SPICER® TRANSMISSIONS

PS110-7A, PS110-7B, & PS145-7A

Service Manual

Bulletin No. 2369

March 2000

TTC TRANSMISSION TECHNOLOGIES Corporation

kuo automotriz Group Company

TABLE OF CONTENTS

Gear Ratios

PS110-7A & PS145-7A			PS110-7B		
Gear	Ratio	% Step	Gear	Ratio	% Step
1	10.13		1	12.27	
		69			75
2	5.99		2	7.00	
		68			69
3	3.56		3	4.13	
		39			63
4	2.57		4	2.54	
		40			38
5	1.84		5	1.84	
		38			38
6	1.33		6	1.33	
		33			33
7	1.00		7	1.00	
R	10.13		R	12.27	

Specifications

Speeds ..... 7 Forward, 1 Reverse

Torque Capacity ..... PS110-7A - 950 - 1100 lbs. ft. (1286 - 1489 nm)
PS145-7A - 950 - 1450 lbs. ft. (1286 - 1964 nm)
PS110-7B - 950 - 1100 lbs. ft. (1286 - 1489 nm)

Length ..... 30.75" (781.05 mm)

Weight ..... 732 lbs. (332 kg)

End Yokes 1710 6-4-7691
1760 6.3-4-1251
1810 6.5-4-3821

Flanges 1710 6-1-5821

Clutch Housing ..... SAE No. 1 or 2, nodal mount standard

Clutch ..... Spicer 14" or 15 1/2" (355.6 or 393.70 mm) 2-plate

Input Shaft ..... PS110-7A - 1.75" standard
PS145-7A - 2" standard
PS110-7B - 2" standard

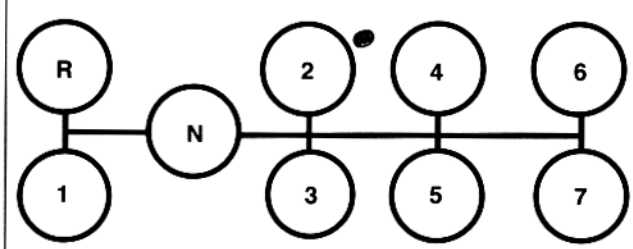
Lube capacity ..... 48 pints (22.7 liters) at 0° installation

Power Take-Off ..... 6-bolt right & lower left. Countershaft PTO provision, standard on the right side, optional on the left.

General Application Guidelines On-Highway Use

	PS110-7A & PS145-7A	PS110-7B
GCW:	90,000 lbs.	80,000 lbs.
HP Range:	210 - 430 HP	210 - 280 HP
RPM Range:	1,000 - 2,200	1,600 - 2,400
Engine Types:	10 - 14 liter	6 - 10 liter

Simple Shift Pattern

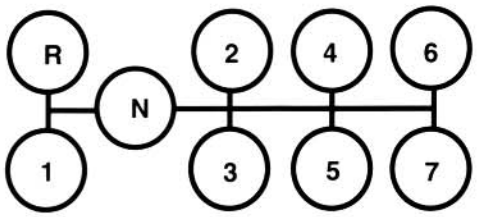


TORQUE SPECIFICATIONS FOR NUTS AND CAP SCREWS

NOM. THREAD SIZE (DIA.)		PART NAME	WRENCH TORQUE FT. LBS.			
			NON-LOCKING TYPE		LOCKING TYPE (Bonded Nylon Patch)	
in.	mm		MIN.	MAX.	MIN.	MAX.
.250	6	Cap Screw 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
.500		"	60	80	78	98
	14	"			80	100
.562		"	90	115	112	137
.625		"	120	150	150	180
.750		"	200	250	240	290
1.250		Nut			400	450
1.375		"			550	600
1.750		"			550	600
		PTO Aperture Cover Cap Screws				
.375		Cap Screw	10	15	16	24
.438		Cap Screw w/Gasket 97-324-2	20	25	36	41
.438		Cap Screw w/Gasket 22p22	20	25	29	34
		Shift Fork Or Bracket Setscrews	**Lockwire Type**			
.375		Setscrew	25	32	34	41
.436		"	25	32	34	41
.438		"	40	50	52	62
		Idler Cover	**Self Tapping**			
	10		25	32		

On all transmissions with .750-14 NPTF drain plugs, the drain plug torque should be 50 - 65 ft. lbs. The only exceptions are the ES42-5, ES52-5, CM40, CM49 and CM55 Models. The torque on these units should be 30 - 45 ft. lbs.

How to Shift Spicer PS110-7A, PS145-7A & PS110-7B Transmissions



Your vehicle has been equipped with a Spicer 7 Speed transmission. This model has seven forward speeds which are engineered to make full use of engine output and to improve fuel economy. This single-stick transmission has seven lever positions with no splitter or range necessary to provide superior performance. Here's how this transmission is designed to work for you in the driver's seat.

Starting

With the engine idling, depress the clutch and move the shift lever into first gear. Gradually release the clutch and accelerate the engine to governed speed (1900 - 1950 RPM).

A clutch brake is used to stop gear rotation to complete a shift into first or reverse when the vehicle is stationary. The clutch brake on this transmission is actuated by depressing the clutch pedal all the way to the floor. For normal upshifts and downshifts, only a partial disengagement of the clutch is necessary to break engine torque.

If a butt-toothed condition exists between the clutching teeth, a momentary re-engagement of the main clutch will allow the gear train to move into a smooth engagement.

Upshifting

Once governed engine speed has been attained, depress the clutch and move the shift lever to neutral. Engage the clutch and allow RPM to drop approximately 750. (RPM drop may vary with engines of different governed speeds*). Depress the clutch and move the lever into second gear. Re-engage the clutch and accelerate to governed speed. Continue upshifting through seventh gear in this manner.

Downshifting

When downshifting from seventh gear, allow RPM to drop approximately 475*. Depress the clutch pedal and move the shift lever to neutral. Engage the clutch. Accelerate to governed speed. Continue by depressing the clutch and moving the stick into sixth gear, then re-engage the clutch. Continue downshifting through first gear in this manner.

Operation

Clutches
A clutch brake is required for use with this transmission. It is recommended that the torque limiting clutch brake be used instead of the three-piece type. Spicer 14" and 15 1/2" 2-plate clutch service manuals are available upon request.

Replacement Parts
The exploded views of subassemblies which are incorporated here are for the mechanic's convenience and show the latest material. The parts are arranged in their correct order and may also be used as a reference for assembly or disassembly of this unit.

Power Flow
The Spicer split torque transmission is designed for medium and heavy duty on- and off-highway applications.

The two-countershaft design allows the engine torque to be equally divided between the two countershafts. This provides a high ratio of torque capacity to transmission weight. This also allows a reduction in the face width of each gear involved in the transmission. All the gears are in constant mesh through spur teeth.

Towing

⊘ **Do not tow vehicles equipped with Spicer Transmissions without first pulling the axle shafts or disconnecting the driveshaft. Lubrication of the internal gear train is inadequate when the vehicle is towed and could result in equipment damage. Also do not pull or roll-start vehicles in first or reverse gears as it may damage gears or bearings.**

***All RPM drops are based on the PS110-7A, PS145-7A and PS110-7B transmission ratios and an engine governed speed of 1900 - 1950 RPM. These drops will vary with other transmission ratios or with engines of higher governed speeds.**

Lubrication

To insure 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

Spicer recommends an initial oil change and flush when the transmission is placed in actual service. At the time of first engine oil change, the transmission should also be serviced. In off-highway use, the change should be made after 24 hours—but before 100 hours—of service have been completed.

Many factors influence oil change requirements. Therefore, the following mileage and time intervals are general guidelines only. In general, a drain and flush should be scheduled at 50,000-mile or one-year intervals. Off-highway uses usually require an oil change every 1,000 hours. The oil level in the transmission should be checked every 5,000 miles (8045 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.

Over Filling

Do not over fill 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. Oil overflow escapes onto the clutch or parking brakes, causing additional trouble.

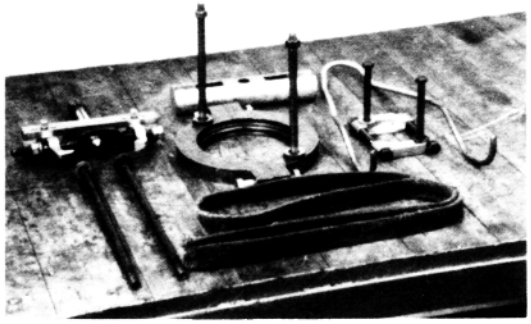
TEMPERATURE	GRADE	TYPE
Above 0°F (-18°C) Below 0°F (-18°C)	SAE 40 or 50 SAE 30	Heavy duty engine oil meeting MIL-L-2104D or MIL-L-46152 B, API-SF, or API-CD (MIL-L-2104 B & C, or 46152 are also acceptable)
Above 0°F (-18°C) Below 0°F (-18°C)	SAE 90 SAE 80	Straight mineral gear oil R & O type API-GL-1
All	CD SAE 50 CD SAE 30	Synthetic engine oil meeting MIL-L-2104 D or MIL-L-46152 B, API-SF or API-CD
All	EP SAE 75W90	*Synthetic gear oil meeting MIL-L-2105C or API-GL5

Do not use extreme pressure additives such as those found in multi-purpose or rear axle type lubricants. These additives are not required for this unit and may, in some cases, create transmission problems. Multi-purpose oils, as a group, have relatively poor oxidation stability, a high rate of sludge formation, and a greater tendency to react on or corrode the bronze parts in this transmission.

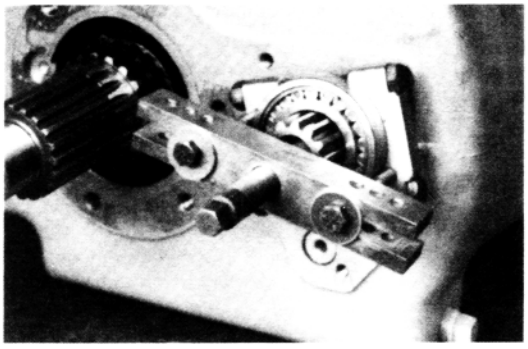
Tool Reference

Spicer Transmissions can be repaired with ordinary mechanic's hand tools. However, this procedure is not only time consuming, but could damage otherwise reusable parts. To reduce maintenance costs and vehicle downtime, Spicer recommends using the special tools shown in this section.

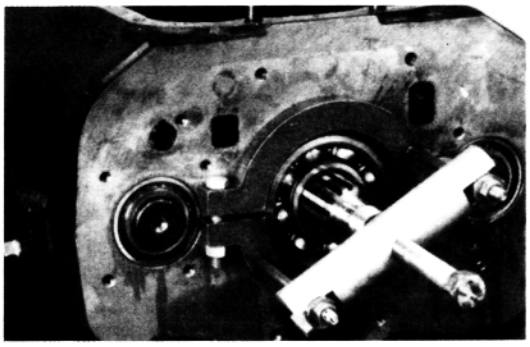
Tools may be purchased through:
Kent-Moore Tools
28635 Mound Road
Warren, MIchigan 48092
Telephone: 1-800-328-6657



Suggested pullers and alignment tools.

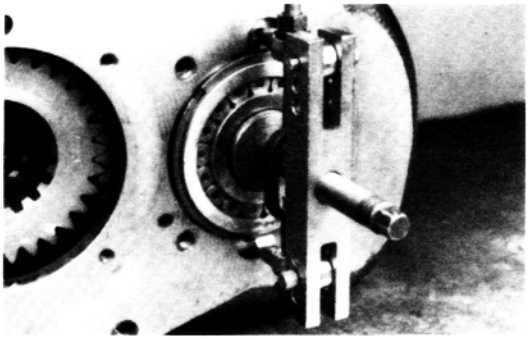


Countershaft rear bearing puller (Snap-on CJ 950).

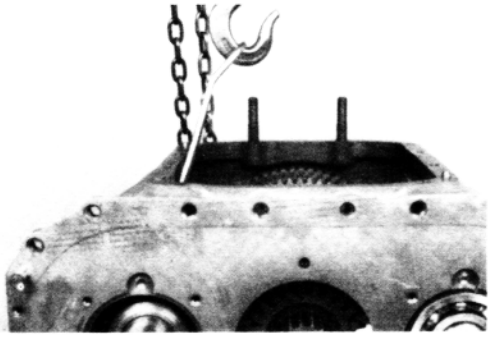


Reversible input and output bearing puller (Kent-Moore J 24348). Used with end yoke remover (J 7804-01).

Countershaft alignment blocks (Kent-Moore J 28720). These provide maximum clearance for mainshaft assembly installation and allow countershafts to be rotated for timing purposes.



Countershaft front bearing puller (Snap-on CJ 80).



Countershaft lift hook (Kent-Moore J 23667). Holds countershaft in time while centering the countershaft in the case bore for easier bearing installation.

Important Procedure

To locate and correct unit power or auxiliary transmission troubles, a systematic procedure should be followed.

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 actually the 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 units. Road testing is most effective when the mechanic drives the vehicle. However, riding with the driver can be very informative.

Check Functioning 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. Bear in mind that a careful inspection of the unit should be made as each disassembly step is performed.

Inspect Thoroughly 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 he examines the parts as each is removed. After the transmission is disassembled, check the lubricant for foreign particles. This is a source of trouble often overlooked during the 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 the result—not the cause—of the problem. All parts that are broken or worn and no longer meet specifications must be replaced.

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 avoid another teardown on the unit in the near future. Also at this time, make any recommended changes or modifications to bring the transmission up to date and increase the service life of the unit.

Read this section before starting the detailed disassembly procedure. Follow each procedure closely in each section, making use of both text and pictures.

Rebuild Facilities

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 - 30 inches. A chain hoist should be used to handle the mainshaft and countershafts during removal and reassembly procedures.

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 mechanics have a wash tank 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 all bearings just prior to reassembly. If accumulated mileage is over 150,000 miles, we suggest that all bearings be replaced. If bearings are worn or damaged, always replace them regardless of mileage.

End Yokes and Flanges

Do not hammer on end yokes and flanges to remove or install them. It is not only destructive to the yoke or the flange itself, but can also cause serious internal 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 early failures of journal needle bearings.

Serious damage can be done internally to bearings, thrust faces and washers, pilot bearings, etc., by hammering on external parts. In most designs, when the yoke/flange locknuts are tightened and secure, the internal bearings and gears are in proper location. When the yoke/flange is driven on the shaft, however, two conditions can exist.

(a) If the bearing fit is tight on the shaft, usually the bearings will brinell as they must absorb the pounding force.

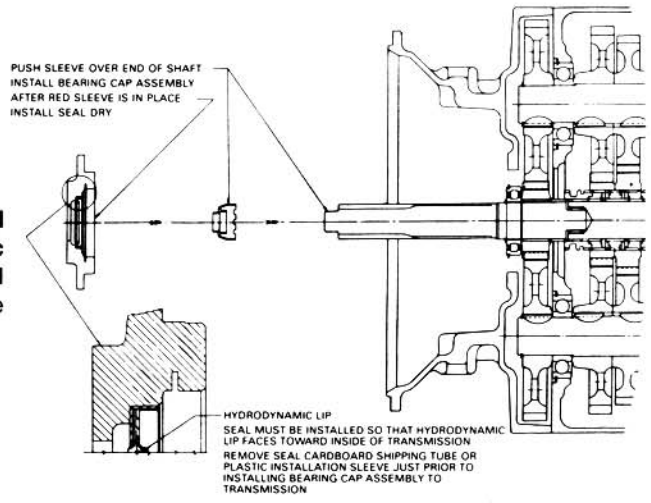
(b) If the bearing fit is loose, the shaft will keep moving inward until it is stopped by the internal parts such as the pilot bearing thrust washers.

Power Take-Offs

Refer to your owner's manual and installation procedures when installing any PTO on your transmission.

Front Bearing Retainer & Seal

When installing a 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 seal sleeve will void the seal warranty.



Shift Tower Disassembly

1. Remove the six retaining cap screws and lockwashers. Separate the tower from the shifter housing and gasket. Lift straight up.

2. Position the shift lever tower on edge in a vise.

3. Pull up on the grommet. Depress the collar against the spring. Remove the lock pin.

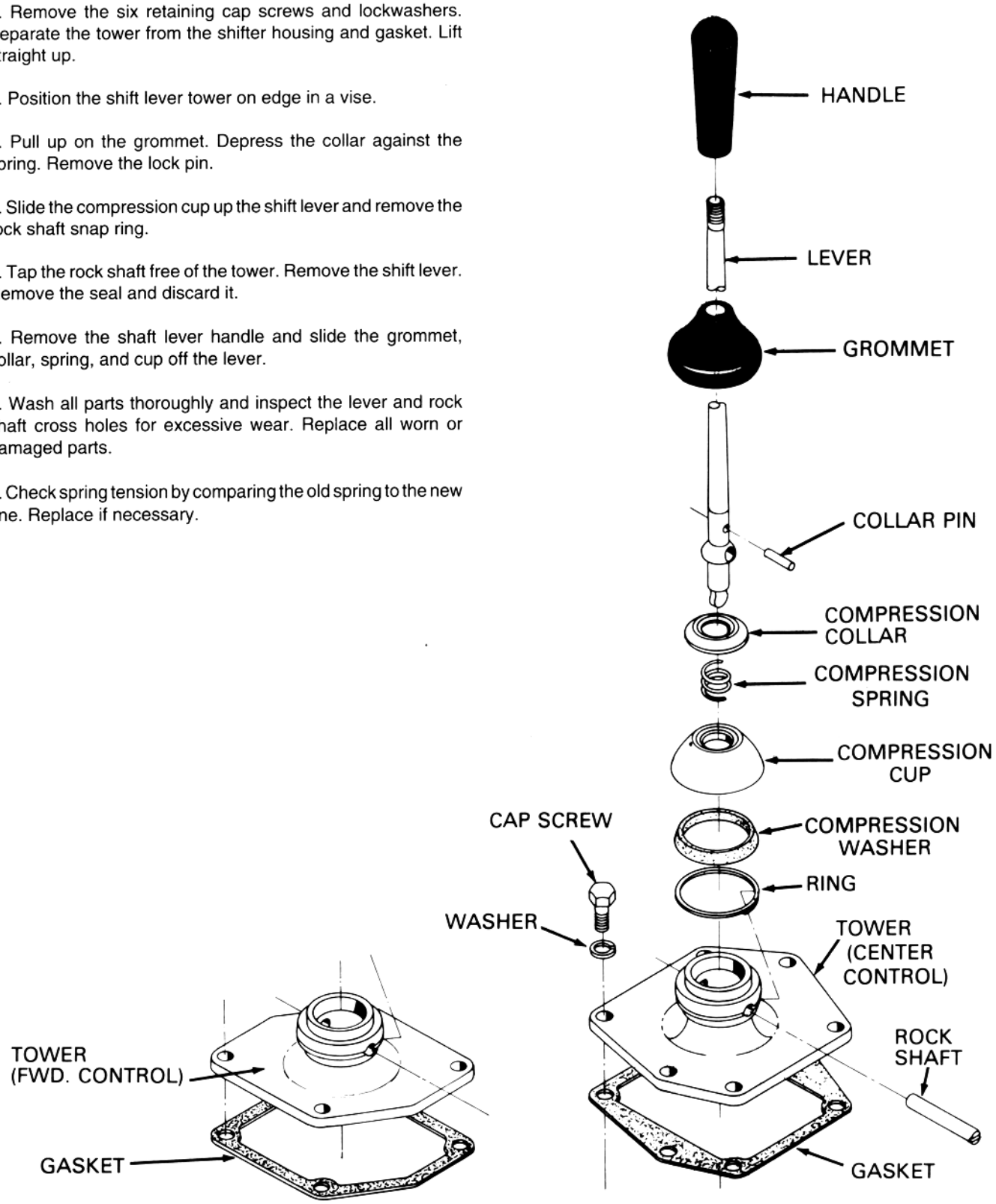
4. Slide the compression cup up the shift lever and remove the rock shaft snap ring.

5. Tap the rock shaft free of the tower. Remove the shift lever. Remove the seal and discard it.

6. Remove the shaft lever handle and slide the grommet, collar, spring, and cup off the lever.

7. Wash all parts thoroughly and inspect the lever and rock shaft cross holes for excessive wear. Replace all worn or damaged parts.

8. Check spring tension by comparing the old spring to the new one. Replace if necessary.



Remote Control Disassembly

1. Remove the cap screws and lockwashers and separate the remote control from the shifter housing.

2. Remove the setscrew from the universal joint assembly and pull the universal joint from the rod.

3. Remove the four cap screws and lockwashers that hold the end cover and gasket in place.

4. Remove the setscrew from the joint shift rod finger and tap the rod through the cross holes in the housing.

5. Remove the finger from the housing.

6. Remove the setscrew from the inner shift finger.

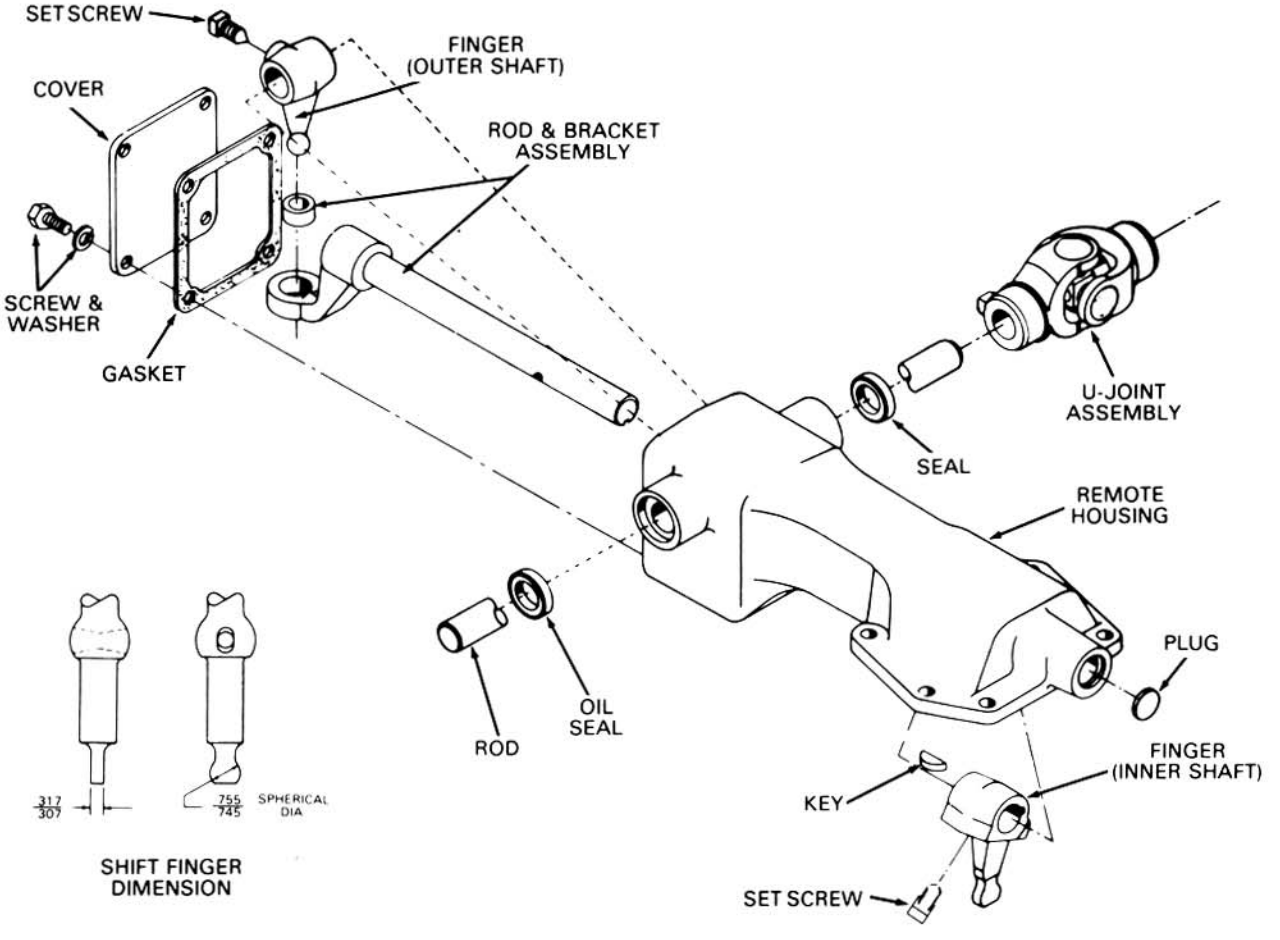
7. Slide the rod and bracket assembly from the inner shift finger.

8. Be careful not to lose the key from the rod or shift finger.

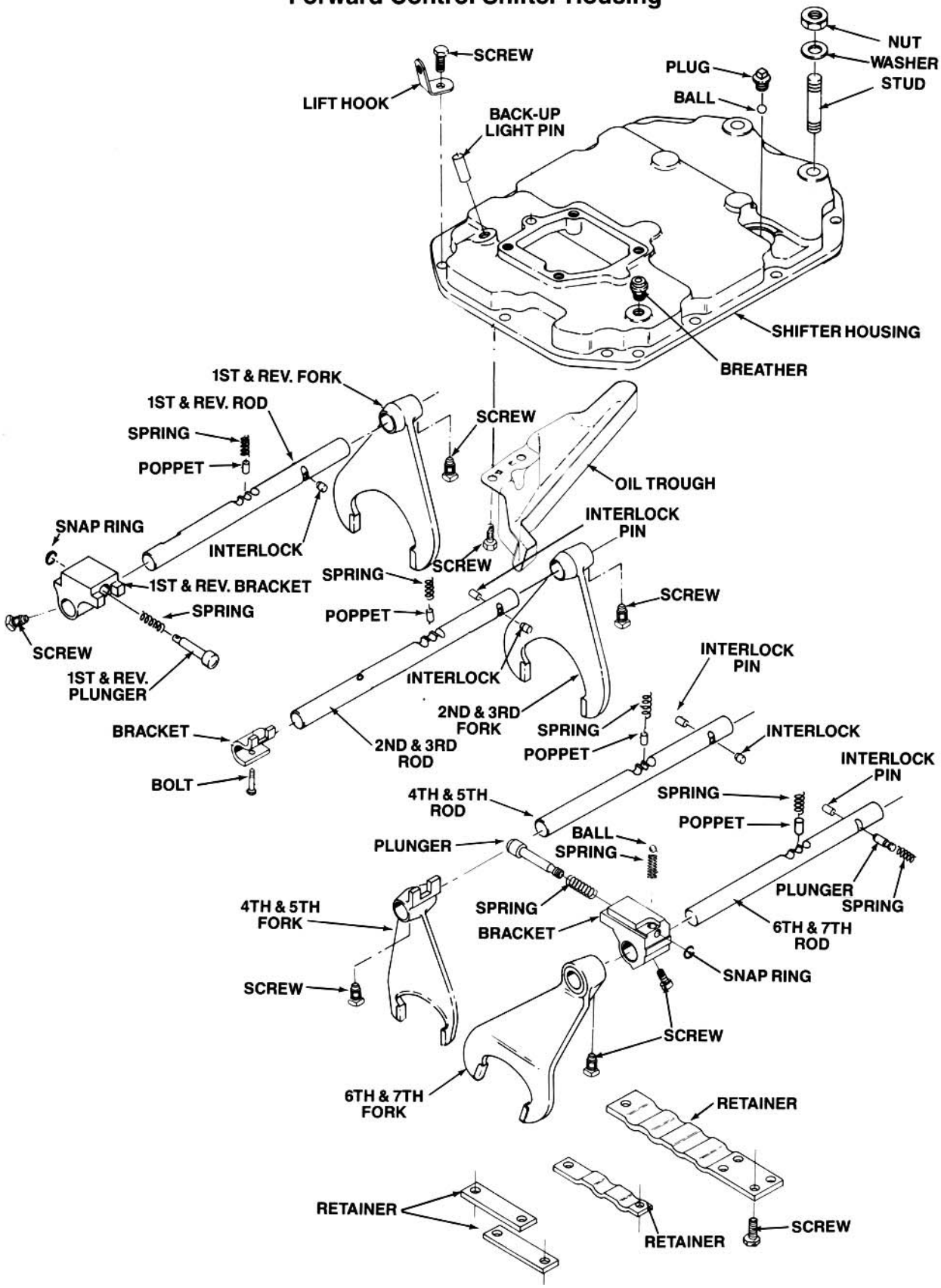
9. Remove the seals from the housing cross holes.

10. Check the shift fingers for excessive wear. Check all bores and rods for excessive wear or scuffing. Replace all worn or damaged parts.

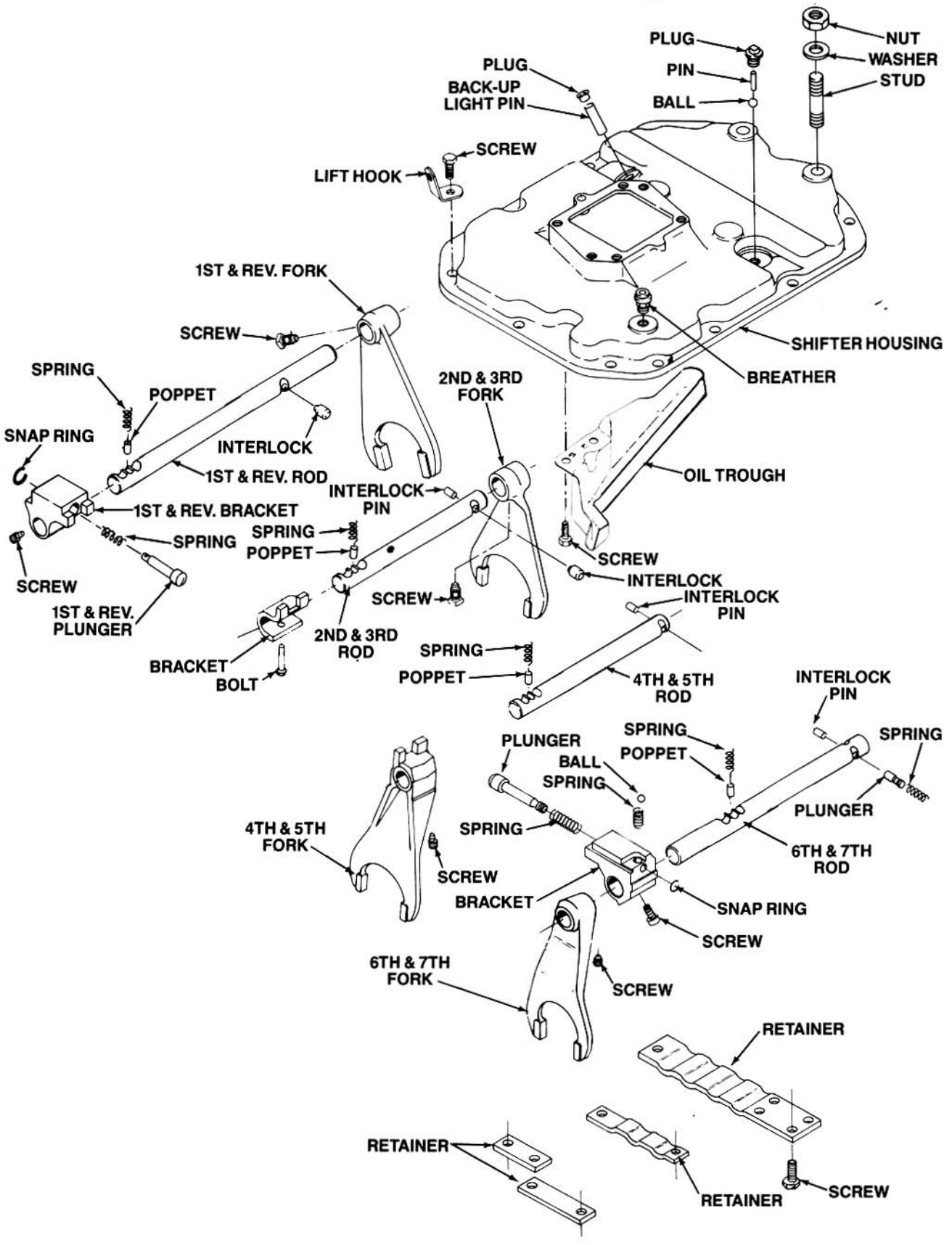
11. Clean all parts thoroughly and apply a light coat of grease to all pivot points prior to reassembly.

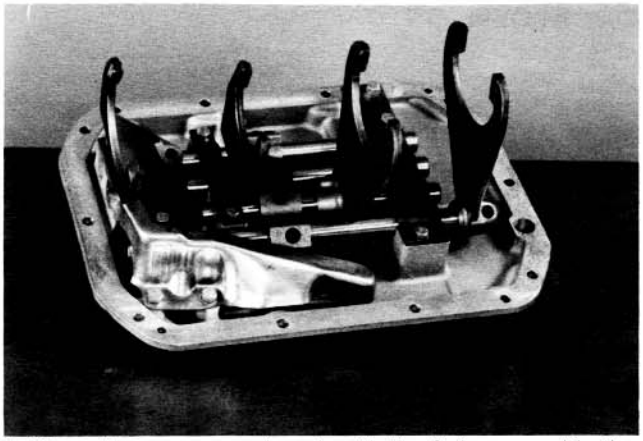


Forward Control Shifter Housing

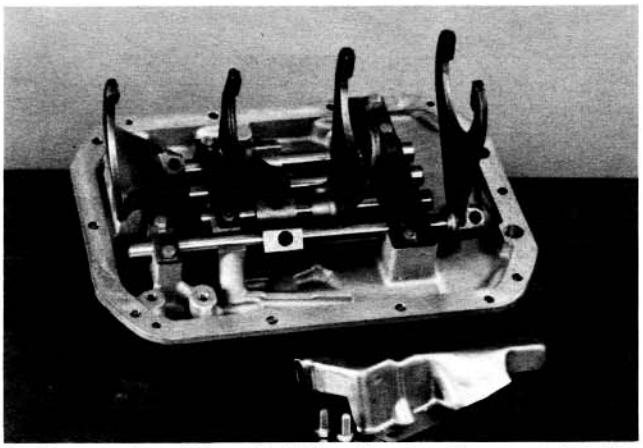


Center Control Shifter Housing

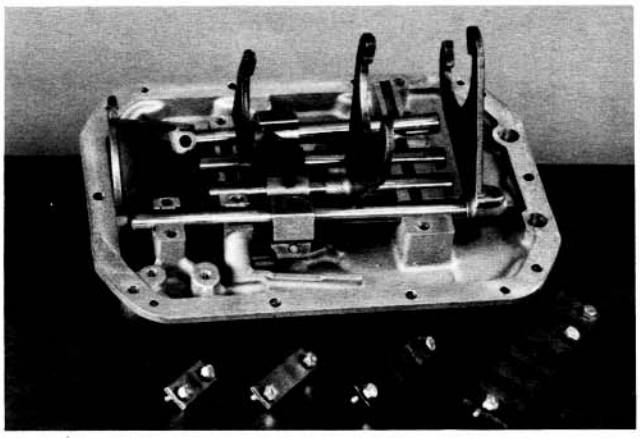




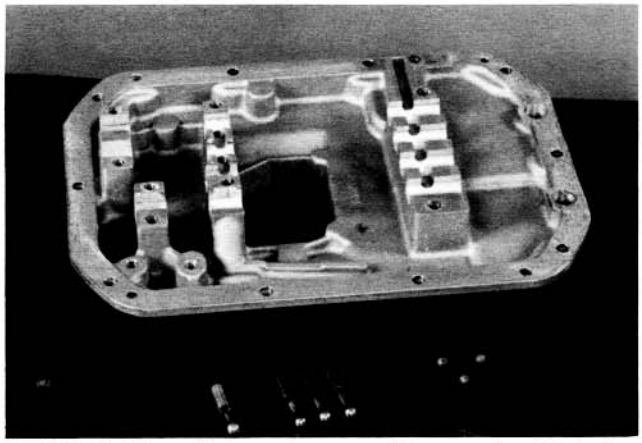
1. Place the cover on a bench with the forks up and in the neutral position.



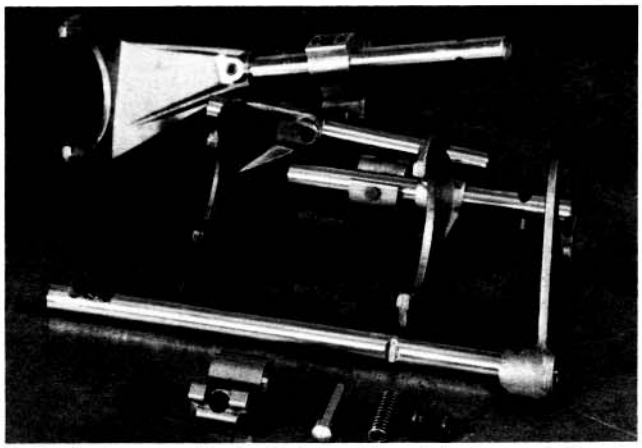
2. Remove the oil trough. This will make disassembling the rest of the cover easier.



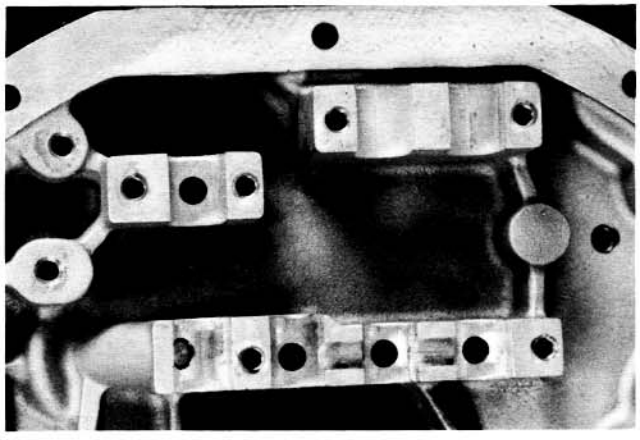
3. Loosen all fork and bracket setscrews, then remove the retainer straps.



4. All forks lift easily from the cover. Remove the interlocks, poppets, and springs. **The 1st-reverse spring has a different tension than the others, so avoid mixing them up during reassembly.** If you do, shifting problems could result.

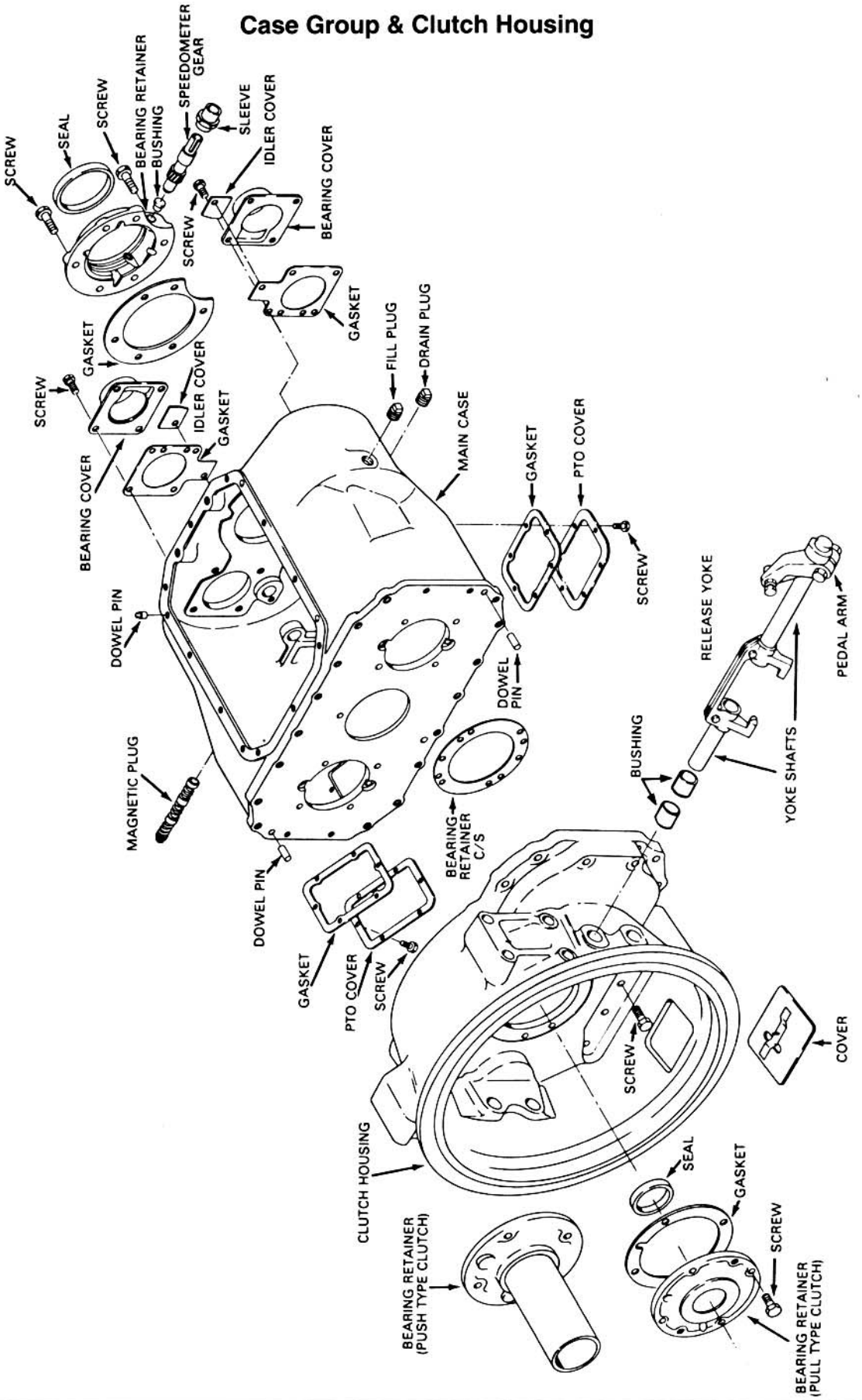


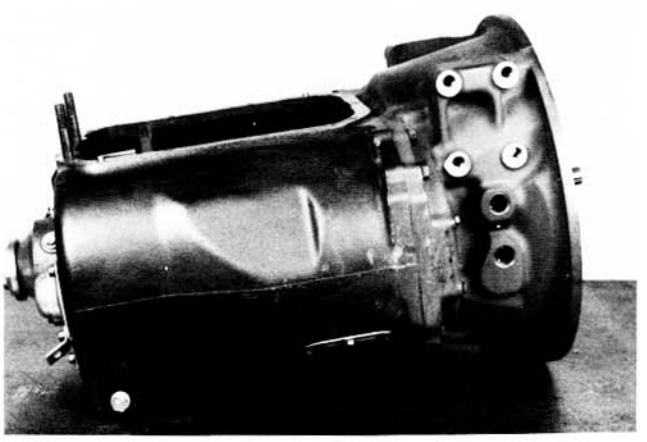
5. Next, disassemble the forks and brackets. Inspect all parts for wear or damage. Replace all worn or damaged parts.



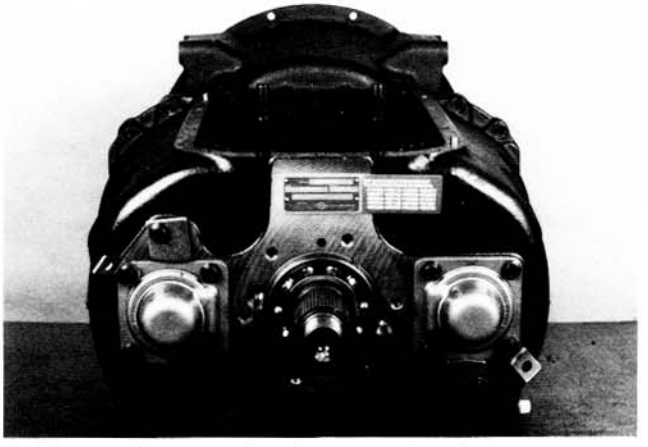
6. Inspect the poppet and detent holes for burrs or damage. If either exists, replace the cover.

Case Group & Clutch Housing



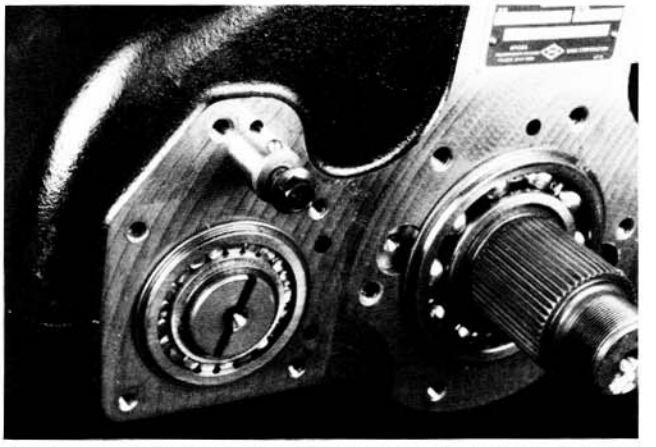


1. Remove the cap screws and shifter housing. If the shifter housing is a forward control, shift the transmission into 6th gear.



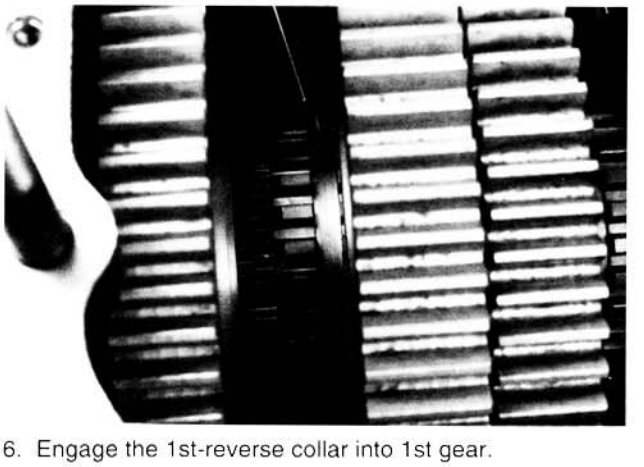
2. Remove the output bearing cap and gasket.

3. Remove the countershaft bearing retainers.



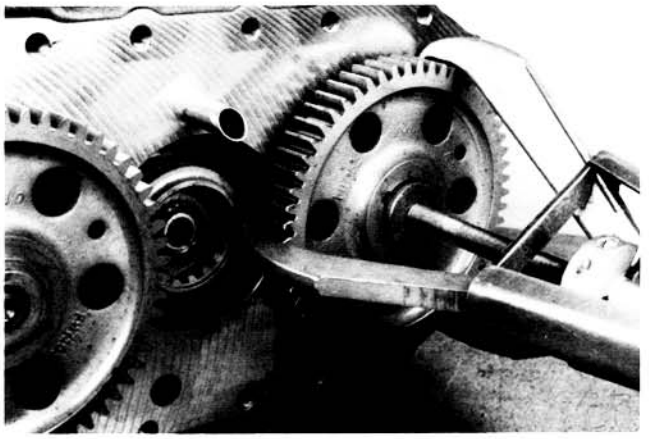
4. Insert a cap screw into the upper reverse idler shaft for removal. Don't lose the lockball in the shaft.

5. Roll the upper reverse idler gear toward the side of the case.

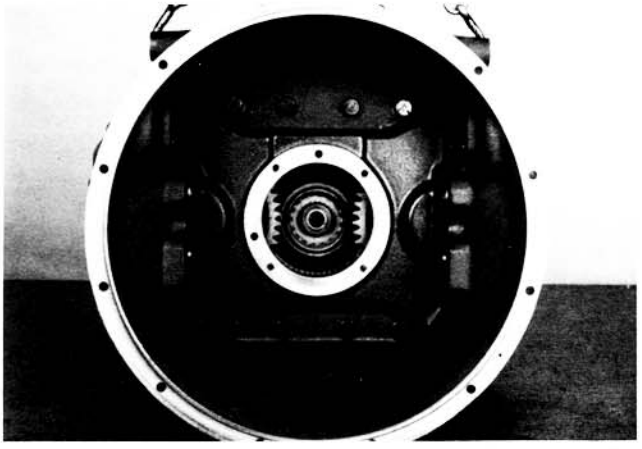


6. Engage the 1st-reverse collar into 1st gear.

7. Remove the input bearing cap, gasket and input shaft.

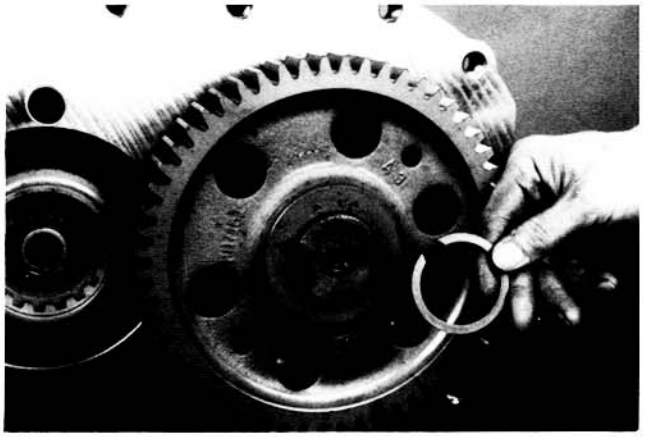


10. Remove the countershaft drive gears with the aid of a large puller.

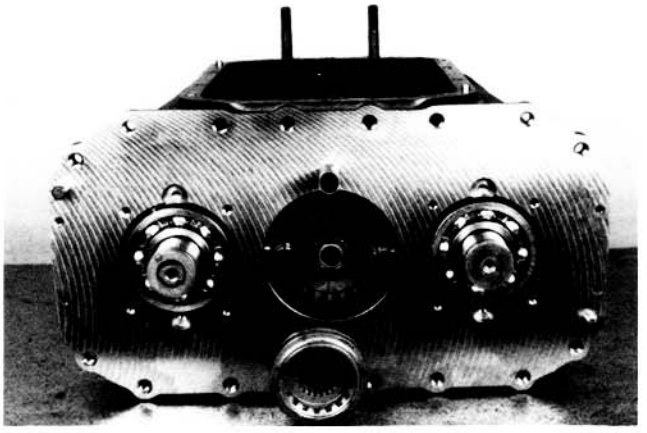


8. Next remove the clutch housing bolts and separate the housing from the case. **Use of a chain hoist is recommended due to the weight of the housing.**

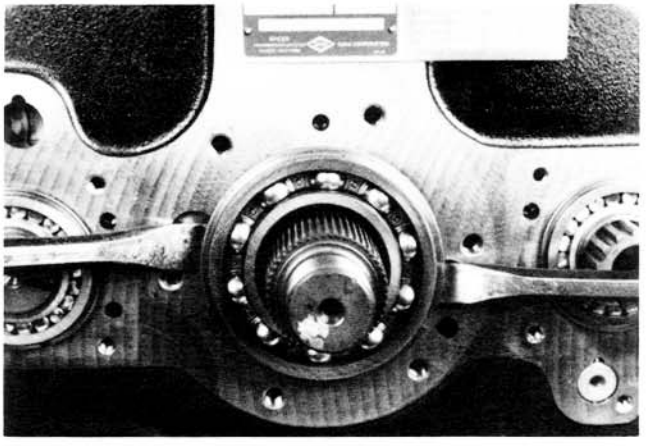
11. Continue by removing the countershaft driver gear countershaft keys.



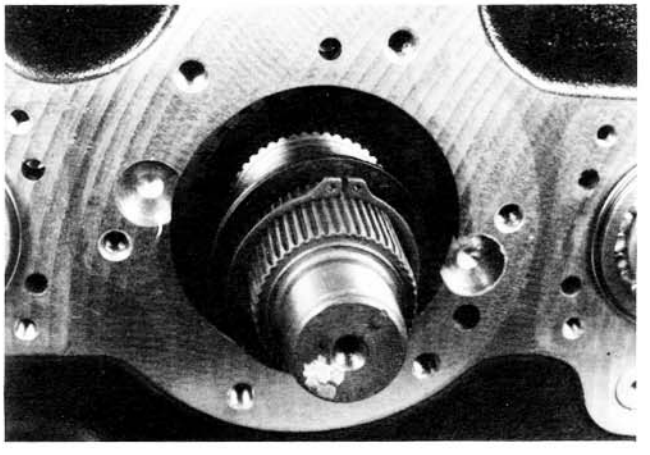
9. Remove the snap rings from the countershafts. **Always wear safety glasses to protect your eyes when removing or installing snap rings or bearings.**



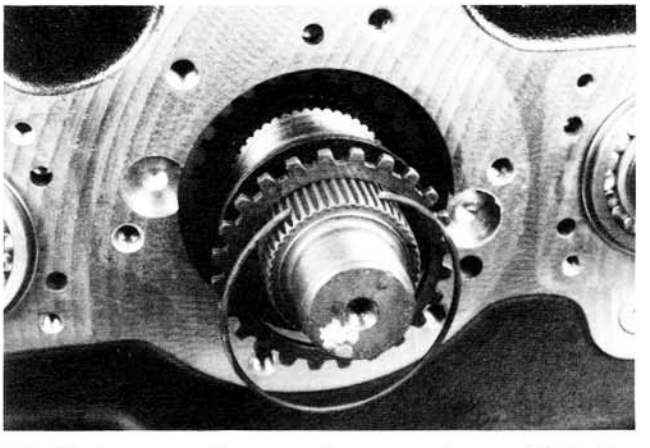
12. The 6th-7th clutch collar may be removed from the mainshaft.



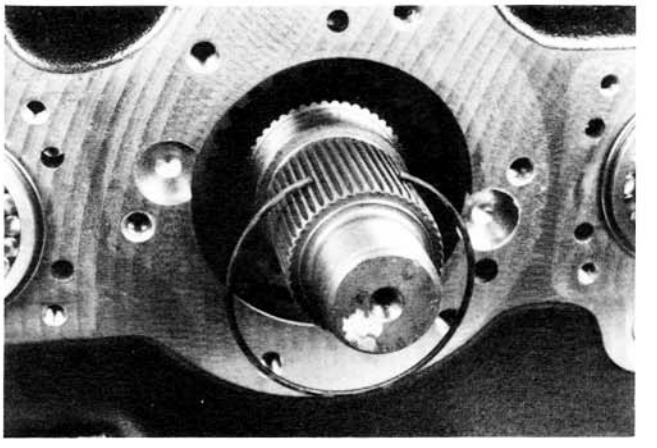
13. Place a sling around the 2nd-3rd mainshaft collar and use a hoist to provide support during bearing removal. The milled slots also help make output bearing removal easier.



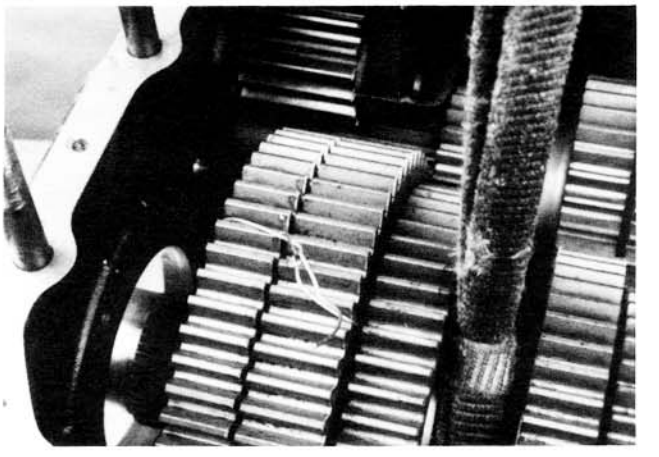
14. Remove the mainshaft snap ring and the internally splined thrust washer.



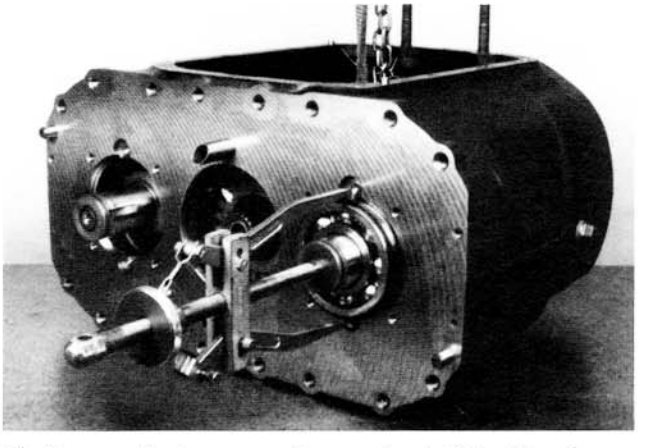
15. Next, remove the gear bore snap ring and both the externally and the internally splined thrust washers.



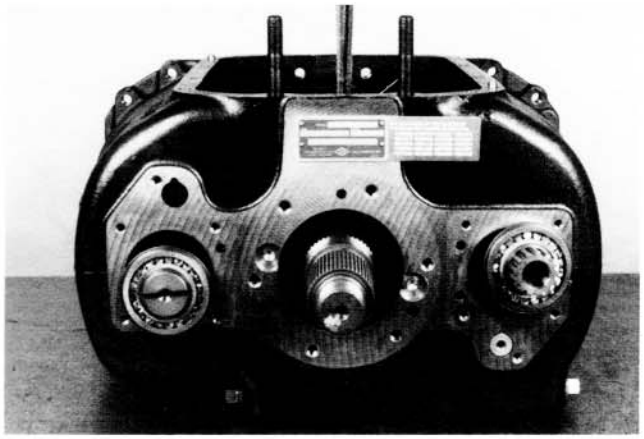
16. Remove the remaining gear bore snap ring.



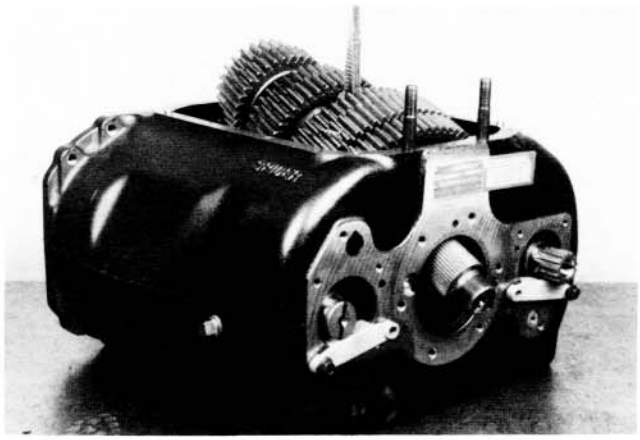
17. Butt 1st and reverse gears together. Secure them with lockwire to provide the necessary clearance for mainshaft removal.



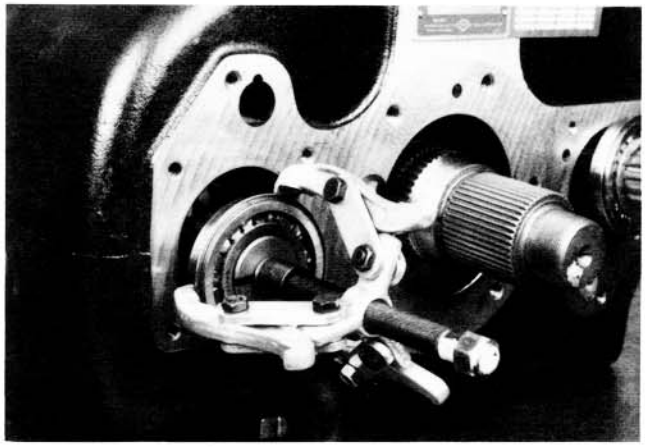
18. Use a puller to remove the countershaft front bearings.



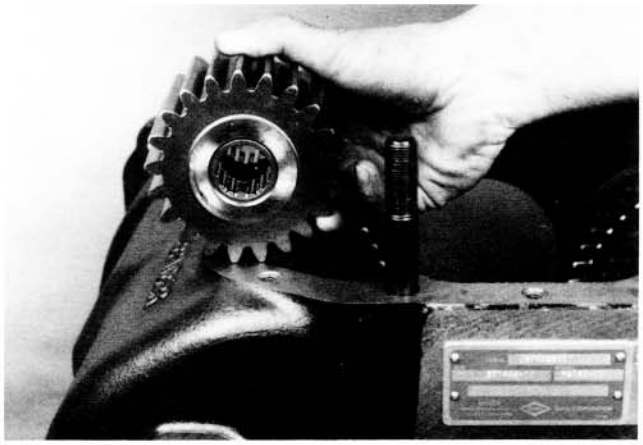
19. Move the countershafts to the rear as far as possible.



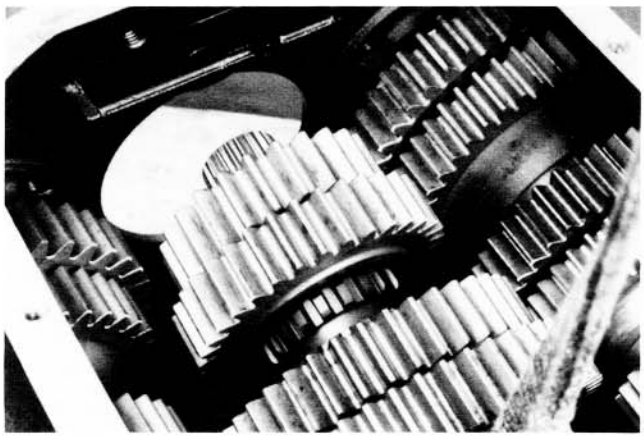
22. Lift the mainshaft assembly out of the case. **Use a chain hoist for this procedure due to the weight of the assembly.**



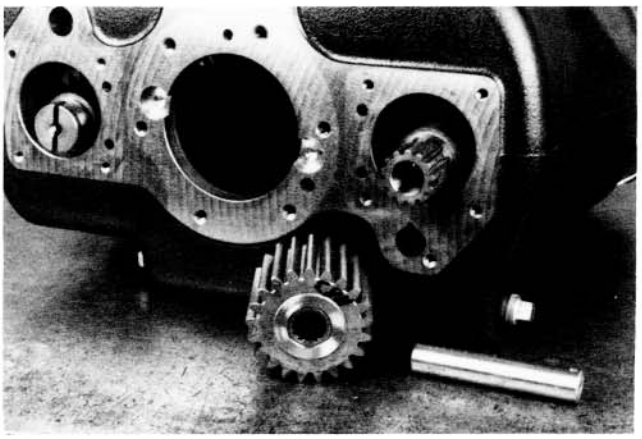
20. Install a puller for bearing removal.



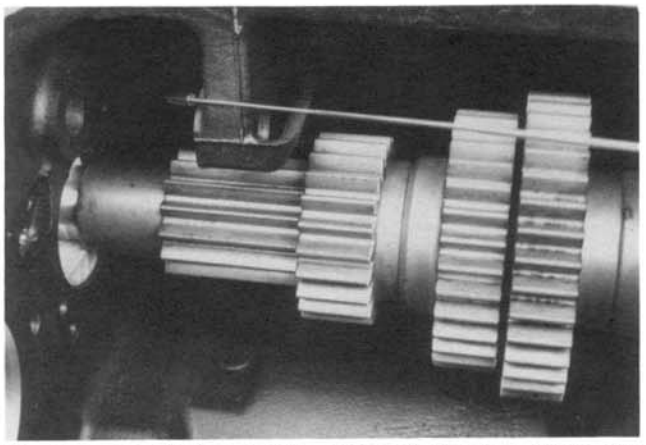
23. Remove the upper reverse idler gear.



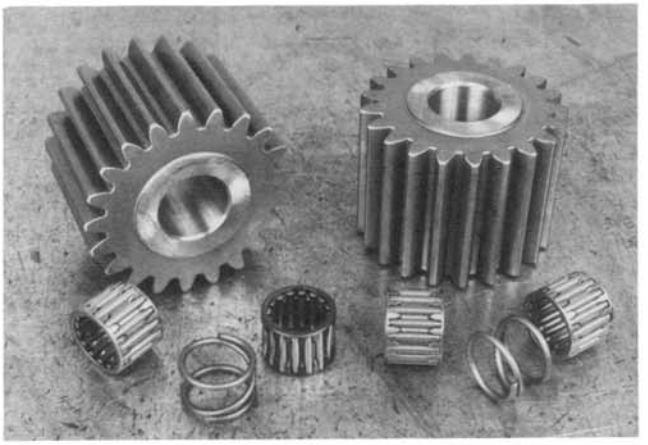
21. To provide necessary clearance for mainshaft removal, move both countershafts forward and toward the side of the case. Countershaft alignment blocks can also be used to help restrain the countershafts.



24. Remove the lower idler shaft and idler gear.

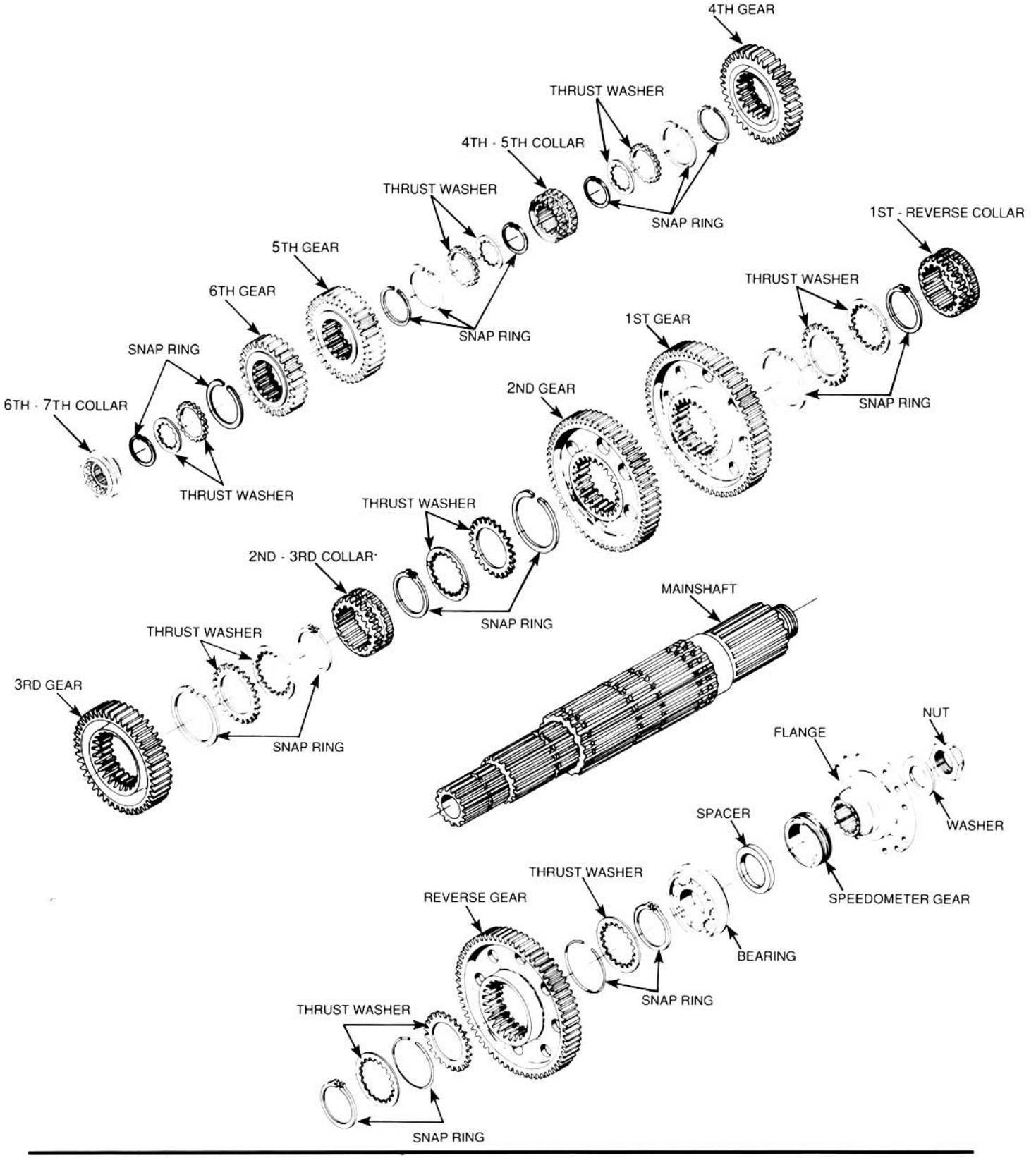


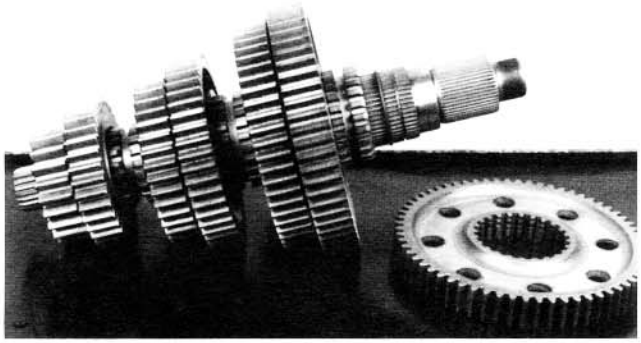
25. Because of this upper idler boss interference, it is easier to remove the right side countershaft first. Then remove the left side countershaft.



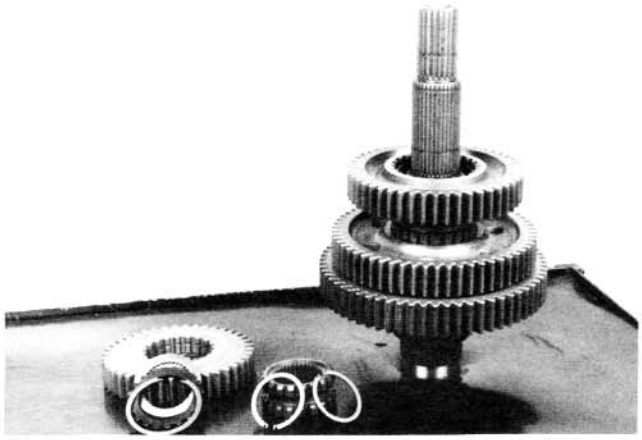
26. Check both idler gears and bearings for excessive wear. Replace all worn or damaged components.

Mainshaft Disassembly

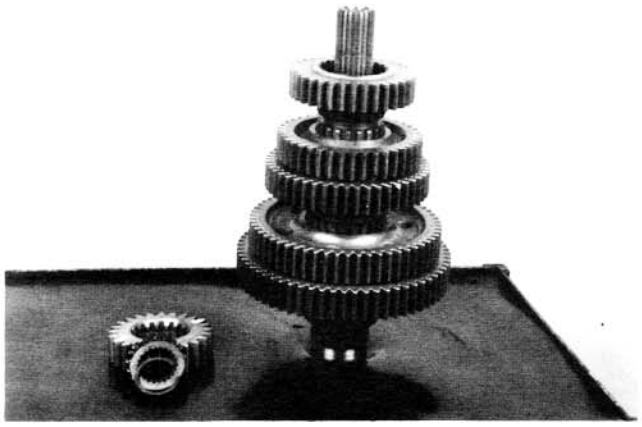




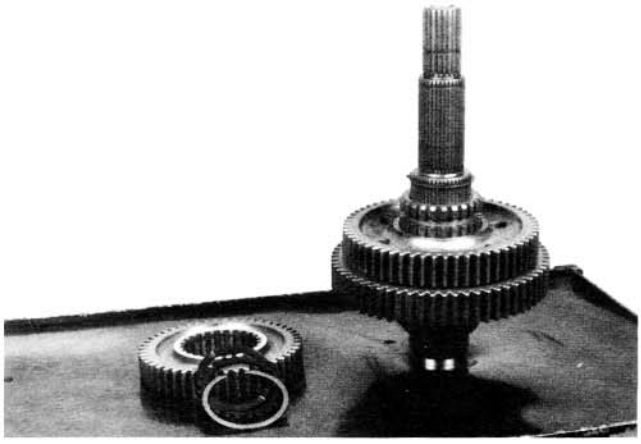
1. Begin mainshaft disassembly by cutting the lockwire and removing reverse gear. **Always remember to wear safety glasses to protect your eyes.**



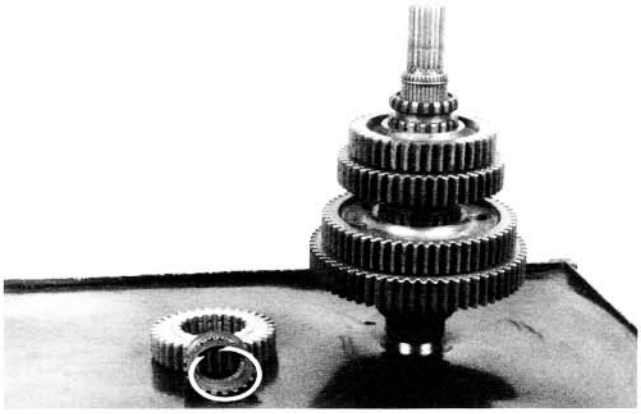
4. Remove the snap ring and the 4th-5th shift collar next. Remove the snap ring and 4th gear. Inside the gear are two thrust washers and a snap ring. Inspect the thrust washers for wear.



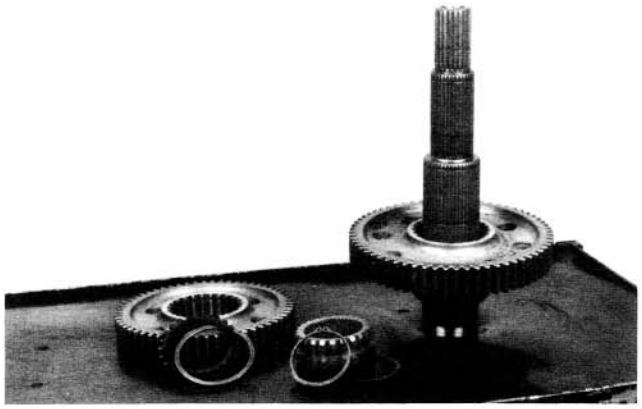
2. Next, remove the snap ring, 6th gear, and the internal and external thrust washers. *Note: The internal thrust washer teeth face toward the center of the washer. The external thrust washer teeth face away from the washer.* Always check washers for wear. Replace worn or damaged components.



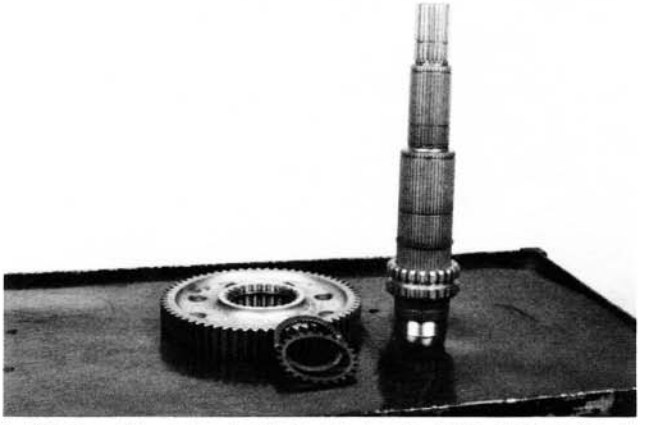
5. Continue by removing 3rd gear. Inside are two thrust washers and a snap ring. Inspect the thrust washers for wear. There is no need to remove the gear snap ring.



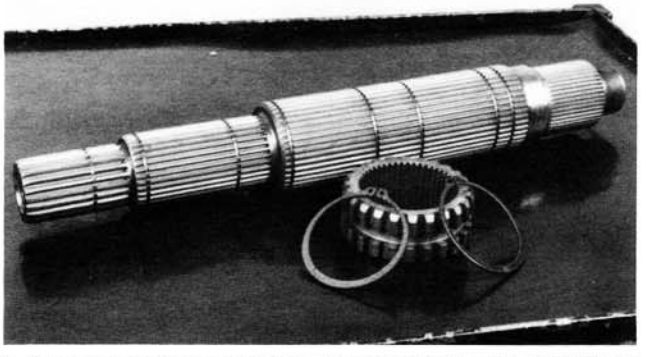
3. Remove 5th gear. There are two thrust washers and a snap ring inside the gear. All gears except reverse gear contain gear bore snap rings. There is no need to remove a gear bore snap ring unless the gear is being replaced.



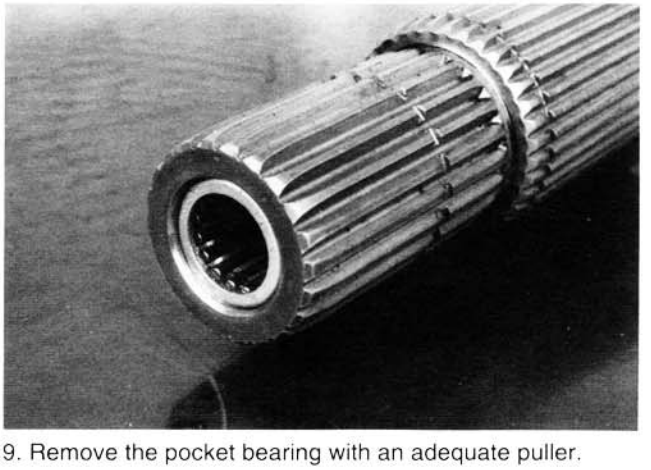
6. Remove the mainshaft snap ring and 2nd-3rd shift collar. Remove the next snap ring and 2nd gear. Also remove and inspect the two thrust washers. There is no need to remove the gear snap ring.



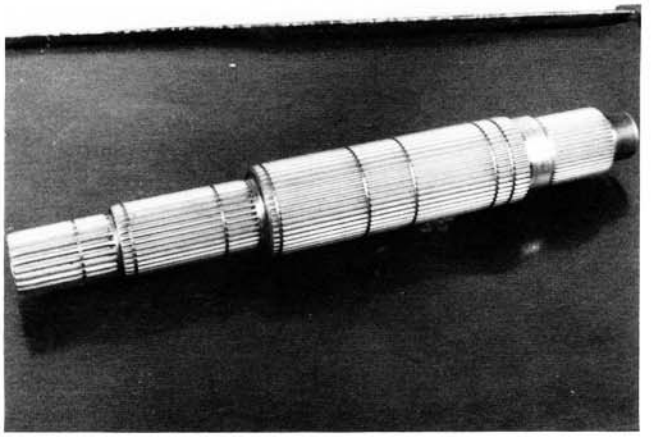
7. Continue by removing 1st gear. Again, there are two thrust washers and a snap ring inside the gear. Inspect the thrust washers. There is no need to remove the gear snap ring.



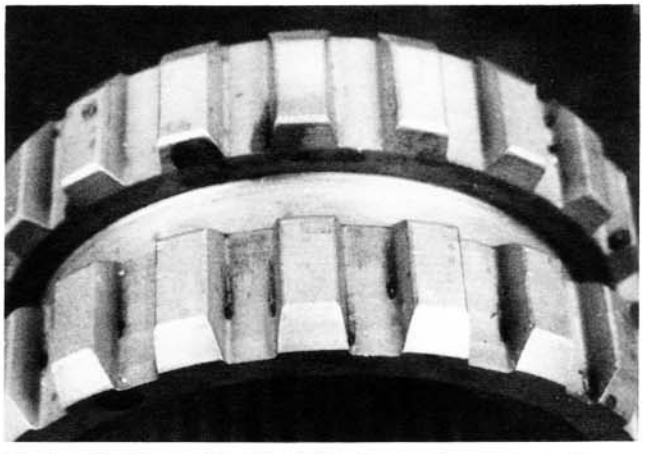
8. Remove the two snap rings and the 1st-reverse collar from the shaft.



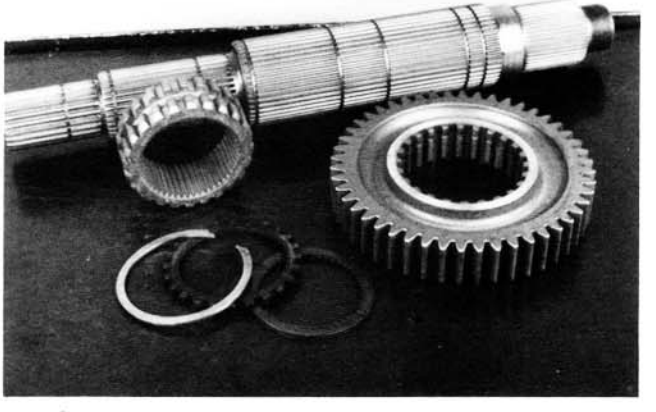
9. Remove the pocket bearing with an adequate puller.



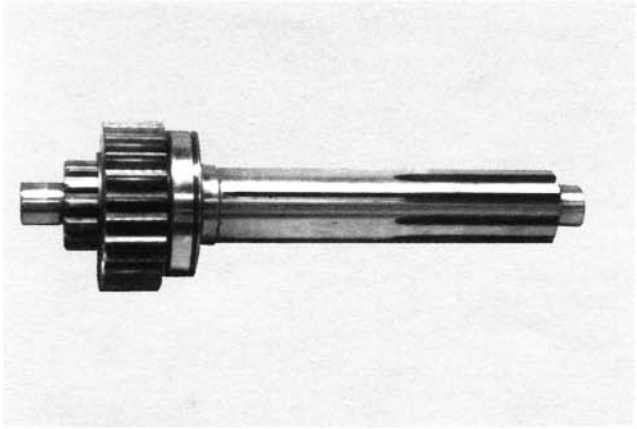
10. The mainshaft has rolled involute splines for greater strength and longer life.



11. The 4th-5th and 6th-7th shift collars and gears have Taper-Lok™ gear locks. They are designed to draw gears into perfect alignment to eliminate gear jump-out.



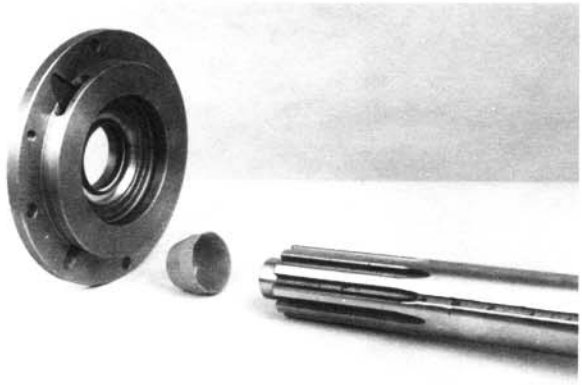
12. Clean all parts and inspect them for wear or damage. (!) Replace them if necessary. **If a gear is damaged, its mating countershaft gears may also be damaged. So anytime you replace a mainshaft gear, replace its mating countershaft gears as well.**



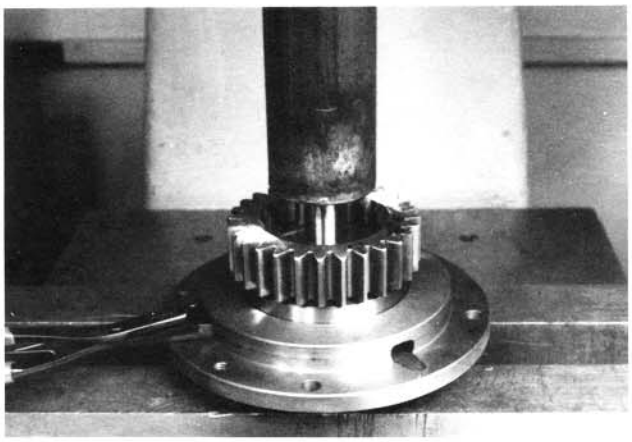
1. The input gear, shaft, and bearing are separate components secured with two snap rings.

2. This view shows the input subassembly when disassembled.

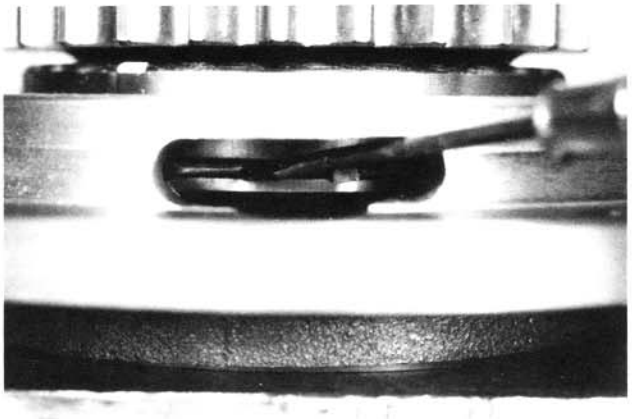
3. When reassembling, first install the snap ring into the input bearing cap.



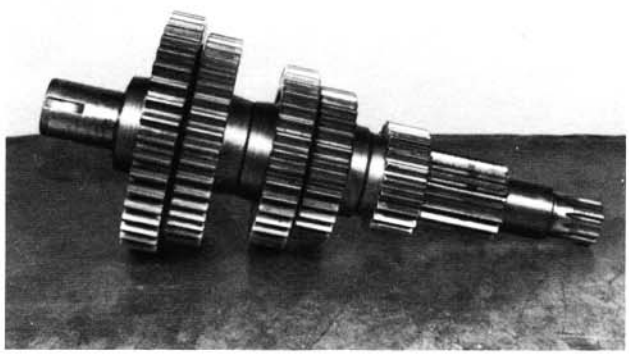
4. Then insert the input shaft through the bearing retainer, ⊘ using an installation sleeve to protect the seal. **Do not use grease on this seal. The shaft and seal must be oil-free when mated to provide an effective seal.**



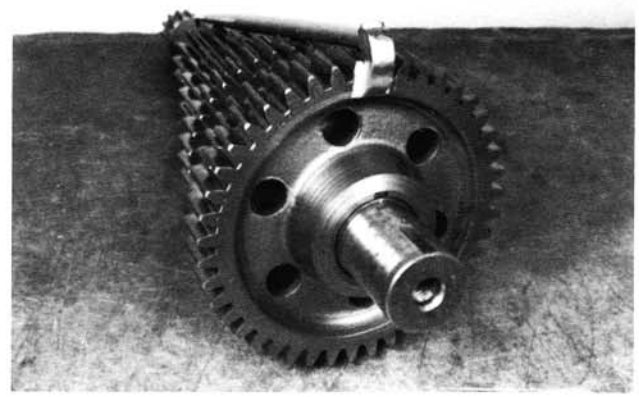
5. Expand the snap ring through the provided slot while pressing the input shaft assembly into the bearing retainer.



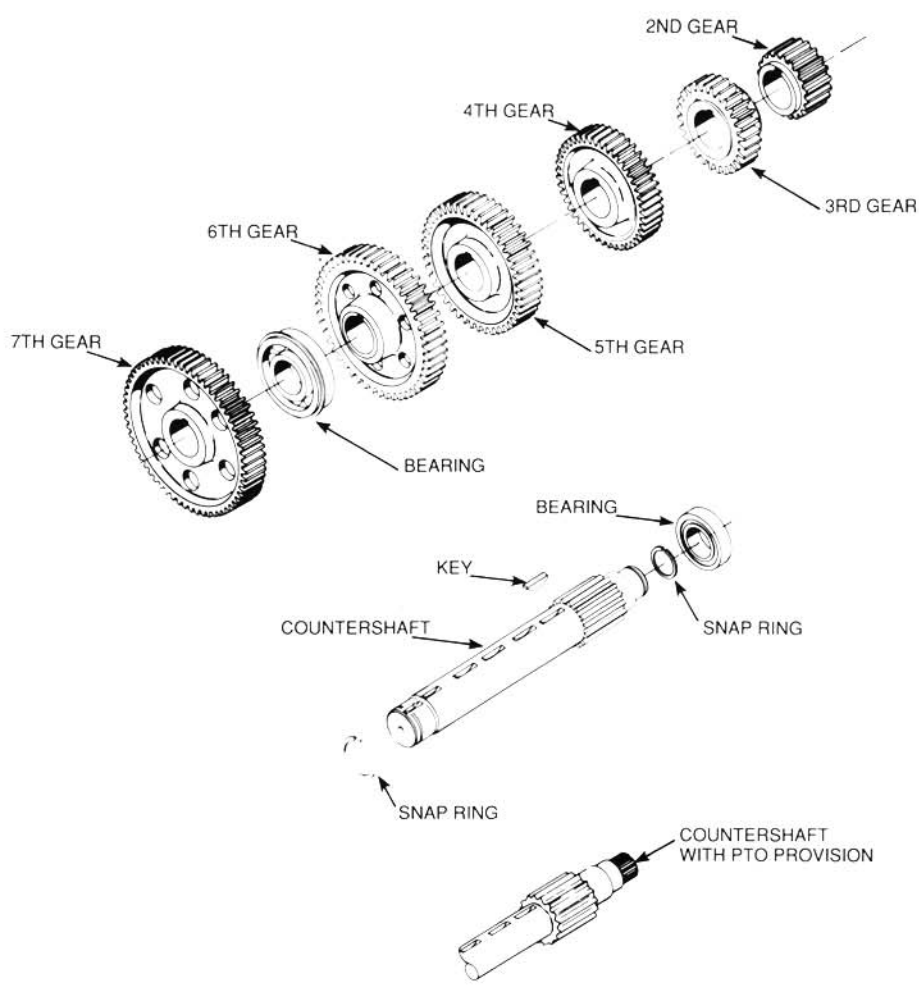
6. When snap ring grooves on the input shaft bearing and bearing retainer are in proper alignment, discontinue pressing. Seat the snap ring in place. Inspect the assembly to assure the snap ring is properly seated and secured.



1. This view shows the hub direction of the gears. First-reverse gear is an integral part of the shaft, while the remaining gears are secured with individual woodruff keys under each gear.



2. If you place a straight edge between these painted teeth, every gear on the countershaft will be in line. When you set the countershafts in time, these marks will be directly across from each other.



CLEANING & INSPECTION PROCEDURES

SECTION IX

Cleaning

Prior to reassembly, wash all parts thoroughly.

Use a petroleum-based solvent. Refer to the solvent manufacturer's safety precautions to prevent personal injury or transmission damage.

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

Do not use water or steam to clean internal components. If you do, it could cause corrosion of these components.

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 contamination out.

Inspect parts thoroughly for wear or damage. Parts damaged or worn from previous service must be replaced to insure 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 exists, 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

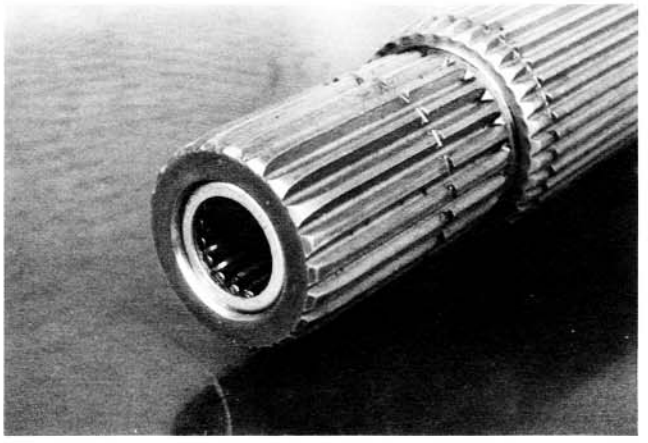
Check the shift fingers, bushing bores and rods for excessive wear or scuffing. Replace springs, bearing races, boots and seals. Clean all reusable parts thoroughly and apply a light coat of grease to the pivot points when reassembling.

Bearings

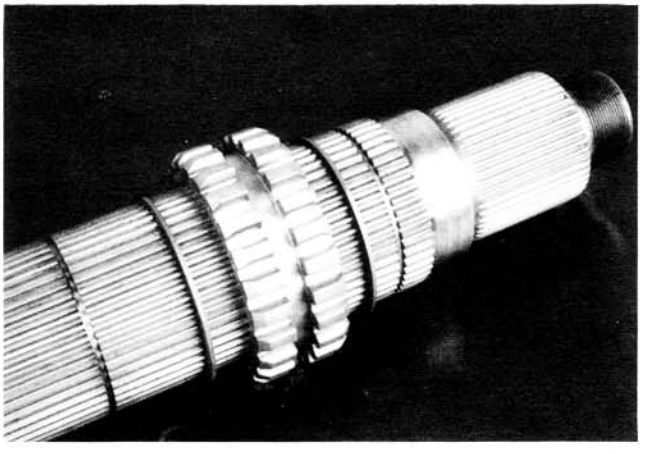
New bearings are recommended with every rebuild. (See "*General Disassembly—Bearings*" for further information.)

Housings

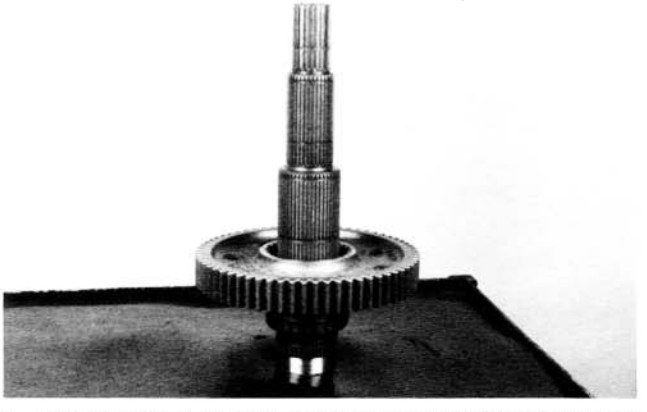
Inspect the housing sections for cracks. If cracks exist, replace that section of the housing. Also inspect the shift bar support bracket for cracks or worn slots. Replace it if either of these conditions exists.



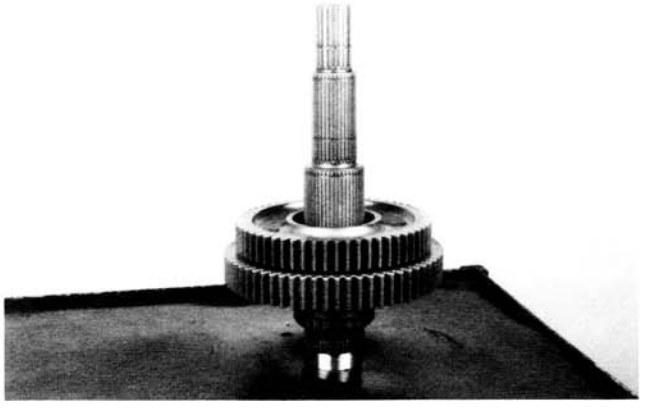
1. Lubricate all parts prior to reassembly. Then install the pocket bearing to a depth of .070 inches. **Remember, always wear safety glasses when reassembling components.**



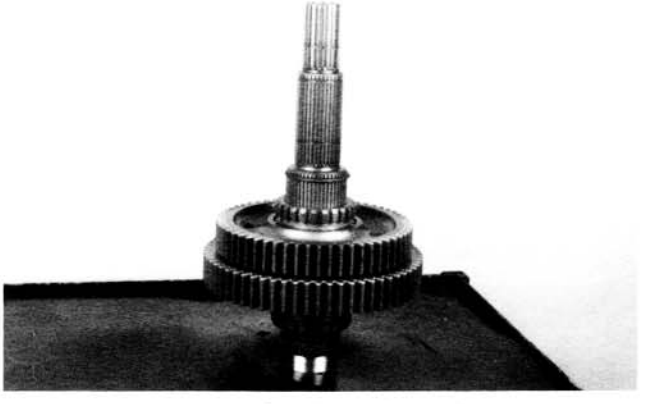
2. Then install the 1st-reverse snap ring in the second groove from the bottom of the shaft. Slide the 1st-reverse collar into place and secure it with a snap ring.



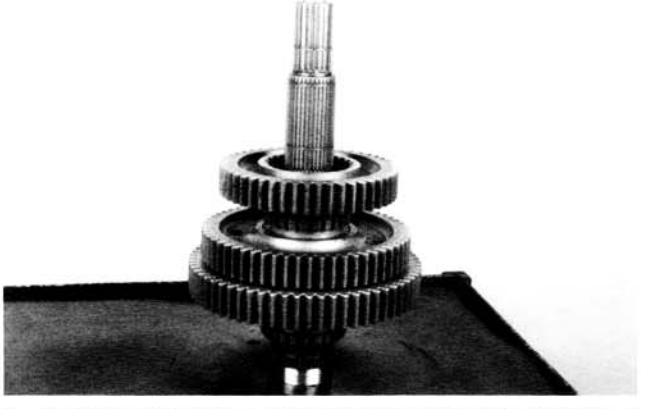
3. Place the internally and externally splined thrust washers on the shaft. The internally splined thrust washer should rest against the snap ring.



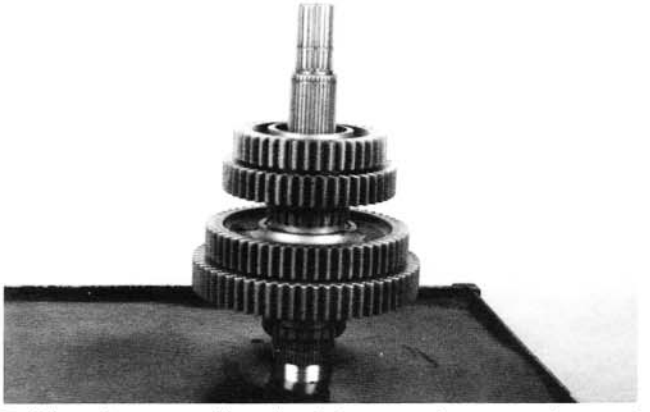
4. Install 2nd gear on the shaft. Install the externally and internally splined thrust washers into the gear. Secure the assembly with a snap ring.



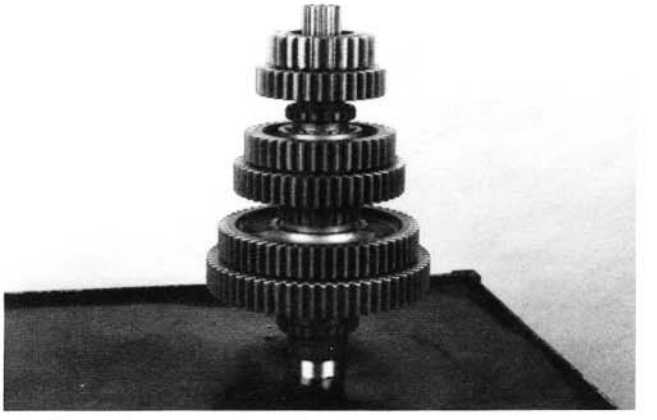
5. Install the 2nd-3rd shift collar and snap ring.



6. Place an internally splined washer and externally splined washer on the shaft. Install 3rd gear.

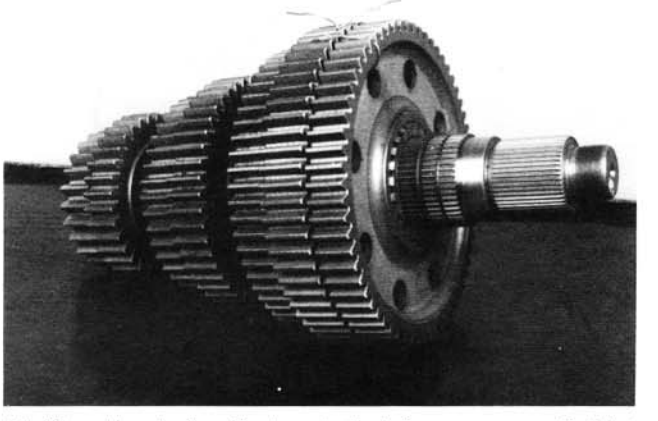


7. Place the externally splined thrust washer, snap ring, and internally splined thrust washer into 4th gear. Place the assembly on the shaft. Secure it with a snap ring.



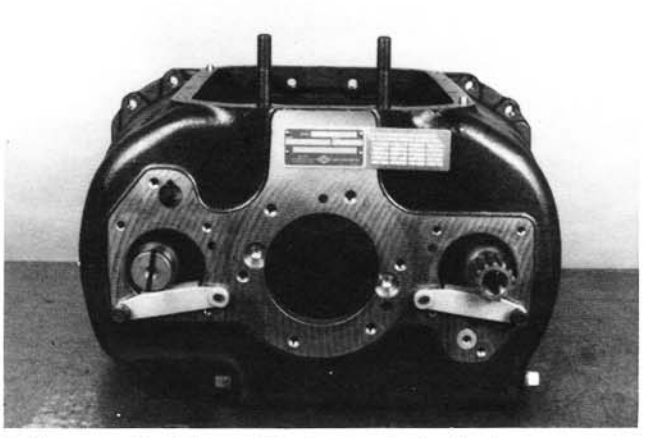
10. Place the externally splined thrust washer, snap ring, and internally splined thrust washer in the gear. Slide 6th gear onto the shaft. Secure it with a snap ring.

8. Fourth-fifth shift collar and snap ring are installed next.

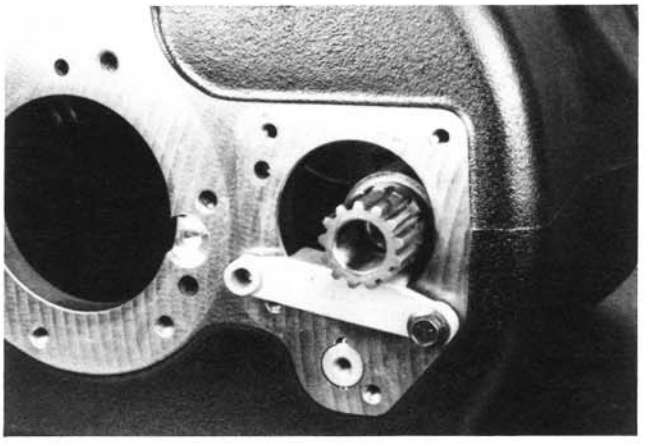


11. Place the shaft on the bench. Install reverse gear. Butt 1st and reverse gears together and secure them with lockwire. This will provide the necessary clearance to install the mainshaft into the case.

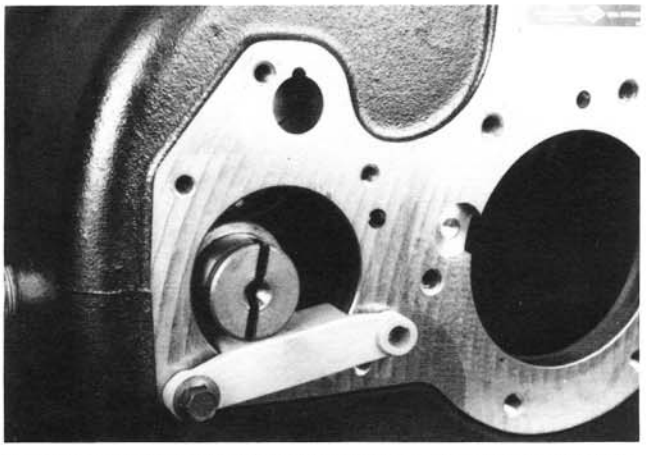
9. Place the externally splined thrust washer, snap ring, and internally splined thrust washer in the gear. Slide 5th gear onto the shaft. Secure it with a snap ring.



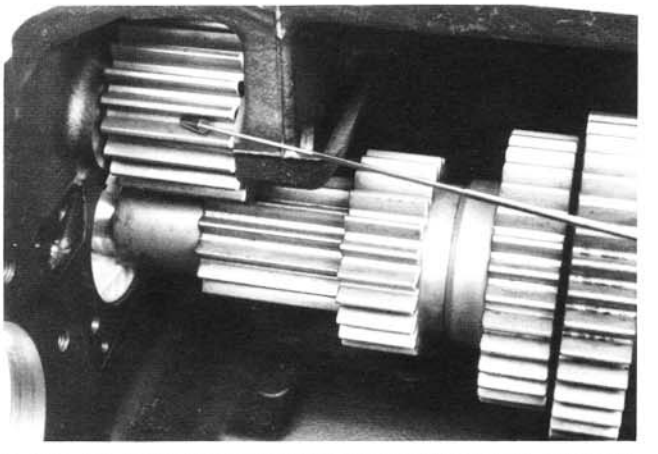
1. Reassembly of the unit begins by placing the lower reverse idler gear into the case. Then install the left side countershaft and the right side countershaft.



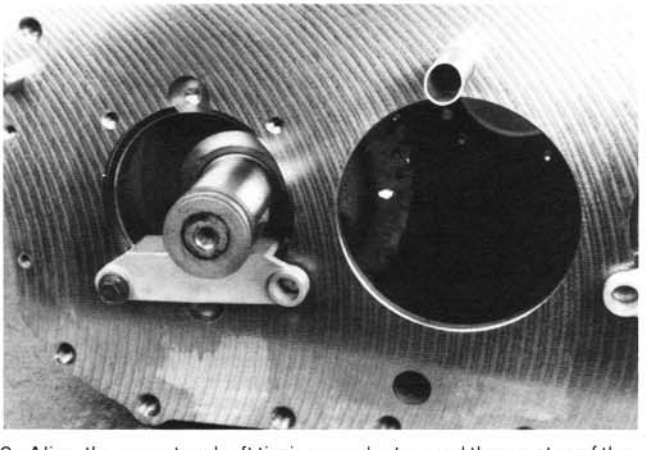
4. Insert the lower idler shaft with lockball.



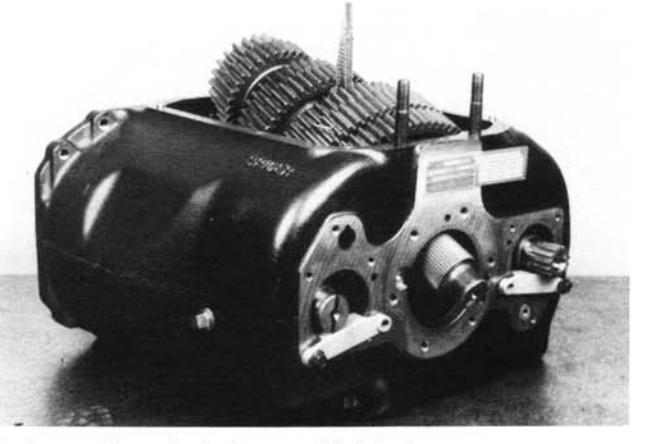
2. These blocks make timing the gears easier. They also help provide the necessary clearance for mainshaft installation.



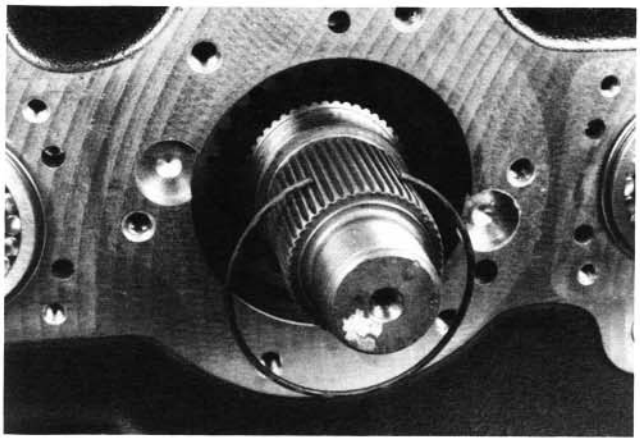
5. Set the upper reverse idler gear into the case, but don't install the idler shaft yet.



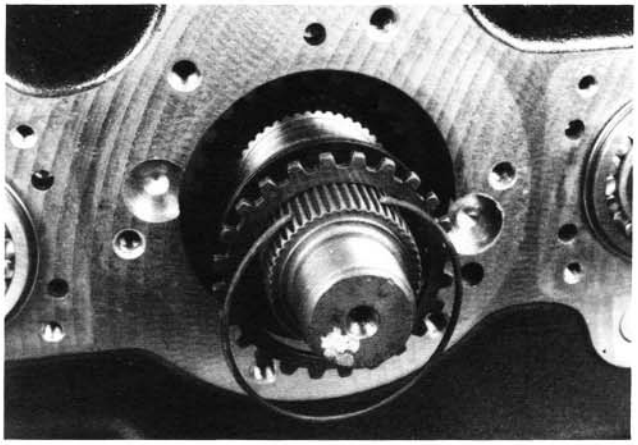
3. Align the countershaft timing marks toward the center of the case.



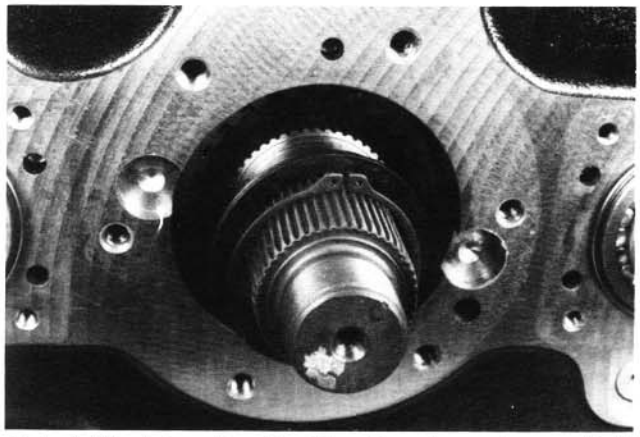
6. Lower the mainshaft assembly into the case.



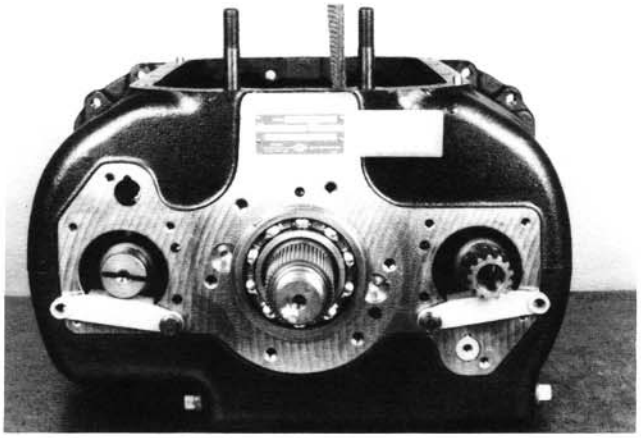
7. Cut the lockwire and slide the reverse gear rearward. Install the 1st gear bore snap ring.



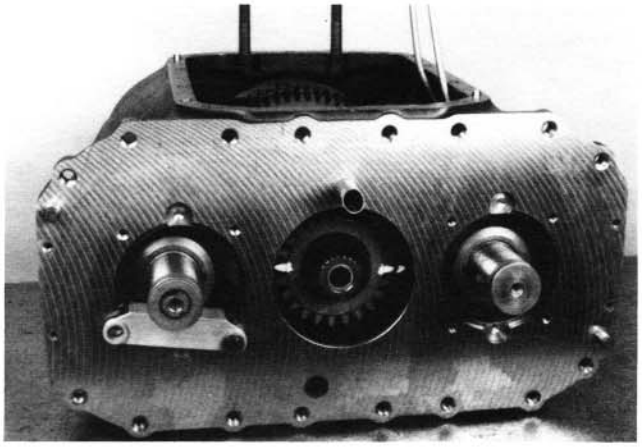
8. Next, install the internally and externally splined thrust washers. Secure them with the gear bore snap ring.



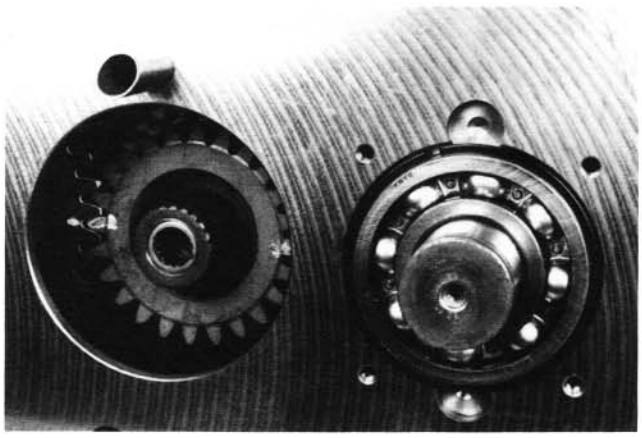
9. Install the internally splined thrust washer and secure it with the mainshaft snap ring.



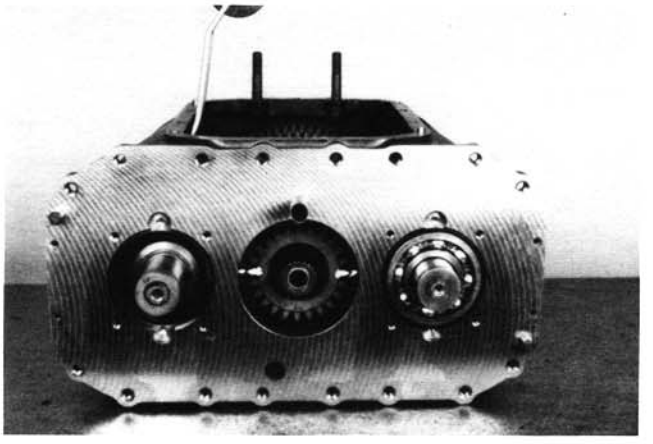
10. Slide the output bearing onto the shaft with a suitable driver. It is properly seated when the snap ring seats against the case.



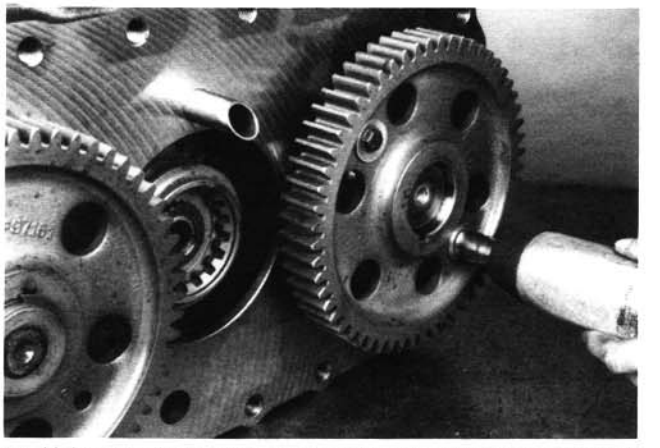
11. With the help of a lift hook, set the countershafts in time by matching the alignment marks.



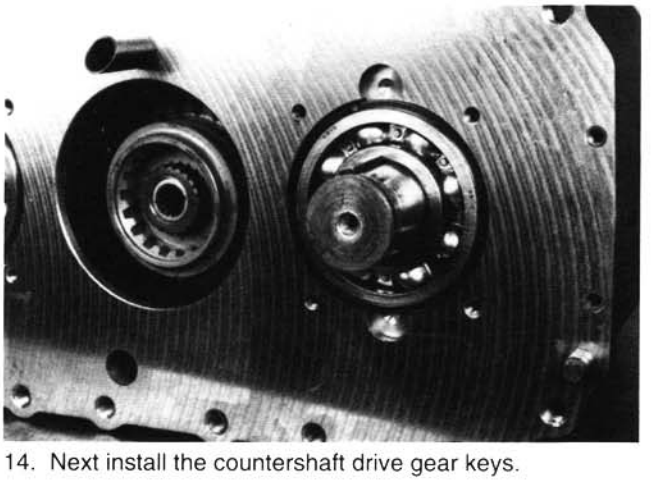
12. Install both the front and rear bearings on one of the countershafts.



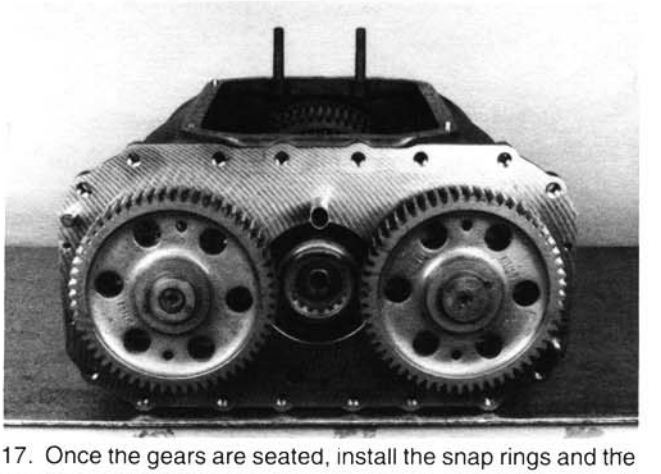
13. Repeat the procedure for the remaining countershaft.



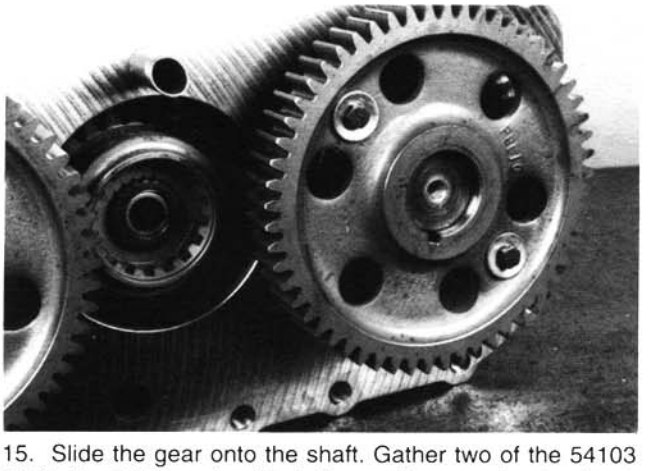
16. Using the alternating method, draw the gear onto the shaft until it is seated behind the snap ring groove. Repeat this method for the other gear.



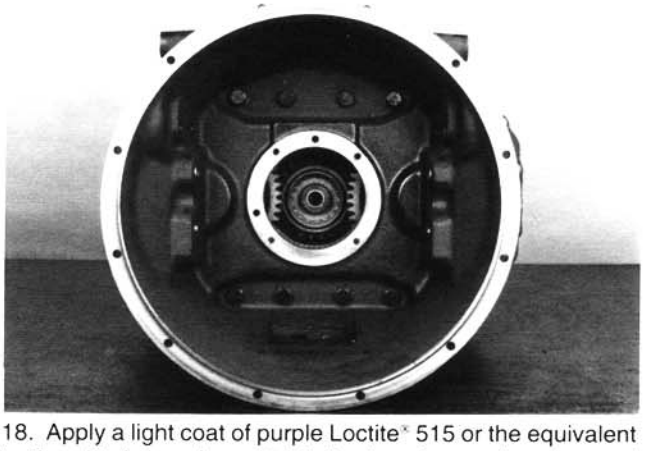
14. Next install the countershaft drive gear keys.



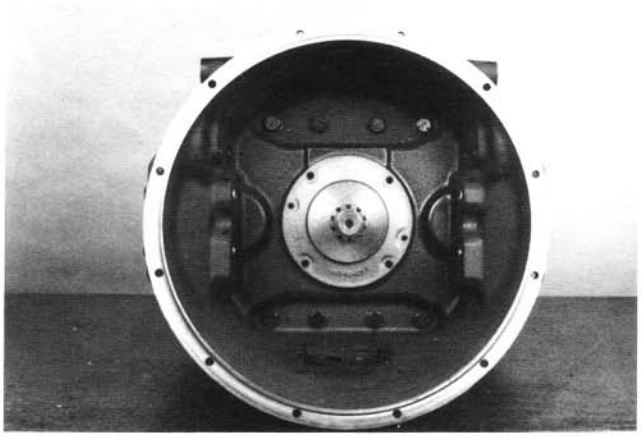
17. Once the gears are seated, install the snap rings and the 6th-7th clutch collar.



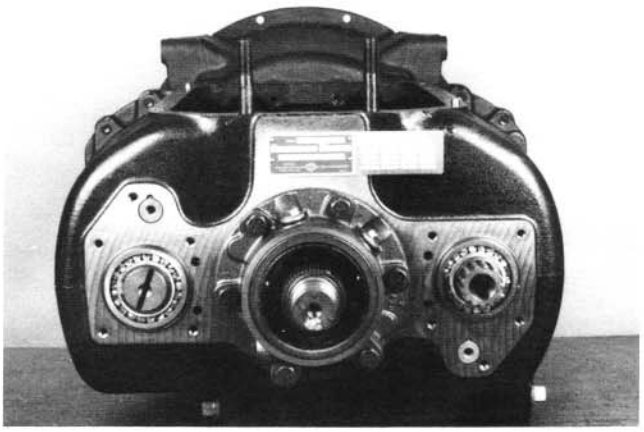
15. Slide the gear onto the shaft. Gather two of the 54103 (.375-16 x 3.00) grade eight bolts used for securing the clutch housing to the case. Place these in the two bolt holes in the gear, and thread them into the tapped installation holes provided in the case.



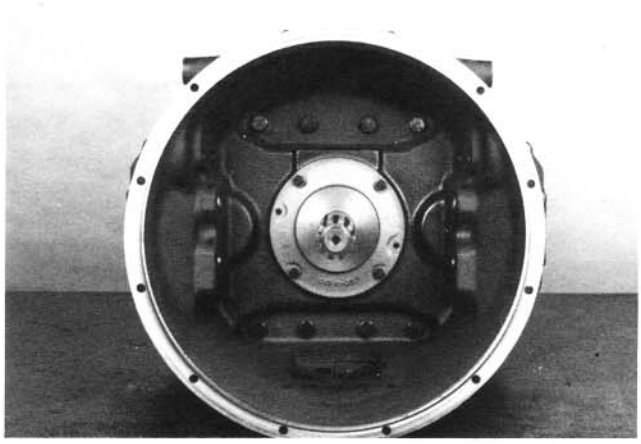
18. Apply a light coat of purple Loctite® 515 or the equivalent to the clutch housing. Attach the housing to the case and secure it with cap screws. Torque them to 150 - 180 ft. lbs.



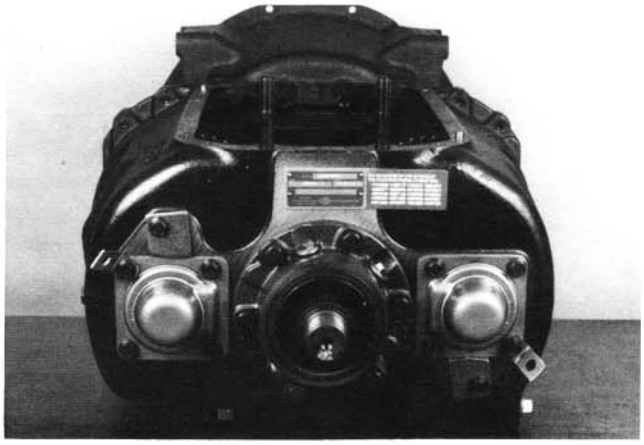
19. Lubricate the pocket bearing with Moly #2 before installing the input shaft.



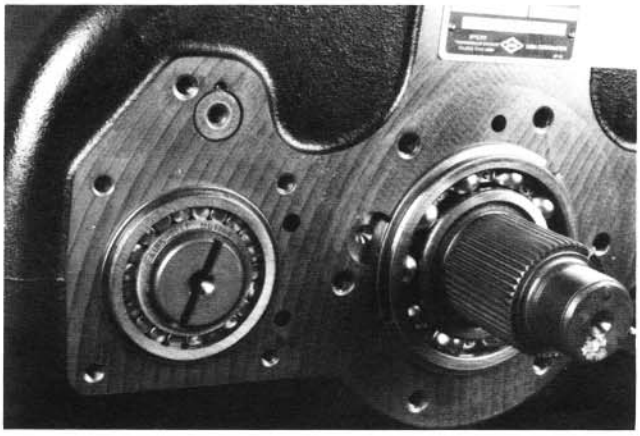
22. The output bearing cap and gasket may be assembled to the case. Torque the cap screws to 78 - 98 ft. lbs.



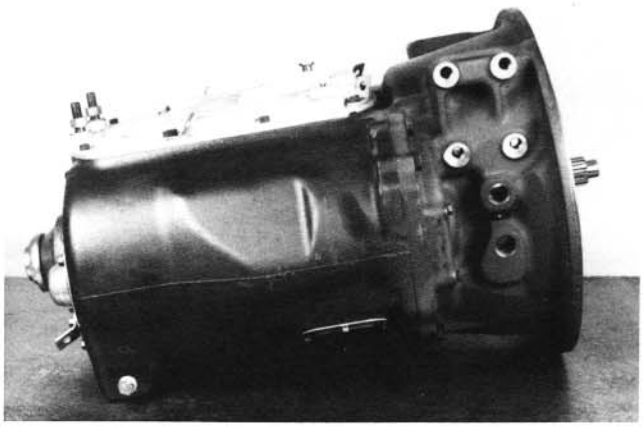
20. Place the input bearing cap and gasket over the input shaft. Be careful to align it with the clutch housing oil hole. Torque the cap screws to 34 - 41 ft. lbs.



23. Place the countershaft bearing caps on the case and secure them with cap screws. Torque to 34 - 41 ft. lbs.



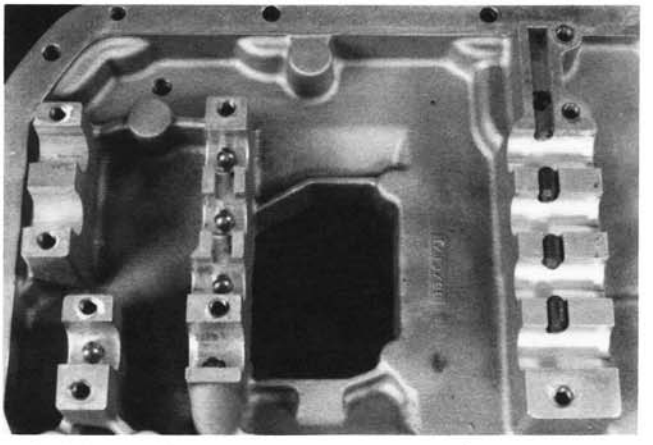
21. Install the upper reverse idler shaft. *Note: It is difficult to align the gear with the case hole unless the input shaft is in the unit. It is also necessary to lift up on the mainshaft reverse gear to obtain proper alignment.*



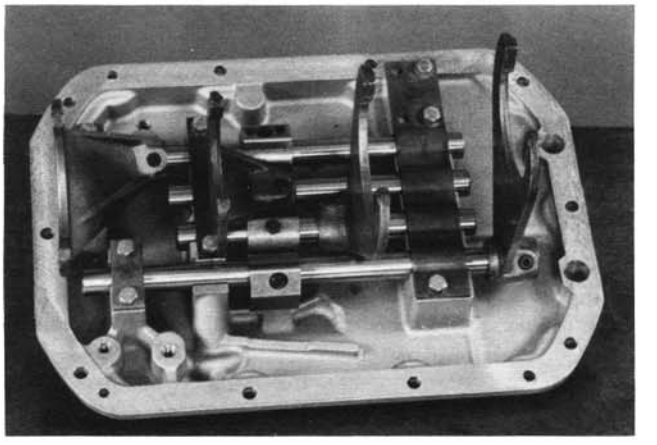
24. Install the shifter housing and secure it with cap screws. Torque to 34 - 41 ft. lbs.

SHIFTER HOUSING REASSEMBLY

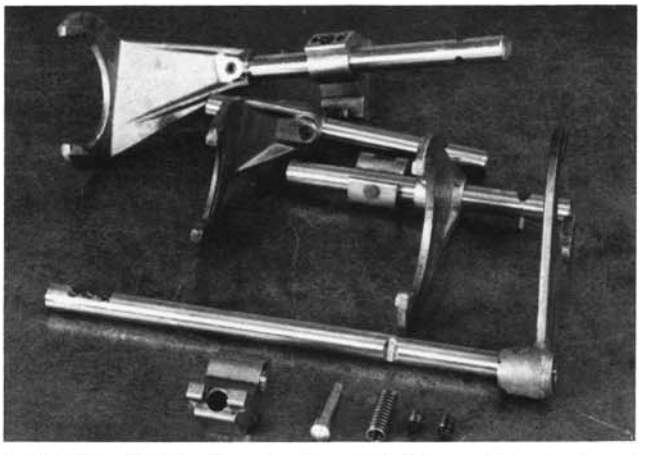
SECTION XII



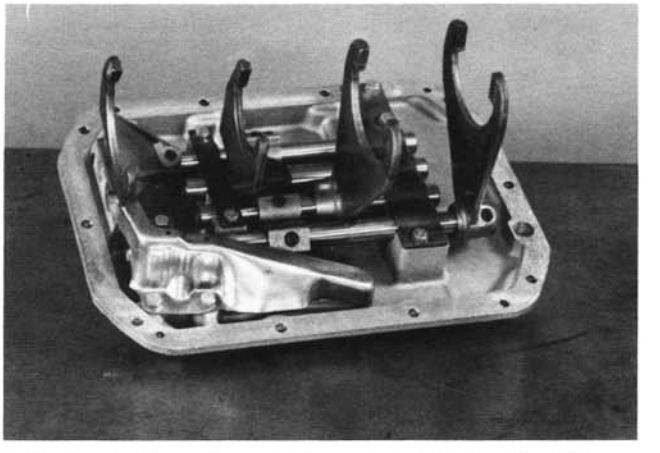
1. Lubricate all parts prior to reassembly. Clean the cover, then install the springs, poppets, and interlocks.



3. Place the fork assemblies into the case. Secure them with the retainer straps. Torque the strap bolts to 34 - 41 ft. lbs. Move each rod in the cover to confirm that it is moving freely.



2. Reassemble the forks and brackets. Torque the allenhead setscrews to 26 - 32 ft. lbs. Torque the 2nd-3rd bracket screws to 13 - 18 ft. lbs.



4. Next install the oil trough. Torque the bolts to 34 - 41 ft. lbs. Check the cover for correct functioning by shifting one fork into gear. If all interlocks were installed correctly, none of the other forks will shift into gear.

Remote Control Reassembly

1. Install a new key into the rod and bracket assembly. Install the assembly into the remote housing, sliding the shift finger (inner shaft) on the end of the rod.

2. Line up the setscrew hole and install the setscrew. Torque it to 40 - 50 ft. lbs.

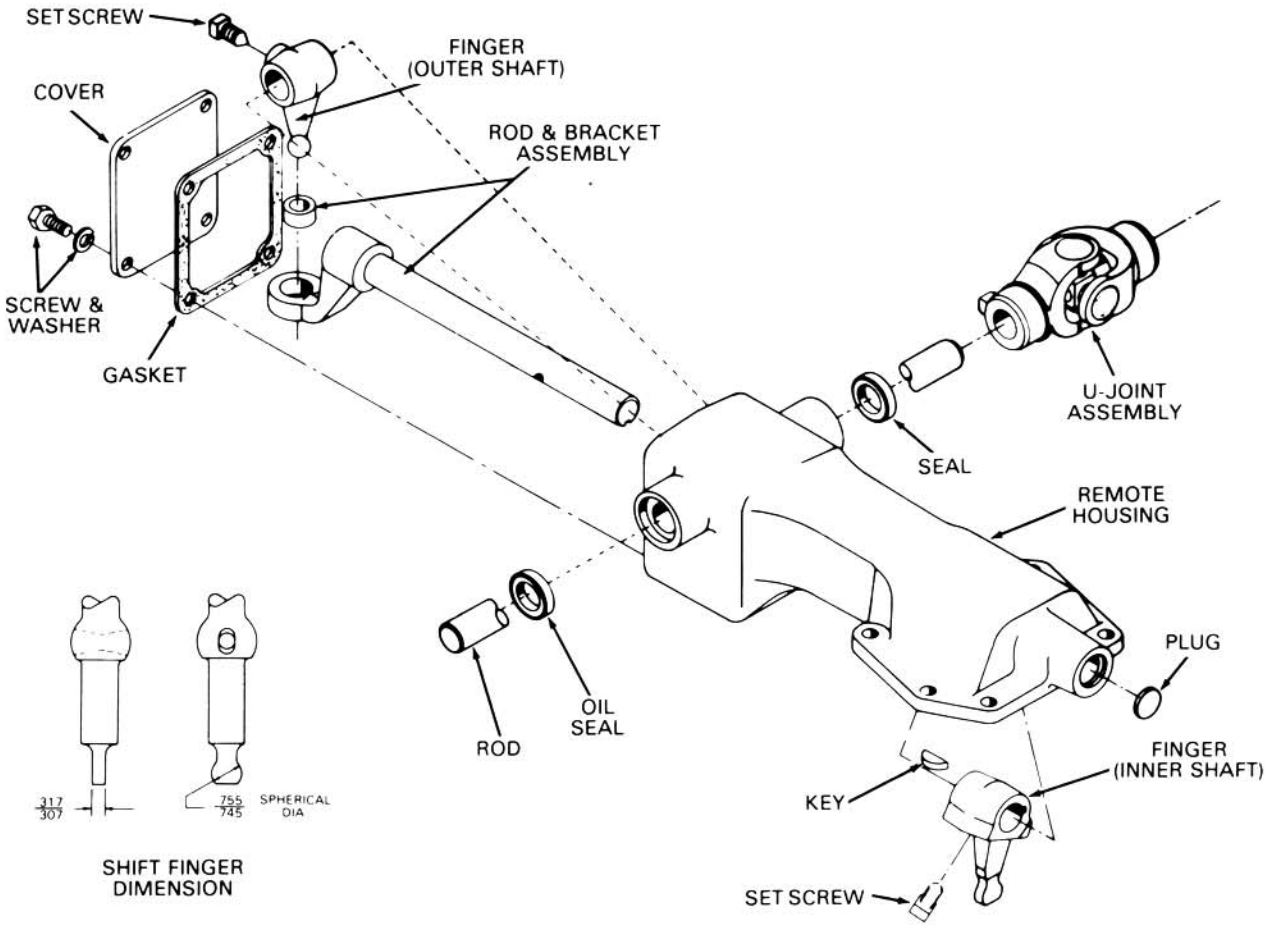
3. Install the joint shift rod through cross holes and outer finger, making sure the finger is inserted into the bracket.

4. Align the setscrew holes and install the setscrew. Torque it to 40 - 50 ft. lbs.

5. Install the end cover. Secure it with four cap screws and lockwashers.

6. Install two new oil seals in the joint shift rod bores.

7. Install the joint assembly. Secure it with a setscrew.



Shift Tower Reassembly

1. Position the shift lever tower on edge in a vise.

2. Hold the shift lever so the cross hole in the lever aligns with the rock shaft cross holes in the tower.

3. Insert the rock shaft through the hole in the tower and the cross hole in the shift lever.

4. Assemble the rock shaft snap ring to the groove of the tower. Lock the rock shaft in place.

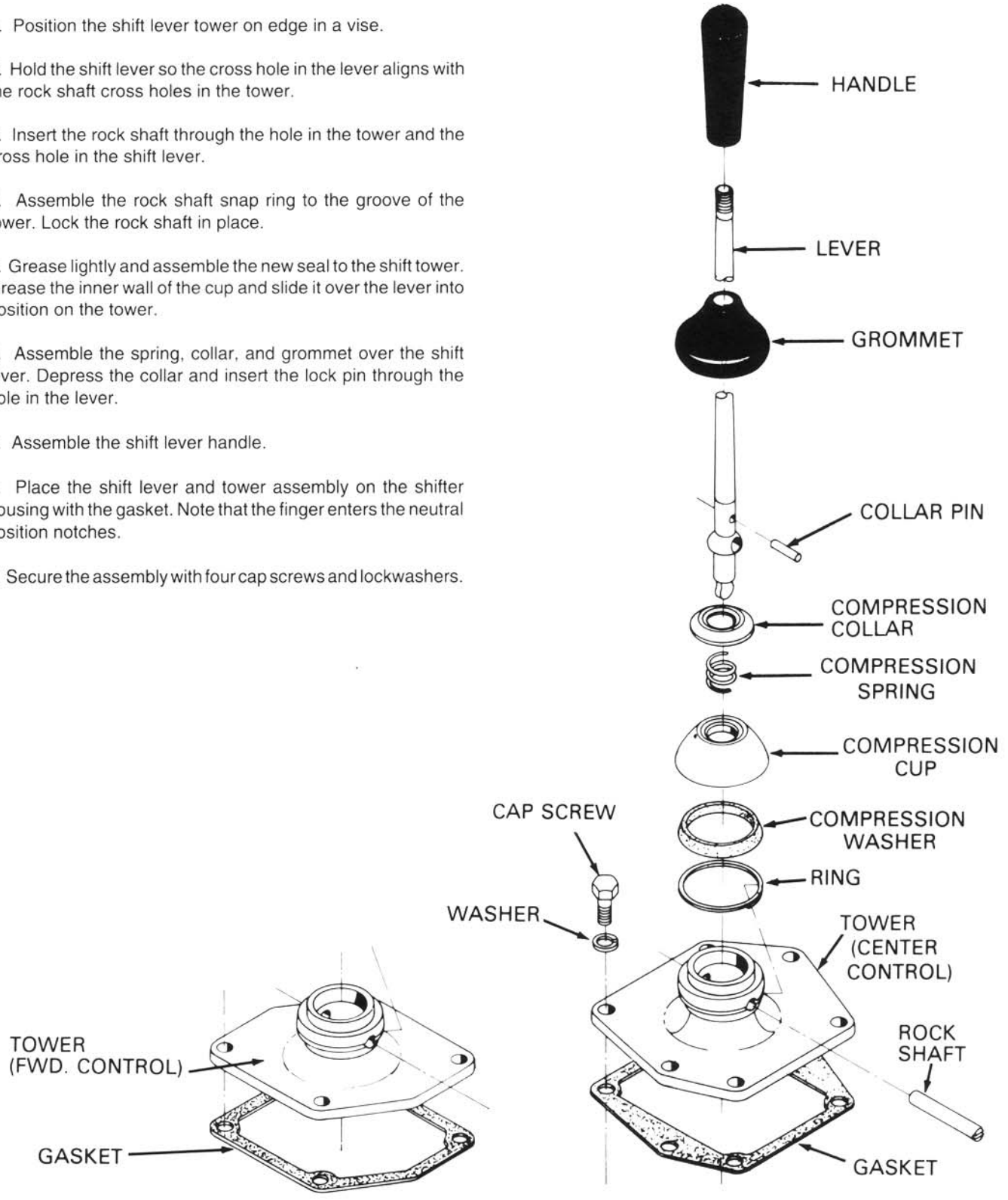
5. Grease lightly and assemble the new seal to the shift tower. Grease the inner wall of the cup and slide it over the lever into position on the tower.

6. Assemble the spring, collar, and grommet over the shift lever. Depress the collar and insert the lock pin through the hole in the lever.

7. Assemble the shift lever handle.

8. Place the shift lever and tower assembly on the shifter housing with the gasket. Note that the finger enters the neutral position notches.

9. Secure the assembly with four cap screws and lockwashers.



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 plane 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 operating 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, 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 likely offender.

(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 can 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.

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) Cap screws loose, omitted or missing from remote control, shifter 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 in 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.

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:

(a) 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.*

(b) No lubrication in, or grease fittings on, u-joints or swivels of remote controls.

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

(d) Badly worn or bent shift forks.

(e) Improper adjustment on shifter linkage.

(f) Sliding clutch gears tight on splines of shaft.

(g) Clutch teeth burred over, chipped or badly mutilated because of improper shifting.

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

(j) Clutch dragging.

(k) Free running gears seized or galled on either the thrust face or diameters.

Sticking in Gear

(a) 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.* **Do not leave these vehicles parked in gear.**

(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 shifter 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 common 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 addition or change of lubricant.

Softer material, such as dirt or dust, usually forms abrasive paste or lapping compounds within the bearings. 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. The result is that 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. 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 interchangeability tables and use the proper bearings for replacement parts.

Clutch Troubleshooting

Faulty clutch operation interferes with proper shifting of gears in any transmission. The most common problems encountered with clutches are as follows.

(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.

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