

Transmission Overhaul

Types 220 and 220a

Operation No.
G 3

The transmissions for both Type 220 and Type 220a come with steering column gear shift and all four speeds positively synchronized. However, the two transmissions differ in several respects. The deviations will be seen from the description of the respective operations. Give the section "Checking and Reconditioning of Transmission" your particular attention, even if only a part has to be exchanged.

Gear Set for Type 220

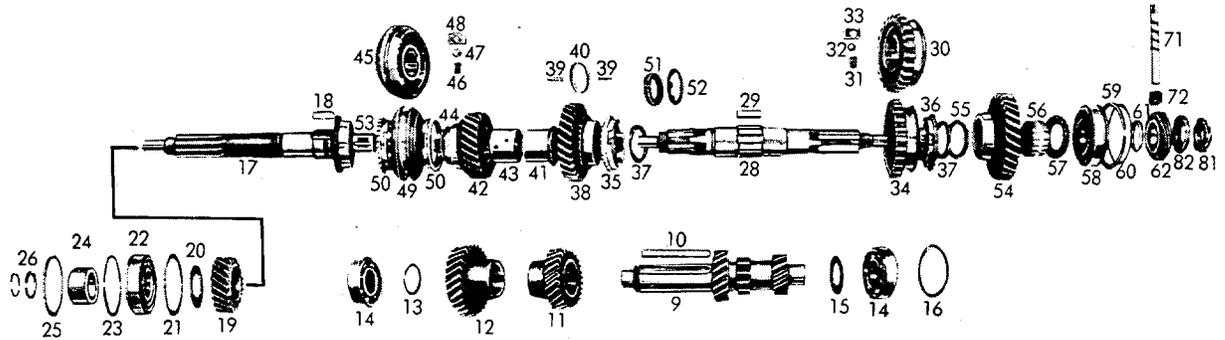


Fig. G 3/01

- | | | | |
|-----------------------------------|---|---|-----------------------------|
| 9 Countershaft | 23 Snap ring | 38 Second speed helical gear | 53 Kling roller bearing |
| 10 Key | 24 Spacer sleeve | 39 Bearing needle | 54 First speed helical gear |
| 11 Countershaft third speed gear | 25 Adjusting washer | 40 Spacer ring | 55 Contact washer |
| 12 Countershaft fourth speed gear | 26 Snap ring | 41 Bushing | 56 Roller assembly |
| 13 Lock ring | 27 Sealing ring | 42 Third speed helical gear | 57 Contact washer |
| 14 Grooved collar bearing | 28 Mainshaft | 43 Bushing | 58 Grooved collar bearing |
| 15 Guard washer | 29 Key | 44 Contact washer | 59 Snap ring |
| 16 Adjusting washer | 30 First and second speed synchronizer unit | 45 Third and fourth speed synchronizer unit | 60 Adjusting washer |
| 17 Driveshaft | 31 Pressure spring | 46 Pressure spring | 61 Spacer ring |
| 18 Key | 32 Steel ball | 47 Steel ball | 62 Speedometer drive gear |
| 19 Helical gear | 33 Follower | 48 Follower | 71 Driveshaft |
| 20 Oil thrower | 34 Gear sleeve | 49 Gear sleeve | 72 Small drive gear |
| 21 Spacer ring | 35 Synchronizer ring | 50 Synchronizer ring | 81 Slotted nut |
| 22 Grooved collar bearing | 36 Synchronizer ring | 51 Slotted nut | 82 Lock plate |
| | 37 Contact washer | 52 Lock plate | |

Gear Set for Type 220a

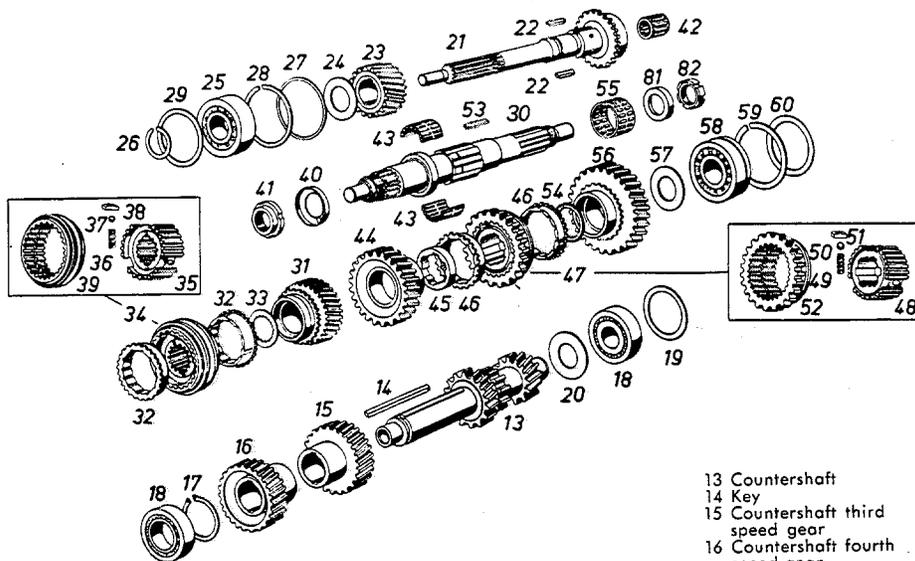


Fig. G 3/02

- | | |
|-----------------------------------|---|
| 13 Countershaft | 23 Helical gear |
| 14 Key | 24 Oil thrower |
| 15 Countershaft third speed gear | 25 Grooved collar bearing |
| 16 Countershaft fourth speed gear | 26 Snap ring |
| 17 Lock ring | 27 Spacer ring |
| 18 Grooved collar bearing | 28 Snap ring |
| 19 Adjusting washer | 29 Adjusting washer |
| 20 Guard washer | 30 Mainshaft |
| 21 Driveshaft | 31 Third speed helical gear |
| 22 Key | 32 Synchronizer ring |
| | 33 Contact washer |
| | 34 Third and fourth speed synchronizer unit |
| | 35 Synchronizer unit |
| | 36 Pressure spring |
| | 37 Steel ball |
| | 38 Follower |
| | 39 Gear sleeve |
| | 40 Lock plate |
| | 41 Slotted nut |
| | 42 Roller assembly |
| | 43 Split roller assembly |
| | 44 Second speed helical gear |
| | 45 Contact ring |
| | 46 Synchronizer ring |
| | 47 First and second speed synchronizer unit |
| | 48 Synchronizer unit |
| | 49 Pressure spring |
| | 50 Steel ball |
| | 51 Follower |
| | 52 Gear sleeve |
| | 53 Key |
| | 54 Contact washer |
| | 55 Roller assembly |
| | 56 First speed helical gear |
| | 57 Contact washer |
| | 58 Grooved collar bearing |
| | 59 Snap ring |
| | 60 Adjusting washer |

Special Tools:

Holding wrench for three-arm flange	187 589 08 07	Puller for ball bearing of mainshaft	136 589 02 33
Pin wrench for slotted nut (4 teeth) at mainshaft front end and Type 220 also rear end	120 589 04 07	Holding yoke for first and second speed gear	136 589 38 61
Pin wrench for slotted nut (6 teeth) at rear end of mainshaft (Type 220)	136 589 05 07	Mounting device for locking plate	191 589 02 31
Pin wrench for slotted nut at rear end of mainshaft (Type 220a), with 6 teeth	186 589 05 07	Mounting pin for needle bearing	187 589 02 39
with 4 teeth	186 589 07 07	Insertion sleeve for grease retainer	187 589 05 61
Bell-type puller for three-arm flange	136 589 03 33	Mounting pin for grease retainer	187 589 03 39
Pliers for mainshaft snap ring	136 589 00 37	Mounting pin for cover plate	187 589 01 39
Two levers for removing ball bearing from countershaft	136 589 00 35	Mounting pin for shifting rail	136 589 09 61
Mounting sleeve 31 × 40 × 93 mm (1.22 × 1.57 × 3.66") for removing and installing the gear set (for Type 220 only)	136 589 07 61	Installing punch for ball bearing on mainshaft	136 589 07 39
Punch for ball bearing on countershaft	136 589 06 39	Mounting sleeve 31 × 40 × 75 mm (1.22 × 1.57 × 2.95") for arresting the gear set (for Type 220 only)	136 589 08 51
Support angle for countershaft	136 589 11 61	Mounting sleeve 31 × 40 × 62 mm (1.22 × 1.57 × 2.44") for arresting the gear set (for Type 220a only)	198 589 02 61
Puller for reverse shaft	136 589 27 33	Test device for checking true run of three-arm flange at transmission	136 589 04 21

I. Disassembly of Transmission

Procedure:

Removal of Gear Set:

1. Remove clutch throwout collar with bearing.
In Type 220 remove snap ring on front cover of transmission case and take off throwout collar with bearing including pressure spring and spring retainer.
In Type 220a press the two wire clips out of the throwout fork towards the rear, turn to the side and pull out as indicated in Fig. G 3/1. Take off throwout collar with bearing.

Note: The clutch throwout bearing of Type 220a requires no maintenance. **The bearing must in no case be washed out!**

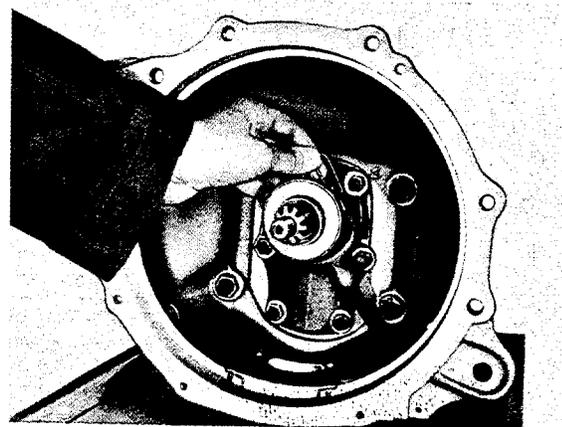


Fig. G 3/1

2. Set gear shift lever to neutral and unscrew transmission cover. To remove the cover, push a screw driver in the recess provided at the cover and pry the cover up (Fig. G 3/2).

Drain the transmission oil.

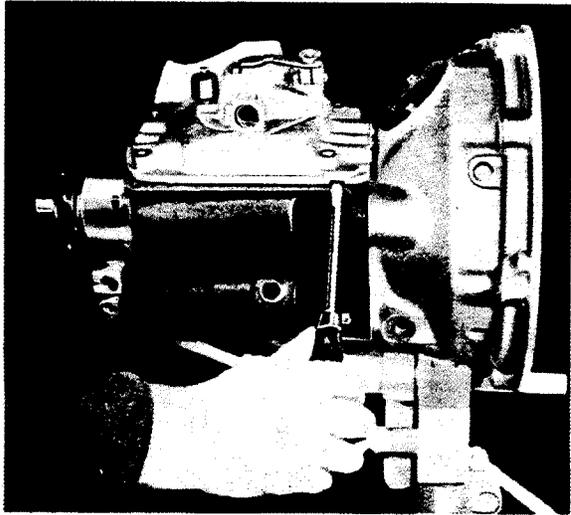


Fig. G 3/2

3. Unscrew clutch housing and front cover of transmission case. Watch out for adjusting washers in cover!
4. Loosen safety at three-arm flange. Engage reverse and fourth speed gear to block the transmission or hold three-arm flange in place by means of holding wrench 187 589 08 07, then unscrew slotted nut with pin wrench 136 589 05 07 or 120 589 04 07 in the case of Type 220 and 186 589 05 07 or 186 589 07 07 in the case of Type 220a. Pull three-arm flange by hand. If necessary, use puller 136 589 03 33.
5. Unscrew rear cover of transmission case with speedometer driveshaft and take off together with helical gear and spacer ring. Watch out for adjusting washers!

Note: In Type 220a the helical gear and spacer ring are made of one piece.

6. Take sealing ring off driveshaft, then remove snap ring in front of spacer sleeve with pliers 136 589 00 37 (Fig. G 3/6) and slip spacer sleeve off.

In Type 220a the snap ring is seated immediately in front of the ball bearing, and the grease retainer is pressed into the front cover of the transmission case.

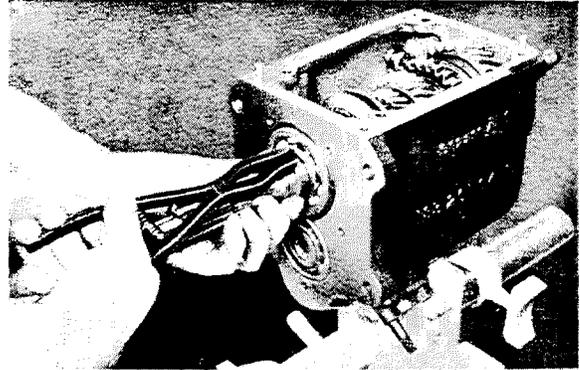


Fig. G 3/6

7. Drive mainshaft towards the front with a plastic hammer until it is possible to grip the bearing at the snap ring and press it forward by means of the two levers 136 589 00 35 (Fig. G 3/7). Pull the bearing with puller 135 589 02 33 (Fig. G 3/7a). Watch out for spacer ring located behind the snap ring!

Note: If it is not required to take the mainshaft apart, install holding yoke 136 589 38 61 between first and second speed gear before driving the mainshaft towards the front and

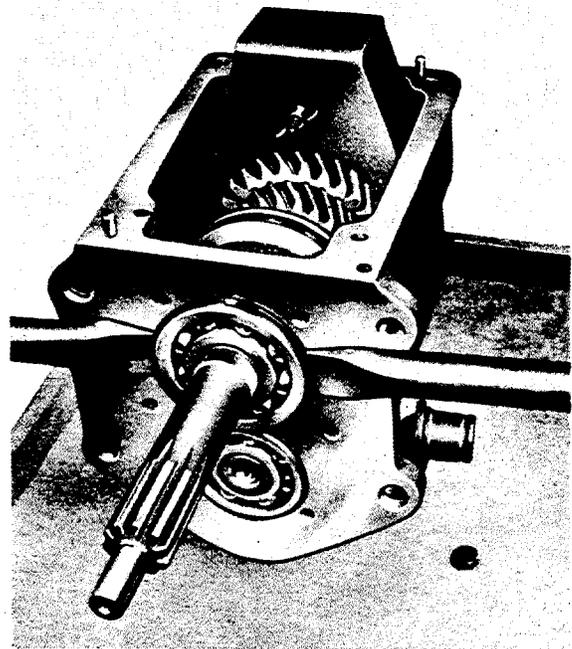


Fig. G 3/7

pulling the ball bearing (Fig. G 3/7). In this way the first speed gear is arrested and will not be displaced when the ball bearing is pulled.

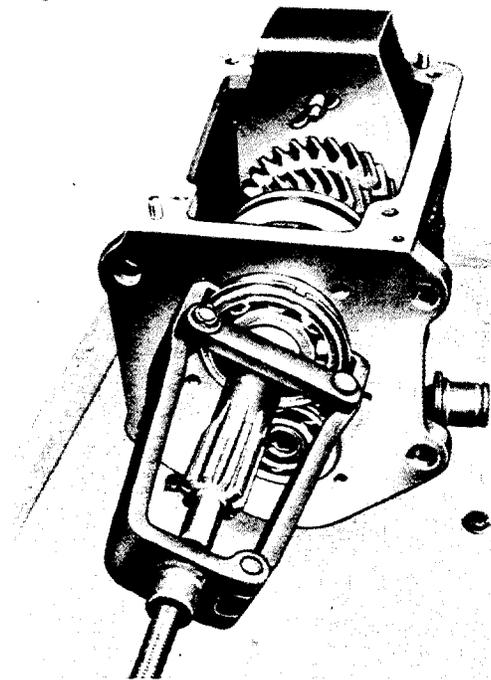


Fig. G 3/7a

8. Force driveshaft with mainshaft towards the rear until snap ring of rear ball bearing can be gripped and pulled by means of pulser 136 589 02 33 (Fig. G 3/8). Immediately after this has been done, tighten sleeve 136 589 07 61 or a suitable length of pipe $31 \times 40 \times 93 \text{ mm} = 1.22 \times 1.57 \times 3.66''$ (in Type 220a sleeve 198 589 02 61 or a length of pipe $31 \times 40 \times 62 \text{ mm} = 1.22 \times 1.57 \times 2.44''$) on mainshaft by means of the slotted nut. This is necessary in order to hold the first speed gear in place. Now the holding yoke 136 589 38 61 can be removed.

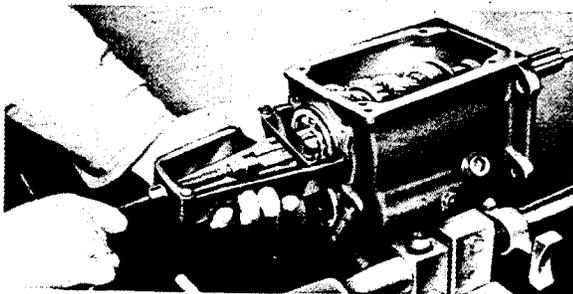


Fig. G 3/8

9. Lift driveshaft and mainshaft somewhat so that countershaft including front bearing can be driven from front to rear by means of punch 136 589 06 39. The countershaft will fall into the bottom part of the housing.

10. Pull driveshaft and mainshaft apart. Take driveshaft out towards the front and lift mainshaft out as indicated in Fig. G 3/10. Remove roller bearing and synchronizer ring.

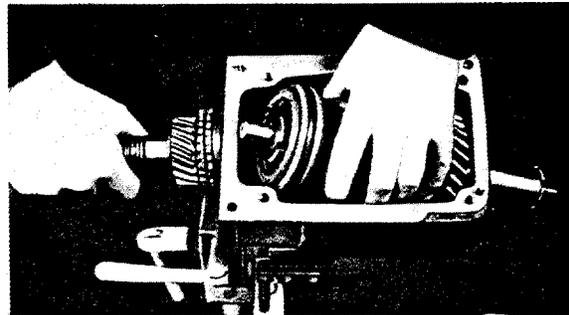


Fig. G 3/10

11. Place angle 136 589 11 61 so on countershaft that the second speed gear is propped against the wall of the transmission case (Fig. G 3/11).

Press rear ball bearing off countershaft by means of the two levers 136 589 00 35 (Fig. G 3/11a). Lift countershaft out of transmission case.

12. Turn out retaining screw with check nut for reverse shaft.

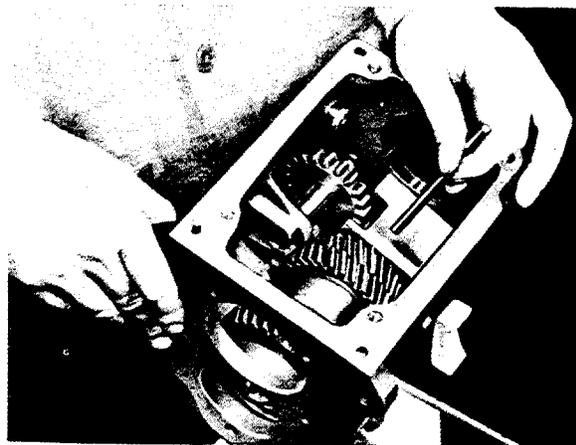


Fig. G 3/11

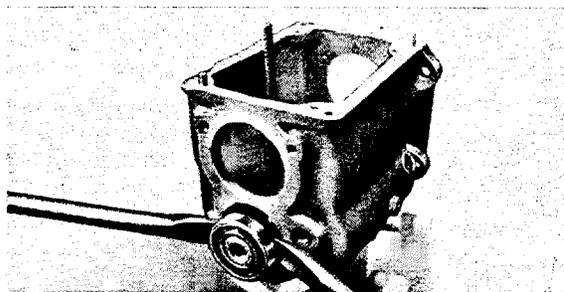


Fig. G 3/11a

Pull reverse shaft out towards the rear with puller 136 589 27 33 (Fig. G 3/12) and take reverse gear out.

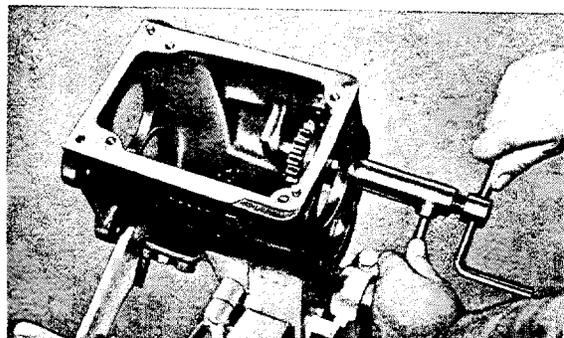


Fig. G 3/12

13. Take off intermediate arm with shift dog to reverse gear.

14. Pull front ball bearing off countershaft. If necessary, press the two front gears off the countershaft. Before this is done, take lock ring off.

Note: The two helical gears are pressed on with a great overlap. They can only be removed by means of a hydraulic press or a large screw press (Fig. G 3/14)

Before the new gears are pressed on, check whether countershaft runs true. The permissible out of true is 0.02 mm (0.0008").

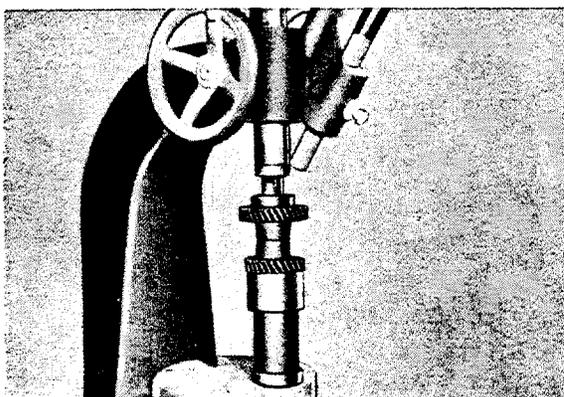


Fig. G 3/14

Mainshaft:

Note: The mainshaft of Type 220a has a collar as butting face for the third speed gear and not a steel bushing with collar as in Type 220. Due to this modification, disassembly of the mainshafts of Type 220 and Type 220a differs in several respects. The deviations will be seen from the following description.

15. Loosen slotted nut and remove sleeve 136 589 07 61.

Take off first speed gear with synchronizer ring, roller assembly and contact washers (Fig. G 3/15).

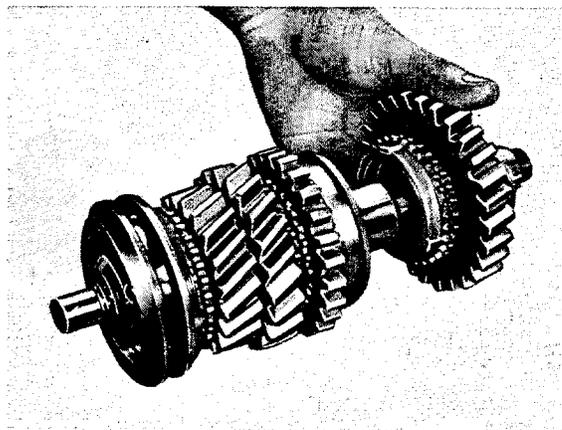


Fig. G 3/15

16. Take off first and second speed synchronizer unit (at the same time reverse gear) with synchronizer ring, contact washer and key (Fig. G 3/16).

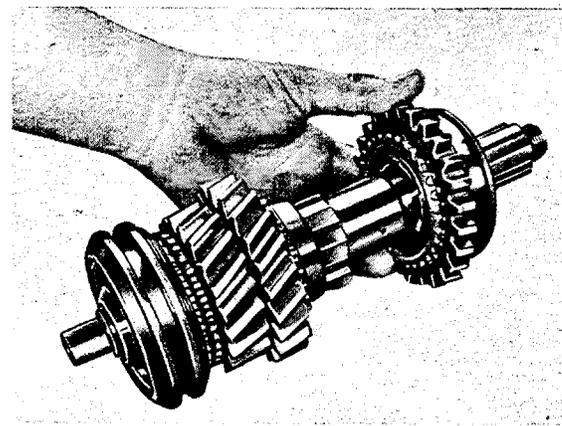


Fig. G 3/16

Type 220

17. Clamp mainshaft in a vise (use lead jaws). Loosen lock plate on mainshaft and unscrew slotted nut with pin wrench 120 589 04 07 (Fig. G 3/17).

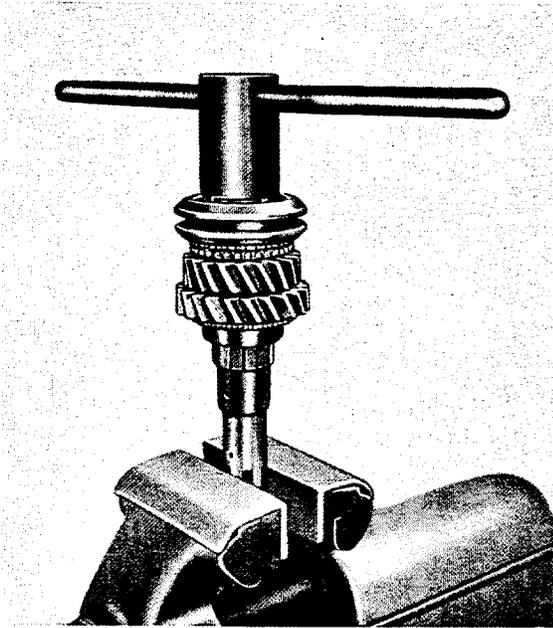


Fig. G 3/17

18. Take off third and fourth speed synchronizer unit.

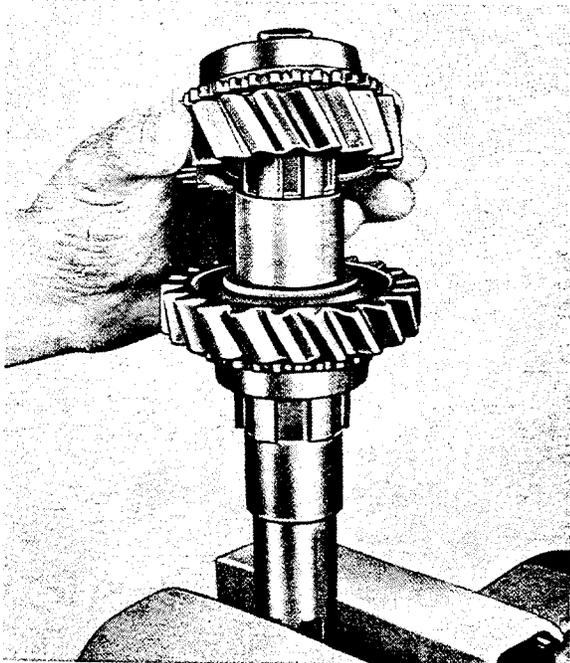


Fig. G 3/19

19. Take off third speed gear with synchronizer ring as well as brass washer (contact washer) and steel bushing with collar (Fig. G 3/19).
20. Take off second speed gear with two sets of 47 needles each and spacer ring as well as contact washer. Watch out for the needles!

Type 220a

- 17a. Turn contact ring of second speed gear so that splines of mainshaft and contact ring (1) coincide (Figs. G 3/17 and 17a).

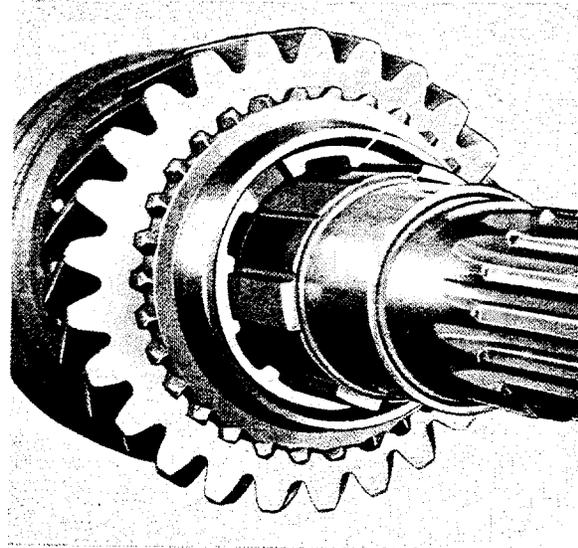


Fig. G 3/17a

Take off second speed gear together with contact ring and split roller assembly (Fig. G 3/17b).

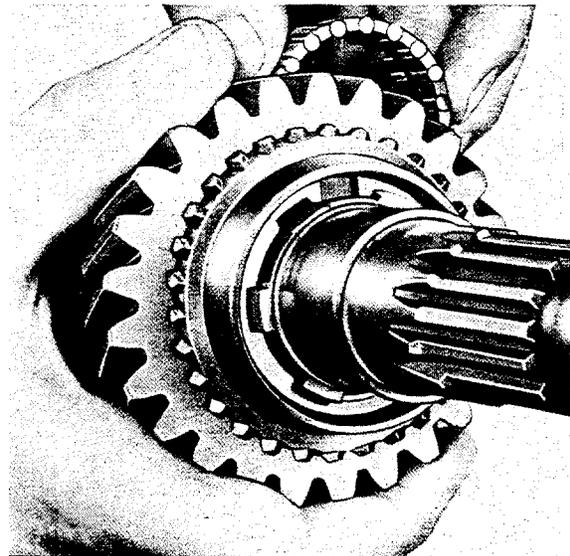


Fig. G 3/17b

18a. Clamp mainshaft in a vise. Loosen lock plate on mainshaft and unscrew slotted nut with pin wrench 120 589 04 07.

19a. Take off third and fourth speed synchronizer unit.

20a. Take off third speed gear with synchronizer ring and contact washer.

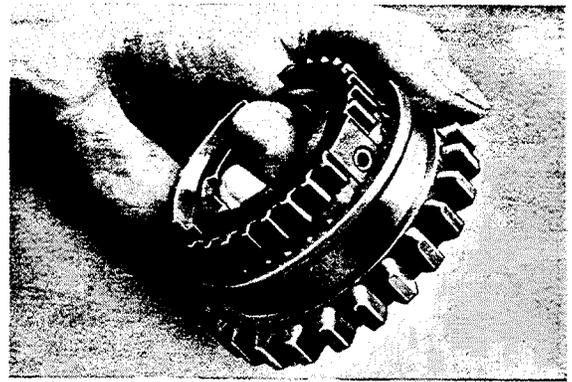


Fig. G 3/22

Synchronizer Units:

21. To disassemble the synchronizer units, insert synchronizer ring using it to push the synchronizer unit together with the followers a little out of the sleeve (Figs. G 3/21 and 21a).

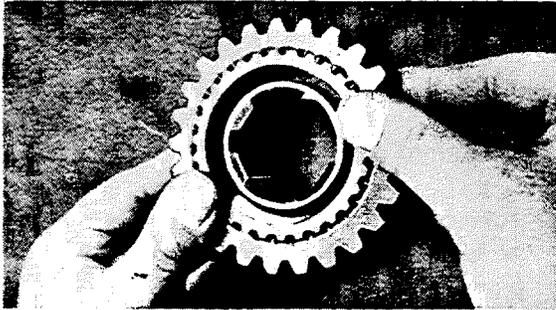


Fig. G 3/21

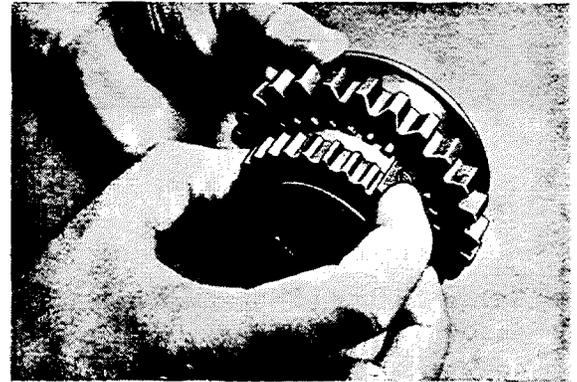


Fig. G 3/22a

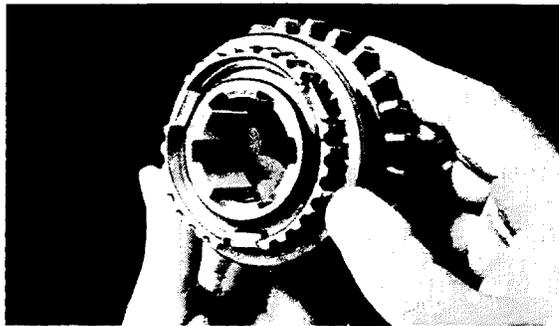


Fig. G 3/21a

Transmission Cover:

23. Drive out key retaining the shifting rails with a drift (Fig. G 3/23).

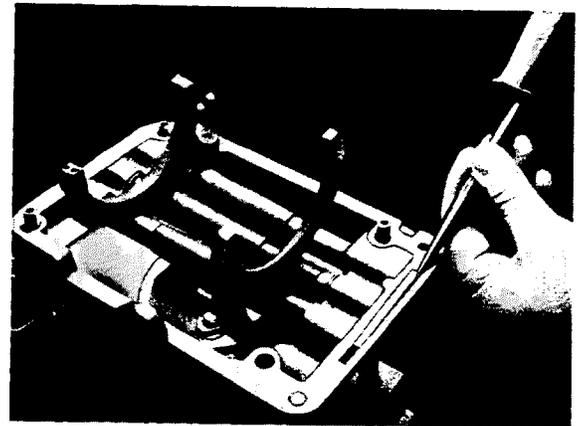


Fig. G 3/23

22. Push the three followers with the index finger forward one after the other and take the ball out (Fig. G 3/22). Take out synchronizer unit (Fig. G 3/22a).

24. Force shifting rails out of the cover with a drift. Be careful! Secure locking balls and pressure springs by following up with a suitable pin (Fig. G 3/24).

Be careful that spacer tubes and shims do not fall into the transmission cover.

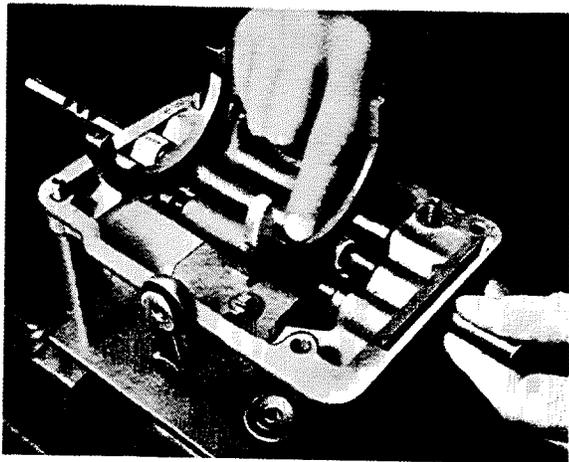


Fig. G 3/24

25. Remove shifting rails and slide spacer tube and shims on the respective shifting rail or note the dimensions.
26. Turn out screw plug for reverse speed stop and take out spring with latch and adjusting washer.
In Type 220, the stop for the reverse speed is located in the bearing body of the steering column gear shift.
27. Remove pointer from gear selector lever (in Type 220 only). Loosen nuts of selector and shift lever and pull both levers.

Note: Before taking off the levers mark the position of selector and shift lever on the respective shaft if there exist no marks.

28. Remove guide plate.
29. Lift out selector finger.

30. Take out lock ring in front of cover plate and drive shifter shaft with a suitable drift towards the cover plate forcing out the plate (Fig. G 3/30).
Take out washer and shift finger.

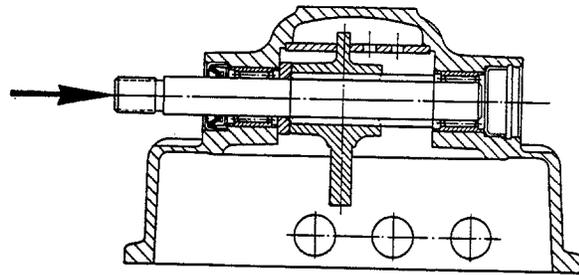
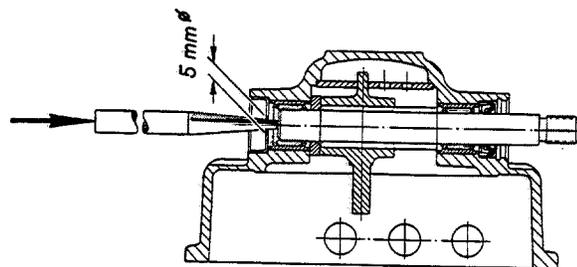


Fig. G 3/30

31. Push needle bearing out of bore in transmission cover. Press out grease retainer.
32. Loosen locking plate fastening screws and remove the plate.

For right-hand steering systems the following deviations regarding cf. 30 and 31 must be taken into consideration:

30. Take out lock ring in front of grease retainer. Use a drill having a diameter of approx. 5 mm (0.2") to drill a hole into the cover plate, then drive shifter shaft out by means of a suitable drift (Fig. G 3/30a). Take out washer and shift finger.



Dia. 5 mm (0.2")

Fig. G 3/30a

31. Push needle bearing out of bore in transmission cover. Press out cover plate.

II. Checking and Reconditioning of Transmission

Examine all parts after they have been cleaned to determine whether they can be reused.

Ball Bearings:

In general ball and roller bearings may be reused when the running grooves or surfaces as well as the balls or rollers, resp., are free from visible defects or worn spots. Before examining the bearings clean them in gasoline or Tri until they are completely free from contaminations. A bearing is perfectly clean if it does not bind at any point when rotated in one's hand.

To check for quiet running, provide the perfectly clean bearing with a few drops of engine or transmission oil. Note that bearings which have been used for a short period are much noisier than new bearings without, however, being unserviceable.

Under normal operating conditions the side play of anti-friction bearings should increase only slightly in the course of time. How long a bearing can be used depends on its service life. The average life expectancy of a conventional anti-friction bearing is approx. 10,000 hours of operation. This means that some bearings will reach a substantially longer operating time without becoming defective.

The bearings should be discarded after 100,000 km (60,000 miles), even if they are found to be serviceable and appear fitted for reuse. The fact whether a bearing can be exchanged readily or only after extensive preliminary work will also be of importance in this respect.

To prevent that serviceable bearings are discarded, the anti-friction bearings should only be examined by an experienced person.

Ball and Roller Bearing Dimensions and Tolerances
in mm (in.)

Nomenclature	Application	Type	Side play	End play	Bore inner race	Dia. outer race	Width
Grooved collar bearing 6305 DIN 625	Countershaft	220 220a	0.008-0.022 (0.00032- 0.00087)	Approx. 0.10-0.20 (0.004-0.008)	25.00 (0.98)	62.00 (2.44)	17.00 (0.67)
Grooved collar bearing 6306 N DIN 625 (220) 6306 ZN DIN 625 (220a)	Driveshaft	220 220a	0.008-0.022 (0.00032- 0.00087)	Approx. 0.10-0.20 (0.004-0.008)	30.00 (1.18)	72.00 (2.83)	19.00 (0.75)
Grooved collar bearing 6306 N DIN 625	Mainshaft	220 220a	0.008-0.022 (0.00032- 0.00087)	Approx. 0.10-0.20 (0.004-0.008)	30.00 (1.18)	72.00 (2.83)	19.00 (0.75)
Roller assembly Cylindrical rollers 4 x 8 DIN 5402 (220) 3.5 x 8 DIN 5402 (220a)	First speed gear	220 220a	For diameter tolerance see under first speed gear		35 (1.38) 35 (1.38)	43 (1.69) 42 (1.65)	20.40 (0.80) 21.40 (0.84)
Needles 2.5 x 9.8 DIN 617	Second speed gear	220	For diameter tolerance see under second speed gear				
Split roller assembly Cylindrical rollers 3.5 x 8 DIN 5402	Second speed gear	220a	For diameter tolerance see under second speed gear		35 (1.38)	42 (1.65)	21.40 (0.84)

The grooved collar bearings 6306 N bear different electrically inscribed markings (1, 2 or X).

The marks 1 and 2 indicate the width of the groove provided in the outer bearing race. Select the snap ring so that it is seated in the groove without play.

The inner race of the bearings marked X has a max. radius of curvature of $r = 2 \text{ mm (0.08")}$.

On the rear transmission end of the mainshaft only bearings marked X must be installed. On the front transmission end of the mainshaft bearings may be used that do not have the X mark.

Sliding Gears:

Gear Ratios

	Type 220					Type 220a	
	I		II		III	VI	
	1st design	2nd design	3rd design	4th design	5th design	1st design	2nd design
First speed	2.95 : 1	3.06 : 1	2.98 : 1	3.33 : 1	3.68 : 1	3.40 : 1	3.52 : 1
Second speed	2.12 : 1	2.12 : 1	2.12 : 1	2.12 : 1	2.25 : 1	2.32 : 1	2.32 : 1
Third speed	1.46 : 1	1.46 : 1	1.45 : 1	1.45 : 1	1.42 : 1	1.52 : 1	1.52 : 1
Fourth speed	1 : 1	1 : 1	1 : 1	1 : 1	1 : 1	1 : 1	1 : 1
Reverse	3.18 : 1	3.18 : 1	2.78 : 1	2.78 : 1	3.08 : 1	3.29 : 1	3.29 : 1

Number of Teeth

	Type 220					Type 220a	
	I		II		III	IV	
	1st design	2nd design	3rd design	4th design	5th design	1st design	2nd design
First speed	14/27	13/28	13/29	12/30	12/30	13/28	13/29
Second speed	18/25	18/25	17/27	17/27	17/26	17/25	17/25
Third speed	22/21	22/21	23/25	23/25	25/24	25/24	25/24
Constant-mesh	17/26	17/26	21/28	21/28	19/28	19/30	19/30
Reverse	12/17/25	12/17/25	12/17/25	12/17/25	12/17/25	12/17/25	12/17/25

When reconditioning the transmission or exchanging the first speed gear, note the following modification:

Type 220 Exchange first speed gear of 1st design against a gear of 2nd design

Exchange first speed gear of 3rd design against a gear of 4th design

Type 220a Exchange first speed gear of 1st design against a gear of 2nd design

At the same time exchange the countershaft together with first speed gear. It is not permitted to interchange sliding gears of Groups I, II, III and IV.

The serviceability of used gears is determined by examining quietness of run and wear of tooth flanks and teeth. In new condition the tooth backlash of the first and second speed gear is 0.10–0.16 mm (0.004–0.006"); the third and fourth speed gear have a backlash of 0.06–0.12 mm (0.0024–0.005") and the reverse gear of 0.10–0.18 mm (0.04–0.007"). The end play between gear and contact washer is 0.10–0.18 mm (0.004–0.007").

Check fit of keys and keyways on shafts and gears as well. It must be possible to displace the sliding gears easily, but without play.

Bearing Surface Dimensions and Tolerances of Mainshaft and Sliding Gears
in mm (in.)

Type	Dia. of mainshaft		Bore of gear		Side play		
	220	220a	220	220a	220	220a	
First speed gear	$\frac{35.000}{34.987}$ (1.37795) (1.37744)	$\frac{35.000}{34.987}$ (1.37795) (1.37744)	$\frac{43.018}{43.033}$ (1.69362) (1.69421)	$\frac{42.018}{42.033}$ (1.65425) (1.65484)	0.030–0.045 (0.0012– 0.0018)	0.030–0.045 (0.0012– 0.0018)	
Second speed gear	$\frac{35.000}{34.987}$ (1.37795) (1.37744)	$\frac{35.000}{34.987}$ (1.37795) (1.37744)	$\frac{40.030}{40.045}$ (1.57598) (1.57657)	$\frac{42.018}{42.033}$ (1.65425) (1.65484)	0.030–0.060 (0.0012– 0.0024)	0.030–0.045 (0.0012– 0.0018)	
Third speed gear	Steel bushing $\frac{37.970}{37.961}$ (1.49488) (1.49452)	formerly $\frac{37.955}{37.946}$ (1.49429) (1.49393)	$\frac{37.970}{37.961}$ (1.49488) (1.49452)	$\frac{38.000}{38.016}$ (1.49606) (1.49669)	$\frac{38.000}{38.016}$ (1.49606) (1.49669)	0.030–0.055 (0.0012– 0.0022)	0.045–0.070 (0.0018– 0.0027) formerly 0.030–0.055 (0.0012– 0.0022)

In the case of Type 220 the mainshaft need not be equipped with a steel bushing for the third speed gear, as the shaft is already provided with a bearing surface and collar for the third speed gear.

First Speed Gear:

The first speed gear is supported on 2 × 18 rollers with cage.

The cylinder rollers (4 × 8 DIN 5402 in Type 220 and 3.5 × 8 DIN 5402 in Type 220a) are available in selected sizes varying from 0.002 to 0.002 mm (0.00008"), namely from –0.004 mm (0.00016") to +0.004 mm (0.00016").

- | | |
|---|--|
| a) – 0.004 mm (0.00016") to – 0.002 mm (0.00008") | } Deviation regarding nominal diameter |
| b) – 0.002 mm (0.00008") to 0.000 mm (0.00000") | |
| c) 0.000 mm (0.00000") to + 0.002 mm (0.00008") | |
| d) + 0.002 mm (0.00008") to + 0.004 mm (0.00016") | |

Be sure to use rollers of the same group, that is a, b, c or d. If individual rollers are damaged or worn, the complete set of rollers must be exchanged. It is not permitted to replace single rollers. In actual practice the complete set of rollers is exchanged together with the cage.

In Type 220 the first series of transmissions had been provided with 2 x 30 cylinder rollers 4 x 6 DIN 5402 with an intermediate ring (8.34–8.36 mm = 0.328–0.329" wide).

Second Speed Gear:

Type 220

The second speed gear of Type 220 is supported on 2 x 47 needles 2.5 x 9.8 DIN 617.

The needles are available in three sizes

- | | |
|--|---|
| a) from 0.000 mm (0.00000") to – 0.003 mm (0.00012") | } Deviation regarding nominal diameter of 2.5 mm (0.098") |
| b) from – 0.003 mm (0.00012") to – 0.006 mm (0.00024") | |
| c) from – 0.006 mm (0.00024") to – 0.009 mm (0.00035") | |

Be sure to use rollers of the same group, that is a, b or c. If individual needles are damaged or worn, the complete set must be exchanged. It is not permitted to exchange single needles.

Type 220a

The second speed gear of Type 220a is supported on 2 x 18 rollers with cage.

The description given in connection with the first speed gear applies also to the cylinder rollers 3.5 x 8 DIN 5402.

Third Speed Gear

In Type 220 the third speed gear is supported on a steel bushing with collar which is seated on the mainshaft. Check the bushing for wear and cracks.

In Type 220a the mainshaft is provided with a bearing surface with collar for the third speed gear, so that the steel bushing is omitted.

Check the bronze bushing rolled into the third speed gear after a special method. Replace the complete gear if it is excessively worn (more than 0.1 mm = 0.004" side play) or if the third speed gear snaps out in spite of the pressure spring in the shifting fork being in good condition.

Reverse Gear:

When the bushing in the reverse gear has to be replaced, press the new bushing in with an overlap of 0.01–0.03 mm (0.0004–0.0012") and enlarge its free ends at an angle of 45° (Fig. G 3/03). After the bushing has been enlarged, it must take a thrust of 1.500 kg (3,300 lb.) The bushing bore "D" is 20.065–20.098–20.000 mm (0.78689–0.78740"); diameter of the reverse shaft is 19.987 mm (0.79000–0.79126") and the hence the play is 0.065–0.111 mm (0.0025–0.0043").

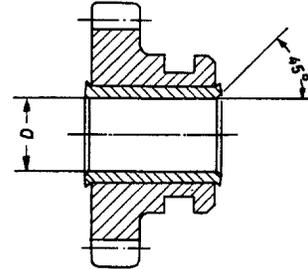


Fig. G 3/03

Synchronizer Rings:

Check synchronizer rings to determine whether they can be reused. To do this, put the ring on the cone of its sliding gear and turn it clockwise. Now the ring should sit firmly on the gear cone, but come off without force being exerted. Check clearance between teeth of ring and gear with ring installed; exchange the synchronizer ring, if clearance is insufficient.

If the transmission has been in service for a lengthy period, it is recommended to replace all synchronizer rings with new ones.

The width of the noses on the synchronizer rings has been modified several times. In a transmission synchronizer rings with narrow or wide nose, or both of them, may be installed. If a transmission is provided with synchronizer rings of both the narrow and wide-nose type, the synchronizer ring with wide nose is to be used on the first speed gear (Fig. G 3/04). **Note that used synchronizer rings must only be reused in connection with the original sliding gear.**

Later on the synchronizer rings were provided with 12 grooves (Fig. G 3/05).

Today the first speed gear will be provided with synchronizer rings having a nose width of 10 mm (0.4"), whereas in connection with the second, third and fourth speed gear rings with 8.4 mm (0.33") wide noses are installed.

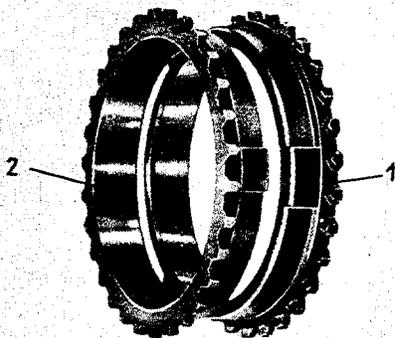


Fig. G 3/04

Second design

- 1 = synchronizer ring for first speed gear
- 2 = synchronizer ring for second, third and fourth speed gear

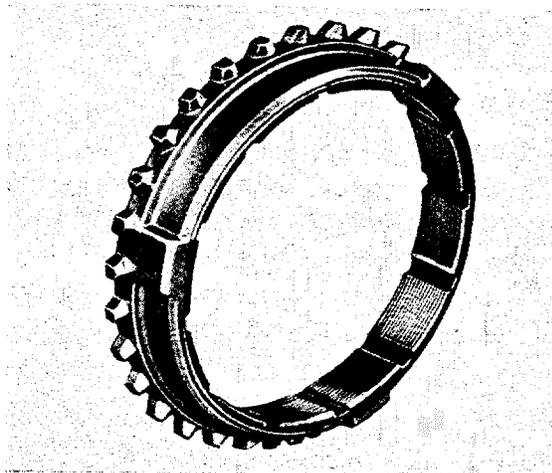


Fig. G 3/05

Third design

In Type 220 the synchronizer rings of the first design are provided with slots instead of cast-on noses (Fig. G 3/06).

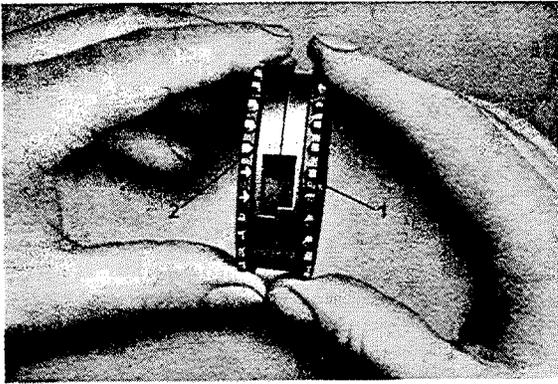


Fig. G 3/06

First design

- 1 = Synchronizer ring for first speed gear
- 2 = Synchronizer ring for second, third and fourth speed gear

If a synchronizer ring of the first design must be replaced, always exchange both rings, that is for first and second speed or third and fourth speed, resp., for rings of the present design. Still better, replace all synchronizer rings with rings of present design.

At the same time exchange the pertaining followers.

Length of followers for synchronizer rings

with slots: 21 mm (0.83")

with noses: 12.2 mm (0.48")

Transmission Cover:

Replace worn shuffling forks and shifting rails as well as worn-out guide and locking plates.

Test the springs provided in the shifting forks (see table).

Spring Test Table

Nomenclature	Outer dia. mm (in.)	Length unloaded mm (in.)	Length loaded		Wire thickness mm (in.)	Loading tolerance %
			mm (in.)	kg (lb.)		
Synchronizer springs Type 220	6 (0.24)	12.6 (0.50)	a) 9.2 (0.36)	1.48 (3.26)	0.8 (0.031)	± 5
			b) 8 (0.315)	2 (4.4)		
Type 220a	6 (0.24)	12.4 (0.49)	a) 8.2 (0.32) b) 7.3 (0.29)	1.65 (3.64) 2 (4.4)	0.75 (0.029)	± 5
Shifting fork for first, second, third and fourth speed	7.6 (0.30)	20.2 (0.795)	a) 15.5 (0.61) b) 13 (0.51)	3.2 (7.05) 5 (11.0)	1.1 (0.040)	± 8
Shifting fork for reverse speed	7.8 (0.31)	20.25 (0.80)	a) 15.5 (0.31) b) 13 (0.51)	9.8 (21.60) 15 (33.0)	1.4 (0.055)	± 8

a) = installed, b) = fully loaded

If the bore for the selector finger is worn out, a bearing bushing must be installed subsequently. To do this, enlarge the hole in the transmission cover with a drill to 15.00–15.01 mm (0.59055–0.59094") strictly at right angles to the mating surface and press bearing bushing in with an overlap of 0.015 to 0.030 mm (0.0006–0.0012").

The bore in the bushing is 12.00–12.018 mm (0.4725–0.47315").

Today the transmission covers are supplied with cast-in bushings.

Front and Rear Cover of Transmission Case:

The following illustrations show the sealing rings used on driveshaft at front end of transmission case and on mainshaft at rear end of transmission case in Type 220 and Type 220a.

Front Cover:

Type 220

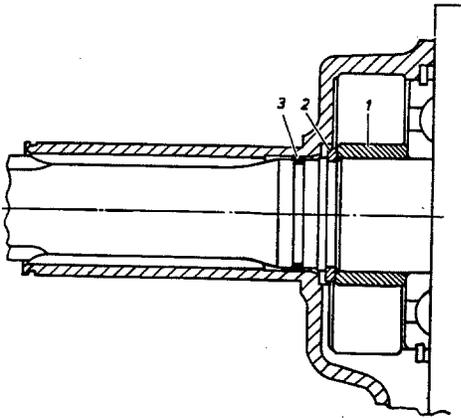


Fig. G 3/07

- 1 Spacer sleeve
- 2 Snap ring
- 3 Sealing ring

Type 220a

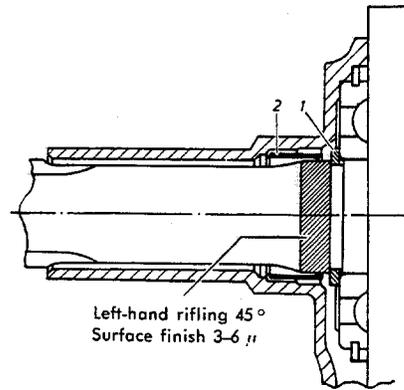


Fig. G 3/08

- 1 Snap ring
- 2 Grease retainer

Rear Cover:

Type 220

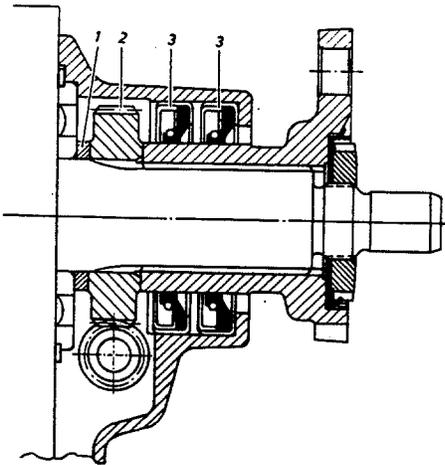


Fig. G 3/09

- 1 Spacer ring
- 2 Speedometer drive gear
- 3 Grease retainer

Type 220a

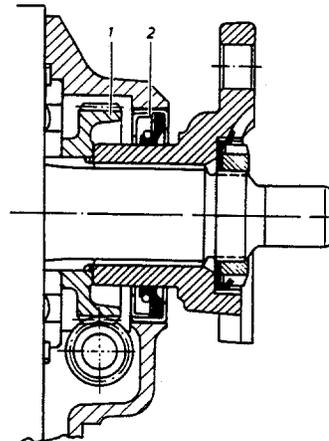


Fig. G 3/010

- 1 Speedometer drive gear
- 2 Grease retainer

Replace damaged grease retainers. Mount front cover and three-arm flange at rear end of transmission case with utmost care in order not to damage the sealing lips of the grease retainers.

Before installing the front cover of Type 220, turn sealing ring so that its gap is at top (see Fig. G 3/07) and then arrest strictly concentric to the driveshaft by applying some grease. It is recommended to check the gap clearance beforehand by inserting the sealing ring in the cover. The clearance must not be more than 0.1 mm (0.004"). If the bore for the sealing ring in the cover has shrunk, replace the cover.

Provide sealing surface of driveshaft for Type 220a with left-hand rifling (Fig. G 3/08). If the sealing surface has shrunk, it may be reworked to a diameter of **29.700 mm (1.16929")**. The standard size is 29.848–29.900 mm (1.17512–1.17716"). After the sealing surface has been corrected, provide it again with left-hand rifling (see Operation No. H 3, cf. 27).

If the sealing surface of the three-arm flange has shrunk, its diameter may be reground by as much as 0.5 mm (0.02"). The standard size is 39.840–40.000 mm (1.56850–1.57480") in Type 220 and 37.840 to 38.000 mm (1.48976–1.49606") in Type 220a. Excessively shrunk sealing surfaces can be restored to standard size by chrome-plating them. After the sealing surface has been reworked, provide it with right-hand rifling (see Operation No. H 3, cf. 27).

The lateral out of true of the three-arm flange, checked at the outer diameter, must not be more than 0.03 mm (0.0012"), otherwise the flange must be displaced on the splines or, if necessary, even reground. If it is not possible to rework the three-arm flange, it must be replaced.

III. Assembly of Transmission

Transmission Cover:

33. Insert locking plate in correct position into the transmission cover and tighten lightly (Fig. G 3/33). The longitudinal slots in the locking plate must be parallel with the shifting rails. To achieve this, install fixing device 191 589 02 31 in the transmission cover, before you tighten the locking plate.

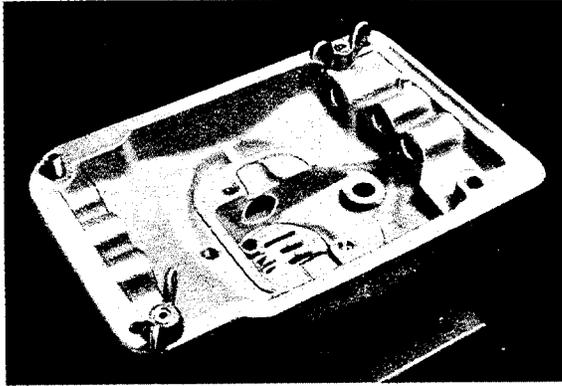


Fig. G 3/33

34. Insert shifter shaft with splined end first so into the transmission cover that the splined end projects out of the left side of the transmission cover (as seen into direction of travel).

When inserting the shifter shaft, push on washer (4) and shift finger (2); see Fig. G 3/34. It must be easily possible to move the shift finger on the shifter shaft.

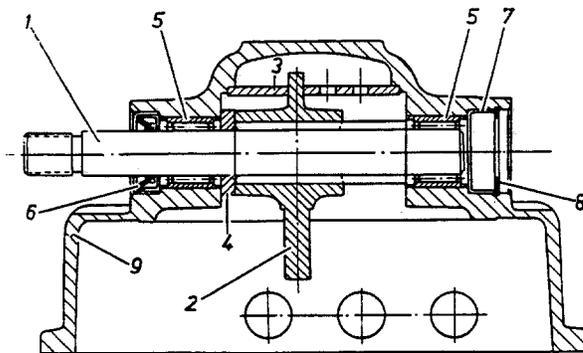


Fig. G 3/34

- | | |
|------------------|-------------------|
| 1 Shifter shaft | 5 Needle bearing |
| 2 Shifter finger | 6 Grease retainer |
| 3 Locking plate | 7 Cover plate |
| 4 Washer | 8 Lock ring |

35. Push the two needle bearings on the shaft and press lightly into the cover by means of pin 187 589 02 39.
36. To push the grease retainer on the shifter shaft, use sleeve 187 589 05 61, as otherwise the lip of the grease retainer will be damaged by the splines. When pressing the retainer into the cover use pin 187 589 03 39.
37. Press cover plate into opposite bore in transmission cover by means of pin 187 589 01 39 and install lock ring in front of cover plate.

Check whether it is possible to move the shift finger on the shaft and make sure that shaft can be rotated easily.

38. Install selector finger so in the transmission cover that it projects into the recess of the shift finger (Fig. G 3/38).

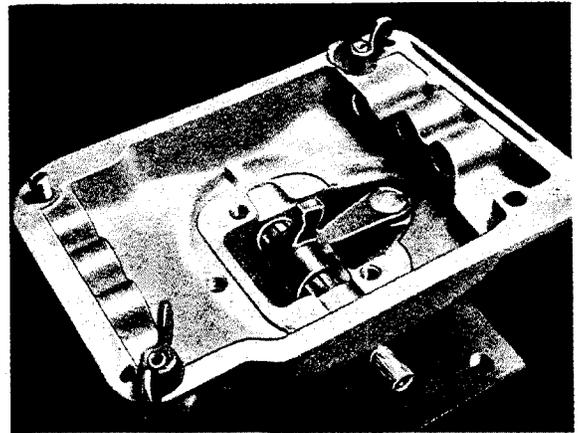


Fig. G 3/38

39. Push out selector lever on selector finger shaft and clamp in place. Observe the mark made during disassembly.

In Type 220 attach pointer to selector lever.

The selector lever must be at right angles to the selector finger and in Type 220 also to the pointer (Fig. G 3/39).

40. Push outer gear shift lever on shifter shaft and clamp in place. In neutral position the gear shift lever should point slightly towards the front (see Fig. G 3/39).

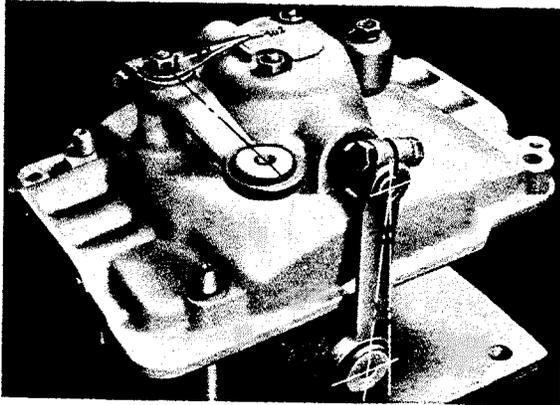


Fig. G 3/39

41. Install guide plate. It must be possible to move the plate easily, but without play. Use new nuts and washers. Secure the nuts by clamping them together.
42. Install shifting forks and shifting rails. To facilitate installation of the springs and locking balls in the shifting forks, use pin 136 589 09 61.
- Note that the spring for the reverse speed shifting fork has to take a greater load (see spring test table on page G 3/13).

Note: When the gear is engaged, the shifting fork must be positively locked in the shifting rail; no lateral thrust must be exerted on the shifting fork.

For this reason the distance between spacer tube or adjusting ring and transmission cover must be 0.1 to 0.15 mm (0.004 to 0.006") in shift position.

For correcting the distance the adjusting rings are available in the following thicknesses:

0.30 mm (0.012"), 0.50 mm (0.02") and 1.0 mm (0.04").

Type 220a only

43. Install latch with adjusting washer for reverse speed stop. Select adjusting washer (2) so that stop (A) of guide plate abuts against the latch when the first or second gear is selected with the selector lever (Fig. G 3/43).

It must then be possible to move the shift finger in slot (B) of guide plate without difficulty; make sure that the finger does not contact the rounded corners of the slots.

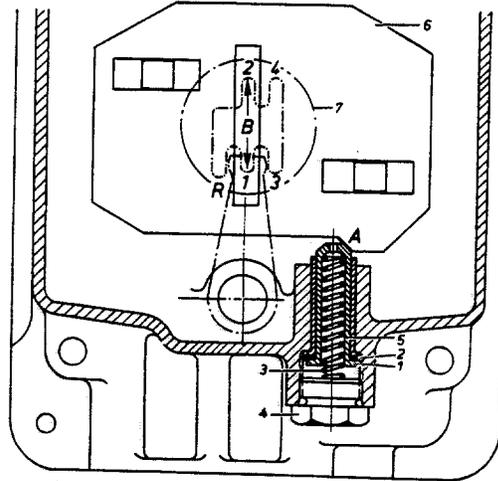


Fig. G 3/43

- | | |
|--------------------|-----------------|
| 1 Latch | 5 Bushing |
| 2 Adjusting washer | 6 Guide plate |
| 3 Pressure spring | 7 Locking plate |
| 4 Screw plug | |

In the case of right-hand steering systems the following deviations regarding cf. 34 to 37 must be considered.

34-37a. The shifter shaft is so positioned in the cover that its splined end projects beyond the right side of cover (as seen in direction of travel).

Hence the grease retainer must be pressed into the right side of the bore. In front of the retainer the lock ring is positioned. The cover plate is pressed into the bore on the left side (Fig. G 3/34a).

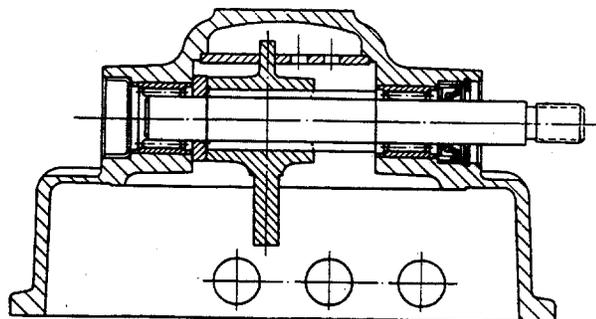


Fig. G 3/34a

Synchronizer Units:

44. Insert followers and springs into the synchronizer unit and insert the unit into the gear sleeve (Fig. G 3/44).

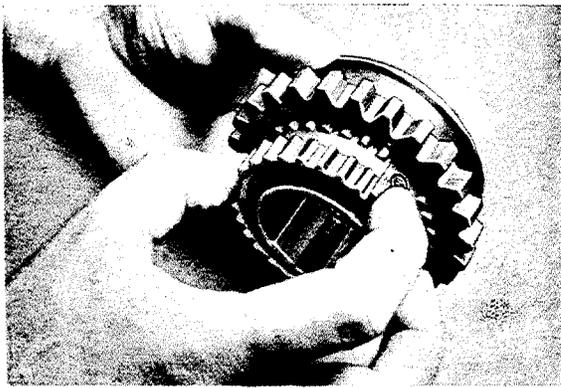


Fig. G 3/44

45. Press one follower at a time towards the front, install a ball and push follower back again (Figs. G 3/45 and 45a).

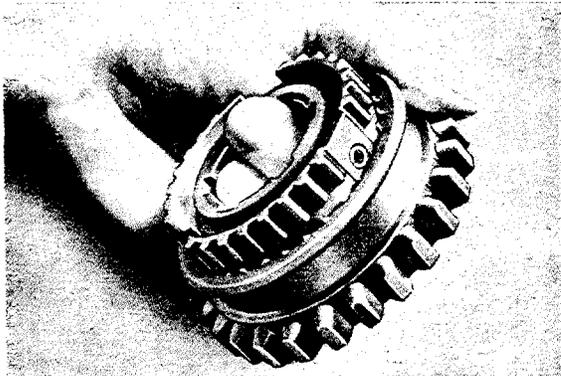


Fig. G 3/45

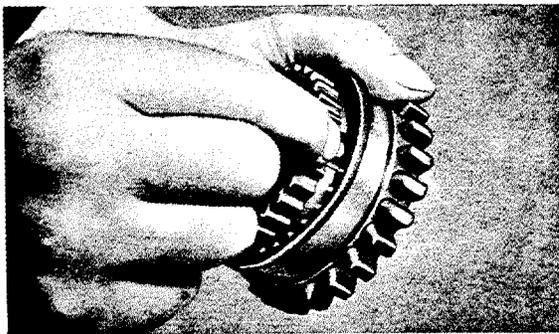
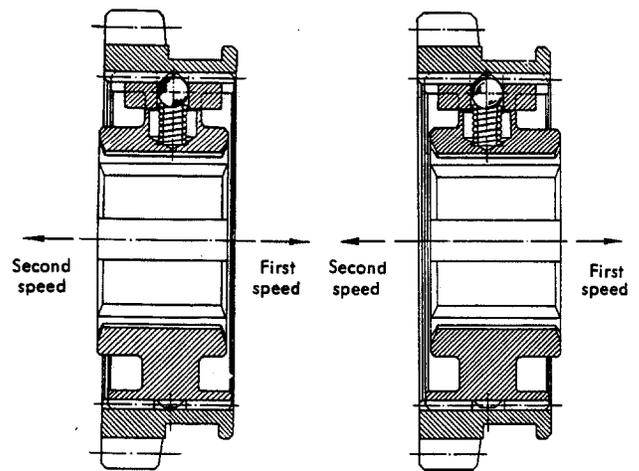


Fig. G 3/45a

Install first and second speed synchronizer unit so that **in Type 220 the short hub side of the synchronizer unit is on the side of the guide groove** (in the gear sleeve); **in Type 220a the short hub side must be on the side where the teeth are** (Fig. G 3/45b). In the case of the third and fourth speed syn-



Type 220a

Type 220

Fig. G 3/45b

chronizer unit the wide hub side of the synchronizer unit and the grooved side of the gear sleeve are on the same side (Fig. G 3/45c).

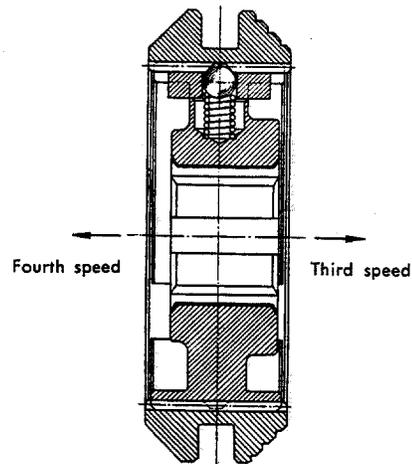


Fig. G 3/45c

After the assembly has been effected, check whether gear sleeve disengages at an axial thrust of 7–11 kg (15.5–24 lb.).

Mainshaft Type 220

46. Clamp mainshaft vertically (centering journal at top) into a vise using lead jaws. Put on first contact washer with keyway downward, install second contact washer, push on first speed gear (cone downward) and place large contact washer (recessed face towards the rear) on collar of shaft.
47. Check overall play between first speed gear and the two contact washers with a tolerance tape (Fig. G 3/47). The specified play (0.1–0.18 mm = 0.004–0.007") can be

achieved by using a contact washer of the required thickness. Exchange only the washer **provided with a keyway!**

The contact washers are available in thicknesses from 3.9–4.1 mm (0.15–0.16"), the sizes varying from 0.05 mm (0.002") to 0.05 mm (0.002").

48. Remove contact washer and first speed gear again. Insert roller assembly into bore of gear, then install gear and contact washer again.
49. Push sleeve 136 589 07 61 or a short length of pipe ($31 \times 40 \times 93$ mm = $1.22 \times 1.57 \times 3.66$ ") and three-arm flange on the shaft and screw in place with slotted nut in order to arrest the gear on the mainshaft.

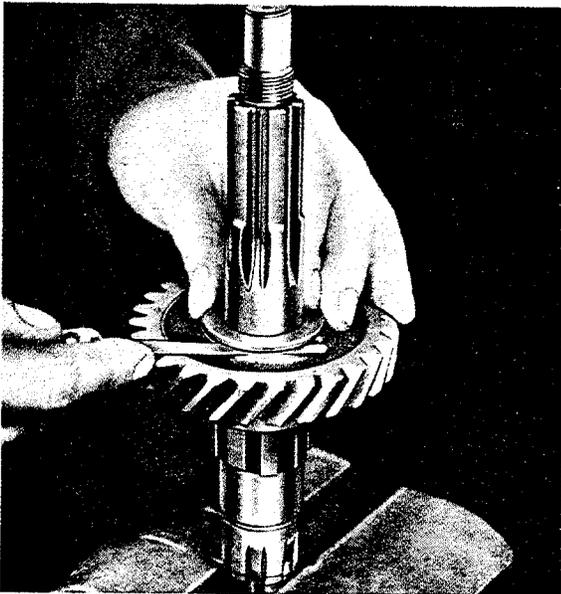


Fig. G 3/47

50. Invert mainshaft and clamp again in the vise; turn contact washer so that the keyway is on key bed of mainshaft. Install synchronizer ring for the first speed gear.
51. Place key on key bed of mainshaft and into keyway of contact washer. Push contact washer on shaft flush with the grooves and check end play of key (min. play 0.1 mm = 0.004") with a tolerance tape (Fig. G 3/51). When making the check take play between first speed gear and the two contact washers into consideration. The contact washers with keyway for the first and second speed gear are identical.



Fig. G 3/51

52. Take contact washer off again. Push synchronizer unit (with guide groove for shifting fork downward) over the installed key. Install contact washer and synchronizer ring for second speed gear. Be careful that keyway of contact washer and key coincide.
53. Push second speed gear and bearing bushing on shaft, then check play (0.1–0.18 mm = 0.004–0.007") in the same way as indicated in connection with the first speed gear (Fig. G 3/53).

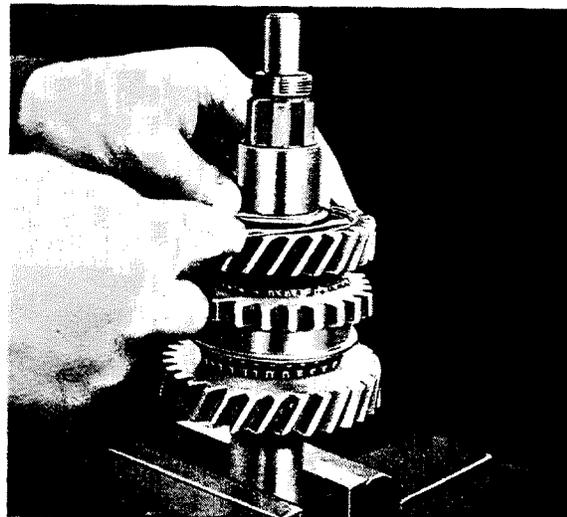


Fig. G 3/53

54. Remove bearing bushing and gear again. Grease mainshaft, install 47 needles each with intermediate ring on the shaft and push the gear carefully over the needles.

55. Push third speed gear on bushing and check end play as indicated in Fig. G 3/55. The specified play will be achieved when the bushing is 0.1–0.18 mm (0.004–0.007") wider than the gear.

The end play can be corrected by selecting a suitable steel bushing. If the end play is insufficient the third speed gear may be re-ground if necessary. Make sure that the gear is perfectly finished, as otherwise it might seize.

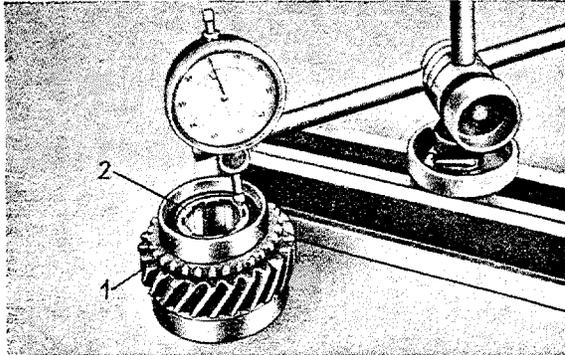


Fig. G 3/55

1 Third speed gear 2 Bearing bushing with collar

56. Install bearing bushing and third speed gear with synchronizer ring and put on contact washer.
57. Push synchronizer unit (with grooved side downward) on shaft. Screw on slotted nut with lock plate and tighten with wrench 120 589 04 07.
Rotate second and third speed gear. Tighten slotted nut so that the two gears can be rotated by hand as easily as before.
Bend lock plate slotted nut **on all four ends**.

Mainshaft Type 220a

- 46a. Clamp mainshaft vertically (with centering journal at top) into a vise using lead jaws.
- 47a. Install split roller assembly on shaft, push second speed gear over the rollers and install contact ring in front.
- 48a. Check end play between second speed gear and collar of shaft (see Fig. G 3/53).

The play should be 0.1–0.18 mm (0.004–0.007") and can be corrected by means of the contact ring. The contact rings are available with thicknesses from 7.90 to 8.10 mm (0.31 to 0.32"), the thickness varying from 0.05 mm (0.002") to 0.05 mm (0.002").

- 49a. Turn contact ring so that keyway and key bed on mainshaft register. Place key on key bed, install contact washer on the shaft flush with the keyways and check end play of the key (min. play 0.1 mm = 0.004") with a tolerance tape (see Fig. G 3/51).

When making the check take play between second speed gear and contact ring into consideration.

- 50a. Take contact washer off again and place synchronizer ring on cone of second speed gear. Push synchronizer unit over installed key with guide groove for shifting fork at top. Install contact washer; make sure that keyway and key coincide.

- 51a. Push first speed gear on shaft, place contact washer (recessed face towards the rear) on collar of shaft and check play between the two contact washers and the first speed gear. The specified play can be achieved by using a contact washer having the required thickness. Exchange only the contact washer with keyway.

The contact washers are available with thicknesses of from 4.40 to 4.60 mm (0.17 to 0.18"), their thickness varying from 0.5 mm (0.002") to 0.05 mm (0.002").

- 52a. Remove contact washer and first speed gear again. Place roller assembly into bore of gear, then install gear with synchronizer ring and contact washer again.

- 53a. Push sleeve 198 589 02 61 or a short length of pipe ($31 \times 40 \times 62$ mm = $1.22 \times 1.57 \times 2.44$ ") and three-arm flange on shaft and screw in place with slotted nut in order to arrest the first speed gear on the mainshaft.

- 54a. Invert mainshaft and clamp again in the vise.

Push third speed gear on shaft and install contact washer.

Check play between third speed gear and contact washer.

The play is 0.1–0.18 mm (0.004–0.007").

55a. Place synchronizer ring on third gear and push synchronizer unit (with grooved side downward) on shaft.

56a. Install slotted nut with lock plate and tighten lightly with wrench 120 589 04 07. Rotate second and third speed gear. Tighten slotted nut so that the two gears can be rotated as easily as before.

Bend lock plate of slotted nut **on all four ends.**

58. If a suitable test device is available, check the shifting play of the various gears before assembling the transmission (Fig. G 3/58).

The travel of the synchronizer unit to the counter cone of the pertaining gear is as follows:

First, second and third speed gear:
= 0.8–1.3 mm (0.03–0.05")

Fourth speed gear
= 0.5–1.0 mm (0.02–0.04")

Deviations can be corrected by means of the large contact washer between first speed gear and ball bearing. The contact washers are available with thicknesses ranging from 3.80 to 4.50 mm (0.15 to 0.18"), the thickness varying from 0.1 mm (0.004") to 0.1 mm (0.004").

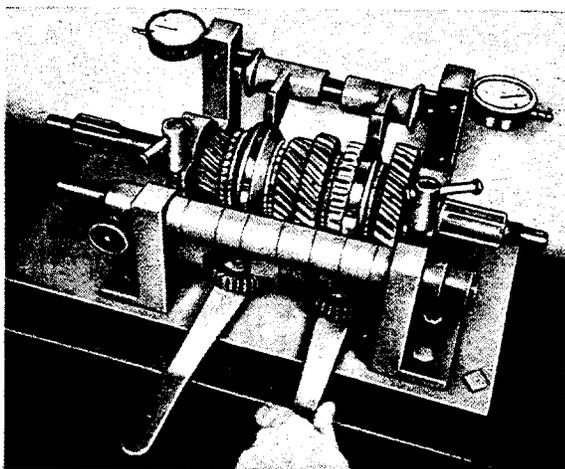


Fig. G 3/58

Installation of Gear Set:

59. Insert intermediate arm for reverse speed with shift dog into the transmission case.

60. Insert reverse shaft into the transmission case, pushing on reverse gear with guide groove towards the rear in such a way that the shift dog of the intermediate arm projects into the guide groove of the reverse gear (Fig. G 3/60).

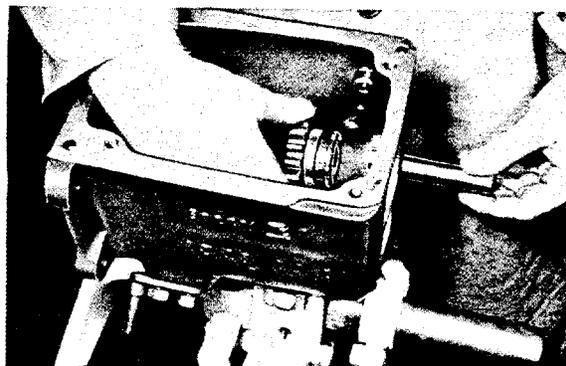


Fig. G 3/60

61. Secure reverse shaft by means of retaining screw and tighten check nut.

62. Insert countershaft from above.

63. Insert mainshaft from top and push Kling roller bearing into bore of driveshaft. Place synchronizer ring on driveshaft and insert shaft from front (Fig. G 3/63).

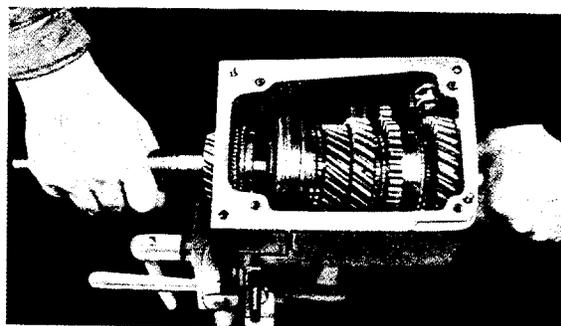


Fig. G 3/63

64. Push guard washer on rear end of countershaft. Force rear ball bearing on countershaft and drive into the transmission case together with countershaft by means of drift 136 589 06 39, lifting the driveshaft and mainshaft somewhat (Fig. G 3/64). Install front ball bearing before installing the countershaft.

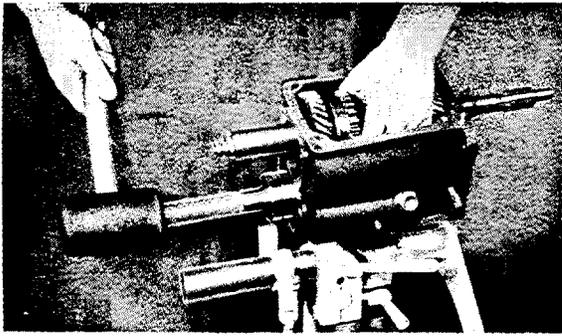


Fig. G 3/64

65. To rule out any possible damage, support first and second speed gear with tool 135 589 38 61. Remove sleeve 136 589 07 61 or 198 589 02 61 resp., push on rear ball bearing (marked X) and drive it into the transmission case with snap ring towards the rear.
66. Push oil thrower on driveshaft and force front ball bearing (snap ring towards the front) with spacer ring on the driveshaft and force into the transmission case with arbor 136 589 07 39.
67. Push sleeve 136 589 07 61 or a length of pipe $31 \times 40 \times 75 \text{ mm} = 1.22 \times 1.57 \times 2.95''$ (in Type 220a length of pipe $31 \times 40 \times 41 \text{ mm} = 1.22 \times 1.57 \times 1.61''$) on the projecting end of the mainshaft and pull mainshaft to the rear by tightening the slotted nut until the contact washer abuts against the rear ball bearing.
68. Check whether the snap rings of the front and rear ball bearing abut snugly against the transmission case.
In Type 220 push spacer sleeve on drive shaft and install snap ring in front. Before this is done, check gap clearance of sealing ring (max. gap $0.1 \text{ mm} = 0.004''$) by inserting the sealing ring into the cover.
Insert sealing ring with gap at top into the driveshaft groove. Before installing the ring, fill groove with grease.
In Type 220a the snap ring is located immediately in front of the ball bearing without a spacer sleeve being provided.
69. Check play between front ball bearing and recess on front cover of transmission case. Correct the play, which should not be more than $0.05 \text{ mm} (0.002'')$, by means of shims (Figs. G 3/69 and 69a). Coat cover with a

sealing compound and bolt to transmission case.

In Type 220 the sealing ring must be centered before the front cover is installed. Slip the cover carefully over the shaft (see Fig. G 3/07).

In Type 220a a rubber grease retainer is provided in the bore on the cover in the place of the grease retainer on the driveshaft. When installing the cover, be careful not to damage the grease retainer (see Fig. G 3/08).

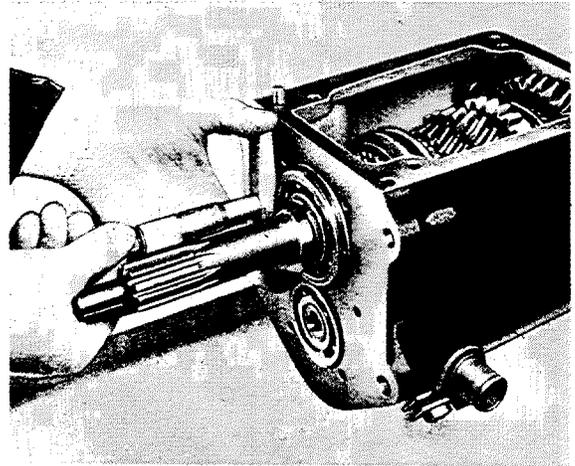


Fig. G 3/69

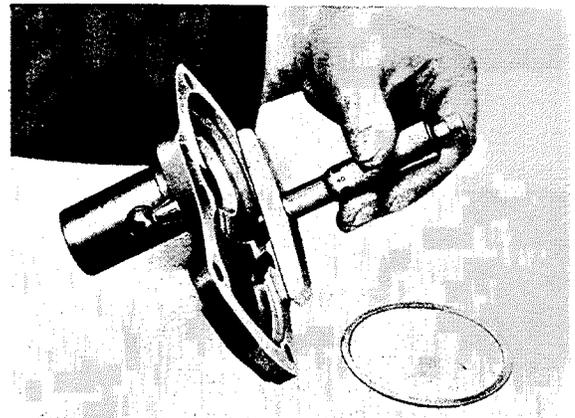


Fig. G 3/69a

70. Drive countershaft carefully towards the front until front ball bearing abuts against cover. Measure rear overhang of ball bearing as well as recess on rear cover of transmission case. The play between rear bearing on countershaft and rear cover of transmission case should be $0.1 \text{ to } 0.15 \text{ mm} (0.004 \text{ to } 0.006'')$, and the play between rear bear-

ing on mainshaft and rear cover should be 0.0–0.05 mm (0.000–0.002"). If the play is excessive, correct it by means of shims (Figs. G 3/70, 70a and 70b). When checking the play, take thickness of paper gasket into consideration.

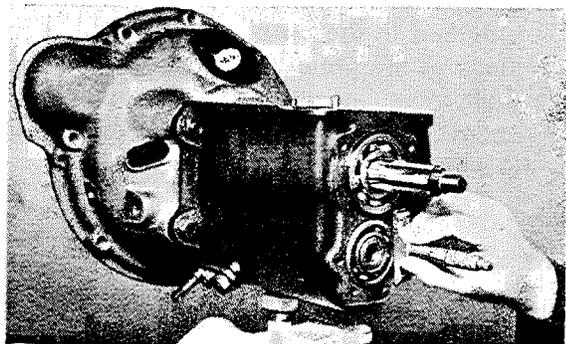


Fig. G 3/70

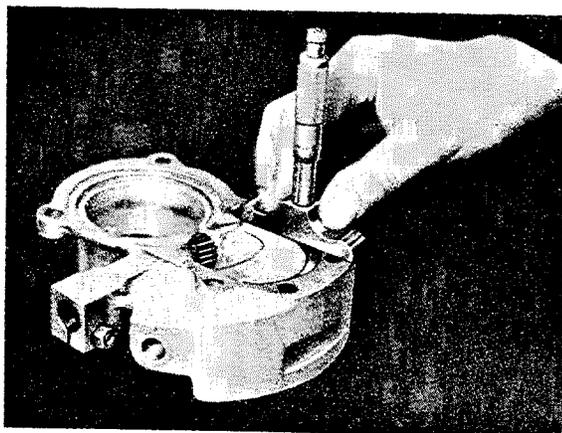


Fig. G 3/70a



Fig. G 3/70b

71. Remove the length of pipe. Push spacer ring and helical gear for speedometer on mainshaft.

Note: In Type 220 a the helical gear and spacer ring are made of one piece.

72. Provide rear cover with a paper gasket and bolt to transmission case.

73. Grease sliding surface for grease retainer on three-arm flange liberally and push flange on shaft. Install lock plate, screw the slotted nut on and tighten forcefully with the pin wrench (see Operation No. G 3, cf. 4). Before securing the nut, check three-arm flange for lateral out of true (Fig. G 3/73). When checking at the outer radius, the out of true must not exceed 0.03 mm (0.0012"), otherwise the flange must be displaced or even ground or replaced, if necessary.

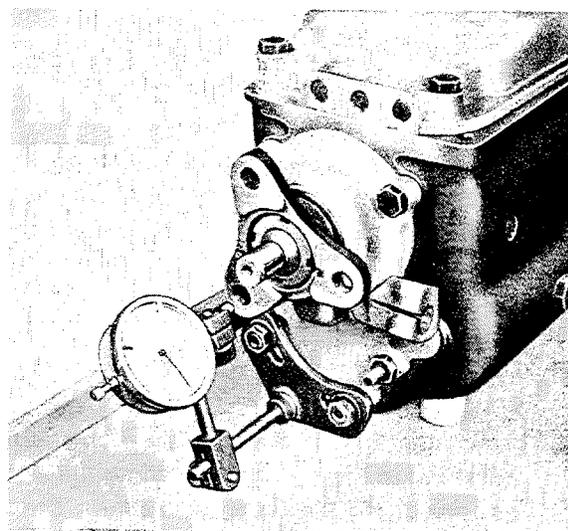


Fig. G 3/73

74. Attach clutch housing.

75. Place throwout fork on ball pin and push on throwout collar.
In Type 220 push on pressure spring and spring retainer, then install snap ring.

In Type 220a install two wire clips into the throwout collar, turn towards the rear and attach the bent ends to the throwout fork.

76. Bring both synchronizer units into middle position (neutral), put on transmission cover in neutral position (after providing with a paper gasket) and tighten.

77. Fill in 1.4 liters (2.96 U.S. pints; 2.46 Imp. pints) of transmission oil.