

**ES65-5, CM50  
TRANSMISSION  
SERVICE MANUAL**

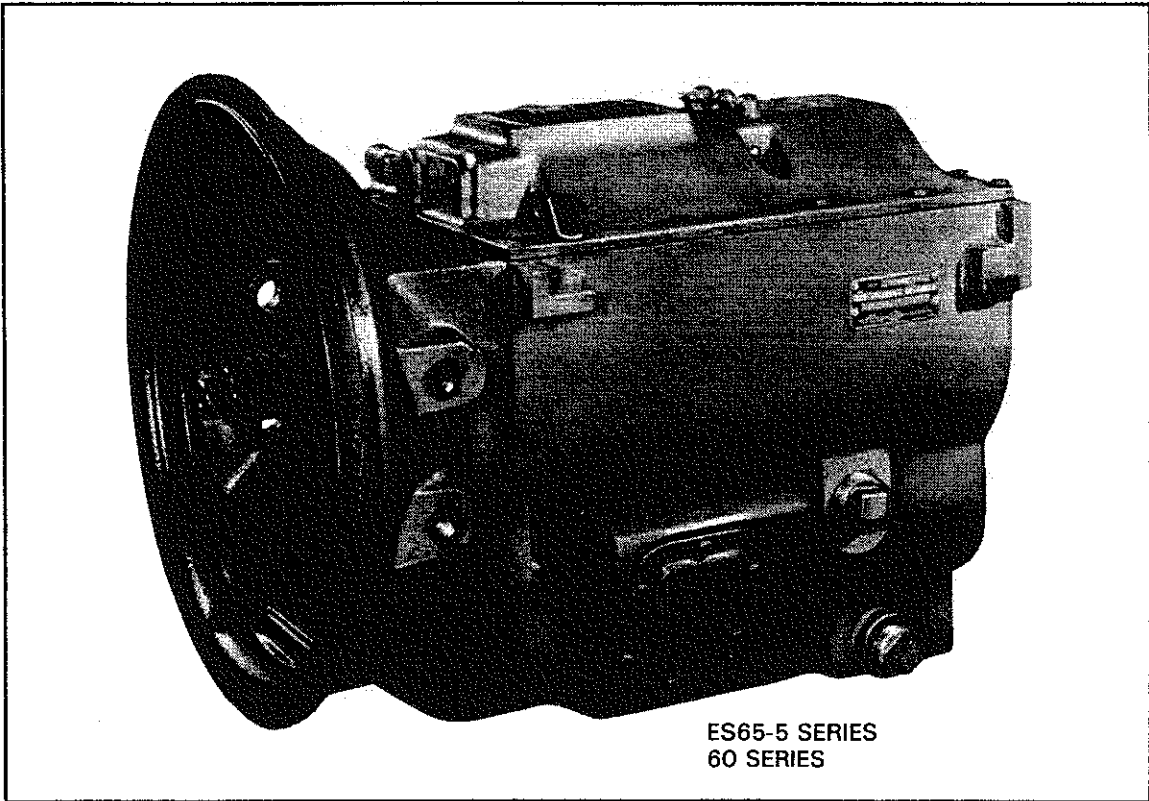
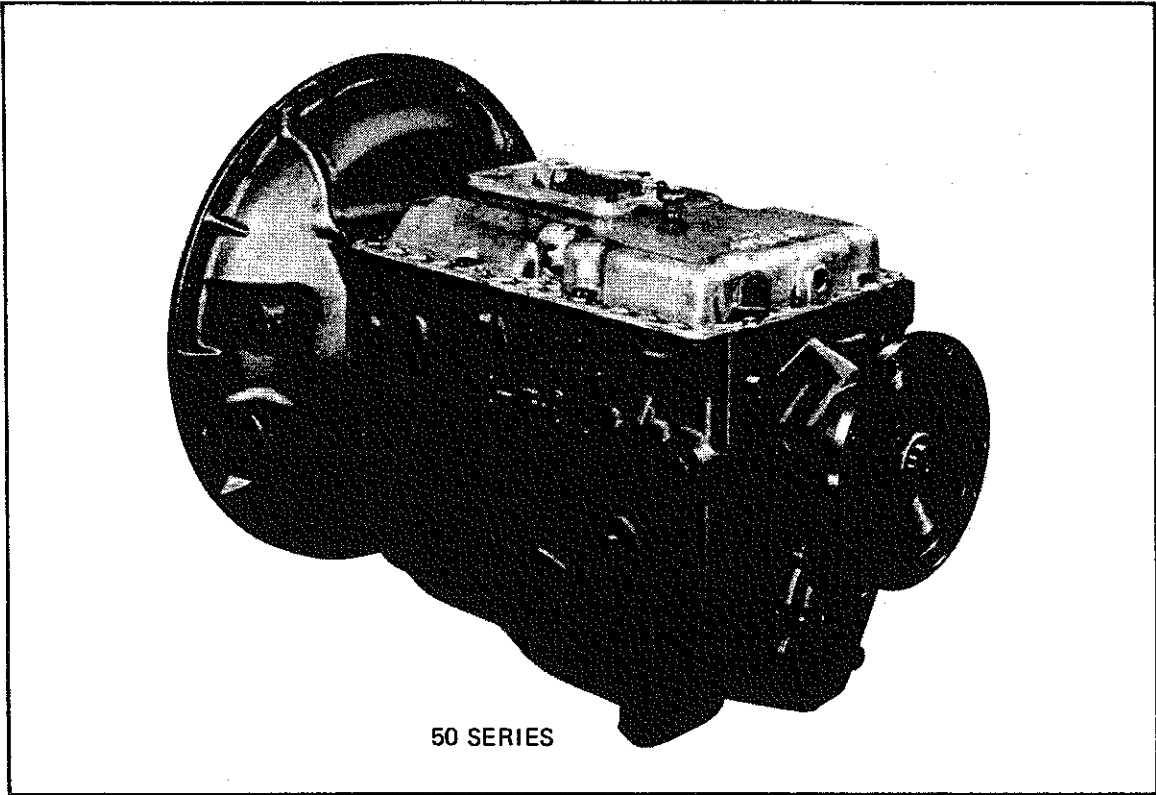


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*Technology in Motion®*



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# ES65-5, CM50, AND CM60 TRANSMISSIONS

## GENERAL SERVICE AND MAINTENANCE RECOMMENDATIONS

### LUBRICATION

#### General Information

The ES65-5, CM50, and CM60 series transmissions utilize splash lubrication for all internal bearings, shafts and gears. To ensure proper lubrication and operating temperatures, it is most important to use the recommended lubricants and maintain correct oil levels.

#### Recommended Lubricants

The following lubricants are recommended for use in all Spicer unit power mechanical transmissions, auxiliaries and transfer cases.

TEMPERATURE	GRADE	TYPE
ABOVE 0°F (-18°C) BELOW 0°F (-18°C)	SAE 30, 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

DO NOT USE EXTREME PRESSURE ADDITIVES, such as found in multi-purpose or rear axle type lubricants. These additives are not required in Spicer transmissions, 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 steel and bronze parts.

#### CAPACITIES\*

CM50 17 pints at 0° installation

ES65-5 18 pints at 0° installation  
CM60

\*Capacity will vary with, and is dependent upon, the angle of installation.

#### Oil Changes

We recommend an initial oil change and flush after the transmission is placed in actual service. This change should be made any time following 1000 miles, but never to exceed 4000 miles, of over-the-road service. In off-highway use, the change should be made after 24 and before 100 hours of service have elapsed. There are many factors that influence the following oil change periods, and we have not specified a definite mileage interval.

In general, it is suggested that a drain and flush period be scheduled every 20,000 miles for normal over-the-highway operations. Off-the-highway usually requires oil change every 30 days. The oil level in the transmission should be checked every 2,000 miles on-highway, or every 24 hours in off-highway operation. The correct oil level in all Spicer transmissions is established by the filler plug opening.

**REFILL** – First, remove all dirt around the filler plug. Then refill with new oil of a grade recommended for the existing season and prevailing service. Fill to the bottom of the level testing plug positioned on the side of the transmission.

#### Overfilling

Do not overfill the transmission. Overfilling 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. Overflow of oil usually escapes onto clutch or parking brakes, causing additional trouble.

### TOWING CAUTION

Do not tow vehicles equipped with Spicer transmissions without first pulling the axles or disconnecting the drive shaft. Lubrication of the internal gear train is inadequate when the vehicle is towed.

# ES65-5, CM50, AND CM60 TRANSMISSIONS

## COMPARISON CHART

	CM50	ES65-5 AND CM60
OVERHEAD CONTROL	Similar	Similar
SHIFTER HOUSING	Similar	Similar
REVERSE IDLER	Similar	Similar
DRIVE GEAR	Internal Bearing Cup	Separate Bearing Cup
MAINSHAFT ASSEMBLY		
Mainshaft	Plain	"Fluted" for 3rd, 4th speed gears
2nd-3rd Speed Clutch Gear	Keyed to mainshaft	Splined to mainshaft
2nd Speed Gear	Loose needle bearings	Needle bearings
3rd Speed Gear	Retained by snap ring	Retained by 4th speed gear fluted sleeve
COUNTERSHAFT ASSEMBLY		
Spacer	Located at front bearing cap.	None
4th Speed Gear	Retained by 4th speed gear snap ring	Retained by drive gear snap ring

## OVERHAUL PROCEDURES

1. This service manual explains how to overhaul the ES65-5, CM50 and CM60 series 5-speed transmissions. As indicated by the comparison chart, they share many similar parts and are of similar design. A CM50 model is used to illustrate procedures that apply to both transmissions. Minor differences should be obvious. Major differences in the mainshaft and countershaft are illustrated in a separate section for ES65-5 and CM60 (pages 32-41).
2. All disassembly and assembly operations can be performed on a plain workbench. However, a vise and/or a 5" diameter hole in the top of the workbench will make much of the work easier and quicker.
3. To avoid distorting snap rings, do not expand them excessively.

### CAUTION

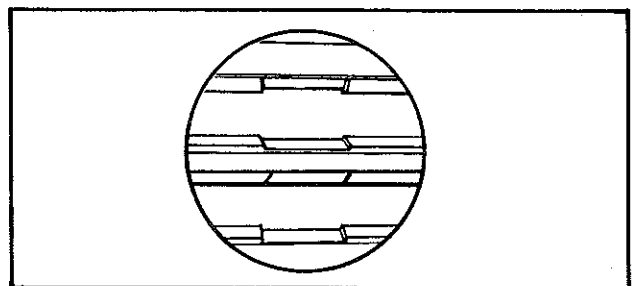
4. Don't over-torque bolts. This may compress gaskets too much, which may put extra loads on the tapered bearings. (NOTE: Spicer 5000, 6000 and ES65-5 series 5-speed transmissions use ball bearings that could tolerate excessive torque.)

### 5. During reassembly:

- Before pressing gears on countershaft, coat bores with white lead.
- Lubricate all caged bearings and loose needle bearings with light grease only.
- Lubricate all thrust or sliding surfaces with light grease or 30W motor oil.

## MAINTENANCE

Remove old gaskets or sealing compound. Clean all parts and dry with compressed air. Inspect the gears, bearings, thrust washers, spacers and all mating surfaces for wear, chipping, burrs and brinelling that may indicate a part malfunction or a problem with misalignment, lubrication or excessive end play. Check the Woodruff keys for burrs. Clean up edges with a mill file to prevent chips and slivers from peeling off and lodging between gear thrust faces. Also check snap rings for stiffness and distortion that may limit their ability to retain gears securely. If there is any doubt about the condition of a part, replace the piece to avoid the possibility of an earlier than normal service interval.



Spicer "Gear Lock"

**CAUTION: THIS IS NOT A WORN OR CHIPPED GEAR. DO NOT GRIND IT DOWN OR DISCARD THE GEAR.**

The splines of many Spicer mainshafts and clutch gears feature a machined relief called a "gear lock" to keep gears engaged. For instance, with the clutch collar in the engaged position, the mating gear is free to slip into this notch, thus preventing the two gears from "walking out of gear" under load.

# OVERHEAD CONTROL

## DISASSEMBLY

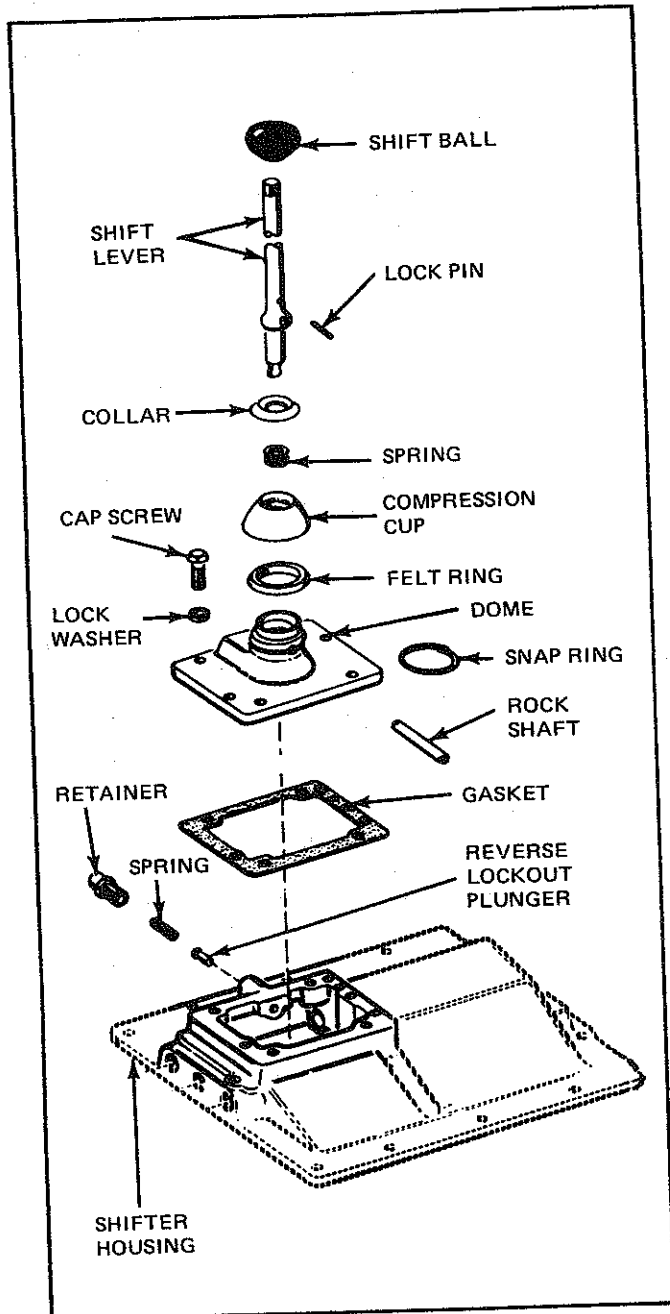


Figure 1 – Overhead Control Components

1. Remove the 1st-reverse lockout plunger retainer, spring and plunger from shifter housing before removing the dome assembly.
2. Remove retaining cap screws and lock washers. Separate dome from shifter housing and gasket, then lift straight up.

3. Position dome on edge in vise.
4. Depress collar against spring and remove lock pin.
5. Slide compression cup up the shaft and remove rock shaft snap ring.
6. Tap rock shaft free of dome and remove shift lever and felt ring.
7. Remove shift handle or ball. Slide collar, spring and cup off lever.

## INSPECTION

1. Wash all parts thoroughly and inspect for excessive wear at cross hole in lever and rock shaft.
2. Inspect finger end of shift lever for excessive wear. See Figure 2 for original contour.
3. Check spring tension by comparing to a new part.
4. Replace seal.

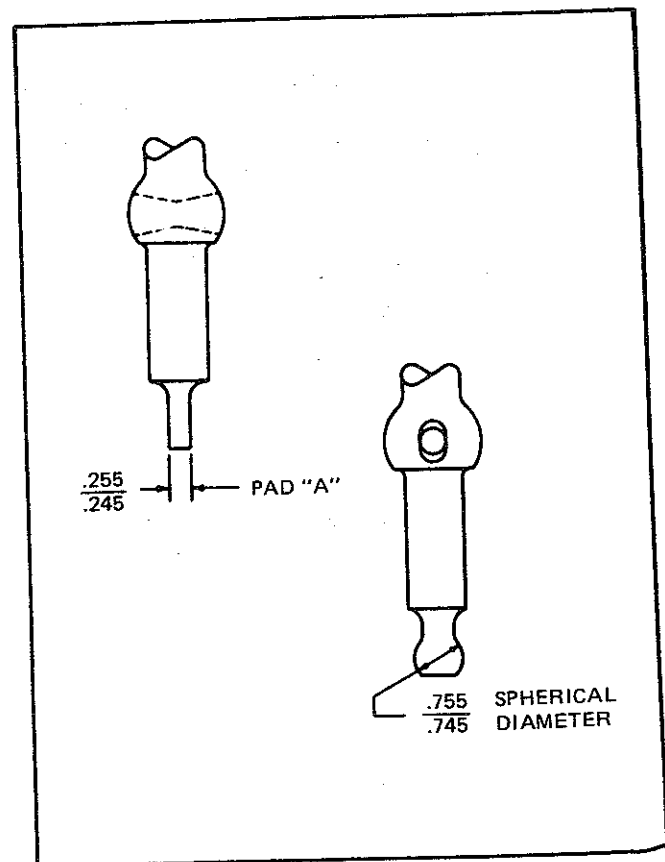


Figure 2 – Shift Lever Finger

# OVERHEAD CONTROL

## REASSEMBLY

1. Position dome on edge in vise.
2. Position shift lever in dome so that slot in lever aligns with the rock shaft cross holes.
3. Align slot and start rock shaft through hole in dome and slot of shift lever.
4. Assemble rock shaft snap ring to groove of dome and lock rock shaft in place.
5. Grease lightly and assemble new seal to dome. Grease inner wall of cup and slide down over lever into position on dome.
6. Assemble spring and collar to lever. Depress collar and assemble lock pin through hole in shift lever.
7. Assemble shift handle to end of lever.

## Assemble Overhead Control to Shifter Housing

1. Place transmission in neutral so that slots of forks and brackets align.
2. If dome assembly also serves as cover plate for shift rod poppet balls and spring, check to determine that balls and springs are in place.
3. Use light coat of grease to locate and assemble gasket to shifter housing opening.
4. Assemble shift lever and dome assembly to shifter housing, with shift lever finger positioned in the neutral notches.
5. Secure with 6 cap screws and 6 lock washers.
6. Assemble lockout plunger to shifter housing. Secure and preload with spring in retainer.
7. Check shifting of transmission into all gear positions to verify workmanship.

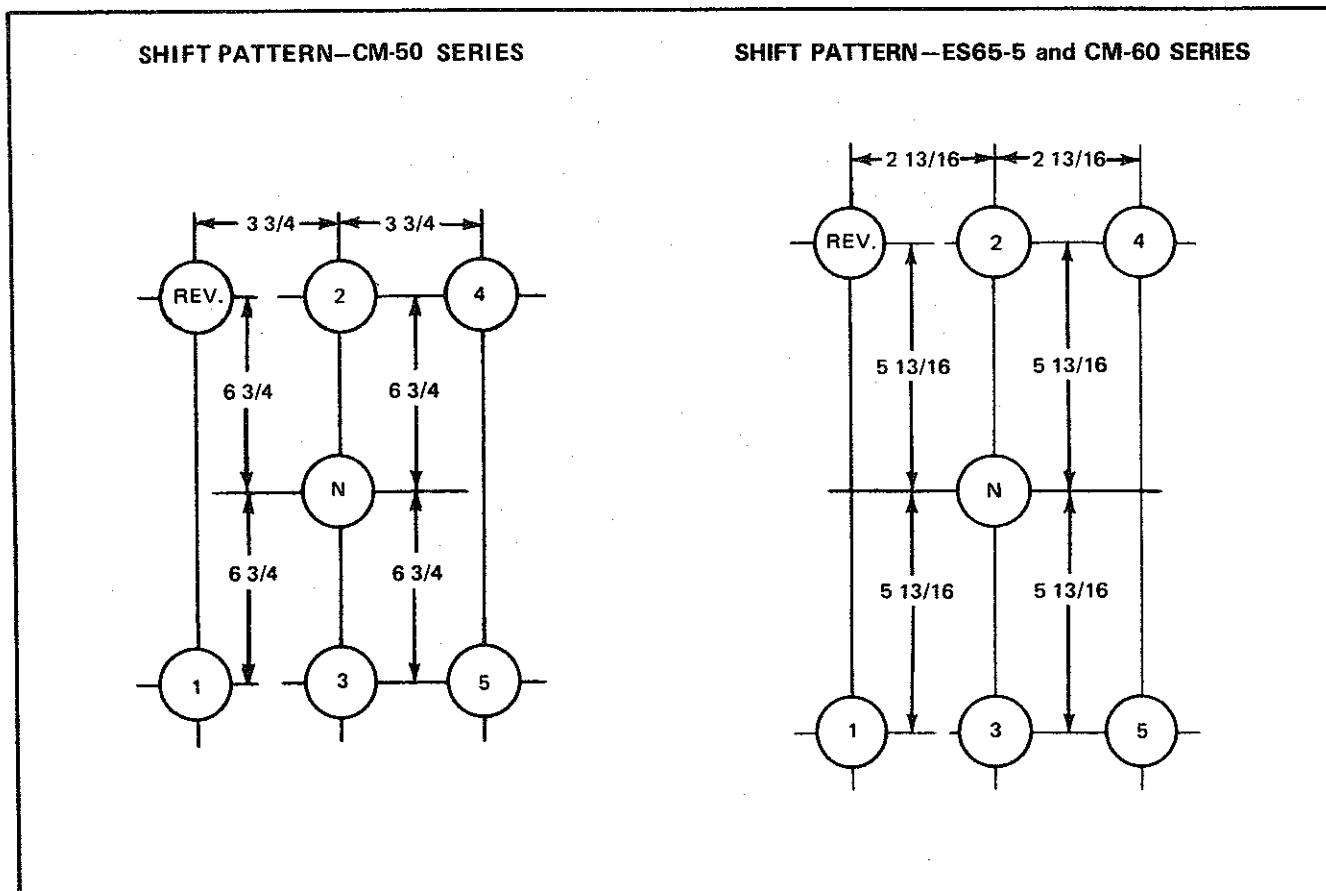


Figure 3 — ES65-5, CM50 and CM60 Shift Patterns

# SHIFTER HOUSING

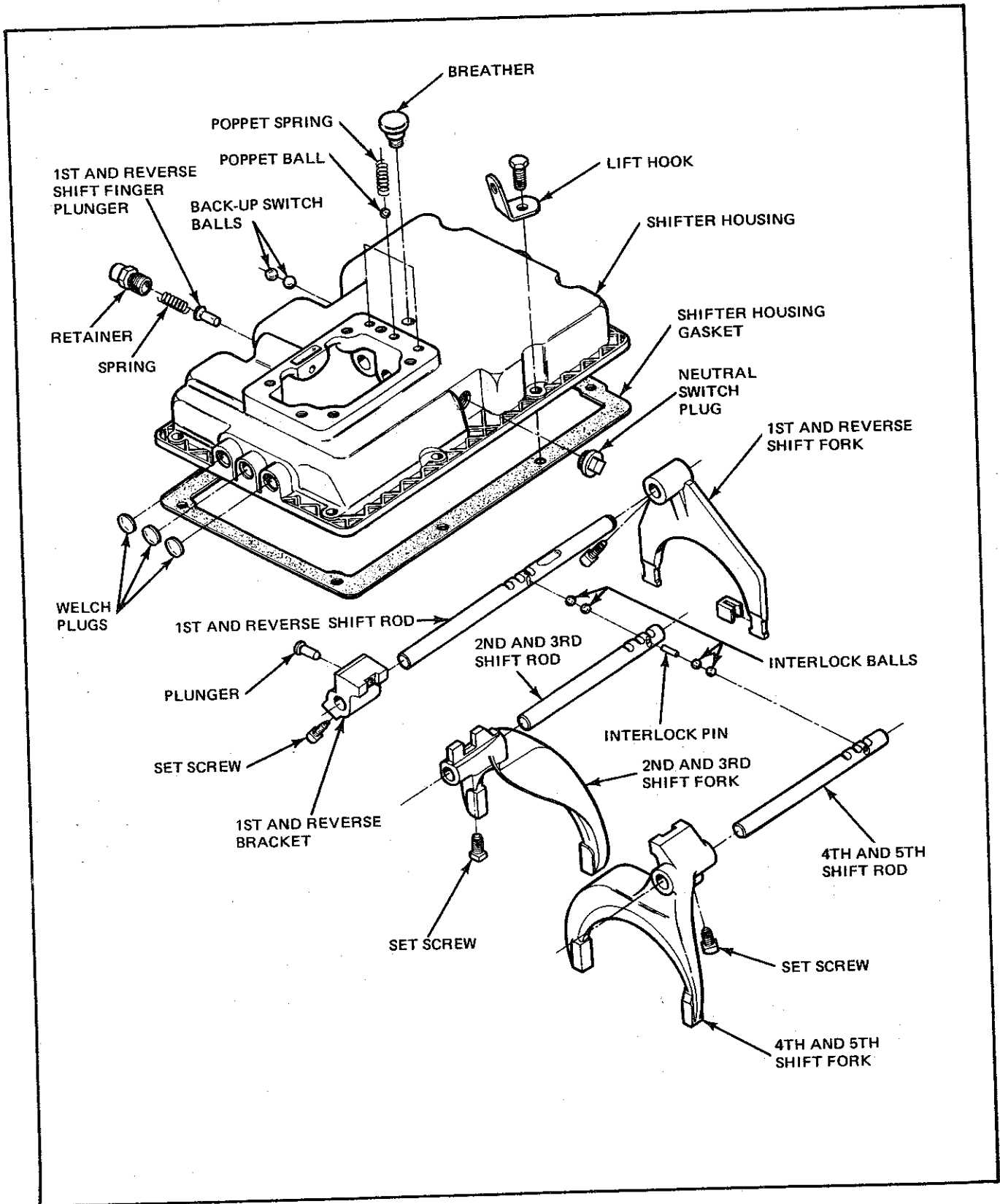


Figure 4 - CM50 Transmission Shifter Housing Parts



# SHIFTER HOUSING

## DISASSEMBLE SHIFTER HOUSING

### NOTE

If overhead control is installed, see page 6 for removal instructions.

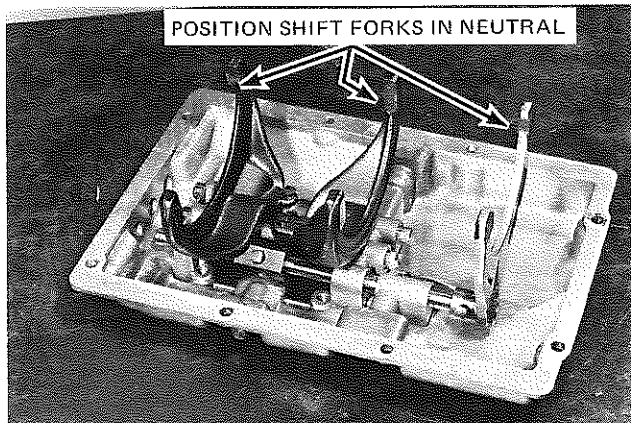


Figure 5 — Preparing To Remove Shifter Rails

Remove three sets of shift rail poppet springs and balls from top of shifter housing. Then, position housing upside down on bench. Before starting to remove the shift rails, position the 1st-reverse and 2nd-3rd shift forks in neutral.

### CAUTION

When the shift rails are removed, the interlock balls and pin (2nd-3rd rail only) may fall out. Watch for them to avoid loss. Remove the 1st-reverse lockout plunger, spring and retainer before turning shifter housing upside down.

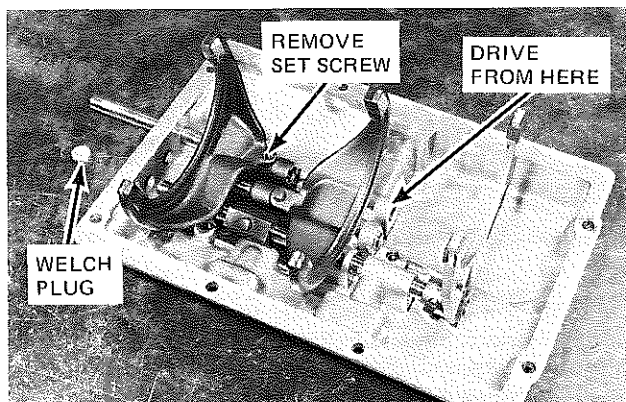


Figure 6 — Removing 4th-5th Shift Rail

Remove set screw from 4th-5th shift fork. Tap rail forward with a drift, until end of rail pops Welch plug from housing. Complete removal by hand, then lift out shift fork.

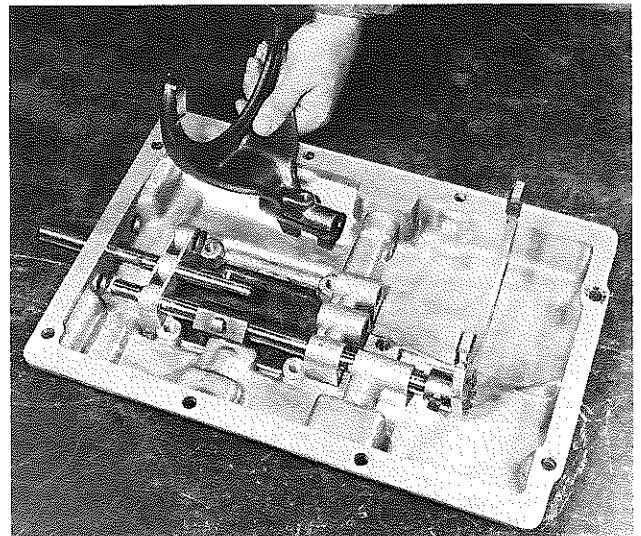


Figure 7 — Removing 2nd-3rd Shift Rail

Remove set screw from 2nd-3rd shift fork. Tap rail forward with a drift, until end of rail pops Welch plug from housing. Complete removal by hand, then lift out shift fork.

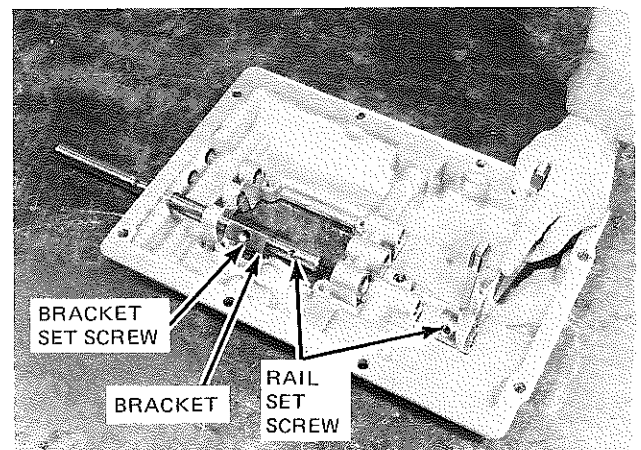


Figure 8 — Removing 1st-Reverse Shift Rail

Remove set screws from bracket and shift rail. Tap rail forward with a drift, until end of rail pops Welch plug from housing. Slide rail forward out end of housing and remove bracket and fork. **NOTE:** Do not lose second lockout plunger located in cross hole of 1st-reverse shift bracket.

# SHIFTER HOUSING

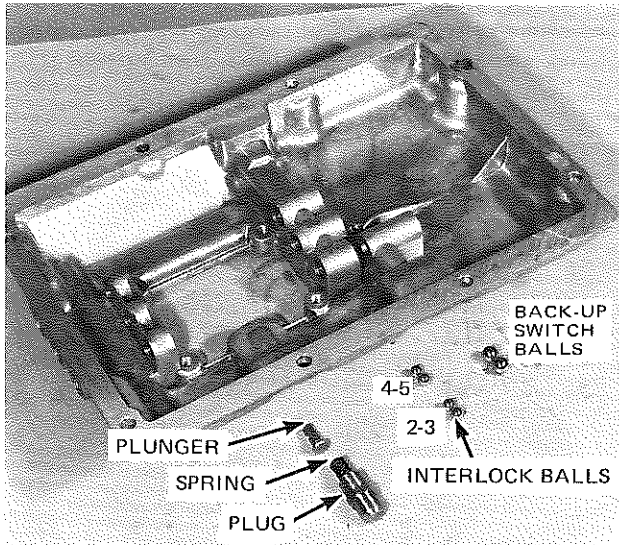


Figure 9 – Shifter Lockout Parts

If not previously removed, remove the interlock balls. Remove the plug or back-up switch to remove the reverse back-up switch balls. NOTE: Back-up switch is supplied by the O.E.M.

## Maintenance

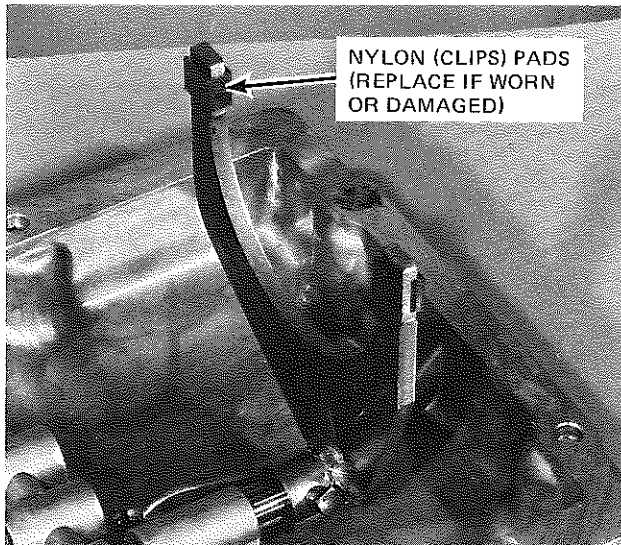


Figure 10 – Inspect Nylon Shift Pads

Remove old gaskets or sealing material from machined surfaces and steam clean shifter housing. Wash all shifter housing parts, dry with compressed air and examine for wear before reassembly. Be sure and replace shift fork pads, if they show wear or damage.

## ASSEMBLE SHIFTER HOUSING

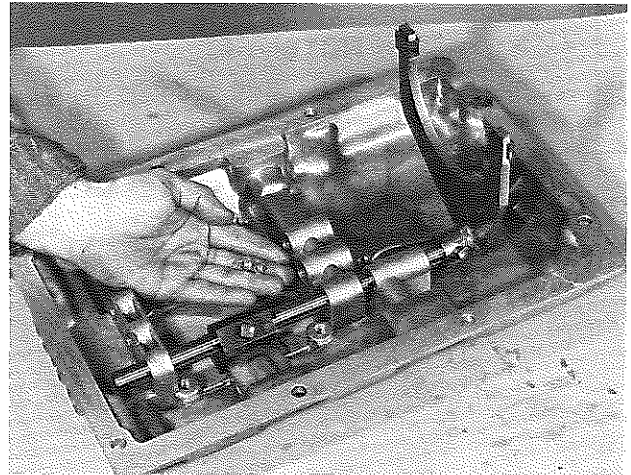


Figure 11 – Assembling 1st-Reverse Rail

First, install a lockout plunger in the 1st-reverse shift bracket. Lubricate the 1st-reverse rail, then slide part way into housing. Align bracket with rail, then slide rail through bracket and remaining bosses. Install fork and both set screws. Tighten to 40-50 lbs. ft. torque. With 1st-reverse in neutral (all rails are loose until poppet balls and springs are installed and overhead control is assembled), install 2nd-3rd interlock balls, which will seat in position.

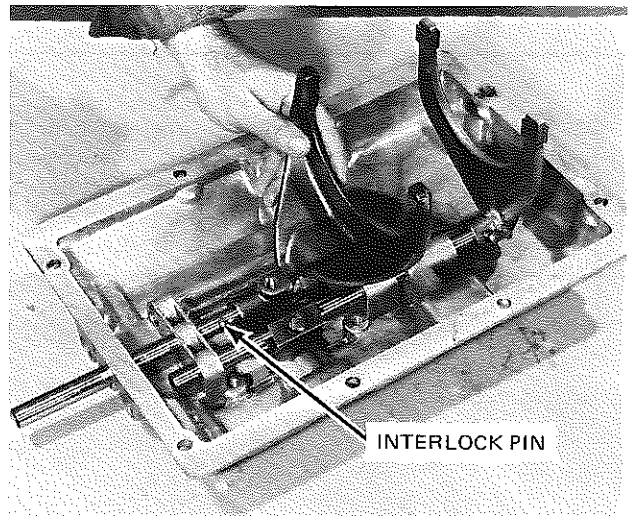


Figure 12 – Assembling 2nd-3rd Rail

Lubricate 2nd-3rd rail and slide part way into housing. Install interlock pin and hold in place with heavy grease. Align fork with rail and slide rail into boss until in detent position. Install set screw and tighten to 40-50 lbs. ft. torque.

# SHIFTER HOUSING

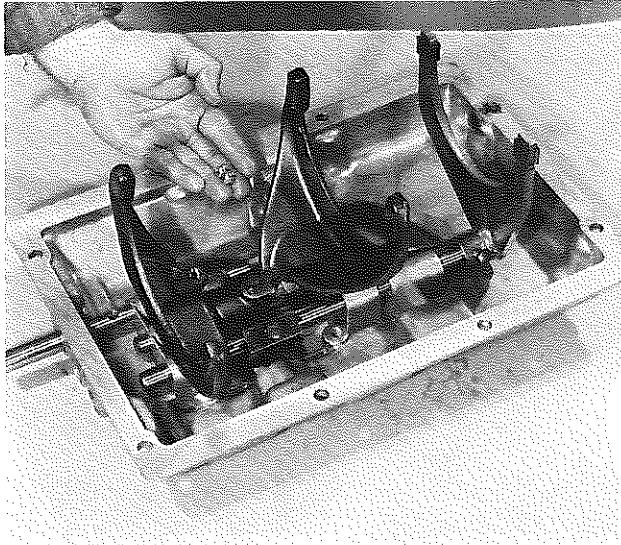


Figure 13 – Assembling 4th-5th Rail

With 2nd-3rd rail in the neutral position, install the interlock balls in the cross-hole of the 4th-5th shift rail boss. Seat the interlock pin and balls in the neutral notch of the 2nd-3rd rail. Slide the 4th-5th rail into position and install the fork and set screw. Tighten 40-50 lbs. ft. torque. Install 1st or reverse lockout plunger, spring and retainer. Check the movement of each rail for proper operation.

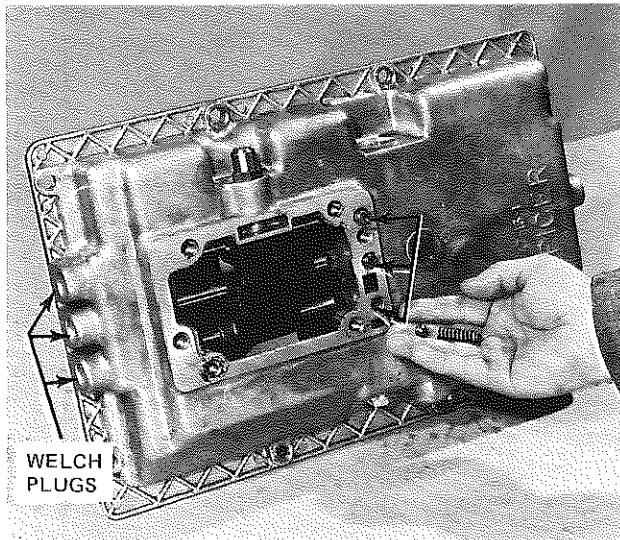


Figure 14 – Assembling Poppet Balls, Springs and Welch Plugs

Install the three Welch plugs into the shift rail openings at the front of the housing. Install the three poppet balls and springs in the top of the housing.

## ASSEMBLE SHIFTER HOUSING TO TRANSMISSION

Use light coat of cement and assemble shift cover gasket to transmission case. Position shifter forks and transmission clutch collars in neutral. Set shifter housing into position on case and make sure all three shift forks are in their proper place in corresponding shift collar. Secure shifter housing to main case with cap screws. Use large screw driver or small pry bar and check movement of each shift rod to make sure transmission will shift readily and completely into each gear position. Make sure the three poppet balls and springs are in proper locations in top of shifter housing over shift rods. Assemble remote or overhead control to shifter housing (see page 7).

# GEARS AND CASE

## DISASSEMBLE TRANSMISSION

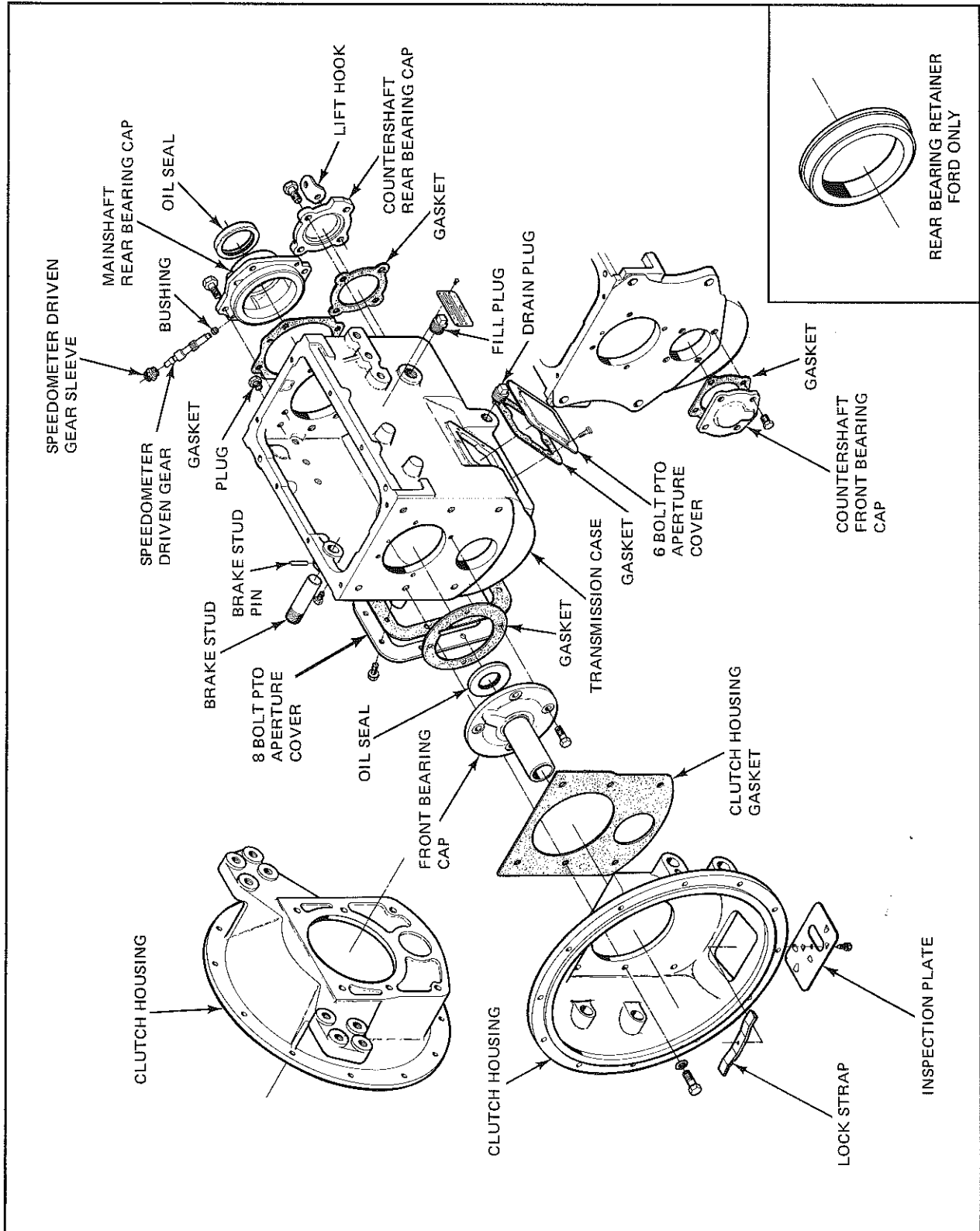


Figure 15 — CM50 Transmission Case, Bearing Caps and Related Parts

# GEARS AND CASE

## DISASSEMBLE TRANSMISSION Shifter Housing Removal

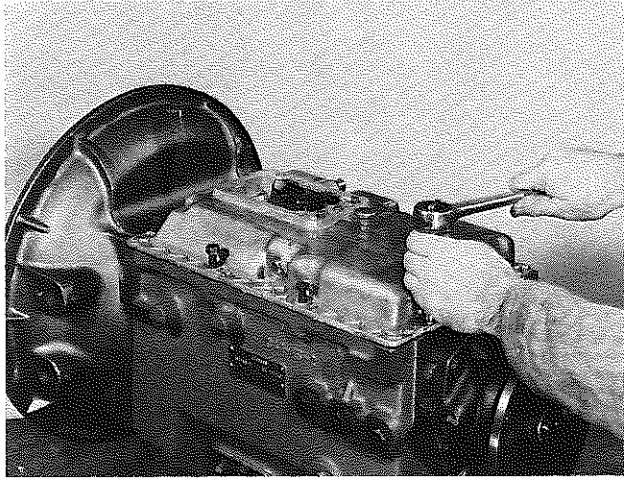


Figure 16 — Loosening Cap Bolts

Remove the eight cap screws that retain the shifter housing to the transmission case.

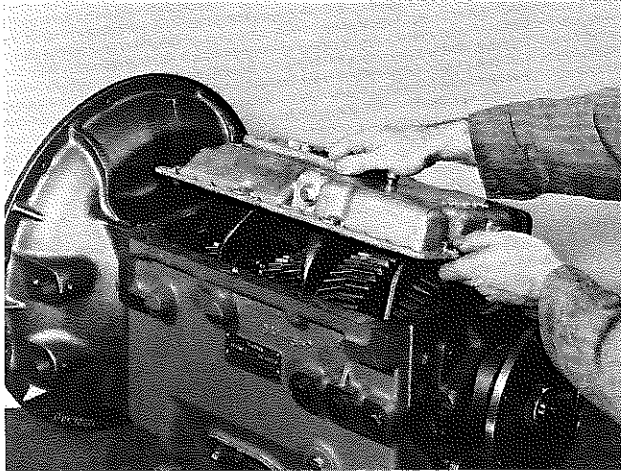


Figure 17 — Removing Shifter Housing

Lift the shifter housing up and off the transmission case. **CAUTION:** Be careful not to lose the three poppet balls and springs from the top of the shifter housing.

## Gear Removal

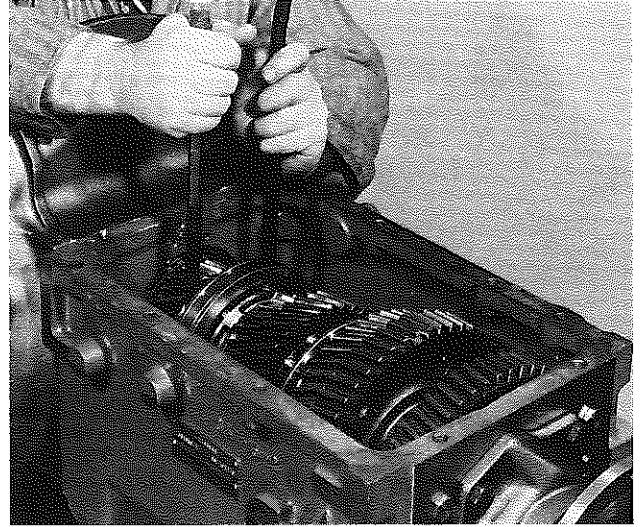


Figure 18 — Lock Transmission In Two Gears

To prevent the gears from rotating, lock the transmission in two gears. For example, engage 2nd-3rd speed synchronizer with 2nd or 3rd speed gear and 4th-5th speed synchronizer with 4th or 5th speed gear. Use pry bars to shift the synchronizers into gear.

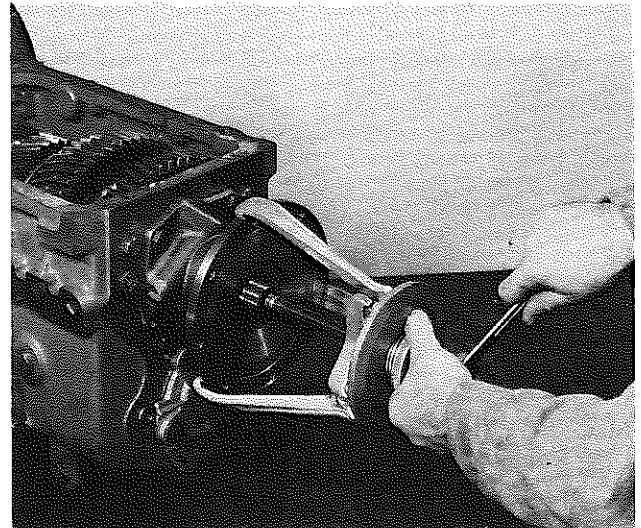


Figure 19 — Removing Output Flange (or Yoke)

ES65-5, CM50 and CM60 series transmissions are connected to the driveshaft with either a flange (illustrated) or a yoke. To disassemble, first unscrew the retaining nut with a 1-13/16" socket and remove the nut and washer. Then remove the output flange, or yoke, with a puller.

# GEARS AND CASE

## DISASSEMBLE TRANSMISSION – Cont'd.

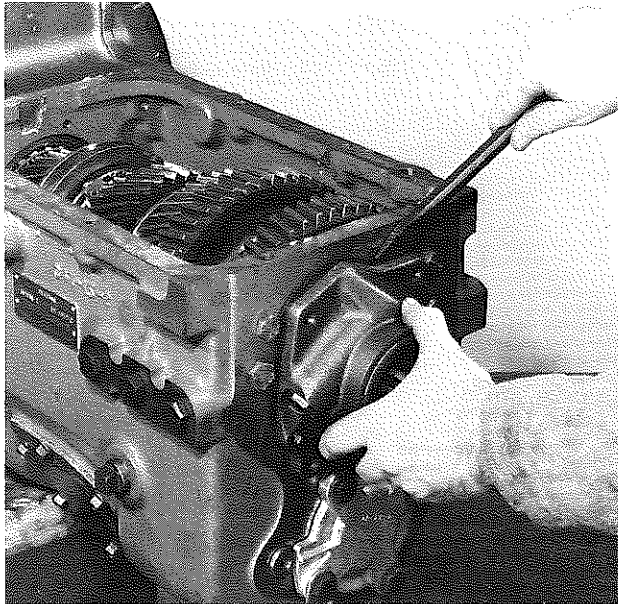


Figure 20 – Removing Rear Main Bearing Cap

Remove cap screws retaining the rear main bearing cap, then pry away from the case with a bar. Separate or scrape gasket from case and bearing cap.

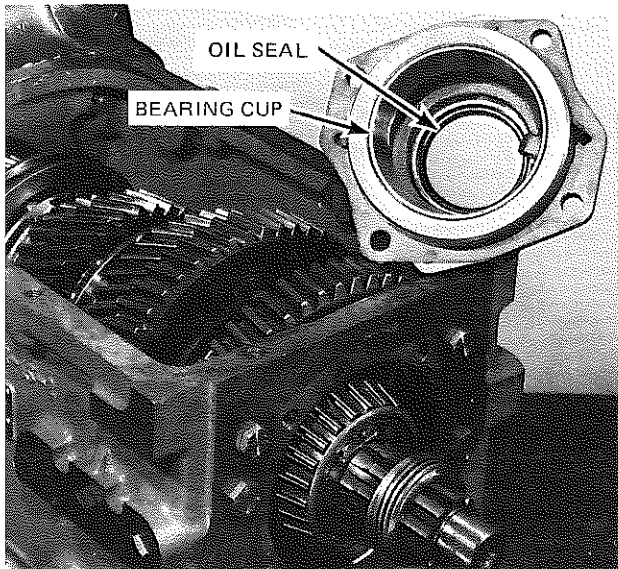


Figure 21 – Inspect Rear Bearing Cup and Oil Seal

Inspect the bearing cup and oil seal for wear or damage. If either needs replacement, tap out with a drift or punch.

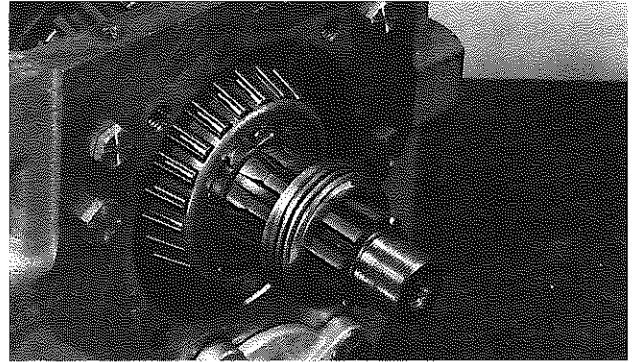


Figure 22 – Remove Speedometer Gear

Slide the speedometer gear from the mainshaft.

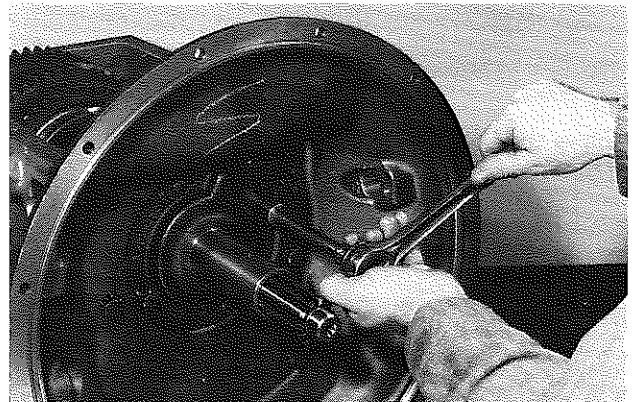


Figure 23 – Removing Front Drive Gear Bearing Cap

Remove the four cap screws and remove the front drive gear bearing cap. Separate or scrape the gasket from case and bearing cap.

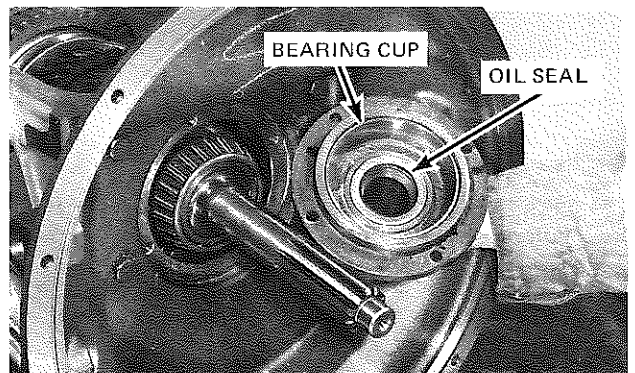


Figure 24 – Inspect Front Bearing Cup and Oil Seal

Inspect bearing cup and oil seal for wear or damage. Replace oil seal or bearing cup if damaged or worn.

# GEARS AND CASE

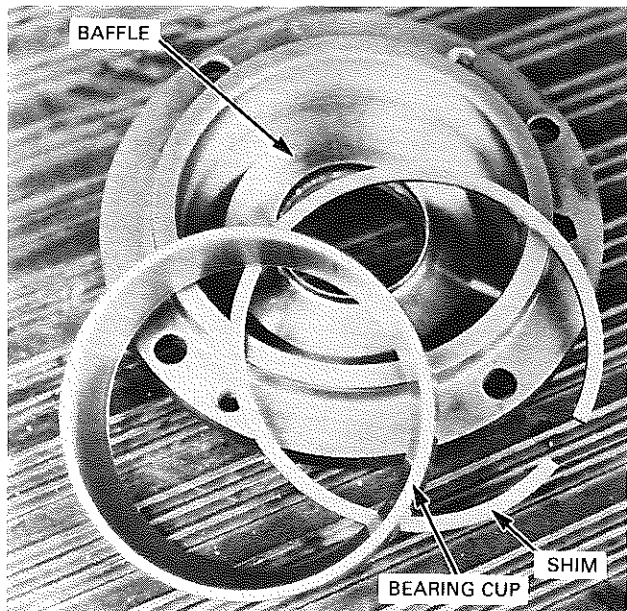


Figure 25 — Front Bearing Cap Shim

A shim is located behind the bearing cup to set the mainshaft end play. Normally, it isn't necessary to replace the shim unless end play exceeds the specified .003-.008" after reassembly.

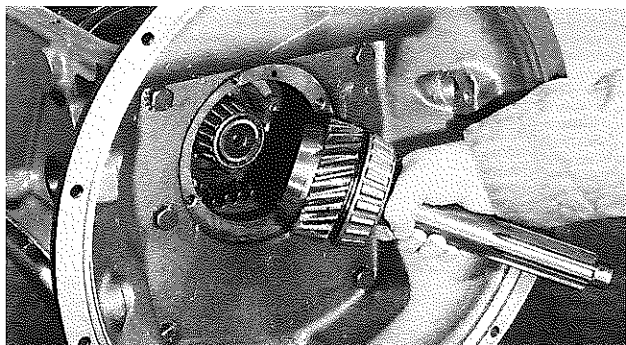


Figure 26 — Removing Drive Gear

Lift out drive gear from the front of the case.

### SPECIAL NOTE:

Procedures marked with an asterisk (\*) are not necessary during normal transmission disassembly to replace gears, etc. Only perform these steps for wear, damage, cleaning or inspection.

### SPECIAL NOTE:

CM series transmissions now use the new baffle lubrication system. Refer to Bulletin #2789 for detailed information.

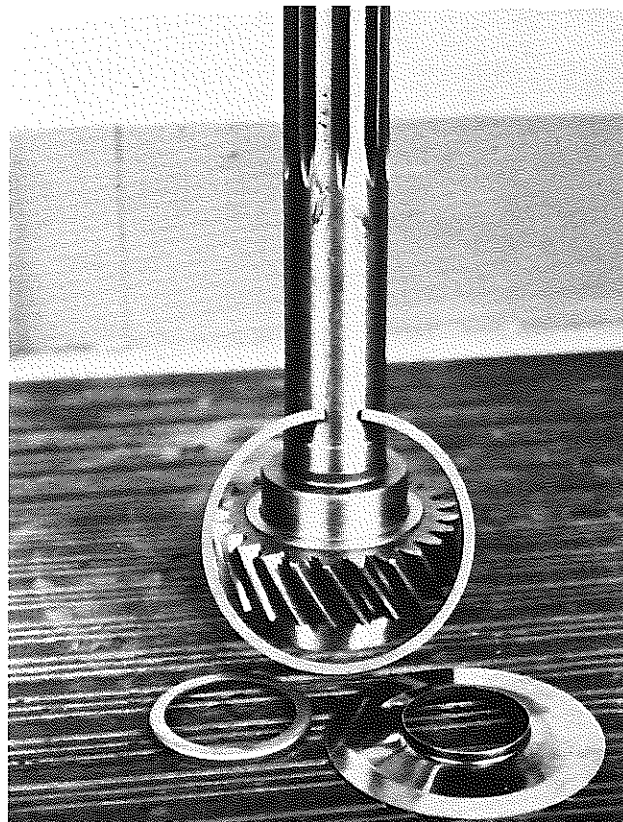


Figure 27 — Drive Gear Bearing

(\*) See special note. If bearing needs to be replaced, remove with suitable puller. Be sure and pull on the inner race to avoid damaging the bearing.

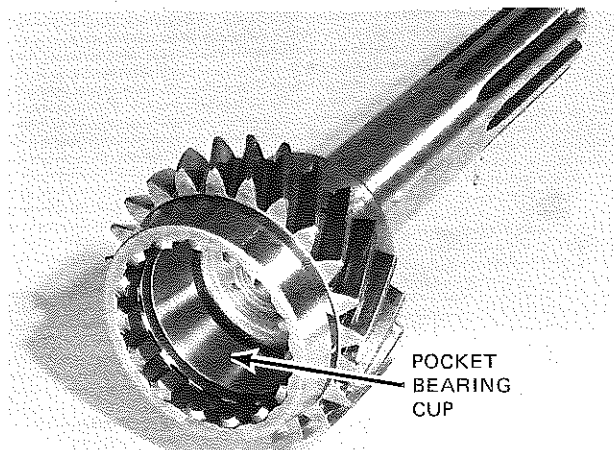


Figure 28 — Inspect Pocket Bearing Cup

Inspect the pocket bearing cup for damage or brinelling. Since the cup is machined into the drive gear, the whole gear must be replaced if the cup is damaged.

# GEARS AND CASE

## DISASSEMBLE TRANSMISSION – Cont'd.

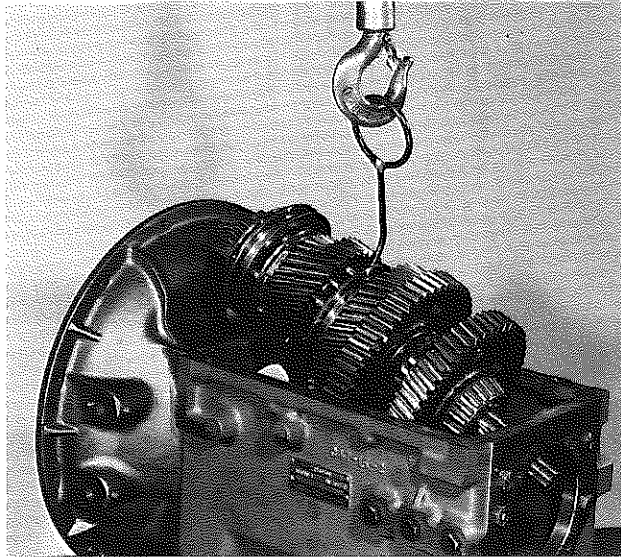


Figure 29 – Removing Mainshaft Assembly

Lift the mainshaft assembly out of the case. The easiest method is with a chainfall and a hook around the 2nd-3rd speed synchronizer blocker pins. Exercise care not to damage the bearings against the case.

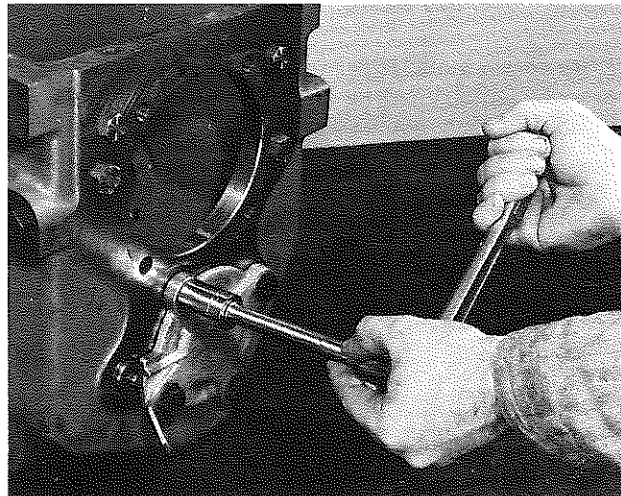


Figure 30 – Removing Countershaft Rear Bearing Cap

Remove the four cap screws and remove the countershaft rear bearing cap. Separate or scrape the gasket from the case and bearing cap. **NOTE:** The countershaft may be moved rearward, causing the bearing cup to fall out of the case bore and exposing the rear bearing as illustrated in Figure 31. Use caution not to damage or brinell the bearing or bearing cup.

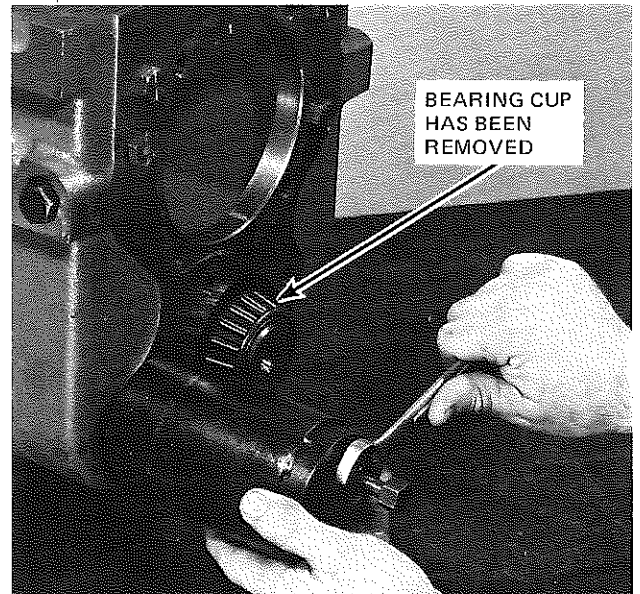


Figure 31 – Removing Reverse Gear Idler Shaft

Use a suitable puller, such as Kent Moore No. J28668-A and remove the reverse gear idler shaft.

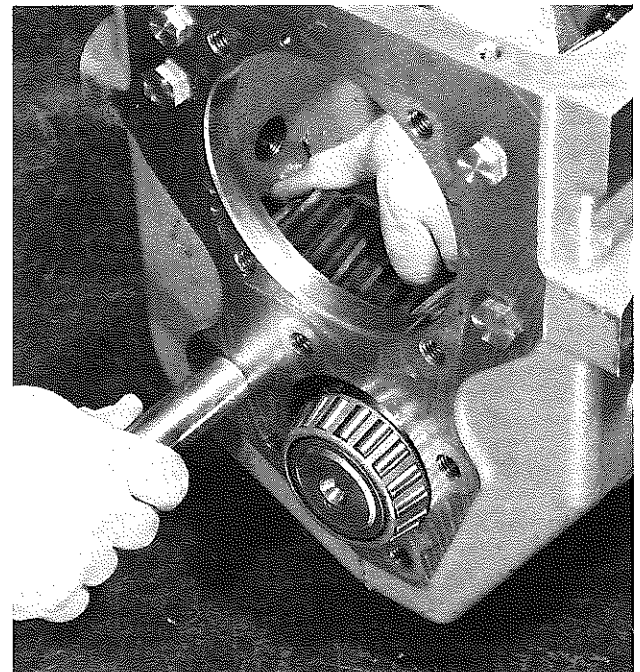


Figure 32 – Removing Reverse Gear Idler Shaft

Slide the idler shaft out of the case. Then, remove the two thrust washers, reverse idler gear, two caged pocket bearings and spacer (between caged bearings).



# GEARS AND CASE

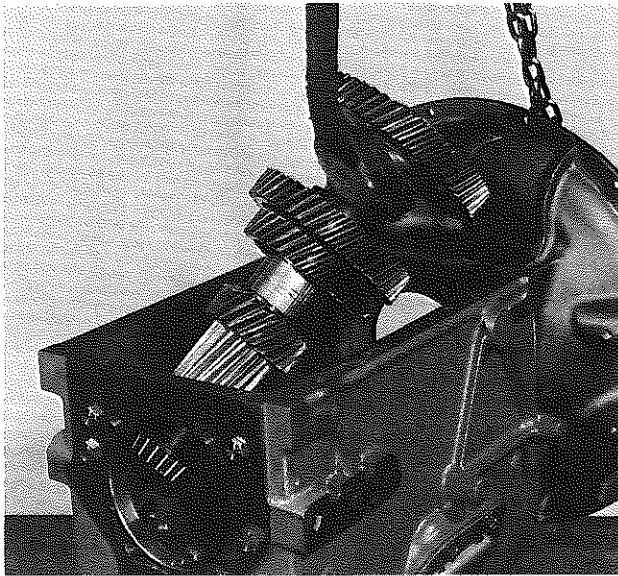


Figure 33 — Removing Countershaft Assembly

Tie a rope or sling around the countershaft (behind the countershaft drive gear) and lift the countershaft assembly from the case.

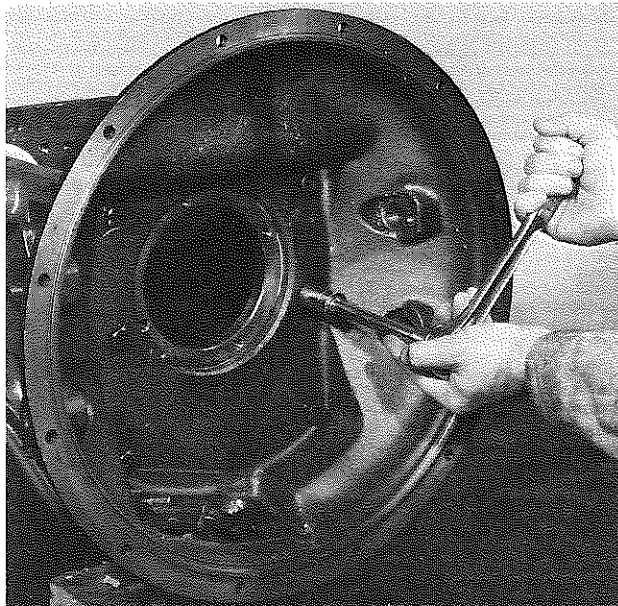


Figure 34 — Removing Clutch Housing

(\*) See special note on page 15. If necessary to replace the countershaft front bearing cup or spacer ring, remove the cap screws and remove the clutch housing. Separate or scrape the gasket from the case and clutch housing.

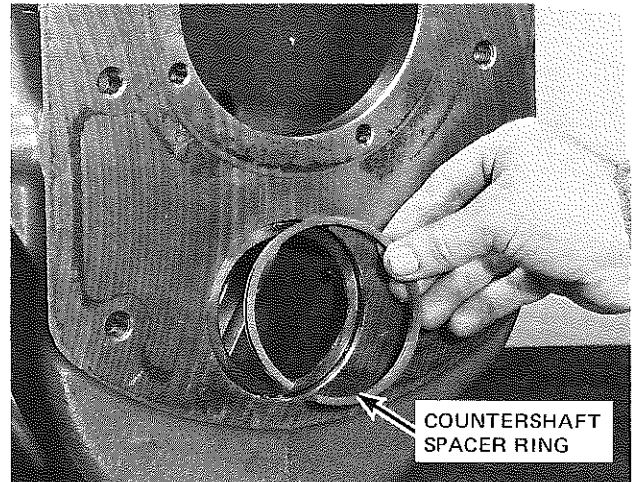


Figure 35 — Removing Countershaft Spacer Ring

(\*) See special note on page 15. Remove the countershaft spacer ring. Inspect the countershaft front bearing cup. If it must be replaced, tap forward with a drift or punch.

## Disassemble Mainshaft (CM50)

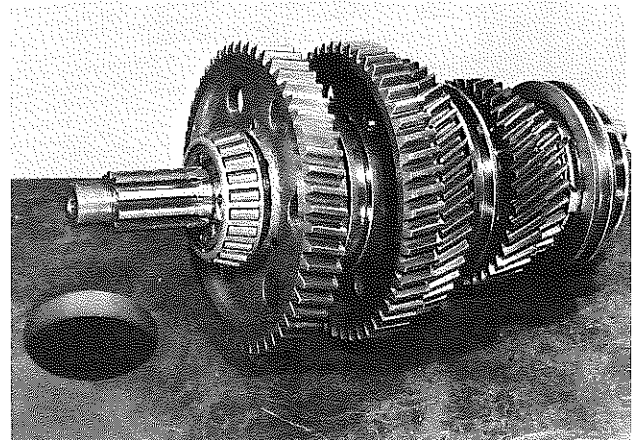


Figure 36 — Preparing To Disassemble Mainshaft

A 5" diameter hole cut in the top of the workbench will speed disassembly. However, these procedures describe how to disassemble the mainshaft on a standard workbench.

# GEARS AND CASE

## DISASSEMBLE TRANSMISSION – Cont'd.

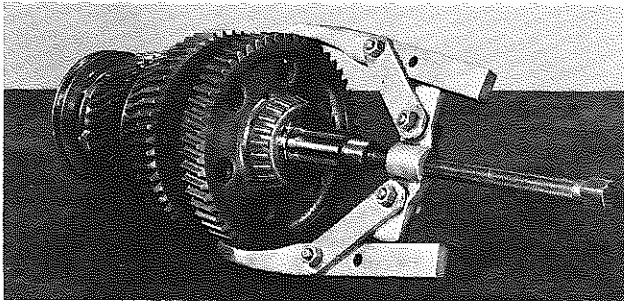


Figure 37 – Removing Rear Bearing and Reverse Gear

Use a suitable puller to remove the rear bearing and reverse gear.

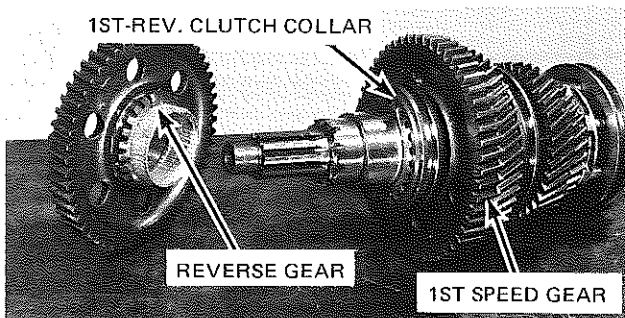


Figure 38 – Reverse Gear Removed

The 1st-reverse sliding clutch collar, thrust washer and caged needle bearings (inside of the reverse gear) can all be removed from the end of the shaft once the bearing is removed.

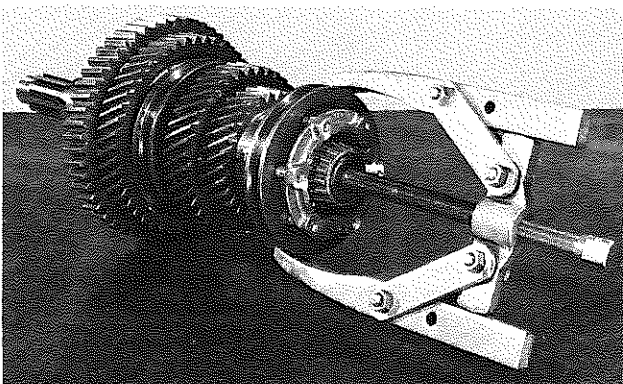


Figure 39 – Removing Drive Gear Pocket Bearing

Use a suitable puller on the 4th-5th speed synchronizer to remove the drive gear pocket bearing from the pilot of the mainshaft. Position puller jaws behind clutch collar of synchronizer. Do not pull on brass ring.

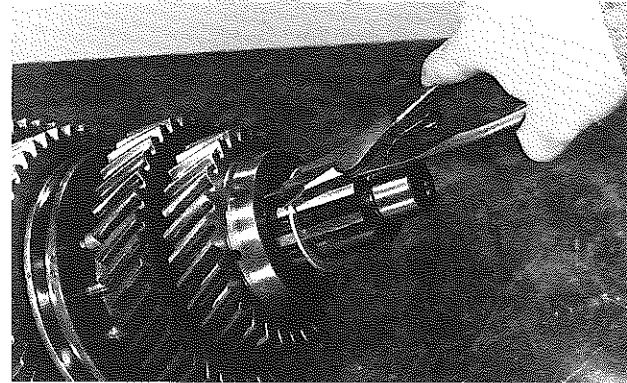


Figure 40 – Removing 4th Speed Gear Snap Ring

Remove the 4th speed gear snap ring, which is located deep inside the gear. Grind off the end of the snap ring pliers (as illustrated) to facilitate this operation. Remove the 4th-speed gear and thrust washer (located behind the snap ring) from the mainshaft.

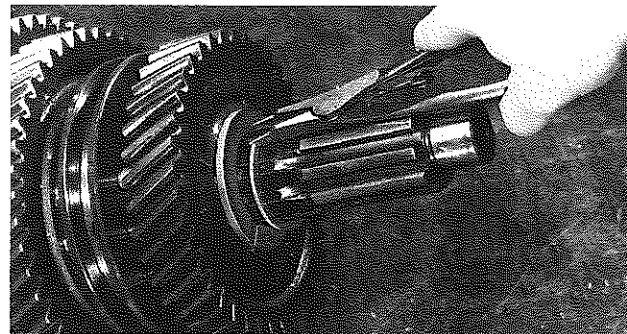


Figure 41 – Removing 3rd Speed Gear Snap Ring

Remove the 3rd speed gear snap ring from the mainshaft.

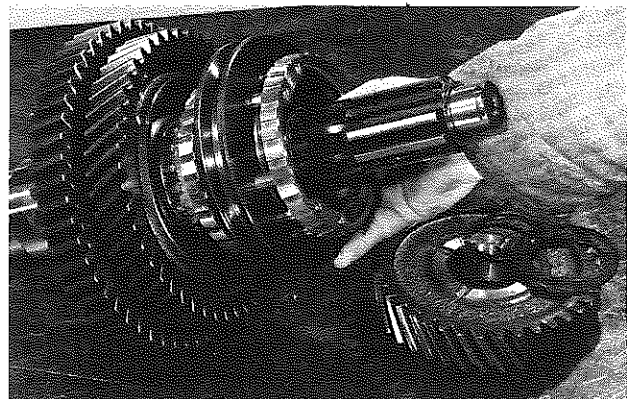


Figure 42 – Removing 2nd-3rd Speed Synchronizer

Remove the thrust washer, slide off the 3rd speed gear, then lift off the 2nd-3rd speed synchronizer.

# GEARS AND CASE

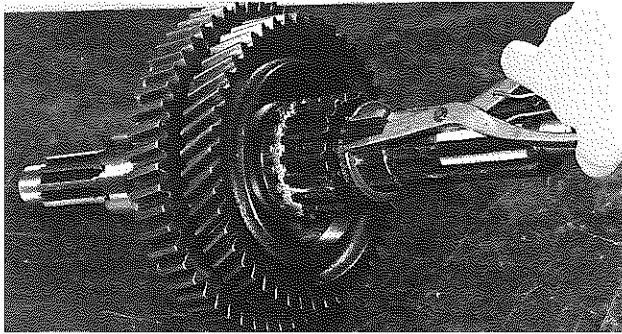


Figure 43 – Removing 2nd-3rd Speed Clutch Gear Snap Ring

Remove the 2nd-3rd speed clutch gear snap ring.

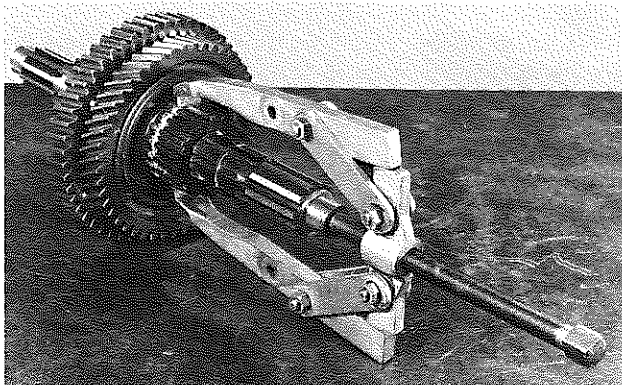


Figure 44 – Removing 2nd-3rd Speed Clutch Gear

Remove the 2nd-3rd speed clutch gear with a suitable puller.

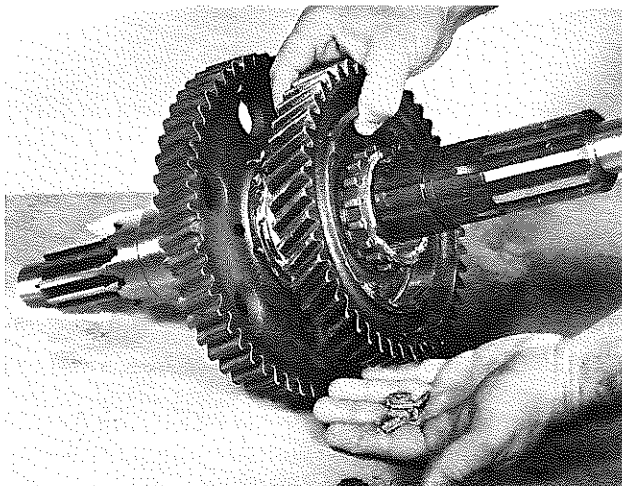


Figure 45 – Removing 2nd Speed Gear

Pull the 2nd speed gear off the mainshaft by hand, being careful not to lose the loose needle bearings.

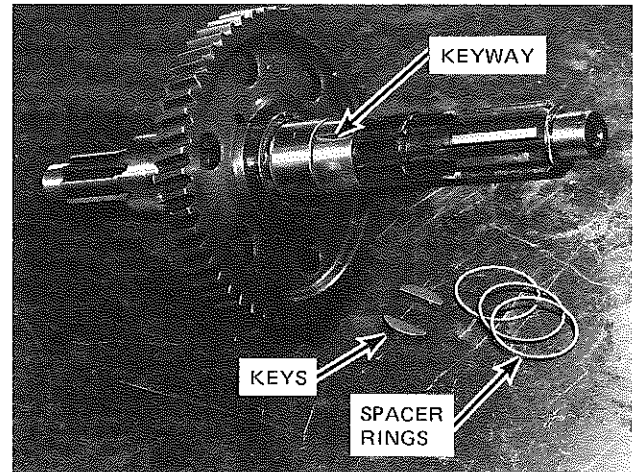


Figure 46 – Needle Bearing Spacers and Keys

Remove the two keys from the mainshaft with a chisel, then slide off the three loose needle bearing spacer rings.

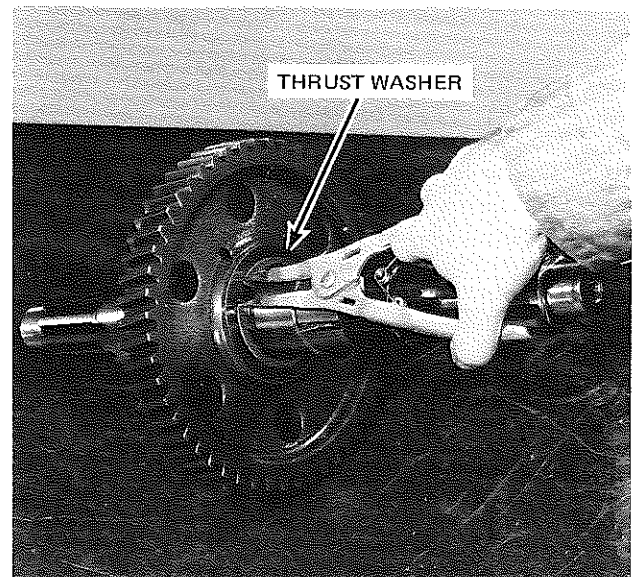


Figure 47 – Removing 1st Speed Gear Snap Ring

Remove the 1st speed gear snap ring. Then, slide off the gear, thrust washer and caged needle bearings.

# GEARS AND CASE

## DISASSEMBLE TRANSMISSION – Cont'd.

Disassemble countershaft (CM 50)

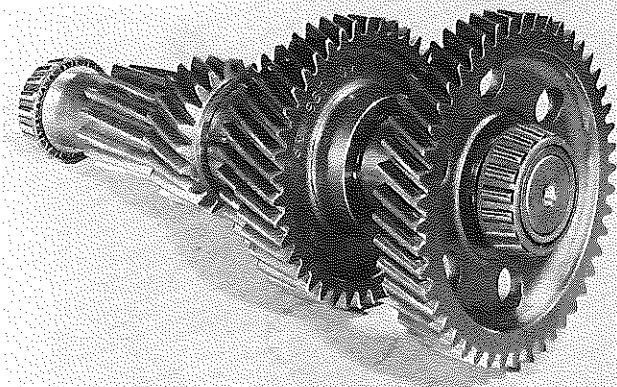


Figure 48 – Countershaft Gears

All of the countershaft gears have a keyway in the gear bore and are a press fit on the countershaft. The 1st speed gear is machined into the countershaft.

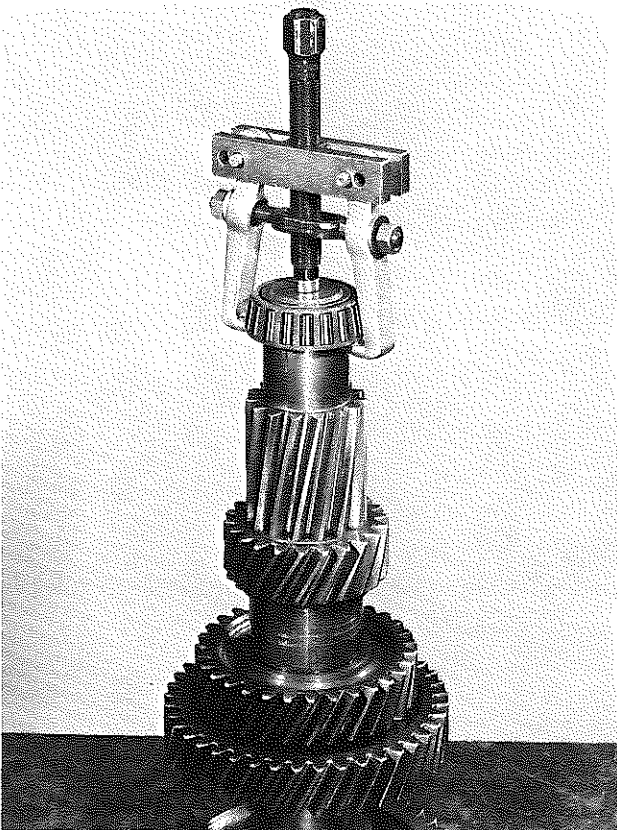


Figure 49 – Removing Rear Bearing

Use a suitable puller to remove the rear bearing from the countershaft. Be sure and pull on the inner race to avoid damaging the bearing.

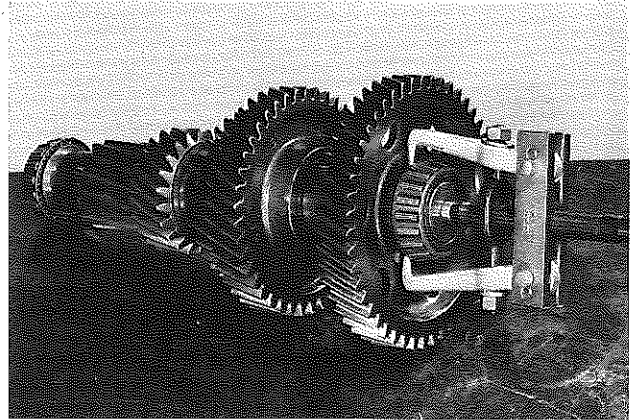


Figure 50 – Removing Front Bearing

Use a suitable puller to remove the front bearing from the countershaft. Be sure and pull on the inner race to avoid damaging the bearing.

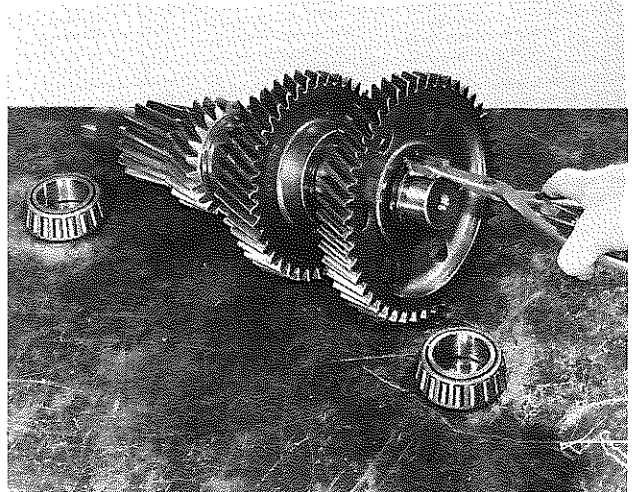


Figure 51 – Removing Drive Gear Snap Ring

**TO REMOVE COUNTERSHAFT DRIVE GEAR** – Remove the countershaft drive gear snap ring. Support the drive gear (as close to the hub as possible) and press the countershaft until free of the drive gear. Remove the Woodruff key.

**TO REMOVE 3RD AND 4TH SPEED GEARS** – Remove the 4th speed gear snap ring. Support the 3rd speed gear and press the countershaft until free of both the 3rd and 4th speed gears. Remove the Woodruff keys for each gear.

**TO REMOVE 2ND SPEED GEAR** – Slide off the spacer. Support the 2nd speed gear and press the countershaft until free of the 2nd speed gear. Remove the Woodruff key.

# GEARS AND CASE

## REASSEMBLE TRANSMISSION

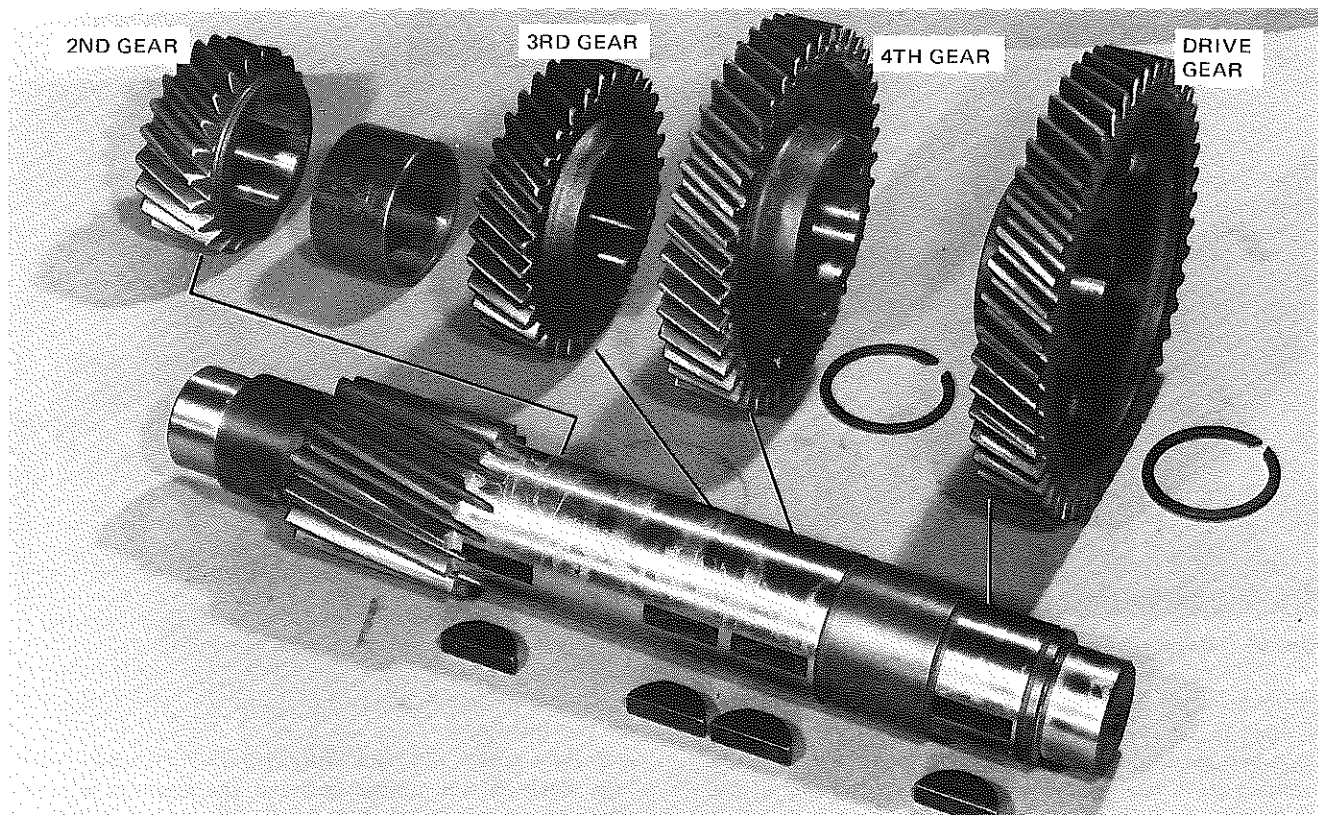


Figure 52 – Countershaft Components

### Reassemble Countershaft (CM 50)

All gears are pressed on the countershaft in approximately the same way.

**2ND SPEED GEAR** – Assemble and securely seat the Woodruff key to the countershaft. Support hub of 2nd speed gear on a press (long hub down, or toward front of countershaft). Align key in countershaft with keyway in gear and press countershaft to gear.

**3RD SPEED GEAR** – Slide spacer onto countershaft. Assemble and securely seat Woodruff key to countershaft. Support hub of 3rd speed gear on a press (long hub down, or toward front of countershaft). Align key in countershaft with keyway in gear and press countershaft to gear, until firmly seated against the spacer.

**4TH SPEED GEAR** – Assemble and securely seat Woodruff key to countershaft. Support hub of 4th speed gear on a press (long hub down, or toward front of countershaft). Align key in countershaft with keyway in gear and press countershaft in gear. Firmly seat 4th speed gear snap ring in groove of countershaft. To avoid distortion, do not expand snap ring excessively.

**COUNTERSHAFT DRIVE GEAR** – Assemble and securely seat Woodruff key to countershaft. Support hub of countershaft drive gear on a press (long hub UP, or toward rear of countershaft). Align key in countershaft with keyway in gear and press countershaft to gear. Firmly seat countershaft drive gear snap ring in groove of countershaft. To avoid distortion, do not expand snap ring excessively.

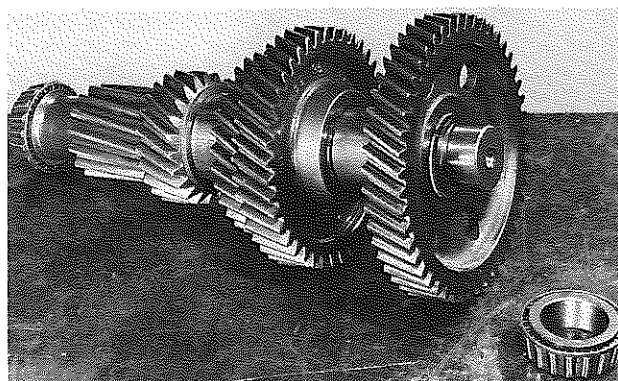


Figure 53 – Countershaft Bearings

After completing installation of the countershaft gears, press on the front and rear bearings.

# GEARS AND CASE

## REASSEMBLE TRANSMISSION – Cont'd. Reassemble Mainshaft (CM 50)

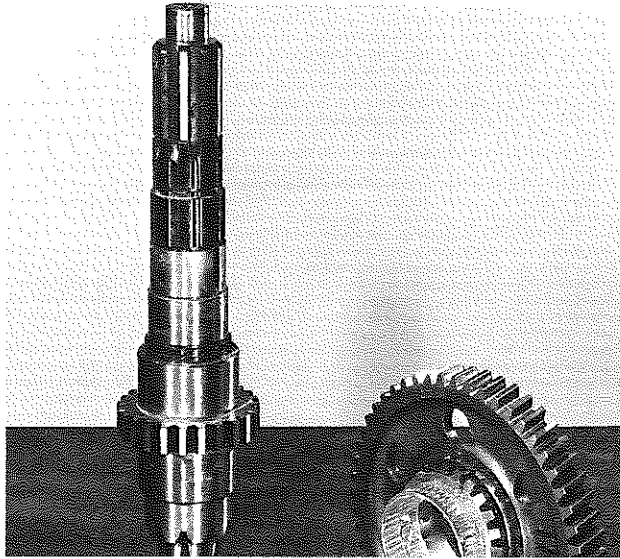


Figure 54 – Mainshaft, 1st Speed Gear and Caged Needle Bearings

Lubricate caged bearings with light coat of grease and assemble to 1st speed gear. Stand mainshaft vertically on bench and assemble 1st speed gear to mainshaft with the clutching teeth facing downward (toward the rear of the mainshaft).

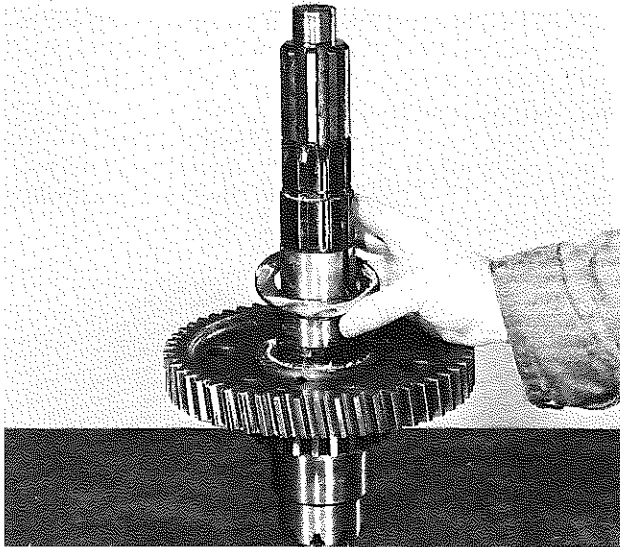


Figure 55 – Assembling Thrust Washer

Lubricate thrust washer and assemble on mainshaft. (This thrust washer will assemble either way, front or rear.) Then firmly seat 1st speed gear snap ring in groove on mainshaft. To avoid distortion, do not expand snap ring excessively.

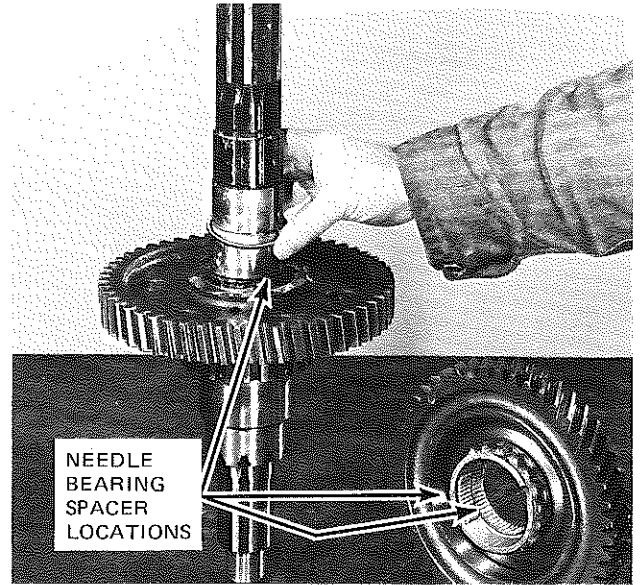


Figure 56 – Assembling 2nd Speed Gear, Loose Needle Bearings and Spacer Rings

Assemble needle bearing spacer to the rear of the shoulder on the mainshaft. Coat the bore of the 2nd speed gear with light grease and pack with two rows of needle bearings. Position one spacer between the bearings and another spacer toward the clutching teeth end of the bore.

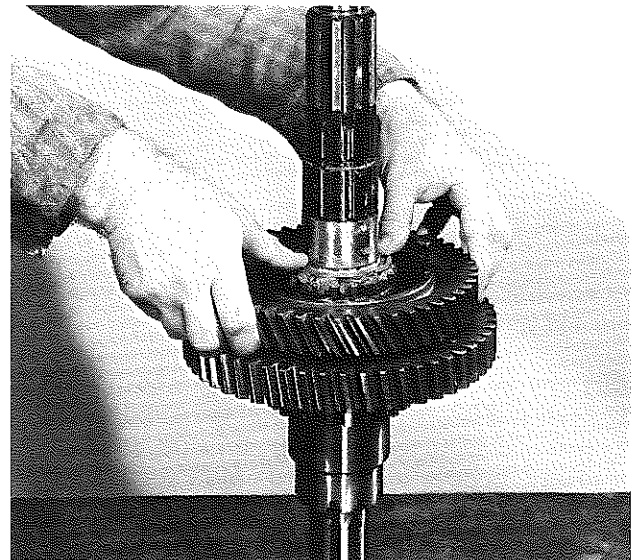


Figure 57 – Assembling 2nd Speed Gear

Assemble the 2nd speed gear on the mainshaft with the clutching teeth facing up (toward the front of the mainshaft). In order to hold the needle bearings and spacers in place, carefully align spacers with shoulder on mainshaft and push gear down with thumbs.

# GEARS AND CASE

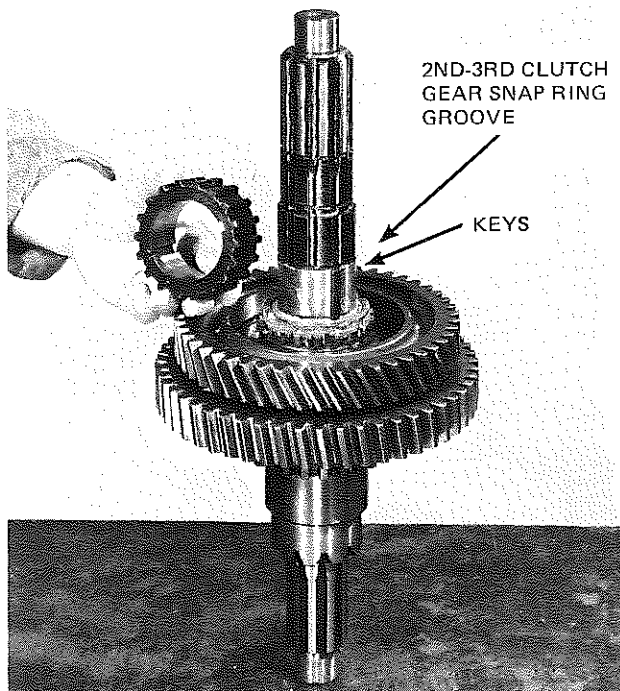


Figure 58 — Assembling 2nd-3rd Speed Clutch Gear

Install a key in the keyway on each side of the mainshaft. Align the keyways in the bore of the 2nd-3rd speed clutch gear with the keys and press on the mainshaft.

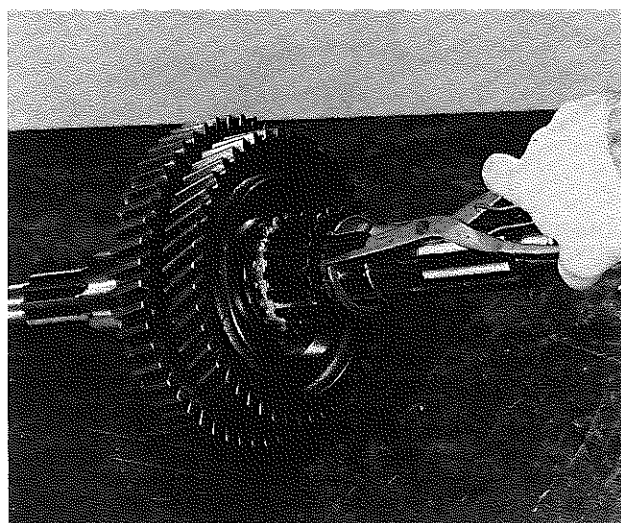


Figure 59 — Assembling 2nd-3rd Speed Clutch Gear Snap Ring

Firmly seat the 2nd-3rd speed clutch gear snap ring in the groove on the mainshaft. To avoid distortion, do not expand snap ring excessively.

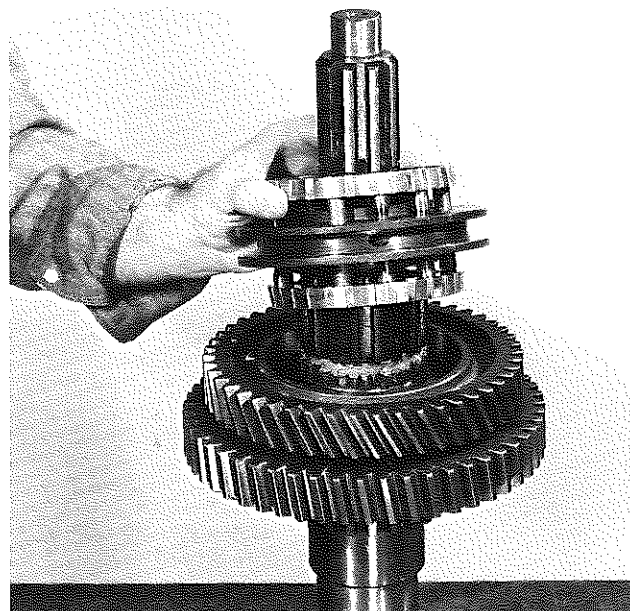


Figure 60 — Assembling 2nd-3rd Speed Synchronizer

Slide 2nd-3rd speed synchronizer onto 2nd-3rd speed clutch gear. NOTE: The synchronizer is symmetrical and can be assembled in either direction on the mainshaft.

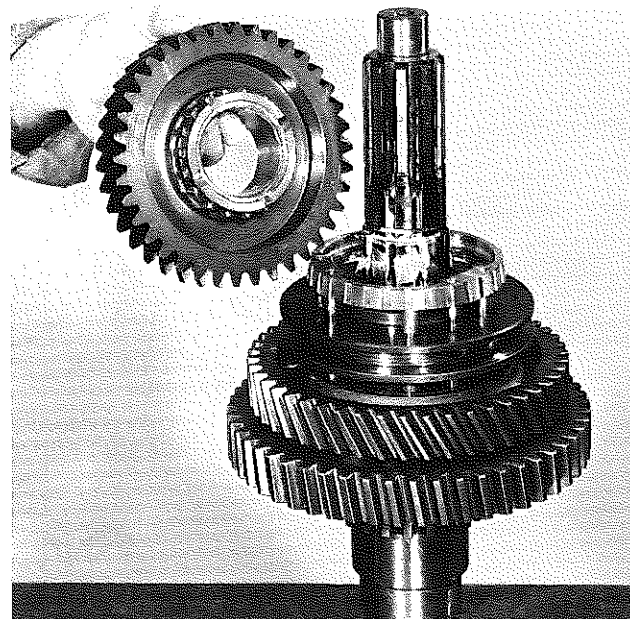


Figure 61 — Assembling 3rd Speed Gear

Apply a light coat of grease to the fluted diameter of the mainshaft, then slide 3rd speed gear onto the mainshaft, with the clutching teeth down (toward the rear of the mainshaft).

# GEARS AND CASE

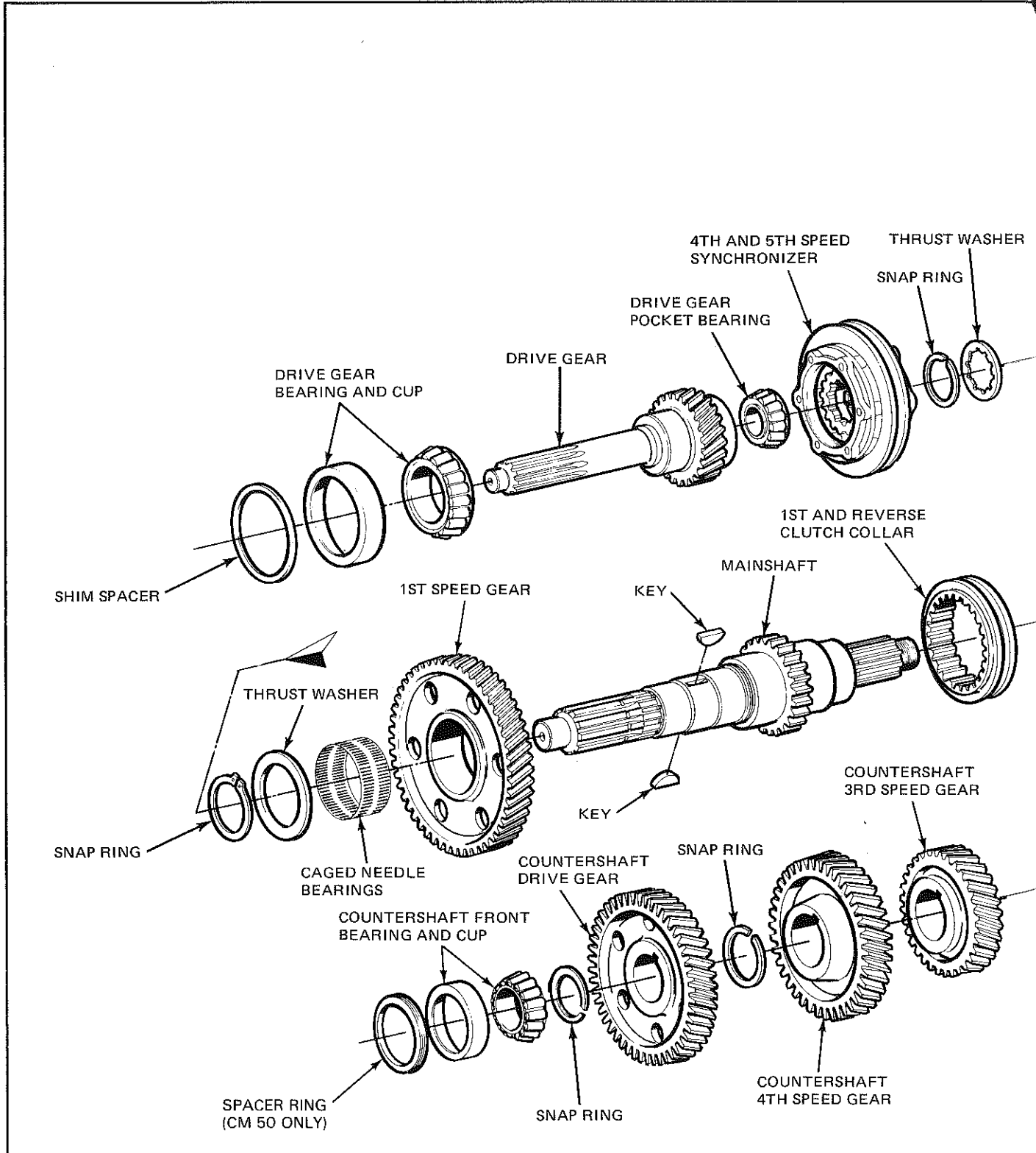


Figure 62 – CM50 Gears and Related Parts



# GEARS AND CASE

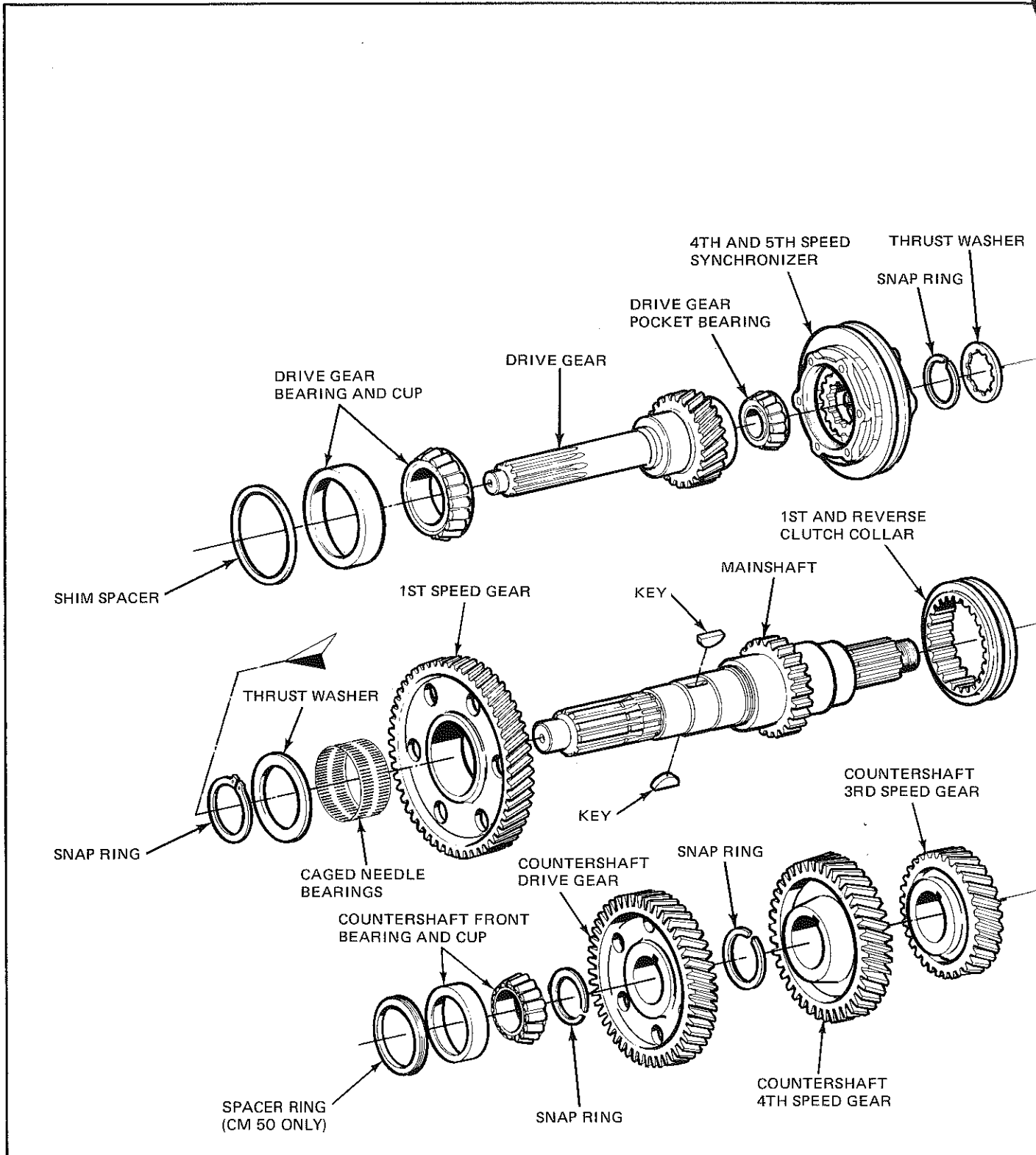
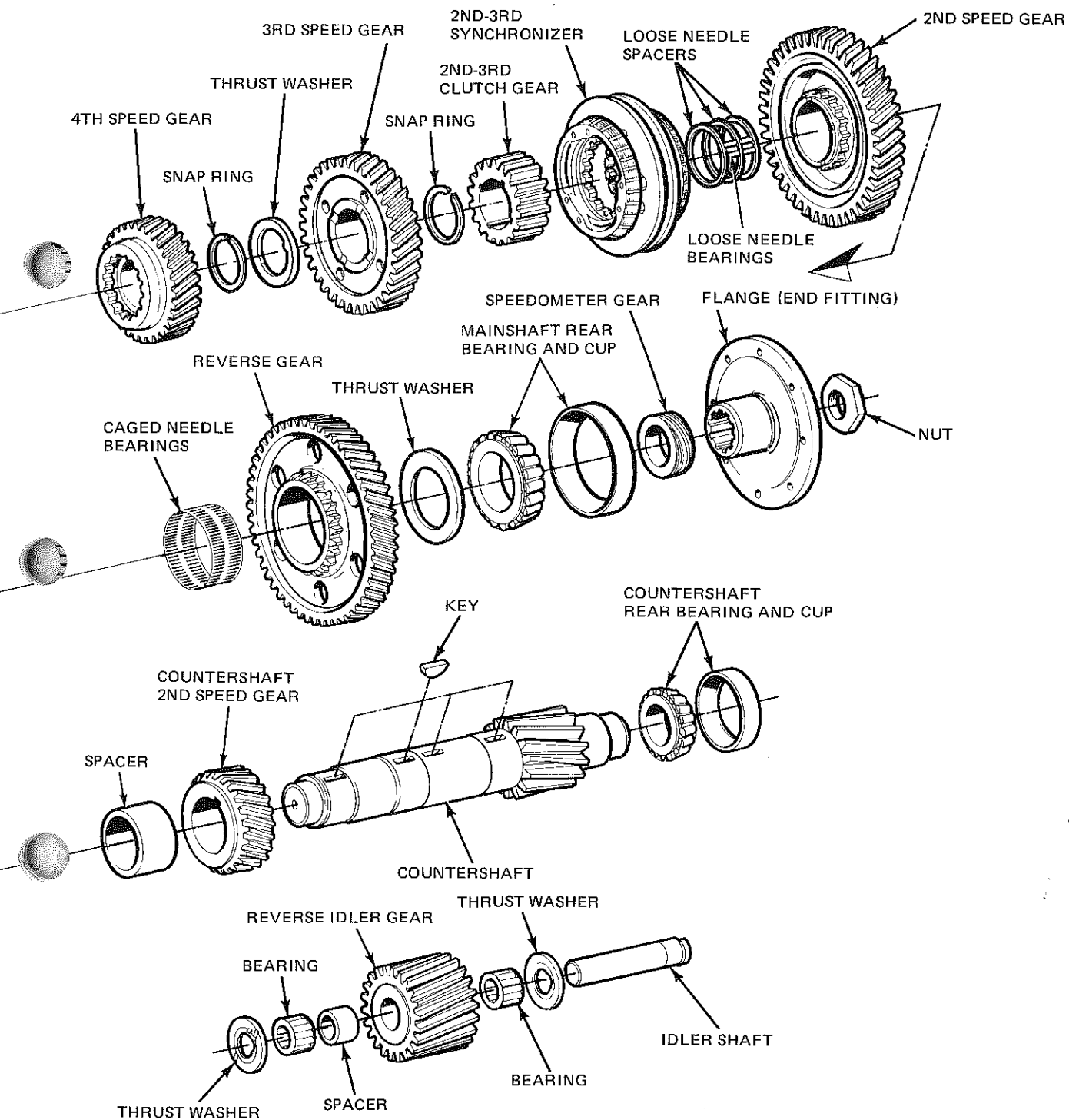


Figure 62 – CM50 Gears and Related Parts

# GEARS AND CASE



# GEARS AND CASE

## REASSEMBLE TRANSMISSION – Cont'd.

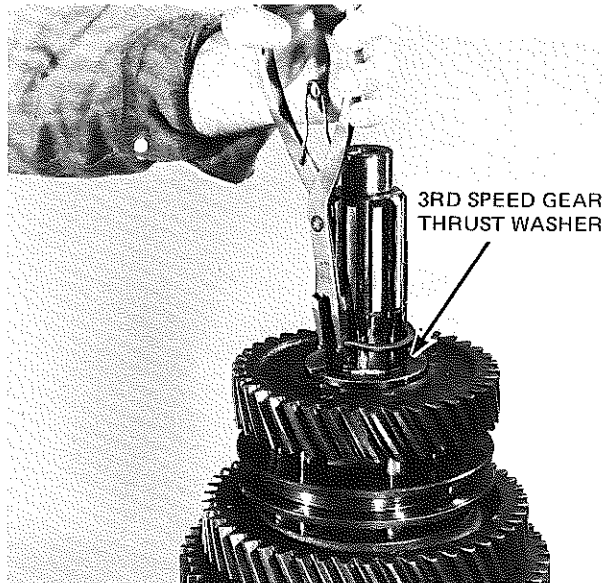


Figure 63 — Assembling 3rd Speed Gear Snap Ring

Install 3rd speed gear thrust washer (will assemble facing front or rear), then firmly seat 3rd speed gear snap ring in groove on mainshaft. To avoid distortion, do not expand snap ring excessively.

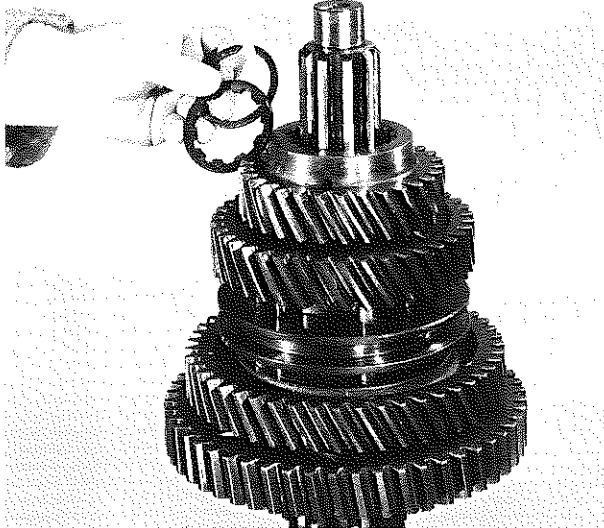


Figure 64 — 4th Speed Gear Thrust Washer and Snap Ring

Lubricate, then slide 4th speed gear onto mainshaft with hub UP (toward front of mainshaft). Install the 4th speed gear thrust washer, then firmly seat the 4th speed gear snap ring in the groove on the mainshaft under the bore of the gear. To avoid distortion, do not expand the snap ring excessively.

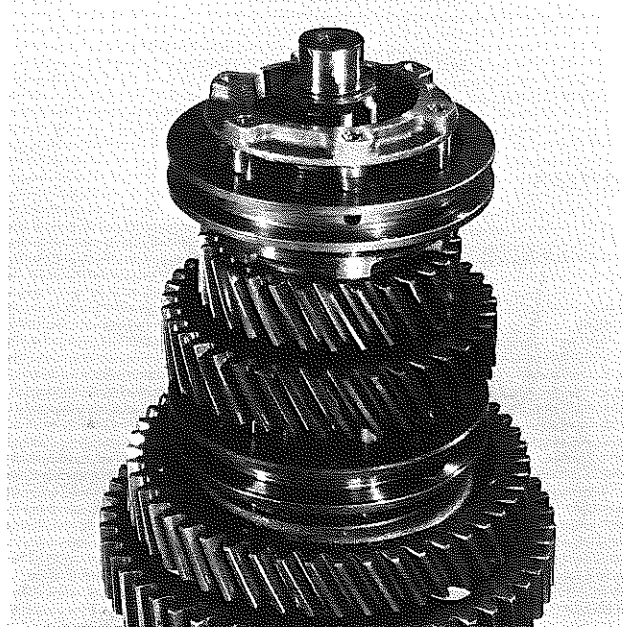


Figure 65 — 4th-5th Speed Synchronizer

Slide the 4th-5th speed synchronizer onto mainshaft with larger brass ring over the 4th speed gear hub.

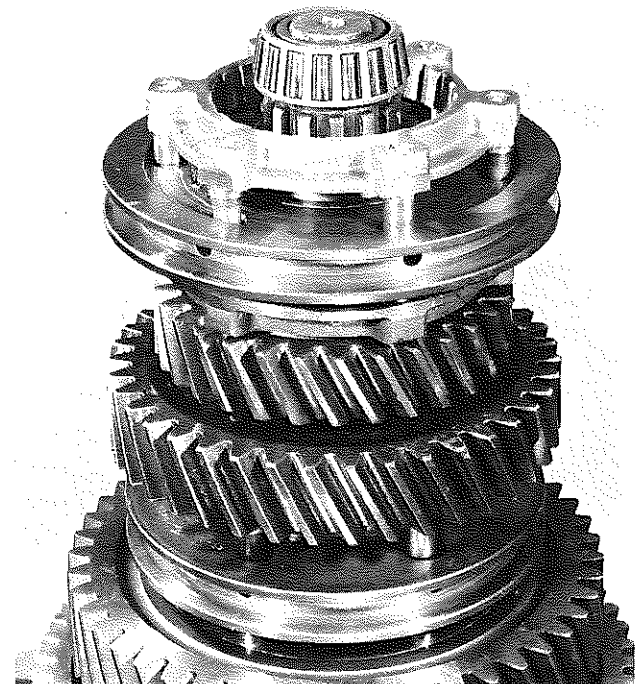


Figure 66 — Drive Gear Pocket Bearing

Press drive gear pocket bearing on pilot of mainshaft, until it firmly seats against shoulder on mainshaft.

# GEARS AND CASE

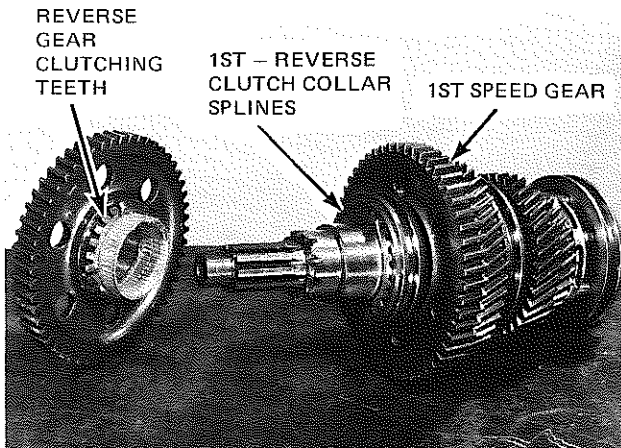


Figure 67 — 1st-Reverse Gear

Slide the 1st-reverse clutch collar over the splines of the mainshaft. The collar can be assembled facing the front or rear. Coat the caged needle bearings with light grease. Assemble the bearings and reverse gear onto the mainshaft, with the clutching teeth toward the 1st speed gear.

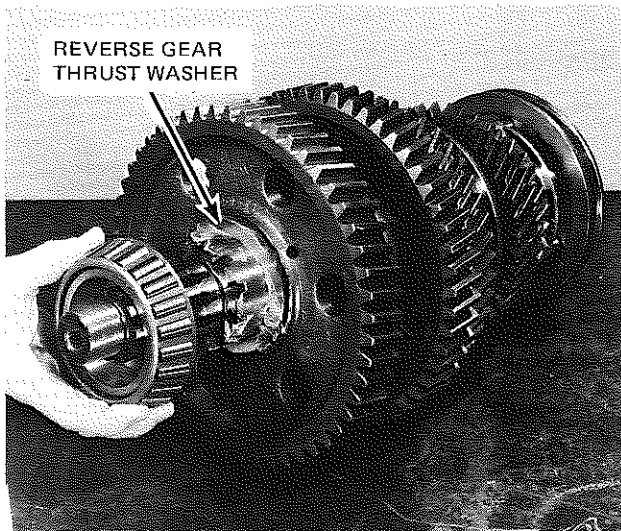


Figure 68 — Rear Bearing

Coat reverse gear thrust washer with light grease and assemble on mainshaft. Press rear bearing on mainshaft until firmly seated against the reverse gear thrust washer.

## Installation of Countershaft and Reverse Idler Gear

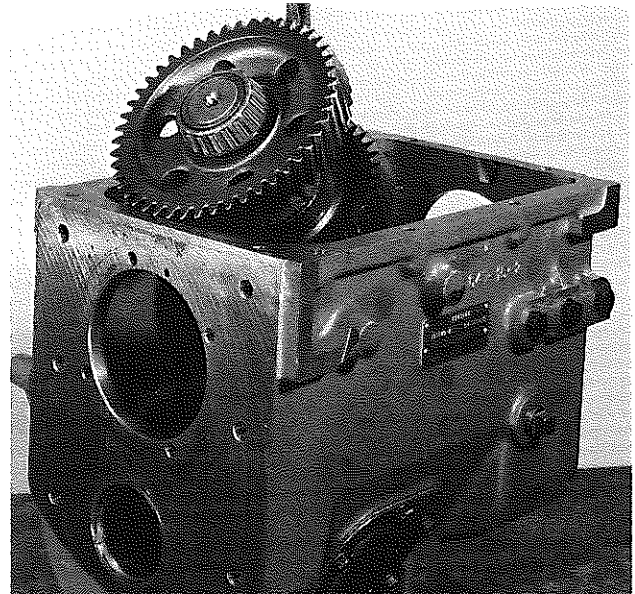


Figure 69 — Lowering Countershaft Into Case

With the aid of a chainfall and sling, lower the countershaft into the case. Do not remove the sling until the rear countershaft bearing cup is installed.

(\* See special note on page 15. If removed during disassembly, install the countershaft front bearing cup and spacer.

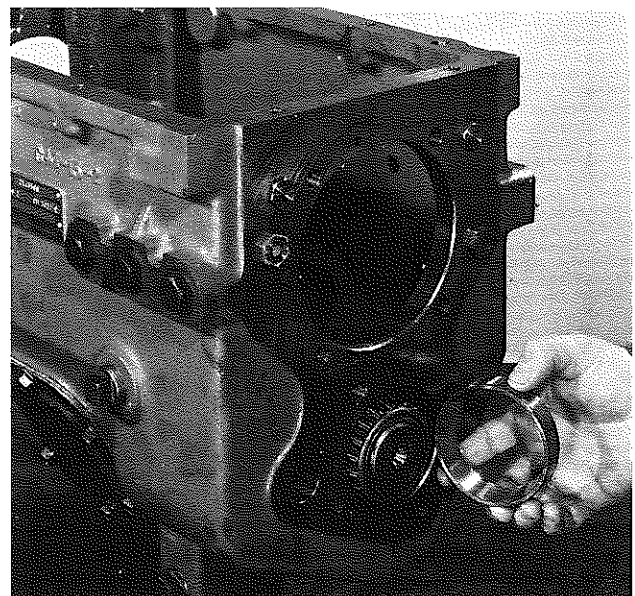


Figure 70 — Countershaft Rear Bearing Cup

Install the countershaft rear bearing cup in the bore of the case.

# GEARS AND CASE

## REASSEMBLE TRANSMISSION – Cont'd.

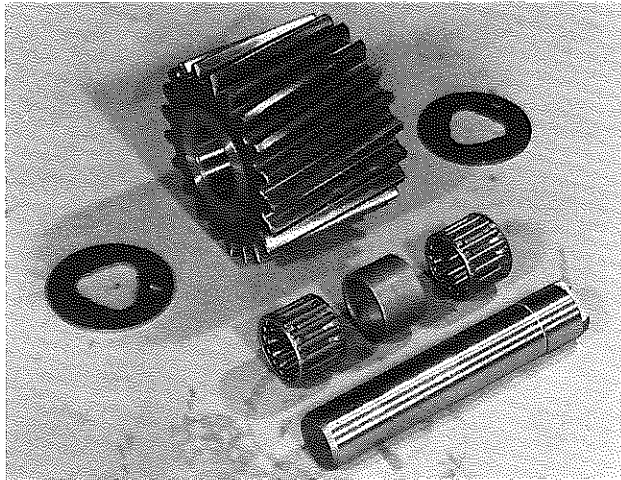


Figure 71 – Reverse Idler Gear Parts

Lubricate the caged needle bearings with 30W oil and insert inside the idler gear with the spacer as illustrated. Coat the thrust washers with grease to hold washers against each end of the idler gear. Position the tangs of each washer "UP" and facing OUTWARD, to align with slots in the boss inside the case.

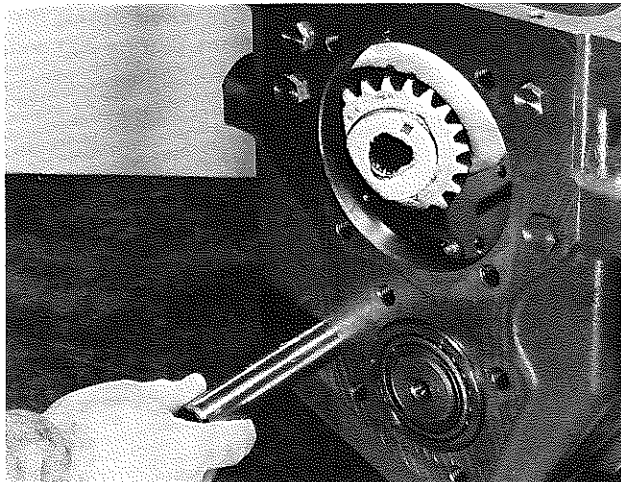


Figure 72 – Installing Reverse Idler Gear

Position reverse idler gear inside case with tangs of washers facing up. Insert idler shaft part way into bore of case with shoulder and threaded hole facing out. Carefully align washer tangs with slots in case, then lower idler gear until aligned with shaft. Insert shaft into case and through idler gear.

Position idler shaft so flat on shoulder will align with flat on countershaft rear bearing cap. Drive the shaft in with a soft mallet until the flat on the shaft is flush with the case.

### CAUTION

It may be necessary to hold the countershaft rear bearing cup in place with a large flat washer and a cap screw.



Figure 73 – Countershaft Rear Bearing Cap

Position the countershaft rear bearing cap and gasket to the case and retain with four cap screws. Tighten screws to 60-80 lbs. ft. torque. The sling around the countershaft can now be removed.

### Installation of Mainshaft

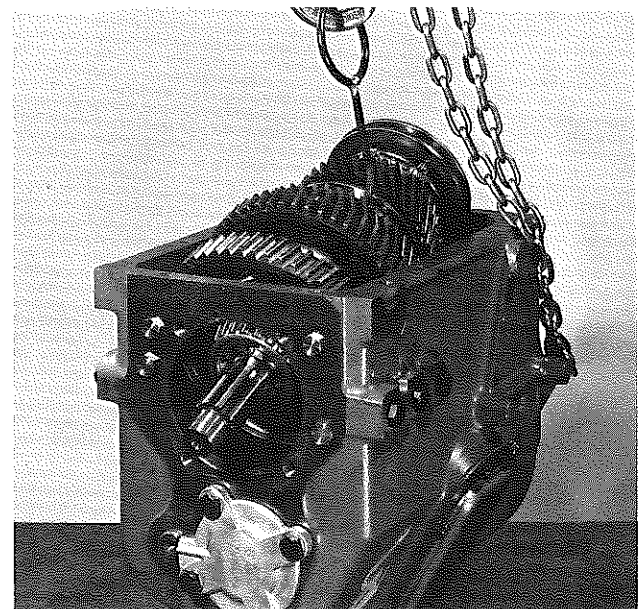


Figure 74 – Installing Mainshaft

Lower mainshaft into case with a chainfall or sling. Exercise care not to damage the bearings against the case. Position the mainshaft gears so they mesh with their mating countershaft gears.

# GEARS AND CASE

## Installation of Drive Gear and Clutch Housing

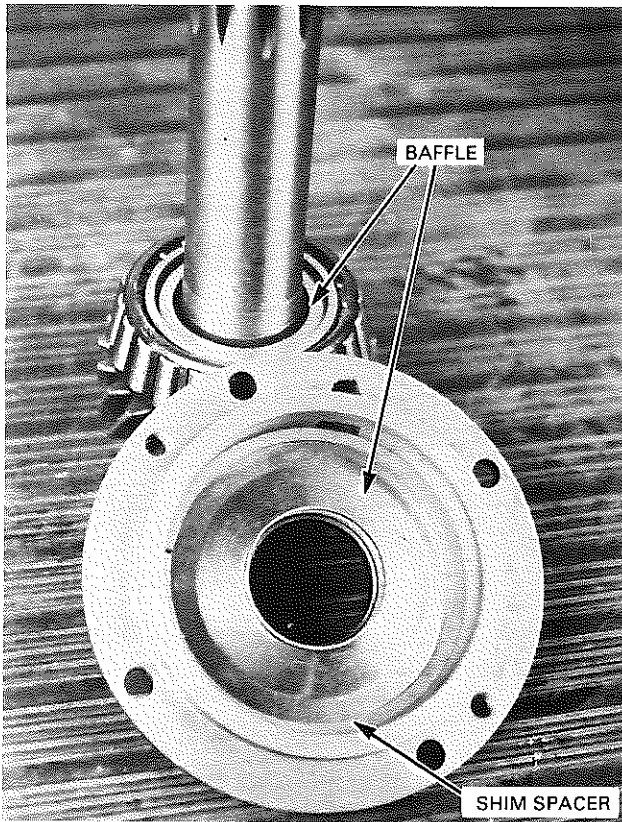


Figure 75 — Drive Gear and Bearing

(\*) See special note on page 15. If the bearing was removed during disassembly, press the bearing on the drive gear.

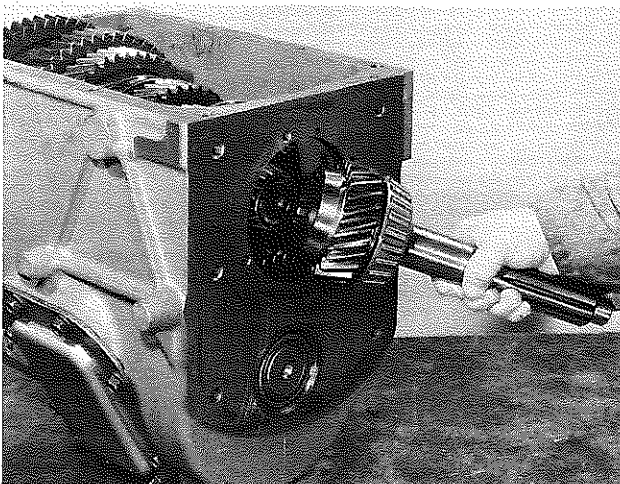


Figure 76 — Installing Drive Gear

Lubricate pocket bearing with Moly #2, then install drive gear in front of case.

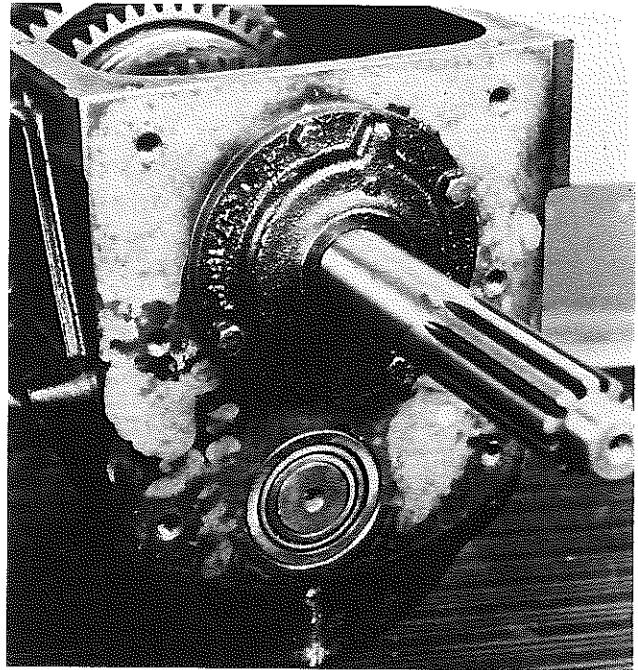


Figure 77 — Drive Gear Cap and Gasket

Assemble drive gear cap and gasket to the case. Be sure oil return hole is properly aligned in the cap, gasket and case. Tighten the cap screws to 25-32 lbs. ft. torque. NOTE: The front bearing cap has the shim ring assembled under the drive gear bearing cup.

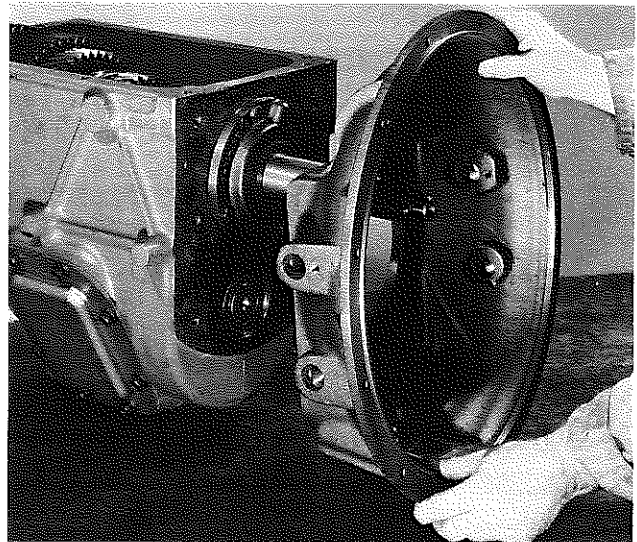


Figure 78 — Installing Clutch Housing

Position clutch housing gasket on front of case and retain with daub of grease. Be sure gasket clears the countershaft front bearing spacer. Assemble clutch housing to case, using drive gear cap as a pilot.

# GEARS AND CASE

## REASSEMBLE TRANSMISSION – Cont'd.

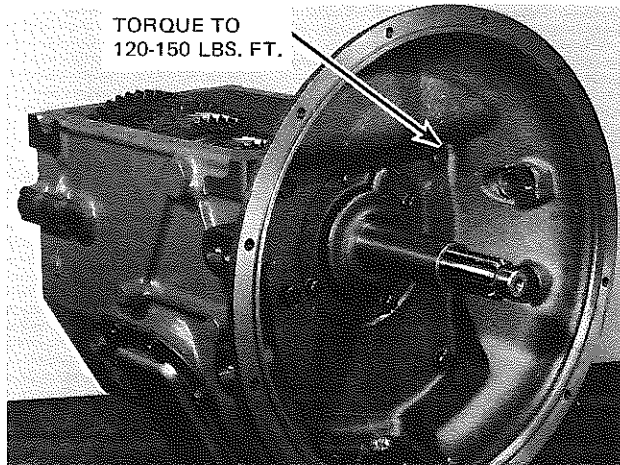


Figure 79 — Cap Screw Torque

Tighten the six clutch housing cap screws to 120-150 lbs. ft. torque.

**IMPORTANT:** Do not over-torque any of the cap screws on the front of the case, as this will distort the end play of the mainshaft and countershaft.

Countershaft end play specifications are .001-.008". Adjustable by shims under the countershaft rear bearing cap.

Mainshaft end play specifications are .003-.008".

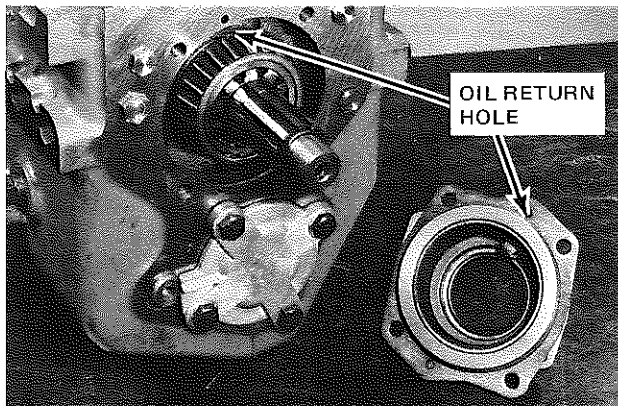


Figure 80 — Mainshaft Rear Bearing Cap and Gasket

Lubricate rear bearing, then install gasket on mainshaft rear bearing cap. Be sure oil holes are properly aligned. Assemble cap and gasket to case, being careful to apply even pressure on all sides. If the cap is misaligned, it may cause brinelling of the bearing cup. Tighten the cap screws evenly and alternately in a criss-cross pattern to 60-80 lbs. ft. torque.

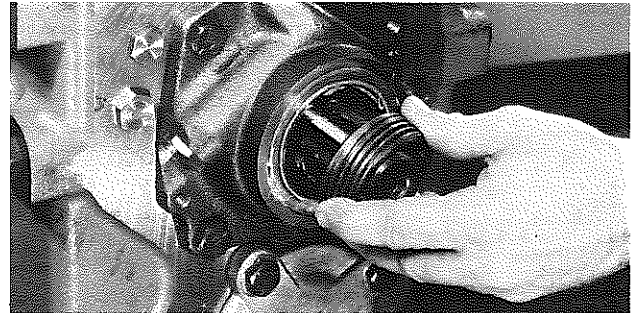


Figure 81 — Installing Speedometer Gear

Slide the speedometer gear onto the rear of the mainshaft.

### Mainshaft End Play

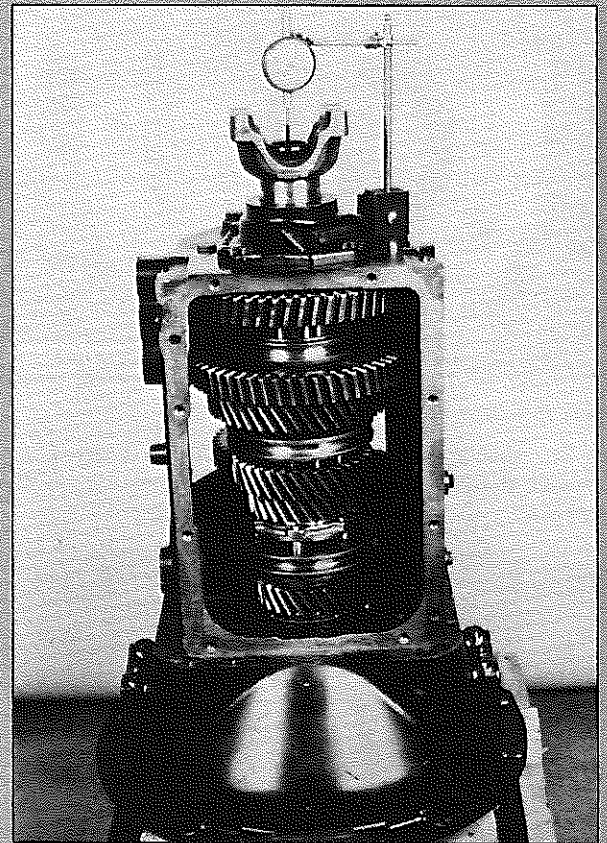


Figure 82 — Checking Mainshaft End Play

Mainshaft end play must be set between .003-.008". Assemble the output fitting and secure with a washer and output nut. Torque 500-550 lbs. ft. Stand the transmission upright and rotate the mainshaft to properly seat the bearings. Place a dial indicator on the mainshaft. Use pry bars under the end fitting to lift the mainshaft and check end play.

# GEARS AND CASE

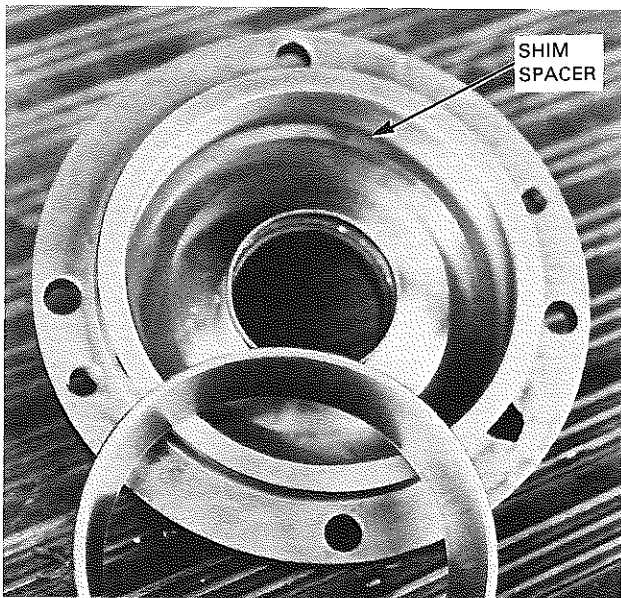


Figure 83 — End Play Shim

Mainshaft end play should measure 0.003-0.008". If it doesn't, remove the front bearing cap. Remove the bearing cup and shim spacer. Measure shim spacer thickness with a micrometer. Install a thicker or thinner shim to bring end play within specifications. Reassemble front bearing cap and recheck end play to be sure it meets specifications.

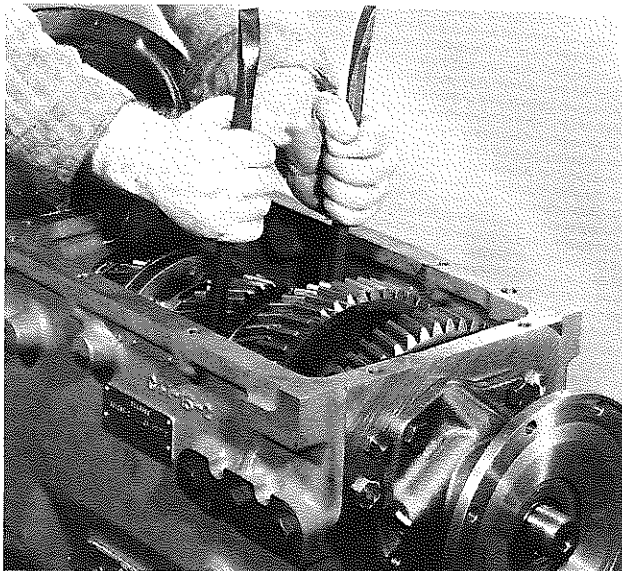


Figure 84 — Using Pry Bars to Lock Up Transmission

Set transmission on bench and lock transmission in two gears. The 1st-reverse clutch collar can be shifted by hand. However, pry bars must be used to shift the 2nd-3rd or 4th-5th speed synchronizers into gear.

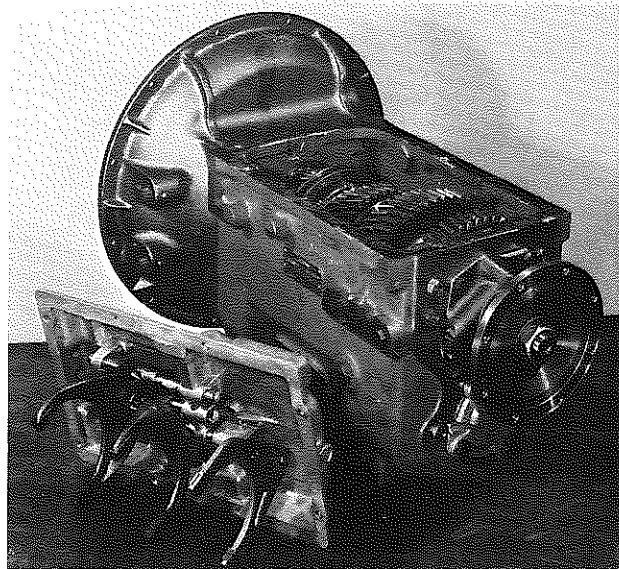


Figure 85 — Tighten Output Shaft Locknut

Tighten the output shaft locknut (1-13/16") to 500-550 lbs. ft. torque, then shift the transmission into neutral.

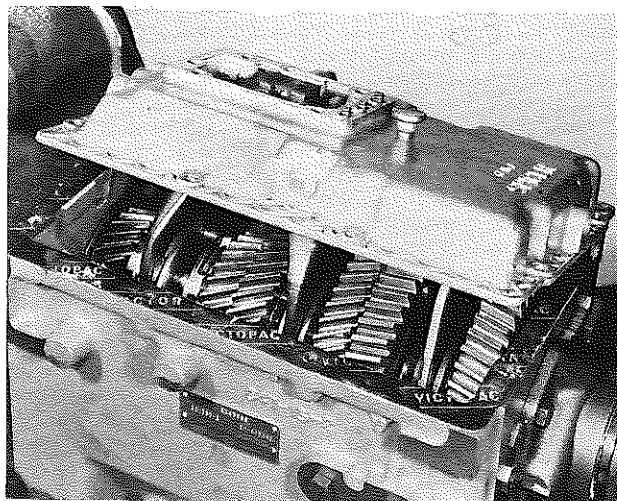
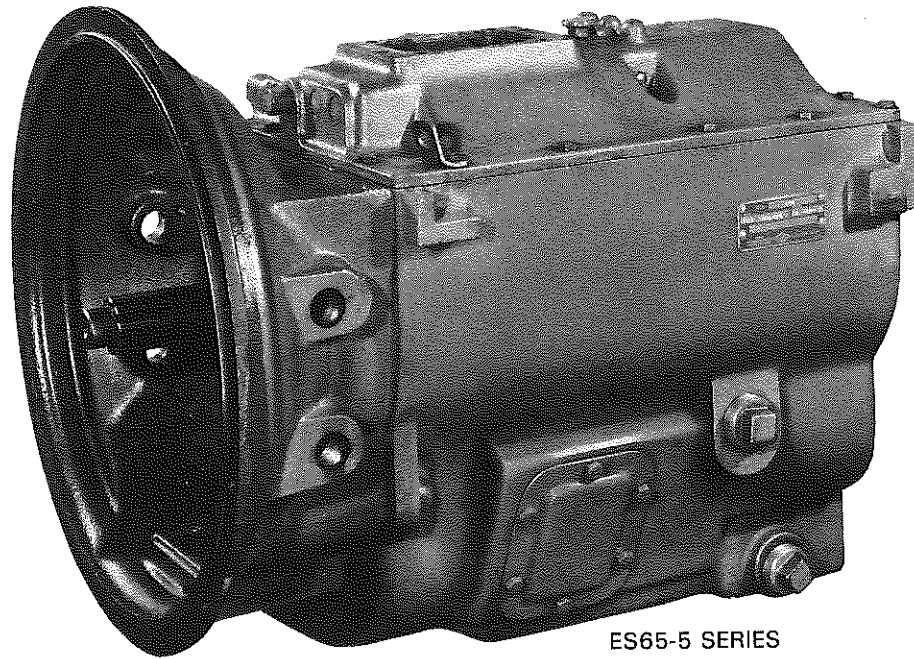


Figure 86 — Assembling Shifter Housing

Install the shifter housing gasket to the top of the case. With the shifter forks in neutral, align them with their respective synchronizers and 1st-reverse clutch collar. Assemble the shifter housing to the case. Tighten the cover screws to 25-32 lbs. ft. torque.



## GEARS AND CASE — ES65-5, CM60



ES65-5 SERIES  
60 SERIES

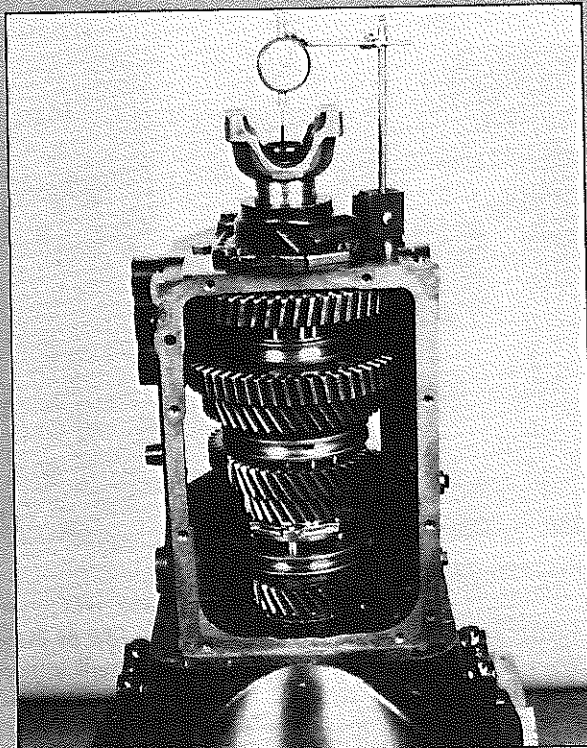


Figure 82 — Checking Mainshaft End Play

### Mainshaft End Play

Mainshaft end play must be set between .003-.008". Assemble the output fitting and secure with a washer and output nut. Torque 500-550 lbs. ft. Stand the transmission upright and rotate the mainshaft to properly seat the bearings. Place a dial indicator on the mainshaft. Use pry bars under the end fitting to lift the mainshaft and check end play.

# GEARS AND CASE — ES65-5, CM160

## DISASSEMBLE MAINSHAFT

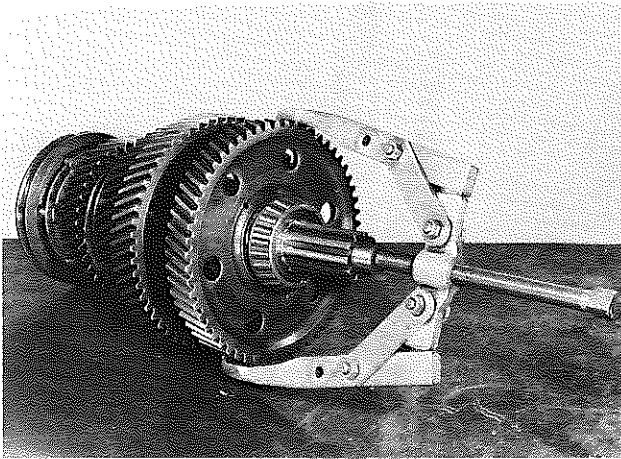


Figure 87 — Removing Reverse Gear and Rear Bearing

Use a suitable puller on reverse gear to remove the rear mainshaft bearing, thrust washer and reverse gear. Then, lift off the reverse gear caged bearings and 1st-reverse clutch collar.

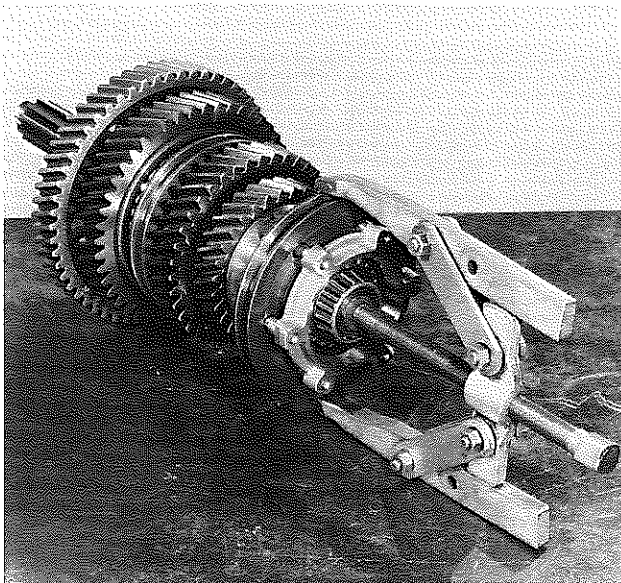


Figure 88 — Removing 4th-5th Speed Synchronizer and Front Bearing

Use a suitable puller to remove the 4th-5th speed synchronizer and the front drive gear pocket bearing. Puller jaws should be positioned behind clutch collar of synchronizer. Do not pull on brass ring.

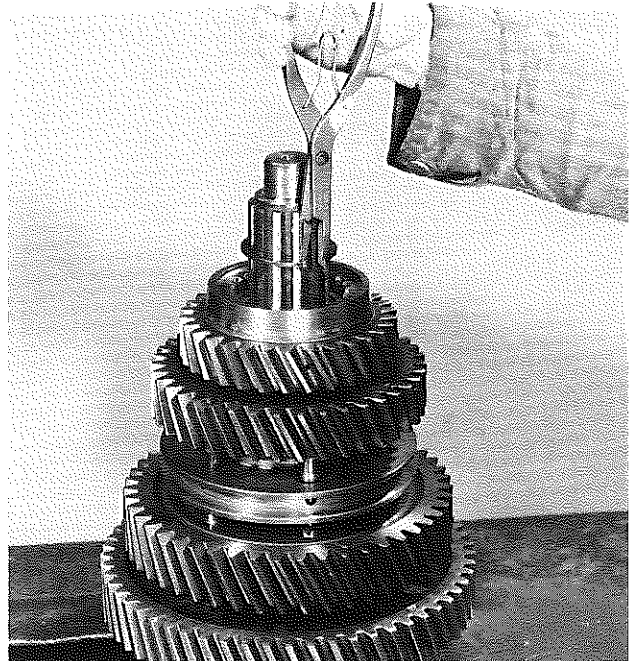


Figure 89 — Removing 4th Speed Gear Snap Ring

Remove the 4th speed gear snap ring, then lift the 4th speed gear and thrust washer from the mainshaft.

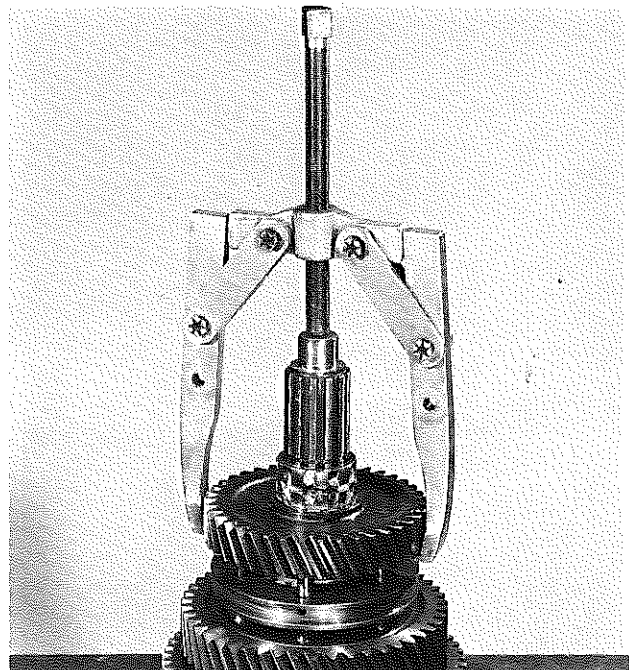


Figure 90 — Removing 3rd Speed Gear

Use suitable puller on 3rd speed gear to remove the 4th speed gear fluted sleeve.

# GEARS AND CASE — ES65-5, CM160

## DISASSEMBLE MAINSHAFT — Cont'd.

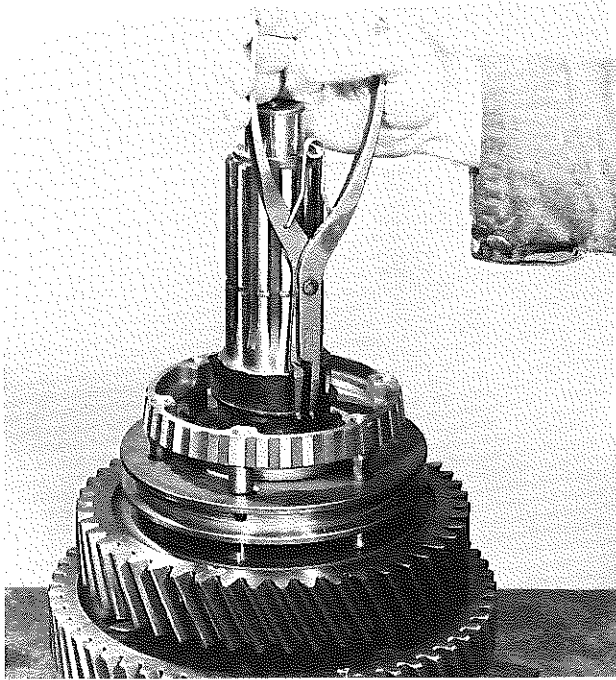


Figure 91 — Removing 2nd-3rd Speed Clutch Gear Snap Ring

Remove 2nd-3rd speed clutch gear snap ring.

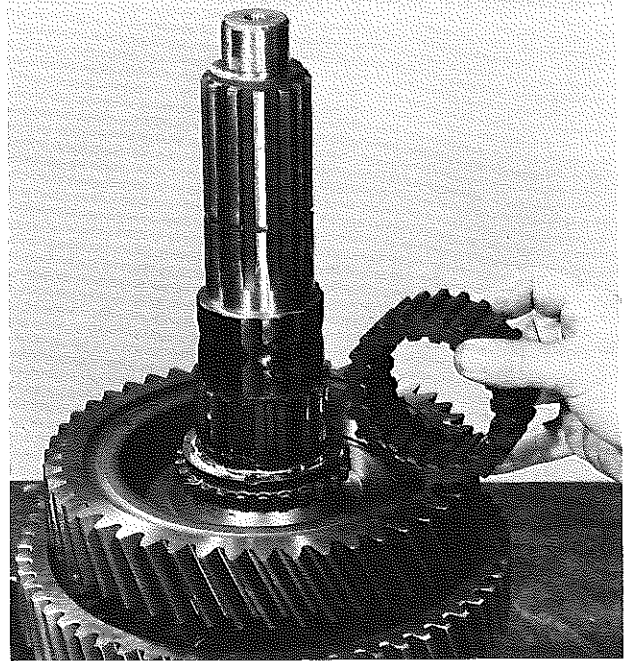


Figure 93 — Removing 2nd-3rd Speed Clutch Gear

Remove 2nd-3rd speed clutch gear, then lift off 2nd speed gear from mainshaft.

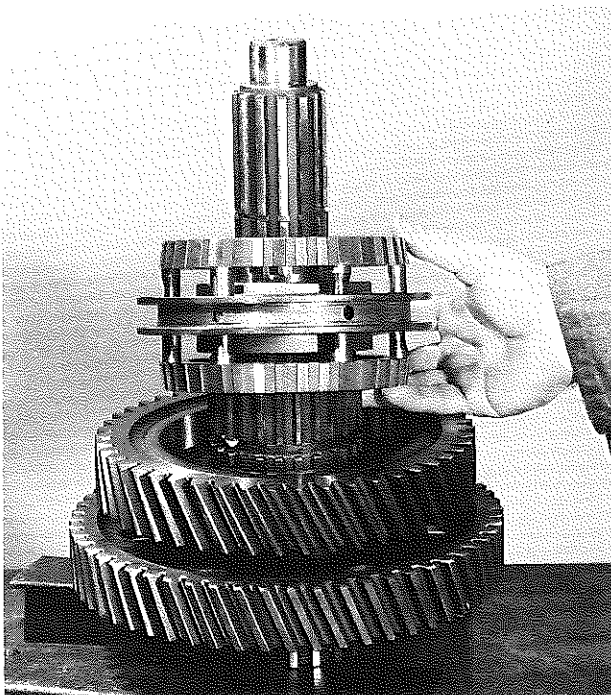


Figure 92 — Removing 2nd-3rd Speed Synchronizer

Remove 2nd-3rd speed synchronizer.

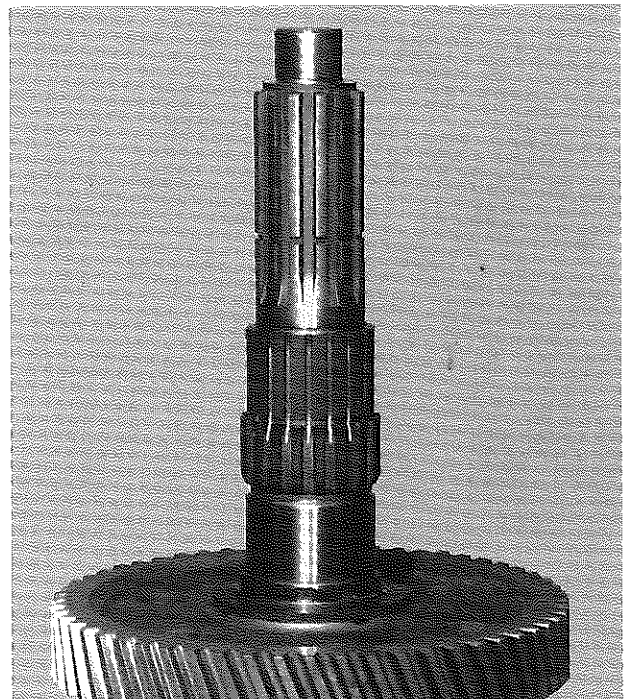


Figure 94 — Removing Snap Rings and Bearings

Remove 2nd speed gear. Remove caged needle bearings and 1st speed gear snap ring from mainshaft.

# GEARS AND CASE — ES65-5, CM60

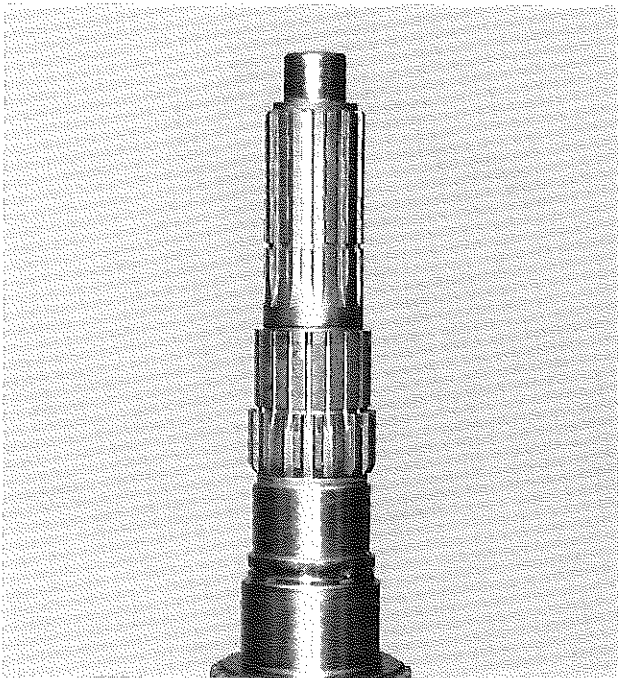


Figure 95 — Removing 1st Speed Gear Caged Bearings

Remove 1st speed gear thrust washer, gear and caged needle bearings.

## REASSEMBLE MAINSHAFT

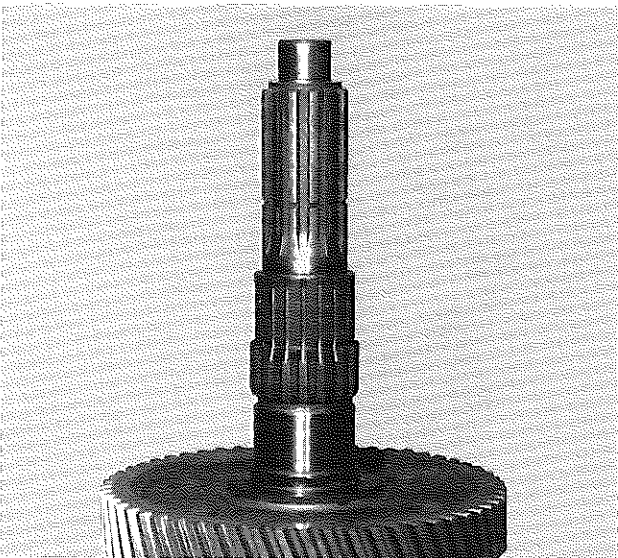


Figure 96 — 1st Speed Gear and Caged Needle Bearings

Lubricate the caged needle bearings with light grease and install in 1st speed gear. Assemble to mainshaft with clutch teeth down (toward the rear of the mainshaft).

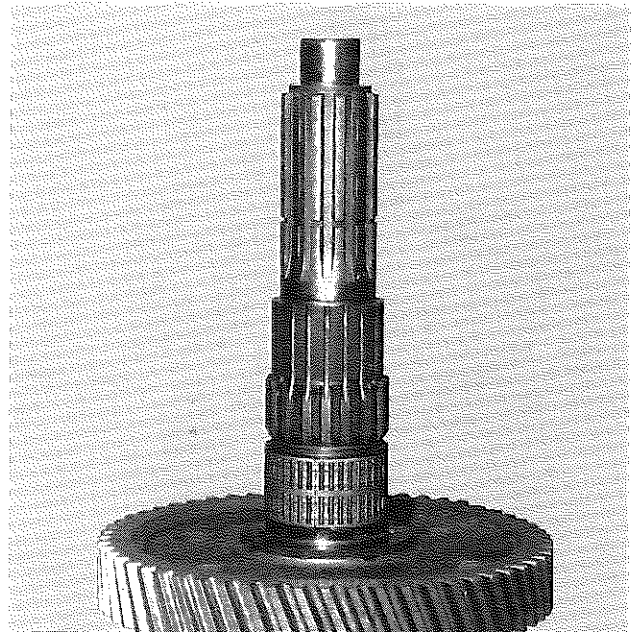


Figure 97 — Assembling 1st Speed Gear Snap Ring

Lubricate thrust washer and assemble on mainshaft. Firmly seat 1st speed gear snap ring in groove on mainshaft. To avoid distortion, do not expand snap ring excessively.

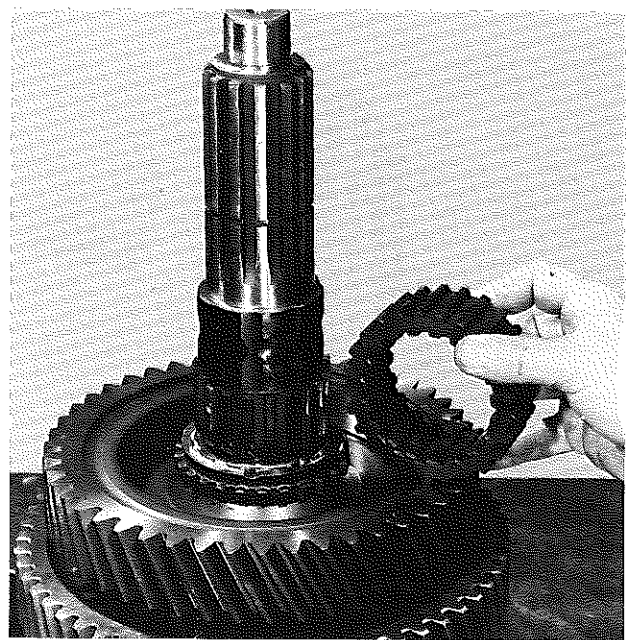


Figure 98 — 2nd-3rd Speed Clutch Gear

Slide 2nd speed gear on mainshaft with clutch teeth up (toward front of mainshaft). Then assemble 2nd-3rd speed clutch gear on splines of mainshaft.

# GEARS AND CASE — ES65-5, CM60

## REASSEMBLE MAINSHAFT—Cont'd.

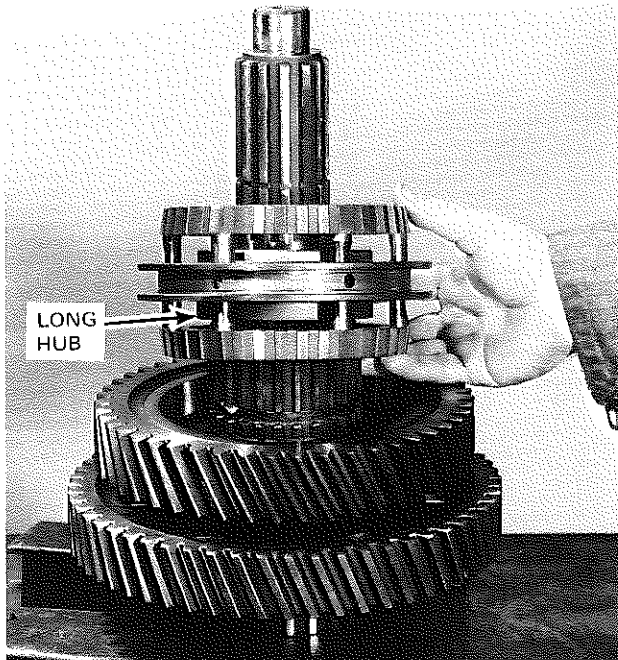


Figure 99 — Assembling 2nd-3rd Speed Synchronizer

Assemble 2nd-3rd speed synchronizer on mainshaft with LONG hub DOWN (toward 2nd speed gear).

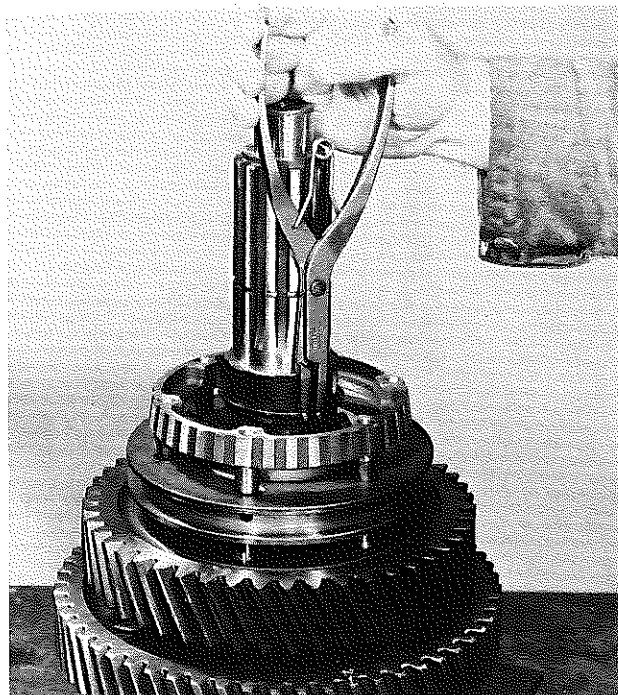


Figure 100 — Installing 2nd-3rd Speed Clutch Gear Snap Ring

Install 2nd-3rd speed clutch gear snap ring.

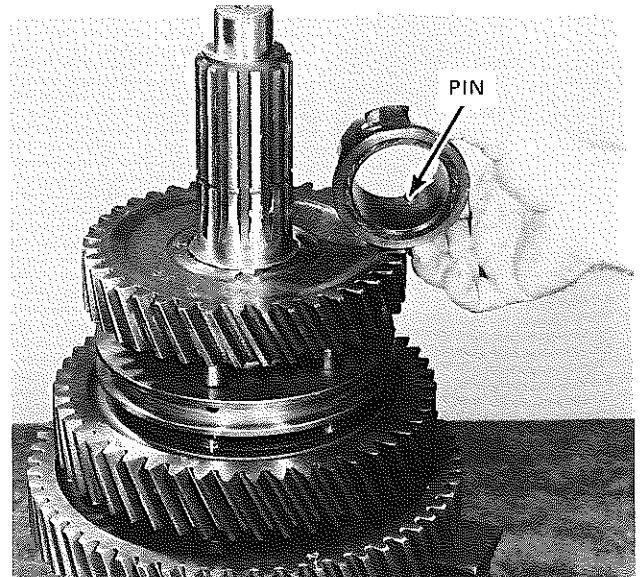


Figure 101 — 4th Speed Gear Sleeve

Assemble 3rd speed gear on mainshaft with clutch teeth down (toward rear of mainshaft). Align pin in bore of 4th speed gear sleeve with spline of mainshaft, and place on mainshaft with flange facing 3rd speed gear (down).

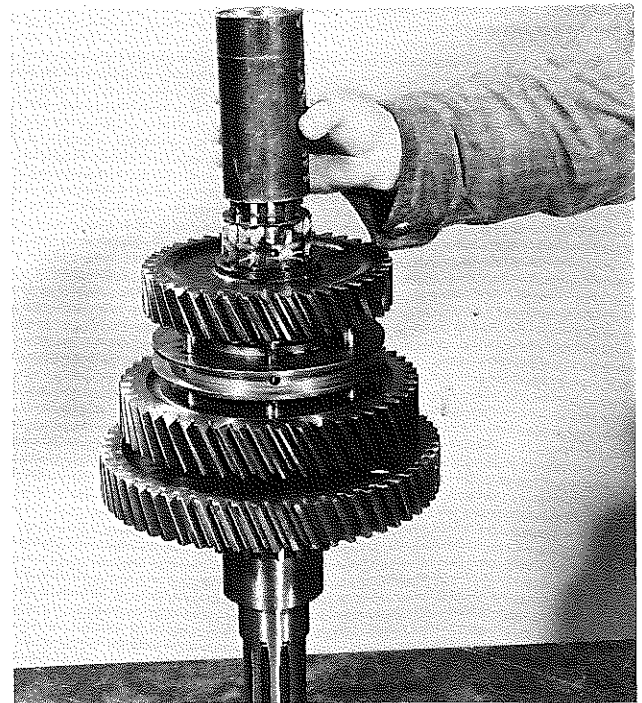


Figure 102 — Positioning 4th Speed Gear Sleeve

Press or drive 4th speed gear sleeve into position with a suitable tool.

# GEARS AND CASE — ES65-5, CM60

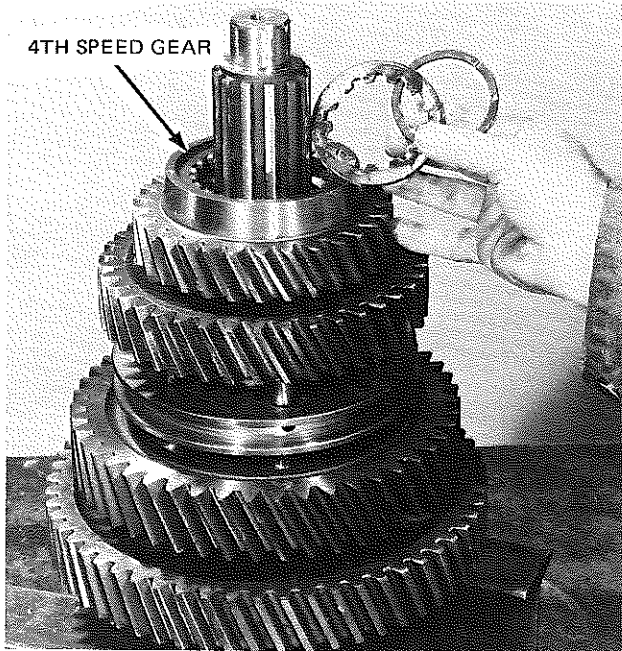


Figure 103 — 4th Speed Gear Thrust Washer and Snap Ring

Slide 4th speed gear with hub up (toward front of mainshaft), over 4th speed gear sleeve. Lubricate thrust washer and install under bore of 4th speed gear. Firmly seat 4th speed gear snap ring in groove on mainshaft.

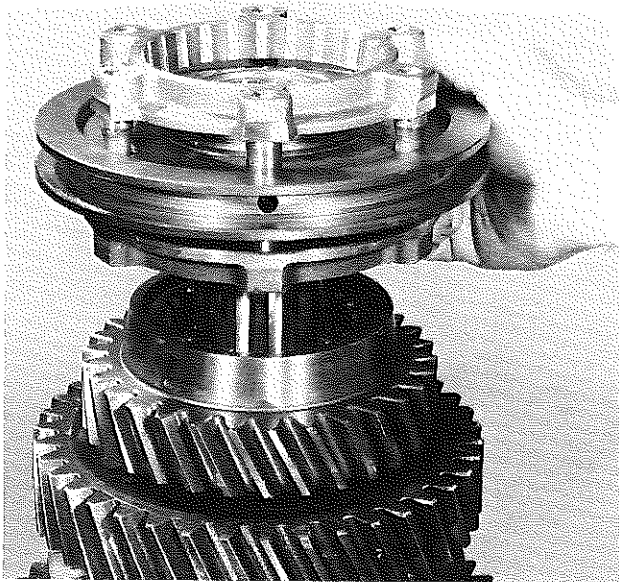


Figure 104 — Assembling 4th-5th Speed Synchronizer

Assemble 4th-5th speed synchronizer to mainshaft with larger brass ring DOWN (toward 4th speed gear).

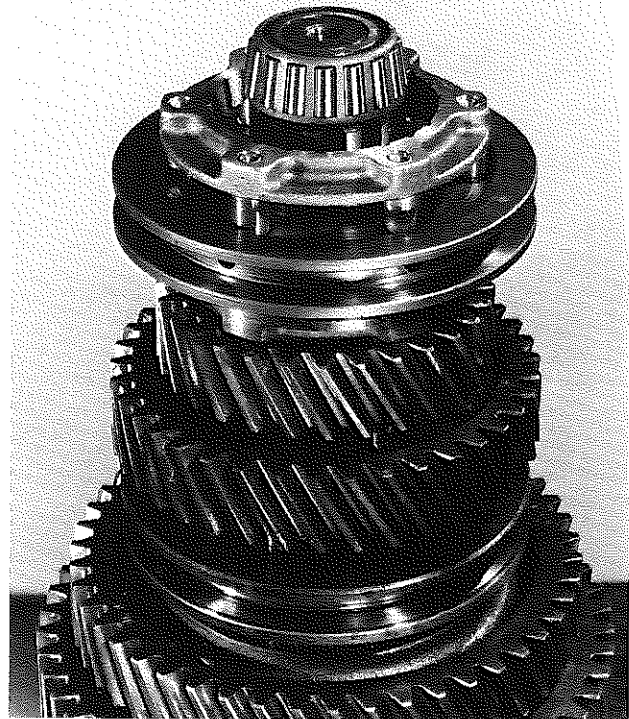


Figure 105 — Drive Gear Pocket Bearing

Press drive gear pocket bearing onto pilot of mainshaft.

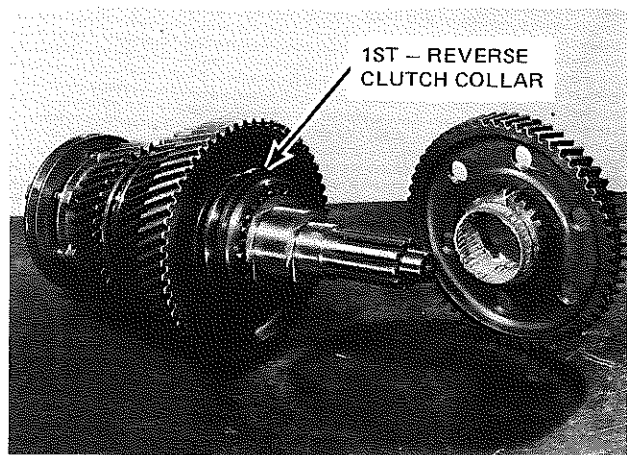


Figure 106 — 1st-Reverse Clutch Collar, Gear and Bearings

Slide 1st-reverse clutch collar onto mainshaft (it's symmetrical). Lubricate caged bearings with light grease and install in bore of reverse gear. Assemble reverse gear on mainshaft, with clutch teeth toward 1st speed gear.

# GEARS AND CASE — ES65-5, CM60

## REASSEMBLE MAINSHAFT — Cont'd.

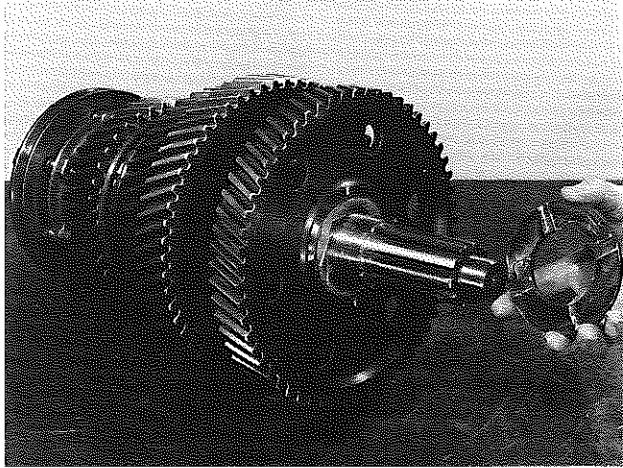


Figure 107 — Reverse Gear Thrust Washer

Lubricate reverse gear thrust washer and assemble on mainshaft.

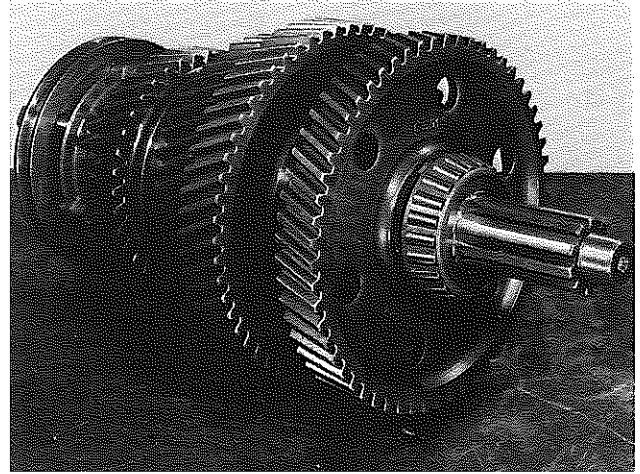


Figure 108 — Mainshaft Bearings

Press the bearing on the rear of the mainshaft.

## DISASSEMBLE COUNTERSHAFT

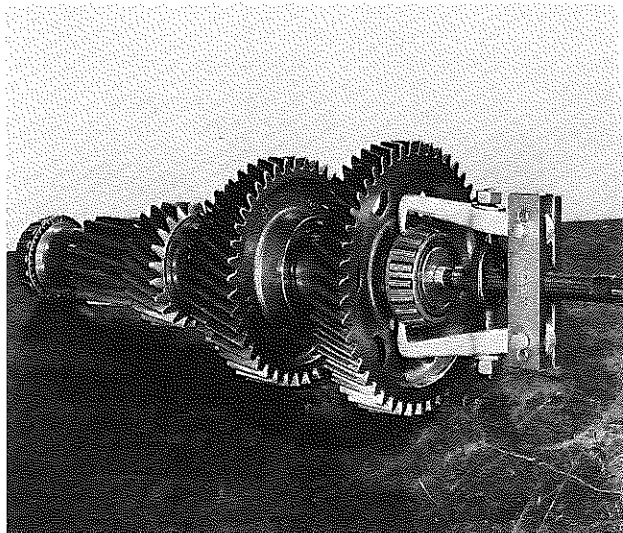


Figure 109 — Removing Countershaft Front Bearing

Use a suitable puller to remove the countershaft front and rear bearings. Be sure and pull on the INNER race to avoid damaging the bearings.

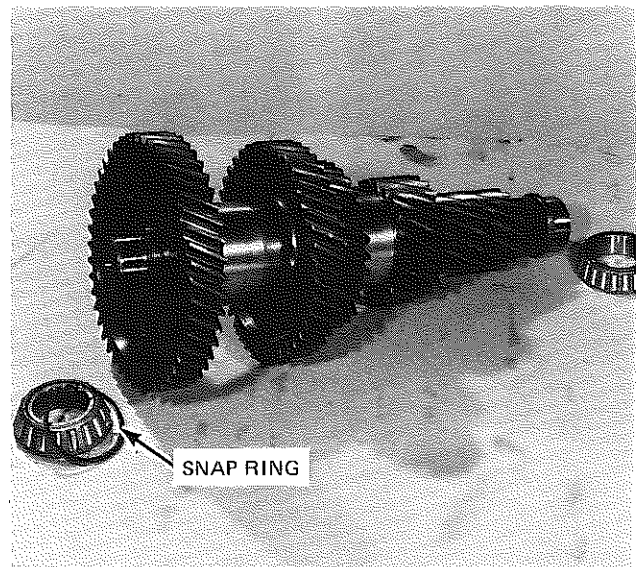


Figure 110 — Countershaft Drive Gear Snap Ring

With bearings off, remove snap ring that retains countershaft drive gear.

# GEARS AND CASE — ES65-5, CM60

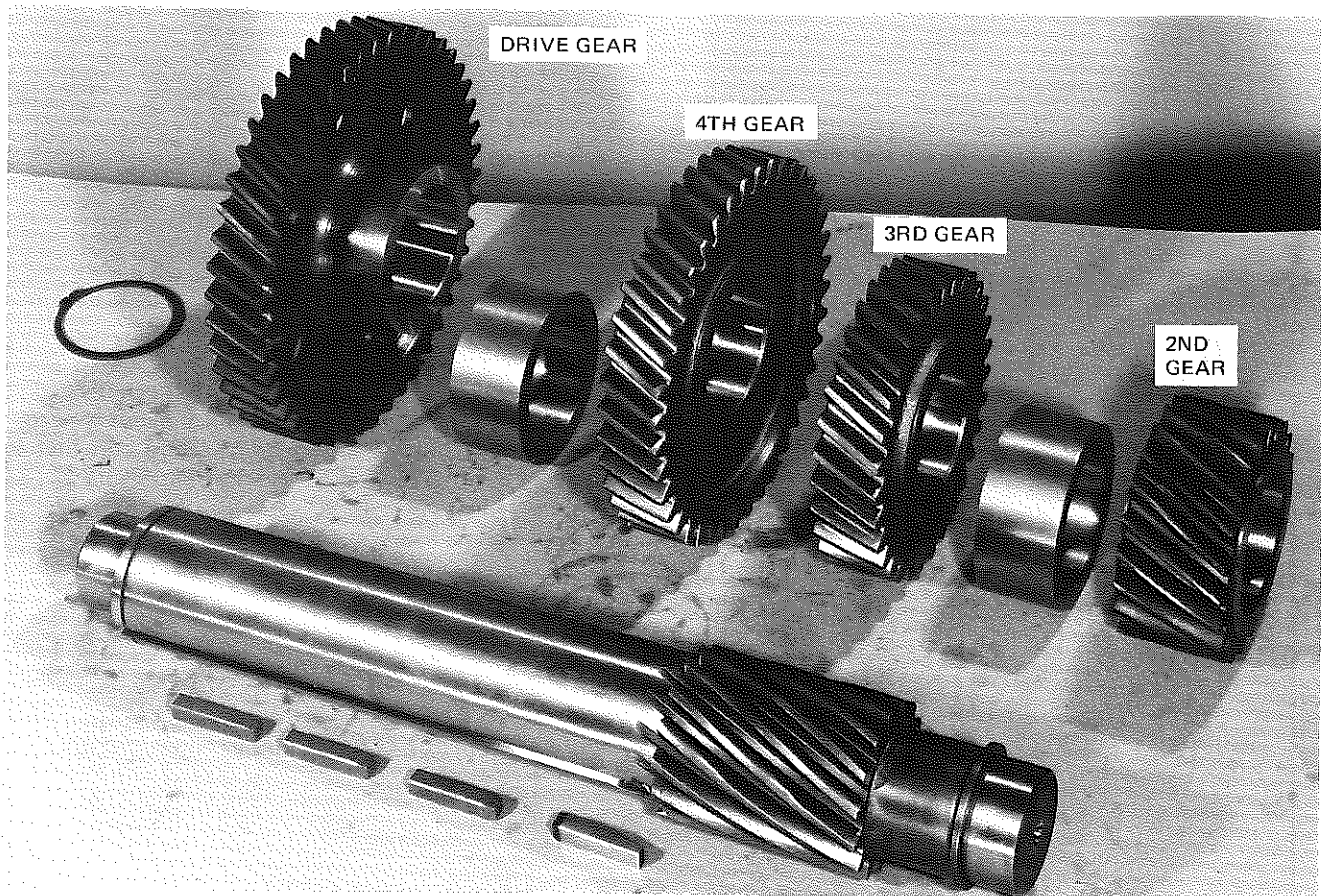


Figure 111 — Countershaft Components

All of the countershaft gears have a keyway in the gear bore and are a press fit on the countershaft. The 1st speed gear is machined into the countershaft and is not removable. The spacers are interchangeable.

**TO REMOVE COUNTERSHAFT DRIVE GEAR** — Support countershaft drive gear (as close to hub as possible) and press the countershaft until free of the drive gear. Remove the key and slide off the spacer.

**TO REMOVE 3RD AND 4TH SPEED GEARS** — Support the 3rd speed gear and press the countershaft until free of both the 3rd and 4th speed gears. Remove the two keys and spacer.

**TO REMOVE 2ND SPEED GEAR** — Support the 2nd speed gear and press the countershaft until free of the 2nd speed gear. Remove the key.

## REASSEMBLE COUNTERSHAFT

All gears are pressed on the countershaft in approximately the same way.

**2ND SPEED GEAR** — Assemble and securely seat the key to the countershaft. Support hub of 2nd speed gear on a

press (gear is symmetrical), align key in countershaft with keyway in gear and press countershaft to gear.

**3RD SPEED GEAR** — Slide spacer onto countershaft. Assemble and securely seat key to countershaft. Support hub of 3rd speed gear on a press (long hub DOWN, or toward front of countershaft). Align key in countershaft with keyway in gear and press countershaft to gear, until firmly seated against the spacer.

**4TH SPEED GEAR** — Assemble and securely seat key to countershaft. Support hub of 4th speed gear on a press (long hub DOWN, or toward front of countershaft). Align key in countershaft with keyway in gear and press countershaft to gear.

**COUNTERSHAFT DRIVE GEAR** — Slide spacer onto countershaft. Assemble and securely seat key to countershaft. Support hub of drive gear on a press (long hub UP, or toward rear of countershaft). Align key in countershaft with keyway in gear and press countershaft to gear. Firmly seat drive gear snap ring in groove of countershaft. To avoid distortion, do not expand snap ring excessively.



# GEARS AND CASE — ES65-5, CM60

## REASSEMBLE COUNTERSHAFT—Cont'd.

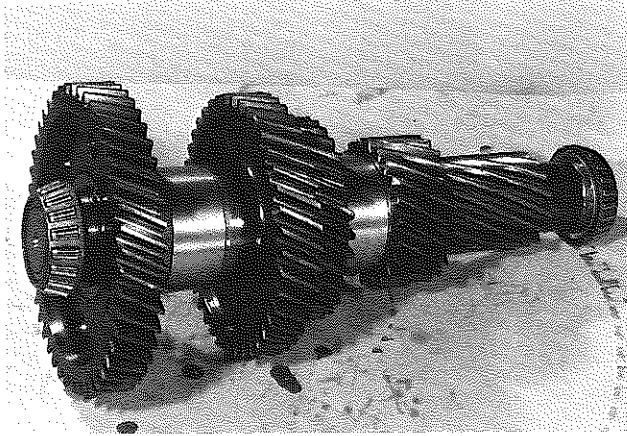


Figure 112 — Countershaft Bearings

Press front and rear bearings onto countershaft.

## DRIVE GEAR

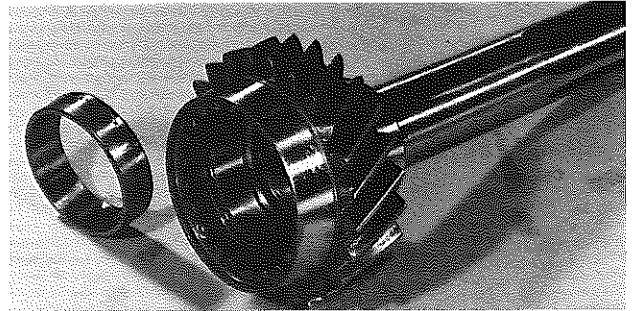


Figure 113 — Drive Gear Bearing Cup

The ES65-5 and CM60 use a separate pocket bearing cup, which must be pressed out if replacement is necessary. The CM50 uses an integral bearing cup that is machined into the drive gear as shown in Figure 28.

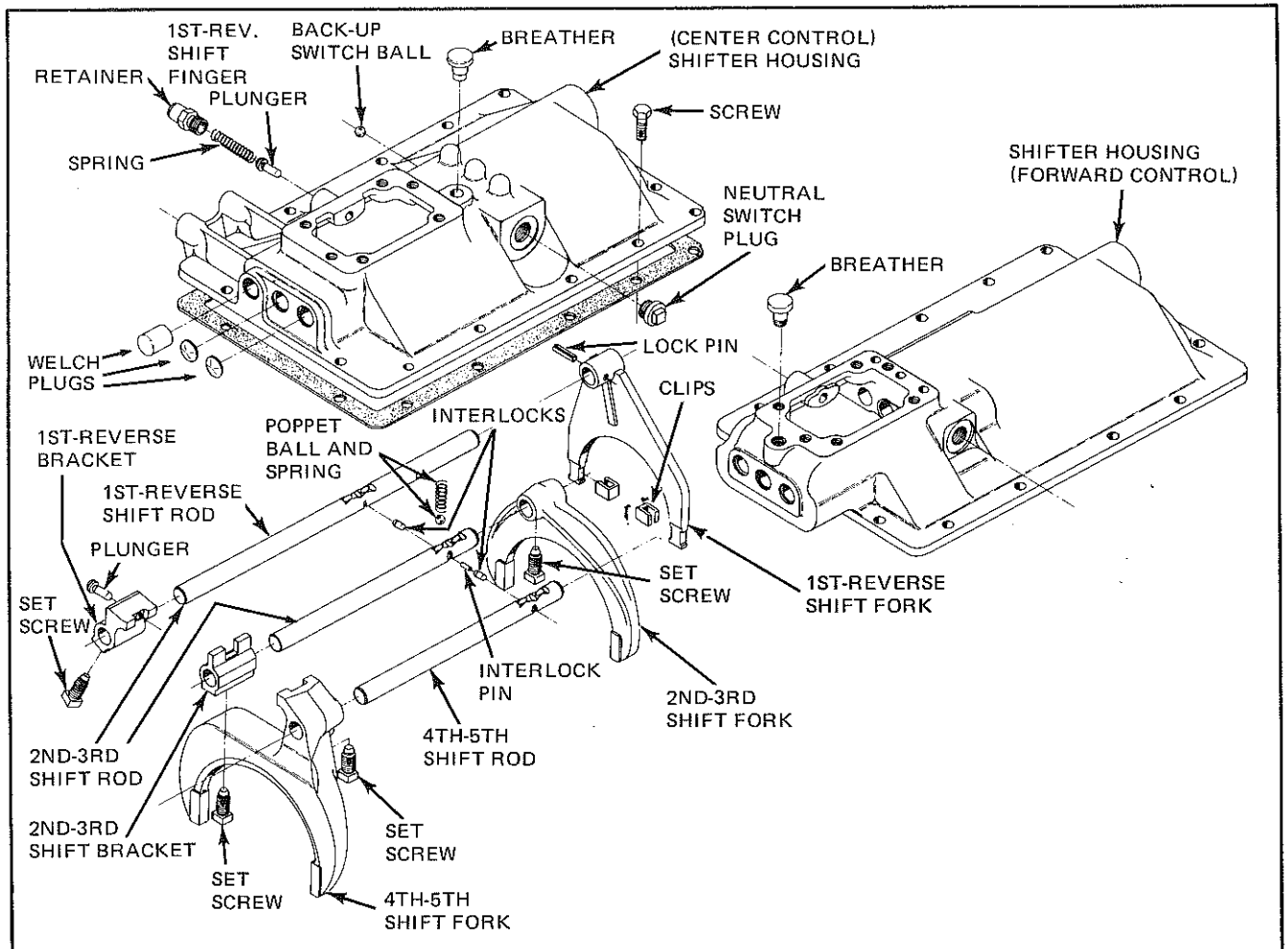


Figure 114 — ES65-5 and CM60 Transmission Shifter Housing Parts

# GEARS AND CASE — ES65-5, CM60

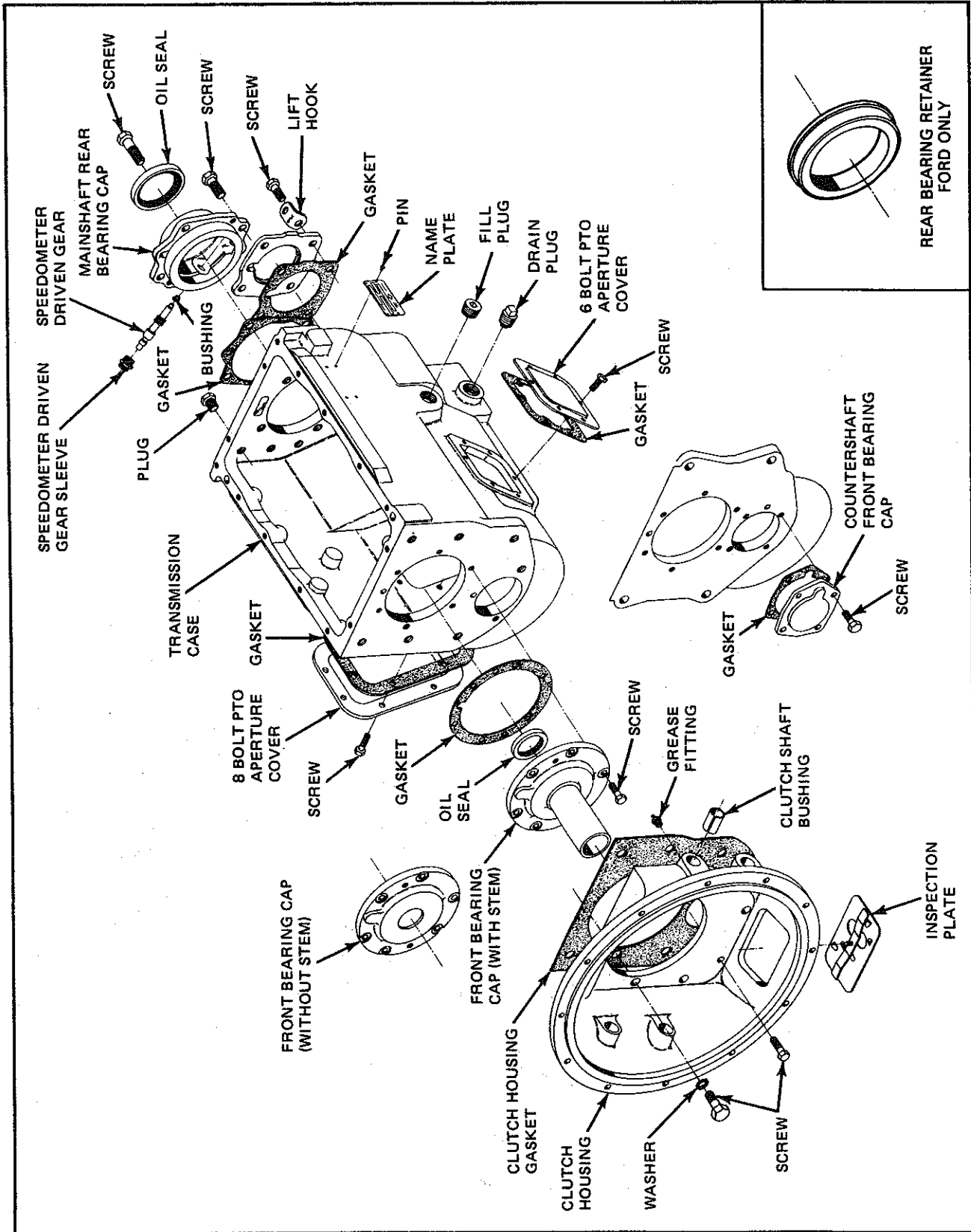


Figure 115 — ES65-5 and CM60 Transmission Case, Bearing Caps and Related Parts

# GEARS AND CASE — ES65-5, CM60

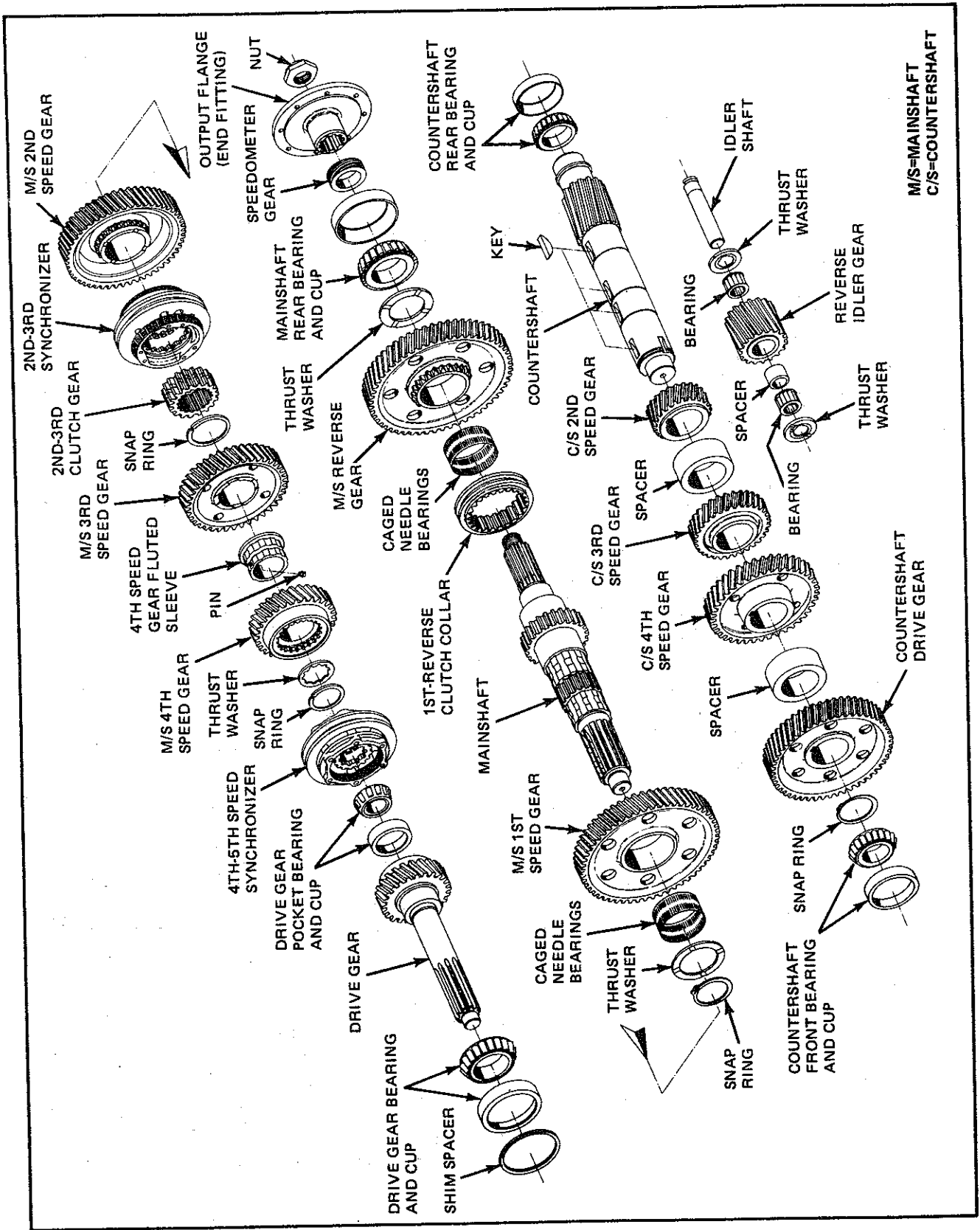


Figure 116 — ES65-5 and CM60 Transmission Gears and Related Parts

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# TROUBLE SHOOTING

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## IMPORTANT PROCEDURE

When locating and correcting 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 and these reports do not always accurately describe the actual conditions. Sometimes symptoms seem to indicate trouble in the transmission; while, actually the trouble may be caused by the axle, propeller shaft, universal joint, engine or clutch. Therefore, before removing transmission or related components to locate trouble, always road test to check possibility that trouble may exist in other closely associated units. If the mechanic can drive, road testing will be more effective; however, just riding with the driver can be very informative.

### Check Functioning Prior to Disassembly:

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.

Further, if remote controls are used, a careful check of the remote and connecting linkage to transmission and auxiliary must be made. The remote units and linkage must be in good working order if the transmission and auxiliary are expected to shift satisfactorily.

### Inspect Thoroughly During Disassembly:

It is poor practice to disassemble a unit or complete transmission as quickly as possible without bothering to examine the parts as they come down. It happens many times that a mechanic has completely disassembled a unit and failed to find the cause of the trouble because he did not bother to examine the parts as they came apart. After the transmission is disassembled, check the lubricant for foreign particles which often reveal sources of trouble that are overlooked during the disassembly.

### Repair or Replace Defective Parts:

Many times the parts or critical adjustments that have caused the trouble are not replaced or corrected because the mechanic will only inspect and replace parts that have failed completely. All pieces should be accurately examined because the broken parts are often just the result and not the cause of the trouble. All parts that are broken or worn and no longer meet specifications should be replaced. On large units, like a transmission, it is suggested that a mechanic replace parts that are worn to the extent that they do not have a long service life remaining. This avoids

another teardown on the unit in the near future. It is also good practice, at this time, to make the changes or modifications recommended to bring the transmission up to date and increase the service life of the unit.

### Noisy Operation:

Noise is usually very elusive and generally not the fault of the transmission; therefore, mechanics should road test to determine if the driver's complaint of noise is actually in the transmission.

In numerous instances, drivers have insisted that the noise was in the transmission; however, investigations revealed the noise to be caused by one of the following conditions:

- (a) Fan out of balance or blades were bent.
- (b) Defective vibration dampers.
- (c) Crankshafts out of balance.
- (d) Flywheels out of balance.
- (e) Flywheel mounting bolts loose.
- (f) Engine rough at idle producing rattle in gear train.
- (g) Clutch assembly out of balance.
- (h) Engine mounts loose or broken.
- (i) Power take-off engaged.
- (j) Universal joints worn out.
- (k) Propeller shafts out of balance.
- (l) Universal joint angles out of plane or at excessive angle.
- (m) Center bearings in drive line dry -- not mounted properly, etc.
- (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 transmission removal, or overhaul. However, if the noise appears to be in the transmission try to break it down into the following classifications. If possible, determine what position the gear shift lever is in when the noise occurs. If the noise is evident in only one gear position, the cause of the noise is generally traceable to the gears in operation.

- (a) *Growl and humming* or more serious, a grinding noise. 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.
- (b) *Hissing* or more serious, a thumping or bumping-type noise. Hissing noises could be caused by bad

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# TROUBLE SHOOTING

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bearings. As bearings wear and retainers start to break up, etc., the noise could change to a thumping or bumping.

- (c) *Metallic rattles* 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 dampeners 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 a rattle in the transmission. Rattle could also be caused by excessive backlash in P.T.O. unit mounting.
- (d) *Improper lubricants* or lack of lubricant can produce noises. Transmissions with low oil levels sometimes run hotter than normal, as there is insufficient lubricant to cool and cover the gears.
- (e) *Squealing*, particularly when the transmission is operating at higher speeds, could be caused by one of the free running gears seizing on the thrust face or fluted diameter temporarily and then letting go. In general, a mild seizure will clear itself up and the transmission will continue to operate very satisfactorily without this defect being known. See (g) below:
- (f) *Gear seizure* at high speed, usually accompanied with loud squealing noise. This type of seizure is readily apparent to the driver since the truck will suddenly slow down as if the brakes were being applied. If the truck continues to move ahead, even though the gear shift lever is placed in neutral, it would indicate the floating gear on the mainshaft had seized. Depressing the clutch should interrupt the driving torque. The seized gear could be checked quite readily by depressing the clutch and checking the action with the gear shift lever progressively in all shift positions. If releasing the clutch tends to kill the engine, then this gear position has not seized. In other words, the transmission would be in two gears at the same time. By a process of elimination, the gear at fault can be readily identified. See (g) below:
- (g) *Vibration*: Gear seizures on thrust faces or fluted diameters are usually caused by vibrations in the power train — this could be engine, propeller shafts, joint angle, rear axle, differentials, etc.

Improved highways permit sustained high speeds. The fact that engines and entire power trains can

now cruise at a higher R.P.M. can introduce vibration frequencies, that were not critical in the past. At slower speeds these items would get by or only pass through critical periods while accelerating or decelerating through the gears.

In the past, drive line vibrations such as bent tubes, joints out of phase or alignment, bad angles due to short couples, clutches out of balance, gears and shafts in transmission out of balance, were fairly obvious. These items will become more critical in vehicles running at sustained high speeds.

Critical vibrations associated with higher speeds are not the old thumping or bumping type but are high frequency vibrations which sting or tingle the soles of your feet, tickle the end of your fingers, etc. This type of vibration will cause gear seizures, broken synchronizer pins, bearing failure due to retainer rivet failures, promote brinelling, fretting corrosion, etc.

- (h) *Gear whine* is usually caused by lack of backlash between mating gears — improper shimming of P.T.O. units is the big offender here.

## Noise In Neutral:

### Possible Causes:

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

## Noise In Gear:

### Possible Causes:

- (a) Worn, or rough mainshaft rear bearing.
- (b) Rough, chipped, or tapered sliding gear teeth.
- (d) Noisy speedometer gears.
- (e) Refer to conditions listed under *Noise in Neutral*.

## Oil Leaks:

### Possible Causes:

- (a) Oil level too high.

# TROUBLE SHOOTING

## Oil Leaks - Cont.

### Possible Causes:

- (b) Wrong lubricant in unit.
- (c) Non-shielded bearing used at front or rear bearing cap. (Where applicable.)
- (d) Seals (if used) defective or omitted from bearing cap, wrong type seal used, etc.
- (e) Transmission breather omitted, plugged internally, etc.
- (f) Capscrews loose, omitted or missing from remote control, shifter housing, bearing caps, P.T.O. or covers, etc.
- (g) Welch "seal" plugs loose or missing entirely from machine openings in case.
- (h) Oil drain-back openings in bearing caps or case plugged with varnish, dirt, covered with gasket material, etc.
- (i) Broken gaskets, gaskets shifted or squeezed out of position, pieces still under bearing caps, clutch housing, P.T.O. and covers, etc.
- (j) Cracks or holes in castings.
- (k) Drain plug loose.
- (l) Also possibility that oil leakage could be from engine.

### Walking or Jumping Out of Gear:

Dana/Spicer transmissions and auxiliaries are provided with "hopping guards" for most gear positions. Therefore, if the units are walking out of gear it could be caused by:

- (a) Interference or resistance in the shift mechanism preventing full engagement of the sliding clutch gear or —
- (b) If the gear has been shifted completely into position some other malfunction which could move the gear or the shaft itself out of its proper location.

If remote controls are used, the mechanic must satisfy himself that the remote units are satisfactory and that transmission is actually at fault. One other point that should be noted is whether the unit walks out of gear under drive (while pulling a load) or on a coast load. Also, does the gear hop occur on smooth or only on rough roads. A number of 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 rods or linkage that limits travel of forward remote from neutral position.
- (c) Loose bell cranks, sloppy ball and socket joints.
- (d) Shift rods, cables, etc., too spongy, 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, loose on frame, etc.
- (g) Set screws loose at remote control joints or on shift forks inside remote or even inside transmission unit.
- (h) Shift fork pads or groove in sliding gear or collar worn excessively.
- (i) Worn taper on gear clutch teeth.
- (j) 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) Shift rod poppet springs broken.
- (c) Shift rod poppet notches worn.
- (d) Shift rod bent or sprung out of line.
- (e) Shift fork pads not square with shift rod bore.
- (f) Excessive end-play in drive gear, mainshaft or countershaft, caused by worn bearings, retainers, etc.
- (g) Thrust washers or faces worn excessively, missing, etc.

### Hard Shifting: (Unsynchronized Units)

An improperly operating clutch will interfere with the proper shifting of gears in any transmission. It is important that the hydraulic, air or similar release mechanism (if used), also be in proper working order. If the mechanic is sure that a 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 units. Forward remote is isolated and is often overlooked. However, many remote controls used on transmissions and auxiliaries require separate lubrication.
- (b) No lubricant 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.

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# TROUBLE SHOOTING

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- (d) Badly worn or bent shift rods.
- (e) Improper adjustment of shifter linkage.
- (f) Sliding clutch gears tight on splines of shaft.
- (g) Clutch teeth burred over, chipped or badly mutilated due to improper shifting.
- (h) Binding or interference of shift lever with other objects or rods inside the cab or near the remote control island.
- (i) Driver not familiar with proper shifting procedure for this transmission. Also includes proper shifting if used with 2-speed axle, auxiliary, etc.
- (j) Clutch or drive gear pilot bearing seized, rough, dragging.
- (k) Clutch brake engaging too soon when clutch pedal is depressed.

## Hard Shifting: (Synchronized Units)

- (a) Loose or flimsy remote controls, spongy or flexible rods and/or cables, preventing full application of force to hold and synchronize gears.
- (b) Improper design of remote controls. If shift lever linkage and mechanical advantage inside the remote control units is not correct, manual shifting will be hard. Further, driver may not be able to feel the synchronizer action which usually results in a snap-type shift.
- (c) Improper adjustment of shift linkage.
- (d) Synchronizer bronze worn, or steel chips imbedded in bronze prevent proper synchronization.
- (e) Damaged synchronizer such as broken poppet springs, poppets jammed, loose or broken blocker pins.
- (f) Wrong lubricant especially if E.P. type lubricants are added.
- (g) 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, etc. Note: On some units employing a full air control for clutch release, air pressure of approximately 60 lbs. or more must be secured before 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.

- (e) Clutch brake set too high on clutch pedal — locking gears behind hopping guard.

## Crash Shifting or Raking of Gears: (Synchronized Units)

Cause: Raking of gears during the manual shift is usually caused by a defective synchronizer or improper shifting technique for synchronized transmission.

When the shift lever moves directly into the manual shift position without resistance, the raking of teeth will be audible and felt through the gear shift lever. This condition does not always mean the synchronizer is worn out. The following may cause this condition:

- (a) Quite often, small chips may lodge in the bronze cone temporarily, which prevents proper synchronization and causes raking shifts. Continued operation of the transmission may either imbed the chip below the surface of the bronze or reject it and the synchronizer will return to normal functioning.
- (b) Use of improper oils often causes raking of synchronizer. Heavy oil prevents the synchronizer cone from breaking through the oil film and doing the job properly. The above condition usually occurs with cold, heavy oil, but the synchronizer begins to work properly when the transmission oil reaches normal operating temperature. We recommend the use of the lighter weight oil, such as SAE 30 Engine Oil.
- (c) The use of E.P. or extreme pressure additives is not required and certainly not desirable in any Dana/Spicer unit power or auxiliary type transmission. Glazing of synchronizer bronze cone due to breakdown of oil is especially common with E.P. additives found in multi-purpose or rear axle type lubricants.
- (d) Broken synchronizer poppet springs sometimes jam under the poppet preventing proper movement of the synchronizer cone, resulting in crash shifts.
- (e) Synchronizer bronze worn smooth with loss of clutching action. This is usually caused by poor driver technique, or failure to control engine speed drop-off during upshift, or failure to bring engine speed nearly up to governor speed when down-shifting, causes overwork of synchronizer and failure to shift. Also, drivers who try to shift without using the clutch will burn or wear out manual synchronizers at relatively low mileage.
- (f) Blocker pin detents of the synchronizer worn excessively, resulting in loss of blocker action and crash shifting.
- (g) Blocker pins loose, broken, or turned over.

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# TROUBLE SHOOTING

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## Bearing Failures:

A high percentage of all ball bearing failures are caused by dirt which is always abrasive.

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

Softer material such as dirt, dust, etc., usually form abrasive paste or lapping compounds within the bearings themselves since the unit 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 chips, etc., may enter the bearings during assembly from hammers, drifts, power chisels, etc., or be manufactured within the unit during service from raking teeth, etc. These chips produce small indentation in balls and races. Jamming of these hard particles between balls and races may cause the inner race to turn on shaft, or the outer race to turn in the housing.

## Corrosion:

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

Brinelling caused by improper assembly or removal usually hammering with off-center blows. Use drivers, preferably under an arbor, or pullers.

## 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.

## Shaft Fits:

Excessive looseness under load is very objectionable because it produces a creeping or slipping of the inner ring on the rotating shaft. This causes the surface metal of the shafts to scrub or wear off.

Bearing fits on rotating shafts are usually specified as tight. When play or looseness, even .001", exists between the bearing and shaft, there is a very powerful force tending to rotate the inner race on the shaft; this force is caused by the looseness or lost motion between the parts and disappears when no looseness exists.

## Removal of Bearings:

It is far more difficult to remove bearings from a shaft than to put them on. In most cases it is necessary to remove the bearing by pulling on the outer-race which can damage the balls or races. Since such damage is seldom visible, it does not become known until after complete reassembly. It is good P.M. to replace most ball bearings during the overhaul period. If a bearing is not going to be replaced, avoid removal during low mileage rebuild.

## 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.

Numbering systems of different bearing manufacturers, however, have not been standardized. Consult interchangeable tables and use proper bearings for replacement parts.





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