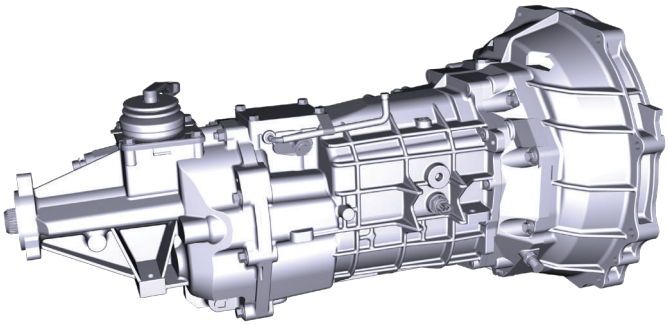
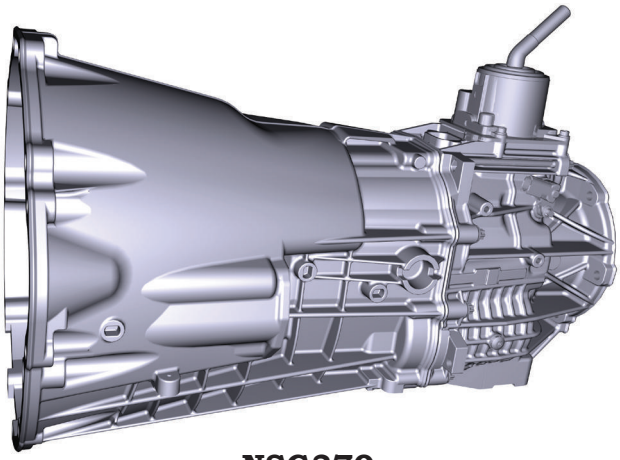
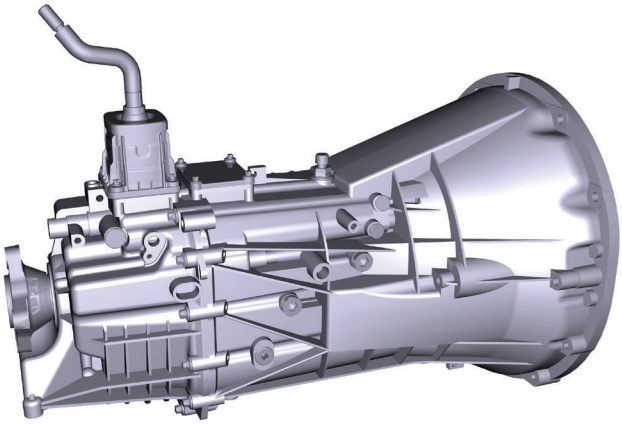
Rear Wheel Drive Manual Transmissions



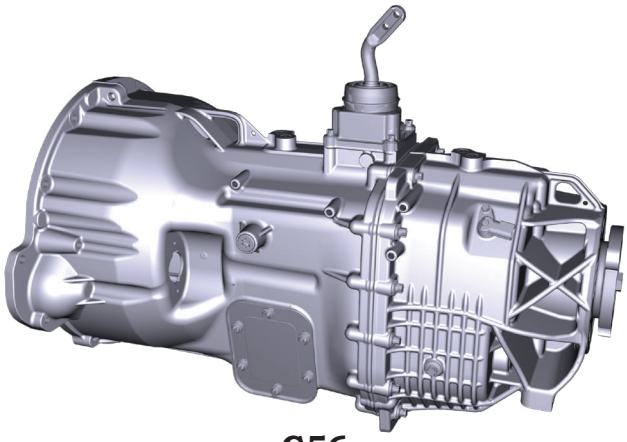
TR6060



NSG370



G238



G56

Rear Wheel Drive Manual Transmissions

TABLE OF CONTENTS

Notes:

Rear Wheel Drive Manual Transmissions

INTRODUCTION

Chrysler's RWD Manual Transmissions training course covers the identification, function, operation, and repair of the following transmissions:

- NSG370—Jeep Liberty (KJ) and Jeep Wrangler (TJ)
- G238—Dodge Ram 1500 (DR) and Dodge Dakota (ND)
- G56—Dodge Ram 2500 and 3500 (DH)
- TR6060—Dodge Viper (ZB) and Dodge Challenger (LC)

The unique service procedures and special tools required for the NSG370, G56, G238, and TR6060 transmissions are covered. Lubrication and identification of the transmission components are covered.

COURSE OBJECTIVES

After completing this course, a technician will be able to:

- Identify the manual transmission visually or using the identification tag.
- Identify the correct lubricant, fill level, and maintenance for the manual transmission.
- Describe the operation of the manual transmission.
- Identify the components of the manual transmission and the differences between the NSG370, G238, G56, and TR6060 transmissions.
- Describe the power flow through the manual transmission for each gear.
- Use the correct service procedures to perform the steps necessary to disassemble and assemble the manual transmission and identify special tools.
- Diagnose and evaluate transmission operation, and determine the appropriate repair path.
- Describe the operation of the clutch and clutch controls and the unique service procedures for the manual transmission.

ACRONYMS

The following is a list of acronyms used throughout this publication:

- 2WD 2–Wheel Drive
- 4WD 4–Wheel Drive
- ATB Automatic Torque Biasing
- ATF Automatic Transmission Fluid
- BUX Built Up for Export
- DMF Dual Mass Flywheel
- NSG Neues Schalt Getriebe (translated means New Manual Transmission)
- PTO Power Take Off
- RWD Rear Wheel Drive
- SB Service Bulletin

MODULE 1 MANUAL TRANSMISSION OVERVIEW

USAGE

The following table details which vehicles use each of the transmissions discussed in this course. This information is accurate for the 2009 model year.

Table 1 Transmission Applications

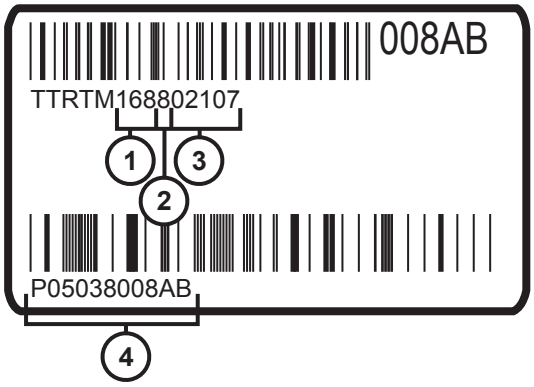
Transmission	Vehicle
NSG370	Jeep Liberty Jeep Wrangler Dodge Nitro
G56	Dodge 2500/3500 PickUp Dodge 3500 Chassis Cab Dodge 4500/5500 Chassis Cab
G238	Dodge 1500 PickUp Dodge Dakota
TR6060	Dodge Viper Dodge Challenger

IDENTIFICATION

Standard Chrysler Bar Code Label

Every transmission currently used in a Chrysler vehicle is required to use a standardized bar code label. This label contains build information which is critical for verifying part and bulletin information.

One line of the barcode starts with the letter "T," for Traceability. This line contains the Julian date, year, and sequence number. The second line starts with the letter "P," for Part, and contains the Chrysler part number.



1	Julian Date	3	Sequence Number
2	Year	4	Chrysler Part Number

Figure 1 Barcode Label

Table 2 Julian Date Reference—Non Leap-Year

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	001	032	060	091	121	152	182	213	244	274	305	335
2	002	033	061	092	122	153	183	214	245	275	306	336
3	003	034	062	093	123	154	184	215	246	276	307	337
4	004	035	063	094	124	155	185	216	247	277	308	338
5	005	036	064	095	125	156	186	217	248	278	309	339
6	006	037	065	096	126	157	187	218	249	279	310	340
7	007	038	066	097	127	158	188	219	250	280	311	341
8	008	039	067	098	128	159	189	220	251	281	312	342
9	009	040	068	099	129	160	190	221	252	282	313	343
10	010	041	069	100	130	161	191	222	253	283	314	344
11	011	042	070	101	131	162	192	223	254	284	315	345
12	012	043	071	102	132	163	193	224	255	285	316	346
13	013	044	072	103	133	164	194	225	256	286	317	347
14	014	045	073	104	134	165	195	226	257	287	318	348
15	015	046	074	105	135	166	196	227	258	288	319	349
16	016	047	075	106	136	167	197	228	259	289	320	350
17	017	048	076	107	137	168	198	229	260	290	321	351
18	018	049	077	108	138	169	199	230	261	291	322	352
19	019	050	078	109	139	170	200	231	262	292	323	353
20	020	051	079	110	140	171	201	232	263	293	324	354
21	021	052	080	111	141	172	202	233	264	294	325	355
22	022	053	081	112	142	173	203	234	265	295	326	356
23	023	054	082	113	143	174	204	235	266	296	327	357
24	024	055	083	114	144	175	205	236	267	297	328	358
25	025	056	084	115	145	176	206	237	268	298	329	359
26	026	057	085	116	146	177	207	238	269	299	330	360
27	027	058	086	117	147	178	208	239	270	300	331	361
28	028	059	087	118	148	179	209	240	271	301	332	362
29	029		088	119	149	180	210	241	272	302	333	363
30	030		089	120	150	181	211	242	273	303	334	364
31	031		090		151		212	243		304		365

Table 3 Julian Date Reference—Leap-Year ONLY

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	001	032	061	092	122	153	183	214	245	275	306	336
2	002	033	062	093	123	154	184	215	246	276	307	337
3	003	034	063	094	124	155	185	216	247	277	308	338
4	004	035	064	095	125	156	186	217	248	278	309	339
5	005	036	065	096	126	157	187	218	249	279	310	340
6	006	037	066	097	127	158	188	219	250	280	311	341
7	007	038	067	098	128	159	189	220	251	281	312	342
8	008	039	068	099	129	160	190	221	252	282	313	343
9	009	040	069	100	130	161	191	222	253	283	314	344
10	010	041	070	101	131	162	192	223	254	284	315	345
11	011	042	071	102	132	163	193	224	255	285	316	346
12	012	043	072	103	133	164	194	225	256	286	317	347
13	013	044	073	104	134	165	195	226	257	287	318	348
14	014	045	074	105	135	166	196	227	258	288	319	349
15	015	046	075	106	136	167	197	228	259	289	320	350
16	016	047	076	107	137	168	198	229	260	290	321	351
17	017	048	077	108	138	169	199	230	261	291	322	352
18	018	049	078	109	139	170	200	231	262	292	323	353
19	019	050	079	110	140	171	201	232	263	293	324	354
20	020	051	080	111	141	172	202	233	264	294	325	355
21	021	052	081	112	142	173	203	234	265	295	326	356
22	022	053	082	113	143	174	204	235	266	296	327	357
23	023	054	083	114	144	175	205	236	267	297	328	358
24	024	055	084	115	145	176	206	237	268	298	329	359
25	025	056	085	116	146	177	207	238	269	299	330	360
26	026	057	086	117	147	178	208	239	270	300	331	361
27	027	058	087	118	148	179	209	240	271	301	332	362
28	028	059	088	119	149	180	210	241	272	302	333	363
29	029	060	089	120	150	181	211	242	273	303	334	364
30	030		090	121	151	182	212	243	274	304	335	365
31	031		091		152		213	244		305		366

NSG370 Identification

The case plate number location on the NSG370 is on the top right side of the transmission bellhousing.

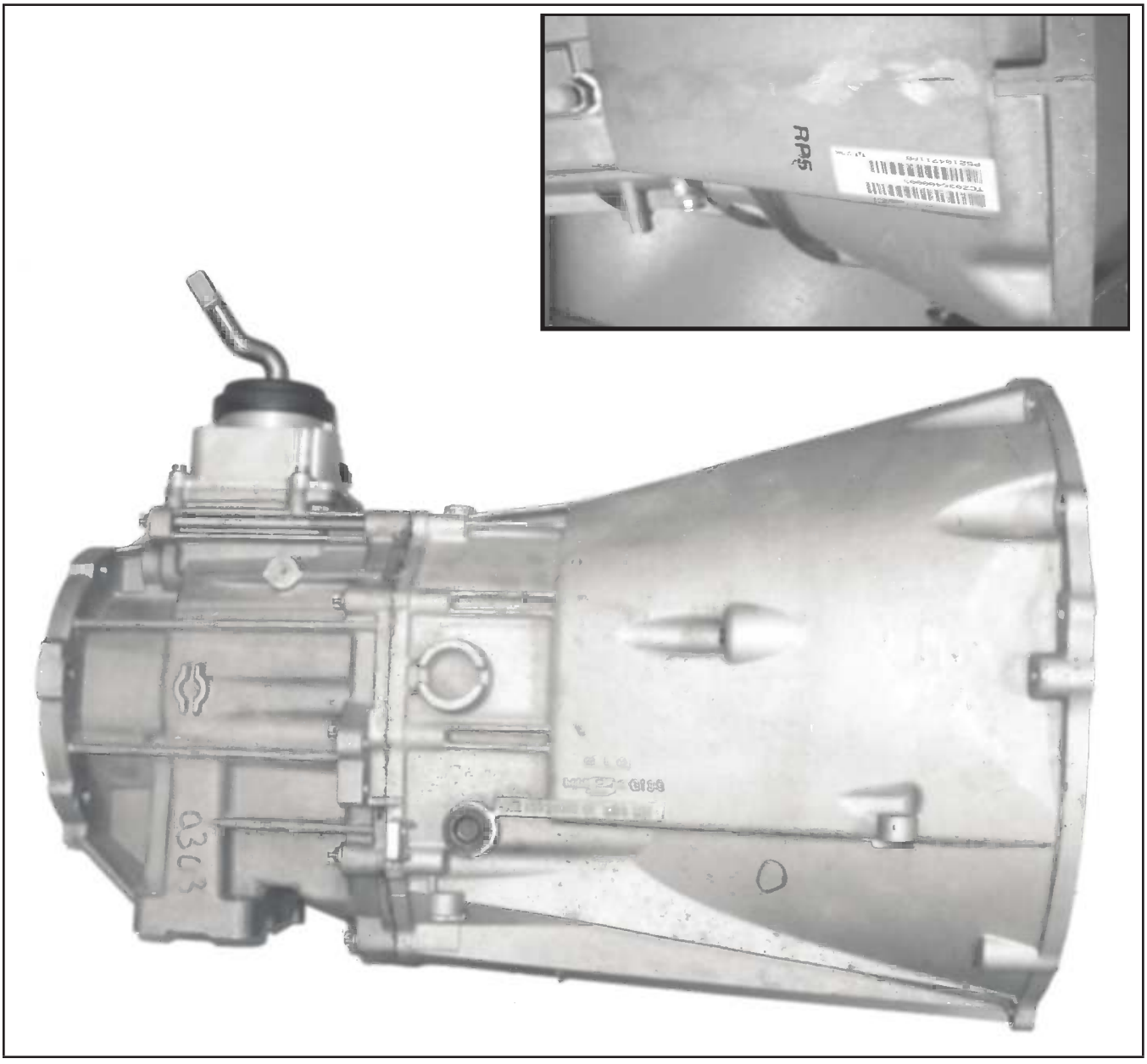


Figure 2 NSG370 Case Plate Number Location (4x4 Shown)

G56 Identification

The G56 case plate number may be located on the left forward side of the transmission bellhousing, or the right rear side of the case housing.

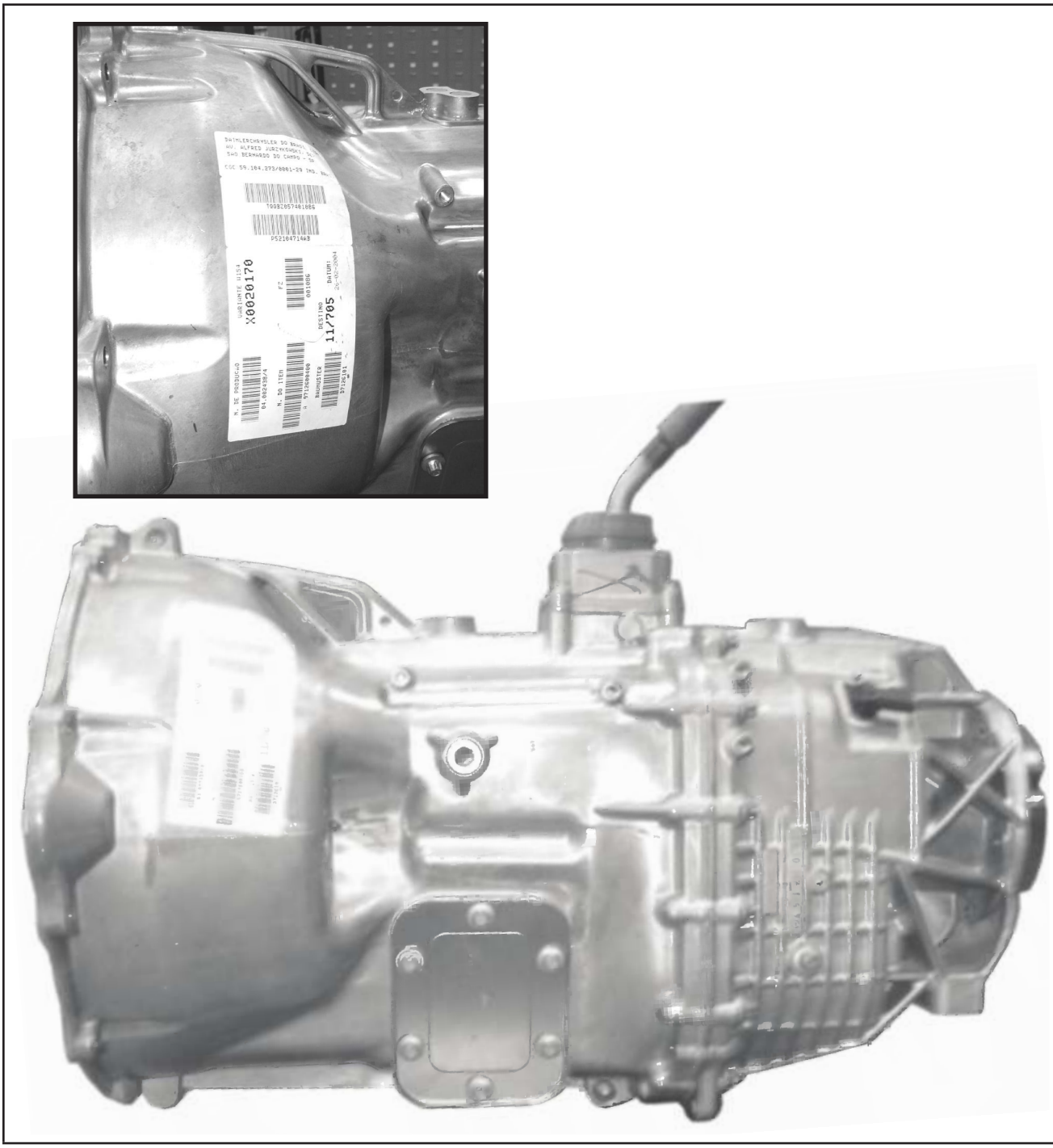


Figure 3 G56 Case Plate Number Location (4x2 Shown)

G238 Identification

The G238 case plate number is located on the top right side of the bellhousing.

Figure 4 G238 Case Plate Number Location (4x4 Shown)

TR6060 Identification

The TR6060 case plate number is located on the top right side of the front case half.

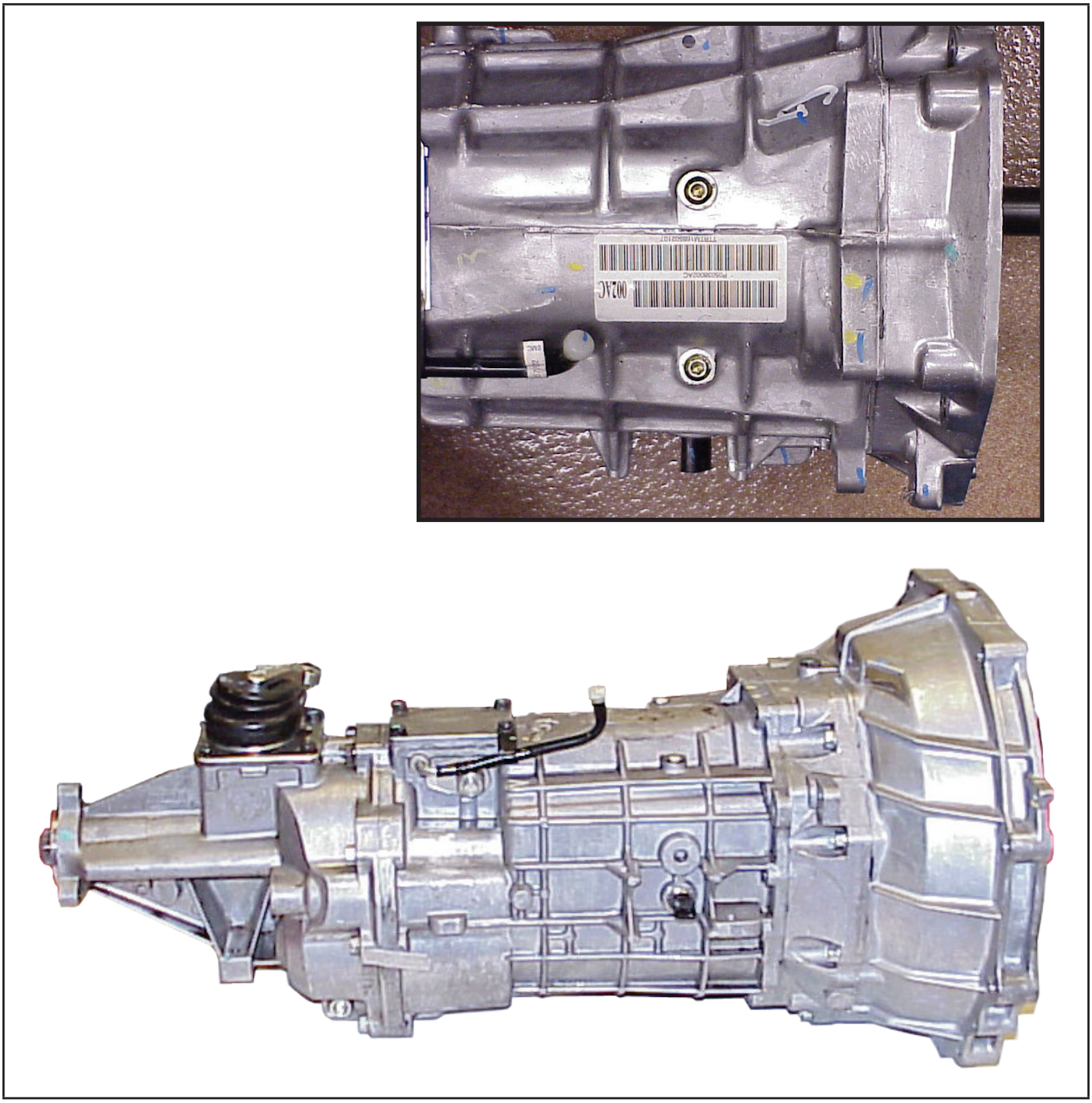
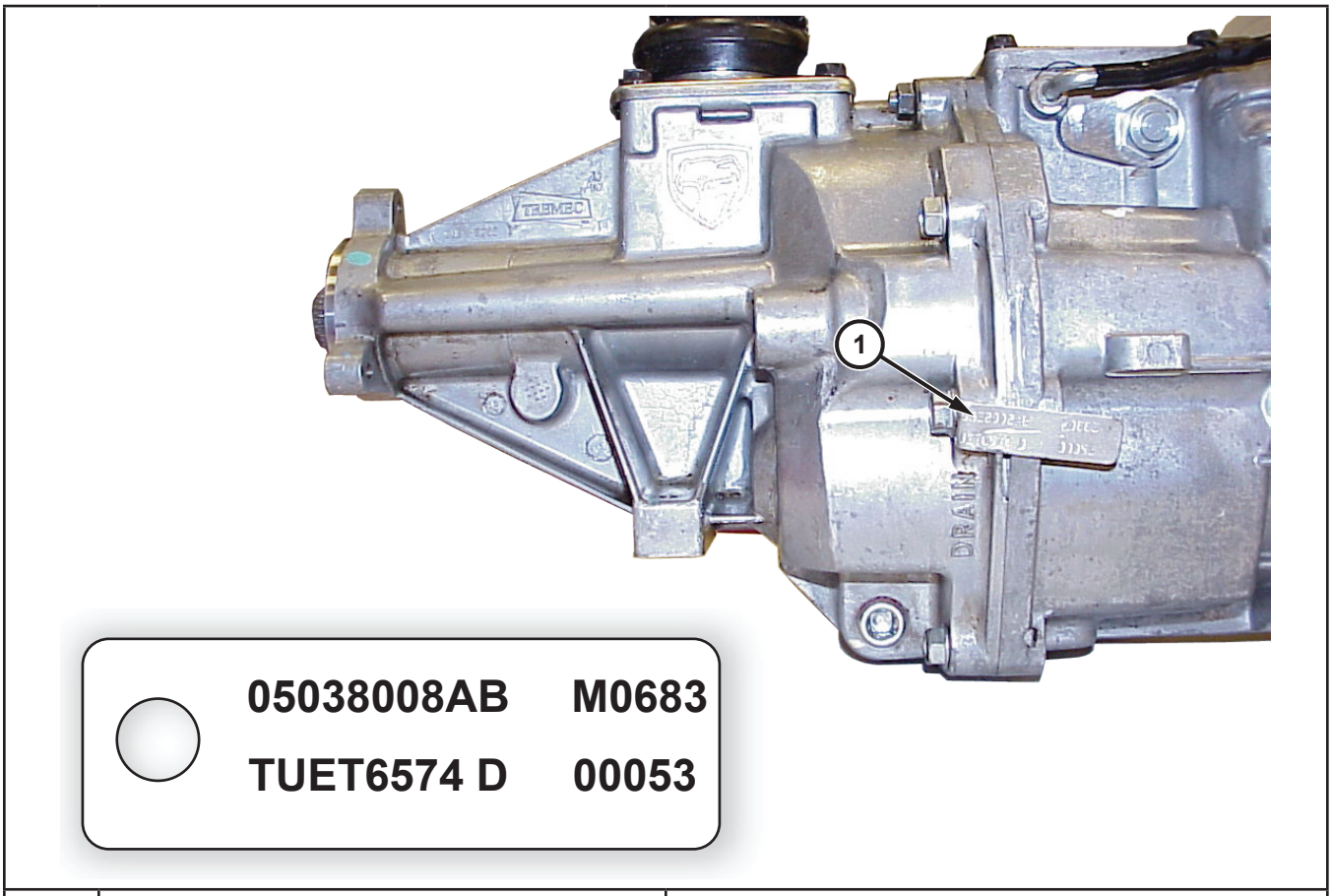


Figure 5 TR6060 Case Plate Number Location

The TR6060 also has a metal identification tag which is attached to the rear case by a case bolt. This tag contains the Tremec part number, Chrysler part number, date of manufacture, and Tremec sequence number. This tag may be located on the left or right side of the transmission.



1	Tremec Identification Label	

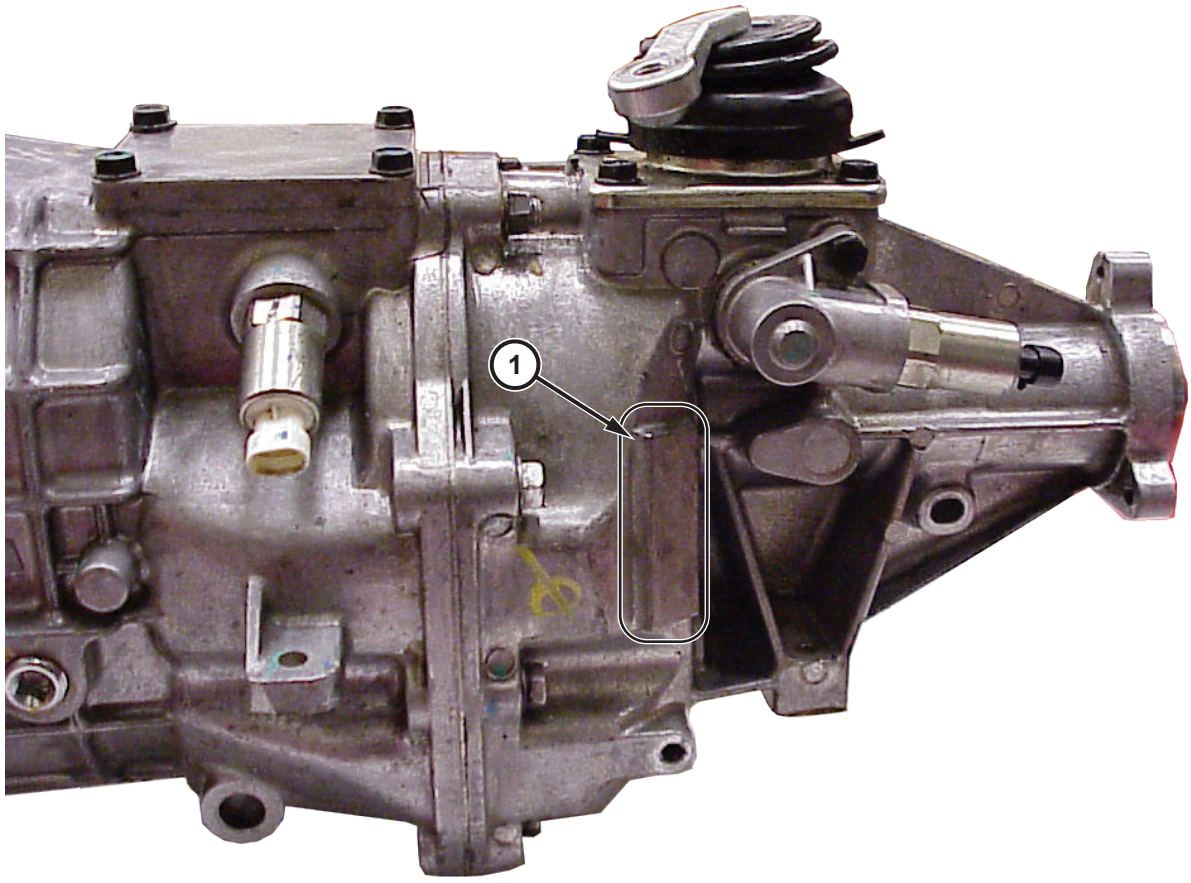
Figure 6 Tremec Identification Label

05038008AB	=	Chrysler Part Number
M0683	=	Mfg. Date & Shift
M	=	December
06	=	06th day of December
8	=	2008
3	=	3rd Shift
TUET6574	=	TREMEC Parts Number
D	=	Revision Level
00053	=	Serial Number

Table 4 Tremec Date Code Information

Month Code	
A = January	G = July
B = February	H = August
C = March	J = September
D = April	K = October
E = May	L = November
F = June	M = December

The TR6060 also has a Vehicle Identification Number (VIN) block which contains the last 8 digits of the VIN.

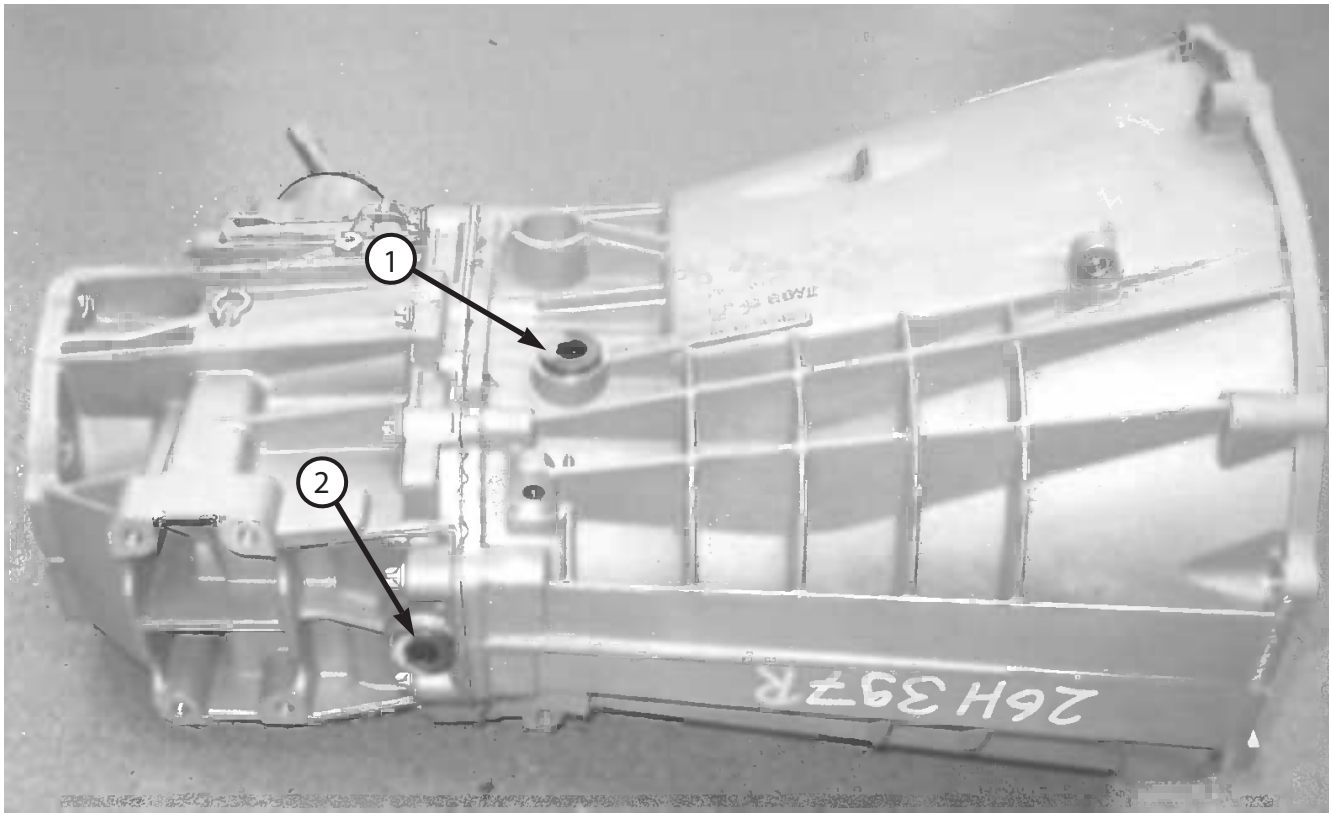


1	VIN Block	

Figure 7 TR6060 VIN Block

DRAIN, FILL, AND FLUID

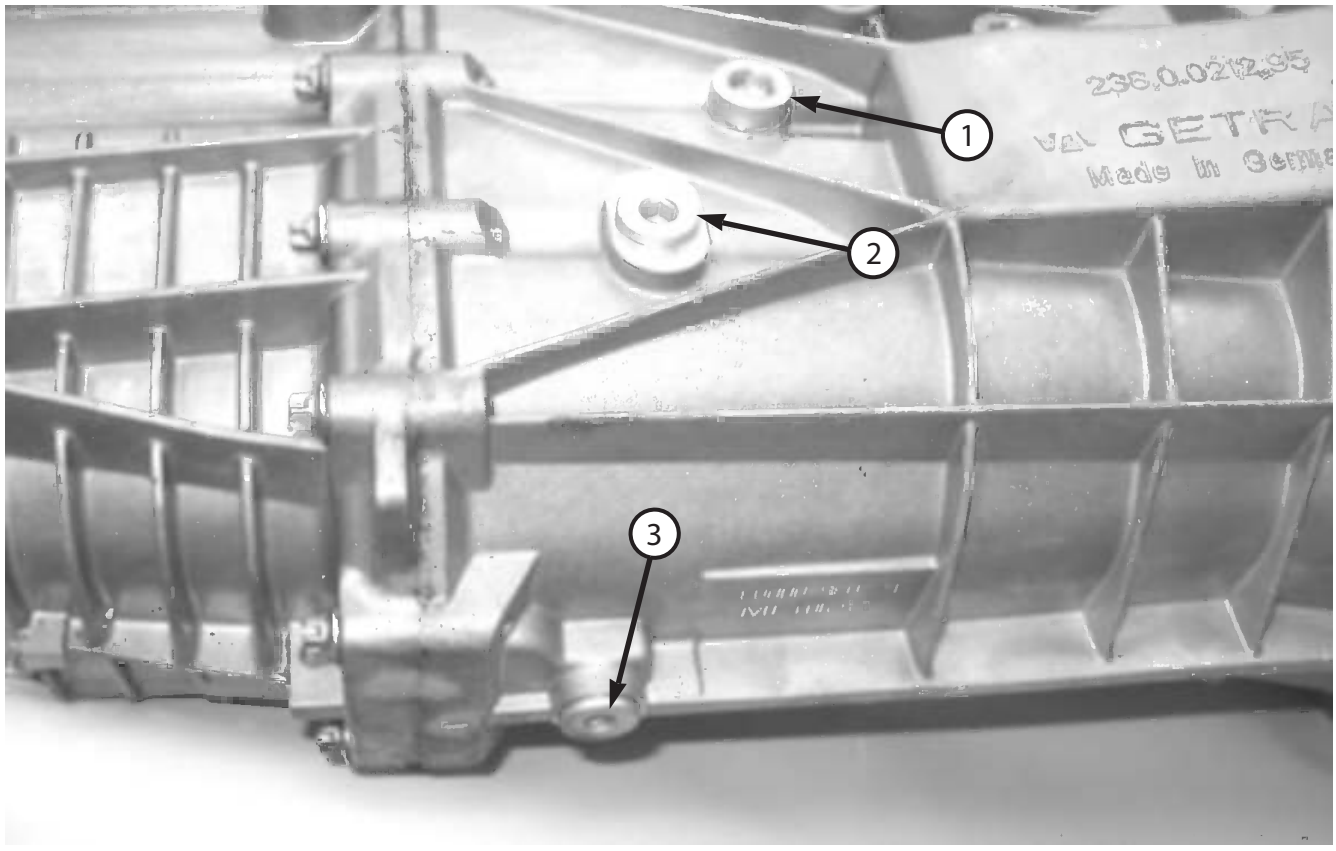
The NSG370 uses Mopar Manual Transmission Lubricant and requires 1.5 liters (1.6 quarts) to fill the transmission to the bottom of the fill plug. The drain plug is located on the bottom of the rear case and the fill plug is located on the right side of the front case. Both plugs use a 14 mm Allen socket.



1	Fill Plug	2	Drain Plug

Figure 8 NSG370 Drain and Fill Plugs

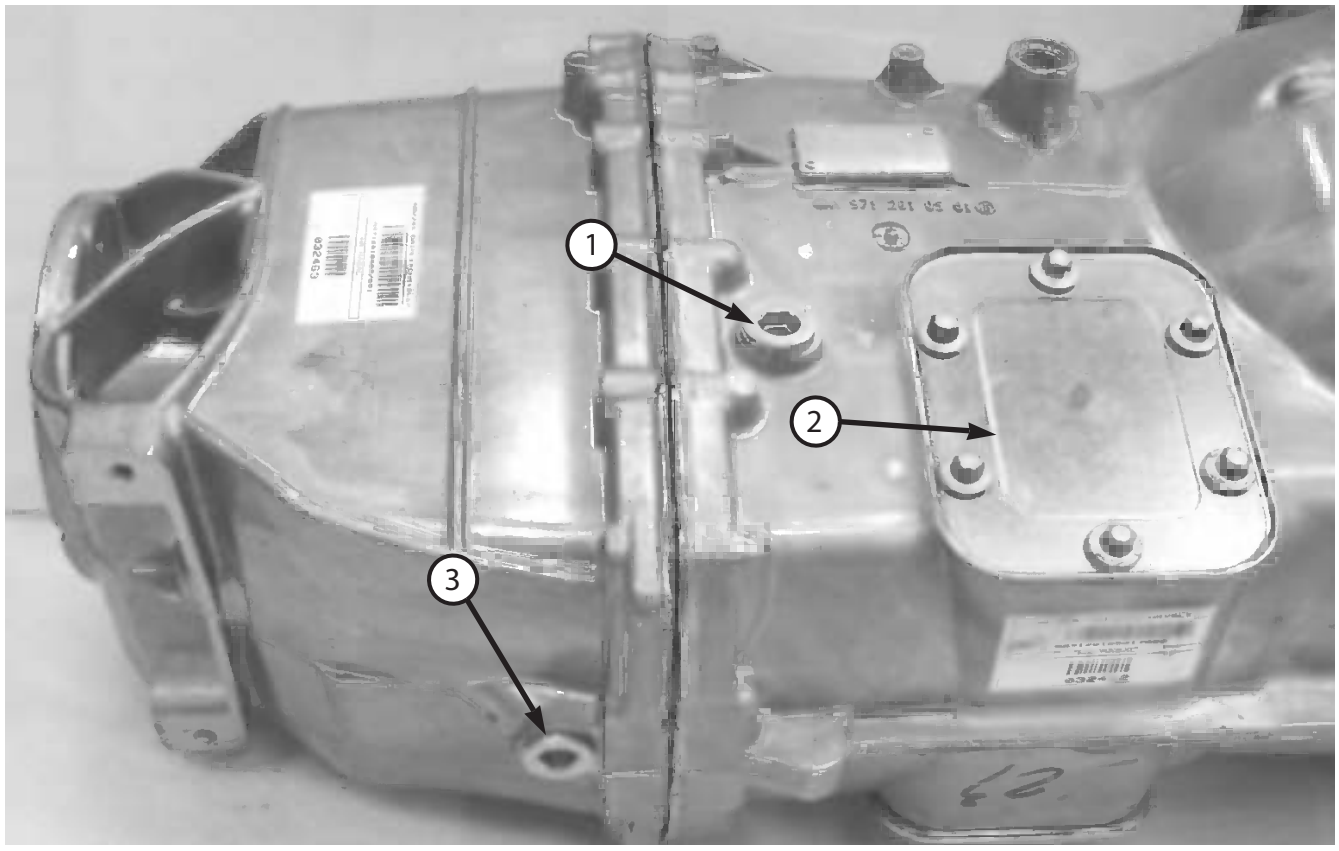
The G238 uses ATF+4 automatic transmission fluid and requires 2.2 liters (2.3 quarts) to fill the transmission to the bottom of the fill plug. The drain plug is located on the bottom of the front case half and the fill plug is located on the right side of the front case half just below the 3/4 synchronizer pivot pin. The fill plug uses an 8 mm allen wrench and the pivot bolt uses a 12 mm allen wrench to remove the pin.



1	3/4 Shift Fork Pivot Pin	3	Drain Plug
2	Fill Plug		

Figure 9 G238 Drain and Fill Plugs

The G56 uses ATF+4 automatic transmission fluid and requires 5.9 liters (6.2 quarts) to fill the transmission on the 5.9L diesel engine and the 5.7L Hemi takes 5.1 liters (5.4 quarts). The transmission is filled to the bottom of the fill plug. The drain plug is located on the bottom of the rear case half and the fill plug is on the right side of the front case half behind the Power Take Off (PTO) plate cover. The fill plug uses a 14 mm allen wrench and the pivot bolt uses a Torx bit to remove the pin.

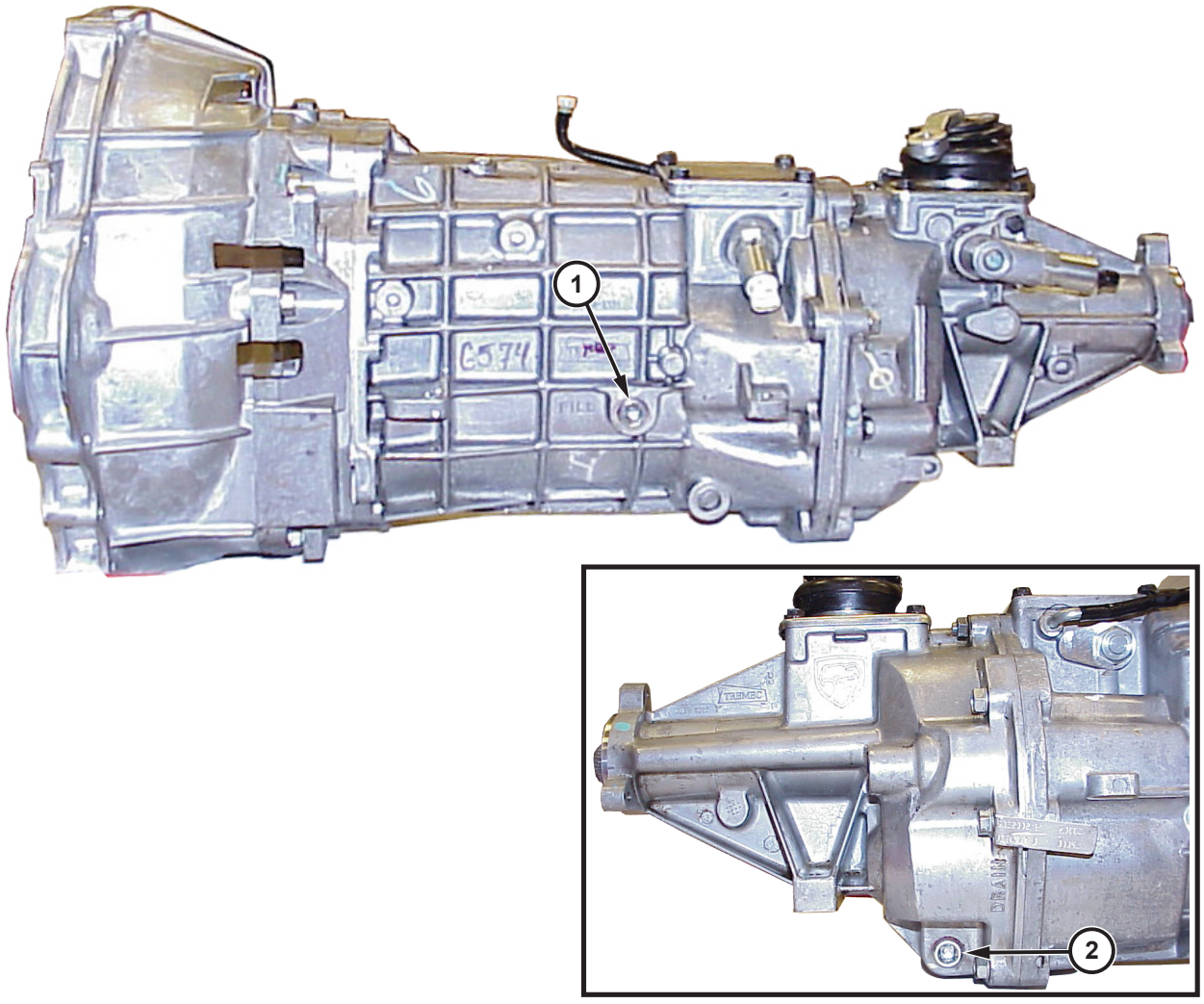


1	Fill Plug	3	Drain Plug
2	PTO Cover		

Figure 10 G56 Drain and Fill Plugs

The TR6060 uses ATF+4 automatic transmission fluid, and require 3.2 liters (3.4 quarts) to fill the Viper transmission, and 3.5 liters (3.7 quarts) for the Challenger. The fill plug is located on the left side of the transmission. The drain plug is located at the right rear of the transmission on the tail extension housing. A 3/8" square drive is required to remove or install the drain and fill plugs.

Note: The factory transmission fill may be slightly above the service fill plug. This may result in a small amount of fluid spilling out the first time the fill plug is removed from the transmission. Refer to the Service Information for the current service fill level.



1	Fill Plug	2	Drain Plug

Figure 11 TR6060 Drain and Fill Plugs

Table 5 Transmission Fluid Types and Capacities

Transmission	Fluid Type	Fluid Capacity
NSG370	Mopar® Manual Transmission Lubricant	1.5 liters (1.6 quarts)
G56	ATF+4	**Diesel:** 5.9 liters (6.2 quarts) **Gas:** 5.1 liters (5.4 quarts)
G238	ATF+4	2.2 liters (2.3 quarts)
TR6060	ATF+4	**Viper:** 3.2 liters (3.4 quarts) **Challenger:** 3.5 liters (3.7 quarts)

Notes:

Notes:

MODULE 2 NSG370 MANUAL TRANSMISSION

GEAR RATIOS

The table below shows the gear ratios for the NSG370 transmissions. The NSG370 is available in the Jeep Wrangler (TJ), the Jeep Liberty (KJ/KK) and the Dodge Nitro (KA).

Table 6 Gear Ratios

Gear	NSG370
1st	4.46
2nd	2.61
3rd	1.72
4th	1.25
5th	1.00
6th	0.84
Reverse	4.06

SHIFT PATTERN

The shift patterns for the NSG370 and G238 transmissions are the same. The illustration below shows the shift patterns for the transmissions.

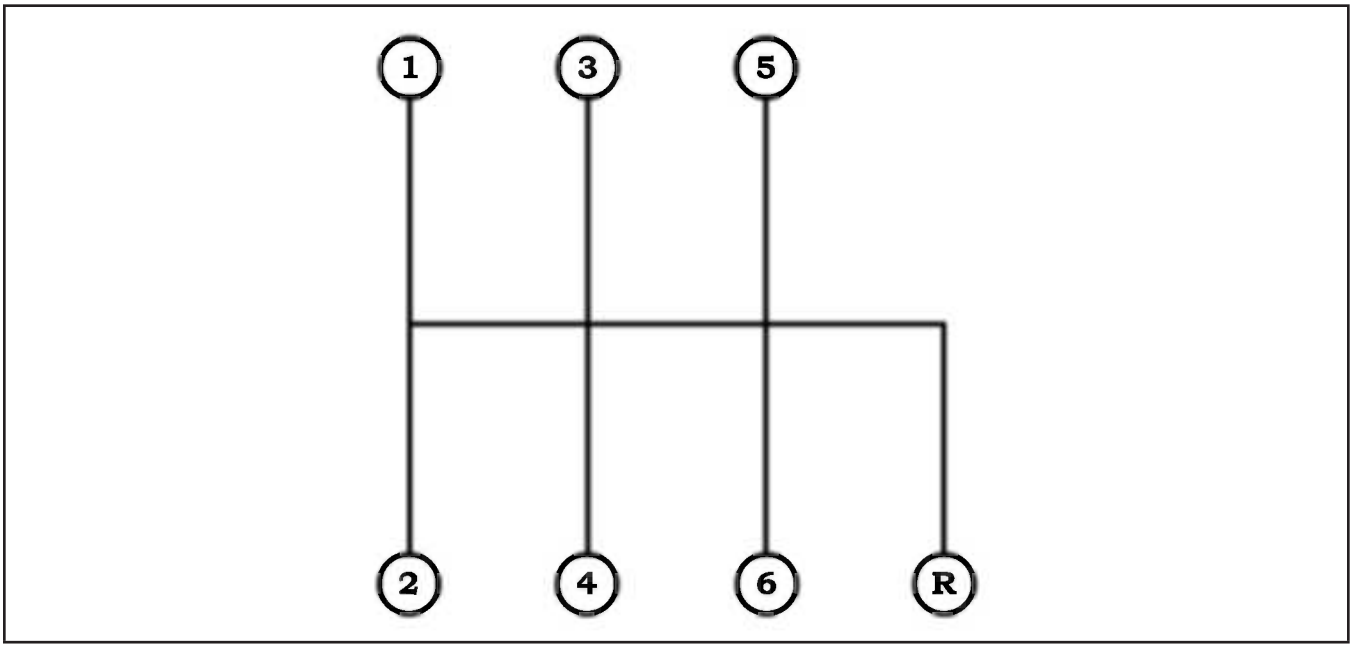
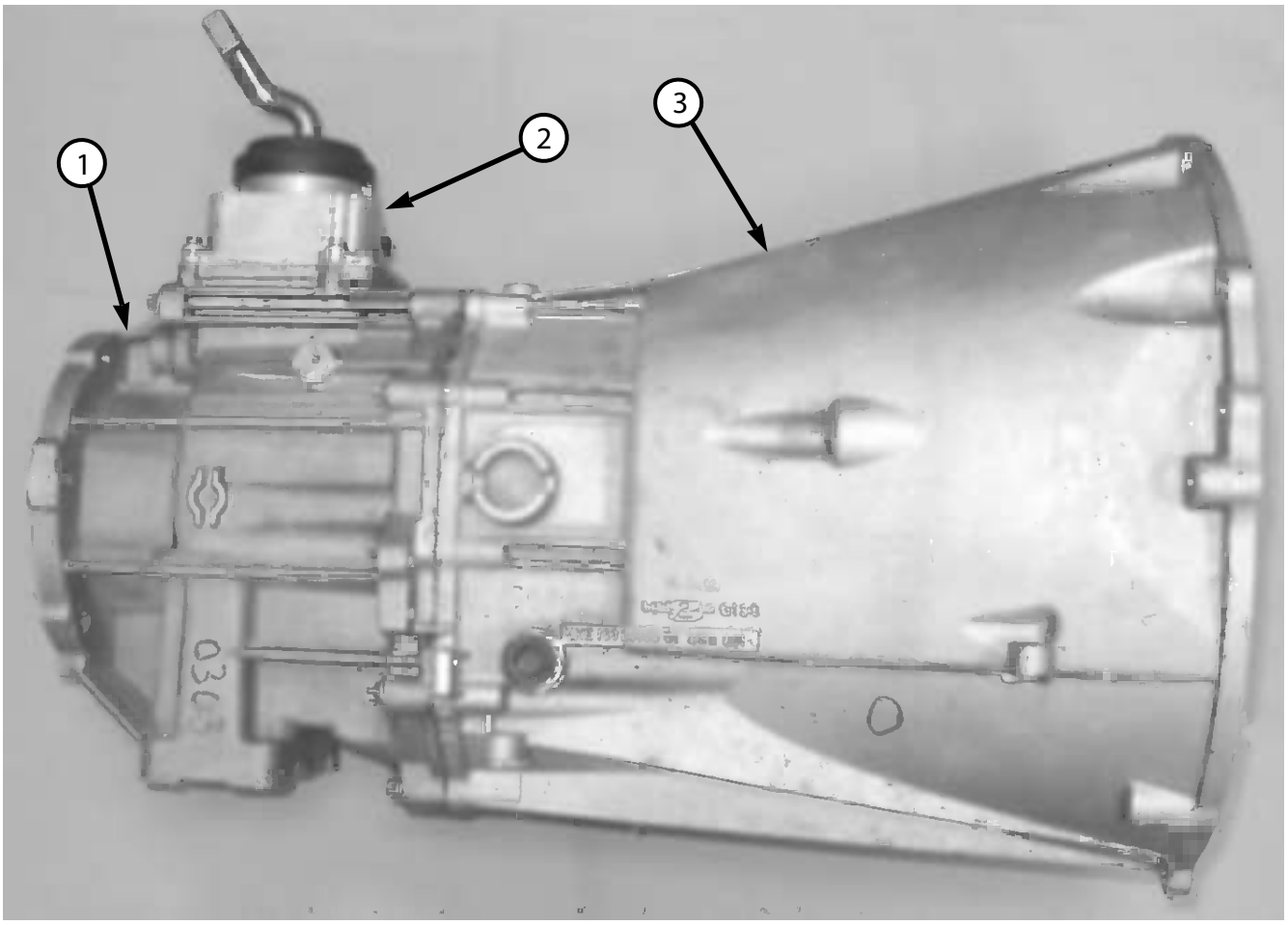


Figure 12 NSG370 and G238 Shift Pattern

COMPONENTS

Housing

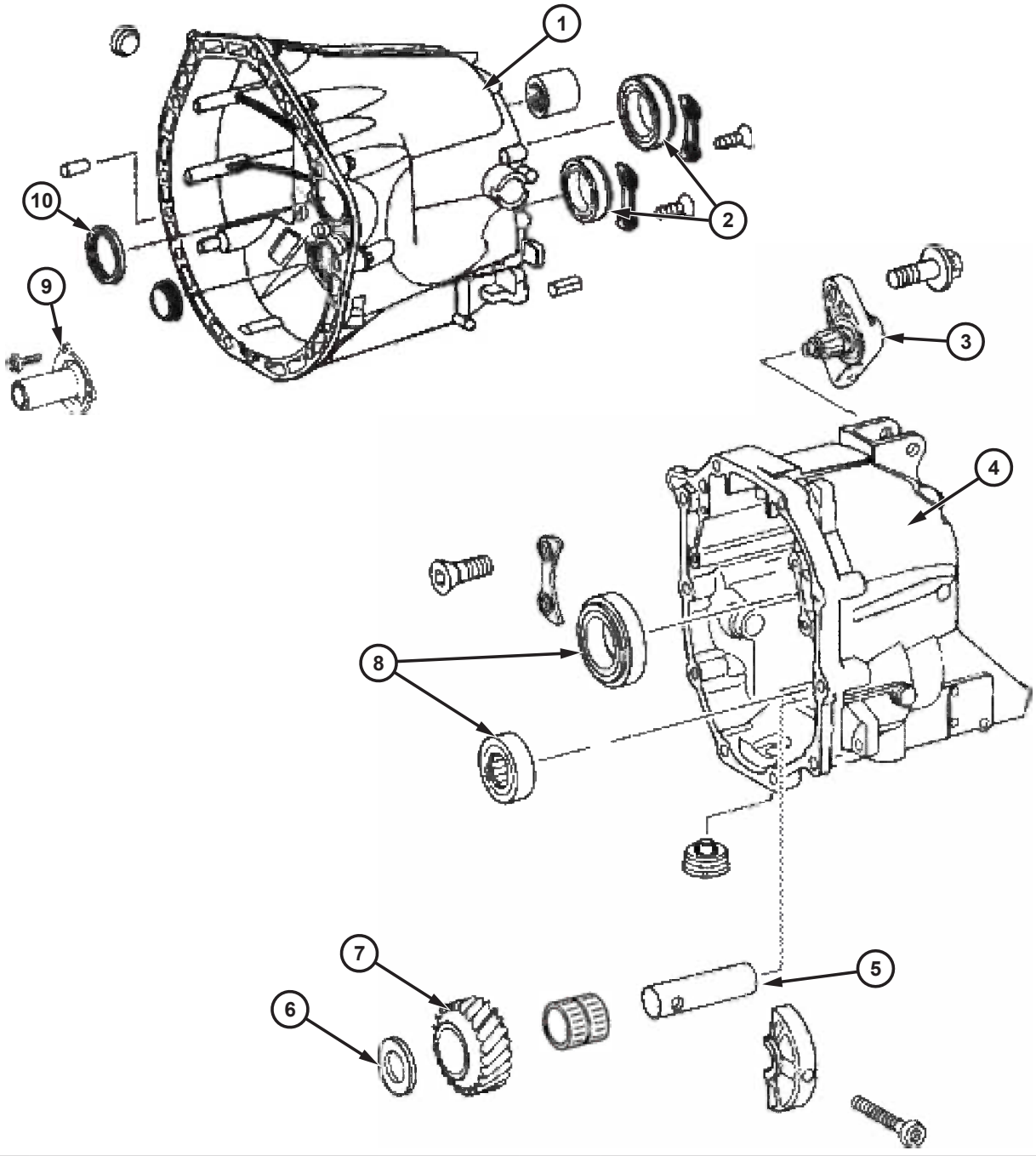
The NSG370 transmission housing contains 3 pieces: the front housing, the rear housing, and the shift tower. The front and rear housing splits to remove the input shaft, main shaft, reverse shaft, and counter shaft.



1	Rear Housing	3	Front Housing
2	Shift Tower		

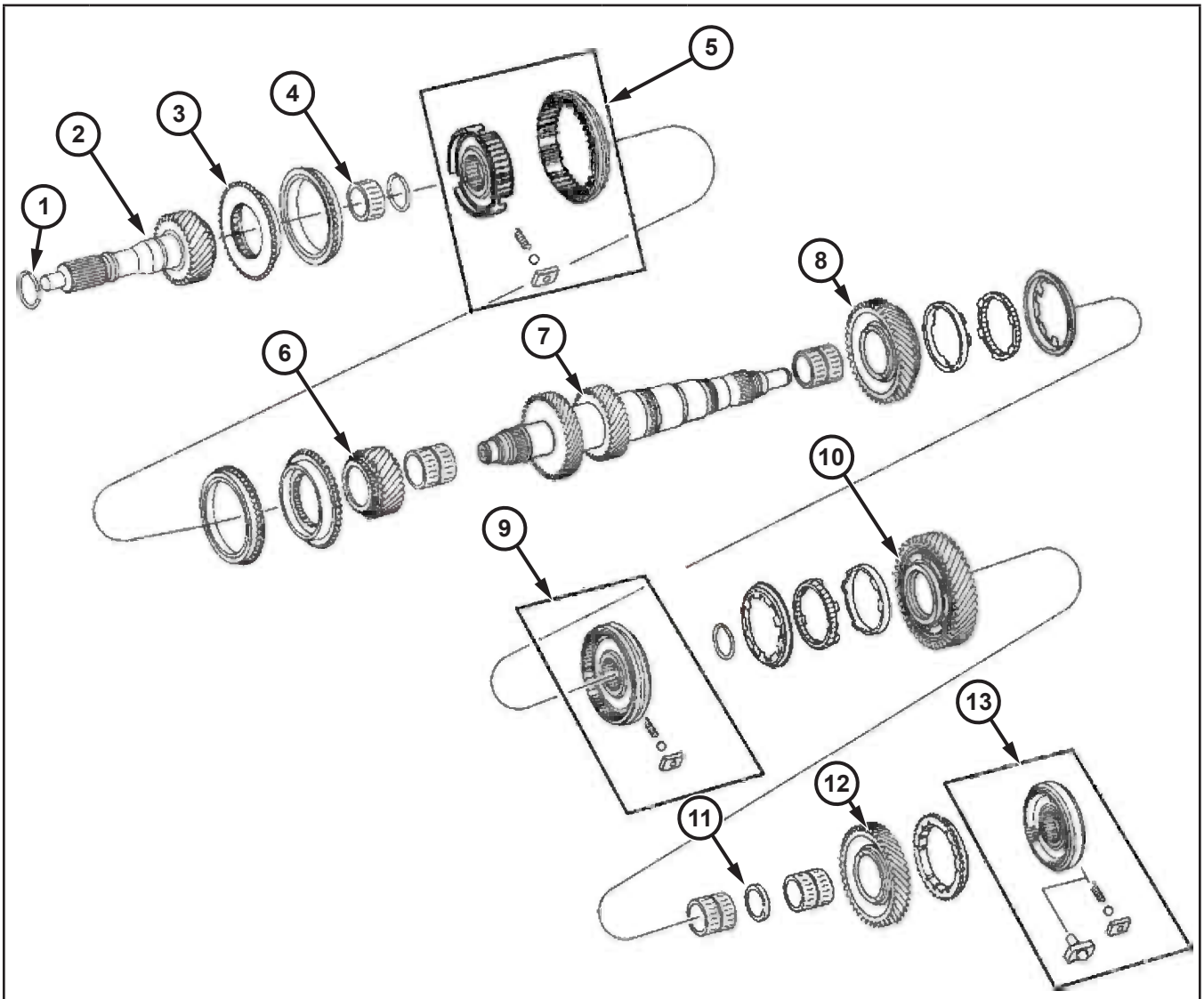
Figure 13 NSG370 Transmission Housing

Disassembled Transmission Views



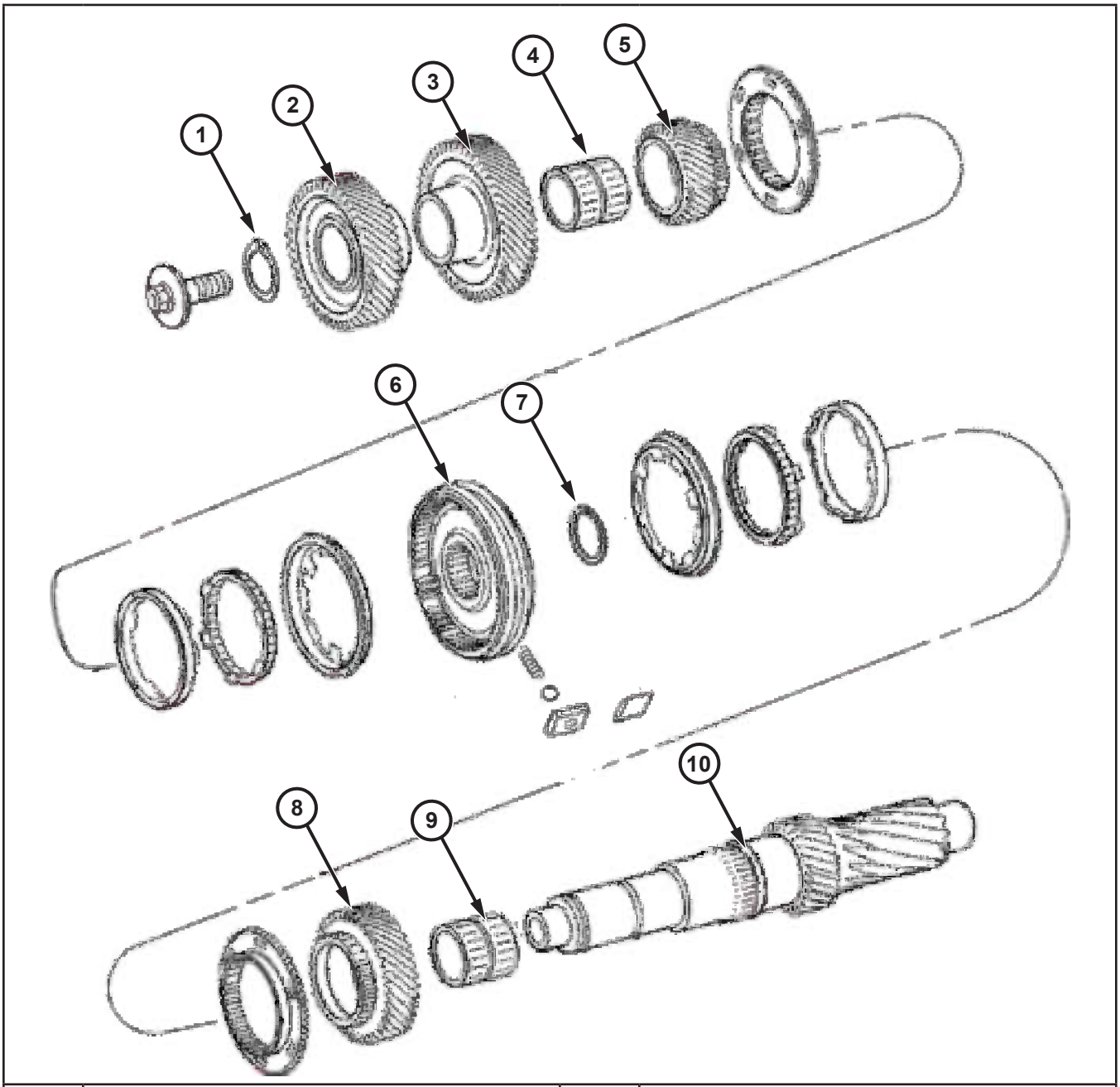
1	Front Case Half	6	Thrust Washer
2	Front Sealed Ball Bearings	7	Reverse Idler Gear
3	Reverse Lamp Switch	8	Rear Sealed Ball Bearings
4	Rear Case Half	9	Clutch Release Bearing Support
5	Reverse Idler Gear Shaft	10	Input Shaft Oil Seal

Figure 14 NSG370 Disassembled Case



1	Snap Ring	8	Second Driven Gear (Freewheeling)
2	Input Shaft	9	1–2 Synchronizer
3	Input Shaft Synchronizer Clutch Ring	10	First Driven Gear (Freewheeling)
4	Input Shaft Support Bearing	11	Thrust Washer
5	5–6 Synchronizer	12	Reverse Driven Gear (Freewheeling)
6	Fifth Driven Gear (Freewheeling)	13	Reverse Synchronizer
7	Main Shaft		

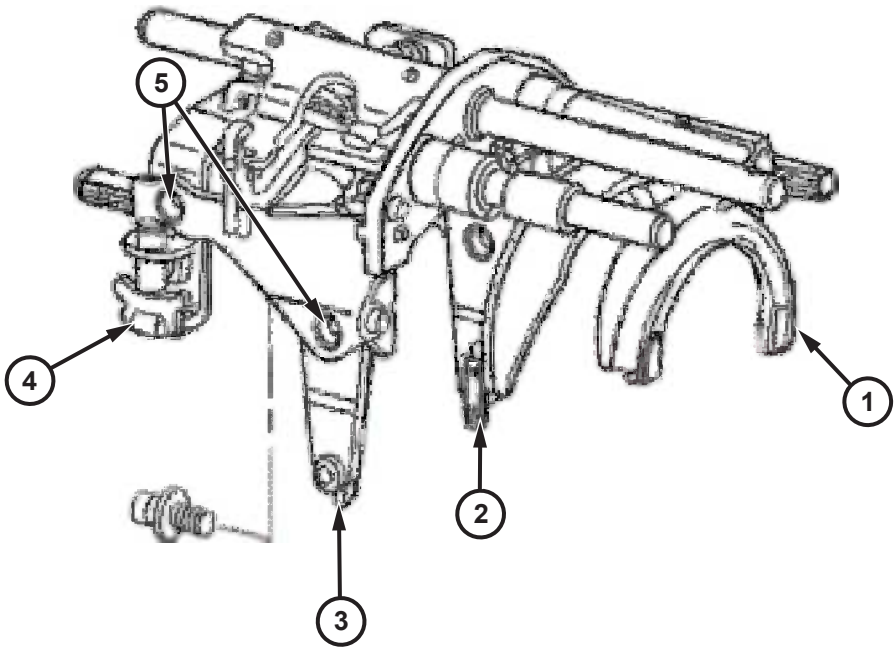
Figure 15 NSG370 Input and Mainshaft Disassembled View



1	Snap Ring	6	3–4 Synchronizer
2	Counter Shaft Input Gear	7	Snap Ring
3	Sixth Drive Gear (Fixed)	8	Fourth Drive Gear (Freewheeling)
4	Third Gear Needle Bearing	9	Fourth Gear Needle Bearing
5	Third Drive Gear (Freewheeling)	10	Counter Shaft

Figure 16 NSG370 Disassembled Counter Shaft

The shift rails and forks for the NSG370 are serviced together as an assembly.

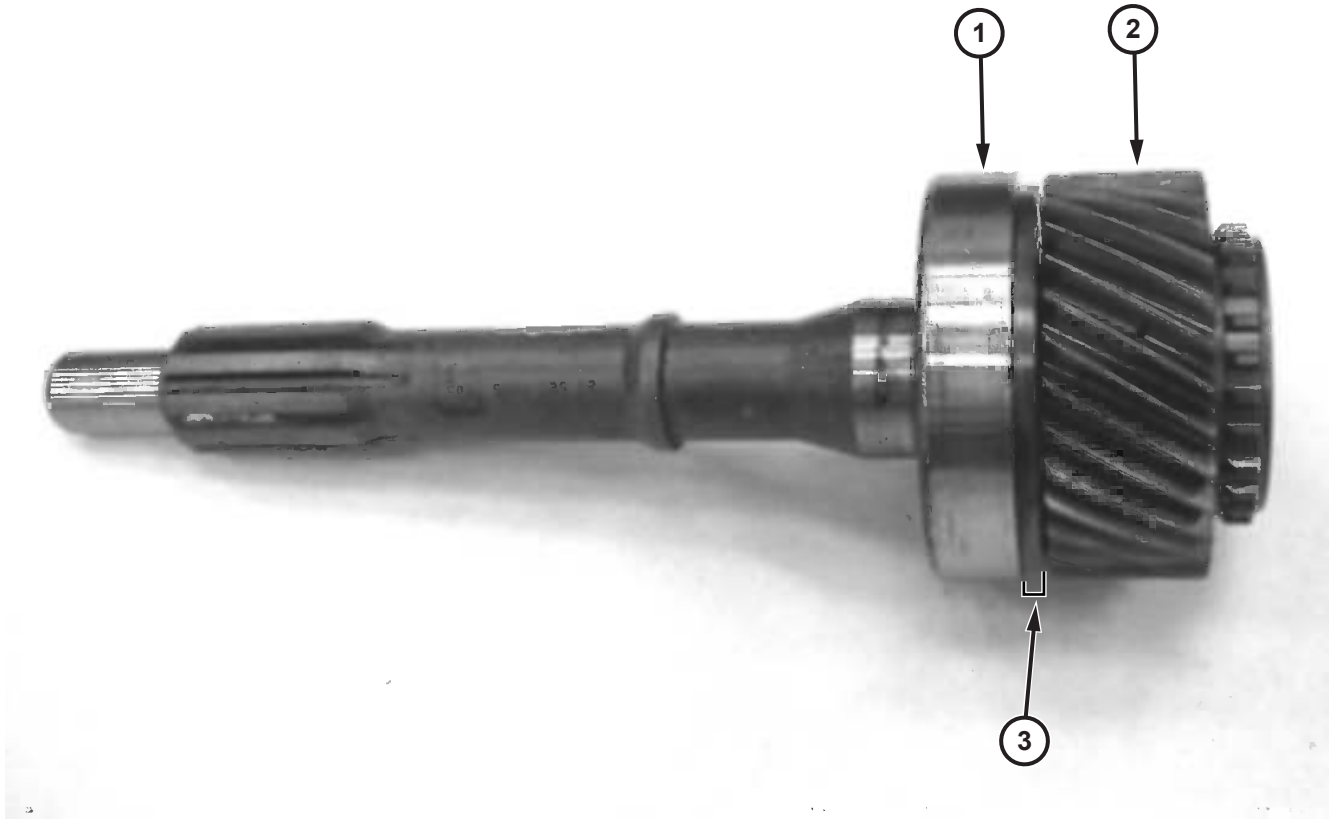


1	Reverse Shift Fork	4	5–6 Shift Fork
2	1–2 Shift Fork	5	Pivot Points
3	3–4 Shift Fork		

Figure 17 NSG370 Shift Rails

Input Shaft

The input shaft connects to the main shaft through the 5–6 synchronizer and contains the input gear. The shaft is supported through a sealed ball bearing in the front housing and a caged roller bearing connecting the input shaft to the main shaft. The input shaft is held into the front housing by two hold down clips. When installing the bearing onto the input shaft, ensure the step is installed toward the input gear. If installed backward, the clips will not be able to fit into the step.

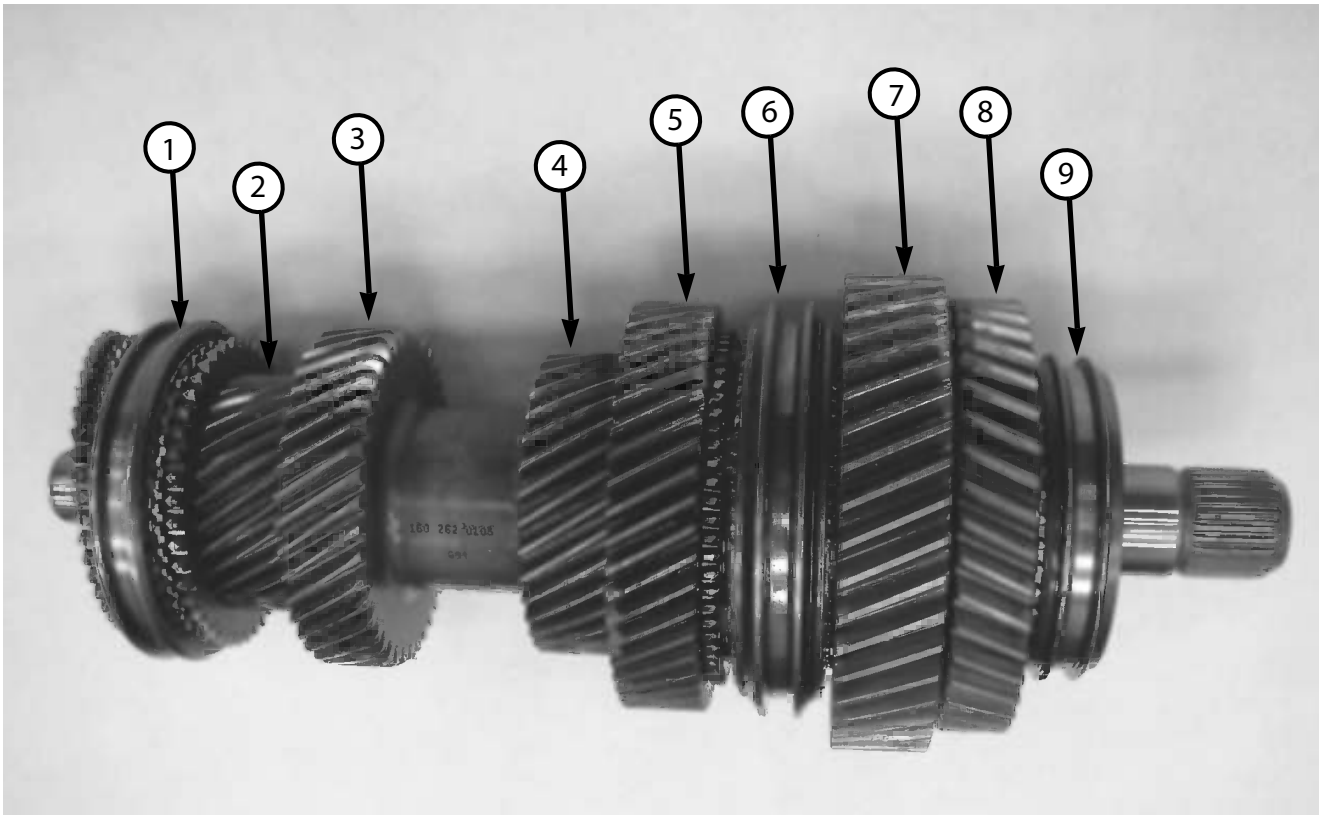


1	Sealed Ball Bearing	3	Bearing 'Step'
2	Input Gear		

Figure 18 NSG370 Input Shaft

Main Shaft and Gears

The main shaft on the NSG370 contains the first, second, sixth and reverse speed gears along with the 1–2, 5–6, and reverse synchronizers. The third and fourth fixed gears are serviced as part of the main shaft assembly.

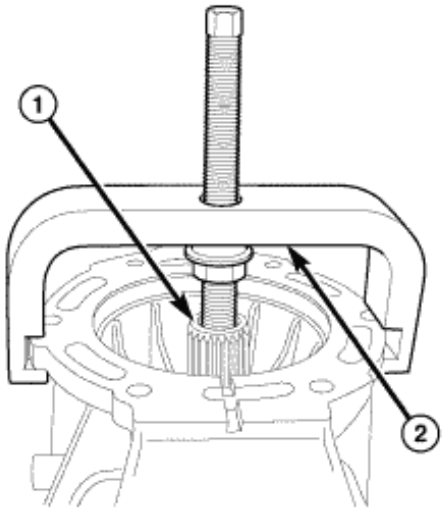


1	5–6 Synchronizer	6	1–2 Synchronizer
2	Sixth Gear	7	First Gear
3	Third Gear	8	Reverse Gear
4	Fourth Gear	9	Reverse Synchronizer
5	Second Gear		

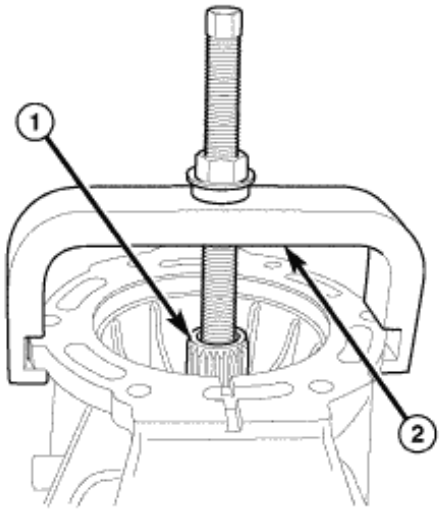
Figure 19 NSG370 Main Shaft

Special tool 9636 is used to remove and install the transmission case to the mainshaft. Pay close attention to the location of the nut. Using the tool with the nut in the wrong location may cause damage.

Removing the Case



Installing the Case

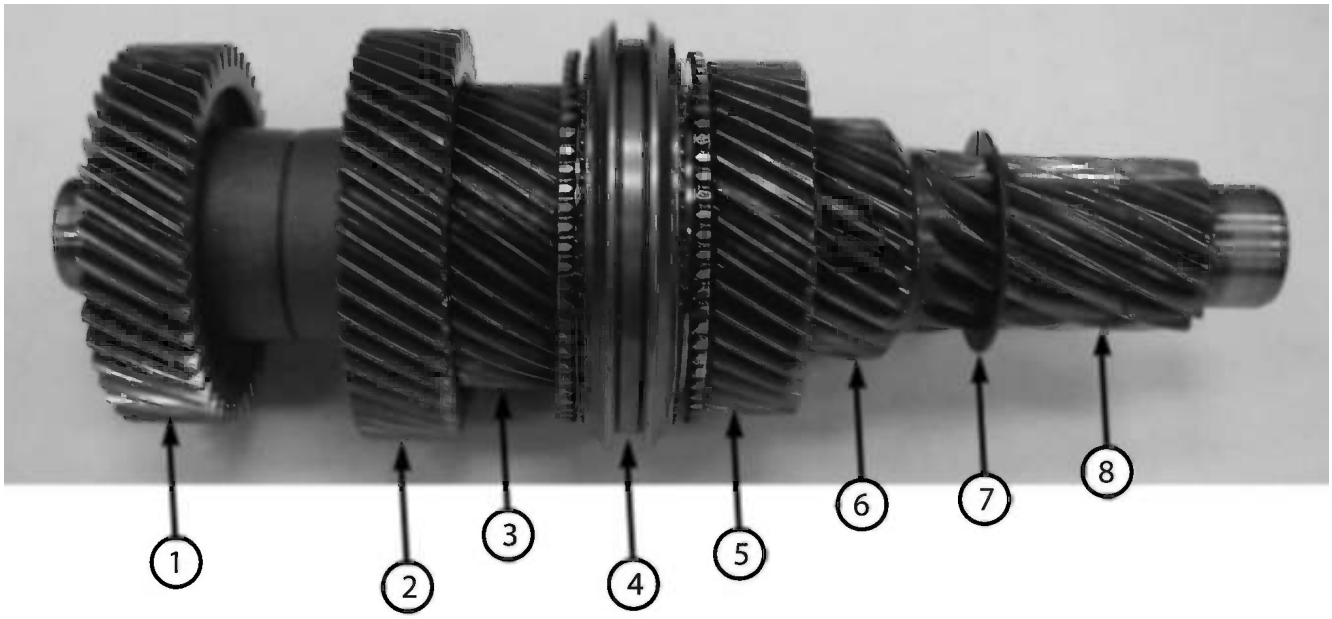


1	Mainshaft	2	Special Tool 9636

Figure 20 Special Tool 9636 Usage

Counter Shaft

The counter shaft on the NSG370 is only serviced as an assembly. The counter shaft contains the first, second, input, sixth and reverse fixed gears and the third and fourth speed gears along with the 3–4 synchronizer. Also, there is an oil slinger that goes between first and reverse gears on the main shaft.

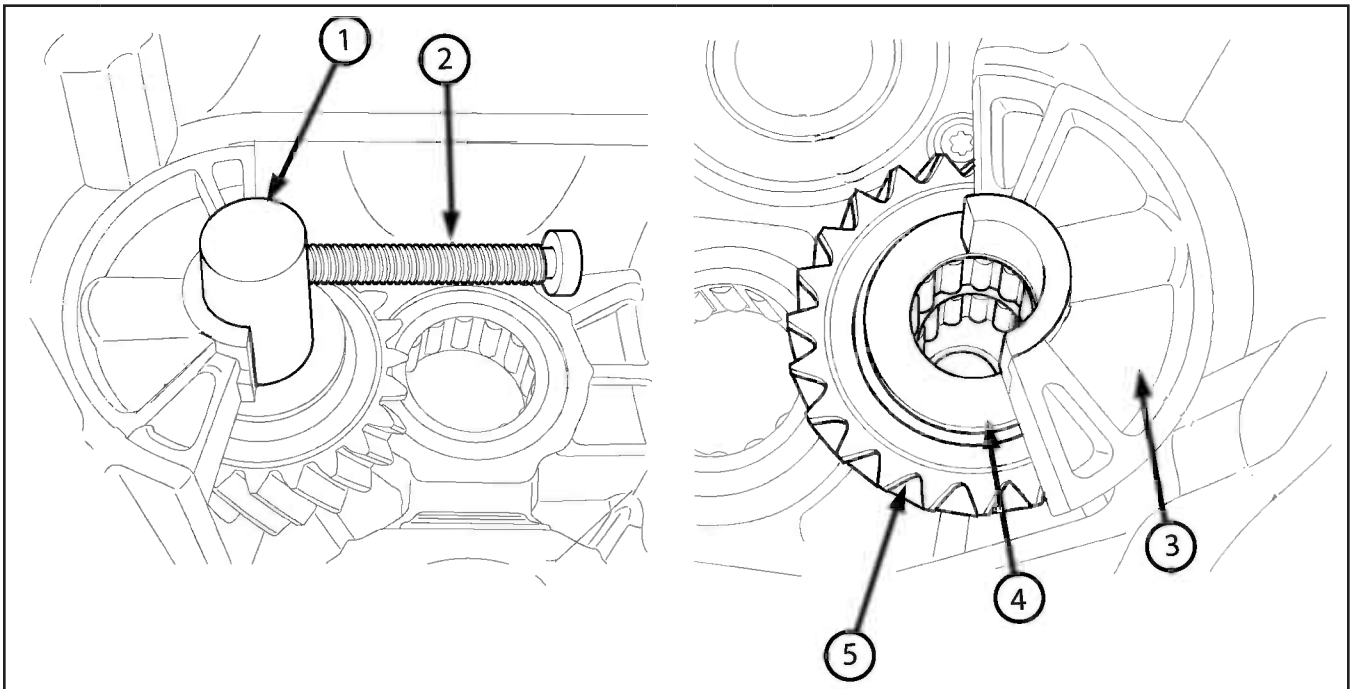


1	Input Gear	5	Fourth Gear
2	Sixth Gear	6	Second Gear
3	Third Gear	7	First and Reverse Oil Slinger
4	3–4 Synchronizer	8	First and Reverse Gear

Figure 21 NSG370 Counter Shaft

Reverse Shaft

The reverse idler gear and shaft is removed after the counter shaft and the main shaft have been removed from the rear case. To remove the reverse idler gear, the bolt that holds the shaft in place must be removed from the outside of the case and be reinstalled as shown in the figure below. Then twist the bolt and shaft while pulling up to remove the shaft. Once the shaft is removed, the reverse idle shaft support and the reverse idle thrust washer can be removed along with the reverse idle gear and bearing.

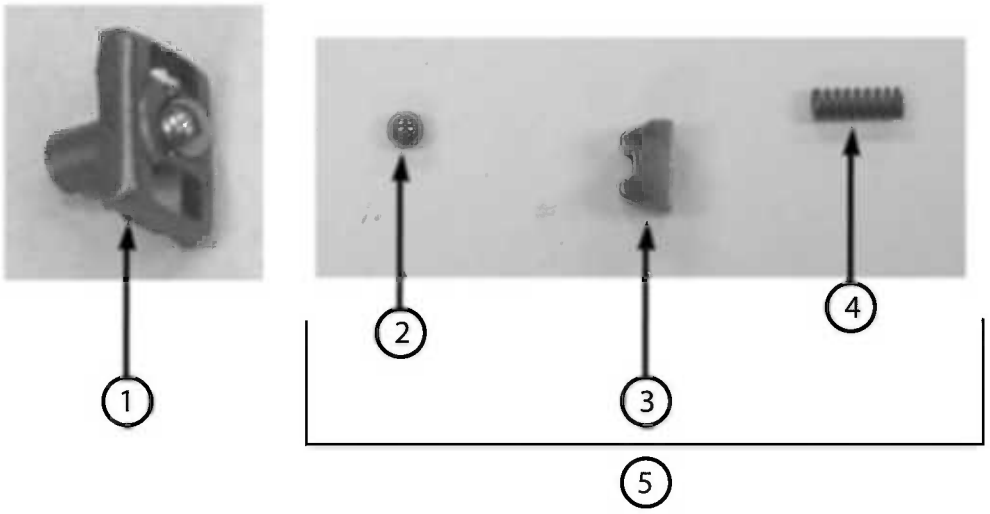


1	Reverse Idler Shaft	4	Reverse Idler Thrust Washer
2	Reverse Idler Shaft Bolt	5	Reverse Idler Gear
3	Reverse Idler Shaft Support		

Figure 22 NSG370 Reverse Shaft

Synchronizer Assembly

The 3–4, 5–6, and reverse synchronizers on the NSG370 are single cone synchronizers. The 3–4 synchronizer is only serviced with the counter shaft assembly. The 1–2 synchronizer is a dual cone synchronizer.



1	Reverse Synchronizer Detents	4	Detent Ball
2	Detent Spring	5	1–2, 3–4, 5–6 Synchronizer Detents
3	Detent Strut		

Figure 23 NSG370 Synchronizer Detents

Bearings

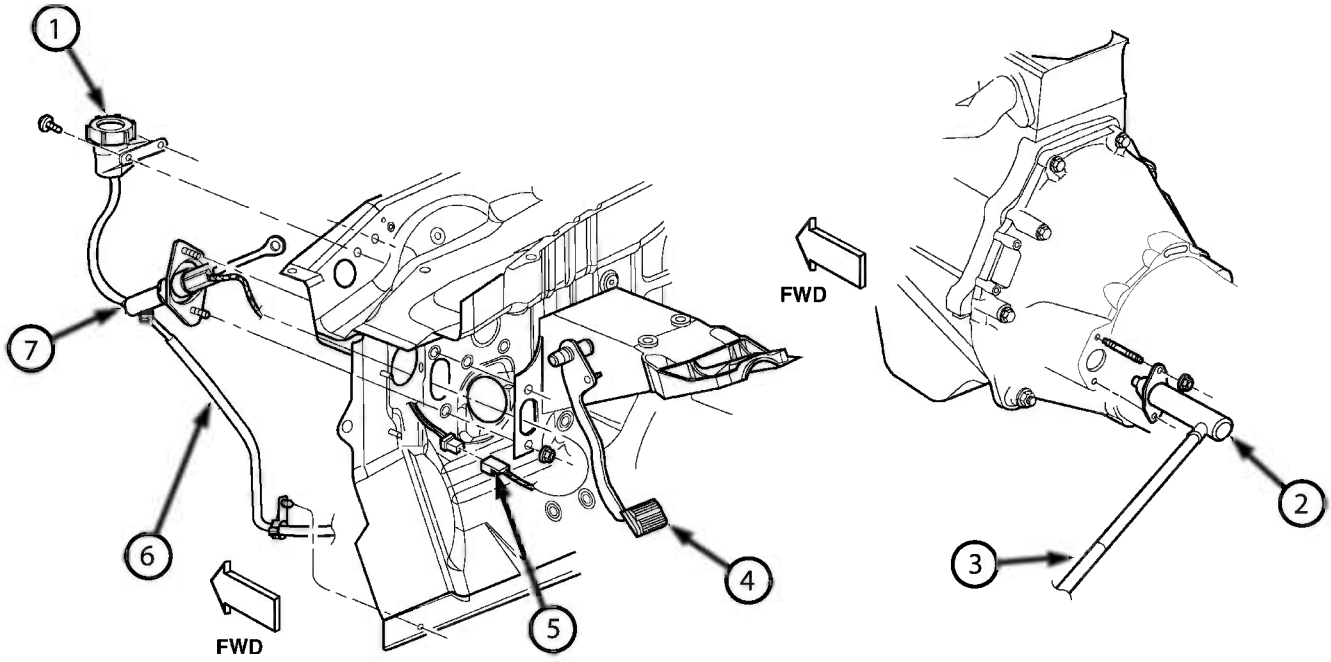
There are four sealed ball bearings used in the NSG370, two to support the counter shaft, one to support the main shaft output, and one to support the input shaft in the case. There is a caged roller bearing between the input and main shaft assemblies and caged needle bearings under all speed gears and the reverse idler gear.

Clutch Master Cylinder

The clutch master cylinder is bolted to the bulkhead, and the master cylinder push rod is connected to the clutch pedal. When the clutch pedal is depressed, the push rod forces fluid pressure from the master cylinder through a fluid line to the slave cylinder.

Slave Cylinder

The slave cylinder is mounted to the transmission front housing. When the clutch pedal is depressed, fluid pressure from the master cylinder actuates the slave cylinder. The slave cylinder actuates the release bearing and fork.

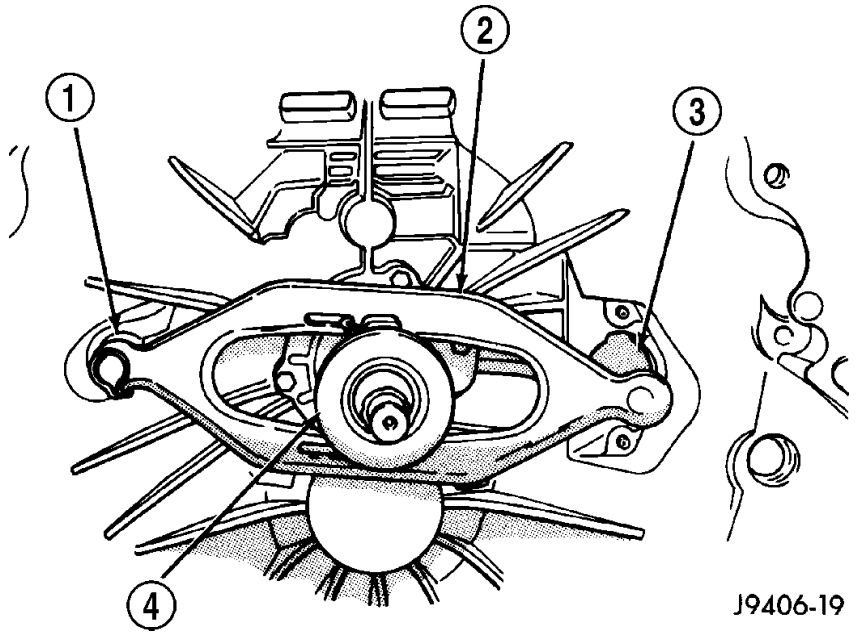


1	Clutch Fluid Reservoir	5	Clutch Pedal Position Switch Connector
2	Clutch Slave Cylinder	6	Clutch Hydraulic Line
3	Clutch Hydraulic Line	7	Clutch Master Cylinder
4	Clutch Pedal		

Figure 24 Hydraulic Clutch Assembly

Release Bearing and Fork

The release bearing is operated by a release fork pivoting on a ball stud mounted in the transmission clutch housing. The release bearing then depresses the pressure plate spring fingers.



1	Pivot Ball	3	Slave Cylinder Opening
2	Clutch Fork	4	Release Bearing

Figure 25 Release Bearing

POWER FLOW

First Gear Power Flow

When the clutch is engaged (clutch pedal up), torque is transmitted to the input shaft. The input shaft and input drive gear transfer power to the counter shaft. The counter shaft transfers power to the first driven gear. When the 1–2 synchronizer is locked to first gear, power is transferred through the first driven gear to the main shaft.

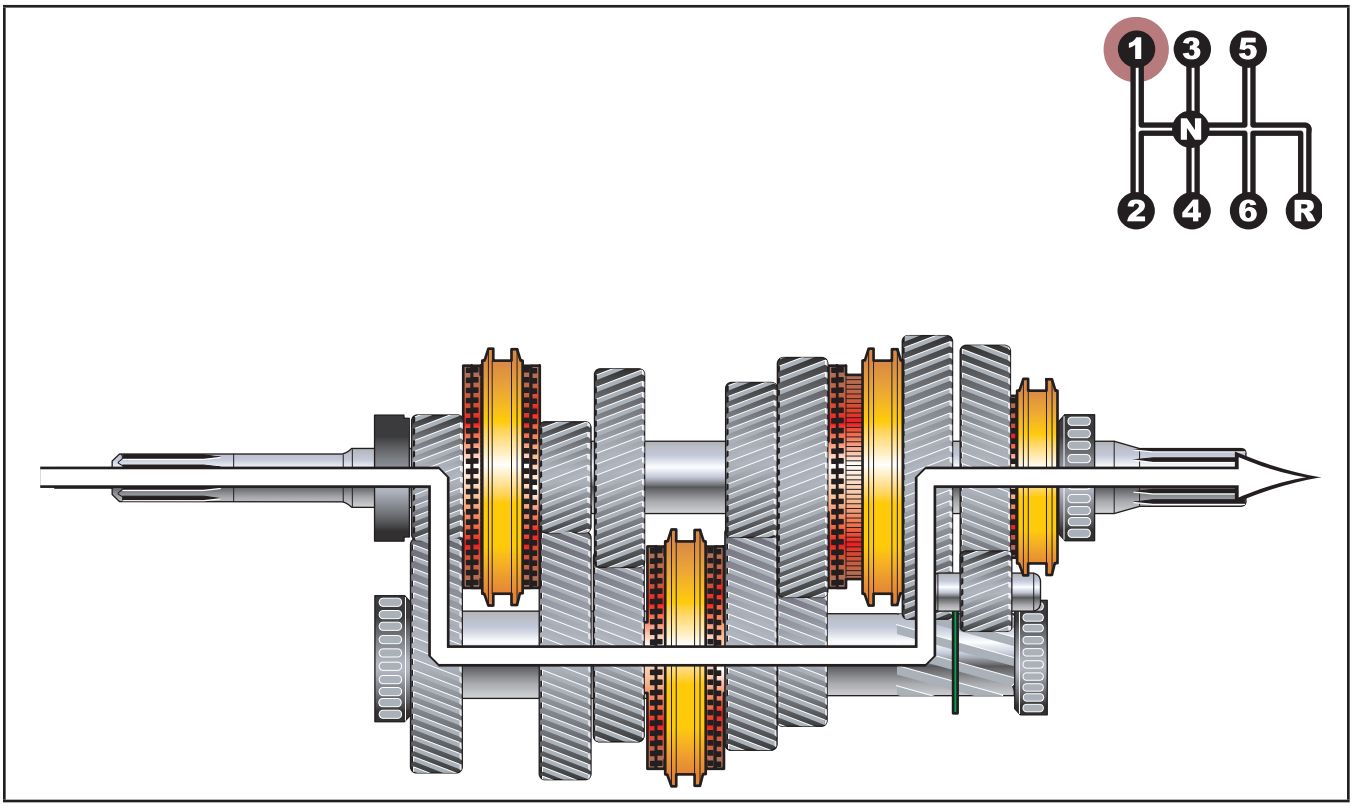


Figure 26 NSG370 First Gear Power

Second Gear Power Flow

When the clutch is engaged (clutch pedal up), torque is transmitted to the input shaft. The input shaft and input drive gear transfer power to the counter shaft. The counter shaft transfers power to the second driven gear. When the 1–2 synchronizer is locked to second gear, power is transferred through the second driven gear to the main shaft.

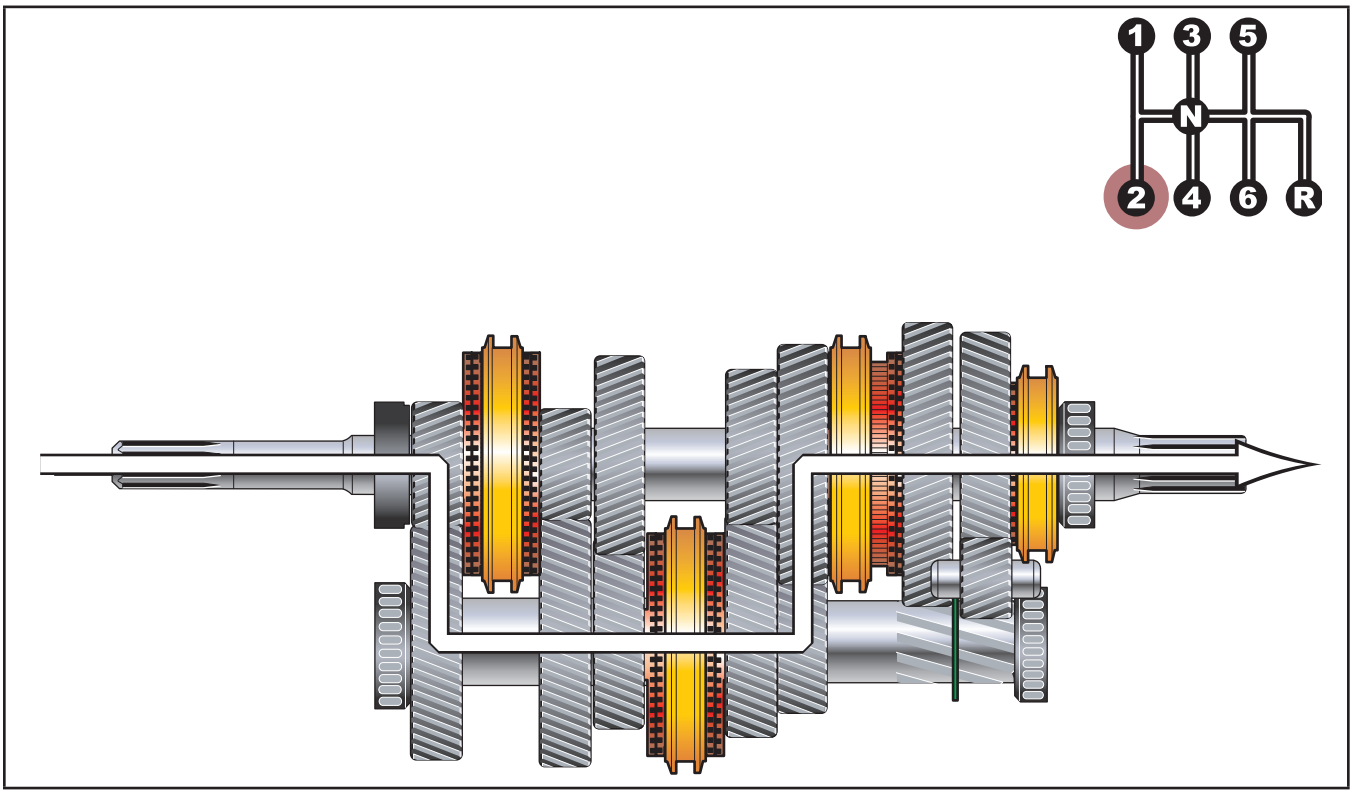


Figure 27 NSG370 Second Gear Power

Third Gear Power Flow

When the clutch is engaged (clutch pedal up), torque is transmitted to the input shaft. The input shaft and input drive gear transfer power to the counter shaft. When the 3–4 synchronizer is locked to third gear, power is transferred from the counter shaft to third drive gear. The third drive gear transfers power to the third driven gear on the main shaft, which drives the wheels.

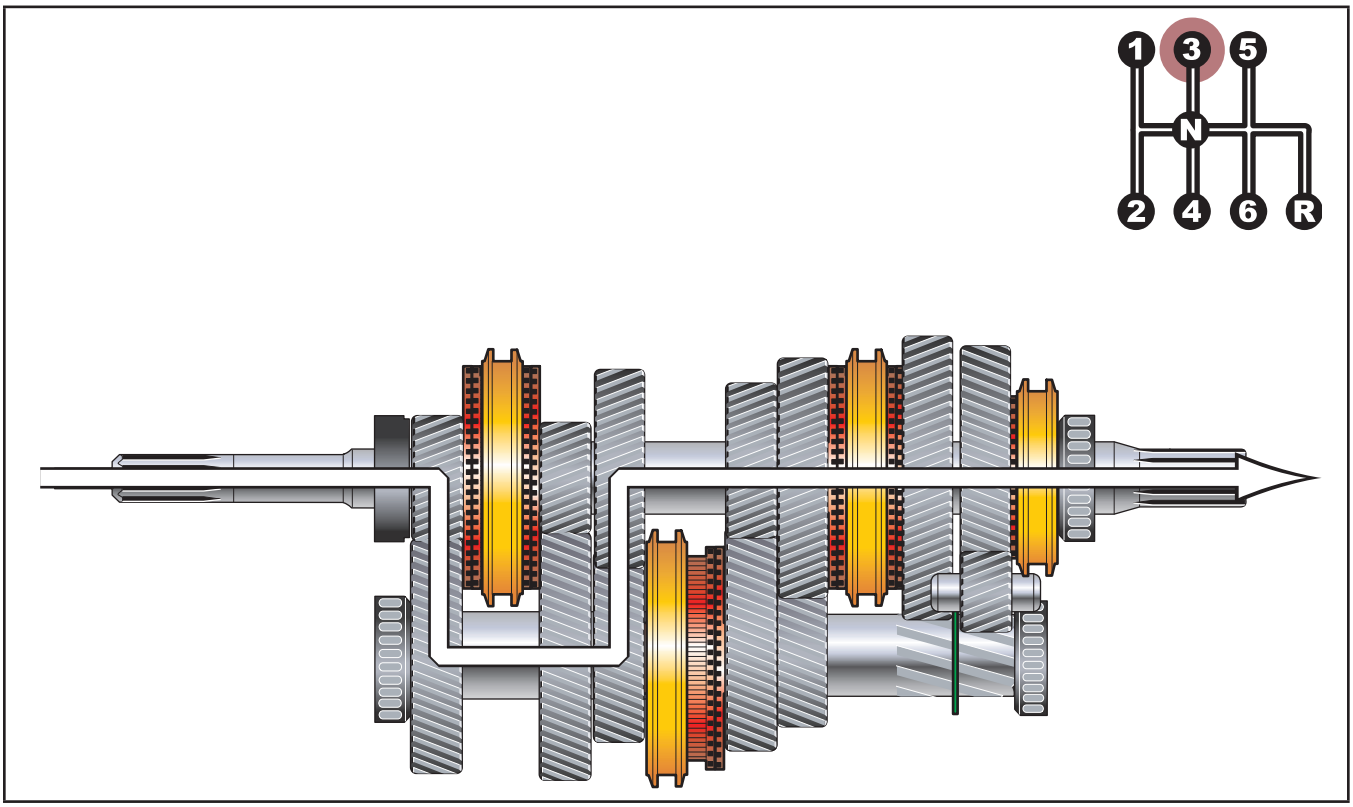


Figure 28 NSG370 Third Gear Power

Fourth Gear Power Flow

When the clutch is engaged (clutch pedal up), torque is transmitted to the input shaft. The input shaft and input drive gear transfer power to the counter shaft. When the 3–4 synchronizer is locked to fourth gear, power is transferred from the counter shaft to fourth drive gear. The fourth drive gear transfers power to the fourth driven gear on the main shaft, which drives the wheels.

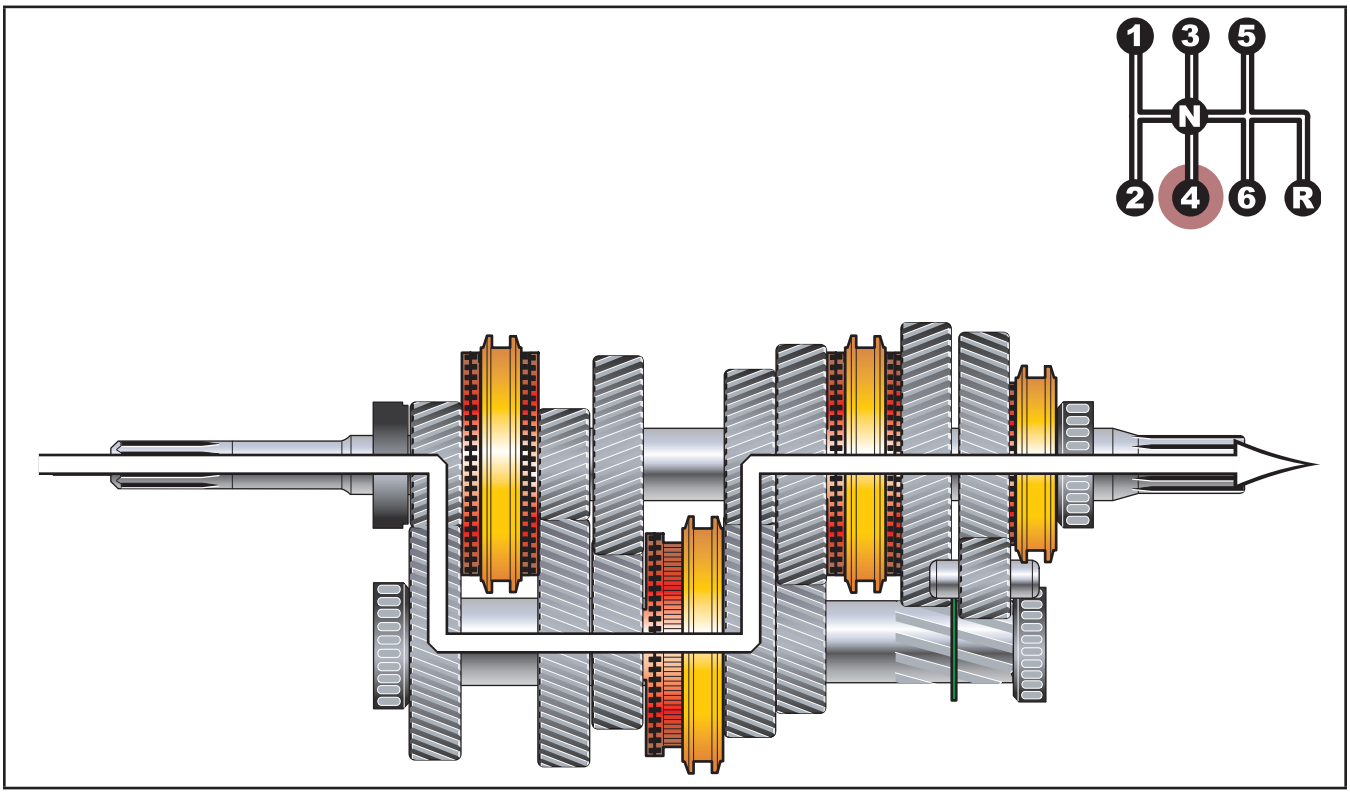


Figure 29 NSG370 Fourth Gear Power

Fifth Gear Power Flow

When the clutch is engaged (clutch pedal up), torque is transmitted to the input shaft. When the 5–6 synchronizer is locked to the input drive gear, torque is transferred directly from the input shaft to the main shaft by locking them together. This gives a fifth gear a 1:1 ratio.

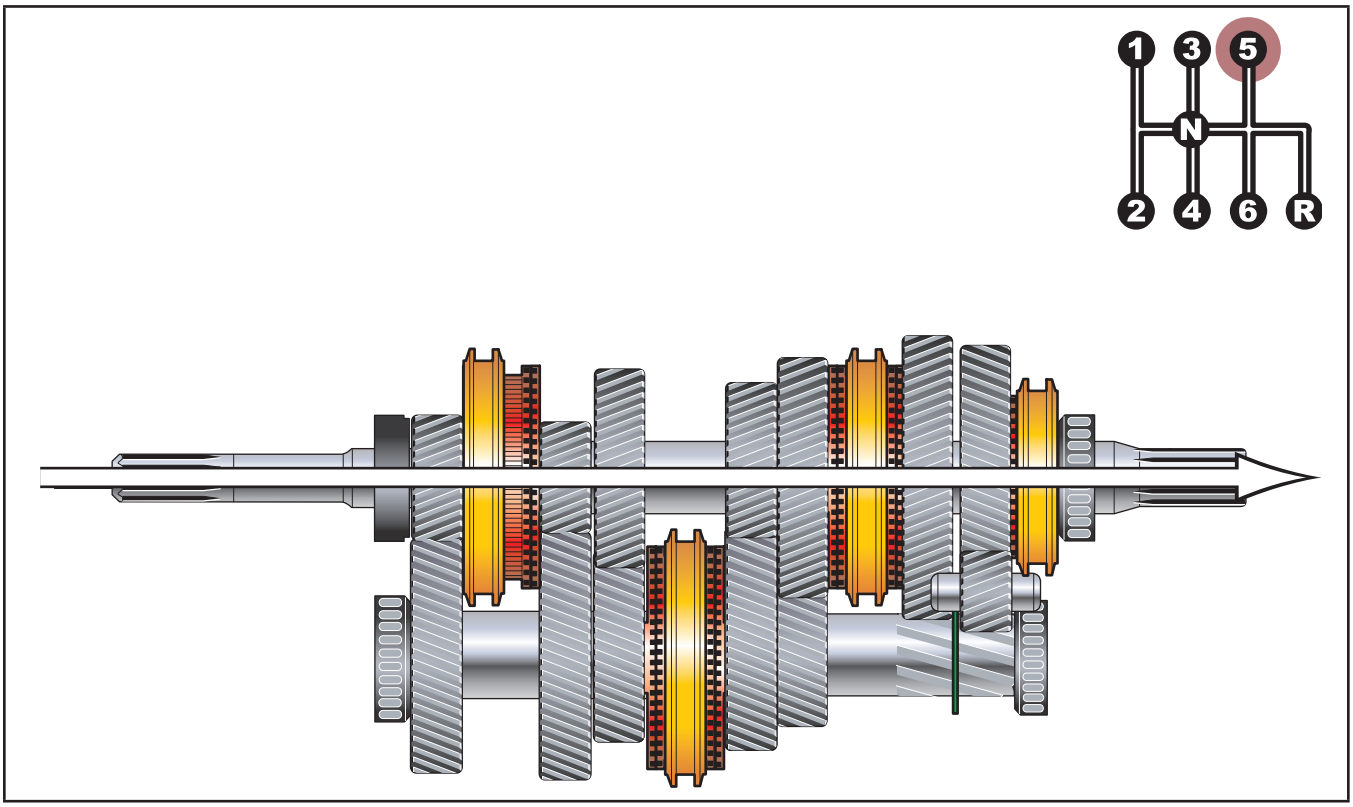


Figure 30 NSG370 Fifth Gear Power

Sixth Gear Power Flow

When the clutch is engaged (clutch pedal up), torque is transmitted to the input shaft. The input shaft and input drive gear transfer power to the counter shaft. The counter shaft transfers power to the sixth driven gear. When the 5–6 synchronizer is locked to sixth gear, power is transferred through the sixth driven gear to the main shaft.

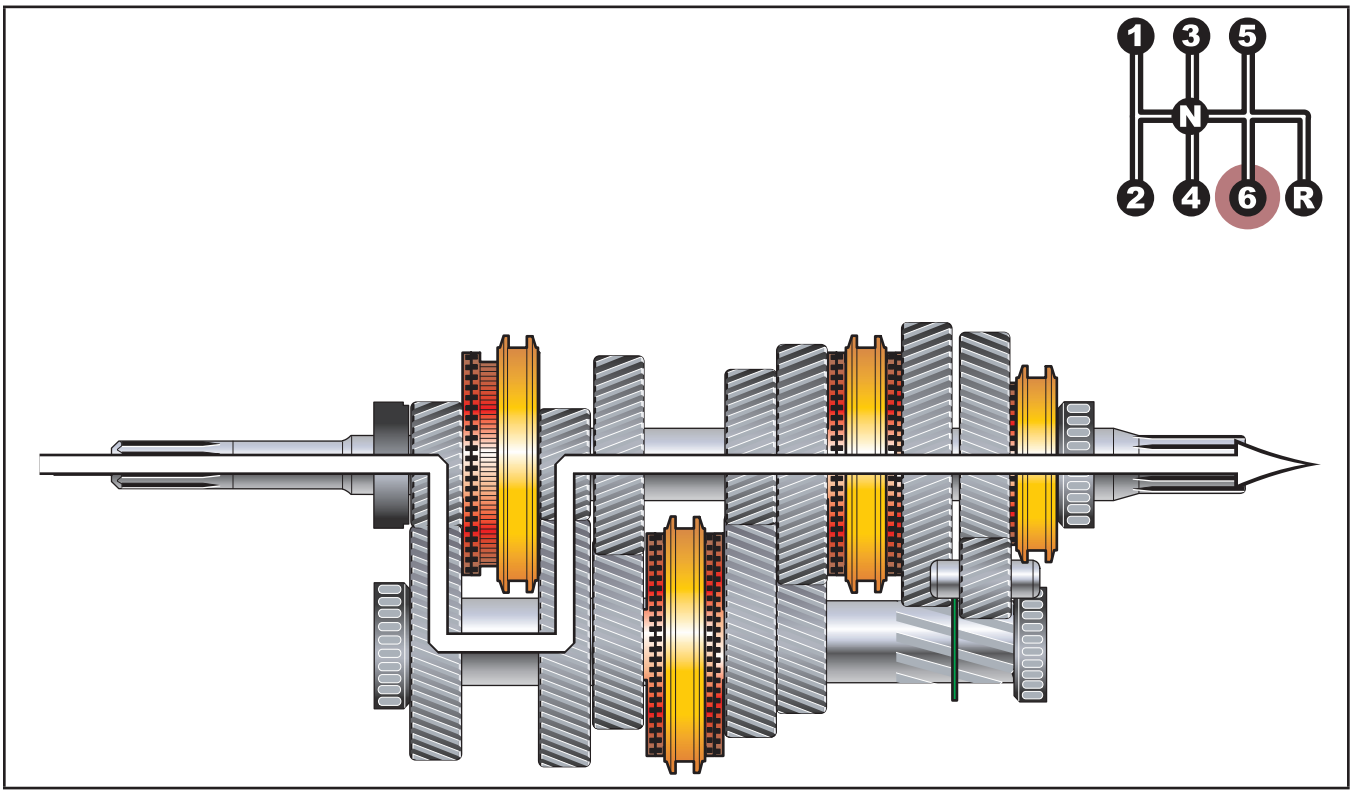


Figure 31 NSG370 Sixth Gear Power

Reverse Gear Power Flow

When the clutch is engaged (clutch pedal up), torque is transmitted to the input shaft. The input shaft and input drive gear transfer power to the counter shaft. The counter shaft transfers power to the reverse gear. When the reverse synchronizer is locked to reverse gear, power is transferred from the counter shaft through the reverse idler gear to the reverse driven gear on the main shaft. The reverse idler gear causes the main shaft to turn the opposite direction of the input shaft.

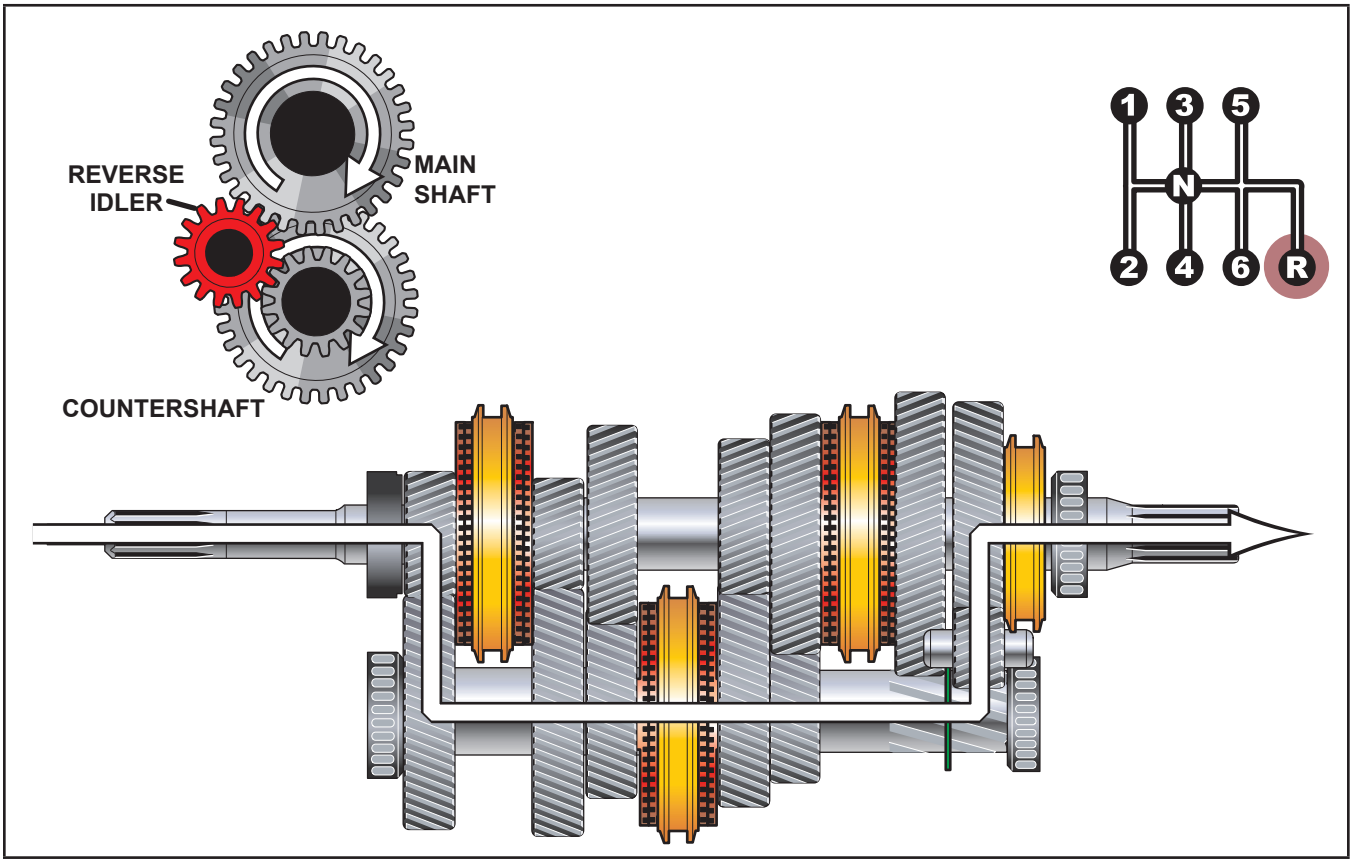


Figure 32 NSG370 Reverse Gear Power

Neutral Power Flow

When the transmission is in Neutral with the clutch engaged (pedal up), power flows into, but not out of the transmission. The input shaft and counter shaft spin at engine speed. The main shaft spins at propeller shaft speed. None of the synchronizers are engaged in Neutral.

Because Reverse, First, Second, and Sixth gears all have fixed gears on the counter shaft, these spin at engine speed. Because Third and Fourth gears have fixed gears on the main shaft, these spin at propeller shaft speed.

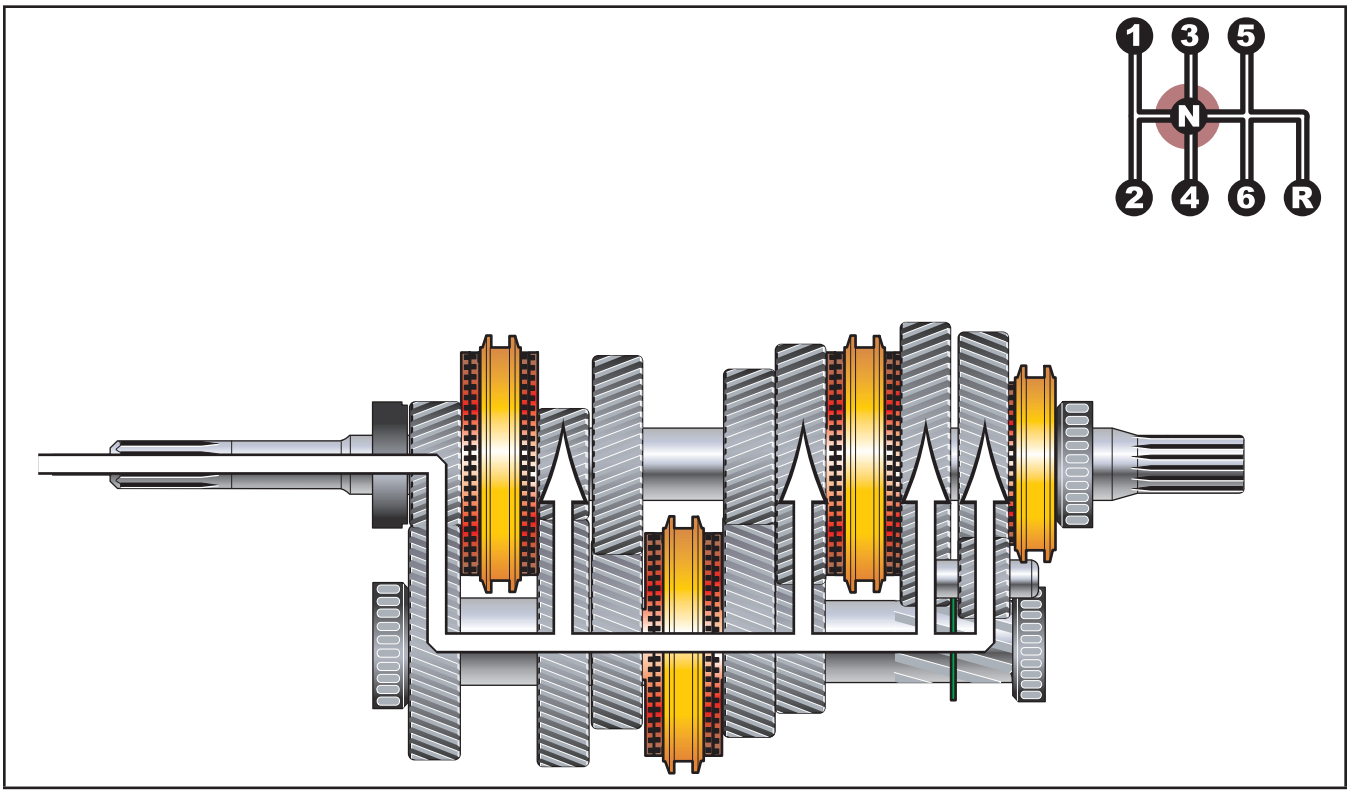


Figure 33 NSG370 Neutral Power

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MODULE 3 G56 MANUAL TRANSMISSION

GEAR RATIOS

The table below shows the gear ratios for the G56 transmission. The G56 is available in the Dodge Ram (DH) 2500 and 3500 models.

Table 7 Gear Ratios

Gear	G56
1st	6.29
2nd	3.48
3rd	2.10
4th	1.38
5th	1.00
6th	0.79
Reverse	5.74

SHIFT PATTERN

The shift pattern for the G56 is different from the NSG370 and G238 transmissions. The illustrations below shows the shift patterns for the G56.

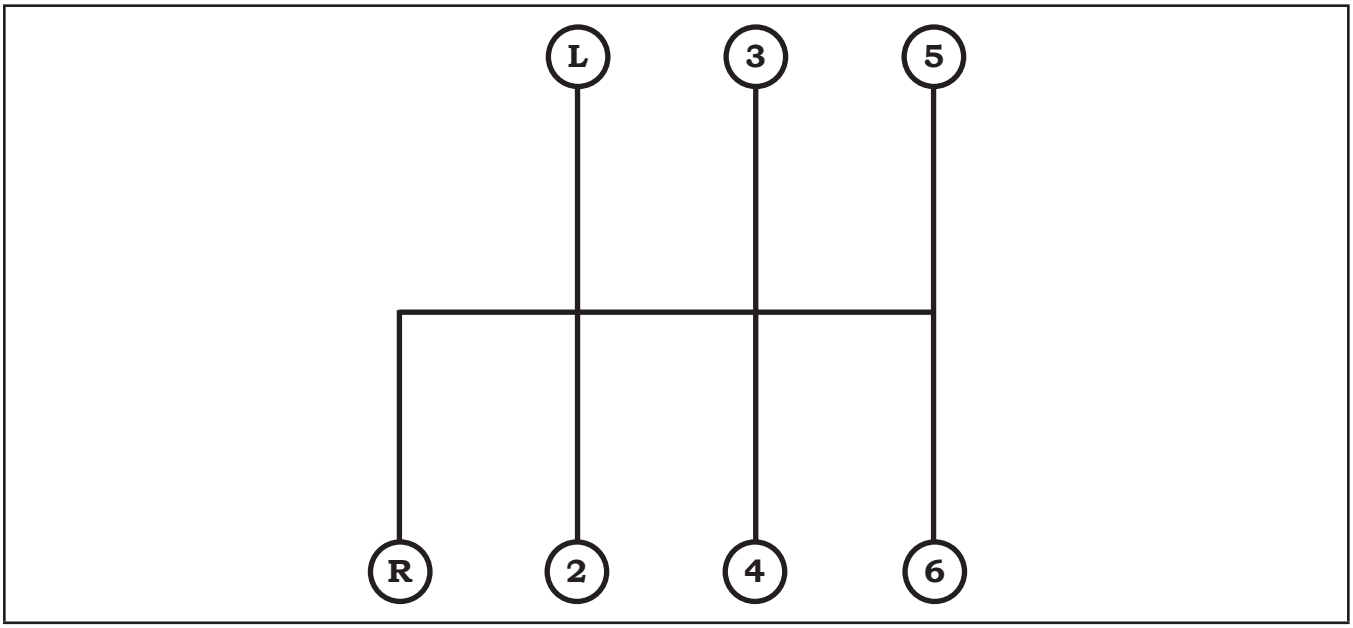
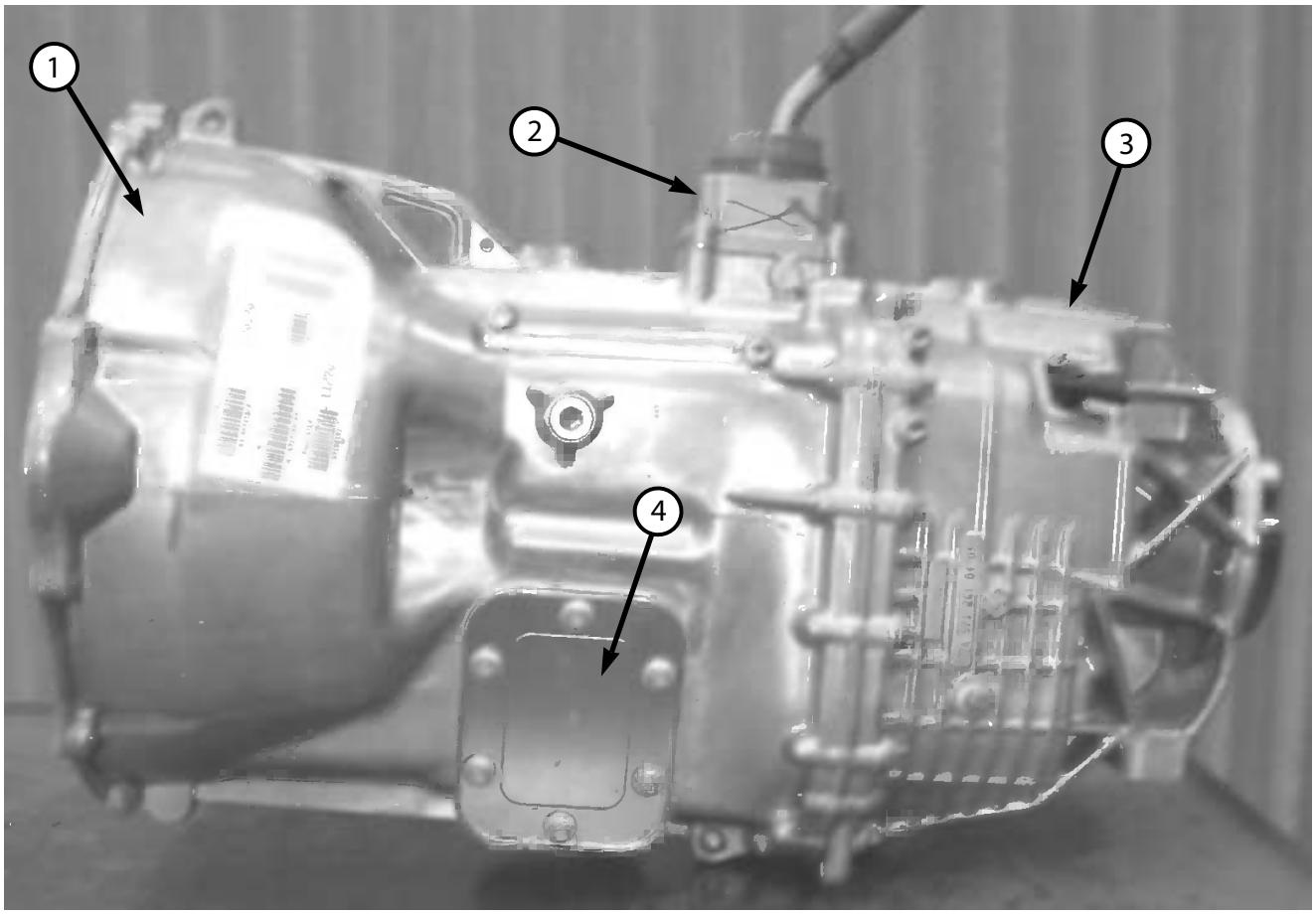


Figure 34 G56 Shift Pattern

COMPONENTS

Housing

The G56 transmission housing contains 3 pieces: the front housing, the rear housing, and the shift tower. The front and rear housing splits to remove the input shaft, main shaft, reverse shaft, and counter shaft.



1	Front Housing	3	Rear Housing
2	Shift Tower	4	PTO Cover

Figure 35 G56 Transmission Housing

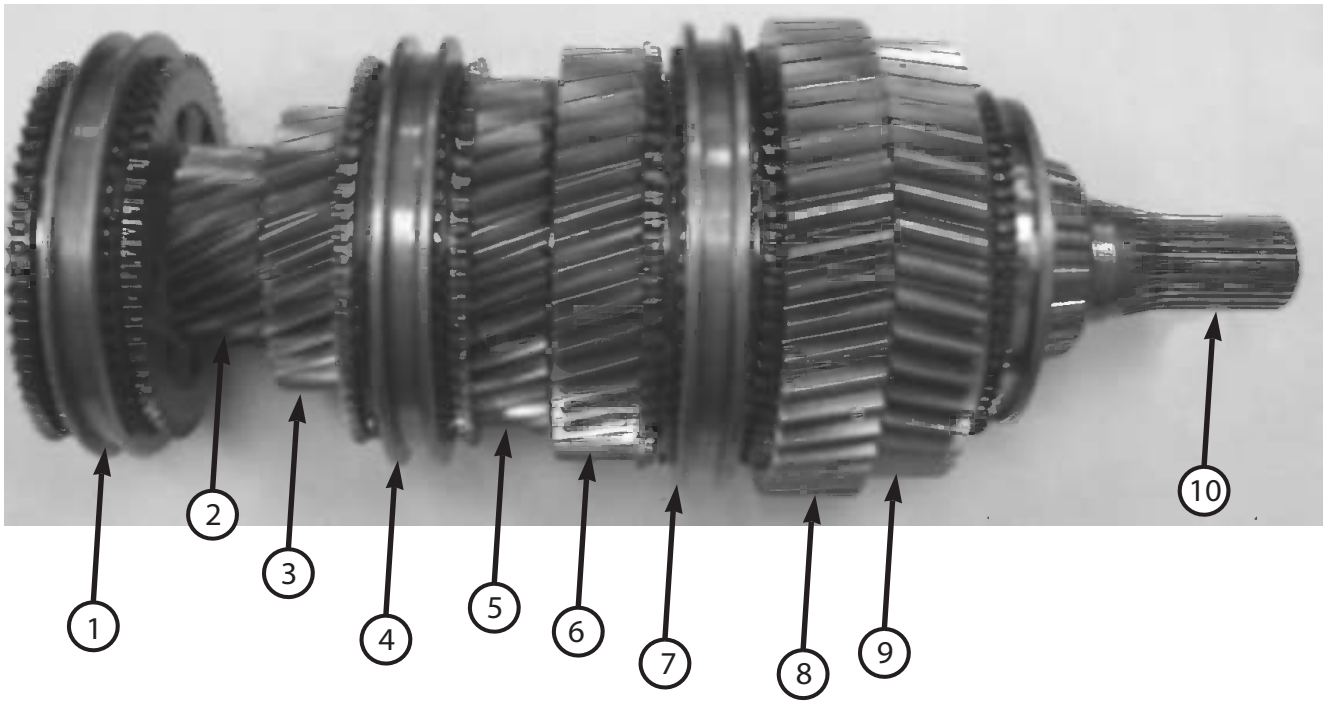
Input Shaft

The input shaft connects to the main shaft through the 5–6 synchronizer and contains the input gear. The shaft is supported through a tapered roller bearing in the front housing and a second tapered roller bearing connecting the input shaft to the main shaft.

Figure 36 G56 Input Shaft

Main Shaft and Gears

The main shaft on the G56 contains the speed gears and the synchronizers. The main shaft can be completely disassembled and components replaced as necessary. All the speed gears ride on a needle bearing. The main shaft is supported by two tapered roller bearings, which must be preloaded, one at the rear of the shaft supported by the rear housing and the other is attached to the front and is supported by the input shaft through the 5–6 synchronizer.

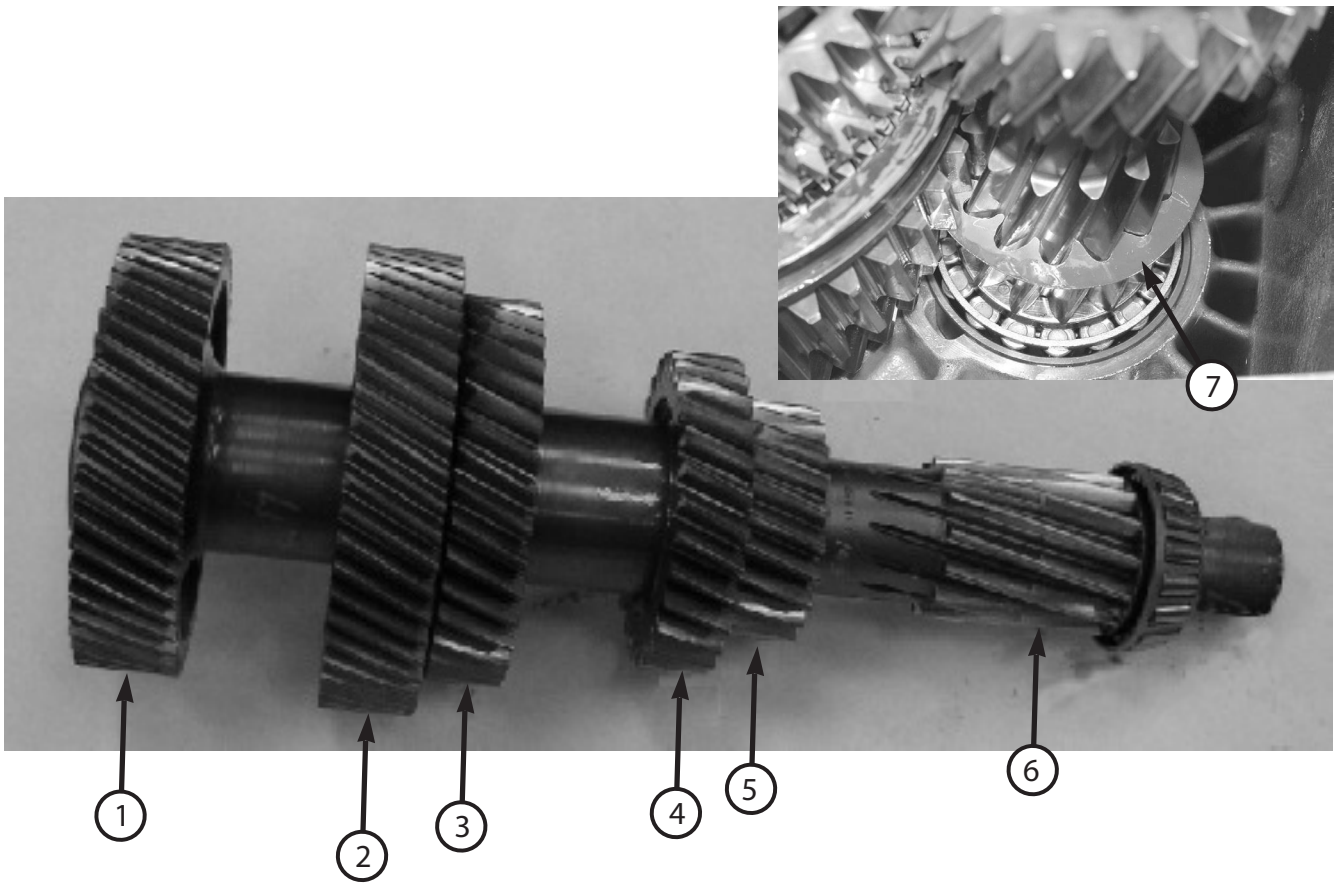


1	5–6 Synchronizer	6	Second Gear
2	Sixth Gear	7	1–2 Synchronizer
3	Fourth Gear	8	First Gear
4	3–4 Synchronizer	9	Reverse Gear
5	Third Gear	10	Transmission Output

Figure 37 G56 Main Shaft

Counter Shaft

The counter shaft is supported by two tapered roller bearings. The counter shaft is replaced as an assembly. The tapered roller bearings which must be preloaded are the only serviceable components on the counter shaft. The counter shaft also contains an oil slinger between first and reverse gears. If a PTO would be installed on this transmission, it would be driven off of the sixth gear on the counter shaft.

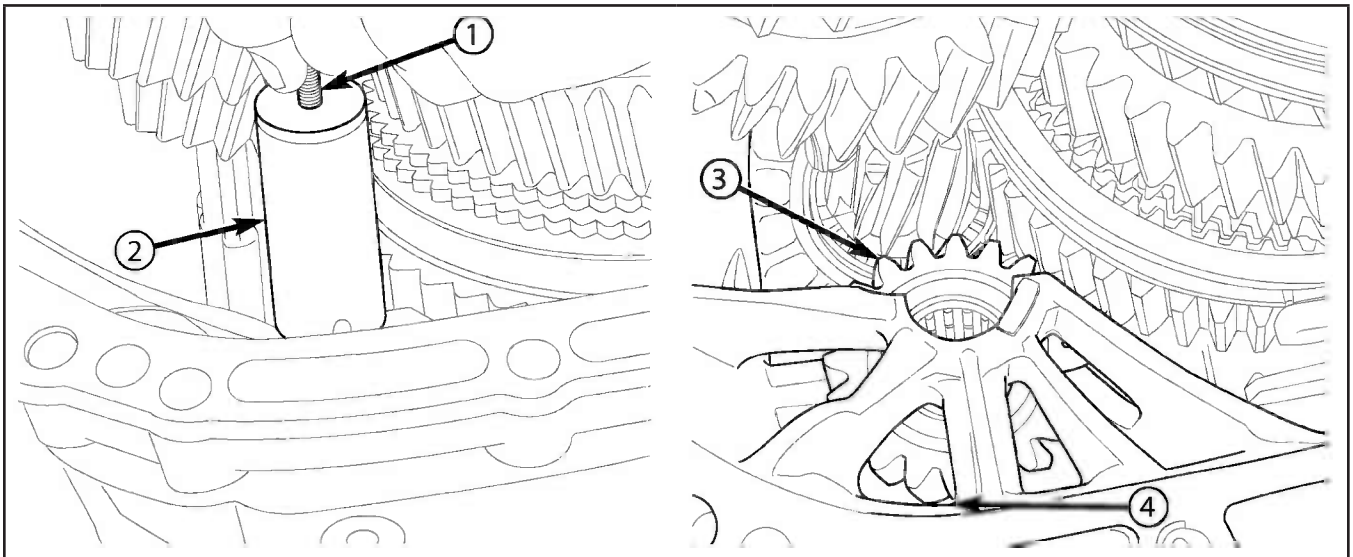


1	Input Gear	5	Second Gear
2	Sixth Gear	6	First and Reverse Gear
3	Fourth Gear	7	Oil Slinger
4	Third Gear		

Figure 38 G56 Counter Shaft

Reverse Shaft

The reverse shaft on the G56 must be removed before the counter shaft and the main shaft can be removed from the rear housing. To remove the reverse shaft, a M6 x 1 bolt must be threaded into the reverse shaft to pull the shaft out. Then move the reverse idler gear back out of the way.

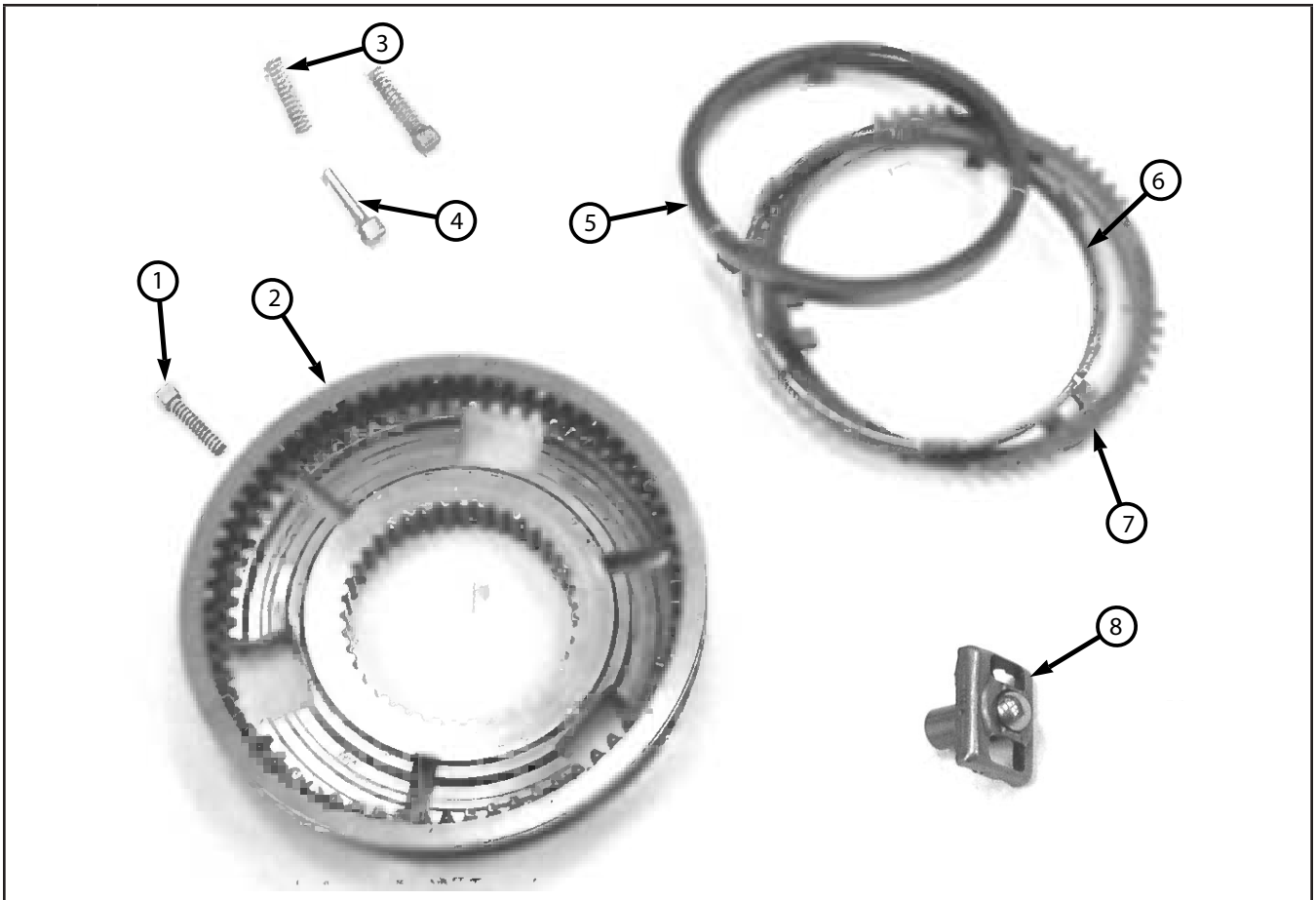


1	M6 X 1 Bolt	3	Reverse Idler Gear
2	Reverse Shaft	4	Rear Housing

Figure 39 G56 Reverse Shaft

Synchronizer Assembly

The 5–6 synchronizer on the G56 is a single cone synchronizer that is removed with a three jaw puller and must be installed with the concave side up. The 3–4 synchronizer is a dual cone synchronizer; the synchronizer ring contains a smaller tooth so that the ring is only installed onto the hub one way. The hub on the 3–4 synchronizer can only be installed on the shaft one way and still allow the snap ring to fit in the groove. The 1–2 synchronizer is a dual cone synchronizer; the synchronizer ring uses the same design as the 3–4 synchronizer in that it also has a smaller tooth. The hub on the 1–2 synchronizer has a wide and a narrow flat surface; the hub is installed with the wide flat side down and it can be installed incorrectly. The reverse synchronizer is a dual cone synchronizer that can only be installed one way to obtain reverse gear.



1	1–2, 3–4, 5–6 Synchronizer Detents	5	Friction Ring
2	Synchronizer Ring and Hub	6	Friction Ring
3	Detent Spring	7	Blocker Ring
4	Detent	8	Reverse Synchronzer Detent

Figure 40 G56 1–2 Synchronizer

Bearings

There are five tapered roller bearings used in the G56. One on the front of the input shaft, one between the input shaft and the main shaft, one on the main shaft output, and two on the counter shaft. Caged needle bearings are used under all speed gears on the main shaft and the reverse idler gear. The tapered roller bearings require a preload adjustment done when repairing this transmission. Refer to the service information for this procedure.

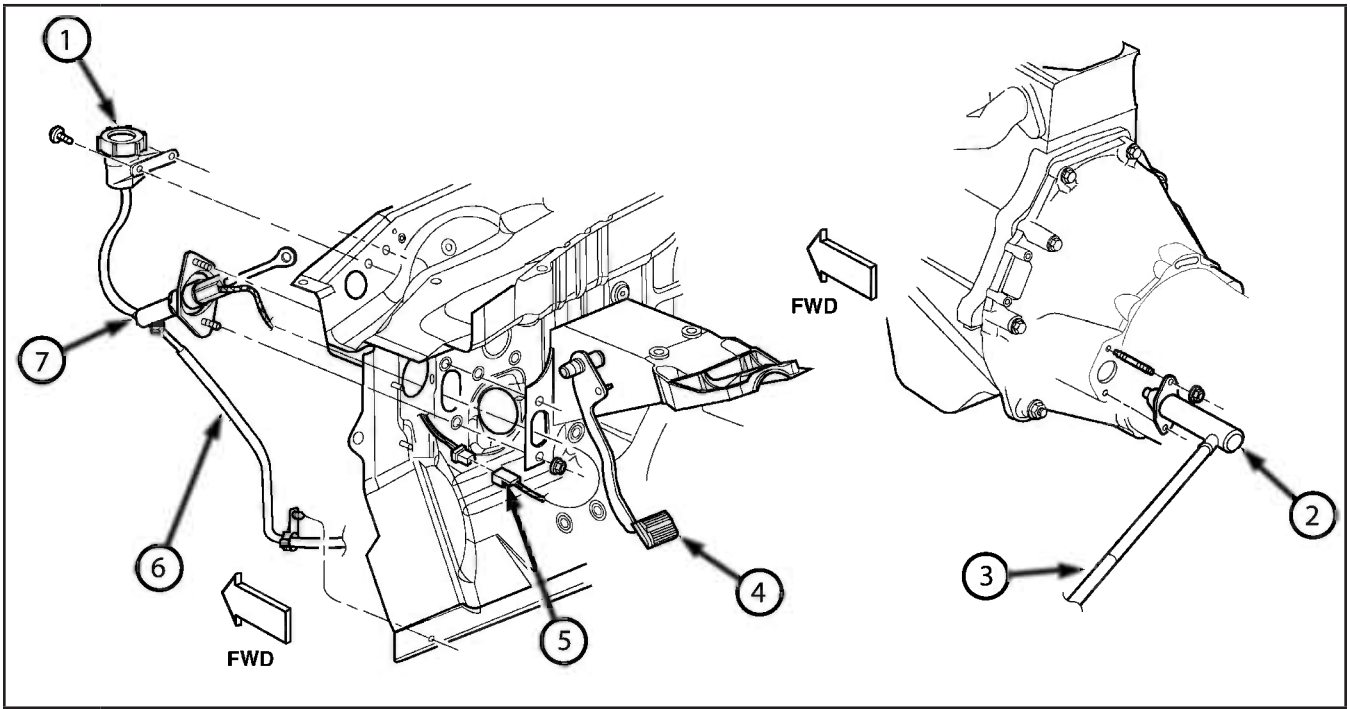
Clutch Master Cylinder

The clutch master cylinder is bolted to the bulkhead, and the master cylinder push rod is connected to the clutch pedal. When the clutch pedal is pressed, the push rod forces fluid pressure from the master cylinder through a fluid line to the slave cylinder.

Slave Cylinder

The slave cylinder is mounted to the transmission front housing. When the clutch pedal is pressed, fluid pressure from the master cylinder actuates the slave cylinder. The slave cylinder actuates the release bearing and fork.

Note: The clutch master cylinder, slave cylinder and connecting line are serviced as an assembly only. Components cannot be overhauled or serviced separately. Cylinders and connecting lines are sealed units.

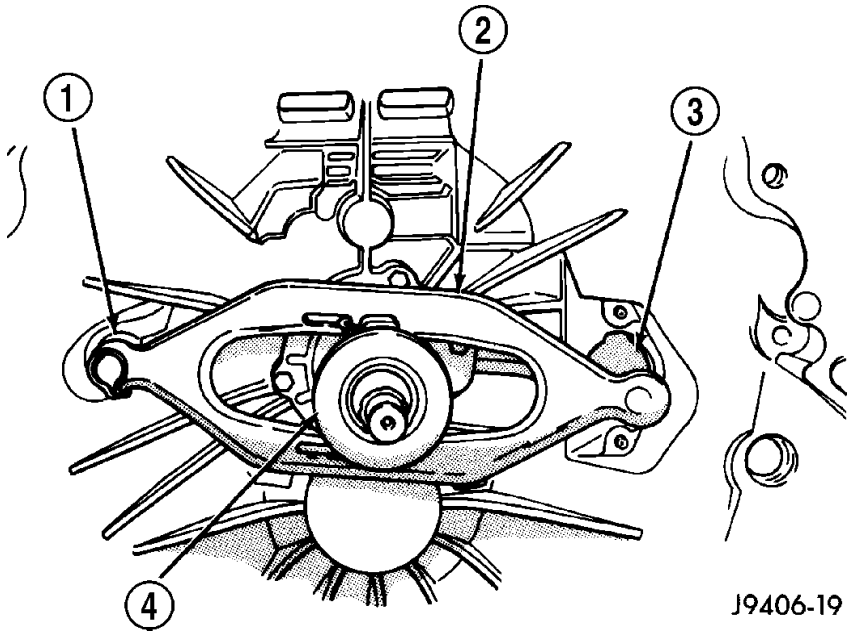


1	Clutch Fluid Reservoir	5	Clutch Pedal Position Switch Connector
2	Clutch Slave Cylinder	6	Clutch Hydraulic Line
3	Clutch Hydraulic Line	7	Clutch Master Cylinder
4	Clutch Pedal		

Figure 41 Hydraulic Clutch Assembly

Release Bearing and Fork

The release bearing is operated by a release fork pivoting on a ball stud mounted in the transmission clutch housing. The release bearing then depresses the pressure plate spring fingers.



1	Pivot Ball	3	Slave Cylinder Opening
2	Clutch Fork	4	Release Bearing

Figure 42 Release Bearing

G56 POWER FLOW

First Gear

When the clutch is engaged (clutch pedal up), torque is transmitted to the input shaft. The input shaft and input drive gear transfer power to the counter shaft. The counter shaft transfers power to the first driven gear. When the 1–2 synchronizer is locked to first gear, power is transferred through the first driven gear to the main shaft.

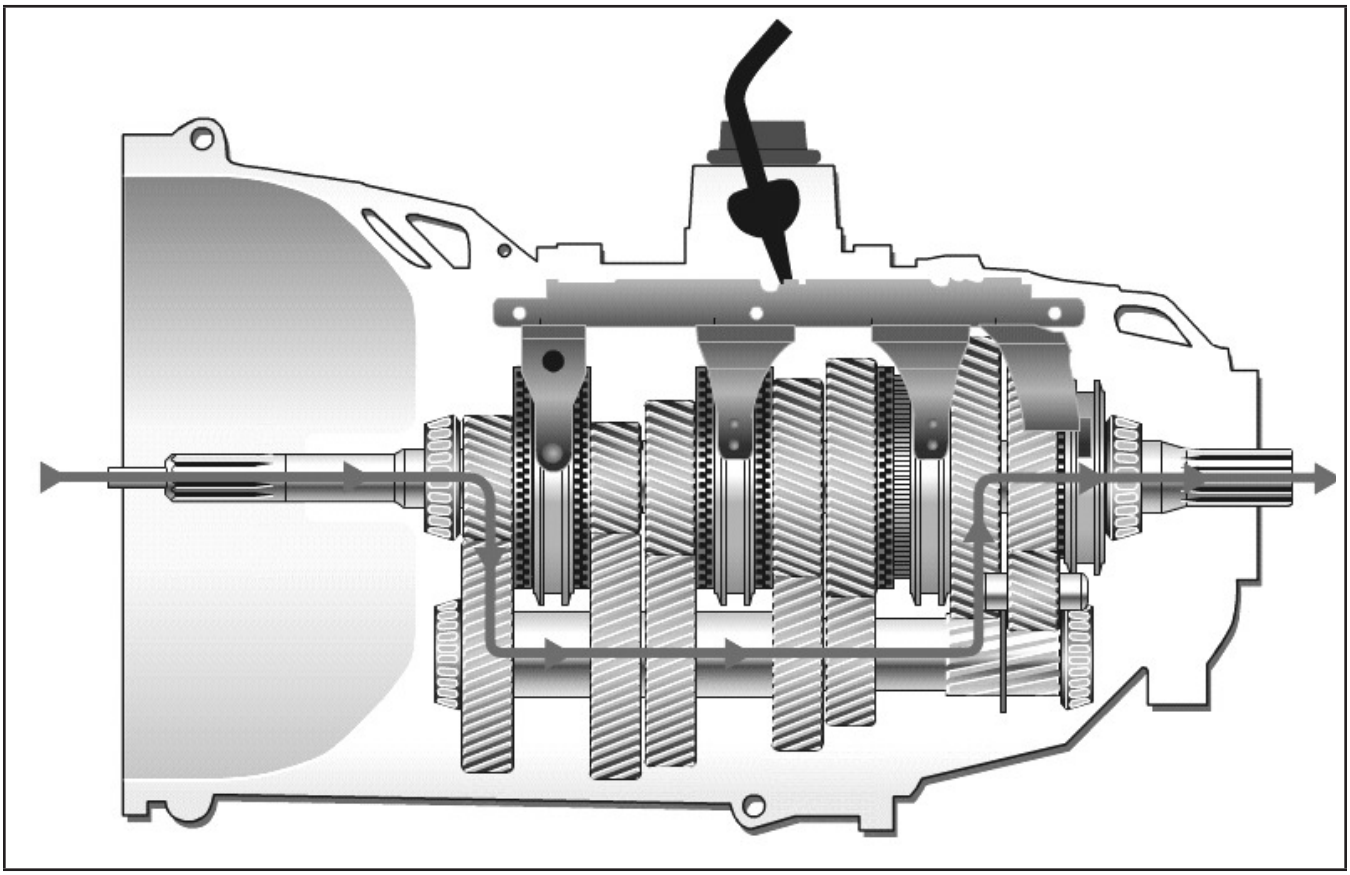


Figure 43 G56 First Gear Power Flow

Second Gear

When the clutch is engaged (clutch pedal up), torque is transmitted to the input shaft. The input shaft and input drive gear transfer power to the counter shaft. The counter shaft transfers power to the second driven gear. When the 1–2 synchronizer is locked to second gear, power is transferred through the second driven gear to the main shaft.

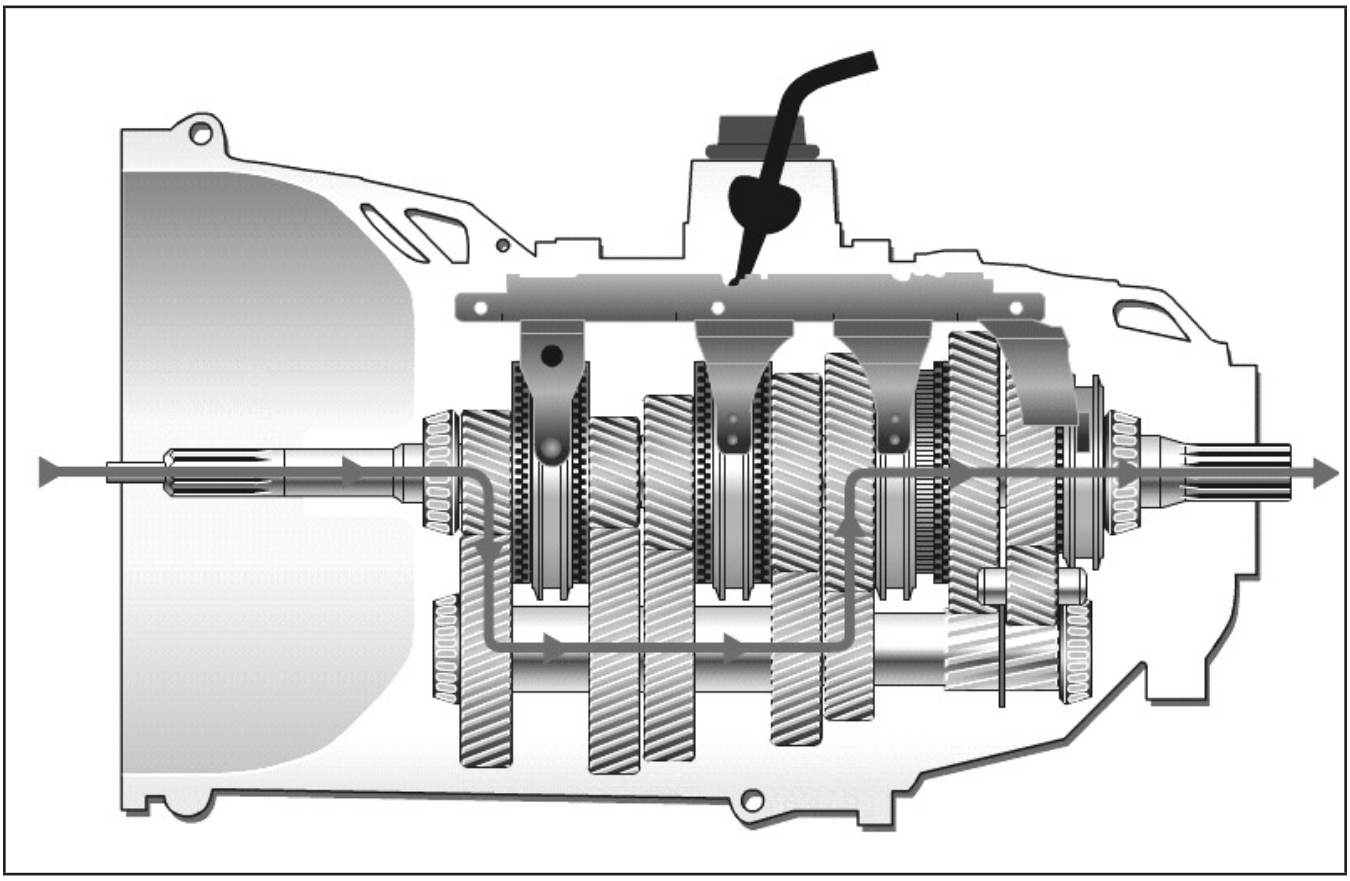


Figure 44 G56 Second Gear Power Flow

Third Gear

When the clutch is engaged (clutch pedal up), torque is transmitted to the input shaft. The input shaft and input drive gear transfer power to the counter shaft. The counter shaft transfers power to the third driven gear. When the 3–4 synchronizer is locked to third gear, power is transferred through the third driven gear to the main shaft.

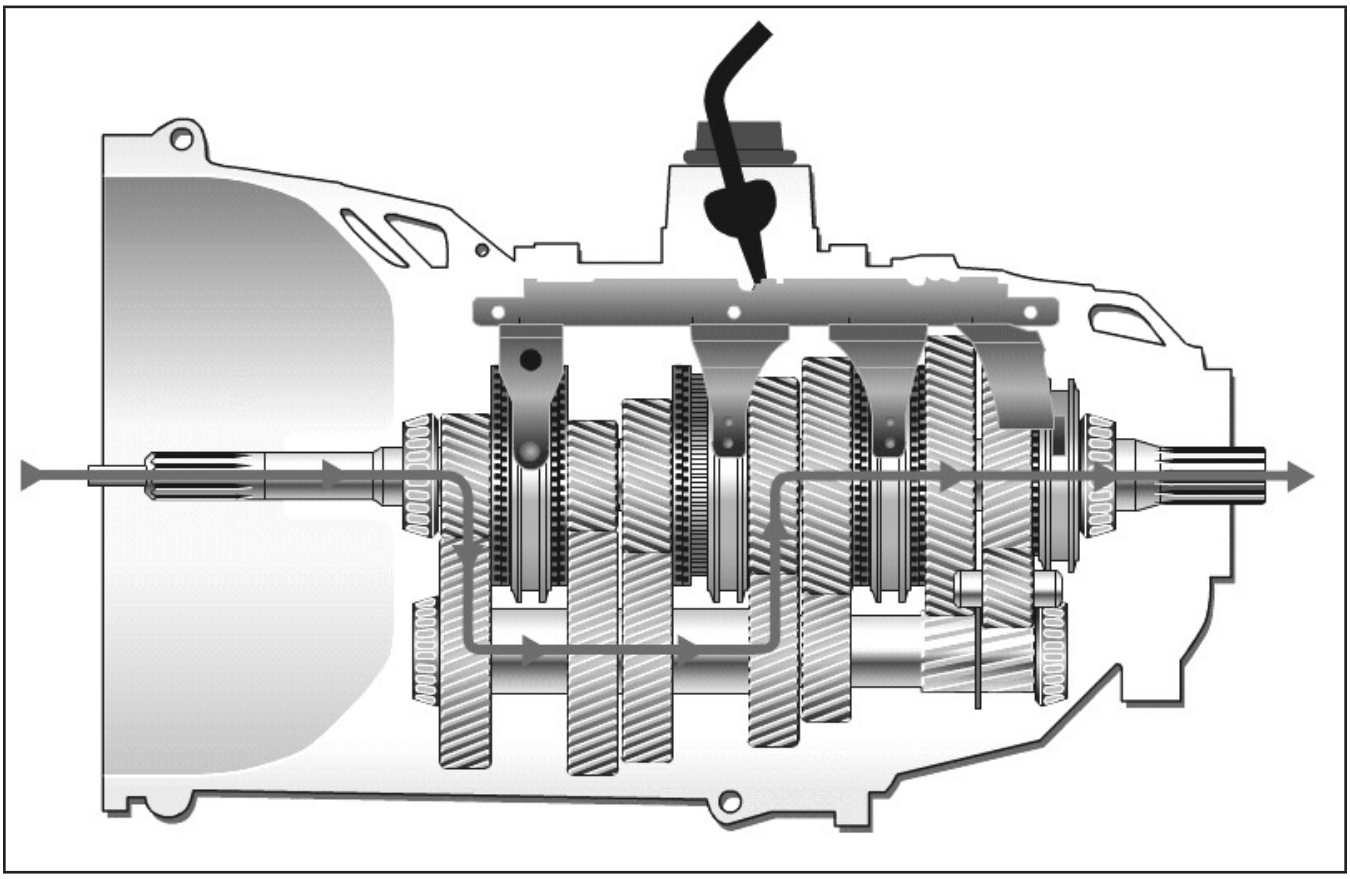


Figure 45 G56 Third Gear Power Flow

Fourth Gear

When the clutch is engaged (clutch pedal up), torque is transmitted to the input shaft. The input shaft and input drive gear transfer power to the counter shaft. The counter shaft transfers power to the fourth driven gear. When the 3–4 synchronizer is locked to fourth gear, power is transferred through the fourth driven gear to the main shaft.

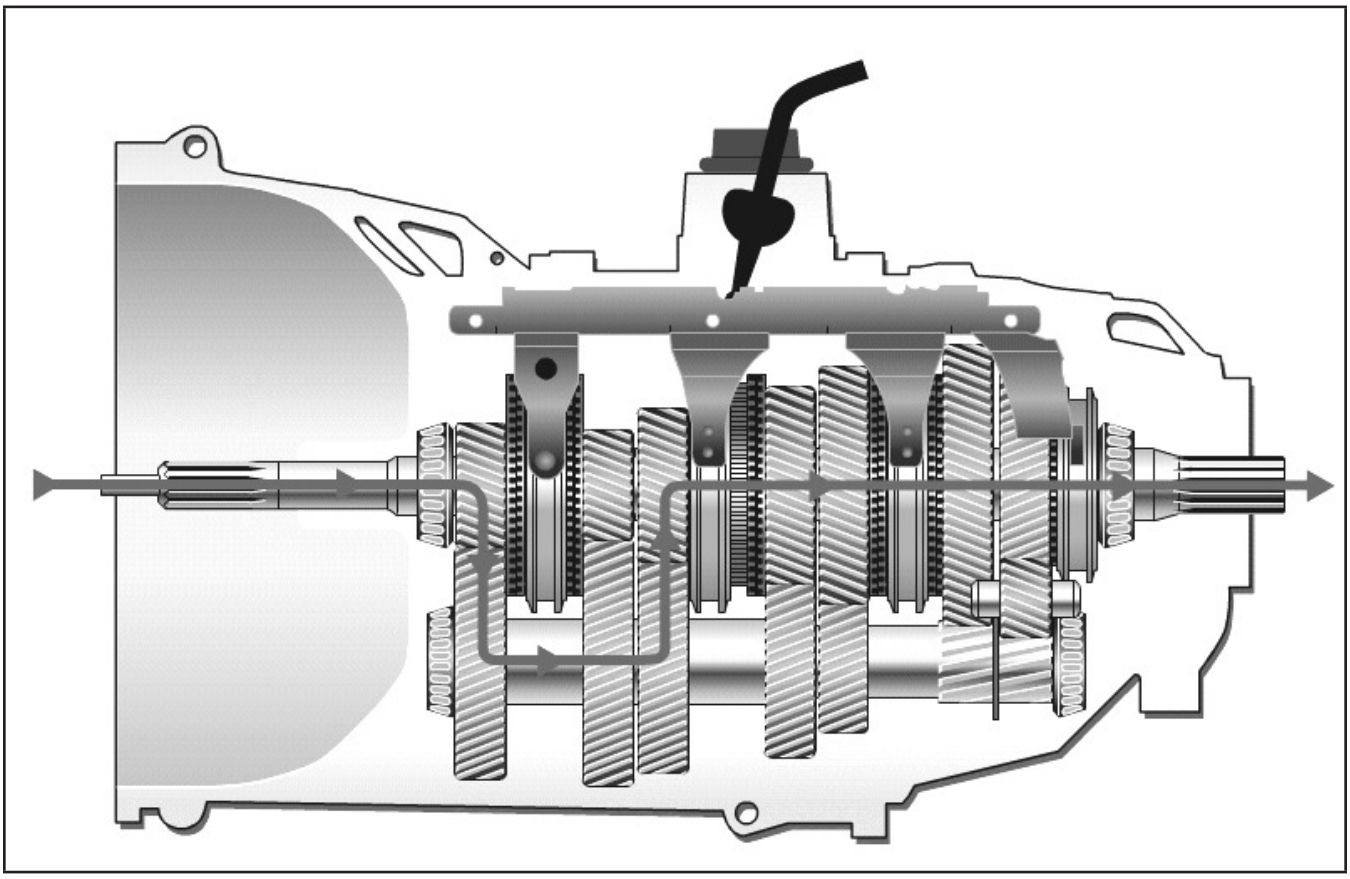


Figure 46 G56 Fourth Gear Power Flow

Fifth Gear

When the clutch is engaged (clutch pedal up), torque is transmitted to the input shaft. When the 5–6 synchronizer is locked to the input drive gear, torque is transferred directly from the input shaft to the main shaft by locking them together. This gives a fifth gear a 1:1 ratio.

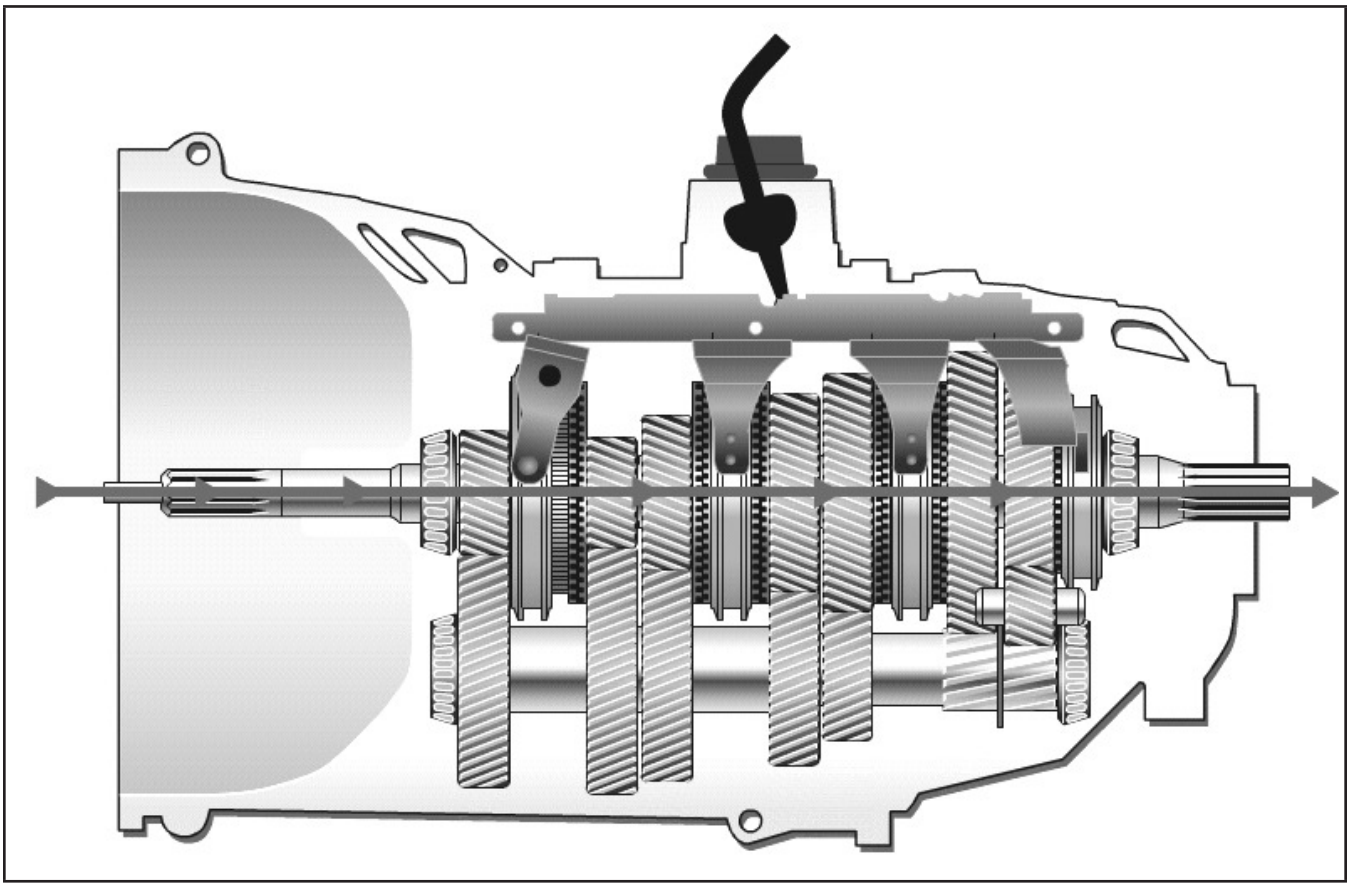


Figure 47 G56 Fifth Gear Power Flow

Sixth Gear

When the clutch is engaged (clutch pedal up), torque is transmitted to the input shaft. The input shaft and input drive gear transfer power to the counter shaft. The counter shaft transfers power to the sixth driven gear. When the 5–6 synchronizer is locked to sixth gear, power is transferred through the sixth driven gear to the main shaft.

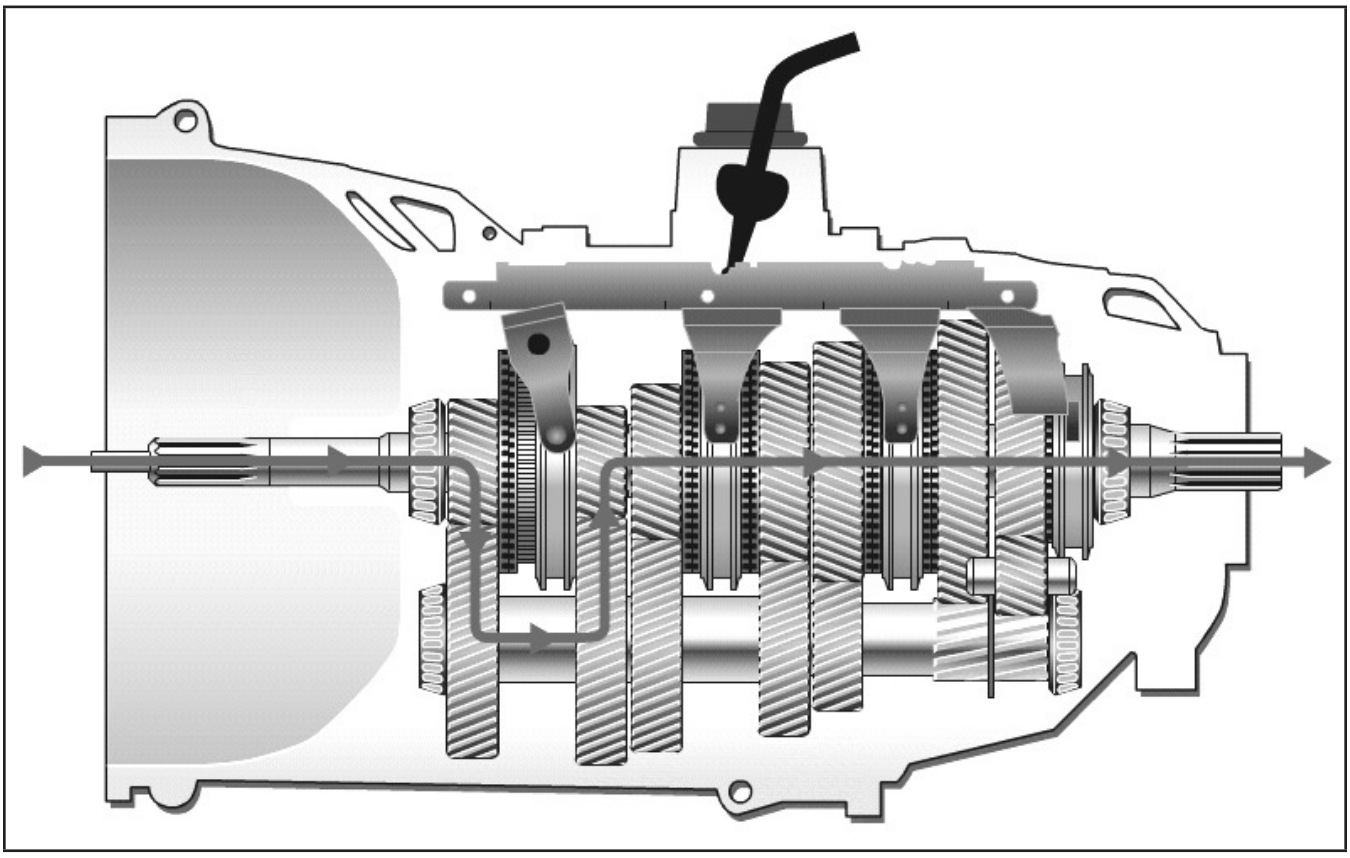
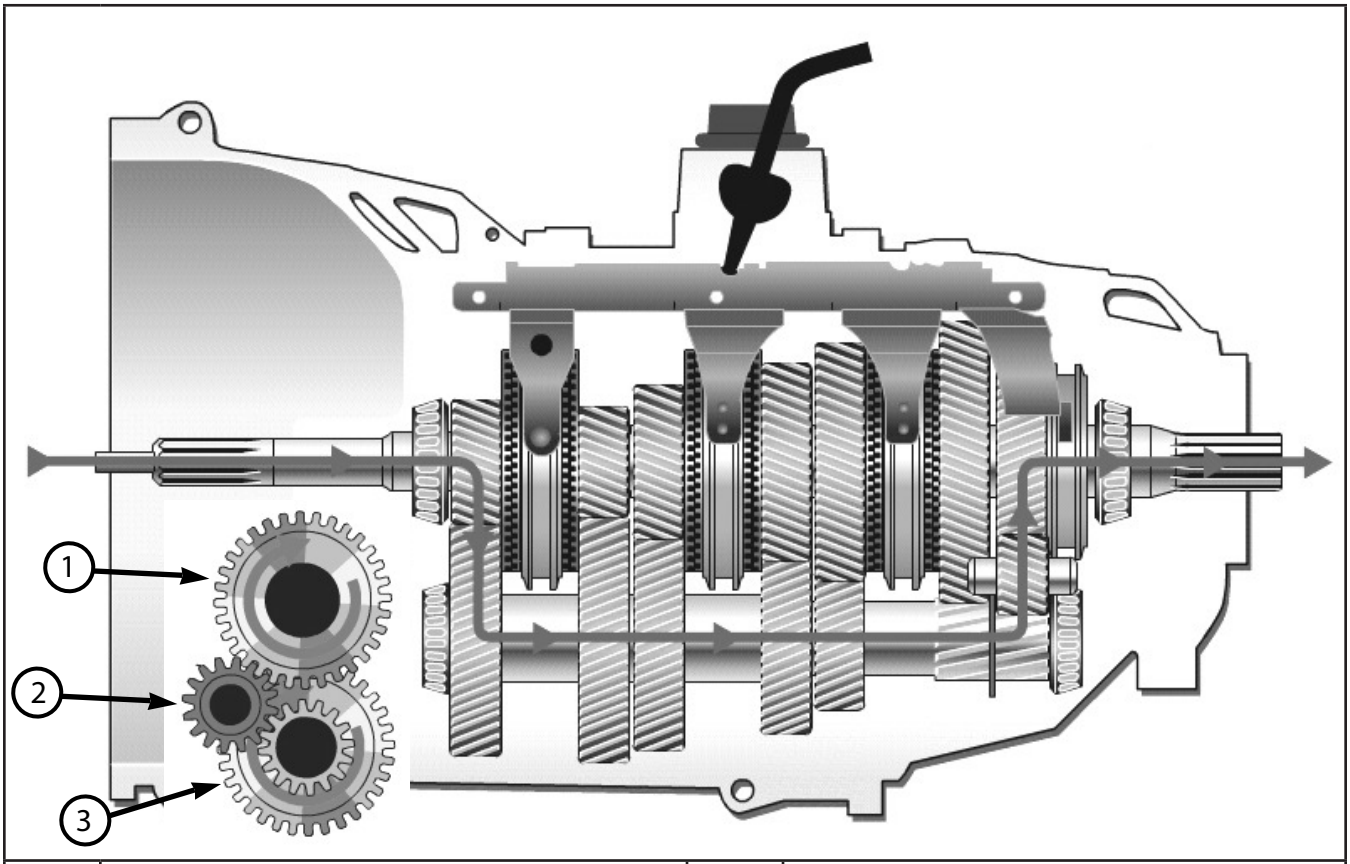


Figure 48 G56 Sixth Gear Power Flow

Reverse Gear

When the clutch is engaged (clutch pedal up), torque is transmitted to the input shaft. The input shaft and input drive gear transfer power to the counter shaft. The counter shaft transfers power to the reverse gear. When the reverse synchronizer is locked to reverse gear, power is transferred from the counter shaft through the reverse idler gear to the reverse driven gear on the main shaft. The reverse idler gear causes the main shaft to turn the opposite direction of the input shaft.



1	Main Shaft Reverse Gear	3	Counter Shaft Reverse Gear
2	Reverse Idler Gear		

Figure 49 G56 Reverse Gear Power Flow

Notes:

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MODULE 4 G238 MANUAL TRANSMISSION

GEAR RATIOS

The table below shows the gear ratios for the G238 transmission. The G238 is available in the Dodge Dakota (ND) and the Dodge Ram (DR) 1500 models.

Table 8 Gear Ratios

Gear	G238
1st	4.23
2nd	2.53
3rd	1.67
4th	1.23
5th	1.00
6th	0.79
Reverse	3.75

SHIFT PATTERN

The shift patterns for the NSG370 and G238 transmissions are the same. The illustration below shows the shift pattern for the transmissions.

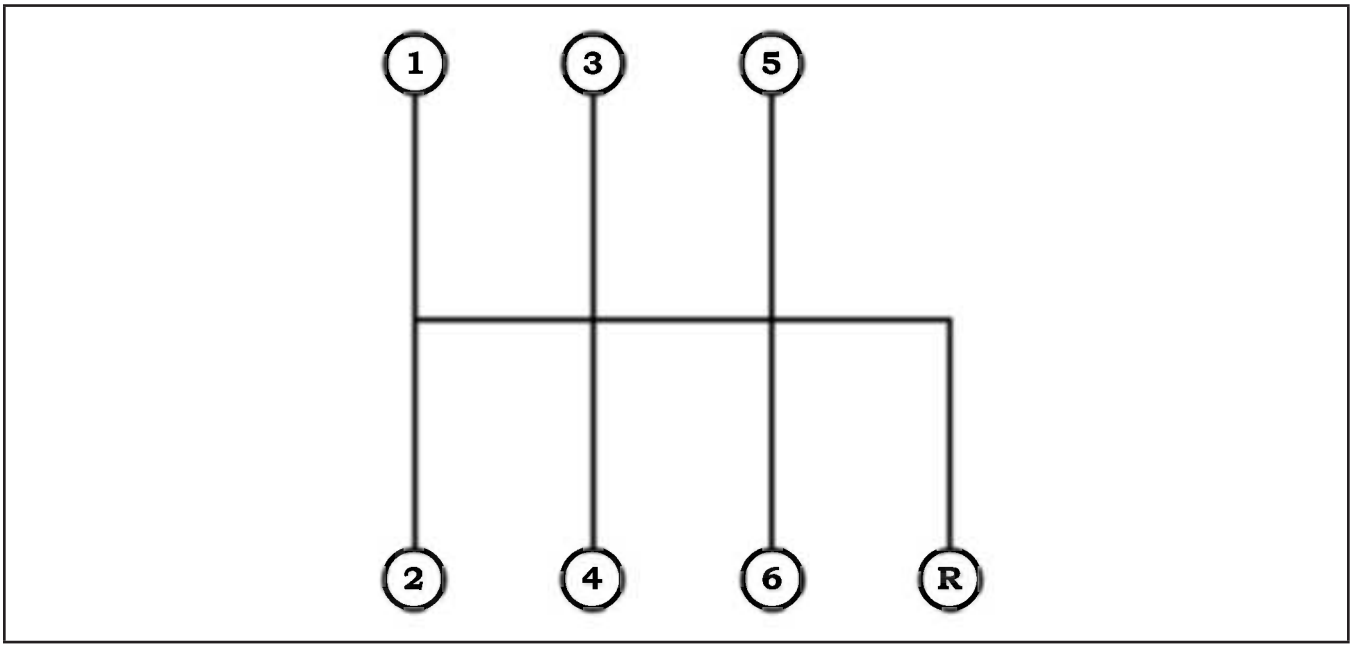
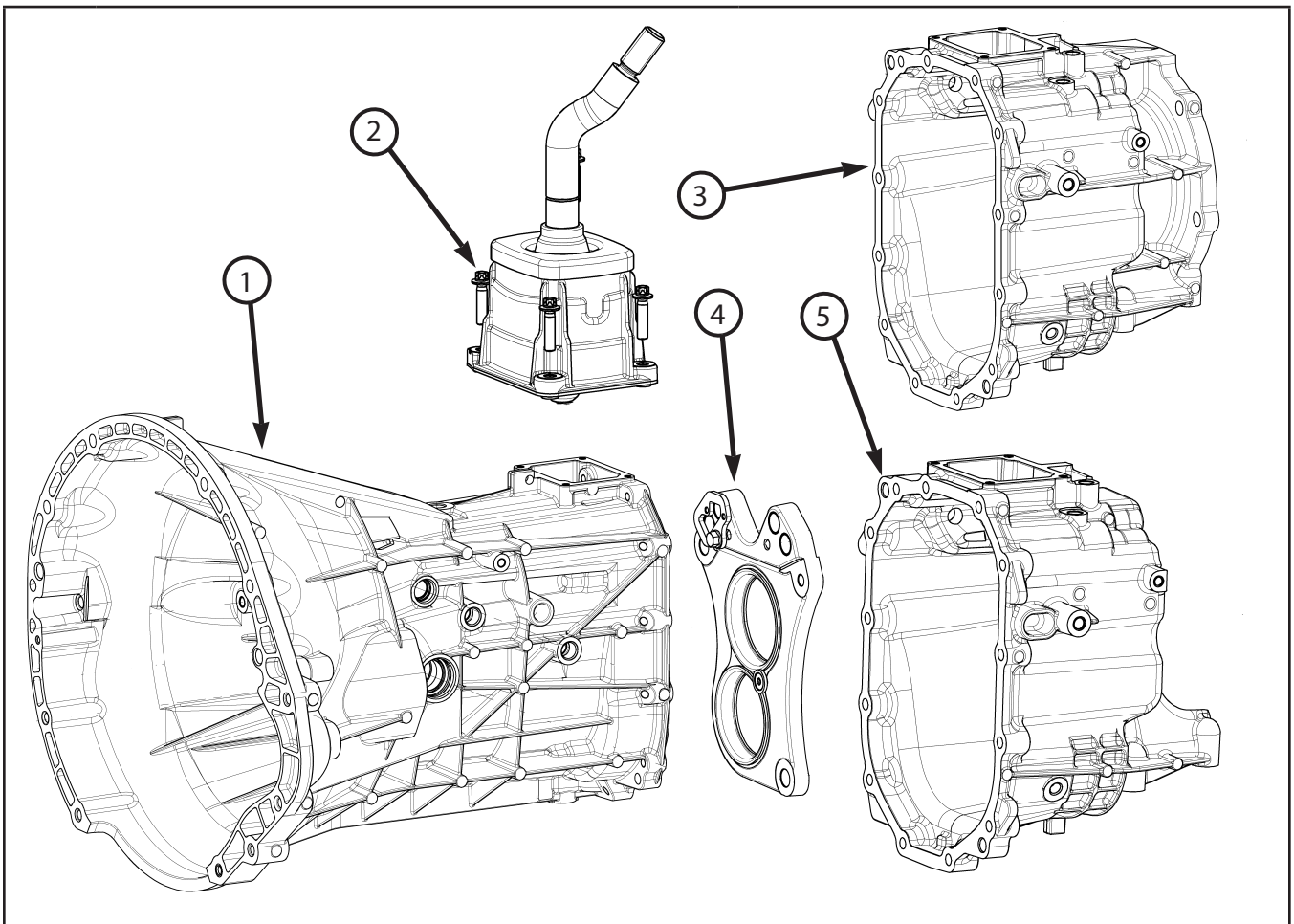


Figure 50 NSG370 and G238 Shift Pattern

COMPONENTS

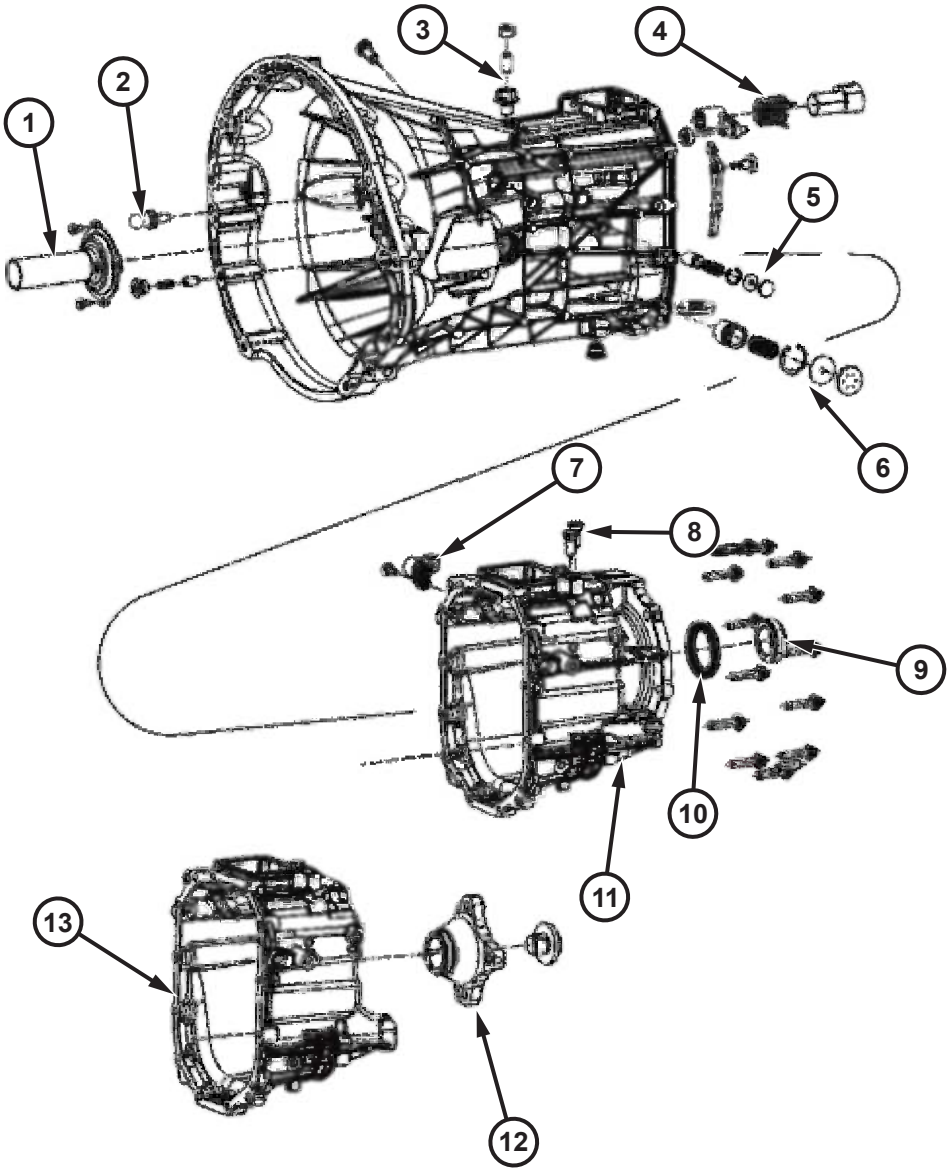
Housing

The G238 transmission housing contains 4 pieces: the front housing, the rear housing, the shift tower, and the center support plate. The front and rear housing splits to remove the input shaft, main shaft, and counter shaft. The shift tower can be installed on the front case housing or the rear case housing depending on the application. The Dodge Dakota (ND) will have the shift tower located on the rear case housing while the Dodge Ram 1500 (DR) will have the shift tower located on the front case housing.



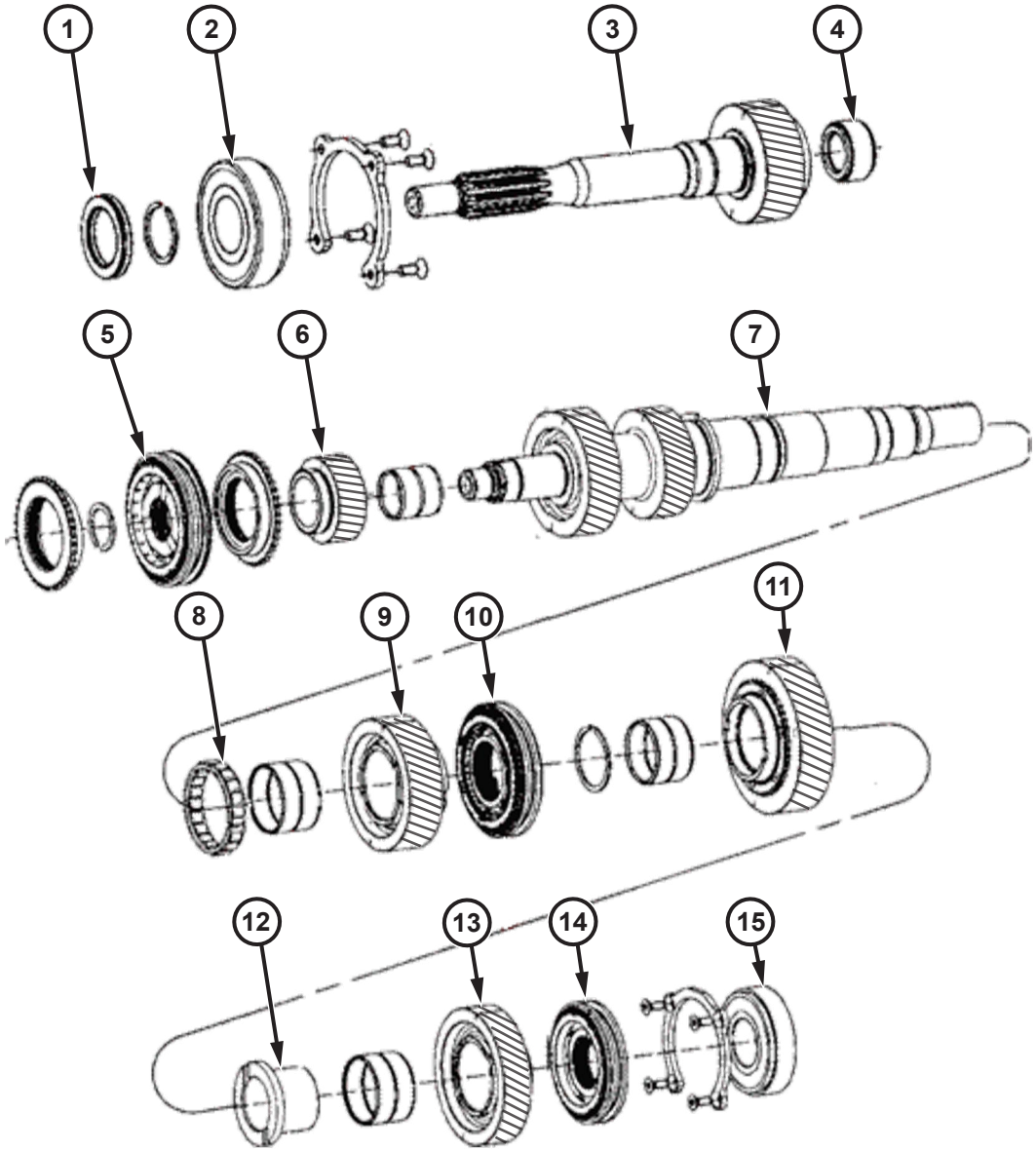
1	Front Housing	4	Center Support Plate
2	Shift Tower	5	4 X 2 Rear Housing
3	4 X 4 Rear Housing		

Figure 51 G238 Transmission Housing



1	Clutch Release Bearing Support	8	Shift Rail Detents (1–2, Reverse)
2	Clutch Fork Pivot Ball	9	Output Shaft Nut
3	Vent Screw & Cap	10	Mainshaft Output Seal
4	Shift Rail Spring	11	Rear Case Half (4x4)
5	Spring & Detent Components	12	Output Flange
6	Spring & Detent Components	13	Rear Case Half (4x2)
7	Reverse Lamp Switch		

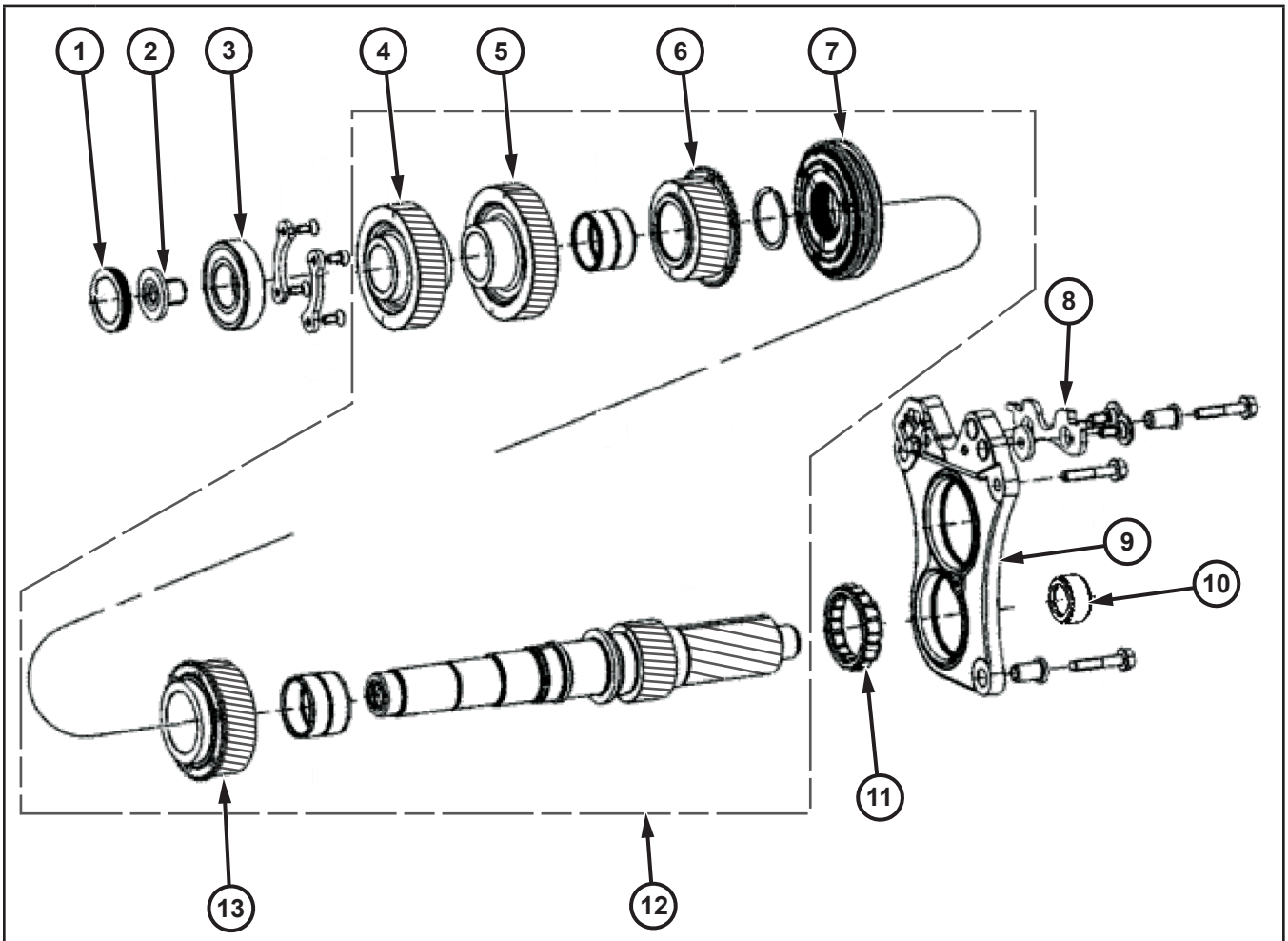
Figure 52 G238 Disassembled Case



1	Input Shaft Seal	9	Second Gear
2	Ball Bearing*	10	1–2 Synchronizer
3	Input Shaft	11	First Gear
4	Input Shaft Support Bearing	12	Reverse Gear Bearing Inner Race*
5	5–6 Synchronizer	13	Reverse Gear
6	Sixth Gear	14	Reverse Synchronizer
7	Main Shaft	15	Ball Bearing*
8	Roller Bearing		

* Part must be heated for assembly.

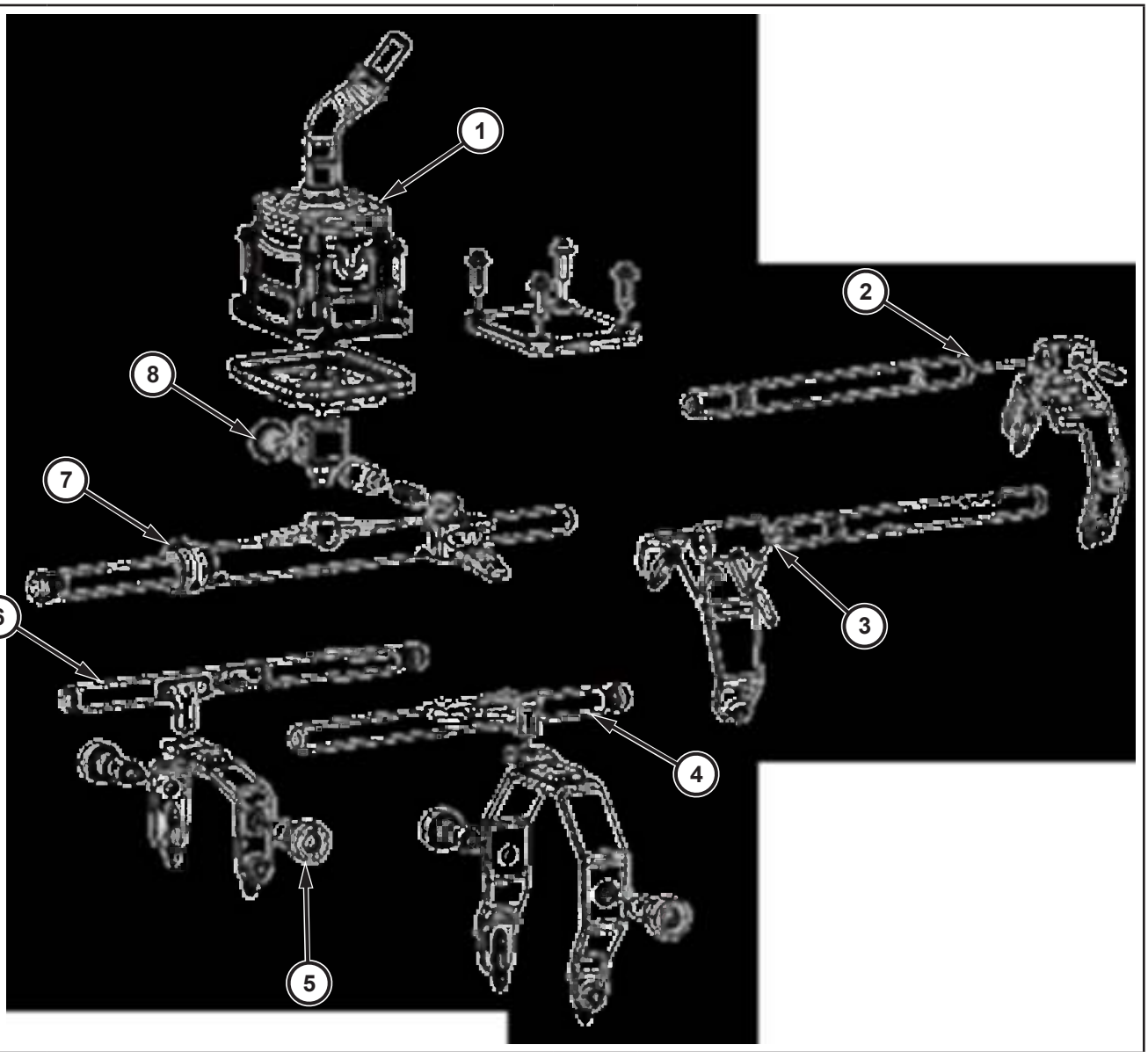
Figure 53 G238 Disassembled Gear Train



1	Countershaft Fluid Plug	8	Shift Rail Interlock
2	Countershaft Bolt	9	Center Support Plate
3	Front Ball Bearing*	10	Roller Bearing
4	Input Gear	11	Roller Bearing
5	Sixth Gear	12	Countershaft Assembly
6	Third Gear	13	Fourth Gear
7	3–4 Synchronizer		

* Part must be heated for assembly.

Figure 54 G238 Disassembled Countershaft



1	Shifter	5	Shift Fork Pivot Bolt
2	Reverse Shift Rail & Fork	6	5–6 Shift Rail & Fork
3	1–2 Shift Rail & Fork	7	Main Shift Rail
4	3–4 Shfit Rail & Fork	8	Detent

Figure 55 G238 Disassembled Shift Mechanisms

Input Shaft

The input shaft connects to the main shaft through the 5–6 synchronizer and contains the input gear. The shaft is supported through a sealed ball bearing retained in the front housing and a caged roller bearing connecting the input shaft to the main shaft. The input shaft is held into the front housing by the interference fit between the bearing and the input shaft.

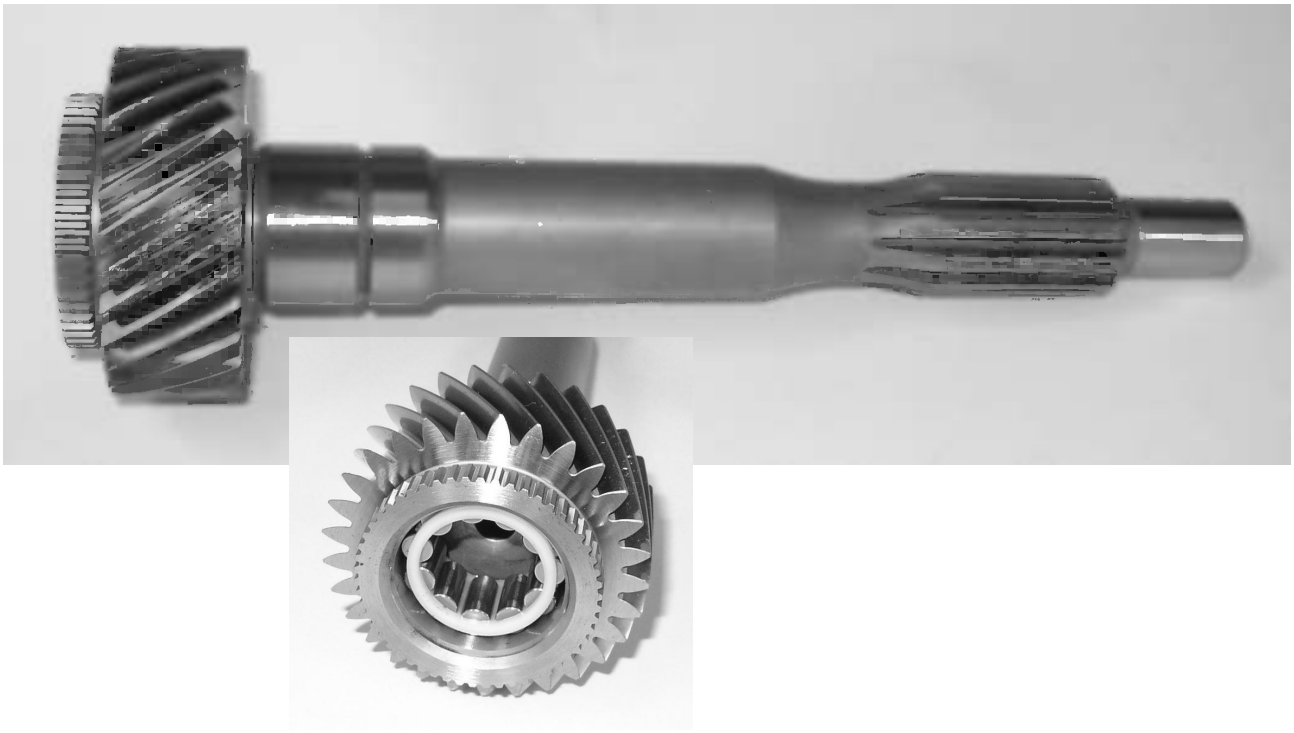
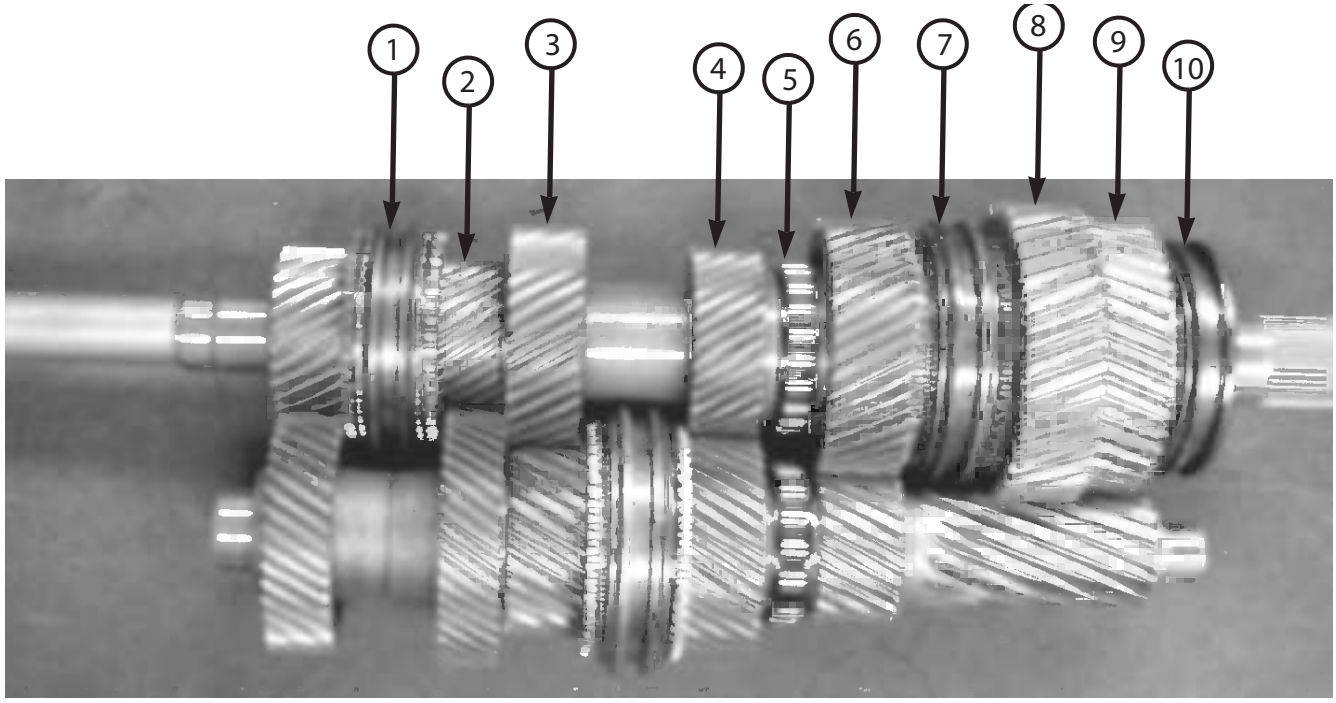


Figure 56 G238 Input Shaft

Main Shaft and Gears

The main shaft on the G238 contains the first, second, sixth and reverse speed gears along with the 1–2, 5–6, and reverse synchronizers. The third and fourth fixed gears are serviced as part of the main shaft assembly. It also contains the center support roller bearing.

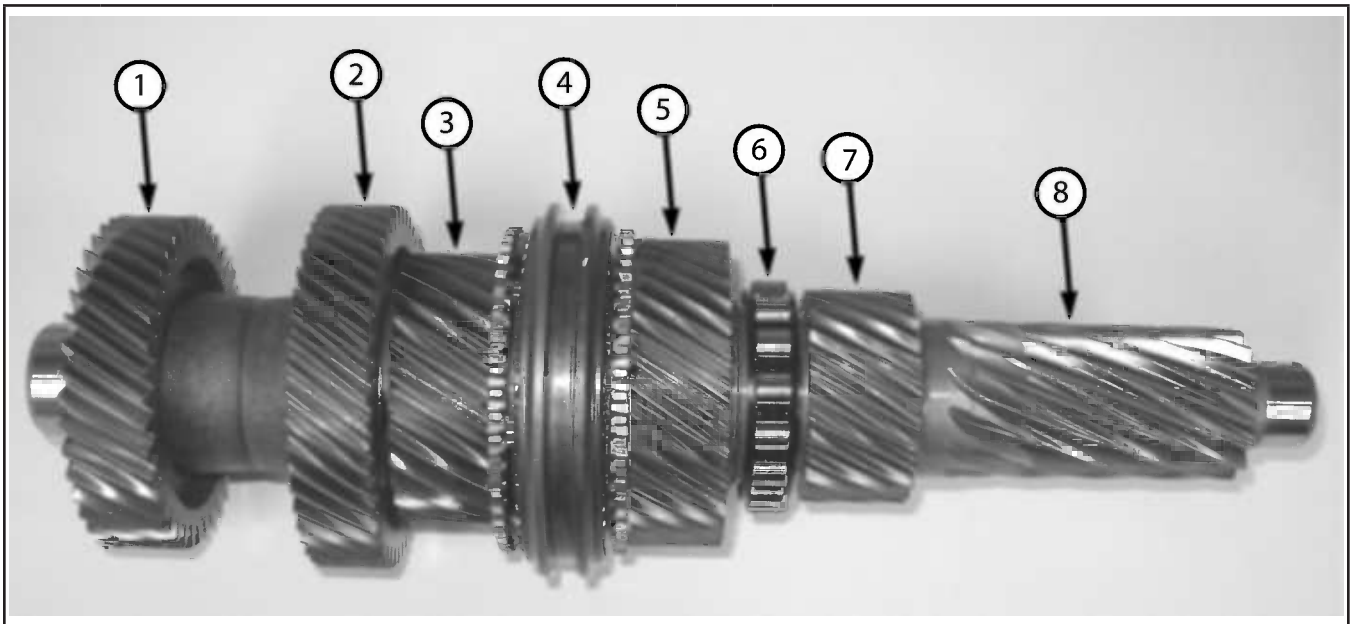


1	5–6 Synchronizer	6	Second Gear
2	Sixth Gear	7	1–2 Synchronizer
3	Third Gear	8	First Gear
4	Fourth Gear	9	Reverse Gear
5	Center Support Bearing	10	Reverse Synchronizer

Figure 57 G238 Main Shaft

Counter Shaft

The counter shaft on the G238 is only serviced as an assembly. The counter shaft contains the first, second, input, sixth and reverse fixed gears and the third and fourth speed gears along with the 3–4 synchronizer. Also, there is a center support bearing (6) that is serviceable.

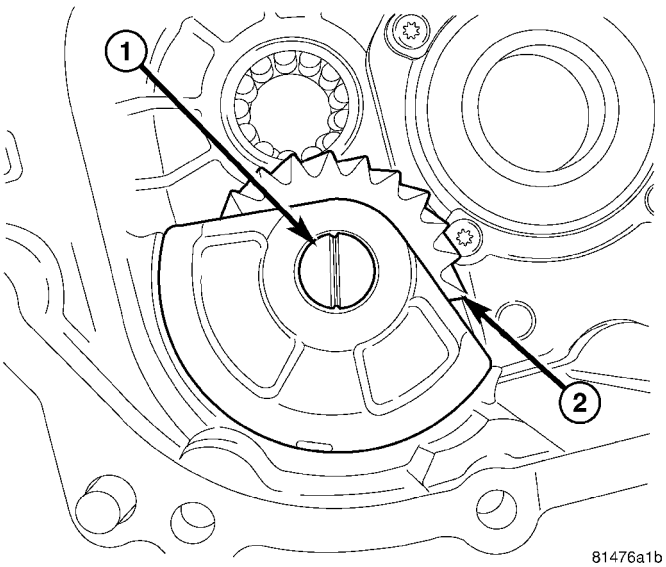


1	Input Gear	5	Fourth Gear
2	Sixth Gear	6	Center Support Bearing
3	Third Gear	7	Second Gear
4	3–4 Synchronizer	8	First and Reverse Gear

Figure 58 G238 Counter Shaft

Reverse Shaft

The reverse idler gear and shaft is removed from the rear case once the housing has been removed from the transmission. To remove the reverse idler gear, the bolt that holds the shaft in place must be removed from the outside of the case. Then lift up on the reverse shaft and shaft support. Once the shaft is removed, the reverse idler gear and bearing can be removed from the housing.



1	Reverse Shaft	2	Reverse Idler Gear

Figure 59 G238 Reverse Shaft

Synchronizer Assembly

The synchronizer assembly on the G238 has triple cone synchronizers on first and second gear and dual cone synchronizers on third and fourth gears. These multiple-cone synchronizers ensure that the gears engage smoothly and quickly, during both upshifts and downshifts. The reverse synchronizer must be installed so that the synchronizer ring slides toward reverse gear.

The shift forks for the 3–4 and 5–6 synchronizers have pivot bolts installed through the case into the shift forks.

Caution: When installing the pivot bolts, ensure the holes are lined up so the pivot bolts go into the holes. If the bolts are installed without the holes lined up, damage to the shift forks will occur.

Figure 60 G238 1–2 Synchronizer

G238 Center Support Plate

The G238 uses a center support plate to give the main shaft and counter shaft extra support. The center support plate houses two roller bearing races and is pinned to the front case half.

Figure 61 G238 Center Support Plate

Bearings

The G238 uses three sealed ball bearings and four roller bearings. The sealed ball bearings are used on the main shaft, input shaft, and front counter shaft bearings. The roller bearings are used on the rear counter shaft, both center support bearings, and between the front main shaft and rear input shaft.

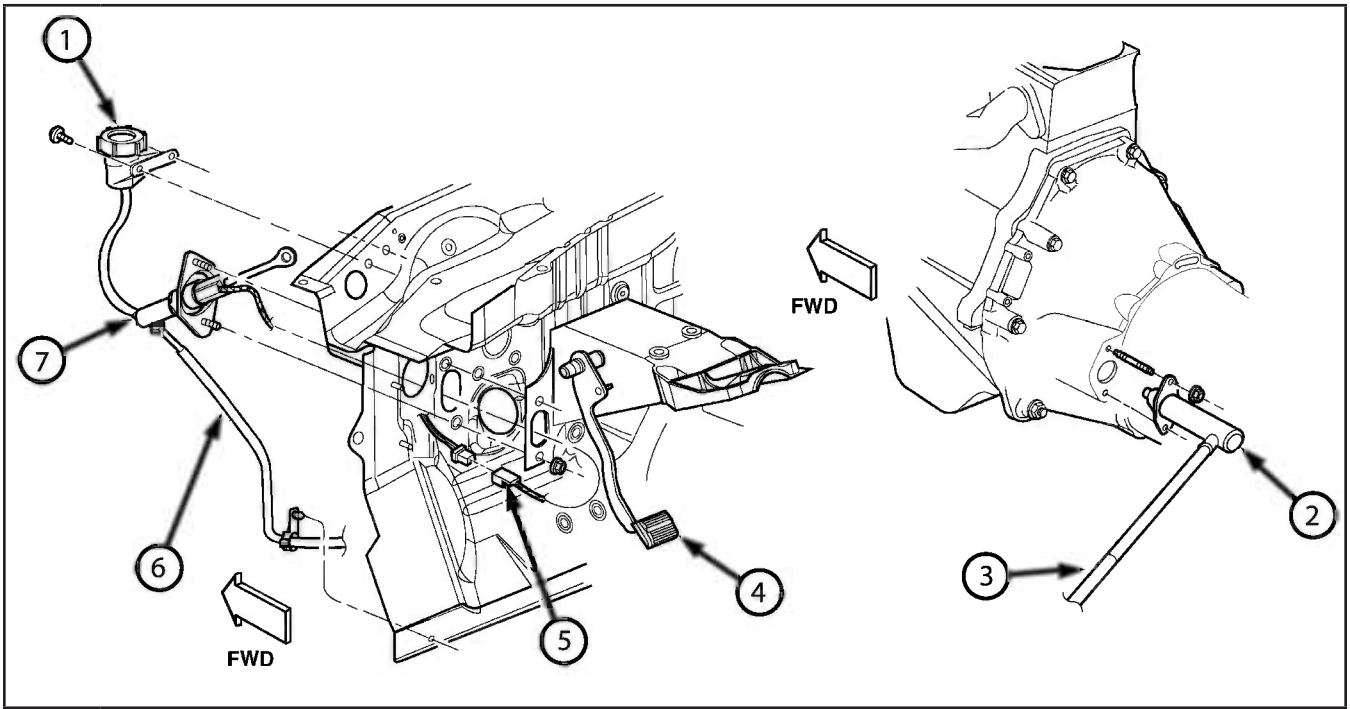
Clutch Master Cylinder

The clutch master cylinder is bolted to the bulkhead, and the master cylinder push rod is connected to the clutch pedal. When the clutch pedal is pressed, the push rod forces fluid pressure from the master cylinder through a fluid line to the slave cylinder.

Slave Cylinder

The slave cylinder is mounted to the transmission front housing. When the clutch pedal is pressed, fluid pressure from the master cylinder actuates the slave cylinder. The slave cylinder actuates the release bearing and fork.

Note: The clutch master cylinder, slave cylinder and connecting line are serviced as an assembly only. Components cannot be overhauled or serviced separately. Cylinders and connecting lines are sealed units.

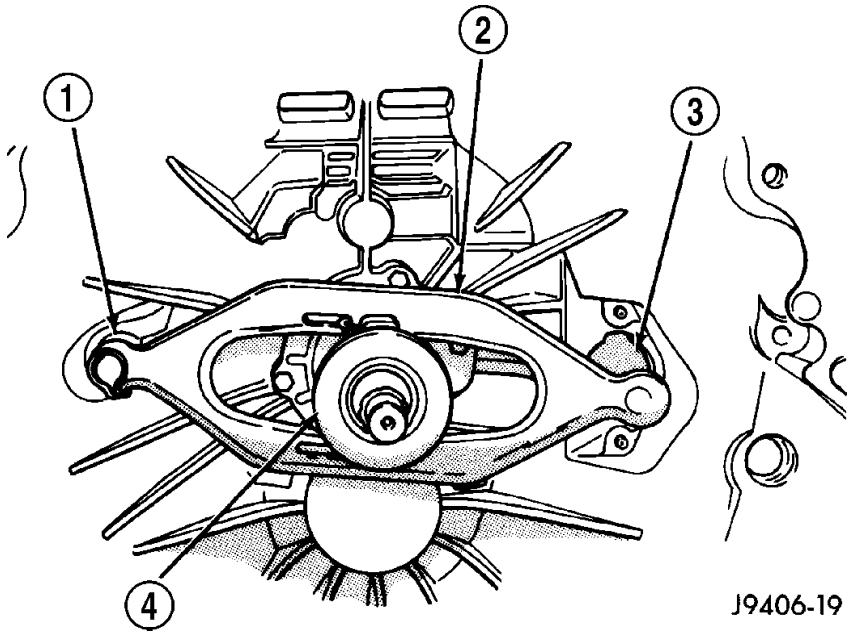


1	Clutch Fluid Reservoir	5	Clutch Pedal Position Switch Connector
2	Clutch Slave Cylinder	6	Clutch Hydraulic Line
3	Clutch Hydraulic Line	7	Clutch Master Cylinder
4	Clutch Pedal		

Figure 62 Hydraulic Clutch Assembly

Release Bearing and Fork

The release bearing is operated by a release fork pivoting on a ball stud mounted in the transmission clutch housing. The release bearing then presses the pressure plate spring fingers.



1	Pivot Ball	3	Slave Cylinder Opening
2	Clutch Fork	4	Release Bearing

Figure 63 Release Bearing

G238 POWER FLOW

First Gear

When the clutch is engaged (clutch pedal up), torque is transmitted to the input shaft. The input shaft and input drive gear transfer power to the counter shaft. The counter shaft transfers power to the first driven gear. When the 1–2 synchronizer is locked to first gear, power is transferred through the first driven gear to the main shaft.

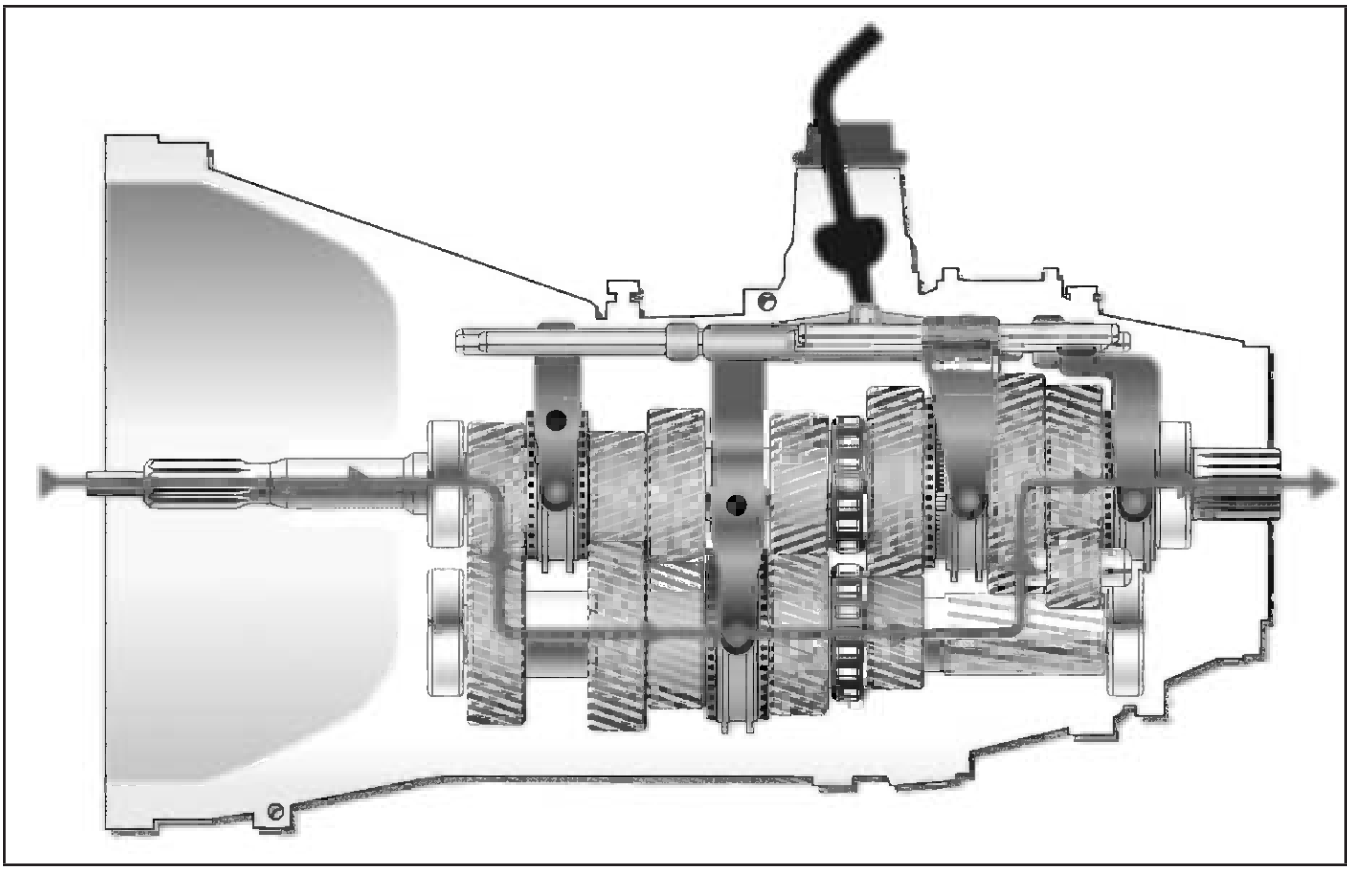


Figure 64 G238 First Gear Power Flow

Second Gear

When the clutch is engaged (clutch pedal up), torque is transmitted to the input shaft. The input shaft and input drive gear transfer power to the counter shaft. The counter shaft transfers power to the second driven gear. When the 1–2 synchronizer is locked to second gear, power is transferred through the second driven gear to the main shaft.

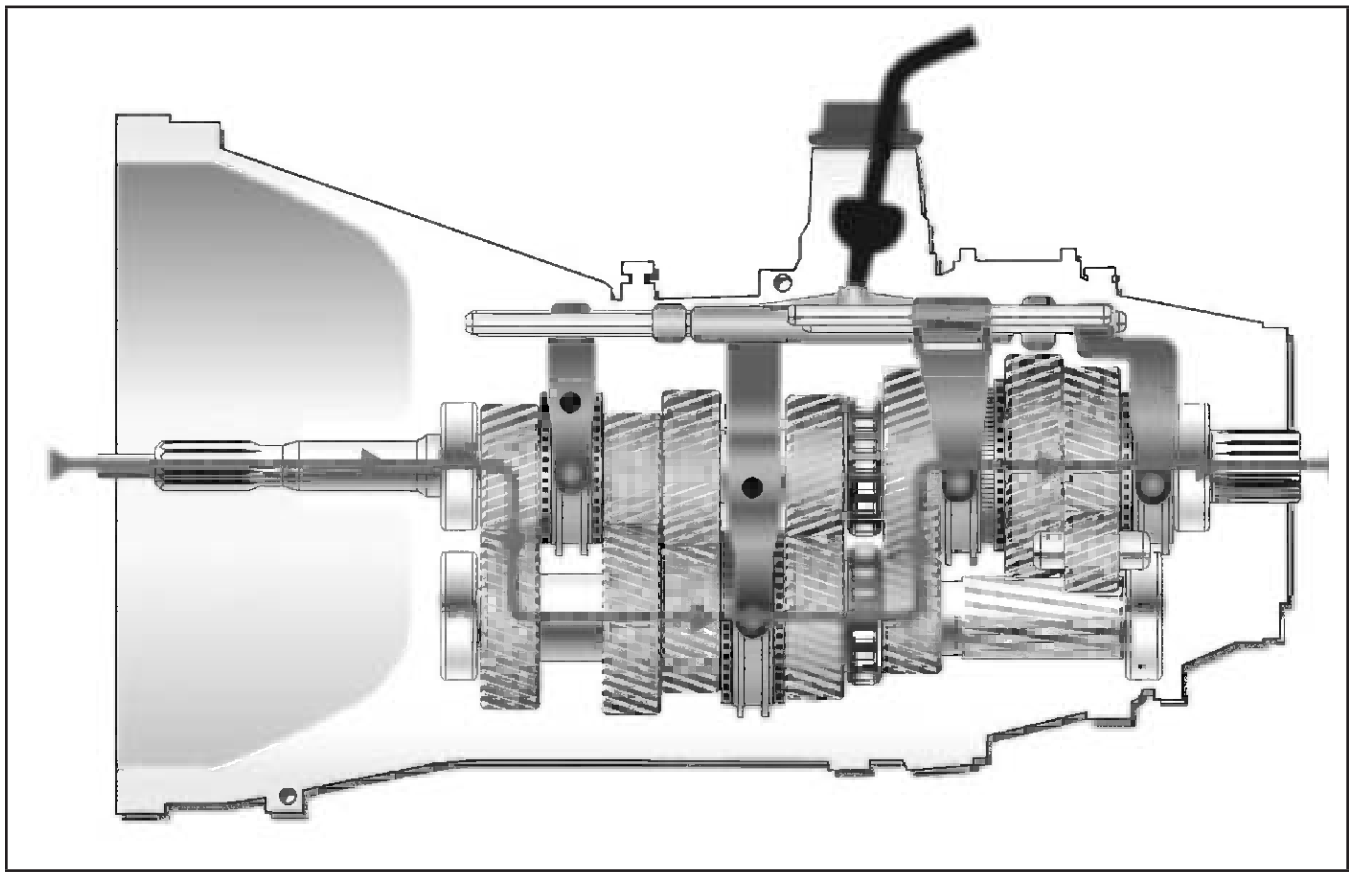


Figure 65 G238 Second Gear Power Flow

Third Gear

When the clutch is engaged (clutch pedal up), torque is transmitted to the input shaft. The input shaft and input drive gear transfer power to the counter shaft. When the 3–4 synchronizer is locked to third gear, power is transferred from the counter shaft to third drive gear. The third drive gear transfers power to the third driven gear on the main shaft, which drives the wheels.

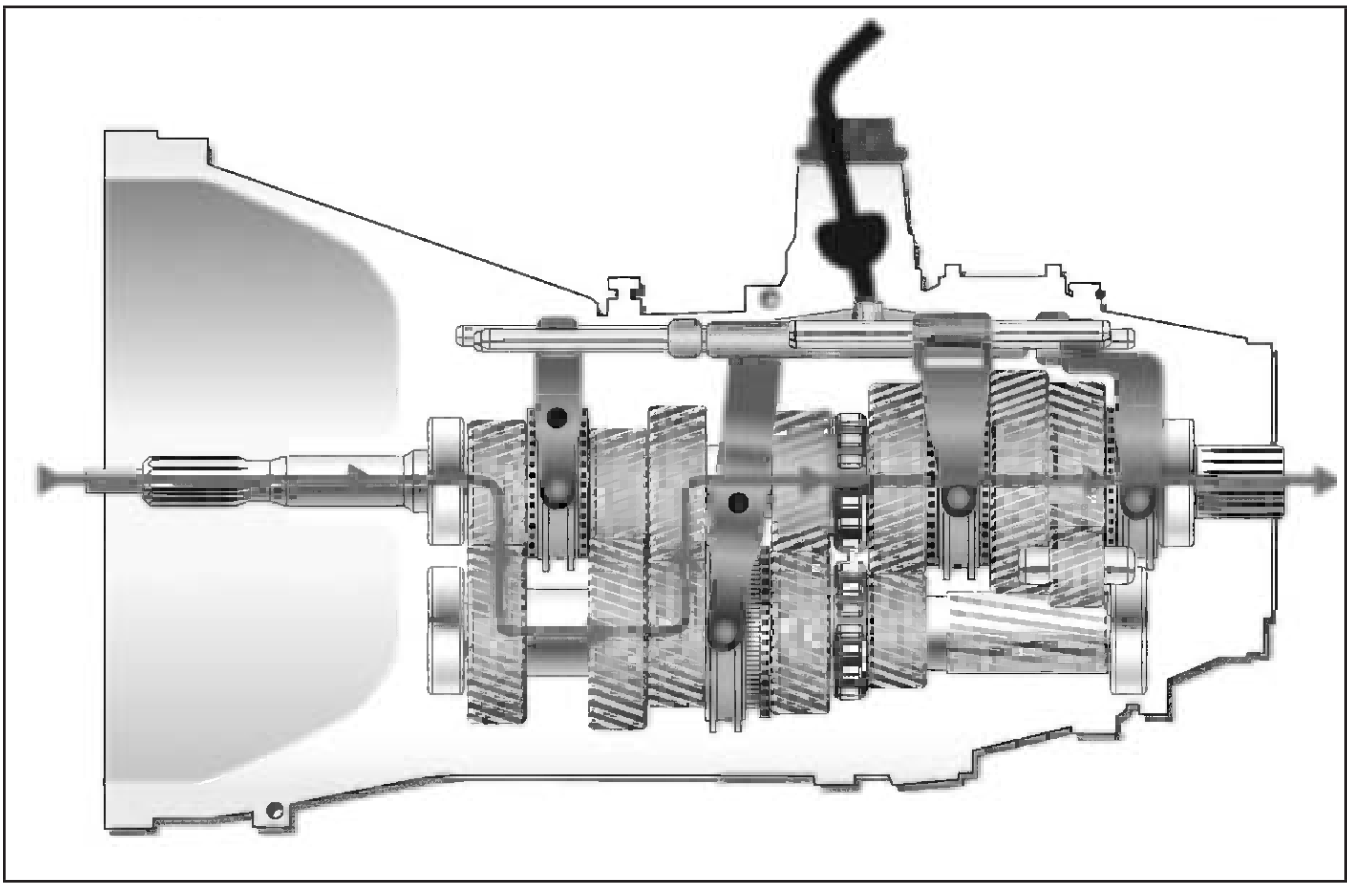


Figure 66 G238 Third Gear Power Flow

Fourth Gear

When the clutch is engaged (clutch pedal up), torque is transmitted to the input shaft. The input shaft and input drive gear transfer power to the counter shaft. When the 3–4 synchronizer is locked to fourth gear, power is transferred from the counter shaft to fourth drive gear. The fourth drive gear transfers power to the fourth driven gear on the main shaft, which drives the wheels.

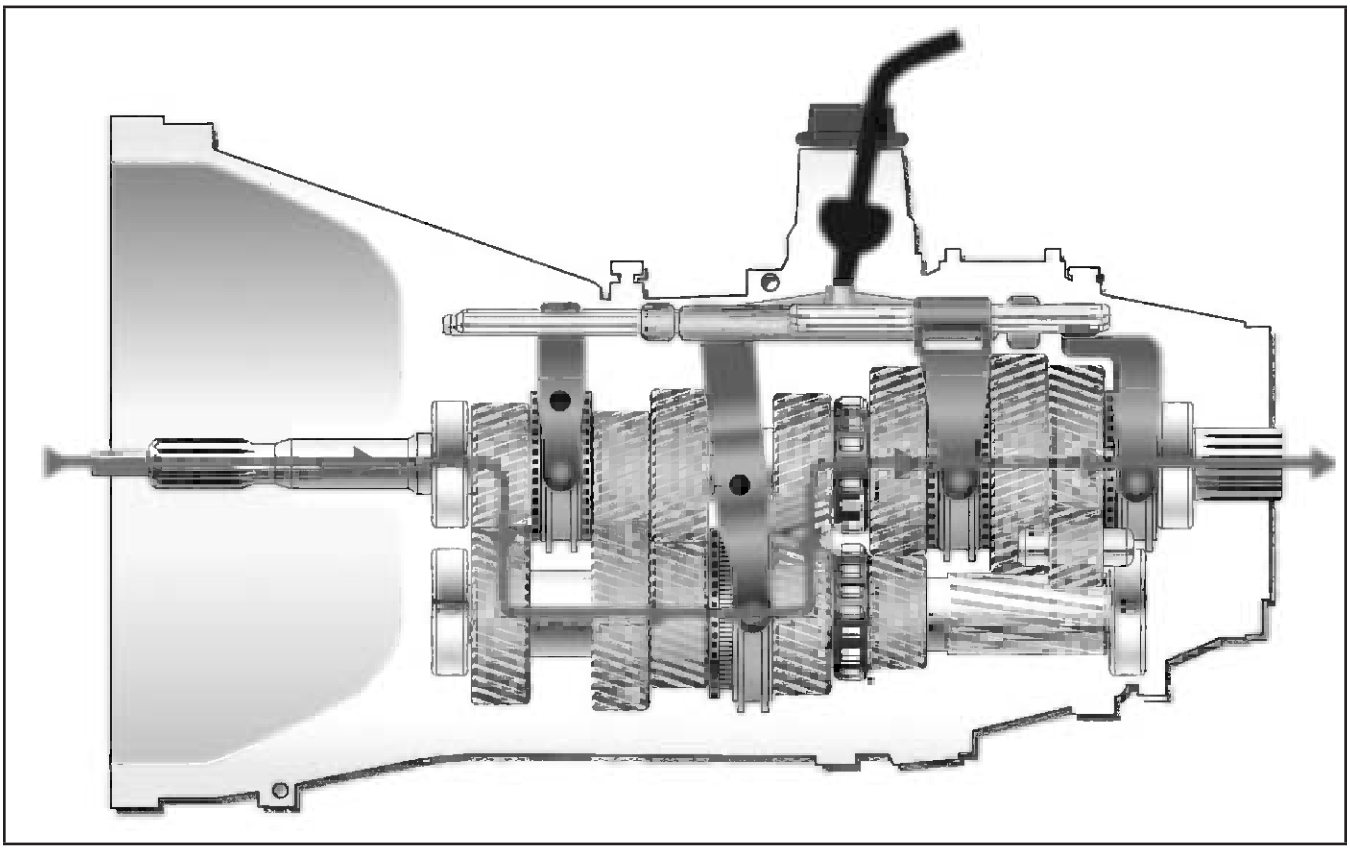


Figure 67 G238 Fourth Gear Power Flow

Fifth Gear

When the clutch is engaged (clutch pedal up), torque is transmitted to the input shaft. When the 5–6 synchronizer is locked to the input drive gear, torque is transferred directly from the input shaft to the main shaft by locking them together. This gives a fifth gear a 1:1 ratio.

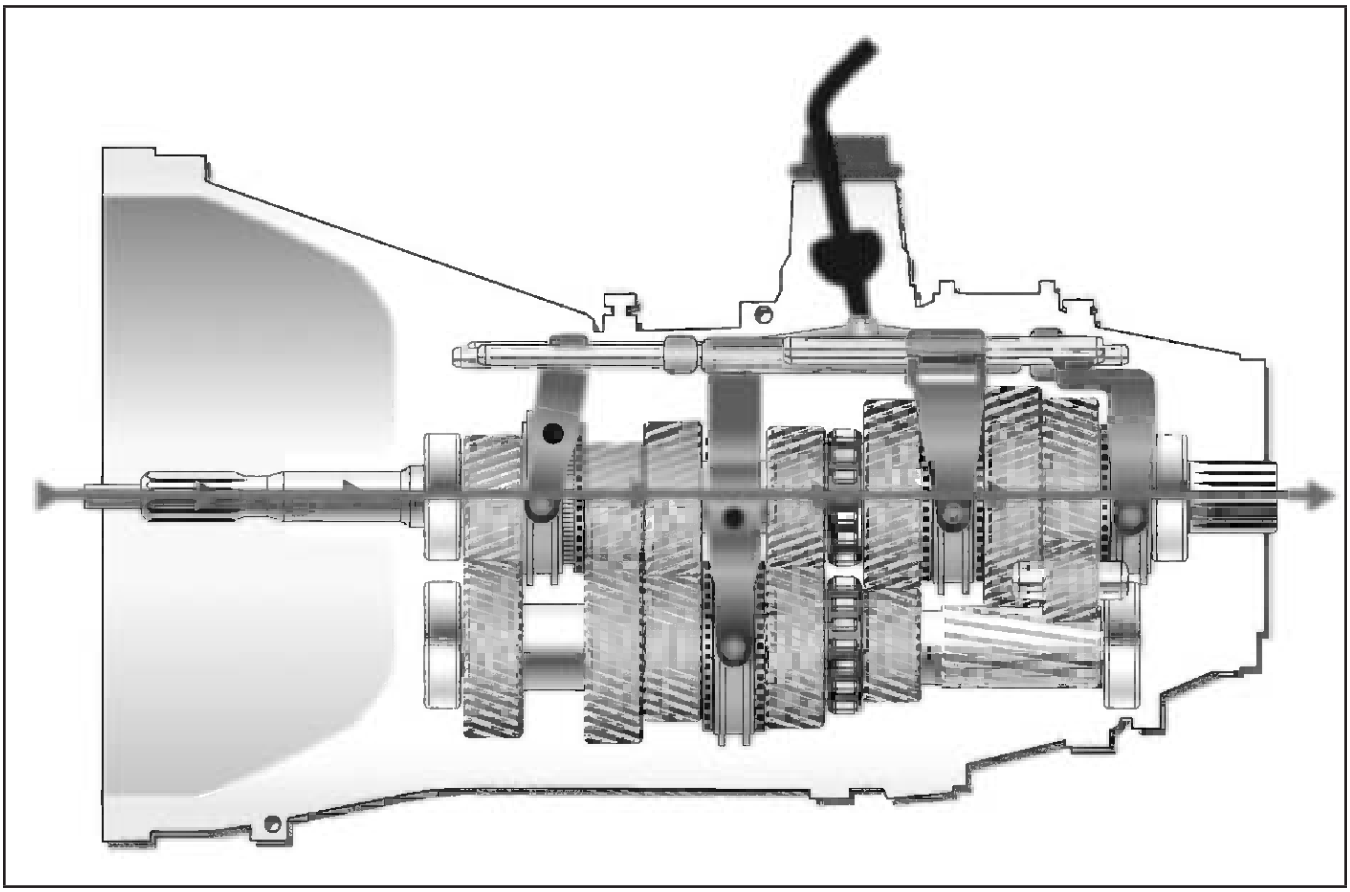


Figure 68 G238 Fifth Gear Power Flow

Sixth Gear

When the clutch is engaged (clutch pedal up), torque is transmitted to the input shaft. The input shaft and input drive gear transfer power to the counter shaft. The counter shaft transfers power to the sixth driven gear. When the 5–6 synchronizer is locked to sixth gear, power is transferred through the sixth driven gear to the main shaft.

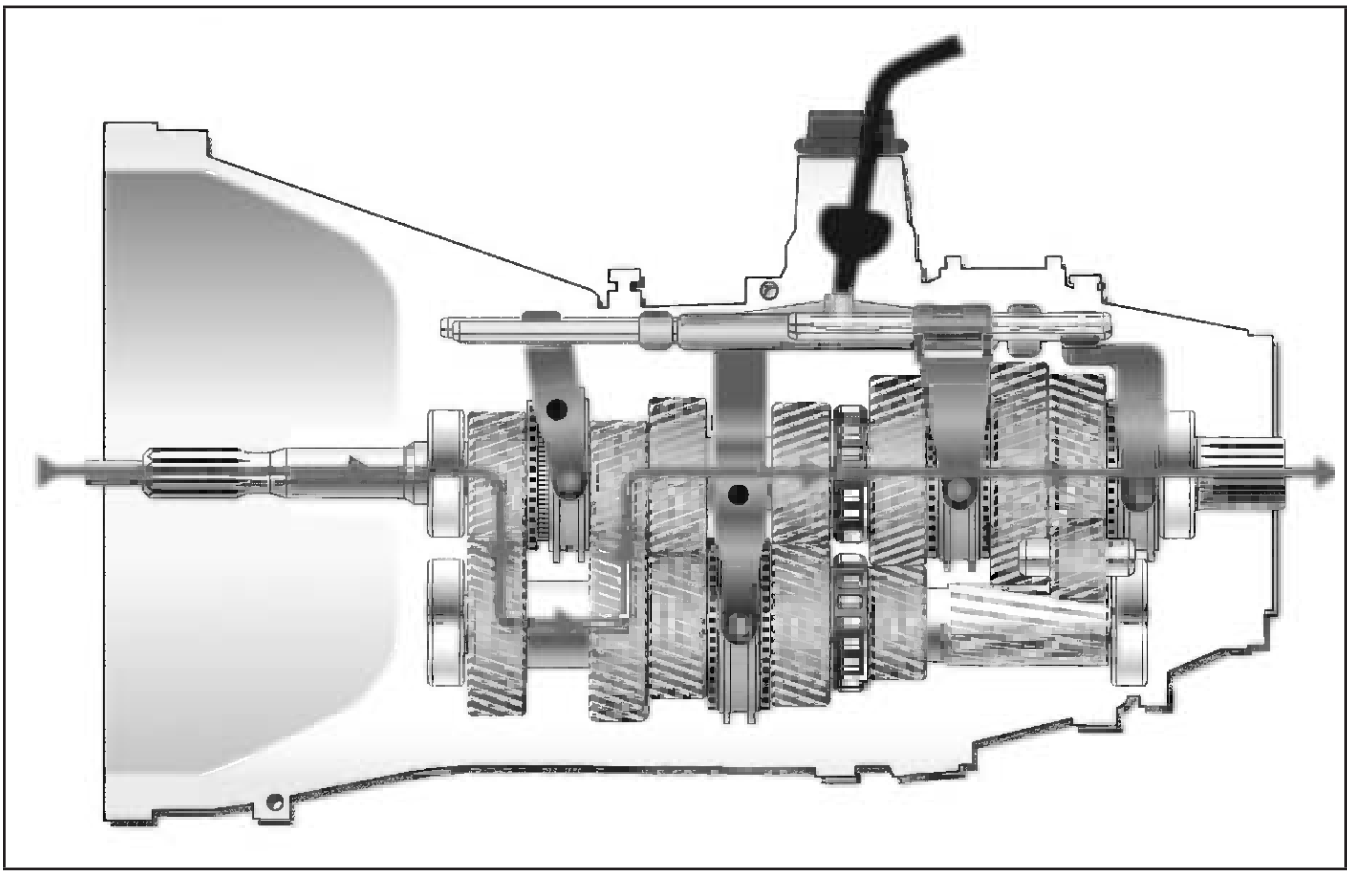
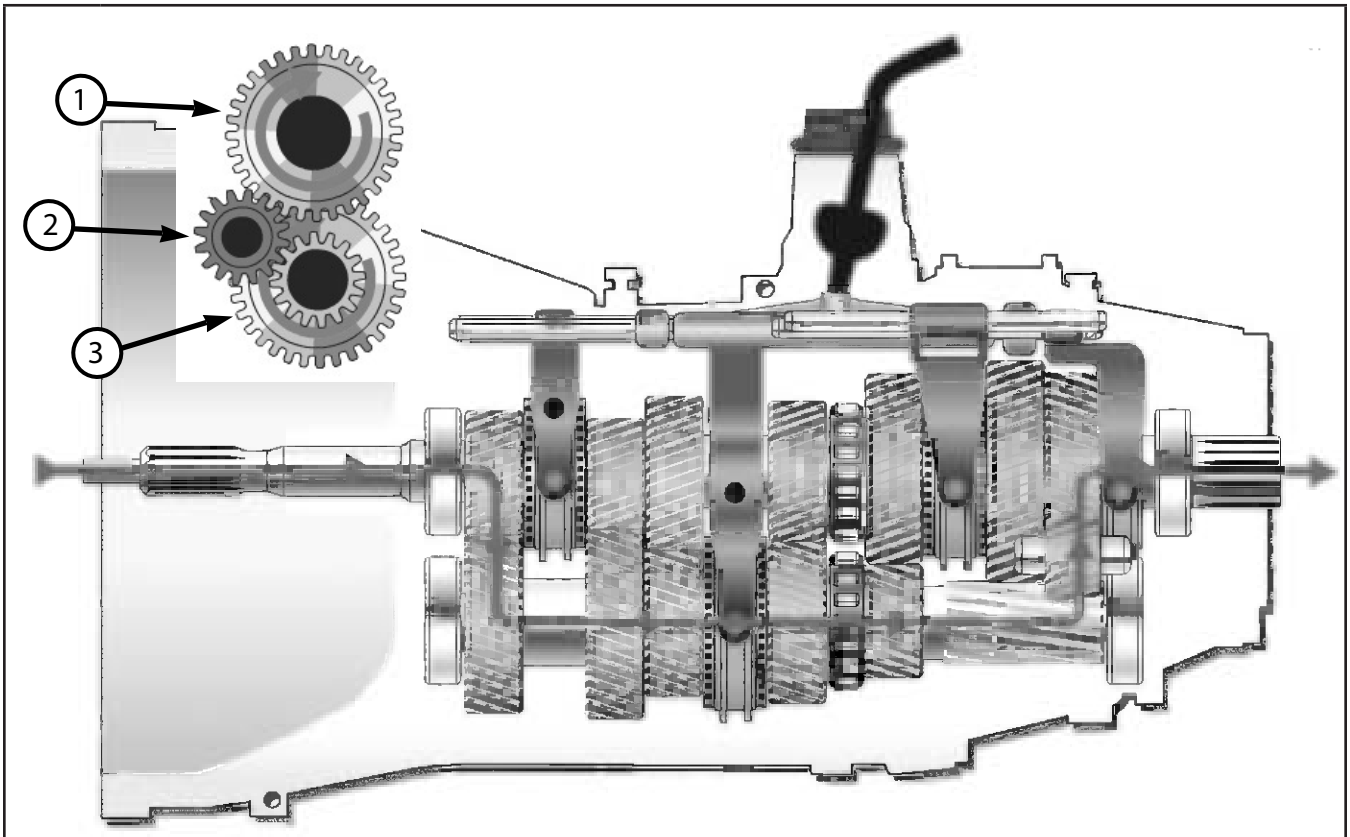


Figure 69 G238 Sixth Gear Power Flow

Reverse Gear

When the clutch is engaged (clutch pedal up), torque is transmitted to the input shaft. The input shaft and input drive gear transfer power to the counter shaft. The counter shaft transfers power to the reverse gear. When the reverse synchronizer is locked to reverse gear, power is transferred from the counter shaft through the reverse idler gear to the reverse driven gear on the main shaft. The reverse idler gear causes the main shaft to turn the opposite direction of the input shaft.



1	Main Shaft Reverse Gear	3	Counter Shaft Reverse Gear
2	Reverse Idler Gear		

Figure 70 G238 Reverse Gear Power Flow

Notes:

Notes:

MODULE 5 TR6060 MANUAL TRANSMISSION

GEAR RATIOS

The table below shows the gear ratios for the TR6060 transmission. The TR6060 is available in the Dodge Viper (ZB) and the Dodge Challenger (LC).

Table 9 Gear Ratios

Gear	TR6060	
	Viper (ZB)	Challenger (LC)
1st	2.66	2.97
2nd	1.82	2.10
3rd	1.30	1.46
4th	1.0	1.0
5th	0.74	0.74
6th	0.50	0.50
Reverse	2.90	2.90

SHIFT PATTERN

The illustration below shows the shift pattern for the Tremec.

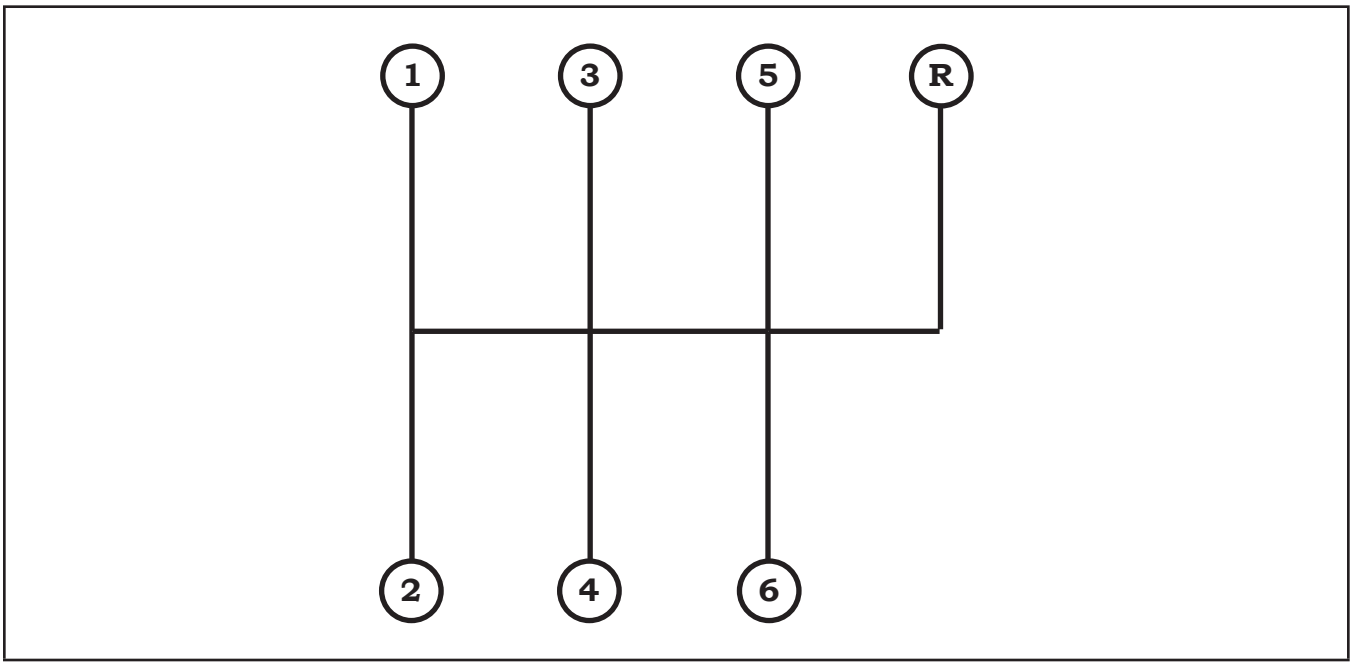


Figure 71 TR6060 Shift Pattern

COMPONENTS

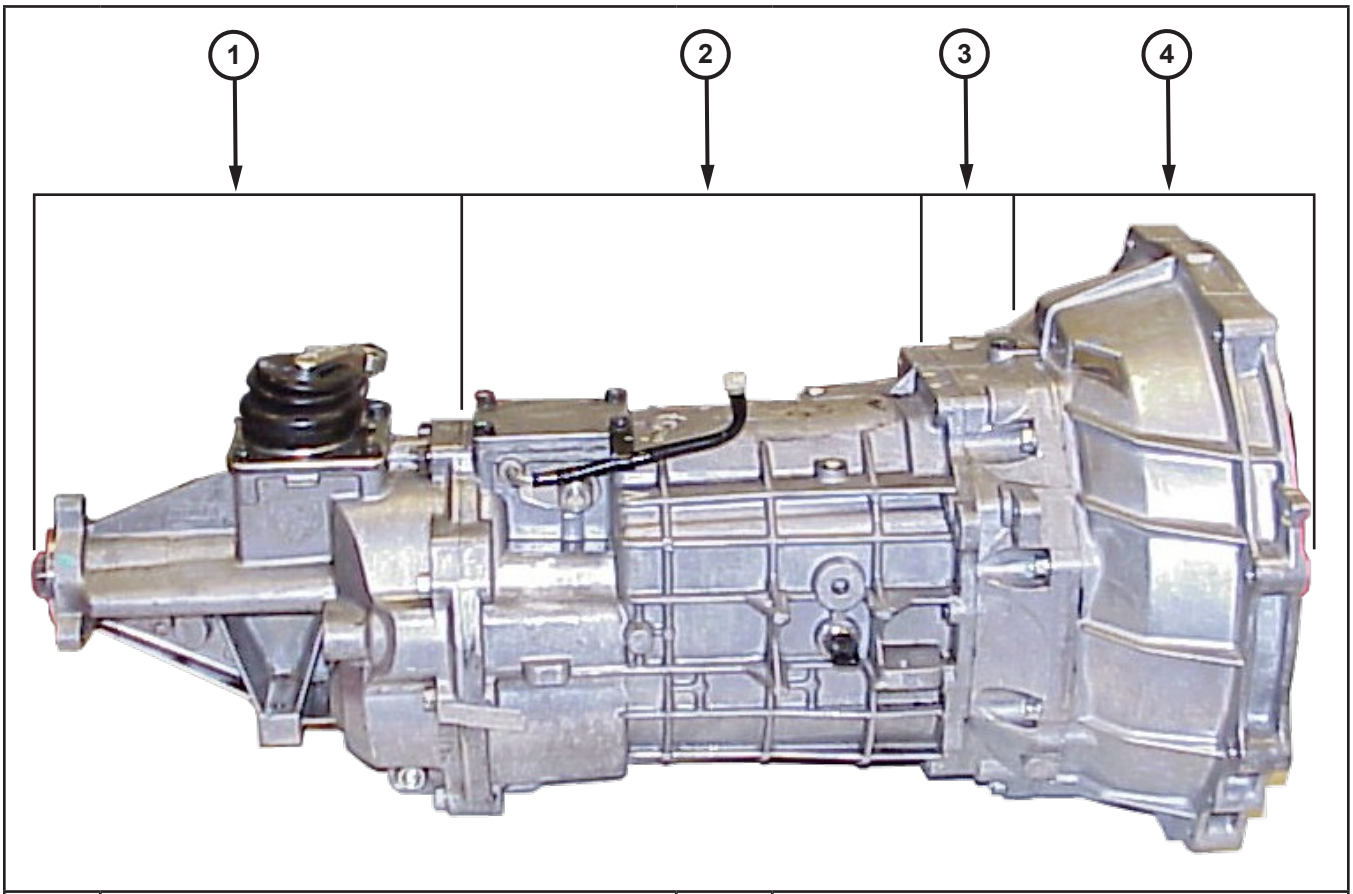
Housing

The housing of the TR6060 is divided into four sections. The extension housing provides a mounting point for the shifter and seals the output shaft. A slip-yoke output shaft is used on the Viper, while a fixed flange output shaft is used on the Challenger. The extension housing also encloses Reverse, Fifth and Sixth gears, and their synchronizers.

The transmission case encloses First through Fourth gears, the Reverse lamp switch, and the shift rail guide pins.

The adapter plate seals the input shaft, supports the front end of the geartrain, and houses the oil pump, if equipped. The oil pump may be available as a Mopar® kit for most TR6060 units, which is only required for severe racing conditions. The oil pump is driven by the countershaft to circulate transmission oil through an external oil cooler.

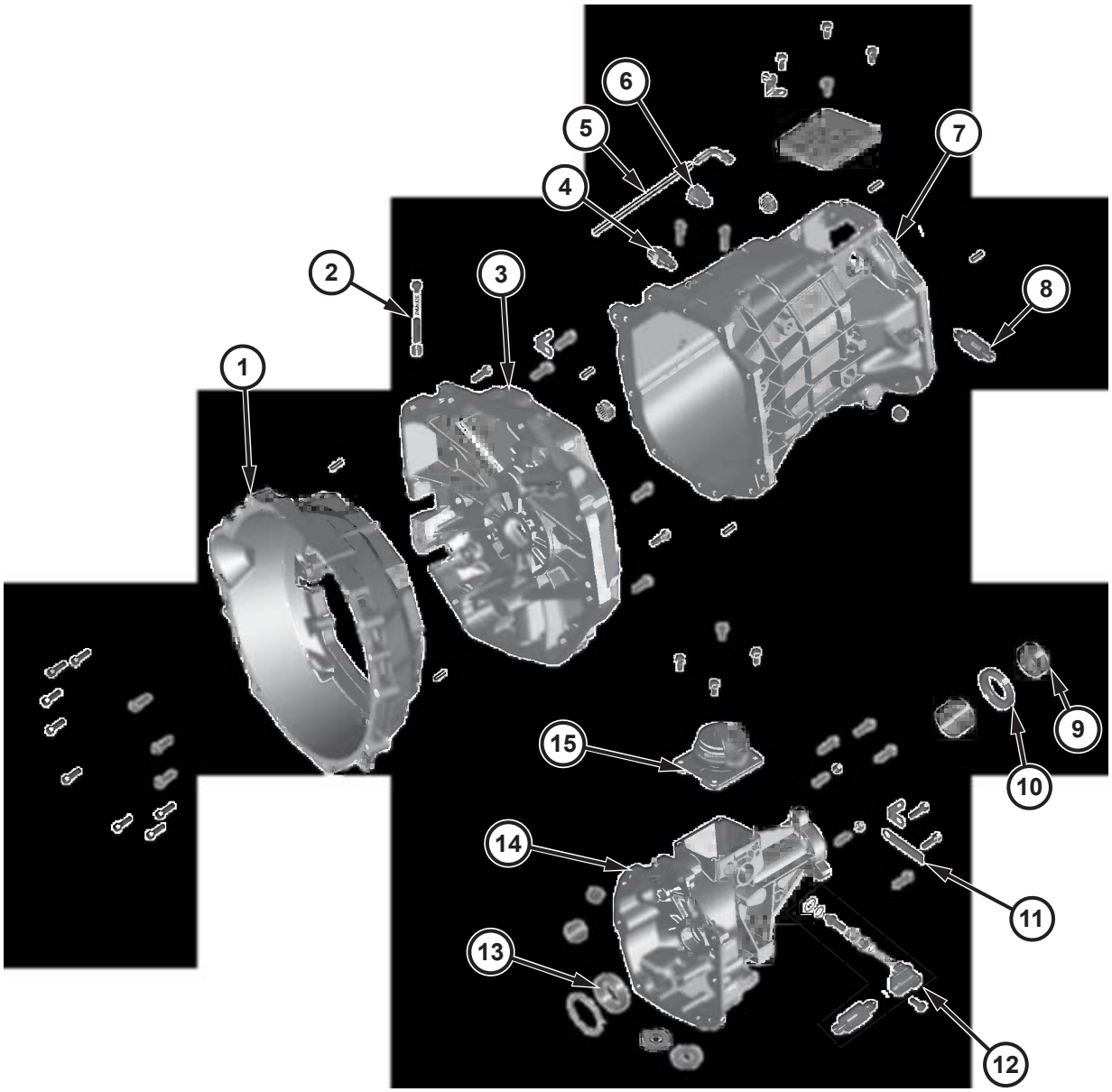
The clutch bellhousing mates the transmission to the engine.



1	Extension Housing	3	Adapter Plate
2	Transmission Case	4	Clutch Bellhousing

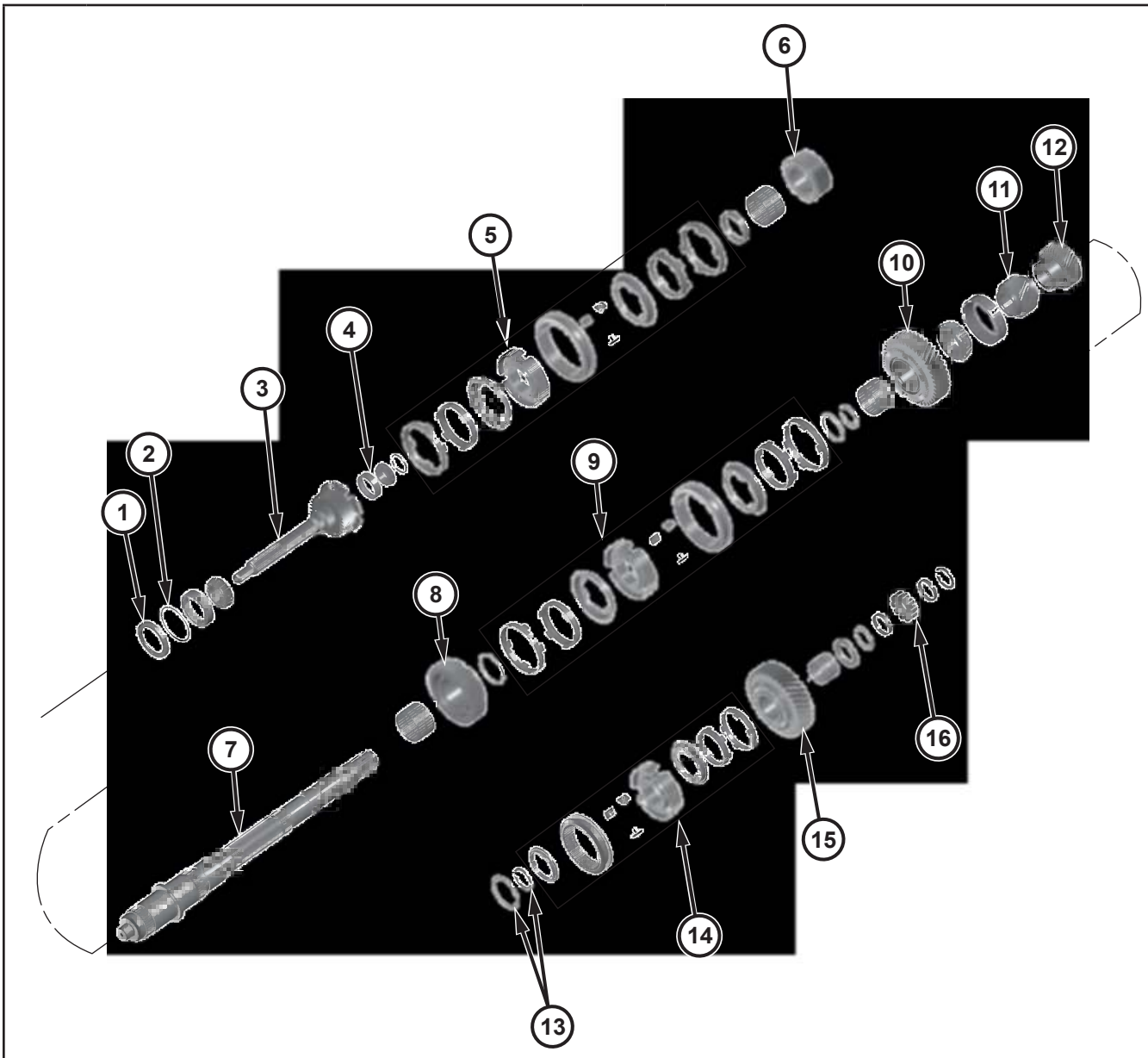
Figure 72 TR6060 Transmission Housing (Viper Shown)

Disassembled Views



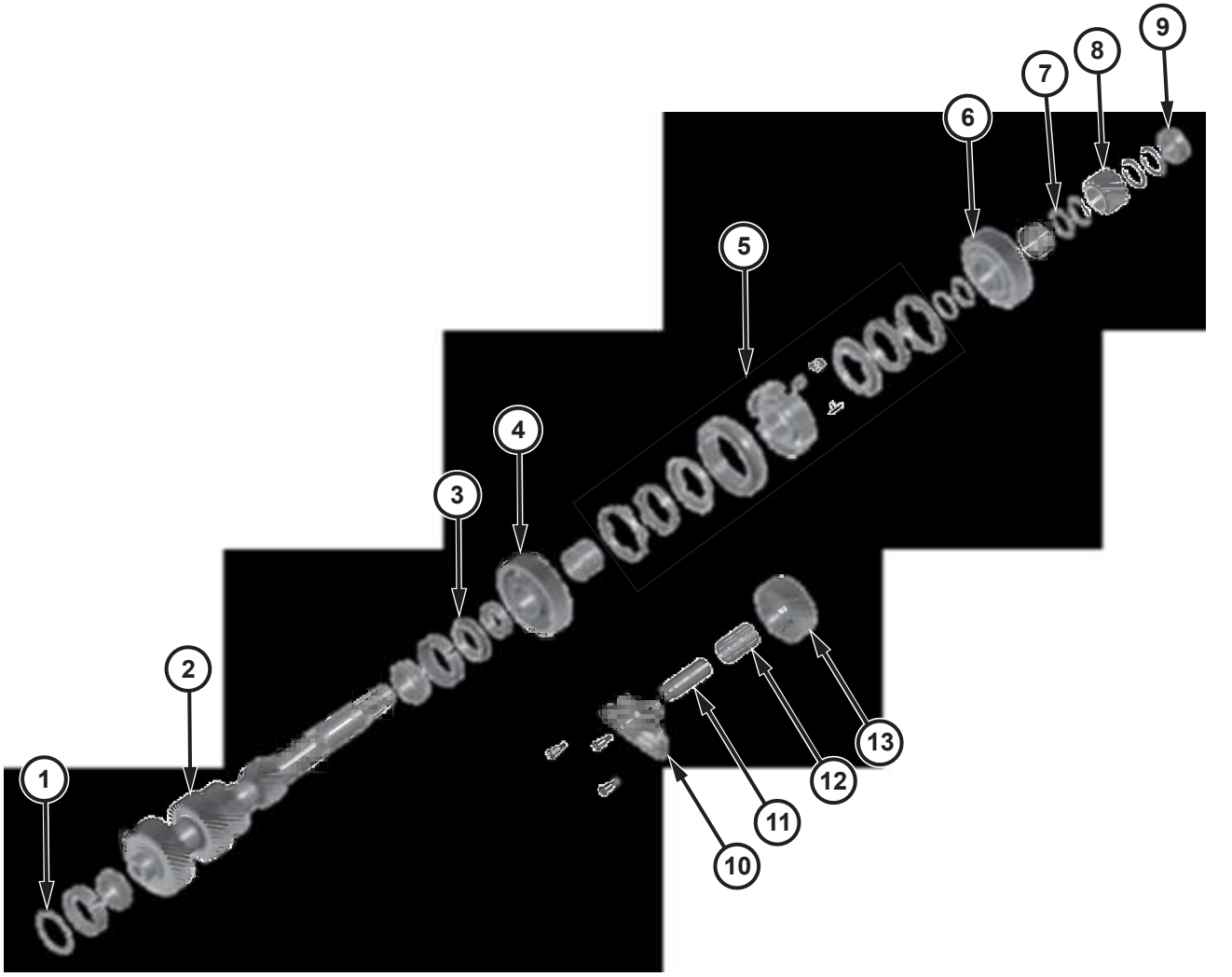
1	Bellhousing	9	Oil Seal (Shipping Only)
2	Shift Rail Detent Assembly	10	Propeller Shaft Oil Seal
3	Adapter Plate	11	Tremec ID Tag
4	Reverse Lamp Switch	12	Reverse Inhibit Solenoid
5	Vent Tube	13	Mainshaft Rear Bearing Race
6	Offset Shift Lever Detent	14	Extension Housing
7	Transmission Case	15	Shifter
8	1–4 Skip Shift Solenoid		

Figure 73 TR6060 Disassembled Case



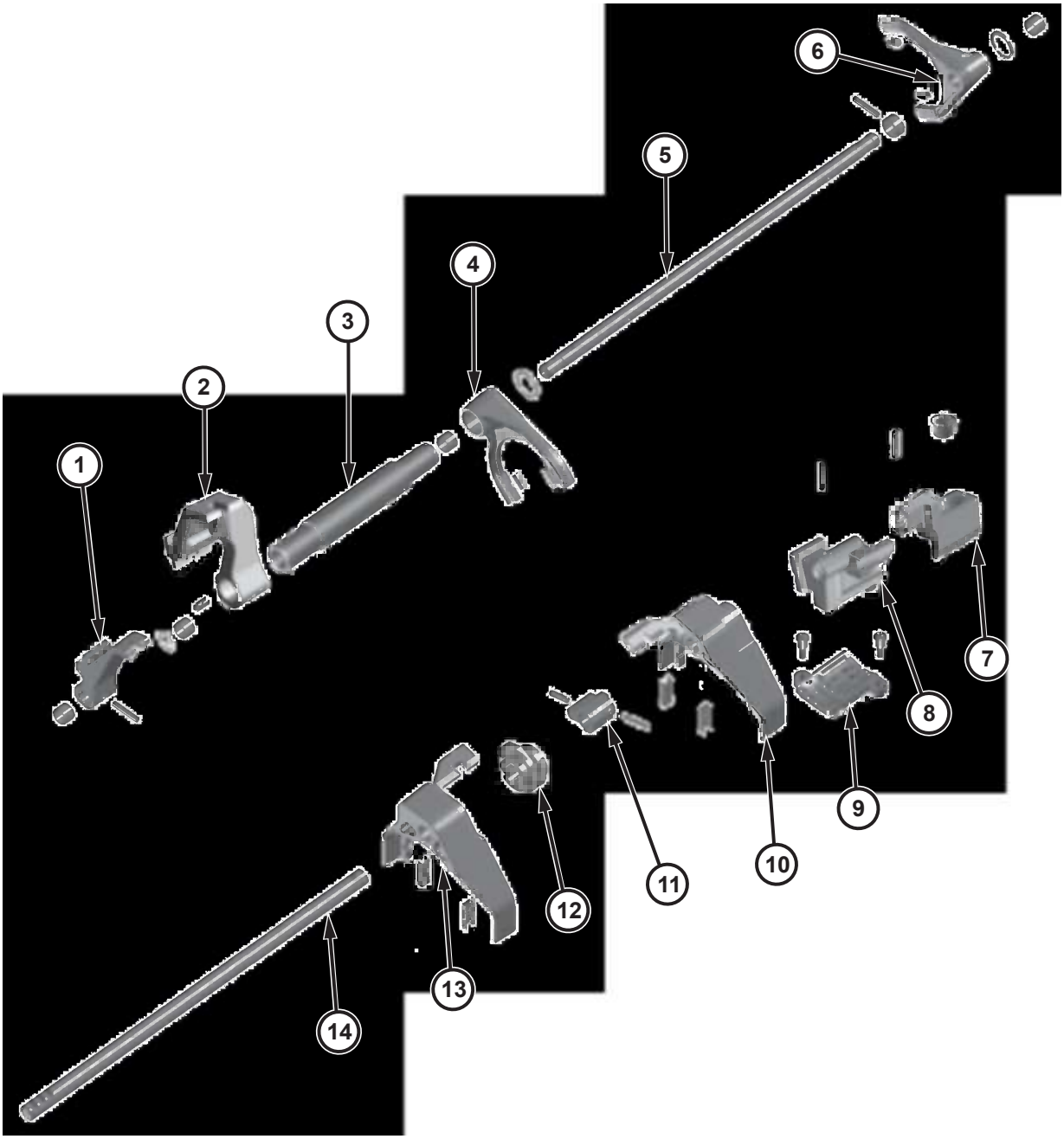
1	Input Shaft Oil Seal	9	1–2 Synchronizer Components
2	Mainshaft Adjusting Shim	10	First Driven Gear (Freewheeling)
3	Input Shaft	11	Sixth Driven Gear (Fixed)
4	Input Shaft Support Bearing	12	Fifth Driven Gear (Fixed)
5	3–4 Synchronizer Components	13	Split Thrust Washer
6	Third Driven Gear (Freewheeling)	14	Reverse Synchronizer Components
7	Mainshaft	15	Reverse Driven Gear (Freewheeling)
8	Second Driven Gear (Freewheeling)	16	Mainshaft Support Bearing (Roller)

Figure 74 TR6060 Disassembled Input & Main Shafts



1	Countershaft Adjusting Shim	8	Reverse Drive Gear (Fixed)
2	Countershaft	9	Countershaft Support Bearing
3	Sixth Gear Thrust Washer (Uni-Directional)	10	Reverse Idler Gear Bracket
4	Sixth Drive Gear (Freewheeling)	11	Reverse Idler Gear Shaft
5	5–6 Synchronizer Components	12	Reverse Idler Gear Bearing (Needle)
6	Fifth Drive Gear (Freewheeling)	13	Reverse Idler Gear
7	Thrust Washer		

Figure 75 TR6060 Disassembled Countershaft



1	Reverse Cam & Shift Fingers	8	Forward Offset Lever
2	5–6 Cam & Shift Fingers	9	Shift Guide Plate
3	5–6 Shift Rail	10	1–2 Shift Fork & Fingers
4	5–6 Shift Fork	11	Shift Selector Assembly
5	Reverse Shift Rail	12	Shift Interlock
6	Reverse Shift Fork	13	3–4 Shift Fork & Fingers
7	Rear Offset Lever	14	Main Shift Rail

Figure 76 TR6060 Disassembled Shift Mechanisms

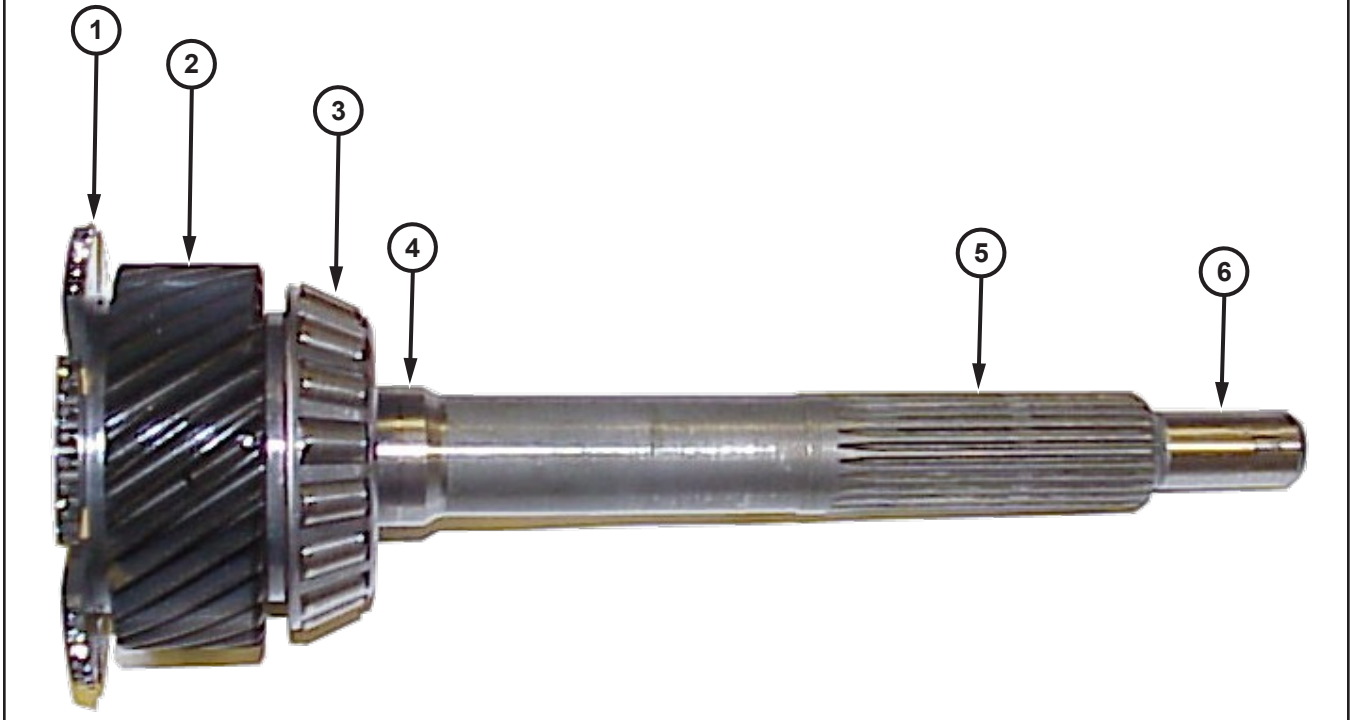
Input Shaft

The input shaft of the TR6060 is supported by bearings in three places:

- The pilot bearing connects the input shaft to the crankshaft.
- A tapered roller bearing (3) supports much of the main shaft thrust and weight.
- The input shaft support bearing connects the input shaft to the main shaft.

The input shaft drives fourth gear through the fourth gear synchronizer teeth (1). The input shaft drives all other gears via the counter shaft through the input drive gear (2).

Note: The clutch splines (5) require a small amount of lubricant to accommodate the dual clutch system. Do not apply too much lubricant—this may contaminate the clutch discs.

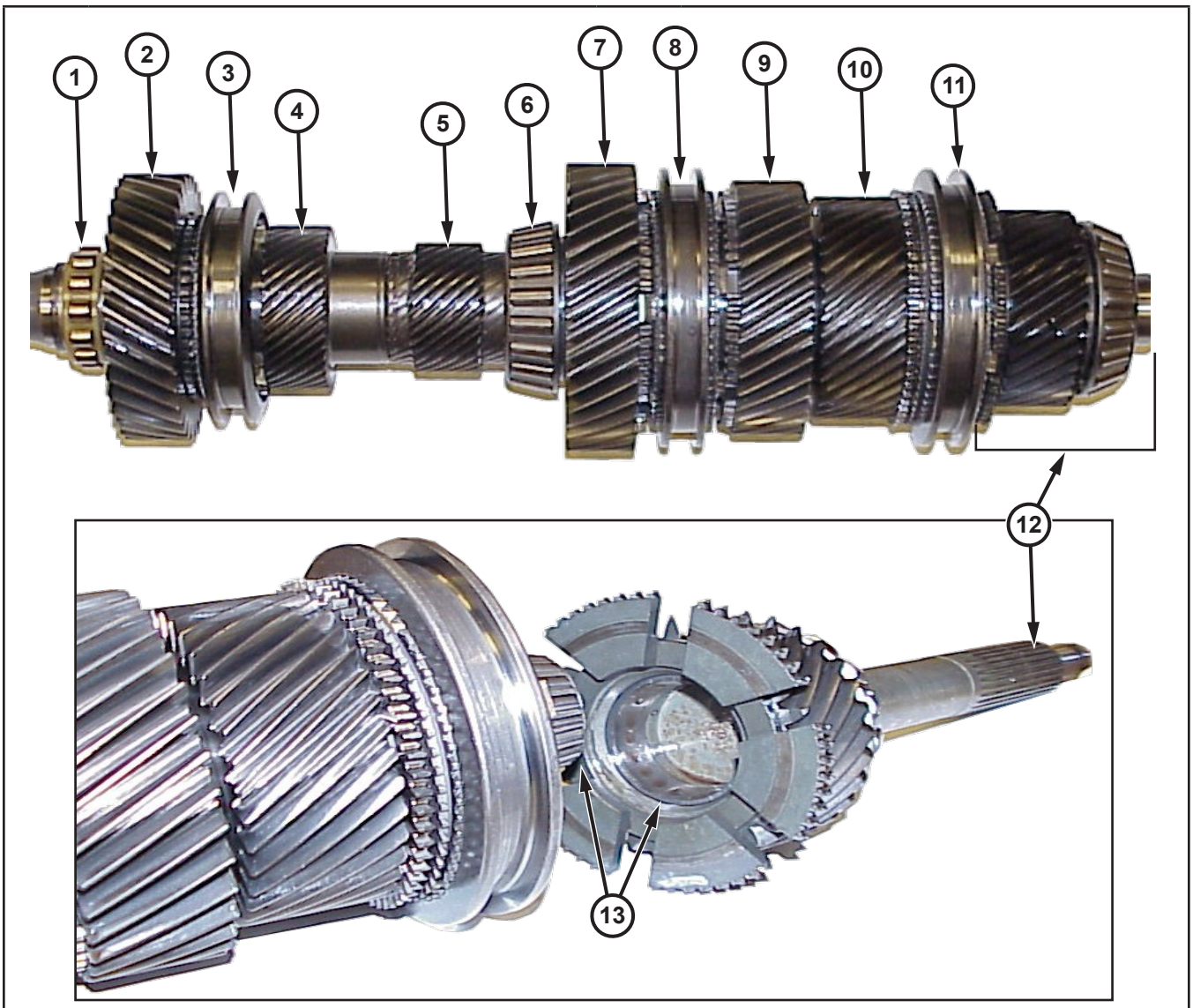


1	Fourth Gear Synchronizer Teeth	4	Input Shaft Oil Seal Race
2	Input Drive Gear	5	Clutch Splines
3	Tapered Roller Bearing	6	Pilot Bearing Race

Figure 77 TR6060 Input Shaft

Main Shaft and Gears

The main shaft of the TR6060 contains both freewheeling and fixed gears, as well as synchronizer assemblies. It is supported at the rear by a roller bearing, the center by a large tapered roller bearing, and the front by a small tapered roller bearing.

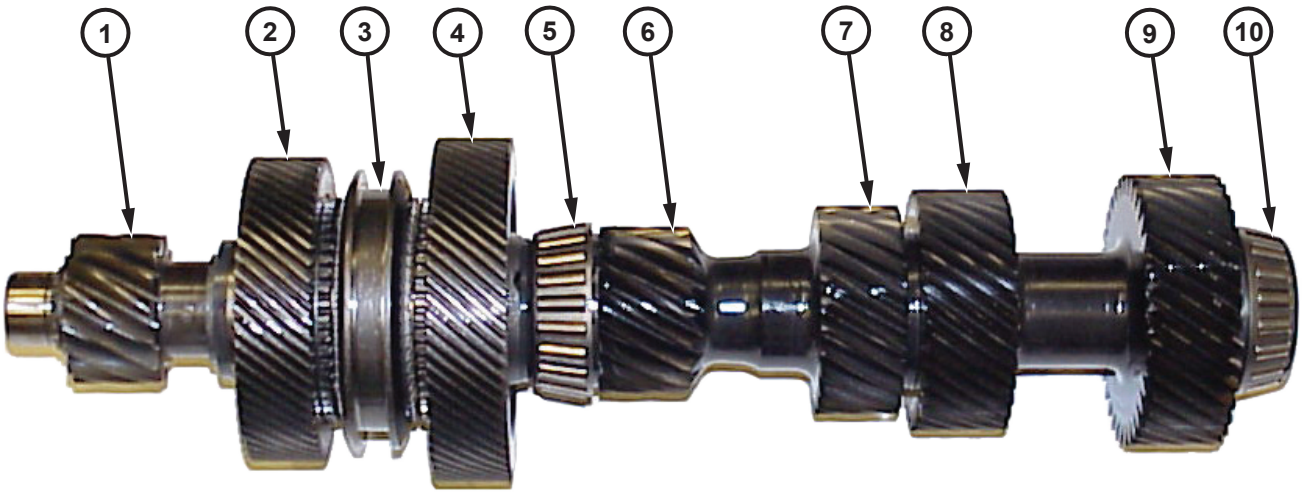


1	Rear Roller Bearing	8	1–2 Synchronizer
2	Reverse Driven Gear (Freewheeling)	9	Second Driven Gear (Freewheeling)
3	Reverse Synchronizer	10	Third Driven Gear (Freewheeling)
4	Fifth Driven Gear (Fixed)	11	3–4 Synchronizer
5	Sixth Driven Gear (Fixed)	12	Input Shaft
6	Tapered Roller Bearing	13	Input Shaft Support Bearing & Race (Tapered Roller)
7	First Driven Gear (Freewheeling)		

Figure 78 TR6060 Main Shaft

Counter Shaft

The TR6060 counter shaft is responsible for transmitting power from the input shaft to the main shaft. The counter shaft has four permanently fixed gears: 1st, 2nd, 3rd, and the counter shaft input gear. The counter shaft must be replaced if any of these gears are damaged. Serviceable components of the counter shaft include the Reverse drive gear, 5th drive gear, 5–6 synchronizer, 6th drive gear, and all bearings.

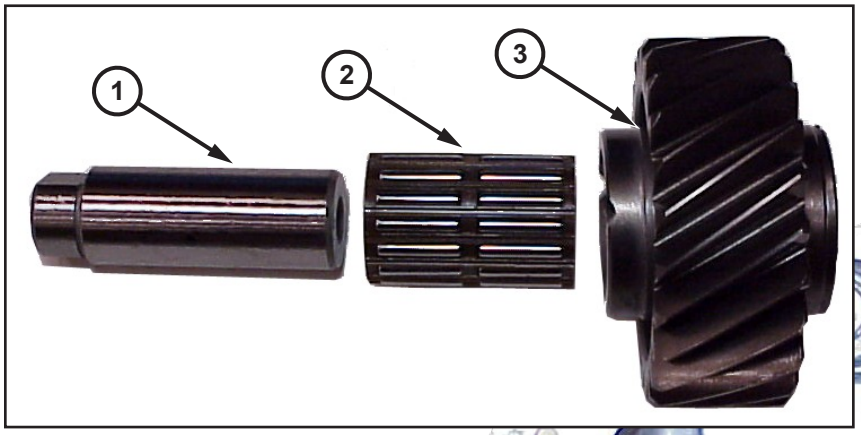


1	Reverse Drive Gear	6	First Drive Gear (Fixed)
2	Fifth Drive Gear (Freewheeling)	7	Second Drive Gear (Fixed)
3	5–6 Synchronizer	8	Third Drive Gear (Fixed)
4	Sixth Drive Gear (Freewheeling)	9	Counter Shaft Input Gear (Fixed)
5	Tapered Roller Bearing	10	Tapered Roller Bearing

Figure 79 TR6060 Counter Shaft

Reverse Idler

The TR6060 reverse idler is installed in the extension housing. The idler gear rides on a needle bearing and the idler shaft. The idler bracket holds the idler shaft to the extension housing.



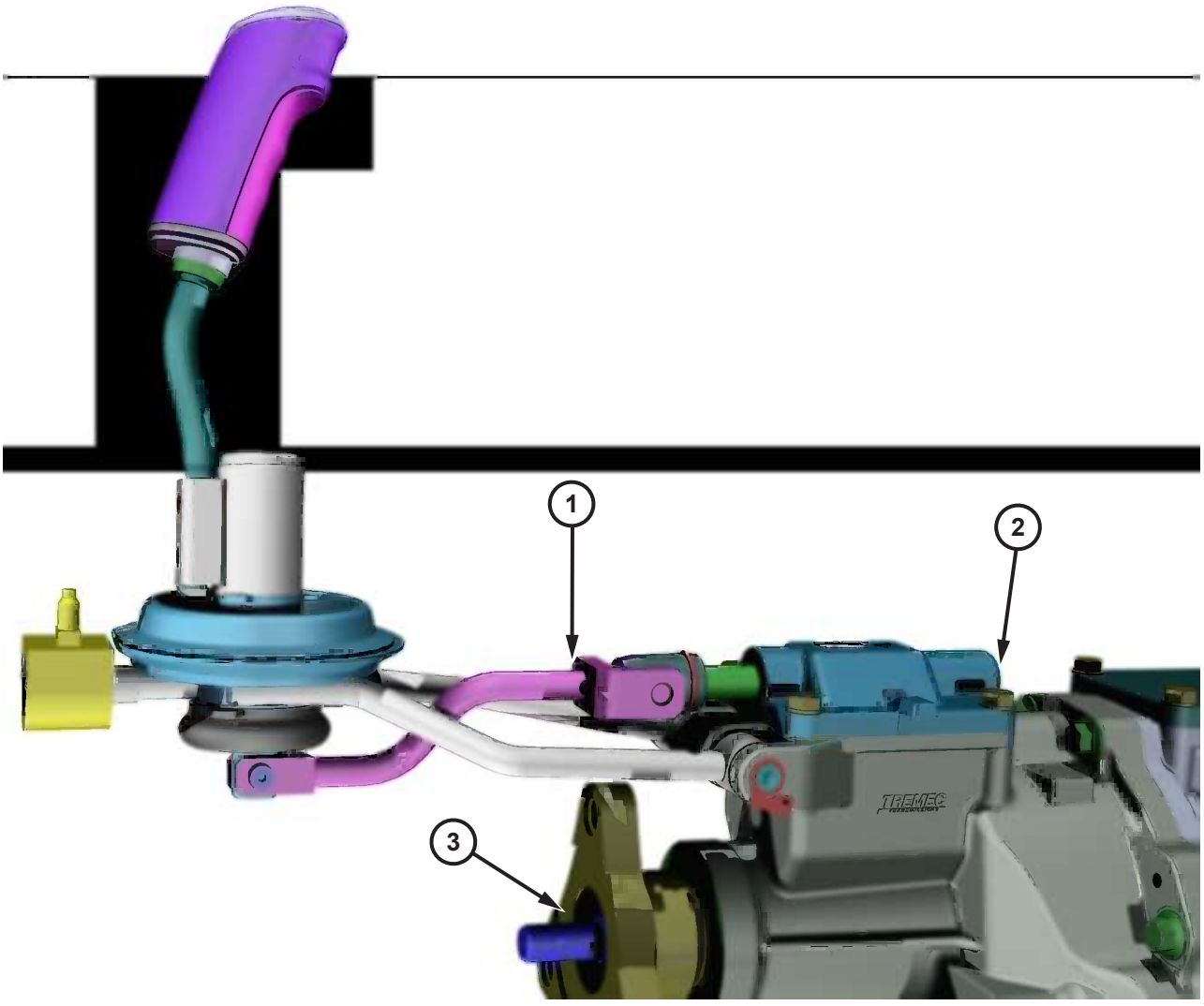
1	Idler Shaft	3	Idler Gear
2	Idler Needle Bearing	4	Idler Bracket

Figure 80 TR6060 Reverse Idler

Shift Linkage (LC Challenger)

The TR6060 used in the Dodge Challenger (LC) has some differences from the TR6060 used in the Viper (ZB). These differences include:

- Shift linkage is used to connect the driver to the transmission.
- The propeller shaft is a fixed flange style instead of a slip-yoke style.
- The extension housing is modified to accommodate the shift linkage and the different propeller shaft.

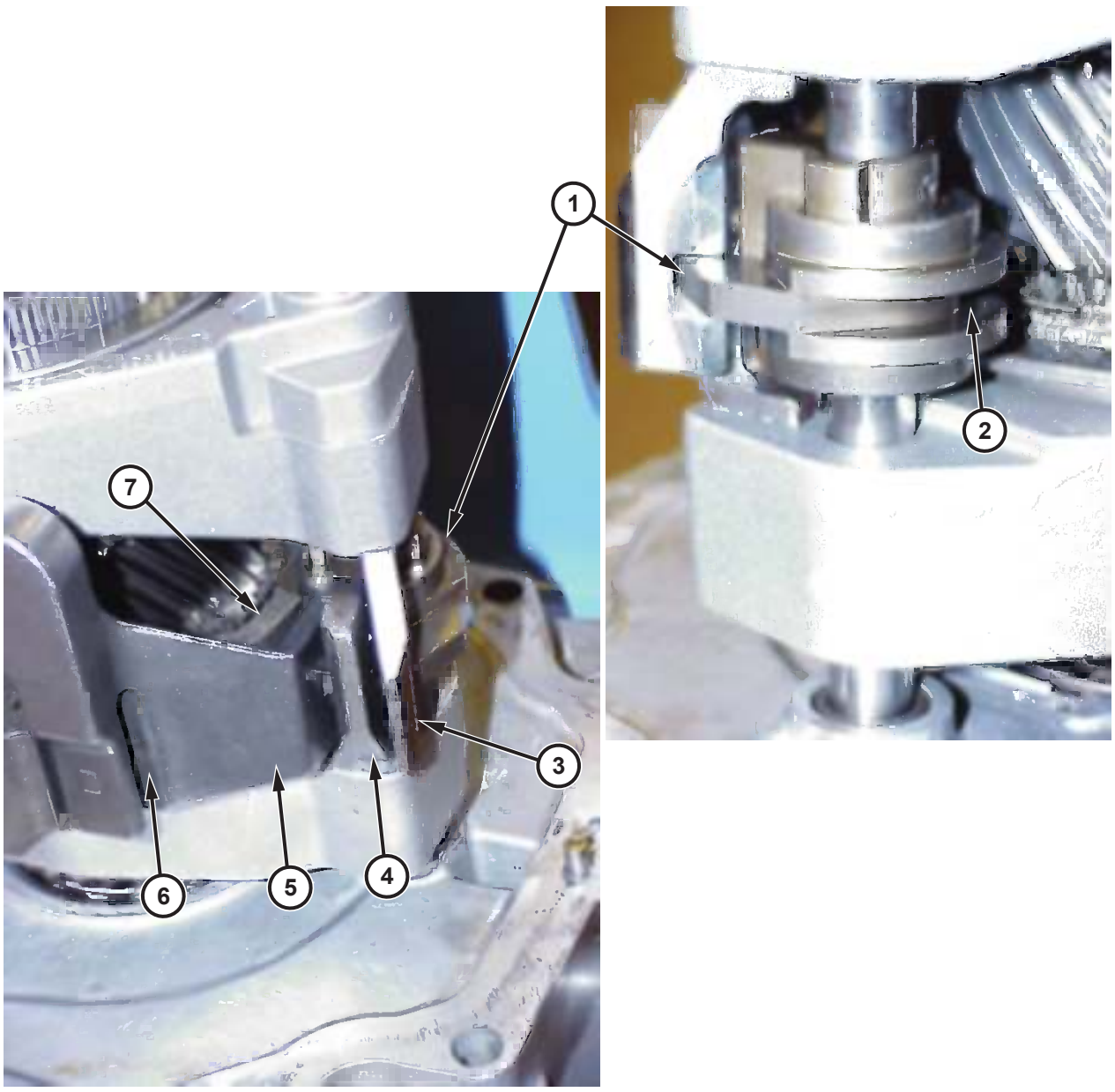


1	Shift Linkage	3	Propeller Shaft Flange
2	Extension Housing		

Figure 81 Challenger (LC) Shift Linkage

Shift Interlock

The shift interlock acts to prevent multiple gears from engaging at the same time. The interlock has a slot (2) which engages one of the shift rail guide pins. The 5–6 shift finger has a slot which engages the other shift rail guide pin. The alignment of the shift interlock and all four shift fingers is critical for transmission assembly.



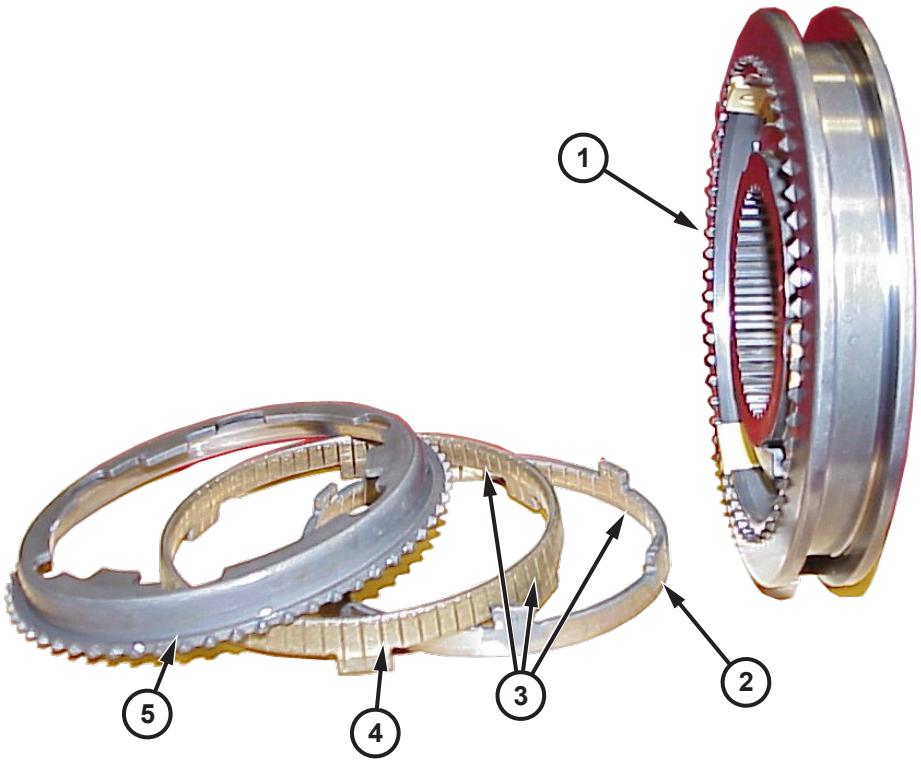
1	Shift Interlock	5	5–6 Shift Fingers
2	Shift Rail Guide Slot; Side-To-Side	6	Shift Rail Guide Slot; Fore-Aft
3	1–2 Shift Fingers	7	Reverse Shift Fingers
4	3–4 Shift Fingers		

Figure 82 TR6060 Shift Interlock

Synchronizer Assembly

The TR6060 uses triple cone synchronizers on First and Second gear, and double cone synchronizers on all other gears. The use of synchronizer rings with multiple friction surfaces multiplies the amount of braking force available in the synchronizer, resulting in less shift effort from the driver.

The synchronizer detents are captured assemblies.



1	Synchronizer Hub & Sleeve	4	Friction Ring
2	Reaction Ring	5	Blocker Ring
3	Friction Surfaces		

Figure 83 TR6060 Triple Cone Synchronizer Assembly

Bearings

The TR6060 uses a combination of bearing styles. The input, counter, and main shafts are all supported by at least two tapered roller bearings. The main shaft and input shaft are linked by a small tapered roller bearing. The counter shaft and main shaft are each supported by an additional roller bearing at the rear of the case. Each freewheeling speed gear rides an a caged needle bearing.

The shift rails are supported by a combination of bushings and caged ball bearings.

The input shaft and engine crankshaft are linked by a caged needle bearing, called the pilot bearing.

All bearings are splash lubricated. The main shaft and counter shaft are hollow to allow oil to reach the needle bearings.

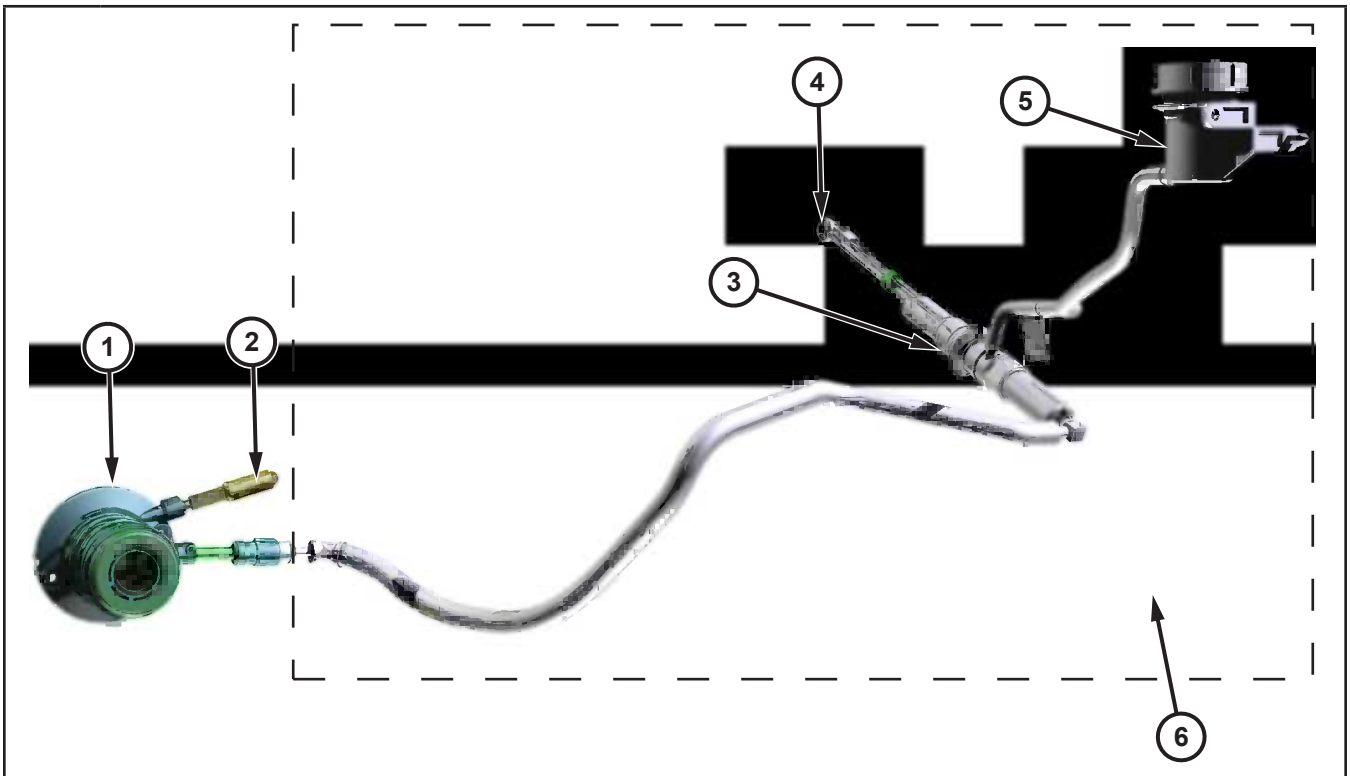
CLUTCH SYSTEM

Clutch Master Cylinder

The clutch master cylinder is bolted to the bulkhead, and the master cylinder push rod is connected to the clutch pedal. When the clutch pedal is pressed, the push rod forces fluid pressure from the master cylinder through a fluid line to the slave cylinder.

Note: The clutch master cylinder, fluid reservoir and connecting lines are serviced as an assembly only. Components cannot be overhauled or serviced separately. The master cylinder and connecting lines are sealed units. The slave cylinder is available as an individual component.

Caution: D.O.T. 4 brake fluid is required for the clutch hydraulic system. Other fluids are not compatible.



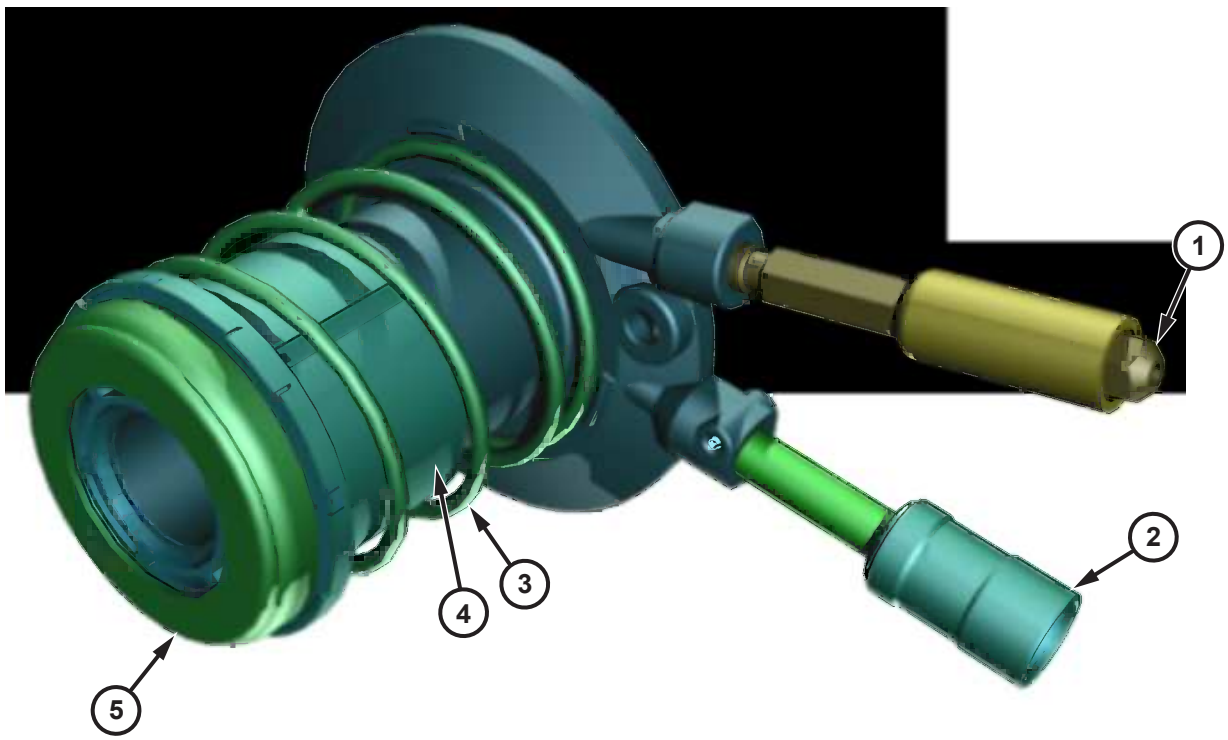
1	Concentric Slave Cylinder	4	Master Cylinder Pushrod
2	Clutch System Bleed Port	5	Clutch Fluid Reservoir
3	Master Cylinder	6	Master Cylinder Assembly

Figure 84 Hydraulic Clutch Assembly (Viper Shown)

Release Bearing and Concentric Slave Cylinder

The Dodge Viper (ZB) and Dodge Challenger (LC) use concentric slave cylinders to release the clutch. The slave cylinder encircles the input shaft and applies a steady, even pressure to the fingers of the pressure plate.

The slave cylinder is mounted to the transmission adapter plate. A tension spring keeps the release bearing tight against the pressure plate at all times. When the clutch pedal is depressed, fluid pressure from the master cylinder actuates the slave cylinder. The slave cylinder applies pressure directly to the fingers of the pressure plate.



1	Clutch System Bleed Port	4	Slave Cylinder Piston
2	Slave Cylinder Attaching Port	5	Clutch Release (Throw-Out) Bearing
3	Clutch Release Bearing Tension Spring		

Figure 85 TR6060 Release Bearing and Slave Cylinder (Viper Shown)

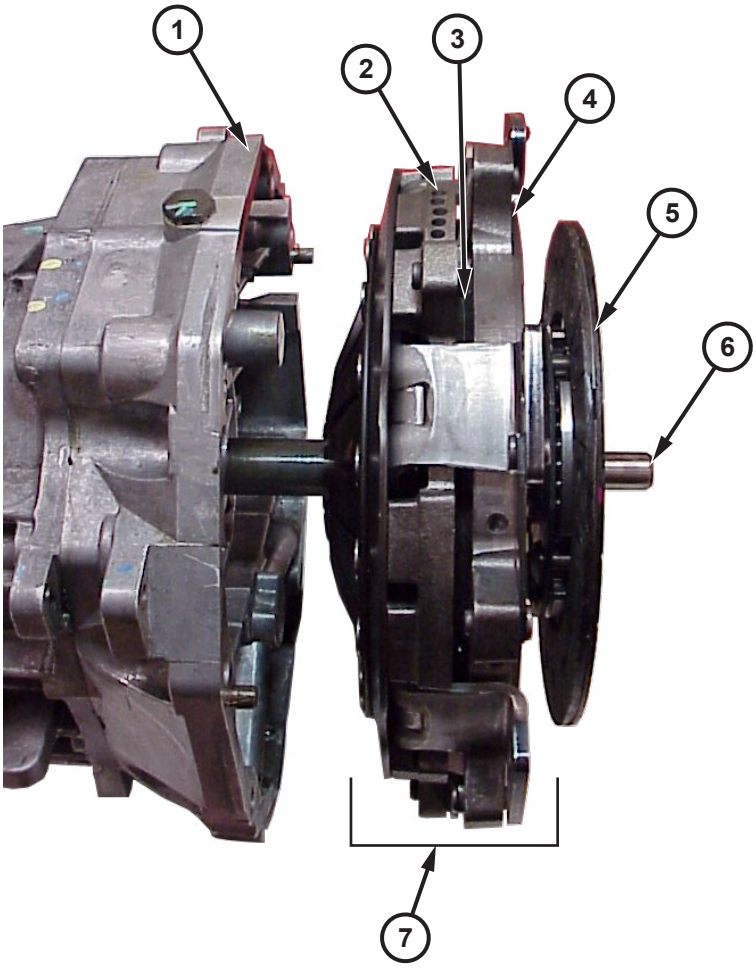
Note: The 2008 Viper clutch slave cylinder is a new design for compatibility with the dual disc clutch. Do NOT attempt to install an earlier design slave cylinder on a 2008+ vehicle.

Clutch Disc and Pressure Plate

The TR6060 transmission receives power through a dual-disc clutch system. This system uses two clutch discs, a pressure plate, an intermediate plate, and a flywheel. The dual-disc design allows more friction material within a small space, resulting in a compact design that can handle the high torque demands of SRT vehicles.

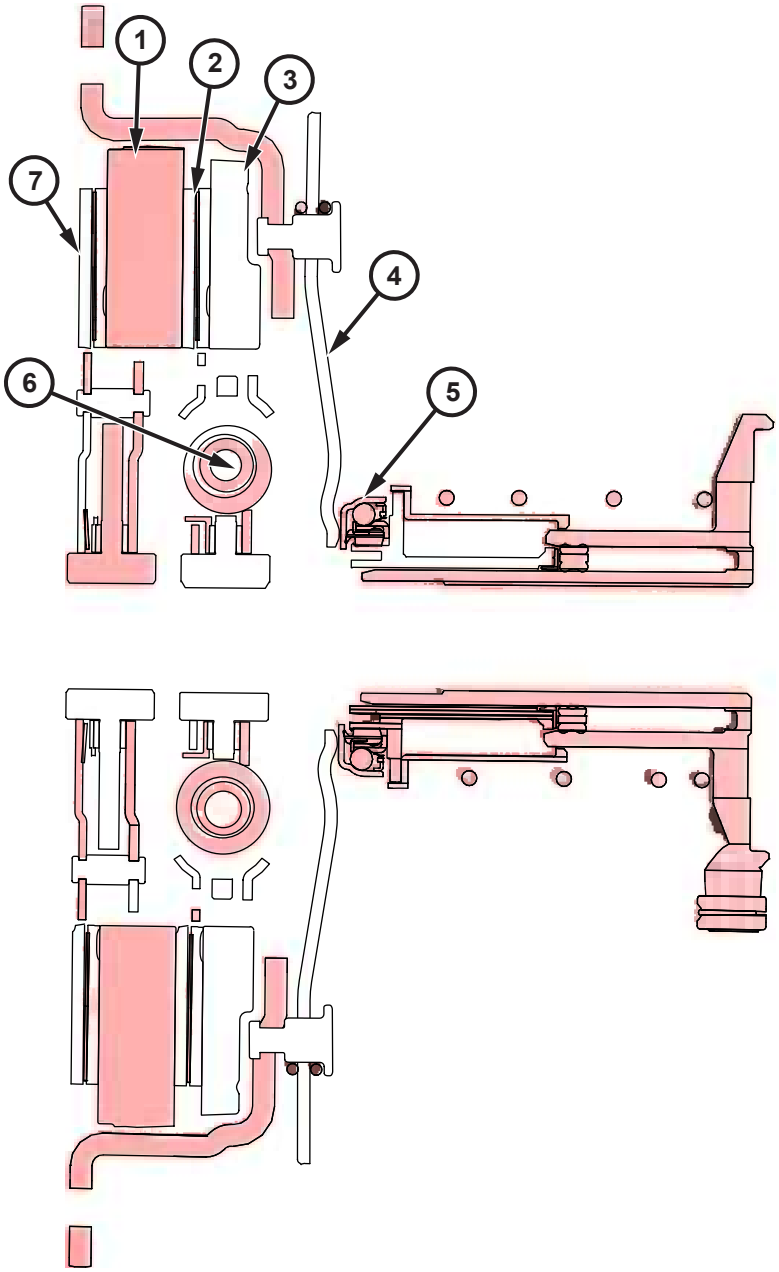
When replacing the clutch, replace the pressure plate assembly and the loose clutch disc at the same time.

Note: The splines of the two discs must be perfectly aligned prior to transmission installation. Use clutch tool 10018 as instructed by the Service Information.



1	Adapter Plate	5	Clutch Disc
2	Pressure Plate	6	Input Shaft
3	Clutch Disc (Captured)	7	Pressure Plate Assembly
4	Intermediate Pressure Plate		

Figure 86 TR6060 Clutch Discs and Pressure Plate



1	Intermediate Pressure Plate	5	Clutch Release (Throw-out) Bearing
2	Clutch Disc (Captured)	6	Clutch Disc Damping Springs
3	Pressure Plate	7	Clutch Disc
4	Pressure Plate Fingers		

Figure 87 TR6060 Clutch Section View

ELECTRICAL SYSTEM

The TR6060 utilizes two electric solenoids to influence operation of the manual transmission. Both solenoids are controlled by the PCM. A constant 12V power supply is available to the solenoid any time the ignition key is ON. The PCM engages the solenoid, if all conditions are met, by completing the ground for each solenoid.

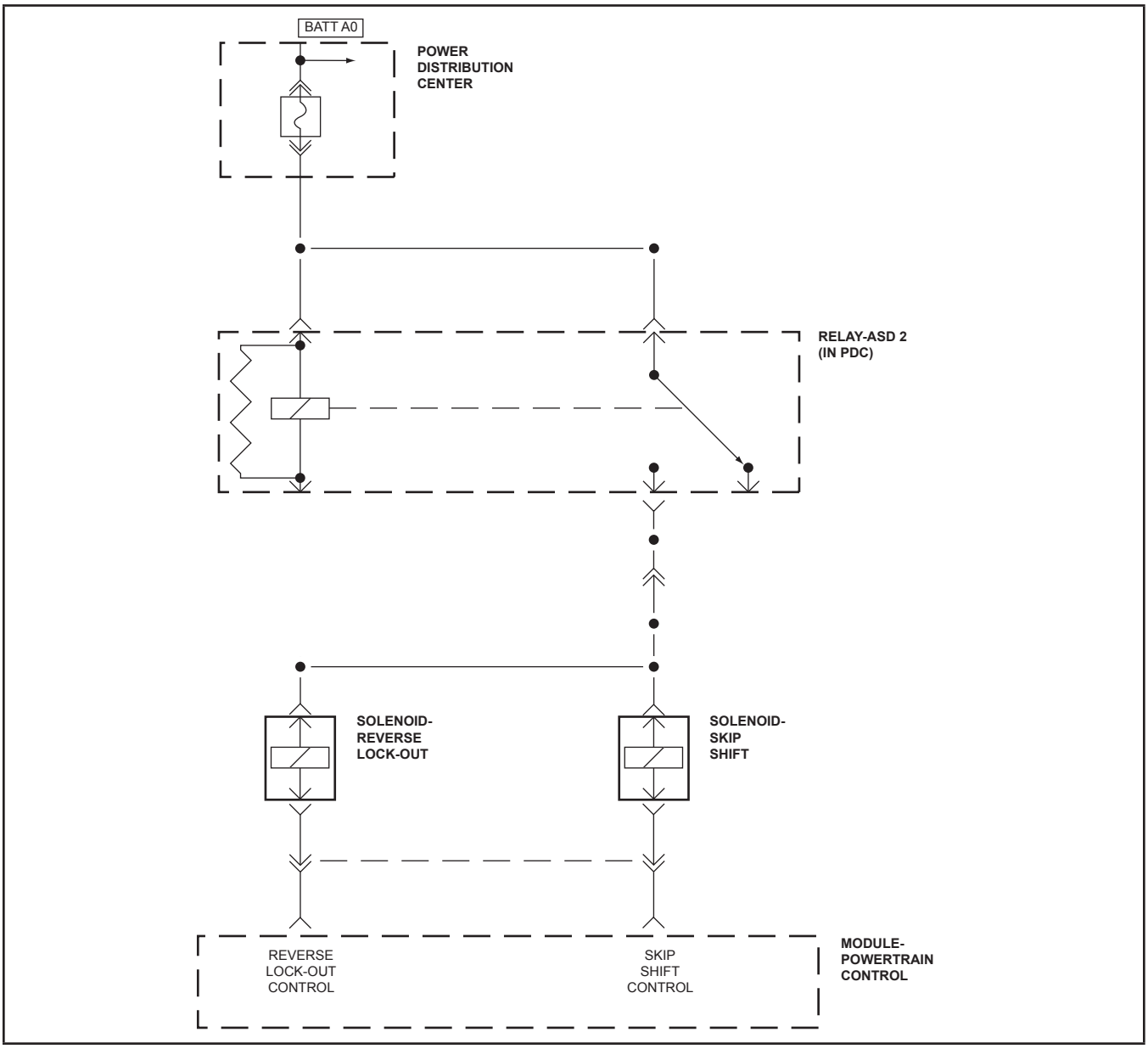


Figure 88 TR6060 Electrical Controls Schematic

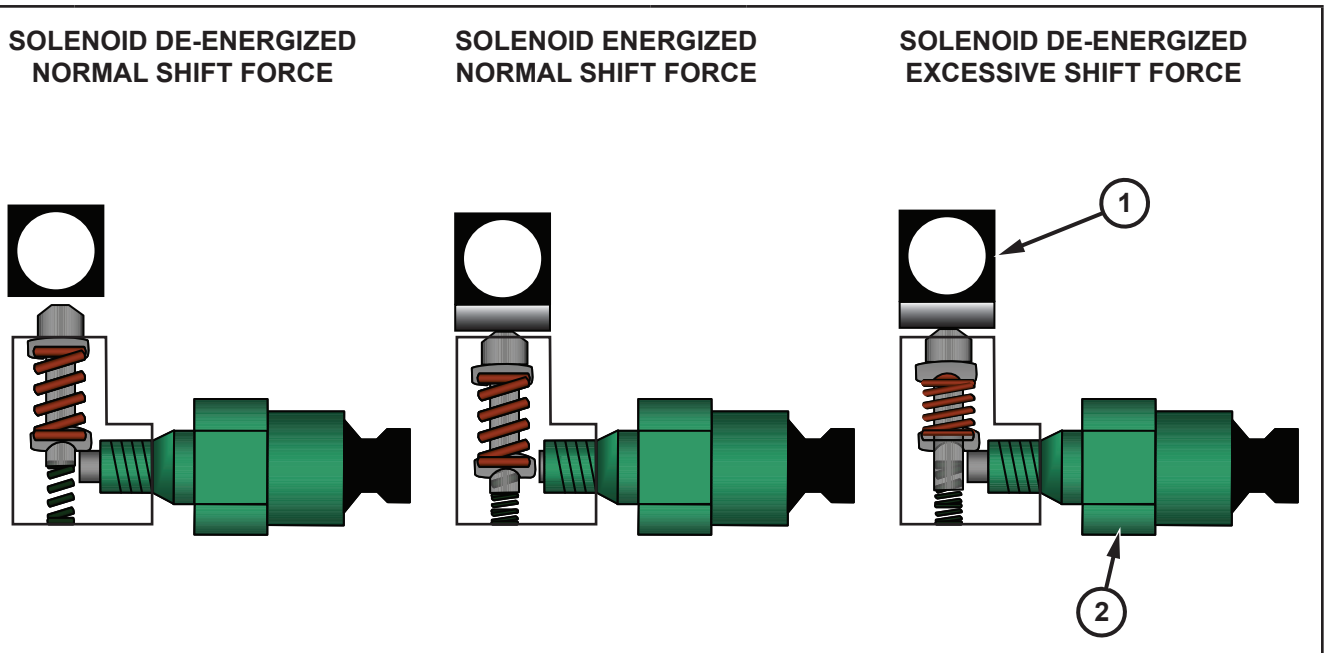
Reverse Inhibit Solenoid

The TR6060 transmission is equipped with a reverse inhibitor system. When vehicle speed is greater than 8 KPH (5 MPH), the reverse inhibit solenoid activates to help prevent the operator from shifting into reverse. The solenoid is located on the left side of the transmission.

The default condition for the system is to help prevent Reverse gear engagement. A PCM ground is required to energize the solenoid, allowing free engagement of Reverse. When at a complete stop, the operator may notice light shift efforts into Reverse with the ignition key ON, but increased shift efforts into Reverse with the ignition key OFF. This is normal operation of the transmission reverse inhibitor system.

Table 10 TR6060 Reverse Inhibit Conditions

Ignition Key State	Vehicle State	Solenoid State	Effort Required to Engage Reverse
OFF		De-energized	Difficult
ON	Below 5 MPH	Energized	Easy
ON	Above 5 MPH	De-energized	Difficult



1	Offset Shift Lever	2	Reverse Inhibit Solenoid

Figure 89 TR6060 Reverse Inhibit Solenoid

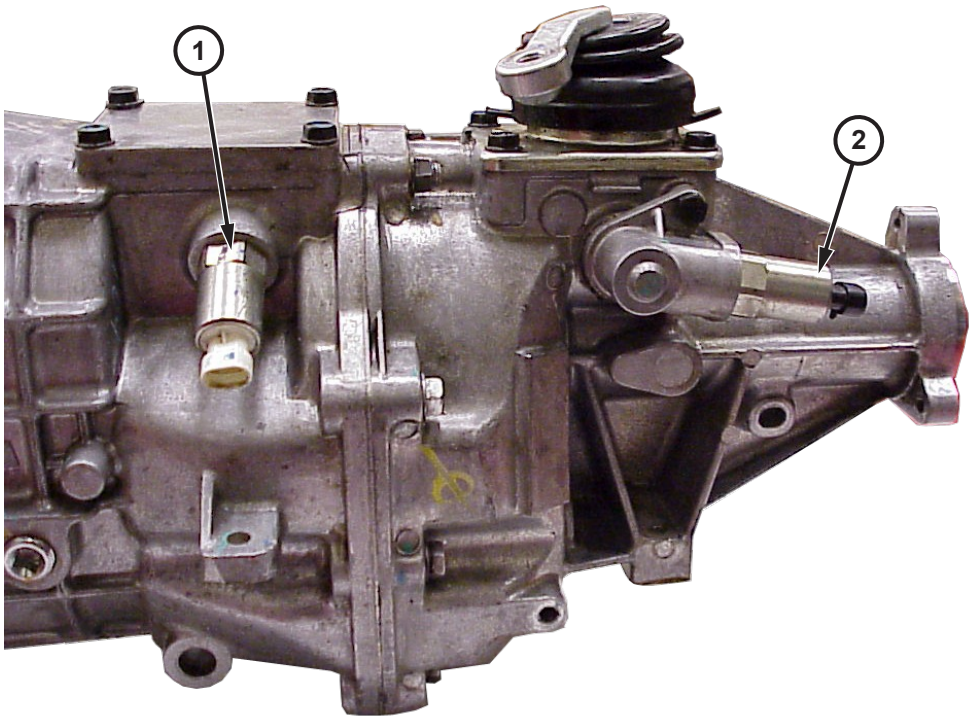
1–4 Skip Shift Solenoid

The TR6060 transmission is equipped with a 1–4 skip shift solenoid. The skip shift solenoid guides the shifter lever from First gear to Fourth gear, instead of allowing a shift from First to Second during the conditions described below. This is to help get the best possible fuel economy for the vehicle. The skip shift indicator light, located in the tachometer, turns amber when all skip shift conditions are met. When the indicator light turns amber, the shifter mechanism only allows shifts from First to Fourth gear. The skip shift solenoid is located on the left side of the transmission case.

The PCM will activate the skip shift solenoid when all of the following conditions are met:

- Engine coolant is above 41° C (106° F)
- Vehicle speed is between 12 and 20 MPH
- Engine is operating above 1322 RPM
- PCM has verified that First gear is selected (Input speed / Output speed)
- Throttle position sensor (TPS) signal is less than 0.68 V above closed throttle (23% throttle opening)

The solenoid resets when vehicle speed drops below 3 MPH.



1	1–4 Skip Shift Solenoid	2	Reverse Inhibit Solenoid

Figure 90 TR6060 Solenoids (Viper Shown)

TR6060 POWER FLOW

First Gear

When the clutch is engaged (pedal up), torque is transmitted to the input shaft. The input shaft drive gear transfers power to the counter shaft. The counter shaft transfers power to the first drive gear. The first drive gear transfers power to the first driven gear. The first driven gear transfers power to the synchronizer sleeve, synchronizer hub, and the main shaft.

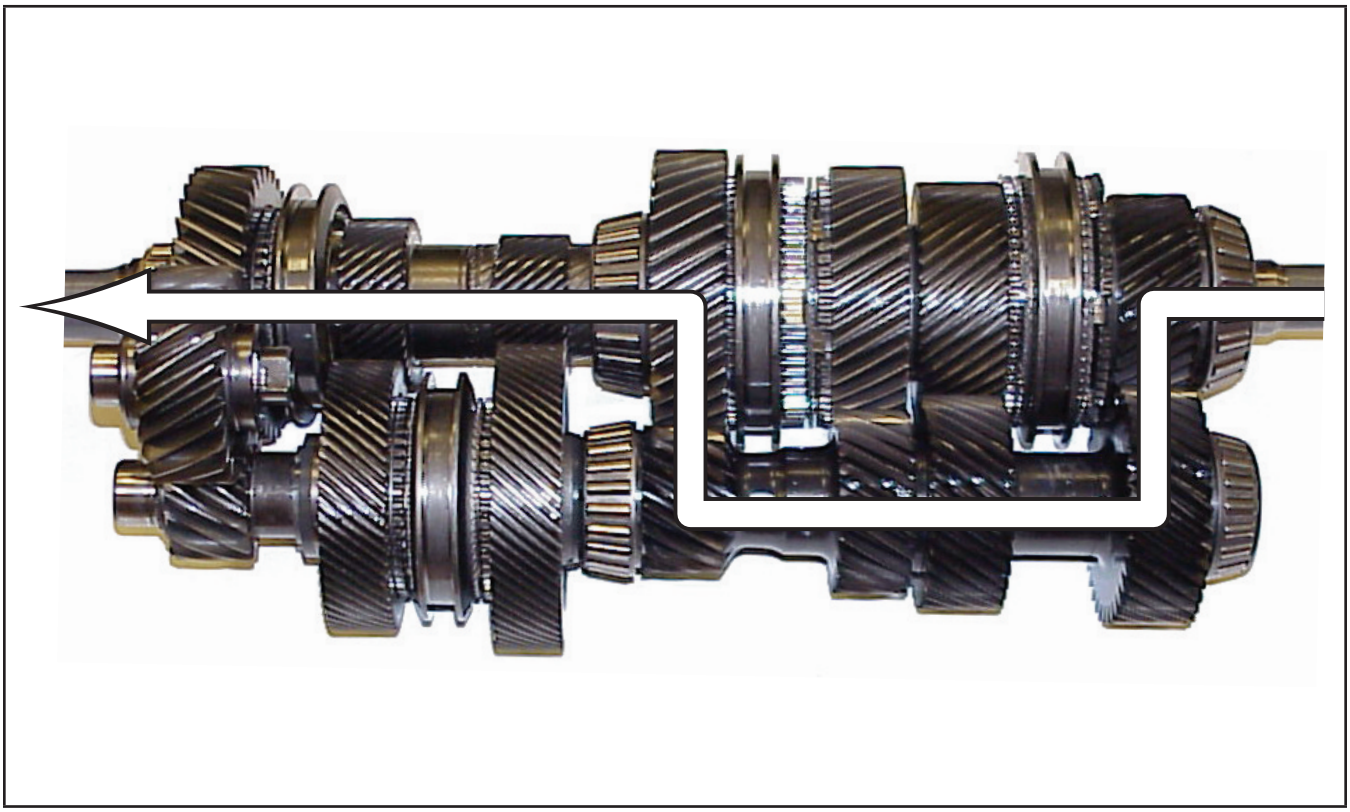


Figure 91 TR6060 First Gear Power Flow

Second Gear

When the clutch is engaged (pedal up), torque is transmitted to the input shaft. The input shaft drive gear transfers power to the counter shaft. The counter shaft transfers power to the second drive gear. The second drive gear transfers power to the second driven gear. The second driven gear transfers power to the synchronizer sleeve, synchronizer hub, and the main shaft.

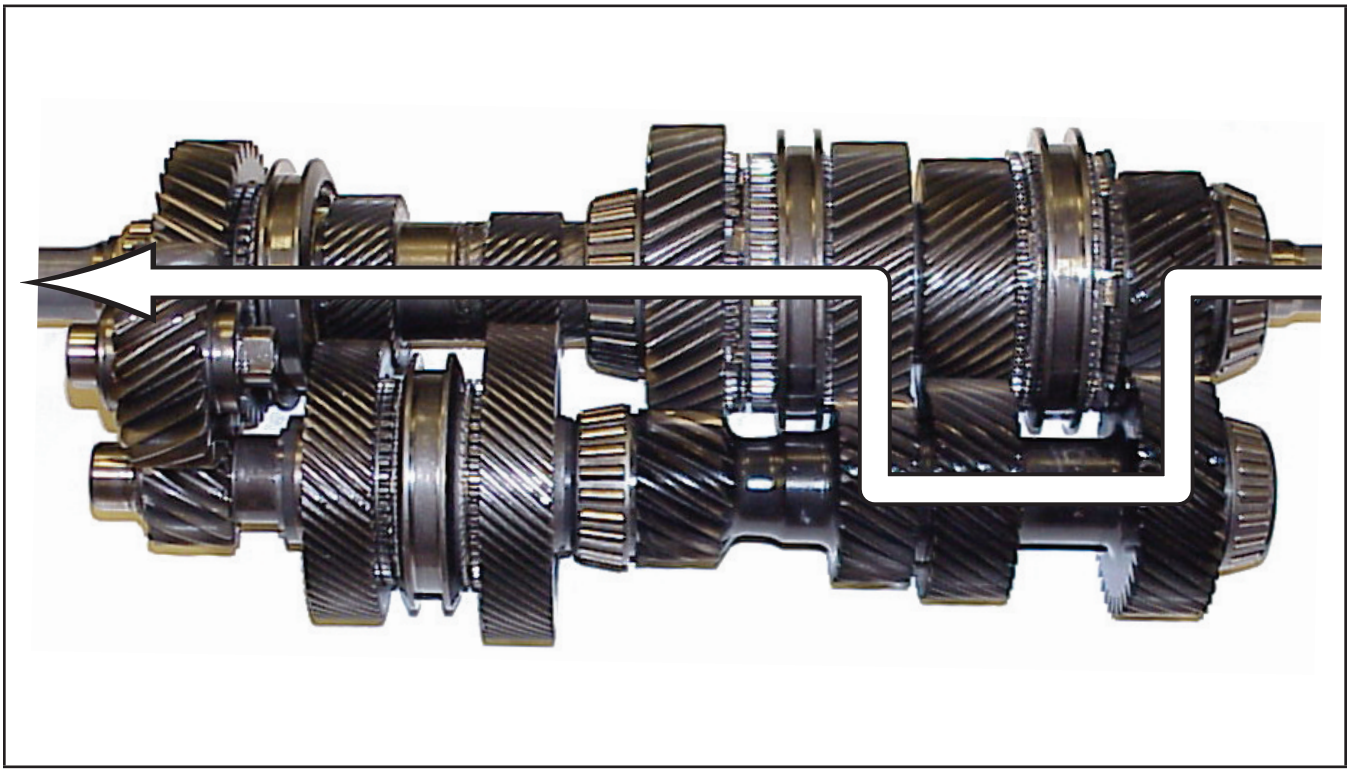


Figure 92 TR6060 Second Gear Power Flow

Third Gear

When the clutch is engaged (pedal up), torque is transmitted to the input shaft. The input shaft drive gear transfers power to the counter shaft. The counter shaft transfers power to the third drive gear. The third drive gear transfers power to the second driven gear. The third driven gear transfers power to the synchronizer sleeve, synchronizer hub, and the main shaft.

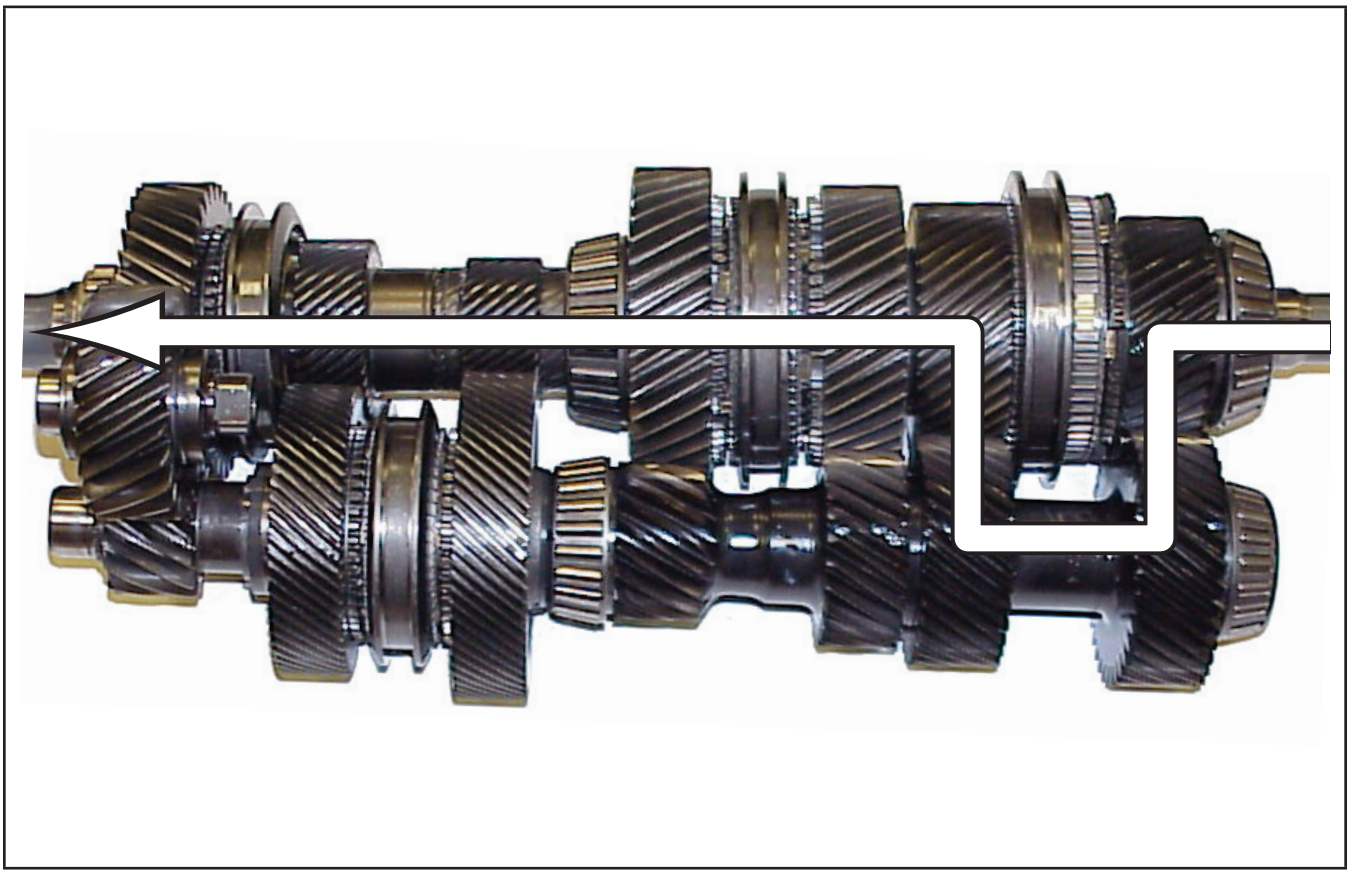


Figure 93 TR6060 Third Gear Power Flow

Fourth Gear

When the clutch is engaged (pedal up), torque is transmitted to the input shaft. The input shaft transfers power to the 3–4 synchronizer sleeve and hub. The hub is splined to the main shaft and transfers power through the main shaft. In fourth gear, the main shaft and input shaft are locked together to produce a 1:1 gear ratio.

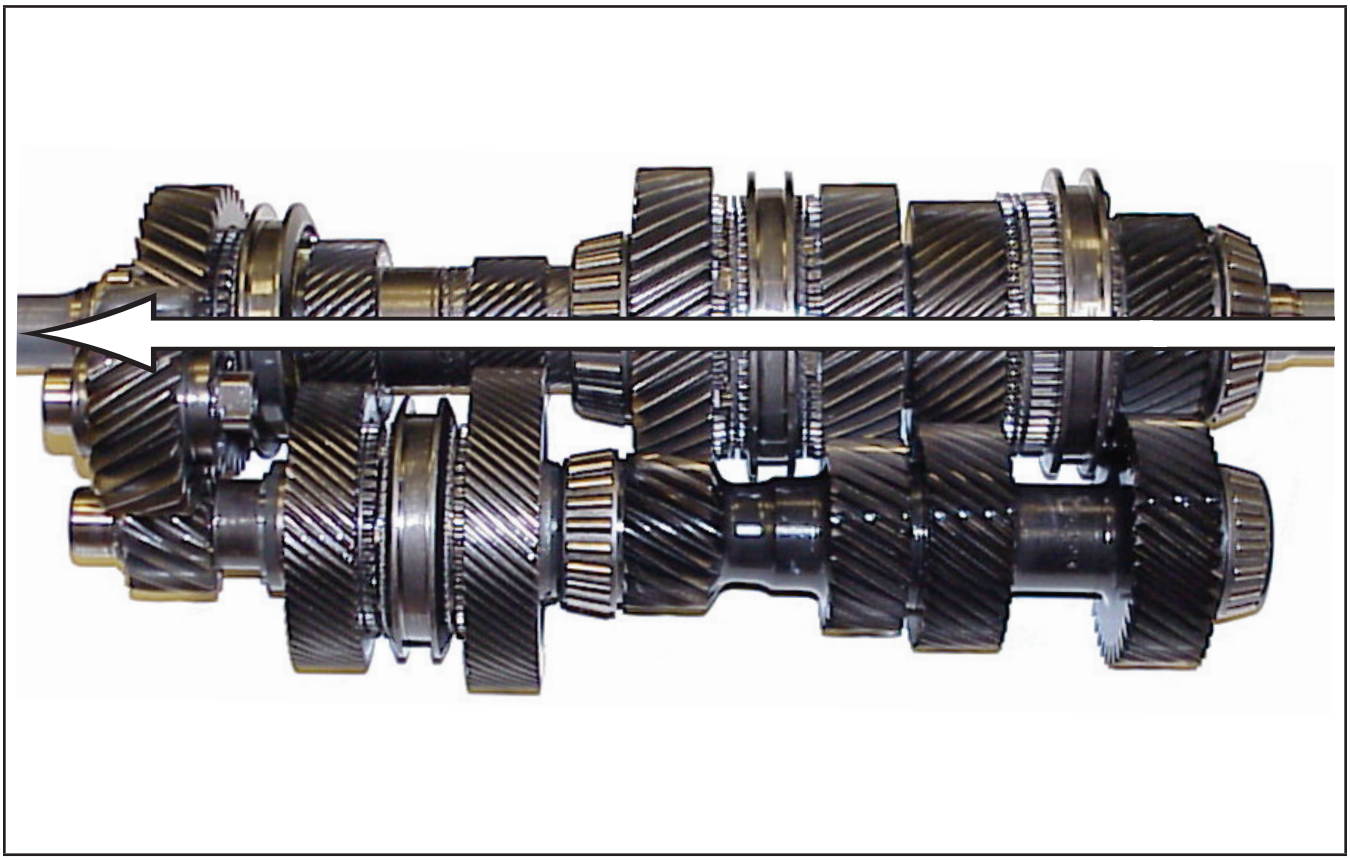


Figure 94 TR6060 Fourth Gear Power Flow

Fifth Gear

When the clutch is engaged (pedal up), torque is transmitted to the input shaft. The input shaft drive gear transfers power to the counter shaft. The counter shaft transfers power to the 5–6 synchronizer hub and sleeve. The 5–6 synchronizer sleeve transfers power to the fifth drive gear. The fifth drive gear transfers power to the fifth driven gear. The fifth driven gear transfers power to the main shaft.

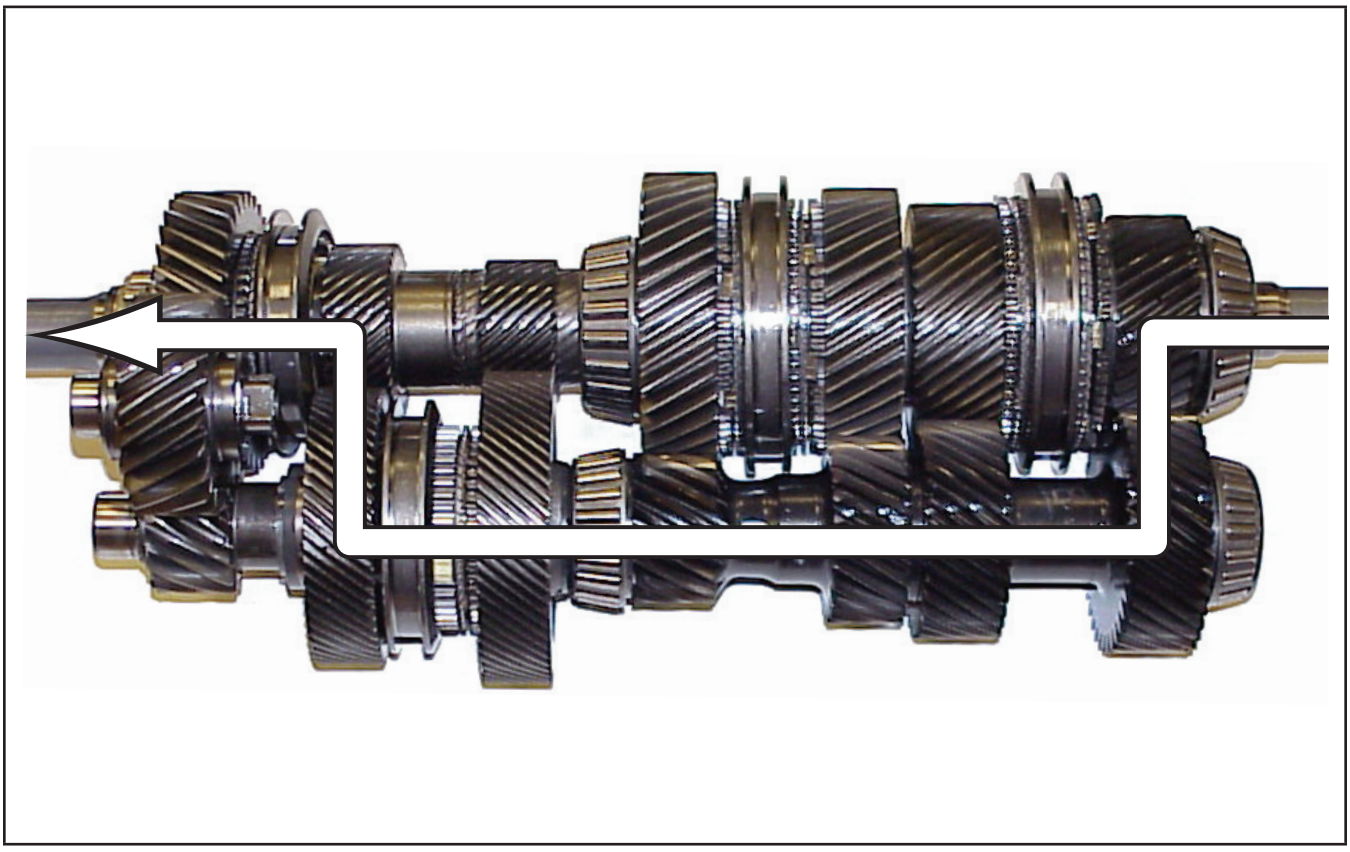


Figure 95 TR6060 Fifth Gear Power Flow

Sixth Gear

When the clutch is engaged (pedal up), torque is transmitted to the input shaft. The input shaft drive gear transfers power to the counter shaft. The counter shaft transfers power to the 5–6 synchronizer hub and sleeve. The 5–6 synchronizer sleeve transfers power to the sixth drive gear. The sixth drive gear transfers power to the sixth driven gear. The sixth driven gear transfers power to the main shaft.

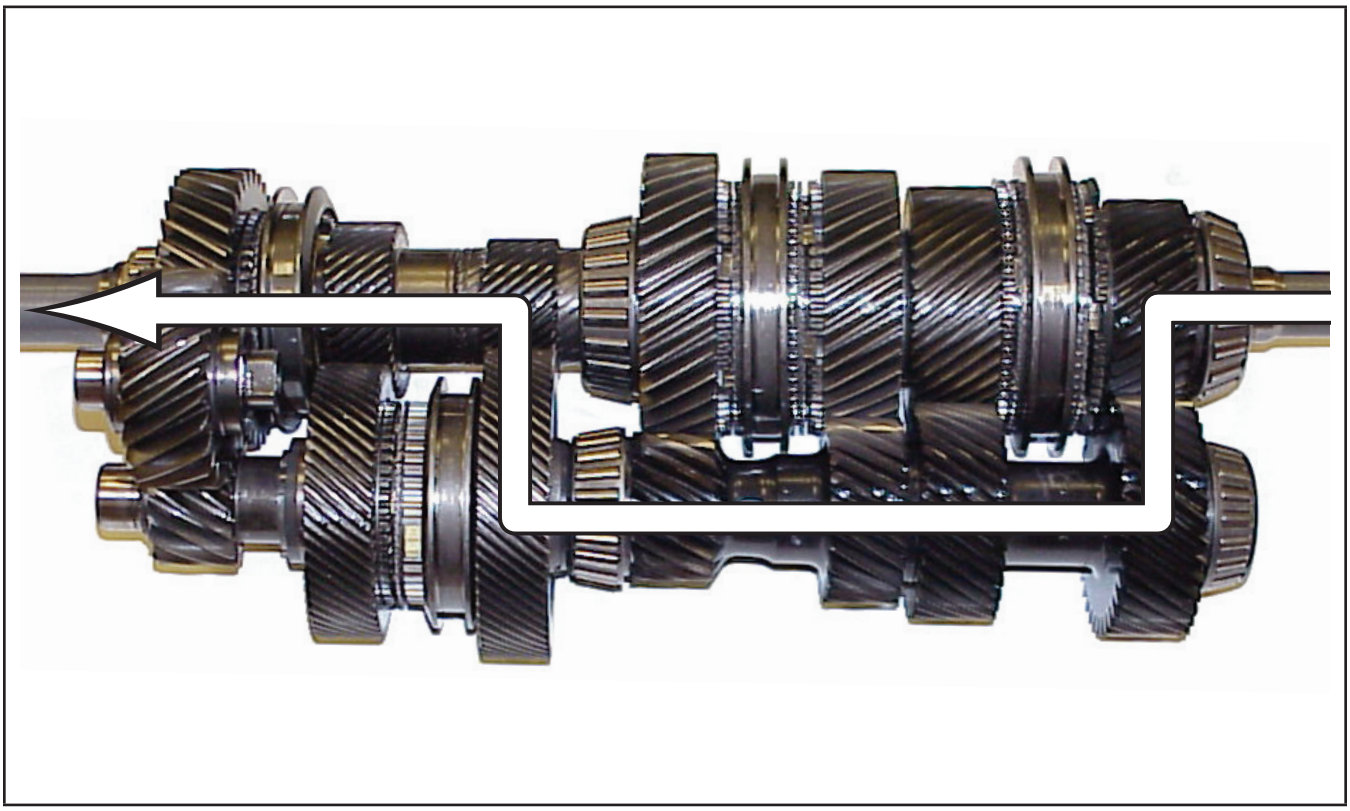


Figure 96 TR6060 Sixth Gear Power Flow

Reverse Gear

When the clutch is engaged (pedal up), torque is transmitted to the input shaft. The input shaft drive gear transfers power to the counter shaft. The counter shaft transfers power to the reverse drive gear. The reverse drive gear transfers power to the reverse idler gear. The reverse idler gear changes the direction of motion and transfers power to the reverse driven gear. The reverse driven gear transfers power to the synchronizer sleeve, synchronizer hub, and the main shaft. When Reverse is engaged, the main shaft spins in the opposite direction of the input shaft.

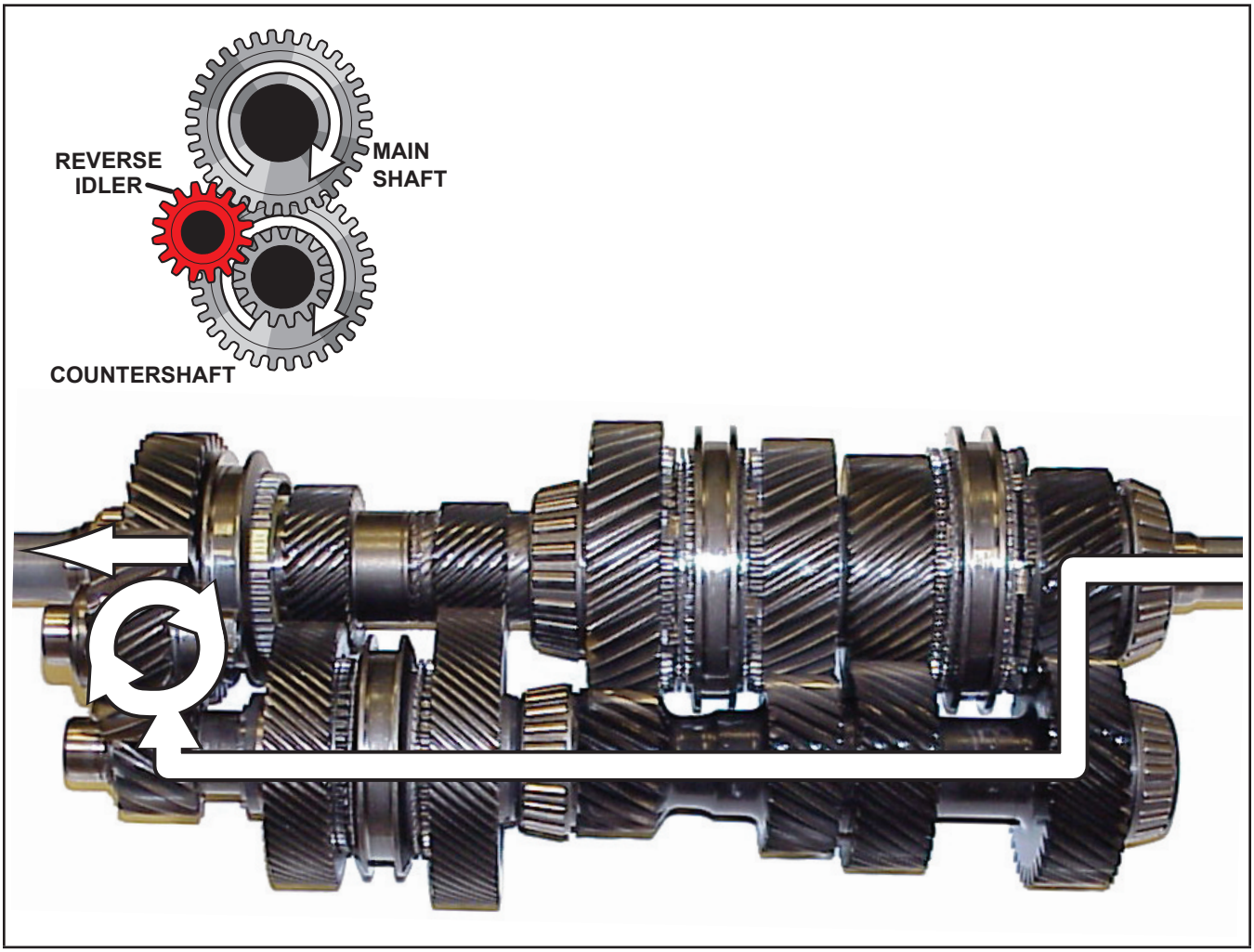


Figure 97 TR6060 Reverse Gear Power Flow

Neutral

When the transmission is in Neutral with the clutch engaged (pedal up), power flows into, but not out of the transmission. The input shaft and counter shaft spin at engine speed. The main shaft spins at propeller shaft speed. None of the synchronizers are engaged in Neutral.

Because Reverse, First, Second, and Third gears all have fixed gears on the counter shaft, these spin at engine speed. Because Fifth and Sixth gears have fixed gears on the main shaft, these spin at propeller shaft speed.

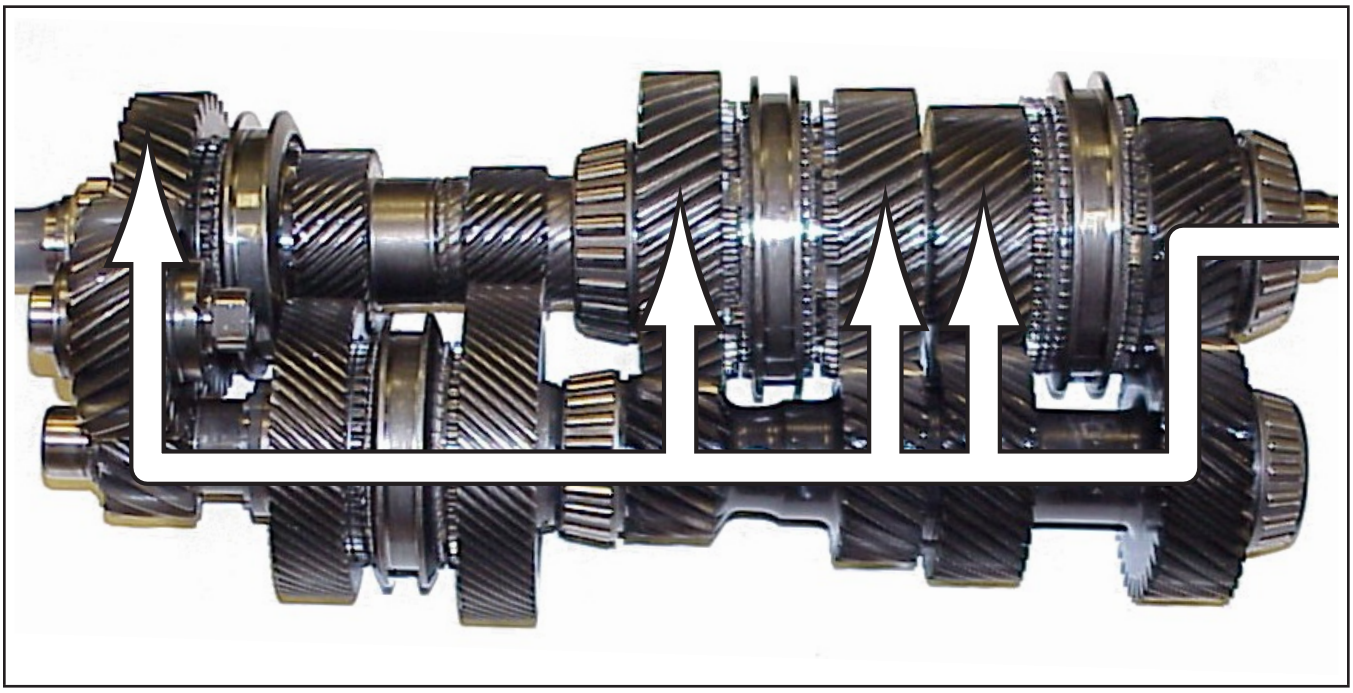


Figure 98 TR6060 Neutral Power Flow

Notes:

Notes:

MODULE 6 MANUAL TRANSMISSION DIAGNOSIS

Performing the correct repair procedure on a malfunctioning transmission depends on a thorough diagnosis. Symptom–based diagnostics are an essential part of being able to diagnose any fault that may occur. From preliminary diagnosis and road testing to isolating the concern and repairing it, the ability to look for and identify symptoms is very important. The following section provides an overview of the diagnostic process that should be used to identify a concern and isolate the cause to a specific component.

When diagnosing a manual transmission concern, this 6-step diagnostic process is recommended:

1. Verify the concern
2. Identify any related symptoms
3. Analyze the symptoms
4. Isolate the concern
5. Correct the concern
6. Verify proper operation

Most complaints are generally a noise or shifting concern. By using a logical sequence and diagnostic test equipment (Chassis Ears), you can usually pinpoint the concern. Whenever a noise is being diagnosed, the first step is to have the engine running and the clutch engaged. The transmission should be tested in every gear, including Neutral, to make a good evaluation. As you listen for noise in each gear, think of what is happening inside the transmission. Keep in mind that it is normal for transmissions to make some noise. What we are looking for during a diagnosis is to duplicate the customer's concern.

GEAR NOISE

Rotating gears generate a mild whine that is audible, but generally only at extreme speeds. Highly audible gear noise is generally the initial indicator of a lubricant concern. Insufficient, improper or contaminated lubricant promotes rapid gear wear. The overheating that results from a lubricant concern also can cause gear breakage.

The forward gears can be diagnosed simply by driving the vehicle and listening for noise as the power flow goes through each selected gear. When a selected gear is noisy, the next step is to remove the transmission. Inspect the input/output gear and gears identified as being noisy during the test drive. If there is a failure, replace the gears involved.

Always inspect all of the gears for worn, cracked, chipped or broken teeth. Check the condition of the bearing bore in each gear. The bores should be smooth and free of surface damage. Replace gears only when tooth damage occurs, the gear overheats, or the bores are brinnelled or severely scored. Gear replacement also is necessary if any damage to the clutch gear teeth is noted.

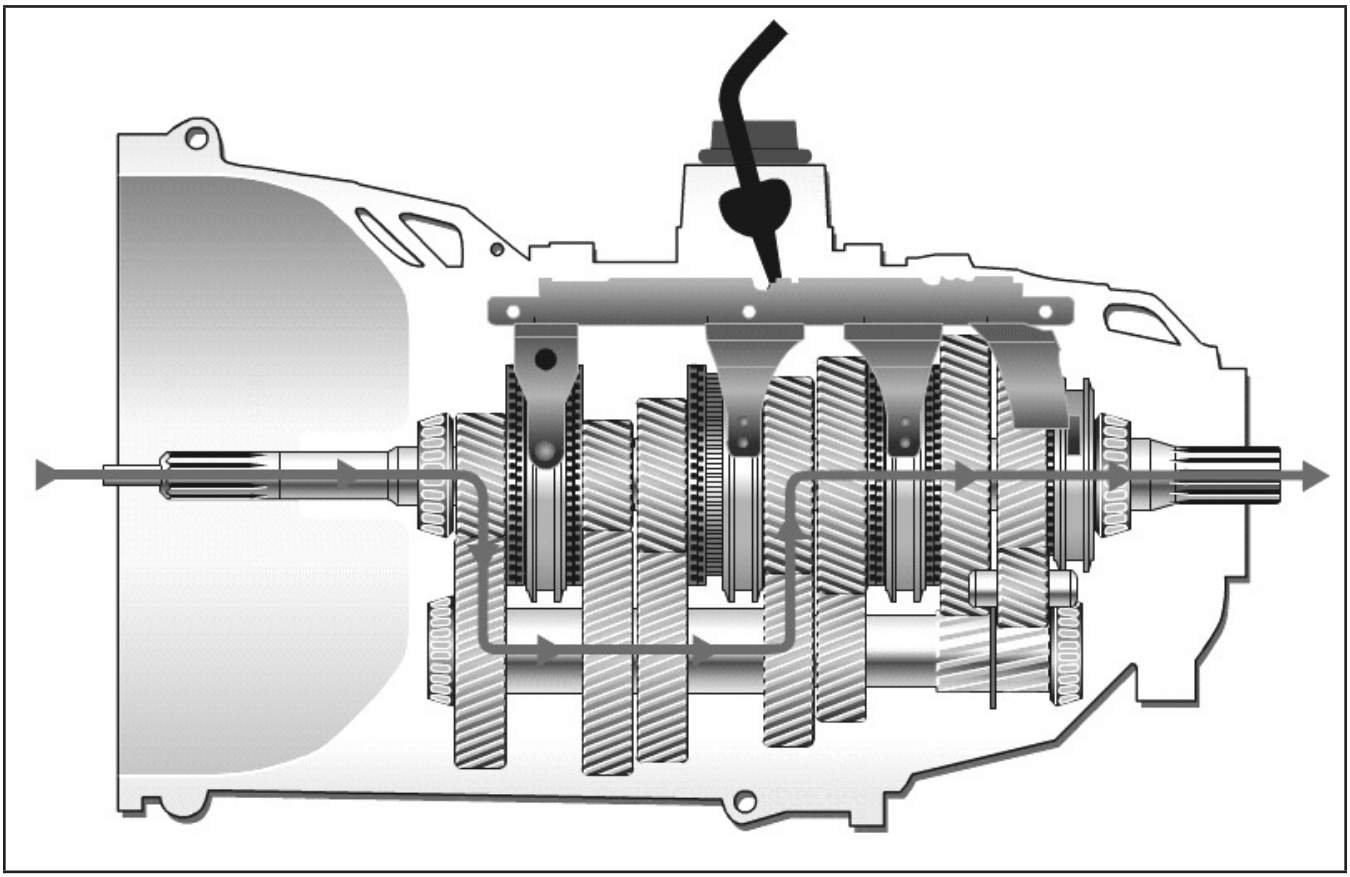


Figure 99 Third Gear Power Flow

SHIFTING CONCERNS

When evaluating shifting concerns in a transmission, note which gear is involved. Does the concern occur while upshifting or downshifting into the gear? Also, note if the concern occurred when the transmission was cold or warm.

Good shifting depends on how well the synchronizer ring cuts through the oil on the synchronizer cone to slow down or speed up the gear for shifting. If the threads or the friction material grooves that cut through the oil are not sharp, the operator must use more effort to get the synchronizer ring to operate properly. When the threads on the synchronizer ring start to go flat or the friction material grooves break down, the synchronizer rings have a tendency to hydroplane on the oil instead of cutting through it and they need to be replaced.

Inspect the synchronizer sleeves for a sliding fit on the synchronizer hubs. Inspect the synchronizer springs and struts for damage. Inspect the blocker rings for excessive wear, scuffing, nicks and burred or broken teeth. Inspect the speed gear friction cones for metal transfer from the blocker ring. Inspect the speed gear teeth for excessive wear. Replace any suspect components.

An inherent characteristic of manual transmissions is that it takes more effort to downshift than to upshift. During a downshift, the synchronizer is speeding up the gear that it is trying to engage. During an upshift, the synchronizer slows the gear down for engagement. Speeding the gear up is more difficult for the synchronizer to perform than slowing down the gear; therefore, worn synchronizers cause a downshift concern first. It is only a matter of time before the concern shows during an upshift.

Note: Pilot bearing, release bearing, pressure plate and incorrect bellhousing alignment can cause shifting concerns.

Cold Shifting

If the operator has to use more effort to shift when it is cold, the reason may be high viscosity oil. This oil could prevent the synchronizer rings from cutting through the oil efficiently. Check the appropriate service information to ensure the transmission is filled with the correct lubricant.

Hard Shifting

Hard shifting usually is caused by a low lubricant level, improper or contaminated lubricants, transmission component damage, clutch linkage malfunction, or a damaged clutch pressure plate or disc.

Substantial lubricant leaks can result in gear, shift component, synchronizer and bearing damage. If a leak goes undetected for an extended period, one of the first indications of a concern is usually hard shifting and noise.

Incorrect or contaminated lubricants also can contribute to hard shifting. The consequences of using non–recommended lubricants are noise, excessive wear, internal bind, hard shifting and high temperatures.

Worn or damaged synchronizer rings can cause gear clash when shifting into any synchronized gear. In some new or rebuilt transmissions, new synchronizer rings may tend to stick, slightly causing stiff and/or noisy shifts. In most cases, this condition declines as the rings wear in. When a synchronizer is damaged, the clutch gear teeth associated with the synchronizer are often damaged. If the clutch gear teeth are damaged, the whole gear must be replaced.

Slips (Pops) Out of Gear

Damaged clutch and gear teeth can cause a pop out of gear concern. Worn detent components, a worn shift shaft and worn synchronizer springs, and detent balls and struts can cause the transmission to pop out of gear. A low lubricant level also may cause a popping out of gear condition. Other things that can cause the transmission to pop out of gear are transmission and engine mounts and the gear shift boot.

BEARINGS

Bearings must be structurally strong and intact to handle the high torque levels present within a transmission.

Assessing the condition of a bearing assembly is critical to proper diagnosis of noise complaints. More often than not, a bearing is replaced when it is suspected that it has failed, or is likely to fail in the near future. In most instances, this is a rather easy determination to make. Even if a bearing does not require replacement, its condition can help isolate other concerns that may exist.

It is not necessary to tear down a transmission solely for the purpose of bearing inspection. More importantly, whenever a unit is disassembled, a thorough inspection of the bearings should be conducted.

To perform a quality inspection of a bearing, it must be thoroughly cleaned. Never use steam or hot water when cleaning the bearings because rust and corrosion form in a very short time after cleaning. Lint–free shop towels should be used to dry them. Bearings should not be dried with compressed air. This can result in overheating and the bearing surfaces may brinell, resulting in noisy operation.

Inspecting for Bearing Failure

Bearings are manufactured to operate properly for a certain length of time under normal conditions. This quality varies depending on application and manufacturer tolerances. The failure of a bearing before reaching its fatigue life goal is referred to as "premature failure." Most concerns related to premature bearing failure are caused by one of the following:

- Insufficient or incorrect lubrication
- Foreign matter or water contamination
- Improper handling and servicing
- Excessive impact loads

Bearings that are removed, cleaned and dried for inspection are often susceptible to corrosion damage. It is important that bearings be cleaned and dried properly. If they are stored, they should immediately be coated with oil or a good rust preventative and wrapped in protective paper. Bearings, whether new or used, should be stored in a clean, dry area.

Table 11 Bearing Failures

Name of Failure	Characterized By...	Probable Cause
Galling	Metal smears on roller ends	Overheating, lubricant failure or overload
Etching	Bearing surfaces appear gray or grayish black with related etching away of material at roller spacing	Fine abrasives, foreign material
Abrasive step wear	Fine pattern on roller ends	Fine abrasives, foreign material
Indentations	Surface impressions on race and rollers	Hard particles of foreign material
Fatigue spalling	Flaking of surface metal	Worn rollers
Brinelling	Surface indentations in raceway	Rollers under impact loading or vibration while bearing is not rotating
Fretting	General corroded appearance	Caused by small relative movement of parts with no lubrication
Heat discoloration	Discoloration ranging from faint yellow to dark blue	Overload on bearing or incorrect lubricant

There are a series of tests to assist in finding which bearing is bad in a manual transmission. Check the following bearings:

- Clutch release bearing
- Transmission pilot bearing
- Transmission bearings

The clutch release bearing is turning all the time when the engine is running and has a light preload pressure when the clutch is engaged (clutch pedal up) and a heavy preload pressure when the clutch is disengaged (clutch pedal down). The clutch release bearing can be tested with the vehicle stationary, engine running, clutch pedal down and transmission in gear. This ensures the input gear is not turning, preventing the input gear bearings from making noise. If you hear a growling noise, it may be the release bearing and the noise goes away when the clutch is released. If the noise does not go away, replace the pilot bearing.

When evaluating bearing noise, many components such as speed gears turn independently of the output shaft. Noisy bearings make noise until a specific gear is selected.

If the roller bearing used between the rear of the input shaft and the front of the main shaft fails, noise is present in all gears except direct drive. Direct drive is fourth on the TR6060, fifth on all other transmissions. Because the bearing allows the input and output shafts to rotate at different speeds, in direct gear the shafts rotate at the same speed (1:1 ratio).

The input shaft and counter shaft support bearings can be tested with the engine running, clutch engaged and transmission in neutral. If bearing noise is experienced in neutral, put the transmission in gear and drive the vehicle. The bearing noise should get louder under load. The rear main shaft bearing only makes noise when the vehicle is moving. The noise increases with speed and when upshifting.

Note: Listening devices like the Chassis EAR are valuable tools when diagnosing bearing noise.

CLUTCH SYSTEM

The term clutch refers to the disc, flywheel, pilot bearing or bushing, release bearing and the pressure plate working together as a system. The clutch system engages and disengages the engine from the transmission, enabling the driver to start, stop, and idle in neutral and shift gears.

Clutch Operation

When the clutch is disengaged (clutch pedal down), the fork keeps the release bearing against the clutch diaphragm spring fingers. This action allows the clutch pressure plate to lift away from the flywheel, opening a very small clearance between the disc, flywheel and pressure plate. With the disc moved away from the flywheel, power flow from the engine to the transmission is interrupted.

When the clutch is engaged (clutch pedal up), the clutch clamps the disc against the flywheel. This causes the input shaft to turn, transmitting engine torque to the transmission.

Disc

The disc is a critical component in providing long service life for the clutch system. It provides smooth engagement and dampens engine vibrations. It is mounted to the input shaft and positioned between the flywheel and the clutch. It can slide forward and backward on the shaft, but cannot rotate without driving the input shaft.

Some discs include idle-stage dampers, in the form of small springs around the hub and friction washers inside the disc. As pulsations from the engine reach the disc, the springs compress and expand to cushion or dampen vibrations and eliminate gear rattle.

Friction material is riveted to numerous metal components called cushion segments. Waves in cushion segments soften engagement.

Pressure Plate

The major parts of a typical diaphragm spring clutch consists of a pressure plate, cover straps, and a diaphragm spring. The release bearing moves the diaphragm spring fingers. When the clutch is engaged the diaphragm spring clamps the disc against the flywheel via the pressure plate. When it is disengaged (clutch pedal down) the release bearing moves the diaphragm spring fingers toward the flywheel, and the diaphragm spring pivots inside the cover, lifting the pressure plate off the flywheel. This creates a gap large enough for the disc to move away from the flywheel which interrupts torque transmission from the engine to the transmission and enables the driver to shift gears.

Diaphragm spring clutches maintain higher clamp load throughout the service life of the clutch. As disc friction material wears, clamp load increases during the first half of the clutch life before de-greasing gradually to its original level. Diaphragm spring clutches require less pedal effort the further the pedal is actuated, reducing stress on the release system components

Flywheel

Bolted to the end of the crankshaft, the flywheel provides the mounting surface for the clutch. During engagement, the disc is clamped against the flywheel by the pressure plate.

In addition to its other functions, the flywheel acts as a heat sink. The flywheel must provide a smooth, flat surface for the clutch to operate properly.

The Dual Mass Flywheel (DMF) is designed to absorb engine vibrations before they are transmitted to the driveline where they can create gear rattle. The primary section of the flywheel contains springs to isolate engine vibrations and a torque limiter to prevent engine torque spikes from exceeding engine and transmission component strength.

Release Bearing

The release bearing is attached to the fork and slides on the bearing guide of the transmission. The movement of the fork causes the release bearing and presses against the tips of the diaphragm spring fingers. Ball bearings in the release bearing enable it to turn while applying pressure to the fingers.

These self-centering bearings are designed to compensate for slight misalignment between the engine and transmission. It is normal for these bearings to be "off center" until they contact the diaphragm spring fingers.

Some vehicle designs utilize a concentric slave cylinder. It eliminates the need for a number of release system components, including the release fork, pivot ball and bearing retainer. Its location inside the bellhousing makes it difficult to troubleshoot.

Pilot Bearing/Bushing

On many vehicles, a pilot bearing or bushing is located in the end of the crankshaft or attached to the flywheel. The pilot bearing supports the end of the transmission input shaft and centers the disc on the flywheel. Types of pilot bearings include ball bearings, needle bearings and sintered bronze bushings.

A small and relatively inexpensive component, the pilot bearing or bushing should always be replaced during clutch installation. The variety of problems caused by a worn or defective pilot bearing or bushing are not worth the risk of having to remove the bellhousing and transmission to replace this component later.

CLUTCH DIAGNOSIS

Begin every clutch diagnosis by discussing the symptoms of the clutch operation with the customer. Collect information about the operating conditions and working environment of the clutch. If possible, road test the vehicle with the customer driving to duplicate the problem. Establish the vehicle's clutch history and mileage.

If the old clutch had relatively low mileage and final diagnosis shows signs of driver abuse, road test the vehicle with the customer to observe their driving habits. Explain how certain behaviors you observe reduce clutch service life.

Driving Habits and Clutch Wear

Constant engagement and disengagement of the clutch will wear away disc friction material. The rate at which wear occurs, however, depends largely on the driving habits of the operator and vehicle usage.

Driving behaviors and conditions that decrease clutch service life include riding the clutch pedal, high RPM engagement, excessive slipping, harsh downshifting, lugging the engine, excessive vehicle loading, and engine, transmission and suspension modifications.

Slipping the clutch during engagement creates excessive heat, damages the clutch and flywheel contact surfaces and accelerates disc friction material wear. Riding the clutch reduces the clamping force of the disc, which causes slipping; power transfer from the spinning flywheel is not fully applied to the disc. The result is premature wear of the disc friction material. Waiting in traffic with the vehicle in gear and the clutch disengaged loads the release bearing excessively. Over time, this shortens release bearing life and can eventually cause noise.

Lugging the clutch occurs when the driver selects the wrong gear for the vehicle speed and load. Under low speed/high load conditions, a lower gear should be used to reduce the torque applied to the clutch. Selecting a higher gear causes excessive loading of the disc that can damage the disc hub and torsion springs as well as the clutch drive straps. Over-revving the engine and high-speed downshifting can burst the friction material.

Complete Repair

Complete clutch repair is diagnosing the cause of the damage, and examining and replacing all worn and damaged components. Some components adjust their operating points to compensate for normal wear in disc friction material.

Examination and replacement of all worn clutch system components is critical to ensure the full service life of the clutch and disc. And, it is inexpensive insurance against comebacks.

Always examine and replace the following parts if worn or damaged: flywheel, slave and master cylinder, cable, fork, linkage, bearing retainer, cross shaft bushings and fork pivot.

Before Removing the Bellhousing

Before teardown, check all components outside the bellhousing that could be defective and create the appearance of a problem with the clutch or disc.

Examine all external release system components. On vehicles that provide for external adjustment, always check and adjust the free play. Hydraulic release and self-adjusting cable systems use constant contact release bearings; this means they have zero free play. Excessive free play causes incomplete release; insufficient free play causes slipping.

As disc friction material wears, the pressure plate moves closer to the flywheel, and the diaphragm spring fingers pivot outward toward the transmission. This causes a gradual decrease in the distance between the release bearing and the diaphragm fingers. Due to this normal wear in the clutch system, release systems that provide for external free-play adjustment must be checked periodically.

With cable release systems, check for binding, stretching, cracks at the pivot and anchor points, cracks or kinks in the housing and a defective self-adjusting mechanism. With mechanical linkages, check all pivot points to ensure they are clean and properly lubricated.

After Clutch Removal

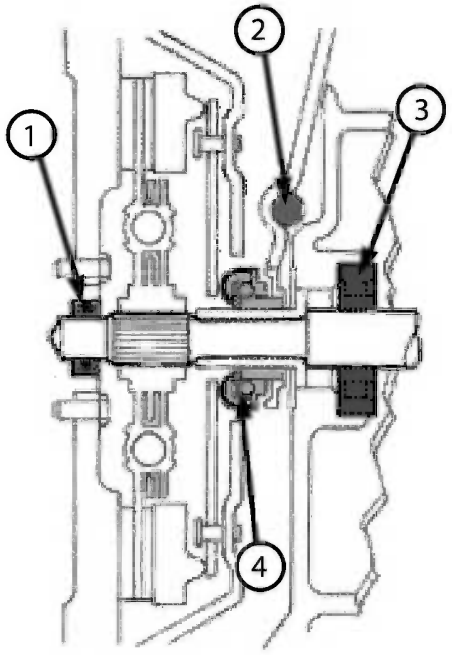
A technician can learn a lot about the clutch system by examining the clutch components they remove. The figures of damaged clutch system components in this section represent common system failures. Compare them to the component that has been removed to assist in diagnosis. Keep in mind that the damage to the components may be more pronounced or more subtle than these examples.

Clutch system problems often exhibit multiple symptoms, and those possibilities are noted as Related Symptoms. The remainder of this section is organized by the following symptoms:

- Noise
- Chatter
- Slipping
- Release Concerns
- Hard Pedal

Noise

Proper lubrication during clutch installation can reduce the chances of noise in the future. Squeals and growls are usually caused by worn or seized bearings. Chirping noises are usually caused by vibration somewhere in the release system. Determine the source of bearing noise by setting the parking brake, putting the vehicle in neutral and starting the engine. Refer to the figure below to determine the source of the noise.



	Noise	Source
1	Squealing when the pedal is actuated and held.	Pilot bearing or bushing
2	Chirping while idling in neutral that disappears when the pedal is slowly actuated.	Fork/pivot ball contact point
3	Growling or grinding when the clutch is engaged.	Transmission input shaft bearing
4	Chirping that intensifies when the pedal is slowly actuated.	Release bearing

Figure 100 Source of Noises

The cause of noises in the clutch system can be external or internal to the transmission bellhousing. Noise that is external may come from the following sources:

- Worn driveshaft components
- Worn engine or transmission mounts
- Worn or improperly lubricated pedal components

Internal noise may come from the following sources:

- Worn or defective input shaft bearing
- Defective or misaligned release bearing
- Worn, misaligned or improperly lubricated pilot bearing/bushing
- Worn, bent or improperly lubricated fork
- Worn input shaft
- Improper disc installation
- Misalignment
- Damaged bearing retainer
- Loose flywheel bolts
- Damaged disc splines, worn stop pins or broken damper

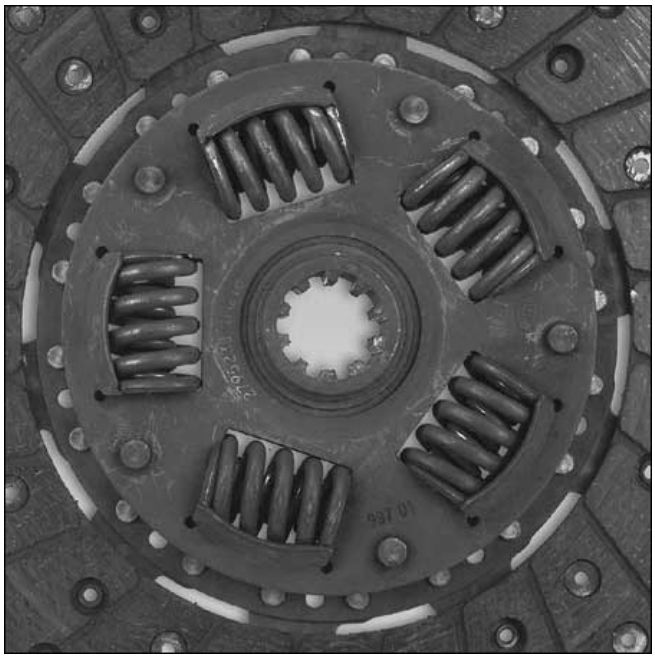


Figure 101 Worn Splines

Related Symptoms: Harsh engagement, chatter.

Cause: Worn pilot bearing, worn input shaft, misalignment between the engine and transmission.

Check for misalignment on high-mileage vehicles and those in which the engine or transmission was replaced.

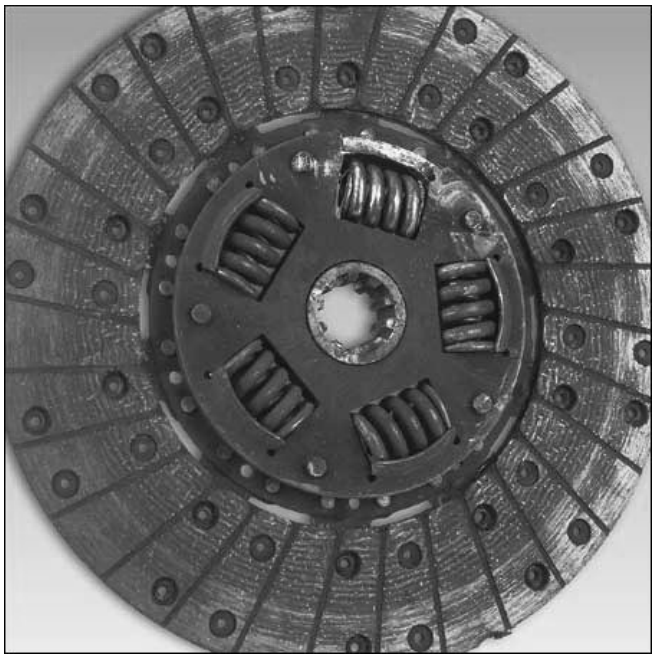


Figure 102 Broken Cover Plate

Related Symptom: No release.

Cause: Driver abuse over-torquing the disc, lugging the engine, high RPM engagement, harsh downshifting, vehicle suspension or engine modifications.

Figure 103 Worn Grooves

Related Symptoms: Slipping, chatter.

Cause: Excessive bearing preload caused by riding the clutch, incorrect release system adjustment, defective hydraulic release system.

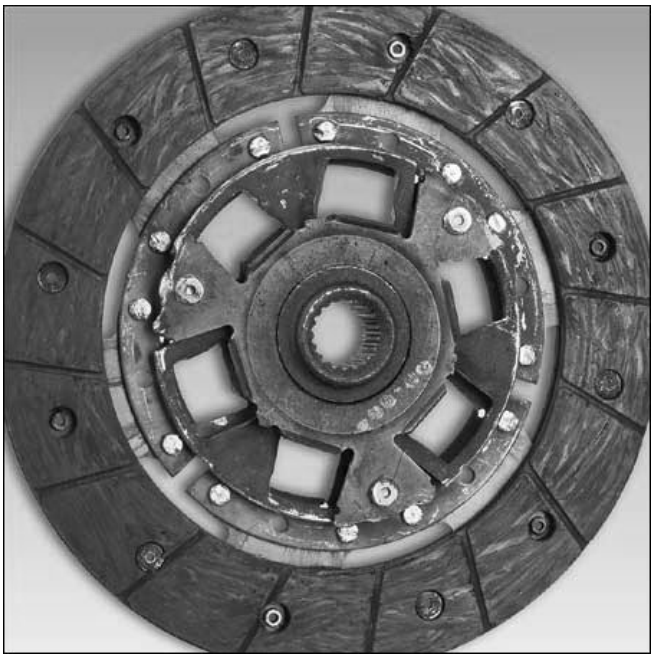


Figure 104 Broken Torsion Damper

Related Symptoms: Harsh engagement, no release.

Cause: High RPM engagement abusing the torsion damper and causing the springs to fracture and dislodge from the retainer plate.

A no-release condition will result if the springs lodge in other clutch system components.

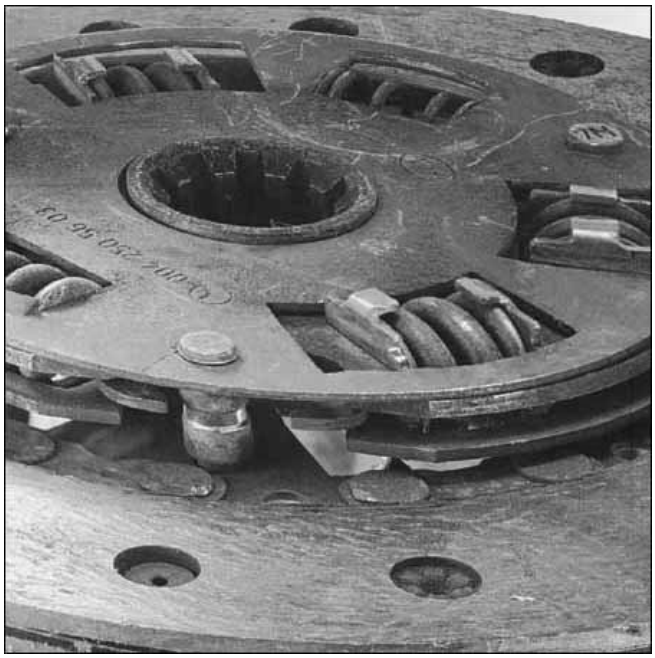


Figure 105 Worn Stop Pins

Related Symptom: Chatter.

Cause: Driving in high gear at low RPMs, causing the disc torsion damper to contact the stop pins, high RPM engagement, excessive vehicle loading.

Figure 106 Worn Bearing Guide

Related Symptoms: Hard pedal, incomplete release.

Cause: Incorrect release system adjustment, worn fork or fork pivot points, insufficient lubrication of the bearing retainer, worn ball stud causing the fork to apply uneven pressure to the release bearing.

For the clutch to function properly, the bearing retainer must have a smooth surface and be exactly parallel to the input shaft.

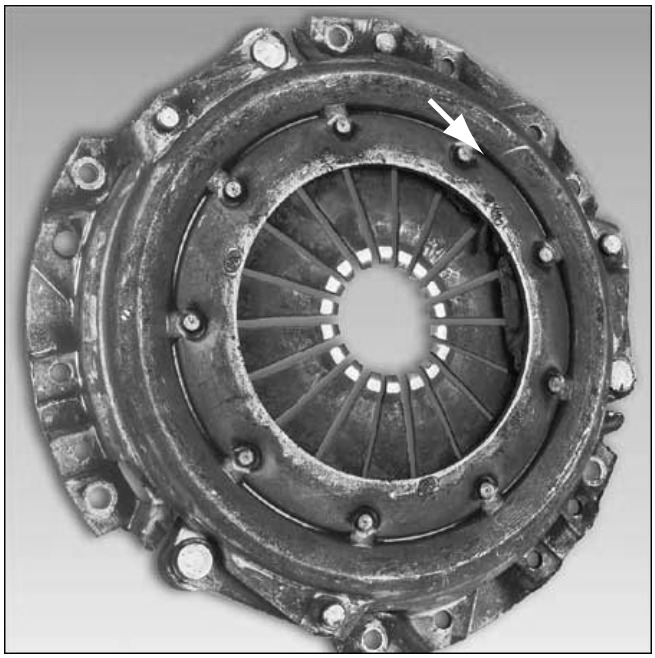


Figure 107 Embedded Friction Material

Related Symptoms: No release or engagement.

Cause: Harsh downshifting, high RPM engagement, engine over-revving caused by missing a gear.

The disc friction material burst when the clutch was disengaged, lodging friction material between clutch system component parts.

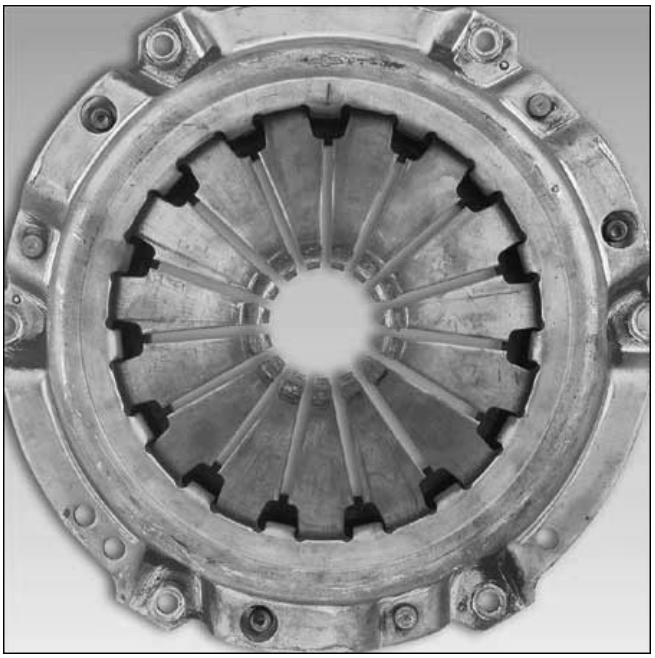


Figure 108 Melted Fingers

Related Symptoms: No release, extreme noise, slipping.

Cause: Worn bearing retainer, incorrect release bearing installation, worn or bent fork.

The release bearing seized and stopped rotating. The contact marks on the diaphragm fingers were caused by abrasion and heat from constant contact with the bearing. The release bearing would be melted, blue and/or destroyed.

Chatter

Chatter is grabbing or jerking during engagement. The most common cause is contamination of the disc friction material. Before removing the bellhousing, inspect the area around it and the engine to locate and repair the source of oil leaks.

Avoid contamination of disc friction material by touching it with clean hands only. Prior to installation, clean the contact surfaces of the flywheel and the clutch pressure plate with brake parts cleaner.

Lubricate input shaft splines with a small amount of high-temperature grease. Slide the disc onto the input shaft splines to distribute a thin film. Remove the disc and wipe away any excess lubricant prior to installation.

Check the release system for wear and damage. Worn or distorted components prevent the clutch from clamping the disc evenly, causing chatter. Check the transmission and the engine mounts, and examine the vehicle for damage that could contribute to vibration as the clutch is engaged.

The cause of chatter in the clutch system can be external or internal to the transmission bellhousing. Chatter that is external may come from the following sources:

- Loose or broken engine or transmission mounts
- Misalignment of chassis and drive line components
- Worn or damaged universal joints
- Missing bellhousing dowel pins
- Loose transmission cross member
- Loose rear leaf spring bushings or spring U-bolt nuts
- Worn or bent fork

Internal chatter may come from the following sources:

- Bent or broken drive straps
- Warped or grooved flywheel
- Missing flywheel dowel pins
- Wear or excessive lubrication of input shaft splines
- Worn pilot bearing/bushing
- Worn bearing retainer
- Worn or damaged disc splines
- Clutch distortion or bent drive straps
- Oil- or grease-contaminated friction material
- Improper bolting of the clutch

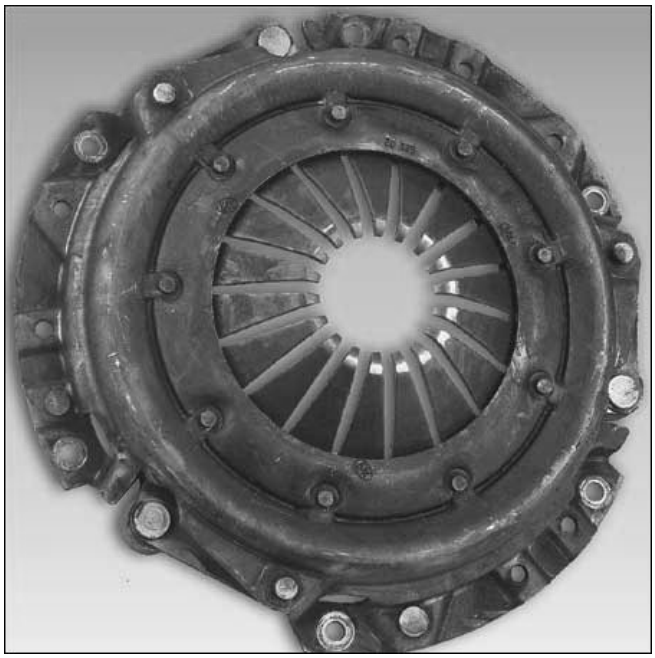


Figure 109 Contaminated Clutch

Related Symptoms: Slipping.

Cause: Leaking transmission or engine seal.

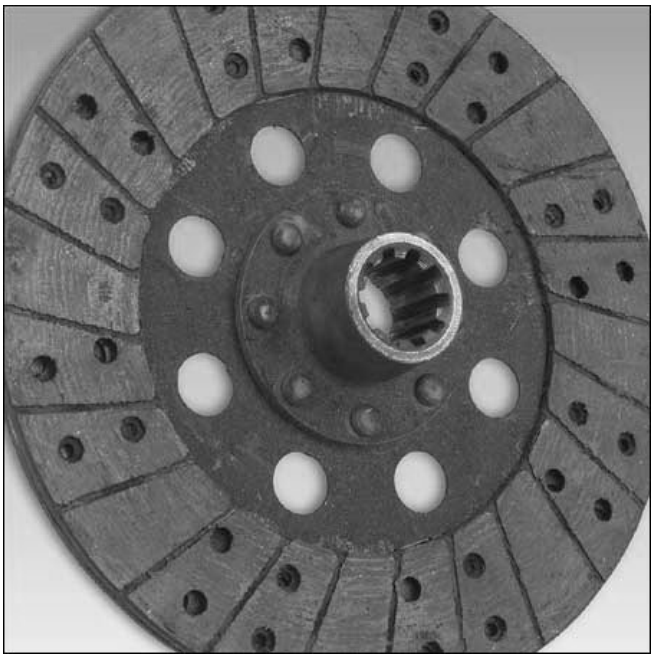


Figure 110 Friction Material Contamination

Related Symptoms: Slipping.

Cause: Leaking transmission or engine seal, contamination of the friction material during installation.

Figure 111 Bent Clutch Cover

Related Symptoms: Release problems.

Cause: Damage prior to installation, misaligned flywheel dowel pins, improper installation of the clutch.

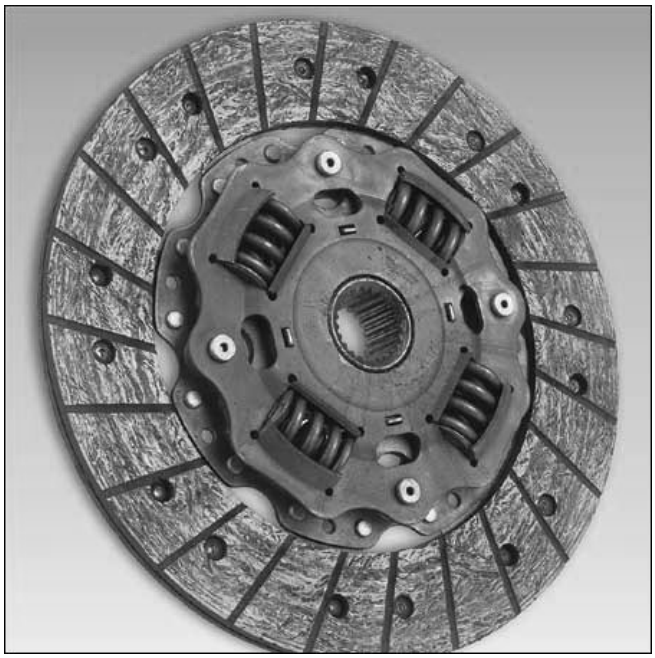


Figure 112 Excessive Lubrication

Related Symptoms: Slipping, release problems.

Cause: Excessive lubrication of the input shaft splines.

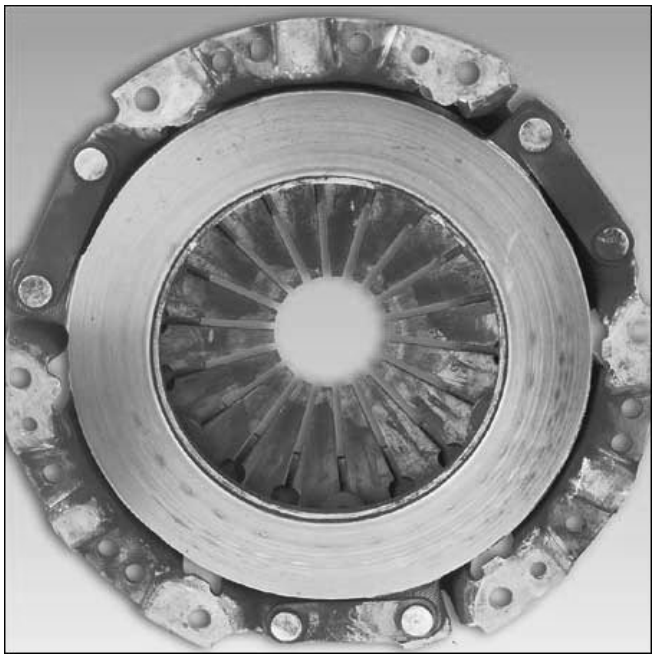


Figure 113 Chatter Marks

Related Symptom: Release problems.

Cause: Incorrect installation of the clutch. The clutch was distorted when it was bolted to the flywheel incorrectly.

Chatter marks were caused by the uneven actuation of the diaphragm spring fingers. Heavy finger wear would be evident on the diaphragm spring fingers opposite the chatter marks.

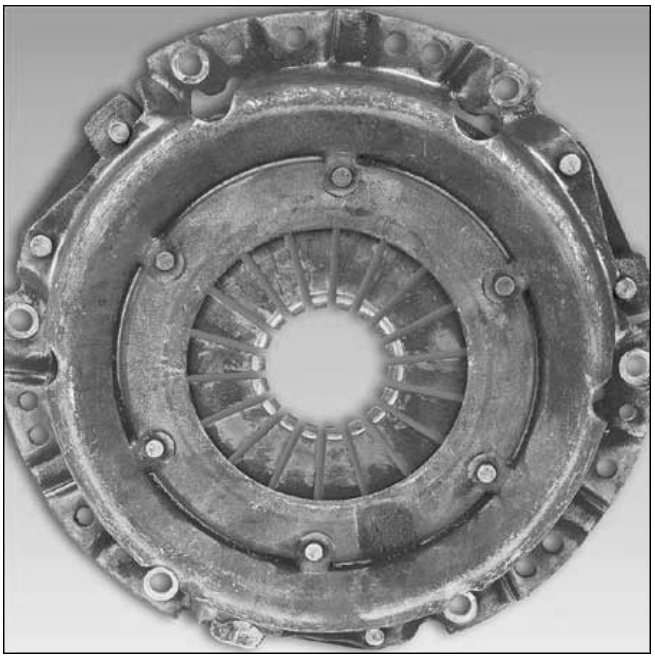


Figure 114 Uneven Finger Wear

Related Symptoms: Incomplete release, noise.

Cause: Incorrect installation of the clutch. The clutch was distorted when it was bolted to the flywheel incorrectly.

The pressure plate side would have chatter marks on the side opposite the lighter finger wear.

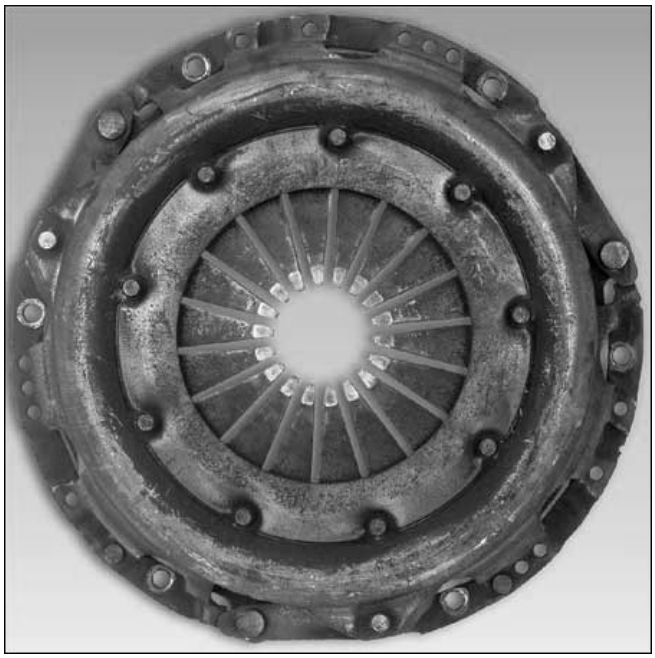


Figure 115 Excessive Finger Wear

Related Symptoms: Slipping, noise.

Cause: Excessive bearing preload caused by riding the clutch, incorrect release bearing installation, defective hydraulic release system or cable self-adjuster, insufficient free play causing the bearing to ride constantly on the diaphragm spring fingers.

The release bearing may seize or make noise before slipping is noticed.

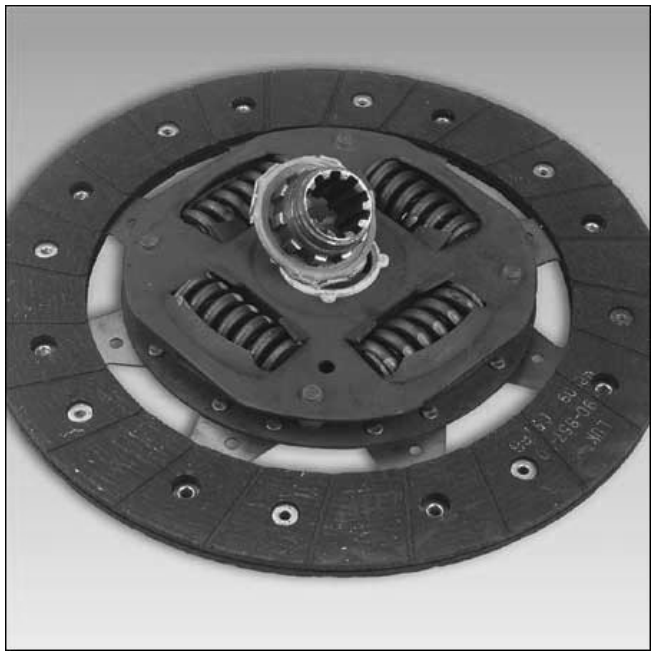


Figure 116 Broken Hub

Related Symptoms: Noise, engagement problems.

Cause: Disc was not properly aligned and the transmission input shaft was forced into the hub, shoving the center of the hub out.

The abrasion marks on the leading edge of the disc splines indicate the input shaft was forced into the hub. Never force the transmission into the disc or use the bellhousing bolts to pull a transmission into place.

Slipping

Normal wear is the most likely cause of slipping if the disc is worn down to the rivets and the clutch has high mileage. If a newly installed clutch is slipping, the most likely causes are oil or grease contamination, incorrect release system adjustment or improper flywheel machining of a stepped or cupped flywheel.

Some slipping of the clutch is normal and necessary for smooth engagement; however, once the clutch is engaged, there should be no slipping. Excessive slipping causes tremendous heat that damages the clutch pressure plate and flywheel.

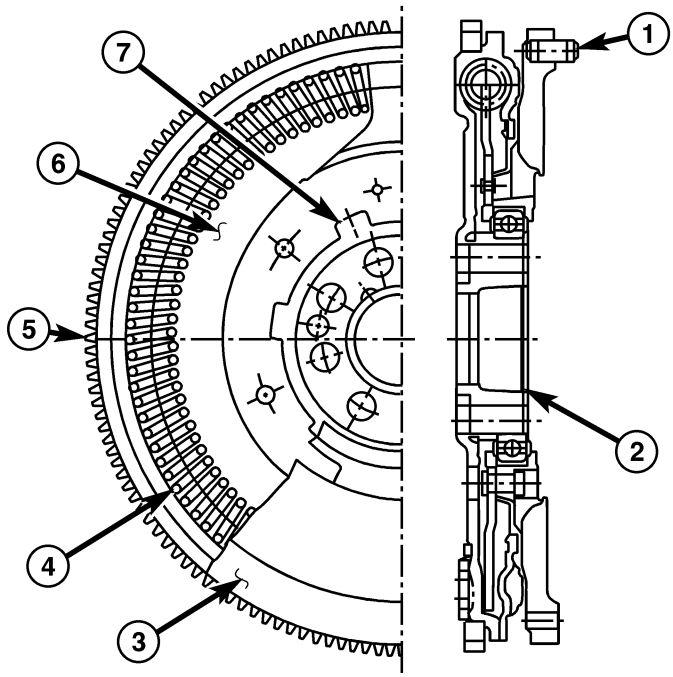
If the vehicle is equipped with a DMF, the flywheel may be the cause of the slipping. Carefully examine the old clutch to rule out the flywheel as the source of the slipping. Indications include heat marks on the pressure plate, disintegrated disc friction material and contamination of the friction material from external leaks. If these symptoms are not evident, install a new flywheel.

The cause of slipping in the clutch system can be external or internal to the transmission bellhousing. Slipping caused by external components may come from the following sources:

- Defective, worn or binding release system components
- Blocked master cylinder port
- Binding slave cylinder

Internal components that may cause slipping may come from the following sources:

- Worn disc
- Oil leaks or excessive lubrication
- Excessive flywheel scoring or runout
- Misalignment of the release bearing
- Defective DMF



1	Locating Stud	5	Ring Gear
2	Bearing	6	Primary Flywheel
3	Secondary Flywheel	7	Friction Disc
4	Damper Spring		

Figure 117 DMF

Figure 118 Worn Friction Material

Cause: If the clutch has high mileage, this wear is normal; however, if mileage is low, possible causes include riding the clutch, excessive vehicle loading, defective release system, improper release system adjustment, improperly machined flywheel.

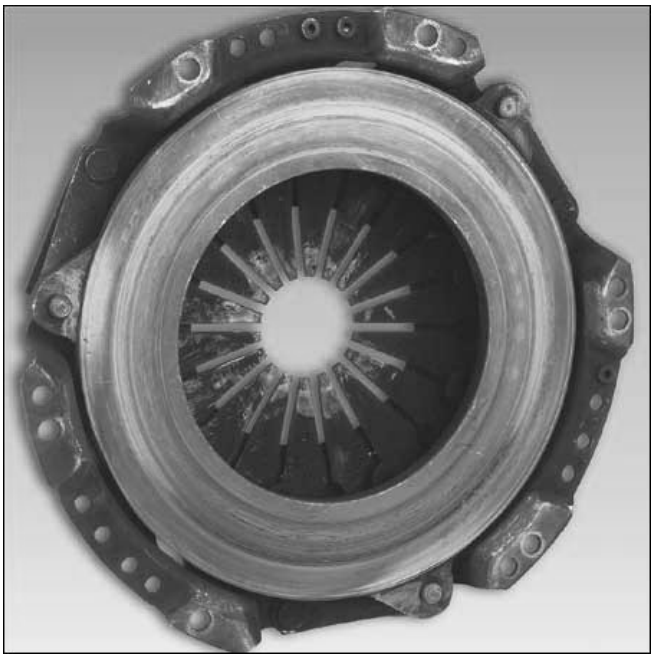


Figure 119 Overheated Pressure Plate

Related Symptom: Release problems.

Cause: Riding the clutch, defective release system, improper release system adjustment, clutch components unsuited for the torque of a modified engine.

The disc would have burnt friction material.

Figure 120 Friction Material Contact

Related Symptom: Chatter.

Cause: Flywheel not resurfaced or resurfaced improperly.

The flywheel must have a smooth, flat surface for the clutch to actuate properly.

Figure 121 Burnt Friction Material

Related Symptoms: Chatter, release problems.

Cause: Riding the clutch, defective release system, improper release system adjustment, friction material contamination during installation.

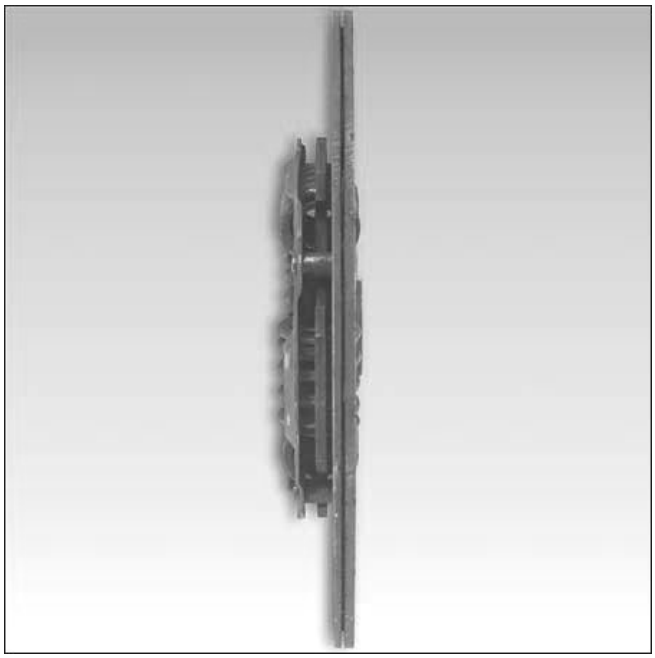


Figure 122 Uneven Friction Material Wear

Cause: Riding the clutch, defective release system, improper release system adjustment.

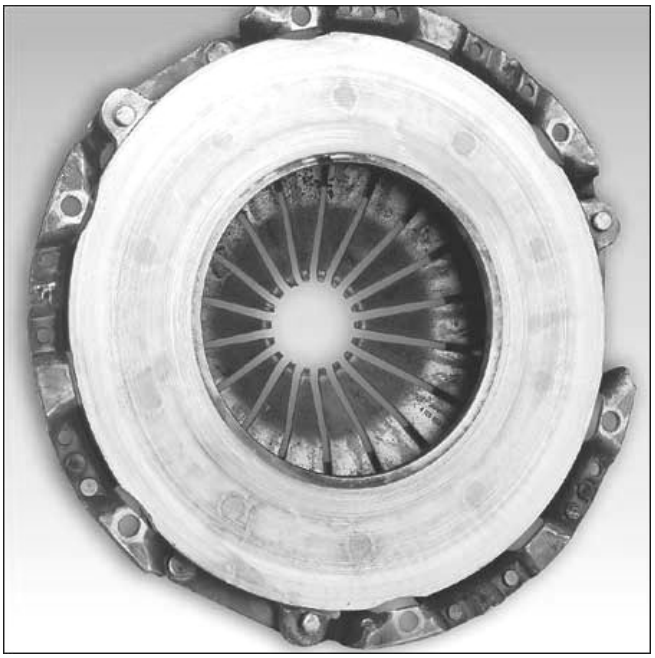


Figure 123 Pressure Plate Heat Rings

Related Symptoms: Chatter

Cause: Oil contamination, flywheel not resurfaced or resurfaced improperly, failure to maintain flywheel step/cup dimensions.

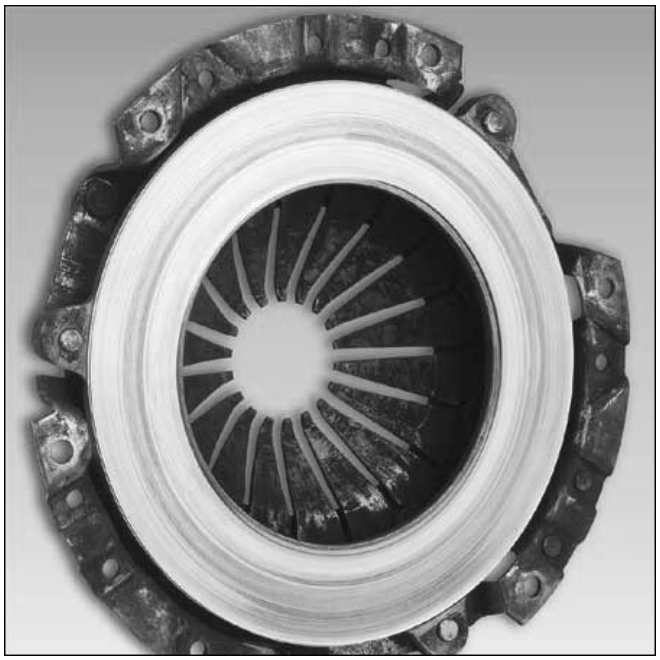


Figure 124 Grooves and Heat Marks

Related Symptom: Release problems.

Cause: Riding the clutch, defective release system, improper release system adjustment, improper resurfacing of a stepped or cupped flywheel.

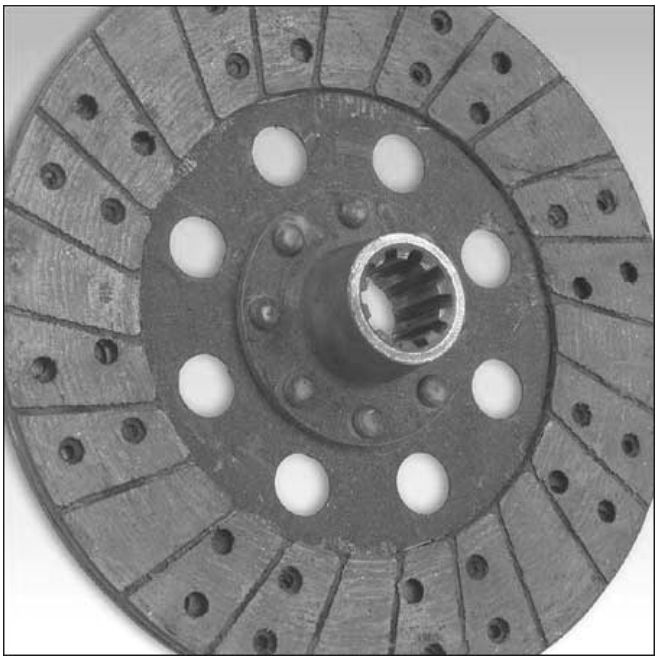


Figure 125 Contaminated Friction Material

Related Symptom: Chatter.

Cause: Leaking transmission or engine seal, excessive lubrication.

Lubricate input shaft splines with a very small amount of high-temperature grease. Slide the disc on the splines to distribute a thin film. Remove the disc and wipe away any excess.

Release Concerns

When the clutch does not release completely, the disc continues to turn the input shaft and transmission gears. Causes of incomplete release include excessive free play, air in the hydraulic system, binding or wear in release system components and a bent disc.

Movement of the master cylinder will also cause release problems. This is especially noticeable when the master cylinder is mounted to the bulkhead, and the bulkhead metal is not rigid enough to hold it in place during actuation. Any movement of the master cylinder reduces the force applied to the hydraulic piston inside, causing incomplete release.

The cause of release concerns in the clutch system can be external or internal to the transmission bellhousing. Release concerns caused by external components may come from the following sources:

- Contaminated hydraulic fluid
- Air in the hydraulic release system
- Defective or worn release system components
- Defective or worn pedal bushings or brackets
- Flexing of the bulkhead or any release component attachment point

Internal components that may cause release concerns may come from the following sources:

- Misalignment of clutch components
- Corroded, damaged or improperly lubricated input shaft splines
- Worn pilot bearing/bushing
- Worn bearing retainer
- Bent or worn release fork or pivot ball
- Worn linkage components
- Excessive flywheel scoring or runout
- Bent clutch drive straps
- Bent or distorted disc
- Improper transmission lubricant
- Improper bolting of the clutch

Figure 126 Bent Clutch Drive Strap

Related Symptom: Chatter.

Cause: Excessive vehicle load, high-speed downshifting, lugging the engine, improper handling causing damage prior to installation.

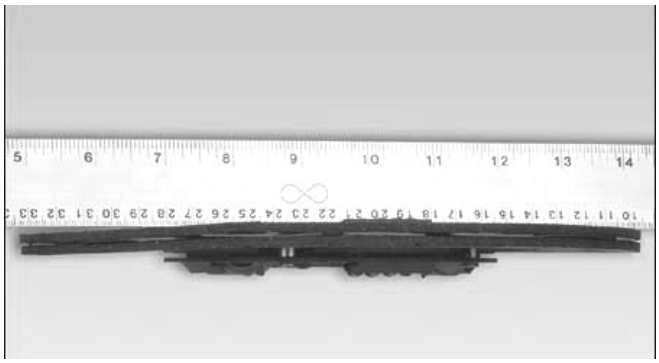


Figure 127 Bent Disc

Related Symptom: Chatter.

Cause: Improperly supported transmission during installation, disc installed backwards.

Incorrect installation of the disc will result in interference between the disc and flywheel, causing clutch malfunction.

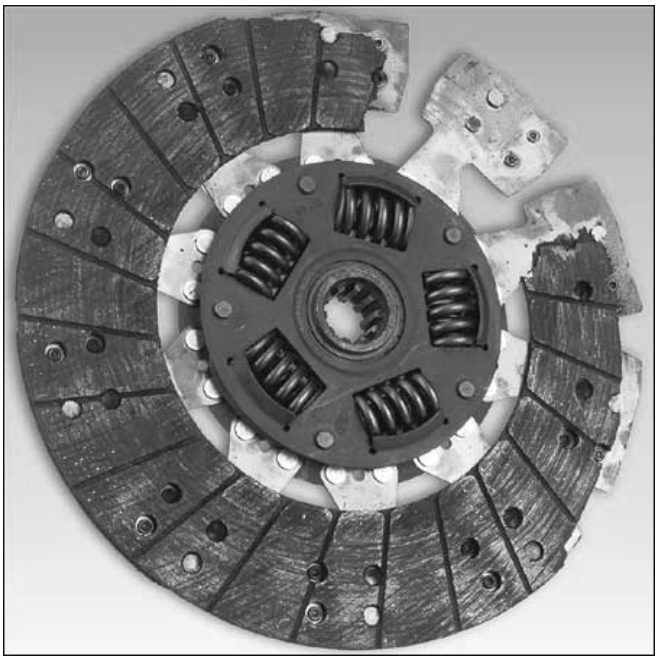


Figure 128 Burst Friction Material

Related Symptom: Hard pedal, chatter.

Cause: Harsh downshifting, high RPM engagement, engine over-revving caused by missing a gear, coasting vehicle at a high speed with transmission in gear and clutch disengaged.

The clutch may have friction material embedded between the diaphragm spring and the cover.

Figure 129 Broken Segments

Related Symptom: Noise.

Cause: High RPM engagement, worn pilot bearing, worn transmission input shaft bearing, misalignment between the engine and transmission, improperly supported transmission during installation.

If the transmission jack is removed before the transmission is bolted to the engine properly, the weight will bend the input shaft, causing uneven engagement and partial release.

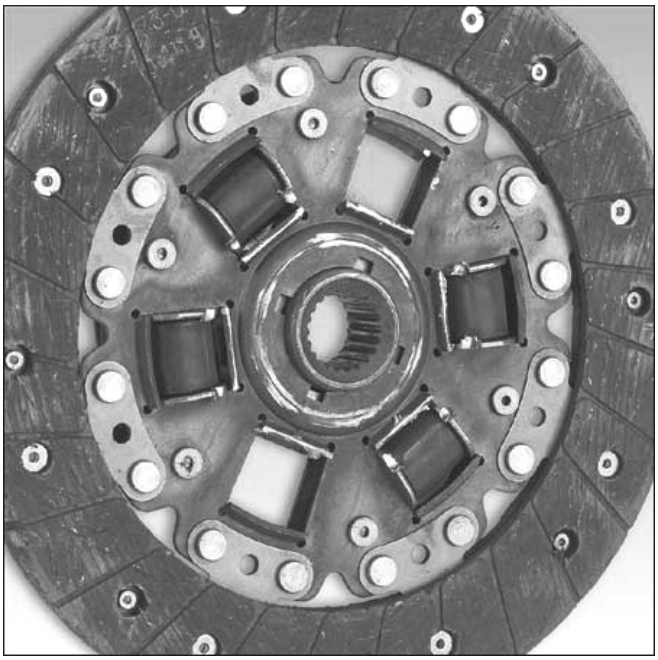


Figure 130 Flywheel Interference

Related Symptoms: Noise, problems with disengagement.

Cause: Excessive flywheel machining causing the disc to contact the flywheel mounting bolts, installing the disc backwards, failure to maintain proper flywheel step dimensions.

If the flywheel shows signs of extreme overheating and deep scoring, replace it.

Hard Pedal

A hard pedal condition is often caused by sticking, binding or improperly lubricated release system components. Something in the release system is restricting movement and increasing the pedal effort needed to release the clutch. Inspect the release system for a binding fork or release bearing. In a mechanical release system, inspect all of the linkages for binding. It may be helpful to disconnect components and test them individually to locate the worn or damaged component.

The cause of a hard pedal in the clutch system can be external or internal to the transmission bellhousing. A hard pedal may be caused by external components from the following sources:

- Binding cross shaft due to worn bushings or incorrect lubrication
- Bent fork
- Worn pedal bushings
- Blockage or worn seals in the hydraulic system
- Worn pivot ball

Internal components that may cause a hard pedal condition may come from the following sources:

- Worn, damaged or improperly lubricated bearing retainer
- Worn or damaged fork

Soft Pedal

A soft- or no-pedal condition on a hydraulic clutch apply system is typically caused by a leak or air pocket. When diagnosing a soft pedal, start by checking the clutch fluid level. If it is low, top off the reservoir and check for leaks while an assistant pumps the clutch pedal. If there are no signs of leaks, you may need to bleed the system. Refer to the Service Information for bleed procedures.

Clutch Testing

Drive the vehicle at normal speeds. Shift the transmission through all gear ranges and observe clutch action. If the clutch chatters, grabs, slips or does not release properly, remove and inspect the clutch components.

Clutch Contamination

Fluid contamination is a frequent cause of clutch malfunctions. Oil, water or clutch fluid on the clutch disc and pressure plate surfaces cause chatter, slip or grab. Inspect components for oil, hydraulic fluid or water/road splash contamination.

Improper Clutch Release or Engagement

Clutch release or engagement concerns are caused by worn or damaged clutch components. A visual inspection of the release components usually reveals the failed part.

Release concerns can result in hard shifting and noise. Look for leaks at the clutch cylinders and lines. Check for loose slave cylinder bolts, a loose or worn release fork, pivot stud, clutch disc, pressure plate or release bearing.

Engagement concerns can result in slip, chatter, shudder and noisy operation. Causes may be contamination, wear distortion or flywheel damage.

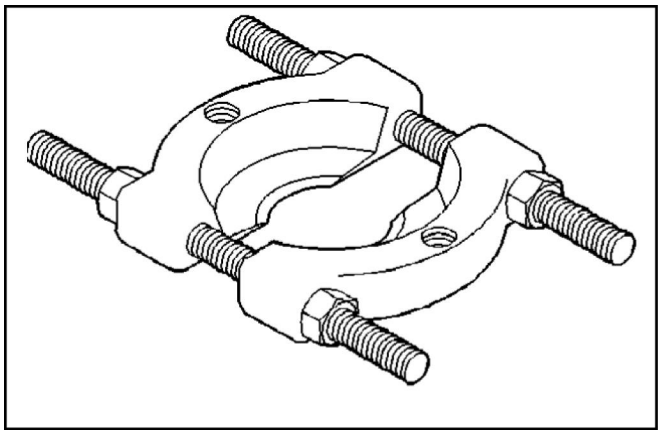
Clutch Alignment

Clutch components must be in proper alignment with the crankshaft and transmission input shaft. Misalignment caused by excessive runout or warpage of any clutch component causes grab, chatter and improper clutch release.

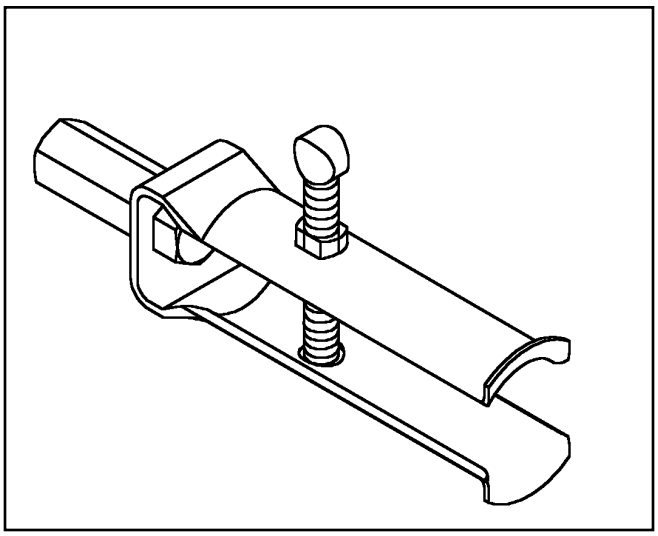
Notes:

SPECIAL TOOLS

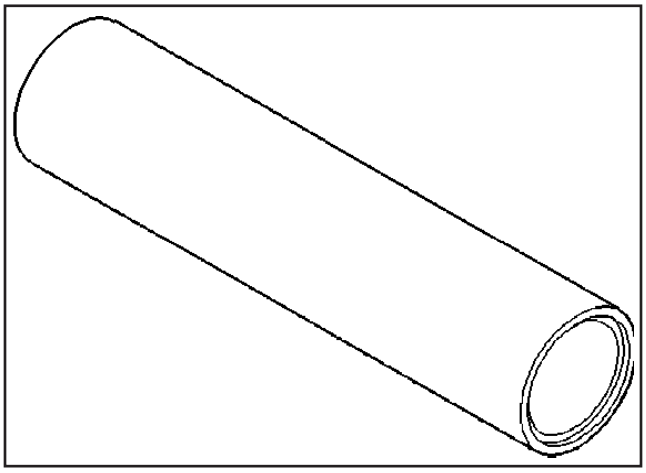
NSG370 SPECIAL TOOLS



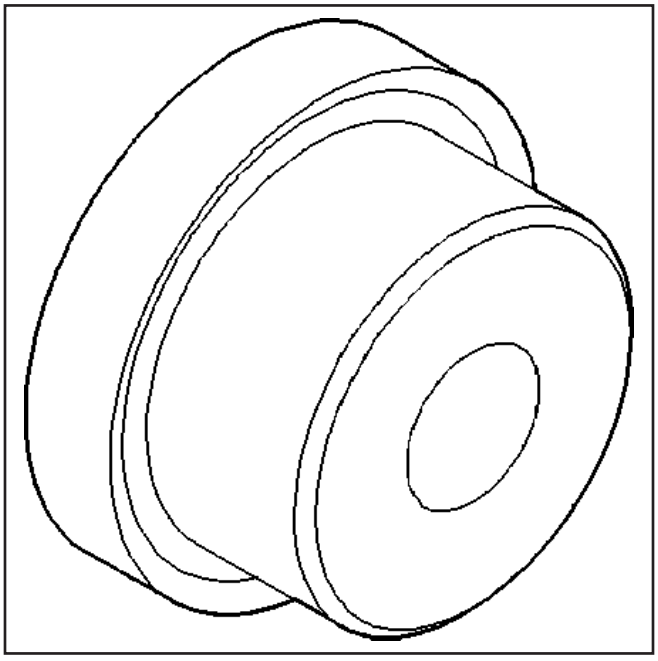
1130 Bearing/Gear Splitter



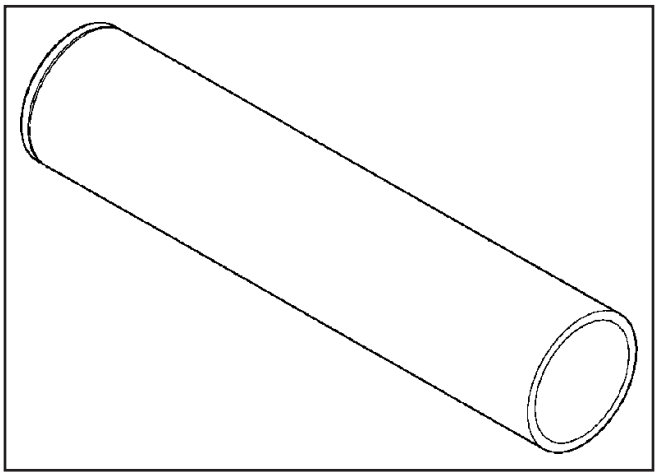
7794-A Seal Remover



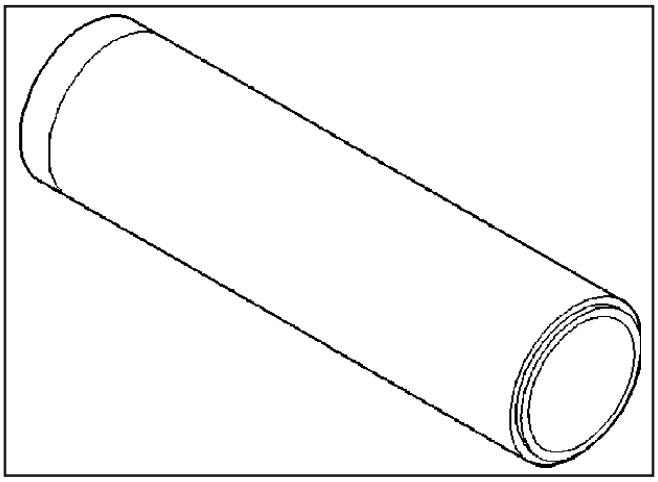
6448-A Bearing Cone Installer



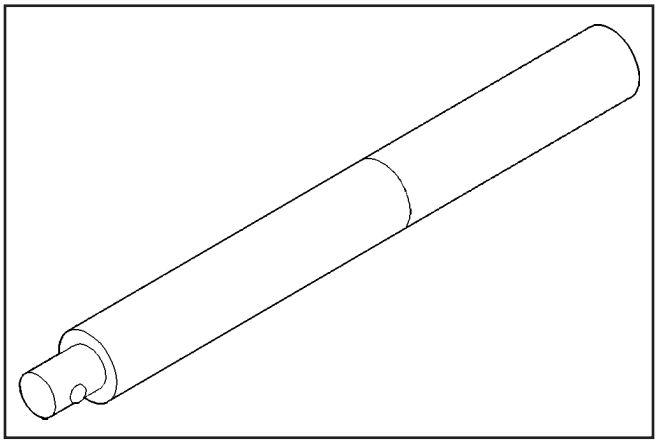
7829-A Bearing Remover



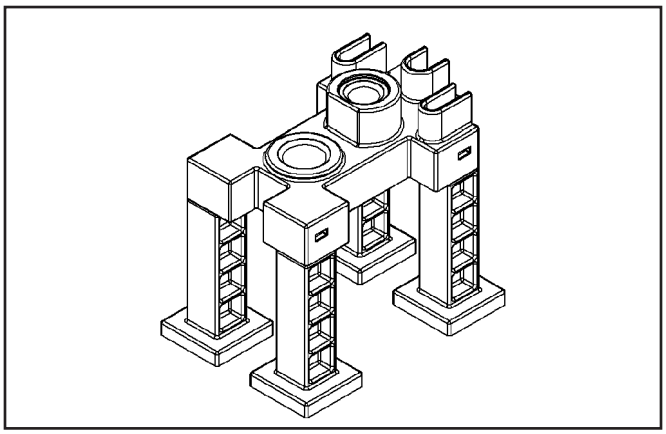
8228 Bearing Installer



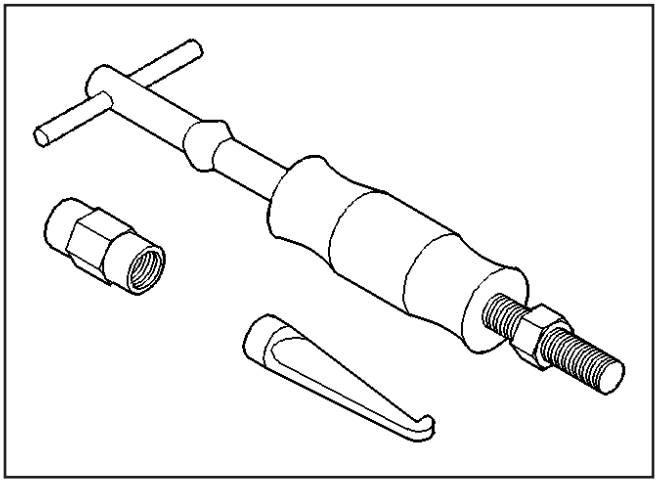
W-262 Bearing Installer



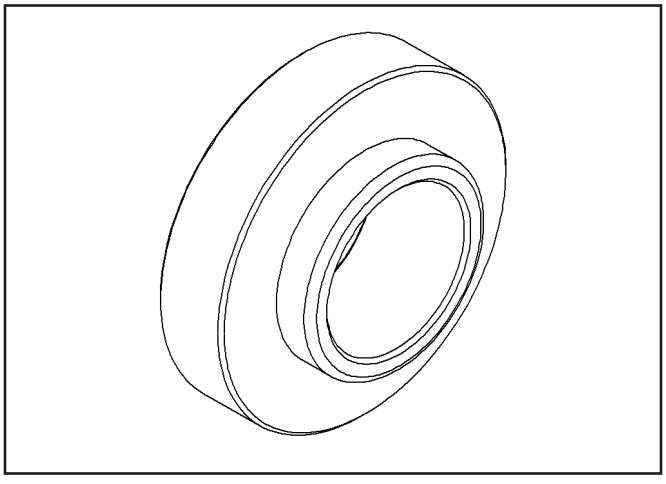
C-4171 Drive Handle



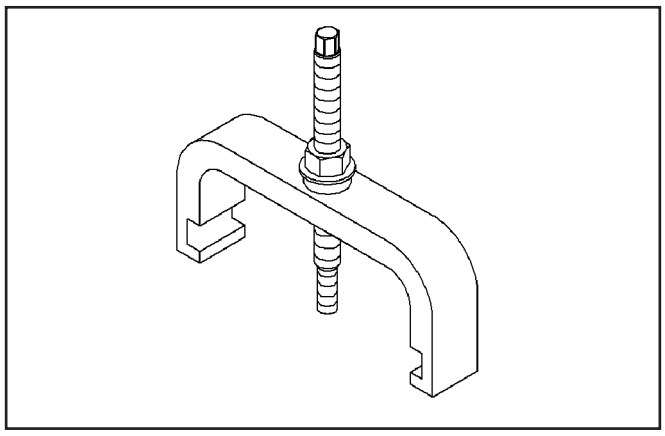
9633 Build Fixture



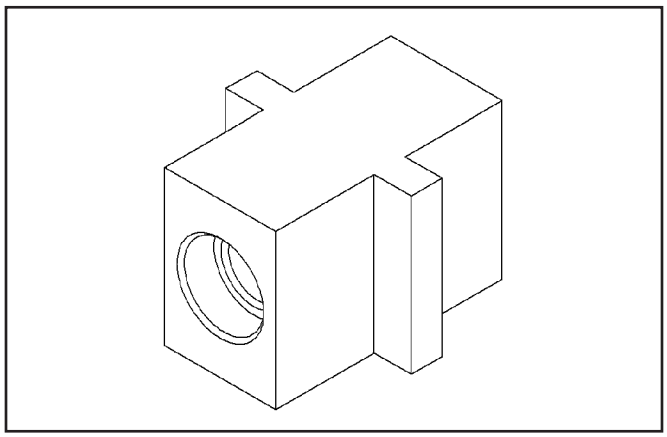
C-637 Slide Hammer



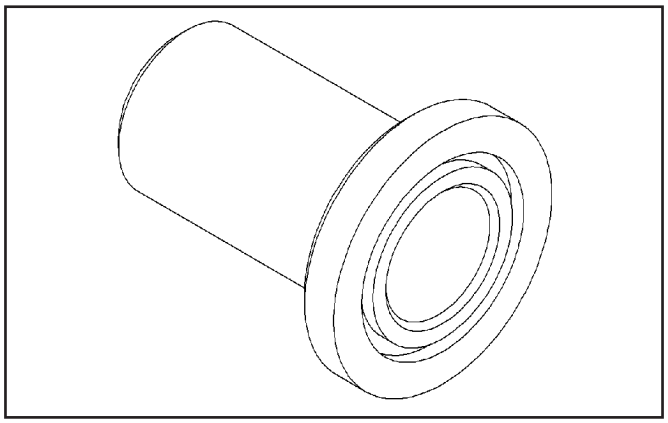
9635 Input/Output 4X2 Shaft
Seal Installer



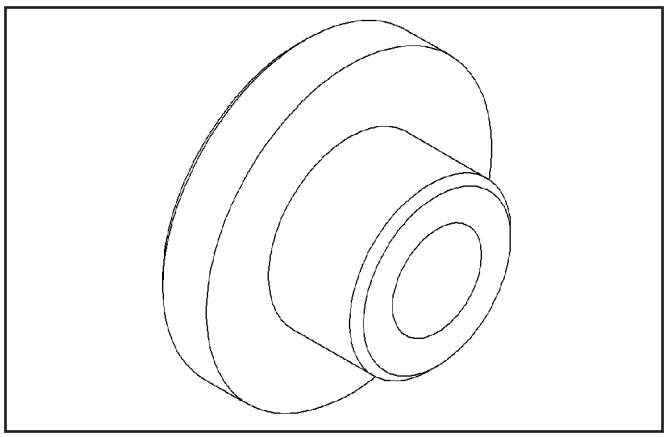
9636 Main Shaft Remover/Installer



9648 Main Shaft Build Fixture

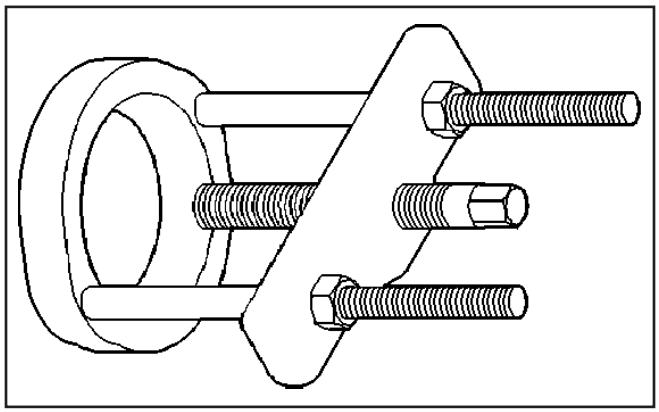


9638 Output Shaft 4X4 Seal Installer

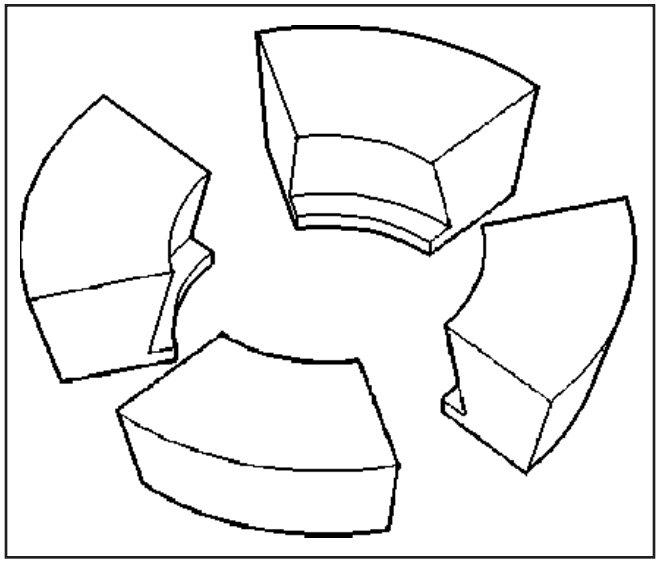


9643 Counter Shaft Bearing Installer

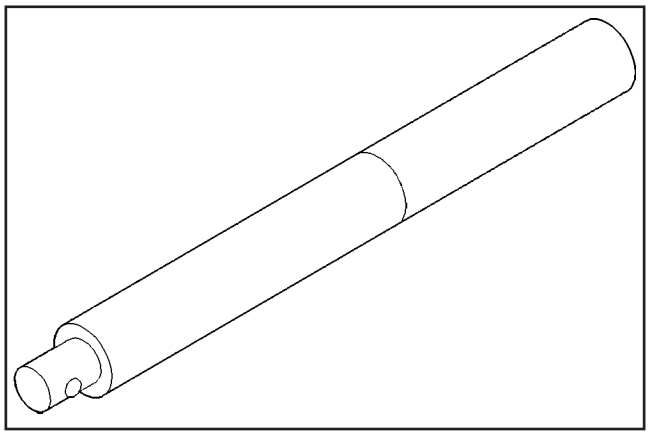
G56 SPECIAL TOOLS



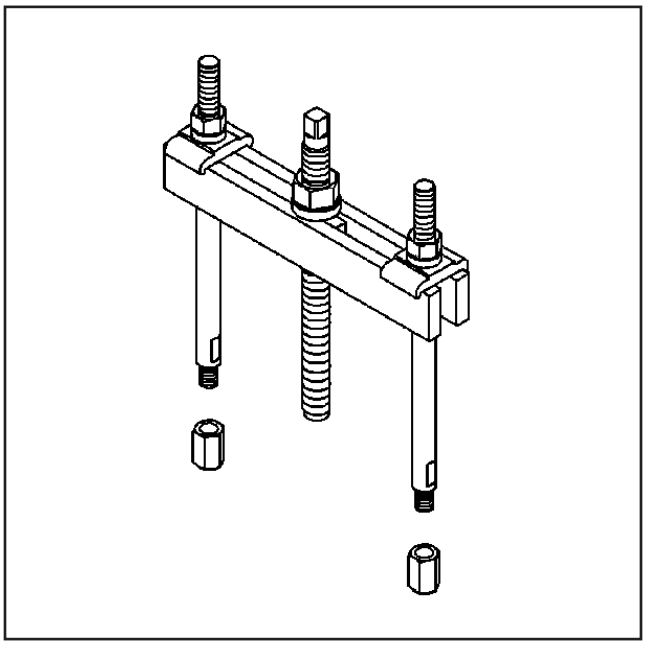
C-293-PA Puller Press



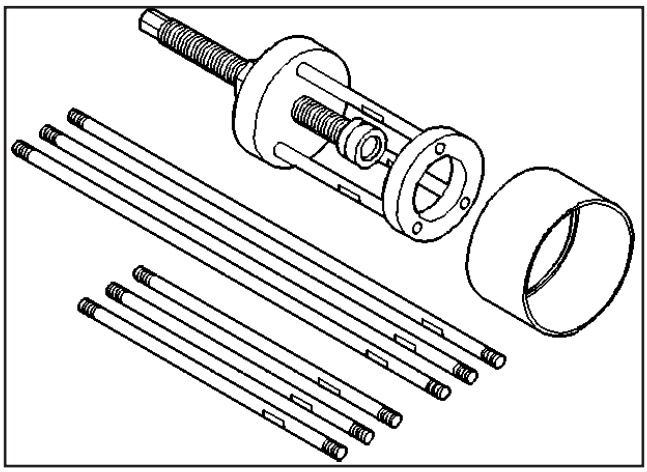
C-293-47 Puller Block Set



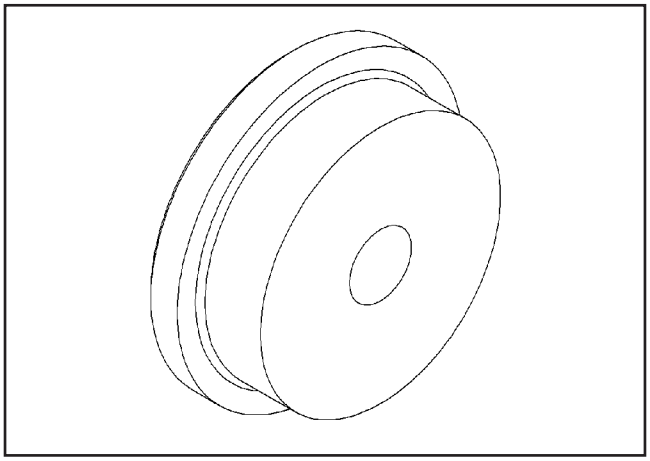
C-4171 Drive Handle



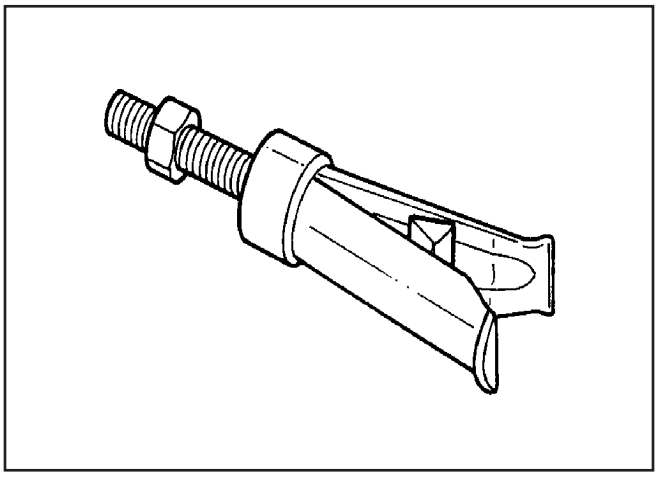
938 Bridge



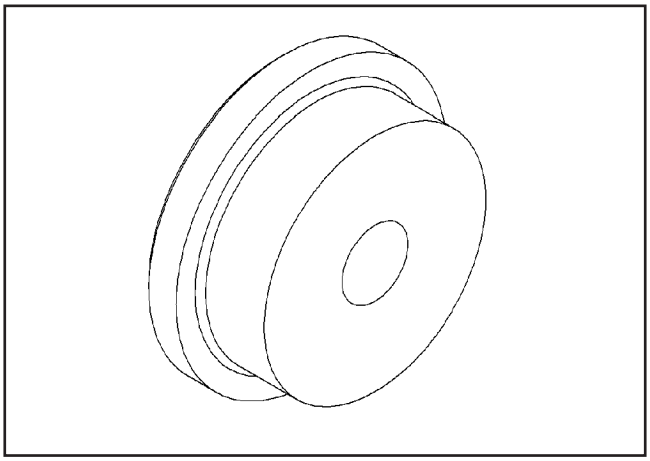
6444 Bearing/Gear Puller



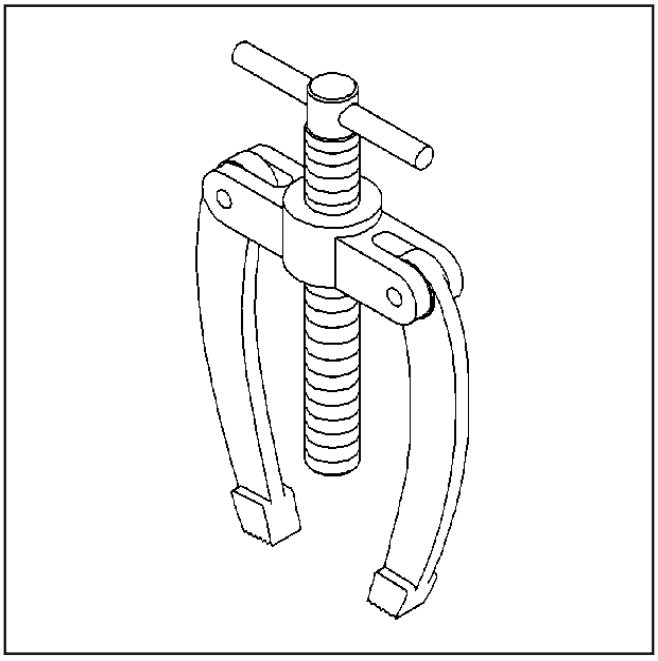
9588 Main Shaft Bearing Cup Installer



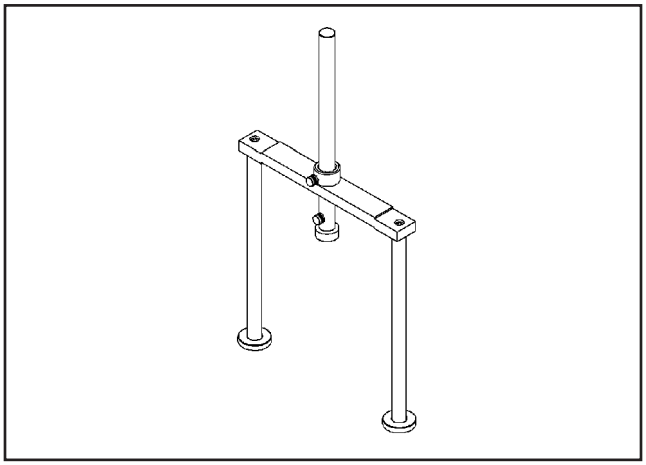
9593 Bearing Cup Remover



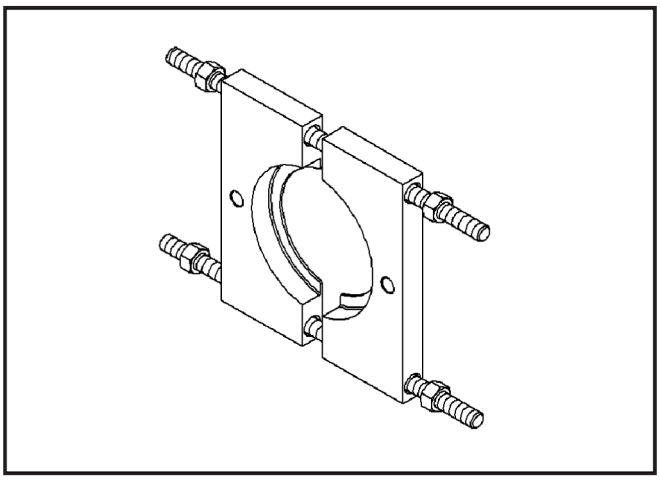
9589 Counter Shaft Bearing
Cup Installer



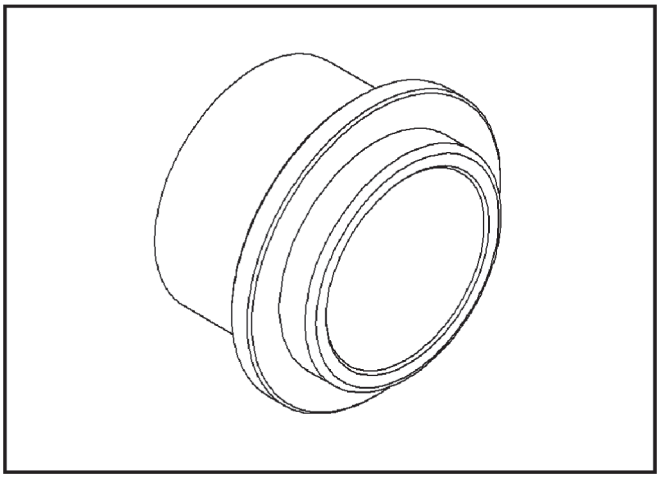
8915 Brace Tool



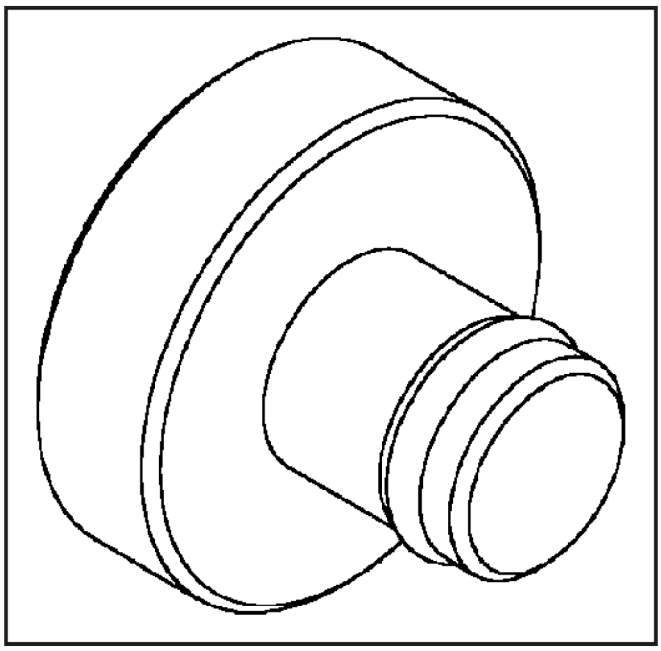
9592 End Play Measurement Fixture



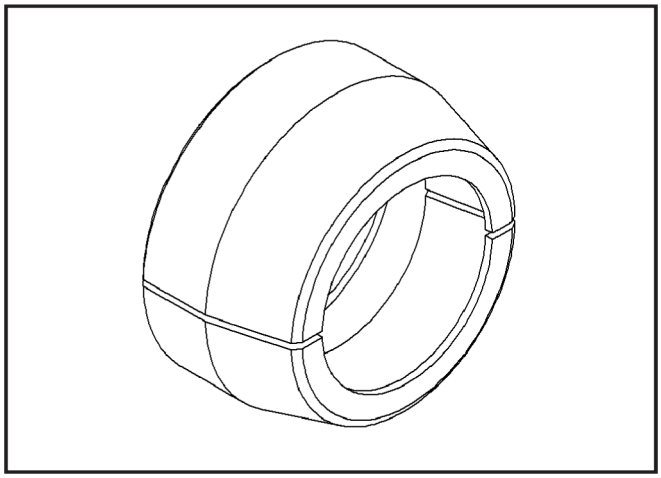
9594 4th Gear/Synchronizer Puller



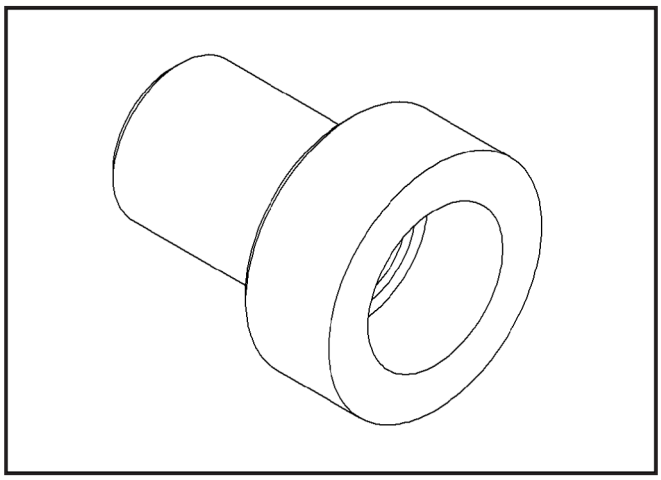
9595 Input Shaft Seal/Output Gas Installer



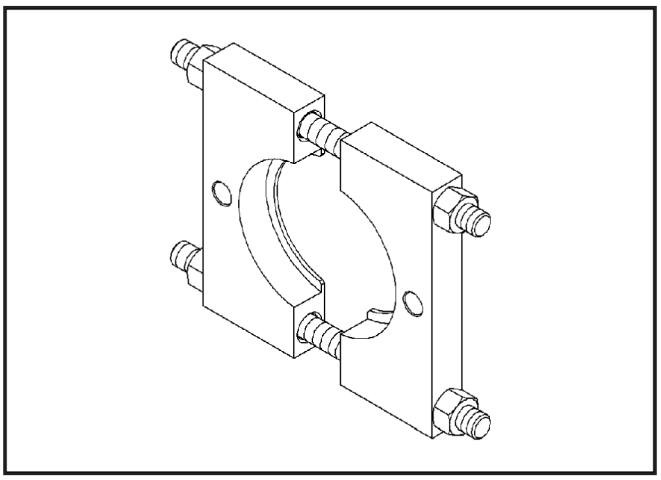
8513A Crank Shaft Insert



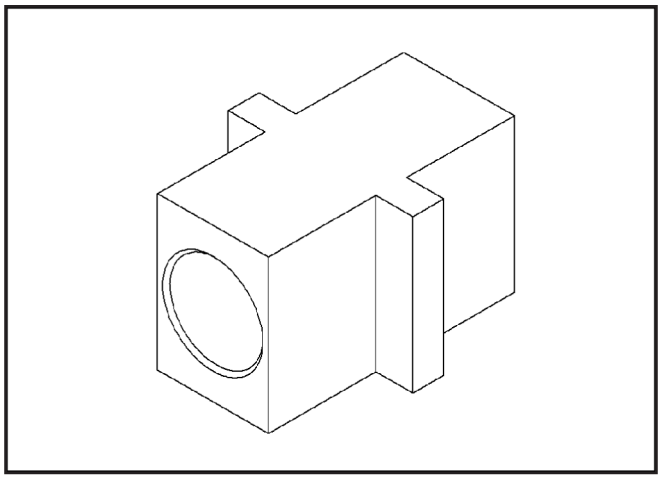
9597 Housing Counter Shaft Bearing Puller



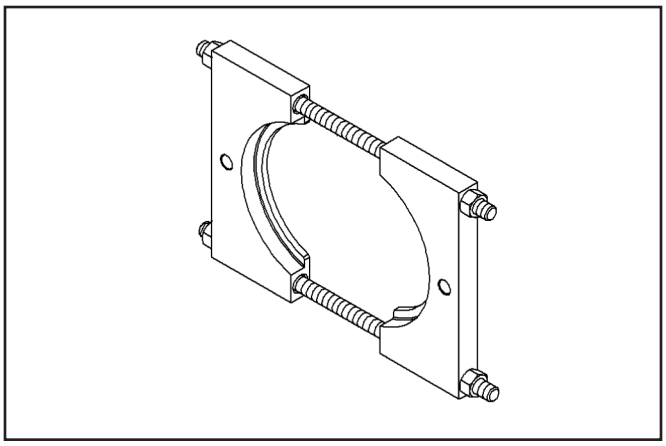
9598 Output Shaft Seal
Installer (Diesel)



9647 Reverse Synchronizer Hub
Puller Plate

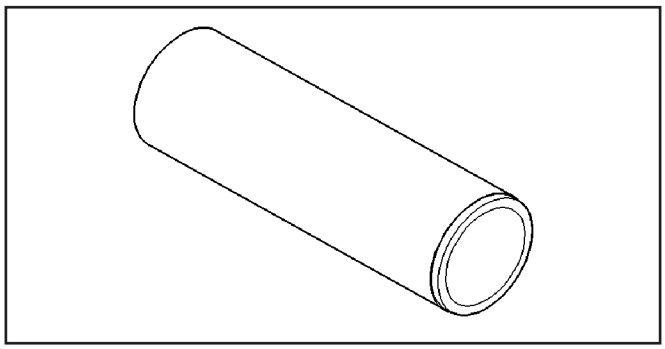


9605 Main Shaft Build Fixture

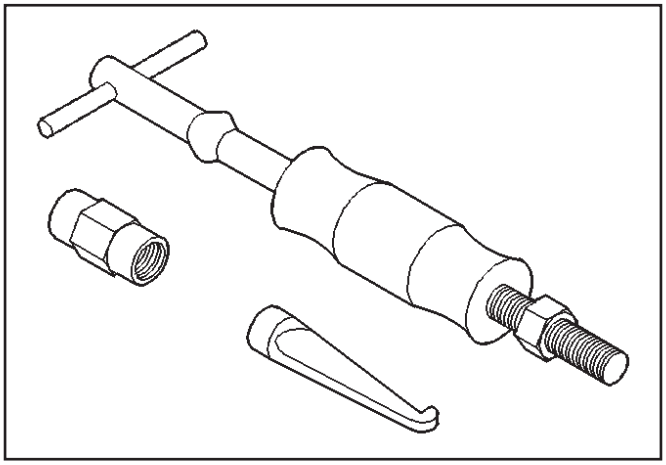


9646 First Gear Puller Plate

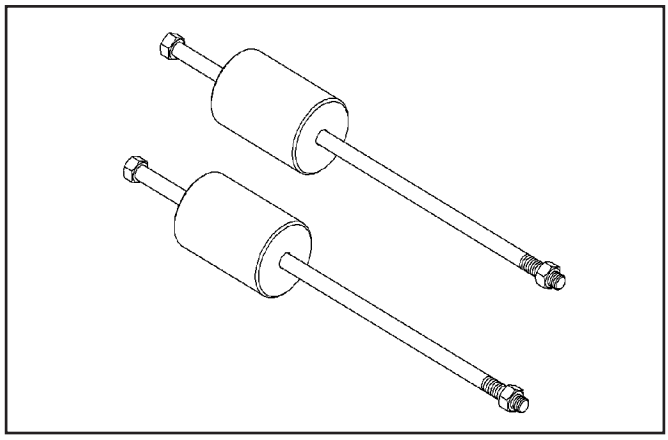
G238 SPECIAL TOOLS



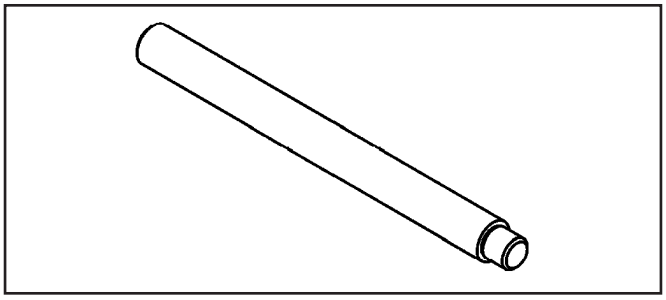
C-3717 Tube



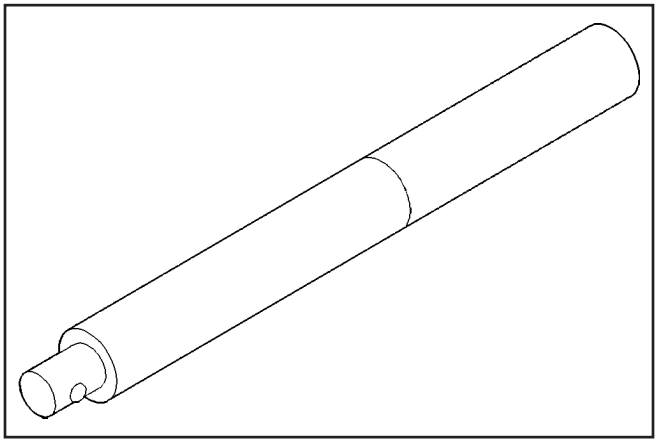
C-637 Slide Hammer



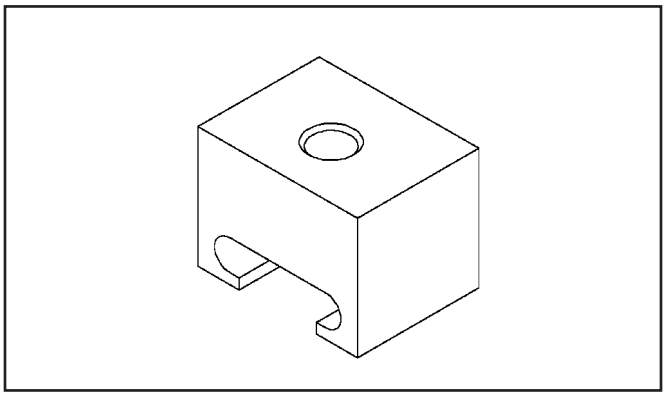
C-3752 Slide Hammer



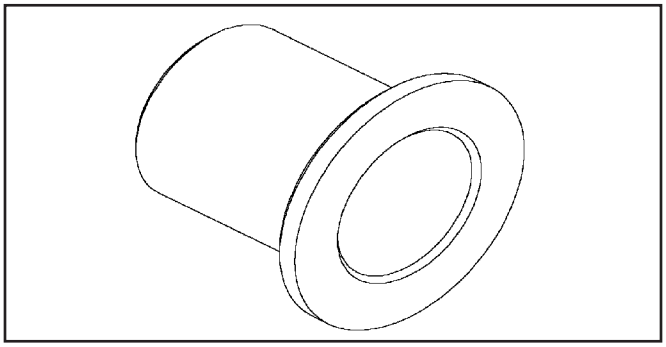
8475 Shift Rail Bearing Installer



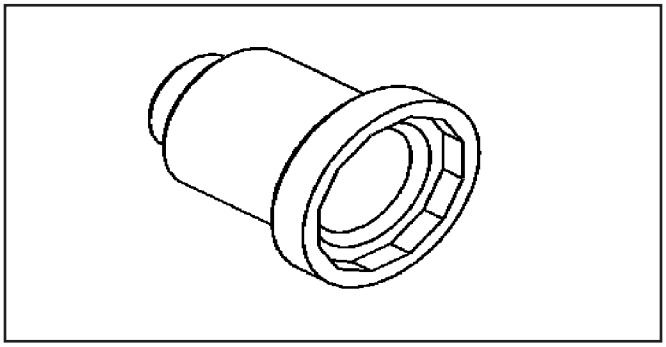
C4171 Handle



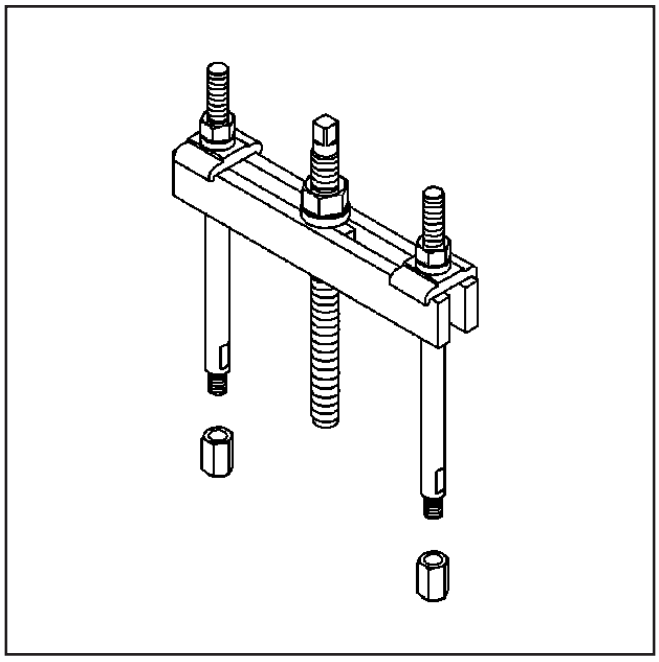
8870 Small Detent Plug Remover



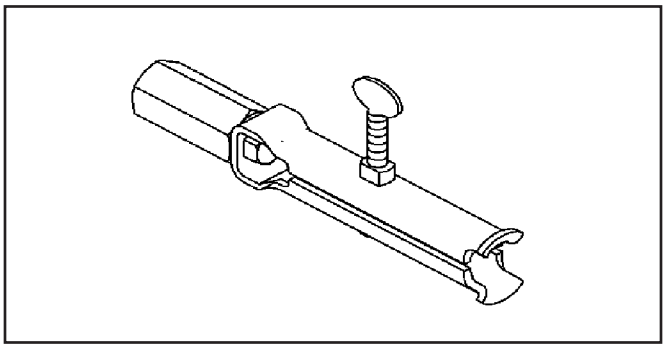
8992 Flange Puller



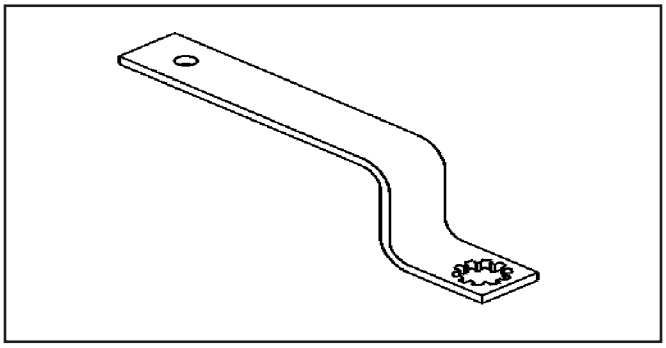
9584 4X4 Output Shaft Socket



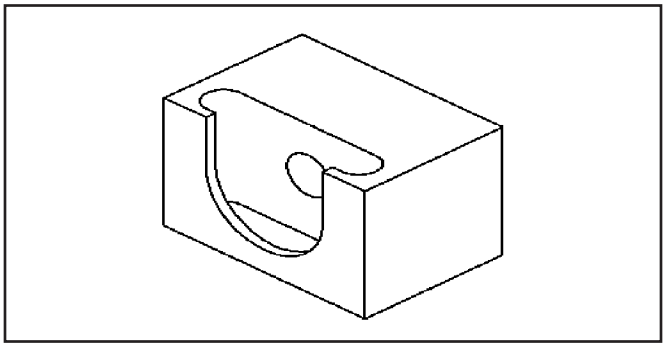
938 Bridge



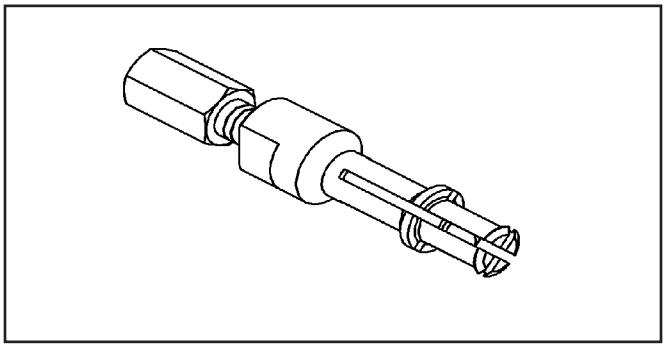
9585 Counter Shaft Rear Bearing Remover



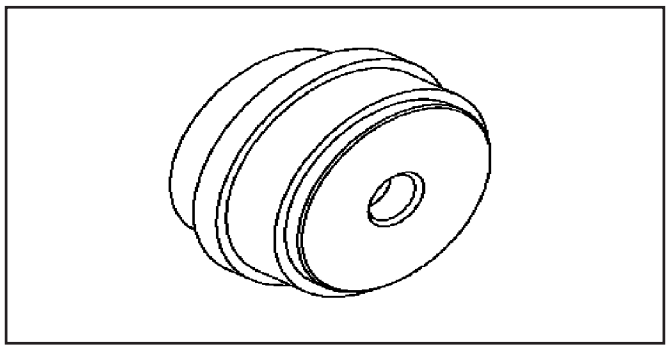
9586 Input Shaft Wrench



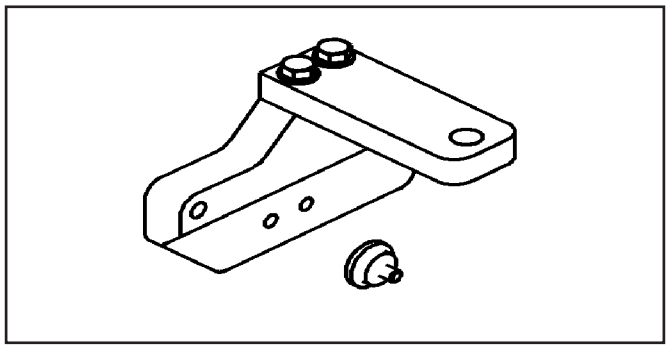
9583 Large Detent Plug Remover



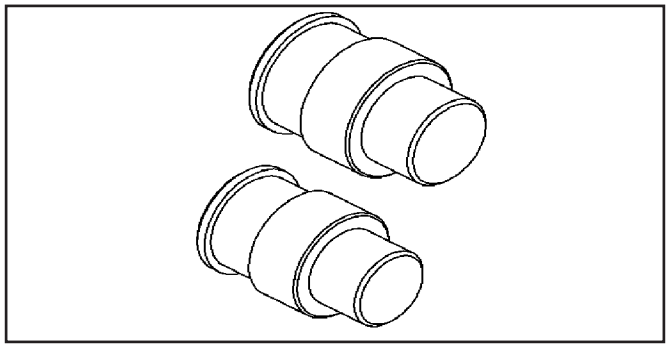
9609 Shift Rail Bearing Remover



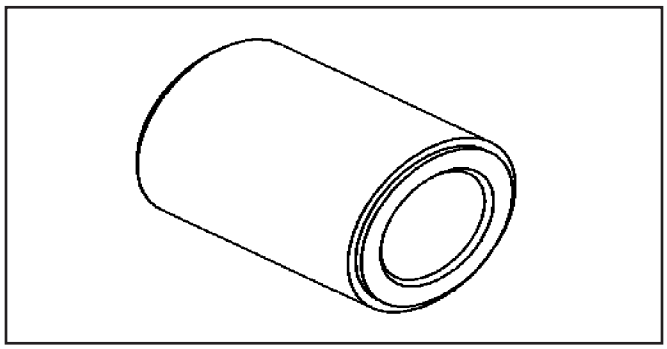
9617 Support Counter Shaft Race Remover/Installer



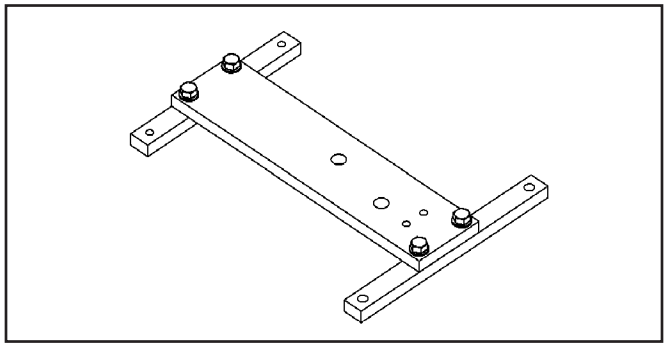
9618 Rear Housing Puller



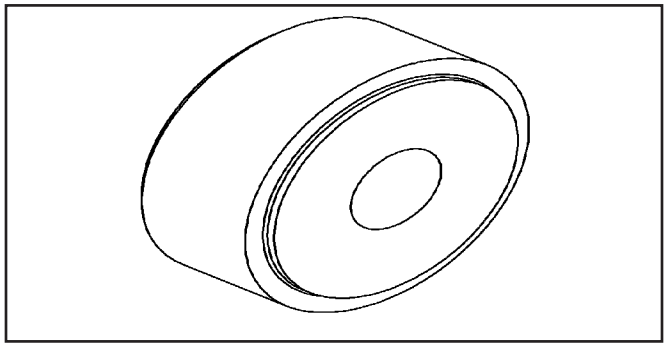
9619 Main Shaft Bearing Heat Plugs



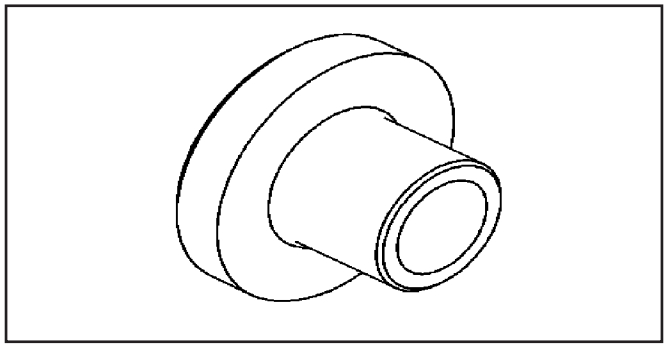
9620 Input Shaft Seal Installer



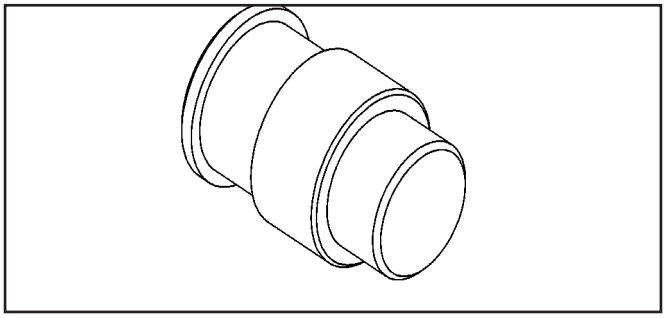
9621 Front Housing Puller



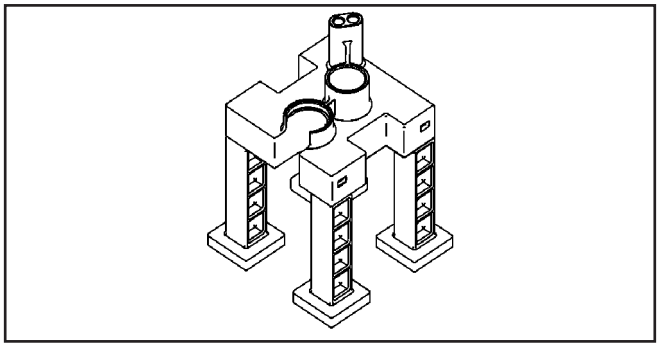
9622 Counter Shaft Plug Installer



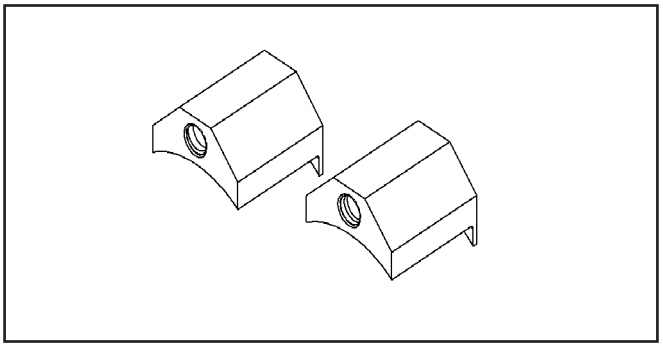
9624 Counter Shaft Rear Bearing Installer



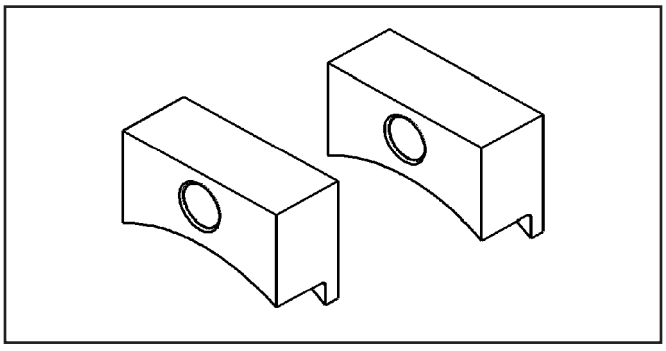
9625 Counter Shaft Heat Plug



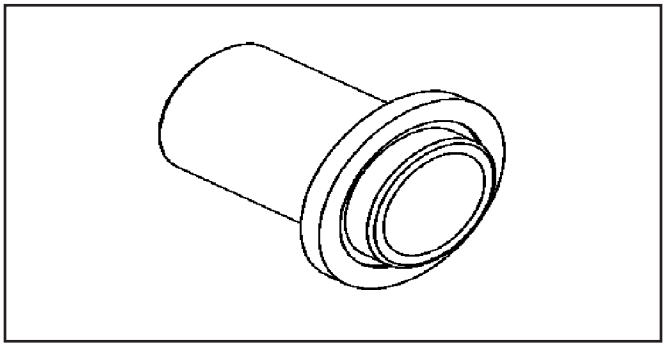
9626 Build Fixture



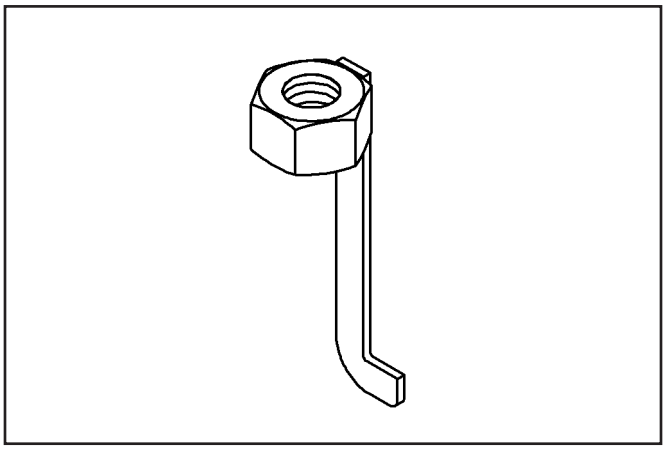
9627 Second Gear Puller



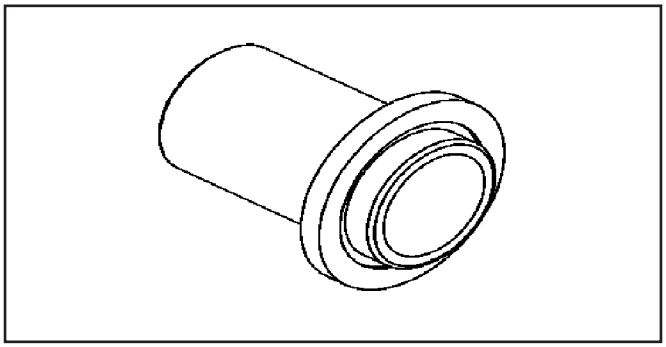
9628 First/Reverse Gear Puller



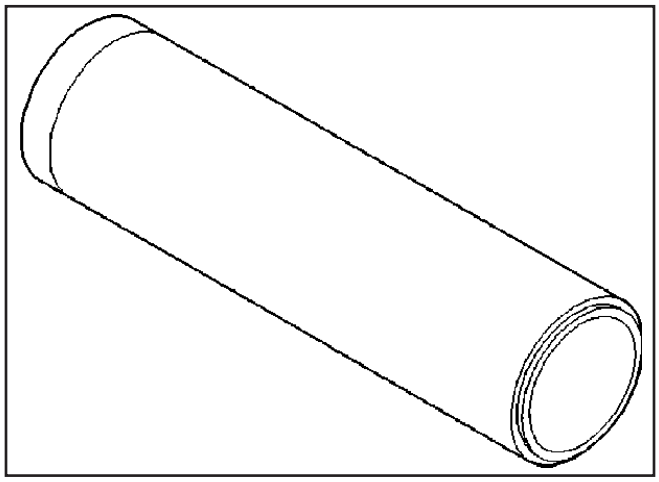
9629 Output Shaft Seal Installer



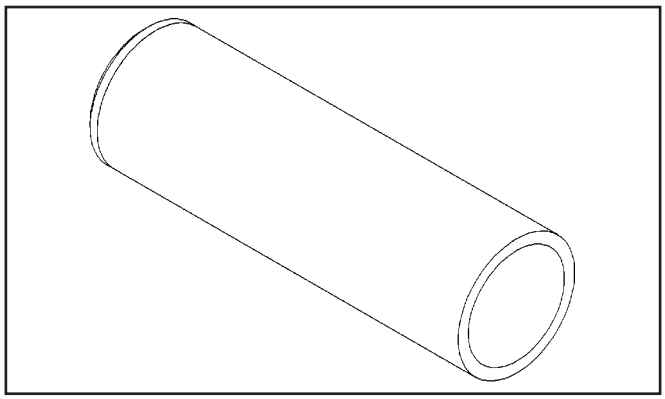
9667 Input Shaft Seal Remover



9668 Support Main Shaft Race Remover/ Installer

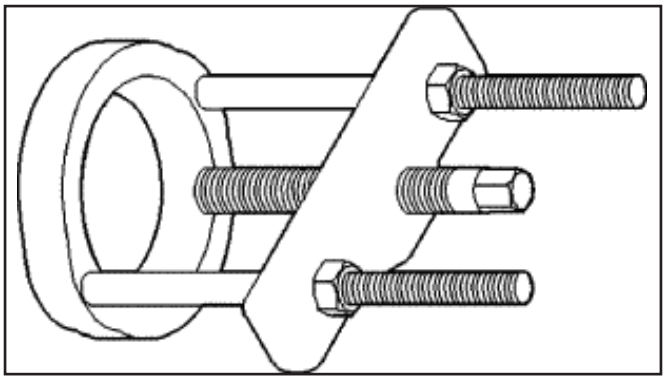


W-262 5/6 Synchronizer Hub Installer

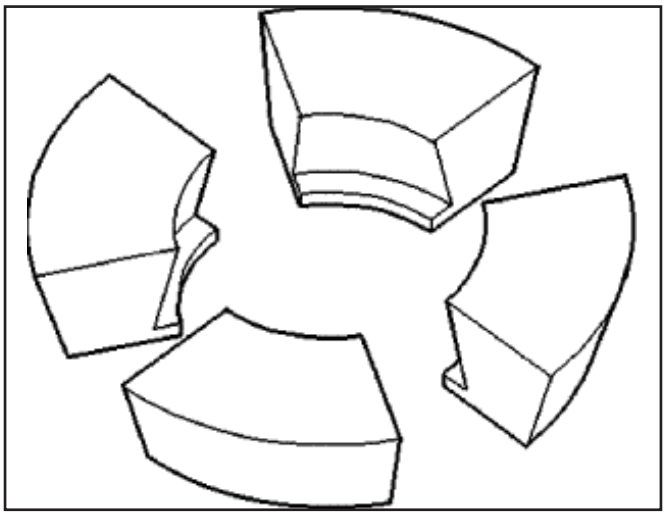


D-389 1/2 Synchronizer Hub Installer

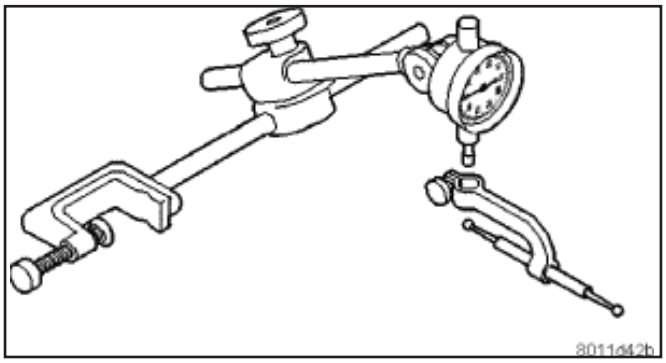
TR6060 SPECIAL TOOLS



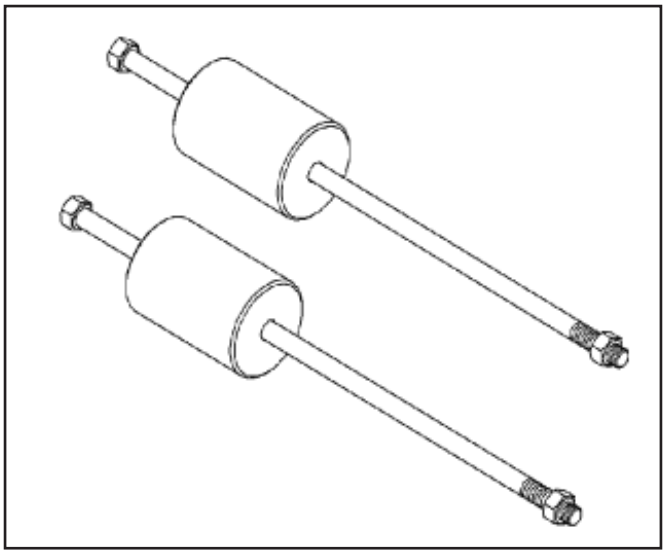
C-293-PA Puller



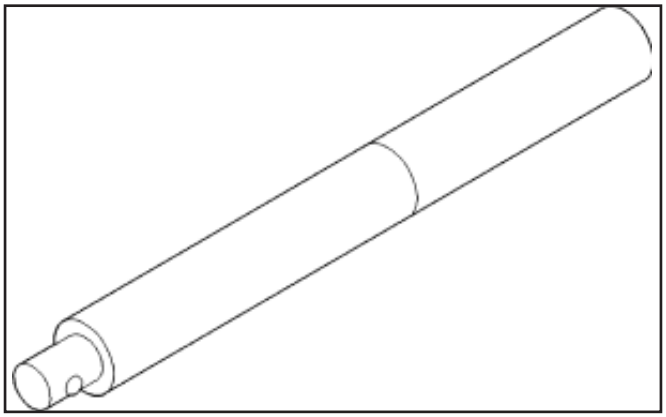
C-293-47 Adapters



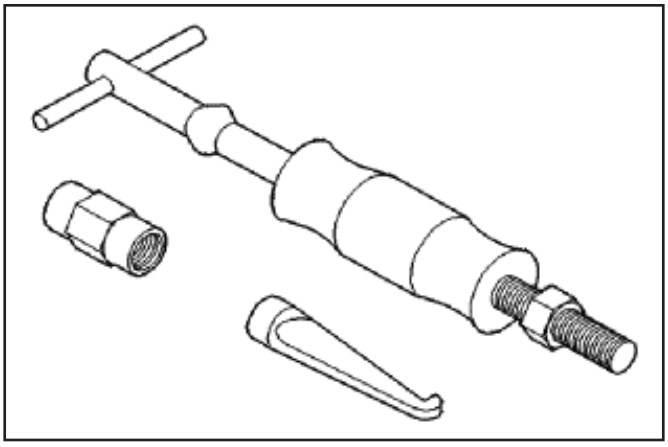
C-3339 Dial Indicator



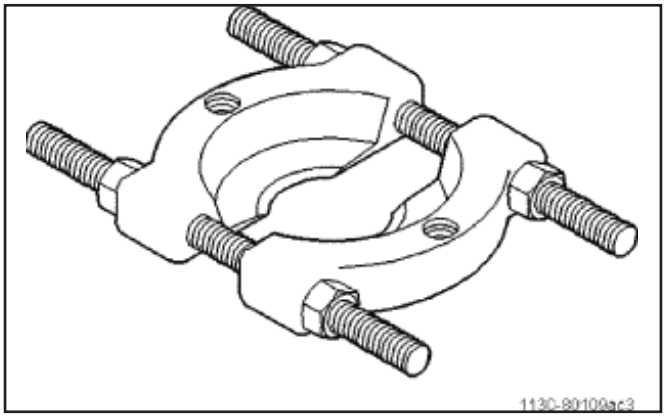
C-3752 Slide Hammer



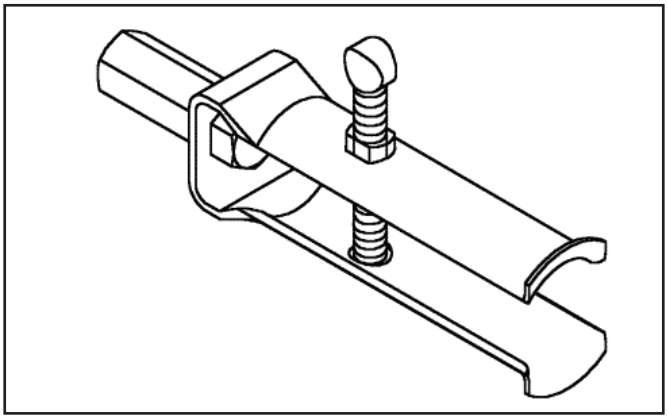
C-4171 Handle



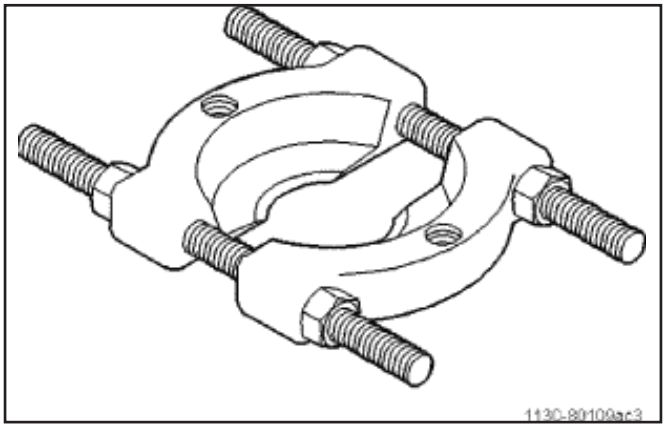
C-637 Slide Hammer



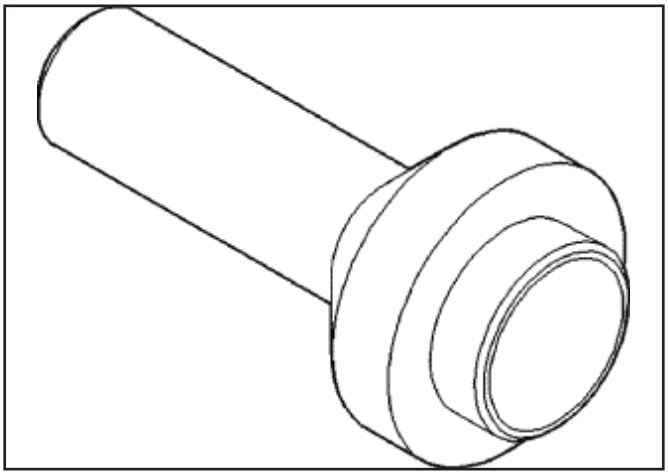
P-334 Splitter



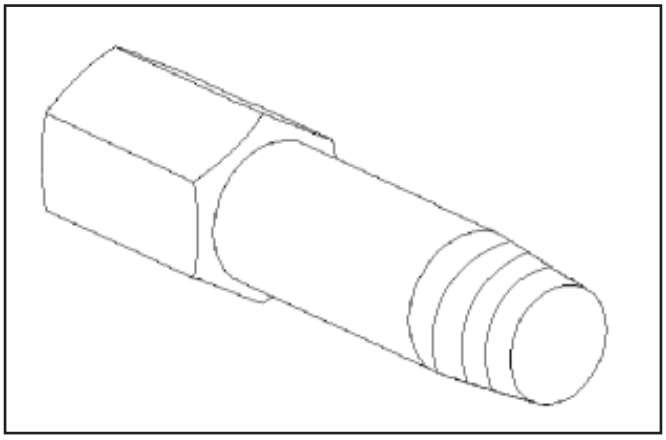
7794-A Remover



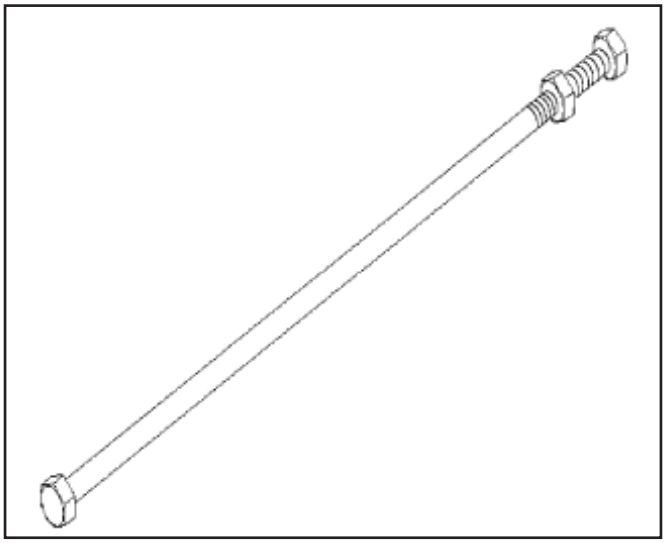
1130 Splitter



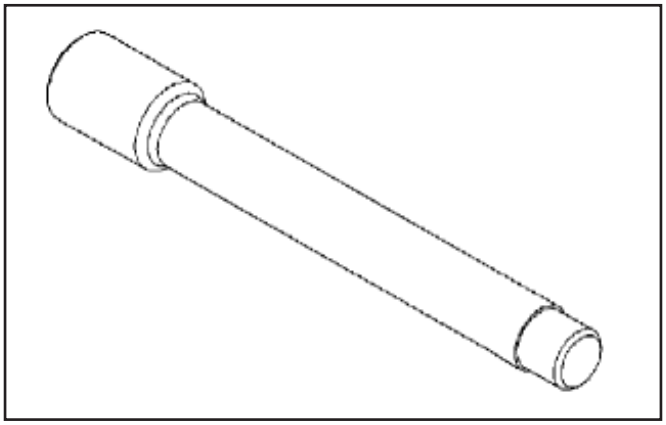
7884 Installer



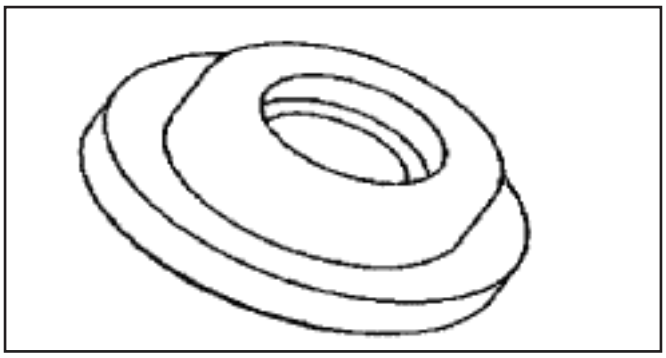
6786 Bushing Remover



8161 Stud



8475 Bushing Installer



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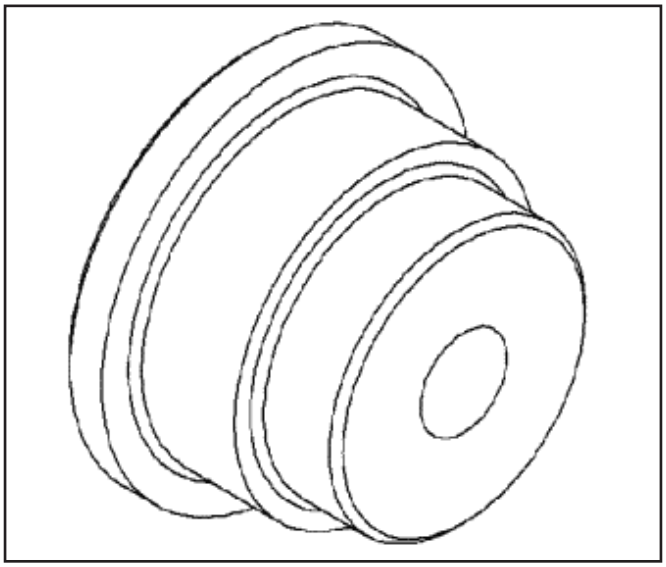
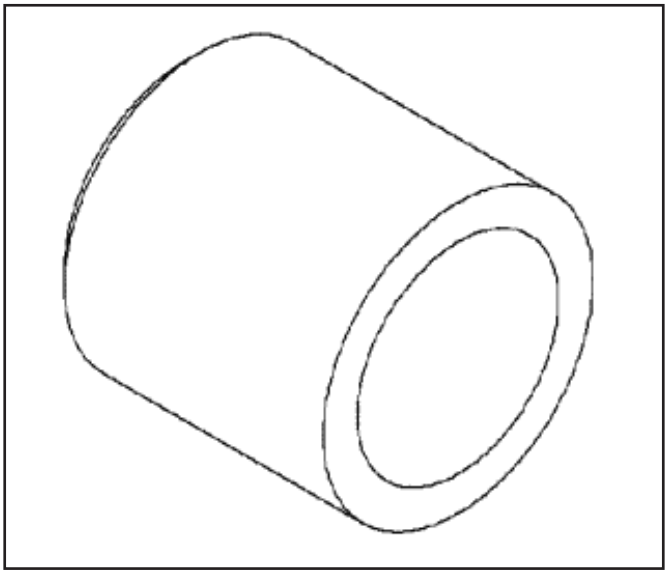
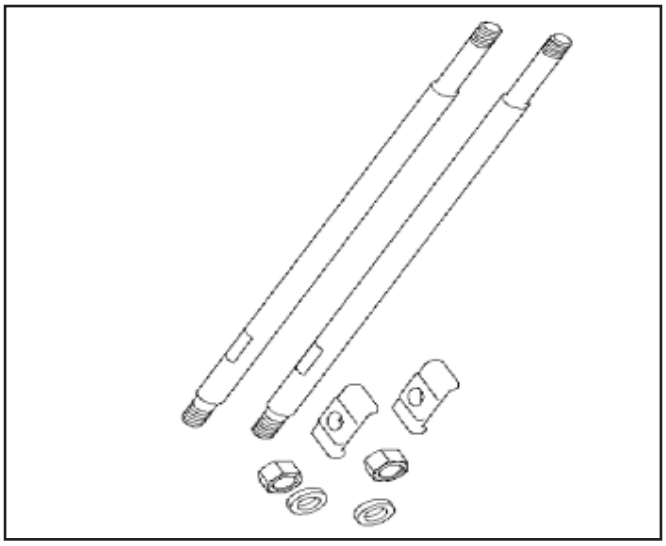


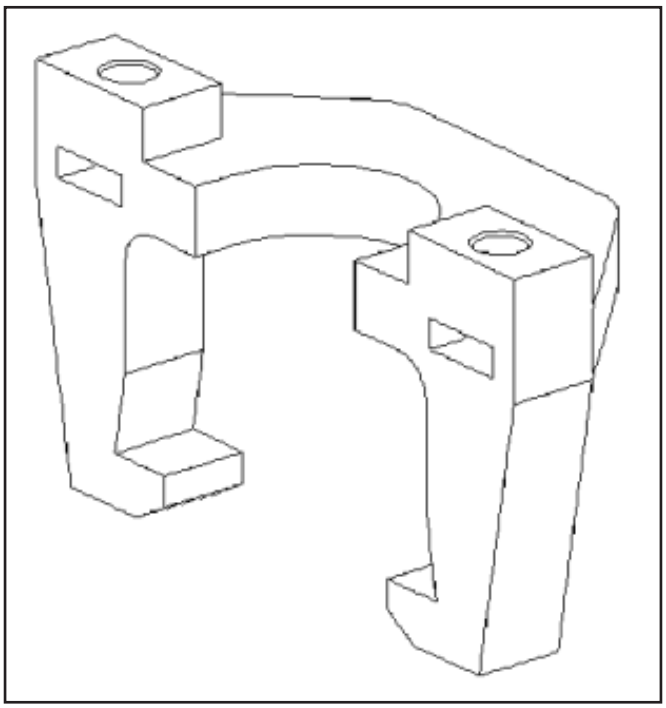
9373 Installer



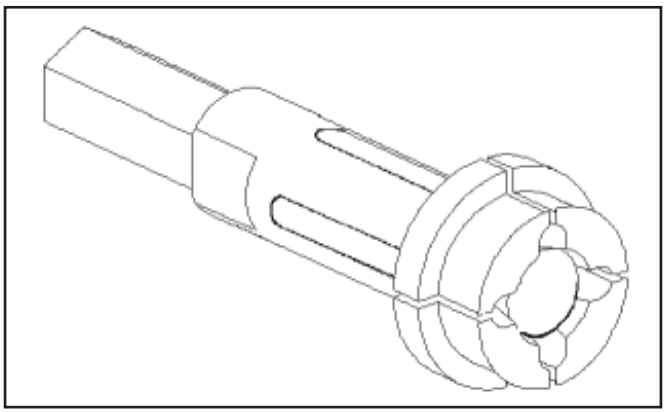
9377 Adapter



9378 Bolts



9379 Remover



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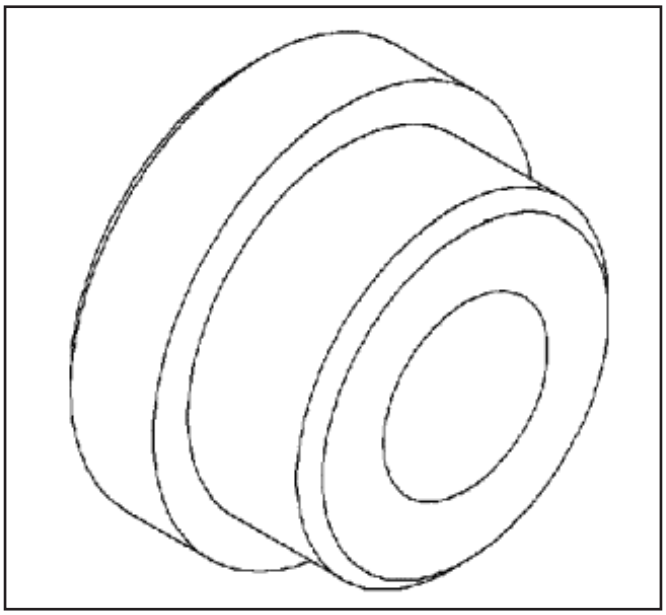
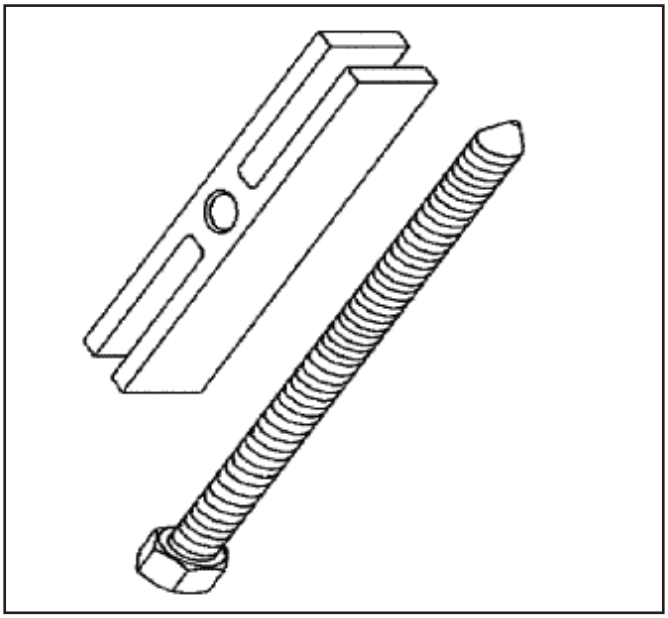


9380 Installer



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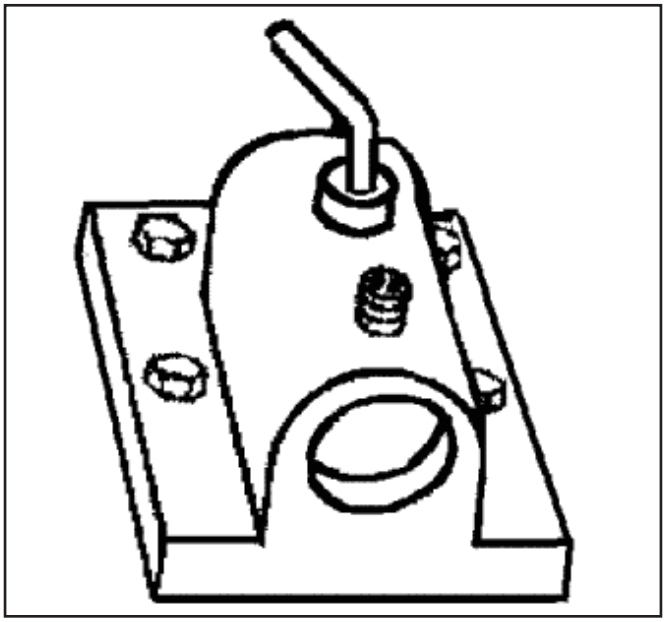
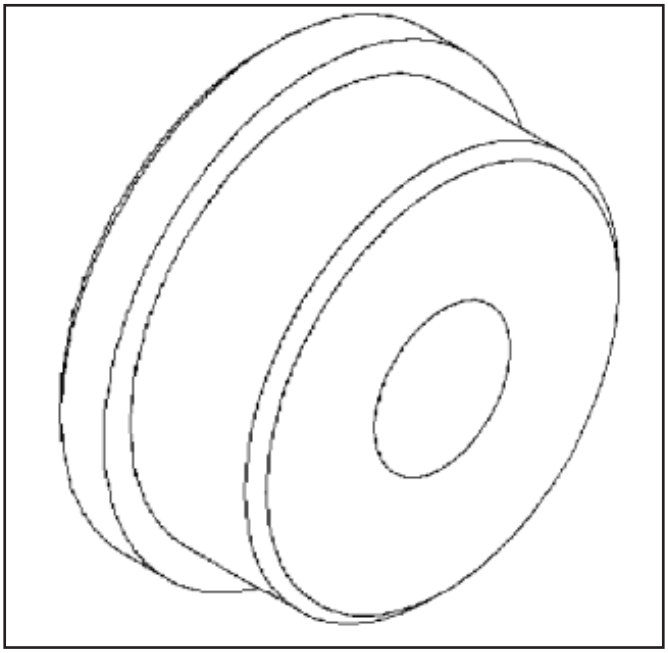
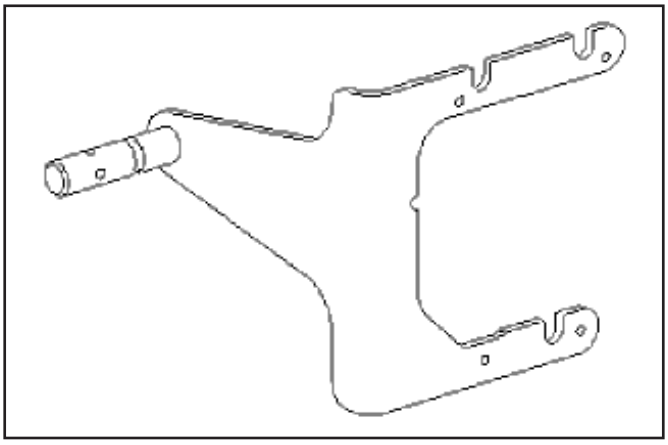


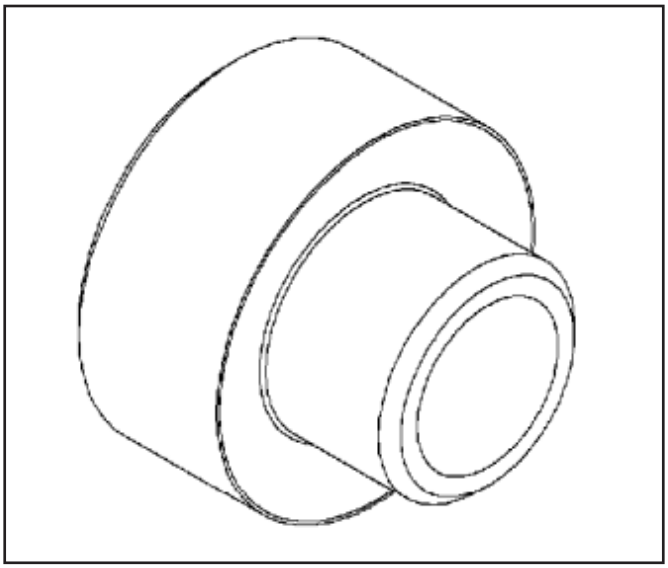
9385 Bench Fixture



9392 Installer



9387 Transmission Fixture



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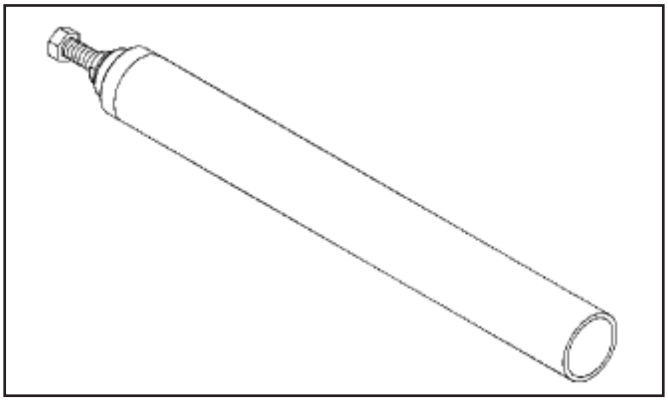

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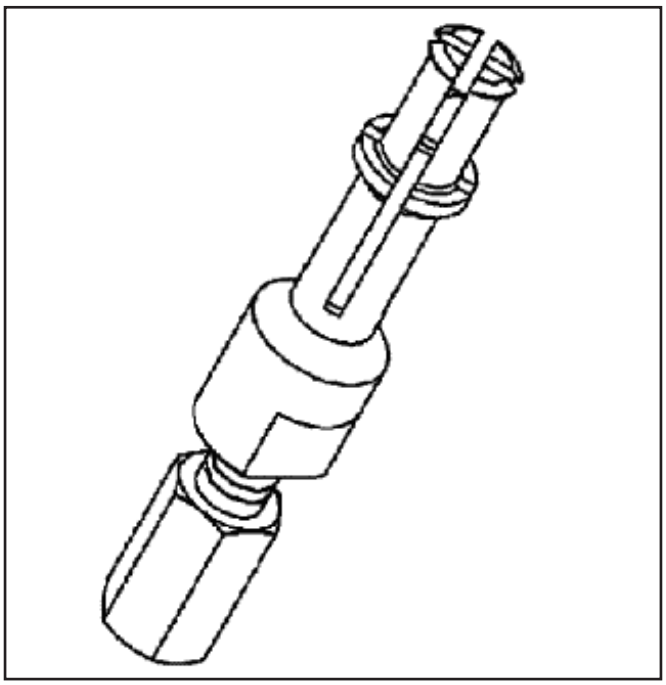
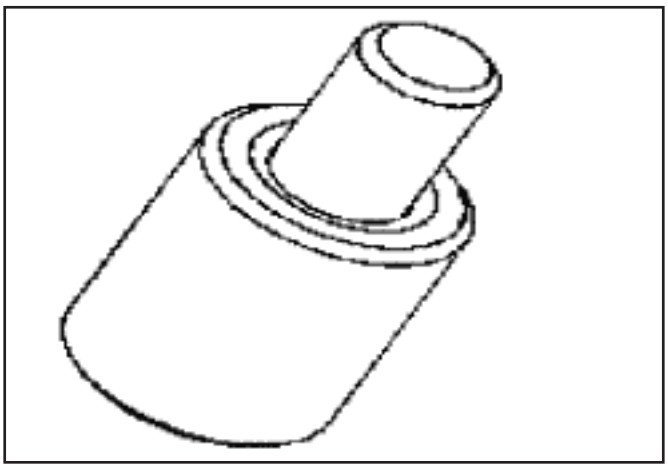
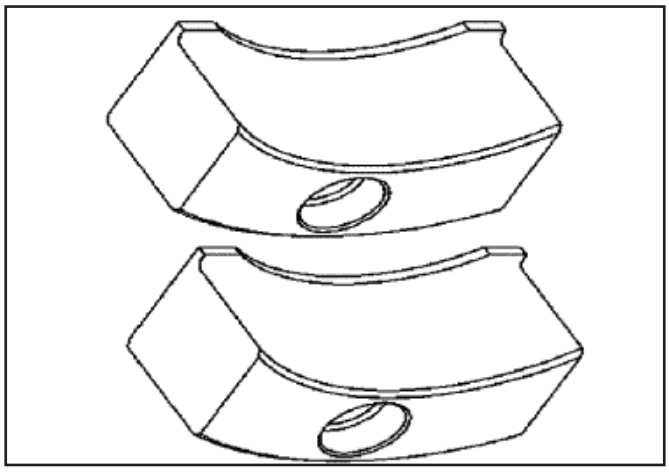


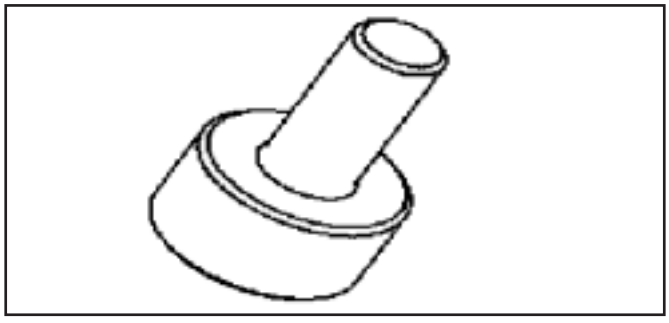
9609 Remover



10028 Installer



10026 Puller



10027 Button

Notes:

Notes:

GLOSSARY

Axle	A shaft that transfers torque to the driving wheels.
Backlash	The clearance between the teeth of two gears, such as ring and pinion.
Bearing Retainer	A device used to hold a bearing in position.
Clutch	A device used to link the engine and powertrain together.
Clutch Chatter	A vibration or shuddering of the clutch during operation.
Clutch Housing	An area between the transmission and the engine where the clutch is installed. Also called the bellhousing.
Clutch/Starter Interlock	A safety device used to prevent starter engagement until the clutch pedal is fully depressed.
Clutch Spin Time	Amount of time required to stop the clutch after it is disengaged.
Constant Mesh	A condition in which gears are always engaged with each other.
Detent	A device that holds a component into a position.
Differential	A set of gears that allows the driving wheels to turn at different speeds while turning.
End Play	The in–and–out movement, or lateral clearance, of an installed shaft.
Facings	A friction material attached to at least one side of a clutch disc.
Final Drive Ratio	The ratio of the differential ring gear to the intermediate or output pinion.
Freewheel	To turn without transferring torque.
Gear	A wheel with teeth that engages another wheel with teeth.
Gear Ratio	The ratio of two meshed gears. To calculate gear ratio, divide the number of teeth on the driven gear by the number of teeth on the driving gear.
Helical Gear	A gear with curved or spiral cut teeth.
Julian Date	A system of recording the date in which each day of the calendar year has a number assigned to it. For example, January 1 is '001' on the Julian calendar. December 31 is '365' in a non leap-year, or '366' in a leap-year.
Overall Top Gear Ratio	The top gear (5th gear) ratio multiplied by the final drive ratio.
Preload	An amount of force present on a bearing at all times.
Roller Bearing	A bearing using cylindrical rollers with an inner and outer race.
Speed Gear	The gear which is free-wheeling and locks to the counter- or main-shaft through the synchronizer assembly.
Spline	A raised area on a shaft that engages another component.

Spline Mesh Angle	The angle of the splines on a shaft.
Spur Gear	A gear with straight cut teeth.
Synchronizer	A device used to bring two rotating components to the same speed.
Tapered Roller Bearing	A tapered or coned bearing using long, round rollers between two races.
Thermal Expansion	The expansion and contraction of metal components due to temperature changes.
Torque	A turning force produced by the engine.
Torque Multiplication	Increasing the torque output through the use of gears.

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