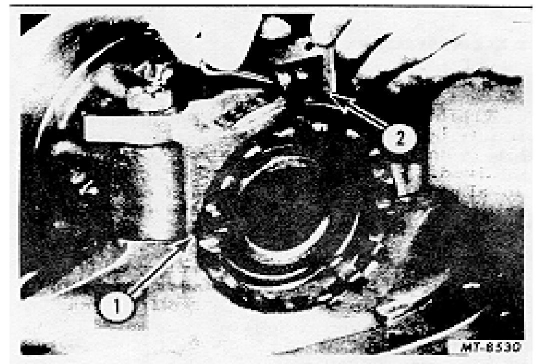

Fig. 9. Adjuster Lock Removal

1. Bearing Adjusting Nut
2. Adjusting Nut Lock

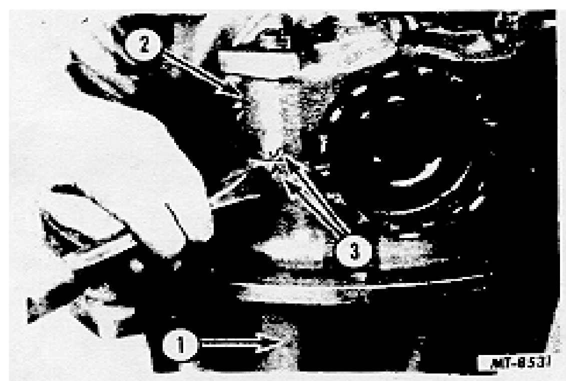

Fig. 10. Marking Bearing Cap for Identity

1. Differential Carrier
2. Bearing Cap
3. Match Marks

4. Tip differential away from pinion and lift assembly out of the differential housing, Fig. 11.

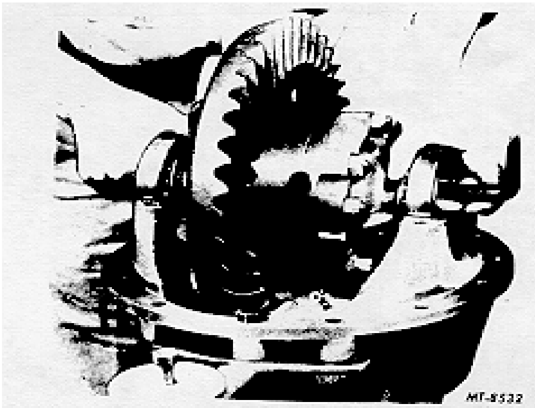

Fig. 11. Lifting out Differential and Gear Assembly

DISASSEMBLE DIFFERENTIAL CASE AND GEAR ASSEMBLY

1. Match mark differential case halves, Fig. 12, with a punch for correct alignment on reassembling.

Fig. 12. Marking Differential Case Halves

1. Match Marks

2. Cut lock wire and remove capscrews or stud nuts to separate case halves, Fig. 13. Some differential assemblies use self-locking capscrews and nuts.

3. Remove spider, pinions, side gears and thrust washers, Fig. 14.

4. To remove drive gear rivets, carefully center punch each rivet head. Next use a drill .8 mm (1/32") smaller than body of the rivet and drill through rivet head, Fig. 15. Use a punch to press out remaining portion of the rivet Never use chisel to cut off rivet heads or damage to differential case might result.

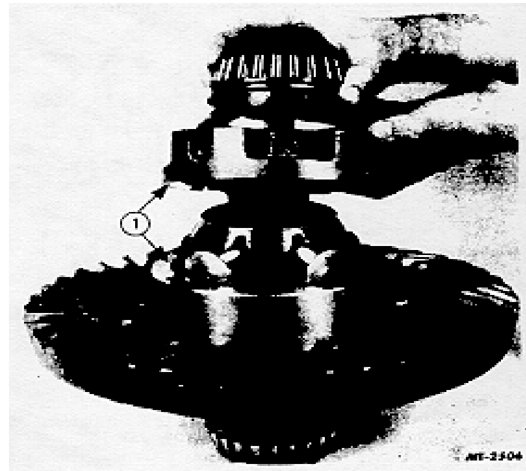

Fig. 13. Separating Differential Case Halves

1. Differential Case Halves

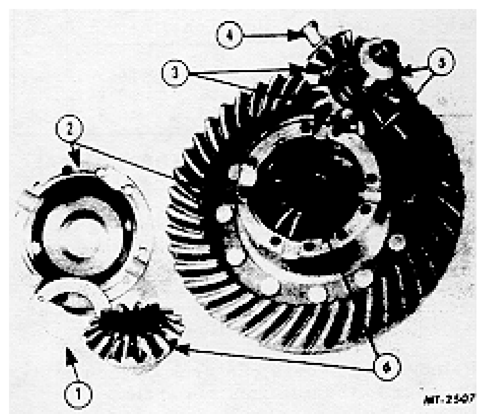

Fig. 14. Component Parts of Differential Case

1. Thrust Washer (2)
2. Differential Case Halves
3. Spider Gears (4)
4. Differential Spider
5. Thrust Washers (4)
6. Side Gears (21

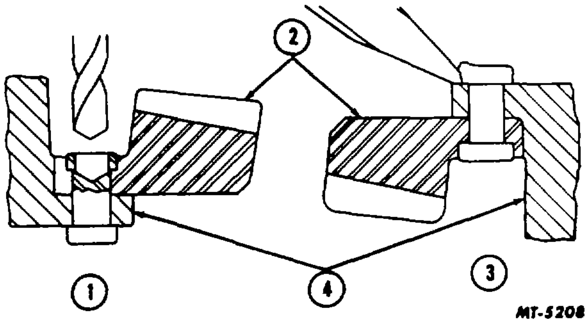

Fig. 15. Drive Gear Rivet Removal

1. Right
2. Drive Gear
3. Wrong
4. Differential Case

5. When reinstalling ring gear, it is suggested that Riveting Fixture SE-2222 be used. This special tool is designed for use with either hydraulic or mechanical press equipment. Rivet pressures for ring gear installation should be in accordance with those given in the following chart.

Rivet Size		Pressure Per Rivet	
Inch	mm	U.S. Tons	Metric Tons
7/16	11.1125	18-20	16.3-18.1
1/2	12.7	20-25	18.1-22.7
5/8	15.8750	45-50	40.8-45.3

REMOVE PINION AND CAGE FROM DIFFERENTIAL HOUSING

There are two methods for removing the pinion and cage assembly and the method to be used will depend on whether puller screw holes have been provided in the pinion cage flange or not. When no puller screw holes are provided, removal is as follows:

1. Remove pinion cage capscrews which hold the cage to the differential carrier.
2. Remove pinion and cage assembly from the differential carrier, Fig. 16.
3. Retain shim pack as an aid to adjustment on reassembly. Do not damage shims.
4. If difficulty is encountered in lifting the cage from the carrier, place a brass drift on the inner end of pinion and tap pinion and cage out of differential housing. Do not allow pinion and cage assembly to fall or damage may result.

When tapped holes for puller screws are provided, removal of the pinion and cage is as follows:

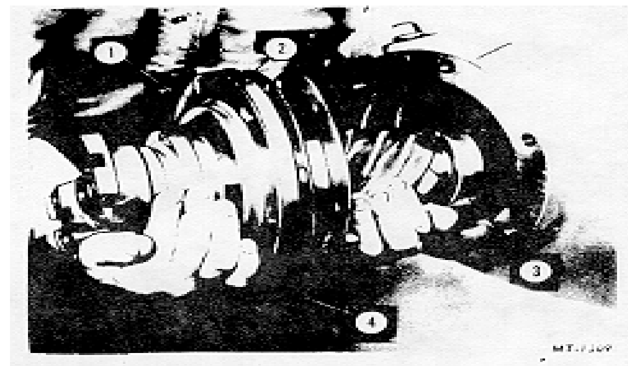

Fig. 16. Removing Pinion and Cage Assembly

1. Oil Seal Retainer
2. Pinion Cage
3. Radial Bearing
4. Shims

1. Hold the companion flange or yoke and remove pinion shaft nut and washer.
2. Remove flange with a suitable puller.
3. Remove pinion cage stud nuts or capscrews.
4. Remove bearing cover and oil seal assembly.
5. Insert puller screws In the cage flange and remove pinion and cage assembly. Using a drift to drive on inner end of pinion of this type axle will damage the bearing lock ring groove.
6. Retain shim pack as an aid to adjustment on reassembly.

DISASSEMBLE PINION AND CAGE ASSEMBLY

1. If the companion flange or yoke has not previously been removed from pinion, mount the pinion and cage assembly in a vise. Remove the cotter pin and take off pinion and nut as shown In Fig. 17.
2. Tap or drive the pinion assembly from flange and out of cage using a soft hammer.
3. Remove outer bearing from cage.
4. Remove spacer or spacer combination from pinion shaft, Fig. 18.

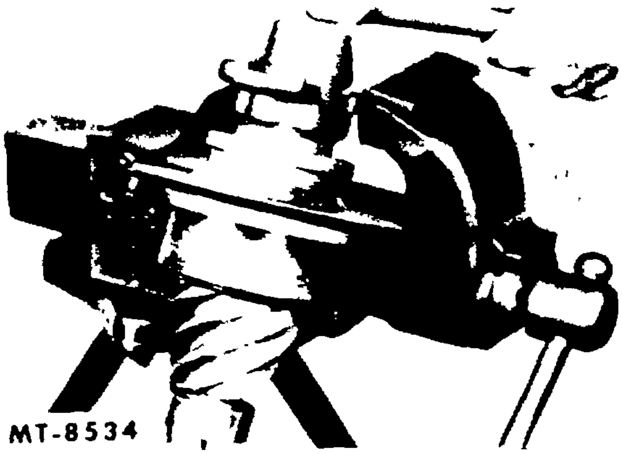

Fig. 17. Pinion and Cage Disassembly

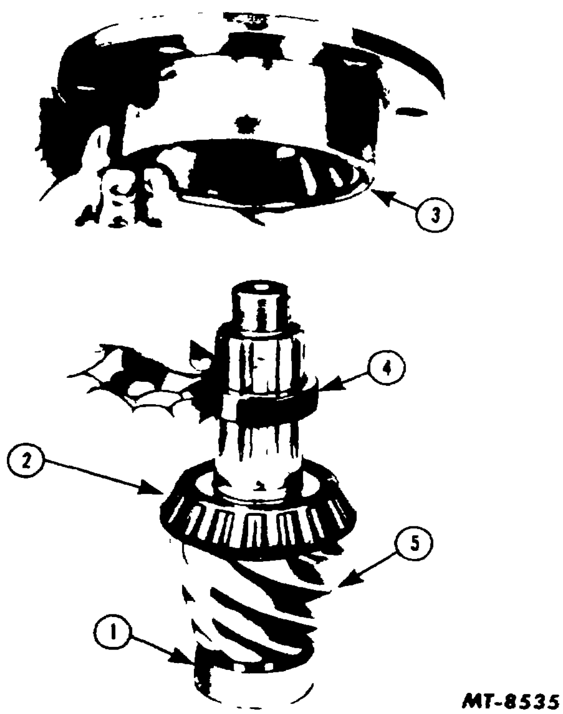

Fig. 18. Removing Pinion Bearing Spacer

1. Pinion Radial or Straddle Bearing
2. Pinion Thrust Bearings (2)
3. Pinion Cage
4. Pinion Spacer (Thickness Determines Preload on Pinion Thrust Bearings)
5. Pinion

5. If It is necessary to remove the rear thrust bearing on the radial bearing, Fig. 18, remove these bearings with a suitable puller.

6. Remove cork seal from pinion cage, Fig. 19. (This seal should be replaced at every disassembly.) If the pinion cage assembly is the type which is removed from the carrier by means of puller screws, remove the oil seal from bearing cover.

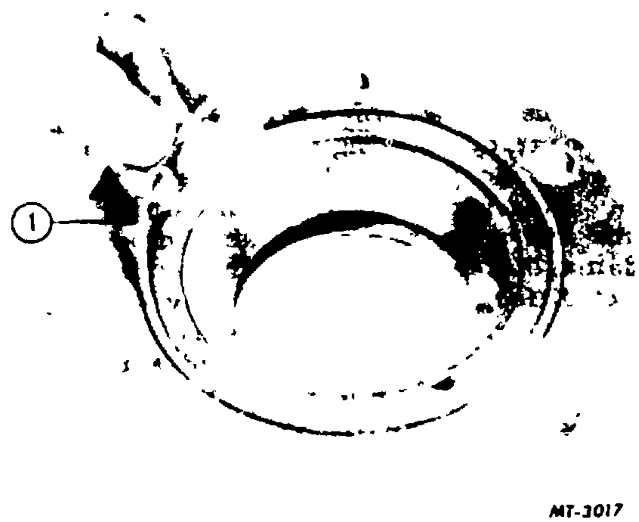

Fig. 19. Removing Pinion Cage Seal

1. Cork Seal

CLEANING

Remove all dirt, old lubricant, and gasket material from components of the rear axle. Immerse in cleaning solvent and use a stiff brush if necessary. Bearings should be cleaned separately in clean solvent and special efforts taken to protect their finely machined surfaces. If compressed air is used for drying, do not spin bearings while drying.

INSPECTION

Examine all bearings for roughness, damage or wear by rotating each bearing slowly in hand. If in doubt as to bearing condition, replace. Ring gear, drive pinion, differential pinions and any other gears should be checked for damaged teeth, worn spots, or distortion. Inspect differential case assembly for cracks, damage or distortion. Make sure splined ends of axle shafts are neither twisted nor cracked. Shim packs should be of uniform thickness. Discard thrust washers and obtain new, even when only slight wear is indicated. Always use new gaskets.

The assembly of the differential carrier is accomplished in the reverse order of the disassembly. There are, however, various adjustments which must be secured as the assembly progresses. In addition to the adjustments there are also a few precautions to be observed. Among these are the following:

1. Prelubricate the pinion thrust bearings when reassembling the pinion cage.
2. If the ring gear was removed from the differential case half, be sure correct rivet pressures are used in reinstalling gear to case.
3. Prelubricate all parts of the differential assembly before bolting case halves together.
4. When installing differential bearing caps, make sure they are correctly aligned and that the bearing cups fit properly. If the bearing caps do not seat easily, the adjusting nuts may be cross threaded. Forcing caps into place will cause irreparable damage to the differential carrier or bearing caps.
5. Observe torque settings from specifications when tightening any parts.

When making axle repairs such as bearing or drive gear replacement, or when simply making an adjustment, it is most important that the ring gear and pinion be positioned correctly to obtain proper tooth contact. Once the adjustment is obtained, quiet and durable performance from the rear axle is assured.

Fundamentally, the correct tooth contact is obtained by moving the pinion toward or away from the ring gear as necessary, or by moving the ring gear toward or away from the pinion. The actual procedure has been reduced to five principal steps. Each step is vitally important to axle life and satisfactory performance, and for that reason, each step is covered more fully in succeeding paragraphs. The five steps and the order in which they should be performed are as follows:

1. **PRELOAD PINION BEARINGS** in pinion cage. This is determined by the thickness of spacer between the two pinion thrust bearings, Fig. 18.
2. **ESTABLISH PINION NOMINAL DIMENSION** Fig. 1. Use the SE1065 Pinion Setting Gauge and add or remove shims to obtain this dimension.
3. **SET GEAR LASH** between ring gear and pinion. Do this by moving the ring gear to or from the pinion by means of bearing adjusting nuts, Fig. 9.
4. **PRELOAD DIFFERENTIAL BEARINGS** This is accomplished by tightening bearing adjusting nuts, Fig. 9.
5. **CHECK GEAR TOOTH CONTACT** Use the paint impression method for this.

PRELOAD PINION BEARINGS

Before the pinion and drive gear can be adjusted for correct tooth contact, the pinion bearing preload must be set. Preloading the pinion bearings is accomplished by selecting the correct size spacer, Fig. 18, located between the two pinion thrust bearings, and tightening pinion end nut to the specified torque. Temporarily bolt up the pinion, cage and flange assembly, less oil seal and retainer, and clamp the assembly in a vise so as to hold the companion flange, Fig. 17. Pinion end nut should then be drawn tight to the torque shown in specifications. The applying of correct torque to the various pinion end nuts, etc. usually calls for torque limits beyond the capacity of the ordinary torque wrench. Where this is the case, the chart listed below may be used as a guide for obtaining the torque required. Fig. 20 illustrates the length of the wrench handle (A) and the effort that must be applied at (B) when tightening to secure the necessary torque.

The cage should be rotated while tightening the pinion end nut in order to seat and align the bearings. The rotation of the pinion bearings is important, otherwise, a false condition of bearing load could exist. The bearing rollers must be seated against the face of the bearing cone as shown in Fig. 21. After the pinion bearing load is established, good practice would be to check the ends of the bearing rollers to see whether they are in contact with the face of the bearing cone. Use a feeler gauge ribbon. There must be no clearance at the ends of the rollers.

Torque		Wrench A		Effort on Wrench (Approx.) B	
Ft. Lbs.	N-m				
200	270	1 foot	.30 m	200 lbs.	90 kg
		2 feet	.61 m	100 lbs.	45 kg
250	340	1-1/2 feet	.46 m	170 lbs.	77 kg
		2 feet	.61 m	125 lbs.	57 kg
300	410	1-1/2 feet	.46 m	200 lbs.	90 kg
		2 feet	.61 m	150 lbs.	68 kg
		3 feet	.92 m	100 lbs.	45 kg
350	475	2 feet	.61 m	175 lbs.	80 kg
		2-1/2 feet	.76 m	140 lbs.	64 kg
		3 feet	.92 m	118 lbs.	54 kg
		3-1/2 feet	1.07 m	100 lbs.	45 kg
450	605	2-1/2 feet	.76 m	180 lbs.	82 kg
		3 feet	.92 m	150 lbs.	68 kg
		3-1/2 feet	1.07 m	129 lbs.	58 kg
		4 feet	1.21 m	113 lbs.	51 kg
500	640	3 feet	.92 m	167 lbs.	76 kg
		3-1/2 feet	1.07 m	144 lbs.	65 kg
		4 feet	1.21 m	125 lbs.	57 kg
		4-1/2 feet	1.37 m	112 lbs.	50 kg
550	675	3-1/2 feet	1.07 m	158 lbs.	71 kg
		4 feet	1.21 m	137 lbs.	62 kg
		4-1/2 feet	1.37 m	123 lbs.	56 kg
		5 feet	1.53 m	110 lbs.	49 kg
600	820	4 feet	1.21 m	150 lbs.	68 kg
		4-1/2 feet	1.37 m	134 lbs.	61 kg
		5 feet	1.53 m	120 lbs.	55 kg
		5-1/2 feet	1.68 m	110 lbs.	49 kg

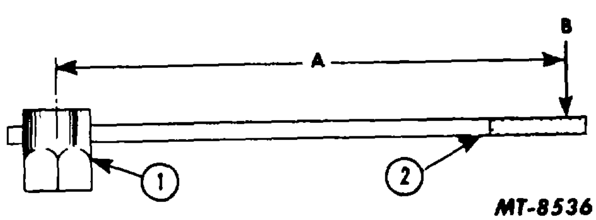

Fig. 20. Wrench Torque Chart and Diagram

1. Socket 2. Handle

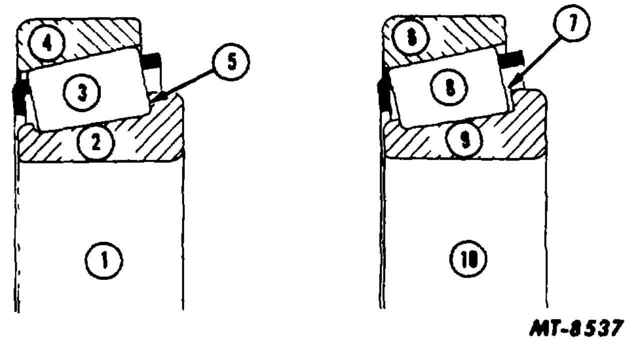

Fig. 21. Roller Bearing When Correct Adjustment is Obtained. (The rollers of the bearing must bear against the face of the cone as shown. Rotation of the bearing during adjustment is necessary to obtain this condition.)

1. Correct
2. Cone
3. Roller
4. Cup
5. Roller Against Face of Cone
6. Cup
7. Clearance
8. Roller
9. Cone
10. Incorrect

To measure the preload, wrap a strong cord or soft wire about the pinion cage and attach end to the spring scale as in Fig. 22. Read scale only while pinion cage is turning. Compare this scale reading or pinion bearing preload with the figure found in the rear axle specifications.

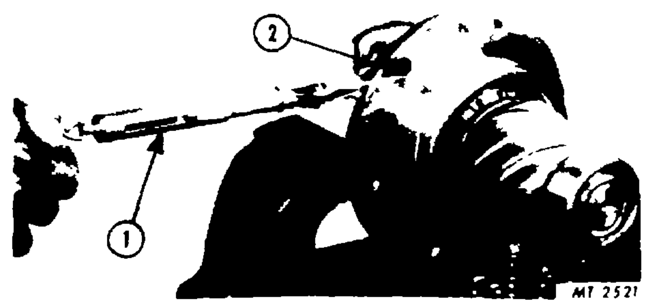

Fig. 22. Measuring Pinion Bearing Preload

1. Spring Scale
2. Cord or Soft Wire Wrapped Around Pinion Cage

When preload reading does not agree with the specifications, the bearing load may be increased by installing a thinner spacer or decreased by using a thicker spacer. Determine spacer thickness with a micrometer, Fig. 23, and make a new selection accordingly. Closer adjustment can be made by working spacer to the desired thickness using emery cloth on a flat surface. Wash spacer clean of emery cuttings before installing on pinion.

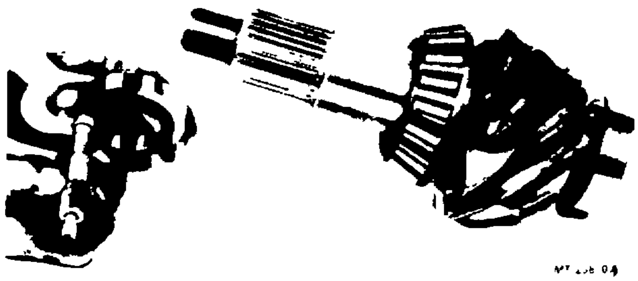

Fig. 23. Measuring Spacer Thickness

If the pinion radial or straddle bearing was removed from the end of the pinion during the disassembly, the bearing should be reinstalled at this time. Press the radial bearing onto the end of pinion and stake with a blunt point punch, as shown in Fig. 24, in six equidistant places.

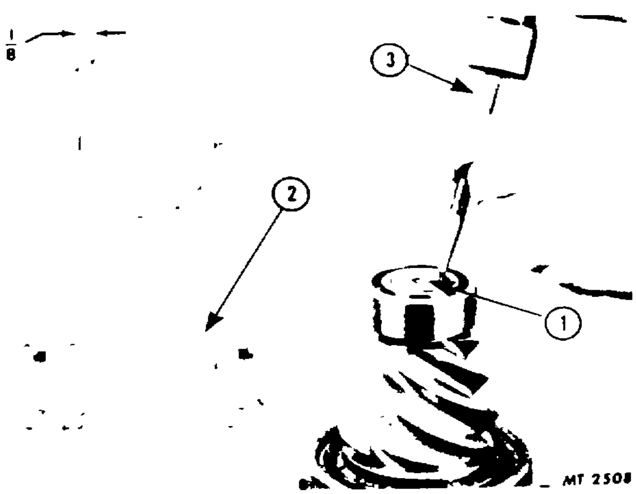

Fig. 24 Staking Pinion Straddle Bearing

1. Ground Face of Pinion
2. Metal Displaced to Secure Bearing
3. Blunt Point Punch

It is suggested that for locating punch positions for staking, the end of the pinion be painted with Prussian Blue and a circle be scribed on end of pinion about 3.175 mm (1/8") in from the pinion circumference. When staking the bearing, be careful to make the depth of the indentations or stake points uniform. Otherwise, the bearing might be damaged. Deep punch or stake marks are not necessary. Apply the staking operation at opposite sides of the pinion end until all stake points are obtained. Smaller pinions having the straddle bearings are staked in four places only. Where special staking tools are available, they can be used; otherwise, the use of a blunt or round-nose punch is satisfactory.

ESTABLISH NOMINAL DIMENSION

The pinion setting gauge (SE-1065) is a precision gauge designed for locating the pinion as it meshes with the ring gear to the correct nominal dimension in the shortest possible time. A step plate and bracket, which are a part of the set, are used whenever hypoid type gears are to be adjusted. Essentially the pinion setting gauge is a direct reading depth micrometer mounted in an arbor. The span of the micrometer is 50-75 mm (21" to 3"), but extensions are provided with the kit to increase the reach. Two sleeves which hold adapter discs slip over the ends of the arbor. Adapter discs are held on the sleeves by knurled nuts. When installed in the differential case, the pinion setting gauge enables the mechanic to measure the distance from the face or finished end of the installed pinion to the centerline of the ring gear or cross shaft. The measurement which the mechanic reads should agree with the nominal dimension, which can be found in the axle specifications, or which in some instances is stamped or etched on the pinion itself. Usually there is a plus or minus correction also stamped on the pinion, Fig. 25, and this also must be figured in with the nominal dimension.

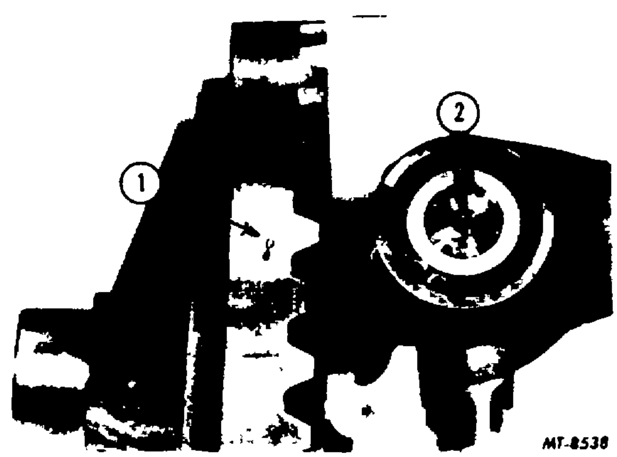

Fig. 25. Location of Pinion Setting Markings

1. Backlash Marking on Bevel Drive Gear (.008")
2. Plus or Minus Correction to Nominal Dimension of Pinion (.-008")

The procedure for establishing the correct nominal dimension by means of the pinion setting gauge is as follows:

1. Install pinion, cage and bearing assembly in the differential carrier.

2. Attach the step plate clamp assembly to the carrier flange and locate step plate clamp screw over the center of the pinion as shown in Fig. 26.

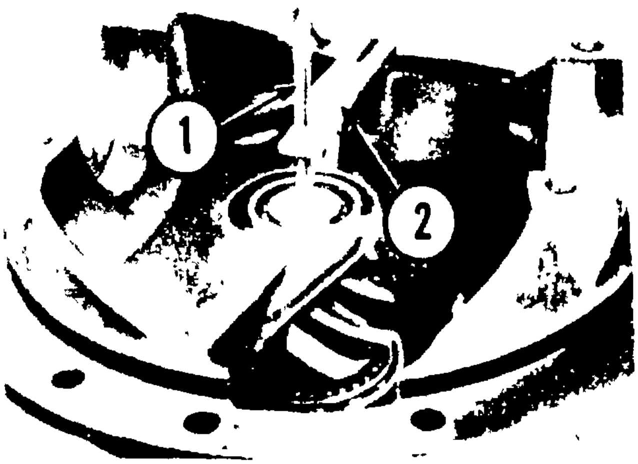

Fig. 26. Locating Step Plate Clamp

1. Step Plate Clamp Screw
2. Step Plate Clamp Asm.

3. Install step plate under clamp screw and tighten screw to hold the step plate securely in position as shown in Fig. 27. The step plate is necessary in order to project the face of the pinion to where it can be measured by the gauge which is on the centerline of the ring gear. <u>Be sure lugs on step plate straddle the bearing staking indentations on end of pinion</u>.

4. Mount assembled SE1065 gauge in bearing bores of carrier as shown in Fig. 28. Make certain that bearing bores are clean and free of nicks and burrs. Adjust micrometer so it is directly over end at a 90 degree angle to the step plate. Take micrometer reading. Run the micrometer thimble down to measure the distance between the center of the ring gear and the step plate, or in the event of a spiral bevel type drive, measure the distance to the face of the pinion itself. Make a note of this measurement.

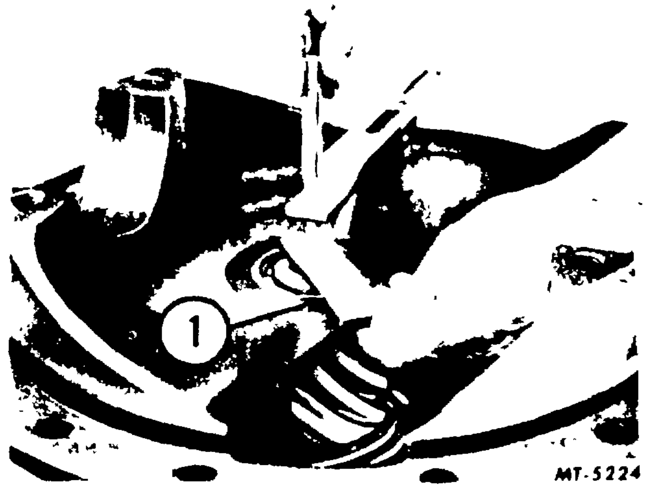

Fig. 27. Installing Step Plate

1. Step Plate

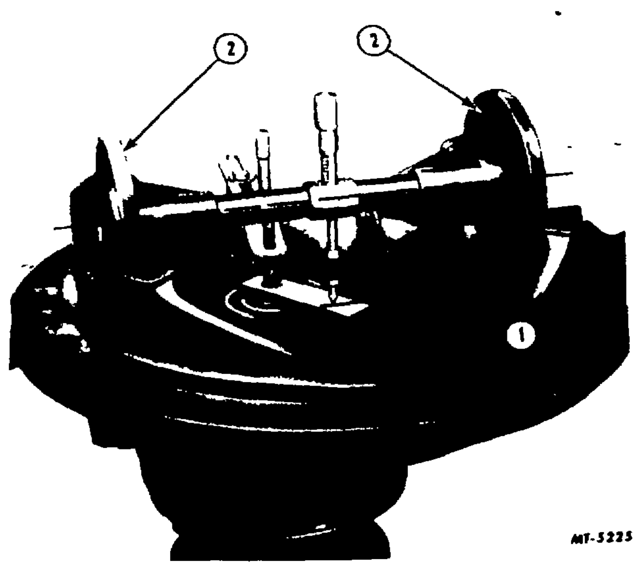

Fig. 28. Assembled Gauge in Position

1. Nominal Dimension Measured Here
2. Adapter Discs

5. Locate pinion nominal dimension (cone center specification) for the axle to be adjusted. On some axles this dimension may be shown on the pinion. Where this is not the case, It will be listed in the rear axle specifications. <u>Write down this specification.</u>

6. Also locate on pinion the etched marking which indicates a variation from zero cone center. If a minus figure, subtract from specified cone center, and if a plus figure, add to specified cone center. The plus or minus variation marked on the pinion will not necessarily show small variations such as -5, +3, or +7. On some pinions the variation marking will range to higher figures such as +56, +59 or perhaps higher.

   Results of calculation give the corrected cone center or pinion nominal dimension to which the pinion must be set.

7. Comparison of corrected cone center (6) with the actual or measured cone center (4) indicates amount of change necessary for pinion position.

8. Remove gauge and install ring gear and differential carrier in the differential housing.

9. Adjust backlash according to marking on ring gear.

SET GEAR LASH

A special effort should be made to set the backlash between pinion and ring gear to the same amount as was originally built into them, 0.1-0.15 mm (.004 to .006) on small gears or 0.15-0.2 mm (.006 to .012) on larger gears. Generally the amount of backlash is stamped or etched on the ring gear, Fig. 25. When installing new gears, backlash is measured with a dial indicator mounted on differential housing, as in Fig. 29. To adjust the backlash, move the ring gear toward or away from the pinion by means of the differential bearing adjusting nuts.

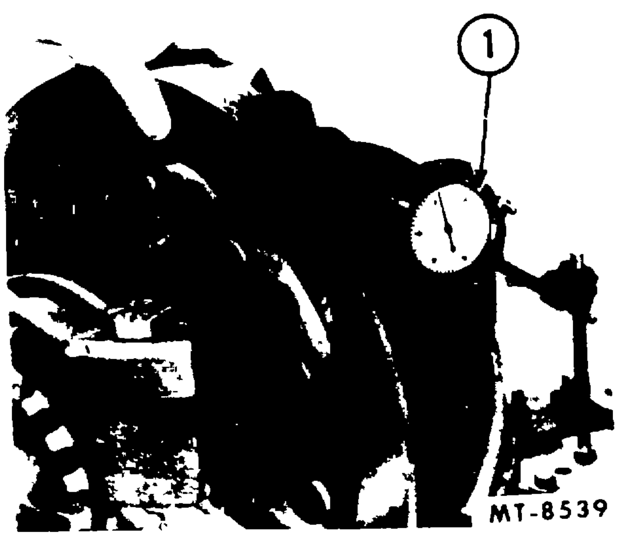

Fig. 29. Using Dial Indicator to Set Correct Backlash

When original gear and pinion sets are being reinstalled, the wear pattern of the gear teeth must be considered in the backlash adjustment. Gears that have been in service for long periods form running contacts which should not be greatly changed. If, in checking backlash, the amount measured is in excess of the amount shown on the ring gear, the lash may be reduced only in the amount that will avoid overlap of the worn tooth section, Fig. 30. A slight overlap at the worn section will cause gear operation to be noisy and rough.

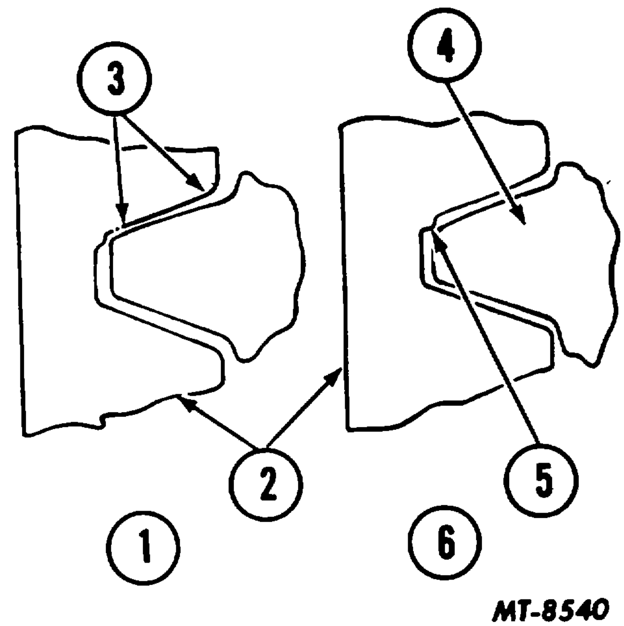

Fig. 30. Right and Wrong Adjustment of Ring Gear and Pinion When Worn Gears Are Reinstalled

1. Correct
2. Ring Gear
3. Worn Section of Ring Gear
4. Pinion Too Deep in Ring Gear
5. Overlap
6. Incorrect

PRELOAD DIFFERENTIAL BEARINGS

After the ring gear has been adjusted for position, another adjustment, the differential bearing preload, is also accomplished by these same differential bearing adjusting nuts. To set the preload, mount dial indicator at side of ring gear, Fig. 31, and continue the adjustment as follows:

1. With the side bearing cap capscrews loosened to permit bearing movement, loosen adjusting nuts only enough to notice end play on indicators.

2. Tighten adjusting nuts only enough to obtain .000" end play reading on indicator.

   While gear is held in .000" end play and before loading bearings, check gear for runout by revolving ring gear. If runout exceeds 0.2 mm (.008"), remove differential and check for cause.

3. Tighten both adjusting nuts from . 000" end play to preload the differential bearings. Tightening nuts one notch each usually gives bearings the correct preload.

4. Tighten bearing cap capscrews or stud nuts to specified torque.

5. Recheck gear lash to make certain that the lash setting has not been changed during the preloading operation.

6. Install adjusting nut locks.

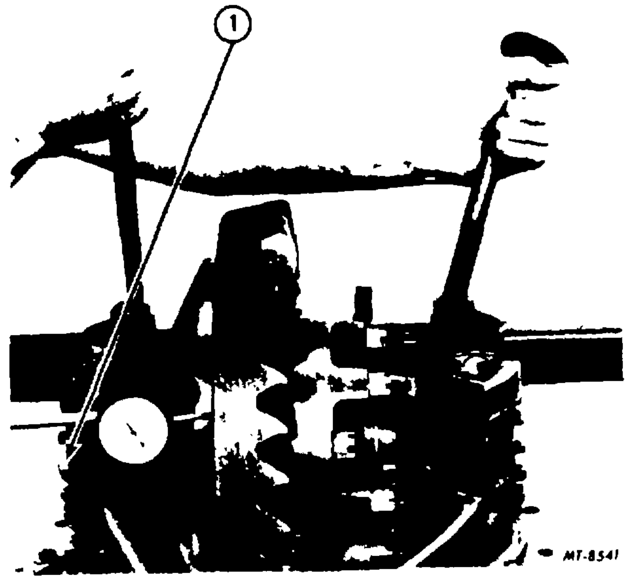

Fig. 31. Adjusting Differential Bearing Preload

1. Bearing Adjuster

CHECK GEAR TOOTH CONTACT

The following instructions cover the paint impression method of checking tooth contact and are especially for the benefit of those not equipped with an SE-1065 pinion setting gauge. The instructions may also be used as a check on the adjustment obtained with the gauge. By this method the mechanic temporarily bolts up the pinion and cage to the differential carrier and coats the drive gear teeth with oiled red lead, as in Fig. 32. When the pinion is rotated, the red lead is squeezed away by the contact of the teeth, leaving bare areas the exact size, shape, and location of the contacts. If these contacts are not acceptable, shims must be added to or taken from the shim pack located between the pinion cage flange and differential carrier housing. In this manner, a satisfactory adjustment is accomplished. Bear in mind that the accuracy of the adjustment obtained with the paint impression method is dependent upon the skill and experience of the mechanic. It may be necessary to make several trials at the right selection of shims to obtain the correct tooth contact.

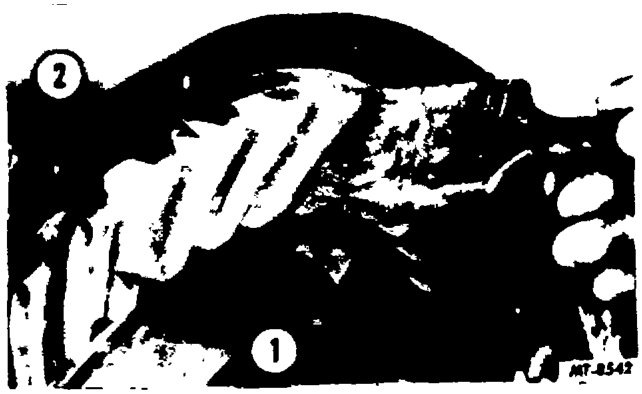

Fig. 32. Painting Gear Teeth for Obtaining Tooth Contact Impressions

1. Bevel Gear
2. Coat With Red Lead

Sharper tooth contact impressions may be obtained by applying a small amount of resistance to the gear with a flat steel bar and using a wrench to rotate the pinion. When making adjustments, check the drive side of the ring gear teeth. Coast side contact should be automatically correct when drive side contact is correct. As a rule, coating about twelve teeth is sufficient for checking purposes.

With adjustments properly made, a correct tooth contact similar to that shown in Fig. 33 will be secured. The area of contact starts near the toe of the gear and extends about 62-1/2 percent of the tooth length. This adjustment results in a quiet running gear and pinion set, which, because the load is distributed over the teeth within the proper area, will deliver all the long service built into it.

When checking paint impressions on gear teeth of an axle under heavy load, the impressions usually spread out somewhat longer than the patterns obtained from a bench test. This can be considered as normal. Ring gears, when mounted, should show a bearing toward the toe or small end of the tooth, but never at the heel or large end. The reason is that it is practically impossible to make gears and gear mounting so rigid that no deflection will occur when full torque is applied. This deflection causes the bearing to approach the heel of the tooth. And when gears are adjusted so that the bearing is toward the heel of the tooth, it results in a concentration of load on the top corner of the heel, and breakage will follow.

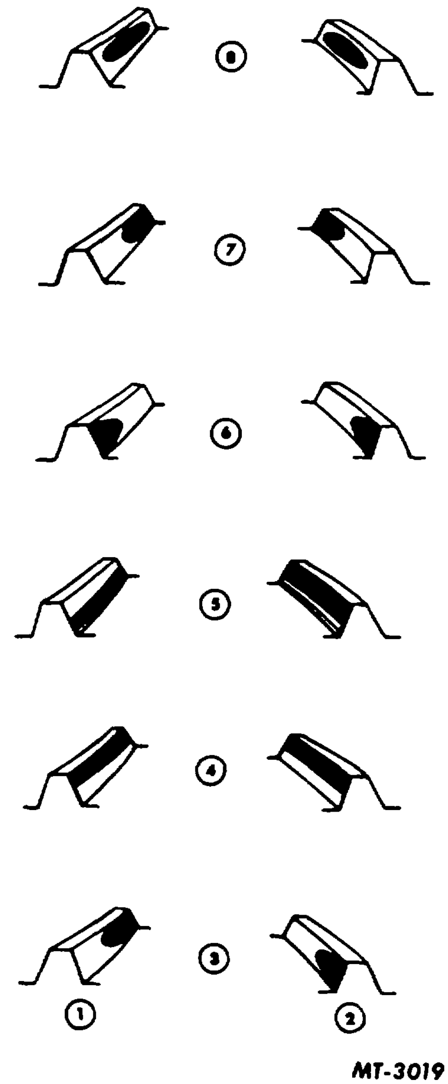

Fig. 33. Location, Size and shape of Correct Tooth Contacts

1. Drive 2. Coast
3. Cross Bearing
4. Bearing Too High
5. Bearing Too Low
6. Too Much Heel Bearing
7. Too Much Toe Bearing
8. Proper Tooth Contact

LOCTITE PLASTIC GASKET MATERIAL

On those axles which utilize Loctite Plastic Gasket material in place of the more common gasket, the plastic gasket material should be applied as follows:

1. Thoroughly clean the mating surface to remove foreign matter.

2. Spread a thin, even coating on one surface. On large or rough surface apply to both surfaces.

3. Assemble parts. Bolt mating parts together.

4. Loctite Plastic Gasket will dry in four to six hours under normal temperatures. If it is not possible to wait the four to six hours, apply Locquic Primer Grade T, which will reduce drying time required to approximately one hour. This primer must be bought locally.

REAR AXLE SPECIFICATIONS		
I.H. MODEL	RA-30	
I.H. CODE	14030	
PINION Nominal Dimension (in.) (mm) SE-1065-9 Disc Cage Rotating Torque Pounds Pull (Kg)	 3.2530 82.63 D(2) 3-8 1.4-3.6	
DIFFERENTIAL Bearing Preload	1 Notch Ea. Side	
HOUSING Lub. Capacity (Pints U.S.) (Liters)	18 8.4	
SERIAL NO. LOCATION	On Bolt Circle of Diff.	

REAR AXLE TORQUE CHART

IH MODEL	RA-30 Ft. Lbs. N-m	
Pinion End Nut	1-1/8-18 325* 440	
Pinion Cage to Carrier	9/16-12 100-120 135-162	
Carrier to Housing	7/16-20 50-70 68-95	
Differential Case	1/2-20 80-90 108-122	
Bearing Cap to Carrier	9/16-18 150-160 200-220	
Drive Flange to Wheel Hub	5/8-11 150-160 200-220	

*Minimum pinion end nut torque with cross type (+) cotter pin holes.
Continue to tighten until cotter pin can be inserted.
Do not back off pinion end nut to insert cotter pin.
All bolt threads are to be coated with Loctite I.H.
No. 576018-C1 before torque is applied.

TROUBLE SHOOTING

Quite often serious trouble in a rear axle can be "headed off" and prevented if sufficient attention is given to the various causes of trouble and the proper remedy is applied. The following list gives most of the common kinds of axle trouble and suggests a possible cause to be corrected.

It should be noted that noises from other units of the truck, such as propeller shafts, universal joints, tires, and even transmissions, are often incorrectly diagnosed as rear axle noise. This possibility should not be disregarded when trouble shooting.

PROBLEM	CAUSE
Constant Noise	1. Lubricant not to specified level. 2. Incorrect kind and weight of lubricant. 3. Wheel bearings out of adjustment or defective. 4. Drive gear and pinion not in adjustment for correct tooth contact. 5. Teeth of drive gear and pinion chipped or worn. 6. Too much or too little pinion-to-gear backlash. 7. Loose or worn pinion bearings. 8. Loose or worn side bearings.
Intermittent Noise	1. Ring gear does not run true. a. Uneven pressures on drive gear rivets. b. Warped drive gear. 2. Loose or broken differential bearings.
Noisy on Turns Only	1. Differential pinion gears tight on cross or pinion shaft. 2. Side gears tight in differential case. 3. Differential pinion or side gears defective. 4. Thrust washers worn or damaged. 5. Excessive backlash between side gears and pinions.
Lubricant Leaks	1. Loss through axle shafts. a. Lubricant above specified level. b. Incorrect kind and weight of lubricant. c. Restricted axle housing breather valve. d. Worn or incorrectly installed axle shaft oil seal. 2. Loss at pinion shaft. a. Lubricant above specified level. b. Incorrect kind and weight of lubricant. c. Restricted axle housing breather valve. d. Pinion oil seal worn or incorrectly installed. e. Lubricant return passage in differential carrier housing restricted. f. Universal joint companion flange loose on pinion shaft.
Rear Wheels Do Not Drive (Propeller Shaft Rotating)	1. Broken axle shaft. a. Loose wheel bearings. b. Axle shaft too short. c. Loose flange studs or nuts. d. Bent housing. 2. Drive gear teeth stripped. 3. Side gear or differential pinion broken. 4. Differential pinion shaft or cross broken.

LOCKING TYPE DIFFERENTIAL

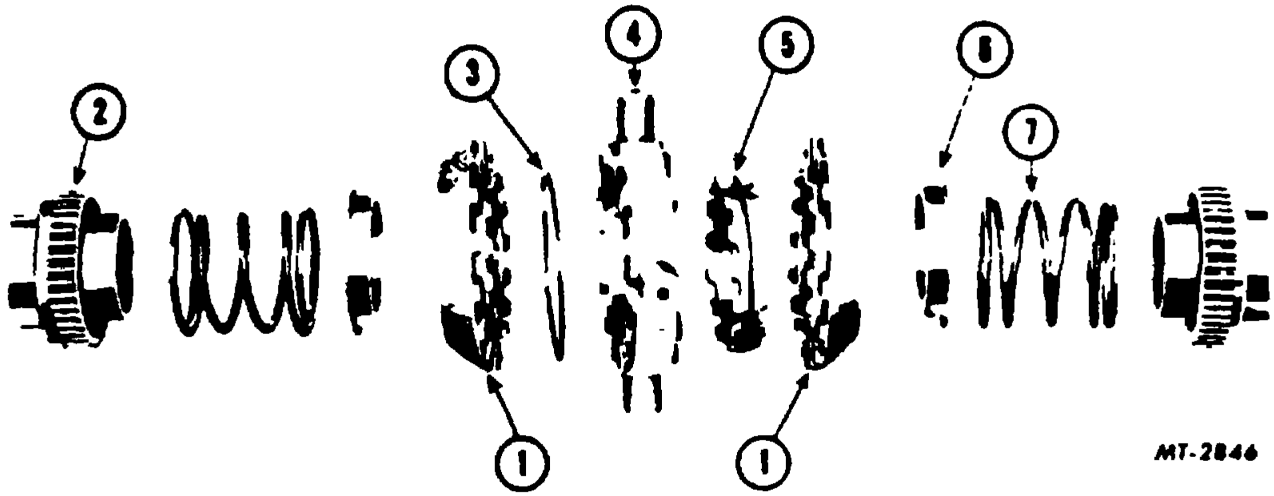

Fig 34. Internal Spring Design Differential Locking Unit (Exploded View)

1. Driven Clutch Member
2. Side Member
3. Center Cam Snap Ring
4. Spider
5. Center Cam
6. Spring Retainer
7. Spring

DESCRIPTION

The NoSPIN differential (Figs. 34 and 35) provides equal amounts of drive line torque to each rear driving wheel and also permits differential action for turning corners.

This differential also provides greater operating flexibility than a conventional differential, because the locking type differential overcomes wheel spinning when required to operate in mud, sand, snow and on ice or wet roads. The unit is installed in the differential came in place of the conventional gears, pinion and spider.

The action of the unit is the same for both drive and coast loads and forward and reverse driving.

CONSTRUCTION

The differential locking unit consists of several parts., all assembled around the spider.

SPIDER AND CENTER CAM ASSEMELY

This assembly consists of the spider, center cam and spider snap ring. The spider has four trunnions projecting radially from a center ring on each side of which are located fixed driving clutch teeth. These teeth vary in number, depending on the size and model of differential. The internal diameter of the spider is uniform. Into it is mounted the center cam. This cam is held in position with a centrally mounted snap ring, which permits the center cam to be rotated within the spider but prevents lateral movement. The center cam is symmetric, having the same number of cam lifts on each side as there are clutch teeth on the spider. Theme lifts or "cam" have uniform contours with rounded surfaces that provide anti-friction ramps for disengaging the driven clutch members.

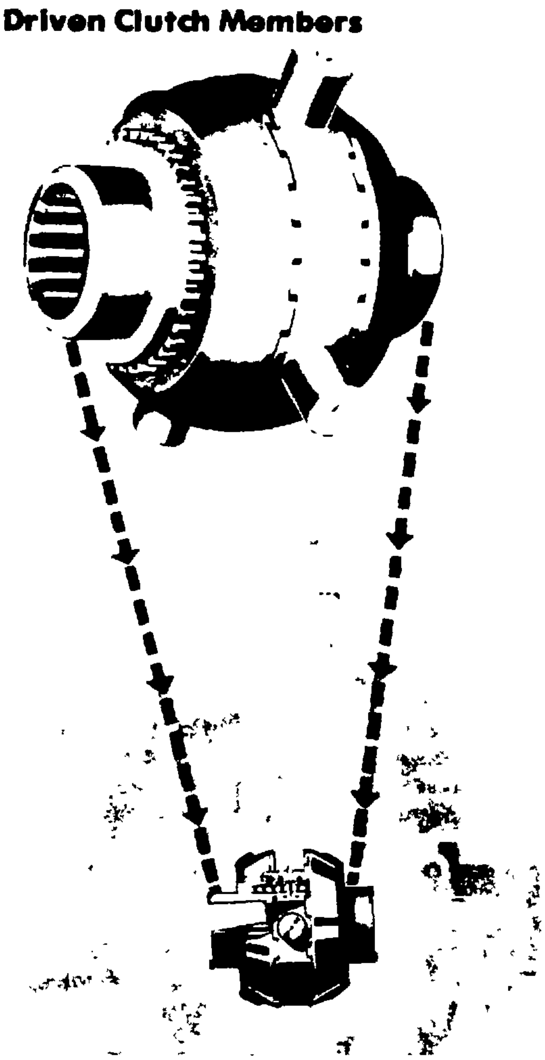

Fig. 36. Typical Installation of NoSPIN Unit
(Cross Sectional View)

Two identical driven clutch members are located on either side of the spider and center cam assembly. Each has a set of clutch teeth to match the clutch teeth on the spider through which driving torque is transmitted. Radially inward from the driven clutch teeth on models using internal spring are cams which mesh with the cams of the center cam member. These cams have been eliminated on the models using the external spring. The internal diameter of each driven clutch member has splines which engage the external splines of the splined side members.

SPRING RETAINERS AND SPRINGS

WITH INTERNAL SPRINGS:

Spring retainers are inserted into the outer ends of driven clutch member. The bowl side of these retainers is mounted first through the outer side of the driven clutch members. The flanged portion of the spring retainers pass through the internal splines to rest on the mating flanges of the driven clutch members. The springs are mounted in spring retainers after assembly and thrust against their inner cupped ends.

SPLINED MEMBERS

These two splined side members are splined internally to receive the truck axle shafts. The inner hubs of the splined side members are inserted in the outer ends of the springs. The external splines of the splined side members engage the internal splines of driven clutch members on each side of the completed assembly.

OPERATION

STRAIGHT FORWARD DRIVING

When a vehicle is being driven in a straight forward direction, the clutch teeth on both sides of the spider assembly are fully engaged with the clutch teeth on each driven clutch member. Likewise, the fixed came of the driven clutch members are fully meshed with the cam surfaces of the floating center cam ring mounted on the inside diameter of the spider, as described previously.

Engagement of the driving and driven clutch teeth is assured by the pressure of the two springs which force the driven clutch members inwardly against the spider and also by the positive locking action developed by the mating undercuts on the driving faces of the clutch teeth, Fig. 37.

In this condition, both clutches remain fully engaged so that the assembly operates as a solid unit and each rear wheel is driven forward at ring gear speed.

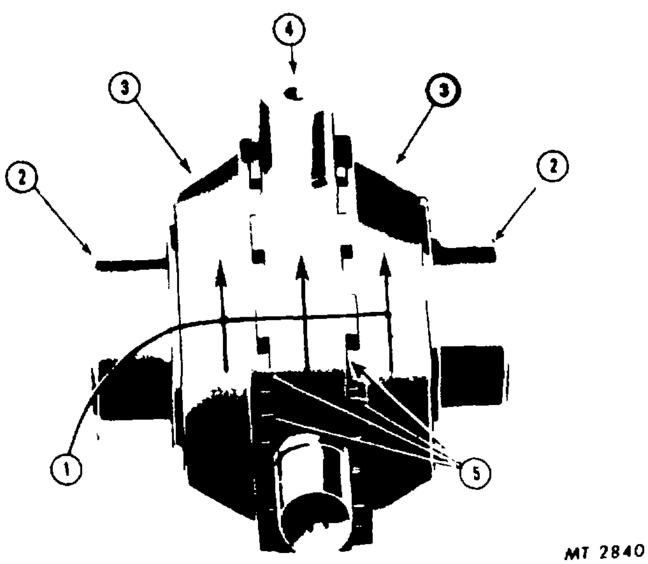

Fig. 37. Straight Forward Driving

1. Both Driven Clutch Members and Spider Travel at Same Speed
2. Side Member
3. Driven Clutch Member
4. Spider
5. Spider Clutch Teeth Drive Driven Clutch Teeth

STRAIGHT REARWARD DRIVING

When driving a vehicle in a straight rearward direction, both driven clutch members are held in full engagement with the spider and center cam as described for straight forward driving. However, in this case, the spider rotates in the reverse direction and shifts the driving force to the opposite set of driving faces on the mating clutch teeth. Again we have the assembly operating as a unit with each wheel being forced to rotate at ring gear speed.

RIGOW-HAND TURN - FORWARD DIRECTION

When making a turn, differential action is required in order to permit the outside wheel to travel a greater distance, and faster, than the inside wheel.

The NoSPIN differential allows either wheel to turn faster than the ring gear speed but does not permit either wheel to turn slower than the ring gear speed when power is applied. When negotiating a right-hand turn in a forward direction, the right-hand driven clutch member remains fully engaged with the spider clutch teeth and the corresponding cams, Fig. 38.

The driving clutch teeth of the spider transmit the driving force to the driven clutch member, which in turn drives the right-hand (inside) wheel constantly at right gear speed, thus propelling the vehicle. The left-hand (outside) wheel covers a greater arc than the right-hand (inside) wheel and driven by the traction of the road, must turn faster than ring gear speed. Likewise, the left-hand driven clutch member must turn faster than the spider. In other words, it permits differences in wheel speeds or differential action.
Fig. 39 illustrates how this is accomplished.

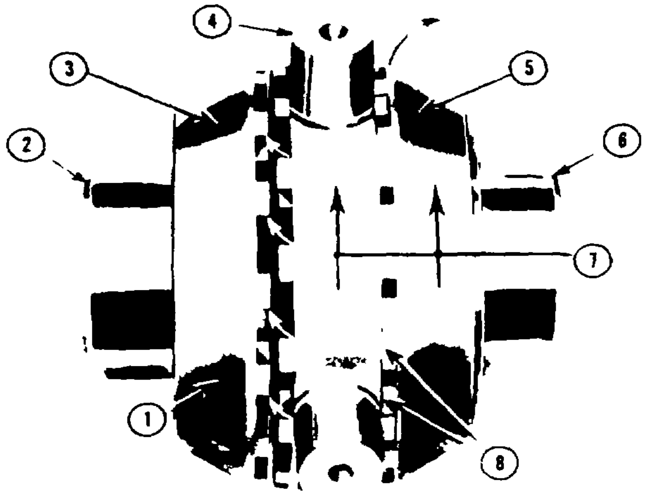

Fig. 38. Right-Hand Turn - Forward Direction

1. Driven Clutch Member Elevated by Cams Disengages from Spider Clutch Teeth and Travels at Faster Speed
2. Splined Side Member
3. Driven Clutch Member
4. Spider
5. Right Hand Turn Driven Clutch Member
6. Splined Side Member
7. Driven Clutch Member and Spider Remain Locked and Travel at Same Speed
8. Spider Clutch Teeth Drive Driven Clutch Member

The right-hand row of cams on the center cam member are meshed securely with the cams on the right-hand driven clutch member. With the center cam thus locked in this position so that it cannot rotate with respect to the spider, its cams on the left-hand side serve as ramps upon which the mating cams on the left-hand driven clutch member can rise, enabling that driven clutch member to disengage from the spider. The ramps on the center cam are high enough to permit the clutch teeth on the driven clutch member to clear the teeth on the spider and when the crest of the ramp is passed, the teeth of the driven clutch member are forced back by spring pressure into full engagement with the clutch teeth of the spider.

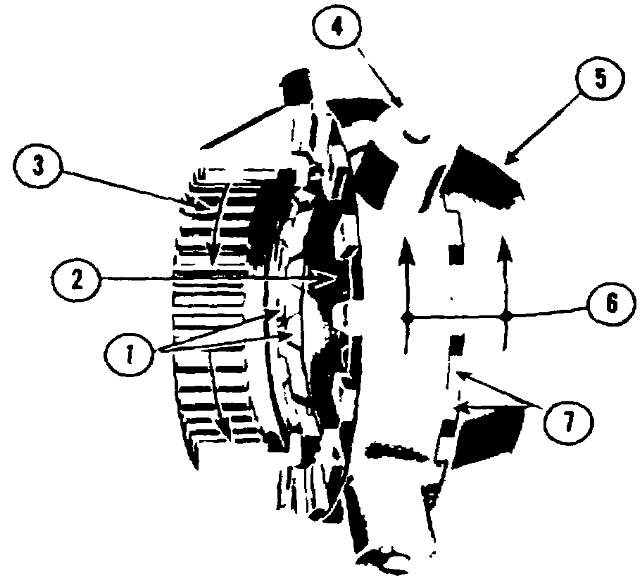

Fig. 39 Forward Right-Hand Turn (Cross Sectional View)

1. Center Cams Serve as Ramps To Elevate the Driven Clutch Members Through Contact with their Fixed Cams
2. Center Cam Member
3. Driven Clutch Member Becomes Disengaged and Travels Faster Than Spider
4. Spider
5. Driven Clutch Member
6. Spider and Driven Clutch Member Travel at Same Speed
7. Driven Clutch Member Teeth Driven by Spider

This engagement and disengagement or indexing operation continues throughout the turn with a rapidity that is in direct relation to the speed of the overrunning wheel.

As the vehicle completes the turn and is again driven in a straight forward direction, differential action no longer being required, both driven clutch members become fully engaged with the clutch teeth of the spider; then the operation, as described in "Straight Forward Driving, " is resumed.

FORWARD RIGHT-HAND TURN-BRAKING CONDITION

In this situation, the vehicle is moving forward, but the direction of torque of the ring gear is reversed, because the vehicle is being slowed down by braking action. This reversal of torque is produced by the action of road traction driving the wheels against the torque of the engine. In this condition, when a right-hand turn is negotiated, the left-hand (outside) wheels rotate at ring gear speed, since the left-hand driven clutch member remains fully engaged while the right-hand (inside) wheels rotate slower than ring gear speed.

The symmetrical design of the differential makes it possible to function in the manner described above, which is, in effect, directly opposite to that described as "Right-Hand Turn--Forward Direction."

It should be noted that if a turn is negotiated in such a manner that power is first applied and then braking action is encountered before the turn is completed, the differential is designed to function without interruption and will automatically take care of such reversal of torque.

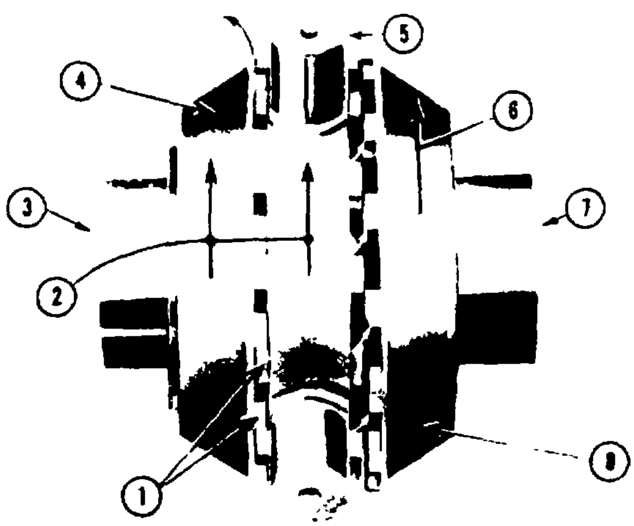

Fig. 40 Left-Hand Turn - Forward Direction

1. Spider Clutch Teeth Drive Driven Clutch Member
2. Driven Clutch Member and Spider Remain Locked and Travel at Same Speed
3. Splined Side Member
4. Driven Clutch Member
5. Spider
6. Driven Clutch Member Elevated by Cams Disen-gages from Spider Clutch Teeth and Travels at Faster Speed
7. Splined Side Member
8. Driven Clutch Member

LEFT-HAND TURN - FORWARD DIRECTION

In making a left-hand turn with the vehicle driven in a forward direction, the left-hand wheel is on the inside of the turn and the power is applied to it so that it must rotate at right gear speed. The right-hand wheel travels through the greater arc, being on the outside of the turn. Its driven clutch member becomes disengaged from the spider clutch teeth, permitting is to be rotated by ground traction faster than the ring gear, Figs. 40 and 41.

The operation of the driven clutch member on the right side of the assembly in the foregoing instance is illustrated.

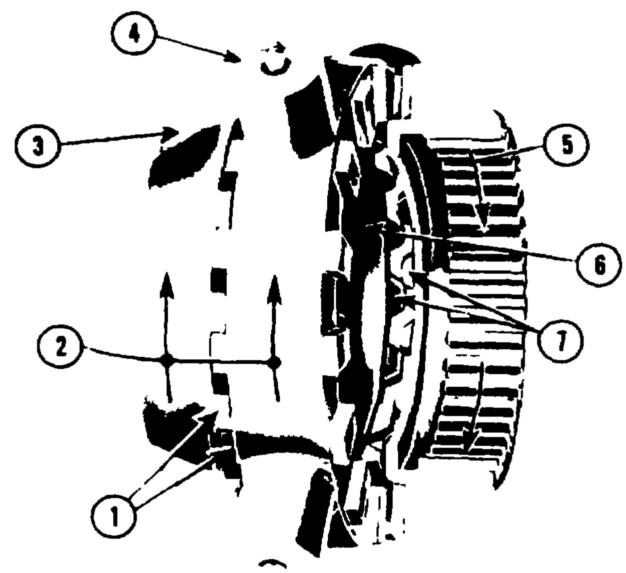

Fig. 41. Forward Left-Hand Turn (Cross Sectional View)

1. Driven Clutch Member Teeth Driven by Spider Clutch Teeth
2. Spider and Driven Clutch Member Travel at Same Speed
3. Driven Clutch Member
4. Spider
5. Driven Clutch Member Becomes Disengaged and Travels Faster than Spider
6. Center Cam Member
7. Center Cams Serve as Ramps to Elevate the Driven Clutch Member Through Contact with its Fixed Cams

RIGHT- AND LIFT-HAND TURNS - REARWARD DIRECTION

The operation of the NoSPIN differential when required to make turns while traveling in a rearward direction is identical to that when making turns in a forward direction. When moving rearward in a turn under power, the inside wheel is driven at ring gear speed while the outside wheel is driven by the ground faster than ring gear speed. When the rearward turn is nearing completion and the vehicle is slowing down because of application of the brakes, the outside wheel it driven by the ground at ring gear speed, as its driven clutch member is fully engaged and acts to "brake' against the engine torque. The inside wheel is driven by the ground through the smaller arc of travel, and since its driven clutch member is disengaged, it will rotate slower than ring gear speed.

Fig. 42 shows the operation of the differential when a right-hand turn in a rearward direction is being negotiated.

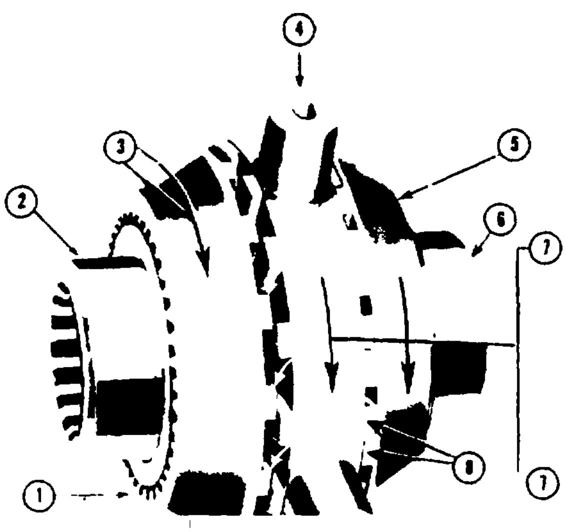

Fig. 42. Right-Hand Turn -- Rearward Direction

1. Driven Clutch Member
2. Splined Side Member
3. Driven Clutch Member Elevated by Cams Dis-engage from Spider Clutch Teeth and Travel at Faster Speed
4. Spider
5. Driven Clutch Member
6. Splined Side Member
7. Driven Clutch Member and Spider Remain Locked and Travel at Same Speed
8. Spider Clutch Teeth Drive Driven Clutch Member

DIFFERENTIAL REMOVAL

IMPORTANT PRECAUTION: Before disassembling the differential case, insert a bolt through the center of the NoSPIN unit (axle shaft openings) with a flat washer on each end against the side members, Fig. 43.

Thread a nut on the bolt against the flat washer finger tight. This will prevent possible injury caused by the unit flying apart due to the spring pressure within itself during disassembly of the differential case.

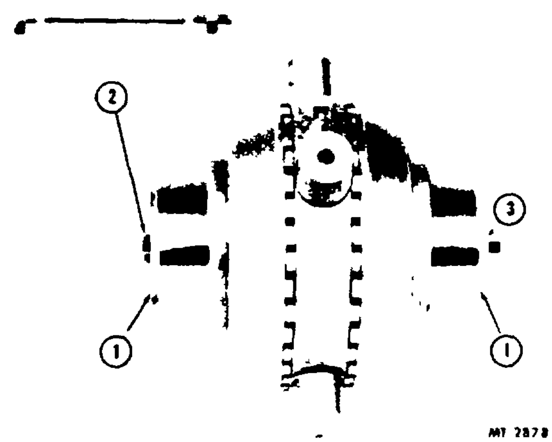

Fig. 43. Inserting Assembly Retaining Bolt

1. Flat Washer
2. Assembly Retaining bolt
3. Nut

DISASSEMBLY

Remove the bolts from the differential case and lift out the NoSPIN unit. Mount unit in a small press, Fig. 44.

Apply enough pressure on the head of the bolt to release the spring pressure against the nut. Remove the nut and flat washer by reaching underneath the press. Slowly release the press and allow the unit to disassemble itself until the spring pressure is fully released.

Remove unit from press.

Remove side members, springs, spring retainers and driven clutch members. The center cam may be removed from the spider by expanding the snap ring with small screwdrivers or wedges.

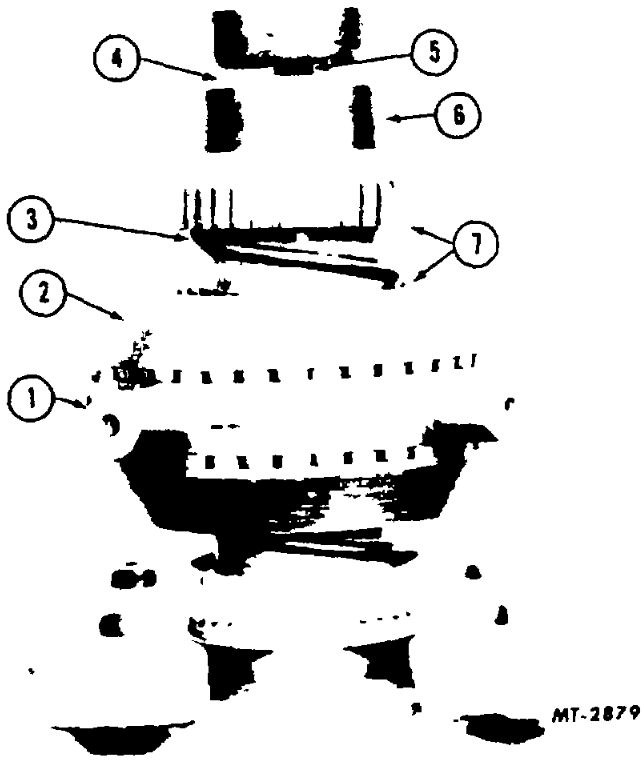

Fig. 44. Release of Spring Pressure

1. Spider
2. Driven Clutch
3. Spring
4. Flat Washer
5. Bolt Head
6. Side Member
7. Splines Must Index

Be careful when removing and reinstalling center cam snap ring to avoid possible injury.

CLEANING, INSPECTION AND REPAIR

Wash all parts thoroughly with a cleaning solvent. Inspect all mating surfaces and teeth for possible wear or damage. Replace all worn or damaged parts before reassembly.

REASSEMBLY

Reassembly is essentially the reverse of disassembly. Lubricate all parts with SAE-30 oil during reassembly. Place side member upright and install spring on same. Place spring retainer on spring with flange end toward side member. Install driven clutch member on spring retainer. Place spider on driven clutch member, indexing teeth of same. Install other driven clutch member, spring retainer, spring and side member on spider.

Insert a bolt through the center of the NoSPIN unit with a flat washer against side member. Mount unit in press as shown in Fig. 44. Compress springs by pressing on head of bolt and index splines of side members with those of driven clutch members.

Keep entire unit aligned in press to prevent it from kicking out while springs are being compressed. Compress unit until side member splines are completely indexed and flush with driven clutch member. Install flat washer on bolt against side member and thread nut on bolt, finger tight, so that it has the appearance of Fig. 43 when removed from the press.

Remove unit from press.

Place unit in differential case and install differential case bolts.

IMPORTANT PRECAUTION

power will be transmitted to the opposite rear wheel or axle if one of the rear wheels or axles slips. Both rear wheels or both rear axles must be raised free of ground if it is necessary to operate one rear wheel with truck stationary; otherwise, the wheel or axle that is not raised will pull truck off its support.

LUBRICATION

Fill differential carrier through filler hole until oil is level with hole.

CAB

S-SERIES

CONTENTS

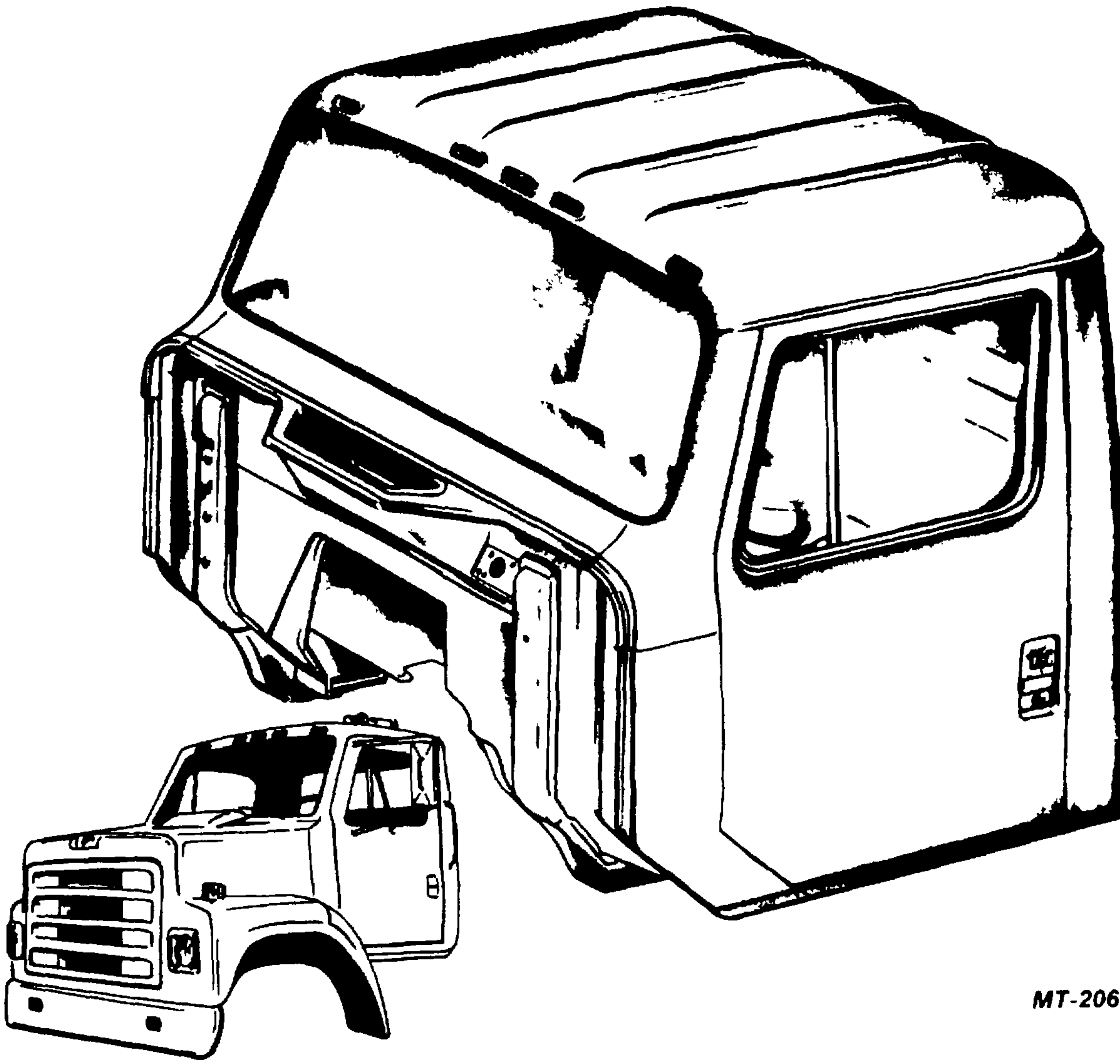

Fig. 1 S-Series Conventional Cab

GENERAL

This manual has been prepared to help servicemen maintain cab in its original condition or restore cabs which may have sustained damage.

CONTROLS--INSTRUMENT PANEL

Fig. 2 shows the cab interior and a typical instrument panel installation. Removable panels provide for easy access to speedometer, cables, gauges, bulbs, wiring, plumbing, switches, valves, etc.

CAUTION

Always disconnect battery ground before servicing or removing instrument panel.

For further information on S-Series instrument panel see INSTRUMENTS.

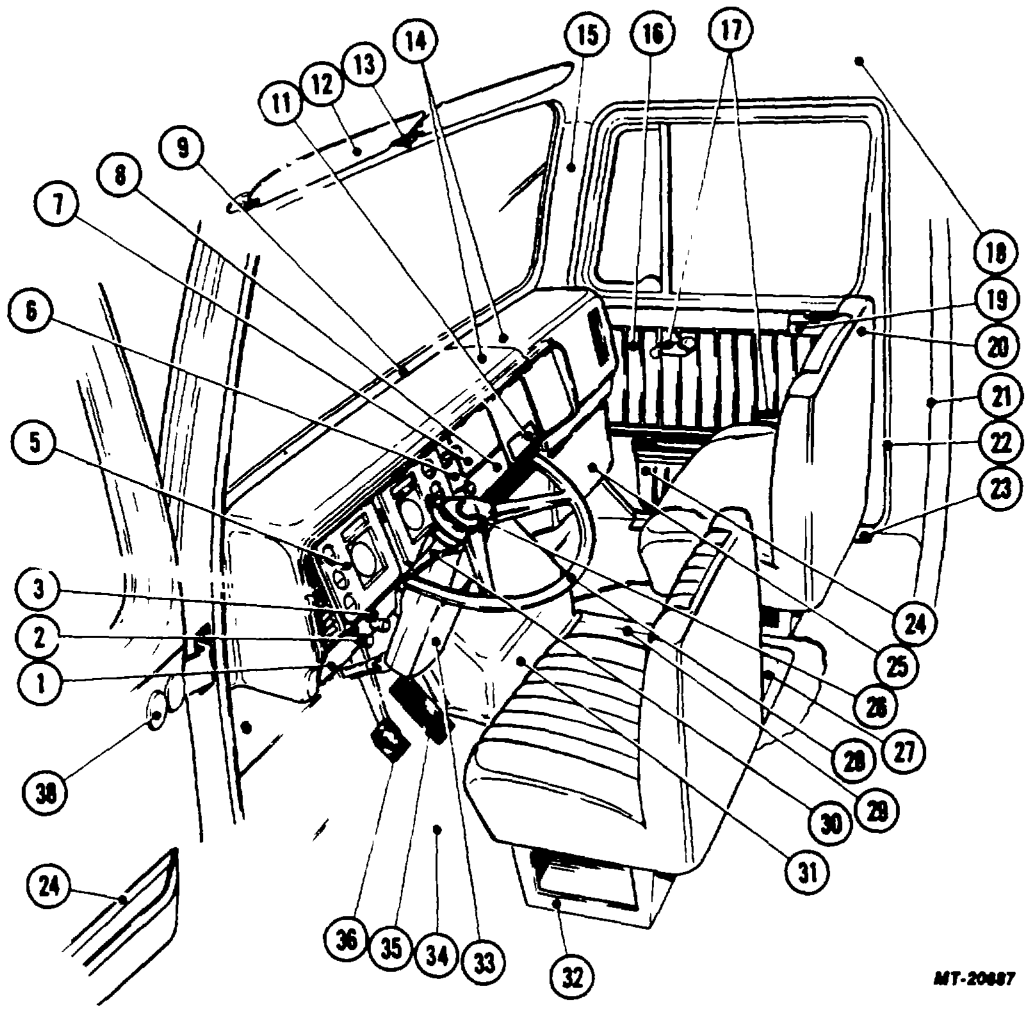

Fig. 2 S-Series Cab Interior View (Typical)

Key Description

1 Lower Instrument Panel
2 Control Knobs
3 Name Plate

5 Instrument Cluster
6 Instrument Panel
7 Air Control Cluster
8 Heater Control
9 Defroster Panel

11 Ash Tray
12 Sun Visor
13 Sun Visor Clip

Key Description

14 Instrument Panel Cover
15 Hinge Pillar Access Cover
16 Door Trim Panel (Custom)
17 Door Hardware
18 Headliner
19 Arm Rest
20 Seat
21 Back Inner Trim Panel
22 Door Trim Strip
23 Scuff Plate
24 Manifest Pocket, Vinyl or Metal
25 Heater
26 Horn Button

Key Description

27 Transmission Cover
28 Steering Wheel
29 Shift Lever
30 Turn Signal Lever
31 Engine Cover
32 Seat Riser
33 Steering Column
34 Floor Mat
35 Accelerator Pedal
36 Brake Pedal

38 Button Plug, Hinge Cover

SERIAL NUMBER LOCATIONS

Serial numbers are necessary if the need for replacement parts should occur. For this reason you will want to know the location for these important numbers. S-Series chassis serial numbers are located on face of cab lock pillar. S-Series cab serial numbers are located at top right of cowl front panel.

MAINTENANCE

Most service requirements, disassembly procedures or adjustments, on this cab and hood can be performed with ordinary mechanic's hand tools. Illustrations and suggested procedures for helping the mechanic are covered in paragraphs which follow.

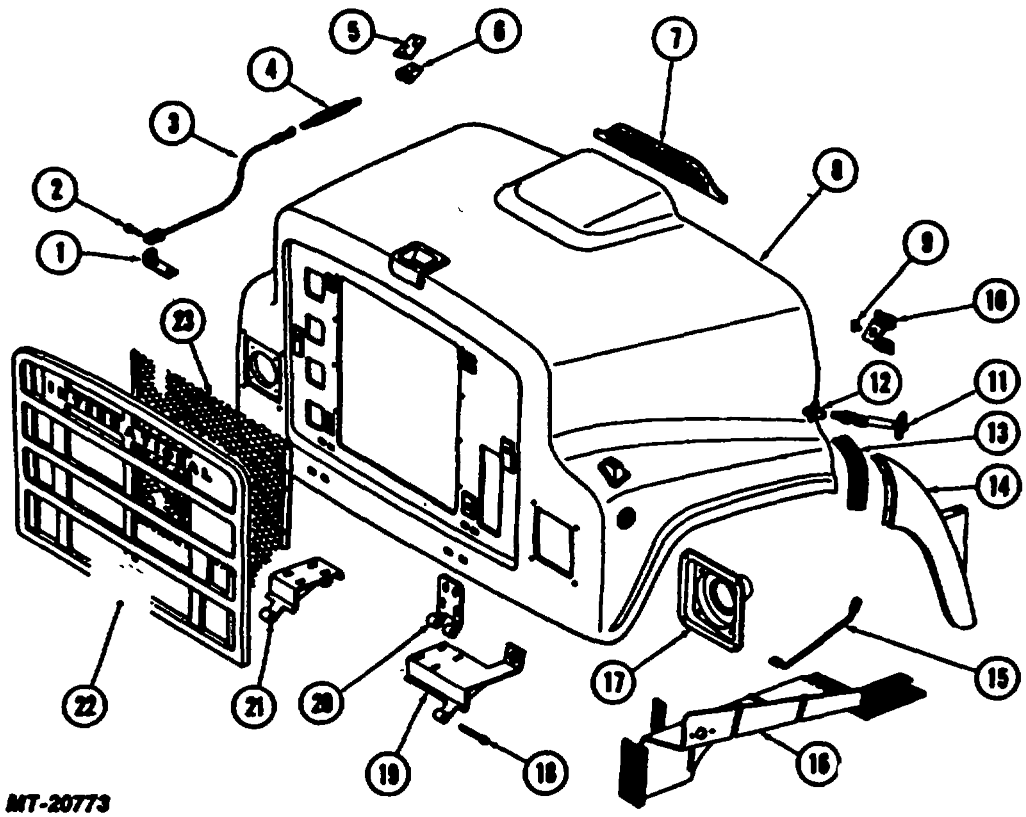

Fig. 3 Hood and Hinge Mounting

Key	Description	Key	Description	Key	Description
1	Bracket, Hood Stop	9	Guide, Hood Locator	17	Shield, Headlight
2	Pin, Cable End	10	Bracket, Locator Guide	18	Pin, Hood Hinge
3	Cable, Assembly, Hood	11	Latch, Hood	19	Hinge, Lower Half Left
4	Spring, Hood Stop	12	Socket, Hood Latch	20	Hinge, Hood Half
5	Reinforcement	13	Seal	21	Hinge, Lower Half Right
6	Bracket, Hood Stop Anchor	14	Fender	22	Grille, Radiator
7	Grille, Fresh-Air Intake	15	Brace, Splash Panel	23	Screen, Radiator
8	Hood, Assembly	16	Panel, Fender Splash		

HOOD AND HINGE MOUNTINGS

Tilt type hoods (Figs. 3 & 4) used with S-Series cabs are one-piece molded fiberglass units.

HOOD OPENING (TILTING)

The hood assembly is hinged near bumper and can be tilted by releasing hood latches on cowl panels. Place foot on bumper step, grasp handle recess and pull complete hood, fenders and grille assembly to front. There are two hood stop cables to prevent over-travel of hood.

To lower hood. push the hood towards cab and at the same time hold back at handle recess to ease the hood into travelling position. Secure both hood latches at cowl panels. Do not allow hood to drop into place or damage can result.

HOOD REMOVAL

1. Release hood latches on each side of cowl and tilt hood assembly forward.

2. Support tilted hood on floor stands or saw horse to relieve tension on hood stop cables. Protect paint from scratches.

3. Remove spring type pins and cable end pins (one for each cable) and detach stop cables from hood stop brackets at top of radiator.

4. Disconnect headlight wiring harness from connector on underside of hood.

5. Remove spring type pin and hinge pin from the two hood hinge assemblies and detach hood from chassis.

6. Hood-to-frame hinge mounting details for the various size hoods are shown in Figs. 3 and 4.

FIBERGLASS REPAIR

Refer to fiberglass repair instruction section.

HOOD INSTALLATION

Hood installation is the reverse of the foregoing removal procedure. Before final tightening of hood mounting bolts, check hood adjustment.

HOOD ADJUSTMENT

When making any adjustment to tilt hood, inspect hood alignment and clearance between hood and cowl. Elongated mounting holes in frame half of hood to frame hinges provide for hood adjustment. If adjustment is required, loosen hinge to frame mounting bolts and adjust hood to cowl clearance a necessary. Tighten mounting bolts to specified torque (see Torque Chart).

CAB DOORS

Doors used on the S-Series cab are of all steel-welded construction with access panel and button plug openings for making hinge adjustments or removal as required. The door is mounted on concealed leaf type hinges and door adjustment is provided by elongated holes in hinge leaves. Door *top is integral with upper hinge. Door striker pin is also adjustable on lock pillar. Service on the door and its components is covered in paragraphs which follow.

DOOR HARDWARE AND TRIM (FIG. 6)

Components of door assembly can be removed while door is either on cab or removed. They can also be removed individually without having to remove other components for access. Servicemen should have little difficulty in making a complete door disassembly or a removal of any of its component parts. (Most components do require the prior removal of door hardware and trim.)

REMOVE

1. Remove window regulator handle and door remote control handle by removing socket head screws from handles.

2. Remove two screws and detach arm rest.

INSTALL

Door hardware and trim installation is the same as reverse of removal procedures.

IMPORTANT

Be careful when reinstalling arm rests so as to avoid stripping out mounting screws. Torque for mounting screws is 2.3 N ·m (20 in. lbs.).

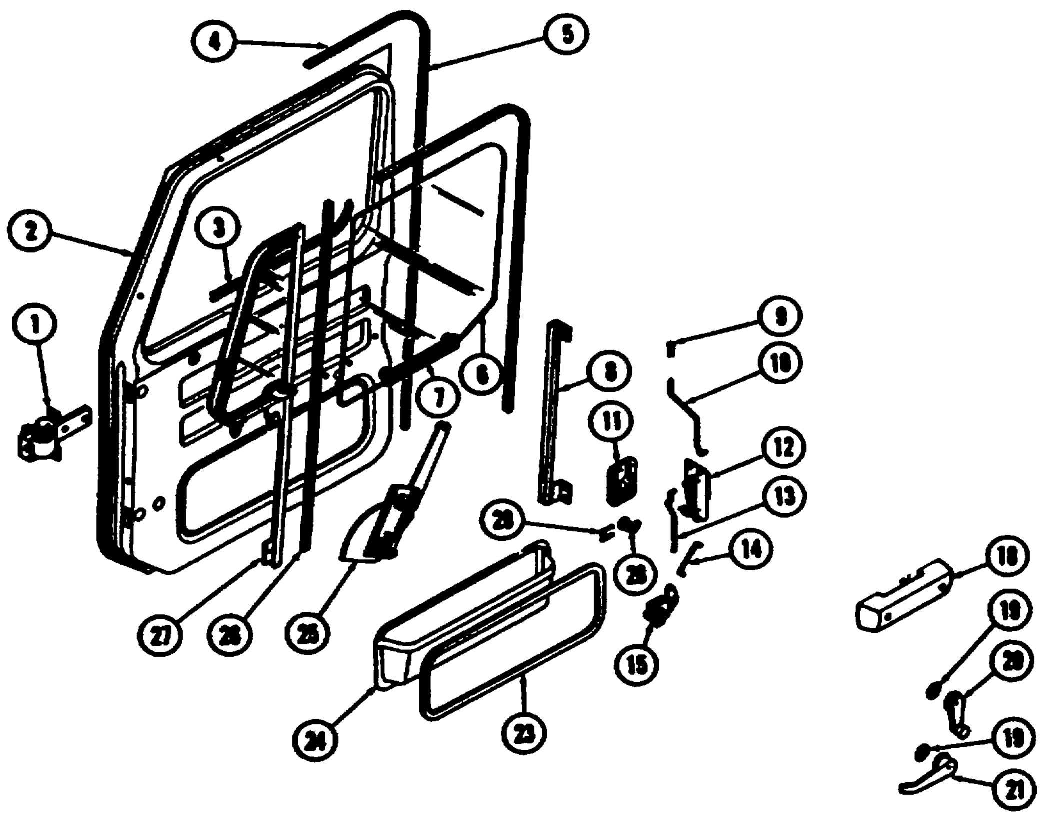

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Fig. 6 Door Hardware, Trim and Internal Components - Exploded View

Key	Description	Keys	Description
1	Hinge, Cab Door	15	Control Assembly. Remote
2	Door, Assembly, Cab		
3	Seal., Door Glass		
4	Seal, Door	18	Arm Rest
5	Seal, Door Glass Rear Channel	19	Washer, Door Trim
6	Glass, Door Window	20	Handle, Window Regulator
7	Guide, Door Window	21	Handle, Door Remote
I	Channel, Rear Run		
9	Knob, Door Lock	23	Retainer, Access Door
10	Rod, Lock Knob to Latch	24	Pocket, Manifest
11	Handle, Assembly Door Outer	25	Regulator, Assembly, Window
12	Latch, Assembly, Door	26	Seal Door Glass Front Channel
13	Rod, Remote Control to Latch	27	Vent, Assembly Window Glass
14	Rod, Lock Cylinder to Latch		

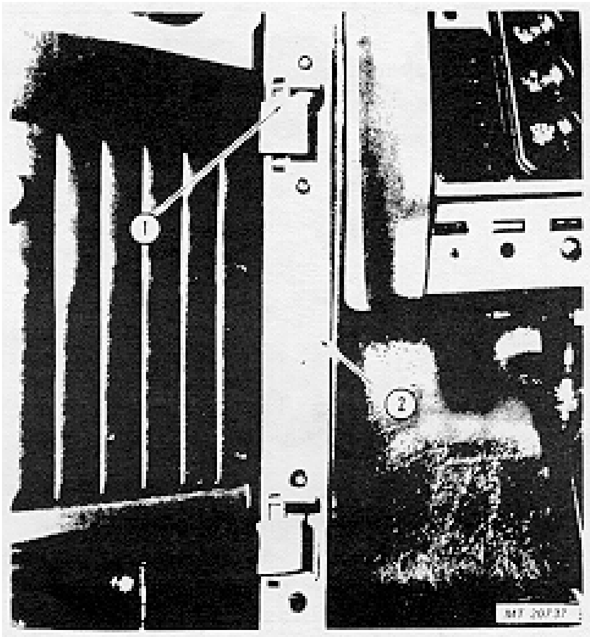

Fig. 7 Door and Hinge Details

1. Integral Door Check in Hinge
2. Hinge Pillar

DOOR HINGES

An integral door check (Fig. 7) is included in the upper hinge used with this door. If door is removed, upper and lower hinges should not be interchanged. There is no disassembly of hinges since they are serviced as a complete unit. It should also be noted that hinge mounting holes are elongated to provide adjustment for positioning cab door in door opening.

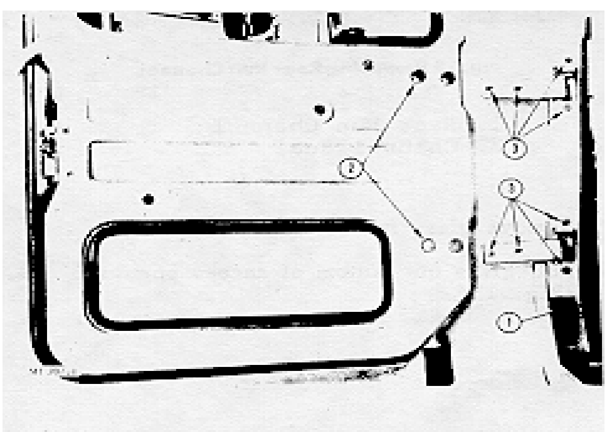

Fig 8 Removing Door from Cab

1. Hinge Pillar
2. Access to Hinge Mounting
3. Enlarged Mounting Holes For Door Adjustment

REMOVE

1. Remove door hardware and trim as covered previously.

2. Using a rope sling (or padded chain) through window opening, attach sling to overhead lift and support door.

3. Remove four button plugs for access to hinge bolts.

4. Remove the four flange head hinge bolts and lift door assembly from hinges (Fig. 8).

5. Place door on saw horses or similar support. Protect paint from scratches.

6. To simplify door adjustment on reassembly, mark hinge position on hinge pillar with scratch awl before loosening hinges. Remove the three flange head bolts and detach door hinge from hinge pillar (Fig. 9).

IMPORTANT
Flange head bolt inside pillar can best be removed with a flex socket. Also be careful when extracting bolt so as to avoid its loss inside pillar.

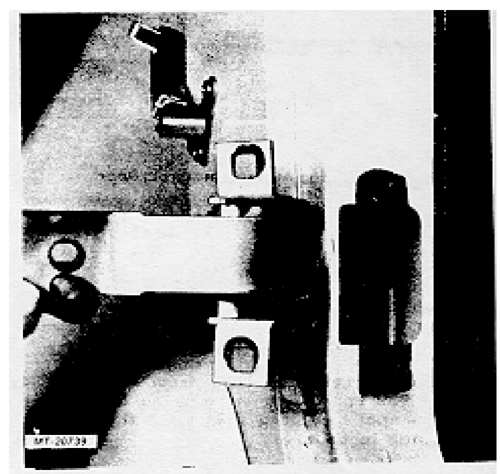

Fig. 9 Removing Cab Door Hinge From Hinge Pillar

INSTALL

Cab hinge and door installation is accomplished by reversing the foregoing removal procedures. Before final tightening hinge mounting bolts, check the door adjustment. See CAB DOOR ADJUSTMENT for complete details.

DOOR GLASS

REMOVE

1. Remove door trim as covered previously.

2. Remove rubber insert from around door access cover. Use blunt nose screwdriver or seal tool as shown (Fig. 10). Lift out cover and remove seal from access opening.

3. Lower window glass to bottom of its channel.

4. Working thru access opening remove two glass fastener screws from window guide and detach guide from glass and window regulator lever (Fig. 11).

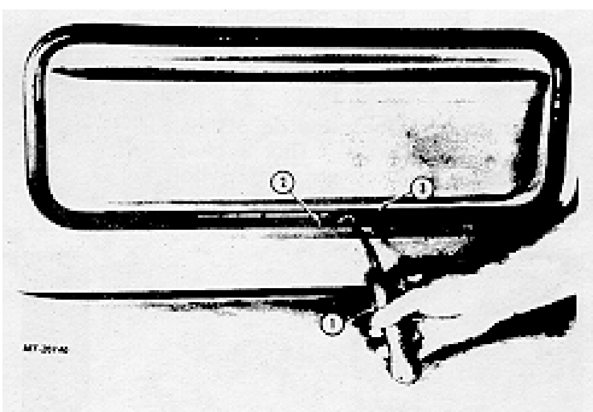

Fig. 10 Removing Access Panel from Door

1. Seal Tool
2. Insert
3. Seal

5. Remove button plug from side of door for access to rear glass run channel upper retaining bolt. Remove bolt.

6. Remove two retaining bolts from lower end of glass rear run channel. Remove channel and channel seal (Fig. 12) from glass and lay aside in door.

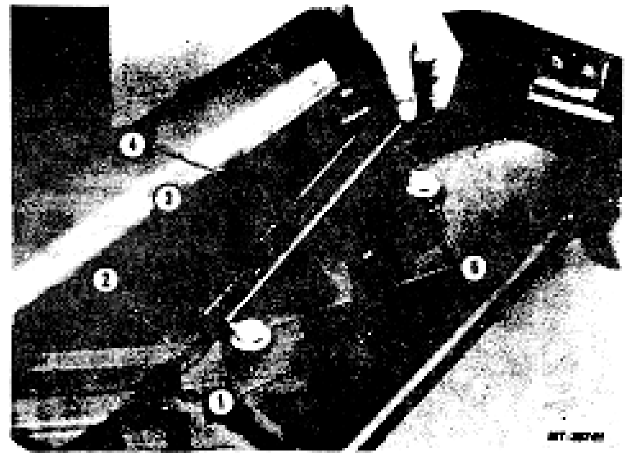

Fig. 11 Removing Window Guide from Window Glass

1. Regulator Lever
2. Window Glass
3. Window Guide
4. Door Access Opening
5. Fasteners

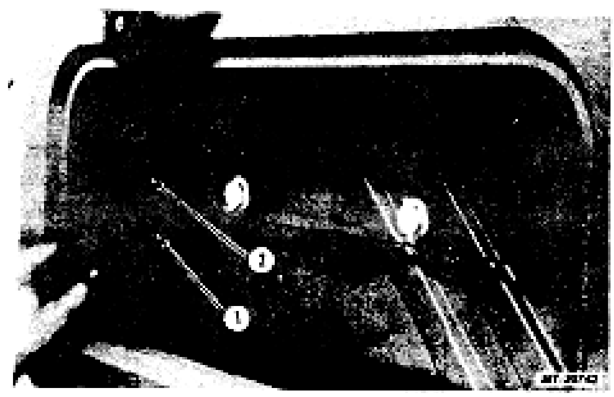

Fig. 12 Removing Rear Run Channel

1. Rear Run Channel
2. Channel Seal

7. Remove glass from front run channel.

8. Pull glass out bottom of access opening (Fig. 13).

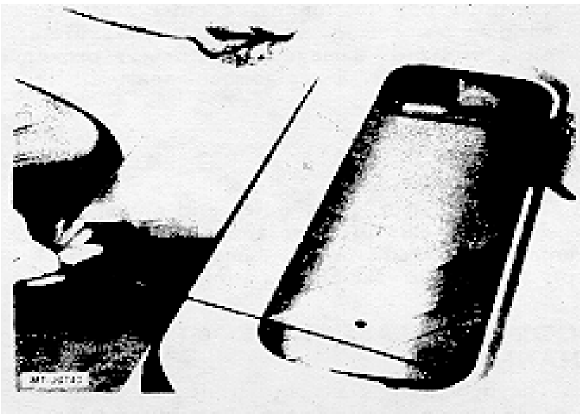

Fig. 13 Removing or Installing Window Glass

INSTALL

1. Insert window glass through access opening (Fig. 13).
2. Enter glass into front run channel.
3. Slide rear run channel and channel seal onto rear edge of glass.
4. Secure rear run channel retainer to upper and lower mounting brackets with bolts and washers.
5. When assured that glass will slide easily from top to bottom in window channels, move window to lowered position.

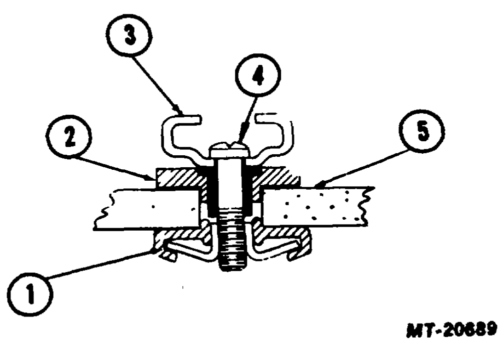

Fig. 14 Window Glass Fastener Cross Section

1. Fastener, Lower Half
2. Fastener, Upper Half
3. Window Guide
4. Screw
5. Window Glass

6. Temporarily install regulator handle and turn regulator lever to engage with bottom edge of window.
7. Install window guide and regulator lever stud to window glass using the two fastener assemblies (Fig. 14) through holes provided in glass.
8. Operate regulator handle to make sure all components have been assembled correctly.
9. Reinstall access door.

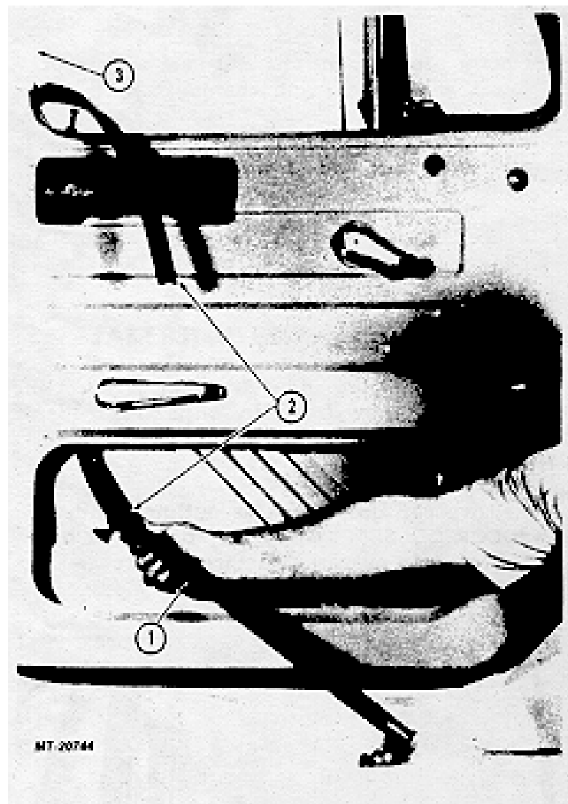

Fig. 15 Removing Rear Run Channel and Seal

1. Rear Run Channel
2. Channel Seal
3. Door Window Frame

DOOR GLASS REAR RUN CHANNEL AND CHANNEL SEAL

The door glass rear channel seal (weather stripping) is moulded for a compression fit in window frame as well as in glass rear run channel. No clips are required to retain it. Channel and seal are removed together.

REMOVE

1. Remove cab door glass as outlined under "DOOR GLASS". Glass may be left in bottom of door or removed through access opening as desired.

2. Pry out channel seal from door window frame (Fig. 15).

3. Since rear run channel is already loosened as outlined under "DOOR GLASS", remove channel and seal through door access opening (Fig. 15).

INSTALL

1. Obtain replacement channel seal and insert lower end in rear run channel.

2. Place channel and seal assembly inside door and press upper end of seal into window frame.

3. Procedure for mounting rear run channel to door is same as covered under "DOOR GLASS".

DOOR GLASS INNER AND OUTER SEALS

Door glass inner and outer seals are retained in bottom of window frame by clips (Fig. 16).

REMOVE

1. Remove cab door glass as outlined under "DOOR GLASS". Glass may be left in bottom of door or removed through access opening as desired.

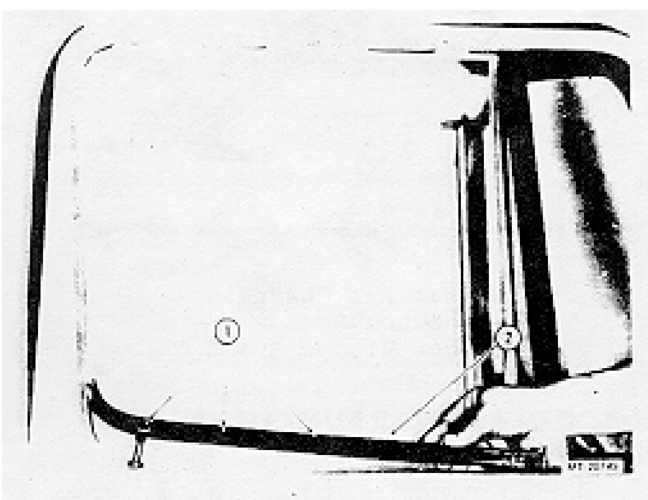

Fig. 16 Door Inner Seal

1. Clips
2. Door Glass Inner Seal

2. Carefully pry out inner and outer seals from window frame (Fig. 16). Apply pressure at clips to avoid damage. If clips are broken during removal, a replacement seal will be necessary.

INSTALL

To install door glass inner and outer seals, simply align seals in place and press clips into openings provided. Avoid damage to seal by applying pressure at clip locations only.

DOOR VENT GLASS AND FRONT RUN CHANNEL

The door vent glass and front run channel (Fig. 17) is serviced as one assembly. It is held in place in door by two pan head screws and two hex head bolts.

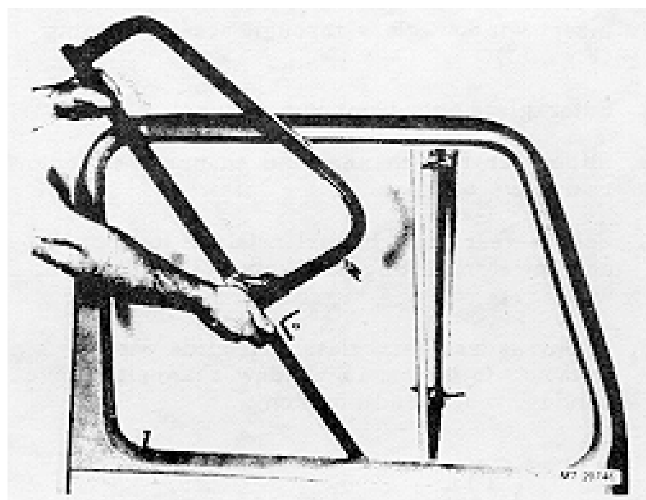

Fig. 17 Removing or Installing Door Vent Glass and Front Run Channel

REMOVE

1. Remove door glass and door glass window seals as outlined previously.

2. At the outside of door remove two pan head mounting screws, one from top and one from front edge.

3. From inside of door remove two hex head bolts and detach vent glass and front run channel from door.

4. Lift out vent glass and front run channel as an assembly through window frame (Fig. 17).

INSTALL

Door vent glass and front run channel installation is accomplished by reversing the foregoing removal procedure.

DOOR GLASS REGULATOR

The cab door glass regulator is serviced as a complete unit with the door glass either in place or removed. If it is not desired or necessary to replace door glass, simply lower glass sufficiently to detach regulator lever from glass and then push glass back up into window frame. Secure glass temporarily to top of door with tape.

REMOVE

1. Remove door hardware, trim and access door (same as for removing door glass).
2. Lower glass to bottom of door and remove the two glass fastener screws and regulator lever from window guide.
3. Remove window guide by sliding it from regulator lever.
4. Push door glass up in window frame and secure glass to top of door with tape.
5. Remove the four retaining screws which hold regulator assembly in door.
6. Push regulator shaft through hole in door inner panel and remove regulator assembly through access opening (Fig. 18).

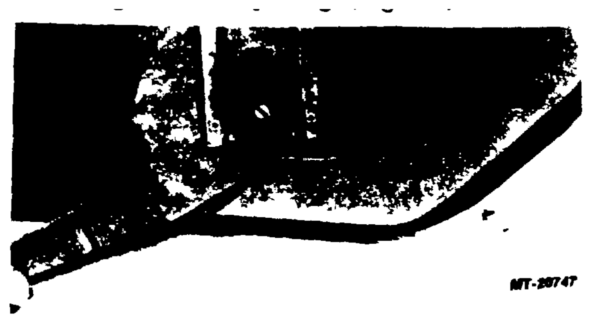

Fig. 18 Removing or Installing Door Glass Regulator

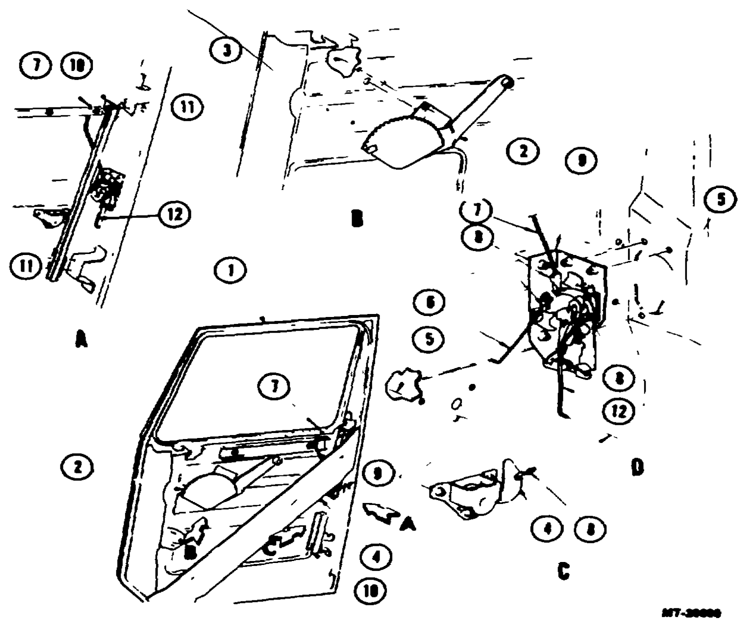

Fig. 19 Door Glass Regulator and Latch Details

Key	Description	Key	Description	Key	Description
1	Door, Assembly, Cab	5	Screw Mounting	9	Latch, Assembly Door
2	Regulator, Assembly; Window	6	Rod, Remote Control to Latch	10	Retainer, Rear Run Channel
3	Screw, Mounting, Pan Head	7	Rod, Lock Knob to Latch	11	Bolt, Mounting, Hex Head
4	Control Assembly, Remote	8	Clip, Rod End	12	Rod, Lock, Cylinder to
A.	View in Direction of Arrow A	C.	View in Direction of Arrow C		Latch
B.	View in Direction of Arrow B	D.	To Lock Cylinder		

IMPORTANT

Be careful when reinstalling door glass, door glass regulator and related parts to avoid glass breakage. Door glass inner and outer seals, channel seals and glass mounting fasteners have been designed to protect glass through rugged operating conditions. Make sure the reassembly of these parts will maintain this same glass protection.

INSTALL

Cab door glass regulator installation is accomplished by reversing the foregoing removal procedure. See Fig. 19 for door internal component details.

LUBRICATE

Lubricate cab door glass regulator gear teeth, arm pin and slide at installation. See Lubrication.

DOOR LATCH ASSEMBLY AND REMOTE CONTROL

The cab door latch assembly (Figs. 19 and 20) used with this door features positive no-rattle latch jaws which engage with striker pin on cab lock pillar. Latch assembly mounts to a small opening in edge of door and connects to remote control, lock cylinder and lock knob by relay control rods.

REMOVE

1. Remove door hardware, trim and access door (same as for removing door glass).

2. Remove lock knob from relay control rod through window frame.

3. Unfasten rod end clips and remove relay control rods from remote control assembly and from lock cylinder assembly. Opposite ends of the three relay control rods can remain attached to latch assembly.

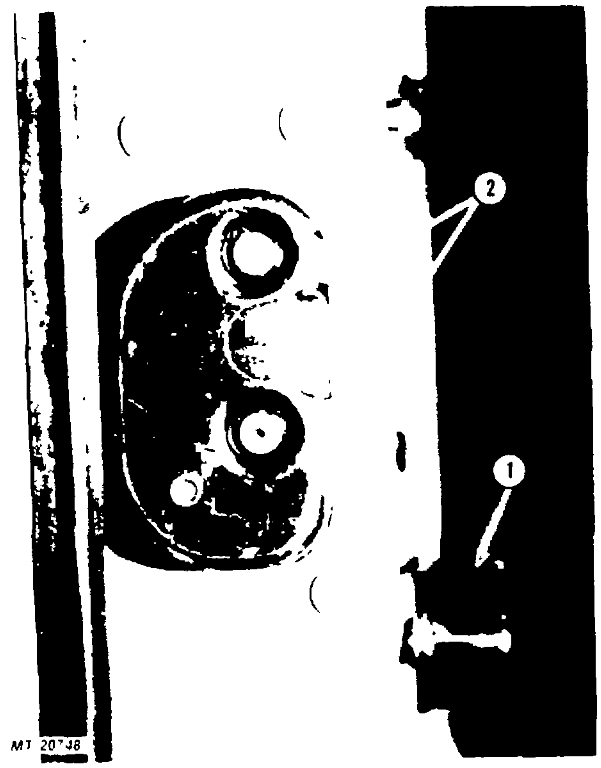

Fig. 20 Door Latch Assembly

1. Remote Control Handle
2. Latch Jaws

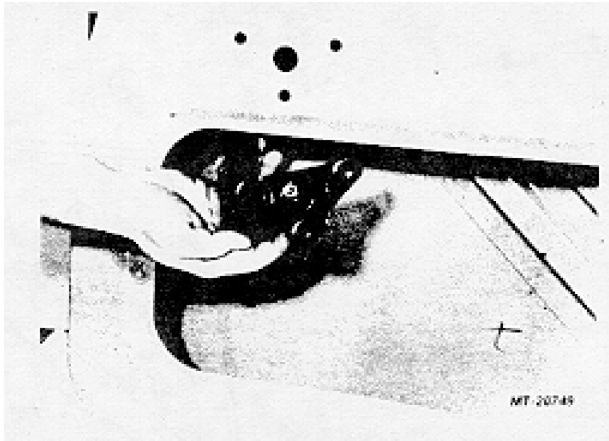

Fig. 21 Removing Remote Control Assembly

4. Remove three socket head screws and detach remote control from inside of door (Fig. 21).

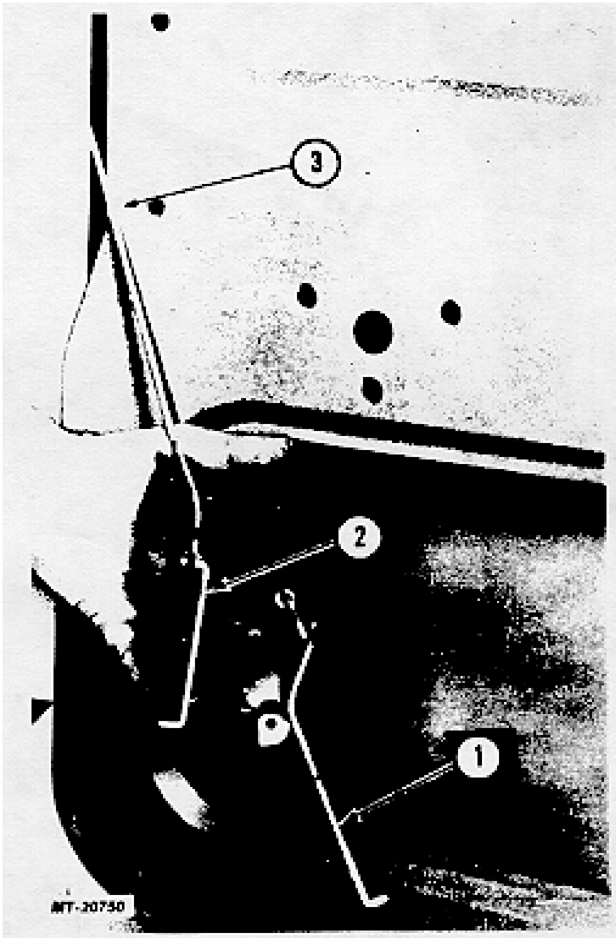

Fig. 22 Removing Latch Assembly

1. Remote Control to Latch Rod
2. Lock Cylinder to Latch Rod
3. Lock Knob to Latch Rod

5. Remove five socket head screws and detach door latch assembly from inside of door frame (Fig. 22). Latch jaws should be closed.

INSTALL (Refer to Fig. 19 for Component Details)

1. Position latch assembly to inside of door. Latch jaws must be closed and the three relay control rods should be pre-assembled to latch.

2. Pilot threaded end of upper lock knob rod through lock knob hole in window frame while positioning latch. Install lock knob.

3. Secure latch assembly in door with five socket head screws.

4. Position remote control assembly in door and secure with three socket head screws.

5. Connect the two remaining relay control rods to remote control assembly and to lock cylinder lever. Secure rods with rod end clips.

6. Operate latch assembly to assure correct assembly.

DOOR OUTER HANDLE

The door outer handle (Fig. 23) is a combination handle and lever operating assembly that connects with the latch assembly mechanism inside door to actuate the latch jaws. Outer handle can be removed without removing latch assembly.

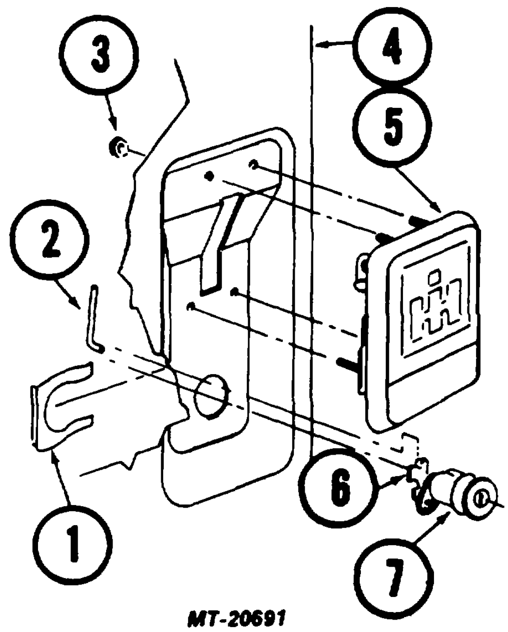

Fig. 23 Door Outer Handle & Lock Cylinder

1. Lock Cylinder Retainer
2. Lock Cylinder to Latch Rod
3. Nut with Washer
4. Door
5. Door Outer Handle Assembly
6. Rod End Clip
7. Lock Cylinder Assembly

REMOVE

1. Remove door hardware, trim and access door (same as for removing door glass).

2. Remove three hex nuts from studs through door from rear of handle.

3. Remove door outer handle from door (Fig. 24).

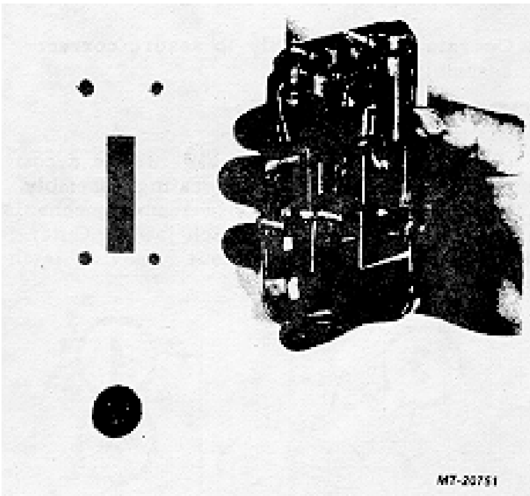

Fig. 24 Removing Door Outer Handle

INSTALL

To install outside door handle, reverse foregoing removal procedure.

DOOR LOCK CYLINDER ASSEMBLY

The door lock cylinder (Fig. 23) is key coded to key switch on instrument panel so that one key operates both. If keys are lost or a replacement of lock cylinder is desired, see special instructions under "KEY SWITCH AND DOOR LOCK CYLINDER REPLACEMENT".

REMOVE

1. Remove door hardware, trim and access door (same as for removing door glass).
2. Disconnect rod end clip and detach control rod from door lock cylinder assembly.

3. Working through door access opening pry lock retainer from lock cylinder assembly (Fig. 25) with a small pry bar or screwdriver.

4. Rotate lock cylinder assembly slightly and remove from door.

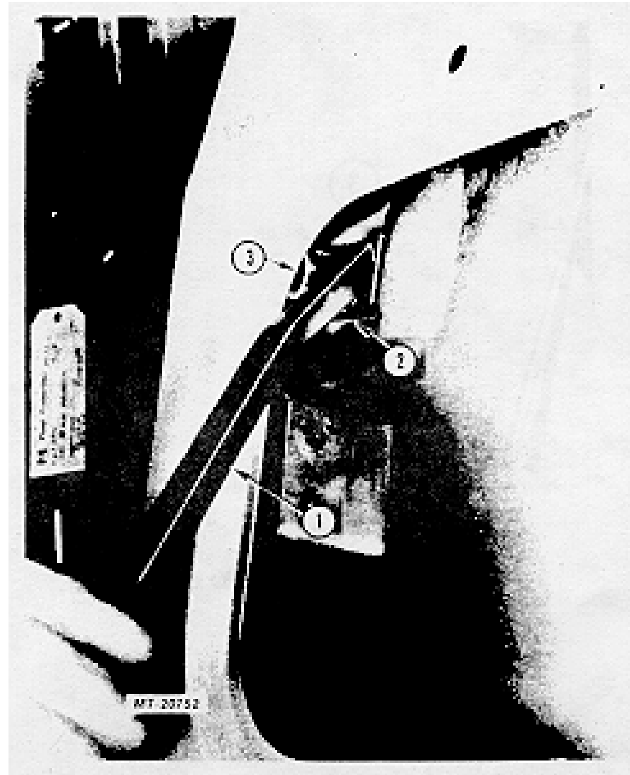

Fig. 25 Removing Lock Cylinder Retainer

1. Pry Bar
2. Lock Cylinder Retainer
3. Lock Cylinder Assembly

IMPORTANT
Lock cylinder retainer can be removed without removing glass rear run channel. Channel removed in Fig. 25 for clarity.

INSTALL

To install door lock cylinder assembly, reverse foregoing removal procedure.

KEY SWITCH AN DOOR LOCK CYLINDER REPLACEMENT

The instrument panel mounted key switch and the lock cylinder in the door are coded so that one key operates both. Code number is stamped on key switch body just back of cap nut. Door lock cylinder assembly does not have a code number stamped on body since this cylinder is coded to the key switch.

To locate code number on key switch, remove key switch mounting cap nut and detach key switch from instrument panel.

The key switch cylinder can be replaced providing the regular key Is used.

REMOVE

To remove key switch cylinder from switch body, place key in switch cylinder and insert a piece of stiff wire or rod 1.5 mm (1/16") dia. in the small hole behind cap nut in switch body Turn key to left (accessory position) and press the cylinder retainer down with the wire. The switch cylinder can then be pulled out of switch body.

INSTALL

To install a new switch cylinder, simply push cylinder into switch body and turn to right ("ON" position) until the cylinder retainer snaps into place.

Door lock cylinder replacement is by the complete assembly. Lock cylinder itself (tumbler unit) is not removable. If door lock replacement is required, lock cylinder assemblies should be replaced in pairs.

If a replacement of key switch cylinder is necessary and the operator wants to use the original key, the tumblers on the new switch cylinder can be coded accordingly.

This is accomplished by inserting original key in new cylinder (cylinder removed from body) and filing off the tumblers that protrude from cylinder. When making this change, be sure n6 burrs are left on tumblers and all filings are blown out with air. Apply a small quantity of powdered graphite to tumblers and reinsert cylinder In key switch body.

IMPORTANT

If keys are lost, switch cylinder must be drilled out using a 7.9 mm (5/16") drill, 12.7-19 mm (1/2-3/4") deep. This will permit tumblers to drop out and free lock.

DOOR WEATHER SEAL

A one piece rubber weatherseal is secured to cab door flange with plastic fasteners and provides a weather-tight seal around door when door is closed.

REMOVE

Pry up old weather seal at fastener locations and remove complete seal from cab door flange.

INSTALL

1. Obtain new seal.

2. Be sure all old fasteners have been removed and door flange is free 6f dirt.

3. Place new weather seal into place on door flange and align fasteners over mounting holes.

4. Apply pressure to each fastener to secure weatherseal.

DOOR STRIKER PIN

Door striker pin (Fig. 26) mounted on lock pillar provides for positive engagement with the door latch assembly (Fig. 20). Striker pin removal and installation requires a special driver tool. Enlarged mounting hole in lock pillar permits adjustment.

For complete details on striker pin adjustment, see "CAB DOOR ADJUSTMENT".

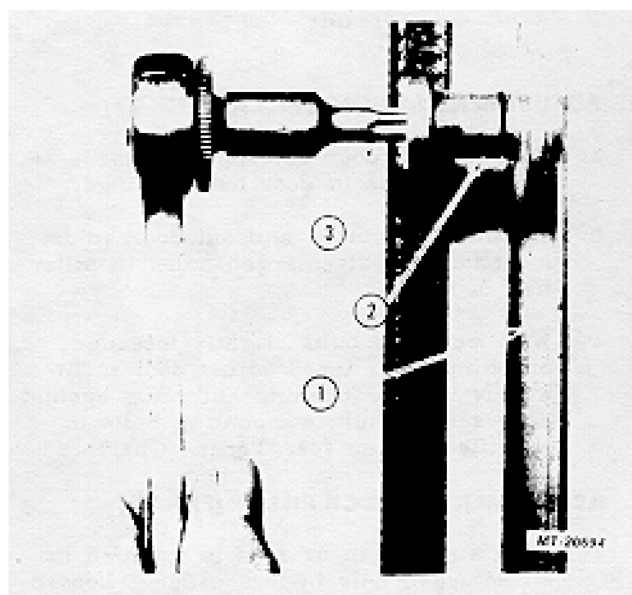

Fig. 26 Removing or Installing Door Striker Pin

1. Lock Pillar
2. Door Striker Pin
3. Driver Tool

CAB DOOR ADJUSTMENT

Getting a good cab door to door opening fit requires a knowledge of where the various adjustments are located and what effect each adjustment has on door fit. These adjustments apply whether door has been removed or door adjustment is simply being changed or improved.

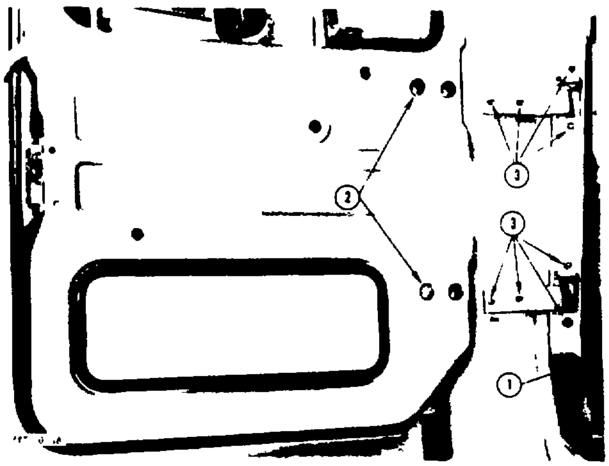

Fig. 27 Location for Door Adjustments at Hinge Pillar

1. Hinge Pillar
2. Access to Hinge Mounting
3. Enlarged Mounting Holes for Door Adjustment

1. ADJUSTMENT AT HINGE PILLAR (FIG. 27)

a. Fore and aft door adjustment is made at enlarged holes in door half of hinge.

b. Up and down or in and out door adjustment is made at enlarged holes in pillar half of hinge.

c. With mounting bolts slightly loosened, one hinge at a time, adjust door to fit evenly in door opening and snug against door seal. Tighten mounting bolts to specified torque (see Torque Chart).

2. ADJUSTMENT AT LOCK PILLAR (FIG. 26)

a. Door striker pin or stud is mounted in an enlarged hole in lock pillar. Loosen pin to move pin up or down and in or out as required.

b. Fore and aft adjustment is by spacer shim between striker pin and pillar.

c. Make final adjustment of striker pin and tighten to specifications (See Torque Chart).

When adjusted (1) door weatherseal should contact door frame all around with slight pressure but without damage to seal (2) door should latch, lock and release without undue effort, and (3) door should be rattle free when vehicle is in motion.

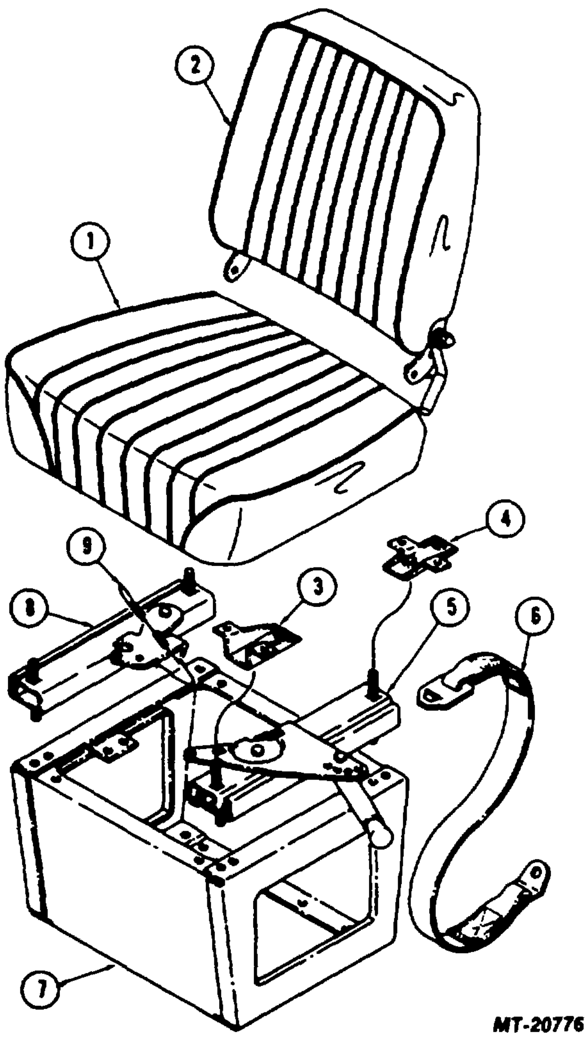

Fig. 29 Individual Drivers Seat

Key	Description
1	Cushion, Seat Assembly
2	Cushion, Back with Support
3	Bracket, Seat Adjuster Front
4	Bracket, Seat Adjuster Rear
5	Adjuster with Handle, Seat Left
6	Belt. Seat
7	Riser, Seat
8	Adjuster, Seat, Right
9	Wire, Seat Adjuster

REMOVE

1. Remove the four bolts which secure the upper adjuster rails to seat bottom on right and left side and detach seat and back assembly. Slide seat fore and aft as necessary for access to mounting bolts.

2. Unlock seat adjuster wire between the two rails.

3. Remove two bolts which secure lower half of each seat adjuster to seat riser and remove right and left seat adjusters.

4. Clean seat adjusters as required. Apply a light coat of multi-purpose lube (IHl 251 HEP) to rails to assure a smooth operation on reassembly. Wipe away excess lube.

INSTALL

Seat Installation procedure is the reverse of removal. See Torque Chart for specified mounting torques.

WINDSHIELD

Page 3047 DELETED

REMOVE

If either windshield or weatherseal must be replaced, procedure is as follows:

1. Remove washer hose from fittings on top of cowl.

2. Remove cap nut and detach windshield wiper arms (Fig. 30).

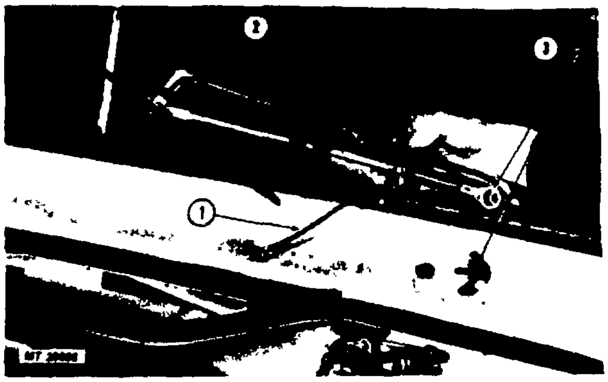

Fig. 30 moving Windshield Wiper Arm

1. Washer Hose
2. Wiper Arm
3. Serrations

3. Pry integral or detached insert from weatherseal with a thin blade screwdriver or seal tool (SE-2442) (Fig. 31) around entire glass. See Fig. 32 for details of weatherseal.

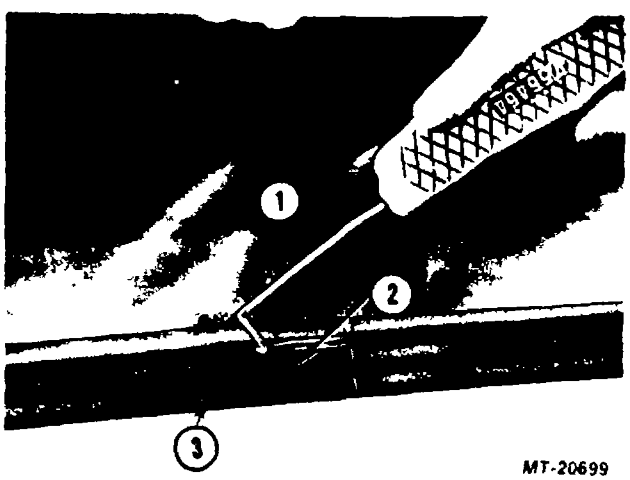

Fig. 31 Removing Windshield Weatherseal Insert

1. Sad Tool
2. Insert
3. Seal

5. Working with one man outside cab and an assistant inside apply light pressure on windshield from inside of cab to push glass from seal. Be careful during this operation since heavy pressure at each one point can lead to glass breakage.

6. Lift glass from opening and peel weatherseal from fence (weld flange).

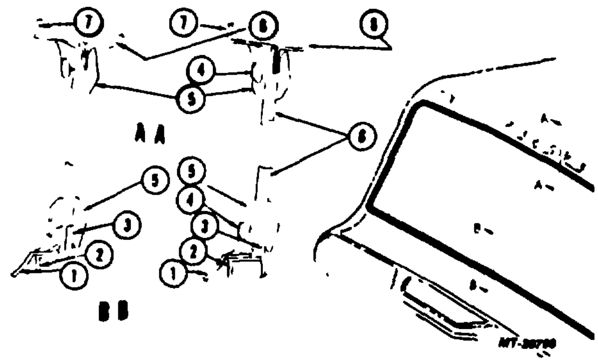

Fig. 32 Windshield Weatherseal (Retainer)

1. Cowl Outer
2. Cowl Inner
3. Cowl Bar
4. Insert
5. Seal
6. Glass
7. Panel Outer
8. Panel Inner

A-A Section thru upper portion of windshield and seal B-B Section thru lower portion of windshield and seal

INSTALL

IMPORTANT
Before installing new weatherseal or windshield, clean body flange and glass free of dirt, old sealing compound, wax, etc.

1. Coat weatherseal with a soapy solution or rubber lubricant for ease of assembly.

2. Install weatherseal carefully around edge of windshield opening flange. Position splice joint of seal ends at centerline of cab and on lower flange.

3. Working from outside the cab, place windshield in channel of weatherseal, starting at lower edge of opening.

REAR WINDOW GLASS

Cab rear window glass (Fig. 34) is secured in cab rear window opening with a molded one piece weatherseal with integral insert similar to that used for windshield. The weatherseal fits around edge of glass and is so formed, that it retains the glass in window opening by fitting over the window opening flange. Old or deteriorated weatherseals should not be reused whenever window glass is replaced.

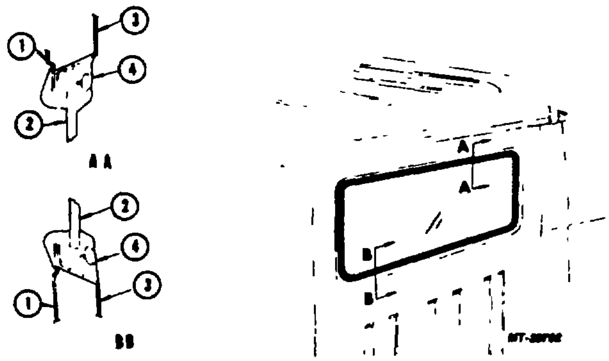

Fig. 34 Cab Rear Window Glass and Weatherseal

1. Panel Inner 3. Panel Outer
2 Glass 4. Insert

A-A Section thru upper portion of rear window glass B-B Section thru lower portion of rear window glass

REMOVE

1. Pry out integral insert of weatherseal with seal tool or a thin blade screwdriver around entire perimeter of glass.

2. Working with an assistant, one man inside cab and one man outside, gently push glass from inside out.

3. Lift glass-from opening.

INSTALL

IMPORTANT

Before installing new weatherseal or window glass, body flange and glass must be cleaned free of dirt, old sealing compound, wax, etc.

1. Coat weatherseal with a soapy solution or rubber lubricant for ease of assembly.

2. Position weatherseal carefully around edge of rear window glass opening flange.

3. Working from outside the cab place rear window glass in channel of weatherseal starting at lower edge of opening.

4. With glass completely seated in weatherseal channel start working weatherseal insert down into groove provided with seal tool or dull screwdriver. A second coat of rubber lubricant will expedite this step.

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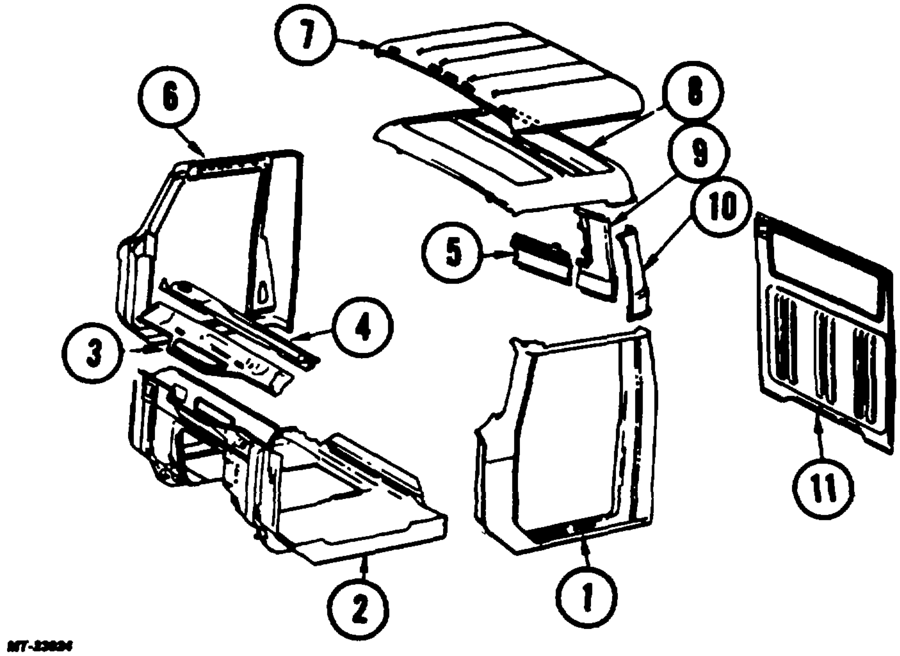

Fig. 35 S-Series Cab Panels

1. Side Panel Assembly
2. Underbody (Not Serviced)
3. Cowl Top Inner Panel
4. Cowl Rear Panel
5. Back Inner Panel
6. Side Panel Assembly
7. Roof Panel
8. Roof Inner Panel
9. Inner Corner Panel Extension (90 x 90 Cab Only)
10. Inner Corner Panel
11. Back Outer Panel

SHEET METAL REPAIRS

A special feature of the S-Series Cab is the availability of complete body panels for repairing the cab. The types of panels available are shown in Fig. 35. These panels enable **a** service man to restore a damaged cab to new condition without the usual problems associated with cab rebuilding. Extensive metal refinishing is not required and most restoration welds are in areas of low stress.

SHEET METAL TOOLS

To perform the necessary cab sheet metal disassembly and rebuild work, the special tools listed here should be on hand. Most of these are common to any cab or body rebuilding shop.

1. Electric or pneumatic drill.
2. Sheet metal drill bits.
3. Pneumatic chisel (SE-2664 or SE-2129).
4. An "sortment of C-clamps.
5. MIG welder (SE-2640).
6. Weld wire Spec. No. E70S-3.

PREPARING CAB FOR PANEL REMOVAL

Before sheet metal repairs to cab can be started some mechanical work must be performed. This will depend on cab damage and which panel is being replaced. Since the side panel (Fig. 36) or door frame is a commonly replaced panel, let us use the left side panel replacement as an example for what mechanical work is required. The following items must be removed:

1. Left door, seat and interior trim.
2. Dash pad and instrument panel left side mounting.
3. Roof and back panel liners.
4. Left scuff plate and floor mat.
5. Windshield and rear window glass.
6. Junction boxes, relays, dimmer switch, wiring harness and brake piping.
7. Marker light harness and air horn supply line.
8. Fuse block, junction block and starter solenoid.
9. Fuel or air tanks.
10. Cowl top outer panel.

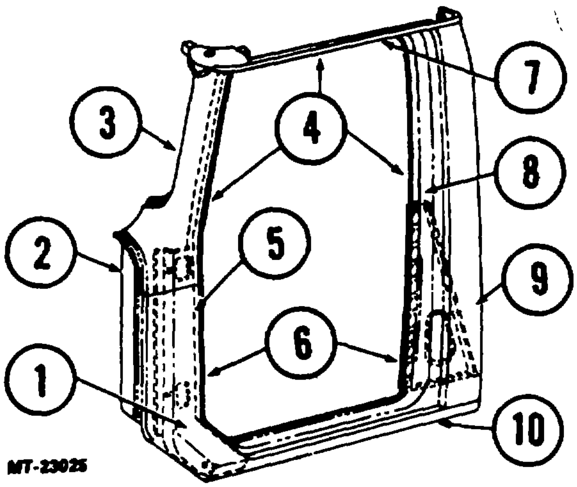

Fig. 36 Components of Side Panel Assembly

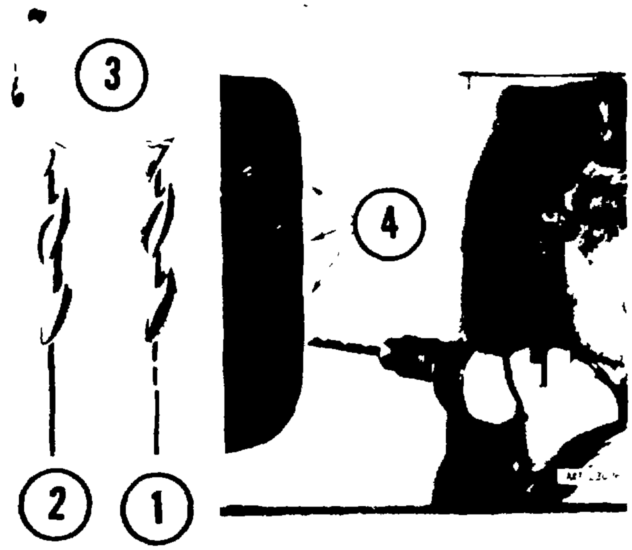

Fig. 37 Removing Cab Inner Corner Panel

1. Cowl Side Panel
2. Dash Filler Panel
3. Windshield Side Inner and Outer Panels
4. Door Frame
5. Hinge Pillar
6. Inner Side Panels
7. Drip Moulding
8. Lock Pillar
9. Outer Corner Panel
10. Rocker Panel

REMOVING SPOT WELDS

The actual side panel removal requires the drilling out of spot welds which attach the side panel to other panels of the cab. Sheet metal drill bits should be used. These are drill bits, the ends of which have been ground for this special purpose. An example of a sheet metal drill bit as compared to a regular drill bit is shown in Fig. 37. When spot welds have been removed, a pneumatic chisel is then used to open seams which have been clinched together.

1. Sheet Metal Grind
2. Regular Grind
3. Drill Bits
4. Spot Welds

SIDE PANEL REMOVAL

1. For access to back panel joint, remove cab inner corner panel. Remove trim strip between corner panel and inner roof panel and drill out spot welds (Fig. 37) around panel. Separate corner panel from back panel, inner roof panel and side panel assembly.

2. Separate inside panel of side panel assembly from sill side inner panel. Free inside panel of side panel assembly by cutting through MIG weld (Fig. 38) at bottom of panel.

3. Drill out spot welds along drip moulding from front to rear and around corner to end of side panel. Separate side panel from outer roof panel (Fig. 39).

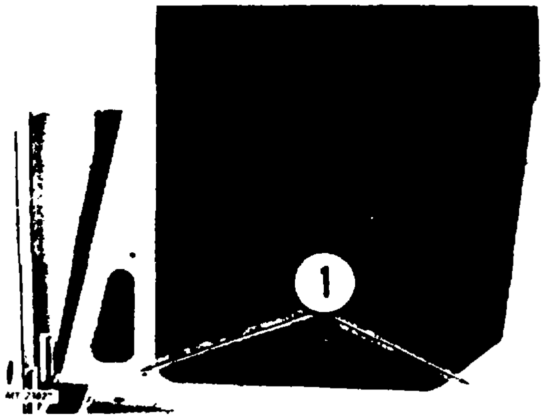

Fig. 38 Location of MIG Weld Seams

1. MIG Welds

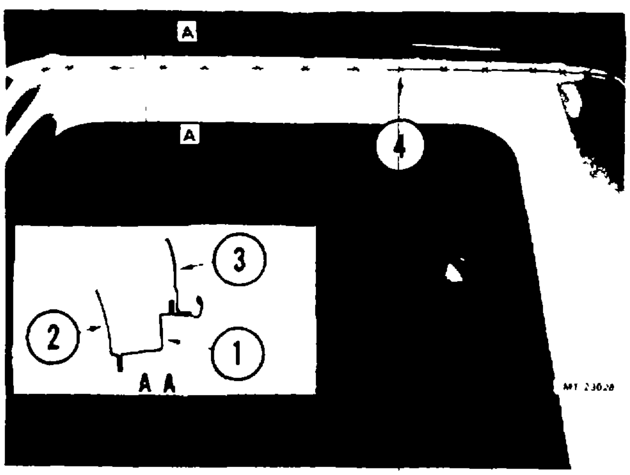

Fig. 39 Side Panel to Outer Roof Panel Spot Welds

1. Side Panel Assembly
2. Inner Roof Panel
3. Outer Roof Panel
4. Drill Out Welds Along Drip Moulding

A-A Section thru Side Panel and Outer Roof Panel

4. Drill out spot welds along seam between back panel and side panel and separate rear of side panel from back panel (FiRg. 40). Drill at outer seam.

5. Drill out spot welds along seam at bottom of cab and separate rocker panel from sill side inner panel (Fig. 41).

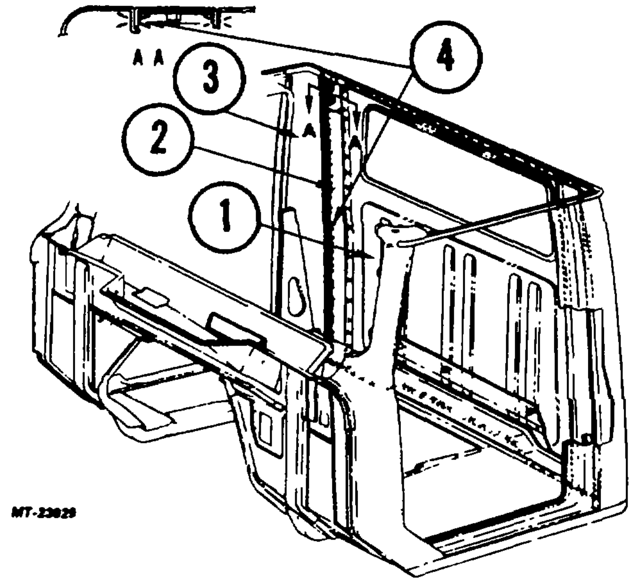

Fig. 40 Side Panel to Back Panel Spot Welds

1. Back Panel
2. Back Panel Filler
3. Side Panel Assembly
4. Drill Out Welds (Outer Seams Only)

A-A Section thru Back Panel and Side Panel

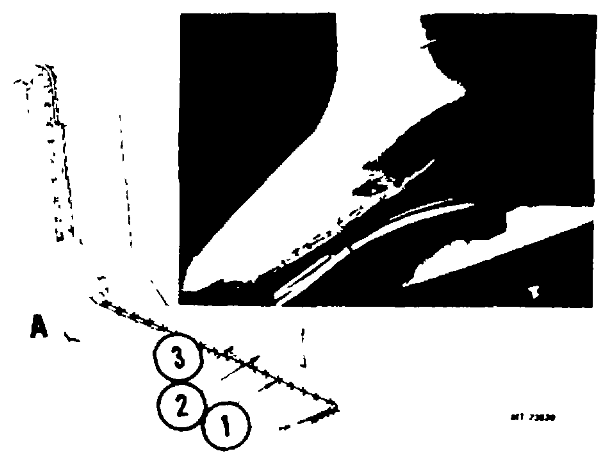

Fig. 41 Rocker Panel to Sill-Side Inner Panel Spot Welds

1. Drill Out Welds
2. Rocker Panel
3. Sill Side Inner Panel
A. Front

6. Drill out spot welds at seam between dash filler panel and dash panel. Separate filler panel from dash panel (Fig. 42).

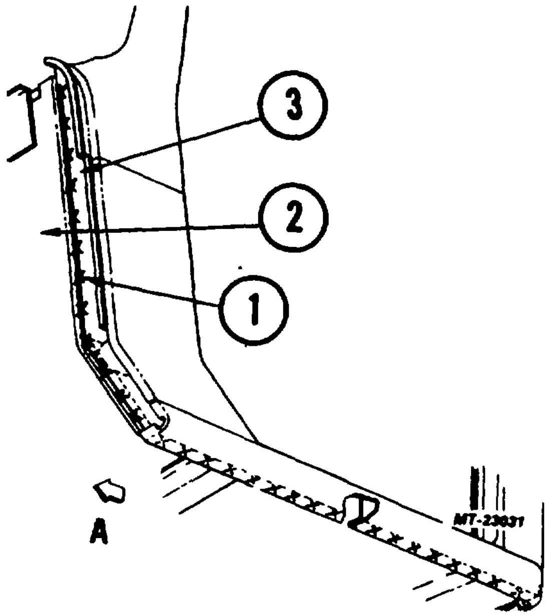

Fig. 42 Filler Panel to Dash Panel Spot Welds

1. Drill Out Welds
2. Dash Panel
3. Dash Filler Panel
A. Front

7. Drill out five spot welds and separate windshield side outer panel from cowl top inner panel (Fig. 43).

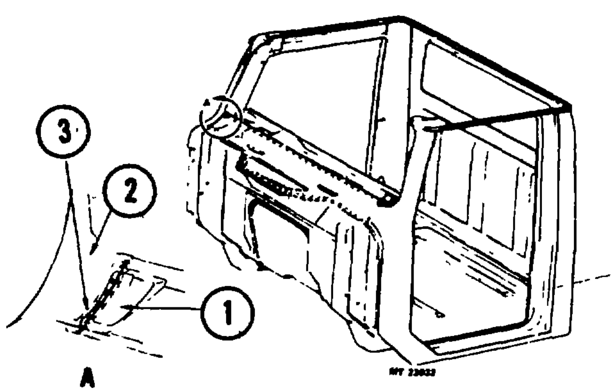

Fig. 43 Windshield Outer Panel to Cowl Inner Panel Spot Weld (Rt. Side Shown)

1. Cowl Top Inner Panel
2. 'Windshield Side Outer Panel
3. Drill Out Welds
A. View in Circle A

8. Drill out six spot welds and separate windshield side outer panel from cowl rear panel and bracket (Fig. 44).

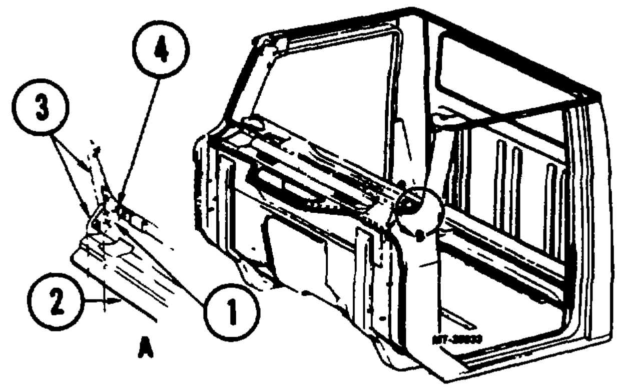

Fig. 44 Windshield Side Outer Panel to Cowl Rear Panel and Bracket Spot Welds

1. Cowl Rear Bracket
2. Cowl Rear Panel
3. Windshield Side Outer Panel
4. Drill Out These Welds
A. View in Circle B

9. Drill out three spot welds and separate side panel from roof outer and inner panels (Fig. 45).

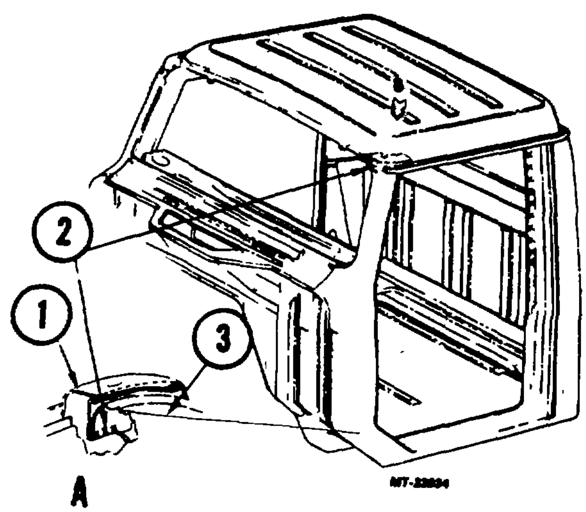

Fig. 45 Side Panel to Roof Outer and Inner Panel Spot Welds (Outer Roof Panel not Shown)

1. **Side** Panel Assembly
2. Drill Out 3 Welds
3. Roof Inner Panel
A. View in Direction of Arrow B

10. Drill out fourteen spot welds along top of door opening and separate side panel from roof inner panel (Fig. 46).

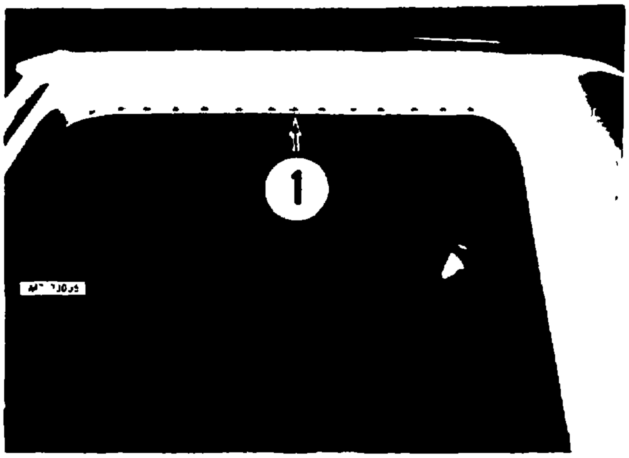

Fig. 46 Side Panel to Roof Inner Panel Spot Welds

1. Drill Out These Welds

11. Drill out fifteen spot welds along bottom of door opening and separate side panel from sill side inner panel (Fig. 47).

12. Drill out three or four additional welds along top edge of windshield opening as required to separate roof panels and raise roof panel sufficiently to permit removal of side panel from cab.

IMPORTANT

Be careful while removing side panel so as to avoid damage to roof panel.

Fig. 47 Side Panel to Sill Side Inner Panel Spot Welds

1. Side Panel Assembly
2. Drill Out Welds
3. Sill Side Inner Panel

A. Front
B. View in Direction of Arrow B

INSPECT CAB STRUCTURE FOR DAMAGE

With side panel removed, inspect remainder of cab for damage. Look especially for and repair.

1. Damage to cab sill welds.
2. Loosening of floor panels.
3. Underbody bent out of alignment. (This step can vary with each job. Keep in mind you are trying to return cab to its original condition.)

Reweld any cracked or missing welds. The sill side inner panel on the cab underbody must be straight and flat.

ALIGN NEW SIDE PANEL TO CAB

1. Position and clamp new side panel assembly to side of cab.

2. Raise roof outer panel sufficiently to insert windshield pillar top corner between inner and outer roof panels.

3. Apply heat expanding type sealer (Plastisol or equivalent) to this seam.

4. Align panels to establish windshield opening and install "C" clamps to secure.

5. Align remaining 3oints at dash panel, cowl, roof panel and back panel using "C" clamps to hold new side panel in place.

WELDING SIDE PANEL TO CAB

1. Using MIG welder inside cab (Fig. 48), plug weld around door opening through holes drilled out of original cab panels during side panel removal.

CAUTION
Adjust welder so as not to damage or burnsheet metal when performing these welds.

2. Where drilled holes are not accessible such as at bottom of rocker panel, use 2.5 cm (1 inch) seam welds spaced 7.5 cm (3 inches) apart to secure rocker panel to sill side inner panel.

Fig. 48 Using MIG Welder For Plug Welds

3. At inside of cab weld base of inner side panels to sill side inner panel (Fig. 49).

Fig. 49 Seam Weld At Inside Of Side Panel

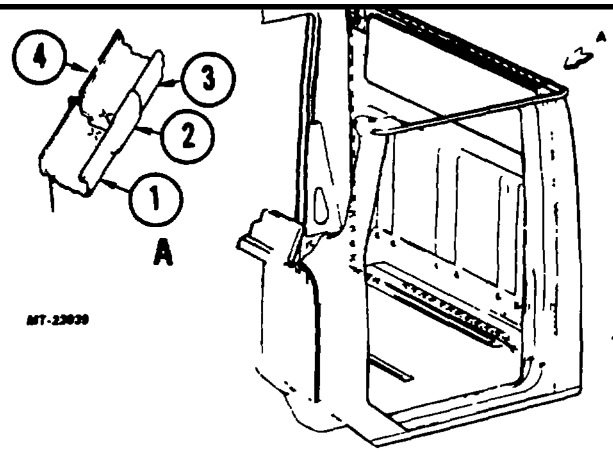

Fig. 50 Securing Drip Moulding Clip

1. Side Panel Drip Moulding
2. Drip Moulding Clip
3. Rear Drip Moulding
4. Back Panel

A View in Direction of Arrow A

4. Obtain drip moulding clip and position clip so as to close joint between old drip moulding on back of cab and drip moulding on new side panel (Fig. 50). Secure with one plug weld at each side of joint.

5. Clamp outer roof panel to drip moulding of new side panel assembly and plug weld roof panel to moulding (Fig. 51).

Fig. 51 Fastening Roof Panel To New Side Panel

6. Plug weld through holes drilled for removing to replace inner corner panel to inside of cab (Fig. 52). If new inner corner panel is used, plug weld holes must be drilled into new panel before welding.

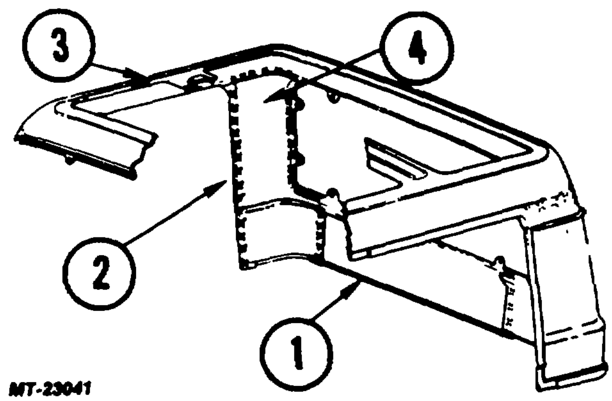

Fig. 52 Installing Inner Corner Panel (Right Side - "80 Wide Cab Shown)

1. Inner Back Panel
2. Plug Weld at these Locations
3. Inner Roof Panel
4. Inner Corner Panel

7. Grind, sand or wire brush away any excess weld or weld ash from all newly welded areas .
8. Obtain body sealant (Plastisol Type 1 or equivalent) and apply to the following locations:
   a. Roof panel to drip moulding seam.

   b. Side panel to back panel joint at rear of cab.

   c. Dash filler panel to dash panel joint at front of cowl.
   d. Drilled out holes on upper side of sill side inner panel to rocker panel seam (under cab).
9. Apply primer paint to affected areas to assure good protection from rust. Finish paint as required.

OTHER PANEL REPAIRS

Since each cab panel component contributes to the overall strength of the cab, proper welding, sealing and rust-proofing practices must be observed for any other panel replacement. Under-cab components especially should be rust-proofed whenever cab repair operations are performed.

When rust-proofing cab components, use a good quality air-dry zinc rich primer. Combination type primer-surfacer paints are not recommended. Finish paint as required.

Fig. 53 Cab Front Mounting Bracket (Left Front View)

Key	Description
1	Sill, Cab Underbody
2	Bolt, Intermediate Bracket
3	Bracket, Intermediate
4	Washer. Flat
5	Insulator, Water Type
6	Sidemember, Frame
7	Insulator, Donut Type
8	Bolt and Nut (Cab Mounting)
9	Bracket, Cab Front Mounting
10	Bushing
11	Bolt, Nut and Washer
12	Reinforcement
A	View in Direction of Arrow A

CAB MOUNTING

A four point rubber cushioned mounting is used for securing cab to frame. This mounting has been designed to give a firm foundation to cab and at the same time provide enough flexi- bility in mounting to prevent severe road shock from being transferred from frame to cab. The hard rubber insulators used are maintenance free.

CAB REMOVAL

The removal of the S-Series cab from chassis can be performed providing an overhead crane and cab lifting fixture are available. Removal procedures may vary for various models depending on type of equipment and accessories.

The following steps may be used as a guide.

1. Block wheels of truck and release parking brake.
2. Tilt or remove hood.
3. Disconnect battery ground cable.
4. Drain radiator and disconnect heater hose.
5. Disconnect steering shaft at gear.
6. Disconnect accelerator linkage.
7. Disconnect electrical connections and ground wire.
9. Disconnect brake system.
10. Disconnect speedometer and tachometer drive cables.
12. Remove shift lever from transmission.
14. Install cab lifting fixture. Make sure fixture is padded to prevent damage to cab.
15. Remove cab to frame stay rods.
16. Partially lift cab so cab weight will be supported on lifting fixture.
17. Remove cab to frame mounting bolts and nuts at front and rear locations.

CAUTION
Inspect all cab to frame attaching points to be sure they are disconnected or damage can result.

18. Carefully lift cab from chassis.

CAB INSTALLATION

Cab installation is the reverse of the foregoing removal procedure. No special adjustment is required for cab to frame mounting bolts and nuts other than the application of specified torques. Connect all wiring harnesses, plumbing and controls. Start engine and check all systems and controls before returning truck to service.

LURICATION

Cab hardware and other mechanisms require a periodic application of lubricant to increase service life and prevent objectionable squeaking. New cabs are lubricated at factory and before they are delivered to customer. After the cab is placed in service, regular lubricating inter- vals based on type of service should be established. Thorough lubrication at definite intervals adds greatly to cab service life and reduces overall expense.

For specified lubrication intervals refer to Operator’s Manual.

Wipe off ail lubricant points before applying new lube to prevent lube contamination. Apply lube sparingly and wipe away excess.

TORQUE CHART

APPLICATION	SIZE	N.M	FT.LBS.
Door Hinge Mounting Bolts	5/16-18	27-30	20-22
Hood Hinge Mounting Bolts	5/16-18	27-30	20-22
Door Striker Pin	1/2-13	60-80	45-60
Cab to Frame Mounting Bolts (Front)	1/2-13	95-115	70-85
Cab to Frame Mounting Bolts (Rear)	1/2-13	95-115	70-85
Seat Riser to Floor Mounting Bolts	5/16-18	27-30	20-22
Seat Adjuster to Seat Mounting Bolts	5/16-18	27-30	20-22
Seat Belt to Cab Sill Mounting Bolts	1/2-13	95-115	70-85
Arm Rest to Door Mounting Screws	1/4-20	2-2.5	1.5-2
Stay Rod Bracket to Dash Mounting Bolt	3/8-16	26-37	19-27
Splash Shield Bracket To Cab Mounting Bolt	5/16-18	18-21	12-16

BODIES AND CABS

Insert this new Section in your CTS-4001 Service Manual

REPAIR INSTRUCTIONS USING FIBER GLASS MATERIAL

CONTENTS

PRINTED IN UNITED STATES OF AMERICA

CONTENTS (Continued)

Portions of Text and Illustrations Courtesy of Owens/Corning Fiberglas

FIBER GLASS TYPES

HAND LAY-UP TYPE

In the past, most fiber glass parts have been made from a hand lay-up type fiber glass. This material Is made of woven fiber glass cloth which has been impregnated with a molding resin and molded to a desired shape Much of the manufacturing process is done by hand as the name implies.

SHEET MOLDING COMPOUND (SMC) TYPE

Currently, various parts are made from a newer type fiber glass called Sheet Molding Compound (SMC) This compression molded fiber glass differs from hand lay-up fiber glass in that it is made from a resin molding compound to which short or shredded glass fibers have been added. The resulting plastic mass can be compression molded to any desired shape without using cloth as is used for the hand lay-up type.

RESIN TRANSFER MOLDING (RTM) TYPE

A third kind of fiber glass called Resin Transfer Molding (RTM) is also being used. This type fiber glass is similar to both hand lay-up and SMC types in that it uses a glass mat or cloth in a closed mold to which the resin molding compound is added. A room temperature catalyst (curing or hardening agent) is also used This type fiber glass also lends itself to production method of manufacture.

NOTE - The external surface appearance of all three types of fiber glass material Is similar. However, the hand lay-up type material Is rough textured on Its Internal surface (back side) while "SMC" and "RTM" materials are smooth.

FIBER GLASS REPAIRS

All types of fiber glass repairs, whether cosmetic or structural, are covered on the following pages. The procedures are illustrated using the Sheet Molding Compound (SMC) type fiber glass. These procedures are also applicable and recommended for repairs to the hand lay-up type and Resin Transfer Molding (RTM) type fiber glass.

NOTE - The Illustrations used In this write-up are typical and do not necessarily represent a particular part or model.

TOOLS

Most of the hand and power-type tools (Figure 1) required to repair fiber glass or sheet metal body components with fiber glass material are common tools that can be found in any automotive body repair shop and include:

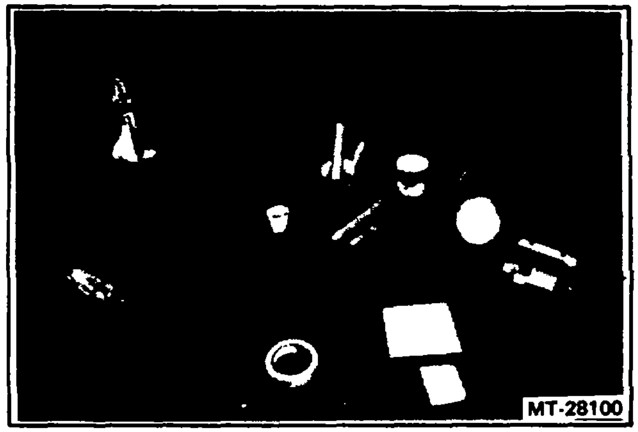

Figure 1 - Tools Required

- Pneumatic or electric drill with sanding attachment, burr bits and tapered bits
- Sandpaper and sanding discs (24-80 grit and 360- 600 grit)
- Electric sander and sanding block.
- Masking tape.
- Sabre saw or hacksaw
- Assortment of clamps.
- Assortment of files.
- Plastic separating film.
- Safety goggles & respirator mask.
- Xylol, acetone or equivalent solvent.

SAFETY PRECAUTIONS

Observe the following when making repairs with fiber glass:

1. **Avoid spilling the resin or hardener on skin or clothing. If this occurs, remove with paint thinner or denatured alcohol. Then wash with soap and water. If the mixture contacts the eyes, flush thoroughly with water immediately. Continue flushing for at least 15 minutes and contact a physician as soon as possible.**

2. **In some cases, some Individuals may have skin sensitivity to the use of these materials. Because of this, protective creams can be applied to the hands to guard against Irritation.**

3. **When protective creams are not available, rubber gloves may be used to protect the hands. The gloves can be removed quickly leaving the hands clean for other work.**

4. **When working with fiber glass, always work in a well ventilated area. DO NOT SMOKE OR EX POSE FLAME WHERE KITS ARE BEING USED OR STORED. If possible, obtain a kit of material large enough to accommodate only one or two jobs to avoid storing any quantity of the material. Resin liquid must be kept in a metal container or cabinet when not being used.**

5. **Repairs must be ground or sanded to match surrounding contours. When grinding or sanding, It Is advisable to use an approved type respirator during the operation. Suitable respirators are available under equipment number SE-1798 and SE-1799. The ground dust or particles of resin or fiber glass must not be Inhaled, or irritation may occur.**

MATERIALS REQUIRED

Fiber Glass Mat (Figure **2)**

This blanket of randomly arranged fibers is the repair material you will use in all repairs requiring a backing patch Its weight is measured In ounces per square foot For most of your repairs, a 1-1/2 oz. mat is required

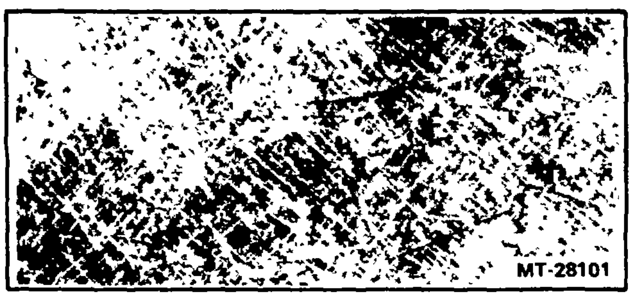

Figure 2 - Fiber Glass Mat

Fiber Glass Cloth (Figure 3)

This material is made from continuous filament glass fibers that are commercially woven on regular textile machinery. Fiber glass cloth is used where the most strength and the least thickness is needed. Its weight is measured in ounces per square yard. A 10 oz cloth is recommended for most automotive repairs

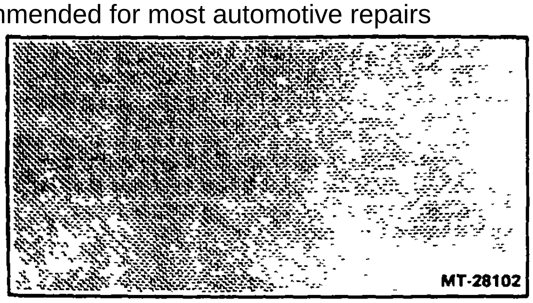

Figure 3 – Fiber Glass Cloth

Resin (Figure 4)

Resin is a liquid plastic that hardens when combined with another substance known as a catalyst or hardener The resin used for most automotive fiber glass repairs Is polyester resin. Because it is inexpensive and has a short hardening (curing) time, it is used for repairs requiring the pre-forming of a backing patch and is available from

Polycomp 5116
Neo-Pruf Industrial Coatings, Inc
3085 W Market St.
Akron, Ohio 44313

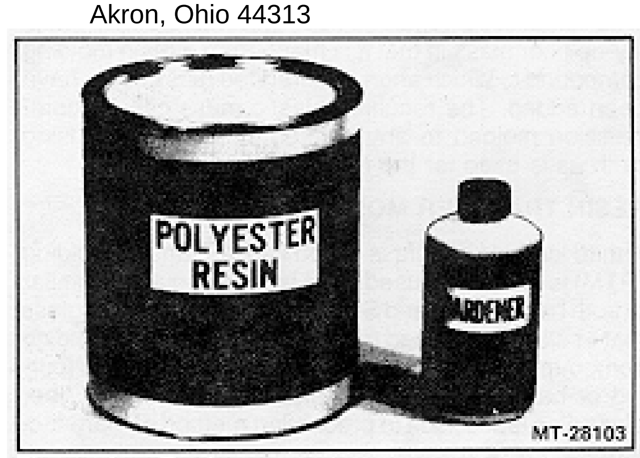

Figure 4 - Resin

Epoxy Adhesive (Figure 5)

This is the bonding cement used to create a strong durable bond between back side of repair area and the backing patch It is also used for bonding reinforcement panels to the back side of an outer panel. It Is available from

REN Plastics 1258 Epoxy or
REN Plastics Fastweld No 10 Epoxy
REN Plastics
A Ciba-Geigy Co
5556 S Cedar
Lansing, MI 48909

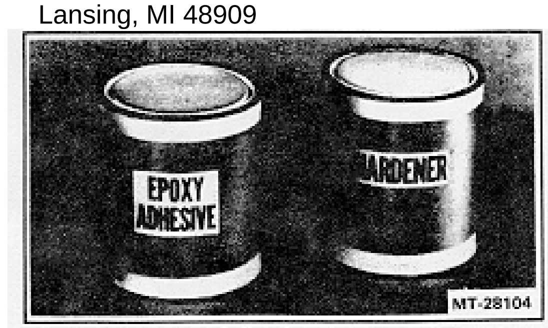

Figure 5 - Epoxy Adhesive

Body Filers (Figure 6)

Polyester body filler Is used in most automotive repair shops because it is easy to apply and shape to the contour of the surrounding piece. Machining of the body filler surface can be followed if necessary by an application of glazing putty to eliminate porosity and provide a smooth surface for painting. It is available from:

Acryl Green Spot Putty
Minnesota Mining & Mfg. Co.
St. Paul, Minnesota 55101
Ditzler Red Oxide Putty
PPG Industries, Inc., Ditzler Auto Finishes
Detroit, MI 48235

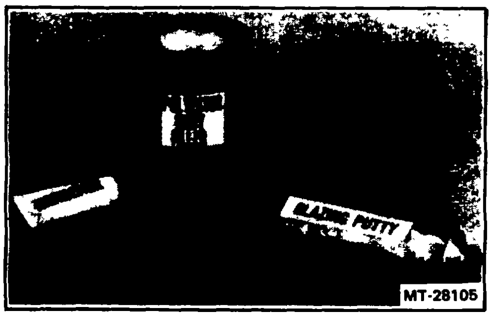

Figure 6 - Body Fillers

As a matter of economy and to maintain the curing properties of the resin, store the resin In a sealed container within a cool, dry enclosure. This precaution will reduce aging caused by changing temperatures Keep a record of each purchase of resin In this way, you can always use the oldest stock first.

NOTE - The shelf life of resin varies; therefore, they should be tested before using and discarded If not up to specifications.

WARNING - FIBER GLASS REPAIRS ARE AS SAFE AS ANY OTHER AUTOMOTIVE SHOP REPAIRS, PROVIDED YOU TAKE THE PROPER PRECAUTIONS. THE FOLLOWING ITEMS SHOULD BE PARTICULARLY NOTED:

1. BEFORE USING ANY MATERIALS, READ THE MANUFACTURER'S INSTRUCTIONS.

2. BE SURE WORK ROOM IS ADEQUATELY VENTILATED. PROLONGED EXPOSURE TO RESIN FUMES IS IRRITATING TO SKIN AND EYES.

3. PROTECT YOUR EYES, FACE, AND BODY FROM THE FINE DUST THAT DEVELOPS DURING GRINDING AND SANDING OPERATIONS. WEAR GOGGLES, RESPIRATOR MASK AND PROTECTIVE CLOTHING.

4. DO NOT RUB YOUR FACE OR EYES WHEN WORKING WITH FIBER GLASS.

PREPARATION PROCEDURE

Prepare for all body repairs using fiber glass by following these steps'

1. Check shop temperature and humidity and compare with specifications on the label for the material being used. A temperature of 21°C (700F) and 70% humidity are considered ideal.
2. Gather required materials.
3. Clean and inspect damaged area.
4. Push on surrounding area and underneath damaged area to determine extent of damage.

REPAIR PROCEDURES -
FIBER GLASS BODY COMPONENTS

COSMETIC REPAIRS

Scratches and Gouges

In general, a scratch or gouge is minor damage that penetrates the paint but only slightly into the laminate (Figure 7).

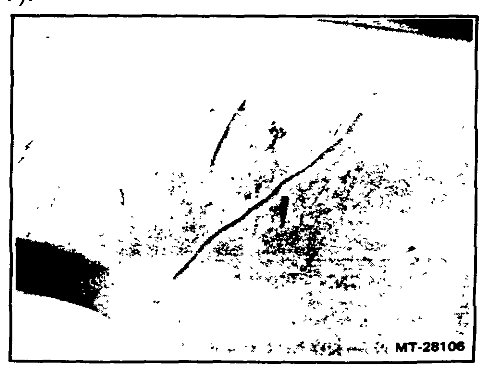

Figure 7 - Scratches and Gouges

Perform the steps listed under Preparation Procedures, and then proceed with the repair as follows:

1 Use a burr bit on a power drill to form a V-groove for the length of the scratch or gouge (Figure 8). The sides of the V should be tapered no more than 45 degrees.

WARNING - WEAR GOGGLES AND RESPIRATOR WHEN CUTTING, GRINDING OR SANDING.

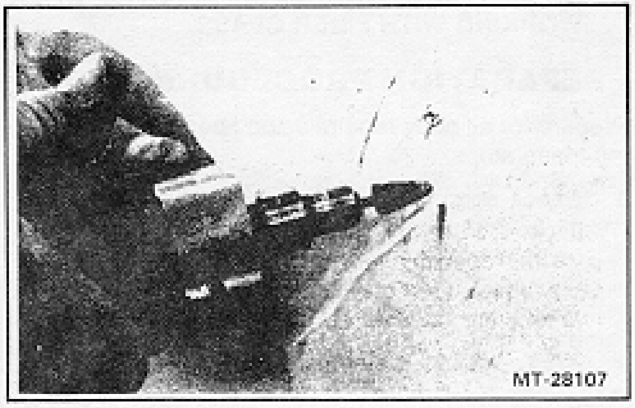

Figure 8 - V-Groove

2 Remove flaky edges and feather the painted surface back about 1/2 Inch beyond the damaged area by hand-sanding or power-sanding with 360 grit sandpaper (Figure 9)

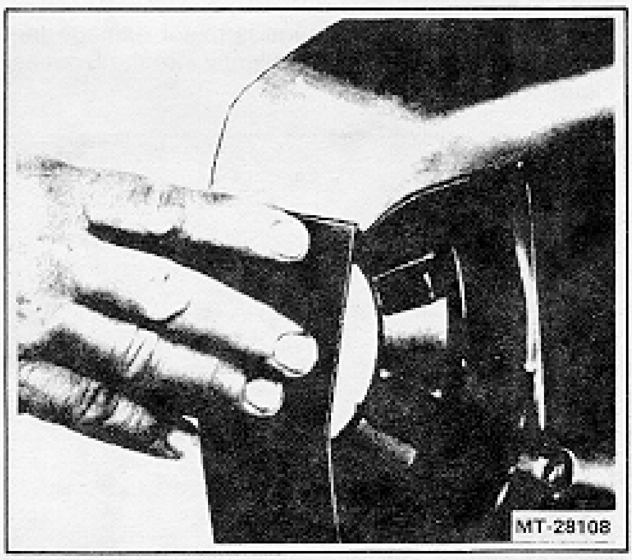

Figure 9 - Surface Preparation

Clean the area with a dry cloth or air
CAUTION - DO NOT WIPE WITH **SOLVENT.**

3 Mask off the undamaged surface, leaving a working area of approximately 5 inches surrounding the repair area (Figure 10)

4 Following the manufacturer's Instructions, mix enough body filler to re-establish the surface (Figure 11)

CAUTION - MIX FILLER ON FORMICA, TEFLON OR OTHER HARD SURFACE. DO NOT WORK ON A POROUS SURFACE SUCH AS CARDBOARD.

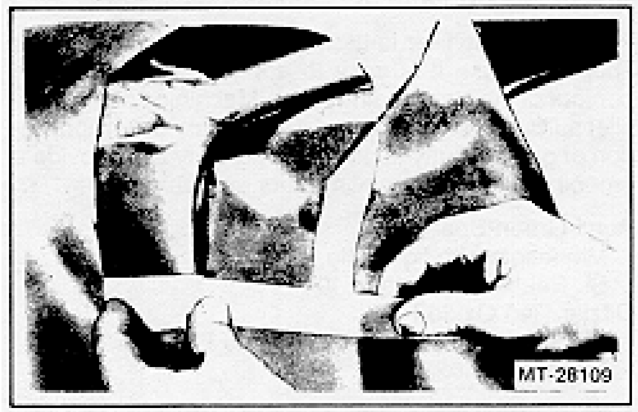

Figure 10 - Masking Undamaged Area

Figure 11 - Preparing Body Filler

5 Apply and spread filler with a plastic squeegee making sure to remove large air bubbles (Figure 12)

NOTE - Allow filler to extend above original surface to allow for shrinkage.

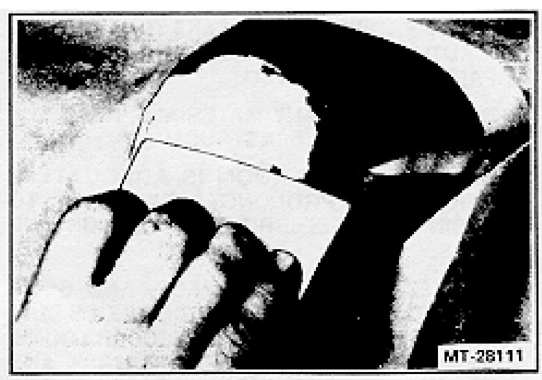

Figure 12 - Applying Body Filler

6 Let filler set up until t is rubbery but not fully hardened. Then re-establish original contour by filing off excess

NOTE-- When filing excess, leave the filler level slightly higher than that of the original surface (Figure 13).

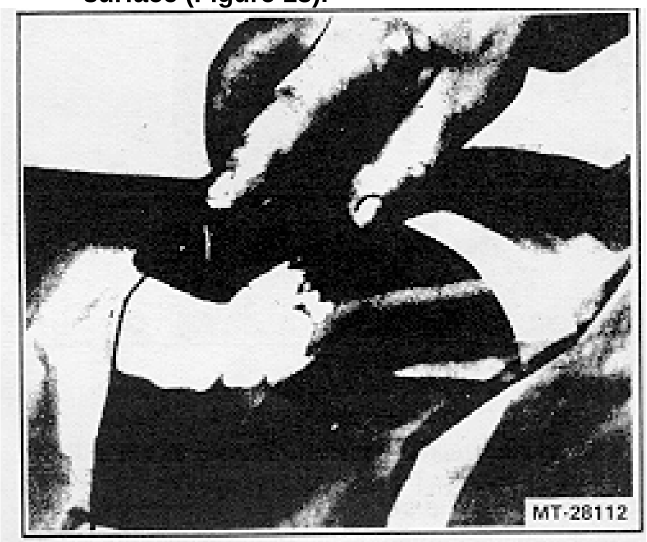

Figure 13 – Establishing Surface Contour

7 Pre-shrink filler, using a heat gun or heat lamp (Figure 14). A minimum temperature of 49°C (1200F) is required for shrinkage.

WARNING - KEEP HEAT SOURCE AT LEAST 12 INCHES AWAY FROM REPAIR AREA.

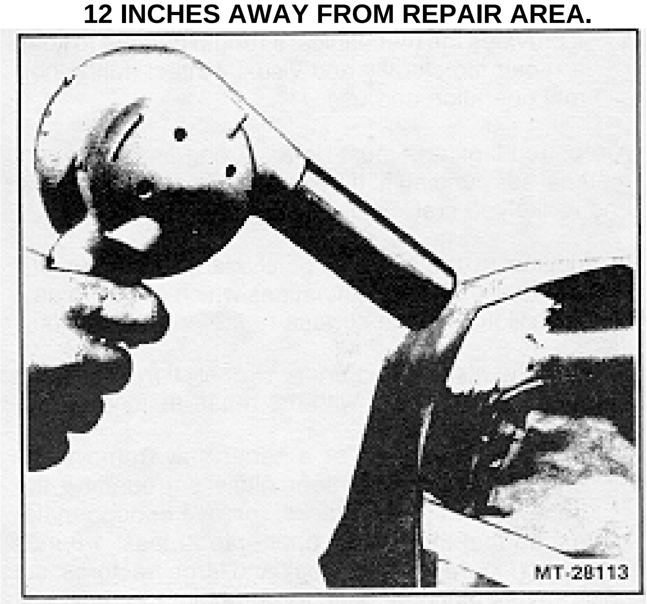

Figure 14 - Shrinking Body Filler

8. Now power-sand the filler with 360 grit sandpaper until it is smooth and even with the original surface (Figure 15)

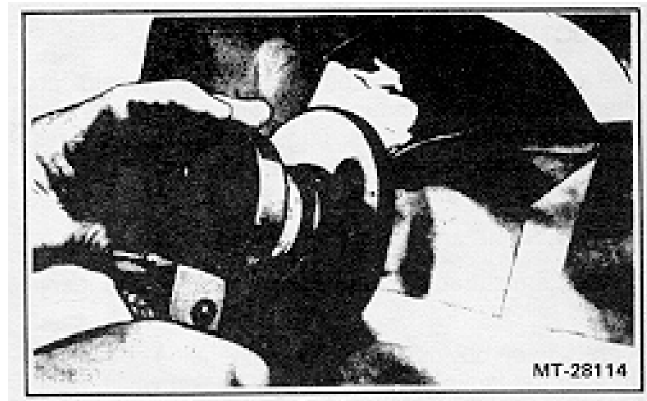

Figure 15 – Sanding Surface

9. If the filler is slightly porous (has fine pinholes). Apply a thin coat of glazing putty (Figure 16)

NOTE-If the filler is pockmarked, do not use glazing putty. Instead, apply another layer of body filler, following steps 4 through 8 before continuing.

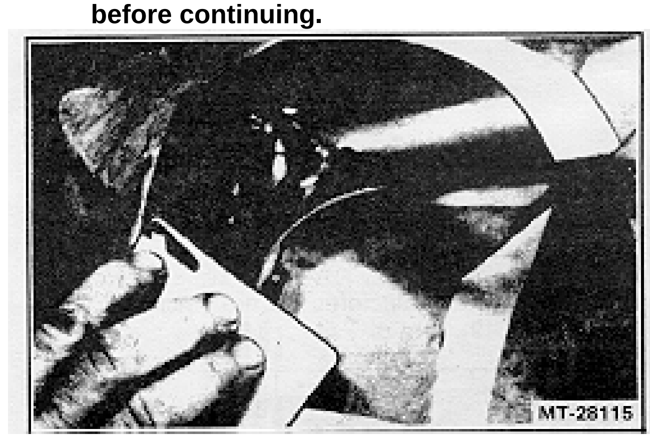

Figure 16—Applying Glazing Putty

10 Clean the area with air, and remask if necessary Then spot prime the surface and wet sand with 400 to 600 grit sandpaper. Complete the repair by painting the surface (Figure 17).

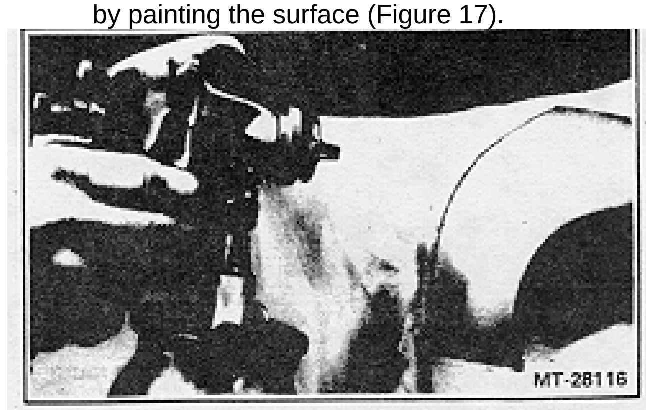

Figure 17 - Painting the Surface

STRUCTURAL REPAIRS

The procedures given under Structural Repairs are used for repairing various types of damage to the fiber glass laminate -cracks, large and small fractures, panel separation, etc - that can affect the structural soundness of the laminate

Cracks, Small and Large Fractures

Cracks, small fractures and large fractures are identified as follows

A crack is an obvious separation extending completely through the laminate (Figure 18) Cracks, which result from stress beyond normal operation, can occur in the center of the laminate or extend from the laminate edge

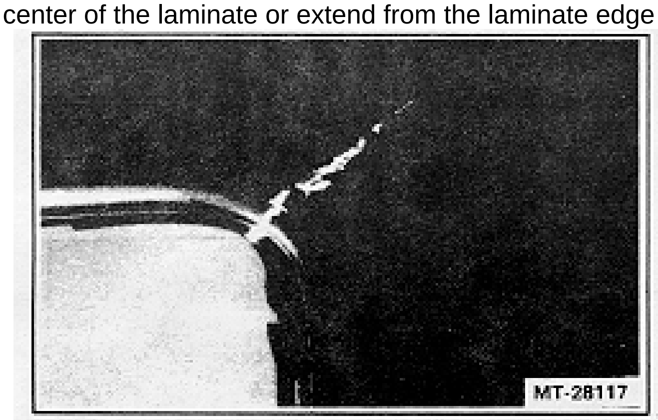

Figure 18- Crack

Small fractures are punctures that are 3 inches or less in size (Figure 19).

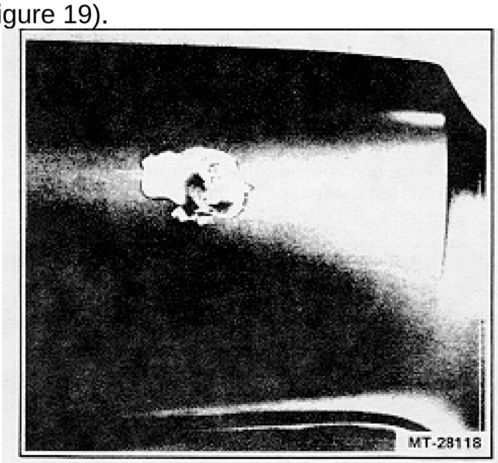

Figure 19 - Small Fractures

Large fractures are punctures that are 3 inches or more in length (Figure 20).

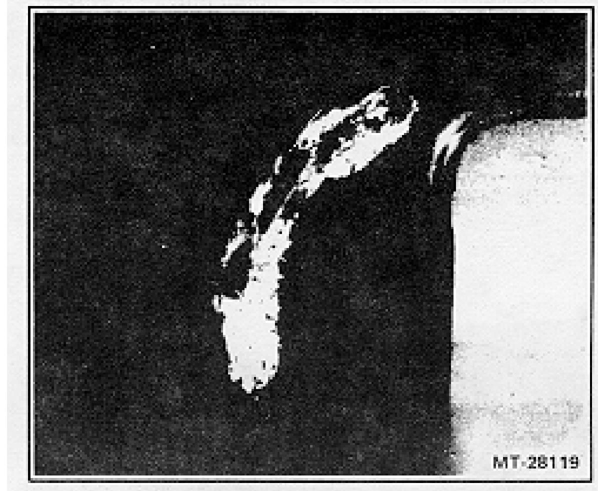

Figure 20 - Large Fractures

Cracks, small fractures and large fractures are repaired following the same basic procedure. All require backing patches or backup strips. These are simple laminates that are formed to the shape of the surface being repaired and bonded with epoxy cement to the back side of the repair area The backing patch serves two functions

1 It provides the foundation on which the exterior surface is built up and formed to match the original contour.

2 It provides the mechanical strength needed to keep a repair structurally and visually intact during normal operation and use

A repaired laminate must be as strong as the original material surrounding it. If it is not, the repair will not last and is likely to crack around the edge of the patch.

In addition to the backing patch, large fractures will require additional mat laminations which are used as a filler in building up the surface to the original contour.

Perform the steps listed under Preparation Procedure (page 5), then proceed with the repair as follows:

1. Using a tapered bit or a saber saw, remove the cracked and flaked fiber glass surrounding the damaged area. For cracks, remove enough mate- rial so that there is an open gap at least 118 inch wide (Figure 21). For small and large fractures, cut away as much material as is required to provide a solid edge (Figures 22 and 23).
   WARNING - WEAR GOGGLES AND RESPIRATOR WHEN CUTTING, GRINDING OR SANDING.

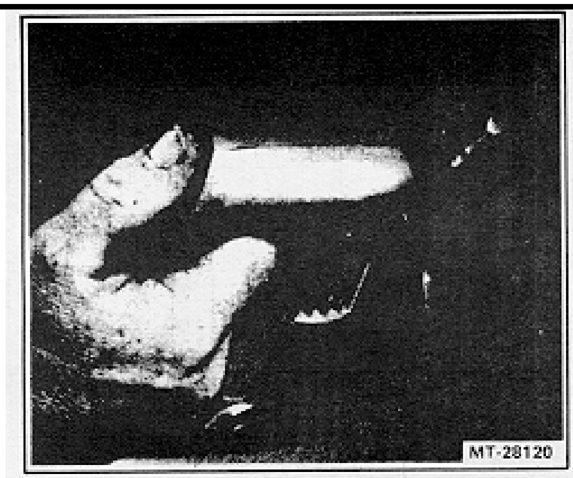

Figure 21 - Opening Cracked Area

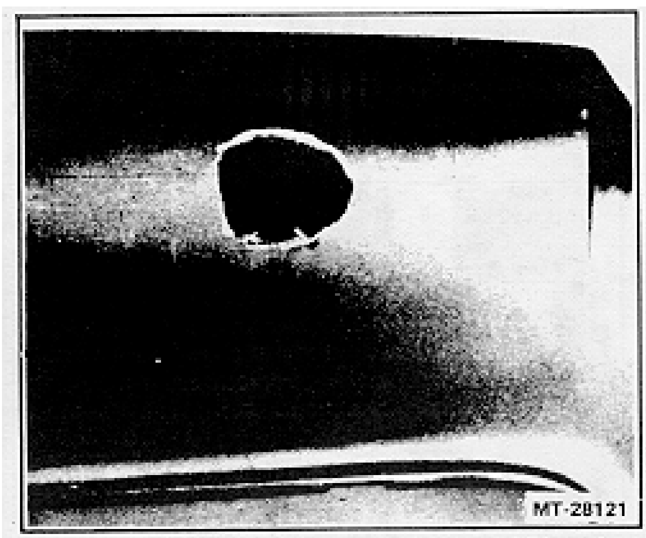

Figure 22 - Small Fracture - Damaged Material Removed

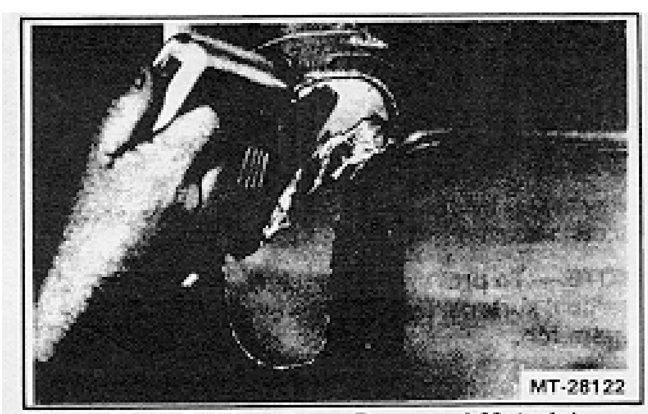

Figure 23 - Cutting Away Damaged Material Large Fracture

2. If panel Is out of alignment, realign it with C-clamps or other clamping device (Figure 24).

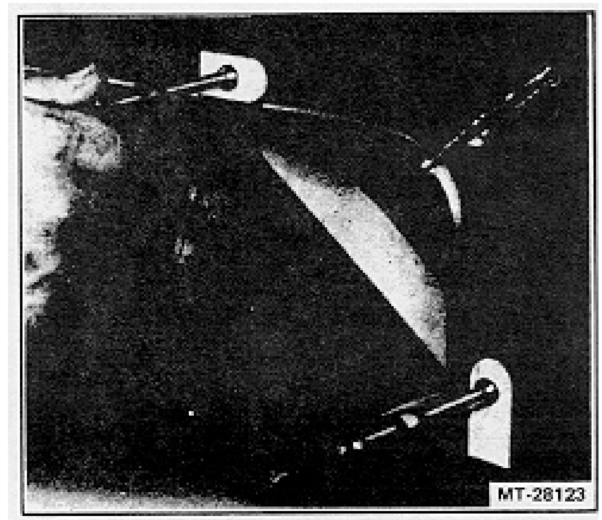

Figure 24 - Aligning Panel '-(Crack Shown - Typical)

3. Mask off undamaged surface, leaving a working area of approximately 5 inches surrounding the damaged area (Figure 25).

NOTE - Steps 4 through 10 describe the procedure for forming a backing patch using the outside surface of the damaged area. If the inner surface of the damaged area is accessible, It is preferable to form the patch to the Inner surface In the same manner.

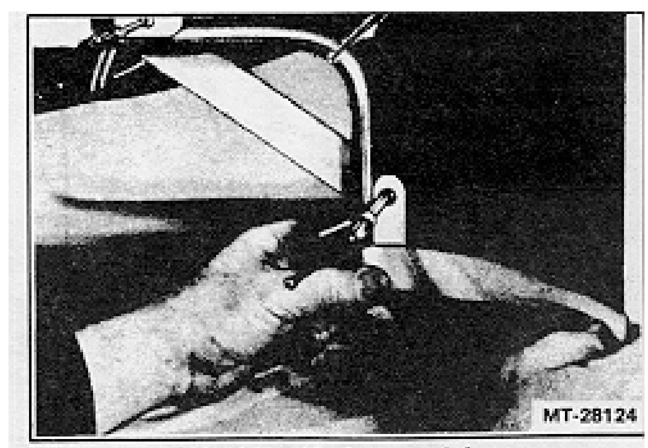

Figure 25 - Masking Undamaged Area

4 Cut a piece of plastic separating film large enough to extend approximately 3 inches beyond the edge of the repair area Tape the film to the outside repair surface (Figure 26).

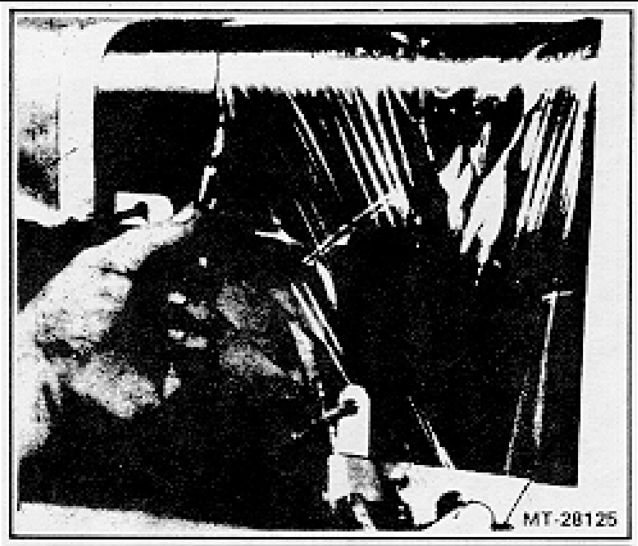

Figure 26 - Covering Repair Area with Separating Film

5. Then, using a cardboard template (Figure 27), cut the required pieces of mat large enough to extend 2 inches beyond the edges of the repair area

NOTE-The number of layers of mat used in the backing patch depends on the thickness of the body panel being repaired. Refer to Figure 28 to determine the number of layers required. Automotive parts are normally 2.5mm (0.100 in.) thick. Therefore, the minimum backing patch thickness must be 3.2mm (0.126 in.) or three layers of 42g (1-1/2 oz.) mat.

Figure 27 - Cutting Fiber Glass Mat

THICKNESS OF ORIGINAL PIECE		LAYERS OF FIBER GLASS MAT REQUIRED FOR PATCH		
mm	inch	quant.	g	oz.
2.5	0.100	3	42	1-1/2
2.8	0.110	3	42	1-1/2
3.0	0.120	2 1	42 57	1-1/2 2
3.3	0.130	1 2	42 57	1-1/2 2
3.6	0.140	3	57	2
4.3	0.170	2 2	42 57	1-1/2 2

Figure 28 - Backing Patch Mat Layer Requirements

6 Mix the recommended amount of polyester resin according to the manufacturer's instructions.

7 Apply some resin to the working area of the separating film (Figure 29).

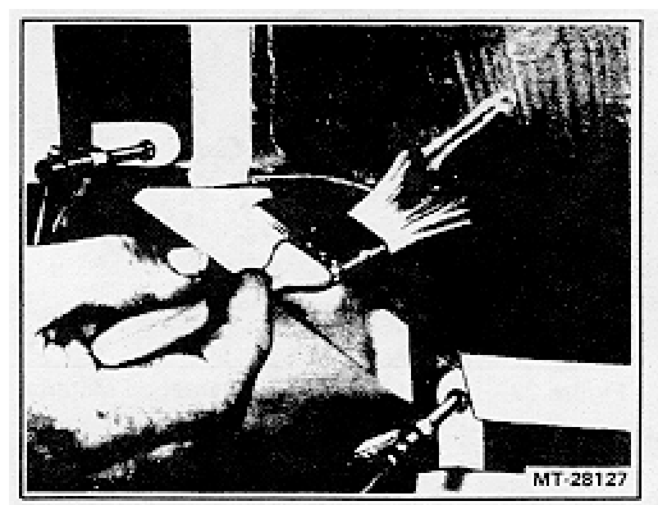

Figure 29 - Applying Resin to Separating Film

8 Soak the first layer of mat In resin, then place it over the repair area and allow it to harden slightly

9. Now lay-up by hand the remaining piece or pieces of resin-soaked mat (Figure 30).

NOTE - To prevent the patch from sliding on a vertical surface, tape a piece of plastic film over the patch.

Figure 30. Mat Lay-Up

10. Allow the patch to harden, then pop It off (Figure 31 and remove the separating film.

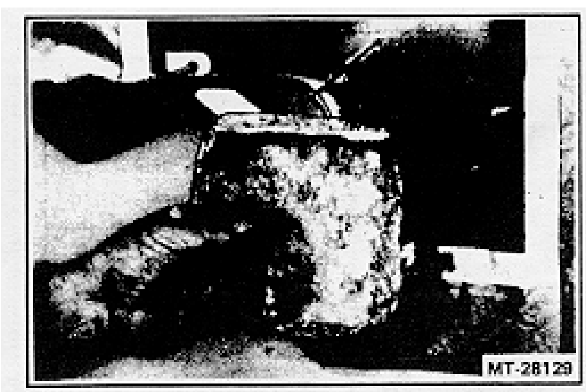

Figure 31 Backing Patch

11. Working from the outside and using a file or grindel taper the edges of the damaged area at an angle c no more than 45 degrees (Figure 32).

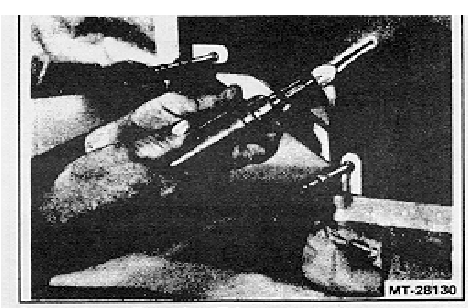

Figure 32 Tapering Edges (Crack Shown Typical)

12 Remove flaky edges and feather the painted surface back about 1/2 inch beyond the damaged area by hand-sanding or power-sanding with 360 grit sandpaper (Figure 33).

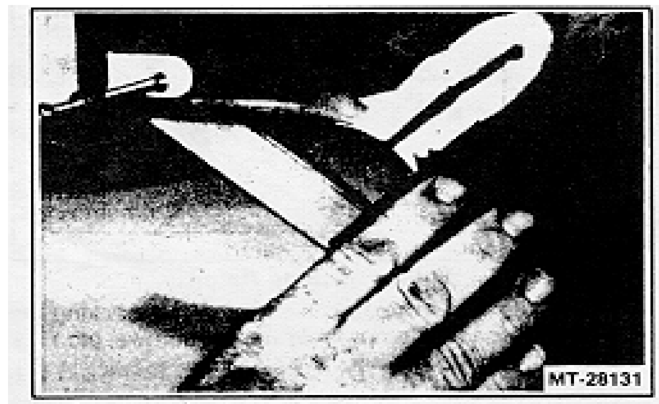

Figure 33 Sanding Exterior Damaged Surface (Crack Shown Typical)

13. Clean the area with a dry cloth or air.

CAUTION DO NOT WIPE WITH SOLVENT.

14. Sand the underside of the repair area with 80 grit (or less) sandpaper to create a rough bonding surface approximately 2 inches from the center of a crack (Figure 34) or 2 inches back from the edge of a fracture.

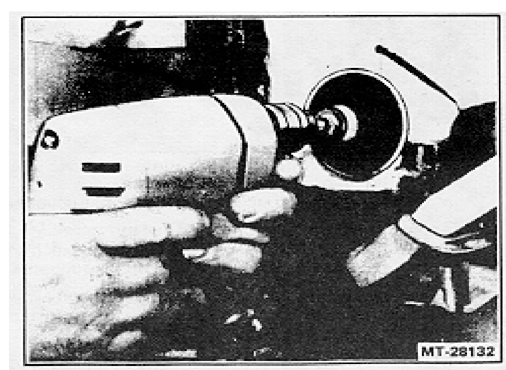

Figure 34. Sanding Underside of Repair Area (Crack Shown Typical)

15. Trim the perimeter and sand the mating surface of the backing patch (Figure 35) with 80 grit sandpaper (or less), checking for smooth fit to the underside. Clean all surfaces with air.

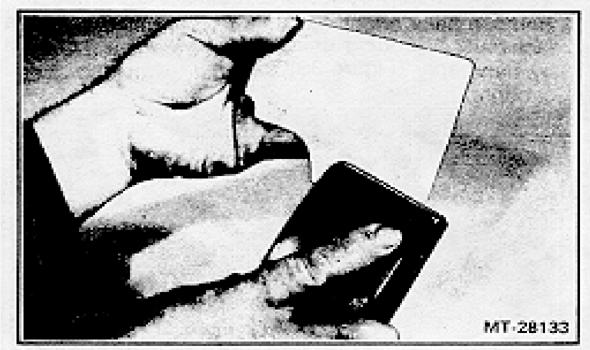

Figure 35 Sanding Backing Patch

16 Now determine a method of holding the backing patch in place (C-clamps, self-tapping screws, etc.) and trial test the method (Figure 36).

NOTE

-If you use self-tapping screws, predrill the holes. Then before finishing the surface, remove the screws and fill the holes with body filler.

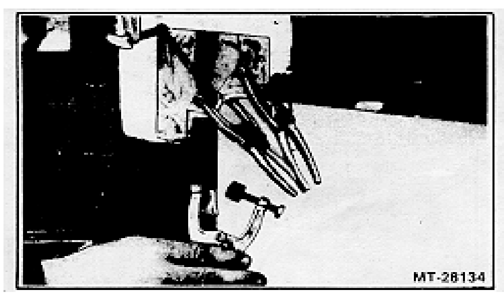

Figure 36 Attaching Backing Plate

17 Mix epoxy adhesive according to the Instructions.

18. Apply the adhesive to underside of the repair area and also to the patch (Figure 37) Press patch In place until epoxy squeezes out from all edges

19. Hold backing patch with clamps or screws and allow the adhesive to harden for the time given in the manufacturer's instructions (Figure 38).

NOTE - If the adhesive is squeezed Into the tapered groove or hole during bonding, clean It out before the adhesive sets, and roughen any remaining adhesive with 360 grit sandpaper after it hardens.

Steps 20 through 23 apply for large fractures only. For cracks or small fractures, omit Steps 20 through 23 and go on to Step 24.

Figure 37 Applying Epoxy Adhesive

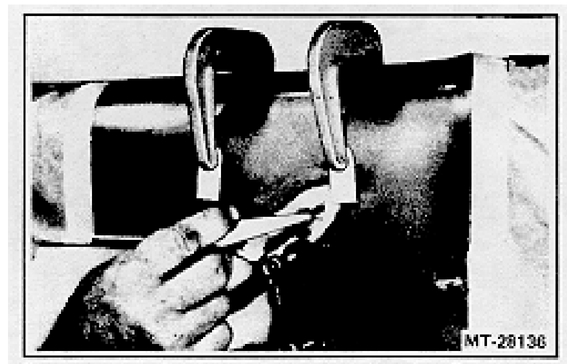

Figure 38 Cleaning Excess Adhesive From Damaged Area

20. While the adhesive Is hardening, cut some pieces of mat to fit into the hole in the panel (Figure 39) The mat is not a structural reinforcement, but a filler

NOTE - Cut enough pieces of mat which when layered will fill the hole to just below the surface of the original panel.

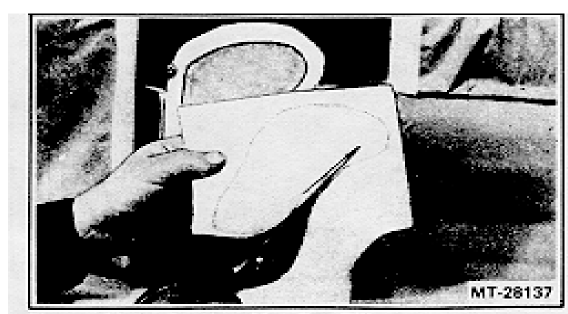

Figure 39 Cutting Mat For Filler

21. Following the manufacturer's instructions, mix enough resin to saturate the piece(s) of mat.

22. Using a stippling motion of your brush, lay-up the resin-soaked mat by hand (Figure 40), one piece at a time, until the top layer is just below the surface of the panel.

Figure 40 - Filler Mat Lay-Up

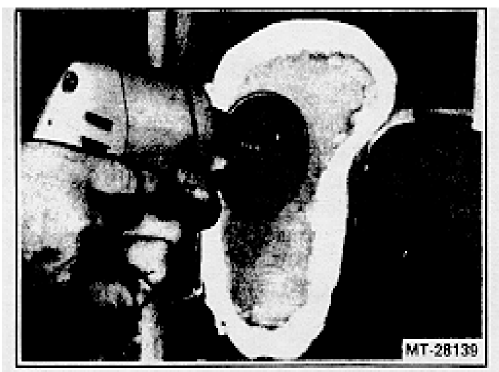

Figure 41 -Sanding Filler Mat

24. To complete the repair, use the procedure for Surface Filling and Finishing on page 16.

Panel Bond Separation Panel separation is a fiber glass structural defect that occurs when the adhesive bond between panels fails. It can be caused by fatigue, abuse or improper assembly.

1. Perform the steps listed under Preparation Procedure on page 5.

2. Separate fiber glass panels until the separation reaches the point where bonding Is secure. Use wood block, screwdriver or putty knife, etc to hold panels apart (Figure 42).

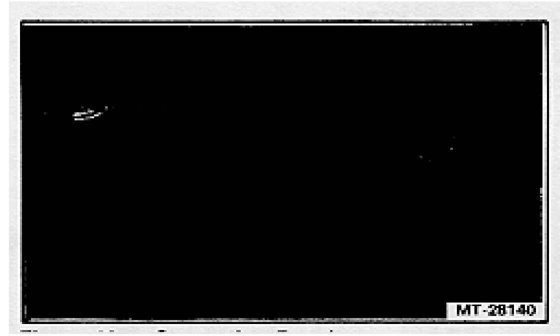

Figure 42 Separating Panels

3. Use a coarse grinder or burr to clean old adhesive from between panels (Figure 43). Use an air gun to remove dust from the bonding surfaces. Then, wipe the surfaces clean using an acetone solvent.

Figure 43 Removing Old Adhesive From Panels

4. Obtain an epoxy adhesive repair kit and mix the adhesive following the instructions supplied with the kit (Figure 44).

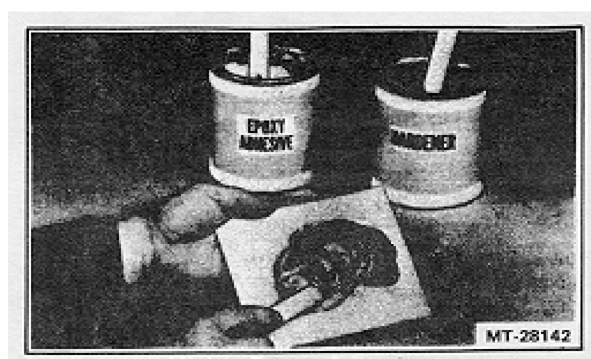

Figure 44 Mixing Epoxy Adhesive

WARNING - BEFORE MIXING AND USING ADHESIVE, OBSERVE THE SUPPLIER INSTRUCTIONS FOR HANDLING AND DISPOSING OF THIS MATERIAL.

5. Use an applicator or make a craft paper cone dispenser to spread adhesive on or between the panels (Figure 45) Make sure the bond area is completely covered.

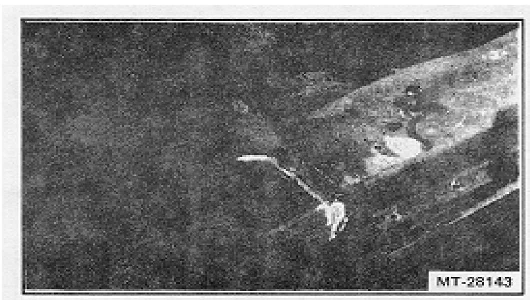

Figure 45 - Applying Adhesive

6. Press panels together and use clamps or weights to hold panels in place (Figure 46).

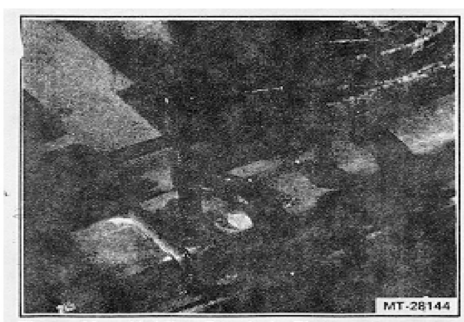

Figure 46 -- Holding Panels in Place

7. Use a rag and acetone to remove any excess adhesive squeezed out After adhesive has cured, it will be difficult to remove except by grinding or sanding

Allow sufficient time for adhesive to cure before removing clamps or weights. Heat lamp or gun will speed up curing time.

WARNING - KEEP HEAT SOURCE AT LEAST 12 INCHES AWAY FROM THE REPAIR AREA.

REPAIR PROCEDURES -
SHEET METAL/ALUMINUM
BODY COMPONENTS

Repairs to sheet metal and aluminum body components can be made using fiber glass mat, cloth resin and/or the polyester body filler and glazing putty. Torn holes, rust holes or damaged surfaces which are difficult to refinish with the usual sheet metal or aluminum repair procedures can be repaired using the materials listed above.

A combination fiber glass mat and cloth patch can be used to repair holes in metal. However, a metal patch, where practical, provides a more permanent repair Procedures are given for both types of repair patches and also for dents.

HOLES

Repair Using Fiber Glass Cloth and Mat Patch

The following procedure can be used to repair both small holes (under 3 inch diameter) and large holes (over 3 inch diameter).

1. Perform the steps listed under Preparation Procedure (page 5)
2. Clean metal to bare surface with 16 or 24 grit sand- paper approximately 6 inches beyond area being repaired.
3. Dent in area being repaired about 2 inches beyond damaged area.
4. Cut a piece of fiber glass mat about 1 inch larger than the surface being repaired, then a piece of fiber glass cloth (two or three pieces of mat may be used to fill the indented area).
5. Brush the resin mixture on the damaged area and then saturate the layers of mat and cloth being used. Allow the resin mixture to get tacky.

   NOTE - When repairing large holes, prepare the patch as follows:

On a piece of polyethylene film, position a piece of cloth larger than the hole being repaired. Saturate the cloth with resin mixture. Apply two layers of mat (Figure 47) saturating both with the resin mixture.

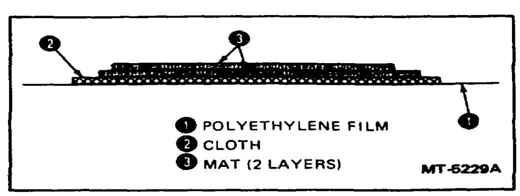

Figure 47 - Preparing Fiber Glass Patch

6. Apply the mat and cloth patches, pressing the laminations down tightly with a sheet of polyethylene film to produce a tight bond (Figure 48). (The cloth patch is installed last.)

   NOTE - When repairing large holes, place the entire patch (Including polyethylene film) as prepared In Step 5, on the repair surface and press the patch onto the metal. Leave the polyethylene film as a cover over the patch until the resin has cured (Figure 49).

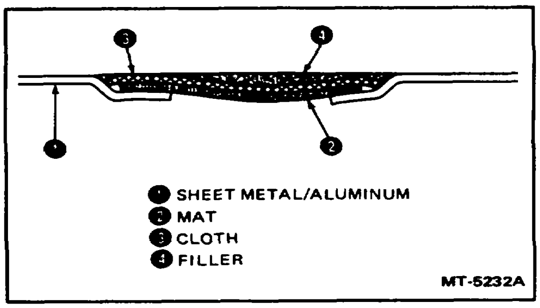

Figure 48 - Fiber Glass Mat and Cloth Patch Installation

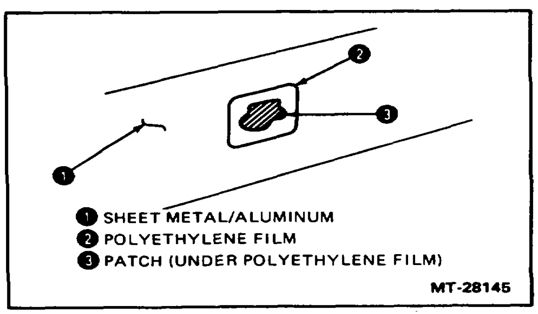

Figure 49 - Applying Fiber Glass Patch

7. Allow the material to cure. Then, peel off the polyethylene film if It was not removed earlier.

8. Sand and file surface after the patches have cured.

9. To complete the repair, use the procedure for Surface Filling and Finishing (page 16).

Repair Using Metal Insert

1. Perform the steps listed under Preparation Procedure (page 5).
2. Using the appropriate tools, cut the rusted or damaged material from the panel.
3. Using an air hammer and a panel crimper, form a step in the original panel so that the new sheet metal or aluminum insert will set flush with the original panel (Figure 50).

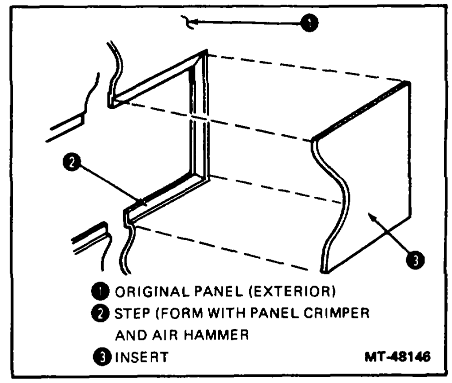

Figure 50 - Forming Insert Step in Original Panel

4. Cut a new sheet metal or aluminum insert to fit within the step area of the panel being repaired.

5. Attach the insert to the original panel by spot or tack welding it in place or by securing it with pop rivets (Figure 51).

   NOTE - If pop rivets are used, countersink the holes in the Insert so that the rivet heads when Installed are near flush with the exterior surface of the insert.

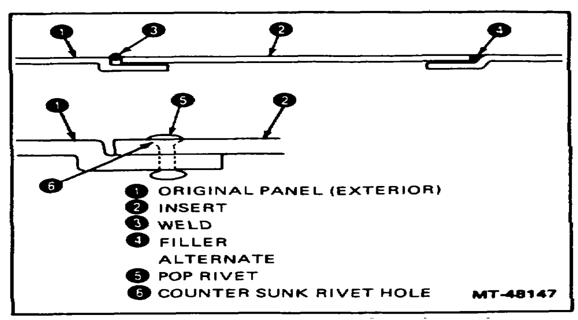

Figure 51 - Panel Metal Insert Attachment

6. Using a grinder, cut down the welds or rivet heads flush with the exterior surface of the repair area

7. To complete the repair, use the procedure for Surface Filling and Finishing (page 16).

DENTS

1. Perform the steps listed under Preparation Procedure (page 5).

2. Clean metal to the bare surface.

3. Drill or punch 112 inch holes in the dent to assure a good anchor for the filler (Figure 52).

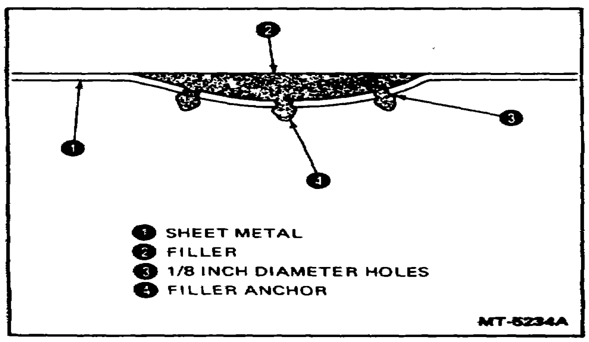

Figure 52 - Repairing Dents

4. If the dent is over 1 inch, cover dent with a piece of fiber glass cloth and saturate it with resin mixture. Allow the resin to cure.

5. To complete the repair, use the procedure for Surface Filling and Finishing (page 16).

SURFACE FILUNG AND FINISHING

After repairing the damaged area, apply filler and finish the surface using this procedure:

1. Following the manufacturer's instructions, mix enough body filler to reestablish the surface.

   CAUTION - MIX FILLER ON FORIMCA, TEFLON OR OTHER HARD SURFACE. DO NOT WORK ON A POROUS SURFACE SUCH AS CARDBOARD.

2. Work the filler Into the repaired surface with a squeegee, making sure to fill all voids and remove large air bubbles (Figure 53).

   NOTE - Allow filler to extend above the original surface to allow for shrinkage.

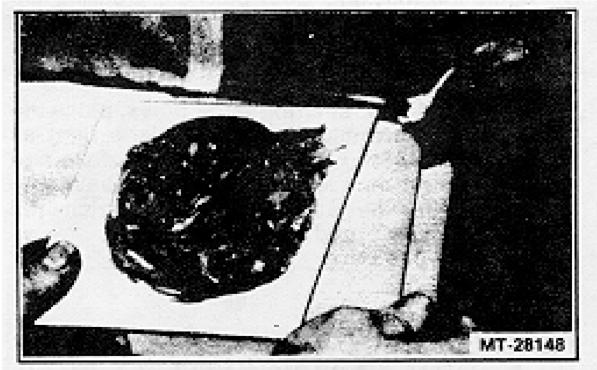

Figure 53 - Applying Body Filler

3. When the filler is firm to the touch, plane and/or file off the excess, still leaving the filler level slightly above that of the original surface (Figure 54).

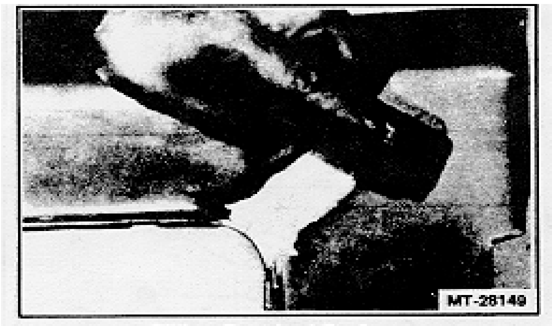

Figure 54 - Filling Repaired Surface

4. Now, pre-shrink the filler, using a heat gun or heat lamp. A minimum temperature of 49°C (120°F) is required for shrinkage (Figure 55).

   WARNING - KEEP HEAT SOURCE AT LEAST 12 INCHES AWAY FROM THE REPAIR AREA.

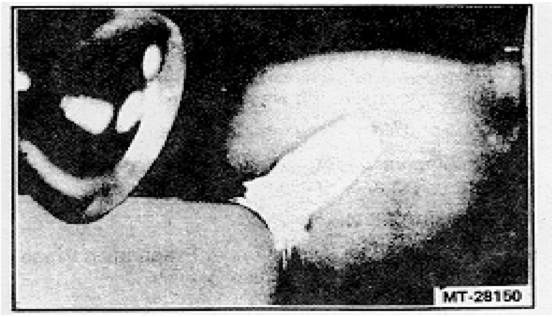

Figure 55 - Shrinking Body Filler

5. Power-sand the filler with 360 grit sandpaper until it Is smooth and even with the original surface.

6. If the filler is slightly porous (has fine pinholes), apply a thin coat of glazing putty (Figure 56). If the filler is pockmarked, do not use glazing putty Instead, apply another layer of body filler as covered in Steps 1 through 5 before applying the glazing putty.

7. Allow the glazing putty to cure under heat gun or heat lamp. Finish by sanding with a sanding block and 360 grit sandpaper.

8. Clean the area with air and remask, if necessary Then spot prime the surface and wet sand with 400 to 600 grit sandpaper. Complete the repair by painting the surface.

   NOTE - If you have used screws to align the panel, remove them and fill the holes with body filler before finishing the panel.

Figure 56 - Applying Glazing Putty

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CAB

WINDSHIELD WIPER (ELECTRIC)

CONTENTS

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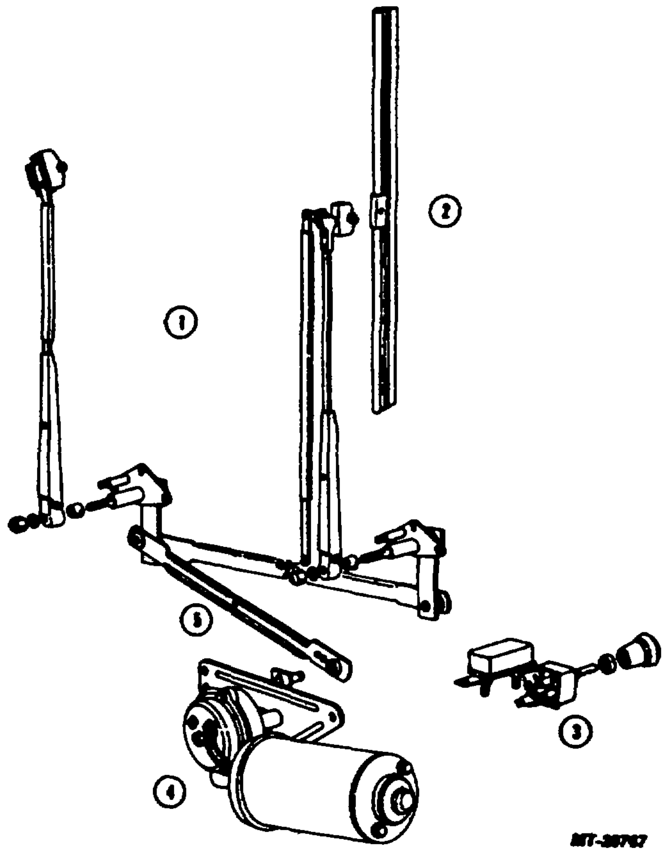

Fig. 1 Electric Windshield Wiper Components

1. Arms, Wiper
2. Blade
3. Switch, Control
4. Motor, Electric
5. Linkage, Assembly

DESCRIPTION

The standard windshield wiper available on S-Series Trucks is the electric cowl mounted dual wiper system shown in Fig. 1. Except for the control switch, which is mounted on the instrument panel, all service on the wiper system is performed at front of cab.

OPERATION

When control switch is turned to "LO" or "HI" wiper speed is controlled accordingly. When control switch is turned off, wiper blades move automatically to "park" position on windshield (50 mm or 2 inches up from bottom of windshield). Reciprocating action of wiper arms results from rotation of drive lever on wiper motor.

> IMPORTANT
> Do not attempt to move wiper blades through their arc by grasping wiper arm. This action can damage motor internal parts or bend wiper linkage. Also, if blades are frozen to windshield, do not operate control switch until blades have been freed.

REMOVAL

LINKAGE

1. Remove windshield washer hose from fittings on top of cowl.

2. Remove wiper blades and arms (Fig. 2).

3. Remove seven mounting screws and detach cowl cover panel from top of cowl (Fig. 3).

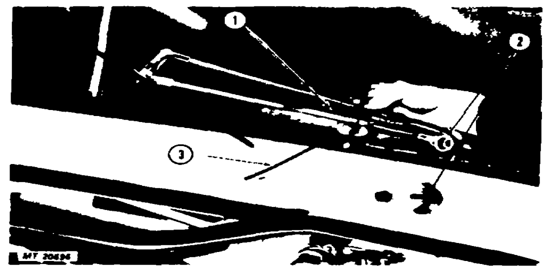

Fig. 2 Removing Wiper Arms

1. Arm, Wiper
2. Serrations
3. Hose, Washer

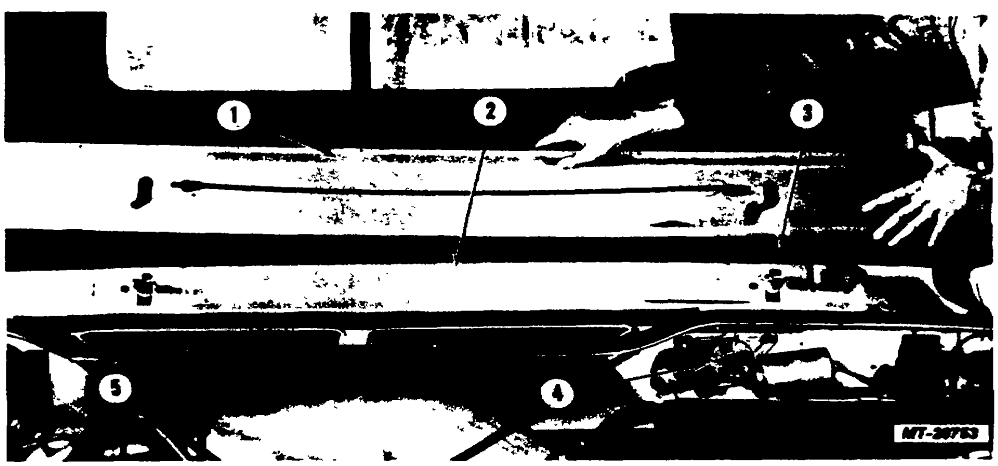

FIG. 3 Removing Cowl Cover Panel

1. Panel, Cowl Cover
2. Cowl
3. Seal, Windshield
4. Motor, Wiper
5. Chamber, Air Intake

4. Disconnect washer hose from fitting on bottom of cowl cover panel.

5. Reaching into cowl air intake chamber, unfasten retainer clip from wiper motor drive lever pin and detach linkage rod from drive lever.

6. Remove three mounting bolts from each pivot bracket and lift out complete pivot brackets and wiper linkage assembly from inside air intake chamber (Fig. 4).

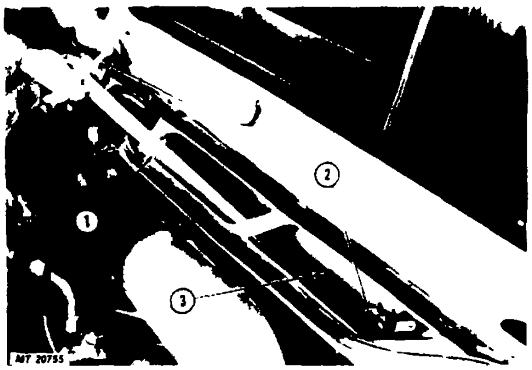

Fig. 4 Removing Windshield Wiper Linkage

1. Linkage 3. Chamber, Air
2. Brackets, Pivot

ELECTRIC MOTOR

1. Disconnect wiring harness from wiper motor.

2. If wiper linkage has not previously been disconnected from motor, reach into cowl air intake chamber and unfasten clip from wiper motor drive lever.

IMPORTANT
Where motor only is being removed, stop wiper blades (with key switch) at their opposite to "PARK" position and loosen motor bracket to cowl mounting bolts. This will facilitate detaching of wiper linkage from motor drive lever.

3. Remove wiper motor bracket mounting bolts and detach motor assembly. Drive lever should remove through hole m cowl (Fig. 5).

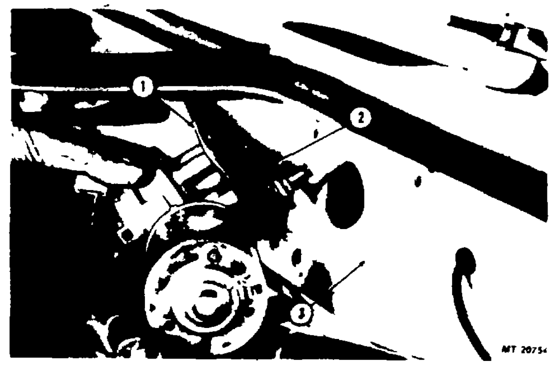

Fig. 5 Removing Windshield Wiper Motor

1. Bracket, Mounting 3. Cowl
2. Lever, Drive

IMPORTANT
Always disconnect battery ground strap before servicing or removing electrical components.

CONTROL SWITCH

1. Remove control knob for electric control switch by depressing retaining clip on back of knob with offset or small screwdriver (Fig. 6).

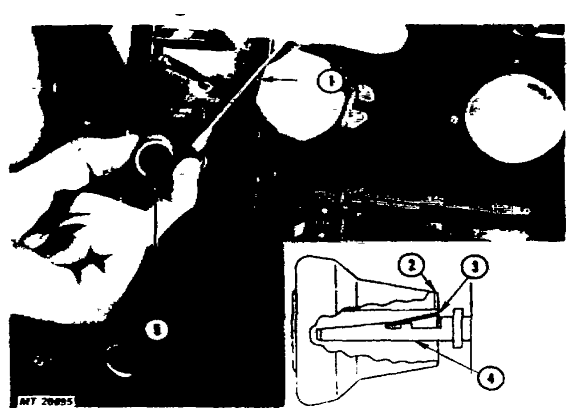

Fig. 6 Removing Control Knob from Switch

1. Screwdriver 4. Shaft, Switch
2. Indent 5. Knob, Control
3. Clip, Spring

2. Remove mounting screws and detach panel to right of wiper control switch and above heater controls.

3. Remove mounting nut from switch shaft and demount switch assembly from instrument panel (Fig. 7).

4. Disconnect wiring leads and remove switch.

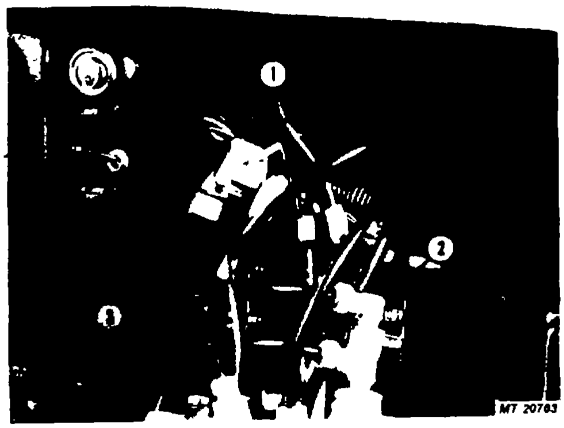

Fig. 7 Removing Wiper Switch

1. Switch, Wiper Control
2. Cluster, Air Control
3. Hole, Control Switch Mounting

INSTALLATION

Reinstalling of windshield wiper system components is the reverse, of removal. Be careful when installing cowl cover panel so as to protect windshield seal from damage. When returning wiper arms to drive shafts, control switch should be in "off" position and blades should be positioned m "park" position on windshield (50 mm or 2 inches up from bottom of windshield). If blades do not park as specified, see "ADJUSTMENT". When blades are correctly positioned, install cap nut and tighten to 6-7 N-m (55-60 in. lbs.).

MAINTENANCE

Service on the windshield wiper system is limited to the replacement of components shown in Fig. 1. Disassembly of either the electric wiper motor or the control switch is not recommended.

ADJUSTMENT

1. Operate wiper motor and turn control switch on instrument panel to "OFF". Wiper blades should automatically move to "park" position on windshield (50 mm or approx. 2 inches up from bottom of windshield).

2. If adjustment is required, loosen motor cover mounting screws and turn cover clockwise or counterclockwise as required to set correct "park" position (Fig. 8). Retighten cover screws. (Length of stroke is fixed and cannot be changed.)

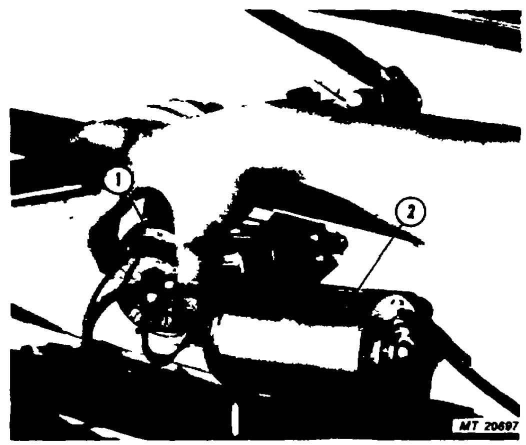

Fig. 8 Adjusting Wiper Blade Park Position

1. Cover Turn to Adjust Park Position
2. Motor, Wiper

SPECIFICATIONS

MOTOR TYPE	Electric, direct current
MANUFACTURER	American Bosch
VOLTAGE	12 Volts
CRANK ARM ROTATION	Counter-clockwise
WIPER BLADE LENGTH	36 cm (14 inches)

TORQUE CHART

Application	N. m	In. Lbs.
Adjusting Cover Mounting Screws	2-2.5	18-22
Bracket to Motor Mounting Screws	4.5-7	40-62
Motor Bracket to Cowl Mounting Bolts	27-30	240-265
Lever Arm Shaft Nut *	8-10	70-88
Wiper Shaft Cap Nut	6-7	54-62
Pivot Brackets to Cowl Bolts	13-16	115-140

- Hold drive lever in position while nut is torqued or drive gear can be stripped.

TROUBLESHOOTING (ELECTRIC)

PROBLEM	PROBABLE CAUSE	SOLUTION
Wiper will not operate.	1. No voltage to wiper motor. 2. Binds in wiper arm, shafts or linkage. 3. Link rod loose from drive lever. 4. Faulty switch. 5. Faulty motor assembly.	1. Check for open circuit or blown fuse. 2. Eliminate binds. 3. Secure rod end clip. 4. Replace switch. 5. Replace motor.
Damaged gear teeth.	1. Wiper blades striking windshield molding during operation. 2. Binding in connecting links. 3. Operator stopping blades manually when wiper is operating. 4. Drive arm not held when drive arm nut is tight-ened.	1. Adjust wiper arm park position. 2. Correct linkage. 3. Caution operator. 4. Hold drive arm in vise or by hand when tightening nut.
Wiper will not shut off.	Faulty switch.	Replace switch.
Wiper continually shutting off.	1. Binding condition in wiper arm shafts, connecting links or drive gear and shaft. 2. Faulty harness connections. connectors and terminals. 3. Faulty motor assembly.	1. Eliminate binds. 2. Correct wiring harness 3. Replace motor.
Wiper operates at one speed only.	1. Faulty switch. 2. Faulty connection.	1. Replace switch. 2. Correct wiring.
Wiper motor speed excessive under light load but stalls under heavy load.	Faulty motor assembly.	Replace motor.
Wiper motor noisy.	Faulty motor assembly.	Replace motor.

CAB

WINDSHIELD WASHER (ELECTRIC)

CONTENTS

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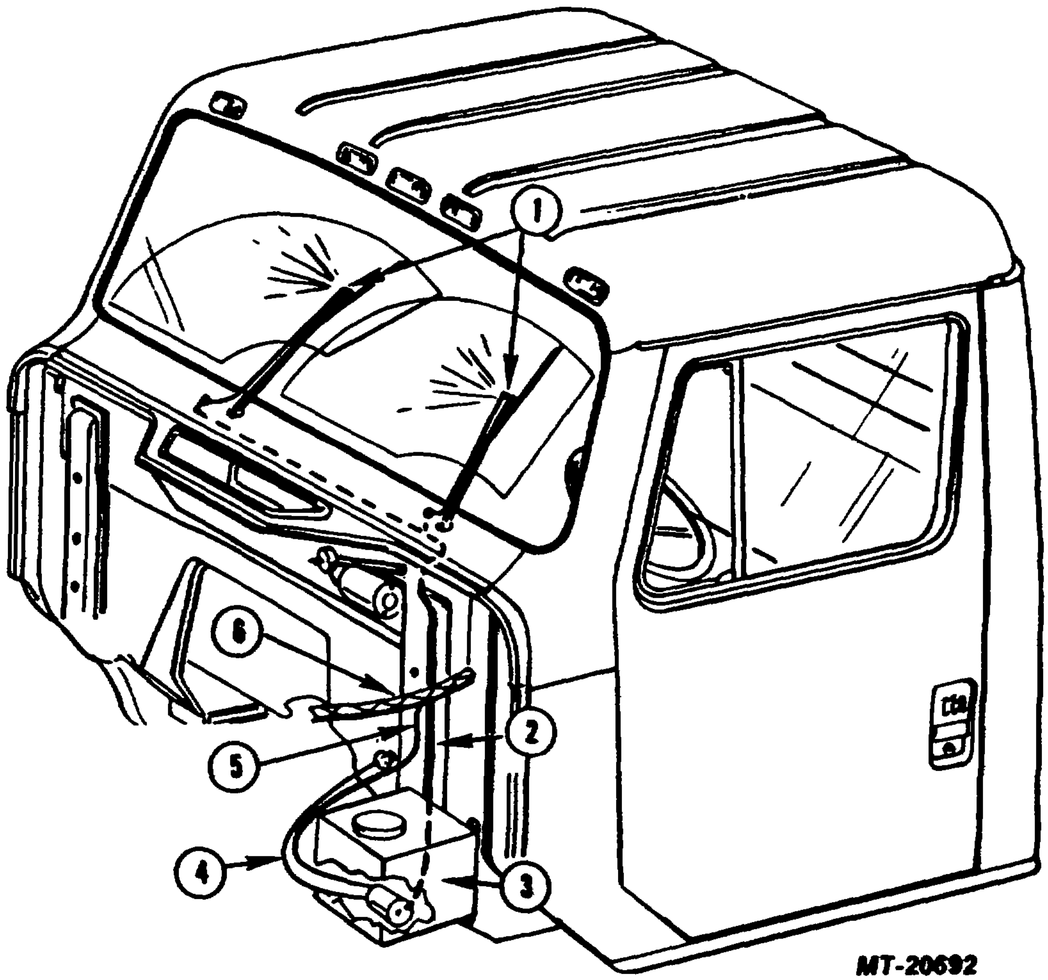

Fig. 1 Windshield Washer Installation

1. Nozzles
2. Hose. Pump to Wiper Nozzles
3. Pump Motor Reservoir Assembly
4. Wire, Motor to Ground
5. Wire, Panel Switch to Motor
6. Harness, Wiring

DESCRIPTION

The windshield washer (Fig. 1) consists of a reservoir mounted motor driven displacement type pump that delivers washer solution to the windshield through hoses and nozzles in the wiper arms. Pump motor may be integral with reservoir or detached.

OPERATION

You can operate windshield washer simply by pushing in on control switch for as long as you want nozzles to spray. Spray will stop as soon as control is released.

MAINTENANCE

A minimum of service is required to keep windshield washer operating. Keep reservoir filled with IH No. 996726-R2 windshield washer solvent and keep wiper nozzles clean. If dirt enters reservoir, remove reservoir and flush out with clean water. Refill reservoir with specified solvent after reinstalling.

REMOVAL AND INSTALLATION

1. Remove the reservoir-to-cowl mounting bolts and lift complete pump, motor and reservoir from cowl.

2. Separate wiring connector for instrument panel switch-to-motor wire and motor-to-ground wire from pump motor.
3. Disconnect pump-to-wiper nozzle hose from pump outlet fitting.

Installation of windshield washer is the reverse of removal procedure. Test the operation of unit and check for leaks after installing.

IMPORTANT

Be sure an ample supply of IH No. 996726-R2 windshield washer solvent is maintained in reservoir to insure satisfactory operation of windshield washer.

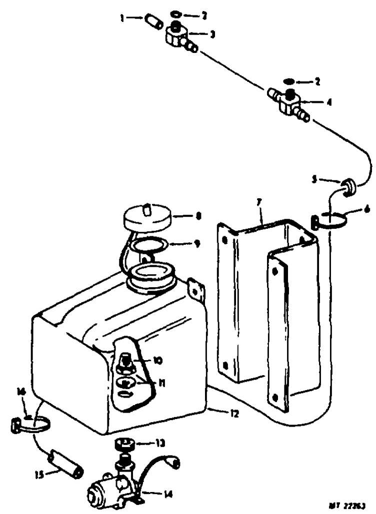

Fig. 2 Pump, Motor Reservoir Assembly

1. Cap, Tube
2. Seal, O-ring
3. Block, Junction
4. Block, Junction
5. Grommet, Hose
6. Strap, Cable Lock
7. Bracket, Reservoir
8. Cap, Reservoir
9. Gasket, Cap
10. Filter, Reservoir
11. Washer, Nylon
12. Reservoir
13. Grommet
14. Pump Motor, Assembly
15. Hose
16. Strap, Cable Lock

TROUBLE SHOOTING

PROBLEM	PROBABLE CAUSE	SOLUTION
Pump will not operate.	1. No voltage to pump motor. 2. Defective switch. 3. Defective motor.	1. Check for open circuit or blown fuse. 2. Replace switch. 3. Replace pump/motor assembly.
Pump operates but pressure is weak.	1. Hoses loose, kinked or damaged. 2. Nozzles plugged or dirt in reservoir. 3. Defective motor or pump.	1. Reinstall or replace hose. 2. Clean nozzles and service reservoir as required. 3. Replace pump/motor assembly.
Pump operates but no washer solution delivered.	1. No solution in reservoir. 2. Hoses loose, kinked or damaged. 3. Nozzles plugged or dirt in reservoir. 4. Solution frozen. place washer solvent. 5. Defective pump.	1. Fill reservoir. 2. Reinstall or replace hoses. 3. Clean nozzles or reservoir as required, 4. Thaw out system and re- 5. Replace pump/motor assembly.

WHEELS

WHEELS, RIMS AND TIRES

CONTENTS

PRINTED IN UNITED STATES OF AMERICA

CONTENTS

GENERAL

The information herein covers wheels and hubs for medium and heavy duty vehicles. Various types of wheels (cast spoke) are available and vary in size, types and materials (steel or aluminum).

The types of wheels used on medium and heavy duty vehicles are the cast spoke (Fig. 1)

Figure 1 illustrates a six spoke wheel, however, a five spoke wheel will be more common.

Fig. 1 Cast Spoke Front Wheel

Two different configurations of drum mountings will also be found:

1. Inboard mounted drum will be secured to hub on brake group side of hub (Fig. 3). Inboard mounted drums can be used with cast or disc wheels.

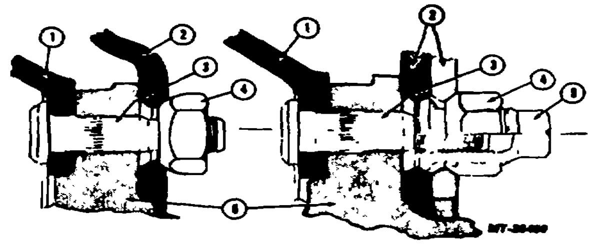

Fig. 3 Inboard Mounted Drum

1	Drum	4	Nut, Wheel Outer
2	Wheel	5	Nut, Wheel Inner
3	Bolt, Wheel		

The upper view of Figure 5 illustrates another version of an inboard mounted drum. This installation has a second flange inboard of the wheel mounting flange. The lower view illustrates a typical rear axle with outboard mounted brake drum.

All cast spoke wheels (front and rear) will have inboard mounted drums.

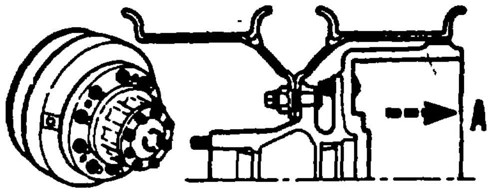

Fig. 5 Cross Section

A Inboard Mounted Drum

SAFETY PRECAUTIONS

Always loosen rim claps before complete removal of nut from stud (cast spoke wheels). With loosened nuts on stud strike claps with a heavy hammer and be sure each clamp is loose.

Always deflate tires completely before removing locks or side rings.

Always inspect and clean all parts before assembly.

Always inflate tires in a safety cage.

Always use a "clip-on" air chuck with remote control valve to inflate tires.

Never strike cast spokes of wheel assembly when loosening rim clamps.

Never mix rim side rings or lock rings of different types or size.

Never use cracked, bent or badly rusted parts.

Never reinflate flat tires on vehicle - use the spare.

Never add air until certain each side or lock ring is fully seated.

Never hammer side or lock ring on a partially or fully inflated tire.

REMOVE AND RINSTALL

tire and rim assembly will be removed for tire service.

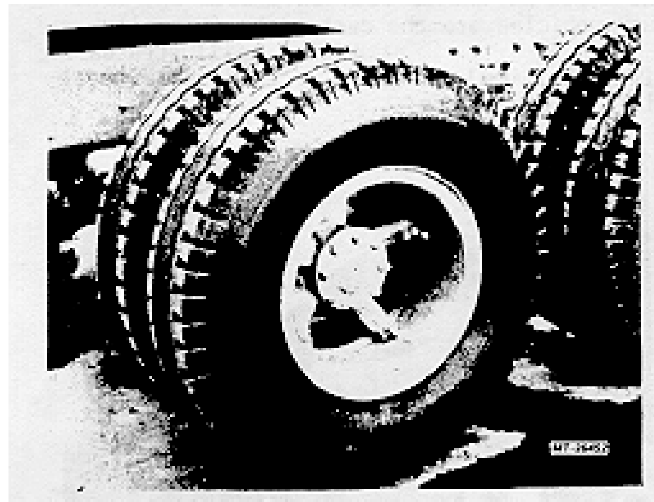

Fig. 6 Cast Spoke Rear Wheel Assembly

Vehicles with cast spoke wheels and inboard mounted brake drums (single tire remove wheel, hub and drum as an assembly.

When installing wheel, hub and drum assemblies, refer to the following: WHEEL BEARING ADJUSTMENT, WHEEL SEALS, AND WHEEL BEARING.

CAST SPOKE WHEEL (Figs. 1 and 6)

Tire and Rim Service Brake Service

1. Set parking brake or block wheels to prevent vehicle from moving.

2. Position vehicle on floor stand/s.

3. Loosen wheel nuts. Before removing nuts use a heavy hammer and strike the rim clamps. Make sure each clamp is loose, then remove the nuts and clamps. Do not strike cast spokes of wheel assembly.

When installing demountable rims, be certain stud threads are clean to permit correct torquing of nuts. Do not use any type of lubrication on threads.

Brake Service, Wheel, Hub and Drum Assembly

1. Position vehicle on floor stands.

2. Loosen or back off brake adjustment so that drum will move freely without drag.

3. Remove outer bearing grease cap and gasket on front axles. Remove axle shaft from rear axles (Fig. 7).

4. Different combinations of wheel bearing adjustment nut locks will be found.

   Rear wheels and some front wheels will require bending locking ring tab, relieving outer bearing jam nut. Then outer bearing lock nut, locking ring, bearing adjustment nut and retaining washer can be removed.

5. Use a wheel dolly to remove wheel and drum assembly (Fig. 8). Be sure to catch outer bearing assembly as wheel and hub is removed.

6. Repeat same procedure for opposite wheel on same axle.

7. Repack wheel bearings and install new seals as outlined in this section.

8. Use a wheel dolly to position wheel hub and drum assembly on spindle or axle end.

9. Adjust wheel bearings as outlined in Wheel Bearing Adjustment in this section.

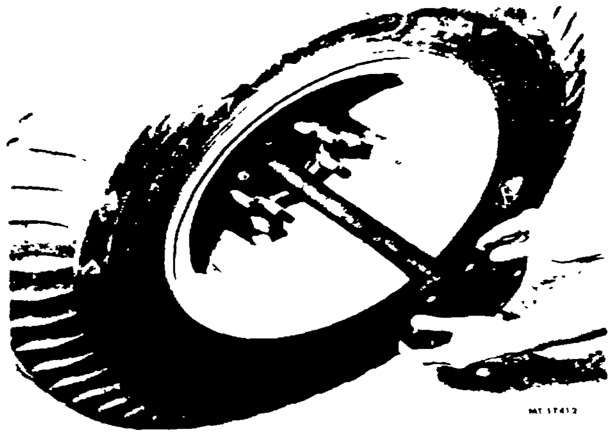

Fig. 7

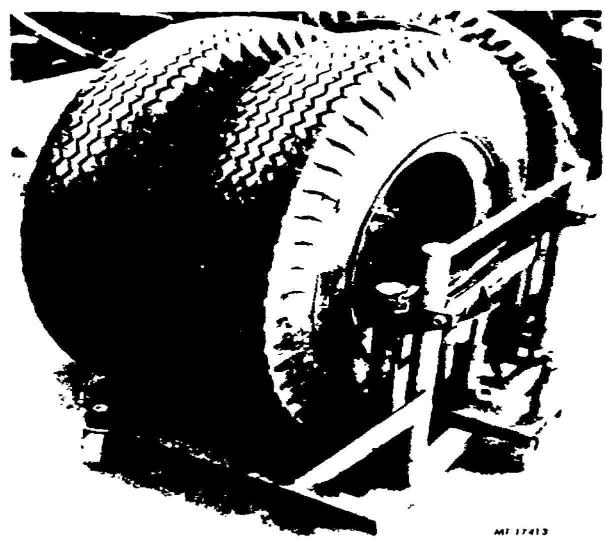

Fig. 8

10. Install outer bearing grease cap and gasket on front axles and install axle shaft on rear axles.

11. Repeat this same procedure for opposite wheel.

12. Adjust both brakes on axle where maintenance is being performed.

13. Remove floor stands.

WHEEL BEARING ADJUSTMENT

Satisfactory wheel seal operation as well as long bearing life depends on correct wheel bearing installation, lubrication and adjustment. The following will help you perform these required services for wheels and hubs.

Wheels or hubs, bearing cups, nuts, locks, hub caps, shafts and spindles are to be free from any foreign matter. Bearing cones must be packed with specified lubricant. Refer to BRICATIO Section. Also, refer to LUBRICATION OF AL BEARINGS found in this sane section.

WHEEL BEARING ADJUSTMENT PROCEDURE

Front and Rear Axle Adjusting in Nut

After wheel hub and bearings are assembled on the spindle or axle tube, tighten the bearing adjusting nut to 68 N-m (50 ft. lbs.) while rotating the wheel and hub assembly. Then back off adjusting nut 1/4 turn. If adjusting, lock or cotter key can be installed at this point do so. If not tighten nut to nearest locking position and insert lock or in. Refer to Cotter Key Installation. On front axles which use locks without pierced lock washer, bend lock over adjusting nut.

Front Axle Jam Nut

Axles have double nut type lock, tight- en Jam nut to 136-203 N-M (100-150 ft. lbs.). After tightening the jam nut, bend lock over one flat of jam nut.

Rear Axle Jam Nut

Rear axles which have dowelled adjusting nut 85.725 am (3-3/8") and larger with pierced lock washer, the jam nut is to be tightened to 475 to 508 N-m (350 to 375 ft. lbs.).

The bearing adjustment procedures are intended to result in zero to .254 am (.010”) end play with no preload. However, for longer seal life the zero end play (clearance) should be strived for.

COTTER KEY INSTALLATION

The cotter key should be inserted with the long tang toward the end of the spindle. Bend long tang of cotter key over end of spindle. Clip remaining tang leaving just enough stock to bend down against side of nut. A correctly installed cotter key should have the appearance as shown in Figure 13.

WHEEL SEALS

To insure satisfactory performance of wheel seals, various precautions are necessary whether the vehicle is equipped with grease or oil lubricated wheel bearings.

Always replace wheel seals whenever the wheel and hub assembly is removed. Seals establish a wear pattern after a period of usage and a reused seal my not be positioned back in its original location and leakage could result.

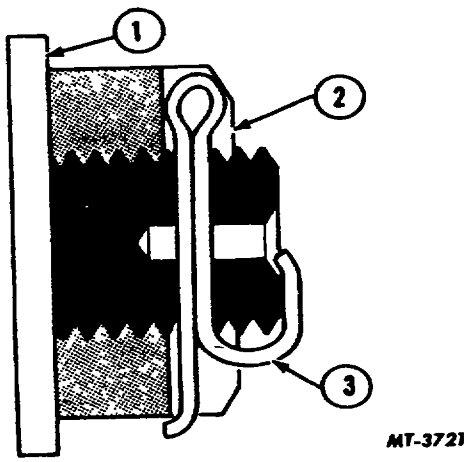

Fig. 13

1 Washer
2 Nut
3 Cotter Key

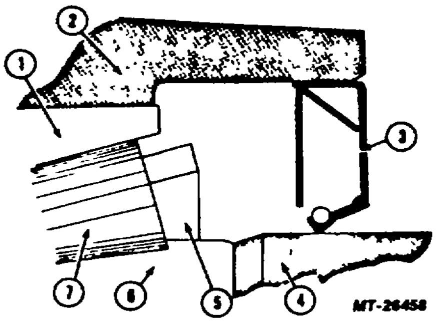

Fig. 14 Wheel Seals Used with Grease Lubricated Wheel Bearings

1	Bearing Cup	4	Axle
2	Hub	5	Bearing Cage
3	Wheel Seal, Lip Type	6	Bearing Cone
		7	Bearing Rollers

GREASE LUBRICATED WHIEL BEARING

For the most part the seals used with grease lubricated heel bearings will be of the lip type seal similar to that shown in Fig. 14. The seal is installed with lip toward the inner wheel bearing.

Scot unitized seals and Barrier unitized seals can also be used with grease lubricated wheel bearings.

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INSTALL

REMOVE

The wheel seals are removed using a brass drift and hammer. Position the drift through the outer opening of hub and against bearing. Tap bearing and seal out through the brake drum side of hub. Take care so that seal bore is not damaged.

The wiper or wear ring used with oil lubricated wheel bearing is removed by using a ball peen hammer and tapping on the ring to fatigue it. Do not use a chisel to cut ring since it could damage the machined surface on the axle.

CLEAN AND INSPECTION

1. Thoroughly clean all parts: axle tube or spindle, bearings, nuts and inside of wheel hub.

2. All burrs from inside back edge of hub must be removed. Hub must be smooth and free from burrs which will scratch the outside diameter of seal.

3. Remove burrs from axle tube or spindle shoulder. Shoulder must be smooth.

4. Inspect for porous or cracked hub which could allow oil leakage. This is important where leakage has been encountered.

5. Replace all parts as warranted. More information pertaining to lubricant leakage causes and corrections will be found in the Wheel Seal Leakage Chart in this section.

Lip Type Seal (Grease Packed Bearings)

1. Apply a thin coat of Loctite Gasket Eliminator (purple) around the outside perimeter of hub seal. The coating must be very light yet cover press fit area. Gasket Eliminator should never be allowed to contact lip of seal nor contaminate oil.

2. Lay wheel flat on a steady surface with brake drum up. Place inner wheel bearing into bearing cup and place hub seal into

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starting position on hub.

3. Install hub seal using SE-1905 Installer Set to prevent cocking seal (Fig. 21). Select the size disc which will apply force to outer edge of hub seal and prevent seal from becoming distorted or damaged.

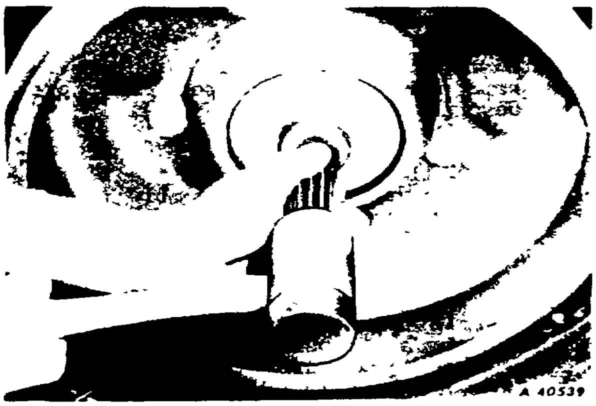

Fig. 21

Drive hub seal into hub until it bottoms in hub bore. Do not continue to drive after seal is once seated as this will distort or damage the seal. After removal of seal installer tool, clean off excess Gasket Eliminator. Be sure to confirm uniform seating of seal (Fig. 22).

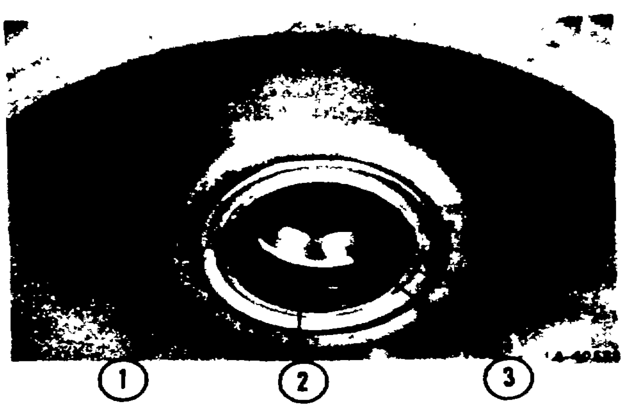

Fig. 22

1 Seal Inner Wheel Bearing
2 Lubricant

WHEEL BEARING INSPECTION

Inspect inner and outer wheel bearing cups, cones and roller for wear or damage. If any following conditions exist the bearing must be replaced if:

Large ends of rollers are worn flush to recess or radii at large ends of rollers are worn sharp (Fig. 27).

Fig. 27

There is a visible wear step, particularly at the large end of roller and roller track, or deep indentations, cracks or breaks in bearing cup and/or cone surfaces (Fig. 28).

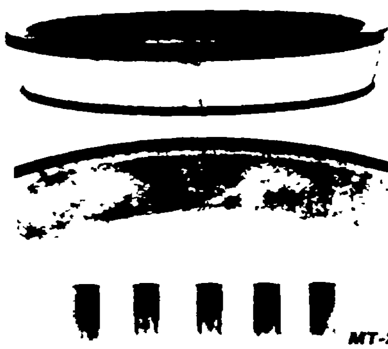

Fig. 28

There are bright rubbing marks on the dark phosphate surfaces of the bearing cage (Fig. 29).

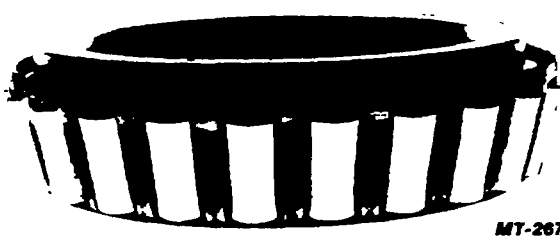

Fig. 29

There is an etching or pitting on contact surfaces of cup, cone or rollers (Fig. 30).

Fig. 30

There is any spalling or flaking on either the bearing cup and/or cone surfaces (Fig. 31).

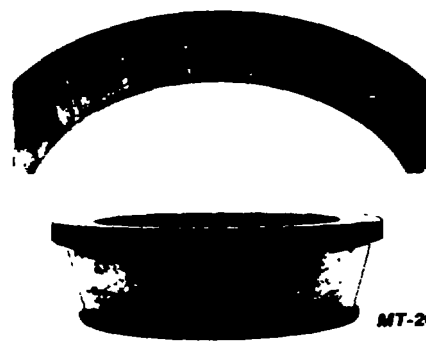

Fig. 31

LUBRICATION

Refer to the LUIBRICATION Section for type of lubricant to use.

Always use a wheel dolly to place wheel/s on spindle or axle tube. Care must be taken so that the seal is not damaged, especially when positioned over the end of the spindle or axle (Fig. 32).

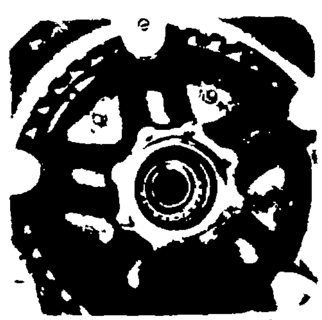

Fig. 32

GREASE LUBRICATED

1. Pressure lubricate inner and outer bearing assemblies, so that grease is forced between the cone and cage until grease is expelled between the cage and rollers (Fig. 33).

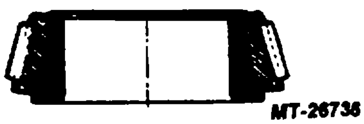

Fig. 33

2. Apply grease to wheel or hub cavity so that it is even with inside diameter of bearing cups.

3. Assemble bearings and seal and adjust bearings as directed elsewhere in this section.

4. When bearing maintenance is performed on rear drive axle bearings, the procedures in oil lubricated bearings can be used. It is important that the rear axle lube level be inspected since that lube also aids in lubricating the bearings.

WHEEL BEARING SEAL DIAGNOSTIC CHART

Prior to replacing a leaking wheel seal the actual cause of the leakage should be diagnosed to insure that the leakage problem will not reoccur. You will note that the chart has categories where the leakage could occur;

CAUSE	CORRECTION
WHEEL SEAL	
Seal Cocked or Not Properly Seated in Hub	Be sure to confirm uniform seating of seal after installation. Use proper installation procedures.
Seal Lip Cut or Rough on Open Lip Type Seals. Inside and Outside Diameter Damaged on Unitized Seals	New seal could have been damaged prior to installation. Inspect lips of new seals before and after installation in hub. Seal can also be damaged due to abuse during installation of hub assembly by contact with spindle or axle end or threads.
Seal Loose or Too Tight in Hub Bore or Seal Lip Over Size	Check for correct application of seal assembly.
Sealant Not Applied to Seal Outside Diameter When Required	Use Loctite Gasket Eliminator when instructed to do so.
Grease On Inside or Outside Diameter of Mechanix Barrier Seal	Grease may cause seal to move in hub bore or at axle housing or spindle. Seal is designed to grip hub bore and axle housing or spindle. Remove grease from inside and outside diameter.
Brake Can Shaft Seal Leakage	Excessive lubrication of brake cam shaft can cause grease to enter brake groups and may be mistaken for faulty wheel seal. Do not overlubricate brake cam shafts.

WHEELS AND BEARINGS

Wheel Hub Bore Has Burrs, Rust or Nicks	Hub must be smooth and free of excessive rough finish which could scratch outside diameter of seal. Clean up if possible or replace hub.
Hub Bore Diameter	Seal should be a press fit. Check for correct application of seal.
Porous or Cracked Hub	Leakage which would appear at the hub (not at axle flange) is an indication of a possible crack or porous opening allowing lube leakage. To correct this condition a new hub must be installed.
Loose wheel Bearing Adjustment	Loose wheel bearing adjustment will permit side movement of seal and cause abnormal wear or shaft to bore misalignment. Set and maintain proper wheel bearing adjustment.

AXLE HOUSING AND SPINDLE

Spindle or Axle Housing Has Burrs or Nicks	Remove all burrs and nicks. Correct rough finish. Do not use chisel to remove wiper ring (wear sleeve).
Leakage at Axle Shaft Flange	Missing or fractured axle gasket or lack of sealing compound. Replace gasket or apply silastic sealing compound.
Cosmolene on Spindle or Axle Housing	Thoroughly clean all cosomolene from sealing surfaces and bearing shoulder.
Axle Breather Inoperative	Excessive lube pressure could cause wheel seal leakage. Clean or replace breather.

RIM, WHEELS AND TIRES

GENERAL

The Occupational Safety and Health Administration (OSHA) has established rules and regulations pertaining to servicing Multi-Piece Rim Wheels.

Basically the regulations state that it is up to the employer to provide employee training to instruct all employees who service multi- piece rims in the safety hazards involved and safety procedures to be followed.

The employer shall see that no employee services multi-piece rim wheels unless trained and demonstrates and maintains the ability to service multi-piece rim wheels safely.

This shall include the following tasks:

1. Demounting of tires which includes deflation.
2. Inspection of components.
3. Mounting of tires which includes inflator with restraining device.
4. Use of restraining device.
5. Handling of wheels.
6. Inflation of tires when a wheel is mounted on the vehicle.
7. Installation and removal of wheels.

OSHA also states the type of tire servicing equipment to be used.

1. Restraining device (inflation cage).
2. Clip-on-chuck with enough hose to permit employees to stand clear of potential trajectory of wheel components. An in- line valve with gauge or pressure regulator preset to a desired value must also be provided.
3. Current charts must also be posted in service area.
4. Current rim manual containing instructions for types of rims being serviced shall be available in service area.
5. The employer must assure that only tools recommended in the rim manual are used to service multi-piece rim wheels.

CARE AND MAINTENANCE

Wheel rims should be periodically inspected both on the vehicle and during tire changes for cracks, loose wheel studs, worn mounting holes or being bent.

Cast spoke wheels (Fig. 1 and 6) have rims that are demountable with the tire; the rim clamp nuts should also be kept tight. Rim and tire to wheel alignment should be checked frequently to make sure the tire is running true. Some left-hand thread nuts can be identified by the small groove machined around the flats. Left-hand studs can be identified by the letter "L" stamped on the head. Use left-hand nuts on the left side of the truck.

Whenever a tire is removed, clean off all grease and road dirt. Use a wire brush or steel wool to remove the rubber from the bead seat.

Projections on the side wall of the gutter may cause uneven seating of the side ring and lead to chipping of the gutter. Remove these and other projections in the mounting area to assure the best possible fits.

Nicks and gouges in the vicinity of the fixed flange may lead to rim fracture.

Do not heat or weld wheels in an attempt to straighten or repair severe road damage. The special alloy used in these wheels is heat- treated, and uncontrolled heating from welding torch affects the properties of the material.

Do not allow dirt to enter the mounting area during installation. See "TORQUE CHART" for correct torque values.

WHEEL STUDS AND MOUNTINO NUTS

Maintaining wheel stud and mounting nut tightness does much to insure safe and satisfactory wheel operation. Loose wheel mount- ing can cause vibration, shimmy, tire wear, stud breakage, worn studs, mounting nuts (Fig. 36) and worn or elongated stud holes (Fig. 37). Parts with these characteristics must be replaced. Always keep wheel stud nuts tightened to specified torque.

Rust streaks (Fig. 38) from stud holes is a good indication that mounting nuts are not tightened to the specified torque.

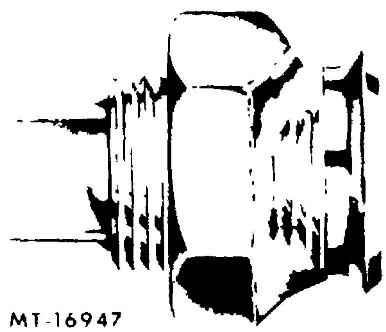

Fig. 36

Before mounting wheel assemblies on vehicle, make sure all parts are clean and free from foreign matter. Excess paint on wheel stud hole perimeters can permit wheel mounting nuts to loosen with use.

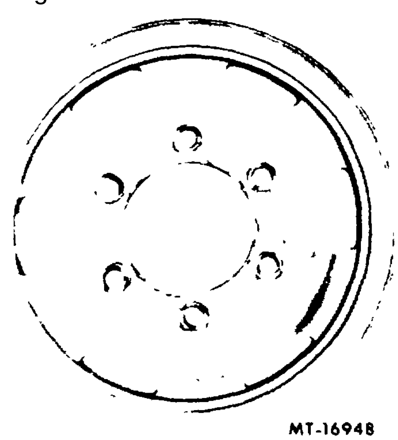

Fig. 37

INSTALLATION. TIGHTENING AND ALIGNMENT OF WHEELS AND RIMS

When installing demountable rims with cast spoke wheels, be certain that the threads on studs and nuts are clean to permit correct torquing of nuts. The mounting surfaces of rims, wheels, spacer rings and clamps are free of dirt, rust or damage.

Use a wire brush to clean mounting contact surfaces. Do not use lubricant on threads.

After rim or wheel has been properly torqued, it should be checked for alignment. This can be accomplished by rotating wheel with a piece of chalk attached to a steady, firm surface and placed to just barely clear out- side surface of tire bead seat. This procedure will point out the "high spot". Keep in mind, however, that a "high spot" does not necessarily mean that lug nuts have been unevenly tightened. This condition or misalignment can also result from a bent wheel.

The checking of the alignment of the wheel/rim installation is more important on cast spoke rims since the rims can be drawn out of alignment when improperly tightened. Therefore it is important that the following installation procedures be followed.

Cast Spoke Wheels

1. Slide inner rear or front tire and rim assembly over the cast spoke wheel and push it back into position against tapered mounting surface. Be sure valve stem faces out and centered between two spokes.

2. Slide spacer ring over wheel. Check spacer ring for concentricity by rotating spacer ring around cast spoke wheel.

3. Slide the outside rear tire and rim assembly on the wheel making sure the valve stem faces inboard and located in same relative position as inner valve stem.

4. Assemble all rim claps and nuts. Turn nuts on studs until each nut is flush with end of stud.

5. Turn top nut "1" (Fig. 39) until it is snug

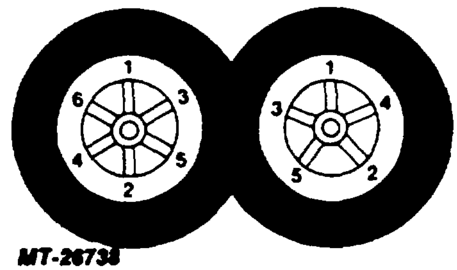

Fig. 39 Cast Spoke Wheel Tightening Sequence

6. Rotate wheel and rim until nut "2" (Fig. 39) is at top position and snug nut.

7. Rotate wheel and rim until nut "3" (Fig. 39) is at top position and snug nut.

8. Rotate wheel and rim until nuts "4", "5" and "6" are respectively at top and snug these nuts.

   Since the entire weight of tire and rim assembly is on top spoke, the foregoing procedure (criss-cross sequence) will assure even application of force at all points on the rim keeping the rim in proper alignment.

9. Repeat the sequence of -tightening the nuts to torque value listed in Torque Chart.

10. After operating the vehicle approximately 80 km (50 miles) check the stud nuts for tightness in same sequence shown in Fig. 39. Once each week inspect and retorque wheel stud nuts.

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WHEEL AND TIRE BALANCING

Front wheel and tire assemblies must be balanced to prevent wheel vibrating and bounce. While the correct front wheel alignment is necessary for easy steering and maximum tire life, the cause of unstable steering can be frequently traced to improper balance of front wheels. When this condition exists, the wheel and tire assembly should be properly balanced.

A vulcanized or retreaded tire, or a tire that has a boot in it, may cause an unbalanced condition that cannot be corrected by balancing. In such cases the tire should be replaced before attempting to balance the assembly.

Static Balancing

A wheel out of balance statically has a tendency to bounce up and down resulting in rapid tire wear in round or oblong spots.

Static balancing is performed while wheel is stationary by attaching weights to rim flange to offset an opposite heavy point.

Static balancing may be sufficient in same instances where vehicle is operated only at slow speeds, however, dynamic balancing (in motion) balances the wheel and tire assembly statically as well as dynamically, thereby eliminating vibrations and wheel bounce at both low and high speeds.

A wheel may be perfectly balanced statically (not in motion) but may still vibrate and bounce at high speed rotation because of its being out of balance dynamically,

Dynamic Balancing

Dynamic balancing is complete wheel balancing of which static balancing is only a part. Dynamic balancing (in motion) takes into consideration the distribution -of weight to be added to the wheel. This is accomplished by rapidly rotating (normal truck operating speed) the

wheel and tire assembly either on the vehicle or with the wheel assembly removed and placed on a dynamic balancing machine. This determines heavy point on wheel.

When the amount of weight required to offset a heavy part in a wheel assembly is known, it is sometimes necessary to attach one-half of the weight to the outside rim flange and the remaining half to the inside rim flange.

With the weight properly distributed on the wheel assembly, the wheel should be in balance both statically and dynamically and should rotate free of vibration and bounce at normal truck operating speeds.

TIRE CARE

Proper tire inflation, tire loads, and road speeds are important determining factors governing tire mileage, and also affect steering ease and maneuverability. How much these three- factors affect tire wear is illustrated in the paragraphs which follow.

INFLATION

Tire pressures should be checked at regular and frequent intervals and the pressures maintained to specifications. Use an accurate tire pressure gauge and check then tires are cool.

Over, inflated or under inflated tires will reduce the service life of. the tire.

“Bleeding" of air from hot tires should never be practiced. The pressure will be reduced but an increase in temperature will result as soon as driving continues.

LOADS

Loading tires beyond their rated capacity is expensive because tire mileages are rapidly decreased with overloads.

Tire Size Designations			Tire Load Limits at Various Cold Inflation Pressures (PSI)															
Tube	Tubeless	* / **	40 / 45	45 / 50	50 / 55	55 / 60	60 / 65	65 / 70	70 / 75	75 / 80	80 / 85	85 / 90	90 / 95	95 / 100	100 / 105	105 / 110	110 / 115	115 / 120
	16.5-22.5					6590	7010	7410	7790	8170	8540	8890	9230H					

Letters listed with weight are the maximum load for load range of tire

For applicable load limits for other than normal highway service, for other size designations and for size designations with suffixes such as “ML” (mining and logging) consult the tire manufacturer.

* Cold Inflation Pressure for Bias Tires.

** Cold Inflation Pressure for Radial Tires. Radial Tires have an “R” in the Size Designation; examples 10.00320.

Pages 3121 and 3122 Deleted

TIRE AND RIM COMBINATIONS
TIRES DESIGNED FOR NORMAL HIGHWAY SERVICE

Tubeless	Rim Width
16.5-22.5	12.25,13.00

Pages 3121 and 3122 DELETED

TORQUE CHART

		Torque	
		N ·m	Ft Lbs

CAST WHEELS

3/4"	Rim Clamp Nut	258 -285	190 - 210

DRY THREADS - NO LUBRICATION

Where excessive corrosion exists, a light coat of lubricant on first three threads of stud on bolt is remitted. Keep lubricant away from cap nut ball faces and rim clamps of cast wheels.

By Order of the Secretary of the Army:

JOHN A. WICKHAM, JR.
General, United States Army
Chief of Staff

Official:

R. L. DILWORTH
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The Metric System and Equivalents

Linear Measure

1 centimeter = 10 millimeters = .39 inch
1 decimeter = 10 centimeters = 3.94 inches
1 meter = 10 decimeters = 39.37 inches
1 dekameter = 10 meters = 32.8 feet
1 hectometer = 10 dekameters = 328.08 feet
1 kilometer = 10 hectometers = 3,280.8 feet

Weights

1 centigram = 10 milligrams = .15 grain
1 decigram = 10 centigrams = 1.54 grains
1 gram = 10 decigram = .035 ounce
1 dekagram = 10 grams = .35 ounce
1 hectogram = 10 dekagrams = 3.52 ounces
1 kilogram = 10 hectograms = 2.2 pounds
1 quintal = 100 kilograms = 220.46 pounds
1 metric ton = 10 quintals = 1.1 short tons

Liquid Measure

1 centiliter = 10 milliters = .34 fl. ounce
1 deciliter = 10 centiliters = 3.38 fl. ounces
1 liter = 10 deciliters = 33.81 fl. ounces
1 dekaliter = 10 liters = 2.64 gallons
1 hectoliter = 10 dekaliters = 26.42 gallons
1 kiloliter = 10 hectoliters = 264.18 gallons

Square Measure

1 sq. centimeter = 100 sq. millimeters = .155 sq. inch
1 sq. decimeter = 100 sq. centimeters = 15.5 sq. inches
1 sq. meter (centare) = 100 sq. decimeters = 10.76 sq. feet
1 sq. dekameter (are) = 100 sq. meters = 1,076.4 sq. feet
1 sq. hectometer (hectare) = 100 sq. dekameters = 2.47 acres
1 sq. kilometer = 100 sq. hectometers = .386 sq. mile

Cubic Measure

1 cu. centimeter = 1000 cu. millimeters = .06 cu. inch
1 cu. decimeter = 1000 cu. centimeters = 61.02 cu. inches
1 cu. meter = 1000 cu. decimeters = 35.31 cu. feet

Approximate Conversion Factors

To change	To	Multiply by
inches	centimeters	2.540
feet	meters	.305
yards	meters	.914
miles	kilometers	1.609
square inches	square centimeters	6.451
square feet	square meters	.093
square yards	square meters	.836
square miles	square kilometers	2.590
acres	square hectometers	.405
cubic feet	cubic meters	.028
cubic yards	cubic meters	.765
fluid ounces	milliliters	29,573
pints	liters	.473
quarts	liters	.946
gallons	liters	3.785
ounces	grams	28.349
pounds	kilograms	.454
short tons	metric tons	.907
pound-feet	newton-meters	1.356
pound-inches	newton-meters	.11296

To change	To	Multiply by
ounce-inches	newton-meters	.007062
centimeters	inches	.394
meters	feet	3.280
meters	yards	1.094
kilometers	miles	.621
square centimeters	square inches	.155
square meters	square feet	10.764
square meters	square yards	1.196
square kilometers	square miles	.386
square hectometers	acres	2.471
cubic meters	cubic feet	35.315
cubic meters	cubic yards	1.308
milliliters	fluid ounces	.034
liters	pints	2.113
liters	quarts	1.057
liters	gallons	.264
grams	ounces	.035
kilograms	pounds	2.205
metric tons	short tons	1.102

Temperature (Exact)

°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

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