

**SPICER AUTOMATE-2
9 & 10 SPEED AUTOMATED
TRANSMISSION**



Bulletin No. 2375-1

March 2000



INTRODUCTION

SAFETY FIRST

Carefully read this service manual before beginning any work on your Spicer transmission.

Throughout this literature, you will see symbols that warn of potential physical danger or product damage if the accompanying instructions aren't followed. Here are the symbols and their meanings.



This symbol indicates a potentially hazardous situation.



This symbol indicates that you must do something in order for the transmission to function properly. For example, you must use only one gasket underneath the shift tower. If more than one gasket is used or the gasket is eliminated, binding can occur. This would prevent proper shifting of the transmission and could damage the unit.



This symbol indicates that you must not do something in order to avoid damaging the transmission. For example, you must not use sealant underneath the shift tower. Using sealant underneath the tower will prevent proper interlock functioning and could damage the unit.

Be sure you understand all procedures and instructions in this manual before you begin working on your Spicer transmission. If you have any questions, contact your Spicer transmission representative or call the Spicer Support Line (800-666-8688).

GENERAL SAFETY PRECAUTIONS



WARNING: Use a hoist whenever lifting the transmission or shaft assemblies. Using a hoist can help prevent muscle strain or other possible injuries.



WARNING: Always wear safety glasses to help prevent possible eye injury caused by small parts (such as snap rings) or metal chips that may fly up unexpectedly during a teardown or rebuild.



WARNING: Be careful when picking up gears or other sharp components. You could cut your hands. Consider wearing heavy cloth gloves or covering sharp objects with shop towels before picking them up.



WARNING: When draining the transmission prior to working on it, be sure to let the unit cool down first. Hot transmission fluid can cause burns.

The information in this service manual was current at the time of publication.

The Technical Support Line (800-401-9866) can advise you of any changes or updates.

TABLE OF CONTENTS

GENERAL INFORMATION	
SPECIFICATIONS	1
TORQUE SPECIFICATIONS	2
DRIVER INSTRUCTIONS	3
MAINTENANCE	
AIR LINE PIPING DIAGRAM	7
FILTER REGULATOR	11
LUBRICATION	12
TOOL REFERENCE	13
WIRING DIAGRAMS	14
GENERAL DISASSEMBLY	17
UPPER SHIFT TOWER DISASSEMBLY	20
LOWER SHIFT TOWER ASSEMBLY	21
REMOTE CONTROL DISASSEMBLY	26
RANGE CASE DISASSEMBLY	
CASE EXPLODED DRAWING	32
GEARS EXPLODED DRAWING	33
DISASSEMBLY	34
OPTIONAL DISASSEMBLY—CONVENTIONAL TRUCKS	40
OPTIONAL DISASSEMBLY—CAB-OVER TRUCKS	41
MAIN CASE DISASSEMBLY	
CASE & SHIFT FORKS EXPLODED DRAWING	42
CLUTCH HOUSING EXPLODED DRAWING	43
MAIN CASE GEARS EXPLODED DRAWING	44
DISASSEMBLY	47
COUNTERSHAFT DISASSEMBLY & REASSEMBLY	51
CLEANING & INSPECTION PROCEDURES	52
MAIN CASE REASSEMBLY	53
RANGE CASE REASSEMBLY	56
REMOTE CONTROL REASSEMBLY	63
LOWER SHIFT TOWER REASSEMBLY	68
UPPER SHIFT TOWER REASSEMBLY	72
TROUBLESHOOTING	73



GENERAL INFORMATION

SPECIFICATIONS

Length 31" (clutch housing mounting face to washer seat face)

Clutch Housing SAE No. 1

Clutch 14" or 15 1/2" Spicer Easy Pedal, 2-plate

Input Shaft 2.00" x 10-spline or 1.75" x 10-spline

Output Shaft 2.5" x 10-spline

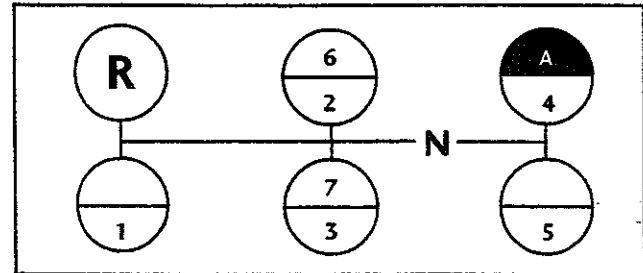
Lube Capacity 18 pints (8.5 liters) with Optilube
27 pints (13 liters) without Optilube

Speedometer Provision for mechanical and electronic

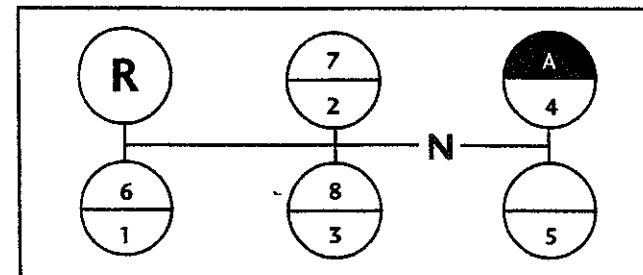
Power Take-Off 6-bolt right side, 8-bolt bottom left
45-tooth 6-pitch drive gear, both sides

PTO Speed Direct 62% of engine RPM
O/D 83% of engine RPM

SIMPLE SHIFT PATTERN - 9-SPEED



SIMPLE SHIFT PATTERN - 10-SPEED



GENERAL INFORMATION

TORQUE SPECIFICATIONS FOR NUTS AND BOLTS

NOM. THREAD SIZE (DIA.)		PART NAME	WRENCH TORQUE (FT. LBS.)				
			NON-LOCKING TYPE		LOCKING TYPE (Booded Nylon Patch)		
			MIN.	MAX.	MIN.	MAX.	
.250	6	BOLT OR NUT	7	10	10	13	
.312			13	17	20	24	
.375	10		25	32	34	41	
.438			40	50	52	62	
	12		60	80	60	80	
.500			90	115	78	98	
	14		120	150	80	100	
.562			200	250	112	137	
.625					150	180	
.750			NUT			240	290
1.250						400	450
1.375						550	600
1.750						550	600
		PTO APERTURE COVER BOLTS					
.375		BOLT	10	15	16	24	
.438		BOLT WITH GASKET 97-324-2	20	25	36	41	
.438		BOLT WITH GASKET 22P22	20	25	29	34	

GENERAL INFORMATION

HOW TO SHIFT THE SPICER MODEL AUTOMATE-2™

The AutoMate-2™ is a 9-speed or 10-speed, semi-automatic transmission. The gear ratios, percent steps and torque capacities of each AutoMate-2™ model exactly match those of the corresponding manual transmission.

The first eight gears and reverse (on a 10-speed AutoMate-2) and the first seven gears and reverse (on a 9-speed AutoMate-2) are shifted in the same manner as the equivalent manual transmission. On a 10-speed AutoMate-2, the 9th and 10th gears are fully automated. On a 9-speed AutoMate-2, the 8th and 9th gears are fully automated. When sufficient road speed is attained in 8th gear (10-speed)/7th gear (9-speed), and the driver selects the "A" (Auto) lever position (Figures 1 and 2), the AutoMate-2™ transmission automatically shifts into 9th gear (10-speed)/8th gear (9-speed) and then into 10th gear (10-speed)/9th gear (9-speed).

The shift points between 9th and 10th gear (10-speed) and 8th and 9th gear (9-speed) are based on the following variables: road speed, engine RPM, throttle position, brake, clutch, and cruise control status. The transmission also automatically downshifts from 10th to 9th gear (10-speed) and 9th to 8th gear (9-speed), according to the variables just mentioned. Automatic shifting is based on software parameters stored in the transmission controller.

STARTING THE VEHICLE FROM A STOP

1. Place the gear shift lever in neutral, depress the clutch pedal and set the brakes. Start the engine and allow it to build to maximum air pressure.
2. With the clutch pedal fully depressed to engage the clutch brake (See "Trucking Tips: Clutch Brake"), position the range selector to low range (Figure 3). Move the gear shift lever into 1st gear.

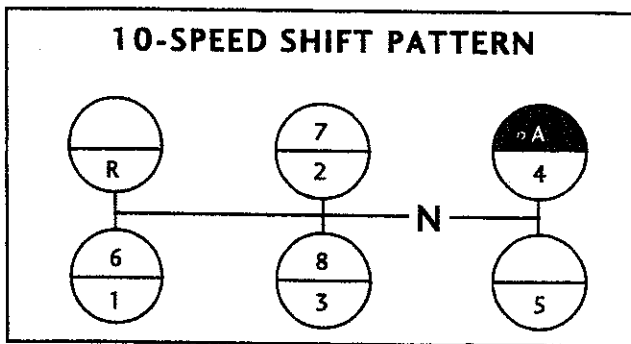


Figure 1

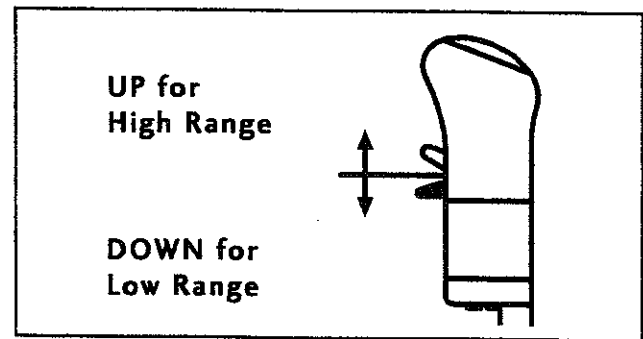


Figure 3

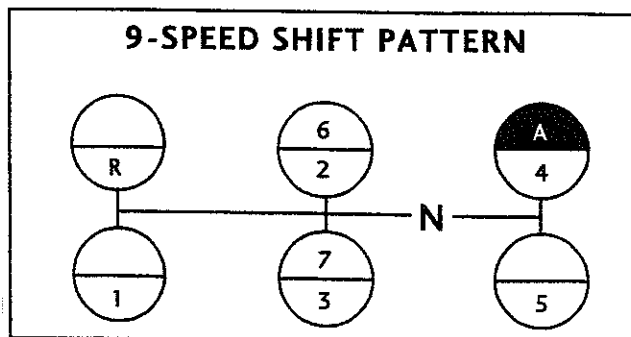


Figure 2

3. Release the tractor parking brakes (and trailer parking brakes, where applicable). Gradually release the clutch pedal to full position and depress the throttle to start the vehicle moving.
4. After attaining optimal speed in 1st gear, depress the clutch pedal. Move the gear shift lever to neutral (See "Double Clutching: Upshifting"). Move the gear shift lever to 2nd gear.

GENERAL INFORMATION

5. Continue the above procedures through 5th gear.
6. To continue upshifting (6th gear through Auto), pre-select high range on the range selector. Depress the clutch pedal and move the gear shift lever from 5th gear to neutral (See "Double Clutching: Upshifting"). Then move the gear shift lever into 6th gear.
7. After attaining optimal speed in 6th gear, depress the clutch pedal. Move the gear shift lever to neutral (See "Double Clutching: Upshifting") and move the gear shift lever into 7th gear.

In a 10-speed AutoMate-2, repeat Step 7 for 8th gear.

8. After attaining optimal speed in 8th gear (10-speed)/7th gear (9-speed), depress the clutch pedal and move the gear shift lever to neutral. Release the clutch pedal and move the gear shift lever to the Auto position. It is not necessary to depress the clutch pedal when shifting into Auto. All up and down shifting between 9th and 10th gear (10-speed) or 8th and 9th gear (9-speed) will now be done automatically.

TRUCKING TIPS

Downshifting

Downshifting is actually just the reverse of upshifting (See "Double Clutching: Downshifting").

Clutch Brake

The clutch brake used with this unit is designed to stop gear rotation so you can shift into 1st and reverse gears. The last 1" of clutch pedal travel activates the clutch brake. On shifts other than 1st or reverse from a stop, depress the clutch pedal only enough to release the clutch. Depressing the pedal to the floorboard will

activate the clutch brake and could cause gear hang-up or hard shifting.

When selecting a starting gear if you have a butt-tooth condition, gradually release the clutch so the drive gear can rotate. This will align the gear clutching teeth to complete the shift.

Double Clutching

Upshifting: The normal double clutching technique is suggested. When you want to shift, depress the clutch and move the lever to neutral. Engage the clutch and allow the engine RPM to drop so that the engine speed and driveline speed match. Depress the clutch and move the lever into gear. Engage the clutch and accelerate as conditions permit. In a 10-speed AutoMate-2, clutching is not required to go from 9th to 10th gear. In a 9-speed AutoMate-2, clutching is not required to go from 8th to 9th gear. These gears shift automatically.

Downshifting: Downshifting is the reverse of upshifting. As the engine approaches the shift point (start the downshift approximately 50 - 100 RPM above the shift point), depress the clutch and move the lever to neutral. Engage the clutch and raise the engine RPM until the engine and driveline speeds are equal (normally, governed speed). Depress the clutch and then shift into the next lower gear. Engage the clutch. In a 10-speed AutoMate-2, clutching is not required to go from 9th to 10th gear. In a 9-speed AutoMate-2, clutching is not required to go from 8th to 9th gear. These gears shift automatically.

Skip Shifting

Experienced drivers sometimes want to skip some of the ratios. This is acceptable; however, you should do this only when operating conditions allow. Your speed, load, and road type and condition should be considered.

GENERAL INFORMATION

REMINDERS



Double clutch when shifting. This will help components match speed better during shifts and help ensure proper engagement.



Downshift through all gear speeds when slowing down. Chassis and trailer brake life can be increased by doing this.



Do not force the shift, since this can cause damage to clutch collars and clutching teeth. Use steady force on the shift lever to complete shifts.



Do not coast in neutral. The vehicle could lose RPMs during coasting, and you may not be able to shift back into the proper gear, leading to loss of vehicle control and possible injury or death.



Do not downshift at excessive road speeds. This could prevent proper gear engagement and could damage clutching teeth.



Do not tow vehicles without first pulling the axles or disconnecting the driveshaft. If you tow a vehicle without doing this, you could damage drivetrain components because the system lubrication is inadequate when a vehicle is towed.

OTHER INFORMATION

- ◆ When the transmission is placed in the Auto position, all shifts between the top two gears are automatic and made without using the clutch.
- ◆ It is not necessary to depress the clutch when placing the shift lever in the Auto position.
- ◆ Throttle movement is not necessary to initiate a shift.

- ◆ Cruise control can be used when the shift lever is in the Auto position.
- ◆ Braking can be performed during a shift.
- ◆ If braking occurs when in the top gear, the transmission will downshift at a higher shift point to optimize engine braking. The transmission will not upshift until the throttle is depressed.
- ◆ When climbing a hill, the transmission will downshift if necessary. If the hill is beyond the capability of the top two gears, downshifting out of Auto is necessary.
- ◆ If the gear selector remains in Auto when the vehicle is brought to a stop, the transmission will shift to neutral to prevent the engine from stalling.
- ◆ If the gear selector is removed from Auto and the vehicle is accelerating, the transmission will stay in Auto.
- ◆ If the transmission is in Auto, 9th gear (10-speed) or 8th gear (9-speed) and going downhill, the transmission will upshift only if the accelerator is depressed, or "Resume" is activated on the cruise control.
- ◆ If the transmission is in neutral and the vehicle speed exceeds what would be governed engine speed for the gear directly before Auto, the transmission will shift into the lowest gear in Auto.
- ◆ When the vehicle is first keyed on, the transmission warning light will illuminate like other dash lights for a bulb check and then go out. This also indicates a successful self-diagnostic routine.
- ◆ If the transmission warning light illuminates at other times, a problem or error in operation has been detected. If a fault has been detected, a fault code will be stored in the transmission's computer to aid the service technician. Expect degraded performance and have the transmission serviced as soon as possible.

GENERAL INFORMATION

GENERAL OPERATING INSTRUCTIONS FOR THE SPICER AUTOMATE™

Clutching

When the transmission is placed in the automatic position, all shifts between the top two gears are automatic and do not require the use of the clutch. It is not necessary to depress the clutch when placing the shift lever in "Automatic". Throttle movement is not necessary to initiate a shift.

Cruise Control

Cruise control can be used when the transmission is in automatic.

Braking

Compression brakes can be used when the transmission is in automatic. Braking can be performed during a shift. If braking occurs when in the top two gears, the transmission will downshift as soon as possible to optimize engine braking. The transmission will not upshift until the throttle is depressed.

Special Shifting Situations

When climbing a hill, the transmission will downshift if necessary. If the hill is beyond the capability of the top two gears, downshifting out of automatic is necessary.

If the gear selector remains in automatic when the vehicle is brought to a stop, the transmission will shift to neutral to prevent the engine from stalling.

If the gear selector is removed from automatic and the vehicle is accelerating, the transmission will remain in automatic.

If the transmission is in automatic 9th gear (on a 10-speed AutoMate-2) or 8th gear (on a 9-speed AutoMate-2) and going down hill, the transmission will upshift only if the accelerator is depressed or if "resume" is activated on the cruise control.

If the transmission is in neutral and the vehicle speed exceeds what would be governed engine speed for the gear directly before automatic, the transmission will shift into the lowest gear in automatic.

Tests and Warnings

When the vehicle is first keyed on, the transmission warning light will illuminate for a bulb check, like all the other dash lights. This second illumination indicates a successful self-diagnostic routine.

If the transmission warning light remains on, a problem or error in operation has been detected. If a fault has been detected, a fault code will be stored in the transmission computer to aid the service technician. Expect degraded performance and have the transmission serviced as soon as possible.

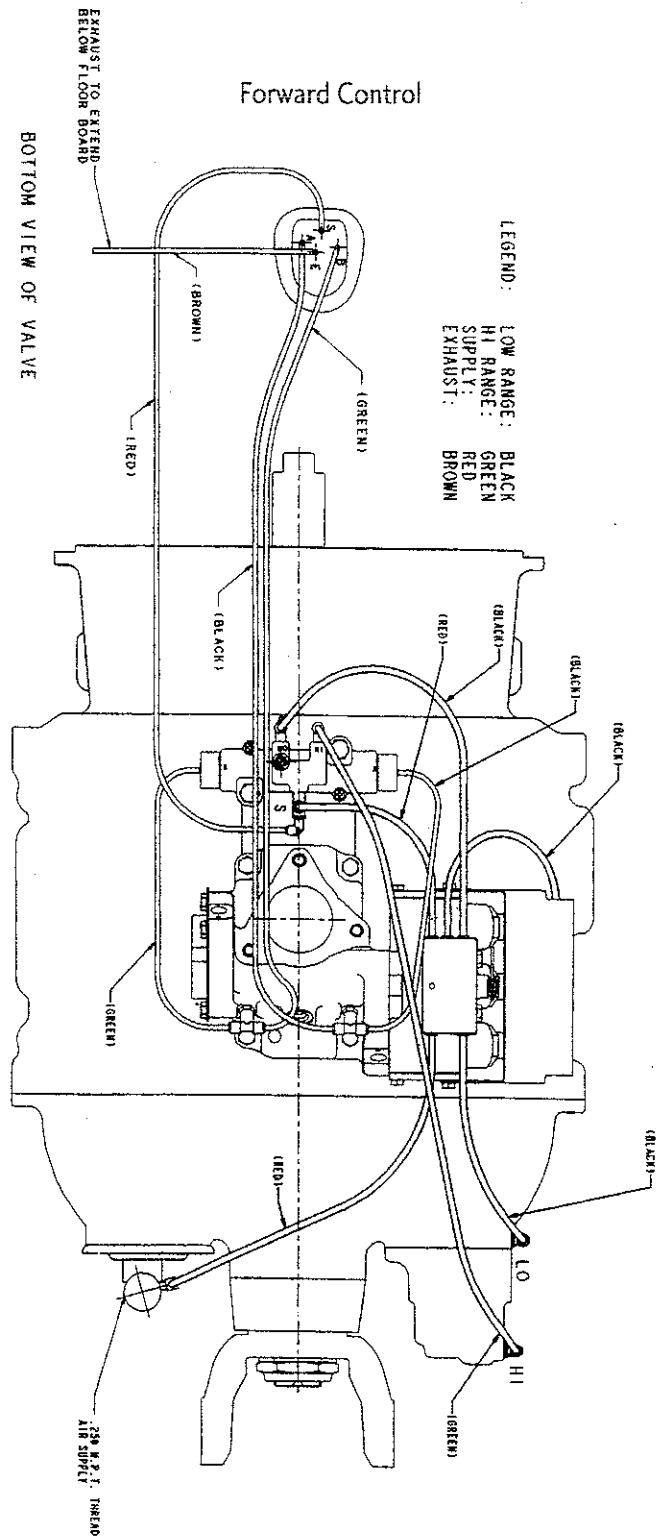
If an illuminated transmission warning light goes out, it is an indication of an intermittent problem. A fault code will be stored in the transmission computer to aid the service technician. Transmission performance may return to normal, but the transmission should be serviced as soon as possible.

If the transmission warning light blinks, a failure has occurred that will not allow the automatic feature to operate. Use the manual gears available to shift and have the transmission serviced immediately. Failure codes will be stored in the transmission computer to aid the service technician.

For additional technical service, please call the Spicer Support Line at 1-800-666-8688.

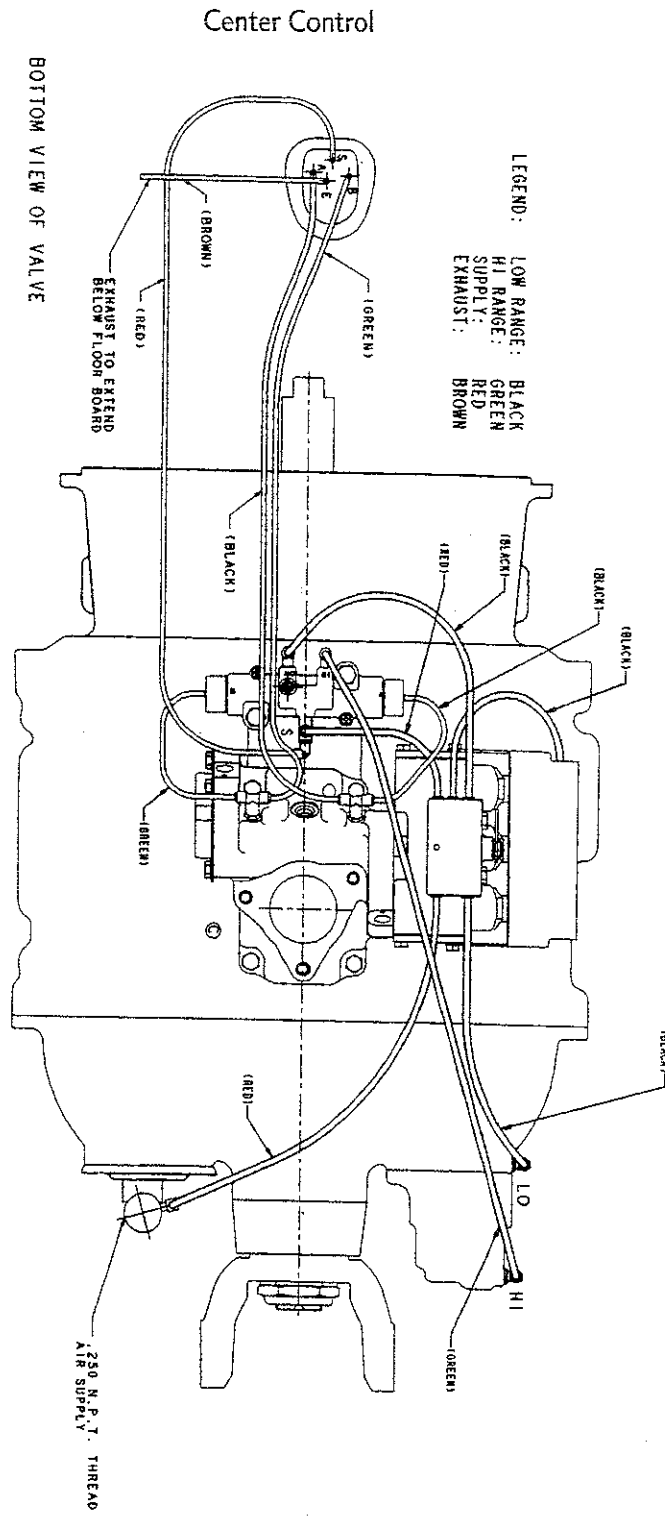
MAINTENANCE

AIR LINE PIPING DIAGRAM



MAINTENANCE

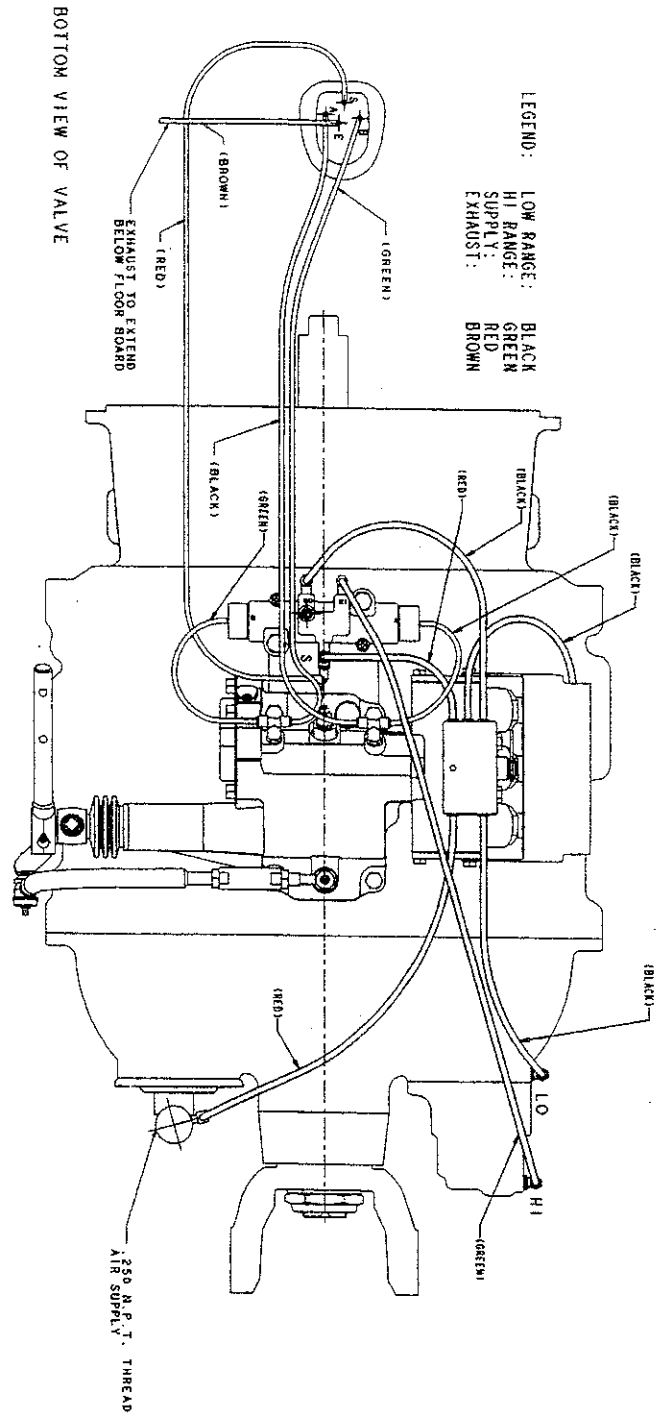
AIR LINE PIPING DIAGRAM



MAINTENANCE

AIR LINE PIPING DIAGRAM

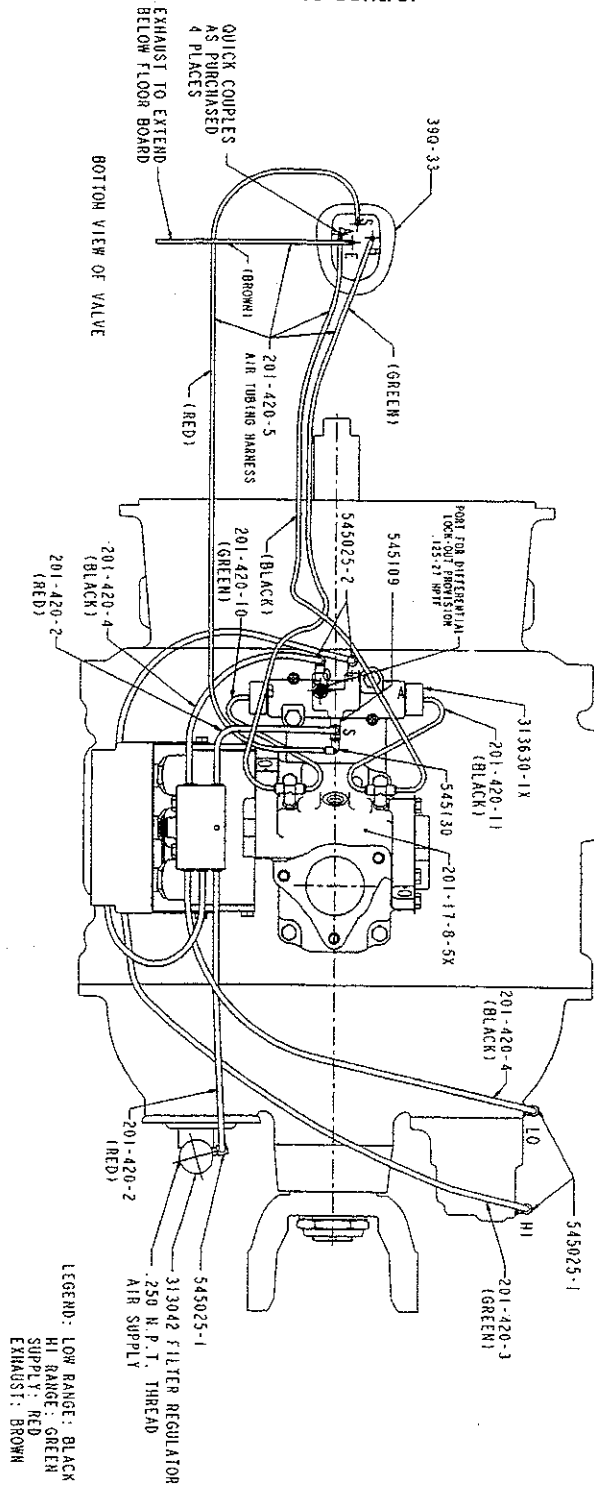
Remote Control



MAINTENANCE

AIR LINE PIPING DIAGRAM

Navistar Pro Sleeper Option Remote Control



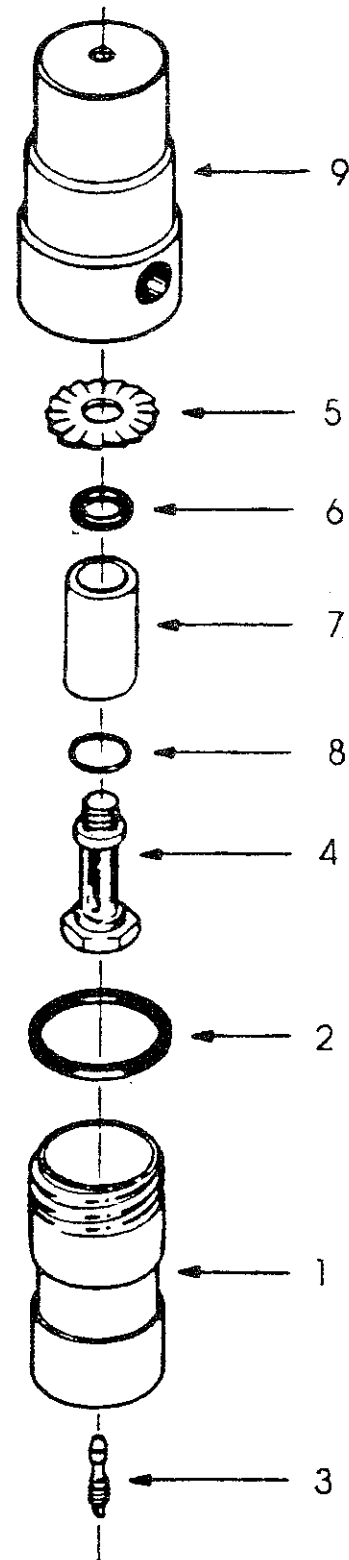
MAINTENANCE

FILTER REGULATOR

This unit uses a filter regulator preset at 50-55 lbs.

- ⚠ **CAUTION:** Use only petroleum-based solvents to clean parts. Other types of solvents may damage filter components and affect proper operation.
- ⚠ **CAUTION:** Blow air through the filter (inside and outside) to dislodge surface contaminants. Otherwise, these contaminants could affect proper filter operation and lead to equipment damage.
- ⊘ **CAUTION:** Do not disassemble the regulator section (9) It is not field-repairable. If it is damaged, replace it.

1. Clean or replace the filter element (7) every six to 12 months, or whenever slow shifting is encountered. Replace the element after three cleanings. If regulator malfunction is indicated, replace the entire unit.
2. To service the filter section, shut off air pressure. Unscrew the bowl (1) and remove the O-ring (2). Unscrew the stud (4). Remove the louver (5), upper gasket (6), element (7), and lower gasket (8) from the stud. Do not disassemble the regulator section (9).
3. After cleaning, inspect the parts carefully. Replace any damaged parts.
4. Reassemble the unit by first installing the filter element (7) on the stud (4), so that the large end of the internal taper (thinnest wall section) is toward the hex on the stud. Torque the stud to 5 - 10 lbs. inch.
5. Apply a wipe coat of Dow Corning DC7 Silicone Grease or the equivalent to the O-ring (2) seating surfaces on the regulator (9) and bowl (1). Apply a light, even coat of Molykote "G" or the equivalent to the bowl threads. Torque the bowl to 5 - 10 lbs. inch. If the drain valve (3) was removed, reinstall it and torque it to 10 - 15 lbs. inch.



MAINTENANCE

LUBRICATION

! **CAUTION:** To ensure proper lubrication and operating temperatures in this unit, the proper lubricants must be used. Correct oil levels must be maintained. Spicer recommends using only lubricants produced by reputable, well-known suppliers. If you want to use a lubricant not specified below, please contact your local truck dealer to determine whether the lubricant is suitable for your purposes.

Recommended Lubricants

The lubricants listed below are recommended for use in all Spicer mechanical transmissions, auxiliaries, and transfer cases.

Oil Changes

Many factors influence oil change periods. Changes should be scheduled at three years or 250,000 miles with synthetic engine oil for normal over-the-highway operations. Off-highway use usually requires an oil change every 1,000 hours. The oil level in the transmission should be checked every 5,000 miles (8,045 km) on-highway, or every 40 hours in off-highway operation. When it is necessary to add oil, Spicer recommends that

types and brands of oil not be mixed. The correct oil level in this transmission is established by the filler plug opening.

Refilling

First, remove all dirt around the filler plug. Then refill the transmission with new oil. Use the grade recommended for the existing season and prevailing service. The lubricant should be level with the oil fill plug located on the right side of the transmission case.

Overfilling

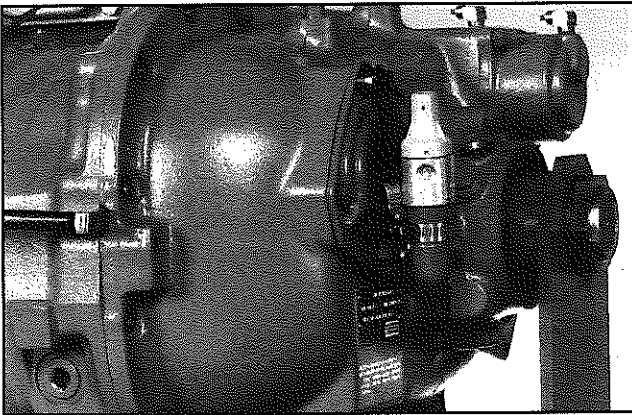
⊘ CAUTION: Do not overfill the transmission. This usually results in oil breakdown due to excessive heat and aeration from the churning action of the gears. Early breakdown of the oil will result in heavy varnish and sludge deposits that plug up oil ports and build up on splines and bearings.

TEMPERATURE	GRADE	TYPE
All	CD 50	Synthetic engine oil meeting MIL-L-21 04 D or MIL-L-461 52 B, API-SF or API-CD
Oil cooler		
See standard application requirements.		

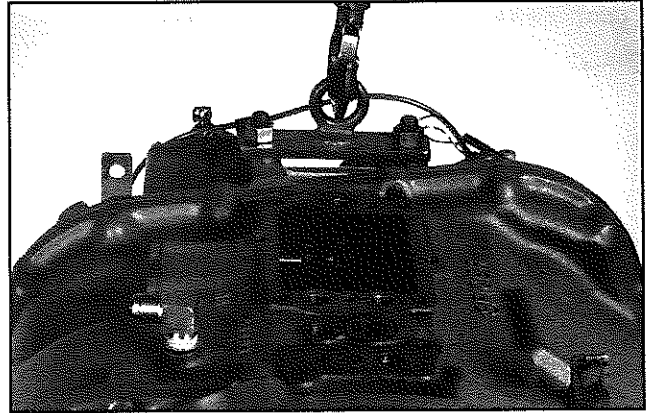
MAINTENANCE

TOOL REFERENCE

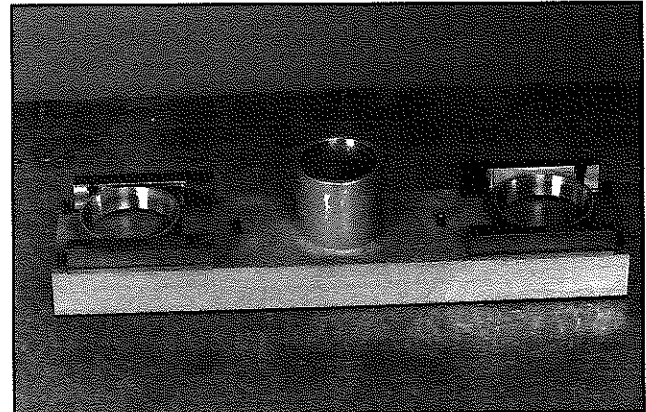
This unit can be repaired with ordinary mechanic's tools. However, to reduce vehicle downtime, we recommend using the special tools listed below. For tool specifications, information about use, and warranty information, please see the manufacturer's literature.



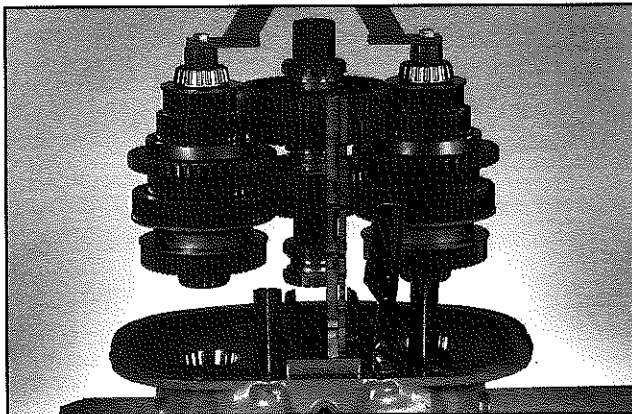
Transmission range case support fixture, part number OEM6595.



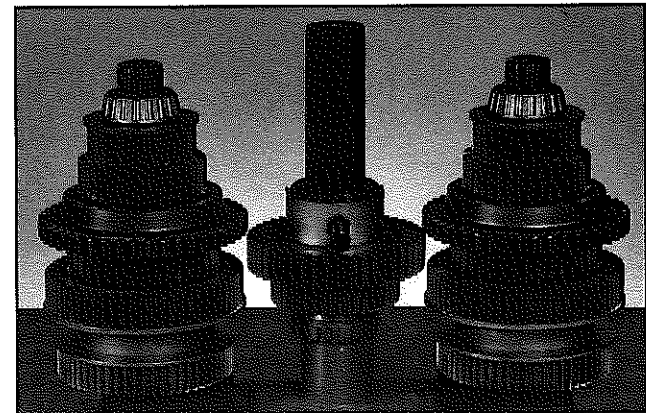
Range case support fixture, part number OEM6595.



Countershaft/mainshaft assembly stand, part number OEM6596A. If you have assembly stand OEM6596, it can be converted for use with this unit by ordering OEM65961.



Gear shaft lifting fixture, part number OEM6598.



Mainshaft assembly spacer, part number OEM6597.

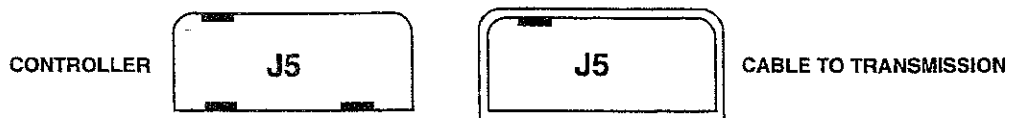
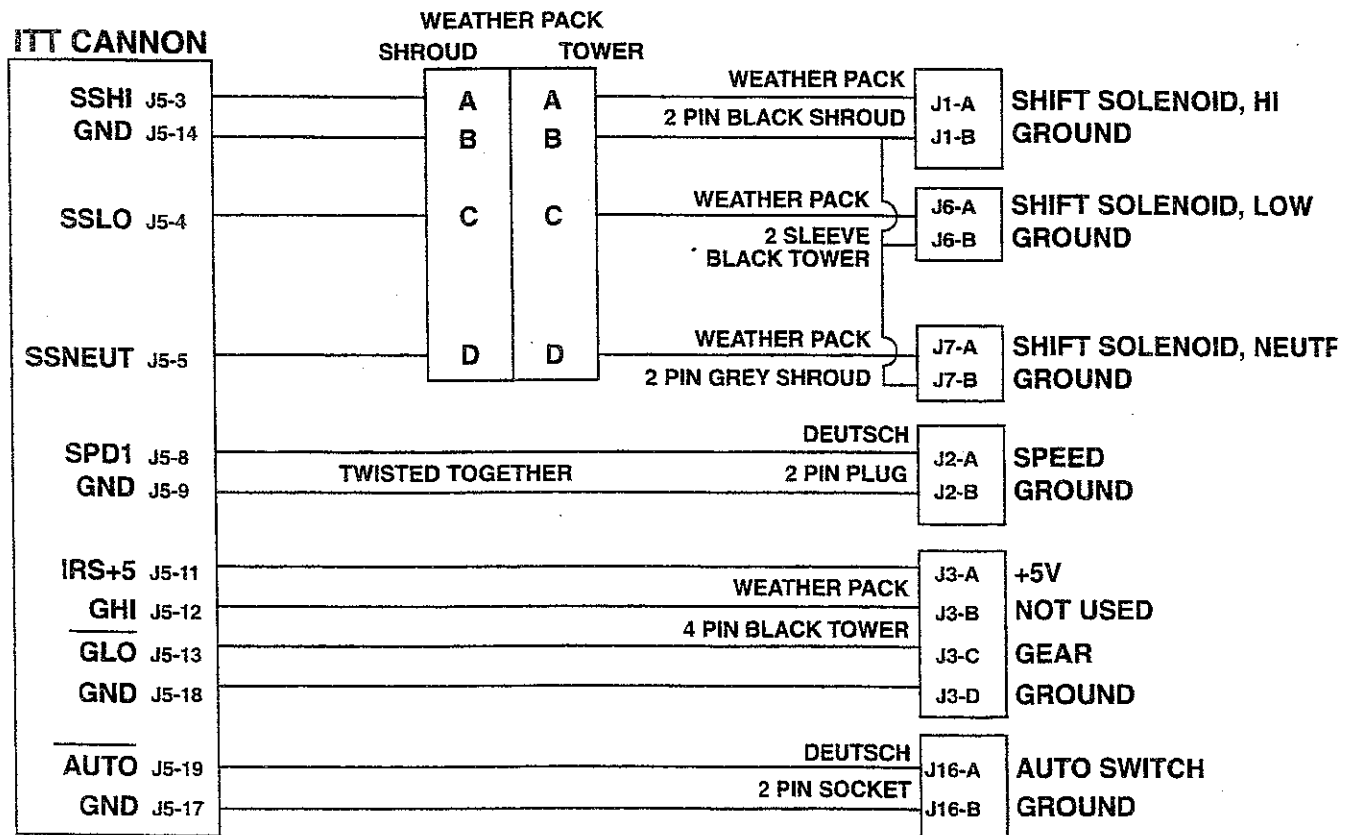
To order tools or for more information, contact:

OTC Division
Sealed Power Corporation*
OEM Sales
655 Eisenhower Drive • Owatonna, MN 55060
Phone: (507) 455-7038 • Fax: (507) 455-7215

**Sealed Power Corporation is not affiliated with Dana Corporation.*

MAINTENANCE

CONTROLLER TO TRANSMISSION WIRING DIAGRAM - NAVISTAR ONLY

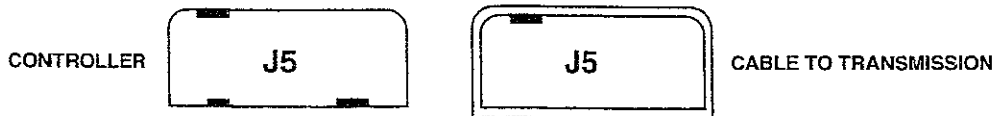
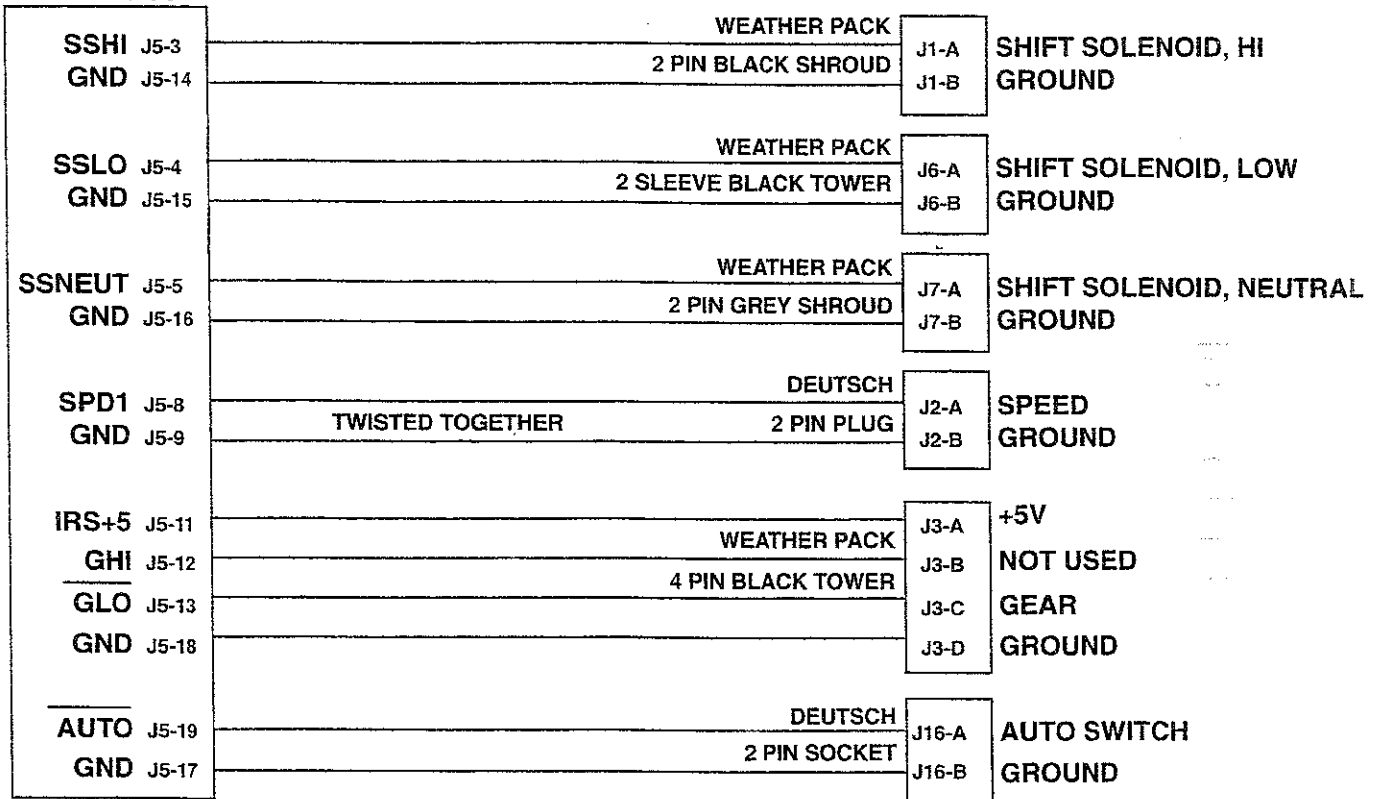


"Z" POLARIZATION
CANNON CONNECTOR
AS VIEWED FROM PIN ENDS

MAINTENANCE

CONTROLLER TO TRANSMISSION WIRING DIAGRAM – ALL EXCEPT NAVISTAR

ITT CANNON

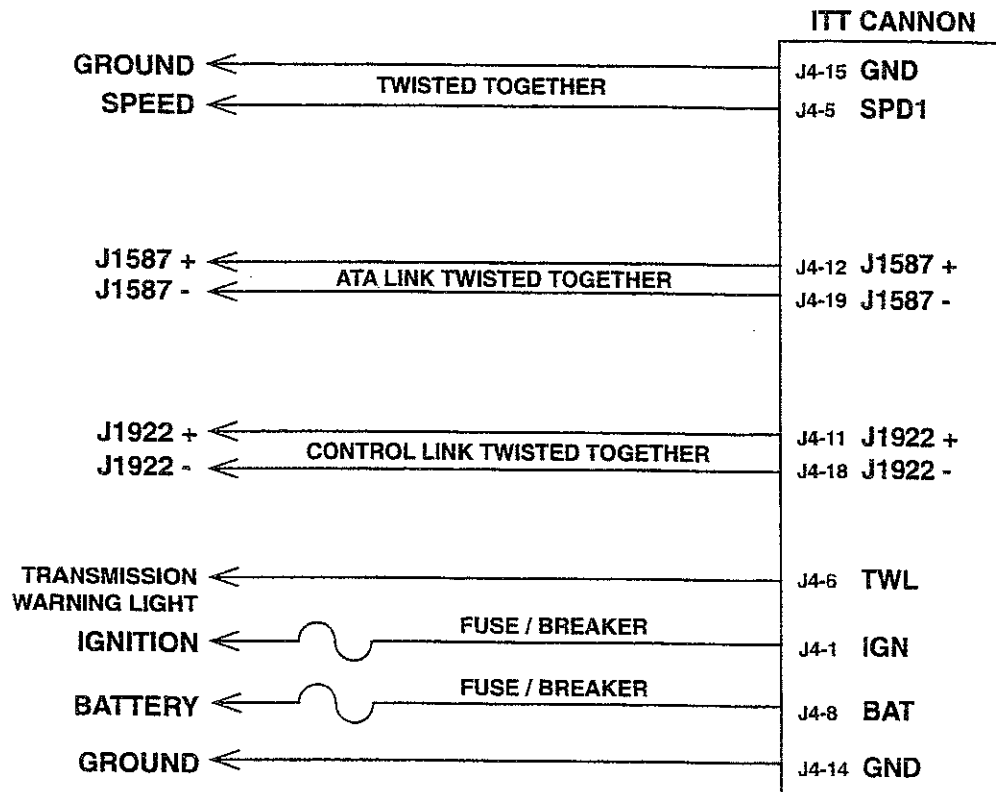


“Z” POLARIZATION
CANNON CONNECTOR
AS VIEWED FROM PIN ENDS

MAINTENANCE

CONTROLLER TO VEHICLE WIRING DIAGRAM -

ALL OEM'S



**"X" POLARIZATION
CANNON CONNECTOR**

AS VIEWED FROM PIN ENDS

GENERAL DISASSEMBLY

IMPORTANT PROCEDURE

To locate and correct unit power or auxiliary transmission troubles, follow a systematic procedure.

Road test whenever possible. Mechanics usually get second- or third-hand reports of trouble experienced with the unit. These reports do not always accurately describe the actual conditions. Sometimes symptoms seem to indicate trouble in the transmission, while the actual problem is with the axle, driveshaft, universal joints, engine, or clutch. This is especially true of noise complaints. Therefore, before removing the transmission or related components to locate trouble, road test to check the possibility of trouble in other closely associated components. Road testing is most effective when the mechanic drives the vehicle. However, riding with the driver can be very informative as well.

INSPECTION PRIOR TO DISASSEMBLY

If a remote control is used, a careful check of the remote and connecting linkages (and their adjustment) must be made. The remote unit must be in good working order if the transmission is expected to shift satisfactorily.

Many times, the answer to the trouble is apparent when the unit is inspected prior to disassembly. But this evidence is often lost when the parts are separated. If possible, check the unit prior to disassembly. Keep in mind that a careful inspection of the unit should be made as each disassembly step is performed.

INSPECTION DURING DISASSEMBLY

It is poor practice to disassemble a unit or the complete transmission as quickly as possible without examining the parts. The mechanic may completely disassemble a unit and fail to find the cause of the trouble unless parts are examined.

After the transmission is disassembled, check the lubricant for foreign particles. This is a source of trouble often overlooked during disassembly.

REPAIR OR REPLACE WORN PARTS

Many times, the parts or critical adjustments causing the trouble are not replaced or corrected because the mechanic only inspects and replaces parts that have failed completely. All pieces should be carefully examined because broken parts are often just the result – not the cause – of the problem. All parts that are broken or worn and no longer meet specifications should be replaced.



WARNING: Be careful when picking up gears or other sharp components. You could cut your hands. Consider wearing heavy cloth gloves or covering sharp objects with shop towels before picking them up.

Also, parts that are worn to the extent that they do not have a long service life remaining should be replaced. Replacing these parts now will prevent the need to tear down the unit again in the near future. Also at this time, make the recommended changes or modifications to update the transmission and increase the service life of the unit.

GENERAL DISASSEMBLY



CAUTION: Read the following section before starting the detailed disassembly procedures. Follow procedures closely to ensure proper transmission operation.

REBUILD FACILITIES

To work on the transmission, a suitable holding fixture or overhaul stand with a hole for the input shaft is desirable. For easier working conditions, table height should be 28" to 30". A chain hoist should be used to handle the mainshaft and countershafts during removal and reassembly procedures.



WARNING: Use a hoist whenever lifting the transmission or shaft assemblies. Using a hoist can help prevent muscle strain or other possible injuries.

CLEANLINESS

Transmissions should be steam cleaned prior to disassembly. Seal all openings before steam cleaning to prevent entry of dirt and water, which can damage serviceable parts. Dirt is abrasive and will cause premature wear of bearings and other parts. Spicer suggests that a wash tank be available to clean parts just prior to reassembly.

BEARINGS

When a transmission is removed at relatively low mileage, bearings should be removed with pullers designed for this purpose. Wrap the bearings to keep out dirt. Clean, inspect, and lubricate bearings just prior to reassembly.

If accumulated mileage is more than 150,000 miles, all bearings should be replaced. If bearings are worn or damaged, always replace them, regardless of mileage.

END YOKES AND FLANGES



CAUTION: Do not hammer end yokes and flanges to remove or install them.

Hammering is not only destructive to the yoke or the flange itself, but doing so can also cause serious internal transmission damage. Hammering destroys or mutilates the pilot diameters and warps or bends the flange. Hammering on end yokes will close in the bearing bores or misalign yoke lugs. This will result in premature failure of the journal needle bearings.

In addition, serious damage can be done internally to bearings, thrust faces, and washers by hammering on external parts. In most designs, when the yoke/flange locknuts are tightened and secure, the internal bearings and gears are in the proper location. However, when the yoke/flange is driven on the shaft, however, two conditions may occur that must be prevented.

- (1) If the bearing fit is tight on the shaft, bearings will usually brinell as they absorb the pounding force.
- (2) If the bearing fit is loose, the shaft will keep moving inward until it is stopped by the internal parts, such as the pilot bearing thrust washers.

GENERAL DISASSEMBLY

POWER TAKE-OFFS

Refer to your owner's manual for installation procedures and safety precautions when installing a PTO on your transmission.

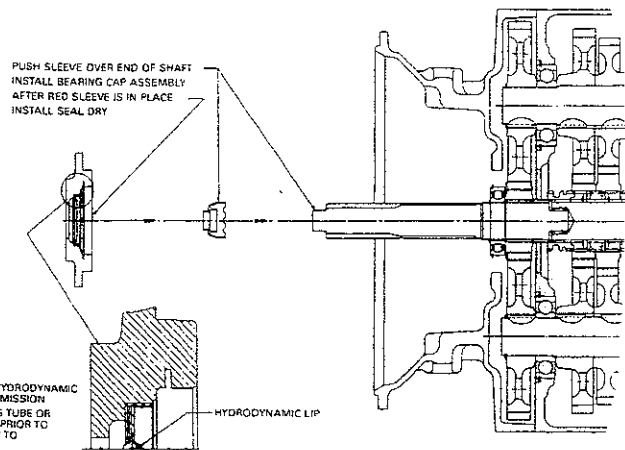


WARNING: Rotating shafts can be dangerous. You can snag clothes, skin, hair, hands, etc. This can cause injury or death. Do not go under the vehicle when the engine is running.

FRONT BEARING RETAINER & SEAL

! CAUTION: When installing the front bearing retainer and seal in the transmission, use the red plastic sleeve to prevent serious damage to the oil seal. Failure to use the sleeve will invalidate the seal warranty.

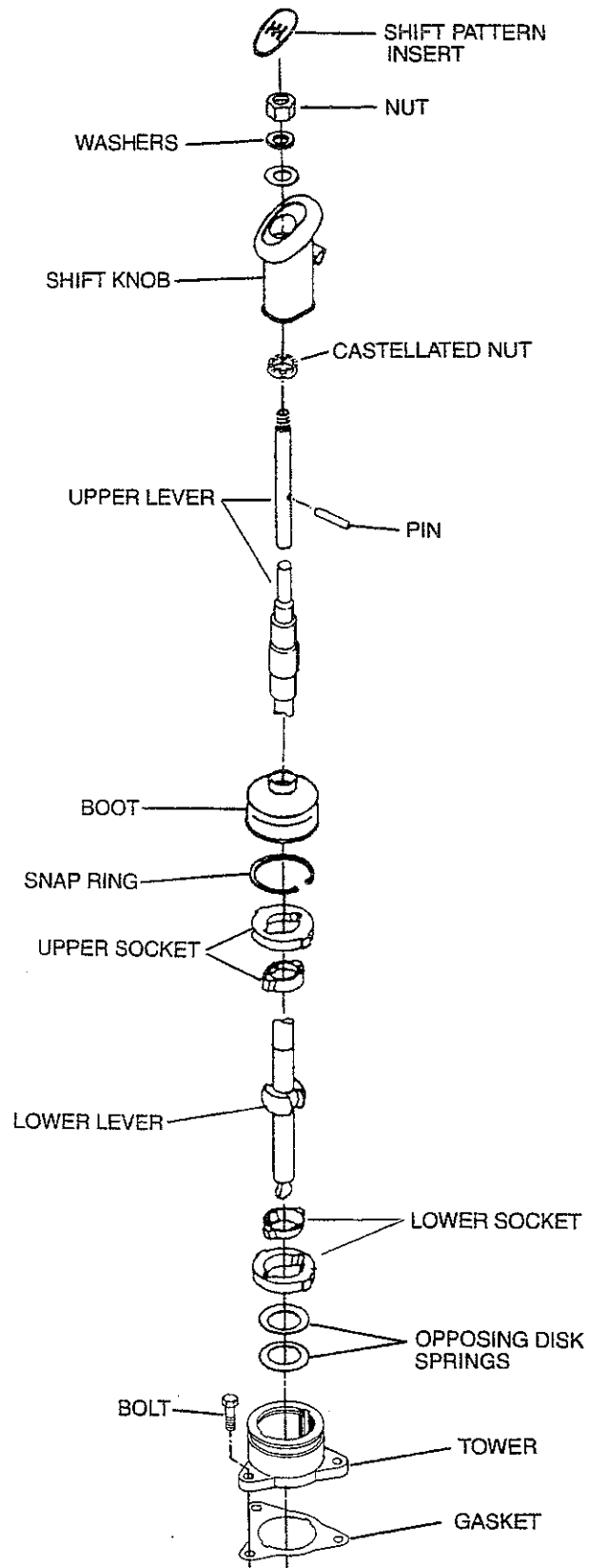
SEAL MUST BE INSTALLED SO THAT HYDRODYNAMIC LIP FACES TOWARD INSIDE OF TRANSMISSION
REMOVE SEAL CARDBOARD SHIPPING TUBE OR PLASTIC INSTALLATION SLEEVE JUST PRIOR TO INSTALLING BEARING CAP ASSEMBLY TO TRANSMISSION



UPPER SHIFT TOWER DISASSEMBLY

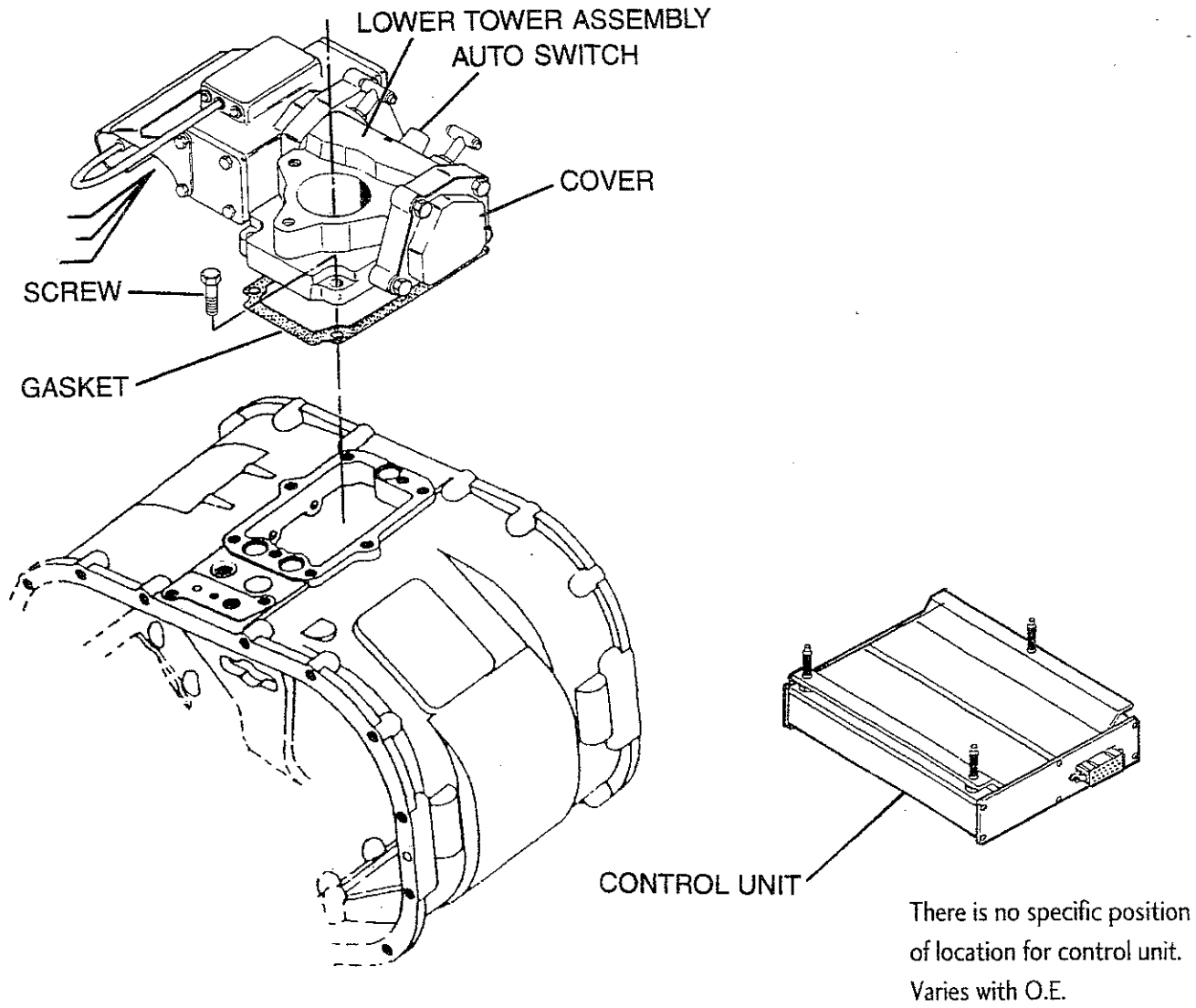
UPPER SHIFT TOWER DISASSEMBLY

1. Cut the tie-down straps and lift the boot off the lever.
2. Holding the lever in a vise, remove the tower snap ring.
3. Pull the lever, the upper and lower plastic sockets, and the two opposing springs from the tower.

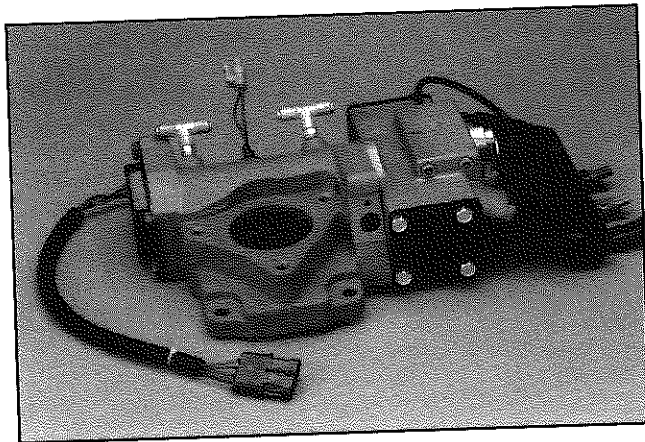


LOWER SHIFT TOWER DISASSEMBLY

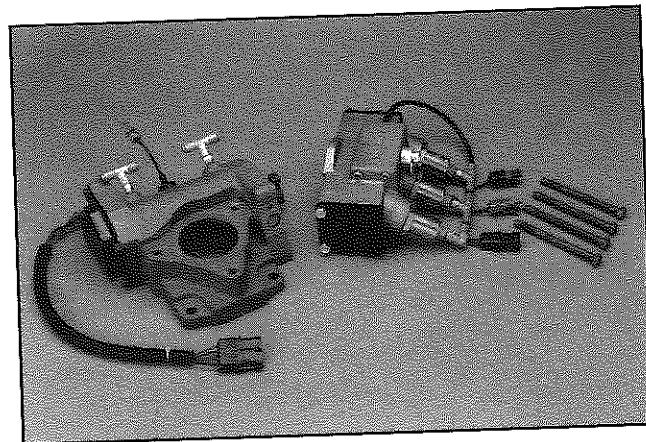
Lower Shift Tower



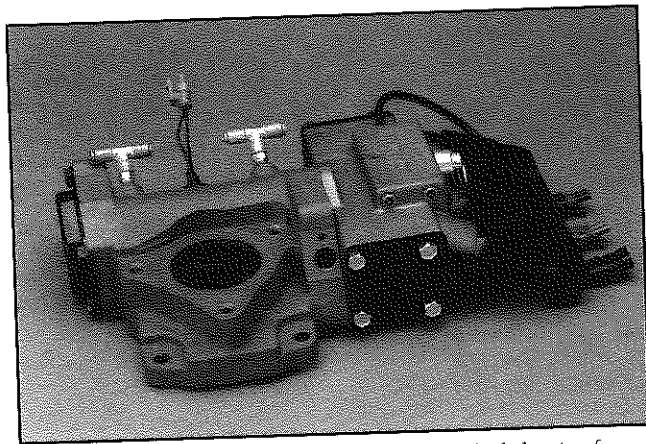
LOWER SHIFT TOWER DISASSEMBLY



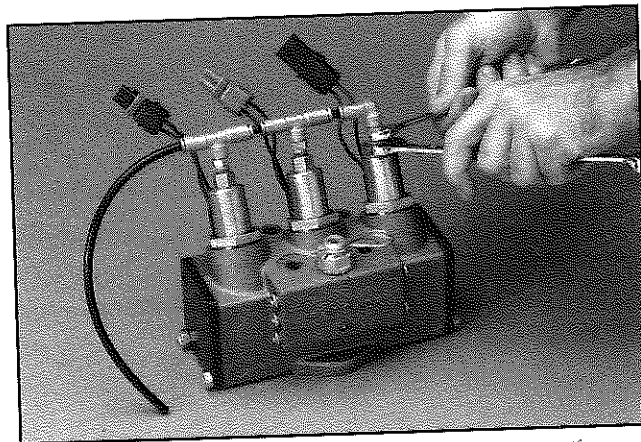
1. **WARNING:** Shut off and bleed the air system to prevent lines from whipping. Remove the upper shift tower assembly. Remove the lower shift tower assembly from the unit and out of the vehicle. Check the housing for cracks and other damage. Replace if necessary.



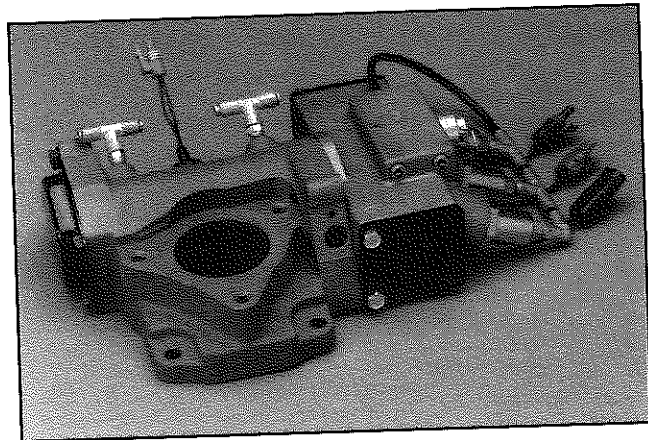
4. Remove four bolts and the actuator assembly from the lower tower.



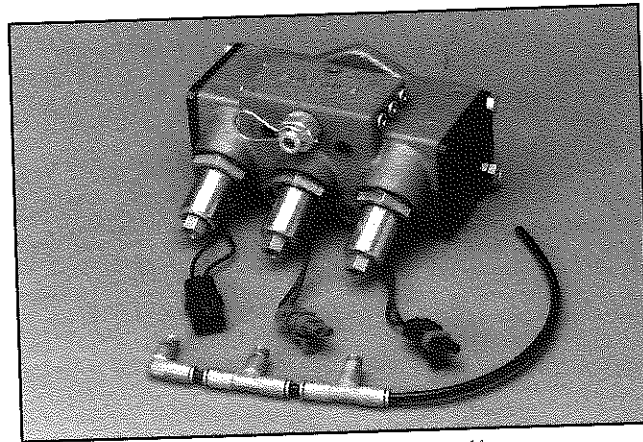
2. Remove gear position sensor wire harness assembly. Check the wires for cracks and breaks. Replace if necessary.



5. Keep the valve nut from turning as you loosen the air fitting nuts. If you don't, you will accidentally disassemble the valves.

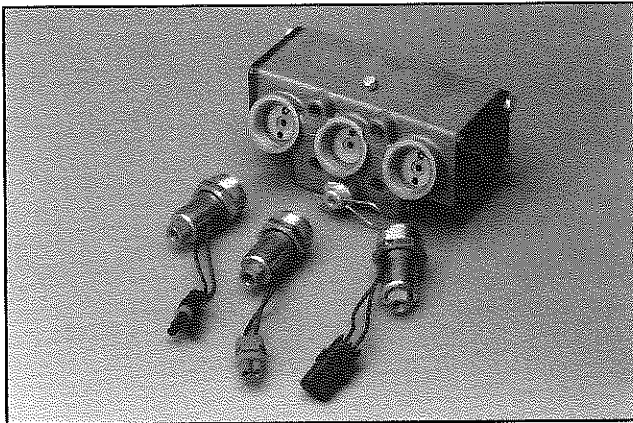


3. Remove four bolts and the actuator assembly shield.

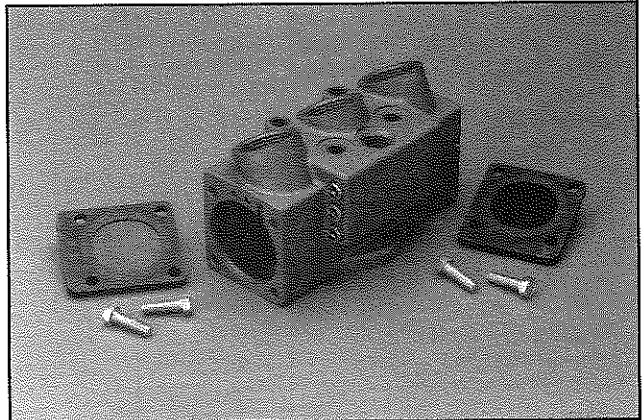


6. The air fittings and lines can be removed as an assembly.

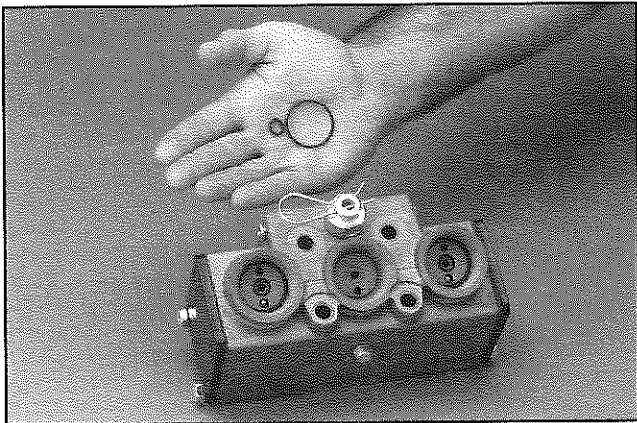
LOWER SHIFT TOWER DISASSEMBLY



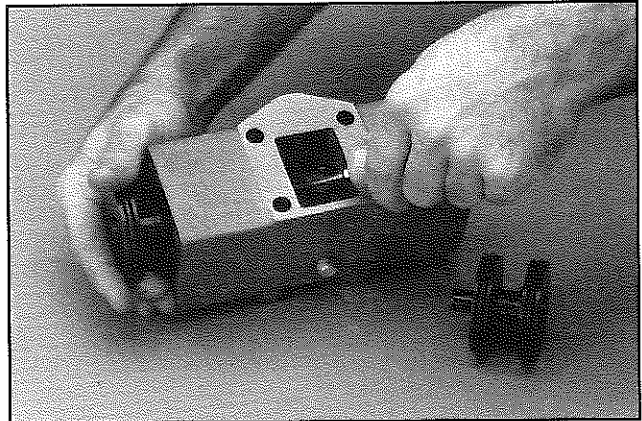
7. Remove the valves. Note that they are marked "HI," "N" for neutral, and "LOW".



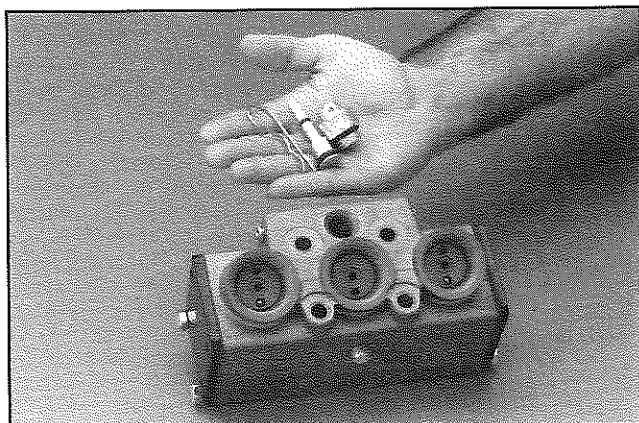
10. Remove both housing end caps and gaskets.



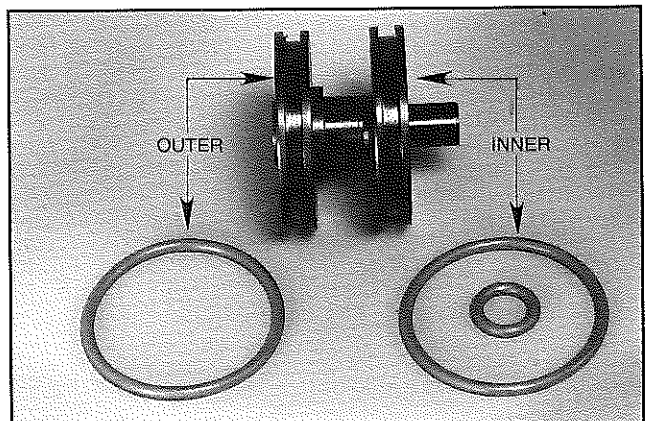
8. Remove the large and small O-ring from the bores of each valve. Replace with new O-rings during reassembly.



11. Use a screwdriver to gently push against the shift rack and remove each piston.

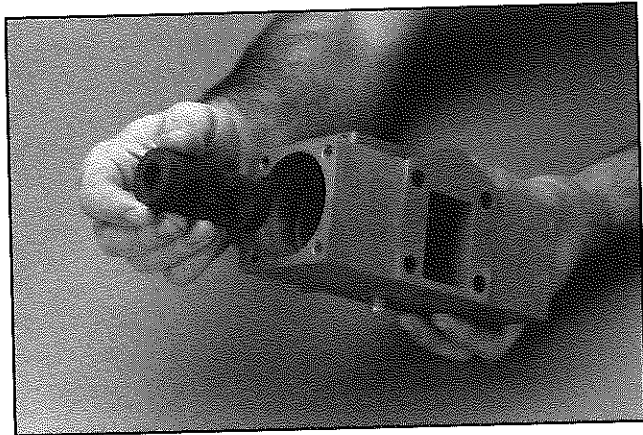


9. Remove the hitch pin and the override plunger. Remove and replace the three O-rings on the plunger and plunger cap.

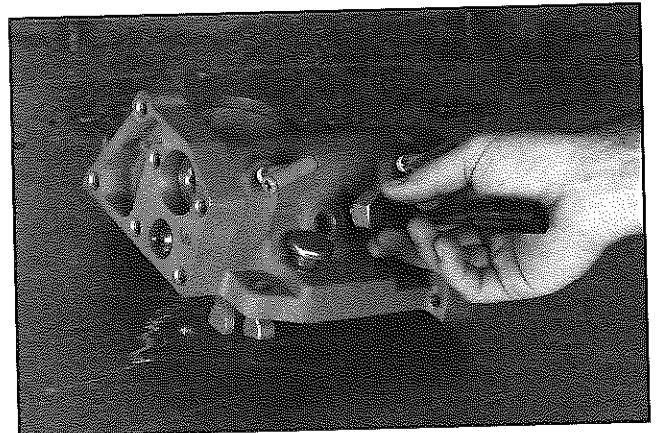


12. Replace the two O-rings on each inner piston, and one O-ring on each outer piston.

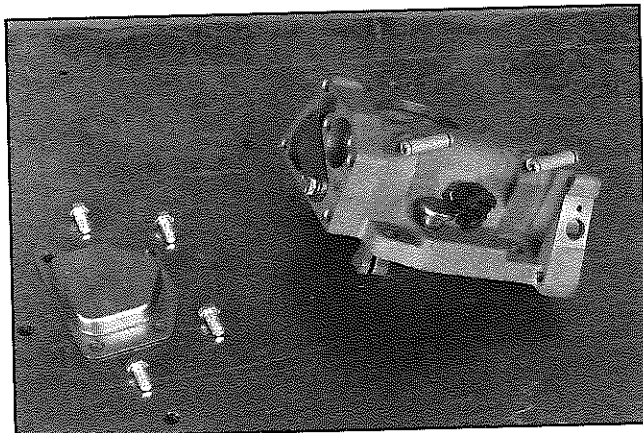
LOWER SHIFT TOWER DISASSEMBLY



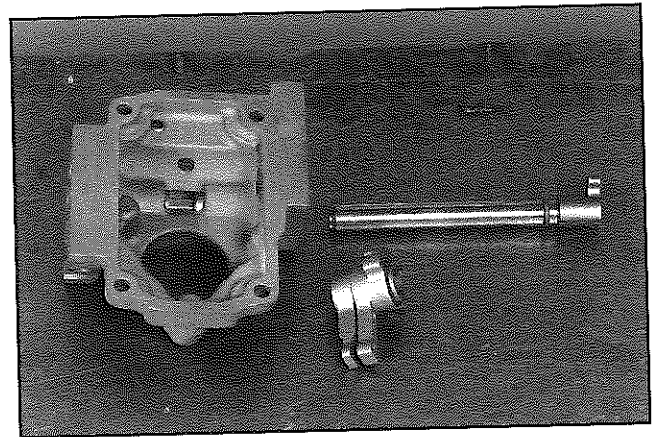
13. Remove the shift rack from the actuator housing.



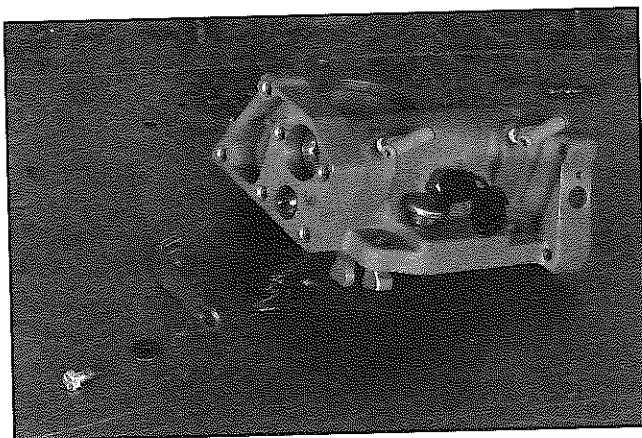
16. Remove the automatic switch.



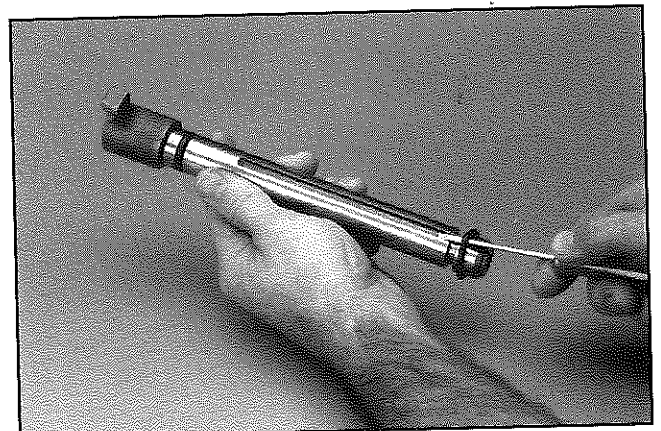
14. Next, remove the four lower tower cover bolts. Remove the cover.



17. Pull the shift shaft and shift fingers out of the housing.

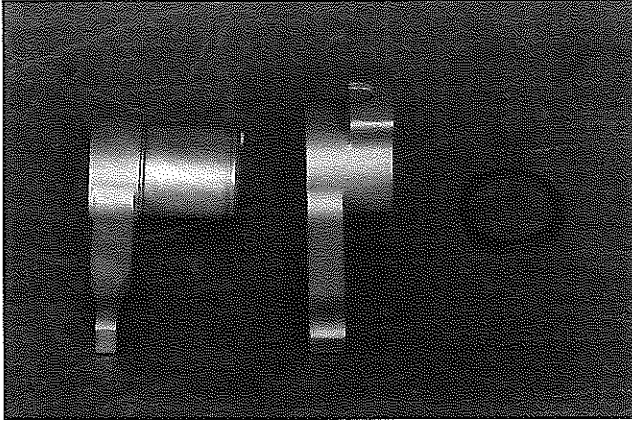


15. Remove the control arm, bolt and washer.
! CAUTION: hold the shift shaft still as you remove the components. Holding the shaft will help prevent damaging the control arm.

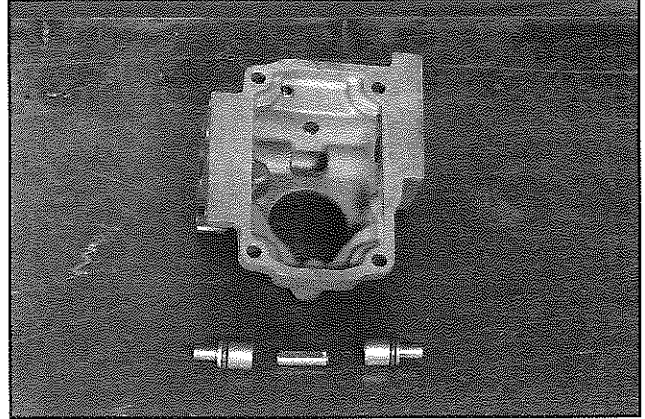


18. Replace the shift shaft O-ring with a new one. Carefully use a screwdriver to lift the ring over the keyway to prevent cutting the ring.

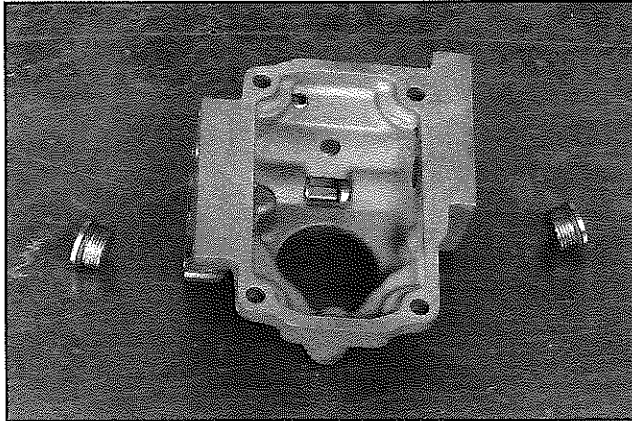
LOWER SHIFT TOWER DISASSEMBLY



19. Remove the snap ring to disassemble the shift fingers. Inspect the shaft and key for wear or damage. If either needs to be replaced, replace them as a set.



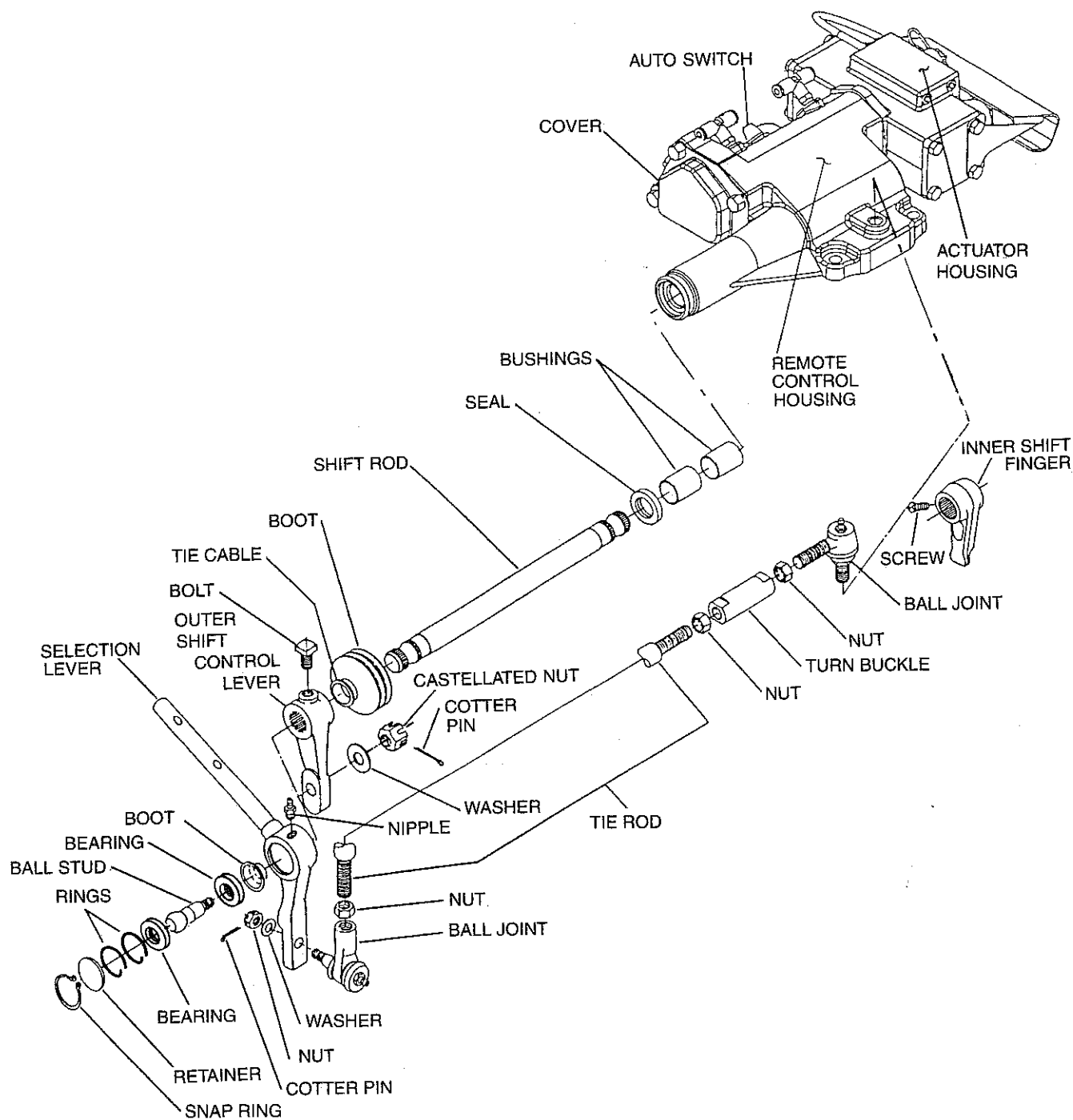
21. Push the shift pistons and joiner pin from the center of the housing out.
⊘ CAUTION: Do not force both pistons out of the same side of the housing at the same time. Doing so might bind the pistons. Replace the piston O-rings. Lower shift tower disassembly is complete.



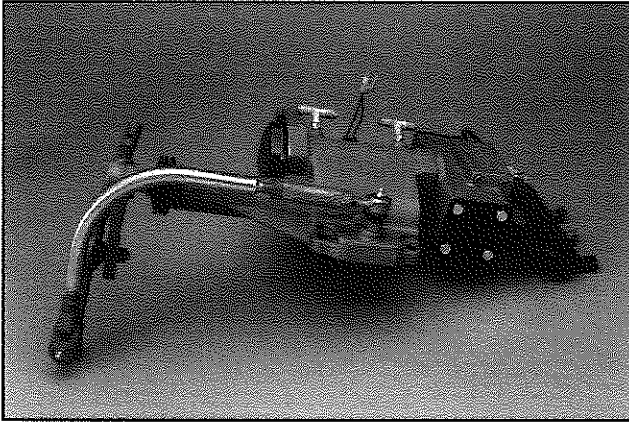
20. Remove the housing plugs. Replace the O-rings.

REMOTE CONTROL DISASSEMBLY

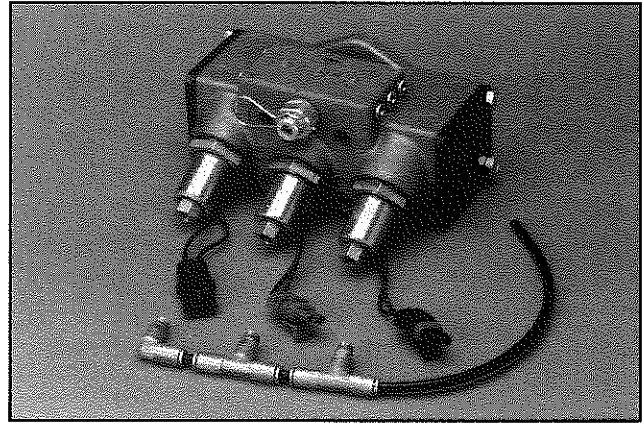
Remote Control



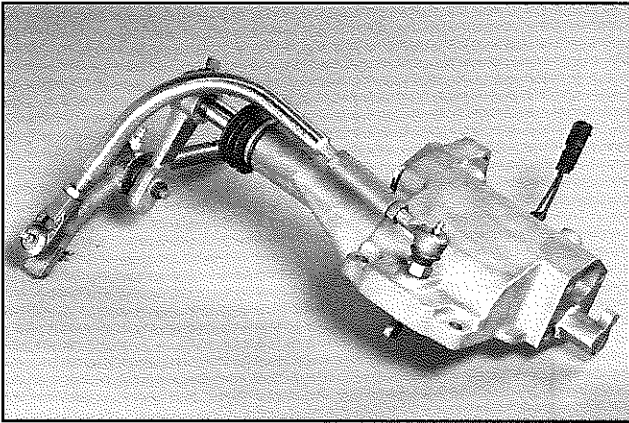
REMOTE CONTROL DISASSEMBLY



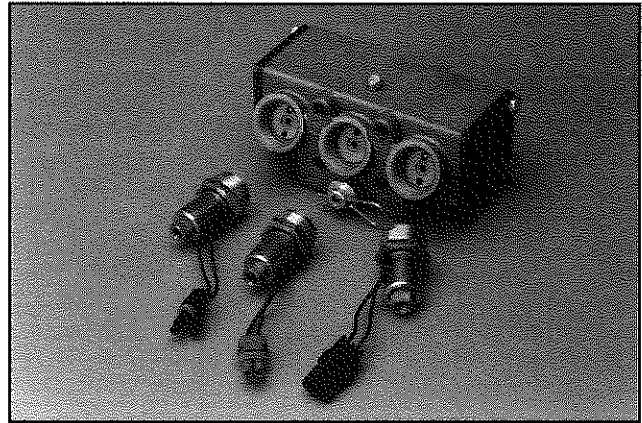
1. **WARNING:** Shut off and bleed the air system to prevent lines from whipping. Remove the spear rod. Remove the remote control assembly from the unit and out of the vehicle. Remove gear position sensor wire harness. Check components for damage.



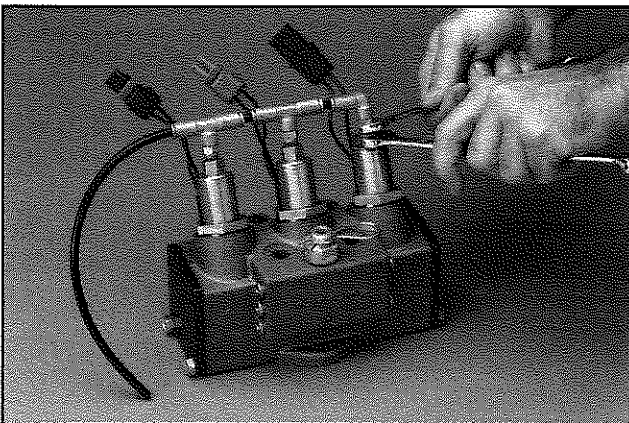
4. The air fittings and lines can be removed as an assembly.



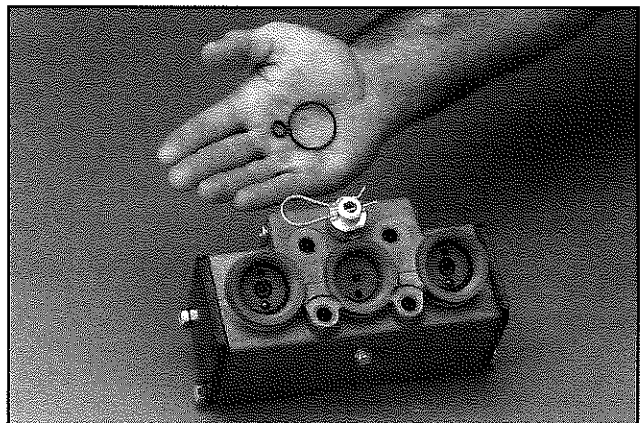
2. Remove the four actuator shield assembly bolts and the shield. Also remove the four actuator cover bolts and the cover.



5. Remove the valves. Note that they are marked "HI," "N" for neutral, and "LOW".

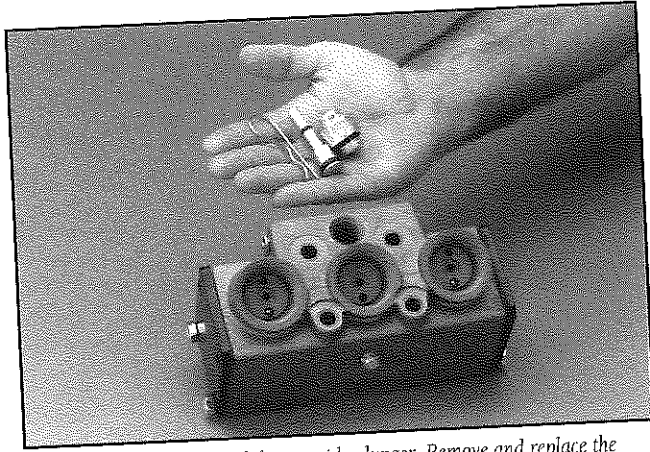


3. Loosen the air fitting nuts, making sure to keep the valve nuts from turning. If you don't, you will accidentally disassemble the valves.

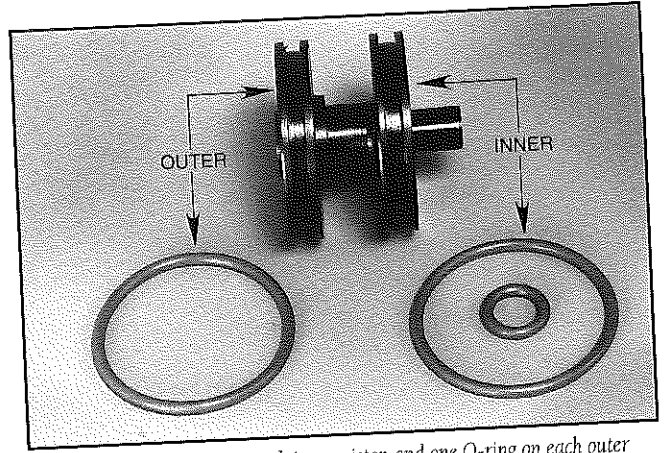


6. Remove the large and small O-ring from the bores of each valve. Replace with new O-rings during reassembly.

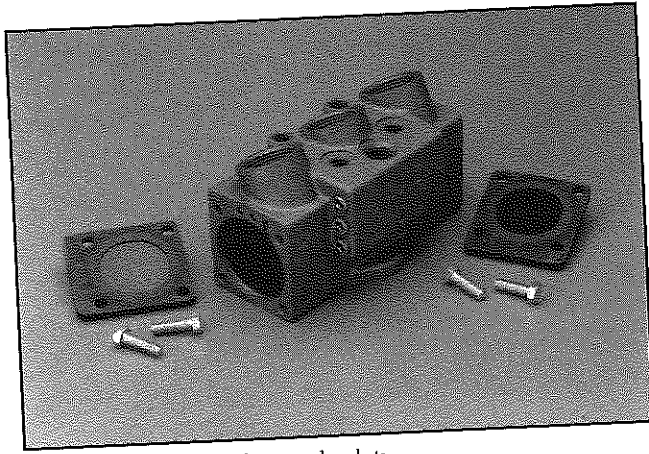
REMOTE CONTROL DISASSEMBLY



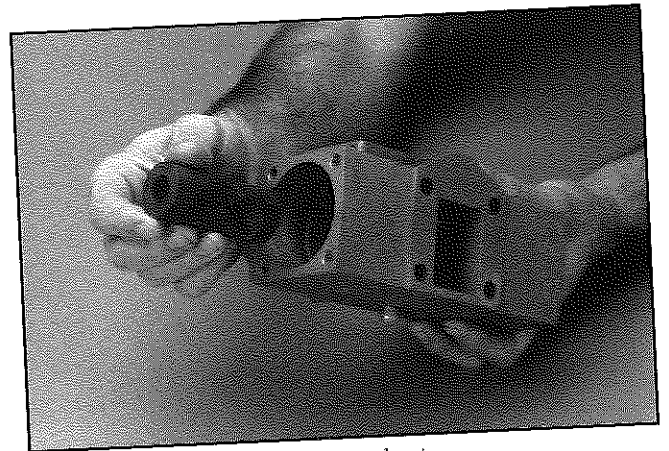
7. Remove the hitch pin and the override plunger. Remove and replace the three O-rings on the plunger and plunger cap.



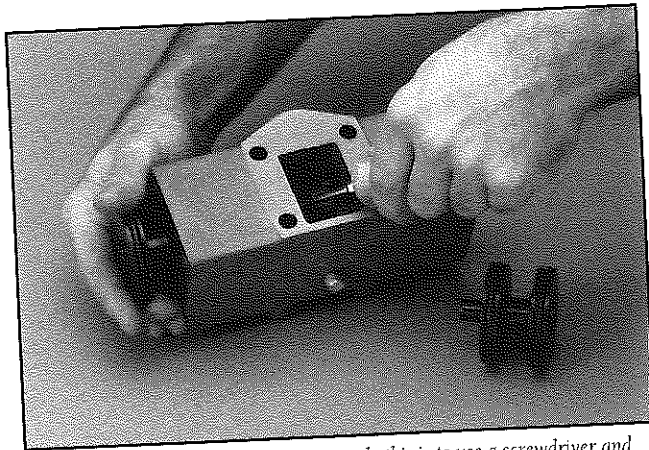
10. Replace two O-rings on each inner piston and one O-ring on each outer piston.



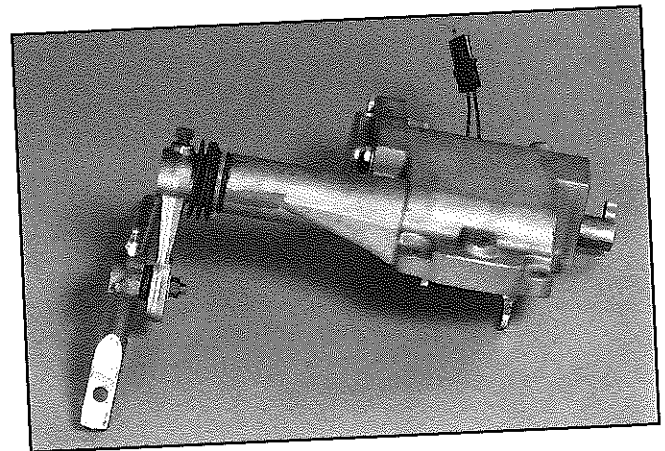
8. Remove both housing end caps and gaskets.



11. Remove the shift rack from the actuator housing.

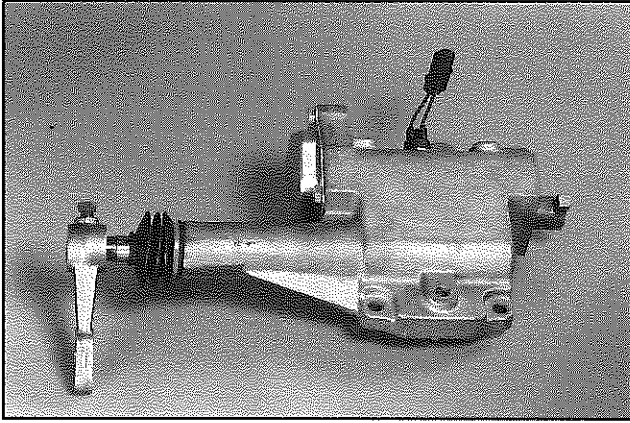


9. Remove the pistons. The easiest way to do this is to use a screwdriver and gently push the shift rack to remove each piston.

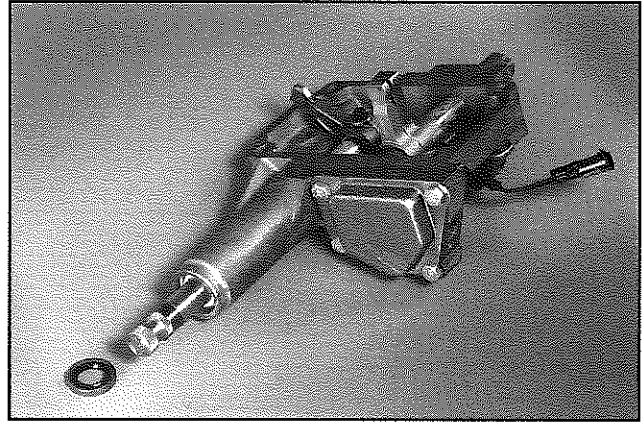


12. Next, remove the tie rod assembly.

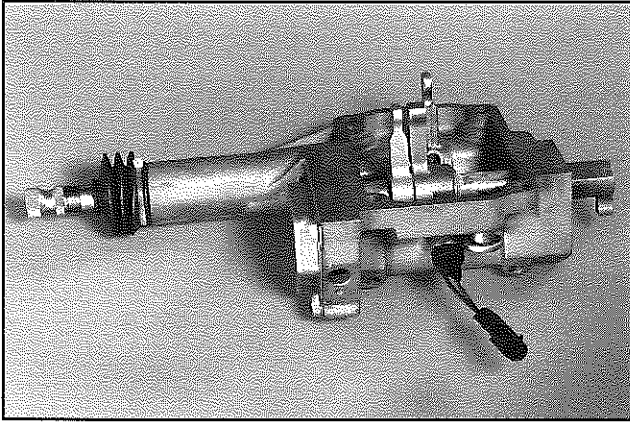
REMOTE CONTROL DISASSEMBLY



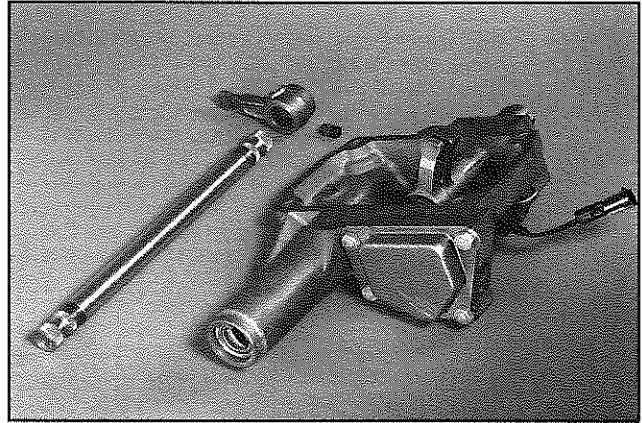
13. Remove the bolt, washer and selection lever.



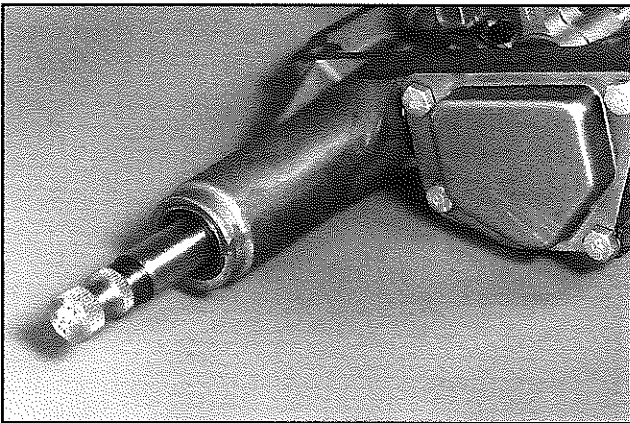
16. Remove the seal from the housing. Replace it with a new one during reassembly.



14. Remove the bolt and outer shift control lever.



17. Remove the setscrew and gently tap the shift rod through the shift finger and housing.

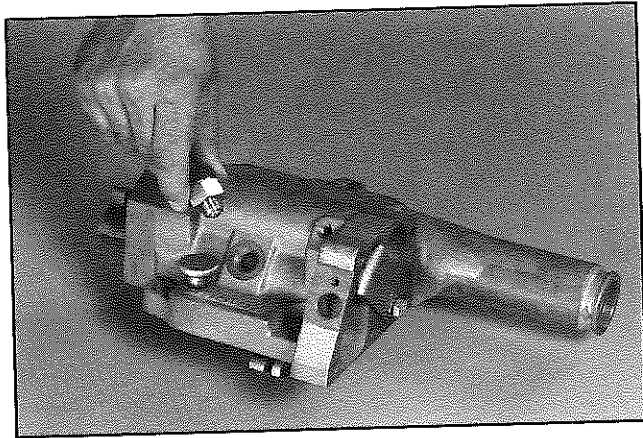


15. Cut the tie-down strap and remove the boot. Replace the boot if it is cut or damaged.

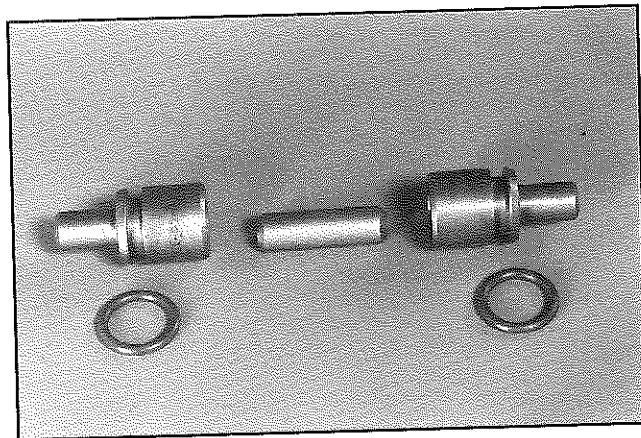


18. Remove the four bolts and the actuator cover.

REMOTE CONTROL DISASSEMBLY

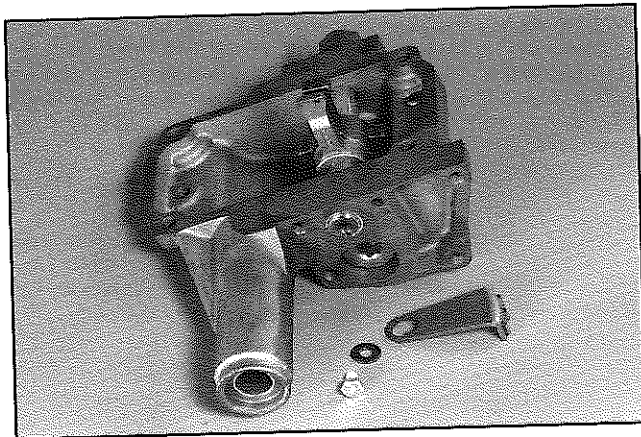


19. Remove the automatic switch.



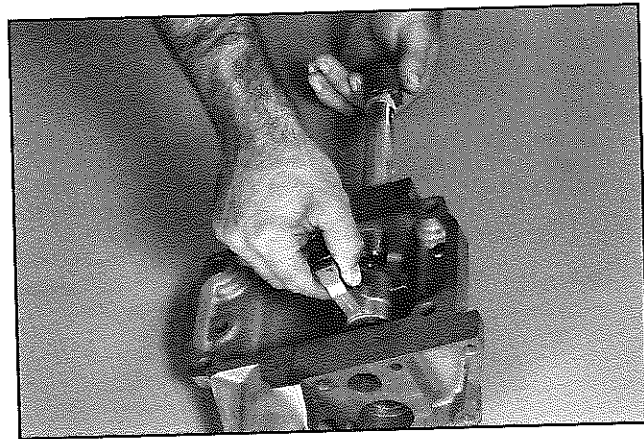
22. Remove the shift pistons from the housing.

⚠ CAUTION: Do not force both pistons out of the same side of the housing at the same time. Doing so might bind the pistons. Place new O-rings on the pistons prior to reassembly. Remove and inspect the joiner pin.

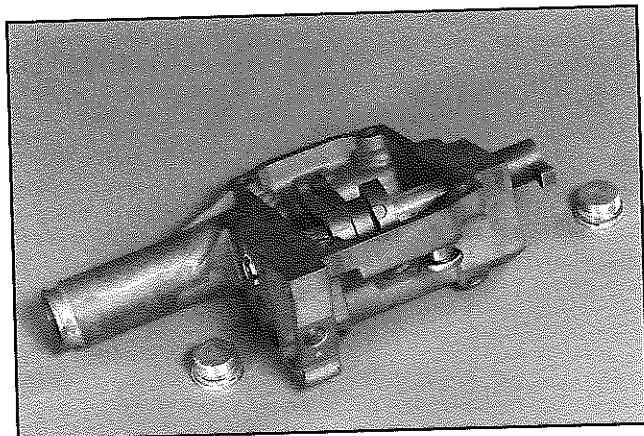


20. Remove the control arm, bolt and washer.

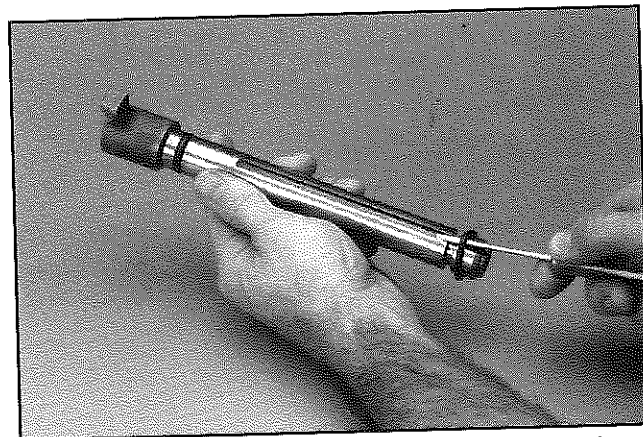
⚠ CAUTION: hold the shift shaft still as you remove the components. Holding the shaft will help prevent damaging the control arm.



23. Remove the shift shaft and shift fingers from the housing.

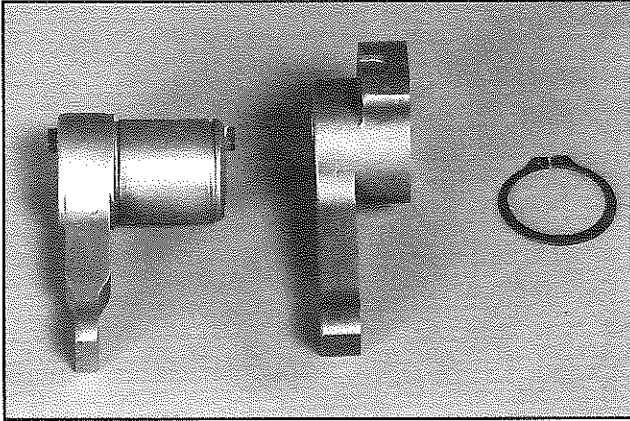


21. Remove the housing plugs. Replace the used O-rings with new ones prior to reassembly.

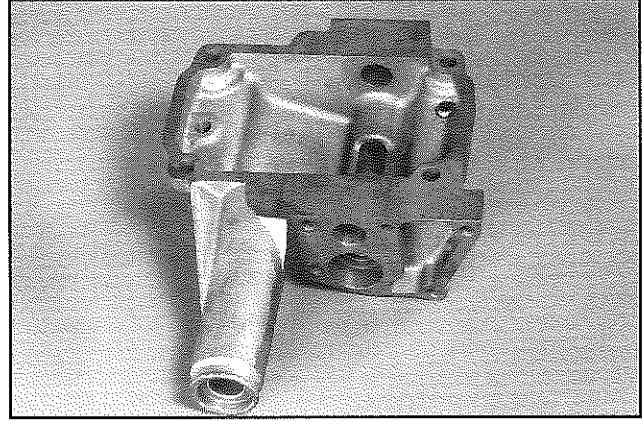


24. Replace the shift shaft O-rings with new ones. Carefully use a screwdriver to lift the rings over the keyway to prevent cutting the rings.

REMOTE CONTROL DISASSEMBLY

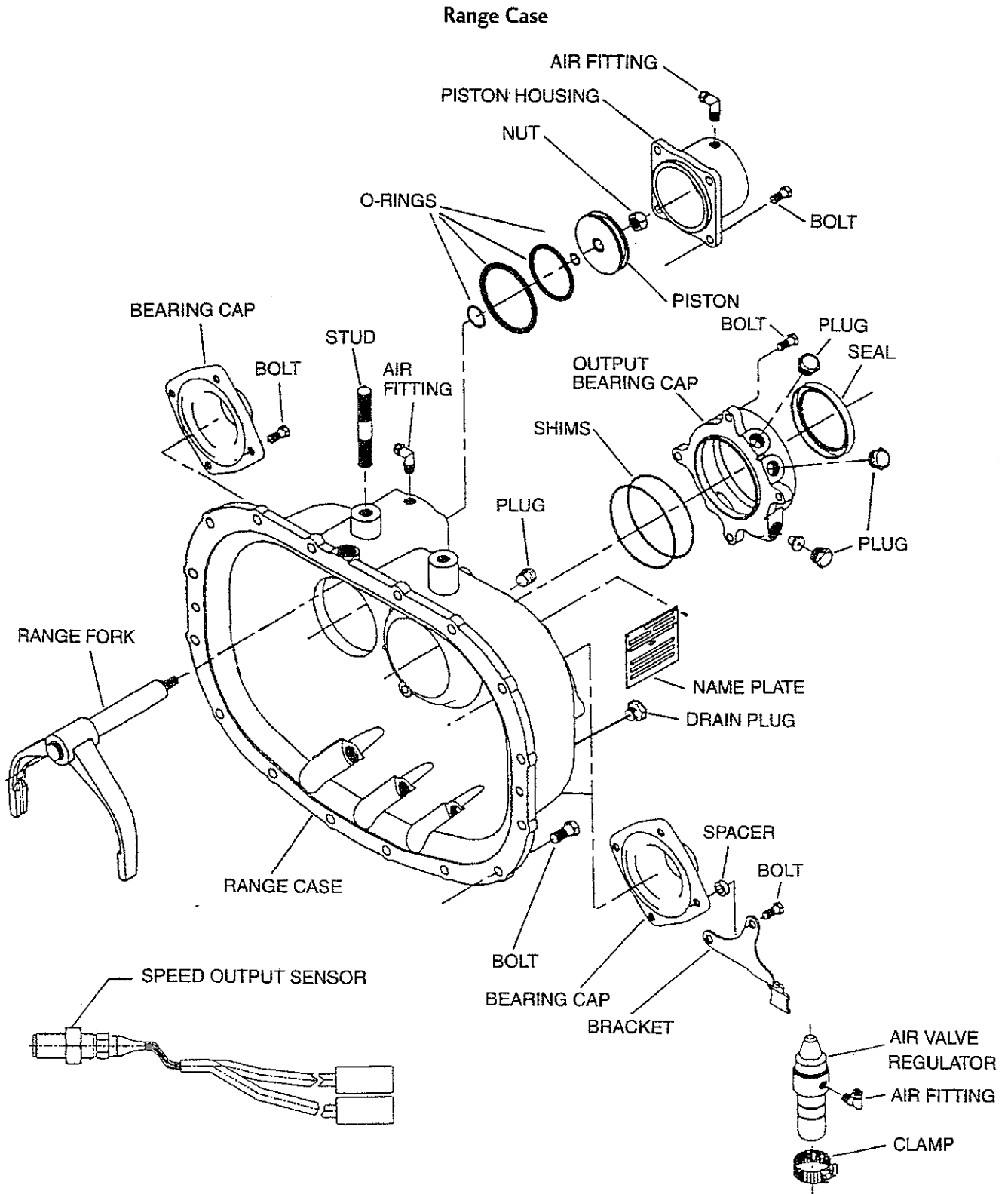


25. Remove the snap ring to disassemble the shift fingers. Inspect the shaft and key for wear or damage. If either needs to be replaced, replace them as a set.

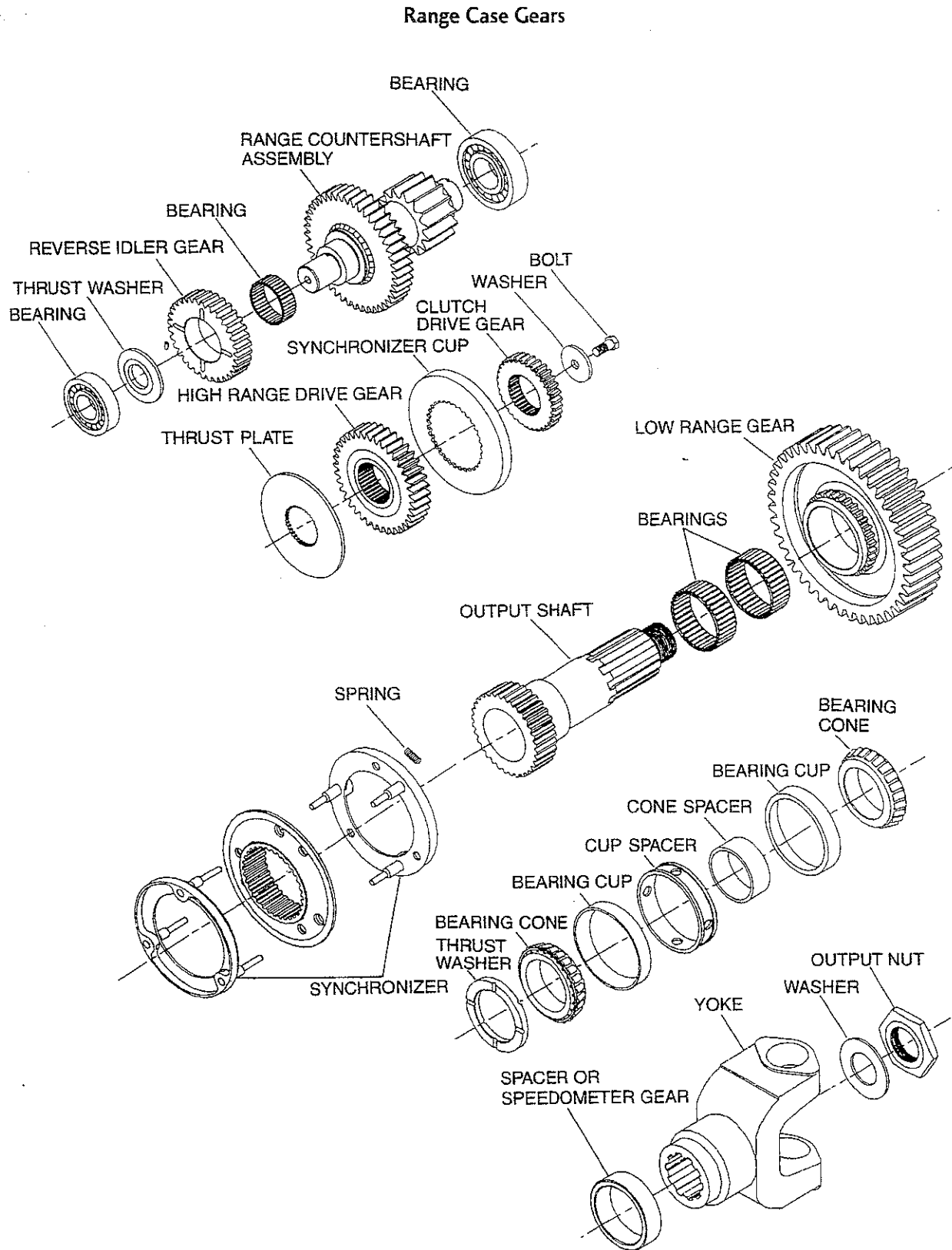


26. Examine the housing for burrs, wear or damage. Replace if necessary. Clean all reusable components prior to reassembly.

RANGE CASE DISASSEMBLY



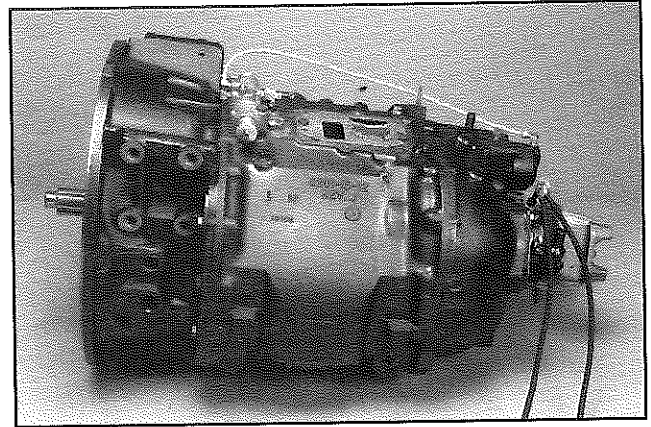
RANGE CASE DISASSEMBLY



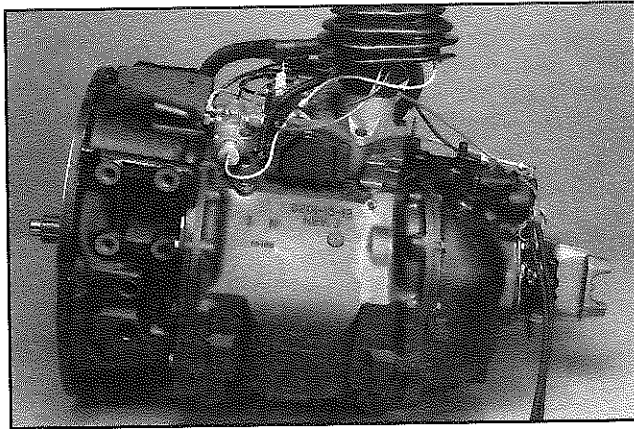
RANGE CASE DISASSEMBLY

It is possible to service the range case without removing the entire unit from the vehicle. If the truck is a conventional model, see p. 41. If the truck is a cab-over model, see p. 43. If the entire transmission is to be serviced, follow the instructions given below.

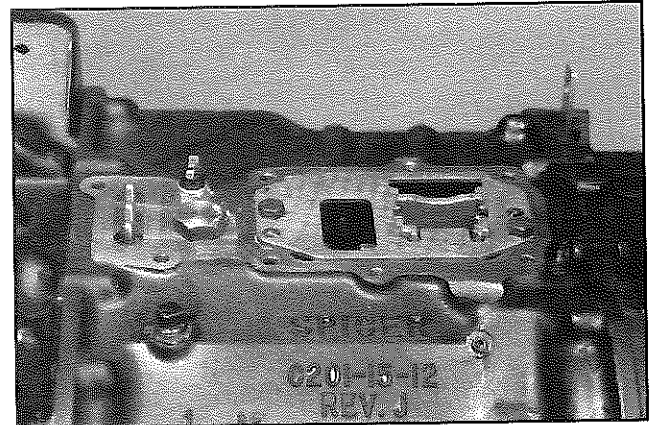
⚠ WARNING: When draining the transmission prior to working on it, be careful to let the unit cool down first. Otherwise, hot transmission fluid could cause burns.



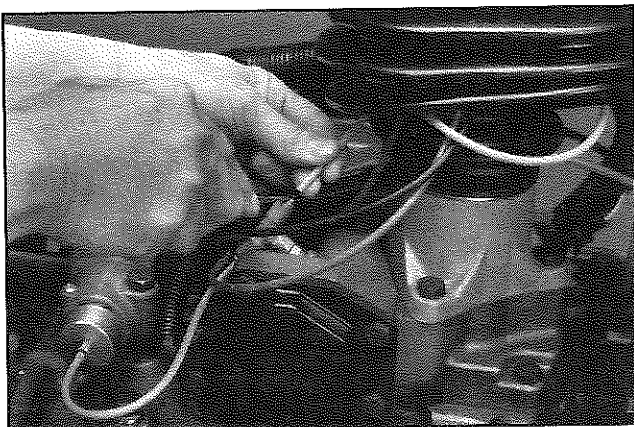
3. Remove the upper tower assembly. Continue by removing the lower tower assembly, gasket and air lines through the cab floor.



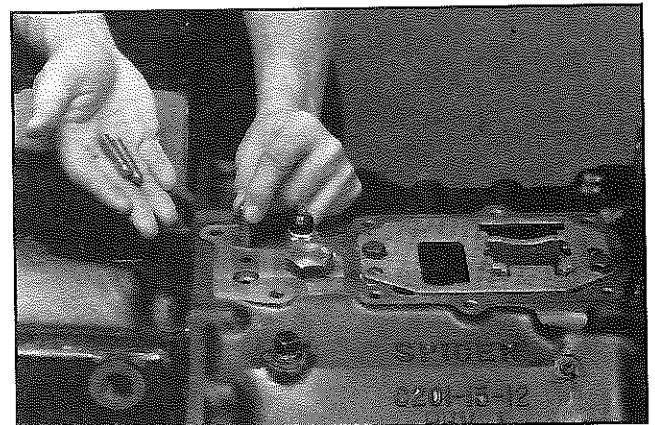
1. Once the unit is cool, drain the transmission fluid. Remove the upper tower assembly, gasket and air lines while the unit is installed in the vehicle. (It is shown here on a bench for illustration purposes only.)



4. Set the transmission on a bench. Remove the air control valve and gasket.

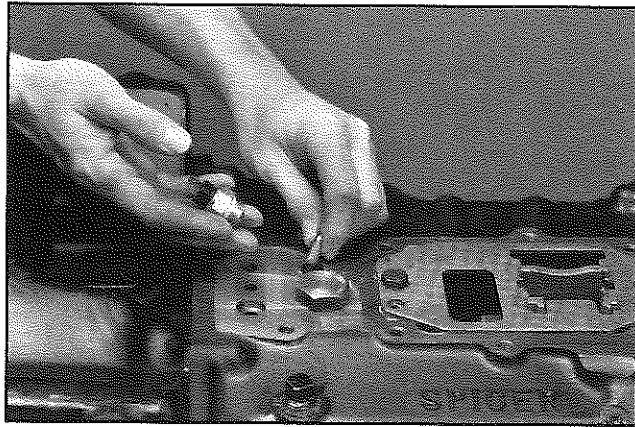


⚠ 2. WARNING: Turn off and bleed the air system to prevent air lines from whipping. To remove an air line from a fitting like the one shown here, push the bushing down with a small screwdriver or your fingernail and pull the tubing.

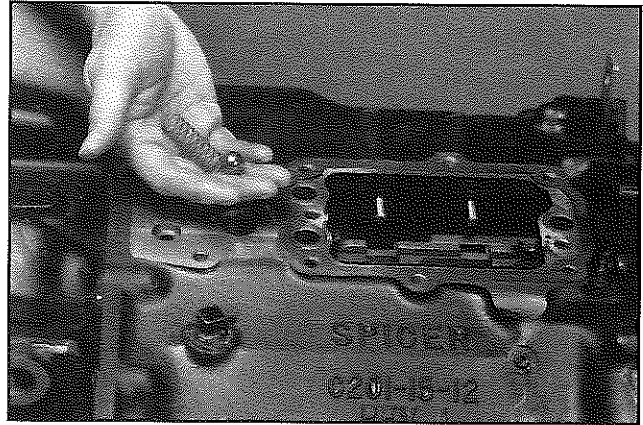


5. Remove the three air control valve interlock pins.

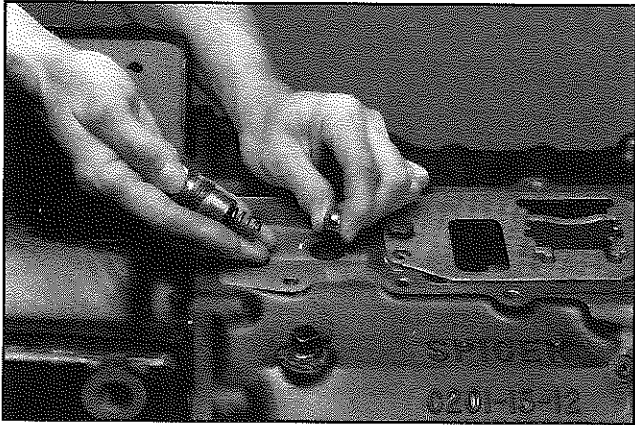
RANGE CASE DISASSEMBLY



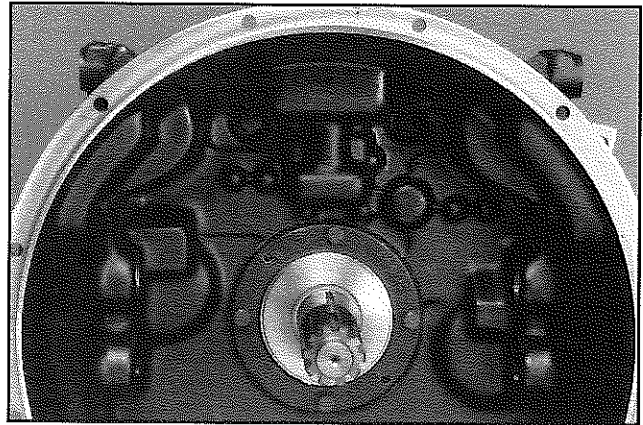
6. Remove the backup light switch and pin.



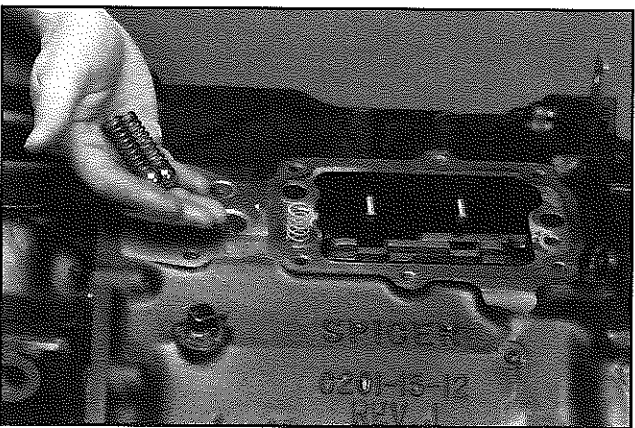
9. Remove the purple auto rail spring. Note that the spring that is removed from the overdrive shift rail poppet hole has less tension than the other two springs.



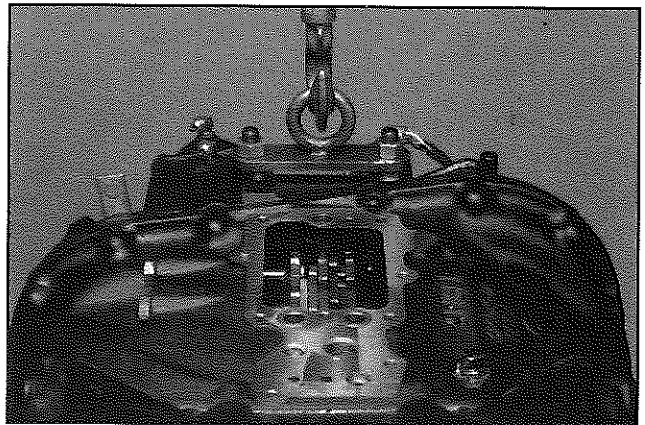
7. Remove the automatic rail poppet insert, spring and poppet ball.



10. Remove the two clutch housing bolts from the case. Also remove all but four clutch housing-to-case bolts.

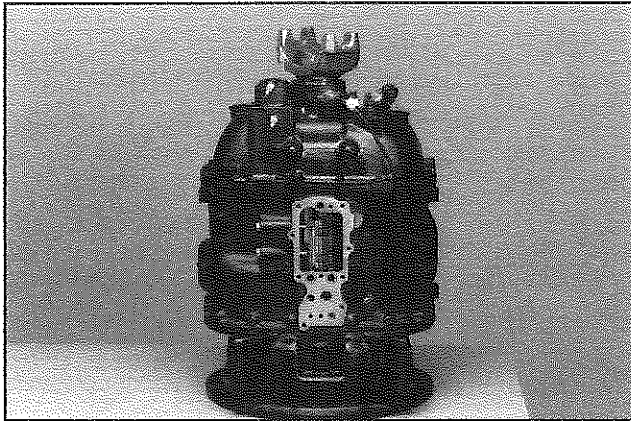


8. Remove the interlock plate and retainer. Also remove the two springs and poppet balls.



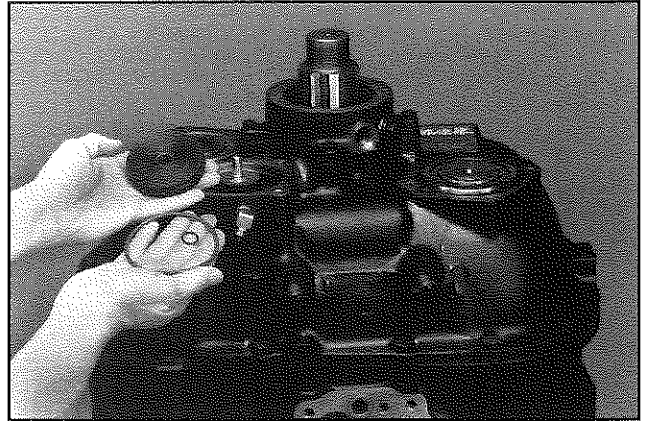
11. Attach a bracket or lift hook to the range section of the transmission. Secure with bolts that are firmly hand-tightened.

RANGE CASE DISASSEMBLY

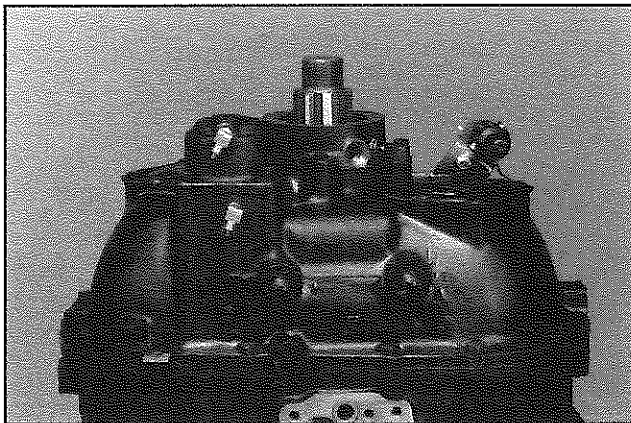


12. Stand the transmission on end on a workbench that contains a hole for the input shaft.

⚠ WARNING: When moving heavy parts, use a chain hoist to help prevent personal injury.



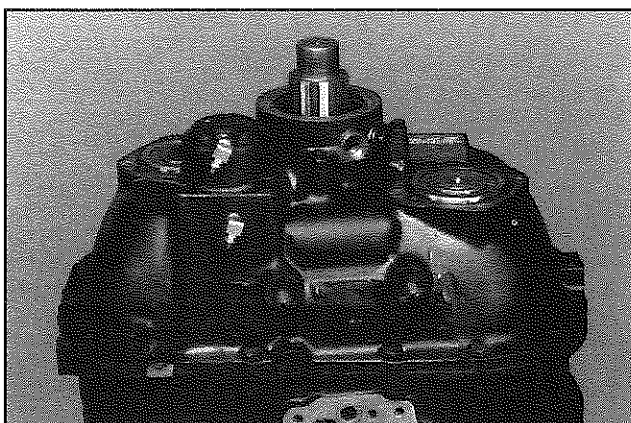
15. Remove the range piston housing and piston. Also remove and replace the three O-rings.



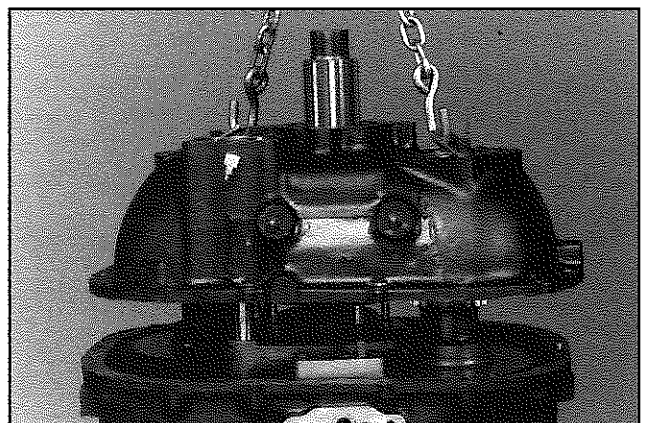
13. Continue by removing the electric speedometer sensing unit and end yoke or flange.



16. Remove the output bearing cap and shims.



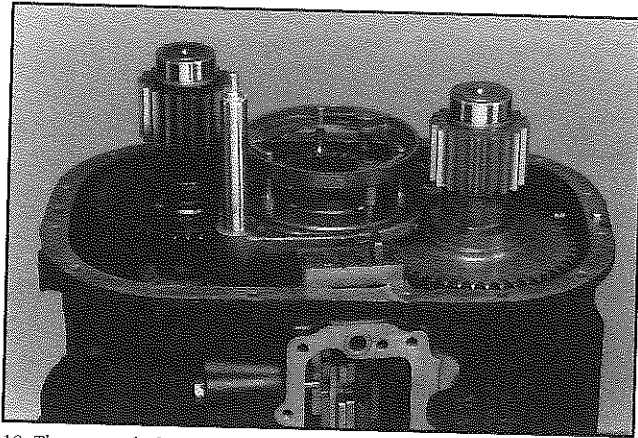
14. Remove the rear countershaft bearing retainer cap and the air regulator valve.



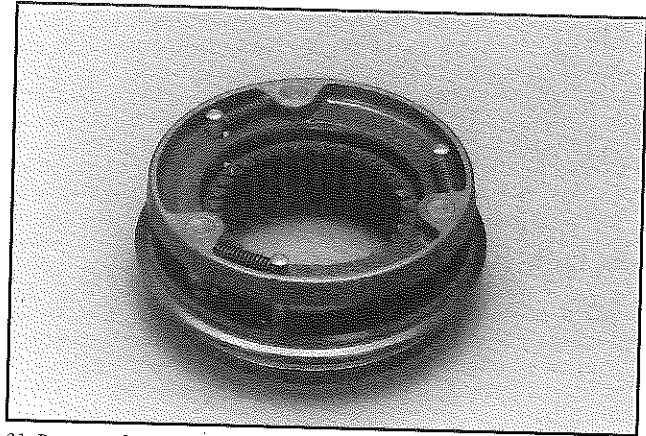
17. Remove the range case bolts and lift the case from the unit. A pry bar can be used to help separate the range case from the main case.

⚠ WARNING: When moving heavy parts, use a chain hoist to help prevent personal injury.

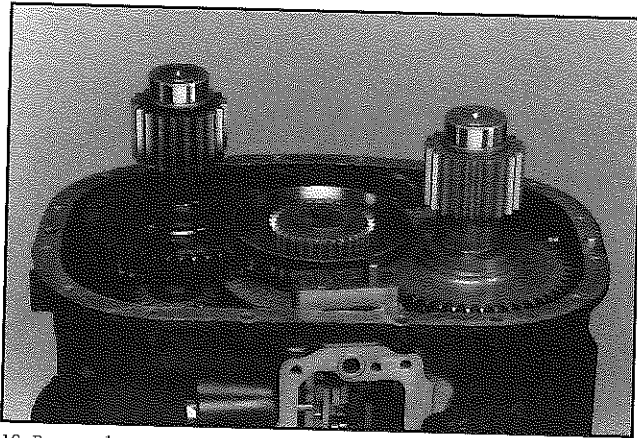
RANGE CASE DISASSEMBLY



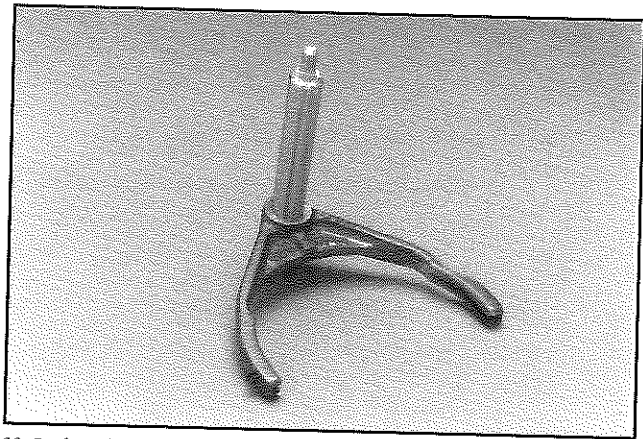
18. The output shaft and low range gear will remain with the case.



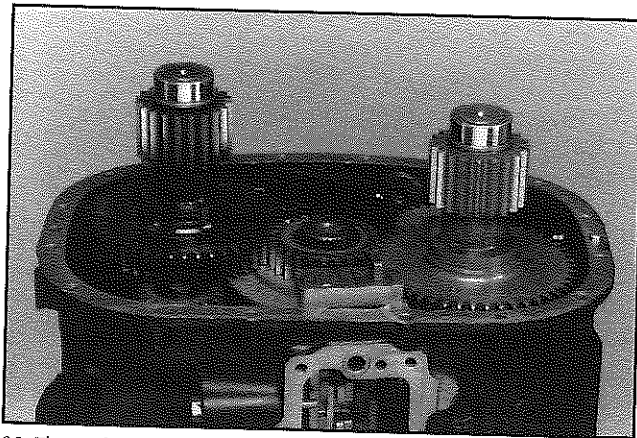
21. Be aware that separating the synchronizer will suddenly release the springs.
⚠ WARNING: Always wear safety glasses to help protect your eyes against flying parts. Synchronizer replacement parts may be purchased separately (refer to diagram on p. 30).



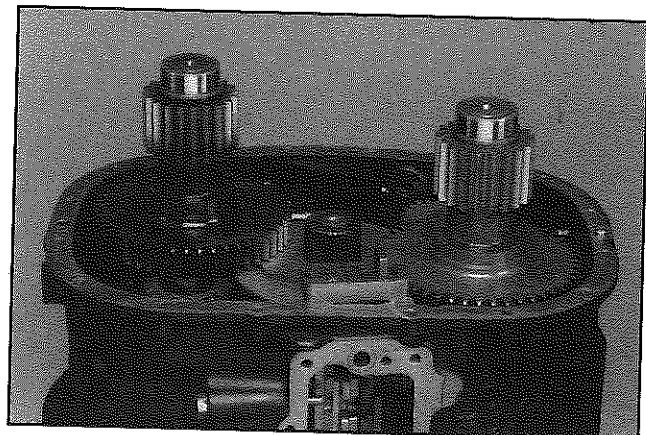
19. Remove the range synchronizer and fork assembly.



22. Replace the fork clips if they are worn or damaged. Also inspect the fork. Replace it if it is damaged.

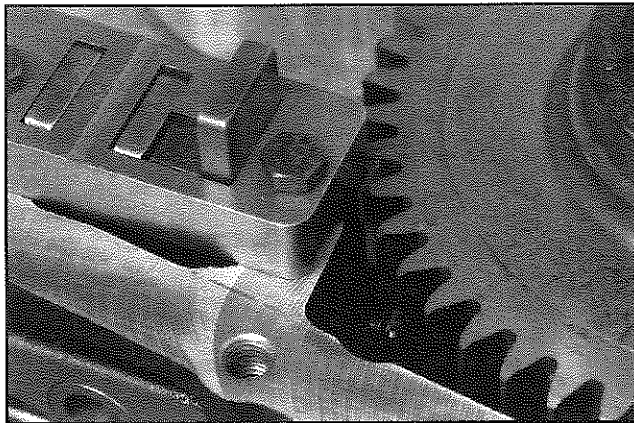


20. The synchronizer cup and the clutch gear are removed next.

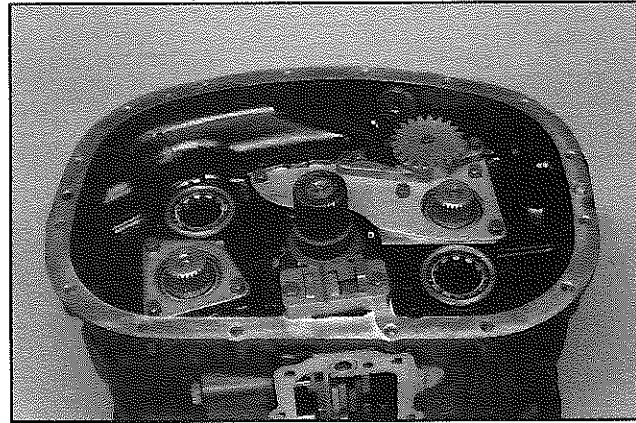


23. Lift high range gear from the case.

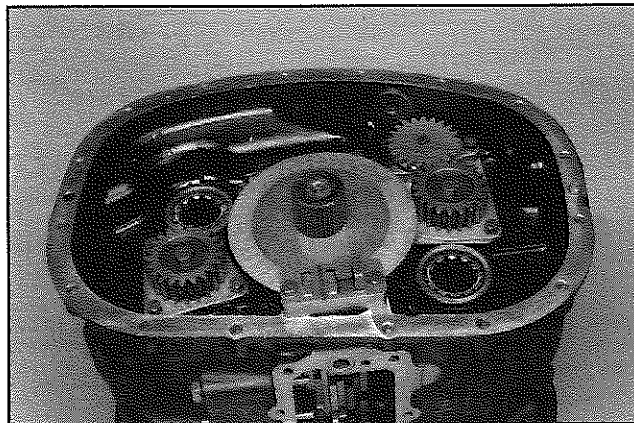
RANGE CASE DISASSEMBLY



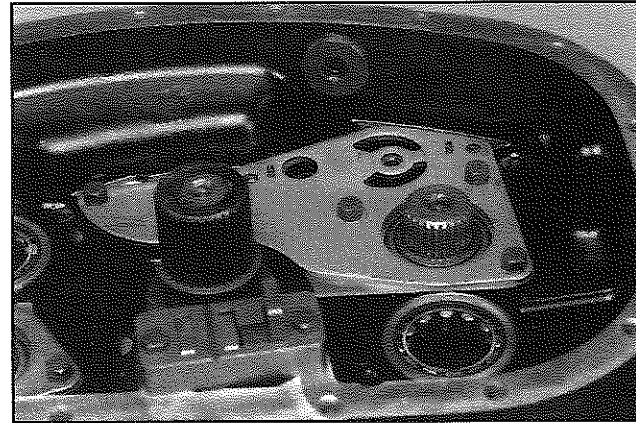
24. Align the valley between the countershaft teeth with the corners of the shift bar support bracket. This will provide enough clearance for countershaft removal.



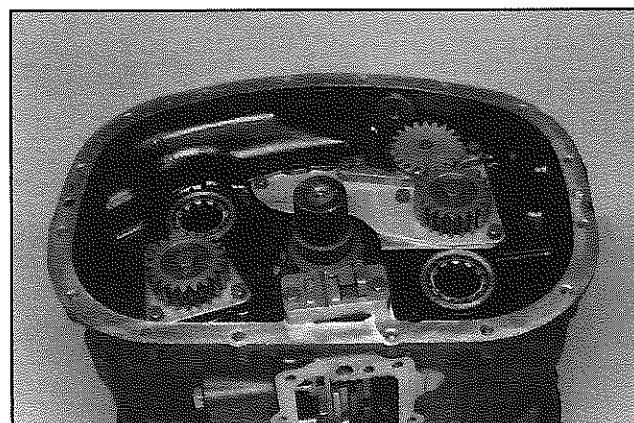
27. Remove the countershaft reverse gears.



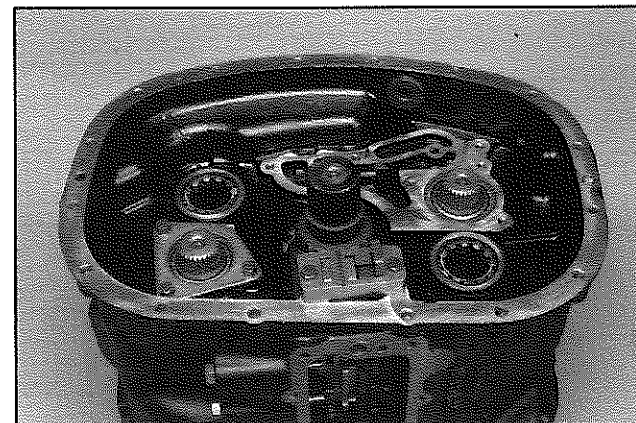
25. Simultaneously lift both countershafts straight up to remove them.



28. Remove the oil pump housing and its screws.

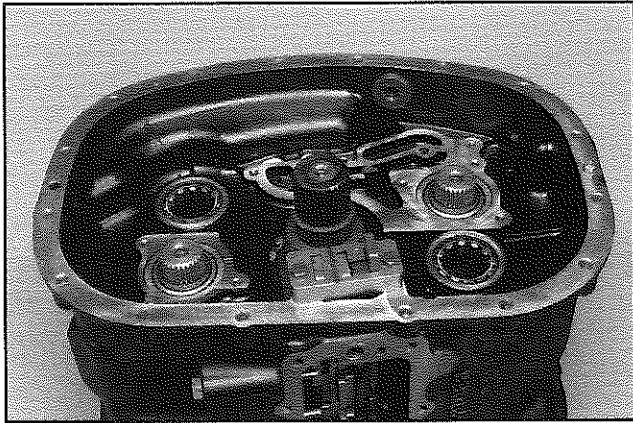


26. Now remove the mainshaft reverse gear and rear thrust plate together.

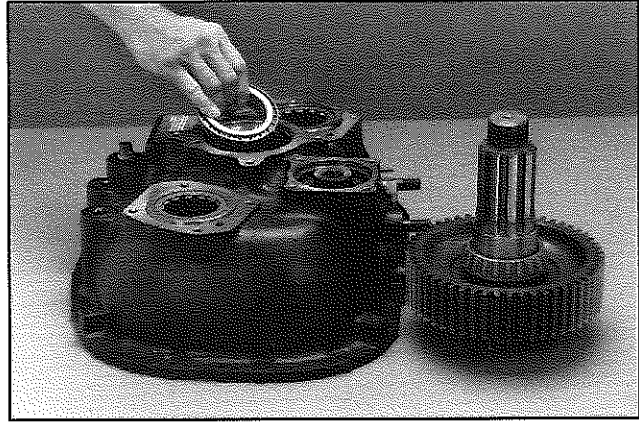


29. Remove the oil pump mounting screws and plate.

RANGE CASE DISASSEMBLY

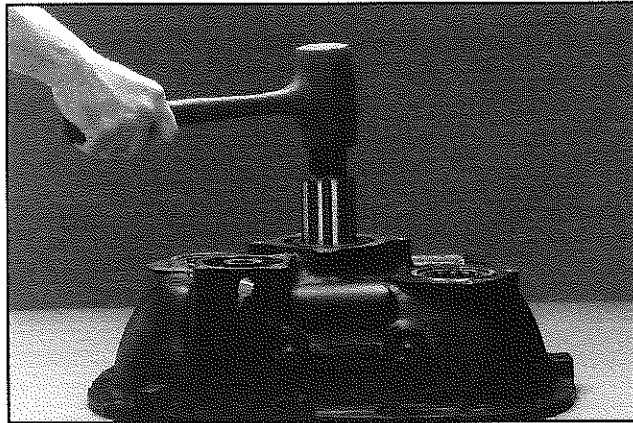


30. Next remove the countershaft rear bearing retainer plates and shims.

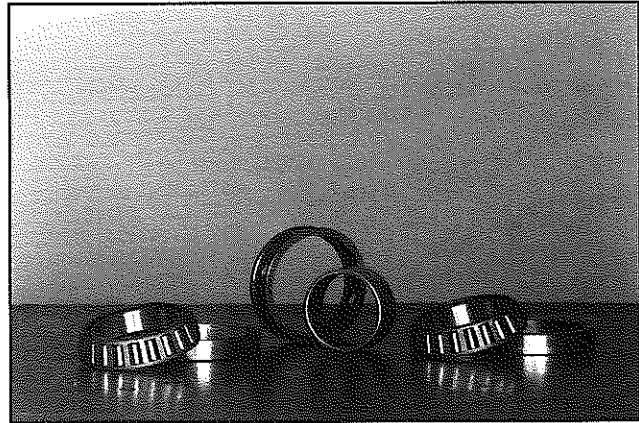


32. Remove the output shaft bearings from the case. Also press the bearing from the shaft.

⚠ WARNING: When pressing bearings, use a shield to protect people from possible flying parts.



31. Use a soft mallet to tap the output shaft from the case.



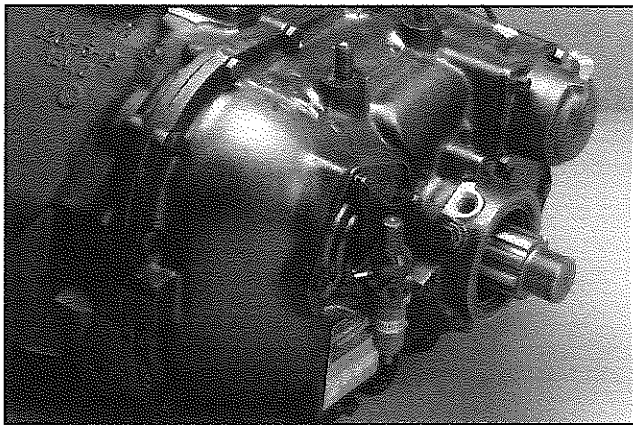
33. These bearings and spacers are a matched set.

⚠ CAUTION: If it is necessary to replace any of these items, replace them as a set to help ensure proper end play.

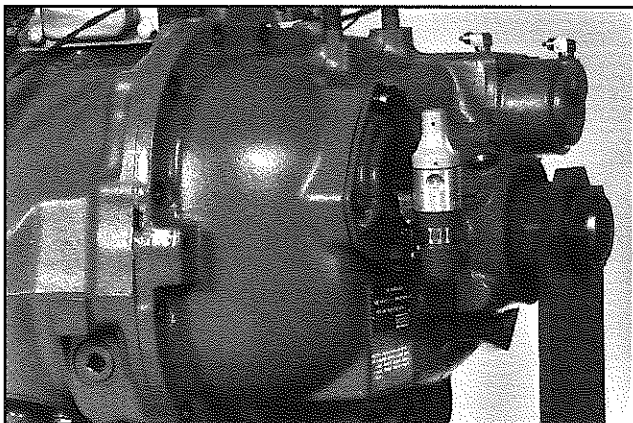
OPTIONAL RANGE CASE DISASSEMBLY

It is possible to service the range case without removing the entire transmission from the vehicle. The procedure for conventional trucks is illustrated below.

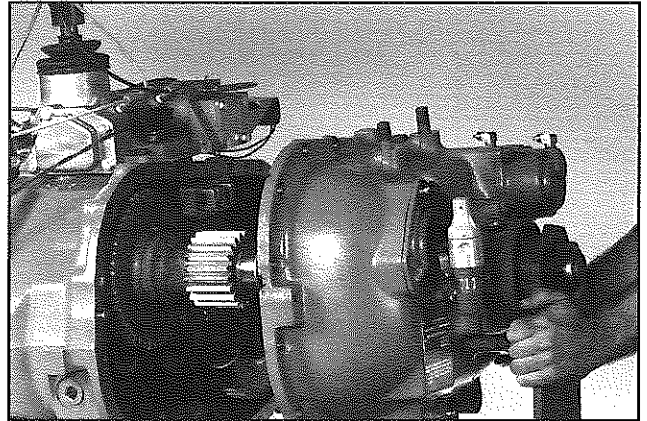
⚠ WARNING: Turn off and bleed the air system to prevent air lines from whipping, which could cause injury.



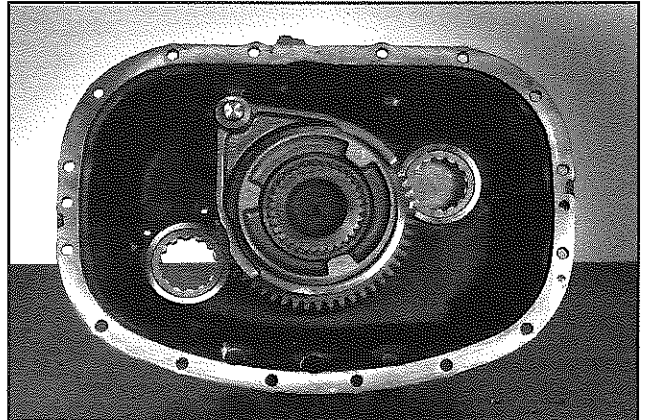
1. Begin by removing the electric speedometer sensor and 1/4" air lines. Remove the end yoke or flange.



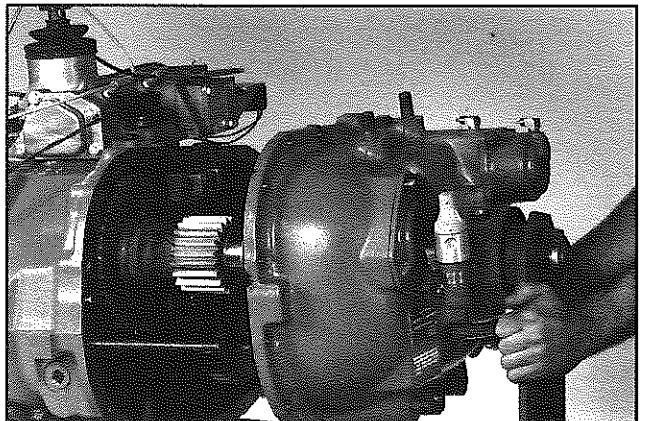
2. Remove all range case bolts except one at the top of the case. Then secure the range case support fixture (OEM6595) and a transmission jack stand to the unit. Secure the bracket to the output shaft using the output washer and nut. Torque the nut to 550 - 600 ft. lbs.



3. Detach the range section from the rest of the unit. It may be helpful to use pry bars in the case slots to separate the range case from the main case. Pull the range section straight off. It must be level with the rest of the unit.



4. These parts can be serviced without removing the entire transmission completely from the vehicle.

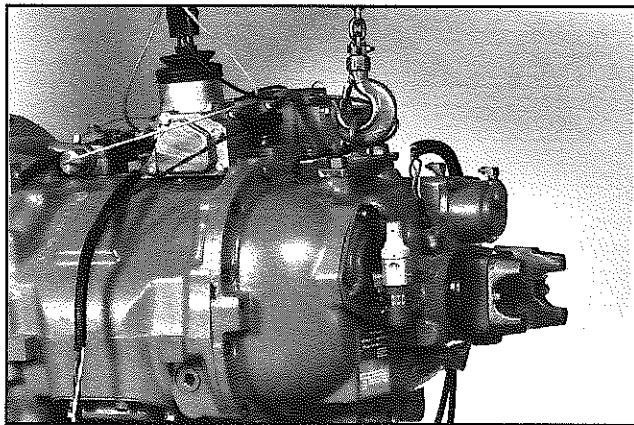


5. During reassembly, use alignment studs (7" length, 1/2" diameter) to make proper installation easier.

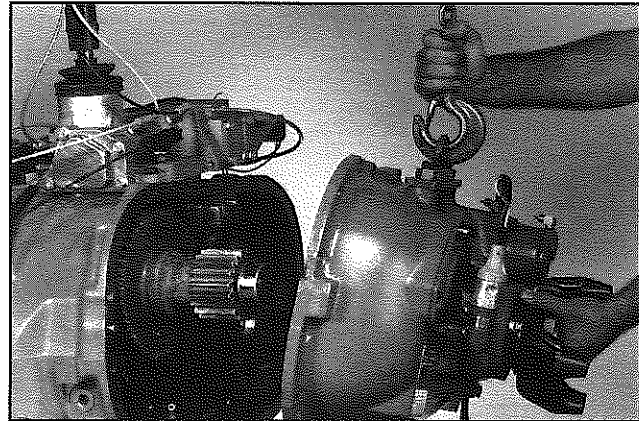
OPTIONAL RANGE CASE DISASSEMBLY

It is possible to service the range case without removing the entire transmission from the vehicle. The procedure for cab-over trucks is illustrated below.

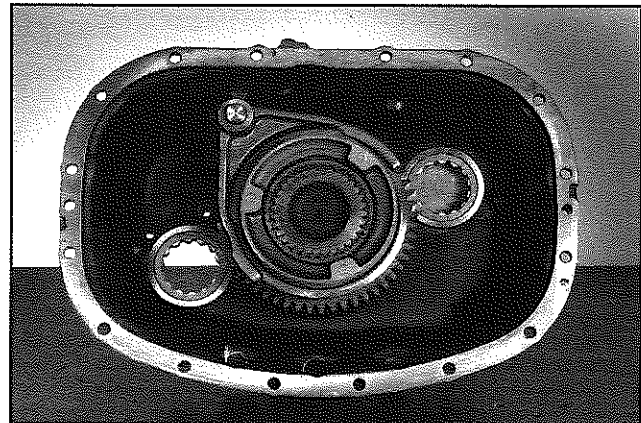
⚠ WARNING: Turn off and bleed the air system to prevent air lines from whipping, which could cause injury.



1. Remove the 1/4" air lines, the rear countershaft bearing cap and oil cooler pump assembly and the oil cooler pump hose. Also unplug the electric speedometer sensing unit from the wiring harness. Remove all case bolts except one at the top of the case. Install the range casew support fixture (OEM6595) and a lift hook.



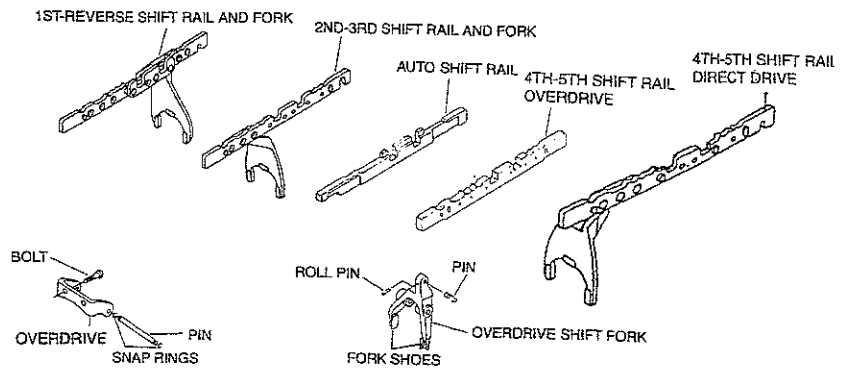
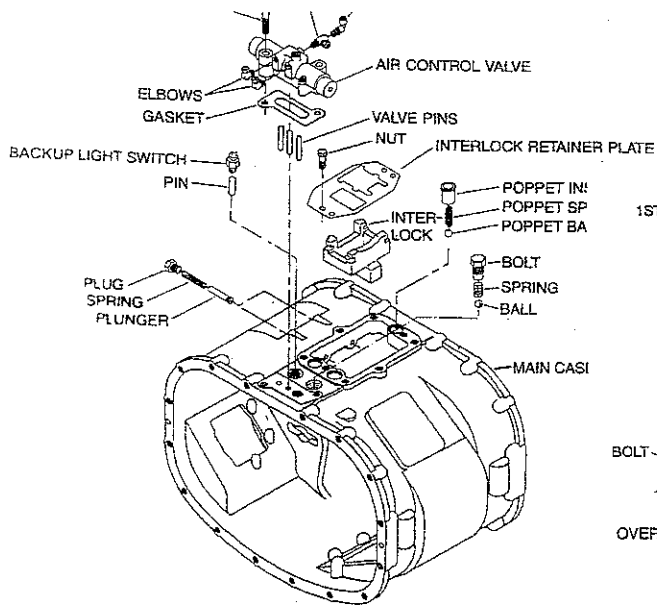
2. Remove the final case bolt and pull the range section from the transmission. It may be helpful to use pry bars in the case slots to separate the range section from the main case.



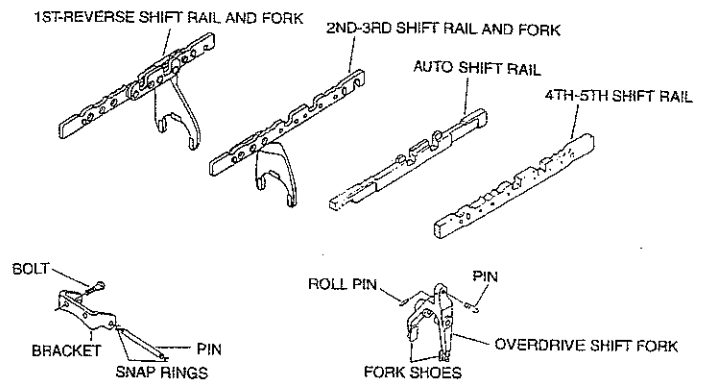
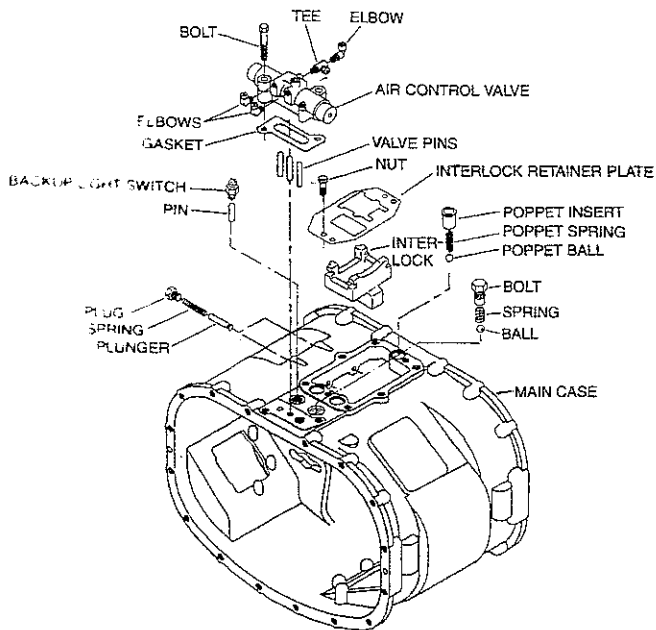
3. These parts can be serviced without removing the entire unit completely from the vehicle. During reassembly, use alignment studs (7" length, 1/2" diameter) to make proper installation easier.

MAIN CASE DISASSEMBLY

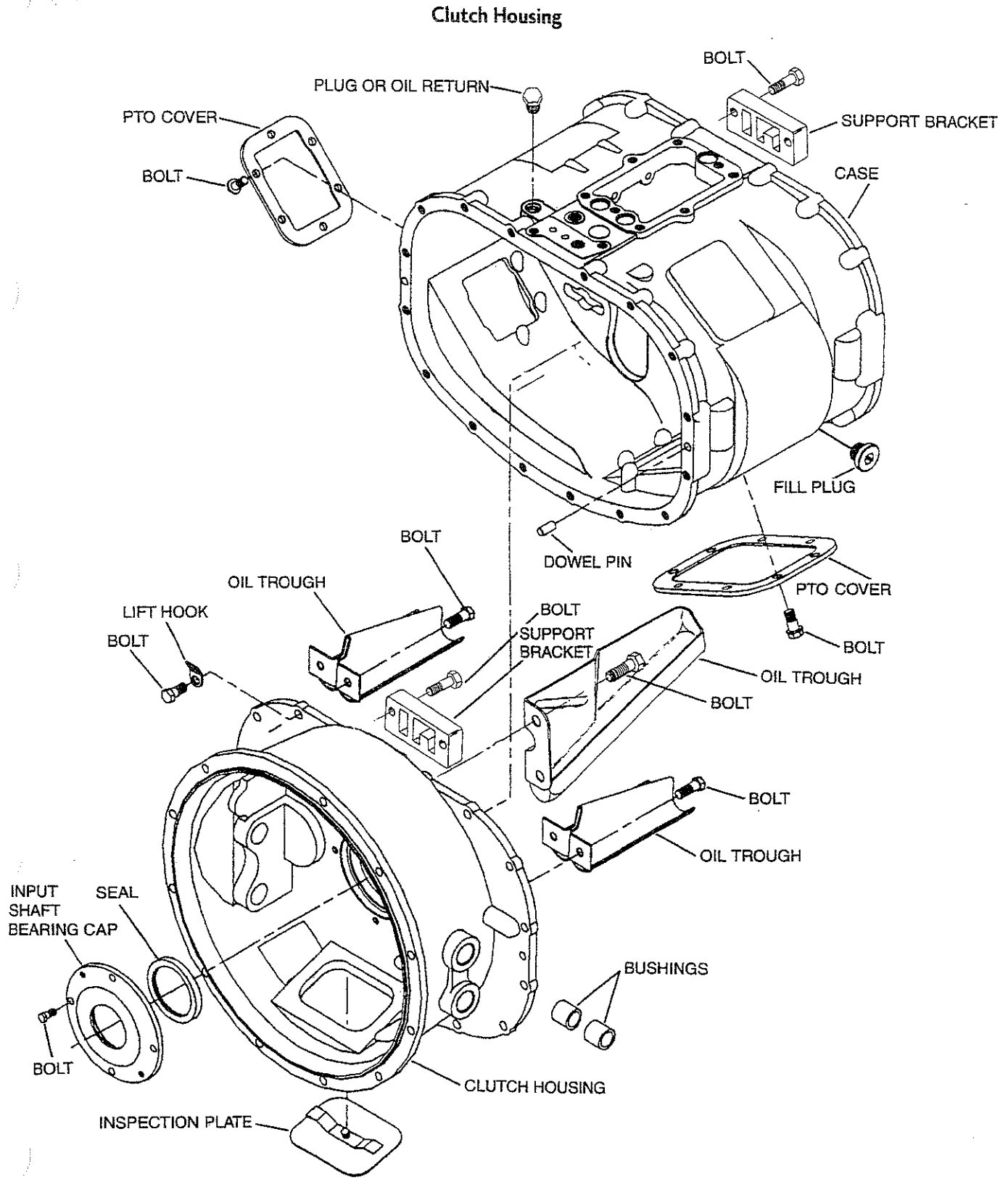
Main Case & Shift Forks 9 Speed



Main Case & Shift Forks 10 Speed

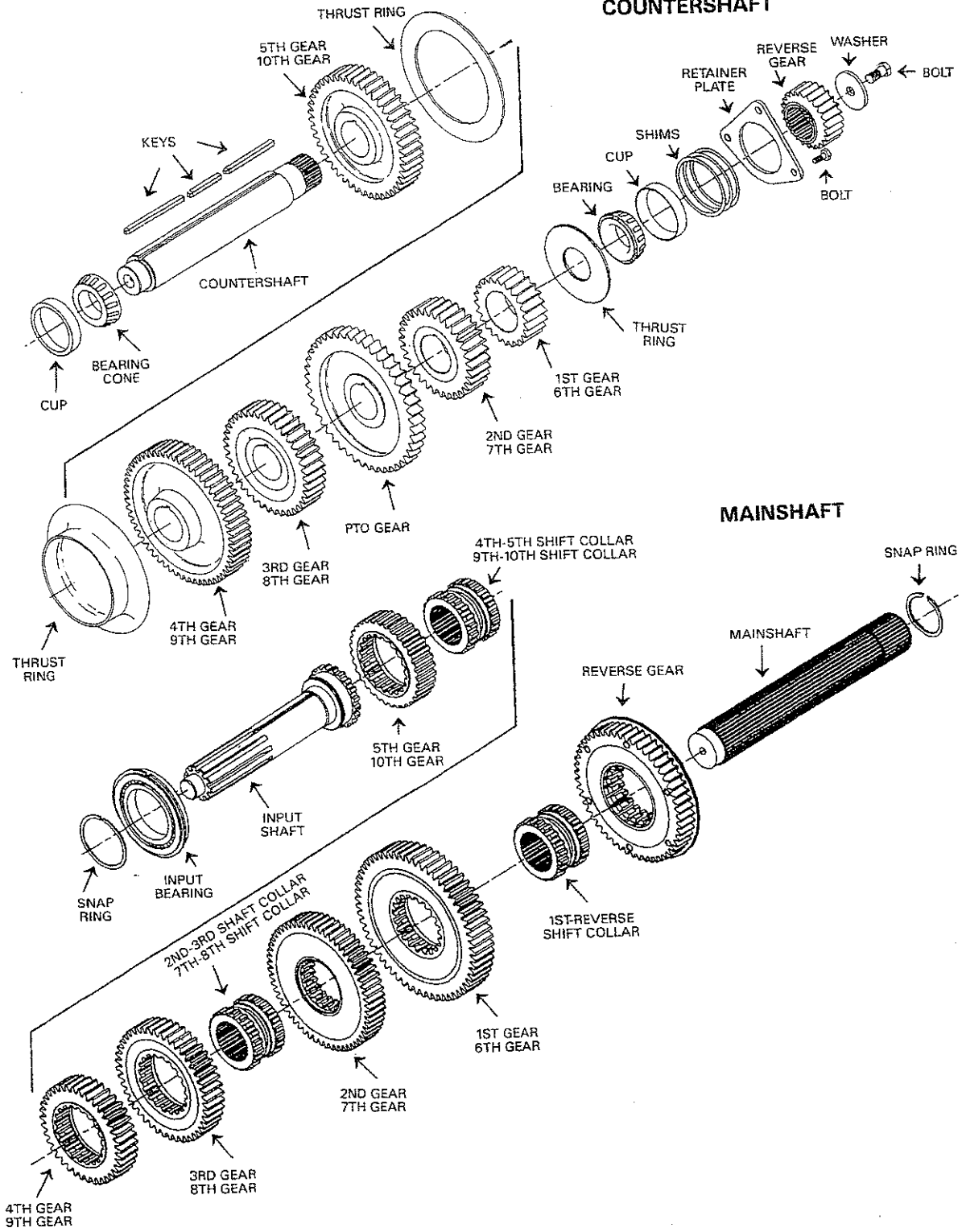


MAIN CASE DISASSEMBLY



MAIN CASE DISASSEMBLY

Main Case Gears 10 Speed

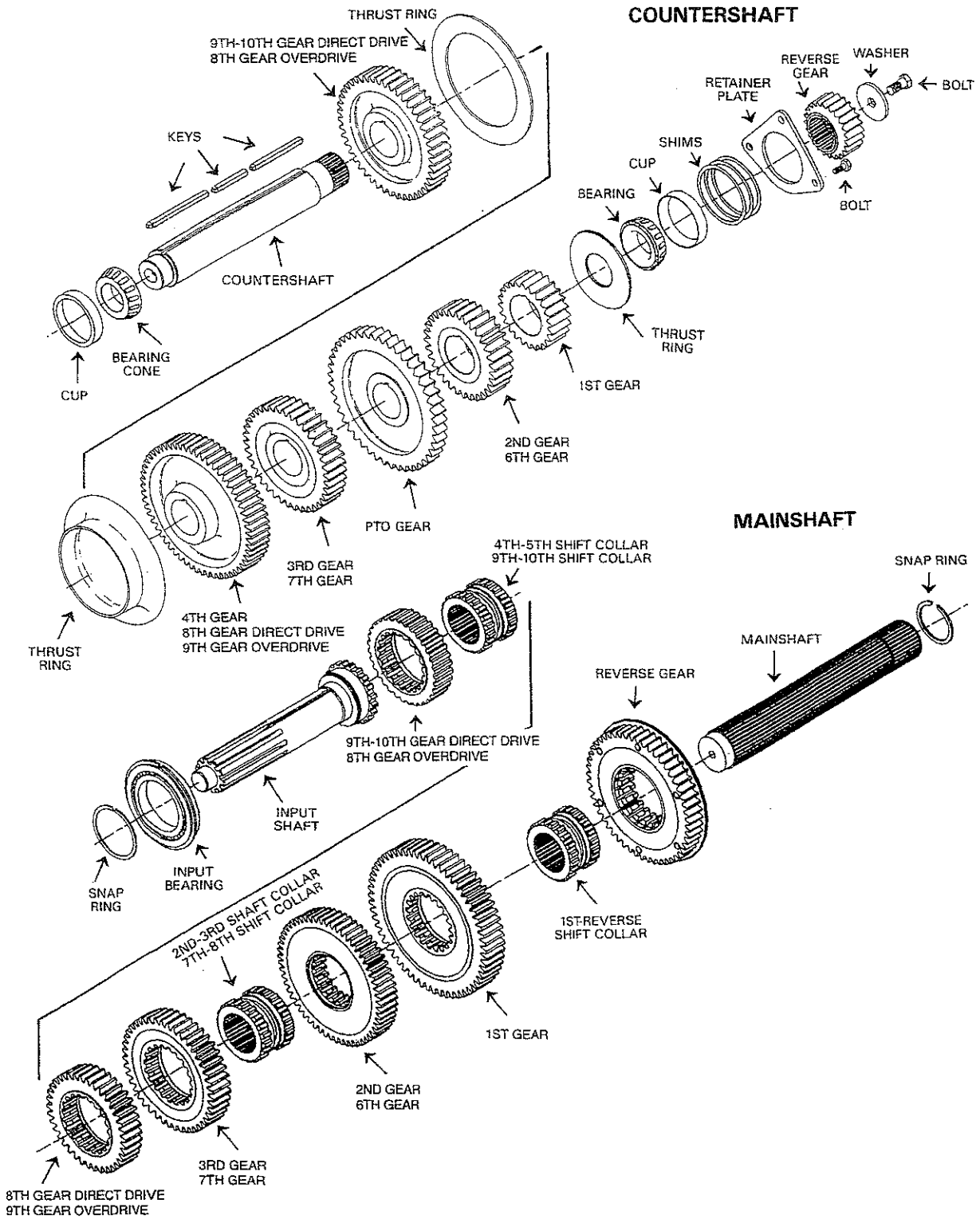


MAIN CASE DISASSEMBLY

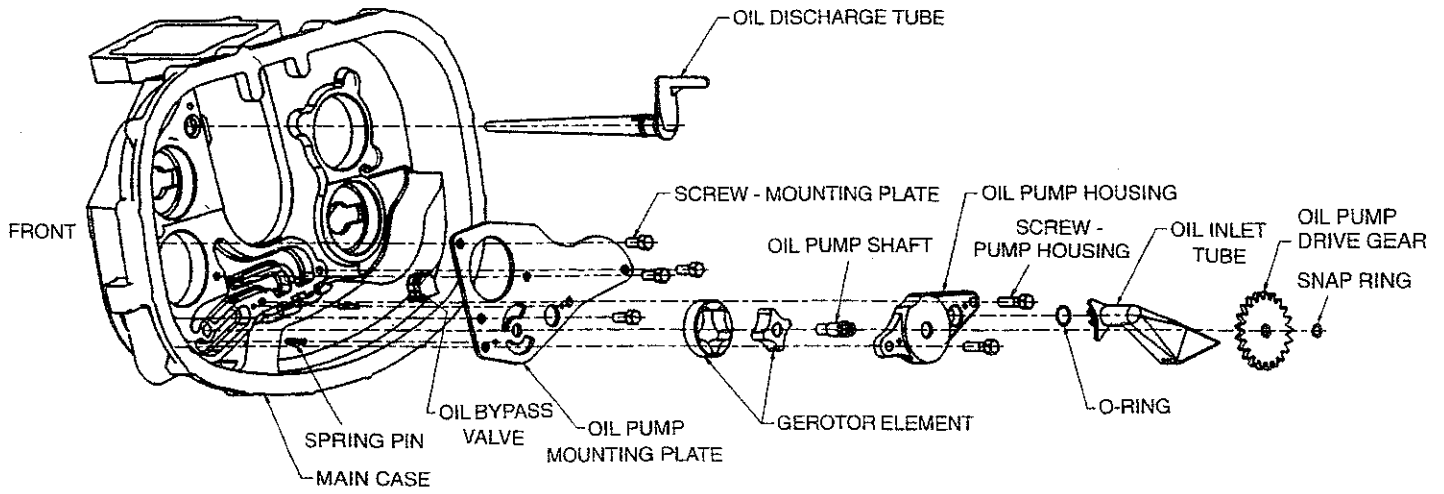
Main Case Gears 9 Speed

COUNTERSHAFT

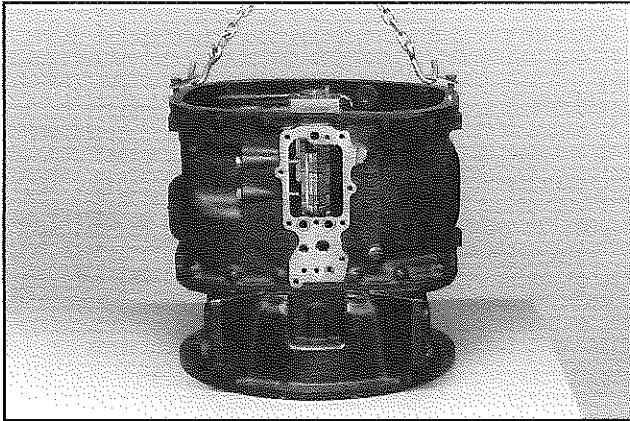
MAINSHAFT



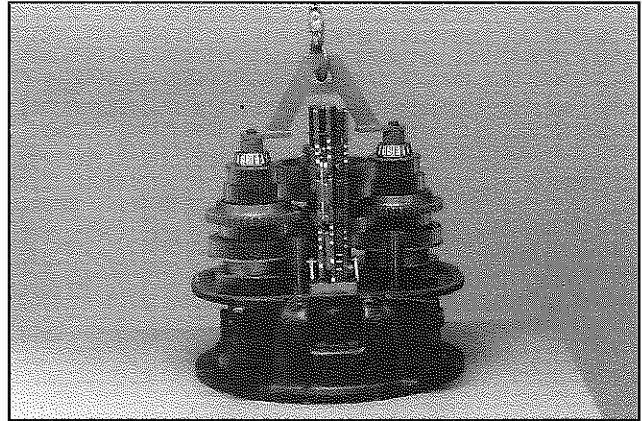
MAIN CASE OPTILUBE EXPLODED DRAWING



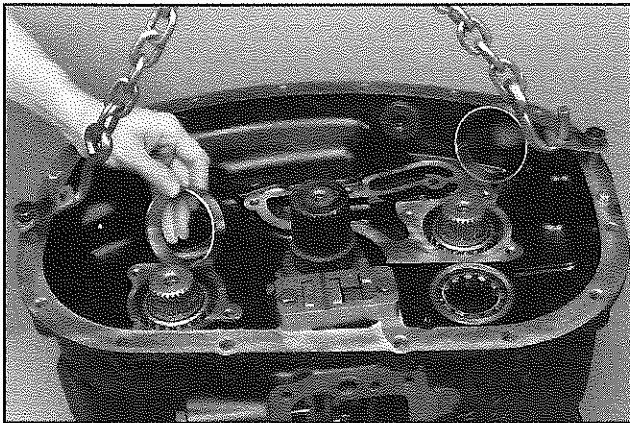
MAIN CASE DISASSEMBLY



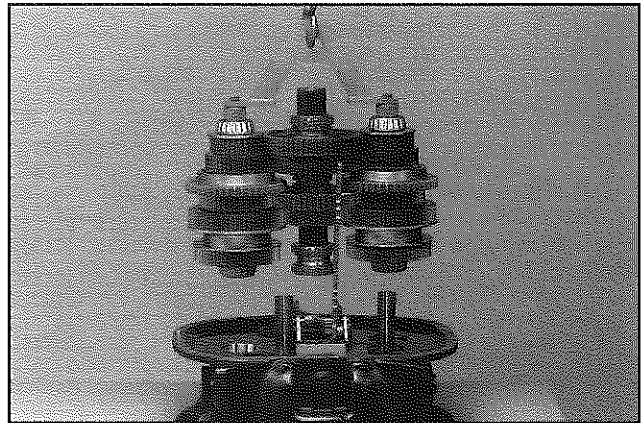
1. Remove the four remaining case bolts. Next, use pry bars in the milled slots to help separate the case from the clutch housing.



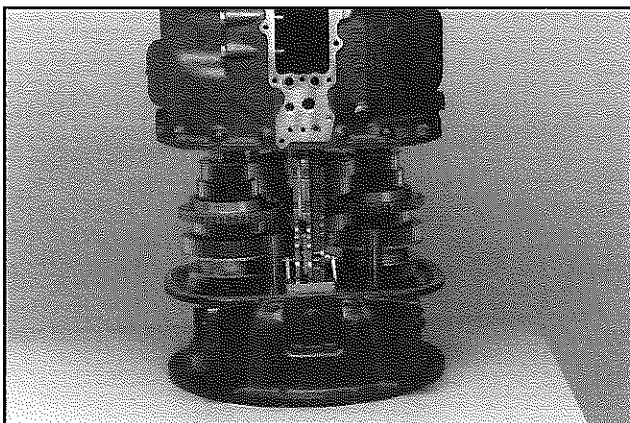
4. Attach the gear shaft lifting fixture to the countershafts. Secure it with bolts from the countershaft reverse gears.



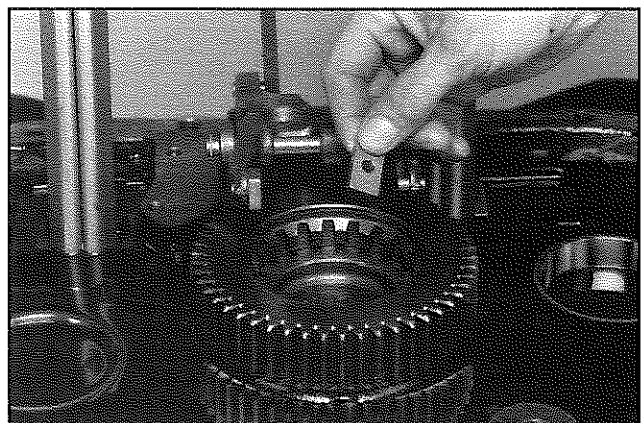
2. If the auxiliary countershaft front bearings are damaged, remove and replace them. Also remove the rear countershaft bearing cup races before removing the main case. This will prevent them from falling into the transmission.



5. Remove the assembly from the clutch housing by lifting it and sliding it out of overdrive fork. Remove all fork assemblies from the mainshaft assembly.
⚠ WARNING: When moving heavy parts, use a chain hoist to help prevent personal injury.

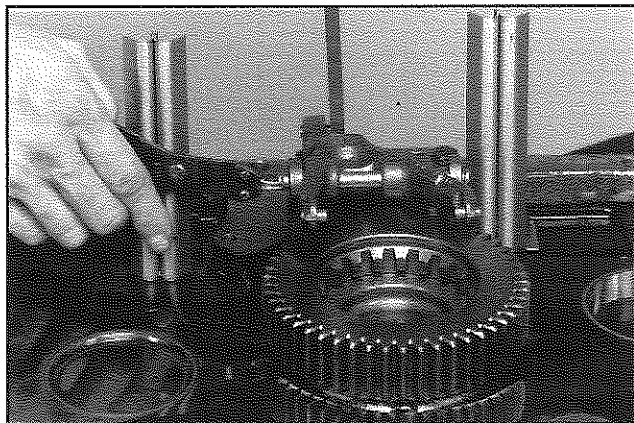


3. Lift the case from the clutch housing. Note that the rear shift bar support bracket remains with the case.
⚠ WARNING: When moving heavy parts, use a chain hoist to help prevent personal injury.

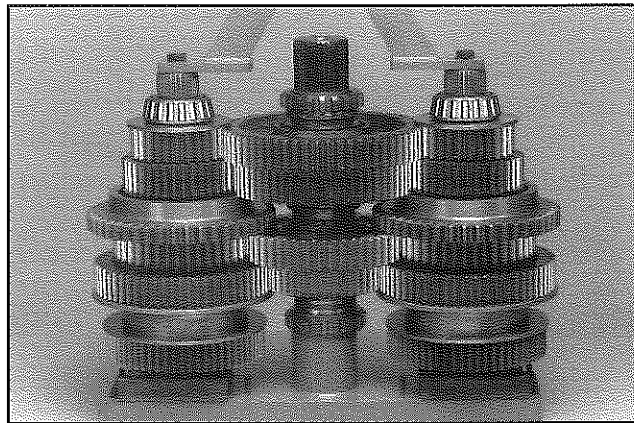


6. Overdrive fork can stay in the case unless it needs to be replaced. If the overdrive shift fork shoes are worn, replace them. It is not necessary to remove the fork to replace the fork shoes.

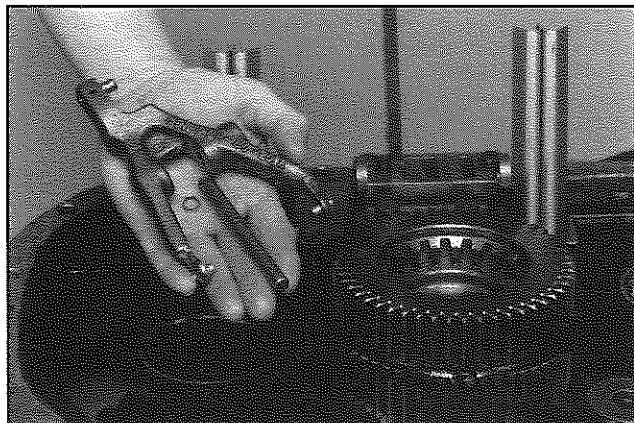
MAIN CASE DISASSEMBLY



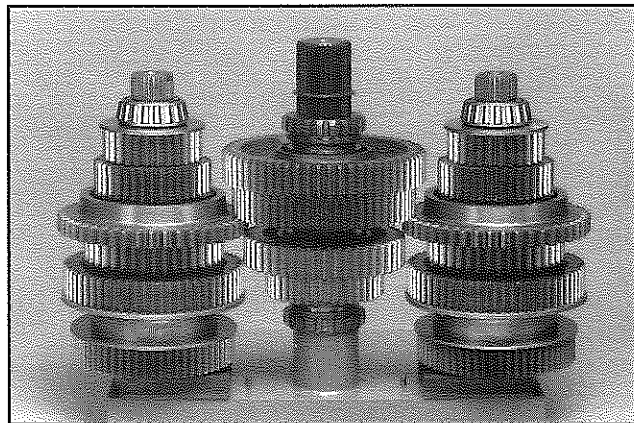
7. To remove the overdrive shift fork, first remove the snap ring. Push the pin through the bracket.



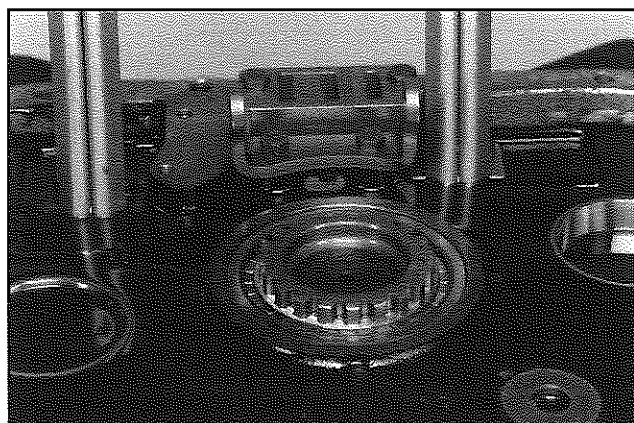
10. Set the shafts in the assembly stand (OEM6596A).



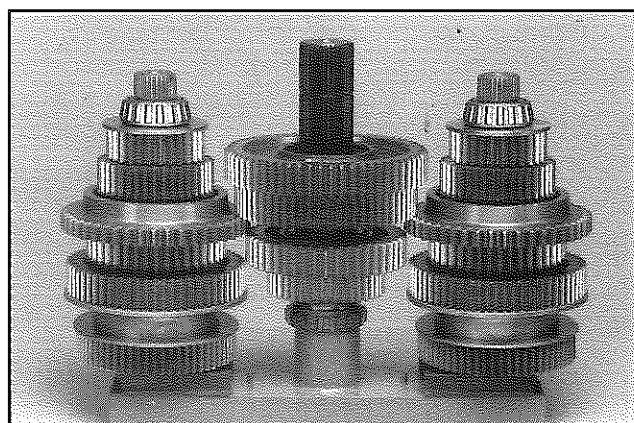
8. Lift the fork from the unit.



11. Remove the lift tool and slide the countershafts apart.

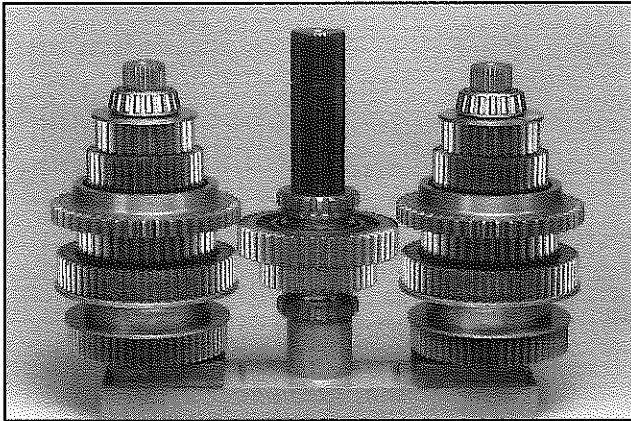


9. The 5th speed gear is removed next. Remove and replace the bearing cups if they are damaged. The oil troughs can remain with the case.

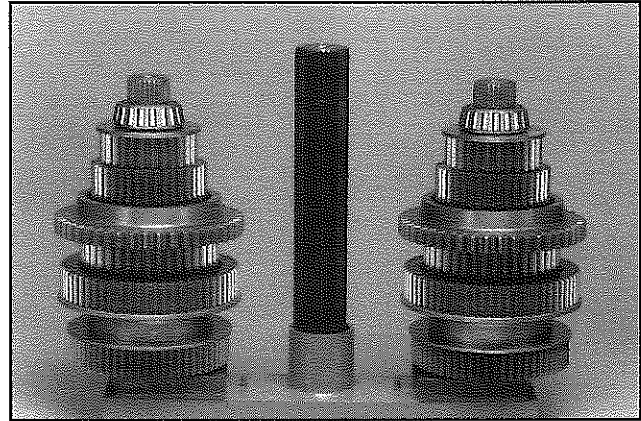


12. Remove the mainshaft snap ring and 1st-reverse shift collar.
⚠ WARNING: Always wear safety glasses to help protect your eyes against flying parts.

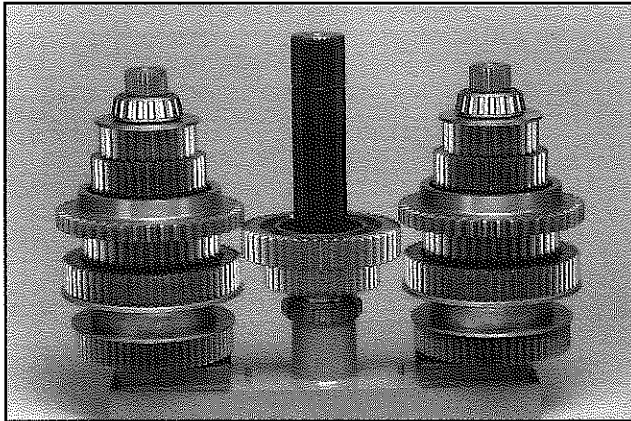
MAIN CASE DISASSEMBLY



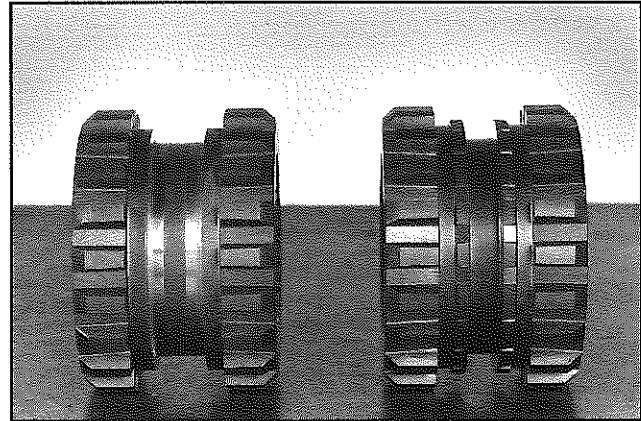
13. Next remove 1st and 2nd speed gears.



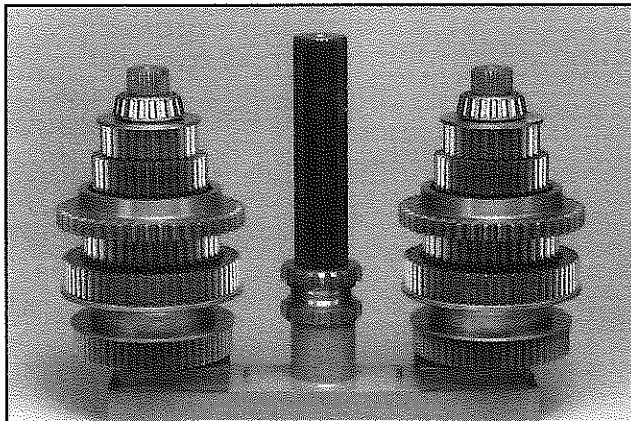
16. Remove the 4th-5th speed shift collar.



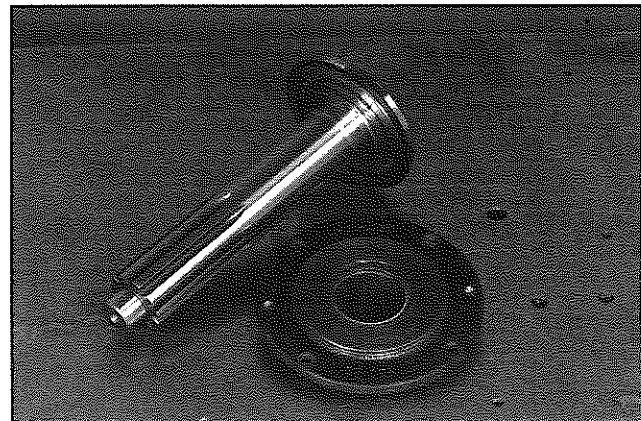
14. Remove the 2nd-3rd speed clutch collar.



17. Notice that the fork slot on the 4th-5th speed shift collar (left) is wider than the fork slot on the other collars in this unit. All shift collars are the same in direct drive.

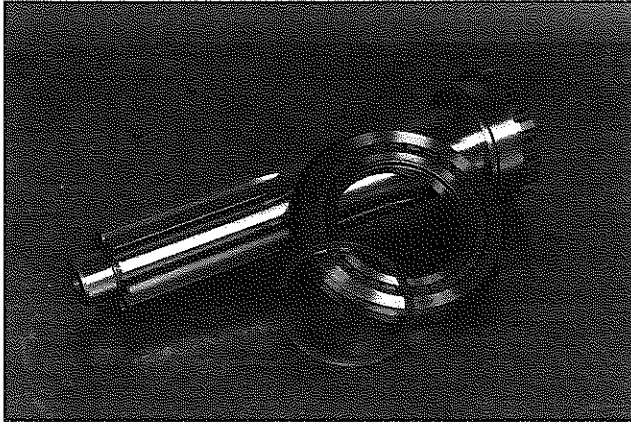


15. The 3rd and 4th speed gears can be removed next.



18. To remove the input shaft and bearing cap, remove the four cap retaining bolts. Pull the shaft from the housing. It may be helpful to place two bolts in the threaded bearing cap holes. Tightening the bolts will draw the bearing cap from the housing. Tap the input shaft out of the bearing cap.

MAIN CASE DISASSEMBLY

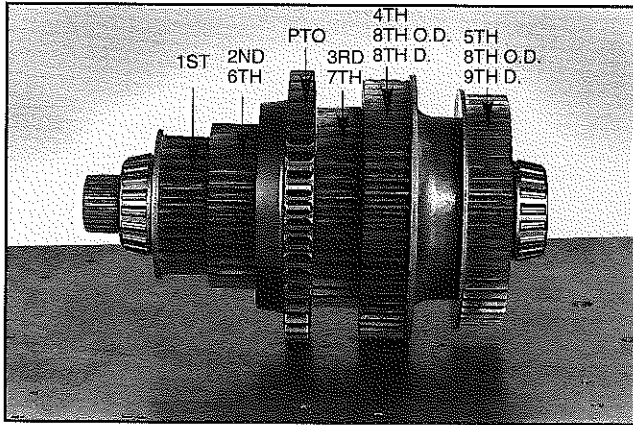


19. To disassemble the input shaft assembly, remove the snap ring. Press the bearing off the shaft.

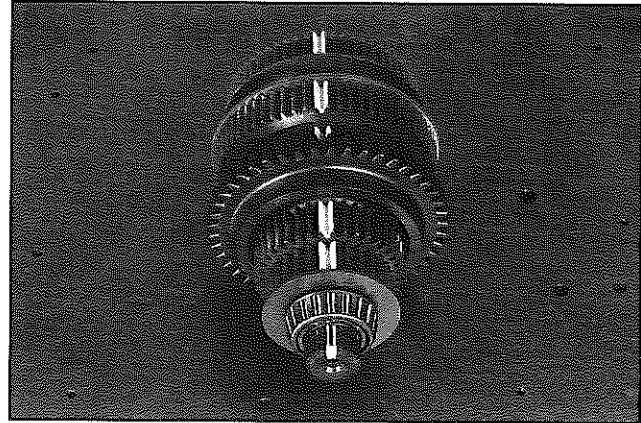
⚠ **WARNING:** When pressing bearings, use a shield to protect people from possible flying parts.

COUNTERSHAFT DISASSEMBLY & REASSEMBLY

9 Speed Countershaft

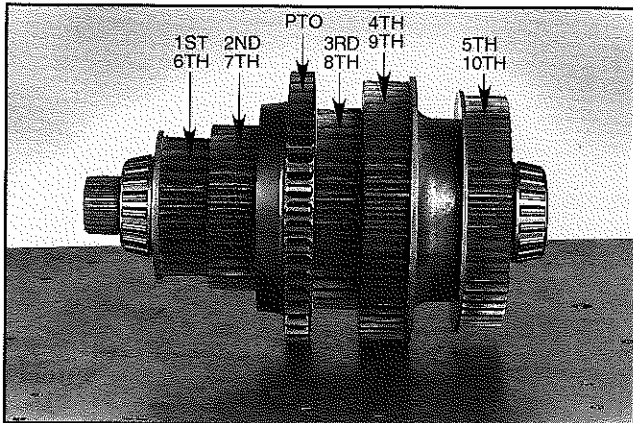


1. This view of the countershaft shows the direction of the gears. The gears are secured with three keys.



3. If a straight edge is placed between the teeth (painted here to show the timing marks) every gear on the countershaft will be in line with the blind spline on the countershaft. When the shafts are in time, these marks will be directly across from each other. If they are out of alignment, check for worn or damaged keys or a twisted shaft.

10 Speed Countershaft



1. This view of the countershaft shows the direction of the gears. The gears are secured with three keys.

CLEANING & INSPECTION PROCEDURES

CLEANING

Prior to reassembly, clean all parts thoroughly with a petroleum-based solvent.

WARNING: Read and understand the solvent manufacturer's safety precautions to prevent personal injury or transmission damage.

CAUTION: Do not use water or steam to clean internal components. Doing so could cause corrosion of these components.

WARNING: Do not use gasoline to clean parts. Gasoline can explode, causing serious physical injury.

Dry the parts immediately with compressed air. Coat them with lubricant if they are to be reassembled immediately. If the parts are to be stored, coat them with a rust inhibitor and wrap them to keep out contamination.

Inspect parts thoroughly for wear or damage. Parts damaged or worn from previous service must be replaced to ensure maximum rebuild life. Suggested inspection procedures include the following.

INSPECTION

Clutch Collars

Both the internal and external teeth must have sharp edges. Check for chipped or broken teeth, or teeth with rounded corners. Also, examine fork slots for wear. Replace collars if any of these conditions exist.

Gears

Examine for broken or cracked operating and clutching teeth. Also check for any unusual wear patterns. If any of the preceding exist, replace the gear. If a gear is replaced, also replace the mating gear.

Thrust Washers

Check for flatness or excessive face wear, cracks, scoring, or signs of heat damage. Replace if any of these conditions exist.

Snap Rings

New snap rings are recommended with every rebuild.

Mainshaft

Check for signs of twisting or misalignment. Also check for worn or damaged splines. Replace the shaft if any of these conditions exist.

Remote Control

Check the shift fingers, bushing bores and rods for excessive wear or scuffing. Replace springs, bearing races, boots and seals. Clean all reusable parts thoroughly and apply a light coat of grease to the pivot points when reassembling.

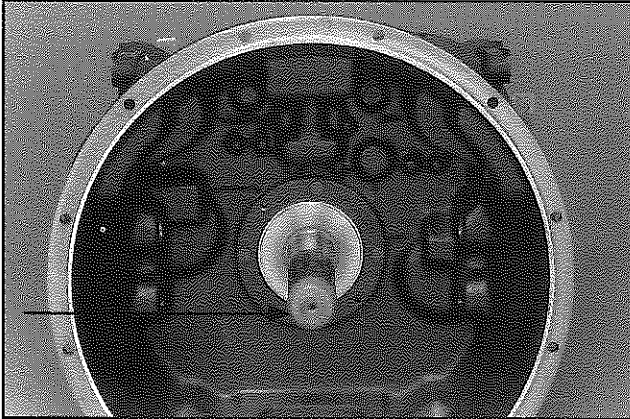
Bearings

New bearings are recommended with every rebuild. (See "General Disassembly: Bearings" for further information.)

Housings

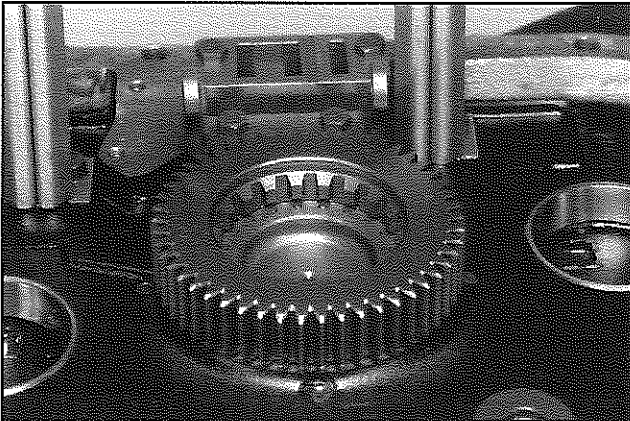
Inspect the housing sections for cracks. If cracks exist, replace that section of the housing. Also inspect the shift bar support bracket for cracks or worn slots. Replace if either of these conditions exist.

MAIN CASE REASSEMBLY

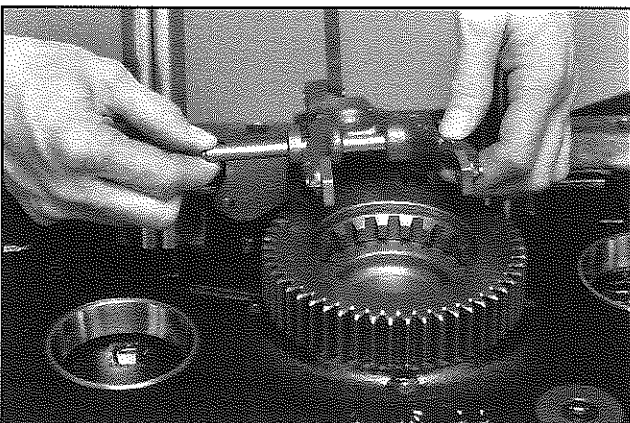


1. Install the input shaft. Next, coat the bearing cap sealing surface with purple Loctite® 515 or the equivalent. Slide the bearing cap into place.

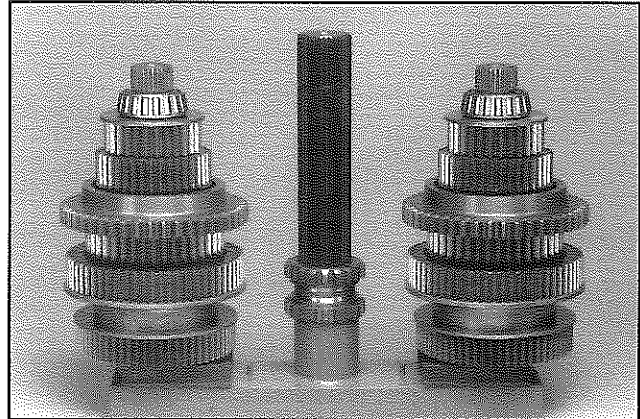
! CAUTION: Use a sleeve to protect the cap seal during cap installation. Torque the cap bolts to 34 - 41 ft. lbs.



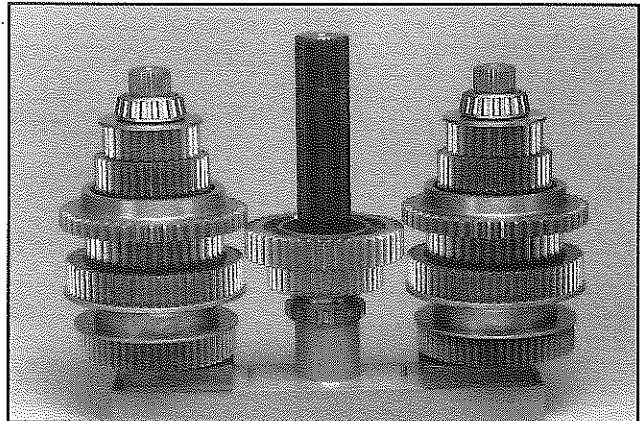
2. Continue by installing 5th speed gear with the thrust face toward the input bearing. The timing marks should be positioned to align with the countershafts.



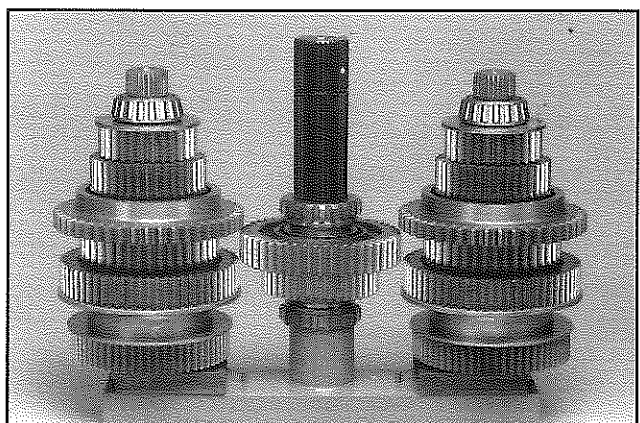
3. Install the 4th-5th speed fork. Secure it with the pin and two snap rings.
! WARNING: Always wear safety glasses to help protect your eyes against flying parts.



4. Place the 4th-5th shift collar on the mainshaft.

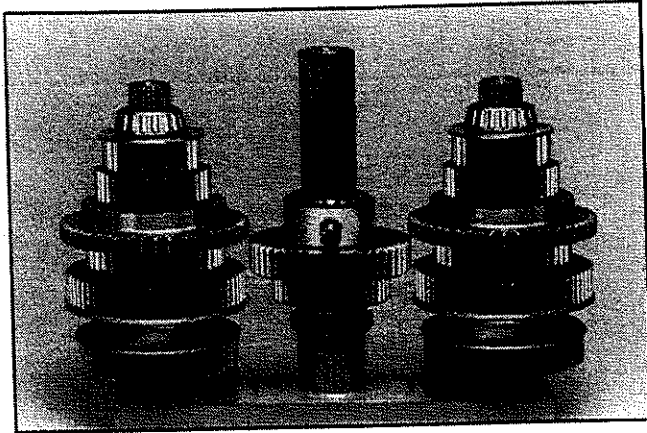


5. Install 4th and 3rd speed gears into place. Each gear has a shift collar bore which must face the collar it will receive.

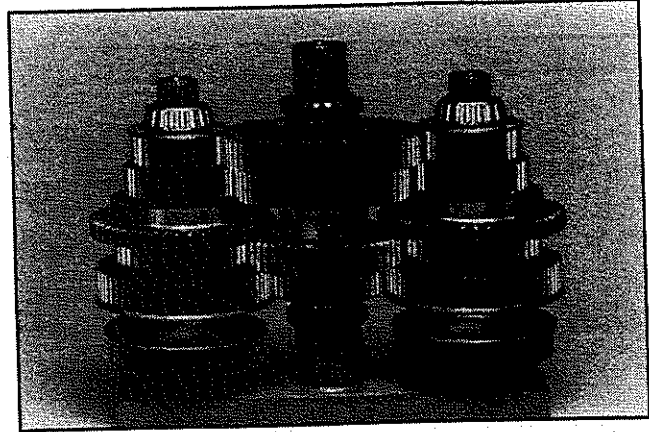


6. Install the 2nd-3rd shift collar.

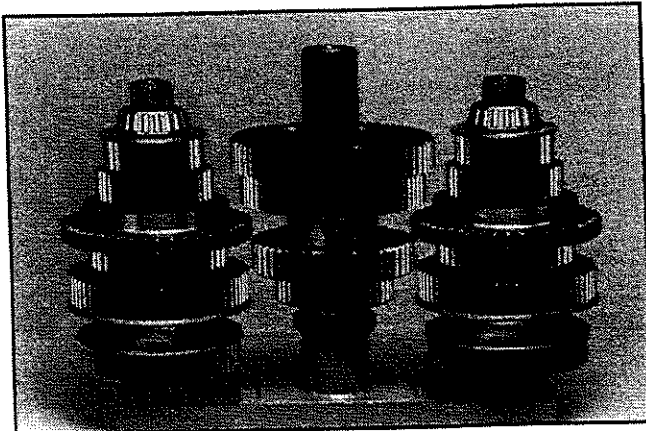
MAIN CASE REASSEMBLY



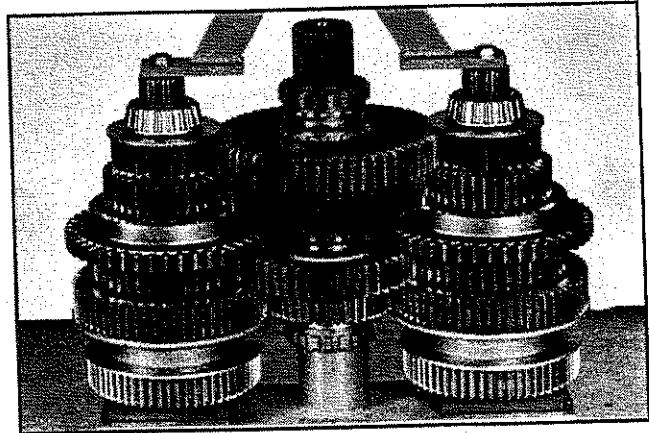
7. Install the mainshaft assembly spacer (OEM6597) onto the shift collar. Center the bolt with the fork bracket slot. This tool holds the collar at the proper height for receiving the countershafts.



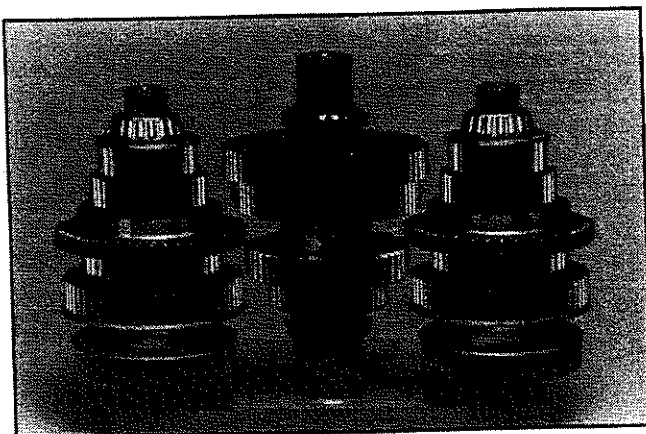
10. Slide the countershafts together. The blind splines are timing marks. Align them across from one another.



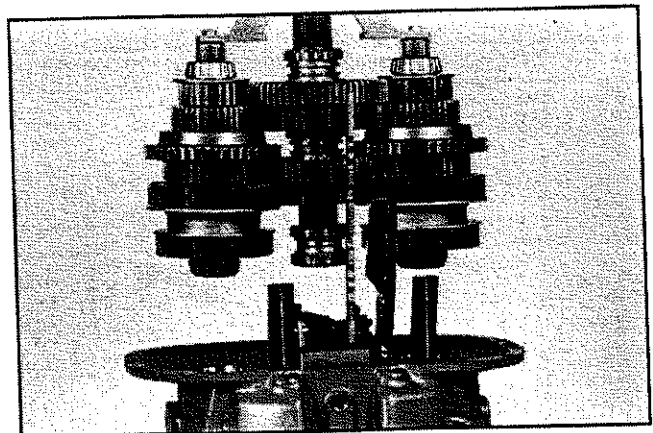
8. Install 2nd and 1st speed gears. Visually center the gears on the shaft.



11. Attach the gear shaft lifting fixture (OEM6598). Now remove the alignment collar.

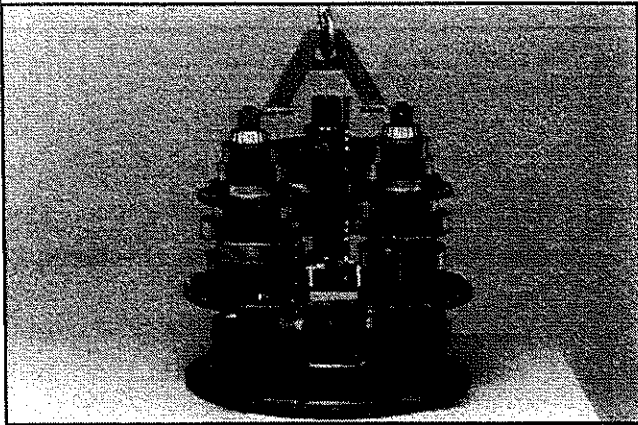


9. Install 1st-reverse shift collar. Secure it with the snap ring.

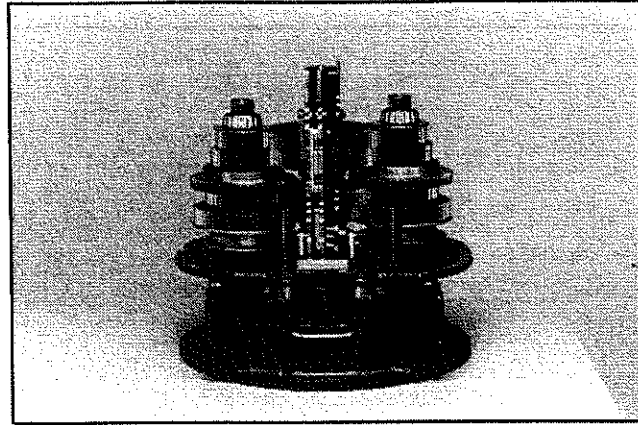


12. Lift the assembly from the stand.
⚠ WARNING: When moving heavy parts, use a chain hoist to help prevent personal injury.

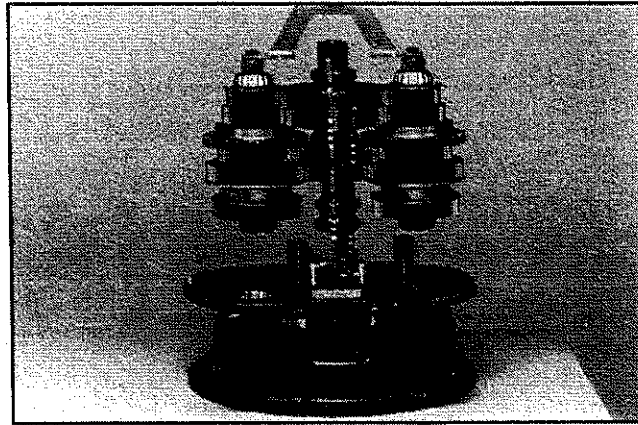
MAIN CASE REASSEMBLY



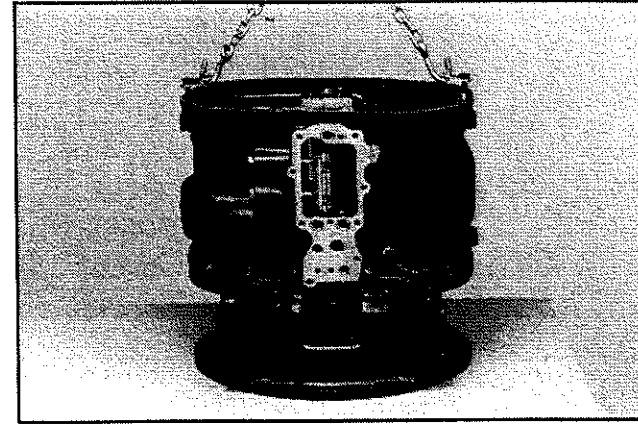
13. Install the automatic shift rail.



16. Make sure the 4th-5th speed fork shoes are in place. A dab of light grease on the fork shoes will help them stay in place. Then position the assembly in the clutch housing so that the 4th-5th shift collar slides into the 4th-5th fork shoes.

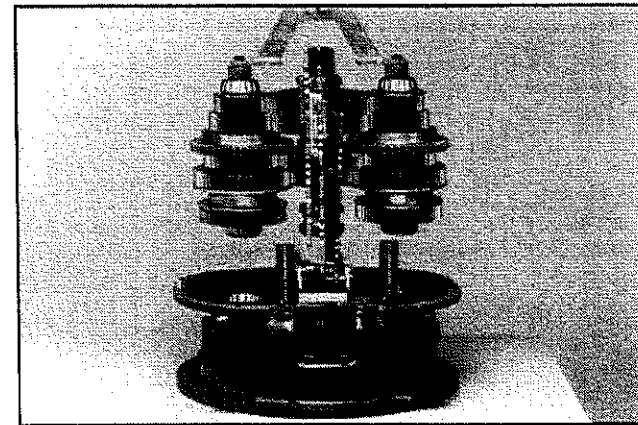


14. Install the 2nd-3rd shift fork.

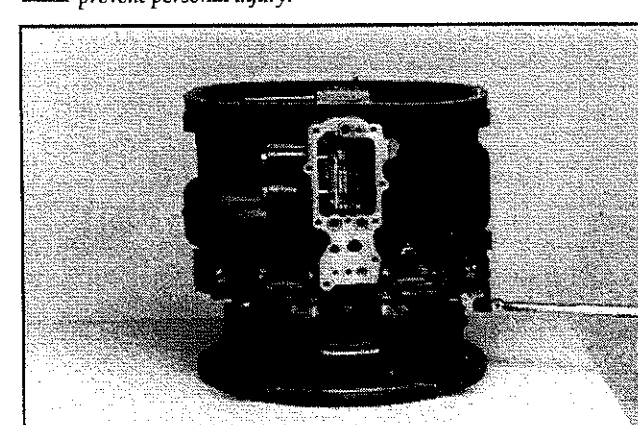


17. Apply purple Loctite® 515 or the equivalent to the clean housing face. Then lower the main case into position, making sure the forks are aligned with the shift bar support bracket in the case.

⚠ **WARNING:** When moving heavy parts, use a chain hoist to help prevent personal injury.



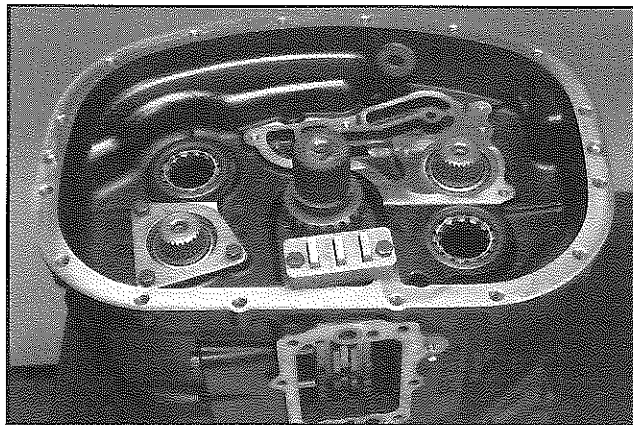
15. Install the 1st-reverse shift fork. Push the fork rails together.



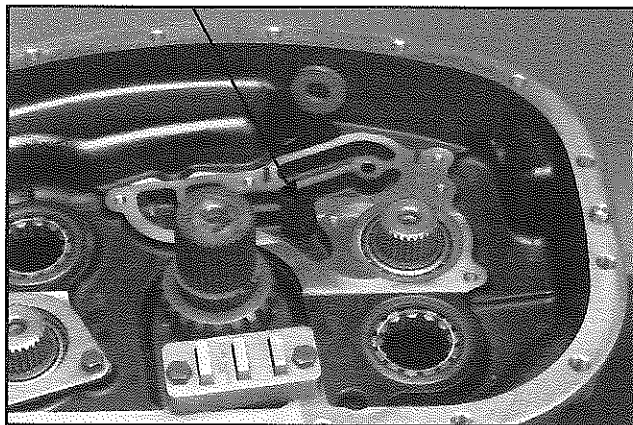
18. Install the case bolts.

⚠ **WARNING:** Do not overtighten the bolts; doing so could break the unit housing and flying parts could cause personal injury. Torque the bolts to 78 - 98 ft. lbs.

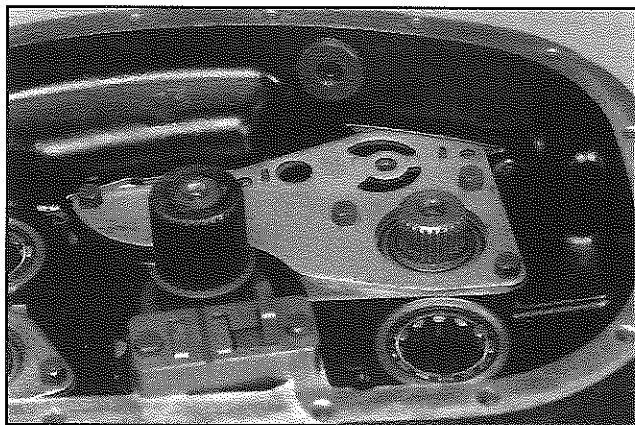
RANGE CASE REASSEMBLY



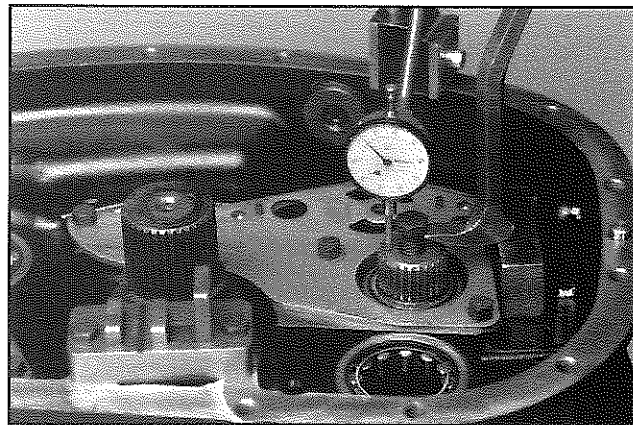
1. Install the range countershaft shims (thin ones first) and retainer plate.
! CAUTION: Make sure the shims are in line with the plate holes to help ensure proper transmission operation. Torque the bolts to 34 - 41 ft. lbs.



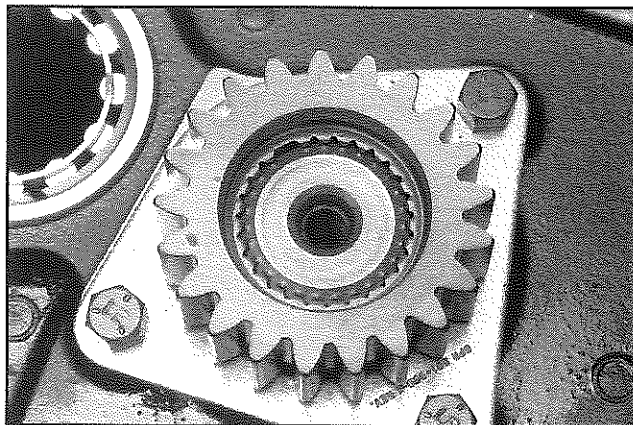
2. Place the oil bypass valve into the opening in the main case oiling system.



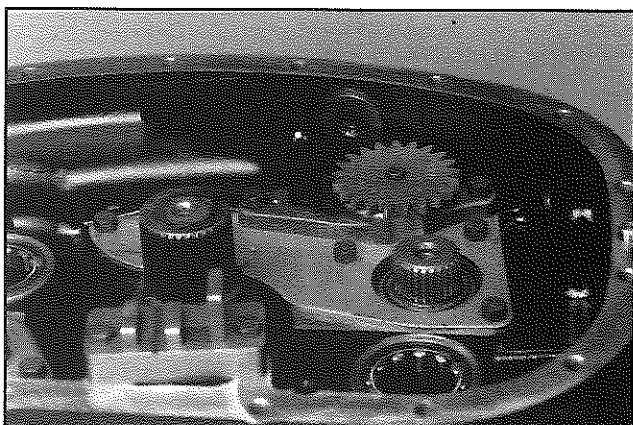
3. Install the oil pump mounting plate. Torque to 34 - 41 ft. lb.



4. Next check the main box countershaft end play.
! CAUTION: Make sure end play is between .003" and .008" on each countershaft. This will help ensure proper transmission functioning.

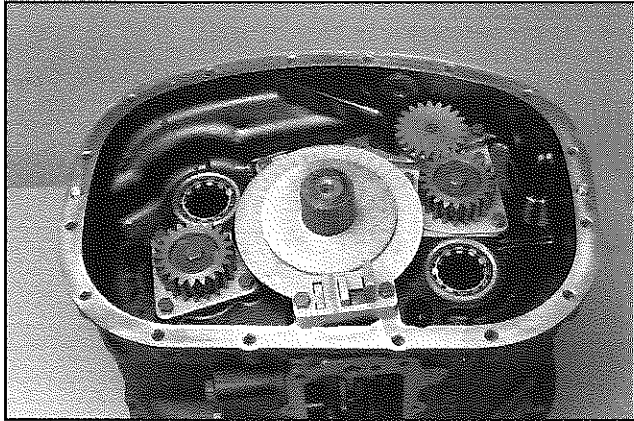


5. Reinstall the countershaft reverse gears. These gears only fit in one position because of the blind spline. Secure each gear with a washer and bolt. Torque the bolts to 78 - 98 ft. lbs.

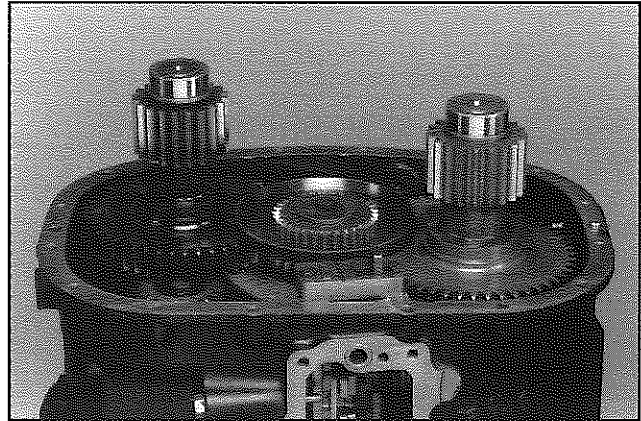


6. Install the oil pump assembly on the oil pump mounting plate. Secure it with bolts and torque to 34 - 41 ft. lb. Spin the oil pump gear to make sure it moves freely.

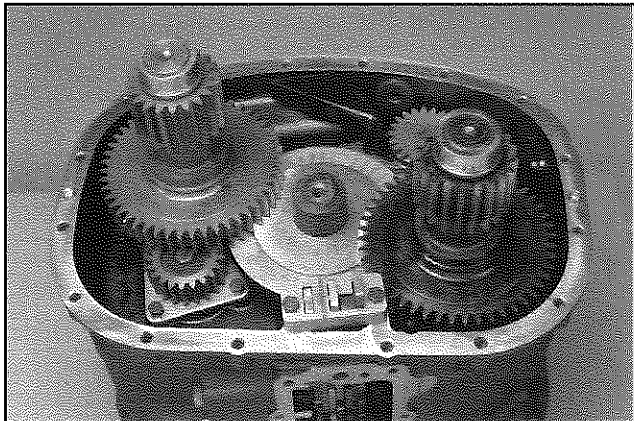
RANGE CASE REASSEMBLY



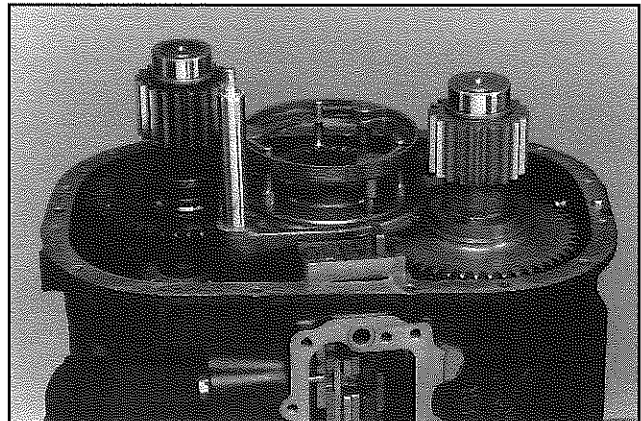
7. Reinstall the countershaft reverse gears. These gears only fit in one position because of the blind spline. Secure each gear with a washer and bolt. Torque the bolts to 78 - 98 ft. lbs. Install the reverse gear and thrust plate next.



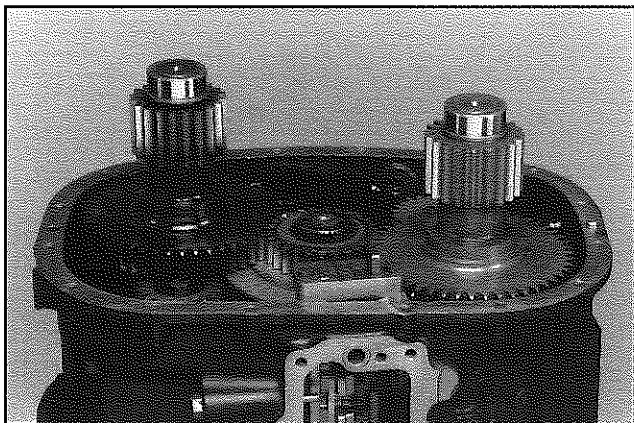
10. Install the rear clutch drive gear and the synchronizer cup. Secure them with the washer and bolt. Torque to 78 - 98 ft. lbs.



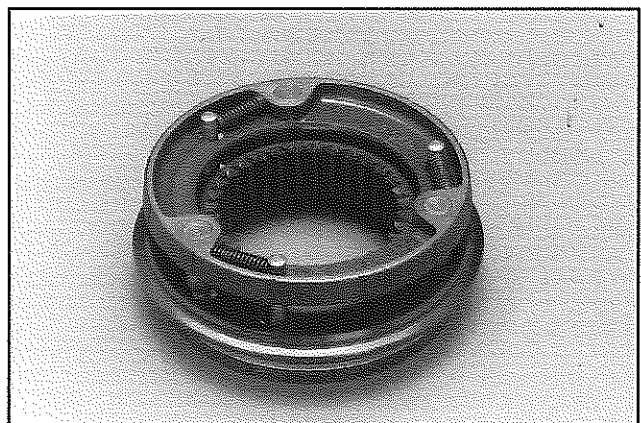
8. Lift up slightly on reverse gear, then place the range countershafts in the housing. Lifting the gear will help center it and the thrust plate once the countershafts are installed.



11. Install the synchronizer and fork with the synchronizer springs facing the output yoke or flange. Make sure the synchronizer springs stay in place during installation. Installation is easiest if the synchronizer is in neutral. Place a new, lubricated O-ring on the fork assembly.

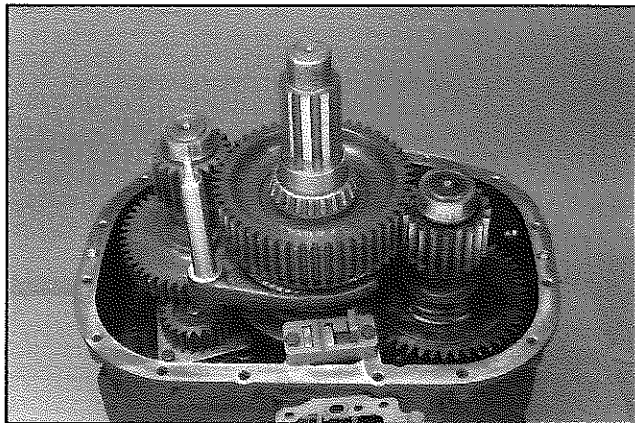


9. Now install the high range drive gear. Align the timing marks with those on the countershafts.



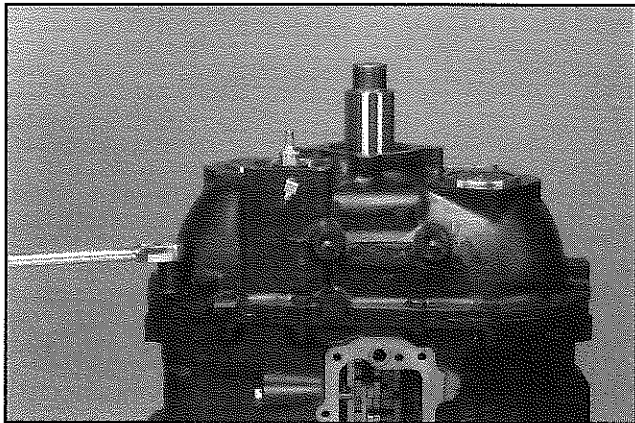
12. Synchronizer parts are available separately.

RANGE CASE REASSEMBLY

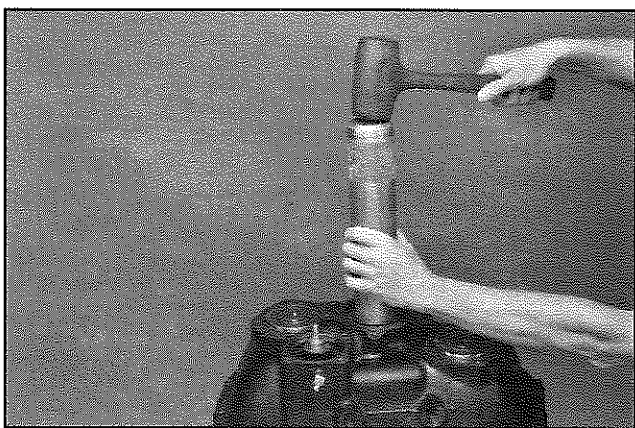


13. Press the tapered bearing and spacer onto the output shaft.

⚠ WARNING: When pressing bearings, use a shield to protect people from possible flying parts. Install the output shaft assembly now. Low range gear should be centered between the countershafts.

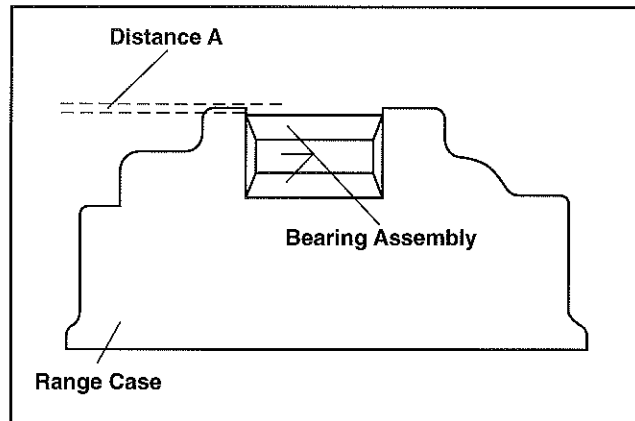


14. Continue by applying purple Loctite® 515 or the equivalent to the housing face, then lower the rear case into place. Torque the case bolts to 78 - 98 ft. lbs.

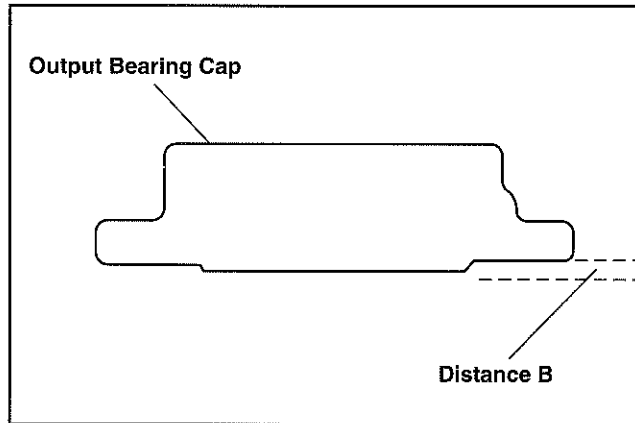


15. Use a proper driver and rubber mallet to drive the cup, spacer, cup and bearing into the case. These bearings are part of a matched set.

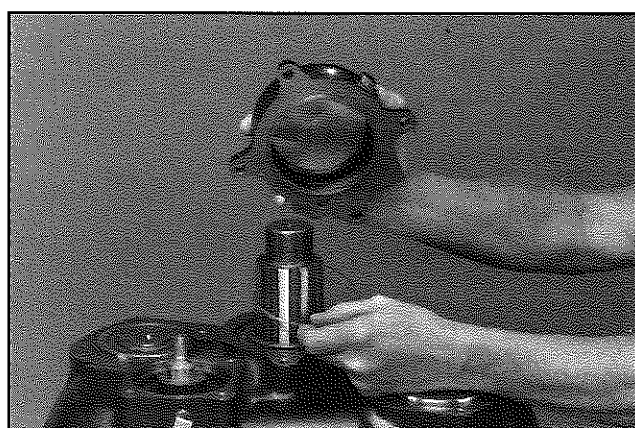
⚠ CAUTION: If one of these components is replaced, the entire set must be replaced. This will help ensure proper end play.



16. The output bearing cap is installed next. To shim the output bearing cap, measure the distance from the end of the case to the bearing cup (A).

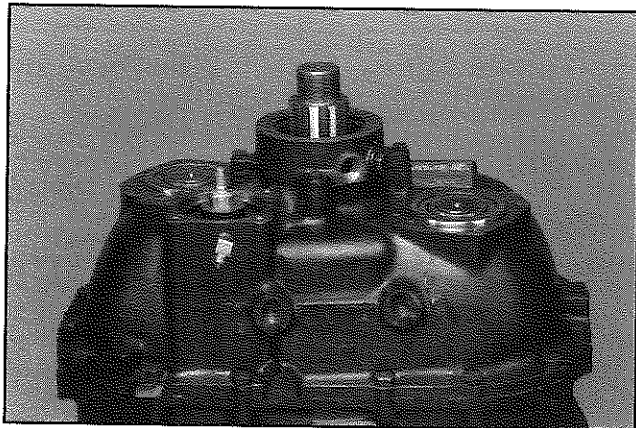


17. Next, measure from the face of the bearing cap to the end of the pilot (B). Subtract the two figures and shim accordingly. You can be within four thousandths of an inch, so select the shims that will give you the amount closest to what is required.

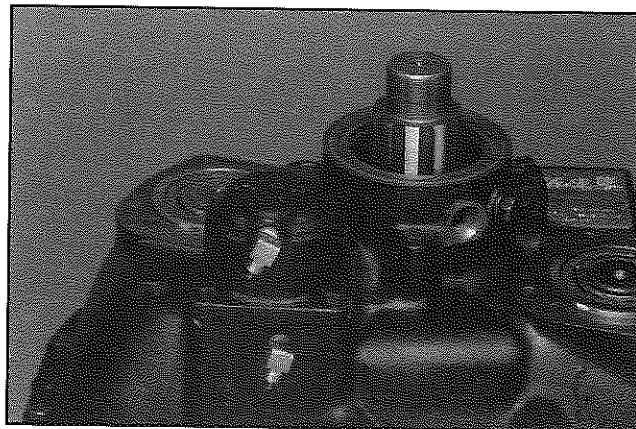


18. Install the output bearing cap shims.

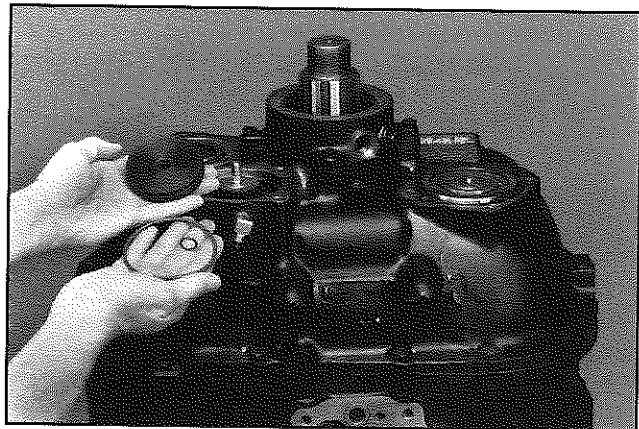
RANGE CASE REASSEMBLY



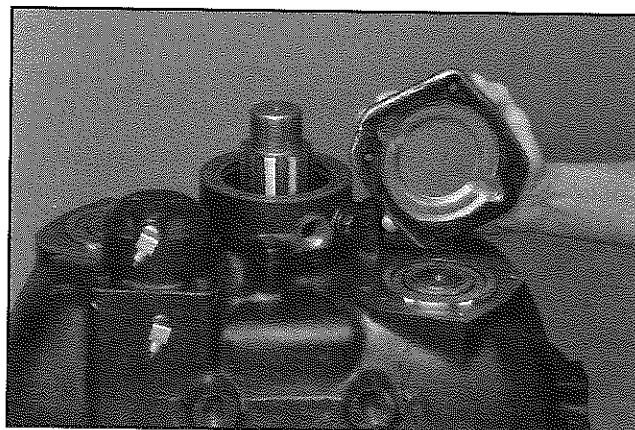
19. Install the output bearing cap. Apply purple Loctite® 515 or the equivalent to the output bearing cap. Secure it with bolts tightened to 34 - 41 ft. lbs.



22. Next install the range piston housing with the four bolts. The air inlet should be at the top. Torque to 34 - 41 ft. lbs.

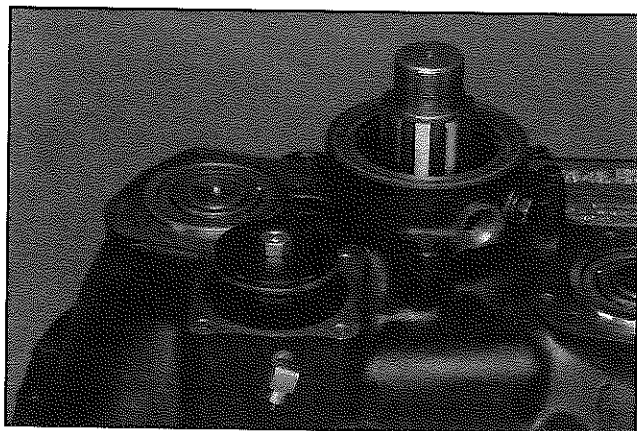


20. Install new O-rings on the piston and in the housing. Then install the piston. The counterbore on the piston should face the new O-ring on the rod.



23. Apply Loctite® 515 or the equivalent to the countershaft bearing cap assembly. Install it.

! CAUTION: Align the bearing cap oil groove with the case oil port to help ensure proper lubrication.

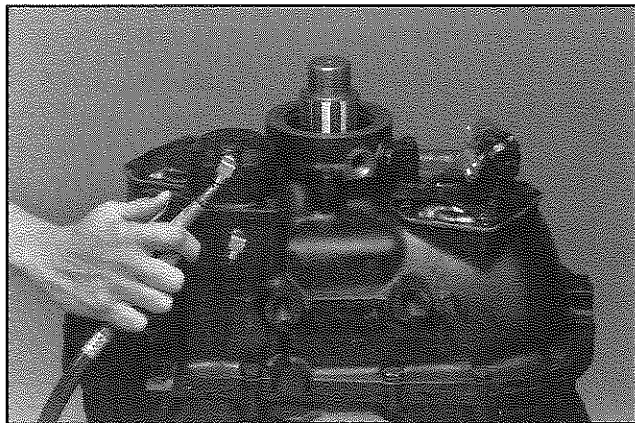


21. Install the retaining nut and torque to 52 - 62 ft. lbs. Lubricate the piston O-ring.

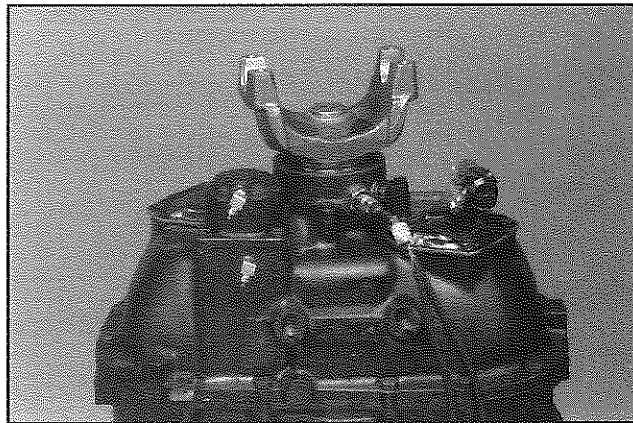


24. Assemble the two spacers and air regulator on the countershaft bearing cap assembly. The air regulator bolts are longer than the bearing cap bolts. Torque the bolts to 34 - 41 ft. lbs.

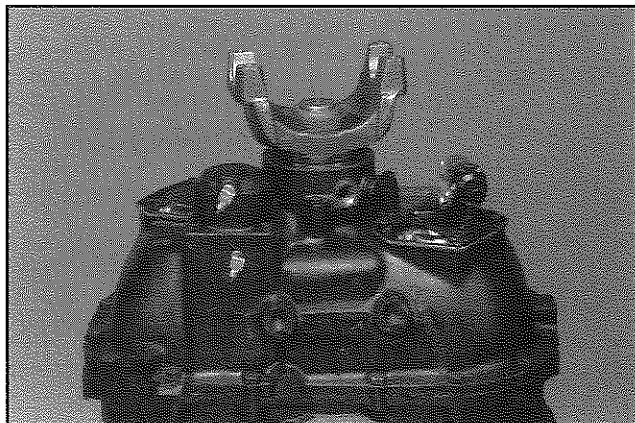
RANGE CASE REASSEMBLY



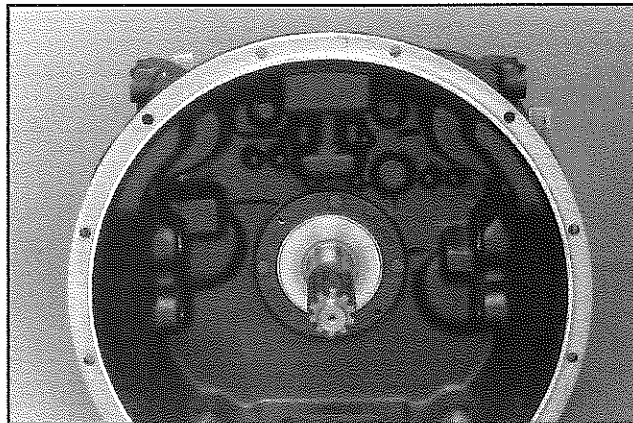
25. Apply 55 psi of air to the piston fitting until you hear the range section shift into high gear. Doing this will make it easier to install the unit into a truck.



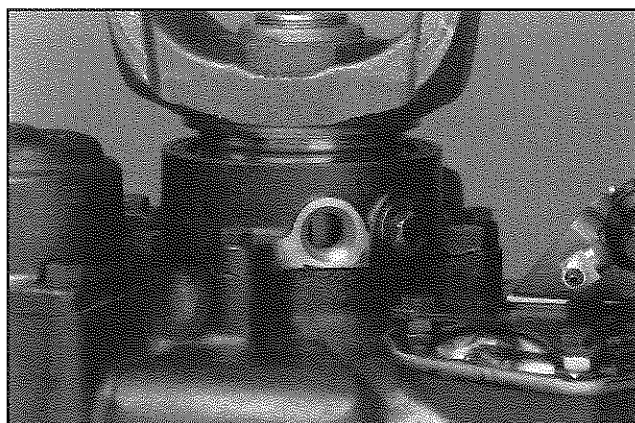
28. Install the electronic speed sensor until it just touches an output shaft tooth. Then back it out 1/2 to 3/4 of a turn. Torque the locknut to 25 ft. lbs.



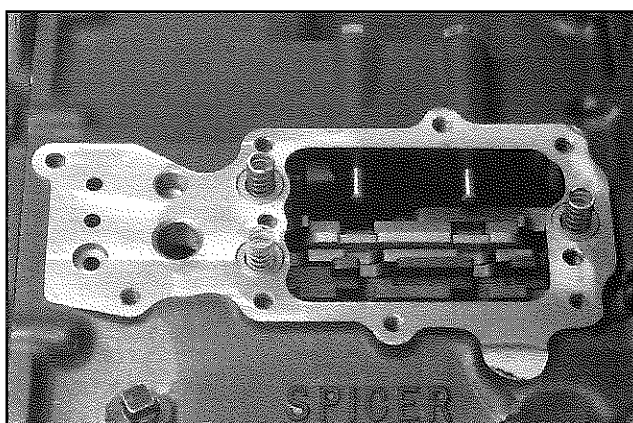
26. Install the end yoke or flange, washer and nut. Torque the nut to 550 - 600 ft. lbs.



29. Place the transmission in a horizontal position.
⚠ WARNING: When moving heavy parts, use a chain hoist to help prevent personal injury. Install the two clutch housing retainer bolts next. Torque to 78 - 98 ft. lbs.

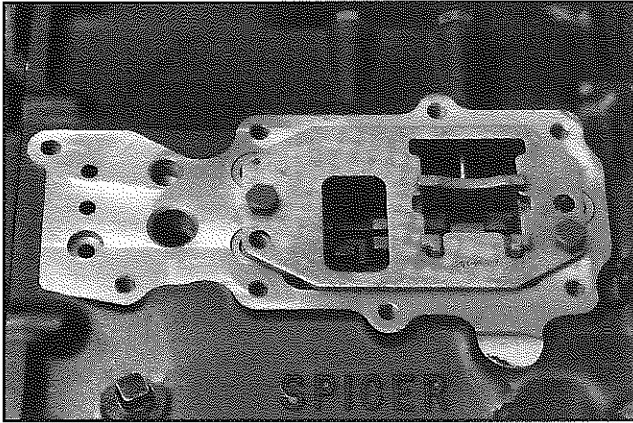


27. Prepare to install the electric speedometer sensing unit by turning the output shaft until a shaft tooth is centered in the sensor port.

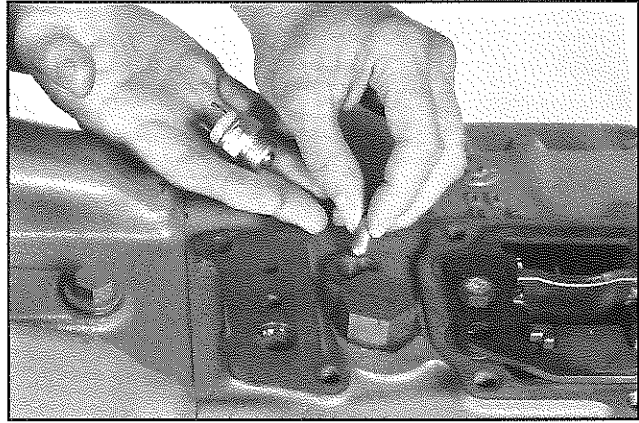


30. Insert the three poppet balls and springs into the case.
⚠ CAUTION: The spring with the least tension must be placed in the overdrive shift rail poppet hole to help provide proper shifting.

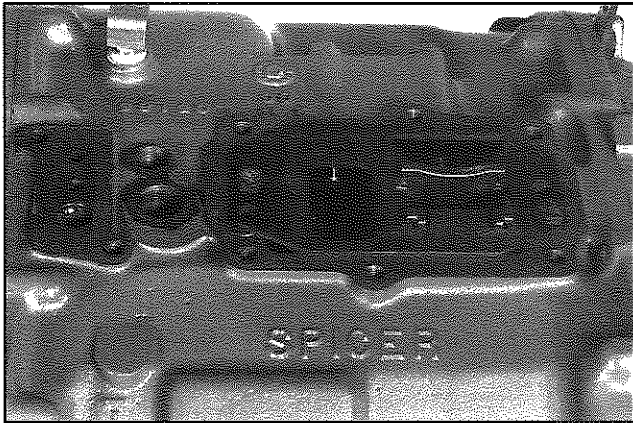
RANGE CASE REASSEMBLY



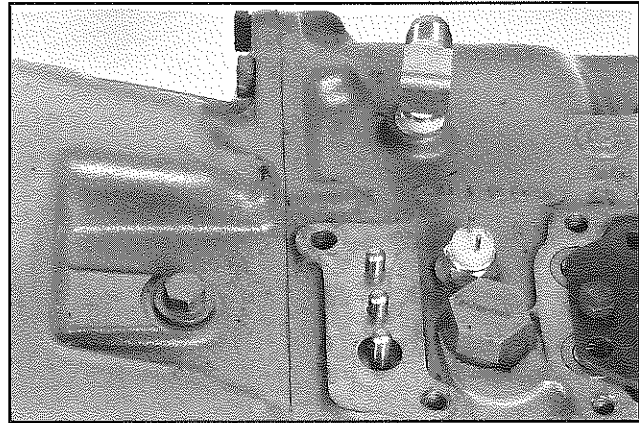
31. Install the interlock and interlock plate. Torque the bolts to 52 - 62 ft. lbs. The forward shift control position is shown here.



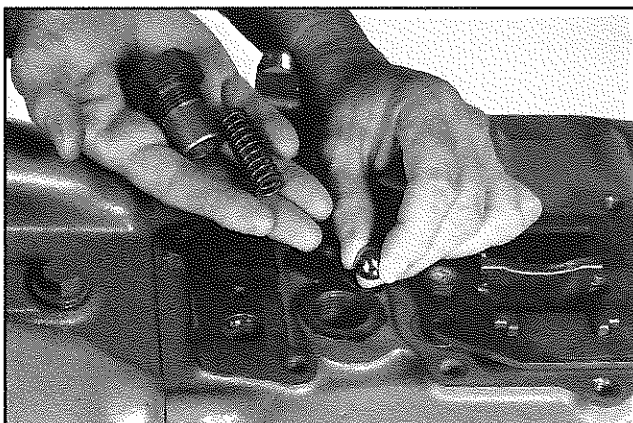
34. Install the backup light pin and switch.



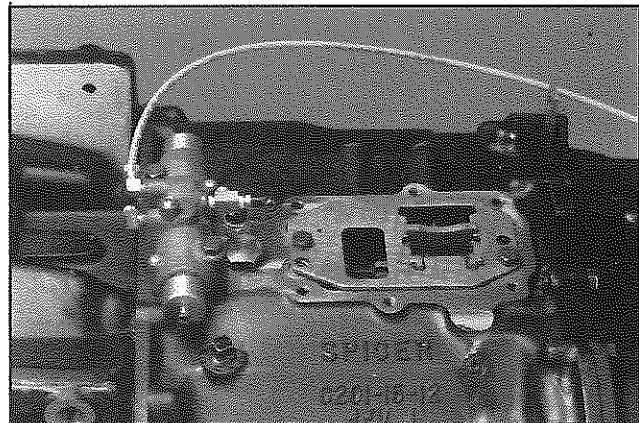
32. The center shift control and remote shift control position is shown here.



35. Shift all forks into neutral, then install the three air control valve pins.

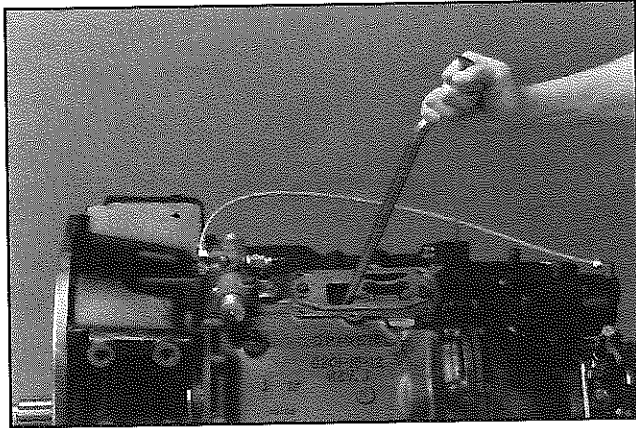


33. Install the automatic shift rail poppet ball, spring, and poppet insert.

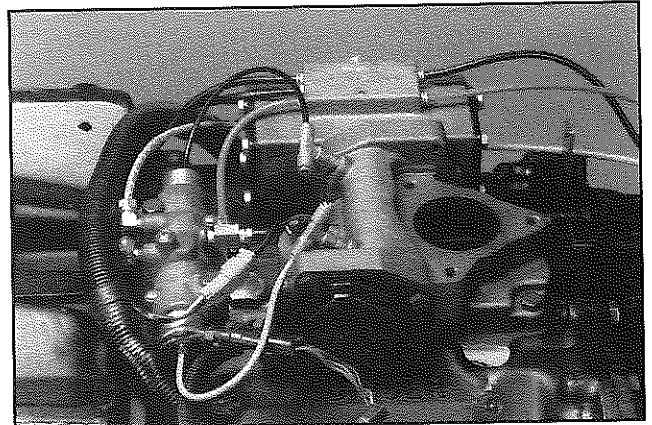


36. Install the gasket and air control valve. Torque the retaining bolts to 52 - 62 ft. lbs.

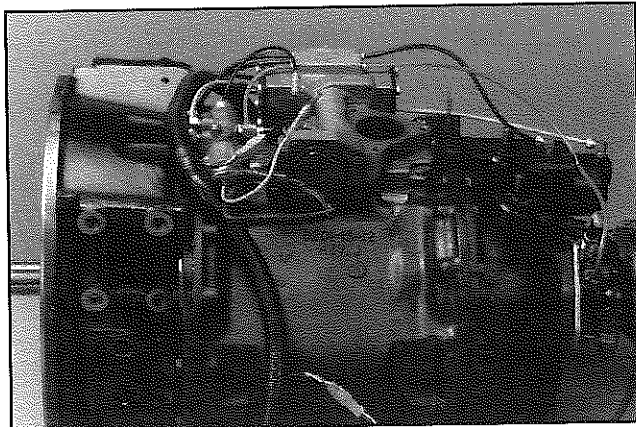
RANGE CASE REASSEMBLY



37. Bench shift the transmission to make sure it is working properly. Install the transmission into the vehicle. Refill the unit with fluid.

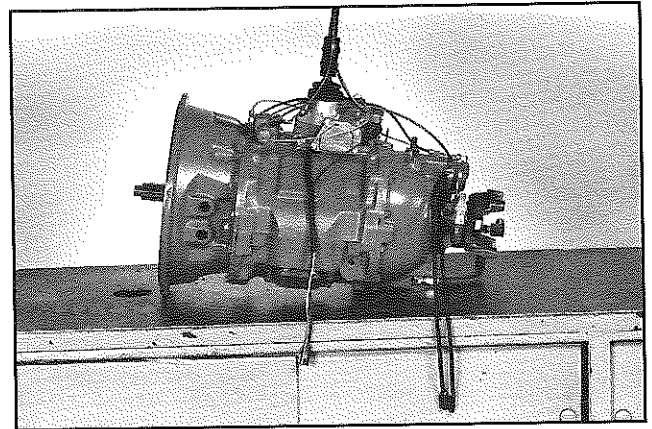


39. Install air lines to range valve and to air regulator.



38. Install the gasket and lower shift tower assembly. The tower shift fingers must align with the overdrive and automatic shift rail detents. Secure the tower with bolts torqued to 52 - 62 ft. lbs.

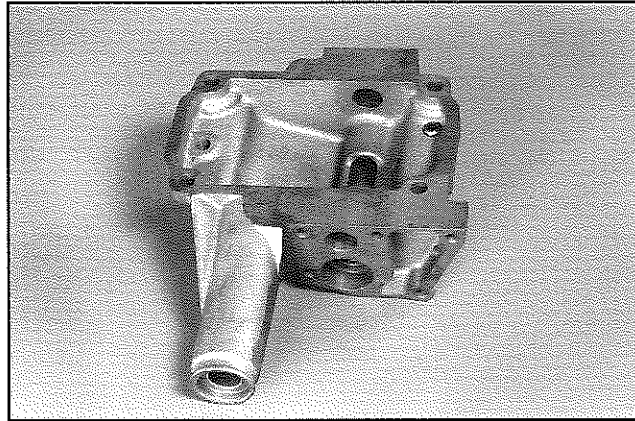
⊘ CAUTION: Do not apply sealant to the shift tower. It could prevent proper interlock functioning.



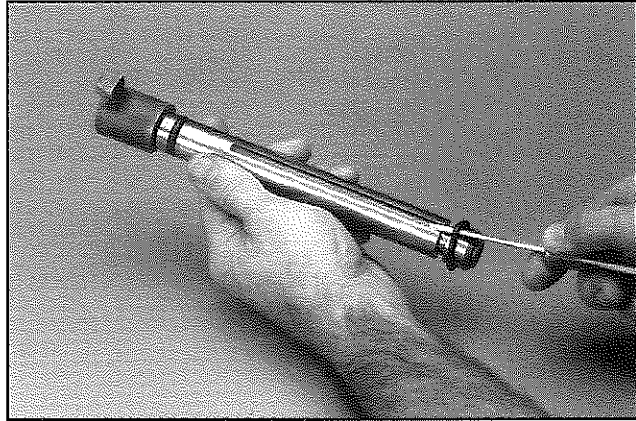
40. Install the upper shift tower. Torque to 52 - 62 ft. lbs. Refer to the diagram on pages 6 and 7 when reinstalling air lines.

⚠ CAUTION: Cut lines squarely to ensure a proper connection. Always use a razor-sharp edge to cut tubing. Never use side cuts.

REMOTE CONTROL REASSEMBLY

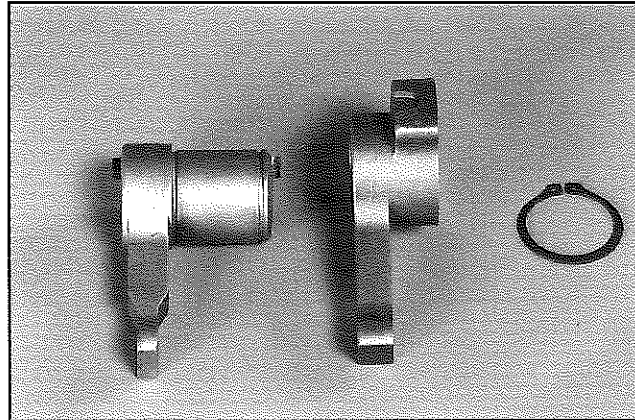


1. Clean the remote housing, making sure it is free from burrs. Place it on a workbench.

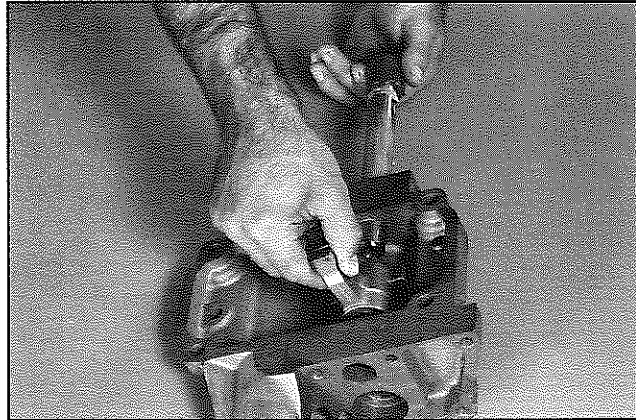


4. Place two new O-rings over the shift shaft if they haven't been installed already. Later models utilize two O-rings on the shift shaft.

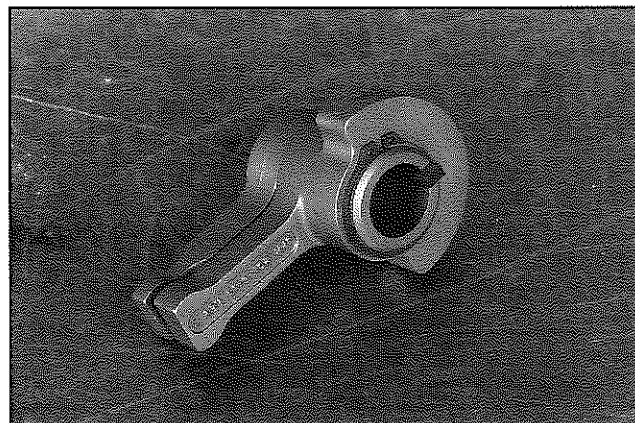
! CAUTION: Avoid cutting the O-rings by using a screwdriver to hold it away from the keyway during installation.



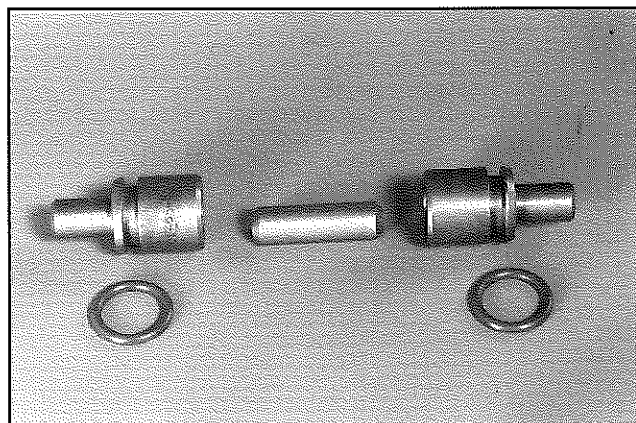
2. Lubricate the idler finger bore with Lubriplate Aero High Temp grease. Place the idler finger over the shift finger, with the two fingers close together.



5. Lubricate the shift shaft with Lubriplate grease. Align the shift fingers with the housing bore, and insert the shaft. It should slide easily through the assembly; do not force it. The shaft keyway must align with the shift finger key.

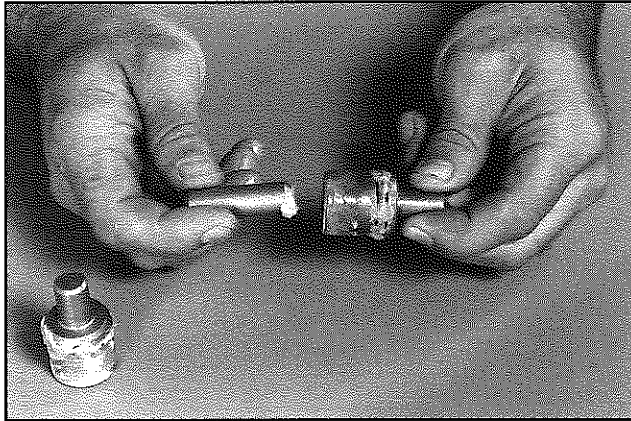


3. Secure the fingers with a snap ring. The rolled die side of the ring should be toward the idler finger.

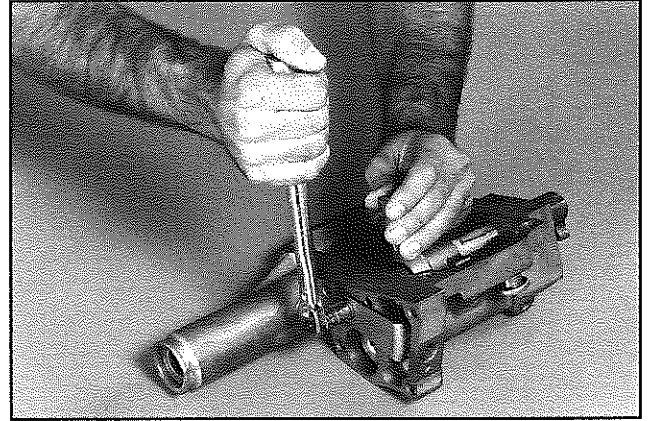


6. Place new O-rings on the shift pistons. Lubricate the O-rings and housing bore with Lubriplate Aero or a comparable high-quality lubricant.

REMOTE CONTROL REASSEMBLY

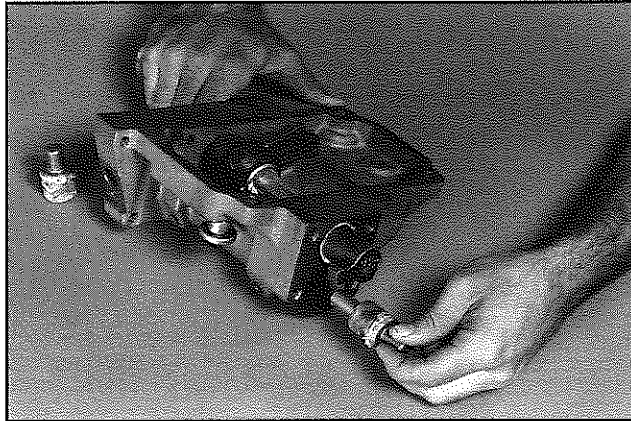


7. Place the joiner pin in one of the pistons, using Lubriplate Aero High Temp grease to hold it in position for assembly.



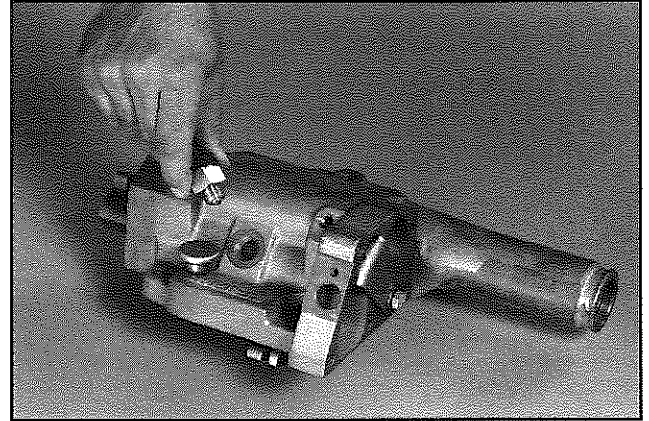
10. Attach the control arm subassembly to the end of the shift shaft. Secure with washer and bolt. Torque the bolt to 10 ft. lbs. (120 inch lbs.).

! CAUTION: Hold the fingers still to prevent the assembly from hitting the housing and becoming damaged during torquing.

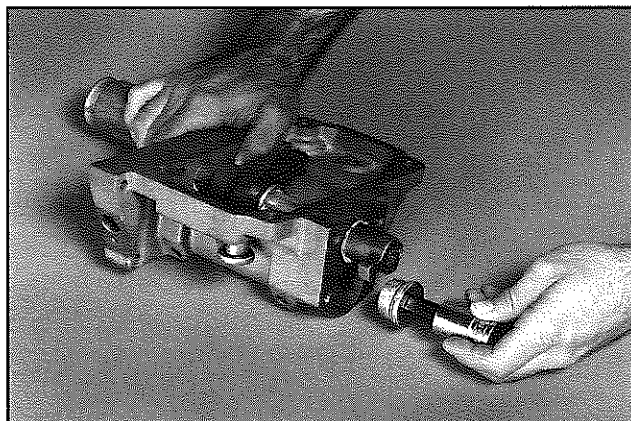


8. Slide the shift pistons in the housing, one from each side.

! CAUTION: Do not push the pistons all the way through the housing from the side; it may cause the pistons to bind.



11. If the breather was removed during disassembly, replace it now. Place a new O-ring on the automatic switch and apply Lubriplate Aero High Temp or the equivalent. Install it and torque to 14 ft. lbs.



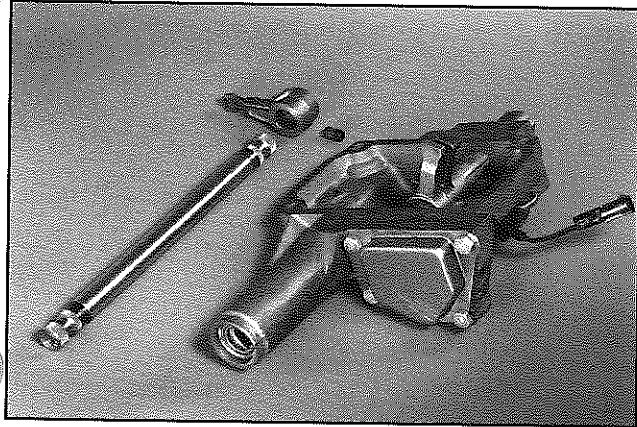
9. Install new O-rings on the housing plugs. Apply Lubriplate Aero High Temp or the equivalent. Install the plugs into the housing. Torque them to 80 ft. lbs.



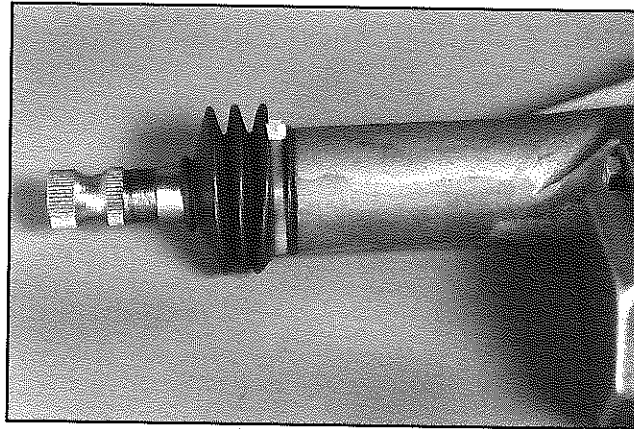
12. Coat the actuator cover mounting surface with purple Loctite® 515 or the equivalent. Install it. Secure with four bolts torqued to 32 ft. lbs.

Note: Loctite 515 not required on later models with two O-rings on the shift shaft.

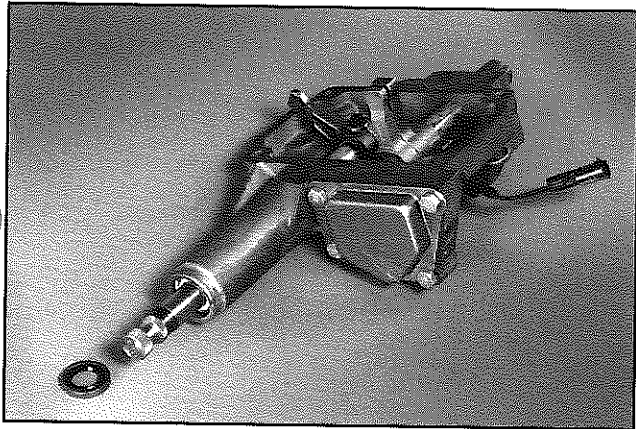
REMOTE CONTROL REASSEMBLY



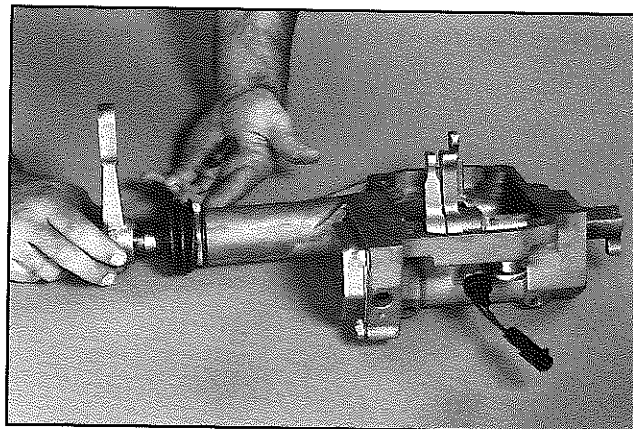
13. Pack the remote shift rod housing with Lubriplate Aero High Temp grease or the equivalent.



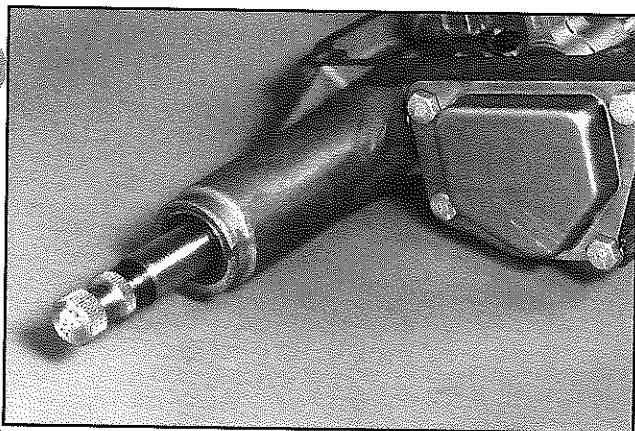
16. Install the boot. Secure it with a tie-down strap.



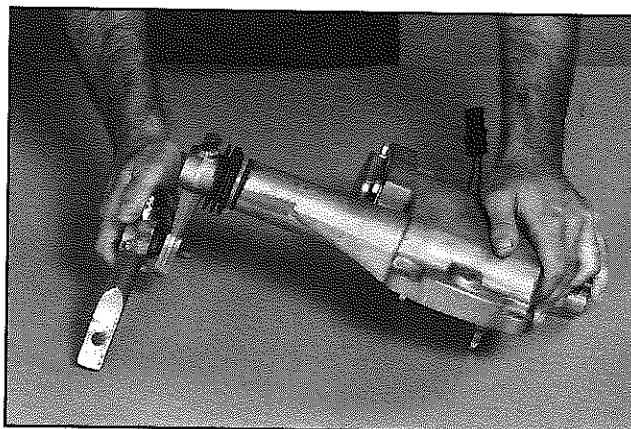
14. Lubricate the shift rod with Lubriplate Aero High Temp grease or the equivalent and slide it into the housing. Install the finger on the shaft and secure it with a setscrew. Torque to 40 - 50 ft. lbs.



17. Install the outer shift control lever, aligning it with the inner shift finger. Secure it with a bolt. Torque to 40 - 50 ft. lbs.

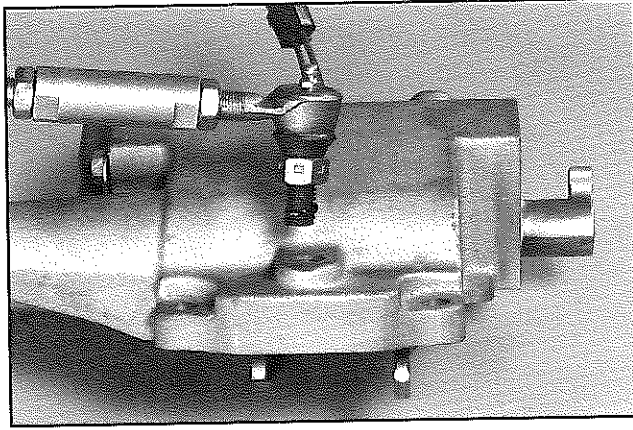


15. Install the seal over the shift rod into the housing bore. The cupped side of the seal goes into the bore first.

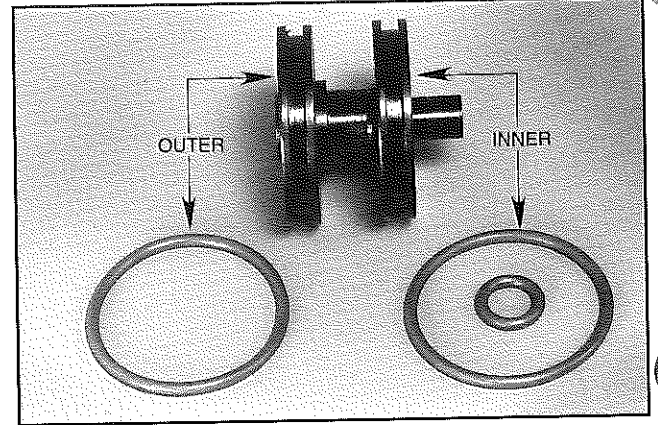


18. Install the selection lever. Secure it with a washer and bolt. Torque to 40 - 50 ft. lbs.

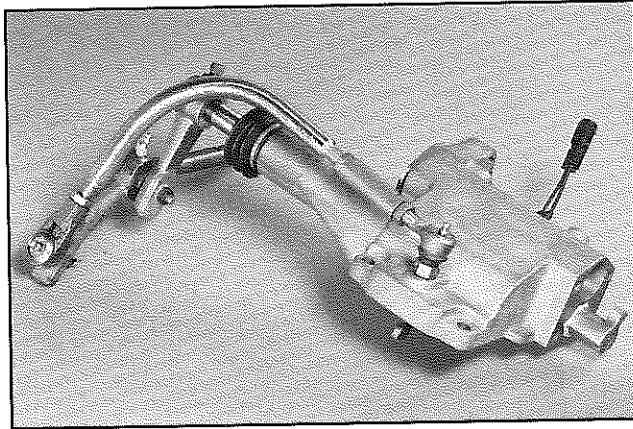
REMOTE CONTROL REASSEMBLY



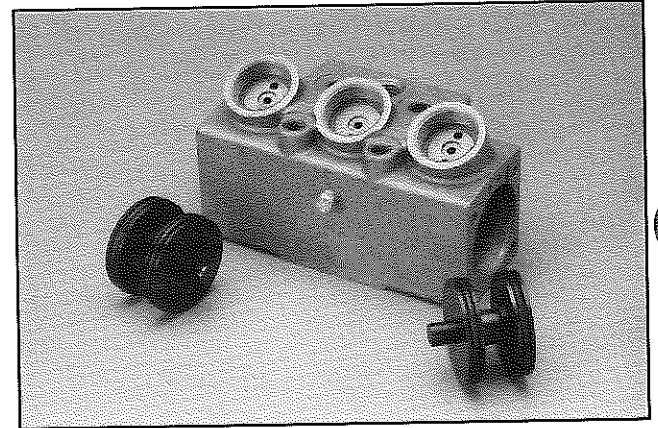
19. Place thread sealer on the tie rod bolt. Install the tie rod assembly. Torque to 60 - 80 ft. lbs.



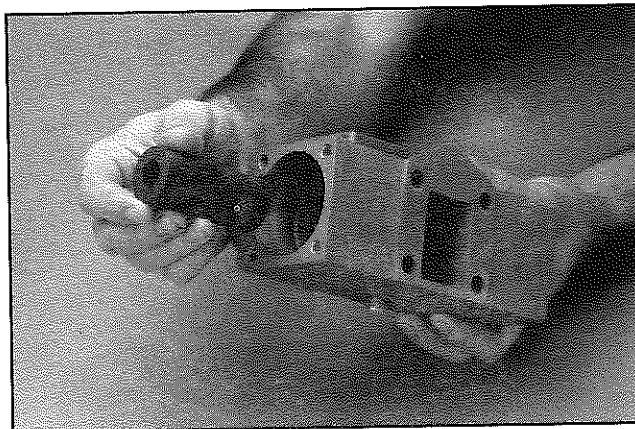
22. Place two new O-rings on each inner piston and one new O-ring on each outer piston. Apply Lubriplate Aero High Temp or a comparable high-quality lubricant.



20. Secure the other end of the tie rod assembly with the castellated nut and cotter pin.

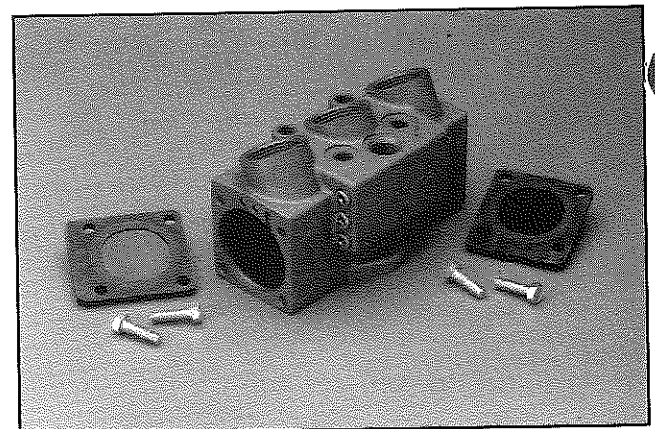


23. Slide the pistons into the housing.



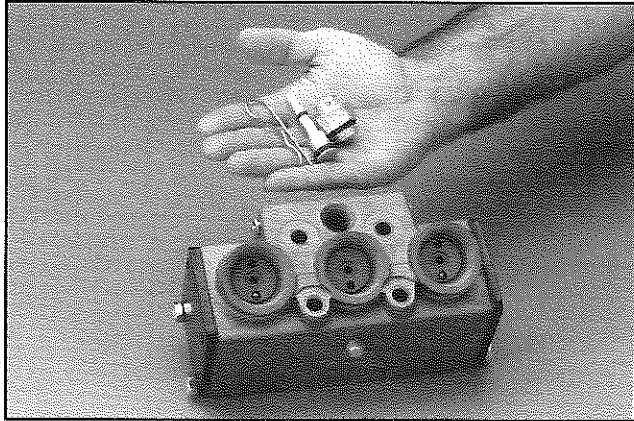
21. Lightly coat the rack bore with Lubriplate Aero High Temp or a comparable high-quality lubricant that won't attack seals or metal parts. Place the shift rack into the housing.

⚠ **CAUTION:** The lever slot must face up and the cut out portion must be seen through the housing for proper operation.

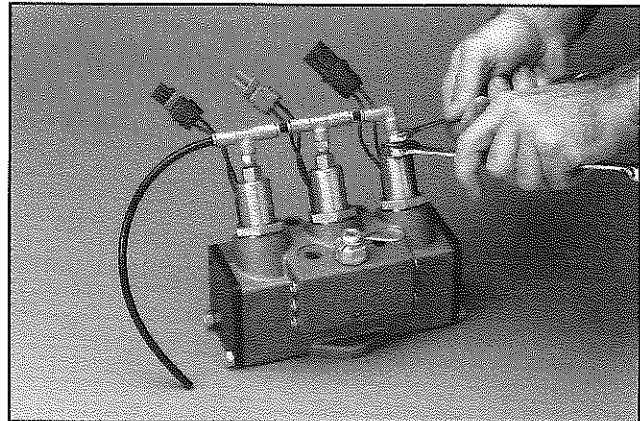


24. Install the end caps and gaskets. Torque the bolts to 20 ft. lbs.

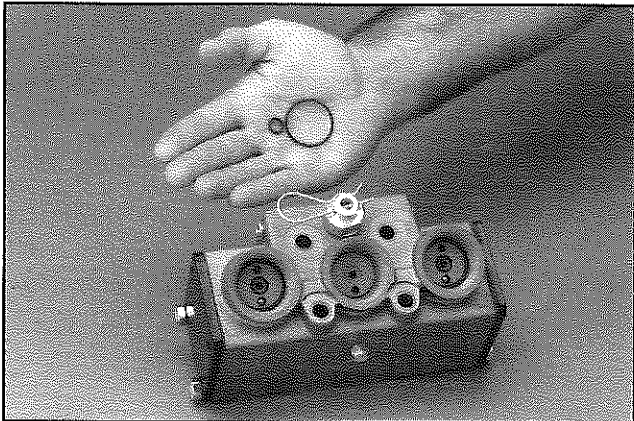
REMOTE CONTROL REASSEMBLY



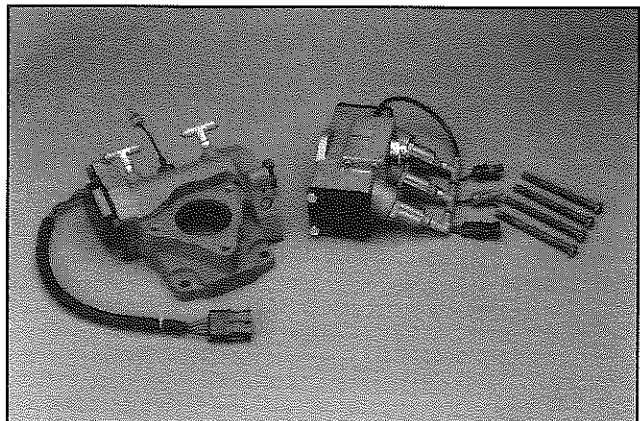
25. Place new O-rings on the override plunger and cap. Apply Lubriplate Aero High Temp or the equivalent. Then install the plunger and cap. Torque the cap to 45 ft. lbs. Secure it with the hitch pin.



28. Install the tube assembly. Hold the valves steady with a wrench while you tighten the fitting nuts.

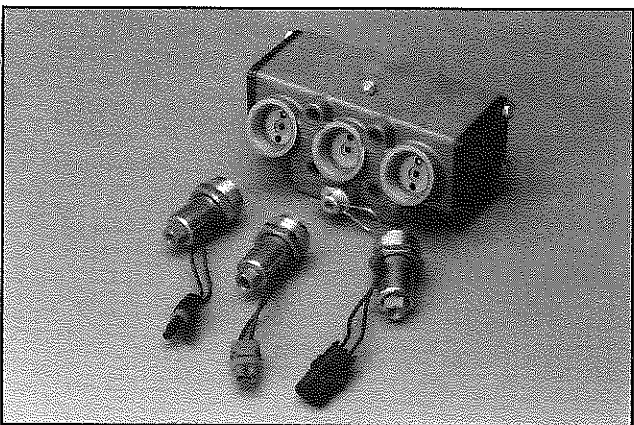


26. Install two new O-rings in each valve port. Lubricate them with Lubriplate Aero High Temp or the equivalent.



29. Lubricate the shift shaft with Moly grease. Place the actuator assembly over the lever. Install gear position sensor and wire harness.
Note: Loctite 515 not required on later models with two O-rings on the shift shaft.

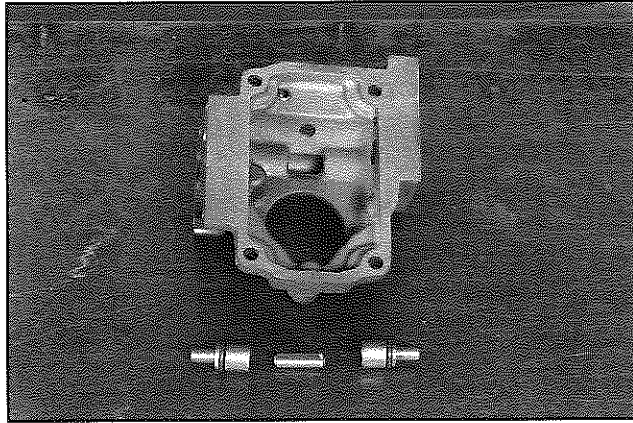
! CAUTION: The control arm must be aligned with the sensor in neutral position to ensure proper operation. Secure it with four long bolts. Torque bolts to 34 ft. lbs.



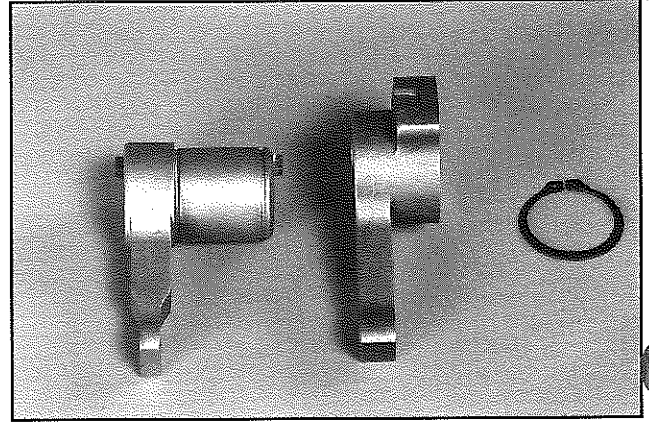
27. Install the valves in their proper location—"HI", "N" and "LOW".

Reinstall the shield. Secure with bolts. Torque to 20 ft. lbs. Reattach the wire harnesses. Place a gasket on the main case and install the remote control assembly. Secure with bolts torqued to 31 - 45 ft. lbs. Attach the spear rod once the unit is reinstalled into the truck.

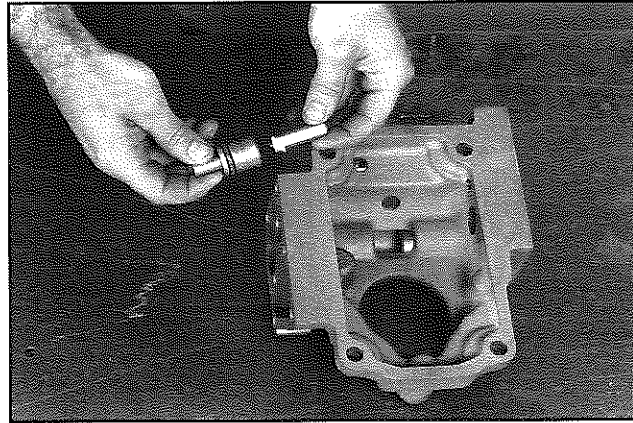
LOWER SHIFT TOWER REASSEMBLY



1. Once all worn or damaged parts have been replaced and new O-rings have been installed, reassembly can begin. The pistons and joiner pin are placed into the housing first.

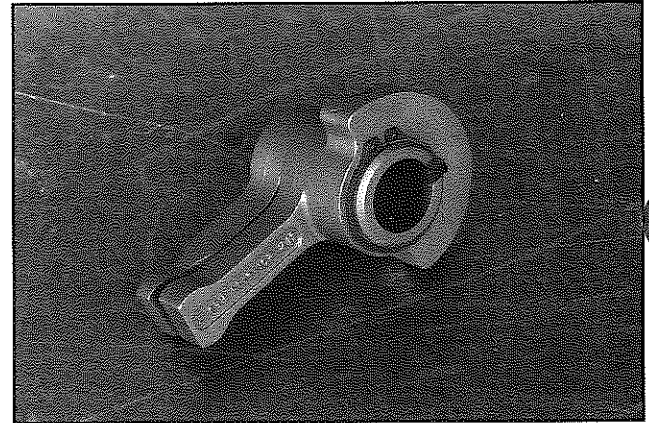


4. Lubricate the idler finger bore with Lubriplate Aero High Temp grease. Place the idler finger over the shift finger, with the two fingers close together.

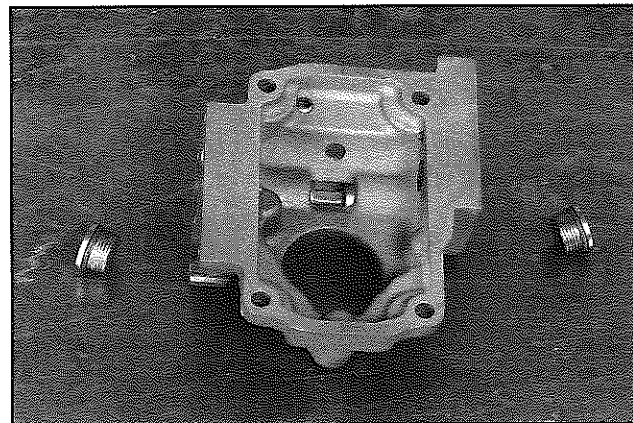


2. Use Lubriplate Aero High Temp grease on all lower shift tower O-rings. Use some of the lubricant to hold the joiner pin in place. Install the pistons from each side of the housing.

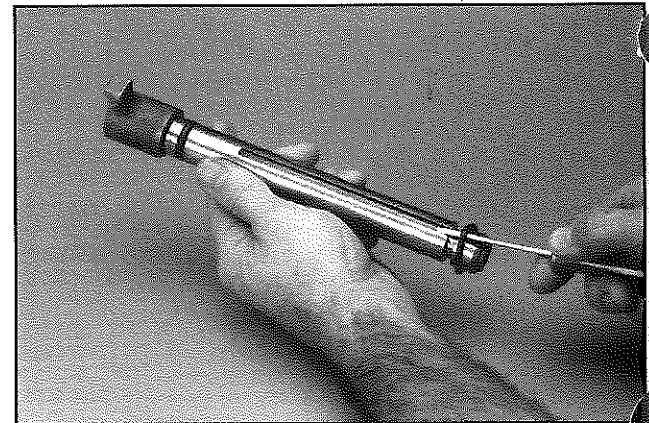
CAUTION: Do not push pistons through the same side of the housing since they may bind.



5. Secure the fingers with a snap ring. The rolled die side of the ring should be toward the idler finger.

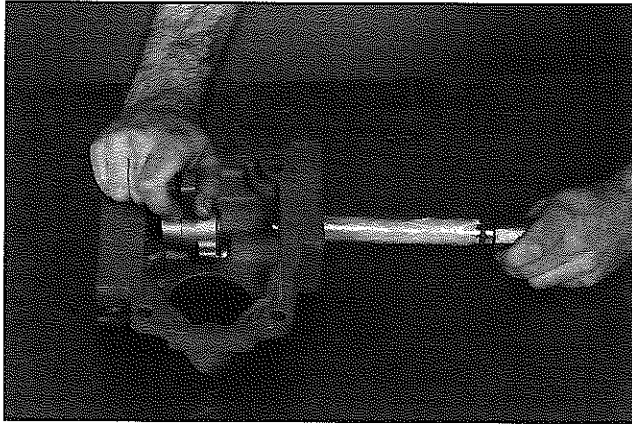


3. Lubricate the new housing plug O-rings with Lubriplate Aero High Temp grease or the equivalent. Install the plugs into the housing. Torque to 80 ft. lbs.

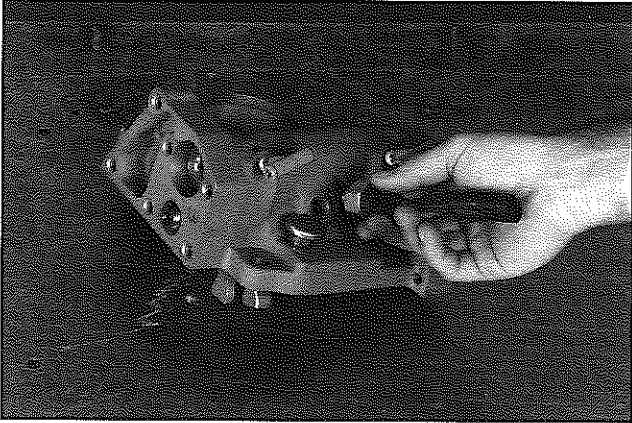


6. Install a new O-Ring over the shift shaft.
CAUTION: Hold the O-ring away from the keyway to avoid damaging the O-ring during installation.

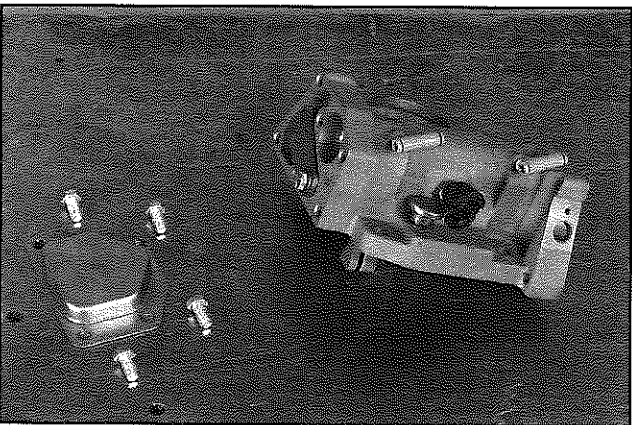
LOWER SHIFT TOWER REASSEMBLY



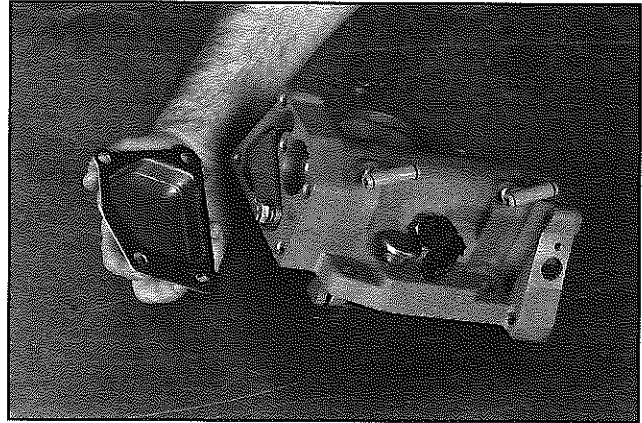
7. Lubricate the shift shaft with Lubriplate Aero High Temp grease or the equivalent. Align the shift fingers with the housing bore and insert the shift shaft. It should slide easily through the assembly; do not force it. The shaft keyway must align with the shift finger key.



8. Install the automatic switch.

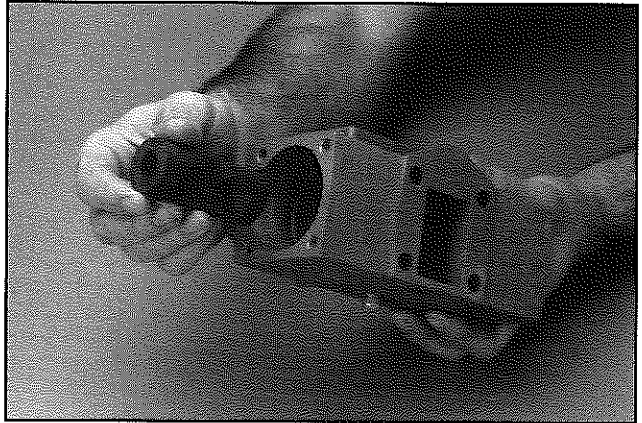


9. Attach the control arm subassembly to the end of the shift shaft. Secure with the washer and bolt. Torque to 10 ft. lbs.



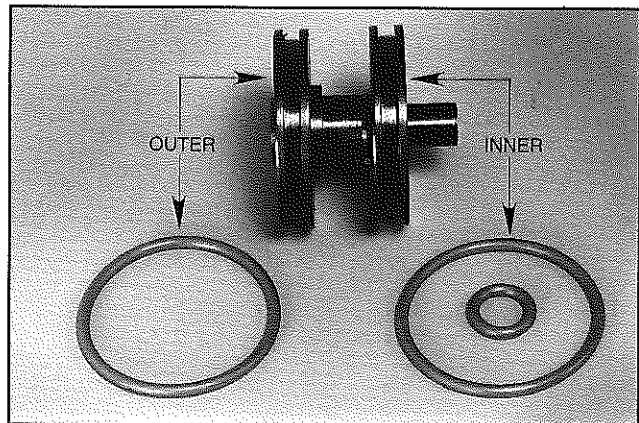
10. Coat the actuator cover with Loctite 515 or equivalent and install. Tighten the four bolts to 32 ft. lbs.

Note: Loctite 515 not required on later models with two O-rings on the shift shaft.



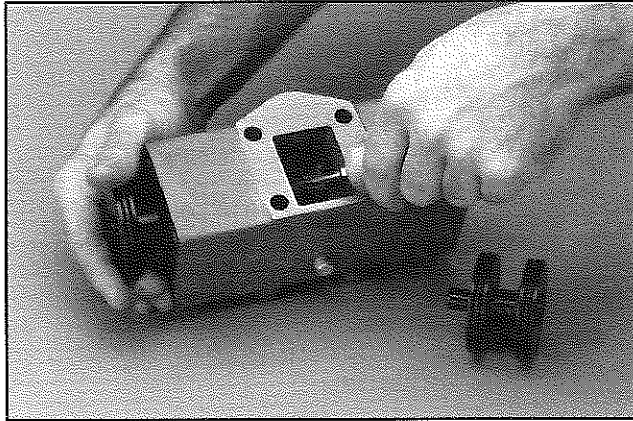
11. Lightly coat the rack bore with Lubriplate Aero High Temp grease or a comparable high-quality lubricant that won't attack seals or metal parts. Place the shift rack into the housing.

! CAUTION: The lever slot must face up, and the cut out portion must be seen through the housing for proper operation.

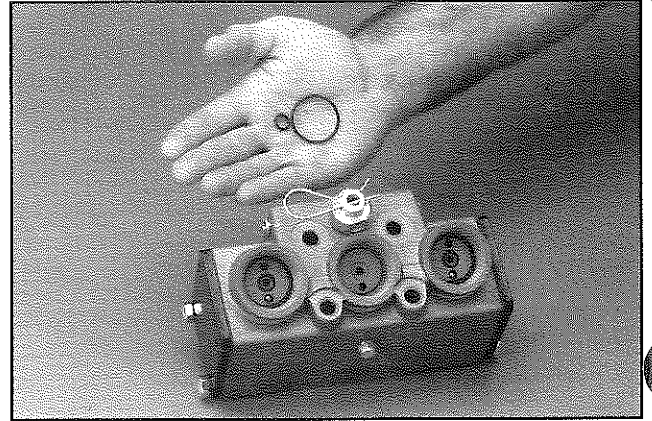


12. Place two new O-rings on each inner piston and one new O-ring on each outer piston. Lubricate them with Lubriplate Aero High Temp grease or the equivalent.

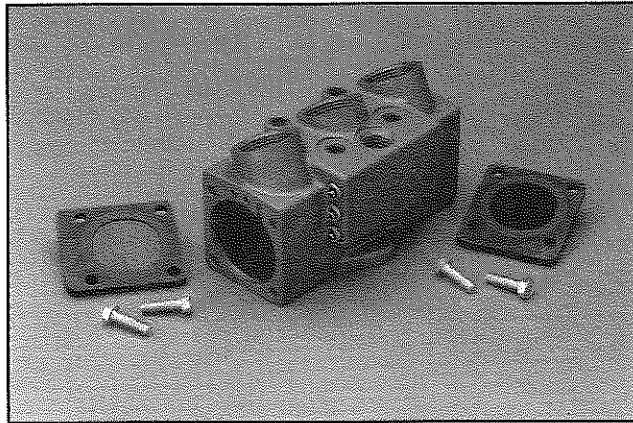
LOWER SHIFT TOWER REASSEMBLY



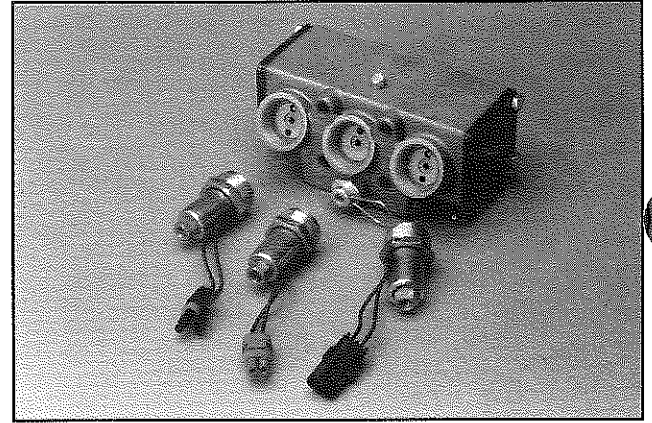
13. Slide the pistons into the housing.



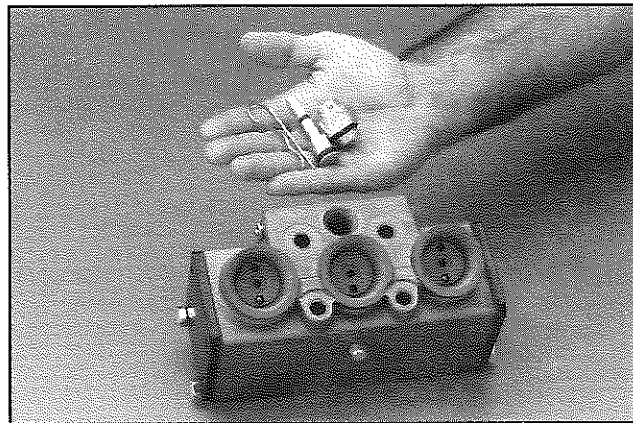
16. Install two new O-rings in each valve port. Lubricate them with Lubriplate Aero High Temp grease or the equivalent.



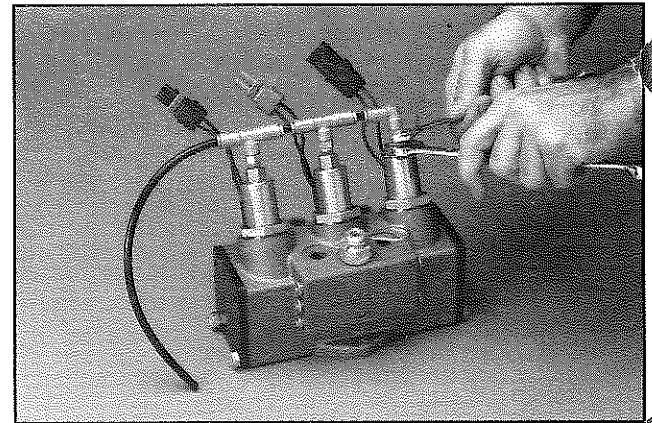
14. Install the end caps and gaskets. Torque the bolts to 20 ft. lbs.



17. Install the valves in their proper location—"HI", "N" and "LOW".

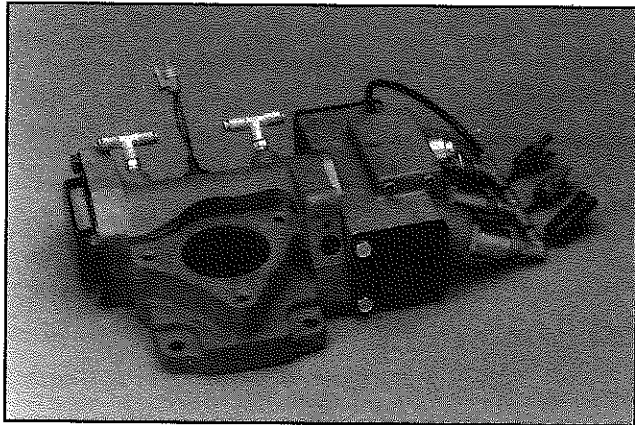


15. Place new O-rings on the override plunger and cap, lubricating them with Lubriplate Aero High Temp grease or the equivalent. Then install the plunger and cap. Torque the cap to 45 ft. lbs. Secure it with the hitch pin.



18. Install the tube assembly. Hold the valves steady with a wrench while you tighten the fitting nuts.

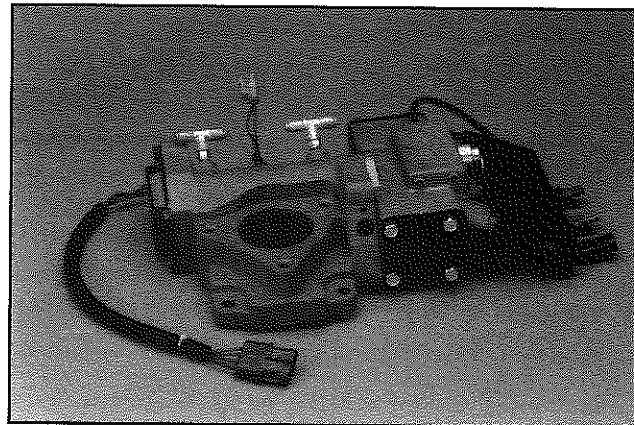
LOWER SHIFT TOWER REASSEMBLY



19. Lubricate the shift shaft with Moly grease. Place the actuator assembly over the lever. Install gear position sensor and wire harness.

Note: Loctite 515 not required on later models with two O-rings on the shift shaft.

! **CAUTION:** Make sure the control arm is aligned with the sensor in neutral position for proper operation. Secure it with four long bolts. Torque the bolts to 34 ft. lbs.

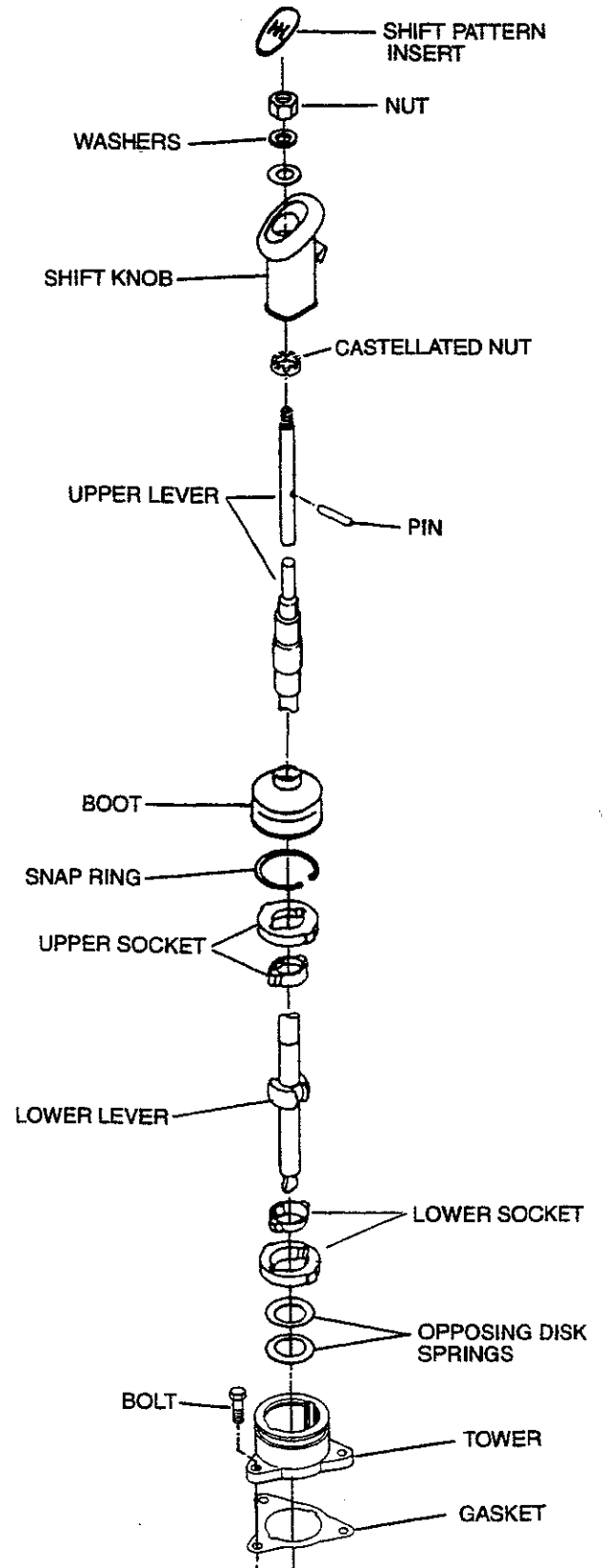


20. Reinstall the shield. Secure with bolts. Torque to 20 ft. lbs. Reattach the wire harness. Next, place a gasket on the main case and install the lower shift tower assembly. Secure with bolts torqued to 31 - 45 ft. lbs. Attach the upper shift tower once the unit is reinstalled into the truck.

UPPER SHIFT TOWER REASSEMBLY

Upper Shift Tower Assembly

1. Place the two opposing springs and the lower socket into the shift tower.
2. Place the lever through the tower and support it in a vise.
3. Install the upper socket. Once the socket clears the groove, install the snap ring.
4. Seat the boot properly and secure it with two tie-down straps.
5. **⚠ CAUTION:** When the upper shift tower is installed onto the transmission housing, one single gasket must be in place between the upper and lower shift tower assemblies for proper gear selection. Failure to use any gasket or using more than one gasket may cause binding and damage to the unit.



TROUBLESHOOTING

Noisy Operation

Noise is usually a very elusive problem and is generally not the fault of the transmission. Mechanics should road test the vehicle to determine if the driver's complaint of noise is actually in the transmission.

In numerous instances where drivers have insisted noise was coming from the transmission, investigations revealed it was caused by one of the following conditions:

- (a) Fan out of balance or blades bent
- (b) Defective vibration dampers
- (c) Crankshaft out of balance
- (d) Flywheel out of balance
- (e) Loose flywheel mounting bolts
- (f) Rough engine idle producing rattle in gear train
- (g) Clutch assembly out of balance
- (h) Loose or broken engine mounts
- (i) Power take-off engaged
- (j) Worn universal joints
- (k) Driveshaft out of balance
- (l) Universal joint angles out of phase or at excessive angles
- (m) Center bearings in driveline dry, not mounted properly
- (n) Wheels out of balance
- (o) Tire treads humming or vibrating at certain speeds
- (p) Air leaks on suction side of induction system, especially with turbo-chargers

Mechanics should try to locate and eliminate noise by means other than a transmission removal or an overhaul. However, if the noise appears to be in the transmission, try to determine what position the gear shift lever is in when the noise occurs. If the noise is evident in only one gear position, the problem is generally traceable to the rotating gears. Next, try to categorize the noise into the following classifications:

(a) *Growling, humming and grinding.* These noises are caused by worn, chipped, rough or cracked gears. As gears continue to wear, the grinding noise will be noticeable particularly in the gear position that throws the greatest load on the worn gear.

A lack of lubricant or use of improper lubricant can also result in growling and grinding noises. This is because there is insufficient lubricant to cool and cover the gears, which allows metal-to-metal contact.

(b) *Hissing, thumping and bumping.* Hissing noises can be caused by bad bearings. As bearings wear and retainers start to break up, etc., the noise could change to a thumping or bumping.

(c) *Gear whine.* This is usually caused by lack of backlash between mating gears. Improper PTO shimming is the big offender here.

(d) *Vibration.* Today's improved highways mean entire power trains are cruising at higher RPMs. These higher speeds mean damage caused by driveline vibration is more obvious than in the past.

When the maximum RPM of a shaft is reached, it begins to bow. A resonant hum can be heard, and a vibration will be set up. This type vibration can cause gear seizures, broken synchronizer pins, bearing failures, brinelling and corrosion.

During acceleration and deceleration, the shaft may pass through half-critical vibration (half the maximum RPM of the shaft). A whine or boom may be heard at this point.

(e) *Metallic rattles.* These noises within the transmission usually result from a variety of conditions. Engine torsional vibrations are transmitted to the transmission through the clutch. In heavy duty equipment, clutch discs with vibration dampers are not used, so a rattle – particularly in neutral – is common with diesel equipment.

In general, engine speeds should be 600 RPM or above to eliminate objectionable rattles and vibration during the idle. A defective or faulty injector would cause a rough or lower idle speed and possibly a rattle in the transmission. A rattle can also be caused by excessive backlash between the PTO input gear and the transmission output gear.

TROUBLESHOOTING

Noise in Neutral

Possible Causes:

- (a) Misalignment of transmission
- (b) Worn flywheel pilot bearing
- (c) Worn or scored countershaft bearings
- (d) Sprung or worn countershaft
- (e) Excessive backlash in gears
- (f) Scuffed gear tooth contact surface
- (g) Insufficient lubrication
- (h) Use of incorrect grade of lubricant

Noise in Gear

Possible Causes:

- (a) Rough, chipped, or tapered sliding gear teeth
- (b) Noisy speedometer gears
- (c) Excessive end play of countershaft gears
- (d) Refer to conditions listed under "Noise in Neutral"

Oil Leaks

Possible Causes:

- (a) Oil level too high
- (b) Wrong lubricant in unit
- (c) Seals defective, wrong type or omitted from bearing cap
- (d) Transmission breather omitted or plugged internally
- (e) Bolts loose, omitted or missing from remote control, shift tower, bearing caps, PTO or covers
- (f) Oil drain-back openings in bearing caps or case plugged with varnish or dirt
- (g) Gaskets shifted or squeezed out of position, broken gaskets with pieces still under the shift tower
- (h) Cracks or holes in castings
- (i) Loose drain plug
- (j) Oil leakage from engine
- (k) Loose speedometer adaptor or connections

Walking or Jumping Out of Gear

If the units are walking out of gear, it could be caused by:

- (a) External interference, such as the floorboard opening, preventing full engagement,
- or
- (b) An internal malfunction, such as worn clutching teeth, allowing the transmission to shift out of position.

If a remote control is being used, make sure it is functioning properly before the transmission is blamed for the problem. Note whether the unit walks out of gear under drive while pulling a load, or on a coast load. Also, notice whether the gear hop occurs on smooth roads or only on rough roads. Items that would prevent full engagement of gears are:

- (a) Improperly positioned forward remote control, which limits full travel forward and backward from the remote neutral position
- (b) Improper length shift rails or linkage that limits travel of forward remote from neutral position
- (c) Loose bell cranks, sloppy ball and socket joints
- (d) Shift rails, cables, etc., too spongy or flexible, or not secured properly at both ends
- (e) Worn or loose engine mounts if forward unit is mounted to frame
- (f) Forward remote mount too flimsy, or loose on the frame
- (g) Setscrews loose at remote control joints, on shift forks inside remote
- (h) Shift fork pads or groove sliding gear or collar worn excessively
- (i) Transmission and engine out of alignment either vertically or horizontally

A few items which could move the gear or shaft out of proper position, particularly on rough roads are:

- (a) Use of heavy shift lever extensions
- (b) Broken shift rail poppet springs
- (c) Worn shift rail poppet notches
- (d) Bent or sprung shift rails
- (e) Excessive end play in drive gear or countershaft, caused by worn bearings or retainers
- (f) Worn or missing thrust rings

DOUBLESHOOTING

Hard Shifting

An improperly operating clutch will interfere with the proper shifting of gears in any transmission. It is also important that the hydraulic, air or similar release mechanism is in proper working order. If full and complete clutch release is being made, the following could be a few of the possible causes for hard shifting complaints:

No lubricant in remote control unit. (Note: The forward remote is isolated and is often overlooked. Many remote controls used on transmissions and auxiliaries require separate lubrication.)

No lubrication in, or grease fittings on, u-joints or swivels of remote controls

Lack of lubricant or wrong lubricant used, causing buildup of sticky varnish and sludge deposits on splines of shaft and gears

Badly worn or bent shift forks

Improper adjustment on shifter linkage

Sliding clutch gears tight on splines of shaft

Clutch teeth burred over, chipped or badly mutilated because of improper shifting

Binding or interference of shift lever with other objects or rods inside the cab or near the remote control island

Clutch dragging

Free running gears seized or galled on either the thrust face or diameters

Slipping in Gear

Possible Causes:

Clutch not releasing. Also check remote units such as hydraulic or air assist. Note: On some units employing a full air control for clutch release, air pressure of approximately 60 lbs. or more must be secured before the clutch can be released.

▲ WARNING: Do not leave these vehicles parked in gear. If the vehicle is started in gear, the truck may lurch forward and injure passersby.

- (b) Sliding clutch gears tight on splines
- (c) Chips wedged between or under splines of shaft and gear
- (d) Improper adjustment, excessive wear or lost motion in shift linkage

Bearing Failures

The service life of most transmissions, main and auxiliary, is governed by the life of the bearings. The majority of bearing failures can be attributed to vibration and dirt. Some other prominent reasons for unit bearing failures are:

- (a) Fatigue of raceways or balls
- (b) Wrong type or grade of lubricant
- (c) Lack of lubricant
- (d) Broken retainers, brinelled races and fretting caused by vibration
- (e) Bearings set up too tight or too loose
- (f) Improper installation resulting in brinelled bearings
- (g) Improper fit of shafts or bore
- (h) Acid etching due to water in lube
- (i) Vehicle overload or too large an engine for the transmission resulting in overload

Dirt

More than 90% of all ball bearing failures are caused by dirt, which is always abrasive.

Dirt may enter the bearings during assembly of units, or may be carried into the bearing by the lubricant while in service. Dirt also may enter bearings through seals, the breather or even dirty containers used for adding or changing lubricant.

Softer material, such as dirt or dust, usually forms an abrasive paste or lapping compounds within the bear-

TROUBLESHOOTING

ings. The pressure between the balls and raceways makes a perfect pulverizer; the rolling motion tends to entrap and hold the abrasives. As the balls and raceways wear, the bearings become noisy. The lapping action tends to increase rapidly as the fine steel from the balls and rollway adds to the lapping material.

Hard, coarse material, such as metal chips, may enter the bearings during assembly from tools such as hammers, drifts and power chisels. It may also be created within the unit during service from raking teeth. These chips produce small indentations in balls and races. When these hard particles jam between the balls and races, it may cause the inner race to turn on the shaft, or the outer race to turn in the housing.

Fatigue

All bearings are subject to fatigue and must be replaced eventually. Your own operating experience will dictate mileage replacement of bearings showing only normal wear.

Corrosion

Water, acid and corrosive materials formed by deterioration of lubricant will produce a reddish-brown coating and small etched holes over outer and exposed surfaces of the race. Corrosive oxides also act as lapping agents.

Shaft Fits

Bearing fits on rotating shafts are usually specified as tight. Excessive looseness – even .001" – under a load produces a creeping or slipping of the inner race on the rotating shaft. As a result, surface metal of the shafts scrub or wear off. The force causing the inner race to rotate disappears when the bearing fits properly.

Installation and Removal of Bearings

Improper installation or removal of bearings, especially hammering the bearing on the shaft with off-center blows, can result in brinelling. Since such damage is seldom visible, it does not become known until after failure or complete disassembly. The correct drivers (preferably under an arbor press) and pullers should be used.

Removing bearings is more difficult than installing them. In most cases, it is necessary to remove the bearing by pulling on the outer race, which can damage the balls or races. Therefore, it is a good idea to replace bearings during an overhaul to prevent problems. However, if a bearing is not going to be replaced, avoid removal during low-mileage rebuilds.

Interchangeability

All ball bearings, whether manufactured here or abroad, are interchangeable in regard to standardized dimensions, tolerances and fits. However, for a given shaft size there are standard bearings for light, medium and heavy duty service.

Numbers and symbols stamped on inner and outer races of bearings designate size and type. Note that the numbering systems of different bearing manufacturers have not been standardized. Consult interchangeable tables and use the proper bearings for replacement parts.

TROUBLESHOOTING

Clutch Troubleshooting

Faulty clutch operation interferes with proper shifting of gears in any transmission. Here are the most common problems encountered with clutches.

- (a) If the clutch slips or does not engage properly, first check the internal clutch adjustment. If adjustment does not remedy the situation, check for weak pressure springs, lack of free pedal, and worn or oily clutch facings and binding release mechanism.
- (b) If the clutch drags or does not release properly, check the internal clutch adjustment. Some other causes for clutch drag are: an intermediate plate sticking on drive pins or drive lugs; the pressure plate not retracting; a distorted or warped driven disc; worn splines on the main drive gear of the transmission; a damaged clutch release bearing; or the bushing in the release sleeve dragging on the transmission drive gear.

Backup Lights

If the backup lights do not function, check the following:

- (a) Continuity of the switch with the ball fully depressed
- (b) Electrical plug connection
- (c) Wiring



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