

CLUTCH ASSEMBLY

## OPERATION AND MAINTENANCE

Each carrier is equipped with a 2 plate direct acting heavy duty clutch assembly. This type of clutch requires no maintenance other than normal lubrication and adjustment. The system utilizes hydraulic pressure as a means of transmitting clutch pedal movement to the clutch release mechanism. It consists of a pedal operated master cylinder and a slave cylinder, interconnected with hydraulic lines. The clutch pedal is connected to the master cylinder pushrod and the slave cylinder pushrod is connected to the clutch throw-out lever.

## Maintenance

In order to maintain a satisfactory clutch operation, the system should be checked and serviced periodically for:

1. Proper level of brake fluid in master cylinder. Once a year drain and flush system and refill with new brake fluid.
2. Inspect system for leakage and correct immediately.
3. Make sure return spring at clutch slave cylinder is not weak or broken.
4. Check and adjust linkage if necessary.

## Clutch Linkage Adjustment

Two adjustments are required to obtain correct clutch operation.

- (A) Master cylinder pushrod and
- (B) Slave cylinder pushrod.

The purpose of the master cylinder pushrod is to make sure the piston is resting all the way back against the piston stop. The clearance between the pushrod and cylinder piston is about 1/8" or 1" free play in the pedal movement. The clearance between the slave cylinder piston and the pushrod connected to the clutch lever should be about 1/4" to 5/16".

NOTE: Before making any adjustments make sure system is free of air and the master cylinder filled with brake fluid.

## Bleeding System

The need for bleeding air from the hydraulic clutch system is generally indicated by a sponge pedal action.

A leaking line or presence of air is the result of a low fluid level in the master cylinder.

Check for leaking hose or fittings and replace where necessary.  
Retighten all connections.

A bleeder valve is provided at the slave cylinder close to the clutch housing.

A bleeder hose can be slipped over the valve and the system bled by the same method as when bleeding hydraulic brakes.

### OUTRIGGER OPERATION

To operate the hydraulic outriggers, apply the emergency brakes, place the gear shift in the "Neutral" position and idle the engine using the hand throttle at 1000 R.P.M. Place the hydraulic selector valve in the "Outrigger" position.

Located on each side of the machine are three hydraulic valve levers, Above each set of levers is a pedal plainly marking the operation of each lever. Please note that the outriggers are operated independently on each side of the vehicle. To avoid accident it is not possible to operate the outriggers on the "Off-Side" without going to the opposite side of the vehicle.

NOTE: Do not lift the vehicle higher than necessary to obtain a level operation. One inch under the tires is sufficient for good operation.

After retracting the outriggers, ensure that the "Hydraulic Selector Valve" is returned to the "Power Steering" position before attempting to move the vehicle.

### GENERAL

The best operating speeds for highway driving are between 30 and 40 M.P.H. Severe 'Down-Shifting' is not recommended at high speeds. Operation at high speeds on the highway usually creates excessive tire wear and heating. When operating on long trips it is suggested that the tires be checked for heat build up every 30 to 45 minutes of travel. "DO NOT OVERLOAD THE MACHINE". It can only result in high cost and possible accidents.

HYDRAULIC OUTRIGGER OPERATION

The following simple steps and precautions should be taken prior to operating the hydraulic outrigger system:

1. Check oil level in hydraulic tank. With outrigger beams retracted and vertical jacks "up" the oil level should be approximately 1" below the filler.
2. Check that all control valve levers are in the neutral position "centre down".
3. Place hydraulic selector valve located in cab in the "out" position.
4. With gear shift in neutral, start engine.
5. The engine should be permitted to warm up for approximately 3 to 4 minutes or until such time as the heat gauge registers approximately 160°.

Operation of the outriggers should be carried out as follows:

1. Set the engine throttle control for 800 - 1000 rpm. If carrier is without tachometer, this is the "high idle" position.
2. Do not rev the engine since this creates foaming of the hydraulic oil and will not increase the speed of operation.
3. Remove floats from their racks and fit to the ball end of the vertical hydraulic jacks.
4. Operate hydraulic valves located on either side of carrier to extend outriggers.
5. Do not continue to operate beyond the maximum extended position since this provides for excessive opening of the pressure relief valve and places high stress on the hydraulic pump.
6. Operate vertical jacks in accordance with the instruction plates located above the hydraulic valve levers and level the carrier with the tires approximately 1" from the ground.
7. Do not raise the carrier in excess of the 1" clearance mentioned above since this provides for high bending stresses to the vertical rams with increased wear on the seals.
8. Check each cylinder for any possible "creep" and when satisfied the engine may be switched off and the crane is ready for operation.

HYDRAULIC OUTRIGGER SERVICE

Prior to the initial operation of the hydraulic outrigger system and at approximately thirty day intervals, the following inspection should be carried out:

1. Check oil level in reservoir which should be maintained approximately 1" below the filler with outriggers retracted and vertical jacks in the "Up" position.
2. Check tension of pump drive belts and tightness of pulley on pump shaft.
3. Visually check all lines for possible damage, fitting leaks, dented tubing etc.
4. Inspect vertical jack ram assemblies (fully extended) for possible damage, scratches or other marks which may tend to score the lower oil seals. Minor scratches may be stoned with fine grade carborundem, however, major damage should be reported to the factory at the earliest opportunity.
5. Lubricate outrigger rollers located in the bottom of each box assembly and insure that they are not frozen to the shaft.
6. Check each float head assembly for possible damage and insure that the locking pins are still attached to their chain and retain the float to the jack when lifted from the ground.
7. Check levelling devices for possible damage or misalignment and if necessary use an engineer's level to ascertain their accuracy.

SPECIAL NOTE: The hydraulic system is filled with Shell Donax T6 hydraulic oil for normal winter temperatures down to 10° below zero and Tellus 15 in summer. Equipment destined for operation in areas where the temperatures fall below -10° should be filled with Aeroshell #4. Do not, however, mix hydraulic fluids since each oil maintains its own rust and oxydation inhibitor and damage to the pump may occur.

CAUTION NOTES FOR MAINTAINING AIR BRAKE SYSTEMS

Before attempting to work on an air brake system, certain precautions should be observed since the compression and storage of air may be compared to the energy in a coiled spring and, when released, may present a hazard if not properly recognized. The wheels of the vehicle should always be blocked by some means other than the air brake system so that depletion of air will not permit the vehicle to roll.

In draining the system, do not look into the air jets or direct them toward a person as dirt or sludge particles may be entrained in the air stream. Hoses which contain air pressure should not be disconnected under pressure since they will whip as air escapes from the line. Follow manufacturers' recommended procedures in working on any air device so as to avoid injury or damage from parts which, when released, are subject to mechanical (spring) or pneumatic propulsion. As system pressure is drained and the emergency brakes apply, hands should be away from brake chamber push rods and spring actuators which will apply automatically with the loss of pressure. This also applies when checking service brake system.

Reservoirs which are closest to the sources of compressed air (compressors or auxiliary sources) should contain a safety valve in known working order and sufficient capacity to limit the reservoir pressure to a safe maximum level. Old, used reservoirs should not be used as replacements. The safety valves should not be reset higher than specified by the reservoir manufacturer, vehicle manufacturer, or code to which the reservoir had been manufactured. Various actuators contain large internal steel springs that require special disassembly procedures. Note and be guided by the warning tags on such units.

ADJUSTMENT PROCEDURE FOR THE AIR-SHIFT

1. Position shift lever (in cab in "Neutral").
2. Disconnect Rotating Cylinder No. 7 (Drwg. 16062-21-6) from lever No. 3 by removing clevis pin No. 9.
3. Loosen locknut No. 29 on front of Indexing Cylinder No. 16.
4. With air system pressurized, check if there is air pressure on Port No. 7 (Drwg. 16089-21-7). If yes, then indexing cylinder No. 16 should be in neutral position.
5. Move lever No. 3 by hand back and forth, while maneuvering indexing cylinder No. 16 slightly forward or backward by turning indexing cylinder shaft until lever No. 3 can be moved freely through its entire travel range.
6. Once this center position has been established, retighten locknut No. 29 and again check for free movement of lever No. 3 and repeat procedure under point 5 if necessary.
7. Reconnect Rotating cylinder No. 7 to lever No. 3.
8. Test system by actuating shift lever in Cab and if satisfactory conduct road test.

Other causes of malfunction can be traced to either of two areas:

- a) loose mechanical linkage parts within the remote control tower or the shift bar housing of the transmission and
- b) air pressure losses in the system due to obstructions or leakage.

All of these problems can be located and remedied by checking through the system step by step.

Repair kits are available for the cylinders and shift valve.

SPECIAL NOTES ON "AIR SHIFT"

If you have not driven an Air-Shift before, please take time out to insure that you are familiar with its operation. An "Air-Shift" is not a "Power-Shift". The transmission is a normal mechanical type, but the gears are engaged by air cylinders. When using the Air-Shift, the clutch must be used in the normal manner and 'Double De-Clutching' should be used.

A red light is fitted in the instrument panel to indicate when the transmission is in the "Neutral" position. Since the Air-Shift has a fixed speed of operation it is necessary to 'Hesitate' in neutral as you shift from one gear to the next. Do not attempt to move to the next gear until the Red Light is "On". "DO NOT TRY TO PRE-SELECT!" This will only cause damage to the transmission and drive line. The normal sequence of operation is as follows:

- A. Depress clutch and select first gear (Red Light Out).
- B. Release clutch and increase speed.
- C. Depress clutch, move shift lever to the neutral position (Red Light On) and hesitate 2 seconds.
- D. Release clutch, depress again and select next gear (Red Light Out).
- E. Release clutch and proceed as above.



INDEXING CYLINDERS

Indexing Cylinders (2") have been developed to service the industrial requirement of remote shifting transmissions. Most automatic transmissions are particularly adaptable to this arrangement as well as are synchronized mechanical gear boxes. Power-takeoff units and clutch controls on drum winches use air shifting to advantage because the operator is usually working in a cab or platform not close to the machinery.

When air pressure is applied to the appropriate port, the cylinder will travel to a certain definite position. The type of control valve required will depend on the holding characteristics of the shift mechanism. (1) If mechanical positioning by the shift rail poppets will hold the elected position, then simple push-button air control valves are satisfactory. (2) If the mechanism requires constant air pressure to maintain position, then rotary or over-center air valves are required.

Most types of popular air controls must also rely on the action of several air shuttles to route air pressure to the proper cylinder ports. The shuttles are available from the Williams Industrial catalog or pre-plumbed with the cylinder as "complete kits" ready for use. The use and supply of the cylinders requires custom tailoring to the installation. Several popular models are listed for reference. When ordering units please specify (1) model number and (2) stroke increments.

COOLING SYSTEM

Each vehicle is fitted with a 'Pressure Circulating' system provided with a pressure radiator cap which has been pre-set at the factory. Permanent type 'anti-freeze' has been added to the water prior to shipment in order to protect the engine block and heads at all times under temperatures down to  $-40^{\circ}\text{F}$ . In conjunction with the radiator system the engine manufacturer has incorporated a temperature controlled 'thermostat' so as to maintain a through put equivalent to the heat dissipation of the engine. The normal engine running temperature is between  $165^{\circ}\text{F}$  and  $175^{\circ}\text{F}$  for gasoline engines and  $170^{\circ}\text{F}$  and  $185^{\circ}\text{F}$  for diesel engines.

CAUTION

Do not drive the vehicle with a cold engine as this will greatly reduce the life of the cylinder liners and other reciprocating parts of the engine.

It is important that the correct amount of 'anti-freeze' be maintained in the system and the density should be checked periodically during winter and summer. Too much anti-freeze will cause overheating of the engine and poor performance. It is recommended that twice yearly the cooling system should be drained and flushed with a checcical solvent to remove rust particles and other sedimentation.

A periodic inspection of the fan belts, hose connections and radiator shutters (when fitted) should be carried out to ensure efficient operation of the cooling system.

TROUBLE SHOOTING

Problem	Possible Cause	Remedy
Loss of water	Loose Hose Clamps	Tighten or Replace
	Broken Rad. Core	Remove & Repair
Overheating	Leaking Water Pump	Check seal & Replace
	Damaged Head Gasket	Replace Gasket
	Blocked Rad Fins	Steam out & Clean
	Jammed Shutter	Free & Lubricate
	Sticky Thermostat	Replace Thermostat
	Too Much Anti-freeze	Drain & Refill

THER-MECH AUTOMATIC RADIATOR SHUTTER  
WITH AUTOMATIC MODULATED CONTROL

Shutter Unit:

The vanes are made of extruded aluminum alloy and are mounted in 5/16" nylon bearings. Shutters located in rear of busses are subject to adverse condition, must be checked and cleaned at regular inspections. Shutter should be opened and closed manually to note that vanes operate absolutely free. Vane bearings should be washed with cleaning fluid and blown out with air. Do not lubricate nylon vane bearings.

Automatic Control

The thermostatic element is mounted in either top or bottom tank of radiator or in housing and operates shutter by thermal expansion. The control is so arranged that shutter will completely open in approximately 8 to 10 degree range. The thermostat opens shutter and is closed by return spring. Control should be adjusted so that shutter is closed when engine is cold. A small spring is provided so as to return piston of thermostat if shutter should be held open while engine cools. However, should piston be in extended position when cold it is necessary that thermostat be heated to operating temperature before attempting to return. Cover radiator completely and bring temperature to normal. Then apply spring tension and piston will reutrn when engine cools. If thermostat is removed, heat in circulating water and apply spring tension until it cools. Never force piston back when cold as serious damage will result. Should the piston not reutrn to proper height, the neoprene diaphragm may be ruptured and thermostat will have to be replaced. Failure of thermostate will always be in extended position, shutter open. Do not discard thermostat because plunger is extended. Follow instructions above.

Maintenance:

The thermostat should be checked annually. Remove piston and clean thoroughly and lubricate with Dow Corning #200 Fluid or Silicone Grease Cadillac Co. No. 3940. When removing piston carefully note if small disc (Anti-friction washer) is stuck to lower end, if so, replace in thermostat. This is very important. Be sure that piston is free from dirt or abrasive material. Examine shutter to note that the vanes are free and do not bind in any way. Check adjustment of control to note that when shutter is closed (engine cold less than 150°) there should be little or no clearance in travel of control rod. A few drops of oil on pins and bearings of control will improve shutter operation and increase the life of thermostat.

TYPE "C" UNIVERSAY JOINT AND SHAFT ASSEMBLY

## INSTALLATION

The first operation is to attach the fitting yokes to the two shafts to be connected. Care should be used when doing this, so as not to nick or bend the flanges to which the bearings are fastened. Then the yoke retaining nut tightened to prevent it coming off the shaft: see fig. 1.

The next operation is to bring one end of the universal joint and shaft up against one of the fitting yokes: see Fig. 2. It will be noted that one of the bearings is inserted in the keyway in the yoke with the male arcuate pilot of the bearing resting on the female pilot of the yoke. Due to the fact that there are cork packings between each of the bearings and the trunnions on which they fit, this cork packing must be compressed a certain amount, before it is possible to enter the male arcuate surface of the other bearings with the yoke pilot on the opposite side.

This should be done by clamping the two opposite bearings with a "C" clamp. Then push the bearings into the yoke pilot and keyway. Do not attempt to put the bolts through into the bearing until both of the bearings have found their seat on the yoke surface. The bolts are then inserted through the yoke and screwed into the bearing: see Fig. 3. It will be noted that the pair of bearings at each end of the shaft that are to assemble to the end yokes, are held in place by means of a weld wire.

The weld wire has no effect on the universal joint action and need not be removed. Rather it should remain in place to hold the bearings on the spider trunnions should the universal joint have to be disassembled. Then tighten the four bolts securely. After one end of the shaft has been put in place, the shaft can be compressed in the slip joint to permit raising the other end of the shaft and then, coming forward against the yoke member, proceed exactly the same as stated above.

Should it be necessary to disassemble the joint for some reason or another - for instance, to replace a spider or bearing - it is only necessary to remove the eight bolts (4 per each yoke), compress the shaft assembly in the slip joint and remove the spider and the four bearing assemblies.

It may be that some of the bearings are tight in their respective pilots and key seats, which will make it necessary to tap the top of the bearing slightly, in order to release it. Then, the spider and bearing assembly can be replaced in part, or as a complete unit.

When installing a double universal joint assembly, it is important that both of the universal joints operate at equal angles. It is also important that the slip joint be assembled to the slip stub so that the slip yoke and the yoke welded to the tube are in the same plane: see fig. 4 & 5.

## LUBRICATION

Universal joints requiring a grease lubricant should be lubricated with any good grade of "O" chassis lubricant.

Grades 1 and 2 may be required for use in hot weather and heavy duty service. A good grade of 140 mineral oil is also approved. The lubricant should be a high melting point fine fibre grease.

The interval between lubrications depends on the types of service. An interval of 400 hours between lubrications is generally satisfactory for normal service. A 100 hour interval is recommended for heavy duty service.

When subjected to extremely severe conditions, more frequent lubrication may be required

Lubrication must be done with a low pressure hand type grease gun or a high pressure gun with a low pressure adapter only!!! High pressure will rupture the cork seals.

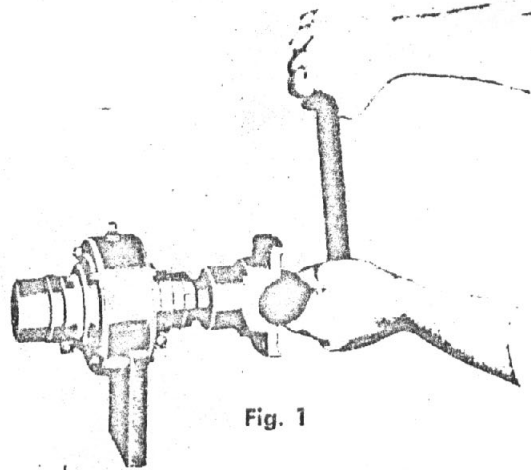


Fig. 1

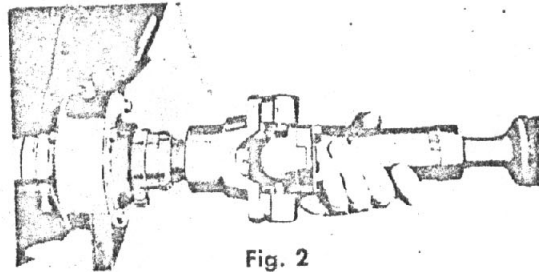
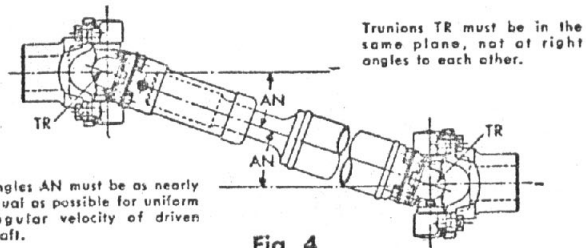
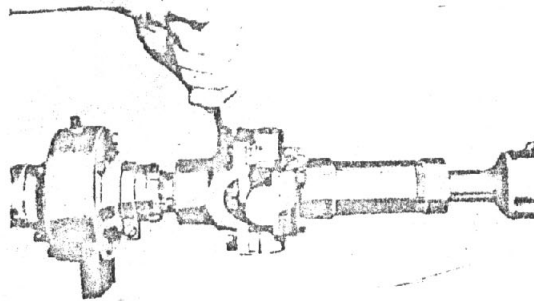
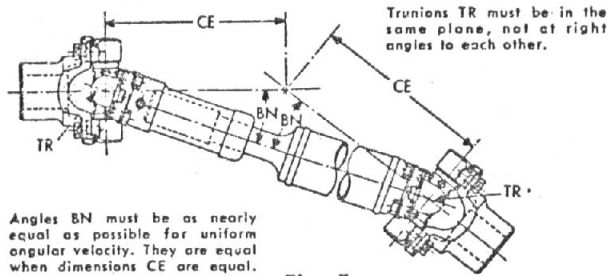


Fig. 2



Angles AN must be as nearly equal as possible for uniform angular velocity of driven shaft.

Fig. 4



Angles BN must be as nearly equal as possible for uniform angular velocity. They are equal when dimensions CE are equal.

Fig. 5

TORQUE PROCEDURE FOR CAST WHEELS

One of the primary causes of misalignment of tire and rim assemblies mounted on spoke wheels is improper tightening of wheel studs. Incorrect torque on a dual spoke wheel can result in over 3/4 of an inch wobble; causing accelerated torque-loss and severe tire wear.

Recommended procedure for torquing cast wheels is by "triangulation". As indicated by the photograph at left, this triangulation procedure is as follows:

1. Turn nut #1 until snug.
2. Rotate the wheel/rim assembly until nut #3 is in the top position. Turn till snug.
3. Again rotate the wheel/rim assembly until nut #4 is in the top position and turn the nut till snug.

Since the entire weight of the tire/rim assembly is on the top spoke position, this procedure allows even application of force against three points of the rim for proper alignment.

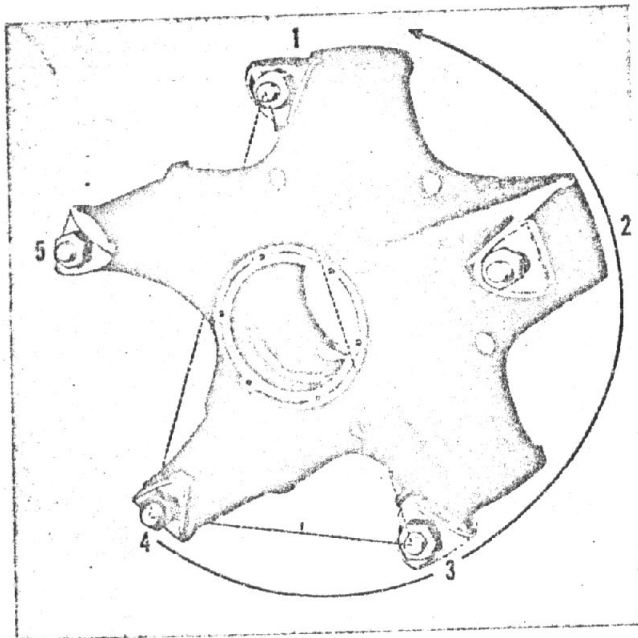
4. Repeat the triangle procedure; this time bringing each nut to recommended torque.

5. Bring remaining nuts to recommended torque.

Even when the triangulation method is used nuts will still lose torque when the vehicle is operated. This is caused by the "seating in" of the rim assembly to the wheel. After 50-100 miles of operation the nuts should again be brought to recommended torque. The wheel/rim assembly will then remain tight, barring accidents such as stud-breakage or clamp failure.

This procedure should be followed every time a tire/rim assembly is put on a spoke wheel.

## TORQUE TABLE



APPLICATION	Stud or Bolt Size and Thread	Recommended Torque in Foot Pounds
<b>LIGHT TRUCKS</b>		
	$\frac{3}{8}$ " 20	75-85
	$\frac{1}{2}$ " 20	75-85
	$\frac{3}{8}$ " 18	80-90
	$\frac{5}{8}$ " 18	140-170
	$\frac{1}{4}$ " 16	250-300
<b>HIGHWAY VEHICLES—Truck-Trailer-Bus</b>		
With Disc Wheels	$\frac{3}{4}$ " 16	450-500
Budd Standard Mounting—countersunk holes	$1\frac{1}{8}$ " 16	450-500
Budd Standard Mounting—countersunk holes	$\frac{1}{2}$ " 18	175-225
Motor Wheel Studs	$\frac{3}{4}$ " 16	300-350
Motor Wheel Spoksteel Studs—Straight stud holes	$\frac{7}{8}$ " 14	325-375
Motor Wheel Bus—Front Wheels and single rear	$\frac{7}{8}$ " 14	350-400
Motor Wheel Bus—Dual rear wheels	$\frac{3}{4}$ " 16	175-200
Back Nuts—on inner end of wheel stud	$\frac{7}{8}$ " 14	175-200
Buck Nuts—on inner end of wheel stud		
With Cast Wheels	$\frac{1}{2}$ " 13	90
With Cast Wheels—Demountable Rims	$\frac{5}{8}$ " 11	150-175
With Cast Wheels—Demountable Rims	$\frac{3}{4}$ " 10	175-200
<b>OFF THE ROAD VEHICLES</b>		
With Disc Wheels	$\frac{3}{4}$ " 16	450-500
Budd Standard Mounting, countersunk holes	$1\frac{1}{8}$ " 16	450-500
Budd Studs—that use back nuts	$1\frac{1}{8}$ " 16	650-700
Budd Studs—with heads—no back nuts	$1\frac{1}{8}$ " 16	650-700
Budd $\frac{3}{4}$ " studs with $\frac{7}{8}$ or 1" back nuts	$1\frac{1}{8}$ " 12	750-900
Budd Heavy Duty Mounting	$1\frac{3}{8}$ " 12	750-900
Budd Heavy Duty Mounting	$\frac{7}{8}$ " 14	175-200
Back Nuts on inner end of wheel stud	1" 14	175-200
Back Nuts on inner end of wheel stud		
With Cast Wheels	$\frac{3}{4}$ " 10	225
With Cast Wheels—Demountable Rims	1" 8	450
With Cast Wheels—Demountable Rims	1" 14	450
With Cast Wheels—Demountable Rims		
<b>AGRICULTURAL WHEELS</b>		
	$\frac{1}{2}$ " 20	75-85
Non Reversible Wheels	$\frac{3}{8}$ " 18	80-90
With Reversible Wheels		
Garden Tractor	$\frac{3}{8}$ " 20	40-50
Light Duty Disc	$\frac{1}{2}$ " 20	45-55
Heavy Duty Disc	$\frac{1}{2}$ " 20	70-80
Light Duty Disc	$\frac{3}{8}$ " 18	60-70
Heavy Duty Disc	$\frac{3}{8}$ " 18	70-80
Heavy Duty Disc	$\frac{5}{8}$ " 18	85-100



## VALVE MAINTENANCE AND RECONDITIONING

Very little maintenance is required to keep the power steering valve operating properly. The internal parts are hardened steel and ground to a precise finish, therefore wear of the working parts is negligible. Foreign matter, such as dirt and grit in the hydraulic system, will score the polished surfaces of the piston and body and will cut the seals. This results in leakage and thus reduces the power needed for effective steering.

When it becomes necessary to service and recondition the valve, the following procedure will apply:

Disconnect the hydraulic lines from the valve. Note the position in which each line is connected to the valve so each can be reassembled in the same position. To disconnect the valve, remove the cotter pin and end plug. Fig. 1. Remove the ball socket end plug lock and the socket end plug. The valve can now be removed from the steering arm of the vehicle. Disconnect the other end of the drag link from the steering arm.

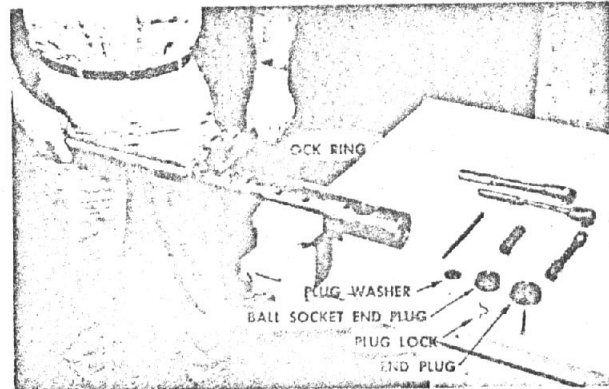


Figure 1

Hold the valve in a vise for disassembly. Clamp only in the center of the housing as this is the heavier section.

The lock ring has been crimped into a notch in the drag link adapter. Straighten the ring, then remove the adapter with a pipe wrench. Fig. 1.

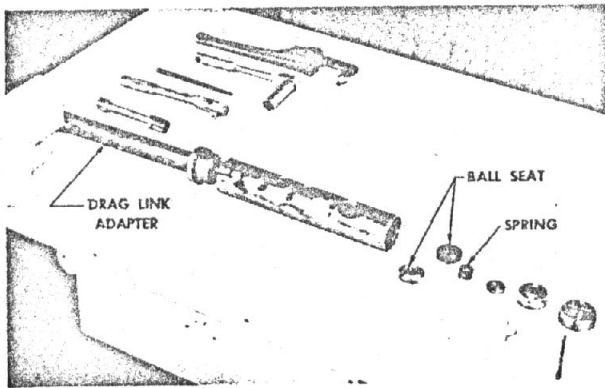


Figure 2

The ball socket must be disassembled before the body can be removed from the housing. Place a punch into oil passage hole in the piston to hold the piston from turning. Fig. 3. Remove the nut from the ball socket end of the piston. This requires a  $\frac{3}{4}$ " hex socket and a 4" extension. Remove the ball socket and ball socket bearing.

When removing the piston, first move it toward the gland end of the body just far enough to permit removing the O-ring seal. Then move the piston in the opposite direction just far enough to permit removing the O-ring seal from the other end. Now slide the piston out from the gland end of the body. Fig. 6 shows the valve completely disassembled.

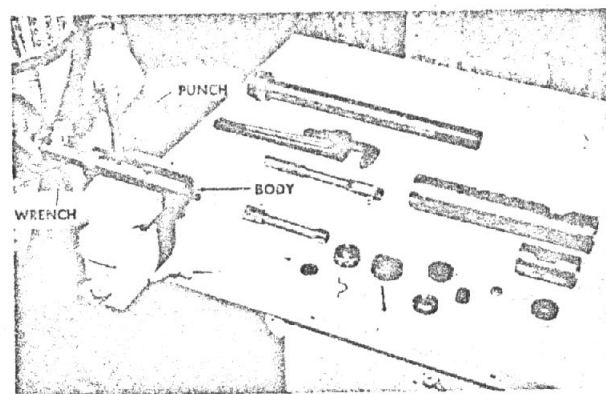


Figure 5

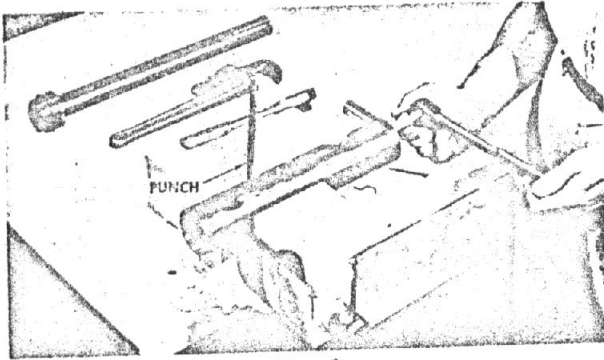


Figure 3

The valve body assembly can now be removed from the housing. Fig. 4. The housing contains a snap ring that provides a stop for the valve body. It is not necessary to remove this snap ring.

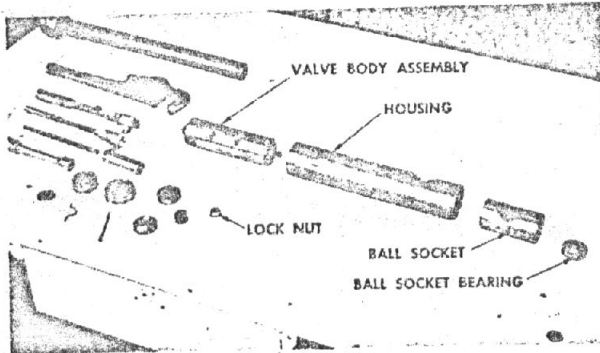


Figure 4

To disassemble the valve body and piston, hold it in a vise. Fig. 5. Place a punch in the oil passage hole in the piston to keep it from turning and remove the nut from the gland end of the piston with a  $\frac{3}{4}$ " hex socket.

Remove the washer. Hold the piston in the body and remove the gland, the two reaction rings and the spacer. Do not try to remove the gland and piston together as the O-ring seals on the piston will be damaged in doing so.

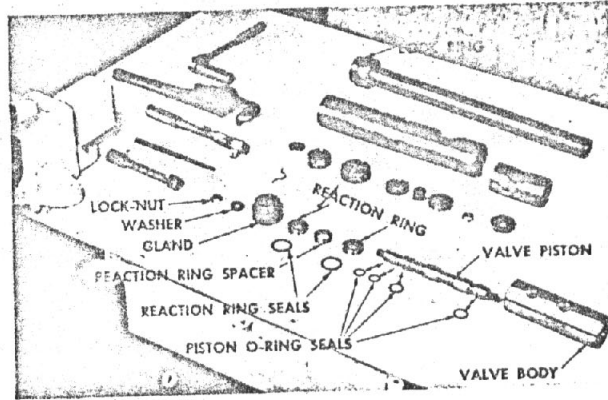


Figure 6

### INSPECTION AND RECONDITIONING

Clean and wash all parts thoroughly in solvent or kerosene. Handle the parts separately and carefully to avoid damaging the finished surfaces. Wear of parts such as piston, reaction rings and valve body is negligible as these parts operate in circulating oil. It is impractical for a field service shop to attempt to measure wear. Therefore a careful visual inspection of all parts is most important.

Examine the surfaces of the piston and the bore of the body for scoring or damage that may have been caused by foreign matter in the fluid. Parts that are badly scored and scratched should be replaced. Light scratches can be removed by polishing with fine crocus cloth. Do not "round-off" or chamfer the port edges of the piston or body. These edges should remain sharp to insure proper sealing. If they are broken the result would be excessive leakage and reduced hydraulic power.

O-Ring seals should be examined carefully for damage. If surface is rough or cut it should be replaced.

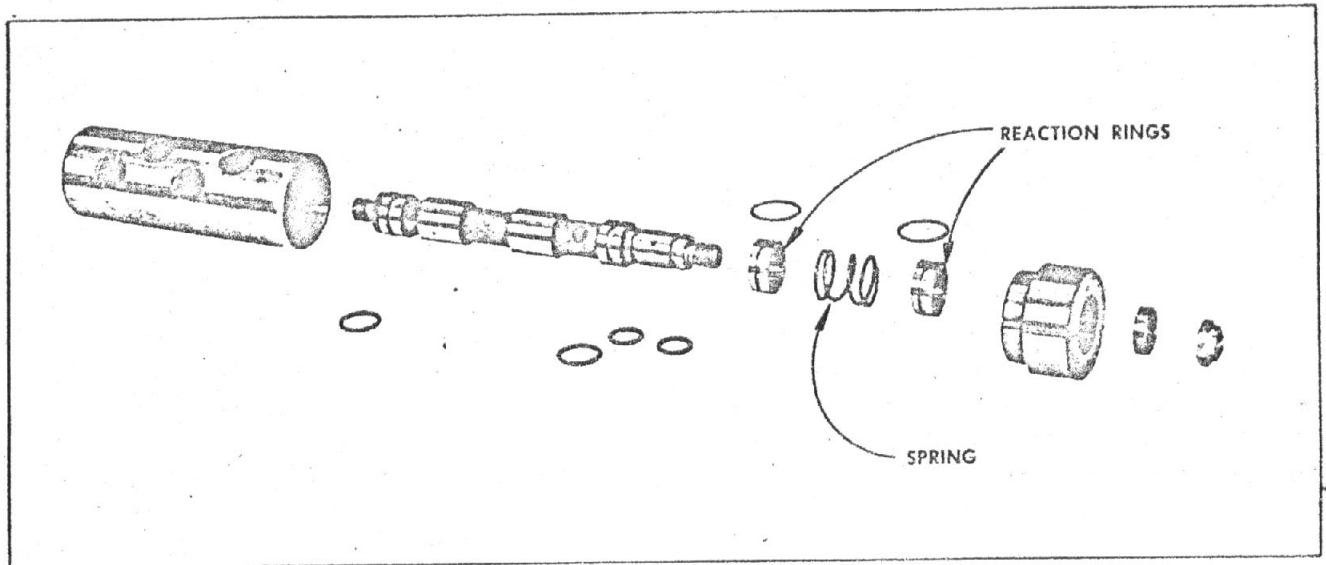


Figure 7

### VALVE REASSEMBLY

Hold the valve body in a vise as illustrated in Fig. 5 and install the valve piston. Insert the piston into the gland end of the body for easy assembly. Install an O-ring on the piston opposite the gland end first and move the piston into the body just far enough to permit installation of an O-ring on the gland end of the piston. Now center the piston on the body by having the shoulder on the gland end of the piston flush with the bottom of the counterbore in the body. **CAUTION** — When installing the O-ring seals on the piston, do not move the piston in the body any farther than is required to assemble the seal. If the seal on the gland end of the piston drops into cavity in the body, it is likely to be cut or damaged. Apply light lubricating oil to the piston and seals when assembling.

Install the two O-ring seals on the gland end of the piston.

Install the O-ring seals on the two reaction rings. Install one ring on the piston, then install the gland in the body and the second reaction ring on the end of the piston.

If the valve gland is furnished with a compression spring, Fig. 7, install the spring in the gland between the two reaction rings and assemble over the piston.

If the valve gland is furnished with a spacer, install the spacer in the gland between the two reaction rings and assemble in the body.

Install the washer and nut and torque nut to 30-35 foot pounds.

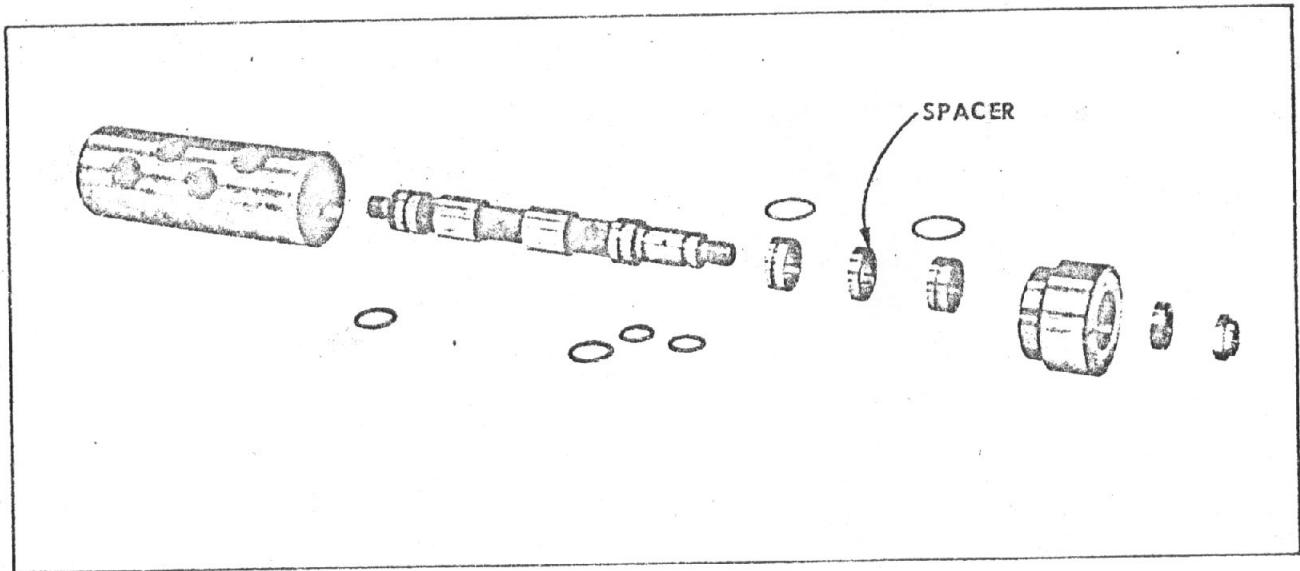


Figure 8

To hold the piston stem from turning while tightening the nut, place a punch in the oil passage hole in the piston as shown in Fig. 5.

Place the body assembly in the housing and assemble the drag link adapter with the lock ring and tighten enough to hold the body in position. Be sure the interior of the housing is cleaned and that no obstruction will prevent the body assembly from bearing against the stop ring in the housing. This can be observed through the opening in the housing.

Place the assembly in a vise with the ball stud opening

in the housing facing upward. **CAUTION** — Clamp only in the center of the valve as this is the heavier section.

Place the ball socket bearing Fig. 4, in the ball socket. The counterbored side should face toward the socket opening.

Assemble the socket in the housing and secure with a nut. Torque the nut to 30-35 foot pounds.

Now tighten the drag link adapter. Torque to 170-175 foot pounds. Bend the edge of the lock ring into a slot in the rim of the adapter.

CARRIER AND  
RELATED COMPONENTS



FRONT AXLE ASSEMBLY

Following removal of front axle from machine, the following steps should be followed:

DISASSEMBLY:

Remove the bolts (11) and the hub cap plates (63 and (64). Then loosen and remove the cotter pin and the wheel bearing nut and washer (46) and (47). Brake drum and front wheel spoke assembly can then be removed (61) and (62).

Further disassembly of the brake drum and the front wheel assembly can be accomplished by removing brake drum bolt, locknut and lockwasher (60). Bearing cups and cones and hub seal can also be removed (48), (49) and (67).

The steering knuckle assembly can then be removed by first removing the adjustment parts such as the air chambers, hydraulic lines or fittings, etc., that might cause an obstruction to the knuckle pin. Disassembly can then be accomplished by removing the screw, lockwasher, dust cap and gasket (26), (27), (28) and (29) from the top and the bottom of the steering knuckle. Remove the drawkey nut (10) and tap out the knuckle pin drawkey (8) and (9) from the small end using a brass hammer on the threaded end. Tap out the knuckle pin (22) by using a bronze drift. Lift off knuckle assembly (20) and also the thrust bearing and shims (32), (33), (24) (25), (30) and (31).

The cross tube assembly (3) can be removed by removing steering arm nut and cotter pin (38) and (39) from both ends. Lift off cross tube assembly. It may be necessary to tap the thread on the vertical socket (5) and (6) with a brass hammer.

Steering arm can be removed by removing the steering arm key, nut and cotter pin (40), (41) and (42). The ball stud (43) can be disassembled by removing the cotter pin and ball stud nut (44) and (45).

CLEANING, INSPECTION AND REPAIR:

This should be followed in accordance with the outline in the Front Axle Field Maintenance Manual located in back of this manual.

REASSEMBLY:

Reassembly should be done in the reverse order of the disassembly.

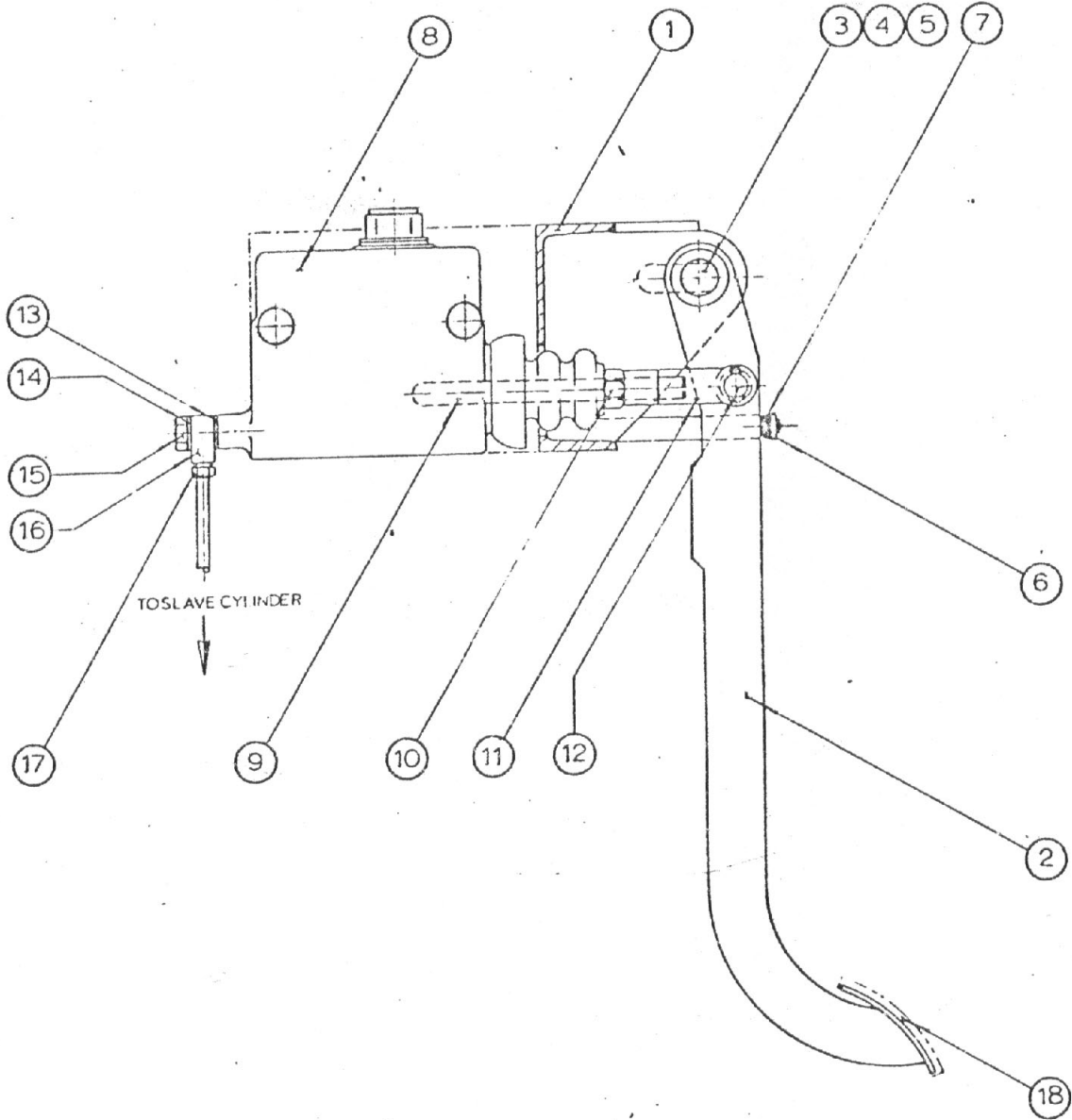
AIR BRAKE ASSEMBLY

See operation and maintenance books in Section 4 for disassembly and assembly procedures for:

1. Stopmaster Brake
2. Rear Axle - Unit "P" Series Brakes
3. Safety Brake Chamber
4. Standard Air Chamber
5. E - 7 Dual Brake Valve with Pedal
6. Basic E - 7 Dual Brake Valve
7. Relay Valve
8. Governor Type D-2



### CLUTCH RELEASE PARTS



CLUTCH RELEASE PARTSMASTER CYLINDERDISASSEMBLY

Disconnect and cap line to master cylinder insuring that no foreign matter enters the system.

Remove nut, rubber bumper, and clutch pedal stop bracket (6) & (7). Remove clevis pin and cotter pin (2) and clutch pedal retaining pin, screw and washer (3), (4) and (5). Clutch pedal (2) can now be removed.

Remove bolts to disconnect master cylinder (8). Copper gaskets, bolt and connector (13), (14), (15) and (16) can be removed from the master cylinder.

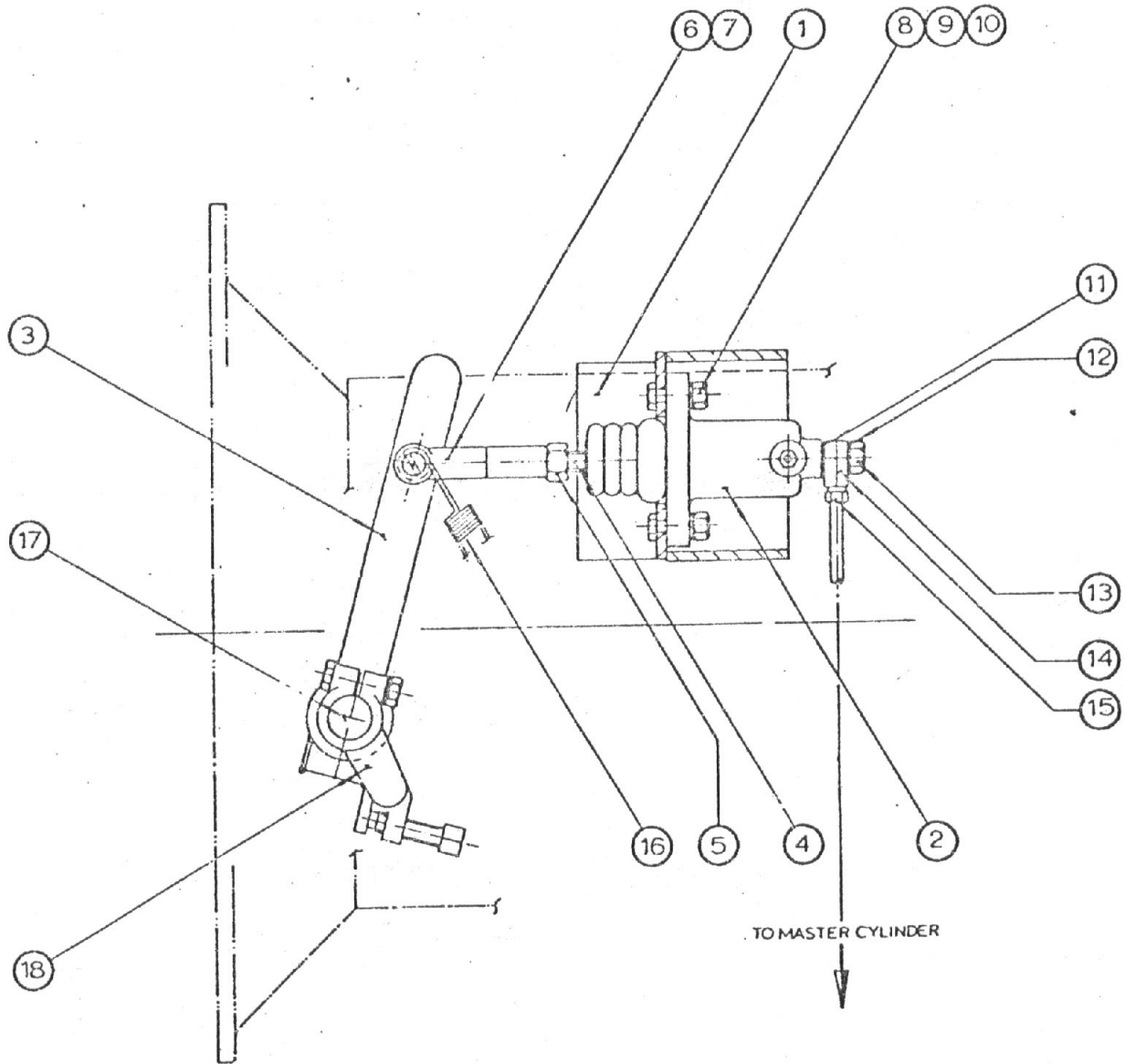
CLEANING, INSPECTION & REPAIR

Clean all metal parts in an approved cleaning solvent and dry with compressed air. Replace any damaged or worn parts.

REASSEMBLY

Do in the reverse of the disassembly.

### CLUTCH RELEASE PARTS



CLUTCH RELEASE PARTSSLAVE CYLINDERDISASSEMBLY

Disconnect and cap off line to slave cylinder, to insure that foreign particles do not enter the system.

Disconnect and remove spring (16). Remove clevis and pin (6) & (7). Loosen nut and remove clutch pedal arm (18) spacer (17) and clutch pedal lever (3).

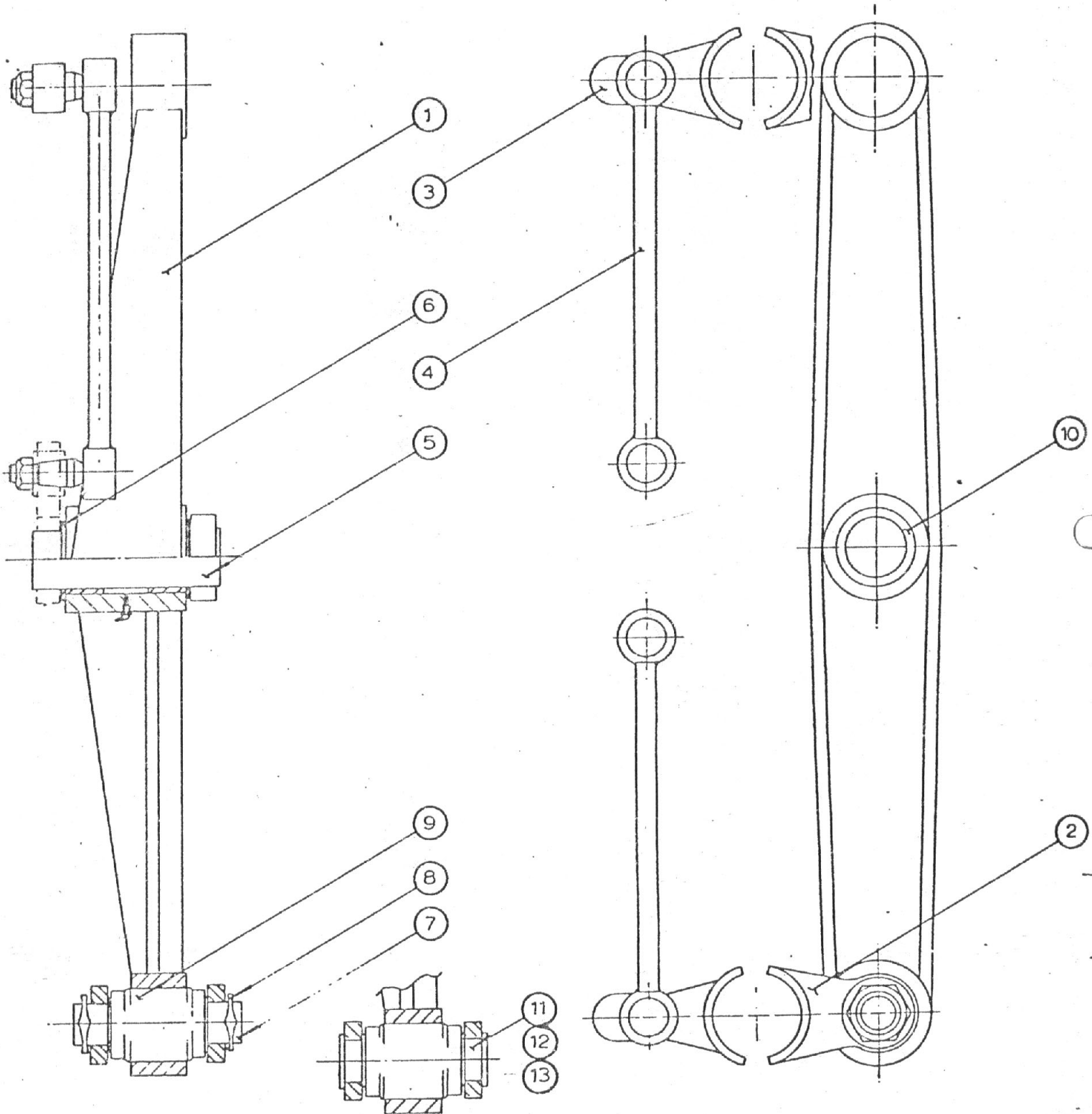
Remove screw, washer and nut (8), (9) and (10) to remove slave cylinder (2). Gaskets, connector, bolt and adapter (11), (12), (13), (14) and (15) can then be removed.

CLEANING, INSPECTION & REPAIR

Clean all metal parts in an approved cleaning solvent and dry with compressed air. Replace any damaged or worn parts.

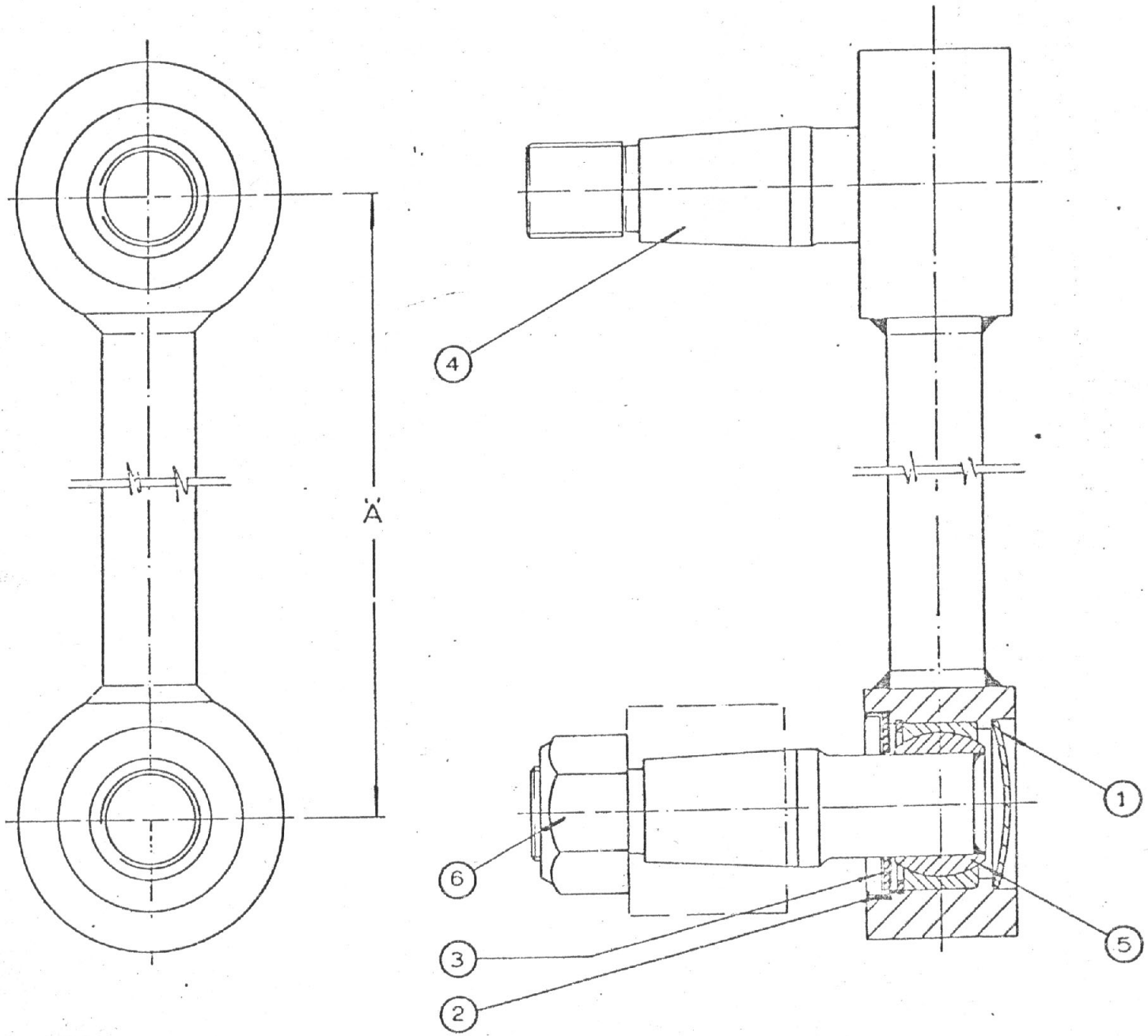
REASSEMBLY

Do in reverse of the disassembly.



ALTERNATIVE ASSEMBLY

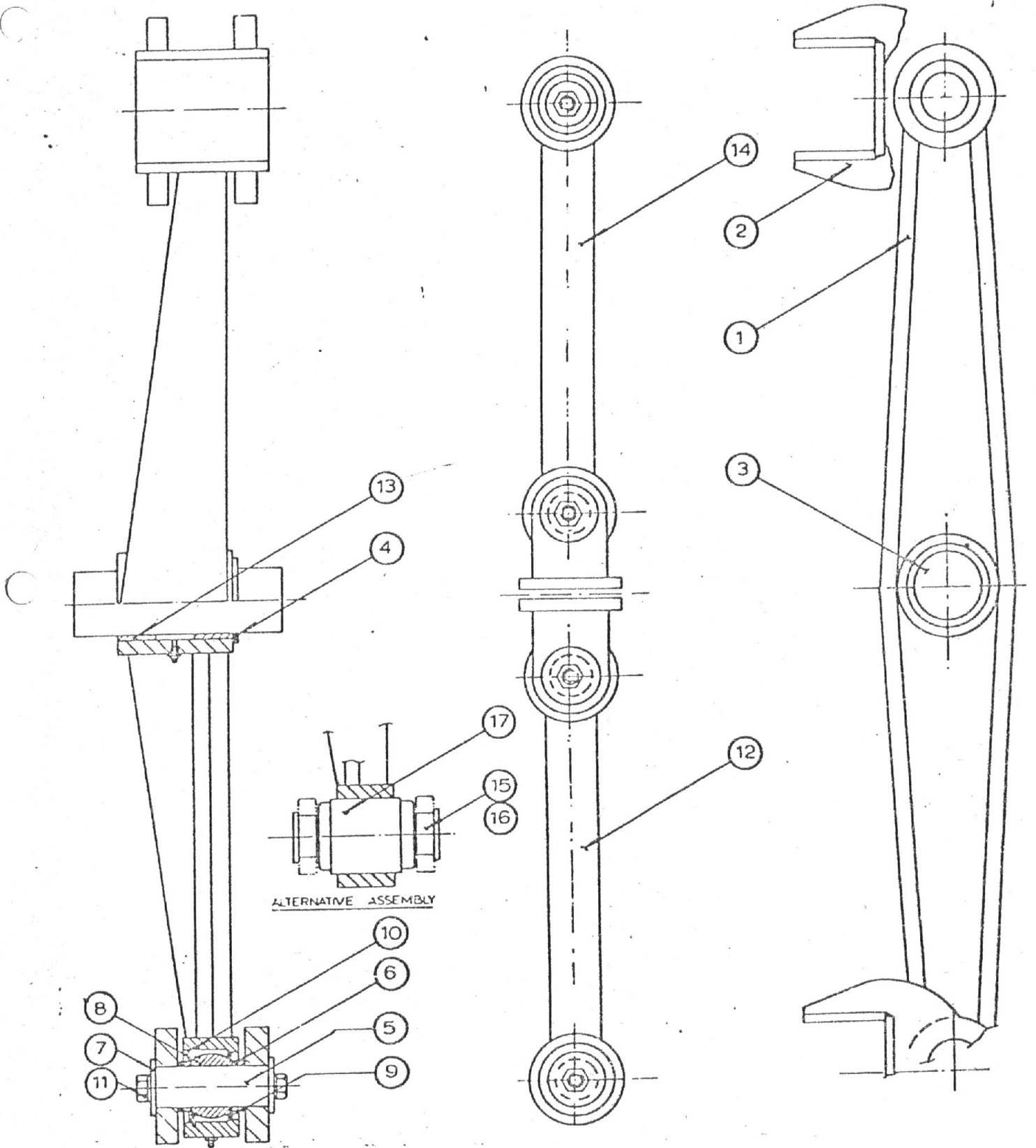
FRONT SUSPENSION ASSEMBLY



TORQUE ROD ASSEMBLY

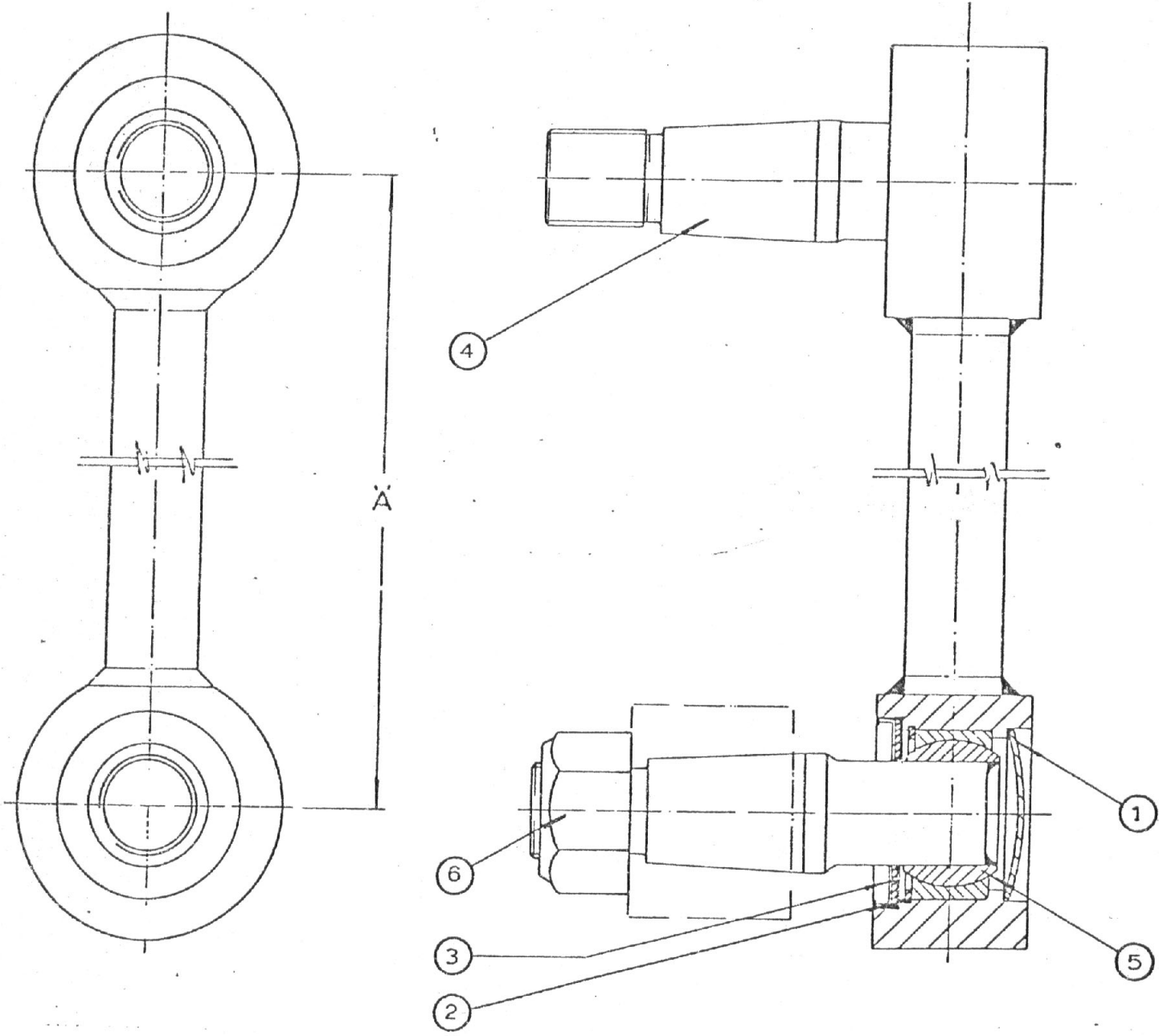
NOTE:

THIS PAGE WILL BE INCLUDED  
IN FINAL PARTS MANUAL



REAR SUSPENSION ASSEMBLY





TORQUE ROD ASSEMBLY

REAR SUSPENSION AND TORQUE ROD ASSEMBLYDISASSEMBLY

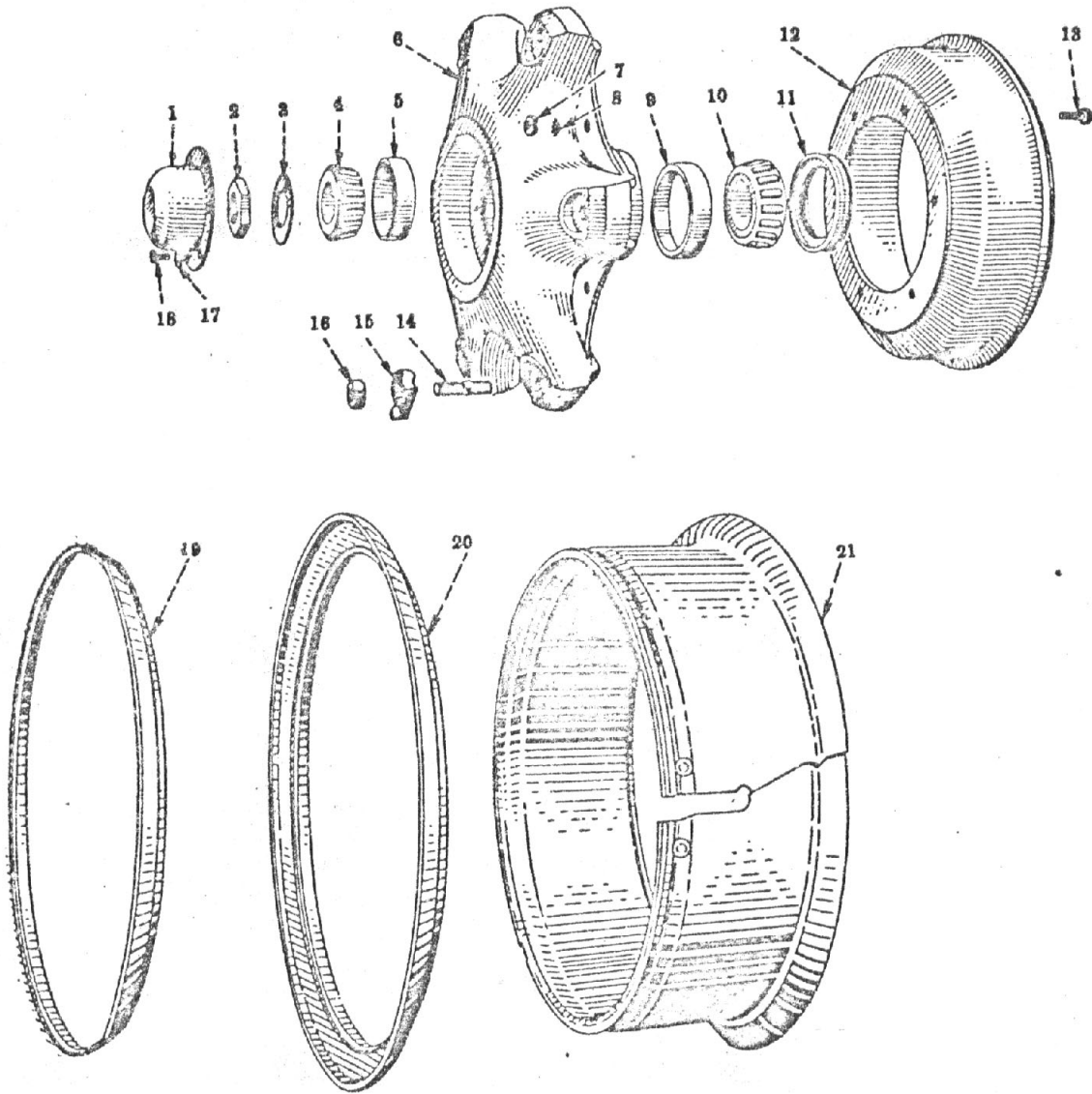
1. Remove locknut (6) from ball stud (4) on torque rod assembly.
2. Remove oil seal (3) and retaining ring (2) allowing removal of ball stud and bearing (5).
3. Remove spherical cover (1).
4. On rear suspension assembly, torque rod assembly (12) and (14) may now be removed.
5. Remove lower saddle (not shown) releasing pin (3) and thrust washer (4).
6. Remove hex bolt (16), adaptor (15) and bushing (17) allowing removal of equalizer beam (1).
7. Remove bushing (13) from equalizer beam.

CLEANING, INSPECTION AND REPAIR

1. Clean all metal parts in an approved cleaning solvent; dry thoroughly with compressed air.
2. Inspect all bushings for cracks and wear.
3. Check all other parts for damage.

ASSEMBLY

1. Reassemble all parts in reverse order of disassembly.



FRONT WHEEL ASSEMBLY

FRONT WHEEL ASSEMBLYDISASSEMBLY

The wheel clamp (15) can be removed by removing the wheel stud nut (16). Removing this nut will also allow removal of the rim assembly (19), (20) & (21).

Remove hub cap (1) gasket (1a) and hub cap bolts (18). Next remove wheel bearing nut (2) and washer (3). Spoke wheel (6) can then be removed.

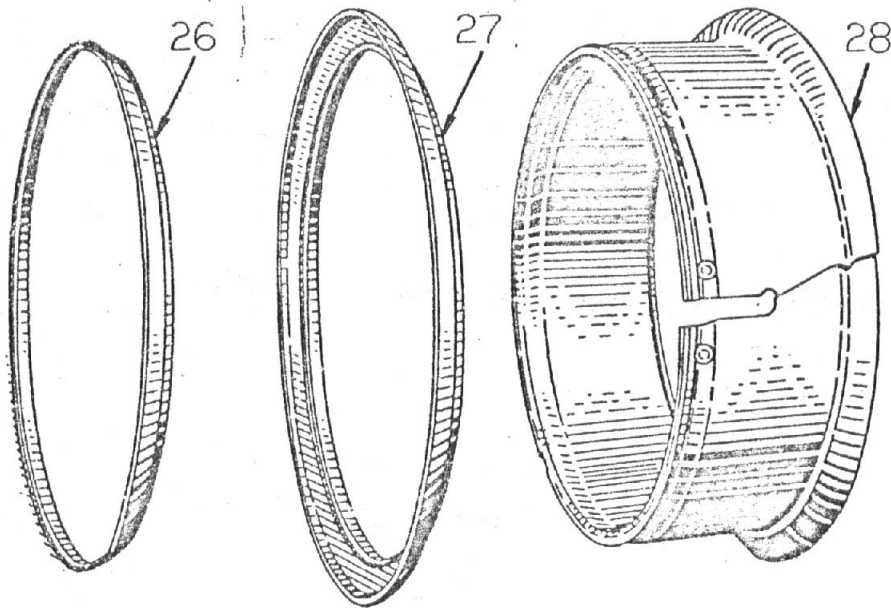
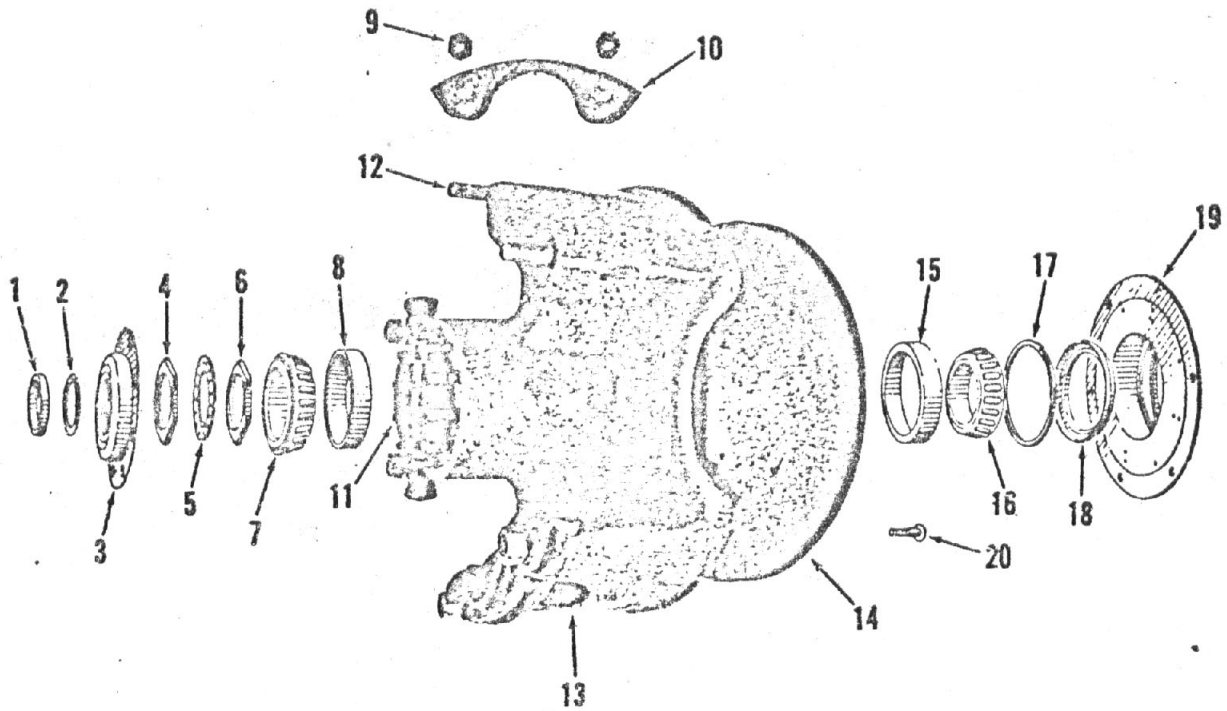
Disassembly of spoke wheel can be accomplished by using a suitable puller to remove the outer bearing cup and cone (4) & (5) and also the inner bearing cup and cone (9) & (10). The oil seal (11) will also then be loose.

CLEANING, INSPECTION & REPAIR

Clean all parts completely with a suitable solvent and inspect for damage and wear. Replace any necessary parts. Repack wheel bearings with suitable wheel bearing grease.

REASSEMBLY

Done in the reverse of the disassembly.



REAR WHEEL ASSEMBLY

REAR WHEEL ASSEMBLYDISASSEMBLY

Remove the rim clamp nuts (9) and the rim clamp (10) to allow removal of the rim assembly (26), (27), (28) and (29).

Remove hub cap kit (25) oil seal (1) ring and cork assembly (2) and the outer oil seal (3). Remove outer nut (4) washer (5) and inner nut (6).

Wheel hub (13) and brake drum (14) assembly can now be removed. Brake drum (14) can be disassembled from the wheel hub (13) by removing the drum bolts (20).

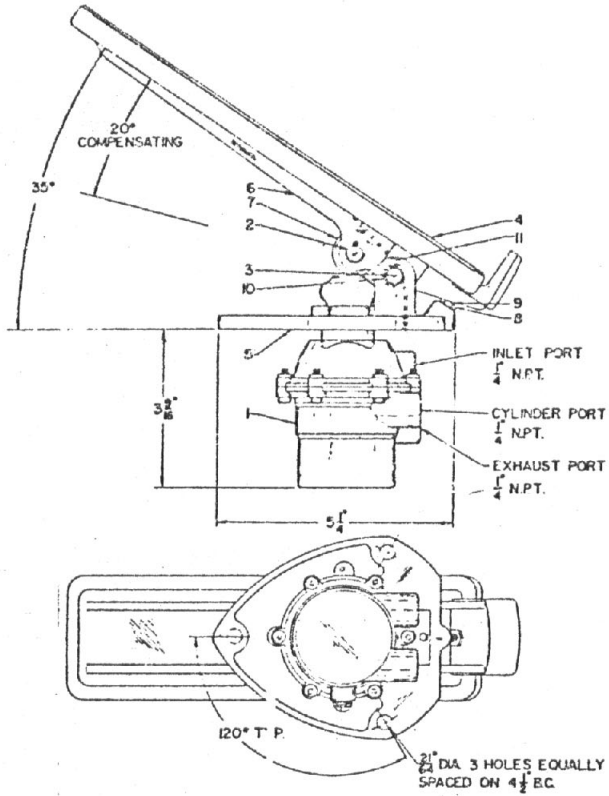
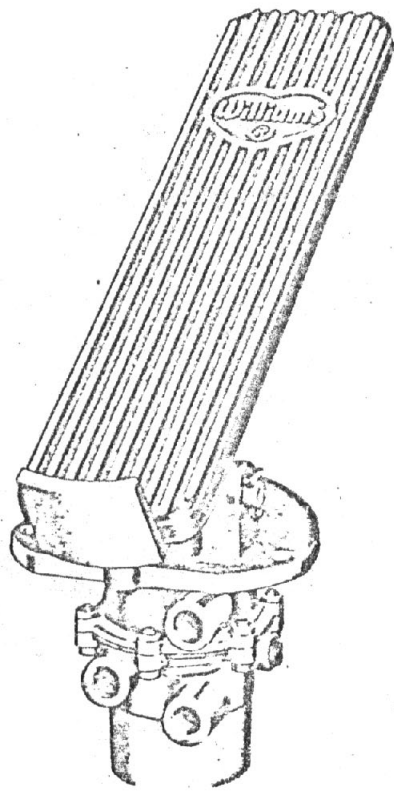
Disassembly of the wheel hub (13) can be accomplished by using a suitable puller to remove the outer bearing cup and cone (7) & (8) and also the inner bearing cup and cone (15) & (16). The inner wiper (17), inner oil seal (18) and the grease guard (19) will have to be removed before removing the inner bearing cup and cone (15) & (16).

CLEANING, INSPECTION & REPAIR

Clean all parts completely with a suitable solvent and inspect for damage and wear. Replace any necessary parts. Repack wheel bearings with suitable wheel bearing grease.

REASSEMBLY

Done in the reverse of the disassembly.



# AIR THROTTLE ASSEMBLY

AIR THROTTLE ASSEMBLYREMOVAL

Disconnect and cap off all existing air lines. Plug ports in valve. Remove three mounting bolts and remove air throttle pedal.

DISASSEMBLY

To disassemble treadle pedal (6) remove push rod pin (2), treadle pin (3) and cotter pins (10). This will allow removal of pedal (6) and roller (7). Treadle cover (4) can also be removed if necessary to replace.

Valve assembly (1) can be removed from the mounting plate (5) by unscrewing the nut on top of the plate which is under a rubber dust boot.

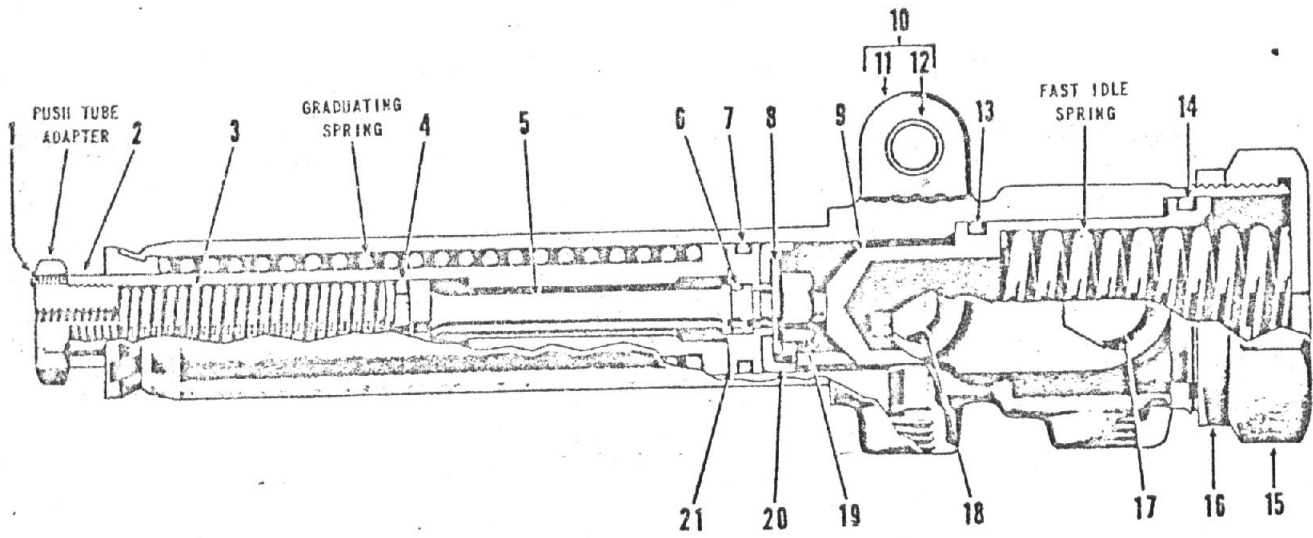
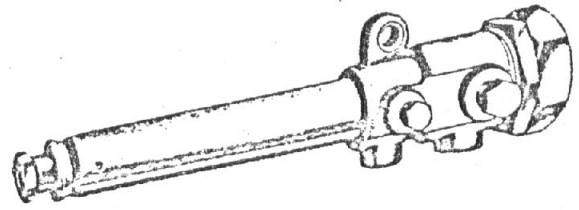
CLEANING, INSPECTION & REPAIR

Clean all parts with a suitable solvent. Place a light coat of oil on moving parts. Replace any parts which appear to be damaged or worn.

REASSEMBLY

Do in the reverse order of the disassembly.





THROTTLE CYLINDER

THROTTLE CYLINDERDISASSEMBLY

1. Remove cylinder cap (15) and locknut (16) allowing removal of fast idle spring and piston (9) from cylinder housing (11).
2. Remove grommets (13) and (14) from fast idle piston.
3. Remove set screw (1) from push tube adaptor allowing removal of adaptor, take-up spring (3), and oil seal (4) from push tube assembly (2).
4. Remove push tube assembly and graduating spring from cylinder housing.
5. Remove nut (19) from piston rod (5) allowing removal of piston cup follower (8), piston cup (20), piston (21) and piston rod from push tube assembly.
6. Remove oil seal (7) from piston and grommet (6) from piston rod.
7. Remove pipe plugs (17) & (18) from cylinder housing.
8. Remove bushing (12) from cylinder housing.

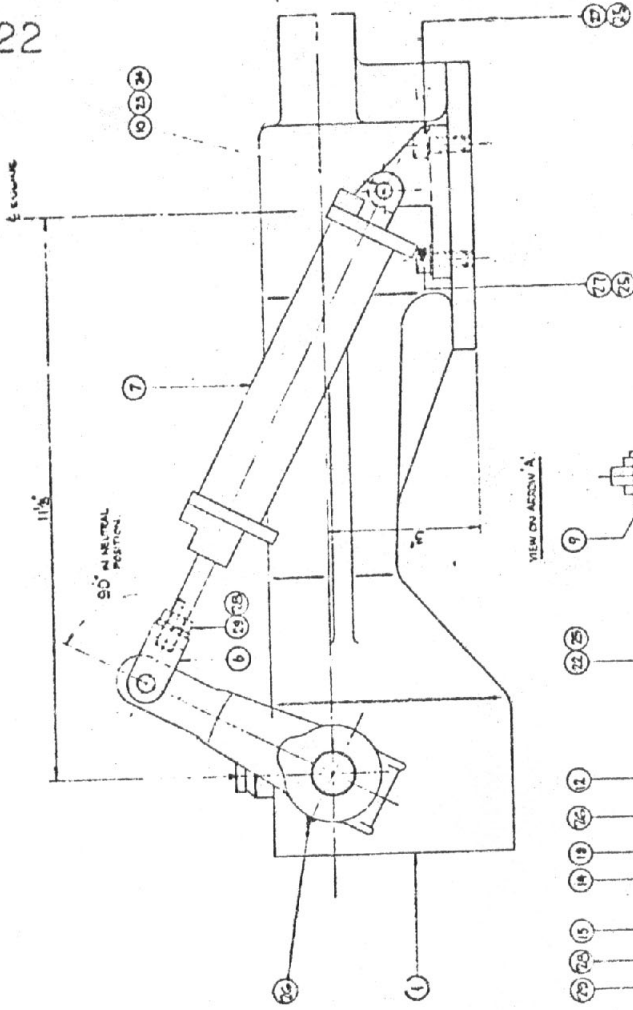
CLEANING, INSPECTION AND REPAIR

1. Clean all metal parts with an approved cleaning solvent; dry thoroughly with compressed air.
2. Inspect for wear, cracks, distortion, scoring and damaged threads.
3. Replace damaged parts.

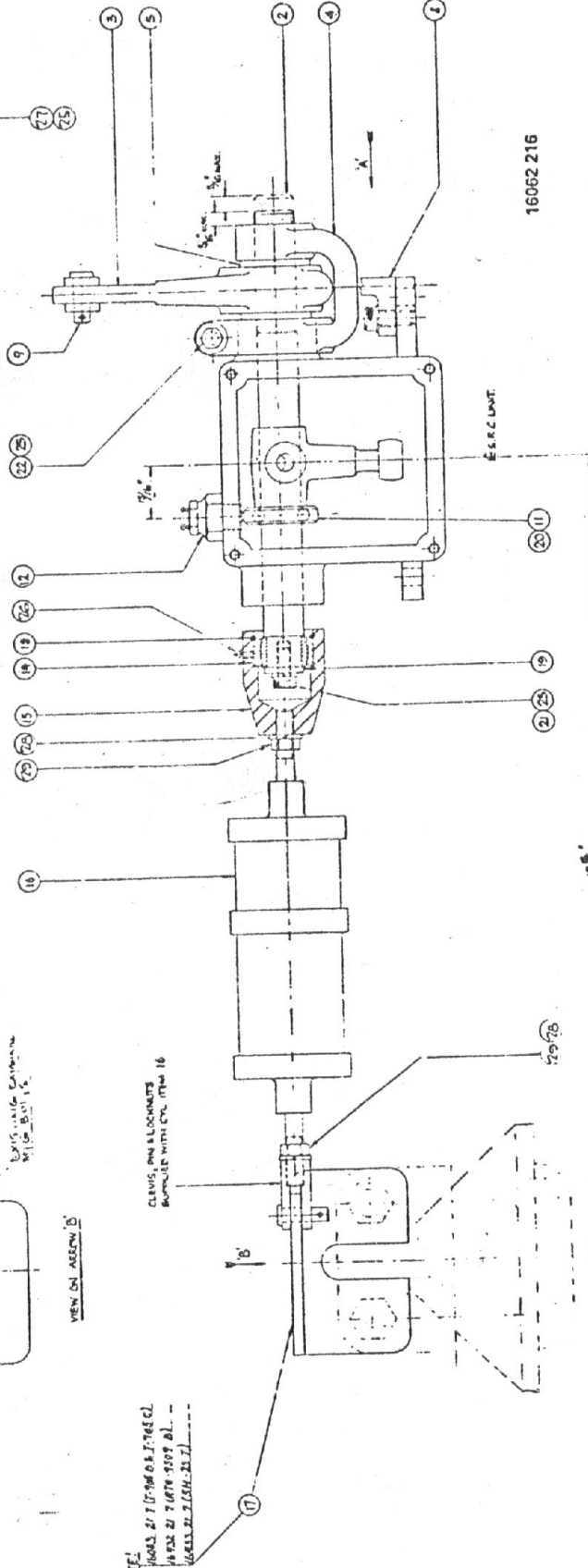
ASSEMBLY

1. Reassemble all parts in throttle cylinder in reverse order of disassembly.

5-22



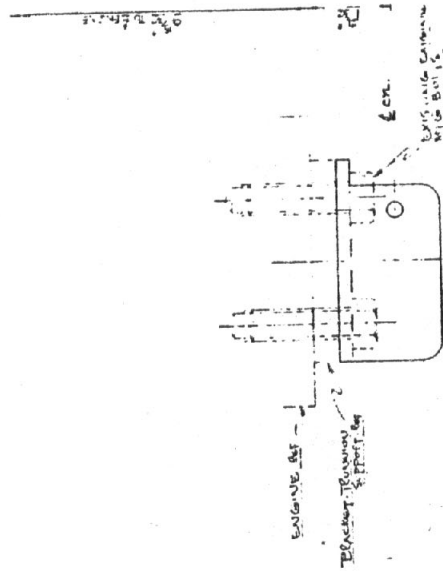
VIEW ON ARROW A



16062 216

50° NEUTRAL POSITION

VIEW ON ARROW B



NOTE:  
 LOCKS 21 (7-94) & 27 (8-51)  
 ARE 21 (7-94) & 27 (8-51) -  
 (6811.21.21.51-21.1)

CLASP AND LOCKNUTS  
 REMOVE WITH CN. ITEM 16

# AIRSHIFT ASSEMBLY

AIRSHIFT ASSEMBLYRemoval

Remove and cap off all air lines. Mark individual air lines to identify for reassembly. Remove Clevis Pin (9) and Yoke Pin (10) to remove Rotating Cylinder Assembly (7). To remove Shift Cylinder (16) remove Clevis Pin from Bracket (17) and loosen Locknut (29) and unscrew from Housing (15). The SRC Slave Unit (1) can be removed from the Transmission by removing the Socket Head Set Screws (27) and Lockwasher (25). Unit can then be lifted off Transmission.

Disassembly

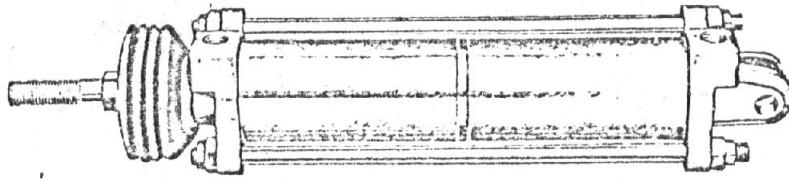
The Housing (15) can be removed by releasing the Retaining Ring (13) and then slipped off the shaft. The Ball Bushing (14) can be removed from the Shaft (2) by removing the Capscrew (21) Lockwasher (25) and Washer (19). Neutral Switch (12) can be removed by unscrewing it from the Housing (1). To remove Lever (3) and Lever Clamp (4) from Shaft (2), remove Capscrew (22) and Washer (25). Disassembly of Rotating Cylinder (7) and Shift Cylinder follow this section.

Cleaning, Inspection and Repair

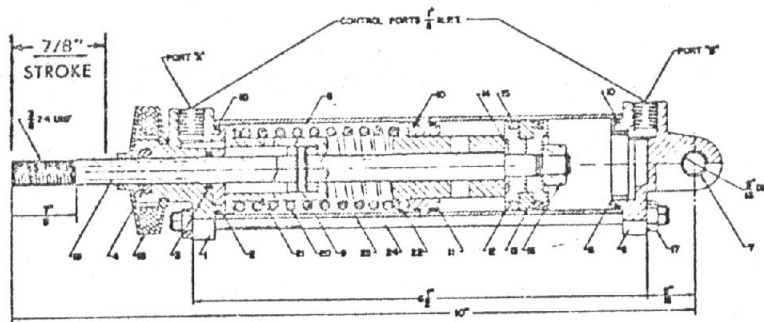
Clean all parts with a suitable solvent and dry completely with compressed air. Check all parts for damage and wear. Replace all necessary parts. Put a light coat of oil on all rods and moving parts.

Reassembly

Do in the reverse order of disassembly.



WEIGHT: 1 LB., 4 OZ.



FEATHERING CYLINDER

FEATHERING CYLINDERDISASSEMBLY

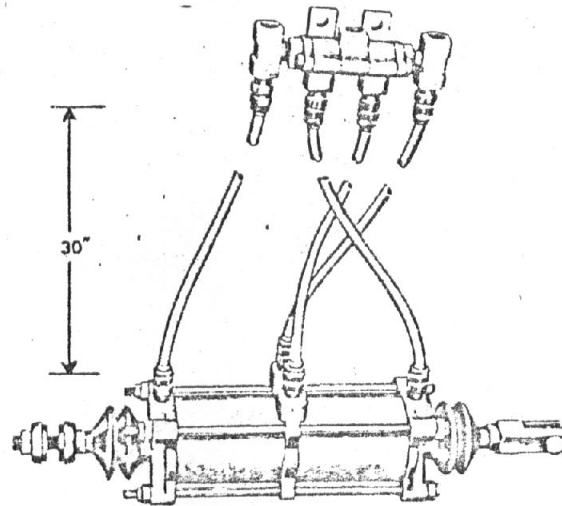
1. Remove locknut (17) from tie rod (24) allowing removal of front end cap (1) and rear end cap (5) from shell (23).
2. Remove dust boot (18), rod wiper (4), retainer ring (2), and "O" rings (3) and (10) front end cap.
3. Remove retaining ring (6), "O" ring (10) and bushing (7) from rear end cap.
4. Remove locknut (16) from piston rod (19) allowing removal of piston half (12), piston ring (13), washer (14), center section (11), spring retainer (22), spring (20), and spring retainer (21).
5. Remove roll pin (9) and stop ring (8).
6. Remove "U" cup (15) from piston halves.
7. Remove "O" ring (10) from center section.

CLEANING, INSPECTION AND REPAIR

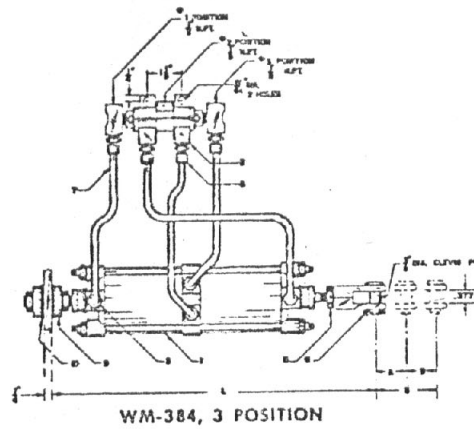
1. Clean all metal parts with an approved cleaning solvent; dry thoroughly with compressed air.
2. Inspect all parts for wear, scoring, distortion and damaged threads.
3. Replace all damaged parts.

ASSEMBLY

1. Reassemble feathering cylinder in reverse order of disassembly.



Cylinder "complete kits" are pre-plumbed with 1/4" polyethelene tubing.



# INDEXING CYLINDER KIT

INDEXING CYLINDER KITDISASSEMBLY

1. Mark all tubing connections to ease in reassembly in respective places.
2. Disconnect tubing (7) at fitting (3) from check-valve (2) and cylinder assembly (1).
3. Remove cotter pin (6) from clevis pin (5) allowing removal of clevis (4) and jam nut (12).
4. Remove elbow (11) from check-valve.
5. Remove locknut (12) allowing removal of washer retainer (9) and washer (10).

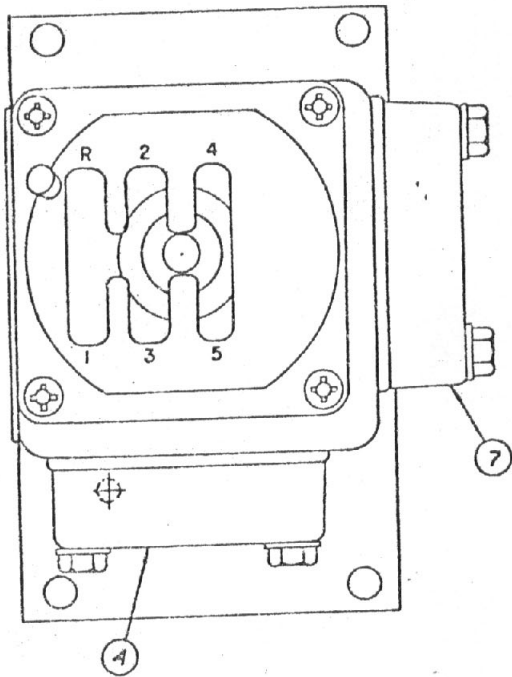
CLEANING, INSPECTION AND REPAIR

1. Clean all metal parts with an approved cleaning solvent and dry thoroughly with compressed air.
2. Inspect all parts for wear, cracks, and damaged threads.
3. Replace all damaged threads.

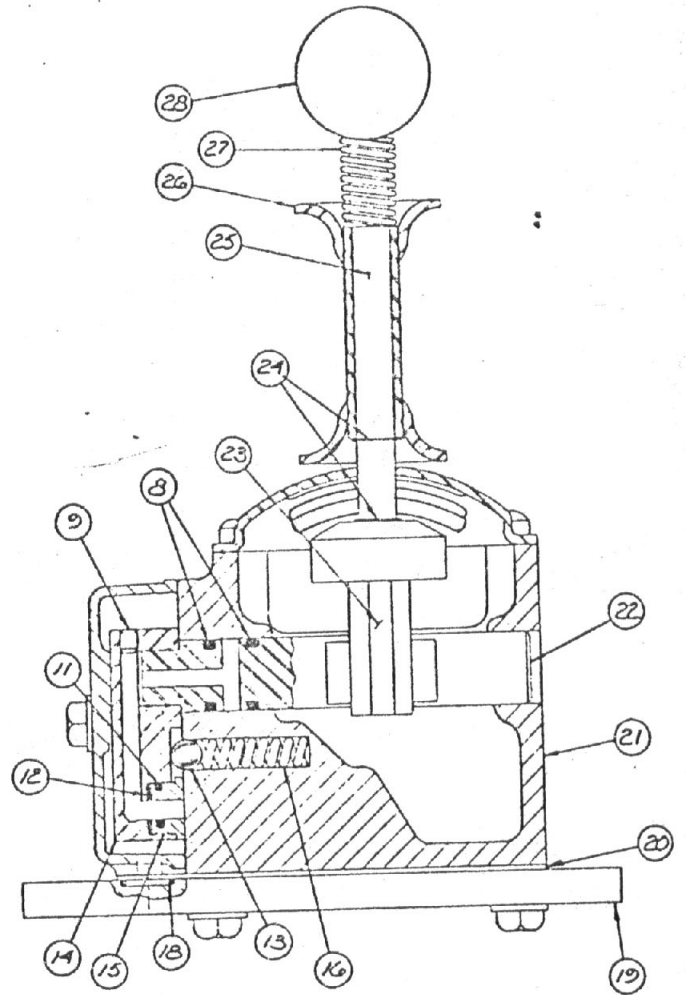
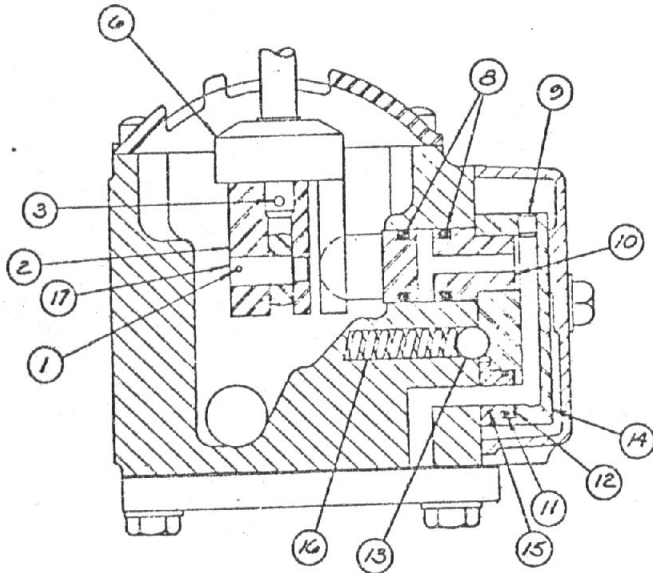
ASSEMBLY

1. Reassemble all parts for cylinder kit in reverse order of disassembly.





AIR SHIFT CONTROL  
ASSEMBLY



AIR SHIFT CONTROL ASSEMBLYDISASSEMBLY

1. Remove lever knob (28) from control lever (25) allowing spring (27) and tube assembly (25) to be removed.
2. Remove shift select cover and retaining rings (24).
3. Remove cotter pin (1) and lever pin (17) allowing removal of control lever.
4. Remove roll pin (3) permitting removal of control lever from cone (6) and clevis (2).
5. Remove shaft (22) and "O" rings (8) from shaft.
6. Remove covers (4) and (7) from body (21) allowing removal of selector arm (14), selector shift (10), ball (13), control spring (16), insert valve (15), "O" ring (11) from insert valve and washer (12).
7. Remove "O" rings (8) from selector shift, and plugs (9) from selector arm.
8. Remove body from bottom plate (19), gasket (20) and "O" ring (18) from bottom plate.

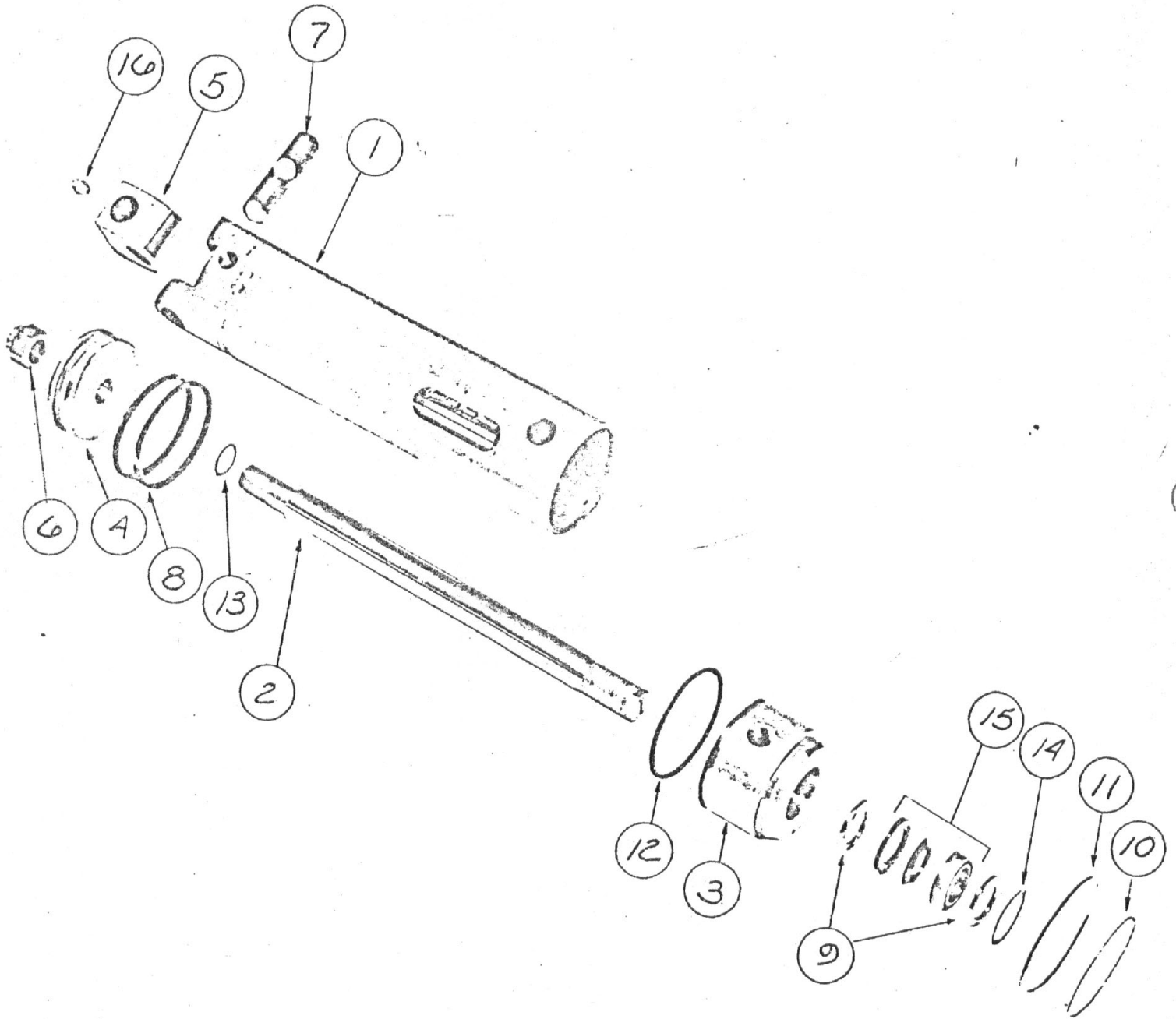
CLEANING, INSPECTION AND REPAIR

1. Clean all metal parts with an approved cleaning solvent and dry thoroughly with compressed air.
2. Inspect all parts for wear, cracks, scoring, and distortion.
3. Replace all damaged parts.

ASSEMBLY

1. Reassemble all parts in reverse order of disassembly.

# 3" Diameter Cylinder



STEERING CYLINDER ASSEMBLY

## SERVICE INSTRUCTIONS

Disassembly

To service the cylinder, first remove the snap ring from the head.

Push the head into the cylinder about one-half inch or far enough to permit removal of the snap ring from cylinder tube.

By pulling the rod outward, the head, and piston and rod assembly can be removed as a unit.

The head can now be removed from the rod.

The rod seal and washers can be removed from the head by taking out the retaining ring.

Examine the piston and piston rings for damage.

These parts should be replaced if they are worn or badly scored.

If the piston is removed from the rod, the copper washer seal (part number 32131) should be replaced with a new one.

Inspect the inner wall of the cylinder body for scoring. Light scratches on the wall can be removed by buffing with crocus cloth.

Examine the O-Ring seal for cuts and abrasions on the outer surface that would cause leakage.

The rod seal assembly (D-W Seal) should be examined carefully for damage.

If the sealing edges of the neoprene ring are cut or worn, leakage will occur.

The nylon wedge ring and gland act as a rod scraper and if the edges are broken or "notched" foreign matter will enter the seal cavity.

Wash and clean all parts thoroughly in solvent or kerosene before reassembly.

Check the rear pin and universal block for wear. The pin should fit snugly when assembled in the cylinder base and universal block.

Reassembly

Lubricate all seals and parts with light oil before assembly.

Install the rings on the piston having the joints positioned opposite each other.

A standard ring compressor will be required for assembling the piston and rod assembly in the body.

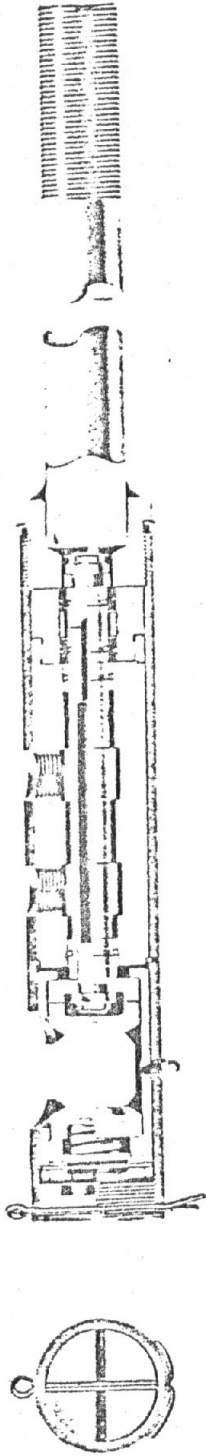
Install the washers and rod seal assembly in the head and secure it with the snap ring.

Install the O-Ring seal on the head.

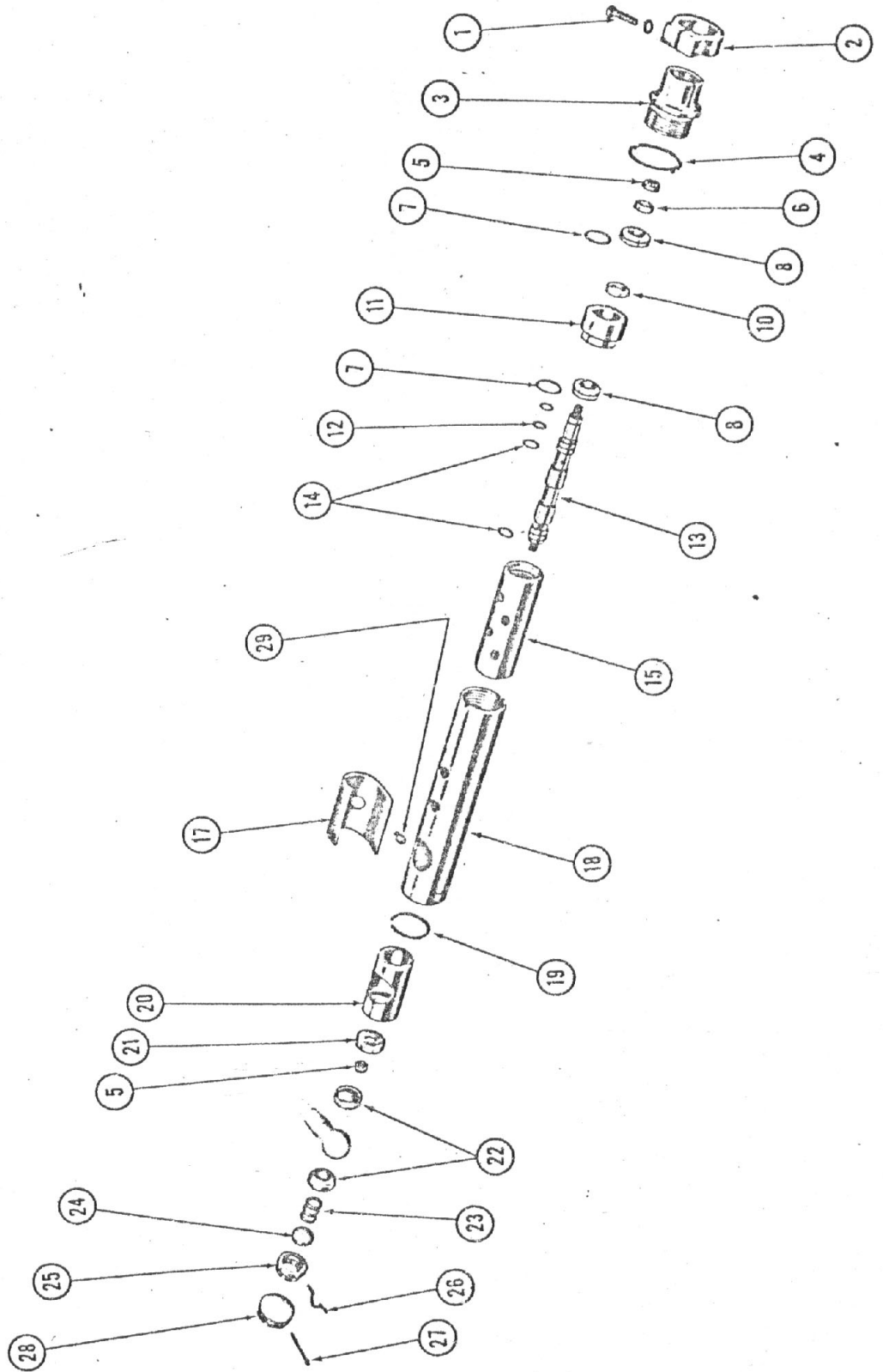
When assembling the head into the body, move it slowly so the O-Ring will not be damaged as it passes the port hole in the body.

Install the snap ring in the body. Pull the rod outward to force the head against the snap ring.

Install the spiral lock ring on the head.



CROSS-SECTION ILLUSTRATION — G21 SERIES VALVES



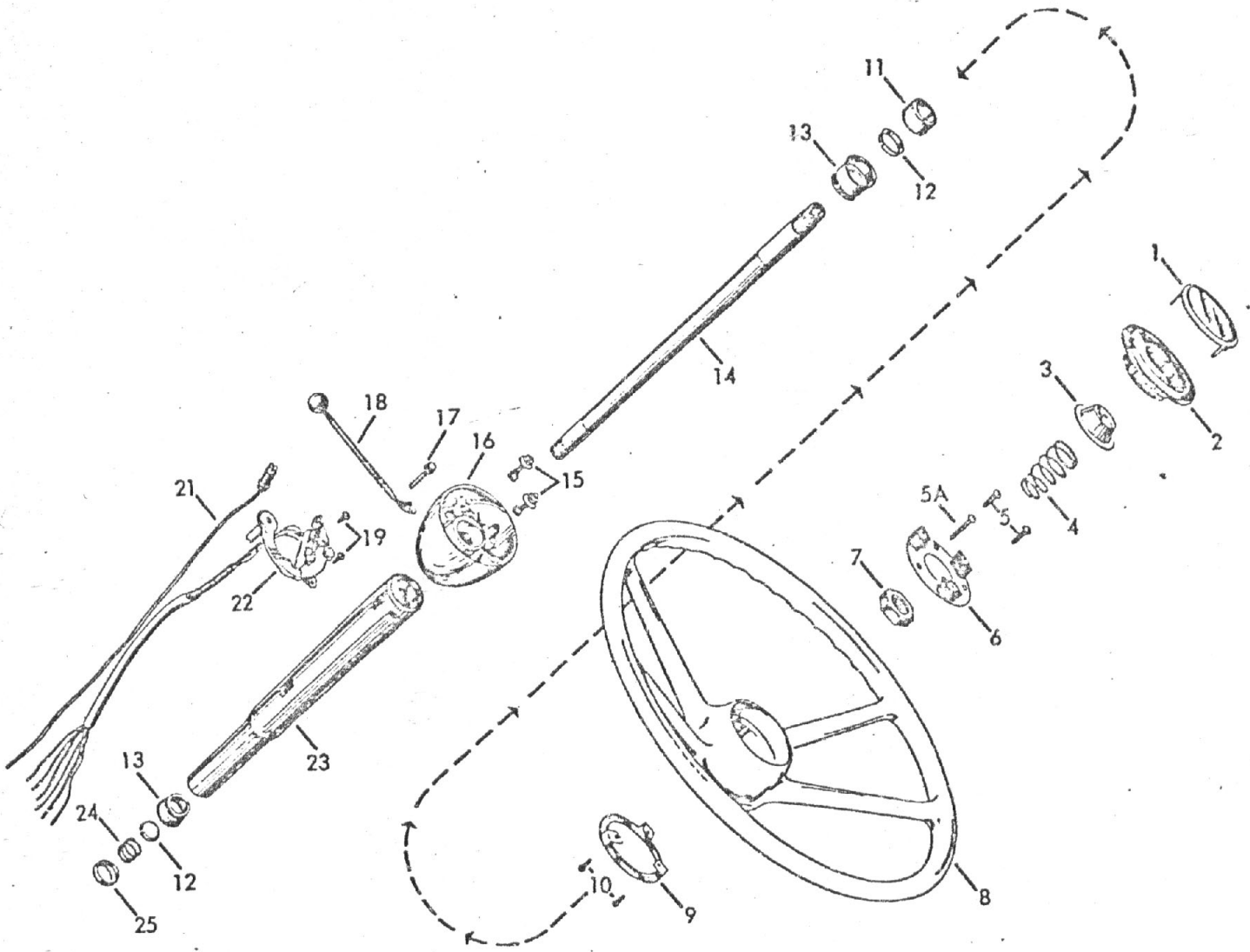
G 21 STEERING VALVE

STEERING VALVERemoval

Disconnect all hydraulic lines and cap them off to insure that they will stay clean. Tag all lines to insure proper hook up at reassembly. Remove Cotter Pin (27) and Back Off Ball Socket Plug (25) until you are able to slip it off the Ball Stud. Remove Hex Head Capscrew (1) and unscrew entire assembly from Draglink.

Disassembly, Cleaning, Inspection and Repair

Refer to the Service and Maintenance Instructions Booklet in the back of this manual.



STEERING COLUMN ASSEMBLY



TURN SIGNAL AND COLUMN ASSEMBLYDISASSEMBLY INSTRUCTIONS

Remove horn button cap and emblem assembly (1 & 2) by twisting counterclockwise. Remove contact cup (3), spring (4). Examine base plate assembly (6) for torn rubber segments and to replace, remove screws (5) and (5A).

Remove wheel nut (7).

Remove wheel (8). Examine contact ring (9), if necessary to replace, remove drive screws (10).

Remove spacer (11) and spring seat (12).

From lower end, remove dust cap (25), spring (24), spring seat (12), and pry out bearing (13). Disconnect wires of horn contact roller assembly (21) and directional switch assembly (22). Remove wheel tube (14) from jacket tube (23) and turn signal housing assembly (16).

To remove directional switch assembly (22) and switch lever (18), remove screws (19) and screw assembly (17).

To remove horn contact roller assembly (21), pull out with pliers, taking care not to damage bakelite shell or cut horn wire cable.

To remove turn signal housing (16) from jacket tube (23), remove clamp bolts (15)

To remove or replace upper bearing (13) press out of turn signal housing (16).

Caution: Press only against outer bearing shell.

REASSEMBLY INSTRUCTIONS

Pressing only against outer shell, assemble upper bearing (13) into position in turn signal housing (16).

With clamp bolts (15) assemble turn signal housing (16) to jacket tube (23), taking care to position housing for alignment of directional switch wiring.

Assemble directional switch assembly (22) by feeding wires and horn contact roller assembly wire (21) through opening in turn signal housing and through wire trough in jacket tube (23) taking care to position plastic wire protector over wires. Assemble switch assembly (22) and switch lever (18) using screws (19) and (17).

Press horn contact roller assembly into bore of turn signal housing (16).

Slide jacket tube assembly (23) down over wheel tube (14).

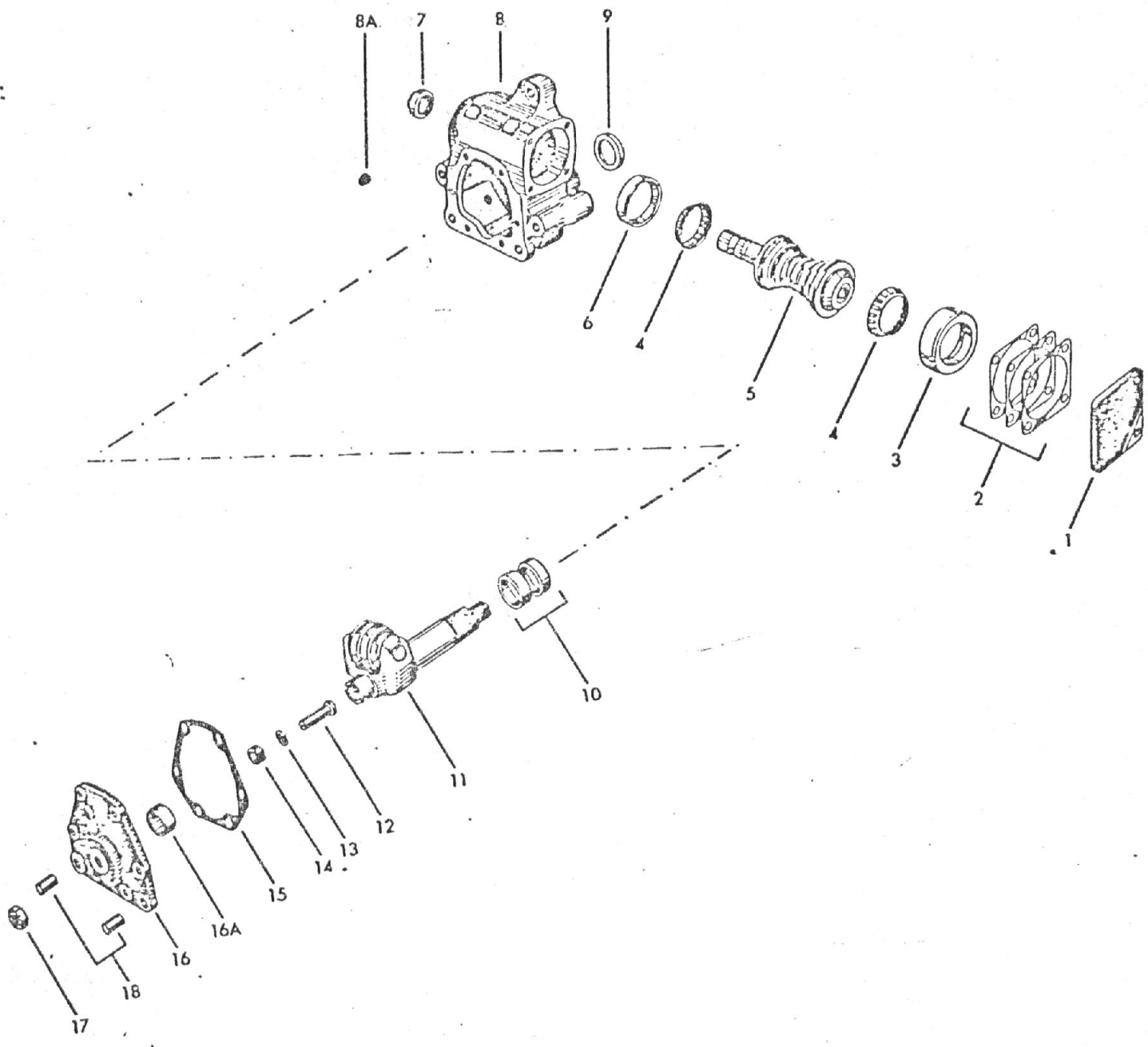
Pressing against outer shell, assemble bearing (13) into lower end of tube (23). Assemble spring seat (12), spring (24), and dust cap (25). Note: Wrap tape around wheel tube (14) to hold parts in position.

Assemble contact ring (9) to wheel (8) using drive screws (10) and base plate (6) using screws (5) and (5A).

Assemble spring seat (12) and spacer (11) over wheel tube (14).

Remove tape and assemble wheel (8) to wheel tube (14) with nut (7). (Tighten to 55-65 foot pounds).

Assemble spring (4), contact cup (3), and horn button cap assembly (1) and (2) by pushing down and turning clockwise.



STEERING GEAR ASSEMBLY

STEERING GEAR ASSEMBLYDISASSEMBLY

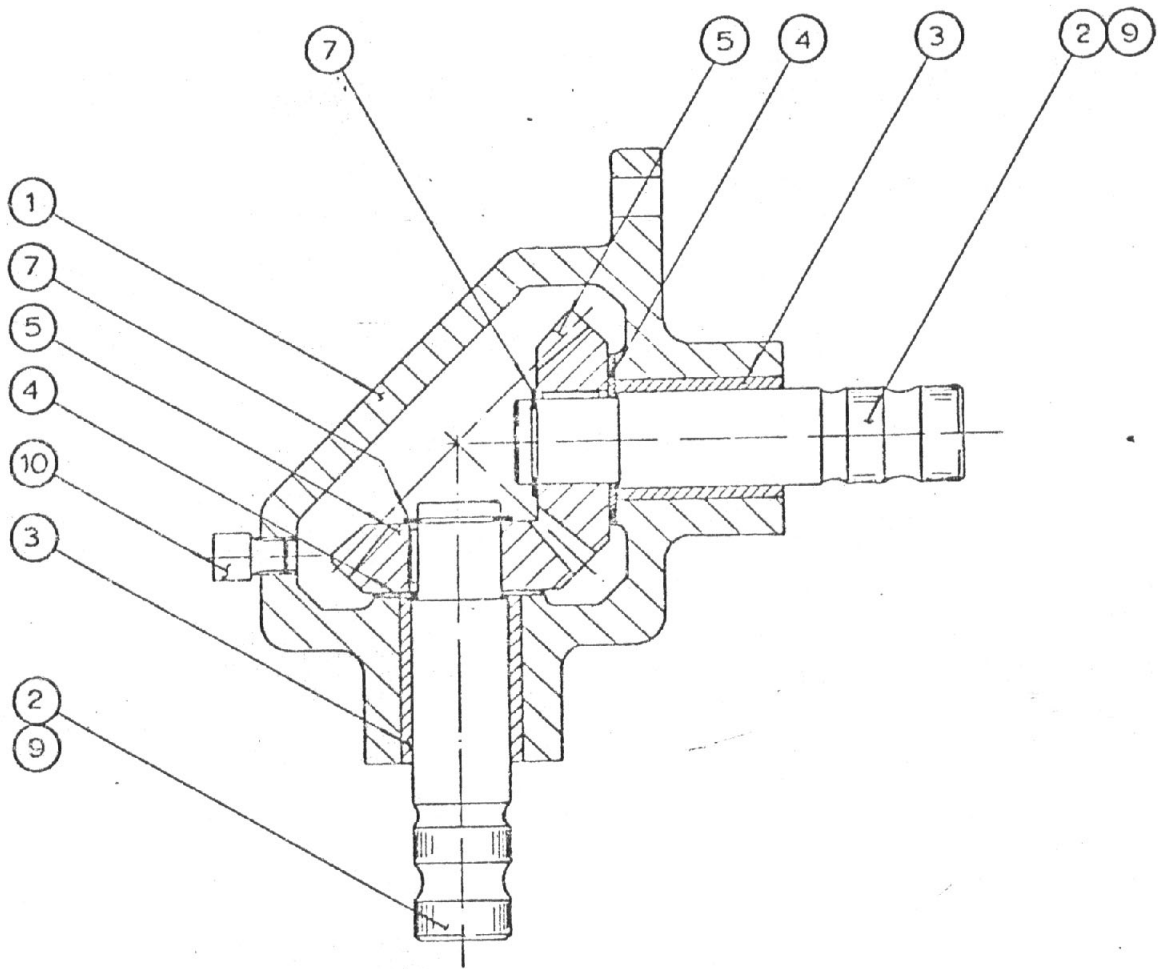
1. Remove mounting screws (1a) allowing removal of worm cover (1), shims (2 - 2d), adjusting cup (3), and bearing (4).
2. Remove pitman arm nut (5a), lockwasher (5b) and pitman arm allowing removal of worm assembly (5), bearing (4), bearing cup (6) and oil seal (7).
3. Remove mounting screws (16b), and adjustment nut (17) allowing removal of shaft cover (16), gasket (15), bearing (16a), retainer (14), thrust washer (13), adjusting screw (12), "O" ring (12a), worm shaft (11), bearings (10) and oil seal (9).
4. Remove filler plug (8a) and vent plug (8b) and dowel (18).

CLEANING, INSPECTION AND REPAIR

1. Clean all metal parts with an approved cleaning solvent; air dry thoroughly with compressed air.
2. Inspect all parts for wear, cracks, and distortion.
3. Replace all damaged and worn parts.

ASSEMBLY

1. Reassemble all parts in steering gear assembly in reverse order of disassembly.



BEVEL GEARBOX ASSEMBLY

BEVEL GEARBOX ASSEMBLYDISASSEMBLY

1. Remove hex. bolt (11), lockwasher (12), cover plate (6) and gasket (8).
2. Remove retaining ring (7) allowing removal of shaft (2), key (9), thrust washer (4), miter gear (5) and bushing (3).
3. Remove plug (10) from housing (1).

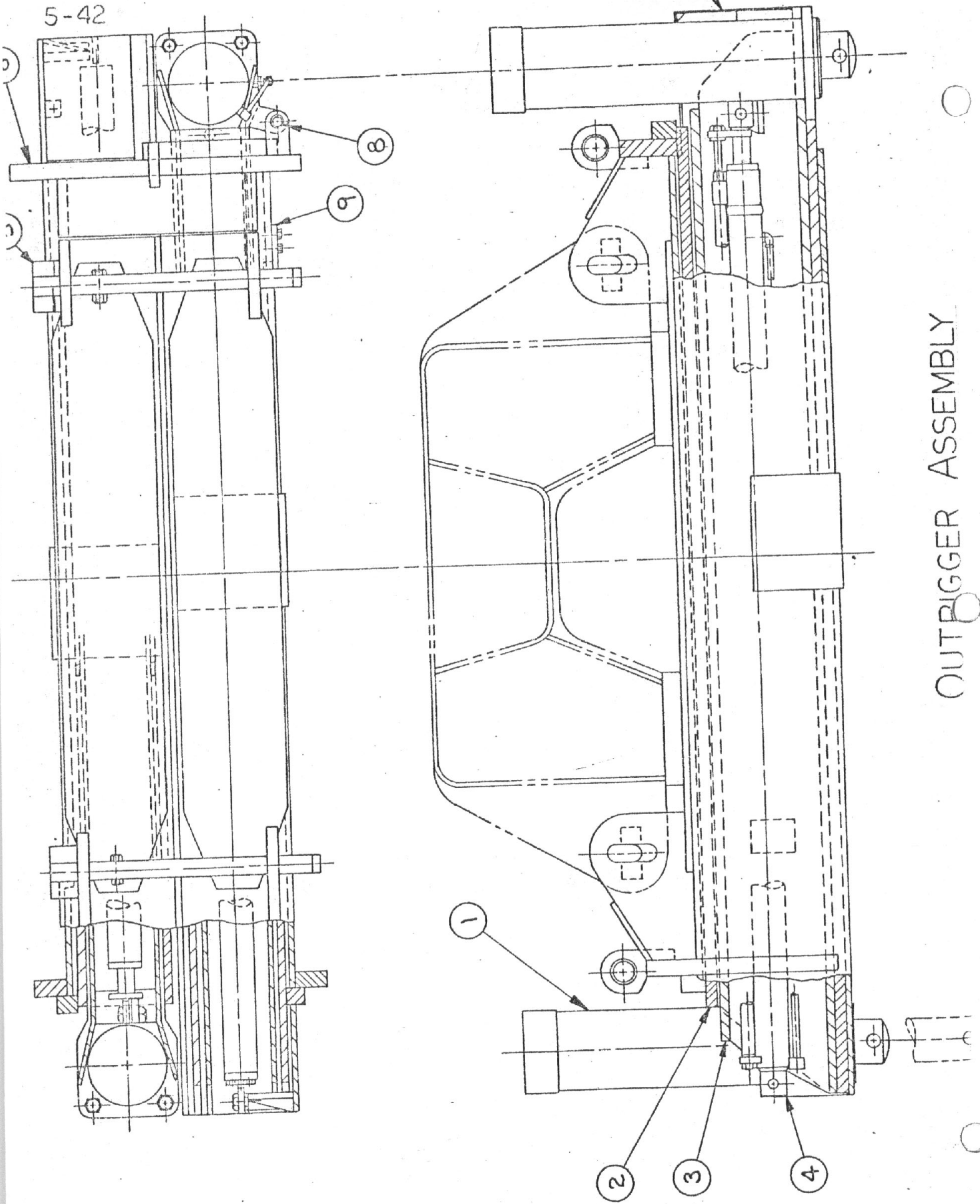
CLEANING, INSPECTION AND REPAIR

1. Clean all parts with an approved solvent and dry thoroughly with compressed air.
2. Inspect all parts for wear, distortion, and cracks.
3. Replace all defective parts.

ASSEMBLY

1. Reassemble gearbox in reverse order of disassembly.

5-42



OUTRIGGER ASSEMBLY

OUTRIGGER ASSEMBLYRemoval

Disconnect and tag all hydraulic lines. Attach chain to lifting lugs and secure to lifting crane. Remove Wedge Pin (5) from both sides of Outrigger Assembly. Remove Outrigger Assembly.

Disassembly

Secure chain around Vertical Cylinder Assembly (1) and remove bolts holding cylinder to beam. Lift out cylinder and place in clean area for disassembly.

Place block under rear end of Extension Cylinder (4) and remove bolt holding cylinder to Outrigger Box Assembly (6). Remove Stop (9) by unscrewing holding bolts. The Beam Assembly (3) can now be pulled out carefully to insure that the back end does not fall down and damage the cylinder.

The Inner Box Assembly (2) can also be pulled out of the Outrigger Box Assembly (6).

The Extension Cylinder (4) can be removed from the Beam Assembly (3) by removing the front pin. Care must be taken to insure that the cylinder rod end does not fall and cause damage to the rod. After setting the cylinder down inside the beam, it can be pulled out the back end. Place the cylinder in a clean area for disassembly.

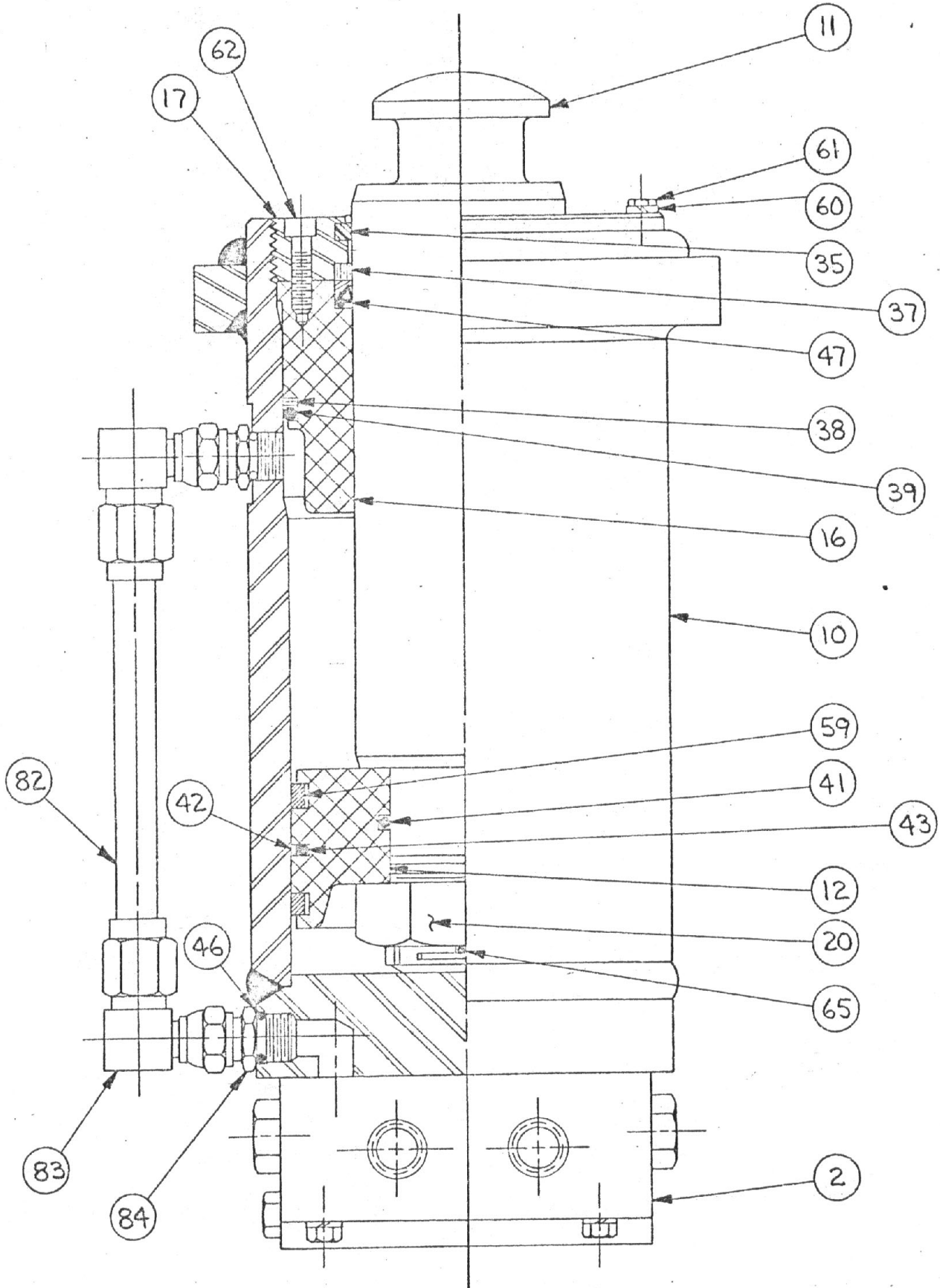
Cleaning, Inspection, and Repair

Clean all parts before reassembly and grease the bottom side of the Inner Box Assembly and the Beam Assembly.

Reassembly

Do in the reverse order of the disassembly.





VERTICAL EXTENSION CYLINDER

VERTICAL EXTENSION CYLINDERDISASSEMBLY

Remove socket head capscrews (62) and hex head capscrew (61) and spring washer (60). Then unscrew thread ring (17) using a spanner wrench. Be very careful not to damage the rod wipers (35) and the back up ring (37) which are in the thread ring (17). These items can now be removed from the thread ring (17).

Very carefully pull the rod (11) out of the case (10) thereby exposing the head gland (16) and the piston (12) which will come out with the rod (11).

Next remove the head gland (16) from the rod (11). The rod wiper loading "O" ring (47) can be removed from the forward end and the back up ring (38) and the static head "O" ring (39) from the back side.

To remove the piston (12) from the rod (11) you must first remove the cotter pin (65) and the hex nut (20). The piston (12) can now be removed from the rod (11). Be careful not to damage the internal "O" ring (41). The piston rings (59), sirvon seal (42) and the "O" ring (43) can now be removed if necessary.

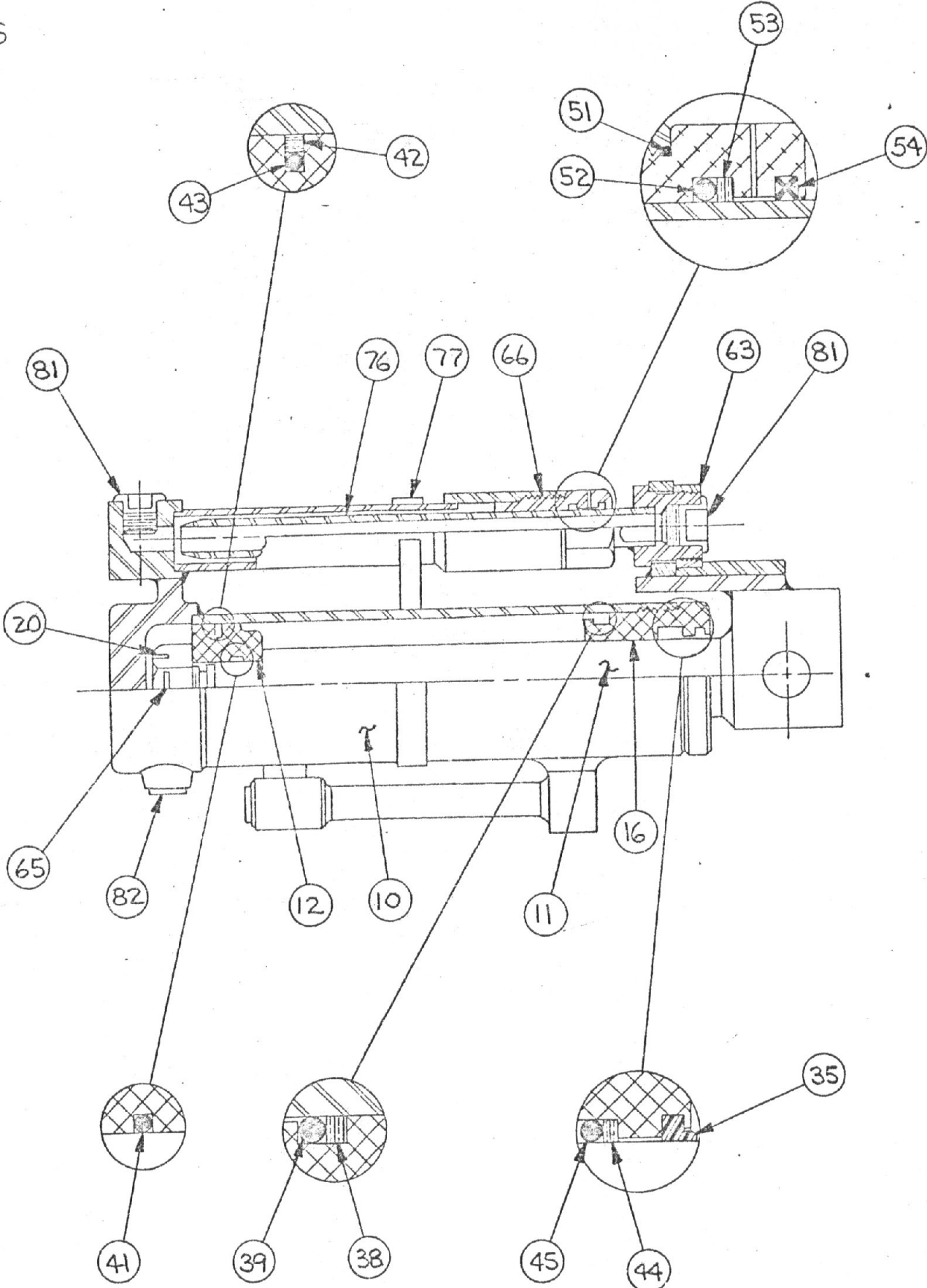
CLEANING, INSPECTION AND REPAIR

Inspect all seals and back up rings to insure that there are no splits or cracks. Also check the inner wall of the tube to see if there are any scores or scratches. Replace parts as necessary.

Clean all metal parts with a good solvent or kerosene. Put a light coat of oil on all parts before reassembly.

REASSEMBLY

Do in the reverse of the disassembly.



HORIZONTAL EXTENSION CYLINDER

HORIZONTAL EXTENSION CYLINDERDISASSEMBLY

The rod (11) must first be extended to allow clearance to remove the head gland (16). Using a spanner wrench slowly turn the head gland (16) until it is loose from the rod (11). Back off the telescoping tube (76) by unscrewing it at the hex retaining nut (63). This will allow removal of the rod (11) without taking out the telescoping tube (76).

The carefully pull out the rod (11), the piston (12) and the head gland (16). The piston (12) can now be removed by taking out the cotter pin (65) and the hex nut (20).

The "O" ring (41), seal ring (42) and the sirvon loading "O" ring (43) can now be removed from the piston (12).

Also the rod wiper (35), back up ring (44), rod seal "O" ring (45), back up ring (38) and the static head "O" ring (39) can now be removed from the head gland (16).

The telescoping tube (76) can be disassembled by unscrewing the trumbone glands (66) and pulling out the tube (76).

CLEANING, INSPECTION AND REPAIR

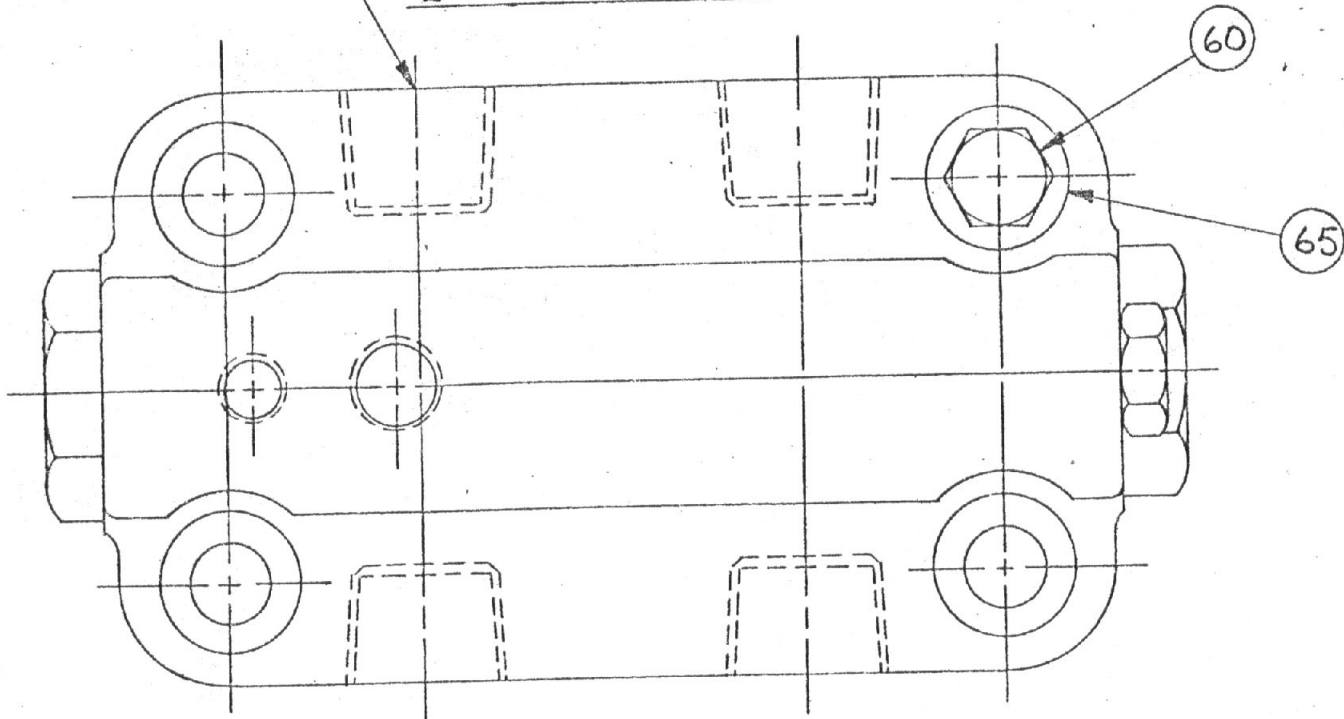
Inspect all seals and back up rings to insure that there are no splits or cracks. Also check the inner wall of the tube to see if there are any scores or scratches. Replace parts as necessary.

Clean all metal parts with a good solvent or kerosene. Put a light coat of oil on all parts before reassembly.

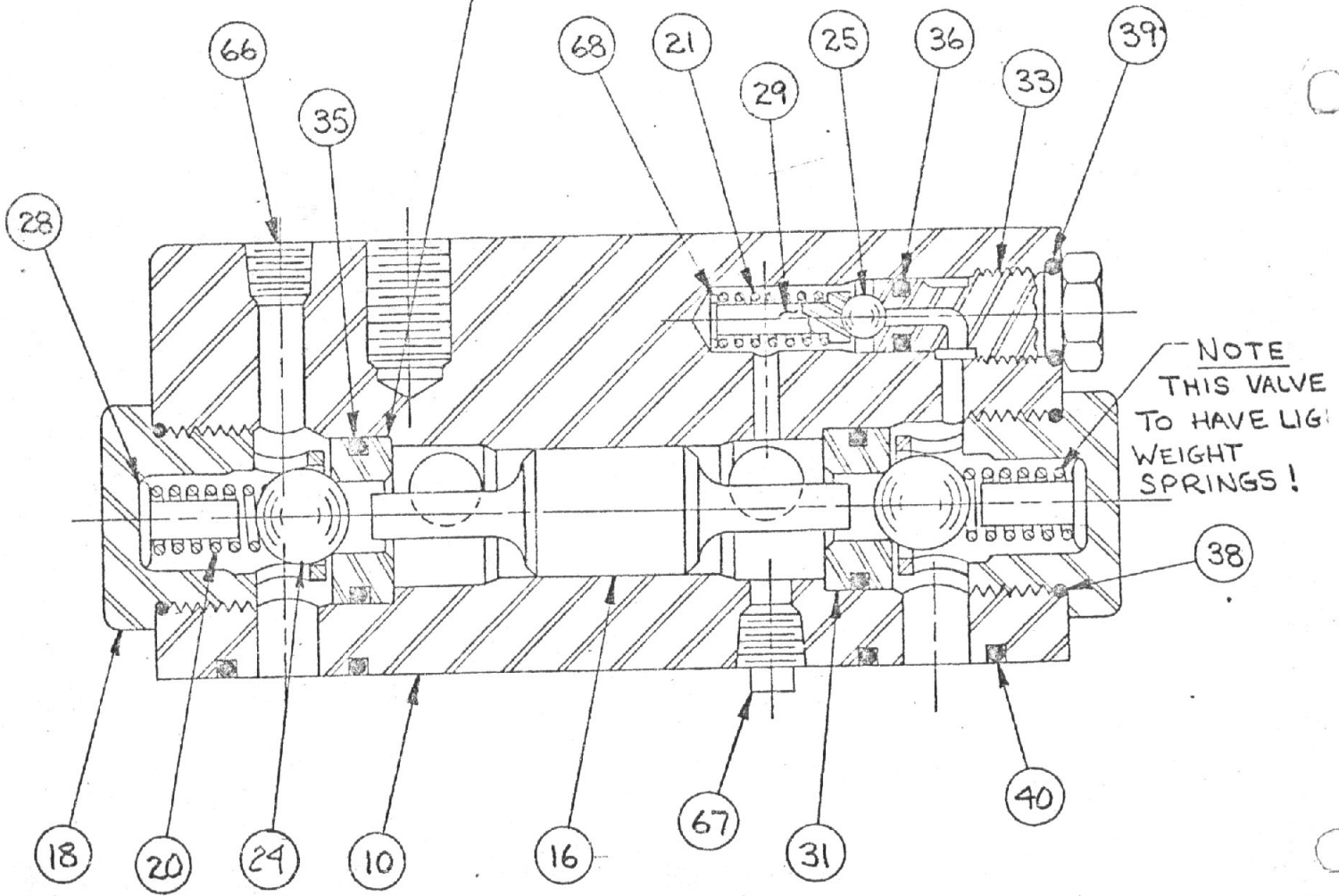
REASSEMBLY

Do in the reverse of the disassembly.

1/2" NPT ~ 4 PORTS



REVERSIBLE DOUBLE SIDED VALVE SEATS (2)



DOUBLE PILOT CHECK LOCK VALVE

DOUBLE PILOT CHECK LOCK VALVEREMOVAL

Remove valve assembly from vertical cylinder by removing the bolts (60) and washers (65) of the valve. Be careful not to lose the bottom "O" rings (40) when removing valve.

DISASSEMBLY

The spool (16) can be removed from either end. First unscrew the main end cap (18) being careful of the spring stop (28), spring (20) and the main ball (24) which will come out next. The valve seat (31) will come out next and after that the spool (16).

To disassemble the upper part of the valve, remove the relief cap (39) which will allow the removal of the relief ball (25), spring stop (29), spring (21) and the flat washer (68).

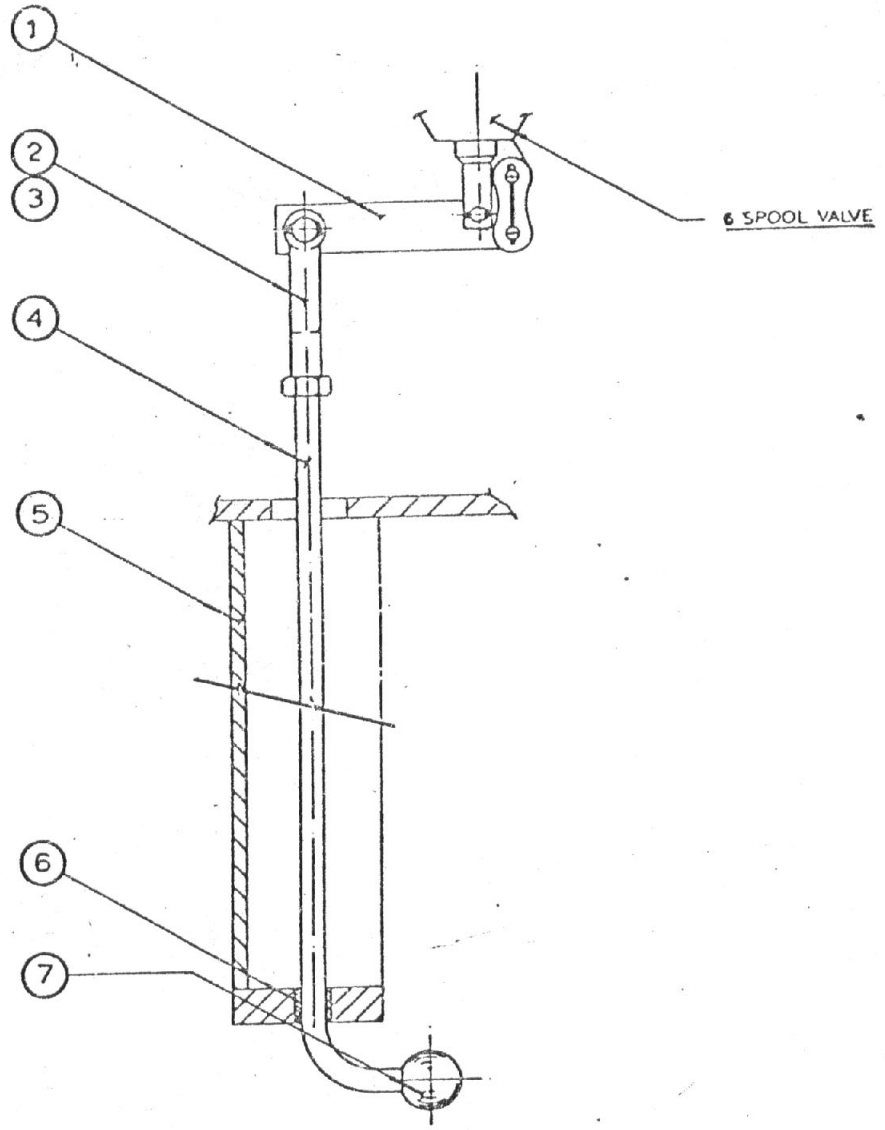
CLEANING, INSPECTION AND REPAIR

Inspect all seals and back up rings to insure that there are no splits or cracks. Also check the inner wall of the tube to see if there are any scores or scratches. Replace parts as necessary.

Clean all metal parts with a good solvent or kerosene. Put a light coat of oil on all parts before reassembly.

REASSEMBLY

Do in the reverse of the disassembly.



PUSHROD ASSEMBLY

PUSH ROD ASSEMBLYDISASSEMBLY

Remove yoke assembly (2) and hex nut (3). Rod (4) can then be pulled out of the bracket (5).

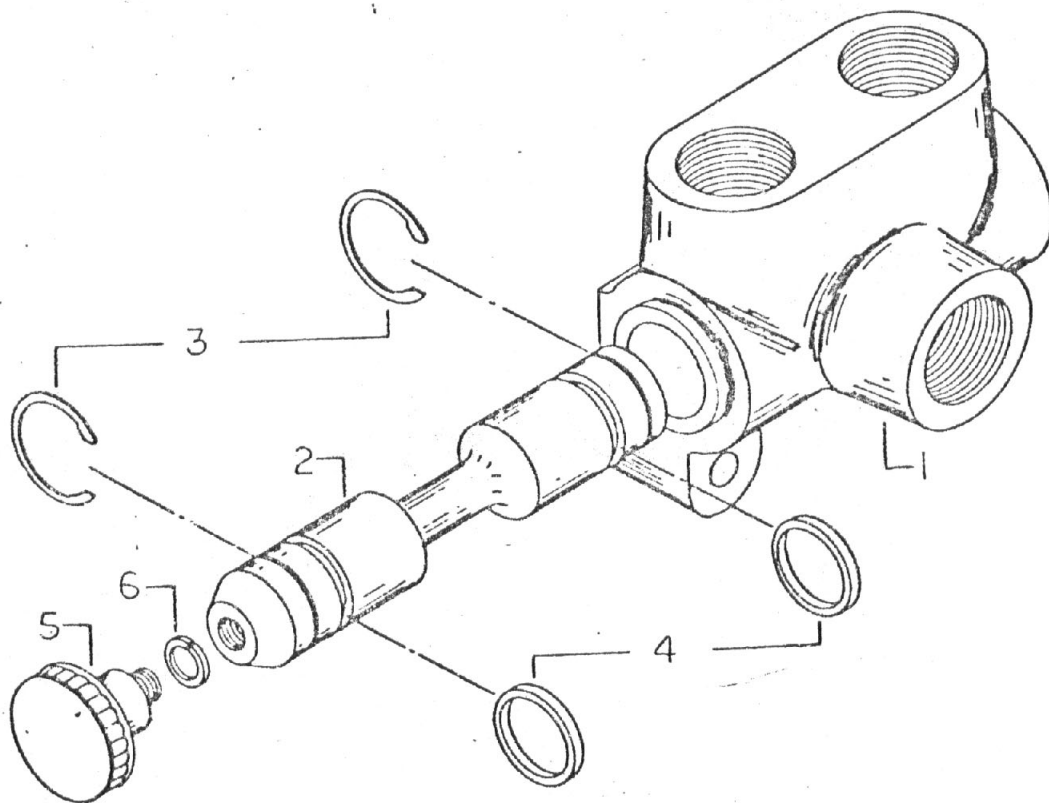
INSPECTION AND REPAIR

Check bronze bushing (6) for wear and replace if necessary.

REASSEMBLY

Do in the reverse of disassembly.





SELECTOR VALVE

SELECTOR VALVEDISASSEMBLY

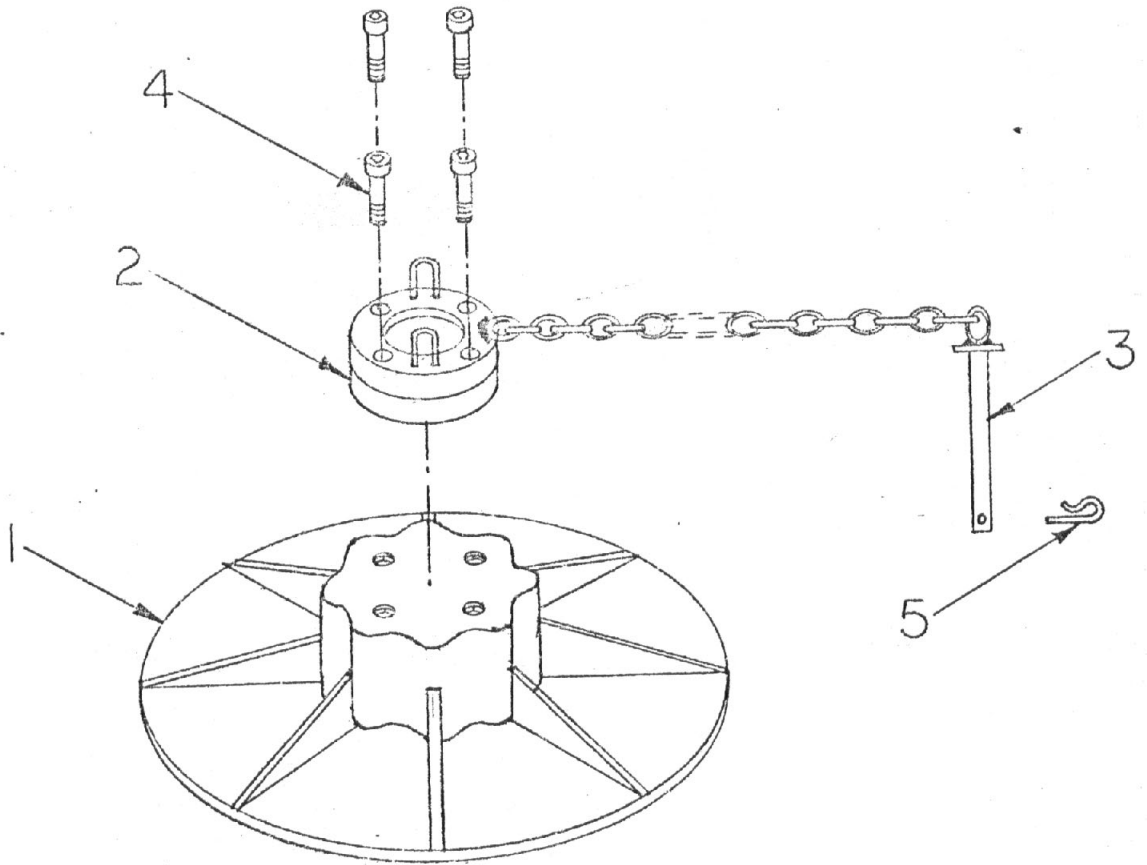
Remove snap ring (3) from outside of spool (2) on back side of valve (1). This will allow the spool (2) to be pulled out the front of the valve (1). Quad ring seals (4) can then be taken off if necessary. The handle (5) and lockwasher (6) can be removed by unscrewing handle (5).

CLEANING, INSPECTION AND REPAIR

Check seals for cracks or breaks. Check spool and inside of valve for scoring or scratching. Replace parts as needed. Clean all parts with a good solvent and place a light coat of oil on parts prior to reassembly.

REASSEMBLY

Do in the reverse of the disassembly.



OUTRIGGER FLOAT ASSEMBLY

OUTRIGGER FLOAT ASSEMBLYDISASSEMBLY

Remove the four socket capscrews (4) to separate the float cup assembly (2) from the float forging (1). The lock pin and chain (3) are welded so they are not removable.

CLEANING, INSPECTION AND REPAIR

Clean all parts with solvent and inspect for damage. Replace as needed.

REASSEMBLY

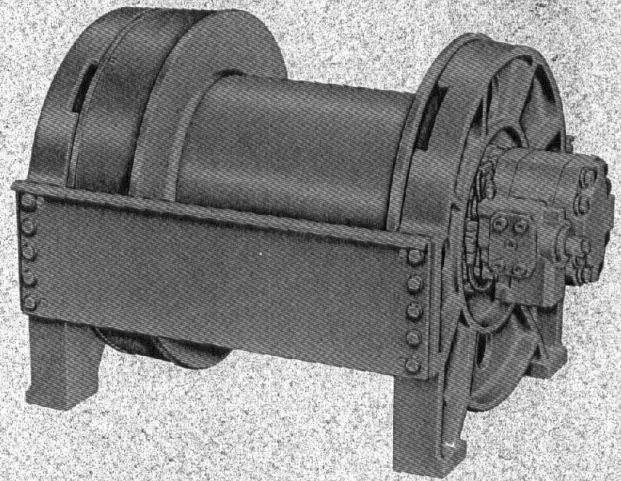
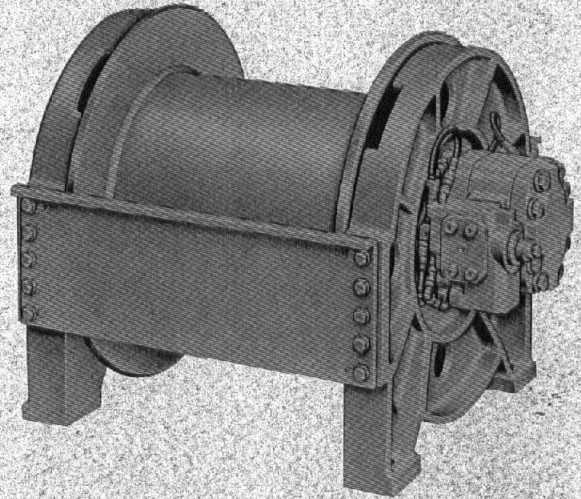
Do in reverse of disassembly.

OVERHAUL MANUALS



**CONSTRUCTION  
EQUIPMENT  
DIVISION**

**BRADEN INDUSTRIES, INC., BROKEN ARROW, OKLAHOMA**



**BRADEN CONSTRUCTION HOISTS  
MODELS C2H16 & C2H16D  
INSTALLATION, MAINTENANCE AND SERVICE**

**FOR BEST RESULTS, USE ONLY FACTORY CERTIFIED REPLACEMENT PARTS.**

**WARNING: GOODS ARE NOT INTENDED FOR USE IN THE LIFTING OR MOVING OF PERSONS.**

The winches described herein are neither designed nor intended for use or application to equipment used in the lifting or moving of persons and it is understood that all such use shall be at the sole risk of the user. The cable clamps on winches are not designed to hold rated loads. A minimum of 4-6 wraps of cable must be left on drum barrel to guarantee holding of rated load.

THIS SALE IS MADE ON THE EXPRESS UNDERSTANDING THAT THERE IS NO IMPLIED WARRANTY THAT THE GOODS SHALL BE FIT FOR THE PURPOSE OF LIFTING OR MOVING PERSONS OR OTHER IMPROPER USE AND THERE IS NO IMPLIED WARRANTY OF MERCHANTABILITY FOR SUCH PURPOSES.

## DESCRIPTION OF WINCH

The winch has three basic component parts:

1. Tie Plates and End Brackets
2. Hydraulic Motor and Brake Valve
3. Cable Drum Assembly

The cable drum assembly is made up of five basic assemblies in the C2H16 and six in the C2H16D:

1. Cable Drum
2. Two-Speed Clutch Assemblies and Primary Planetary Reducer
3. Brake Assembly
4. Secondary Planetary Reducer
5. Final Planetary Reducer
6. Free Fall Clutch Assembly (C2H16D only)

The hydraulic motor is bolted to the end bracket. The two-speed assembly housing is bolted and doweled to the end bracket. The brake assembly housing is bolted and doweled to the two-speed assembly housing. The ring gear of the secondary planetary reducer and final planetary reducer is splined to the brake housing. The cable drum is supported by the two-speed assembly housing through a large ball bearing. A spring loaded oil seal prevents oil leakage.

In the C2H16 the cable drum is supported on the other end by the final planet carrier to which it is splined. The carrier is supported by an anti-friction roller bearing on a ground and polished shaft projecting from the end bracket.

In the C2H16D the cable drum is supported on the other end by a bronze bushing running on the drop clutch hub. The drop clutch hub is supported by the final planet carrier to which it is splined. The carrier is supported by an anti-friction roller bearing on a ground and polished shaft projecting from the end bracket. A series of friction discs and drive discs are positioned between a splined land on the drop clutch hub and an internally splined area in the cable drum. Fifteen large, heavy-duty springs supply the pressure to engage the clutch. A large single acting hydraulic cylinder and piston located between the final planet carrier and the clutch pressure plate can, when pressurized, completely release the spring pressure on the clutch allowing the cable drum to rotate freely.

## TWO-SPEED ASSEMBLY

This assembly has five operating component parts:

1. Primary Planetary Reducer
2. Floating Ring Gear
3. High Speed Friction Clutch (Spring Loaded)
4. Low Speed Friction Clutch
5. Double Acting Hydraulic Piston

The friction elements of the high speed clutch are located between the planet carrier and the ring gear of the primary planetary reducer assembly. When engaged, the high speed clutch locks the ring gear to the planet carrier causing it to rotate with the planet assembly, directly connecting the motor shaft to the sun gear of the secondary planetary reducer.

The friction elements of the low speed clutch are located between the ring gear of the planet assembly and the stationary two-speed assembly housing. When engaged, the low-speed clutch locks the ring gear to the housing causing the planetary assembly to function as a reducer, increasing the ratio of the gear train between the hydraulic motor and the cable drum with resulting lower drum speed and greater hoisting capacity.

The high speed clutch is engaged by the brake springs. The low speed clutch is engaged by the movement of the hydraulic, clutch operating piston. Further movement of this piston compresses the brake springs, releasing the high speed clutch. Directing oil to the opposite side of the piston moves the piston away from the low speed clutch allowing the brake springs to fully engage the high speed clutch.

As no neutral exists during the change from one speed to the other, the winch will not drop its load if the shift is made in either raising or lowering operations.

## CAUTION

Both clutches are momentarily engaged during the shift. Excessive wear will result on the high speed clutch if the speed change is repeatedly and unnecessarily made while the winch is in operation.

Hydraulic pressure must always be present on one or the other side of the clutch operating piston when the winch is operated. Rapid wear of the low speed clutch will result if the piston is not moved



completely away from the clutch so there will be no dragging of the low speed clutch when the spring pressure engages the high speed clutch.

The valve used to operate the shift must be of the type that has no neutral position. A spring offset, four way, solenoid valve is highly recommended.

## HOW IT OPERATES

The hydraulic motor drives the sun gear of the small primary planetary reducer. In high speed this speed and torque is transmitted directly to the sun gear of the secondary planetary reducer. In low speed a reduced speed and higher torque is transmitted to the secondary sun gear. The output of the secondary planetary reducer is transmitted by the planet carrier to the sun gear of the final planetary reducer. In the C2H16 the output of this reducer is transmitted directly to the cable drum by the spline between the planet carrier and the drum. In the C2H16D the output of the final planetary reducer is transmitted to the large free fall clutch and thence to the cable drum.

## THE BRAKE SYSTEM

The automatic braking system has four operating component parts:

1. Brake Valve attached to Hydraulic Motor
2. Spring Loaded Friction Brake
3. Over-riding Cam Clutch
4. Hydraulic Piston and Cylinder

The brake valve is basically a counterbalance valve. It contains a check valve to allow free flow of oil to the motor in a hoisting direction of rotation, and a pilot operated check valve that prevents flow of oil out of the motor when the operating valve is placed in the reverse or lowering position until sufficient pressure is present for the pilot piston to open the check valve. It also contains a small pressure relief valve set to prevent excessive shocks on the motor when a lowering operation is stopped.

The friction brake is a load holding brake only and has nothing to do with dynamic braking or stopping the descent of a load.

The over-riding clutch is splined to the secondary sun gear shaft between the primary planet carrier and the secondary sun gear. It will allow this shaft to turn freely in a rotation to raise a load and force the brake discs to turn with the shaft in rotation to lower a load.

The hydraulic cylinder, when pressurized, will release the spring pressure on the brake discs. This is a double-acting cylinder and is balanced to back pressure when the winch is not being operated.

## HOW IT OPERATES

When the winch is powered in a hoisting direction, the drive from the motor thru the primary planet carrier to the secondary sun gear runs free. The over-riding clutch between the secondary sun gear shaft and the brake discs allows complete freedom of rotation in this direction. The brake remains fully engaged as the brake release piston is balanced to back pressure up to 200 P.S.I.

When the lifting operation is stopped, the brake, being fully engaged, prevents the load from lowering.

When the winch is powered to reverse, the motor cannot rotate until sufficient pressure is present to open the brake valve. The friction brake within the winch will completely release at a pressure lower than that required to open the brake valve. The extent to which this valve will open will determine the amount of oil that can flow through it and the speed at which the load will be lowered. Increasing the flow of oil to the winch motor will cause the pressure to rise and the opening in the brake valve to enlarge, speeding up the descent of the load. Decreasing this flow causes the pressure to lower, the opening in the brake valve to decrease, slowing down the descent of the load.

When the operating valve is shifted to neutral the pressure will drop, the brake valve will close, stopping the load. The friction brake will engage after the valve has closed and hold the load.

When lowering a load very slowly for precise positioning, no oil flow actually occurs through the winch motor. The pressure will build up to a point where the brake will release sufficiently to allow the load to rotate the motor through its own leakage. This feature results in a very slow speed and extremely accurate positioning.

## SUMMARY

The winch, in raising a load, is not affected by any braking action. When lowering a load the brake valve has complete control of the speed at which it is lowered. When the winch is stopped by returning the control lever to neutral — the brake valve stops the load and the friction brake engages to hold the load.

Thus the brake receives very little wear in lowering operations. All of the heat generated by the lowering and stopping of a load is absorbed by the hydraulic oil where it can be readily dissipated. The only heat absorbed by the winch in either hoisting or lowering is due to the efficiency losses within the winch itself.

## FREE FALL VALVE — C2H16D ONLY

The free fall clutch is a spring loaded hydraulically released multiple disc clutch.

The free fall clutch control contains nine operating component parts:

1. A sensitive pressure reducing valve
2. Double acting hydraulic piston and cylinder
3. Control lever
4. Movable rod with a center detent to operate winch directional control valve
5. Single acting hydraulic piston with spring return
6. Steel ball poppet
7. Four way, spring offset, solenoid valve
8. Micro switch in lever to operate solenoid
9. Micro switch in lever to operate two speed

The pressure reducing valve can direct oil pressure to the free fall clutch spring pressure release cylinder.

The double acting piston, when pressurized on one side, can move to compress the spring of the pressure reducing valve to increase the pressure to the free fall clutch release cylinder. When pressurized on the other side, the piston and piston rod is locked in an out position.

The control lever is pivotally attached to this piston rod and also pivotally attached to the winch directional control actuating rod.

The single acting hydraulic piston, when pressurized, locks the winch control actuating rod in its center or neutral position.

The spring, in this piston cylinder also applies pressure to the steel ball poppet forming the neutral detent in the winch control rod.

The four way, spring offset, solenoid valve is bolted to the pressure reducing valve housing and normally directs oil pressure to the double acting hydraulic piston to lock it in its out position.

The two micro switches, in the control handle, are momentary contact type switches and must be held down to maintain winch operation. One switch energizes the solenoid of the two speed valve. This valve should normally direct oil to place the winch in low speed; and, when its solenoid is energized, shift the winch to high speed. The other switch energizes the solenoid of the valve fastened to the free fall control valve and places the winch in free fall operation.

## HOW IT OPERATES

This one lever controls all of the winch functions. With neither switch depressed the double acting piston rod is locked in its out position forming the pivot point for the lever. Moving the lever will operate the winch in low speed raise or lower. Depressing the high speed switch and moving the lever will operate the winch in high speed raise or lower.

When the free fall switch is depressed, oil pressure is directed to the single piston locking the directional control valve actuating rod in its center or neutral position. This forms a new pivot point for the lever. Oil pressure is also directed to the pressure reducing valve and to the double acting piston to move it in the direction to compress the spring of this valve. The piston must move compressing the spring before free fall can occur. As the piston rod is attached to the lever, the lever must also move. The force of the compressed spring determines the amount of oil pressure that is directed to the free fall clutch release cylinder.

If the lever is allowed to be pulled forward, increasing the oil pressure to the free fall clutch release cylinder, free fall will occur. If the lever is pulled back against the force of the piston the oil pressure will drop and the clutch re-engage, stopping the descent of the load. The maximum force that can be exerted by the piston is 125 pounds. With a 10:1 lever ratio the maximum pull on the lever handle is twelve and one-half pounds.

This free fall control is accident proof. The switch button must remain depressed and the lever must move before free fall can occur. If at any time during free fall operation the lever or switch button is released, the clutch will be instantly and fully engaged.

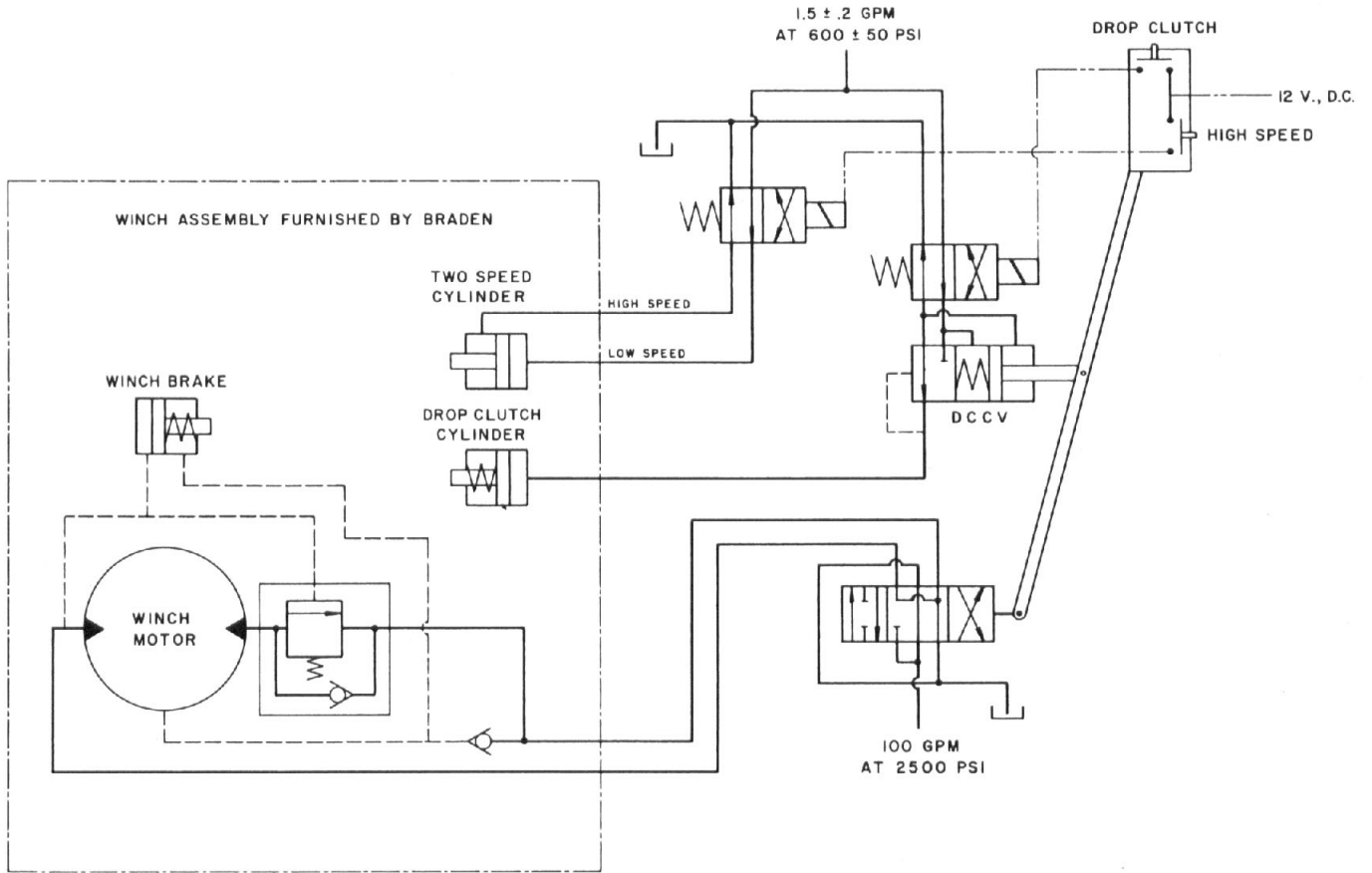
### CAUTION

The thermal capacity of the free fall clutch is 100,000 ft. lbs. per minute. That is, a 1,000 pound load can be dropped and caught from a height of 100 feet once every minute; or, a 2,000 pound load can be allowed to free fall and be caught from a height of 100 feet every two minutes.

No load heavier than 4,500 pounds should be dropped and caught.

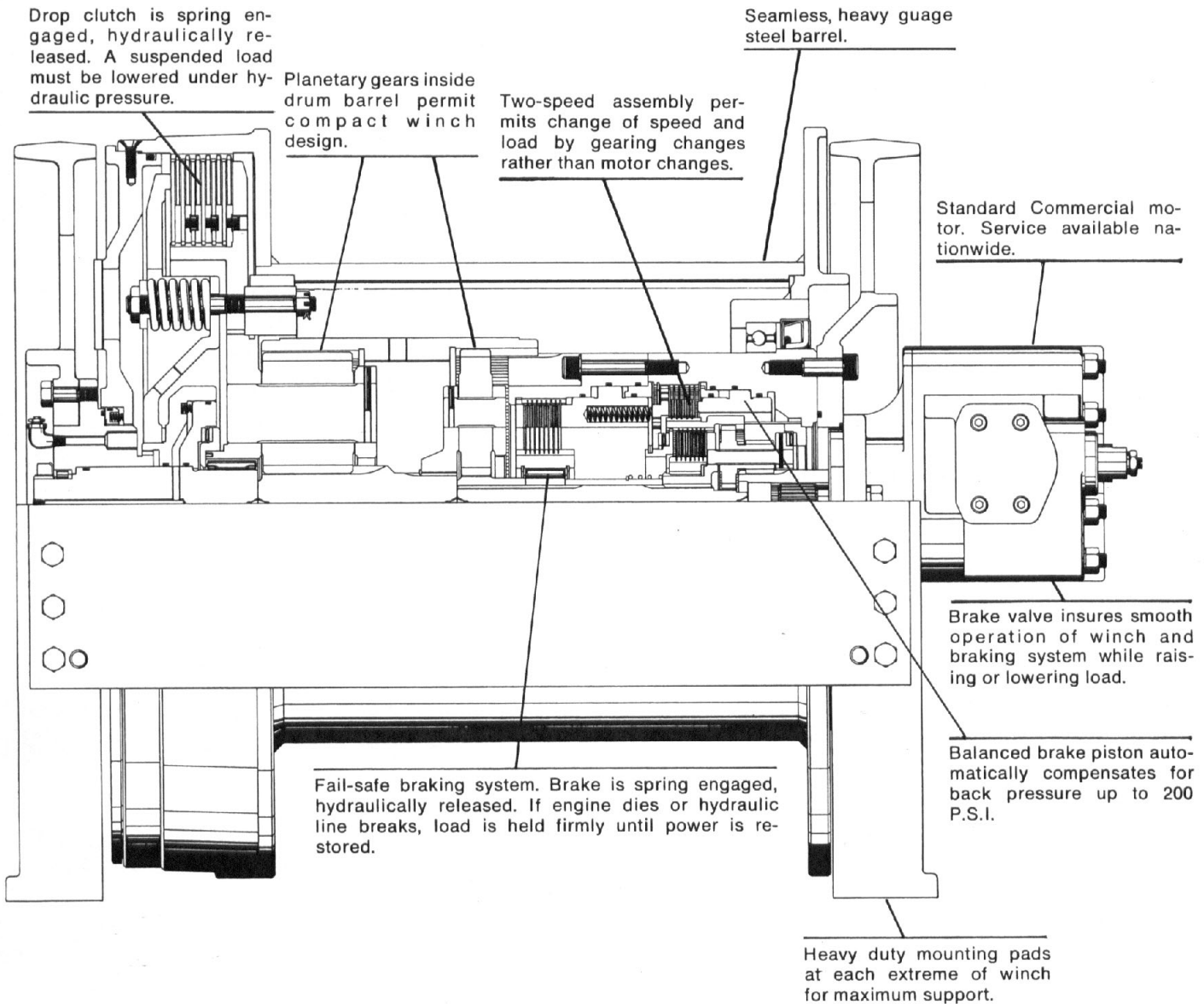
In pile driving operations, as no heat is absorbed by the clutch, there is no load or time limit.

# WINCH CONTROL CIRCUIT



Drop Clutch Control Valve (DCCV) shown is available from Braden as an option. Part Number 61256.

# CROSS-SECTIONAL VIEW



**Model C2H16D Illustrated**

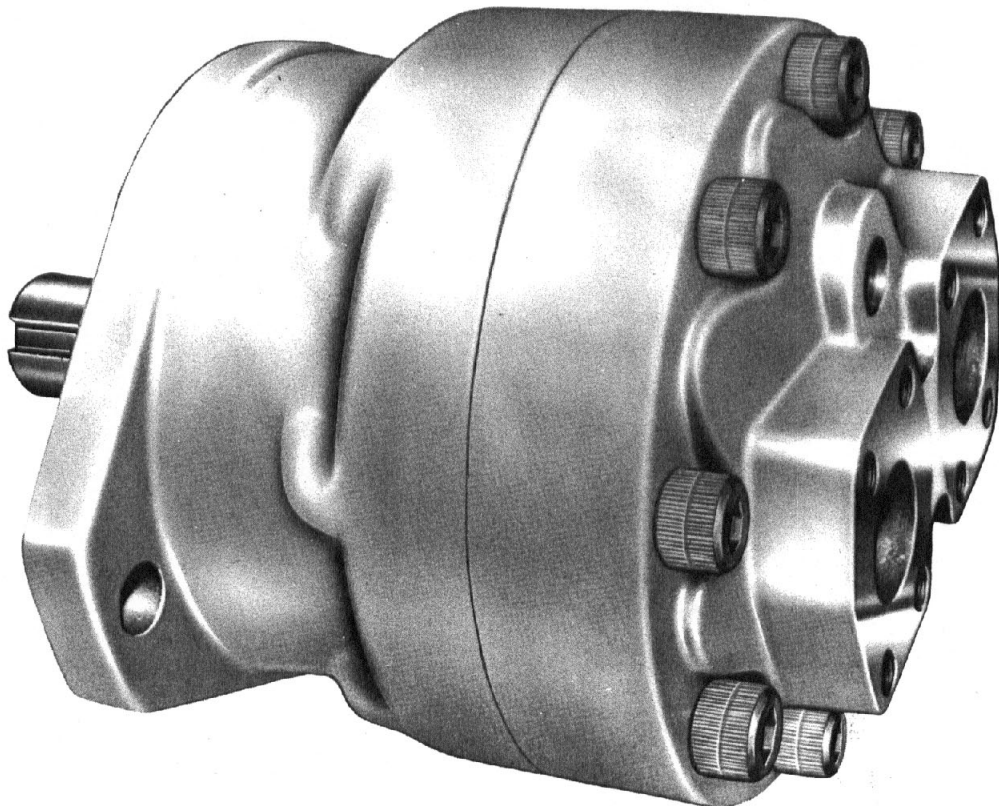
**Abex**

**DENISON**

**SERVICE LITERATURE**

VANE TYPE FLUID MOTOR-MODEL M1E & M1E1

# **INSTALLATION, OPERATION AND OVERHAUL INSTRUCTIONS**



**Vane Type Fluid Motor-Model M1E & M1E1**

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## Section I INTRODUCTION AND DESCRIPTION

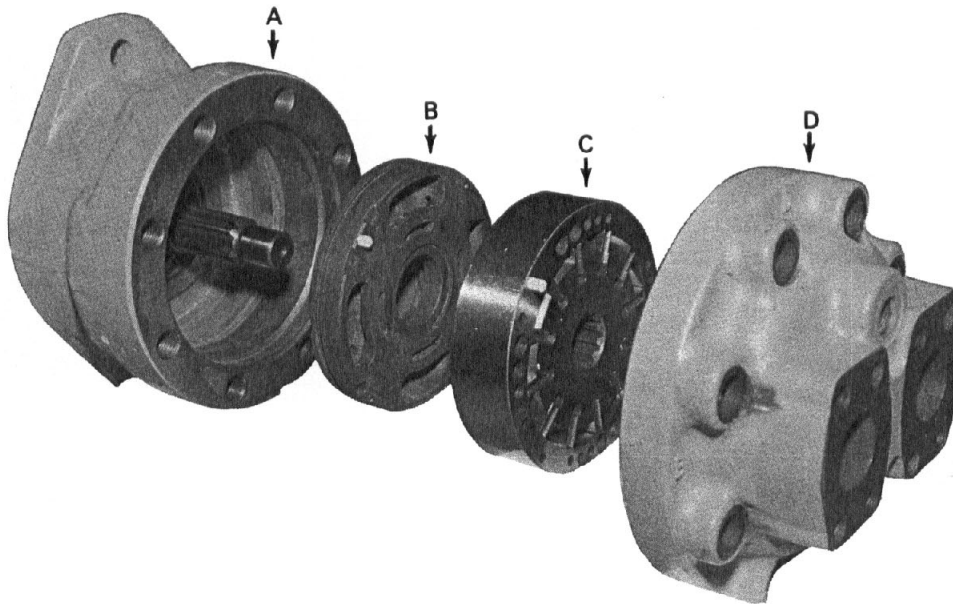


FIG. I

### GENERAL

This manual contains installation, operating maintenance and overhaul instructions for ABEX/DENISON M1E series fluid motor.

### DESCRIPTION

The fixed displacement motor is a rotary balanced vane type motor converting hydraulic forces into rotary mechanical motion. To determine the maximum

operating pressure and speed of any model, refer to Table I.

The motor consists of four basic sub-assemblies; (A) body or housing and shaft with a permanently lubricated bearing and a rotary type shaft seal; (B) a front port plate assembly consisting of port plate with a built in check valve; (C) a cam ring assembly containing the rotor, vanes, vane springs, spring guides and cam ring; (D) end cap assembly consisting of end cap and needle bearing. Two check valves are contained in the end cap assembly for model M1E1 which is internally drained.

**TABLE I**  
**PERFORMANCE DATA**  
**THEORETICAL OPERATING CHARACTERISTICS\***

Model	Speed		Volume		Torque**	Horsepower Output		Pressure
	Max. RPM	Min. RPM	Cu. In. Per REV.	GPM Per 100 RPM		In. Lb/ 100PSI	Per 100 RPM @ MAX PSI	
M1E or M1E1-139	2100	100	8.75	3.79	139.0	4.41	92.67	2000
M1E or M1E1-153	2100	100	9.64	4.17	153.0	4.86	102.00	2000
M1E or M1E1-185	2100	100	11.65	5.04	185.0	5.87	123.33	2000

\*Data is based on the use of fluid with a viscosity of 200 SUS @ 100° F.

\*\*Optimum running torque is 90% theoretical. Optimum stall torque is 75% theoretical.

To reverse motor, reverse flow to ports. Flow in port "A" gives clockwise rotation when viewed from the shaft. Flow in port "B" gives counterclockwise rotation when viewed from the shaft end.

Model M1E is externally drained from the end cap. Model M1E1 is internally drained and requires a special end cap assembly.

## Section II INSTALLATION

### MOUNTING

This motor is designed to operate in any position.

The motor shaft must be in alignment with the shaft of the driven load and should be checked with a dial indicator. The mounting pad or adapter into which the fluid motor pilots must be concentric with the motor shaft within 0.010 TIR to prevent bearing failures. This concentricity is particularly important if the fluid motor shaft is rigidly connected to the driven load without a flexible coupling.

### PIPING

Connect inlet and outlet lines to the end cap of the motor. The externally drained model must have a drain line connected to the end cap drain connection of sufficient size to prevent back pressure in excess of 50 PSI and returned to the reservoir below the surface of

the oil as far away from the supply pump suction as possible. Model M1E1 does not require an external drain line, however, the outlet pressure at either port (A or B) must not exceed 50 PSI.

All fluid lines either pipe, tubing or hose must be of adequate size and strength to assure free flow through the motor. An undersize inlet line will prevent the motor from reaching full speed and will not develop sufficient torque. An undersized outlet line will create back pressure in the motor and prevent proper operation. Flexible hose lines are recommended. If rigid pipe or tubing is used, the workmanship must be accurate in order to eliminate strain on the motor end cap or the fluid connectors. Sharp bends in the lines should be eliminated whenever possible. All system piping must be cleaned with solvent or equivalent before the motor is connected. Be sure that the entire hydraulic system is free from dirt, lint, scale and other foreign material. *DO NOT USE GALVANIZED PIPE.* Galvanized coating may flake off after continued use.



**NOTE:**

*If the circuit used will allow the motor to operate as a pump or restrict the inlet fluid availability when using the motor for dynamic braking, the inlet side of the motor must be replenished. The minimum replenishing pressure at the motor inlet should be 25 PSI.*

**OIL**

It is recommended that a hydraulic oil be used as specified in Table II.

**TABLE II  
RECOMMENDED OIL SPECIFICATIONS\***

Viscosity Range .....	150 to 300 SUS at 100° F
Viscosity Index .....	90 or higher
Maximum Viscosity at Starting Temperature .....	7500 SUS
Minimum Operating Viscosity .....	70 SUS or as approved by Denison Div.
Rust and Oxidation Inhibitors .....	Yes
Anti-Foam Additive .....	Yes
API Gravity, Degrees, Range .....	25 through 37
Specific Gravity, 60° F/60° F, Range .....	0.904 through 0.840

**NOTE:** It is recommended, but not necessary, that the fluid contain anti-wear additive. To provide minimum noise and greater life, the hydraulic fluid selected should contain a minimum of 0.05%, by weight, of zinc and a minimum of 0.05%, by weight of phosphorous as zinc dithiophosphate or an amount of other anti-wear additive which will impart equal properties to the fluid.

Consult a Denison Division representative before using fluids which do not meet these specifications or for high temperature operation. In addition, consult him for Fire Resistant Hydraulic Fluid applications.

**CAUTION:** Inlet temperature of the oil for most efficient operation should be 130° F and should not exceed 150° F for vane equipment without dropping below minimum operating viscosity.

\*It is suggested that the fluid supplier provide the user with certification that his product meets the requirements.

**Section III  
OPERATION**

During operation, oil under pressure flows through either one of the two ports "A" or "B" in the end cap and is directed to both sides of the cam ring assembly through cast ports in the end cap and port plate assembly. The pressure applied against the vanes forces the rotor to turn and at the same time rotates the motor shaft. As the rotor turns, the oil moves to the discharge ports in the port plate and end cap (B or A). Oil entering through port "A" will force the shaft to rotate right-hand (clockwise) facing the shaft end. Oil entering through port "B" will reverse the rotation. The port plate assembly is free to move axially within the limits and is held against the cam ring assembly by a wavy washer spring until internal pressure is built up.

**Section IV  
MAINTENANCE**

Since this motor is self-lubricating, preventative maintenance is limited to keeping the fluid in the system clean by changing filters frequently. Do not allow dirt to accumulate on the motor, especially around the shaft seal. Keep all fittings and screws tightened. Do not operate the motor at pressures or speeds in excess of the recommended limit.

If the motor does not operate properly, check the "Trouble Shooting Chart" in Table III before attempting an overhaul.

Overhaul is relatively simple and may be accomplished by following the procedure in Section V.

**TABLE III  
TROUBLE-SHOOTING CHART**

TROUBLE	PROBABLE CAUSE	POSSIBLE REMEDY
1. External Leakage	a. Seal failure b. Defective casting	a. Replace seal b. Replace casting
2. Leakage At Fittings	a. Cracked casting b. Defective threads c. Damaged "O" Ring d. Burr	a. Replace b. Replace c. Replace d. Stone or file flat.
3. Loss In Speed Under Load	a. Low inlet pressure b. Excessive back-pressure at outlet. c. Scored port plate or end cap e. High oil temperature	a. Check Pressure b. Check pressure-increase line size. c. Relap flat to clean up. d. Use heavier oil; use oil cooler; adjust relief valve setting.
4. Poor Speed Control	a. Insufficient fluid supply  b. Worn rotating group	a. Use more efficient pump. Use larger pump. Use flow control valve. b. Replace
5. Motor Fails to Start Turning	a. Insufficient torque  b. Excessive motor leakage.  c. Worn port plates. d. Worn rotating group e. Defective "O" ring on O.D. of front port plate. f. Insufficient pump delivery g. Motor too small	a. Increase relief valve pressure setting. b. Check flow from motor outlet if excessive, check shuttle valve in front port plate. Pressure not loading plate causing plate to move away from cam ring. c. Replace d. Replace e. Replace "O" ring if damaged.  f. Pump worn or too small. g. Use larger size cam ring.
6. Shaft Play	a. Worn bearings b. Excessive side load or end load on shaft c. Hammering coupling on shaft	a. Replace. b. Design problem; consult engineer. c. Coupling bore should be slip fit on shaft.
7. Bursting of Fluid Supply Inlet or Outlet Lines	a. Excessive pressure	a. If high inertia load over runs motor relief valve protection is required in one or possibly both lines between directional valve and motor. Use closed center valve with caution. Relief valve protection probably required as described above.
8. Excessive Noise	a. Worn or damaged internal parts.  b. Air in System	a. Disassemble to remove rotor, vane, cam ring assembly. Inspect for excessive wear. Check condition of faces of port plate and end cap. Rework (lap) or replace if scuffed. b. Bleed air off-check fittings for tightness.
9. Seal Failure	a. High drain line pressure on externally drained unit. b. High outlet pressure on internally drained unit.	a. Provide larger drain line. Provide shorter less restricted drain line. b. Revise circuit to reduce back pressure. Increase line size.

Problems encountered not indicated in this table should be referred to the Customer service Center or nearest Abex/Denison representative.

## Section V OVERHAUL

### GENERAL

The instructions contained in this section cover a complete disassembly, inspection and assembly of the vane type fluid motor.

Drain all fluid from the motor and thoroughly clean the exterior surface. Prepare a clean, lint-free surface on which to lay the internal parts of the motor.

### SPECIAL TOOLS

No special tools are required to disassemble and reassemble this motor.

### DISASSEMBLY

See Figure V for item numbers listed below.

1. Secure the motor in a vise or other suitable holding fixture with the shaft (17) extended down.
2. Remove screws (1) and remove the end cap (2) from the body.
3. Remove the rubber seal ring (3) from the end cap (2).
4. Check the needle bearing (4) in the end cap. If it is worn or damaged, remove it.
  - (a) See additional instructions on page 10 for disassembly of M1E1 internally drained end cap.
5. Remove the dowel pin (5) from the cam ring assembly (6).
6. Thread two 3/8-16 screws in the two tapped holes provided as puller holes in the cam ring (6a) and remove the cam ring assembly (6) as a unit (6a, 6b, 6c, 6d and 6e).

#### NOTE:

*If resistance is encountered when lifting the cam ring assembly, lightly tap the outside of the body while lifting the assembly. This will help in removing the cam ring, rotor, vanes and springs as a unit.*

#### WARNING!

*The vanes are held against the cam ring by tension from the springs in the rotor. If the rotor is pulled from the cam ring with no protection, tension from the springs will throw the vanes out in all directions. The following procedure must be followed when disassembling the rotor and vanes from the cam ring.*

*Place the cam ring assembly on a clean, flat surface. Push the rotor and vanes from the cam ring far enough to secure a piston ring compressor over the vanes and around the rotor. After the compressor is in place, push the rotor and vanes the remainder of the way out of the cam ring. Release the tension on the compressor and remove the vanes (6c), spring guides (6e) and vane springs (6d) from the rotor (6b).*

7. Remove dowel pin (7) from the port plate assembly.
8. Thread two 10-24 screws into the puller holes in the port plate assembly (8) and remove it from the body (19).
  - (a) Port plate assembly teardown:  
Remove the two 5/16-18 x 1/2" socket set screw in the sides (do not reuse if the nylon inserts in the screws are badly damaged). Remove the 1/4 x 3/4 shuttle pin from the drilled passage. The drilled holes in the port plate must be clean and free from burrs.
9. Remove the rubber seals (9 & 10) and coil spring (11).
10. Remove the internal snap ring (12) from the body (19).
11. Press on the coupling end of the shaft and remove items 13 thru 17 as an assembly.
12. The shaft seal assembly (14) consists of eight parts, spring retainer, spring, steel band, rubber friction ring, shell, carbon ring, cast iron seat

with lapped face and an "O" Ring. Remove the spring retainer and spring. Remove the "O" ring from the cast iron seat. To separate the cast iron seat from the bearing (16), position the seat in a vise and tap on the rotor end of the shaft. Remove the seat and the remainder of the seal assembly from the shaft.

**"CAUTION"**

**DO not damage the carbon ring and the lapped surface of the cast iron seat.**

13. Remove the external snap ring (15) and press the bearing (16) from the shaft.

## CLEANING & INSPECTION

1. Wash all metal parts in cleaning solvent (Stoddard Solvent or equal) and dry thoroughly.
2. Inspection of Parts.
  - (a) Inspect the seals for wear, breaks, cuts and brittleness. Check closely the lapped surface of the seal seat and the carbon ring of the shaft seal assembly for scratches and cracks. Discard and replace all defective seals.
  - (b) Inspect all springs for wear on the O. D., for cracks or permanent set. Replace all defective springs.
  - (c) Inspect bearings for wear or flat spots. If the bearings are rough or loose, they must be replaced.
  - (d) Inspect the cam ring for excessive wear (ripples or washboard marks on the contour). Replace a badly worn or defective cam ring.
  - (e) Inspect the rotor for scored, marred or scratched (faces and vane slots) surfaces. Replace a defective rotor.
  - (f) Inspect the vanes for excessive wear marks (burrs, nicks and scoring). Replace defective vanes.
  - (g) Inspect the wear surfaces of the port plate and end cap for deep scratches. Replace if defective.
  - (h) Inspect the body and end cap for cracks or other casting damage. Replace all damaged castings.

- (i) Inspect the shaft for excessive wear (internal spline, bearing surface and drive end). Replace if defective.

**"CAUTION"**

**Dirt is a major cause of wear and motor failure. Cover all parts after cleaning to prevent dust and dirt from settling on them. All surfaces should be coated with a film of hydraulic lubricating oil after they have been cleaned.**

## LUBRICATION

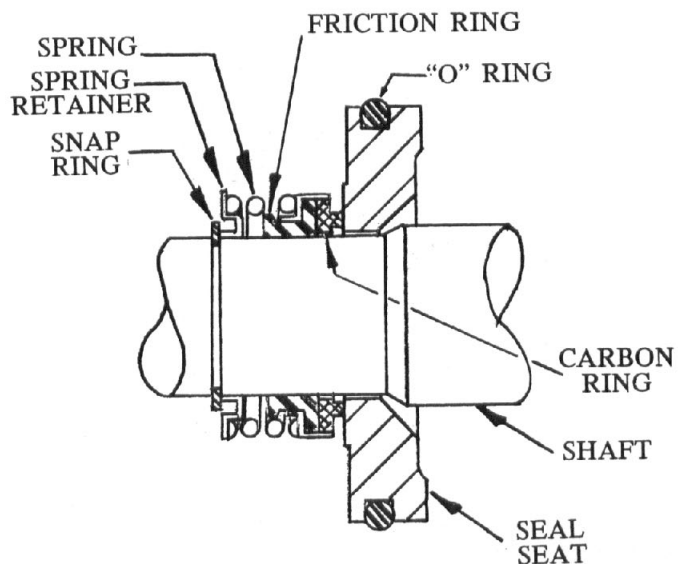
No external lubrication is required. The hydraulic fluid which operates the motor provides adequate internal lubrication. The shaft ball bearing is prelubricated and sealed.

## REASSEMBLY

1. Press bearing (16) on the shaft (17) and install external snap ring (15). Be certain that the ring is seated in the snap ring groove. Press the shaft assembly into the body (19).
2. Installation of the seal assembly (14).

**"CAUTION"**

**Before installing the seal assembly, study and examine all of the parts. The seal seat and carbon ring have a precision finish and must be handled with care. Take particular care not to mar the lapped faces.**



**SHAFT SEAL DETAIL**

(a) Place some oil on the inner surface of the rubber friction ring before installing it. Be certain that there are no burrs or sharp edges on the shaft. Apply heavy grease to the "O" ring which is a part of the seal assembly and install on the cast iron seat. Insert the cast iron seal seat against the bearing (16) with the unfinished side facing the bearing (lapped surface out). Install the snap ring (12) on top of the seal seat. Slide the shell containing the rubber friction ring and carbon ring over the internal splined end of the shaft. The carbon ring must seal against the lapped seat. Insert the coil spring over the friction ring and install the spring retainer on the spring. Depress the spring retainer and spring and install external snap ring (13) in the groove on the shaft.

3. Place the coil spring (11) in the body.

4. Port Plate Sub-Assembly (8)

The special screws and the port plate including the internal threads must be degreased. Apply a very small amount of Loctite #242 to the special screws only. An excessive amount of Loctite on the screws would be forced into the shuttle spool bore when the screws are installed. Allow the Loctite to cure for one hour after installing the screws.

(a) Install one of the special screws in the shuttle spool bore of the port plate. Torque screw to 9 to 10 ft. lbs. maximum. Insert the shuttle spool in the shuttle bore and install the other special screw and torque. Tilt the port plate subassembly back and forth to be certain that the spool travels the full length of the bore.

5. Apply heavy grease to seals (9) and (10) and install in the grooves on the port plate.

6. Thread two 10-24 screws in the tapped hole in the face of the port plate assembly (8) and install in the body. See Fig. III for correct position.

7. Insert the dowel pin (7) in the port plate assembly.

8. Assemble the cam ring assembly (6) in this manner. Place the cam ring (6a), rotor (6b), vane springs (6d), spring guides (6e) and vanes (6c) on a clean flat surface. Arrange the vanes side by side with the three spring holes up. Insert the vane springs

in the vanes, insert the spring guides in the springs. Install the vanes with the guides and springs in the slots in the rotor.

**"WARNING"**

***Be certain that the heads of the spring guides and springs are started in the holes in each rotor slot.***

(a) Place a ring compressor around the vanes and tighten the compressor gradually until the springs and vanes are in the position they will occupy while in the cam ring. Place a back up plate, slightly smaller than the outside diameter of the rotor in the ring compressor and push the rotor, springs and vanes into the cam ring. The back up plate will prevent the vanes from sliding end wise in the rotor slots and damaging the slots and springs.

**"WARNING"**

***Be certain that the rotor and vane assembly is inserted far enough in the cam ring to prevent the vanes from flying out of position when the ring compressor is removed.***

9. Thread two 3/8-16 screws into the cam ring assembly on the same side of the ring that indicates the cam size. Insert the dowel pin (5) in the cam ring and position the complete assembly in the body over the dowel pin (7). (See Fig. 3 & 5).

10. Apply heavy grease to the rubber seal (3) and install in the groove in the cap (2).

11. Press the needle bearing (4) into the end cap (2) with markings on the bearing 7/32 below the face of the counter bored surface of the end cap.

(a) See additional instruction on page 11 for re-assembly of M1E1 internally drained end cap.

12. Position the end cap (2) over the dowel pin (5). Hold the end cap firmly against the cam ring assembly and rotate to line up the bolt holes.

13. Insert screws (1) and tighten evenly to 230 ft. lbs. torque.

**SPECIAL INSTRUCTIONS**  
**M1E1 Internally Drained Cap Assembly**  
**Code #S14-16935**

**DISASSEMBLY**

Remove the hex head plug (20) from the fluid connection face. Remove the needle bearing (4) from the counter bore in the wear face of the end cap (22). Remove the two check valves (21) from the drilled passages between ports "A" and "B" in the cap.

Wash the cap and all parts in cleaning fluid and dry thoroughly.

Inspect the bearings, check valves, plug and "O" Ring. Make certain that all drilled and cored passages are open and clean. Carefully check the spring and ball in

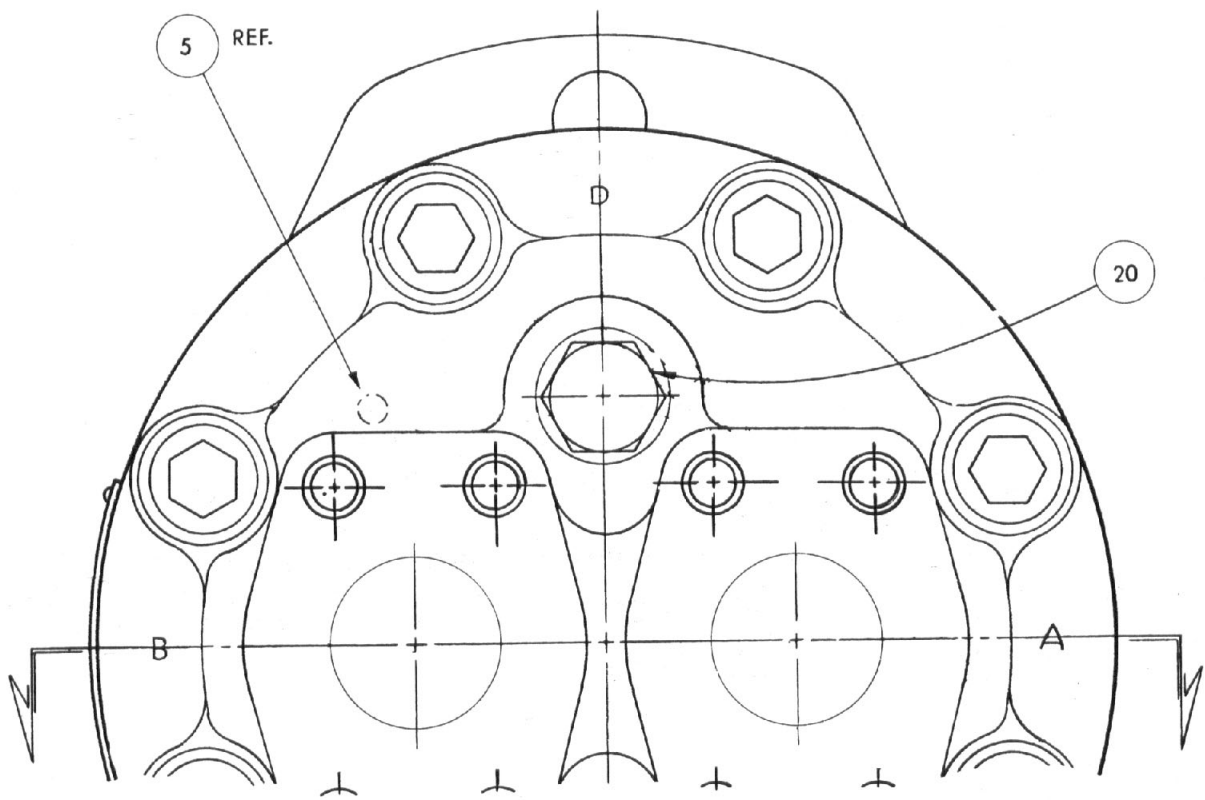
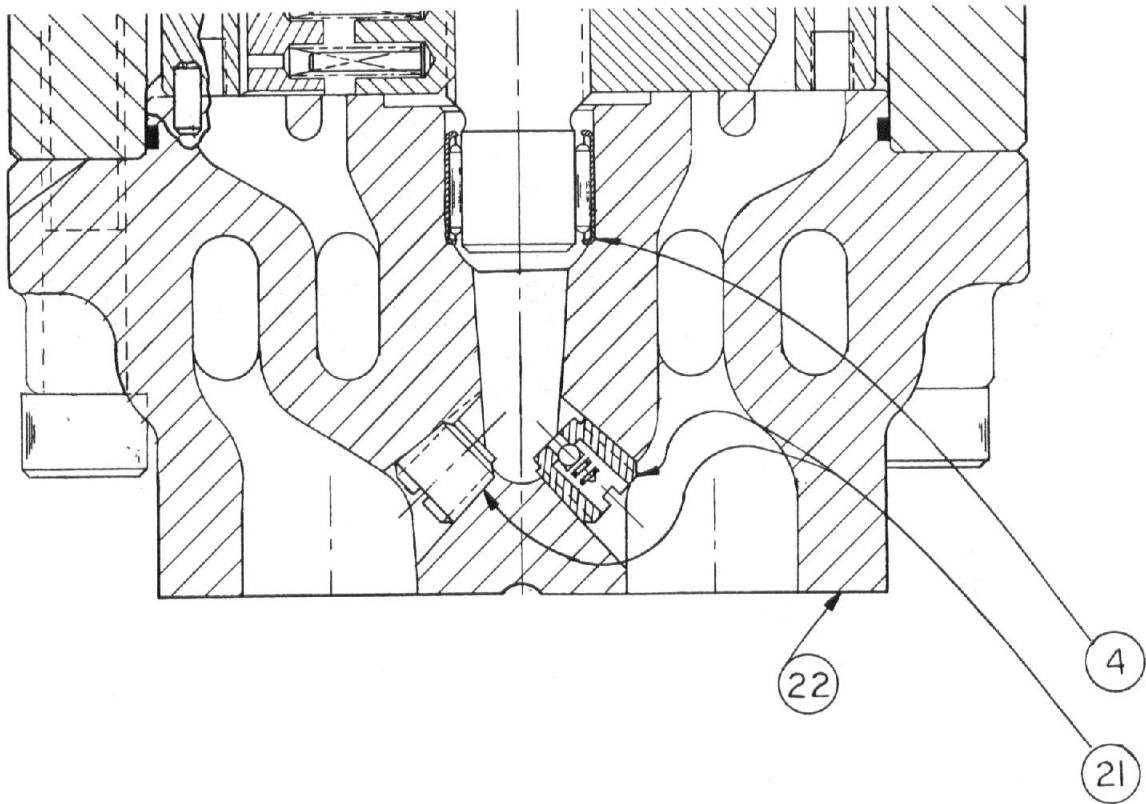
the check valves. The ball must seat for the checks to function. Check the bearing for wear or flat spots. If any parts are defective, they must be replaced.

**REASSEMBLY**

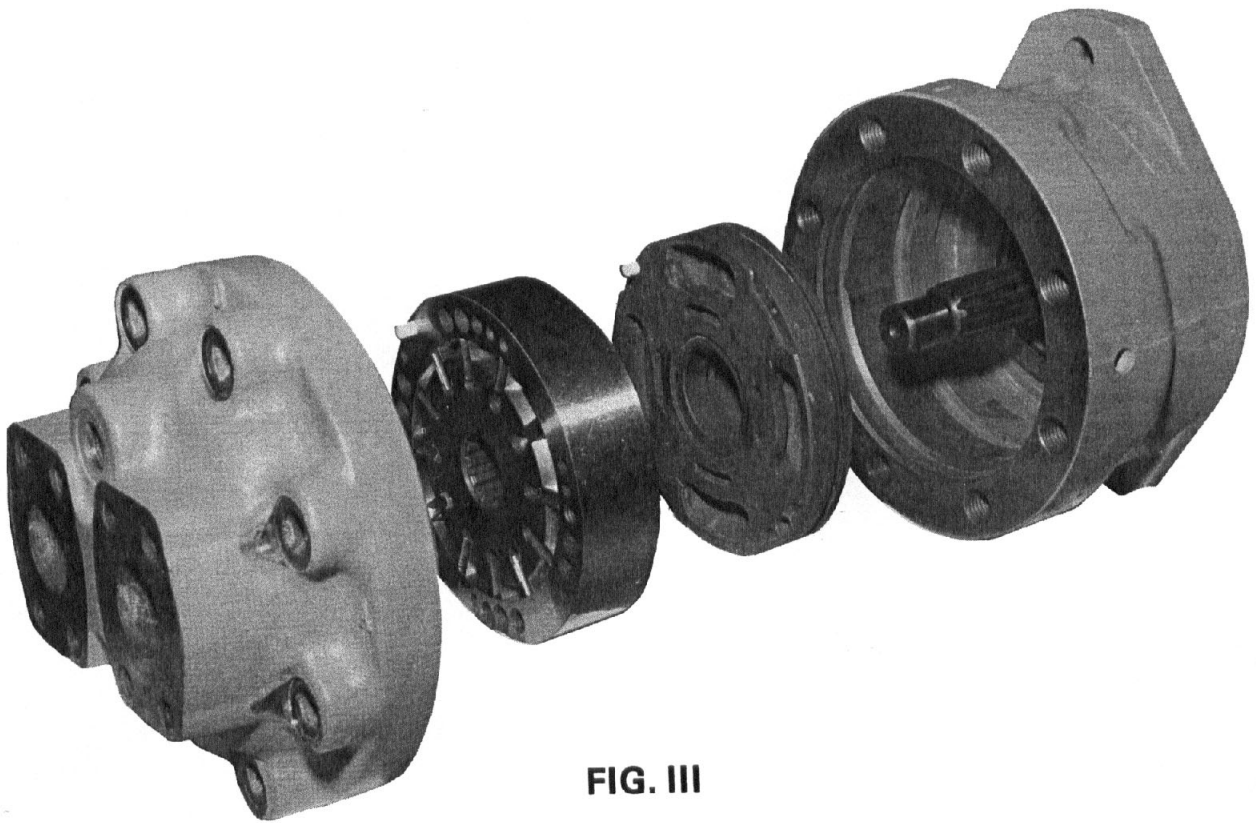
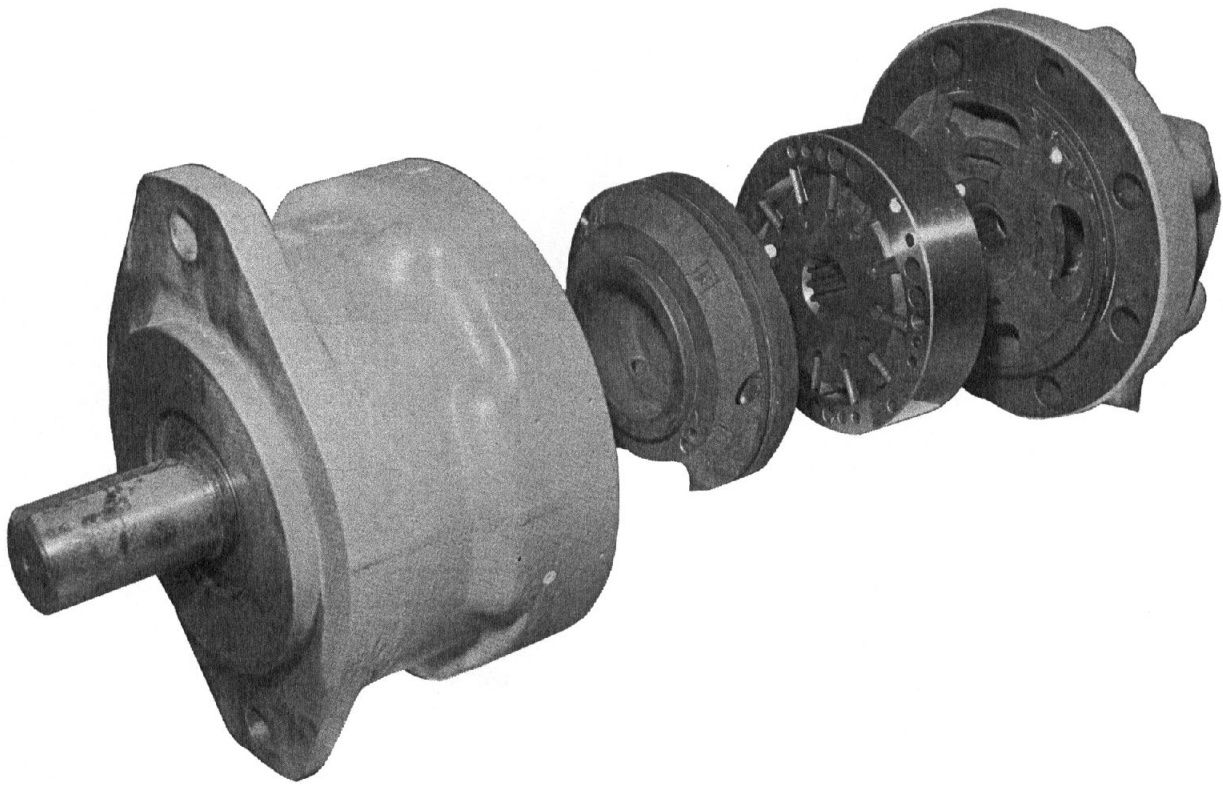
Lubricate both check valves (21). Install one check valve in each threaded hole provided in port "A" and "B". Press the needle bearing (4) into the end cap (22) with the markings on the bearing 7/32" below the counterbored surface of the end cap. Install the hex head plug (20) and "O" ring in the fluid connection face.

**S14-16935 M1E1 CAP ASSEMBLY**

ITEM	PART NUMBER	DESCRIPTION	QUANTITY
4	230-82040	Needle Bearing JH1616	1
20	488-35022	Hex head plug & "O" ring	1
21	S14-27259	Check valve assembly	2
22	034-70003	End Cap with internal drain	1

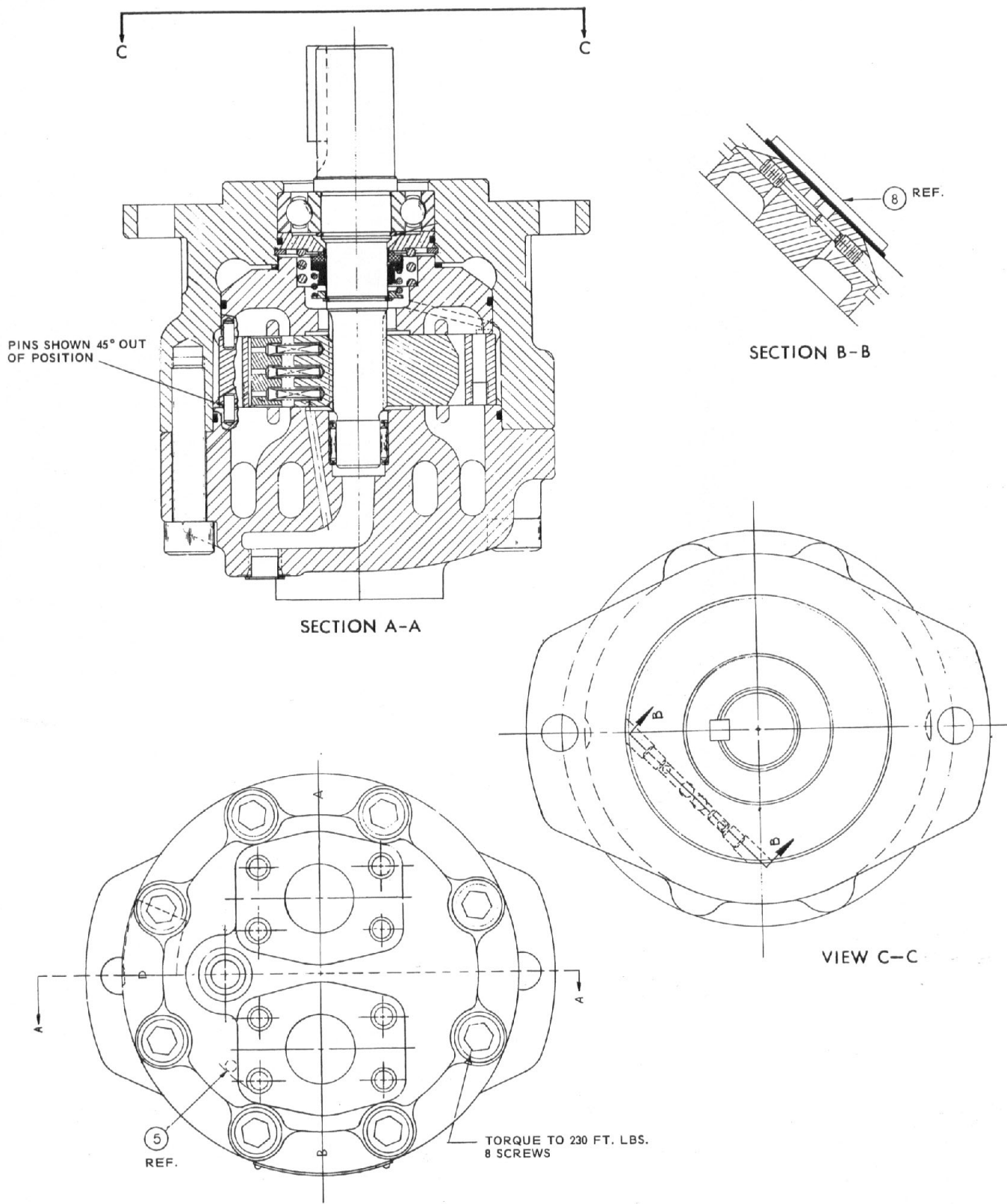


**FIG. II**  
**S14-16935 CAP ASSEMBLY**



**FIG. III**





**FIG. IV**  
**M1E SERIES**

## M1E PARTS LIST

ITEM	PART NUMBER	DESCRIPTION	QUANTITY
1	358-26340	Socket head cap screw 3/4-10 x 3 1/2	8
2	034-42312	End cap	1
3	691-10259 (s)	Square section seal TS-33-259	1
4	230-82040	Needle bearing JH-1616	1
5	324-21610	Dowel pin 1/4 x 5/8	1
6	see below	Cam ring assembly	1
7	324-21610	Dowel pin 1/4 x 5/8	1
8	S14-20504	Front port plate assembly	1
	034-48755	- Front port plate	1
	311-45032	- Soc. set screw 3/8 - 16 flat point w/spotlok	2
	034-70341	- Shuttle spool	1
9	691-10257 (s)	Square section seal TS-33-257	1
10	691-10238 (s)	Square section seal TS-33-238	1
11	034-18026	Coil spring	1
12	356-30354	Internal snap ring 5000-354	1
13	356-31137	External snap ring 5100-137	1
14	623-13091 (s)	Rotary shaft seal	1
15	356-14308	External snap ring #916-R	1
16	230-99608	Ball bearing N.D. 99608 (double seal)	1
17	034-42316	Motor shaft with keyway	1
	034-42317	Motor shaft with spline	1
18	034-42330	Shaft key (for 034-42316)	1
19	034-42310	Body	1
(s)	S14-11383	Seal Kit (Includes Seals for Connection)	1
	*S14-11383-S4	Seal Kit (Includes Seals for Connection)	1
	**S14-11383-S5	Seal Kit (Includes Seals for Connection)	1

\*Phosphate Ester Fluid    \*\*High Temperature Petroleum Base & Synthetic Fluid

UNIT MODEL NO.	ITEM 6 CAM RING ASSEMBLY CODE NO.	These Parts Are A Complete Cam Ring Assembly				
		6a Cam Ring	6b Rotor	6c Vanes	6d Vane Spring	6e Spring Guide
M1E or M1E1-139	S14 -14601	034-42332				
M1E or M1E1-153	S14 -14602	034-42334	034-15954	034-24852	034-17031	034-42561
M1E or M1E1-185	S14 -14603	034-42333				
Qty. Per Unit		1	1	12	36	36

## FLUID CONNECTION KITS

MODEL NO.	CODE NO.	THREAD SIZE	These parts are a complete kit		
			CONNECTION	SEAL	SCREW
FS4-P-24-19-58	S14-07429	1 1/2" NPTF	034-23144		
FS4-W-24-19-60	S14-07431	1 1/2" IPS Socket Weld	034-24158	671-00227	1/2-13 x 2 1/2
FS4-S-30-20-62	S14-08434	SAE 24 (1 7/8-12)	034-24469		
Quantity			1	1	4

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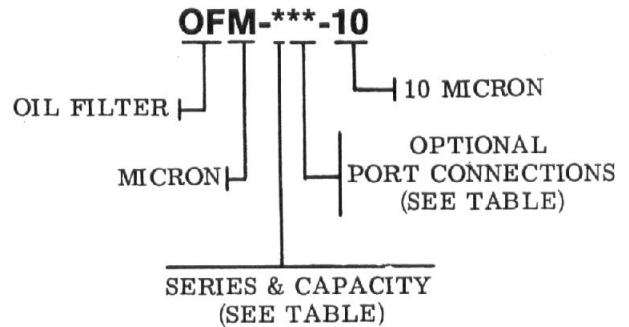
**ABEX CORPORATION, DENISON DIVISION**, 1160 Dublin Road, Columbus, Ohio 43216 (614) 488-1191  
An IC Industries Company

**Service Parts  
Information**

**OFM SERIES -100, -200 & -300**

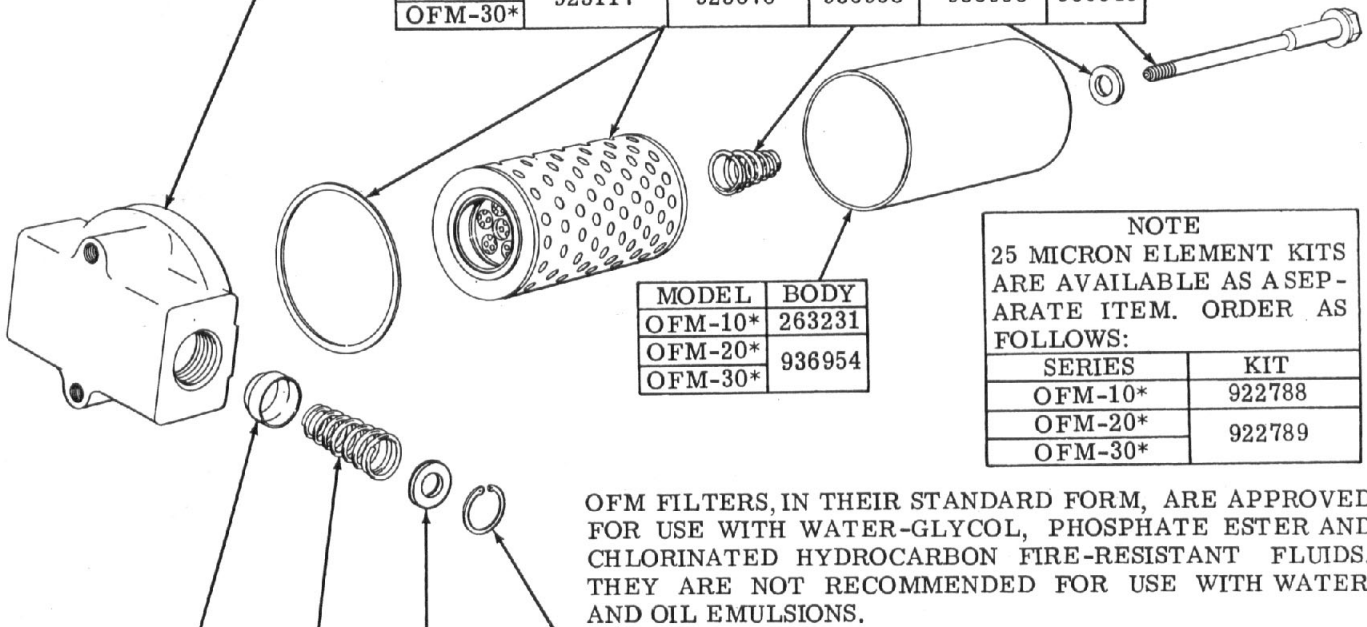
**LOW PRESSURE RETURN LINE FILTERS**

**MODEL CODE BREAKDOWN**



MODEL	CAPACITY (gpm)	BASE	PORT CONNECTION
OFM-100	0-50	936965	1" 4-BOLT FLANGE
OFM-101		936967	1" PIPE THREAD
OFM-102		936974	1" TUBE
OFM-200	0-125	936975	1-1/4" 4-BOLT FLANGE
OFM-201		936977	1-1/2" 4-BOLT FLANGE
OFM-202		936978	1-1/2" PIPE THREAD
OFM-300	100-300	936980	2" 4-BOLT FLANGE
OFM-301		936889	2-1/2" 4-BOLT FLANGE

MODEL	THREE ELEMENT KIT	SINGLE ELEMENT KIT	SPRING	WASHER	BOLT
OFM-10*	923115	923069	936955	936949	936947
OFM-20*	923117	923070	936958	936950	936948
OFM-30*					



MODEL	BODY
OFM-10*	263231
OFM-20*	936954
OFM-30*	

**NOTE**  
25 MICRON ELEMENT KITS ARE AVAILABLE AS A SEPARATE ITEM. ORDER AS FOLLOWS:

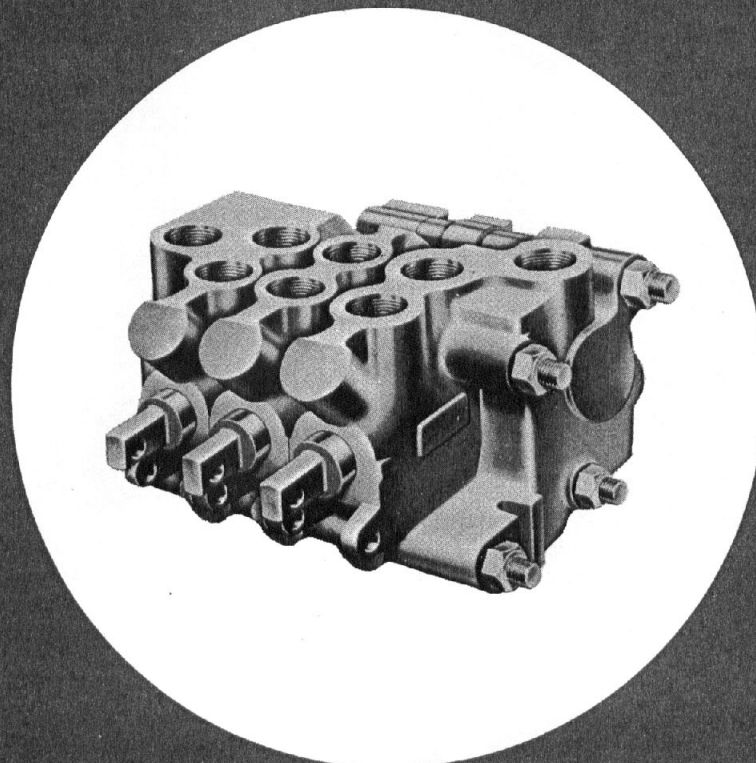
SERIES	KIT
OFM-10*	922788
OFM-20*	922789
OFM-30*	

OFM FILTERS, IN THEIR STANDARD FORM, ARE APPROVED FOR USE WITH WATER-GLYCOL, PHOSPHATE ESTER AND CHLORINATED HYDROCARBON FIRE-RESISTANT FLUIDS. THEY ARE NOT RECOMMENDED FOR USE WITH WATER AND OIL EMULSIONS.

MODEL	POPPET	SPRING	WASHER	SNAP RING
OFM-10*	936944	936941	938375	87764
OFM-20*	936945	936942	938376	936939
OFM-30*	936946	936943	936854	936940

SPERRY VICKERS

MULTIPLE  
UNIT  
VALVES



## OVERHAUL MANUAL

CM2 & CM3 SERIES-20 DESIGN  
CM2 & CM3 SERIES-30 DESIGN

SPERRY VICKERS  
TROY, MI. 48064

## FOREWARD

This manual illustrates and describes the recommended procedure for servicing the CM2 and CM3 series valves.

Valves of the -30 design will be referred to throughout this manual, but this information is essentially the same for the -20 design valves. Service parts are generally interchangeable between the -20 and -30 design valves, however, it is recommended that the catalogs referenced in Table I be consulted for service parts for the respective design. Customers who wish to incorporate -30 design sections in -20 design valves can do so without concern. In this instance, a tie bolt must be left out. This does not affect the operation or function of the valve as one tie bolt on the -20 design is redundant.

To service these valves, read this manual thoroughly, and follow the instructions carefully.

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# SECTION I - INTRODUCTION

## A. PURPOSE OF MANUAL

This manual has been prepared to assist the users of Vickers CM2 and CM3 Series-20/-30 Design Multiple Unit Valves in properly maintaining and repairing their units. In the sections which follow, the multiple unit valves are described in detail, their theory of operation is discussed and instructions are given for their proper installation, maintenance and overhaul.

## B. GENERAL INFORMATION

1. Related Publications - Service parts information and installation dimensions are not contained in this manual. The parts catalogs and installation drawings listed in Table I are available from your local Vickers Mobile Division application engineering office, or from:

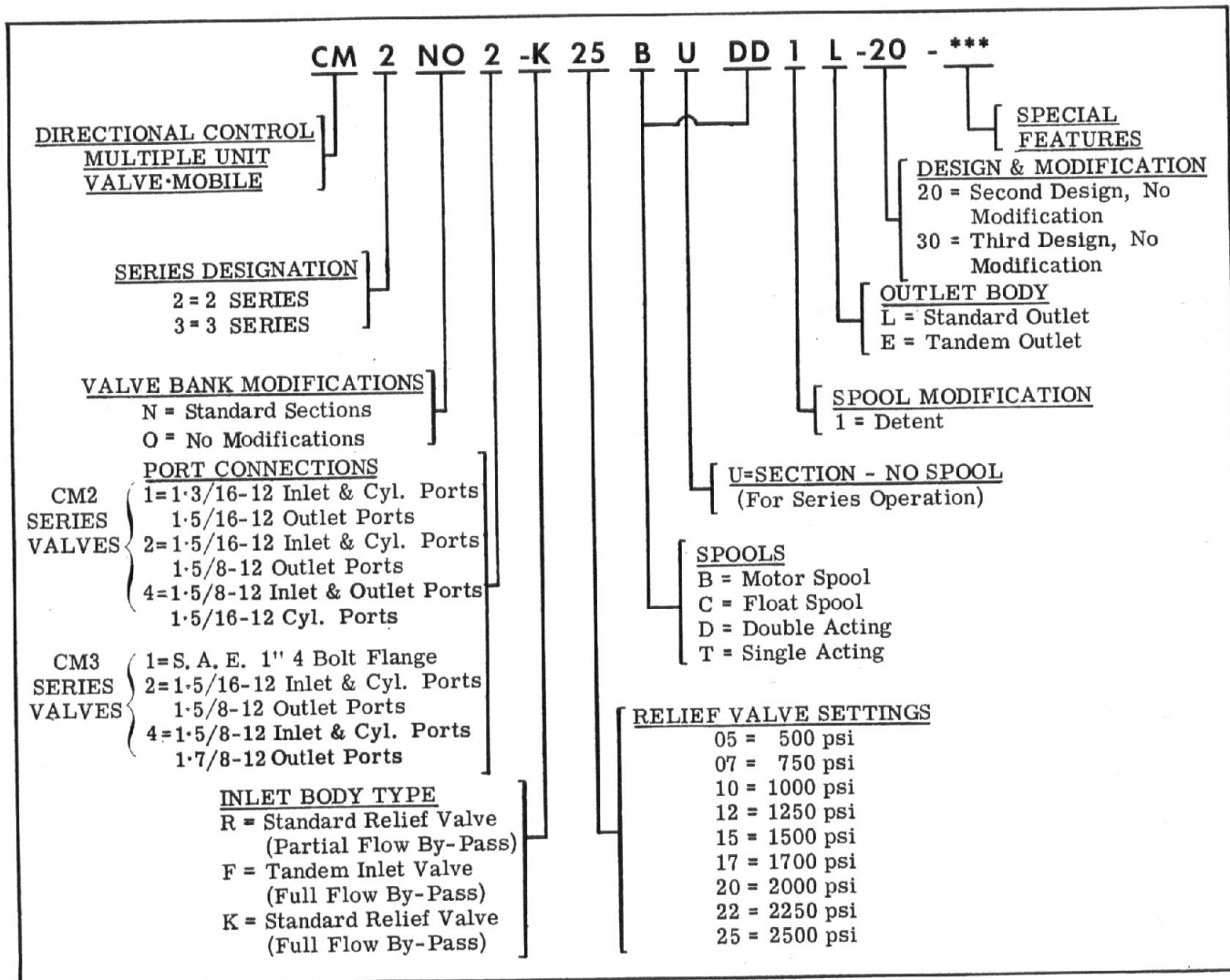
Vickers  
 Mobile Hydraulics Division  
 P. O. Box 302, Troy, Michigan 48084  
 Attn: Mobile Service Department

2. Model Codes - There are many variations within each basic model series, which are covered by variables in the model code. Table II is a complete breakdown of the codes covering these units. Service inquiries should always include the complete unit model number, which is stamped on the valve bodies.

TABLE I  
 AVAILABLE PARTS CATALOGS AND  
 INSTALLATION DRAWINGS

MODEL SERIES	PARTS CATALOGS	INSTALLATION DRAWINGS
CM2-20	M-2401-S	M-259218
CM2-30	M-2403-S	
CM3-20	M-2402-S	M-259219
CM3-30	M-2404-S	

TABLE II - MODEL CODE BREAKDOWN





## SECTION II - DESCRIPTION

### A. GENERAL

CM2 and CM3 Series -20/-30 Design Valves are made up of directional control valve sections mounted in banks and connected internally to common pressure and tank return passages. A valve bank usually consists of an inlet and operating (R\*, F\*, or K\*), a number of operating sections (\*) and an operating and outlet section (\*L or \*E). Each operating section contains a sliding spool (for example B, C, D or T Spool). In valve banks where only one operating section is required, an R\* section is used with an L or E tank plate section.

### B. ASSEMBLY AND CONSTRUCTION

Figure 1 is a cross-sectional view showing the construction and assembly of a three-section valve. Each section normally contains a sliding spool with centering springs and a check valve. The inlet section also contains a relief valve assembly.

Passages between the bodies connect each section to the common inlet and tank ports. Seal rings between the sections seal the connecting passages. Sections are held together by studs and nuts.

### C. DETENT FEATURES

1. Spool Detents - A spool detent assembly consists of a special end cap with a spring loaded plunger and a spool extension. The plunger engages in grooves of the spool extension to hold the spool in the desired position (see Figure 9).

### D. MOUNTING

CM2 and CM3 Series -20/-30 Design Valves have mounting lugs cast into the inlet and outlet sections.

### E. INSTALLATION DRAWING

Vickers Mobile Hydraulics Division application engineers should be consulted for valve ratings and applications. (Refer to the installation drawing listed in Table I for the performance information.)

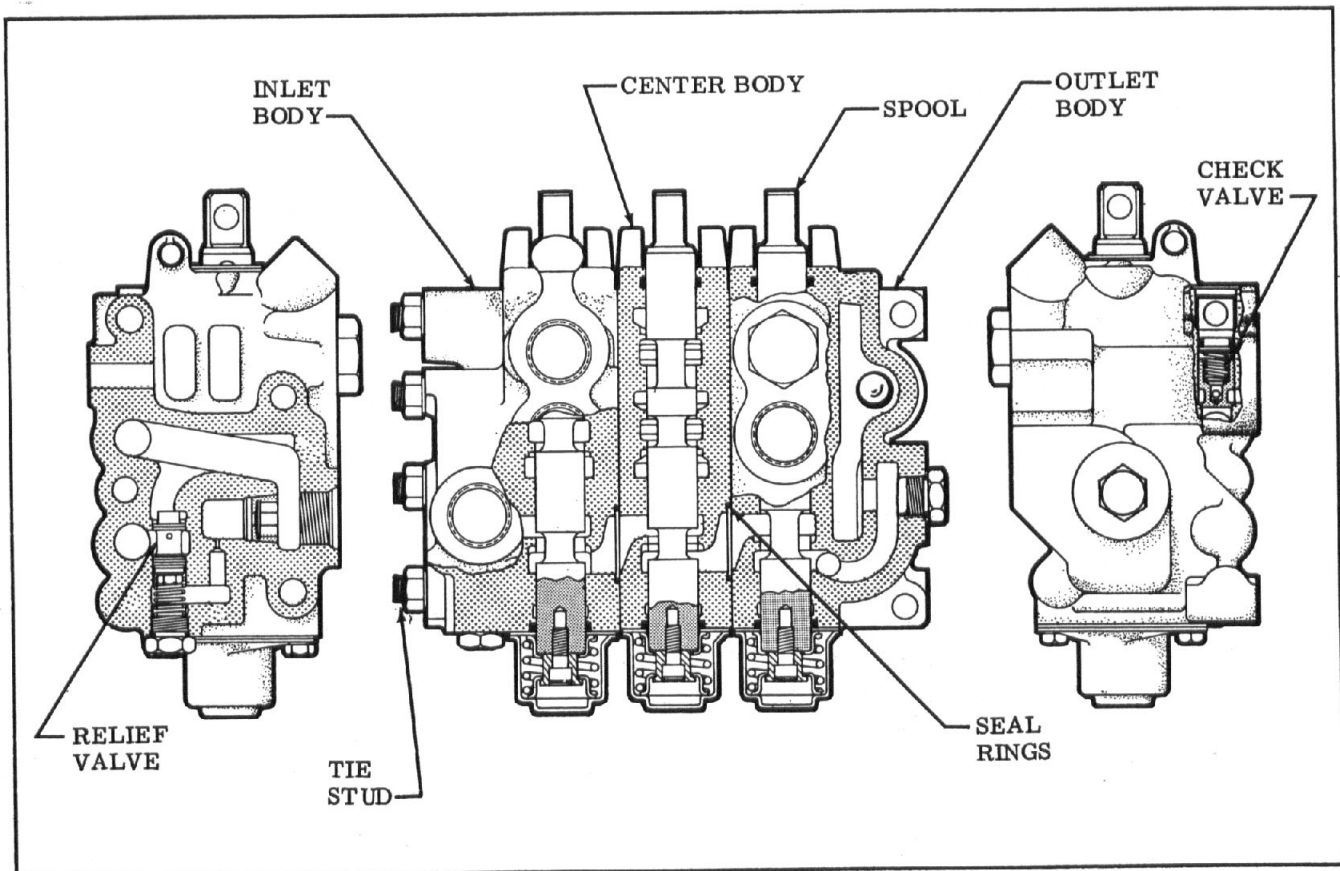


Figure 1

## SECTION III - PRINCIPLES OF OPERATION

### A. GENERAL

Figure 2 is a schematic illustration of a four section valve, showing the cylinder ports and the by-pass pressure and tank passages. The pressure passage is used to carry fluid to the cylinder ports when the spools are shifted. The by-pass passage permits flow directly to the outlet when the spools are not being operated. The tank passages carry fluid to the tank port by return flow from the cylinder ports or fluid diverted past the flow control and relief valve.

The spools are shown in the centered or neutral position. Under these conditions, fluid in the pressure passage is blocked from the cylinder ports by the spool lands. Flow through the valve is through the by-pass and tank passage to the tank port.

### B. OPERATING SECTIONS

1. Inlet Section - The CM2 and CM3 series valve banks may be obtained with operating, R\*, F\*, or K\*, inlet sections. These sections are available with B, C, D, or T, type spools.

These sections are individually described below.

(a) R\* Section - The R\* section is equipped with an integral relief valve for overload protection. It is built to accept a check valve to prevent return flow through the valve.

The integral relief valve, with an orifice plug, also acts as a partial flow control valve. This feature lowers the pressure drop between the inlet and outlet ports. (See paragraph 4 for relief valve and flow control operation.)

The relief valve cracking pressure is pre-set at the factory. The pre-set cracking pres-

ures range up to 2500 psi maximum. (See Table II Model Code for pressure settings.)

(b) F\* Section - The F\* section has two pressure connections. One connection is made to the pump source and the second connection is made with a preceding valve assembly to accept the by-pass flow for tandem operation.

The F\* section like the R\* section is built to accept a check valve to prevent return flow when this feature is required. However, F\* sections do not employ relief valve or partial flow by-pass.

(c) K\* Section - The K\* section is essentially the same as the R\* section except it has a full flow by-pass feature.

### 2. Outlet Sections

(a) \*L Section - When two or more spools are required in a valve bank, the last section will be an \*L section. The "\*" denotes the spool type. This section contains the exhaust oil port and also is built to accept a check valve to prevent back flow when this feature is required.

(b) \*E Section - This section is used for tandem operation by providing an outlet connection through which the by-pass feature for pump unloading is extended on to a subsequent valve bank. It is used in conjunction with an "F\*" type inlet section in the next valve bank. Like the \*L section it contains an operating spool and is built to accept a check valve to prevent back flow when this feature is required.

### 3. Spool Operation

General - Four standard spool designs are available ("B," "C," "D," or "T"). Any combination of spools may be used with a valve bank to perform a variety of operations. All operating spools are equipped with centering springs which return the spools to neutral.

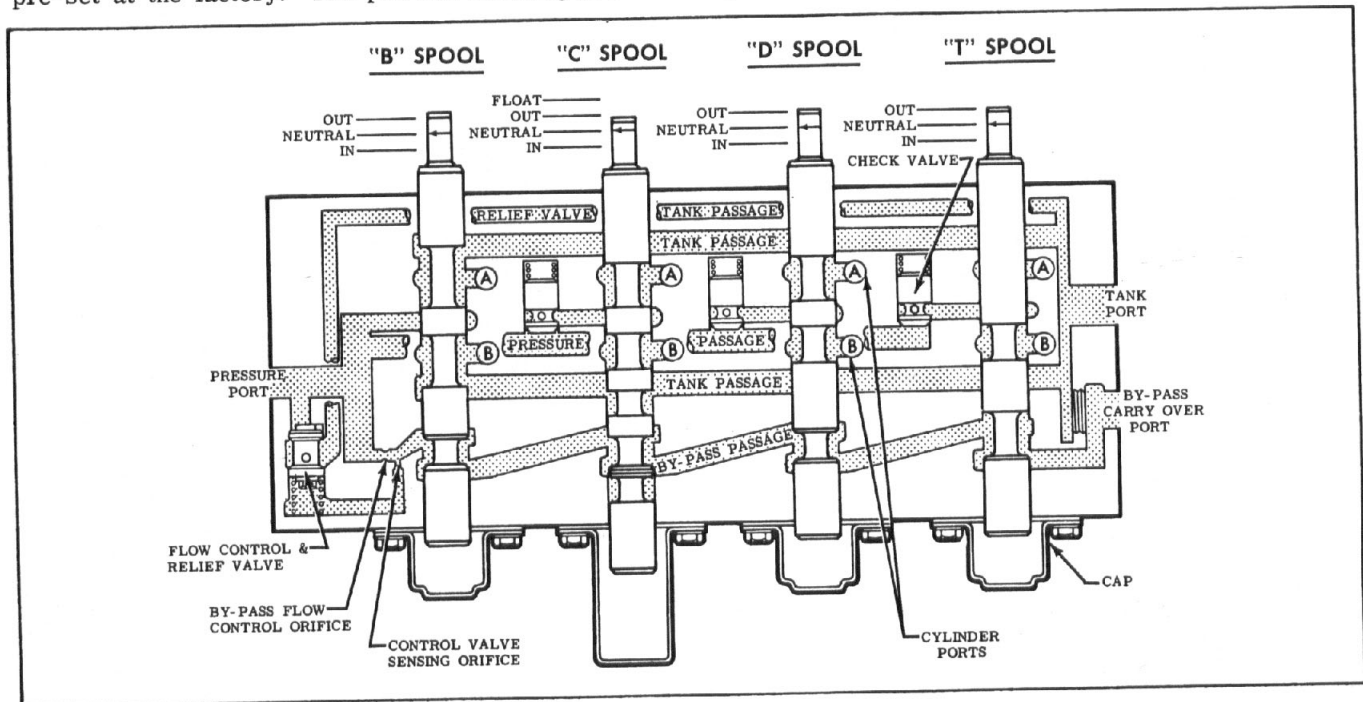
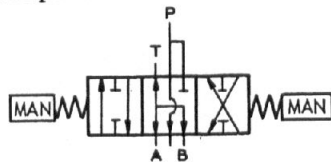


Figure 2

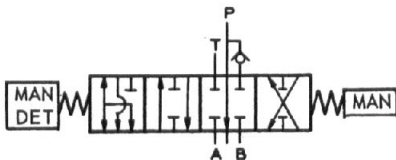
For convenience A. S. A. symbols (Y32. 10-1958) are also shown with the following descriptions of each spool.

(a) **"B" - Motor Spool** - "B" spools are used when flow is directed to the operation of a hydraulic motor instead of a cylinder. These spools are double acting in character so that the motor may be rotated in either direction. The cylinder ports are left partially open in the neutral position to allow free flow of oil between the motor and reservoir. See Figure 3 for spool position vs. flow characteristics.



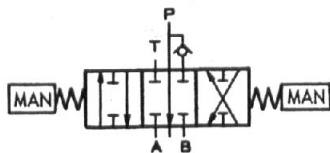
"B" MOTOR SPOOL

(b) **"C" Float Spools** - "C" spools are double acting with an additional float position. The spool is retained in the float position by a detent, and it is spring centered to neutral from the "in" and "out" positions. Both cylinder ports are open to the tank in the float position to permit free flow of oil in either direction. See Figure 4 for spool position versus flow.



"C" FLOAT SPOOL

(c) **"D" Double Acting Spool** - "D" spools are used for applications where pump flow must be directed to either end of a cylinder, depending on the direction of movement required. The end of the cylinder not under pressure has its return flow directed to tank via internal coring of the valve sections. See Figure 5 for spool position versus flow.



"D" DOUBLE ACTING SPOOL

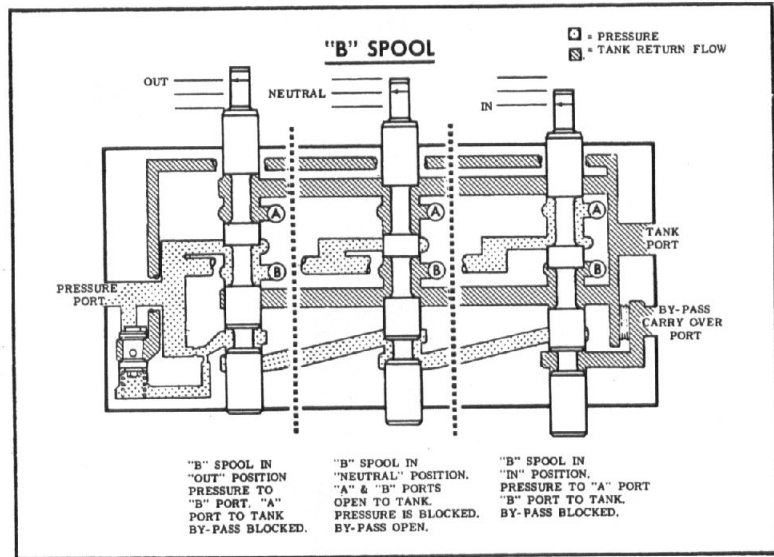


Figure 3

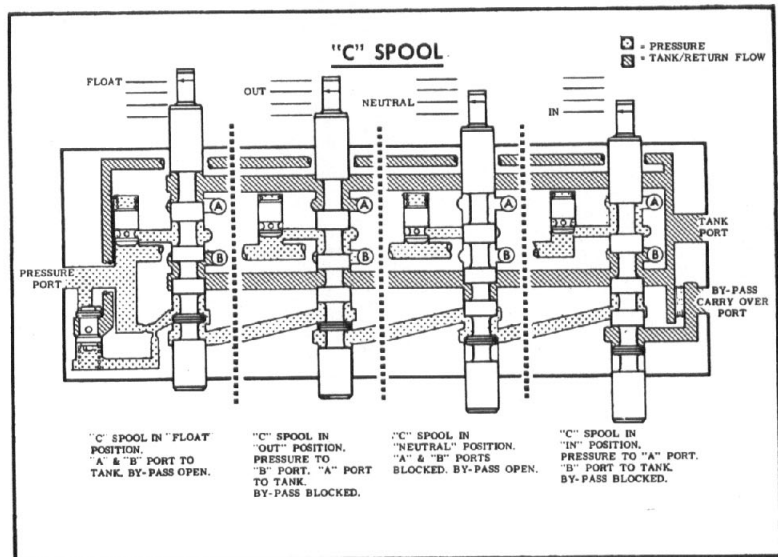


Figure 4

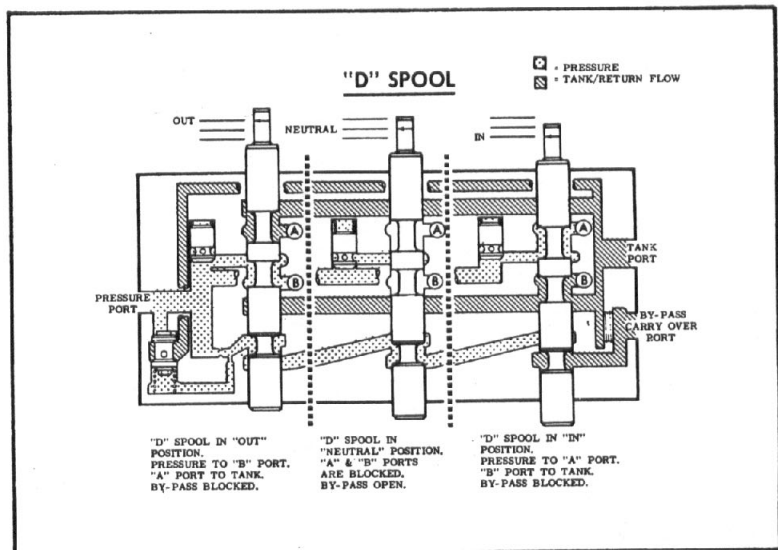
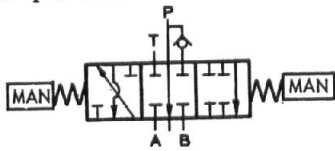


Figure 5

(d) **"T" Single Acting Spool** - "T" spools direct flow to one end of an operating cylinder only as in the example of the lift mechanism on a fork-type truck. Return flow is from the same end of operating cylinder and relies on gravity or mechanical means. See Figure 6 for spool position versus flow.



"T" SINGLE ACTING SPOOL

#### 4. Flow Control and Relief Valve

**General** - The partial flow by-pass system in the CM2 and CM3 series valves makes use of a compound type flow control and relief valve arrangement. By sensing the pressure drop across an orifice at the entrance to the by-pass, the valve acts as a flow control to limit flow through the by-pass.

When a spool is completely shifted, the flow control is inoperative and full pump volume is available to the system. The control valve then functions as an overload relief valve. System pressure is limited to a prescribed maximum by the action of this valve.

(a) **Flow Control** - Figure 7A shows the flow control valve operation with the spool in neutral. Flow across the by-pass orifice results in a pressure drop. The decreased pressure is sensed at the spring end of the valve sub-assembly through a sensing orifice. The slightly higher pressure at the other end of the valve permits it to shift down, diverting excess flow to the tank passage. With less than rated flow, shown on the installation drawing, there would be insufficient pressure drop across the by-pass orifice and the flow control valve would return to the closed position. Since the control valve is held closed by the large spring and all flow would be through the by-pass passage.

(b) **Relief Valve** - Operation of the relief valve feature is shown in Figure 7B. Here an operating spool would be shifted, porting fluid to the system and blocking the by-pass.

Figure 7B shows operation at less than the relief valve setting. There is no flow over the by-pass orifice, so full system pressure is sensed at the spring end of the control valve, as well as the

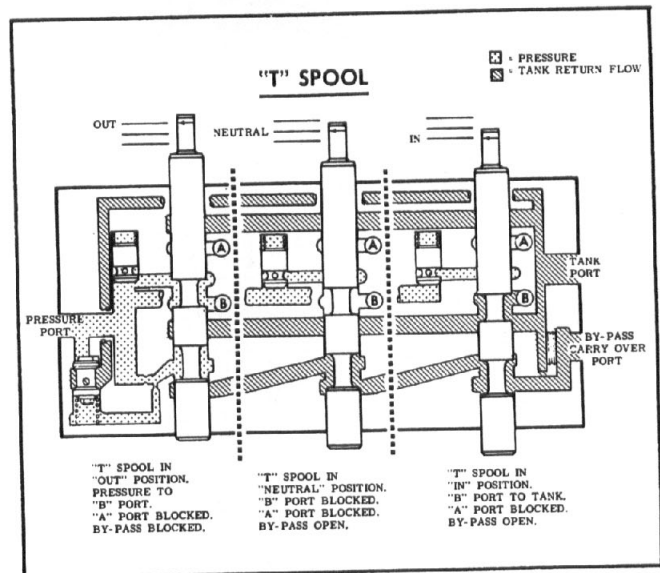


Figure 6

opposite end. The valve is thus hydraulically balanced and the large spring holds it closed.

Maximum pressure is determined by the setting of the small spring inside the control valve assembly. When system pressure is high enough to overcome this small spring, the poppet is forced off its seat. (See Figure 7C) Fluid immediately flows past the poppet to the tank passage. This flow creates a pressure drop across the sensing orifice and the control valve is no longer hydraulically balanced. When this pressure differential is great enough to overcome the large spring, the valve shifts permitting flow to the tank passage.

5. **Check Valve** - Timing of the valve spools is such that the cylinder port opens to pressure and tank before the by-pass passage is completely blocked. To prevent return flow from passing into the pressure passage, check valves are provided in each operating section except the "B" section. The load is thus prevented from dropping.

6. **Detent** - The spool detent consists of a special end cap with a spring loaded plunger. The plunger engages in a groove in the spool extension and holds the spool in the desired position. Detent parts are illustrated in the exploded view in Figure 9A.

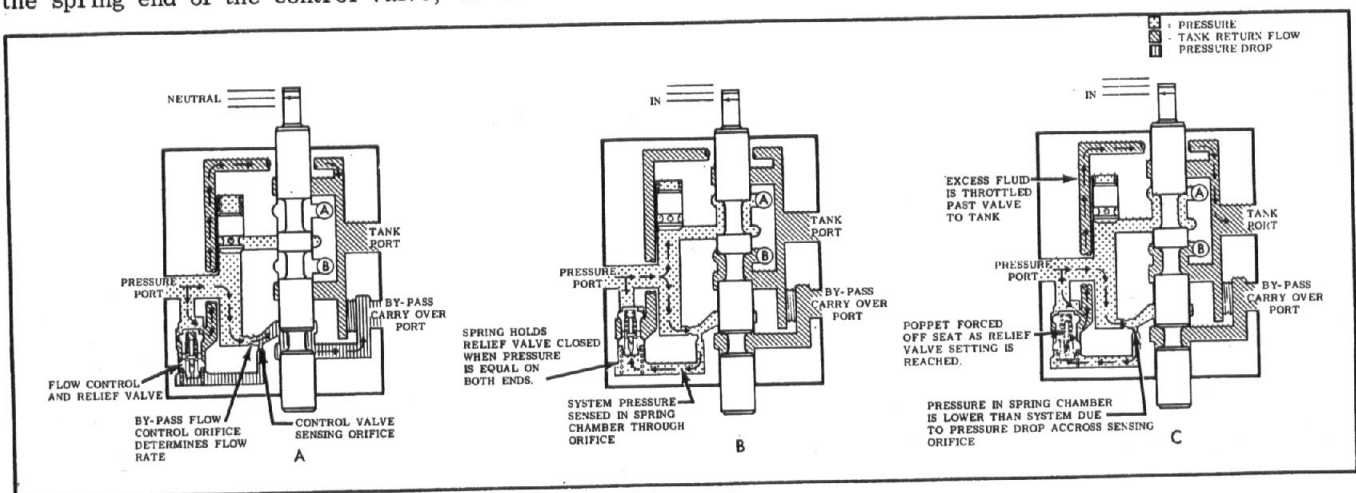


Figure 7

7. Tandem Operation - Tandem operation permits operation of two banks of valves from the same pumping source. An internal plug in the outlet section of the first bank (see Figure 8) separates the by-pass passage from the tank passage. Cylinder exhaust oil is returned to tank via the alternate discharge port, and by-pass oil is directed out the primary discharge port to the by-pass port of the bank.

In Figure 8, either bank can be operated separately or both simultaneously. This is possible because of the tandem by-pass connection from the inlet connection of the first bank to the F inlet connection of the second bank. If neither bank is operating, part of the fluid flows through both by-pass passages directly to tank. The balance is diverted through the tank passage of the first section as shown in Figure 2.

In some cases, it is desirable to have tandem valves connected in series where, the second bank is dependent upon the operation of the first bank. The first bank has control priority because the tandem by-pass connection is not used. The cylinder discharge oil of the first bank is directed out of primary discharge port to the inlet port of the second bank. Use a "K" inlet section in the first bank if full flow is desired to the second bank. Otherwise reduced flow will be encountered.

### C. NON-OPERATING SECTIONS

1. General - The CM2 valve non-operating sections are the "E" and "L" outlet sections and a center "U" section. These sections do not have operating spools. The functions of these sections are as follows:

(a) "E" Outlet Section - The "E" type section provides an outlet section by which the by-pass feature for pump unloading is extended to a subsequent valve bank (tandem operation). It is generally used in conjunction with the "F" type inlet section on the subsequent valve bank assembly. This "E" type section is only used with one spool banks.

(b) "L" Outlet Section - The "L" type section is basically the same section as the "E" section except it provides only one connection for exhaust oil and is used as the last section on a single spool bank where tandem operation is not required.

(c) "U" Center Section - The "U" section, when mounted between two operational sections, permits the operation of two cylinders or motors in series. This is accomplished by porting the outlet of the first operating section to the inlet of the second operating section.

#### NOTE

It should be noted that the pressure drop across the valve, when used in series operation, will be the sum of the pressure drops for each section.

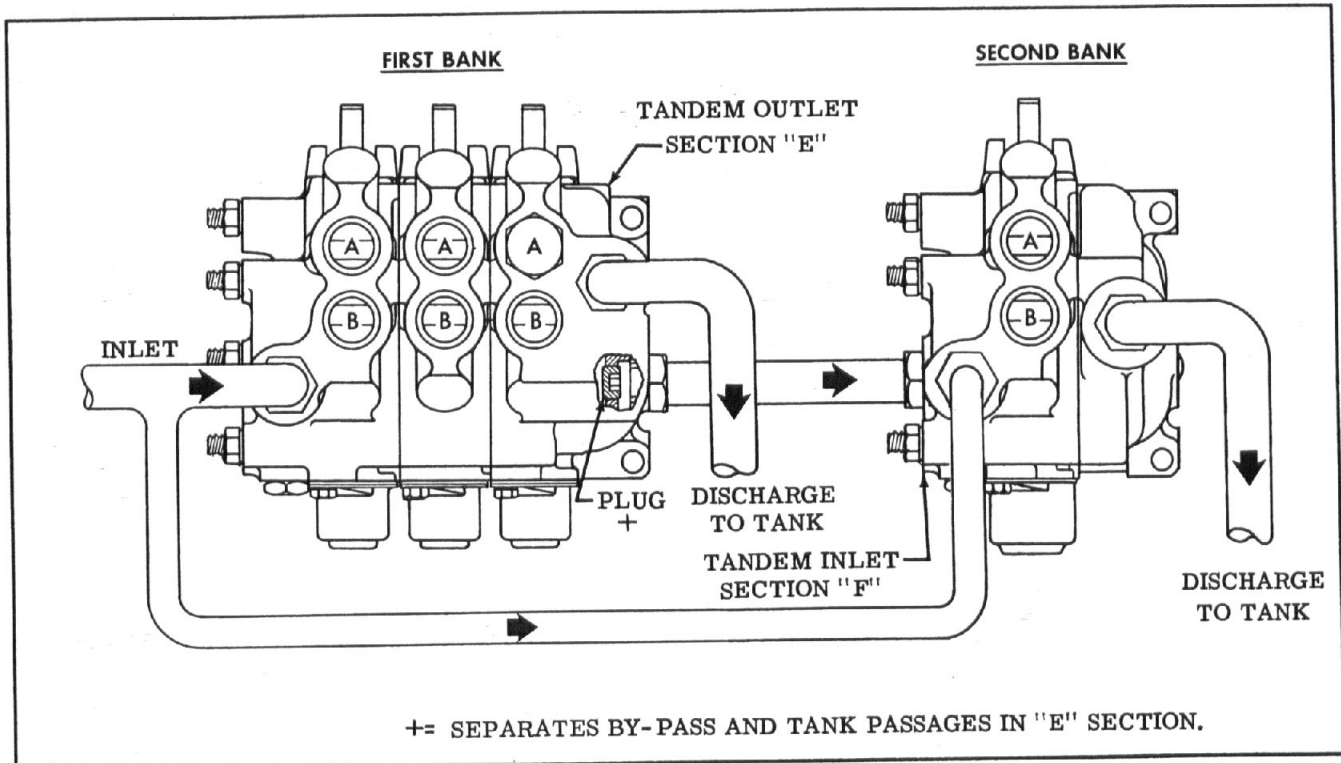


Figure 8

## SECTION IV - INSTALLATION AND OPERATING INSTRUCTIONS

### A. INSTALLATION DRAWINGS

Installation drawings M-259218 and M-259219 should be consulted for installation dimensions.

### B. MOUNTING

These valves can be mounted in any position. Enough clearance must be left to provide access to the port connections and to permit actuating the control mechanism. The valves should be securely bolted to the mounting surface.

#### NOTE

Valves should be mounted on a relatively flat surface to prevent possible distortion of the valve bodies.

### C. PORT CONNECTIONS

All connections are compatible with standard SAE fittings and "O" ring seals. It is only necessary to tighten fittings so that there is a firm metal-to-metal contact.

### D. RELIEF VALVE

Relief valve sub-assemblies in the inlet section are preset and tested by Vickers for given pressure settings. Selection of the relief valve setting is based on the work requirements of the system. If a different relief valve setting is required, the valve sub-assembly should be replaced (see parts catalog M-2401-S, M-2402-S, M-2403-S or M-2404-S).

### E. TANDEM INSTALLATION

1. Piping arrangement for tandem series operation is shown in Figure 8.

2. The outlet section of the first bank must be an "E" section which is equipped with a plug (see Figure 8) to block the primary discharge port from tank. The discharge to tank port must be connected to tank.

#### NOTE

Slight leakage past the internal plug is permissible. The plug should not be tightened excessively, as there is the danger of distorting the body and causing the spool to bind.

### F. HYDRAULIC TUBING

#### NOTE

For instructions on pickling, refer to Vickers Instruction Sheet M-9600.

1. All tubing must be thoroughly cleaned before installation to remove dirt, rust and scale. Recommended methods of cleaning are sand blasting, wire brushing and pickling.

2. The number of bends in tubing should be kept to a minimum to prevent excessive turbulence and friction of oil flow.

3. Tubing should not be bent too sharply. The minimum radius for bends is three times the inside diameter of the tube.

4. To minimize flow resistance and the possibility of leakage, only as many fittings and connections as are necessary for proper installation should be used.

### G. HYDRAULIC FLUID RECOMMENDATIONS

The oil in a hydraulic system serves as the power transmission medium. It is also the system's lubricant and coolant. Selection of the proper oil is a requirement for satisfactory system performance and life. Oil must be selected with care and with the assistance of a reputable supplier.

#### TWO IMPORTANT FACTORS IN SELECTING AN OIL ARE:

1. Antiwear Additives - The oil selected must contain the necessary additives to insure high antiwear characteristics.

2. Viscosity - The oil selected must have proper viscosity to maintain adequate lubricating film at system operating temperature.

#### SUITABLE TYPES OF OIL ARE:

1. Crankcase Oil meeting API service classification MS. The MS (most severe) classification is the key to proper selection of crankcase oils for Mobile hydraulic systems.

2. Antiwear Type Hydraulic Oil - There is no common designation for oils of this type. However, they are produced by all major oil suppliers and provide the antiwear qualities of MS crankcase oils.

3. Certain Other Types of Petroleum Oils are suitable for Mobile hydraulic service if they meet the following provisions:

(A) Contain the type and content of antiwear compounding found in MS crankcase oils or have passed pump tests similar to those used in developing the antiwear type hydraulic oils.

(B) Meet the viscosity recommendations shown in the following table.

(C) Have sufficient chemical stability for Mobile hydraulic system service.

The following types of oil are suitable if they meet the above three provisions:

Series 3 Diesel Engine Oil  
Automatic Transmission Fluid Types A, F  
and DEXRON  
Hydraulic Transmission Fluid Types C-1  
and C-2

The following table summarizes oil types recommended for use with Vickers equipment in Mobile hydraulic systems by viscosity and service classification.

TABLE III

Hydraulic System Operating Temperature Range (Min. * To Max.)	SAE Viscosity Designation	American Petroleum Institute (API) Service Classification
0°F. to 180°F.	10W	MS
0°F. to 210°F.	10W-30**	MS
50°F. to 210°F.	20-20W	MS

\* Ambient Start Up Temperature

\*\* See paragraph on Viscosity Index

## OPERATING TEMPERATURE:

The temperatures shown in table III are cold start-up to maximum operating. Suitable start-up procedures must be followed to insure adequate lubrication during system warm-up.

## ARCTIC CONDITIONS:

Arctic conditions represent a specialized field where extensive use is made of heating equipment before starting. If necessary, this, and judicious use of SAE 5W or SAE 5W-20 oil in line with the viscosity guide lines shown in the table, may be used. Dilution of SAE 10W (MS) oil with maximum of 20% by volume of kerosene or low temperature diesel fuel is permissible. During cold start-up, avoid high speed operation of hydraulic system components until the system is warmed up to provide adequate lubrication. Operating temperature should be closely monitored to avoid exceeding a temperature of 130° F. with any of these light weight or diluted oils.

## OTHER FACTORS IN SELECTING AN OIL ARE:

1. Viscosity - Viscosity is the measure of fluidity. In addition to dynamic lubricating properties, oil must have sufficient body to provide adequate sealing effect between working parts of pumps, valves, cylinders and motors, but not enough to cause pump cavitation or sluggish valve action. Optimum operating viscosity of the oil should be between 80 SSU and 180 SSU. During sustained high temperature operation viscosity should not fall below 60 SSU.

2. Viscosity Index - Viscosity index reflects the way viscosity changes with temperature. The smaller the viscosity change the higher the viscosity index. The viscosity index of hydraulic system oil should not be less than 90. Multiple viscosity oils, such as SAE 10W-30, incorporate additives to improve viscosity index (polymer thickened). Oils of this type

generally exhibit both temporary and permanent decrease in viscosity due to the oil shear encountered in the operating hydraulic system. Accordingly, when such oils are selected, it is desirable to use those with high shear stability to insure that viscosity remains within recommended limits.

3. Additives - Research has developed a number of additive agents which materially improve various characteristics of oil for hydraulic systems. These additives are selected to reduce wear, increase chemical stability, inhibit corrosion and depress the pour point. The most desirable oils for hydraulic service contain higher amounts of antiwear compounding.

## SPECIAL REQUIREMENTS:

Where special considerations indicate a need to depart from the recommended oils or operating conditions, see your Vickers sales representative.

## CLEANLINESS:

Thorough precautions should always be observed to insure that the hydraulic system is clean:

1. Clean (flush) entire system to remove paint, metal chips, welding shot, etc.
2. Filter each change of oil to prevent introduction of contaminant into the system.
3. Provide continuous oil filtration to remove sludge and products of wear and corrosion generated during the life of the system.
4. Provide continuous protection of system from entry of airborne contamination.
5. During usage, proper oil filling and servicing of filters, breathers, reservoirs, etc., cannot be over-emphasized.

## SECTION V - INSPECTION AND MAINTENANCE

### A. SERVICE TOOLS

No special tools are required to service Vickers CM2 or CM3 series multiple unit valves.

### B. INSPECTION

Periodic inspection of spool operation, oil condition and pressure connections saves time-consuming breakdowns and unnecessary parts replacement.

1. All hydraulic connections must be tight. Loose connections not only allow leakage but also permit air to be drawn into the system, resulting in noisy and erratic operation.

2. Spools should return to neutral automatically when the control is released. The centering spring force is approximately 60 to 120 pounds. If more force is necessary, the spool may be binding or control linkage may be faulty.

3. System filters and reservoir should be checked periodically for foreign particles. If excessive contamination is found, the system should be drained. The reservoir must be cleaned thoroughly before refilling.

### C. ADDING FLUID TO THE SYSTEM

When hydraulic fluid is added to the system, it should be pumped through a 25 micron filter. If such a filter is not available, or practical to use in the

field, a funnel with a fine wire screen (200 mesh or better) can be used.

It is important that oil be clean and free of all substance which will cause improper operation and excessive wear of the pump or other hydraulic units in the system. Be sure to purge all air from the system.

### D. LUBRICATION

Internal lubrication is provided by system oil.

### E. REPLACEMENT PARTS

Only genuine parts manufactured or sold by Vickers should be used as replacement parts for these valves. Only Vickers knows the true quality level required of each part. These are listed in parts catalogs M-2401-S, M-2402-S, M-2403-S and M-2404-S copies of which are available on request.

### F. TROUBLE SHOOTING

Table IV lists the difficulties which may be experienced with the unit and hydraulic system. It indicates the cause and remedy for each of the troubles listed. It should always be remembered that pressure and delivery are factors which are usually dependent upon each other. Adequate pressure gage equipment and a thorough understanding of the operation of the complete hydraulic system are essential to diagnose improper operation.

TABLE IV - TROUBLE, CAUSE AND REMEDY CHART

TROUBLE	PROBABLE CAUSE	REMEDY
Oil leaks at either end of spool.	Defective "O" rings in valve body.	Replace "O" rings.
Spring-centered spools do not return to neutral.	Broken springs.	Replace springs.
	Bent spool.	Replace with new section of same size and type.
	Foreign particles.	Clean system and valve.
	Misalignment of operating linkage	Check linkage for binding condition.
	Valve tank improperly torque.	Retorque nuts to specified ratings.
Detent type spools will not stay in detent position.	Worn detent barrel.	Replace detent barrel.
	Weak or broken detent spring.	Replace detent spring.
No motion, slow or jerky action of hydraulic system.	Relief valve not properly set, or stuck in base and/or worn.	Repair, clean and readjust.
	Dirt or foreign particles lodged between releivalve control poppet and seat.	Disassemble, clean and reassemble.
	Valve body cracked inside.	Replace valve section.
	Spool not moved to full stroke.	Check travel.
No relief valve action (High Pressure)	Small particle of dirt plugging orifice in relief valve sub-assembly.	Remove relief valve and check hole. If blocked, clear hole.
	Relief Valve S.A. installed backwards.	Install properly.
Load will not hold.	Oil by-passing between spool and body.	Replace valve.
	Oil by-passing piston in cylinder.	Repair or replace cylinder.
	Spool not centered	Refer to above spool remedies.
Load drops when spool is moved from neutral to a power position.	Dirt or foreign particles lodged between check valve poppet and seat.	Disassemble, clean and reassemble.
	Scored or sticking check valve poppet.	Replace poppet.

## SECTION VI - OVERHAUL

### A. GENERAL

During disassembly, particular attention should be given to identification of parts for reassembly. Spools are selectively fitted to valve bodies and must be returned to the same bodies from which they were removed. Valve sections should be reassembled in the same order.

Figure 9 and 9A is an exploded view showing the proper relationship for reassembly. Reference is made to these figures in the procedures which follow.

### B. DISASSEMBLY

1. Controls - Be sure the unit is not subjected to pressure. Disconnect and cap all lines and disconnect linkage to the spool. If hand levers are used, remove the "E" rings which retain the fulcrum rod and remove the links, levers and retaining rings.

2. Attaching Parts - Remove the four tie studs and nuts and separate the valve sections. Be careful not to destroy or lose spacers.

3. End Caps - Remove the two screws which secure the spool and cap and remove the cap. If the cap

has a detent assembly, screw out the detent plug and remove the spring and piston. Remove the "O" ring from the body.

4. Operating Spool - Slide the spool out of its bore from the cap end and remove the "O" rings from the valve body around the spool bore. Do not remove the centering spring and retainers unless it is necessary to replace them.

5. Check Valve - Grip the stem of the check valve plug with pliers and pull it out of the valve body. Remove the "O" ring and back-up ring. Remove the spring and poppet from the valve body.

6. Relief Valve Sub-Assy - Screw out the plug which retains the relief valve and remove the "O" ring from the plug. Remove the spring and the relief valve sub-assembly. In F\* sections, remove the solid plug.

7. Valve Body - Remove the plug and "O" ring from the blocked cylinder port on models with a single acting spool. If the alternate discharge port is plugged, it is not necessary to remove the plug unless the body is to be replaced.

### C. CLEANING, INSPECTION AND REPAIR



1. Discard all old seals. Wash all parts in a clean mineral oil solvent and place them on a clean surface for inspection.

2. Carefully remove burrs by light stoning or lapping. Be certain there is no paint or burrs on mating surfaces of valve bodies.

3. Inspect the valve spools and bores for burrs and scoring. If scoring is not deep enough to cause objectionable leakage, the surfaces can be stoned or polished with crocus cloth. If scoring is excessive, the valve body and spool must be replaced by ordering a new section. Check the valve spool for freedom of movement in the bore.

4. Check the relief valve for smooth movement in its bore. The valve should move from its own weight.

#### D. ASSEMBLY

##### NOTE

Coat all parts with clean hydraulic oil to facilitate reassembly and provide initial lubrication. Petroleum jelly can be used to hold seal rings in place on assembly.

1. Valve Body (Figure 9) - On models with single-acting spool, install the "O" ring on the port plug and plug the appropriate cylinder port. Tighten the plug securely, but DO NOT over tighten.

2. Relief Valve - Install the "O" ring on the relief valve plug. Place the relief valve assembly in its bore, hex nut end towards opening. Install the spring and plug and tighten the plug securely but DO NOT over tighten.

3. Check Valve - Install a new back-up ring and "O" ring on the check valve plug with the "O" ring toward the spring and poppet. Place the poppet and spring in the body and install the plug.

4. Operating Spool - If centering spring and spool have been removed, install new "O" rings in the "O" ring groove in the body at each end of the spool bore. Install spool in bore from the cap end. Install the flat retainer, guide and screw. Tighten the screw securely. Align the flat retainer by shifting the spool. Spool bind is an indication of flat retainer misalignment. Install the end cap and attaching screws. Tighten the end cap screws securely. On models with detents grease all the detent parts and install the piston, spring and plug. Be sure to screw the plug in all the way.

#### 5. Assembly of Unit Sections.

##### CAUTION

Make sure all mating surfaces of valve bodies are free of burrs and paint.

Install seal rings in the grooves in the body of each inlet and center section. Use petroleum jelly to hold the seals in place. For CM2 valves, install the spacers to insure against spool bind when the studs are tightened. With the mounting feet on a flat surface carefully place the sections together in the same order in which they were removed. The mounting feet must be maintained in a flat plane to prevent spool bind (due to body distortion) when the valve is mounted for operation. If levers are used, install pins in each spool and assembly the levers, fulcrum rod and "E" rings. Tighten the nuts on the CM2 to 45-50 foot pounds torque and on the CM3 to 55-60 foot pounds torque.

## SECTION VII-VALVE OPTIONS

A. GENERAL - Operating sections can be supplied with anti-cavitation check valves, and combination anti-cavitation check valves with cylinder port relief valves. The use of these accessories will be identified by a special feature suffix on the model number. Refer to the installation drawings listed in Table 1 for these options.

1. Anti-Cavitation Check Valve - To eliminate cavitation created in the system, an anti-cavitation check valve may be employed. The valve can be installed on each cylinder port of any operating section where required. When the system pressure is less than tank pressure, a vacuum is created. The anti-cavitation check valve equalizes the unbalanced pressure condition by metering fluid from the tank passage back to the pressure port. The anti-cavitation check valve is located in valve operating sections next to the

cylinder ports and function when the spool is in neutral and operating position.

2. Anti-Cavitation Check With Cylinder Port Relief Valve - The anti-cavitation check with cylinder port relief valve is a combination of anti-cavitation check valve with an integral cylinder port relief valve sub-assembly. The operation of the anti-cavitation check feature is described in paragraph VII, A, 1. The cylinder port relief sub-assembly limits the maximum pressure in the cylinder port. The relief sub-assembly normally functions when the valve spool is in the neutral position. Fluid is discharged from the cylinder port to the tank passage of the directional valve. The pressure setting is generally higher than the main system relief valve. The relief valve sub-assemblies are pre-set at the factory.

## SECTION VIII-TESTING

Vickers Mobile Division application engineering personnel should be consulted for recommendations on test stand circuit requirements and construction. If

test equipment is available, valves should be tested at the recommended flow and pressure shown on installation drawings M-259218 and M-259219.

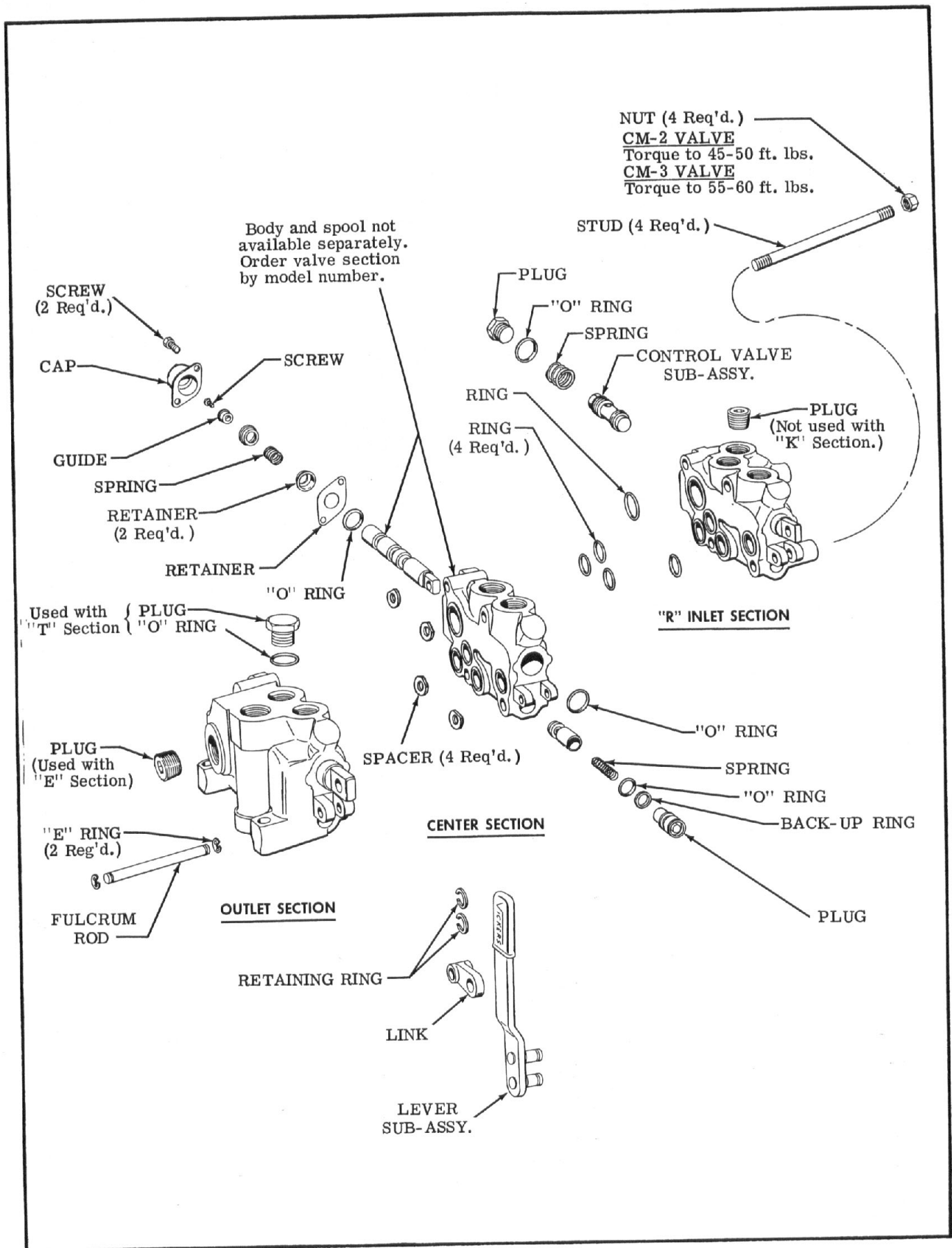
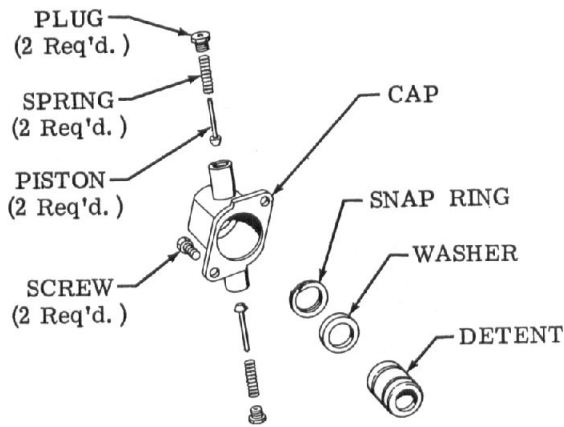
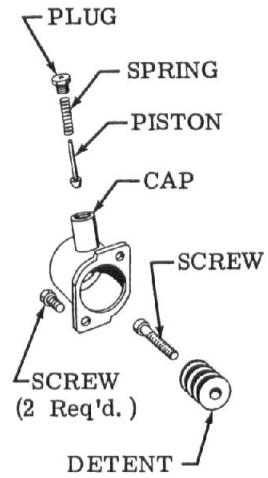


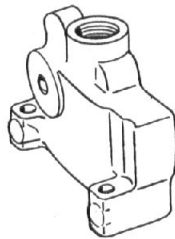
Figure 9



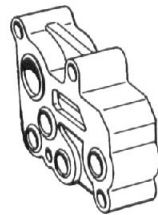
DETENT USED ON "C" FLOAT SECTION



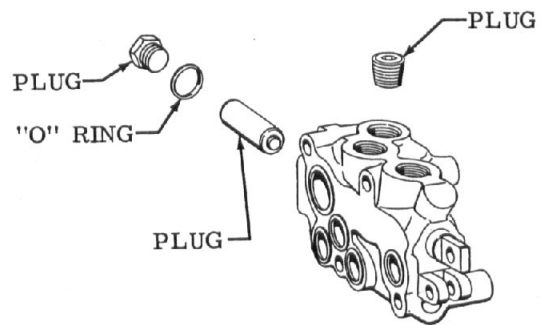
DETENT USED ON "I" SECTION



"L" SECTION

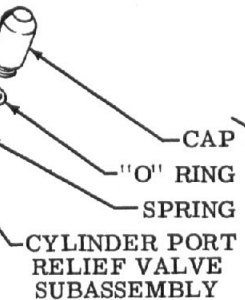
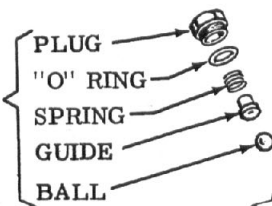


"U" SECTION



"F" INLET SECTION

ANTI-CAVITATION  
CHECK VALVE  
ASSEMBLY



ANTI-CAVITATION  
CHECK WITH  
CYLINDER PORT  
RELIEF VALVE  
ASSEMBLY

CHECK AND CYLINDER PORT RELIEF OPTIONS

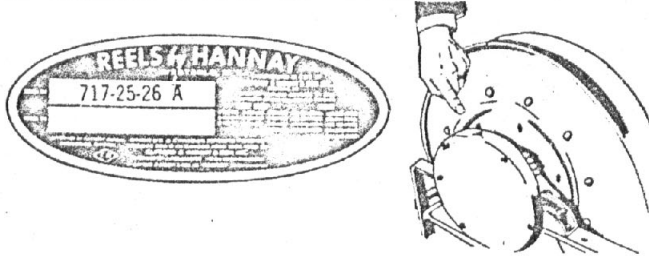
Figure 9A

# IMPORTANT INSTRUCTIONS

FOLLOW CAREFULLY OR GUARANTEE MAY BE VOID.

## SPRING REWIND REELS

### 1. CHECK TYPE OF SPRING

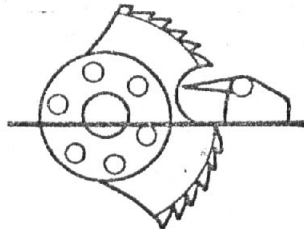


The spring type is indicated by a letter at the end of the model number on the nameplate and stamped in the casting at the top of the spring housing. The maximum number of usable turns for which each spring is designed is shown below:

- A — spring designed for 25 usable turns
- B — spring designed for 20 usable turns
- C — spring designed for 16 usable turns

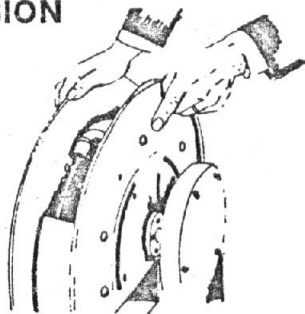
### 2. RELEASE SPRING

To release the spring, disengage the pawl from the ratchet wheel and allow the spring to unwind completely.



### 3. SET SPRING TENSION

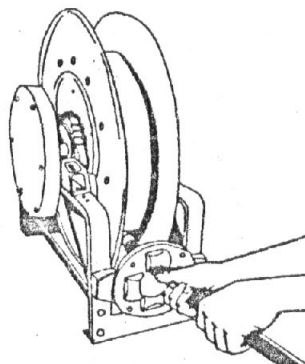
To set spring tension, turn the discs by hand, in the direction the outlet is facing, the number of turns listed above for your particular spring. Lock the reel by engaging the pawl in the ratchet wheel.



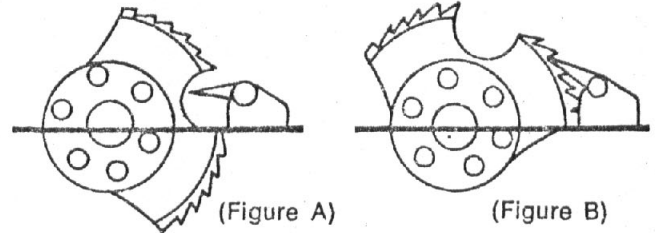
**CAUTION:** Do not wind more than the number of turns required to handle the hose or cable. Never wind more than the number of turns listed above.

### 4. ATTACH HOSE

Insert hose between rollers and attach hose fitting to reel outlet. **NOTE:** On Series 900 reels, outlet may be removed to attach hose.



### 5. WIND HOSE ON REEL



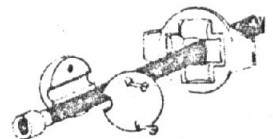
Pull gently on hose until pawl drops into one of the cut-out positions on the ratchet wheel. (Figure A) Release hose slowly and allow to retract until it is completely on the reel. Then, pull hose out until the pawl drops into one of the locking notches on the ratchet wheel (Figure B) to lock the reel.

### 6. REDUCE SPRING TENSION

If spring tension is greater than needed to properly retract the amount of hose attached, tension can be decreased by winding hose completely on reel, allowing end of hose to pass through the roller assembly, and allowing spring to unwind until the proper tension is reached. Relock the reel, as above, and pass hose back through rollers.

### 7. ATTACHING HOSE STOP

Draw hose through rollers to point where hose stop should be attached according to your individual requirements. At this point, put the two halves of hose stop over hose and fasten with bolts provided.



## IMPORTANT

A flexible connector *must be used* between the inlet pipe and the swivel joint on the reel or our guarantee will be void.

Spring motors are matched to a specific length and diameter of hose. The reel may not function properly if the length or diameter of hose varies from that for which the reel is designed.

When ordering parts, always give model number and serial number of reel and describe part as fully as possible.

**GUARANTEE:** HANNAY REELS are guaranteed against defects in material and workmanship when installed according to our instructions and given proper care. Reels, or parts thereof, which prove to be defective when returned to us for our inspection, will be replaced free of charge.

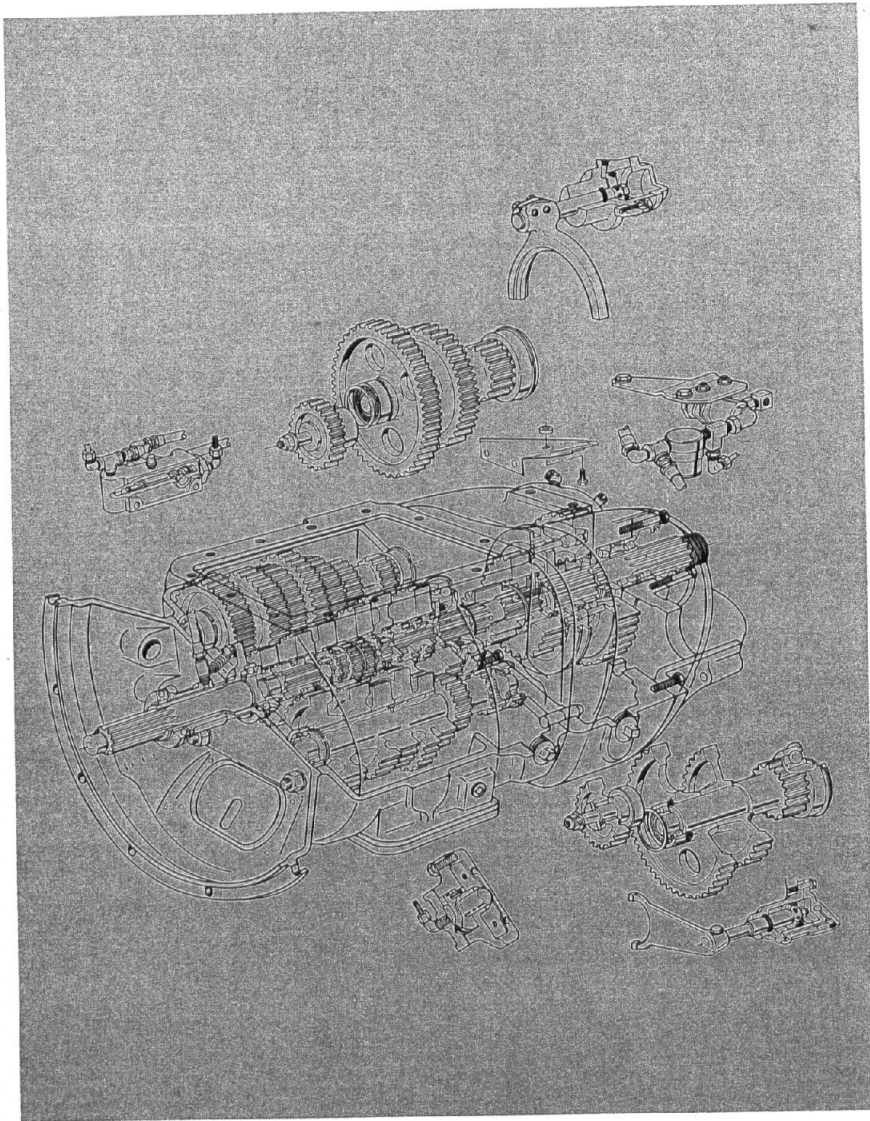
Our liability is limited to the extent of replacement of materials only; no allowances will be made for damages or charges for labor in making changes or repairs.



CLIFFORD B. HANNAY & SON, INC., WESTERLO, NEW YORK 12193

# Service Manual

Fuller  
Models  
**RT-613**  
Series



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**RT-613 Series  
Twin Countershaft  
Roadranger Transmissions**

**RT-613 Direct Models  
RTO-613 Overdrive Models**

---

**EATON** Truck  
Components

Eaton Corporation  
Transmission Division  
Kalamazoo, Michigan

# Service Manual

- Operation
- Lubrication
- Maintenance
- Repair

## RT-613 Series

Fuller  
Twin Countershaft  
Roadranger®  
Transmissions

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## LETTER DESIGNATIONS

- "R" — Roadranger® transmission.
- "T" — Twin Countershaft type.
- "O" — Indicates overdrive.

Unless stated otherwise, this manual applies to all models in the RT-613 series which includes: RT-613, RTO-613.

### NOTE

Illustrated parts lists with parts numbers are available upon request. Write Service Department, Eaton Corporation, Transmission Division, 222 Mosel Ave., Kalamazoo, Michigan 49001.



## DESCRIPTION

Models in the RT-613 series are twin countershaft, Roadranger transmissions with 13 forward speeds and 3 reverse.

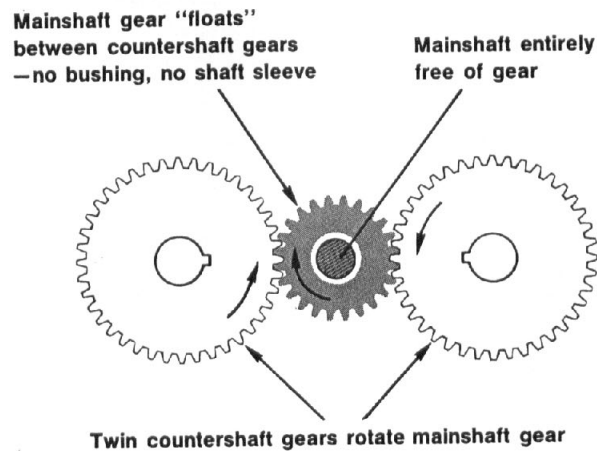
These units consist of a 5-speed front section and a 3-range auxiliary section.

Ratios in the front section are used once through INTERMEDIATE range of the auxiliary and once through DIRECT range. This provides a simple Roadranger repeat shift pattern.

All speeds are controlled with one lever. The range selection is made with a 3-position selector valve mounted on top of the gear shift lever.

The twin countershaft design, developed by Fuller, splits torque evenly between two countershafts, reducing gear tooth pressure and wear. The floating mainshaft gears of this design eliminate gear bushings and sleeves as gears "float" between mating gears on the countershafts.

## FLOATING GEAR PRINCIPLE



## SPECIFICATIONS

Speeds — 13 forward, 3 reverse.

Torque Capacity — 600 lb.-ft.

Clutch Housing Size — SAE No. 2, gray iron, deep only, 6-5/8", for push or pull type clutches.

Power Take-off —

Openings: Two SAE standard for 6/8 pitch gears.

Right Side: Regular duty type, 6 bolt. PTO shaft projections limited.

Bottom Side: Heavy duty type, 8 bolt.

PTO Gear Speeds —

Right and Bottom: 33-tooth 6/8 pitch gears turning at .723 engine speed.

Weight — 620 lbs.

Length — 34-11/16" from face of clutch housing to end of splines on tailshaft.

Oil Capacity — 16 pints, depending upon inclination of engine and transmission. There are two internal oil troughs for improved lubrication.

## GEAR RATIOS

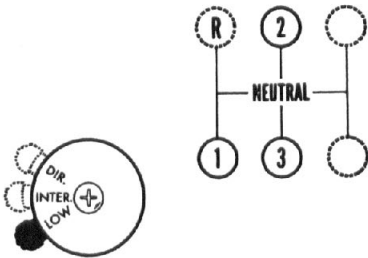
	Speed	RT-613 Ratio	% Step	RTO-613 Ratio	% Step
	13th	1.00		.80	
			24		25
	12th	1.24		1.00	
			29		29
Direct Range	11th	1.60		1.29	
			28		28
	10th	2.05		1.65	
			28		27
	9th	2.62		2.11	
Range Shift			26		28
	8th	3.29		2.65	
			24		24
	7th	4.09		3.29	
			29		29
Intermediate Range	6th	5.26		4.24	
			28		28
	5th	6.74		5.43	
			28		28
	4th	8.64		6.96	
Range Shift			27		27
	3rd	10.96		8.83	
			28		28
	2nd	14.04		11.31	
			28		28
Low Range	1st	18.00		14.50	
	Dir. Rev.	2.77			
	Inter. Rev.	9.12			
	Low Rev.	19.00			

# OPERATION

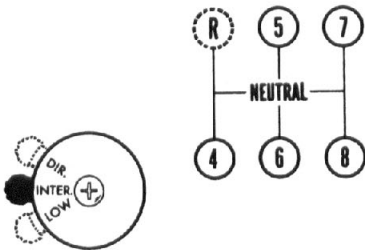
In the following instructions it is assumed that the driver is familiar with motor trucks and tractors, and that he can coordinate the necessary movements of the shift lever and clutch pedal to make progressive and selective gear engagements in either direction, up or down.

Use Normal Double Clutching Procedures Between Shifts.

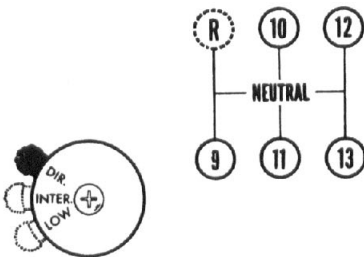
Shift this Pattern with Selector Valve in **LOW** Range



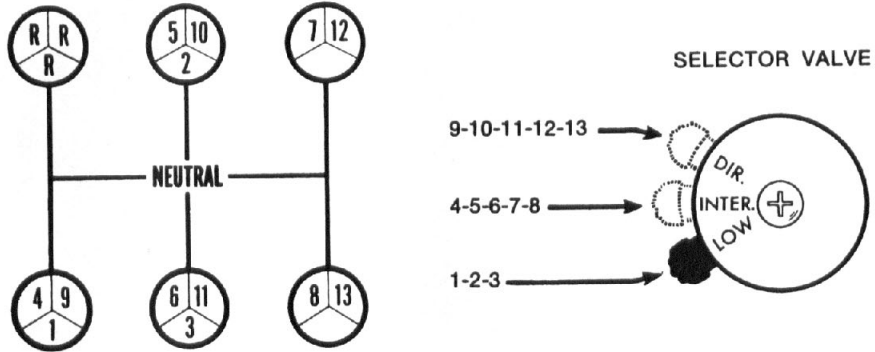
Shift this Pattern with Selector Valve in **INTERMEDIATE** Range



Shift this Pattern with Selector Valve in **DIRECT**



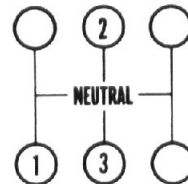
## RT-613 Gear Shift Lever Pattern and Selector Valve Positions



NOTE: For RTO-613 models, the 7/12 and 8/13 speed locations are reversed.

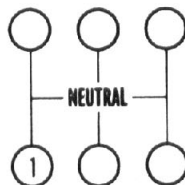
### UPSHIFTING

1. With the transmission in neutral, start engine and bring vehicle's air pressure to normal.
2. Make sure the selector valve is in the **LOW** range position.

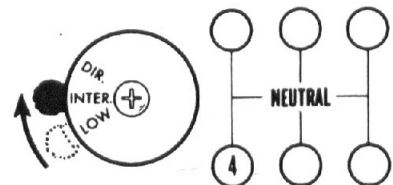


4. Shift from 1st speed through 2nd and to the 3rd speed gear position.

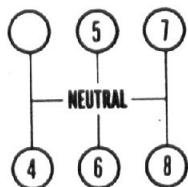
3. Shift into the 1st speed gear position. See page relating to transmission countershaft brake.



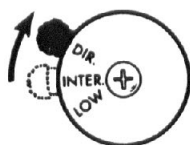
5. Move the selector from **LOW** to **INTERMEDIATE** range, and *immediately* shift to the 4th speed gear position. After the selector valve is moved, the auxiliary will shift as soon as there is a relief in torque.



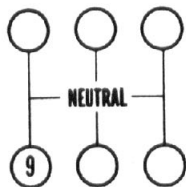
6. Shift progressively from 4th through 5th, 6th, and 7th to the 8th speed gear position.



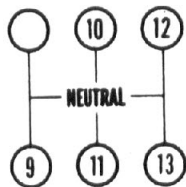
7. Move the selector from INTERMEDIATE to DIRECT range.



8. Move the gear shift lever to the 9th speed gear position. The auxiliary section will automatically shift from INTERMEDIATE to DIRECT when the gear shift lever reaches neutral.

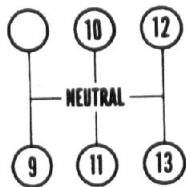


9. Shift upward from 9th through 10th, 11th and 12th to the 13th speed gear position.

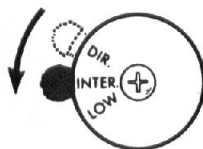


**DOWNSHIFTING**

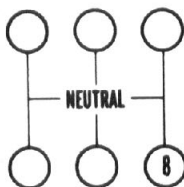
1. Move the shift lever from the 13th speed position through each successive lower speed to the 9th speed gear position.



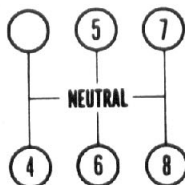
2. When in 9th and ready for the next down shift, move the selector valve from DIRECT to INTERMEDIATE range.



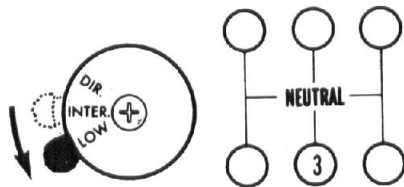
3. Move the shift lever to the 8th speed gear position. As the lever reaches neutral the auxiliary will automatically shift from DIRECT to INTERMEDIATE range.



4. Shift from the 8th speed gear position through each gear and to 4th.



5. Move the selector valve from INTERMEDIATE to LOW and immediately shift to the 3rd speed gear position. The auxiliary section will shift as soon as there is a relief in torque.



6. Downshift from 3rd to 2nd and to 1st.

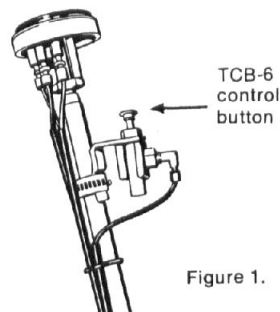
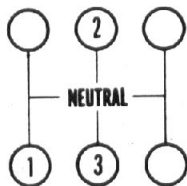


Figure 1.

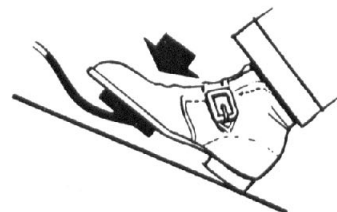


Figure 2.

Model RT-613 transmission is equipped with either a Transmission Countershaft Brake, or an Upshift Clutch Brake.

**Transmission Countershaft Brake . . .** Model TCB-6 or TCB-8 . . . To be used only to assist *initial* gear engagement in first or reverse when vehicle is standing still.

Disengage clutch, press down control button and shift into first or reverse. (Figure 1.)

This is an air-operated mechanical brake which slows down the transmission gearing by forcing a piston against the transmission's PTO gear.

Model TCB-6 mounts on the 6-bolt PTO opening, model TCB-8 mounts on the 8-bolt PTO opening.

**Do not use an upshift brake. Use only when vehicle is standing still.**

**Upshift Clutch Brake . . .** To provide a brake for initial gear engagement in first or reverse, and to provide a brake capable of use for upshifting when required with adverse conditions.

Brake is activated by extreme clutch pedal travel during regular upshift sequence. (Figure 2.)

The upshift clutch brake is a disc-type brake incorporated into the clutch and transmission drive gear cover assemblies.

When activated the upshift clutch brake slows down the transmission gearing.

**Do not use when downshifting. Do not use as a brake to slow vehicle.**

# LUBRICATION

## RECOMMENDED LUBRICANTS

*Heavy-duty engine oil.* Make sure to specify heavy-duty type meeting MIL-L-2104B specifications.

*Mineral gear oil* inhibited against rust, oxidation and foaming.

*Extreme pressure oils* under some conditions might form carbon deposits on gears, shafts, bearings and synchronizer discs, and may also glaze friction surfaces of synchronizer discs—conditions which will result in transmission malfunction and premature failure. It is suggested that if these conditions exist, and E.P. oil is being used, a change should be made to straight mineral gear oil or heavy-duty engine oil as recommended.

### ON-HIGHWAY VEHICLES

Type	Grade	Temperature
Heavy Duty Engine Oil MIL-L-2104B	SAE 50 SAE 30	Above +10°F. Below +10°F.
Mineral Gear Oil R and O Type	SAE 90 SAE 80	Above +10°F. Below +10°F.
Mild E.P. Oil (except Sulfur-chlorine-lead type) MIL-L-2105B	SAE 90 SAE 80	Above +10°F. Below +10°F.

### OFF-HIGHWAY AND MINING EQUIPMENT

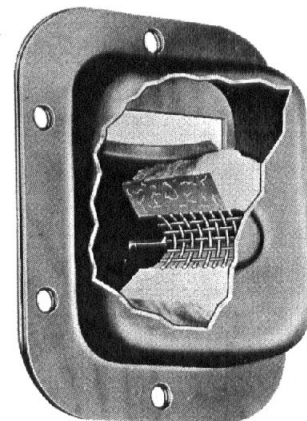
Heavy Duty Engine Oil MIL-L-2104B	SAE 50 SAE 30	Above +10°F. Below +10°F.
<i>Special Recommendation — For extreme cold weather where temperature is consistently below 0°F.</i>		
Heavy Duty Engine Oil MIL-L-2104B	SAE 20W	Below 0°F.

FULLER TRANSMISSIONS are designed so that the internal parts operate in a bath of oil circulated by the motion of gears and shafts. Grey iron parts have built-in channels where needed, to help lubricate bearings and shafts.

Thus, all parts will be amply lubricated if these procedures are closely followed:

1. MAINTAIN OIL LEVEL. INSPECT REGULARLY.
2. CHANGE OIL REGULARLY.
3. USE THE CORRECT GRADE AND TYPE OF OIL.
4. BUY FROM A REPUTABLE DEALER.

To keep the gear oil clean between oil changes use the Fuller Transmission Gear Oil Filter which can be attached to the right-side power take-off opening. This assembly includes a replaceable filter element that removes the accumulation of metallic particles, road dirt and grit deposited in the lubricant.



Fuller Transmission Gear  
Oil Filter.

**Draining Oil**

To drain the transmission remove the two drain plugs: One at the bottom of the front case and one at the bottom of the intermediate case. Drain oil when transmission is warm. After the transmission has been drained and before it is re-filled, the case should be thoroughly flushed with a clean flushing oil or kerosene. Do not use flushing compound if unit is equipped with side or front mounted pressure lubrication pumps unless pump is removed and opening covered with plate. Clean both drain plugs before reinstalling.

**Refilling**

In order to assure complete filling of the transmission with 16 pints of oil, the following two methods may be used:

- 1) At any inclination: Plug both fill holes (one in the front case and one in the intermediate case) and add entire 16-pint quantity through opening in shift bar housing. The transmission must be *completely drained* before using this method in order to avoid overfilling.
- 2) At upgrade inclinations from 0 through 3 degrees: Add sufficient quantities through both fill holes to level the oil at the bottom of both fill holes.

Do not overfill. Overfilling will cause the oil to be forced out of the case through the mainshaft openings.

**Adding Oil**

It is recommended that types and brands of oil not be intermixed because of possible incompatibility.

Additions of oil during servicing operations should be made through both fill holes to level the oil at the bottom of both fill holes with the transmission at a 0 to 3 Degree up-grade angle.

**Operating Temperature**

It is imperative that the operating temperature of the transmission does not exceed 250°F.

Extensive operation at temperatures exceeding 250°F. will result in rapid breakdown of the oil and shorten transmission life.

Transmissions used in stationary equipment, or in vehicles operating at slow road speeds, may have to be equipped with external coolers so that the 250°F. temperature is not exceeded.

**Inspection**

Gear oil is to be kept even with the level of the filler opening at all times. Check at the following intervals:

- Highway Service ..... 1,000 miles
- Off-highway Service ..... 40 hours

**Gear Oil Change**

Change the gear oil on all new equipment after the first 3000 to 5000 miles (on-highway), or first 40 hours (off-highway); thereafter, make oil changes as follows:

- Highway Service ..... 25,000 miles
- Off-highway Service
  - Logging and associated operations ..... 1,000 hours
  - Dirt moving, mining and associated operations ..... 250 to 500 hours, as indicated by operation and contamination of lubricant.

**Special Recommendation**

The above oil inspection and change periods are based on the average use and operating conditions for the applications listed. It is recommended that the individual owner make a periodic lab analysis of the lubricant to determine contamination based on the individual's own operating conditions. After this has been determined, the individual owner can then set his own inspection and oil change periods.

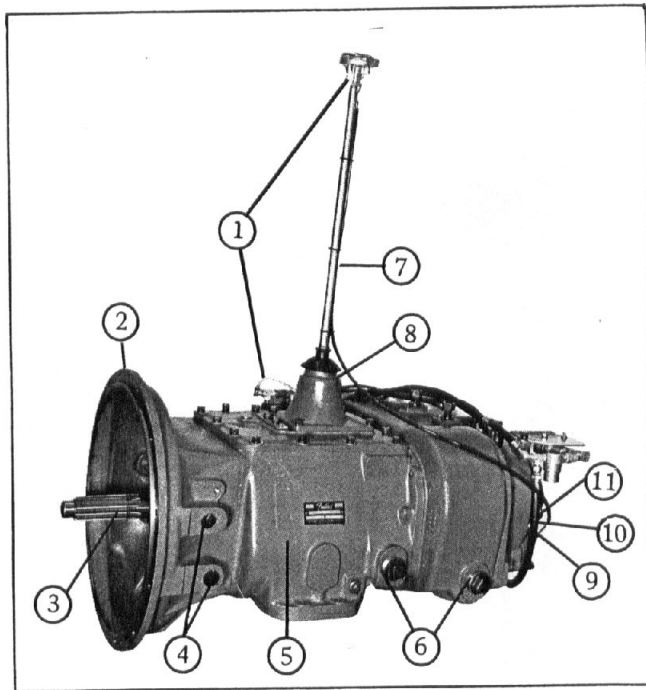
**Clutch Release Bearing**

Lubricate the clutch release bearing after each 40 hours of operation with Mobilgrease No. 5 or its equivalent.

**Oil Filter**

If so equipped, replace filter element at each oil change; clean filter element housing.

# PREVENTIVE MAINTENANCE CHECK CHART



**CHECKS WITHOUT PARTIAL DISASSEMBLY  
OF CHASSIS OR CAB**

## 1. Air System and Connections

- a. Check for leaks, worn air lines, loose connections and capscrews. See Air Systems.

## 2. Clutch Housing Mounting

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

## 3. Clutch Release Bearing

- a. Remove hand hole cover and check radial and axial clearances in release bearing.
- b. Check relative position of thrust surface of release bearing with thrust sleeve on push type clutches.

## 4. Clutch Pedal Shaft and Bores

- a. Pry upward on shafts to check wear.
- b. If excessive movement is found, remove clutch release mechanism and check bushings in bores and wear on shafts.

## 5. Gear Lubricant

- a. Change at specified service intervals.
- b. Use only gear oils as recommended. See Lubrication section.

## 6. Filler and Drain Plugs

- a. Remove filter plugs and check level of lubricant at specified intervals. Tighten filler and drain plugs securely.

## 7. Gear Shift Lever

- a. Check for looseness and free play in housing. If lever is loose in housing, proceed with Check No. 8.

## 8. Gear Shift Lever Housing Assembly

- a. Remove air lines at air valve and remove the gear shift lever housing assembly from transmission.
- b. Check tension spring and washer for set and wear.
- c. Check the gear shift lever pivot pin and pivot pin slot for wear.
- d. Check bottom end of gear shift lever for wear and check slot of yokes and blocks in shift bar housing for wear at contact points with shift lever.
- e. If so equipped, check O-ring in housing for wear or cracks.

## CHECKS WITH DRIVE LINE DROPPED

## 9. Universal Joint Companion Flange Nut

- a. Check for tightness. Tighten to recommended torque.

## CHECKS WITH UNIVERSAL JOINT COMPANION FLANGE REMOVED

## 10. Output Shaft

- a. Check splines for wear from movement and chucking action of the universal joint companion flange.
- b. Pry upward against output shaft to check radial clearance in mainshaft rear bearing.

## 11. Mainshaft Rear Bearing Cover

- a. Check oil seal for wear.

# GENERAL PRECAUTIONS FOR DISASSEMBLY

**IMPORTANT: Read this section before starting the detailed disassembly procedures.**

It is assumed in the detailed disassembly instructions that the lubricant has been drained from the transmission, the necessary linkage and air lines removed and the transmission has been removed from the chassis. Removal of the gear shift lever housing assembly is included in the detailed instructions; however, this assembly must also be removed from transmission before removing unit from vehicle.

Air lines from the range shift and splitter gear controls must be disconnected at the transmission before removing unit from vehicle.

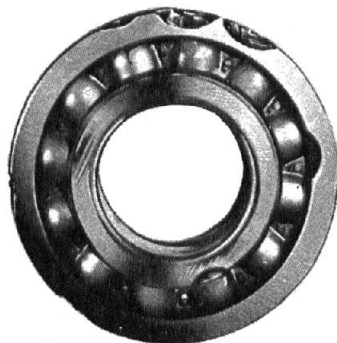
*Follow each procedure closely in each section, making use of both the text and pictures.*

- 1. BEARINGS** — Carefully wash and relubricate all bearings as removed and protectively wrap until ready for use. Remove bearings with pullers designed for this purpose.

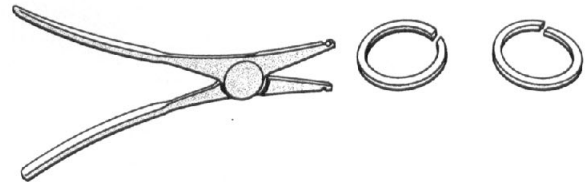


BEARING  
REMOVED WITH  
PUNCH, DAMAGED  
SHIELD.

BEARING  
REMOVED WITH  
CHISEL, DAMAGED  
OUTER RACE.



- 2. ASSEMBLIES** — When disassembling the various assemblies, such as the mainshaft, countershafts and shifting bar housing, lay all parts on a clean bench in the same sequence as removed. This procedure will simplify reassembly and reduce the possibility of losing parts.

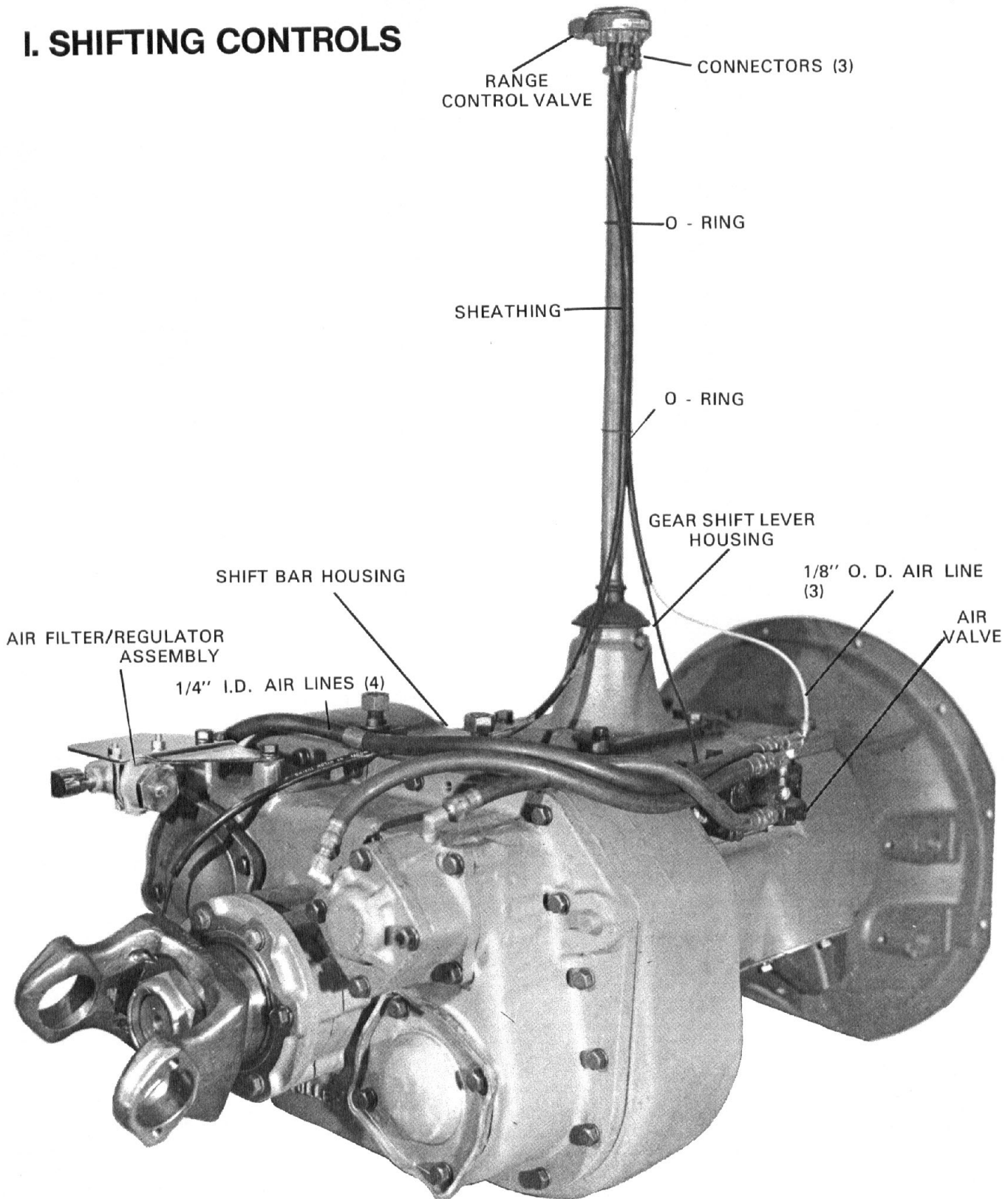


- 3. SNAP RINGS** — Remove snap rings with pliers designed for this purpose. Rings removed in this manner can be reused.
- 4. INPUT SHAFT** — The clutch or input shaft can be removed without removing the countershafts, mainshaft or drive gear. Refer to page 38.
- 5. CLEANLINESS** — Provide a clean place to work. It is important that no dirt or foreign material enters the unit during repairs. The outside of the unit should be carefully cleaned before starting the disassembly. Dirt is abrasive and can damage bearings.
- 6. WHEN DRIVING** — Apply force to shafts, housings, etc., with restraint. Movement of some parts is restricted. Do not apply force after the part being driven stops solidly. Use soft hammers and bars for all disassembly work.

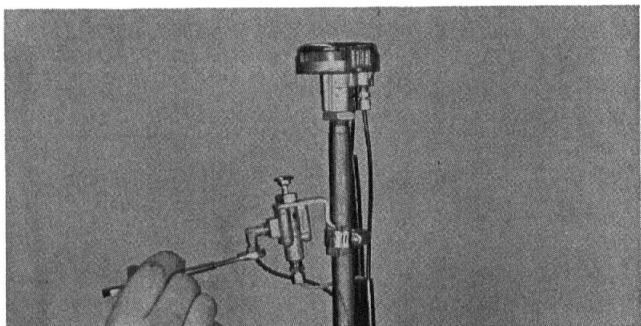


# DISASSEMBLY INSTRUCTIONS

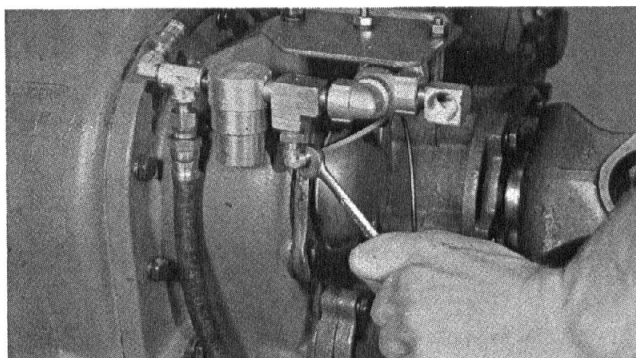
## I. SHIFTING CONTROLS



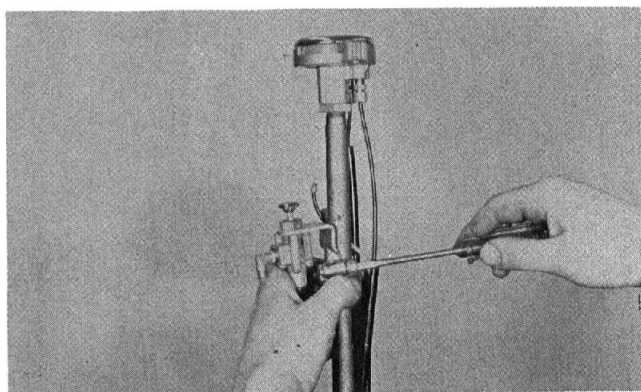
**A. Removal and Disassembly of the Range Shift Air System**



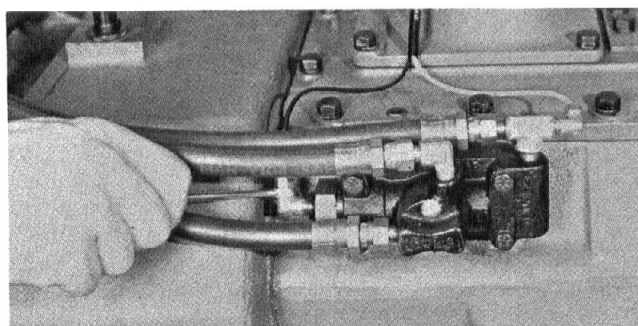
1. If so equipped, disconnect the two 1/8" OD countershaft brake control air lines at the control valve.



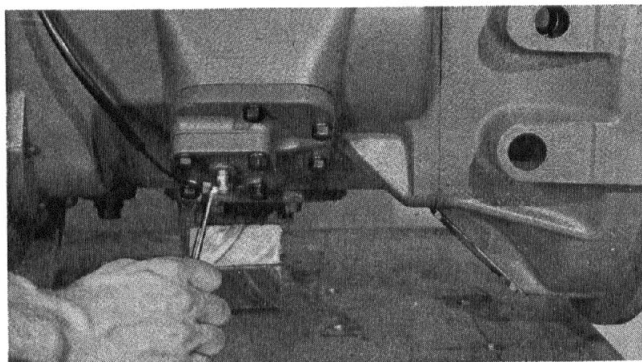
4. Disconnect the 1/8" OD air line at the tee block fitting between the air filter and regulator.



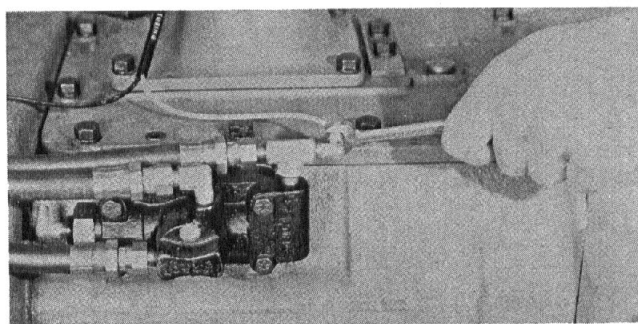
2. Loosen the clamp and remove the countershaft brake control valve from the shifting lever.



5. Disconnect the 1/8" OD range shift control air line at the rear port of the slave air valve.

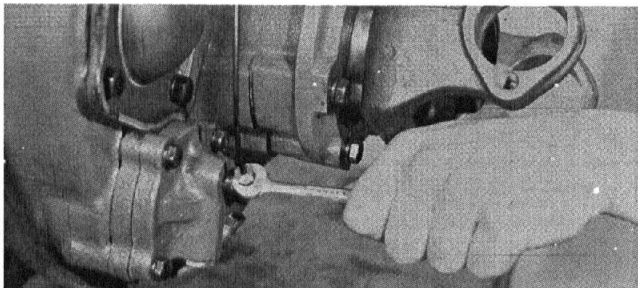


3. Disconnect the 1/8" OD air line at the TCB-6 brake on the right side PTO opening.



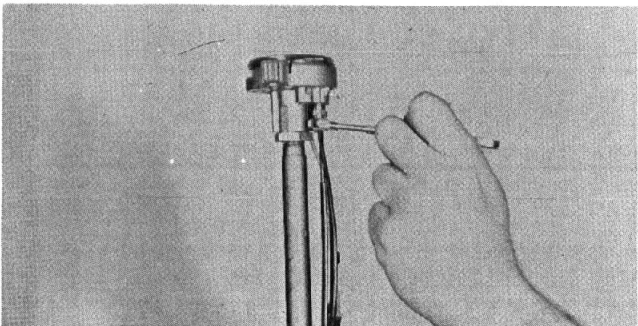
6. Disconnect the 1/8" OD range shift air line at the forward port of the slave air valve.

### A. Removal and Disassembly of the Range Shift Air System – Continued

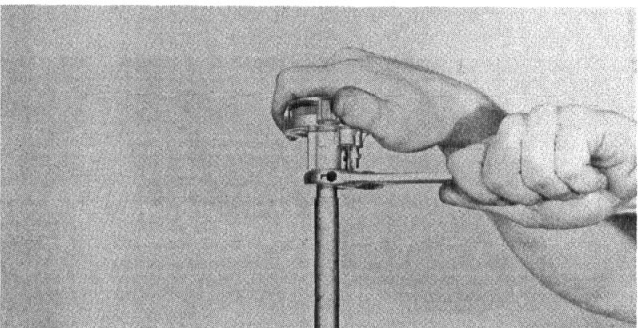


7. Disconnect the  $\frac{1}{8}$ " OD range shift control air line at the intermediate shift cylinder.

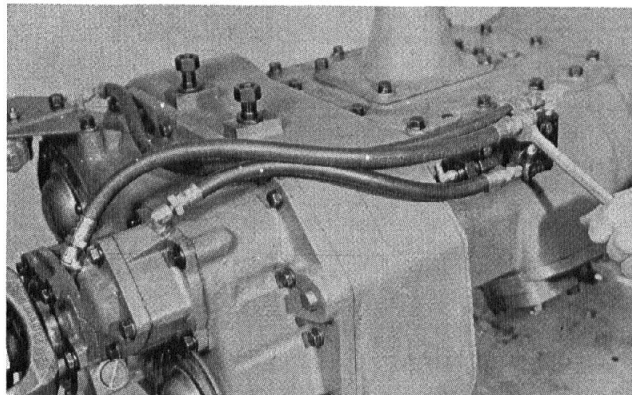
NOTE: If desired, the gearshift lever housing, control valve and air lines can now be removed from the shift bar housing as a unit by turning out the four capscrews at the base of the gearshift lever housing.



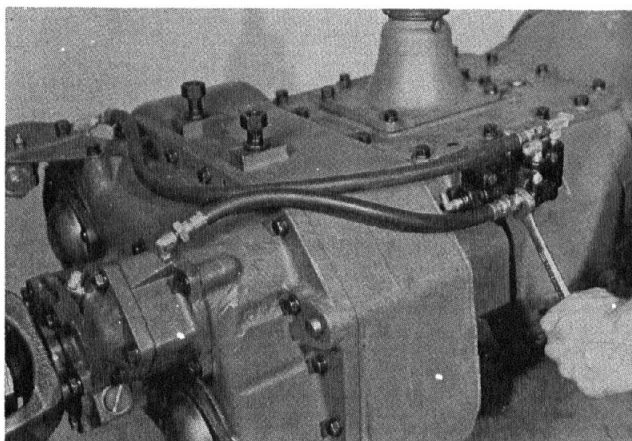
8. Disconnect the three  $\frac{1}{8}$ " OD air lines at the control valve.



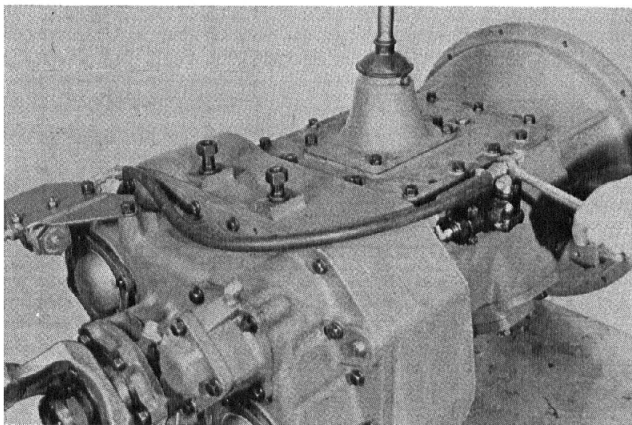
9. Loosen the jam nut and turn the nut and control valve from the shifting lever. Remove the air lines, sheathing and O-rings from the lever.



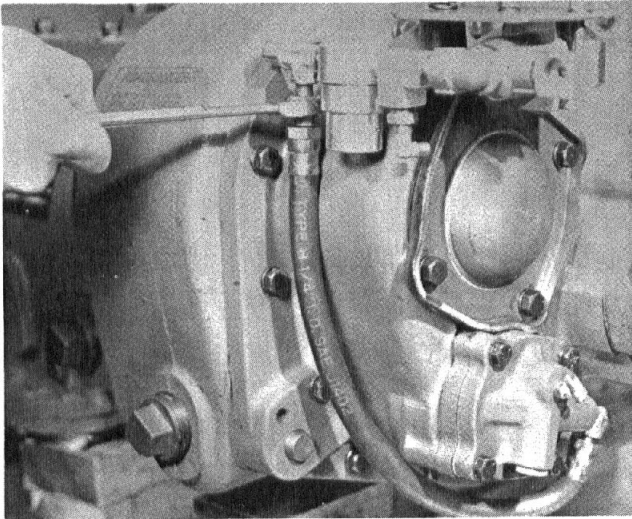
10. Remove the  $\frac{1}{4}$ " ID air line between the air valve and the direct range port of the auxiliary shift cylinder.



11. Remove the  $\frac{1}{4}$ " ID air line between the air valve and the low range port of the auxiliary shift cylinder.



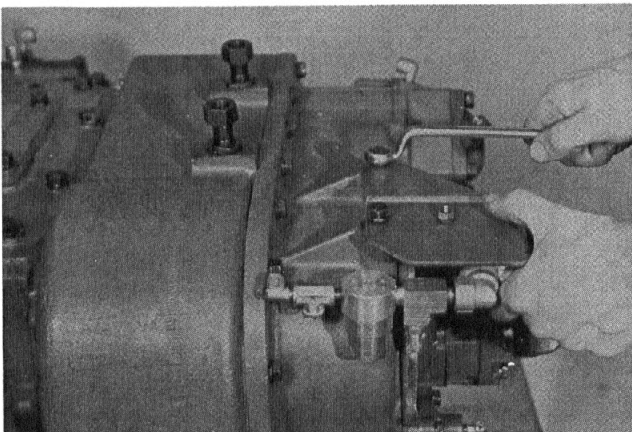
12. Remove the  $\frac{1}{4}$ " ID air line between the air valve and the air filter/regulator assembly. If so equipped, the hose-retaining clamp will have to be removed to allow removal of the air line.



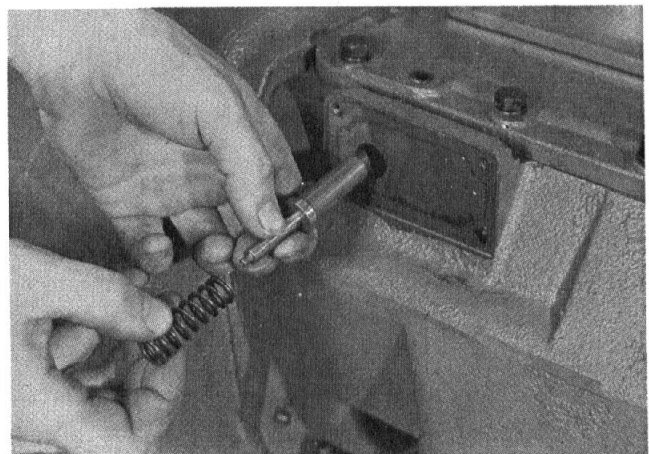
13. Remove the ¼" ID air line between the air filter/regulator assembly and the intermediate shift cylinder.



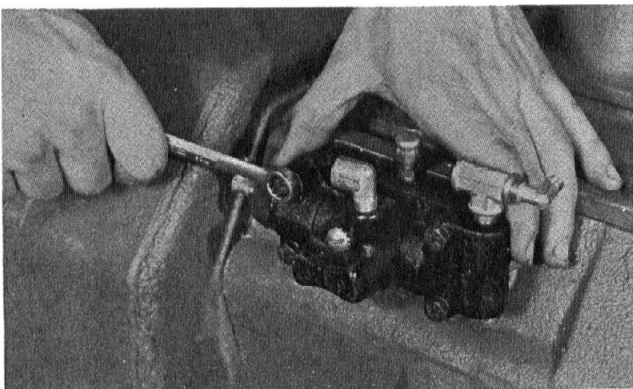
16. Remove the hat-type sleeve from the bore in the valve.



14. Turn out the two cap screws and remove the air filter/regulator assembly. For further disassembly of the unit, refer to page 85.

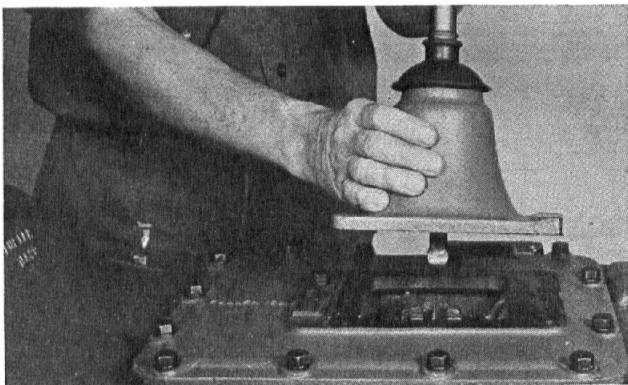
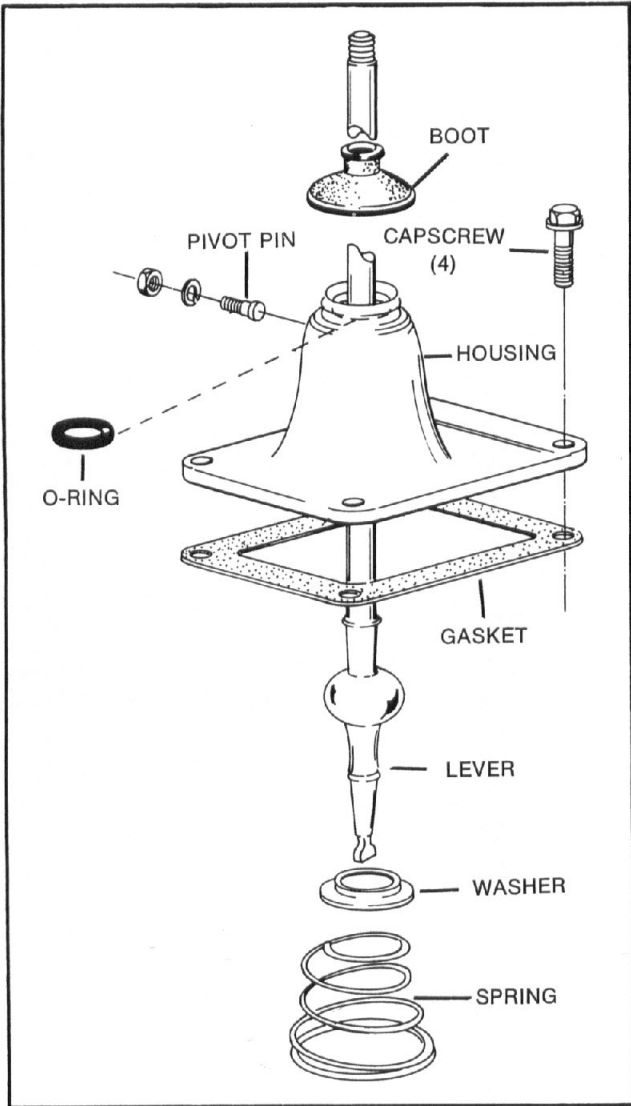


17. Remove the spring and plunger from the bore in the transmission.

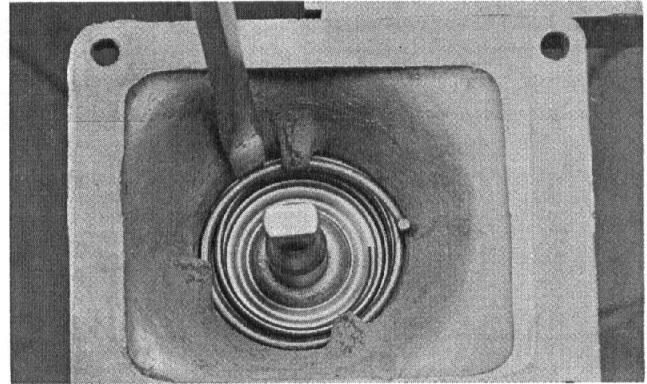


15. Turn out the four retaining cap screws and remove the slave air valve from the transmission. For further disassembly of the valve, refer to page 84.

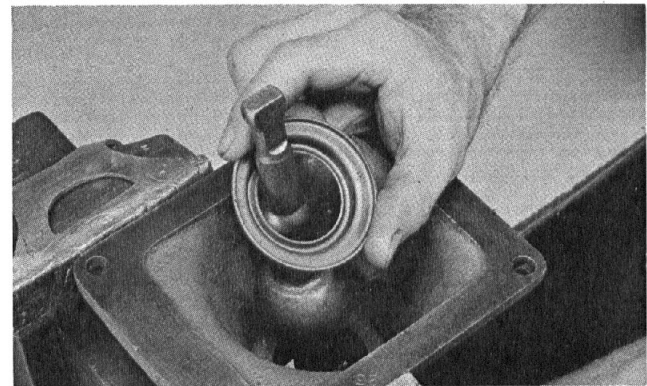
**B. Removal and Disassembly of the Gear Shift Lever Housing Assembly**



1. Turn out the four retaining capscrews, jar lightly to break the gasket seal, and lift the assembly from the shift bar housing.



2. Secure the assembly upside down in a vise and remove the tension spring by prying it up and over the spring retainers, one coil at a time.

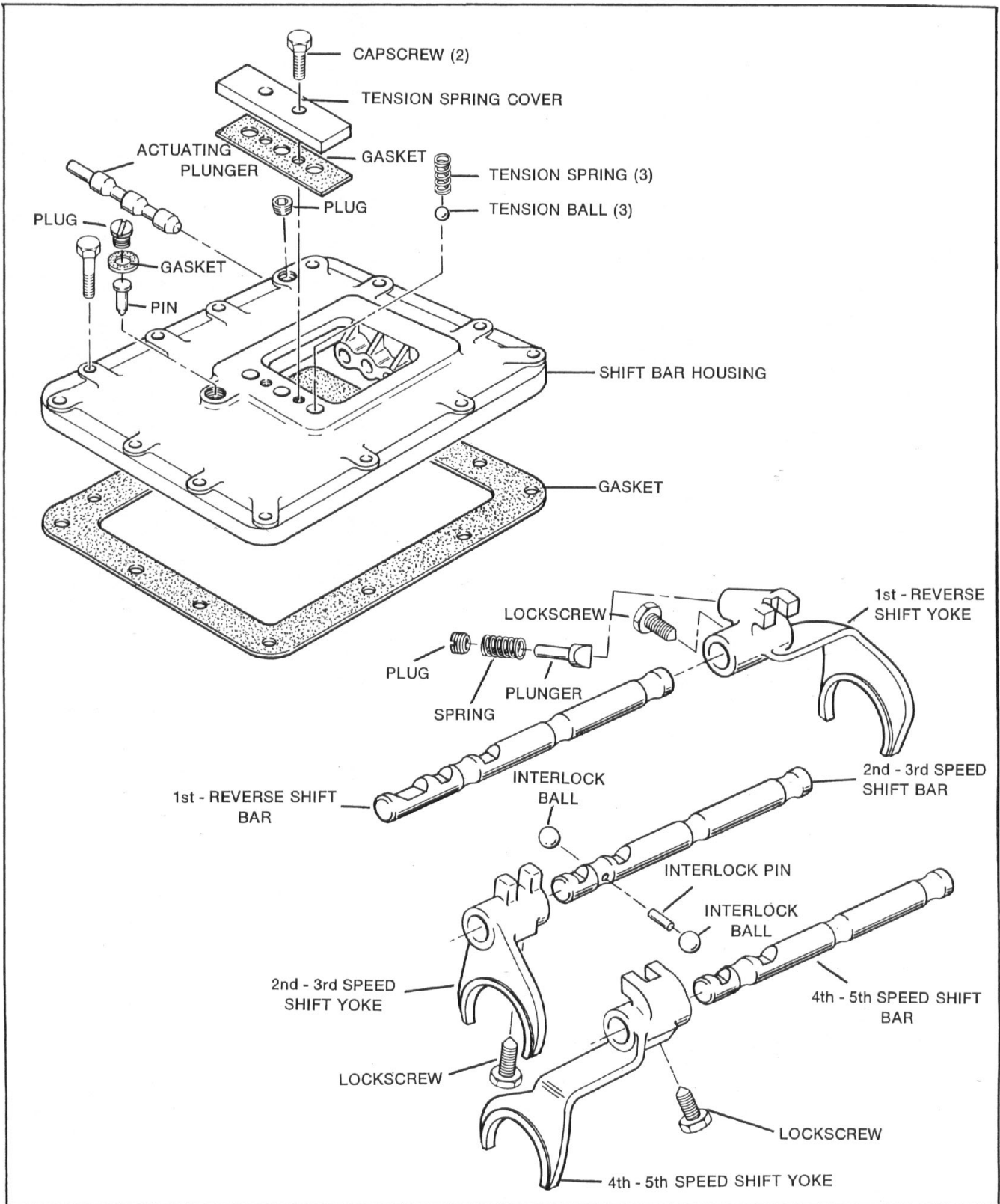


3. Remove the washer and lever from the housing.

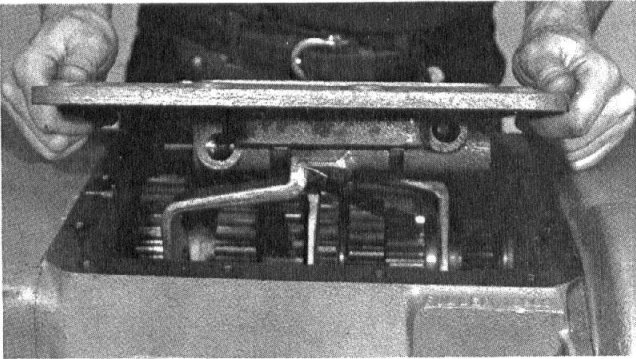


4. Remove the housing from the vise and, if necessary, remove the nut, washer, pivot pin, and O-Ring.

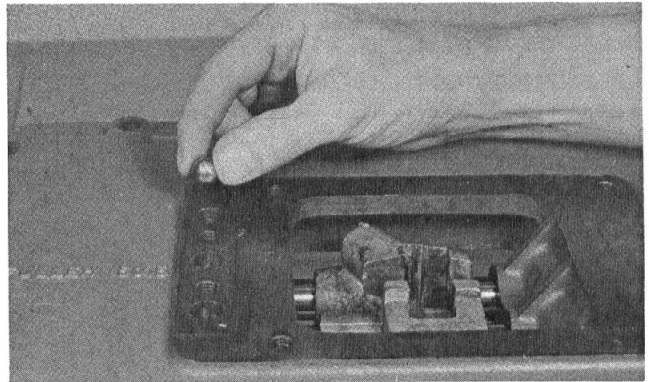
C. Removal and Disassembly of the Shift Bar Housing



## C. Removal and Disassembly of the Shift Bar Housing – Continued

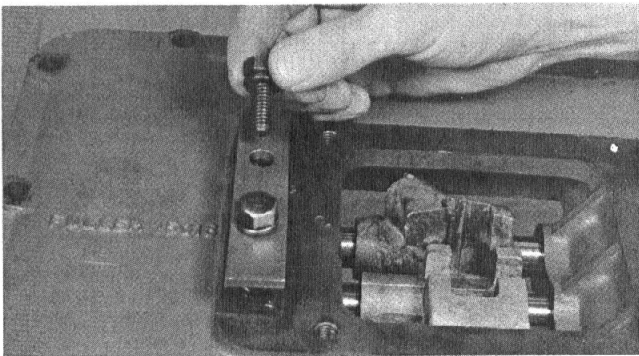


1. Turn out the 13 retaining capscrews, jar to break gasket seal, and remove the shift bar housing from the transmission.

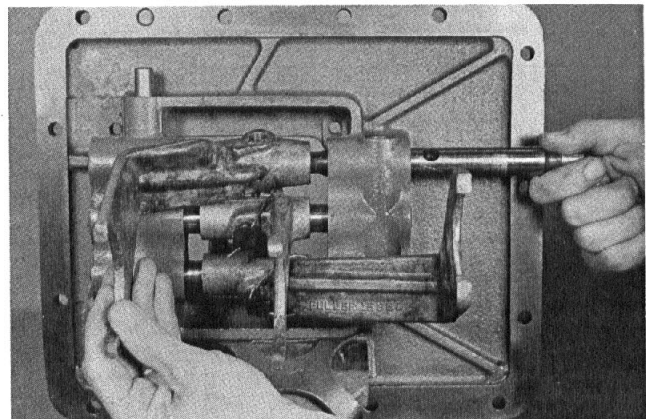


4. Remove the three tension balls located under the springs.

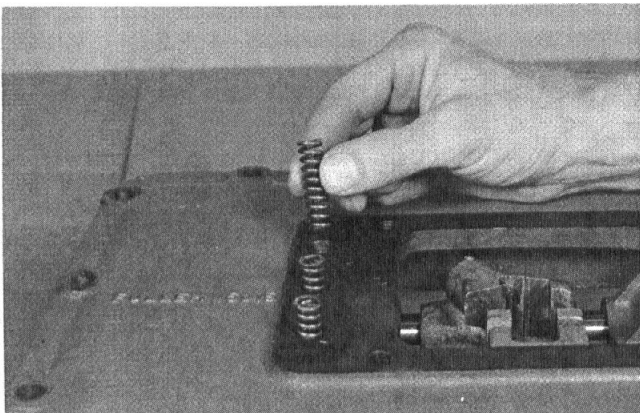
NOTE: For ease of reassembly, lay all parts on a clean bench in order of removal. Bars not being removed must be kept in the neutral position or interlock parts will lock the bars.



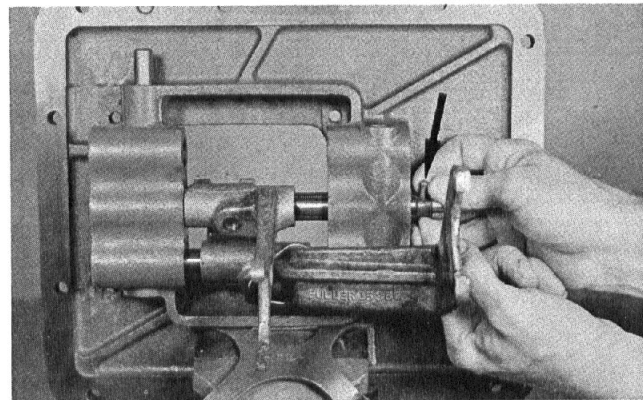
2. Turn out the two capscrews and remove the tension spring cover.



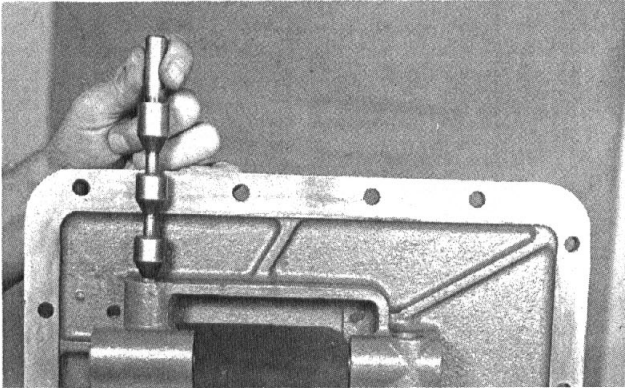
5. Place the shift bar housing in a vise, cut the lockwire, turn out the lockscrew and pull the 1st-reverse shift bar from the housing, removing the yoke.



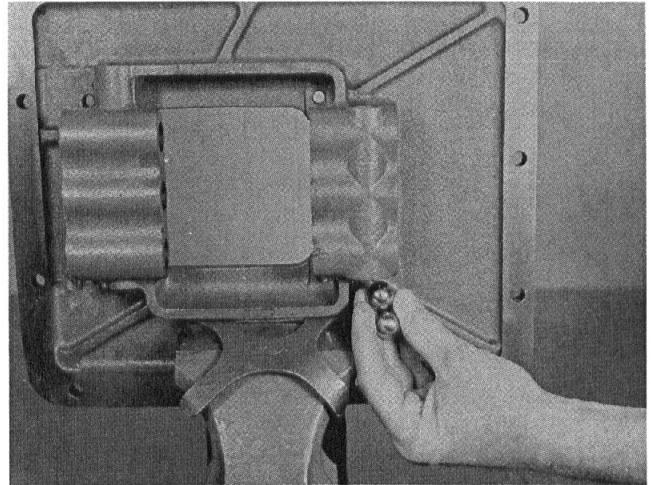
3. Remove the three tension springs.



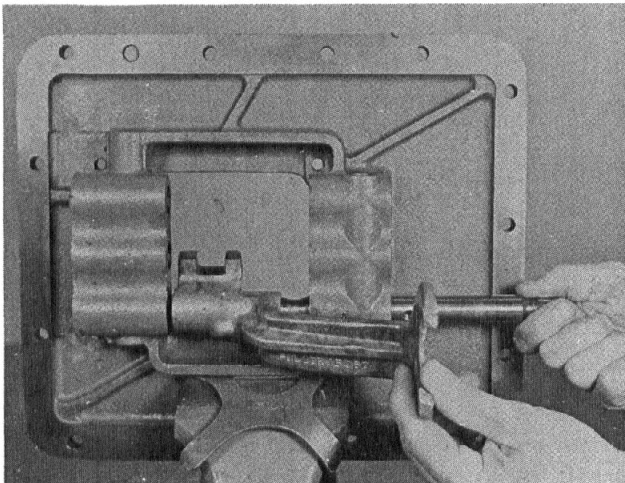
6. Cut the lockwire, turn out the lockscrew and pull the 2nd-3rd speed shift bar from the housing, removing the interlock pin from the neutral notch; remove yoke.



7. Remove the actuating plunger from the housing.



9. Remove the two interlock balls from the web of the housing.

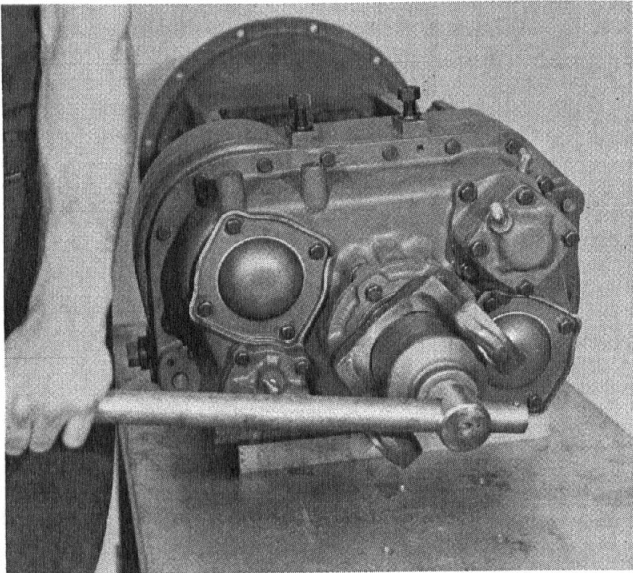


8. Cut the lockwire, turn out the lockscrew and pull the 4th-5th speed bar from the housing, removing the yoke.

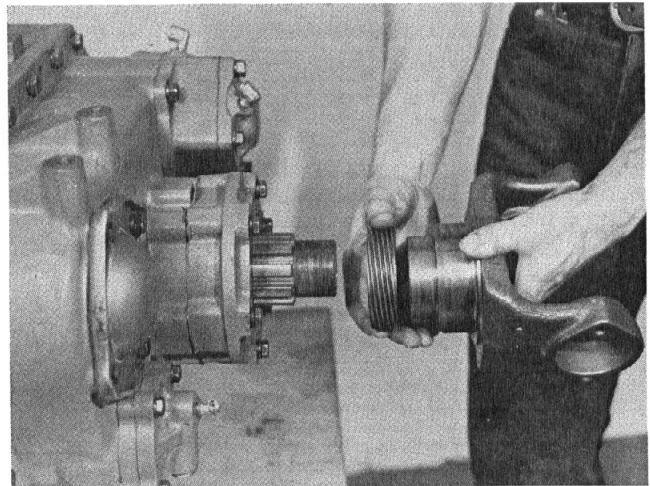


## II. COMPANION FLANGE AND CLUTCH HOUSING

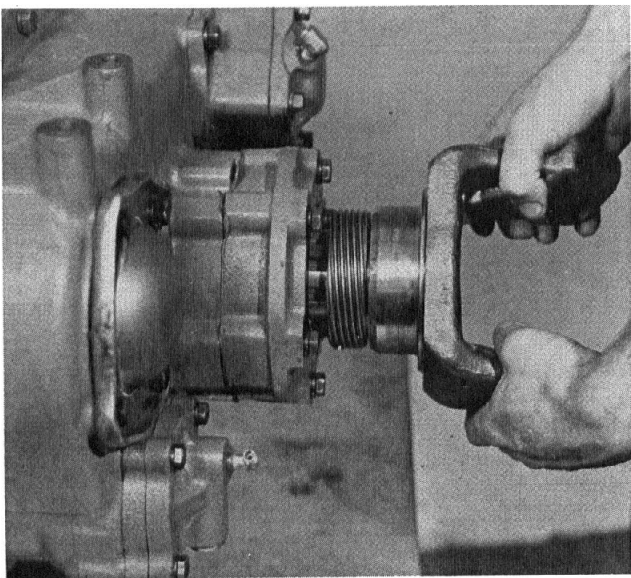
### A. Removal of the Companion Flange



1. Lock the transmission in two speeds and turn the nut from the tailshaft.

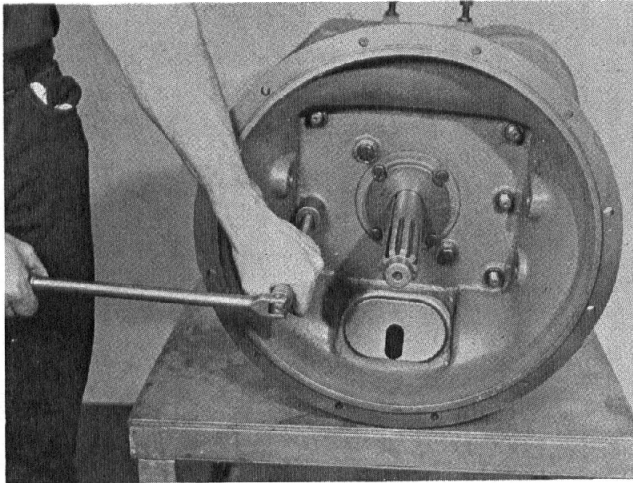


3. Remove the speedometer drive gear or replacement spacer from the companion flange or yoke.

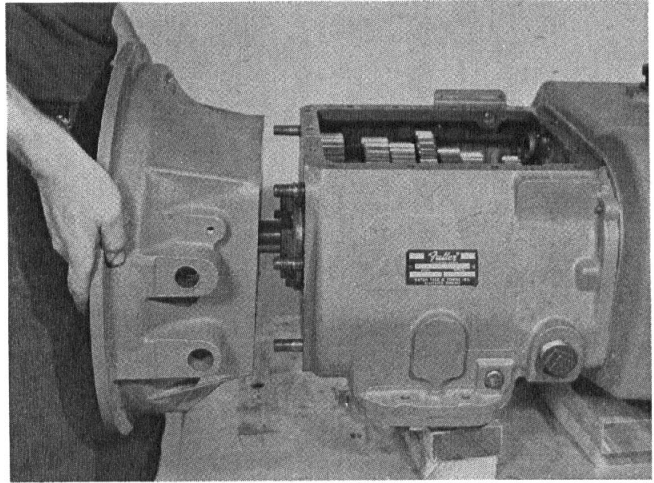


2. Pull the companion flange or yoke from the splines of the tailshaft.

**B. Removal of the Clutch Housing**

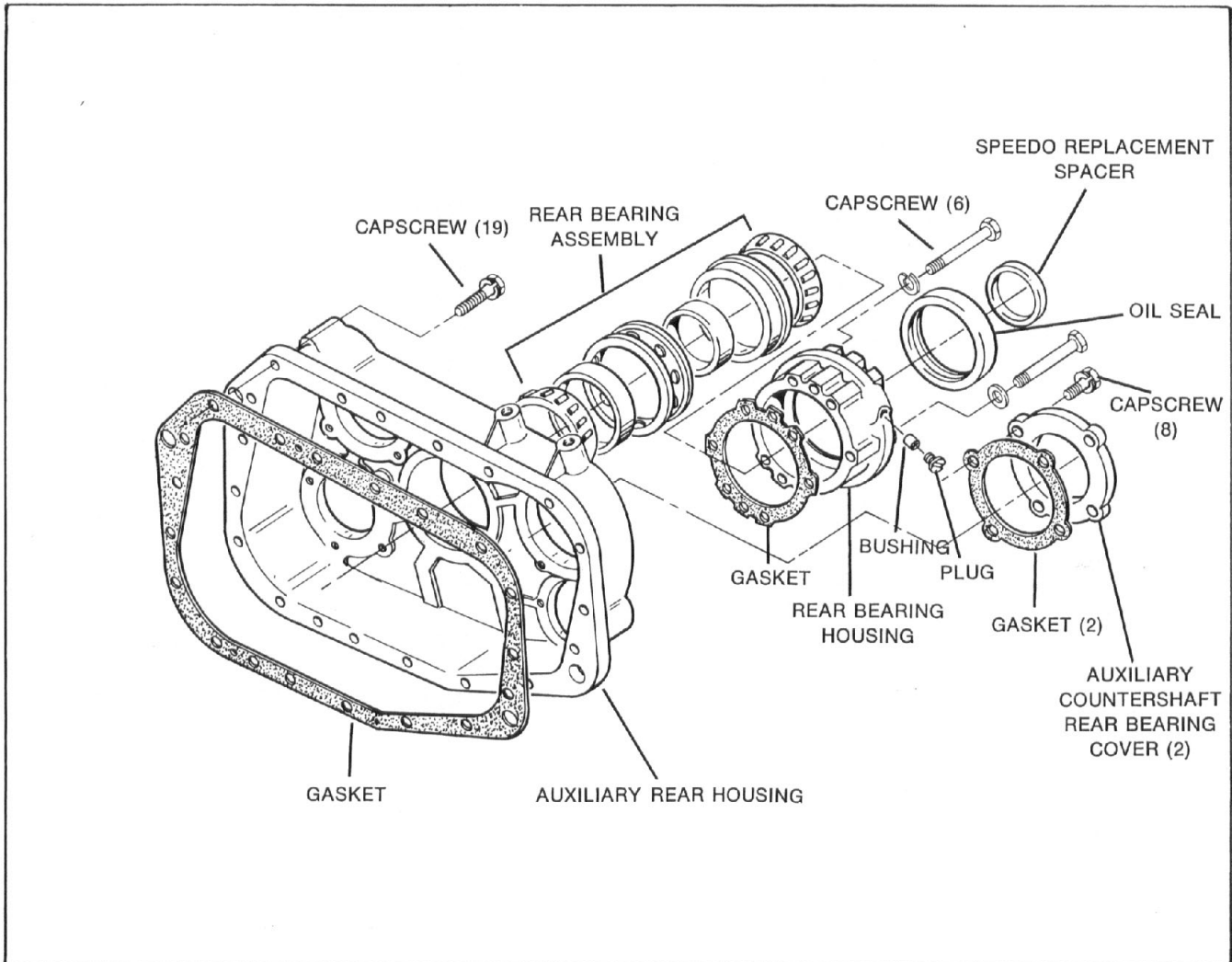


1. Remove the clutch release mechanism or upshift clutch brake assembly and turn out the six nuts and two bolts which attach the clutch housing to the case.

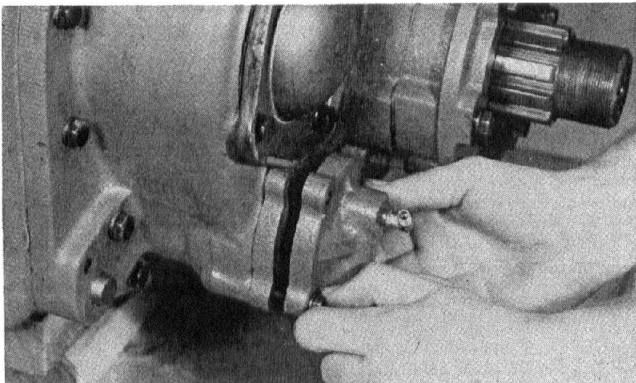


2. Jar the housing to break the gasket seal and pull from the studs and transmission case.

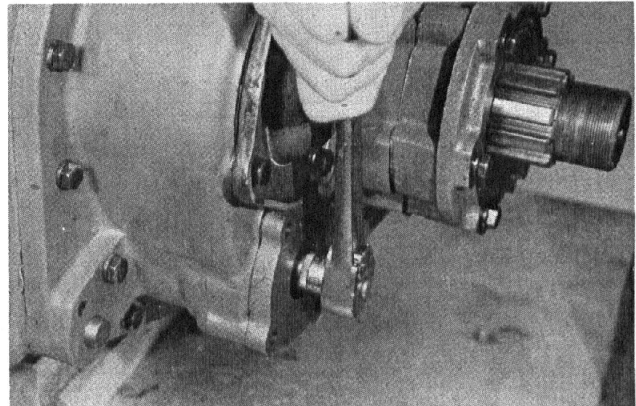
### III. AUXILIARY REAR HOUSING ASSEMBLY



#### A. Removal of the Rear Housing Assembly

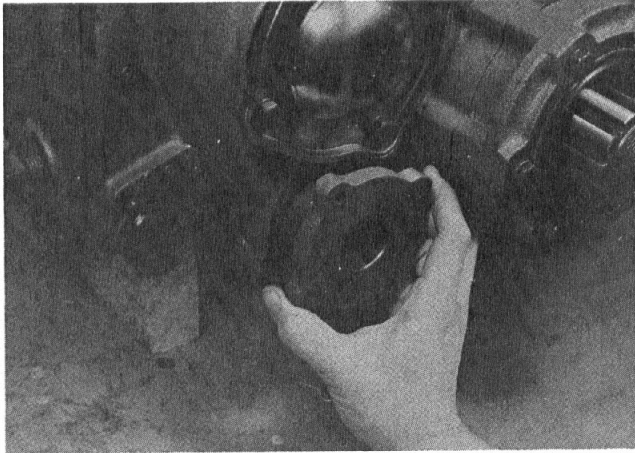


1. Turn out the four cap screws and remove the cover from the intermediate shift cylinder.

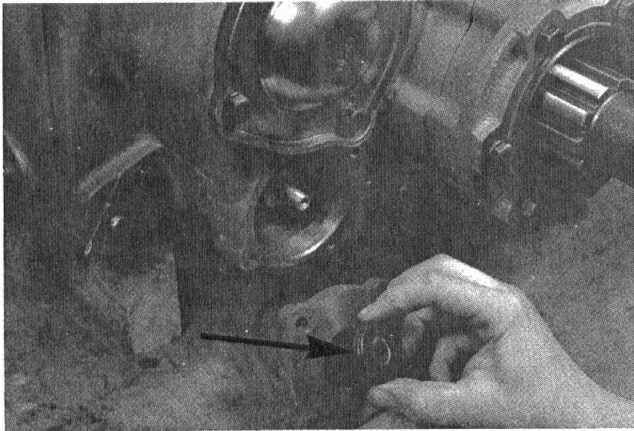


2. Remove the locknut from the shaft in the cylinder.

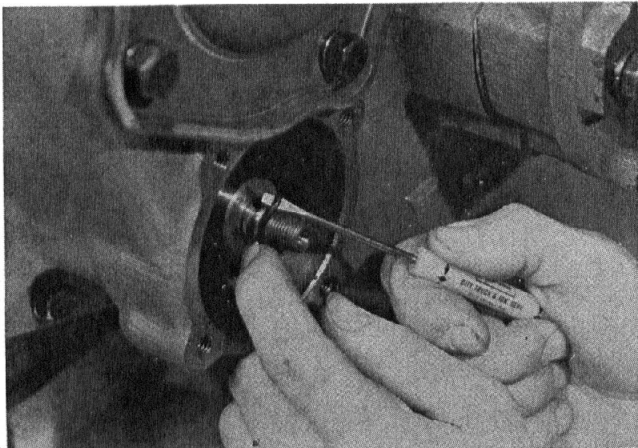
## DISASSEMBLY – AUXILIARY REAR HOUSING



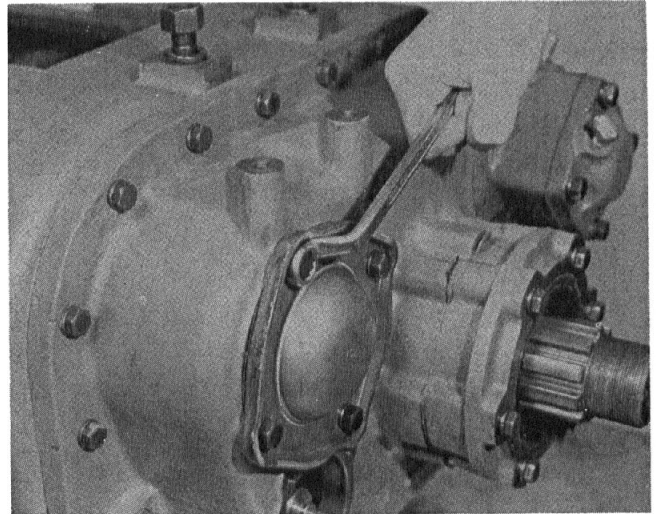
3. Pull evenly to the rear and remove the cylinder housing from the bore in the auxiliary housing.



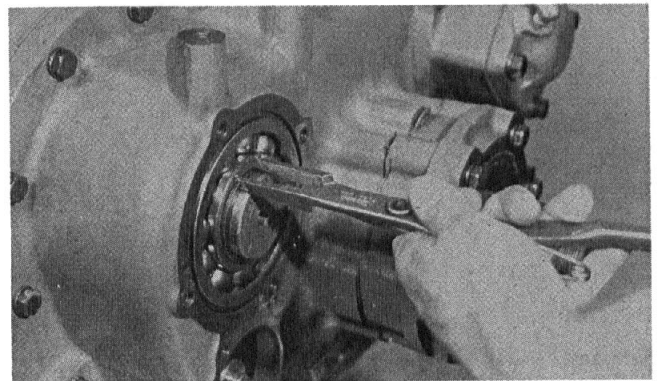
4. Remove the piston from the cylinder housing and, if necessary, remove the O-ring from the outer diameter of the piston.



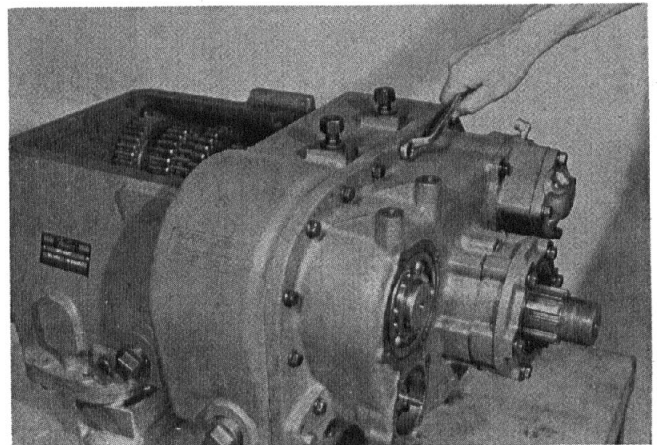
5. If necessary, remove the O-rings from the bore in the cylinder housing and the shaft.



6. Turn out the capscrews and remove the two rear counter shaft bearing covers.

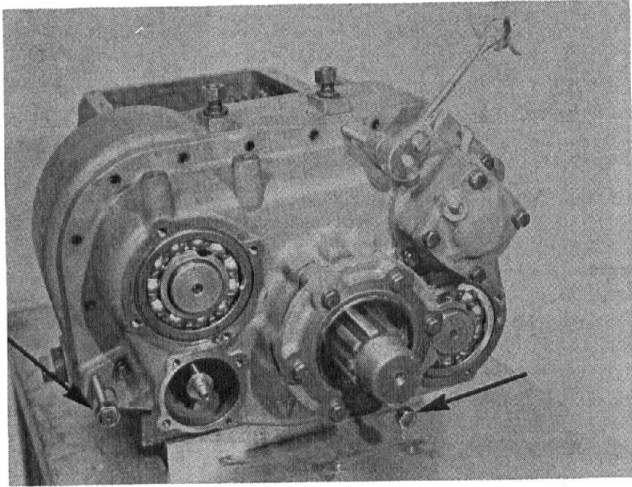


7. Remove the snap ring from the rear of both counter shafts.

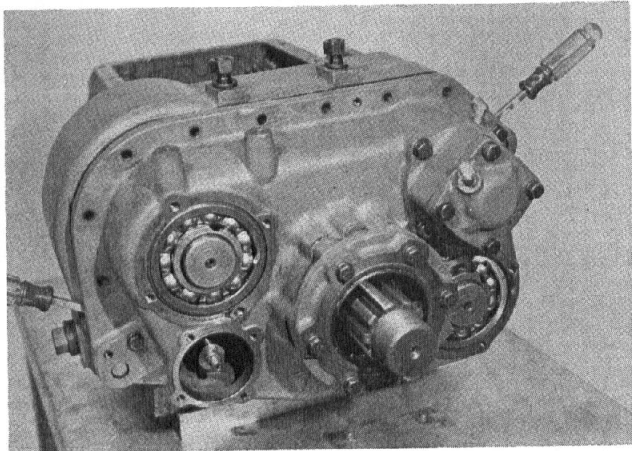


8. Turn out the 19 capscrews which attach the rear housing to the intermediate case. Re-insert one capscrew near both dowel pin locations and turn in just far enough to catch two or three threads.

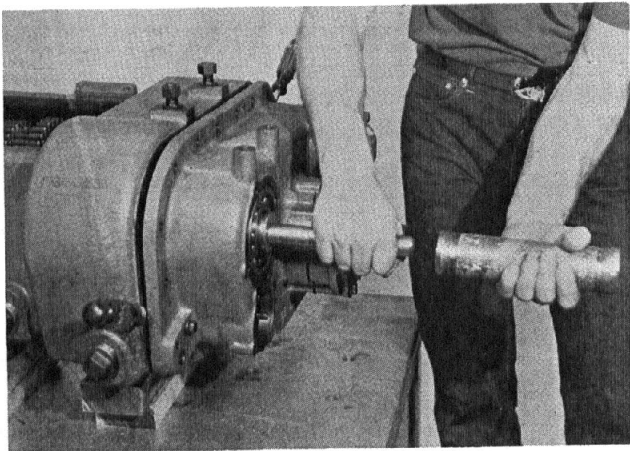
## A. Removal of the Rear Housing Assembly – Continued



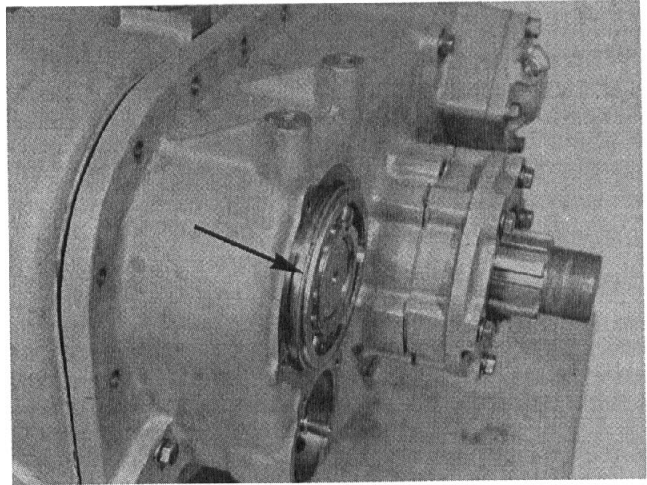
9. Insert three puller screws and move the rear housing approximately  $\frac{1}{4}$ " to the rear.



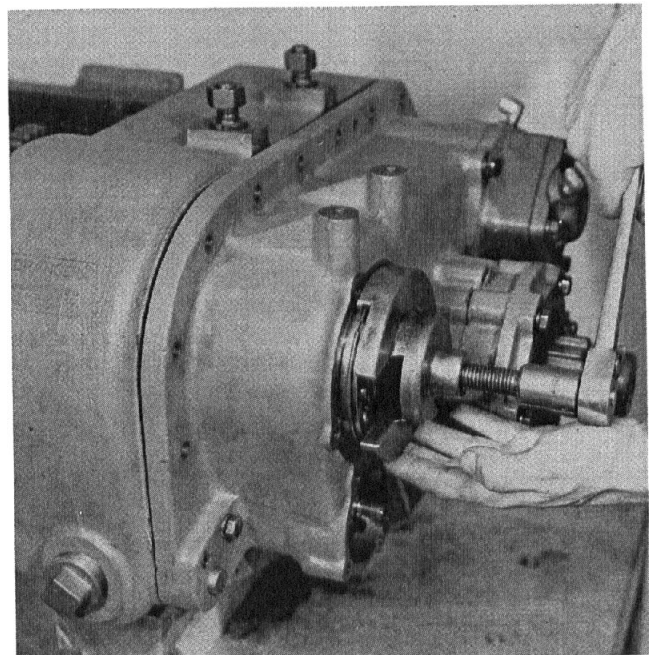
10. Insert flat stock, such as flat-bladed screwdrivers, between the auxiliary and intermediate housings.



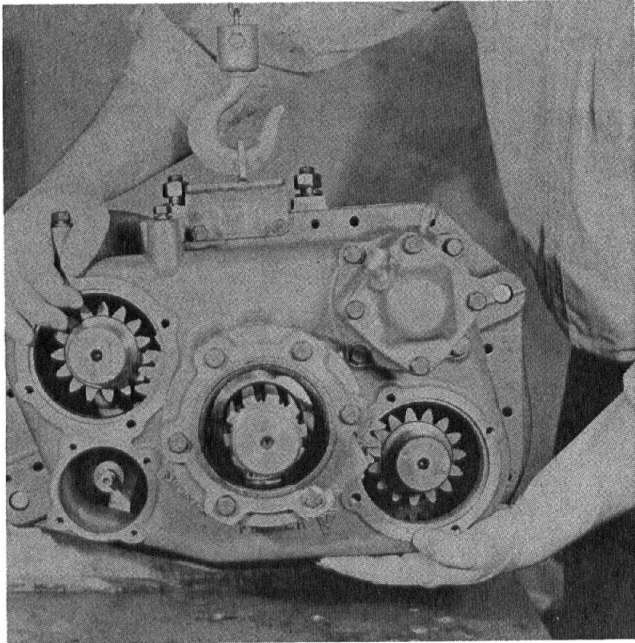
11. Use a soft bar and mallet against the rear of both countershafts to move them as far forward as possible. This will move the bearings to the rear on the shafts.



12. Remove the flat stock and puller screws. Move the rear housing to its original position against the intermediate housing by turning in evenly the two remaining cap screws. This will expose the two rear bearing snap rings.

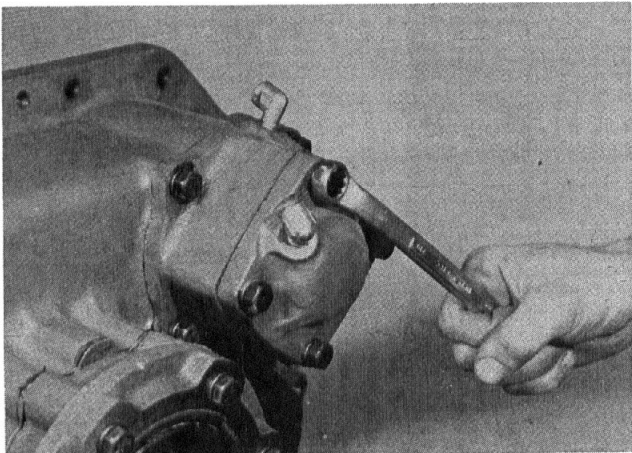
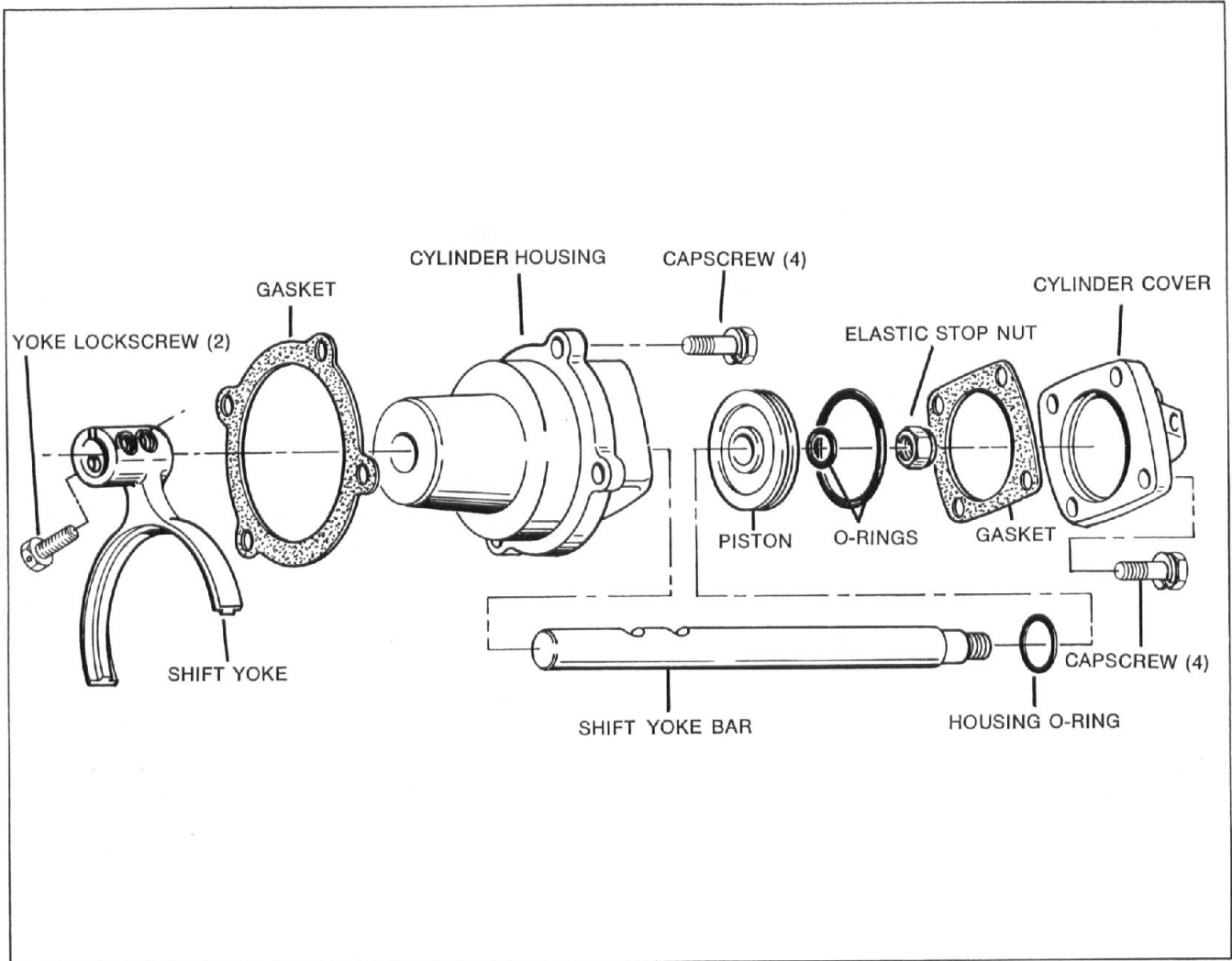


13. Attach a bearing puller to each snap ring and remove both rear bearings from the countershafts.

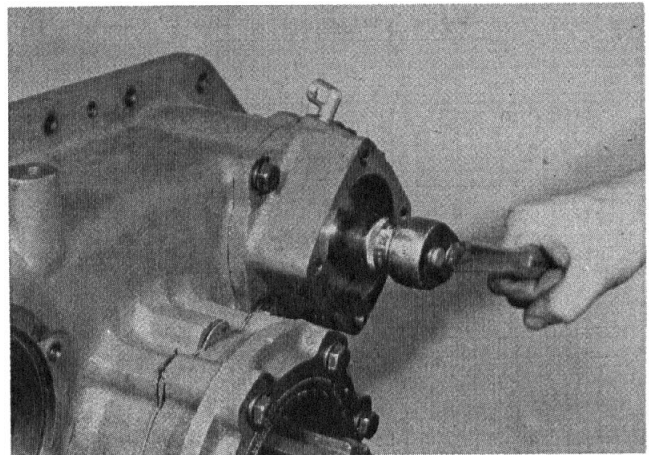


14. Remove the two remaining capscrews. Attach a chain hoist to the rear housing and move the assembly straight to the rear and away from the intermediate housing, taking care not to damage the oil trough located at the top rear of the intermediate housing. Mount the assembly in a vise in the upright position.

**B. Removal and Disassembly of the Auxiliary Shift Cylinder**

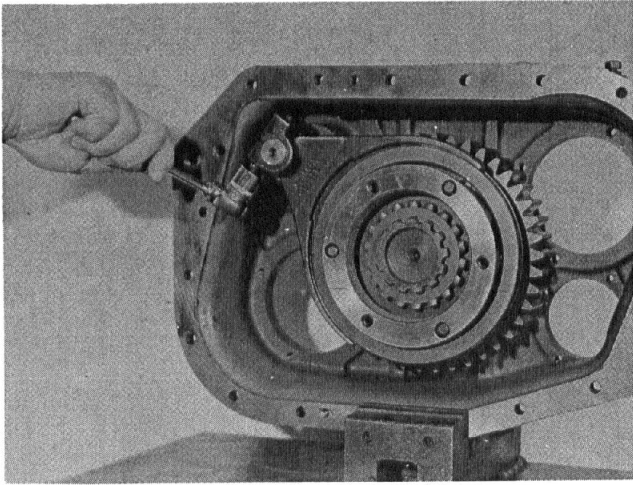


1. Turn out the four cap screws and remove the cover from the shift cylinder.

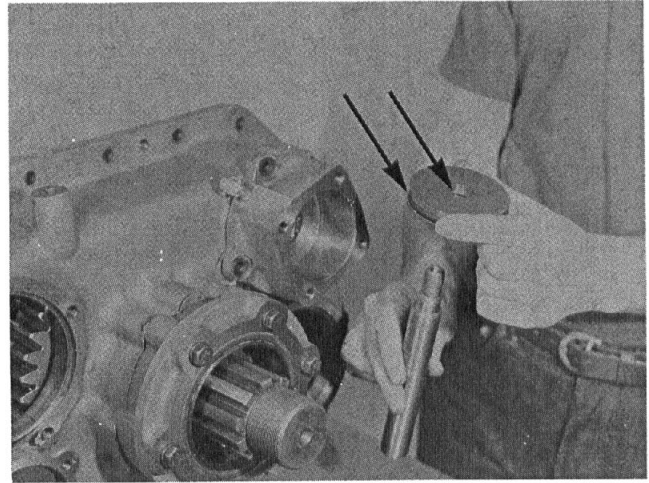


2. Remove the locknut from the shifting shaft in the cylinder.

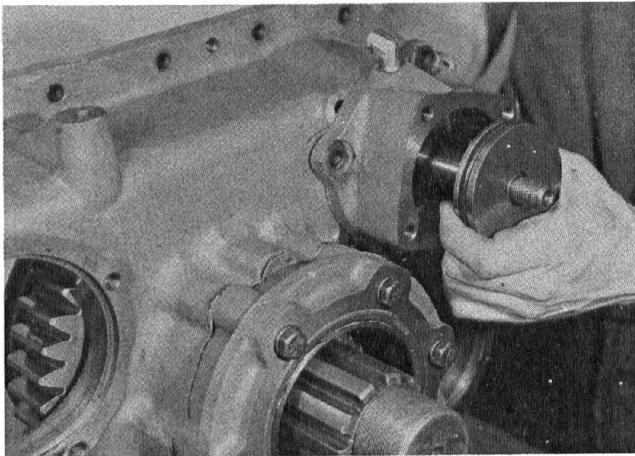
## DISASSEMBLY – AUXILIARY REAR HOUSING



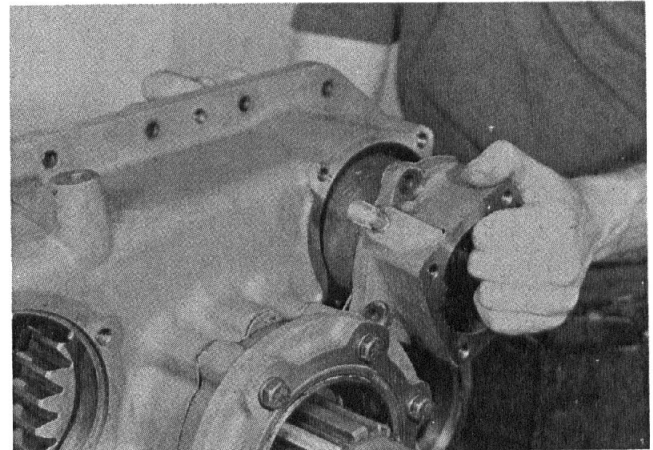
3. Cut the lockwire and turn out the two yoke lockscrews.



5. Remove the piston from the shaft and remove the O-rings on the inner and outer diameters of the piston.



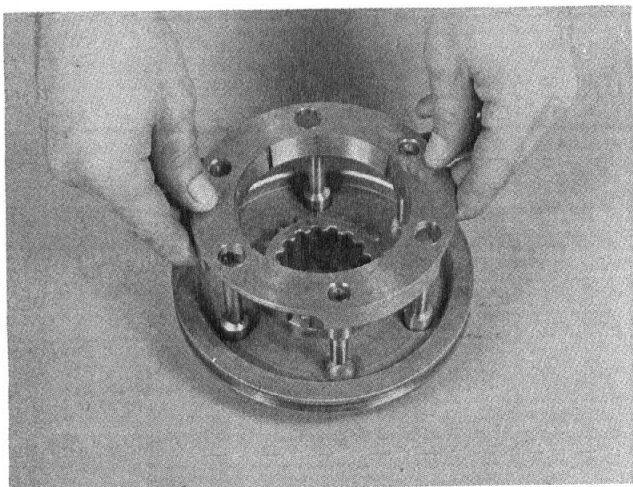
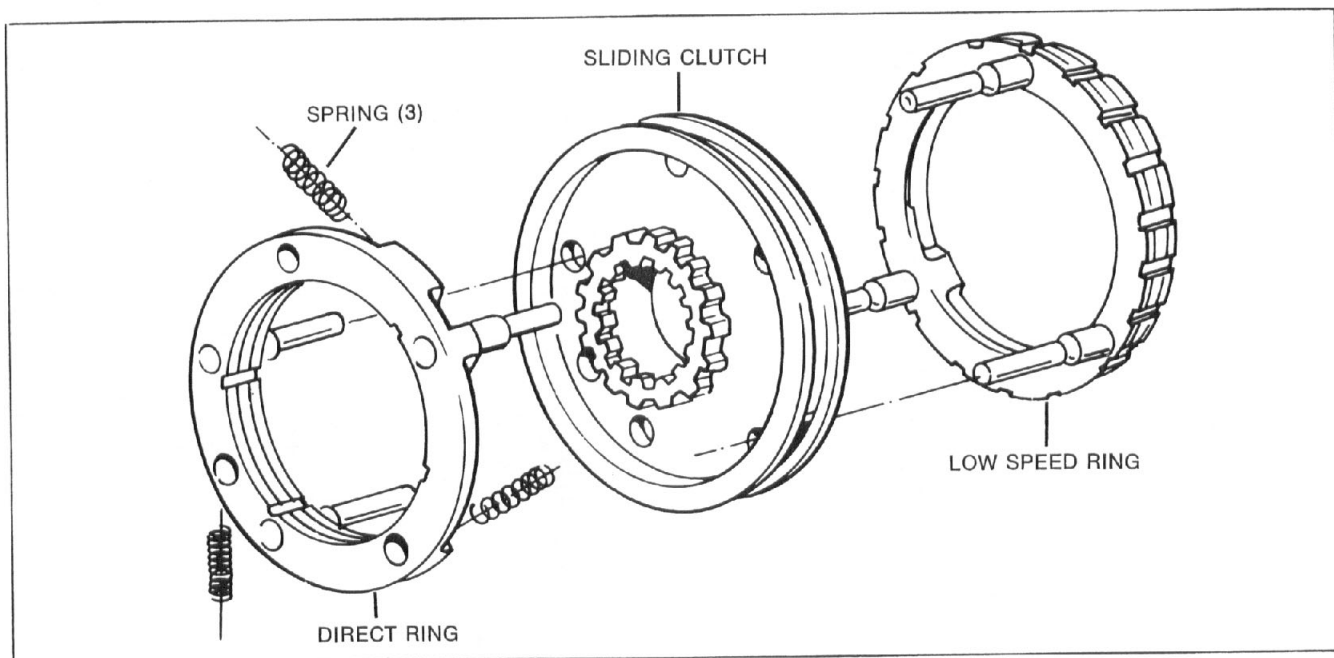
4. Push the shifting shaft and piston to the rear and remove from the cylinder housing. At the same time remove shifting yoke from sliding clutch gear.



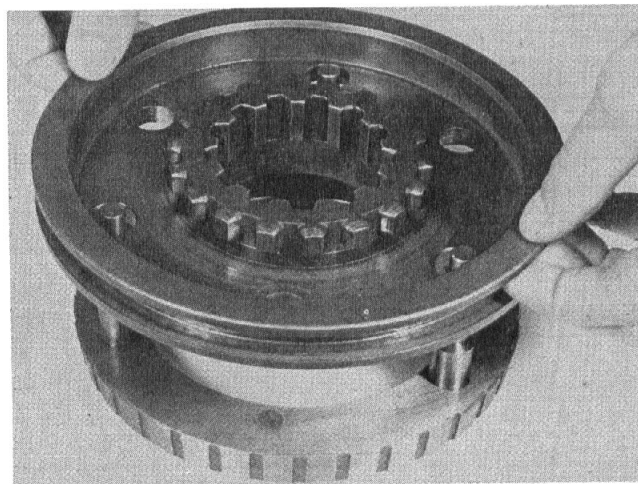
6. Turn out the four capscrews and remove the cylinder housing from the bore in the auxiliary rear housing. Remove the O-ring from the bore in the cylinder housing. Remove synchronizer assembly from splines of tailshaft.



## C. Disassembly of the Synchronizer Assembly

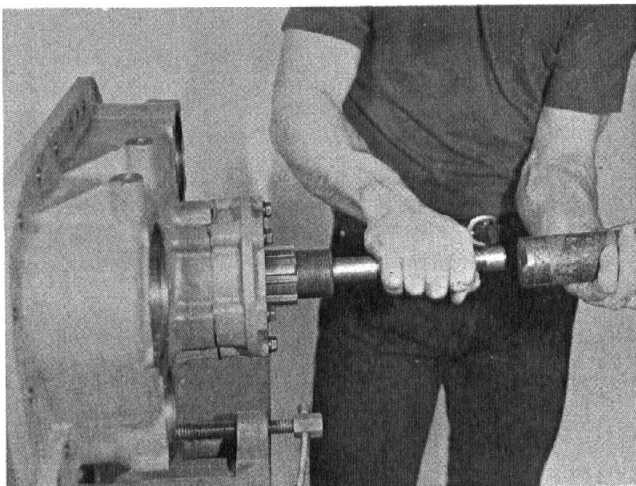
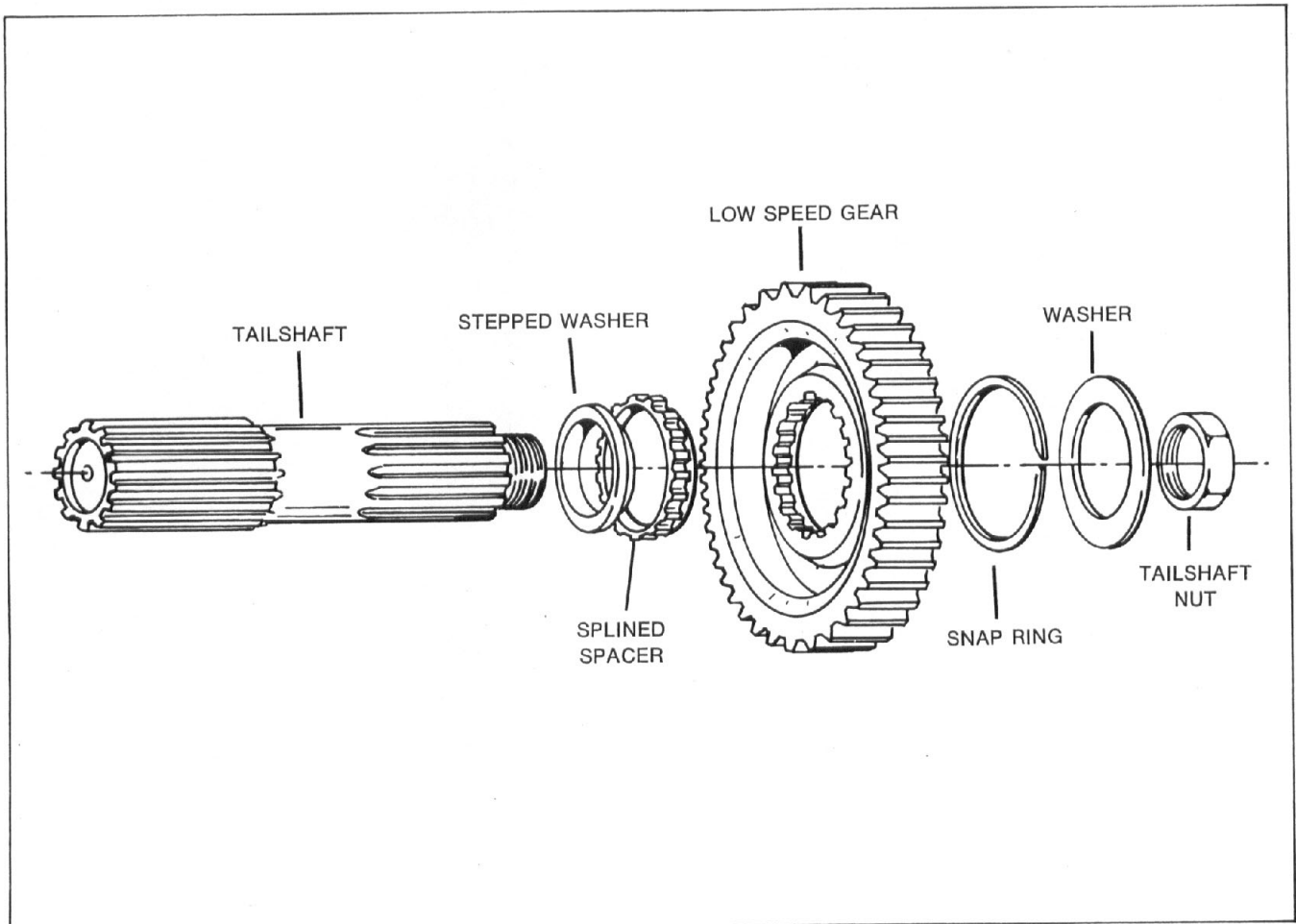


1. Pull the direct synchronizer from the blocker pins of the low speed synchronizer. Place a cloth over rings during removal as the three springs in the direct ring will be released at the pin locations.

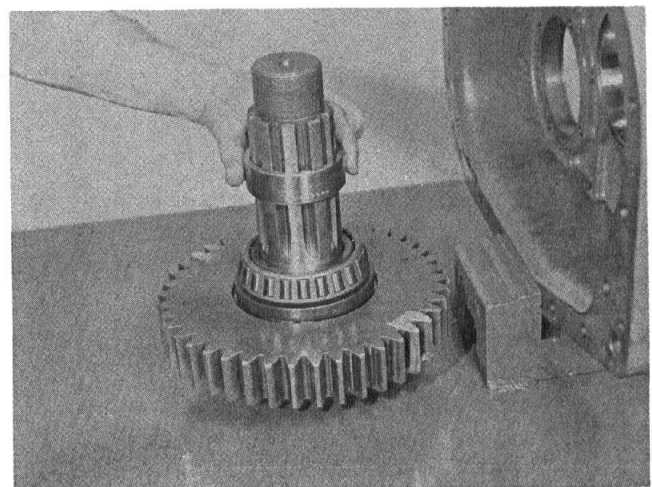


2. Remove the sliding clutch from the low speed synchronizer.

D. Removal and Disassembly of the Tailshaft and Low Speed Gear Assembly

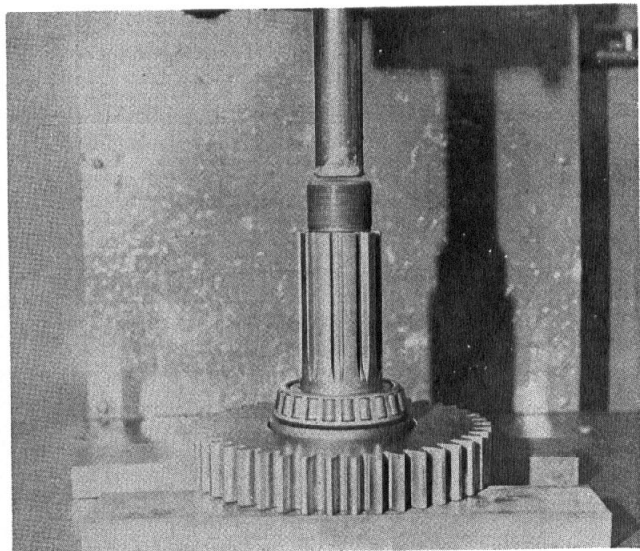


1. Use a soft bar and mallet against the rear of the tailshaft to move the assembly forward and from the rear bearing.

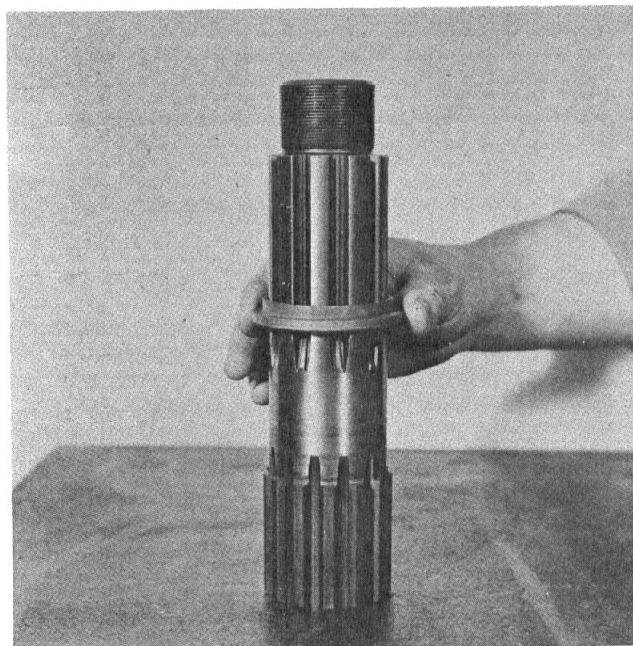


2. Remove the bearing inner sleeve from the shaft.

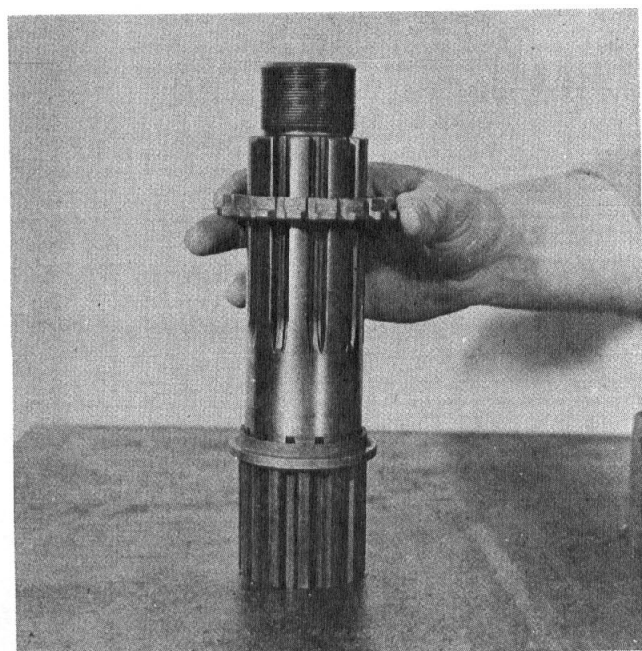
**D. Removal and Disassembly of the Tailshaft and Low Speed Gear Assembly – Continued**



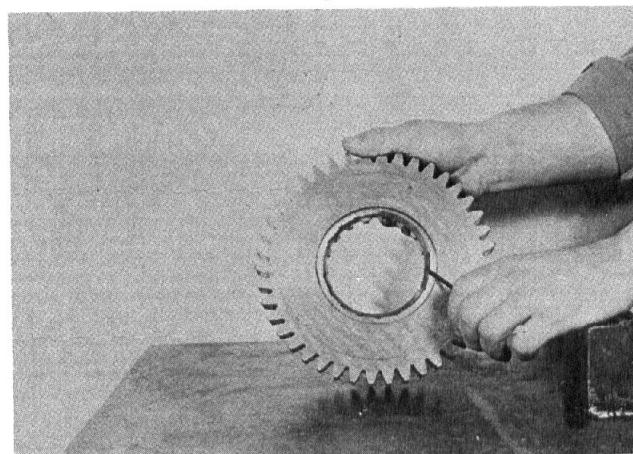
3. Use the low speed gear as a base to press the bearing from the shaft and to free the gear and rear washer.



5. Remove the stepped washer from the shaft.

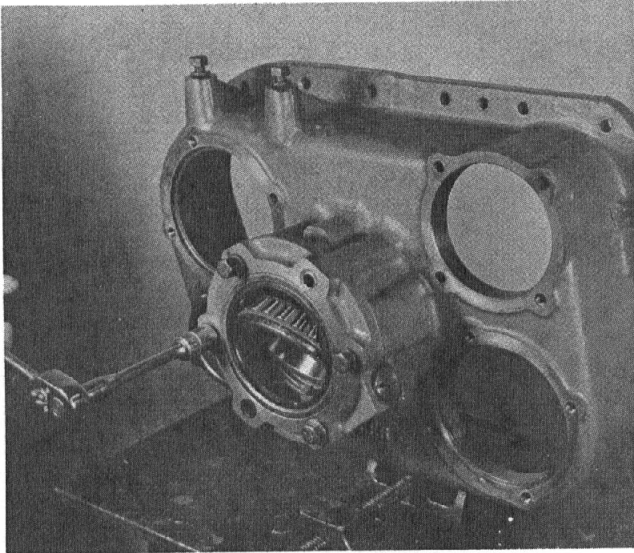


4. Remove the splined washer from the shaft.

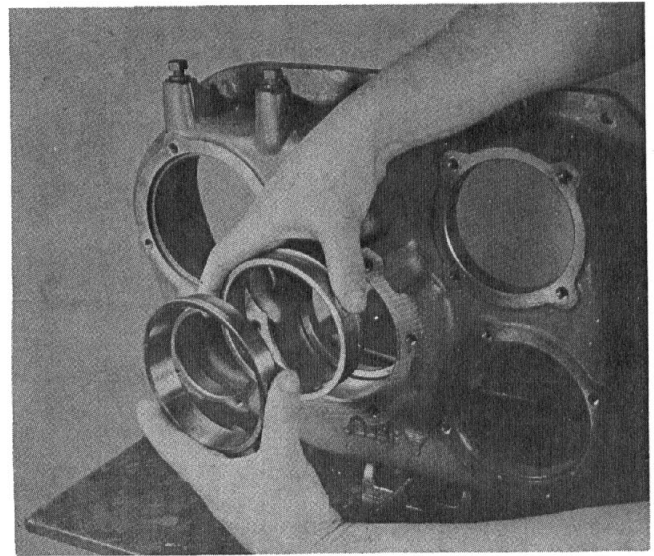


6. If necessary, remove the snap ring from the inner diameter of the low speed gear.

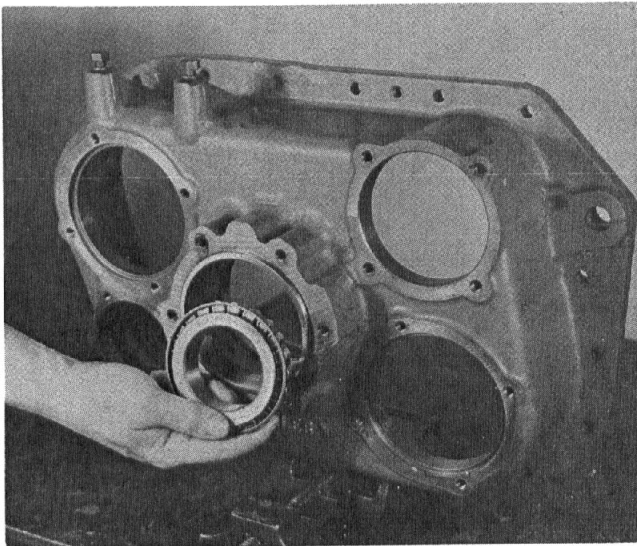
## DISASSEMBLY – AUXILIARY REAR HOUSING



7. Turn out the cap screws and remove the rear bearing cover. If necessary, remove the oil seal from the cover.

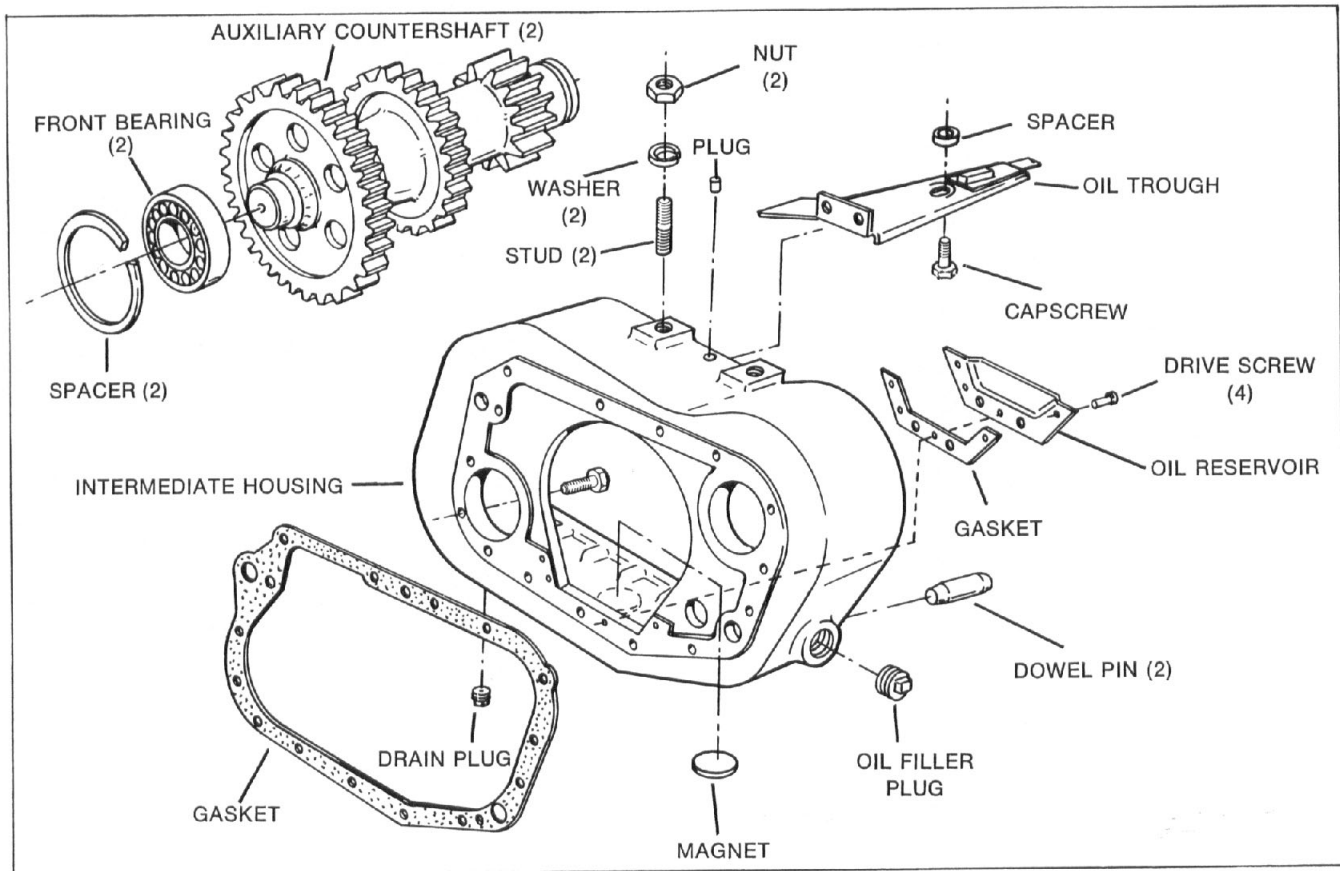


9. Remove the two bearing cups and outer spacer from the housing bore.

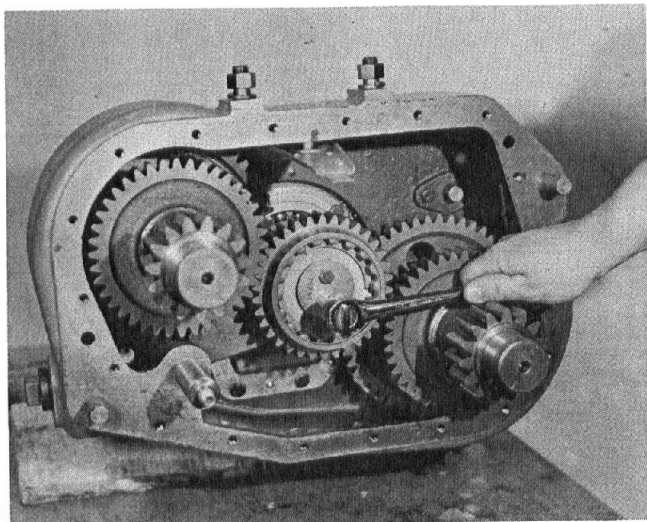


8. Remove the bearing rear cone.

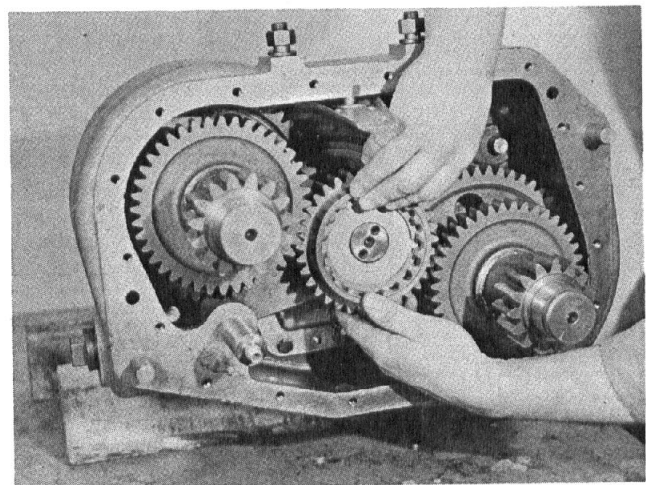
## IV. AUXILIARY INTERMEDIATE HOUSING



### A. Removal and Disassembly of the Intermediate Housing and Gearing

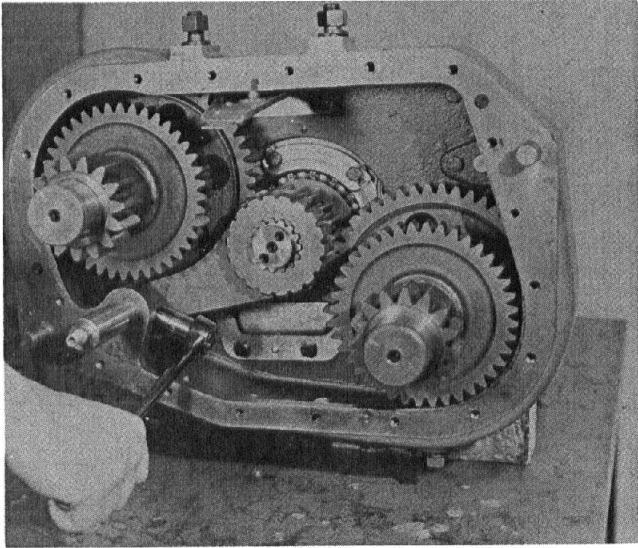


1. Cut the lockwire, turn out the two cap screws and remove the plate from the rear of the mainshaft.

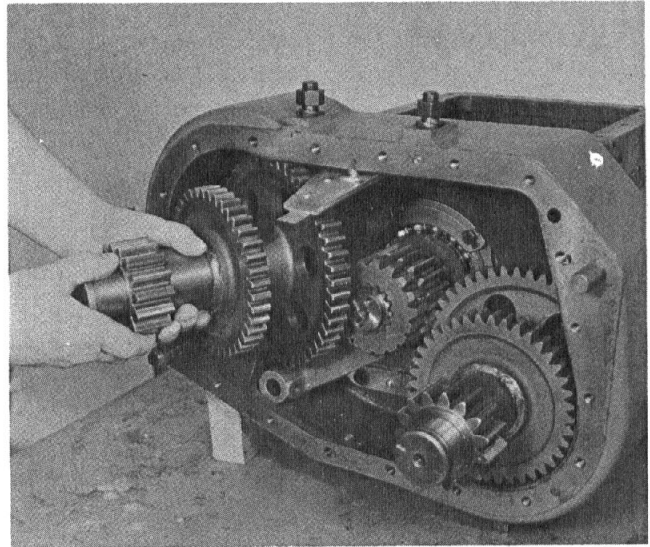


2. Remove the intermediate drive gear from the shaft and if necessary, remove the two snap rings and plate from the inner diameter of the intermediate drive gear.

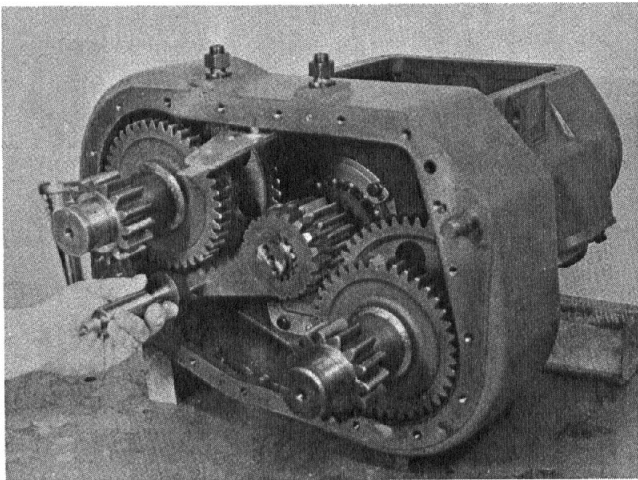
## DISASSEMBLY – AUXILIARY INTERMEDIATE HOUSING



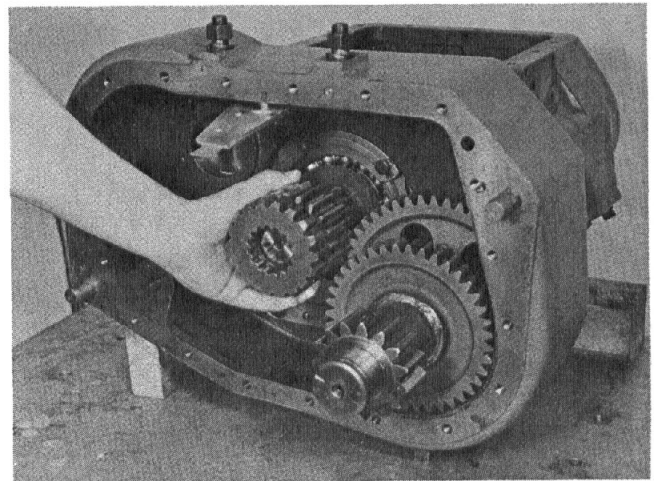
3. Cut the lockwire and turn out the lock screw from the intermediate shift yoke.



5. Remove the left countershaft from the housing, using caution to avoid damage to the oil trough.

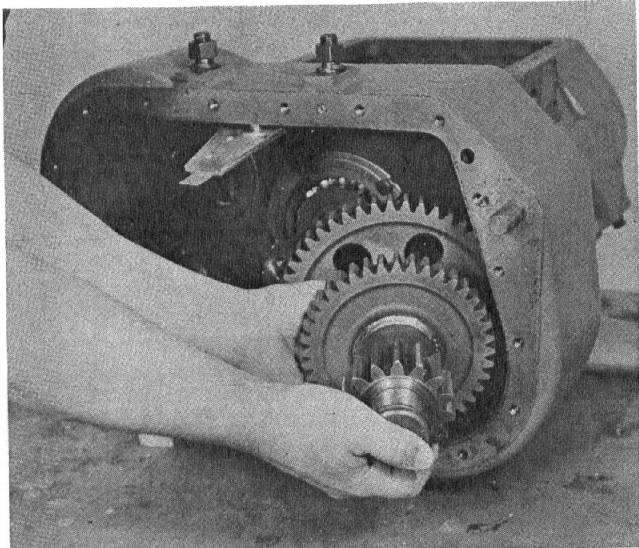


4. Remove the intermediate shift shaft from the housing.

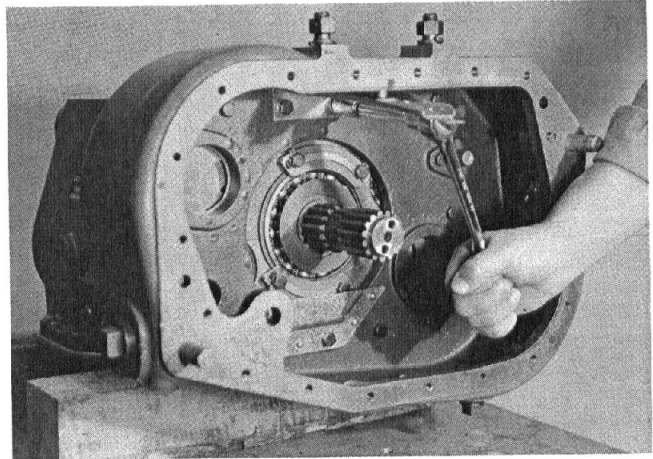


6. Remove the shift yoke and pull the auxiliary drive gear and sliding clutch assembly from the splines of the main shaft. Both sections must align with the splines for removal.

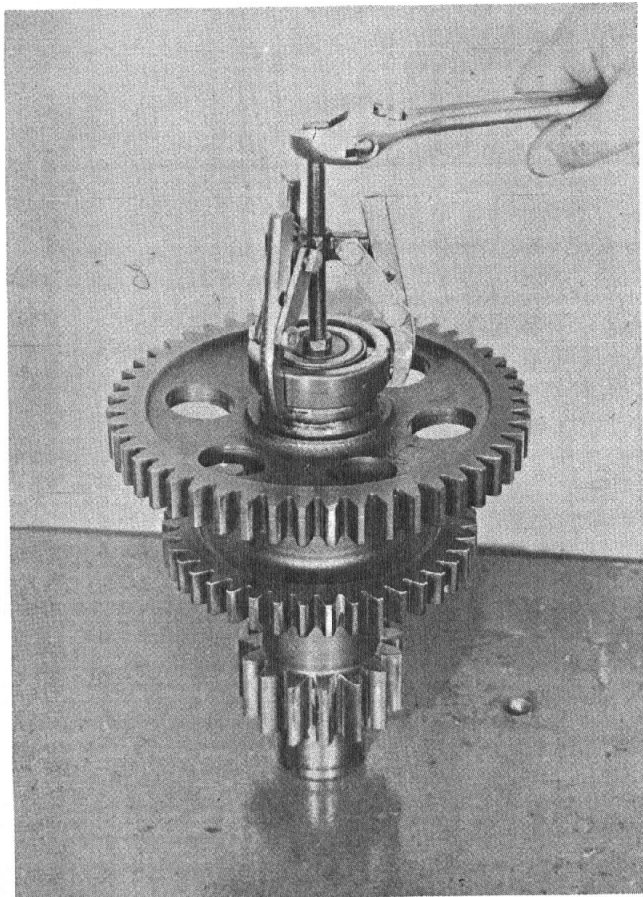
**A. Removal and Disassembly of the Intermediate Housing and Gearing – Continued**



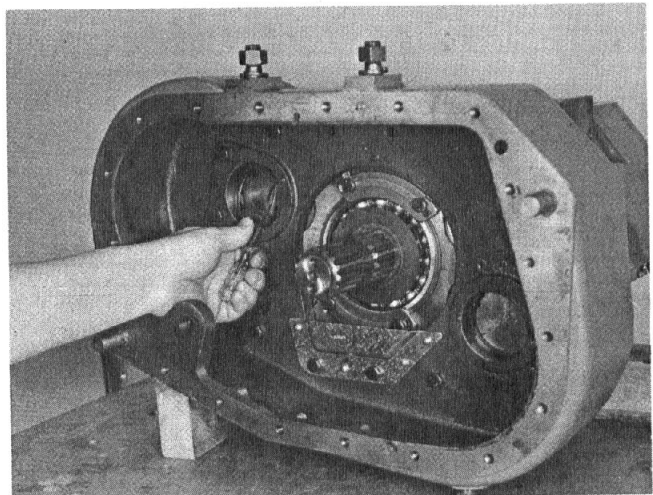
7. Pull the right auxiliary countershaft from the intermediate case.



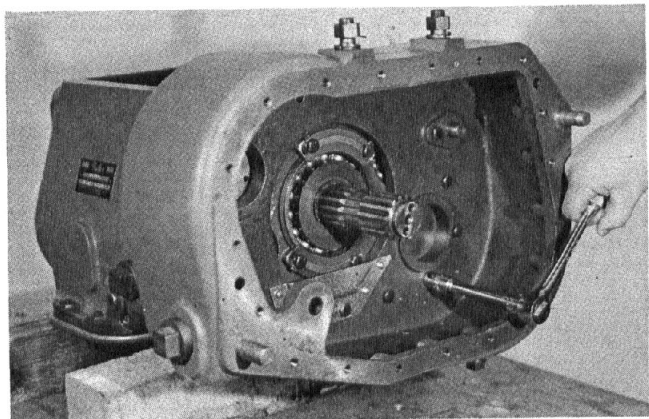
9. Turn out the three cap screws and remove the oil trough from the intermediate housing.



8. Pull the front bearings from the countershafts if necessary.

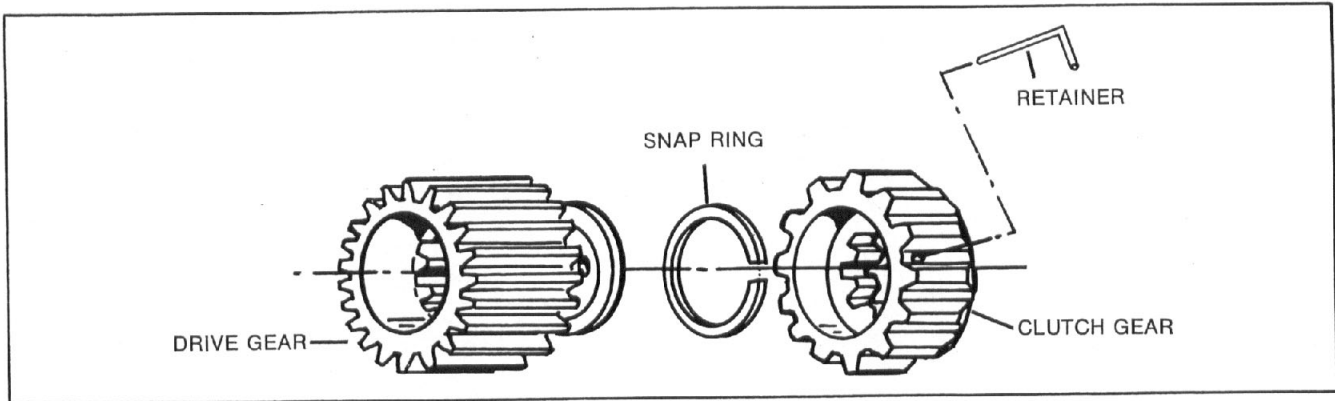


10. Remove the snap ring spacers from the front countershaft bearing bores.

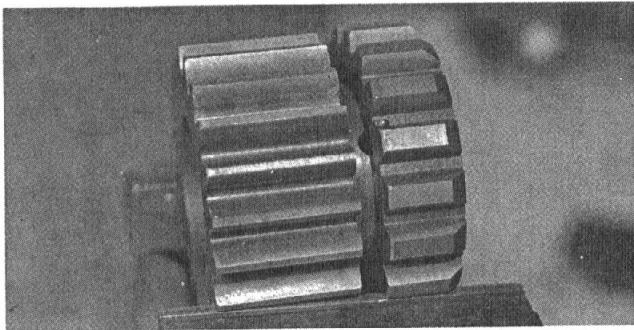


11. Turn out the 13 remaining cap screws and remove the intermediate housing from the transmission.

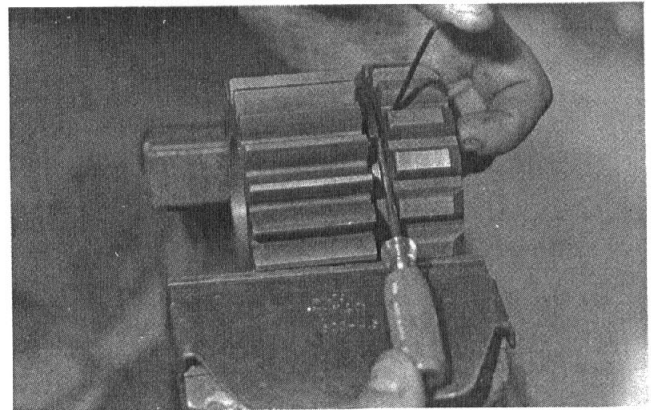
## B. Disassembly of the Auxiliary Drive Gear/Clutch Gear Assembly



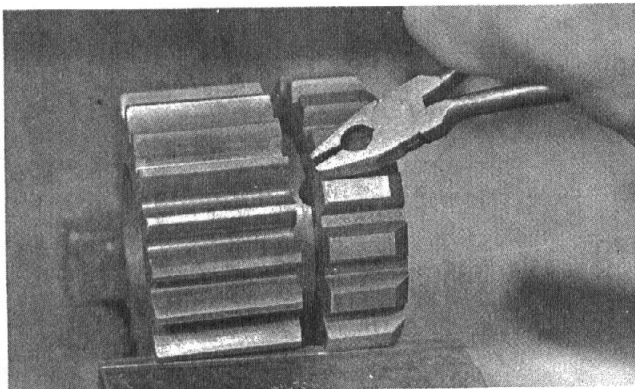
**NOTE:** Assembly should be disassembled only if absolutely necessary. The retaining pin is not reusable and must be replaced.



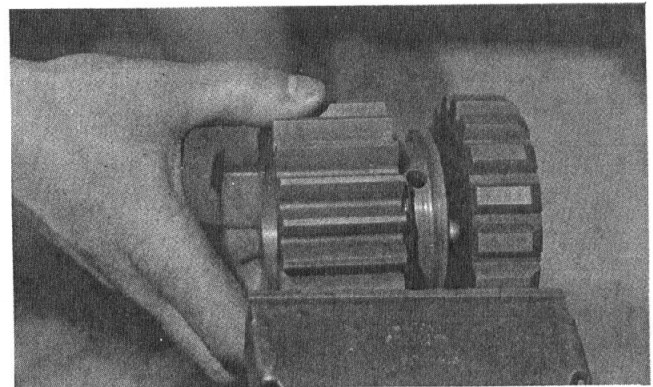
1. Align one of the holes in the small diameter of the drive gear with the retaining pin of the clutch gear and mount the assembly in a vise.



3. Position the snap ring in the clutch gear so that the retaining pin hole is approximately  $\frac{1}{2}$ " from the open section of the snap ring. Insert a small Allen wrench or equivalent into the retaining pin hole and force down so that the snap ring is forced out of the groove. Insert a small screwdriver between the snap ring and clutch gear and pry the snap ring from the groove.



2. Remove the bended end of the pin and drive the pin down and through the hole in the drive gear.

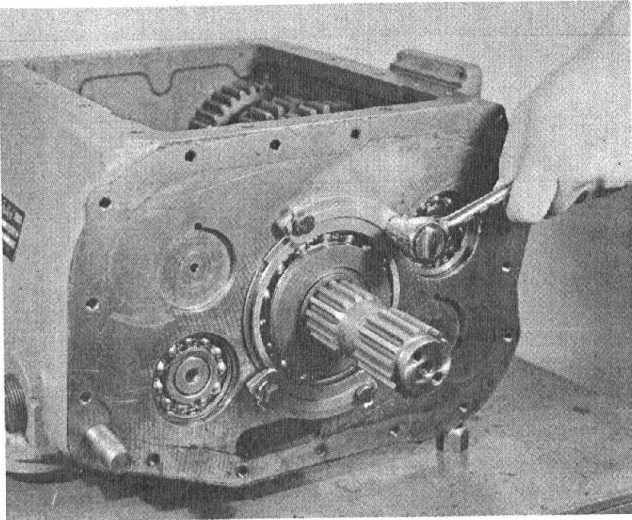


4. Remove the drive gear from the clutch gear and, if necessary, remove the snap ring from the drive gear.

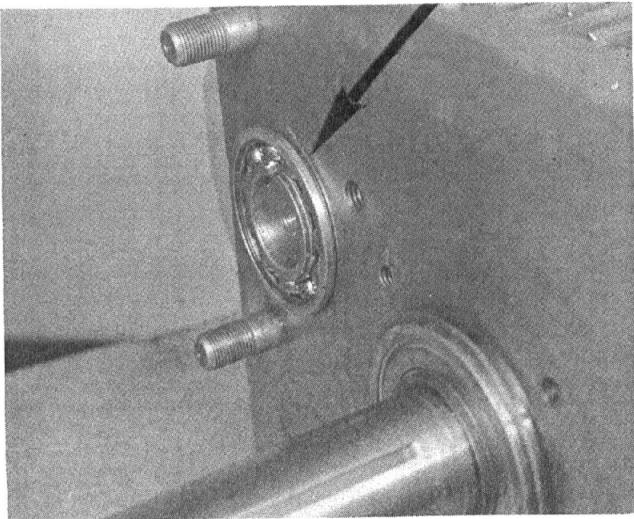


## V. FRONT SECTION

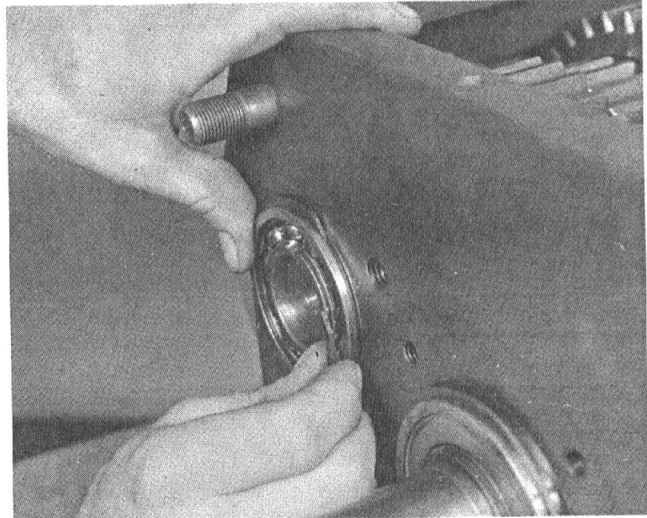
### A. Removal of the Right Countershaft Bearings



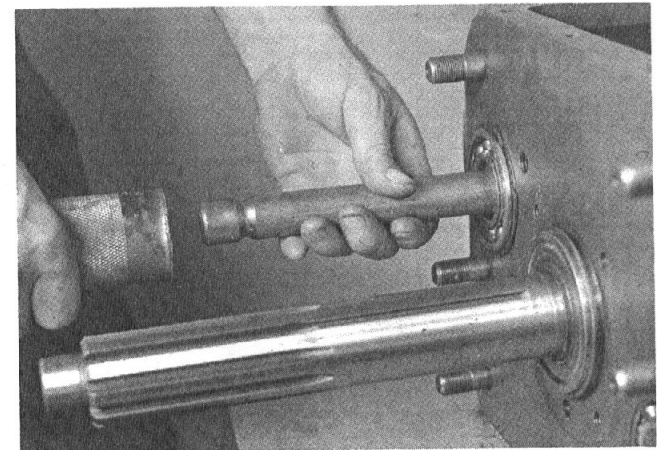
1. Loosen, but do not remove the two mainshaft rear bearing retainers.



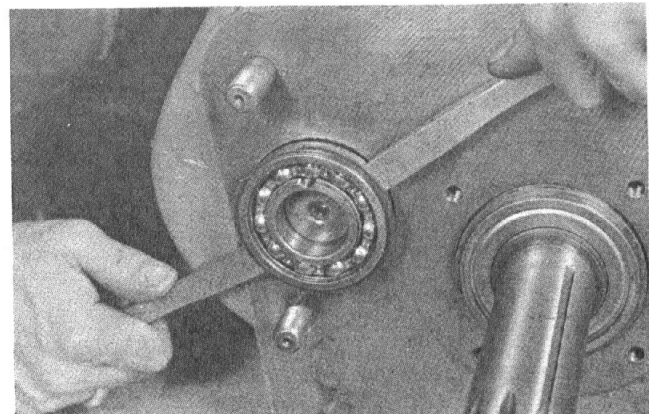
2. Use a soft bar and mallet against the rear of the right countershaft to drive the assembly as far forward as possible, exposing the snap ring groove in the front bearing.



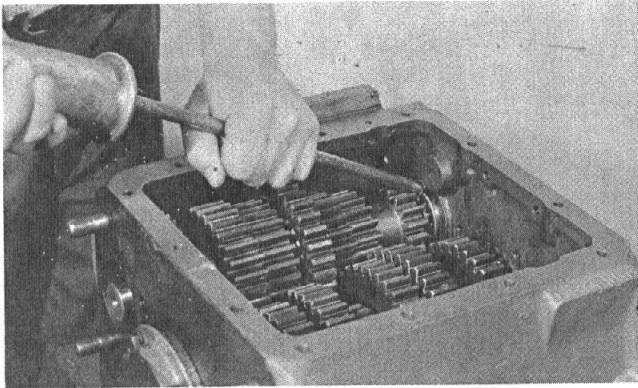
3. Remove the snap ring from the rear countershaft bearing bore and install in the front bearing snap ring groove.



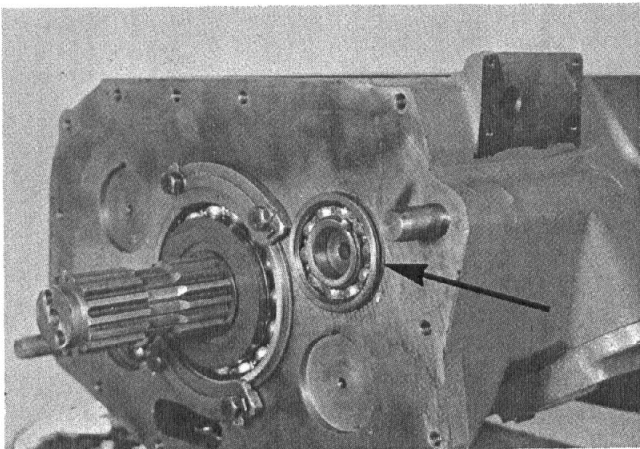
4. Use a soft bar and mallet to move the assembly to the rear as far as possible, partially unseating the front bearing from the shaft.



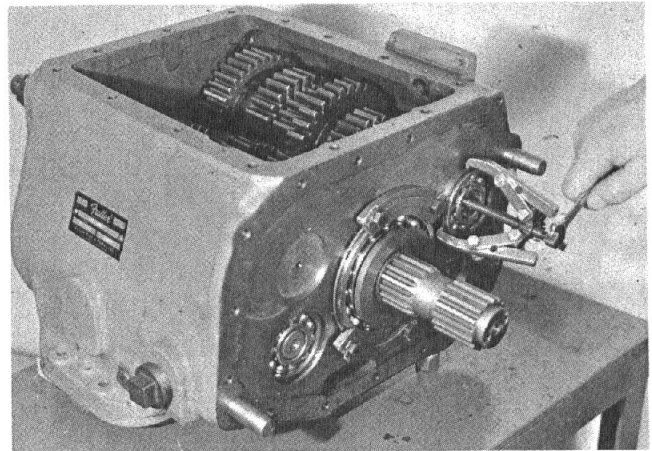
5. Move the countershaft forward and remove the front bearing with a puller or pry bars.



6. Use a blunt punch or equivalent from inside the case and tap the rear bearing back approximately  $\frac{1}{4}$ " on the shaft. Tap on the outer race to avoid damaging the bearing.



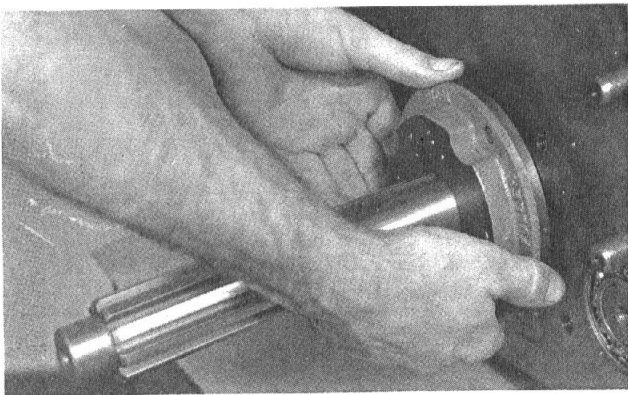
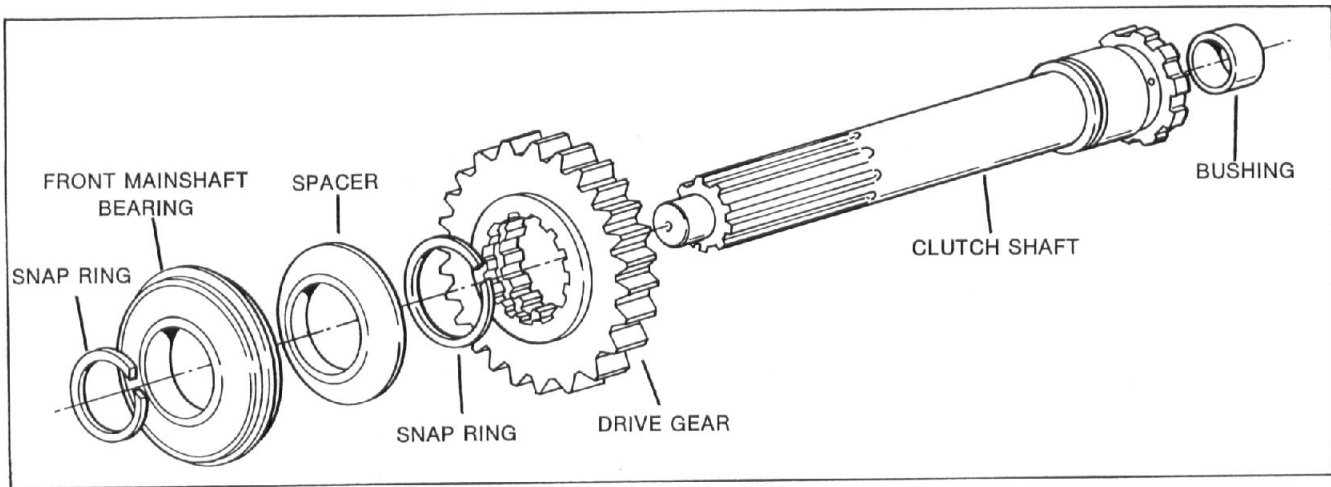
7. Use a soft bar and a mallet to drive the countershaft to the rear, exposing the snap ring groove in the rear bearing.



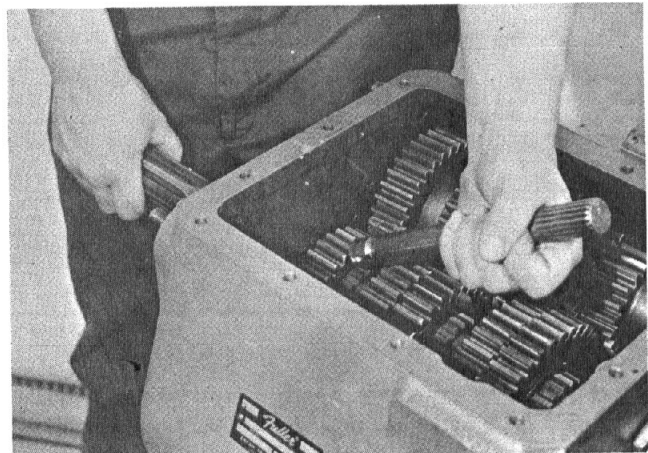
8. Remove the snap ring from the front bearing and install on the rear bearing. Use a puller or pry bars to remove the rear bearing, and re-tighten the two mainshaft rear bearing retainers.

## DISASSEMBLY – FRONT SECTION

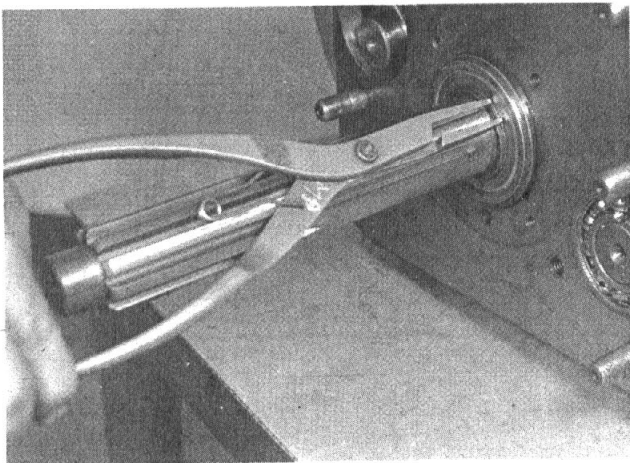
### B. Removal of the Clutch Shaft



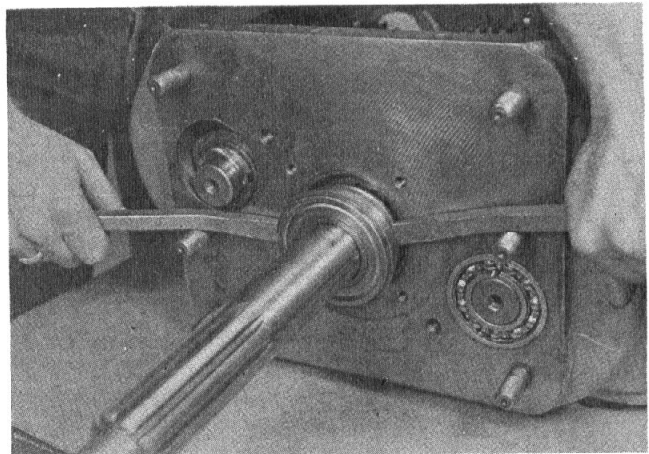
1. Remove the front bearing cover or upshift clutch brake plate.



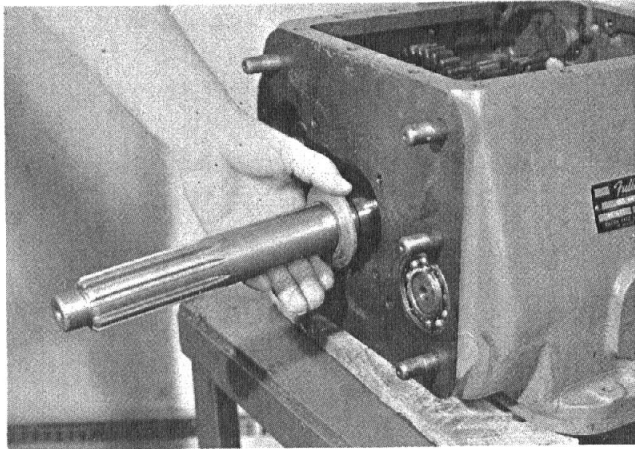
3. Hold the shaft in position and then tap the drive gear forward to unseat the front mainshaft bearing.



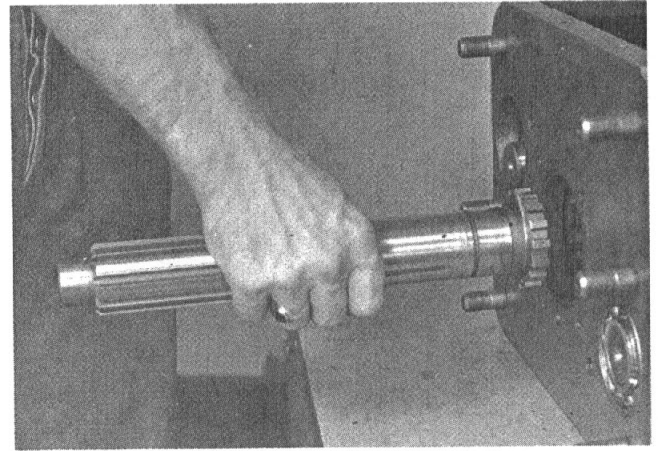
2. Move the drive gear and shaft as far forward as possible and remove the snap ring from the groove in the clutch shaft.



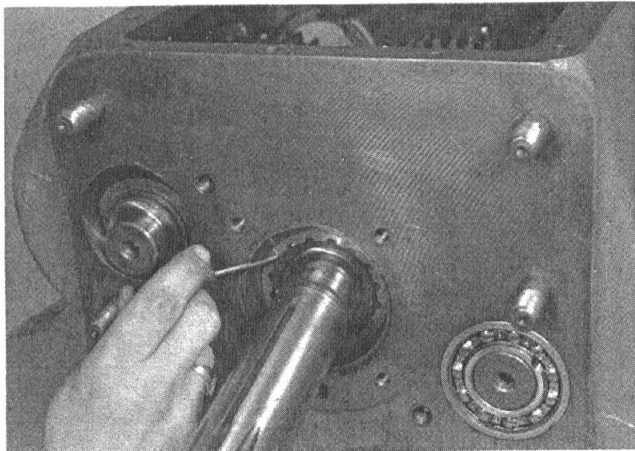
4. Use a puller or pry bars to remove the bearing from the shaft.



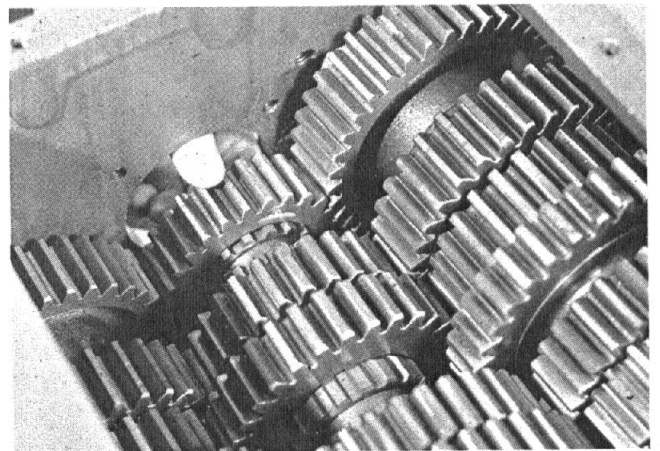
5. Remove the spacer from the shaft.



7. Pull the shaft forward and from the splines of the drive gear.

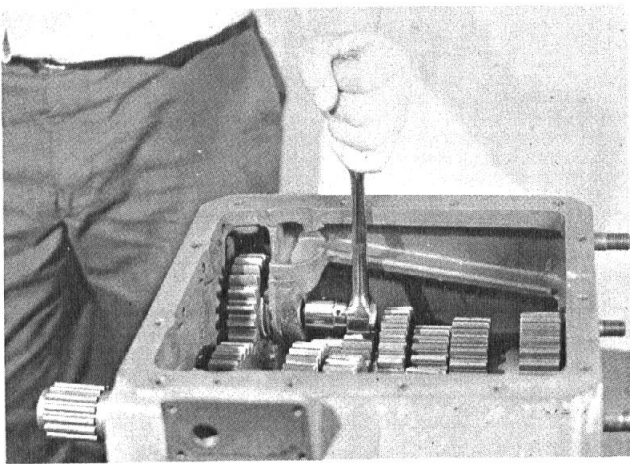
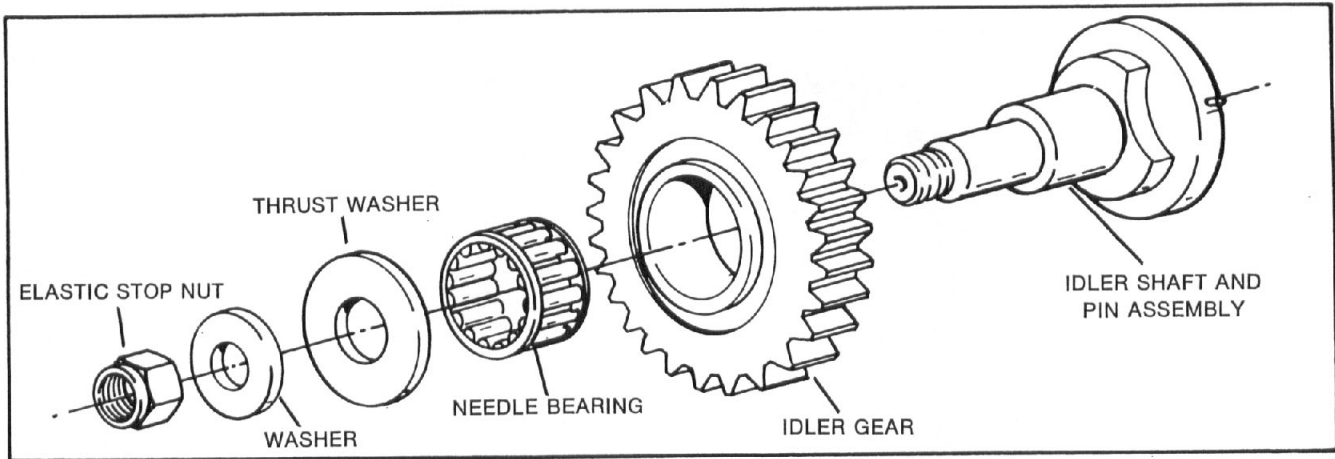


6. Remove the snap ring from the inner diameter of the drive gear.

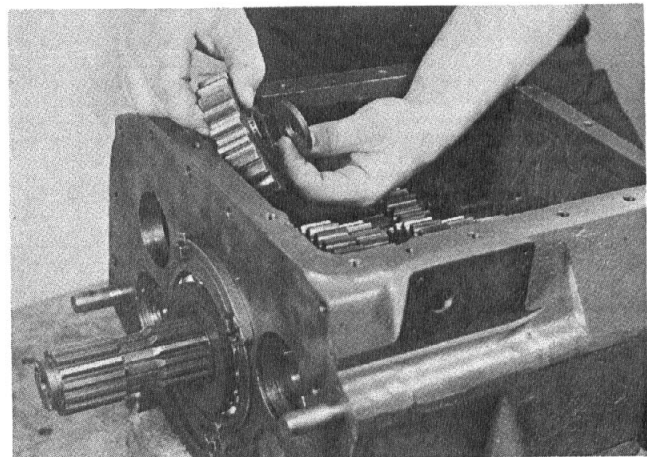


8. Move the drive gear to the rear and against the 4th speed gear, engaging the splines of the sliding clutch.

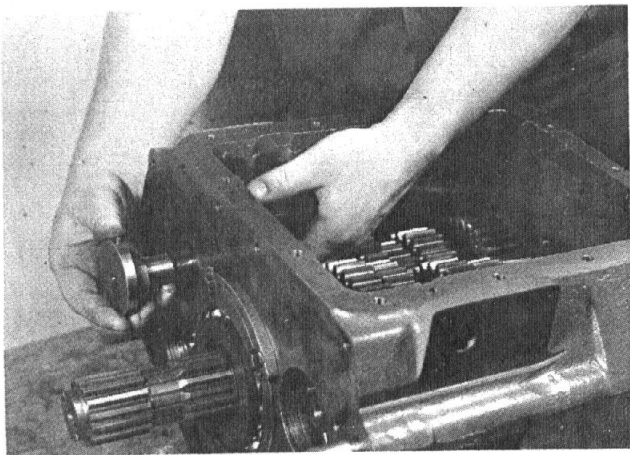
**C. Removal of the Left Reverse Idler Gear**



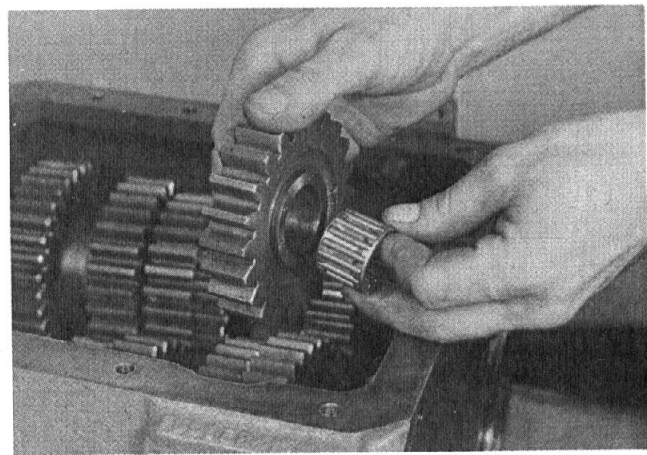
1. Remove the elastic stop nut and washer from the reverse idler shaft.



3. Remove the thrust washer and gear from the case.

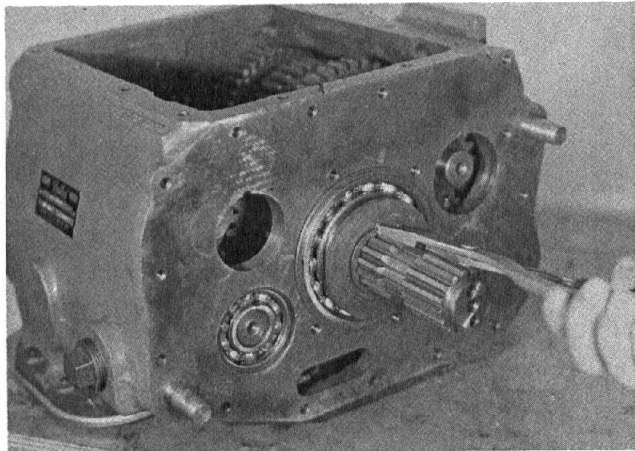
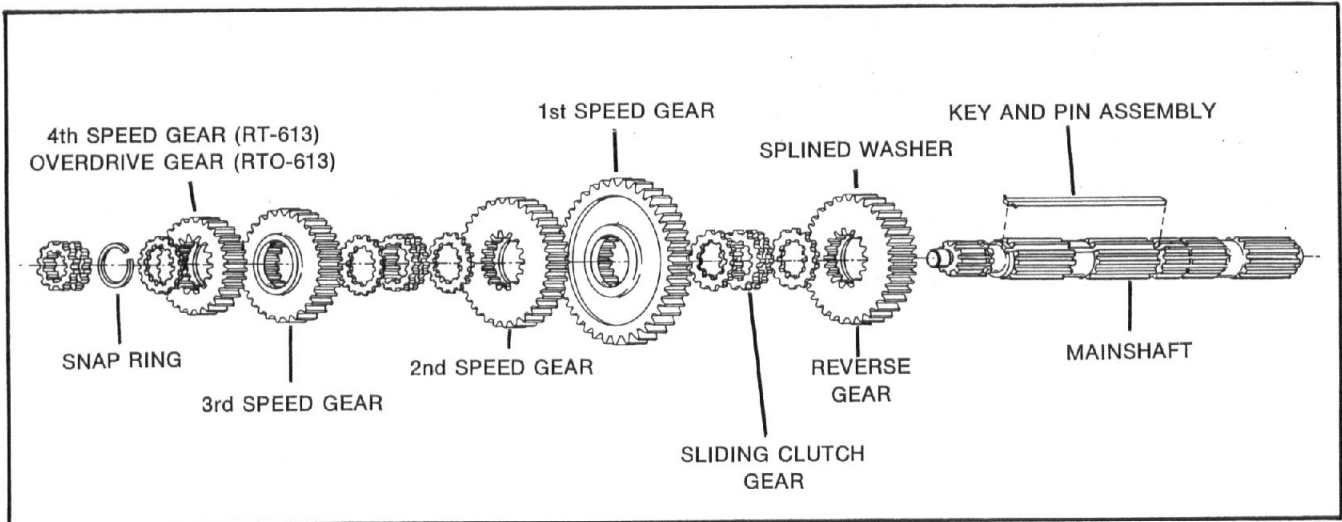


2. Push the shaft to the rear and remove from the case.



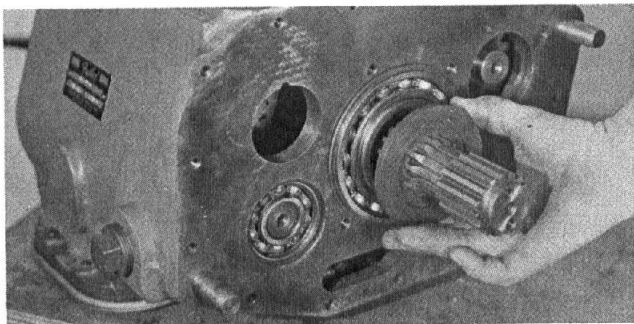
4. Remove the needle bearing from the gear.

D. Removal and Disassembly of the Mainshaft

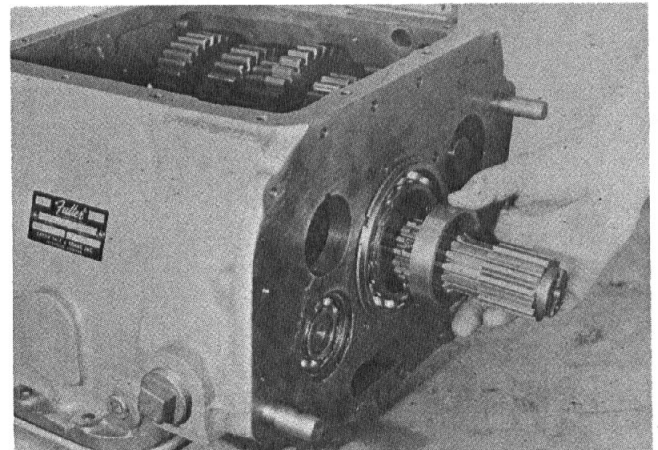


1. Remove the two mainshaft rear bearing retainers, and remove the snap ring from the groove in the rear of the mainshaft. Use caution as this will free the spring-loaded centering ring.

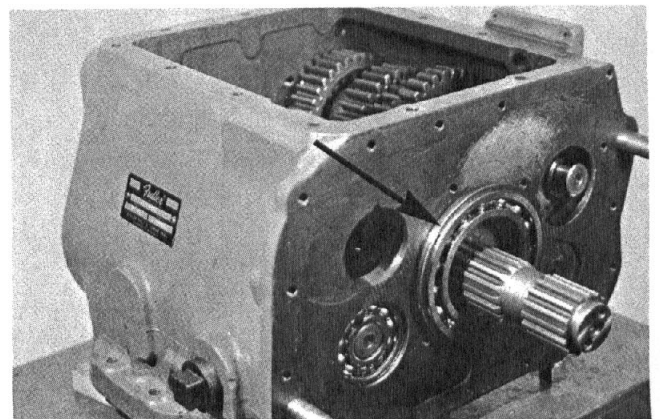
NOTE: It may be necessary to relieve pressure on the snap ring by tapping on the front of the mainshaft.



2. Remove the splined retainer from the mainshaft.

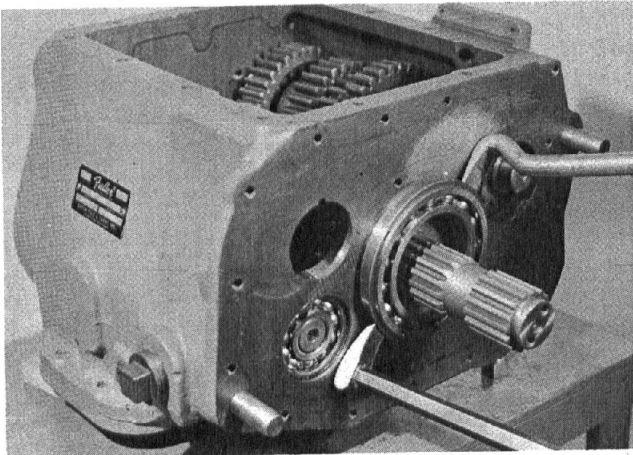


3. Center the front of the mainshaft in the case bore and remove the centering ring. Remove the six springs from the centering ring.

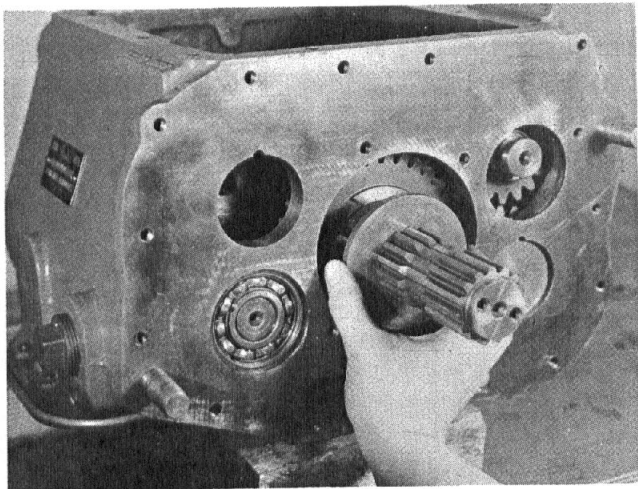


4. Keep the mainshaft centered and tap to the rear to expose the mainshaft rear bearing snap ring.

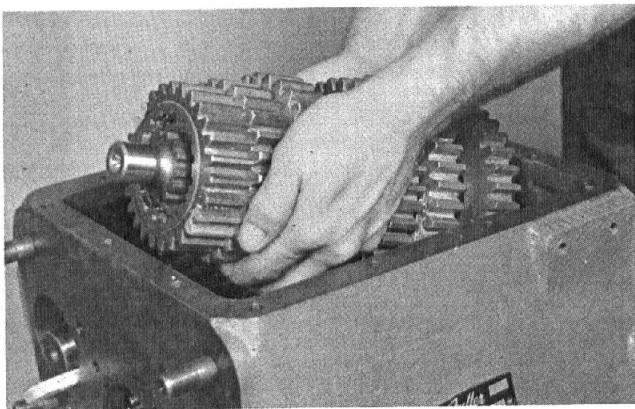
D. Removal and Disassembly of the Mainshaft – Continued



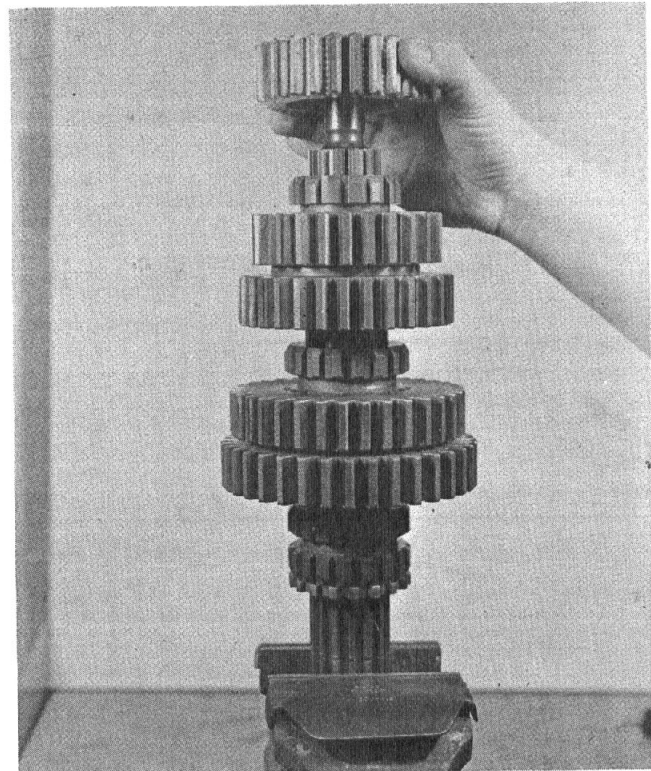
5. Remove the bearing from the case with pry bars.



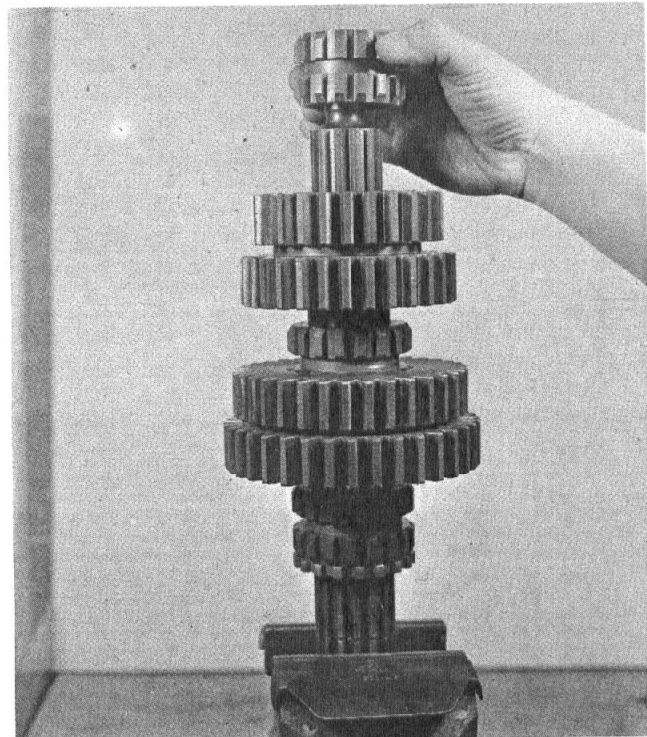
6. Remove the reverse gear washer from the mainshaft.



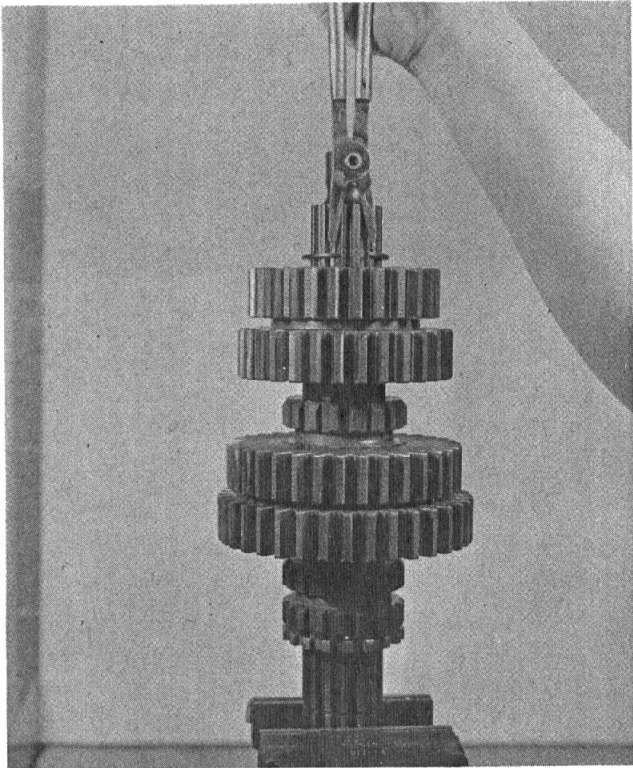
7. Block the right countershaft against the side of the case and move the mainshaft assembly to the rear. Tilt the front of the shaft up and lift the assembly from the case. Use caution as the reverse gear is free and can fall from the shaft during removal. Remove the reverse gear from the mainshaft.



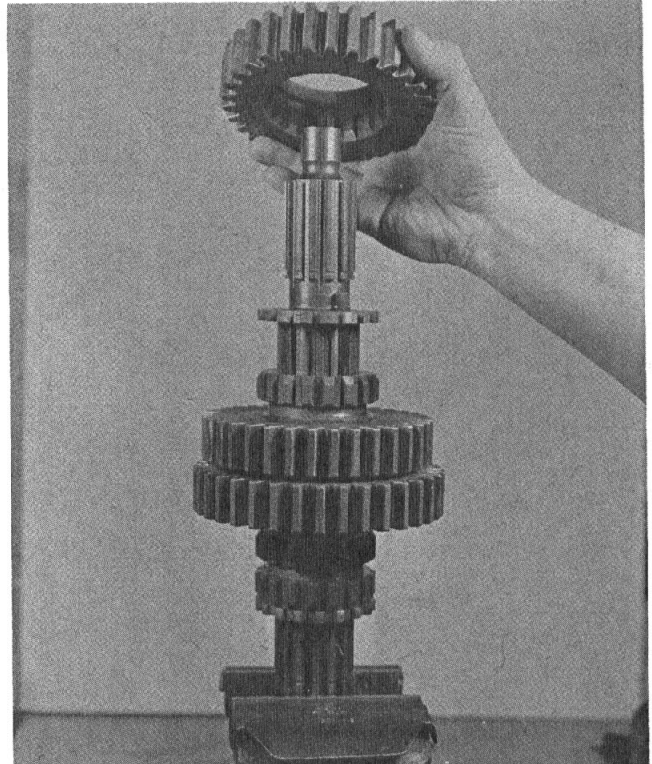
8. Secure the mainshaft assembly in a vise with the pilot (front) end up and remove the drivegear.



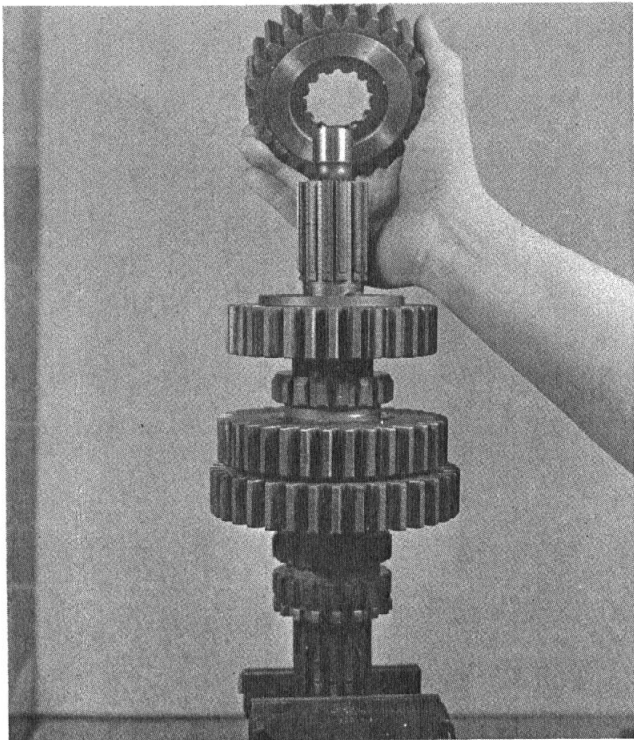
9. Remove the 4th-5th speed sliding clutch.



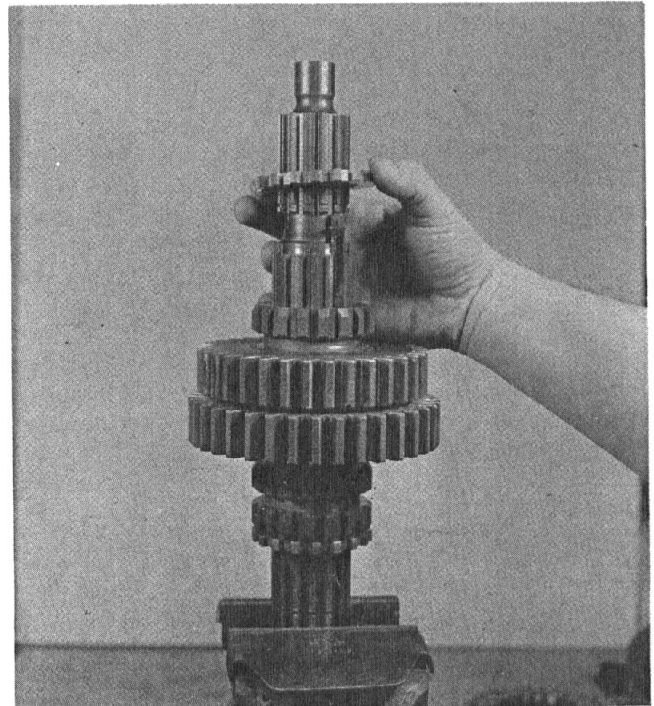
10. Remove the snap ring from the groove in the hub of the 4th speed gear.



12. Remove the 3rd speed gear.



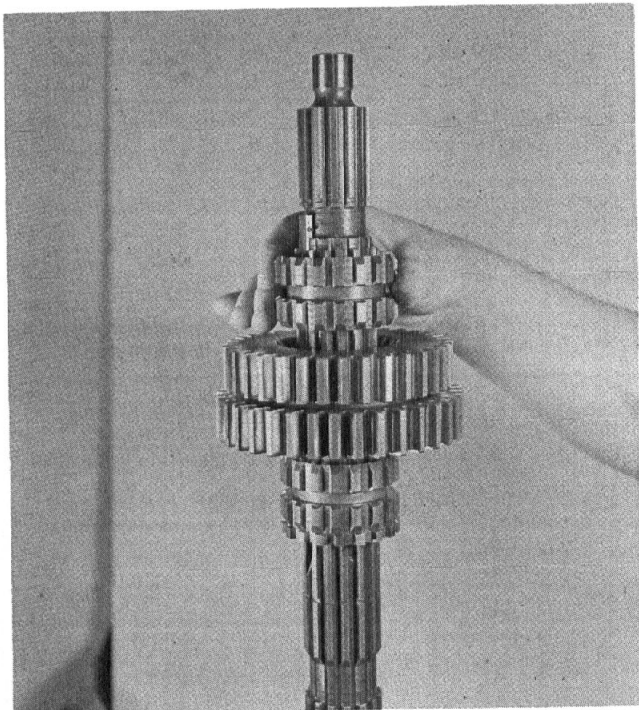
11. Remove the 4th speed gear and splined washer.



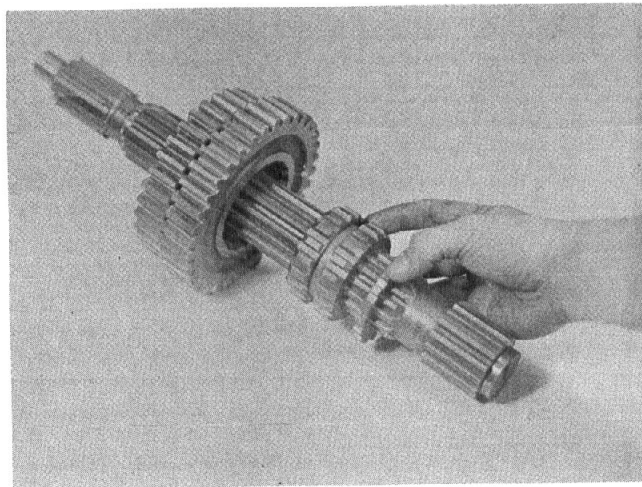
13. Lift the key and remove the 3rd speed gear splined washer.



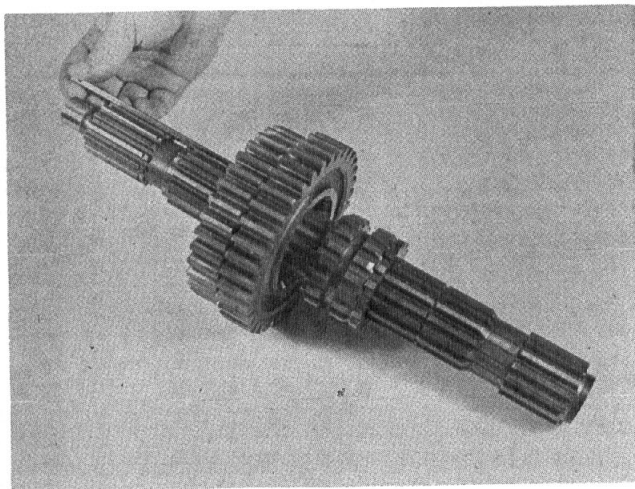
**D. Removal and Disassembly of the Mainshaft – Continued**



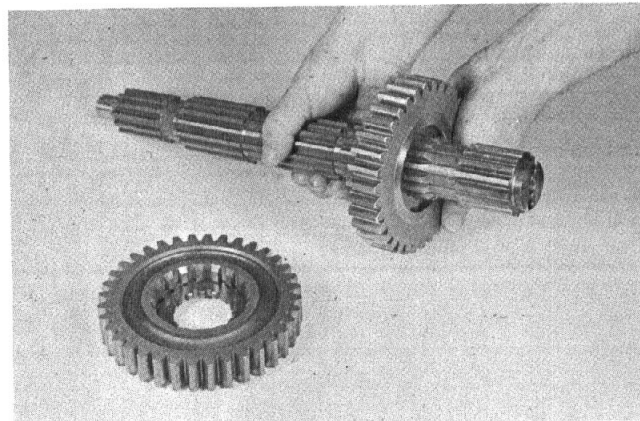
14. Remove the 2nd-3rd speed sliding clutch.



16. Remove the reverse gear splined spacer and the 1st-reverse sliding clutch.

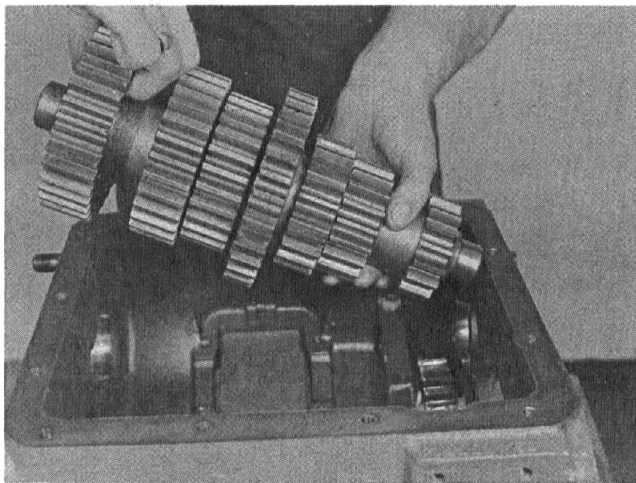
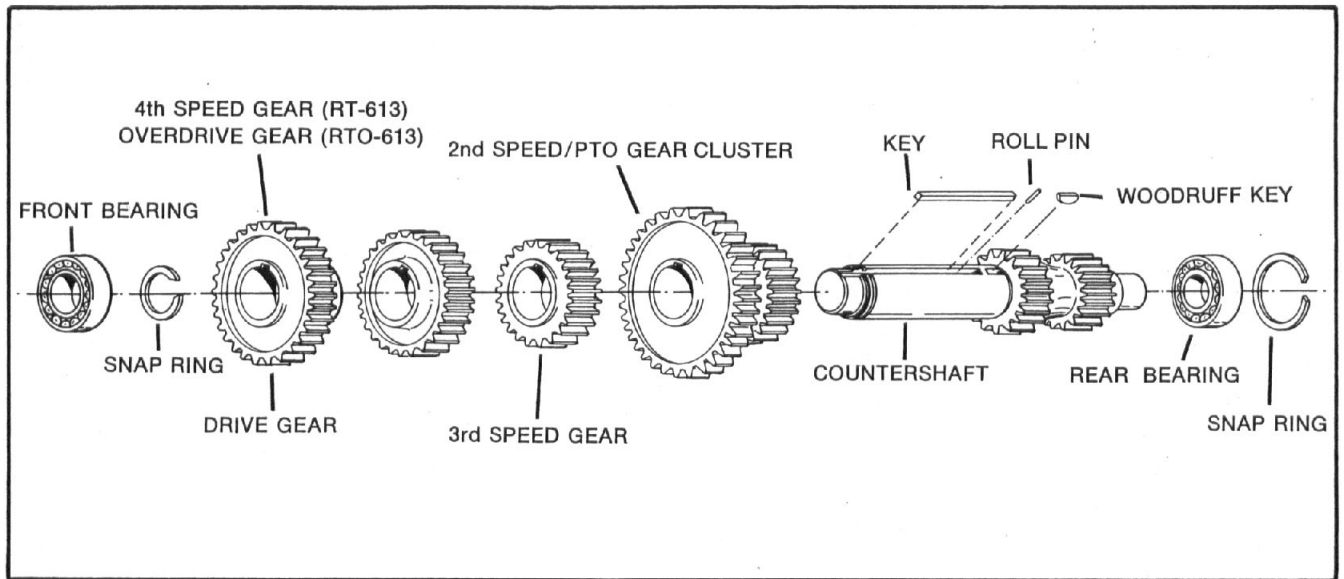


15. Remove the assembly from the vise and pull the key from the mainshaft.

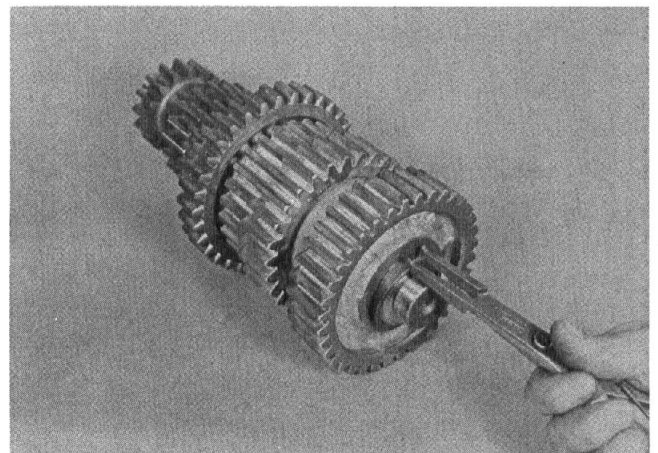


17. Remove the 1st and 2nd speed gears and splined spacers.

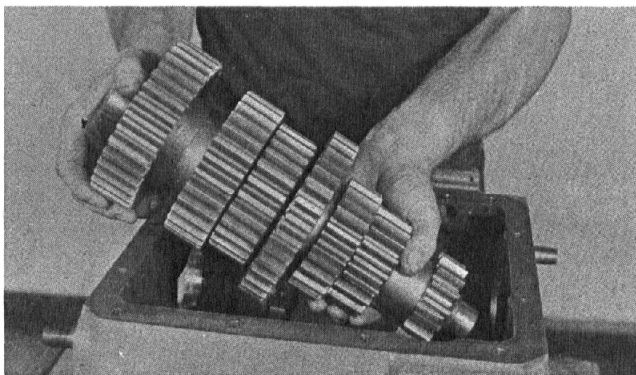
E. Removal and Disassembly of the Countershaft Assemblies



1. Remove the blocking and lift the right countershaft from the case.



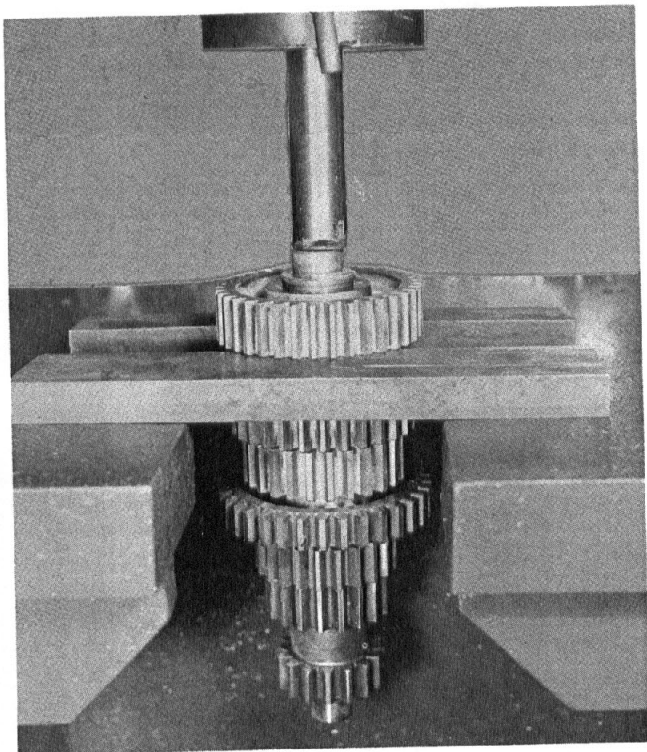
3. Remove the snap ring from the front of both countershafts.



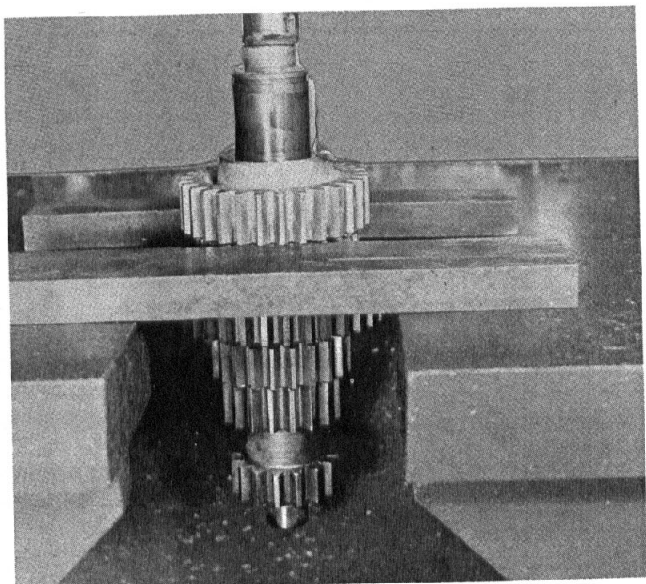
2. Remove the left countershaft bearings in the same manner as those removed from the right and lift the left countershaft from the case.

## DISASSEMBLY – FRONT SECTION

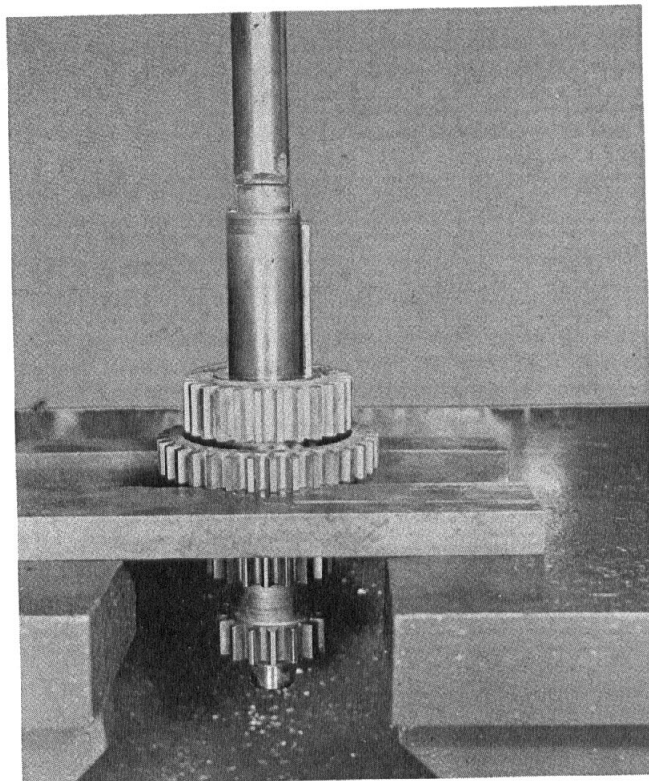
### E. Removal and Disassembly of the Countershaft Assemblies – Continued



4. Press the drive gear from the shaft.



5. Press the 4th speed gear from the shaft.



6. Using the rear face of the PTO gear as a base, press the 3rd speed gear and PTO/2nd speed gear cluster from the shaft. If necessary, remove the Woodruff key, long key and roll pin from the shaft.

**NOTE:** Countershafts are identical and disassembled in the same manner.

### F. Removal of the Right Reverse Idler Gear

1. Remove the right reverse idler gear in the same manner as the left, as both are identical.

# INSPECTION

Before reassembling the transmission, the individual parts should be carefully checked to eliminate those damaged from previous service. This inspection procedure should be carefully followed to insure the maximum of wear life from the rebuilt unit.

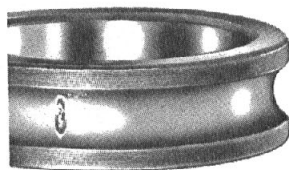
The cost of a new part is generally a small fraction of the total cost of downtime and labor, should the use of a questionable part make additional repairs necessary before the next regularly scheduled overhaul.

Recommended inspection procedures are set forth in the following check list:

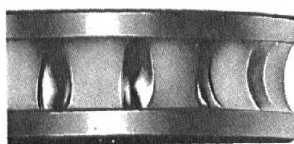
## A. Bearings

1. Wash all bearings in clean solvent. Check balls, rolls and races for pits and spalled areas. Replace bearings which are pitted or spalled.

2. Lubricate bearings which are not spalled or pitted and check for axial and radial clearances. Replace bearings with excessive clearances.



3. Check fits of bearings in case bores. If outer races turn freely in the bores, the case should be replaced.



## B. Gears

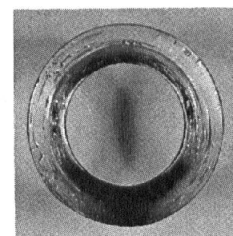
1. Check operating gear teeth for pitting on the tooth faces. Gears with pitted teeth should be replaced.
2. Check all engaging gear teeth. Gears with teeth worn, tapered or reduced in length from clashing in shifting should be replaced.
3. Check axial clearances of gears. Where excessive clearance is found, check gear snap ring, washer, spacer and gear hub for excessive wear. Maintain .005 to .011 axial clearance of mainshaft forward speed gears, .011 to .032 on reverse gear.

## C. Splines

1. Check splines on all shafts for wear. If sliding clutch gears, companion flange or clutch hub have worn into the sides of the splines, the shafts in this condition should be replaced.

## D. Thrust Washers

1. Check surfaces of all thrust washers. Washers scored or reduced in thickness should be replaced.

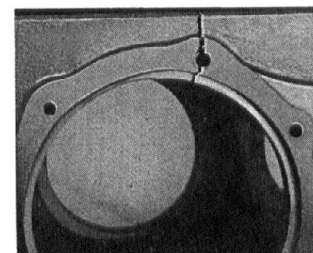


## E. Reverse Gear and Shaft

1. Check bearing sleeve for wear from action of roller bearings.

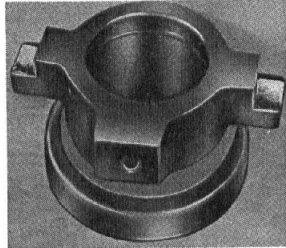
## F. Gray Iron Parts

1. Check all gray iron parts for cracks and breaks. Replace or repair parts found to be damaged. Heavy castings may be welded or brazed providing the cracks do not extend into bearing bores or bolt-surfaces.



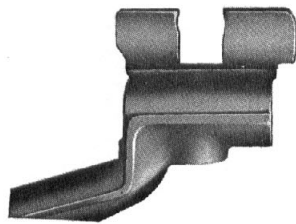
### G. Clutch Release Parts

1. Check clutch release parts. Replace yokes worn at cam surfaces and bearing carrier worn at contact pads.
2. Check pedal shafts. Replace those worn at bearing surfaces.



### H. Shifting Bar Housing Assembly

1. Check yokes and blocks for wear at pads and lever slot. Replace worn parts.
2. Check yokes for alignment. Straighten those which are sprung.
3. Check yokes for excessive wear; replace worn yokes.
4. Check lockscrews in yokes and blocks. Tighten and rewire those found loose.
5. If housing has been dismantled, check neutral notches of shifting bars for wear from interlock balls. Bars indented at points adjacent to the neutral notch should be replaced.



### I. Gear Shift Lever Housing Assembly

1. Check spring tension on shift lever. Replace tension spring and washer if lever moves too freely.
2. If housing is dismantled, check pivot pin and corresponding slot in lever for wear. Replace both parts if worn. If so equipped, check O-ring in housing for wear or cracks.

### J. Bearing Covers

1. Check covers for wear from thrust of adjacent bearing. Replace covers worn and grooved from thrust of bearing outer race.
2. Check bores of covers for wear. Replace those worn over-size.

### K. Oil Return Threads and Seals

1. Check oil return threads in front bearing cover. If sealing action of threads has been destroyed by contact with input shaft, replace the cover.
2. Check oil seal in mainshaft rear bearing cover. If sealing action of lip has been destroyed, replace seal.

### L. Synchronizers

1. Check high and low range synchronizers for burrs, uneven and excessive wear at contact surface.
2. Check blocker pins for excessive wear or looseness.
3. Check synchronizer contact surfaces on the high and low range gears for excessive wear.

### M. Sliding Clutches

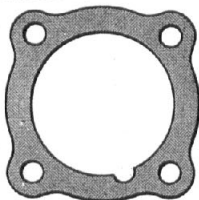
1. Check all yokes and yoke slots in sliding clutches for extreme wear or discoloration from heat.
2. Check engaging teeth of sliding clutches for partial engagement pattern.

# GENERAL PRECAUTIONS FOR REASSEMBLY

**IMPORTANT: Read this section before starting the detailed reassembly procedures.**

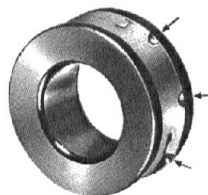
Make sure that interiors of case and housing are clean. It is important that dirt be kept out of transmission during reassembly. Dirt is abrasive and can damage polished surfaces of bearings and washers. Use certain precautions, as listed below, during reassembly.

1. **GASKETS** — Use new gaskets throughout the transmission as it is being rebuilt. Make sure all gaskets are installed, as omission of gasket can result in oil leakage or misalignment of bearing covers. See "Location of Gaskets" heading.



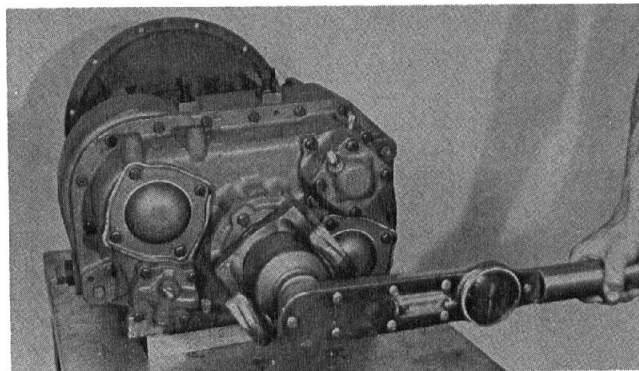
2. **CAPSCREWS** — To prevent oil leakage, use shellac on all capscrews. See torque rating chart for recommended torque.
3. **O-RINGS** — Lubricate all O-rings with "Dow Corning 200 Fluid," 50,000 cs.
4. **ASSEMBLY** — Refer to the disassembly illustrations as a guide to reassembly.
5. **INITIAL LUBRICATION** — Coat all thrust washers and splines of shafts with Lubriplate during installation to provide initial lubrication, preventing scoring and galling.
6. **AXIAL CLEARANCES**—Maintain original axial clearances of mainshaft forward speed gears of .005" to .011". Mainshaft reverse gear clearance is .011" to .032".

7. **BEARINGS** — Use of flanged-end bearing drivers is recommended for the installation of bearings. These



drivers apply equal force to both races of bearing, preventing damage to balls and races and maintaining correct bearing alignment with shaft and bore. If tubular or sleeve type driver is used, apply force only to inner race.

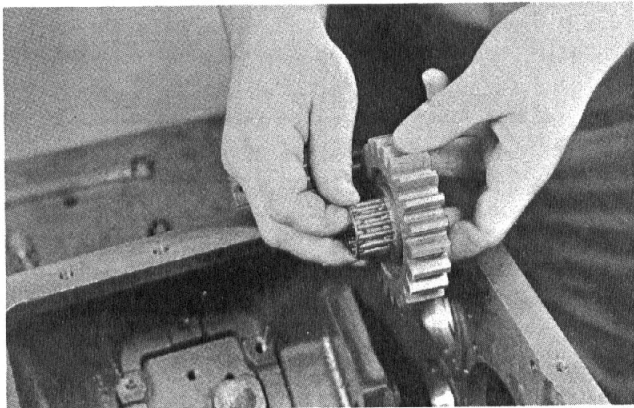
8. **UNIVERSAL JOINT COMPANION FLANGE** — Pull the companion flange tightly into place with the mainshaft nut, using 450-500 foot-pounds of torque. Make sure the speedometer gear has been installed on yoke. If a speedometer gear is not used, a replacement spacer of the same width must be used. Failure to pull the yoke or flange tightly into place will permit the shaft to move axially with resultant damage to rear bearing.



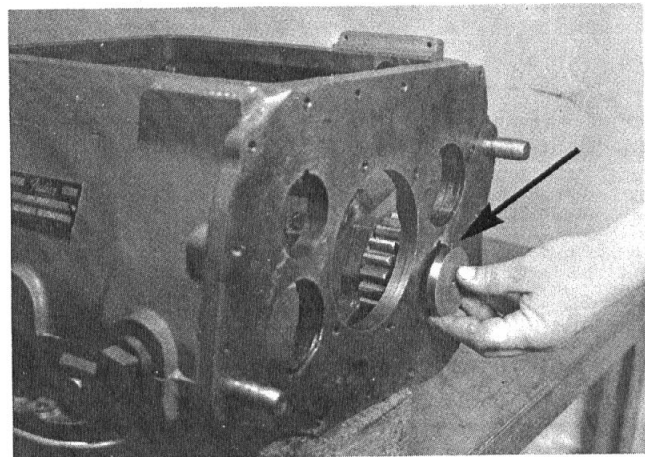
# REASSEMBLY INSTRUCTIONS

## I. FRONT SECTION

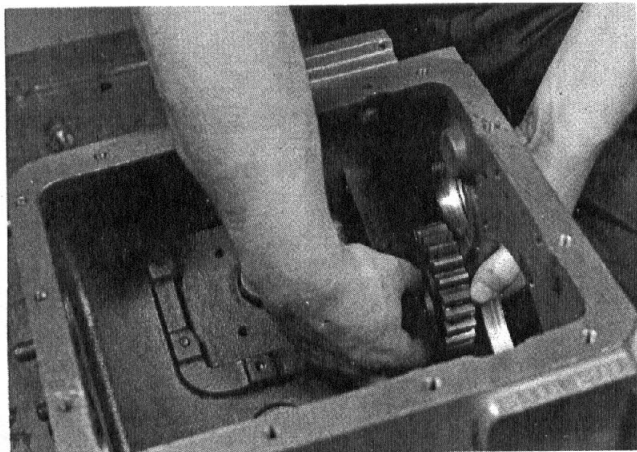
### A. Installation of the Right Reverse Idler Gear



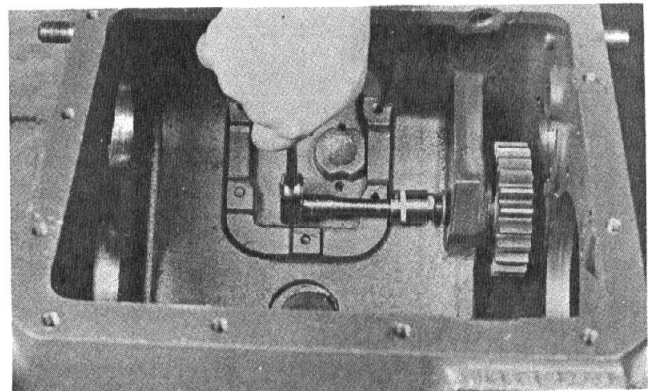
1. Install the needle bearing in the bore of the gear.



3. Make sure that the roll pin is in place in the large diameter of the idler shaft and insert the shaft through the gear, washer and boss, aligning the roll pin with the notch in the rear case bore.



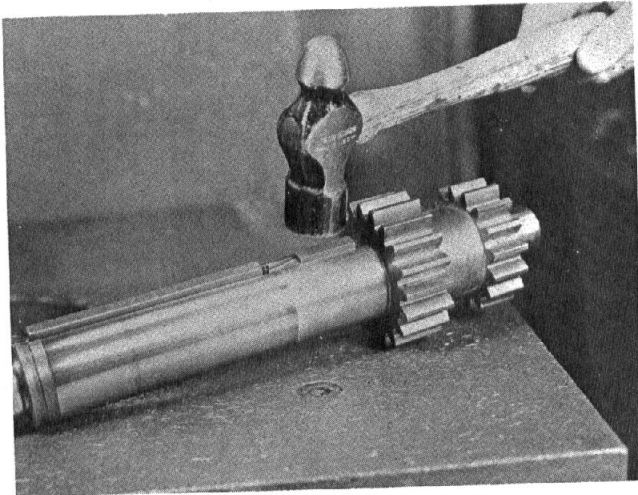
2. Slide the thrust washer into position on the rear of the case boss and hold the gear behind the washer.



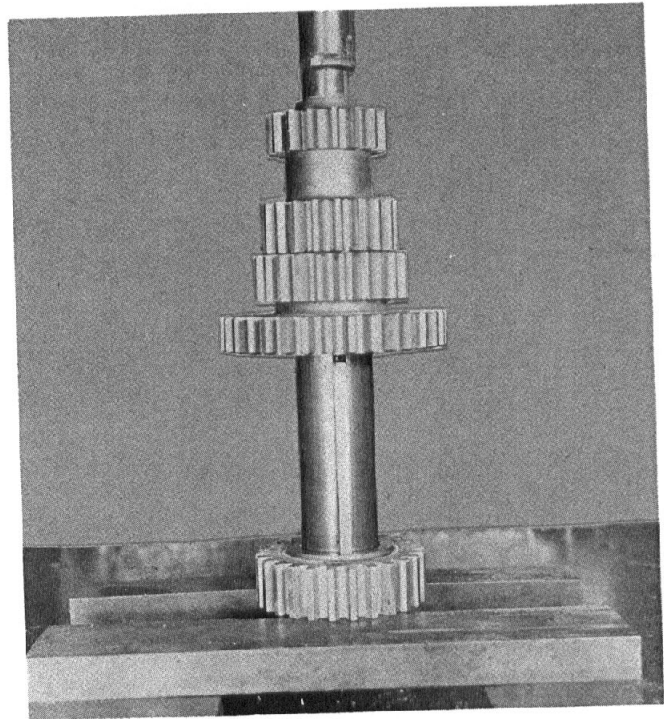
4. Secure the shaft with the washer and elastic stop nut.

## B. Reassembly and Installation of the Countershafts

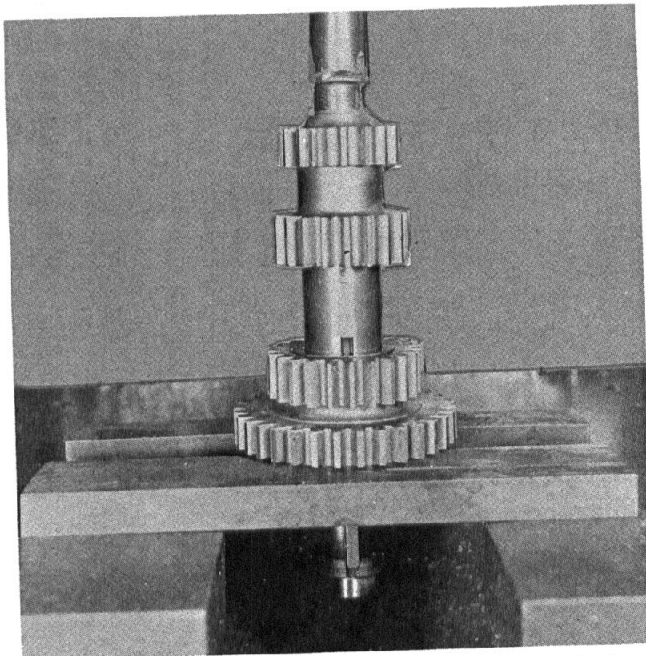
NOTE: Countershafts are identical and assembled in the same manner.



1. If previously removed, install the roll pin, long key and Woodruff key in the countershaft.

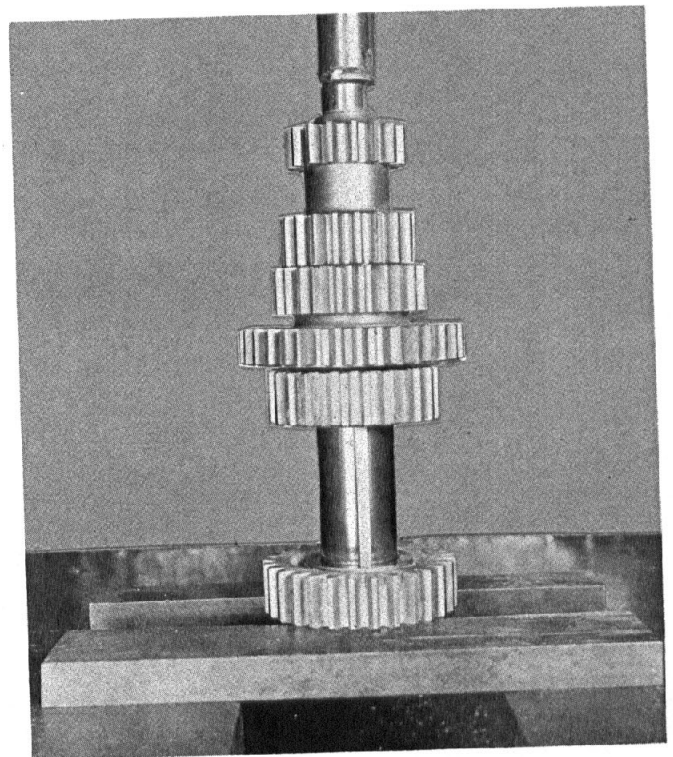


3. Press the 3rd speed gear onto the shaft with the long hub to the rear.



2. Press the PTO/2nd speed gear cluster onto the shaft.

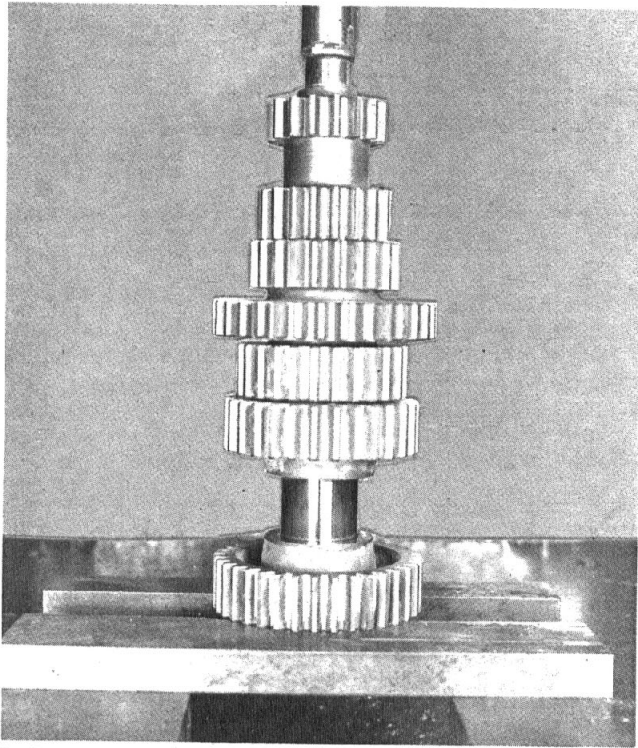
NOTE: For RTO-613 models, the drive gear and 4th speed gear locations are reversed.



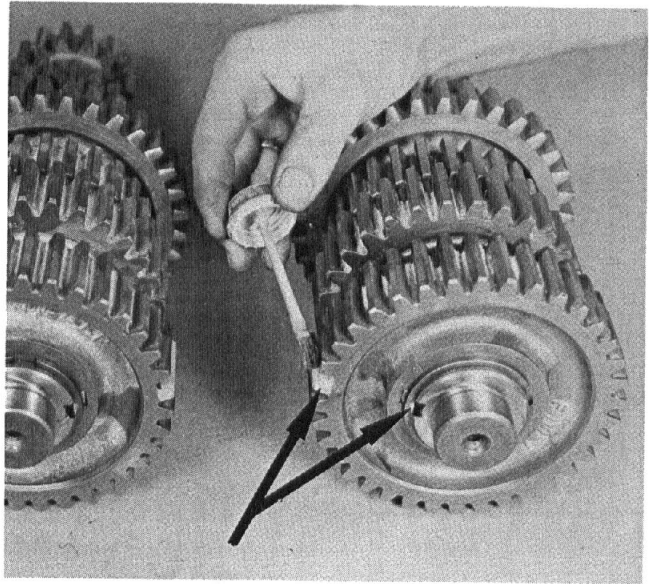
4. Press the 4th speed gear onto the shaft with the long hub to the front.



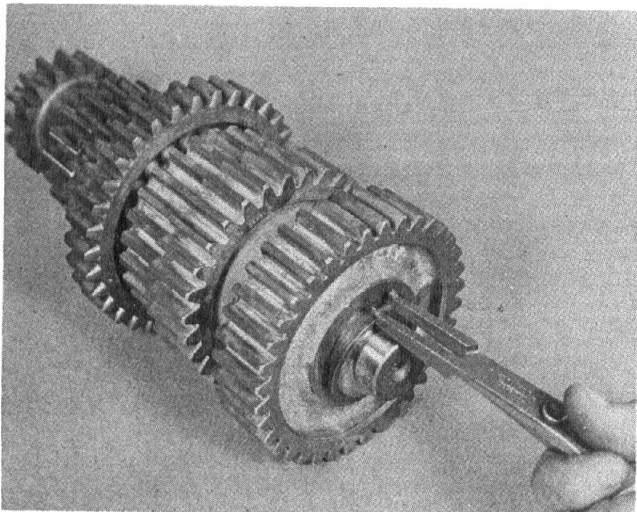
**B. Reassembly and Installation of the Countershafts – Continued**



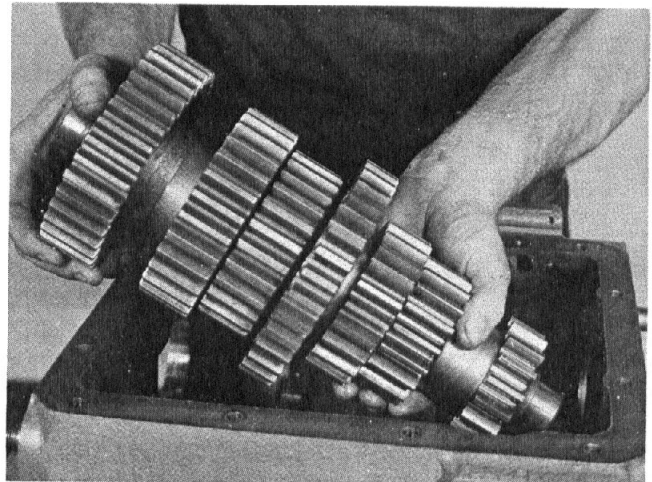
5. Press the drive gear onto the shaft with the long hub to the rear.



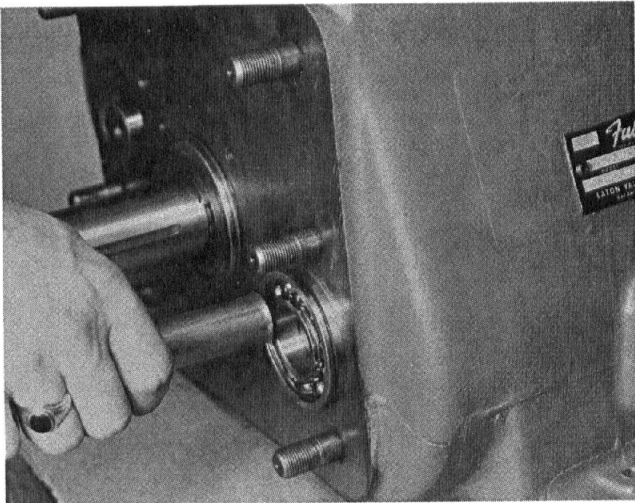
7. On the drive gear of each shaft mark the gear tooth which is aligned with the keyway. The tooth is also stamped with an "O".



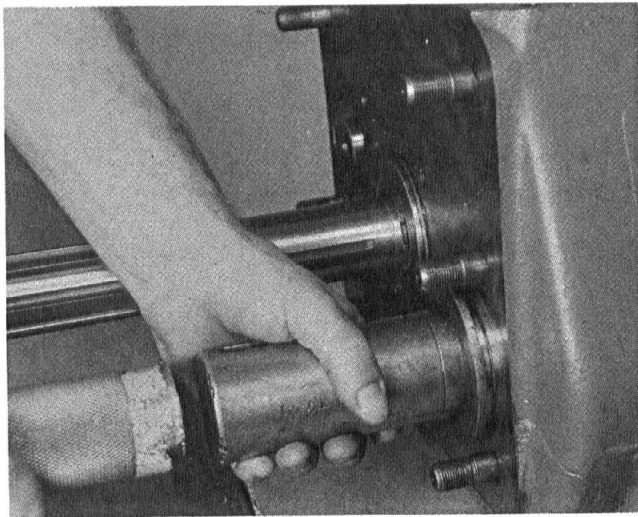
6. Install the snap ring in the groove in the front of the countershaft.



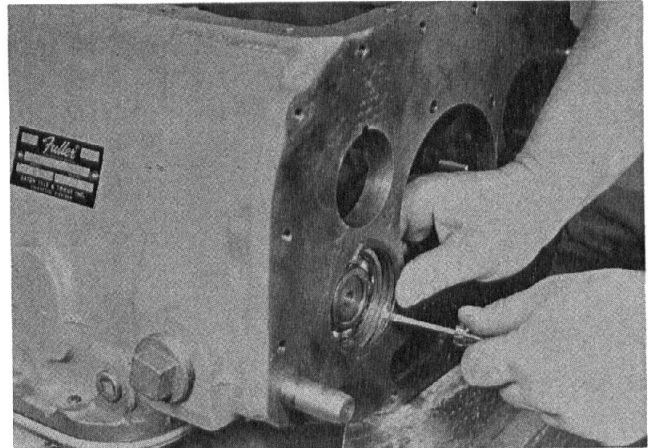
8. Place the left countershaft into position in the case.



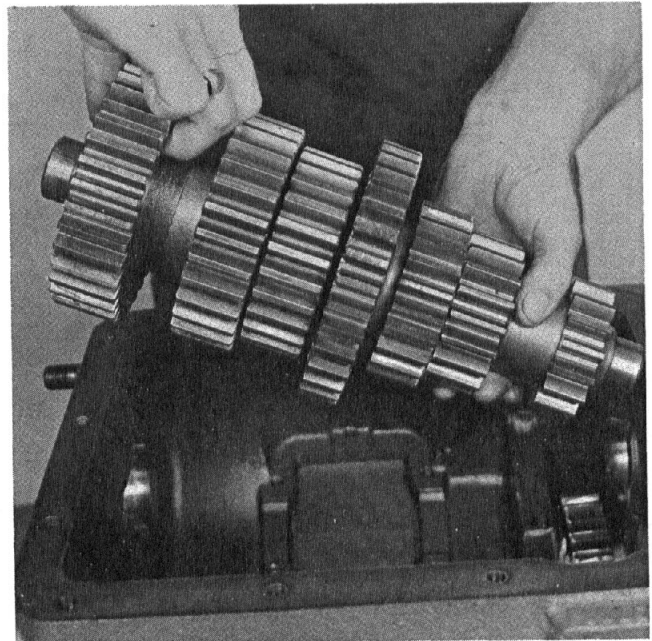
9. Center the rear of the countershaft in the case bore and partially install the front bearing on the shaft and in the case bore. Partially install the rear bearing.



10. Use a bearing driver to complete installation of the front and rear bearings.

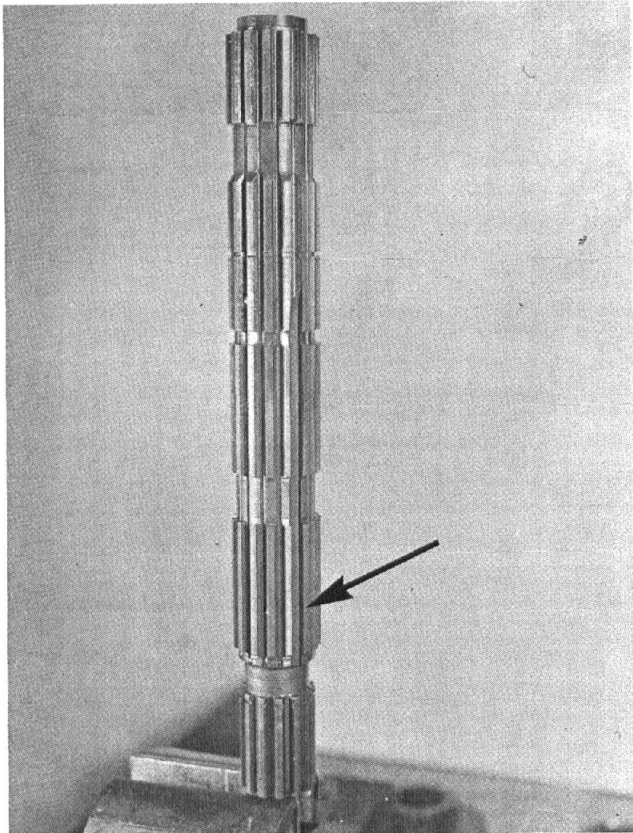


11. Install the snap ring in the groove in the rear bearing bore.

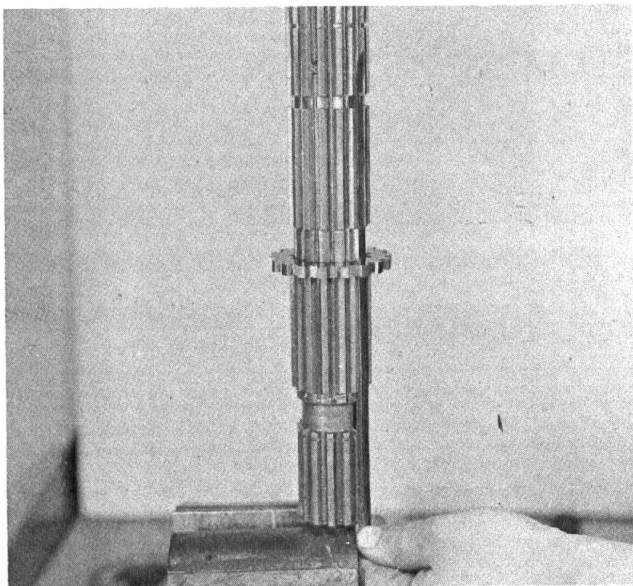


12. Place the right countershaft into position but **DO NOT** install the bearings.

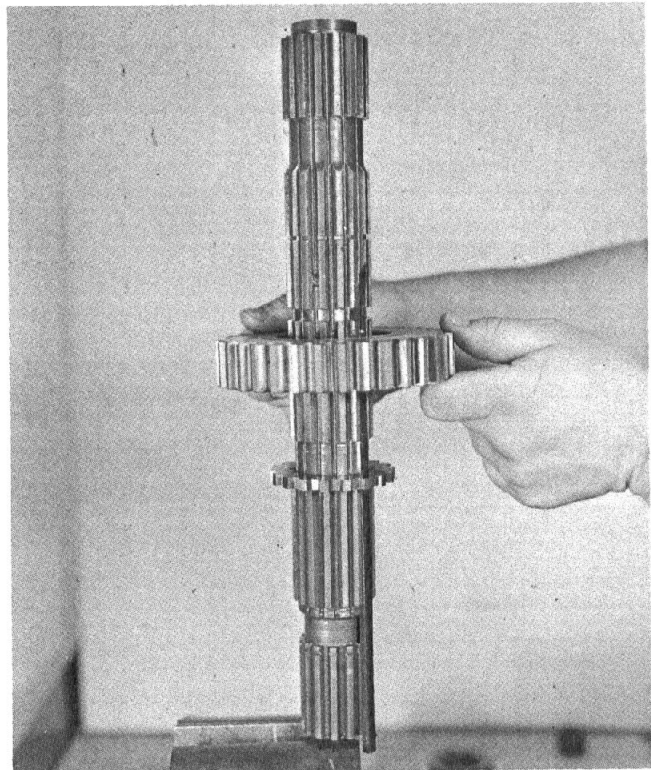
C. Reassembly of the Mainshaft



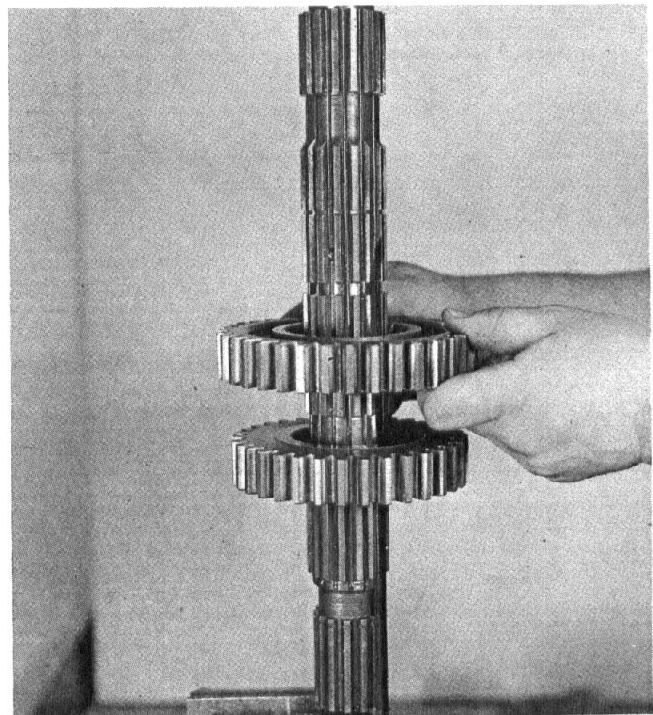
1. Place the mainshaft in a vise with the pilot (front) end down, keeping the keyway free for insertion of the key.



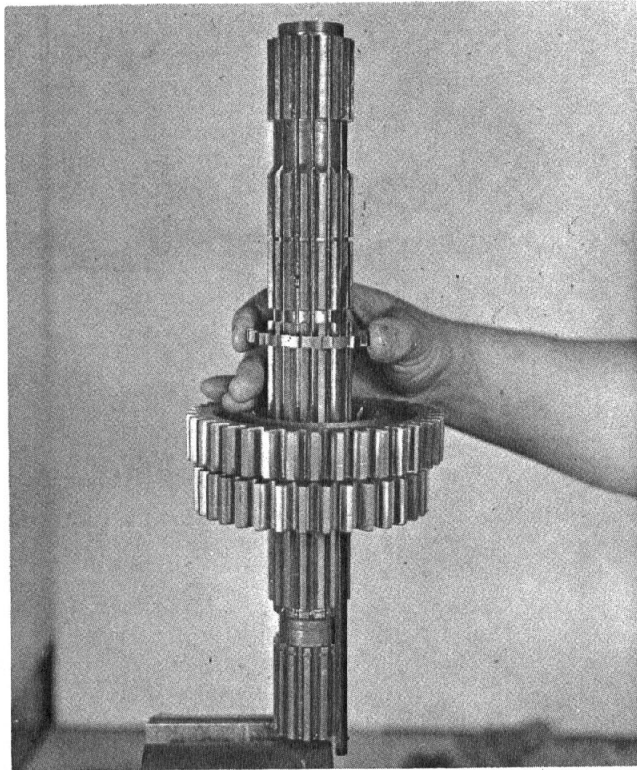
2. Install the 2nd speed gear washer at the 2nd speed gear location, inserting the key from the bottom to lock the washer in position.



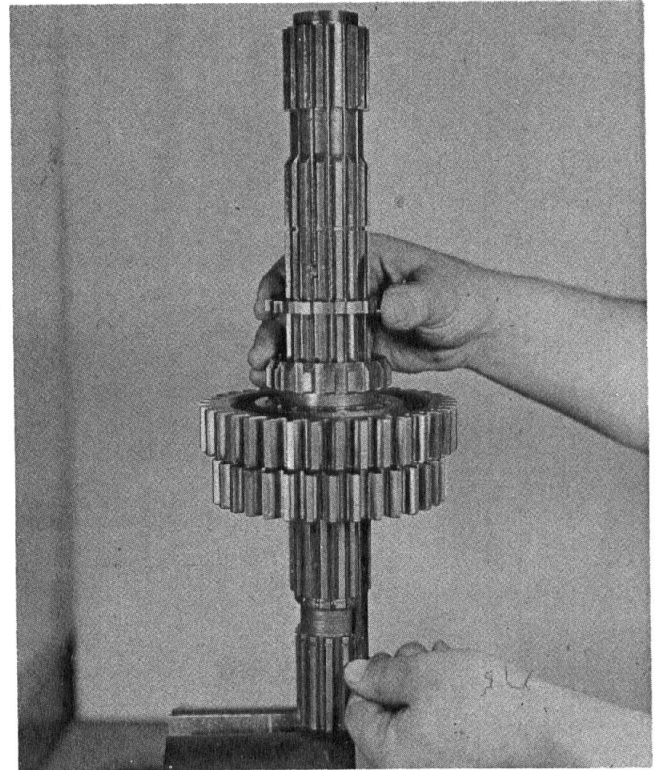
3. Install the 2nd speed gear on the splined washer, clutching teeth down.



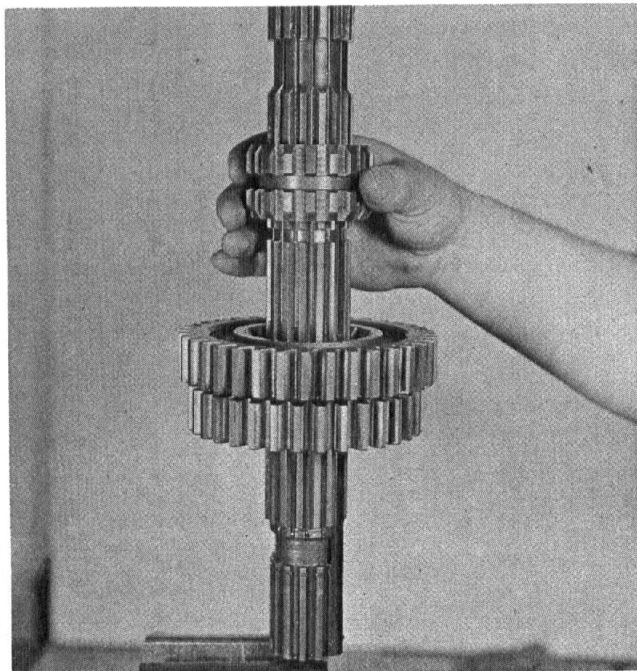
4. Install the 1st speed gear against the 2nd speed gear, clutching teeth up.



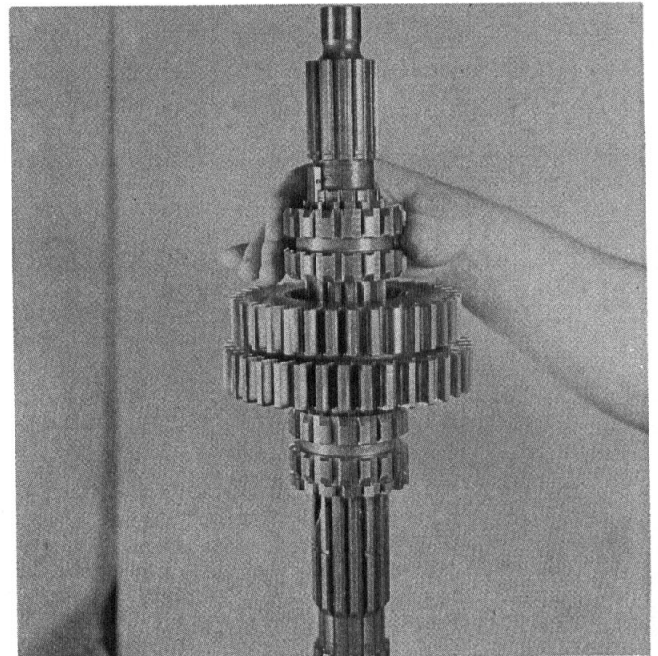
5. Insert the splined washer in the hub of the 1st speed gear. Align the washer with the mainshaft splines and move the key up to lock the washer in position.



7. Install the reverse gear splined washer, align the keyway and lock in position with the key.

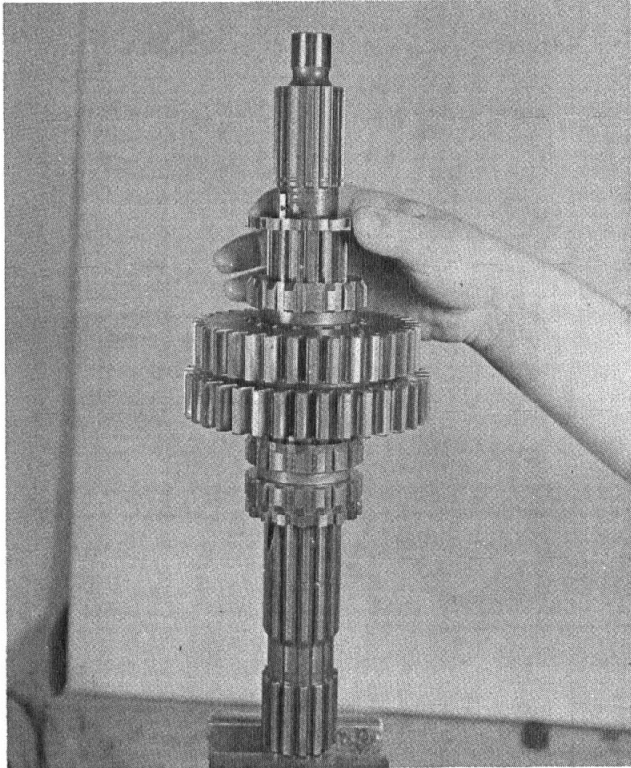


6. Install the 1st-reverse sliding clutch, aligning the slot in the clutch with the key.

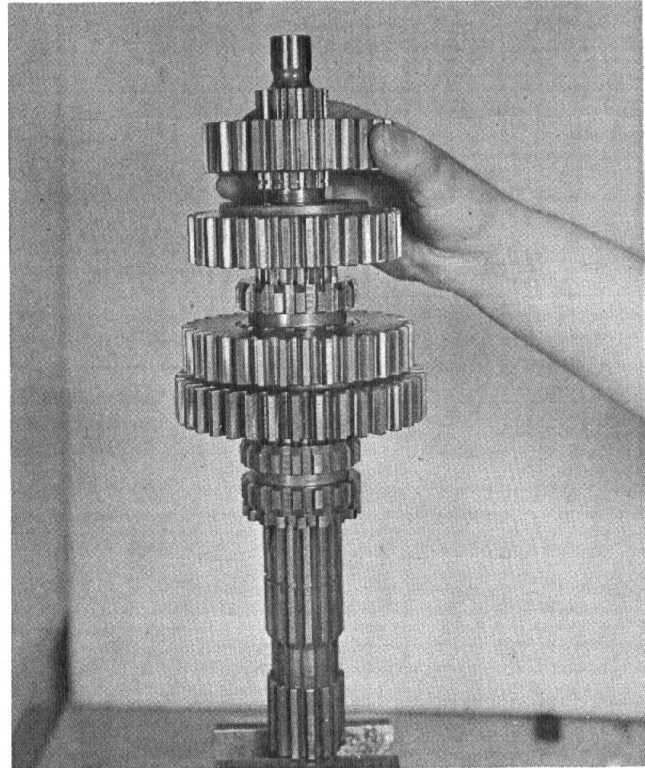


8. Reposition the assembly in the vise with the pilot end up and pull the key up approximately  $\frac{1}{2}$ ". Install the 2nd-3rd speed sliding clutch, aligning the slot in the clutch with the key.

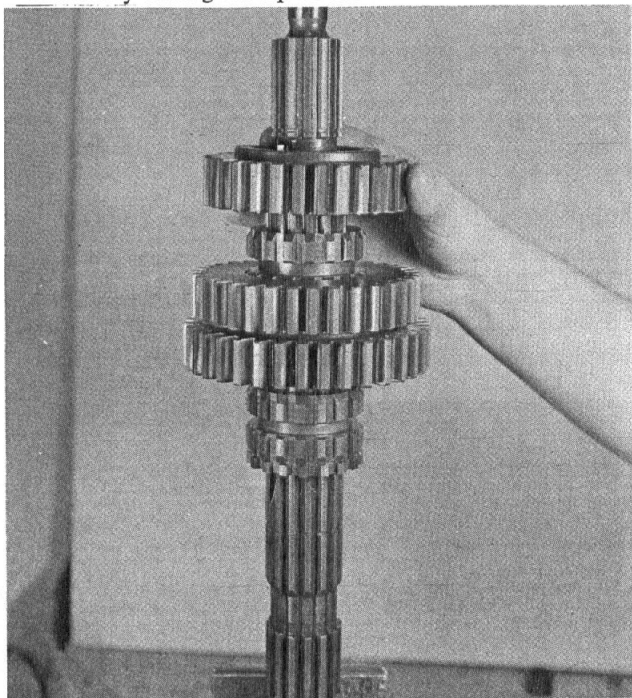
**C. Reassembly of the Mainshaft – Continued**



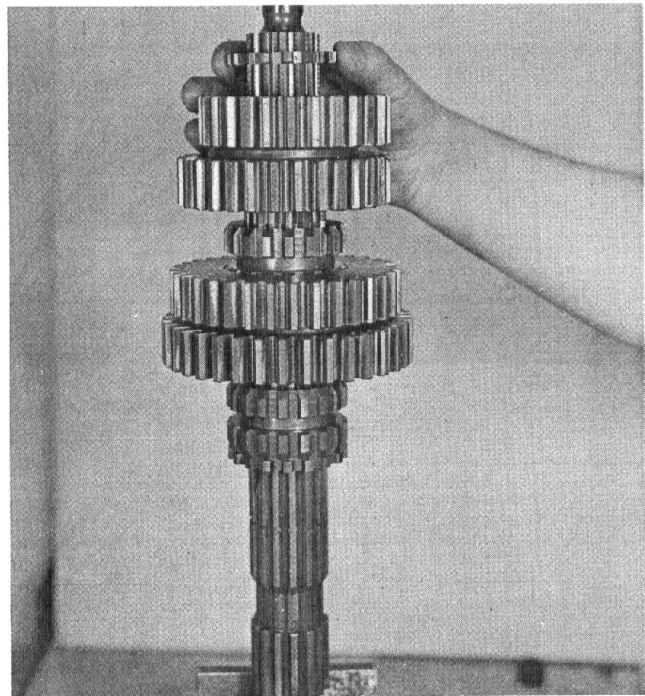
9. Slide the 3rd speed gear splined washer down over the key and push the key down into position, with the pin in the key resting on top of the washer.



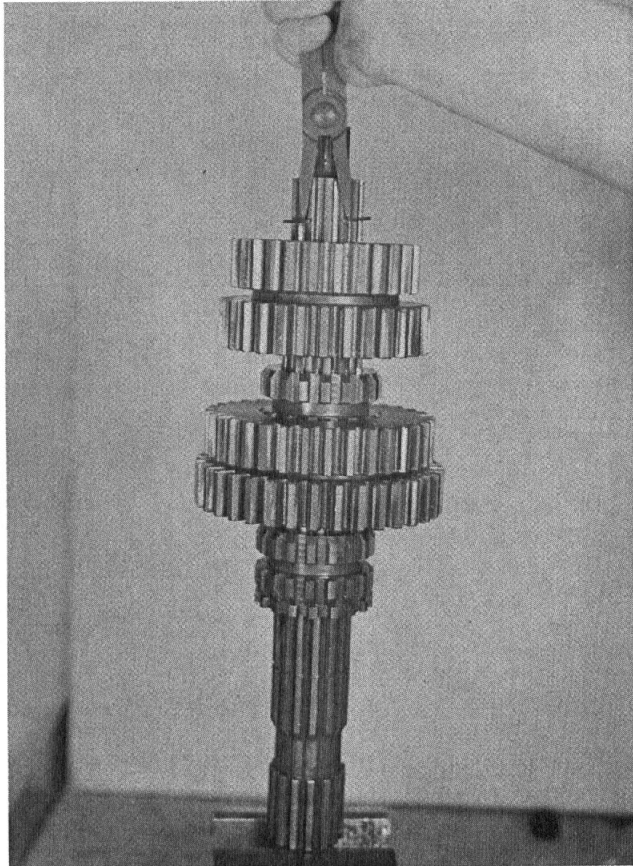
11. Install the 4th speed gear against the 3rd speed gear, clutching teeth up.



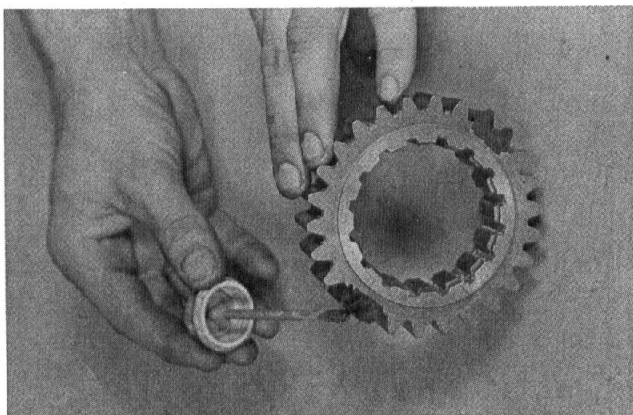
10. Install the 3rd speed gear on the splined washer, clutching teeth down.



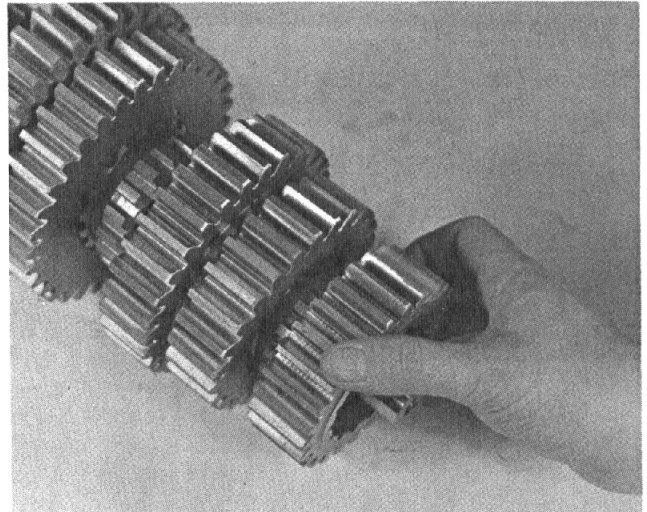
12. Install the 4th speed gear splined washer on the shaft and in the hub of the gear.



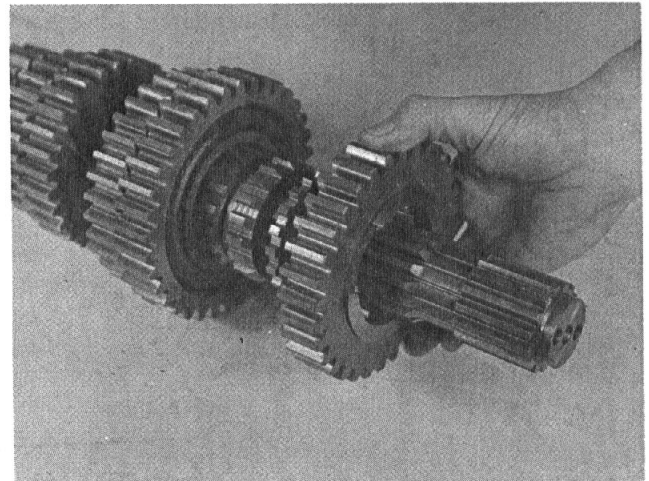
13. Install the snap ring in the groove in the mainshaft to secure the 4th speed gear splined washer.



14. **IMPORTANT:** Mark two adjacent teeth on the drive gear and the two teeth directly opposite for timing purposes.

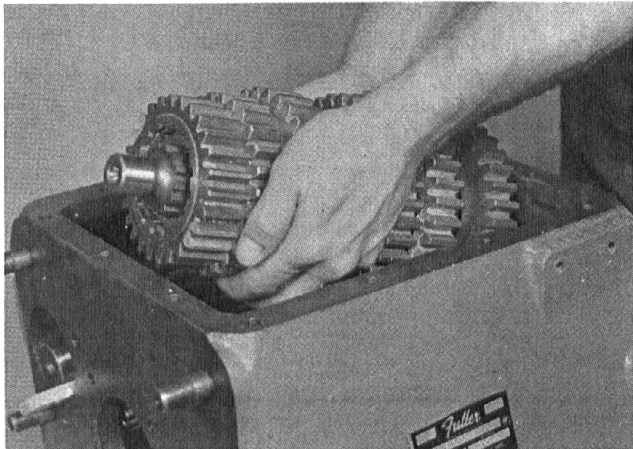


15. Remove the mainshaft from the vise. Install the 4th-5th speed sliding clutch on shaft and install the drive gear against the 4th speed gear, clutching teeth towards the 4th speed gear and engaging the sliding clutch.

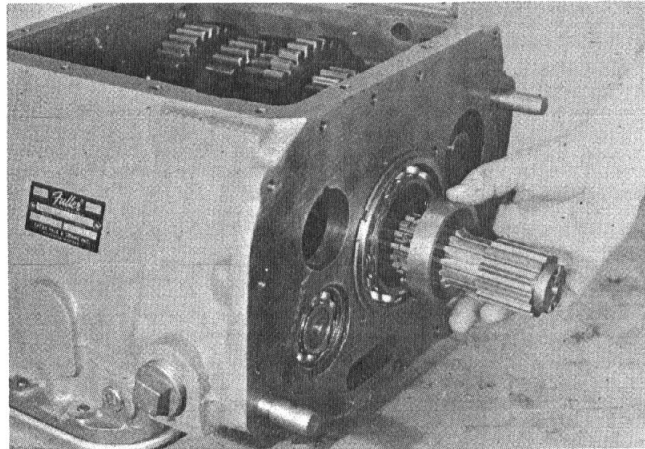


16. Place the reverse gear on the splined washer which is locked to the shaft.

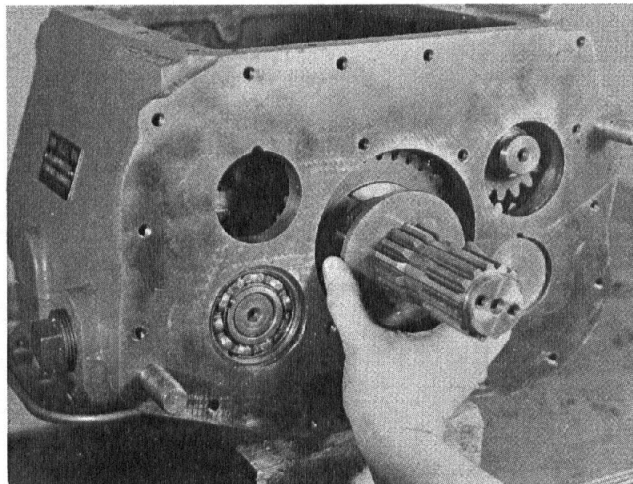
**D. Installation of the Mainshaft Assembly**



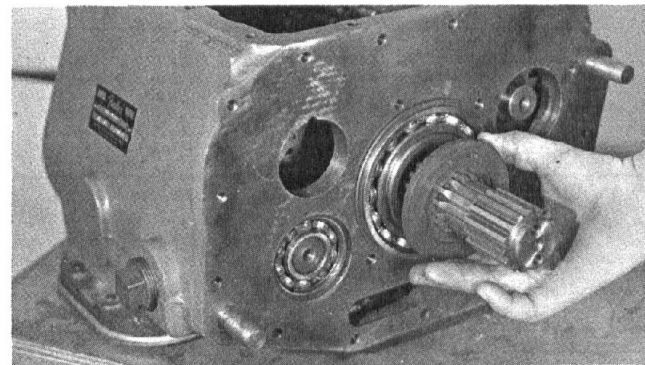
1. Block the right countershaft against the wall of the case and place the mainshaft into position, meshing gears with those of the left countershaft.



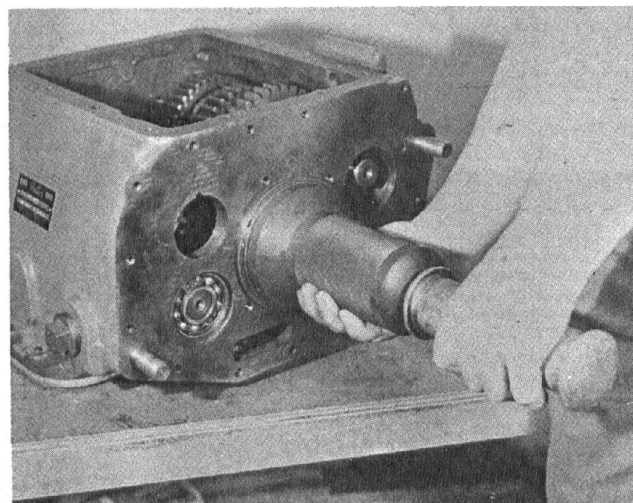
4. Install the six springs in the centering ring using a small amount of grease or equivalent in each of the centering ring bores to hold the springs in place. Place the centering ring on the shaft and slide into the rear bearing against the reverse gear washer.



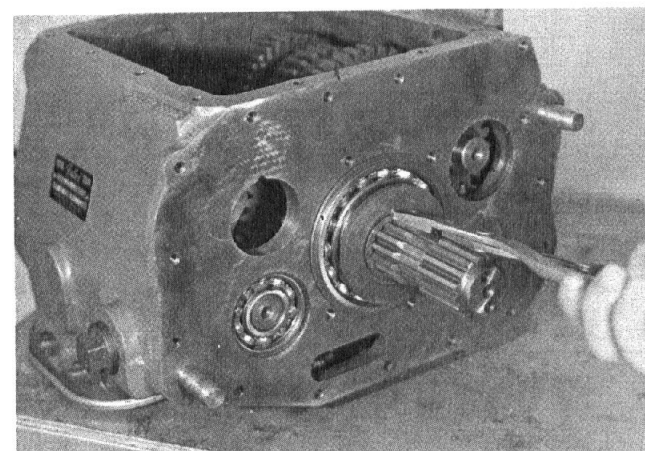
2. Install the reverse gear washer, flat side to the rear.



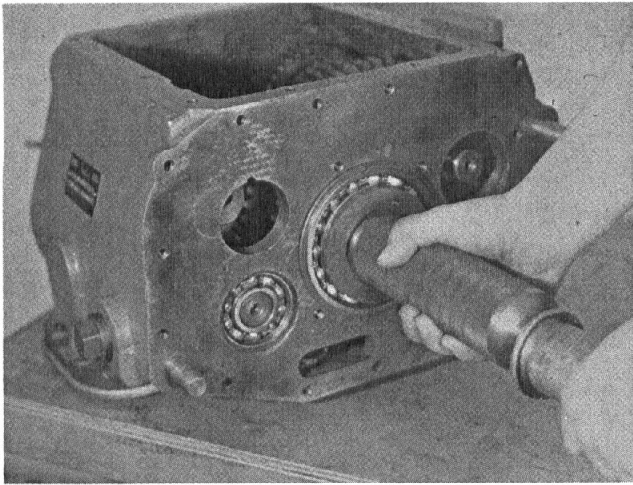
5. Install the splined retainer washer on the shaft, cone surface towards the centering ring.



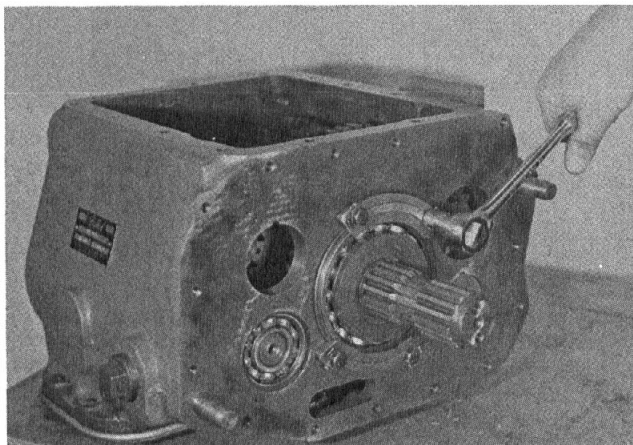
3. Seat the mainshaft rear bearing in the case bore.



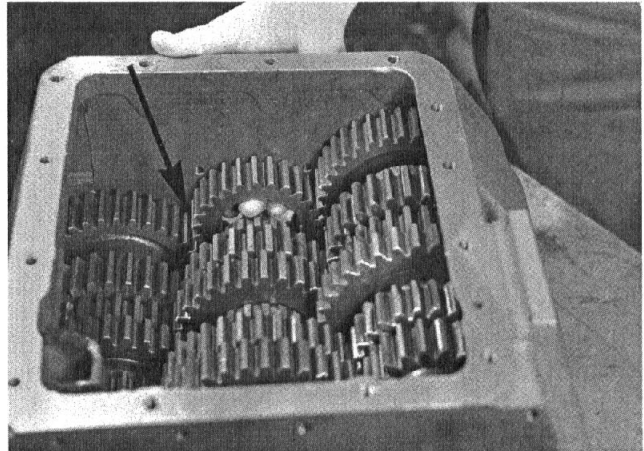
6. Place the snap ring on the shaft against the splined retainer washer.



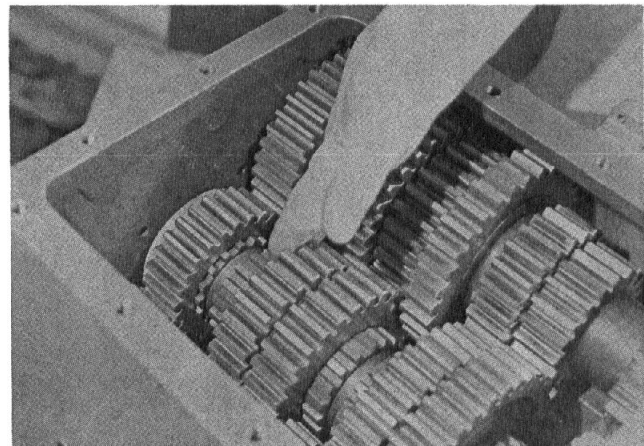
7. Block against the front of the mainshaft and use a sleeve driver to move the centering ring, retainer washer and snap ring forward until the snap ring seats in the groove in the mainshaft.



8. Install the rear bearing retainers and secure the cap-screws with the locking lugs.



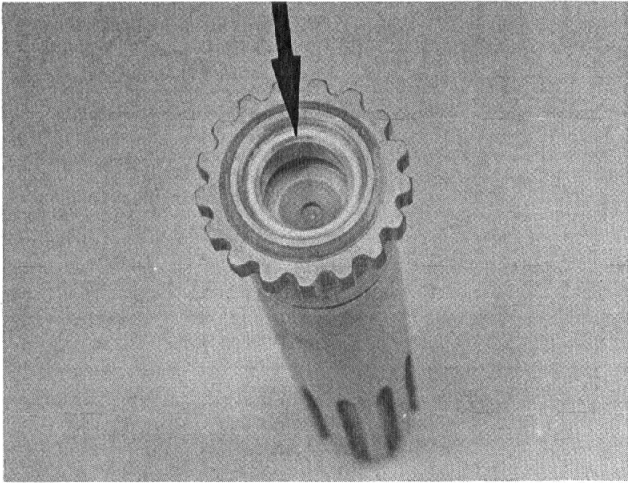
9. Slide the drive gear forward off the splines of the sliding clutch and align the timing marks with the marked tooth on the left countershaft.



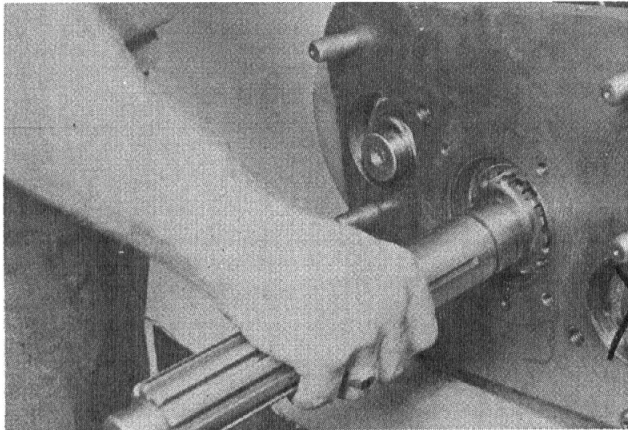
10. Slide the 4th-5th speed sliding clutch forward to engage the splines of the drive gear.



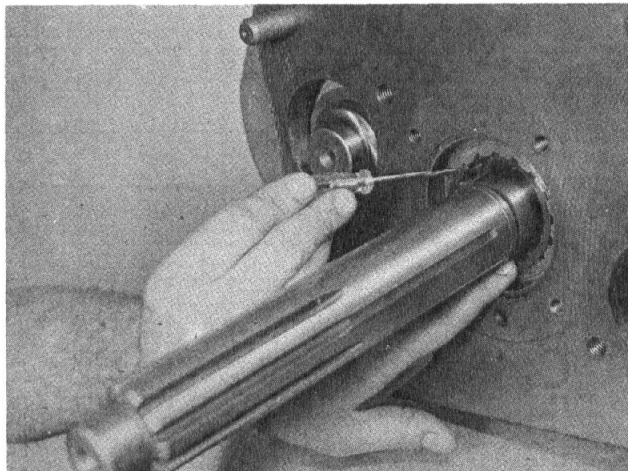
**E. Installation of the Clutch Shaft**



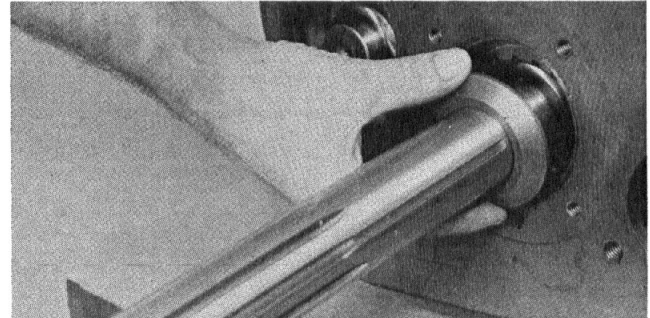
1. If previously removed, install bushing in pocket of clutch shaft; install flush with shaft, making sure that oil hole in shaft is not plugged.



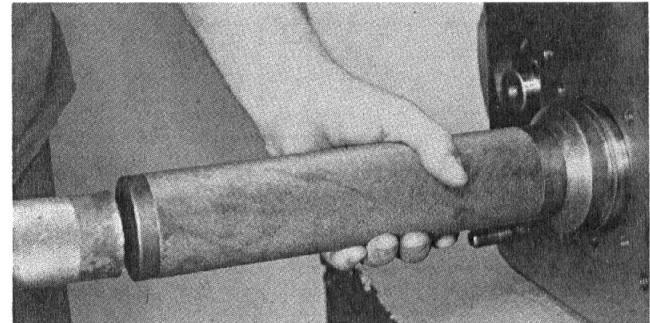
2. Insert the clutch shaft into the drive gear.



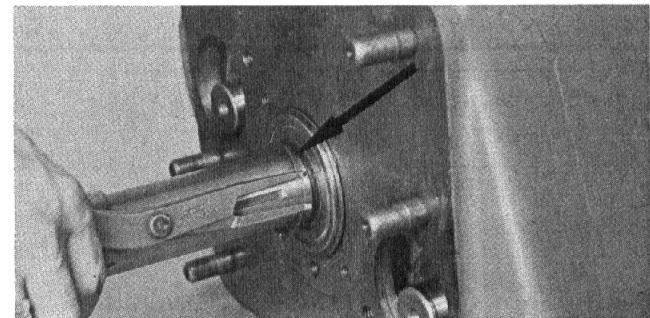
3. Install the snap ring in the inner diameter of the drive gear.



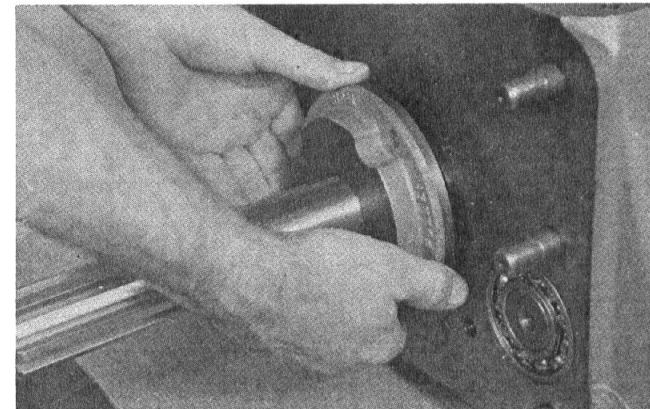
4. Install the spacer on the shaft, flat side against the gear.



5. Install the drive gear bearing on the shaft and in the case bore.

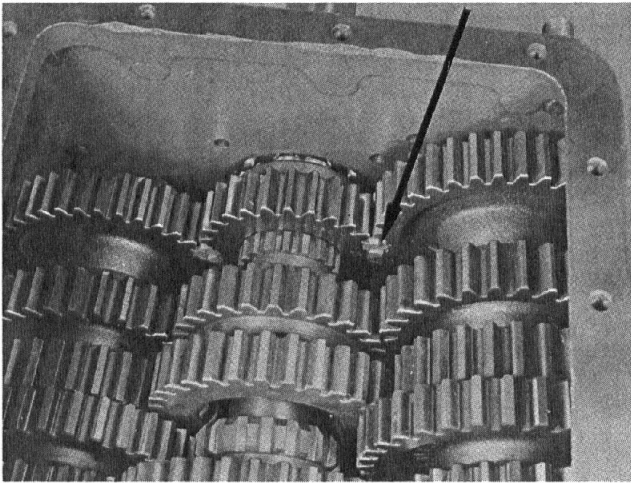


6. Install the snap ring in the groove in the shaft, flat side towards the bearing.

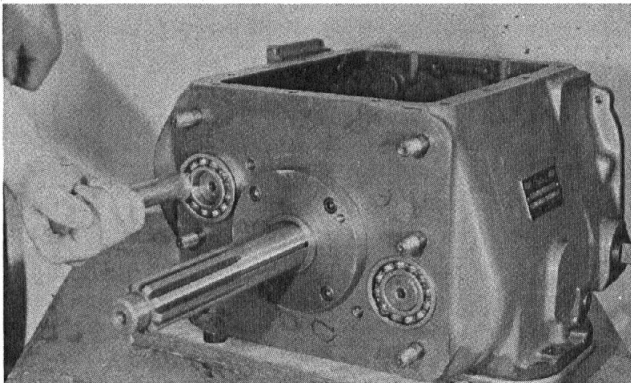


7. Install the front bearing cover or upshift clutch brake.

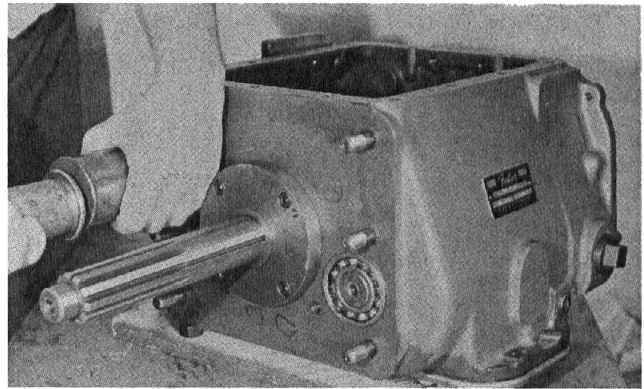
**F. Installation of the Right Countershaft Bearings**



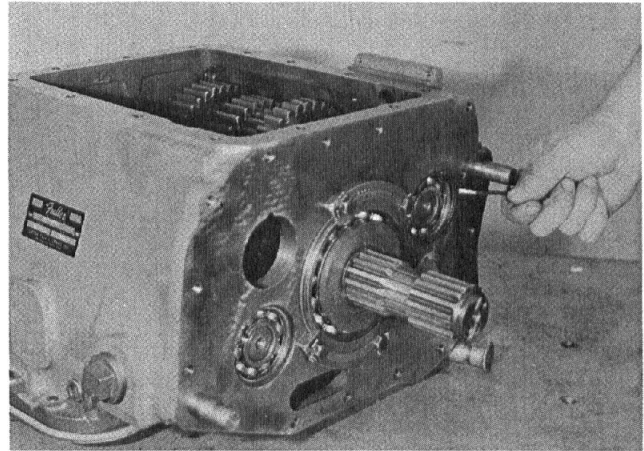
1. Engage the timing tooth on the right countershaft between the two marked teeth on the drive gear, ensuring that the left countershaft is still in time.



2. Center the rear of the shaft in the bore and partially install the front bearing. Partially install the rear bearing.



3. Use a bearing driver to complete the installation of the bearings.



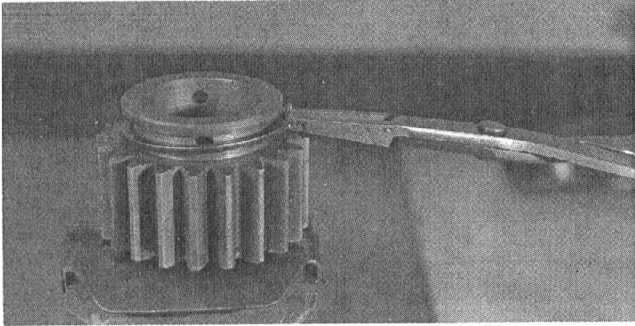
4. Install the snap ring in the groove in the rear countershaft bearing bore. Drive both countershafts back until the rear bearings seat against the snap rings.

**G. Installation of the Left Reverse Idler Gear**

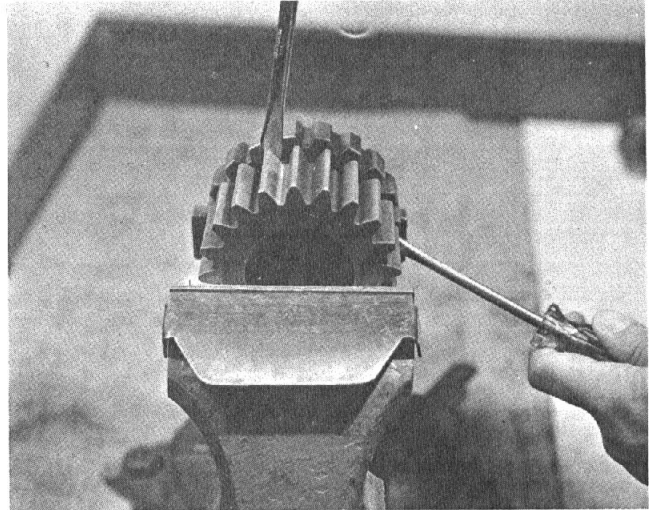
1. The left reverse idler gear is installed in the same manner as the right, as both are identical. Refer to page 50.

## II. AUXILIARY INTERMEDIATE HOUSING

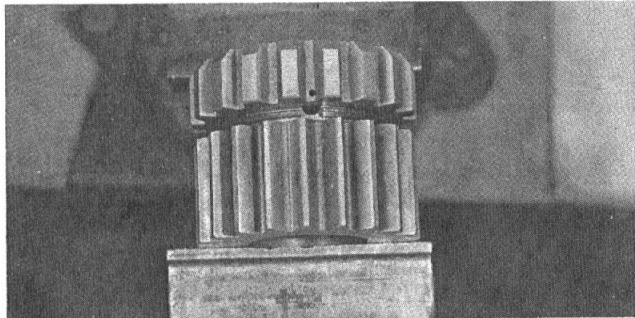
### A. Reassembly of the Auxiliary Drive Gear/Clutch Gear Assembly



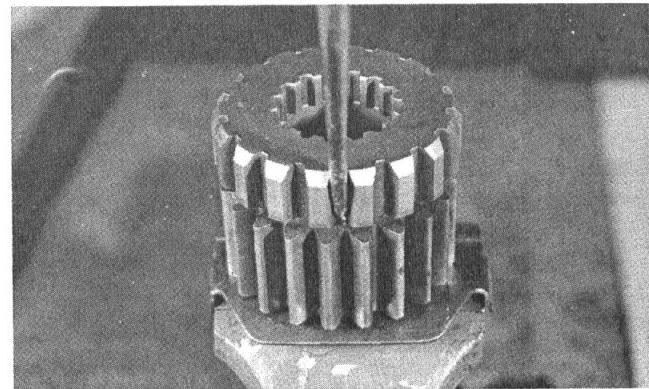
1. If previously removed, install the snap ring on the drive gear, large diameter facing out.



3. Use two screwdrivers to pry the snap ring into position inside the clutch gear.

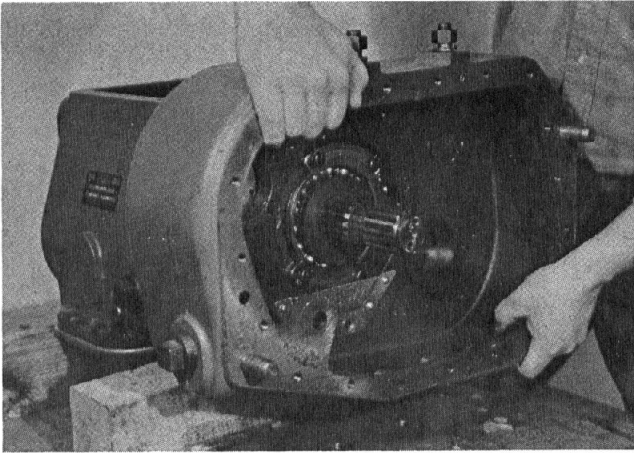


2. Place the small diameter of the drive gear inside the clutch gear and mount the assembly in a vise so that the two gears are forced together. For ease in installation of the retaining pin, place the snap ring so that the open section is underneath the retaining pin hole.

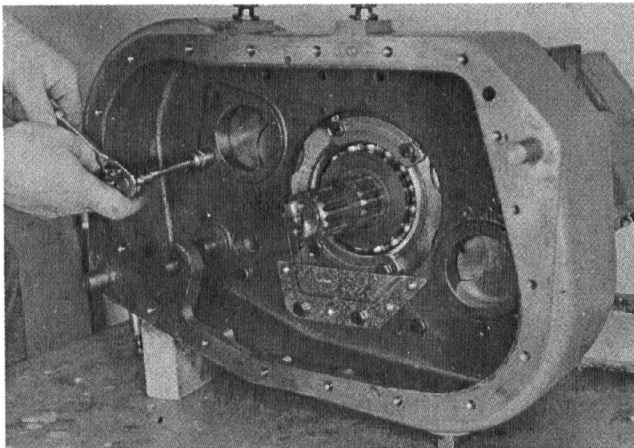


4. Align one of the holes in the drive gear with the retaining pin hole and insert the pin from inside the drive gear into place in the pin hole with the elbow bend facing away from the clutch gear. Turn the drive gear so the pin cannot fall out. Use a hammer and punch to bend the end of the retaining pin down in between the teeth of the clutch gear.

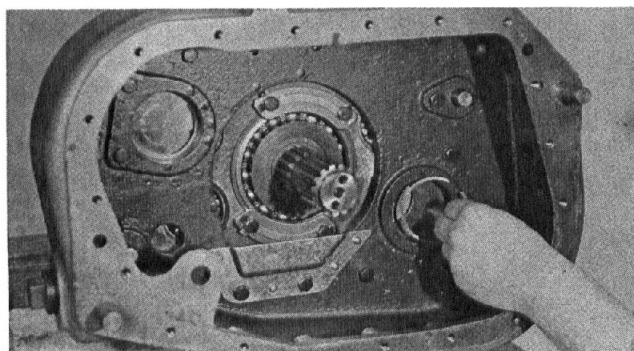
**B. Reassembly of the Intermediate Section**



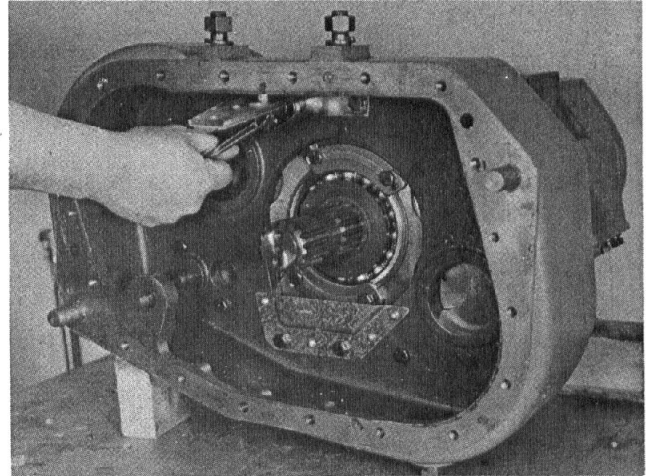
1. Place the intermediate housing on the dowel pins and against the front case.



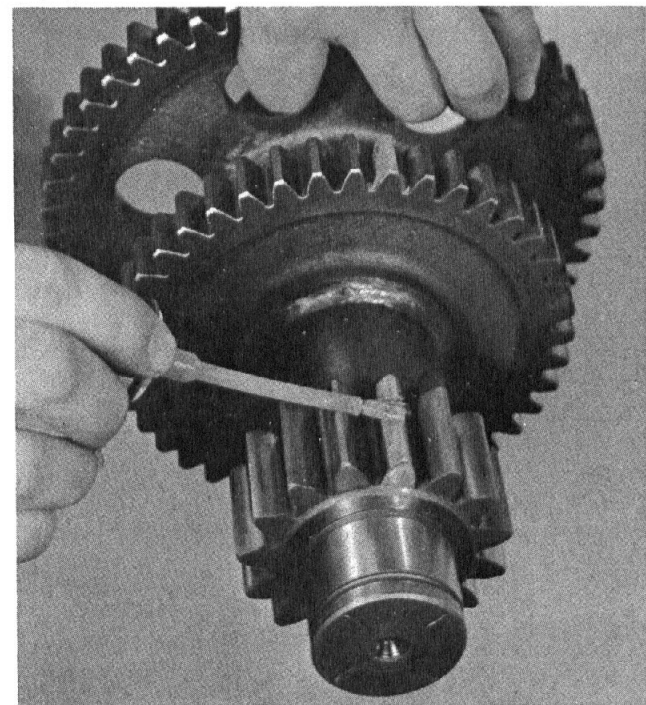
2. Secure the intermediate housing to the front case with 13 capscrews (9 short, 4 long.) DO NOT install capscrews in the two top center holes.



3. Place a snap ring spacer in both front auxiliary countershaft bearing bores.

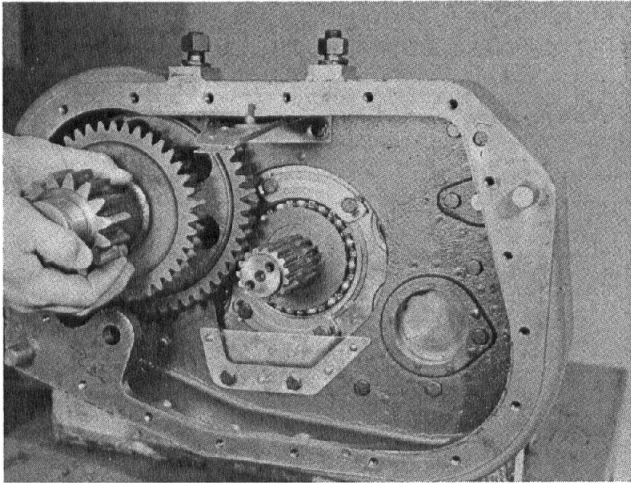


4. Install the metal oil trough in the intermediate housing with two capscrews in the front wall and one capscrew in the top of the housing. The spacer is placed between the oil trough and the top of case.

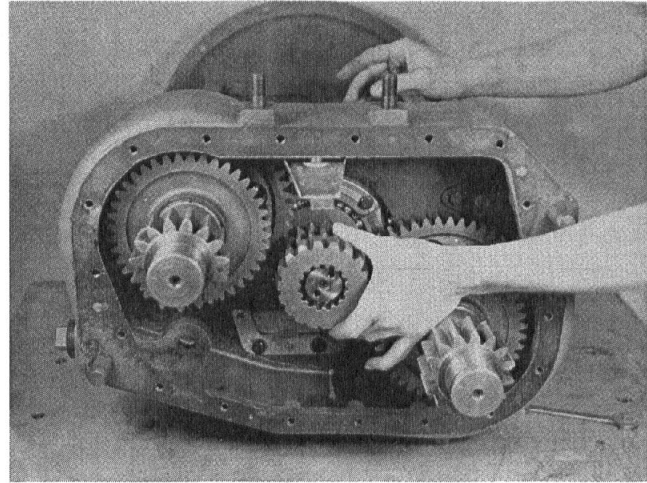


5. **IMPORTANT:** Mark the low speed gear tooth identified with an "O" on each auxiliary countershaft for timing purposes. Then mark the tooth on the intermediate and drive gears which align with this tooth. If previously removed, install the bearing on the front of each countershaft, seating against the shaft shoulder.

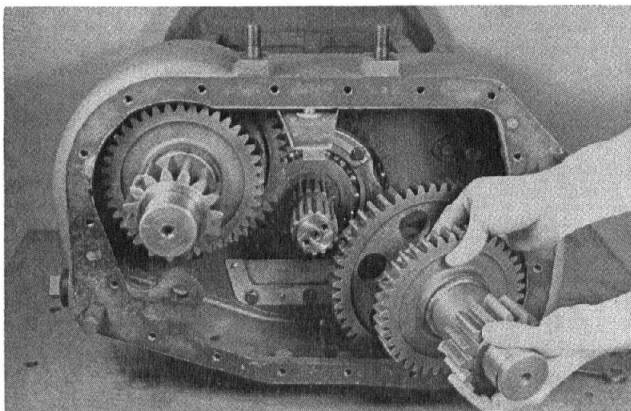
**B. Reassembly of the Intermediate Section – Continued**



6. Place the left countershaft into position, but do not completely seat the front bearing in the bore.

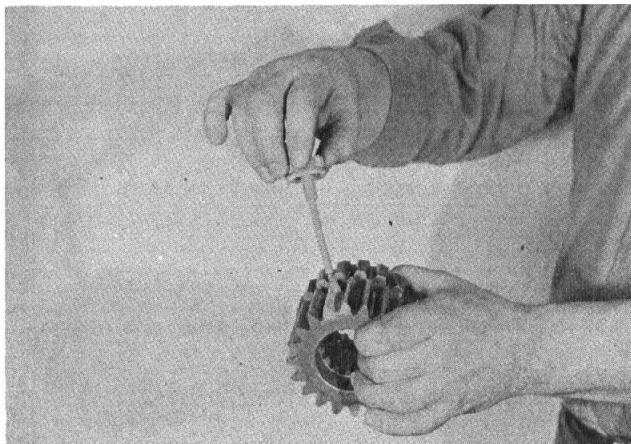


9. Install the auxiliary drive gear and sliding clutch assembly on the splines of the mainshaft, aligning both sections with the splines. Mesh the marked tooth on each countershaft between the marked teeth of the auxiliary drive gear.

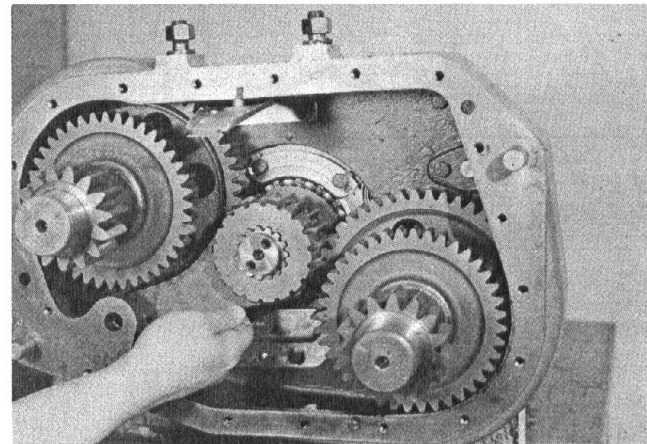


7. Place the right countershaft into position, but do not completely seat the front bearing in the bore.

NOTE: Keep the marked teeth on the countershafts parallel.

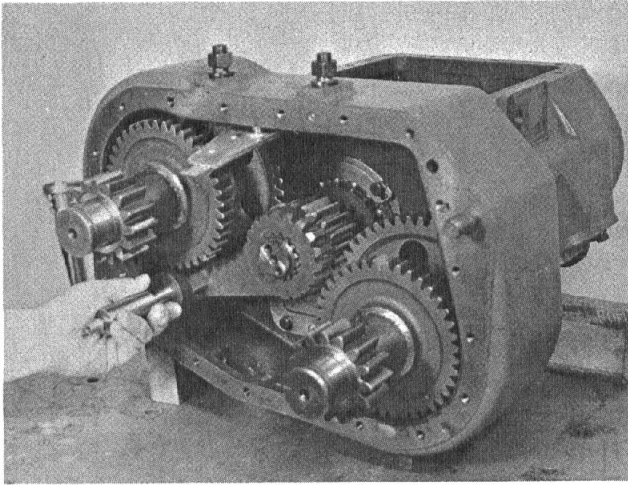


8. On the auxiliary drive gear and sliding clutch assembly mark two adjacent teeth on the drive (larger width) gear and mark the two teeth directly opposite.

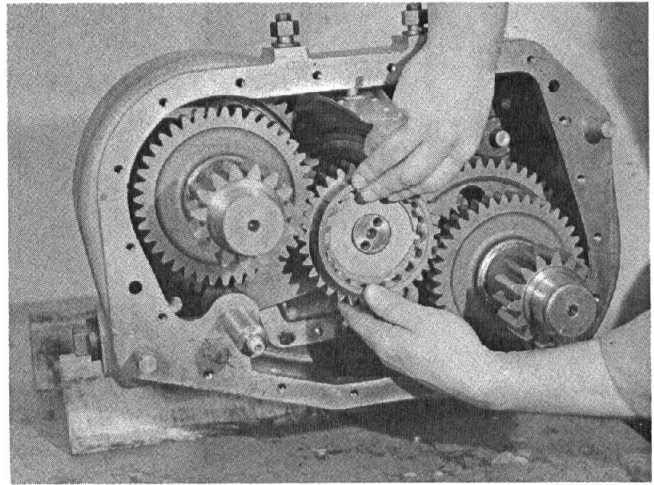


10. Place the intermediate shift yoke in the yoke slot of the auxiliary drive gear/sliding clutch assembly, hub to the rear.

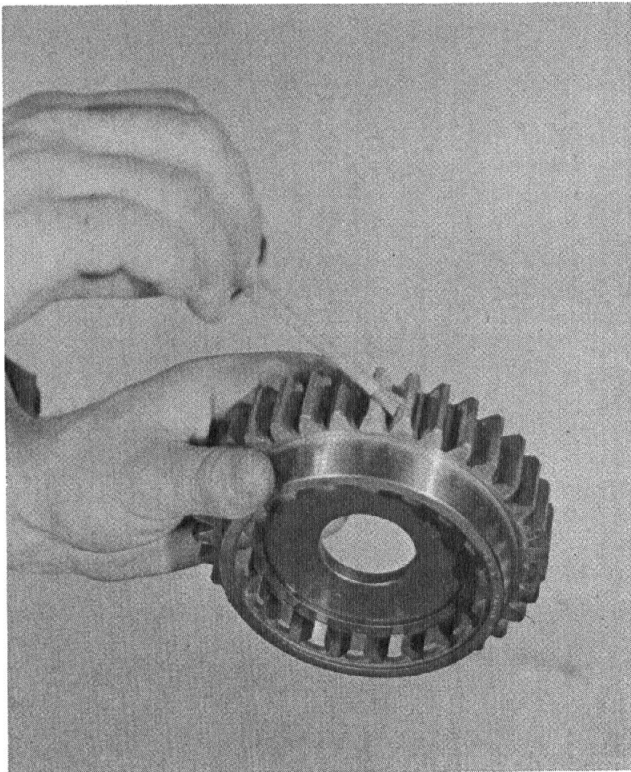
## REASSEMBLY – AUXILIARY INTERMEDIATE HOUSING



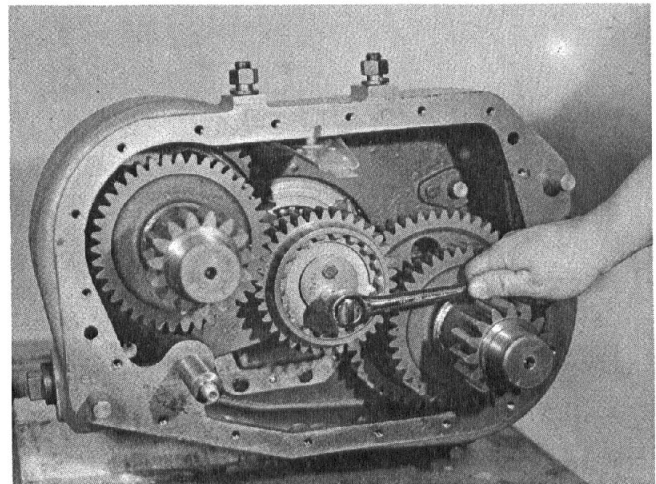
11. Install the intermediate shift shaft through the bore in the housing and the yoke hub. Secure with the lock-screw and wire.



13. Place the drive gear on the rear of the mainshaft, meshing the marked tooth on each countershaft between the marked teeth on the drive gear.



12. If previously removed, install the snap ring, plate, and second snap ring in the inner diameter of the intermediate drive gear, noting that the raised side of the plate faces towards the clutching teeth of the drive gear. Mark two adjacent teeth on the gear and the two teeth directly opposite.



14. Install the retaining plate on the rear of the mainshaft with the two capscrews. Tighten and wire the capscrews securely.