

**SECTION 9**  
**TRANSMISSIONS**  
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*\*Note: For service and overhaul procedures covering the Twin Disc marine gear, refer to Marine Manual - Twin Disc Model MG506, Form 20SE29.*

## WARNER HYDRAULIC MARINE GEAR

Two models of the Warner Marine Gear are used with the Series 53 engine-- Model 71 shown in Fig. 1 and Model 72 shown in Fig. 2. Each model is available in direct drive, 1.5:1, 2.1:1, 2.5:1 and 3:1 reduction gear ratios. Since the two models of the marine gear are similar, the following general description as well as the procedures for removal, disassembly, assembly and replacement of parts apply to either model.

Although many parts are interchangeable between the two models, some of the parts are not interchangeable; therefore, make sure of the marine gear model before ordering replacement parts. The reduction gear ratio, model and serial numbers will be found on the name plate on the top left-hand side of the reverse gear housing.

The Warner Hydraulic Marine Gear assemblies, shown in Figs. 1 and 2, consist of a hydraulically operated multiple disc forward and reverse clutch, a 2.1:1 ratio reduction gear assembly, an oil pump and oil screen, an oil pressure regulator valve and an oil sump independent of the engine oil system. On current engines, the oil cooler is mounted at the heat exchanger. Former engines have the oil cooler engine mounted; thus, the marine gear is a self contained assembly.

Oil pressure for the operation of the marine gear is provided by a crescent type oil pump which is attached to the forward face of the gear housing adaptor and keyed to the drive gear (input) shaft. The oil pump is driven continuously while the engine is running. The oil is delivered under pressure from the pump to the selector (control) valve and to the pressure regulator valve inside of the selector valve.

The pressure regulator valve maintains constant pressure over a wide speed range, and the selector (control) valve directs the oil under pressure to either the forward or reverse clutch piston cavity, the lubricating circuit and the oil cooler. The operating oil pressure range for the marine gear at operating speed is 120 to 160 psi, and the maximum operating oil temperatures for the various marine gears are shown in the following chart.

MAXIMUM OIL TEMPERATURES

Gear Ratio	Forward	Reverse
1:1	200°F	250°F
1.5:1	215°F	250°F
2:1	225°F	250°F
2.5:1	215°F	250°F
3:1	215°F	250°F

All of the marine gear oil does not flow through the marine gear oil cooler. Only the oil that flows by the pressure regulator valve, when the oil pressure moves the valve off its seat, flows through the oil cooler and is cooled by the engine water flowing around the oil cooler core.

A breather assembly is mounted in the top of the marine gear housing directly above the selector (control) valve for venting the marine gear.

Figures 1, 4 and 5 illustrate the reduction gear assemblies used on the 1.5:1, 2.1:1 and 2.5:1 reverse and reduction gear assemblies.

The reduction gear assembly consists of a planetary gear set which reduces the revolutions put into the unit by a predetermined ratio and is always engaged. The direction of rotation of the drive shaft of the reduction gear assembly is the same as the engine rotation in forward drive. Lubrication of the reduction gear assembly is supplied by the marine gear oil pump.

### Operation

#### FORWARD DRIVE

When the selector valve lever is moved to the forward position (lever should cover the letter "F" on the housing), the selector (control) valve directs the oil under pressure from the oil pump down through the oil passage in the gear housing and reduction gear input shaft, then through the drilled passages in the drive gear shaft and through the three drilled passages in the inner diameter of the forward clutch cylinder, and then to the cavity back of the forward clutch piston. The resulting movement of the forward clutch piston and the lever action of the clutch spring forces the multiple discs of the forward clutch together and, with the aid of the forward clutch hub, locks the input shaft to the ring gear. This in turn prevents rotation of the planetary pinions about their axis and thus locks the input shaft, ring gear and reduction gear input shaft together, causing them to rotate as a solid concentric coupling. In this way, input shaft speed and direction of rotation are transmitted directly to the reduction gear drive shaft.

**NOTE:** The position of the selector valve lever on the reverse gear when in forward should be shifted to the point where it covers the letter "F" on the gear housing and is located in its proper position by the poppet ball. *Do not* remove the selector valve lever poppet spring and/or ball, nor change the lever in any

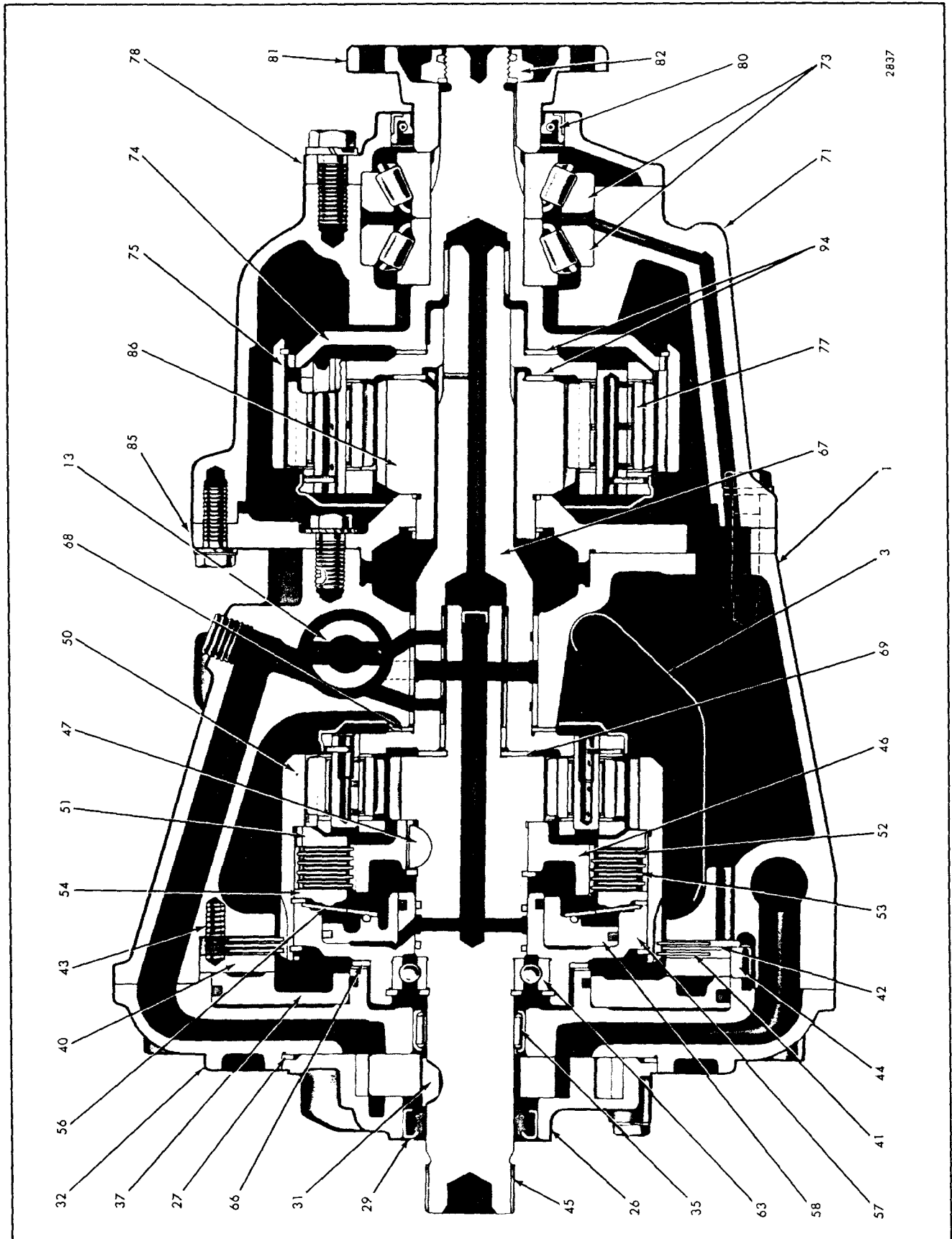


Fig. 1 - Warner Marine Gear Assembly (2.1:1 Ratio Model 71C Shown)

Fig. 1 - Warner Marine Gear Assembly (2.1:1 Ratio Model 71C Shown)

1. Housing--Reverse Gear	43. Spring--Pressure Plate Release	57. Cylinder--Forward Clutch Piston	74. Shaft Assy.--Reduction Gear Drive
3. Baffle--Gear Housing Oil	44. Pin--Reverse Clutch Stationary Plate Dowel	58. Piston--Forward Clutch	75. Ring Gear--Reduction Gear Planetary
13. Valve--Selector Control	45. Shaft Assy.--Drive Gear Input	63. Bearing--Drive Gear Input Shaft Ball	77. Gear Assy.--Reduction Gear Planetary
26. Pump Assy.--Reverse Gear Oil	46. Hub--Forward Clutch	66. Thrust Washer--Forward Clutch Cylinder	78. Retainer--Drive Shaft Bearing
27. Gasket--Oil Pump to Adaptor	47. Woodruff Key--Forward Clutch Hub	67. Shaft Assy.--Planetary Gear and Reduction Gear Input	80. Oil Seal--Bearing Retainer
29. Oil Seal--Oil Pump	50. Ring Gear--Forward Clutch Planetary	68. Thrust Washer--Reduction Gear Input Shaft	81. Drive Flange
31. Woodruff Key--Oil Pump Drive	51. Plate--Forward Clutch Pressure (Rear)	69. Thrust Washer--Reduction Gear Planetary Gear	82. Nut--Drive Flange
32. Adaptor--Reverse Gear Housing	52. Plate--Forward Clutch Inner (Copper Faced)	71. Housing--Reduction Gear	85. Adaptor--Reduction Gear
35. Bearing--Gear Housing Adaptor Roller	53. Plate--Forward Clutch Pressure (Front)	73. Bearing Assy.--Drive Shaft	86. Sun Gear--Reduction Gear
37. Piston--Reverse Clutch	54. Plate--Reverse Clutch Stationary (Steel)		94. Thrust Washer--Planetary Gear
40. Plate--Reverse Clutch Pressure			
41. Plate--Reverse Clutch (Inner)			
42. Plate--Reverse Clutch Stationary (Steel)			

manner. Also *do not* reposition the linkage between the remote control and gear selector valve lever so that it does not have sufficient travel in both direction.

## NEUTRAL

When the selector valve lever is moved to the neutral position, the selector (control) valve blocks off the flow of pressurized oil to the forward and reverse clutches and a portion of the oil flows into the gear housing for lubrication and a portion of the oil is by-passed through the oil cooler and back to the gear housing oil sump. The forward and reverse clutches are also vented, by a different portion of the selector valve, permitting the oil in the cavity behind the pistons to drain in the gear housing oil sump. The forward and reverse clutch release springs force the pistons back to their respective positions, thereby permitting complete disengagement of the forward and reverse clutches.

## REVERSE DRIVE

When the selector valve lever is moved to the reverse position, the selector (control) valve directs oil under pressure from the oil pump through an oil passage in the top portion of the gear housing to the oil passage in the top of the gear housing adaptor, then to the cavity back of the reverse clutch piston. The resulting movement of the reverse clutch pressure plate locks the reverse clutch plates to the reverse gear housing. The stationary reverse clutch (steel) plate which is doweled to the gear housing and the two reverse clutch plates which are splined to the ring gear, prevent rotation of the ring gear. With the ring gear held stationary and the drive (sun) gear rotating at input

speed, the pinions of the compound planetary gear assembly are rotated about their own axis and reverse the direction of rotation of the pinion carrier and reduction gear drive shaft.

**CAUTION:** Shift from forward to reverse drive through neutral at engine speeds below 1000 rpm to prevent damage to the engine, marine gear or reduction gear drive shaft.

It is recommended that vessels utilizing a marine gear have a suitable locking device or brake to prevent rotation of the propeller shaft when the vessel is not under direct propulsion. If the marine gear is not in operation and the forward motion of the vessel causes the propeller shaft to rotate, lubricating oil will not be circulated through the gear because the oil pump is not in operation. Overheating and damage to the marine gear may result unless rotation of the propeller shaft is prevented.

## Lubrication

The reverse and reduction gear assembly is lubricated by pressure and splash. The main oil gallery is open to oil pump pressure whenever the engine is running and all of the moving parts are lubricated through drilled passages in the control valve, gear housing, drive gear (input) shaft, reduction gear input shaft, reduction gear drive shaft and reduction gear adaptor. Lubricating oil is transferred from the reduction gear housing to the reverse gear housing by gravity and jet flow through the drilled passage at the lower inside face of the reduction gear housing.

Check the oil level in the marine gear daily and add

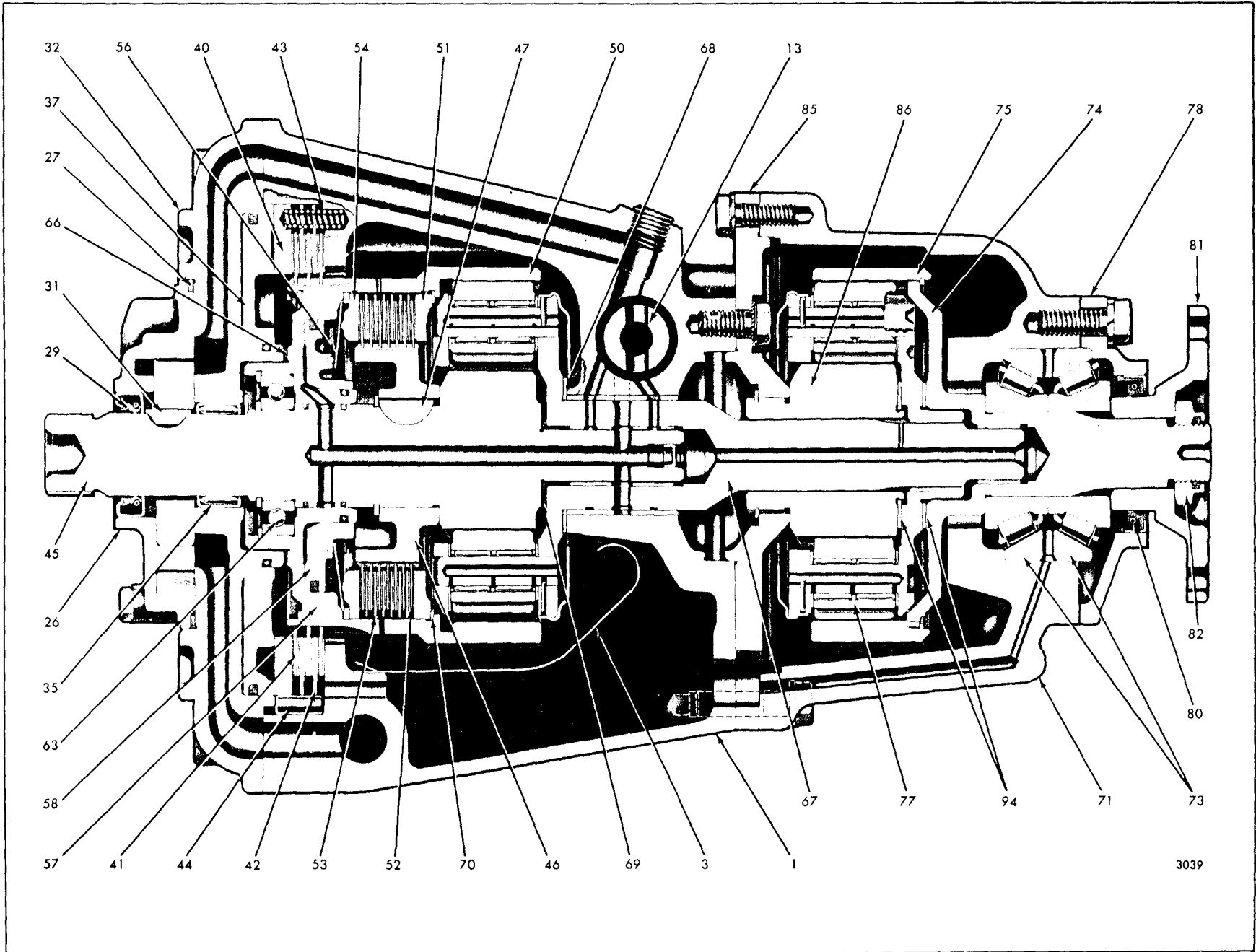


Fig. 2 - Warner Marine Gear Assembly (2.1:1 Ratio Model 72C Shown)

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Fig. 2 - Warner Marine Gear Assembly (2.1:1 Ratio Model 72C Shown)

1. Housing--Reverse Gear	42. Plate--Reverse Clutch Stationary (Steel)	54. Plate--Forward Clutch Pressure (Front)	Selective (Snap Ring)
3. Baffle--Gear Housing Oil	43. Spring--Pressure Plate Release	56. Spring--Forward Clutch Release	71. Housing--Reduction Gear
13. Valve--Selector Control	44. Pin--Reverse Clutch Stationary Plate Dowel	57. Cylinder--Forward Clutch	73. Bearing Assy.--Drive Shaft
26. Pump Assy.--Reverse Gear Oil	45. Shaft Assy.--Drive Gear Input	58. Piston--Forward Clutch	74. Shaft Assy.--Reduction Gear Drive
27. Gasket--Oil Pump to Adaptor	46. Hub--Forward Clutch	63. Bearing--Drive Gear Input Shaft Ball	75. Ring Gear--Reduction Gear Planetary
29. Oil Seal--Oil Pump	47. Woodruff Key--Forward Clutch Hub	66. Thrust Washer--Forward Clutch Cylinder	77. Gear Assy.--Reduction Gear Planetary
31. Woodruff Key--Oil Pump Drive	50. Ring Gear--Forward Clutch Planetary	67. Shaft Assy.--Planetary Gear and Reduction Gear Input	78. Retainer--Drive Shaft Bearing
32. Adaptor--Reverse Gear Housing	51. Plate--Forward Clutch Pressure (Rear)	68. Thrust Washer--Reduction Gear Input Shaft	80. Oil Seal--Bearing Retainer
35. Bearing--Gear Housing Adaptor Roller	52. Plate--Forward Clutch Inner (Copper Faced)	69. Thrust Washer--Reduction Gear Planetary Gear	81. Drive Flange
37. Piston--Reverse Clutch	53. Plate--Forward Clutch (Steel)	70. Spacer--Forward Clutch	82. Nut--Drive Flange
40. Plate--Reverse Clutch Pressure			85. Adaptor--Reduction Gear
41. Plate--Reverse Clutch (Inner)			86. Sun Gear--Reduction Gear
			94. Thrust Washer--Planetary Gear

oil as required to bring it up to the FULL mark on the dipstick.

**NOTE:** A new "Threaded Type" oil level dipstick assembly has replaced the former "Filler Cap Type" dipstick assembly used in the marine gears. To check the oil level in marine gears equipped with the current "Threaded Type" oil level dipstick, place the dipstick in the housing so the bottom of the threaded plug contacts the housing. Then remove the dipstick and check the oil level. The dipstick must be threaded into the housing after the oil level has been checked to prevent oil leakage during operation of the marine gear.

Change the marine gear oil every 200 hours of operation.

Drain the oil from the current marine gears, except the current 2.1:1 marine gears, by disconnecting the oil tube from the elbow at the lower right-hand side of the reverse gear housing, then remove the reducing bushing, oil return tube, nipple and elbow assembly from the housing. After draining the oil, remove the oil strainer assembly from the housing, rinse it thoroughly in clean fuel oil, dry it with compressed air, then reinstall the oil strainer assembly and the reducing bushing, oil return tube, nipple and elbow assembly in the housing and connect the oil tube to the elbow.

Drain the oil from the former marine gears and the current 2.1:1 marine gears by removing the oil strainer retaining plug at the lower right-hand side of the reverse gear housing. After draining the oil, remove the oil strainer assembly (oil deflector in current 2.1:1 marine gears) from the housing, rinse it thoroughly in clean fuel oil, dry it with compressed air, then reinstall

the oil strainer assembly or oil deflector and the oil strainer retaining plug in the housing.

Refill the marine gear to the proper oil level on the dipstick (approximately 1-1/2 quarts in direct drive gears and 3 quarts in reverse and reduction gears) with the same heavy-duty lubricating oil that is used in the engine.

Start and run the engine and marine gear unit at idle speed for a few minutes to fill the lubrication system. Stop the engine, then immediately check the oil level in the marine gear. Bring the oil level up to the FULL mark on the dipstick. Do not overfill.

### Remove Reverse Gear from Engine

If reconditioning of the reverse gear assembly becomes necessary, the reverse gear and reduction gear assembly must be removed from the engine.

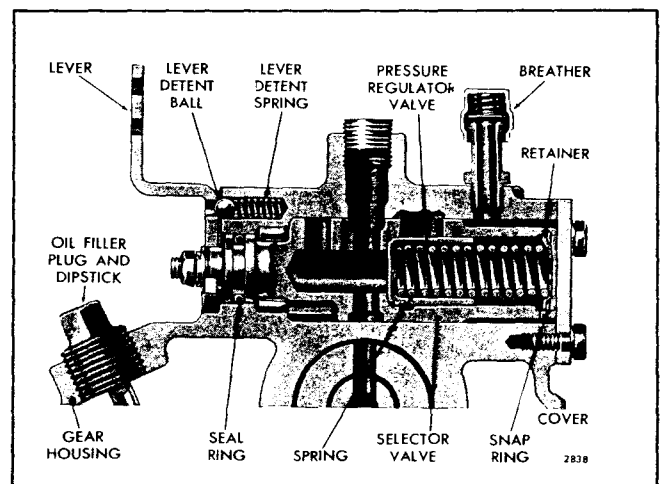


Fig. 3 - Marine Gear Control Valve Assembly

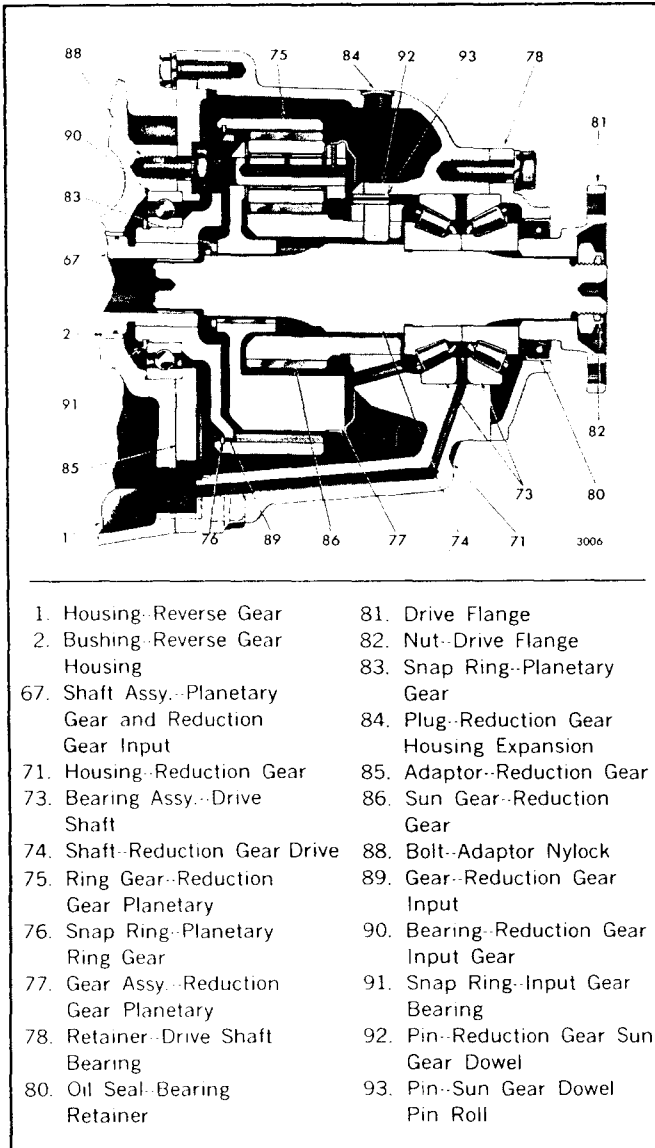


Fig. 4 - Reduction Gear Assembly (1.5:1 Ratio)

However, if reconditioning of only the reduction gear assembly is desired, the reduction gear assembly may be removed as a unit from the reverse gear assembly.

If space limitations do not allow the reverse and reduction gear to be lifted clear as an assembly, the reduction gear only may be removed first, then remove the reverse gear; however, if space permits, remove the reverse and reduction gear as an assembly.

The procedure for removal of the former marine gear is essentially the same for the current marine gear. Exceptions in the procedure for the current marine gears will be indicated. With the engine suitably supported, refer to Figs. 7 and 8 and remove the reverse and reduction gear assembly as follows:

1. Disconnect the oil tube from the elbow at the lower

right-hand side of the reverse gear housing, then remove the reducing bushing, oil return tube, nipple and elbow assembly from the housing. After draining the oil, reinstall the reducing bushing, oil return tube, nipple and elbow assembly in the housing.

On the former marine gears and the current 2.1:1 marine gear, remove the oil strainer retaining plug at the lower right-hand side of the reverse gear housing. After draining the oil, reinstall the plug in the housing.

2. Disconnect the reverse gear oil cooler supply tube at the top of the reverse gear housing.

3. On the former marine gears, disconnect the reverse gear oil cooler return tube at the lower right-hand side of the reduction gear housing or at the top of the reduction gear housing on current 2.1:1 marine gears.

4. Remove the two rear engine supports that are secured to the sides of the reverse gear housing.

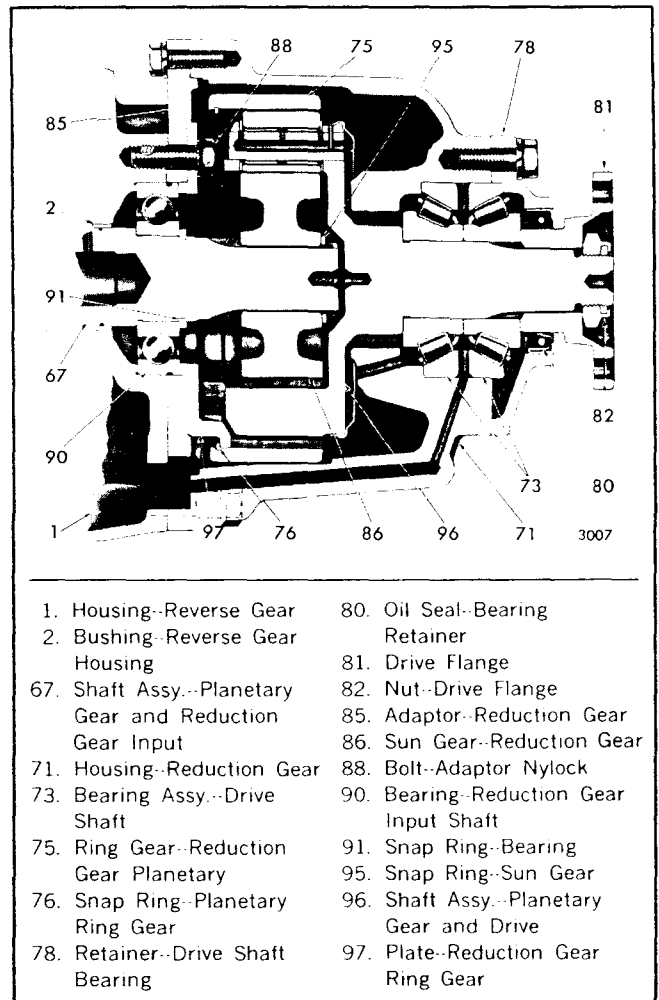


Fig. 5 - Reduction Gear Assembly (2.5:1 Ratio)

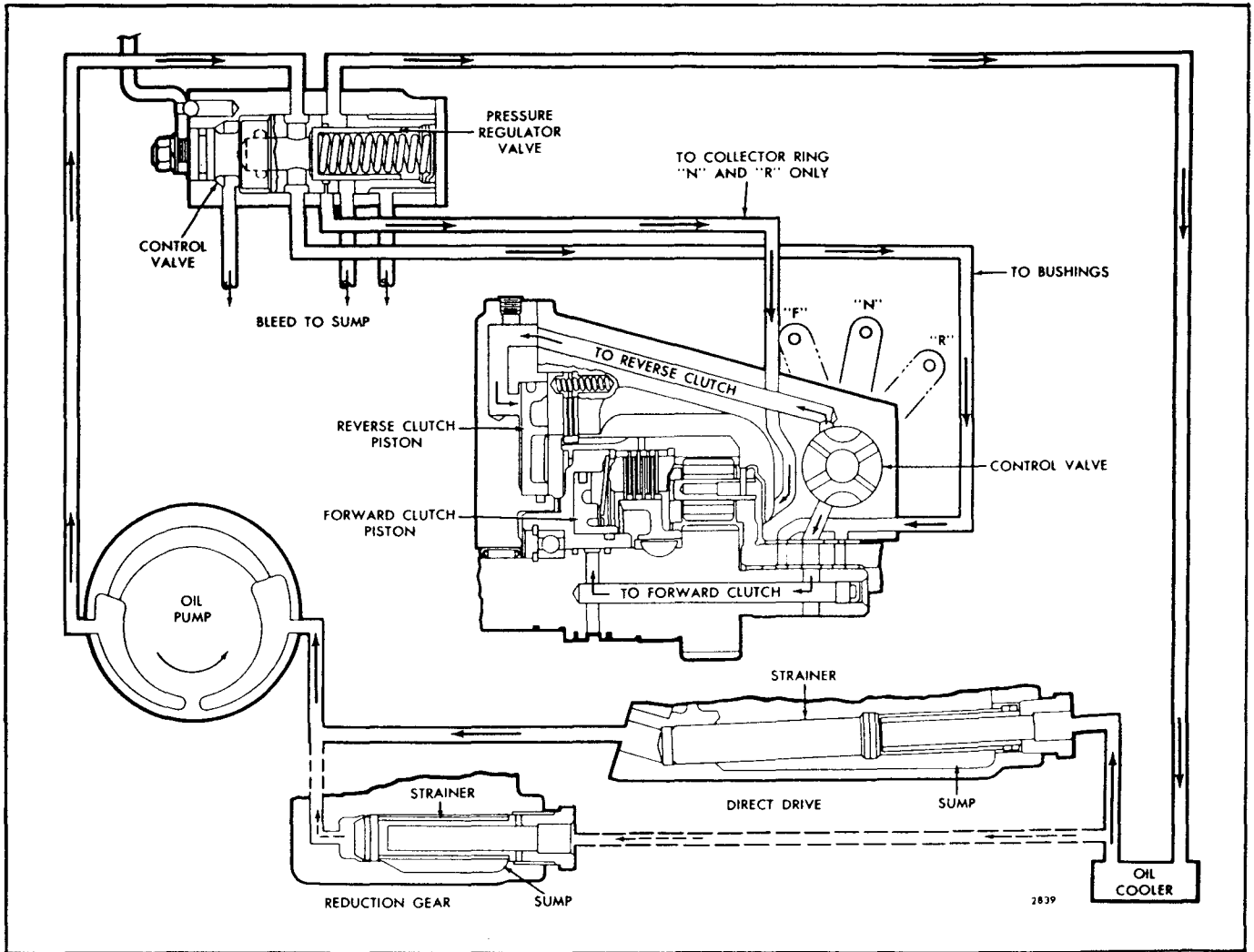


Fig. 6 - Marine Gear Oil Flow Diagram

5. Install a 7/16" -14 eyebolt in the top bolt hole at each side of the reverse gear housing (Fig. 9).
6. Support the reverse and reduction gear assembly with a rope sling and chain hoist as shown in Fig. 9.
7. Remove the six 7/16" -14 x 3-1/4" bolts and lock washers securing the reverse gear housing to the flywheel housing adaptor, then pull the reverse and reduction gear assembly away from the adaptor.

**Disassemble Reverse and Reduction Gear**

After removal from the engine, the reverse and reduction gear assembly may be divided into two sub-assemblies listed below to simplify the disassembly procedure.

**Reverse Gear Assembly**

**Reduction Gear Assembly**

Disassembly need be carried out only as far as is required to correct those difficulties which interfere with proper marine gear operation.

If, at any time, it becomes necessary to remove or recondition the reverse gear oil pump, reverse clutch assembly or forward clutch and ring gear assembly on any of the reverse gear assemblies, they may be removed from and reinstalled in the reverse gear housing without disturbing the drive flange on the direct drive unit or without removing the reduction gear assembly and adaptor from the reverse gear housing on reduction gear units.

On the 1.5:1 and 2.1:1 reverse and reduction gear units, the planetary gear and reduction gear input shaft assembly also may be removed from the reverse gear housing without removing the reduction gear assembly.



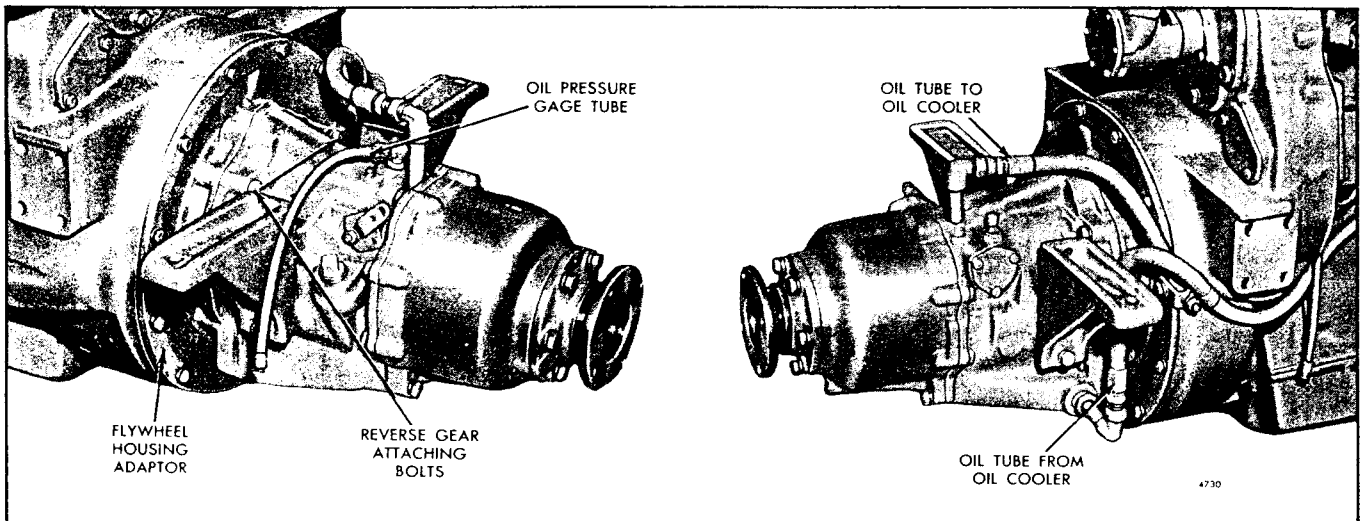


Fig. 7 - Reverse and Reduction Gear Mounting to Engine (Current)

On the direct drive reverse gear unit, the drive flange must be removed in order to remove the planetary gear and output shaft assembly from the reverse gear housing.

On the 2.5:1 and 3:1 reverse and reduction gear units, the reduction gear assembly, sun gear and reduction gear input shaft bearing snap ring must be removed in order to remove the planetary gear and reduction gear input shaft assembly from the reverse gear housing.

The disassembly procedure outlined below covers the right-hand and left-hand rotating direct drive, and 1.5:1, 2.1:1, 2.5:1 and 3:1 ratio reduction gears used on Model 71 and 72 marine gears.

To separate the reduction gear assembly from the reduction gear adaptor and reverse gear assembly, refer to Figs. 1, 4 and 5 for the various gear ratios and location of the parts and proceed as follows:

1. Support the reverse and reduction gear assembly on

a bench with the top of the assembly facing up and the drive flange facing the outside of the bench.

2. Install two bolts, or bolts and nuts, in two of the bolt holes in the drive flange next to each other (Fig. 11).

3. Place a large spanner wrench over the outside of the two bolts with one end hooked over one bolt and the other end resting on the bench as shown in Fig. 11; then, while holding the reverse and reduction gear assembly from moving, attach a wrench to the drive flange nut and loosen it.

4. Remove the two 7/16" -14 bolts and lock washers and the six 3/8" -16 bolts and lock washers securing the reduction gear assembly to the reduction gear adaptor.

5. Place a 3/4" x 1" x 4" wood block under the reverse gear housing next to the flange of the reduction gear housing to support the reverse gear housing.

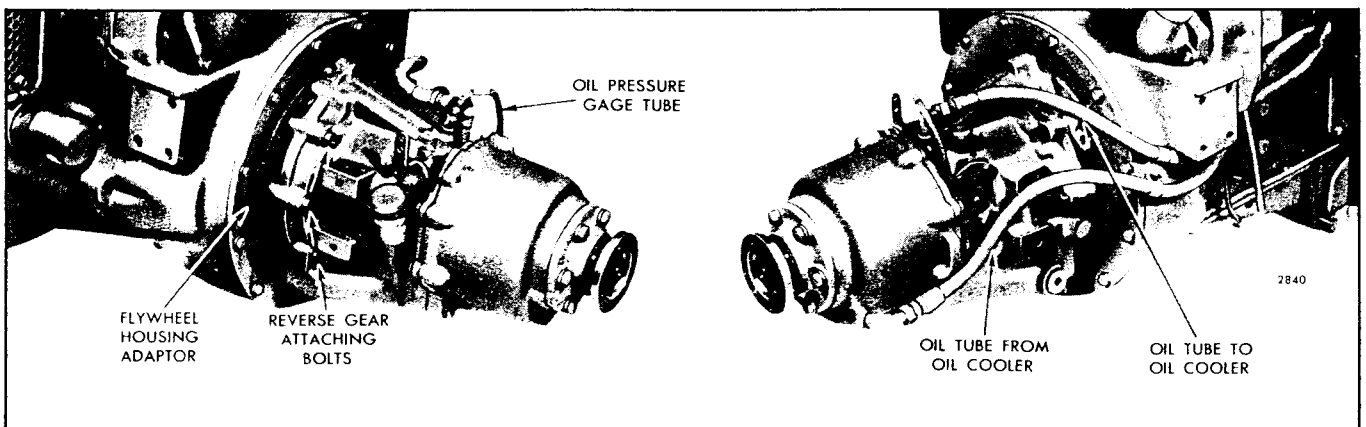


Fig. 8 - Reverse and Reduction Gear Mounting to Engine (Former)

6. Tap the side of the drive flange with a plastic hammer to loosen the reduction gear assembly from the reduction gear adaptor, then lift the reduction gear assembly away from the reduction gear adaptor as shown in Fig. 12. Remove the gasket from the adaptor or the gear housing.

On a 2.1:1 ratio reduction gear, remove the reduction gear planetary gear assembly (77) and the two planetary gear thrust washers (94), Fig. 1, from the sun gear and the reduction gear input shaft as shown in Fig. 13.

7. Remove the reduction gear adaptor assembly from the reverse gear housing on the various reduction gears as outlined below.

On the 1.5:1 ratio reduction gear shown in Fig. 4, remove adaptor (85), reduction gear input gear (89), ring gear (75) and input gear bearing (90) as an assembly from the reverse gear housing as follows:

- a. Remove and discard the six 7/16" -14 Nylock bolts and lock washers securing the adaptor to the reverse gear housing through the two access holes in the flange of the input gear as shown in Fig. 14.
- b. Tap the forward face of the adaptor lightly with a plastic hammer to loosen the adaptor from the reverse housing and the input gear bearing.
- c. Place two pinch bars diametrically opposite each other, between the adaptor and the rear face of the gear housing as shown in Fig. 15, and pry the input gear bearing out of the gear housing. Then slide the adaptor assembly straight off of the

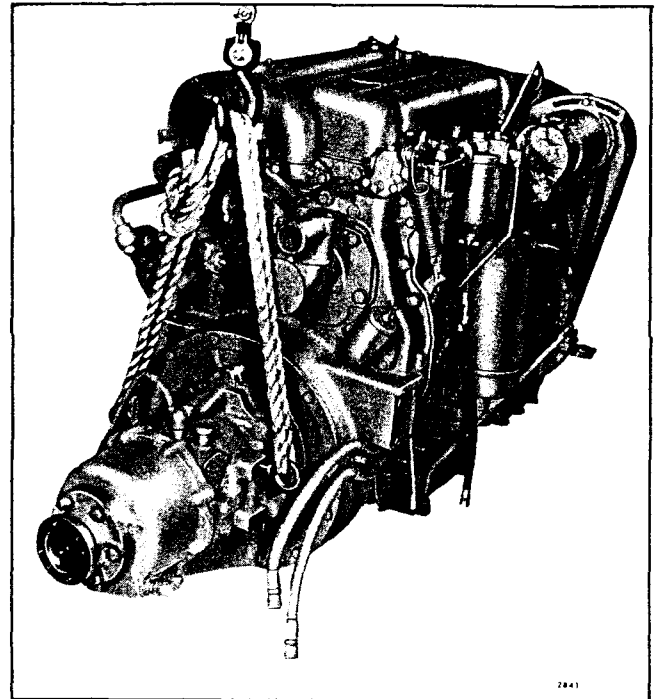


Fig. 9 - Removing Reverse and Reduction Gear Assembly from Engine

reduction gear input shaft. Remove the gasket from the adaptor or the gear housing.

On the 2.1:1 ratio reduction gear shown in Fig. 1, remove adaptor (85) and sun gear (86) as an assembly from the reverse gear housing as follows:

- a. Remove and discard the six 7/16" -14 Nylock bolts and lock washers securing the adaptor to the reverse gear housing.

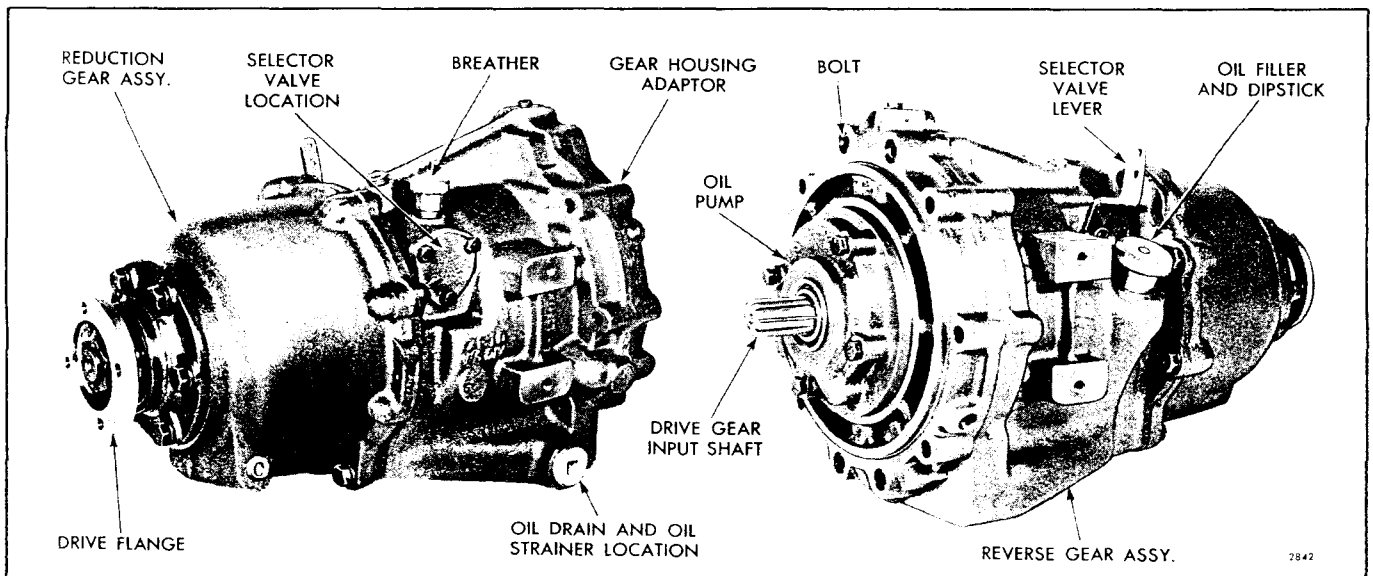


Fig. 10 - Three Quarter View of Former Reverse and Reduction Gear Assembly

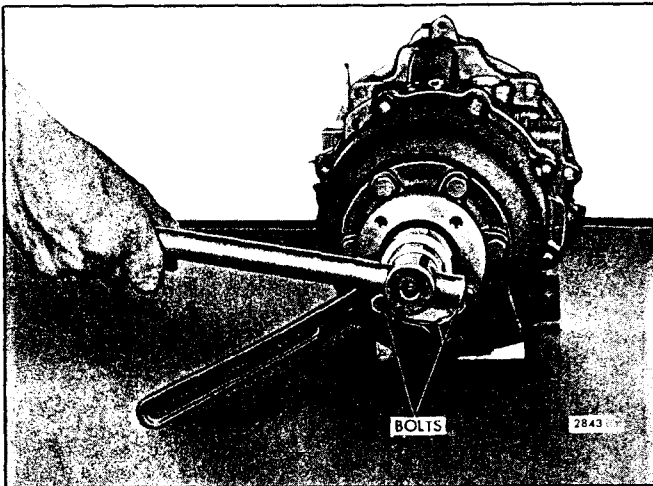


Fig. 11 - Loosening Drive Flange Retaining Nut

- b. Tap the forward face of the adaptor lightly with a plastic hammer to loosen the adaptor from the reverse gear housing, then slide the adaptor and sun gear assembly straight off of the reduction gear input shaft as shown in Fig. 16. Remove the gasket from the adaptor or the gear housing.

On the 2.5:1 and 3:1 ratio reduction gears shown in Fig. 5, remove the reduction gear adaptor (85), planetary ring gear plate (97) and ring gear (75) as an assembly from the reverse gear housing as follows:

- a. Remove the reduction gear sun gear snap ring from the reduction gear input shaft with a pair of snap ring pliers J 5586 as shown in Fig. 17. Then slide the sun gear off the end of the shaft.

**NOTE:** On a 3:1 ratio reduction gear, the reduction gear ring gear plate and adaptor may be removed without removing the sun gear from the reduction gear input shaft.

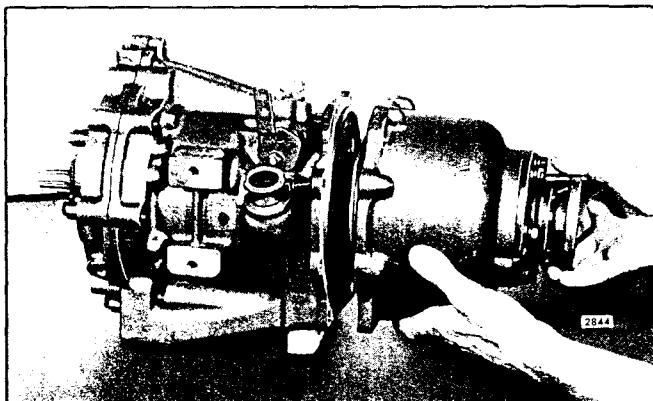


Fig. 12 - Removing or Installing Reduction Gear Assembly from/on Reverse Gear Assembly

- b. Remove and discard the six 7/16" -14 Nylock bolts and lock washers securing the adaptor and the planetary ring gear plate to the reverse gear housing.
- c. Tap the forward face of the adaptor lightly with a plastic hammer to loosen the adaptor from the reverse gear housing and the reduction gear input shaft bearing, then slide the adaptor assembly straight off of the reduction gear input shaft as shown in Fig. 18. Remove the gasket from the adaptor or the gear housing.

**Disassemble Reverse Gear**

With the direct drive reverse gear assembly removed from the engine, or the reduction gear assembly and reduction gear adaptor assembly removed from the reverse gear housing, the reverse gear may be disassembled as outlined below.

The disassembly procedure for the direct drive reverse gear and the reverse gears used in conjunction with the 1.5:1, 2.1:1, 2.5:1 and 3:1 ratio reduction gears are similar. Therefore, disassembly will be covered as a single procedure and any differences between the various assemblies will be noted therein.

The current 1.5:1 and 2.1:1 reverse and reduction gear units use a .061" to .063" thrust washer between the forward clutch piston cylinder and the gear housing adaptor to obtain the proper input shaft end play of .004" to .043". The former and current direct drive, 2.5:1 and 3:1 gears also use a .061" to .063" thrust washer.

In the former 1.5:1 and 2.1:1 reverse and reduction

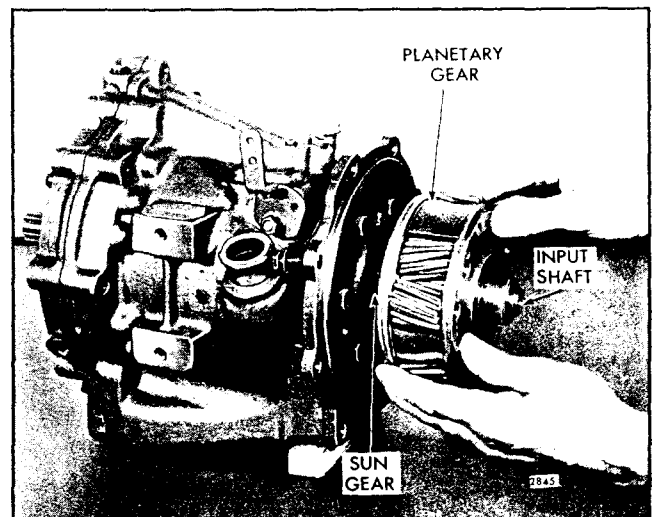


Fig. 13 - Removing or Installing Reduction Gear Planetary Gear Assembly from/on Sun Gear and Input Shaft (2.1:1 Ratio)

gear units, one of two different thickness thrust washers was used between the forward clutch piston cylinder and the gear housing adaptor to obtain the proper input shaft end play of .004" to .043". They are .061" to .063" and .085" to .087" thick. However, when servicing the former 1.5:1 and 2.1:1 reverse and reduction gear units, use the .061" to .063" thrust washer only to obtain the proper input shaft end play of .004" to .043".

The end play of the input shaft should be taken and recorded at this time to determine if a new thrust washer should be used when reassembling the reverse gear unit.

Refer to Figs. 1, 2 and 43 for the location of the various parts and disassemble as follows:

1. Check the drive gear input shaft or reduction gear input shaft end play as follows:

- a. Remove one of the selector valve cover bolts at the side of the gear housing, then install a 1/4" -20 x 1-1/2" bolt in the cover bolt hole, or install a 7/16" -14 x 2" bolt in one of the tapped holes in the side of the reverse gear housing. Tighten the bolt securely.
- b. Attach a dial indicator to the 1/4" -20 or 7/16" -14 bolt with the indicator button contacting the end of the drive gear input shaft or the reduction gear input shaft as shown in Fig. 19.

**NOTE:** On the direct drive unit, the dial indicator must contact the forward end of the

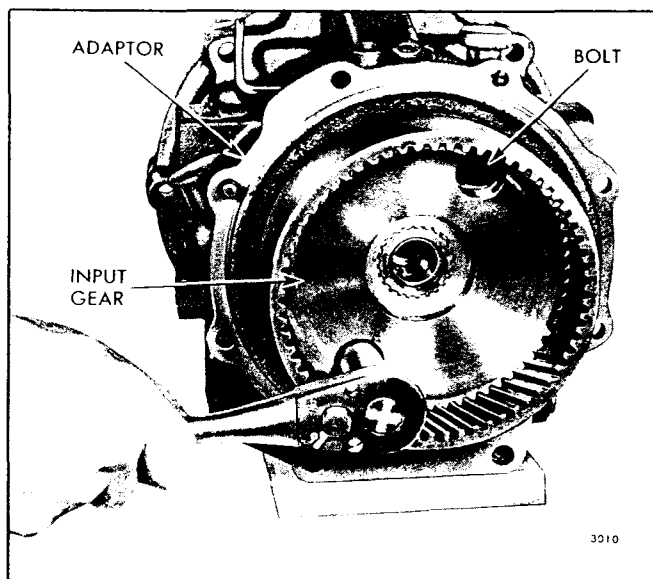


Fig. 14 - Removing Reduction Gear Adaptor to Reverse Gear Housing Bolts (1.5:1 Ratio)

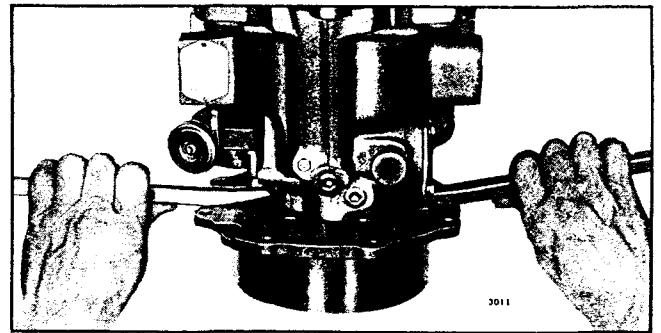


Fig. 15 - Removing Reduction Gear Input Gear and Bearing Assembly from Reverse Gear Housing (1.5:1)

drive gear input shaft. On the reduction gear units, the dial indicator may contact the end of either the drive gear input shaft or the reduction gear input shaft.

- c. Move all of the parts inside of the gear housing forward by pulling on the drive gear input shaft. Set the dial indicator at zero, move all of the parts back by pushing on the drive gear input shaft, then read the indicator and record the end play.

2. Remove the selector valve assembly from the reverse gear housing as follows:

- a. Remove the nut, lock washer and flat washer securing the selector valve lever to the selector valve, then slide the lever off the end of the selector valve. Remove the selector valve lever detent steel ball and spring from the gear housing.

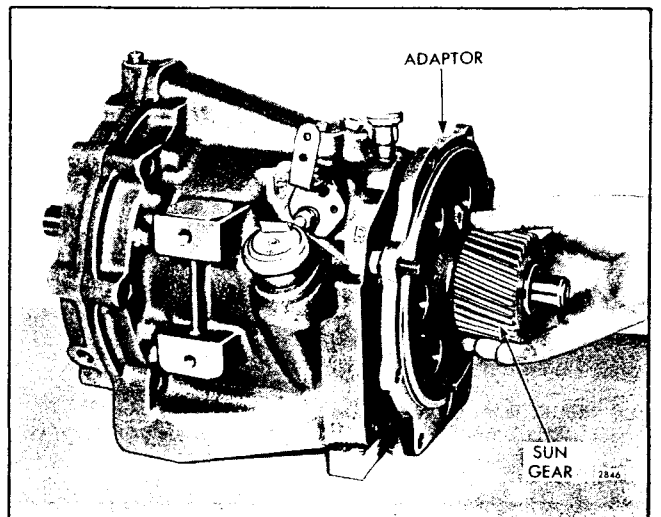


Fig. 16 - Removing or Installing Reduction Gear Adaptor and Sun Gear Assembly from/to Reverse Gear Housing (2.1:1 Ratio)

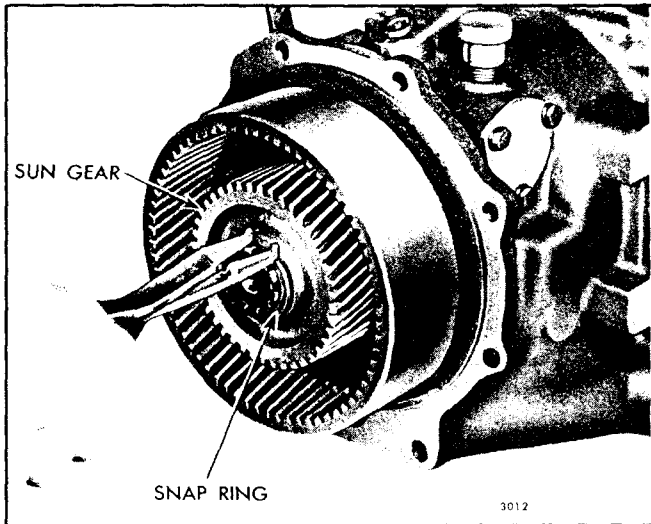


Fig. 17 - Removing or Installing Reduction Gear Sun Gear Snap Ring from/on Input Shaft (2.5:1 and 3:1 Ratio)

**CAUTION:** Do not lose the steel detent ball when removing the selector lever.

- b. Remove the three 1/4" -20 bolts and lock washers securing the selector valve cover to the side of the reverse gear housing, then remove the cover and gasket.
- c. Push on the threaded or lever end of the selector valve and force the selector valve out of the

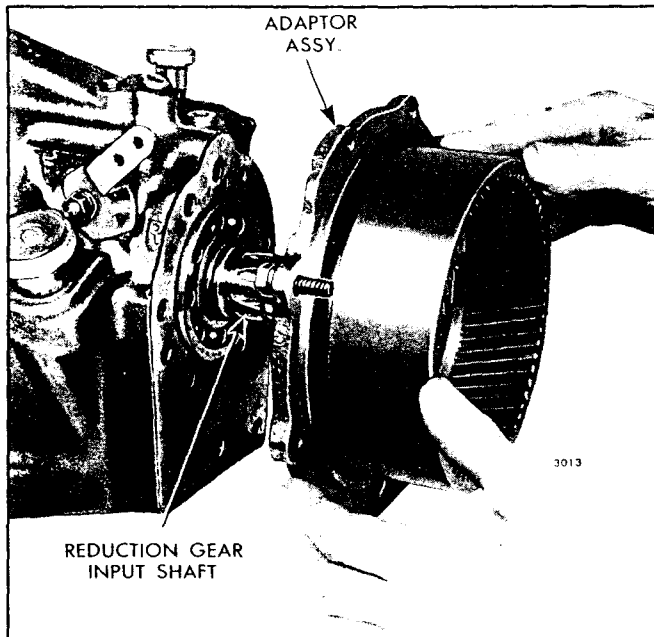


Fig. 18 - Removing or Installing Reduction Gear Adaptor, Planetary Ring Gear Plate and Ring Gear Assembly from/to Reverse Gear Housing (2.5:1 and 3:1 Ratios)

opposite side of the gear housing, then pull the selector valve straight out of the gear housing.

- 3. Remove the pressure regulator valve from the selector valve as follows:
  - a. Remove the selector valve seal ring from groove in the small or threaded end of the selector valve.
  - b. Place a 1-1/4" inside diameter sleeve approximately two inches long over the small or threaded end of the selector valve.
  - c. Support the selector valve and sleeve on the bed of an arbor press with the open end of the selector valve up.
  - d. Place a 3/4" diameter x 2" long round steel rod on top of the valve spring retainer and under the ram of an arbor press as shown in Fig. 20.
  - e. Compress the regulator valve spring just enough to permit removal of the snap ring. With the spring compressed, remove the snap ring from the groove inside of the selector valve with a small screw driver as shown in Fig. 20.
  - f. While supporting the selector valve assembly with one hand, very carefully release the load on the pressure regulator valve spring; then remove the selector valve and parts from the arbor press.

**CAUTION:** The valve spring retainer is a very close fit in the bore of the selector valve. Extreme care must be used when releasing the load on the valve spring so as not to allow the edge of the retainer to catch in the snap ring groove and damage the retainer.

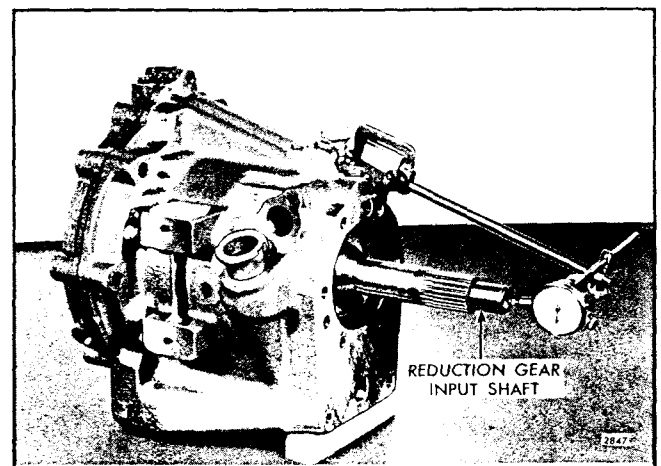


Fig. 19 - Checking Reduction Gear Input Shaft End Play

- g. Remove the pressure regulator valve spring and regulator valve from inside the selector valve.

4. Remove the reducing bushing, oil return tube, nipple and elbow assembly on the current marine gear, or the oil drain plug on the former marine gear, from the lower right-hand side of the reverse gear housing, then remove the oil strainer assembly from the housing.

5. Remove the reverse gear oil pump assembly from the reverse gear housing adaptor as follows:

- a. Note and record the rotation marks on the forward face of the oil pump housing prior to removal. For a right-hand rotating input shaft, the TOP RH will be facing the top of the gear housing adaptor and for a left-hand rotating input shaft, the TOP LH will be facing the top of the gear housing adaptor (Fig. 86).
- b. Remove the four 5/16" -18 bolts securing the oil pump assembly to the reverse gear housing adaptor.
- c. Pull the oil pump assembly straight forward away from the gear housing adaptor and off the Woodruff key and input shaft.
- d. Remove the oil pump gasket from the top of the oil pump housing or cover plate, or inside the counterbore of the gear housing adaptor.
- e. Remove the oil pump inner rotor (gear) drive (Woodruff) key from the drive gear input shaft.

6. Dissassemble the reverse gear oil pump assembly as follows:

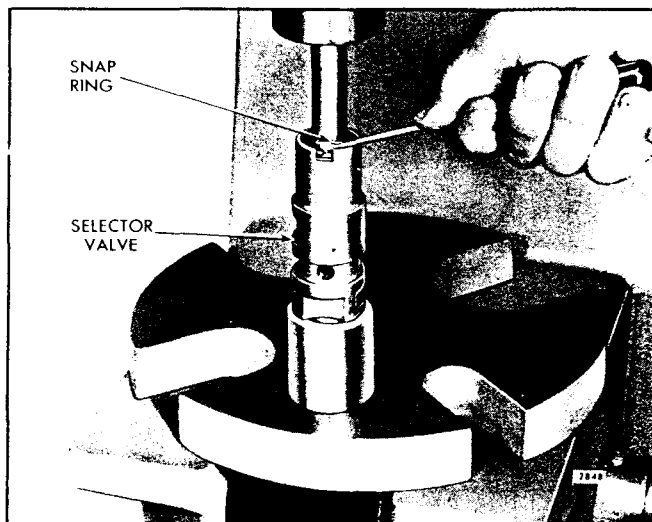


Fig. 20 - Removing Snap Ring from Selector Valve

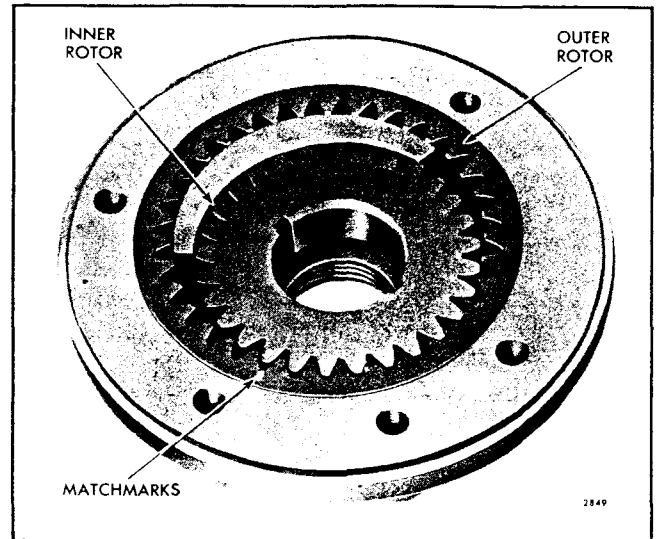


Fig. 21 - Location of Matchmarks on Inner and Outer Oil Pump Rotors (Gears)

- a. On the former oil pump, remove the two flat head No. 10-24 screws securing the oil pump cover plate to the oil pump housing, then lift the oil pump cover plate straight out of the oil pump housing.
- b. Matchmark the teeth of the inner and outer rotors (gears) where they mesh as shown in Fig. 21 so they may be reassembled in the same position.
- c. Lift the inner and outer rotors (gears) straight up out of the oil pump housing.
- d. To remove the oil seal in the oil pump housing,

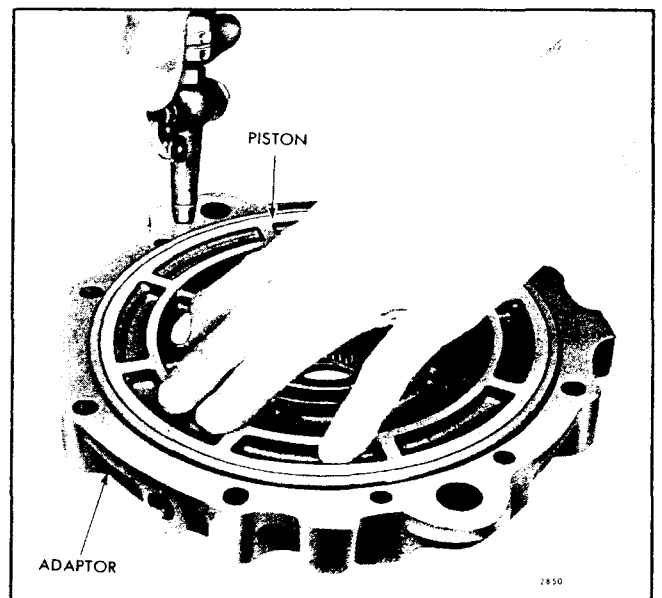


Fig. 22 - Removing Reverse Clutch Piston from Gear Housing Adaptor

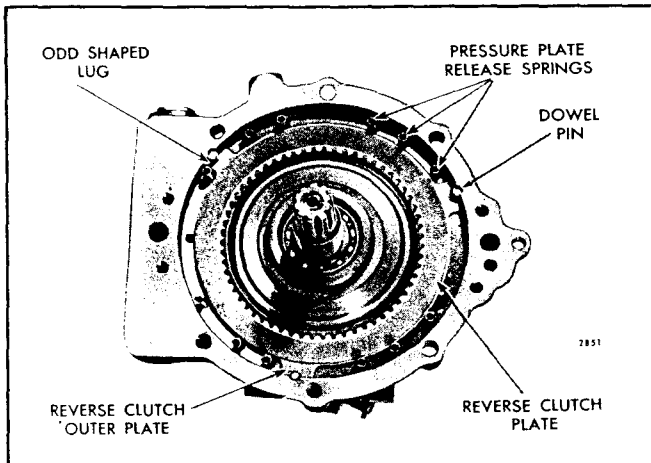


Fig. 23 - Location of Reverse Clutch Release Springs, Clutch Plates and Dowel Pins

support the oil pump housing on the bed of an arbor press with the oil seal over the opening in the bed of the press and the forward face of the housing down.

**NOTE:** Due to the various positions the oil seal has been installed in the reverse gear oil pump housing (Fig. 82), it is recommended that the position of the oil seal in the housing be noted and recorded before removal so that the new oil seal may be reinstalled in the same position.

- e. Place a 1-7/8" x 3" round steel bar on top of the oil seal and under the ram of the press. Then press the oil seal out of the oil pump housing. Discard the oil seal.
7. On a direct drive reverse gear unit, stand the reverse gear assembly in a vertical position with the rear face of the drive flange resting on a bench.
- On all other reverse gear assemblies, stand the reverse gear assembly in a vertical position with the rear face of the gear housing resting on wood blocks high enough to prevent the outer end of the reduction gear input shaft from resting on the bench.
8. Remove the four 3/8" -16 bolts securing the reverse gear housing adaptor to the gear housing, then lift the adaptor straight off of the drive gear input shaft. Remove the gasket from the adaptor or the gear housing.

On some early marine gear units, five 3/8" -16 bolts were used to secure the adaptor to the gear housing.

9. Remove the reverse clutch piston and roller (needle) bearing from the reverse gear housing adaptor as follows:

- a. Place the gear housing adaptor on a bench with the reverse clutch piston side facing up.
  - b. Place the nozzle of an air hose in the small oil hole at the top of the adaptor, then apply light air pressure behind the reverse clutch piston and force the piston up out of the adaptor as shown in Fig. 22.
  - c. Remove the reverse clutch piston seal rings from the piston and the hub of the adaptor.
  - d. If the roller (needle) bearing is to be replaced, support the gear housing adaptor on the bed of an arbor press with the bearing over the opening in the bed of the press.
  - e. Place a 1-5/8" x 3" round steel bar on top of the roller bearing and under the ram of the press. Then press the bearing out of the gear housing adaptor. Catch the bearing by hand to prevent the bearing from falling on the floor.
10. Remove the thrust washer from the hub of the forward clutch piston cylinder.
  11. Lift the reverse clutch pressure plate straight off of the clutch pressure plate release springs.
  12. Refer to Fig. 23 for their location and remove the reverse clutch pressure plate release springs, reverse

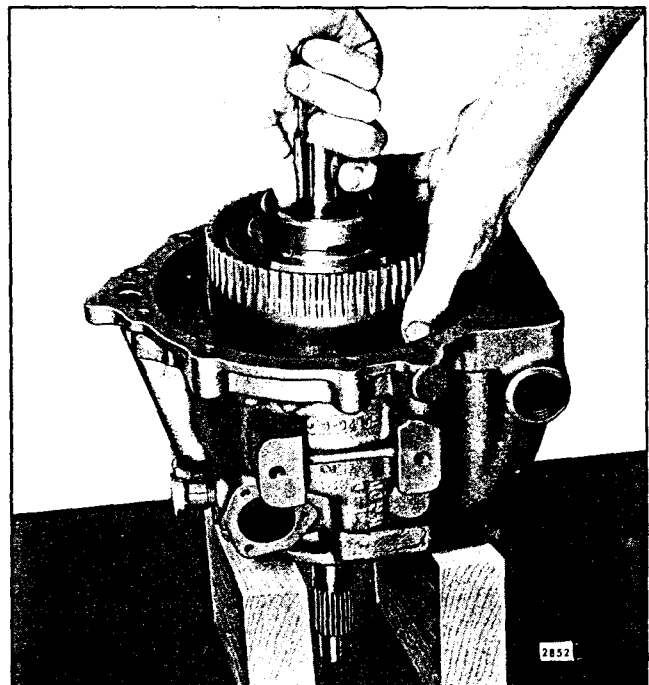


Fig. 24 - Removing Drive Gear Input Shaft, Forward Clutch and Ring Gear Assembly from Reverse Gear Housing

clutch plates and dowel pins out of the reverse clutch cavity in the reverse gear housing.

13. Lift the drive gear input shaft, forward clutch and ring gear as an assembly straight out of the reverse gear housing as shown in Fig. 24.

14. Remove the reduction gear input shaft planetary gear thrust washer from the non-splined end of the drive gear input shaft, or from inside the reduction gear input shaft planetary gear.

15. Remove the drive gear input shaft and forward clutch hub assembly from the forward clutch and ring gear assembly as follows:

- a. Place the drive gear input shaft, forward clutch and ring gear assembly on a wood block 3" thick and 6" square with a 1" hole in the center as shown in Fig. 25.
- b. Remove the drive gear input shaft bearing snap ring from the groove in the shaft next to the bearing inner race with a pair of snap ring pliers J 5586 as shown in Fig. 25.
- c. Place the drive gear input shaft, forward clutch and ring gear assembly on two steel supports on the bed of an arbor press with the non-splined end of the shaft over the opening in the bed of the press as shown in Fig. 26.
- d. Press the drive gear input shaft and clutch hub assembly straight out of the bearing and forward clutch. Catch the drive gear input shaft assembly

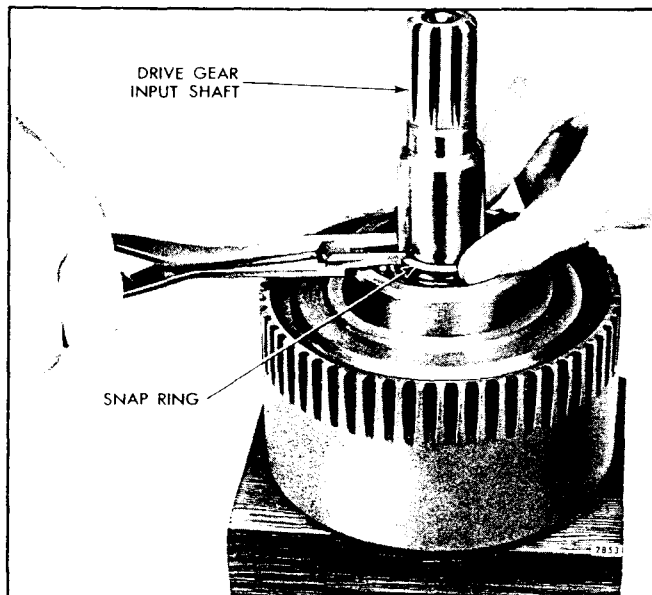


Fig. 25 - Removing or Installing Snap Ring from/on Drive Gear Input Shaft

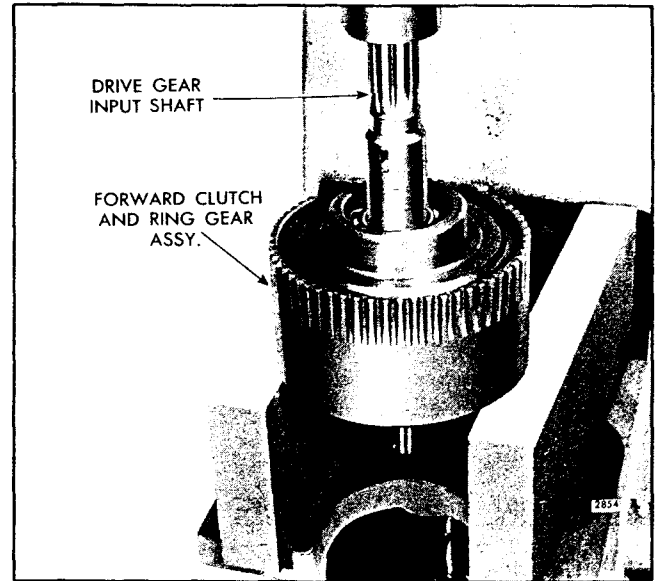


Fig. 26 - Removing Drive Gear Input Shaft from Bearing and Forward Clutch and Ring Gear Assembly

by hand to prevent the shaft assembly from falling and being damaged.

16. Remove the forward clutch piston assembly and the forward clutch plates from the ring gear as follows:

- a. Remove the snap ring inside the ring gear that retains the forward clutch piston and cylinder assembly in the ring gear.
- b. Lift the forward clutch piston and cylinder straight out of the ring gear.

If necessary, place the forward clutch and ring gear assembly on two steel supports on the bed of an arbor press as shown in Fig. 27. Space the supports far enough apart to permit the forward clutch piston cylinder to pass through between the supports.

Place a 2-1/2" outside diameter round steel bar on top of the forward clutch piston cylinder and under the ram of the press. Then press the forward clutch piston and cylinder assembly straight out of the ring gear as shown in Fig. 27. Catch the forward clutch piston and cylinder assembly by hand to prevent it from falling and being damaged.

- c. Place the ring gear with the forward clutch plates on a bench with the forward clutch piston cylinder end of the ring gear facing up.



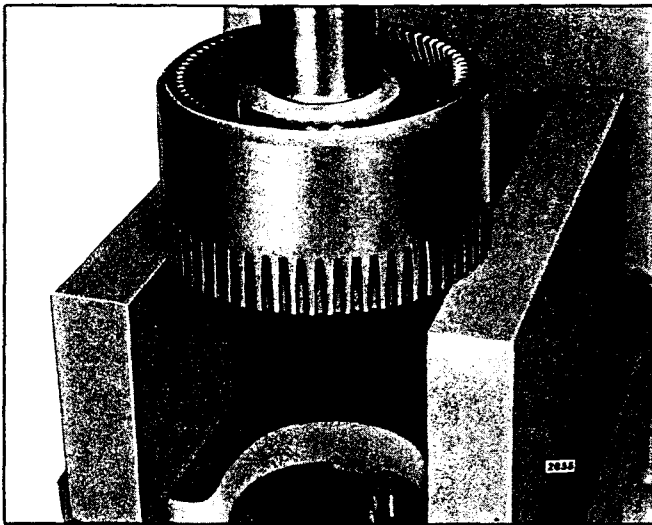


Fig. 27 - Removing Forward Clutch Piston and Cylinder Assembly from Ring Gear

- d. Remove the snap ring (spacer) inside the ring gear next to the front clutch pressure plate from the ring gear.
- e. Lift all of the forward clutch plates and pressure plates straight out of the ring gear.
- f. On the Model 72 reverse gears, remove the rear clutch pressure plate spacer (snap ring) from the shoulder inside of the ring gear.

17. Remove the forward clutch piston and the drive gear input shaft bearing from the forward clutch piston cylinder as follows:

- a. Place the forward clutch piston and cylinder assembly on a bench with the piston side of the assembly facing up.

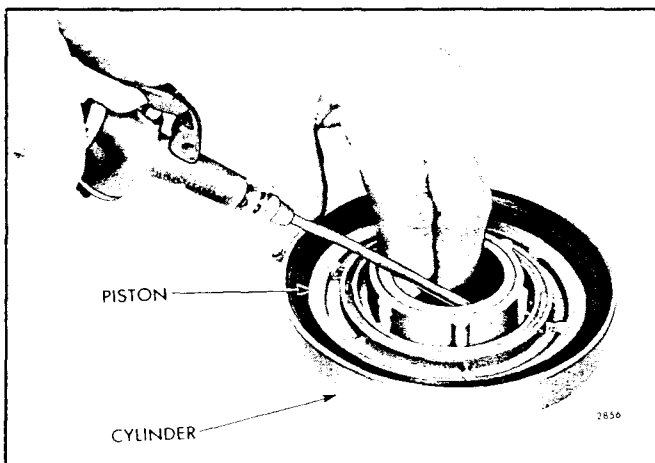


Fig. 28 - Removing Forward Clutch Piston from Forward Clutch Piston Cylinder

- b. Remove the forward clutch spring support ring from the groove in the top of the forward clutch piston.
- c. Place the nozzle of an air hose in one of the three oil holes in the inside diameter of the forward clutch piston cylinder. Then, while covering the two remaining oil holes as shown in Fig. 28, apply light air pressure behind the piston and force the piston up out of the cylinder.
- d. Remove the forward clutch piston seal rings from the piston and the hub of the forward clutch piston cylinder.
- e. Turn the forward clutch piston cylinder over and remove the snap ring from the groove inside the hub of the cylinder next to the bearing outer race.
- f. Pull the drive gear input shaft bearing straight out of the forward clutch piston cylinder.

If necessary, use a hard wood block and hammer and tap the bearing straight out of the cylinder.

18. Remove the forward clutch hub from the drive gear input shaft as follows:

- a. Place the non-splined end of the drive gear input shaft and forward clutch hub assembly in the 1" hole in the 3" x 6" wood block as shown in Fig. 29.

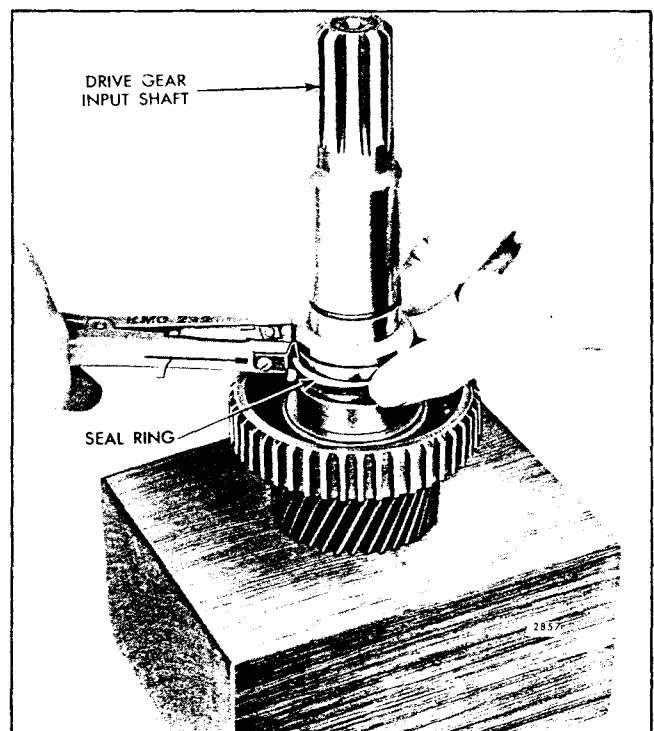


Fig. 29 - Removing Drive Gear Input Shaft Seal Rings from Shaft

- b. Unhook the ends of the drive gear input shaft seal rings. Then remove the seal rings from the grooves in the shaft with a pair of snap ring pliers as shown in Fig. 29.

**CAUTION:** To avoid breaking the seal rings, do not spread them any more than necessary to slip them over the shaft.

- c. Remove the forward clutch hub snap ring from the grooves in the drive gear input shaft with a pair of snap ring pliers J 5586 as shown in Fig. 30.
- d. Support the drive gear input shaft and forward clutch hub assembly on the bed of an arbor press with the rear face of the clutch hub resting on the bed of the press as shown in Fig. 31.
- e. Then press the drive gear input shaft straight out of the forward clutch hub as shown in Fig. 31. Catch the drive gear input shaft by hand to prevent it from falling and being damaged when pressed from the hub.
- f. If necessary, remove the forward clutch hub Woodruff key from the keyway in the drive gear input shaft.

19. On the direct drive units, remove the planetary gear and drive (output) shaft assembly from the reverse gear housing as follows:

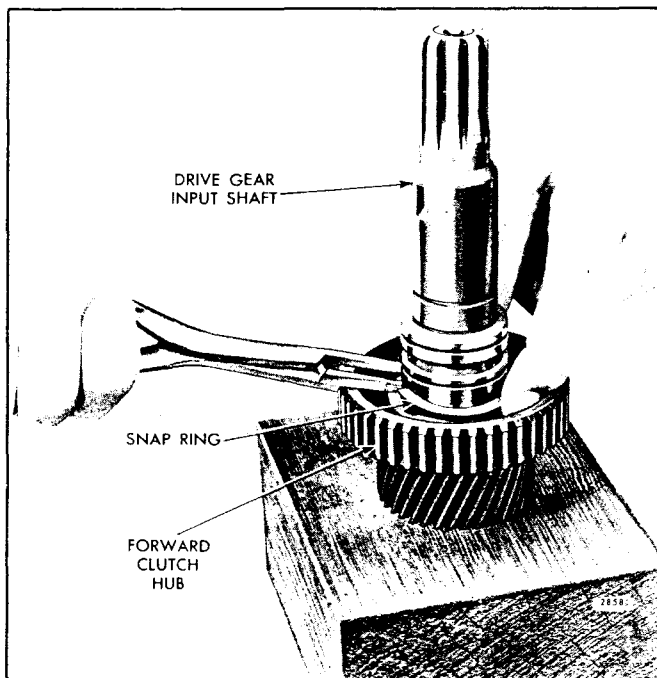


Fig. 30 - Removing or Replacing Forward Clutch Hub Snap Ring

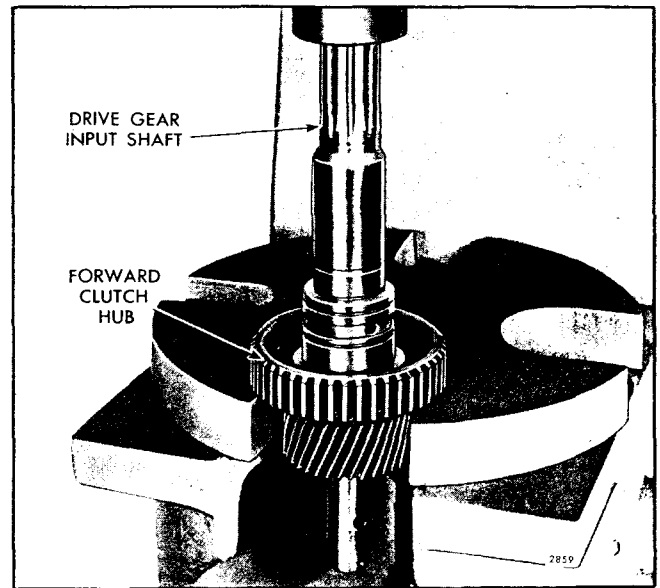


Fig. 31 - Removing Forward Clutch Hub from Drive Gear Input Shaft

- a. If not previously performed, perform Steps 1, 2 and 3 under *Disassemble Reverse and Reduction Gear*.

- b. Remove the drive flange nut, then pull the drive flange off the end of the drive (output) shaft.

If necessary, attach a bar type puller to the drive flange and pull the drive flange off the drive shaft.

- c. Remove the six 7/16" -14 bolts and lock washers securing the drive shaft bearing retainer to the reverse gear housing.

- d. Tap the sides of the bearing retainer lightly with a plastic hammer to loosen it, then lift the bearing retainer straight off the bearing. Remove the bearing retainer gasket.

- e. Place a couple of clean folded shop towels on the bed of an arbor press to protect the forward face of the planetary gear and drive shaft assembly from being damaged when pressed from the drive shaft bearing.

- f. Place the reverse gear housing over the top of the shop towels with the forward face of the gear housing resting on the bed of the press and the outer end of the drive shaft under the ram of press in the same manner as shown in Fig. 33.

- g. Then press the planetary gear and drive shaft assembly out of the bearing.

- h. Remove the reverse gear housing and the planetary gear and drive shaft assembly from the

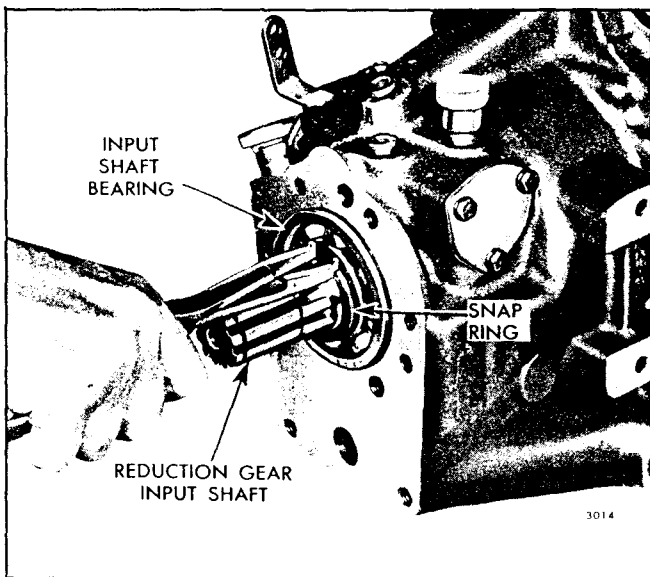


Fig. 32 - Removing or Installing Reduction Gear Input Shaft Bearing Snap Ring (2.5:1 and 3:1 Ratios)

arbor press. Do not drop the planetary gear and drive shaft assembly or injury to personnel or damage to the planetary gear and drive shaft assembly may result.

- i. Lift the drive shaft bearing straight out of the reverse gear housing.

If necessary, use a hard wood block and hammer and tap the bearing out of the reverse gear housing.

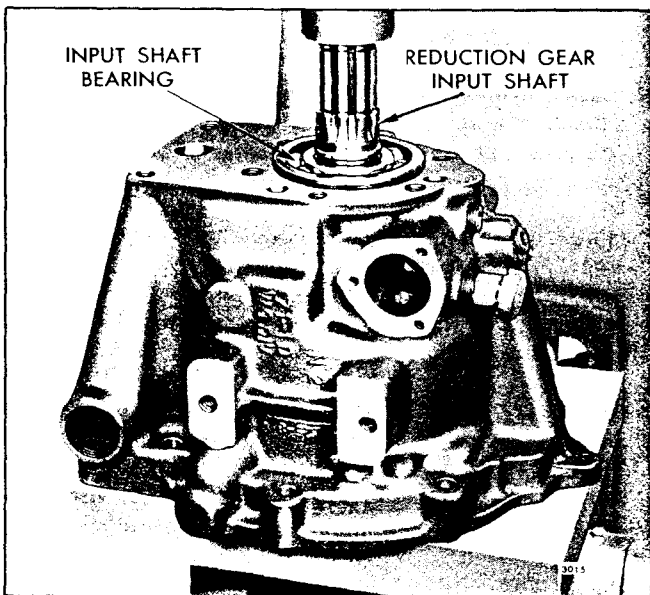


Fig. 33 - Removing Reduction Gear Planetary Gear and Input Shaft Assembly from Input Shaft Bearing (2.5:1 and 3:1 Ratios)

- j. Refer to Step 9 under *Disassemble Reduction Gear* for removal of the oil seal from the drive (output) shaft bearing retainer.

20. On the 1.5:1 and 2.1:1 reverse and reduction gear units, lift the planetary gear and reduction gear input shaft assembly straight out of the reverse gear housing, then remove the thrust washer from the rear face of the planetary gear cage or from the boss inside of the reverse gear housing.

21. On the 2.5:1 and 3:1 reverse and reduction gear units, remove the planetary gear and reduction gear input shaft assembly from the reverse gear housing as follows:

- a. Remove the snap ring from the groove in the reduction gear input shaft next to the bearing inner race with a pair of snap ring pliers J 5586 as shown in Fig. 32.
- b. Place a couple of clean folded shop towels on the bed of an arbor press to protect the forward face of the planetary gear and reduction gear input shaft assembly from being damaged when pressed from the input shaft bearing.
- c. Place the reverse gear housing over the top of the shop towels with the forward face of the gear

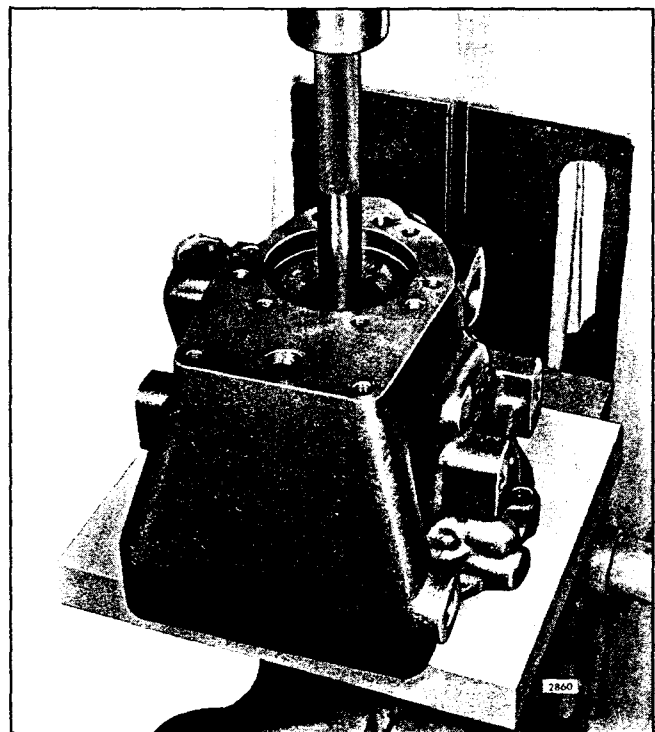


Fig. 34 - Removing Drive Shaft Bushings from Gear Housing

housing resting on the bed of the press and the outer end of the input shaft under the ram of the press.

- d. Then press the planetary gear and input shaft assembly out of the bearing as shown in Fig. 33.
- e. Remove the reverse gear housing and the planetary gear and input shaft assembly from the arbor press. Do not drop the planetary gear and input shaft assembly or injury to personnel or damage to the planetary gear and input shaft assembly may result.
- f. Lift the reduction gear input shaft bearing straight out of the reverse gear housing.

If necessary, use a hard wood block and hammer and tap the bearing out of the reverse gear housing.

22. Remove the oil baffle from the reverse gear housing as follows:

- a. On a current direct drive gear unit, press down on the center of the oil baffle and pry the ends of the baffle off the cast bosses at each side of the gear housing with a screw driver; then, remove the oil baffle from the housing.
- b. On a former direct drive and all reverse and reduction gear units, pull forward on the curved end of the oil baffle inside the reverse gear housing until the holes in the curved end of the oil baffle are off of the spherical bosses, then push the curved end of the baffle down under the spherical bosses. Lift the forward end of the oil baffle off of the spherical bosses and out of the gear housing.

23. Remove the drive (output) shaft or reduction gear input shaft outer bushings (if used) from the reverse gear housing.

If inspection of the bushings in the reverse gear housing, as outlined under *Inspection*, reveals the bushings need replacing, remove the bushings as follows:

- a. Support the reverse gear housing on the bed of an arbor press with the rear face of the gear housing facing up.
- b. Place the bushing remover and installer J 8466 with handle J 7079-2 down in the bushing with the handle under the ram of the press as shown in Fig. 34.

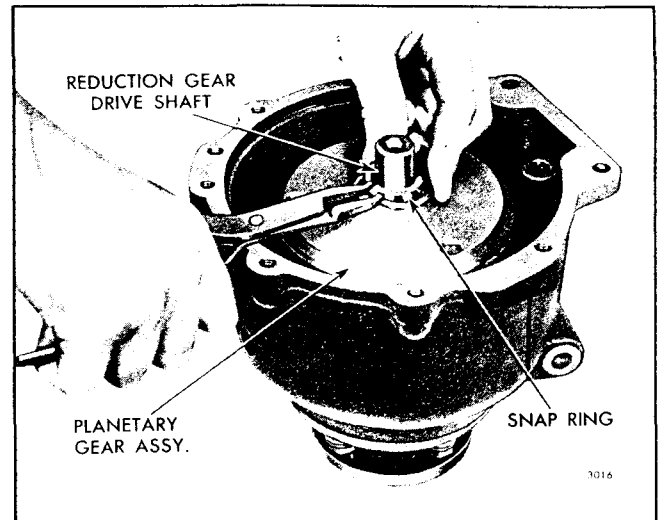


Fig. 35 - Removing or Installing Planetary Gear Snap Ring from/on Reduction Gear Drive Shaft (1.5:1 Ratio)

- c. Then press the two bushings straight out of the gear housing. Catch the bushings and remove by hand so they will not drop on the floor when the top bushing is pressed out of the gear housing.

24. If the reverse gear housing is to be washed and cleaned, remove all of the pipe plugs, breather and lubricating oil fitting from the gear housing.

#### Disassemble Reduction Gear

The disassembly procedure for the various reduction gears will vary depending upon the ratio. The disassembly procedure for the 1.5:1 ratio reduction gear is covered separately. Due to the close similarity of the 2.1:1, 2.5:1 and 3:1 ratio reduction gears, the disassembly procedure for these gears will be covered as a single procedure and the difference noted therein.

With the reduction gear assembly removed from the reverse gear assembly, the reduction gear may be disassembled as outlined below.

Disassemble 1.5:1 Ratio Reduction Gear - Refer to Fig. 4 for the location of the parts and disassemble as follows:

1. Support the reduction gear assembly on a bench with the forward end of the drive shaft facing up.
2. Remove the planetary gear snap ring from the groove in the reduction gear drive shaft with a pair of snap ring pliers J 5586 as shown in Fig. 35.

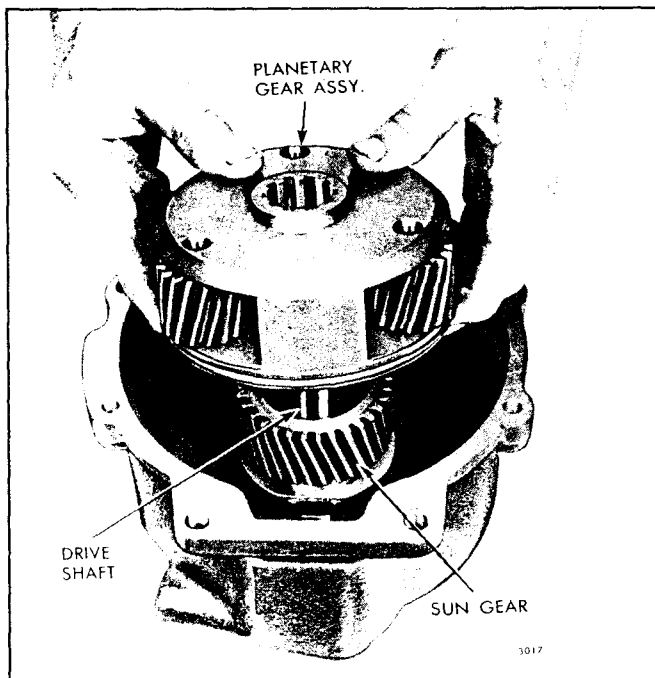


Fig. 36 - Removing or Installing Planetary Gear Assembly from/on Reduction Gear Drive Shaft (1.5:1 Ratio)

3. Lift the planetary gear assembly straight off of the reduction gear drive shaft and sun gear as shown in Fig. 36.

If difficulty is encountered in removing the planetary gear assembly from the drive shaft, it may be removed by tapping the shaft out of the planetary gear hub with a plastic hammer after performing Steps 4, 5 and 6 listed below.

4. Support the reduction gear housing on its side on a bench with the drive flange facing the outside of the bench.

5. Remove the drive flange nut, then pull the drive flange off the end of the reduction gear drive shaft.

If necessary, attach a bar type puller to the drive flange and pull the drive flange off the drive shaft.

6. Pull the reduction gear drive shaft (or planetary gear and drive shaft assembly) straight out of the roller bearing and gear housing from the forward end of the gear housing.

7. Remove the six 7/16" -14 bolts and lock washers securing the reduction gear drive shaft bearing retainer to the gear housing.

8. Tap the sides of the bearing retainer lightly with a plastic hammer to loosen it, then lift the bearing retainer straight off the bearing. Remove the bearing retainer gasket.

9. Remove the reduction gear drive shaft bearing retainer oil seal from the bearing retainer as follows:

- a. Support the bearing retainer on the bed of an arbor press with the forward face down and the oil seal over the opening in the bed of the press.
- b. Place a 2-1/2" round steel bar on top of the oil seal and under the ram of the press, then press the oil seal out of the bearing retainer. Discard the oil seal.

10. Remove the reduction gear drive shaft bearing from the reduction gear housing as follows:

- a. Matchmark the outer roller bearing cone and bearing cup so it may be reinstalled in the same side of the bearing cup.

**NOTE:** The roller bearing cones and cup must be matchmarked so they can be reinstalled in the same position.

- b. Lift the outer roller bearing cone out of the bearing cup and place it in a clean spot on the bench.
- c. Support the rear face of the reduction gear housing on the bed of an arbor press with the roller bearing cup over the opening in the bed of the press as shown in Fig. 37.
- d. Place the drive flange end of the reduction gear drive shaft straight down through the sun gear

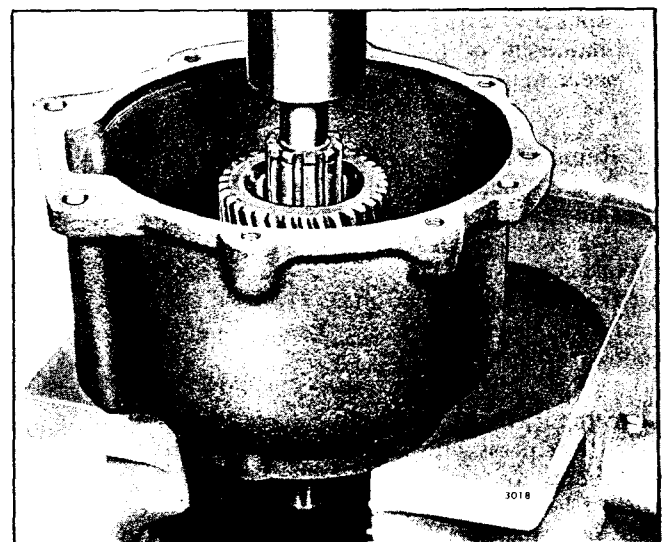


Fig. 37 - Removing Reduction Gear Drive Shaft Roller Bearing Cone and Cup from Gear Housing (1.5:1 Ratio)

and roller bearing cone until the shoulder on the drive shaft rests on the bearing cone with the forward end of the drive shaft under the ram of the press.

- e. Then press the roller bearing cup straight out of the reduction gear housing as shown in Fig. 37. Catch the roller bearing cup, cone and drive shaft by hand to prevent them from falling and being damaged.
- f. Remove the drive shaft from the inner bearing cone and cup, then place the outer bearing cone inside of the bearing cup it was removed from and place the bearing assembly in a clean spot on the bench.

11. Remove the reduction gear sun gear from the reduction gear housing as follows:

- a. Support the reduction gear housing on a bench with the rear face of gear housing facing up.
- b. Place a 1/8" long shank punch in the drilled hole in the bearing bore of the gear housing as shown in Fig. 38 and drive the roll pin out of the sun gear dowel pin and gear housing.
- c. Support the reduction gear housing, rear face up, on a bench, then push the sun gear dowel pin out



Fig. 38 - Removing Roll Pin from Sun Gear Dowel Pin (1.5:1 Ratio)

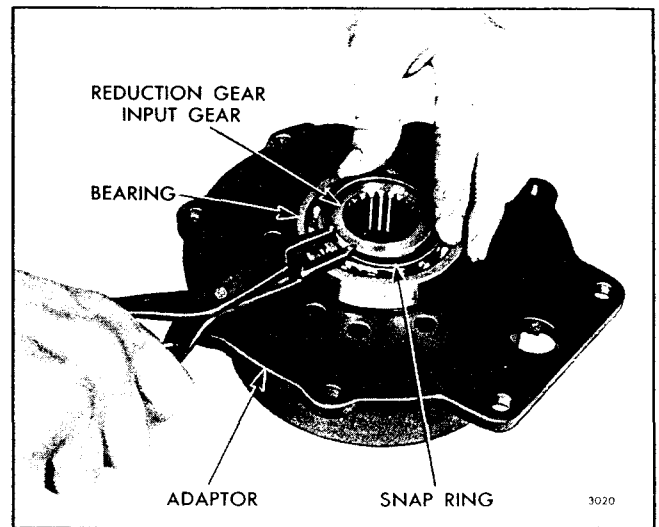


Fig. 39 - Removing or Installing Reduction Gear Input Gear Bearing Snap Ring (1.5:1 Ratio)

of the sun gear and gear housing with an offset steel rod from the inside of the sun gear.

- d. Lift the sun gear straight out of the gear housing.
12. Remove the reduction gear input gear bearing, adaptor and ring gear from the input gear as follows:

- a. Place the reduction gear adaptor, input gear and ring gear assembly on a bench with the bearing side facing up.
- b. Remove the input gear bearing snap ring from the groove in the input gear hub with a pair of snap ring pliers J 5586 as shown in Fig. 39.
- c. Support the reduction gear adaptor, input gear and ring gear assembly on two steel supports on the bed of an arbor press with the ring gear side down as shown in Fig. 40.
- d. Place a 1-7/8" round steel bar on top of the input gear hub and under the ram of the press as shown in Fig. 40.
- e. Then press the input gear and ring gear assembly out of the input gear bearing. Catch the input gear and ring gear assembly by hand to prevent it from falling and being damaged.
- f. Remove the snap ring from the groove in the ring gear that retains the flange of the reduction gear input gear in the ring gear, then lift the input gear straight out of the ring gear.

Disassemble 2.1:1, 2.5:1 and 3:1 Ratio Reduction

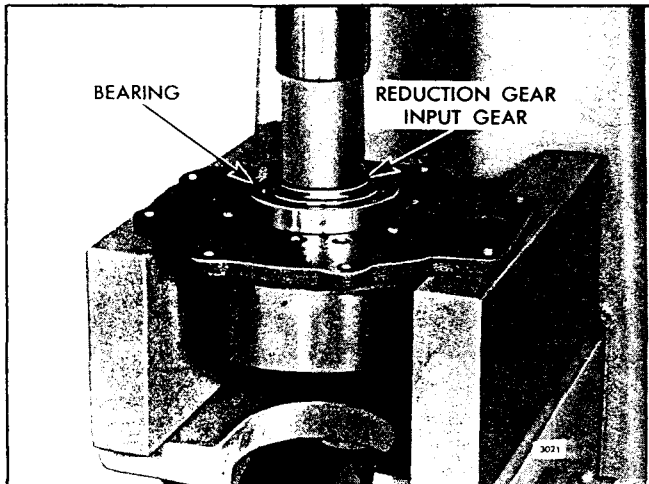


Fig. 40 - Removing Reduction Gear Input Gear from Input Gear Bearing (1.5:1 Ratio)

Gears - Refer to Figs. 1, 2 and 5 for the location of the parts and disassemble as follows:

1. Support the reduction gear assembly on a bench with the drive flange facing up.

2. Remove the drive flange nut, then lift the drive flange straight off the end of the reduction gear drive shaft.

If necessary, attach a bar type puller to the drive flange and pull the drive flange off the drive shaft.

3. On the 2.1:1 ratio reduction gear, lift the reduction gear housing straight off of the reduction gear planetary ring gear and drive shaft assembly.

On the 2.5:1 and 3:1 ratio reduction gears, lift the reduction gear housing straight off of the reduction gear planetary gear and drive shaft assembly.

4. Perform Steps 7, 8, 9, 10. a, b and c under *Disassemble 1.5:1 Ratio Reduction Gear* above, then proceed with Step "d" below.

d. Place a 2-1/4" round steel bar on top of the inner bearing cone, inside the reduction gear housing, and under the ram of the press as shown in Fig. 41.

e. Then press the roller bearing cup straight out of the reduction gear housing. Catch the roller bearing cup and cone by hand to prevent them from falling and being damaged.

f. Place the outer bearing cone inside of the bearing cup it was removed from and place the bearing assembly in a clean spot on a bench and cover.

5. On the 2.1:1 ratio reduction gear, remove the reduction gear sun gear from the reduction gear adaptor as follows:

- a. Place the reduction gear adaptor and sun gear assembly on a bench with the forward face of the adaptor facing up.
- b. Remove the snap ring from the groove in the sun gear with a pair of snap ring pliers as shown in Fig. 42, then lift the adaptor off of the sun gear.

6. On the 2.1:1 ratio reduction gear, remove the reduction gear drive shaft from the planetary ring gear as follows:

- a. Place the reduction gear planetary ring gear and drive shaft assembly on a bench with the outer end of the shaft facing up.
- b. Remove the snap ring from the groove in the inside diameter of the ring gear next to the drive shaft flange with a small screw driver. Then lift the drive shaft out of the planetary ring gear.

7. On the 2.5:1 and 3:1 ratio reduction gears, remove the reduction gear planetary ring gear plate from the adaptor and the planetary ring gear as follows:

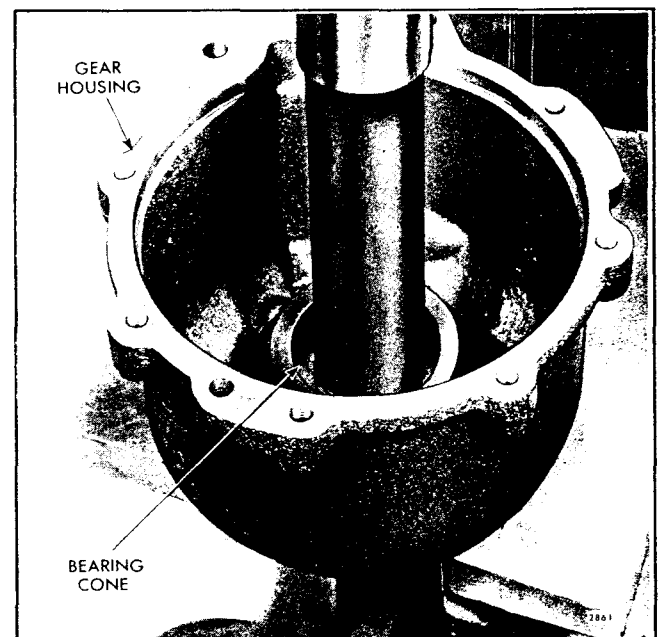


Fig. 41 - Removing Reduction Gear Drive Shaft Roller Bearing Cone and Cup from Gear Housing (2.1:1 Ratio)

- a. Support the adaptor, planetary ring gear plate and ring gear assembly on two 3" wood blocks with the ring gear side down and between the wood blocks.
- b. Tap the planetary ring gear plate out of the reduction gear adaptor with a small brass rod and hammer.
- c. Place the planetary ring gear plate and ring gear assembly on a bench with the ring gear plate side facing up.
- d. Remove the snap ring from the groove in the inside diameter of the ring gear next to the outside diameter of the planetary ring gear plate with a small screw driver. Then lift the ring gear plate straight out of the ring gear.

### Inspection

Wash all of the marine and reduction gear parts thoroughly with clean fuel oil and dry them with compressed air.

Examine the ball and roller bearings for corrosion and pitting. Lubricate each bearing with light engine oil; then, while holding the inner race or cone from turning, revolve the outer race or cup slowly by hand and check for rough spots.

Examine the oil seals, and if the lips of the oil seals are rough or hard, replace the seals.

Examine the forward and reverse clutch piston seal rings for cuts or scratches.

Examine the oil pump rotors (gears), cover plate (if used) and housing for score marks and wear.

**NOTE:** The oil pump housing, rotors (gears) and cover are matched at the factory and are not serviced separately. If it becomes necessary to replace any of the oil pump parts, a new oil pump assembly must be used.

Examine the inside diameters of the forward and reverse clutch pistons which contact the seal ring for scratches.

Examine the inside diameters of the forward clutch cylinder and the gear housing adaptor, which contact the seal ring, for scratches.

Examine the forward and reverse clutch plates, pressure plates and the forward inside face of the marine gear housing which contact the reverse clutch plate for scoring, burning or warping; also, examine

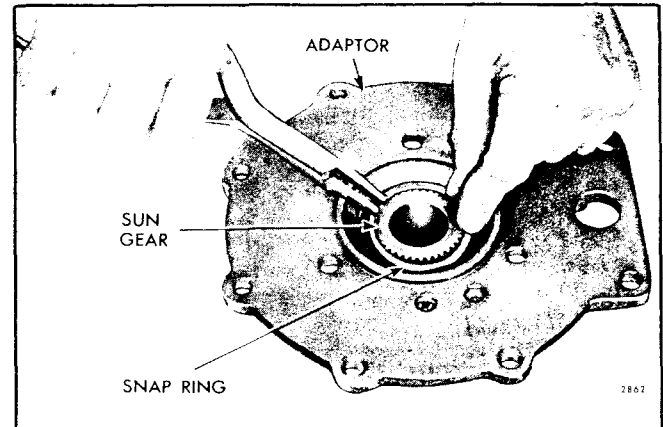


Fig. 42 - Removing or Installing Sun Gear Snap Ring (2.1:1 Ratio)

the teeth in the inner and outer diameters of the clutch plates for wear or peening.

Examine the teeth of the forward clutch hub and the internal and external teeth of the forward and reverse clutch ring gear for wear and peening.

Examine the thrust washers for wear and score marks.

If preliminary inspection of the planetary gears reveals nicks, burrs, pitting, over-heating, score marks or if excessive backlash (more than .015") between any two mating gears is found, the planetary gear assembly must be replaced.

**NOTE:** The parts of the reduction gear planetary gear are not serviced separately and must be replaced with a complete new assembly. Also, the reverse planetary gear and output shaft, which includes two inner bushings, is not serviced separately and must be replaced with a complete new assembly.

Examine the teeth of the drive gear and sun gear for wear, scoring or chipping. The gears may show considerable wear and still be usable.

Examine the splines on the shafts for wear and peening.

Examine the bushing in the reduction gear drive shaft for wear.

**NOTE:** The bushing in the reduction gear drive shaft is not serviced separately and requires replacement of the complete assembly.

On the reverse gear housing with bushings, examine the bushings inside the housing for wear. If worn excessively, they must be replaced. The bushings are



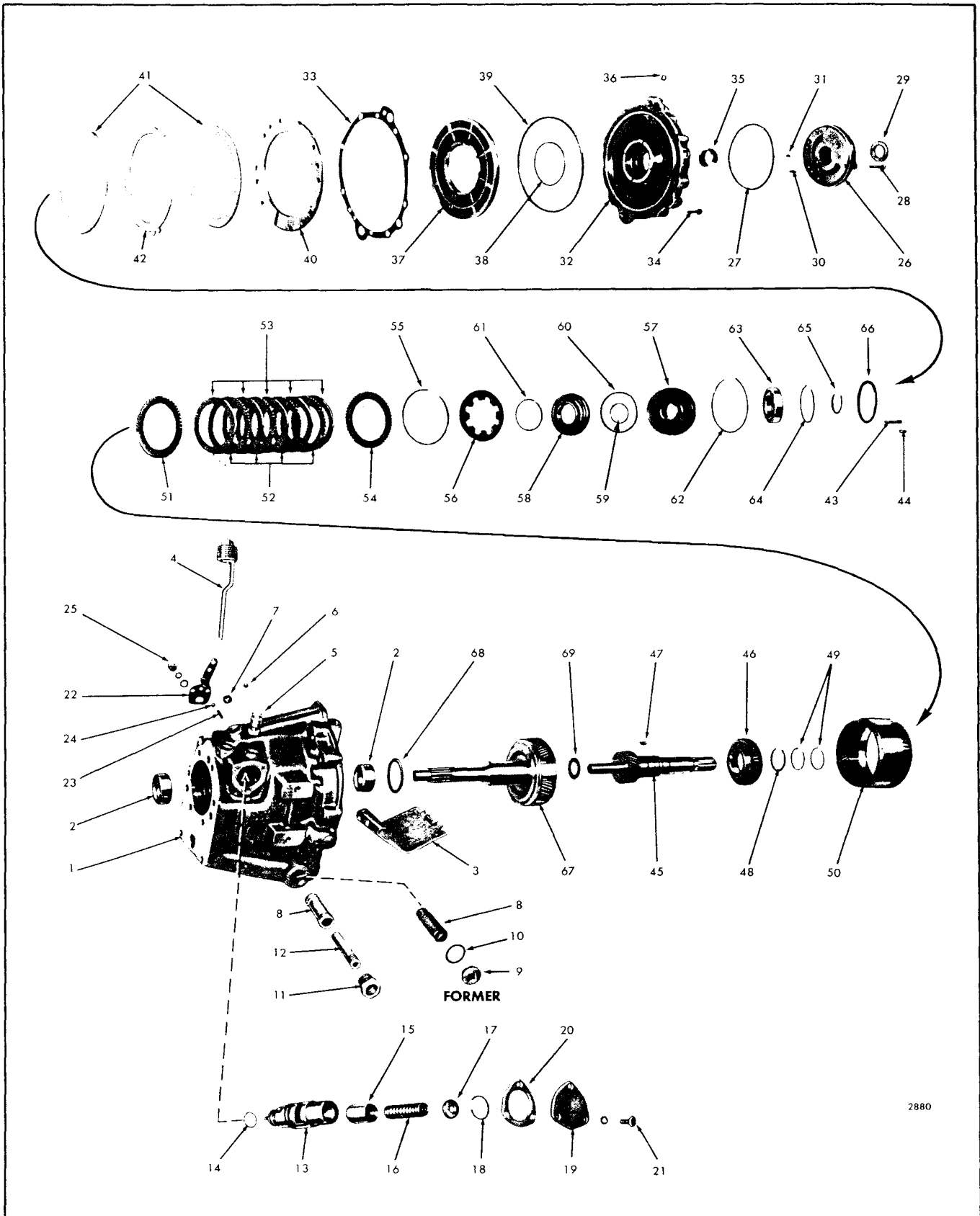


Fig. 43 - Reverse Gear Details and Relative Location of Parts (2.1:1 Ratio Model 71C Shown)

Fig. 43 - Reverse Gear Details and Relative Location of Parts (2.1:1 Ratio Model 71C Shown)

1. Housing-Reverse Gear	20. Gasket-Valve Cover	40. Plate-Reverse Clutch Pressure	56. Spring-Forward Clutch Release
2. Bushing-Reverse Gear Housing	21. Bolt-Valve Cover	41. Plate-Reverse Clutch (Inner)	57. Cylinder-Forward Clutch
3. Baffle-Gear Housing Oil	22. Lever-Selector Valve (Shifter)	42. Plate-Reverse Clutch Stationary (Steel)	58. Piston-Forward Clutch
4. Oil Filler Plug and Dipstick Assy.	23. Spring-Lever Detent	43. Spring-Pressure Plate Release	59. Seal Ring-Forward Clutch Piston (Inner)
5. Breather Assy.-Gear Housing	24. Ball-Lever Detent Spring	44. Pin-Reverse Clutch Stationary Plate Dowel	60. Seal Ring-Forward Clutch Piston (Outer)
6. Pipe Plug-1/8"	25. Nut-Lever Retaining	45. Shaft Assy.-Drive Gear Input	61. Ring-Forward Clutch Release Spring Support
7. Pipe Plug-3/8"	26. Pump Assy.-Reverse Gear Oil	46. Hub-Forward Clutch	62. Snap Ring-Forward Clutch Cylinder
8. Strainer Assy.-Reverse Gear Oil	27. Gasket-Oil Pump to Adaptor	47. Woodruff Key-Forward Clutch Hub	63. Bearing-Drive Gear Input Shaft Ball
9. Plug-Oil Drain	28. Bolt-Oil Pump	48. Snap Ring-Clutch Hub	64. Snap Ring-Bearing (Clutch Cylinder)
10. Gasket-Oil Drain Plug Annular	29. Oil Seal-Oil Pump	49. Seal Ring-Drive Gear Input Shaft	65. Snap Ring-Bearing (Input Shaft)
11. Bushing-Reducing	30. Screw-Oil Pump Cover	50. Ring Gear-Forward Clutch Planetary	66. Thrust Washer-Forward Clutch Cylinder
12. Tube-Oil Return	31. Woodruff Key-Oil Pump Drive	51. Plate-Forward Clutch Pressure (Rear)	67. Shaft Assy.-Planetary Gear and Reduction Gear Input
13. Valve-Selector Control	32. Adaptor-Reverse Gear Housing	52. Plate-Forward Clutch Inner (Copper Faced)	68. Thrust Washer-Reduction Gear Input Shaft
14. Seal Ring-Selector Control Valve	33. Gasket-Gear Housing Adaptor	53. Plate-Forward Clutch (Steel)	69. Thrust Washer-Reduction Gear Planetary Gear
15. Valve-Pressure Regulator	34. Bolt-Gear Housing Adaptor	54. Plate-Forward Clutch Pressure (Front)	
16. Spring-Pressure Regulator Valve	35. Bearing-Gear Housing Adaptor Roller	55. Snap Ring-Forward Clutch Pressure Plate	
17. Retainer-Regulator Valve Spring	36. Pipe Plug-Adaptor		
18. Snap Ring-Valve Spring Retainer	37. Piston-Reverse Clutch		
19. Cover-Selector Control Valve	38. Seal Ring-Reverse Clutch Piston (Inner)		
	39. Seal Ring-Reverse Clutch Piston (Outer)		

prefinished and do not require reaming or boring after installation in the housing.

On the reverse gear housing without bushings, examine the planetary gear and reduction gear input shaft bore in the housing for score marks and wear.

Examine the inside diameter of the forward clutch piston cylinder for seal ring score marks.

Examine the drive gear input shaft seal rings for wear, scoring or cracks.

Examine the reverse clutch pressure plate release springs for defects and check the spring with spring tester J 9666. The spring has a free length of approximately 1.250". Replace the spring when a load of less than 13.5 lbs. will compress it to 1.00".

Examine the selector valve and the pressure regulator valve for scoring.

Examine the pressure regulator valve spring for defects and check the spring with spring tester J 9666. The spring has a free length of approximately 2.6562". Replace the spring when a load of less than 94 lbs. will compress it to 2.073".

Replace the selector valve seal ring at each teardown.

Examine the selector valve bore in the gear housing for burrs or score marks.

Blow out all oil passages in the various parts with compressed air.

Remove all of the old gaskets and clean the surfaces before installing new gaskets.

Replace all of the marine gear parts that cannot be cleaned up with crocus cloth, and the excessively worn or damaged parts.

**ASSEMBLE REVERSE AND REDUCTION GEAR**

With the parts cleaned and inspected and the necessary parts on hand, the reverse and reduction gear may be assembled as outlined below.

**Assemble Reverse Gear**

The assembly procedure for the direct drive reverse gear and the reverse gears used in conjunction with the 1.5:1, 2.1:1, 2.5:1 and 3:1 ratio reduction gears on Models 71 and 72 are similar. Therefore, assembly will be covered as a single procedure and any differences between the various assemblies will be noted therein.

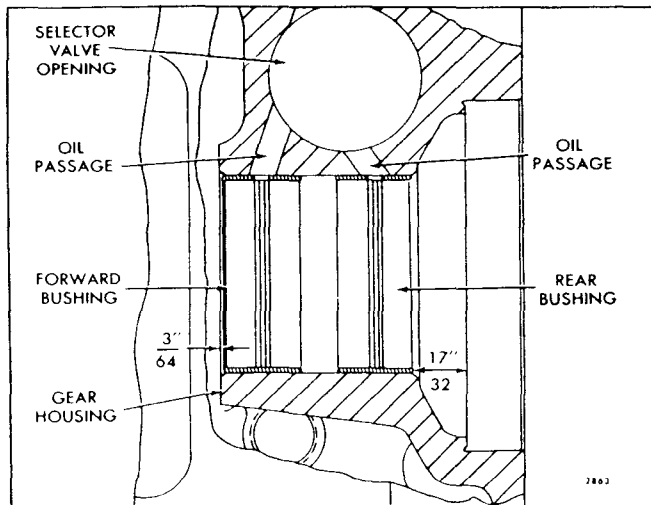


Fig. 44 - Location of Planetary Gear and Reduction Gear Input Shaft Bushings in Reverse Gear Housing

Three different types of reverse gear housings and two different types of planetary gear and reduction gear input shaft assemblies have been used in the marine gears. TYPE 1 incorporated two planetary gear and reduction gear input shaft prefinished bushings and a planetary gear and reduction gear input shaft assembly without oil grooves. In TYPE 2, the planetary gear and reduction gear input shaft bushings in the housings were eliminated and the bore in the housing reduced from 1.989" -1.990" to 1.8625" -1.8635", and a new planetary gear and reduction gear input shaft assembly with three oil grooves was used. In TYPE 3 (current type), the planetary gear and reduction gear input shaft bore in the housing was increased from 1.8625" -1.8635 to 1.989" -1.990" and new prefinished bushings were installed in the housing.

The finished inside diameter of the new bushings is 1.8625" -1.8635" and differ from the bushings used in the TYPE 1 reverse gear housing only by having a slightly larger outside diameter to assure a tighter fit in the housing.

The former planetary gear and reduction gear input shaft assembly, without oil grooves, and the current planetary gear and reduction gear input shaft assembly, with oil grooves, can be used in both TYPE 1 and TYPE 3 reverse gear housings with bushings. The current planetary gear and reduction gear input shaft assembly, with oil grooves, MUST be used in the TYPE 2 reverse gear housings without bushings.

Refer to Figs. 1, 2 and 42 for the location of the various parts and assemble them as follows:

1. If removed, install the new direct drive (output)

shaft or the planetary gear and reduction gear input shaft outer bushings in the reverse gear housing as follows:

- a. Lubricate the outside diameter of one bushing with engine oil, then start the bushing straight into the bushing bore of the reverse gear housing from the rear face with the oil hole in the bushing in alignment with the oil hole in the gear housing.
- b. Support the reverse gear housing, forward face down, on the bed of an arbor press.
- c. Place the bushing remover and installer J 8466 with handle J 7079-2 in the bushing with the end of the handle under the ram of the press as shown in Fig. 46. Then press the bushing straight into the gear housing to the dimension shown in Fig. 44.

**CAUTION:** Be sure the oil hole in the bushing is in alignment with the oil hole in the gear housing when the bushing is pressed into position.

- d. Invert the gear housing on the bed of the arbor press, then install the second bushing in the gear housing as described in Steps a, b and c above.

2. If removed, install the oil baffle in the reverse gear housing as follows:

On a current direct drive unit, perform Step a.

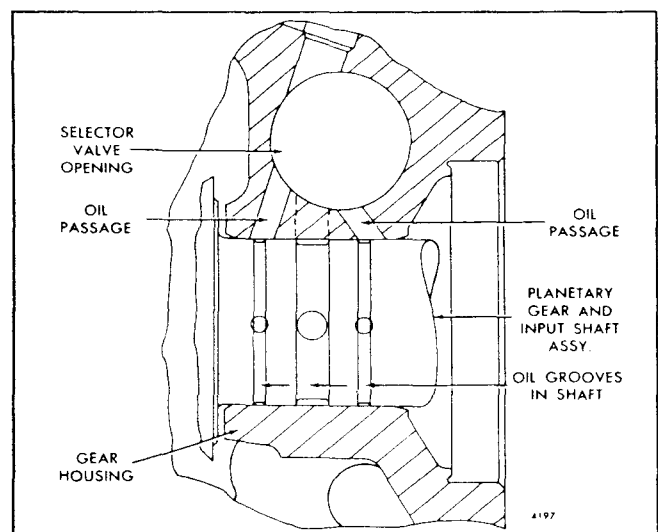


Fig. 45 - Location of Planetary Gear and Reduction Gear Input Shaft in Reverse Gear Housing Without Bushings

- a. Place the oil baffle inside the reverse gear housing with the notched edge facing the front and the curved side toward the bottom of the housing. Then press down on the center of the oil baffle and snap the rectangular slots at each end on the cast bosses at each side of the housing.

On a former direct drive unit and all reverse and reduction gear units, perform Steps b, c and d.

- b. Place the oil baffle inside of the gear housing with the curved portion below the cast spherical bosses in the gear housing as shown in Figs. 1 and 47.
- c. Position the forward end of the oil baffle so that the center of the baffle rests on top of the boss, at the front center of the gear housing, and the turned down corners of the baffle are located below the cast spherical bosses.
- d. Snap the oil baffle into position by lifting up on the curved portion so that the two large holes are located on top of the spherical bosses at the rear inside face of the gear housing as shown in Figs. 1 and 47.

3. On the direct drive units, install the planetary gear and drive (output) shaft assembly in the reverse gear housing as follows:

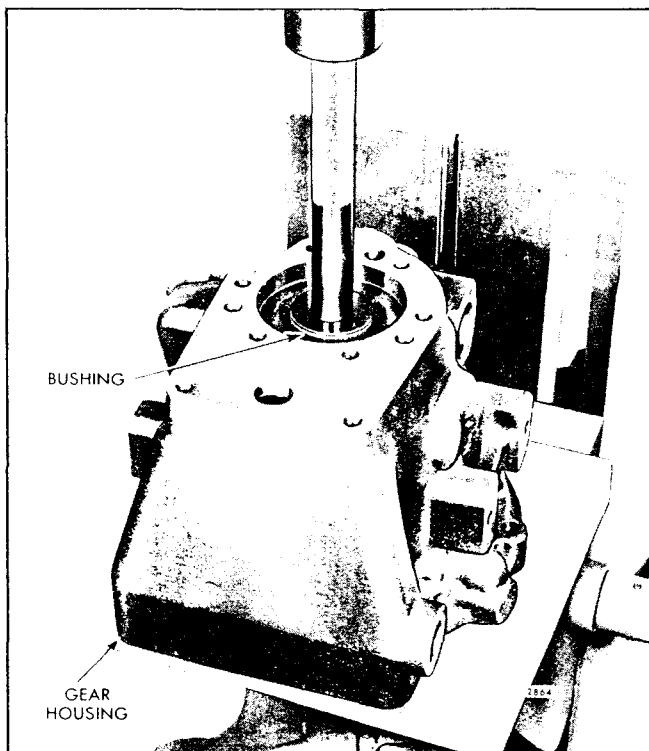


Fig. 46 - Installing Drive Shaft Bushings in Reverse Gear Housing

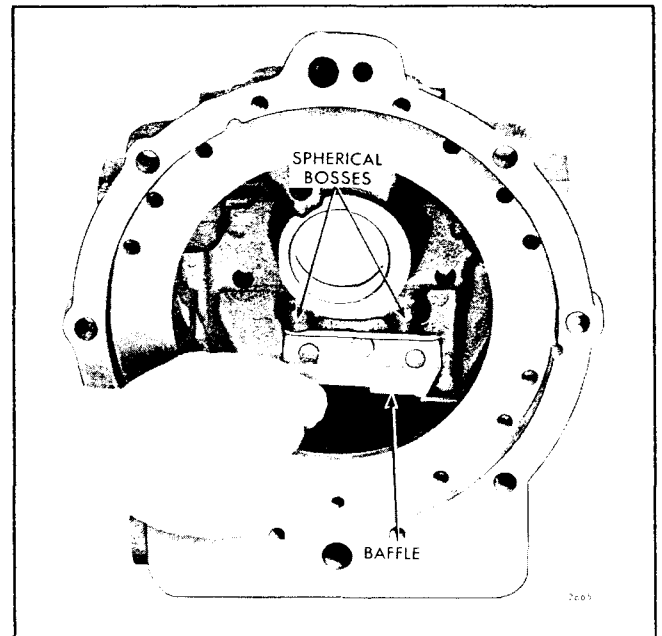


Fig. 47 - Installing Oil Baffle in Gear Housing

- a. Support the reverse gear housing on two 3" wood blocks, with the forward face of the gear housing facing up and the opening in the rear face of the housing over the opening between the two wood blocks, thus allowing clearance for the end of the drive (output) shaft to project through the reverse gear housing when assembled.
- b. Lubricate the pinion gears in the planetary gear and the outside diameter of the drive (output) shaft, where it makes contact with the bushings or the gear housing, with engine oil.
- c. Position the planetary gear and drive (output) shaft assembly over the top of the gear housing (Fig. 51), then insert the end of the drive (output) shaft straight down through the bushings or housing until the rear face of the planetary gear rests on the gear housing.
- d. Place a 3" x 6" x 6" wood block down inside the gear housing with the 6" face of the block resting on top of the planetary gear.
- e. Place the reverse gear housing, planetary gear and drive shaft assembly and the wood block on the bed of an arbor press, with the forward face of the gear housing down and the assembly resting on the wood block (Fig. 49).
- f. Lubricate the drive (output) shaft bearing with engine oil. Place the bearing over the end of the shaft with the groove in the outer race of the bearing up; then, start the bearing straight on the bearing surface of the shaft.

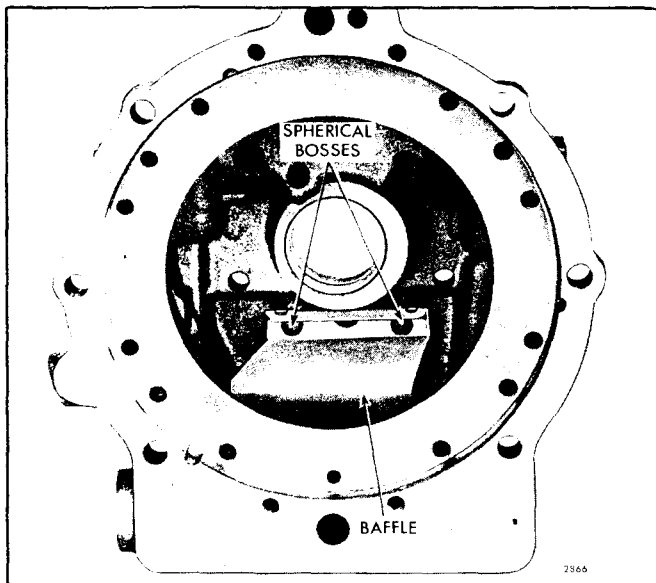


Fig. 48 - Oil Baffle in Position in Gear Housing

- g. Place a sleeve over the end of the drive (output) shaft and rest it on the inner race of the bearing; then, place a flat steel plate on top of the sleeve and under the ram of the press as shown in Fig. 49. Then press the bearing straight down in the housing and on the shaft until it seats on the shoulder on the drive shaft.
- h. Remove the reverse gear housing and drive (output) shaft assembly from the arbor press and place it on a bench, with the rear face of the gear housing facing up.
- i. Refer to Step 4 under *Assemble Reduction Gear* for installing the oil seal in the drive (output) shaft bearing retainer.
- j. Affix a new bearing retainer gasket to the rear face of the reverse gear housing with the bolt holes in the housing and gasket in alignment.
- k. Place the bearing retainer over the end of the drive (output) shaft and start it straight over the bearing with the bolt holes in the retainer and housing in alignment. Then push it down tight against the gasket and housing.
- l. Install the six 7/16" -14 x 1-1/4" bolts and lock washers. Tighten the bolts to 46-50 lb-ft torque.
- m. Lubricate the splines of the drive shaft and the lip of the oil seal lightly with engine oil; then, start the drive flange on the end of the drive shaft and push it down tight against the bearing.

If necessary, tap the drive flange down on the drive shaft until it contacts the bearing with a hard wood block and hammer.

- n. Lubricate the threads on the drive (output) shaft with engine oil. Then thread the retainer nut on the shaft and against the drive flange. Do not tighten the nut at this time.

4. On the 1.5:1 and 2.1:1 reverse and reduction gear units, install the planetary gear and reduction gear input shaft assembly in the reverse gear housing as follows:

- a. Support the reverse gear housing on two 6" wood blocks, with the forward face of the gear housing facing up and the opening in the rear face of the housing over the opening between the two wood blocks, thus allowing clearance for the end of the reduction gear input shaft to project through the reverse gear housing when assembled.
- b. Lubricate the reduction gear input shaft thrust washer with engine oil; then, place the thrust washer down in the reverse gear housing with the tang on the edge of the washer in the notch inside of the gear housing as shown in Fig. 50.
- c. Lubricate the pinion gears in the planetary gear and the outside diameter of the input shaft, where it makes contact with the bushings or the gear housing, with engine oil.

**NOTE:** The 2.1:1 reverse and reduction gear unit cannot be reversed from right-hand rotation to left-hand rotation by relocating the

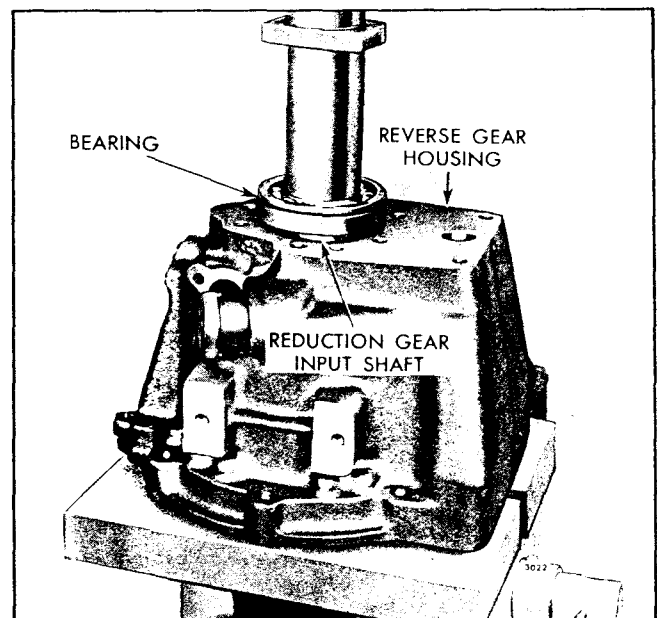


Fig. 49 - Installing Reduction Gear Input Shaft Bearing on Input Shaft and in Gear Housing (2.5:1 and 3:1 Ratios)

reverse gear oil pump like the other reverse and reduction gear units. However, if it becomes necessary to change the rotation of the 2.1:1 reverse and reduction gear unit to the opposite hand rotation, it can be accomplished by removing the present reduction gear planetary gear assembly and installing the opposite hand rotating planetary gear assembly and relocating the oil pump assembly to the opposite hand rotation.

- d. Position the planetary gear and input shaft assembly over the top of the gear housing as shown in Fig. 51; then, insert the end of the input shaft straight down through the thrust washer and bushings or housing until the rear face of the planetary gear rests on the thrust washer.

5. On the 2.5:1 and 3:1 reverse and reduction gear units, install the planetary gear and reduction gear input shaft assembly in the reverse gear housing as follows:

- a. Support the reverse gear housing on two 6" wood blocks, with the forward face of the gear housing facing up and the opening in the rear face of the housing over the opening between the two wood blocks, thus allowing clearance for the end of the reduction gear input shaft to project through the reverse gear housing when assembled.

**NOTE:** The thrust washer shown in Fig. 50 is not used on the direct drive, 2.5:1 and 3:1 ratio reverse and reduction gear units.

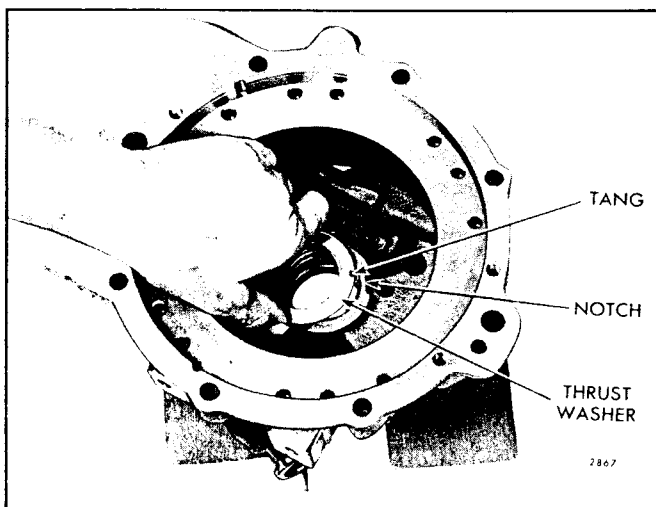


Fig. 50 - Installing Reduction Gear Input Shaft Thrust Washer in Gear Housing (1.5:1 and 2.1:1 Ratios)

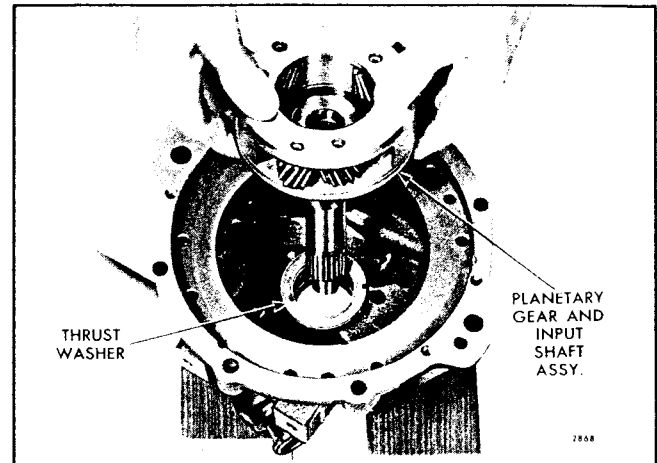


Fig. 51 - Installing Planetary Gear and Reduction Gear Input Shaft Assembly in Gear Housing (1.5:1 and 2.1:1 Ratios)

- b. Lubricate the pinion gears of the planetary gear and the outside diameter of the input shaft, where it makes contact with the bushings or the gear housing, with engine oil.
- c. Position the planetary gear and input shaft assembly over the top of the gear housing (Fig. 51); then, insert the end of the input shaft straight down through the bushings or housing until the rear face of the planetary gear rests on the gear housing.
- d. Place a 3" x 6" x 6" wood block down inside the gear housing with the 6" face of the block resting on top of the planetary gear.
- e. Place the reverse gear housing, planetary gear and input shaft assembly and the wood block on the bed of an arbor press, with the forward face of the gear housing down and the assembly resting on the wood block (Fig. 49).
- f. Lubricate the reduction gear input shaft bearing with engine oil. Place the bearing over the end of the shaft with the groove in the outer race of the bearing up; then, start the bearing straight on the bearing surface of the shaft.
- g. Place a sleeve over the end of the input shaft and rest it on the inner race of the bearing; then, place a flat steel plate on top of the sleeve and under the ram of the press as shown in Fig. 49. Press the bearing straight on the shaft and in the housing until it seats on the shoulder on the shaft and the snap ring groove in the shaft is fully exposed.
- h. Install the snap ring in the groove in the shaft next to the bearing inner race with a pair of snap ring pliers J 5586.

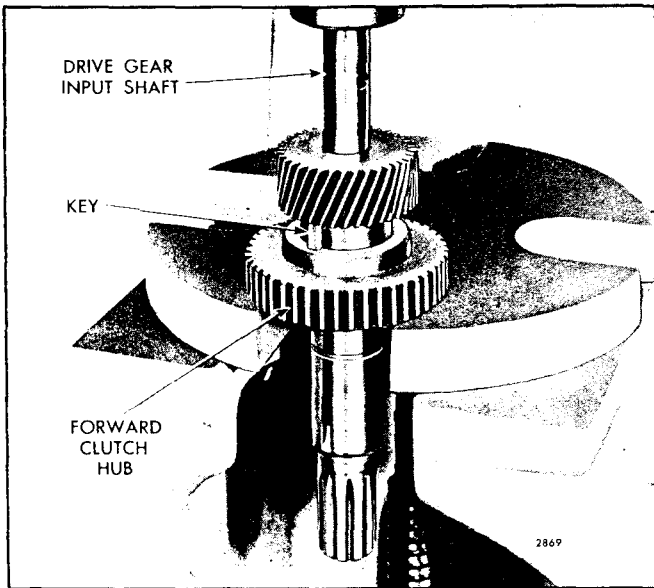


Fig. 52 - Installing Forward Clutch Hub on Drive Gear (Input) Shaft

- i. Remove the reverse gear housing and input shaft assembly from the arbor press and place it on the two six inch wood blocks with the forward face of the gear housing facing up.
6. Install the forward clutch hub on the clutch drive gear shaft as follows:

A new drive gear input shaft assembly has replaced the former drive gear input shaft assembly. The

current drive gear shaft differs from the former in that it is 1" shorter in length, has 26 splines at the pilot end, a relocated Woodruff keyway and a cup plug pressed in the small end of the shaft to seal off the horizontal oil passage. The former drive gear shaft was 1" longer in length, had 10 splines at the pilot end, and a steel ball and a roll pin in the small end of the shaft to seal off the horizontal oil passage.

- a. Install the Woodruff key in the keyway provided in the shaft next to the drive gear.
- b. Lubricate the outside diameter of the drive gear shaft, where it makes contact with the forward clutch hub, with engine oil.
- c. Place the forward clutch hub over the end of the drive gear shaft, with the extended hub end of the clutch hub down, and lower it straight over the shaft with the keyway in the clutch hub in alignment with the Woodruff key in the shaft.
- d. Place the forward clutch hub and drive gear shaft on the bed of an arbor press, with the short end of the drive gear shaft under the ram of press as shown in Fig. 52. Then press the drive gear shaft straight into the forward clutch hub and tight against the drive gear.
- e. Install the snap ring in the groove in the shaft with a pair of snap ring pliers J 5586 as shown in Fig. 30. Be sure the snap ring is fully seated in its groove.

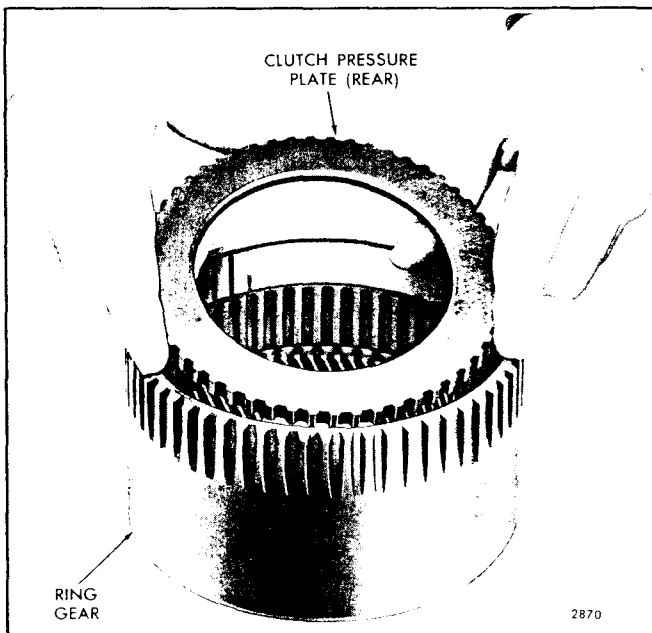


Fig. 53 - Installing Rear (Forward) Clutch Pressure Plate in Ring Gear

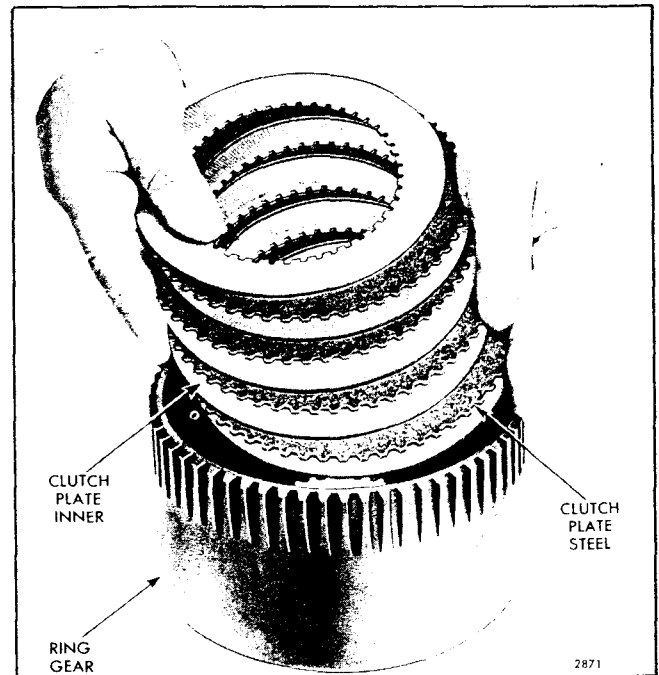


Fig. 54 - Position of Forward Clutch Plates for Assembly in Ring Gear

**NOTE:** If a new service drive gear input shaft assembly is being installed, be sure the steel ball and roll pin or cup plug, whichever is used, is in place in the small (non-splined) end of the drive gear shaft before installing it in the reverse gear housing.

7. Install the forward clutch plates and the forward clutch piston and cylinder assembly in the planetary ring gear as follows:

- a. Place the planetary ring gear on a bench, with the external teeth of the ring gear facing up.
- b. Install the rear clutch pressure plate inside the planetary ring gear with the smooth flat face side facing up as shown in Fig. 53. Align the teeth on the pressure plate with the internal teeth in the ring gear; then, lower the pressure plate straight into the ring gear until it seats squarely on the shoulder inside the ring gear.
- c. Lubricate the inner forward clutch plates (copper faced) and the outer forward clutch plates (steel) with engine oil.
- d. Place an inner forward clutch plate (copper faced) down inside the ring gear and rest it on the rear clutch pressure plate. Then place the outer forward clutch plate (steel) down in the ring gear next to the inner clutch plate so the teeth on the clutch plate mesh with the internal teeth in the ring gear.

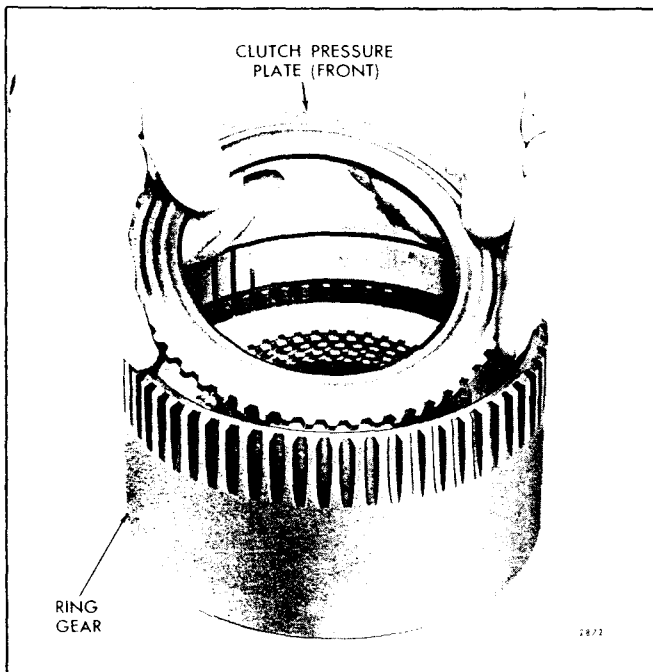


Fig. 55 - Installing Front (Forward) Clutch Pressure Plate in Ring Gear

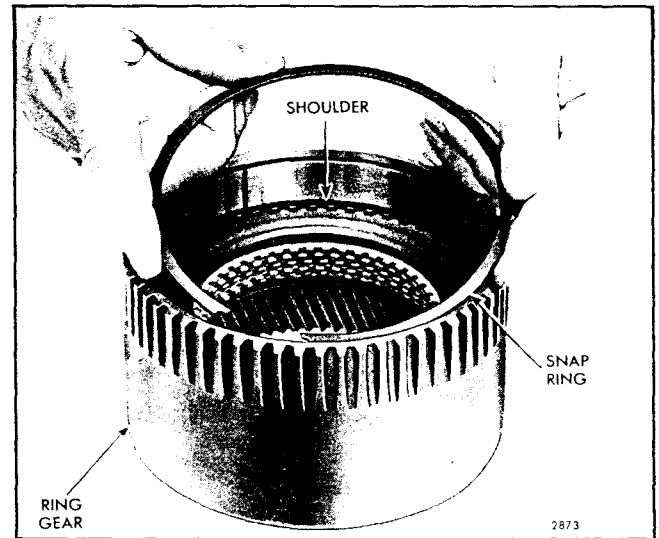


Fig. 56 - Installing Forward Clutch Pressure Plate Snap Ring in Ring Gear

Install the remaining inner and outer forward clutch plates as outlined above and in the same sequence as shown in Fig. 54.

- e. Install the front clutch pressure plate inside the planetary ring gear with the smooth flat face side down as shown in Fig. 55.

Align the teeth on the pressure plate with the internal teeth in the ring gear; then, lower the pressure plate on top of the (copper faced) inner clutch plate.

- f. Install the forward clutch pressure plate snap ring inside the ring gear and seat it squarely on the internal shoulder inside the ring gear as shown in Fig. 56.

**NOTE:** The forward clutch pressure plate snap ring shown in Fig. 56 is .090" to .093" thick and has a free diameter of  $5-19/32" + 1/16"$  and is only used as a spacer and clutch release spring seat. The groove at the top of the shoulder in the ring gear is not designed to accommodate the snap ring.

- g. Place the forward clutch release spring in the ring gear and rest it on the snap ring (spacer), with the concave side of the release spring facing down as shown in Fig. 57, and center it in the ring gear.
- h. Lubricate the forward clutch piston outer seal ring with engine oil; then, install the seal ring in the groove in the outside diameter of the forward clutch piston as shown in Fig. 58.
- i. Lubricate the forward clutch piston inner seal ring with engine oil; then, install the seal ring in the



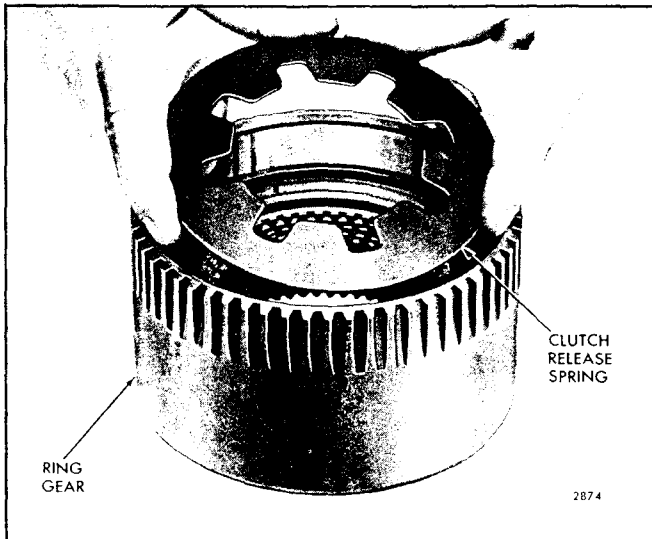


Fig. 57 - Installing Forward Clutch Release Spring in Ring Gear

groove in the hub of the forward clutch piston cylinder as shown in Fig. 59.

- j. Lubricate the forward clutch piston inner and outer seal rings with engine oil; then, start the forward clutch piston with seal ring straight into the bore of the forward clutch piston cylinder, with the flat side of the piston facing down. Then push the piston straight down in the cylinder until it bottoms as shown in Fig. 60.

**CAUTION:** This is a hand assembly and should not be tapped in with a hammer or pressed in with an arbor press.

- k. Install the forward clutch piston release spring support ring in the groove in the top of the piston (Figs. 41 and 43).
- l. Lubricate the outside diameter of the forward clutch piston cylinder, where it makes contact with

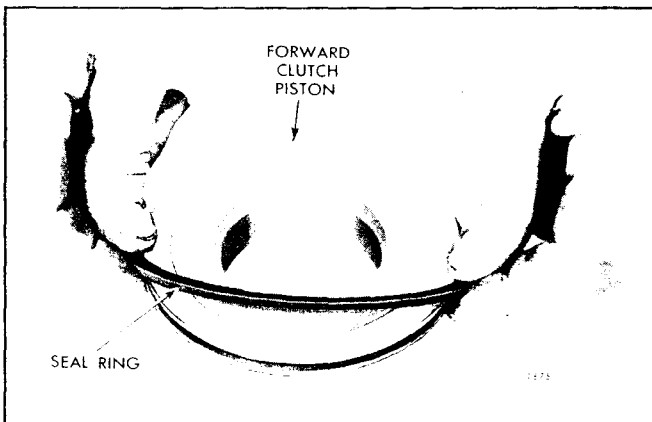


Fig. 58 - Installing Forward Clutch Piston Seal Ring on Piston

the ring gear, with engine oil; then, start the forward clutch piston and cylinder assembly straight into the bore of the ring gear, with the forward clutch piston side facing the piston release spring.

- m. Place the planetary ring gear assembly on the bed of an arbor press, with the forward clutch piston cylinder end facing up and under the ram of the press. Place a short 3" outside diameter steel bar on top of the forward clutch piston cylinder; then, very carefully press the piston cylinder straight into the ring gear as shown in Fig. 61 until it contacts the snap ring and the groove in the top of the ring gear is fully exposed.

**CAUTION:** Be sure the forward clutch release spring is centrally located so the outer edge of the forward clutch piston cylinder will not ride on the edge of the spring. The clutch release spring must be centered so the outer edge of spring rides in the counterbore of the piston cylinder when the piston cylinder is down against the snap ring.

**NOTE:** If the snap ring groove in the top of the ring gear is not fully exposed when the piston cylinder is pressed down in the ring gear as far as it will go, it is evident that the piston cylinder is riding on the edge of the clutch release spring. This can be determined by removing the ring gear assembly from the arbor press and checking the fingers of the release spring through the rear of the ring gear to see if they are centrally located on the release spring support ring. If necessary, place a screw driver between the fingers of the spring and the edge of the piston and reposition the spring. Replace the ring gear assembly on the bed of the arbor press and press the forward

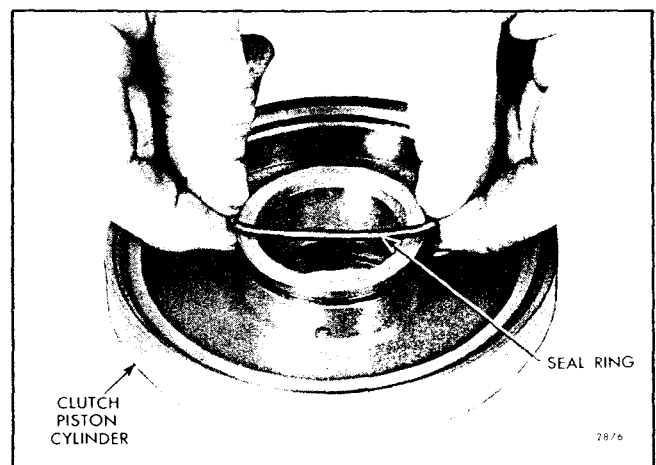


Fig. 59 - Installing Forward Clutch Piston Seal Ring in Clutch Piston Cylinder

clutch piston cylinder down against the snap ring.

- n. Place the ring gear and forward clutch assembly on a bench, with the forward clutch piston cylinder end facing up; then, install the snap ring in the groove inside the ring gear next to the piston cylinder as shown in Fig. 62.

If necessary, apply light pressure on the forward clutch piston cylinder with the arbor press while installing the snap ring.

**NOTE:** The forward clutch piston cylinder snap ring shown in Fig. 62 is .074" -.078" thick and has a free diameter of 5-7/8" + 1/16" and is only used at this location to retain the forward clutch piston cylinder in the ring gear.

- 7. On the Model 72 reverse gear units, perform the additional Steps a, b, c and d as outlined below:

- a. Support the ring gear and forward clutch assembly on the bed of an arbor press, with the forward clutch piston cylinder end of the assembly facing down (Fig. 63) and the end of the ring gear resting on steel or wood supports.

**CAUTION:** Be sure the forward clutch piston cylinder does not contact or ride on the supports under the end of the ring gear.

- b. Place a 1/4" x 4-1/2" diameter steel plate down inside the ring gear and rest it on the face of the rear clutch pressure plate.
- c. Bring the ram of the press down on the center of the steel plate and apply just enough force to

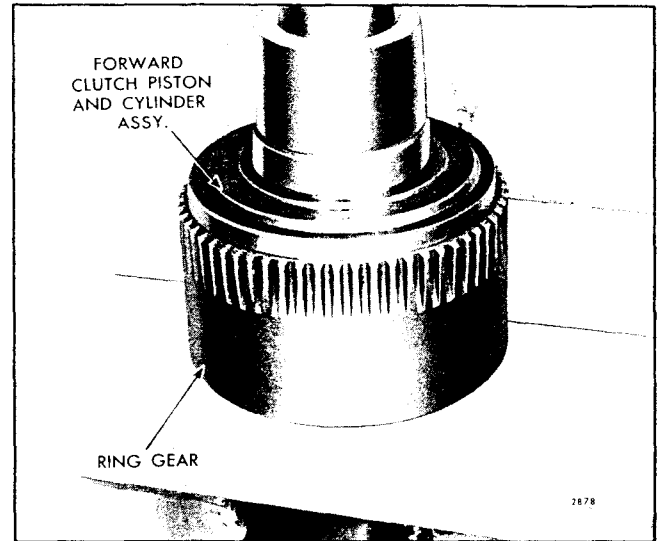


Fig. 61 - Installing Forward Clutch Piston and Cylinder Assembly in Ring Gear

compress the pressure plates and clutch plates against the snap ring (spacer) between the front clutch pressure plate and the clutch piston cylinder. Then measure the clearance between the rear face of the rear pressure plate and the shoulder of the snap ring groove inside the ring gear at several places with feeler gages as shown in Fig. 63 and record.

- d. Release the load off of the clutch plates and remove the steel plate from inside the ring gear. Then install one of the selective spacers (snap rings) in the snap ring groove between the rear face of the rear pressure plate and the shoulder of the snap ring groove as shown in Fig. 64.

One of three different thickness spacers (snap rings) are used between the rear pressure plate and the shoulder in the ring gear to retain the

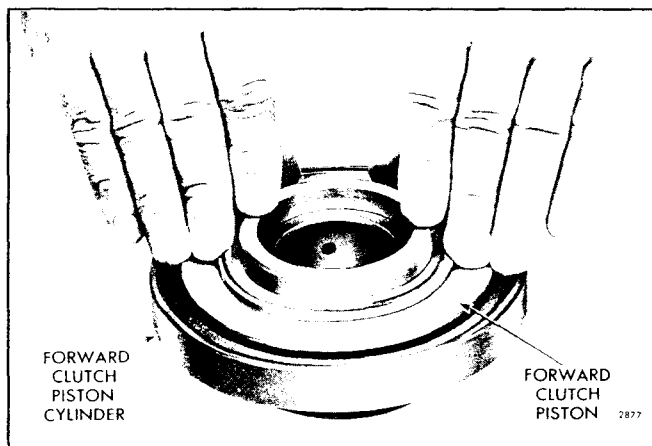


Fig. 60 - Installing Forward Clutch Piston in Clutch Piston Cylinder

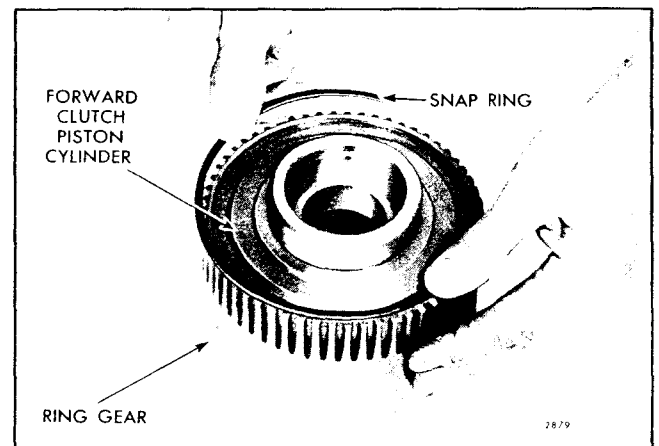


Fig. 62 - Installing Forward Clutch Piston Cylinder Snap Ring in Ring Gear

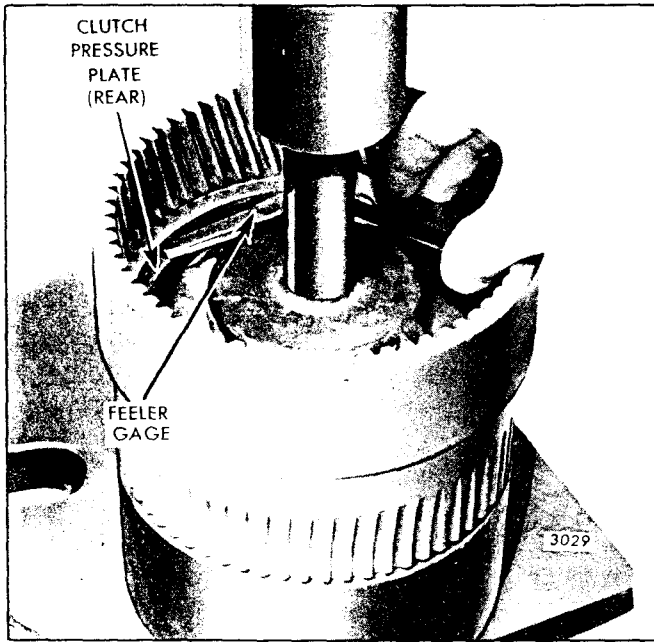


Fig. 63 - Measuring Gap for Forward Clutch Selective Spacer (Snap Ring)

proper clearance of .040" to .065" between the two parts. They are .050" to .054", .074" to .078" and .096" to .100" thick. All have a free diameter of  $5\text{-}11/16 + 1/16$ " and are only used at this location on the Model 72 reverse gears.

The three different thickness spacers (snap rings)

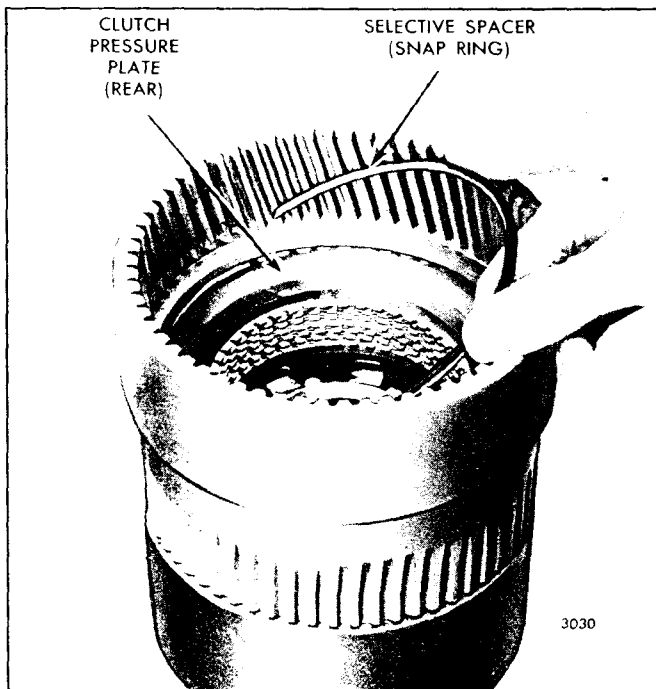


Fig. 64 - Installing Forward Clutch Selective Spacer (Snap Ring) in Ring Gear

may be identified by a spot of paint on the outside diameter of each snap ring: green on .050" to .054", orange on .074" to .078" and white on .096" to .100".

8. Install the drive gear and forward clutch hub assembly in the ring gear and forward clutch assembly as follows:

- a. Lubricate the drive gear input shaft seal rings with engine oil, then place the seal rings over the splined end of the drive gear input shaft and into the grooves in the shaft with a pair of snap ring pliers as shown in Fig. 29. Hook the ends of each seal ring together.

**CAUTION:** To avoid breaking the seal rings, do not spread them any more than necessary to slip them over the shaft.

- b. Rotate the inner forward clutch plates in the ring gear so that all of the teeth on the plates are in alignment.

- c. Place the ring gear assembly on its side on a bench. Lubricate the drive gear shaft and seal rings with engine oil; then, insert the splined end of the drive gear shaft in the rear of the ring gear as shown in Fig. 65. Push the drive gear shaft straight through the bore of the forward clutch piston cylinder until the seal ring enters the bore of the piston cylinder and the teeth of the clutch hub enter the teeth of the inner clutch plates; continue to work the clutch hub through all of the

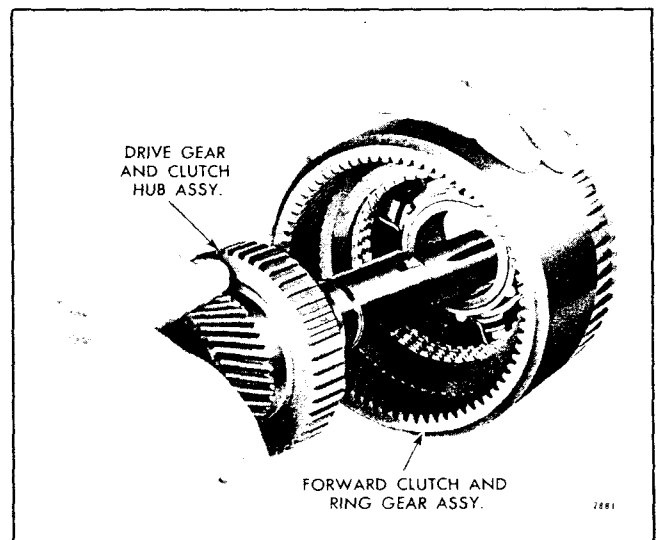


Fig. 65 - Installing Drive Gear and Forward Clutch Hub Assembly into Forward Clutch and Ring Gear Assembly

inner clutch plates until the rear face of the drive gear is flush with the face of the ring gear as shown in Fig. 66.

**CAUTION:** Do not drive or force the drive gear and clutch hub assembly through the inner clutch plates. If forced, the teeth of the inner clutch plates will be damaged.

**IMPORTANT:** During assembly, the inner clutch plate at the rear of the forward clutch pack can move off center and hook over the rear face of the clutch hub. This will prevent alignment of the gear faces as mentioned in Step "c" above.

**NOTE:** When installing the drive gear and clutch hub assembly in the forward clutch piston cylinder and the inner clutch plates, do not push the drive gear and clutch hub in too far or the forward seal ring will slip out of the forward clutch piston cylinder and cannot be reinstalled in the piston cylinder by pulling the drive gear and clutch hub backwards. The seal ring must be removed from the groove in the shaft and the drive gear and clutch hub removed from the piston cylinder and the inner clutch plates and reinstalled again as outlined above.

- d. Place the 3" x 6" x 6" wood block with the 1" hole drilled through its center over the drive gear shaft at the rear of the ring gear as shown in Fig. 67 to support the ring gear and drive gear assembly while installing the drive gear shaft bearing and snap rings.

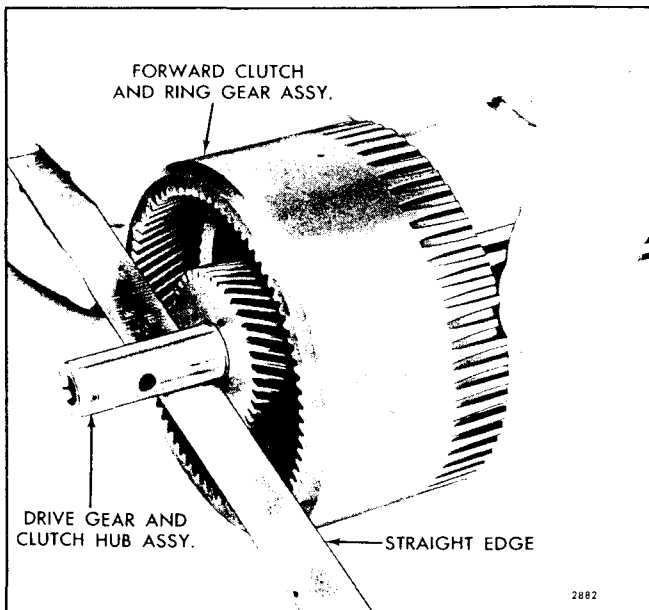


Fig. 66 - Aligning Rear Face of Drive Gear with Face of Ring Gear

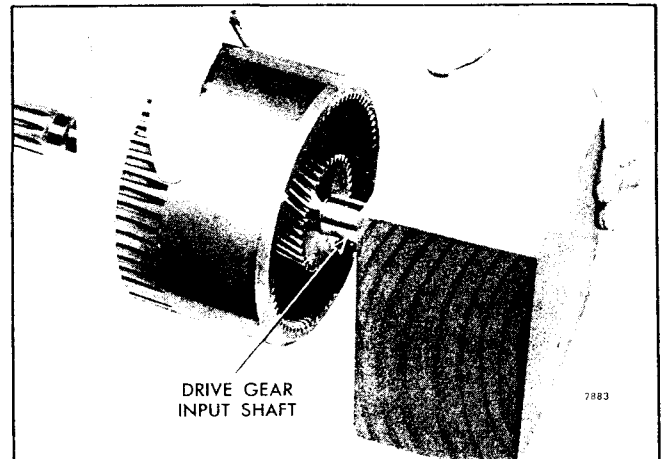


Fig. 67 - Placing Wood Block over End of Drive Gear Shaft

- e. Place the drive gear, forward clutch and ring gear assembly with the wood block on the bed of an arbor press, with the splined end of the drive gear shaft facing up.
- f. Lubricate the drive gear shaft ball bearing with engine oil; then, place the bearing, numbered end up, over the end of the drive gear shaft and start it straight into the bearing bore of the forward clutch piston cylinder.
- g. Place a sleeve over the end of the drive gear shaft and rest it on the inner race of the bearing; then,

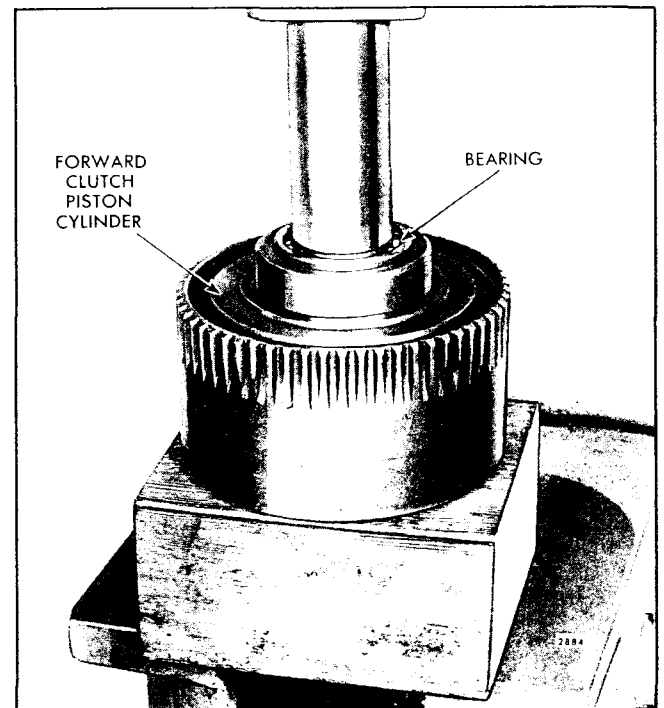


Fig. 68 - Installing Gear Shaft Bearing in Forward Clutch Piston Cylinder

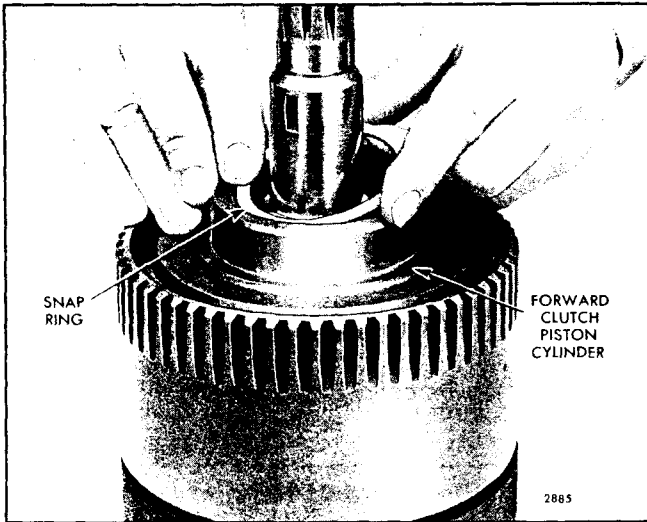


Fig. 69 - Installing Bearing Retaining Snap Ring in Forward Clutch Piston Cylinder

place a steel plate on top of the sleeve and under the ram of the press as shown in Fig. 68. Press the bearing straight into the bore of the forward clutch piston cylinder until it bottoms and the snap ring groove in the bearing bore of the piston cylinder is fully exposed.

- h. Install the snap ring in the groove of the drive gear input shaft next to the bearing inner race with a pair of snap ring pliers J 5586 as shown in Fig. 25.
- i. Install the snap ring in the groove of the forward clutch piston cylinder next to the bearing outer race as shown in Fig. 69.

9. Install the forward clutch and planetary ring gear assembly, reverse clutch plates and reverse clutch pressure plate in the reverse gear housing as follows:

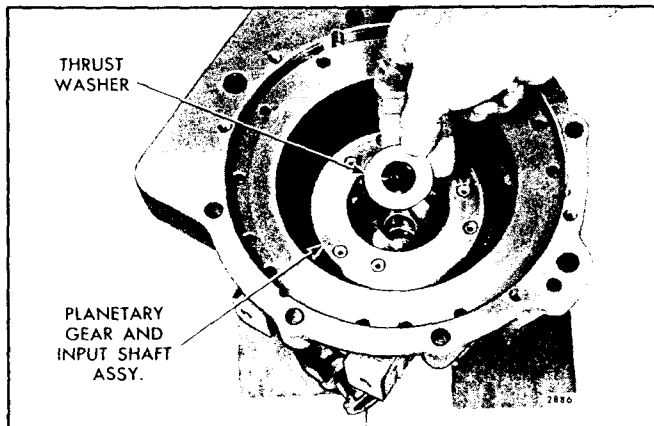


Fig. 70 - Installing Planetary Gear Thrust Washer

- a. With the reverse gear housing still supported on the drive flange or the wood blocks and with the forward face of the gear housing facing up, install the planetary gear thrust washer down inside of the planetary gear as shown in Fig. 70 and center the thrust washer over the drive gear input shaft bore.
- b. Lubricate the small end of the drive gear input shaft with engine oil; then, position the planetary ring gear assembly over the top of the gear housing with the splined end of the drive gear input shaft up as shown in Fig. 71.
- c. Lower the planetary ring gear assembly into the reverse gear housing and enter the end of the drive gear input shaft straight through the thrust washer and into the bushings in the center of the direct drive (output) drive shaft or the reduction gear input shaft. Align the teeth of the drive gear with the teeth of the pinion gears, then lower the assembly until the drive gear rests on the thrust washer.
- d. Install the twelve reverse clutch pressure plate release springs in the holes provided in the reverse clutch cavity as shown in Fig. 23. These holes should be free of foreign matter and the springs firmly seated.
- e. Coat the three dowel pins with grease and install them in the grooves provided in the outside

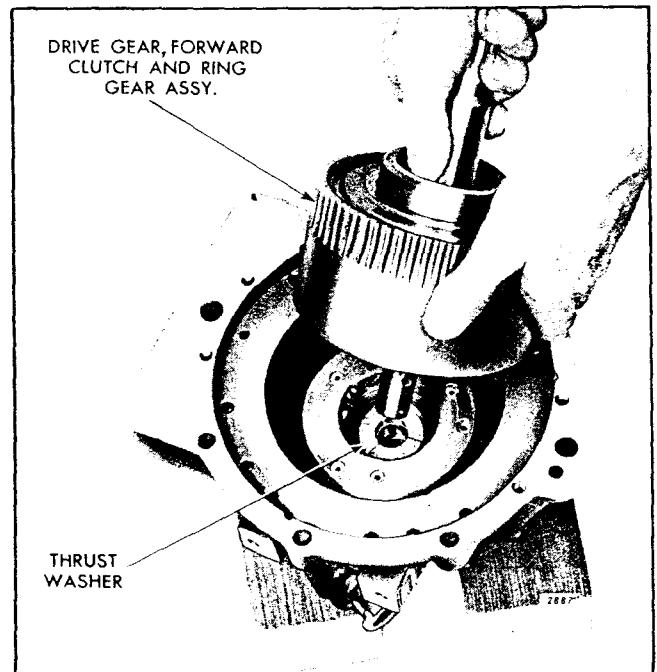


Fig. 71 - Installing Planetary Ring Gear, Forward Clutch and Drive Gear Assembly in Reverse Gear Housing

diameter of the reverse clutch cavity as shown in Fig. 23. The dowel pins must be firmly seated in the grooves.

- f. Place an inner reverse clutch plate down in the reverse clutch cavity of the gear housing with the teeth of the clutch plate in mesh with the splined teeth of the ring gear as shown in Fig. 72. Then place the stationary reverse clutch plate (steel) down over the dowel pins and on the inner clutch plate with the odd shaped lug over the left-hand lower dowel pin as shown in Fig. 73. Place the second reverse clutch plate down on the steel plate with the teeth of the clutch plate in mesh with the splined teeth of the ring gear.

The Model 72 reverse gear assemblies have been revised to incorporate two additional reverse clutch plates, one stationary plate and one with internal teeth, making a total of five reverse clutch plates (Fig. 2). Formerly, the reverse gear assemblies consisted of three reverse clutch plates: one stationary plate and two plates with internal teeth. When installing the reverse clutch plates in the current Model 72 reverse gear, place the two additional reverse clutch plates in the reverse gear housing in the same sequence as the other clutch plates are installed.

- g. Place the reverse clutch pressure plate (with the twelve holes in the plate down) on top of the release springs and over the dowel pins with the

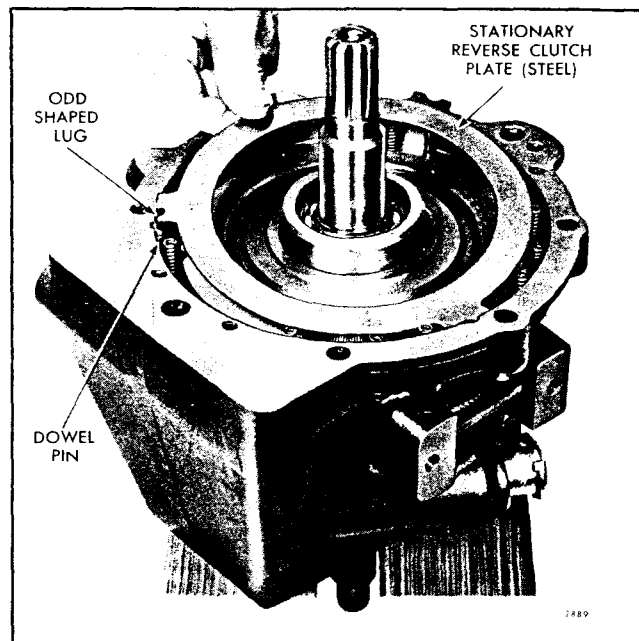


Fig. 73 - Installing Stationary Reverse Clutch Plate (Steel) in Gear Housing

cast slot in the outer rim of the pressure plate in alignment with the large oil hole in the top front face of the reverse gear housing as shown in Fig. 74.

Since the twelve pressure plate release springs are

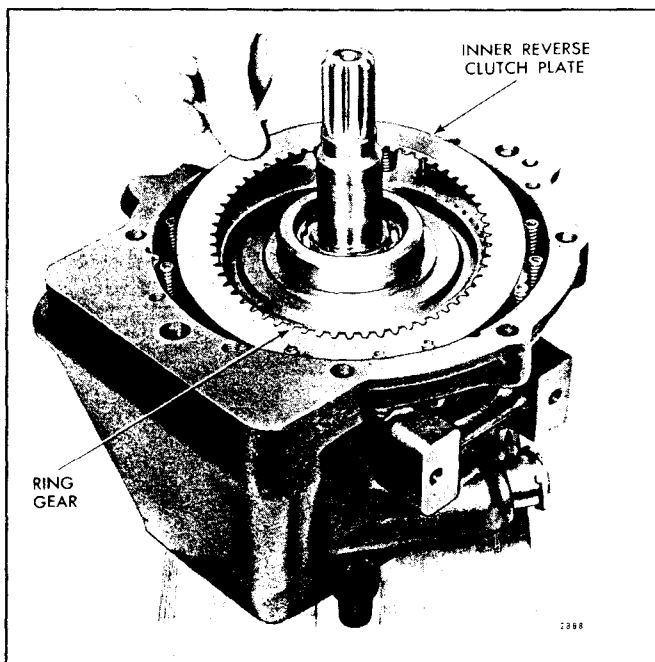


Fig. 72 - Installing Inner Reverse Clutch Plate in Gear Housing

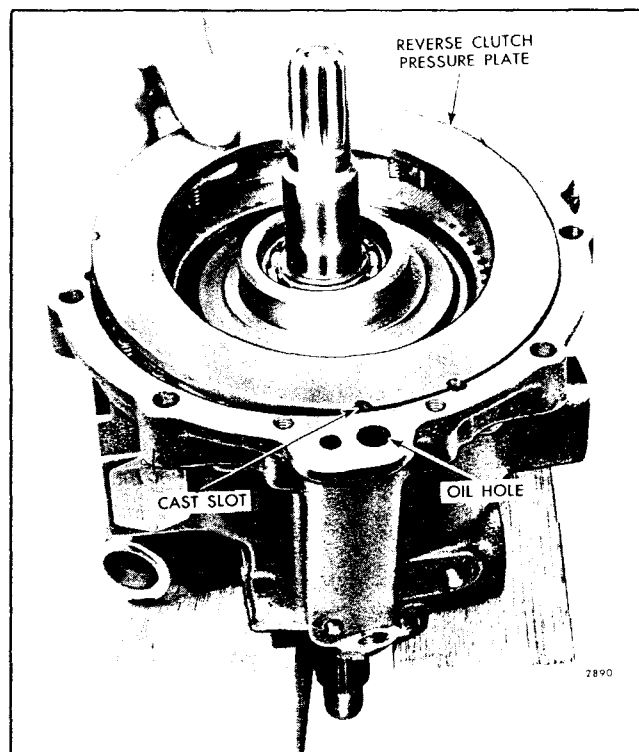


Fig. 74 - Installing Reverse Clutch Pressure Plate in Gear Housing

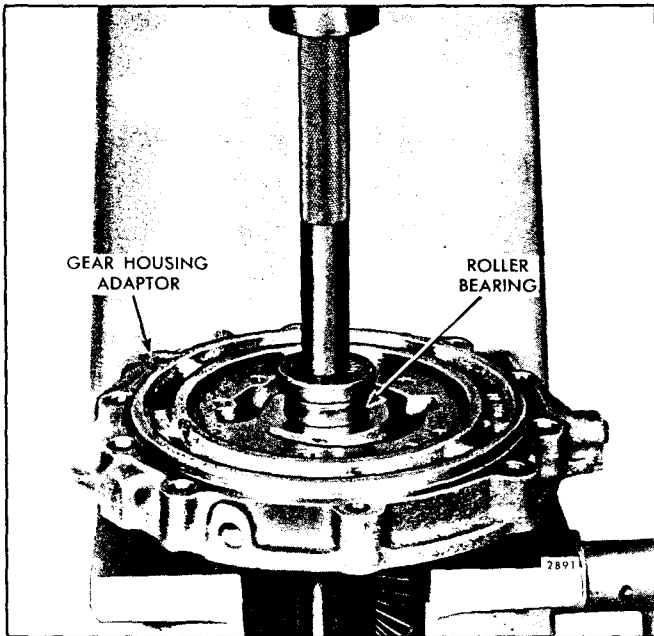


Fig. 75 - Installing Roller (Needle) Bearing in Gear Housing Adaptor

not evenly spaced, it is necessary that the cast slot in the pressure plate and the large oil hole in the gear housing be in alignment in order to properly locate the holes in the pressure plate with the springs in the gear housing.

**NOTE:** If the pressure plate does not go down into position, approximately flush with the front face of the housing, check the three dowel pins and the springs for misalignment.

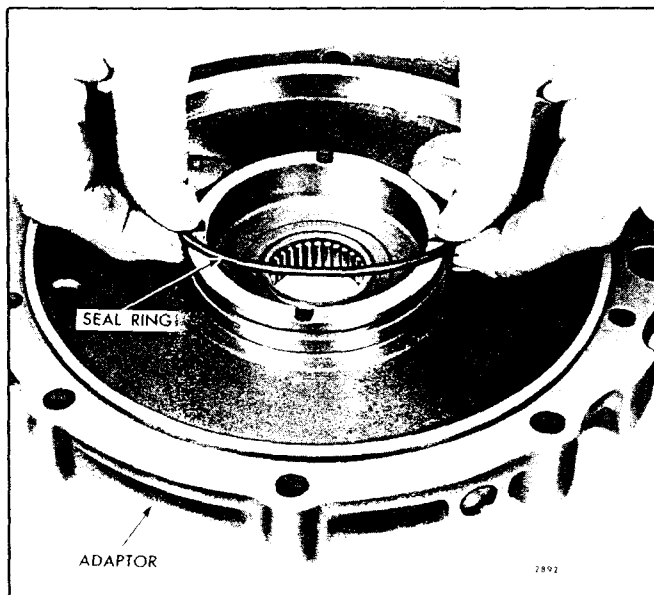


Fig. 76 - Installing Reverse Clutch Piston Seal Ring in Adaptor

10. Install the roller (needle) bearing and the reverse clutch piston in the reverse gear housing adaptor as follows:

- a. Lubricate the outside diameter of the roller (needle) bearing with engine oil; then, start the bearing straight into the bearing bore of the adaptor from the forward face side of the adaptor.
- b. Support the reverse gear housing adaptor with the bearing on the bed of an arbor press, with the rear face of the adaptor down as shown in Fig. 75.
- c. Place the bearing installer J 8561 with handle J 7079-2 in and on top of the bearing, with the end of the handle under the ram of the press as shown in Fig. 75. Then press the bearing straight into the adaptor until the installer J 8561 contacts the face of the adaptor.  
  
A step under the flange of the installer J 8561 properly positions the bearing in the adaptor.
- d. Lubricate the reverse clutch piston inner seal ring with engine oil; then, install the seal ring in the groove in the hub of the gear housing adaptor as shown in Fig. 76.
- e. Lubricate the reverse clutch piston outer seal ring with engine oil and install the seal ring in the groove in the outside diameter of the reverse clutch piston as shown in Fig. 77.
- f. Lubricate the reverse clutch piston inner and outer seal rings with engine oil; then, start the reverse clutch piston with seal ring straight into the bore of the gear housing adaptor, with the flat smooth side of the piston down. Press down on the piston with one hand while pulling a clean screw driver around the exposed portion of the seal ring as

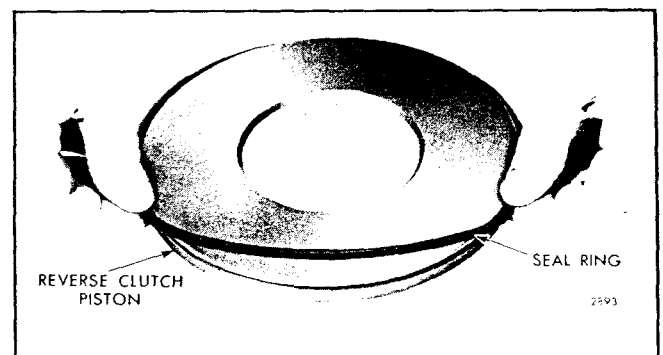


Fig. 77 - Installing Reverse Clutch Piston Seal Ring on Piston

shown in Fig. 78. to aid the chamfered bore in the adaptor to compress the seal ring into the groove of the piston.

Push the assembly straight down in the bore of the adaptor until it bottoms. The exposed face of the reverse clutch piston should be flush with the adjacent surrounding surface of the adaptor when completely assembled.

**CAUTION:** This is a hand assembly and should not be tapped in with a hammer or pressed in with an arbor press.

11. Select the forward clutch piston cylinder thrust washer as outlined below.

The current 1.5:1 and 2.1:1 reverse and reduction gear units use a .061" to .063" thrust washer between the forward clutch piston cylinder and the gear housing adaptor to obtain the proper input shaft end play of .004" to .043". The former and current direct drive, 2.5:1 and 3:1 gears also use a .061" to .063" thrust washer.

In the former 1.5:1 and 2.1:1 reverse and reduction gear units, one of two different thickness thrust washers was used between the forward clutch piston cylinder and the gear housing adaptor to obtain the proper input shaft end play of .004" to .043". They are .061" to .063" and .085" to .087" thick. However, when servicing the former 1.5:1 and 2.1:1 reverse and reduction gear units, use the .061" to .063" thrust washer only to obtain the proper input shaft end play of .004" to .043".

Refer to the record of the input shaft end play when the reverse gear was disassembled to determine if a

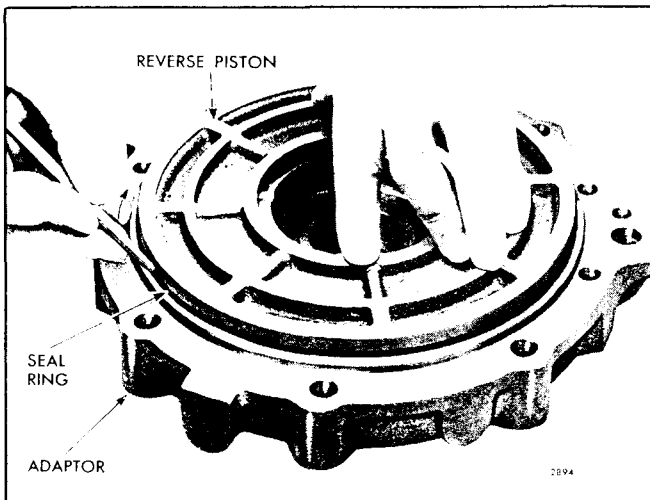


Fig. 78 - Installing Reverse Clutch Piston in Adaptor

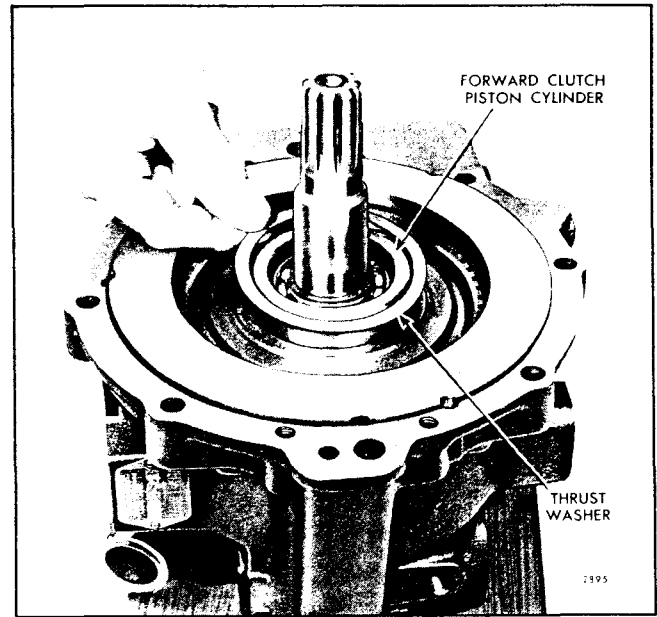


Fig. 79 - Installing Forward Clutch Piston Cylinder Thrust Washer

new forward clutch piston cylinder thrust washer is needed.

Refer to Step 12 below for the installation of the gear housing adaptor and the reverse clutch piston assembly and checking the input shaft end play.

12. Install the reverse gear housing adaptor and reverse clutch piston assembly on the reverse gear housing and check the input shaft end play as follows:

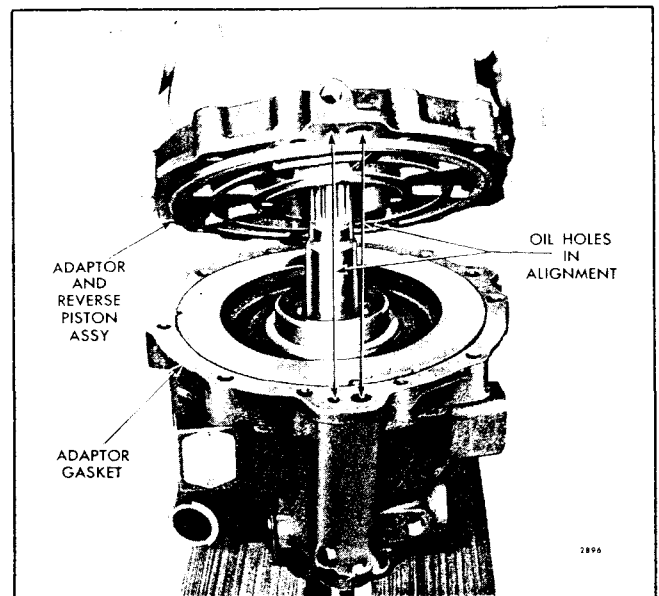


Fig. 80 - Installing Adaptor and Reverse Clutch Piston Assembly on Input Shaft and Gear Housing



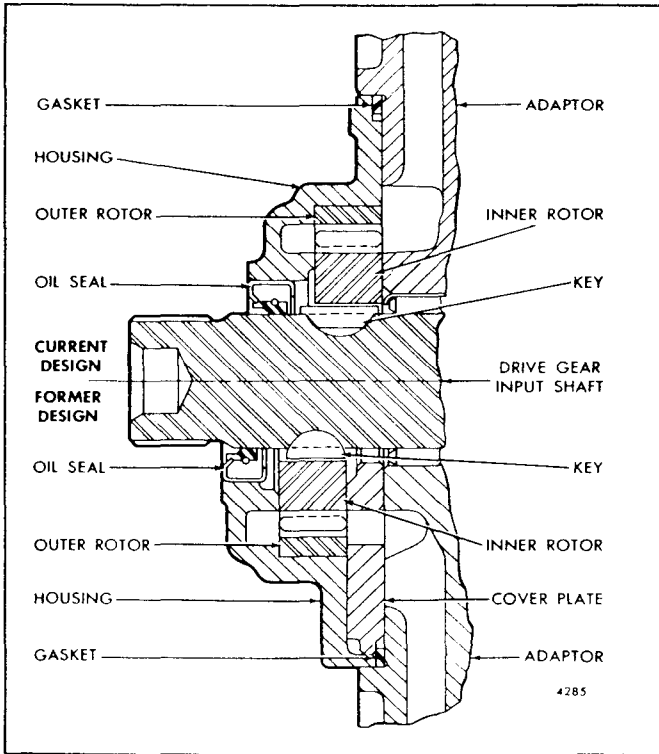


Fig. 81 - Current and Former Marine Gear Oil Pump Assemblies

- a. Refer to Step 11 above for the dimensions of the thrust washers and install a new thrust washer over the hub of the forward clutch piston cylinder as shown in Fig. 79.
- b. Affix a new gear housing adaptor gasket to the bolting flange of the gear housing with the bolt and oil holes in the gasket and the gear housing in alignment as shown in Fig. 80.
- c. Lubricate the rollers (needles) of the bearing in the adaptor with engine oil; then, position the

gear housing adaptor over the top of the drive gear input shaft, with the oil holes in the adaptor in alignment with the oil holes in the gear housing as shown in Fig. 80.

- d. Enter the drive gear input shaft in the roller (needle) bearing, then lower the adaptor assembly over the shaft and rest it on top of the reverse clutch pressure plate.
- e. Install the four bolts in the four counter-sunk bolt holes in the adaptor. Tighten the bolts evenly and draw the pilot on the rear face of the adaptor straight into the mating bore of the reverse gear housing. Tighten the bolts to 28-30 lb-ft torque.

On some marine gear units, five bolts were used to secure the adaptor to the gear housing.

**NOTE:** When drawing the adaptor down, check frequently for any bind by rotating the drive gear input shaft by hand.

- f. Support the reverse gear housing on wood blocks or a bench, with the drive gear input shaft in a horizontal position.
- g. Install a 1/4" -20 x 1-1/2" bolt in one of the selector valve cover bolt holes, or install a 7/16" - 14 x 2" bolt in one of the tapped holes in the side of the reverse gear housing. Tighten the bolt securely.
- h. Attach a dial indicator to the bolt with the indicator button contacting the end of the drive gear input shaft or the reduction gear input shaft as shown in Fig. 19.

**NOTE:** On the direct drive units, the dial indicator must contact the forward end of the

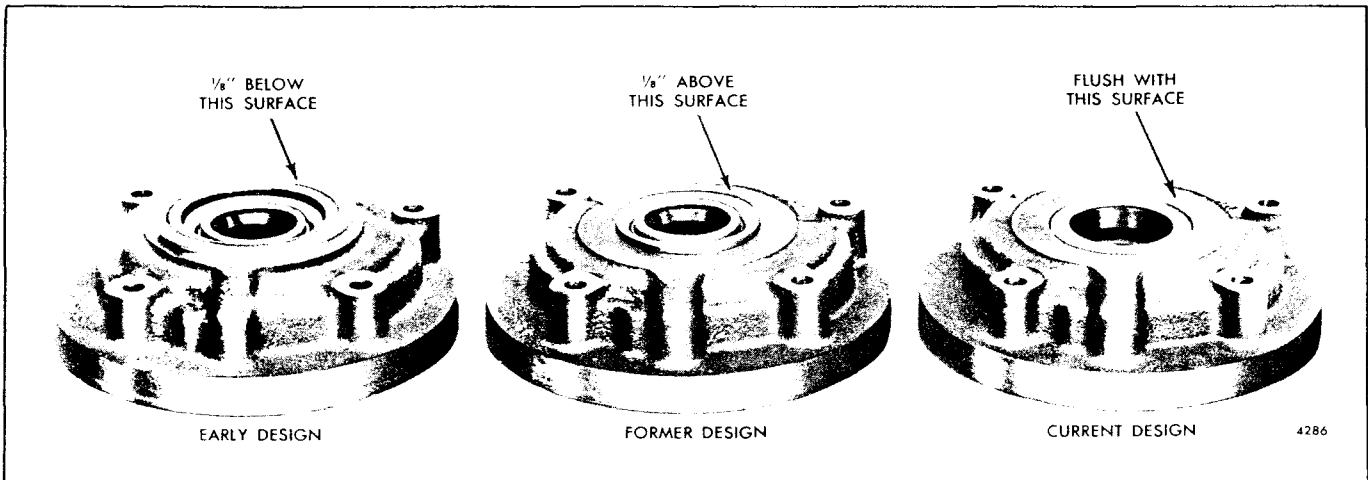


Fig. 82 - Position of Oil Seals Installed in Marine Gear Oil Pump Housings

drive gear input shaft. On the reduction units, the dial indicator may contact the end of either the drive gear input shaft or the reduction gear input shaft.

- i. Move all of the parts inside of the gear housing forward by pulling on the drive gear input shaft. Set the indicator at zero, then move all of the parts back by pushing on the drive gear input shaft and read the indicator.

If the end play is within the limits of .004" to .043", continue with the assembly.

### 13. Assemble the reverse gear oil pump.

A new reverse gear oil pump assembly shown in the upper half of Fig. 81 has replaced the former reverse gear oil pump assembly shown in the lower half of Fig. 81. The current oil pump assembly differs from the former in that the cover plate attached to the rear face of the former oil pump housing has been eliminated and the oil pump housing has been redesigned. The current reverse gear oil pump requires the current double-lip oil seal. The former reverse gear oil pump requires the former single-lip oil seal.

Removal of the oil pump cover plate allows the oil pump assembly to be moved  $9/32$ " toward the rear of the reverse gear.

Moving the oil pump assembly back made it necessary to relocate the oil pump drive key and the keyway in the drive gear input shaft (Fig. 81). The revised drive gear input shaft can be used with either the former or the current oil pump assembly and adaptor. The former drive gear input shaft cannot be used with the current oil pump assembly and adaptor as the oil pump drive key would interfere with the oil pump oil seal.

Refer to the record taken at disassembly or Fig. 82 for the installed seal position in the reverse gear oil pump housing and proceed as follows:

- a. Support the oil pump housing on the bed of an arbor press with the inside face of the housing facing down.
- b. Apply a thin coat of sealing compound to the outside diameter of a new oil seal casing.
- c. Start the oil seal straight into the oil pump housing with the lip of the oil seal facing down.

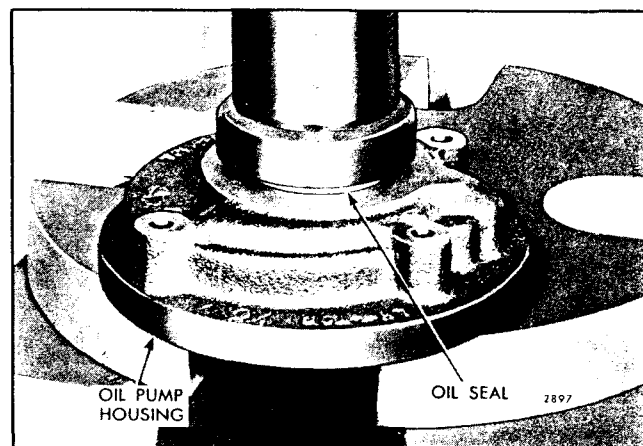


Fig. 83 - Installing Oil Seal in Oil Pump Housing

- d. Place the oil seal installer on top of the oil seal and under the ram of the press as shown in Fig. 83; then, press the oil seal straight into the housing until the flange of the installer contacts the housing.

**NOTE:** If both lips of the current double-lip oil seal do not ride on the shaft, the seal will be ineffective.

Use oil seal installer J 8467 for the oil seal that extends  $1/8$ " above the forward face of the oil pump housing and oil seal installer J 22389 for the oil seal that is flush with the forward face of the housing.

**NOTE:** On the early design oil pump housing, the oil seal was pressed in  $1/8$ " below the outside face of the housing (Fig. 82).

- e. Lubricate the inner and outer rotors (gears) with engine oil, then place the outer rotor (gear) inside of the oil pump housing with the matchmark between two of the rotor teeth facing up.
- f. Place the inner rotor (gear) over the center of the oil pump housing, align the matchmark on the inner rotor with the matchmark on the outer rotor, then lower the inner rotor straight in the mesh with the teeth of the two rotors (gears) in mesh (Fig. 21).
- g. If used, place the oil pump cover plate on top of the rotors and inside the oil pump housing with the plain flat side of the cover facing down and the bolt holes in the cover and housing in

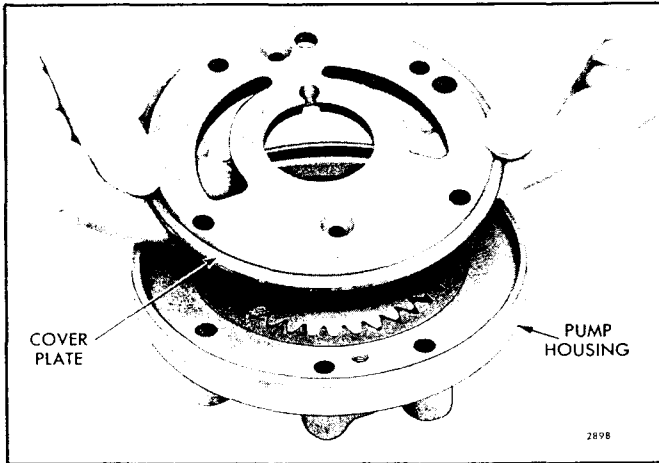


Fig. 84 - Installing Oil Pump Cover Plate on Oil Pump Housing

alignment as shown in Fig. 84. Install the two No. 10-24 x 3/4" flat head screws in the two countersunk holes in the cover plate and tighten them securely.

14. Install the reverse gear oil pump on the drive gear input shaft and the gear housing adaptor as follows:

- a. Install the Woodruff key in the keyway of the drive gear input shaft next to the roller bearing in the gear housing adaptor, then turn the shaft until the key faces the top of the gear housing.
- b. Place the oil pump to gear housing adaptor gasket in the oil pump cavity of the adaptor as shown in Fig. 85.
- c. Support the reverse gear assembly on a bench, with the drive gear input shaft and the reduction

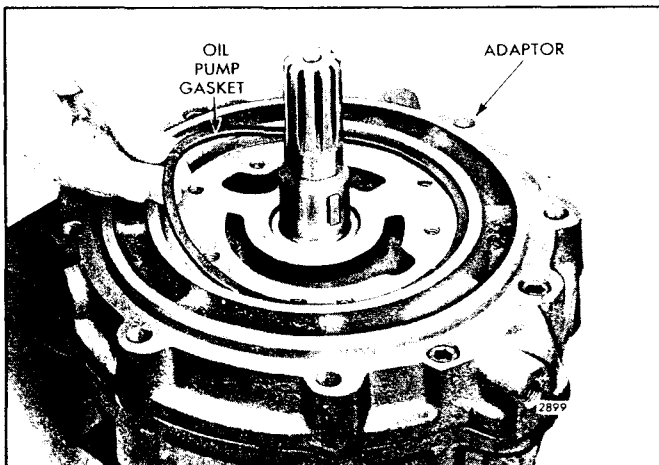


Fig. 85 - Installing Oil Pump Gasket in Adaptor

gear input shaft in a horizontal position and the top side of the reverse gear housing facing up (Fig. 87).

- d. Rotate the oil pump rotors (gears) so the keyway in the inner rotor (gear) is pointed toward the TOP L.H. or TOP R.H. mark (whichever rotation is being used) on the forward face of the oil pump housing.

**NOTE:** Two keyways are present in the inner rotor (gear); it makes no difference which one is used at assembly.

- e. Lubricate the lip of the oil seal with engine oil; then, carefully insert the tapered end of the oil seal lip protector through the oil seal from the forward face of the oil pump housing.

Use oil seal lip protector J 8491 when installing the oil pump assembly on the former drive gear input shaft incorporating 10 splines and oil seal lip protector J 22390 when installing the oil pump assembly on the current drive gear input shaft incorporating 26 splines.

If an oil seal lip protector is not available, place a piece of .005" x 4" x 4" shim stock around the

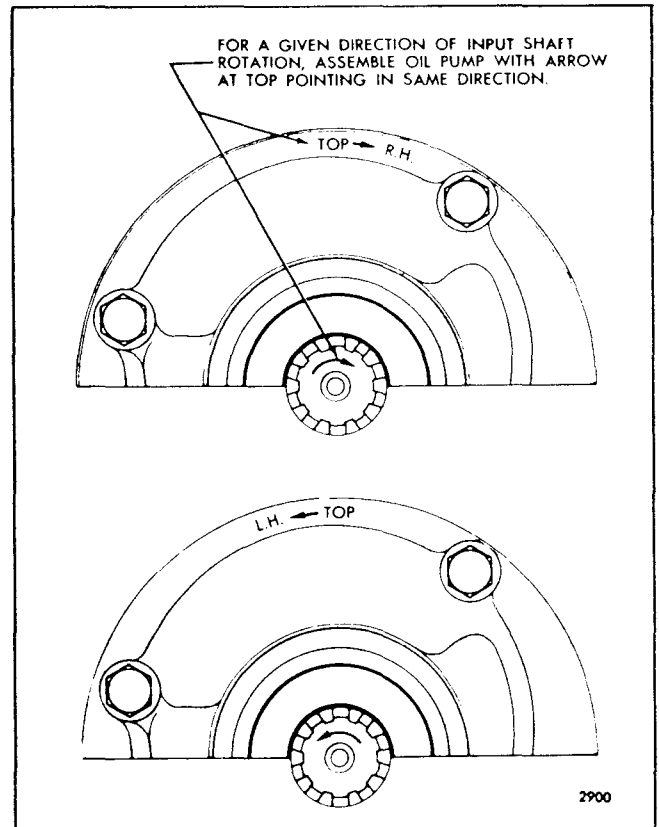


Fig. 86 - Location of Oil Pump Markings in Relationship to Input Shaft Rotation

splines on the end of the drive gear input shaft; then, place a strip of cellulose tape over the seam of the shim stock to protect the lip of the oil seal from being cut or damaged.

- f. Note the markings on the forward face of the oil pump housing which are TOP L.H. and TOP R.H. Then determine the direction the drive gear input shaft will turn when the unit is attached to the engine. With this in mind, position the oil pump assembly with the arrow mark on the forward face of the oil pump housing corresponding with the drive gear input shaft rotation as shown in Fig. 86, and the marks TOP L.H. or TOP R.H. on the oil pump housing (whichever rotation is desired) facing up towards the top side of the gear housing, as viewed from the forward face of the unit.

**NOTE:** The 2.1:1 reverse and reduction gear unit cannot be reversed from right-hand rotation to left-hand rotation by relocating the reverse gear oil pump like the other reverse and reduction gear units. However, if it becomes necessary to change the rotation of the 2.1:1 reverse and reduction gear unit to the opposite hand rotation, it can be accomplished by removing the present reduction gear planetary gear assembly and installing the opposite hand rotating planetary gear assembly and relocating the oil pump assembly to the opposite hand rotation.

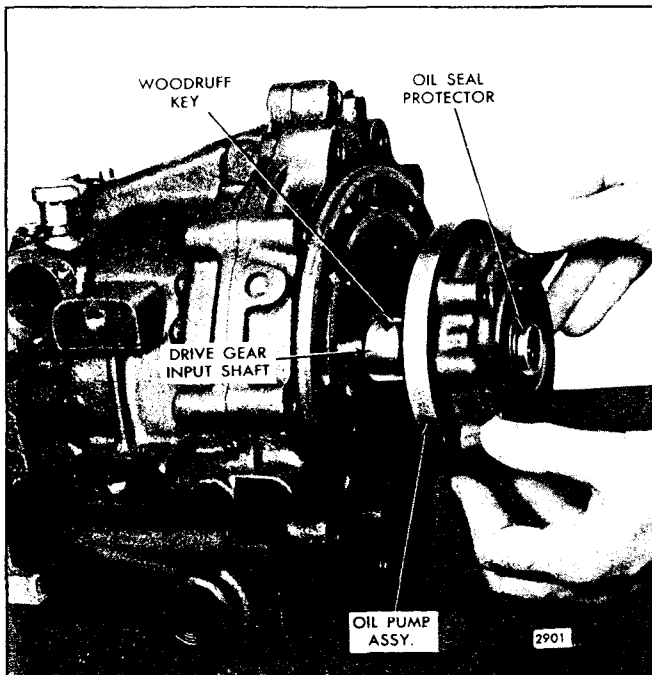


Fig. 87 - Installing Oil Pump Assembly on Input Shaft and Adaptor

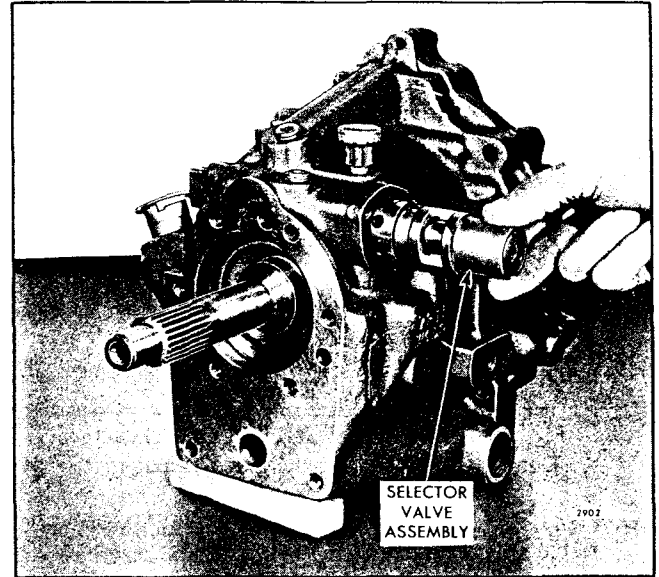


Fig. 88 - Installing Selector Valve Assembly in Gear Housing

- g. Start the oil pump assembly with the oil seal lip protector in place, straight over the end of the shaft as shown in Fig. 87; then, push the oil seal lip protector against the shoulder on the shaft. Push the oil pump assembly in and enter the Woodruff key in the shaft straight in the keyway in the inner rotor (gear); continue to push the oil pump assembly in against the gasket in the counterbore of the adaptor.
- h. Remove the oil seal lip protector from the oil seal and the drive gear shaft.
- i. Rotate the oil pump assembly slightly to the right or left to align the bolt holes, then install the four 5/16" -18 bolts (less lock washers). Tighten the bolts to 13-17 lb-ft torque.
15. Assemble the reverse gear selector valve assembly as follows:
- Lubricate the outside diameter of the pressure regulator valve with engine oil, then insert the valve into the opening in the end of the selector valve with the open end of the pressure regulator valve facing up.
  - Place the pressure regulator valve spring in the pressure regulator valve and push the valve down until it seats inside the selector valve.
  - Place the pressure regulator valve spring retainer on top of the valve spring with the concave side of the retainer on the spring.

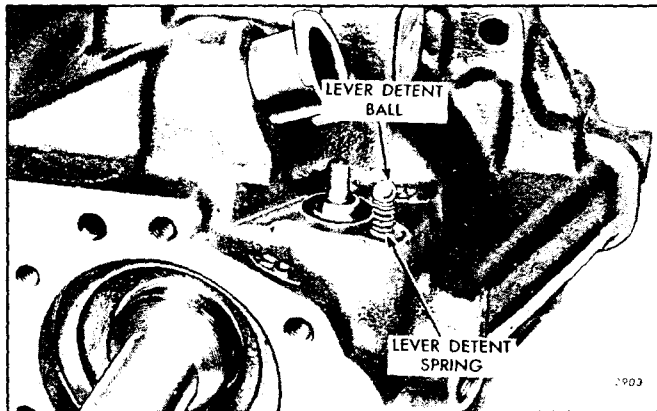


Fig. 89 - Location of Selector Valve Lever Detent Spring and Ball in Gear Housing

**CAUTION:** The valve spring retainer is a very close fit in the bore of the selector valve. Extreme care must be used when pressing the spring retainer down in the bore of the selector valve so as not to allow the edge of the retainer to catch on the top of the bore or the snap ring groove in the selector valve and damage the retainer.

- d. Place the selector valve, pressure regulator valve, valve spring and valve spring retainer assembly in a 1-1/4" inside diameter sleeve and rest it on the bed of an arbor press as shown in Fig. 20.
- e. Place a 3/4" diameter x 2" long round steel rod on top of the valve spring retainer and under the ram of the press (Fig. 20).
- f. Hold the steel rod to keep it from tipping; then, carefully press the valve spring and retainer straight down into the selector valve until the snap ring groove inside of the selector valve is exposed.

- g. While holding the valve spring and retainer down in the selector valve, install the snap ring in the groove inside of the selector valve.
- h. Install a new selector valve seal ring in the groove at the small or threaded end of the selector valve.

16. Install the reverse gear selector valve assembly in the reverse gear housing as follows:

- a. Lubricate the outside diameter of the selector valve and seal ring with engine oil, then insert the small or threaded end of the selector valve in the opening, on the right rear side of the gear housing as shown in Fig. 88, with the flat spot on the shoulder of the selector valve, at the threaded end, facing down toward the bottom of the gear housing. Push the selector valve straight into the gear housing until it contacts the shoulder in the housing.

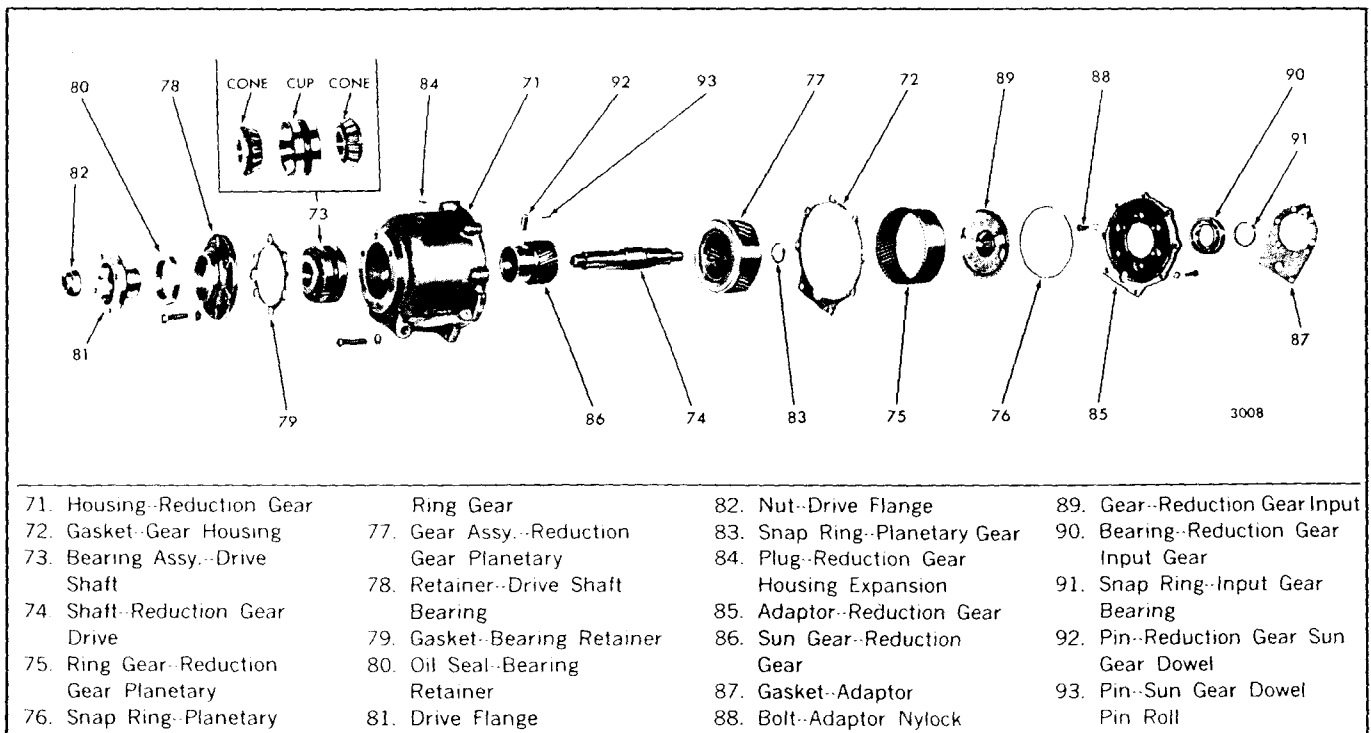


Fig. 90 - Reduction Gear Details and Relative Location of Parts (1.5:1 Ratio)

- b. Affix a new gasket to the rear face of the selector valve cover.
- c. Place the selector valve cover and gasket over the selector valve opening in the gear housing and install the three 1/4"-20 bolts and lock washers. Tighten the bolts to 7-9 lb-ft torque.
- d. Turn the reverse gear housing assembly on its side so the selector valve will be in a vertical position with the threaded end of the selector valve facing up.
- e. Place the selector valve lever detent spring in the drilled hole in the gear housing just above the threaded end of the selector valve (Fig. 89).
- f. Place the 5/16" steel ball on top of the selector valve lever detent spring (Fig. 89).
- g. Place the selector valve lever over the end of the selector valve with the flat portion in the large hole of the lever over the flat on the end of the selector valve and against the steel ball. Then install a flat washer, lock washer and nut. Tighten the nut to 12-16 lb-ft torque.

17. Insert the tapered end of the lubricating oil strainer assembly in the opening in the lower right-hand side of the gear housing (Fig. 43); then, install the reducing bushing, oil return tube, nipple and elbow assembly (current marine gears), or install the annular gasket and oil drain plug (former marine gears) and tighten securely.

18. If removed, install the breather assembly, pipe plugs and lubricating oil fitting in the reverse gear housing.

#### Assemble Reduction Gear

The assembly procedure for the various reduction gears will vary depending upon the ratio. The assembly procedure for the 1.5:1 ratio reduction gear is covered separately. Due to the close similarity of the 2.1:1, 2.5:1 and 3:1 ratio reduction gears, the assembly procedure for these gears will be covered as a single procedure and the differences noted therein.

With the reduction gear parts cleaned and inspected and the necessary parts on hand, the reduction gear may be assembled as outlined below.

Assemble 1.5:1 Ratio Reduction Gear - Refer to Figs. 4 and 90 for the location of various parts and assemble as follows:

1. Install the ring gear (75), adaptor (85) and bearing (90) on the reduction gear input gear (89) and attach

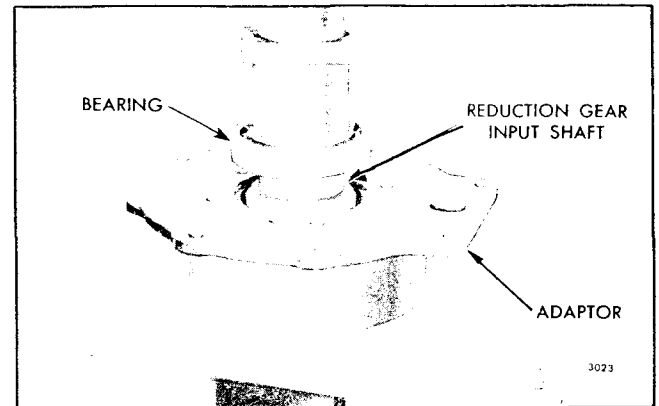


Fig. 91 - Installing Reduction Gear Input Gear Bearing on Input Gear (1.5:1 Ratio)

the reduction gear adaptor assembly to the reverse gear housing as follows:

- a. Place the reduction gear planetary ring gear on a bench with the end which incorporates a snap ring groove in the inside diameter facing up.
- b. Position the reduction gear input gear over the top of the planetary ring gear. Align the splines in the flange of the input gear with the splines inside the ring gear; then, lower the input gear straight in the ring gear until it seats on the shoulder in the ring gear.
- c. Install the snap ring in the groove in the ring gear.
- d. Place the reduction gear adaptor over the hub of the input gear with the forward face (flat surface) facing up and rest it on the input gear.
- e. Lubricate the inside diameter of the reduction gear input gear bearing with engine oil; then, start the bearing, numbered end up, straight on the hub of the input gear.
- f. Place the bearing, adaptor, input gear and ring gear assembly, bearing side up, on the bed of an arbor press.
- g. Place a sleeve on the inner race of the bearing and a steel plate on top of the sleeve as shown in Fig. 91. Then press the bearing straight on the hub of the input gear and against the shoulder on the gear.
- h. Install the snap ring in the ring groove in the hub of the input gear with a pair of snap ring pliers J 5586 as shown in Fig. 39. Be sure the snap ring is fully seated in the groove.
- i. Affix a new gasket to the forward face of the adaptor with the bolt and oil holes in alignment.

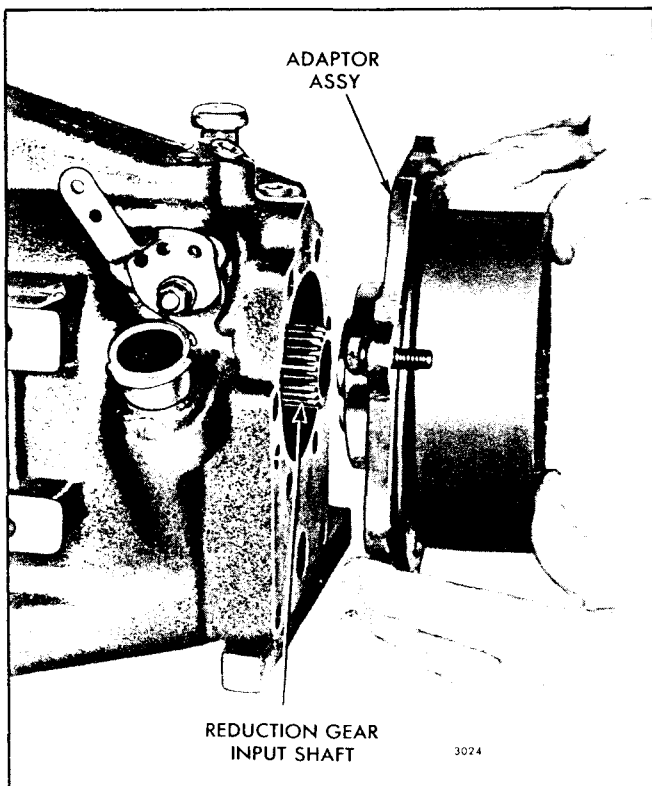


Fig. 92 - Installing Reduction Gear Adaptor, Input Gear, Ring Gear and Bearing Assembly to Reverse Gear Housing (1.5:1 Ratio)

- j. On the reverse gear assembly incorporating the oil filler tube, install a 3/8" -16 reduction gear housing adaptor to gear housing bolt and lock washer in the bolt hole of the adaptor adjacent to the oil filler tube (Fig. 92).
- k. Lubricate the outside diameter of the reduction gear input gear bearing with engine oil; then, start the hub of the input gear straight on the end of the reduction gear input shaft as shown in Fig. 92 with the splines of the gear and shaft in alignment. Push the assembly straight forward on the input shaft and enter the bearing straight into the bearing bore in the reverse gear housing, then continue to push the assembly forward until the bearing seats on the shoulder in the gear housing.  
  
If necessary, tap the input gear bearing in the gear housing by tapping on the rear face of the input gear with a plastic hammer.
- l. Raise the adaptor slightly and enter the counterbore of the adaptor straight over the rear face of the bearing. Align the bolt holes in the adaptor with the bolt holes in the gear housing, then push the adaptor against the reverse gear housing.

m. Install six new 7/16" -14 Nylock bolts and lock washers with external teeth in the six countersunk bolt holes in the adaptor through the two access holes in the flange of the input gear as shown in Fig. 14. Tighten the bolts to 46-50 lb-ft torque.

2. Install the reduction gear sun gear in the reduction gear housing as follows:

- a. Place the reduction gear housing on a bench with the forward face of the gear housing facing up.
- b. Insert the sun gear dowel pin in the dowel pin hole in the gear housing with the roll pin hole in the dowel pin towards the outside of the gear housing and in alignment with the roll pin hole in the gear housing as shown in Fig. 93.
- c. Lubricate the outside diameter of the sun gear hub, where it makes contact with the reduction gear housing, with engine oil.
- d. Start the hub of the sun gear straight into the bore of the reduction gear housing with the dowel pin hole in the side of the hub in alignment with the dowel pin as shown in Fig. 93. Lower the sun gear until the hole in the hub of the sun gear is in alignment with the dowel pin, then push the dowel pin in until the roll pin hole in the dowel pin is in alignment with the roll pin hole in the gear housing.
- e. Start the roll pin in the roll pin hole in the gear housing; then, drive the roll pin down into the dowel pin, until it is flush with the face of the gear housing, with a punch and hammer.

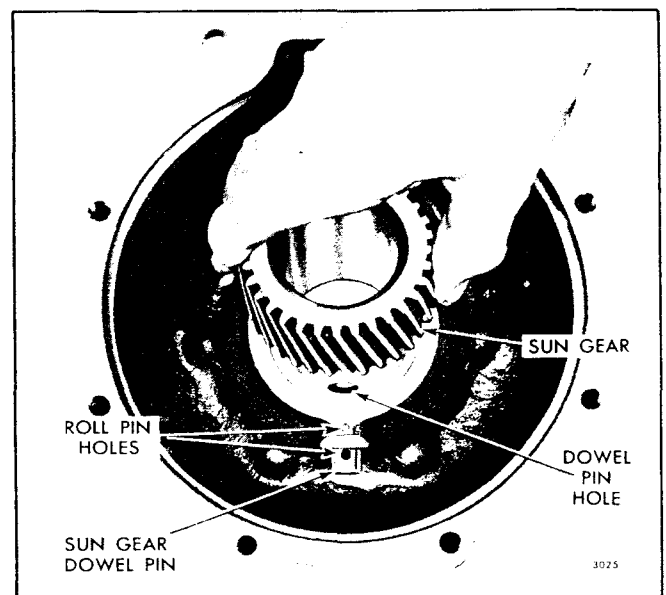


Fig. 93 - Installing Sun Gear in Reduction Gear Housing (1.5:1 Ratio)

3. Install the reduction gear drive shaft bearing in the reduction gear housing as follows:

- a. Note the matchmarks previously placed on the reduction gear drive shaft bearing cone and cup at disassembly.

**CAUTION:** When installing the same bearing that was removed from the reduction gear housing, it must be installed in its original position.

- b. Lubricate the rollers of the inner bearing cone with engine oil, then place the inner bearing cone down in the bearing bore in the rear face of the reduction gear housing with the (tapered) small outside diameter of the cone facing up (Fig. 94).
- c. Lubricate the outside diameter of the bearing cup with engine oil, then start it straight into the bearing bore of the reduction gear housing, with the matchmarked inner cone side of the cup facing down.
- d. Support the forward face of the reduction gear housing on the bed of an arbor press. Place a steel plate on top of the bearing cup and under the ram of the press as shown in Fig. 95. Then press the bearing cup straight into the gear housing until it seats on the shoulder in the housing.
- e. Lubricate the rollers of the outer bearing cone with engine oil, then place it down in the bearing cup with the (tapered) small outside diameter of the cone facing down.

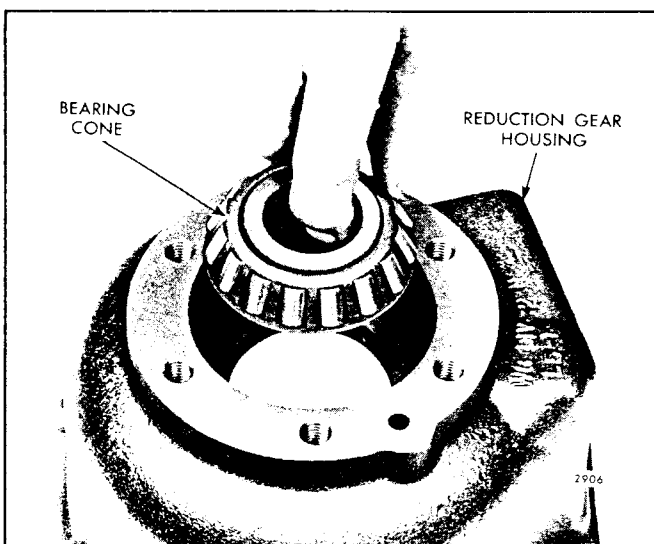


Fig. 94 - Installing Reduction Gear Drive Shaft Inner Bearing Cone in Gear Housing

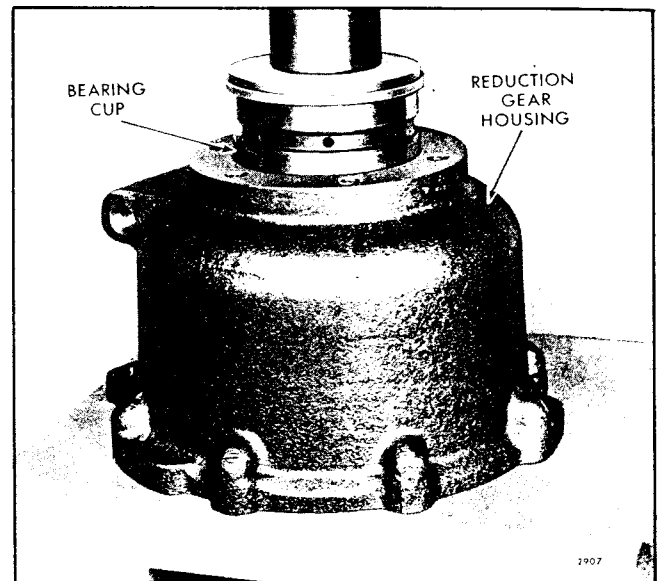


Fig. 95 - Installing Reduction Gear Drive Shaft Bearing Cup in Gear Housing

4. Install a new double-lip oil seal in the reduction gear drive shaft bearing retainer as follows:

**NOTE:** The current reduction gear includes a double-lip oil seal; the former reduction gear used a single-lip oil seal. Only the double-lip oil seal is serviced.

- a. Apply a thin coat of sealing compound to the outside diameter of the bearing retainer oil seal casing.
- b. Start the oil seal straight into the bore of the bearing retainer, from the rear face, with the lip of the oil seal facing down.
- c. Support the bearing retainer and oil seal on the bed of an arbor press, with the rear face of the retainer and oil seal facing up.
- d. Place a steel plate, or tool J 3154-04 with suitable plates, on top of the oil seal as shown in Fig. 96. Then press the oil seal straight into and flush with the outside face of the bearing retainer.

**NOTE:** If both lips of the double-lip oil seal do not ride on the drive flange, the seal will be ineffective.

5. Attach the reduction gear drive shaft bearing retainer and oil seal assembly to the reduction gear housing as follows:

- a. Affix a new gasket to the rear face of the reduction gear housing, with the notch in the inner diameter



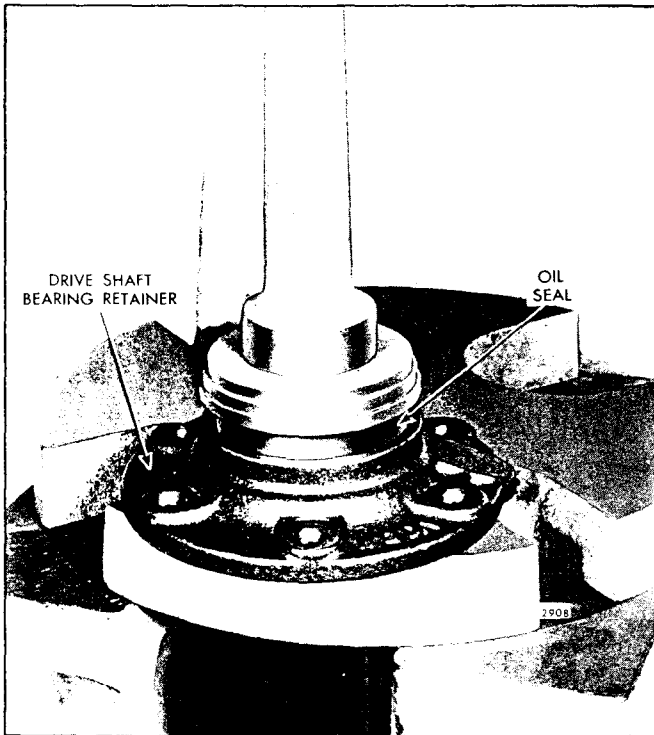


Fig. 96 - Installing Oil Seal in Drive Shaft Bearing Retainer

of the gasket over the oil hole and the bolt holes in the gasket and gear housing in alignment as shown in Fig. 97.

- b. Place the bearing retainer straight over the bearing and gasket with the oil drain notch in the retainer directly over the oil hole in the gear housing, and the bolt holes in the retainer and gear housing in alignment as shown in Fig. 97.
- c. Install the six 7/16" -14 bolts and lock washers. Tighten the bolts to 46-50 lb-ft torque.

6. Install the reduction gear drive shaft in the reduction gear housing as follows:

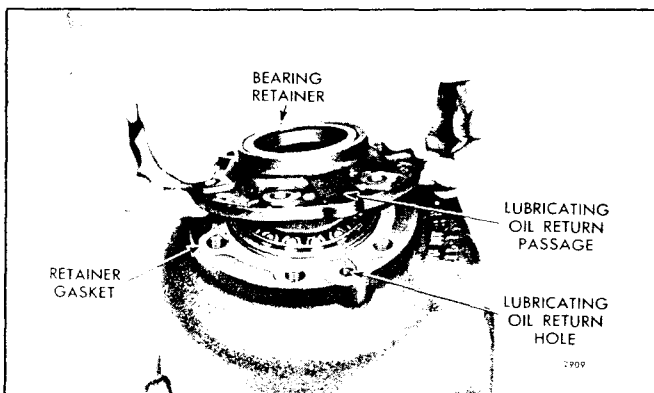


Fig. 97 - Installing Drive Shaft Bearing Retainer on Gear Housing

- a. Lubricate the bearing contact surface of the reduction gear drive shaft with engine oil; then, insert the drive flange end (threaded end) of the drive shaft straight through the sun gear and the drive shaft bearing from the forward face of the gear housing as shown in Fig. 98.

- b. Lubricate the splines of the drive shaft and the lip of the oil seal with engine oil. Start the drive flange straight over the splines of the drive shaft; then, while holding the drive shaft, push the drive flange tight against the bearing.

If necessary, tap the drive flange on the drive shaft and against the bearing with a plastic hammer.

- c. Install the drive flange retaining nut on the drive shaft. Do not tighten it at this time.

7. Install the reduction gear planetary gear assembly on the drive shaft and sun gear as follows:

- a. Support the reduction gear housing and drive shaft assembly on a bench with the forward face of gear housing facing up.

- b. Lubricate the splines on the forward end of the drive shaft and the pinions of the planetary gear assembly with engine oil; then, start the planetary gear assembly over the forward end of the drive shaft and sun gear as shown in Fig. 36, with the splines in the hub of the planetary gear and the splines of the drive shaft in alignment. Lower the planetary gear assembly on the drive shaft and engage the pinions of the gear assembly with the teeth of the sun gear, then lower the assembly until the snap ring groove in the end of the drive shaft is fully exposed.

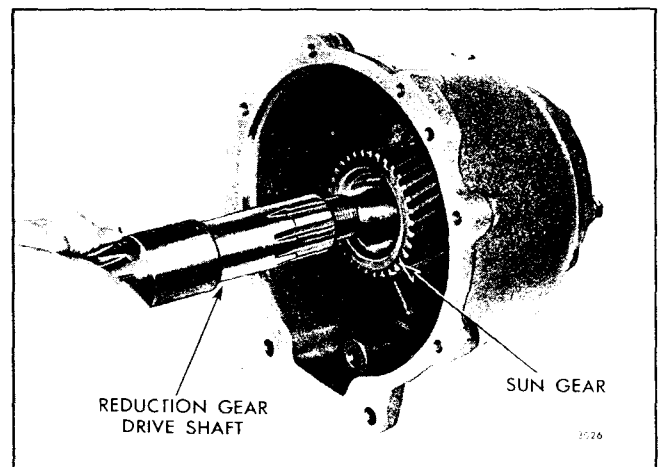


Fig. 98 - Installing Reduction Gear Drive Shaft in Sun Gear and Bearing (1.5:1 Ratio)

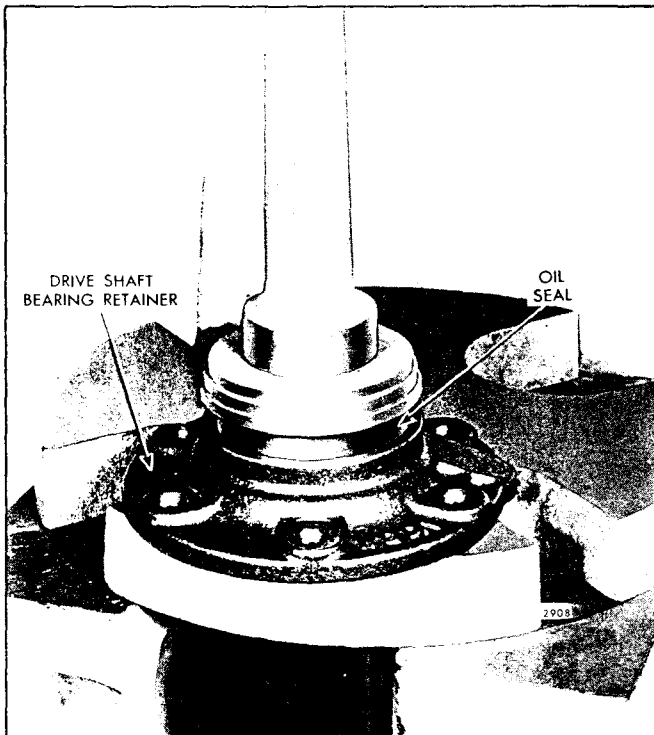


Fig. 96 - Installing Oil Seal in Drive Shaft Bearing Retainer

of the gasket over the oil hole and the bolt holes in the gasket and gear housing in alignment as shown in Fig. 97.

- b. Place the bearing retainer straight over the bearing and gasket with the oil drain notch in the retainer directly over the oil hole in the gear housing, and the bolt holes in the retainer and gear housing in alignment as shown in Fig. 97.
  - c. Install the six 7/16" -14 bolts and lock washers. Tighten the bolts to 46-50 lb-ft torque.
6. Install the reduction gear drive shaft in the reduction gear housing as follows:

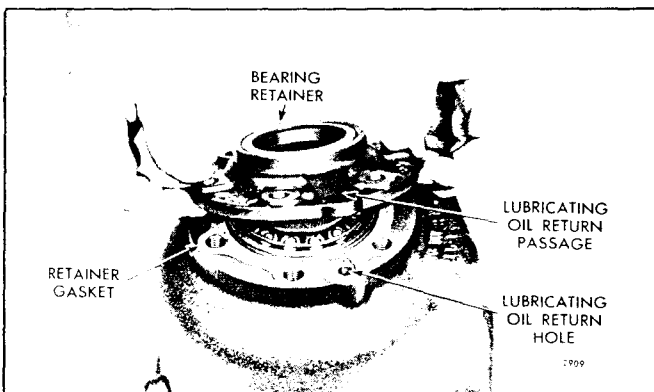


Fig. 97 - Installing Drive Shaft Bearing Retainer on Gear Housing

- a. Lubricate the bearing contact surface of the reduction gear drive shaft with engine oil; then, insert the drive flange end (threaded end) of the drive shaft straight through the sun gear and the drive shaft bearing from the forward face of the gear housing as shown in Fig. 98.
- b. Lubricate the splines of the drive shaft and the lip of the oil seal with engine oil. Start the drive flange straight over the splines of the drive shaft; then, while holding the drive shaft, push the drive flange tight against the bearing.  
  
If necessary, tap the drive flange on the drive shaft and against the bearing with a plastic hammer.
- c. Install the drive flange retaining nut on the drive shaft. Do not tighten it at this time.

7. Install the reduction gear planetary gear assembly on the drive shaft and sun gear as follows:

- a. Support the reduction gear housing and drive shaft assembly on a bench with the forward face of gear housing facing up.
- b. Lubricate the splines on the forward end of the drive shaft and the pinions of the planetary gear assembly with engine oil; then, start the planetary gear assembly over the forward end of the drive shaft and sun gear as shown in Fig. 36, with the splines in the hub of the planetary gear and the splines of the drive shaft in alignment. Lower the planetary gear assembly on the drive shaft and engage the pinions of the gear assembly with the teeth of the sun gear, then lower the assembly until the snap ring groove in the end of the drive shaft is fully exposed.

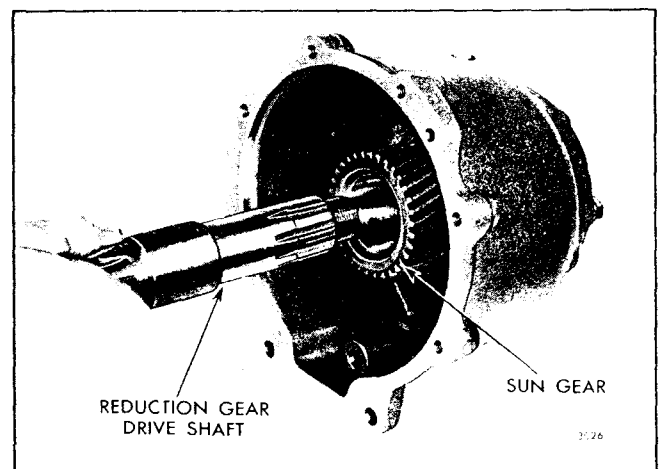


Fig. 98 - Installing Reduction Gear Drive Shaft in Sun Gear and Bearing (1.5:1 Ratio)

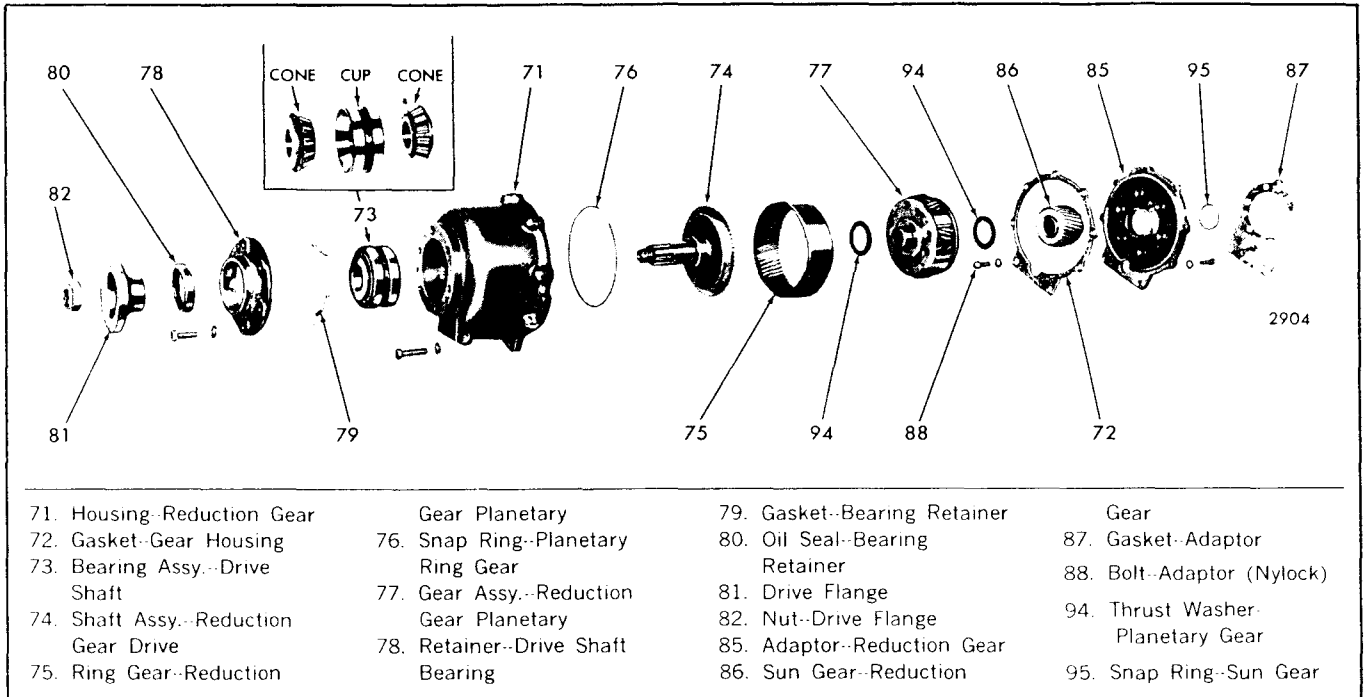


Fig. 99 - Reduction Gear Details and Relative Location of Parts (2.1:1 Ratio)

c. Install the snap ring in the ring groove in the drive shaft, next to the hub of the planetary gear assembly, with a pair of snap ring pliers J 5586 as shown in Fig. 35.

the various parts and assemble them as follows:

1. On the 2.1:1 ratio reduction gear, install the sun gear (86) in reduction gear adaptor (85) as follows:

Assemble 2.1:1, 2.5:1 and 3:1 Ratio Reduction Gears - Refer to Figs. 1, 2, 5, 99 and 100 for the location of

a. Place the reduction gear adaptor on a bench with the rear face of the adaptor facing up.

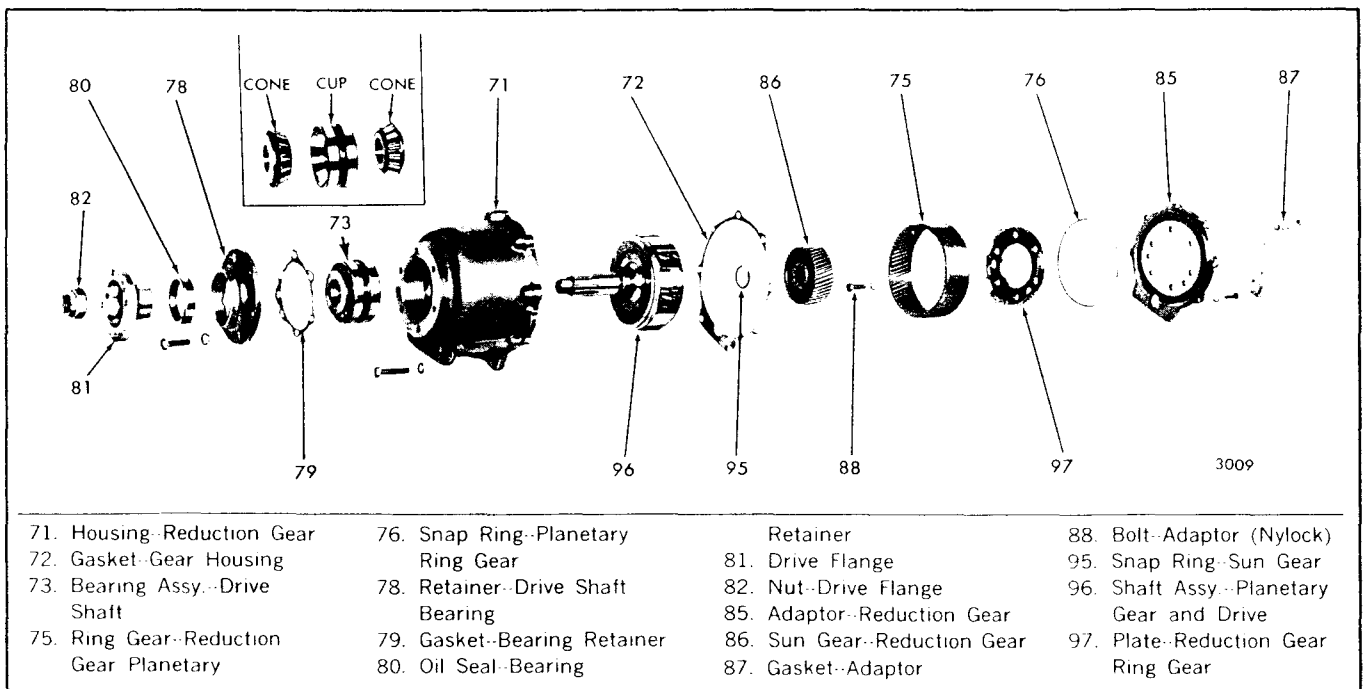


Fig. 100 - Reduction Gear Details and Relative Location of Parts (2.5:1 and 3:1 Ratios)

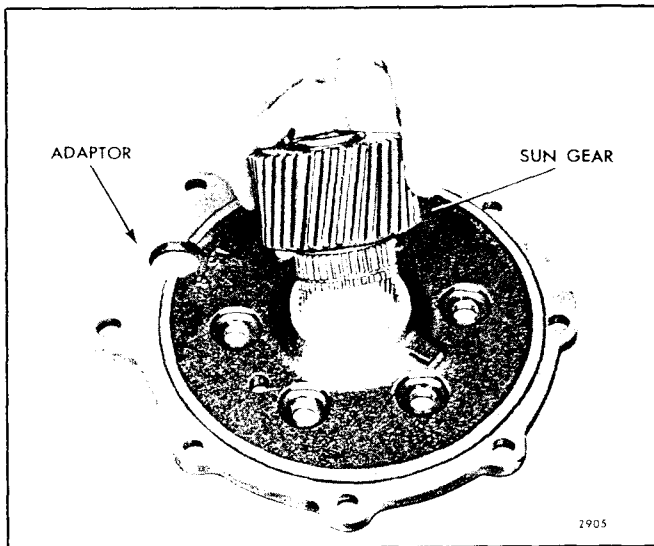


Fig. 101 - Installing Sun Gear in Reduction Gear Adaptor (2.1:1 Ratio)

- b. Insert the splined end of the sun gear straight in the hub of the adaptor as shown in Fig. 101 until it seats against the shoulder of the adaptor.
  - c. Turn the adaptor and sun gear assembly over and rest the rear face of the sun gear on the bench.
  - d. Install the snap ring in the groove in the splined end of the sun gear with a pair of snap ring pliers J 5586 as shown in Fig. 42.
2. On the 2.5:1 and 3:1 ratio reduction gears, install the reduction gear planetary ring gear plate (97) in the planetary ring gear (75) and the planetary ring gear plate in the reduction gear adaptor (85) as follows:
    - a. Place the reduction gear planetary ring gear on a bench with the end incorporating the ring groove in its inside diameter facing up.
    - b. Position the planetary ring gear plate over the top of the planetary ring gear. Align the splines in the outside diameter of the ring gear plate with the splines inside of the ring gear, then lower the plate straight in the ring gear as shown in Fig. 102 until it seats on the shoulder in the ring gear.
    - c. Install the snap ring in the ring groove in the ring gear, just above the ring gear plate.
    - d. Lubricate the inside diameter of the reduction gear adaptor with engine oil, then place the adaptor on a bench with the forward face (flat surface) facing down.
    - e. Position the planetary ring gear plate and ring

gear assembly over the top of the adaptor. Align the bolt and oil holes in the ring gear plate with the holes in the adaptor, then start the ring gear plate straight into the bore of the adaptor and push the ring gear plate down until it seats on the adaptor.

Due to the close fit, it may be necessary to tap the ring gear plate lightly at several places with a plastic hammer after it has been started in the adaptor.

3. Attach the reduction gear adaptor assembly to the reverse gear housing on the 2.1:1, 2.5:1 and 3:1 ratio reduction gears as follows:

- a. Affix a new gasket to the forward face of the adaptor with the bolt and oil holes in the gasket and the adaptor in alignment.

**CAUTION:** On the 2:1 ratio reduction gear, the lubrication of the reduction gear planetary gear assembly originates from the oil hole in the upper portion of the reverse gear housing rear face. If the small oil hole in the adaptor is plugged by improper gasket installation, failure of the planetary gear assembly will result.

- b. On the reverse gear assembly incorporating the oil filler tube, install a 3/8" -16 reduction gear housing adaptor to gear housing bolt and lock washer in the bolt hole of the adaptor adjacent to the oil filler tube (Fig. 16).
- c. On the 2.1:1 ratio reduction gear, place the adaptor and sun gear assembly over the end of the reduction gear input shaft as shown in Fig. 16

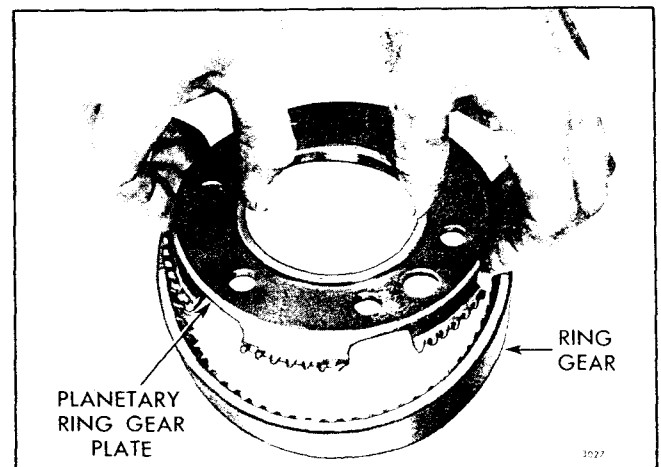


Fig. 102 - Installing Reduction Gear Planetary Ring Gear Plate in Ring Gear (2.5:1 and 3:1 Ratios)

and enter the flange on the forward face of the adaptor straight into the counterbore of the gear housing. Then push the adaptor up against the gear housing.

On the 2.5:1 and 3:1 ratio reduction gears, place the reduction gear adaptor, planetary ring gear plate and ring gear assembly over the end of the reduction gear input shaft in the same manner as shown in Fig. 18. Start the adaptor straight over the reduction gear input shaft bearing and push it up against the gear housing.

- d. Align the bolt holes and install six new 7/16" -14 Nylock bolts and lock washers with external teeth in the six countersunk bolt holes. Tighten the bolts to 46-50 lb-ft torque.

4. On the 2.5:1 and 3:1 ratio reduction gears, install the reduction gear sun gear on the reduction gear input shaft as follows:

- a. Lubricate the splines of the reduction gear input shaft with engine oil. Then start the sun gear straight on the input shaft with the splines in the hub of the sun gear and the splines on the input shaft in alignment. Push the sun gear on the input shaft until the snap ring groove in the input shaft is fully exposed.

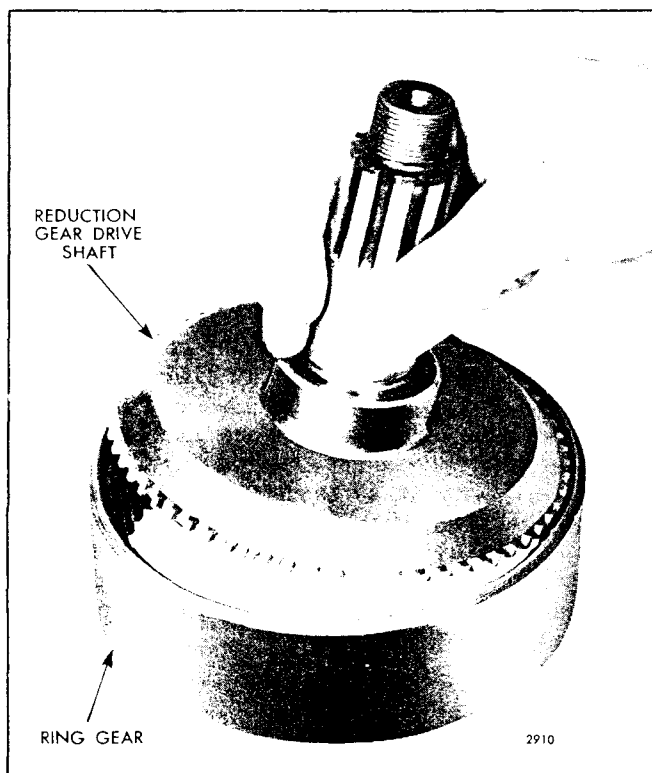


Fig. 103 - Installing Reduction Gear Drive Shaft in Ring Gear (2.1:1 Ratio)

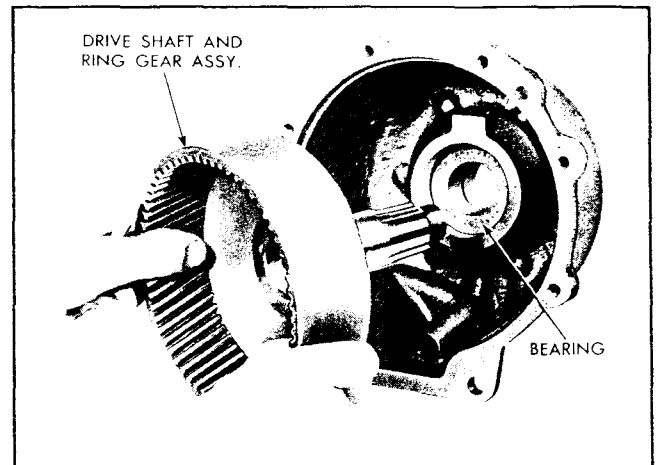


Fig. 104 - Installing Reduction Gear Drive Shaft and Ring Gear Assembly in Gear Housing (2.1:1 Ratio)

- b. Install the snap ring in the ring groove in the reduction gear input shaft, next to the sun gear, with a pair of snap ring pliers J 5586 as shown in Fig. 17.

5. Perform Steps 3, 4 and 5 under *Assemble 1.5:1 Ratio Reduction Gear* above, then proceed with Step 6 below.

6. On the 2.1:1 ratio reduction gear, install the reduction gear drive shaft in the reduction gear planetary ring gear as follows:

- a. Place the planetary ring gear on a bench with the end incorporating the ring groove in the inside diameter facing up.
- b. Position the reduction gear drive shaft over the top of the planetary ring gear. Align the splines in the flange of the drive shaft with the splines inside of the ring gear, then lower the drive shaft straight in the ring gear as shown in Fig. 103 until it seats on the shoulder in the ring gear.
- c. Install the snap ring in the ring groove just above the reduction gear drive shaft flange.

7. Install the reduction gear drive shaft and ring gear assembly or the reduction gear drive shaft and planetary gear assembly in the reduction gear housing as follows:

- a. Place the reduction gear housing on its side on a bench. Lubricate the outside diameter of the reduction gear drive shaft and ring gear assembly

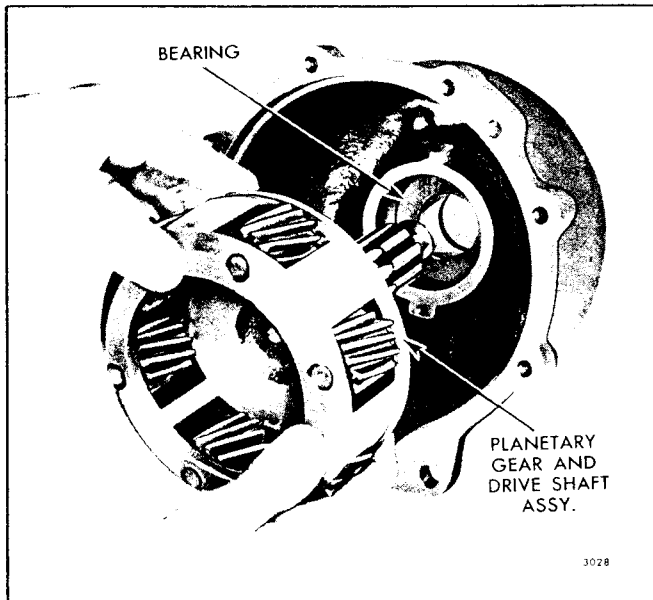


Fig. 105 - Installing Reduction Gear Drive Shaft and Planetary Gear Assembly in Gear Housing (2.5:1 and 3:1 Ratios)

or the drive shaft and planetary gear assembly with engine oil. Then insert the end of the drive shaft straight through the reduction gear drive shaft bearing from the forward face of the gear housing as shown in Figs. 104 or 105.

- b. On the 2.1:1 ratio reduction gear, place a 4" square wood block inside the ring gear and against the forward face of the reduction gear drive shaft, then stand the reduction gear housing and drive shaft assembly up and rest it on the wood block.

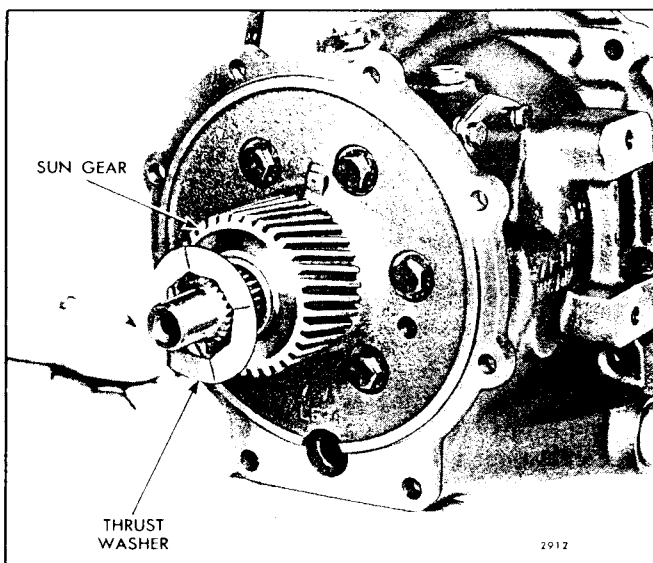


Fig. 106 - Installing Thrust Washer on Hub of Sun Gear (2.1:1 Ratio)

On the 2.5:1 and 3:1 ratio reduction gears, place a 1" x 6" x 6" wood block against the planetary gear assembly, then stand the reduction gear housing and drive shaft assembly up and rest it on the wood block.

- c. Lubricate the splines of the drive shaft and the lip of the oil seal with engine oil; then, start the drive flange on the splined end of the drive shaft and push it down tight against the bearing.

If necessary, tap the drive flange on the drive shaft with a plastic hammer until it contacts the bearing.

- d. Install the drive flange retaining nut on the drive shaft. Do not tighten it at this time.

8. On the 2.1:1 ratio reduction gear, install the reduction gear planetary gear assembly and thrust washers on the reduction gear input shaft and sun gear as follows:

**NOTE:** The planetary gear assembly for the left-hand rotation reduction gear assembly is identified by two drill spots on the rear face of the planetary cage.

- a. Place the reverse gear assembly on a bench with the reduction gear input shaft in a horizontal position, with a small wood block directly under the rear bottom side of the gear housing (Fig. 106).
- b. Lubricate both sides of the planetary gear thrust washer with engine oil. Then place the thrust washer over the end of the reduction gear input shaft and against the rear face of the sun gear as shown in Fig. 106.
- c. Lubricate the pinions of the planetary gear assembly with engine oil. Then place the planetary gear assembly over the end of the input shaft with the internal splined hub end of the gear assembly out as shown in Fig. 13. Engage the pinion gears of the planetary gear assembly with the teeth of the sun gear and rotate the gear assembly slightly to align the splines in the hub of the cage with the splines on the reduction gear input shaft. Then push the gear assembly against the thrust washer.
- d. Lubricate the second planetary gear thrust washer with engine oil. Then place it over the input shaft and hub of the planetary gear and against the rear face of the planetary gear assembly as shown in Fig. 107.

9. Attach the reduction gear assembly to the reduction gear adaptor as follows:

- a. Affix a new gasket to the bolting flange of the reduction gear adaptor with the notch in the inner diameter of the gasket over the oil return hole in the lower (square) portion of the adaptor and the bolt holes in the gasket and adaptor in alignment.
- b. On the 1.5:1 ratio reduction gear, lubricate the reduction gear drive shaft bushing in the end of the reduction gear input shaft with engine oil.

On the 2.1:1 ratio reduction gear, lubricate the reduction gear input shaft bushing in the center of the reduction gear drive shaft with engine oil.

- c. Position the reduction gear assembly in back of the reverse gear assembly with the oil hole in the lower portion of the reduction gear housing in alignment with the oil hole in the lower portion of the reduction gear adaptor (Fig. 12).
- d. On the 1.5:1 ratio reduction gear, place the reduction gear assembly up against the planetary ring gear and engage the teeth of the pinion gears with the teeth of the ring gear by rotating the drive flange slightly. Then carefully push the reduction gear assembly forward and enter the forward end of the reduction gear drive shaft straight into the bushing in the end of the reduction gear input shaft.

On the 2.1:1 ratio reduction gear, place the reduction gear assembly up against the planetary gear assembly and engage the teeth of the ring gear with the teeth of the pinion gears by rotating the drive flange slightly. Then carefully push the reduction gear assembly straight forward and enter the end of the reduction gear input shaft straight into the bushing in the center of the reduction gear drive shaft.

On the 2.5:1 and 3:1 ratio reduction gears, place the reduction gear assembly up against the planetary ring gear and sun gear and engage the teeth of the pinion gears with the teeth of the ring gear and the sun gear by rotating the drive flange slightly.

- e. Push the reduction gear assembly up against the adaptor with the bolt holes in the adaptor in alignment with the bolt holes in the gear housing. Then enter the pilot on the rear face of the adaptor into the bore of the gear housing.
- f. Install the two 7/16" -14 bolts and lock washers in the two holes at the bottom side of the gear housing, and the six 3/8" -16 bolts and lock

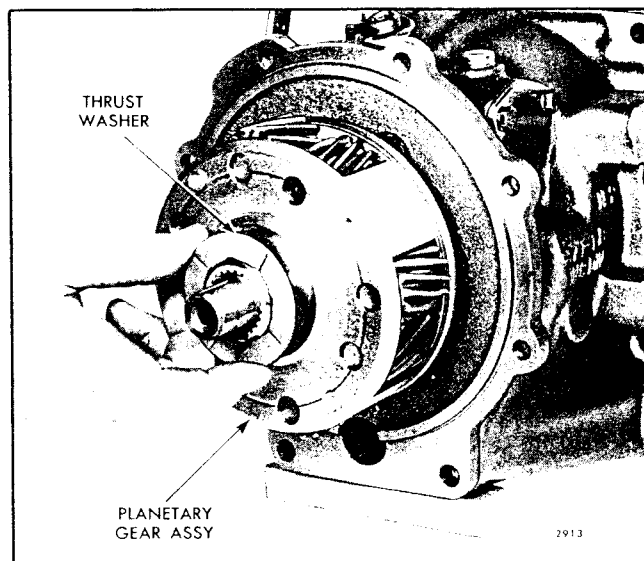


Fig. 107 - Installing Thrust Washer on Hub of Planetary Gear Assembly (2.1:1 Ratio)

washers in the six remaining bolt holes in the forward face of the adaptor.

- g. Tighten the 3/8" -16 bolts to 30-35 lb-ft torque and the 7/16" -14 bolts to 46-50 lb-ft torque.

10. Attach a spanner wrench to the drive flange, as shown in Fig. 11, to prevent it from turning. Then, while holding the reverse and reduction gear from moving, attach a wrench to the drive flange nut (Fig. 11) and tighten it to 150-200 lb-ft torque.

11. On the former reverse and reduction gear units, install the lubricating oil fitting in the lower right-hand side of the reduction gear housing, if removed.

#### Attach Reverse Gear to Engine

With the reverse and reduction gear assembled, refer to Figs. 7 and 8 and proceed as follows:

1. If removed, attach the marine gear drive coupling to the engine flywheel.
2. Install a 7/16" -14 eyebolt in the top bolt hole at each side of the reverse gear housing (Fig. 9).
3. Support the reverse and reduction gear assembly with a rope sling and a chain hoist as shown in Fig. 9, then position the assembly at the rear of the flywheel housing adaptor, with the drive gear input shaft in line with the center of the drive coupling attached to the flywheel.
4. Lubricate the splines of the input shaft with engine oil. Push the gear assembly straight forward and enter

the input shaft straight into the splines of the drive coupling. Then push the gear assembly up against the flywheel housing adaptor and enter the pilot on the gear housing adaptor straight in the bore of the flywheel housing adaptor.

5. Align the bolt holes in the gear housing with the holes in the flywheel housing adaptor, then install the six 7/16" -14 bolts and lock washers. Tighten the bolts to 46-50 lb-ft torque.
6. Remove the chain hoist, rope sling and eyebolts from the reverse gear housing.
7. Attach the two rear engine supports to the sides of the reverse gear housing.
8. Refer to Figs. 7 and 8 and connect the oil cooler

return tube to the elbow at the lower right-hand side of the reverse gear housing on current marine gears (except current 2.1:1 marine gear), or the lower right-hand side of the reduction gear housing on former marine gears or at the top of the reduction gear housing on current 2.1:1 marine gears.

9. Connect the reverse gear to oil cooler tube to the elbow at the top of the reverse gear housing.

10. Refill the marine gear with lubricating oil as specified under *Lubrication*.

11. Start and run the engine and marine gear unit at idle speed for a few minutes to fill the lubrication system. Stop the engine, then immediately check the oil level in the marine gear. Bring the oil level up to the FULL mark on the dipstick. Do not overfill.

## OIL COOLER

In order to provide additional cooling for the lubricating oil used in the marine gear, a separate oil cooler, similar to the engine lubricating oil cooler, is mounted at the heat exchanger. Thus, sufficient additional cooling is provided to insure that normal operating temperatures are maintained in the marine gear oil system under all conditions of speed and load in both forward and reverse.

On current 6 and 8V engines, the oil cooler core and cover is a one piece assembly mounted in the heat exchanger housing directly below the heat exchanger core. On former engines, the oil cooler core was mounted on the side of the engine.

Remove the oil cooler core for cleaning and inspection as follows:

The oil cooler core should be removed and cleaned periodically, or at the time of each engine or marine gear overhaul.

1. Drain the engine cooling system.
2. Disconnect the two marine gear oil tubes from the elbows in the oil cooler cover.

**NOTE:** Tag the oil tubes, inlet and outlet, for future reference.

3. Remove the bolts and lock washers securing the oil cooler cover to the heat exchanger. If necessary, tap

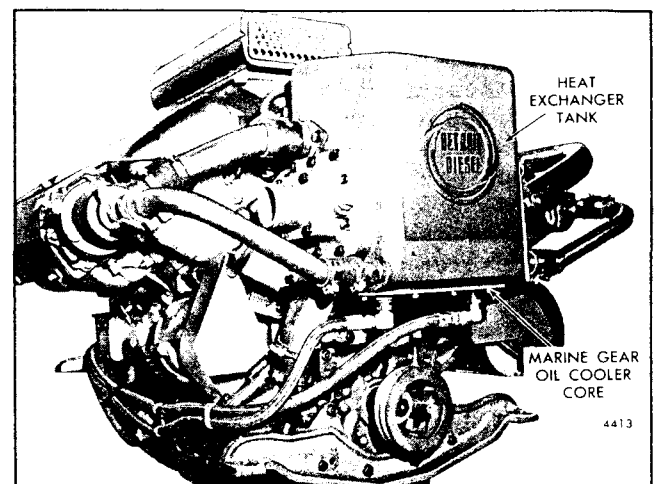


Fig. 108 - Typical Marine Gear Oil Cooler Core Mounting

the edge of the oil cooler cover with a plastic hammer to loosen it.

4. Remove the gasket from the oil cooler cover or heat exchanger.
5. Clean and pressure check the oil cooler core as outlined in Section 4.4.
6. Use a new gasket and install the oil cooler core by reversing the procedure for removal.



**TROUBLE SHOOTING - SPECIFICATIONS - SERVICE TOOLS**

**TROUBLE SHOOTING CHARTS**

Chart 1

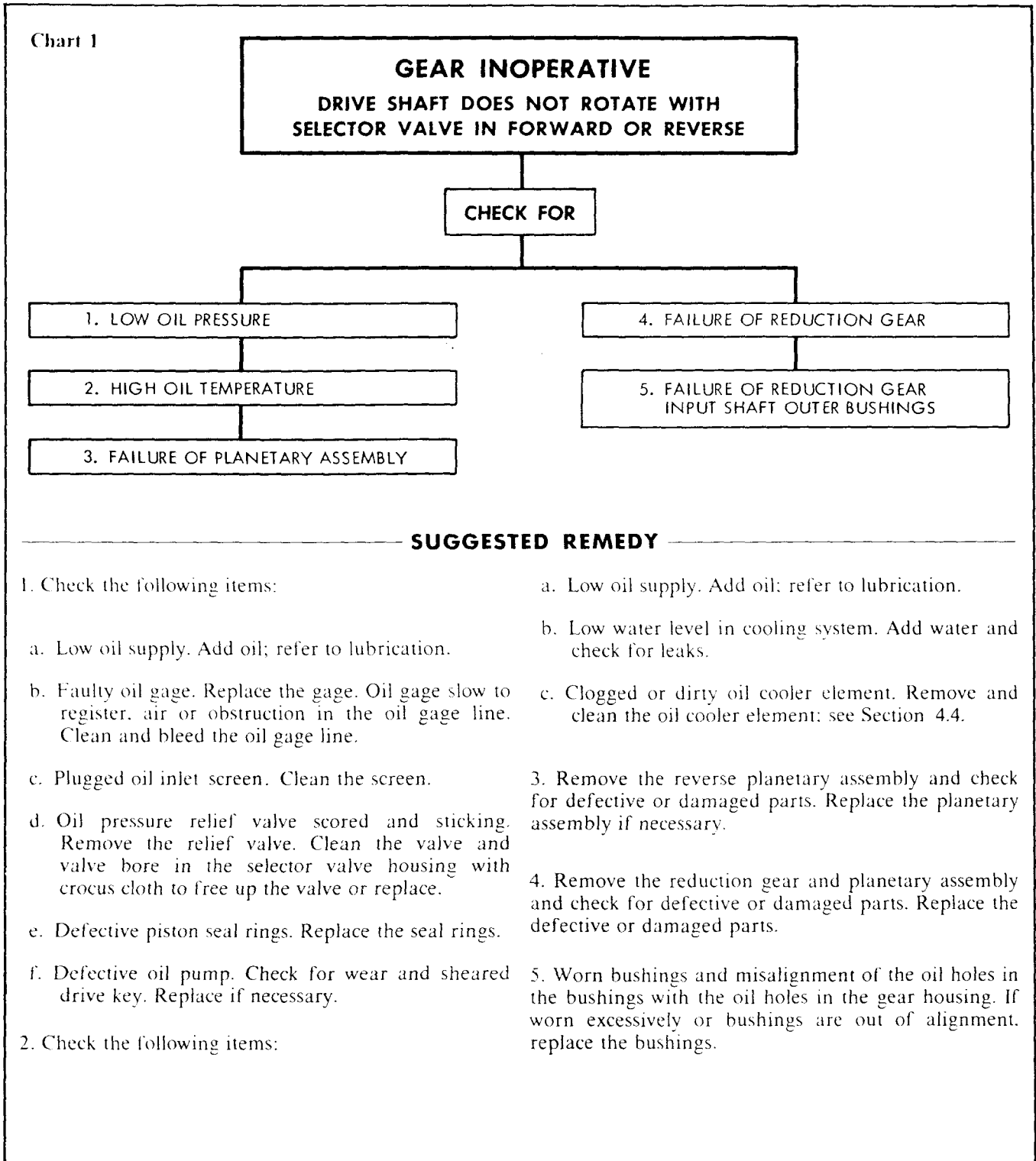
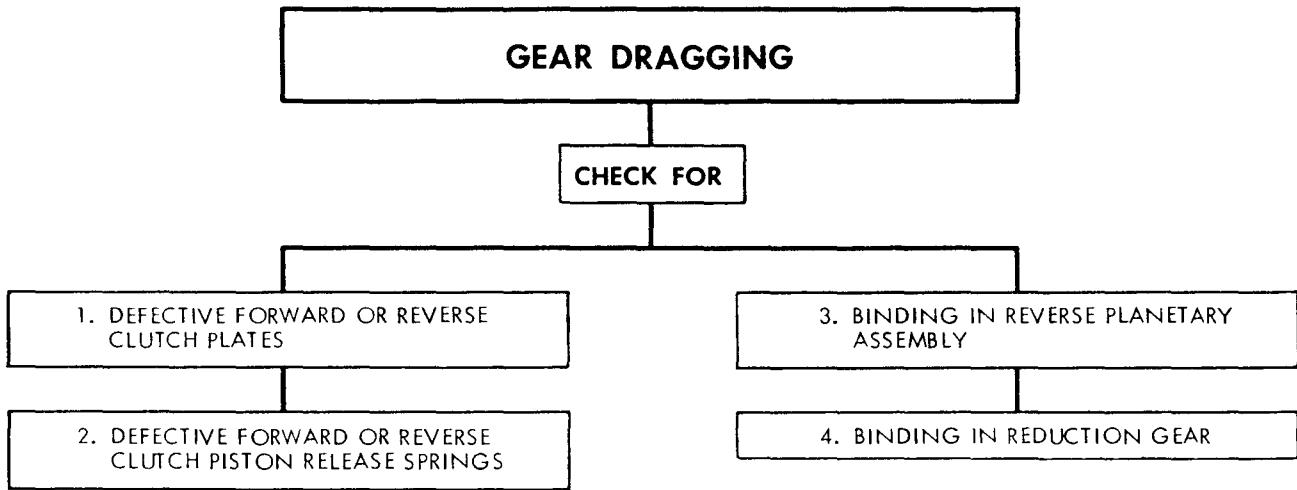


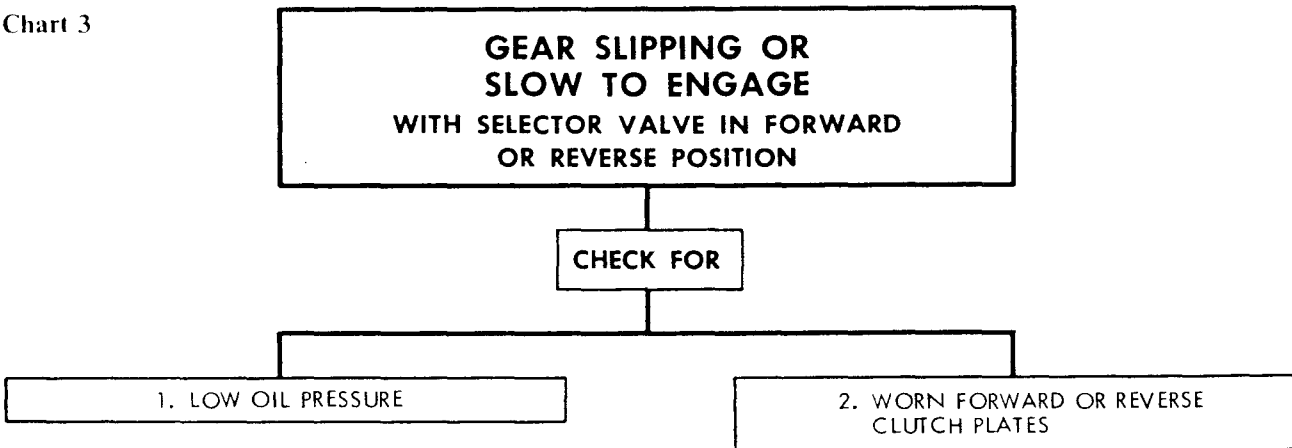
Chart 2



**SUGGESTED REMEDY**

- |  |  |
|--|--|
| <p>1. Forward and reverse clutch plates warped and sticking. Remove the clutch plates and replace.</p> <p>2. Forward and reverse clutch piston release springs broken or weak. Replace the springs.</p> <p>3. Check the following items:</p> <p>a. Bearings and gears worn excessively in the planetary assembly. Replace the planetary assembly.</p> <p>b. Input shaft bearing worn excessively causing misalignment of the input shaft. Replace the necessary parts.</p> | <p>4. Check the following items:</p> <p>a. Bearings and gears worn excessively in the planetary assembly. Replace the planetary assembly.</p> <p>b. Bushings in the reduction gear input shaft and drive shaft worn excessively causing misalignment of the input and drive shaft. Replace the necessary parts.</p> <p>c. Reduction gear drive shaft roller bearing worn excessively, replace the bearing.</p> |
|--|--|

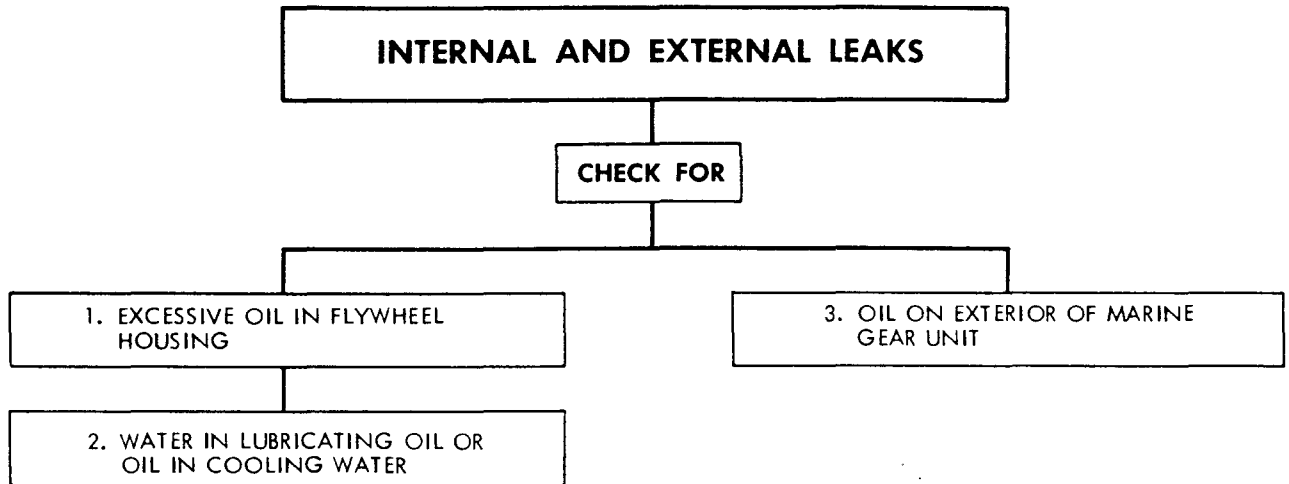
Chart 3



**SUGGESTED REMEDY**

- |   |  |
|---|--|
| <p>1. Low oil pressure, see Chart 1, Item 1.</p> <p>2. Remove the forward and reverse clutch plates and</p> | <p>check for wear. If worn excessively, replace the clutch plates.</p> |
|---|--|

Chart 4



#### SUGGESTED REMEDY

1. Defective reverse gear oil pump oil seal, pump to adaptor gasket or loose oil pump bolts. Replace the oil seal and gasket. Tighten the oil pump bolts.
2. Check the following items:
  - a. Hole in the oil cooler element permitting water to seep into the oil compartment, or oil seeping into the engine cooling system due to the oil pressure being greater than the water pressure. Replace the oil cooler element.
  - b. Oil cooler gaskets damaged. Replace the oil cooler gaskets.
3. Check the following items:
  - a. Reverse gear housing adaptor, reduction gear adaptor, reduction gear housing and bearing retainer gaskets damaged.
  - b. Defective selector valve "O" seal ring. Replace the seal ring.
  - c. Defective reduction gear drive shaft bearing retainer oil seal. Replace the oil seal.
  - d. Loose reverse gear to oil cooler supply and return oil tube fittings. Tighten all of the fittings.

**SPECIFICATIONS**

**STANDARD BOLT AND NUT TORQUE SPECIFICATIONS**

THREAD SIZE	TORQUE (lb-ft)	THREAD SIZE	TORQUE (lb-ft)
1/4 -20	7-9	9/16-12	90-100
1/4 -28	8-10	9/16-18	107-117
5/16-18	13-17	5/8 -11	137-147
5/16-24	15-19	5/8 -18	168-178
3/8 -16	30-35	3/4 -10	240-250
3/8 -24	35-39	3/4 -16	290-300
7/16-14	46-50	7/8 - 9	410-420
7/16-20	57-61	7/8 -14	475-485
1/2 -13	71-75	1 - 8	580-590
1/2 -20	83-93	1 -14	685-695

**EXCEPTIONS TO STANDARD BOLT AND NUT TORQUE SPECIFICATIONS**

APPLICATION	THREAD SIZE	TORQUE (lb-ft)
Selector valve lever to selector valve nut	5/16-24	12-16
Reverse gear housing adaptor to gear housing bolts	3/8 -16	28-30
Drive flange nut (elastic stop)	1 -20	100-200
Drive flange nut (Marsden)	1 -20	150-200

**SERVICE TOOLS**

TOOL NAME	TOOL NO.
Oil seal removing and replacing tool set	J 3154-04
Snap ring pliers	J 5586
Universal remover and installer tool handle	J 7079-2
Gear housing bushing remover and installer	J 8466
Oil pump oil seal installer	J 8467
Oil pump oil seal lip protector	J 8491
Input shaft roller bearing installer	J 8561
Spring tester	J 9666
Oil pump oil seal installer	J 22389
Oil pump oil seal protector	J 22390

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**SECTION 12**  
**SPECIAL EQUIPMENT**  
**CONTENTS**

**Bilge Pump**..... 12.2

**Air Compressor**..... 12.4

**Cold Weather Starting**..... 12.6

**Hydrostarter System** ..... 12.6.1

**Trouble Shooting - Specifications - Service Tools**..... 12.0

## BILGE PUMP

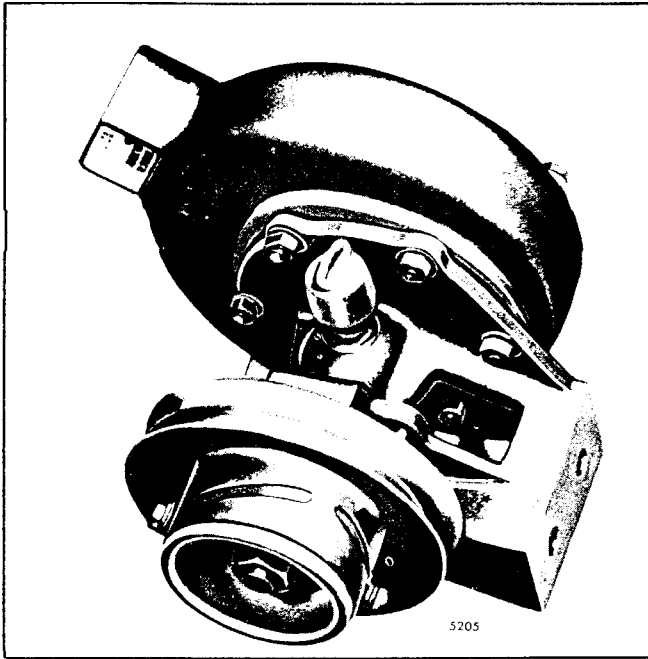


Fig. 1 - Bilge Pump

The bilge pump (Fig. 1) is mounted at the front of the engine and is driven by a V-belt from a pulley on the crankshaft.

The bilge pump runs continuously whenever the engine is operating and is kept in prime by a stream of overflow water from the engine, introduced on the intake side of the pump, through a priming pipe.

The drive shaft is supported on a bronze bushing at the impeller end and a ball bearing to take radial load at the pulley end.

### Lubrication

A grease cup provides lubrication for the bronze bushing at the impeller end of the shaft. The cup

should be given one-half turn daily, using water-proof grease of the same grade as used on the raw water pump. The ball bearing used at the pulley end of the shaft is grease packed and requires no attention.

A packing gland is provided to adjust the seal on the shaft. Do not tighten it more than necessary to stop leakage. When tightening, draw the nuts down evenly to avoid leaks and scoring of the pump shaft.

### Service

Since the bilge pump runs continuously when the engine is operating, the drive belt should be checked at regular intervals. Tension on the belt should be sufficient to avoid slipping, but not great enough to impose an undue load on the pump bearings. Three-fourths inch slack midway between the two pulleys should provide satisfactory operation. Adjustment is accomplished by loosening the adjusting screws at the forward pulley hub and moving the hub in the slot to obtain suitable slack. In freezing weather, open the drain cock to empty the pump if the engine is to be standing idle for any length of time.

### Remove and Install Pump

The bilge pump may be removed from the engine by removing the four bolts which attach the mounting bracket to the engine.

The pump is simple in construction and may be disassembled for inspection and re-assembled without special instructions. Since the pump priming pipe is permanently connected to the pump as installed on the engine, no special precautions are required for installation other than to make correct connections to the inlet and outlet sides.

**CAUTION:** All piping on the intake side of the bilge pump must be air tight. Use white lead or red lead on pipe threads at all connections.