

## II. Assembly

Before attempting to reassemble the engine, study Operation Nos. M 4 g, M 4 i, M 4 k, M 16, M 17, M 18, M 20, M 26, M 26 b, M 29 and M 30 carefully. In addition note the following:

1. Check damaged small parts, such as screws, nuts, washers, spring washers, etc. to decide whether they can be reused. Recondition all parts that are to be used again.
2. Renew all gaskets, sealing rings, lock plates, etc.
3. Have close look at all ground and fine-finished parts and their bearing surfaces before you install them into the engine. Damaged bearing surfaces must by all means be refinished. Watch out for burrs.

### Special Tools:

Torque wrench 0–13 mkg (0–94 ft.lb.)	000 589 22 21
Torque wrench 0–6 mkg (0–43.5 ft.lb.)	000 589 27 21
Socket wrench insert, opening 14, 17 and 19 mm (0.55, 0.67 and 0.75"), from	000 581 18 09
Pin wrench insert, opening 10 mm (0.39"), length 140 mm (5.51"), for tightening the cylinder head	000 589 05 07
Pin wrench insert, opening 8 mm (0.315"), length 80 mm (3.15"), for tightening the rocker arm brackets	000 589 06 07
Installer for intermediate gear and shaft	187 589 07 61
Inserting sleeve with pressure piece, for grease retainer/ crankshaft	187 589 04 61
Piston ring compressor	136 589 02 61
Special pliers for lock plate of crankshaft bearing screws	120 589 01 37
Valve lifter, 4 parts	186 589 02 31
Special Allen wrench, width over flats 6 mm (0.235"), length 425 mm (16.73"), for cylinder head screws M 8	187 589 03 07
Adjustment pointer for TDC	187 589 01 23
Chain alignment gauge	187 589 02 23
2 Clamps for vibration damper	187 589 04 31
Special wrench, opening 14 mm (0.55"), for lower check nut at rocker arm	187 589 00 01
Wrench combination for upper check nut at rocker arm	187 589 01 09

Valve gauge bracket with toler- ance gauge	136 589 00 23
Offset spark plug wrench, opening 20.9 mm (0.82")	186 581 03 36
Mechanic's set, 20 parts, for hexagonal socket head screws	000 589 04 07

### Equipment:

Engine assembly jig

### Procedure:

40. Before placing the cylinder crankcase in the assembly jig, screw on the two front engine supports and the intermediate plate on flywheel side. Together with the right engine support turn in generator tightening screw (Type 220: with thread M 10, Type 220a: with thread M 8).

**Note:** Two intermediate plate designs have been used.

- a) Up to engine No. 1711/51 intermediate plate and clutch housing have been provided with collar pins. From engine No. 1712/51 on cylindrical pins have been used.

This means that up to engine No. 1711/51 the intermediate plate can only be exchanged in connection with a clutch housing with collar pins.

- b) In the case of the engine for Type 220a the holes for the two fastening screws at the cylinder crankcase are countersunk. **By no means should an intermediate plate not provided with countersunk holes be installed on an engine of Type**

220a, as then the clearance between screw head and flywheel would be too small.

41. Drive vertical bearing bushing for distributor drive helical gear with a suitable punch into bore of cylinder crankcase (see Fig. M 3/67).
42. Press in rear bearing bushing for intermediate gear shaft with a suitable punch. Insert the bushing so that continuous outer longitudinal groove is on top and open end of longitudinal groove in the bore points towards the rear (Fig. M 3/42).

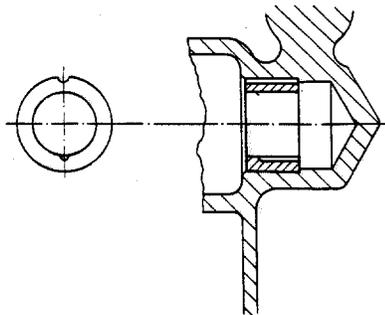


Fig. M 3/42

43. Press intermediate gear shaft together with front bearing bushing into bore in cylinder crankcase after spraying the bearing surfaces with oil. If necessary, use tool 187 589 07 61. Be sure to position front bushing so that lock disc can be attached (Fig. M 3/43).

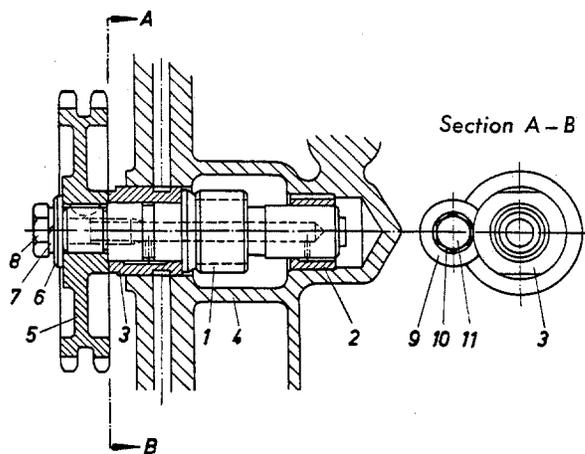


Fig. M 3/43

- |                                    |                    |
|------------------------------------|--------------------|
| 1 Intermediate gear shaft with key | 6 Washer           |
| 2 Rear bearing bushing             | 7 Spring washer    |
| 3 Front bearing bushing            | 8 Hexagonal screw  |
| 4 Cylinder crankcase               | 9 Lock disc        |
| 5 Intermediate gear                | 10 Spring washer   |
|                                    | 11 Hexagonal screw |

44. Fasten lock disc for front bearing bushing by means of screw with spring washer (Fig. M 3/43).
45. Place double-type roller chain in sprocket housing of cylinder crankcase.
46. Press intermediate gear on shaft with tool 187 589 07 61 (Fig. M 3/46).

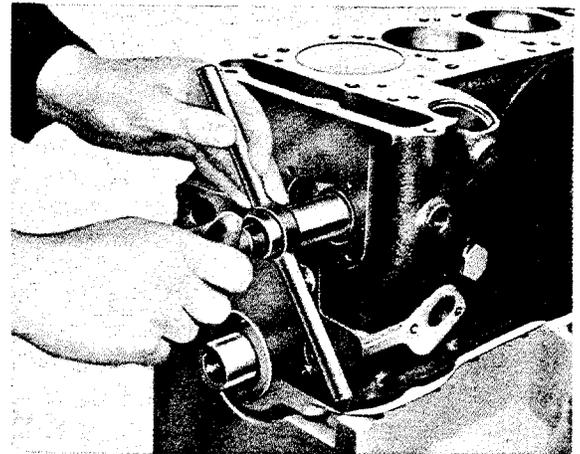


Fig. M 3/46

Do not forget key.

Place an approx. 15 cm (6") long piece of wood between chain and gear, so that the gear will be prevented from turning when the screw is being tightened (do not forget washer and snap ring). See Fig. M 3/46a.

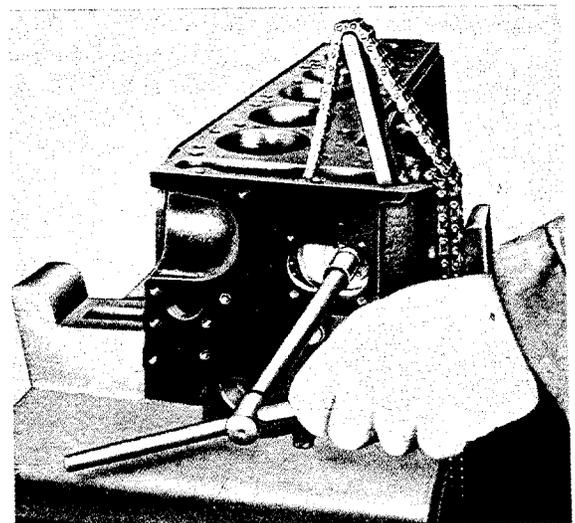


Fig. M 3/46a

47. Place bearing shells in cylinder crankcase and bearing caps (see also Operation No. M 4g).

**Note:** Insert bearing shells into groove of basic bore with nose first and then press them into the bore. This is to avoid any damage to the nose.

48. Install lower left and right-hand guide rails. Note that the pins are simply driven in. Be careful not to damage thread M 5 of pin. The guide rail lock wire must engage the groove of the retaining pins. **Do not yet install lower retaining pin of right-hand guide rail** (as seen in direction of travel) to ensure that the crankshaft sprocket can be readily pulled, if it is found necessary to exchange the adjusting washer.

**Note:** The retaining pins for the two lower guide rails are 51 cm (20.08") long. At the upper end of the lower left-hand guide rail (as seen in direction of travel) a retaining pin with screw plug is used (do not forget sealing ring!).

49. Insert sealing ring retainer half on flywheel side into cylinder crankcase and provide with oil. Do not fit in the retainer half too tight.

50. Insert crankcase with flywheel placing chain over sprocket. Put on crankshaft bearing caps, screw in place and secure. Before installing the crankshaft, spray the bearing surfaces with oil.

Tighten fastening screws as follows:

1st pull	2 mkg (14.5 ft.lb.)
2nd pull	5 mkg (36 ft.lb.)
3rd pull	8 mkg (58 ft.lb.)
4th pull (check)	8 mkg (58 ft.lb.)

Rotate crankshaft by hand and check whether it turns freely (see also Operation No. M 4g).

**Note:** In the engine for Type 220 the lock plate for the 2nd crankshaft bearing cap is provided with a strap for fastening the clamp on the oil pump suction pipe. Do not interchange the lock plates (see Fig. M 3/56).

The crankshaft bearing cap screws of Type 220 are **not secured**.

51. Check alignment of sprockets (crankshaft sprocket – intermediate gear) by measuring the distance from front end of cylinder crankcase to crankshaft sprocket and to intermediate gear with a depth gauge or micrometer (Fig. M 3/51).

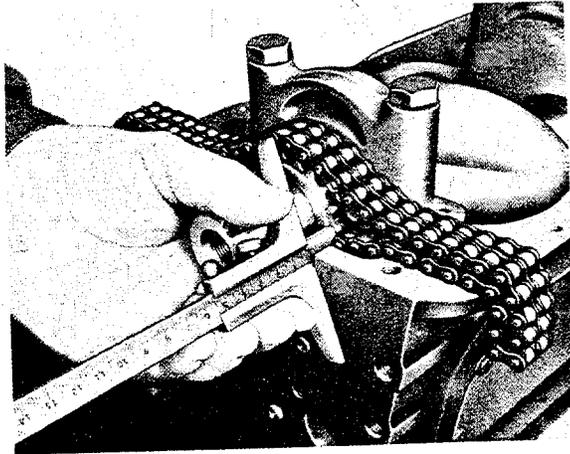


Fig. M 3/51

For checking, push both crankshaft and intermediate gear back as far as they will go to eliminate any end play.

The permissible out of alignment of the sprockets is 0.1 mm (0.004"). If this value is exceeded, exchange adjusting ring beyond the crankshaft sprocket (see Fig. M 3/53). To pull the crankshaft sprocket, use tool 187 589 00 33 (see Fig. M 3/36).

The adjusting rings are available in five sizes varying from 0.15 to 0.15 mm (0.006").

Out of alignment of sprocket	Thickness of adjusting ring
— 0.30 mm (0.012")	5.45 mm (0.215")
— 0.15 mm (0.006")	5.60 mm (0.22")
Normal thickness of ring	5.75 mm (0.225")
+ 0.15 mm (0.006")	5.90 mm (0.23")
+ 0.30 mm (0.012")	6.05 mm (0.235")

**Note:** Formerly no adjusting ring had been installed.

If it is not sufficient to exchange the adjusting ring, measure the distance from front end of cylinder crankcase to intermediate gear. The distance should be 18.30–18.40 mm

(0.72–0.725"). If it is larger, install a thicker offset lock plate for front bushing intermediate gear shaft in order to compensate for the deviation from the normal distance of 18.30–18.40 mm (0.72–0.725").

52. Install lower retaining pin of right-hand guide rail.
53. Push oil thrower, spacer ring and grease retainer on crankshaft journal (Fig. M 3/53).

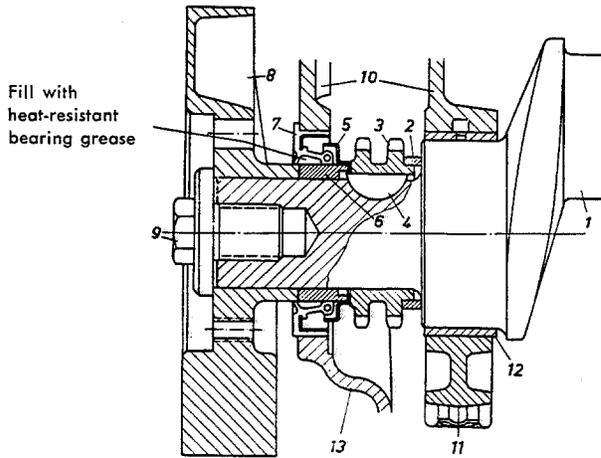


Fig. M 3/53

- |                       |                             |
|-----------------------|-----------------------------|
| 1 Crankshaft          | 8 Counterweight             |
| 2 Adjusting ring      | 9 Collar screw              |
| 3 Crankshaft sprocket | 10 Cylinder crankcase       |
| 4 Key                 | 11 Crankshaft bearing cover |
| 5 Oil thrower         | 12 Bearing shell            |
| 6 Spacer ring         | 13 Oil pan                  |
| 7 Grease retainer     |                             |

When installing the grease retainer, use insertion sleeve with pressure piece 187 589 04 61 to ensure that the sealing lips will not be damaged (Fig. M 3/53a). The collar half of the grease retainer must abut snugly against the cylinder crankcase.

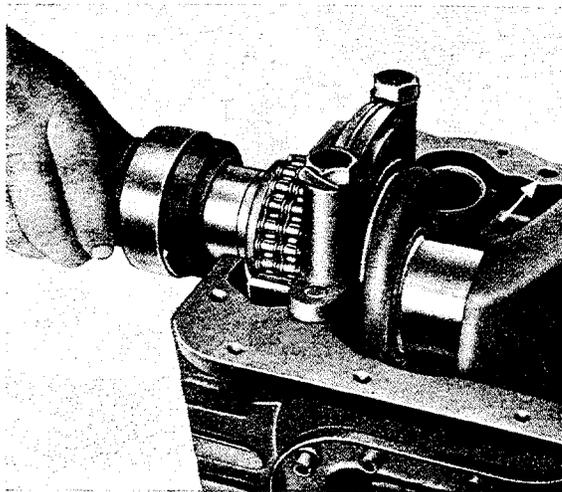


Fig. M 3/53a

**Note:** Before pushing on the grease retainer, fill the space between the two sealing lips with heat-resistant grease (see Fig. M 3/53). In engines not provided with an oil thrower, the spacer ring is longer by the thickness of the oil thrower (0.75 mm = 0.0295"). Keep this in mind as there may be not enough space left to properly tighten the collar screw securing the counterweight on the crankshaft.

The length of the spacer ring is 16.25 mm (0.64") when an oil thrower is installed, and 17.00 mm (0.67") when no oil thrower is provided.

In some cases an additional 0.75 mm (0.03") thick washer has been installed instead of a longer spacer ring.

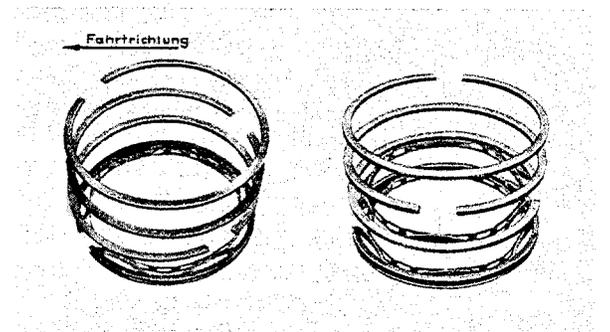
54. Install the connecting rods with piston attached and bearing shells inserted (see also Operation No. M 4h).

The connecting rods are marked 1 to 6. Watch out for correct order and position of piston rings (see Fig. M 4d/2). Before installing the rings, position them as indicated in Fig. M 3/54.

To insert the pistons into the cylinders, use piston ring compressor 136 589 02 61. Be careful! Do not damage the cylinder walls when inserting the connecting rods.

See that the connecting rod bolts do not project; the bolt head must fit tightly or the piston will jam when it is inserted into the cylinder.

**Note:** Spray pistons with oil before inserting them.



Piston ring arrangement Type 220

Piston ring arrangement Type 220a

← Direction of travel

Fig. M 3/54

55. Put on connecting rod caps and tighten. See that nuts are correctly positioned (Fig. M 3/55).

Tighten connecting rod bolts to an expansion of 0.1 mm (0.004"), which corresponds to a torque of 3.75 to 3.80 mkg (27 to 27.5 ft.lb.). The bolts are not secured. Check the expansion with a micrometer.

When the nut is loosened, the bolt must again reach its original length. Small deviations of up to 0.01 mm (0.0004") are permissible when the bolts are tightened to the prescribed torque as well as after the nuts have been loosened.

If the deviation is larger, this indicates that the bolt has been overtightened, i.e. excessively expanded. In this case a new connecting rod bolt and nut are to be used.

As a rule the connecting rod bolts are to be tightened to expansion only. In exceptional cases the nuts may be tightened with a torque wrench. Note that before tightening the threads of both connecting rod bolt and nut are to be provided with "Auto Kollag" or graphite oil.

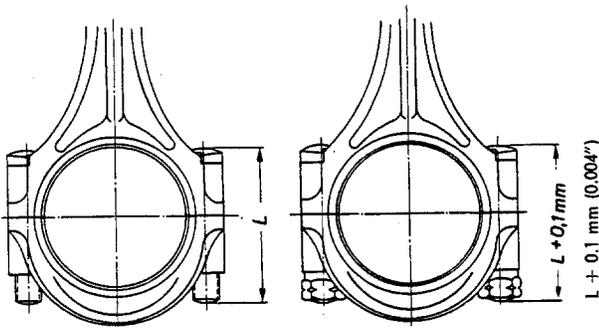


Fig. M 3/55

L = before tightening  
 L + 0.1 mm (0.004") = after tightening - corresponds to 3.75-3.80 mkg (27-27.5 ft. lb.)

On the crankshaft bearing journal the connecting rods must have sufficient clearance on either side, otherwise the connecting rod or piston, resp. will jam.

56. Install oil pump and bolt in place. Secure suction pipe to strap on lock plate of 2nd crankshaft bearing cap by means of the clip. The suction basket must be parallel with the bottom of the oil pan. If this is not the case, swivel it into correct position (Fig. M 3/56).

**Note:** In the case Type 220a the oil pump suction pipe is shorter and not provided with a clip (Fig. M 3/56a).

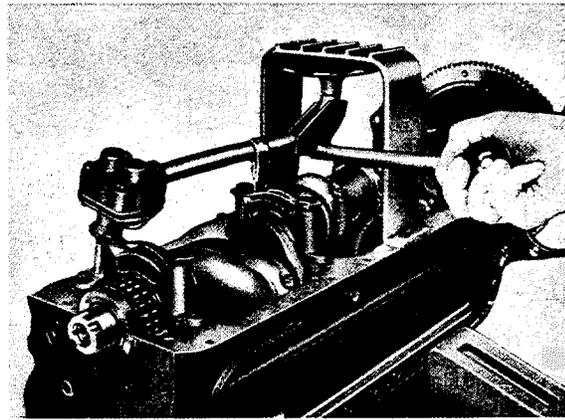


Fig. M 3/56

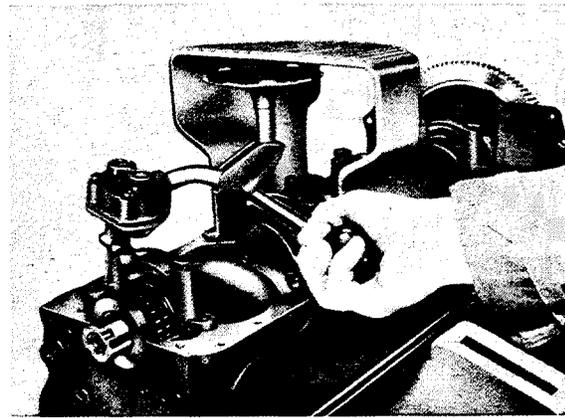


Fig. M 3/56a

57. Provide rear part of oil pan with a sealing compound and bolt in place (Fig. M 3/57) after installing the sealing ring retainer half and providing it with oil.

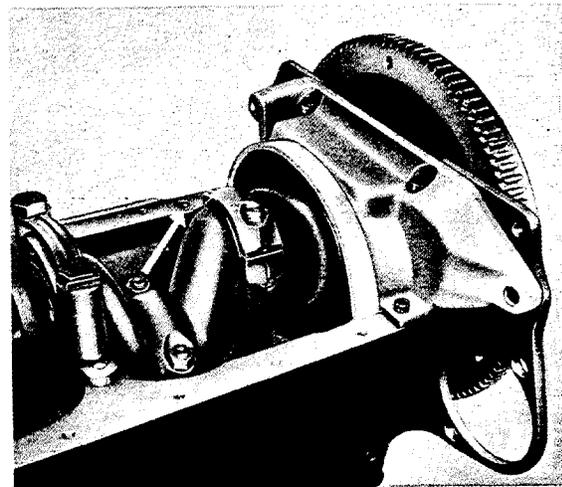


Fig. M 3/57

58. Put on front part of oil pan and bolt in place (coat with a sealing compound).

Do not forget gasket between front and rear part of oil pan. See that collar half of grease retainer on crankshaft fits snugly against cylinder crankcase.

The mating surface of both cylinder crankcase and oil pan is on the left side provided with two through holes each, which are used during production (see arrow in Figs. M 3/53a and M 3/57). To prevent any loss of oil, exercise particular care when applying the sealing compound around these holes.

**Note:** The oil pan front part of Type 220a is of a different shape.

After front and rear part of the oil pan have been bolted in place, check again whether the crankshaft can be turned easily. The sealing ring retainer halves must by no means press against the shaft.

59. Insert valves in cylinder head after coating the stem with graphite oil. Mount spring supporting ring, inner and outer spring, valve spring retainer with sealing ring and valve cone halves. Use valve lifter 186 589 02 31. Be careful! Do not damage grease retainer during installation. If necessary, replace it. See that the grease retainer does not jam, but is correctly seated. To facilitate installation, spray valve stem lightly with oil.

When installing the new design in the place of the former valve packing with Burgmann sealing ring, first install the two oil throwers and the sealing ring retainer, then inner and outer spring, valve spring retainer and valve cones. (See also Operation No. M26b).

**Note:** The outer diameter of the spring supporting ring in a light metal cylinder head is larger, so that both springs – the outer as well as the inner – rest on the ring; in the case of the cast iron cylinder head the spring supporting ring has a smaller outer diameter, so that only the inner spring rests on the ring, while the outer spring rests on the cylinder head.

Be careful! Do not interchange the rings.

60. Place cylinder head on cylinder crankcase. Before doing this, drive two dowel pins and the water distributors (three large ones and six small ones) into the cylinder crankcase,

and put on a new correct cylinder head gasket (Fig. M 3/60).

**Note:** The cutouts for the combustion area in the cylinder head gasket are smaller for the high-compression head ( $\varepsilon = 7.6$ ) than they are for the low-compression head.

To be sure that the correct gasket is used, place it on the cylinder head prior to installation; the shape of the cutout in the gasket must coincide with the shape of the combustion area in the cylinder head.

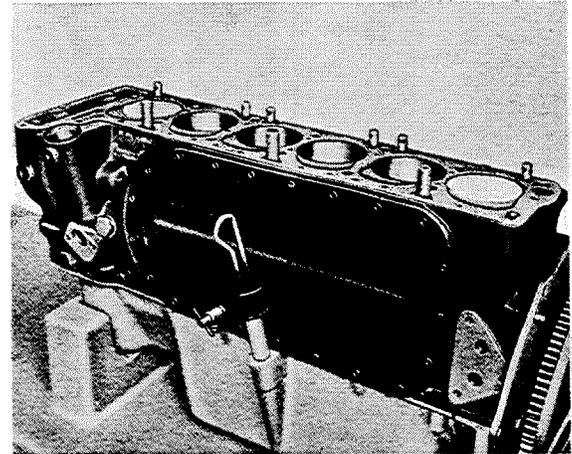


Fig. M 3/60

61. Insert camshaft into bearings from the rear after spraying bearing surfaces with oil.

**Note:** Do not interchange the camshaft! The cams on the camshaft for the high-compression cylinder head have a shape different from the ones on a shaft used in connection with low-compression heads (see Operation No. M 28).

62. Put on yoke for cylinder head cover. Insert cylinder head screws and tighten to 8 mkg (58 ft.lb.). See also Operation No. M 20, cf. 8. Do not forget the 4 hexagonal socket head screws M 8 (Fig. M 3/21). Use wrench 187 589 03 07.

**Note:** After the cylinder head bolts have been tightened, make sure that camshaft turns easily.

63. Install idler gear support with idler gear into sprocket housing, and insert spring on pin between housing wall and support.
64. Set first piston to TDC. In Type 220 this is done with the aid of adjustment pointer 187 589 01 23 (Fig. M 3/64), whereas in Type 220a in addition to the marks on the lower flywheel half another mark is provid-

ed on the upper half, which must coincide with the mark on the intermediate plate, when the 1st piston is set to TDC (Fig. M 3/64a).

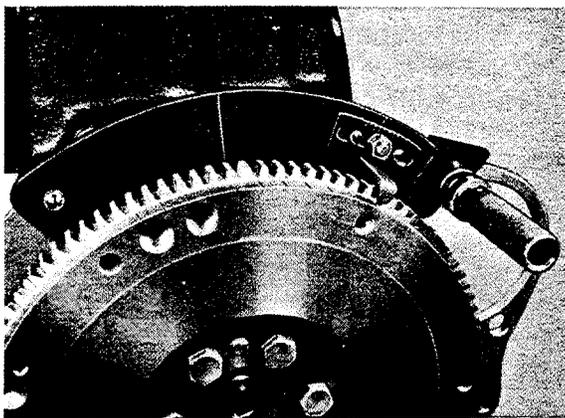


Fig. M 3/64

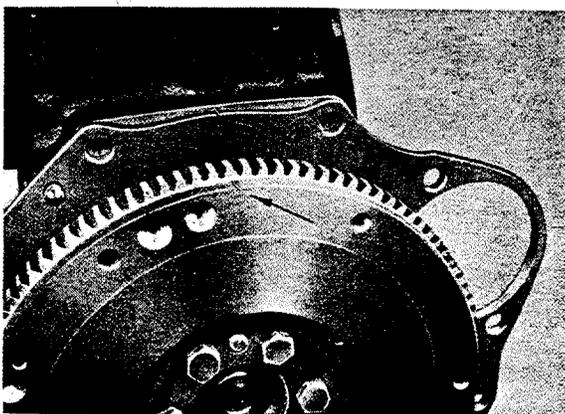


Fig. M 3/64a

Insert key. If an offset key has been installed, it must by all means be returned into correct position.

Push adjusting washer on camshaft. Rotate

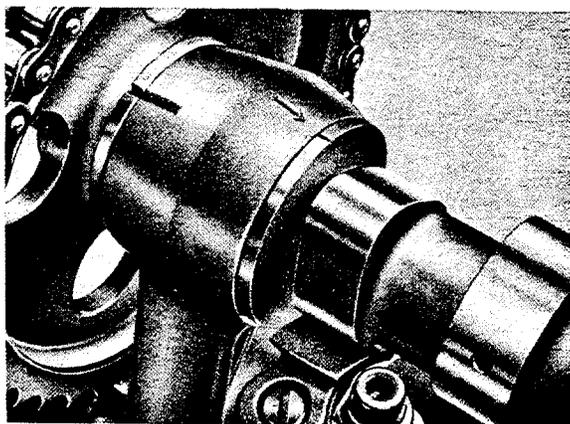


Fig. M 3/64b

camshaft with adjusting washer until marks on adjusting washer and first camshaft bearing coincide (Fig. M 3/64b).

**Note:** In the first few engines the camshaft collar is provided with a notch and the camshaft bearing is marked with an arrow. In this case the arrow must register with the notch in the camshaft collar. When installing a new camshaft, refer to the marks on adjusting washer and camshaft bearing.

**It is advisable to check the valve setting after installation of the camshaft has been completed (see under Operation No. M 30).**

65. Lift chain out of sprocket housing with a hook and place so over the camshaft sprocket that key and groove fit together when the sprocket is pressed on the camshaft. Note that the left half of the chain must be tensioned. Then put on disc and spring washer, and tighten by means of the screw. Check end play of camshaft (Fig. M 3/65).

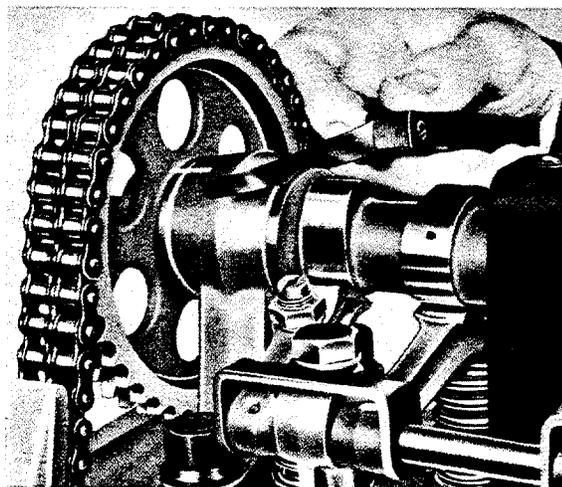


Fig. M 3/65

**Note:** Before pressing on camshaft sprocket with chain, install sprocket on camshaft without chain and check alignment of sprockets with gauge 187 589 02 23 (see Figs. M 3/65a and 65b). The misalignment of all sprockets must not be more than 0.1 mm (0.004"). If necessary, correct the alignment by using a different adjusting washer on the camshaft.

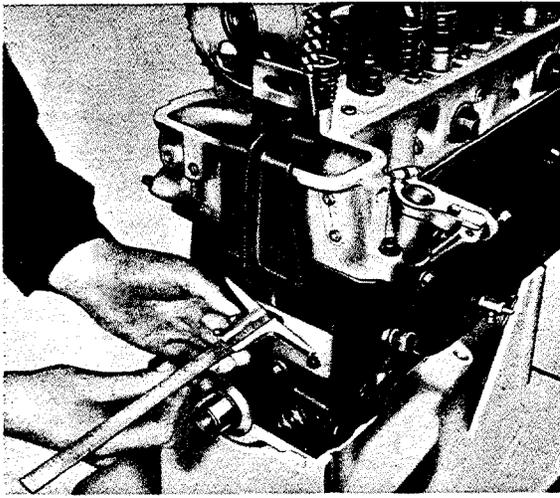


Fig. M 3/65a

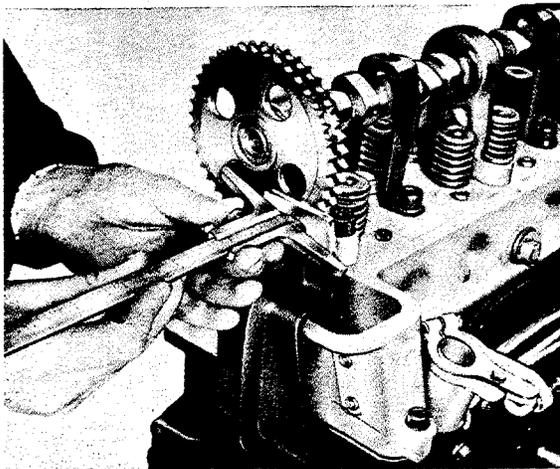


Fig. M 3/65b

The adjusting washers are available with the following thicknesses:

2.50, 2.75, 3.00, 3.25 and 3.50 mm  
(0.1, 0.11, 0.12, 0.13 and 0.14 in.)

When checking the alignment, push sprockets back as far as they will go. This is to eliminate any end play.

66. Install upper guide rail. The retaining pins are 58 mm (2.28") long. Be sure that the lock wire of the guide rail engages the groove in the pin.
67. Insert distributor drive helical gear (Fig. M 3/67); spray bearing surface with oil. Mount distributor support with adjusting lever and arrest by means of trunnion screw (3). See Fig. M 3/9.)
68. Insert, fasten and adjust distributor. Set 1st piston to 5° after TDC in the case of cylinder heads with compression ratio 6.5 : 1 and to

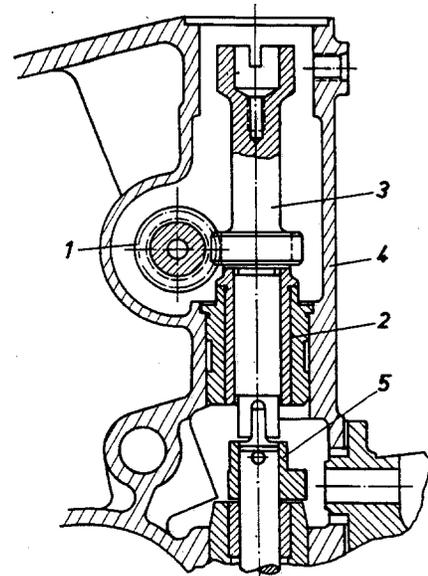


Fig. M 3/67

- 1 Intermediate gear shaft
- 2 Bearing with bushing
- 3 Distributor drive helical gear
- 4 Cylinder crankcase
- 5 Oil pump drive shaft with cam

2° after TDC in the case of cylinder heads with compression ratio 7.6 : 1. Rotate intermediate gear clockwise (move over chain), until rotor points to contact point for 1st cylinder in distributor cap (marked 1). The distributor housing as well is provided with a mark. Turn distributor head until movable point just lifts off the cam (see also Operation No. M 30). Then tighten cheese-head screw (1) to arrest the adjusting lever (see Fig. M 3/9).

Run chain drive securing screw (1) into cylinder crankcase and tighten. Interpose a sealing ring (Fig. M 3/68).

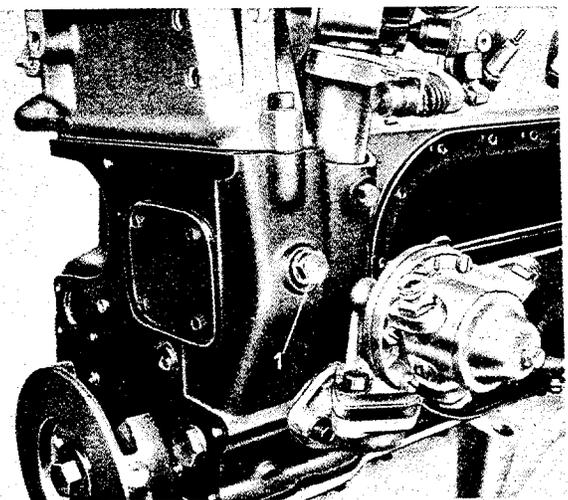


Fig. M 3/68

69. Bolt sprocket housing cover with gasket to cylinder crankcase.
70. Install chain tensioner with gasket. Before this is done, fill with engine oil and vent. Fill oil pocket in cylinder head, in which chain tensioner is accommodated, with oil as well. Then vent chain tensioner again (see Operation No. M 73a, cf. 3-5).

71. Insert fitting rings for rocker arm brackets into bores in cylinder head. See that rings are snugly seated.  
Install rocker arm brackets in mounted condition and tighten to a torque of 3.75 mkg (27 . ft.lb.). Note that during installation the camshaft must not bear on the rocker arm brackets. (See also Operation No. M 74.)

72. Adjust valve play (see Operation No. M 26c).

73. Bolt fuel pump with intermediate flange and push rod to cylinder crankcase. Do not forget to interpose a gasket. Before mounting the pump, check play of push rod (see also Operation No. M 34).

74. Bolt oil filter with filter element to cylinder crankcase. Do not forget gasket. The uppermost fastening screw for the oil be tightened to a torque of 3.8 mkg (27.5 ft.lb.). Screw oil relief valve into cylinder crankcase.

**Note:** In the case of Type 220a the procedure is as follows. First bolt upper part of oil filter case to cylinder crankcase and then install oil filter pot with filter element (see also Operation No. M 3 cf. 11).

75. Mount water pump assembly with sealing flange. Install vent line from water pump to cylinder head (see Fig. M 3/80).

**Note:** The water pump used in Type 220a is larger and has a bigger pulley for pointed V-belts (see also Operation No. M 45).

76. Push counterweight on crankshaft. Drive in two dowel pins and screw in collar screw. Do not interchange the counterweight; note that the counterweights for Type 220 and

220a are of a different shape (see Operation No. M 17).

77. Mount assembled vibration damper with pulley, adding friction facings (see also Operation No. M 18). After the screws have been tightened, remove assembly yokes 187 589 04 31 again (Fig. M 3/77).

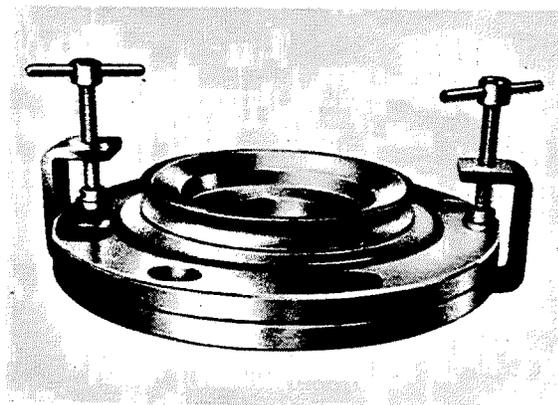


Fig. M 3/77

78. Fasten ignition cable set with protective pipe to cylinder head. Screw spark plugs in with plug wrench 186 581 03 36 and connect to ignition cable.

79. Bolt on intake and exhaust line with carburetor mounted; use new gaskets.

**Note:** In the Type 220a the flanges of the two exhaust manifolds are offset in relation to each other. It is recommended to make an installation gauge, so that the dimensions given in Fig. M 3/79 will be adhered to. If this is not done, it may be found difficult to connect the exhaust pipe in the car.

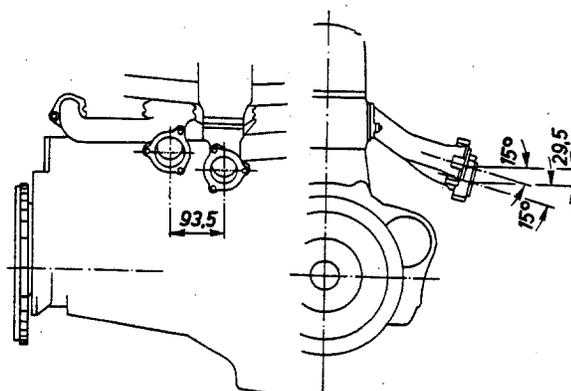


Fig. M 3/79

93.5 mm (3.68")

29.5 mm (1.16")

80. Fasten generator. Check alignment of pulleys, install belt and tension it. Tighten all screws (Fig. M 3/80).

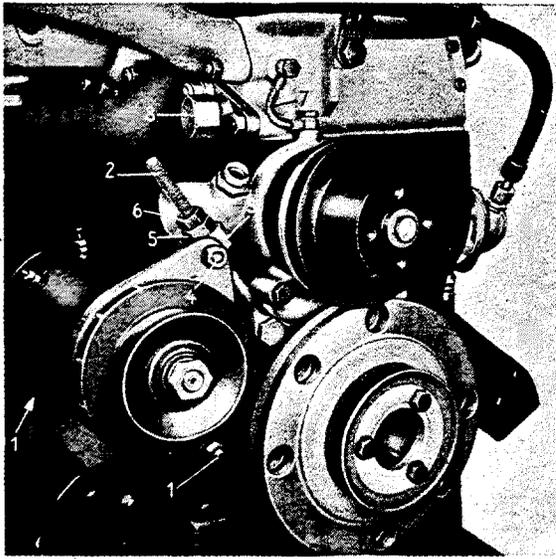


Fig. M 3/80

- 1 Front and rear generator suspension
- 2 Generator tightening screw
- 3 Intermediate piece
- 4 Screw with nut and spring ring
- 5 Tightening nut
- 6 Check nut
- 7 Vent line
- 8 Chain tensioner

81. Bolt fan in place. In the case of Type 220, do not forget the adjusting washer between pulley and fan!

**Note:** Use correct V-belt. The pulleys used in Type 220a are narrower and the V-belt is of the pointed type.

82. Connect vacuum line and fuel line and fasten to cylinder head by means of a clamp.

83. Bolt cooling water outlet with gasket in place.

84. Put cylinder head on and bolt in place. Watch out for correct seat of gasket!

85. Fasten the two struts for the intake silencer (in Type 220a also the holder for the accelerator linkage) and install intake silencer. Mount vent pipe. Be sure that rubber sleeve in intake silencer is properly seated!

86. Insert oil dip stick.

**Note:** Oil dip stick and guide tube of Type 220a are longer. In the oil dip stick the type of car is marked on the venting filter.

Length of guide tube:

Type 220 = 110 mm (4.33")

Type 220a = 144 mm (5.67")

87. Fill in 6.5 liters (13.7 US pints, 11.5 Imp. pints) of engine oil (incl. oil filter). Check screw plug in oil pan for tightness.

#### Modifications:

1. In Type 220 as well the screws for the crankshaft bearing caps are no longer secured, but simply tightened to a torque of 8 mkg (58 ft.lb.).
2. In Type 220a as well the oil pump suction pipe is now fastened with a clamp to a strap which is bolted to the second crankshaft bearing cap. In the case of a repair the strap and clamp are to be installed subsequently. The following parts will be required:

1 Strap	180 186 02 40
1 Clamp	186 995 09 44
1 Hexagonal screw	M 6 × 15 DIN 933-8 G
1 Spring ring	B 6 DIN 127
1 Hexagonal nut	M 6 DIN 934-5 S

These changes must be taken into consideration when installing an engine. Correct and modify Operation Nos. M 3/29, M 3/31, M 3/50 and M 3/56 correspondingly.