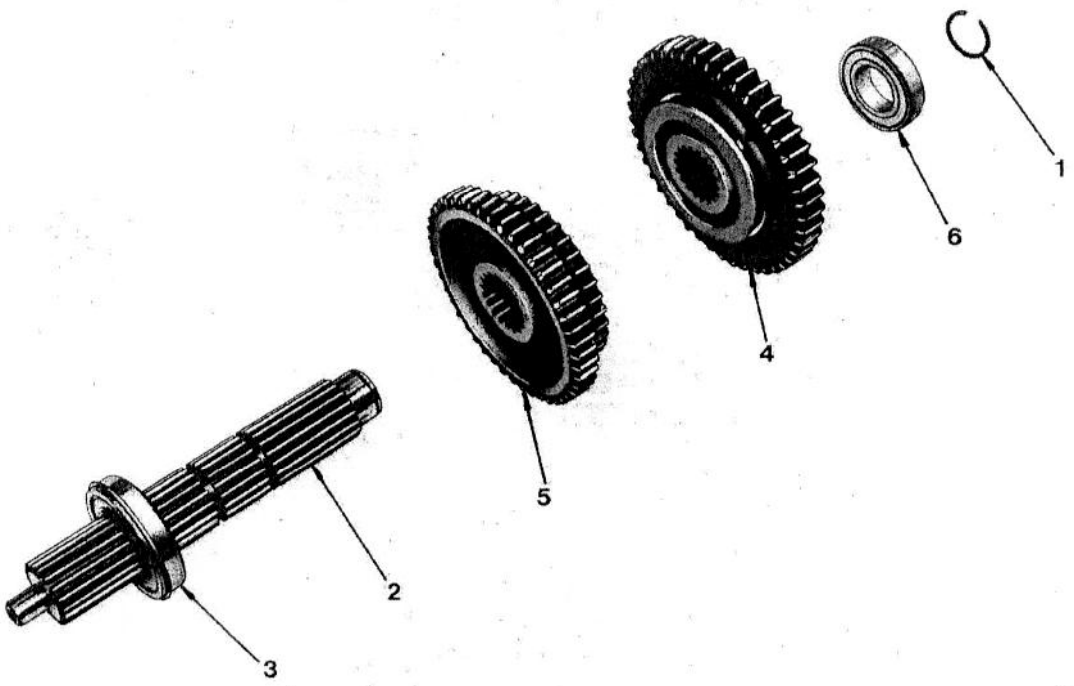

FIG. 8

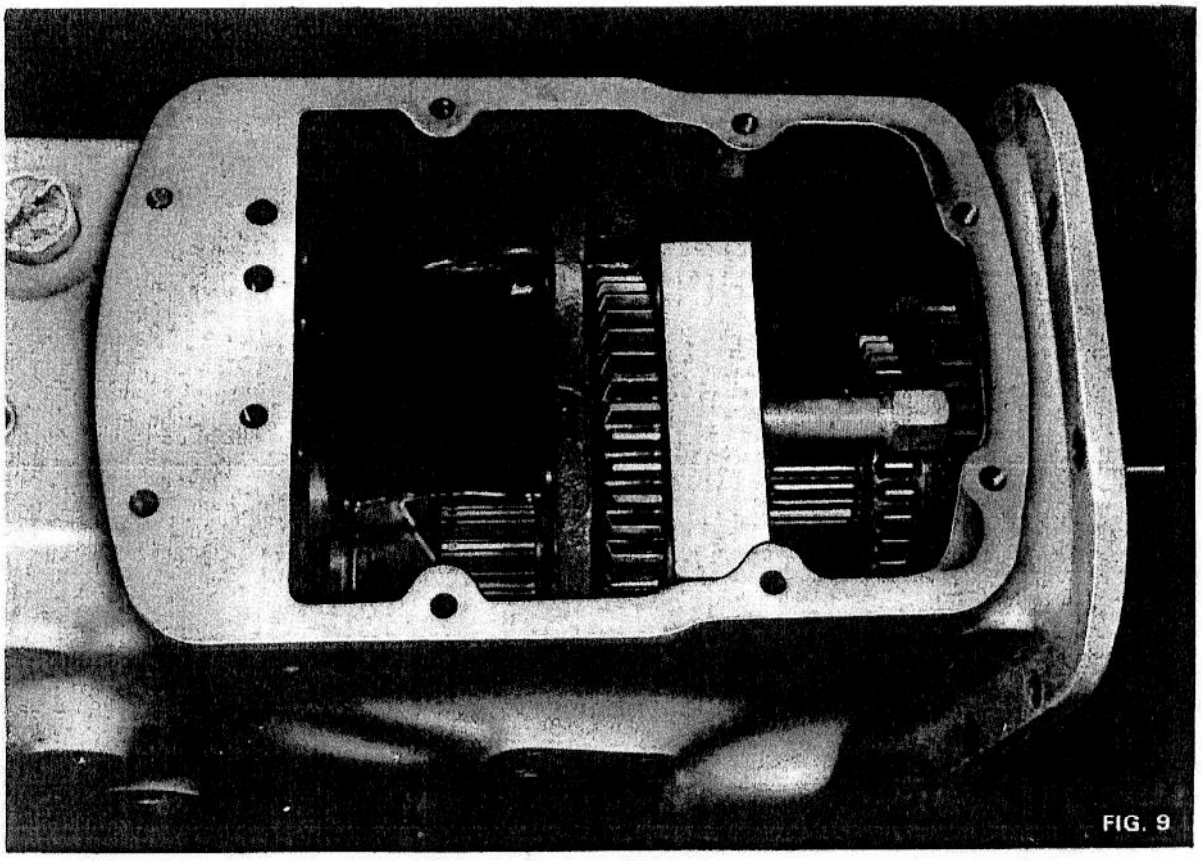

FIG. 9

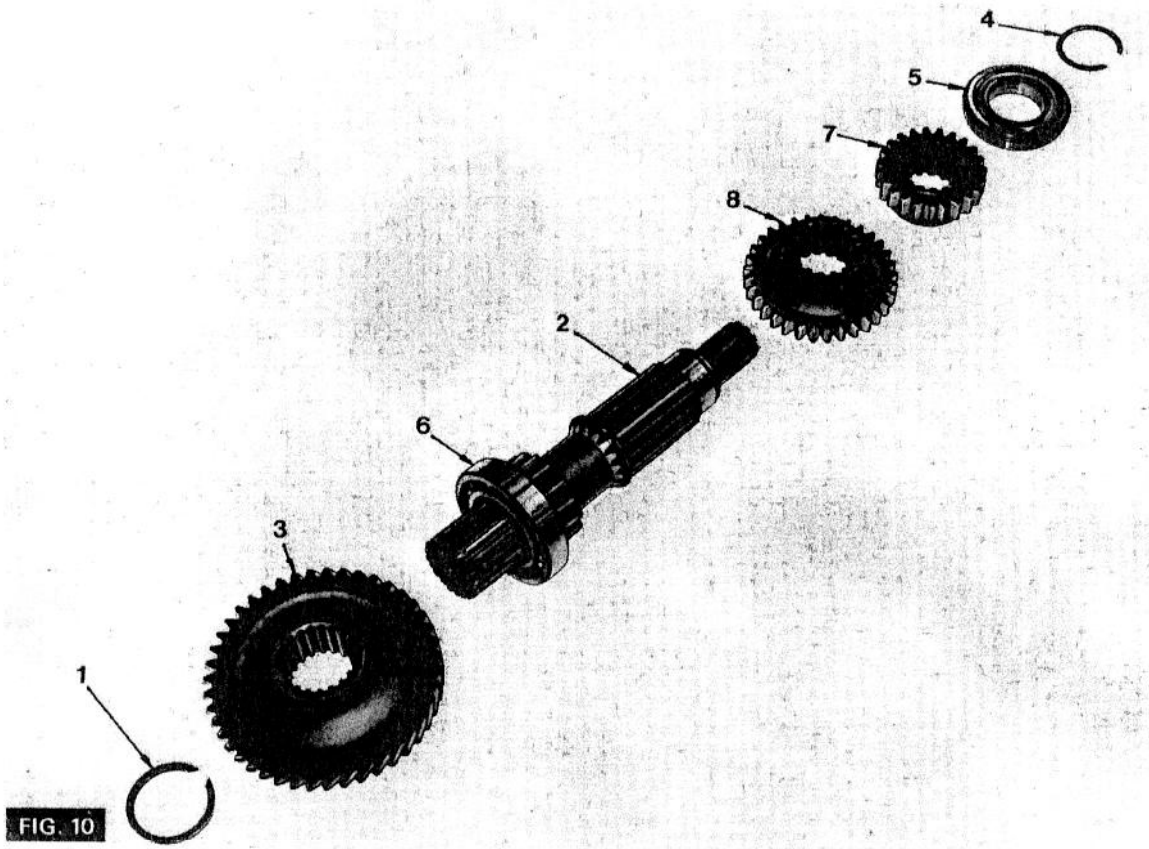

FIG. 10

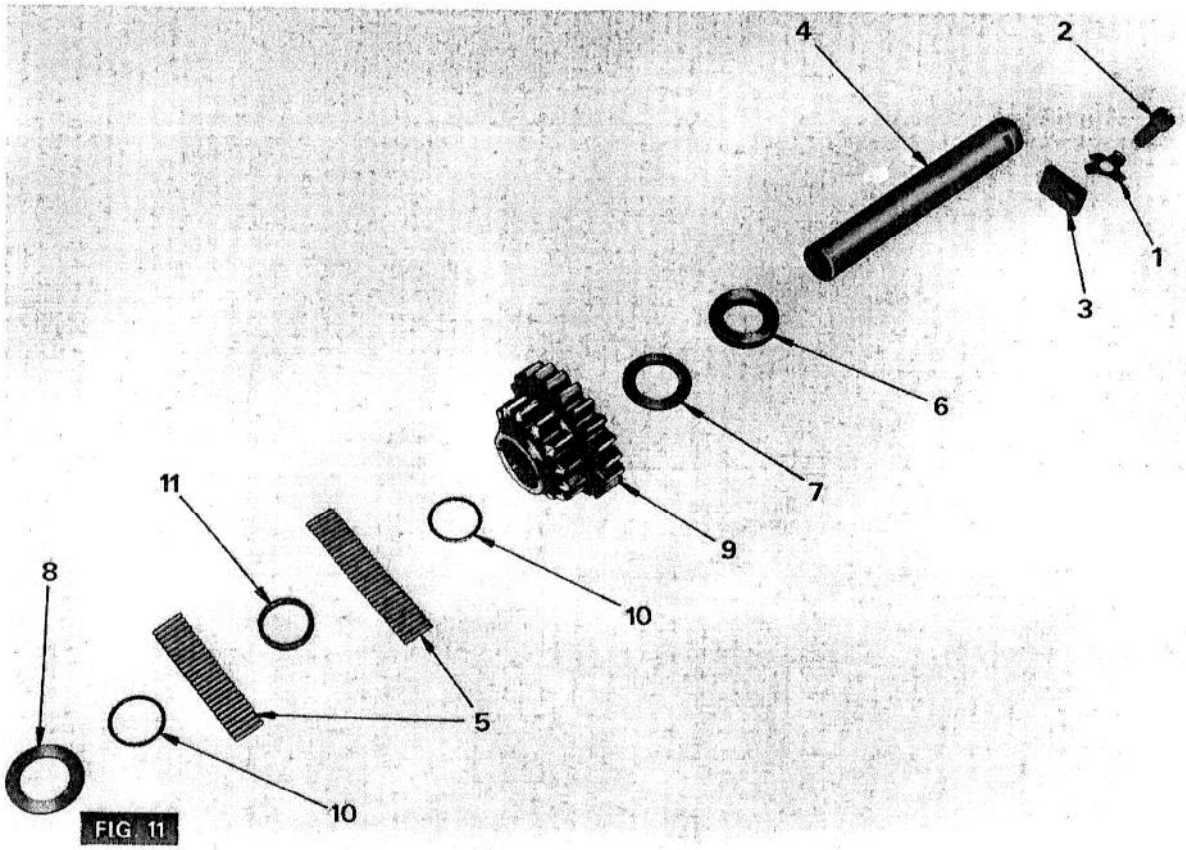

FIG. 11

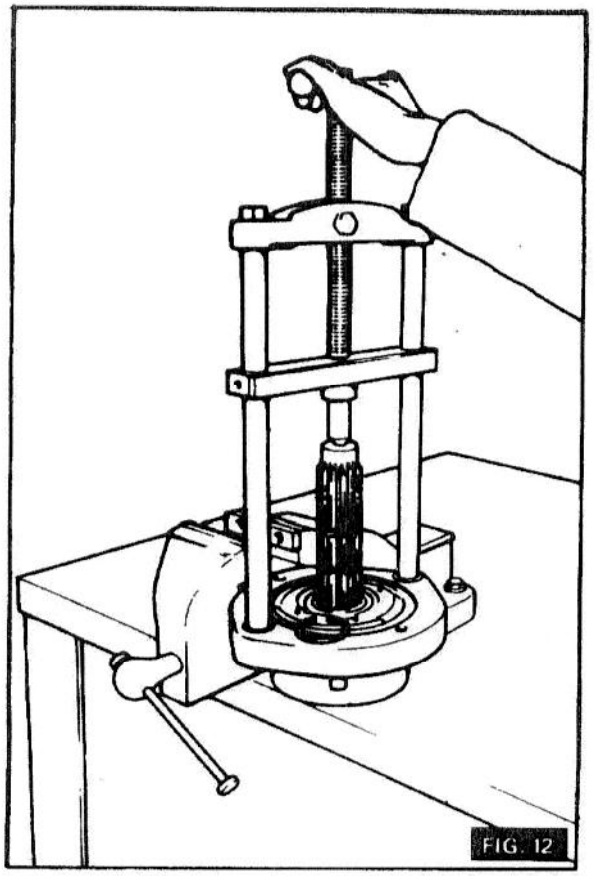

FIG. 12

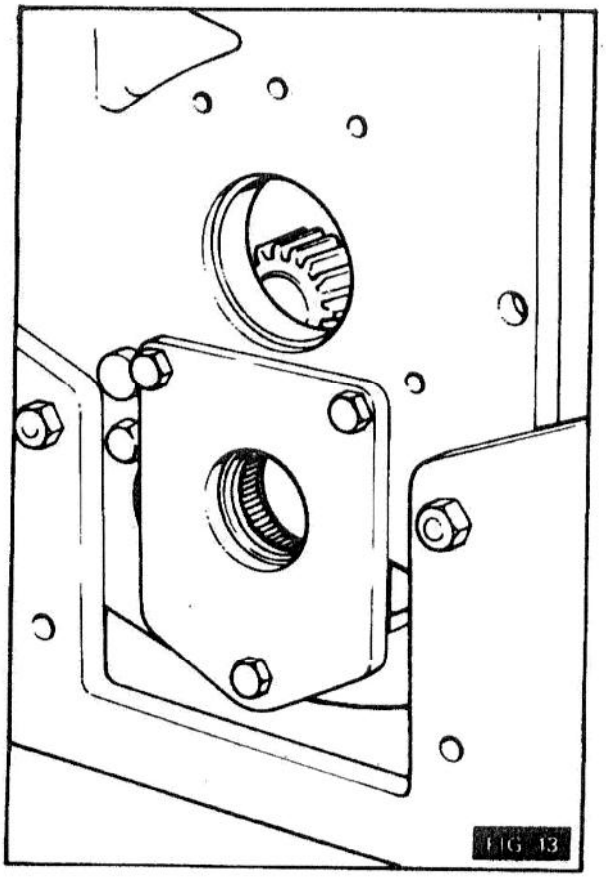

FIG. 13

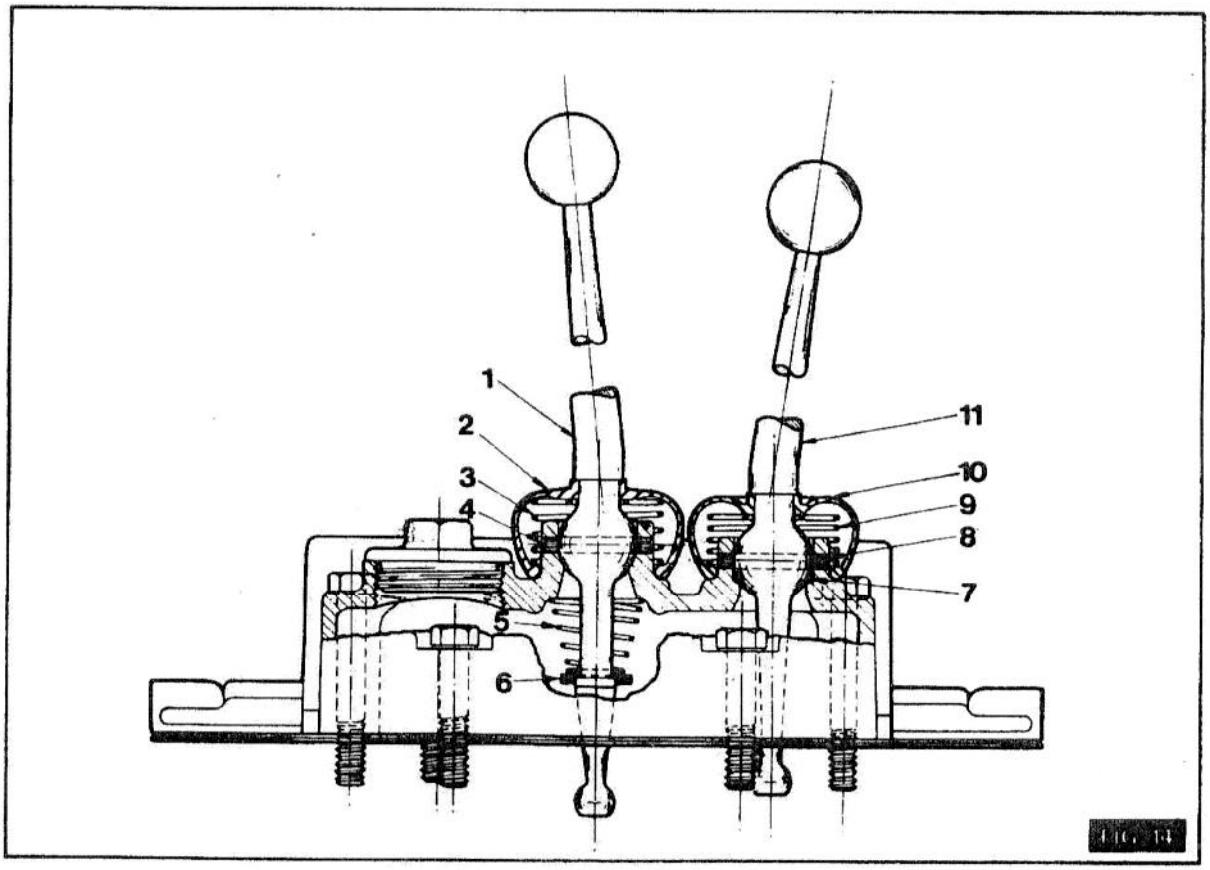

FIG. 14

TRANSMISSION

Reassembly . . . Cont'd

D Main Drive Shaft and Retainer Unit

1. Reassemble and refit as described in operation

E Epicyclic Reduction Unit

1. (Fig. 7) Fit the front thrust washer (6), front cover plate (7) and shim (8) to the planet ring gear (5). Ensure that the grooved face on the front cover face is to the rear.
2. Position the ring gear, dowel located, to the rear face of the transmission housing. Ensure that the front thrust washer is located into its groove in the ring gear.
3. Fit the planet pinion carrier assembly (4) to the ring gear.
4. Assemble the rear thrust washer (3) to the carrier and the rear cover plate (2) to the ring gear. Ensure that the grooved face on the rear cover plate is facing forwards.
5. Secure the epicyclic reduction unit with four bolts and spring washers (1).

F Shift Rails and Forks

1. (Fig. 6) Fit the high/low shift rail (5), slide the high/low shift selector (4) onto the rail and secure with a locking peg (3). Wire lock the peg to the rail.
2. Locate the 1st/Rev. shift fork (9) and the 2nd/3rd shift fork (12) to their respective grooves in the mainshaft gears. The two forks are identical.
3. Assemble the 1st/Rev. shift rail (10) and 2nd/3rd shift rail (13) with interlock pin grooves facing each other, to the forks. Secure each fork with its locking peg (8) (11). Wire lock the pegs to the rails. The shorter 2nd/3rd shift rail (13) is fitted to the left hand side.
4. Locate the high/low shift fork (6) to the groove in the coupler. Assemble the coupler into the planet pinion carrier assembly, simultaneously sliding the fork (6) onto the high/low shift rail (5).
5. Secure the high/low shift fork (6) to its rail with the locking peg (7). Wire lock the peg to the rail.
6. Fit interlock pin (17) to the stop plate (14) and secure the stop plate with two bolts (15) and spring washers (16).
7. Fit the three plungers (2) (pointed and downwards) and the three springs (1).

G Clutch Release

1. Fit the clutch release shafts and fork as described in items 2—4 in operation 6A/3.

When transmission assembly is complete replace the transmission into the machine as stated in operation 6A/6.

GEAR SHIFT LEVER

Disassembly and Reassembly (6A/9)

1. Remove the steering box as described in operation 5B/3.
2. Remove the eight bolts securing the transmission cover to the transmission housing, then lift the cover complete with levers off the machine.
3. (Fig. 14) Release and remove the spring retaining seat (6) from the lower end of the gear lever (1) then remove the spring (5).
4. Remove the gear lever rubber cover (2) and spring (3) fitted under the cover.
5. Drive out the pin (4) securing the gear lever (1) to its housing.
6. Lift out the gear lever (1).
7. Reassembly is a reversal of the above procedure.

TRANSMISSION

HIGH/LOW RANGE GEAR SHIFT

Disassembly and Reassembly 6A/10

1. Remove transmission cover as in items 1 and 2 of operation 6A/9.
2. (Fig. 14) Remove the rubber cover (10) and spring (9), fitted under the cover.
3. Lift out the lever (11) and 'O' ring (7).
4. Reassembly is a reversal of the above procedure.

CLUTCH

CONTENTS

LIST OF ILLUSTRATIONS

CLUTCH

General

A heavy duty single clutch 12" diameter is used on the MF 50B Fig.1. The primary plate is operated by a pressure plate against the flywheel.

Pressure plate movement is obtained by three clutch release levers which, when the clutch pedal is depressed, causes the pressure plate to move rearwards against spring pressure and break the drive from the engine to the transmission.

DATA

Friction Disc Diameter	12" (30.48 cm.)
Coil Springs	
Number	12
Colour	Red
Fitted Load	117 lb ± 5% (53.07 kg. ± 5%)
Free Length (approx.)	2.32 " (58.93 mm.)
Release Levers	
Height From Flywheel Face	4.406" / 4.469" (111.912 / 113.513 mm.)
Clutch Pedal	
Free Movement Measured between Clutch Pedal and rear of floorplate slot	1" (2.54 cm.)

WARNING

SPRING PRESSURE WILL CAUSE THE CLUTCH COVER TO FLY APART IF PRESSURE IS NOT RELEASED SLOWLY AND EVENLY. THE GIVEN SEQUENCE OF INSTRUCTIONS MUST BE CAREFULLY FOLLOWED.

CLUTCH UNIT

Removal (6B/1)

1. Split the machine between transmission and engine as described in operation 6A/1.
2. (Fig. 2) Fit three slave bolts 1/4" U.N.F. by 2 1/8" (53.98 mm) to the three equispaced holes in the clutch cover plate.
3. Progressively slacken and remove the six bolts that secure the clutch assembly to the flywheel. Detach the complete clutch assembly from the flywheel.
4. If necessary the clutch release mechanism in the bell housing of the transmission case, can be serviced as stated in operations 6A/3 and 6A/4.

Replacement (6B/2)

1. Fit the friction disc to the flywheel with the splined boss falling away from the flywheel. A very slight smear of H.M.P. grease should be applied to the friction disc splines.
2. Position the clutch assembly onto the flywheel and centralise the assembly and friction disc with centralising tool MF 159A.
3. Fit the six bolts and washers securing the clutch to the flywheel and progressively tighten the bolts.
4. Remove the three 1/4" U.N.C. slave bolts and then the centralising tool.

Disassembly (6B/3)

1. Remove the clutch assembly from the flywheel as stated in operation 6B/1
2. Release the three tab washers and remove the six bolts which secure the flywheel to the engine and lift off the flywheel.

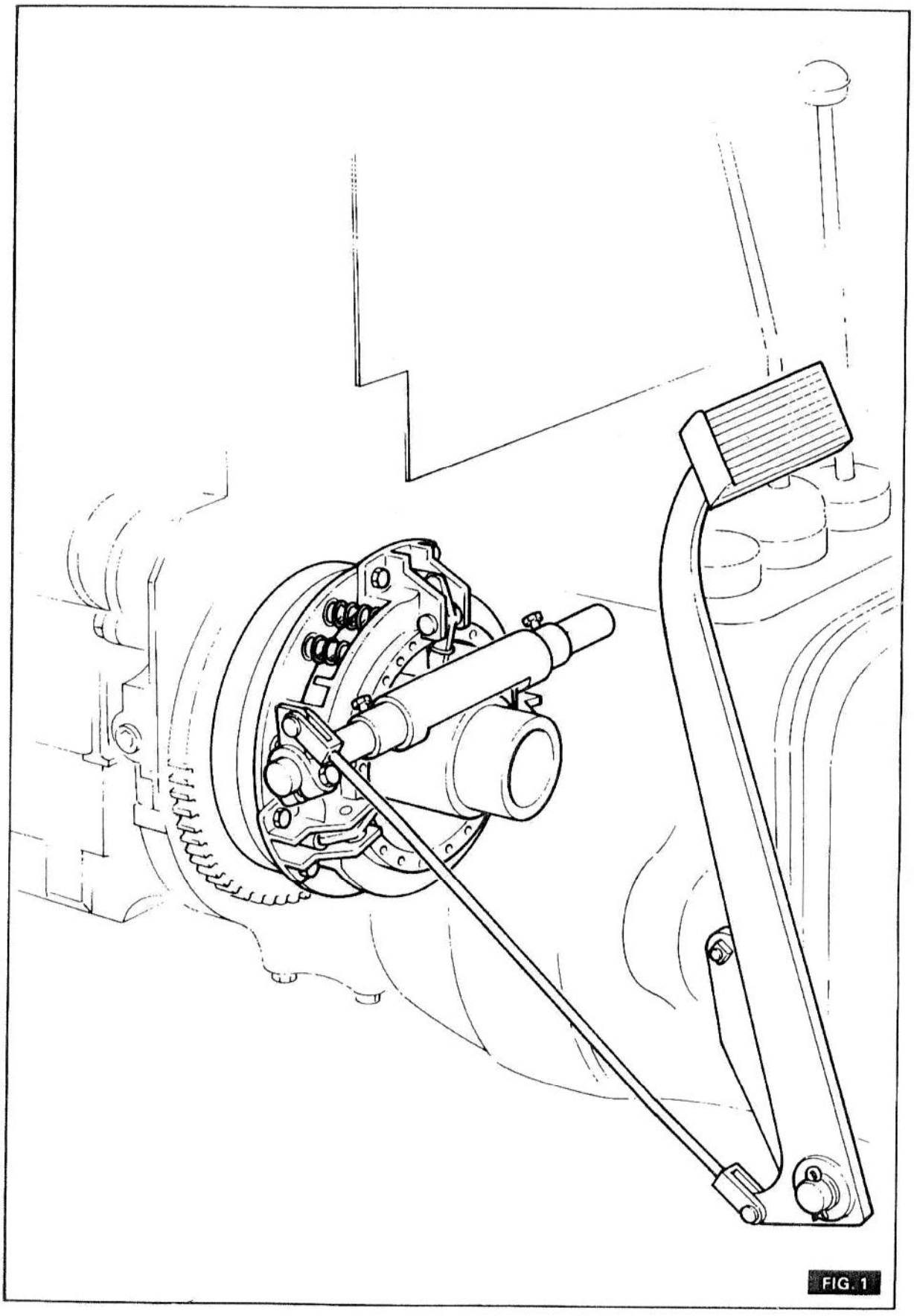

FIG. 1

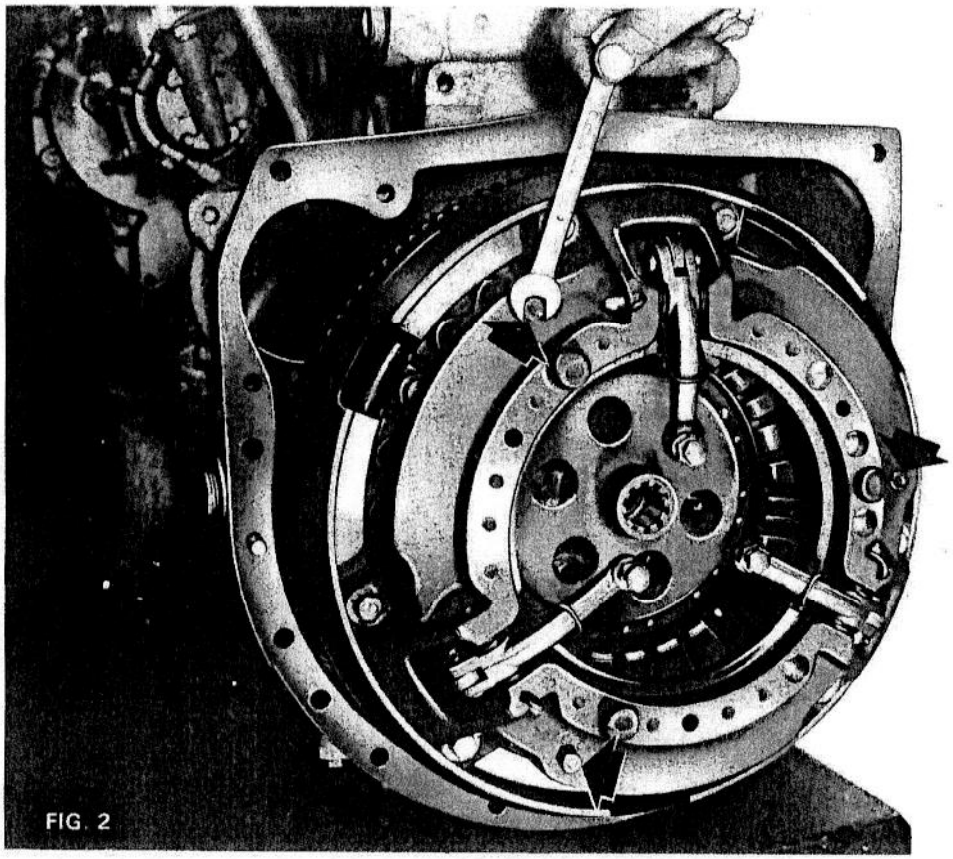

FIG. 2

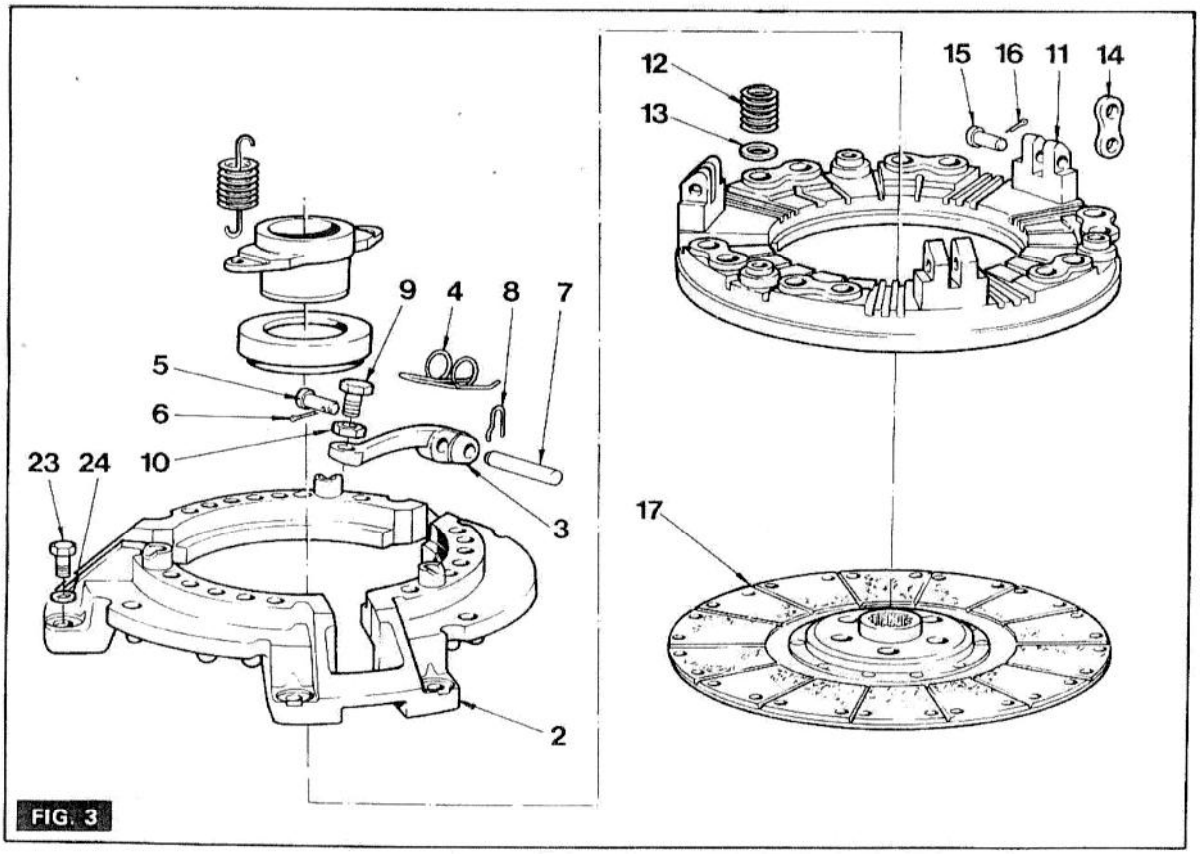

FIG. 3

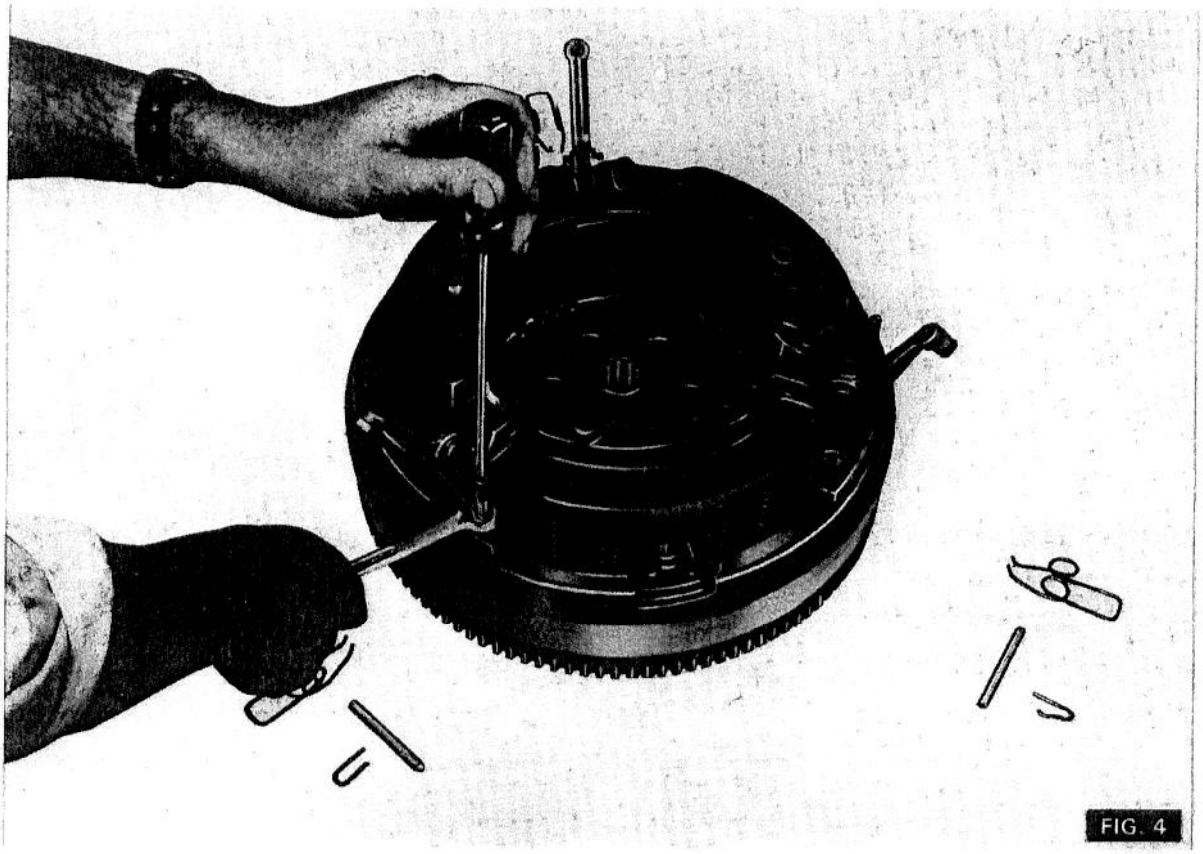

FIG. 4

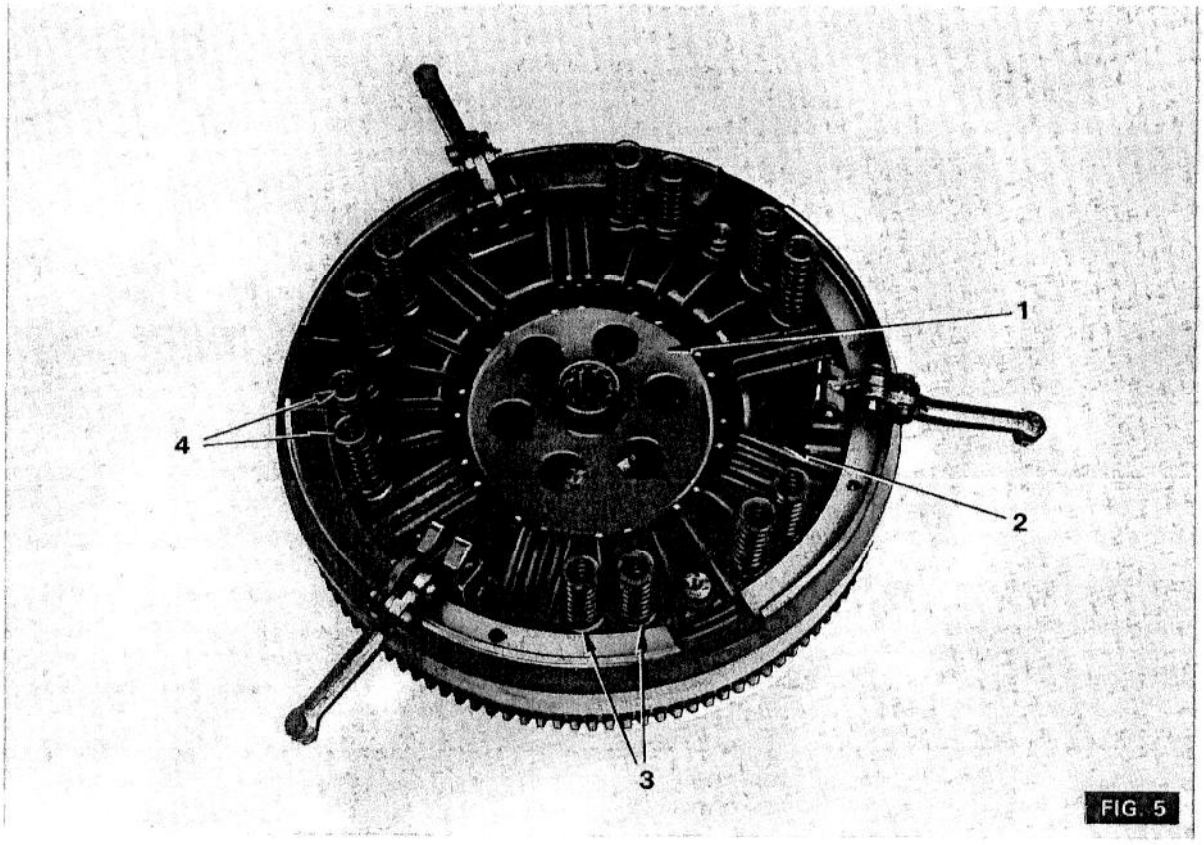

FIG. 5

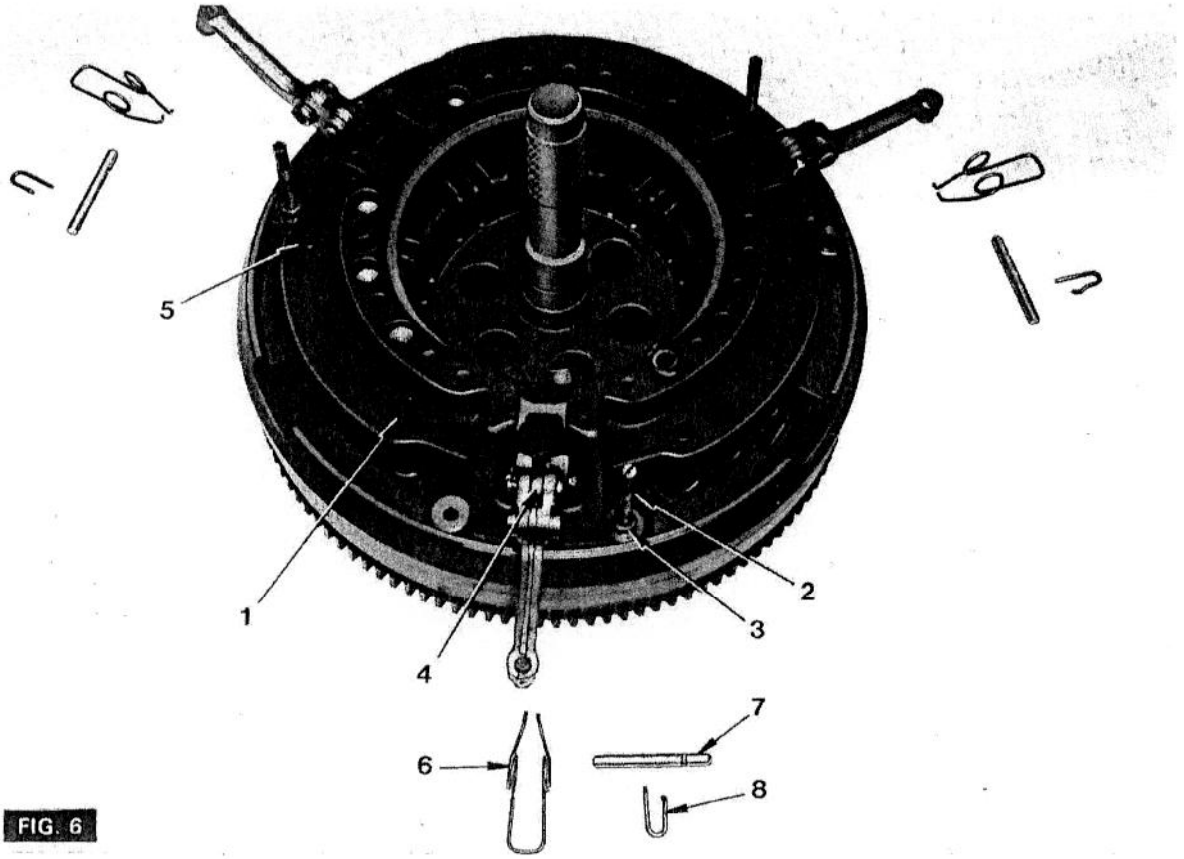

FIG. 6

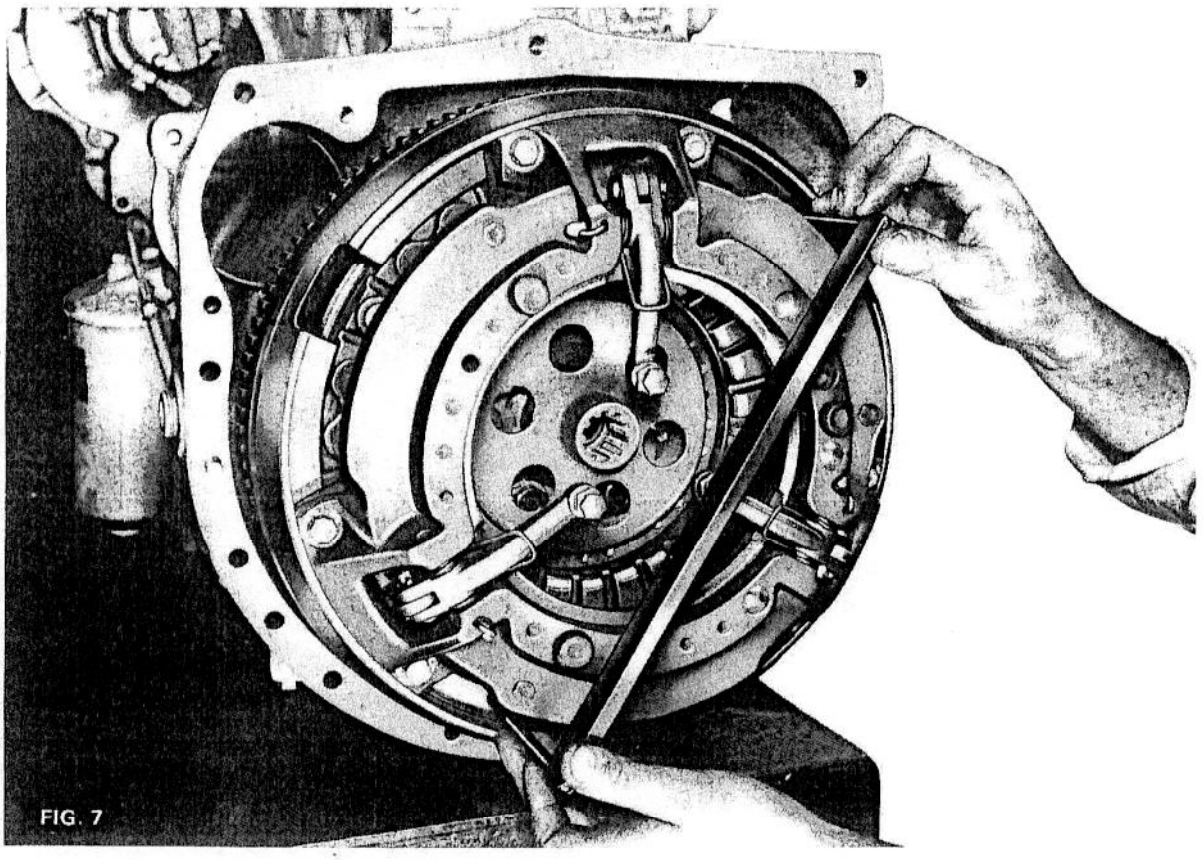

FIG. 7

CLUTCH UNIT

Disassembly . . . Cont'd

3. (Fig. 3) Mark the cover plate (2) and pressure plate (11) so that they can be reassembled in the same relative position.
4. Fit the friction disc (17) and the clutch assembly to the flywheel using three setscrews 5/16" U.N.C. by 3 1/4" (82.55 mm) equispaced in three of the six holes in which the clutch to flywheel bolts were fitted.
5. Screw in the setscrews as far as possible and secure each setscrew with a locknut.
6. Remove the clips (8) which secure the release lever pivot pins (7) and remove the pivot pins.
7. Remove the release lever securing springs (4).
8. Progressively slacken and remove the three 1/4" U.N.C. slave bolts.
9. (Fig. 4) Progressively slacken the three 5/16" U.N.C. locknuts two flats at a time until all spring pressure has been released. Remove the three slave setscrews.

Note

Spring pressure can also be released by using a press. Proceed as follows :—

Mount the clutch assembly on the press cover plate upwards and position a suitable bar across the centre of the cover plate, clear of the release levers. Compress the clutch assembly until the three 1/4" U.N.C. slave bolts can be removed, then gradually release the press.

10. (Fig. 3) Remove the following components. Cover plate (2), twelve coil springs (12), twelve washers (13), three release levers (3), pressure plate (11) and drive plate (17).

Reassembly (6B/4)

1. (Fig. 5) Place the friction disc (1) on the flywheel. Ensure that the splined boss faces away from the flywheel.
2. Fit the pressure plate (2) noting the position of the mark.
3. Position the twelve washers (3) onto the pressure plate.
4. Locate the twelve red springs (4) onto the washers.
5. (Fig. 6) Place the cover plate (1) on top of the springs passing the three release levers through the plate. Align the mark on the cover plate with the mark on the pressure plate. Ensure that the coil springs are correctly located.
6. Fit centralising tool MF 159A.
7. Refit the three 5/16" U.N.C. slave setscrews (2), and screw in as far as possible. Fit a locknut (3) to each screw.
8. Progressively tighten the three locknuts ensuring during tightening that the three release lever links (4) do not contact the cover plate.

Note

The clutch springs can also be compressed by using a press. Proceed as follows :—

Mount the clutch assembly on the press, cover plate upwards and position a suitable bar across the centre of the cover plate clear of the release levers. Compress the clutch assembly until the three 1/4" U.N.C. slave bolts can be fitted.

9. Refit and tighten the three 1/4" U.N.C. slave bolts (5).
10. Refit the release lever securing springs (6), locating the ends of the springs into the recesses in the cover plate.
11. Refit the release lever pivot pins (7) and securing clips (8). Locate the clips into the slots in the pivot pins.
12. Remove the centralising tool MF 159A and progressively slacken and remove the three 5/16" U.N.C. locknuts (3) and setscrews (2).
13. Refit the flywheel to the engine. Torque the flywheel bolts to 75 lb. ft. (10.37 Kg.m.).
14. Reattach the clutch assembly to the flywheel as stated in operation 6B/2

CLUTCH RELEASE LEVERS

Adjustment (6B/5)

1. (Fig. 7) Fit gauge MF 314 to the clutch assembly as shown and check the height of each release lever. The domed head of the release lever setscrew must be just touching the gauge.
2. If necessary adjust setscrew by slackening the locknut and moving setscrew in required direction. Tighten the locknut after adjustment.

CLUTCH PEDAL

Adjustment (6B/6)

1. (Fig. 8) Slacken the pinch bolt (1) on the clutch actuating lever.
2. Using a tommy bar rotate the actuating shaft (2) clockwise against the resistance of the internal return springs until all free travel is taken up.
3. Holding the shaft in this position set the pedal lever to dimension 'A'. Dimension 'A' is 1" (2.54 cm.) and tighten the pinch bolt to a torque of 76–85 lb.ft. (10.51–11.76 Kg.m.).

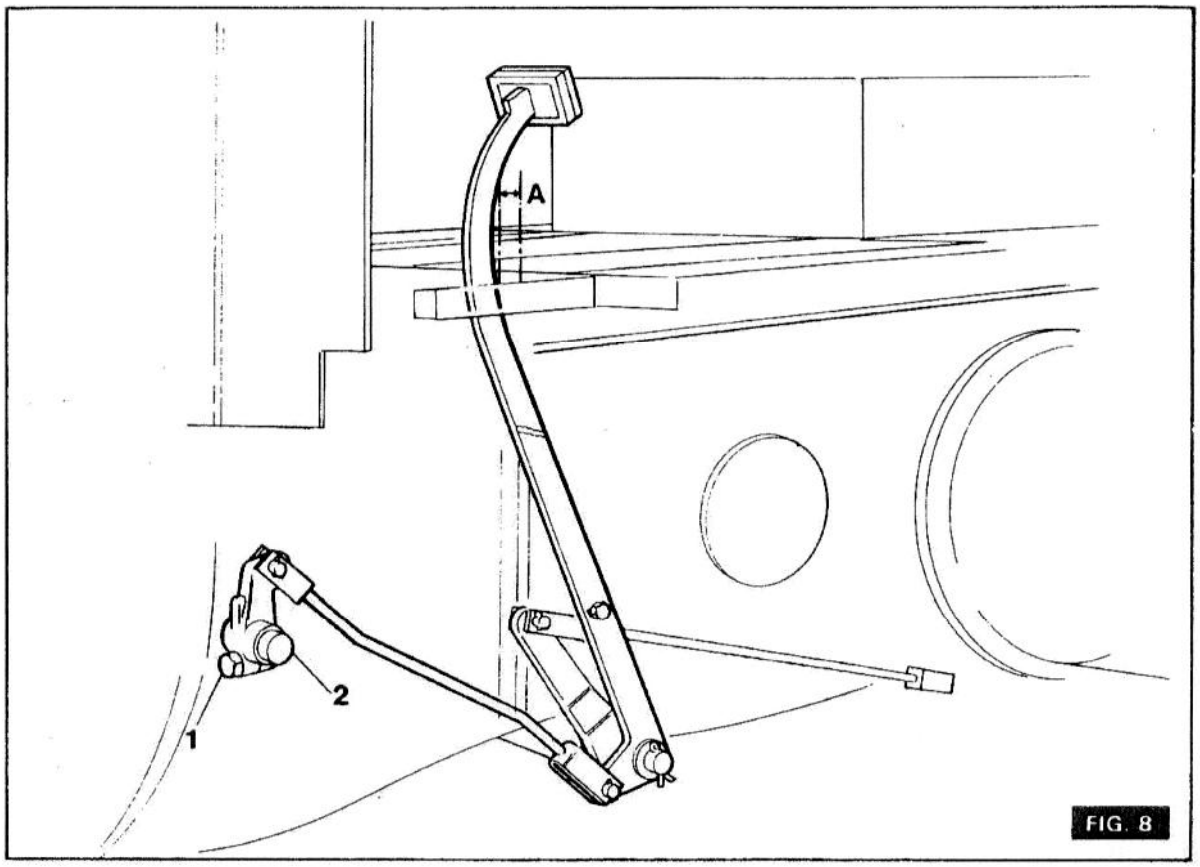

FIG. 8

REVERSOMATIC TRANSMISSION

CONTENTS

LIST OF ILLUSTRATIONS

INSTANT REVERSE TRANSMISSION

GENERAL

The instant reverse transmission is an automatic shuttle transmission with hydraulically operated clutches for forward and reverse travel. The shuttle transmission comprises a two speed sliding spur gear and a 4:1 planetary reduction gear, giving 4 speeds forward and 4 reverse.

The drive is taken from the input shaft (1), through a reverse idler (2) to the layshaft (3) which is engaged to a gear rotating on the output shaft. The hubs of both multi-plate clutches are splined to the output shaft and to their respective driven plates. Both clutch drums are splined to their respective drive plates. The forward clutch drum is also attached to the input shaft, the reverse clutch drum to the output shaft. When the forward clutch is engaged, the output shaft is locked to the input shaft and the 'drive' and 'driven' plates in the reverse clutch are forced to counter rotate. When the reverse clutch is engaged, the reverse clutch locks the reverse gear to the output shaft, thereby creating a drive from the input shaft, through the reverse idler and layshaft, thus causing the 'drive' and 'driven' plates in the forward clutch to counter rotate.

Both clutches are actuated by hydraulic pressure which is generated by a gear pump mounted on the input shaft and driven by the impeller hub of the torque converter. The torque converter is bolted to the flywheel on the engine crankshaft. As soon as the engine is started, the oil pump operates and supplies oil to the torque converter and to the oil distribution housing.

The oil passes through two 80 p.s.i. (5.625 kg./sq.cm.) valves thus giving a total of 160 p.s.i. (11.25 kg./sq.cm.). The oil is then directed via drillings in the manifold to the pedal operated control valve. From the control valve, the oil is fed to either the forward or the reverse clutch, whenever the appropriate pedal is depressed. Oil to the forward clutch passes round the sleeve, fitted to the output shaft and through the bore of the sleeve to the reverse clutch.

Two shift levers positioned in front of the operator's seat, select the appropriate gear and speed range. The left hand lever is the gear shift lever and moves the 'change speed' gears into engagement, whilst the right hand lever, the dual range selector lever alters the high or low range at the planetary reduction unit. Both levers must be engaged before the machine will move. When the dual range selector lever is in the 'L' (low) position, the planetary gears effect a 4:1 reduction of the transmission speed for both gears. The gear selector forks are secured to the selector rails by lock pins, and the rails slide in bores in the end walls of the transmission case. Cone ended spring plungers, attached to the casing end walls, locate in recesses on the rails, thus ensuring a positive selection of the gears.

The planetary reduction unit is coupled directly to the rear or output end of the transmission mainshaft. The planetary pinion is the rotating member whilst the ring gear, which is an extension of the conventional gearbox mainshaft, is fixed. In the high range the selector fork brings the sleeve forward to engage the splines of the sunwheel giving a direct drive. In the low range the splined sleeve is pulled back, locating the planetary carrier to the rear drive, giving a 4:1 reduction in shaft speed.

INSTANT REVERSE TRANSMISSION

Removal (7A/1)

1. Remove the engine, transmission and final drives from the machine as stated.
2. Level the whole unit using a trolley jack under the transmission housing. Take the weight of the engine with chain blocks or other suitable lifting gear.
3. Drain the oil from the torque converter housing.
4. Remove the bell housing bolts.
5. With the engine supported by the chain blocks, roll clear the transmission and final drive assembly. A drip tray should be positioned to contain any spillage from the torque converter.
6. Drain the transmission housing.
7. Support the centre housing on a rail trolley and, with the transmission case supported on a suitable jack, re-

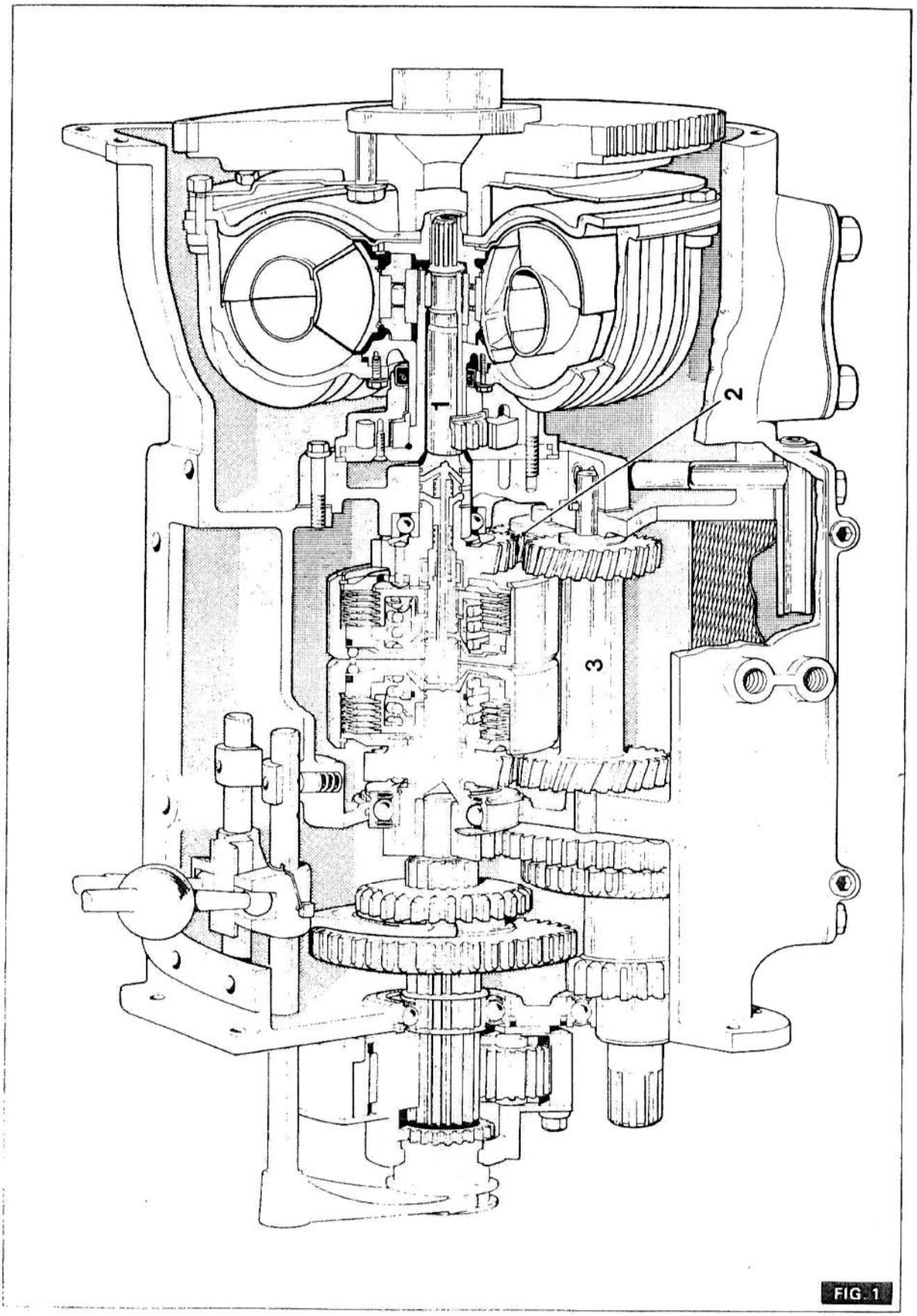

FIG. 1

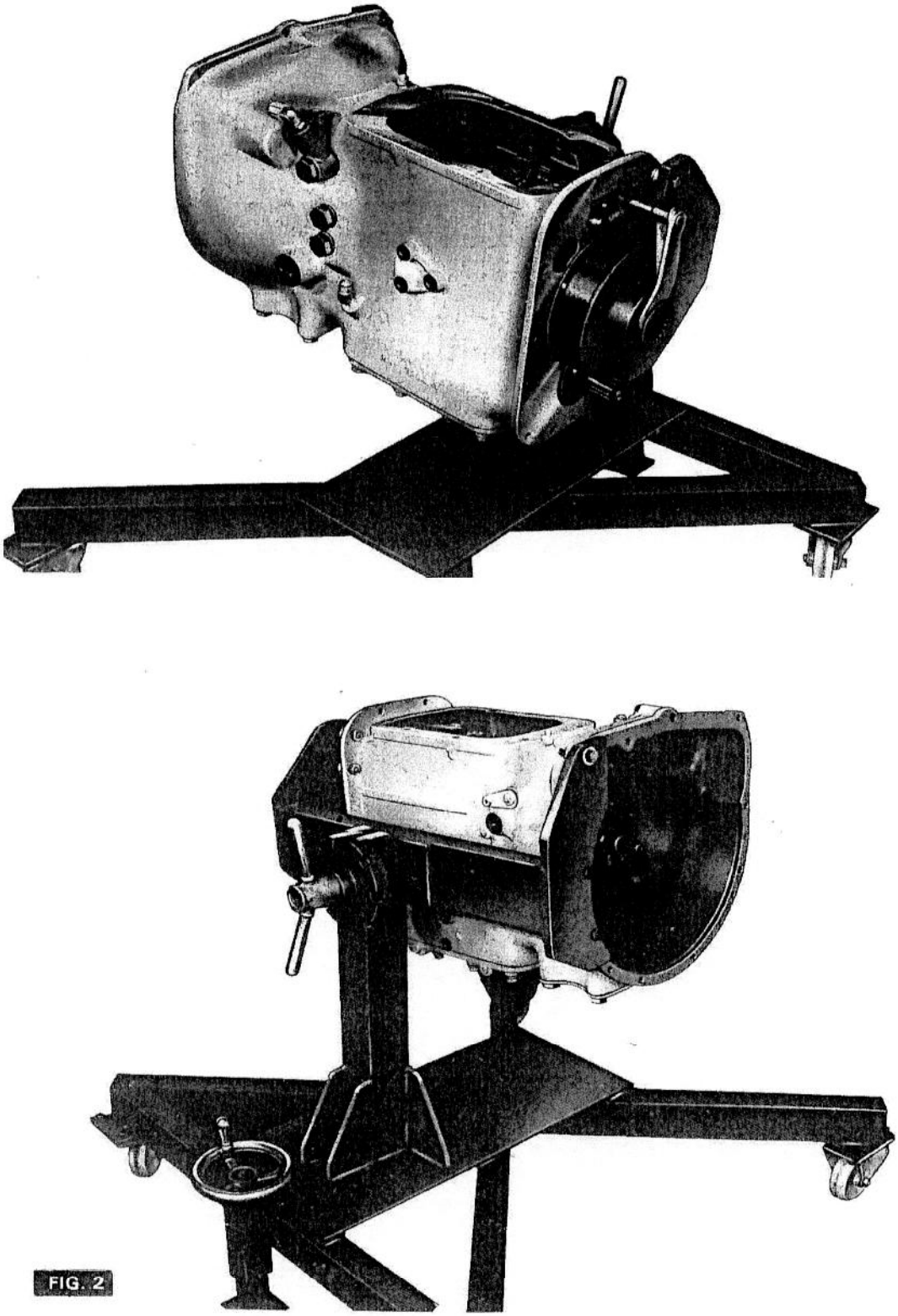

FIG. 2

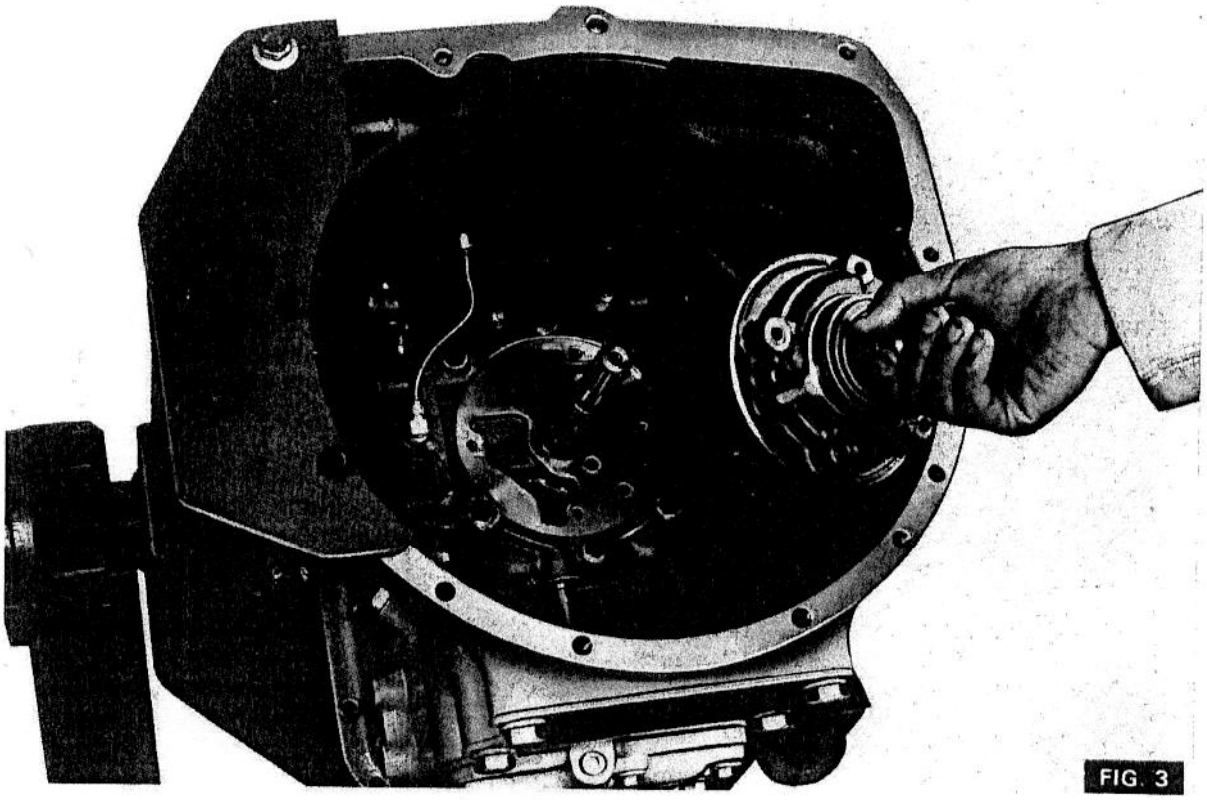

FIG. 3

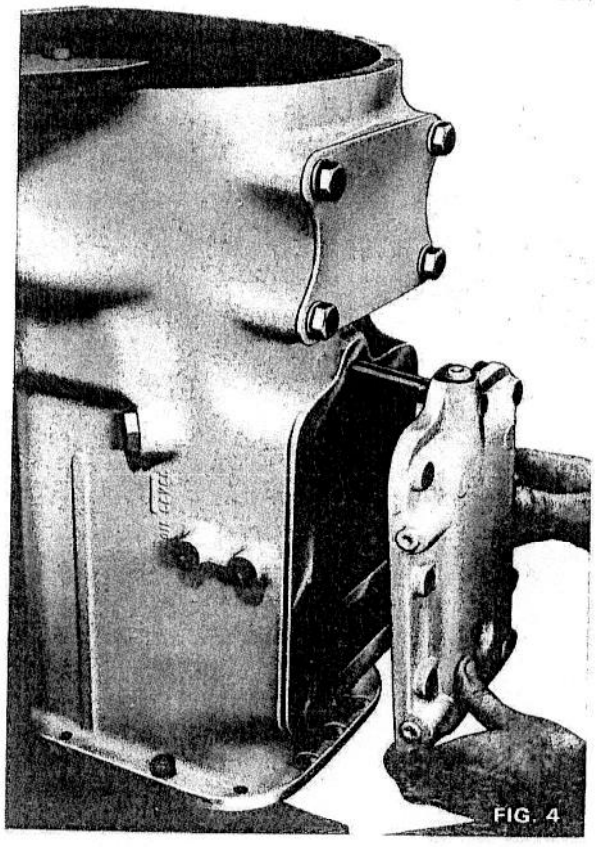

FIG. 4

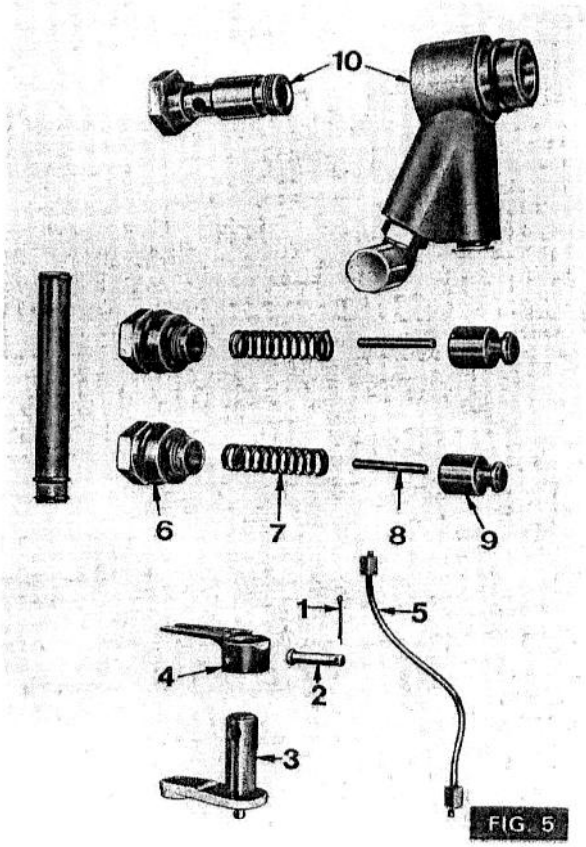

FIG. 5

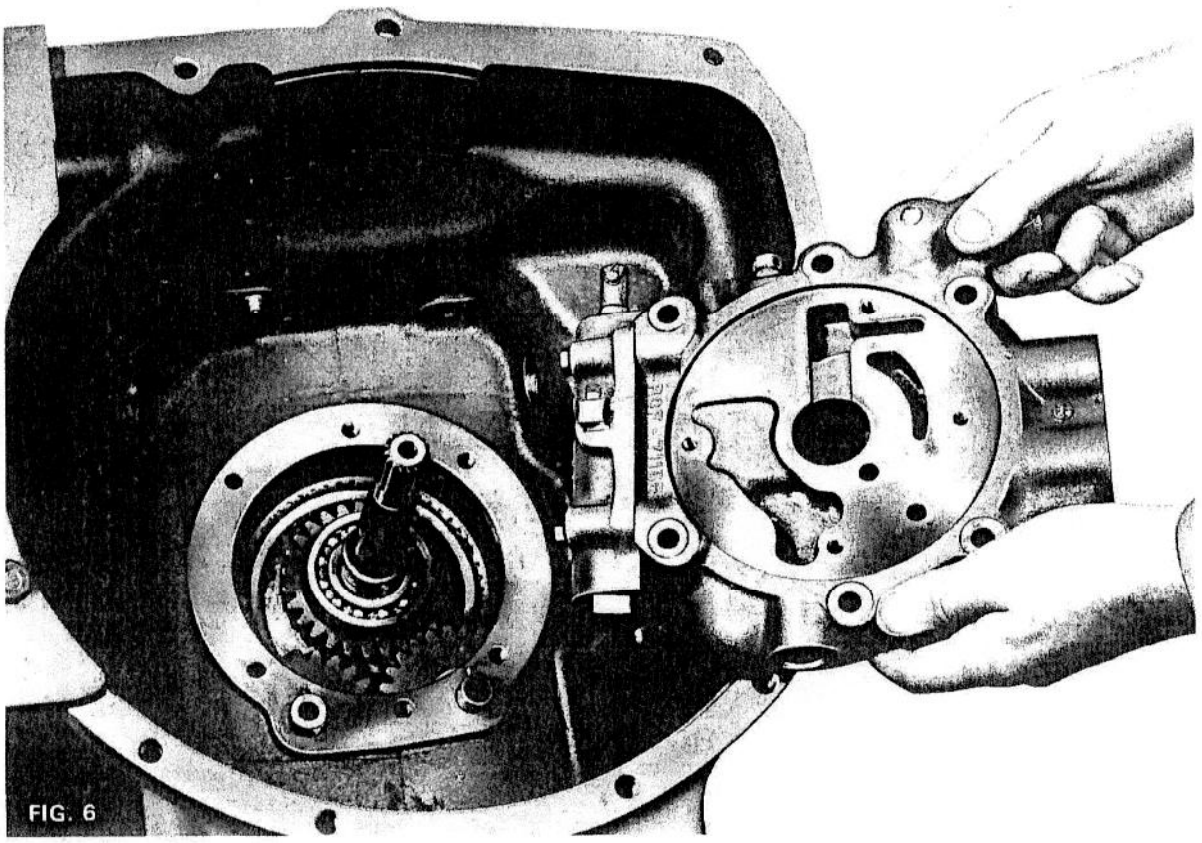

FIG. 6

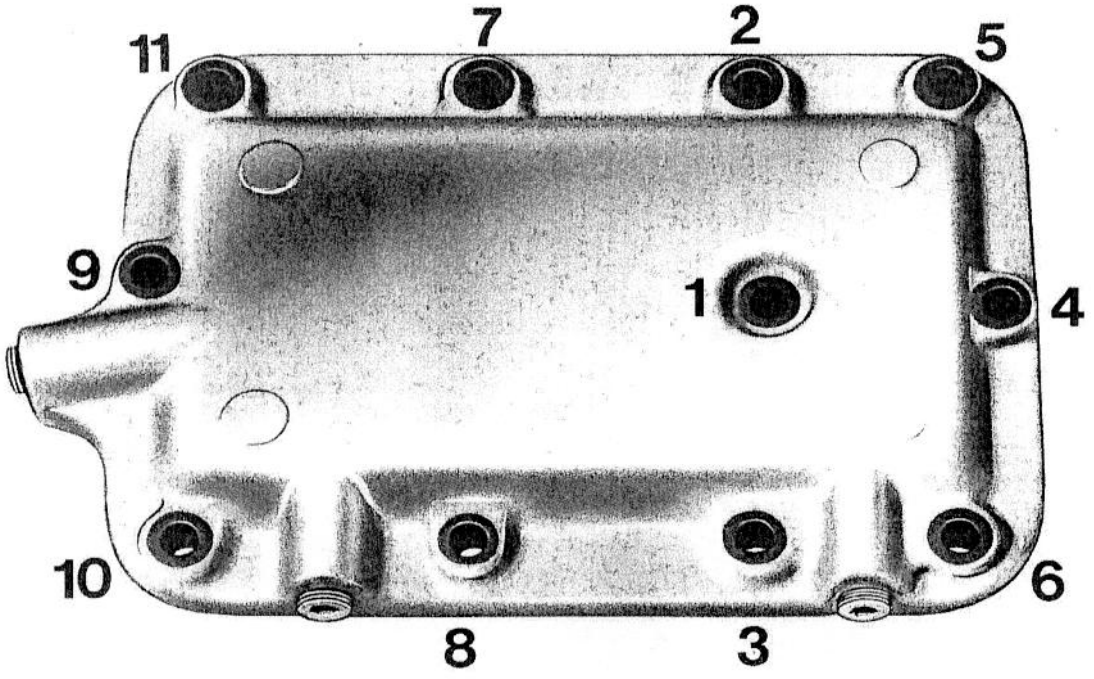

FIG. 7

INSTANT REVERSE TRANSMISSION

Removal . . . Cont'd

move the bolts holding the transmission case and centre axle housing together. The centre axle housing may now be rolled clear on the trolley rails leaving the complete transmission case on the trolley jack.

8. In order to simplify further disassembly of the transmission, the case should be attached to a suitable stand as shown in Fig. 2.
9. To replace the transmission assembly, reverse the above procedure.

INSTANT REVERSE TRANSMISSION

Disassembly and Reassembly

OIL PUMP

Removal and Refitting (7A/2)

1. (Fig. 3) Remove the four bolts and washers securing the oil pump to the oil distribution housing and lift the pump clear over the input shaft.
2. Replace the oil pump using a new seal. Tighten the four bolts to a torque setting of 15 - 20 lb.ft. (2.07 - 2.77 kg.m.).

The pump should be examined for any damage, especially to the white metal bearing in the pump body. If this is scored or damaged in any way the efficiency of the seal between the impeller hub and the pump will be impaired.

The only servicing which can be carried out on the oil pump is the renewal of the front oil seal. This is done by tapping out the seal with a punch and drifting in the new seal until it bottoms against the white metal bearing.

INSTANT REVERSE TRANSMISSION

OIL DISTRIBUTION HOUSING

Removal and Replacement (7A/3)

1. Remove the oil pump as described in operation 7A/2.
2. (Fig. 4) Remove the bolts and spring washers securing the sump to the transmission housing. Remove the sump and oil suction pipe.
3. Remove the gasket.
4. (Fig. 5) Remove the split pin (1) and clevis pin (2) securing the spool valve operating lever (3) to the internal lever (4). Remove the levers.
5. Remove the oil pressure test pipe (5).
6. Remove the two regulator valves, i.e. cap (6), spring (7), guide pin (8) and valve (9), and the outlet manifold (10).
7. (Fig. 6) Remove the six bolts and washers securing the oil distribution housing to the transmission case. Lift the housing and gasket clear over the input shaft.
8. To replace the housing, reverse the above procedure ensuring that any damaged gaskets, sealing washers and 'O' rings are renewed. Tighten the oil distribution bolts to a torque setting of 25 - 30 lbs.ft. (3.46 - 4.15 kg.m.). The bolts should be tightened evenly on opposite pairs in order to avoid any possible distortion of the housing.
9. Replace the oil suction pipe and the sump and tighten the bolts to a torque setting of 45 - 50 lb.ft. (6.22 - 6.91 kg.m.) following the correct sequence shown in fig. 7.

INSTANT REVERSE TRANSMISSION

CONTROL VALVE

Disassembly and Reassembly (7A/4)

1. Remove the oil distribution housing as described in operation 7A/3.
2. (Fig. 8) Withdraw the split pin (1) and the clevis pin (2) from the valve spool (3).
3. Unscrew the valve end cap (4) and push the spool out of the control valve body (5).
4. Remove the circlip (6) and slide the two spring guides(7) and spring (8) off the spool.
5. Unscrew the two bolts holding the spool valve housing to the oil distribution housing.
6. Remove the five 'O' rings. When the housing is replaced these 'O' rings should be renewed.
7. To reassemble the control valve, reverse the above procedure.

INSTANT REVERSE TRANSMISSION

Disassembly (7A/5)

1. Remove the engine, transmission and final drives from the machine as stated.
2. Separate the transmission case from the final drives as stated in operation 7A/1.
3. With the transmission bell housing facing upwards, remove the oil pump and oil distributor housing as stated in operations7A/2 and 7A/3.
4. (Fig. 9) Withdraw the internal shafts from the countershaft gear and the reverse idler gear.
5. Remove the reverse idler gear, retaining the thrust washers.
6. (Fig. 10) Remove the countershaft gear; the special tool detailed in Fig. 11 will ensure that the thrust washers and roller bearings are not displaced or lost in the transmission case when removing the countershaft gear.
7. (Fig. 12) Lift out the complete clutch pack assembly from the bell housing and remove the shim(s) (if fitted).

INSTANT REVERSE TRANSMISSION

Reassembly (7A/6)

1. Reassemble the countershaft, fig. 13.
2. Reassemble the reverse idler gear, fig. 14.

Note

The fibre thrust washer (1) must be fitted between the reverse gear (2) and the outer shaft (3). The bronze thrust washer should be fitted on the front face of the gear.

3. Replace the clutch pack assembly into the transmission casing, ensuring that any shim(s) which were removed are replaced between the rear bearing and its bore face.
4. Fit the countershaft back into position using the special 'C' tool to hold the rear thrust washer in place. Check that the front thrust washer is properly located and replace the inner shaft.
5. Replace the idler shaft gear in position engaging the gears in the clutch pack and the countershaft, replace the inner shaft.
6. Replace the oil distribution housing using a new gasket and sealing washers. Tighten the bolts to a torque setting of 25 - 30 lb.ft. (3.456 - 4.148 kg.m.).
7. Refit the oil pump using a new sealing ring and washers. Tighten the bolts to a torque setting of 15 - 20 lbs. ft. (1.974 - 2.765 kg.m.).
8. Replace the regulator valves, oil pressure test pipe and the control valve lever assembly.
9. Carry out the end float check as described in operation 7A/12.
10. Clean the sump and gauze filter and replace the sump and the oil suction pipe using a new gasket and 'O' rings.

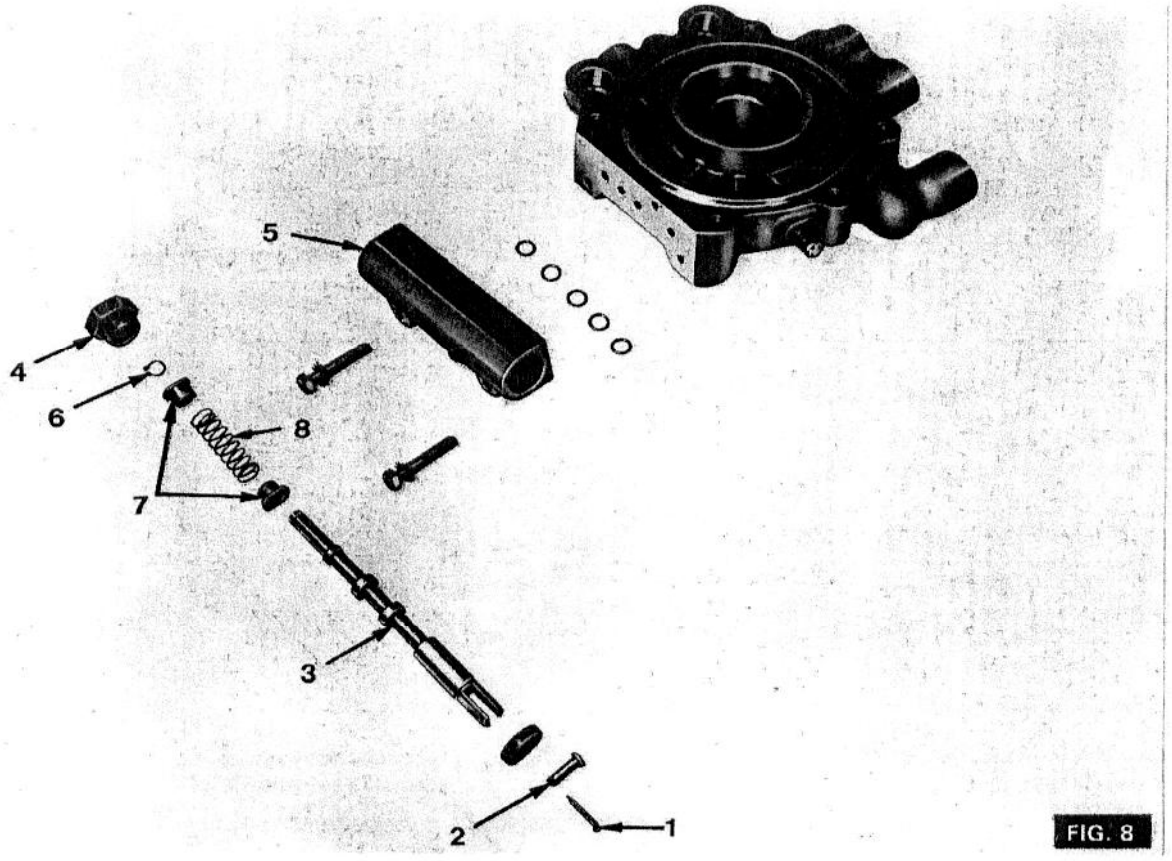

FIG. 8

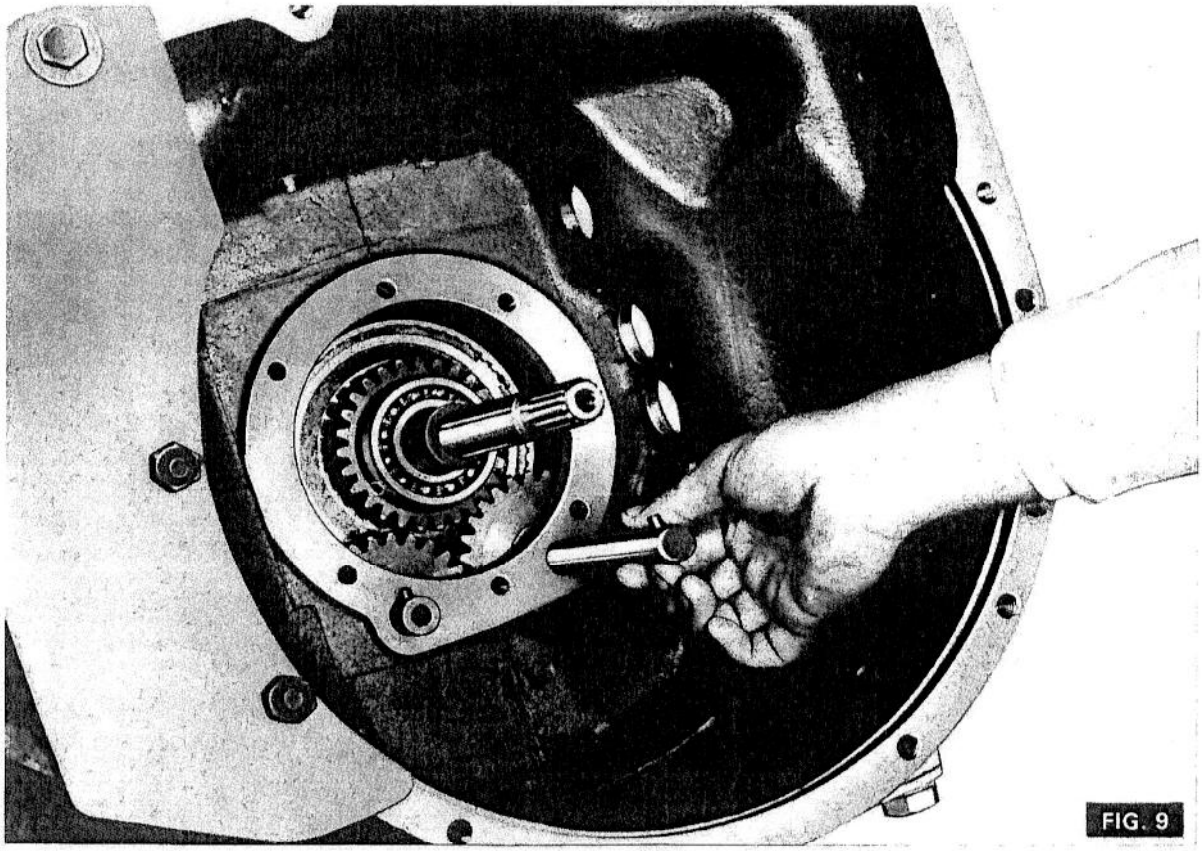

FIG. 9

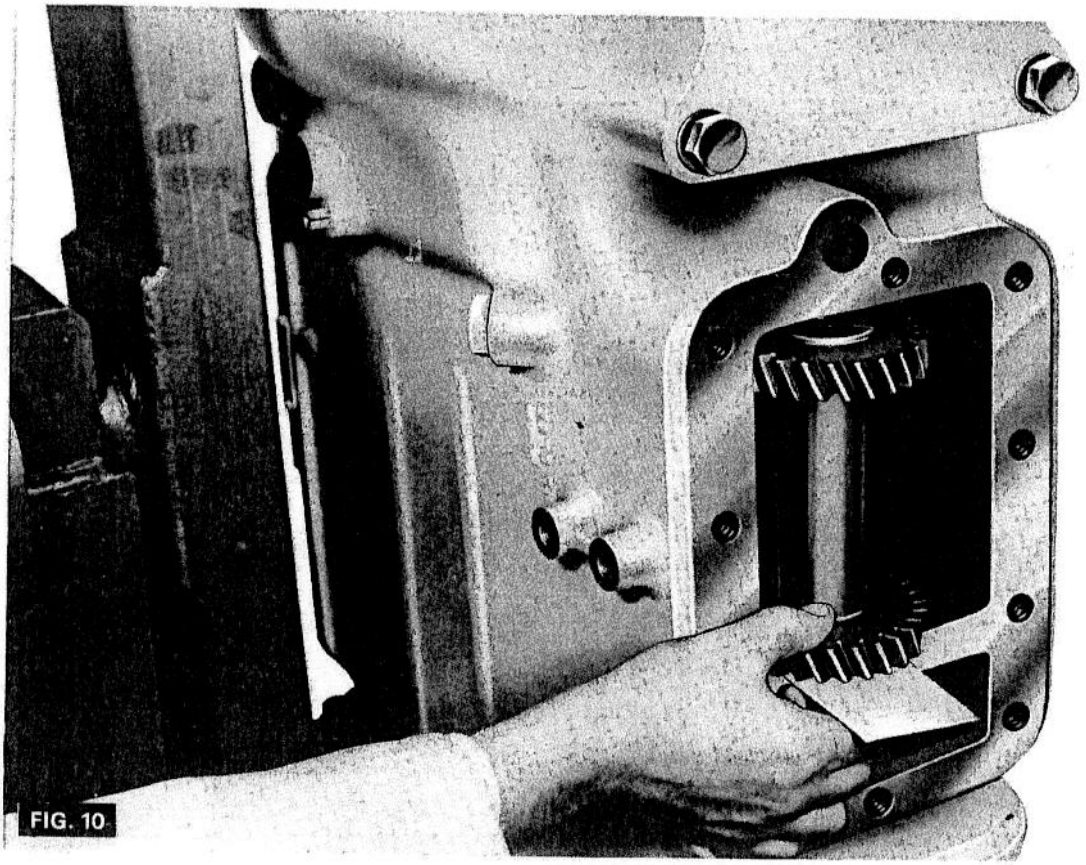

FIG. 10

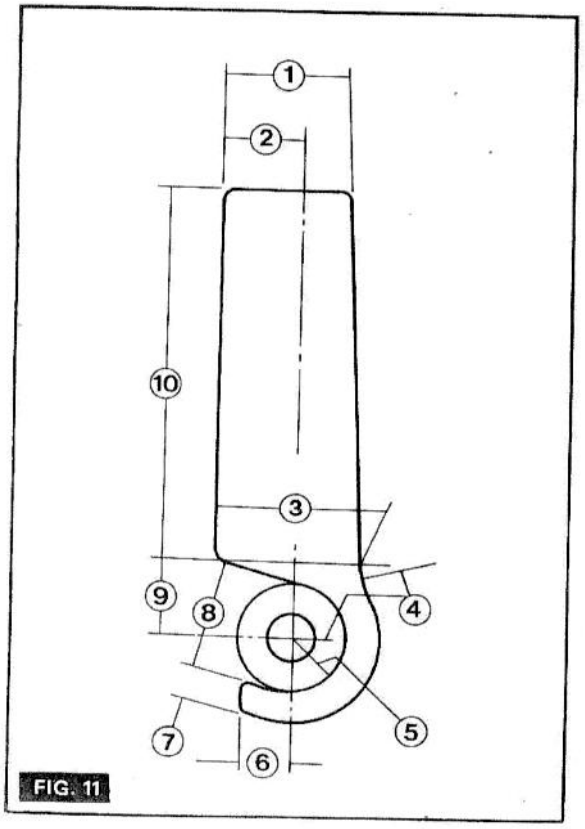

FIG. 11

FIG. 12

INSTANT REVERSE TRANSMISSION

Reassembly . . . Cont'd

Note

The special tool illustrated in Fig. 11 should be made from a piece of mild steel 9 in. x 3 in. (22.8 cm. x 7.6 cm.) 17 S.W.G. (.056 in.) (1.42 mm.) to the dimensions given.

(1)	2 in.	(50.8 mm.)		(6)	¾ in.	(19 mm.)
(2)	1¼ in.	(31.75 mm.)		(7)	½ in.	(12.7 mm.)
(3)	2 3/8 in.	(60.3 mm.)		(8)	1 3/8 in.	(35 mm.)
(4)	1 3/8 in.	(35 mm.)	Rad.	(9)	1 3/16in.	(30.2 mm.)
(5)	7/8 in.	(22.23 mm.)	Rad.	(10)	6 in.	(152.4 mm.)

INSTANT REVERSE TRANSMISSION

CLUTCH PACKS AND SHAFTS

Disassembly (7A/7)

1. Remove the clutch pack assembly from the transmission case as described in operation 7A/5.
2. Stand the assembly upright with the input shaft uppermost.
3. (Fig. 15) Remove the large circlip from the forward clutch drum and lift off the input shaft.

   To further dismantle the shaft :—

   (a) Remove 3 steel sealing rings.
   (b) Lever off the bearing.
   (c) Remove the inner bearing.

4. (Fig. 16) Remove the thrust washer (1).
5. Lift out the forward clutch hub (2) which is splined to the driven plates of the clutch and to the output shaft.
6. Remove the sintered bronze driven plates (3) and the dished steel drive plates (4) from the clutch drum (5).
7. (Fig. 17) Remove the small circlip retaining the forward clutch.
8. Lift off the clutch drum.

   To further dismantle the drum :—

   (a) Fig. 18. Compress the spring using tool MF 244.
   (b) Fig. 19. Remove the coil circlip (1). Release the tension on the spring and remove the spring retainer (2) and the spring (3).
   (c) Use compressed air directed into the hole in the back of the drum to remove the piston (4).
   (d) Remove the two sealing rings and the ball bearing (5).

9. (Fig. 20) Turn the clutch assembly over and remove the large circlip (1) retaining the reverse clutch cover (2).
10. Turn the clutch back to the upright position and remove the reverse clutch drum and the plates from the output shaft.
11. Remove the small circlip retaining the reverse clutch hub to the output shaft taking great care not to damage the seal rings on the shaft.
12. Remove the reverse clutch hub.
13. Remove the reverse clutch gear and clutch cover and the thrust washers.
14. To further dismantle the clutch drum, procedure is as described at reference 8 above.
15. To further dismantle the output shaft, proceed as follows :—

INSTANT REVERSE TRANSMISSION

CLUTCH PACKS AND SHAFTS

Removal . . . Cont'd

(a) Remove the circlip retaining the bearing.
(b) Remove the forward oil slinger plate.
(c) Tap off the bearing.
(d) Remove the rear oil slinger plate.

Note

If any of the six steel sealing rings on the output shaft have been damaged, remove them all, noting the order of removal. These rings should not be disturbed unless they are damaged in any way.

INSTANT REVERSE TRANSMISSION

OUTPUT SHAFT

Reassembly (7A/8)

1. Reassemble the oil slinger plates, sealed bearing and circlip onto the output shaft.
2. If the steel sealing rings have been removed in order to replace a damaged item, refit them in the order of removal.

INSTANT REVERSE TRANSMISSION

INPUT SHAFT

Reassembly (7A/9).

1. Press the bearing onto the shaft.
2. Refit the three steel oil seal rings.
3. Press in a new inner bearing.

INSTANT REVERSE TRANSMISSION

CLUTCH DRUM

Reassembly (7A/10)

1. (Fig. 19) Fit a new rubber seal to the drum spigot and also to the piston (4).
2. Replace the steel ball (5) into its location hole.
3. Push the piston right down into the drum.
4. Fit the spring (3) and the spring retainer (2) onto the piston.
5. Use the tool MF 244 to compress the spring, ensuring equal compression all round. Replace the coil circlip (1) and remove the tool.

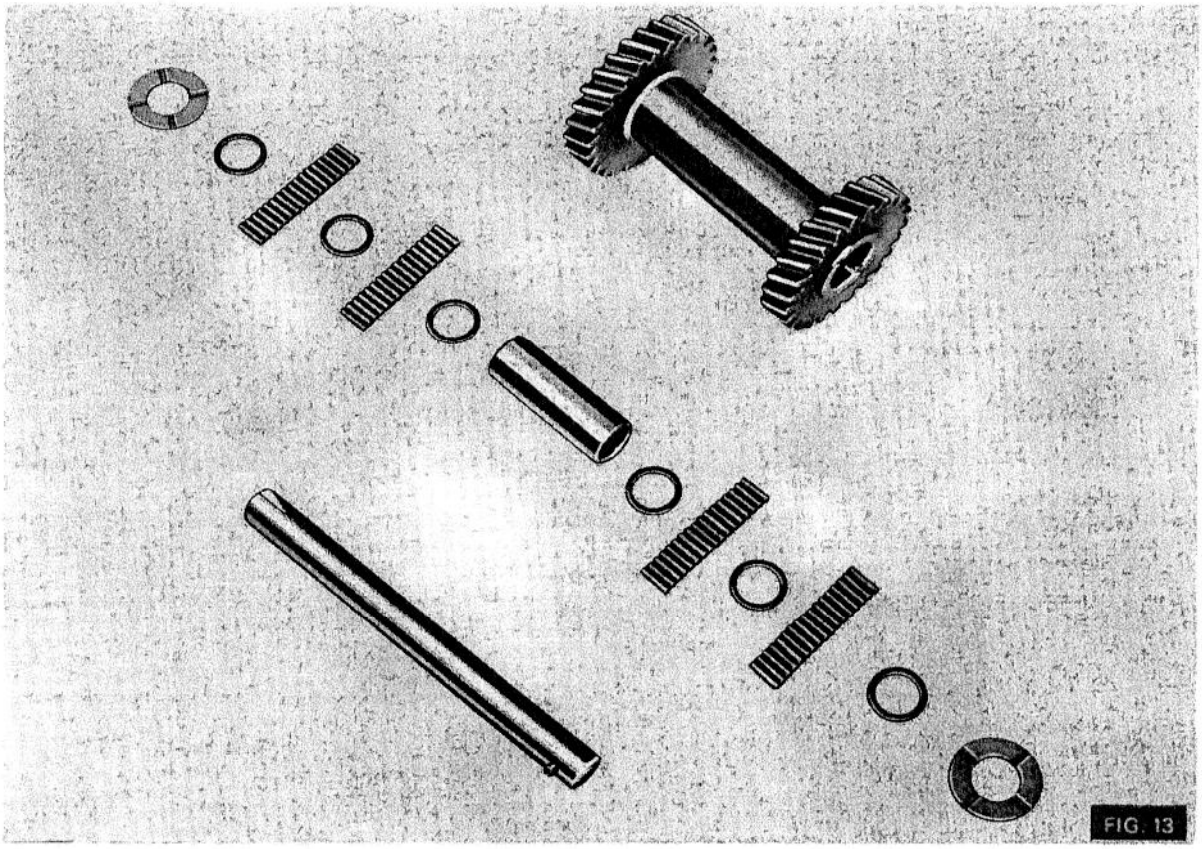

FIG. 13

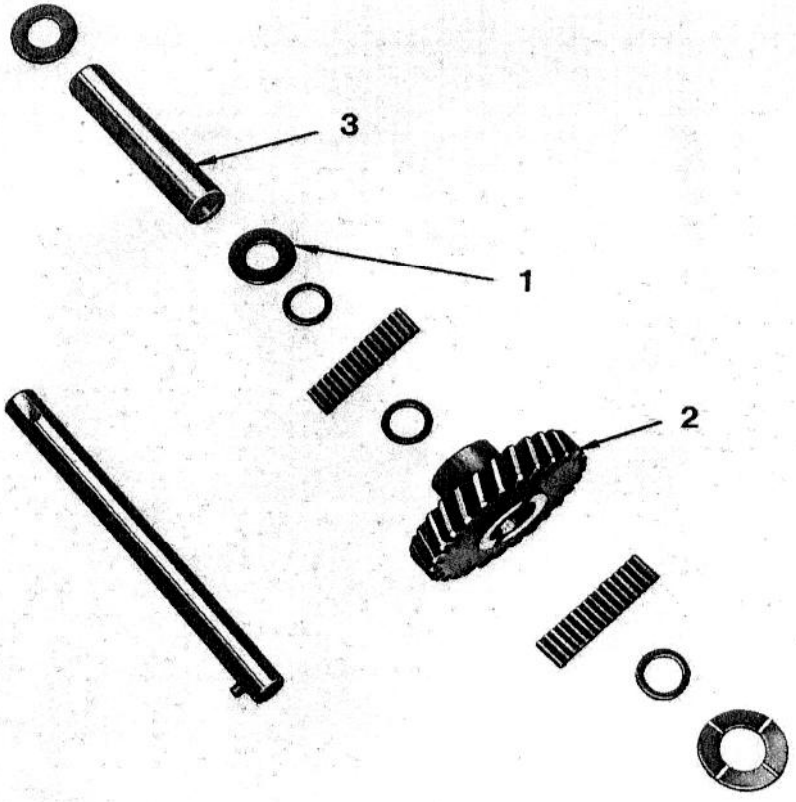

FIG. 14

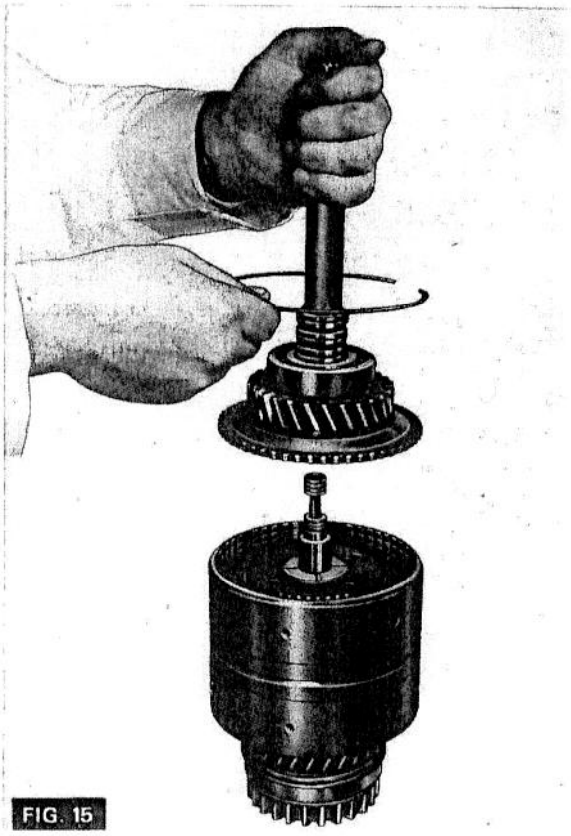

FIG. 15

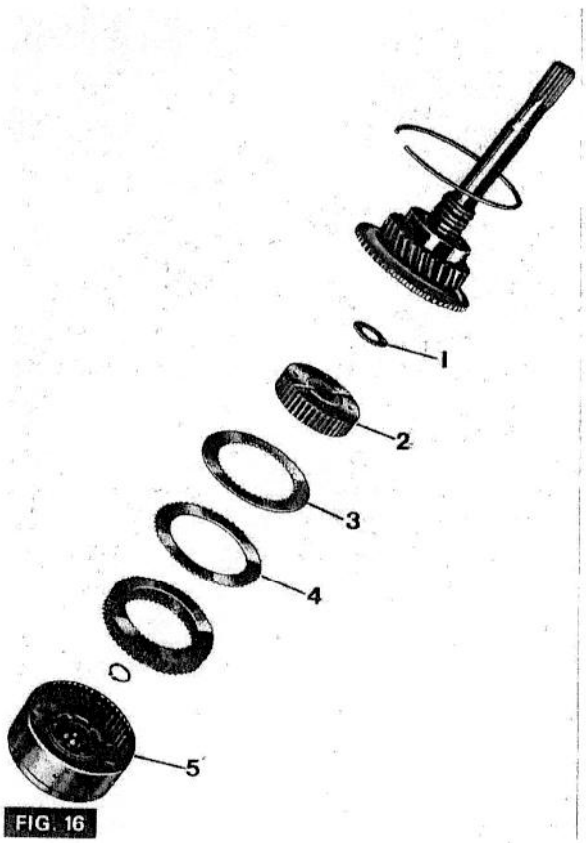

FIG. 16

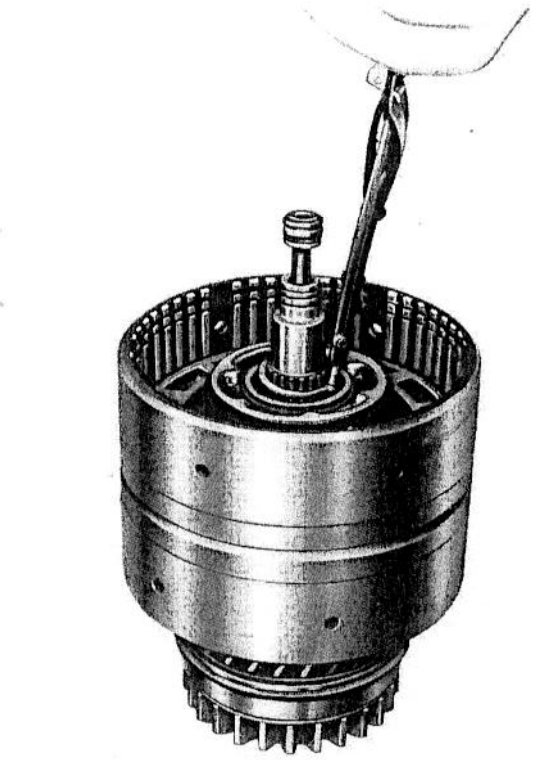

FIG. 17

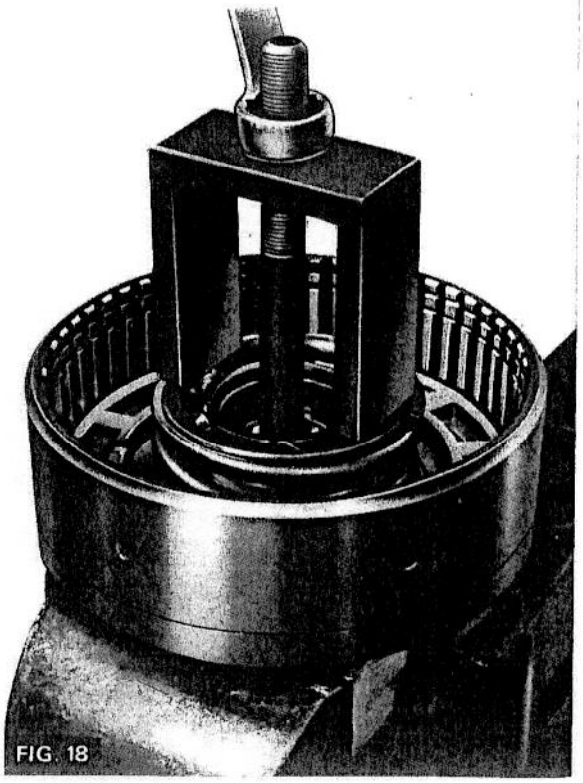

FIG. 18

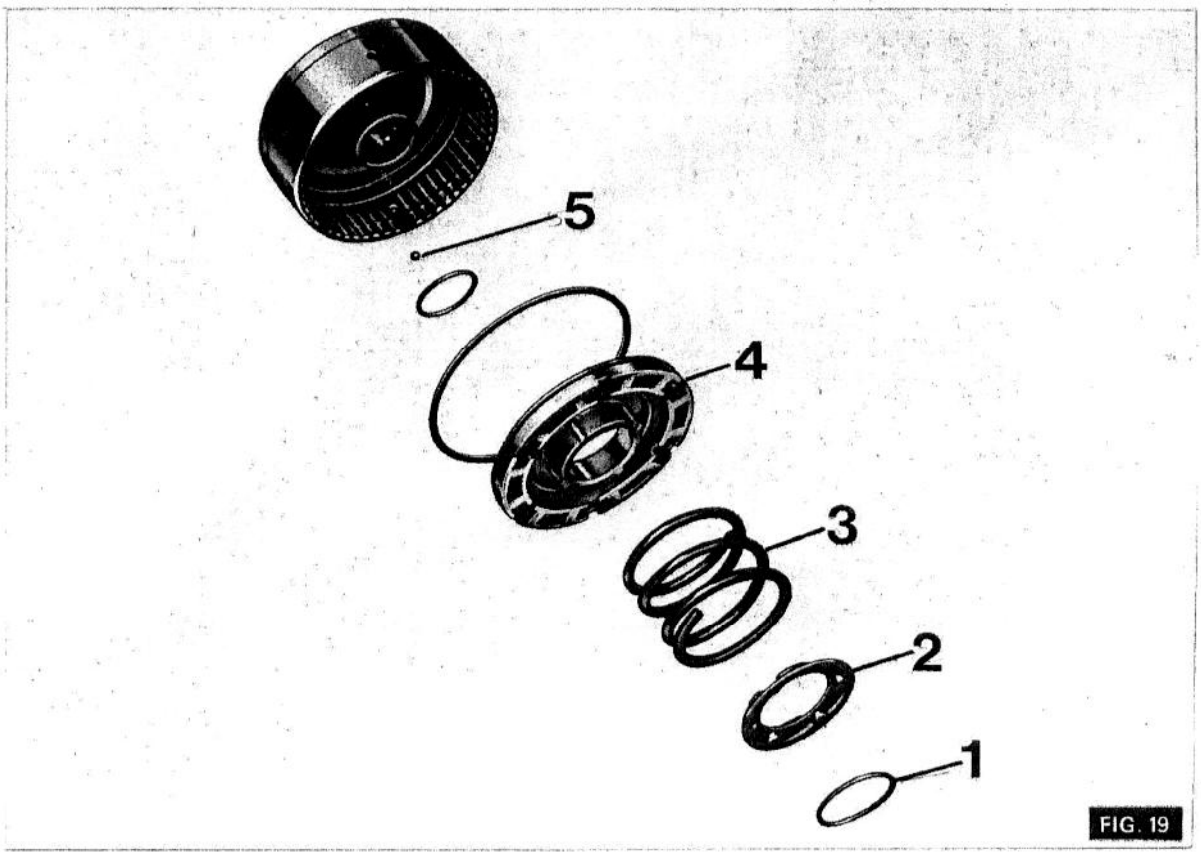

FIG. 19

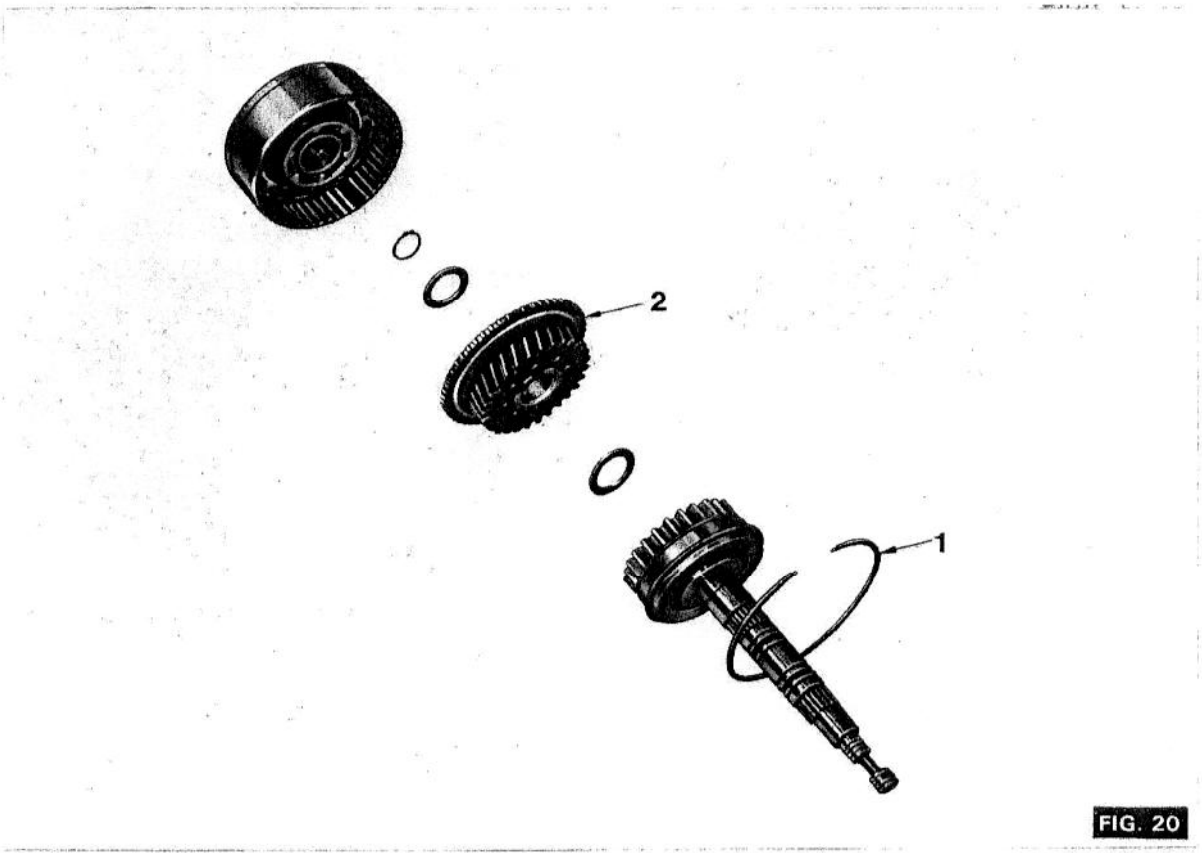

FIG. 20

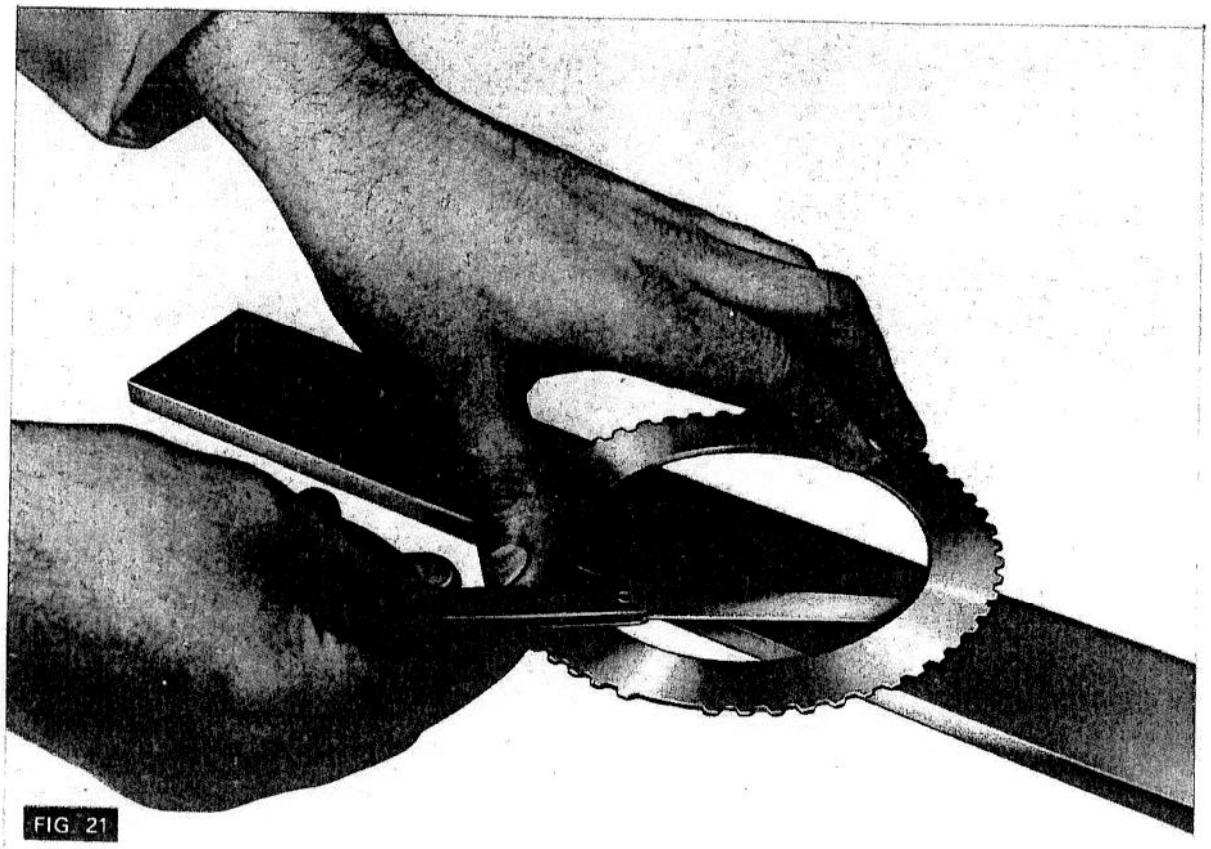

FIG. 21

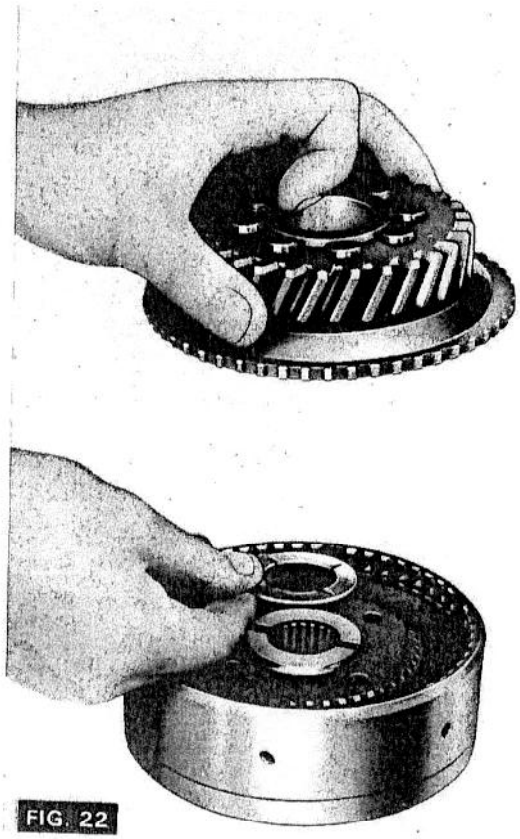

FIG. 22

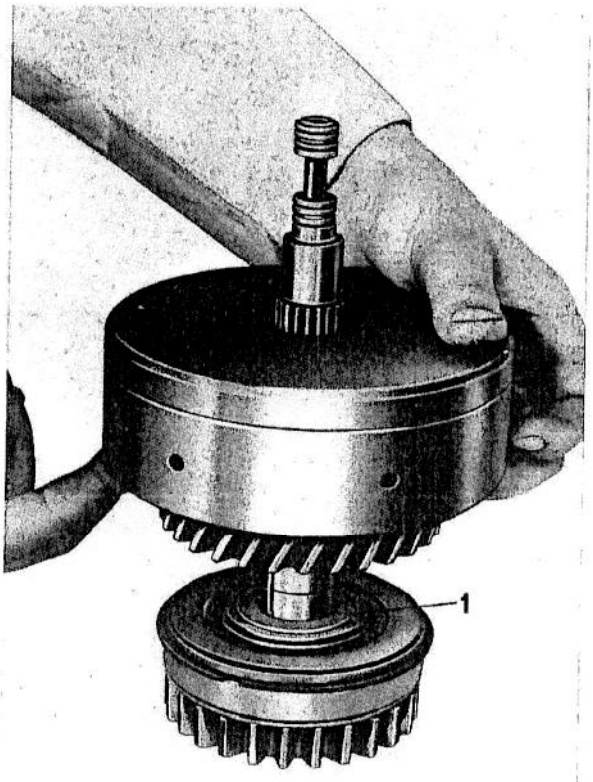

FIG. 23

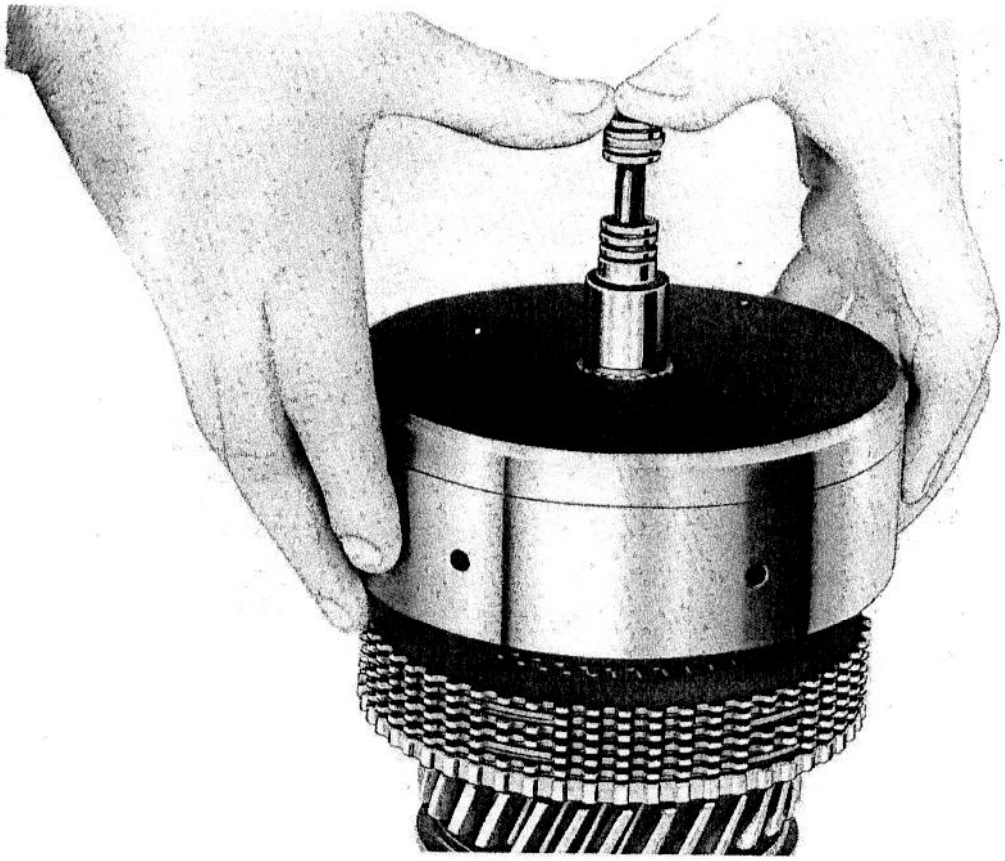

FIG. 24

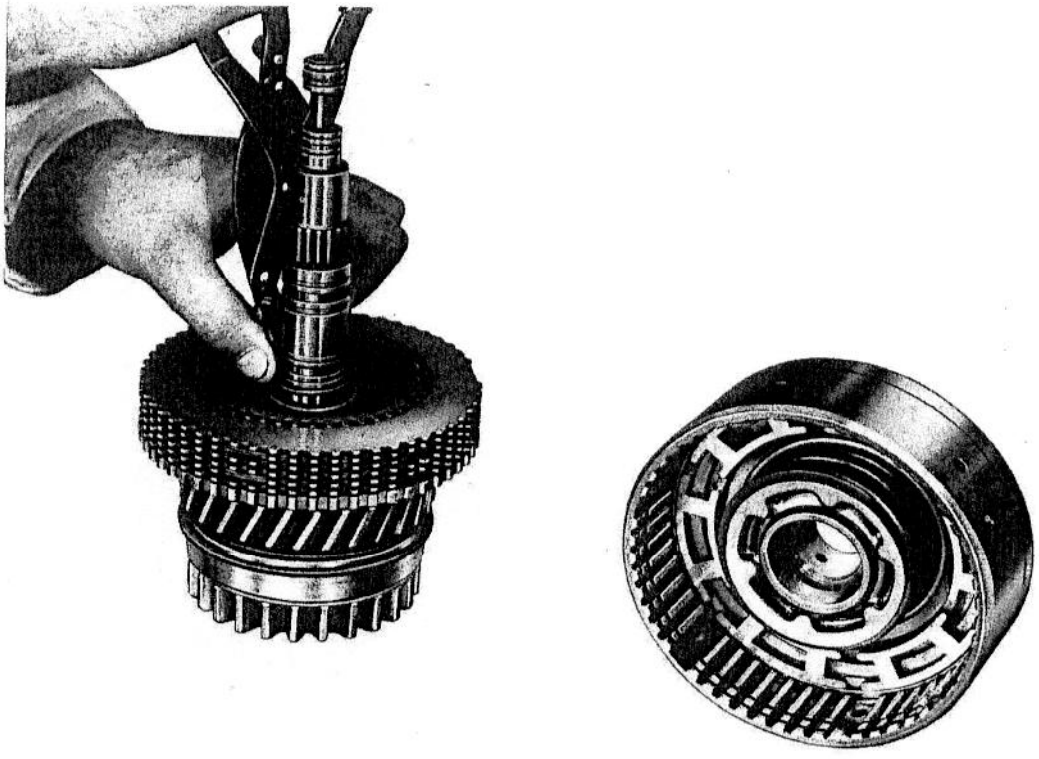

FIG. 25

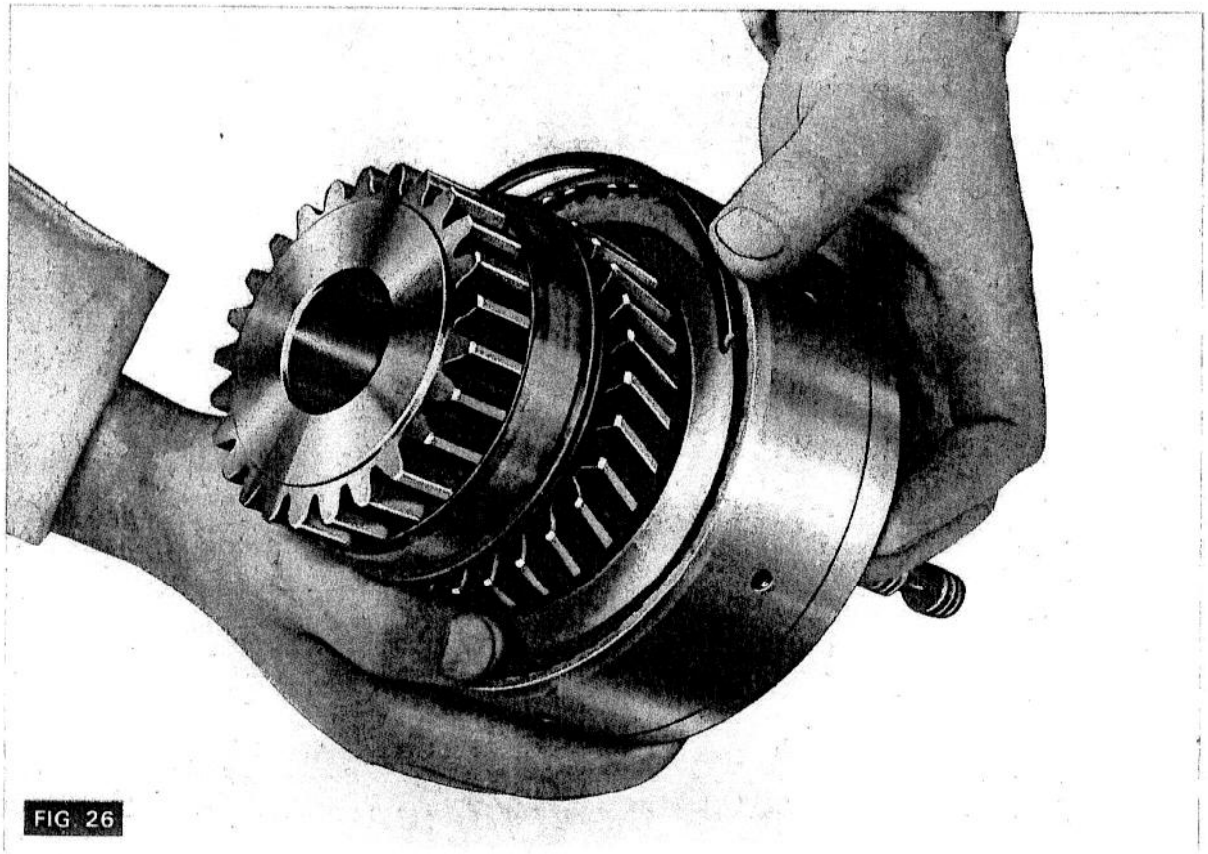

FIG. 26

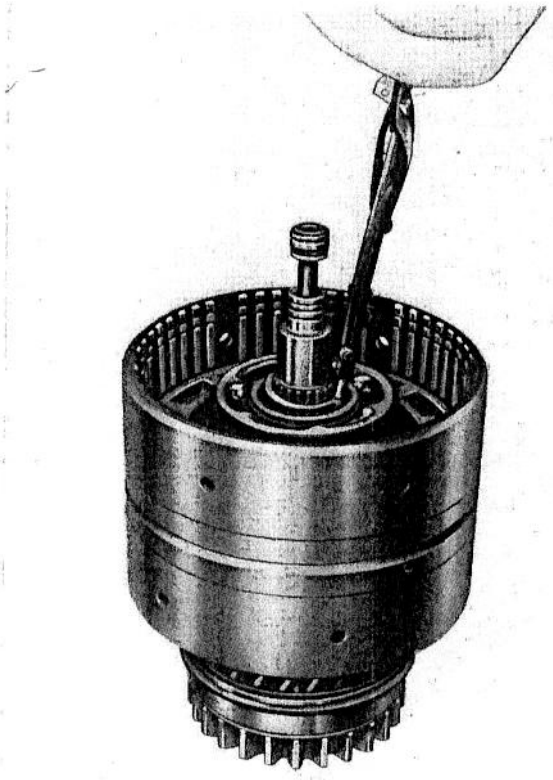

FIG. 27

FIG. 28

INSTANT REVERSE TRANSMISSION

CLUTCH PACKS

Reassembly (7A/11)

1. Before reassembling the clutch packs, check the clearance of the steel drive plates. Place the plates on a flat surface with the concave face down. Insert a feeler gauge under the inside edge of the plate as shown in Fig. 21. The clearance must not be less than 0.005 in. - 0.007 in. (0.127 mm. - 0.177 mm.).
2. Stack the drive plates with the concave faces uppermost.
3. Fit the reverse clutch hub inside the drum.
4. Fit the first drive plate into the drum.
5. Place the first sintered bronze driven plate over the hub. The driven plates may be fitted either way.
6. Build up the reverse clutch pack by alternately fitting the drive and driven plates into the reverse clutch drum.

Note

It is imperative that the concave faces of the steel drive plates are all lying the same way.

7. (Fig. 22) Place the thrust washer onto the hub and fit the reverse clutch cover and gear assembly into the drum.
8. (Fig. 23) Place the output shaft upright on the bench and fit the thrust washer (1) onto the shoulder above the oil slinger.
9. Turn the assembled reverse clutch over and place it onto the output shaft, pushing it fully home onto the thrust washer.
10. Line up the top of the shaft and the oil hole in the drum with a suitable mark on the bench, so that the drum may be replaced in exactly the same position.
11. (Fig. 24) Lift off the clutch drum carefully. DO NOT DISTURB THE PLATES IN ANY WAY.
12. (Fig. 25) Fit the small circlip to retain the reverse clutch hub.
13. Replace the drum ensuring the correct alignment of the shaft and oil hole with the mark on the bench. It is essential that the drum is replaced in exactly the same position.
14. (Fig. 26) Turn the assembly over and fit the large circlip to retain the clutch cover.
15. (Fig. 27) Fit the forward clutch drum over the output shaft to rest on the reverse clutch drum and secure with circlip.
16. Locate the hub in the forward clutch drum.
17. Build up the forward clutch pack in the manner described at references 5 - 8.
18. Replace the thrust washer over the output shaft.
19. (Fig. 28) Fit the input shaft and clutch cover over the output shaft and into the drum.
20. (Fig. 29) Insert a screwdriver between the two clutch drums and lever the forward clutch upwards so that the large circlip can be fitted to retain the forward clutch cover in the drum.

INSTANT REVERSE TRANSMISSION

CLUTCH PACK ASSEMBLY

To Check the End Float (7A/12)

Note

This check must be carried out with the oil distribution housing properly seated and with the bolts tightened to the correct torque setting.

1. (Fig. 30) Set up the dial indicator on the transmission bell housing.
2. With a suitable tool, such as a screwdriver, push the clutch packs down by levering against the transmission case. Set the dial indicator to zero.
3. With the tool underneath the reverse gear, lever the clutch packs up and note the end play indicated on the gauge. The permissible end float is .031 - .050 in. (0.768 - 1.27 mm.).

INSTANT REVERSE TRANSMISSION

CLUTCH PACK ASSEMBLY

To Check the End Float . . . Cont'd

Note . . . Cont'd

4. (Fig. 31) If the end float indicated is greater than .050 in. (1.27 mm.) place a shim between the rear bearing and the transmission case.
5. (Fig. 32) If the end float is less than .031 in. (0.768 mm.) with all the shims removed, add a second gasket between the oil distribution housing and the transmission case.

Note

A maximum of three gaskets is allowed to adjust end float. At least one gasket must be fitted at all times.

INSTANT REVERSE TRANSMISSION

OIL FILTER

Removal and Refitting (7A/13)

1. (Fig. 33) Unscrew the lower half of the body (1) and remove the filter element (3).
2. To dismantle the filter cap further, proceed as follows :—

   (a) Release the inlet and outlet pipe connections and remove the three bolts securing the filter cap to the bracket.
   (b) Remove the circlip (4) and then the washer (5), spring (6) and steel ball (7).
3. Reassemble in the reverse order ensuring that each part is absolutely clean.
4. Renew the rubber 'O' ring (2) and the filter element if necessary. Reassemble the oil filter.

OIL COOLER UNIT

Removal and Refitting (7A/14)

1. Remove the hood and radiator grille, as stated in operation 3A/1.
2. Disconnect the air cleaner hose at the air cleaner.
3. Remove four bolts and nuts securing the air cleaner in position.
4. Remove the four bolts and nuts securing the air cleaner support bar. Remove the support bar.
5. Slacken off the oil cooler inlet and outlet pipes by removing the screw and clip.
6. Disconnect two clips securing the oil cooler pipes and pull the inlet and outlet pipes clear.
7. Release the four bolts and nuts which hold the hydraulic oil cooler in position and withdraw the cooler.
8. Disconnect the transmission oil cooler pipes by releasing the two unions at the radiator side of the oil cooler frame.
9. Remove the four bolts and nuts securing the transmission oil cooler to the oil cooler frame.
10. (Fig. 34) Withdraw the transmission oil cooler.
11. Replacement is a reversal of the above procedure.

Note

Before replacing the oil cooler, ensure that the cooling fins are clean and free from mud or dust.

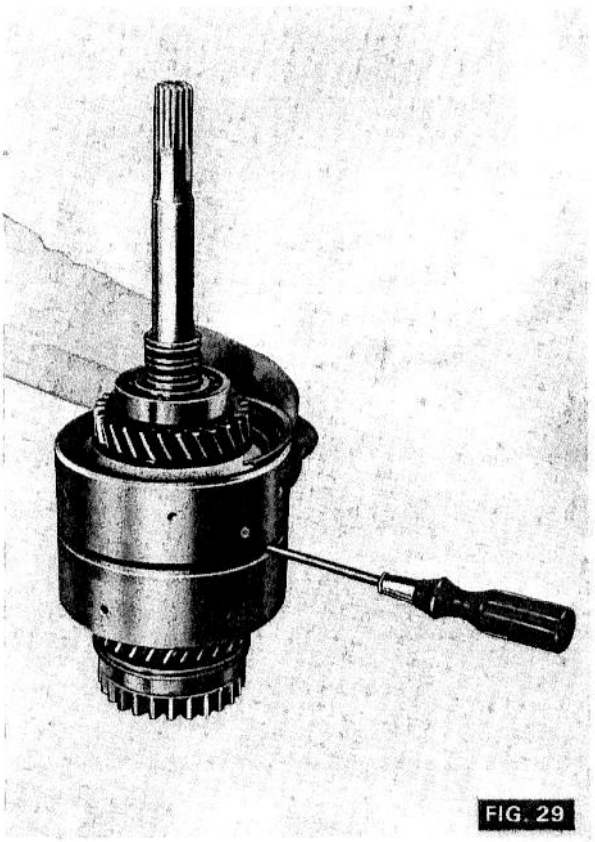

FIG. 29

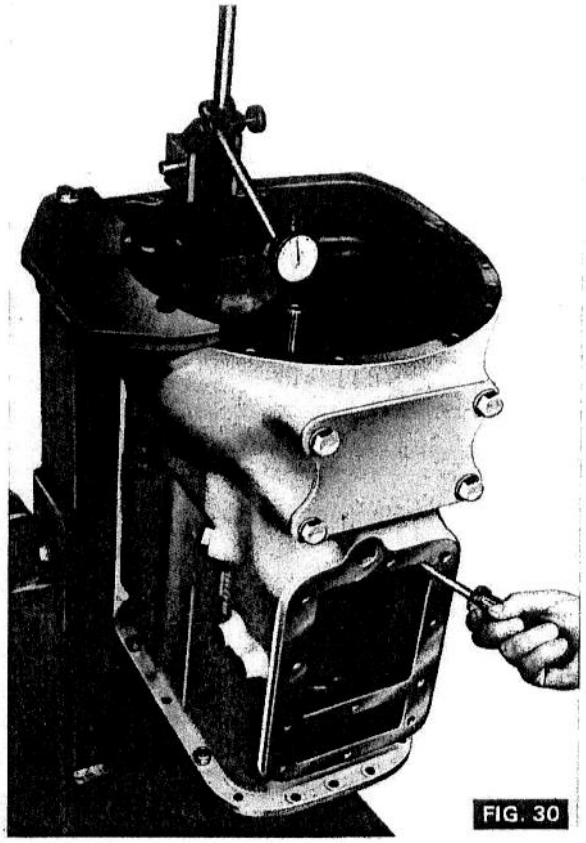

FIG. 30

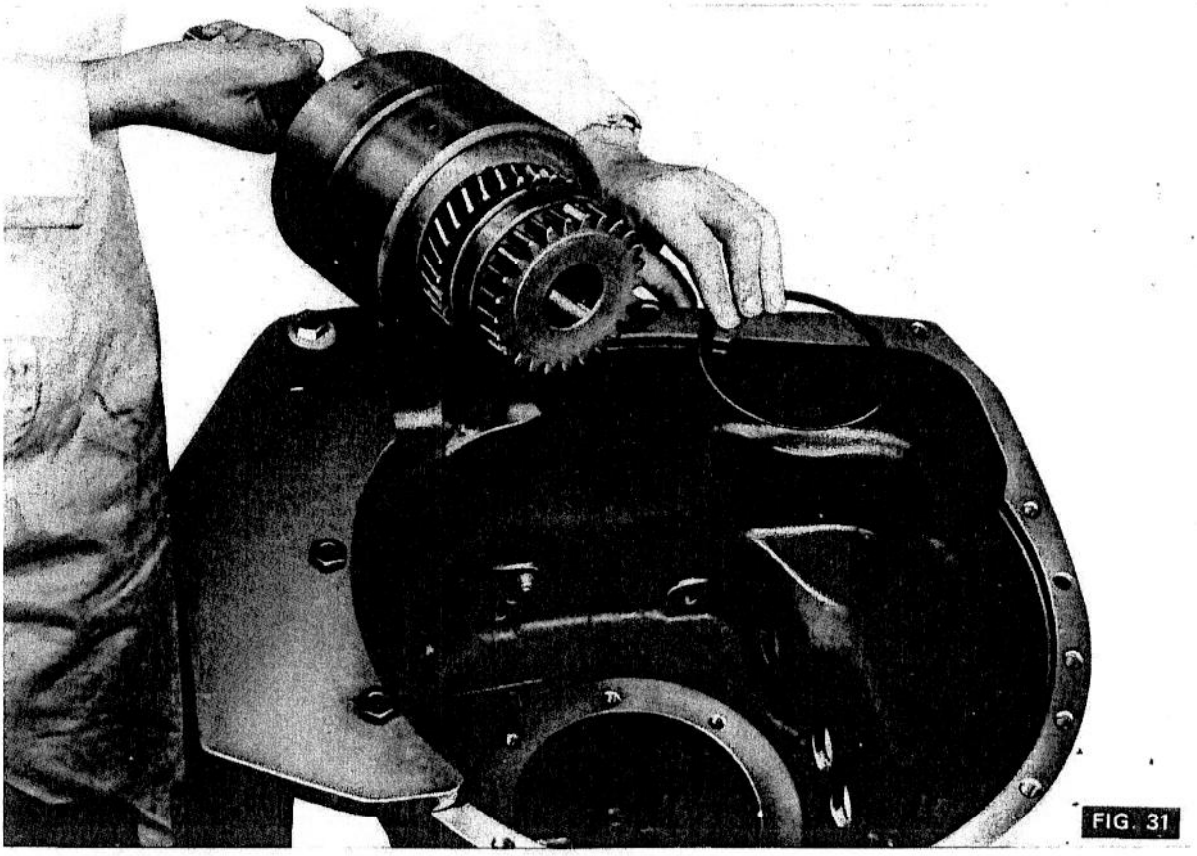

FIG. 31

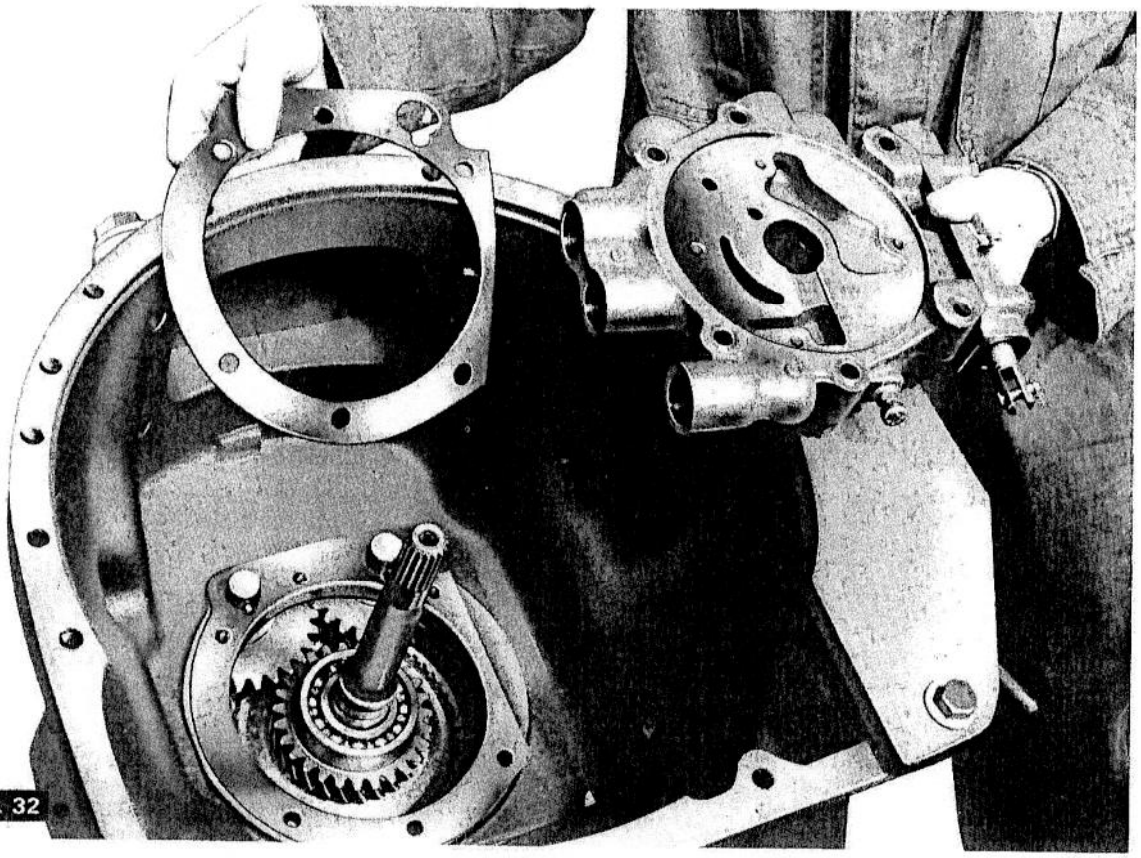

FIG. 32

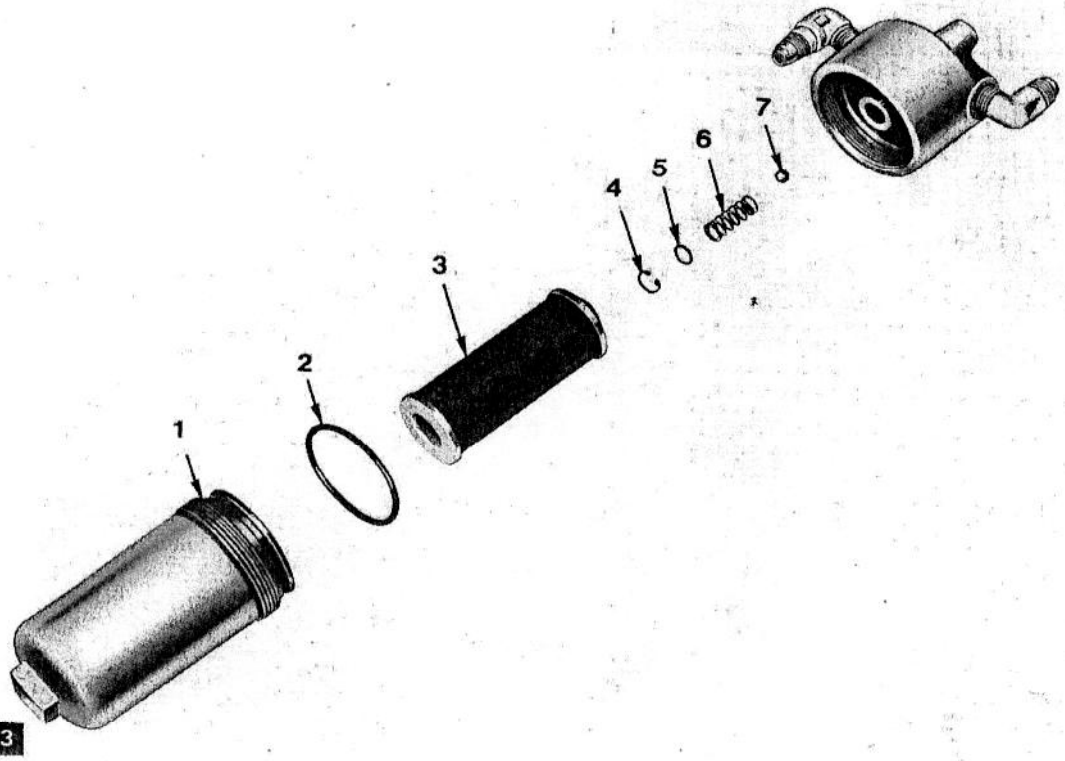

FIG. 33

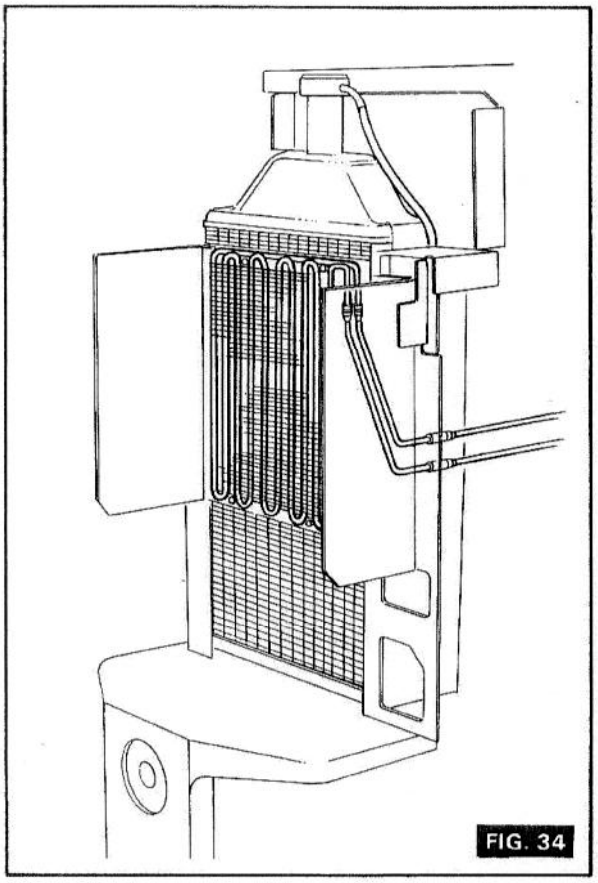

FIG. 34

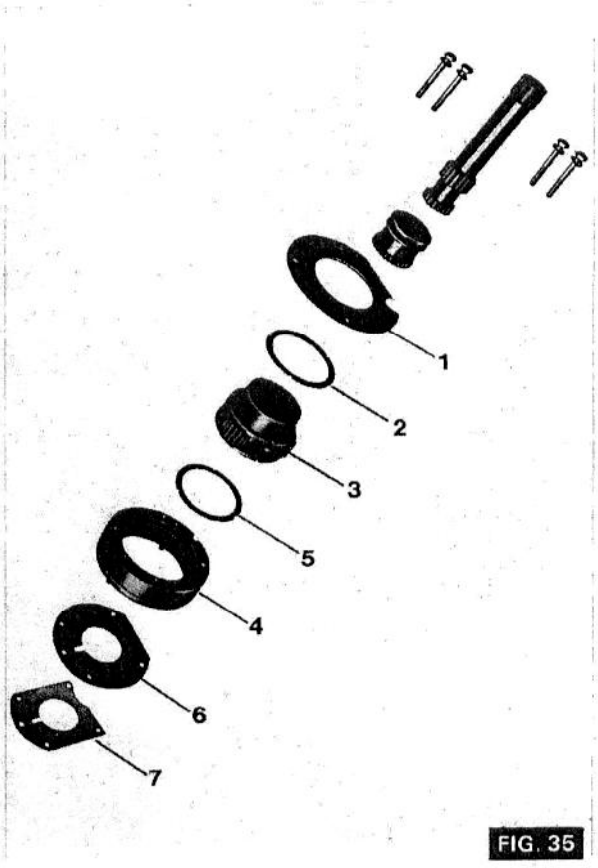

FIG. 35

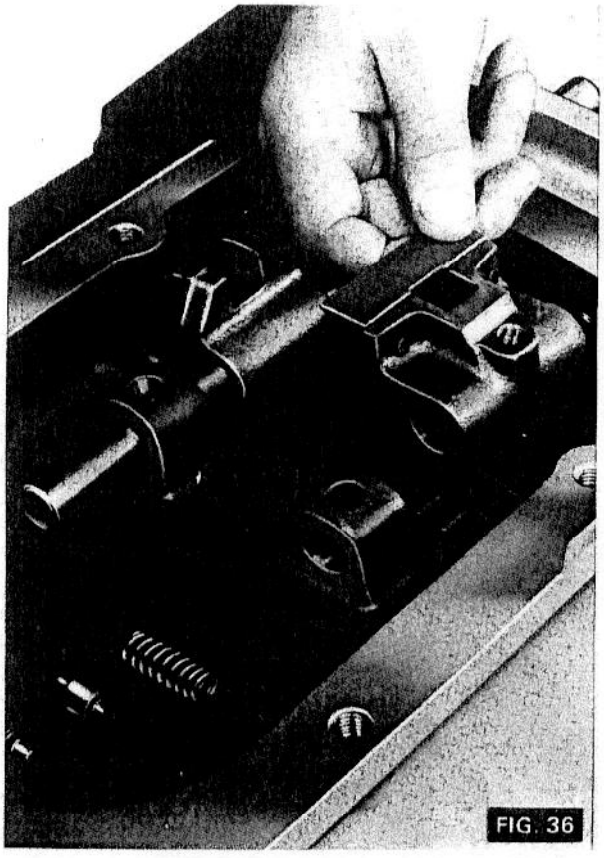

FIG. 36

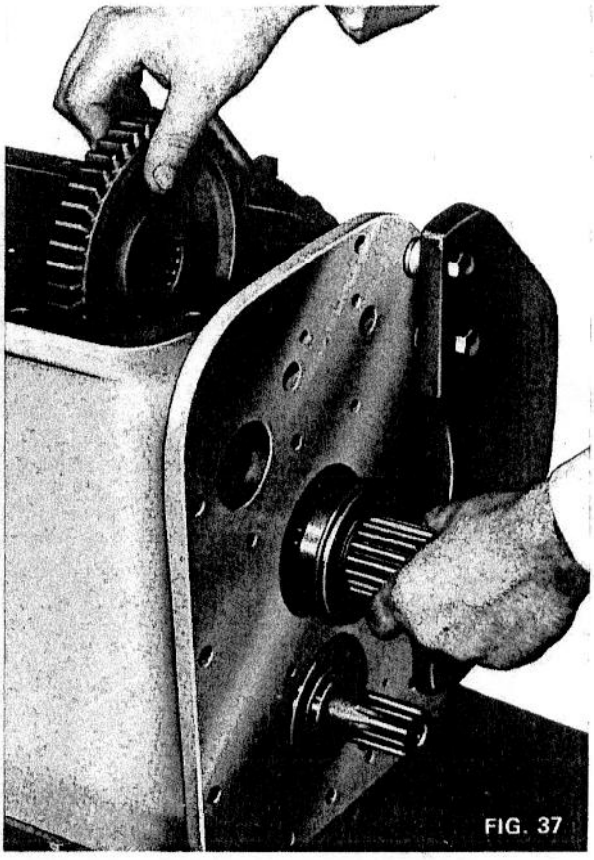

FIG. 37

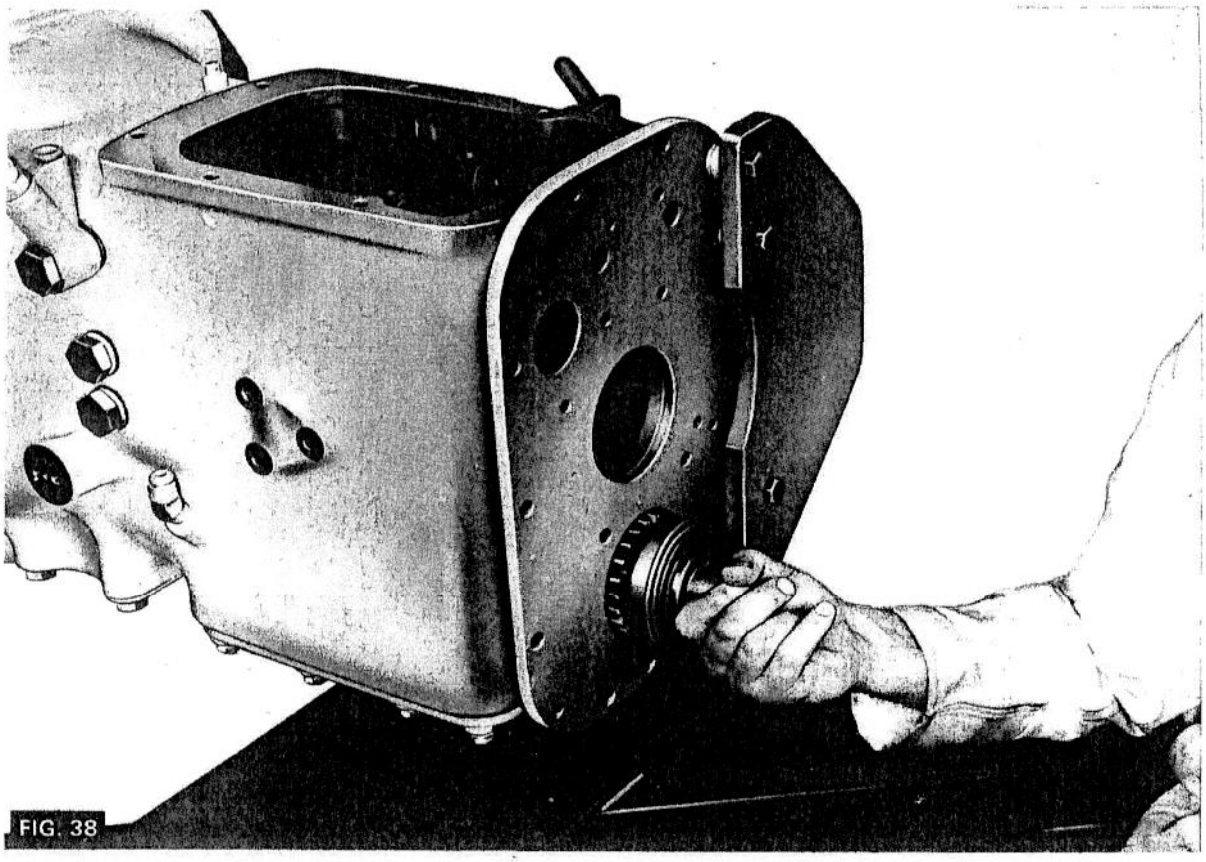

FIG. 38

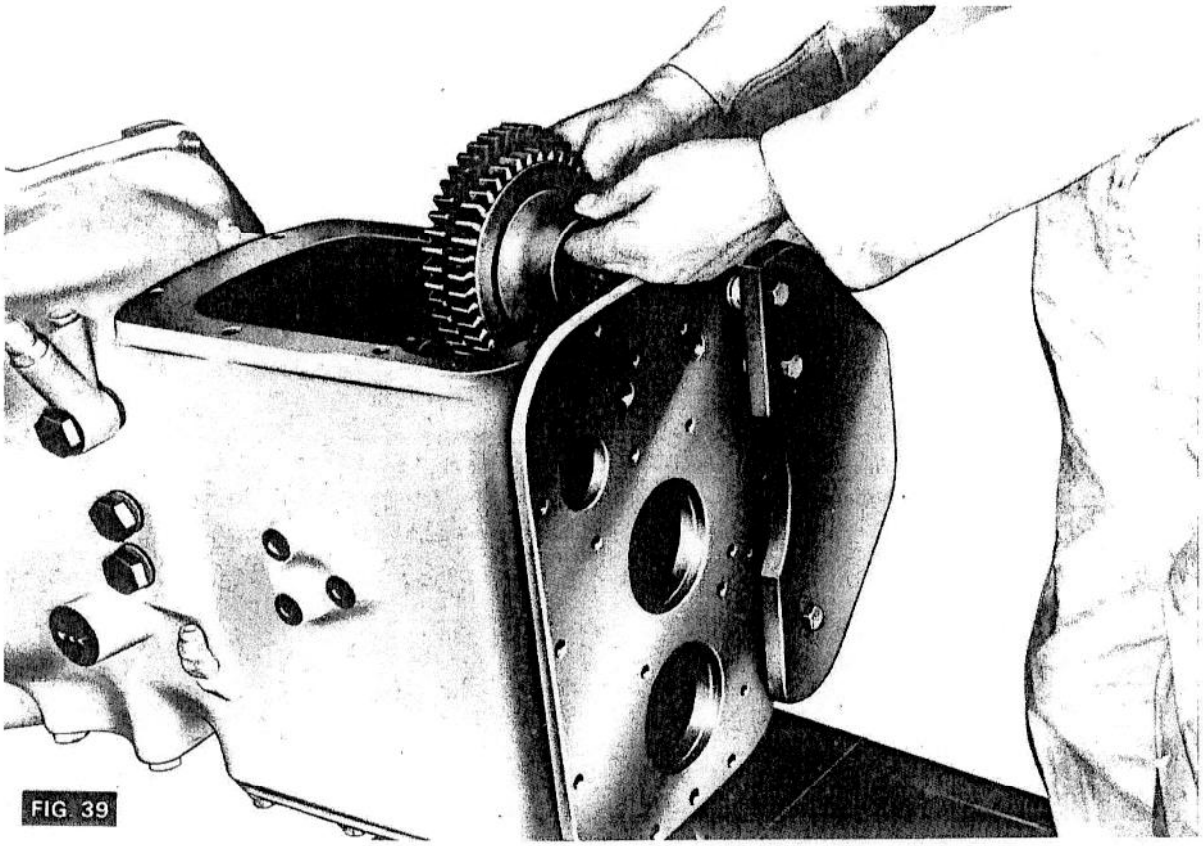

FIG. 39

INSTANT REVERSE TRANSMISSION

THE TWO SPEED GEARBOX

Disassembly (7A/15)

1. Remove the power train from the machine as described.
2. Detach the engine from the transmission case and split the power train between the transmission case and the centre axle housing as described in operation 7A/1.
3. Remove the eight bolts securing the gearbox cover to the transmission case. Lift the cover and gasket clear.
4. Remove the two bolts and washers securing the stop plate to the transmission case. Remove the stop plate.
5. Cut the locking wire and slacken the locking screws from the planetary shifter rail and selector fork. Remove the selector fork.
6. Remove the four bolts and spring washers securing the epicyclic reduction unit to the transmission case.
7. (Fig. 35) Remove the planetary gear plate (1), thrust washer (2), carrier assembly (3), planetary gear ring (4), thrust washer (5), front cover plate (6) and shim (7).
8. Slide out the planetary shifter rail and remove the plunger and spring.
9. Slacken the locking screws from the two speed shifter rail.
10. (Fig. 36) Slide out the selector rail and remove the plunger and spring.
11. Lift out the selector fork.
12. (Fig. 37) Pull out the mainshaft complete with bearing. Lift out the 1st and 2nd gear.
13. Remove the pilot bearing from the power output shaft of the instant reverse clutches.
14. (Fig. 38) Remove the countershaft with outer bearing and pinion gear through it's bore in the transmission case.
15. (Fig. 39) Lift out the pinion and driven gears from inside the transmission case.
16. Remove the countershaft inner bearing from its bore.
17. Reassembly is a reversal of the dismantling procedure.

INSTANT REVERSE TRANSMISSION

MAINSHAFT

Removal (7A/16)

1. Remove the two snap rings.
2. Remove the bearing on an hydraulic press. Ensure that the blocks are pressing against the inner race. The bearing must be pressed off the front end of the shaft.
3. Assembly is a reversal of this procedure. Renew the snap rings.

INSTANT REVERSE TRANSMISSION

COUNTERSHAFT BEARING

Removal (7A/17)

1. Remove the bearing using an hydraulic press, replace in the same way.

TORQUE CONVERTER

CONTENTS

LIST OF ILLUSTRATIONS

TORQUE CONVERTER

General

The drive from the engine is transmitted to the gearbox through an 11.3/4 in. (29.84 cm.) Borg and Beck torque converter coupling, comprising three main components:

(a) An impeller assembly (1), which is bolted directly to a drive plate mounted directly onto the engine flywheel. The impeller also drives the oil pump.
(b) A turbine assembly (2), which is splined to the input shaft of the instant reverse transmission.
(c) The stator assembly (3), which is located between the impeller and the turbine assembly and is keyed to a one way clutch. This allows the stator to revolve only in the direction of engine rotation. The clutch hub is splined to a fixed shaft of the oil pump assembly mounted on the front of the instant reverse transmission.

The oil pump, attached to the front of the instant reverse transmission, supplies oil at 80 p.s.i. (5.624 kg/sq.cm.). Oil is directed through drillings in the oil pump housing and then between the fixed shaft of the oil pump and the instant reverse input shaft, which revolves inside the fixed shaft.

As the converter housing is filled with oil at all times whilst it is working, the amount of wear which takes place is negligible and therefore should cause no trouble. Any failures will usually be confined to the cover assembly gasket or the hub gasket.

The torque ratio of the converter alters according to the load imposed on it. The stall speed of the converter is approximately 1600 r.p.m. At this speed the stator is still stationary, but the oil drag is such that the power of the engine is insufficient to drive the turbine. With this condition maximum torque multiplication occurs. The maximum torque ratio is 2.1·1.

The normal working temperature of the oil is 180° 210°F (82° · 99°C). The temperature of the oil should never be allowed to exceed 250°F (121.1°C). This is indicated by the red zone on the torque converter oil temperature gauge. If the oil does overheat, DO NOT STOP THE ENGINE. Stop work and allow the engine to idle until the temperature returns to normal.

Key to Fig 1

1. Cover Plate
2. Turbine
3. Impeller
4. Stator

TORQUE CONVERTER

Removal (7B/1)

1. Remove the engine, transmission and final drives from the machine as described
2. Remove the transmission and final drives from the engine as described
3. (Fig. 2) Mark the flywheel, cover and impeller with a centre punch or scriber in order to facilitate correct reassembly.
4. Remove the six bolts, washers and special nuts holding the torque converter to the flywheel.
5. (Fig. 3) Lift the torque converter clear from the flywheel, maintaining a vertical position in order to prevent oil spillage through the hub.
6. Remove the two taper plugs from the cover plate and drain the oil. Replace the plugs when the oil has been drained.

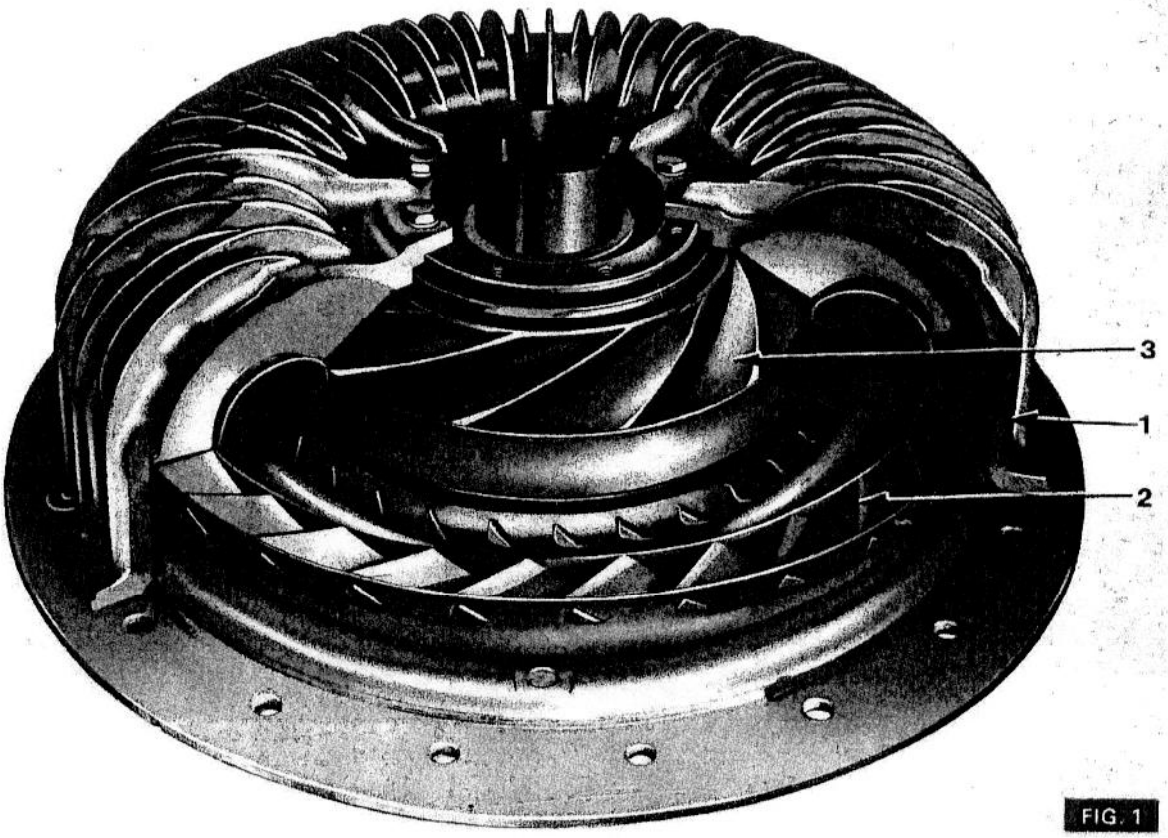

FIG. 1

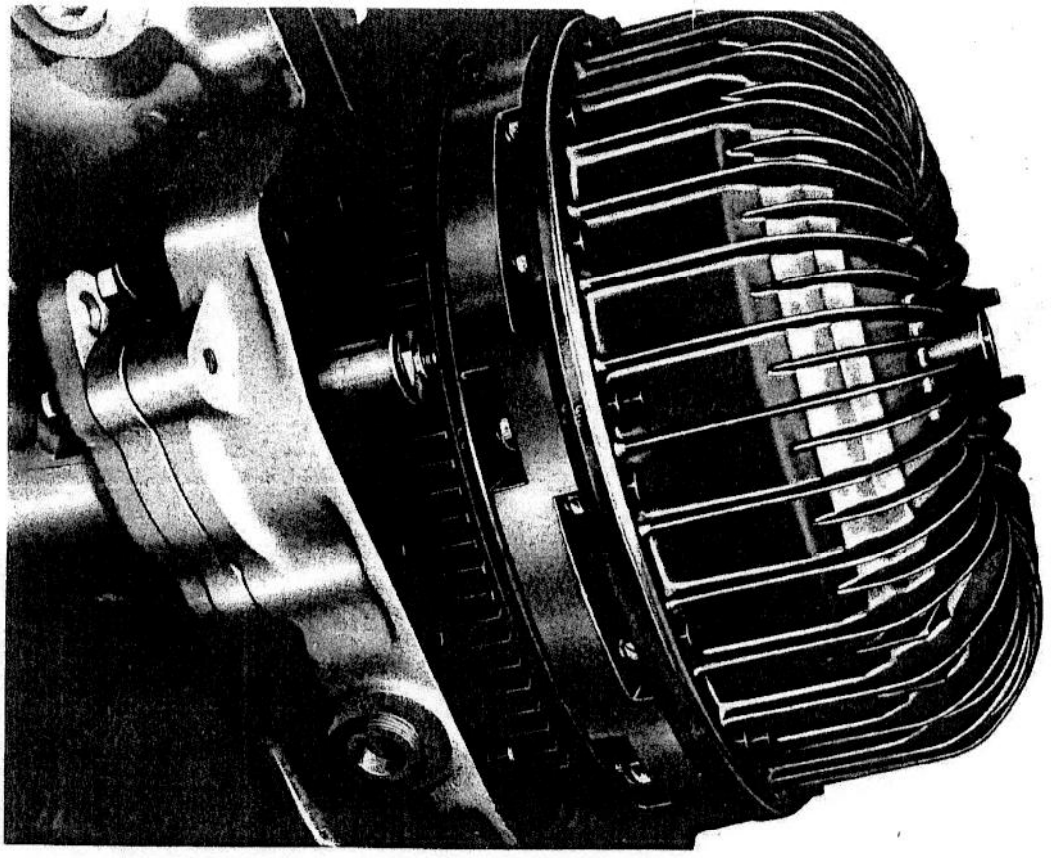

FIG. 2

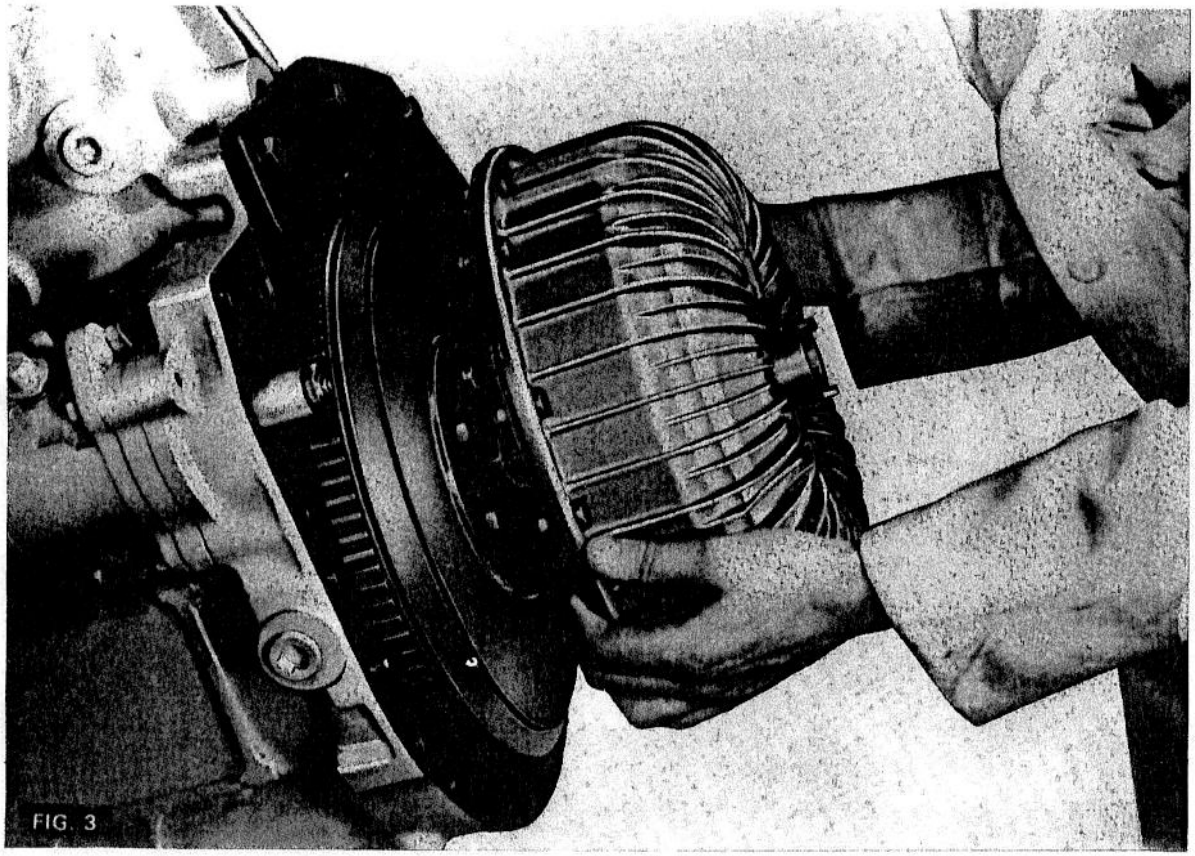

FIG. 3

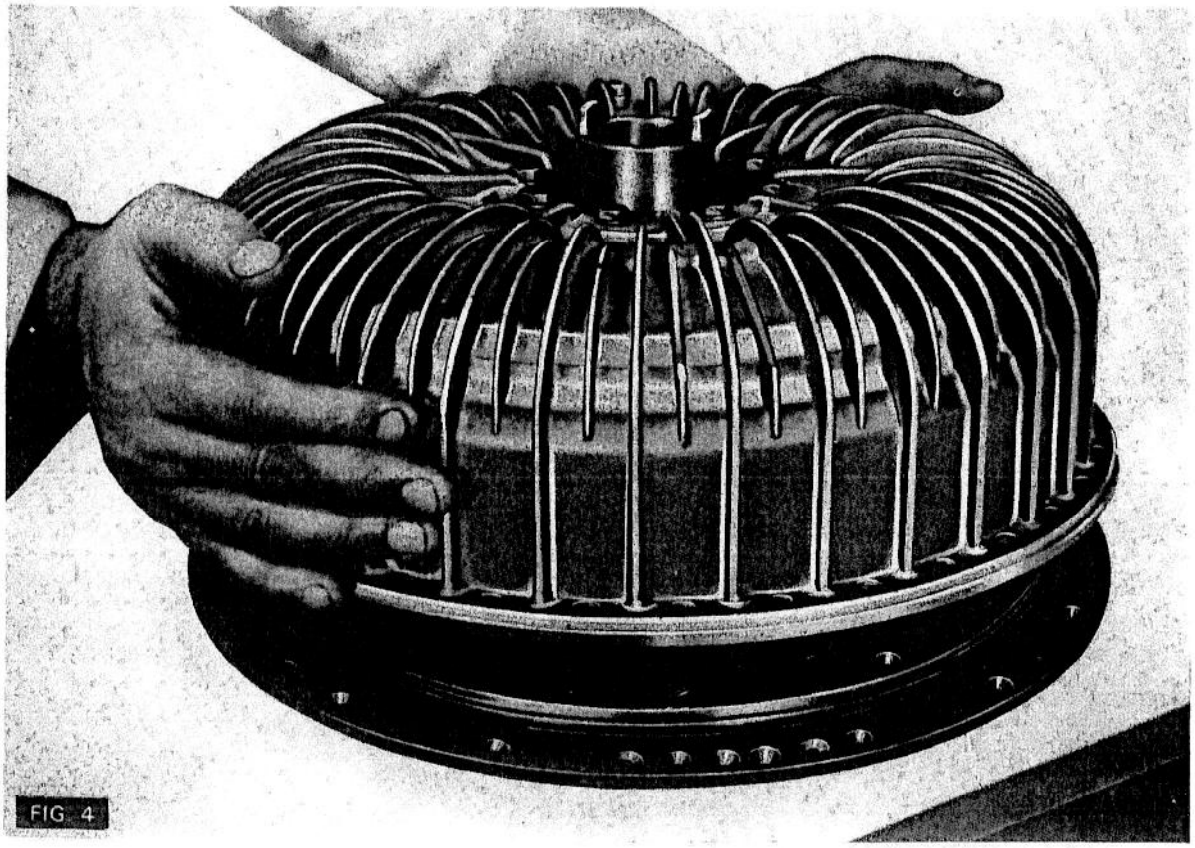

FIG. 4

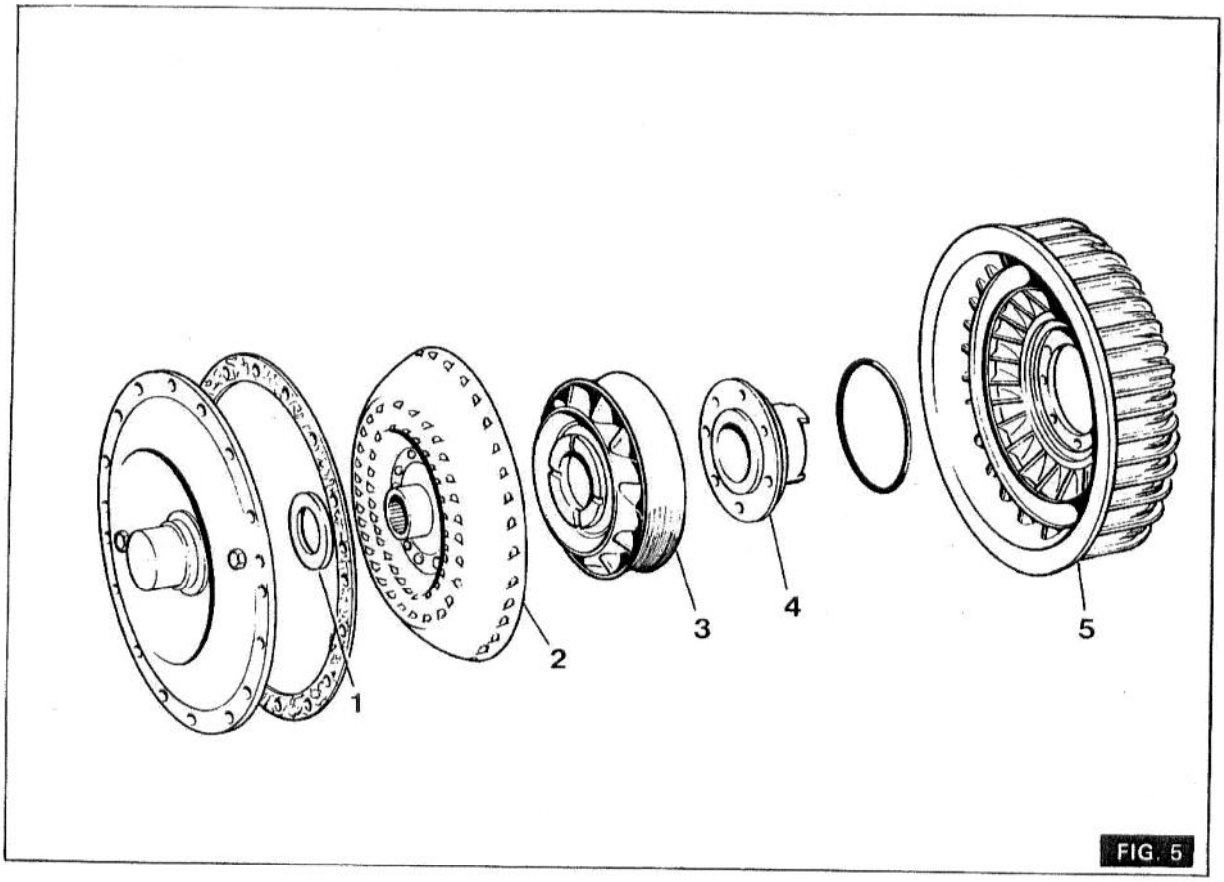

FIG. 5

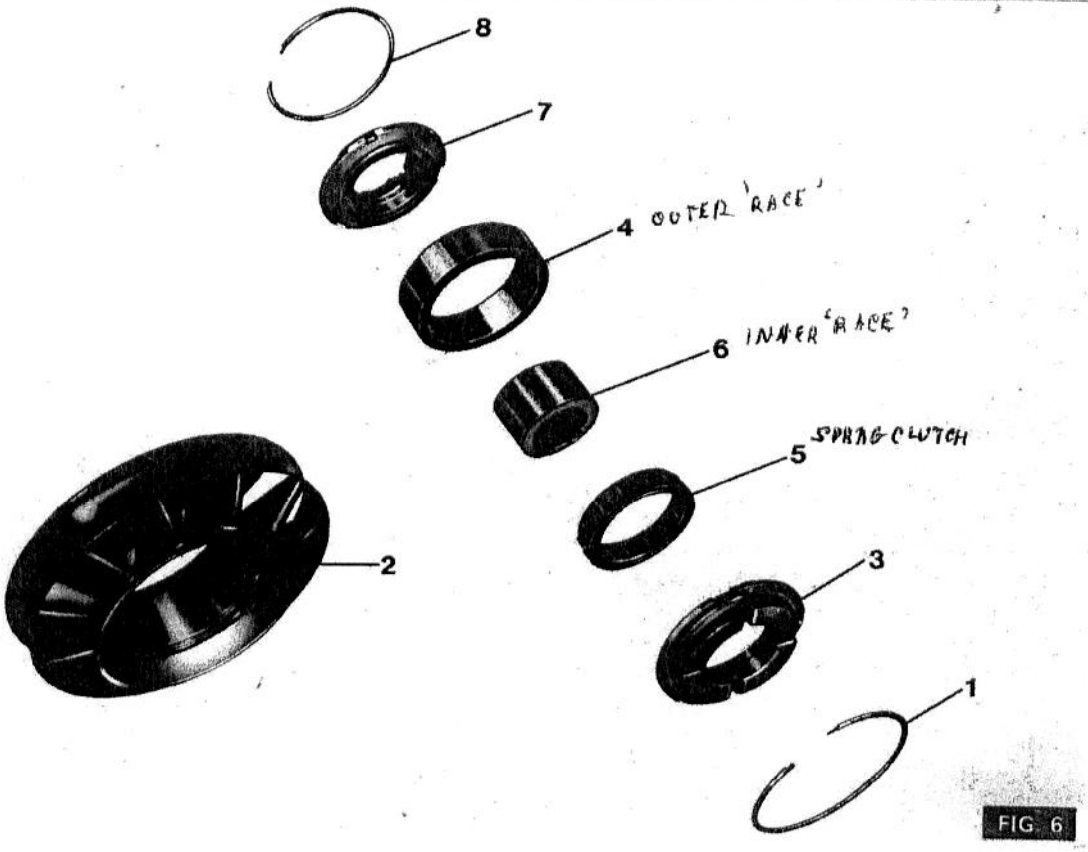

FIG. 6

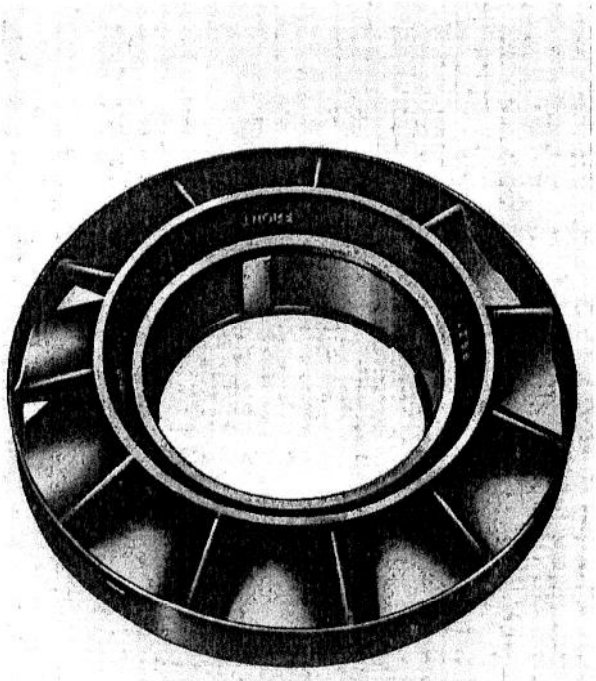

FIG. 7

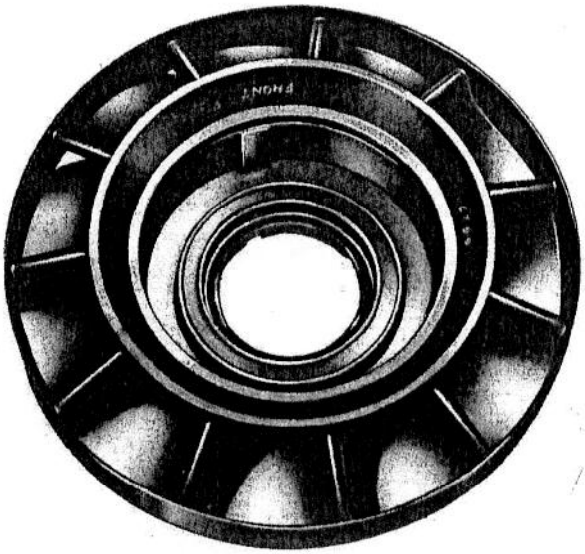

FIG. 8

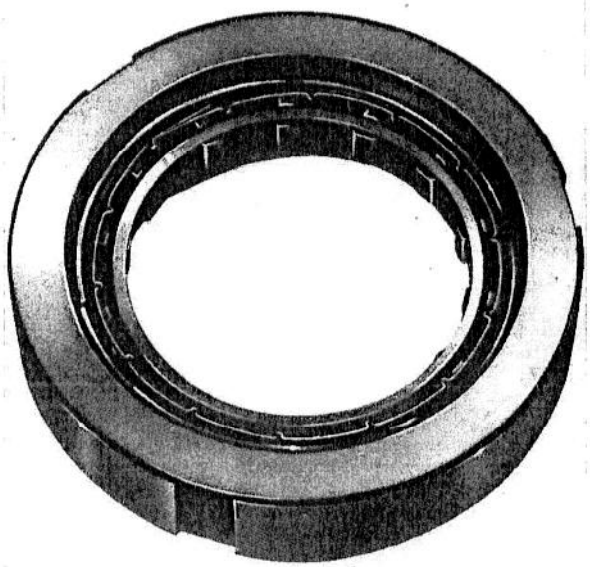

FIG. 9

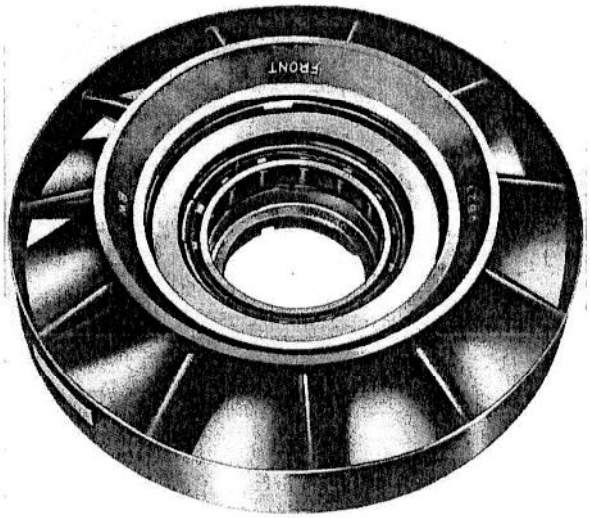

FIG. 10

TORQUE CONVERTER

Refitting (7B/2)

1. Fit the torque converter to the flywheel, ensuring that the alignment marks are correctly positioned.
2. Fit the washers to six new bolts and insert the bolts into the converter.
3. Screw on six new special nuts and tighten evenly to a torque setting of 22 lb.ft. (3.04 kg.m.).
4. Carry out the hub height test as detailed in operation 7B/9 and the hub run out test as detailed in operation 7B/10.
5. Replace the transmission and final drives to the engine.

TORQUE CONVERTER

Disassembly (7B/3)

1. Remove the torque converter as described in operation 7B/1.
2. Remove the twelve special bolts and nuts securing the impeller to the cover assembly.
3. (Fig. 4) Lift the cover plate and gasket from the impeller.
4. (Fig. 5) Remove the turbine thrust washer (1) and the turbine assembly (2).
5. Withdraw the stator assembly (3).
6. Mark the hub and impeller assembly to indicate the reassembly position.
7. Remove the eight bolts securing the hub (4) to the impeller (5). Lift the hub and gasket from the impeller.

STATOR

Disassembly (7B/4)

1. Remove the stator assembly as stated in operation 7B/3.
2. (Fig. 6) Remove the snap ring (1) from the stator body (2) and lift out the thrust washer (3).
3. Slide out the clutch mechanism, i.e. the clutch ring (4), the outer race (5) and the inner race (6).
4. Remove the second thrust washer (7) and snap ring (8).
5. Slide the inner race from the outer race and the outer race from the clutch ring.
6. Carefully examine all parts of the torque converter to ensure that no component is damaged. Renew damaged items where necessary. Individual assemblies, with the exception of the stator clutch assembly, cannot be serviced and must be replaced complete.
   If the lugs on the impeller hub become worn more than .125 in. (3.175 mm.) at the tip of the lug, the hub must be replaced.

STATOR

Reassembly (7B/5)

1. (Fig. 7) Fit the snap ring into the groove in the stator body, on the opposite side to the face of the stator marked 'FRONT'.
2. Place the stator with the face marked 'FRONT' uppermost.
3. (Fig. 8) Replace one thrust washer with the slotted side against the circlip.
4. (Fig. 9) Insert the outer race into the clutch ring.
5. (Fig. 10) Slide the outer race and clutch ring into the stator body, with the broader flange of the clutch uppermost.
6. (Fig. 11) Insert the inner race into the outer race with the splined end uppermost.
7. (Fig. 12) Replace the second thrust washer and lock in place with the snap ring.
8. Ensure that, with the inner race held stationary, the stator body will only rotate clockwise when viewed from the front.

TORQUE CONVERTER

Reassembly . . . Cont'd

Note

Reassembly must be performed with the stator body face marked 'FRONT' uppermost. This is important.

Reassembly (7B/6)

1. (Fig. 13) Fit a new hub seal into place in the impeller assembly.
2. Align the marks on the hub with the mark on the impeller and secure the hub in position with the eight bolts and washers. Apply a torque loading of 8 - 10 lb.ft. (1.106 kg.m.) to the bolts.
3. Replace the stator assembly with the face marked 'FRONT' uppermost, in the impeller assembly.
4. Fit the turbine into the impeller assembly.
5. Place the thrust washer onto the turbine hub.
6. (Fig. 14) Fit a new seal onto the cover plate and place the cover on the impeller assembly, ensuring that the alignment marks correspond.
7. Replace the twelve special bolts, fit new nuts and tighten to 22 lb.ft. (3.04 kg.m.).

FLYWHEEL

Removal (7B/7)

1. Remove the torque converter as stated in operation 7B/1.
2. Turn the flywheel until the dowel hole is at the top.
3. (Fig. 15) Straighten the tab washers (1) and slacken the setscrews (2) that secure the flywheel to the crankshaft.
4. Insert a suitable rod into the dowel hole and remove the setscrews and tabwashers.
5. (Fig. 16) Insert the rod into the dowel hole in the flywheel and gently lever the flywheel, complete with shims, onto the rod.
6. Remove the shims from the flywheel.

FLYWHEEL

Refitting (7B/8)

1. Insert the rod through the flywheel, place the shims onto the rod.
2. (Fig. 17) Lift the flywheel, with shims on the rod. Insert the rod into the locating hole in the crankshaft.
3. Slide the shims and flywheel into position against the crankshaft.
4. Fit three new tabwashers and the six setscrews to secure the flywheel to the crankshaft. Tighten the setscrews to a torque loading of 70-80 lb.ft. (10.5 - 11.1 kg.m.).
5. Bend the tabwashers over to lock the setscrews in position.

CHECKING IMPELLER HUB HEIGHT (7B/9)

1. Remove the power train and detach the engine from the transmission as stated in operation 7A/1.
2. (Fig. 18) Place the special tool, MF 246, over the torque converter with the feet of the gauge on the engine backplate.
3. By moving the gauge, determine whether the hub height is within the limits of the gauge.
4. (Fig. 19) If the 'NO GO' limit passes over the hub face, add shims between the flywheel and crankshaft until the height is within the limits.
5. To add shims, carry out operations 7B/7 and 7B/8, fitting or removing shims as required.

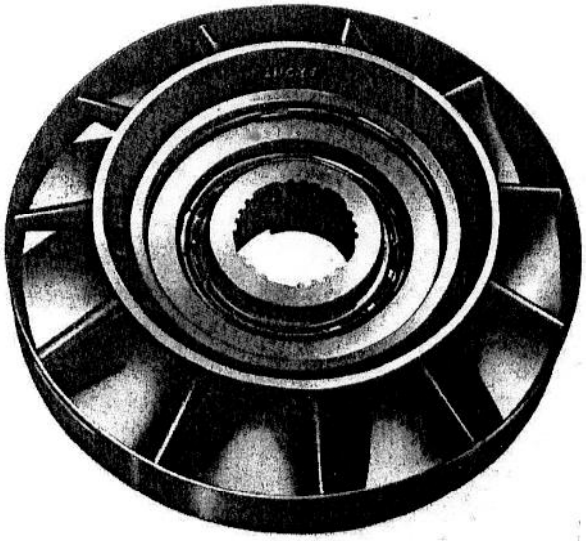

FIG. 11

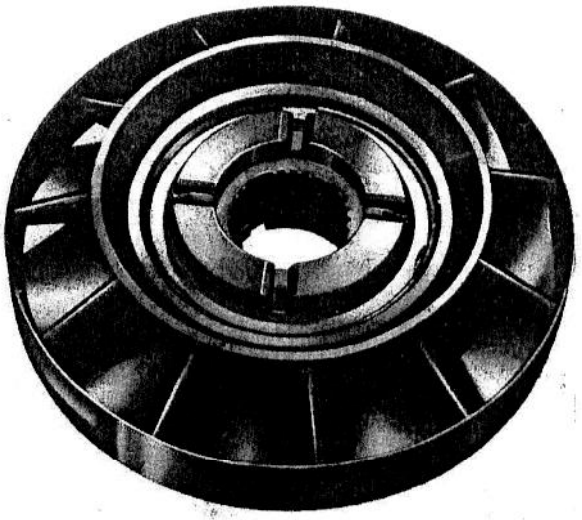

FIG. 12

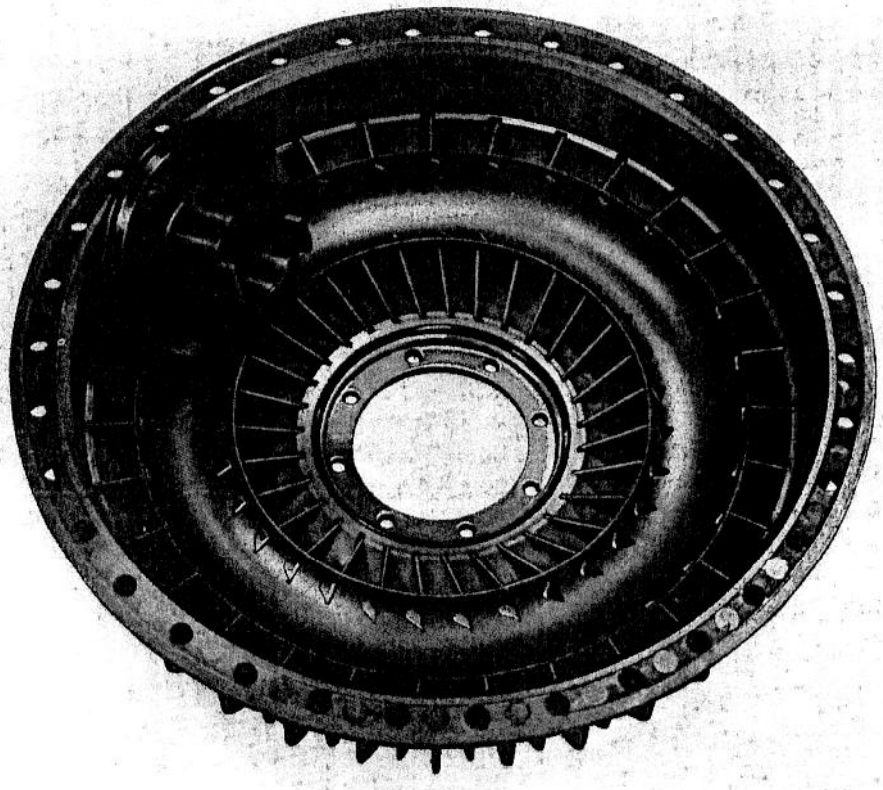

FIG. 13

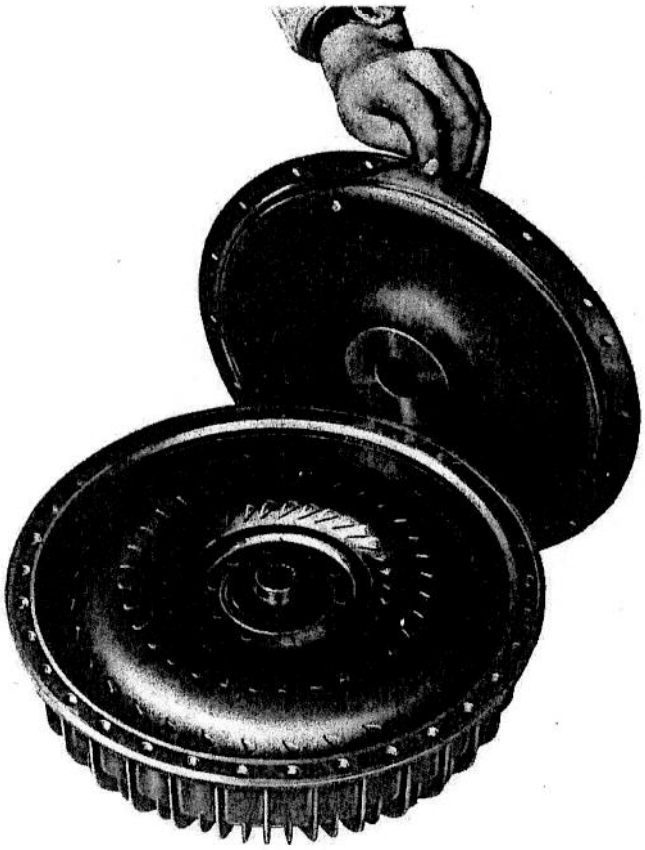

FIG. 14

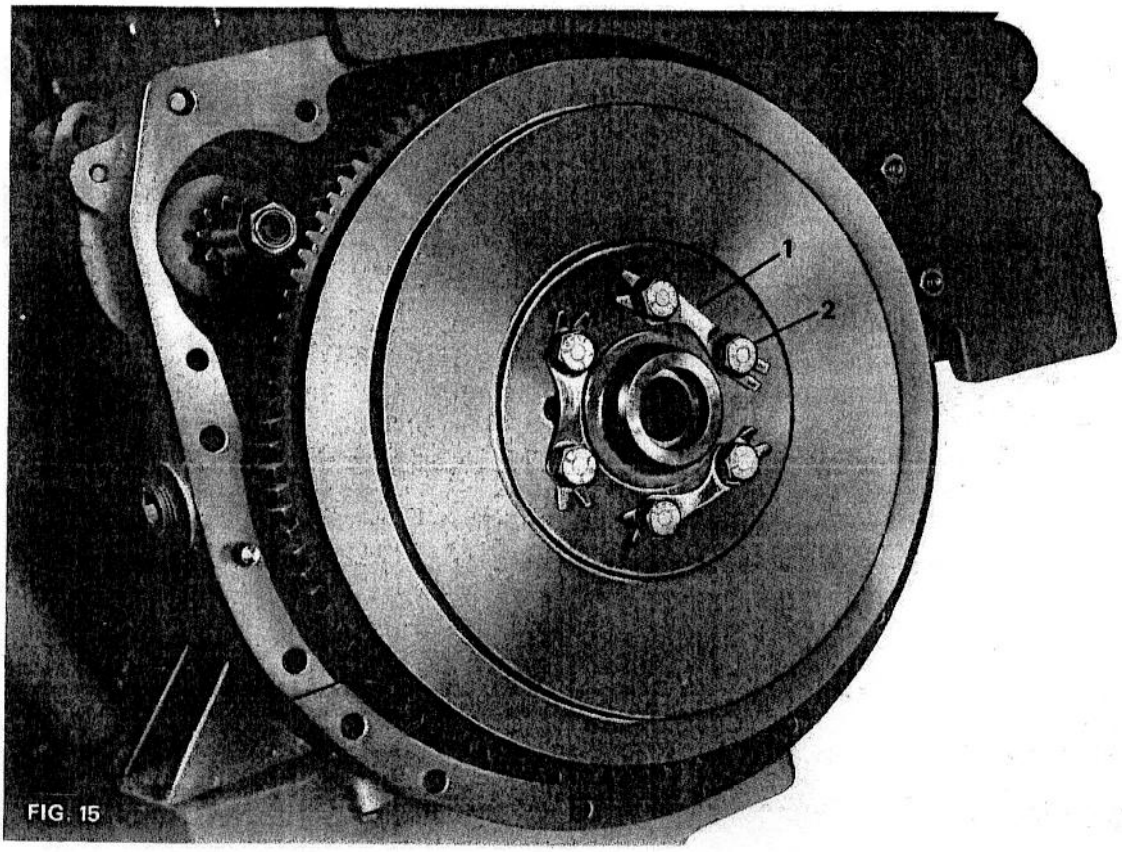

FIG. 15

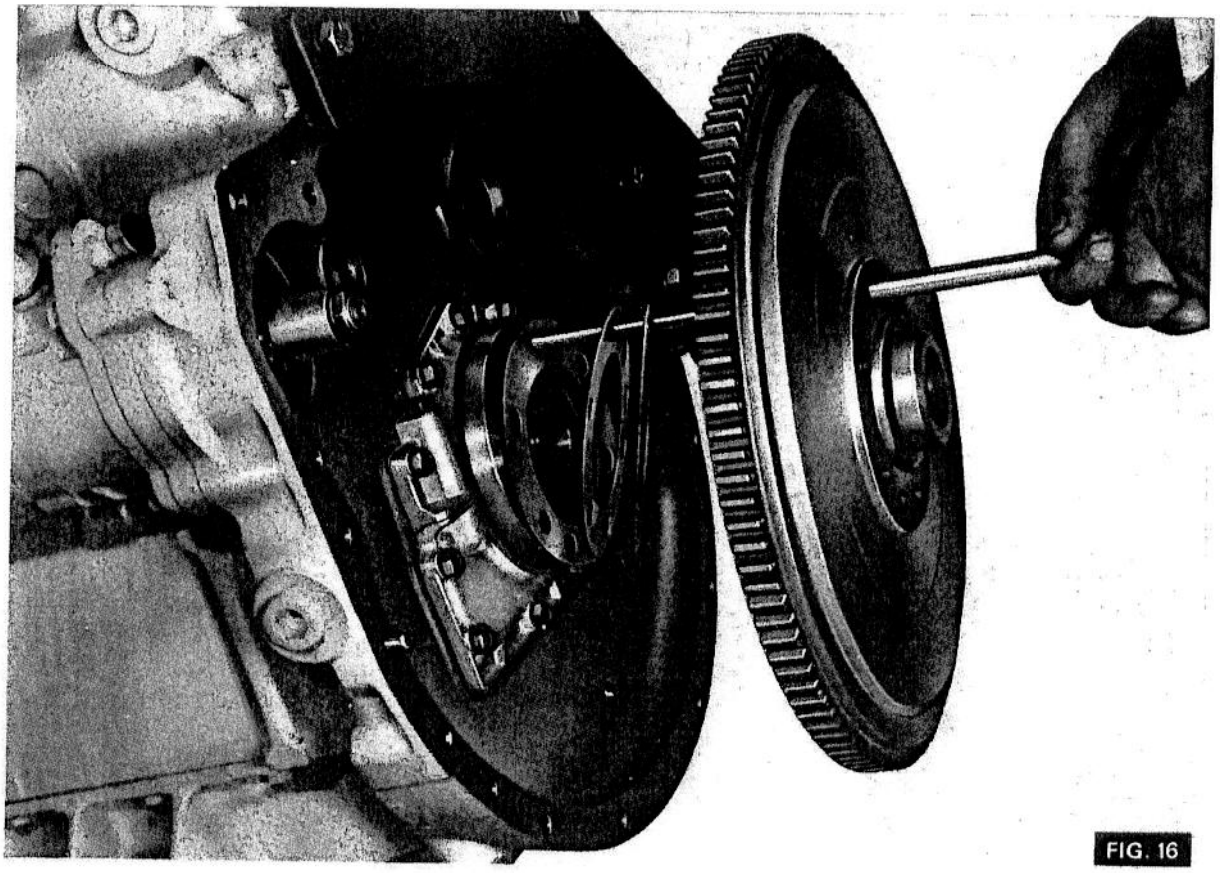

FIG. 16

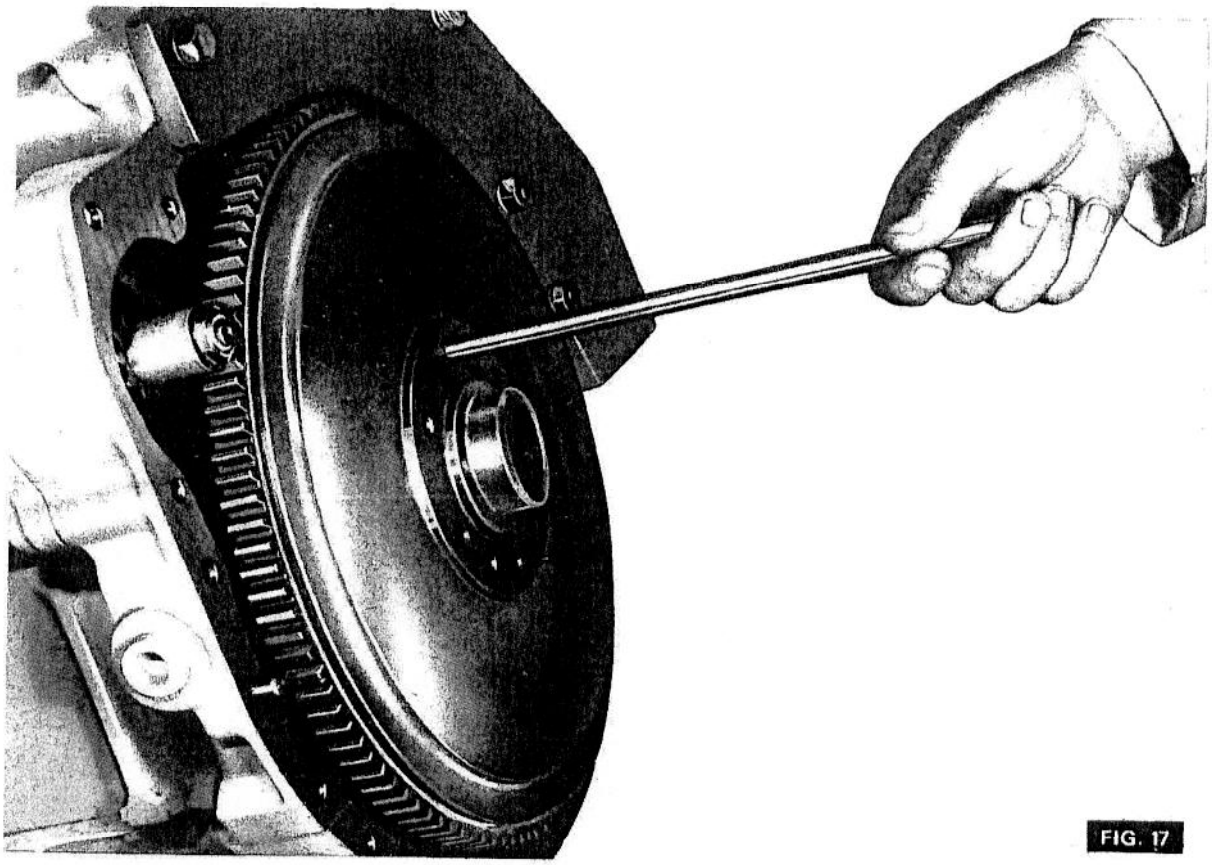

FIG. 17

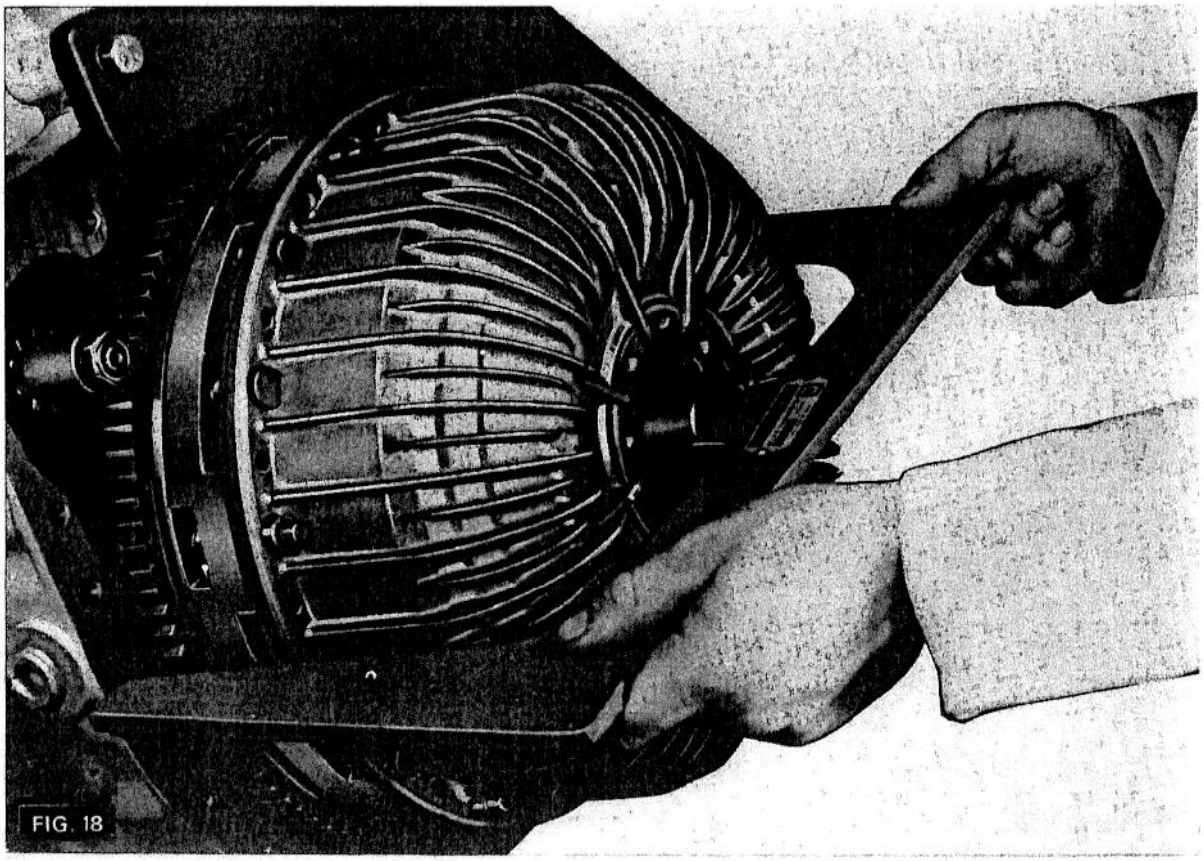

FIG. 18

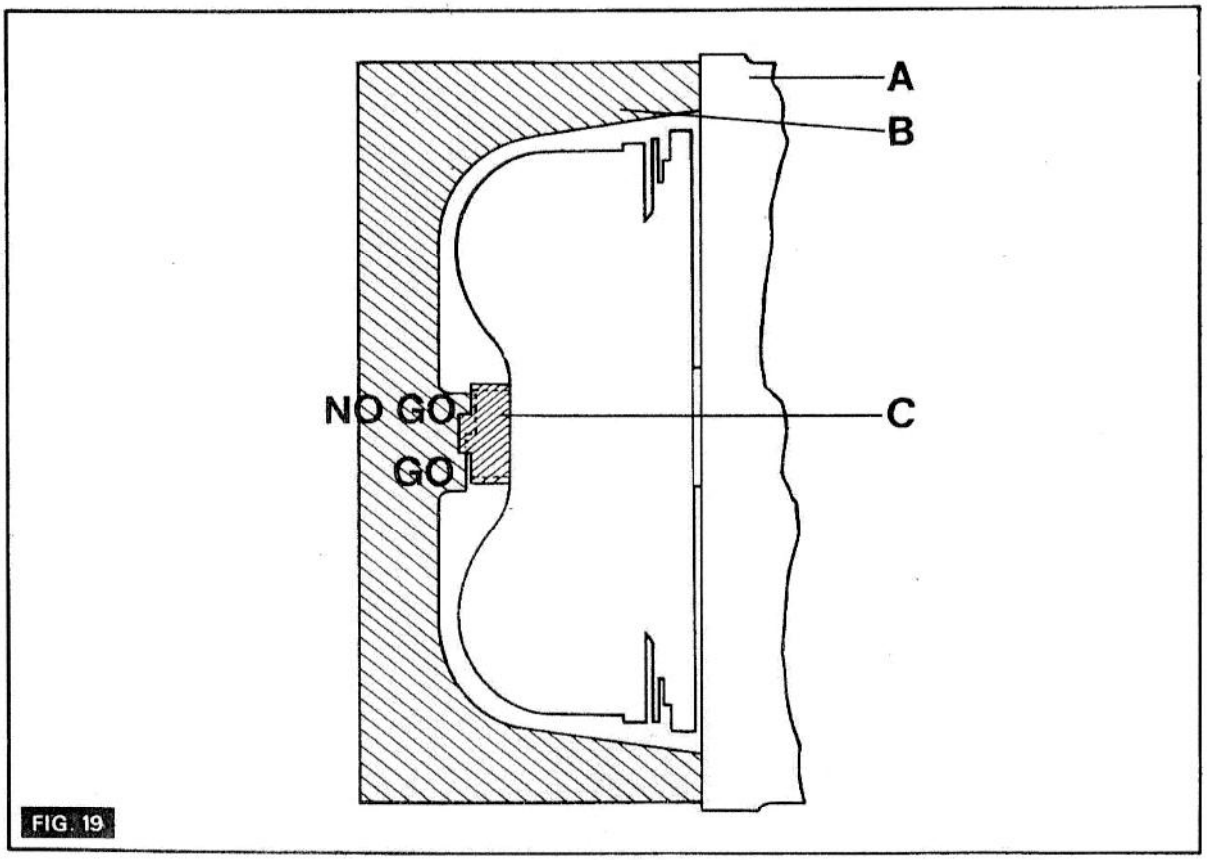

FIG. 19

CHECKING IMPELLER HUB HEIGHT . . . Cont'd

Note

Shim thickness is 0.020 in. (.508 mm.) and the difference between the 'GO' and 'NO GO' limit is 0.080 in. (2.032 mm.). Determine the number of shims necessary by checking with feeler gauges. Add shims between the flywheel and crankshaft until the hub height is as near to the 'GO' limit as possible.

CHECKING IMPELLER RUN OUT (7B/10)

1. (Fig. 20) Fix a dial indicator base to the engine backplate.
2. Adjust the indicator plunger to run on the edge of the hub. Set the indicator to zero.
3. Turn the torque converter and check the indicator reading (run out).
4. Total run out should not exceed 0.010 in. (0.154 mm.). If the run out exceeds this figure, insert a suitable lever between the flywheel and drive plate. Bend the drive plate slightly at the point of maximum run out, until a satisfactory reading is obtained.

TORQUE CONVERTER AND INSTANT REVERSE TRANSMISSION

Pressure Checking Procedure (7B/11)

1. Check the oil level.
2. (Fig. 21) Remove the plug (1) from the top of the bell housing. Grip the base nut firmly with a spanner when removing the nut.

CAUTION

DO NOT TURN THE BASE NUT (2) AS THIS WILL SHEAR THE INTERNAL PIPE NECESSITATING A COMPLETE STRIP DOWN.

3. Install the pressure gauge MF 260vwith adaptor MF 260/2 into the base nut on top of the bell housing.
4. (Fig. 22) Remove the top regulator valve cap (A) on the left hand side of the transmission case.
5. (Fig. 23) Remove the spring, guide pin and regulator valve. Examine the 'O' ring on the valve cap, renew if necessary, and refit the valve cap.
6. Start the engine and set the speed at 1800 r.p.m.
7. The pressure reading on the gauge should be 80 ± 5 p.s.i. (5.6 ± 0.35 kg./sq.cm.). This pressure is set by the LOWER regulator valve.
8. If the pressure reading is low, stop the engine and fit shim(s) between the spring and regulator cap on the LOWER regulator valve (B) until a satisfactory reading is obtained.
9. When a satisfactory reading is obtained, stop the engine and replace the TOP regulator valve assembly ensuring that the guide pin is correctly located in the valve poppet.
10. Set the engine speed again to 1800 r.p.m. and check the pressure reading which should now be 160 ± 5 p.s.i. (11.15 ± 0.35 kg./sq.cm.). This pressure is set by the TOP regulator valve which should be adjusted by shim(s) if necessary in the same manner as the LOWER valve. The free length of the springs in the valves should be 2.14 ± 1/16 in. (57 ± 1.6 mm.).

Note

The oil must be up to the correct level and at the correct working temperature of 180° - 210°F (82° - 99°C.) when pressure testing. Always check the pressure of the lower valve before adjusting the top valve. The presence of air in the system is indicated by a buzzing noise. Do not test the pressure under these circumstances, but allow the engine to idle for a short time to dispel any air from the system.

INSTANT REVERSE CLUTCHES

To Check for Oil Leaks (7B/12)

1. Set the engine speed at 1800 r.p.m.

INSTANT REVERSE CLUTCHES

To Check for Oil Leaks . . . Cont'd

2. With the gear levers in the neutral position, fully depress the FORWARD and REVERSE pedals in turn.
3. Check that the indicated pressure drops momentarily and then re-establishes a reading of 160 p.s.i. (11.25 kg./sq.cm.). If a low reading is apparent, this indicates a leak in the feed system to the clutches.

TO CHECK STALL TORQUE SPEED (7B/13)

1. Check the level of the oil in the system. Run the engine until the oil temperature is within the working range of 180° - 210°F (82° - 99°C).
2. Apply the brakes to ensure that the tractor cannot move.
3. Check the maximum engine speed with the gears in neutral. This should be 2,000 r.p.m.
4. Place the planetary gear-selector in the HIGH range and the gear shift in SECOND gear.
5. Depress fully the FORWARD pedal. The engine speed should be 1350-1450 r.p.m.
6. Repeat above procedure with the REVERSE pedal. If the engine speed is higher than 1450r.p.m. during either of the above operations, then it indicates the respective clutch is slipping or that the torque converter is cavitating, the latter condition is made apparent by a high pitched whine. If the engine speed is lower than 1350r.p.m. then this indicates that the engine requires attention.

Note

This test must be carried out with the oil at its normal working temperature 180° - 210° (82° - 99°C) The test should be concluded as quickly as possible as the oil temperature will rise rapidly. The oil temperature must not, at any time, exceed 250°F (121°C).

OIL TEMPERATURE

Operating Range

The normal temperature range of the transmission and torque converter oil is 180° - 210°F (82° - 99°C). Under no circumstances must the oil temperature exceed 250°F (121°C).

If the oil temperature should reach 250°F (121°C), stop work and allow the engine to idle until the oil temperature drops to the normal working range.

DO NOT STOP THE ENGINE WITH THE OIL AT THIS HIGH TEMPERATURE, AS THIS WILL CAUSE THE OIL SEALS TO BE DAMAGED.

Persistent overheating is usually caused by operating the machine in too high a gear or because the oil is not up to the correct level.

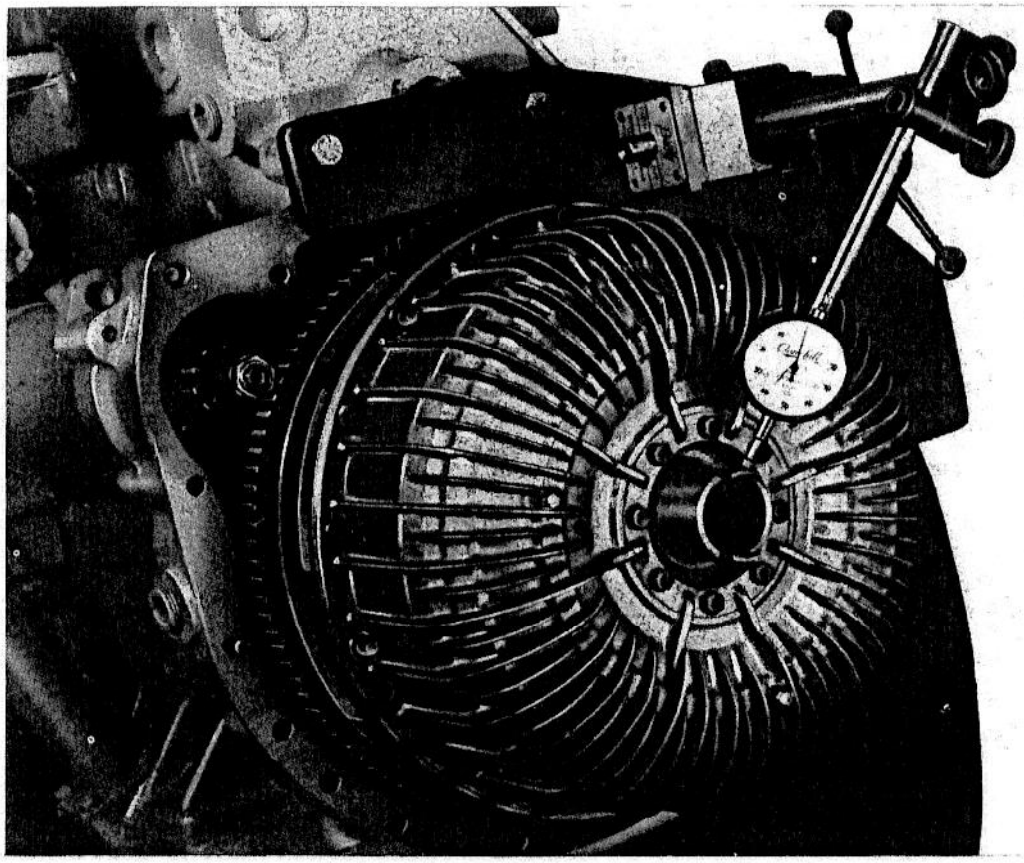

FIG. 20

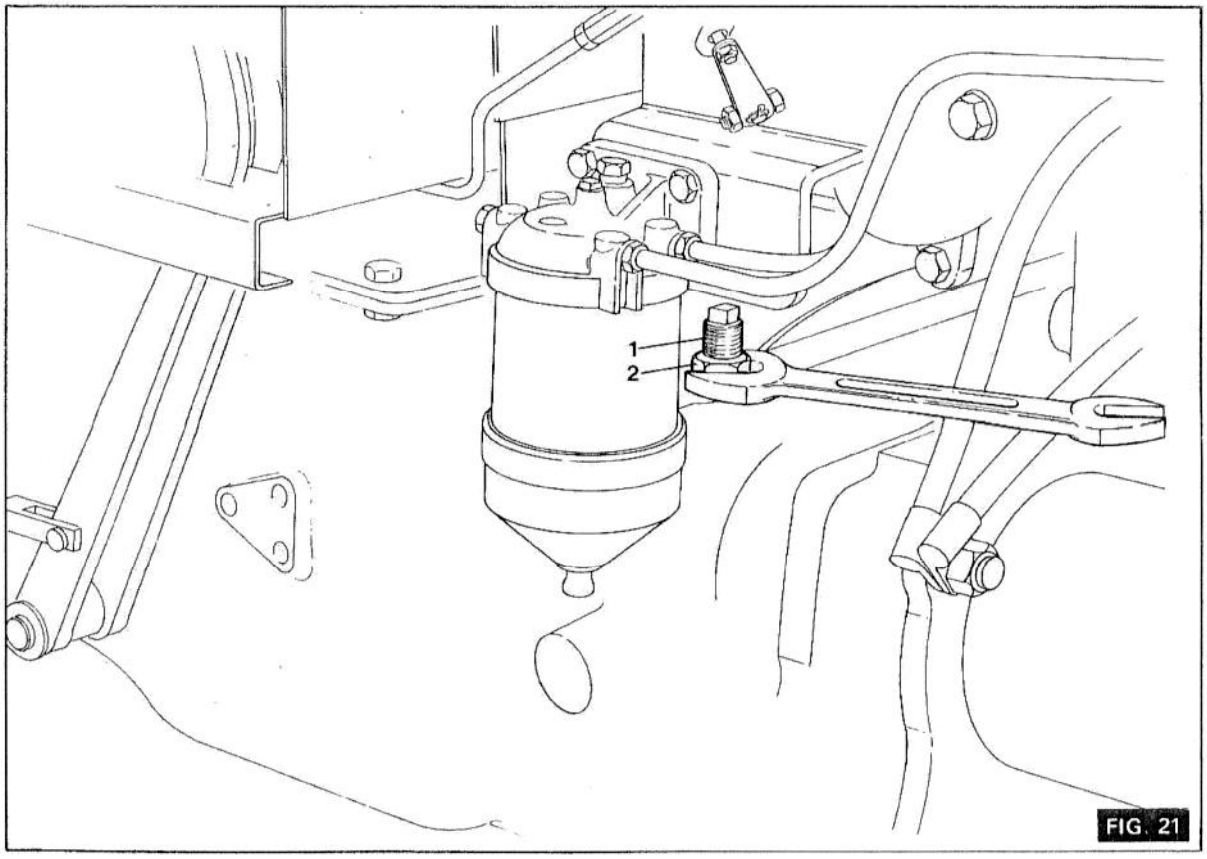

FIG. 21

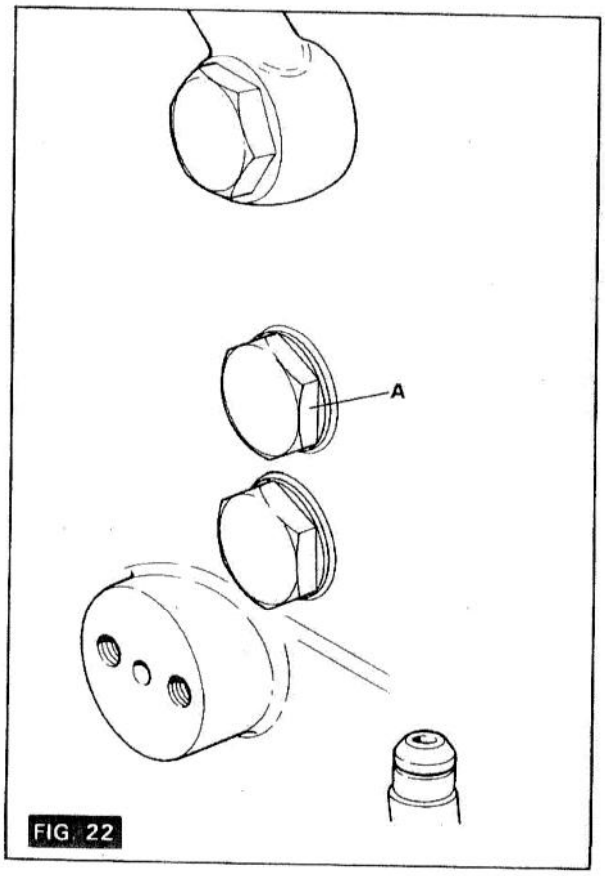

FIG. 22

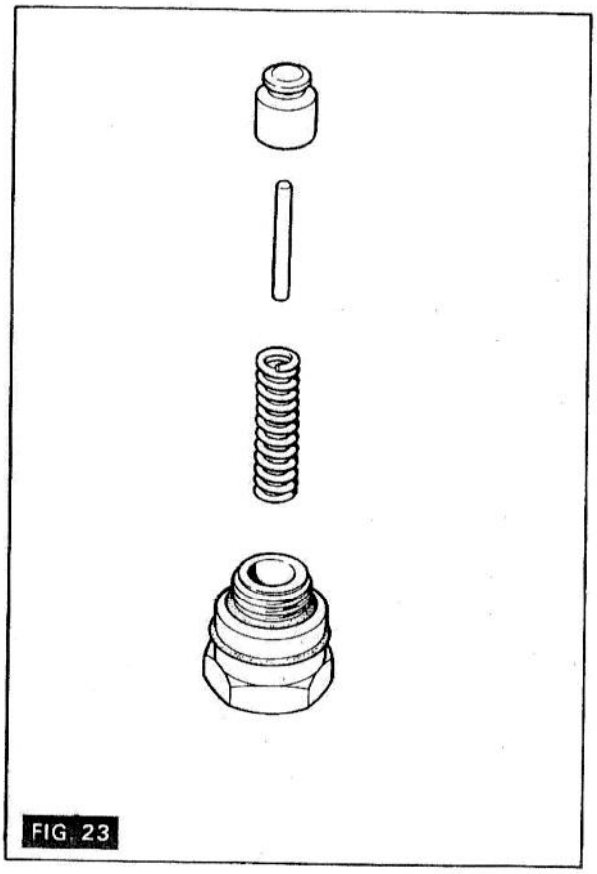
FIG. 23

ON50D. 1983 APPROX JUNE (EARLY)

Aluminium Torque Converters were fitted in production again with different ratio from the steel ones previously in use.

From 2WD 2882 W 1372
4WD 2915 W 582
PLUS W 544

} + 7 lg KPS

C.J.CANN
A.C. BAKER
D. HODGES
R CARTER
N. DUNSTON
WARNER
GOLDSWORTHY.

REAR AXLE AND WET BRAKES

CONTENTS

LIST OF ILLUSTRATIONS

REAR AXLE AND WET BRAKES

GENERAL

The drive from the transmission mainshaft is transmitted through the rear drive shaft and shear tube to a spiral bevel driving pinion and crown wheel, then through the axle shafts and epicyclic reduction units to the rear wheel axles.

The driving pinion is supported in the centre housing by a straight roller pilot bearing and a pre-loaded taper roller bearings mounted in a separate housing.

The crown wheel is attached to the split differential case, which is supported each side by a tapered roller bearing. The differential pinions run on a cross joint and thrust is taken by thrust washers behind the pinions.

The axle shaft inner ends are splined into differential gears and the outer ends are splined into the sun gear in the epicyclic unit.

The wheel axles are splined into the epicyclic carrier which is driven by the sun gear and planetary pinions.

A differential lock is fitted to the right hand axle housing. When the spring loaded lever is pulled, a shaft engages a coupler with a coupling cap on the differential case, thus locking the differential.

This machine is fitted with Girling multi-disc oil cooled brakes between the axle housings and the differential carrier plates adjacent at the centre housing.

The brakes are operated by two independently operated pedals located on the right of the floorplate, on machines with standard transmission and on the left of the floorplate on machines with reversomatic transmission.

The right pedal operates the right hand brake and the left pedal operates the left hand brake, to assist turning. For highway use the brakes are used together by operating an interlocking latch which joins the two brake pedals. When only single brakes are supplied on the machine the parking brake also actuates these disc brakes. Pressure on the brake pedal brings an actuating assembly in contact with two rotating middle (friction) discs splined to each axle shaft, these in turn contact fixed friction faces provided in the axle housing and in the differential carrier plate fitted between the centre and axle housings. The mechanism of each brake consists of two cast iron actuating discs, held together by tension springs and separated by steel balls located in inclined seats. Pressure on the brake pedal, by pulling on the operating rod, rotates one actuating disc relative to the other, and the steel balls ride up their inclined seats and so spread the actuating discs apart. These come into contact with the rotating (friction) discs, which are splined to the shaft being braked. The actuating assembly will move slightly in the direction of rotation until the torque ear of one actuating disc comes into contact with a shaft in the housing. The other actuating disc tends to rotate further increasing the angular displacement between the discs, and assisting the braking action. When the operating pull is released, the tension springs cause the discs to return to their normal position.

Dual brake tractors are fitted with disc brakes at the inner end of the two rear axle shafts and have an additional and entirely separate mechanical braking system comprising two brake assemblies mounted at the outer ends of the rear axle housings. These secondary brakes are Girling 14 in x 2 in, two shoes, double acting floating cam full servo brakes.

All the operations which follow assume that the cab, platform, digger and loader have been removed.

EPICYCLIC UNIT

Removal and Refitting (8A/1)

1. Apply the parking brake.
2. Drain the oil from the unit by removing the drain plug.
3. Jack up the machine and remove the wheel.
4. Suitably mark the axle housing, planetary ring gear and drive cover so that the same relative position can be maintained on assembly.
5. Remove the setscrews and disconnect the parking brake cross shaft at the drum brake actuator.
6. Remove the nuts and bolts which secure the epicyclic unit to the trumpet housing.
7. (Fig. 2) Withdraw the epicyclic unit complete with ring gear from the trumpet housing. Do not withdraw the axle shaft.
8. Remove the ring gear and the two cork gaskets.

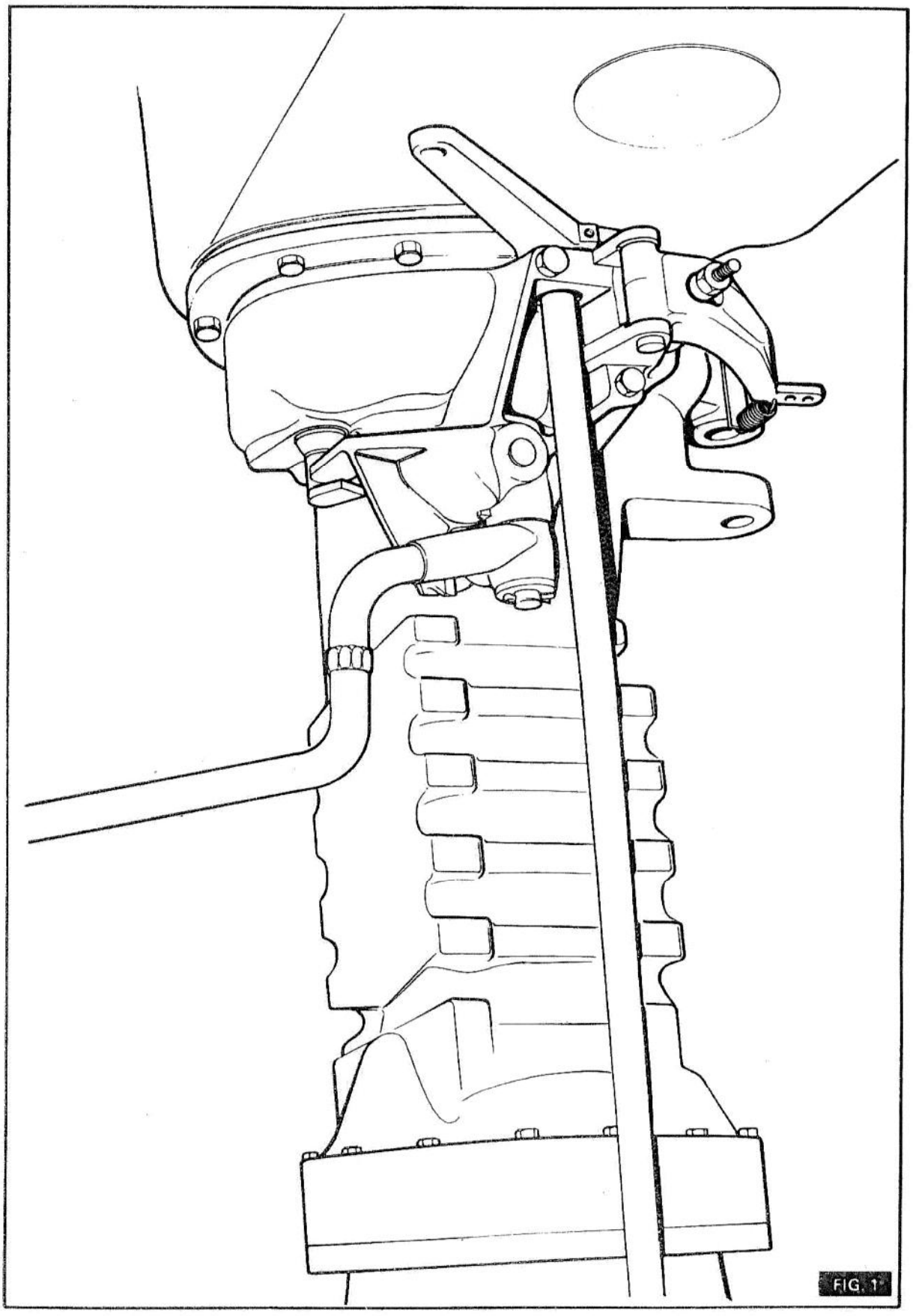

FIG. 1

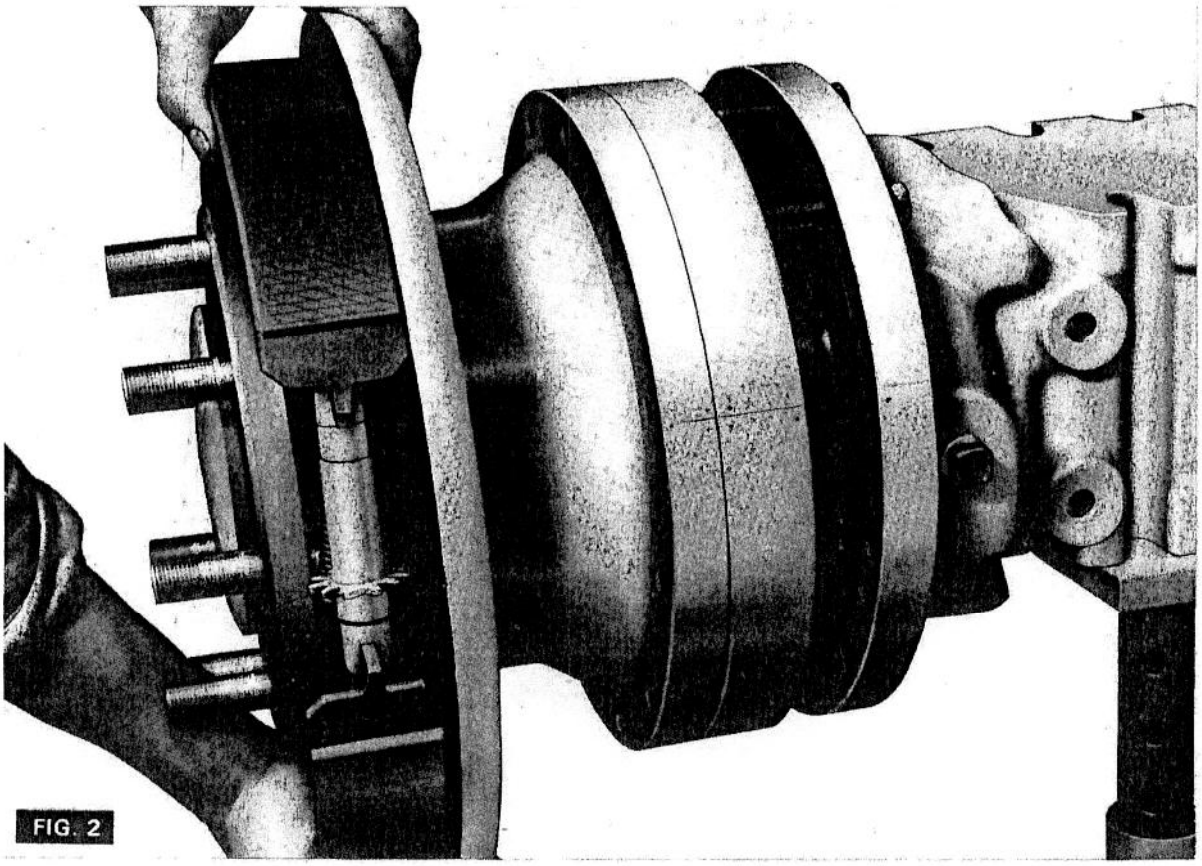

FIG. 2

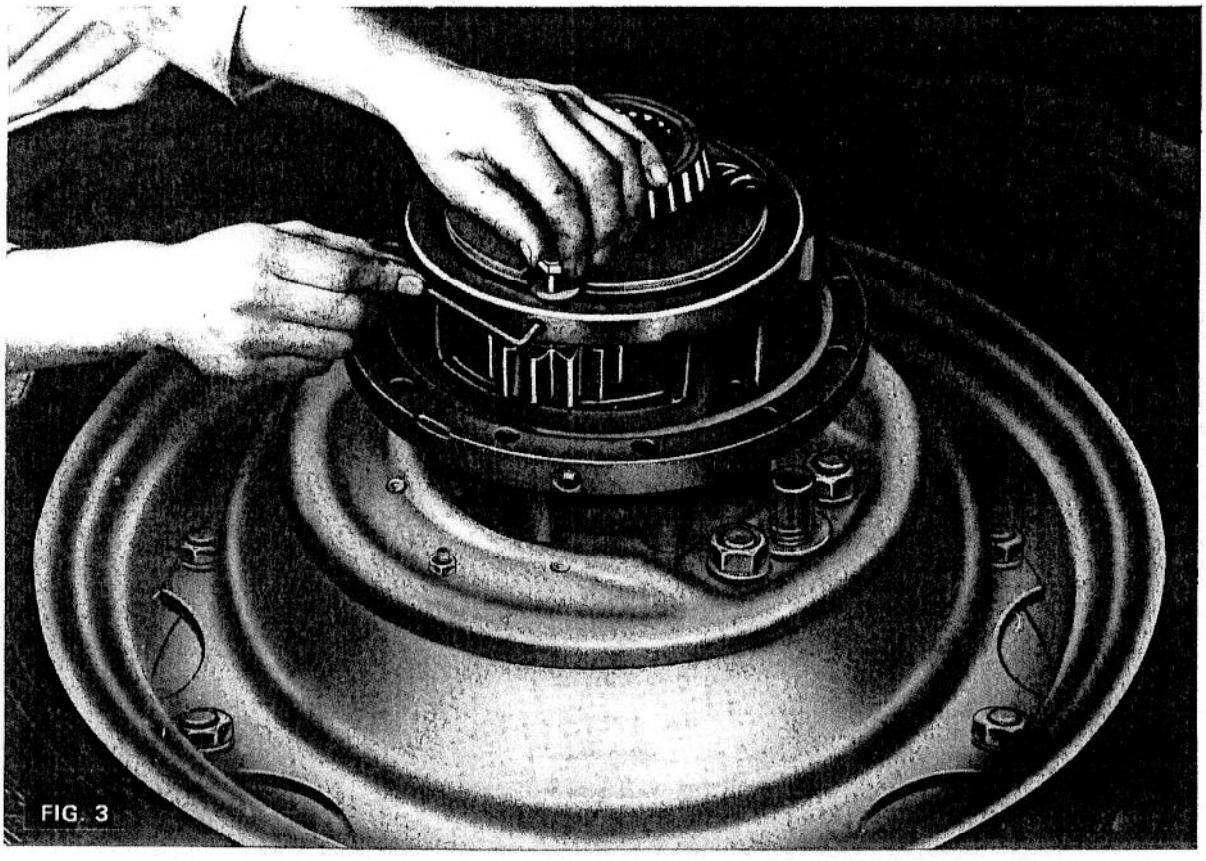

FIG. 3

EPICYCLIC UNIT

Removal and Refitting . . . Cont'd

9. To refit the unit reverse the above procedure using new cork gaskets. Ensure that the planetary ring gear is fitted the correct way round with the ring gear teeth in full engagement. Align the marks on the axle housing planetary ring gear and drive cover. Refill the epicyclic unit with a recommended oil to the level of the filler plug.

PLANETARY PINION CARRIER

Disassembly (8A/2)

1. Remove the epicyclic unit as described in operation 8A/1.
2. Remove the planetary ring gear from the axle housing.
3. Attach the epicyclic unit to the wheel.
4. Release the staking from around the three socket screws which secure the planetary pinion shafts.
5. (Fig. 3) Remove the socket screw which secures the pinion shaft carrying the master pinion i.e. the pinion fitted in the widest of the three apertures in the carrier. Screw a bolt into the tapped hole in the end of the planet gear shaft.
6. (Fig. 4) Withdraw the shaft taking care not to dislodge the roller bearings then remove the planetary pinion complete with roller bearings and thrust washers, out of the carrier.
7. Slide the sun gear from the carrier through the widest of the three apertures.
8. Fit the special tool MF 265A into the epicyclic carrier.
9. Screw down the bolt of the special tool in order to pull the epicyclic carrier from the wheel axle.
10. Lift off the carrier and remove the tool.
11. Remove the two remaining planetary pinion shafts and pinions from the carrier.
12. Remove the taper roller bearing from the carrier using special tool MF 200 and 200-24.

PLANETARY PINION CARRIER

Reassembly (8A/3)

1. Position the sun gear into the carrier.
2. Slide the planetary drive pinions, complete with needle rollers and thrust washers into the carrier. There are 58 rollers fitted to each planetary drive pinion.
3. Insert the planetary pinion shafts into the carrier and pinions, aligning the screw hole in the shaft with the hole in the carrier.
4. Thoroughly clean the socket screws and remove all traces of oil from the tapped holes in the carrier. Coat the socket screw threads with Loctite, fit the screws into the carrier and tighten to a torque of 10-13 lbs.ft. (1.38 - 1.79 kg.m.), thus locking the planetary pinion shafts firmly in position. Remove any surplus Loctite from the screws and stake them in position using a centre punch.
   Take care that the side of the hole is not completely collapsed when staking the screws as this may well cause the screws to become loosened.
5. (Fig. 5) Mount the wheel axle assembly and carrier onto a suitable press. Press the carrier fully home onto the wheel axle.
6. Replace the roller bearing onto the carrier as stated in operation 8A/2.
7. Determine the epicyclic carrier bearing pre-load as described in operation 8A/4.

EPICYCLIC CARRIER BEARING

To Determine Pre-Load (8A/4)

1. Assemble the epicyclic carrier assembly and press the carrier onto the wheel axle as stated in operation 8A/3.
2. Fit the ring gear to the drive cover, without gaskets, and secure the four suitable bolts, equispaced. The step in the ring gear must face towards the drive cover.

EPICYCLIC CARRIER BEARING

To Determine Pre-Load . . . Cont'd

3. Remove the planetary carrier inner bearing cup, and shim(s) if fitted, as described in operation 8A/7. Fit the cup without shims to the pre-load gauge MF 267.
4. (Fig. 6) Position the complete epicyclic carrier onto the pre-load gauge, locating the carrier inner roller bearing in its cup.
5. (Fig. 6) Measure the clearance between the gauge posts and the ring gear with two feeler gauges. Note the clearance and select the appropriate shim from the list below.
6. Replace the correct shim(s) and the inner bearing cup as described in operation 8A/8.

TABLE OF SHIMS TO ADJUST PRE-LOAD ON EPICYCLIC CARRIER BEARING

Gap Measured by Feeler Gauges (Both Sides)		Shim Thickness Required	
mm	ins	mm	ins
0,025 to 0,13	0,001 to 0,005	0,76	0,030
0,15 to 0,25	0,006 to 0,010	0,64	0,025
0,28 to 0,38	0,011 to 0,015	0,51	0,020
0,41 to 0,51	0,016 to 0,020	0,38	0,015
0,53 to 0,64	0,021 to 0,025	0,25	0,010
0,66 to 0,76	0,026 to 0,030	0,13	0,005
0,79 to 0,89	0,031 to 0,035	0	0

Shims are available in three sizes : -

0.005 in.(0.127 mm.), 0.010 in.(0.254 mm.), 0.015 in.(0.381 mm.)

EPICYCLIC CARRIER, INNER ROLLER BEARING

Removal (8A/5)

1. Remove the epicyclic as stated in operation 8A/1.
2. (Fig. 7) Assemble the special tool MF 200 and 200 - 24 onto the epicyclic carrier bearing and remove the bearing.

Replacement (8A/6)

1. (Fig. 8) Place the roller bearing squarely onto the carrier.
2. Drive the bearing home fully using special Tool No. MF 266 and 550 handle.

EPICYCLIC CARRIER, INNER BEARING CUP

Removal (8A/7)

1. Remove the epicyclic unit as described in operation 8A/1.
2. Remove the planetary ring gear from the axle housing.
3. Ensure that the disc brakes are still fully applied, then slide out the axle shaft from its housing.
4. (Fig. 9) Using pry bars, lever the epicyclic inner bearing cup out of the trumpet housing.
5. Remove the shim(s), if fitted, from behind the cup.

EPICYCLIC CARRIER, INNER BEARING CUP . . . Cont'd

Replacement (8A/8)

1. Fit the shim(s), if required, into place.
2. Place the cup squarely into position and drive the cup firmly into place with tools MF 1105 - 8, 1105 - 7A/3 and 550 handle.
3. Smear the wiping edges of the outer oil seal with grease.
4. Ensure that the brakes are still applied, align the splines and slide the axle shaft into its housing through the brake discs to the differential.
5. Refit the planetary ring gear.
6. Replace the epicyclic unit as described in operation 8A/1.

WHEEL AXLE AND DRIVE COVER

Disassembly (8A/9)

1. Remove the epicyclic unit as described in operation 8A/1.
2. Carry out items 2 to 10 of operation 8A/2.
3. (Fig. 10) Remove the circlip securing the wheel axle bearing to the axle.
4. (Fig. 11) Assemble tool MF200 and 200 - 24 onto the drive cover and draw the drive cover and roller bearing off the axle shaft.
5. Lift out the taper roller bearing from its cup in the drive cover.
6. Remove the bearing cup and oil seal from the drive cover.

Reassembly (8A/10)

1. Replace the oil seal and bearing cup into the drive cover.
2. Fit the drive cover assembly to the wheel axle, taking care not to damage the oil seal.
3. (Fig. 12) Position the taper roller bearing squarely in place on the axle shaft and, with a suitable press, push the bearing fully home.
4. There are nine sizes of wheel axle snap rings. Use half of one of the thinnest snap rings 0.230" / 0.232" (5.842/5.893 mm) thick, as a guide to measure the clearance between the snap ring and bearing cone.
5. Fit half of the thinnest snap ring to the groove in the wheel axle and measure the clearance between the snap ring and bearing cone with feeler gauges as shown in Fig. 13. Note this clearance (if there is no clearance the thinnest ring is the required size). Calculate the required snap ring thickness by adding the clearance between the thinnest snap ring and bearing cone, to the thickness of the thinnest snap ring.
6. (Fig. 14) Measure snap rings with a micrometer as shown and obtain the required thickness.

Snap rings are available in the following nine thicknesses :-

0.230"/0.232" (5.842/5.893 mm)	Marked 0
0.2321"/0.234" (5.895/5.944 mm)	Marked 1
0.2341"/0.236" (5.947/5.944 mm)	Marked 2
0.2361"/0.238" (5.997/6.045 mm)	Marked 3
0.2381"/0.240" (6.048/6.096 mm)	Marked 4
0.2401"/0.242" (6.099/6.147 mm)	Marked 5
0.2421"/0.244" (6.150/6.198 mm)	Marked 6
0.2441"/0.246" (6.201/6.248 mm)	Marked 7
0.2461"/0.248" (6.251/6.299 mm)	Marked 8

ONE SIZE ONLY AVAILABLE
See Bulletin 50B/2700/27
20th June 77.

When assembled a maximum clearance of 0.001" (0.0254 mm) is permissible between the snap ring and bearing cone.

[LATEST {INFORMATION SHEET IN 50B's} SIMPLY DELETES item 4, 5, 6, gives no mention of alternate sizes]

WHEEL AXLE AND DRIVE COVER

Reassembly . . . Cont'd

7. Fit the correct snap ring to its groove in the wheel axle.
8. Carry out items in operation 8A/3.
9. Replace the eipcyclic unit as described in operation 8A/1.

AXLE SHAFT OUTER OIL SEAL

Removal and Replacement (8A/11)

1. Remove the planetary carrier inner bearing cup as stated in operation 8A/7.
2. Remove the axle shaft outer oil seal.
3. Apply a thin coating of "Well Seal" to the bore of the axle housing and fit the new oil seal using tool MF 266 and 500 handle.

AXLE SHAFT HOUSING

Removal and Refitting (8A/12)

1. Drain oil from the centre axle housing.
2. Release the brake pull rods, hand brake cable (single brakes only) and return spring. If dual brakes are fitted disconnect the parking brake actuator rod at the cross shaft.
3. Jack up the machine and support it on rail trolley 270.
4. Remove rear wheel.
5. Support axle housing on trolley jack.
6. (Fig. 15) Remove the speedometer gearbox. Left hand shaft housing only.
7. If the right hand shaft housing is to be removed the differential lock lever can be removed for ease.
8. Remove the nuts and bolts which hold the axle shaft housing to the centre housing.
9. (Fig. 16) With the axle shaft housing supported by the jack manoeuvre the complete axle housing clear of the tractor.
10. To replace the axle shaft housing, reverse the above procedure and refill the centre axle housing with a recommended oil.

LEFT HAND DIFFERENTIAL CARRIER PLATE

Removal and Replacement (8A/13)

1. Remove the axle shaft housing as described in operation 8A/12.
2. Stand the axle shaft housing on end.
3. (Fig. 17) Remove the two countersunk screws which secure the carrier plate to the housing.
4. Lift off the carrier plate complete with bearing cone.
5. Remove the inner 'O' ring from the housing.
6. Replacement is a direct reversal of above procedure using a new 'O' ring.

LEFT HAND DIFFERENTIAL CARRIER PLATE BEARING CONE

Removal and Refitting (8A/14)

1. Remove the left hand differential carrier plate as described in operation 8A/13.
2. (Fig. 18) Remove the bearing cone using tool MF 100 and 200 - 3.
3. (Fig. 19) Replace the bearing cone using tool MF 197 and 197 - 2.

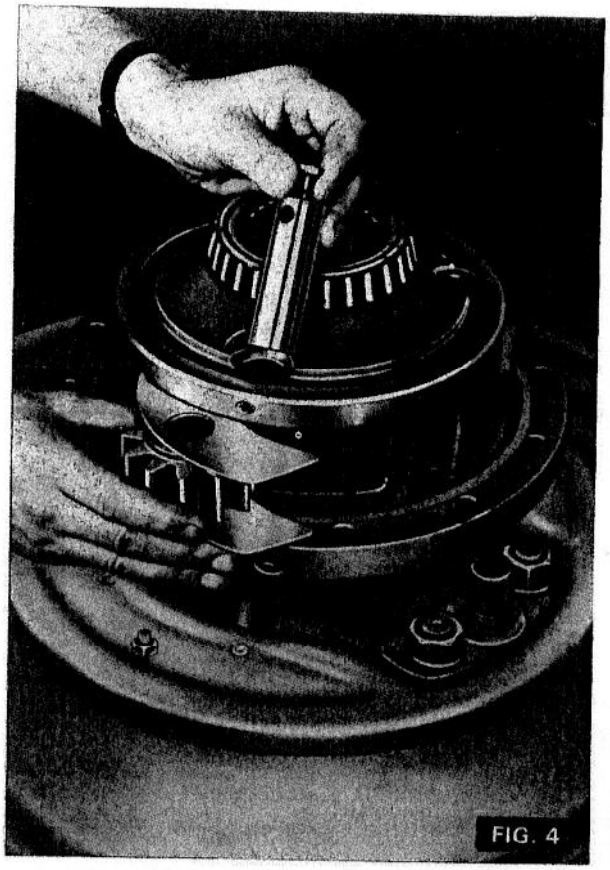

FIG. 4

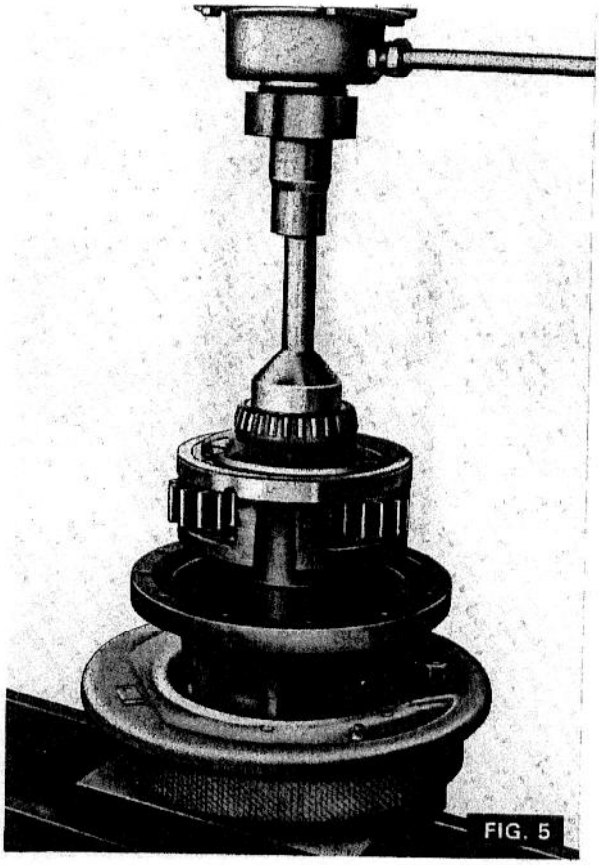

FIG. 5

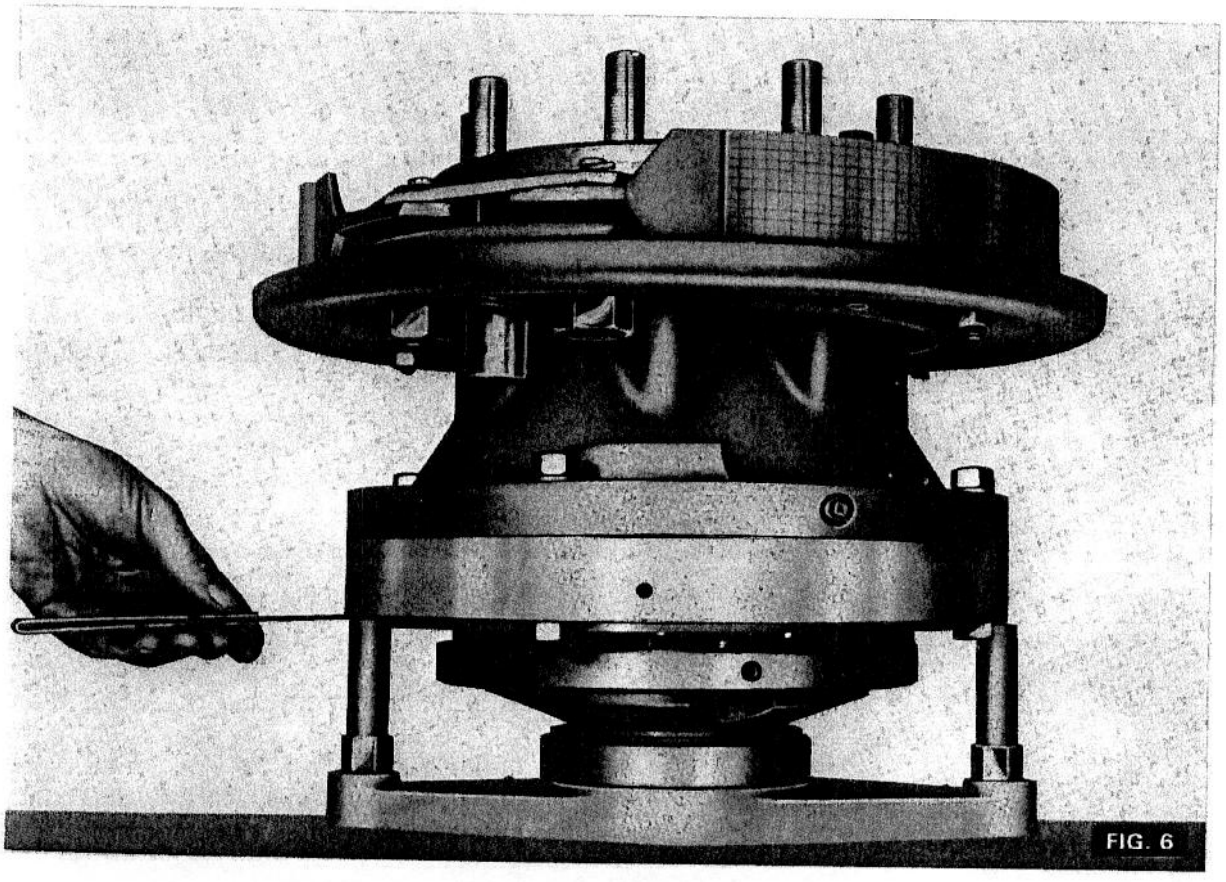

FIG. 6

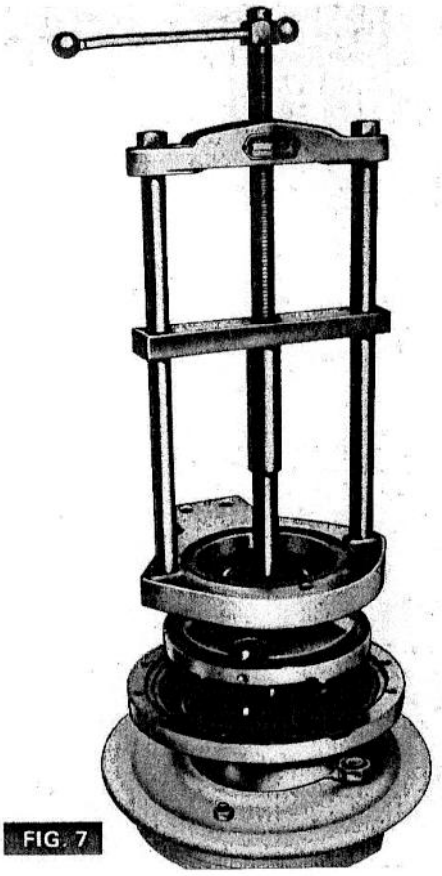

FIG. 7

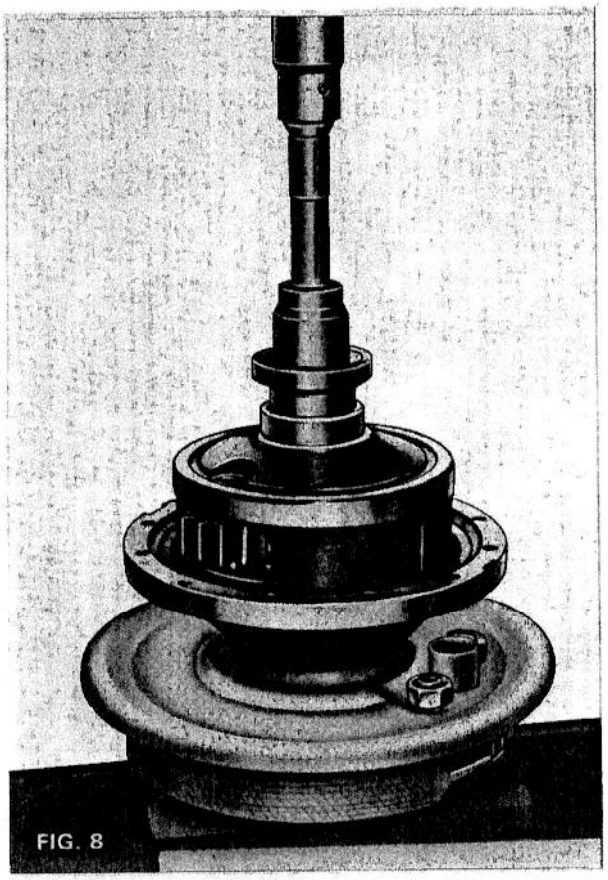

FIG. 8

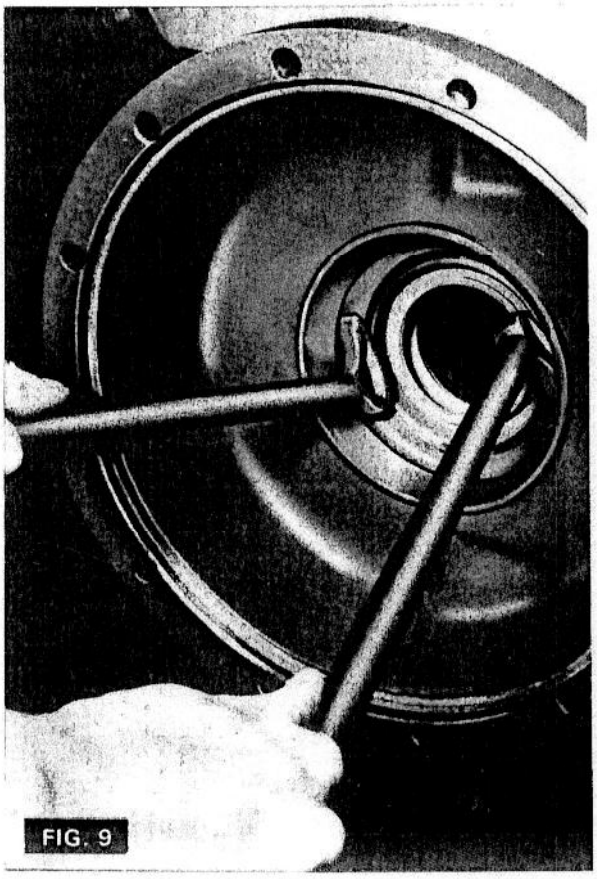

FIG. 9

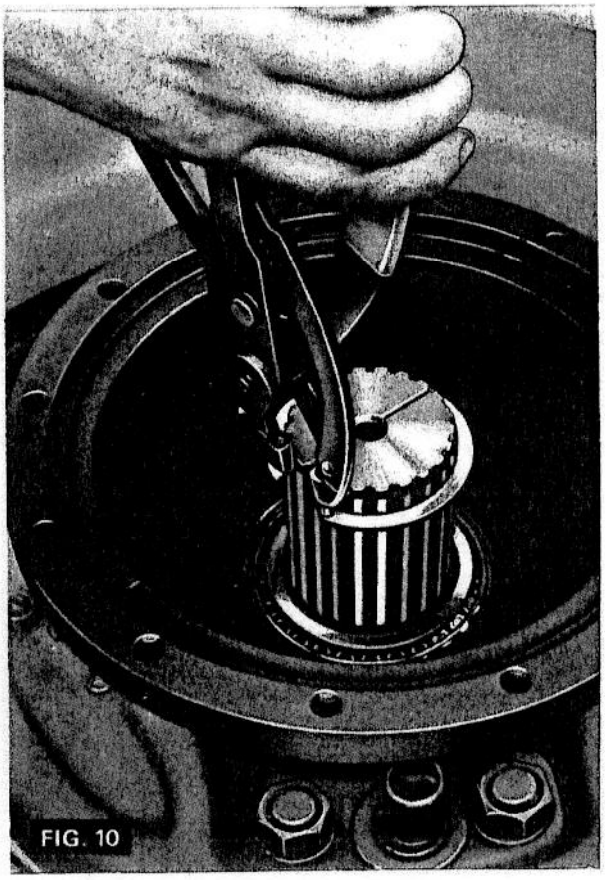

FIG. 10

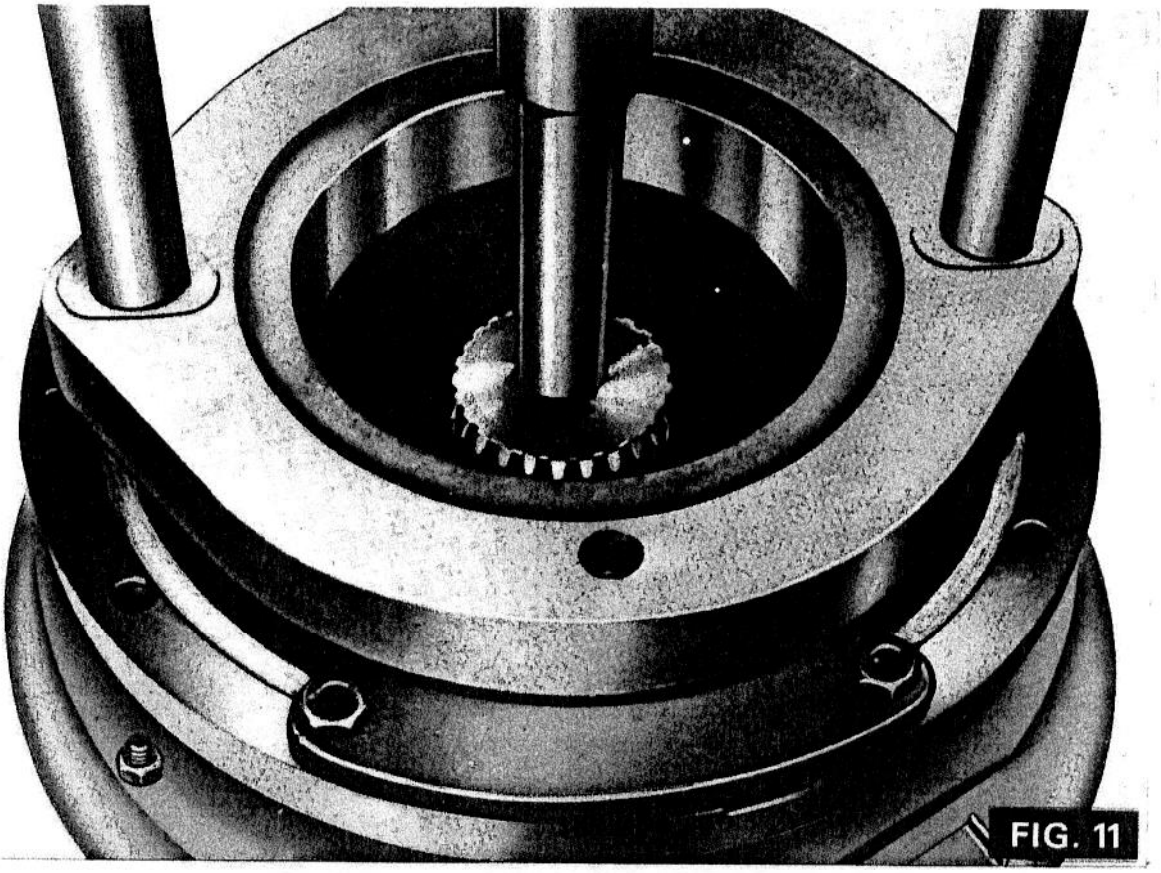

FIG. 11

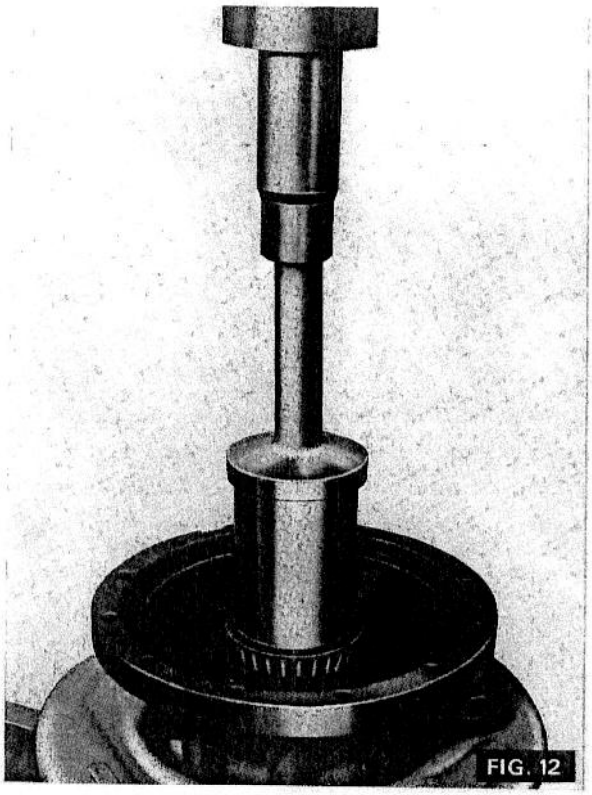

FIG. 12

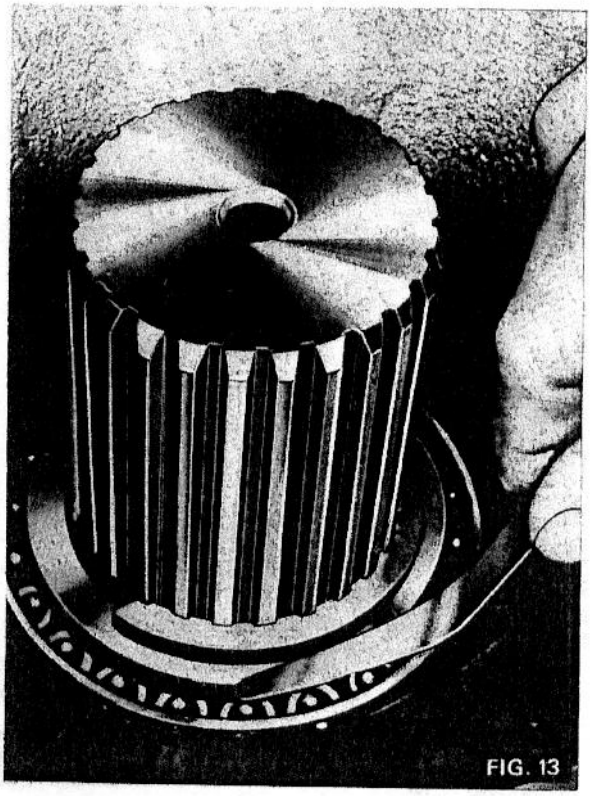

FIG. 13

FIG. 14

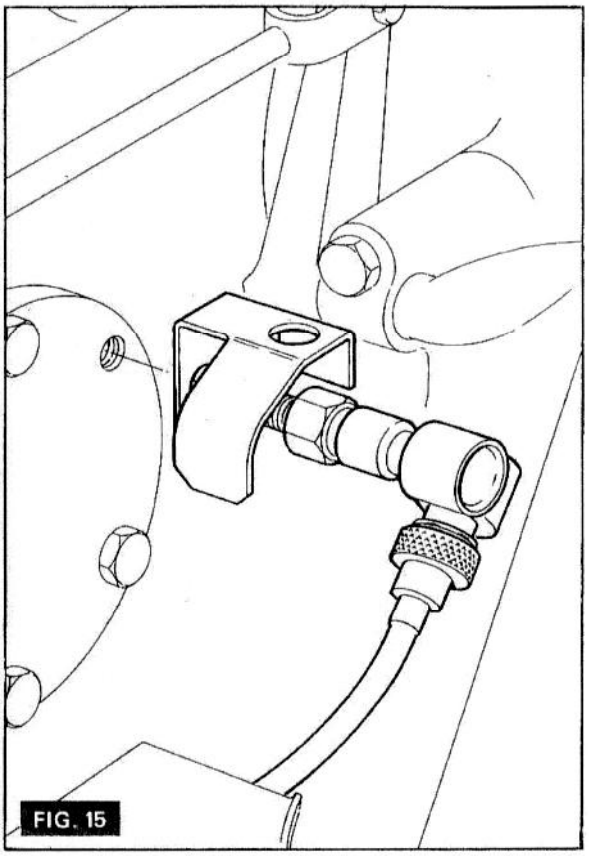

FIG. 15

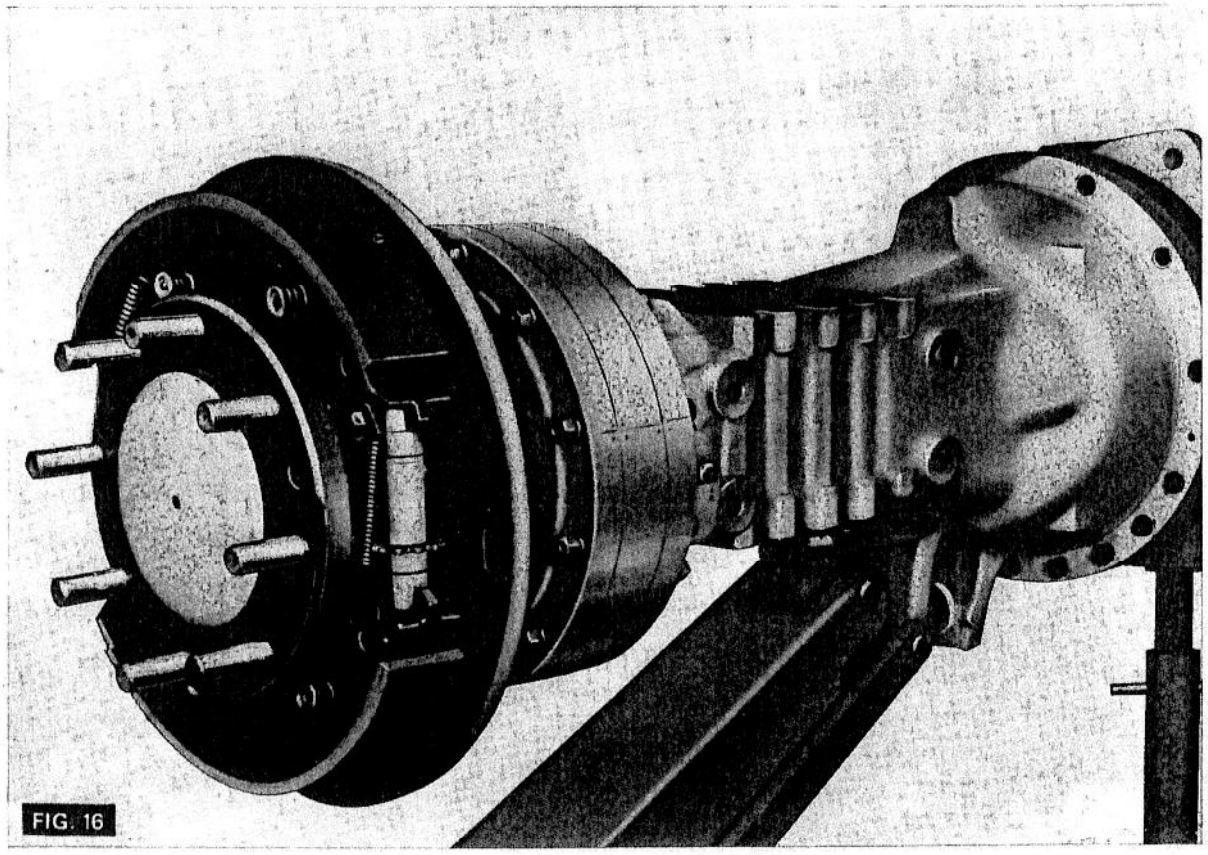

FIG. 16

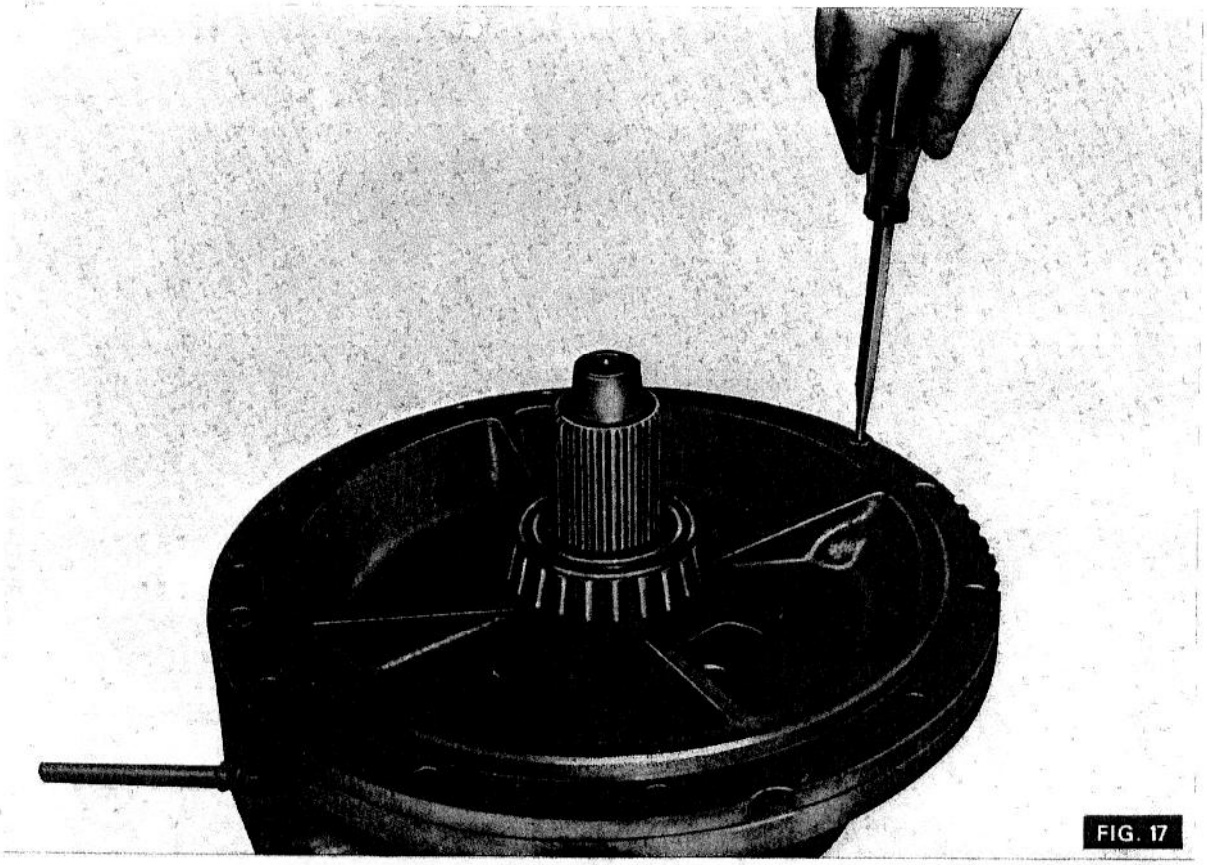

FIG. 17

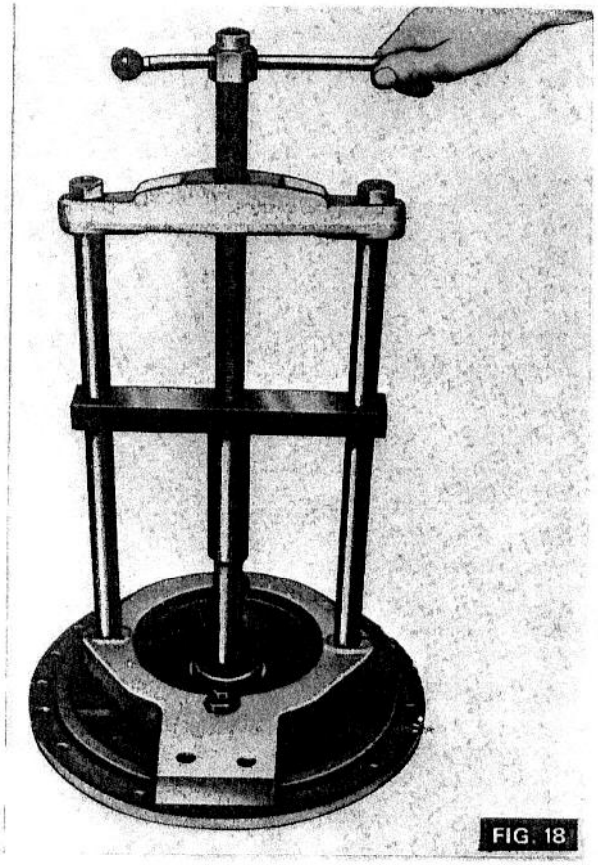

FIG. 18

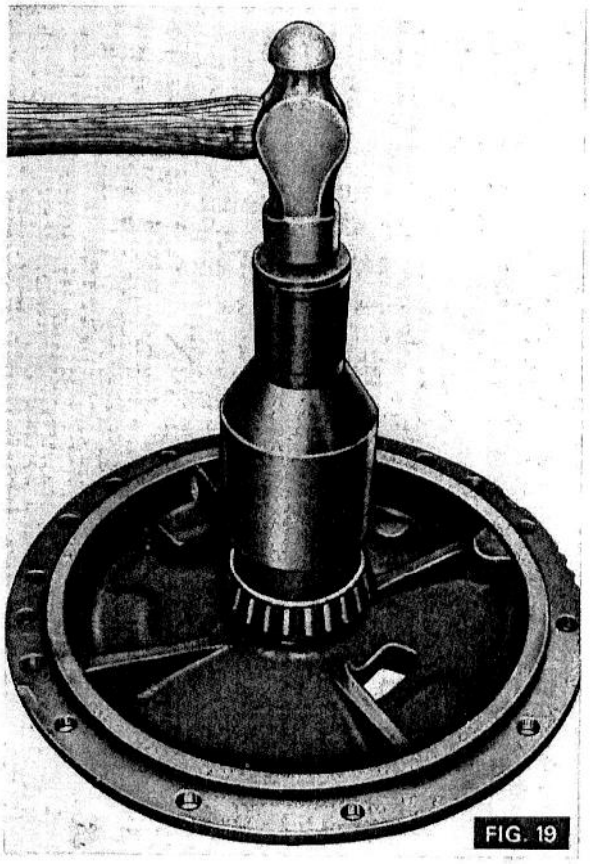

FIG. 19

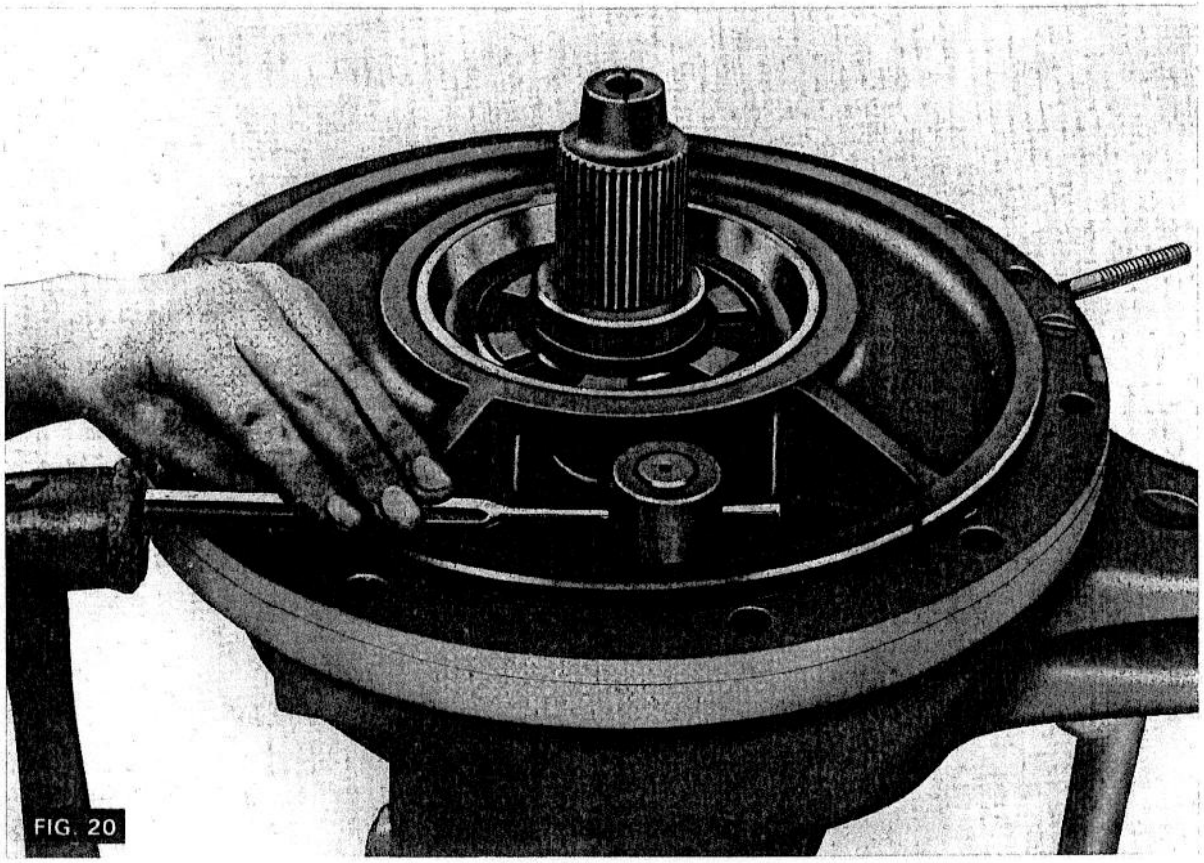

FIG. 20

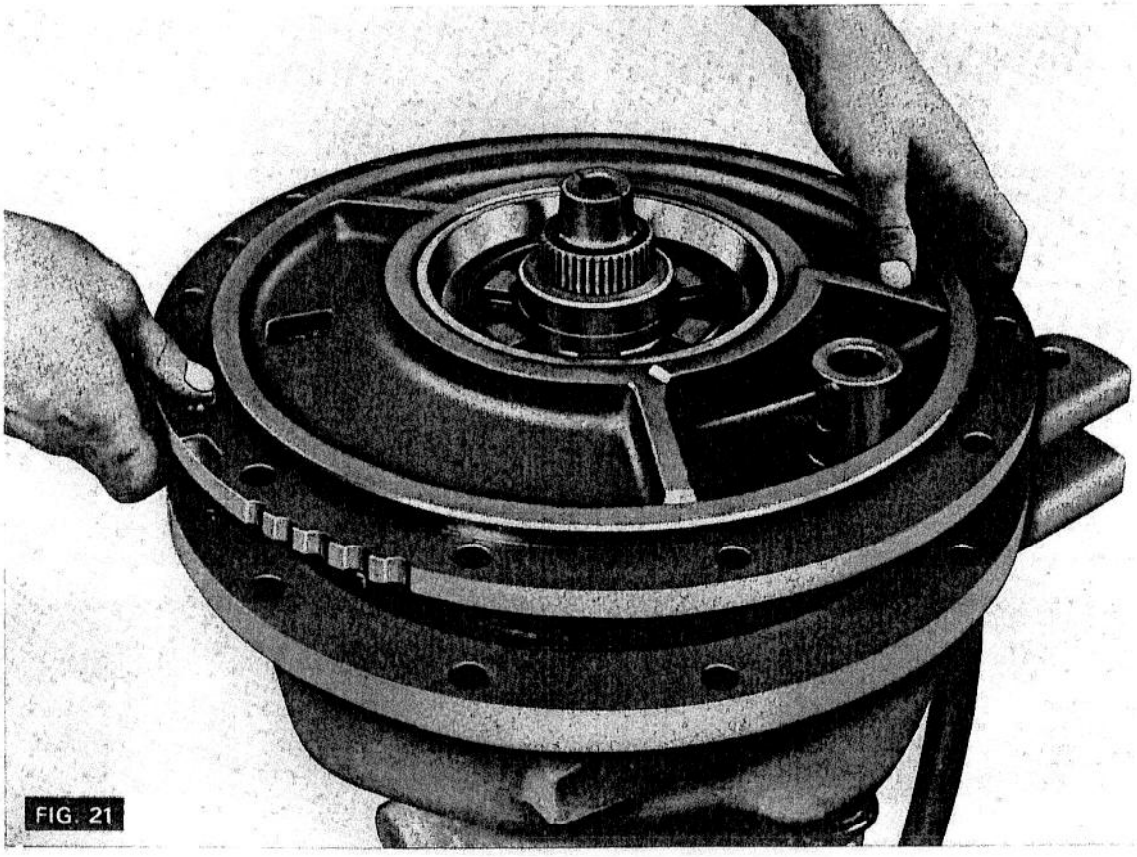

FIG. 21

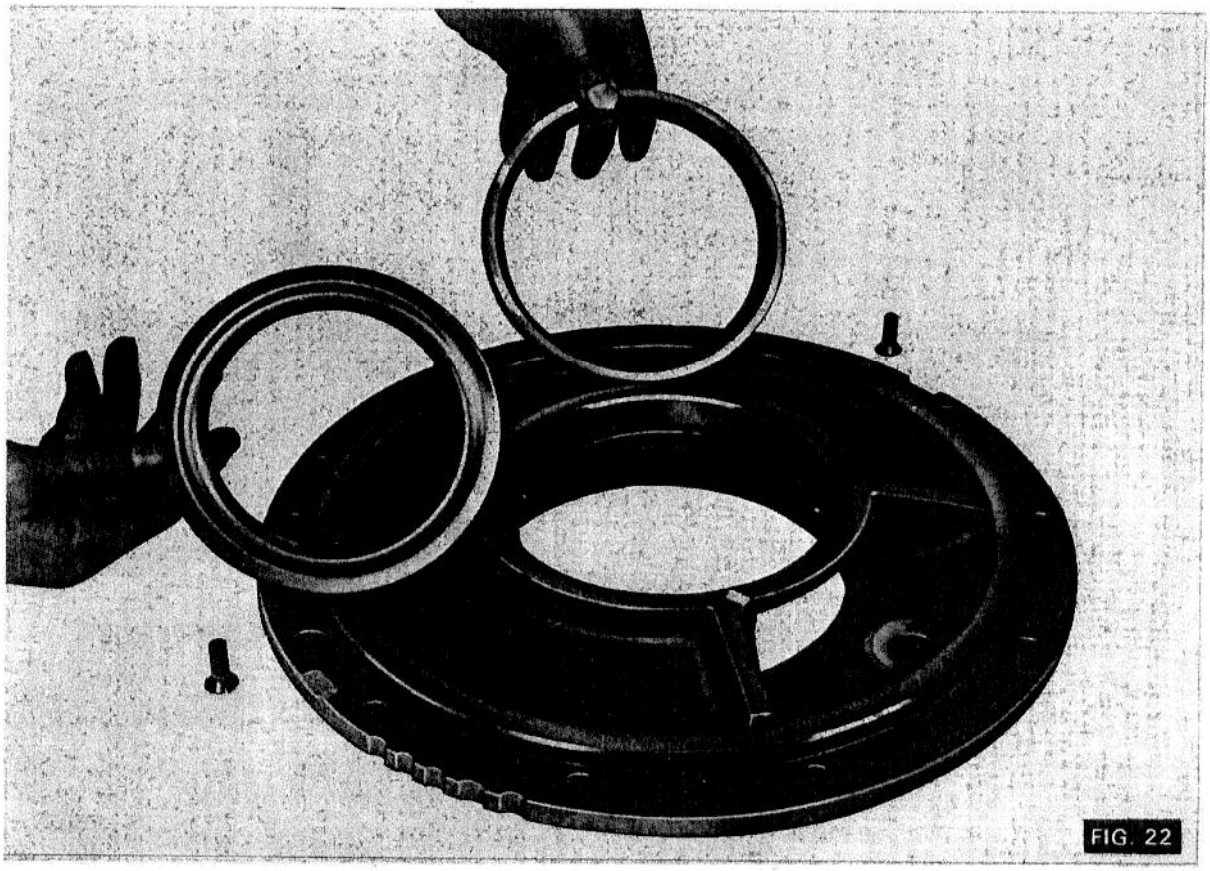

FIG. 22

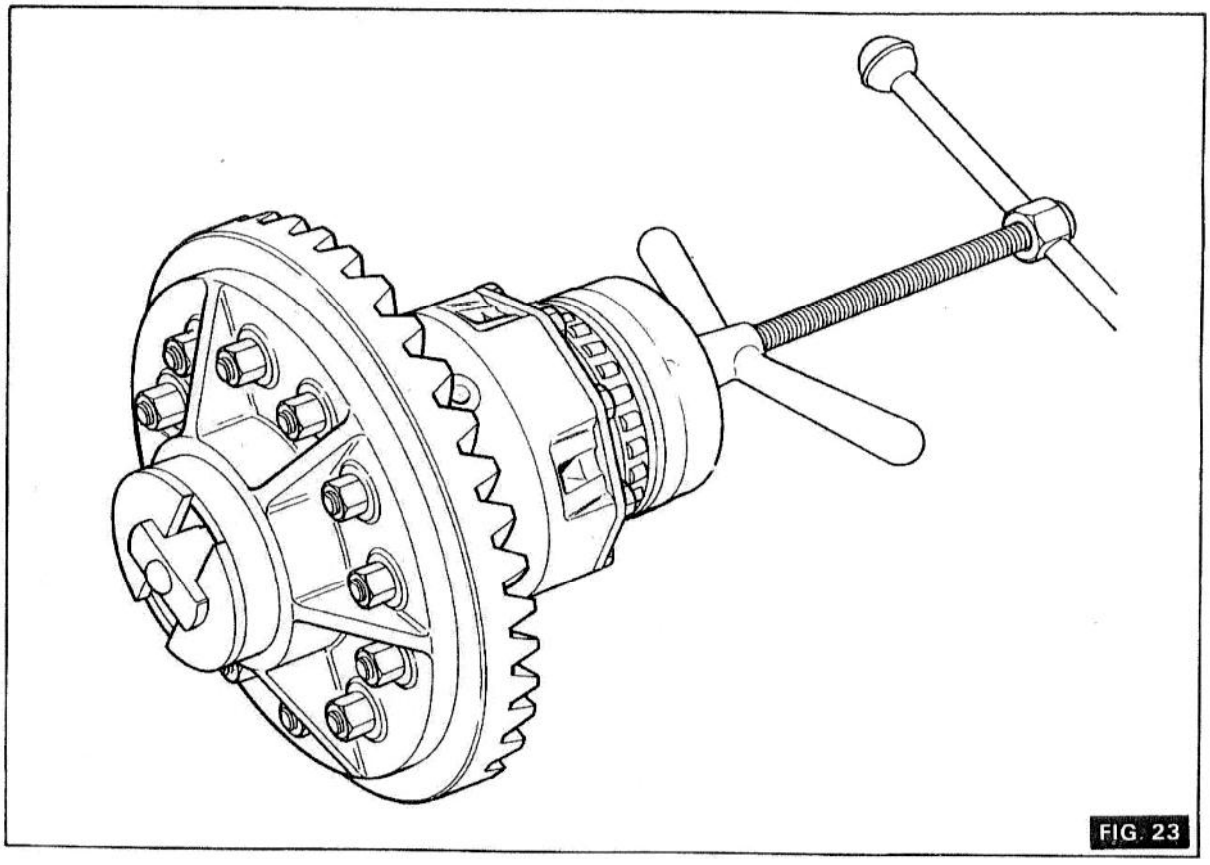

FIG. 23

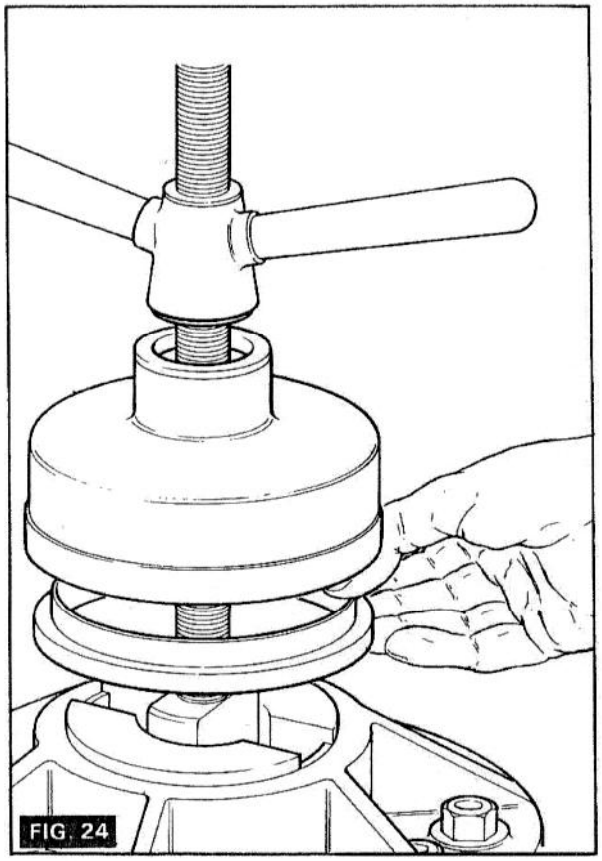

FIG. 24

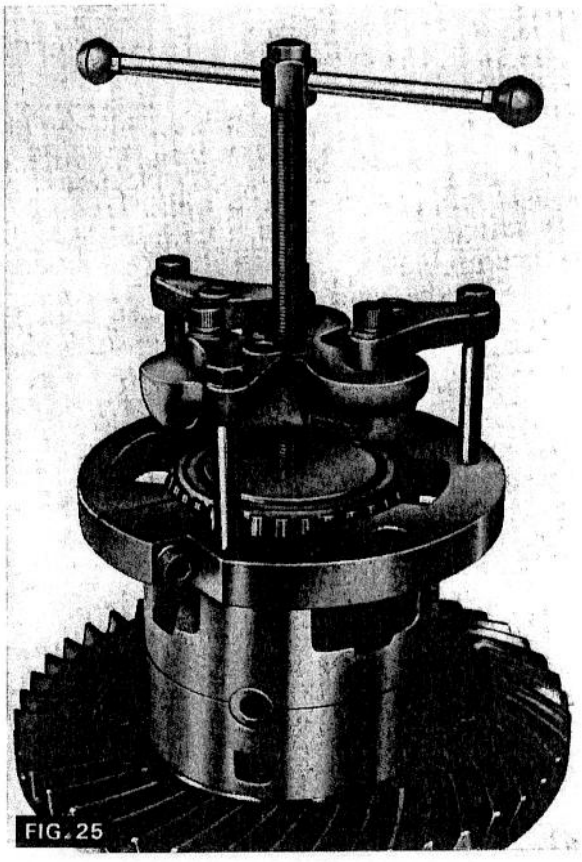

FIG. 25

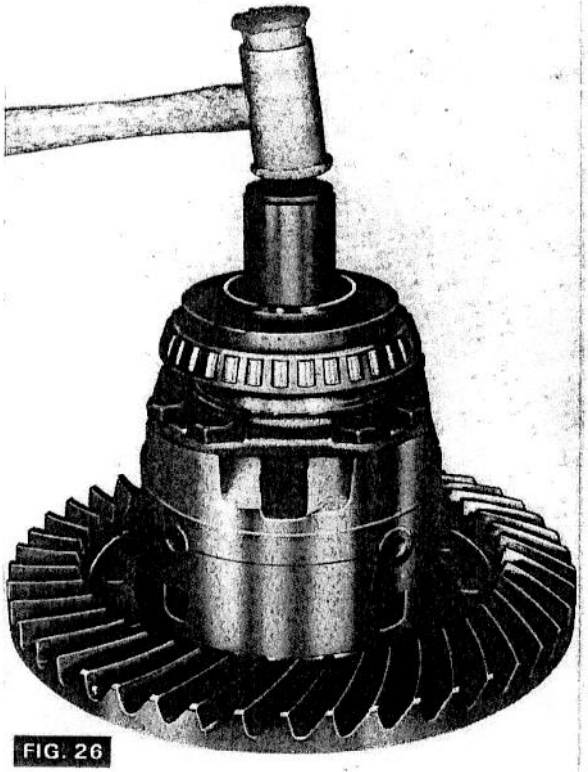

FIG. 26

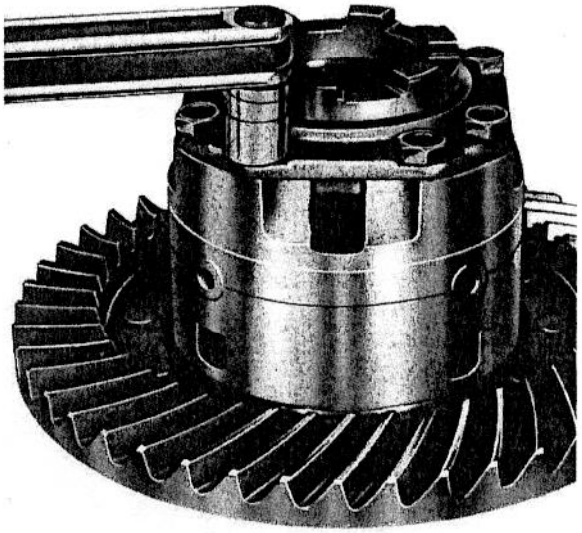

FIG. 27

RIGHT HAND DIFFERENTIAL CARRIER PLATE

Removal and Replacement (8A/15)

1. Remove the axle shaft housing as described in operation 8A/12.
2. (Fig. 20) Drive out the roll pin securing the differential lock shifter fork to its shaft.
3. Remove the two screws securing the carrier plate to the axle housing.
4. (Fig. 21) Lift off the carrier plate complete with bearing cup, differential shifter fork and coupler.
5. Replacement is a reversal of the above procedure.

RIGHT HAND DIFFERENTIAL CARRIER PLATE BEARING CUP

Removal and Replacement (8A/16)

1. Remove the right hand differential carrier plate as described in operation 8A/15.
2. Remove the shield from behind the bearing cup.
3. Remove the bearing cup using tool MF 1105, 1105/1, 1105/7A/1 and 1105/7A/2. Adjust the bearing pre-load as described in operation 8A/21.
4. (Fig. 22) Fit new shield to the carrier plate.
5. Replace the bearing cup using tool MF 1105, 1105/1, 1105/7A/1.

DIFFERENTIAL CASE ASSEMBLY

Removal and Refitting (8A/17)

1. Remove the left hand axle shaft housing as described in operation 8A/12 .
2. Insert a suitable bar into the differential case assembly, then manoeuvre the differential assembly out of the centre housing.
3. Replacement is a reversal of the removal procedure. Align the splines on the differential gears and the axle shafts.

LEFT HAND DIFFERENTIAL BEARING CUP

Removal and Refitting (8A/18)

1. Remove the differential case as described in operation 8A/17.
2. (Fig. 23) Remove the bearing cup using tool MF 1105, 1105 - 2A/1 and 1105 - 2A/4.
3. (Fig. 24) Replace the bearing cup using tool MF 1105, 1105 - 2A/1 and 1105 - 2A/4.

RIGHT HAND DIFFERENTIAL BEARING CONE

Removal and Refitting (8A/19)

1. Remove the differential case assembly as described in operation 8A/17.
2. (Fig. 25) Assemble tool MF 555 and 555 - 2A/2 and withdraw the bearing cone from the differential case.
3. (Fig. 26) Replace the bearing cone using MF 257.

DIFFERENTIAL CASE

Disassembly and Reassembly (8A/20)

1. Remove the differential case assembly as stated in operation 8A/17.
2. (Fig. 27) Remove the eight bolts from the differential case assembly.
3. (Fig. 28) Lift off the differential lock coupler cap (1) and casing (2).
4. Lift out the differential gear (3), thrust washer (4), cross joint and pinions assembly (5) with thrust washers and finally remove the remaining differential gear and thrust washer.
5. To reassemble, reverse the above procedure.

NOTE All components should be examined for scoring, chipping or wear. Any component showing signs of wear should be renewed.

When reassembling the differential case, ensure that the markings on the case are aligned.

DIFFERENTIAL BEARING PRE-LOAD

Adjustment (8A/21)

NOTE This operation must be carried out whenever the differential unit is dismantled or when the bearings are replaced. Service tool MF 245 D will be required.

1. Pre-load must be adjusted with the differential assembly and the left hand axle shaft housing assembly fitted to the centre housing. Remove the right hand axle shaft housing as stated in operation 8A/12.
2. Remove the carrier plate as described in operation 8A/13.
3. Remove the carrier plate bearing cup as described in operation 8A/16.
4. Fit the bearing cup into the centraliser (2) (Fig. 29).
5. (Fig. 29) Fit the guide (1) and centraliser (2), of tool MF 245C, into the splined differential gear.
6. Assemble the clamp bar (3) to the centraliser, with the pre-load adjusting bolt fully slackened.
7. Position the clamp bar ends over two of the studs on the centre housing and secure the bar with the two special sleeved nuts (4).
8. Screw the two setting blocks (5) onto diagonally opposite studs on the centre housing as shown in Fig. 30.
9. (Fig. 31) Place the straight edge across the two setting blocks and measure the distance between the centraliser gauge pin and the straight edge. This distance is the shield thickness required behind the bearing cup.

Bearing shields are available in five sizes as follows :-

Shield Thickness		Means of Identification
ins	mm	
0.029/0.031	0.737/0.787	No Dots
0.034/0.036	0.864/0.914	One Dot
0.039/0.041	0.991/1.041	Two Dots
0.044/0.046	1.118/1.168	Three Dots
0.049/0.051	1.245/1.295	Four Dots

10. Fit the required shield and the bearing cup to the right hand differential carrier plate as described in operation 8A/16.

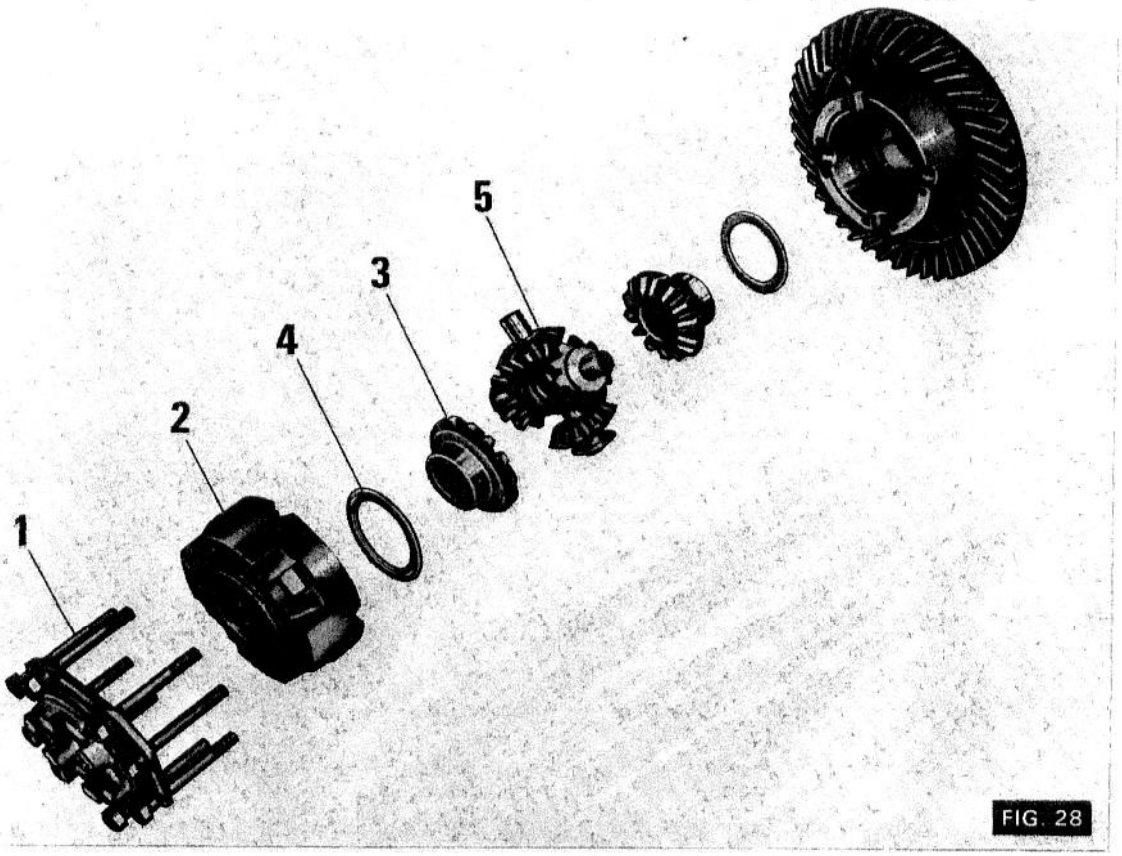

FIG. 28

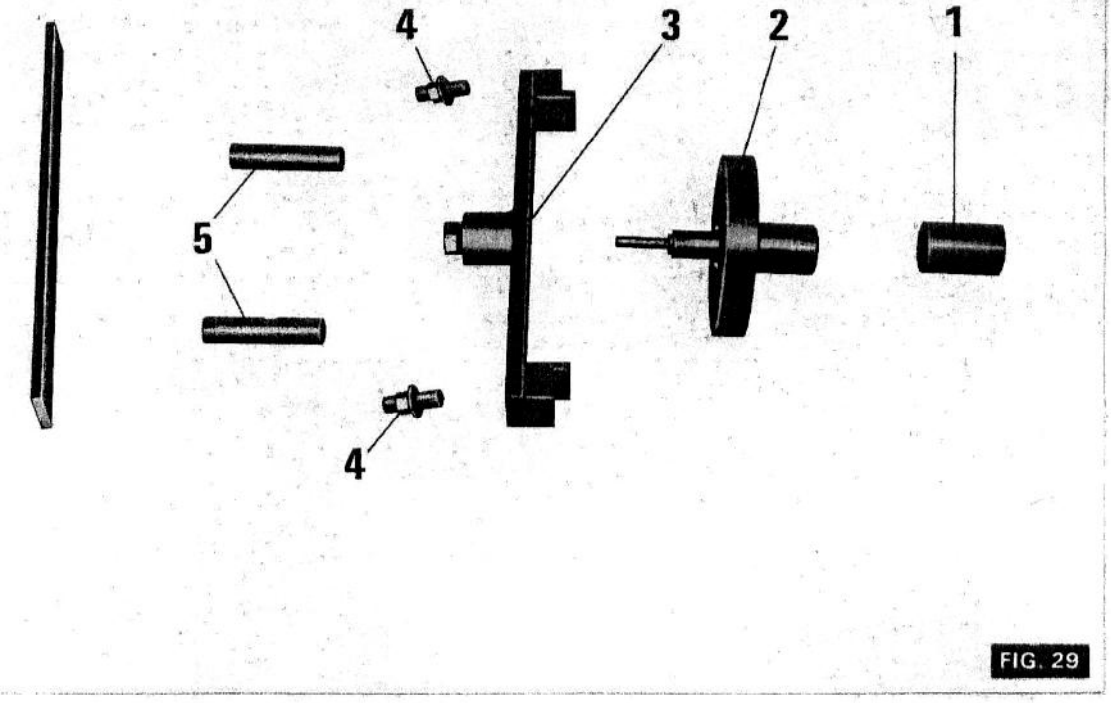

FIG. 29

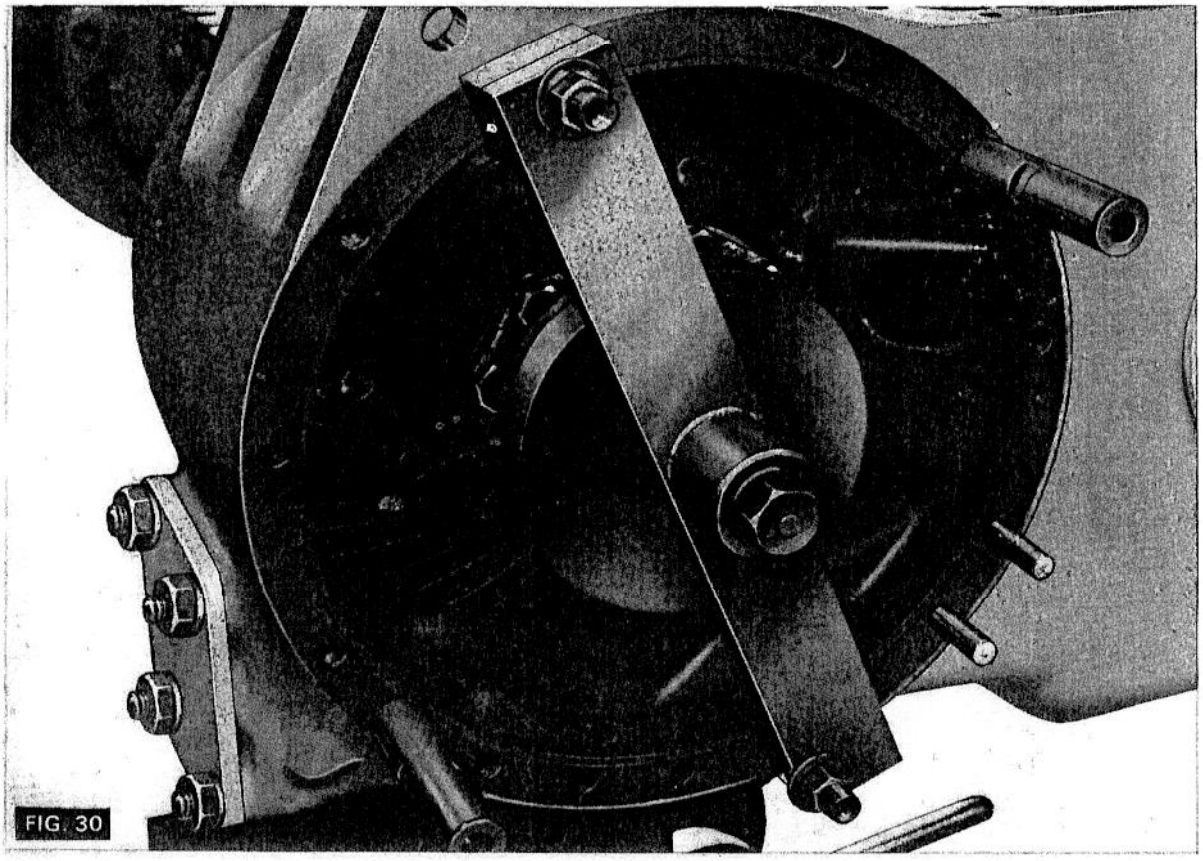

FIG. 30

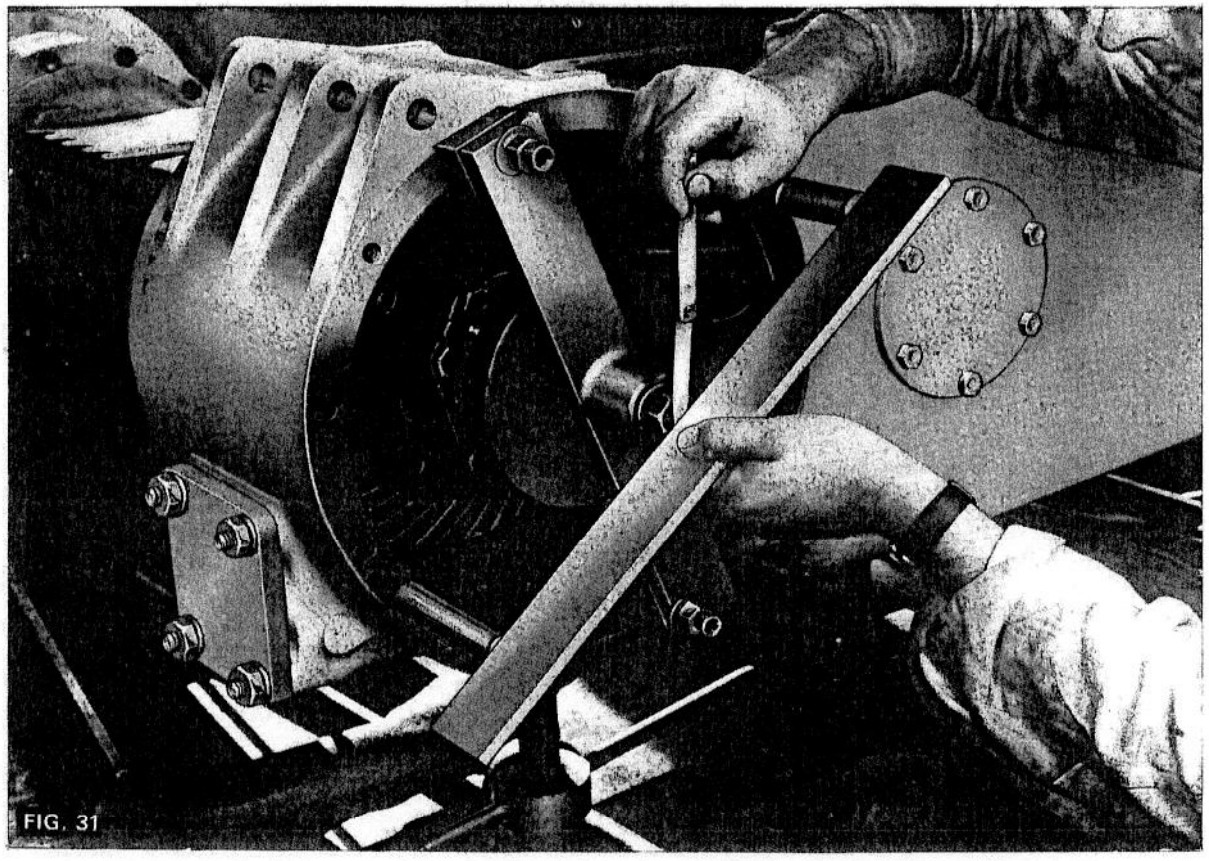

FIG. 31

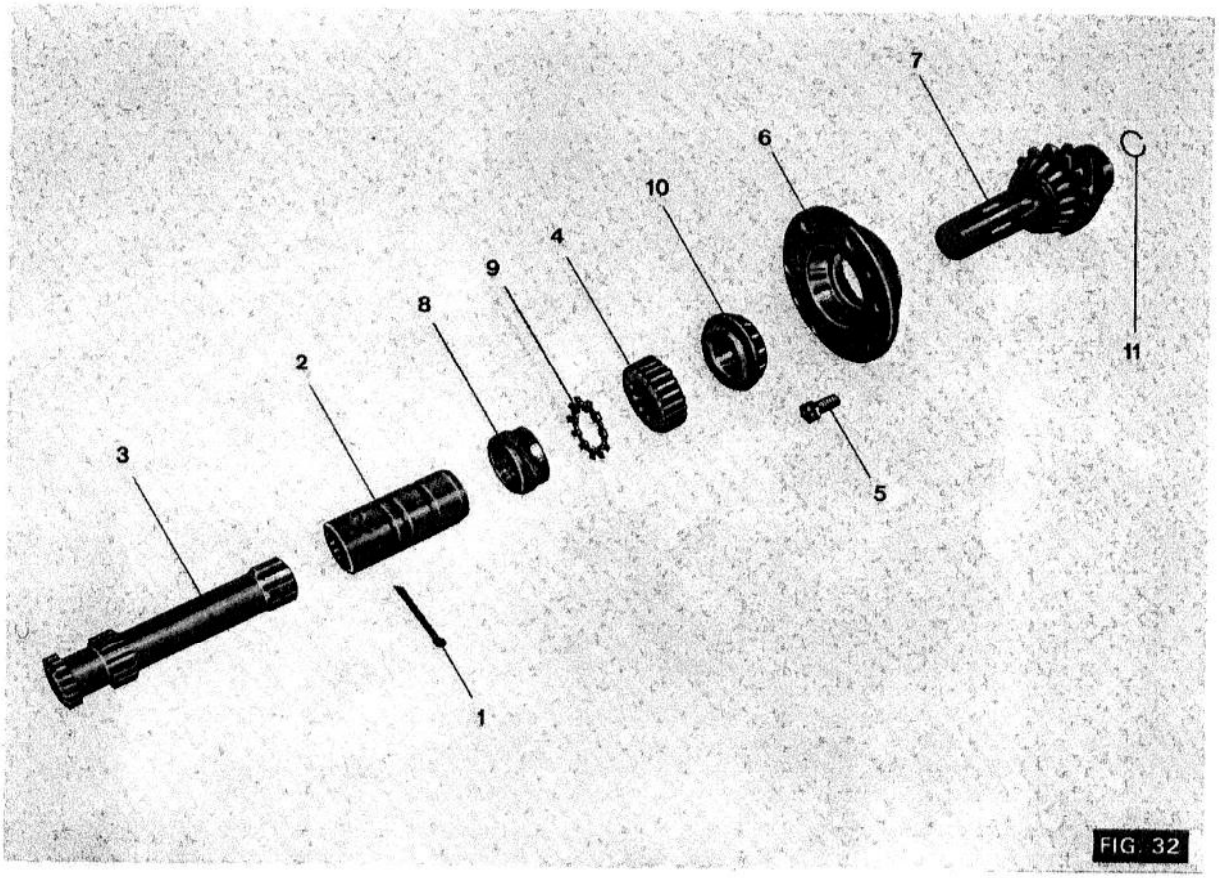

FIG. 32

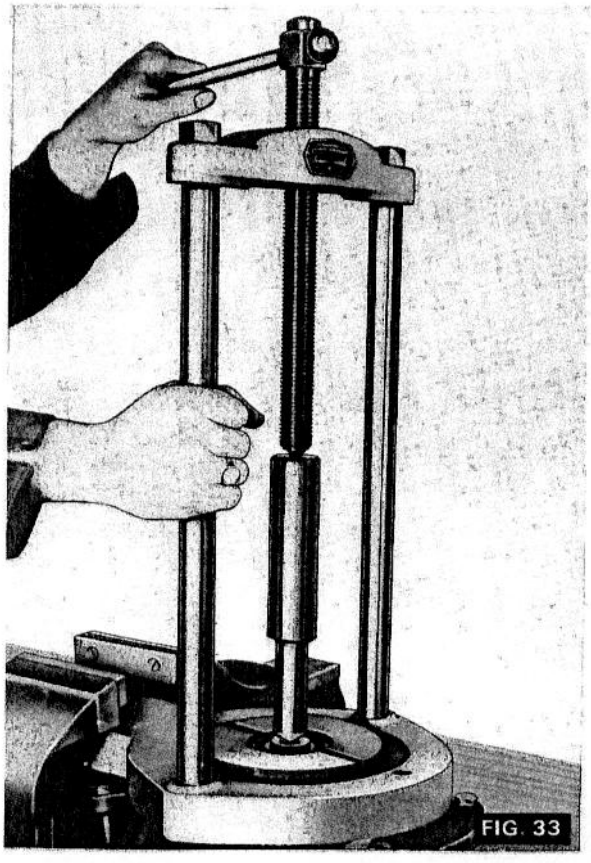
FIG. 33

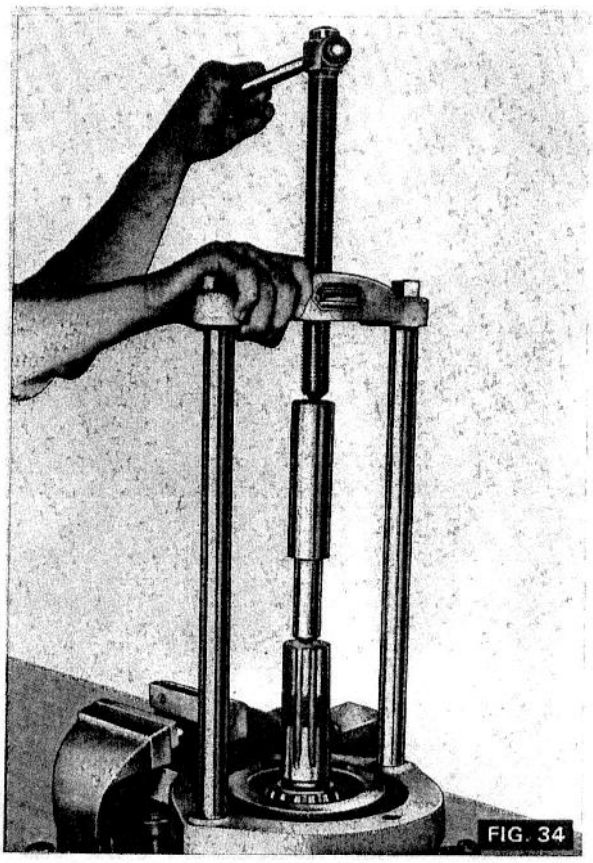
FIG. 34

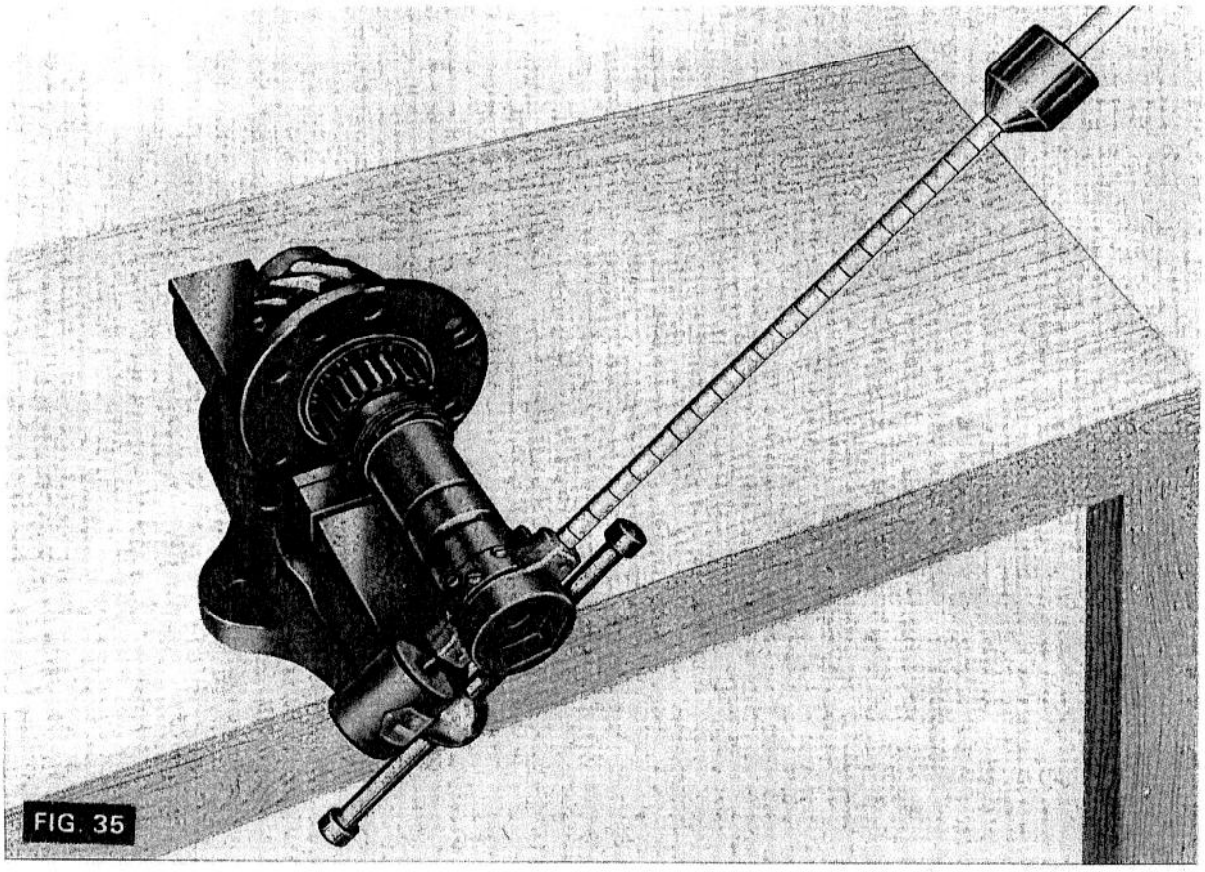

FIG. 35

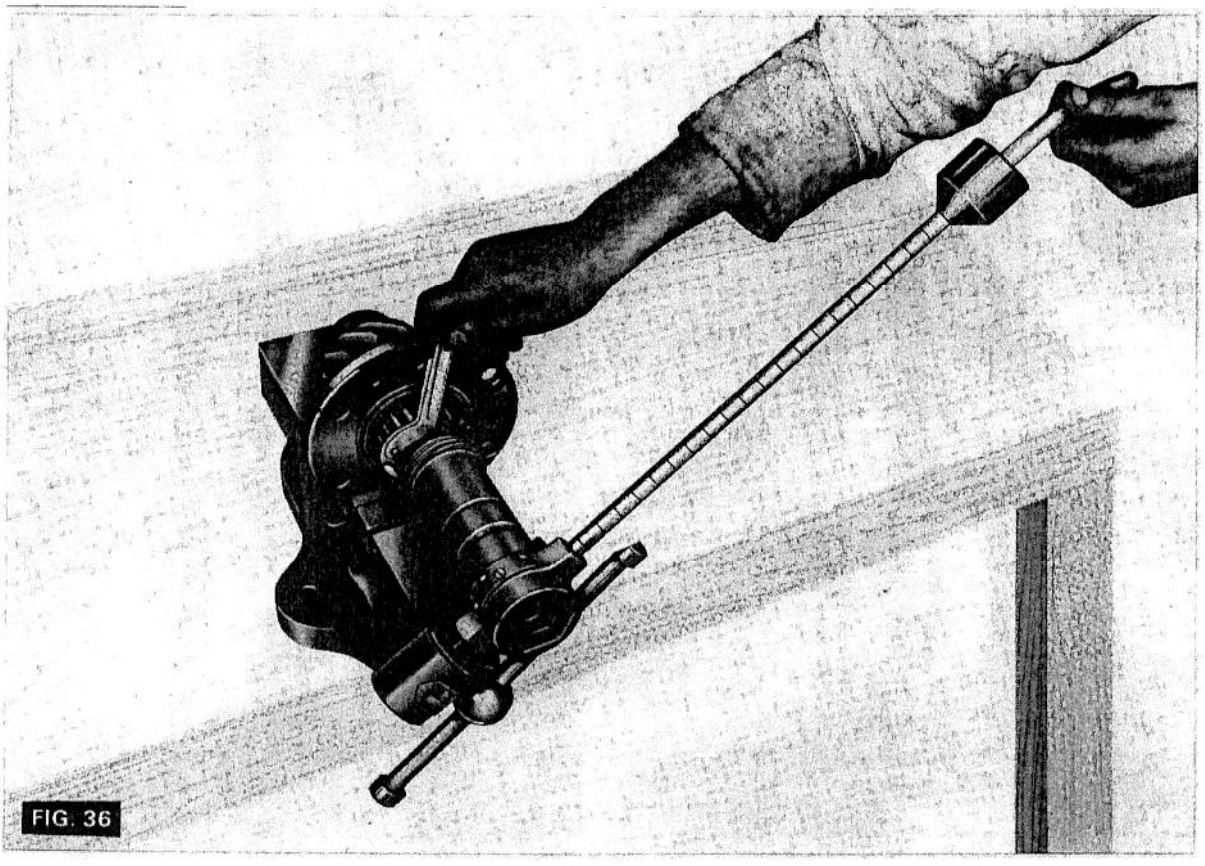

FIG. 36

DRIVE PINION ASSEMBLY

Removal and Disassembly (8A/22)

1. Drain the centre housing of oil.
2. Remove the hand brake support pillar assembly from the top of the centre housing. Remove centre axle housing cover.
3. (Fig. 32) Remove the split pin (1) from the shear tube (2), then remove the shear tube.
4. Remove the rear drive shaft (3).
5. Remove the speedometer drive assembly as stated in operation 8A/30.
6. Remove the six bolts (5) and spring washers securing the pinion housing (6).
7. Screw two of the bolts into the two tapped holes in the housing then extract pinion (7) from centre housing complete with locking ring (8) tab washer (9) hub (10) bearing housing (6) and bearings.
8. Release tab washer (9) and unscrew locking ring (8) from the pinion (7), remove the tab washer.
9. Slide the hub (4) bearing cone (10) and bearing housing (6) off the pinion (9).

PINION INNER BEARING CONE

Removal and Refitting (8A/23)

1. Remove and dismantle the pinion as described in operation 8A/21.
2. (Fig. 33) Press the inner bearing cone (taper roller bearing) off the pinion using multi-purpose bearing remover/replacer MF 200 - 25 with tool MF 200 - 23.
3. Replace the inner bearing cone using adaptor MF 200 - 23 and tool MF 200 - 25.

PINION PILOT BEARING

Removal and Refitting (8A/24)

1. Remove and dismantle the pinion as described in operation 8A/21.
2. Remove the pilot bearing snap ring (13 Fig. 32).
3. (Fig. 34) Press the pilot bearing off the pinion using tool MF 200 - 23.
4. Replace the pilot bearing using tool MF 200 - 23.
5. Refit the pilot bearing snap ring.

DRIVE PINION ASSEMBLY

Reassembly, Pre-load Setting and Refitting (8A/25)

1. (Fig. 32) Assemble the bearing housing (6), bearing cone (10), splined hub (4), new tabwasher (9) and locking ring (8) to the pinion (7).
2. (Fig. 35) Mount the pinion assembly in a soft faced vice, then assemble the CP 4030 pre-load gauge as shown. Adjust the pre-load gauge to 18 - 22 lb.in. (0.207 - 0.249 kg.m.).
3. (Fig. 36) Tighten the locking ring using the 3150C spanner simultaneously tapping the pinion to centralise the bearing. When the pre-load is correctly set, the weight on the gauge should just fall freely under its own weight.
4. Secure the locking ring with the tab washer.
5. Fit the pinion assembly into the centre housing, locating the pin on the bearing housing. Fit the six bolts to hold the bearing housing in position.
6. Replace the speedometer drive assembly as described in operation 8A/30.
7. Replace the rear drive shaft and shear tube into the centre housing.
8. Fit a new gasket to the centre housing and replace the centre axle housing cover.
9. Refill the centre housing with a recommended oil.

DIFFERENTIAL LOCK MECHANISM

Disassembly (8A/26)

1. Remove the right hand axle shaft housing assembly as stated in operation 8A/12.
2. (Fig. 37) With the differential lock lever removed lift up the rubber seal (1) and release the locknut (2) securing the actuator fork (3) to the shaft (4). Fully unscrew the fork from the shaft, complete with its locknut and rubber seal.
3. Remove the carrier plate as described in operation 8A/15.
4. Push the shaft (4) upwards and withdraw it from the axle shaft housing, complete with spring (5) washer (6) circlip (7) and 'O' ring (8).
5. Examine shaft for wear or scoring.

DIFFERENTIAL LOCK MECHANISM

Reassembly (8A/27)

1. (Fig. 37) Fit a new 'O' ring (8) to the shaft (4). If the shaft has been renewed, also fit a new circlip (7) and washer (6).
2. Slide the shaft into the housing taking care not to damage the 'O' ring. Refit the spring.
3. Refit the carrier plate as described in operation 8A/15.
4. Refit the axle shaft housing as stated in operation 8A/12.
5. Refit differential lock lever and adjust as stated in operation 8A/28.

DIFFERENTIAL LOCK

Adjustment (8A/28)

1. (Fig. 37) Lift up the rubber seal (1) covering the actuator fork locknut (2). Slacken the locknut then rotate the fork (3) out of engagement with the lever. Fully unscrew the fork from the shaft (4) complete with its locknut and seal.
2. Clean and degrease the threads of the actuator fork and the shaft.
3. Apply a small quantity of either Loctite Grade "A" or "AV", or Casco 'ML15' to the threads of the actuator fork, then screw the actuator fully into the shaft. Unscrew the actuator fork until it will engage the end of the differential lock bracket with the lever in the fully forward position. Fully tighten the locknut and push the rubber seal into place.

DIFFERENTIAL LOCK OPERATING BRACKET

Removal and Refitting (8A/29)

1. (Fig. 38) Remove the Differential lock lever (1) by removing the split pin (2), washer (3) and sliding the lever off the shaft.
2. Drive out the pin (4), remove the shaft (5) and lift the operating bracket clear. The shaft (6) can now be removed.
3. Replace in a reverse order of the above procedure.

SPEEDOMETER DRIVE ASSEMBLY

Removal and Refitting (8A/30)

1. (Fig. 39) Disconnect the speedometer drive cable (1) from the speedometer and the gearbox (4).
2. Remove the centre axle housing cover.

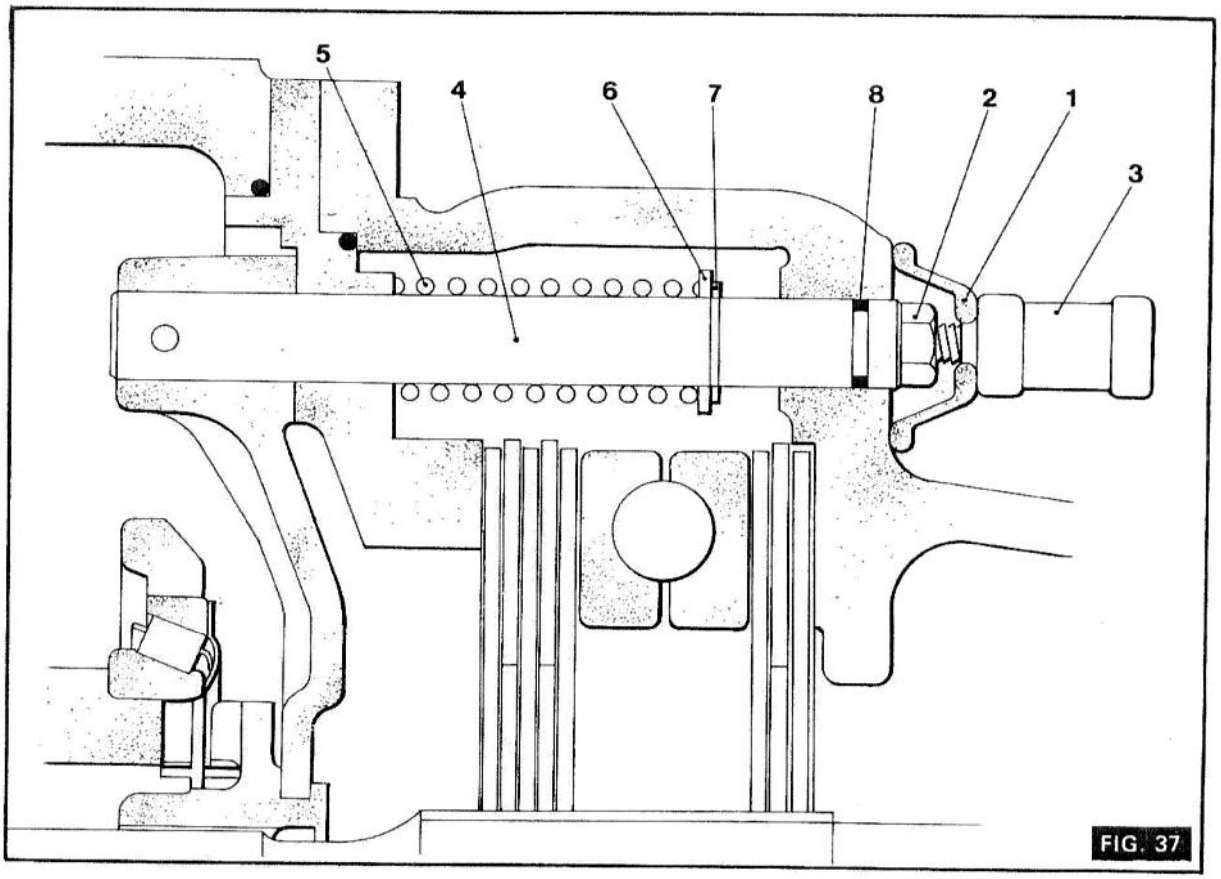

FIG. 37

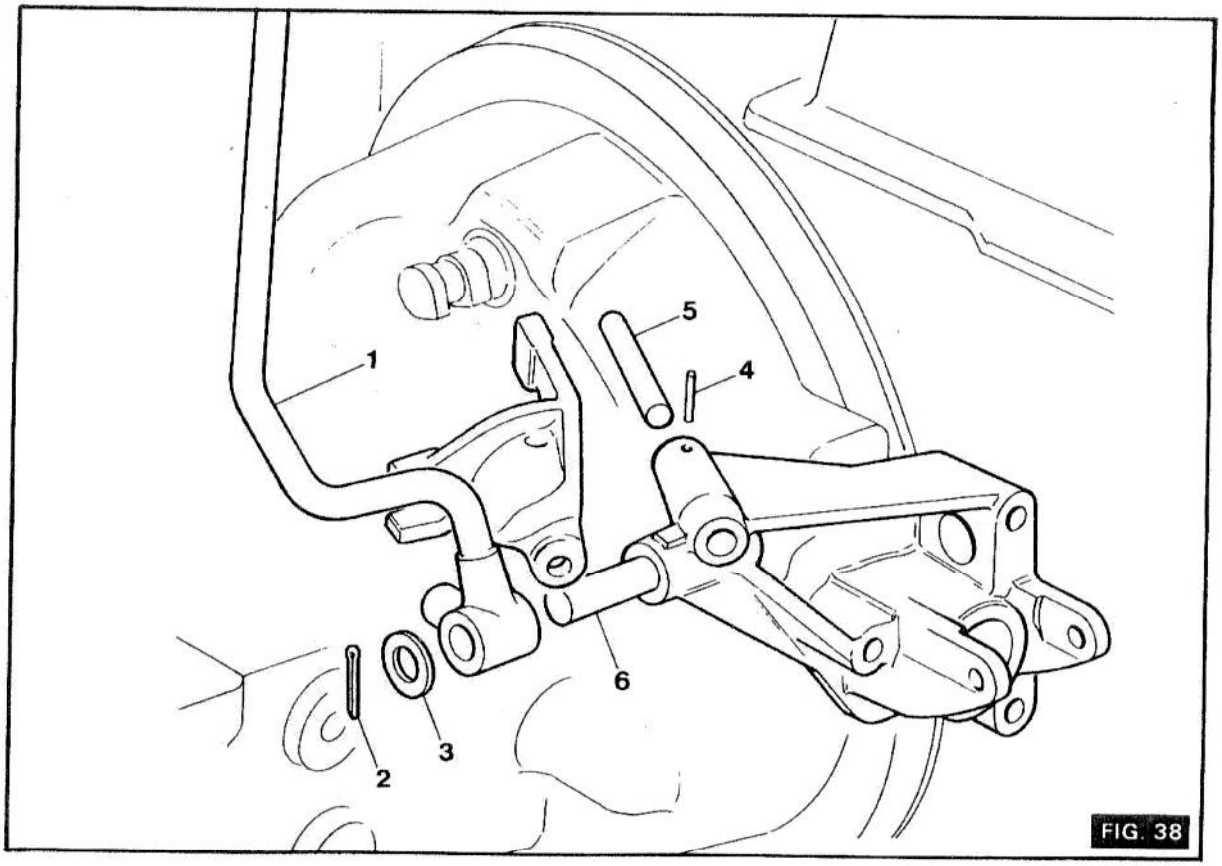

FIG. 38

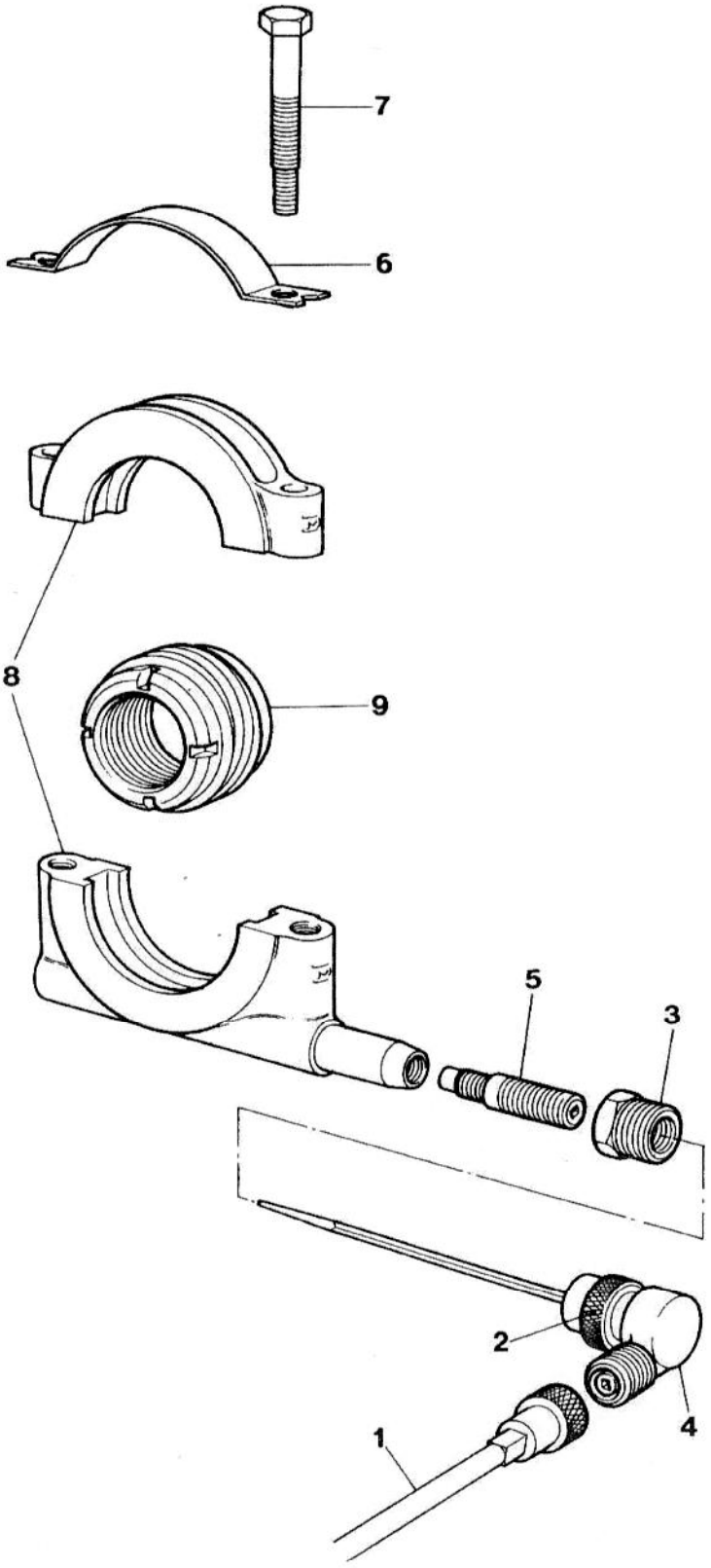

FIG. 39

SPEEDOMETER DRIVE ASSEMBLY

Removal and Refitting . . . Cont'd

3. Remove the split pin, shear tube and main drive shaft.
4. Remove the guard and unscrew the knurled nut (2) from the adaptor (3). Remove the gearbox (4).
5. Remove the adaptor (3) from the stud (5).
6. Release the tabwasher (6), unscrew the two bolts (7) and lift out the two halves of the speedometer drive housing (8).
7. Remove the drive pinion assembly and the locking ring/drive wheel (9) as stated in operation 8A/22
8. Replace the locking ring/drive wheel and the drive pinion as stated in operation 8A/25.
9. Refit the speedometer drive assembly by reversing the above procedure.

NOTE

A number is stamped on the arm of each half of the speedometer housing. These numbers should be matched up on reassembly.

BRAKE ACTUATOR HOUSING

Removal and Refitting (8A/31)

1. Drain the transmission oil to the MIN mark on the dipstick.
2. Disconnect the brake pull rods and remove the brake return spring.
3. Remove the speedometer gearbox and guard (left hand housing only).
4. (Fig. 40) Slacken the setscrew (1) and slide the brake lever (2) off the cross shaft (3). Take care that the key (4) is not misplaced.
5. Remove the bolt (5) from the cross shaft (3) and lift the cross shaft clear of the axle taking care not to misplace the key (6).
6. (Fig. 41) Remove the brake adjusting nut (1) and spacer (2).
7. Remove the three bolts securing the actuator housing to the axle housing then lift off the housing.
8. Tap out the rubber boot.
9. Only if necessary, remove the brake pull lever by removing the split pin and pushing out the pivot shaft.
10. Refitting is a reversal of the above procedure.

NOTE

If removing the right hand brake actuator housing remove the Differential lever and manoeuvre the housing complete with differential lock operating bracket clear of the tractor.

DISC BRAKES

Adjustment and Balancing (8A/32)

1. Jack up the machine until both wheels are clear of the ground.
2. Disengage the brake return springs and release the parking brake.
3. Measure the height of the right hand pedal from the floorboard then apply a load of approximately 10 lb. (4.5 kg). The correct free travel is 2 5/8 in. (67 mm).
4. (Fig. 41) Adjust the nut if necessary, clockwise to reduce the travel or anticlockwise to increase it.
5. After correctly setting the free travel of the right hand pedal adjust the left hand pedal to match for height and check that the latch will engage freely.
6. Remove the jack then road test the machine with the pedals locked together, checking for binding or pulling to one side.

"multi speed" oil used at one time was 1863 434 M1.

L.H. DISC BRAKE UNIT

Removal and Refitting (8A/33)

1. Remove the left hand axle shaft housing as described in operation 8A/12.
2. Remove the brake actuator housing as described 8A/31, items 6 to 8.
3. Remove the carrier plate as described in operation 8A/13.
4. (Fig. 42) Remove the brake components, marking them as they are withdrawn to facilitate reassembly. The order of removal is: first friction plate, first interplate, second friction plate, second interplate, third friction plate, actuator unit, fourth friction plate, third interplate, fifth friction plate.
5. Check the friction plates for wear signs i.e. grooves are starting to disappear. Interplates should be replaced whenever new friction plates are fitted.
6. Refit in a reverse manner of the above removal procedure.

R.H. DISC BRAKE UNIT

Removal and Refitting (8A/34)

1. Remove the right hand axle shaft housing as described in operation 8A/12.
2. Remove the brake actuator housing as described in operation 8A/31 itmes 6 to 8.
3. Remove the carrier plate as described in operation 8A/15.
4. (Fig. 42) Remove the brake components, marking them as they are removed to facilitate reassembly. The order of removal is: first friction plate, first interplate, second friction plate, second interplate, third friction plate, actuator unit, fourth friction plate, third interplate, fifth friction plate.
5. Check the friction plates for wear signs i.e. grooves are starting to disappear. Interpaltes should be replaced whenever new friction plates are fitted.
6. Replacement is a reversal of the above procedure.

BRAKE EXPANDER UNIT

Disassembly and Reassembly (8A/35)

1. Remove the disc brake assembly as described in operation 8A/33 or 8A/34.
2. (Fig. 43) remove the two studs and nuts (A) securing the linkage to the expander unit.
3. Remove the four springs (B), separate the two plates and remove the six steel balls (C).
4. When the unit is stripped check the following points.
   (a) That there are no broken or damaged parts.
   (b) That the bronze friction disc surfaces and splines are not excessively worn.
   (c) That the steel interplates are not heavily scored.
   (d) That the pull-off springs between the actuator plates retain sufficient tension.
   (e) That all bolts, pins and studs are in good condition.
5. Reassembly is a reversal of the above procedure.

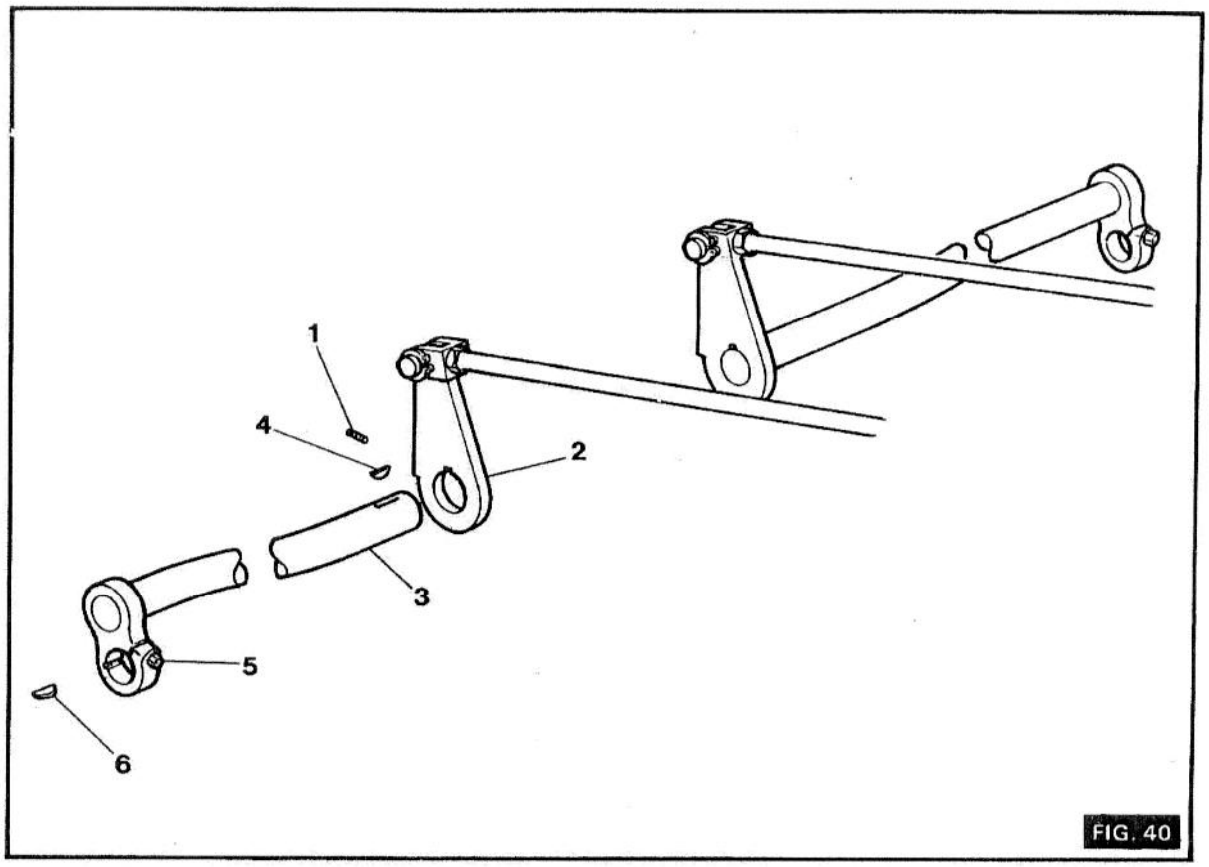

FIG. 40

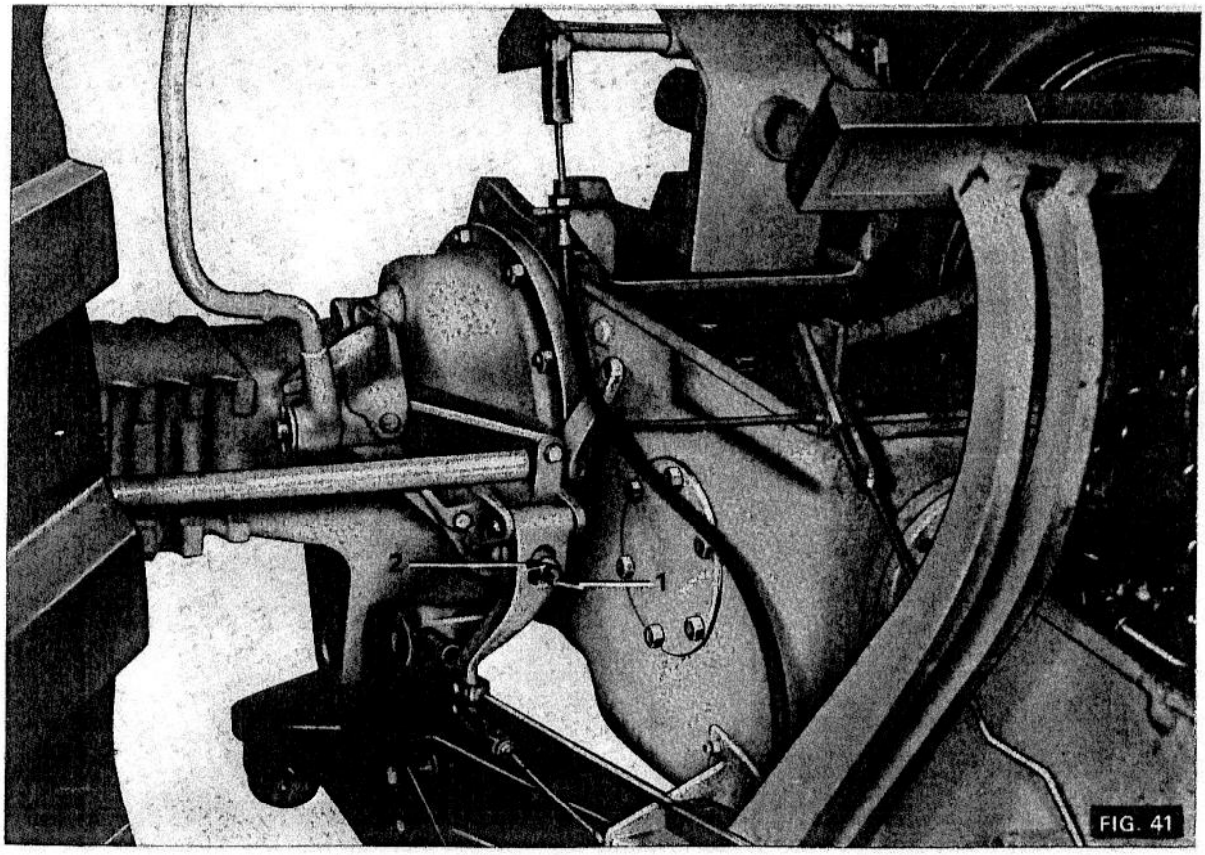

FIG. 41

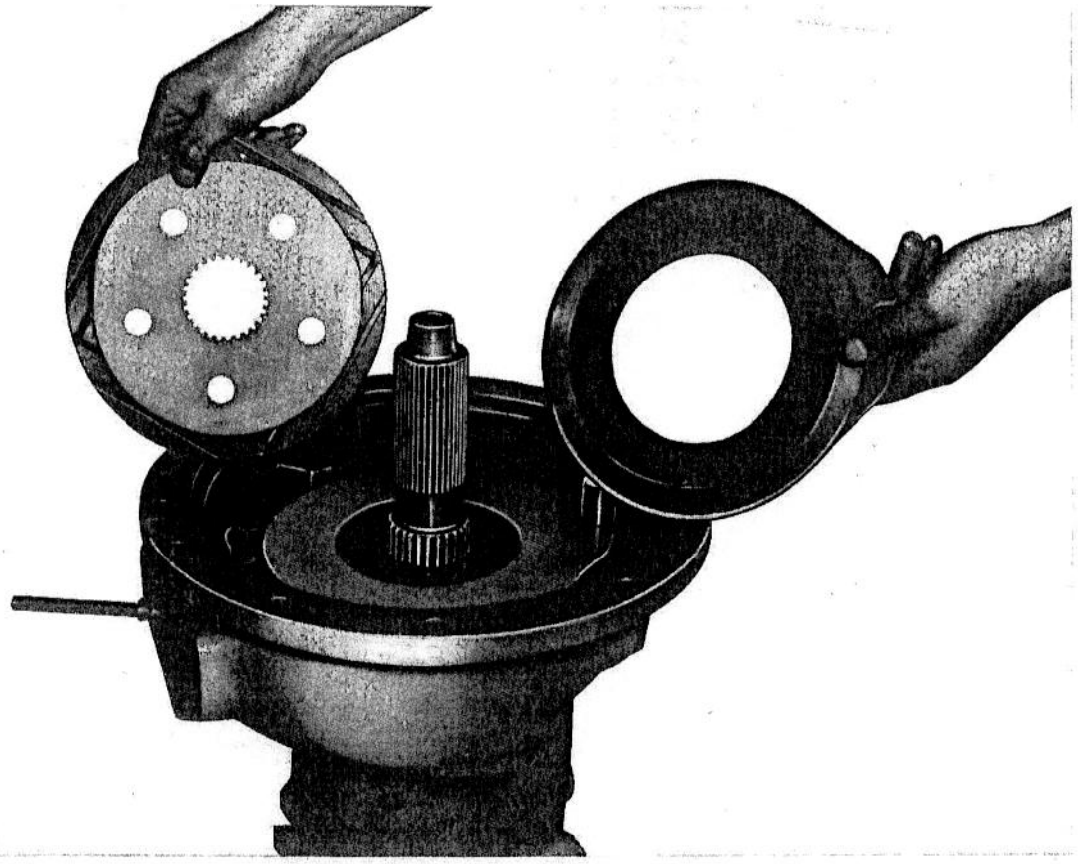

FIG. 42

FIG. 43

DRUM BRAKES
(Parking Brake)

CONTENTS

LIST OF ILLUSTRATIONS

DRUM BRAKES
(Parking Brakes)

GENERAL

In addition to the normal service brakes, an independant mechanically operated parking brake system can be fitted to the MF 50B Tractor Digger Loader.
The parking brake system consists of two Girling type drum brakes, actuated by hand lever control via an arrangement of connecting rods and linkage, see Fig.1.
When the parking brake lever is applied, it engages with a pawl which serves to lock the parking brake mechanism on. To release the parking brake release the hand brake lever. This will cause the locking pawl to disengage from the parking brake lever, thus allowing the parking brake mechanism to be released.
The drum brake assemblies are Girling two shoe, floating cam, double acting units with a total lining area of 108 sq. in. (696 sq. cm). The size of each brake shoe is 14 in. x 2 in. (35.6 x 50.8 cm).

DRUM BRAKES

Adjustment (8B/1)

1. Raise the rear of the machine until the rear wheels are clear of the ground.
2. Ensure that all shafts and pins work freely. Check that the brake pedals come up against their stops when the parking brakes are off.
3. Move aside the adjuster cover on the back-plate.
4. (Fig. 2) Insert a screwdriver through the hole in the back-plate and lever the clicker adjuster to expand the shoes in the drum, by turning the starwheel; clockwise on the R.H. wheel and anti-clockwise on the L.H. wheel. Continue to turn the adjuster until the wheels are locked.
5. Slacken the adjuster by six to eight clicks, at which point the wheels should spin freely.
6. Ensure that the brakes are evenly adjusted.

WARNING

Do not adjust the parking brakes by altering the length of the operating rods. The shoes only must be adjusted in the drums.

BRAKE SHOES

Removal and Refitting (8B/2)

Excessive travel of the parking brake lever, or failure of the parking brake to hold the machine stationary on an incline, indicates that the brake linings are excessively or unevenly worn or possibly contaminated with oil or grease.

When these symptoms become evident, the brake shoes and linings should be examined. If the linings are worn to within 1/16 in. (1.59 mm) of the shoe face, they should be renewed.

When fitting replacement shoes use only genuine spares of approved quality. If varied lining materials are used it will be difficult to achieve a satisfactory braking balance.

1. Jack up the rear of the machine until the rear wheels are clear of the ground. Remove the wheel and brake drum.
2. (Fig. 3) Remove the shoe return springs and the adjuster.
3. Remove the retainer springs and cups by pressing the cups down and turning.
4. Remove the brake shoes.
5. Reassemble in reverse order and adjust as described in operation 8B/1.

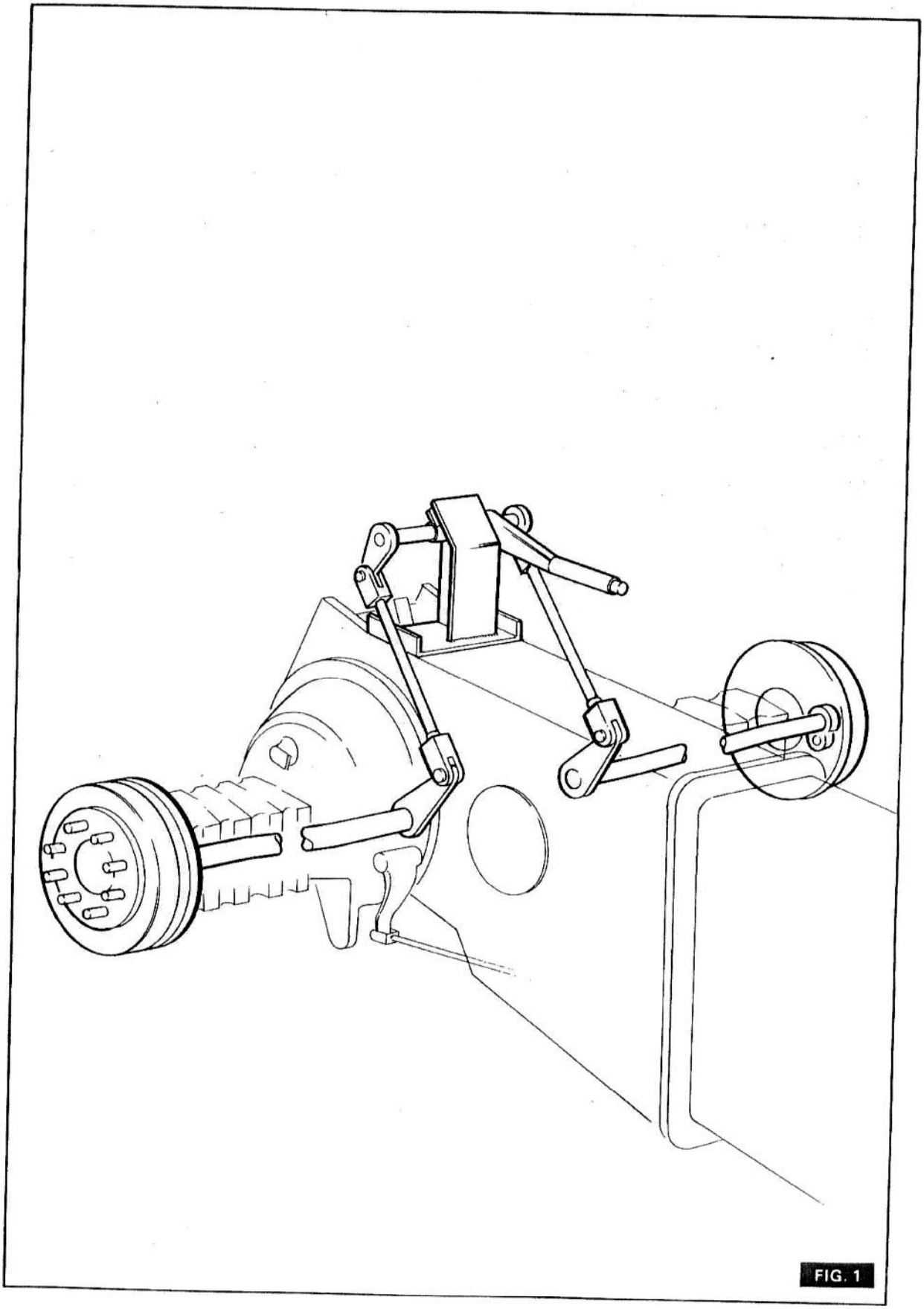

FIG. 1

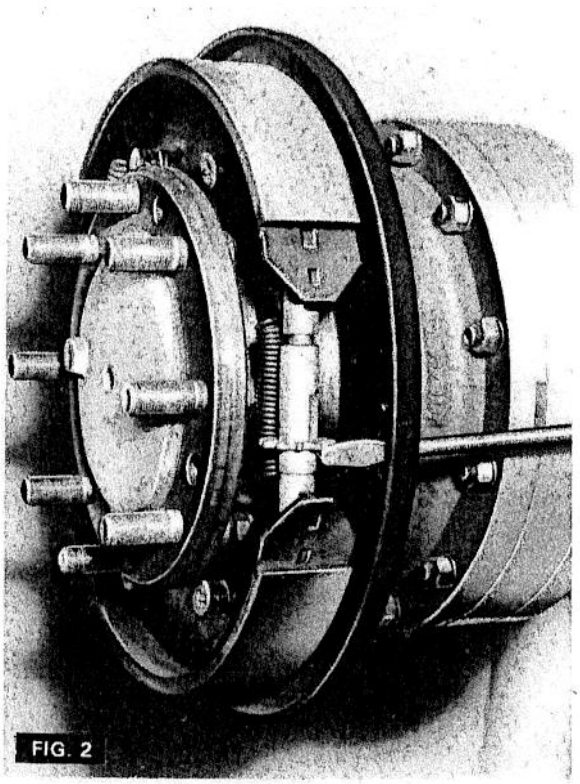

FIG. 2

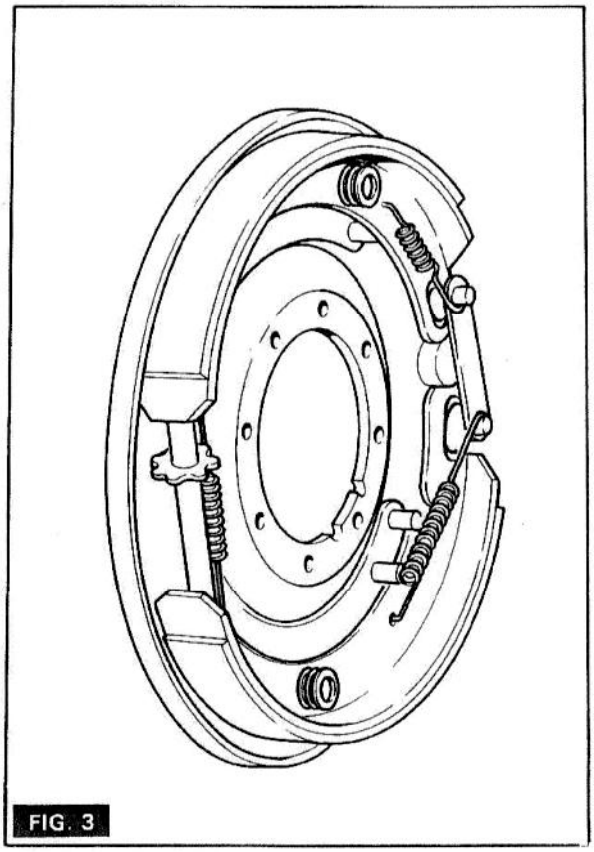

FIG. 3

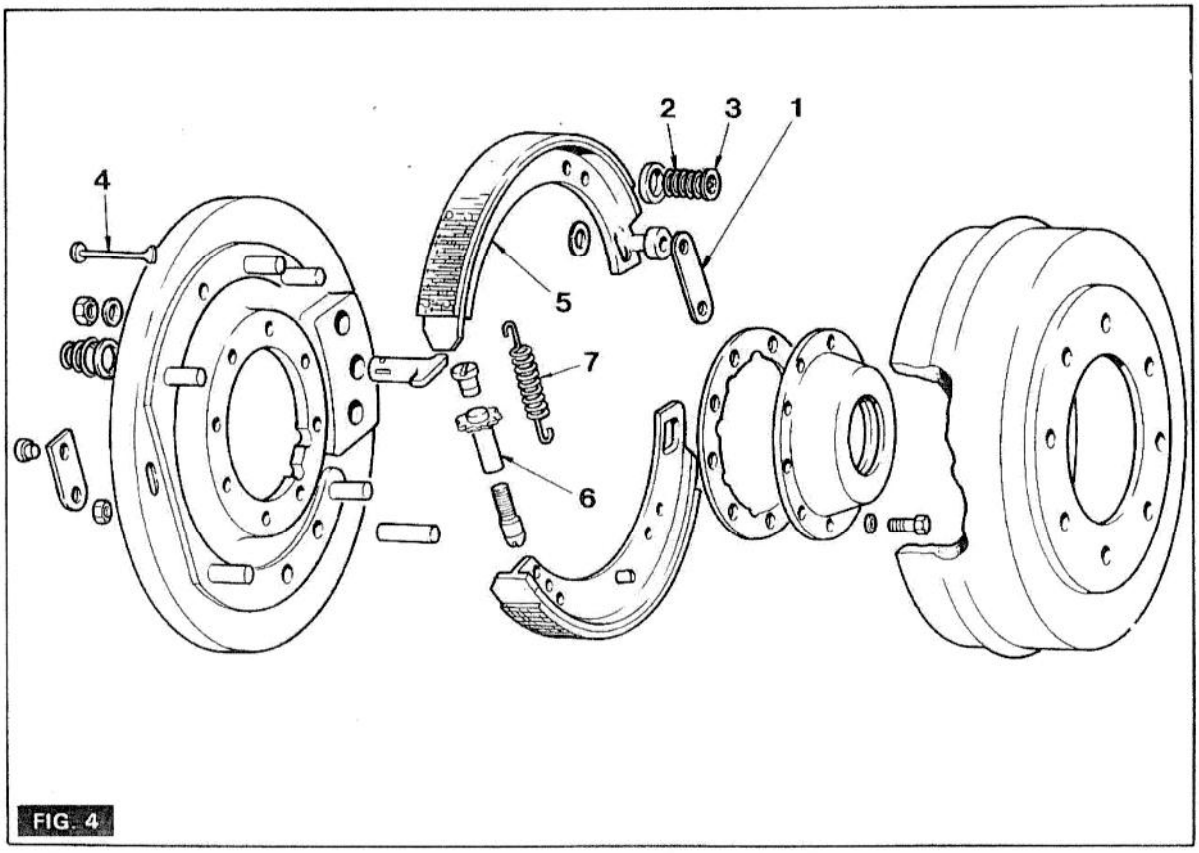

FIG. 4