Section 5
Assembly

5-1. GENERAL INFORMATION

5-2. During assembly, refer to the illustrations specified in the text. In addition, an exploded view of the complete assembly and major subassemblies can be viewed in Section P, Parts. These exploded view illustrations are listed at the beginning of Section P. Note the following during assembly:

1. When a torque value is specified, use a torque wrench to tighten the threaded part. Torque values are specified in the text and also in Table 5-1 at the end of this section.

2. Coat small parts with petroleum jelly to help hold them in place during assembly.

5-3. LUBRICATION DURING ASSEMBLY. Lubricate all internal parts, not coated with petroleum jelly or with approved transmission lubricant (refer to paragraph 2-4) just prior to assembly. This will ease assembly and provide initial lubrication.

1. O-rings, sealing rings and shaft seal lips may be damaged during assembly if not lubricated.

2. Make sure bearing cones (20, 24 and 31, figure P-1; 301, figure P-3; and 402, figure P-4) and needle bearings (306, figure P-3; and 404, figure P-4) are thoroughly lubricated before assembly. Running bearings dry, even for a brief period, will cause damage.

5-4. LAY SHAFT ASSEMBLY

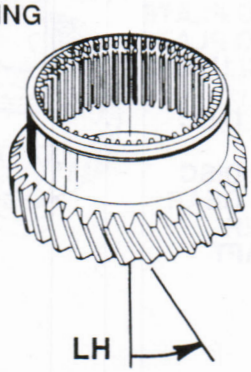
5-5. ASSEMBLY OF CLUTCH PISTON AND CYLINDER Assemble lay clutch piston and cylinder as follows (see figure 5-1):

1. Install ball (431), spring (430) and spacer (429) into end of lay shaft (427). Use a suitable drift to press on spacer and compress spring while installing snap ring (428).

2. Install seal rings (426) and o-ring (425) in grooves in lay shaft (427).

3. Install sealing ring assembly (422), consisting of o-ring (424) and sealing ring (423), in groove in ID of clutch piston assembly (418). Install sealing ring assembly (419), consisting of o-ring (421) and sealing ring (420) in groove in OD of clutch piston.

411. BOLT
413. CLUTCH GEAR CYLINDER
414. SNAP RING
415. THRUST WASHER
416. SPRING RETAINER
417. SPRING
417A. SPRING
418. CLUTCH PISTON ASSY
419. SEALING RING ASSY
420. SEALING RING
421. O-RING
422. SEALING RING ASSY
423. SEALING RING
424. O-RING
426. SEAL RING
427. LAY SHAFT
428. SNAP RING
429. SPACER
430. SPRING
431. BALL



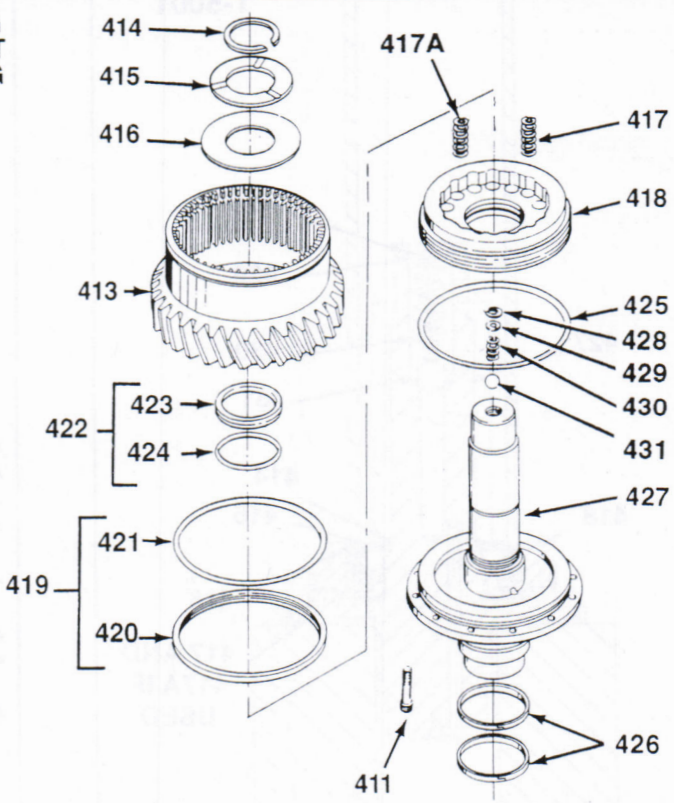


Figure 5-1. Lay Clutch Cylinder and Piston

4. Install clutch piston assembly (418) on lay shaft (427) with sixteen spring holes facing away from shaft flange. Seat piston against shaft flange.

5. Support lay shaft with parts previously installed in suitable holding fixture (see figure 5-2) in arbor press.

6. Install springs (417, and if used 417A) in holes in clutch piston assembly (418) as follows:

a. For transmissions 2001-000-011 thru -016, and 2001-000-R01 thru 2001-000-R06 install sixteen springs (417).

b. For transmissions 2001-000-001 thru -006, first install four springs (417) equally spaced. Then install three springs (417A) between each of the springs (417)—twelve springs (417A) total.

7. Install spring retainer (416) and **thrust washer** (415). Expand snap ring (414) and slide onto shaft up against thrust washer.

8. Using assembly tool T-5001, press down on spring retainer (416) to compress springs (417, and 417A if used) and provide access to shaft groove for snap ring (414) (see figure 5-2). Install snap ring in shaft groove. Remove shaft assembly, holding fixture and assembly tool from arbor press. Remove assembly tool from shaft assembly.

9. The helical on the lay clutch gear must be left handed. That means the teeth must be inclined to the left when viewed from the face of the gear (see figure 5-1). If the incorrect helical (input clutch) gear is installed there may be resulting damage to the lay shaft pump side bearing.

10. Using Guide pins, install clutch gear cylinder (413) over clutch piston assembly (418) and onto lay shaft (427). Install twelve bolts (411). Torque bolts to 16-18 lb-ft (22-25 Nm).

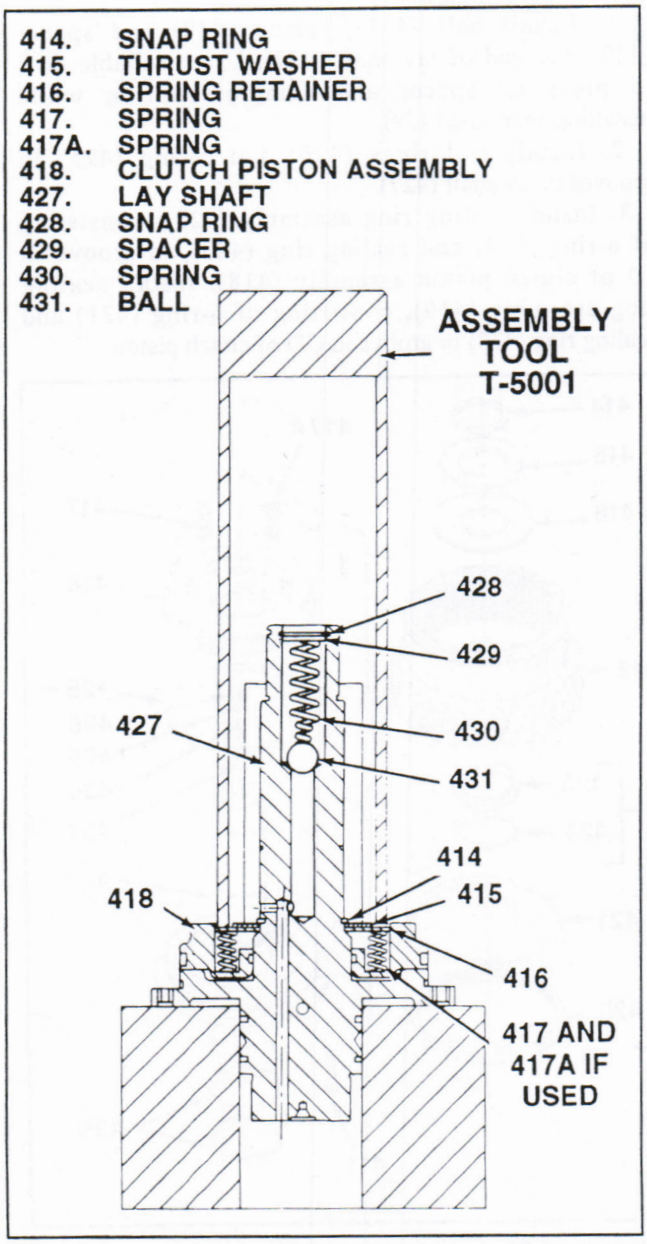


Figure 5-2. Installing Snap Ring

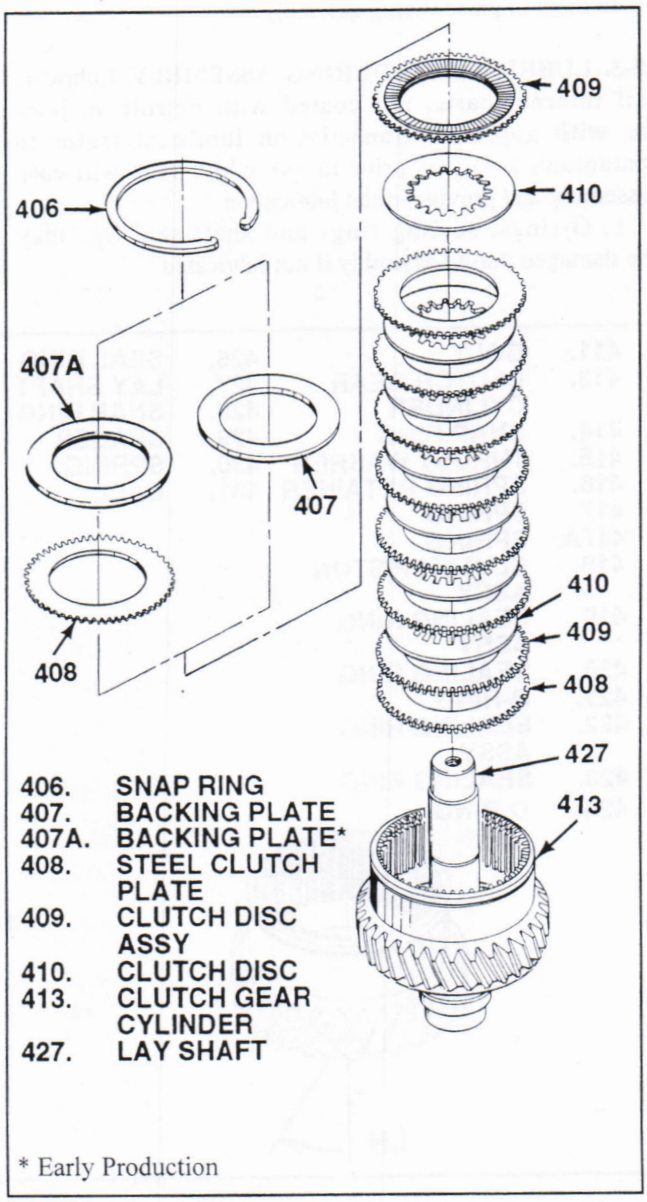


Figure 5-3. Lay Clutch Group

5-6. ASSEMBLY OF CLUTCH GROUP. With shaft assembly in holding fixture as described in paragraph 5-5, proceed as follows (see figure 5-3):

1. Align splines and install one steel clutch plate (408) over lay shaft (427), into clutch gear cylinder (413).

2. Starting with one clutch disc assembly (409), alternately install eight clutch disc assemblies and seven clutch discs (410).

3. Install 5.0 mm (0.200 in) thick backing plate (407). If 3.0 mm (0.112 in.) thick backing plate (407A) is used, it must be installed over an additional steel clutch plate (408).

4. Secure clutch group in clutch gear cylinder (413) with snap ring (406).

5-7. ASSEMBLY OF CLUTCH GEAR AND BEARINGS. With shaft assembly in holding fixture as described in paragraph 5-5, proceed as follows (see figure 5-4):

1. Install snap ring (405) on lay shaft (427).

2. Select lay clutch gear (403)—not input clutch gear (304) (see figure 5-4). Align splines on clutch discs previously installed and install lay clutch gear (403). This is best done by using a twisting, orbitting motion. Make sure clutch gear is fully installed, engaging all clutch discs. Outside end of gear should be flush to below shoulder on lay shaft (427).

3. Install three needle bearings (404) on lay shaft (427).

4. Position shaft assembly on holding fixture in arbor press. Using drift T-5002, press bearing cone (402) on shaft to seat on shaft shoulder.

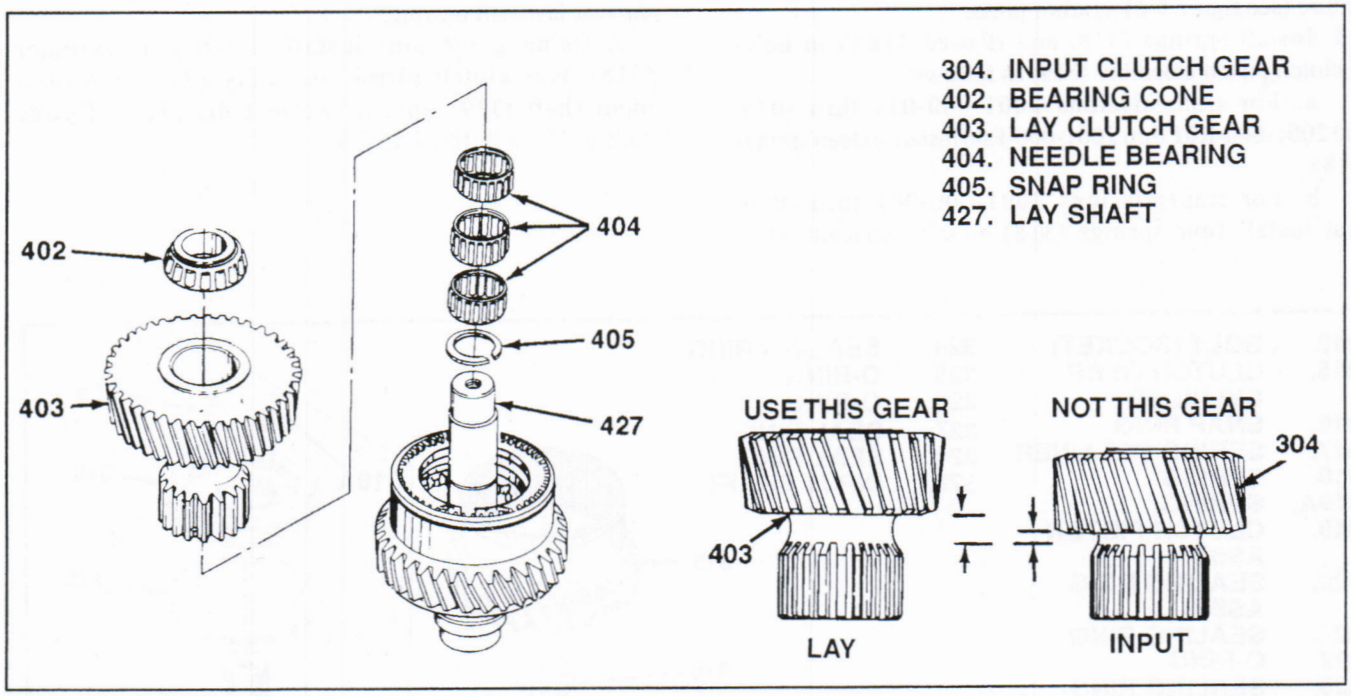


Figure 5-4. Lay Clutch Gear and Bearings

5-8. INPUT SHAFT ASSEMBLY

5-9. ASSEMBLY OF CLUTCH PISTON AND CYLINDER Assemble input clutch piston and cylinder as follows (see figure 5-5):

1. Install seal rings (328 and 327) and o-ring (326) in grooves on input shaft (329).

2. Install sealing ring assembly (323), consisting of o-ring (325) and sealing ring (324), in groove in ID of clutch piston assembly (319). Install sealing ring assembly (320), consisting of o-ring (322) and sealing ring (321) in groove on OD of clutch piston.

3. Install clutch piston assembly (319) on input shaft (329) with sixteen spring holes facing away from shaft flange. Seat piston against shaft flange.

4. Support input shaft with piston, o-rings and seal rings (319 through 329) in suitable holding fixture (see figure 5-6) in arbor press.

5. Install springs (318, and if used 318A) in holes in clutch piston assembly (319) as follows:

a. For transmissions 2001-000-011 thru -016, and 2001-000-R01 thru 2001-000-R06 install sixteen springs (318).

b. For transmissions 2001-000-001 thru -006, first install four springs (318) equally spaced. Then install three springs (318A) between each of the springs (318)—twelve springs (318A) total.

6. Install spring retainer (317). Expand snap ring (316) and slide onto shaft up against spring retainer (317).

7. Using assembly tool T-5001, press down on spring retainer (317) to compress springs (318, and if used 318A) and provide access to shaft groove for snap ring (316). Install snap ring in shaft groove. Remove shaft assembly, holding fixture and assembly tool from arbor press. Remove assembly tool from shaft assembly.

8. The helical on the input clutch gear must be right handed. That means the teeth must be inclined to the right when viewed from the face of the gear (see figure 5-5). If the incorrect helical (lay clutch) gear is installed there may be resulting damage to the rear lay shaft bearing.

9. Using guide pins install clutch gear cylinder (315) over clutch piston assembly (319) and onto input shaft (329). Install twelve bolts (313). Torque bolts to 16-18 lb-ft (22-25 Nm).

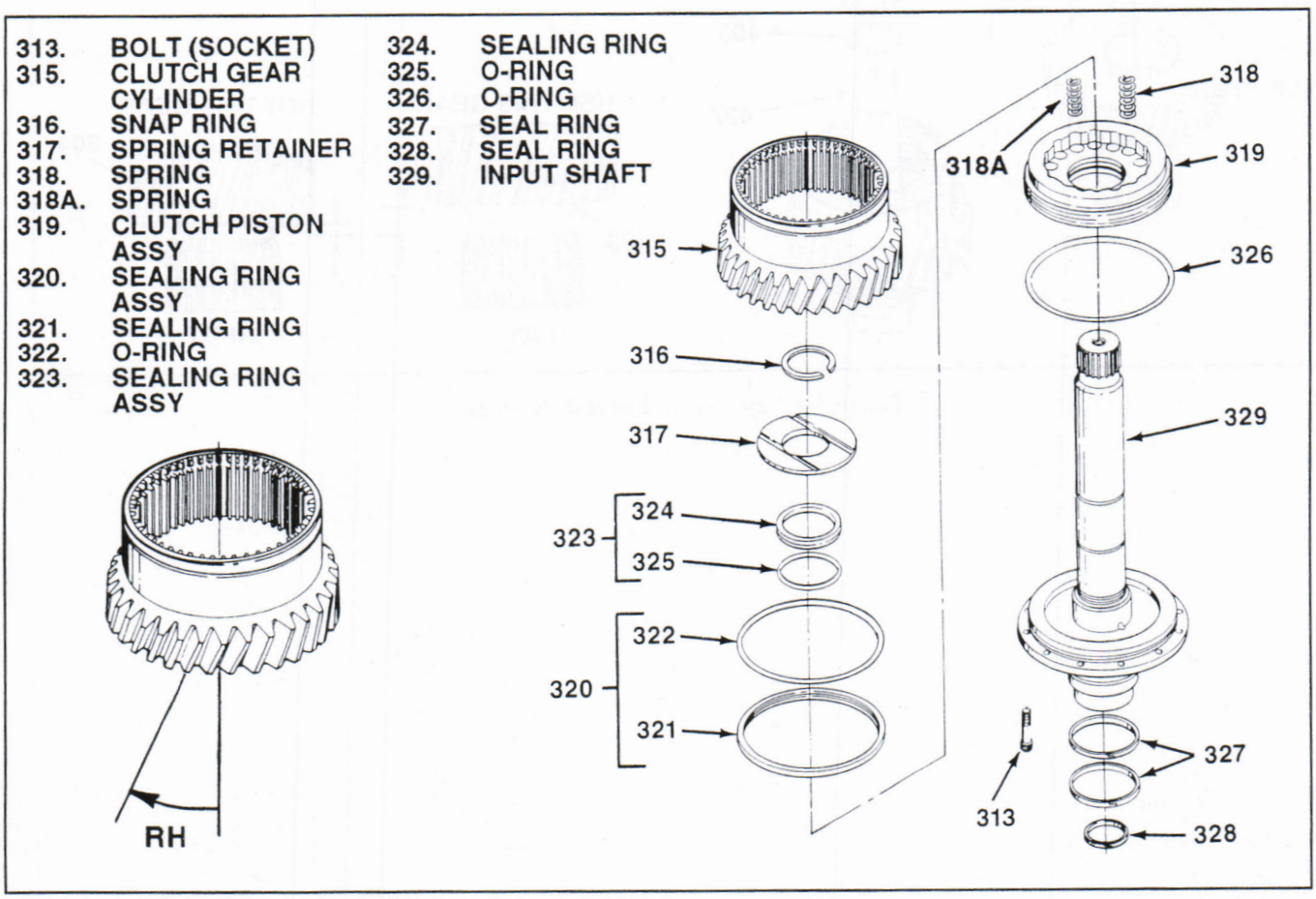


Figure 5-5. Input Clutch Cylinder and Piston

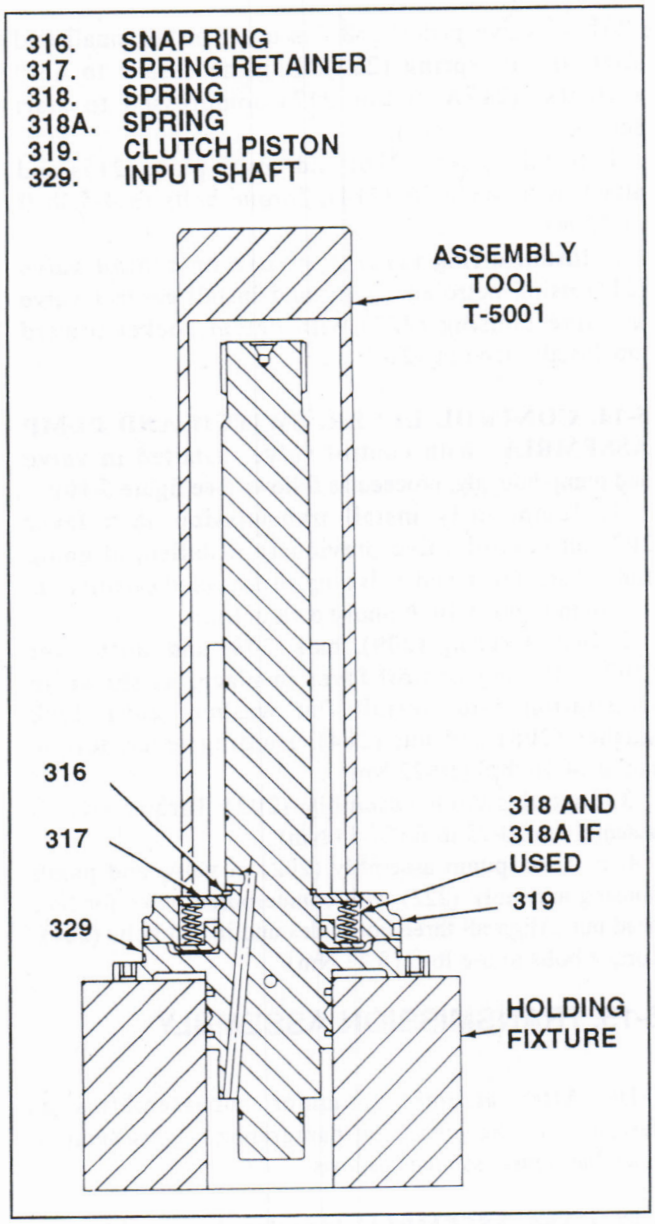


Figure 5-6. Installing Snap Ring

5-10. ASSEMBLY OF CLUTCH GROUP. With shaft assembly in holding fixture as described in paragraph 5-9, proceed as follows (see figure 5-7):

1. Align splines and install one steel clutch plate (310) over input shaft (329), into clutch gear cylinder (315).

2. Starting with one clutch disc assembly (311), alternately install eight clutch disc assemblies and seven clutch discs (312).

3. Install 5.0 mm (0.200 in) thick backing plate (309). If 3.0 mm (0.112 in.) thick backing plate (309A) is used, it must be installed over an additional steel clutch plate (310).

4. Secure clutch group in clutch gear cylinder (315) with snap ring (308).

5-11. ASSEMBLY OF CLUTCH GEAR AND BEARINGS. With shaft assembly in holding fixture as described in paragraph 5-9, proceed as follows (see figure 5-8):

1. Install snap ring (307) on input shaft (329).

2. Select input clutch gear (304)—not lay clutch gear (403) (see figure 5-8). Align splines on clutch discs previously installed and install input clutch gear (304). This is best done by using a twisting, orbitting motion. Make sure clutch gear is fully installed, engaging all clutch discs. Outside end of gear should be flush to below shoulder on input shaft (329).

3. Install three needle bearings (306) on input shaft (329).

4. Install snap ring (305). If there are two (2) available groves about 5/16 in (8mm) apart use the grove closest to the bearing. The second grove is not used in the models described in this manual and must remain empty.

5. Install **thrust washer** (302) and **spacer** (303). The spacer (303) fits inside the thrust washer (302).

6. Position shaft assembly on holding fixture in arbor press. Using drift T-5003, press bearing cone (301) on shaft to seat on spacer (303) against snap ring (305).

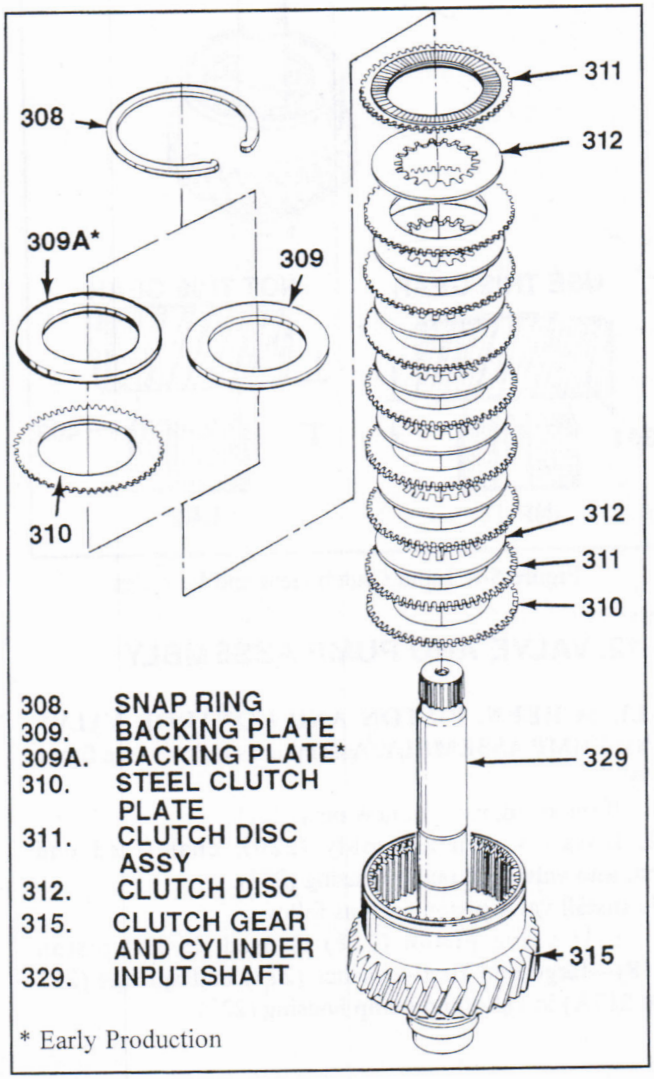


Figure 5-7. Input Clutch Group

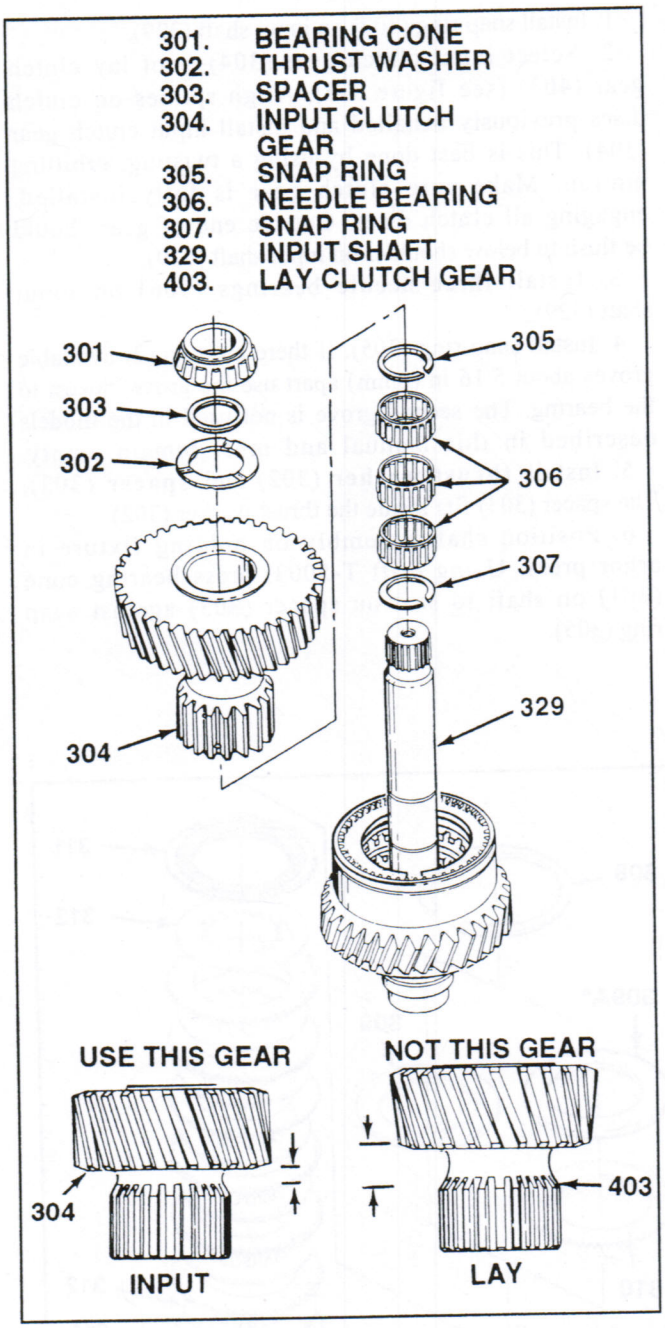


Figure 5-8. Input Clutch Gear and Bearings

5-12. VALVE AND PUMP ASSEMBLY

5-13. SCREEN, PISTON AND CONTROL VALVE AND PUMP ASSEMBLY. Assemble as follows (see figure 5-9):

1. If removed, press in new pins (221).
2. Install screen assembly (220), chamfered end first, into valve and pump housing (222).
3. Install valve piston parts as follows:

a. If valve piston (218) is used, install piston (218)—large end first—washer (219) and springs (217 and 217A) in valve and pump housing (222).

b. If valve piston 218A is used, install small end first. Install spring (217). It is necessary to hold spring(s) (217A and/or 217) compressed to start screws.

4. Install gasket (216) and cover plate (215) and attach with six bolts (214). Torque bolts to 4-5 lb-ft (5-7 Nm).
5. Install o-ring (212) in groove on control valve (211) using petroleum jelly and install control valve in valve housing (222) with detent socket toward top. Install snap ring (210).

5-14. CONTROL LEVER, SWITCH AND PUMP ASSEMBLY. With control valve installed in valve and pump housing, proceed as follows (see figure 5-10):

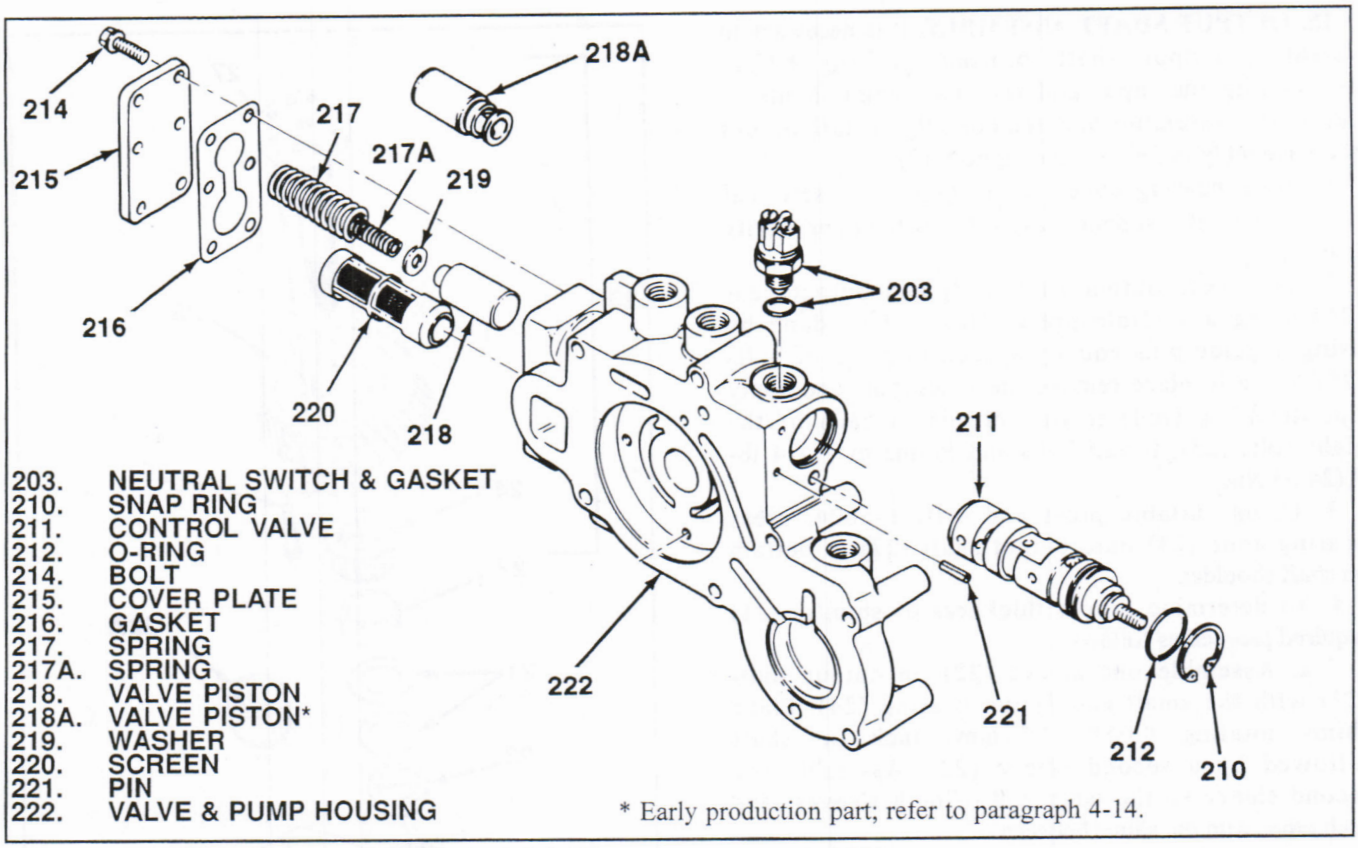
1. Temporarily install transmission shift lever 207) on control valve previously installed, aligning flats. Turn lever and valve up to installed position as shown in figure 5-10. Remove control lever.
2. Install spring (209), ball (208) and shift lever (207). Holding control lever in place, as shown in illustration 5-10, install flat washer (206), lock washer (205) and nut (204). Holding lever, torque nut to 14-16 lb-ft (19-22 Nm).
3. Install switch assembly (203) Torque switch assembly to 20-25 lb-ft (27-34 Nm).
4. Position pump assembly (202) in valve and pump housing assembly (222) with counterbored holes for bolt head out. Align all three bolt holes and install bolts (201). Torque bolts to 6-8 lb-ft (8-11 Nm).

5-15. TRANSMISSION ASSEMBLY

5-16. After assembling major subassemblies as described in the preceding paragraphs of this section, assemble transmission as follows:

5-17. CASE ASSEMBLY. If replaced, assemble case assembly parts as follows (see figure 5-11):

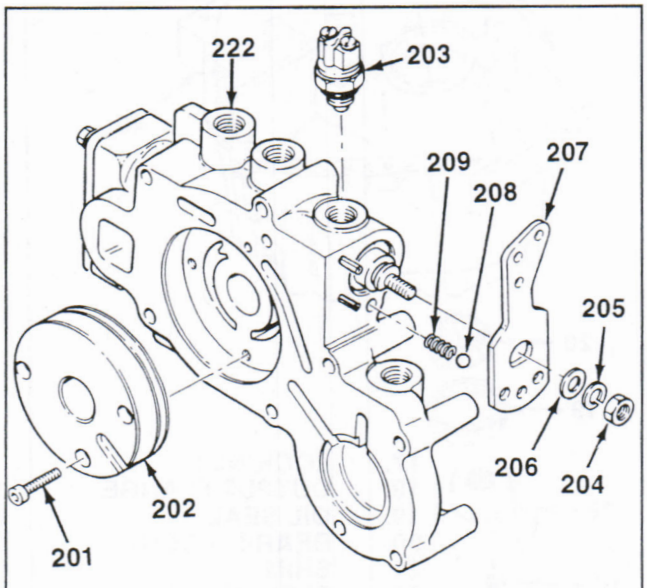
1. If removed, press new bearing cups (44 and 45) in to bottom in case (46) bores. If bearing cones are replaced, the cups (44 and 45) must be replaced also. Care must be take to support case so that centerline through cup bores is vertical.
2. If removed, install new thread inserts (42) using standard Heli-Coil ® installation tools. Install inserts flush to one turn below mounting face of case (46). Follow Heli-Coil ® instructions carefully.



203. NEUTRAL SWITCH & GASKET
210. SNAP RING
211. CONTROL VALVE
212. O-RING
214. BOLT
215. COVER PLATE
216. GASKET
217. SPRING
217A. SPRING
218. VALVE PISTON
218A. VALVE PISTON*
219. WASHER
220. SCREEN
221. PIN
222. VALVE & PUMP HOUSING

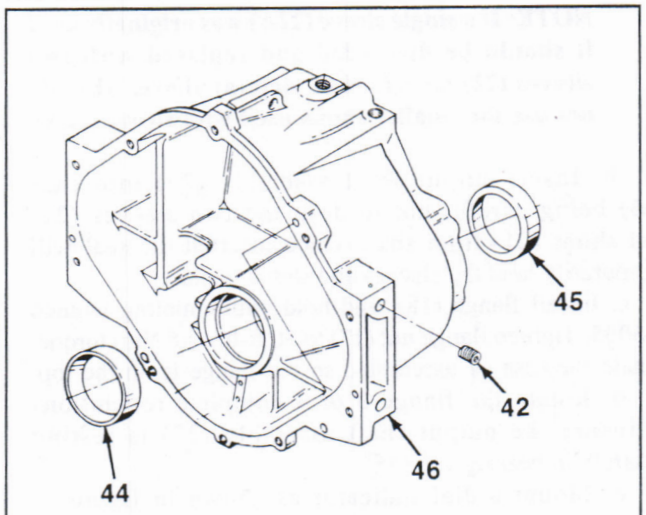
* Early production part; refer to paragraph 4-14.

Figure 5-9. Filter, Piston and Control Valve



201. BOLT
202. PUMP ASSY
203. SWITCH ASSY
204. NUT
205. LOCK WASHER
206. FLAT WASHER
207. CONTROL LEVER
208. BALL
209. SPRING
222. VALVE & PUMP HOUSING

Figure 5-10. Control Lever, Switch and Pump



42. THREAD INSERT
44. BEARING CUP
45. BEARING CUP
46. TRANSMISSION CASE

Figure 5-11. Case Assembly

5-18. OUTPUT SHAFT ASSEMBLY. It is necessary to establish output shaft bearing preload before assembling the input and lay shaft components in the case. Assemble and temporarily install output shaft assembly as follows (see figure 5-12).

1. Place bearing cone (20) in cup and insert seal (19). Rotate and support case (46) so the open cavity is facing up.

2. Assemble output shaft (27) and output gear (26) using a suitable press. This is best done by using 4 guide pins equally spaced in place of bolts (25). Once in place remove the guide pins and apply Loctite 271® (red) to the threads of each of the eight bolts (25). Install bolts and torque to 18-24 lb-ft (24-33 Nm).

3. Using suitable press and drift T-5004, press bearing cone (24) onto output shaft (27) to bottom on shaft shoulder.

4. To determine proper thickness of shim(s) (21) required proceed as follows:

a. Assemble one sleeve (22) on output shaft (27) with the small end facing bearing (24). Place shims totaling 0.050 (1.27mm) inch on shaft followed by a second sleeve (22). Assemble the second sleeve so the large end of both sleeves face each other with the shims between.

NOTE: If a single sleeve (22A) was originally used it should be discarded and replaced with two sleeves (22) described in step (a) above. Also, do not use the smaller shims used with sleeve (22A).

b. Insert output shaft assembly (23) into case (46) being careful not to drop the two sleeves (22) and shims (21) from shaft. Once inserted the seal will temporarily hold the sleeves and shims in place.

c. Install flange (18), and hold with coupling wrench T-5005. Tighten flange nut (17) to 50 ft-lbs (68 Nm) torque. Rotate the case as assembled so the flange is on the top.

d. Rotate the flange 3 or 4 complete revolutions to insure the output shaft assembly (23) is resting squarely in bearing cup (45).

e. Mount a dial indicator as shown in figure 5-13.

NOTE: It is extremely important these next three steps are followed exactly:

1. The magnetic base of the dial indicator is firmly mounted on the flange.

2. The dial indicator shaft is parallel to output shaft center line.

3. The exact point of dial indicator shaft contact with the case is marked and maintained throughout this procedure.

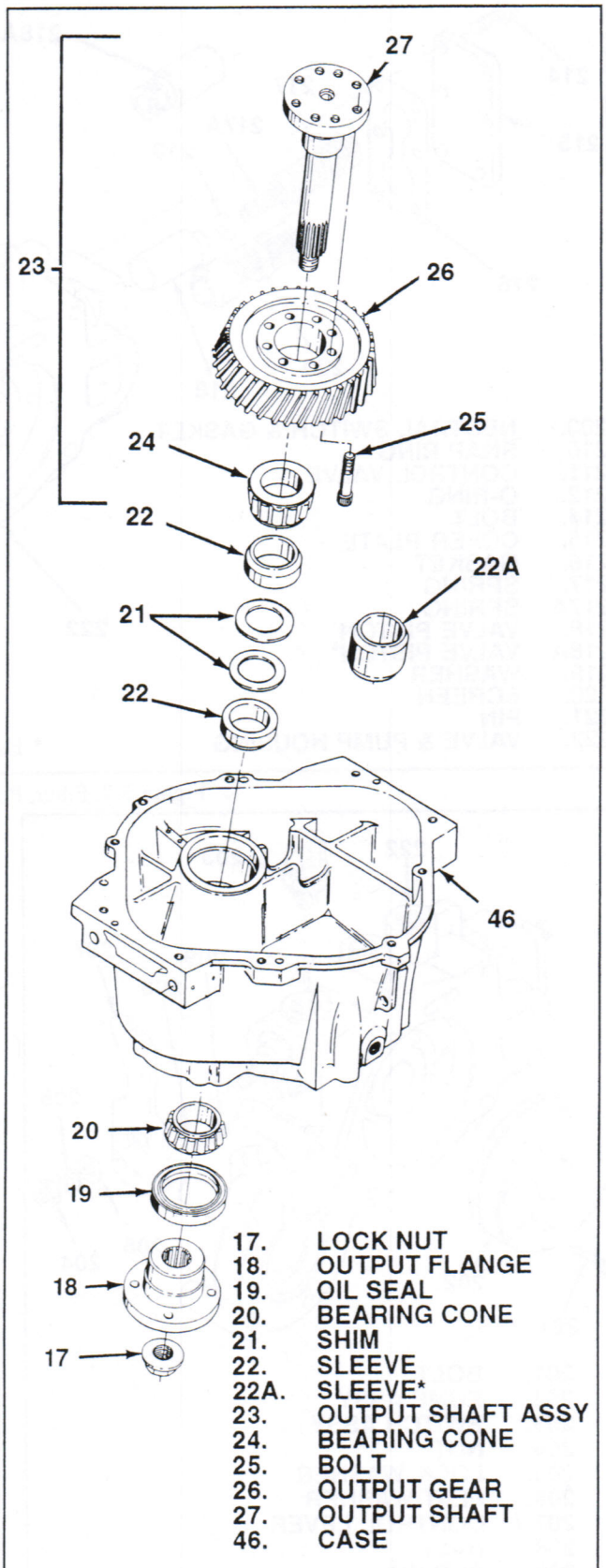


Figure 5-12. Output Shaft Assembly

f. Turn the dial indicator to zero. (0.000).

g. Raise the flange as far as possible using suitable leverage. Hold the shaft assembly in this upward position and take a second reading. Make sure the dial indicator shaft touches the case IN THE EXACT POINT AS IT WAS WHEN ZEROED. Step "g" should be repeated several times with a repetitive reading to insure a proper reading is taken.

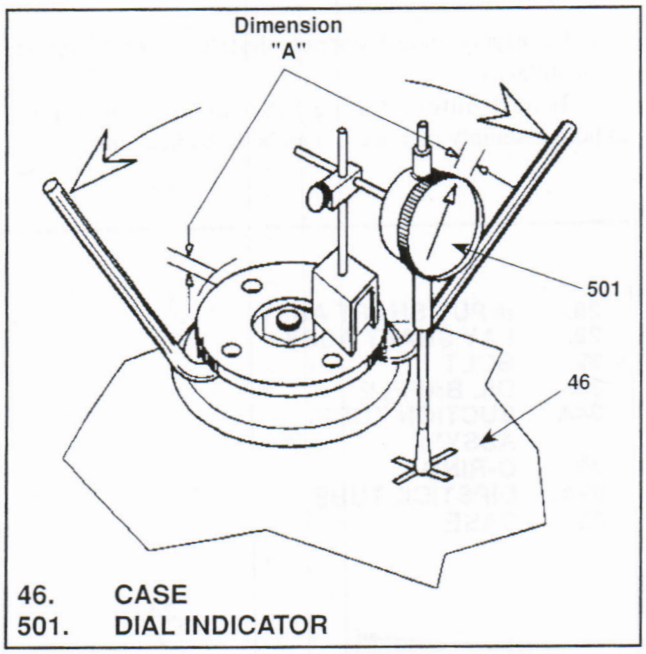


Figure 5-13. Magnetic Base Dial Indicator

We will call this reading DIMENSION "A"

h. The proper bearing preload is 0.004 inch 0.102mm. Calculate the required shim (21) thickness as follows:

	Formula in/mm	Example in/mm
- Shims temporarily installed in step "a" above	0.050/1.270	0.050/1.270
- Subtract desired preload	- 0.004/-0.102	- 0.004/-0.102
Sub total		0.046/1.168
- Subtract Dimension "A"	- 0.???	- 0.010/0.254
- Proper amount to be installed when output shaft is ultimately installed.	+ 0.XXX	0.036 in/.914mm

In the example above 0.036/0.914 inch is the proper amount of shims to be used when transmission is reassembled.

NOTE: Reducing the amount of shims will increase pre-load.

i. Remove flange (18) and flange nut (17) from output shaft (27) and lift output shaft assembly (23) from case (46). Make sure all temporary shims (21) are retrieved from case (46) cavity. Set output shaft assembly (23), two sleeves (22) and shims (21) calculated in paragraph 5-18 step "h" aside to be installed later as a matched set.

CAUTION If the clearing achieved in step 4g is negligible, increase the initial shim build up in step 4a to .070 inch (1.778 mm), and proceed as instructed in steps 4a through 4g, altering all your calculations accordingly.

5-19. LAY SHAFT AND INPUT SHAFT

ASSEMBLIES. Using lay shaft assembly as assembled in paragraph 5-4, input shaft assembly as assembled in paragraph 5-8 (see figure 5-15) and output shaft as assembled in paragraph 5-18 step "i" proceed as follows (see figure 5-16).

NOTE: If oil pick up tube (34A see figure 5-15) is used, perform step "2" before step "1".

1. Install oil pick up tube (34), oil baffle (33) and secure with two bolts (32). Use Loctite ® 242 on bolts (32).

2. Position lay shaft/clutch assembly (29) and input shaft/clutch assembly (28) in case (46). (see figure 5-15).

3. Check to make sure the garter spring is correctly positioned on the output seal (19) (see figure 5-17). Coat the large diameter of both sleeves (22) and shims (21) established in 5-18 step "h" with cup grease. Place sleeves (22) and shims (21) in case (46) cavity, resting on bearing cone (20) and seal (19) as illustrated in figure 5-17.

NOTE: The total shim and sleeve (22) thickness installed at this point must be the same thickness as established in 5-19 step "h".

4. Carefully insert output shaft/gear as illustrated in figure 5-16.

5. Install output flange (18) and flange nut (17) to hold assembly in place. It can be tightened later.

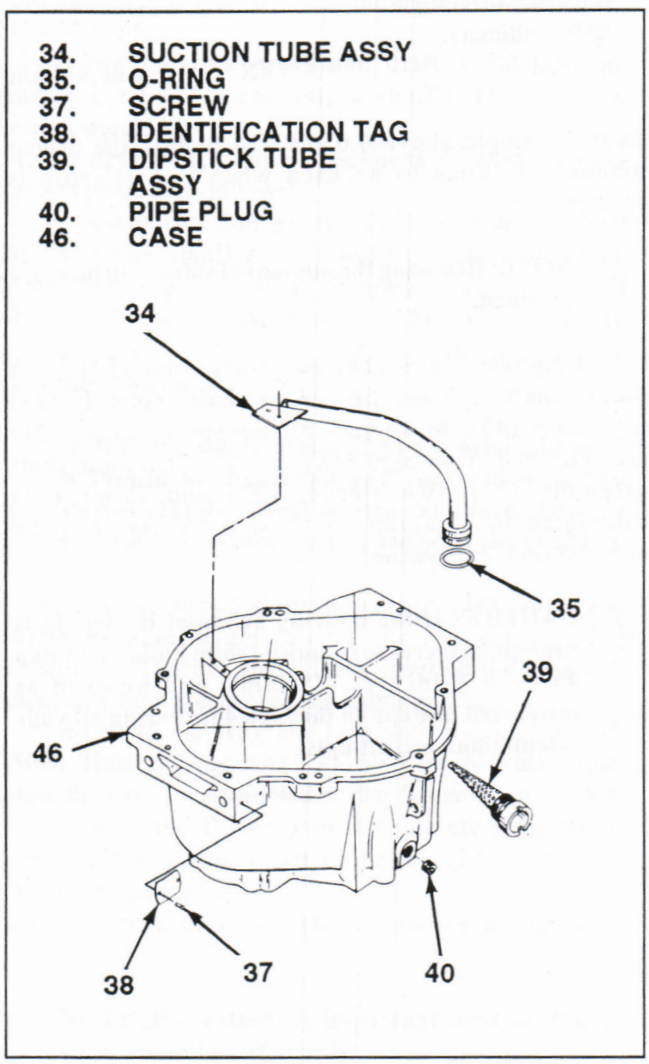


Figure 5-14. Case Components

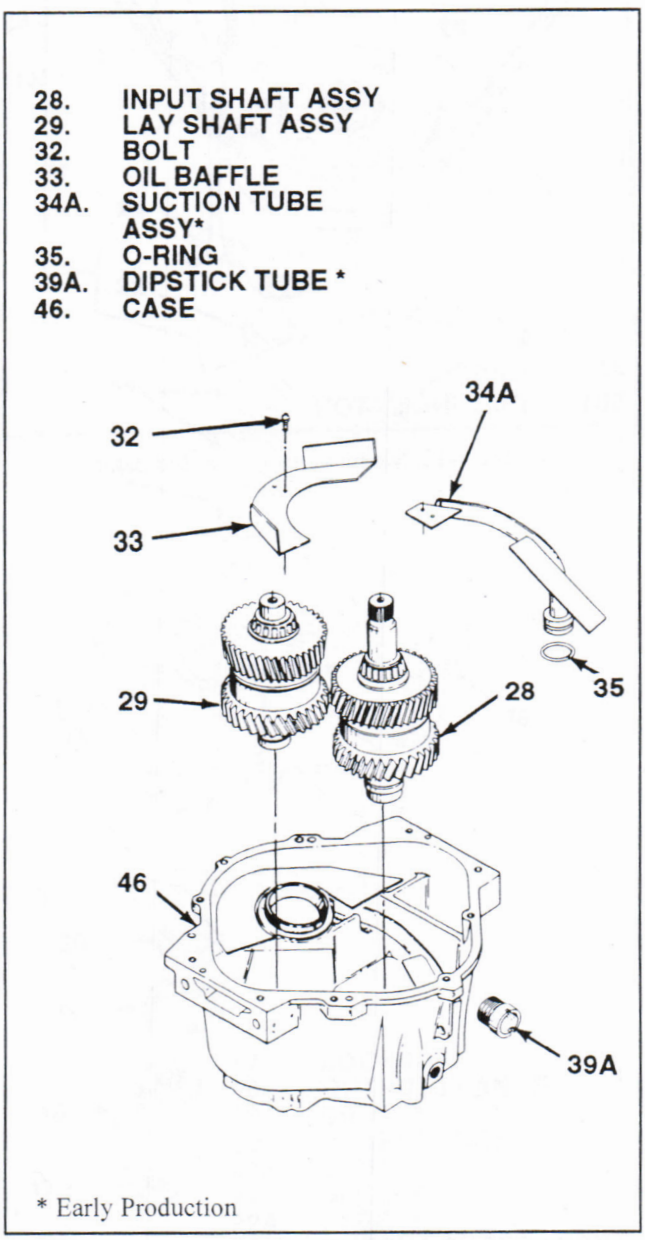


Figure 5-15. Input and Lay Shaft Assemblies

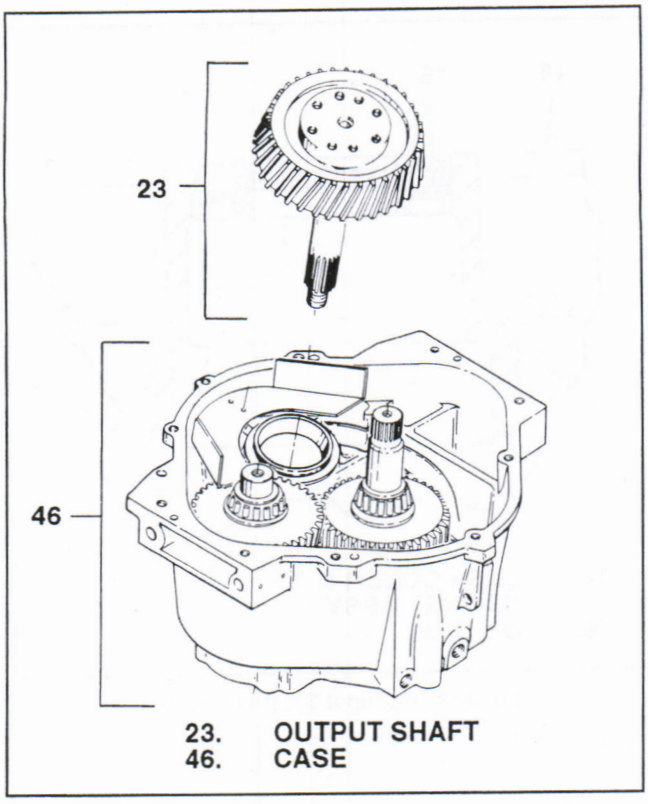


Figure 5-16. Installing Output Shaft/Gear Assembly

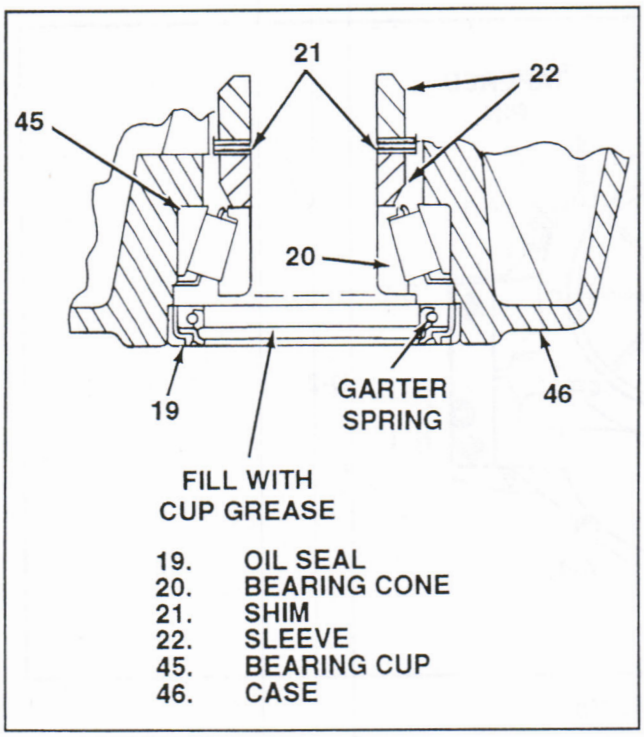


Figure 5-17. Placement of Sleeves and Shims for Assembly

5-20. ASSEMBLY AND INSTALLATION OF CASE COVER ASSEMBLY. Assemble as follows (see figure 5-18):

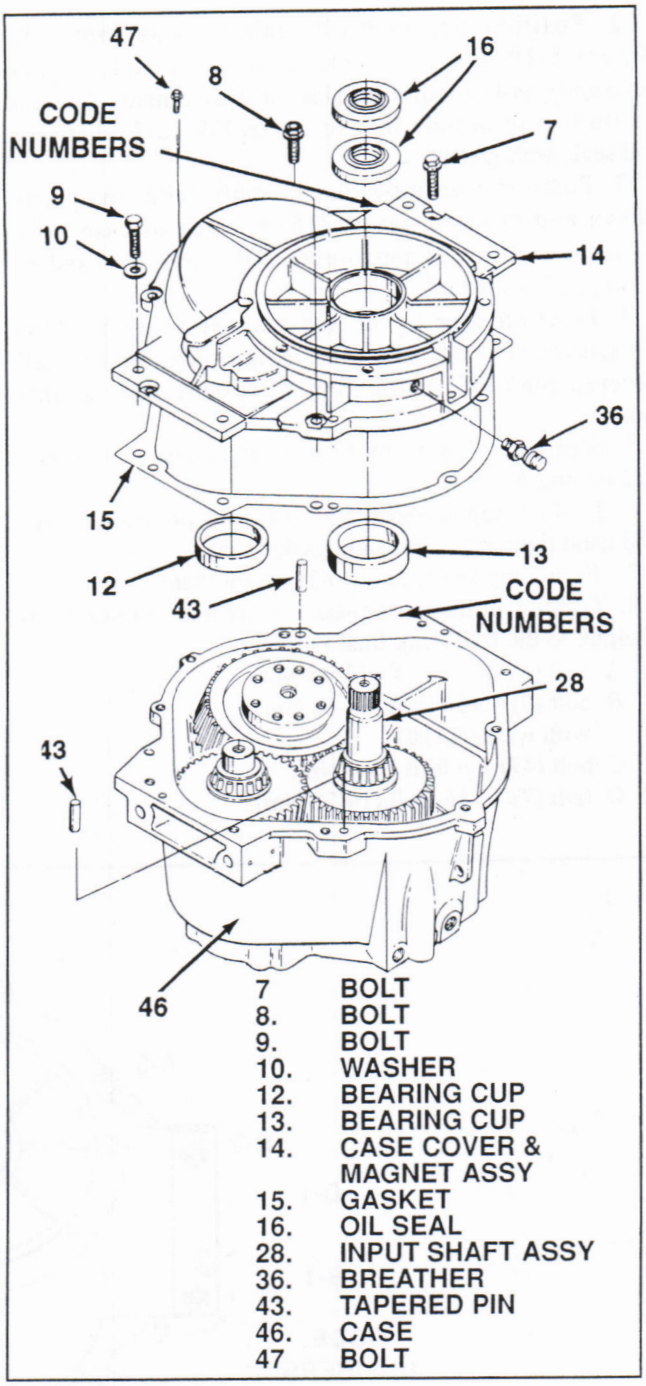


Figure 5-18. Case Cover and Bearing Cup Assembly

NOTE: Case cover and magnet assembly (14) and case (46) are a matched set as specified in paragraph 4-15. Check the code numbers as shown in figure 5-18 to make sure a matched set is being assembled. A mismatched case (46) and case cover and magnet assembly (14) may result in severe transmission damage.

1. If removed, press in new bearing cups (12 and\or 13) to bottom in case cover and magnet assembly (14).

2. Position two new oil seals (16) as shown in figure 5-19 and press into case cover and magnet assembly (14) so that outside face of outside oil seal is flush with outside face of cover. Fill cavity between oil seals with grease.

3. Position transmission assembly with pump end down and position gasket (15) on face of case (46). A light coating of petroleum jelly may be used to hold gasket in place.

4. Position case cover and magnet assembly (14) on gasket (15) on case (46). Align holes and install tapered pins (43) using finger pressure only at this time.

5. Start bolts (7, 8, 9 and 47) hand tight. Use Loctite ® 222 on bolt 47.

6. Lightly tap tapered pins (43) to position cover and hand tighten bolts to snug gasket (15).

7. Firmly tap tapered pins (43) to seat them.

8. Tighten bolts in sequence shown in figure 5-20 diagram to the following final torque:

A. bolt (8) 24-34 lb-ft (33-46 Nm)
B. bolt (9) 40-50 lb-ft (54-68 Nm) with washers (10)
C. bolt (47) 4-6 lb-ft (5-7 Nm)
D. bolt (7) 14-16 lb-ft (19-22 Nm)

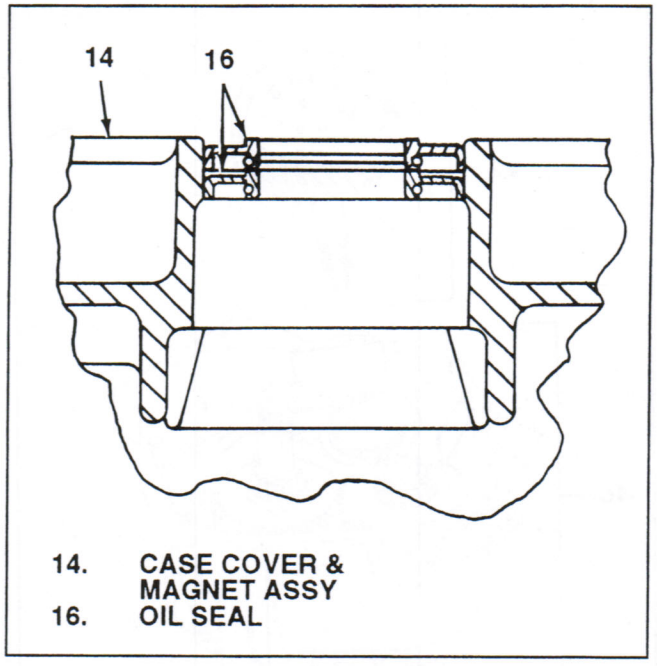


Figure 5-19. Input Shaft Oil Seals

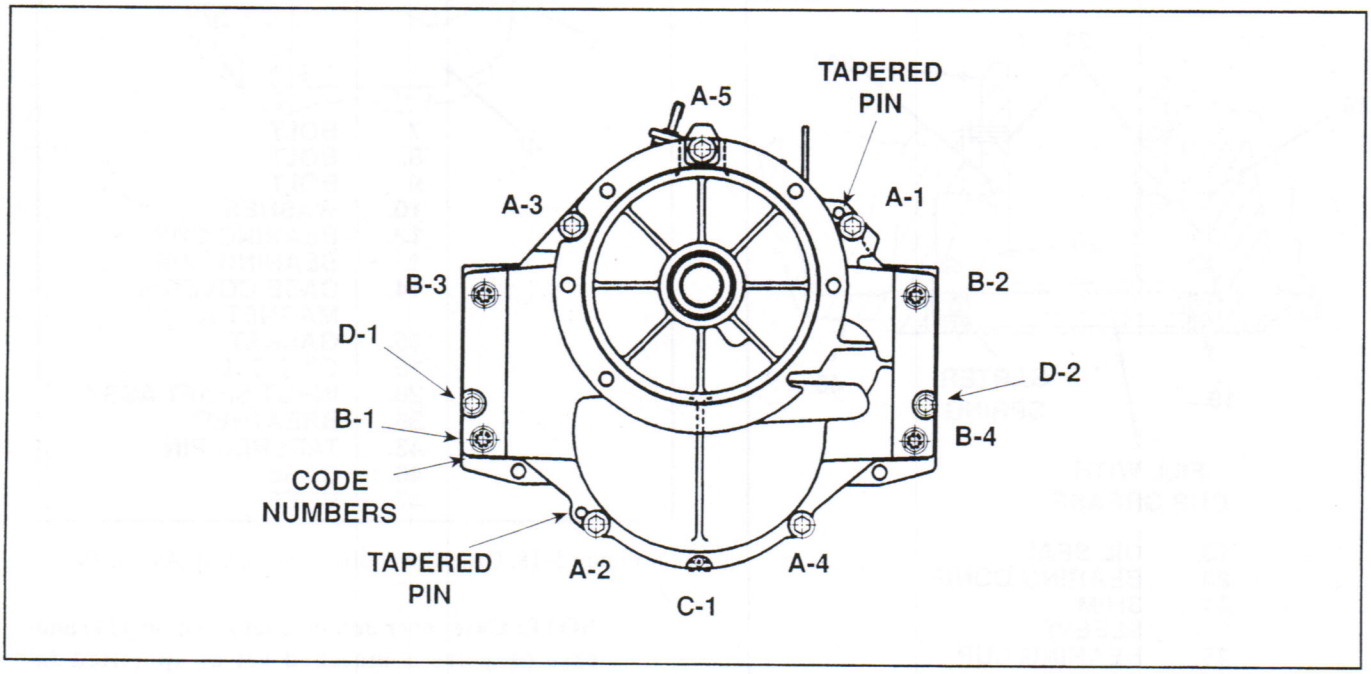


Figure 5-20. Torque Sequence

5-21. INSTALLING VALVE AND PUMP HOUSING ASSEMBLY.

Position transmission assembly with pump end up and proceed as follows (see figure 5-21):

NOTE: Steps 1 and 2 are mandatory.

1. Install bearing cone (31) and bearing cup (30). Position new gasket (5) on pump mounting face of case (46) and determine thickness of shim(s) (6) to be used at lay shaft bearing as follows:

a. Push down firmly on lay shaft assembly (29) and bearing cup (30) (see figure 5-22) to make sure parts are seated.

b. Measure and record dimension C as shown in figure 5-22 [from top face of gasket (5) to top face of bearing cup (30)].

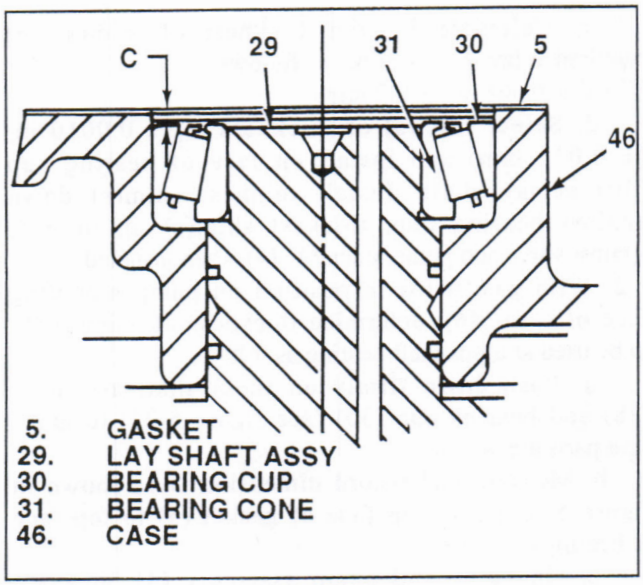


Figure 5-22. Determining Lay Shaft Bearing Shim Thickness

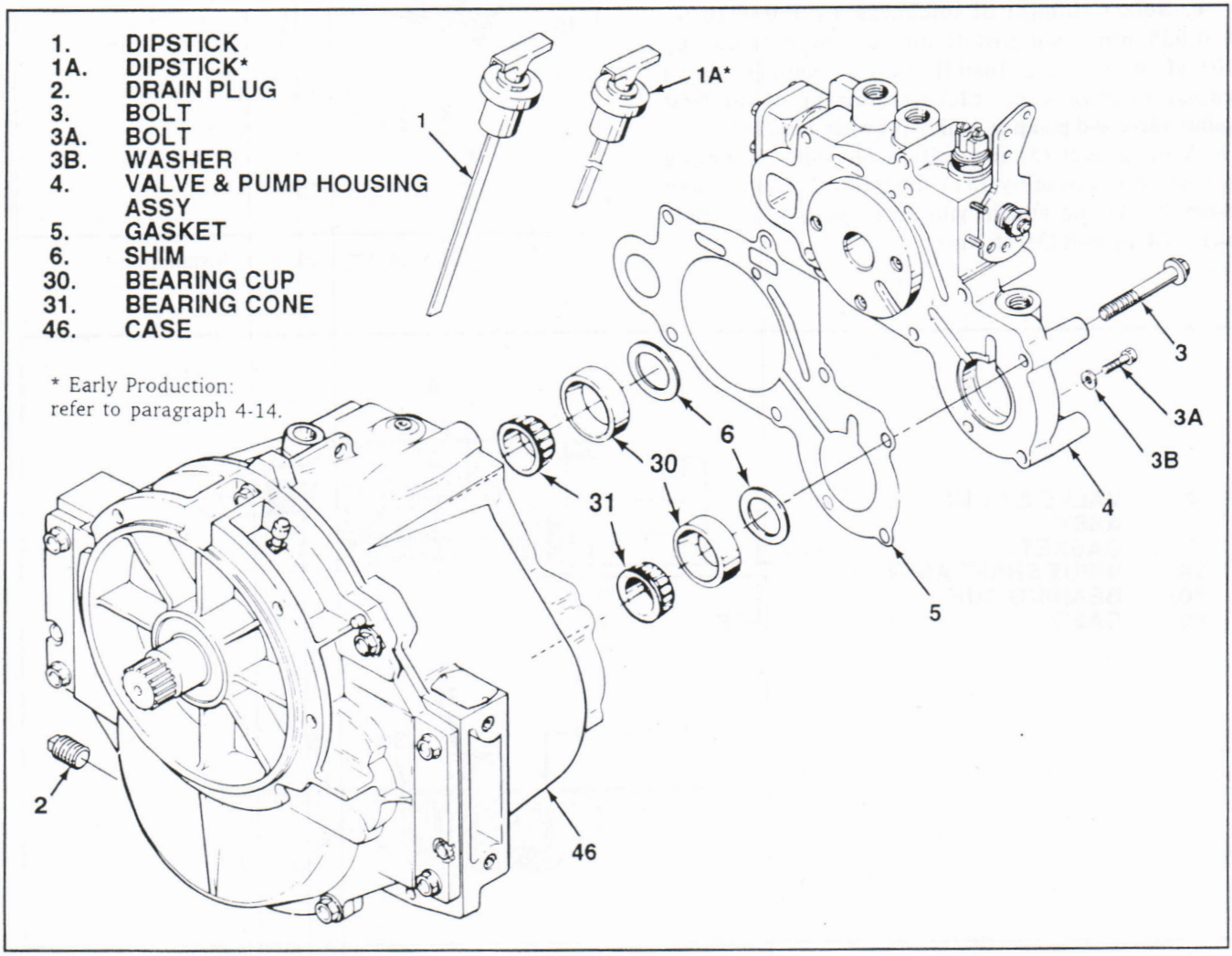


Figure 5-21. Valve and Pump Housing Assembly

c. Calculate T_1, the thickness of shim(s) (6) required at lay shaft bearing, as follows:

$T_1 = C + 0.004$ in. (0.102 mm)

d. Select shim(s) of thickness $T_1 \pm 0.0010$ in. (± 0.025 mm) and install on face of bearing cup (30) at lay shaft. Install thinnest shim(s) down against bearing cup, thickest shim(s) up to bear against valve and pump assembly (4) when installed.

2. With gasket (5) in position on pump mounting face of case (46), determine thickness of shim(s) (6) to be used at input shaft bearing as follows:

a. Push down firmly on input shaft assembly (28) and bearing cup (30) (see figure 5-23) to make sure parts are seated.

b. Measure and record dimension D as shown in figure 5-23 [from top face of gasket (5) to top face of bearing cup (30)].

c. On valve and pump assembly (4), measure and record dimension E as shown in figure 5-23.

d. Calculate T_2, the thickness of shim(s) (6) required at input shaft bearing, as follows:

$T_2 = D - E + 0.004$ in. (0.102 mm)

e. Select shim(s) of thickness $T_2 \pm 0.0010$ in. (± 0.025 mm) and install on face of bearing cup (30) at input shaft. Install thinnest shim(s) down against bearing cup, thickest shim(s) up to bear against valve and pump assembly (4) when installed.

3. With gasket (5) in position on pump mounting face of case assembly (41), install valve and pump assembly (4) and attach with seven bolts (3). Torque bolts to 24-34 lb-ft (33-46 Nm).

4. Install drain plug (2) and torque to 20-25 lb-ft (27-34 Nm).

5. Install dipstick tube assembly (39 or 39A) to a height of 0.875-0.900 (22-23mm). Install dipstick (1 or 1A). (See figure 5-24)

6. If breather (36, figure 5-18) was replaced install new breather with silicone sealant and seat with seating tool T-5006 as shown in figure 5-25.

7. Tighten output flange nut to 225-275 lb-ft (311-380 Nm).

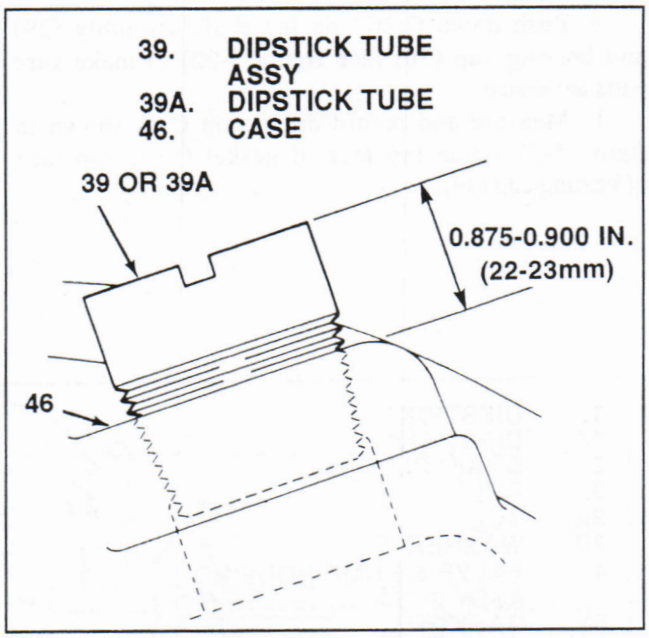


Figure 5-24. Dipstick Tube Installation

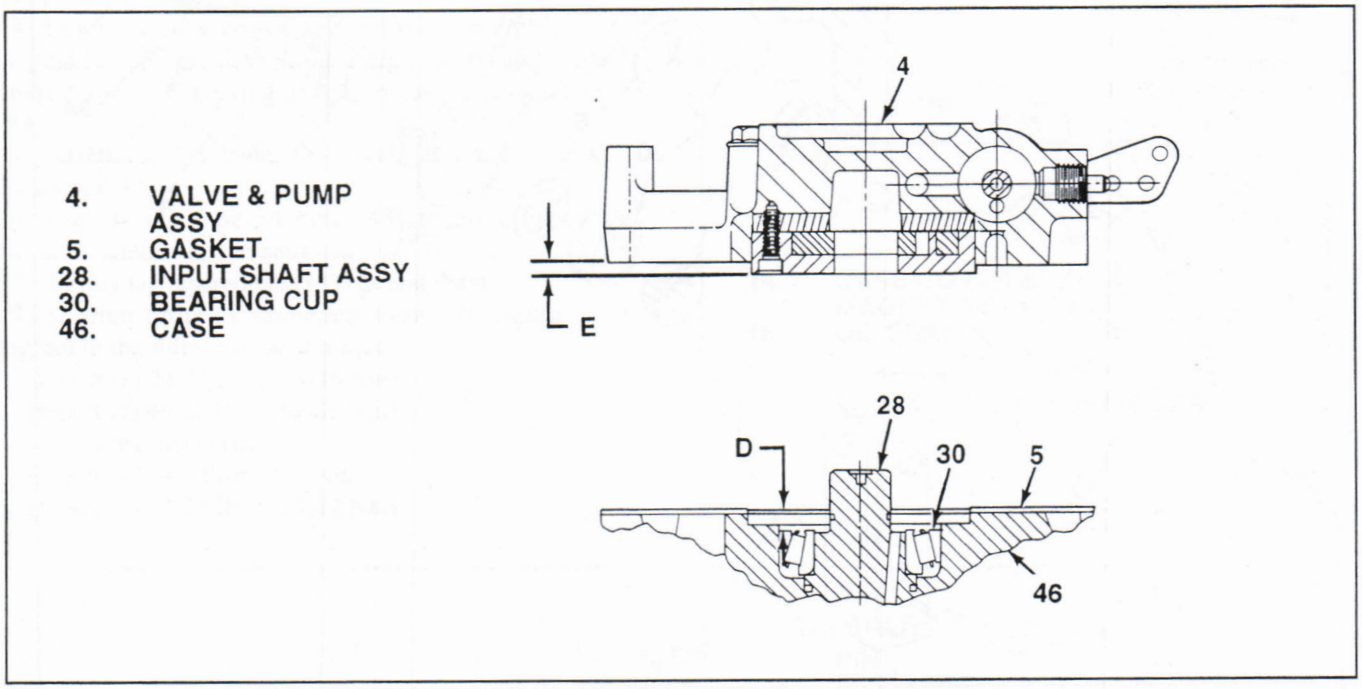


Figure 5-23. Determining Input Shaft Bearing Shim Thickness

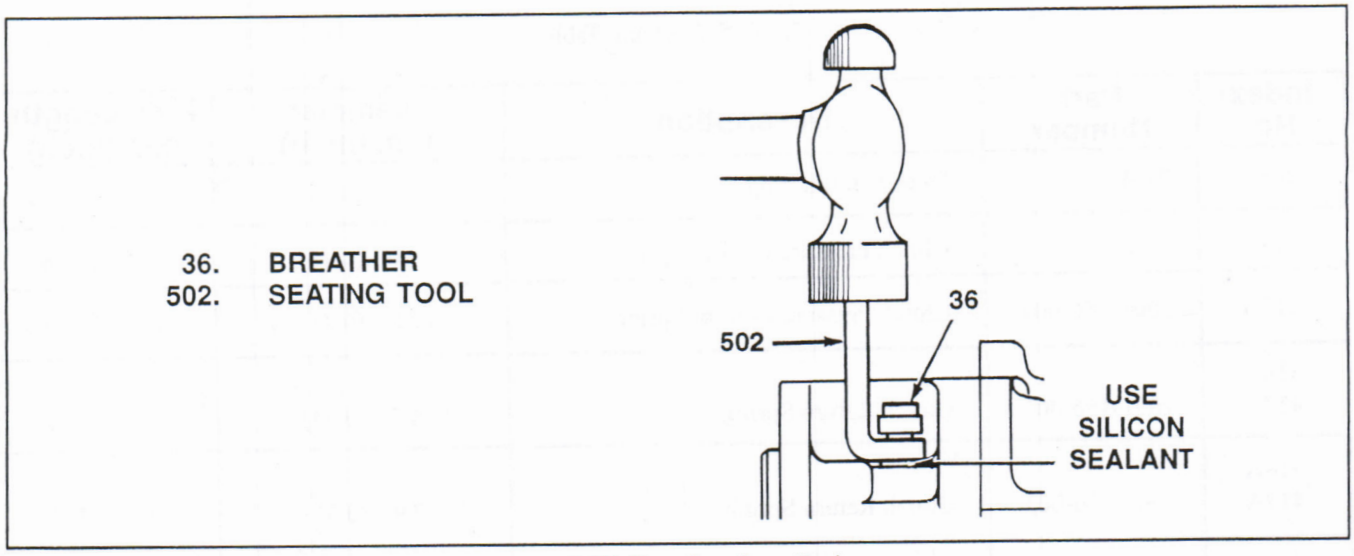


Figure 5-25. Breather Installation

Table 5-1. Torque Values

PART (INDEX No.)	TORQUE IN LB-FT	TORQUE IN Nm
Drain plug (2)	20-25	27-34
Bolt (3) (with Loctite* 242)	34-38	47-53
Bolt (7)	14-16	19-22
Bolt (8)	24-34	33-46
Bolt (9)	40-50	54-68
Flange Nut (17) (with nylon insert)	225-275	311-380
Bolt (25) (with Loctite* 271)	18-24	24-33
Bolt (32) (with Loctite* 242)	4-6	5-7
Bolt (47) (with Loctite* 222)	4-6	5-7
Bolt (2O1)	6-8	8-11
Switch Assy (203)	20-25	27-34
Nut (204)	14-16	9 22
Bolt (214)	4-5	5-7
Bolt (313) (with pre-applied Loctite*)	16-18	22-25
Bolt (411) (with pre-applied Loctite*)	16-18	22-25

* Loctite is registered trademark of Loctite Corporation.

Table 5-2. Spring Table

Index No.	Part Number	Description	Diameter mm (inch)	Free Length mm (inch)
209	71-42	Detent Ball Spring	7.9 (0.31)	25.8 (1.02)
217	71-242	Clutch Pressure Control Spring	4.0 (0.16)	16.7 (0.66)
217A	2001-156-004	Clutch Pressure Control Spring	12.2 (0.48)	63.5 (2.50)
318 417	2001-156-001	Clutch Return Spring	8.7 (0.34)	17.5 (0.69)
318A 417A	2001-156-003	Clutch Return Spring	7.9 (0.31)	24.9 (0.98)
430	72P-273	Relief Valve Spring	15.0 (0.59)	50.8 (2.00)