

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.)

	Dia. of mainshaft		Bore of gear		Side play	
Type	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) (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").

- | | | |
|--|---|--------------------------------------|
| <ul style="list-style-type: none"> a) -0.004 mm (0.00016") to -0.002 mm (0.00008") 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") | } | Deviation regarding nominal diameter |
|--|---|--------------------------------------|

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 2×30 cylinder rollers 4×6 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 2×47 needles 2.5×9.8 DIN 617.

The needles are available in three sizes

- | | | |
|---|---|---|
| <ul style="list-style-type: none"> a) from 0.000 mm (0.00000") to -0.003 mm (0.00012") 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") | } | Deviation regarding nominal diameter of 2.5 mm (0.098") |
|---|---|---|

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 2×18 rollers with cage.

The description given in connection with the first speed gear applies also to the cylinder rollers 3.5×8 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 inspite 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").

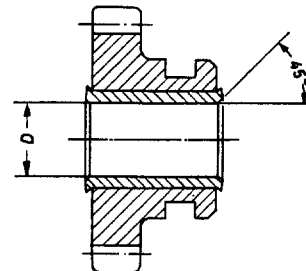


Fig. G 3/03

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.

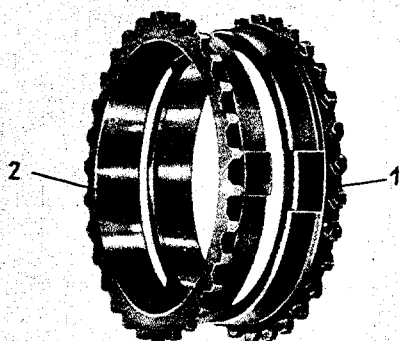


Fig. G 3/04

Second design

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

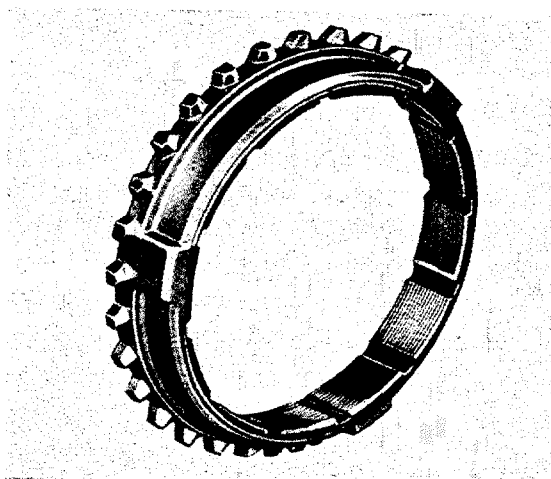


Fig. G 3/05

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).

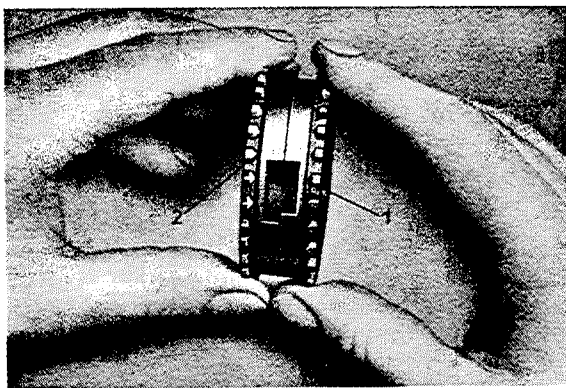


Fig. G 3/06

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 shafing 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.)			
Synchron- izer springs	Type 220	6 (0.24)	12.6 (0.50)	a) 9.2 (0.36) b) 8 (0.315)	1.48 (3.26) 2 (4.4)	0.8 (0.031)	± 5
	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

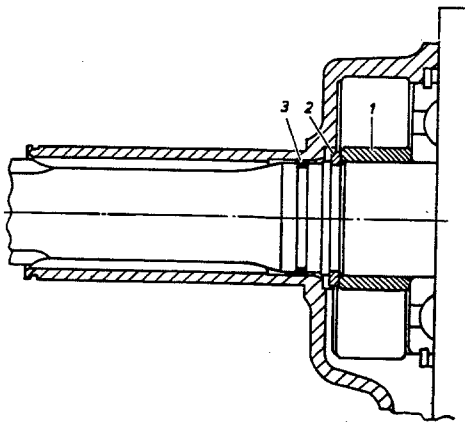


Fig. G 3/07

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

Type 220a

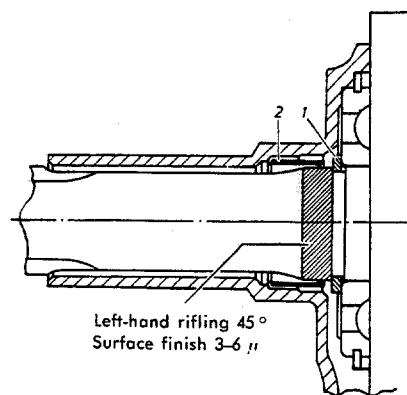


Fig. G 3/08

- 1 Snap ring
- 2 Grease retainer

Rear Cover:

Type 220

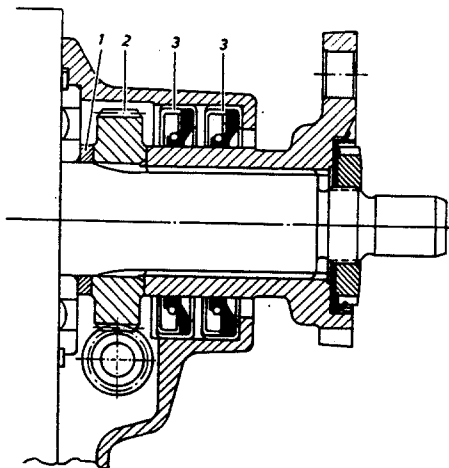


Fig. G 3/09

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

Type 220a

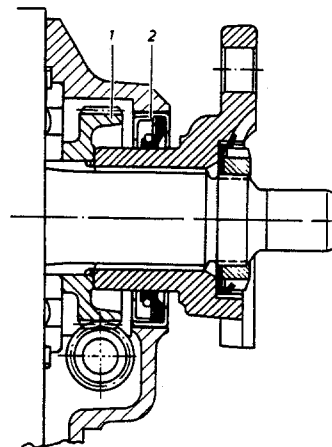


Fig. G 3/010

- 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.