A. Grinding Crankshaft

For Models 180 a, 180 b, 190 SL, 220 a, 219, 220 S, and 220 SE this procedure is the same as described for Model 190.

Table of Crankshaft Grinding Overhaul Stages

Model	Overhaul stage	Crankshaft journals		Crankpins	
		Diameter of journals	Width of journals at locating bearing	Crankpin diameter	Crankpin width
180 a, 108 b, 190, 190 b 190 SL	Standard size	69.96 / 69.94	34.000 / 34.025	51.96 / 51.94	32.000 / 32.100
	1st Overhaul stage	69.71 / 69.69	34.000 / 34.025 to 34.700 [1] / 34.725	51.71 / 51.69	32.000 to 32.300
	2nd Overhaul stage	69.46 / 69.44		51.46 / 51.44	
	3rd Overhaul stage	69.21 / 69.19		51.21 / 51.19	
	4th Overhaul stage	68.96 / 68.94		50.96 / 50.94	
220 a, 220 S, 219, 220 SE	Standard size	59.96 / 59.94	30.000 / 30.021	47.96 / 47.94	30.000 / 30.084
	1st Overhau stage	59.71 / 59.69	30.000 / 30.021 to 30.700 [1] / 30.725	47.71 / 47.69	30.300 to 30.000
	2nd Overhaul stage	59.46 / 59.44		47.46 / 47.44	
	3rd Overhaul stage	59.21 / 59.19		47.21 / 47.19	
	4th Overhaul stage	58.96 / 58.94		46.96 / 46.94	

[1]) In steps of 0.1 mm, according to the available check plates.

The tolerances given in the above table for the various overhaul stages must on no account be exceeded, and it goes without saying that all journals and pins must be ground to the same overhaul stage. Make sure that the fillet radii (2.5–3 mm) on the crankshaft journals and crankpins are strictly adhered to.

Machining Tolerances of Crankshaft

Model		180 a 180 b 190 190 b 190 SL	219 220 a 220 S 220 SE
Permissible out-of-round tolerance of crankshaft journals and crankpins		0.005	
Permissible conicity of crankshaft journals and crankpins		0.01	
Permissible misalignment of crankpins with regard to crankshaft journals, related to bearing length		0.01	
Permissible run-out of center crankshaft journal with crankshaft supported on the outside journals		0.02	
Permissible lateral deflection of locating journal		0.015	
Permissible radial deflection of flywheel flange related to the crankshaft journals		0.02	
Permissible lateral deflection of flywheel flange related to the crankshaft journals, measured at external diameter		0.01	0.012
Fillet radii on the crankshaft journals and crankpins		2.5—3	
Hardness of crankshaft journals and crankpins	Scleroscope hardness	68—74	70—74
	Rockwell hardness	55—61	57—61
Permissible unbalance of crankshaft		15 cmg [1]	

[1]) The crankshaft is balanced together with the front counterweight and the flywheel.

B. Re-Bedding of Crankshaft

The procedure for models 180 a, 180 b, 180 c, 190 SL, 220 a, 219, 220 S and 220 SE is the same as for model 190.

Bearing Play of Crankshaft

Models 180 a, 180 b, 180 c, 190, 190 b, 190 SL, 220 a, 219, 220 S and 220 SE

Radial[1])	End Play of locating bearing[2])
0.045–0.060	0.09–0.236*

[1]) The above radial play for new engines is attained by proper selection of crankshafts and bearing shells, with a bearing play of 0.05 mm the goal. This radial play should be definitely maintained also during repairs.
[2]) During repairs, an end play of 0.30 mm is permitted.

Diameter of Crankshaft Bearings with Bearing Shell Halves Fitted

Model	Standard	Overhaul Stages I	II	III	IV
180 a, 180 b 180 c, 190 190 b, 190 SL	69.99 70.02	69.74 69.77	69.49 69.52	69.24 69.27	69.99 69.02
220 a, 219 220 S, 220 SE	59.99 60.02	59.74 59.77	59.49 59.52	59.24 59.27	58.99 59.02

Base Bore in Crankcase

Model	180, 180 b, 180 c, 190, 190 b, 190 SL	220 a, 219, 220 S 220 SE
Housing bore	74.500–74.519	67.000–67.019
Perm. out-of-round of base bore	0.01	
Perm. conicity of base bore	0.01	
Crush of bearing shell halves	+ 0.01	

Thickness of Check Plates on Locating Bearing

Model	Standard	Overhaul Stages I	II	III	IV	V	VI	VII
180 a, 180 b, 190, 190 b, 190 SL	1.980 1.965	2.030 2.015	2.080 2.065	2.130 2.115	2.180 2.165	2.230 2.215	2.280 2.265	2.330 2.315
220 a, 219, 220 S, 220 SE	2.980 2.965	3.030 3.015	3.080 3.065	3.130 3.115	3.180 3.165	3.230 3.215	3.280 3.265	3.330 3.315

To fix crankshaft in axial direction the engines were provided with a shouldered locating bearing, as well as with check plates. The check plates are fastened to the second crankshaft bearing cap on both sides with heavy dowel pins (Fig. 03–5/1).

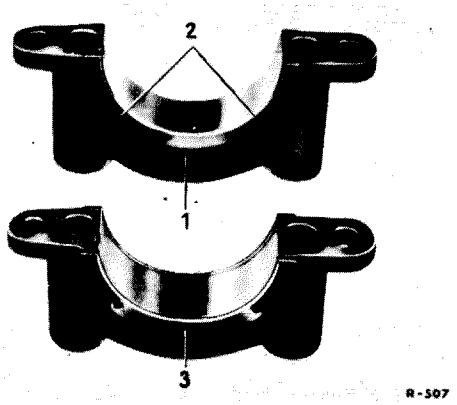

Fig. 03–5/1

1 Crankshaft bearing cap 2 Heavy dowel pin 3 Check plates

Here, the heavy dowel pins may not project more than 1.5 mm from the hole. They should be sufficiently withdrawn with regard to the check plate that any contact with the crankshaft is made impossible.

When repairs are made, and the crankshaft bearings are replaced, the former, and now still partially used check plates are replaced on all our engines by a shouldered locating bearing in the cylinder crankcase (upper bearing shell half) and in part also in the crankshaft bearing cap (lower bearing shell half). For the overhaul stages these shouldered bearings – bearing shell halves also as to width – are supplied in oversizes for refinishing to the specified end play.

C. Reconditioning and Re-bushing of Connecting Rods

This work for models 180 a, 180 b, 180 c, 190 SL, 220 a, 219, 220 S and 220 SE is the same as for model 190.

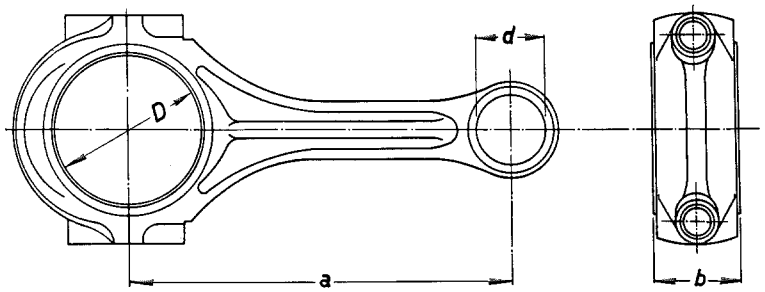

Fig. 03–5/3

Bearing Play Values For Connecting Rod

Model	Radial Play[1]	End Play	
		when new	after repairs
180 a, 180 b, 180 c, 190, 190 b, 190 SL	0.045–0.060	0.120–0.259	up to 0.5
220 a, 219, 220 S, 220 SE	0.045–0.060	0.110–0.227	

[1] The stated radial play with new engines is produced by proper selection of crankshaft and bearing shells, trying for a bearing play of 0.05 mm. When repairing, this radial play should by all means be adhered to.

Diameter of Conrod Bearings with inserted Bearing Shell Halves Fitted

Model	Standard	Overhaul Stages			
		I	II	III	IV
180 a, 180 b, 180 c, 190, 190 b, 190 SL	51.99 / 52.02	51.74 / 51.77	51.49 / 51.52	51.24 / 51.27	50.99 / 51.02
220 a, 219 220 S, 220 SE	47.99 / 48.02	47.74 / 47.77	47.49 / 47.52	47.24 / 47.27	46.99 / 47.02

Dimensions of Connecting Rod

Model		180 a, 180 b, 180 c, 190, 190 b, 190 SL	220 a and 219, 220 S 1st Version	219, 220 S 2nd Version and 220 SE
Base bore D		55.600 / 55.619	54.000 / 54.019	
Base bore d[1]	Standard Size	28.000 / 28.021	25.000 / 25.021	27.000 / 27.021
	Overhaul Stage	28.500 / 28.521	25.500 / 25.521	27.500 / 27.521
Perm. out-of-roundness of base bore		0.01		
Perm. conicity of base bore		0.01		
Crush of bearing shell halves		+ 0.01		
Distance "a" from center of bore to center of bore[2]		153.95 / 154.05	134.95 / 135.05	
Width of connecting rod "b"		31.880 / 31.841	29.890 / 29.857	
Perm. difference in weight between connecting rod assemblies in any one engine		5 g		
Perm. departure from axial parallelity for a length of 100 mm		0.03		
Perm. longitudinal distortion for a length of 100 mm		0.1		

[1] The base bore "d" for models 180 c and 190 SL as from engine No. 121 928 000 001 = 29.000–29.021 mm.
[2] Distance a for models 180 c and 190 SL as from engine No. 121.928 000 001 = 148.95–149.05 mm.

Dimensions of Piston Pin Bushing

Model	O. D.		I. D.	
	Standard Size	Overhaul Stage	Rough-turning Dimensions	Final Dimensions[1])
180 a, 180 b, 190, 190 b, 190 SL	28.048 / 28.035	28.548 / 28.535	24.500 / 24.552	25.007 / 25.013
180 c, 190 SL[2])	29.108 / 29.070	29.608 / 29.570	25.705 / 25.603	26.012 / 26.018
220 and 219, 220 S 1st Version	25.048 / 25.035	25.548 / 25.535	21.500 / 21.552	22.007 / 22.013
219, 220 S 2nd Version	27.048 / 27.035	27.548 / 27.535	21.500 / 21.552	22.007 / 22.013
220 SE	27.048 / 27.035	27.548 / 27.535	23.500 / 23.552	24.007 / 24.013

[1]) Tolerance subdivisions of final-turned piston pin bushing, refer to page 03–5/7
[2]) 190 SL as from engine design 121.928.

For model 220 SE the connecting rod eyes are larger and the I. D. and O. D. of the pressed-in bushings are 2 mm larger. For reasons of standardization models 219 and 220 S are now also provided with heavier connecting rods, with the O. D. of the bushings also increased by 2 mm, while the I. D. remains the same.

D. Fitting Pistons, together with Rings, into Cylinders

This work is for models 180 a, 180 b, 180 c, 190 SL, 220 a, 219, 220 S and 220 SE the same as for model 190.

Similar to model 190, models 190 SL, 220 a, 219, 220 S and 220 SE are provided with full-skirt autothermic pistons (so-called slipper pistons) with extended skirt. Models 180 a and 180 b on the other hand have full-skirt autothermic pistons without extended skirt (Fig. 03–5/4).

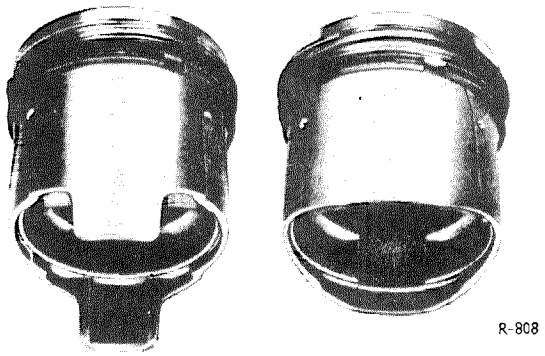

Fig. 03–5/4

Piston for models 180 c, 190, 190 b, 190 SL, 220 a, 219, 220 S and 220 SE

Piston for models 180 a and 180 b

Pistons Available for Overhaul Stages

Model	Piston Dia.				
	Standard	Intermediate Stage	I. Overhaul Stage	II. Overhaul Stage	III. Overhaul Stage
180 a, 180 b, 180 c, 190 b, 190 SL	84.96–84.98	85.21–85.23	85.46–85.48	85.96–85.98	86.46–86.48
220 a, 219, 220 S, 220 SE	79.96–79.98	80.21–80.23	80.46–80.48	80.96–80.98	81.46–81.48

Piston Ring with Gap and Groove Clearance

Piston Rings		180 a, 180 b	180 c, 190, 190 b 190 SL	220 a, 219, 220 S		220 SE
	Groove I	Compression ring 10 f 85/77.6×2 Cr S 001 037 38 16		Compression ring[1] 10 f 80/73×2 Cr S 001 037 57 16		Compression ring 10 f 80/73×2 Cr S 001 037 57 16
	Groove II	Tapered compr. ring 11 f 85/77.6×2.5 001 037 43 16		Tapered compr. ring 11 f 80/73×2.5 KE 54 N 277		Tapered compr. ring 11 f 80/73×2.5 KE 54 N 277
	Groove III	Stepped oil control ring 30 f 85/77.6×3 KE 54 N 278	Novix stepped ring with F 3 S expander 85×3 T–16 Nova 000 037 00 17	80×3 T–16 Nova[2] 000 037 10 17		Tapered compr. ring 1 f 80/73×3 KE 54 N 277
	Groove IV	Novix slotted ring with F 5 S expander 85×5 T–17 Nova 000 037 29 18		85×5 T–17 Nova 000 037 30 18		Wide channel oil control ring with Goetze expander spring 80/73.4×5 001 037 79 18
Gap	Groove I	0.55–0.70		0.55–0.70		0.55–0.70
	Groove II	0.45–0.60		0.30–0.45		0.30–0.45
	Groove III	0.30–0.45				
	Groove IV	0.25–0.40		0.25–0.40		0.25–0.40
Groove clearance	Groove I	0.035–0.062		Mahle 0.035–0.062	Nüral 0.030–0.057	0.045–0.072
	Groove II					
	Groove III					0.035–0.062
	Groove IV				0.035–0.062	0.045–0.072

[1]) Height of compression ring of former Mahle piston 2.5 mm.
[2]) Height of stepped ring of former Nüral piston 2.5 mm.

Note: The designations of pistons and piston rings refer to the standard size, while the gap and groove clearances of the rings apply to all overhaul stages.

To maintain piston pin clearance or overlap, pistons and piston pins having the same color code should be used.

Color Code for Associated Piston Pins and Pistons

Pistons pins, connecting rods and pistons	Color code	Piston pin O.D.	Bore of piston pin bushing	Running	Bore in piston	
					Nüral	Mahle
180 a, 180 b, 190, 190 b, 190 SL	black	24.997 / 24.994	25.007 / 25.010	0.010–0.016	24.994 / 24.997	24.994 / 24.997
	white	25.000 / 24.097	25.010 / 25.013		24.997 / 25.000	24.997 / 25.000
180 c, 190 SL[1])	black	25.997 / 25.994	26.012 / 26.015	0.015–0.021	—	25.994 / 25.997
	white	26.000 / 25.997	26.015 / 26.018		—	25.997 / 26.000
220 a, 219, 220 S	black	21.997 / 21.994	22.007 / 22.010	0.010–0.016	21.994 / 21.997	21.992 / 21.995
	white	22.000 / 21.997	22.010 / 22.013		21.997 / 22.000	21.995 / 21.998
220 SE	black	23.997 / 23.994	24.007 / 24.010	0.010–0.016	—	23.992 / 23.995
	white	24.000 / 23.997	24.010 / 24.013		—	23.995 / 23.998

[1]) 190 SL as from engine design 121.928.

E. Replacement of Starter Rim Gear

For models 180 a, 180 b, 180 c, 190 SL, 220 a, 219, 220 S and 220 SE with standard clutch and for models 219, 220 S and 220 SE with hydraulic-automatic clutch procedure is the same as for model 190. However, the flywheel for models 219, 220 S and 220 SE with hydraulic-automatic clutch is designed as a disk (Fig. 03–5/5). On this flywheel the ring gear is mounted to project uniformly on both sides. Then, the runout of clamping face B should be checked over a diameter of 200 mm. It should not exceed 0.05 mm.

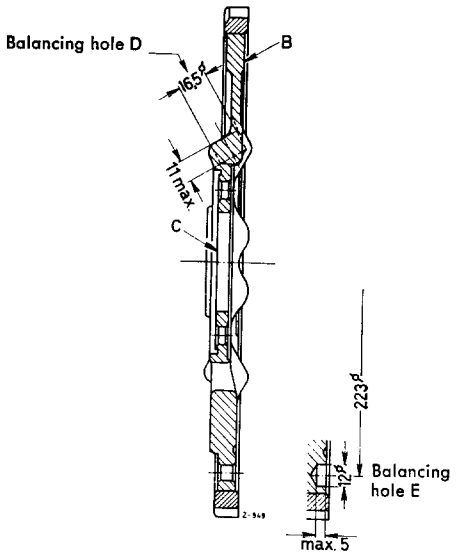

Fig. 03–5/5

Flywheel for hydraulic-automatic clutch

B = Clamping face for hydraulic-automatic clutch
C = Clamping face for crankshaft

Following attachment of a new ring gear on models 220 a, 219, and 220 S having a flywheel acc. to Fig. 03–5/7 the ring gear requires six thread holes for attachment of the clutch. First drill six holes of 6.7 mm dia. accurately centered with holes in flywheel, then chamfer and cut 8 mm threads (M 8).

F. Grinding of Clutch Face of Flywheel

For models 180 a, 180 b, 180 c, 190 SL and 220 a as well as for models 219, 220 S and 220 SE with standard clutch this procedure is the same as for model 190.

Fig. 03–5/6 shows the flywheel for model 190, 1st version and for model 190 SL, 2nd version. The 1st Version of model 190 SL differs from the 2nd version only by its attaching flange (refer to section H).

Fig. 03–5/7 shows the flywheel for models 220 a and 219, 220 S, 1st version.

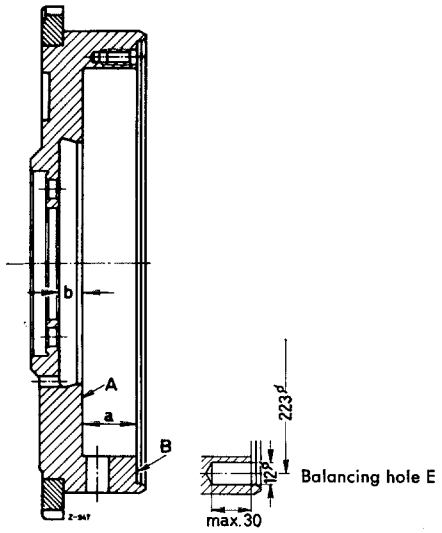

Fig. 03–5/6

190 1st version
190 SL 2nd version
as from engine end No. 65 00795

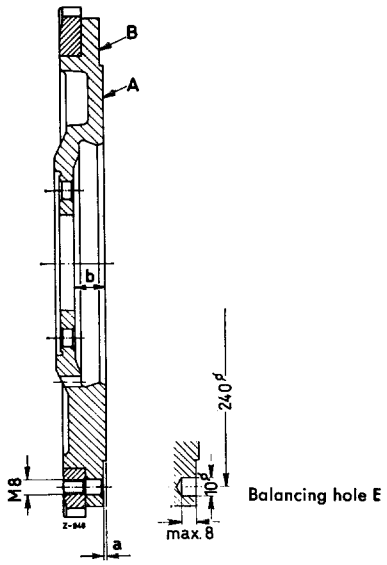

Fig. 03–5/7

220 a as well as 219
and 220 S, 1st version

A = Clutch face, B = Clutch fixing surface

When grinding or finish-turning the clutch face A, surface B must be remachined by the same amount.

With model 180 a and models 219, 220 S with a compression ratio ε = 8.7:1 the flywheels were standardized as to their shape (Fig. 03–5/8). This type of flywheel is also provided with a fitted recess for perfect centering of the clutch. In addition, the front flange side is provided with "humps" for balancing the flywheel.

The flywheel for model 220 SE is similar in shape, though its dimensions are larger (Fig. 03–5/9).

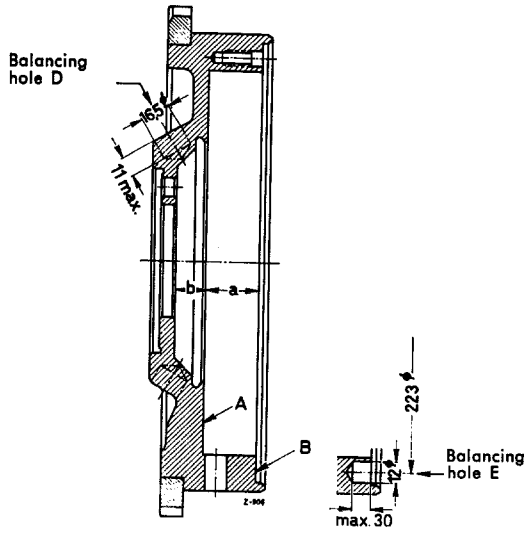

Fig. 03-5/8

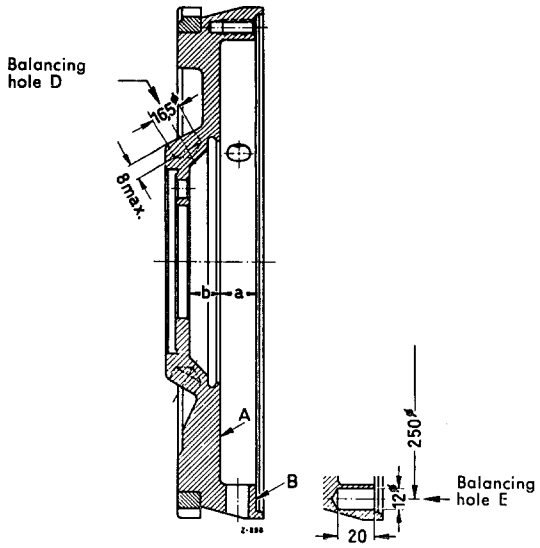

Fig. 03-5/9

220 SE (Injection engine)

180 a, 180 b, 190 b	as from 1st engine
190	2nd Version as from Engine End No. 75 13562
190 SL	3rd Version as from Engine End No. 75 01383
219	2nd Version as from Engine End No. 75 04073
220 S	2nd Version as from Engine End No. 75 08462

A = Clutch face, B = Clutch fixing surface

When the clutch face A is reground or finish-turned, the surface B must be re-machined by the same amount.

On models with hydraulic automatic clutch the flywheel carries the ring gear and has the primary member of the hydraulic clutch attached to it (see Fig. 03-5/5). On these models the mechanical clutch is attached to the drive plate.

Dimensions for Re-Machining Flywheel

Model		190 SL 1st Version	180 a, 180 b 190, 190 b and 190 SL 2nd, 3rd V.	220 a and 219, 220 S 1st V.	219, 220 S 2nd V.	220 SE
Distance "a" between clutch face and clutch fixing surface (see Figs. 03-5/6 to 03-5/9).		29±0.1	29±0.1	0.2—0.3	29+0.1	19.4±0.1
Distance "b" between clutch face and flywheel attaching flange (see Figs. 03-5/6 to 03-5/9).	new	18	12.5	16	16	16
	after repairs up to	17	11.5	15	15	15
Permissible lateral deflection of fitted flywheel		0.05				

G. Dynamic Balancing of Crankshaft with Counterweight and Flywheel

For Models 180 a, 180 b, 190 SL, 220 a, 219, 220 S and 220 SE the dynamic balancing procedure is the same as for Model 190. The crankshaft is balanced together with the mounted counterweight and the flywheel. A maximum unbalance of 15 cmg is permissible.

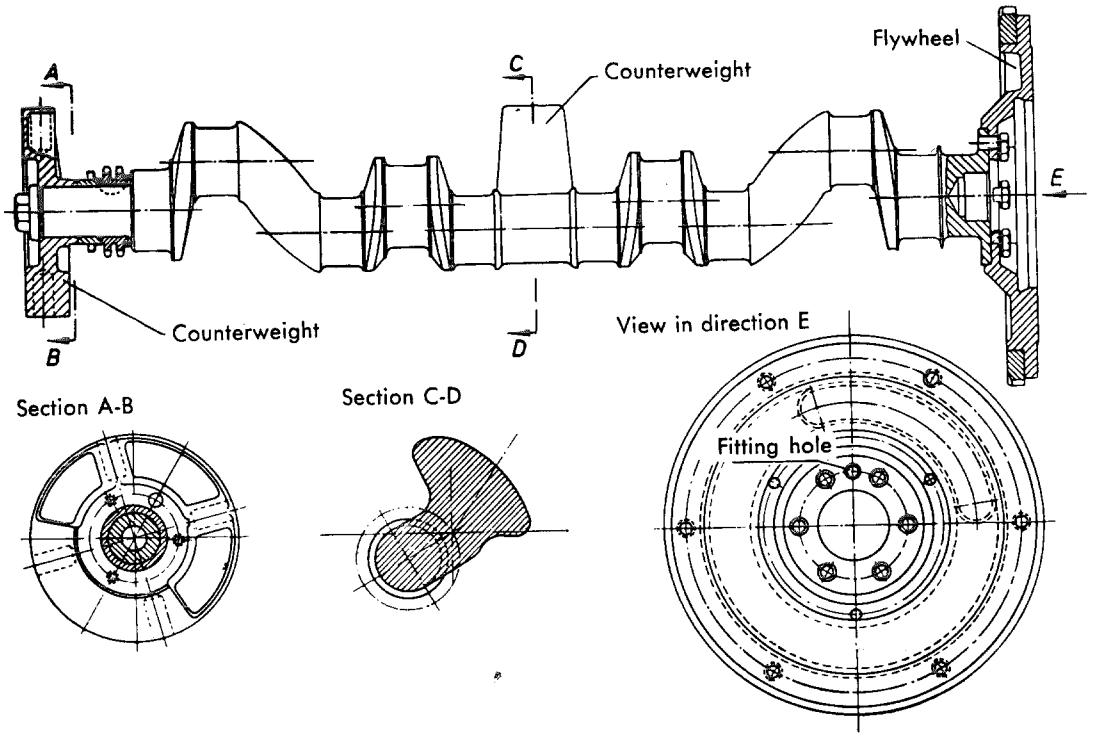

Fig. 03-5/10
Crankshaft for Model 220 a and Models 219 and 220 S with flywheel 1st version

1. Drill the balancing holes at the circumference on the front counterweight of the crankshaft in a radial direction using a 14 mm ⌀ drill (Fig. 03-5/10). The maximum bore depth is 30 mm.

2. If an abnormal degree of unbalance of the crankshaft is found in cars of Models 220 a, 219, 220 S and 220 SE, it is permissible under certain circumstances to drill balancing holes also into the center counterweight using a 14 mm ⌀ drill and not exceeding a depth of 35 mm.

3. The dimensions of the balancing holes on the flywheel are listed in the table below. See also Figs. 03-5/5 to 03-5/9. If two holes have to be drilled side by side, the distance between bore hole centers should be 22 mm.

Note: To facilitate production the flywheels of the design used today have "humps" on the engine side into which the balancing holes are drilled at an angle of 30° (Figs. 03-5/5, 03-5/8, and 03-5/9). This can only be done on a special drilling machine and in repair shop work the balancing holes must be drilled as described above.

Balancing Holes for Flywheels

Model	Hole circle diameter for balancing hole E	Drill diameter	Maximum bore depth
180 a, 180 b, 190, 190 b, 190 SL	223	12	30
220 a as well as 219 and 220 S 1st Version	240	10	8
219 and 220 S 2nd Version	223	12	30
219 and 220 S with hydraulic automatic clutch	223	12	5
220 SE	250	12	20

H. Static Balancing of New Flywheel

For Models 180 a, 180 b, 190 SL, 220 a, 219, 220 S and 220 SE the static balancing procedure for the flywheels is the same as for Model 190.

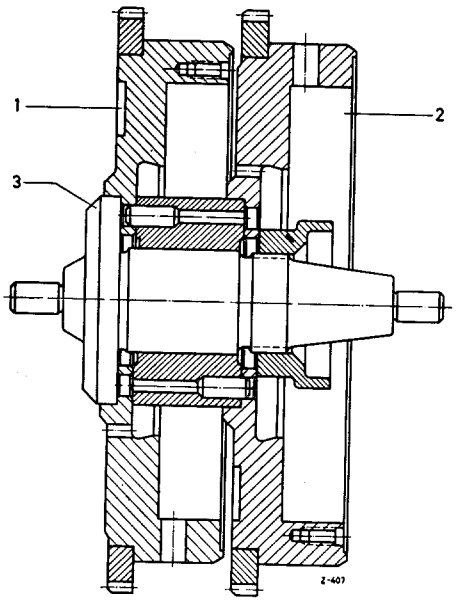

Fig. 03-5/11

1 Old flywheel
2 New flywheel
3 Arbor Fixture 180 589 00 27

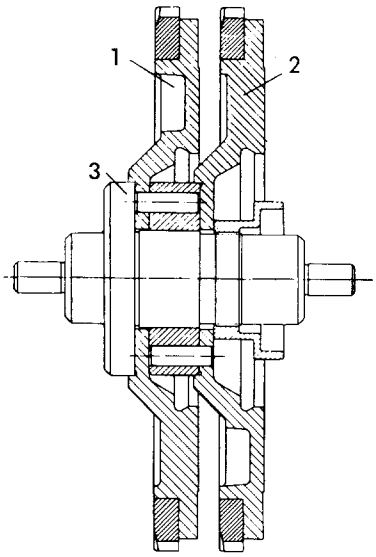

Fig. 03-5/12

1 Old flywheel
2 New flywheel
3 Arbor Fixture 187 589 02 27

Use Arbor Fixture 180 589 00 27 (Fig. 03-5/11) for the static balancing of flywheels in Models 180 a, 180 b, 190 SL as well as Models 219, 220 S 2nd version and 220 SE; for the flywheels of Model 220 a as well as Models 219, 220 S 1st version and 219 and 220 S with hydraulic automatic clutch use Arbor Fixture 187 589 02 27 (Fig. 03-5/12).

The 2nd version flywheel can be installed subsequently on Model 220 a as well as on Models 219 and 220 S with the 1st version flywheel, if the clutch is replaced (without drive plate). However, the 2nd version flywheel must be statically balanced with the 1st version flywheel which has been removed.

The early engines of Model 190 SL have a flywheel with a recess of 75 mm diameter and a bolt hole circle of 56 mm diameter. Because of its smaller recess and bolt hole circle, this flywheel cannot be replaced by a 2nd or 3rd version flywheel when repairs are carried out; it can only be replaced by another 1st version flywheel. Make a suitable arbor fixture for balancing the new flywheel.

Note: For Model 190 SL only crankshafts with a recess of 98 mm diameter and a bolt hole circle of 78 mm diameter, together with a counterweight and a 3rd version flywheel are supplied as replacement parts.

I. Repair of Vibration Damper

Models 220 a, 219, 220 S and 220 SE

For removal, disassembly, reassembly and installation procedures see Job No. 01–4, Section N, II.

1. After disassembling the vibration damper, check all parts for wear.
   The shear blocks (7) should always be replaced if they have been in use for some time. Scored or cracked contact disks (4) should also be replaced.

2. Check the pressure springs (6) according to the table below.

3. Carefully smooth down the friction surfaces of the flywheel rings (5), the counterweight (2) and the pulley (8) using emery cloth No. 50. If the friction surfaces are badly worn, the affected part must be replaced.

4. If the contact ring (9) shows spot-like scorings which are due to rapid oscillating movements of the flywheel rings (5) the pulley with the mounted contact ring must be replaced.

External diameter mm	Wire gage mm	Free length mm	Length mm	Under load kg
17.5	2.5	27.3	19	20±1.5

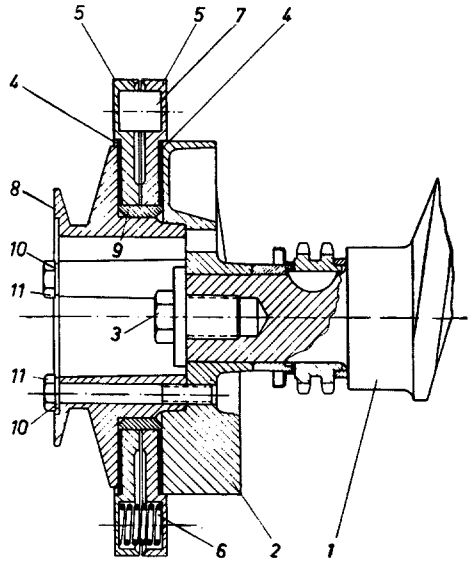

Fig. 03-5/13

1 Crankshaft
2 Front counterweight
3 Shoulder screw
4 Contact disk
5 Flywheel ring
6 Pressure spring
7 Shear block
8 Pulley
9 Contact ring
10 Spring washer
11 Fixing screw