PHASE 19
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FUNCTION

In examining the automotive drive line, it would be well to start with a review of drive shaft operation. A critical examination of why it is there and what it must do may be helpful in analyzing its effect on the entire drive line system. A drive shaft's functions can be briefly described as follows:

1. It must transmit torque from the transmission to the axle. This requirement makes it necessary that the drive shaft be capable of transmitting the maximum low gear torque developed by the engine and transmission ratio and any shock loads which may develop. It must also be capable of rotating at the maximum speed required for vehicle operation. This speed is often engine speed increased by an overdrive ratio in the transmission.

2. The drive shaft must operate through constantly changing relative angles between transmission drive shaft and axle.

3. The length of the drive shaft must be capable of changing while transmitting torque. Length changes are caused by necessary axle movement due to torque reaction, road deflections, braking loads, etc.

TYPICAL PARTS IDENTIFICATION

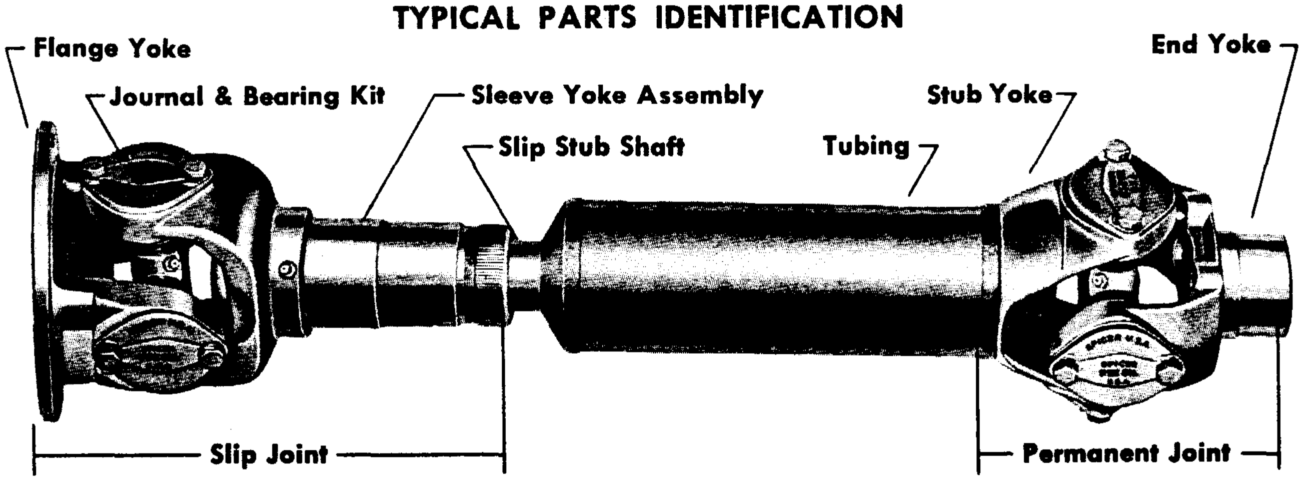


FIGURE 1

COMPONENTS

PERMANENT JOINT

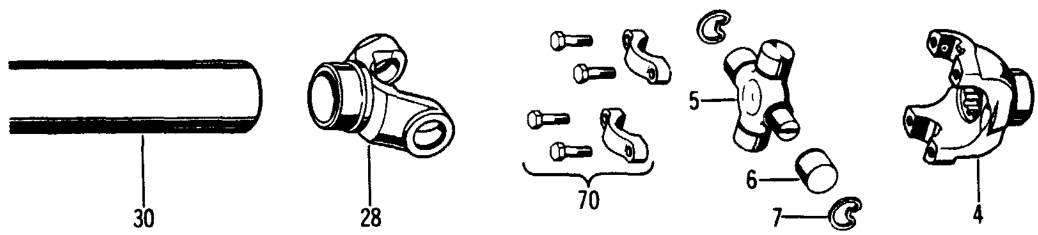


FIGURE 3

CENTER BEARING ASSEMBLY

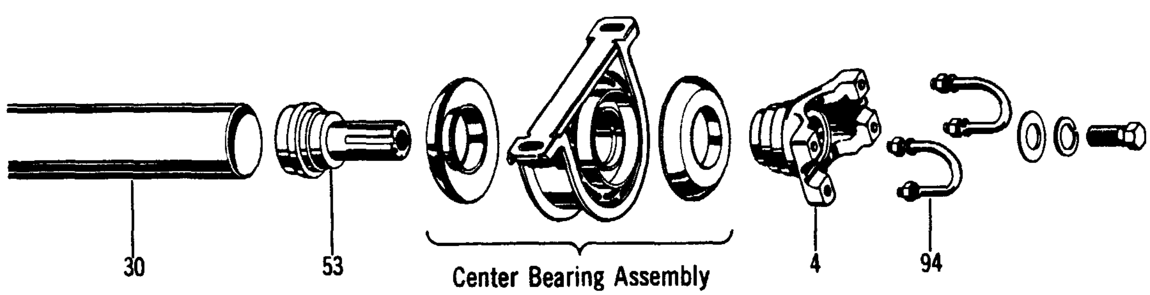


FIGURE 4

SLIP JOINT

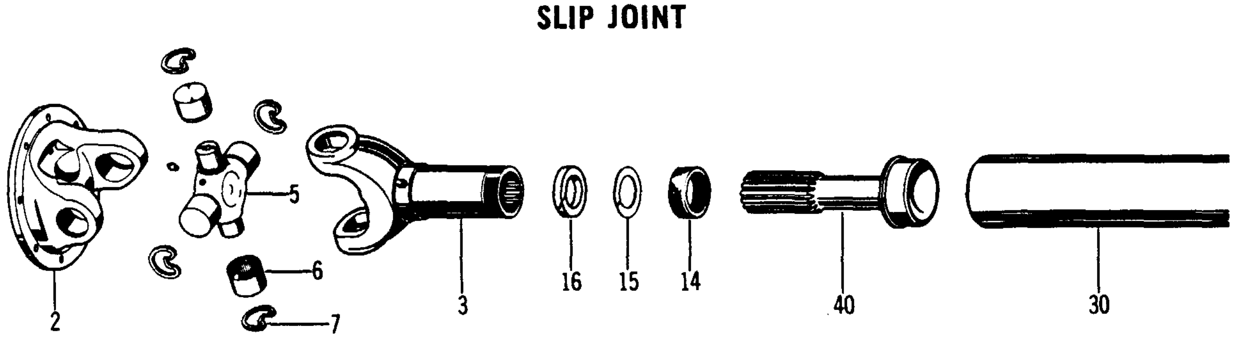
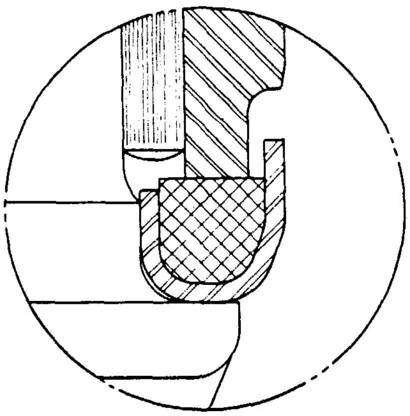
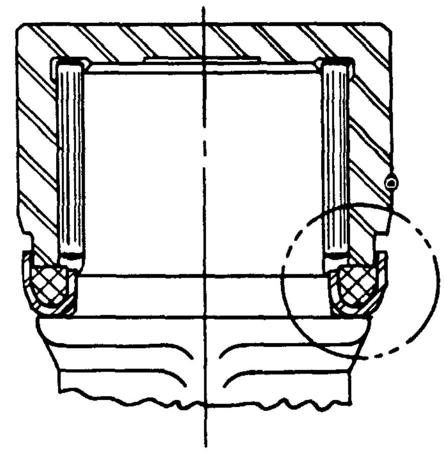


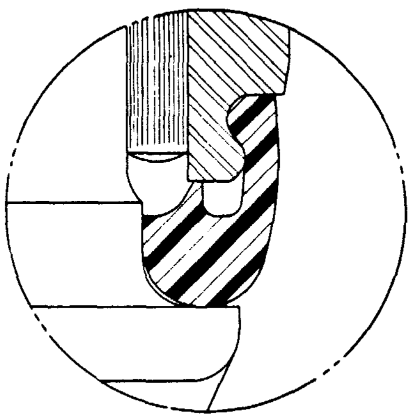
FIGURE 5

UNIVERSAL JOINT SEALS

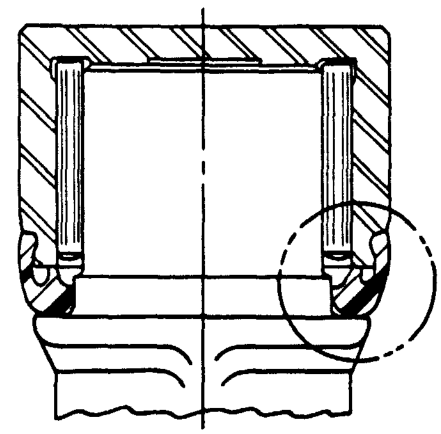


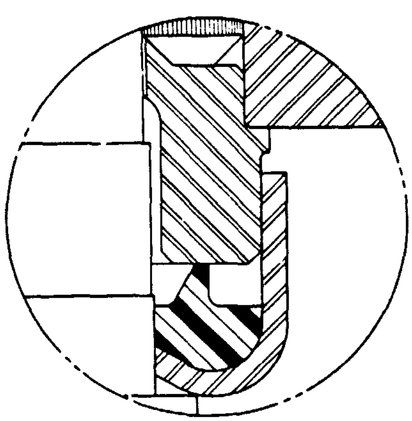
CORK SEAL





RUBBER SEAL





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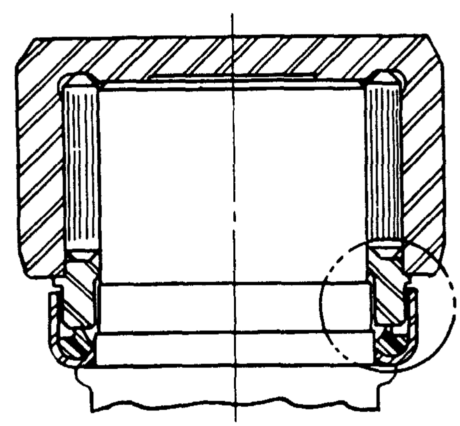
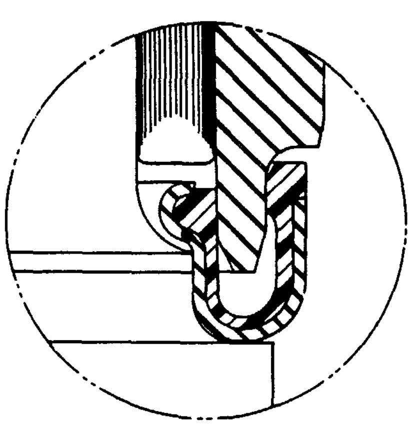
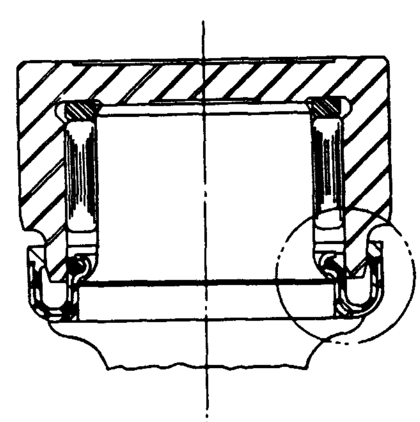




EXTENDED LIFE SEAL



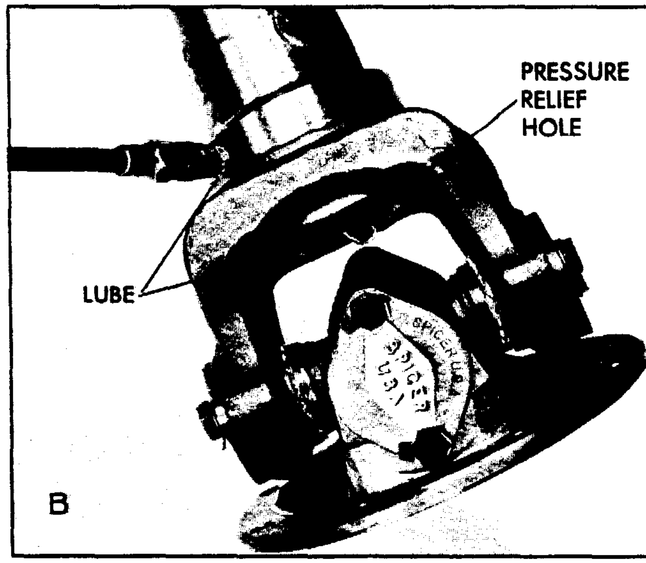
LUBE SPECS

Lubricants

For driveshaft applications involving shaft speeds over 500 RPM, a high quality extreme pressure (EP) grease recommended by lubricant manufacturers for universal joints should be used. Lithium soap base greases meeting *NLGI Grade 1 and Grade 2 specifications are preferred. The use of greases that tend to separate and cake should be avoided.

For driveshaft applications involving shaft speeds below 500 RPM, a mineral oil in the SAE 140 to SAE 250 viscosity range should be used.

* National Lubricating Grease Institute



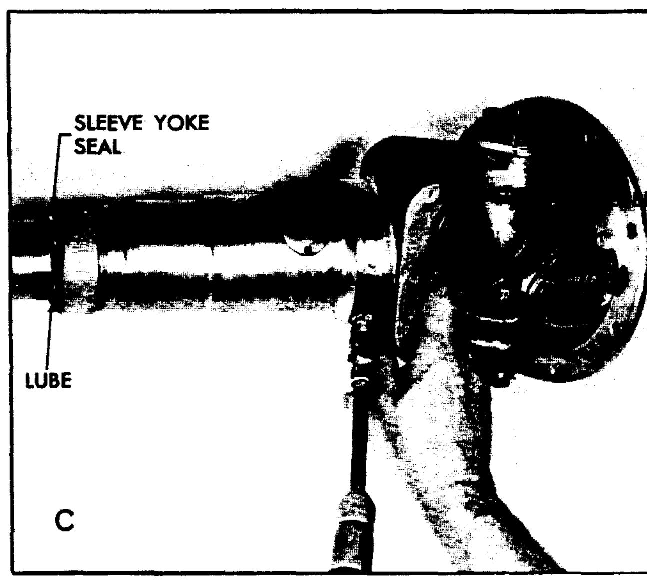
Relube spline at the intervals prescribed above. Apply grease gun pressure to lubrication zerk **until lubricant appears at pressure relief hole in welch plug** at sleeve yoke end of spline. (Illustration B). At this point, cover pressure relief hole with finger and continue to apply pressure **until grease appears at sleeve yoke seal.** (Illustration C). This will insure complete lubrication of spline.

Relube Cycles

Relubrication cycles for drive shaft universal joints and slip splines will vary with service requirements and operating conditions. The following re-lubrication schedule has been used successfully.

OPERATING CONDITION	RE-LUBE CYCLE	
	Miles	Hours
Normal	6000-8000	150-200
*Severe	2000-3000	50-75

* For applications where conditions such as high speeds, high ambient temperatures or high angles are present.



Sliding Spline Sections

Lubricants

Steel Splines: Driveshaft steel splines should be lubricated with a good extreme pressure grease as recommended by lubricant manufacturers. Extreme pressure grease satisfying NLGI Grade 1 has been adopted as the standard by our factories.

Glidecote TM Splines: Any high grade multi-purpose grease can be used. Greases recommended by lubricant manufacturers for universal joints have been found satisfactory for Glidecote splines.

Center Bearings

Initial lubrication is done by the bearing manufacturers. **No attempt is made to add or change grease within the commercial bearing itself.** However, when servicing a driveshaft in the field with a new center bearing, it is necessary to fill the entire cavity around the bearing with waterproof grease to shield the bearing from water and contaminants. The quantity should be sufficient to fill the cavity to the extreme edge of the slinger surrounding the bearing.

Lubricants used must be waterproof. Consult your grease supplier for recommendation.

SERVICE INSTRUCTIONS

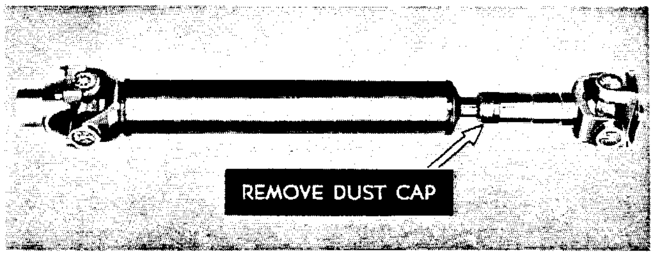


FIGURE 15

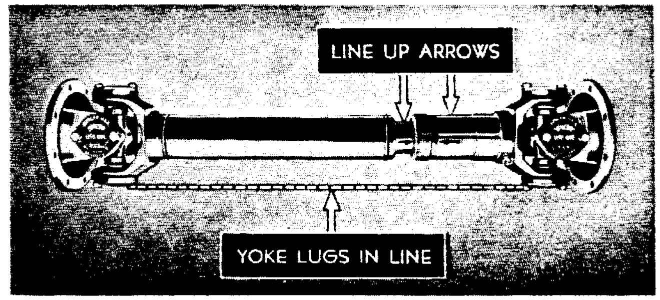
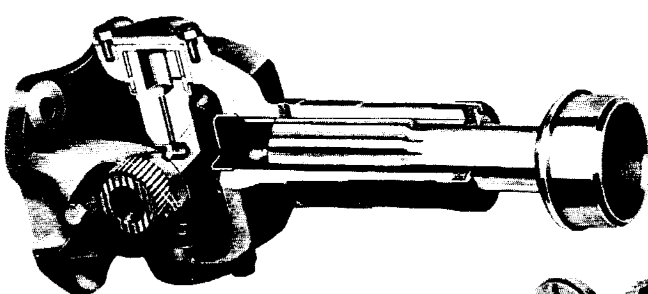


FIGURE 16

REMOVAL OF THE SLIP JOINT

1. Slip Joint (All Types). Unscrew the dust cap from the sleeve yoke and slide the joint off the drive shaft.

BEARING CAP CONSTRUCTION



2. ARROW MARKS—Make sure arrow marks are stamped on the shaft and sleeve yoke before removing the slip joint. If arrow marks are not readily seen, mark both members so that when reassembled they will be in exactly the same relative position, since the sleeve yoke lugs must be in the same plane as the stub ball yokes to prevent excessive vibration in operation.

DISASSEMBLING UNIVERSAL JOINT

1. LOCK STRAP (98) — Bend down the locking lugs with a screwdriver and remove the cap screws (73).

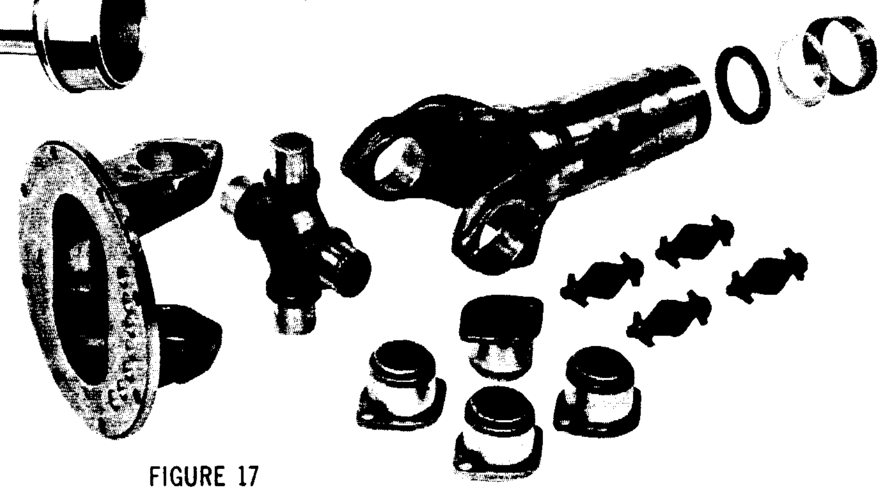


FIGURE 17

2. NEEDLE BEARINGS & RETAINING CAP SUB-ASSEMBLY (6) — Remove by using a large pair of channel lock pliers on retaining cap edges, turn retaining cap and bearing sub-assembly at the same time lifting upward to remove the sub-assembly from the journal trunnion diameter and out of the yoke hole. Turn the joint over and tap the exposed end of the journal cross (5) until the opposite needle bearing is free. Use a soft round drift with flat face about 1/32" smaller in diameter than the hole in the yoke, otherwise there is danger of damaging the bearing.

3. JOURNAL CROSS (5) — Remove by sliding it to one side of the yoke and tilting it over the top of the yoke lug.

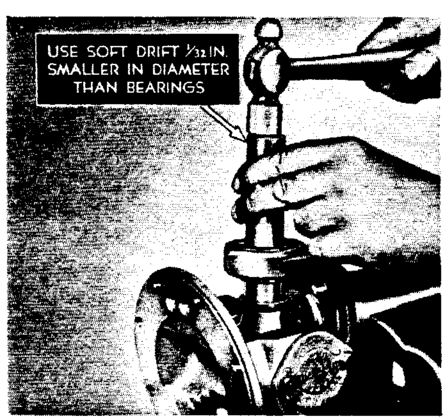


FIGURE 18

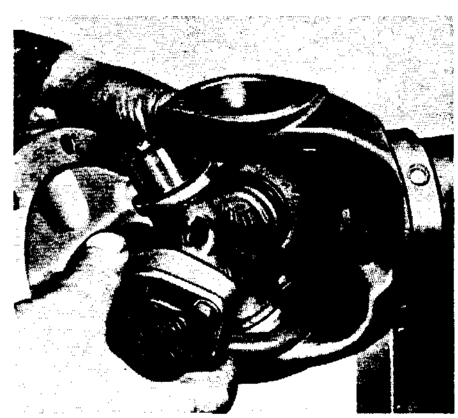


FIGURE 19

REBUILDING DRIVESHAFTS

BALANCING

The rebuilding of a drive shaft assembly usually consists of replacing worn journal cross and bearings with a new kit. These kits replace the part of a drive shaft most subject to wear in operation. The slight off-center condition present in the journal cross assemblies makes it desirable to balance the assembly after installing new journal and bearing kits.

Generally, unbalance resulting after installation of a journal and bearing kit is equivalent to the unbalance existing after straightening the shaft. If balancing cannot be done, it is advisable to check assembly for smooth operation in vehicle before it is put into operation.

It is sometimes necessary to revise drive shaft lengths when rebuilding a vehicle. This job requires proper facilities to produce a quality assembly. It is necessary to properly assemble fittings into the tube and straighten, before welding, to be sure parts are centralized. This can be done by mounting shaft assembly on center and straightening at fittings until ends of tube run concentric within about .005 TIR. The welding of the tube in the fittings must provide for adequate strength and prevent distortion which could cause excessive runout. It is often desirable to tack weld and recheck for runout before proceeding with final weld. *After welding*, the entire drive shaft should be straightened to the following limits: (See Fig. 25)

.005 TIR	On shaft neck
.015 TIR	On ends of tubing 3″ from welds
.010 TIR	In center of tube

These runouts should be taken with entire drive shaft assembly mounted on master attaching flanges or yokes, selected for dynamic balance to eliminate as much unbalance as possible. During balancing, the drive shaft again should be mounted on these selected flanges or yokes.

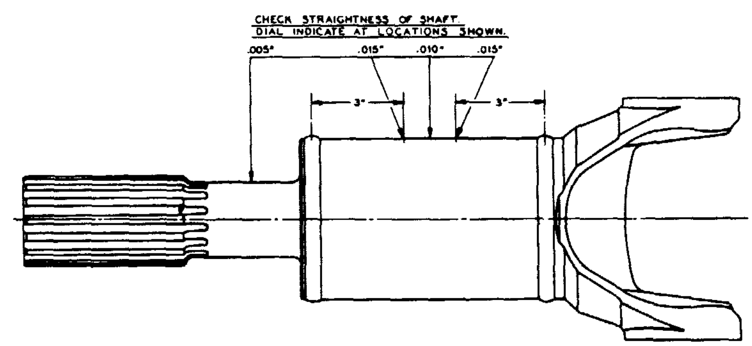


FIGURE 25

ASSEMBLING UNIVERSAL JOINT

1. Seal -- If unnecessary to install a new kit make sure that four new seals are installed in the journal retainers.

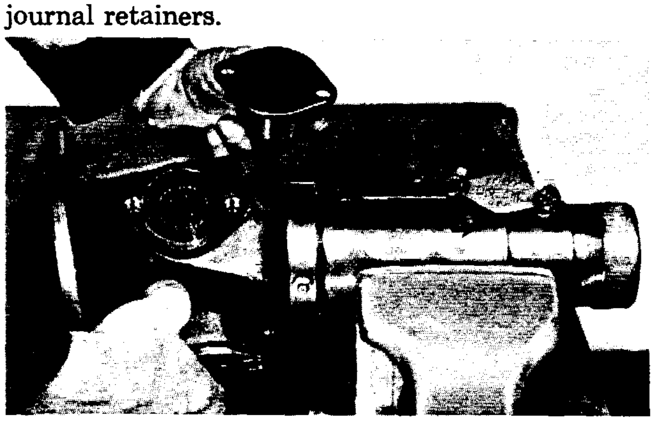


FIGURE 26

2. JOURNAL CROSS — With the relief valve facing the flange yoke, insert one trunnion of the journal cross into the bearing hole in the yoke lug from the inside between the lugs and tilt until the trunnion of the journal cross will clear the hole in the opposite yoke lug.

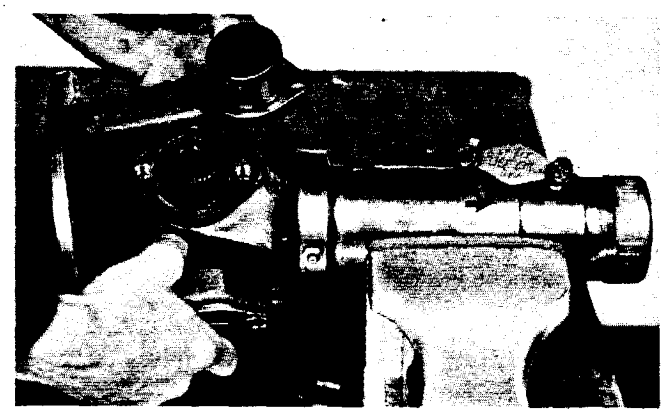


FIGURE 27

3. NEEDLE BEARING AND RETAINING CAP SUB-ASSEMBLY — Insert from outside of yoke. Press into place with an arbor press or tap with a soft round drift taking care not to mar any surfaces.

4. LOCK STRAP AND CAP SCREWS — Assemble and bend the lugs of the lock strap up against the flat of the cap screw. If the joint appears to bind, tap the lugs lightly to relieve any pressure of the bearing on the end of the journal.

INSTALLATION

UNIVERSAL JOINT PHASING (See Fig. 29)

When U-Joints or yokes are assembled to their shafts in the same plane, they are in phase. When they are assembled to the shaft in different planes, they are out of phase. To obtain vibration free operation, check the following.

1. Yokes or flanges between the main and auxiliary transmission must be "*In Phase*".

2. In the case of a two-piece drive shaft assembly, between the transmission (Main or Auxiliary) and the forward rear axle, the joints on this shaft should be assembled "In Phase", unless otherwise specified by the manufacturer of the vehicle.

3. The inter-axle drive shaft yokes must be "In Phase".

4. If a vehicle has drive shafts that do not have intersecting angles but parallel angles throughout the drive line system, the yokes or flanges must be held parallel to within 1° of each other.

INSTALLING DRIVESHAFT

1. Drive Shaft Assembly — Place in a pair of centers and check the Shaft for runout if not previously done during assembly. The runout on the Tube should not be more than .015" indicator reading, and on the neck of the Slip Stub Shaft the runout should not be more than .005" indicator reading. Mark the high and low points on the shaft with chalk and straighten if necessary. Install with the Slip Joint nearest the source of power. Tighten the Flange Bolts evenly after the Nuts and NEW Lock Washers are in place.

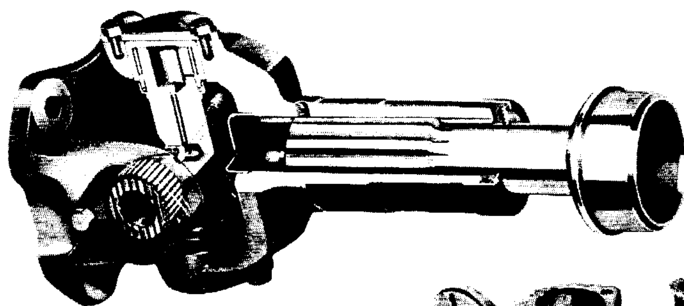


FIGURE 30

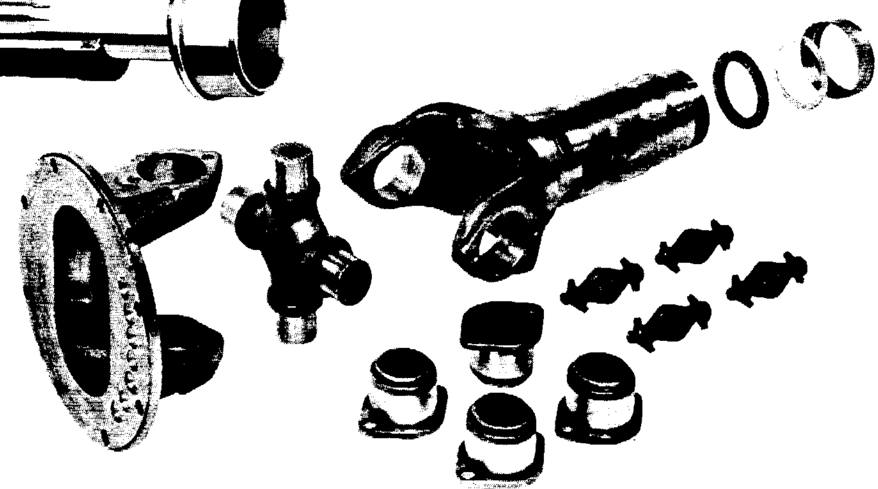


FIGURE 31

CHECKING DRIVESHAFT ANGLES

The procedure to check drive shaft angles for proper universal joint operating angles follows:

1. Remember to check drive shaft angles both with the tractor fifth wheel *unloaded*, and *loaded* with a trailer.

2. To determine drive shaft angles, a spirit level protractor is required. When angles are read from the 0° mark (for example, measuring inter axle shaft angle — 5°), record and use the angle shown on the protractor. When angles are read from either of the 90° marks (vertically) for example, measuring yoke angles, do not record the angle shown on the protractor since the 90° marks must be understood to be the same as 0° on the horizontal plane. Thus, if a vertical reading is 85°, the angle being measured is 5°.

3. All angles should be read within ¼° (15 min.) and they should be measured with the protractor held plumb on a clean, flat surface.

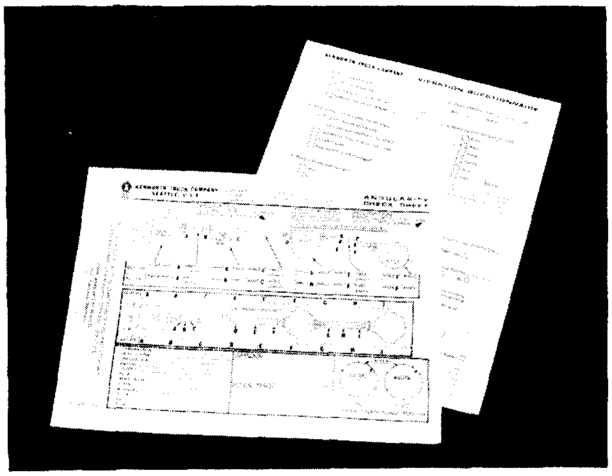
4. Inflate all tires to the pressure at which they are normally operated. Park the tractor on a surface which is as nearly level as possible both from front-to-rear and from side-to-side.

5. The tractor must be in its normal operating position. Do not attempt to level the truck by jacking up the front or rear axles to obtain a level condition.

DIAGNOSIS

Begin with the driver. He spends the best part of every day in the cab. Discuss the problem with him. Find out when it occurs, and where.

While you're talking to the driver, fill out the questionnaire on the back of the Kenworth Angularity Check Sheet.



Have an experienced mechanic road test the vehicle.

The mechanic must be able to observe the vibration within a reasonable driving distance.

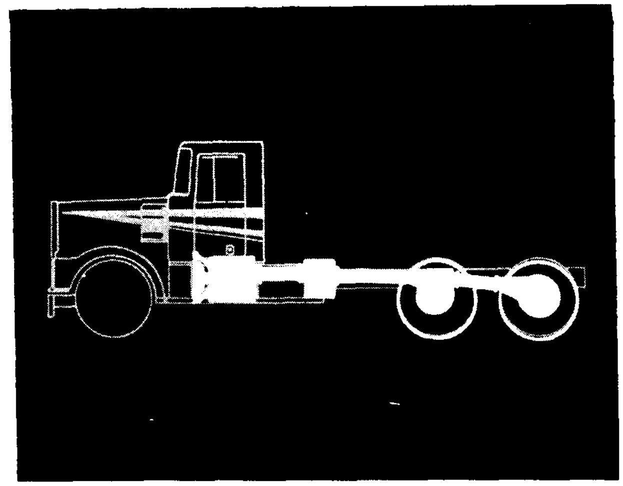
If the vibration only exists when the truck is pulling a load, the test drive should be made in a loaded condition.

It's up to the man in the truck to decide if the problem is vibration or a ride complaint.

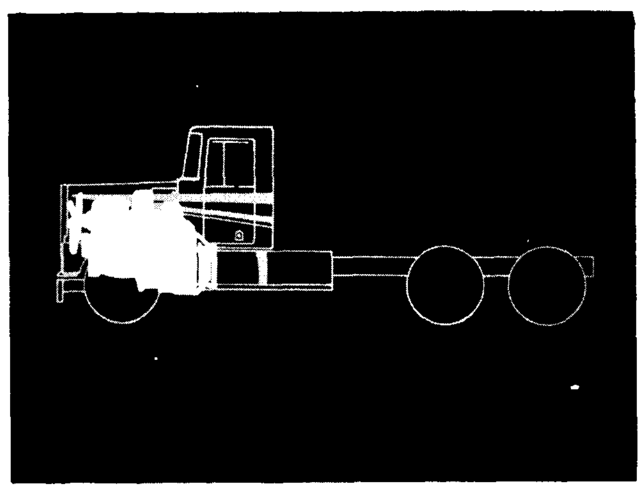
When the mechanic has decided it's a vibration problem, he has to conduct a few on-the-road tests.

First, he must disengage the clutch and drop the engine speed and let the truck coast.

If the vibration continues, the problem is in the differentials, the transmission, the drive-line, the wheels, or the brake drums.



But if the vibration stops when the engine speed drops, and reappears when the mechanic brings the speed back up again, the problem is in the engine, the engine mounts, or the clutch pressure plate or discs.

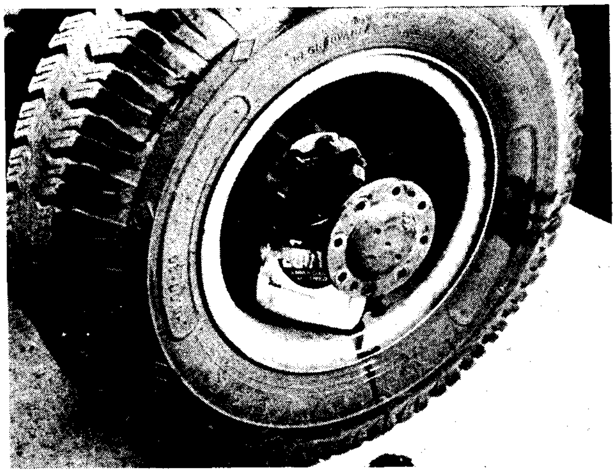


PRELIMINARY CHECKS

Once the mechanic has decided the vibration is caused by a problem in the drive-train, there are a few preliminary checks that can save you a lot of time.

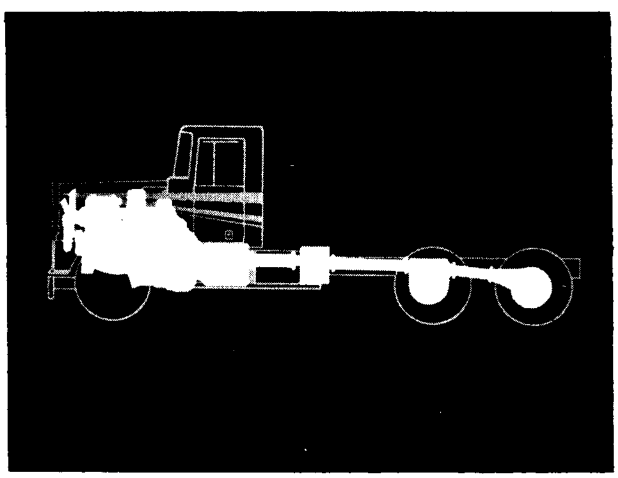
First, check the alignment of the universal joints on the drive shafts.

Pull the axle-shafts to isolate the power train from the wheels.



Lock the inter-axle differential so the full torque of the driveline will be transmitted to the inter-axle drive shaft, and start the engine.

Engage the clutch and run the engine at the speed at which the vibration occurs. If the vibration is still present, the problem is in the power-train, rather than in the wheels.



If the vibration stops when the axle shafts are pulled, the problem is in the wheels or brake drums, and they must be thoroughly checked according to manufacturers specifications.

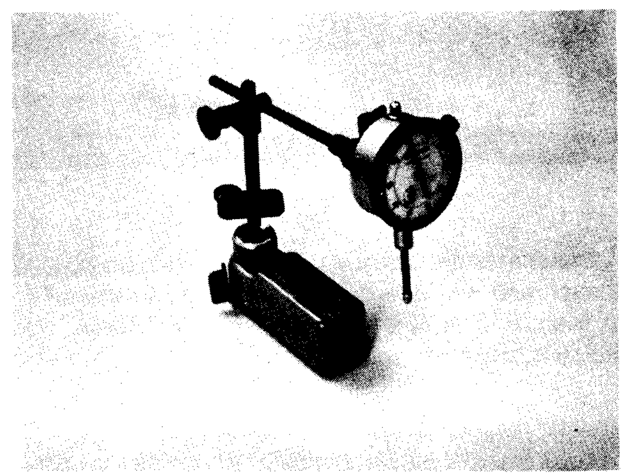
You must also check the alignment of the axles, and the suspension height with the vehicle fully loaded. Also check the suspension bushings for excessive wear. Refer to the procedures and specifications in the Kenworth maintenance manual.

If the vibration has not stopped, disengage the clutch to isolate the engine from the drive line. If the vibration stops, the problem is in the drive line or the transmission.

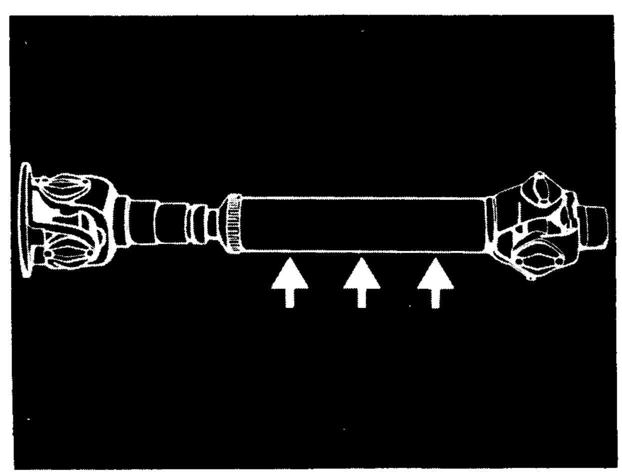
If the vibration appears to be in the drive line, re-engage the clutch, run the engine at low speed, and visually check the drive-shafts for run-out.

RUN-OUT MEASUREMENT

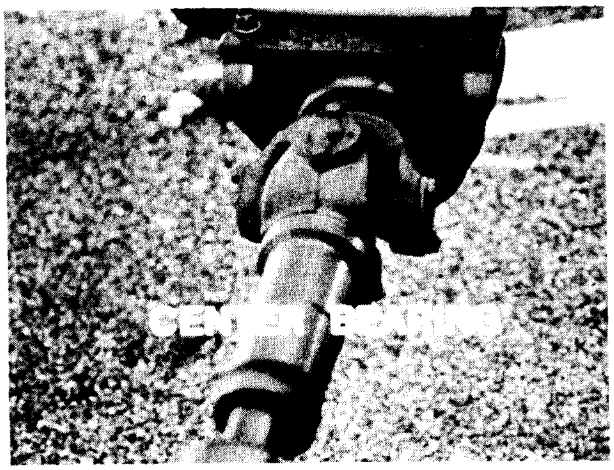
Any apparent run-out must be checked with a dial indicator. Attach the dial indicator firmly to the frame.



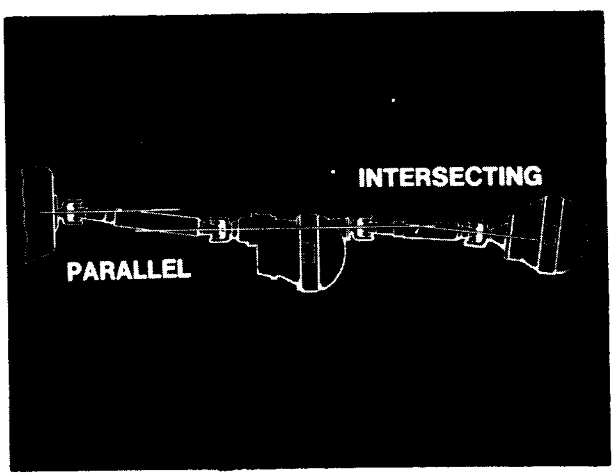
Clean the drive shafts with sand paper to smooth out any irregularities on the surface, and then measure each drive shaft at three points. At least three inches from the weld at each end, and in the middle.



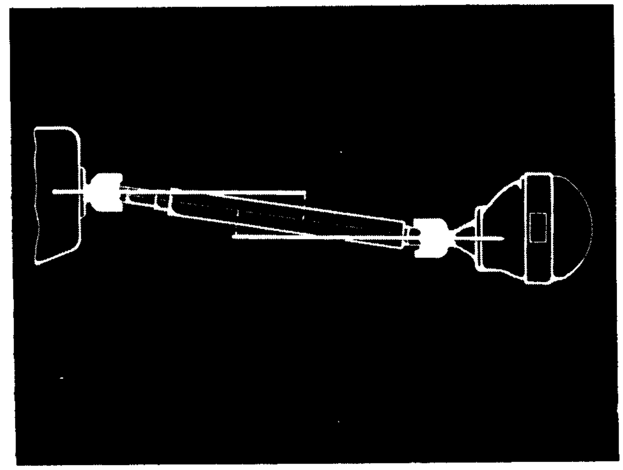
There is one exception to this rule. When there is a drive-shaft with a center bearing, the operating angle of the universal-joint between the transmission and the first drive-shaft must be 0°. In other words, the angle of the first drive-shaft must be the same as the angle of the transmission.



There are two kinds of drive shaft installations: parallel and intersecting.



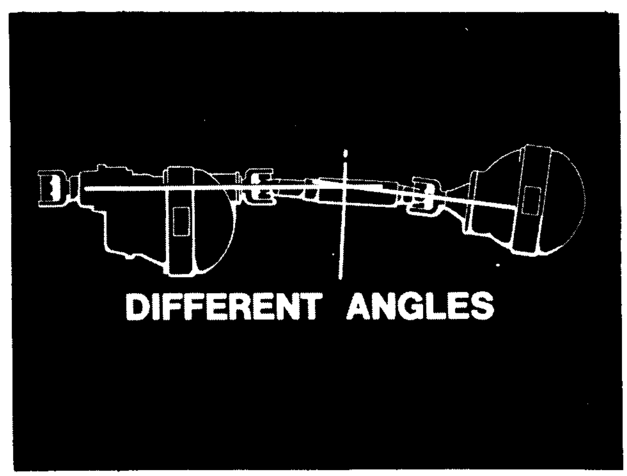
In a parallel installation, the component yokes of the universal-joints at each end of the shaft are of approximately equal angles.



Thus, in a truck with only one drive axle and one drive shaft, if the transmission yoke is set at an angle of two degrees, the angle of the drive-axle yoke must also be two degrees plus or minus one degree.

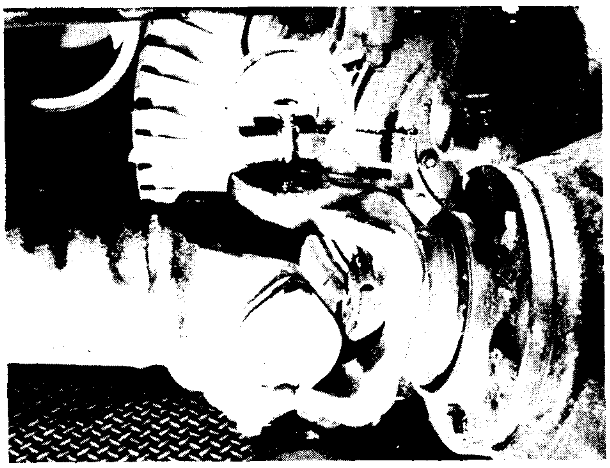
The universal-joint operating angles on a parallel installation are called outside opposite angles.

In an intersecting, or broken-back, installation, the component yokes on the universal-joints on each end of the shaft are at different angles.



Turn the drive shaft until the bubble in the spirit level is centered. The universal joint is now vertical. If both the universal-joints on the same shaft are now vertical, the joints are exactly in phase.

Measure the angle of the component by placing the base of the protractor on the machined surface in-line with the drive shaft. Record the angle on the check sheet.



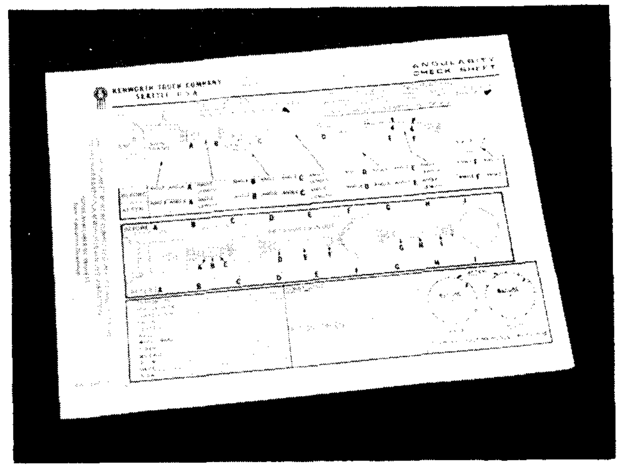
Next, put the protractor base along the top of the drive shaft and measure the angle of the shaft.

Read every angle from the same side of the truck. This will eliminate the effects of protractor inaccuracies.

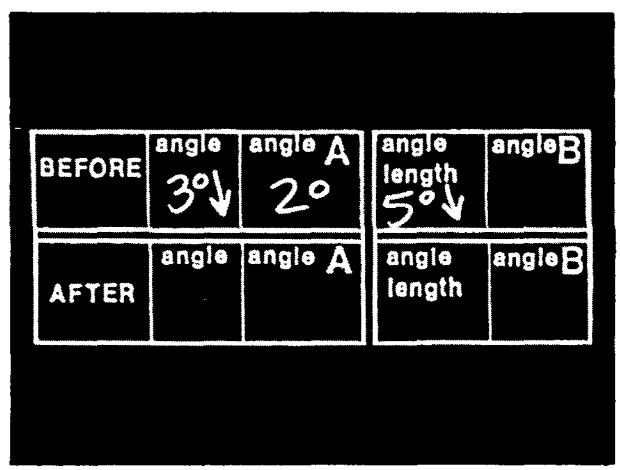
Also measure the lengths of each driveshaft and record them on the angularity check sheet. The length of the drive shaft is the distance between the centers of the universal-joints on each end of the shaft.

Remember to fill out both sides of the Angularity Check Sheet as you record the driveline angles.

The check sheet is easy to use. Measure the angles of the drive shafts and other drive line components with the protractor. The universal-joint operating angles are computed from the measured angles.

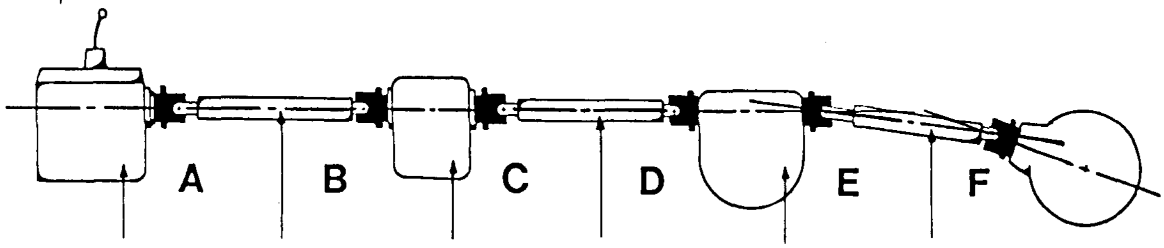


For instance, if the main transmission angles 3° down to the rear, and the angle of the first drive shaft is 5°, then angle A is 2°. This is the difference between the two measured angles.



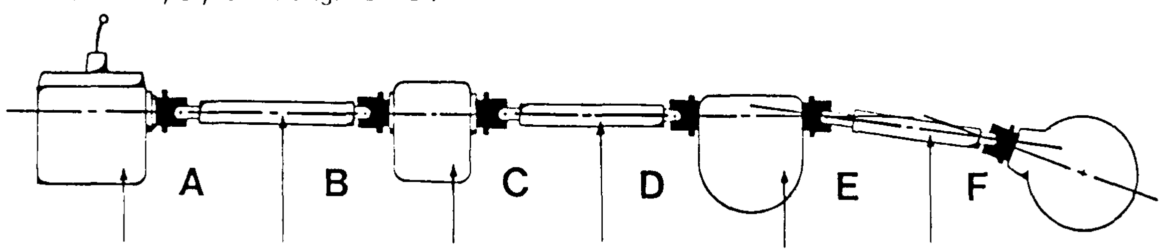
Examples

This truck has no center bearing or auxiliary transmission. I've measured the angles of the transmission, the axle, and the driveshaft. What are the angles between the shaft and the components?



	angle	angle A	angle length	angle B	angle	angle C	angle length	angle D	angle	angle E	angle length	angle F	angle
BEFORE	6°↓						8°↓		3°↓				
AFTER													

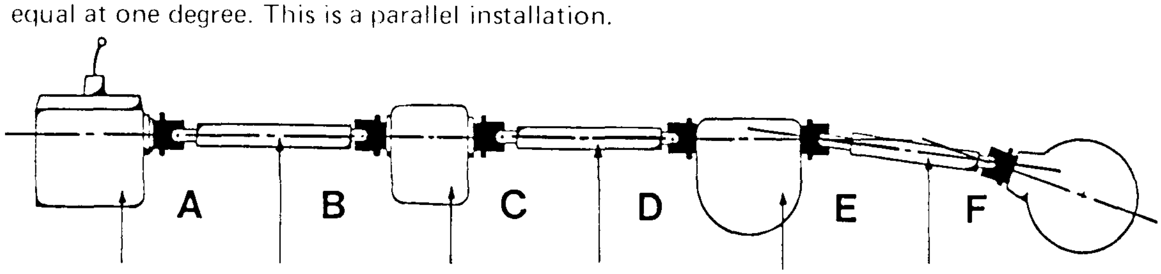
The difference between the angle of the transmission, 6 and the angle of the drive shaft 8°, is the angle A - 2 . And the difference between the angle of the shaft, 8 , and the angle of the rear axle, 3 , is the angle D - 5 .



	angle	angle A	angle length	angle B	angle	angle C	angle length	angle D	angle	angle E	angle length	angle F	angle
BEFORE	6°↓	2°					8°↓	5°	3°↓				
AFTER													

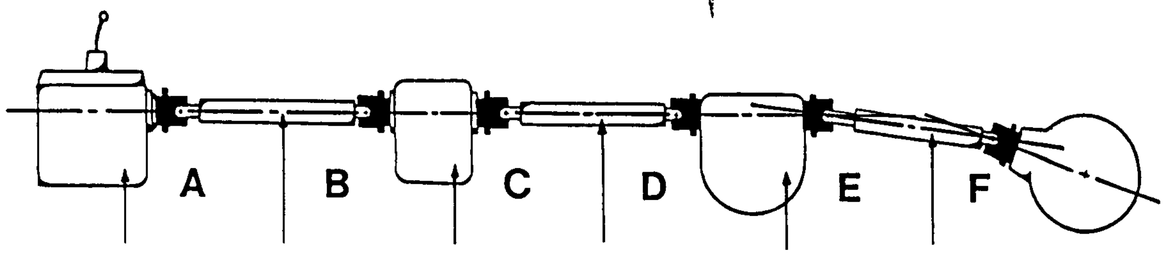
Since the angles A and D are not within one degree of each other, the angles must be changed so that they are within 1 of each other.

To correct the angles, the drive axle angle must be changed from 3 to 6 . This will change the angle of the drive shaft to approximately 5 . The universal joint working axles are now equal at one degree. This is a parallel installation.



	angle	angle A	angle length	angle B	angle	angle C	angle length	angle D	angle	angle E	angle length	angle F	angle
BEFORE	6°↓	2°					8°↓	5°	3°↓				
AFTER	6°↓	1°					5°↓	1°	6°↓				

In this example, the truck has two drive axles, and a center bearing. I've measured the angles of the shafts and the components; now you can compute the lettered angles.

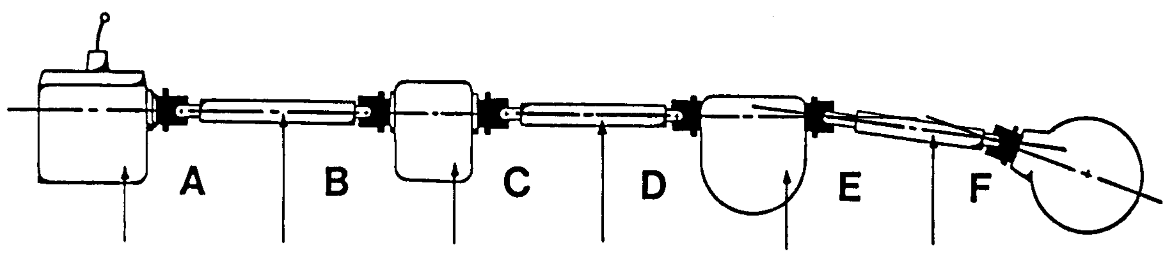


	angle	angle A	angle length	angle B	angle	angle C	angle length	angle D	angle	angle E	angle length	angle F	angle
BEFORE	2°↓		0°				4°↓		2°↓		7°↓		12°↓
AFTER													

The difference between the angle of the transmission, 2°, and the angle of the first drive shaft, 0°, is the angle A - 2°, and the difference between the angle of the first drive shaft, 0°, and the angle of the second drive shaft, 4°, is the angle C - 4°.

Similarly, the difference between the angle of the second drive-shaft, 4°, and the angle of the forward drive-axle, 2°, is the angle D - 2°.

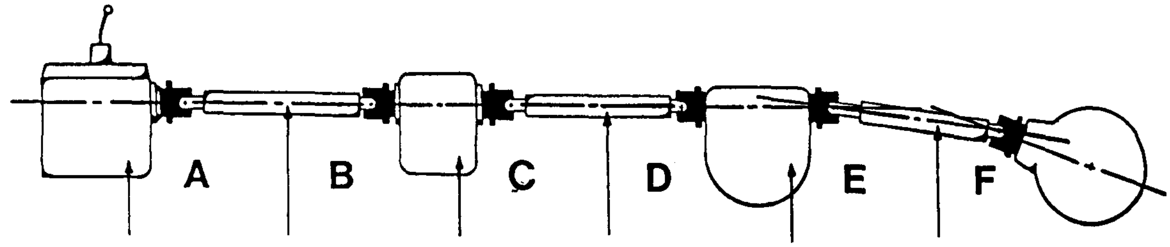
The difference between the angle of the forward drive-axle, two degrees and the angle of the inter-axle driveshaft, 7°, is the angle E - 5°, and the difference between the angle of the inter-axle driveshaft, 7°, and the angle of the rear drive axle, 12°, is the angle F - 5°.



	angle	angle A	angle length	angle B	angle	angle C	angle length	angle D	angle	angle E	angle length	angle F	angle
BEFORE	2°↓	2°	0°			4°	4°↓	2°	2°↓	5°	7°↓	5°	12°↓
AFTER													

The problem here is the angle between the transmission and the first driveshaft. If there is a center bearing in the driveline, the first driveshaft must be at the same angle as the transmission. Thus the operating angle of the universal-joint between the transmission and the first drive-shaft is 0°. This is the one exception to the rule that all universal-joints must have a minimum operating angle of 1°.

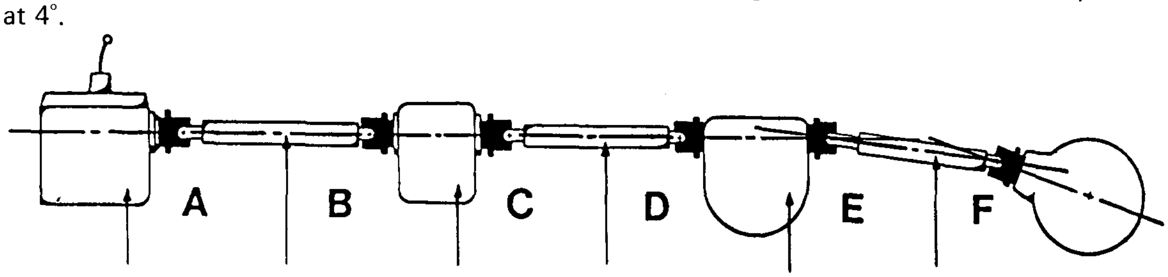
Also, the difference between the angle of the forward drive axle, 0°, and **the angle of the** inter-axle drive shaft, 7°, is the angle E - 7°, and the difference between the angle of the inter-axle drive shaft, 7°, and the angle of the rear drive-axle, 10°, is the angle F - 3°.



	angle	angle A	angle length	angle B	angle	angle C	angle length	angle D	angle	angle E	angle length	angle F	angle
BEFORE	2°↓	1°	1°↓	1°	2°↓	2°	4°↓	4°	0°	7°	7°↓	3°	10°↓
AFTER													

The angles A and B are within 1° of each other. The angles C and D, however, are not within 1° of each other. Nor are the angles E and F.

To correct the problem, change the angle of the forward drive-axle to 2°. This will also change the angle of the second drive shaft to 3°, and the angle of the inter-axle drive shaft to 6°. The angles C and D will now be equal at 1°, and the angles E and F will also be equal at 4°.



	angle	angle A	angle length	angle B	angle	angle C	angle length	angle D	angle	angle E	angle length	angle F	angle
BEFORE	2°↓	1°	1°↓	1°	2°↓	2°	4°↓	4°	0°	7°	7°↓	3°	10°↓
AFTER	2°↓	1°	1°↓	1°	2°↓	1°	3°↓	1°	2°↓	4°	6°↓	4°	10°↓

Quiz 1

Are these statements true or false:

1. If the vibration only exists when the truck is pulling a load, the test drive must be made in a loaded condition. T ___ F ___
2. An experienced man must conduct the test drive. T ___ F ___
3. If the universal-joints on each end of a drive-shaft are not exactly in phase with each other, the shaft will vibrate. T ___ F ___
4. If the vibration stops when you pull the axles and run the truck with the clutch engaged, the problem is in the drive-line. T ___ F ___
5. you must measure the run-out on each shaft with a dial indicator at five places. T ___ F ___

Quiz 2

Fill in the blank words:

1. The drive line ______________ are very critical to the smooth running of the truck.
2. The universal-joint angles on any one shaft must be within __________ degree(s) of each other.
3. There are two kinds of drive-shaft installations: ____________________ and ____________________.
4. To measure drive line angles you will need a machinists ____________________.
5. A simple rule to remember to compute universal-joint working angles is that if the angles slope in the ______________ direction, subtract the smaller from the larger to get the working angle. If they slope in ____________ directions, add the angles to get the total working angle.

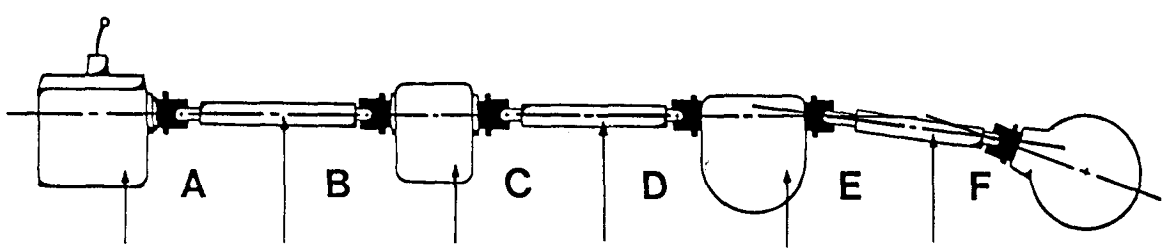
Quiz 3

Compute the universal-joint working angles for these vehicles.

Which angles are within acceptable limits and which are not?

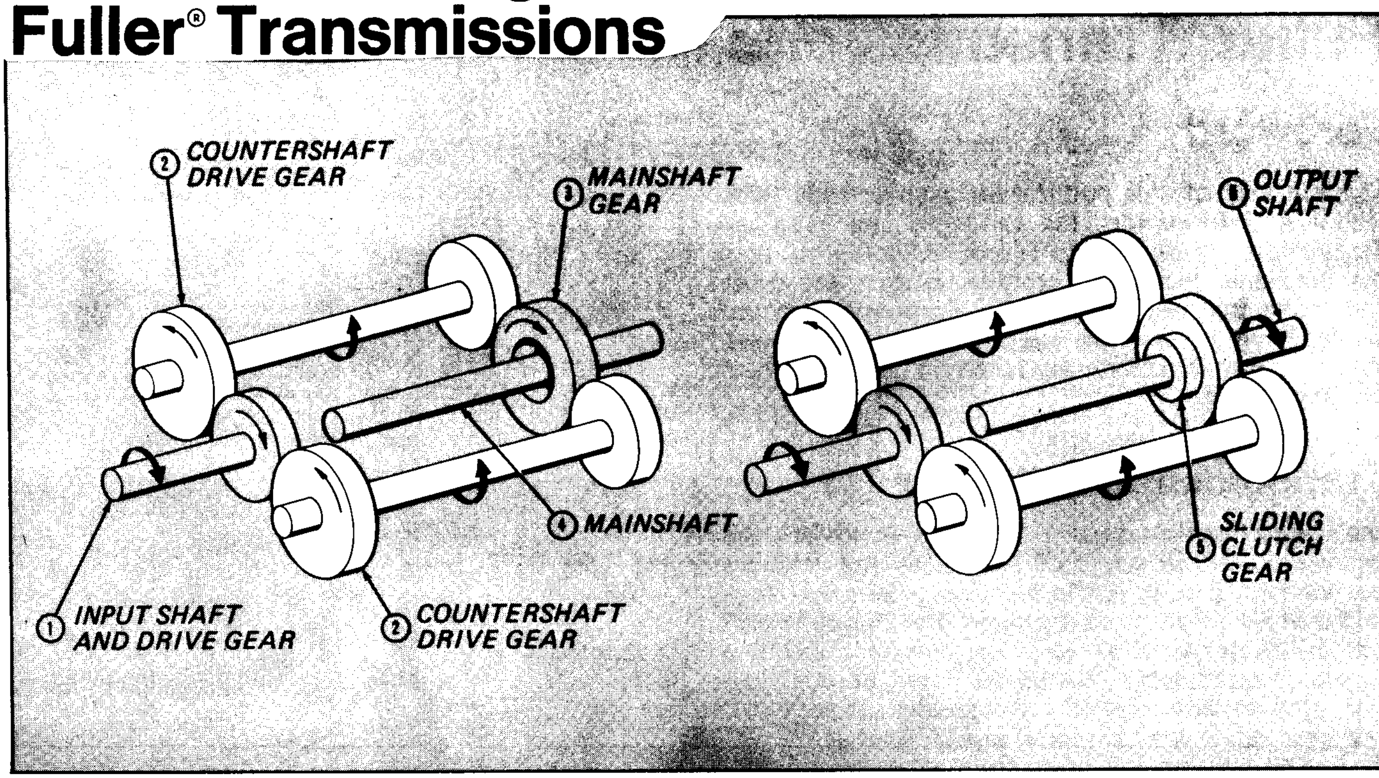
How would you correct the installations to bring all the angles within acceptable limits?

1. This vehicle doesn't have a center bearing, or auxiliary transmission.



BEFORE	angle 0°	angle A	angle length 4° ↓	angle B	angle	angle C	angle length	angle D	angle 3° ↓	angle E	angle length 6° ↓	angle F	angle 13° ↓
AFTER	angle	angle A	angle length	angle B	angle	angle C	angle length	angle D	angle	angle E	angle length	angle F	angle

Trouble Shooting Guide
Fuller® Transmissions



A simplified diagram of the power flow through a Fuller twin countershaft transmission will help show how torque and speed are changed, and how torque is divided between the two countershafts.

The input shaft and drive gear (1) are in constant mesh with both countershaft drive gears (2); when the input shaft turns, the countershafts turn. The countershaft gears are in constant mesh with the "floating" mainshaft gears (3). The mainshaft gears are simply free-wheeling on the mainshaft (4). A sliding clutch gear (5), which is splined to the main-shaft, is engaged into the internal clutching teeth of the mainshaft gear, coupling it to the mainshaft. The mainshaft will now be turning at the selected gear ratio.

Fuller twin countershaft Roadranger transmissions commonly consist of a five speed front section and either a two or three speed auxiliary section, both in one case.

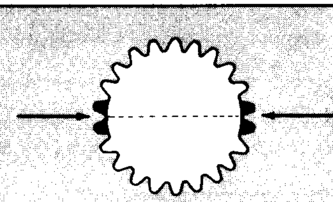
Timing

All Fuller twin countershaft transmissions are "timed" at assembly. It is important that proper timing procedures are followed when reassembling the transmission. Timing assures that the countershaft gears will contact the mating mainshaft gears at the same time, allowing mainshaft gears to center on the mainshaft and equally divide the load.

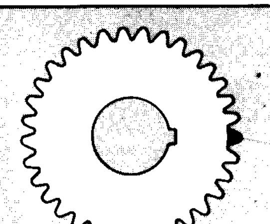
One set of gears must be timed in the front section, and one set in the auxiliary section. Timing consists of marking the proper teeth before installation and meshing the marked teeth during assembly. Following is a step by step procedure for timing:

Front Section

1. Main Drive Dear – Mark any two adjacent teeth on the drive gear, then mark the two adjacent teeth which are directly opposite the first set marked. There must be an equal number of teeth between the markings on each side of the gear.



Drive Gear Teeth correctly marked for timing



Tooth on Countershaft directly over Keyway marked for timing

2. Countershaft Drive Gears – Mark on each drive gear the gear tooth which is directly over the keyway. This tooth is stamped with an "O" for identification.

Lubrication

Proper lubrication is the key to a good all-round maintenance program and long transmission life. If the oil is not doing its job, or if the oil level is ignored, damage to the transmission will result and transmission life will be shortened.

Effective transmission oils must have the following characteristics:

Provide a protective film, to protect surface of heavily loaded parts such as gear teeth and bearings, thus preventing metal to metal contact which causes scoring, scuffing and seizure.

Act as coolant, to dissipate heat.

Have sufficient fluidity, to follow, coat and cushion all loaded surfaces.

Be chemically stable, to withstand heat and agitation without separation, gumming-up, oxidizing or corroding.

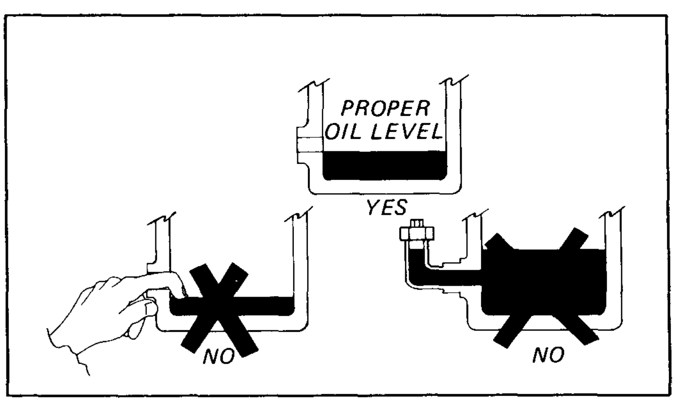
Be non-foaming, to prevent excessive foam and increased volume under severe conditions.

Be free of sediment and water, to prevent sludge and rust.

Fuller transmissions are designed so that internal parts operate in a bath of oil circulated by the motion of gears and shafts. Thus, all parts will be amply lubricated if these important procedures are closely followed:

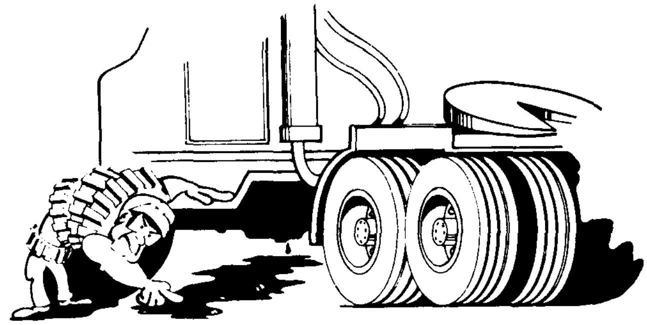
1. Maintain oil level. Inspect regularly.
2. Change oil regularly as recommended.
3. Use the correct grade and type of oil.
4. Buy quality lubricants.

Oil Level



Make sure oil is level with the filler opening. Because you can reach the oil with your finger does not mean oil is at proper level. Low oil will cause damage to moving parts; overfilling will cause overheating and cause oil to be forced out of the case at breather and front and rear seals.

Changing Oil



1. Check for oil leaks and determine cause before refilling.
2. Drain transmission while oil is warm by removing drain plug at bottom of case. On models with two drain plugs, both must be removed.
3. Flush the transmission with flushing oil or petroleum spirits. Fill transmission to the proper level with the flushing fluid; idle engine for one minute with the clutch engaged and the transmission in neutral.
4. Drain the flushing fluid and, if so equipped, change the filter element. Re-install drain plugs.
5. Refill the transmission with recommended oil to the level of the filler opening. On models having two filler openings, fill to the level of both openings. The exact amount of oil will depend on the transmission inclination and model. In every instance, fill to the level of the filler opening.

Lubrication Change and Inspection	
On highway	
First 3,000 to 5,000 miles (4827 to 8045 Km)	Change transmission oil on new units.
Every 5,000 miles (8045 Km)	Inspect oil level. Check for leaks.
Every 50,000 miles (80450 Km)	Change transmission oil.
Off-highway	
First 30 hours	Change transmission oil on new units.
Every 40 hours	Inspect oil level. Check for leaks.
Every 500 hours	Change transmission oil where severe dirt conditions exist.
Every 1,000 hours	Change transmission oil (Normal off-highway use).
Change oil filter element, if so equipped, at each oil change.	

Oil changes should be made at the recommended intervals as shown above.

For severe operating conditions, operators should make oil changes based on their own particular operation. Oil suppliers will analyze samples of oil at various mileages to determine the contamination point.

Air Systems

Fuller Roadranger transmissions use a regulated air system to operate range and splitter shifts in the auxiliary section. The air system consists of a control valve, slave valve, filter, regulator and connecting lines. There are four types of control valves: 1) two-position range control, push-pull type; 2) two-position splitter valve, button type; 3) three-position combination range/splitter valve, button type and 4) deep reduction or lo-lo gear, in and out lever type. A faulty air system can result in: failure to shift, slow shift, incorrect shift, or damaged parts in the transmission. By understanding the operation of the air system and using a few simple checks, problems can be easily located and corrected.

Range Shift Air System – All Roadranger Transmissions

NOTE: On transmissions equipped with a three-position control valve, the Low Range and High Range air lines are reversed at the air valve. (Except RT-613)

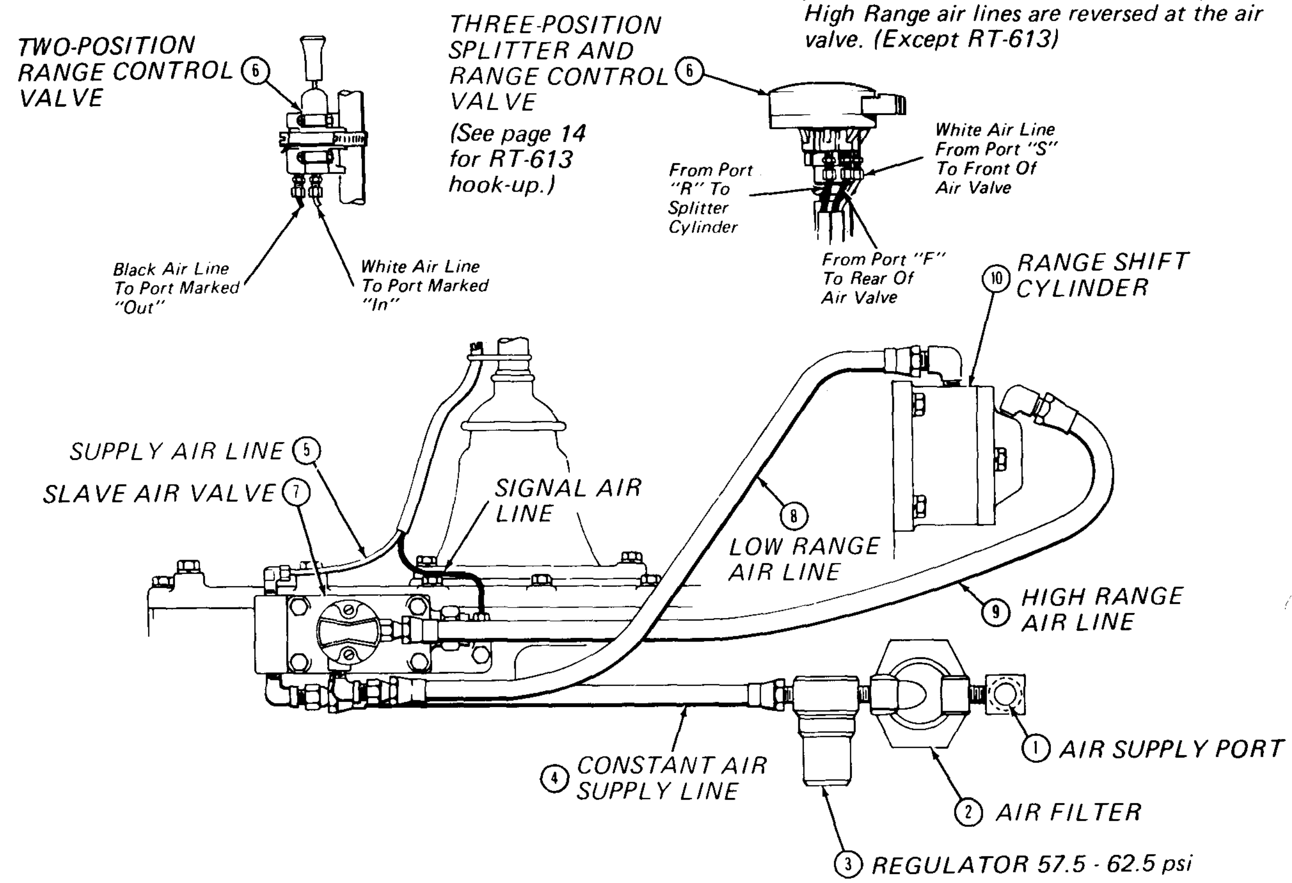


Figure 1. Range Shift Air System

Operation

Air is supplied to the system at the AIR SUPPLY PORT (1) by the vehicle's air system. The AIR FILTER (2) removes foreign matter from the air then allows it to pass through the AIR REGULATOR (3) where the pressure is adjusted for 57.5 to 62.5 PSI (4.0 daN/cm^2). From there the air passes through the 1/4" ID SUPPLY AIR LINE (4) and the 1/8" OD CONTROL VALVE SUPPLY AIR LINE (5) to the supply ports of the RANGE CONTROL VALVE (6) and the SLAVE AIR VALVE (7). Depending upon the position of the knob on the RANGE CONTROL VALVE, air will pass through either the LOW RANGE AIR LINE (8) or the HIGH RANGE AIR LINE (9) to the RANGE SHIFT CYLINDER (10).

The following steps have been designed to aid in the recognition and correction of problems which may result in unsatisfactory performance of the range shift operation of applicable Fuller transmissions. It is advised that the checks be made in the sequence set down to avoid unnecessary double-checking and delay, unless the problem has already been narrowed down to a specific part of the system. In this case, refer to the appropriate heading of this section.

Range Shift Air System (continued)

Air Regulator

1. With normal vehicle air pressure and the gear shift lever in neutral, check the exhaust port on the side of the regulator. There should be no air leaking from the port. If there is a steady leak of air from this port, this indicates a defective regulator which should be replaced.

2. Cut off the vehicle air pressure and install an air guage in the output port of the regulator. Bring the vehicle air pressure back to normal. Regulated air pressure should be 57.5 to 62.5 psi. If correct pressure readings are not obtained, replace the regulator.

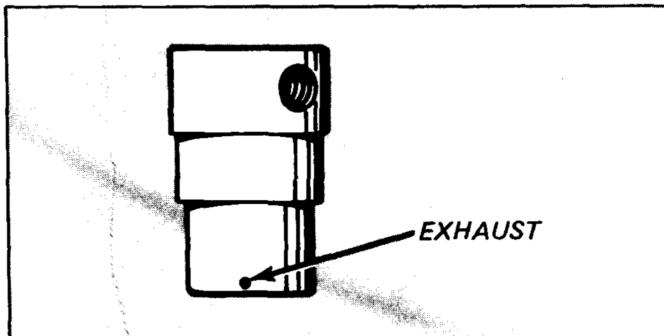


Figure 2. Air Regulator

Two-Position Control Valve

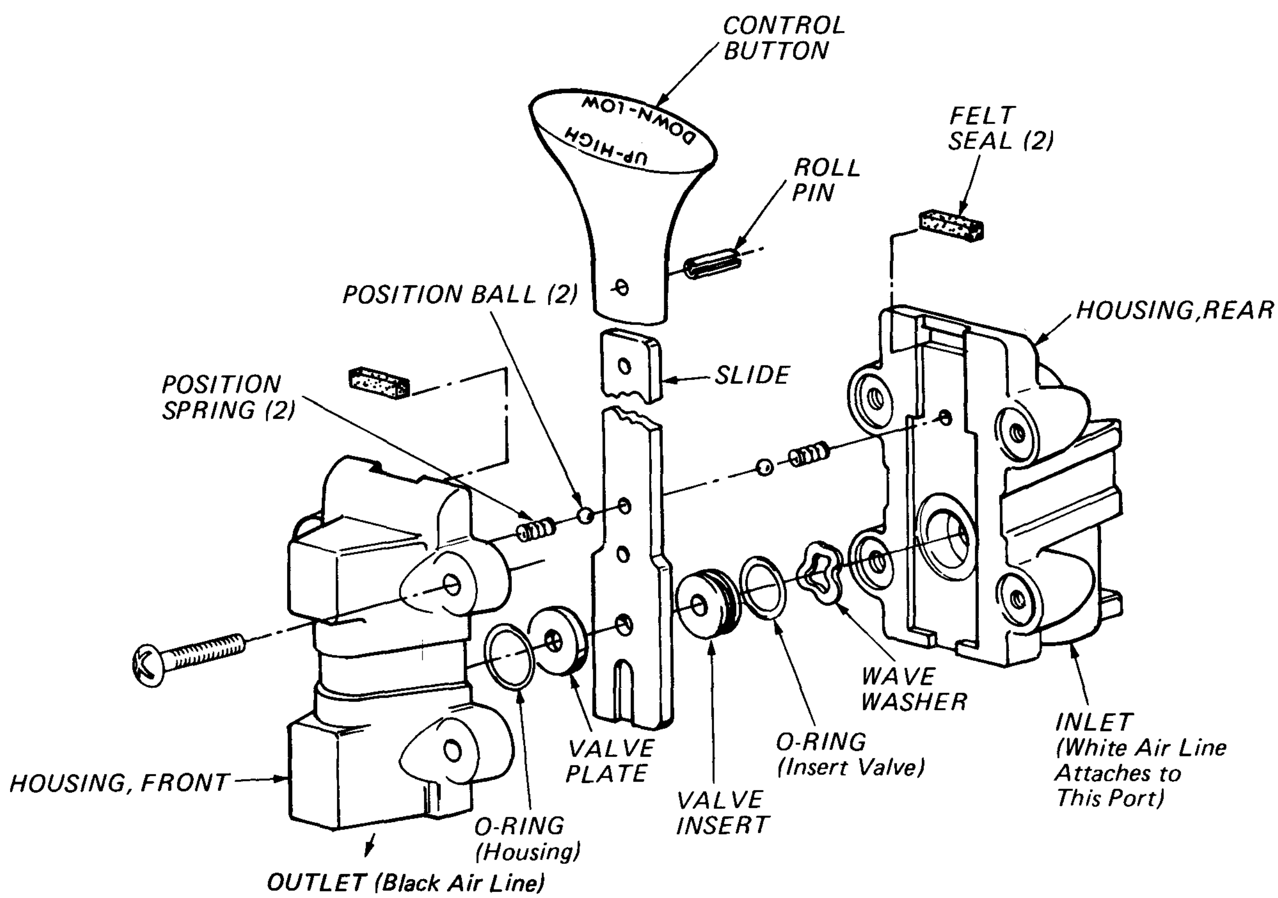


Figure 3. Two-Position Range Control Valve

1. With the gear shift lever in neutral, pull the control button up to high range and disconnect the black 1/8" OD nylon air line at the air valve. When the control button is pushed down into low range, there should be a steady blast of air from the disconnected line. The air should stop when the button is pulled up. This indicates that the control valve is operating correctly.

2. If the control valve does not operate correctly, refer to the remainder of the two-position control valve section for further breakdown.

Range Shift Air System (continued)

Slave Air Valve (continued)

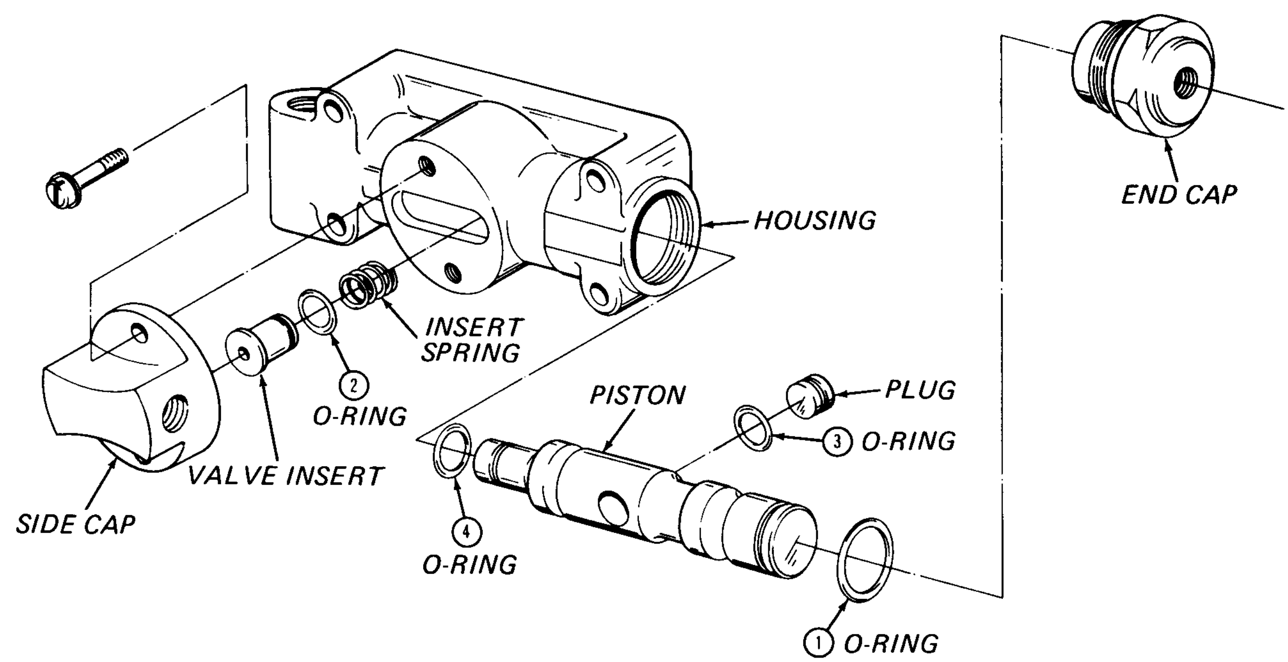


Figure 4. Slave Air Valve

The four O-rings are indicated by circled numbers on Figure 4. If any of these are defective, there will be a constant air leak out of the exhaust on the air valve. In normal operation, exhaust will occur only for an instant as the range shift is made. The chart at right is to be used as a guide to determine defective O-rings.

Defective O-Rings	RESULT
①	Constant leak through exhaust in low range only.
② or ③	Constant leak through exhaust in both ranges.
④	Constant leak through exhaust in high range; steady but low volume leak through exhaust in low range.

To Disassemble the Slave Air Valve

1. Disconnect all air lines, turn out the four capscrews and remove the air valve from the transmission.
2. Turn out the two screws and remove the side cap.
3. Remove the valve insert from the piston and remove the O-ring from the valve insert.
4. Remove the spring from the piston.
5. Turn the end cap from the valve body and remove the piston from the bore.
6. Remove the two O-rings from the piston.
7. Remove the nylon plug from the piston and remove the O-ring from the plug.
8. Clean the piston and air valve bore as necessary with emery cloth or a wire brush. Lubricate all O-rings and the piston with silicone lubricant and reassemble the air valve.
9. When reinstalling the end cap, do not use more than 40 pounds of torque. Excessive torquing may result in binding the piston in the valve bore.

Deep Reduction Air System

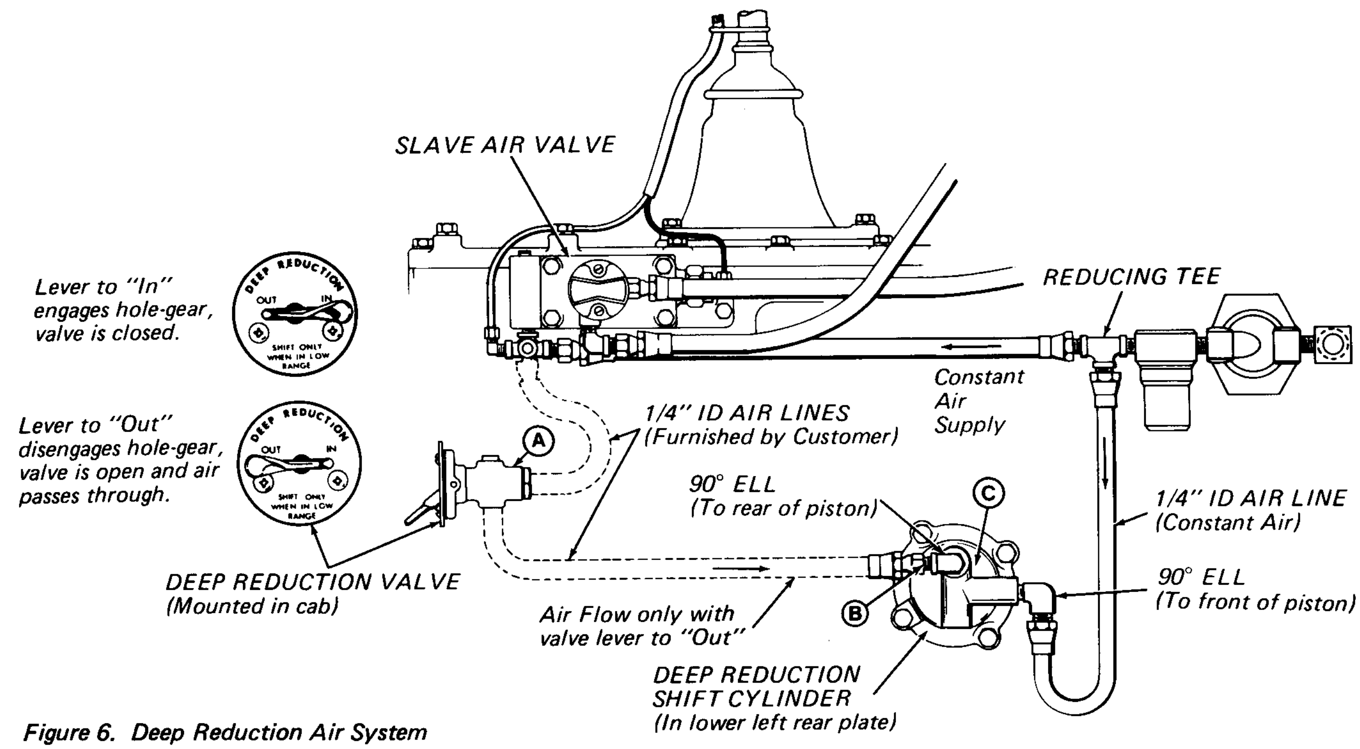


Figure 6. Deep Reduction Air System

The system consists of a set of deep reduction gearing and shift cylinder in the auxiliary section and a deep reduction control valve mounted in the vehicle's cab.

This air system is found on RT-915, RT-12515 and T-955ALL series transmissions and on the RTO-958LL transmissions.

1. Air Input – Check Point A

With gear shift lever in neutral and normal vehicle air pressure, loosen the connection at input (end port) of the deep reduction valve until it can be determined that there is a constant flow of air at this point. Reconnect line.

If there is no air at this point, there is a restriction in the line between the deep reduction valve and air valve. Also check to make sure this line is connected to constant supply.

2. Deep Reduction Valve – Check Point B

With the deep reduction valve lever to "IN", remove the line from the deep reduction valve at the port in hole-gear shift cylinder; there should be no air at this point.

Move the deep reduction valve lever to "OUT". There should now be a constant air flow from line. Move lever to "IN" to shut off air. If the above conditions do not exist, deep reduction valve is faulty or there is a restriction in air line.

3. Deep Reduction Shift Cylinder – Check Point C

If any of the seals in the shift cylinder are defective the shift will be affected. The degree of lost air will govern the degree of failure, from slow shift to complete failure to shift.

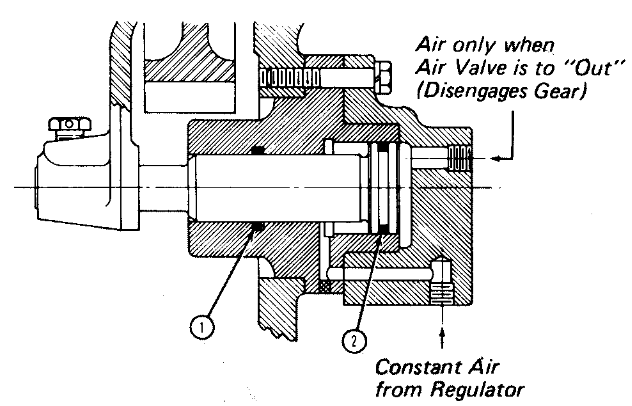


Figure 7. Deep Reduction Shift Cylinder

Refer to Figure 7 for location of O-rings:

Leak at O-ring 1

Failure to engage gear; pressurizing of transmission; gear can be disengaged.

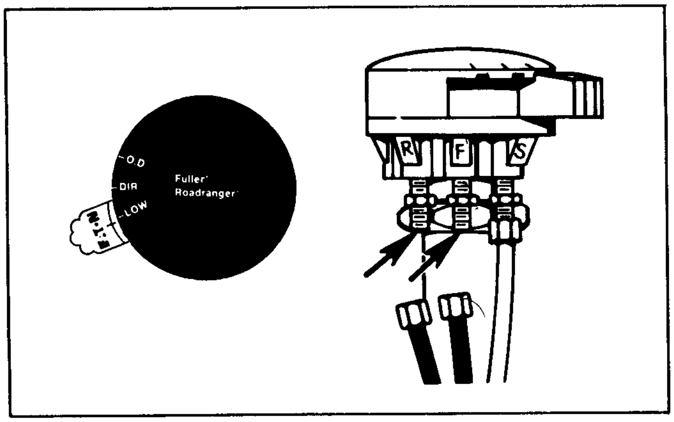
Leak at O-ring 2

Failure to engage gear; leak from deep reduction valve exhaust port when valve is "IN".

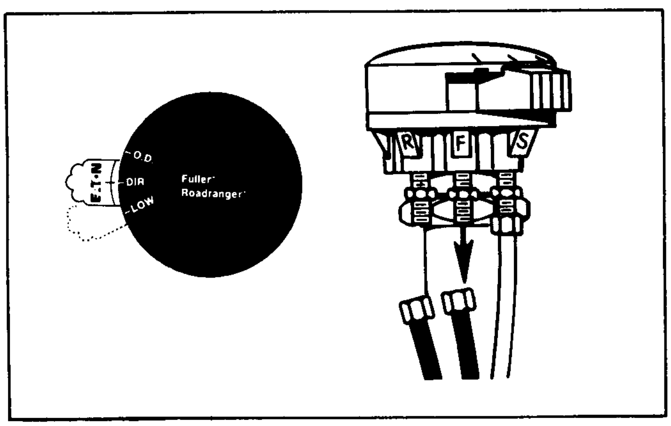
Air Systems (continued)

Splitter Gear Air System (continued)

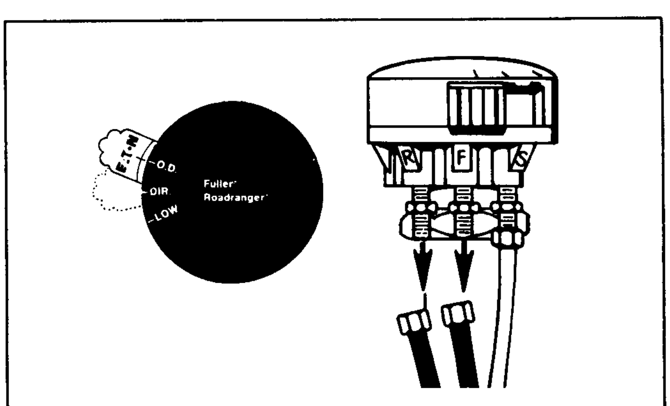
Three-Position Splitter Control Valve



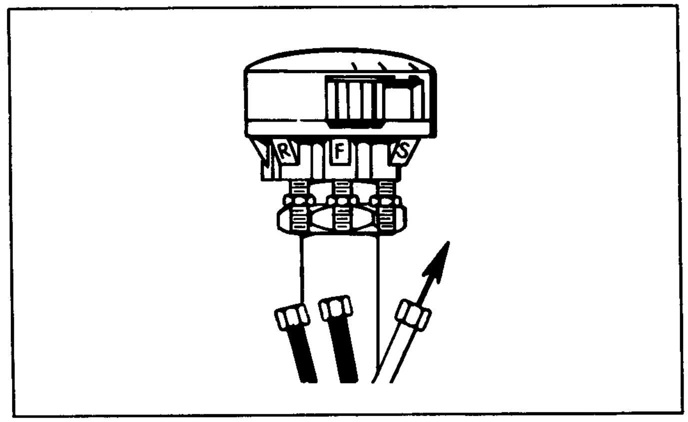
1. With the control button in the "LOW" position, disconnect the two black air lines connected to the ports on the valve marked, "F" and "R". There should be no air coming from these ports.



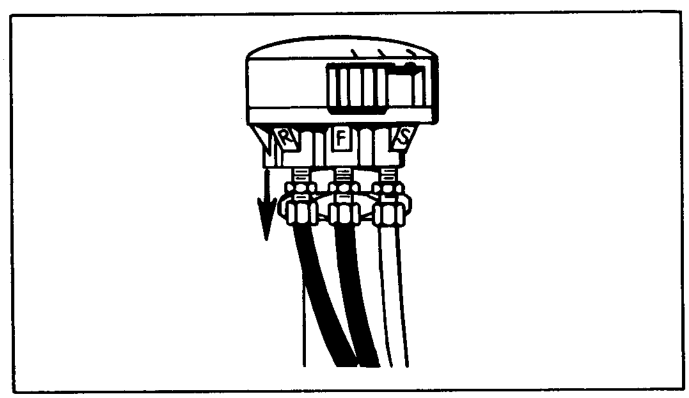
2. Move the control button to the "DIR." position. There should now be a steady flow of air coming from the "F" port, but still no air coming from the "R" port.



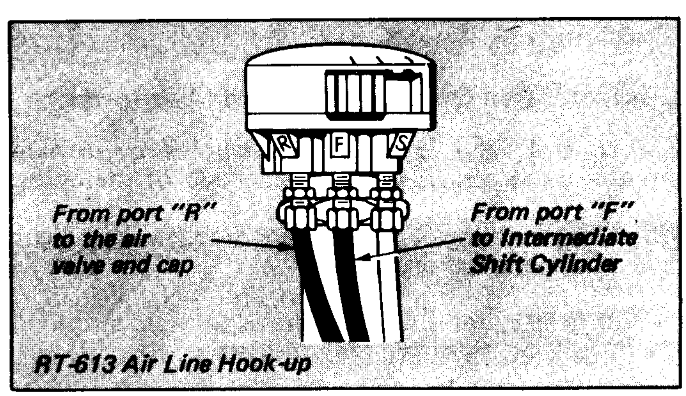
3. Move the control button to the "OD" or "UD" position. There should now be a steady flow of air coming from both the "F" and "R" ports.



4. If these results are not obtained, disconnect the supply air line at the "S" port and make sure that a steady flow of air is coming through the line. If air is present, this indicates a faulty control valve. The cause can be defective parts, damaged O-ring or a loose top plate.



5. Any steady flow of air from the exhaust "E" port indicates a faulty control valve or incorrect air line hook-up. Refer to the remainder of this section for further break down.



RT-613 Air Line Hook-up

NOTE: Control valve check for the RT-613 is the same as for the RT-9513 and RT-12513. However, "DIR." will read as "INTER." and "OD" or "UD" will read as "DIR." on the valve top plate.

Air Systems (continued)

Splitter Gear Air System (continued)

Splitter Gear Shift Cylinder

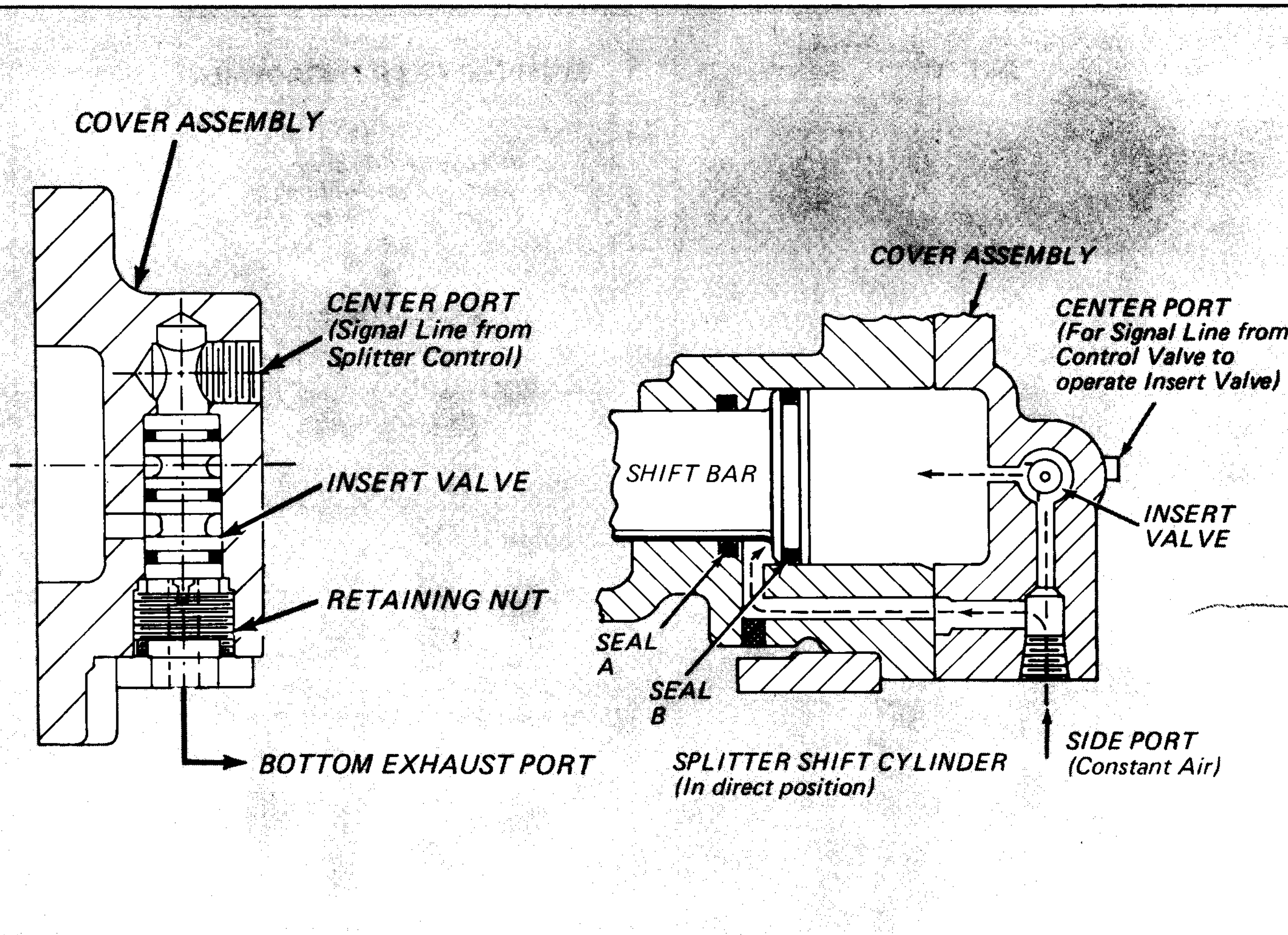


Figure 9. Splitter Shift Cylinder and Cover Assembly

Operation – Constant, regulated air is channeled through the cover to the front side of shift piston – air is always on this side of piston.

The shift piston is moved by removing or applying air (from constant supply) to the backside of piston. This piston area is larger and can overcome area of front side of piston. The removal or application of air on backside of piston is controlled by the insert valve in cylinder cover; this valve in turn is controlled by the splitter control valve.

Trouble Shooting Cylinder

There are two O-rings in the shift cylinder.

1. **Leak at seal A** – Possible failure to shift or slow shift to overdrive, or underdrive, plus pressurizing of transmission.
2. **Leak at seal B** – Slow shift in either direction, plus leak out cover exhuast when in overdrive or underdrive.

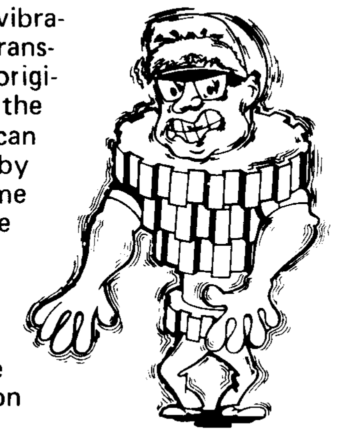
Trouble Shooting Cover Assembly

1. **Exhaust port** – Any constant flow of air out the cover exhaust port usually indicates a faulty insert valve. Exhaust should occur breifly ONLY when the splitter control is moved from "DIRECT" to "OVERDRIVE" or "UNDERDRIVE".
2. **Insert valve** – A faulty insert valve, leaking at the outer diameter O-rings or inner seals will result in failure to shift. Two indications of O-ring or seal failures are:
   a. Constant leak out cover exhaust.
   b. Constant leak out splitter control exhaust with splitter control in "DIRECT".

   The three O-rings on outer diameter of the insert valve can be replaced. If an inner seal is damaged, the entire insert valve will have to be replaced.

Common Transmission Complaints

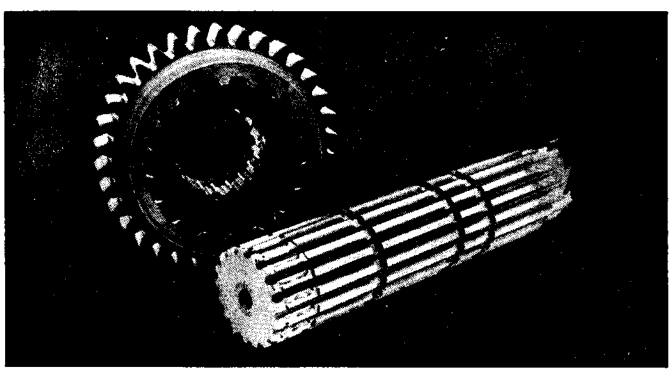
Vibration



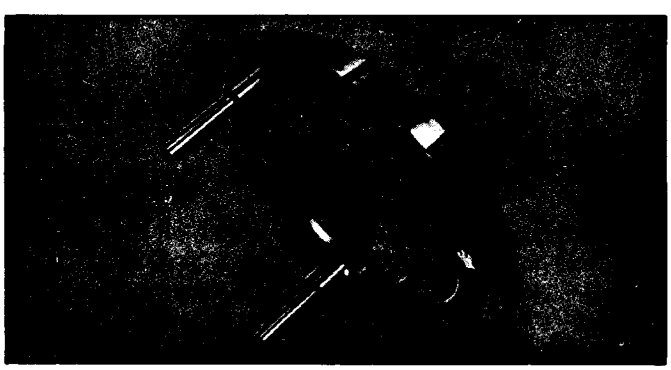
Although the effects of vibration will show up in the transmission, vibration usually originates somewhere else in the drive train. Vibration can usually be felt or heard by the driver; however, in some cases, transmission damage caused by vibration will occur without the driver's knowledge. (Refer to the "Torsional Vibration" section for the causes and cures of vibration problems.)

Some of the problems found in the transmission due to drive train vibration are:

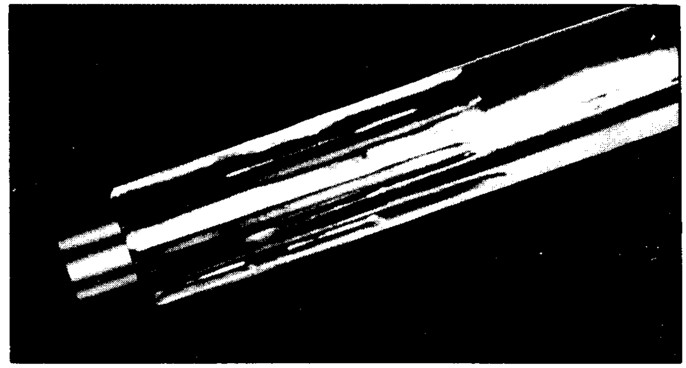
1. Gear rattle at idle. (See "Gears and Shafts" section.)



2. Gear and Shaft splines "fretted".



3. Broken or loose synchronizer pins.
4. Noise. (See "Noise", this section.)
5. Fretted bearings. (See "Bearing" section.)
6. Repeated rear seal leakage.
7. Continuous loosening of capscrews, brackets and mountings.



8. Input shaft spline wear.
9. Worn universal joints. (Not a transmission symptom, but an indicator of vibration.)

Some of the causes of vibration are:

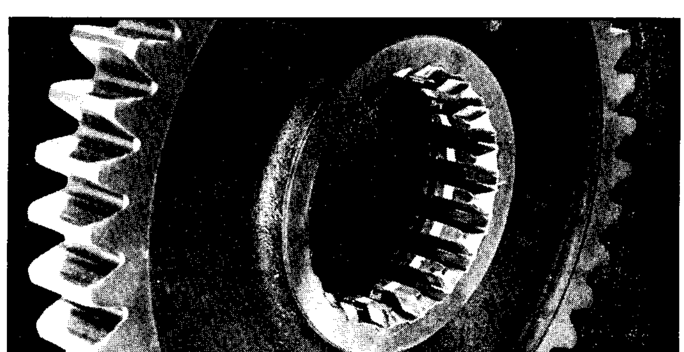
1. Drive line unbalance or misalignment. (See "Alignment" section.)
2. Unbalanced wheels or brake drums.
3. Rough running engine.
4. Broken or worn engine mounts.
5. Worn suspension.

Gear Slipout and Jumpout

Front Section

When a clutching gear is moved to engage with a mainshaft gear, the mating teeth must be parallel. Tapered or worn clutching teeth will try to "walk" apart as the gears rotate. Under the right conditions, slipout will result. Some of these conditions are:

1. Transmission mounted eccentrically with engine flywheel pilot.
2. Excessive gear clashing which shortens clutching teeth.

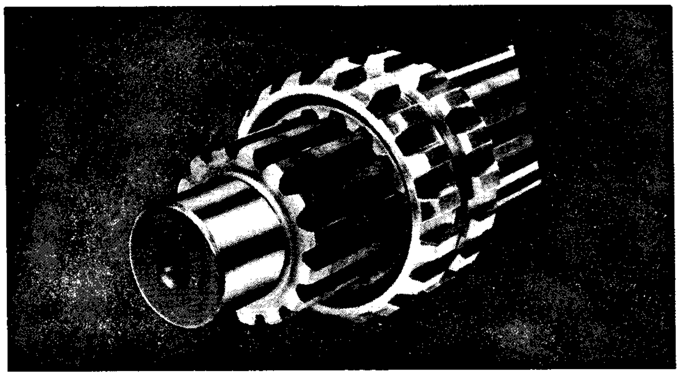


3. Gear clutching teeth wearing to a taper.

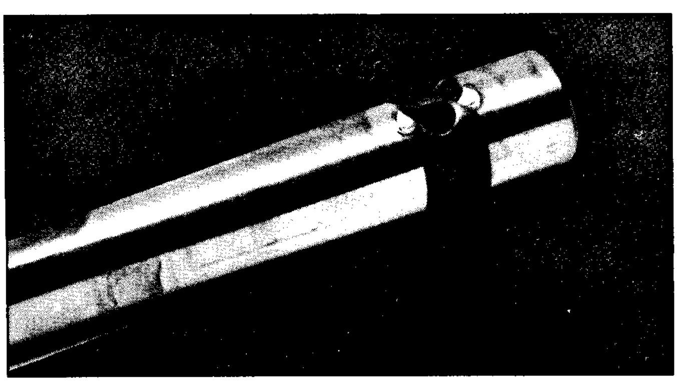
Common Transmission Complaints (continued)

Hard Shifting (continued)

To determine if the transmission itself is the cause of hard shifting, remove the shift lever or linkage from the top of the transmission. Then, move the shift blocks into each gear position using a prybar or screwdriver. If the yoke bars slide easily, the trouble is with the linkage assembly. If the trouble is in the transmission, it will generally be caused by one of the following:



1. **Splines of sliding clutch gear binding on mainshaft** as a result of a twisted mainshaft, bent shift yoke or bowed mainshaft key.
2. **Yoke bars binding in the bar housing** as a result of cracked housing, overtorqued shift block lockscrew, sprung yoke bar, or swelled areas on the yoke bar.



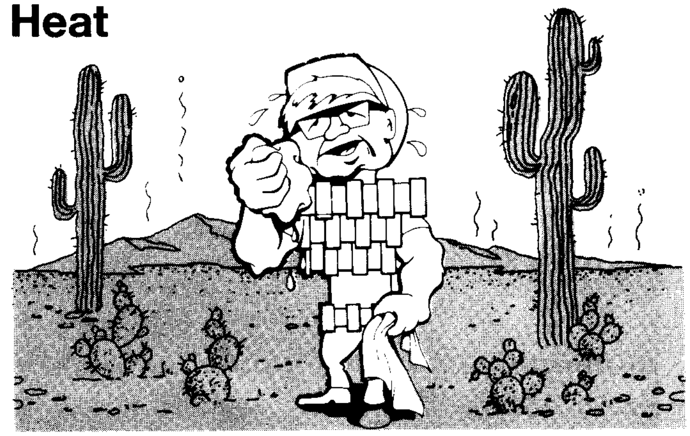
Swelling may occur at the edges of the interlock ball notches of the yoke bar if the shift lever is positioned so as to try to shift two bars at once. If this is repeated, the swelling becomes larger until it restricts the free movement of the bar.

Swelled areas may be ground off and smoothed with emery paper. Sprung rails should be replaced.

If hard shifting occurs only in first and reverse, the shift block detent plunger movement may be restricted. This can result from burrs on the plunger, or from overtightening the plunger spring plug. With the plunger blocked in the depressed position, the plug should be tightened until it bottoms out against the spring, then backed out 1/4 to 1/2 turns.

Gear clashing should not be confused with hard shifting. Gear clashing occurs when an attempt is made to engage the clutch gear before it has reached synchronization with the mainshaft gear. (See "Gears and Shafts" section.)

Heat



The transmission operating temperature should never exceed 250°F. (120°C.) for an extended period of time. If it does, the oil will breakdown and shorten transmission life.

Because of the friction of moving parts, transmissions will produce a certain amount of heat. Normal operating temperature is approximately 100°F. (40°C.) above ambient. Heat is dissipated through the transmission case. When conditions prevent the proper dissipation of heat, then overheating occurs.

Before checking for possible causes of overheating, the oil temperature gauge and sending unit should be inspected to make sure they are giving correct readings.

Following are some of the causes of overheating. (See also "Lubrication" section.)

1. Improper lubrication. Oil level too low or too high, wrong type of oil, or an operating angle of more than 12 degrees.
2. Operating consistently under 20 MPH.
3. High engine RPM.
4. Restricted air flow around transmission, due to transmission being "boxed in" by frame rails, deck lids, fuel tanks and mounting brackets, or by a large bumper assembly.
5. Exhaust system too close to transmission.
6. High ambient temperature.
7. High horsepower, overdrive operation.

In some cases an external oil cooler kit can be used to correct overheating problems.

Gears and Shafts

This section deals with analyzing gear and shaft failures to determine the type of failure. This in turn can give the mechanic a clue as to the cause.

Clashing

Snubbing and clashing gears while shifting are frequent abuses to which unsynchronized transmissions are subjected. Light snubbing will do little damage. The real damage is done by the hard clash shift caused by engaging gears which are far out of synchronization. This can break pieces of metal from the ends of the clutching teeth, Figure 1.

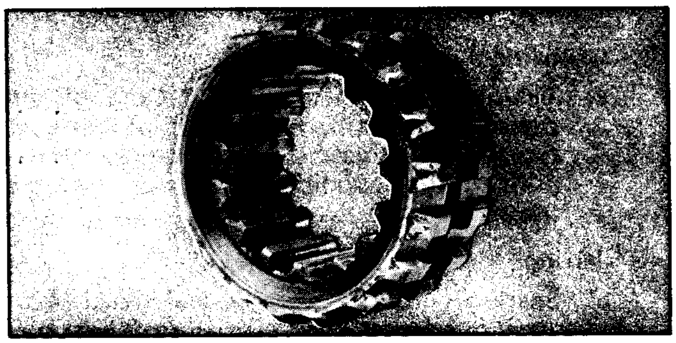


Figure 1. Broken and snubbed clutching teeth due to clashing.

Clashing gears can be traced to one of three causes:

1. **Improper shifting** — This applies to drivers who are not familiar with the shift pattern or have not learned the RPM spread between shifts.
2. **Clutch** — Clashing when starting up in first or reverse gear can be caused by insufficient clutch clearance or a dragging clutch not releasing properly. This makes the transmission countershafts and mainshaft gears continue rotating while the clutch pedal is depressed. Clashing results when the non-rotating clutch gear is forced to mesh with a rotating mainshaft gear.
3. **Inertial force** — Countershafts and mainshaft gears usually take from 3 to 5 seconds to stop rotating after the clutch has been disengaged. Attempting to mesh a clutch gear with a mainshaft gear before the mainshaft gear stops will result in clashing. If the transmission is not equipped with a clutch brake or countershaft brake, it is necessary to pause a few seconds after depressing the clutch pedal before attempting initial engagement of the transmission.

Gear Failures

Normal Wear

All gear teeth wear because of the sliding action which takes place as mating teeth mesh. Normal wear is a constant and slow wearing of the tooth surface. Transmission gear tooth life can be shortened by various adverse conditions. These conditions and the failures resulting from them are discussed in the following paragraphs.

Gear Tooth Fracture

A serious failure is the actual breaking of a tooth. Not only will the broken gear fail, but serious damage may occur as a result of the broken tooth running through the gearing.

Fractures which result from a severe shock load or occur after running only a very few cycles under a heavy load are considered impact fractures.

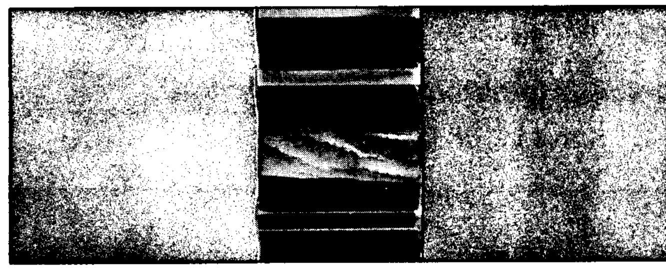


Figure 2. Broken tooth caused by impact fracture.

Impact fractures are identified by a "hump" on the compression side of the fractured area, Figure 2. The more cycles the gear has run, the smaller this hump will be.

Fatigue fractures occur after running many cycles under light to moderate overload or after a number of minor shock loads.

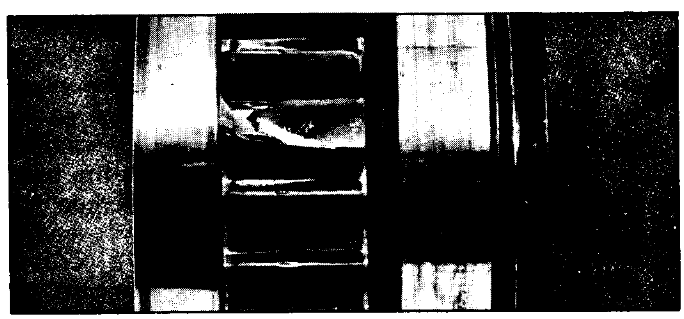


Figure 3. Fatigue fracture identified by "beach" marks.

Fatigue fractures are recognized by the presence of "beach marks" on the fractured area, Figure 3. These marks are made as the tooth progressively cracks under a load which is heavy enough to enlarge the crack, but not great enough to break the entire tooth off at one time. The tooth breaks off when there is insufficient gear tooth strength remaining to carry the load.

Pitting and Spalling

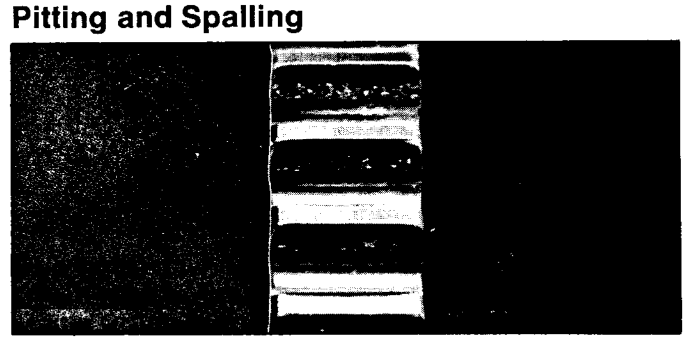


Figure 4. Gear tooth pitting caused by excessive loading.

Gears and Shafts (continued)

Gear Rattle at Idle

Mainshaft gears are designed to have a specified amount of axial clearance which allows them to rotate freely on the mainshaft. The amount of clearance is governed by the use of washers. A rough idling engine can set up vibrations, causing the mainshaft gears to rattle as they strike mating gears. This condition can usually be cured by improving the idling characteristics of the engine. Tolerence washers may have to be changed to bring the axial gear clearance to within tolerance on high mileage units.

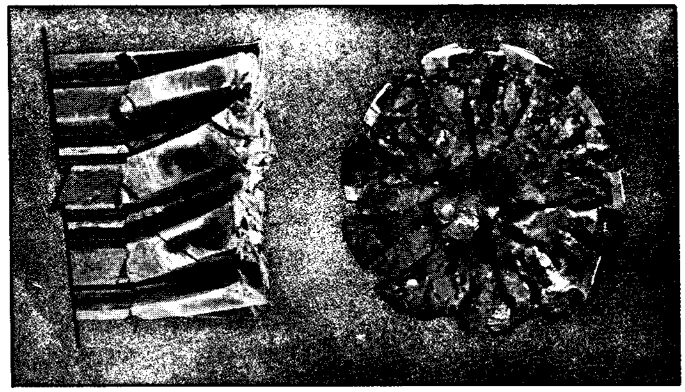


Figure 9. Side and front view of shaft impact fracture.

Shaft Twist and Fracture

Failure of transmission shafts through fracturing or twisting is caused when stresses are imposed on them which are greater than they were designed to withstand. The main causes for these failures are:

1. Improper clutching techniques.
2. Starting in too high of gear (either front or auxiliary section).
3. Lugging.
4. Attempting to start with brakes locked.
5. Transmission used for application it was not designed to withstand.
6. Bumping into dock when backing.
7. Improper mounting of adjustable 5th wheel.

As with gear teeth, shafts may fracture as a result of fatigue or impact. An example of an impact fracture is shown in Figure 9.

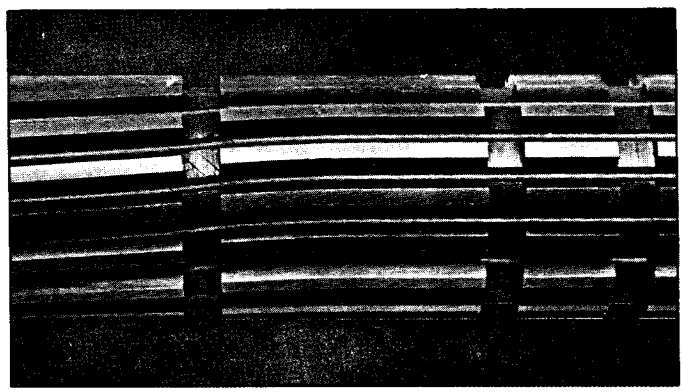


Figure 10. Shaft twist

Loads not severe enough to cause shaft fractures may cause the shaft to twist, Figure 10.

Bearings

Fatigue

Figure 1. Raceway metal breaking down causing flaking or spalling.

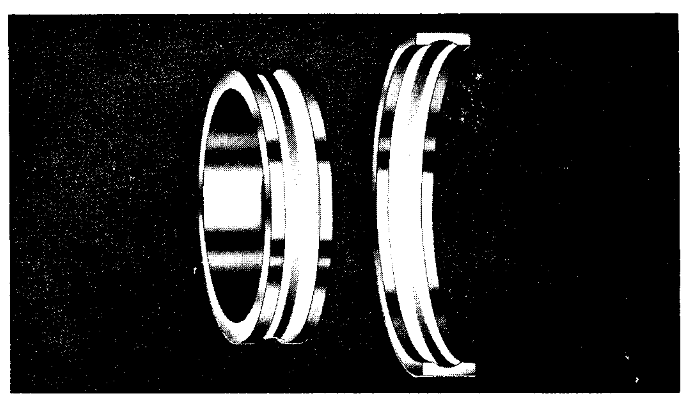


Figure 2. Ball path pattern caused by out of round squeeze.

Bearing fatigue is characterized by flaking or spalling of the bearing raceway, Figure 1. Spalling is the granular weakening of the bearing steel which causes it to flake away from the raceway. Because of their rough surfaces, spalled bearings will run noisy and produce vibration.

Normal fatigue failure occurs when a bearing "lives out" its life expectancy under normal loads and operating conditions. This type of failure is expected and is a result of metal breakdown due to the continual application of speed and load. Premature fatigue failure may occur in transmissions when the bearing

Bearings (continued)

Contamination (continued)

lapping compound and produce a very highly polished surface on the raceways and balls or rollers. This lapping process will significantly shorten the life of the bearing.

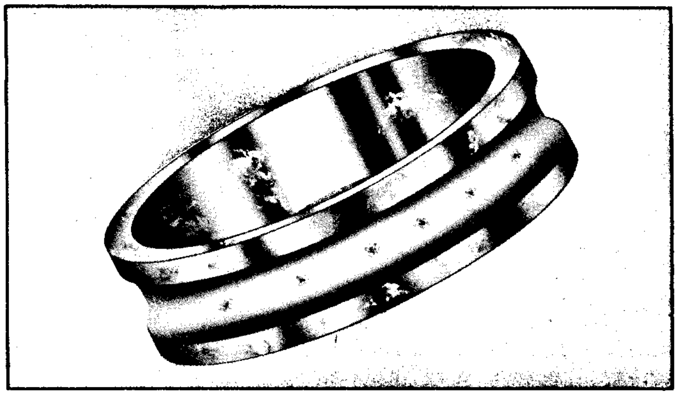


Figure 6. Inner race showing contamination.

Impurities will always enter the transmission during its normal breathing process. This will not seriously affect the bearings if the transmission oil is changed as recommended.

New bearings should be stored in their wrappers until ready for use. Used bearings should be thoroughly cleaned in solvent, light oil or kerosene, covered with a coat of oil and wrapped until ready for use. Always use a new wrapping after reoiling.

Misalignment

Misalignment, Figure 7, can possibly occur in the input shaft drive gear bearing if the transmission is mounted eccentrically with the pilot bearing bore in the flywheel. An indication of this condition would be damaged to the ball separators and shield.

The clutch housing, clutch housing mounting face, and pilot bearing should be checked for eccentricity, foreign matter and proper mounting position when trying to locate the cause of the misalignment. (See "Alignment" section.)

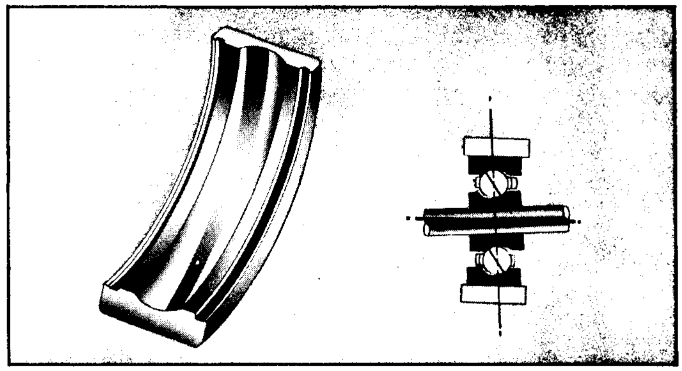


Figure 7. Angular ball path due to misalignment.

Electric Arcing

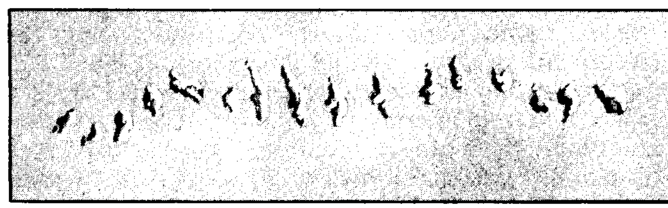


Figure 8. Electrical pitting on surface of raceway.

When an electric current passing through a bearing is broken at the contact surfaces of the ball and races, arcing results, which will pit the bearing components, Figure 8. In extreme cases, the balls or rollers may actually be welded to the bearing races, preventing the bearing from rotating.

This condition may occur in truck transmissions as a result of electric welding on the truck with an improper ground. When doing either A.C. or D.C. welding, never place the ground so as to allow current to pass through the transmission.

Transmission Alignment

Concentric Alignment of Transmission to Engine

To correct:

- **Direct gear slipout**
- **Drive gear bearing failure**
- **Premature input shaft spline wear from rear hub of two plate clutches.**

Concentric alignment means that the engine and transmission must have a common axis, Figure 1. The purpose of this section is to set forth the procedures to use in checking for possible misalignment.

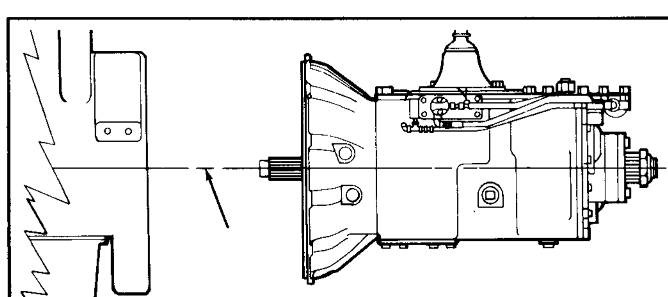


Figure 1. Concentric alignment, common axis.

Engine Flywheel Housing Face

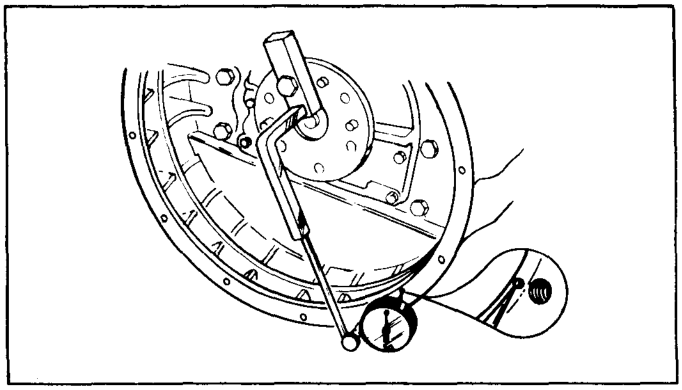


Figure 7. Dial indicating face of engine flywheel housing.

Dial indicate the face of engine flywheel housing. With dial indicator secured to flywheel, move gauge finger to contact face of flywheel housing, Figure 7. Mark high and low points in the same manner as in previous step. SAE maximum total runout for the flywheel housing face is .008" with SAE No. 1 and No. 2 housings. **NOTE:** Mark the high and low runout readings in clock positions if it is necessary to reposition the flywheel housing.

Flywheel Face

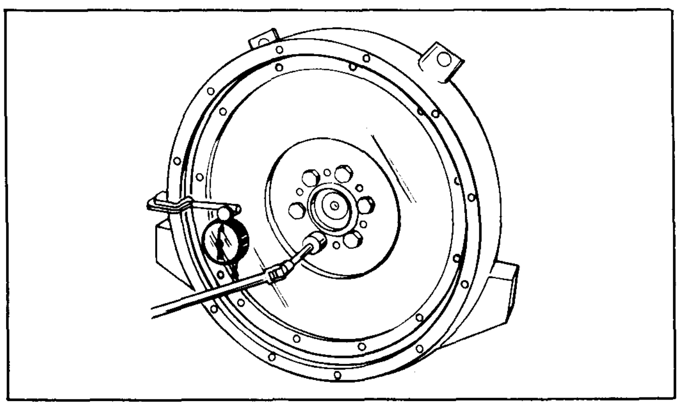


Figure 8. Dial indicating face of flywheel.

Dial indicate the flywheel face. Secure dial indicator to engine flywheel housing near the outer edge, Figure 8. Turn flywheel to obtain readings. Maximum allowed is .001" runout or face wobble per inch of flywheel radius. For example, if vehicle has a 14" clutch and readings are taken just off the outer edge of the clutch disc wear, maximum tolerence would be .007".

Flywheel Pilot Bore

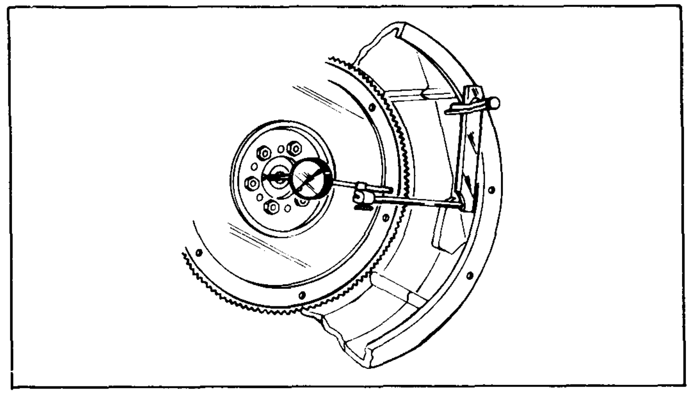


Figure 9. Dial indicating pilot bearing bore.

Dial indicate pilot bearing bore of flywheel. With indicator secured to flywheel housing, move gauge finger to contact pilot bearing bore surface, Figure 9. Turn flywheel and obtain readings. SAE maximum total runout for the pilot bearing is .005".

Transmission Clutch Housing

The transmission clutch housing face and pilot can not be checked accurately in the field without special measuring tools. Recommended maximum runout for the transmission clutch housing face and pilot is .003" with SAE No. 1 and No. 2 housings.

Torsional Vibration

Checking Drive Line U-Joint Operation Angles

The action of a drive line with a universal joint at either end working through an angle results in a peculiar motion. The drive line will speed up and slow down twice for each revolution. If the working angles at either end of the shaft are unequal, torsional vibration results. This torsional vibration will tend to cancel itself out if both joint working angles are equal.

Types of Noise

Noise or vibration which occurs only at certain road speeds and diminishes as speed increases is generally caused by unequal working angles of drive line joints.

Noise or vibration which is persistent throughout the speed range and varies in intensity with change of speed may be caused by unbalanced drive lines, unbalanced brake drums or discs, or drive lines with universal joints out of phase.

Taking Readings (continued)

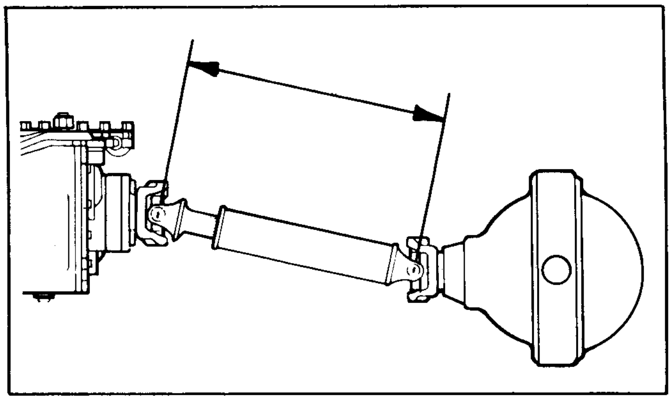


Figure 14. Measure from joint to joint.

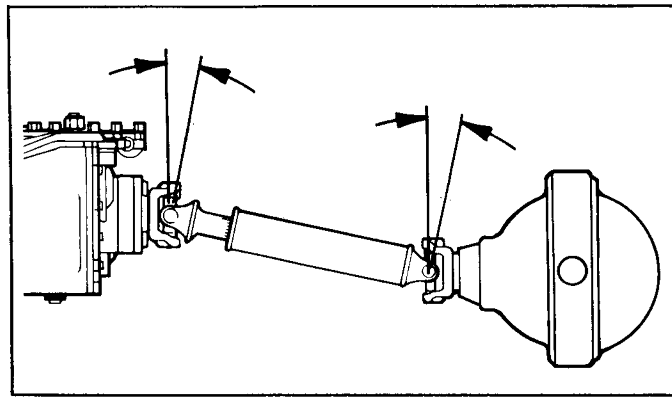


Figure 15. Transmission and rear axle readings should be equal.

At the rear axle, take readings from a machined surface differential carrier that is in the same plane as the axle pinion shaft, or from machined surface that is perpendicular to pinion shaft, whichever is easier.

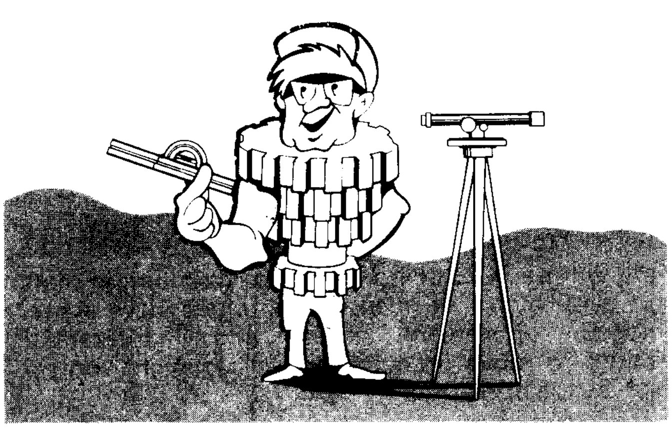
If vibration occurs while operating empty, take readings in empty condition. If it occurs when loaded, take readings when loaded.

When it is necessary to measure drive line lengths, measure from joint center to joint center, Figure 14.

Limits

Manufacturer's specifications should be followed when making initial angularity check. Some manufacturers have found it necessary to vary from the ideal due to geometrical limitations. If vibration persists after adhering to manufacturer's specifications, contact the manufacturer's representative.

Angularity Checks Parallel Flanges or Yokes



1. Single Axle Vehicles
   a. Transmission angle. Take reading of transmission angle. This angle is the angle to which the rear axle joint angle must match. The transmission angle will have a declination reading of from 0 to 5 degrees in most cases.
   b. Axle angle. Take reading either from machined surface of axle housing or pinion bearing retainer. **This angle must be within one degree of the transmission angle.**
   c. **Example:** If transmission angle reading is 3 degrees down to the rear, the rear axle angle should be 3 degrees up, Figure 15.
2. Tandem Axles or Vehicles with Auxiliary Units
   a. Take transmission angle reading.
   b. Take reading from joint of front tandem axle or auxiliary joint. **This reading should be within one degree of transmission angle.** **NOTE:** The rear joint of front tandem axle will be the same as the front joint.
   c. Take reading of joint angle at tandem rear axle, or axle to rear of auxiliary. **This angle must be within one degree of transmission angle.**

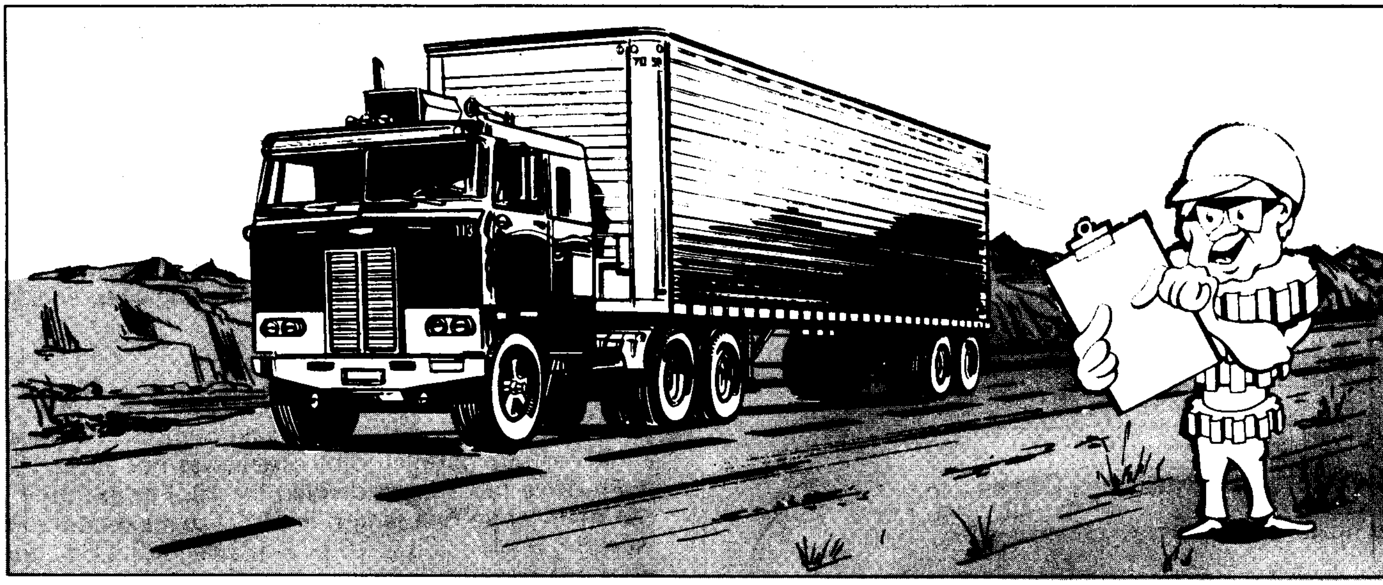
Joint Working Angle Limits (Parallel)

Universal joints have a maximum working angle, depending on type and manufacture. It is recommended that the joint working angle for parallel joint assembly not exceed 8 degrees for main drive lines over 40" long. For main drive lines under 40" the maximum angle should not exceed Length (L) divided by 5. (This limit does not apply to inter-axle drive lines.) **Example:** For a 35" drive line, the maximum joint working angle would be 35 ÷ 5 or 7°. This working angle must not be exceeded.

Place protractor on drive line to obtain angle of drive line from transmission to axle. The difference between the drive line angle and the joint angle is the joint working angle. For instance, if the transmission is 3 degrees down, and the drive line angle is down 7 degrees, the transmission joint working angle is 7 minus 3 or 4 degrees.

On tandem drive or auxiliary installations, take readings in the same manner, comparing the universal joint angles to the drive line angle to which it is attached.

Preventative Maintenance



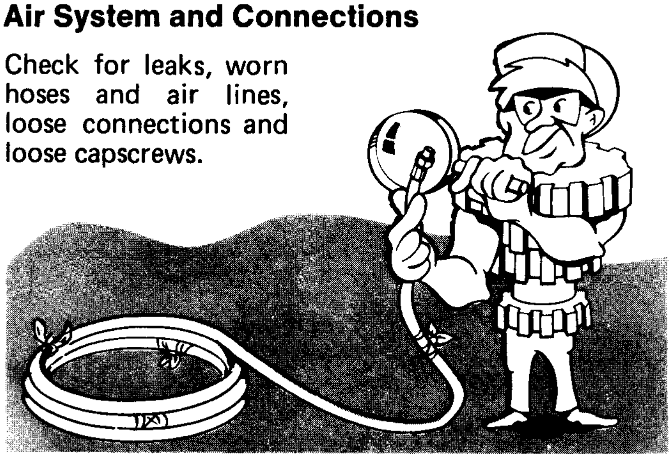
A good preventative maintenance program can avoid breakdowns, or reduce the cost of repairs. Often, transmission problems can be traced directly to poor maintenance.

Following is an inspection schedule that may be helpful in setting up a PM program. This schedule is not all inclusive as inspection intervals will vary depending upon operating conditions.

Inspection to be Made Daily

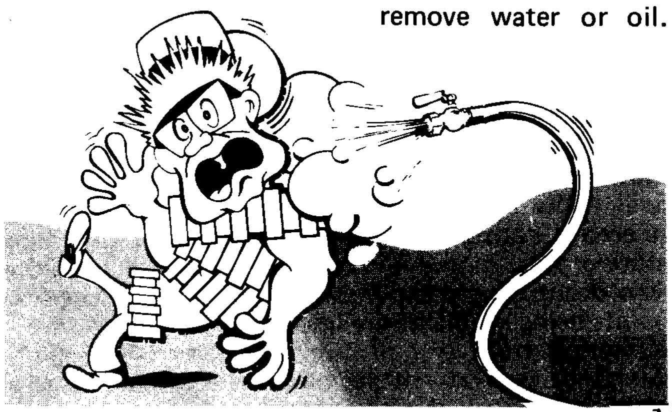
Air System and Connections

Check for leaks, worn hoses and air lines, loose connections and loose capscrews.



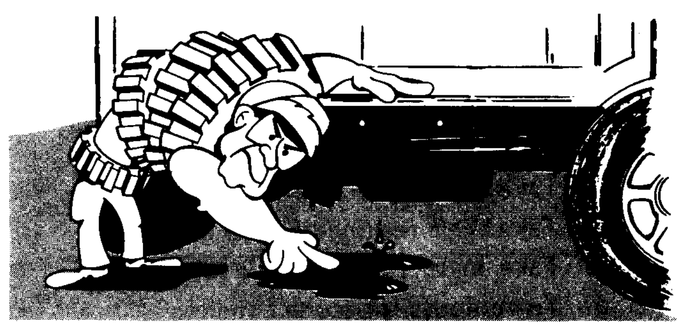
Air Tanks

Bleed air tanks to remove water or oil.



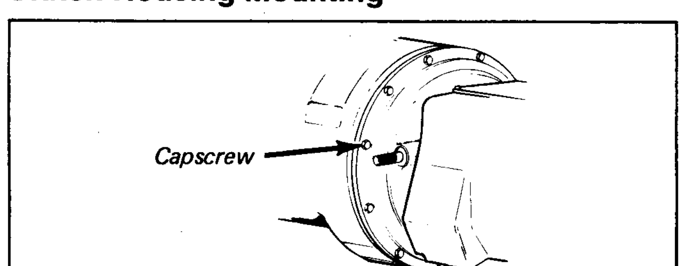
Oil Leaks

Check around bearing covers, PTO covers and other machined surfaces. Also check for leaks on ground before starting truck in the morning.



Inspections to be Made Every 5,000 Miles

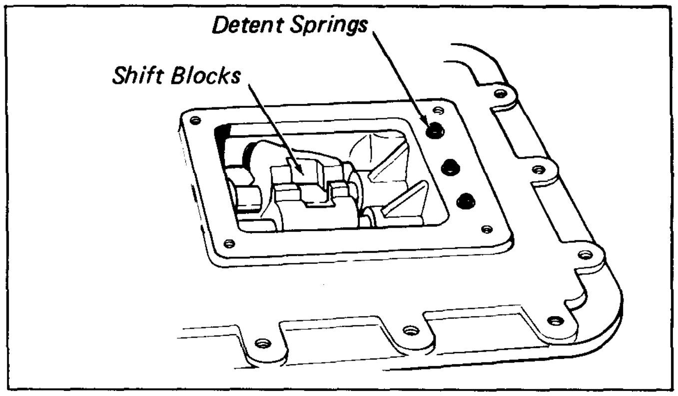
Clutch Housing Mounting



Check all capscrews in bolt circle of clutch housing for looseness.

Preventative Maintenance (continued)

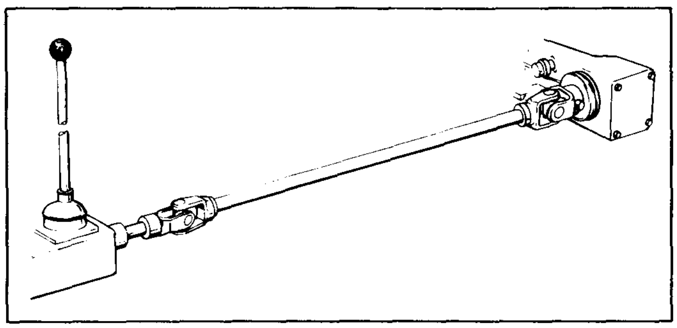
Shift Blocks and Poppet Springs



Check shift block slots for wear.

Check for broken, set or missing detent springs.

Check Remote Control Linkage



Check linkage U-joints for wear.

Check for binding.

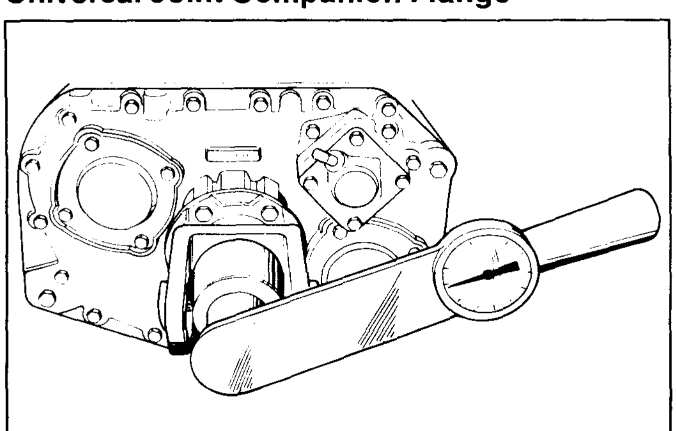
Lubricate U-joints.

Check connections for tightness.

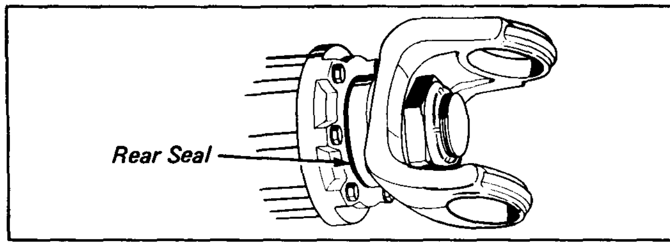
Check for bushing wear.

Inspections to be Made Every 30,000 Miles

Universal Joint Companion Flange



Check for proper torque, 450 to 500 ft. lbs.



Check for rear seal wear.

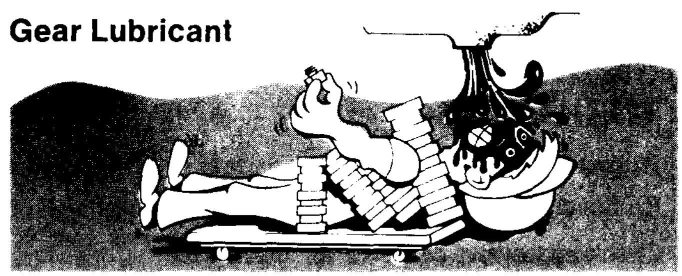
Output Shaft

Pry upward against output shaft to check radial clearance in mainshaft rear bearing.

Check splines for wear from movement and chucking action of the universal joint companion flange.

Inspections to be Made at Each Oil Change

Gear Lubricant



Change at specified intervals. (See "Lubrication" section.)

Use only recommended gear oils. (See "Lubrication" section.)

Inspect oil for excessive contamination. Reduce oil change interval if necessary.

Shift Cylinders

Remove caps and check for contamination.

Inspections to be Made According to Manufacturer's Specifications

Clutch

Check clutch disc faces for wear.

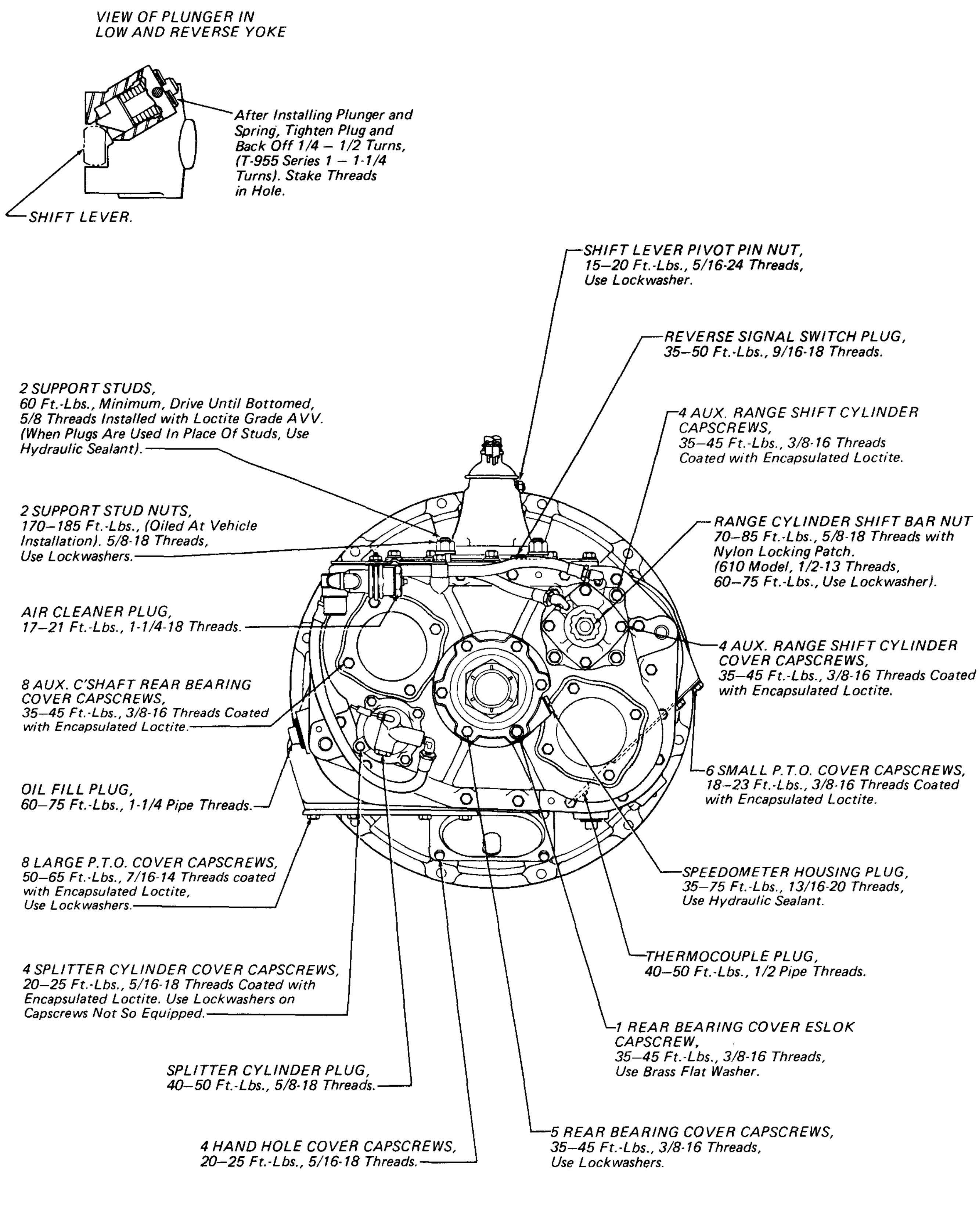
Check dampening action of clutch driven plate.

Release Bearing

Remove hand hole cover and check axial and radial clearance in release bearing.

Check relative position of thrust surface of release bearing with thrust sleeve on push type clutches.

Torque Recommendations (continued)



inspection and failure analysis

This section, basically compiled from actual case histories, describes some of the common types of rear axle failures and their causes. The unretouched photos illustrate conditions that occurred under actual vehicle operation or situations duplicated by testing dynamometers in the Eaton Corporation, Axle Division.

There are four items to consider when repairing an axle.

1. What parts failed?
2. How to repair the axle.
3. What caused failure?
4. How to prevent a repeated failure.

The text outlines these procedures under each failure condition listed.

To complete the investigation of failure and to definitely prevent repeat failures, information must be available to provide answers to the following list of questions:

1. Is vehicle of sufficient capacity to do satisfactorily all that the owner expects?
2. Does general mechanical condition of vehicle indicate proper maintenance or are signs of abuse in evidence?
3. Is unrecommended equipment used? Is equipment overloaded?
4. Does operator understand correct operation of vehicle and handle it in prescribed manner?
5. Is lubricant used of recommended quality, quantity and viscosity?

Ring Gear and Drive Pinion

fractured ring gear teeth (figs. 1 and 2)

Repair: Replace ring gear and pinion as a matched set.

Cause of Failure: Figure 1 shows failure resulting from concentrated contact area on tooth heel, caused by excessive overloading beyond the designed strength of the gearing or incorrect gear adjustment (excessive backlash). Figure 2 shows failure resulting from excessive loading on tooth toe, caused by shock impact loading or incorrect gear adjustment (insufficient backlash). Shock loading also may cause the above conditions; even to the extent of breaking an entire ring gear tooth or teeth.

Prevent Recurrence: Proper operation of vehicle within approved rated capacity. Correct adjustment of ring gear to pinion backlash. (Refer to Adjustment Section of this manual.) Use ring gear and pinion matched set for replacement.

Fig. 1

Fig. 2

inspection and failure analysis

Ring Gear and Drive Pinion (continued)

pitted drive pinion teeth (fig. 5)

Repair: Replace ring gear and pinion as a matched set.

Cause of Failure: Extremely severe service. Deflection in the assembly resulting in abnormal pressures caused this concentration of pitted areas at tooth heel. Normally pressures are evenly distributed over the entire gear and pinion tooth faces. Under excessive loading, deflection throws pinion out of correct position in relation to ring gear thus concentrating contact areas on tooth heels. Pressures build up in these concentrated areas and the high pressures exceed strength of oil film. Without correct oil film, tooth surfaces break down and pitting condition occurs.

Prevent Recurrence: The more severe the service, the greater the need for quality and correct lubricant. (Refer to Lubrication Section of this manual.)

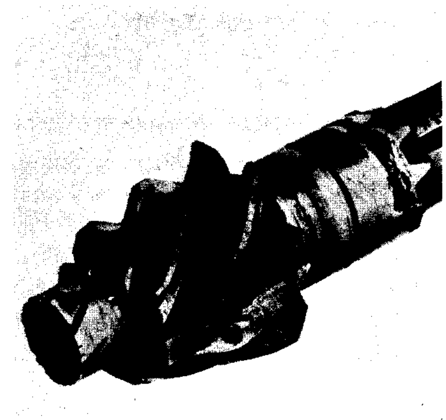


Fig. 5

fatigue fracture—drive pinion teeth (fig. 6)

Check for broken teeth and note type of break. A clear cut wavy fracture identifies fatigue as the cause. A shock fracture will not show these wavy lines. Fractured area will have a dull granular appearance.

Repair: Replace ring gear and pinion as a matched set.

Cause of Failure: Concentration of stresses frequently caused by abnormal and abusive operations.

During vehicle operation, momentary excessive stresses applied through the gears will frequently crack tooth surfaces. These cracks become focal points of stresses and fatigue fracture is the final result.

Continued operation of worn or pitted gears will also result in fatigue fracture. When part of the tooth is worn or pitted, the remaining bearing area must carry an increased load. Thus, concentration of stresses starts fatigue which results in fracture.

Prevent Recurrence: Avoid abusive and abnormal vehicle operation.

Fig. 6

Differential

shock fracture
side gears and pinions (fig. 7)

Repair: Replace damaged side gears. Replace side gears, side pinions and spider as a set.

Cause of Failure: Abusive operation of vehicle will frequently cause the shock fractures shown in figure 7. Note that broken teeth areas of side gear are spaced approximately 90° (where side pinions meshed). Sufficient shock load was exerted on one side pinion to cause it to split. When stresses exceed strength of gears, fractures of this type will occur.

Prevent Recurrence: Correct operation of vehicle. Do not overload vehicle.

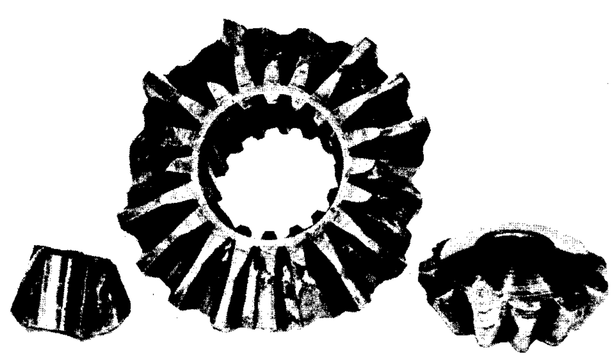


Fig. 7

inspection and failure analysis

Differential (continued)

worn splines—side gears (fig. 11)

Repair: Replace side gears with worn splines.

Cause of Failure: Abusive vehicle operation causing repeated shock load on splines will cause wear. Excessive backlash between axle shaft and side gear will result. This condition will cause shock throughout the entire axle assembly.

Prevent Recurrence: Proper vehicle operation.

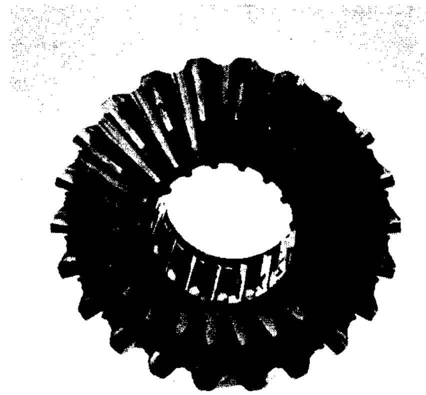


Fig. 11

scored or worn surfaces—thrust washers (fig. 12)

Compare thrust washer thickness with a comparable new washer. If thrust washer is worn more than 0.005 in., replace it.

Repair: Replace thrust washers scored or worn more than 0.005 in.

Cause of Failure: Lack of lubrication or improper lubricant. When lubricant film is not present, friction between metal to metal surfaces will cause wear or scoring. Lubricant may contain foreign substance or abrasive.

Prevent Recurrence: Maintain correct lubricant level. Use proper approved lubricant and change at regular intervals. (Refer to Lubrication Section of this manual for lubricant specifications.)

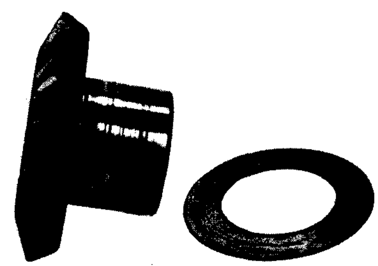


Fig. 12

Planetary Unit

worn teeth—high-speed clutch plate and differential bearing adjuster (figs. 13 and 14)

Repair: Replace high-speed clutch plate and differential bearing adjuster. Also examine sliding clutch gear for worn teeth and replace gear if faulty.

Cause of Failure: Improper shifting of gears.

Figure 13 illustrates worn teeth on high-speed clutch. This is caused by shifting too rapidly from low to high range without sufficient pre-select time or with improper throttle action. Wear is due to sliding clutch gear teeth clashing against high-speed clutch plate teeth.

Figure 14 illustrates worn teeth in differential bearing adjuster. This is caused by shifting too slowly from high to low range. Wear is due to sliding clutch gear teeth clashing against differential bearing adjuster (low speed clutch plate) internal teeth.

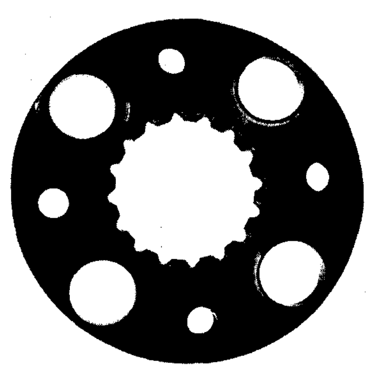


Fig. 13

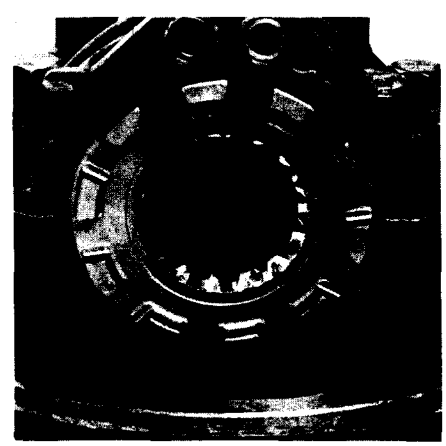


Fig. 14

Prevent Recurrence: Observe correct procedures when shifting 2-Speed or 3-Speed axle. Also observe correct maintenance of the axle shift system.

inspection and failure analysis

Bearings

worn bearing rollers (fig. 18)

Also examine for pitted rollers, cups and cones.

Repair: Replace bearing. Always replace both cups and cones.

Cause of Failure: Foreign substance in lubricant. Comparing roll ends with new bearing (A) and worn bearing (B), it is readily apparent that wear has occurred. New bearing (A) rollers have a raised ground and polished shoulder that contacts a matching shoulder on the inner race. Worn bearing (B) rollers have no shoulder. This lapping and wearing of the roll ends was caused by foreign substance in the lubricant.

Prevent Recurrence: Use of recommended lubricant changed at regular intervals. (Refer to Lubrication Section of this manual.) *Readjustment of bearings in this worn condition will not provide a satisfactory repair job.*

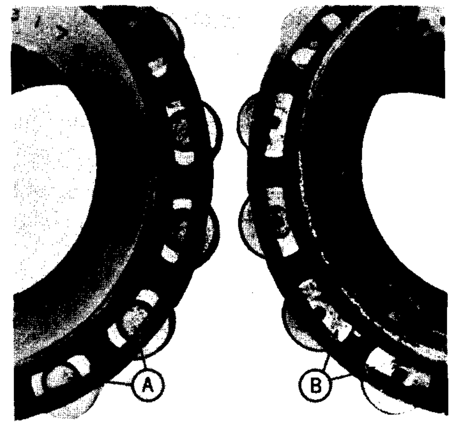


Fig. 18

Axle Shaft

twisted or broken axle shaft (fig. 19)

Repair: Replace shaft.

Cause of Failure: Abusive or very severe operation of vehicle. Usually, investigation will disclose overloading of vehicle or that drivers are improperly using equipment. Continuous abnormal twisting of the shaft may result in a complete fracture (see fig. 19). Technically, the failure is the result of a series of torque or stress applications greater than the strength of the material.

Prevent Recurrence: Operate vehicle properly. Avoid abusive overload.

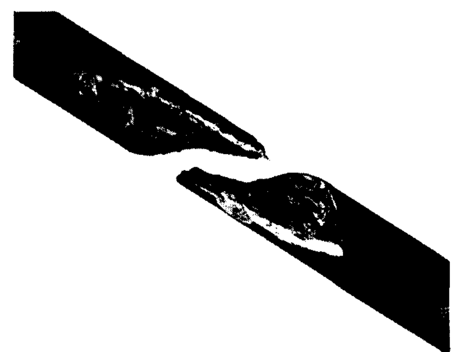


Fig. 19

fractured axle shaft at flange (fig. 20)

Repair: Replace axle shaft. Also examine axle housing for bent condition.

Cause of Failure: Misalignment due to loose wheel bearing adjustment or bent axle housing. Figure 20 illustrates a progressive fracture of shaft extending from outside diameter to approximately one-third the distance to the center of the shaft. This progressive fracture occurred slowly until shaft was too weak at this point. The remaining portion (dark area at center of shaft) was then broken through in a single action. This final fracture could occur when vehicle is operating under desirable conditions.

Prevent Recurrence: Replace bent axle housing. Make certain wheel bearings are correctly adjusted. (Refer to Adjustment Section of this manual.)

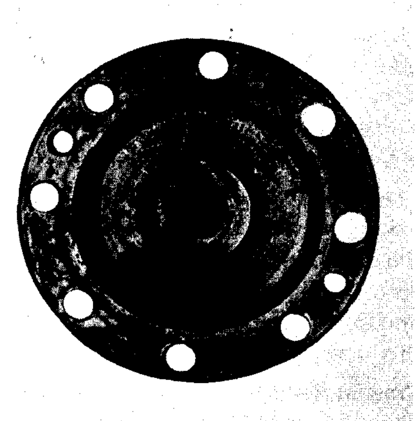


Fig. 20

inspection and failure analysis

Companion Flange

spline wear or seal bearing surface wear

Repair: Replace companion flange if splines or seal bearing surface are worn.

Cause of Failure: Spline wear may be caused by abusive and abnormal operation of vehicle. Another cause of this type of failure can be attributed to loose flange nuts. Hard non-flexible oil seal bearing lip will cause wear of flange seal bearing surface.

Prevent Recurrence: Prevent spline wear by normal operation of vehicle. Replace flange and oil seal if flange oil seal bearing surface is worn. When installing flange, make sure the nut is tightened to the proper torque value.

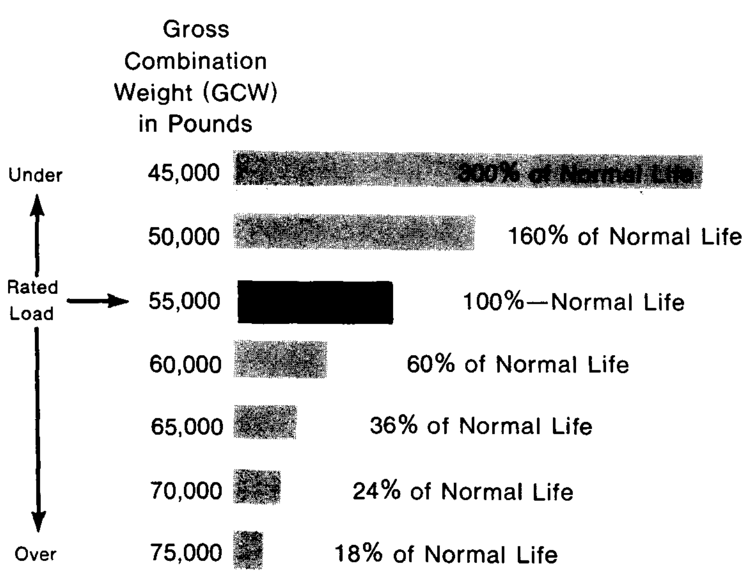
NOTE: It is recommended that your Preventive Maintenance schedule include inspection of the flange for looseness and make sure the flange nut is tightened to the correct torque value.

Gaskets—"O" rings—Oil Seals

Replace all gaskets, "O" rings and oil seals when axle has been disassembled. Make certain bearing lip of new encased-type oil seals is flexible. If lip (leather-type seals) seems hard and non-flexible, soak oil seal in oil before installing. *A hard, non-flexible oil seal bearing lip may wear the metal surface that it contacts.*

Average Life of Overload and Underloaded Gears

This graph shows the approximate percentage of life expectancy of axle gear sets and other axle parts. The figures are based upon dynamometer tests conducted at Eaton Corporation, Axle Division and are the direct result of accurately simulated load conditions.



These figures are based on axles with 55,000 lbs. gross combination weight (GCW) ratings. The same life expectancy holds true with axles rated at other GCW ratings.

Hints for Longer Axle Life

Years of experience in building and servicing truck axles has resulted in the conclusion that there are four major factors governing their performance.

APPLICATION. Misapplication of a vehicle generally reduces axle life. To ensure economical operation under such conditions as logging, mining and continuous operation in mountainous terrain, it is advisable that an axle one size larger than normally used for normal service be selected.

LOADS. Loads will affect both the housing and the differential assembly. An axle housing can take some bending and still spring back to its original shape. Shock loading, hitting an obstruction and other similar abuse can bend the housing past the yield point and result in extensive damage to axle components. Overloading an axle can put undue stress on the axle gears, thereby reducing axle life.

DRIVER. The driver of a vehicle must be considered, just as well as other factors, in determining desired performance. Correct operation of the axle, as well as other vehicle components, is the direct result of driver performance. Proper handling instructions for drivers can increase the economy of any truck operation.

LUBRICATION. The use of proper lubricants in an axle has proved to be one of the best preventions of axle failure. Refer to Lubrication section of this manual for lubricant specifications.

Drive Pinion Bearing Preload Adjustment (continued)

spring scale method

To check pinion bearing preload with a spring scale, hold drive pinion in a vise or arbor press. If a vise is used, tighten drive pinion nut to torque setting shown in table on pages 13 and 14. If an arbor press is used, apply pressure to setting shown in table on pages 13 and 14.

Wrap a soft wire around bearing cage (see figs. 23 and 24), and pull on a line tangent to outside diameter of cage with pound scale attached to wire. Note scale reading and compare with correct preload range shown in table on pages 13 and 14. If within range indicated, bearing preload adjustment is correct.

If bearing preload is incorrect, adjust by changing pinion bearing spacer. Use a thicker spacer to decrease preload and a thinner spacer to increase preload. *Do not use shim stock to increase thickness of spacer. Always use correct size spacer.*

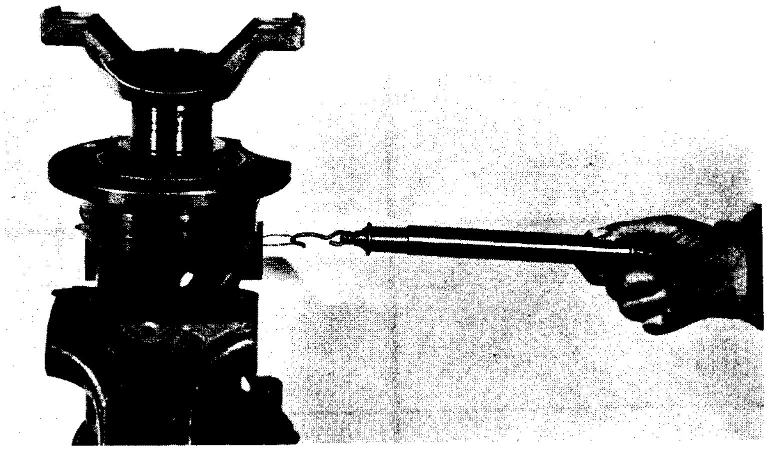


Fig. 23. Checking Drive Pinion Bearing Preload with a Spring Scale (pinion in vise) for Tandem Drive Axles

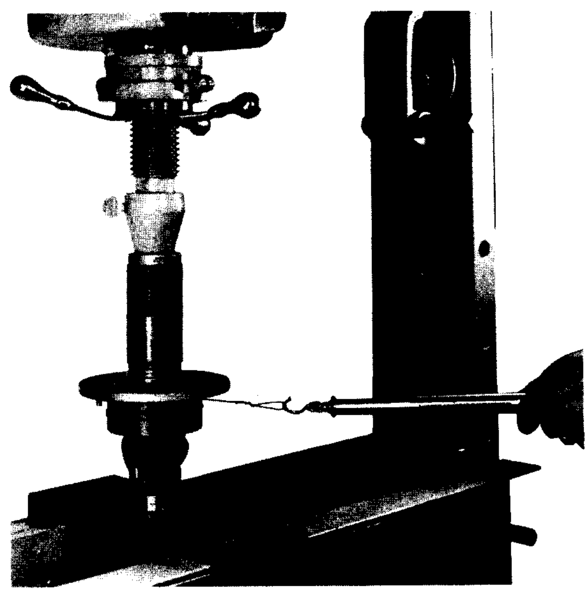


Fig. 24. Checking Drive Pinion Bearing Preload with a Spring Scale (pinion in press)

Drive Pinion Position Adjustment

preset pinion position during reassembly

Drive pinion position in relation to ring gear is adjusted by removing or adding shims between pinion bearing cage and differential carrier or power divider case.

To assist in adjustment of ring gear and drive pinion, pinion should be positioned as near as possible to the correct position during reassembly. This can be accomplished by using the same size and quantity of shims removed during disassembly. This applies regardless if original or new ring gear and drive pinion set is used in reassembly.

The drive pinion position may also be set with a depth gauge. Refer to table on pages 13 and 14 for basic dimension used for gauge setting.

Drive Pinion Adjustment Specifications (continued)

TANDEM DRIVE AXLES	Specifications for Drive Pinion Bearing Preload Adjustment				Drive Pinion Position Adjustment		
	PINION BEARING SPACER THICKNESS (nominal)	DRIVE PINION NUT TORQUE SETTING (ft.-lbs.)	ARBOR PRESS PRELOAD PRESSURE SETTING (tons)	SPRING SCALE READING (pounds) To obtain 15 to 35 in.-lbs. Torque	PINION BEARING CAGE SHIM PACK (nominal)		DEPTH GAUGE SETTING
AXLE MODELS					Conical or Late Model Ribbed Carriers	Early Model Ribbed Carriers	
30DS	0.638	500-700	9-10	6-14	0.023	0.040	4.125
30DT, 30D-3, 30DP	0.638	500-700	9-10	6-14	0.023	0.040	4.125
30RS	0.528	320-450	5-6	7-16	0.020	0.030	4.125
30RT, 30R-3, 30RP	0.528	320-450	5-6	7-16	0.020	0.043	4.125
34DS, 34DT, 34D-3, 34DP	0.642	500-700	9-10	5-12	0.031	0.056	4.4062
34RS	0.639	400-600	7-8	6-14	0.022	0.030*	4.4062
34RT, 34R-3, 34RP	0.638	400-600	7-8	6-14	0.022	0.037	4.4062
38DS, 38DT, 38D-3, 38DP	0.642	500-700	9-10	5-12	0.031	0.056	4.4062
38RS	0.639	400-600	7-8	6-14	0.022	0.030*	4.4062
38RT, 38R-3, 38RP	0.638	400-600	7-8	6-14	0.022	0.037	4.4062
42DT, 42DP	0.642	500-700	9-10	5-12	0.031	0.056	4.4062
42RT, 42RP	0.638	400-600	7-8	6-14	0.022	0.037	4.4062
44DS	0.188	550-850	10-11	5-11	0.025		4.7812
44DT, 44DP	0.188	550-850	10-11	5-11	0.025		4.7812
44RS	0.185	550-850	10-11	5-11	0.023		4.600
44RT, 44RP	0.188	550-850	10-11	5-11	0.023		4.7812
44DSM	0.188	550-850	10-11	5-11	0.025		4.7812
44RSM	0.185	550-850	10-11	5-11	0.025		4.600
50DT, 50DP DS340, DT340, DP340 DS380, DT380, DP380 DS400, DT400, DP400	0.642	500-700	9-10	5-12	0.031		4.4062
50RT, 50RP RS340, RT340, RP340 RS380, RT380, RP380 RS400, RT400, RP400	0.638	500-700	7-8	6-14	0.022		4.4062

*Used with 0.125 spacer on some models

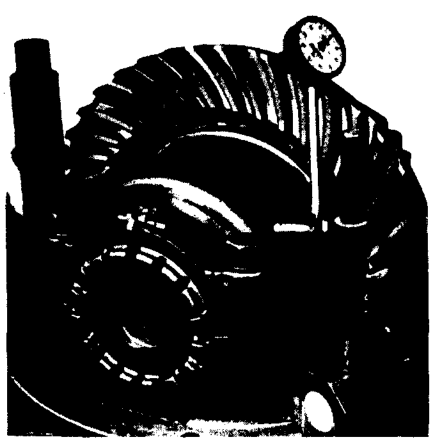


Fig. 25. Measuring Ring Gear Backlash with Dial Indicator

Tooth Contact Pattern

check tooth contact pattern

Tooth contact pattern consists of the lengthwise bearing and profile bearing. The lengthwise bearing is the bearing along the tooth of the ring gear. The profile bearing is the bearing up and down the tooth (See fig. 26). In determining correct ring gear tooth contact, these two types of bearings must be considered separately to obtain proper results in combination.

With differential bearings adjusted correctly, paint at least ten ring gear teeth with red lead or prussian blue. Turn ring gear by hand a few revolutions in both directions to obtain impressions (or patterns) of tooth contact. Compare contact patterns with those shown in figure 28. If tooth contact patterns are not correct, move ring gear and/or drive pinion as necessary to adjust for correct pattern. Keep in mind that ring gear movement affects lengthwise bearing and that drive pinion movement affects the profile bearing.

Adjust to obtain correct tooth contact on drive side of teeth. Under this condition, the coast side tooth contact is usually satisfactory.

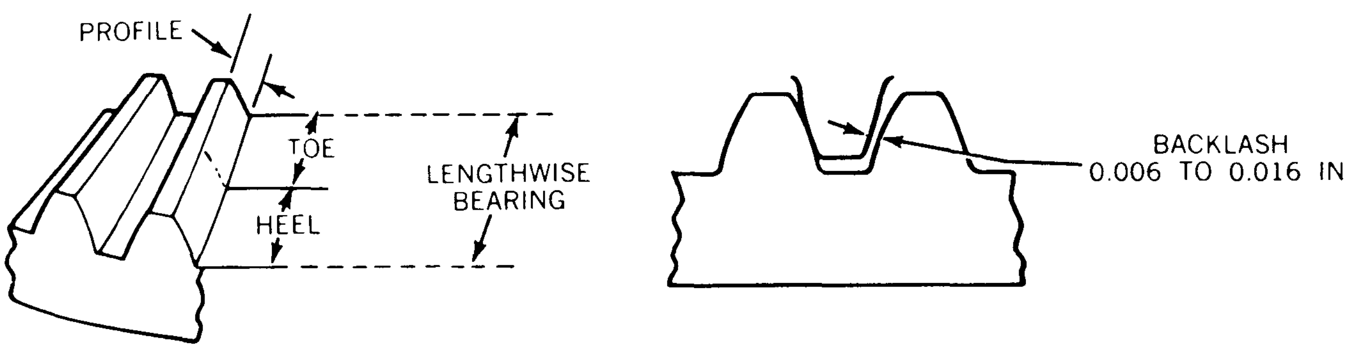
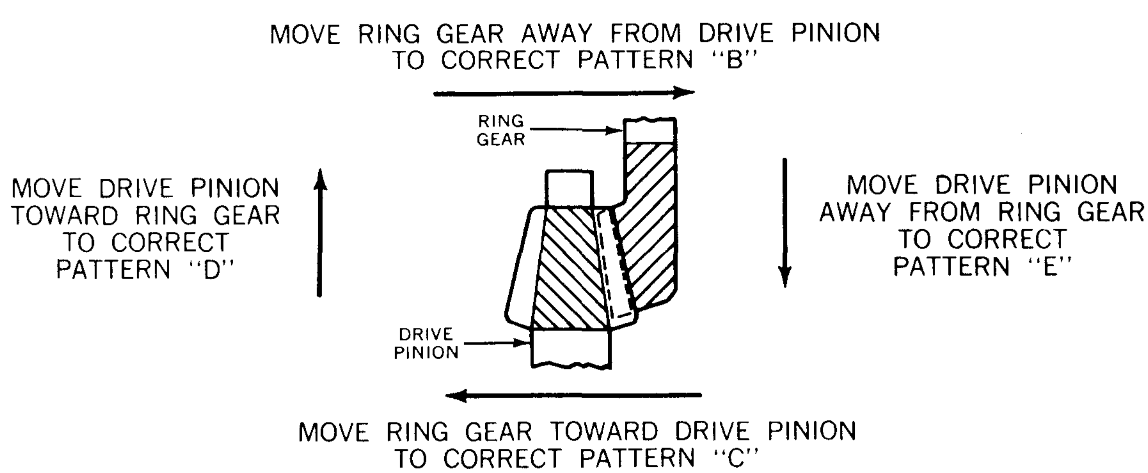


Fig. 26. Ring Gear Tooth Nomenclature



See Figure 28 for Pattern Identification

Fig. 27. Ring Gear and Drive Pinion Movement to Obtain Correct Tooth Contact Pattern

lubrication

The ability of any truck axle to deliver quiet trouble-free operation over a period of years is largely dependent upon the use of gear lubricants of good quality and suitable body.

In Eaton Axles, the use of suitable oil becomes even more important in view of the heavier loads the truck and the gears are required to handle.

Eaton Corporation, Axle Division approves only the use of MIL-L-2105 Gear Oils that meet Lever Score Load of 50 or greater, or MIL-L-2105B with *No Zinc Additive.*

The most satisfactory results will be obtained only when the lubricant is of the correct viscosity. Select viscosity according to the following

Weather Temperature	Viscosity
Below -10° F.	SAE 80
Up to 100° F.	SAE 90
Above 100° F. consistently	SAE 140

when to change

On all new axles, after the first 1000 miles of service, the original factory lubricant is to be drained and refilled using approved lubricant as outlined above. The axle lubricant level should be checked each 1000 miles thereafter.

Lubricant should be changed each 35,000 miles or each six months, whichever comes first.

Never add lubricant to axle unless it is the same make and grade as that which is already in axle. If the same lubricant is not available, drain and refill as instructed under Draining and Filling.

On 44D tandem axles, change oil filter with each axle lubrication change.

checking level

It is recommended that magnetic drain plugs be used in filler openings. Thus plug can be cleaned each time lubricant level is checked.

Single Reduction Axles. Remove rear filler hole plug. Lubricant should be level with bottom of rear filler hole.

2-Speed Axles. Remove rear filler hole plug. Lubricant should be level with bottom of rear filler hole.

Planetary Double Reduction Axles. Remove rear filler hole plug. Lubricant should be level with bottom of rear filler hole.

Tandem Drive Axles. Axle must be run first, then allowed to stand for 5 minutes. The reason being that the power divider and the forward rear axle use the same lubrication system and the 5 minute interval allows the lubricant to settle to the proper levels in the power divider case and axle housing. After the 5 minute interval, check the lubricant level in the rear filler hole of the forward rear axle only. It is not necessary to check oil level in power divider. If the level is up to the bottom of the filler hole, the power divider is also adequately lubricated. If the level is not up to the bottom of the filler hole, add the necessary lubricant. Check the rear rear axle lubricant level through the rear filler hole.

NOTE: For axles using wet wheel bearings, check lubricant level at wheels.

draining

It is recommended that magnetic drain plugs be used in drain openings. Plugs should be cleaned each time lubricant is drained.

All Type Axles. Draining is best accomplished immediately after the vehicle has completed a trip. The lubricant is then warm and will run freely allowing full drainage in minimum time. This is especially desirable in cold weather.

To drain, unscrew plug at bottom of housing and allow sufficient time for all the old oil to run out. On tandem drive axles, it is also necessary to unscrew plug at bottom of power divider for drainage of lubricant in power divider.

filling

Oil capacities for Eaton Axles are listed on page 19.

Single Reduction Axles. Fill axle through rear filler hole until oil flows from bottom of hole. After filling axle with the specified amount of lubricant, reinstall oil filler hole plug.

2-Speed Axles. Fill axle through rear filler hole with the specified amount of lubricant *(lubricant should be at the level of the bottom of filler hole),* then reinstall filler hole plug.

Planetary Double Reduction Axles. Fill axle through rear filler hole with the specified amount of lubricant *(lubricant should be at the level of the bottom of filler hole),* then reinstall filler hole plug.

"D" Series Tandem Drive Axles. Fill the forward drive axle until level with bottom of filler hole in rear cover. Then, add two pints through the forward filler hole located slightly offset to the right in top portion of differential carrier. *Do not use the rear hole at top of differential carrier as an oil filler hole.* Fill rear rear axle in accordance with instructions for Single Reduction, 2-Speed or Planetary Double Reduction, depending on type axle used.

"D" Series Torque Selector Tandem Drive Axles. Fill the forward drive axle until level with bottom of filler hole in axle housing rear cover. Add two pints through the forward filler hole located slightly offset to the right in top portion of differential carrier. *Do not use the rear hole at top of differential carrier as an oil filler hole.* Then remove magnetic plug at side of torque selector case and add 2 pints to torque selector unit. Fill rear rear axle in accordance with instructions for Single Reduction, 2-Speed or Planetary Double Reduction, depending on type axle used.

tightening torque requirements

This section includes tightening torque requirements for bolts, nuts and cap screws as used on Eaton Axles.

The information is divided into individual tables covering axle types and specific attaching part locations. Thread sizes, grades and recommended torque values are listed.

To determine bolt or cap screw grade, check for a designation (see below) stamped on the bolt head.

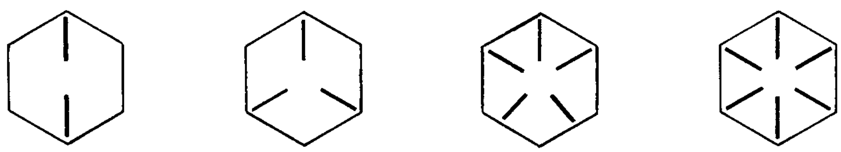
Tightening torque for a given location will vary with steel grade of the attaching part. Be sure to check grade when determining torque values.

Correct tightening torque values are extremely important to assure long Eaton Axle life and dependable performance. Under-tightening of attaching parts is just as harmful as over-tightening.

Special attention should be given to tightening the inspection or bearing cover cap screws when a cork cover gasket is used. Cork gaskets should be assembled "DRY". Use of lubricant or sealer will cause gasket to slide out when cap screws are tightened. Excessive torquing of cap screws may buckle cover between mounting holes and create a lubricant leak.

Exact compliance with recommended torque values given herein will assure the best results.

Bolt Head Markings for Grade Identification



Grade 3 Grade 5 Grade 7 Grade 8

Torque settings in ft-lbs. unless otherwise specified.

Single Drive and Tandem Rear Axles

(for single reduction axles)

DIFFERENTIAL BEARING ADJUSTER LOCK

CAP SCREW	9/16-12 (Grade 5)	115-125
CAP SCREW	5/8-11 (Grade 5)	160-175

DIFFERENTIAL BEARING CAP to CARRIER

CAP SCREW	5/8-11 (Grade 7)	150-170
CAP SCREW	11/16-11 (Grade 7)	210-250
CAP SCREW	13/16-10 (Grade 7)	320-380
CAP SCREW	3/4-10 (Grade 7)	320-380

DIFFERENTIAL CARRIER to AXLE HOUSING

CAP SCREW	7/16-14 (Grade 5)	45-55
CAP SCREW	1/2-13 (Grade 5)	75-85
CAP SCREW	5/8-11 (Grade 5)	160-175
STUD NUT	1/2-20 (Grade 8)	110-130
STUD NUT	5/8-18 (Grade 8)	220-240

DIFFERENTIAL CASE (Axle)

CAP SCREW	7/16-14 (Grade 5)	45-55
CAP SCREW	7/16-14 (Grade 7)	55-65
CAP SCREW	1/2-13 (Grade 7)	85-105
CAP SCREW	9/16-12 (Grade 7)	135-155
BOLT/NUT	1/2-20 (Grade 7)	100-120

RING GEAR to DIFFERENTIAL CASE

BOLT/NUT	7/16-20 (Grade 5)	50-60
BOLT/NUT	1/2-20 (Grade 8)	90-100
BOLT/NUT	9/16-18 (Grade 7)	115-135
BOLT/NUT	5/8-18 (Grade 7)	166-190
BOLT/NUT	5/8-18 (Grade 8)	190-200

DRIVE PINION

NUT	1 -20	220-350
NUT	1 1/8-18	320-450
NUT	1 1/4-12	400-600
NUT	1 1/2-18	500-700
NUT	1 3/4-12	550-850
NUT	1 7/8-12	550-850

DRIVE PINION BEARING CAGE to CARRIER
(or Power Divider Case)

CAP SCREW	9/16-12 (Grade 5)	115-125
CAP SCREW	9/16-12 (Grade 7)	135-155
CAP SCREW	5/8-11 (Grade 5)	160-175
CAP SCREW	5/8-11 (Grade 7)	170-190

INSPECTION COVER to AXLE HOUSING

CAP SCREW	7/16-14 (Grade 3)	35-50
CAP SCREW	7/16-14 (Grade 5)	35-50
STUD NUT	7/16-20 (Grade 8)	70-85

Controlled Traction Differentials

OIL PICKUP TROUGH to CARRIER

NYLOCK SCREW	1/4-20 (Grade 4)	35-60 in.-lbs.

SHIFT UNIT to CARRIER

STUD/NUT	7/16-20 (Grade 8)	55-60

SHIFT OPENING COVER

CAP SCREW	7/16-14 (Grade 5)	35-45

RING GEAR to SUPPORT CASE to COVER

BOLT/NUT	5/8-18 (Grade 8)	190-200

DIFFERENTIAL CASE (INTER-AXLE)
(in Power Divider)

BOLT/NUT	5/16-24 (Grade 8)	15-25

INPUT SHAFT

NUT	1 5/8-18	500-700

tightening torque requirements

Tandem Forward Axles
(for single reduction, 2-Speed, 3-Speed and planetary double reduction axles)

Torque settings in ft-lbs. unless otherwise specified.

DIFFERENTIAL BEARING ADJUSTER LOCK

CAP SCREW	9/16-12 (Grade 5)	115-125
CAP SCREW	5/8-11 (Grade 5)	160-175

DIFFERENTIAL BEARING CAP to CARRIER

CAP SCREW	5/8-11 (Grade 7)	150-170
CAP SCREW	11/16-11 (Grade 7)	210-250
CAP SCREW	3/4-10 (Grade 7)	320-380
CAP SCREW	13/16-10 (Grade 7)	320-380

DIFFERENTIAL CARRIER to AXLE HOUSING

CAP SCREW	1/2-13 (Grade 5)	75-85
CAP SCREW	5/8-11 (Grade 5)	160-175
STUD NUT	1/2-20 (Grade 8)	110-130
STUD NUT	5/8-18 (Grade 8)	220-240

DIFFERENTIAL CARRIER COVER to CARRIER

CAP SCREW	9/16-12 (Grade 5)	115-125
CAP SCREW	9/16-12 (Grade 7)	115-125
CAP SCREW	9/16-12 (Grade 8)	115-125

DIFFERENTIAL CASE (AXLE)

CAP SCREW	7/16-14 (Grade 7)	55-60
CAP SCREW	1/2-13 (Grade 7)	85-105
CAP SCREW	1/2-13 (Grade 8)	95-115
CAP SCREW	1/2-20 (Grade 7)	100-120
CAP SCREW	9/16-12 (Grade 7)	135-155

DIFFERENTIAL CASE (INTERAXLE) (in Power Divider)

BOLT/NUT	7/16-20 (Grade 5)	50-60
BOLT/NUT	5/16-24 (Grade 8)	17-23

RING GEAR to DIFFERENTIAL CASE
(Single Reduction)

BOLT/NUT	1/2-20 (Grade 8)	90-100
BOLT/NUT	5/8-18 (Grade 8)	190-200

RING GEAR SUPPORT CASE
(2-Speed, 3-Speed, PDR)

BOLT/NUT	1/2-13 (Grade 7)	90-105
BOLT/NUT	1/2-20 (Grade 7)	85-105
BOLT/NUT	9/16-18 (Grade 7)	130-150

DRIVE PINION

NUT	1⅛-18	320-450
NUT	1¼-12	400-600
NUT	1½-18	500-700
NUT	1¾-12	550-850

DRIVE PINION BEARING CAGE to CARRIER
(or Power Divider Case)

CAP SCREW	9/16-12 (Grade 5)	115-125
CAP SCREW	9/16-12 (Grade 7)	135-155

DRIVE PINION PILOT BEARING SLEEVE

CAP SCREW	5/16-18 (Grade 5)	16-20

INPUT SHAFT

NUT	1½-18	500-700
NUT	1⅝-18	500-700
NUT	1¾-12	500-700
NUT	1⅞-12	500-700

OUTPUT SHAFT

NUT	1¼-12	175-325
NUT	1¾-12	350-500

INPUT SHAFT BEARING COVER

CAP SCREW	1/2-13 (Grade 5)	75-85

OIL COLLECTOR DRUM to DIFFERENTIAL CASE

CAP SCREW	7/16-14 (Grade 5)	45-55

INSPECTION COVER to AXLE HOUSING

CAP SCREW	7/16-14 (Grade 5)	48-55
STUD NUT	7/16-14 (Grade 5)	48-55
STUD NUT	7/16-20 (Grade 8)	70-85

LOCKOUT UNIT to CARRIER

CAP SCREW	7/16-14 (Grade 5):	
	Vacuum Type	45-55
	Air Type	30-40
CAP SCREW	3/8-16 (Grade 5):	
	Air Type	30-35

SHIFT UNITS to CARRIER
(2-Speed and 3-Speed)

STUD NUT	7/16-20 (Grade 5)	45-50
STUD NUT	7/16-20 (Grade 8)	55-60

COVER PLATE to CARRIER (PDR)
(At Shift Unit Opening)

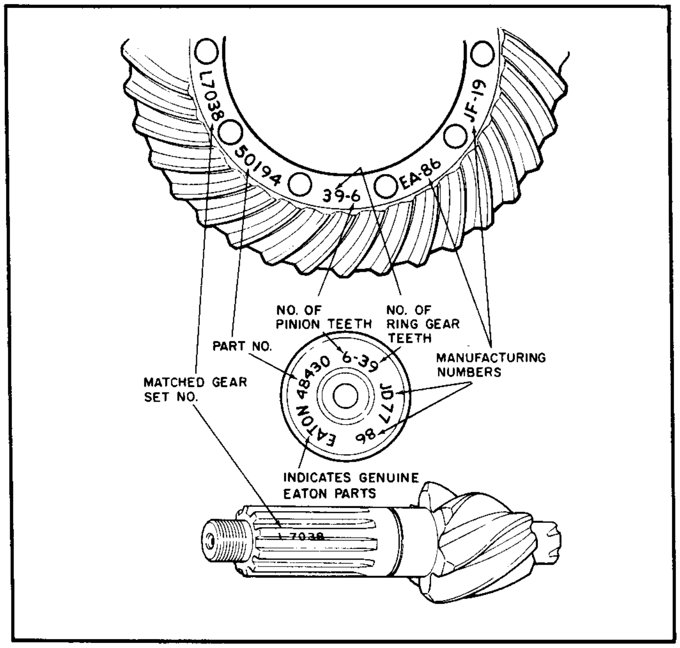
CAP SCREW	7/16-14 (Grade 5)	35-45

OIL PICKUP TROUGH to CARRIER

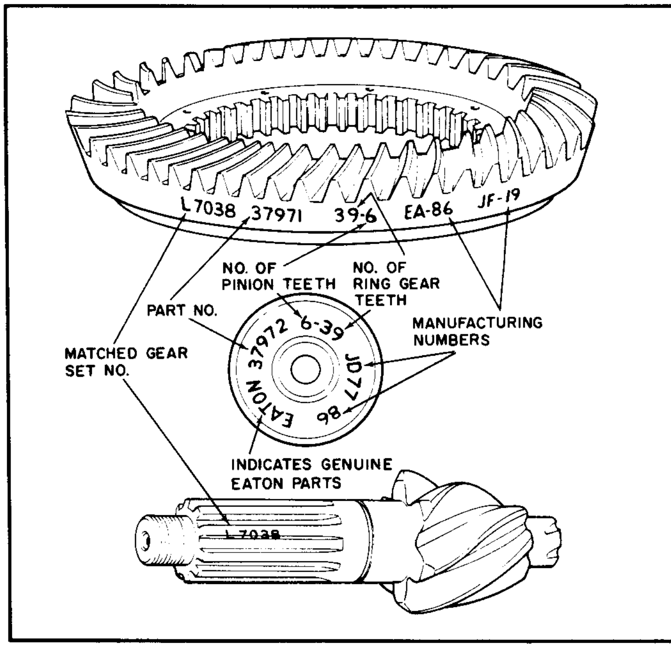
NYLOCK SCREW	1/4-20 (Grade 5)	35-50 in.-lbs.

axle identification markings

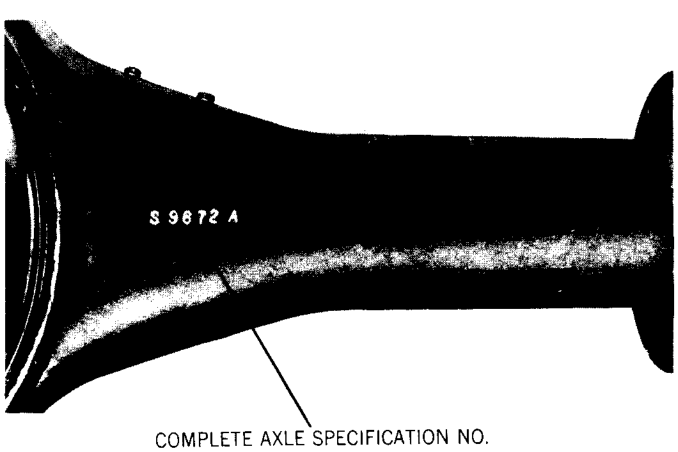
Typical Single Reduction Gear Set



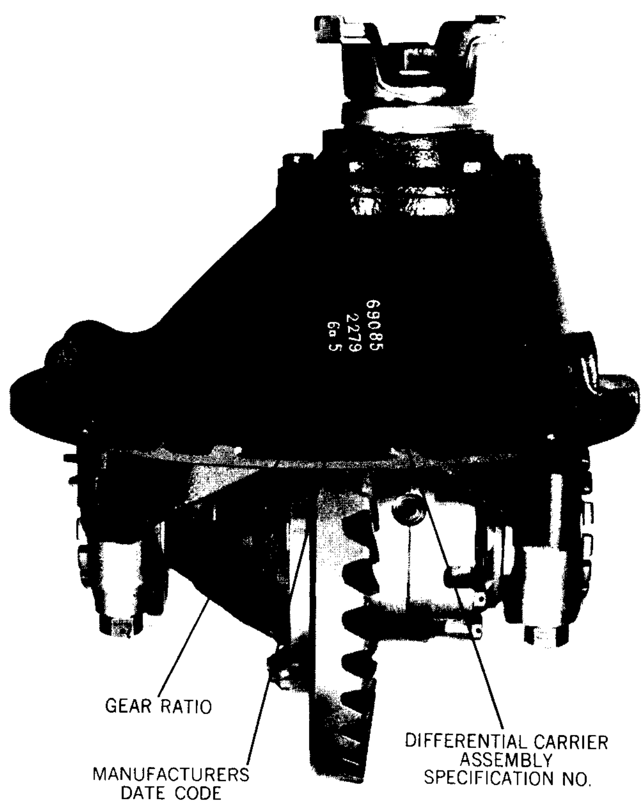
Typical Planetary Gear Set



Axle Housing



Differential Carrier



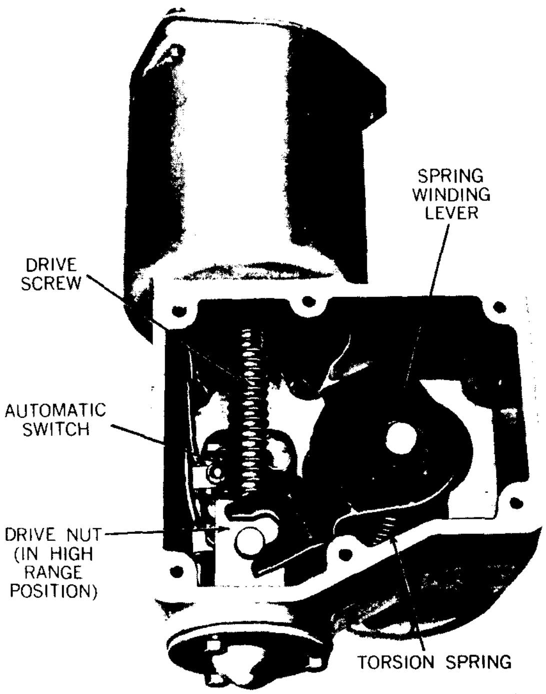


Fig. 40. Electric Shift Unit in High Range Position

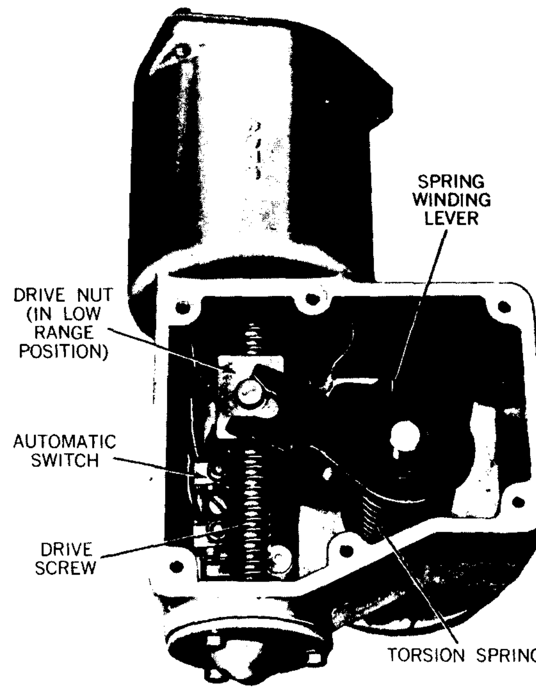


Fig. 41. Electric Shift Unit in Low Range Position

Electric Shift System Operation

OPERATION IN HIGH RANGE.
Figure 40 illustrates electric shift unit in high range operating position.

With control switch knob pulled up, the motor operates to rotate armature and drive screw in a clockwise direction and moves the drive nut down.

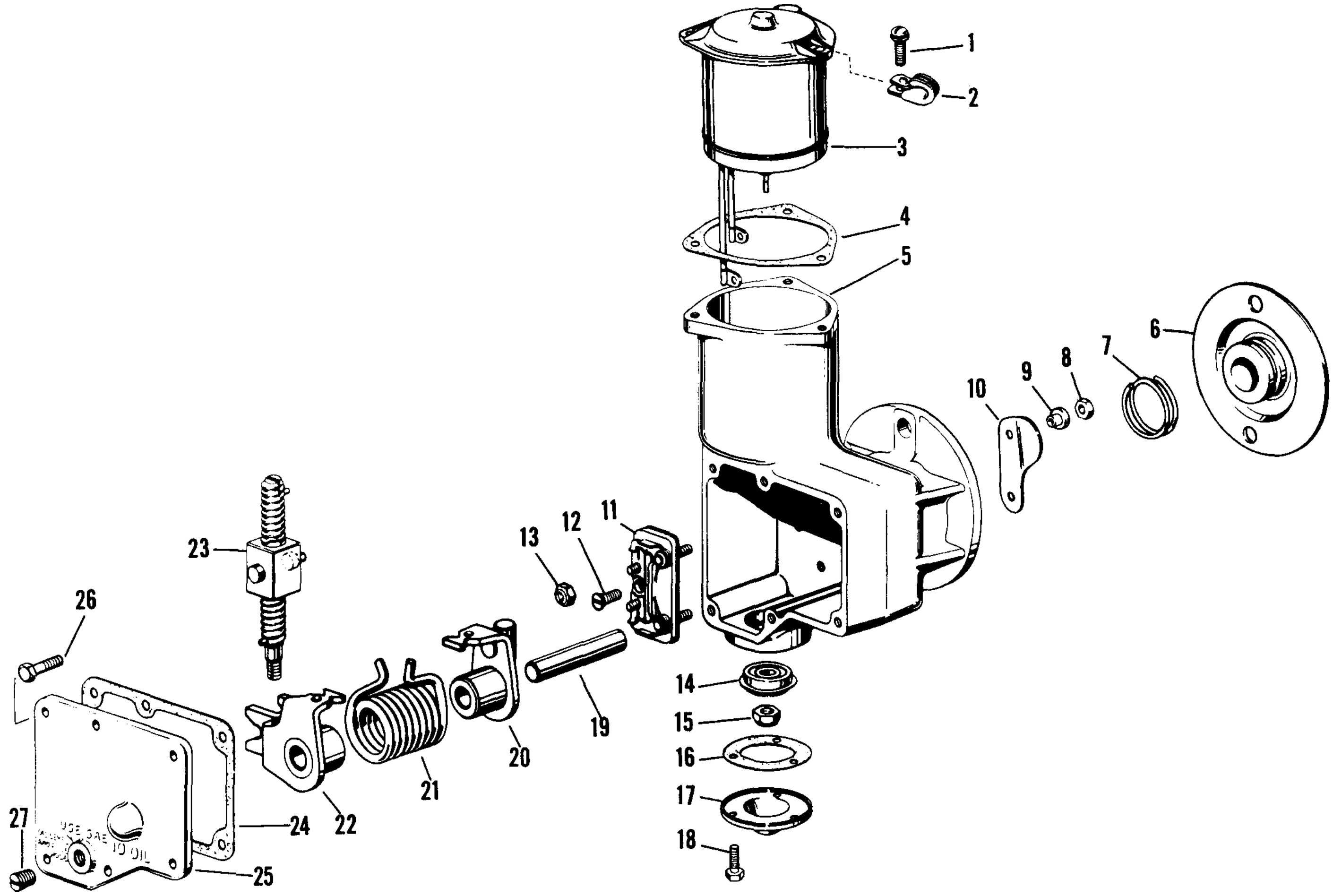
When the drive nut has traveled a sufficient distance to wind the torsion spring, a contact bumper *(on the drive nut)* breaks electrical connection on the automatic switch which, in turn, stops the motor. *To make certain that vibration does not move nut, a ball screw detent spring holds nut at the end of its travel on the screw.*

The drive nut moves the spring winding lever down which, in turn, winds the torsion spring. Thus, an increased load is placed on the spring and, in this position, the axle is ready to shift into high range as soon as the load (torque) on the axle is relieved by opening and closing the throttle or declutching.

The torsion spring is assembled under a preload of 50 to 80 pounds pressure. When the spring winding lever is moved so that spring is wound, the pressure is increased to 90 to 135 pounds.

This additional spring load is used to shift the axle and when shift is completed, the initial 50 to 80 lbs. preload again becomes effective and holds the axle in high range.

OPERATION IN LOW RANGE.
When control switch knob is pushed down, the motor rotates to operate armature and drive screw in a counter-clockwise direction. The drive nut travels to the top of the drive screw (see fig. 41) thus winding the torsion spring for a shift to low range in the same manner as described for high range.



1. Screw
2. Motor cable clip
3. Motor assembly
4. Motor gasket
5. Shift unit housing
6. Shift fork seal
7. Shift fork seal spring
8. Locknut
9. Insulator bushing
10. Insulator
11. Automatic switch
12. Screw
13. Terminal locknut
14. Drive screw bearing
15. Locknut
16. Bearing cover gasket
17. Bearing cover
18. Cap screw
19. Lever shaft
20. Shift fork actuating lever
21. Torsion spring
22. Spring winding lever
23. Drive screw assembly
24. Housing cover gasket
25. Shift unit housing cover
26. Cap screw
27. Cover pipe plug

Fig. 42. Exploded View of Electric Shift Unit

Electric Shift Unit

disassembly (continued)

disassemble electric shift unit (continued)

3. Remove screws and bearing cover from shift unit housing. Push drive screw toward bearing until bearing is free of housing. Hold drive screw by inserting screwdriver in drive slot then remove nut and bearing. Remove drive screw assembly from housing.

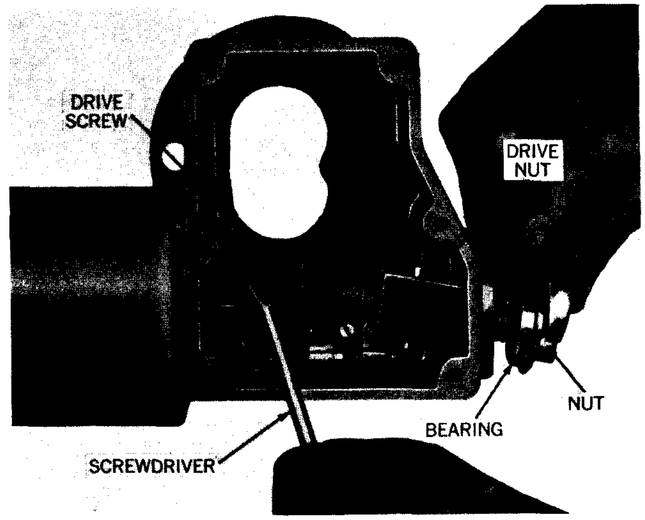


Fig. 47. Removing Drive Screw Nut and Bearing

4. Remove locknuts to disconnect motor leads from automatic switch. Remove screws, cable clip and motor assembly from shift unit housing. *Do not under any conditions immerse motor assembly in cleaning solutions.*

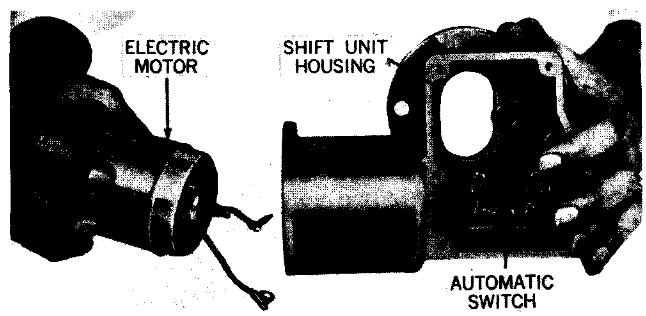


Fig. 48. Removing Electric Motor

5. Remove locknuts, insulator and insulator bushings (some shift units use fibre washers and insulator bushings) from automatic switch mounting studs. Remove screw from center of automatic switch then remove switch assembly from housing.

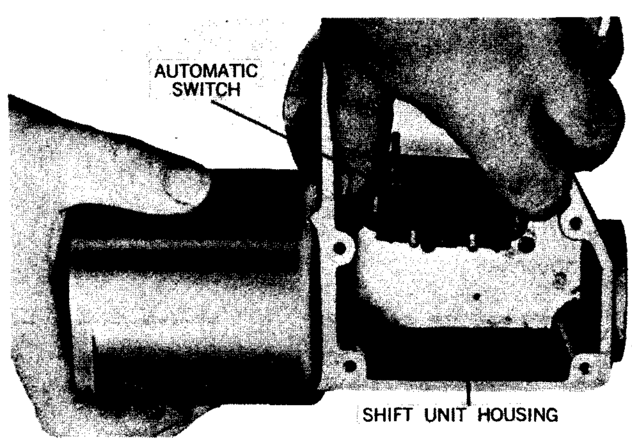


Fig. 49. Removing Automatic Switch

electric shift systems

Electric Shift Unit

reassembly

assemble torsion spring drive

NOTE: Torsion springs vary with axle model as shown by color identification in the following table.

Axle Series	Color
13-16	Black Stripe
17-20, 26	Red Stripe
22	Green Stripe

CAUTION: The torsion spring is assembled under spring tension. Use caution during the following assembly procedures.

1. Clamp end of lever shaft in vise jaws. Position shift fork actuating lever, torsion spring and spring winding lever on shaft as shown in figure 51. Grasp spring winding lever by hand, turn lever and push until end of torsion spring engages shift fork actuating lever.

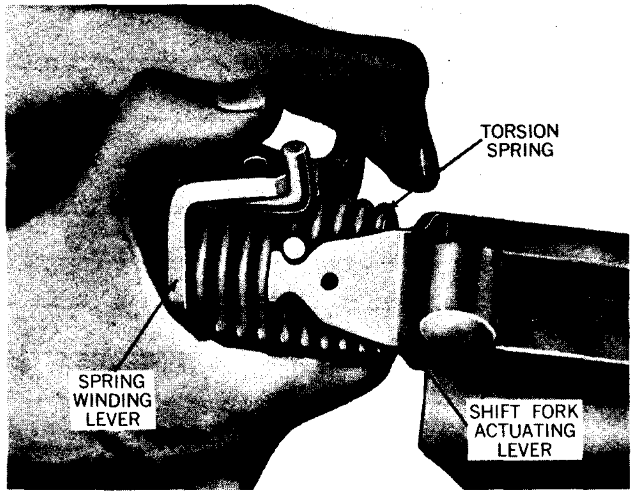


Fig. 51. Assembling Torsion Spring Drive

assemble electric shift unit

1. Position automatic switch in shift unit housing and install screw at center of switch. Install insulator bushings *(some shift units use fibre washer and insulator bushings)*, insulator and locknuts on switch mounting studs.

2. Place gasket and electric motor in shift unit housing. Install screws, placing motor cable clip under one of the mounting screws.

3. Connect motor leads to automatic switch terminals and install locknuts.

4. Position drive screw assembly in shift unit housing to permit installation of bearing. Install bearing and locknut on end of drive screw. When tightening locknut, hold drive screw by placing screwdriver blade in drive slot. Position drive screw to engage drive slot with motor armature shaft and place bearing in housing. *Make certain bearing is properly seated in bearing bore.* Install gasket and bearing cover then install screws.

Be sure that contact bumper on nut is toward switch and position drive nut at center of drive screw, then install torsion spring drive assembly as follows:

5. Place torsion spring drive assembly in housing. Engage spring winding lever with pin at center of drive nut and install lever shaft.

6. Install gasket, housing cover and screws.

install electric shift unit on differential carrier

1. Place shift fork seal on studs and differential carrier. Install spring on seal.

2. Connect electric wires to shift unit terminals *(long or red wire connects to bottom terminal).*

3. Place shift unit on mounting studs and make certain shift fork actuating lever engages slot in shift fork. Install stud nuts and lockwashers.

lubrication

LUBRICANT. Use SAE 10 motor oil for temperatures above 0° F. For temperatures below 0° F., mix three parts of SAE 10 motor oil with one part of kerosene. This cold weather mixture can be safely used up to 32° F.

LUBRICANT CHECK AND LEVEL. Each 10,000 miles or 3 months, remove pipe plug in shift unit housing cover to check lubricant level. Lubricant should be level with bottom of filler hole.

LUBRICANT CHANGE. At least twice a year remove shift unit housing cover and drain old lubricant. Wash parts thoroughly and air dry. Reinstall cover. Remove pipe plug in cover. Fill through pipe plug opening until lubricant is level with bottom of filler hole.