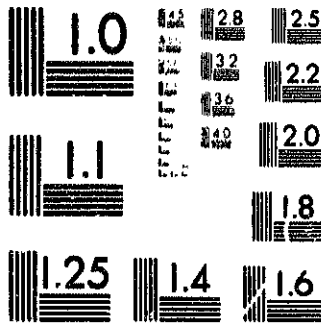


Testvorlage für die Mikroverfilmung



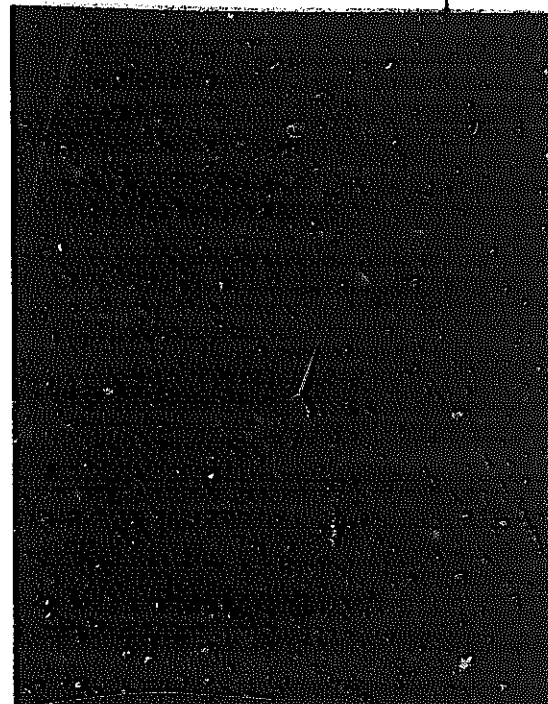
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

Schriftgrößenmuster

- 6l Kodak-Mikrofilm
KODAK-MIKROFILM
Kodak-Mikrofilm
KODAK-MIKROFILM
- 8l Kodak-Mikrofilm
KODAK-MIKROFILM
Kodak-Mikrofilm
KODAK-MIKROFILM
- 9p Kodak-Mikrofilm
KODAK-MIKROFILM
Kodak-Mikrofilm
KODAK-MIKROFILM
- 10p Kodak-Mikrofilm
KODAK-MIKROFILM
Kodak-Mikrofilm
KODAK-MIKROFILM
- 11p Kodak-Mikrofilm
KODAK-MIKROFILM
Kodak-Mikrofilm
KODAK-MIKROFILM
- 12p Kodak-Mikrofilm
KODAK-MIKROFILM
Kodak-Mikrofilm
KODAK-MIKROFILM
- 13p Kodak-Mikrofilm
KODAK-MIKROFILM
Kodak-Mikrofilm
KODAK-MIKROFILM
- 14p Kodak-Mikrofilm
KODAK-MIKROFILM
Kodak-Mikrofilm
KODAK-MIKROFILM



Linienmuster

- 0,25 mm — — — — —
- 0,25 mm —
- 0,35 mm — — — — —
- 0,35 mm —
- 0,25 mm —————
- 0,35 mm —————
- 0,5 mm —————
- 0,7 mm —————
- 1,0 mm —————



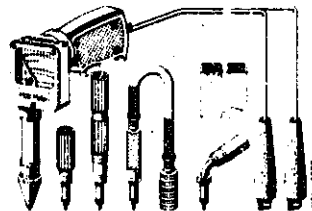
01-010 Checking compression pressure

Test values with engine at operating temperature in bar gauge pressure (atü)

Engine	Compression pressure normal	Minimum compression pressure	Permissible difference between individual cylinders
Normal compression	10-12	approx. 8.5	max. 1.5
Low compression and  	9-10	approx. 7.5	

Special tool

Compression manograph with accessories and contact handle



001 589 46 21 00

Note

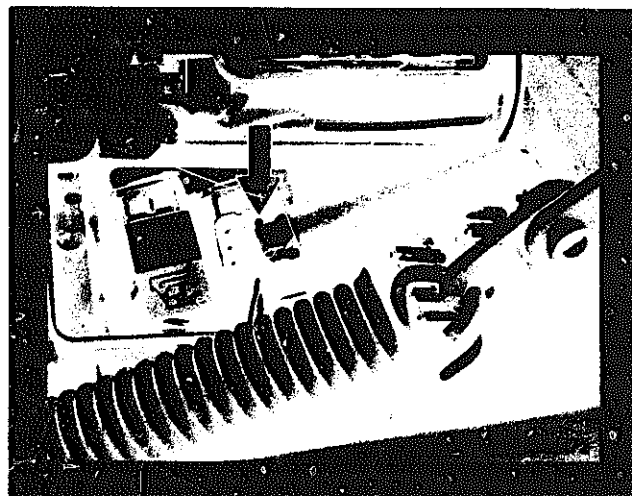
Check compression pressure at operating temperature (approx. 80 °C).

If pressure is below minimum compression pressure, check cylinders for leaks (01-015).

Unscrew all spark plugs for checking.

Checking

- 1 Connect contact handle to battery + into coupling for relay 21 in fuse box (arrow). Disconnect cable on ignition coil terminal 1.
- 2 Rotate engine several times with ignition switched off and at selector lever position "P" to throw out residue and soot.
- 3 To check, rotate engine for 8 turns while opening throttle valve.



01-015 Checking cylinders for leaks

Data

Total pressure loss	max. 25 %
On valves and cylinder head gasket	max. 10 %
On pistons and piston rings	max. 20 %

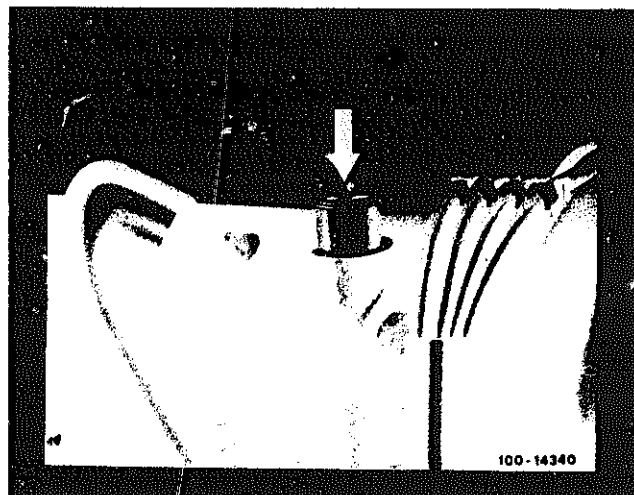
Special tool

Cylinder leak tester	e.g. made by Bosch, EFAW 210 A made by SUN, CLT 228-1
Adaptor 1/2" square socket to 3/4" square head	e.g. made by Stahlwille, D-5600 Wuppertal order No. 514
Socket 50 mm, 3/4" square for rotating engine	e.g. made by Stahlwille, D-5600 Wuppertal order No. 55

Checking

- 1 Run engine to operating temperature.
- 2 Remove air filter.
- 3 Set throttle valve to full opening.
- 4 Unscrew spark plugs.
- 5 Pull venting hose on lefthand valve cover (arrow).
- 6 Open coolant expanding tank and add required coolant.
- 7 Connect cylinder leak tester with hose to a compressed air system.

Calibrate tester.



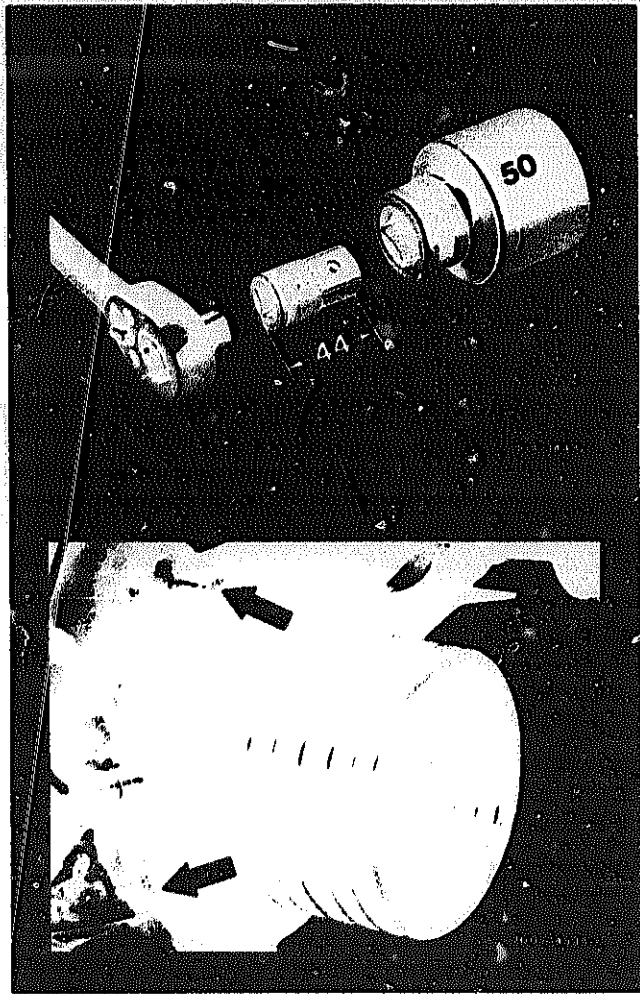
8 Set cylinder to be checked to ignition TDC. For this purpose, rotate crankshaft with tool combination.

Attention!

The marking numbers 0, 90, 180 and 270 are punched into vibration damper.

At the following positions of markings opposite pointer, the following pistons are at TDC:

Marking No.	Piston at TDC
0	1 and 6
90	5 and 3
180	4 and 7
270	8 and 2



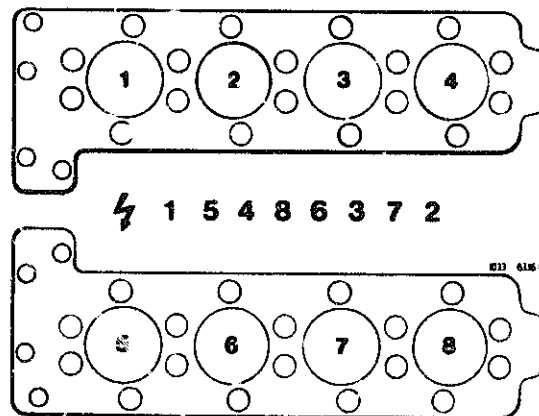
9 Screw connecting hose into spark plug bore to be tested and connect to connecting hose of tester.

Crankshaft should not rotate.

10 Read pressure loss on tester.

11 Check by listening whether pressure escapes through intake pipe, exhaust, engine breather, spark plug bore of adjacent cylinder or coolant filler hole.

12 Check all cylinders in firing sequence.



Conventional tool

Cylinder illuminating lamp

e.g. made by Karl Storz GmbH,
D-7200 Tuttlingen
Motoskop TW (cold light)
with lens probe 103 26 CW (570 mm)

Note

The visual checkup can be made by means of a cylinder illuminating lamp with cylinder heads mounted.

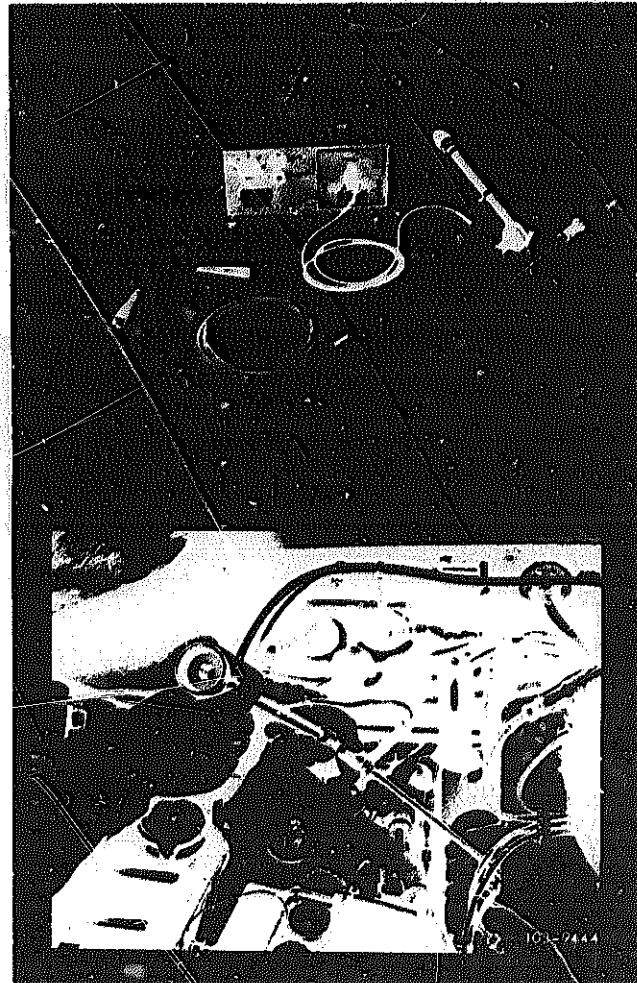
The lens probe is introduced through spark plug bore at BDC position of piston and permits evaluation of cylinder bore.

Motoskop TW
220 Volts and 12 Volts

When evaluating scored or streaked cylinder walls, it is often difficult for a workshop to decide whether the damage is already extensive and requires removal or repair of the engine, or whether the evidence is harmless. The following instructions will help in making an expert and correct decision.

With regard to marks on cylinder walls, the first important difference is between "optical streaks" and "seizure streaks". As a rule, "optical streaks" are about 3 mm wide, they are produced by the piston ring gaps and do not destroy honing structure; "seizure streaks", however, obliterate honing structure.

With streaks in direction of "land" (in direction of piston pin) skirt streaks or seizure are not possible since there is no contact between piston skirt and cylinder liner.



01-025 Measuring oil consumption

Special tools

Oil dipstick jacket and oil dipstick
with millimeter scale



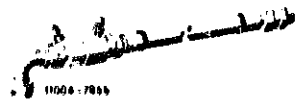
100 589 14 21 00

Oil telethermometer



116 589 27 21 00

Valve for interrupting oil return flow



110 589 00 91 00

Note

Measure oil consumption with oil dipstick and millimeter graduation, oil dipstick jacket and pertinent measuring sheet.

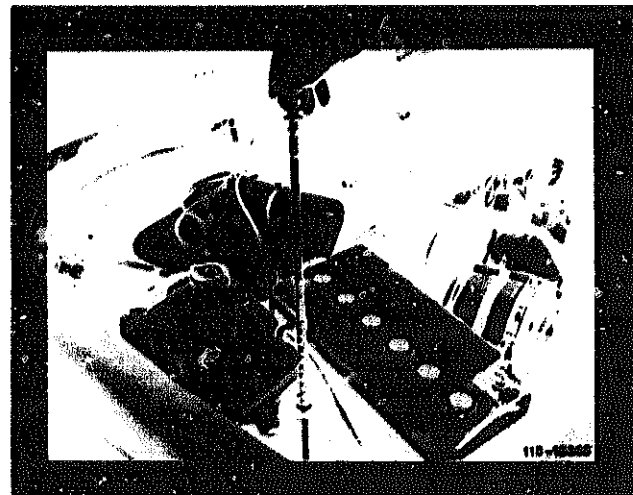
The sequence for measuring oil consumption is described on front page of measuring sheet.

Read oil consumption shown in millimeters on dipstick with reference to diagram on back of measuring sheet in cc.

Measuring sheet

Engine 100.985

Print No.
800.99.469.00 A
German/English
800.99.469.01 A
French/Spanish

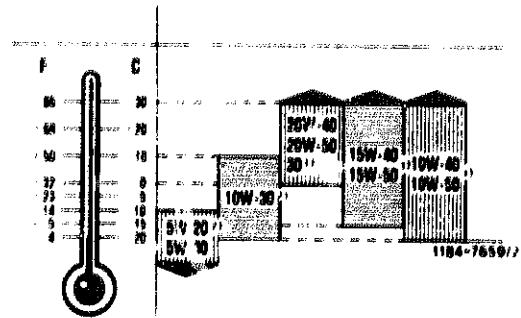


Attention!

To prevent faulty readings, check engine oil prior to measuring consumption for fuel dilution.

01-030 Removing and installing engine (oil capacity)

Specified viscosity classes
according to SAE
during constant outside temperatures







- 1) SAE 40 may be used if ambient temperatures constantly exceed + 30 °C (+ 86 °F).
- 2) For engine oils identified with a footnote¹⁾ on sheets 226.1 and 227.1 of Specifications for Service Products the following applies:
SAE 5W-20 below + 10 °C (+ 50 °F).
- 3) SAE 10W-30 in temperature zones all-season.
All season oil.

Oil capacity in liters (for approved engine oils refer to specifications for service products)

Engine (total quantity for refills)	12	
Tightening torques	Nm	(kpm)
Oil drain plug to oil pan	50	(5)
Fastening screw for filter lower half	40	(4)

Special tools

Taster for cooling system		001 589 48 21 00
Double connection for radiator and expansion tank-closing test		000 589 73 53 00
Open-end wrench 46 mm for clamping nut of universal shaft		126 589 00 01 00
Torque wrench 25-130 Nm for open end wrench 126 589 00 01 00		001 589 66 21 00

Conventional tool

Load regulator e.g. made by Backer, 5630 Remscheid

Note

Remove and install engine with transmission at an angle of about 45°.

Removing

1 Drain coolant.

Attention!

Drain plugs (arrow) are located on left and right sides of engine block and must not be mixed up with the crankshaft bearing cap bolts located underneath.

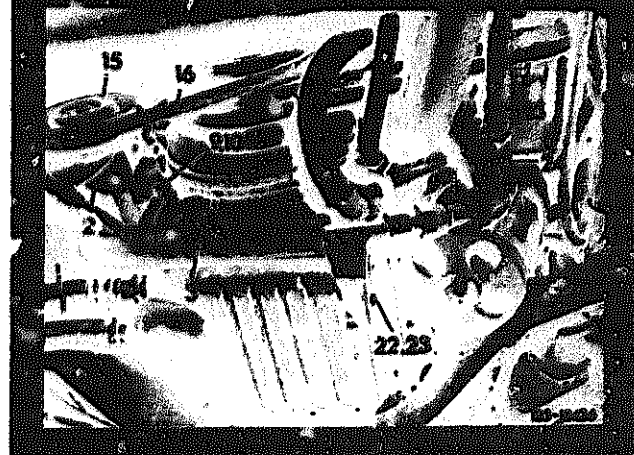
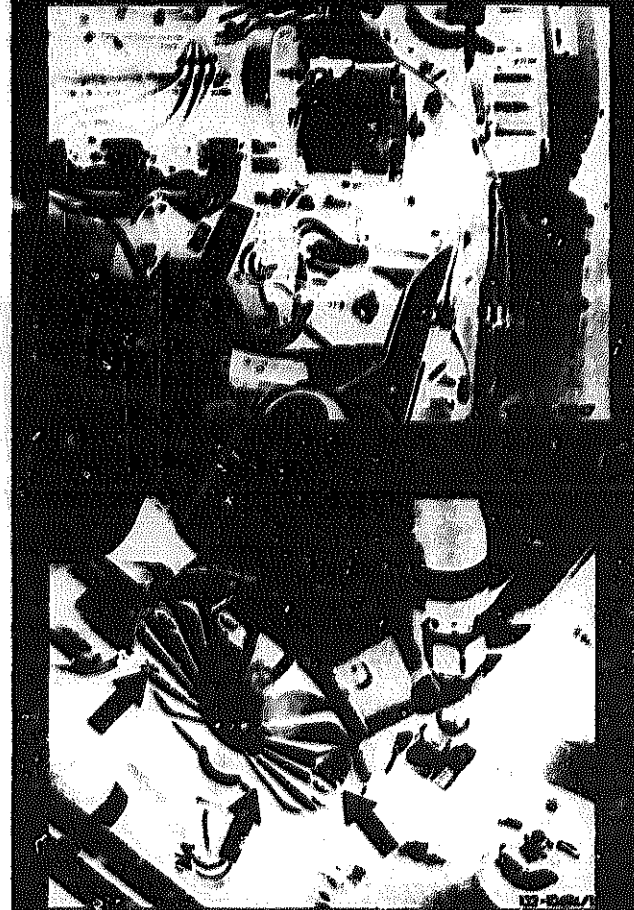
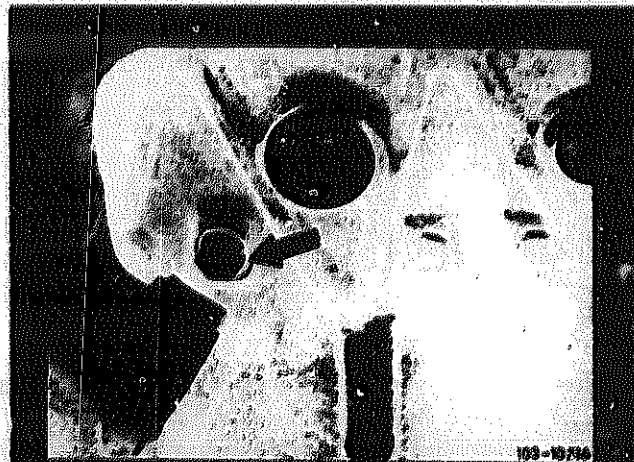
2 Remove fan and radiator.

3 Remove battery and battery console.

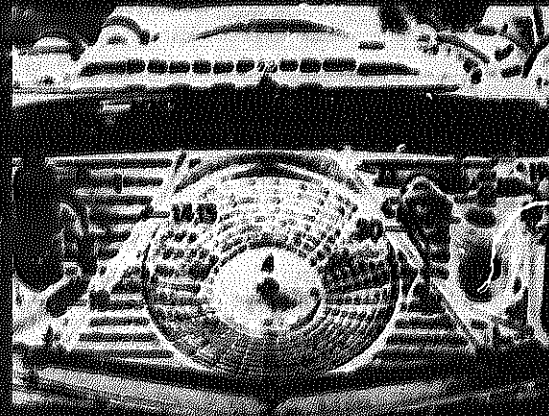
4 Detach lines at oil pressure pump. Only loosen bolts (see arrows), if oil pressure pump must be removed.

5 Discharge air conditioner (83-850).

6 Detach intake line (24).



7 Detach pressure line (1B).

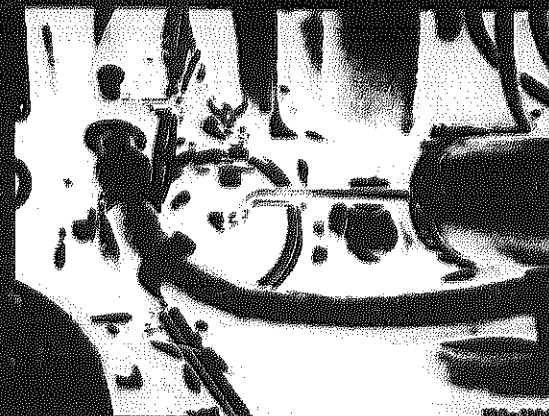


8 Remove longitudinal control shaft.



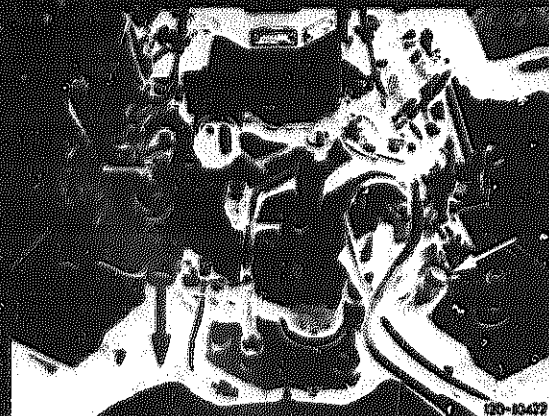
9 Draw fluid out of power steering pump tank.

10 Detach oil pressure hoses at power steering.

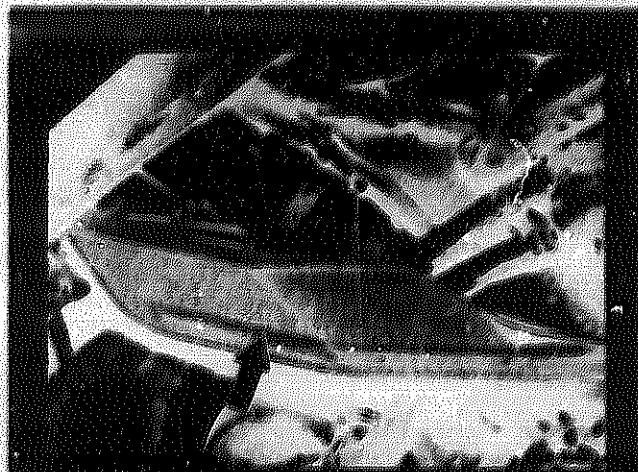


11 Detach all coolant, vacuum, oil, fuel and electric lines leading to engine.

Disconnect TDC sensor wires at test socket. This requires unscrewing test socket.

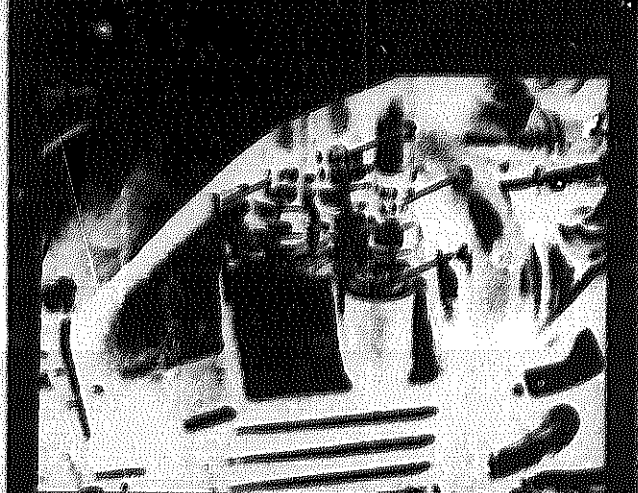


12 Unscrew guard (arrow).

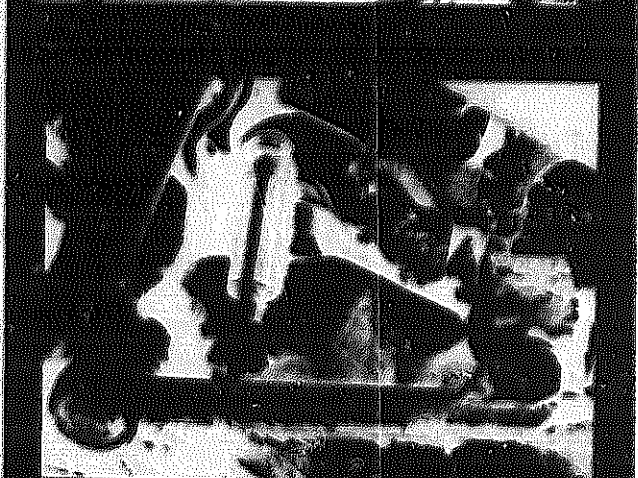


13 Drain engine oil at drain plug (4).

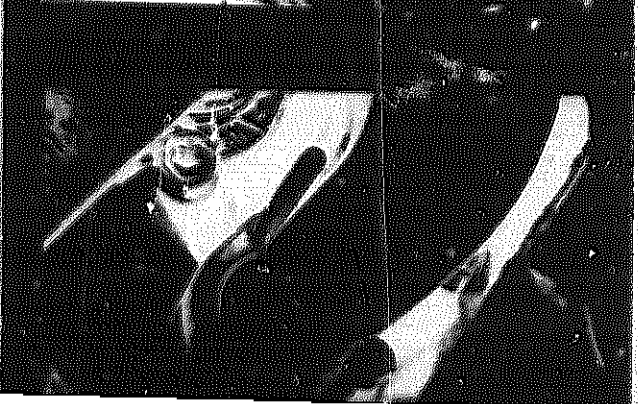
14 Detach oil hoses (1, 2 and 3) at oil pan.



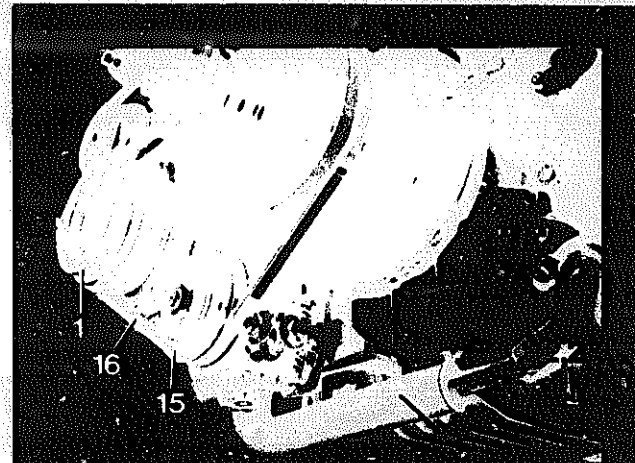
15 Remove left and right engine dampers.



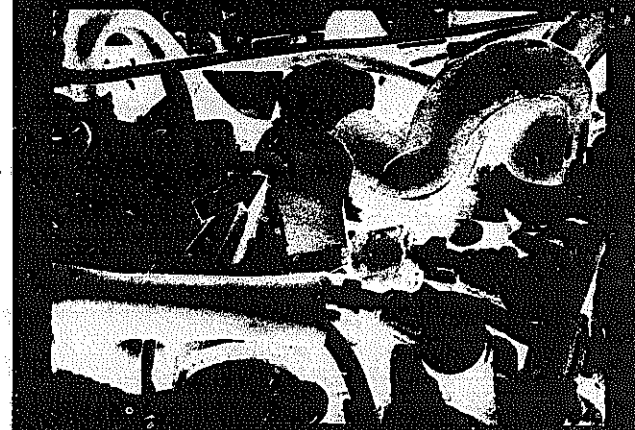
16 Remove entire exhaust. This requires the removal of the left bottom and right top studs in exhaust manifolds with a counternut.



17 On USA vehicles, remove gear oil pump together with holder.



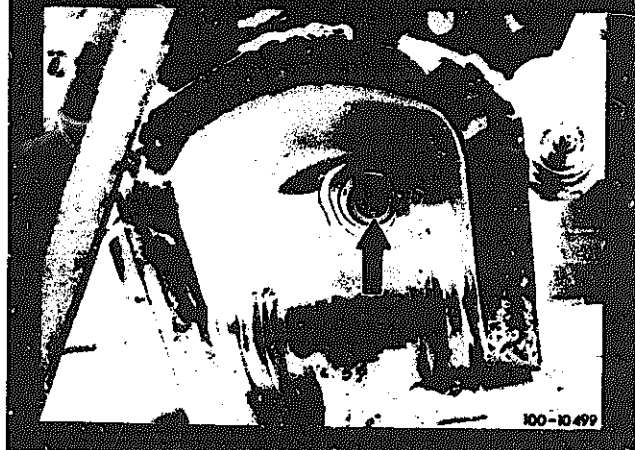
18 Engage engine at front hoisting eye (arrow).



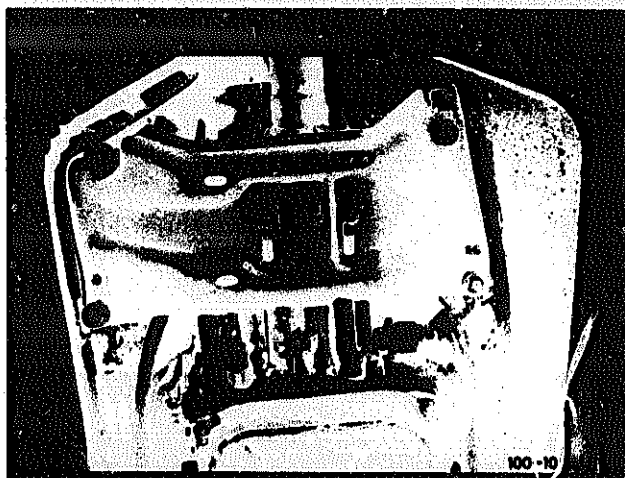
19 Engage engine at rear hoisting eyes (arrows).



20 Unscrew engine carrier mounting bolts at front left and right engine mounts.



21 Remove rear engine carrier with engine mount.

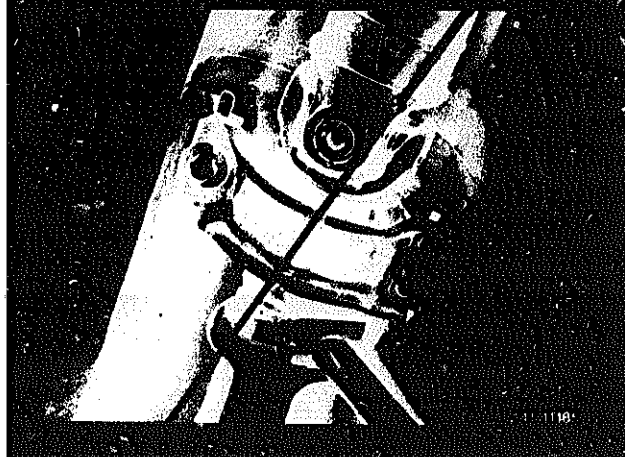


22 Unscrew propeller shaft holding nut.

23 Detach propeller shaft at transmission.

24 Disconnect lines at transmission.

25 Lift out engine.



Installing

Attention!

When installing a new engine because of bearing damage, flush oil tank, oil hoses and oil cooler thoroughly.

26 Check engine mounts, coolant, vacuum, oil and fuel hoses, replacing if necessary.

27 Install and connect engine.

28 Install rear engine mount to be without tension. Adjust propeller shaft (41-020).

29 Check tightness of all drain plugs.

30 Add oils, coolant and refrigerant.

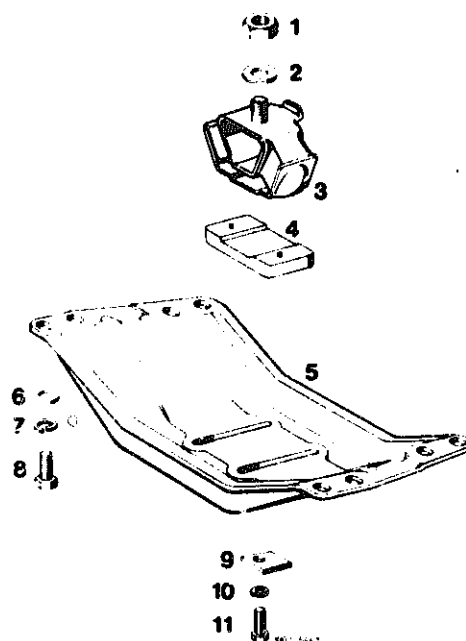
31 Check cooling system for leaks with a leak detector. Check antifreeze content of coolant.

32 On vehicles with auxiliary heater, vent coolant circuit (20-010).

33 Clean air cleaner and renew, if required.

34 Check dwell angle and firing point (15-500).

35 Adjust idle speed and emission value (07.3-100).



1 Nut M 12 x 1.5
2 Washer
3 Engine mount
4 Liner
5 Engine carrier
6 Washer

7 Lock washer
8 Bolt
9 Liner
10 Lock washer
11 Bolt

01-040 Engine breather – description of function

The engine has a closed, maintenance-free crankcase ventilation system. The engine blow-by gases and crankcase vapors flow through the connection tubes in the left cylinder head cover (as seen in driving direction) to the idle air distributor. A breather valve (1) with a 2 mm dia. is installed in the idle air distributor.

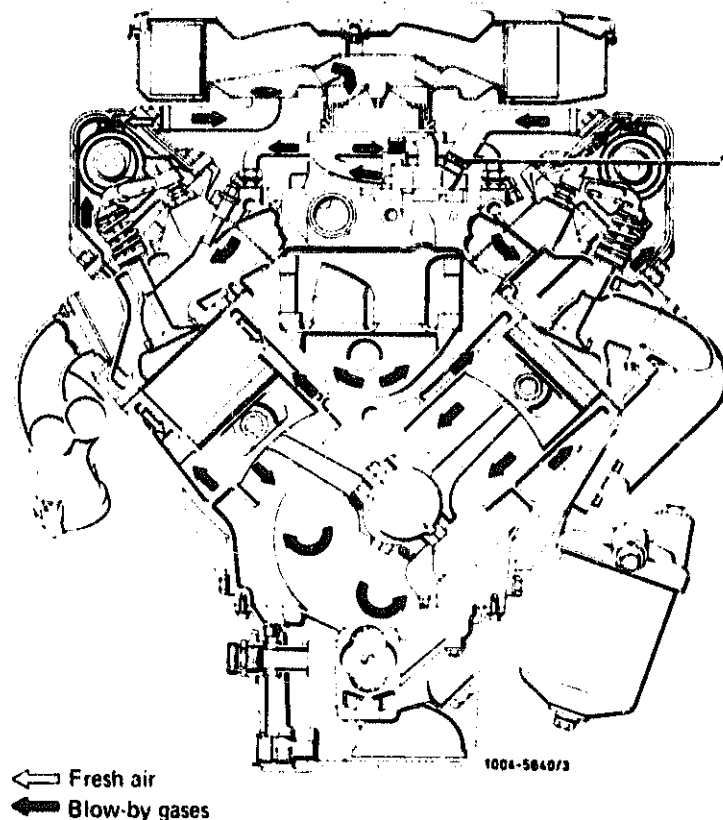
From the breather valve the blow-by gases and crankcase vapors flow together with the idle air to both idle air ducts via a branching tube (one duct for each cylinder bank), which are cast on the intake manifold. From this point they go direct to the intake ducts and continue into the combustion chambers.

The breather line goes from the breather connection of the right-cylinder head cover directly to the clean air side of the air cleaner.

The engine is vented with fresh air from the right bank of cylinders in lower and medium speed ranges by way of intake manifold vacuum, which enters the crankcase via the left breather line. This means that the air cleaner draws in fresh air via the breather line.

There is also ventilation in the upper speed range. The blow-by gases and crankcase vapors flow into the air cleaner and continue into the intake manifolds and combustion chambers via the throttle housings.

To prevent the water from condensation from freezing in the breather valve at low outside temperatures, the idle air distributor is heated by the coolant.



01-110 Measuring, boring and honing cylinder bores

Data

Standard dimension		107.00 107.02
Repair stage		107.50 107.52
Max. wear limit in driving or transverse direction		0.10
Piston clearance	when new	0.015-0.025
	wear limit	0.08
Machining tolerances		
Permissible deviation from cylindrical shape	when new	0.013
	wear limit	0.05
Permissible deviation from square with reference to cylinder height		0.05
Roughness (Rz) after ceramic-finish honing		0.002-0.004
Permissible waviness (Wt)		50 % of roughness
Chamfer of cylinder bores		refer to ill. item 2
Honing angle		50° ± 5°

Note

In addition to a visual checkup, the cylinder bores should be measured particularly when complaints refer to "high oil consumption".

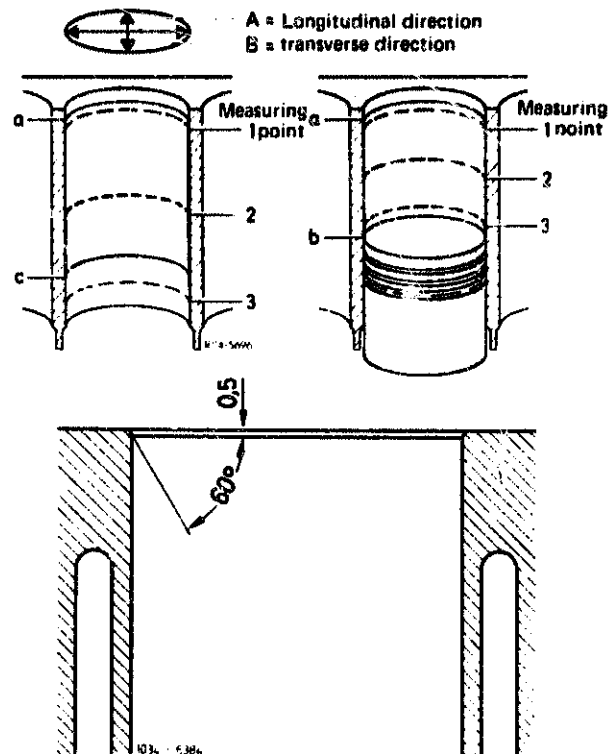
- a Top reversing point of 1st piston ring
- b Bottom dead center of piston
- c Bottom reversing point of oil scraper ring

1 Measure cleaned cylinder bores with an internal measuring instrument at measuring points 1, 2 and 3 in longitudinal direction A (piston pin axis) and in transverse direction B.

With the piston installed, measuring point 3 is located closely above piston, which should be at its BDC

2 The allowance for honing should not exceed 0.05 mm.

Chamfer cylinder bores after boring.

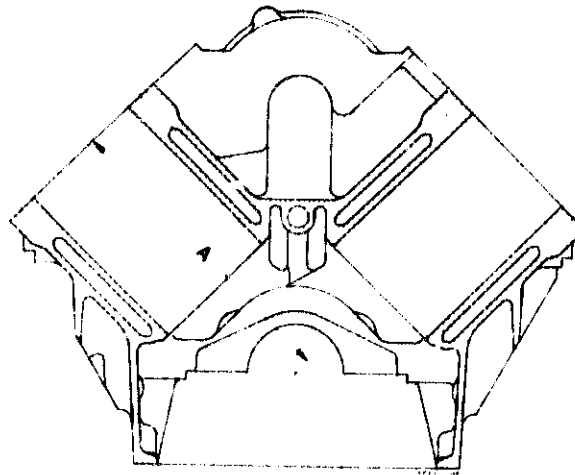


01-120 Facing cylinder crankcase parting surface

Data

Height "A" of cylinder crankcase when new	259.9-260.0		
Min. height following required material removal	259.7		
Permissible deviation from parallel of upper parting surface in relation to crankshaft bearing center	in long. direction	0.10	
	in transv. direction	0.05	
Permissible deviation from flat of upper parting surfaces	0.02		
Average roughness (Rz) of upper parting surfaces	0.012-0.020		
Test pressure with air under water in bar overpressure (atü)	2		
Chamfer of cylinder bores	refer to ill. item 1		
Distance between piston crown and cylinder crankcase parting surface	standard dimension	excess max.	0.25
		recess max.	0.15
	repair stage +0.5	recess max.	1.05
		recess min.	0.65

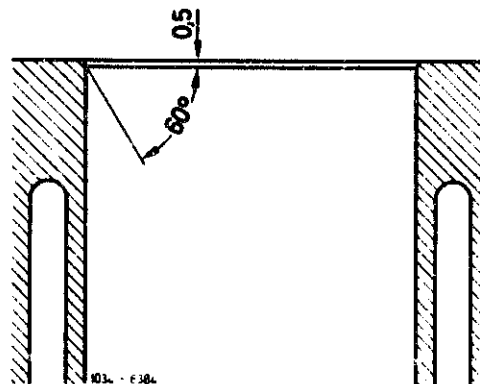
1) Material removal on cylinder crankcase and on cylinder head of one engine may amount together to max. 0.8 mm (refer to 01-418).



Note

Chamfer cylinder bores after facing.




If a cylinder crankcase parting surface has been refinished, adjust timing (05-215).



01-215 Removal and installation of front crankcase cover

Tightening torques	Nm	(kpm)
Clamping nut to crankshaft	400	(40)
Screws pulley to hub	25	(2.5)

Special tools

Detent (starter flange left)		116 589 01 40 00
Torque wrench 3/4" square, 150-500 Nm (15-50 kpm)		001 589 31 21 00
Hub puller		100 589 12 33 00

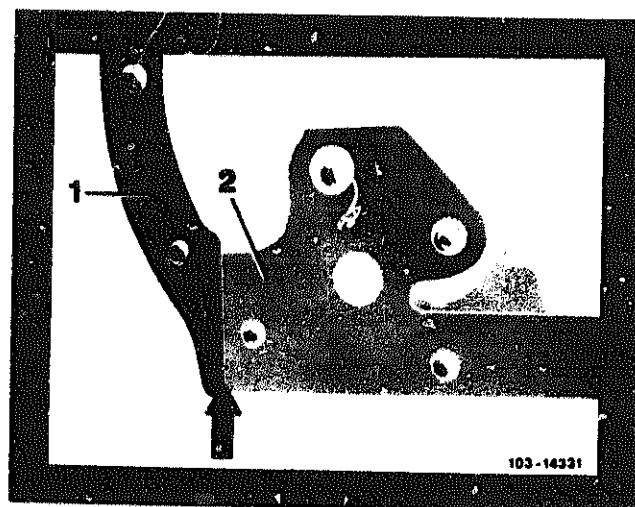
Conventional tools

Extension 75 mm, 3/4" square	e.g. made by Hazet, D-5630 Remscheid order no. 1017-3
Socket 50 mm, 3/4" square	e.g. made by Stahlwille, D-5800 Wuppertal order no. 55

Note

The front crankcase cover is machined and numbered together with crankcase.

If a front crankcase cover has been replaced, fit lower sealing surface of crankcase cover (1) to sealing surface of crankcase (2). Both sealing surfaces should be in alignment without projection, for tight sealing of oil pan (arrow).



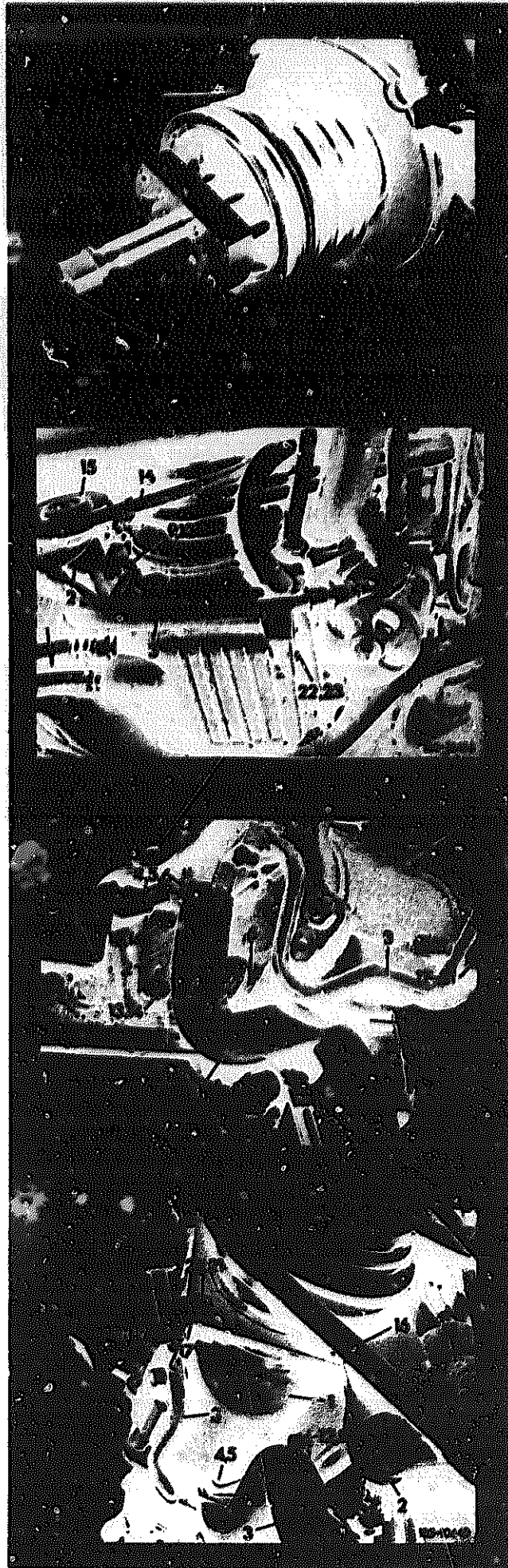
Removing

1 Remove hub, vibration damper and pulley (03-342).

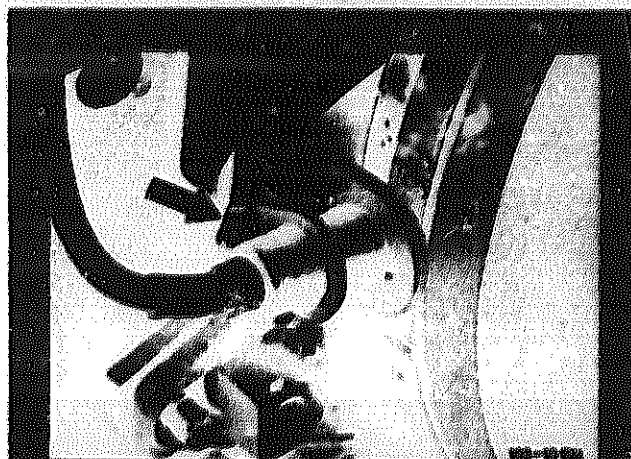
2 Unscrew pipe line (3) on engine.

3 Unscrew mounting bracket with refrigerant compressor. For this purpose, unscrew both screws (13) at the rear.

4 Unscrew mounting bracket with refrigerant compressor. For this purpose, unscrew both screws (12) at bottom.



5 Unscrew hex nut (arrow) and pull out TDC indicator.



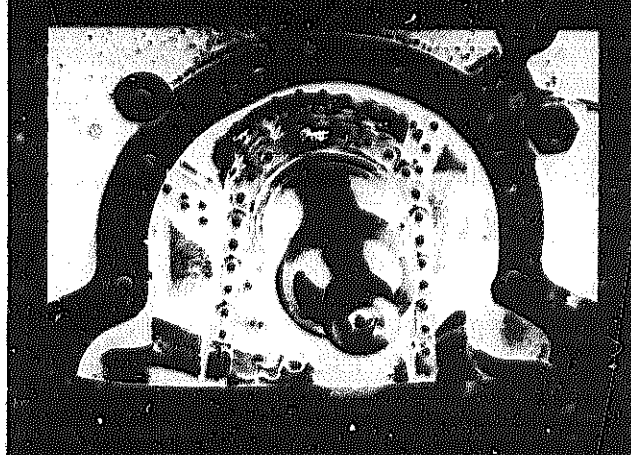
6 Unscrew front crankcase cover and remove.



Installing

7 Clean sealing surfaces on crankcase and oil pan.

8 Coat sealing surfaces with sealing compound.



9 Mount cover, while pushing clamping lever sideways with a screwdriver.

10 Screw on mounting brackets with refrigerant compressor. Screw pipe line to engine.

11 Install hub, vibration damper and pulley (03-342).

Note: When replacing crankcase cover, readjust TDC indicator (03-345).



01-220 Installation and centering of intermediate flange

Data

Permissible concentric runout at fitted shoulder of intermediate flange during one full turn	0.05	
Permissible axial runout at fitted shoulder of intermediate flange during one full turn	0.05	
Fitted bore in intermediate flange for set pins	12.016-12.043	
Set pin dia.	12.007-12.018	
Tightening torques	Nm	(kpm)
Fastening bolts for intermediate flange	65	(6.5)
Necked-down screw for driven plate	50	(5)

Special tools

Dial gauge holder (required 2 each)



383 589 02 21 00

Conventional tools

Connection 1/2" square socket to 3/4" square head

e.g. made by Stahlwille, D-5600 Wuppertal
order No. 514

Socket 50 mm, 3/4" square for rotating engine

e.g. made by Stahlwille, D-5600 Wuppertal
order No. 55

Self-made tool

Threaded bolt

refer to Fig. item 3

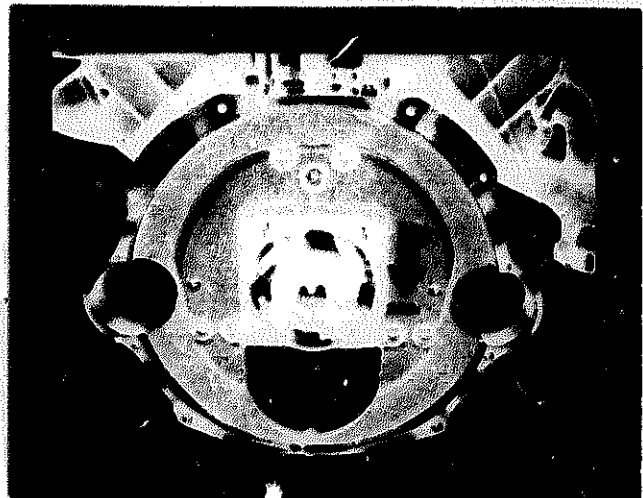
Note

The intermediate flange is fitted to crankcase and marked (arrow).

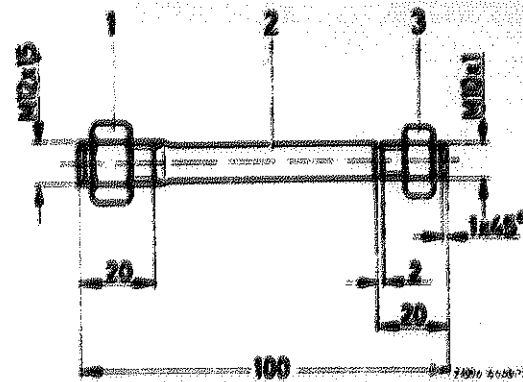
A new intermediate flange must be centered.

1 Insert intermediate flange into set pins (1) on cylinder crankcase.

2 Slightly tighten the six fastening screws.



3 Screw threaded bolts into crankshaft and tighten with counter-nut.



- 1 Hex. nut M 12 x 1.5
- 2 Threaded bolt 10 mm dia.
- 3 Hex. nut M 10 x 1

4 Attach dial gauge holder with dial gauge to threaded bolt.

5 Position feeler pin at pilot bore of intermediate flange for measuring concentric runout or position pilot pin at rest for measuring axial runout.

Set dial gauge to 0 first.

6 Rotate crankshaft with tool combination in direction of rotation each time for one complete turn. Concentric runout or axial runout should not exceed 0.05 mm. That is, the total deflection of needle should not exceed max. 0.05 mm. If axial runout exceeds 0.05 mm, replace intermediate flange.

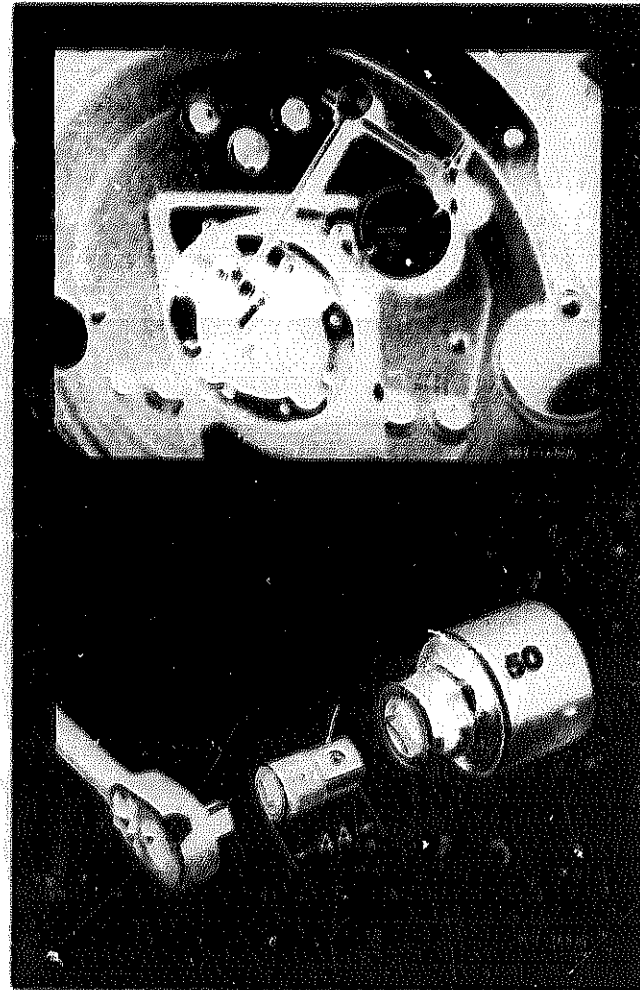
Note: When rotating crankshaft, make sure that the feeler pin of the dial gauge is not getting stuck.

7 Correct concentric runout by means of light blows against intermediate flange.

8 Tighten fastening screws to 65 Nm (6.5 kpm).

Note: If concentric runout exceeds 0.10 mm, remove intermediate flange.

9 Increase both fitted bores in intermediate flange to 12.1 mm.



01-310 Complete removal and installation of oil pan



Oil capacity in liters

Total capacity	11
Oil filter	1.3

Tightening torques

	Nm	(kpm)
Oil drain plug to oil pan	50	(5)
Connecting flange to oil pan	25	(2.5)

Special tools

Combination socket-box wrench 14 x 13 mm		117 589 02 07 00
Pin spanner 5 mm, 300 mm long		116 589 02 07 00
Pin spanner 6 mm, 440 mm long		116 589 03 07 00

Note

The oil pan can be removed in forward direction after lifting engine.

The oil pan is sealed toward cylinder crankcase by means of sealing compound.

Removal

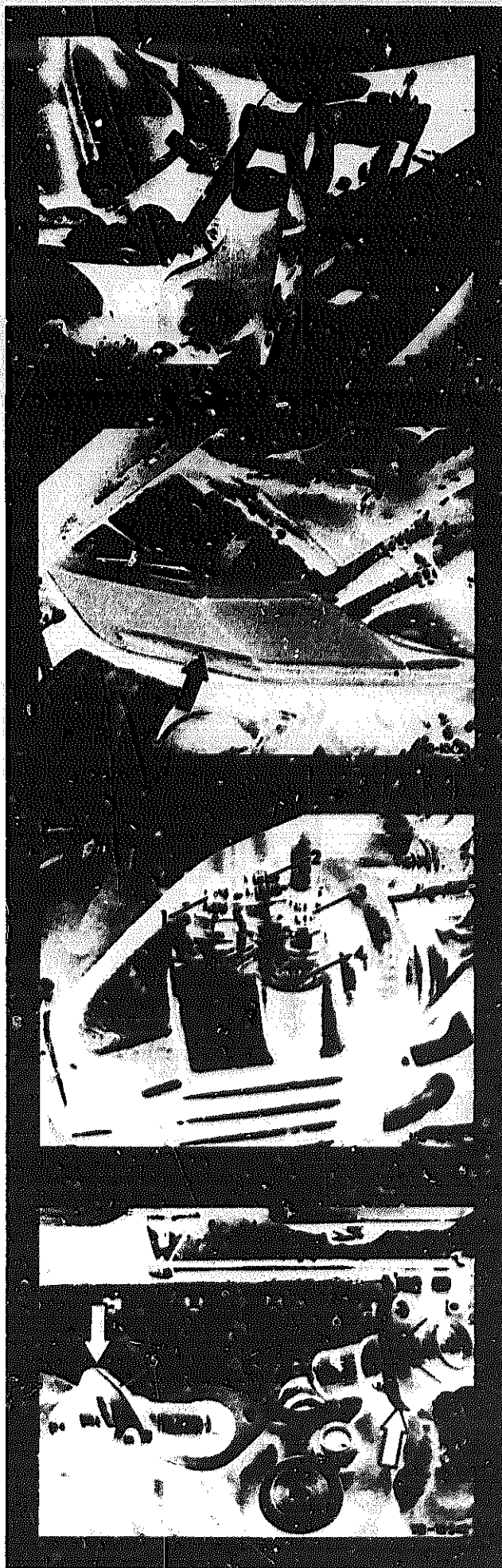
- 1 Remove engine hood.
- 2 Drain coolant and remove upper coolant hose.
- 3 Remove air filter.

- 4 Remove longitudinal regulating shaft.
- 5 Loosen cooler frame.
- 6 Loosen gear oil lines on transmission and on cooler.
- 7 Loosen lower oil line on air-oil cooler.
- 8 Drain engine oil.

9 Remove guard plate.

10 Unscrew oil hoses (1, 2 and 3).

11 Remove connecting flange (5) and (6).



12 Remove refrigerant compressor and pipe line (83-519).

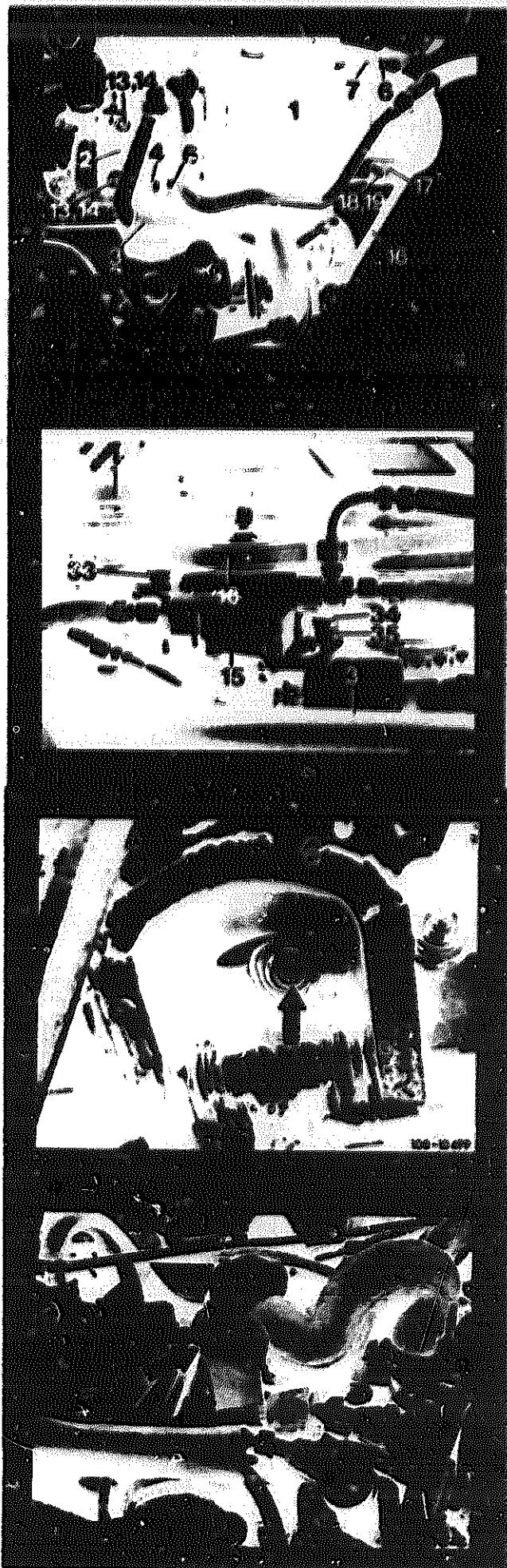
13 On USA vehicles, remove gear oil pump with holder.

14 Loosen fastening bolts on front engine carriers.

15 Loosen engine damper on cross member.

16 Unscrew oil pan.

17 Lift engine at front eye until oil pan can be removed.



Installing

18 Clean parting surface and coat oil pan with sealing compound.

19 Replace O-rings and gaskets of connecting flanges.

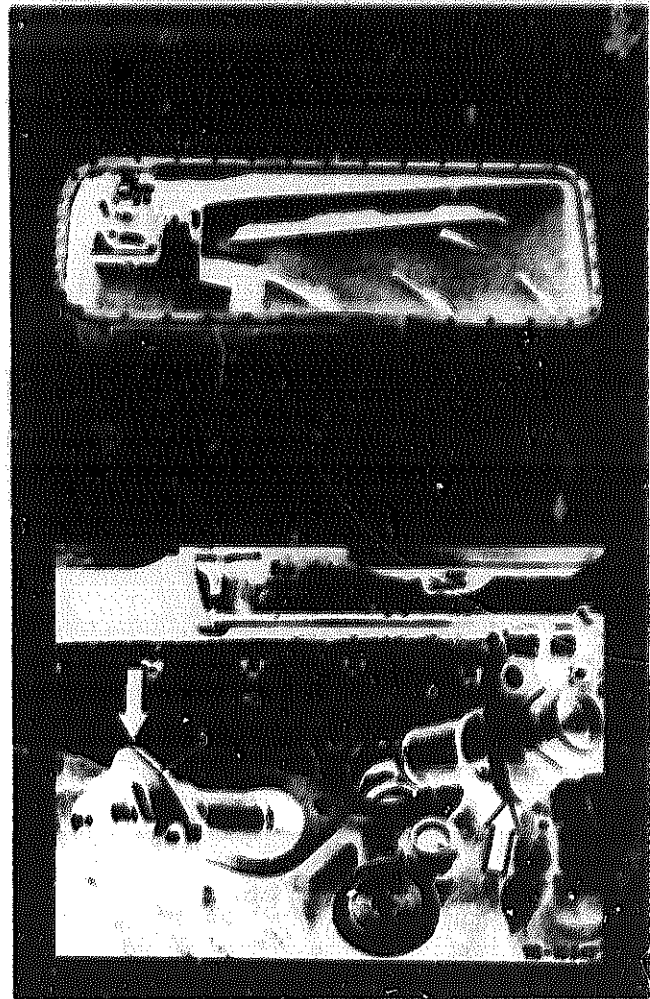
Attention!

Do not mix up connecting flanges and do not install in turned around position.

20 For further installation proceed vice versa to removal.

Attention!

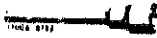



Check regulating shaft for correct function.



01-415 Removing and installing cylinder head

Tightening torques			Nm	(kpm)
Cylinder head bolts	Engine cold	1st step	40	(4)
		2nd step	90	(9)
	Control at 80 °C coolant temperature		90	(9)
Cylinder head cover nuts			15	(1.5)
Camshaft sprocket mounting bolts			100	(10)
Chain tensioner threaded ring			40	(4)
Chain tensioner plug			50	(5)

Special tools

Allen wrench insert 10 mm, 1/2" square, 140 mm long		000 589 05 07 00
Allen wrench 6 mm, 440 mm long		116 589 03 07 00
Bearing pin extractor (basic equipment)		116 589 20 33 00
Threaded pin 6 x 100 mm (for 116 589 20 33 00)		116 589 02 34 00

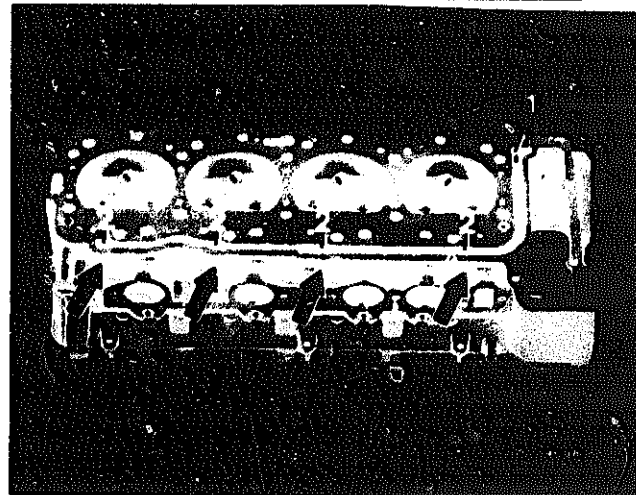
Conventional tools

Screwdriver insert 17 mm	e.g. Hazet, D-5630 Remscheid, Order No. 985-17
Screwdriver insert 19 mm	e.g. Hazet, D-5630 Remscheid, Order No. 985-19
Socket screw wrench socket 10 mm, 1/2" square 60 mm long, for fillister head bolts	e.g. Stahlwille, D-5600 Wuppertal, Order No. 54/10

Notes

Cylinder heads of **AUS** and **USA** version differ from standard version by the air injection duct (1) and the air injection bores (2).

Cylinder head, right
AUS and **USA** version



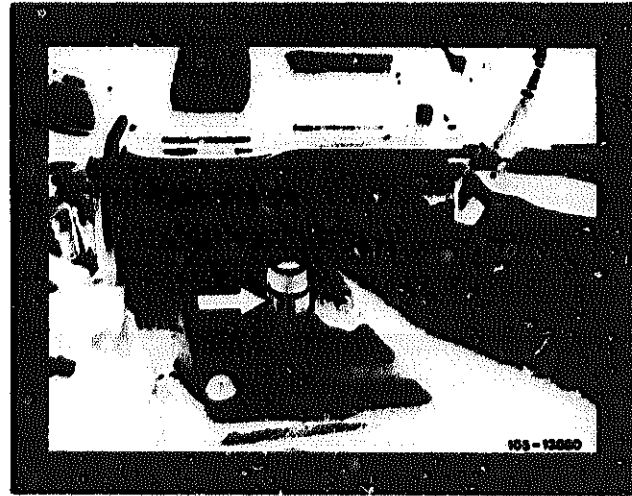
Remove cylinder heads with cooled-down engine only.

Face cylinder head parting surface only in the event of porous or damaged spots. A slightly distorted parting surface will adapt itself automatically again when cylinder head is tightened.

Each cylinder head is located in relation to cylinder crankcase by means of 2 fitted sleeves (dowel sleeves) in relation to cylinder crankcase and is fastened to cylinder crankcase by means of 18 cylinder head bolts, 6 each per cylinder bore.

Starting with engine end No. 001285 the cylinder head bolt at front left (arrow) is mounted with a spacing sleeve 13 mm high instead of washer 3 mm high.

If on these engines the spacing sleeve 13 mm high is not used, the thread base may be driven out in direction of coolant space.



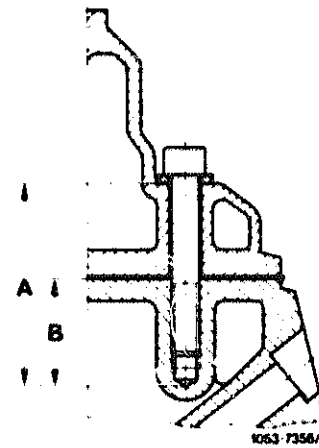
If in doubt, measure depth of thread dimension B.

Up to engine end no. 001284:

Dimension A = 85 mm

Dimension B = 45 mm

Mount cylinder head bolt with washer 3 mm high, part No. 110 016 03 76.

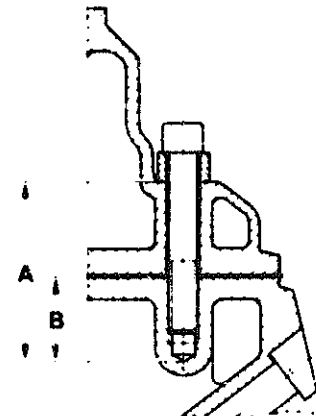


Starting engine end No. 001285:

Dimension A = 75 mm

Dimension B = 35 mm

Mount cylinder head bolt with spacing sleeve 13 mm, part No. 100 016 00 53.



Removal

- 1 Drain coolant from radiator and cylinder crankcase.

Attention!

The drain plugs (arrow) are located at right and left on engine block and should not be mixed up with crankshaft bearing bolts underneath.

- 2 Remove battery and battery frame.

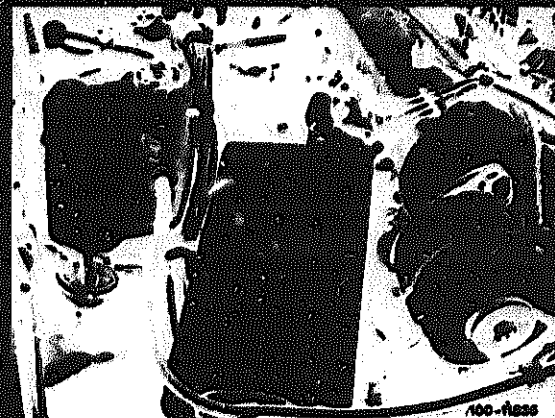
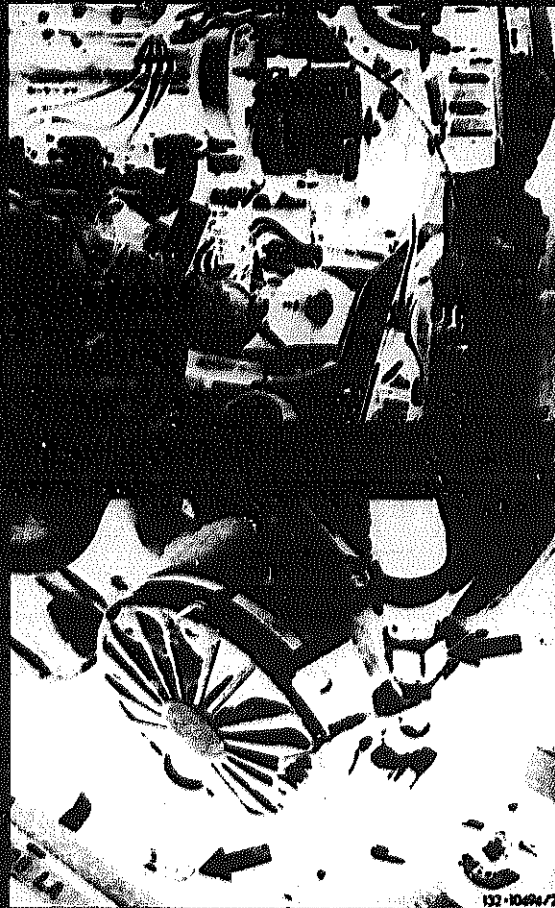
- 3 Remove fan and radiator shell.

- 4 Lefthand cylinder head: Disconnect lines (arrows) on pressure oil pump.

- 5 Righthand cylinder head: Remove alternator with carrier.

- 6 Righthand cylinder head: Remove supply tank for windshield washer with holder.

- 7 Righthand cylinder head: Loosen oil dipstick guide tube for automatic transmission on cylinder head.



8 Disconnect fuel feed and return line (arrows).



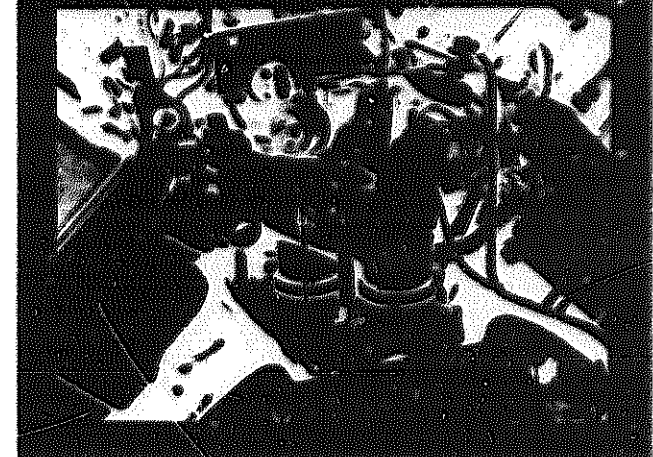
9 Disconnect regulating linkage.



10 Remove longitudinal regulating shaft (arrow).



11 Unscrew guide lever with cruise control cables and gate lever.



12 Loosen injection lines on injection valves and on warm-up compensator.

13 Remove mixture controller with lower half by loosening nuts (arrows).

14 Remove contoured hose (arrows).

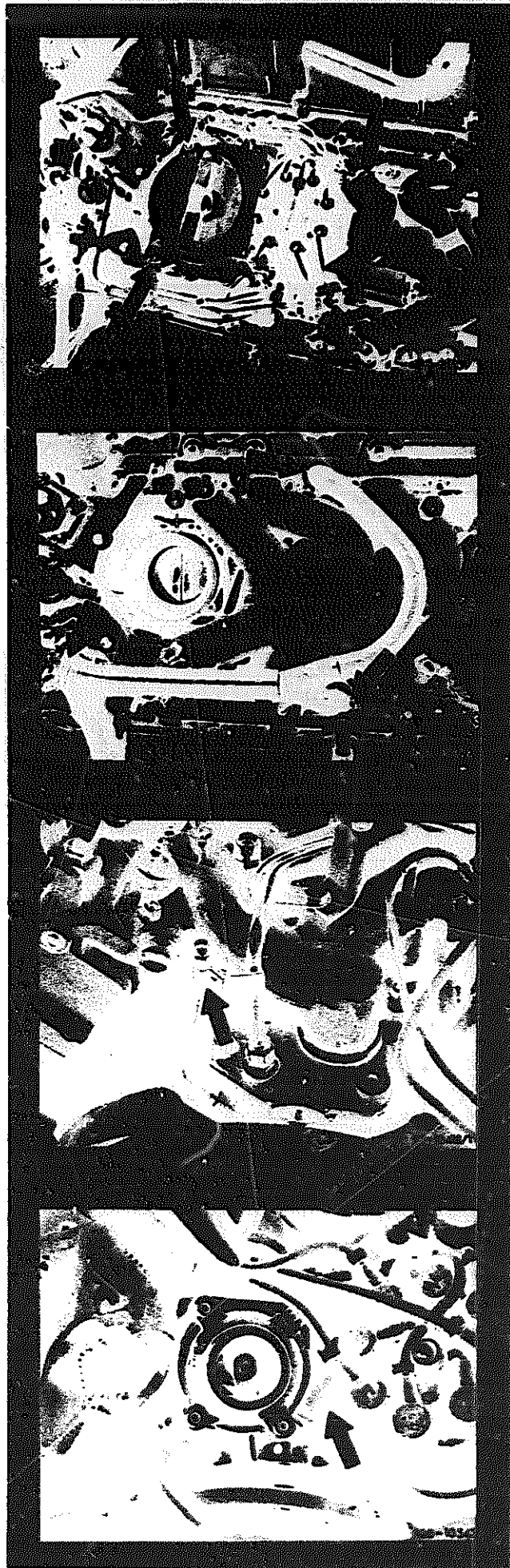
15 Remove injection valves. Cover bores in cylinder heads.

16 Loosen connection oil pressure gauge. Unscrew holder for oil pipe (arrow).

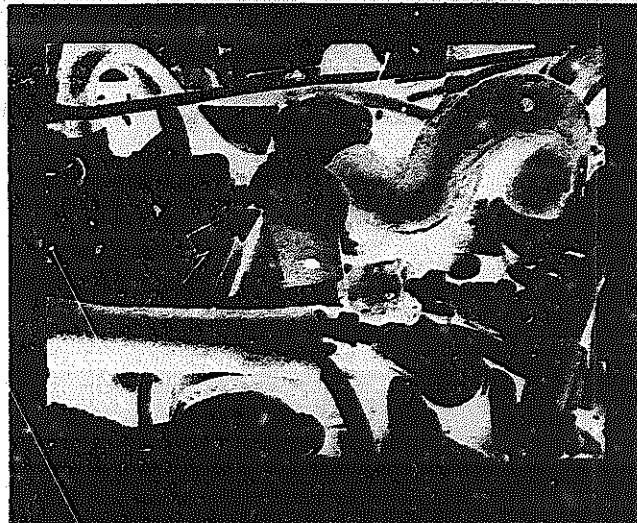
17 Loosen hot water hoses at rear on intake pipe and on coolant pump.

18 Loosen all electric lines. Pull off vacuum lines.

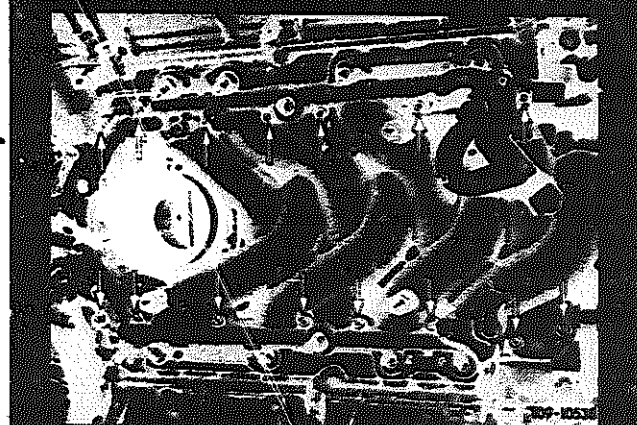
19 Remove thermostat housing.



20 Unscrew front suspension eye (arrow).



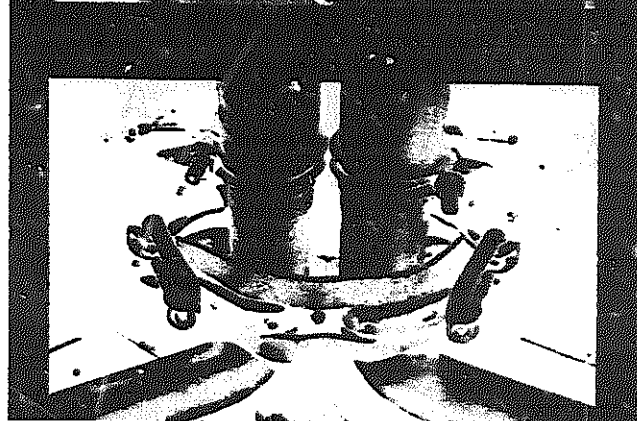
21 Remove intake pipe by unscrewing screws (arrows).



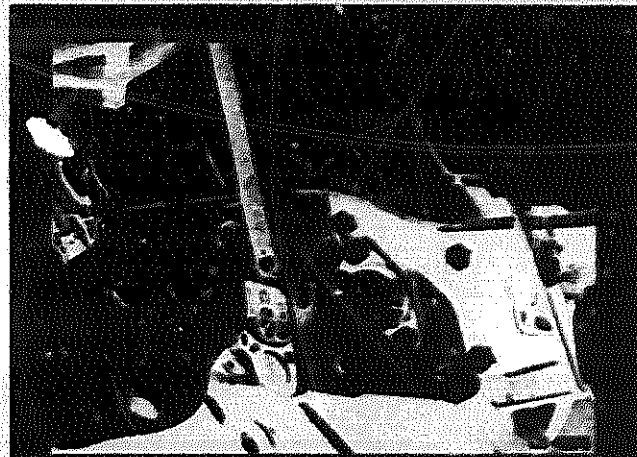
22 Unscrew exhaust pipe on exhaust manifold. Screw righthand upper and lefthand lower threaded pin out of exhaust manifold. Starting chassis end No. 001 755, hex. bolts M 8 x 50 are used instead of studs.



23 Remove holding rubber.

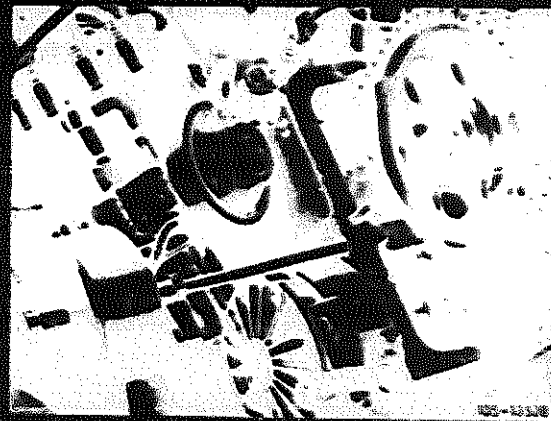


24 Remove compression spring of chain tensioner by unscrewing screw connection.



25 Lefthand cylinder head: Remove outer slide rail.

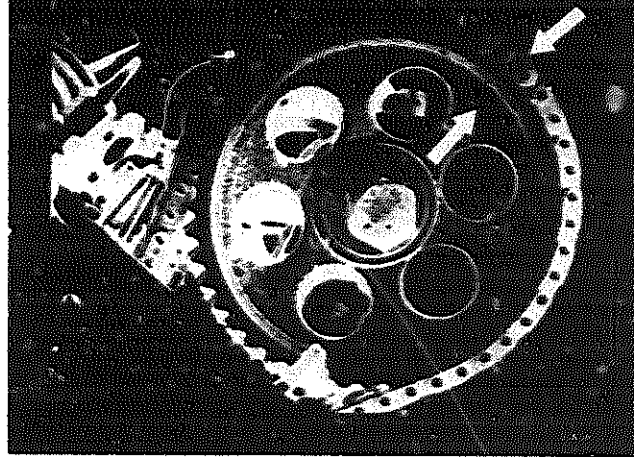
Righthand cylinder head: Remove slide rail.



26 Mark camshaft sprockets and timing chain in relation to each other.

Attention!

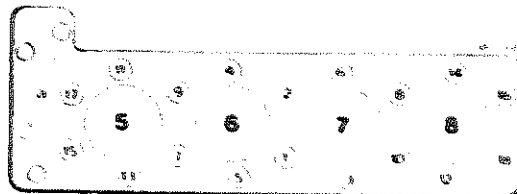
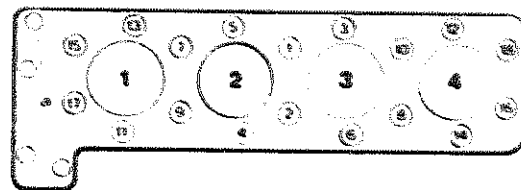
Remove camshaft sprockets carefully without using force. Let timing chain drop.



27 Unscrew cylinder head bolts vice versa to rightening diagram.

Attention!

To loosen cylinder head bolts No. 12 and 18 on left-hand cylinder head, lift engine on transmission.

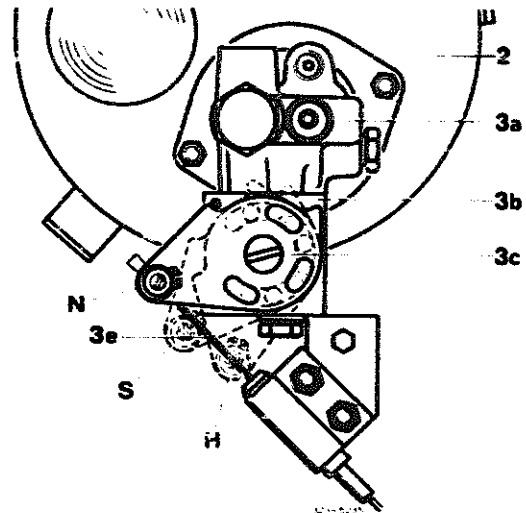
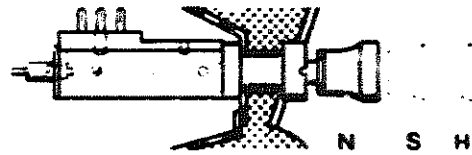


For this purpose, set level control switch to S = locking position (1st detent pulled).

Pull up all cylinder bolts which cannot be pulled out and tie down.

Remove M 8 bolts and washers in chain box with a magnet.

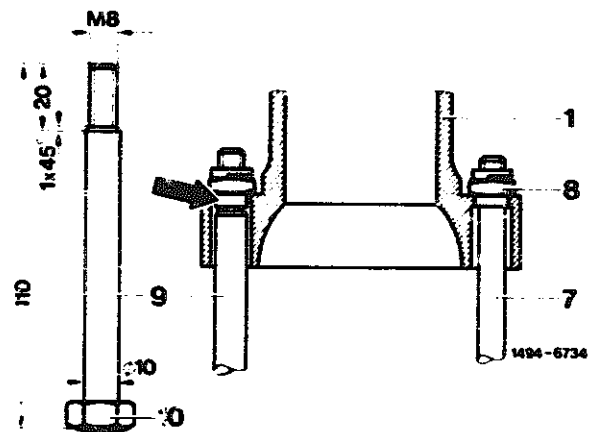
28 Remove cylinder head at an angle in upward direction.



Installation

29 Knock out old rivet nuts in exhaust manifold and install new rivet nuts with a self-made assembly screw (10) (arrow).

30 Thoroughly clean cylinder head and cylinder crankcase parting surface.



Attention!

Mount cylinder head, lift and only then install new cylinder head gasket. Two hollow set pins in crankcase serve to locate cylinder head.

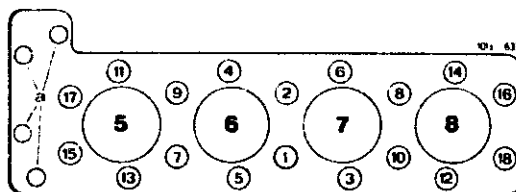
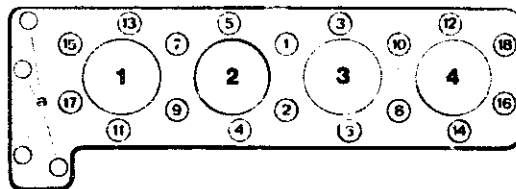
31 Lubricate cylinder head bolts on threads and on head contact surface.

32 Tighten cylinder head bolts in steps and in sequence of tightening diagram, starting with 1, first to 40 Nm (4 kpm) and then to 90 Nm (9 kpm).

Attention!

Pay attention to length of bolts, refer to note.

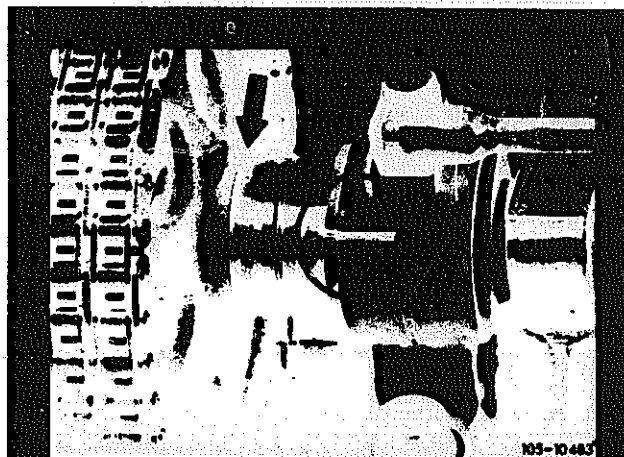
33 Tighten M-8 bolts (a) to 25 Nm (2.5 kpm).



Attention!

Check camshaft sprockets at keyway for cracks and replace, if required.

34 Mount camshaft sprocket together with timing chain. Check position of camshaft sprocket. The wide flange on camshaft sprocket (arrow) should face camshaft.



35 Mount slide rails. Check installation position (arrows).

36 Mount chain tensioner compression spring.

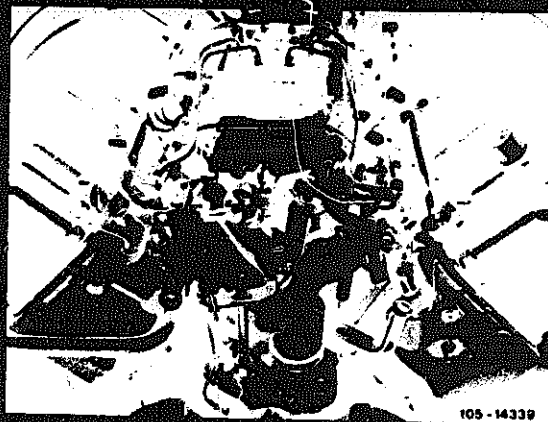


37 Mount intake pipe with new gasket.

38 For further installation proceed vice versa.

Attention!

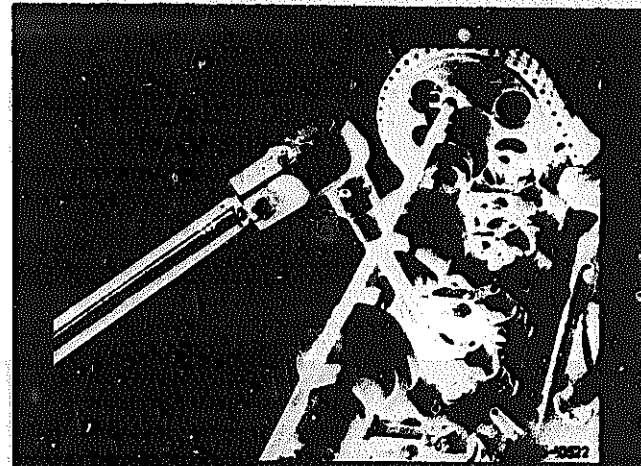
Fill-in coolant with antifreeze up to -30°C (-22°F). Use anti-corrosion oil (treating agent) only when no antifreeze is used.



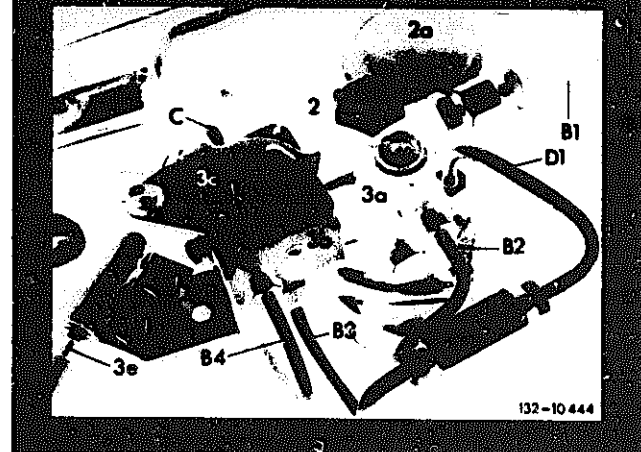
39 Run engine warm.

40 Slightly loosen cylinder head bolts individually and retighten in sequence of tightening diagram starting at 1 to 90 Nm (9 kpm).

Note: Cylinder head bolts are not retightened after 500–1000 km since the cylinder head gaskets require no retightening.



41 Disconnect pressure line B 1 and hold into oil supply tank. Run engine until oil comes out uniformly at pressure line B 1. Stop engine, connect pressure line B 1.



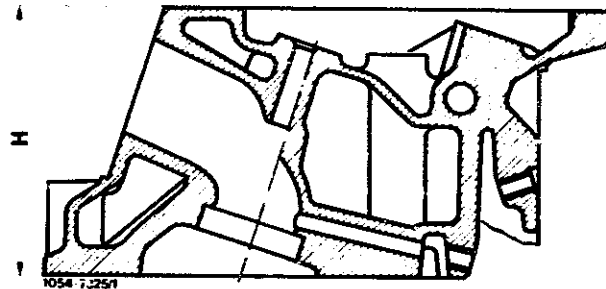
01-418 Machining cylinder head mating surface

Data

Total height H of cylinder head 110.4-110.6

Min. height H after machining 109.9¹⁾

¹⁾ The material removal on cylinder head and on cylinder crankcase of one engine should together not exceed max. 0.8 mm (refer to 01-120).



Combustion chamber volume in cylinder head with intake and exhaust valves mounted and spark plug screwed-in

89.2 + 15 cm³
- 10

Permissible deviation from flat of parting surface

in longitudinal direction 0.08

in lateral direction 0.0

Max. deviation from parallel between upper and lower mating surface in longitudinal direction

0.1

Surface peak-to-valley depth

0.006-0.014

Pressure test with air underneath water in bar

2

Min. distance A with new valves and new valve seats

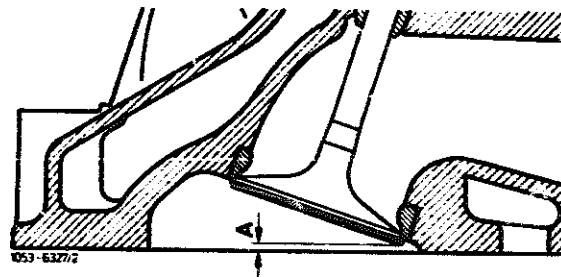
Intake 2.9

Exhaust 3.1

Max. distance A with new valves and machined valve seats

Intake 3.8

Exhaust 4.0



Minimum distance between valves and pistons with cylinder head mounted

intake 4° after TDC 3.56
exhaust 3° before TDC 3.98

Conventional tools

Surface grinding machine with milling fixture for light alloy surface

e.g. Scledum, type RTY
made by Ruaro u. Fi., Schio, Italy

Straightedge approx. 500 mm long

Note

Face cylinder head parting surface only if porous or damaged spots are showing up.

If an arched, distorted cylinder head is not clamped down tightly for facing, the camshaft may subsequently bind. In such a case, face cylinder head also at surface.

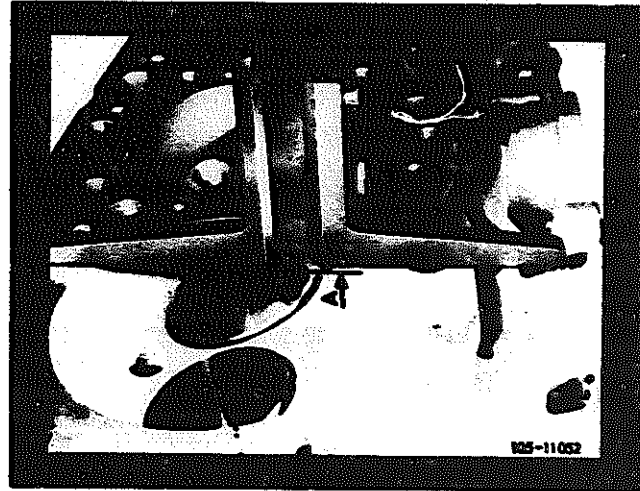
Machining

1 Machine cylinder head mating surface.

2 Measure distance A.

3 Machine valve seats until minimum distance A is reached.

Note: If a cylinder head has been faced, check timing.



01-420 Pressure testing cylinder head

Data

Test pressure with air underneath water in bar

2

Special tools

Pressure test plate



100 589 01 25 00

Suspending device



115 589 34 63 00

Conventional tool

Electrically heated sink

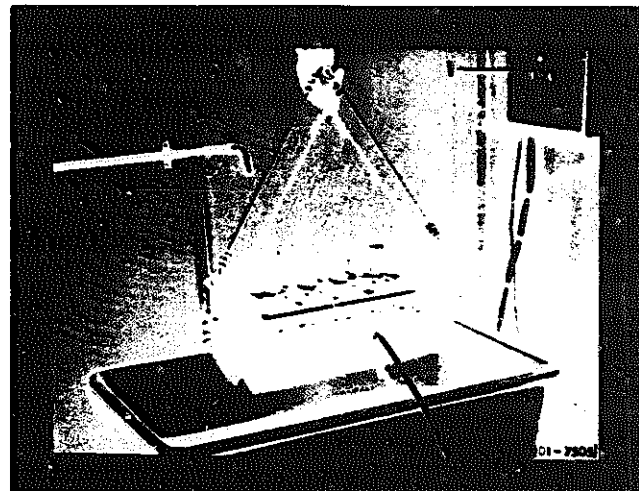
e.g. Otto Dürr, D-7123 Sachsenheim-Ochsenbach

Pressure testing

The cylinder head must be pressure tested, if cracks (water loss) are suspected.

- 1 Bolt pressure test plate on cleaned cylinder head.
- 2 Plug bores and connections.
- 3 Connect air pressure line and regulate pressure to 2 bar.
- 4 Lower cylinder hanging from suspending device into heated (80 °C = 176 °F) water.
- 5 Find leaks, if air bubbles rise.

01.5-420/1 F 3



03-310 Checking, renewing and tightening of connecting rod bolts

Dimensions of connecting rod bolt

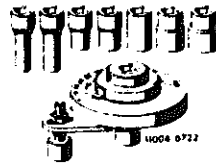
Part Number	Thread dia. d	Necked-down shank dia. c when new (ill. item 1)	Min. necked-down shank dia. c	Dimension a and b (ill. item 1)	
				a	b
116 038 04 71	M 10 x 1	8.4-0.1	8.0	6.6	4.5

Tightening connecting rod nuts

Initial torque	40-50 Nm (4-5 kpm)
Angle of rotation torque	90-100°

Special tool

Angle of rotation wrench



116 589 01 13 00¹⁾

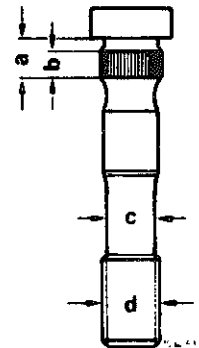
¹⁾ Special tool is no longer supplied; in this connection, refer to note following item 5.

Self-made tool

Steel plate refer to ill. item 3

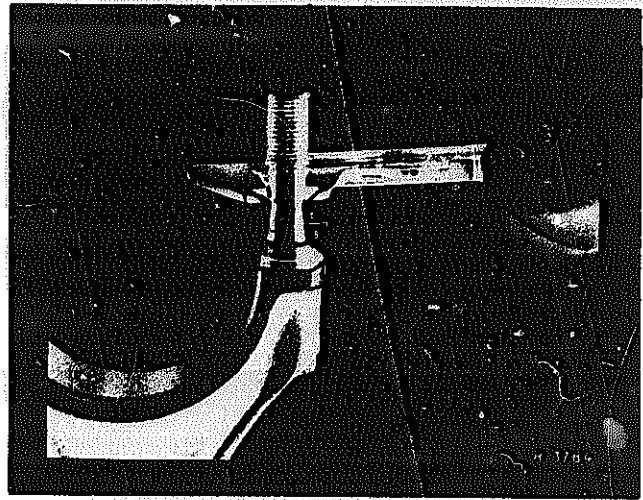
Checking

1 Prior to re-use, measure smallest necked-down shank dia. c.



Note: When the minimum necked-down shank dia. c. shown in Table is attained, renew connecting rod bolt.

Knock out connecting rod bolts only when they are about to be replaced.

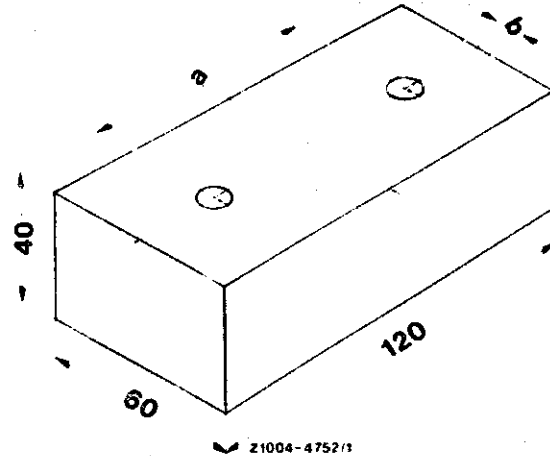


Replacing

- 2 Knock out connecting rod bolts.
- 3 Press new connecting rod bolts into connecting rod at approx. 45,000 N (4,500 kp) or knock in with a hammer and mandrel.

When knocking or pressing in connecting rod bolts, place connecting rod on a ground steel plate.

Hole spacing a = 71 mm
Bore b = 11 mm



Tightening

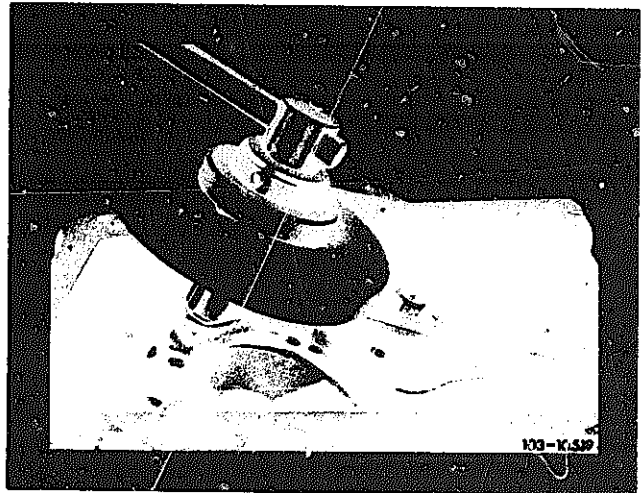
- 4 Lubricate nuts and bearing surface.
- 5 Tighten connecting rod nuts to 40–50 Nm (4–5 kpm) initial torque and then to 90–100° angle of rotation torque.

Attention!

Tighten connecting rod bolts knocked in with a hammer for the first time to 60–70 Nm (6–7 kpm) initial torque and then to 90–100° angle of rotation torque.

These instructions must be fully observed, since otherwise the nuts of the connecting rod bolts might become loose.

Note: If no angle of rotation wrench is available, the nut can also be tightened by means of a normal socket wrench and tommy bar to the specified angle in a single operation. This requires estimating the angle of rotation as accurately as possible. To eliminate a wrong angle, do not use a torque wrench for final tightening according to angle of rotation.



03-313 Repairing and squaring connecting rods

Data

Conrod bore centerline to conrod bushing centerline	165.95
	166.05
Width of conrod at conrod bearing bore and at conrod bushing bore	25.89
	25.86
Conrod bearing shell standard bore	58.60
	58.62
Conrod bushing standard bore	29.00
	29.02
Conrod bushing inside dia.	26.007
	26.013
Inside conrod bushing surface peak-to-valley height	0.002
Max. offset of conrod bearing bore to conrod bushing bore at length of 100 mm	0.1
Max. deviation from parallel between conrod bearing bore and conrod bushing bore at length of 100 mm	0.04
Max. difference in weight of all connecting rods in one engine	4 grams

Tightening torques

Conrod bolt	Initial torque	40-50 Nm (4-5 kpm)
	Torque angle	90-100°

Conventional tool

Conrod straightener	e.g. Model BC 503, Hahn & Kolb, D-7000 Stuttgart
---------------------	--

Note

Conrods, which were overheated due to shot bearings (blue discoloration), may not be reused.

Connecting rod shaft must not show any lateral scoring or notches.

Connecting rods with machined bushings are available as replacement parts.

- 1 Weight balancing
- 2 Oil bore
- 3 Lock grooves

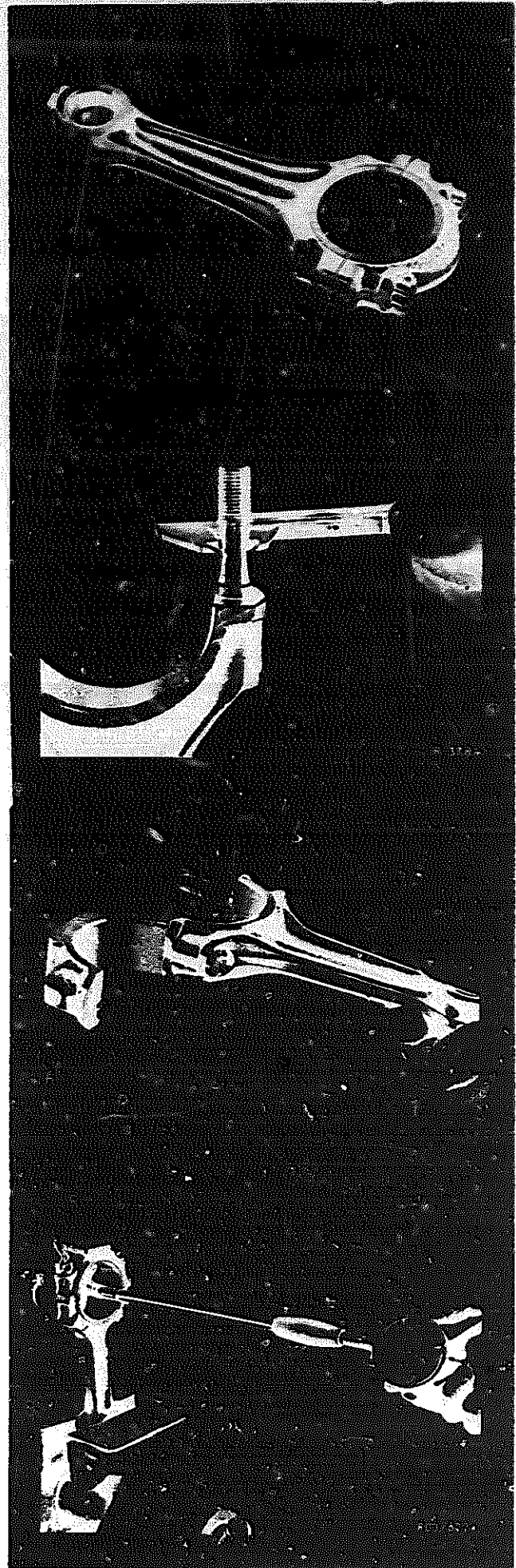
Repairing

1 Check conrod bolts, replacing if necessary (03-310).

2 Check bores for connecting rod bolts. Place connecting rod bearing cap on a connecting rod bolt. If connecting rod bearing cap moves downwards under its own weight, replace connecting rod.

3 Mount connecting rod bearing cap and tighten connecting rod nuts to 40-50 Nm (4-5 kpm) initial torque and 90-100° angle of rotation torque.

4 Check conrod bore size. If a standard bore exceeds the specified value or is conical, grind up to max. 0.02 mm off of conrod cap's bearing surface on a surface plate.

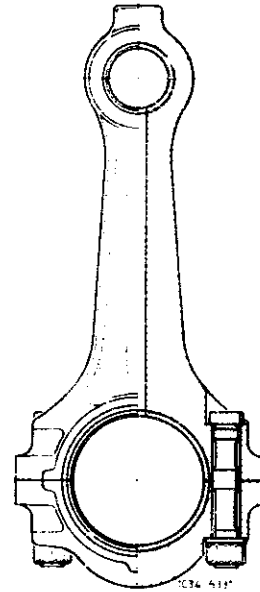


5 Install new conrod bushing that the oil bores align with each other. Minimum pressure for installing is 2500 N (250 kp).

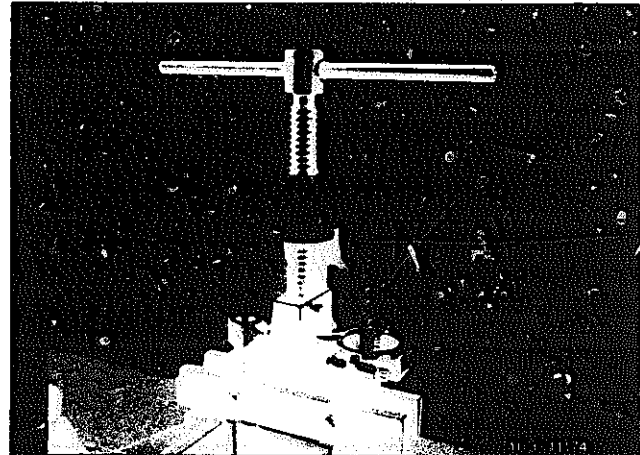
6 Turn or ream conrod bushing.

7 Grind side bearing surface of conrod on surface plate.

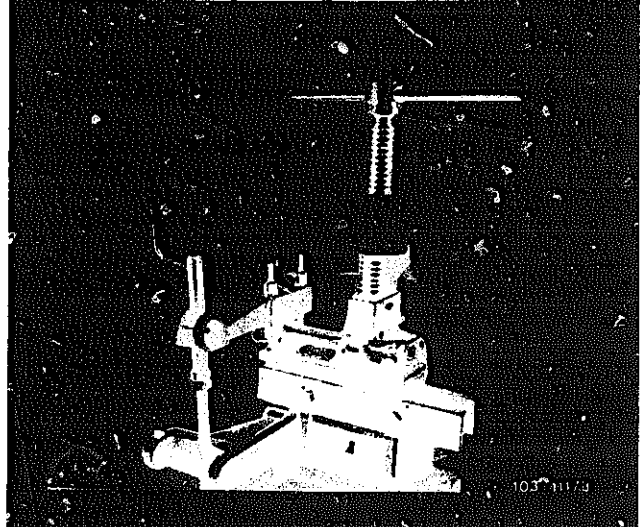
8 Square conrod with conrod tester.



9 Align conrod bearing bore parallel to conrod bushing bore.



10 Correct offset between conrod bearing bore and conrod bushing bore.




03-316 Removal and installation of piston

Data

Piston		standard dimension Std					
Group number	0	0 +	1	1 +	2	2 +	
Piston dia.	<u>106.983</u>	<u>106.988</u>	<u>106.993</u>	<u>106.998</u>	<u>107.003</u>	<u>107.008</u>	
	<u>106.978</u>	<u>106.983</u>	<u>106.988</u>	<u>106.993</u>	<u>106.998</u>	<u>107.003</u>	
Cylinder dia.	<u>106.998</u>	<u>107.004</u>	<u>107.009</u>	<u>107.014</u>	<u>107.019</u>	<u>107.024</u>	
	<u>107.003</u>	<u>107.008</u>	<u>107.013</u>	<u>107.018</u>	<u>107.023</u>	<u>107.028</u>	

Piston		repair stage + 0.5		
Group number ¹⁾	0	1	2	
Piston dia.	<u>107.483</u>	<u>107.493</u>	<u>107.503</u>	
	<u>107.478</u>	<u>107.488</u>	<u>107.498</u>	
Cylinder dia.	<u>107.498</u>	<u>107.509</u>	<u>107.519</u>	
	<u>107.503</u>	<u>107.513</u>	<u>107.523</u>	

¹⁾ Exchange engines are manufactured with 6 group numbers (0, 0+, 1, 1+, 2, 2+).

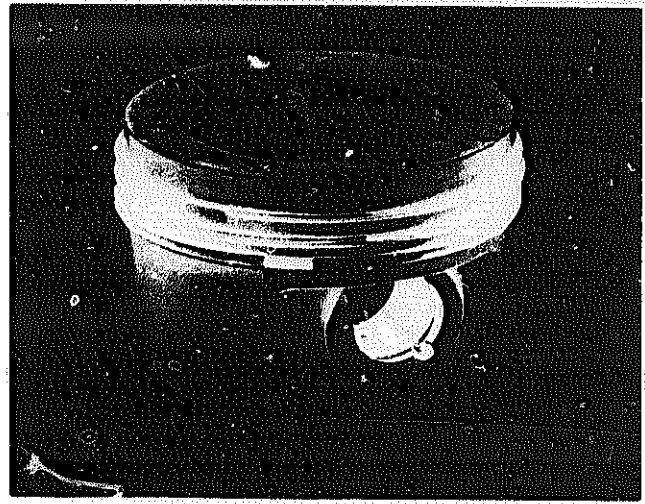
Engine	Piston code number		Piston crown refer to illustration	Distance between piston crown and cylinder crank-case parting surface		Compression $\epsilon : 1$
	Std	+ 0.5		Std	+ 0.5	
100.985	70 ¹⁾ 68 ²⁾ 74 ³⁾	71 ¹⁾ 69 ²⁾ 75 ³⁾	Cavity 2.65 mm deep d = 80 mm	Excess max. 0.25 Recess max. 0.15	Recess max. 1.05 min. 0.65	8.8 : 1 8.6 : 1 ⁵⁾
	74 ⁴⁾	75 ⁴⁾	Cavity 3.9 mm deep d = 80 mm			8.4 : 1
100.985 Low compression	76	77 ⁶⁾	Cavity 7.45 mm deep d = 82 mm			7.5 : 1
100.985 	72	73	Cavity 5.6 mm deep d = 80 mm			8.0 : 1

- ¹⁾ Version 1, cavity in piston crown eccentrically located.
- ²⁾ Version 2, piston pin 1.3 mm off center.
- ³⁾ Version 3, piston pin 1.5 mm off center, starting engine 000597.
- ⁴⁾ Version 4, depth of cavity modified and centrally located, starting engine 001452 (7/76).
- ⁵⁾ Intermediate version.
- ⁶⁾ Starting engine 002309 (2/77).

Note

The piston version **Std** or **+0.5**, the group number **0**, **0+**, **1**, **1+**, **2** or **2+**, the piston code number, for example **74** and the directional arrow are punched into piston crown.

Pistons with repair stage **+0.5 mm** are supplied only with group numbers **0**, **1** and **2**.



	When new	Wear limits	
Piston clearance	0.015 to 0.025	0.08	
Piston pin dia.	25.99–26.00		
Piston pin clearance in connecting rod bushing	0.007–0.017		
Piston pin in piston	0.003–0.011		
Difference in weight of pistons in one engine	4 g	10 g	
Gap clearance of piston rings	Groove I	0.40–0.60	1.0
	Groove II	0.40–0.60	0.8
	Groove III	0.30–0.45	0.8
Side clearance of piston rings	Groove I	0.04–0.06	0.15
	Groove II	0.02–0.04	0.08
	Groove III	0.02–0.04	0.08

Tightening torques

Connecting rod nuts

Initial torque 40–50 Nm (4–5 kpm)

Angle of rotation torque 90–100°

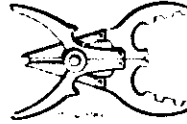
Special tools

Piston ring compressor



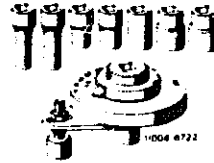
000 589 04 14 00

Piston ring pliers



000 589 51 37 00

Angle of rotation wrench



116 589 01 13 00¹⁾

¹⁾ Special tool no longer available. In this connection, refer to job No. 03-310: Checking, renewing and tightening of connecting rod bolts.

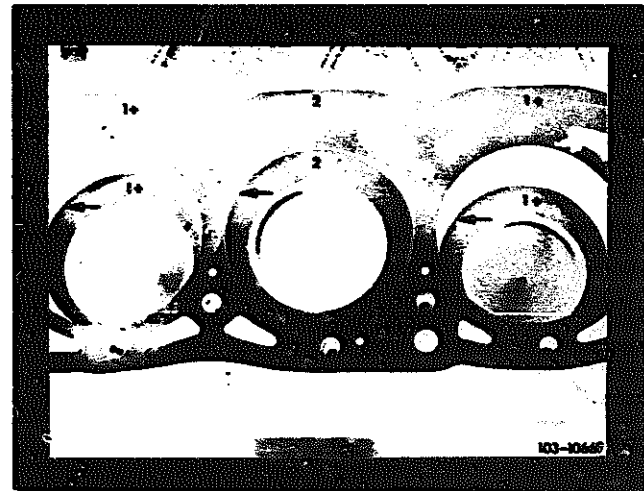
Note

The piston group number (e.g. 1 +) agrees with the cylinder bore group number.

The specified piston play is given in this manner.

When repairing, the cylinder bores can be honed according to the dimensions of the existing pistons plus the piston play (see chart).

Piston and piston pins are paired in relation to each other.



Removing

- 1 Take out conrod with piston from above.
- 2 Remove piston pin retainer and press out piston pin.
- 3 Repair and square conrod (03-313).

Installing

4 Check end gap and axial clearances of rings on run pistons.

5 Lubricate piston pin and conrod bushing.

6 Install piston that arrow faces forward in driving direction and lock grooves (3) in conrod toward center of engine.

Install pistons with eccentric recess (1st version) that wide edge faces center of engine.

1 Conrod bearing surface
3 Lock grooves for bearing tabs

7 Press in piston pin by hand.

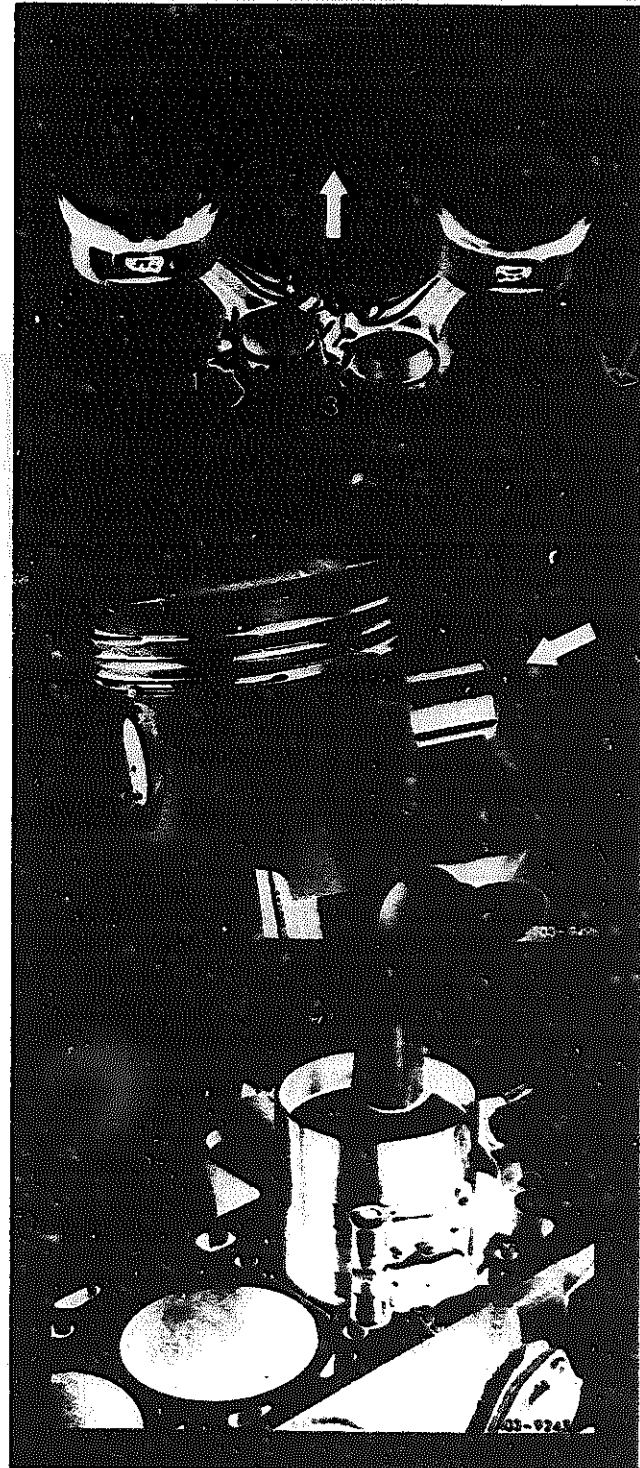
Attention!
Never heat piston.

8 Insert piston pin retainer into groove.

9 Lubricate cleaned cylinder bores, conrod bearing journals, conrod bearing shells and pistons.

10 Distribute gaps of piston rings around circumference of piston evenly.

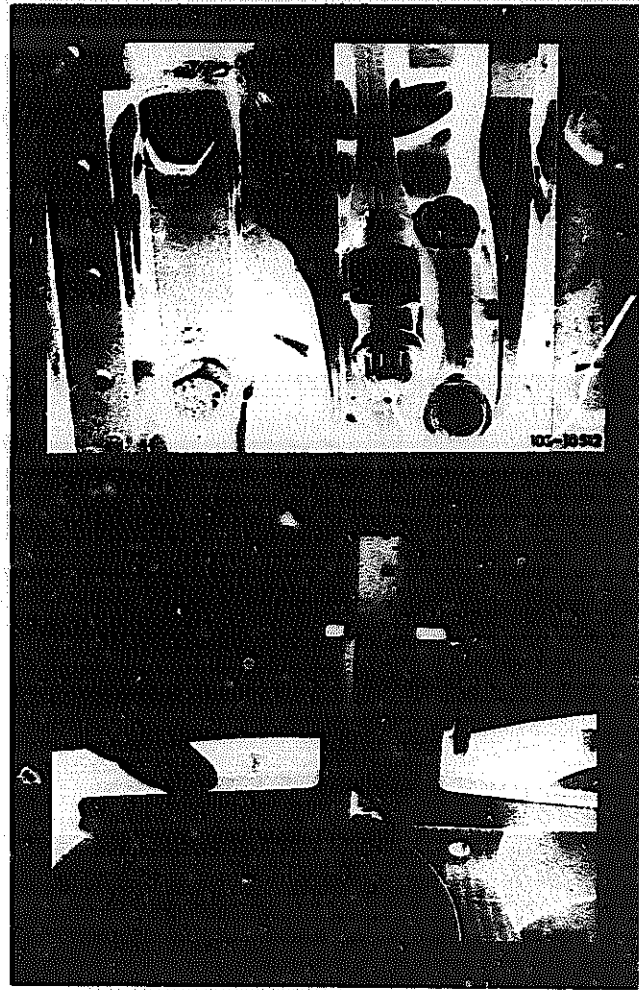
11 Insert piston ring compressor and guide in piston with arrow facing forward in driving direction.



12 Place connecting rod bearing caps with code numbers next to each other on connecting rod and tighten connecting rod nuts (03-310).

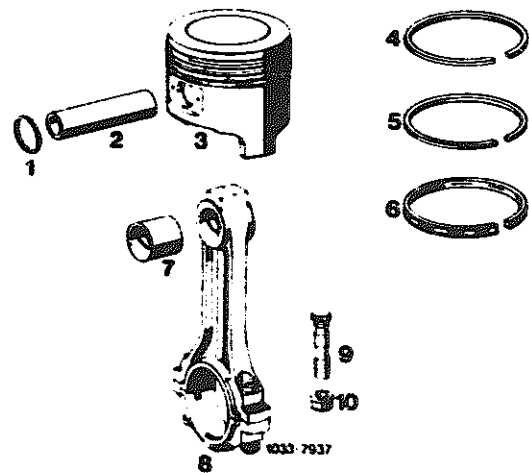
13 Turn crankshaft and check clearance between piston pin eye and conrod.

14 Measure distance between piston crown and crankcase mating surface when piston is at TDC (see chart).



Piston and connecting rod

- 1 Snap ring
- 2 Piston pin
- 3 Piston
- 4 Plain compression ring
- 5 Oil scraper ring
- 6 Bevelled ring with spring
- 7 Conrod bushing
- 8 Connecting rod
- 9 Conrod bolt
- 10 Conrod nut



03-318 Checking and reconditioning crankshaft

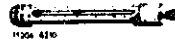
Data

Crankshaft standard dimension and repair stages	Crankshaft bearing journal dia.	Width of journal at fitted bearing	Crank pin dia.	Width of crank pin
Standard dimension	<u>69.96</u> 69.95	<u>30.00</u> 30.02	<u>54.96</u> 54.95	<u>52.00</u> 52.12
Repair stage 1	<u>69.71</u> 69.70	to 30.50	<u>54.71</u> 54.70	to 52.30
Repair stage 2	<u>69.46</u> 69.45		<u>54.46</u> 54.45	
Repair stage 3	<u>69.21</u> 69.20		<u>54.21</u> 54.20	
Repair stage 4	<u>68.96</u> 68.95		<u>53.96</u> 53.95	
Permissible deviation of crankshaft journals and crankpins from true			0.0025	
Permissible deviation of surface line of crankpins and crankshaft journals in relation to reference axis of crankshaft bearing journals I and V from parallel			0.01	
Permissible concentric runout of crankshaft flange with reference to crankshaft bearing journal V			0.02	
Permissible axial runout of crankshaft flange at dia. 130 mm with reference to crankshaft bearing journal V			0.015	
Permissible concentric runout of crankshaft bearing journals			journal II, IV	0.03 ³⁾
			journal III	0.05 ³⁾
Permissible cylindrical runout of front crankshaft bearing journal			0.005	
Permissible concentric runout ^{2) 3)} of front crankshaft journal			0.03	
Permissible axial runout of running surfaces of fitted bearing ³⁾			0.02	
Fillets on crankshaft journals and crankpins			2.5-3	
Crankshaft journal dia. front			47.984-48.000	
Dia. of running surfaces for radial sealing ring rear, 1/2 mm knurl DIN 82, pitch 1 mm, 0.06-0.10 deep, and ground			74.894-74.940	
Scleroscope hardness of crankshaft journals and crankpins			when new	71-81
			limit value	60 ¹⁾

1) The limit value should be available at least on 2/3 of journal circumference.
 2) When measuring in installed condition, eliminate radial bearing play by pushing against crankshaft journal.
 3) With crankshaft mounted on outer crankshaft bearing journals I and V and rotated by one full turn.

Special tool

Impact hardness tester (scleroscope)

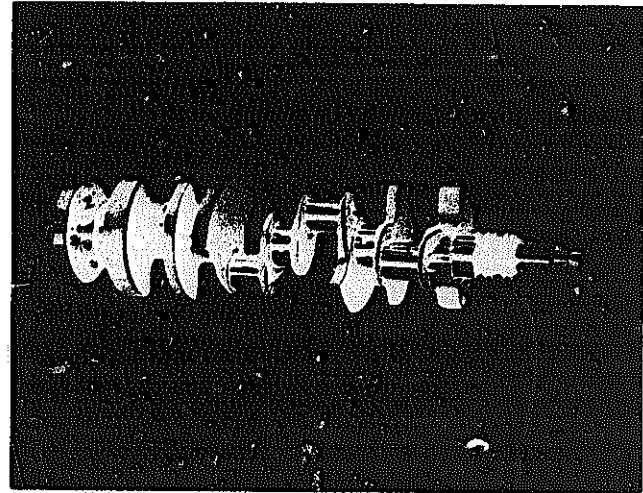


000 589 20 21 00

Note

For repairs, no balancing of crankshaft is required.

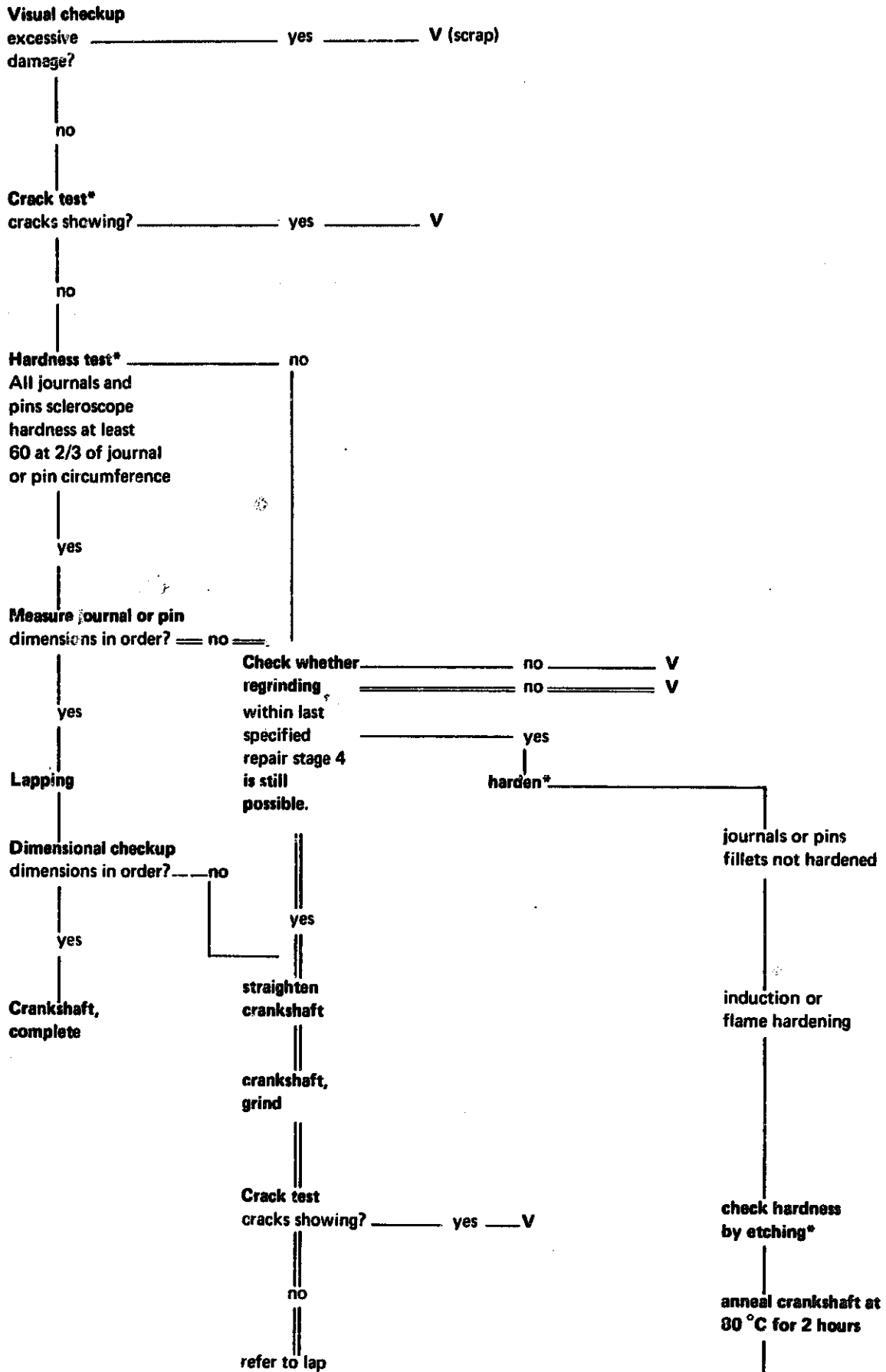
When checking and reconditioning crankshaft, proceed in sequence of diagram shown below.



Diagram

*Refer to section "explanations concerning diagram".

V = scrap.



Explanations concerning diagram

Crack test

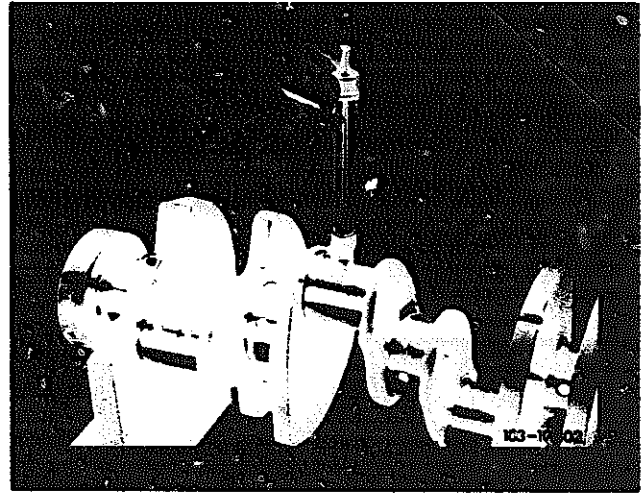
Clean crankshaft. Journals and pins should be free of oil and grease. Magnetize crankshaft and sprinkle with fluorescent powder (flux). A color penetration test (immersion in bath or spray can) can also be employed

Flux: paint or UV-oil, cleaning agent, developer.

Hardness test

Test hardness with impact hardness tester.

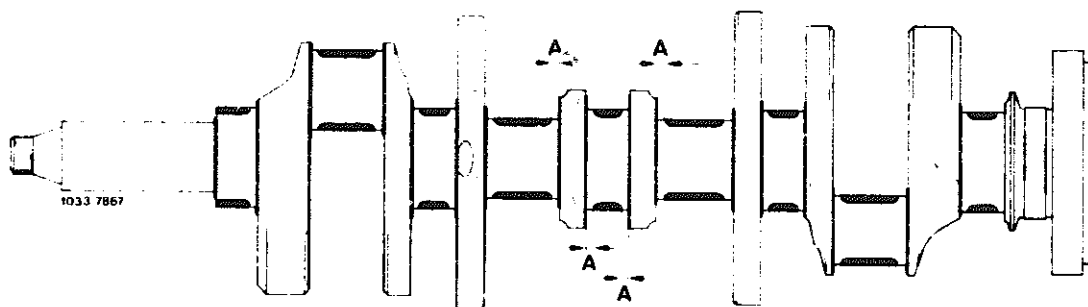
Minimum hardness should be present at 2/3 of journal or pin circumference.



Hardening

Journals or pins can be inductance or flame-hardened.

When hardening journals and pins, maintain distance A between runout or hardening zone and fillet (4-5 mm).



Inspection of hardening procedure

For perfect hardening, check setup of hardening process by means of metallographic grinding cuts.

Samples for hardening can be taken from scrapped crankshaft.

Check hardening of journal or pin surface by etching with a 2 % alcoholic nitric acid (HNO_3) solution.

No dark spot should appear on journal or pin surface.

Comparing etched surface on a metallographically controlled journal or pin is recommended.

Then, carefully wash off nitric acid with alcohol.

Corrosion protection

Lubricate crankshafts which are not immediately installed again with engine initial operation oil (SAE 30).

03-320 Mounting crankshaft

Data

Crankshaft standard dimension and repair stages	Crankshaft bearing journal dia.	Width of journal on fitted bearing	Crankpin dia.	Width of pins
Standard	$\frac{69.96}{69.95}$	$\frac{30.00}{30.02}$	$\frac{54.96}{54.95}$	$\frac{52.00}{52.12}$
Repair stage 1	$\frac{69.71}{69.70}$	up to 30.50	$\frac{54.71}{54.70}$	up to 52.30
Repair stage 2	$\frac{69.46}{69.45}$		$\frac{54.46}{54.45}$	
Repair stage 3	$\frac{69.21}{69.20}$		$\frac{54.21}{54.20}$	
Repair stage 4	$\frac{68.96}{68.95}$		$\frac{53.96}{53.95}$	

Basic bore and bearing clearance	Crankshaft bearing	Connecting rod bearing
Basic bore dia.	$\frac{74.50}{74.52}$	$\frac{58.60}{58.62}$
Permissible out-of-round and conicity of basic bore	0.01	0.01
Bearing clearance radial	When new	0.03-0.08 ¹⁾
	Wear limit	0.09
Bearing clearance axial	When new	0.10-0.22
	Wear limit	0.30




¹⁾ For radial bearing clearance try for mean value.

Bearing shells	Wall thickness crankshaft bearing	Width of fitted bearing shells	Wall thickness connecting rod bearing
Standard dimension	2.25	33.80-33.90	1.80
Repair stage 1	2.37	34.40-34.60 ¹⁾	1.92
Repair stage 2	2.50		2.05
Repair stage 3	2.62		2.17
Repair stage 4	2.75		2.30

¹⁾ Fitted bearing shells for repair stage 1 to 4 are supplied in oversize widths and must be finished to dimension of reground crankshaft bearing journal.

Tightening torques		Nm	(kpm)
Crankshaft bearing bolts	M 10 x 65	60	(6)
	M 12 x 95	80	(8)
Connecting rod nuts	initial torque	40-50	(4-5)
	angle of rotation torque	90-100°	
Clamping nut to crankshaft front		400	(40)
Necked-down screws for driven plate		50	(5)

Special tools

Angle of rotation torque wrench		116 589 01 13 00 ¹⁾
Clamping strap for piston rings		000 589 04 14 00
Dial gauge holder (for measuring end play)		136 589 04 21 00

¹⁾ Special tool no longer available. In this connection, refer to note item 22.

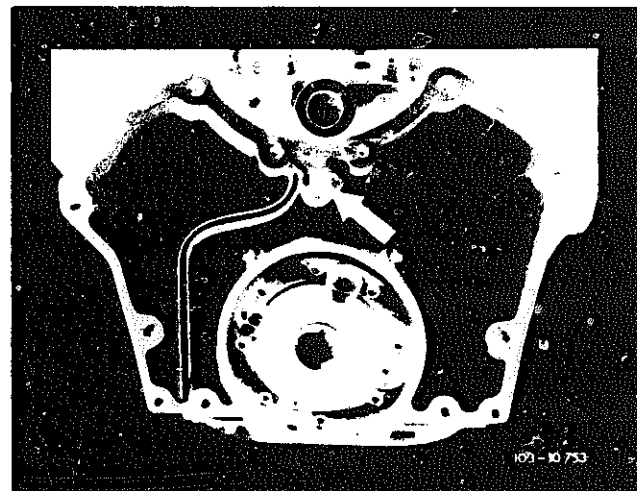
Note

Engine removed and disassembled.

Main oil duct in crankcase open.

Oil ducts in crankcase and in crankshaft carefully cleaned.

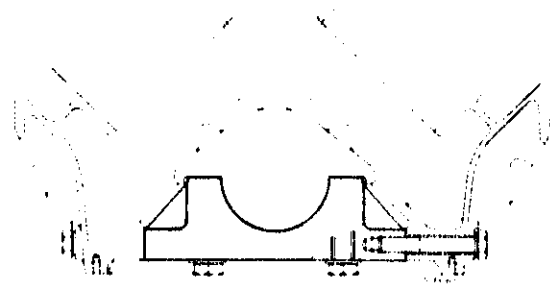
Crankshaft checked for cracks, dimensional accuracy and hardness (03-318).



Associating crankshaft bearings, installing crankshaft

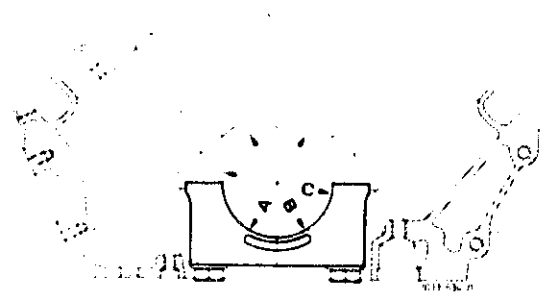
1 Install crankshaft bearing caps, observe identification, 1 is in front.

Tighten screws to specified torque.



2 Measure basic bore in direction A, B and C in two planes (conicity)...

3 If a basic bore exceeds the specified value or if bore is conical, touch up bearing cap contact surface by max. 0.02 mm on surface plate.



4 Mount crankshaft bearing shells and bearing caps, tighten screws to specified torque.

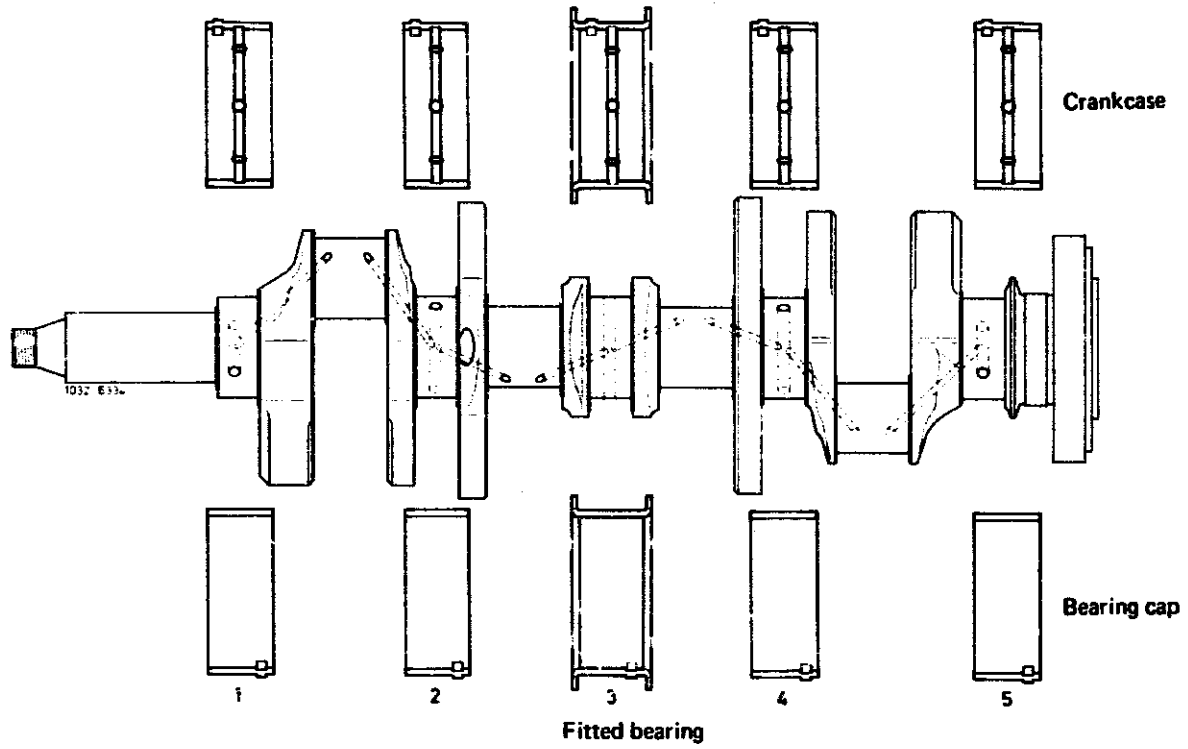
5 Measure bearing dia. and write down.

6 Measure crankshaft bearing journals, determine radial crankshaft bearing clearance.

7 Measure width of fitted bearing journal and fitted bearing. Determine end play of crankshaft bearings.

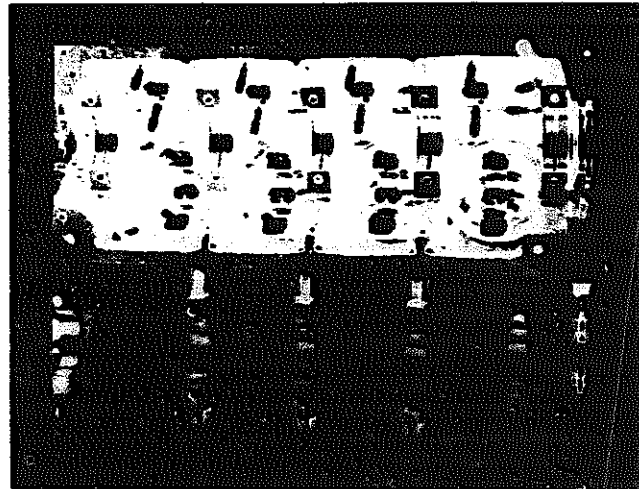
The fitted bearing shells of the individual repair stages are supplied at oversize.

Machine both fitted bearing shells together on both sides to width of fitted bearing journal minus the end clearance.

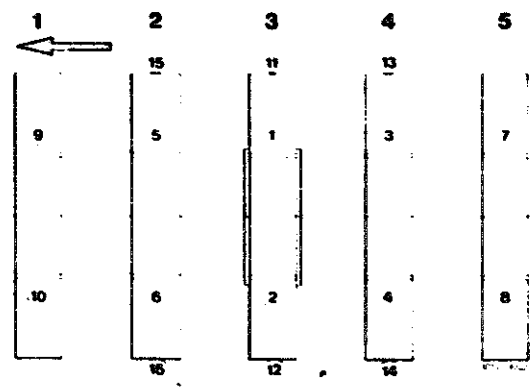


8 Replace rear crankshaft radial sealing ring (03-327).

9 Provide bearing shells, crankshaft and radial sealing ring with engine oil SAE 30 and install crankshaft.



10 Tighten crankshaft bearing caps in sequence of tightening pattern to specified torque.



- 11 Measure crankshaft bearing play axially.
- 12 Rotate crankshaft manually and check for unobstructed rotation.

Associating connecting rod bearings and installing connecting rod

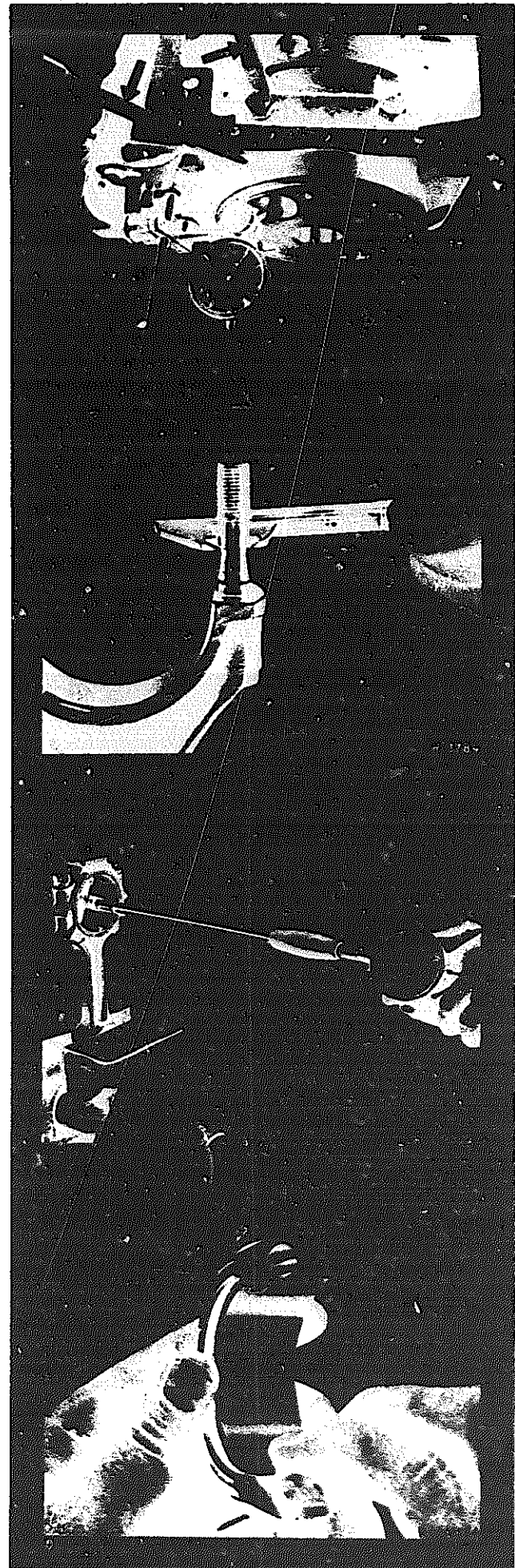
- 13 Check connecting rod bolts (03-310).
- 14 Recondition connecting rod and square (03-313).

15 Mount connecting rod bearing cap while observing identification. Tighten connecting rod nuts to 40-50 Nm (4-5 kpm).

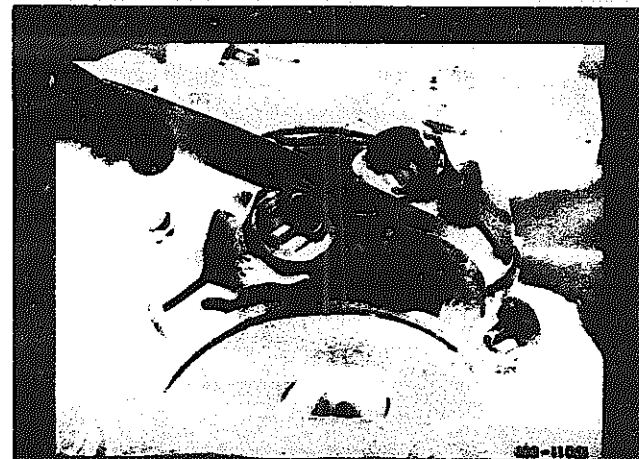
16 Measure basic bore in two directions. On a basic bore which exceeds specified value or which is conical, touch up bearing cap contact surface on a surface plate up to max. 0.02 mm.

17 Insert connecting rod bearing shells, mount connecting rod bearing cap with bearing shells and tighten connecting rod nuts to 40-50 Nm (4-5 kpm).

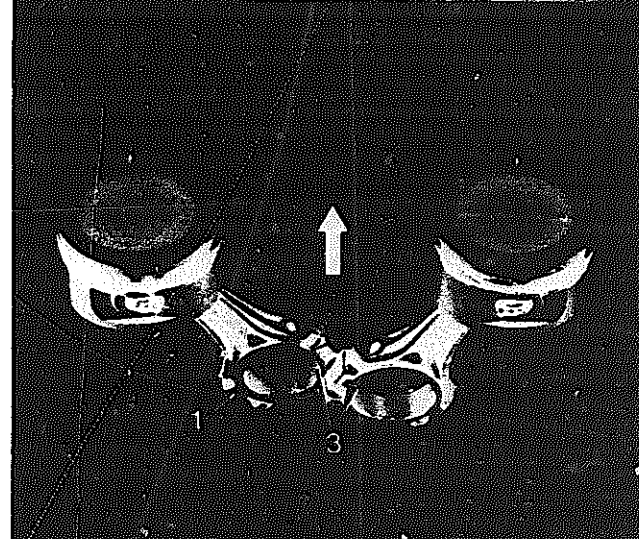
18 Measure bearing dia. and write down.



19 Measure crankpins. Determine radial connecting rod bearing clearance.



20 Mount pistons and connecting rods (03-316).



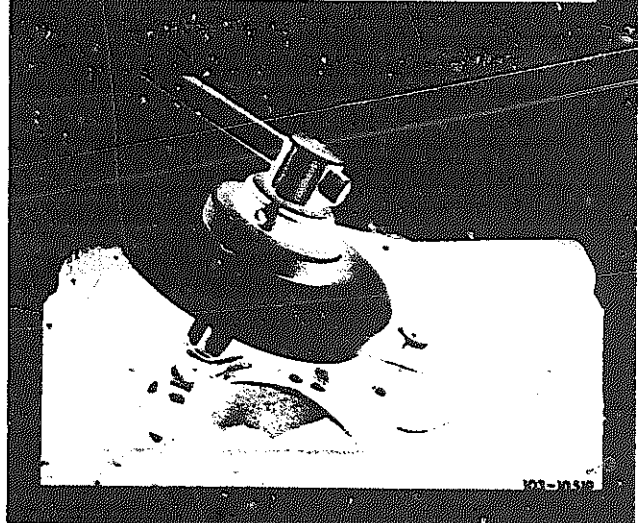
1 Connecting rod thrust end
3 Retaining grooves for bearing shells

21 Provide bearing shells, crankshaft, pistons and cylinders with engine oil SAE 30. Install connecting rods with piston (03-316). Observe identification.

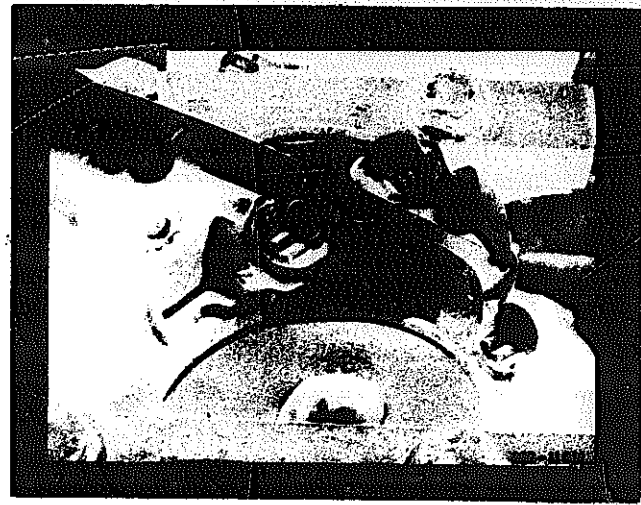


22 Tighten connecting rod nuts to 40–50 Nm (4–5 kpm) initial torque and to 90–100° angle of rotation torque.

Note: If no angle of rotation wrench is available, the nut can also be turned to specified angle in one step by means of a normal socket wrench with tommy bar. The angle should be estimated as accurately as possible. To prevent angle faults, do not use a torque wrench when tightening according to angle degrees.



23 Measure end clearance of connecting rod bearings. Check connecting rod in piston for unobstructed operation.



Attention!

Disassemble and clean oil pump, replace if required (18–210).

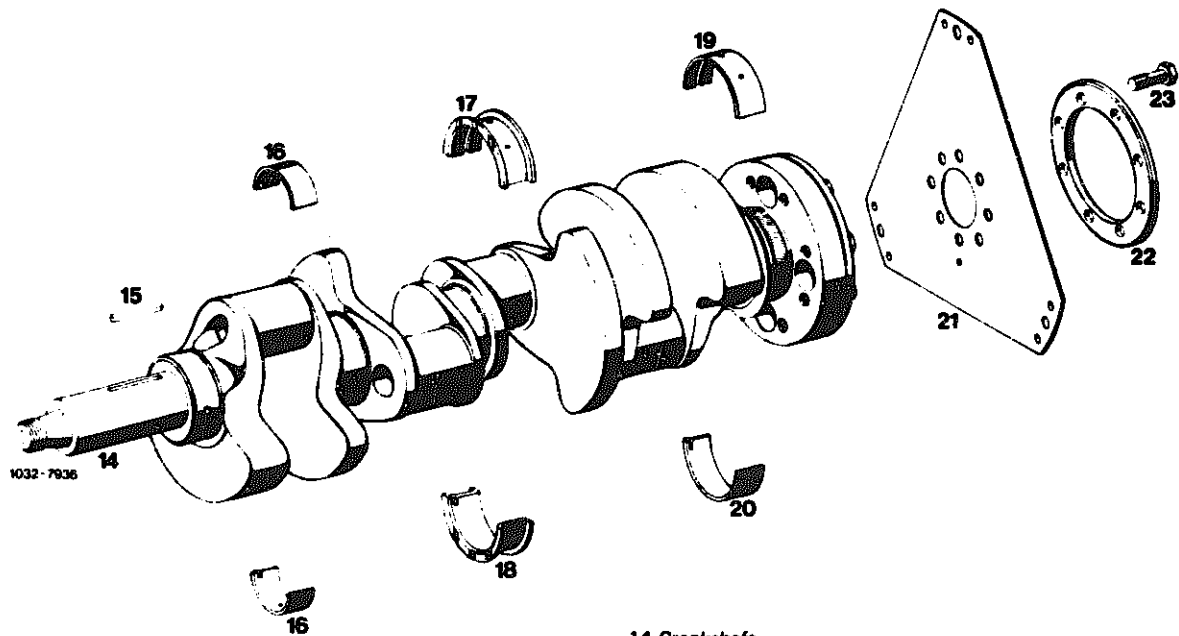
Replace oil pressure relieve valve (18–215).

Disassemble and clean oil filter top (18–005).

Carefully clean air-oil cooler.

Install initial operation oil filter element.

Change engine oil and oil filter element after 500–1,000 km.







- 14 Crankshaft
- 15 Woodruff key 6 x 4 x 50
- 16 Conrod bearing shell (sixteen)
- 17 Thrust bearing shell (crankcase)
- 18 Thrust bearing shell (bearing cap)
- 19 Crankshaft bearing shell, case (four)
- 20 Crankshaft bearing shell, bearing cap (four)
- 21 Drive plate
- 22 Spacer
- 23 Stretch bolt (eight)

03-324 Replacing front crankshaft radial seal

Tightening torques	Nm	(kpm)
Holding nut to crankshaft	400	(40)
Pulley bolts to hub	25	(2.5)

Special tools

Detent (starter flange left)		116 589 01 40 00
Torque wrench 3/4" square, 150-500 Nm (15-50 kpm)		001 589 31 21 00
Hub extractor		100 589 12 33 00
Radial sealing ring installer		100 589 07 61 00

Conventional tools

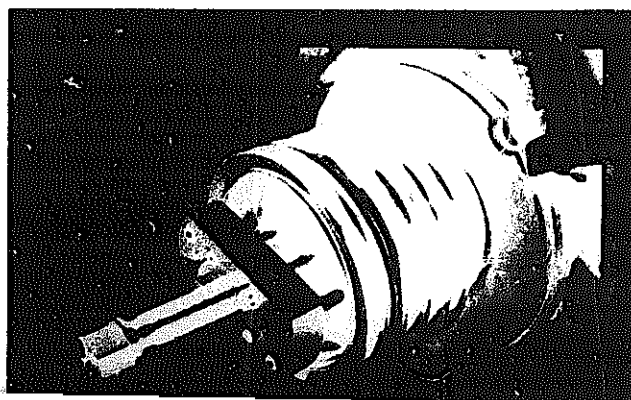
Extension 75 mm long, 3/4" square	e.g. made by Hazet, D-5630 Remscheid order No. 1017-3
Socket 50 mm, 3/4" square	e.g. made by Stahlwille, D-5600 Wuppertal order No. 55

Note

Owing to complaints about noise the plastic end cover on pulley is no longer installed since November 1979.

Replacing

- 1 Remove hub, vibration damper and pulley (03-342).



2 Pry off radial seal with a screwdriver.

Attention!

Do not damage crankshaft and radial seal bore.

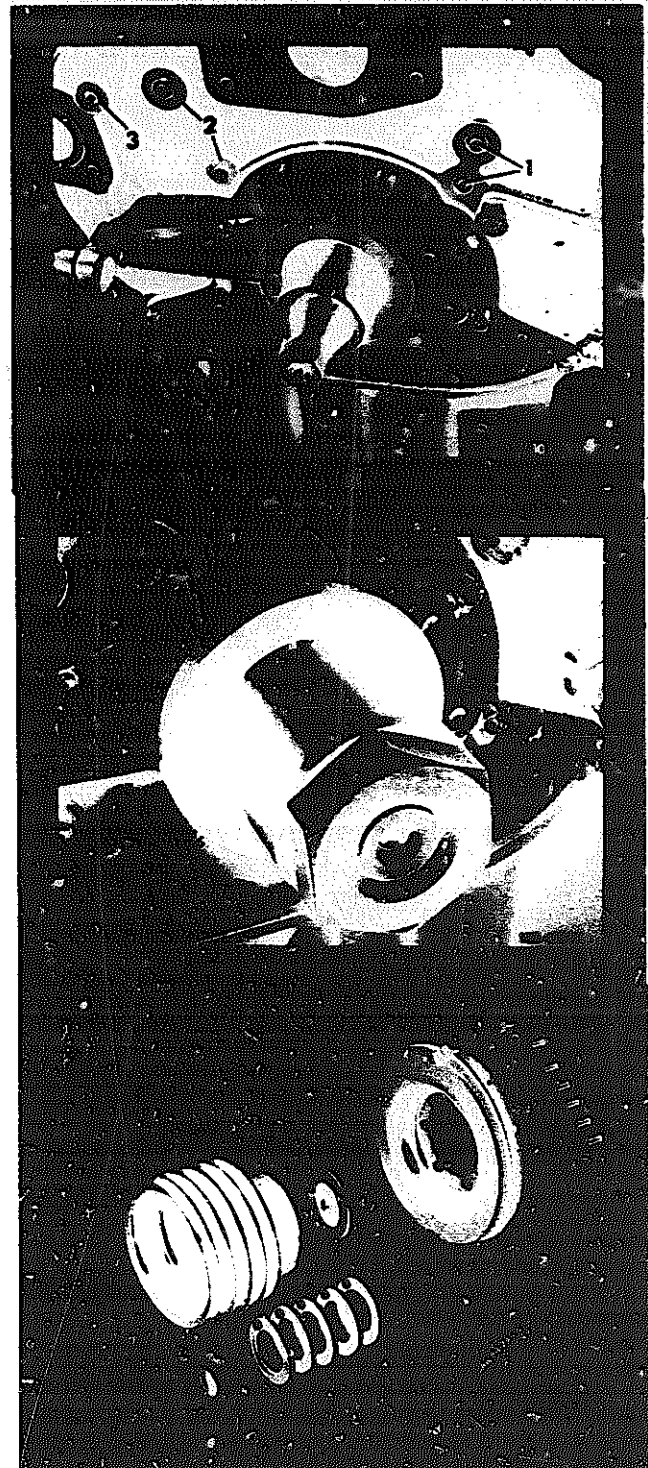
3 Give radial seal grease at sealing lip and pull in with installer.

Use holding nut to pull in seal.

Radial seal must be at right angles to crankshaft journal.

Note: Replace hubs showing traces of wear from radial seal.

4 Install hub, vibration damper and pulley (03-342).



03- 327 Replacing rear crankshaft radial seal

Tightening torques	Nm	(kpm)
Drive plate to crankshaft	50	(5)
End cover to crankcase	25	(2.5)
Intermediate flange to crankcase	65	(6.5)

Special tool

Angle of rotation wrench



116 589 01 13 00¹⁾

¹⁾ Special tool no longer available. In this connection, refer to job No. 03-310, checking, grinding and tightening connecting rod bolts.

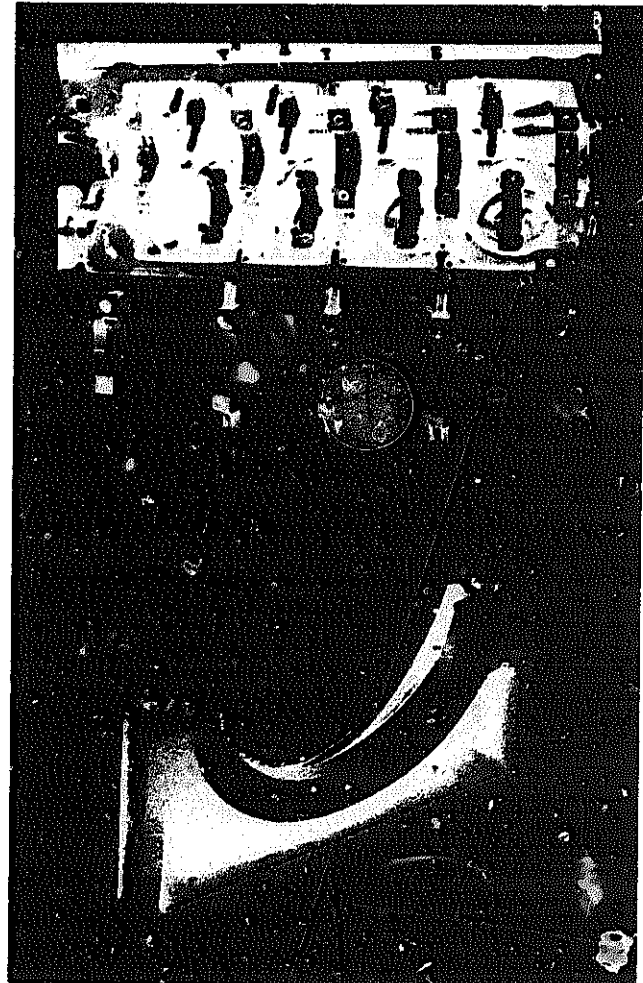
Replacing

- 1 Remove crankshaft with engine removed (03-320).
- 2 Check crankshaft at sealing ring running surface. Score marks on running surface dia. 74.894-74.940 mm with 1/2 mm knurl should not be too deep.

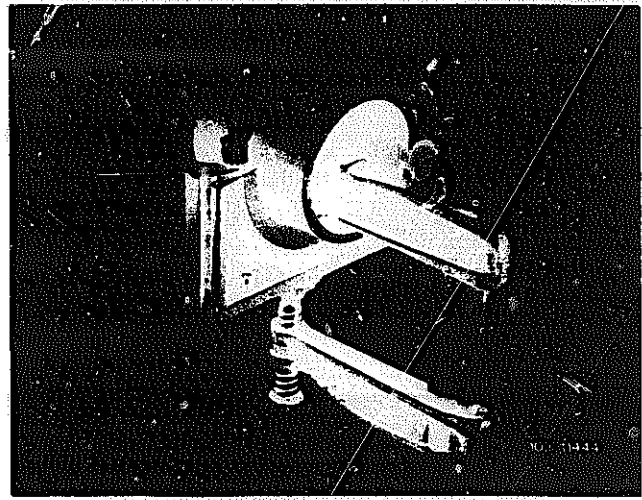
- 3 Place rubber strips (2) and radial seal (1) in crankcase and end cover.

Attention!

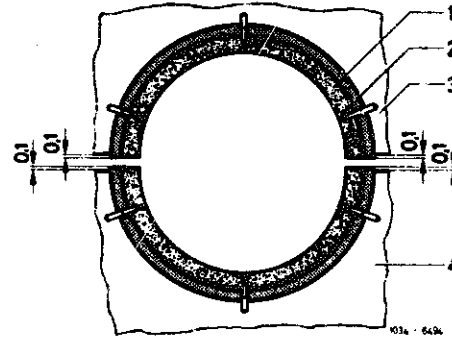
Press in rubber strips and radial seal separately, first in lower lockpin and then, without tension, in side lockpins.



4 Preload rubber strip and radial seal in end cover and crankcase with a 75 mm dia. pipe.



5 Cut off preloaded rubber strip and radial seal leaving a protrusion of 0.1 mm.



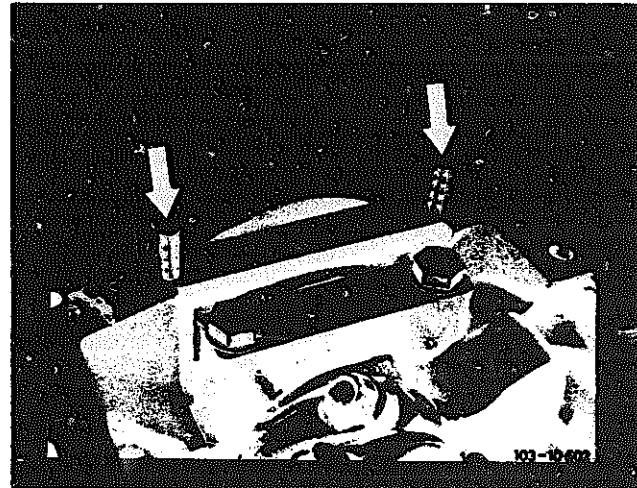
- 1 Radial seal
- 2 Rubber strip
- 3 End cover
- 4 Crankcase

6 Lubricate radial seal.

7 Install crankshaft.

8 Coat bearing surface of end cover with a sealing compound.




Install, align and bolt end cover together with the sealing pins (arrows).



03-342 Removal and installation of hub, vibration damper and pulley

Tightening torques	Nm	(kpm)
Clamping nut to crankshaft	400	(40)
Screws for vibration damper to hub	65	(6.5)
Screws for pulley to hub	25	(2.5)

Special tools

Detent (starter flange left)		116 589 01 40 00
Torque wrench 3/4" square, 150-500 Nm (15-50 kpm)		001 589 31 21 00
Puller for hub		100 589 12 33 00

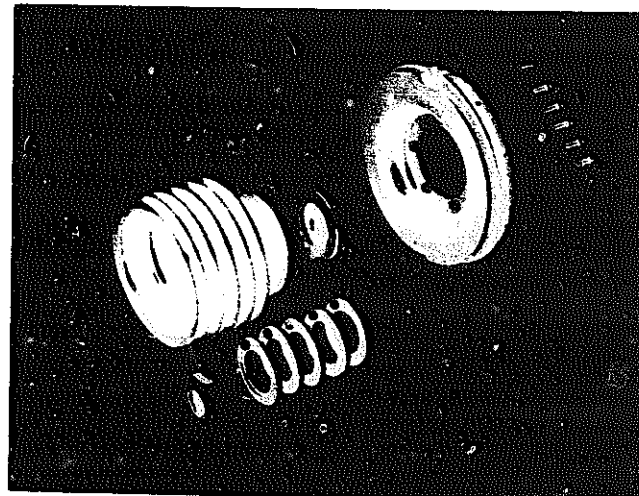
Conventional tools

Extension 75 mm long, 3/4" square	e.g. made by Hazet, D-5630 Remscheid order No. 1017-3
Socket 50 mm, 3/4" square	e.g. made by Stahlwille, D-5600 Wuppertal order No. 55

Note

Hub, vibration damper and pulley can be exchanged without balancing.

The plastic end cover on pulley is no longer installed since November 1979 owing to complaints about noise.



Removing

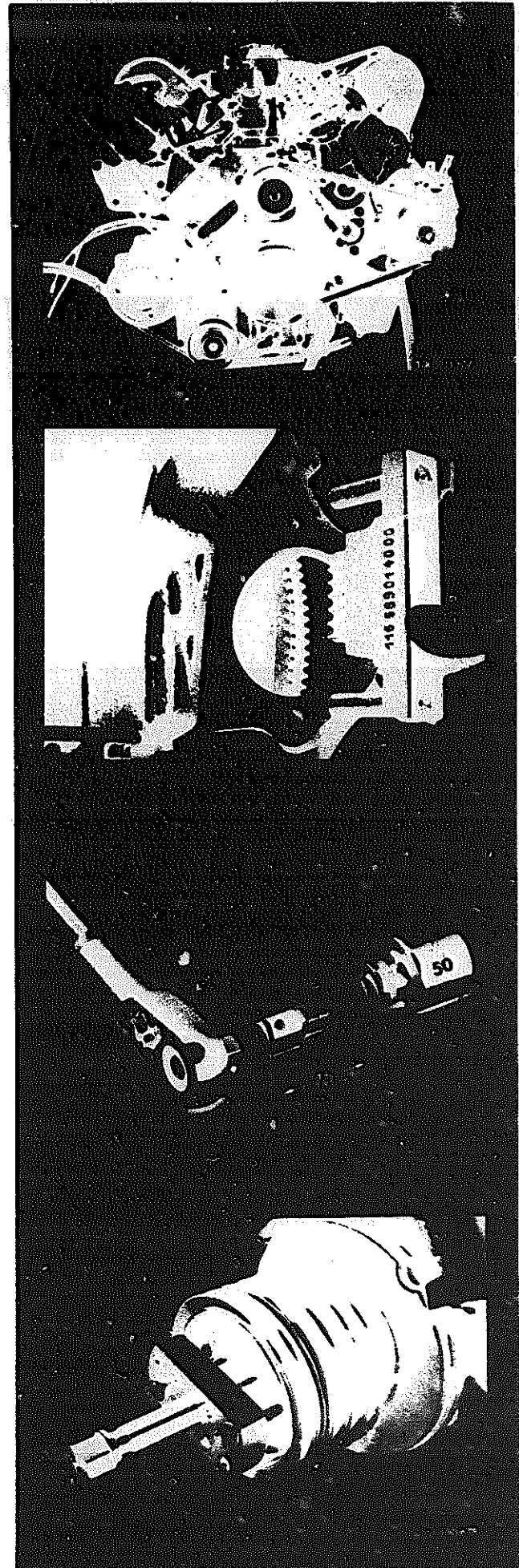
- 1 Remove radiator frame and visco coupling with fan.
- 2 Remove all V-belts (13-340).

- 3 Locate crankshaft with detent.

- 4 Unscrew clamping nut on crankshaft with tool combination.

- 5 Pull off hub with vibration damper and pulley.

Unscrew pulley.



Installing

6 Heat hub and vibration damper up to approx. 80°C. (176°F).

Attention!

Do not exceed this temperature, since otherwise the elastic insert of vibration damper will be damaged.

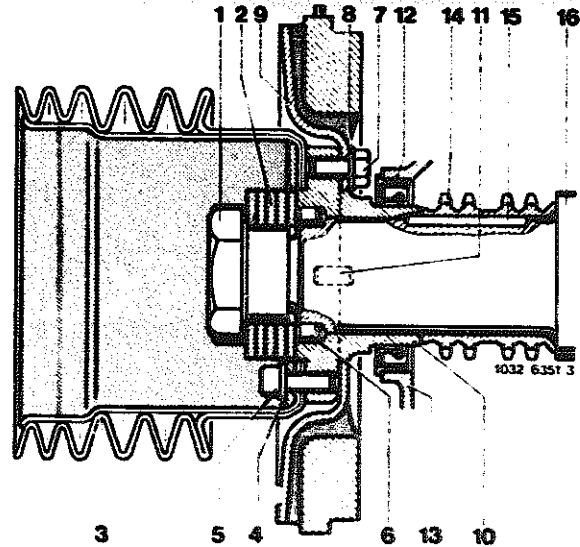
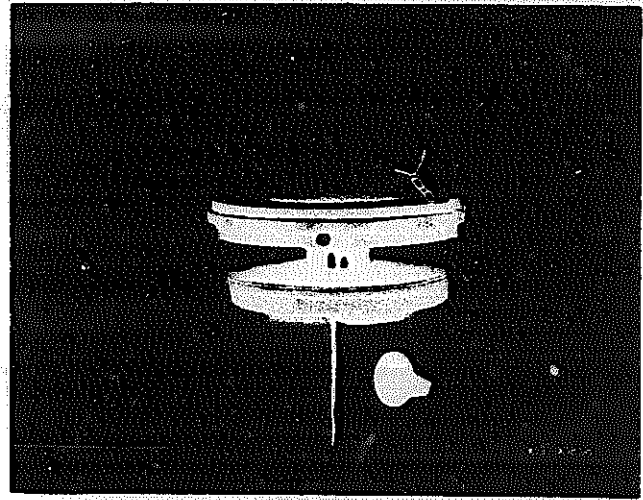
7 Slip hub with vibration damper on crankshaft in such a manner that the groove of hub (8) is in alignment with the projecting portion of the key (9).

Attention!

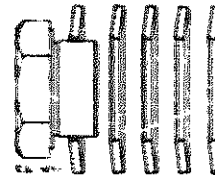
If this step cannot be proceeded in one operation, pull off hub again and heat for a second time.

8 Knock-in fitted pin (6).

9 Position 5 plate springs with crown facing outwards.



- 1 Clamping nut
- 2 Cup spring (5 each)
- 3 Pulley
- 4 Washer 8.4
- 5 Screw M 8 x 22
- 6 Cyl. pin 8h 8 x 8 (2 each)
- 7 Screw M 10 x 12
- 8 Washer 10.5
- 9 Vibration damper
- 10 Hub
- 11 Cyl. pin 8h 8 x 14
- 12 Radial sealing ring
- 13 Front crankcase cover
- 14 Crankshaft sprocket
- 15 Woodruff key A 6 x 4 x 50
- 16 Crankshaft



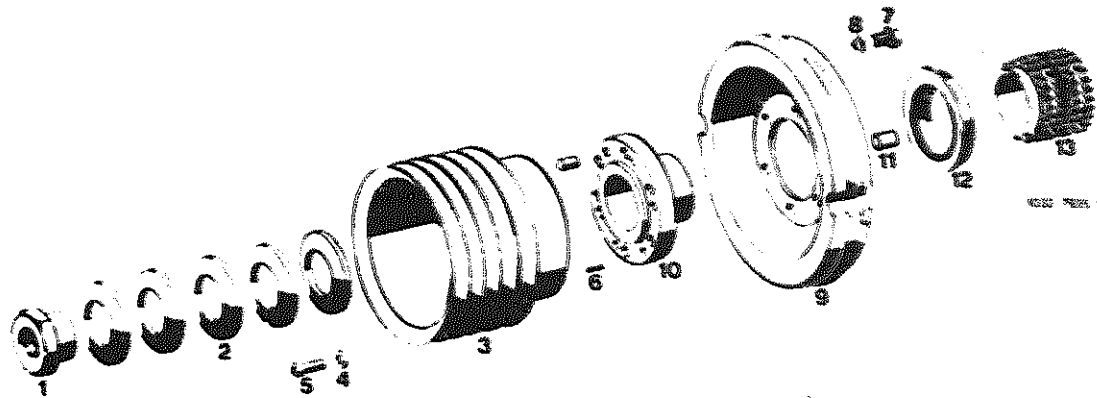
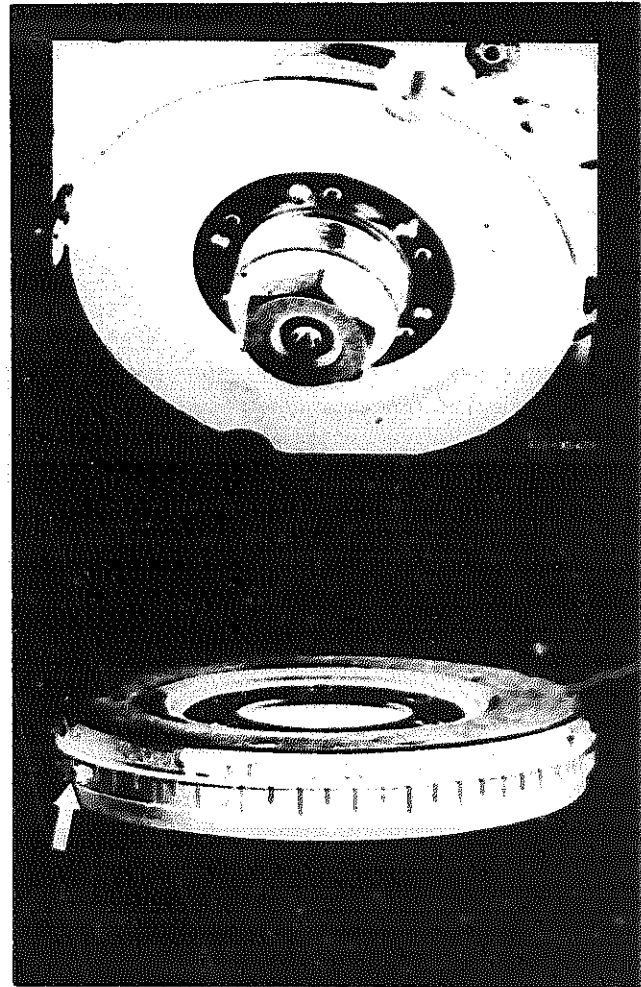
10 Tighten clamping nut to 400 Nm (40 kpm).

11 Mount pulley.

12 For further installation proceed vice versa to removal.

Attention!

When replacing the vibration damper, readjust TDC indicator (03-345).



- 1 Clamping nut
- 2 Cup springs (5 each)
- 3 Pulley
- 4 Washer 8.4 (6 each)
- 5 Screw M 8 x 18 (6 each)

- 6 Cyl. pin 8 x 8 (2 each)
- 7 Screw M 10 x 18 (6 each)
- 8 Washer 10.5 (6 each)
- 9 Vibration damper

- 10 Hub
- 11 Cyl. pin 8x 8 x 14
- 12 Radial sealing ring
- 13 Crankshaft sprocket

03-345 Checking and correcting TDC transmitter adjustment

Special tools

TDC tester



116 589 17 21 00

Locating tool for adjusting slide



102 589 03 21 00

Conventional tools

Adaptor 1/2" square socket to 3/4" square head

e.g. made by Stahlwille, D-5600 Wuppertal, order No. 514

Socket 50 mm, 3/4" square for rotating engine

e.g. made by Stahlwille, D-5600 Wuppertal order No. 55

Note

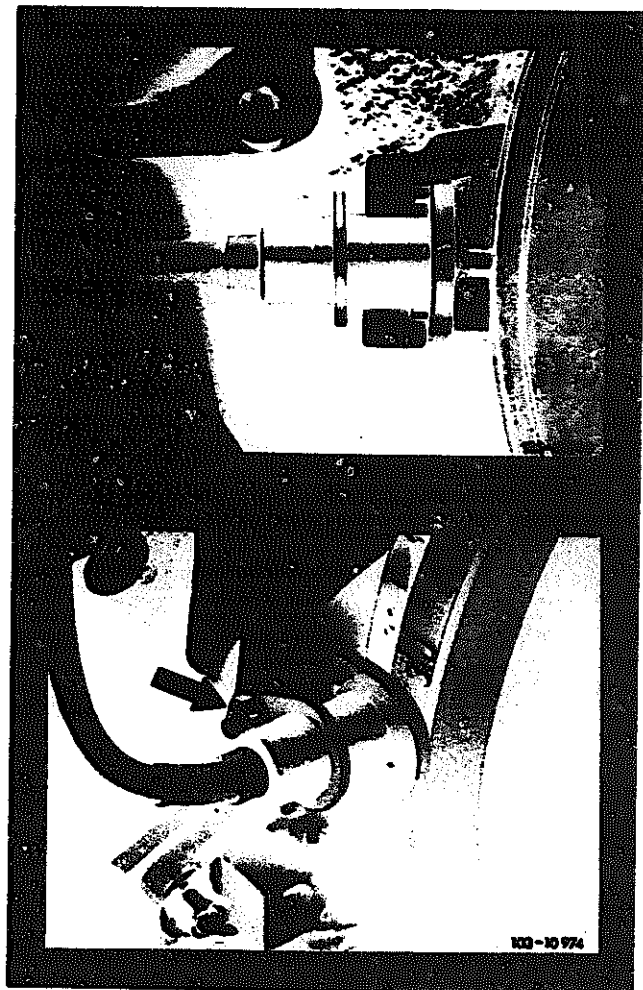
At crankshaft position 20° after TDC, the TDC transmitter should be positioned accurately above pin in vibration damper (arrow).

Check or correct TDC transmitter adjustment as follows:

- a) When replacing TDC transmitter adjusting slide,
- b) When replacing crankshaft, hub and vibration damper,
- c) when replacing front crankcase cover,
- d) when completing partial engines.

Checking

- 1 Unscrew hex. nut (arrow) and pull out TDC sensor.



2 Screw tester into spark plug bore of 1st cylinder. Push adjusting pin down (arrow) until seated.

3 Rotate crankshaft with tool combination or a mandrel on vibration damper until adjusting pin is at its highest point. Piston is then at TDC.

4 Remove adjusting pin.

Insert dial gauge and clamp down at approx. 5 mm preload.

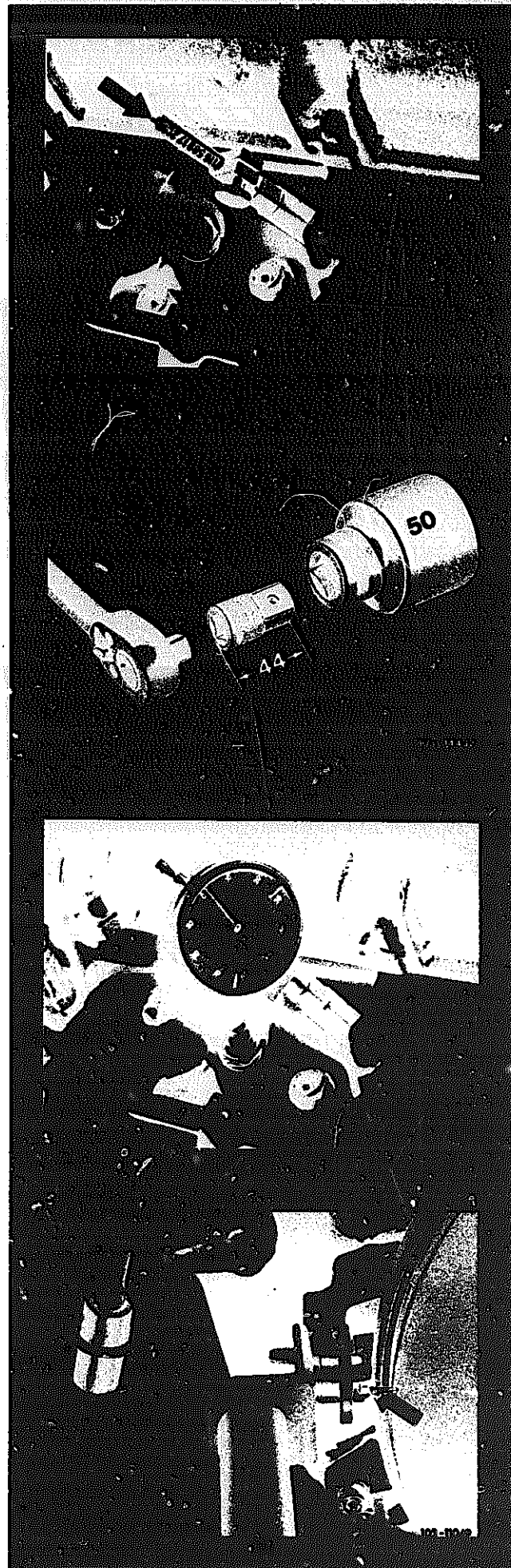
Rotate crankshaft and set TDC accurately by means of dial gauge.

Turn dial gauge scale until needle points to 0.

5 Keep turning crankshaft in direction of rotation until dial gauge runs back by 3.95 mm.

Note: If measured vertically in relation to piston with cylinder head removed, the dial gauge should run back by 3.66 mm.

6 Insert locating tool into adjusting slide. Pin of vibration damper should engage in groove of locating tool (arrow).



Correcting

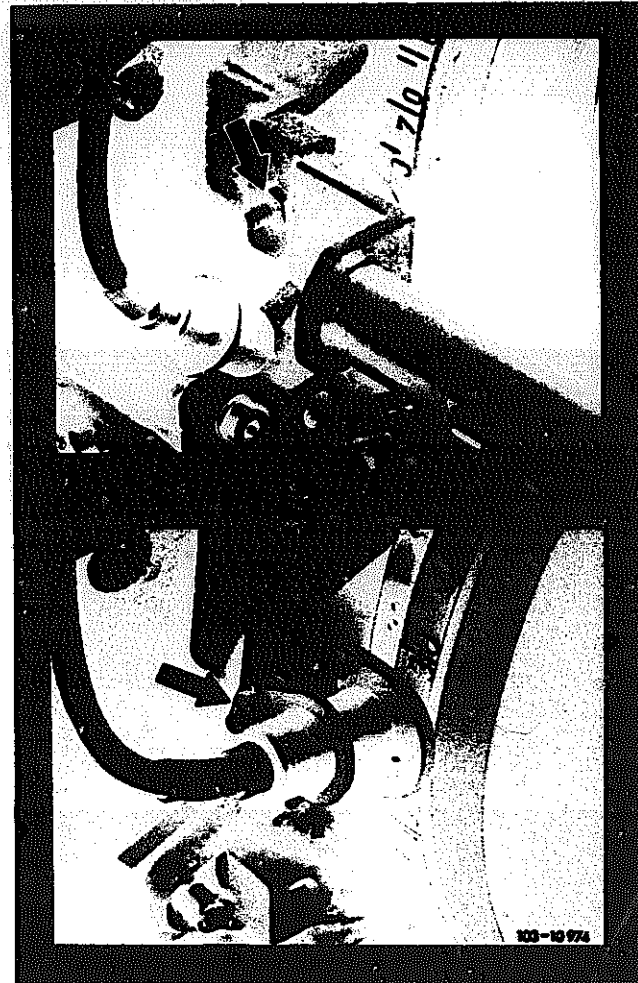
7 Loosen adjusting slide (arrow) and slide until pin engages in locating tool.

8 Screw-on adjusting slide (arrow) and remove locating tool.

9 Install and bolt (arrow) TDC sensor.

10 Remove dial gauge.

Turn crankshaft just briefly in direction of rotation, and then unscrew tester.

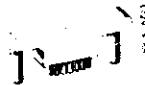


03-350 Removing and installing crankshaft sprocket

Tightening torques	Nm	(kpm)
Holding nut to crankshaft	400	(40)
Crankshaft bearing bolt M 10 x 95	80	(8)
Camshaft sprocket mounting bolt	100	(10)

Special tools

Detent (starter flange left)



116 589 01 40 00

Torque wrench 3/4" square,
150-500 Nm (15-50 kpm)



001 589 31 21 00

Hub extractor



100 589 12 33 00

Conventional tools

Extension 75 mm long, 3/4" square

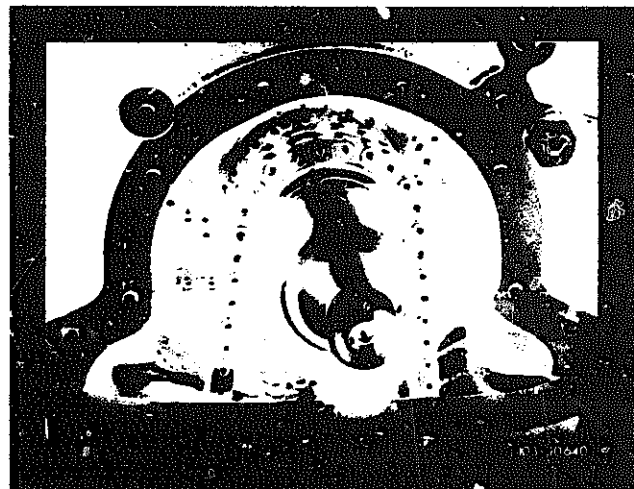
e.g. made by Hazet, D-5630 Remscheid
order No. 1017-3

Socket 50 mm, 3/4" square

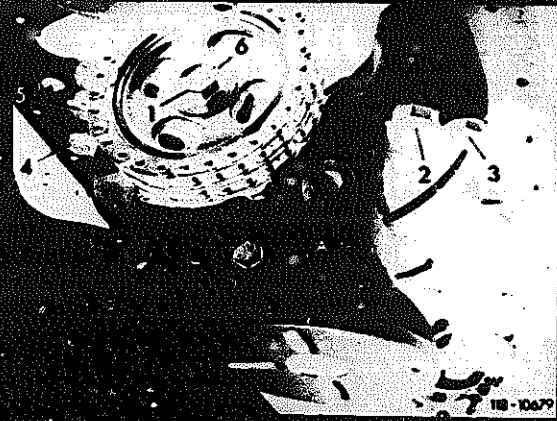
e.g. made by Stahlwille, D-5600 Wuppertal
order No. 55

Removing

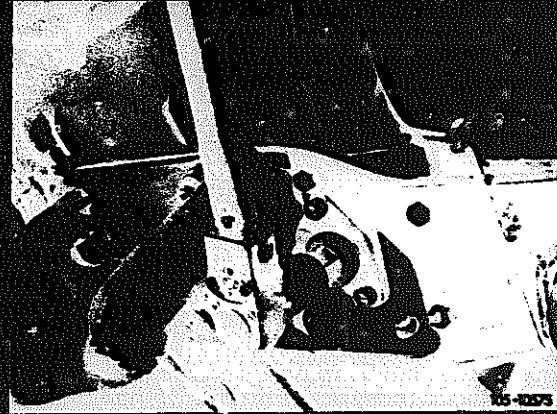
- 1 Remove front crankcase cover (03-107).



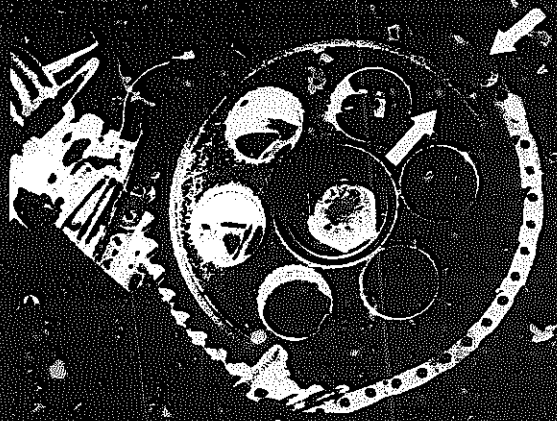
2 Remove oil pump (18-210).



3 Remove chain tensioner spring (05-310).

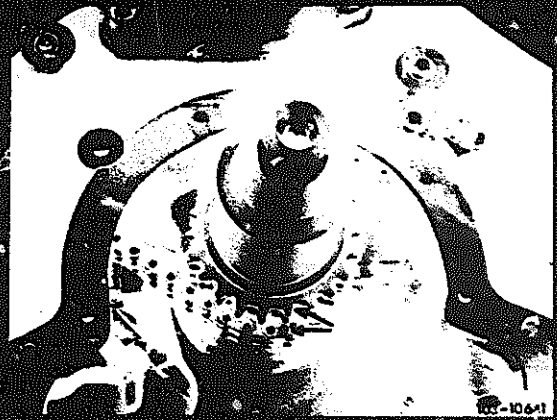


4 Mark position of right camshaft sprocket to timing chain and remove.

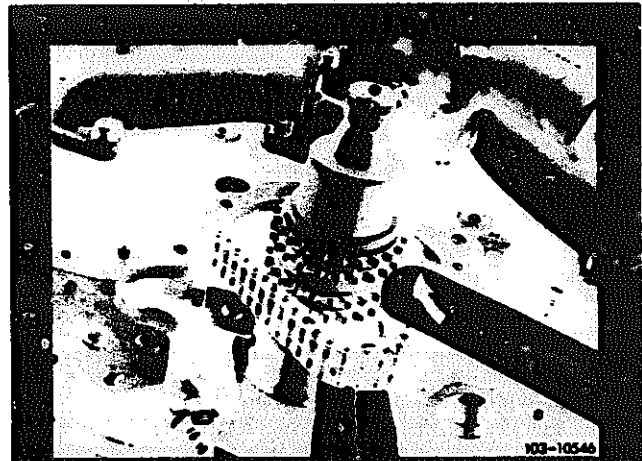


5 Mark position of crankshaft sprocket to timing chain.

6 Remove 1st crankshaft bearing cap.



7 Press off crankshaft sprocket or pull it off with a two-arm extractor.



Installing

8 Transfer mark from old to new crankshaft sprocket.

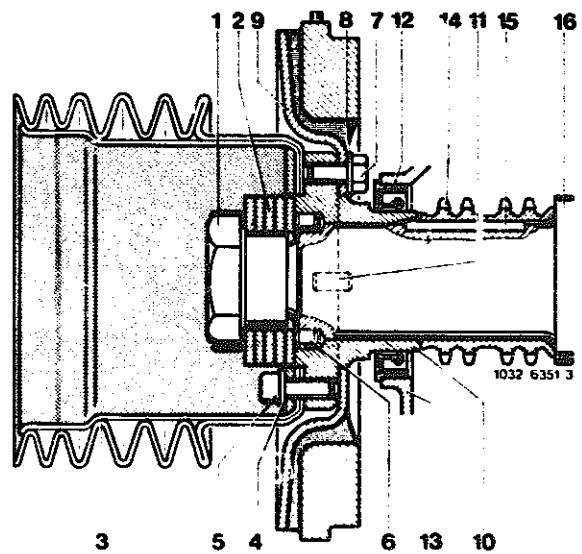
9 Install crankshaft sprocket on crankshaft.

10 Place timing chain on crankshaft sprocket so that the marks align with each other.

11 Install 1st crankshaft bearing cap.



12 Rest of installation in reverse sequence.



03-410 Removing and installing driven plate

Data

Deviation on outside diameter

0.3

Stretch bolt for driven plate to crankshaft

Stretch bolt Part No. 100 990 02 19

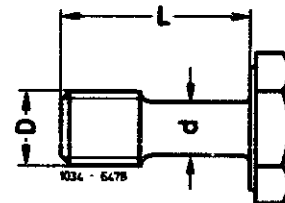
Thread outside dia. M 10 x 1

Reduced shaft
outside diameter
new 8.0-0.2
minimum 7.6

Length L 30

Torque specification

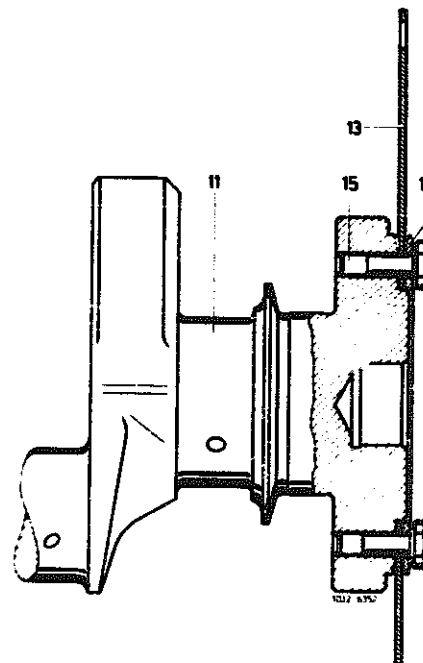
50 Nm (5 kpm)



Removing

1 Unscrew stretch bolt. Take off driven plate and spacer.

11 Crankshaft
13 Driven plate
14 Spacer
15 Stretch bolt



Installing

2 Measure reduced shaft diameter. If minimum diameter has been reached, replace stretch bolts.

3 Install driven plate and spacer. Keep to sequence.

4 Tighten necked-down screws to 50 Nm (5 kpm).

03-430 Replacing ring gear

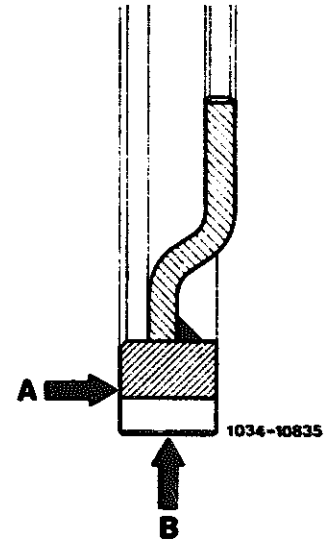
Data

Axial runout at ring gear (A)		max. 0.3
Concentric runout at ring gear (B)	mm	max. 0.15

Note

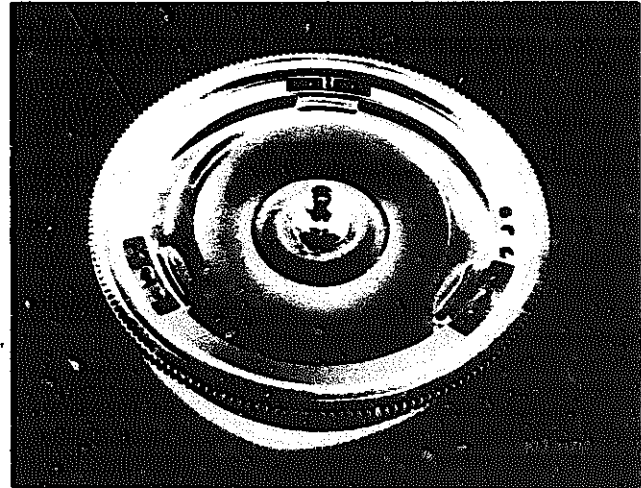
Drive ring with welded-on ring gear is balanced.

In the event of damage to ring gear by starting when engine is about to stop, install an ignition starter switch 116 462 00 93 with larger repeat angle (series since August 1978). As a result, during repeated starting, the ignition key must be turned back to "0" ("1" before), which may cause crankshaft to come to a stop.



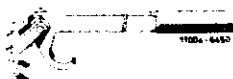
Replacing

- 1 Remove transmission.
- 2 Unscrew drive ring with ring gear from torque converter.
- 3 Screw new drive ring with welded-on ring gear to torque converter.
- 4 Install transmission.



05-211 Checking and replacing hydraulic valve clearance compensating elements

Tightening torques	Nm	(kpm)
Cyl. head cover nuts	15	(1.5)
Correction part in cylinder head	60	(6)

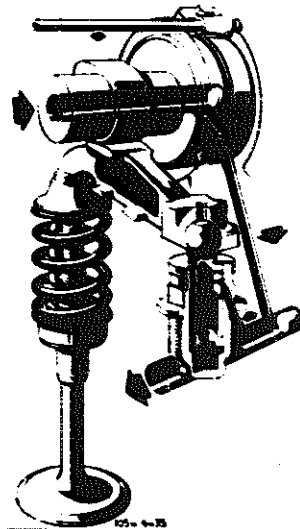
Special tool		
Valve spring depresser		100 589 06 61 00

Note

Store compensating elements only upright and do not disassemble.

Install rocker arms and compensating elements at same locations again.

Check compensating elements, if complaints about noise are filed.



Checking

- 1 Position cam peaks up as compared to rocker arms.
- 2 Press down on rocker arm with handle of hammer.

If the ball pin drops too fast when compared with other pins, replace hydraulic valve clearance correction part (compensating element).



3 Try to move rocker arm by hand.

If it has any movement, basic setting of compensating elements must be checked (05-213).

Replacing

4 Remove rocker arm (05-230).

5 Unscrew compensating element with 24 mm socket wrench socket.

6 Lubricate threads of new compensating element, install it and tighten to torque of 60 Nm (6 kpm).

7 Install rocker arm (05-230).

8 Check basic setting (05-213).



05-213 Checking and correcting basic setting of hydraulic valve clearance compensating elements

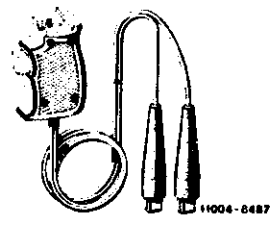
Tightening torque	Nm	(kpm)
Nuts for cylinder head cover	15	(1.5)

Thickness of pressure pads "S" in mm	Part No.
5.8	117 053 06 53
5.45	117 053 05 53
5.1	117 053 04 53
4.75	117 053 03 53
4.4	117 053 02 53
4.05	117 053 01 53
3.7	117 053 00 53



Special tools

Test gauge for hydraulic correction parts (compensating elements)		100 589 04 23 00
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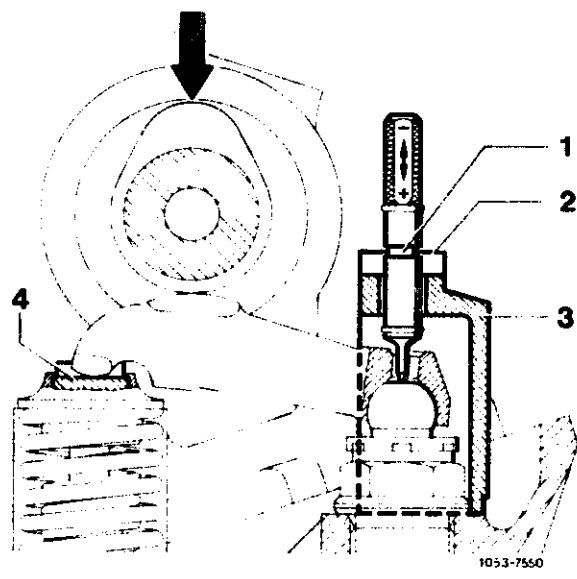
Contact handle for rotating engine (component of 001 589 46 21 00)		001 589 46 21 08
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Valve spring depressor		100 589 06 61 00
------------------------	--	------------------

Notes

Test gauge serves to determine basic position or a plus deviation (+) or minus deviation (-) of hydraulic element.

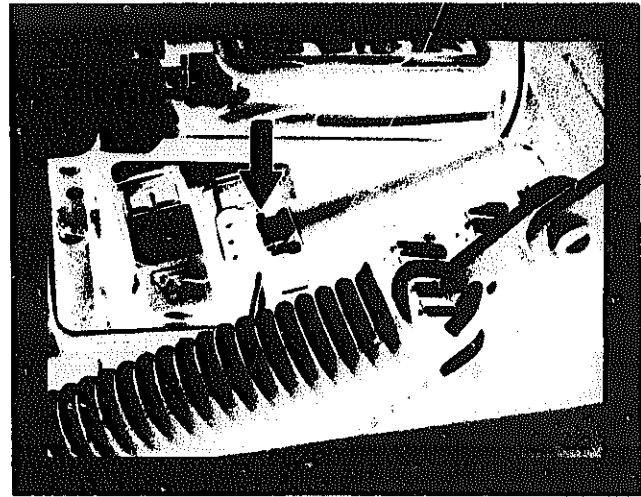
In the event of a plus deviation (+) or a minus deviation (-), the installation of a thinner or thicker pressure pad (4) permits resetting of basic position.



Checking

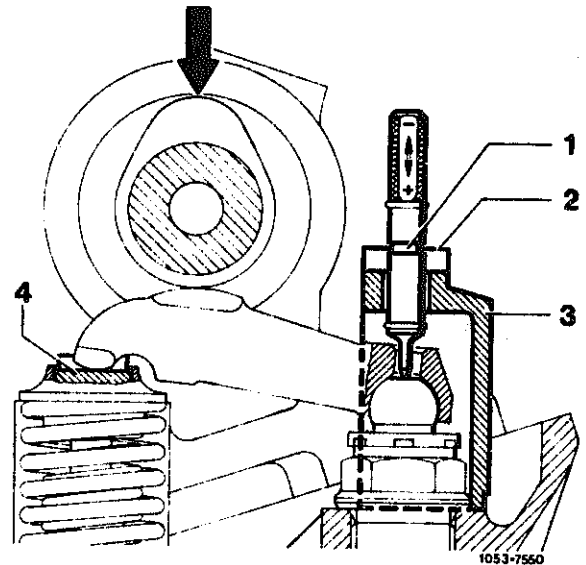
1 With newly installed compensating elements rotate engine with starter for approx. 30 seconds prior to checking.

For rotating engine, pull out fuel pump relay code No. 21 in fuse box. Connect contact clip to battery + and by means of a pin on contact bushing 1 of coupler (arrow).



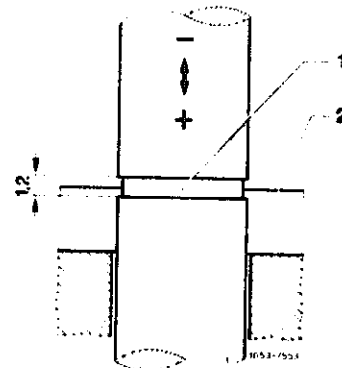
2 Take load from hydraulic element about to be checked, that is, cam tip should point upwards (arrow).

3 Set test gauge (3) above hydraulic element to be checked and place measuring pin on ball pin.



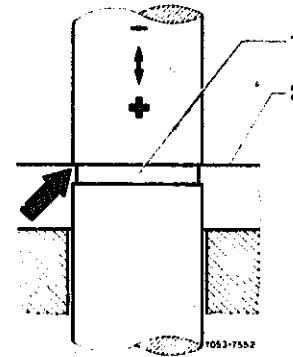
4 Check position of measuring groove (1) in relation to measuring edge (2):

a) The basic position is correct when the measuring edge (2) is located within the red measuring groove (1) 1.2 mm wide.



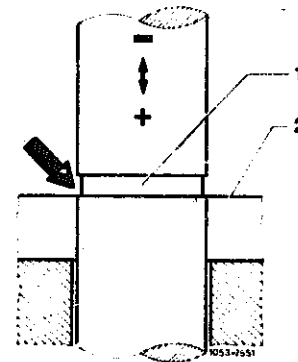
b) Plus deviation (+) is indicated when measuring edge (2) is above red measuring groove (1).

Remedy:
In the event of a plus deviation (+), insert thinner pressure pad.



c) Minus deviation (-) is indicated when measuring edge (2) is below red measuring groove (1).

Remedy:
In the event of a minus deviation (-), insert thicker pressure pad.



Correcting

5 Remove rocker arm with depressor. Remove pressure pad.

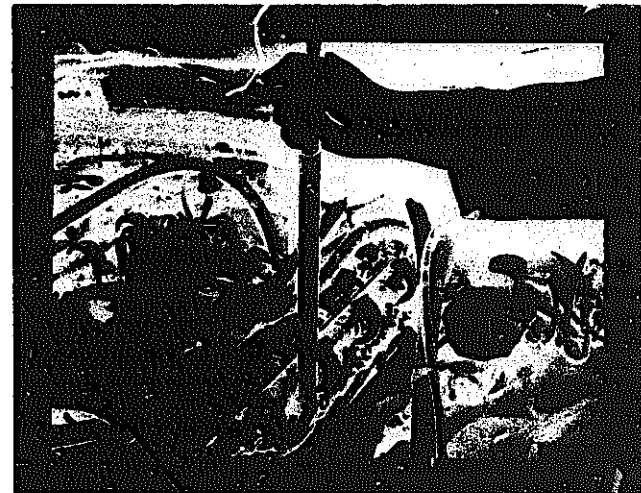
6 Measure thickness "S" of pressure pad.

Thickness "S" of pressure pad in mm	Part No.
5.8	117 053 06 53
5.45	117 053 05 53
5.1	117 053 04 53
4.75	117 053 03 53
4.4	117 053 02 53
4.05	117 053 01 53
3.7	117 053 00 53

7 In the event of a plus deviation (+), insert a thinner pad, and for a minus deviation (-) a thicker pad.

Note: During new adjustment try for center position on measuring groove.

8 Install swivel lever and check again.



05-215 Checking and adjusting camshaft timing

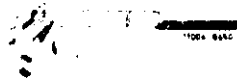


Timing for 2 mm valve lift

Engine 100.985	Camshaft Code ¹⁾	Intake valve Opens ATDC	Closes ABDC	Exhaust valve Opens BBDC	Closes BTDC
New engine or new timing chair	left 36	12°	25°	32°	19°
	right 37	10°	23°	34°	21°
After running approx. 20.000 km	left 36	14°	27°	30°	17°
	right 37				

¹⁾ Code is stamped on rear end of camshaft.

Tightening torques	Nm	(kpr.)
Cylinder head cover nuts	15	(1.5)
Camshaft sprocket bolts	100	(10)
Chain tensioner plug	50	(5)
Chain tensioner threaded ring	40	(4)
Hydr. valve clearance correction parts in cylinder head	60	(6)

Special tools

Valve spring depresser		100 589 06 61 00
Dial gauge holder		363 589 02 21 00
Valve adjusting wrench 17 mm		116 589 02 01 00

Conventional tools

Adaptor 1/2" square socket to 3/4" square head	e.g. made by Stahlwille, D-5600 Wuppertal order No. 514
Socket 50 mm, 3/4" square for engine	e.g. made by Stahlwille, D-5600 Wuppertal order No. 55

Conventional tools

Screwdriver insert 17 mm

e.g. Hazet, D-5630 Remscheid
Order No. 985-17

Screwdriver insert 19 mm

e.g. Hazet, D-5630 Remscheid
Order No. 985-19

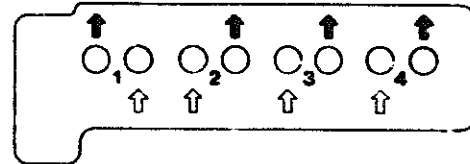
Dial gauge A 1 DIN 878

e.g. Mahr, D-7300 Esslingen
Order No. 810 St

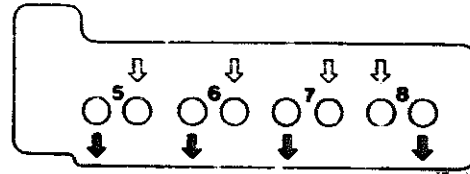
Note

For assembly jobs it is sufficient when the marks on the camshafts align with the ignition TDC point of the 1st cylinder.

Check „intake valve opening degree” on 1st and 6th cylinders with 2 mm valve lift.

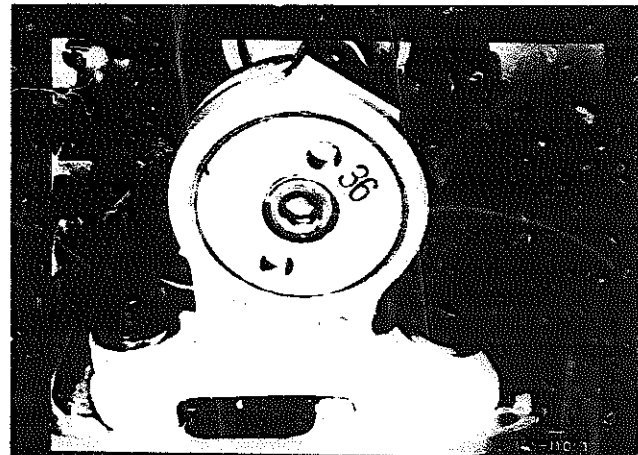


⚡ 1 5 4 8 6 3 7 2



Checking

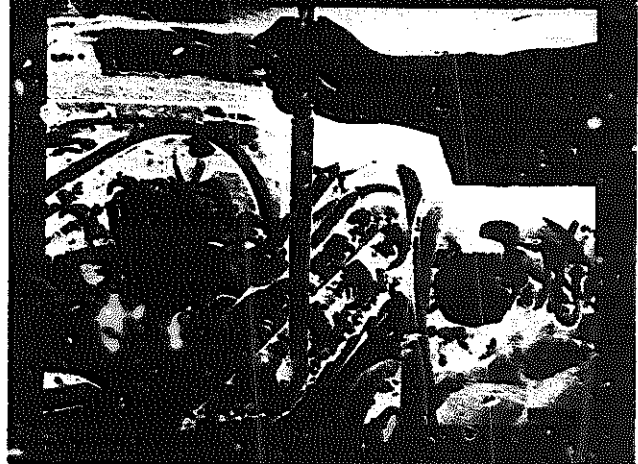
1 Check camshaft code on rear end of camshafts.



2 Remove rocker arms and valve clearance correction parts on intake valve of 1st and 6th cylinders.

Attention!

Rocker arms and valve clearance correction parts must be installed at their same locations again.



3 Install valve adjusting bolt, Part No. 116 050 11 20, at intake valve of 1st and 6th cylinders.

Install rocker arm.

4 Rotate crankshaft with tool combination or a mandrel at vibration damper until cam tip at intake valve of 1st cylinder is in upward position.

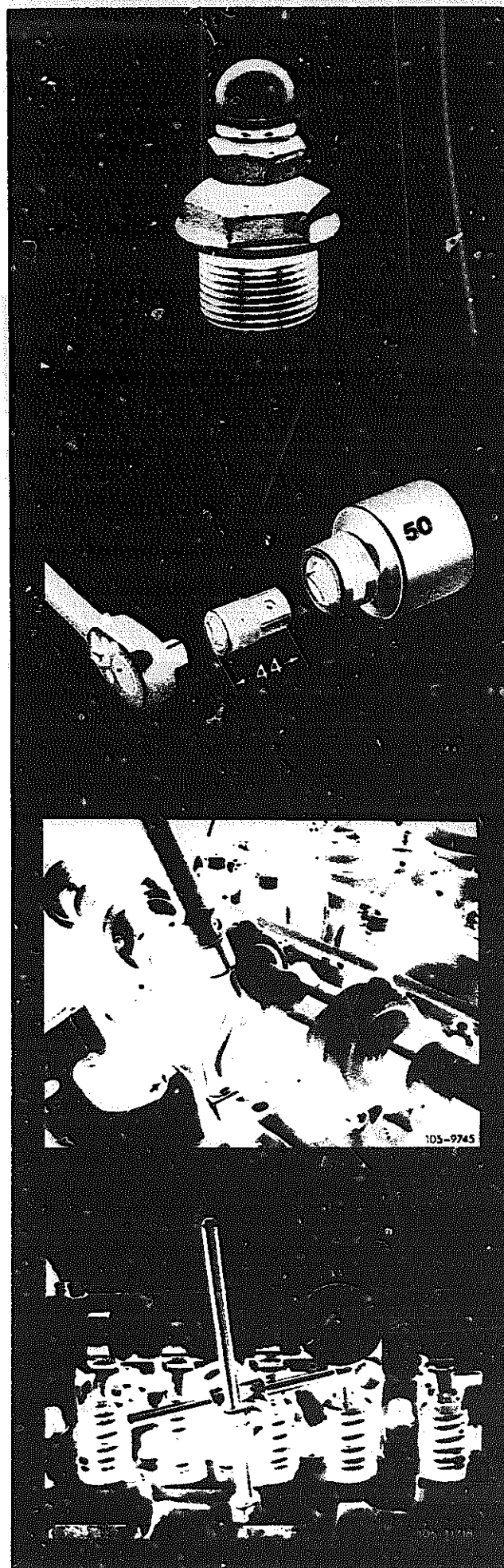
Only turn crankshaft in engine's direction of rotation.

5 Turn valve adjusting bolt until rocker arm rests on camshaft base circle without play.

6 Mount dial gauge holder on cylinder head.

7 Insert dial gauge and clamp with preload of 3 mm.

Gauge pin must be at an exact right angle to valve spring retainer.



8 Set large needle at 0.

9 Turn crankshaft in direction of rotation until the dial gauge needle moves back by 2 mm to a preload of 1 mm. The valve lift is now 2 mm.

10 With the engine set as it is, the value on the vibration damper must agree with the "intake valve opens" value in the chart.

11 Carry out check on intake valve of 6th cylinder, repeating points 4 through 10.

Adjusting

12 Correct timing by installing an offset woodruff key.

Woodruff keys are available with the following offsets.

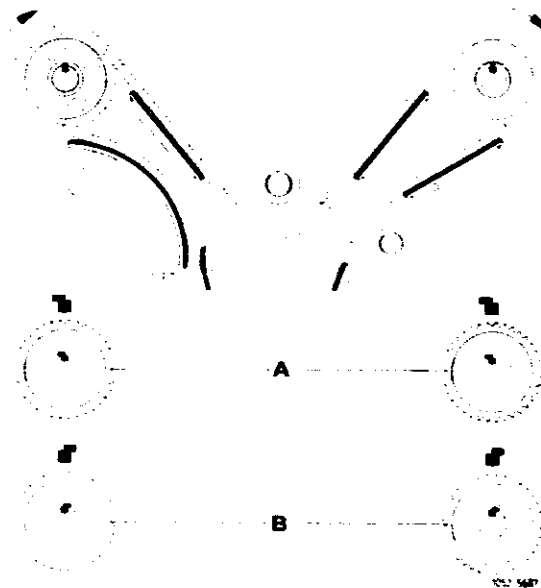
Offset in mm	Part Number	for a correction of about
0.7	621 991 04 67	4° on crankshaft
0.9	621 991 02 67	6 1/2° on crankshaft
1.1	621 991 01 67	8° on crankshaft
1.3	621 991 00 67	10° on crankshaft

An offset by one tooth on the camshaft sprocket will mean about 18° on the crankshaft.

Note: Install a new timing chain, if chain stretch is excessive.

Check timing after installation of a new timing chain and adjust the ignition timing.

13 Install valve clearance correction parts and rocker arms of intake valves from 1st and 6th cylinders.



Installed as A will mean an earlier opening
Installed as B will mean a later opening

05-220 Removing and installing camshaft

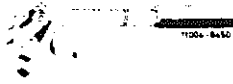

Timing for 2 mm valve lift

Engine 100.985	Camshaft code ¹⁾	Intake valve		Exhaust valve	
		opens ATDC	closes ABDC	opens BBDC	closes BTDC
New engine or new timing chain	left 36	12°	25°	32°	19°
	right 37	10°	23°	34°	21°
After running approx. 20.000 km	left 36	14°	27°	30°	17°
	right 37				

¹⁾ Code is stamped on rear end of camshaft.

Tightening torques		Nm	(kpm)
Cylinder head cover nuts		15	(1.5)
Camshaft sprocket bolts		100	(10)
Cylinder head bolts on cold engine	1st step	40	(4)
	2nd step	90	(9)
Camshaft bearing bolts		50	(5)
Chain tensioner plug		50	(5)
Chain tensioner threaded ring		40	(4)

Special tools

Valve spring depressor		100 589 06 61 00
Socket screw wrench socket 8 mm, 1/2" square, 130 mm long, for camshaft bearing bolts		000 589 33 07 00

Conventional tools

Screwdriver insert 17 mm	e.g. Hazet, D-5630 Remscheid Order No. 985-17
Screwdriver insert 19 mm	e.g. Hazet, D-5630 Remscheid Order No. 985-19
Socket screw wrench socket, 10 mm, 1/2" square, 60 mm long, for cylinder head bolts	e.g. Stahlwille, D-5600 Wuppertal Order No. 54/10

Note

Note camshaft code!

If a camshaft is replaced, the corresponding rocker arms must also be replaced.

Camshaft bearing journals can be ground; for this purpose undersize camshaft bearings are available (05-225).

Removing

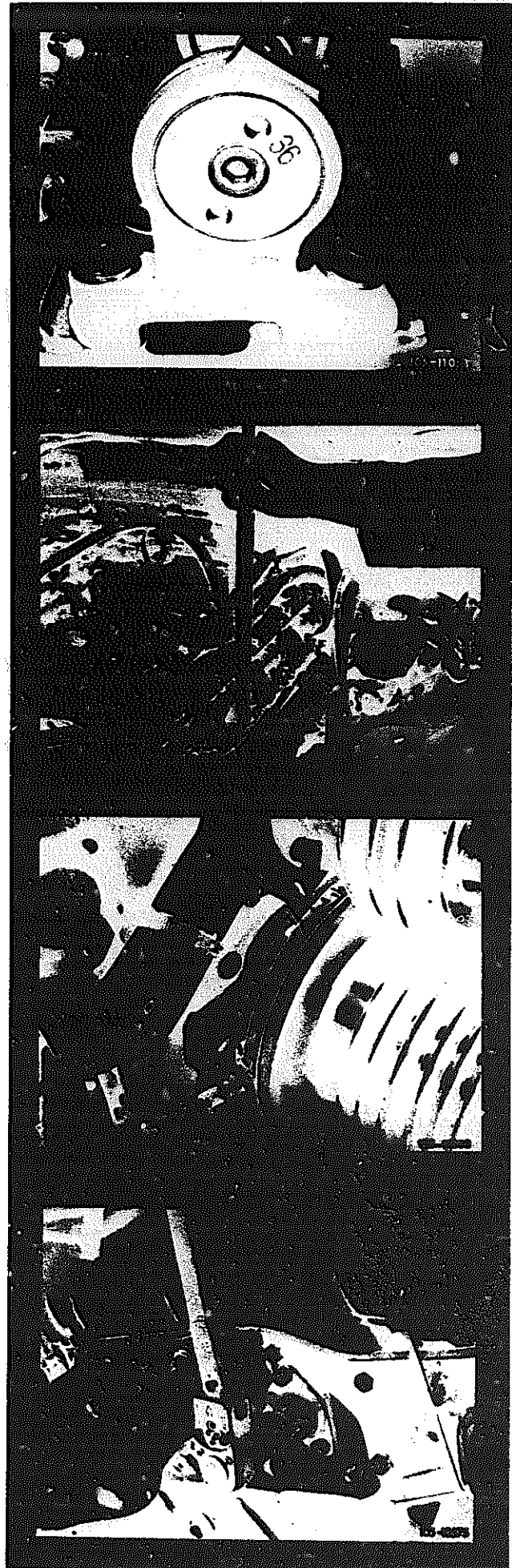
- 1 Remove rocker arms (05-230).

Attention!

Install rocker arms at same locations.

- 2 Move piston of 1st cylinder to TDC.

- 3 Remove chain tensioner spring (05-310).



4 Mark timing chain and camshaft sprocket together (arrows).

5 Remove camshaft sprocket.

6 Remove oil pipe.

7 Remove V-belt of alternator and swing alternator away laterally.

3 Unscrew fastening bolts for 1st, 2nd and 3rd camshaft bearing.

Note: Unscrew 4th and 5th camshaft bearing only when replacing camshaft bearings.

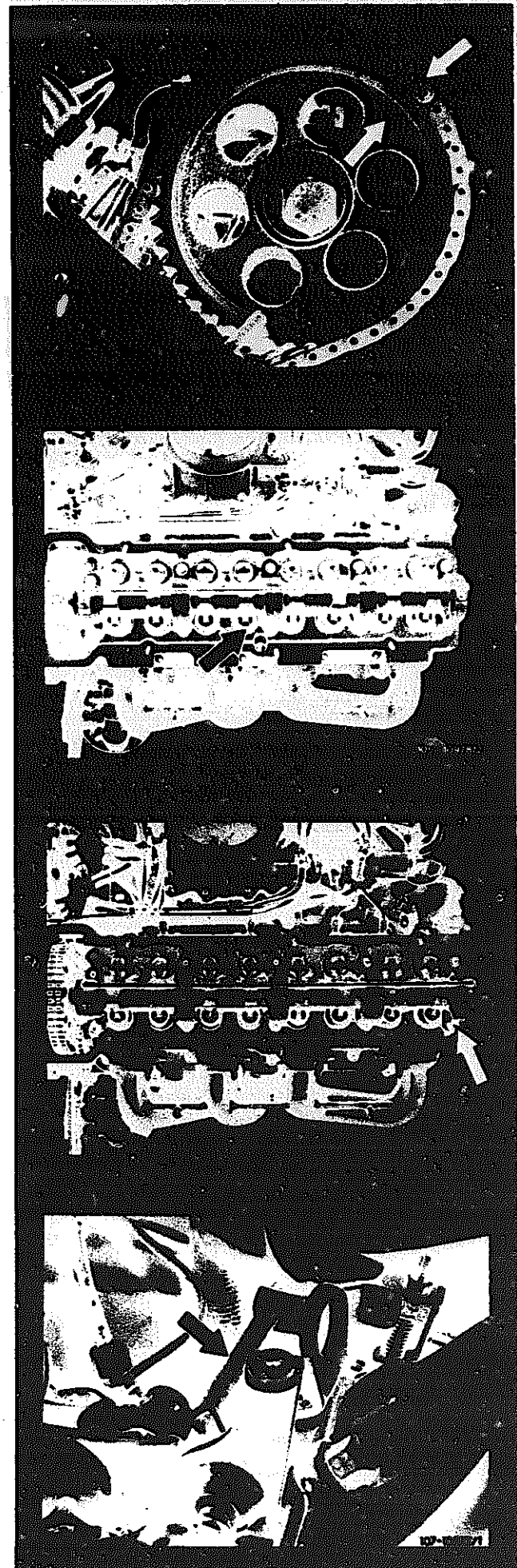
9 Pull camshaft out of camshaft bearings 4 and 5 in forward direction and remove.

The rear fastening bolt (arrow) can be pulled out only when engine is lifted at the left.

For this purpose, remove engine mount left, engine shock absorber left, radiator shell, oil line on oil cooler top and upper coolant hose.

Attention!

Remove regulating shaft (arrow) when engine is lifted.

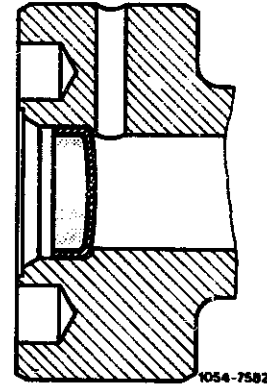


Installation

Note: When the hollow camshaft is cleaned inside, knock-in a new closing cap.

10 Lubricate camshaft bearing.

11 Mount camshaft with camshaft bearings or introduce camshaft, respectively.

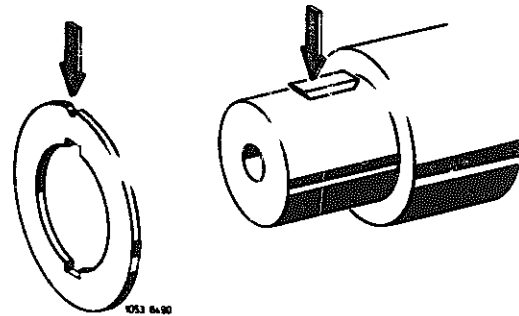


12 Tighten fastening bolts in steps from inside out.

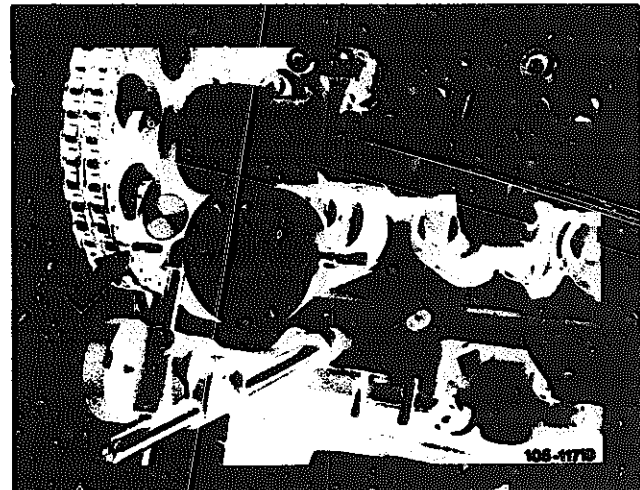
Make sure of easy operation of camshaft.

13 Mount compensating washer correctly (arrow).

14 Mount camshaft sprocket with timing chain. Pay attention to applied marks.



Note: When the first camshaft bearing or a camshaft is replaced, measure end play of camshaft (05-255).

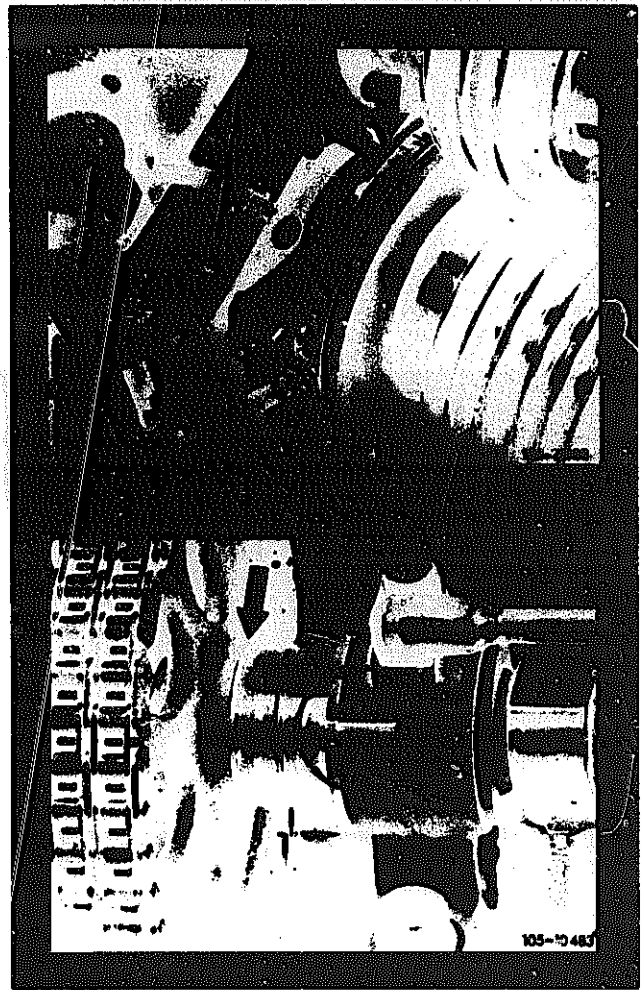


15 Turn crankshaft and move piston of 1st cylinder to TDC.

16 When 1st cylinder is at TDC the marks on both camshafts must align.

Attention!

The wide shoulder on camshaft sprocket (arrow) should face camshaft.



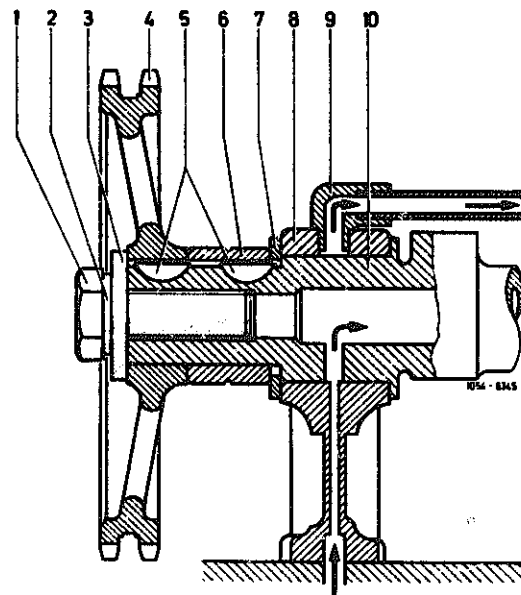
17 Tighten camshaft sprocket mounting bolts to a torque of 100 Nm (10 kpm).

18 Attach oil tube.

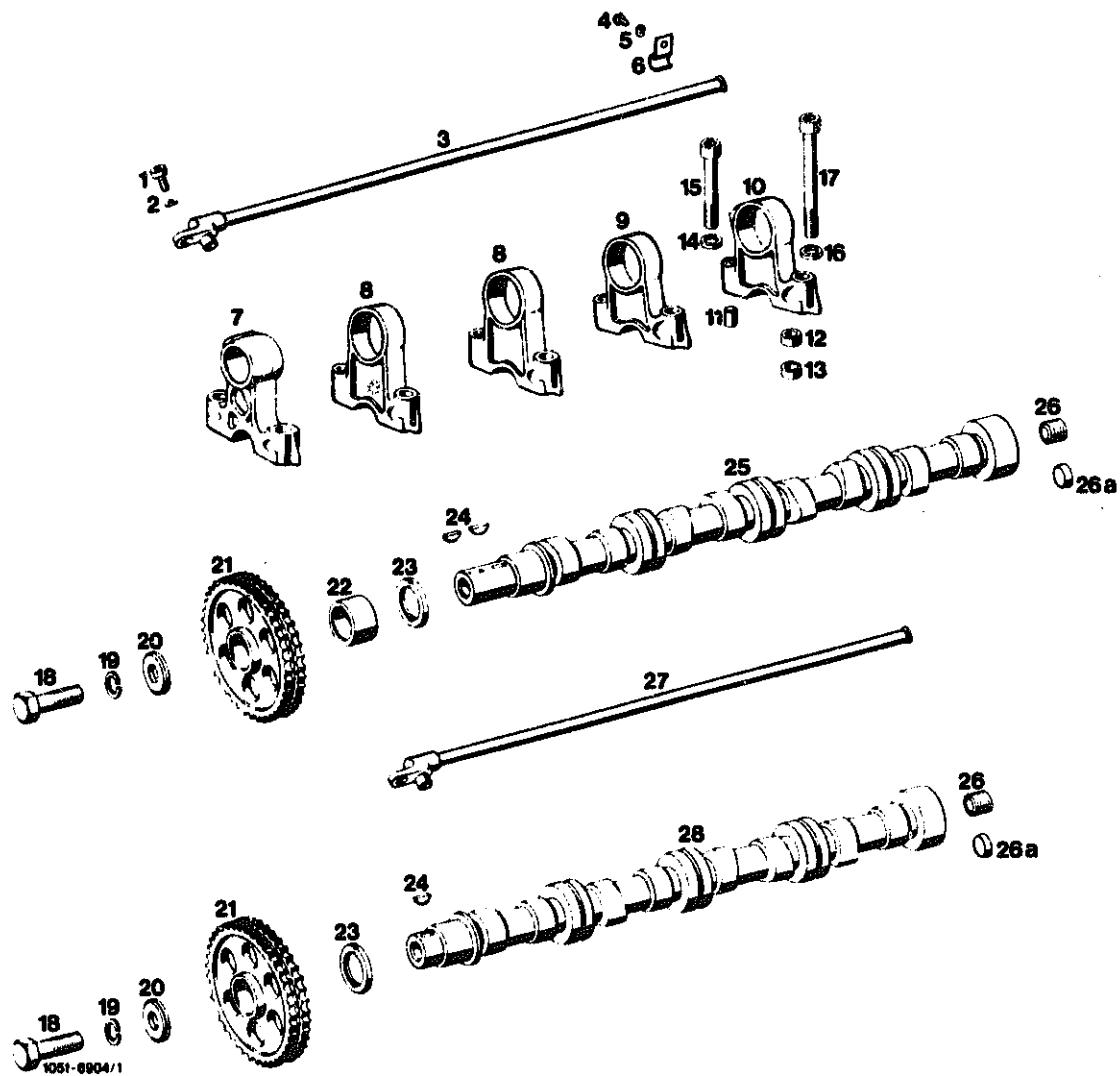
19 Rest of installation in reverse sequence.

Attention!

If new camshafts and rocker arms are installed, check timing (05-215) and basic setting of hydraulic valve clearance correction parts (05-213).



- | | |
|---------------------|--------------------|
| 1 Hexagon head bolt | 6 Sleeve |
| 2 Lock washer | 7 Ring |
| 3 Plain washer | 8 Camshaft bearing |
| 4 Camshaft sprocket | 9 Oil tube |
| 5 Woodruff keys | 10 Camshaft |



- 1 Bolt M 6 x 15 (two)
- 2 Washer B 6 (two)
- 3 Right oil tube
- 4 Bolt M 5 x 8
- 5 Washer B 5
- 6 Clamp A 8 (two)
- 7 Camshaft bearing 1 (two)
- 8 Camshaft bearings 2 and 3 (four)
- 9 Camshaft bearing 4 (two)
- 10 Camshaft bearing 5 (two)

- 11 Dowel pin 8h 8 x 10 (ten)
- 12 Dowel sleeve (left four, right five)
- 13 Dowel sleeve (left one)
- 14 Plain washer 10.5 (ten)
- 15 Bolt M 10 x 50 (ten)
- 16 Plain washer 12.5 (ten)
- 17 Bolt M 12 x 165
- 18 Bolt M 14 x 1.5 x 40
- 19 Lock washer B 14
- 20 Plain washer

- 21 Camshaft sprocket
- 22 Right spacer
- 23 Shim
- 24 Woodruff key 4 x 6.5
- 25 Right camshaft
- 26 Plug M 18 x 1.5
- 26a Closing cap
- 27 Oil tube left
- 28 Left camshaft

05-225 Grinding camshaft bearing journals

Data

Camshaft bearing journal peak-to-valley surface		0.003		
Max. runout of center bearing journal and camshaft sprocket seat when camshaft runs on outer bearing journals		0.01		
Bearing locations (fig.)		a	b	c
Standard Size	Bearing dia.	35.00	50.50	51.00
		35.02	50.52	51.02
	Journal dia.	34.97	50.47	50.97
		34.95	50.45	50.95
Repair stage 1	Bearing dia.	34.90	50.40	50.90
		34.92	50.42	50.92
	Journal dia.	34.87	50.37	50.87
		34.85	50.35	50.85
Repair stage 2	Bearing dia.	34.75	50.25	50.75
		34.77	50.27	50.77
	Journal dia.	34.72	50.22	50.72
		34.70	50.20	50.70
Thrust bearing	Bearing width	29.93		
		29.89		
	Journal width B	30.00		
		30.03		
Camshaft bearing play	radial	0.02-0.06	0.03-0.07	0.03-0.07
	axial	0.07-0.14		

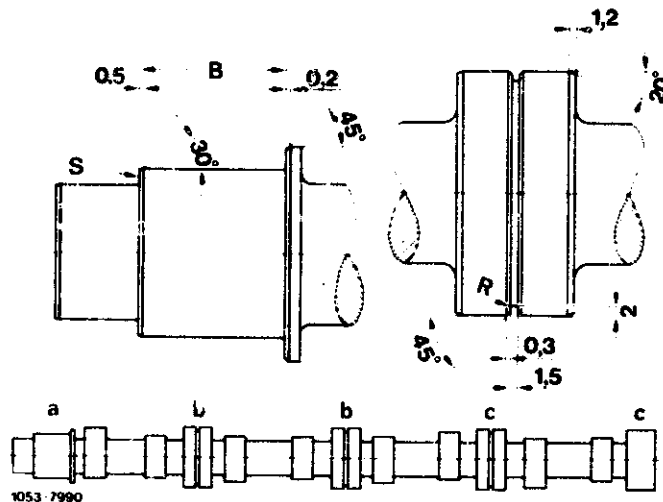
Note

Pertinent camshaft bearings for repair stages are available.

When grinding the bearing surface of bearing journal "a", the surface "S" must also be ground enough to guarantee journal width "B" and thus the axial play.

Bearing journals are not hardened.

The oil grooves in bearing points b and c were introduced starting engine no. 1025.



1053-7990

Special tool

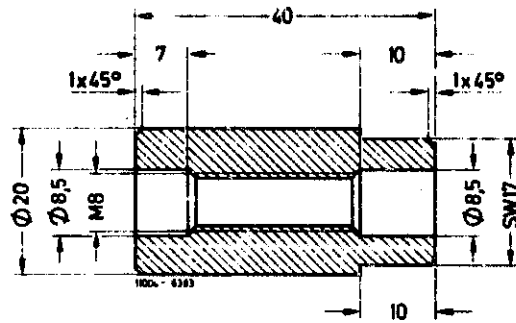
Dial gauge holder for camshaft axial play



363 589 02 21 00

Self-made tool

Threaded bushing for dial gauge holder 121 589 00 21 00



Conventional tool

Dial gauge A 1 DIN 878

e.g. Mahr, D-7300 Esslingen
Order No. 810

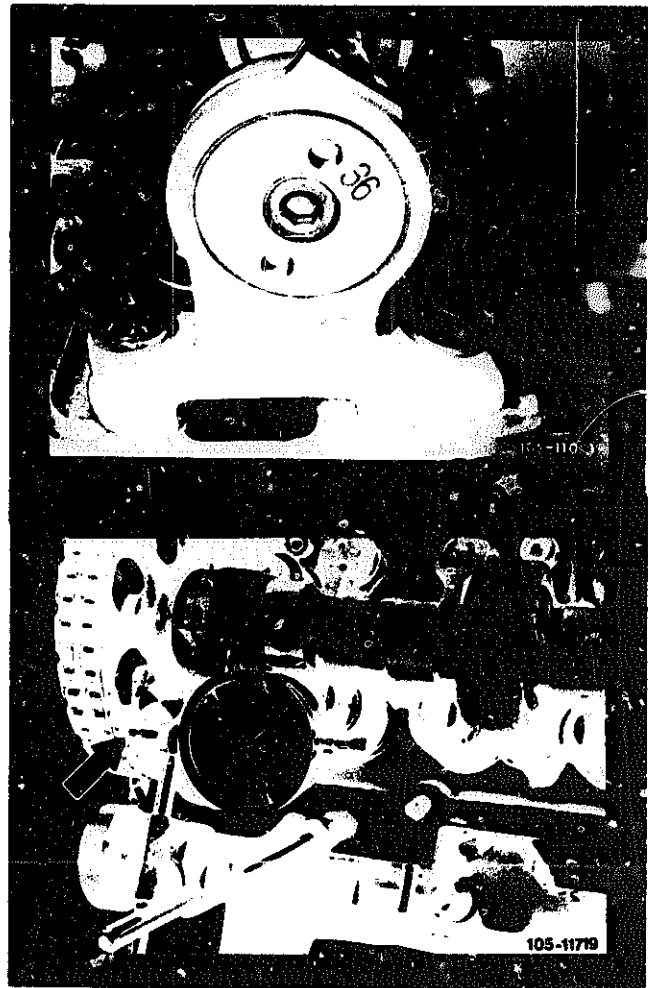
Note: Camshafts are hollow drilled.

After grinding unscrew plug or knock out cover, and clean inside of camshaft.

Attention!

Use end cover only once.

If the thrust surface of the bearing journal "a" is ground, measure end play following installation of camshaft.



05-230 Removing and installing rocker arms

Tightening torque	Nm	(kpm)
Cylinder head cover nuts	15	(1.5)

Special tools

Valve spring depresser		100 589 06 61 00
------------------------	--	------------------

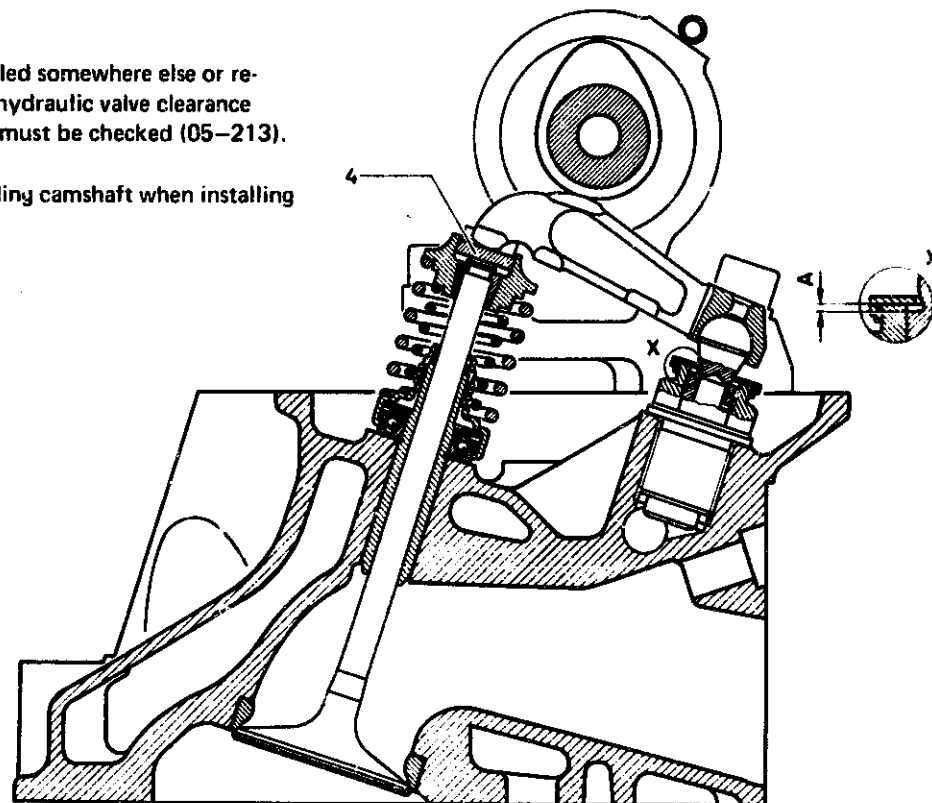
Contact handle for rotating engine (component of 001 589 46 21 00)		001 589 46 21 08
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Note

Rocker arms must be installed in their same original location.

If rocker arms are installed somewhere else or replaced, basic setting of hydraulic valve clearance compensating elements must be checked (05-213).

Also replace corresponding camshaft when installing new rocker arms.



053-6327/1

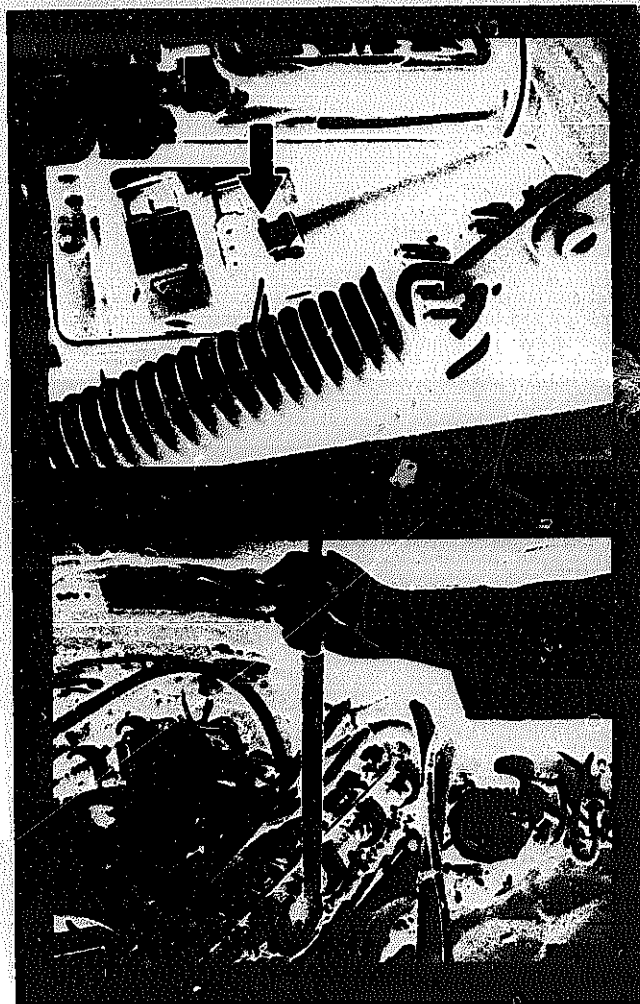
Removal and installation

1 For rotating engine, pull out fuel pump relay code No. 21 in fuse box. Connect contact handle to battery + and by means of a pin to contact bushing 1 of coupler (arrow).

2 Remove rocker arm with depressor. Cam tip should point away from rocker arm.

3 Lubricate sliding and contact surface of rocker arm prior to installation.

4 Install rocker arm with depressor.



05-250 Removal and installation of valve springs

Tightening torque	Nm	(kpm)
Nut for cylinder head cover	15	(1.5)

Special tools

Valve spring depressor		100 589 06 61 00
------------------------	--	------------------

Magnetic lifter for valve cone halves		116 589 06 63 00
---------------------------------------	--	------------------

Conventional tools

Cylinder leak tester	e.g. made by Bosch, EFAW 210 A made by SUN, CLT 228-1
Adaptor 1/2" square socket to 3/4" square head	e.g. made by Stahlwille, D-5600 Wuppertal order No. 514
Socket 50 mm, 3/4" square for rotating engine	e.g. made by Stahlwille, D-5600 Wuppertal order No. 55

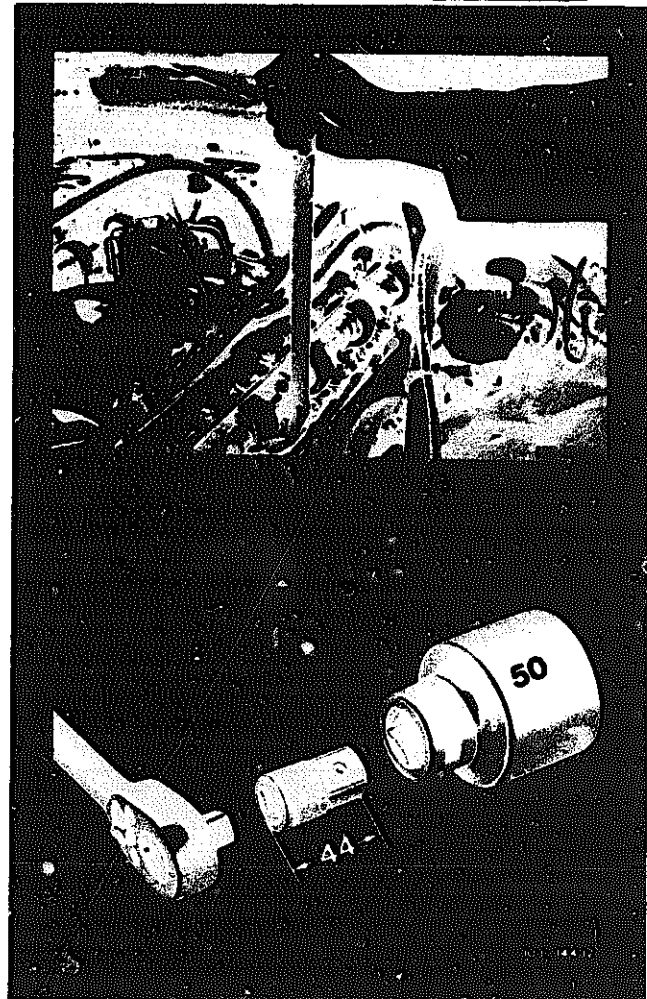
Removal

- 1 Remove rocker arms (05-230).

Attention!

Install rocker arms again at the same spot.

- 2 Unscrew spark plug.
- 3 Set piston of respective cylinder to ignition TDC.
For this purpose, rotate crankshaft with tool combination or a mandrel at vibration damper.



Attention!

The marking numbers 0, 90, 180 and 270 are punched into vibration damper.

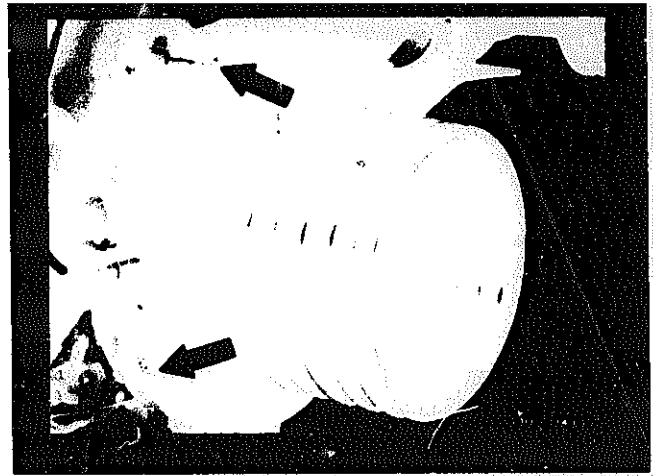
At the following positions of the marking number opposite pointer, the following pistons are at TDC:

Marking number	Piston at TDC
0	1 and 6
90	5 and 3
180	4 and 7
270	8 and 2

4 Support valves by means of compressed air (cylinder leak tester).

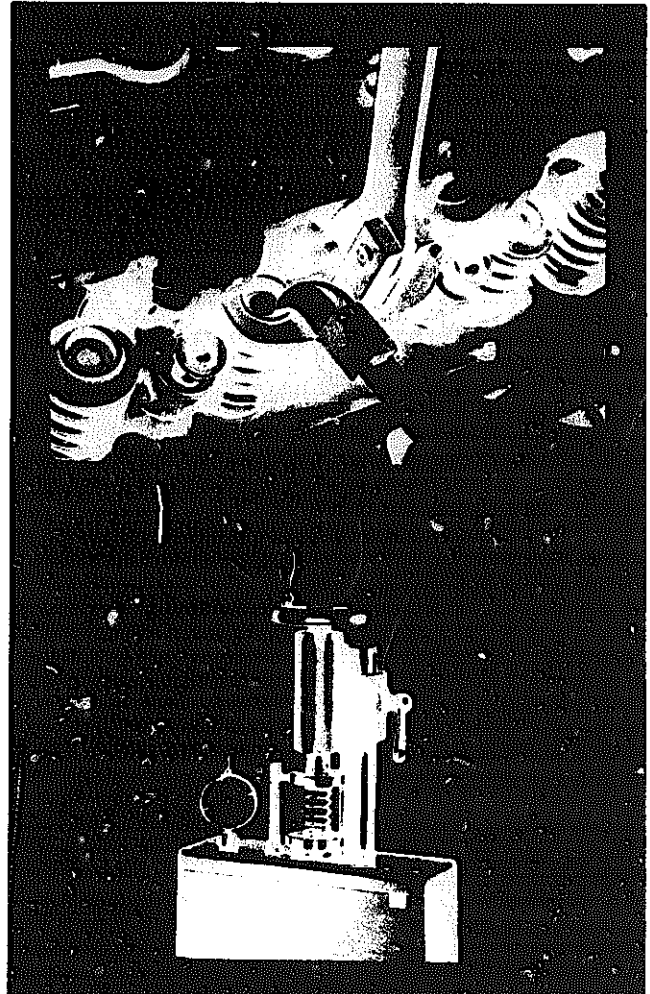
Attention!

Valves should not seat on piston crown to prevent bending of valves.



5 Push valve spring retainer down with depressor.

6 Remove valve cone halves with magnetic lifter.



Installation

7 Check valve springs, replace according to condition (05-260).

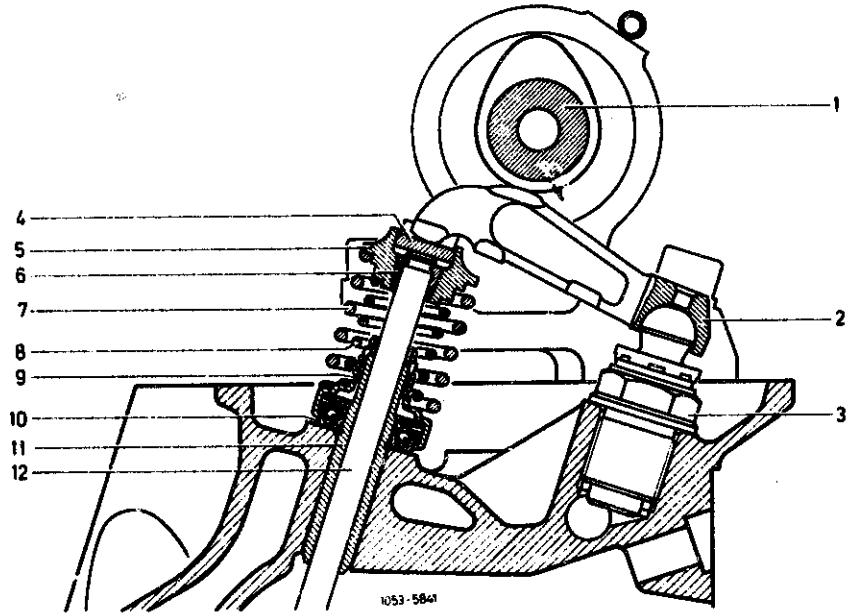
8 Replace valve stem seals (05-270).

Attention!

Mount valve springs in such a manner that the close coils are seated against rotocap.

9 For further installation proceed vice versa to removal.

- 1 Camshaft
- 2 Rocker arm
- 3 Hydraulic valve clearance compensating element
- 4 Thrust piece
- 5 Valve spring retainer
- 6 Valve cone halves
- 7 Outer valve spring
- 8 Inner valve spring
- 9 Valve stem seal
- 10 Rotocap
- 11 Valve guide
- 12 Intake valve



05-260 Checking valve springs

Data

Valve spring	Part number	Color code	Outside dia. in	Wire dia.	Length unloaded	Spring force at preloaded length		
			mm	mm	mm	when new N (kp)	limit value N (kp)	
Inner	130 053 00 22	yellow	22-22.4	2.5	45	21.5	228-252 (22.8-25.2)	205 (20.5)
Outer	100 053 01 20	none	35.5	4.75	53	35.4	602-682 (60.2-68.2)	540 (54.0)

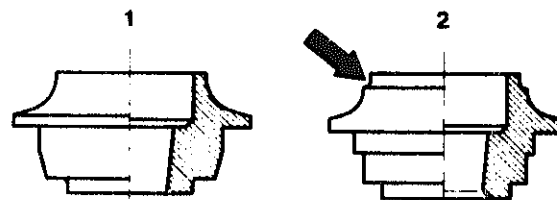
Checking

In the event of repairs, check valve springs for corrosion prior to re-use.

In addition, check spring force at specified length by means of a spring testing scale. If results are below limit value, renew valve springs.

In installed condition and at 12 mm valve stroke the valve spring force amounts to 1000-1245 N (102-127 kp). To make sure that this value is not less than specified on valves which are set lower (by valve seat machining), use valve spring retainer, part No. 130 053 06 25.

This valve spring retainer (2) is identified by a machined groove (arrow) and provides a spring force increase of approx. 60 N (6 kp) as compared with standard valve spring retainer.



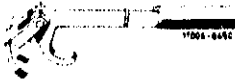


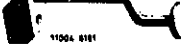
- 1 Valve spring retainer, series
- 2 Valve spring retainer for increasing spring force, with machined groove

1054 9492

05-270 Replacing valve stem seals

Tightening torque	Nm	(kpm)
Nuts for cylinder head cover	15	(1.5)

Special tools

Valve spring depressor		100 589 06 61 00
Magnetic lifter for valve cone halves		116 589 06 63 00
Assembly mandrel 9 mm dia. for valve stem seals		116 589 00 43 00
Assembly mandrel 11 mm dia. for valve stem seals		116 589 01 43 00

Conventional tools

Cylinder leak tester	e.g. made by Bosch, EFAW 210 A made by SUN, CLT 228-1
Adaptor 1/2" square socket to 3/4" square head	e.g. made by Stahlwille, D-5600 Wuppertal order No. 514
Socket 50 mm, 3/4" square for rotating engine	e.g. made by Stahlwille, D-5600 Wuppertal order No. 55

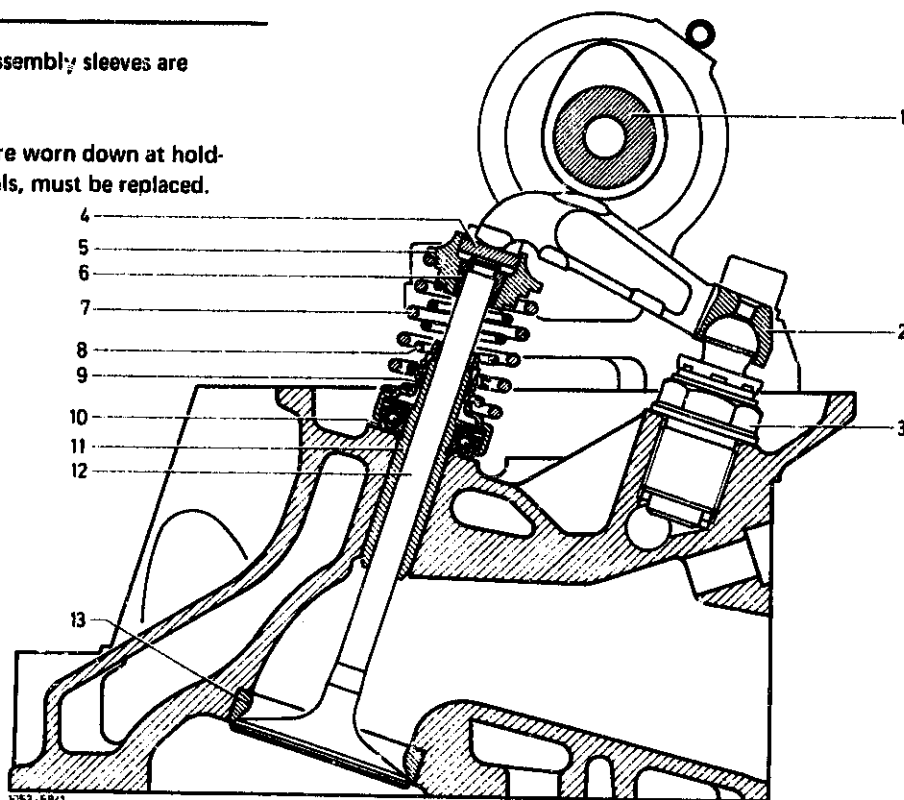
Note

Valve stem seals including assembly sleeves are included in repair kit.

Intake valve guides, which are worn down at holding groove for valve stem seals, must be replaced.

Attention!
Install rocker arms at same spot from which they were removed.

- 1 Camshaft
- 2 Rocker arm
- 3 Hydraulic valve clearance compensating element
- 4 Pressure pad
- 5 Valve spring retainer
- 6 Valve cone halves
- 7 Outer valve spring
- 8 Inner valve spring
- 9 Valve stem seal
- 10 Rotocap
- 11 Valve guide
- 12 Intake valve
- 13 Valve seat ring



Replacing

- 1 Remove valve springs (05-250).
- 2 Press valve stem seals off with a screw driver or with pliers.

Attention!

Do not damage valve stem and valve guide.

- 3 Debur valve stem at groove.

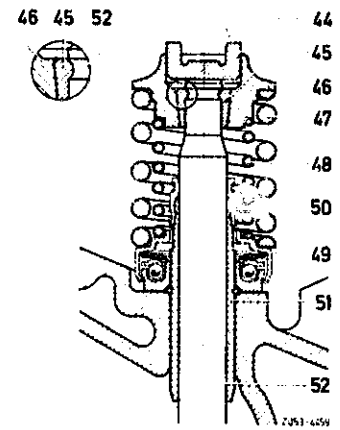
Replace worn out valve cone halves and spring retainers.

- 4 Check rotocap and replace, if required.

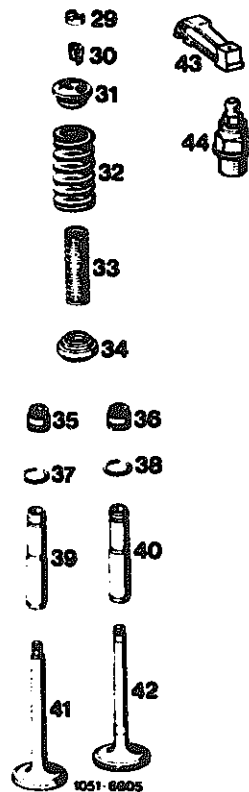
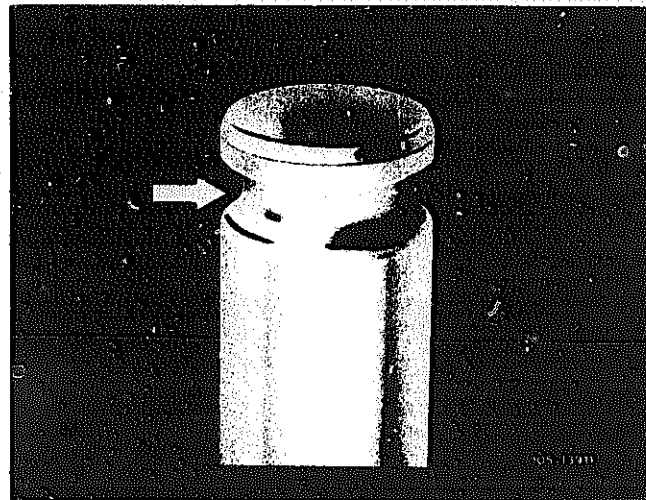
- 5 Lubricate valve stem seals and press-on with assembly mandrel.

Use assembly sleeve at intake valve.

- 6 Install valve springs (05-250).



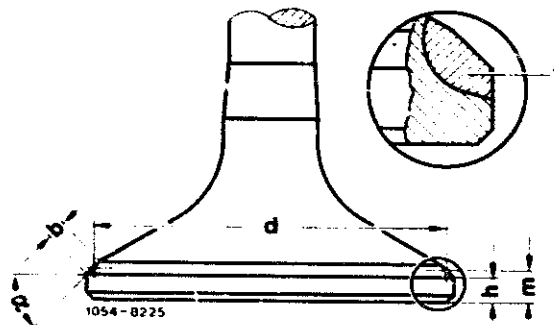
- 44 Pressure pad
- 45 Valve cone half
- 46 Valve spring retainer
- 47 Outer valve spring
- 48 Inner valve spring
- 49 Rotocap
- 50 Valve stem seal
- 51 Valve guide
- 52 Valve



- 29 Pressure pad (7 different sizes)
- 30 Valve cone member (32 each)
- 31 Valve spring retainer
- 32 Outer valve spring
- 33 Inner valve spring
- 34 Rotocap, intake and exhaust
- 35 Valve stem seal, exhaust
- 36 Valve stem seal, intake
- 37 Circlip exhaust
- 38 Circlip intake
- 39 Valve guide exhaust
- 40 Valve guide intake
- 41 Exhaust valve
- 42 Intake valve
- 43 Rocker arm
- 44 Hydraulic valve clearance compensating element

Data	Intake valve	Exhaust valve	
Valve disc dia.	50.9-51.0	42.9-43.1	
Valve stem dia.	8.95-8.97	10.93-10.95	
Valve length	142.65-142.85	143.90-144.10	
Code number at end of stem	E 100 09	100 01 27	
Sodium charge	without	with	
Valve seat plating	with	with	
Height "h" of valve disc	when new	1.5	2.6
	limit value	1.0	2.0
Width "b" of valve seat	1.8-2.5	1.5-2.5	
Dia. "d" at valve seat center	49.9-50.1	42.2	
Height "m" up to valve seat	when new	1.8-2.0	2.9-3.1
	limit value	1.4-1.6	2.5-2.7
Adjusting angle for machining valves	$45^{\circ} + 15'$		
Permissible concentric runout vertical to valve seat when mounted at valve stem	0.03		
Permissible axial runout at valve stem end when mounted at valve stem	0.02		

1 Valve seat plating



Conventional tools

Valve cone grinding machine
or
Valve cone machining tool

e.g. made by Krupp, D-5309 Meckenheim
model VS
e.g. made by Hunger, D-8000 Munich 55
type VKDR 1, order no. 203.00.200

Note

Exhaust valves are sodium-filled

When scrapping, pay attention to safety rules. Do not melt sodium-filled valves or make such valves into tools (punch etc.) without removing sodium charge first.

Be careful when removing sodium from valves, since sodium, when mixed with water or solvents containing water, reacts extremely violent and explosive, so that the resulting hydrogen gas may be the cause of fires.

Sodium from sawed-open and broken-up valves can be neutralized in the open air in a vessel containing a mixture of 2 liters of spirit of alcohol and 1 liter of water.

Sodium-filled valves can be collected and sent to the "Garantieprüfstelle Werk Stuttgart-Untertürkheim" for neutralization.

Checking and machining

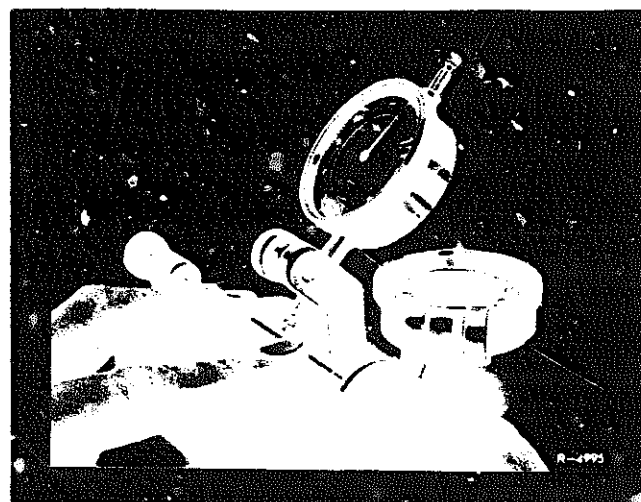
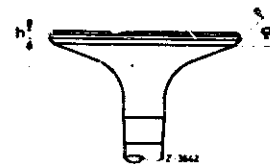
1 Clean and visually inspect valves.

Replace any valves with a burnt valve head, with insufficient height "h" for valve head or valves with worn or scored valve stems.

2 Check permissible concentric runout of valve stem and valve seat.

3 Check axial runout at end of valve stem.

Re-saw valve, if limit value is attained.

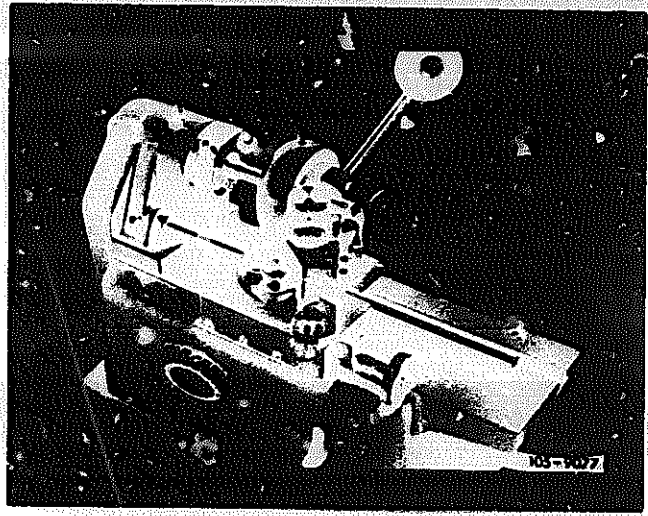


4 Machine valve seat and face of valve stem.

Conform with instructions accompanying tool and valve machining angle.

5 Measure valve seat runout and height "h" of valve head.














Renew valve, if limit value is attained.



Valve guides

	Steps and part No.	OD	Color code	Basic bore in cylinder head	Valve guide ID
Intake	Standard dimension I 100 050 48 24	14.043-14.050	gray/brown	14.030-14.035	9.000-9.015
	1st repair stage 100 050 49 24	14.214-14.232	red	14.198-14.203	
Exhaust	Standard dimension I 100 050 56 24	15.043-15.050	gray/brown	15.030-15.035	11.000-11.018
	1st repair stage 100 050 57 24	15.214-15.232	red	15.198-15.203	

Special tools

Check plug 9 mm dia. intake		117 589 03 23 00
Check plug 11 mm dia. exhaust		117 589 04 23 00
Knock-out plug 9 mm dia. intake		110 589 02 15 00
Knock-out plug 11 mm dia. exhaust		110 589 03 15 00
Check plug for valve guide basic bore		117 589 05 23 00
Reamer 14.035 mm dia. intake		110 589 03 53 00
Reamer 15.035 mm dia. exhaust		110 589 02 53 00
Broach 14.2 mm dia. for 1st repair stage intake		115 589 00 53 00
Broach 15.2 mm dia. for 1st repair stage exhaust		110 589 00 53 00
Knock-in plug 9 mm dia. intake		110 589 00 15 00
Knock-in plug 11 mm dia. exhaust		110 589 01 15 00
Reamer 8.99 mm dia. H 7 intake		000 589 10 53 00
Reamer 10.99 mm dia. H 7 exhaust		000 589 15 53 00

Note

In the event of repairs, cylinder heads with standard normal dimension valve guides should be provided with standard dimension I valve guides (gray-brown). First, ream basic bores with reamers 15.035 mm dia. (intake) or 15.035 mm dia. (exhaust), so that the overlap is not getting too high.

Basic bores in which normal dimension I valve guides are not providing an adequately tight seat (minimum overlap 0.007 mm), finish with broaches for repair stage valve guides. For this purpose, check basic bores with check plug.

Checking valve guide

With cylinder head removed, check valve guides with check plug in longitudinal and crosswise direction.

Replace valve guides, into which the not-good plug with limit wear dimension (+220) can be slipped with its complete length (5 mm).

Valve guides which are worn out outside at seat of valve stem seal, with the result that the valve stem seal is no longer tightly seated, should also be replaced.

Replacing valve guides

1 Knock-out valve guide by means of knock-out plug from combustion chamber side.

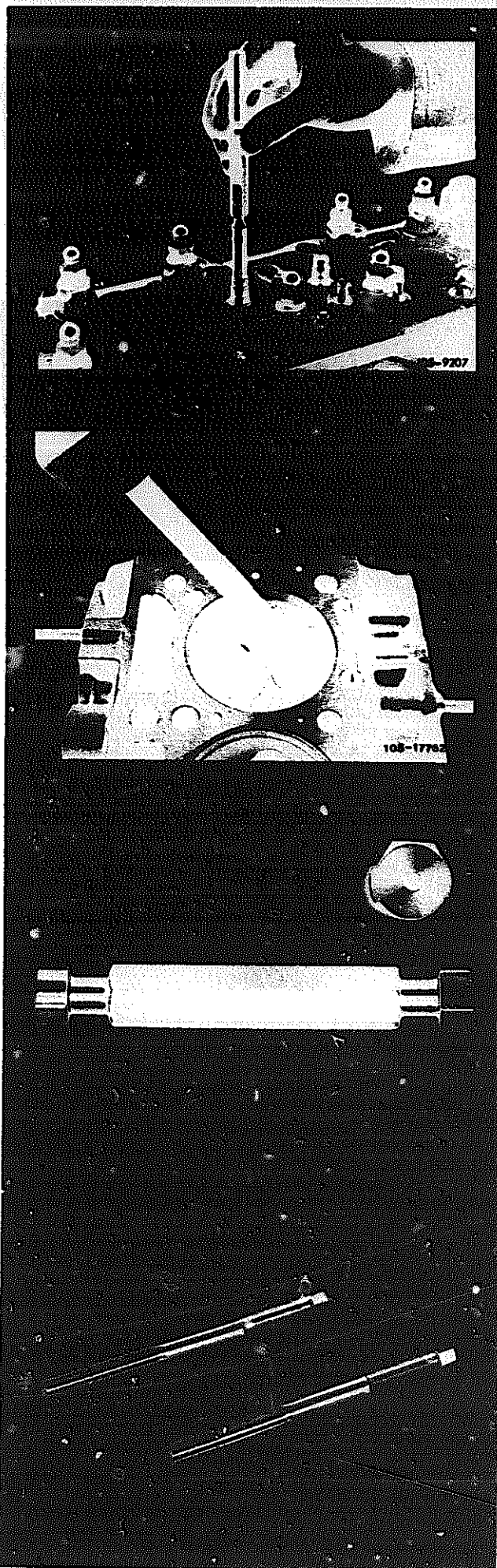
2 Check valve guide basic bore with check plug in longitudinal and crosswise direction at both bore ends.

Basic bores into which the measuring plug can be inserted at one point with its entire length (8 mm) should be refinished to repair stage. If the measuring plug cannot be slipped in at all or not completely, the basic bore may be reamed for normal dimension of valve guides.

Machining basic bore normal dimension

3 Ream basic bore with reamer 14.035 mm dia. or 15.035 mm dia., while lubricating with kerosene. Ream with little pressure and do not cant reamer.

Note: Handle reamers carefully and keep in protective jacket, so that the cutting edges are not damaged.



**Machining basic bore
repair stage**

4 Force respective broach through basic bore in cylinder head.

The broach can be forced through bore on a column-type drill press or a hydraulic press. The important point is that the broach is in vertical position in relation to support of cylinder head. The spindle of the drill press or the hydraulic press must be free of play.

Inserting valve guide

5 Undercool valve guide in liquid nitrogen (for approx. 3 minutes) and insert.

If no liquid nitrogen is available, heat cylinder head in a water bath to approx. 80 °C, knock-in valve guide by means of knock-in plug until the circlip rests against cylinder head.

6 Check tight seat of valve guide with cooled-down cylinder head only.

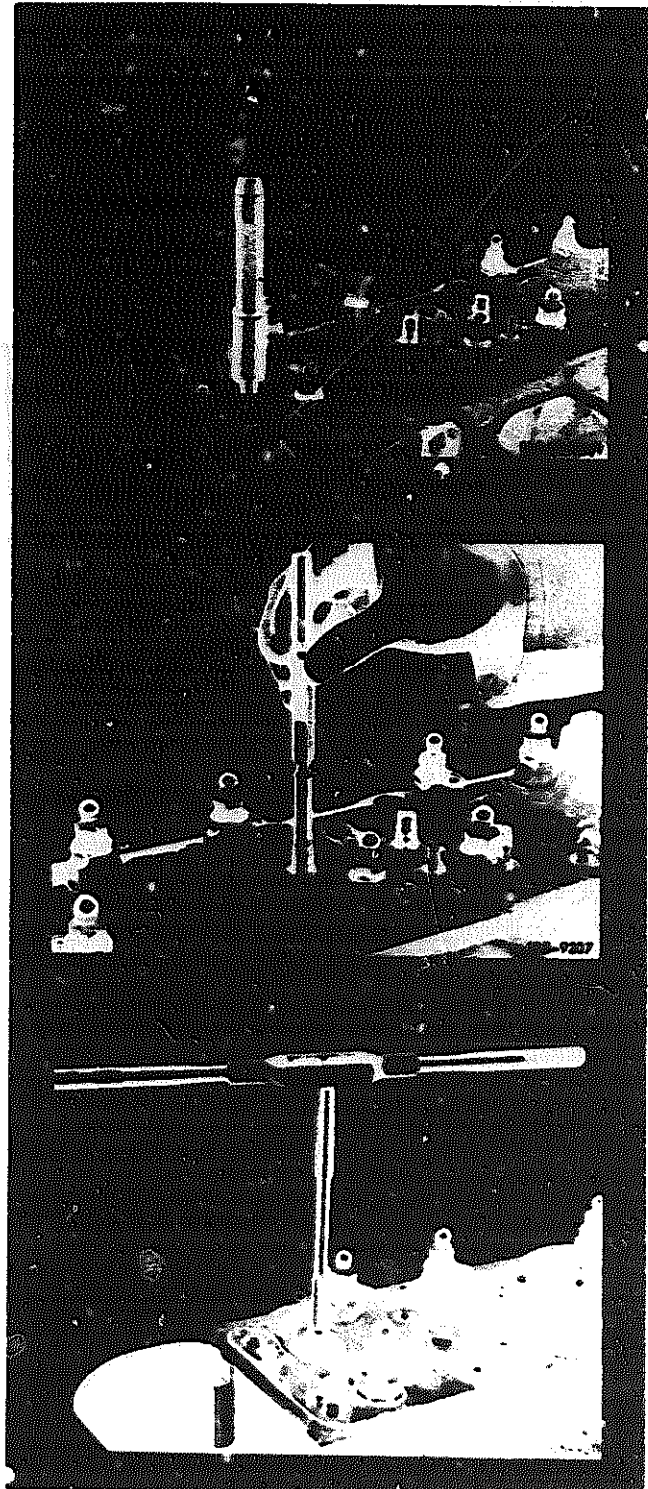
Tight seat pressure 3500 N.

7 Check ID of valve guide with check plug.

The good end should slip in.

8 If required, ream ID with reamer.

9 Check valve seats for runout and refinish, if required.

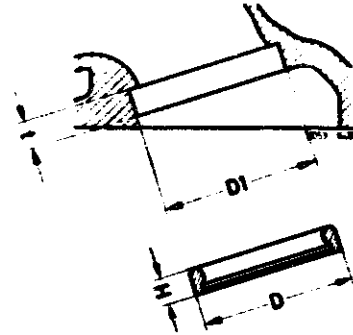


05-290 Replacing valve seat inserts

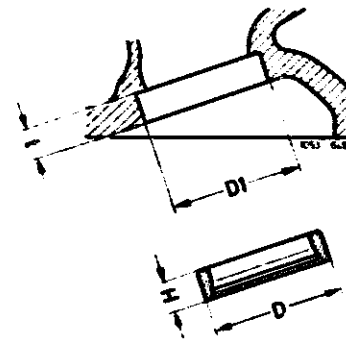
Data

Valve seat insert overlap in cyl. head 0.08-0.10

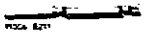
Intake	Standard Size	Repair stage
D1	$\frac{52.90}{52.92}$	max. up to 53.9
D	$\frac{53.00}{52.99}$	rough turn 54.2
t	$\frac{9.00}{9.10}$	
H	$\frac{9.00}{8.91}$	



Exhaust	Standard Size	Repair stage
D1	$\frac{45.00}{45.01}$	max. up to 46.00
D	$\frac{45.10}{45.09}$	rough turn 46.30
t	$\frac{10.00}{10.10}$	
H	$\frac{10.00}{9.91}$	



Special tools

Control gauge 9 mm dia. intake valve guide		117 589 03 23 00
Control gauge 11 mm dia. exhaust valve guide		117 589 04 23 00

Conventional tools

Cyl. head holder	e.g. made by Rohenberger, D-6333 Kerkheim Order No. DBK 60-2
Ring seat machining tool	e.g. made by Hunger, D-8000 München size 2, order No. 220.03.110
Valve seat machining tool	e.g. made by Hunger, D-8000 München type VDSNL 1/45/30 Order No. 236.03.308
Test set for valve seats	e.g. made by Hunger, D-8000 München order No. 216.93.300

Internal micrometer (range 25–60 mm)

e.g. Mahr, D-7300 Esslingen
Order No. 844

External micrometer (range 25–50 and 50–75 mm)

e.g. Mahr, D-7300 Esslingen
Order No. 40 S

Replacing

- 1 Remove old valve seat ring by means of ring seat machining tool.
- 2 Check valve guides, replacing if necessary (05–285).
- 3 Measure standard bore D1.

A new valve seat insert of standard size can be used, if the specified amount of overlap is given.

- 4 Machine basic bore repair stage D1 with ring seat machining tool.
- 5 Measure standard bore repair stage D1.

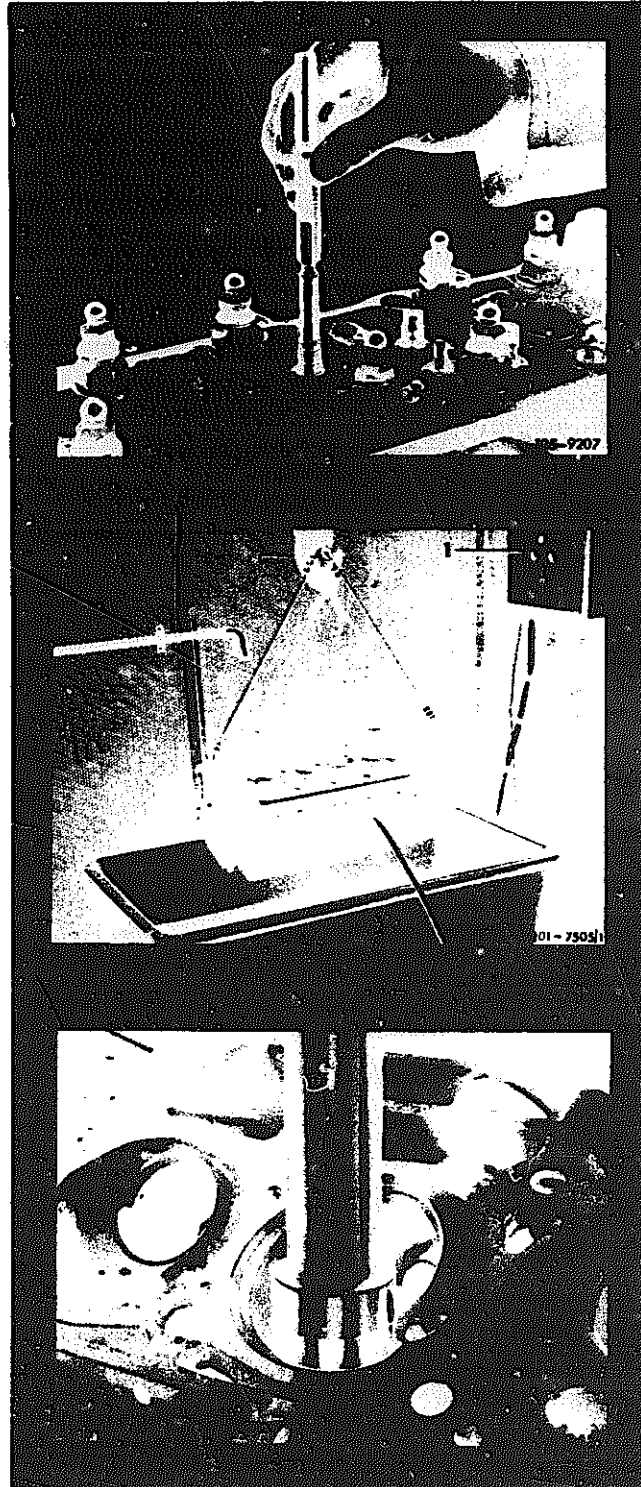
- 6 Lap valve seat insert repair stage until specified amount of overlap is given.

- 7 Heat cylinder head in a water bath at about 80 °C.

- 8 Undercool valve seat ring with liquid nitrogen or dry ice.

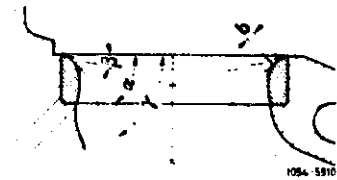
- 9 Drive in valve seat insert with an appropriate guide mandrel.

- 10 Machine valve seat inserts (05–291).



05-291 Machining valve seat rings

Specifications	Intake	Exhaust
Valve seat width b	1.3-2.0	1.5-2.0
Valve seat angle α	45°	
Upper correction angle β	15°	
Lower correction angle γ	60°	
Max. valve seat runout	0.04	

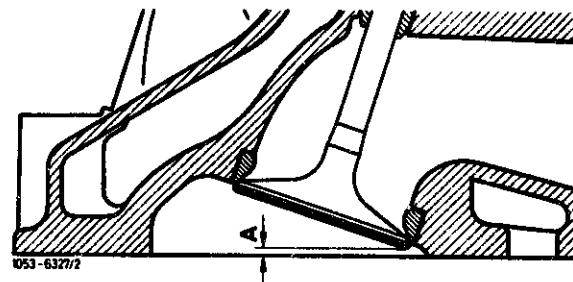


Min. distance A with new valves and new valve seats

Intake	2.9
Exhaust	3.1


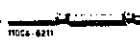
Max. distance A with new valves and new valve seats

Intake	3.8
Exhaust	4.0



The maximum distance will be reduced by the same amount, as the amount machined off of the cylinder head mating surface.

Special tools

Magnetic lifter for valve poppets		116 589 06 63 00
Contr. gauge 9 mm dia. intake valve guide		117 589 03 23 00
Contr. gauge 11 mm dia. exhaust valve guide		117 589 04 23 00

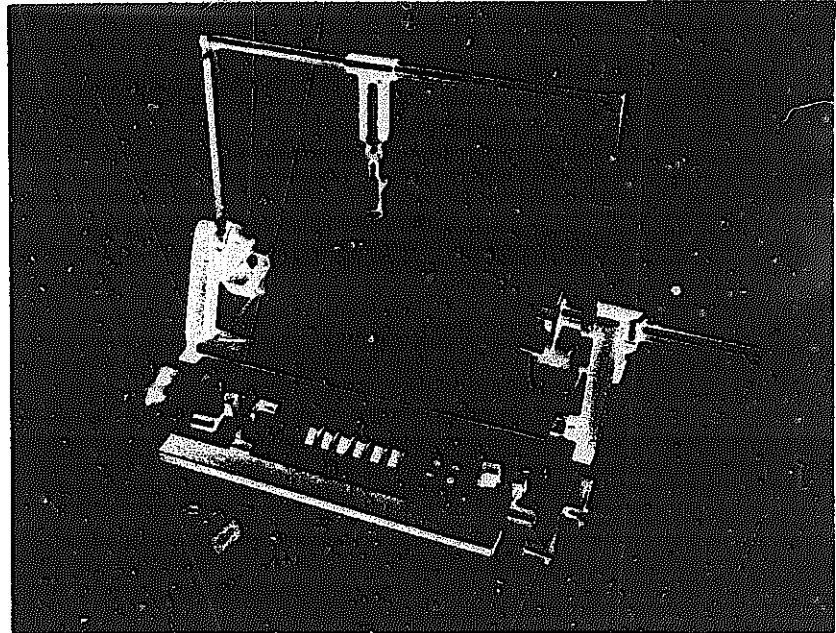
Conventional tools

Cylinder head holder	e.g. made by Rohenberger, D-6333 Kelkheim Order No. DBK 60-2
Valve seat machining tool	e.g. made by Hunger, D-8000 München type VDSNL 1/45/30, order No. 236.03.308
Test set for valve seats	e.g. made by Hunger, D-8000 München order No. 216.93.300
60° correction tool No. 13 for lower correction angle	e.g. made by Hunger, D-8000 München order No. 216.64.622

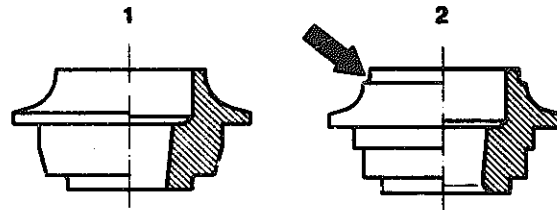
Note

Clamp cylinder head in holder for disassembling and machining.

Machine valve seat rings with valve seat turning tools, with valve seat grinder or with valve seat cutters.



- 1 Valve seat retainer, series
- 2 Valve seat retainer to increase spring force with machined groove



1054-9492

In installed condition and at 12 mm valve stroke the valve spring force amounts to 1000–1245 N (102–127 kp). To make sure that this value is not less than specified on valves with are set lower (by valve seat machining), use valve spring retainer, part No. 130 054 06 25.

This valve spring retainer (2) is identified by a machined groove (arrow) and provides a spring force increase of approx. 60 N (6 kp) as compared with standard valve spring retainer.

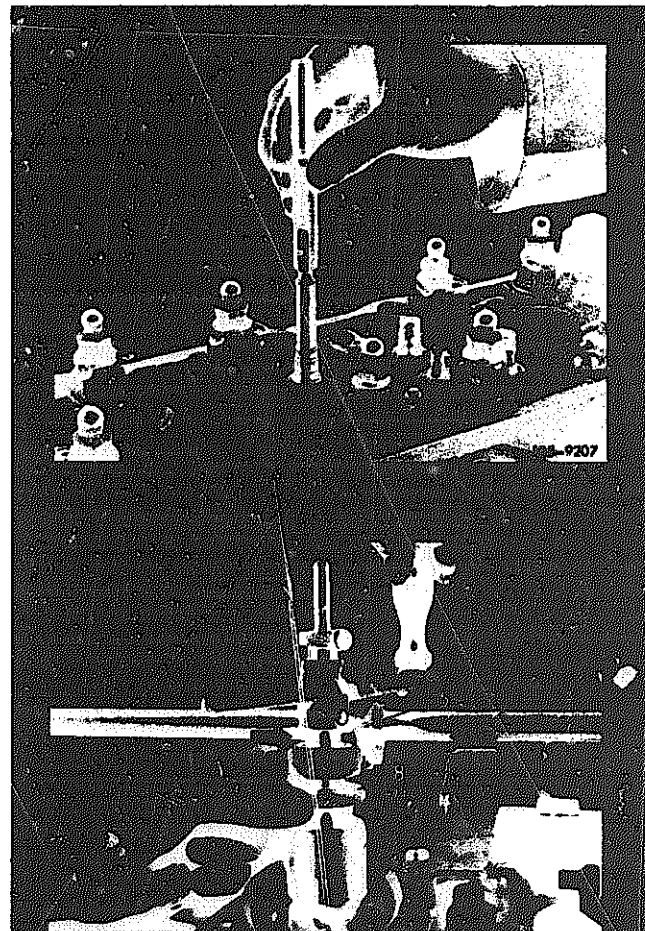
Machining valve seats

1 Check valve guides, replacing if necessary (05-285).

2 Machine valve seats (see instructions of tool manufacturer).

Attention!

Release pilot only after valve seat runout has been checked (point 3).



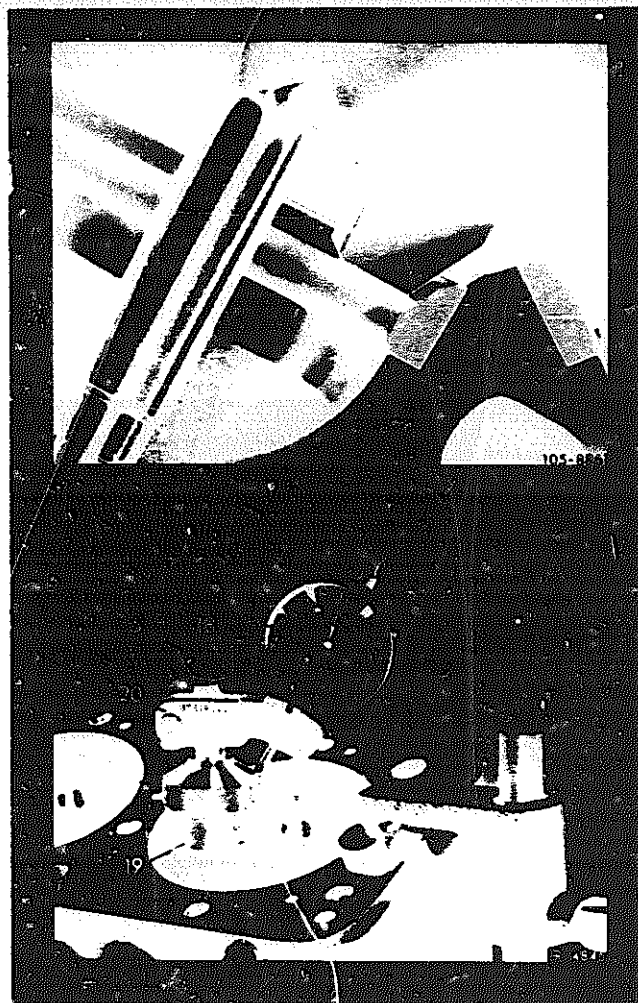
Attention!

Never machine bead or lower part of valve seat ring.

3 Check valve seat runout.

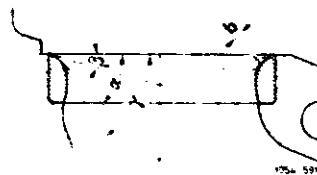
This requires installing test sleeve (19) with dial gauge holder (20) and dial gauge on pilot (5).

- 5 Pilot
- 18 Dial gauge
- 19 Test sleeve
- 20 Dial gauge holder



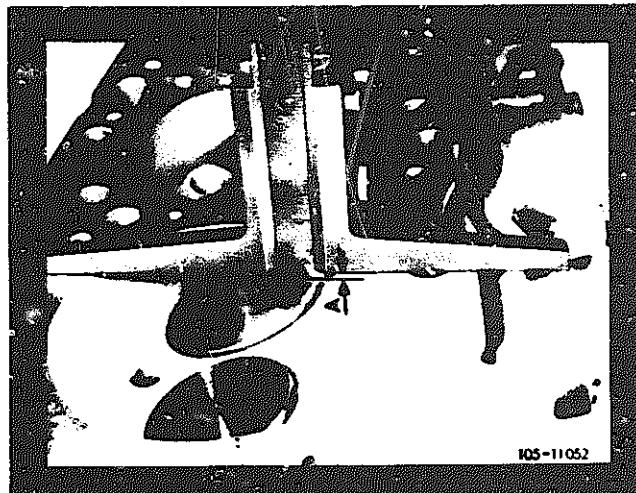
4 Measure valve seat width „b” and, if necessary, correct top to 15° and bottom to 60°.

When machining with machining tool made by Hunger, use 60° correction bit No. 13 for lower valve seat correction.



5 Install new valve and check maximum distance A.

if necessary, replace valve seat insert (05-290).



05-310 Removing and installing chain tensioner

Tightening torques	Nm	(kpm)
Plug	50	(5)
Threaded ring	40	(4)

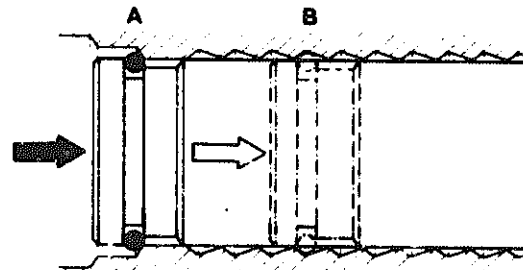
Conventional tools

Screwdriver insert 19 mm	e.g. Hazet, D-5630 Remscheid, Order No. 985-19
Screwdriver insert 17 mm	e.g. Hazet, L-5630 Remscheid, Order No. 985-17

Note

Pin in chain tensioner has a spring lock and cannot be pressed back.

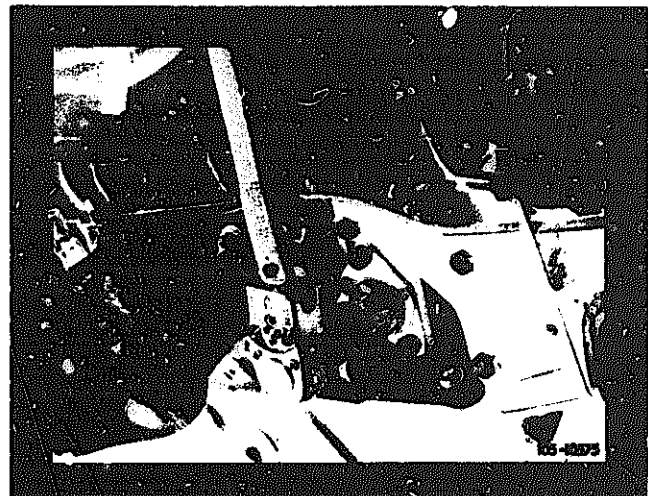
Before installation the chain tensioner must be disassembled and the pin positioned at A.



A Chain tensioner positioned for installation
B Chain tensioner positioned for operation

For assembly work on the chain drive (e.g. removal of camshaft sprocket or sliding rail) it is sufficient to first remove the chain tensioner spring.

This requires unscrewing the plug.



Removing and disassembling

- 1 Remove battery and battery console.
- 2 Unscrew plug (1) and remove spring (11).

Plug is under pressure from spring.

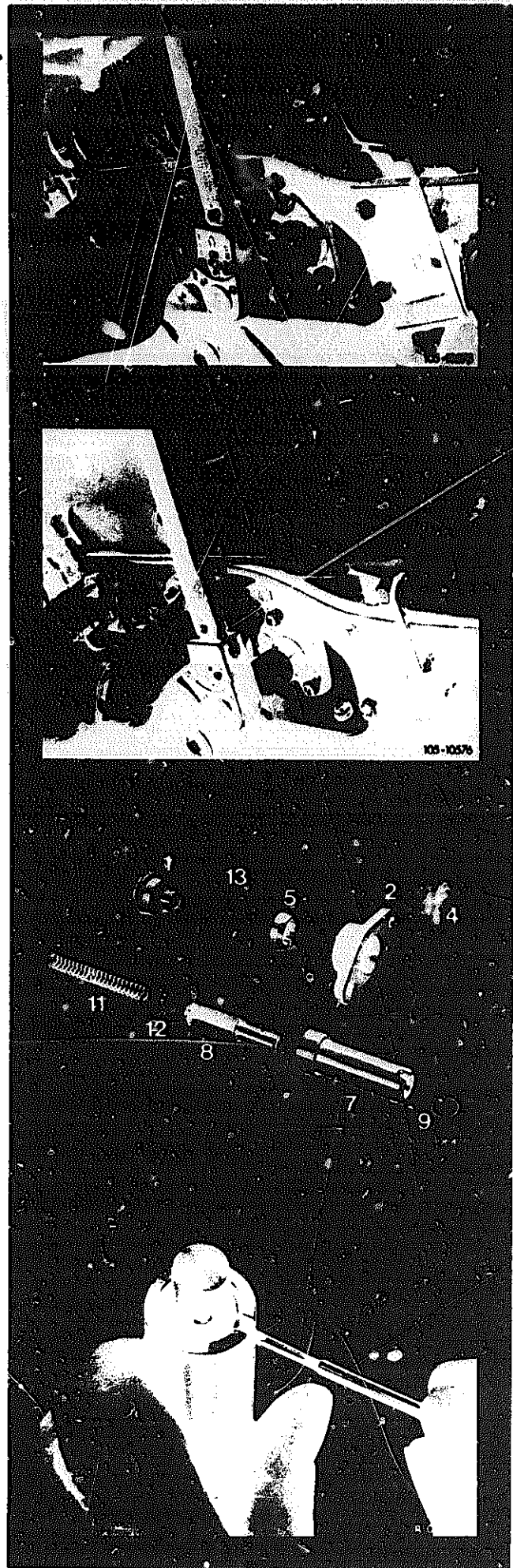
- 3 Unscrew threaded ring (5).

- 4 Detach flange (2) and remove with gasket (4).

- 5 Pull out chain tensioner housing (7) with pin (8).

- 6 Pry off snap ring (9).

- 7 Pull out pin (8) toward front.



Installation

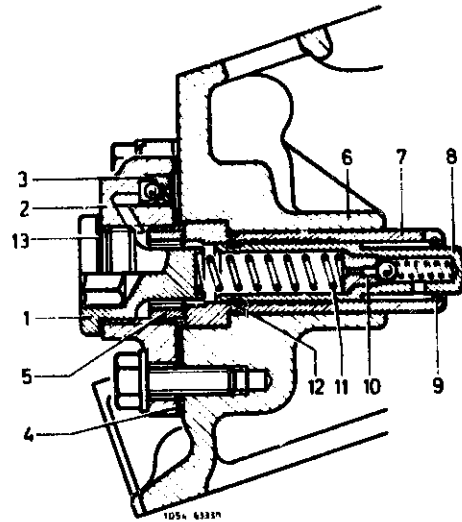
- 8 Insert circlip (9) into chain tensioner housing (7).
- 9 Slip chain tensioner housing (7) into cylinder head (6).
- 10 Mount flange (2) with new gasket (4).

Attention!

A chain tensioner with reinforced flange is installed starting engine end No. 000463 (flange thickness 13 mm, formerly 9 mm).

Mount chain tensioner of flange thickness 13 mm with screw M 8 x 30 mm (formerly M 8 x 25 mm).

- 11 Screw-in threaded ring (5) and tighten to 40 Nm (4 kpm).
- 12 Slip-in thrust bolt (8) with detent spring (12).
- 13 Install compression spring (11) 76 mm long and mount closing plug (1) with sealing ring, tighten to 50 Nm (5 kpm).
- 14 Install battery frame and battery.



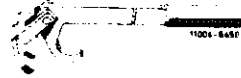
- | | | | |
|---|-------------------------|----|-------------------------------|
| 1 | Closing plug | 8 | Thrust bolt |
| 2 | Flange | 9 | Circlip |
| 3 | Check valve | 10 | Pressure limiting valve |
| 4 | Seal | 11 | Compression spring 76 mm long |
| 5 | Threaded ring | 12 | Detent spring |
| 6 | Cylinder head | 13 | Sealing ring |
| 7 | Chain tensioner housing | | |

05-320 Replacing timing chain

Tightening torques	Nm	(kpm)
Camshaft sprocket fastening bolt	100	(10)
Nuts for cylinder head cover	15	(1.5)

Special tools

Valve spring depressor



100 589 06 61 00

Conventional tool

Adaptor 1/2" square socket to 3/4" square head

e.g. made by Stahlwille, D-5600 Wuppertal
order No. 51~

Socket 50 mm, 3/4" square for
rotating engine

e.g. made by Stahlwille, D-5600 Wuppertal
order No. 515

Note

A repair chain with connecting link is available for repairs.

If only an endless timing chain is available, chain can be split by grinding through both bolts of a link and using a connecting link for assembly.

And endless timing chain can be mounted with timing housing cover removed.

Check sprockets for score marks and pitting.

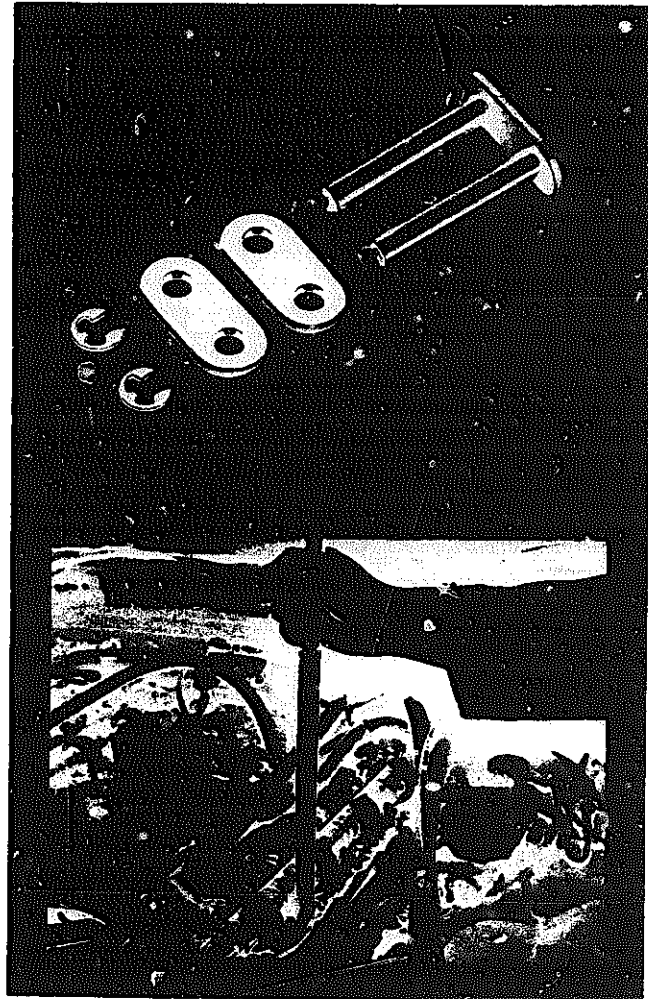
Repair chain with connecting link engine 100.985:
2. 2 links, part No. 000 997 79 94.

Replacement

- 1 Remove spark plugs.
- 2 Remove rocker arm on righthand camshaft (05-230).

Attention!

Reinstall rocker arms in same spot as before.



3 Remove chain tensioner (05-310).

4 Cover chain box with cleaning rag and separate timing chain with chain separating device or grind through both bolts of one link.

Engine should be at ignition TDC and the adjusting marks on camshaft and camshaft bearing should be in alignment.

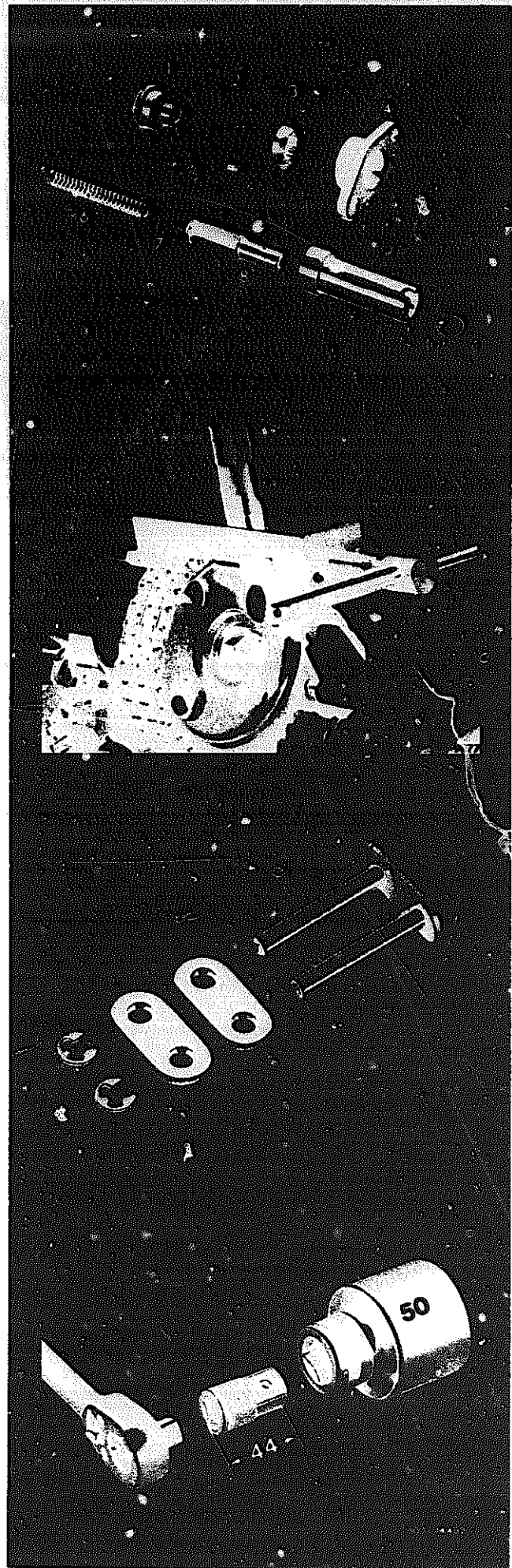
5 Attach new timing chain with a plug-type link to old timing chain while removing cut-up link.

6 Rotate crankshaft with tool combination slowly in direction of rotation of engine. Simultaneously, pull up old timing chain until plug-type link comes to rest at topmost portion of righthand camshaft sprocket.

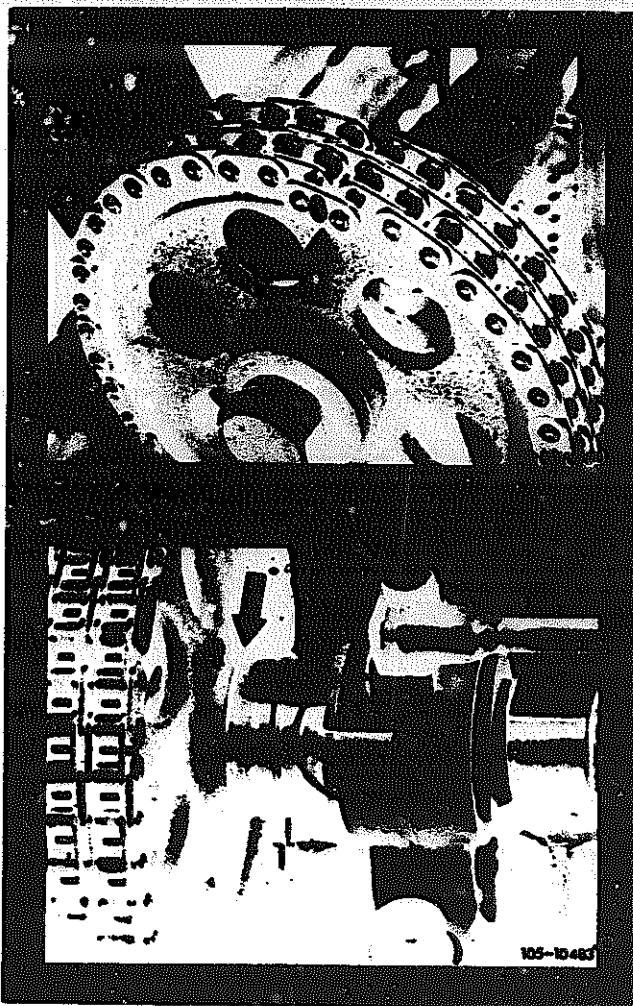
Attention!

During rotation of camshaft, the timing chain should always be in mesh with both camshaft sprockets.

Check sprockets for score marks and pitting.



7 Disconnect old timing chain and connect the ends of the new timing chain with a plug-type link.



8 Set engine to ignition TDC of 1st cylinder.

If markings (arrow) are not accurately in alignment, check timing (05-215).

9 Complete engine.

05-330 Removing and installing tensioning rail

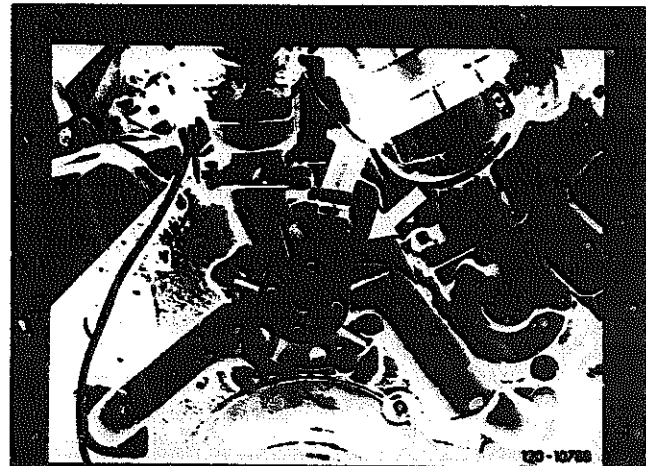
Tightening torques	Nm	(kpm)
Cylinder head cover nuts	15	(1.5)
Camshaft sprocket bolt	100	(10)
Chain tensioner threaded ring	40	(4)

Special tools

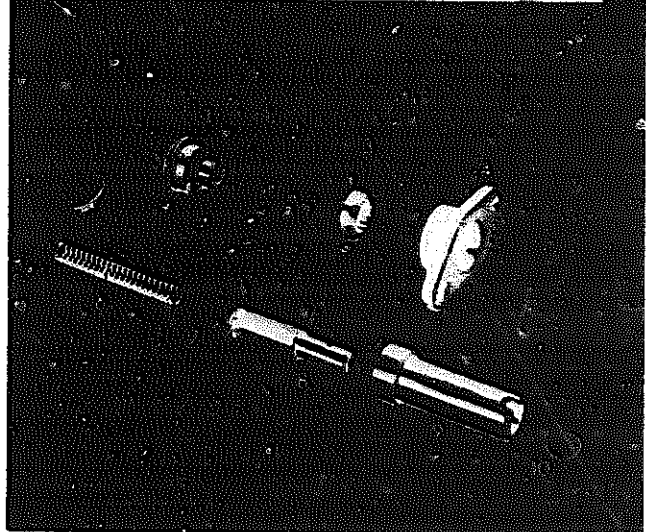
Bearing pin extractor (basic tool)		115 589 20 33 00
Threaded pin M 8 x 30 for 115 589 20 33 00		115 589 00 34 00

Removing

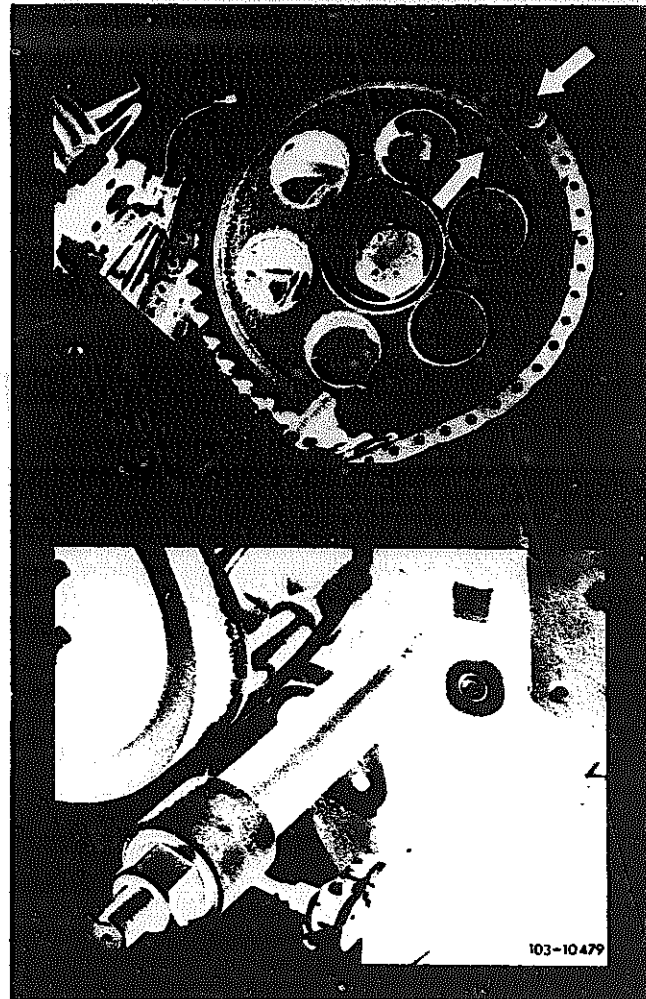
- 1 Remove coolant pump housing (20-212).



- 2 Remove chain tensioner (05-310).



3 Mark position of right camshaft sprocket and timing chain to each other. Remove camshaft sprocket.



4 Pull out bearing pin.

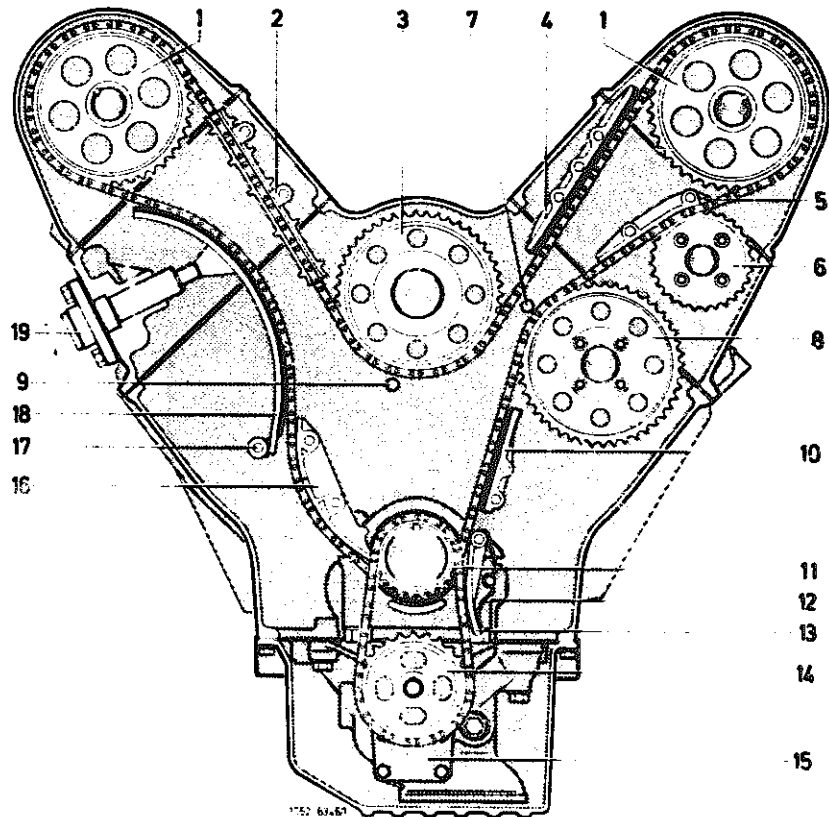
5 Remove tensioning rail.

Installing

6 Install tensioning rail. Coat bearing pin with a sealing compound and knock in.

7 Rest of installation in reverse sequence.





- 1 Camshaft sprocket
- 2 Sliding rail
- 3 Guide sprocket (crankcase)
- 4 Sliding rail
- 5 Sliding rail
- 6 Intermediate sprocket for level control pump drive
- 7 Lockscrew
- 8 Intermediate sprocket for distributor drive
- 9 Lockpin
- 10 Sliding rail
- 11 Crankshaft sprocket
- 12 Leaf spring (chain tensioner)
- 13 Tensioning bracket
- 14 Drive sprocket (oil pump)
- 15 Oil pump
- 16 Sliding rail
- 17 Bearing pin
- 18 Tensioning rail
- 19 Chain tensioner



05-340 Removing and installing sliding rails

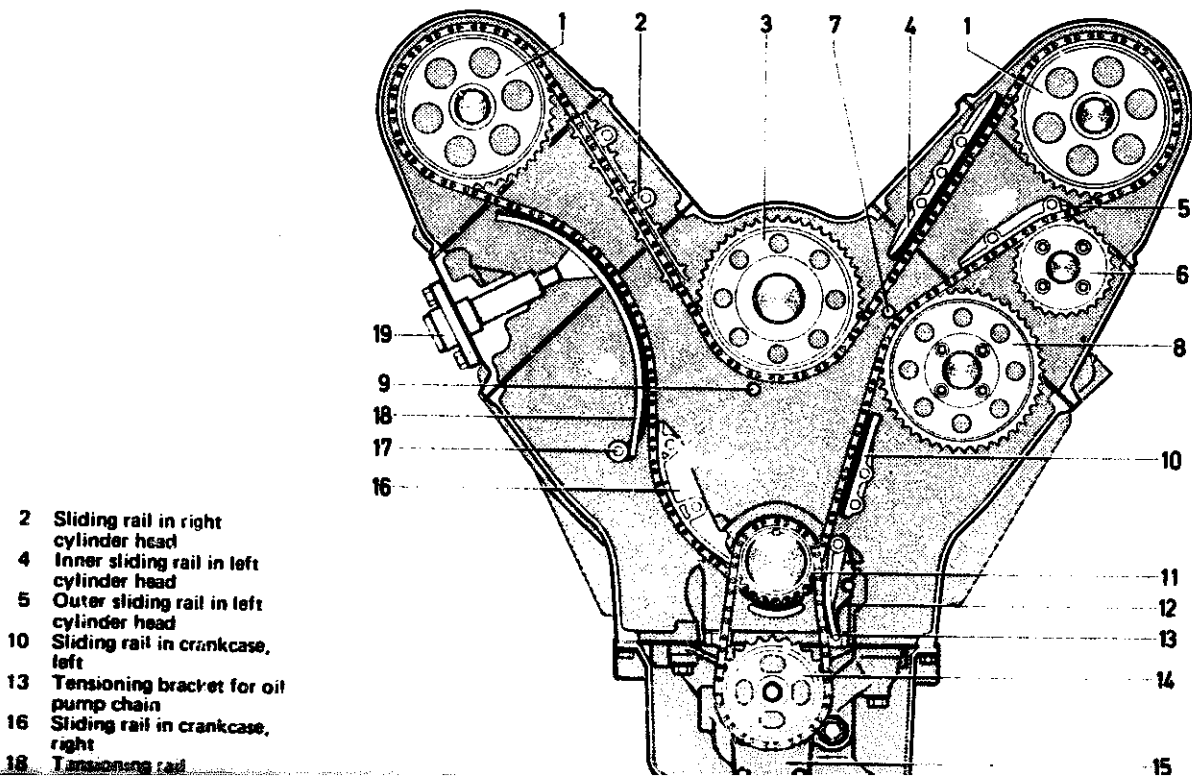
Tightening torques	Nm	(kpm)
Cylinder head cover nuts	15	(1.5)
Front crankshaft nut	400	(40)
Camshaft sprocket bolt	100	(10)

Special tools

Bearing pin impact extractor (basic tool)		116 589 20 33 00
Threaded bolt 6 x 150 mm for 116 589 20 33 00		116 589 02 34 00
Detent (starter flange)		116 589 01 40 00
Torque wrench 3/4" square, 150-500 Nm (15-50 kpm)		001 589 31 21 00

Conventional tools

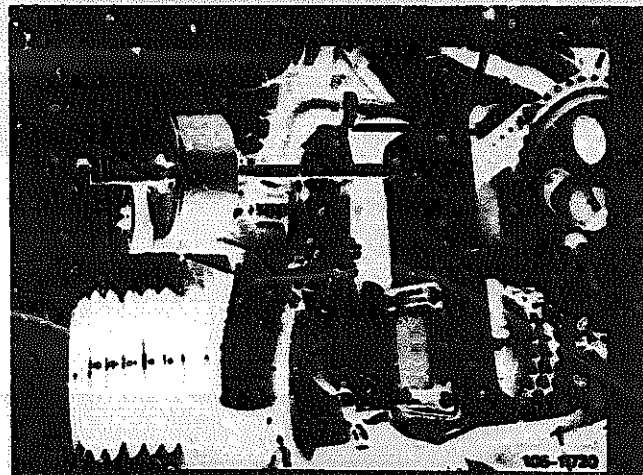
Extension 75 mm long, 3/4" square	e.g. made by Hazet, D-5630 Remscheid order No. 1017-3
Socket 50 mm, 3/4" square	e.g. made by Stahlwille, D-5600 Wuppertal order No. 55



Inner left sliding rail in cylinder head

- 1 Set piston of 1st cylinder to ignition TDC.
- 2 Remove distributor (07.5-510).
- 3 Knock out bearing pin with an impact extractor and remove sliding rail.

When installing watch position of sliding rail (3) (arrow).



Outer left bent sliding rail in cylinder head

- 1 Knock out bearing pin with an impact extractor and remove sliding rail.

When installing watch position of sliding rail.



- 1 Sliding rail in cylinder head right
- 2 Bearing pin in cylinder head 8 x 58
- 3 Sliding rail in cylinder head left inner
- 4 Bent sliding rail in cylinder head left outer
- 5 Bearing pin in crankcase 8 x 51
- 6 Sliding rail in crankcase left
- 7 Bent sliding rail in crankcase right
- 8 Bearing pin
- 9 Tensioning rail

Right sliding rail in cylinder head

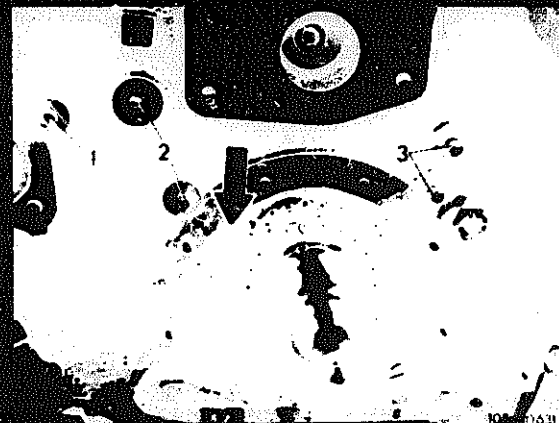
- 1 Remove alternator with holder.
- 2 Knock out bearing pin with an impact extractor.
- 3 Guide down sliding rail and remove.



Left sliding rail in crankcase

- 1 Remove front crankcase cover (01-215).
- 2 Knock out bearing pin (3) with an impact extractor. Remove sliding rail downward.

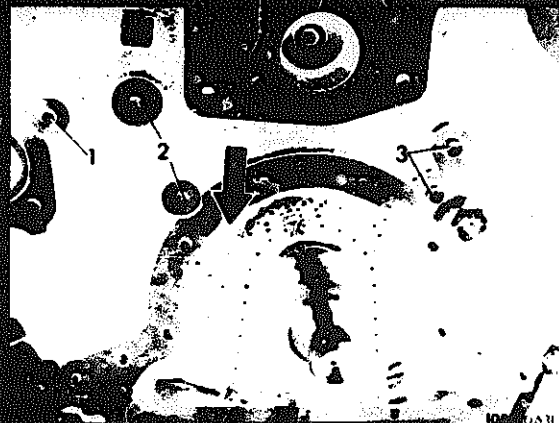
When installing watch position of sliding rail.



Right bent sliding rail in crankcase

- 1 Remove water pump housing (20-230).
- 2 Remove tensioning rail (05-330).
- 3 Knock out bearing pin (2) with an impact extractor. Remove sliding rail upward.

When installing watch position of sliding rail (arrow) (see also sliding rail 7).



Oil pump chain tensioning bracket

- 1 Remove front crankcase cover (01-215).

Remove retainer and tensioning bracket.






- 1 Tensioning bracket
- 2 Tensioning spring

05-434 Removing and installing intermediate sprocket for distributor drive

Tightening torques	Nm	(kpm)
Level control pump bolts on cyl. head	10	(1)
Screws for shaft on intermediate sprocket (hydraulic oil pump)	10	(1)
Intermediate sprocket shaft to intermediate sprocket (distributor drive)	10	(1)
Camshaft sprocket bolt	100	(10)

Special tools

Bearing pin impact extractor (basic tool)		116 589 20 33 00
Threaded pin 6 x 50 mm for 116 589 20 33 00		116 589 01 34 00
Socket screw wrench 5 mm		116 589 2 07 00

Removing

1 Remove intermediate sprocket and shaft for level control pump (05-436).

2 Remove distributor housing with distributor.

Note: Ignition distributor-identification:

Standard version

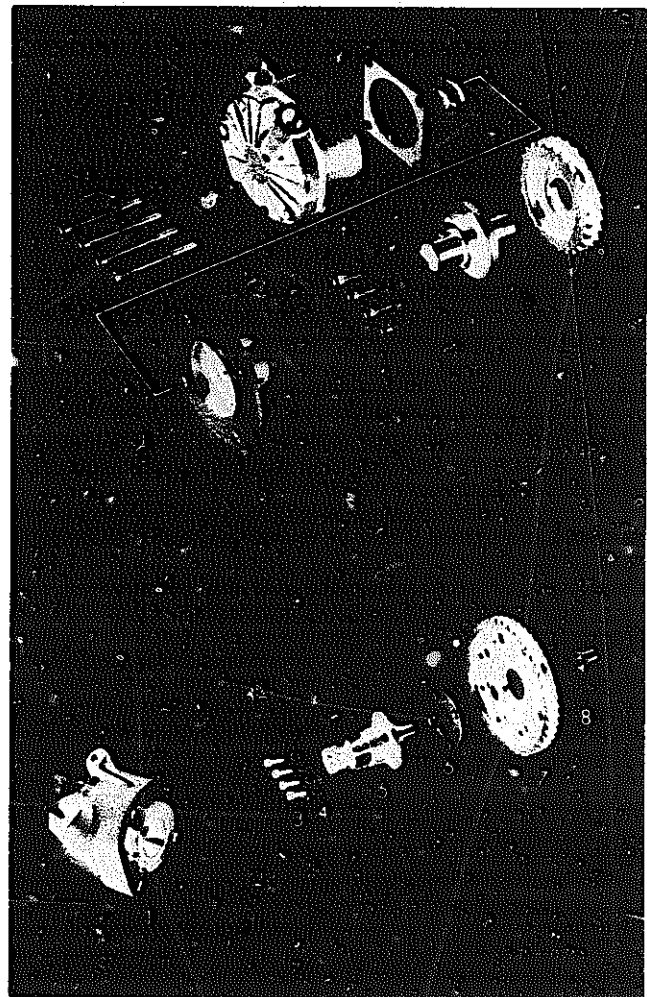
Bosch No. 0 237 404 007 TGFUDS

National version  

Bosch No. 0 237 405 002 TGFUS

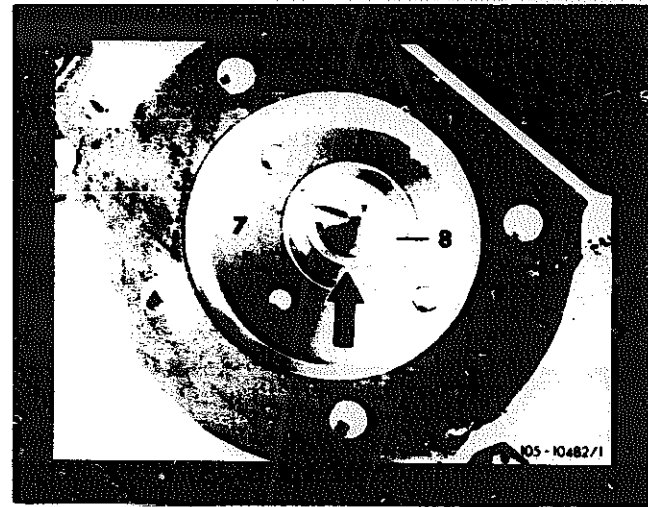
3 Unscrew intermediate sprocket shaft (5) at intermediate sprocket (7) and remove with spacer (6).

Note: From engine series no. 000 228 intermediate sprocket (7), part no. 100 157 01 14, is installed instead of intermediate sprocket (7), part No. 100 157 00 14. Spacer: (6) is omitted.



4 Remove intermediate sprocket (7) upward.

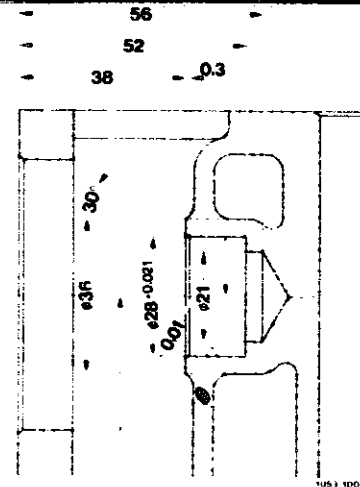
5 Pull out rear bearing bushing (8) with internal claw extractor.



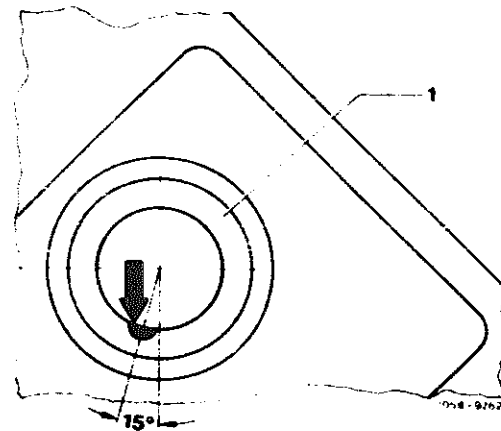
Installing

6 Check basic bore in cylinder crankcase for correct dimensions.

Note: The bearing bushing should attain an overlap of 0.015 mm to 0.045 mm in cylinder crankcase.

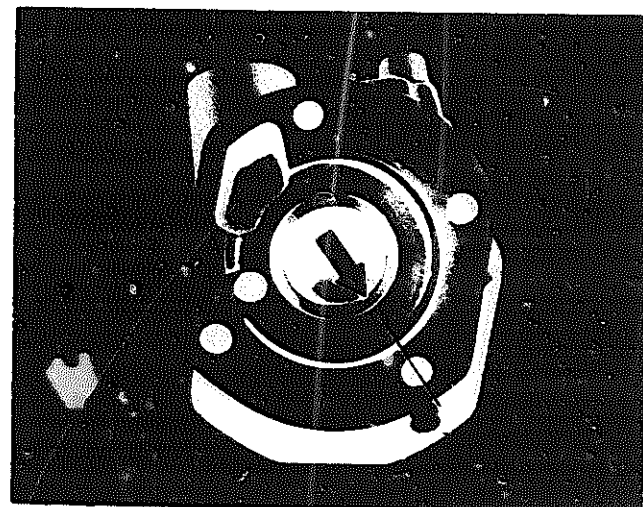


7 Knock bearing bushing into cylinder crankcase up to stop, while paying attention to position of oil groove (arrow).



8 Heat distributor housing to about 80 °C and press in bearing bushing that lubrication groove is at lowest point (arrow).





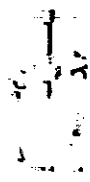
9 For further installation proceed vice versa.



05-436 Removing and installing intermediate sprocket for hydraulic oil pump drive

Tightening torques	Nm	(kpm)
Bolts for hydraulic oil pump on cylinder head	10	(1)
Bolts for shaft on intermediate sprocket (hydr. oil pump)	10	(1)
Fastening screw for camshaft sprocket	100	(10)

Special tools

Bearing pin impact extractor (basic tool)		116 589 20 33 00
Threaded pin 6 x 50 for 116 589 20 33 00		116 589 01 34 00
Socket screw wrench 5 mm		116 589 02 07 00
Internal puller 18.5-23.5 mm		000 589 26 33 00
Counter-support for 000 589 26 33 00		000 589 33 33 00

Removing

- 1 Remove hydraulic oil pump after unscrewing bolts (arrows).



2 Remove dog and bearing flange with gasket.

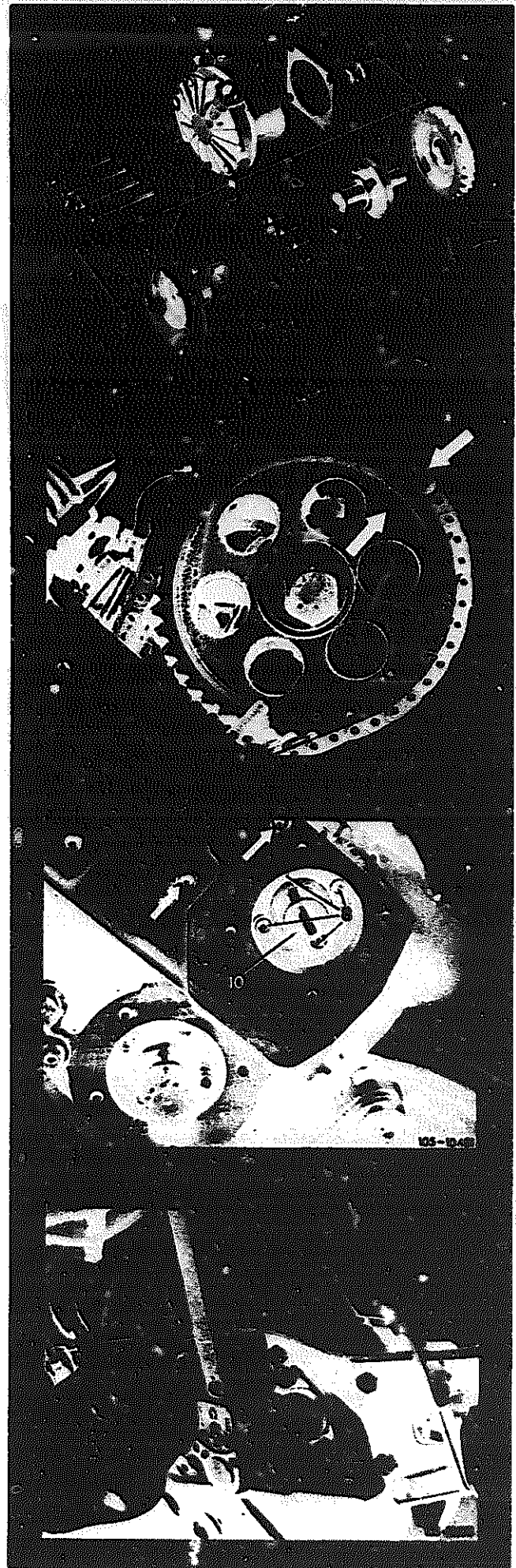
3 Mark position of left camshaft sprocket and timing chain to each other.

Unscrew camshaft sprocket mounting bolt.

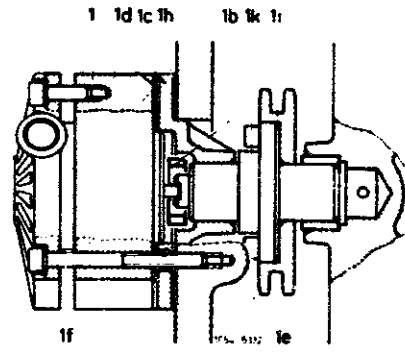
4 Unscrew bolts (8) for shaft (10) on intermediate sprocket.

5 Knock out sliding rail pins (arrows) and remove sliding rail.

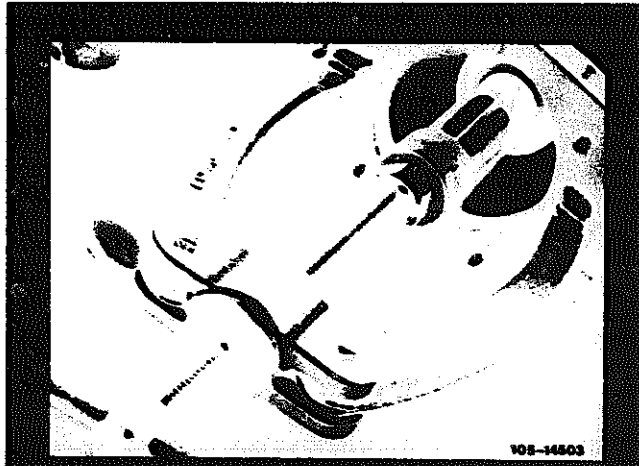
6 Remove chain tensioner spring (05-310).



7 Take off left camshaft sprocket, shaft (1k) and intermediate sprocket (1i).



8 Pull out rear bearing bushing with an internal claw extractor.



Installing

9 Knock-in rear bearing bushing up to stop. Check position of oil groove (arrow).







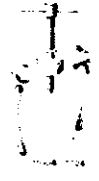


10 Rest of installation in reverse sequence.



05-440 Removing and installing guide sprocket

Tightening torques	Nm	(kpm)
Closing plug for chain tensioner	50	(5)
Screws for hydraulic oil pump on cylinder head	10	(1)
Screws for shaft on intermediate sprocket (hydraulic oil pump)	10	(1)
Intermediate sprocket shaft to intermediate sprocket (ignition distributor drive)	10	(1)
Fastening screw for camshaft sprocket	100	(10)
Drain plug radiator	10	(1)
Water pump housing to cylinder crankcase	30	(3)
Viscofan clutch to coolant pump hub	25	(2,5)
Thermostat housing to coolant pump housing	23	(2,3)
Coupling nut for oil hoses (apply counterhold)	30	(3)

Special tools

Impact puller for bearing bolt (basic unit)		116 589 20 33 00
Threaded bolt 6 x 50 mm for 116 589 20 33 00		116 589 01 34 00
Allen wrench 5 mm		116 589 02 07 00
Puller for bearing bolt (basic unit)		115 89 20 33 00
Threaded bolt M 8 x 30 mm for 115 589 20 33 00		115 589 00 34 00
Internal puller for bearing bushing		000 589 28 33 00
Counter-support for 000 589 28 33 00		000 589 33 33 00
Tester for cooling system and radiator cap		001 589 48 21 00
Double connection for checking radiator and expansion tank cap		000 589 73 63 00

Note

The guide sprocket used up to now and the bearings must be replaced by the new guide sprocket and bearing in the event of repairs. The modified guide sprocket with bearing is installed as standard equipment starting with engine end No. 001 817.

Guide sprocket and bearing starting engine end No. 001817

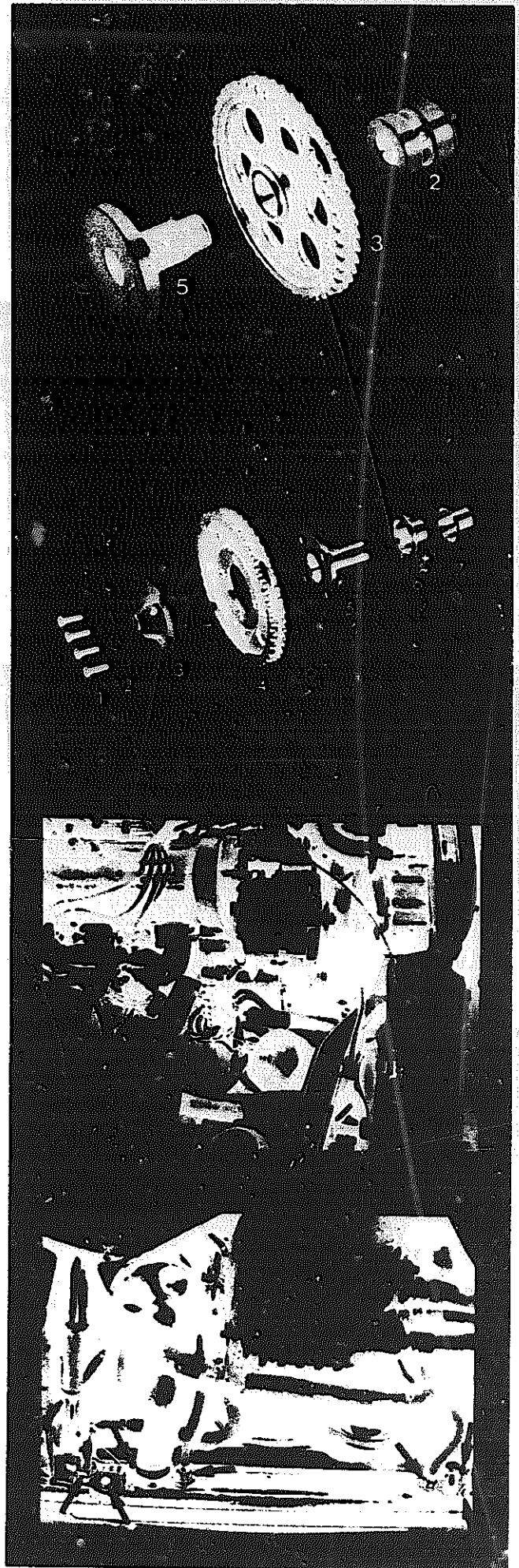
Guide sprocket and bearing up to engine end No. 001816

Replacement

1 Remove battery and battery frame.

2 Drain coolant from radiator.

3 Remove radiator by unscrewing radiator shell at top and pulling out of holder at bottom. Cover condenser for air conditioner inside.



4 Unscrew viscofan coupling and remove together with fan.

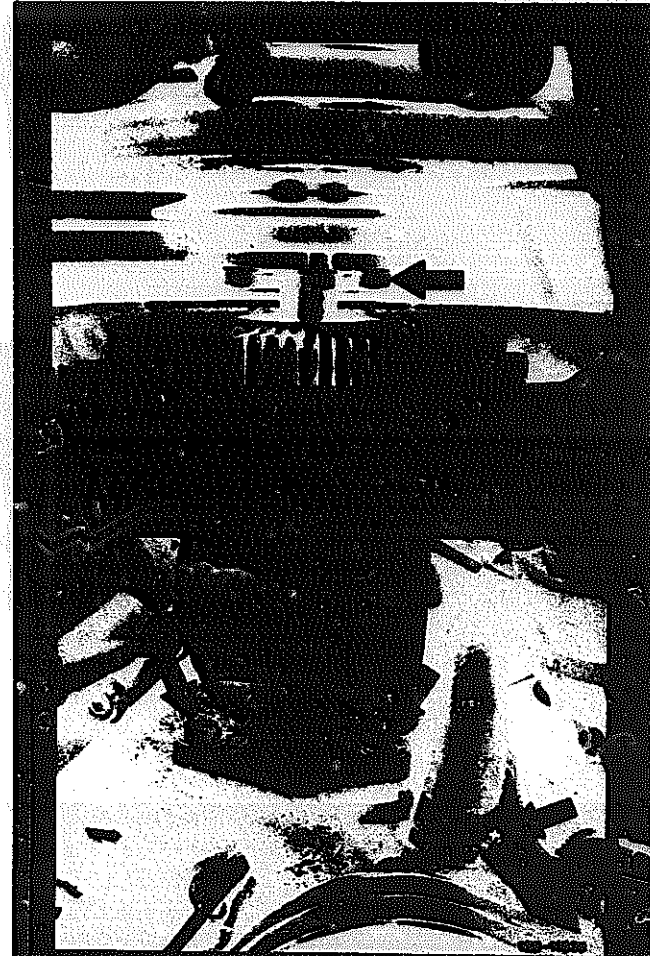
5 Remove air filter and righthand cylinder head cover.

6 Unscrew thermostat housing on coolant pump.

7 Unscrew coolant pump housing and remove. For this purpose, pull refrigerant compressor slightly away.

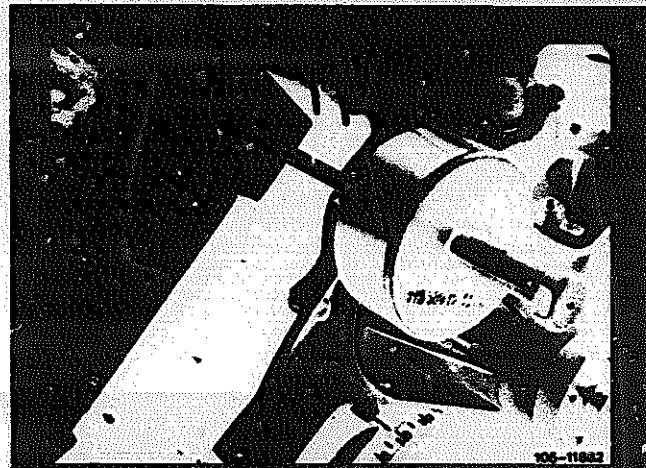
8 Completely remove chain tensioner (05-310).

Note: Prior to installation, move chain tensioner into assembly position.

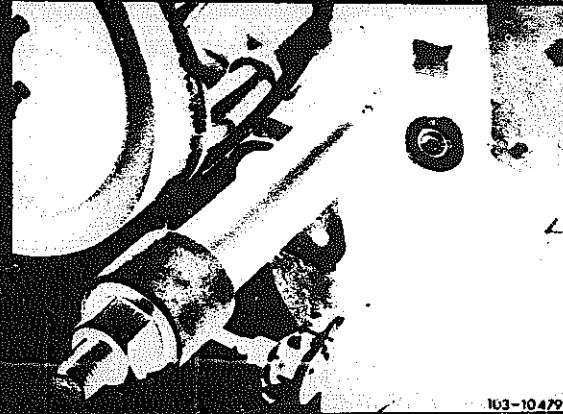


9 Remove alternator with upper holder.

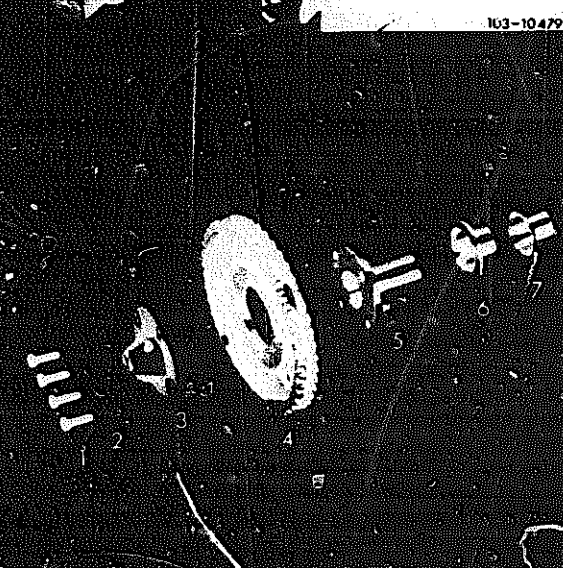
10 Knock out bearing bolt for slide rail in righthand cylinder head.



11 Pul. out bearing bolt for tensioning rail and remove tensioning rail.



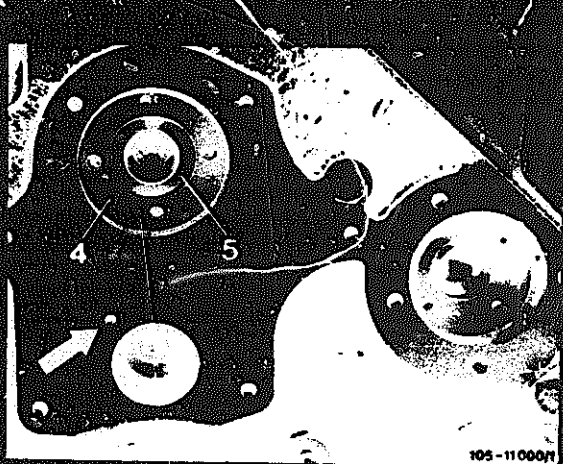
12 Unscrew spacer (3) and remove.



Guide sprocket and bearing up to engine end No. 001816

13 Pull out bearing bolt (arrow) for timing chain lock.

14 Remove guide sprocket (4) and shaft (5).



15 Pull out front bearing bushing (6) and rear bearing bushing (7) by means of internal claw-type puller.

Guide sprocket and bearing up to engine end No. 001816



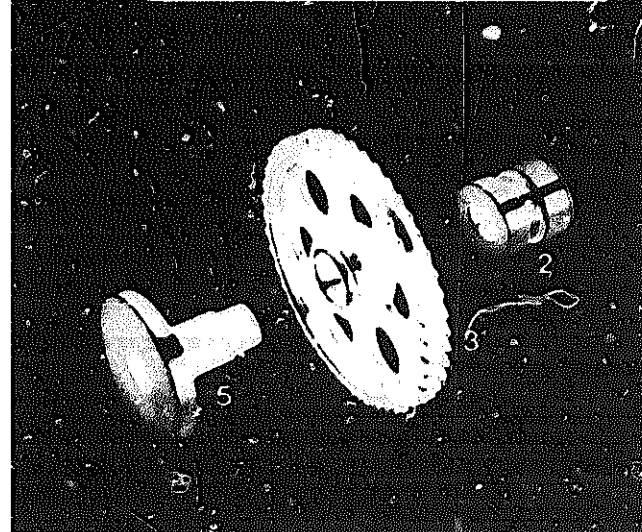
16 Knock out bearing bolt of guide sprocket 2nd version with impact puller and remove guide sprocket in upward direction.

Guide sprocket and bearing starting engine end No. 001817



Note: The bearing bushing (2) is shrunk into cylinder crankcase with overlap and need not be replaced.

Guide sprocket and bearing starting engine end No. 001817



17 Measure basic bore for bearing bushing of cooled-down cylinder crankcase with internal measuring instrument.

Basic bore dia. = 40.00 to 40.13 mm.

18 Measure new bearing bushing.

Bearing bushing dia. = 40.04 to 40.06 mm

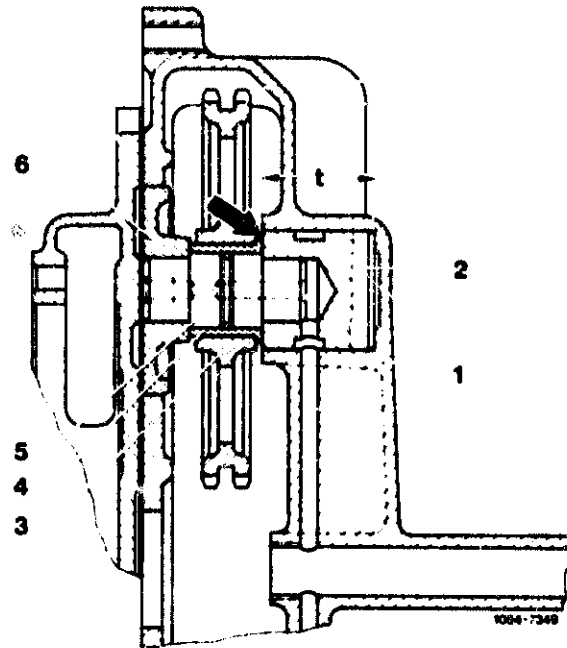
Attention!

The new bearing bushing (2) should have an overlap of 0.01 to 0.06 mm in cylinder crankcase. If this minimum overlap is not attained, replace crankcase.

19 Undercool bearing bushing (2) with liquid nitrogen for approx. 10 minutes and then immediately introduce ω to stop into cylinder crankcase

Attention!

Bearing bushing (2) should be flush with cylinder crankcase (1) and should not project (arrow) since the end play of the guide sprocket would be too small. The oil bore should come to rest in downward position.



- | | |
|-------------------|------------------|
| 1 Crankcase | 4 Bushing |
| 2 Bearing bushing | 5 Bearing bolt |
| 3 Guide sprocket | 6 Bearing washer |

20 Introduce guide sprocket in such a manner that the collar of the pressed-in bushing (4) rests against bearing bushing (arrow).

21 Lubricate bearing-bolt (5) with bearing washer (6) and lock-in with an aluminum mandrel until bearing washer is flush with cylinder crankcase.

22 For further installation proceed vice versa.

Press off radiator, check cooling system for leaks.

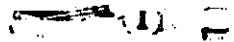
13-335 Instructions for renewing and tensioning of V-belts

Adjusting values

V-belts (width of profile in mm)	New V-belts (KG-scale on measuring instrument)	Used V-belts KG-scale on measuring instrument)
9.5	30	20-25
12.5	50	40-45

Special tool

Krikkit measuring instrument for
measuring V-belt tension



000 589 69 21 00

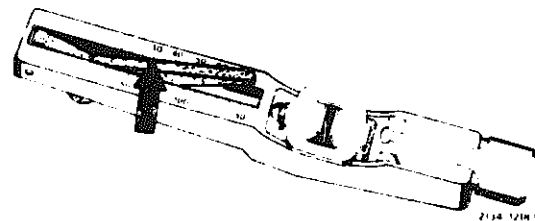
Checking condition of V-belt

Renew cracked, porous, burnt or worn V-belts.

Checking tension

For handling of instrument, refer to operating
instructions and renewing and tensioning V-belts
(13-340).

The adjusting values named refer to KG-scale of
measuring instrument (a. row).



Used V-belts

Check tension of V-belts and compare with the values for used V-belts named in table (e.g. V-belts, width of profile 9.5 mm = adjusting value 20–25) and re-tension accordingly, if required.

Mounting and tensioning of new V-belts

Perfect mounting of a V-belt requires loosening of respective auxiliary unit or of tensioning device of V-belt to the extent that the belt can be mounted without effort. In addition, the running surfaces on pulleys should be free of burr, rust and dirt.

Double V-belts may be installed only in pairs made by one and the same manufacturer.

Keep away oils, greases, chemicals. Do not use belt wax or similar agents. By the following optimal adjustment of V-belt tension (for adjusting values refer to table) complaints such as squealing V-belts and low life will be avoided.

Within scope of maintenance jobs, mount V-belts prior to engine checkup and tension to value for new V-belts named in table (e.g. V-belt, width of profile 9.5 mm = adjusting value 30).

If the V-belt tension is checked during final inspection or following a test drive, the value measured then should be the same as value for **used V-belts** on table (e.g. V-belts with width of profile 9.5 mm = adjusting value 20–25). If values are less, re-tension V-belt to this value.

13-340 Replacing and tensioning V-belts

V-belt dimensions and adjusting values

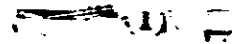
V-belt	A Coolant pump power steering pump	B Air pump	C Refrigerant compressor	D Alternator
Dimensions	12.5 x 1200 ¹⁾	9.5 x 940	12.5 x 1000 12.5 x 1025 ²⁾	9.5 x 1184
Adjusting value KG-scale on measuring instrument	new	50	30	50
	used	40-45	20-25	40-45

¹⁾ Double V-belts may be installed in pairs only and made by one and the same manufacturer.

²⁾ Up to chassis end No. 000846 with 5 5/8" clutch on refrigerant compressor (pulley dia. approx. 143 mm).

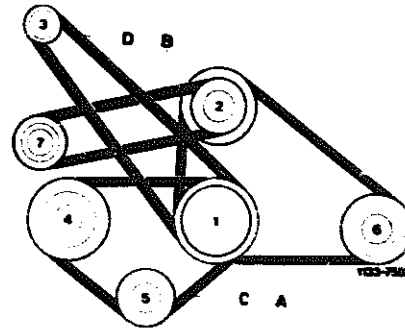
Special tool

Krikit measuring instrument for
measuring V-belt tension



000 589 69 21 00

- 1 Crankshaft
- 2 Coolant pump
- 3 Alternator
- 4 Refrigerant compressor
- 5 Tensioning roller or auxiliary oil pump
- 6 Power steering pump
- 7 Air pump (USA)



Note

The recess on fan (arrow) serves for mounting and removing V-belts.

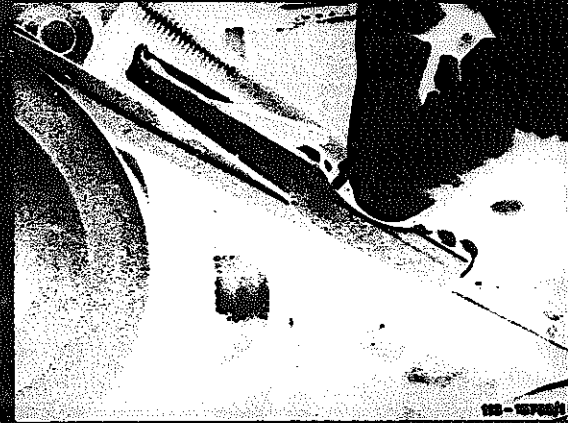
For checking V-belt tension, the measuring instrument "Krikit" is recommended.



Handling of measuring instrument

To check V-belt tension, the measuring instrument can be held in several ways:

a) With thumb and forefinger at rubber loop, with finger tips resting on pushbutton.



b) With forefinger from above in rubber loop.



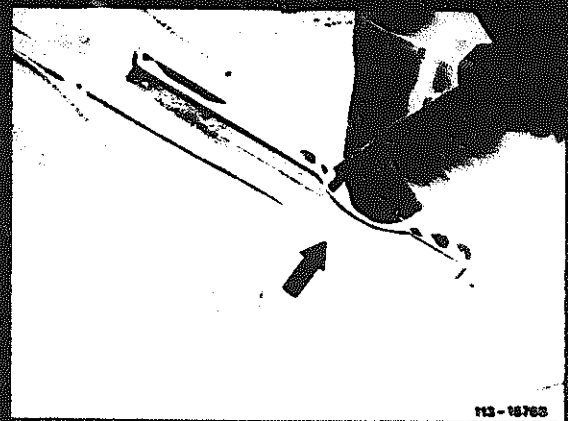
c) With forefinger laterally between rubber loop and pushbutton.



Checking

1 Conceal indicating arm on measuring instrument.

2 Place measuring instrument on V-belt in center between belt pulleys. The lateral stop of measuring instrument should rest laterally against V-belt (arrow).



Attention!

With double belt drive, make sure that the measuring instrument rests on one V-belt only.

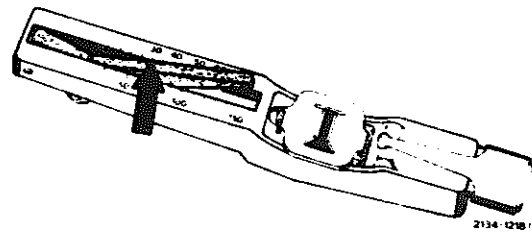
3 Exert uniform, vertical pressure against top of V-belt by means of pushbutton until click spring disengages audibly or noticeably.

Note: Following disengagement of click spring, do not continue pushing against measuring instrument, since otherwise a wrong measuring value will be indicated.

4 Carefully lift measuring instrument from V-belt. Avoid knocks and do not change position of indicating valve.

5 Read tensioning value at point of intersection of indicating arm (upper scale, arrow).

The adjusting values shown refer to KG-scale of measuring instrument.



Replacement

Check condition of V-belts

Renew cracked, burnt or worn V-belts.

Attention!

If on double belt drive for coolant pump and power-steering pump one of the two V-belts shows excessive wear, always replace both V-belts.

Use only V-belts which are made by one and the same manufacturer.

V-belts as spare parts are available in sets only.

- 1 Set holders and/or units at starting position.
- 2 Install V-belt without force.
- 3 Tighten V-belt.

Tensioning

V-belt A Coolant pump – power steering pump

- 1 Loosen nut (1) and fastening screw (2).
- 2 Loosen nut (3).
- 3 Tension V-belt with tensioning screw (4).
- 4 Tighten nuts (3) and (1), as well as fastening screw (2).

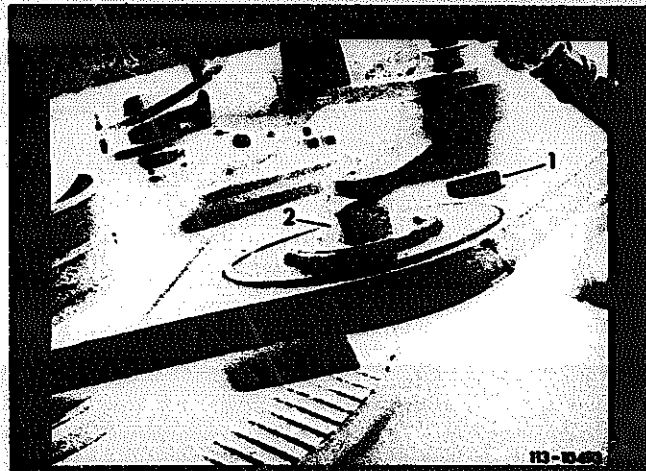


V-belt B Air pump (, only)

- 1 Loosen fastening screw (1).
- 2 Tension V-belt with tensioning screw (2).
- 3 Tighten fastening screw (1).

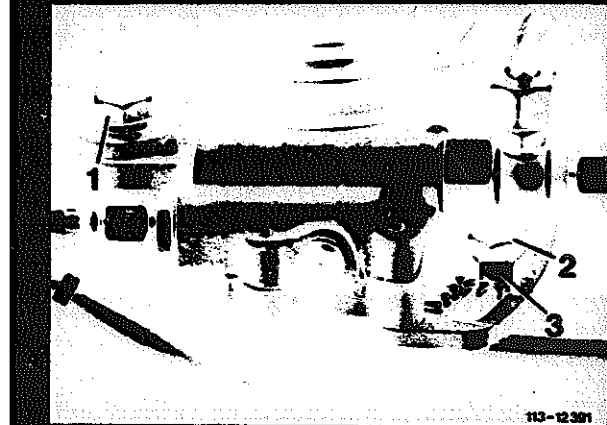
V-belt C refrigerant compressor standard version

- 1 Loosen fastening screw (1).
- 2 Tension V-belt by swivelling tensioning wheel (2).
- 3 Tighten fastening screw (1).



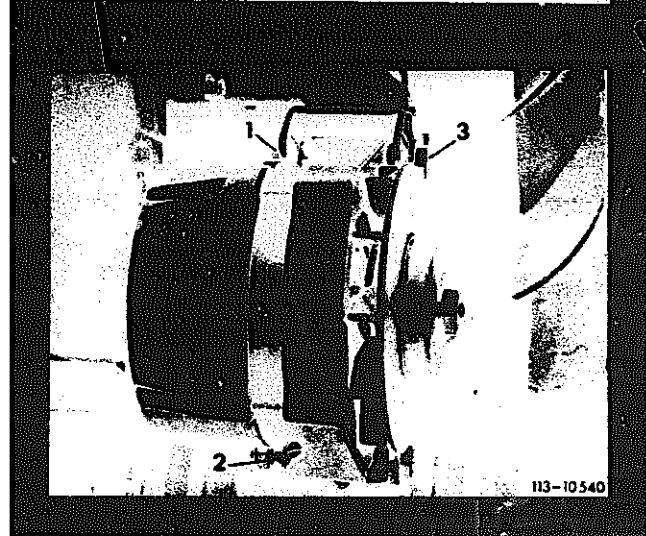
V-belt C

- 1 Loosen fastening screws (1 and 2).
- 2 Tension V-belt with toothed plate (3).
- 3 Tighten fastening screws (2 and 1).



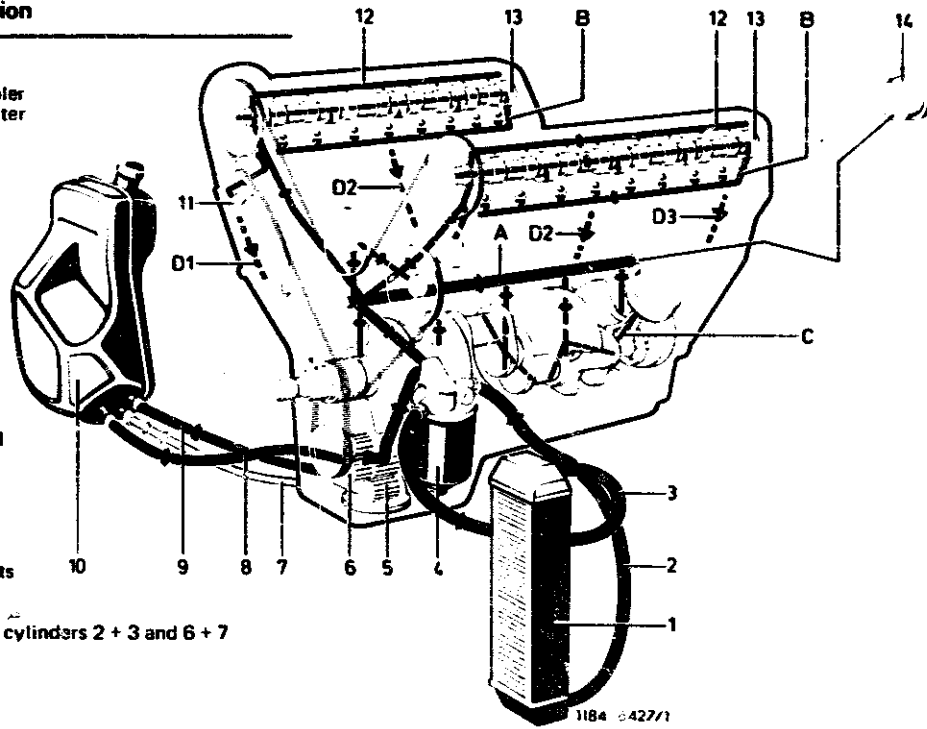
V-belt D alternator

- 1 Loosen nuts (2 and 1).
- 2 Tension V-belt with tensioning screw (3).
- 3 Tighten nuts (1 and 2).



Oil circuit standard version

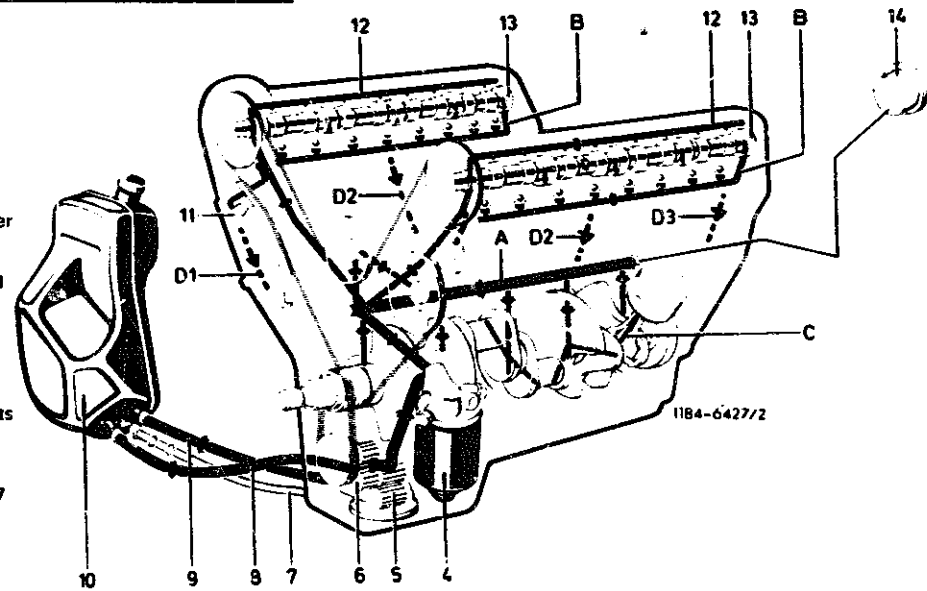
- 1 Oil cooler
- 2 From oil filter to oil cooler
- 3 From oil cooler to oil filter (not filtered)
- 4 Oil filter
- 5 Recirculating pump
- 6 Oil pressure pump
- 7 Vent line
- 8 From oil supply tank to oil pressure pump
- 9 From recirculating pump to oil supply tank
- 10 Oil supply tank
- 11 Hydraulic chain tensioner
- 12 Oil tube for cam lubrication
- 13 Camshaft, hollow-drilled for camshaft bearing lubrication
- 14 Oil pressure gage
- A Main passage
- B Bore for hydraulic valve clearance correction parts
- C Piston pin lubrication
- D1 Timing case oil return
- D2 Oil return bore between cylinders 2 + 3 and 6 + 7
- D3 Rear oil return bore



1184-6427/1

Oil circuit (AUS) (USA)

- 4 Oil filter
- 5 Recirculating pump
- 6 Oil pressure pump
- 7 Vent line
- 8 From oil supply tank to oil pressure pump
- 9 From recirculating pump to oil supply tank
- 10 Oil supply tank
- 11 Hydraulic chain tensioner
- 12 Oil tube for cam lubrication
- 13 Camshaft hollow-drilled to lubricate camshaft bearings
- 14 Oil pressure gage
- A Main passage
- B Bore for hydraulic valve clearance correction parts
- C Piston pin lubrication
- D1 Timing case oil return
- D2 Oil return bore between cylinders 2 + 3 and 6 + 7
- D3 Rear oil return bore



1184-6427/2

Opening pressures of relief valves	bar	(atü)
Overflow valve in filter cartridge	3.5	(3.5)
Relief valve built in oil pump	8.0	(8)

Oil filter thermostat (with air oil cooler only)

Starts to open at	95 ± 4 °C
Fully open at	110 ± 4 °C

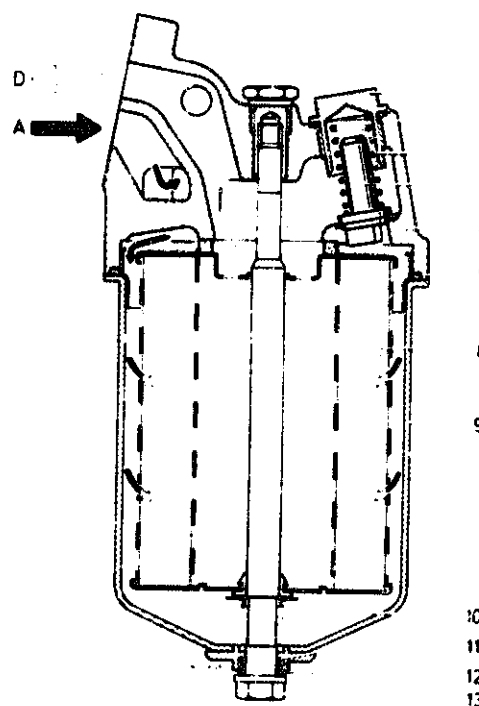
Oil pressure

With engine at operating temperature and running at idle speed the oil pressure must not drop below 0.3 bar (0.3 atü).

When the accelerator pedal is pressed the oil pressure must rise again immediately and reach at least 3 bar at 3000/min.

Oil filter

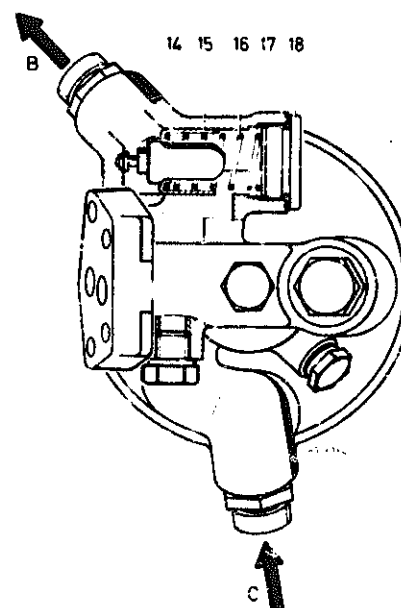
- 1 Mounting bolt
- 2 Plug
- 3 Seal
- 4 Spring
- 5 Overflow valve for filter cartridge (3.5 bar)
- 6 Filter upper section
- 7 Seal
- 8 Filter cartridge
- 9 Filter lower section
- 10 Spring with spring retainer
- 11 Seal
- 12 Seal
- 13 Hexagon head bolt
- A From oil pump
- B To main oil passage



Note

If for any reason whatsoever the oil cooler has to be disconnected, either the two adaptors on the filter upper section have to be connected with a bypass line, or the adaptors must be plugged and the thermostat (14) removed together with control sliding valve (15) and spring (16). Otherwise the supply of oil to the bearings would be interrupted after about 95 °C.

- | | |
|--------------------------|-------------------|
| 14 Thermostat | 18 Plug |
| 15 Control sliding valve | B To oil cooler |
| 16 Spring | C From oil cooler |
| 17 Seal | |



18-120 Checking thermostat in oil filter

Oil filter thermostat

Starts to open at

$95 \pm 4^{\circ}\text{C}$

Fully open at

$110 \pm 4^{\circ}\text{C}$

Special tool

Temperature gauge



116 589 27 21 00

- 1 Take cap off of oil supply tank and insert probe of temperature gauge.
- 2 Let engine run at high speed and observe temperature gauge.
- 3 At $80 - 85^{\circ}\text{C}$ a definite increase of temperature must be felt by hand on the oil cooler.



Note: Due to the temperature drop between oil filter and oil supply tank, the temperature of the oil in the oil supply tank will be below the opening temperature of $95 \pm 4^{\circ}\text{C}$.

18-125 Removing and installing thermostat in oil filter upper section

Filling capacity

Air oil cooler approx. 0.5 ltr.

Tightening torques

	Nm	(kpm)
Plug (18) for thermostat	80	(8)
Oil cooler drain plug (install without seal)	30-35	(3-3.5)

Note

A well functioning thermostat should only be removed at temperatures below 60°C, since otherwise the operating pin would be pressed out.

Operating pin (1) should never be pulled out of wax thermostat (2), since otherwise the function can no longer be guaranteed.

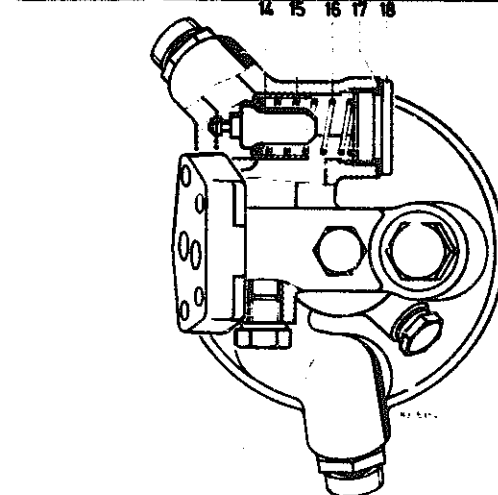
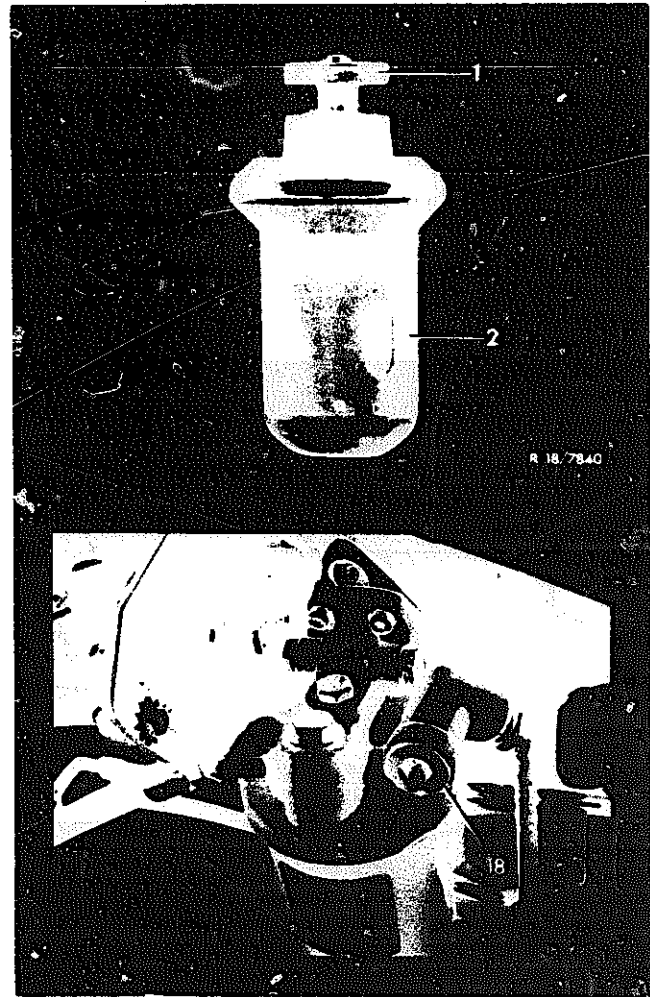
Removing

- 1 Drain oil from air oil cooler.
- 2 Unscrew plug (18).
- 3 Remove thermostat (14) with control sliding valve (15) and spring (16).

Installing

Installation is in reverse sequence.

Run engine and check for leaks.



18-210 Removing and installing oil pump

Tightening torques	Nm	(kpm)
Oil pump to crankcase	25	(2.5)
Sprocket to oil pump drive shaft	30	(3)

Note

The oil pump part No. 100 180 10 01 (1st version) with integrated oil pressure relief valve has been replaced by oil pump part No. 100 180 11 01 (2nd version) with screwed-in oil pressure relief valve starting engine end No. 001 155.

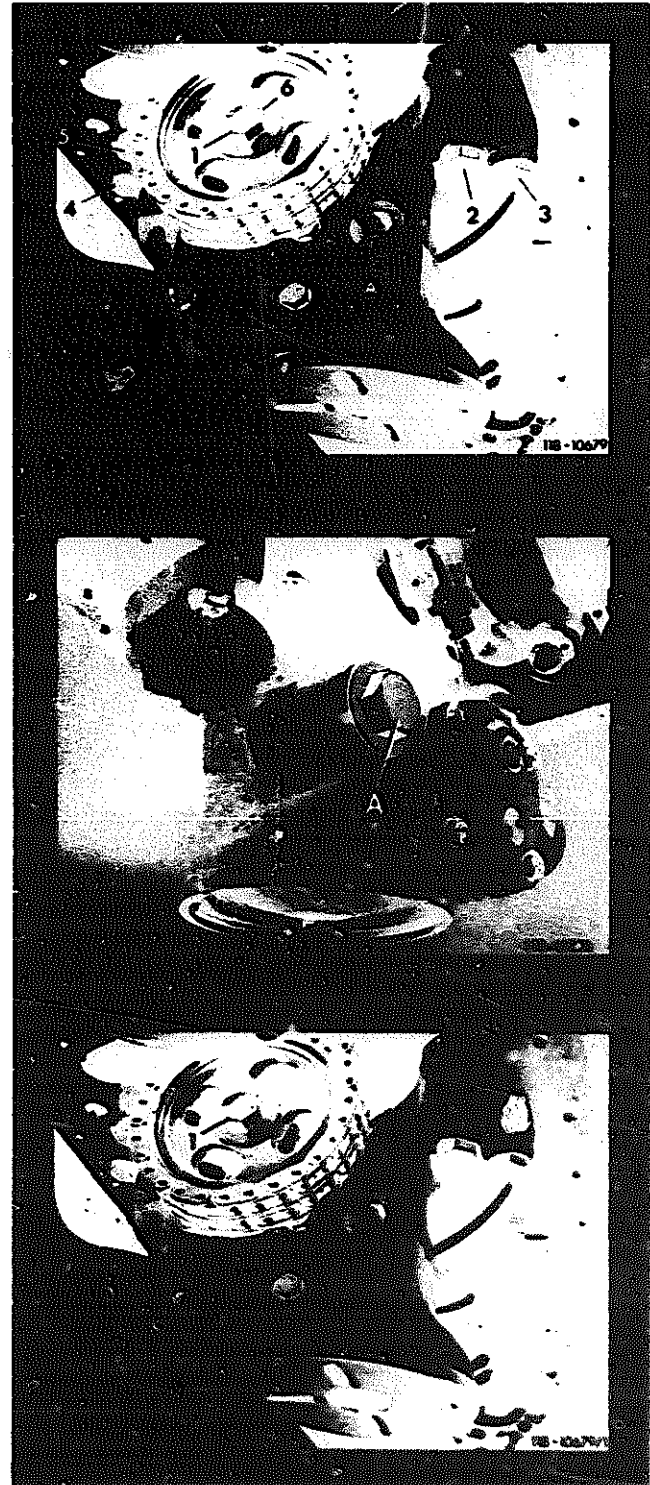
1st version

In the event of repairs, replace oil pump 1st version with oil pump 2nd version.

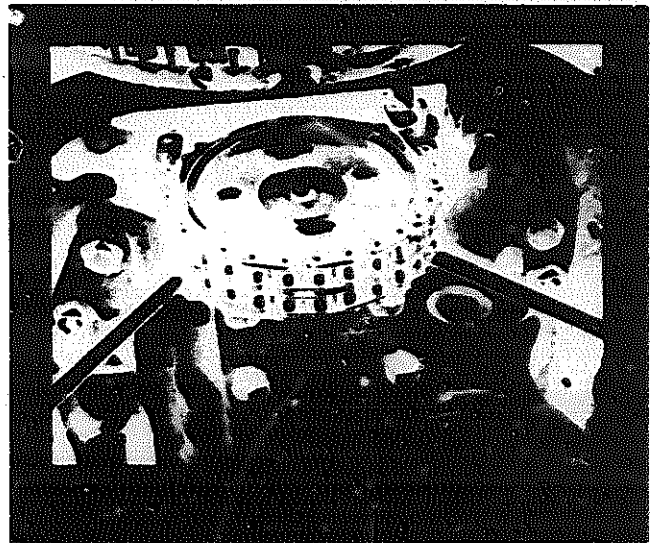
2nd version

Removal

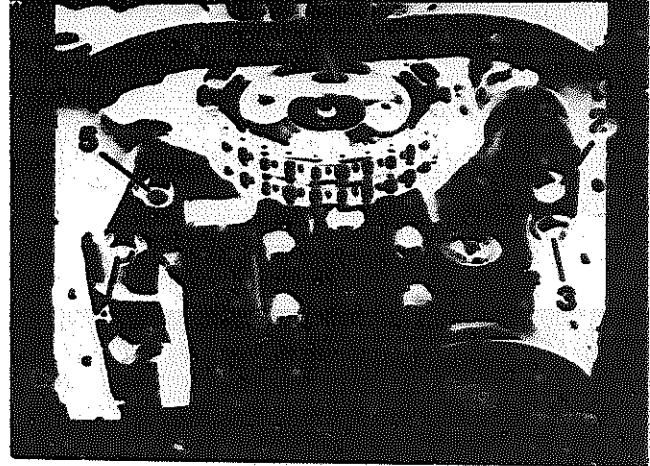
- 1 Completely remove oil pan (01-310).
- 2 Unscrew hex. bolt (1) on sprocket.



3 Press off chain sprocket.



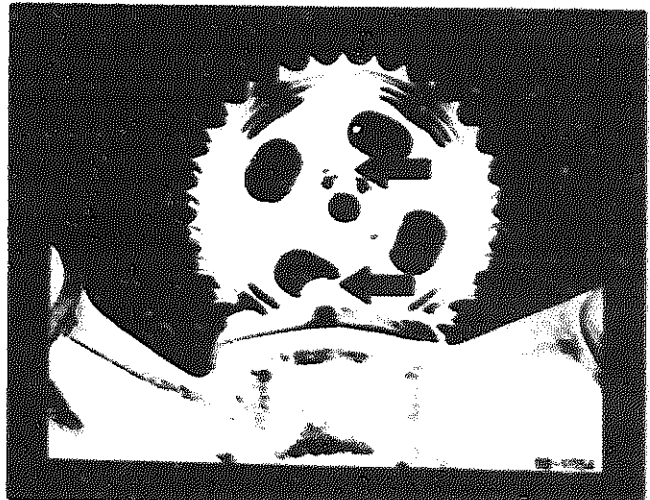
4 Loosen bolts (2-5) and remove oil pump.



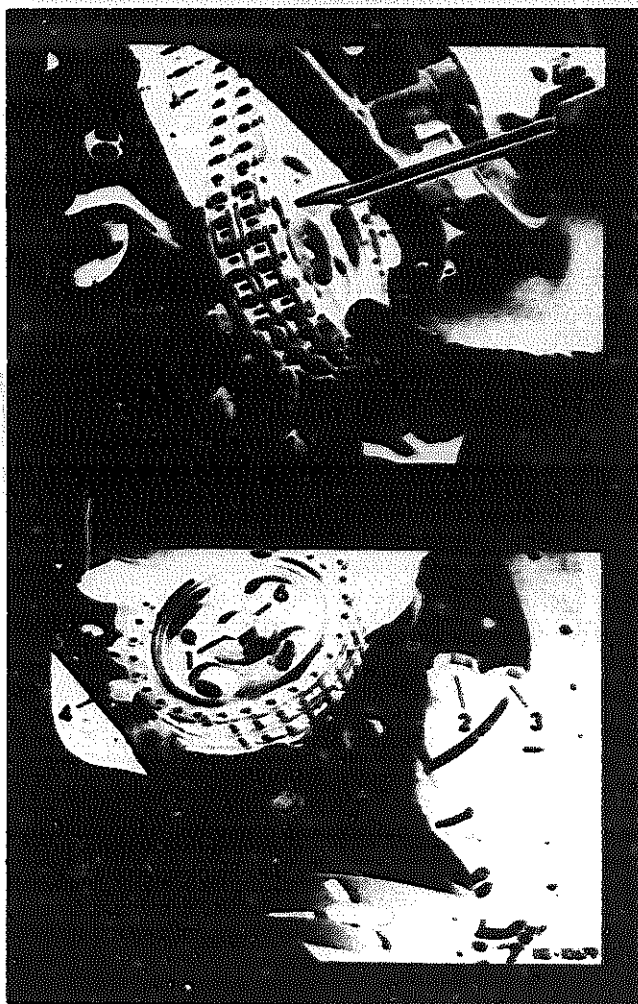
Installing

5 Bolt oil pump to crankcase.

6 Turn cut on drive shaft, that cut and key of chain sprocket align.



7 Press chain sprocket to height of drive shaft with a screwdriver and slide chain sprocket onto drive shaft.



8 Tighten bolts (1-5) to specified torque.

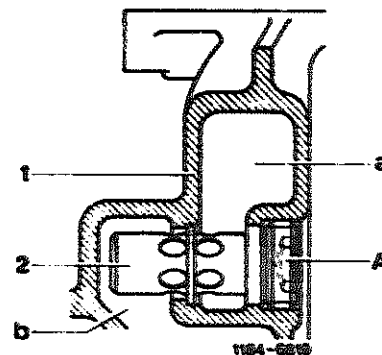
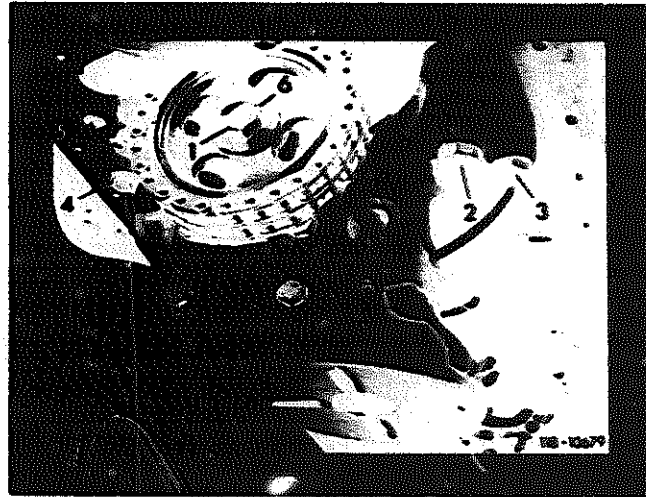
18-215 Removing and installing oil pressure relief valve in oil pump

Tightening torques	Nm	(kpm)
Plug (A) for oil relief valve 1st version	30	(3)
Plug (A) for oil relief valve 2nd version	40	(4)
Oil relief valve	40	(4)

1st version

Up to engine end No. 001154 or up to chassis end No. 001125 the oil pump 100 180 10 01 has been used with oil pressure relief valve (A) located at front.

In the event of repairs, this oil pump should be replaced by oil pump 100 180 11 01 with improved output and shunt capacity.



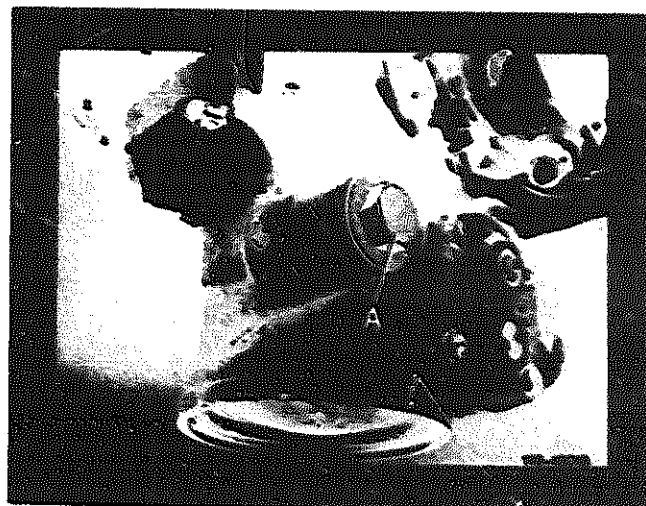
1st version

- 1 Oil pump housing
- 2 Oil pressure relief valve
- A Closing plug
- a Pressure end
- b Suction end

2nd version

Starting engine end No. 001155 or starting chassis end No. 001126 the oil pump 100 180 11 01 has been used with oil pressure relief valve (A) located at the rear.

Starting engine end No. 001626 the oil pressure relief valve 100 180 03 15 (shunt holes not in offset positions) has been replaced with the oil pressure relief valve 616 180 01 15 (shunt holes in offset positions) to eliminate breaking of compression spring.

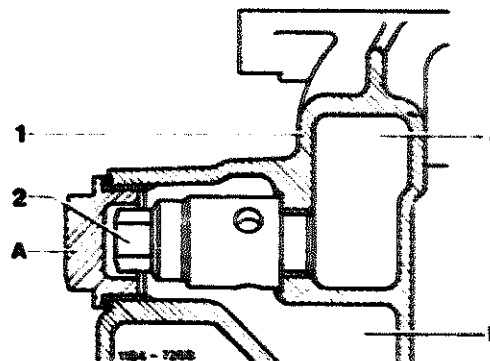


In the event of repairs, compression spring
100 993 09 02 in pressure relief valve 2nd version
must be replaced by compression spring 616 993 02 01
(starting engine end No. 001626 standard).

2nd version

- 1 Oil pump body
- 2 Oil pressure relief valve
Part no. 616 180 01 15

- A Plug
- a Pressure side
- b Intake side



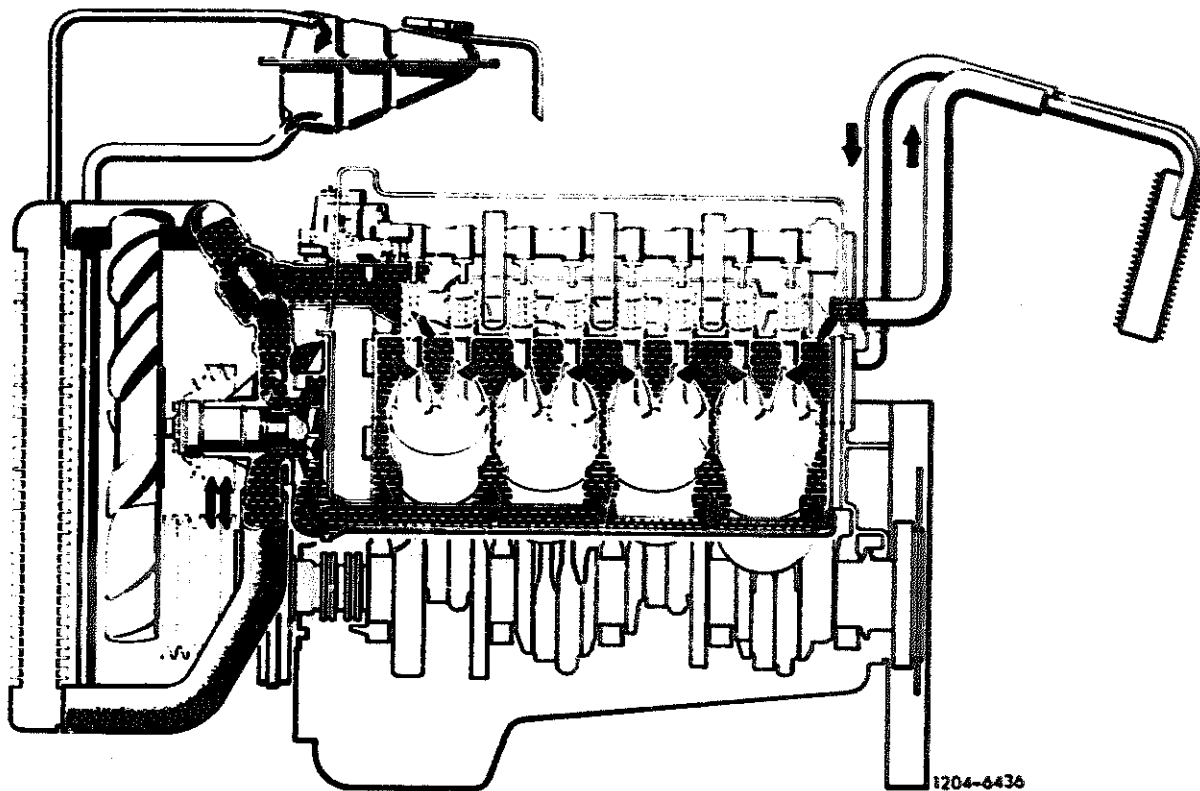
Removing

- 1 Remove complete oil pan (01-310).
- 2 Unscrew plug (A).
- 3 Unscrew oil relief valve (2).

Installing

For installation proceed vice versa to removal.

Coolant circuit



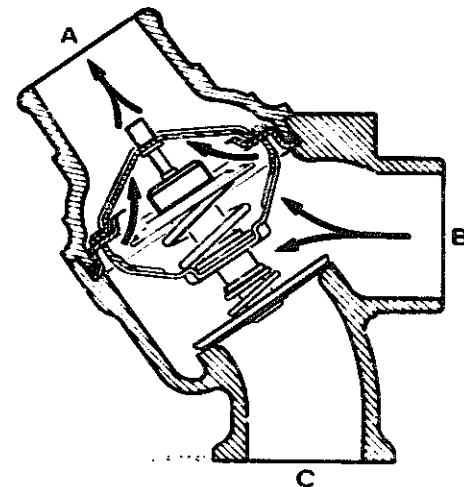
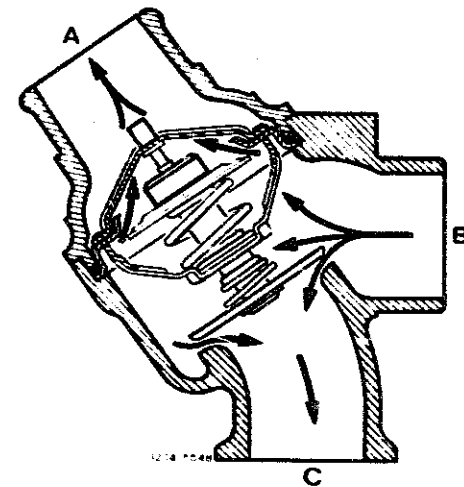
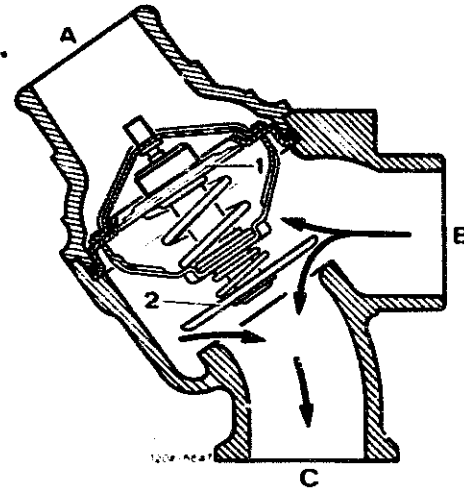
The coolant delivered by the coolant pump, after flowing through crankcase and cylinder heads, flows out again at intake pipe front and from there to thermostat housing (arrow).



During the warm-up phase the disk of the main valve (1) is shut and the bypass disk (2) open. Flow (A) to the radiator is interrupted and the coolant flows through the bypass line (C) and coolant pump back to the engine.

When the engine is at operating temperature the main valve and bypass valve will be open to an extent matching the engine load and outside temperature. The coolant will flow through the radiator (A) and the bypass line (C) depending on the thermostat position.

When engine loads are heavy and outside temperatures are high, the bypass line (C) will close at the latest at a coolant temperature of 102 °C. The entire amount of coolant must flow through the radiator. Thus it would be completely wrong to want to "improve" the engine's cooling by removing the thermostat.



Engine cooling

A pressure of about 1 bar is produced in the cooling system by way of the spring-loaded radiator cap (code 100).

The cooling system is filled at the factory with a coolant, which consists of water to 55 % by volume and antifreeze to 45 % by volume, thus offering all year service.

The system guarantees protection against freezing down to -30°C and prevents corrosion in the cooling system because of additives in the antifreeze. Since the additives are subject to an aging process, the coolant must be replaced every three years.

To provide adequate protection against corrosion the concentration of antifreeze should not be less than 30 % by volume (protection down to -20°C).

If an antifreeze is not available and only water is added, it is essential to mix 1 % of purifier (corrosion inhibitor) (10cc/ltr. water).

The antifreeze will increase the boiling point of the mixture filled at the factory to about 125°C , while for water and at a pressure of 1 bar it is about 118°C .

The red mark on the temperature gauge begins at 122°C .

This point deserves special attention, if only water with a purifier is added. Water could be forced out before the needle of the temperature gauge has reached the red mark.

Full throttle, mountain or convoy driving, fast highway driving followed by a traffic jam or driving in areas with high outside temperatures and an antifreeze for protection of at least -30°C could cause the coolant temperature gauge needle to rise up to the red mark, without that coolant is forced out or that it means engine trouble.

If the engine must run for a long time with the car stationary, e. g. in a traffic jam, it would be advantageous to move the selector lever to position "N". This will reduce the development of heat in the transmission and consequently the additional heating of the coolant from the transmission oil cooler.

If coolant is lost through a leak in the coolant system or because of boiling over, an appropriately prepared coolant must be added. The small amount missing by way of evaporation can be replaced with drinking water.

20-010 Draining and filling coolant – antifreeze chart

Mixing ratio between antifreeze¹⁾ and water²⁾ in litres

Protection down to	Antifreeze	Water
-30 °C	7.25	8.75
-40 °C	8.25	7.75
Total filling capacity in liters	16	

1) Only approved antifreezes may be used, refer to specifications for service products page 325.

2) Refer to specifications for service products page 310.

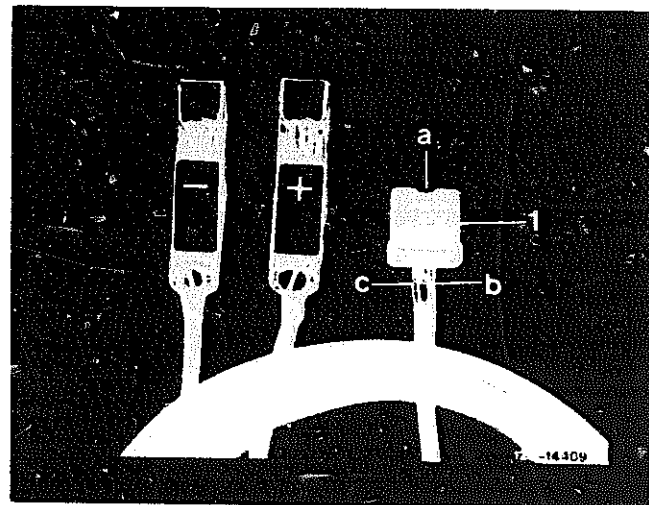
Tightening torque

	Nm	(kpm)
Radiator drain plug	6-10	(0.6-1.0)

Self-made tool for vehicles with automatic climate control

Coupler (1), part No. 002 545 49 28
 approx. 1 m cable 1.5 mm², black (b) +
 approx. 1 m cable 1.5 mm², brown (c) –
 1 cable terminal +
 1 cable terminal –

a = Locating groove

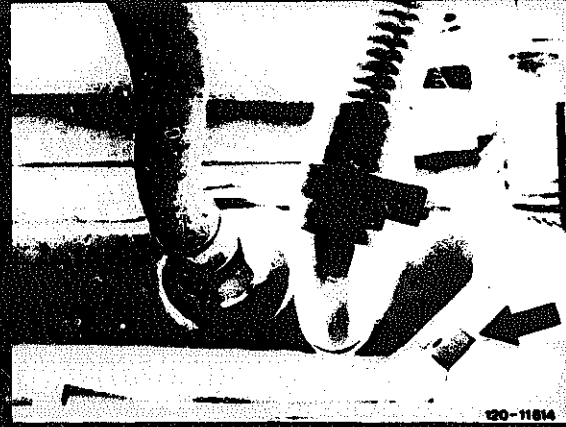


Draining

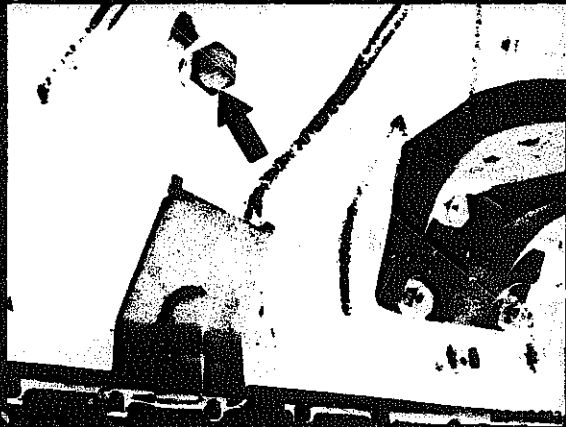
1 Open closing cap on expansion tank in steps (only below 90 °C). Set both operating levers of heater to "warm" (upwards).



2 Unscrew drain plug on radiator.



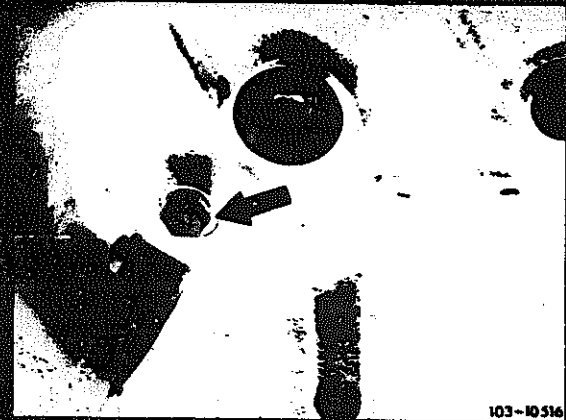
3 Unscrew drain plug on engine block right.



4 Unscrew drain plug on engine block left.

Attention!

Do not mix up drain plugs (arrow) with fastening bolts of crankshaft bearing cap underneath.



Filling

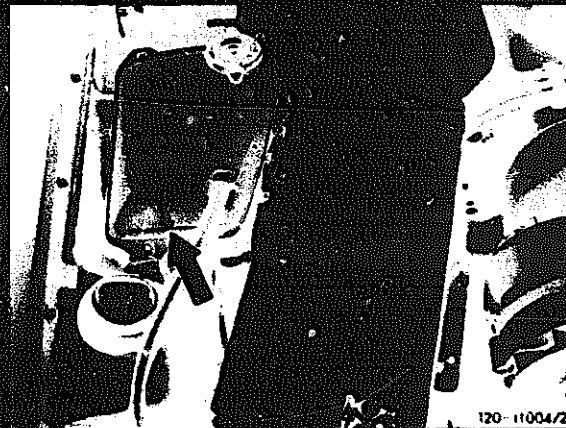
Vehicles without automatic climate control and without auxiliary heater

1 Set both operating levers of heater to "warm" (upwards).

Add coolant slowly up to mark on expansion tank.

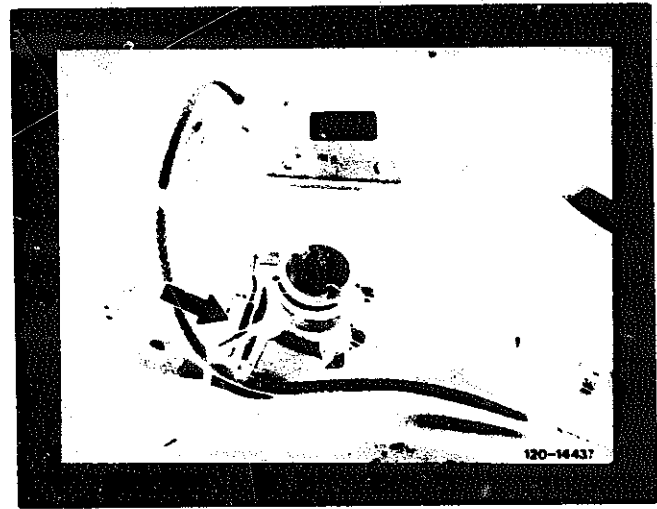
2 Run engine warm under intermittent acceleration and with cooling system closed starting at 60 °C until thermostat opens.

3 Check coolant level (below 90 °C) and add coolant up to specified level.



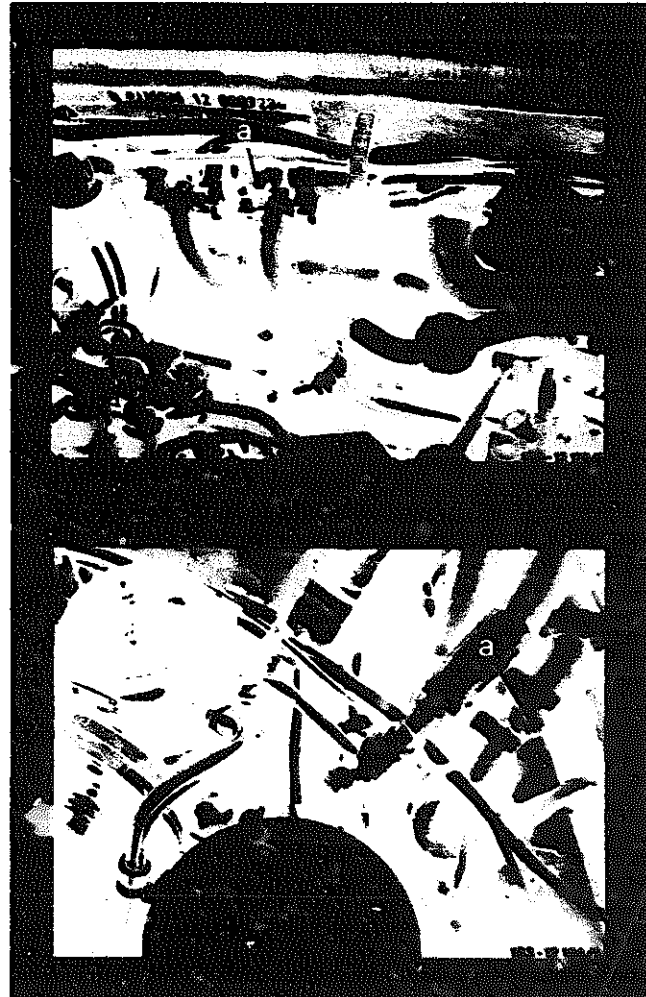
Vehicles with automatic climate control

- 1 Fill-in coolant slowly up to mark on expansion tank.
- 2 Start engine and run warm up to approx. 40 °C.
- 3 Disconnect plug (arrow.) of heating water pump from supply line. Connect heating water pump to battery with special tool and push "DEF"-button.
- 4 Run engine warm under intermittent acceleration with cooling system closed starting at 60 °C, until thermostat opens.
- 5 Connect plug of heating water pump again to supply line.
- 6 Check coolant level (below 90 °C) and add coolant up to specified level.



Vehicles with auxiliary heater

- 1 Set both operating levers of heater to "warm" (upwards).
- 2 Connect plastic hoses (self-made from part No. 002 997 59 82 or 010 997 89 82) to venting valves (a) and open venting valves.
- 3 Add coolant slowly up to mark on expansion tank.
- 4 Run engine warm under intermittent acceleration. Switch-on auxiliary heater at approx. 60 °C and close cooling system with cap.
- 5 Vent until thermostat opens and coolant comes out of venting valves free of bubbles.
- 6 Check coolant level below 90 °C and add coolant up to specified level.



A. De-oiling

- 1 Completely drain coolant.
- 2 Remove coolant thermostat and set heater lever to warm.
- 3 Fill cooling system with a 5 % solution of water and a neutral cleaning agent or with a mild alkaline cleaner such as P 3-Croni (supplier: Henkel) or Grisiron 7220 (supplier: Farbwerke Hoechst).
- 4 Run engine warm at medium speed up to approx. 80 °C (176 °F) and hold at this temperature for approx. 5 minutes.
- 5 Stop engine and let cooling system cool down to approx. 50 °C (122 °F).
- 6 Completely drain solution.
- 7 Immediately thereafter, fill cooling system twice with fresh water, let system run warm (approx. 5 minutes) and drain.

B. De-calcification, de-rusting

Attention!

Prior to de-calcification, be sure to de-oil the cooling system, even if there is no visible oiling up.

- 1 After second flushing job during de-oiling, fill cooling system with a 10 % (100 g/l) solution of water and citric acid, tartaric acid or oxalic acid (sold by the chemical trade) while giving preference to citric acid.

2 Run engine warm at medium speed up to approx. 80 °C (176 °F) and hold for approx. 10 minutes at this temperature.

3 Stop engine and permit cooling down to approx. 50 °C (122 °F).

4 Completely drain de-calcification solution.

5 Flush cooling system at least 3 times with fresh water, while running engine for at least 5 minutes with each flushing charge.

Badly calcified cooling system may require a repetition of treatment. Always prepare a fresh de-calcification solution and repeat flushing steps.

6 Install coolant thermostat with new sealing ring.

7 Fill cooling system with specified coolant (specifications for service products sheet 310 to 325).

Note: For de-calcification and de-rusting, commercial products made with the acid named above may also be used.

Chromic acid or products containing chrome are prohibited by sewage regulations.

20-210 Removing and installing coolant pump

Tightening torques	Nm	(kpm)
Radiator drain plug	6-10	(0.6-1.0)
Coolant pump to coolant pump housing	10	(1.0)
Visco fan clutch to coolant pump hub	25	(2.5)
Thermostat housing to coolant pump bearing housing	23	(2.3)

Coolant capacity

Cooling system with heater	approx. 16 ltr.
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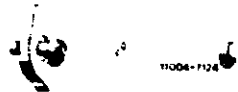
Special tools

Tester for cooling system



001 589 48 21 00

Radiator cap with hose for leak test



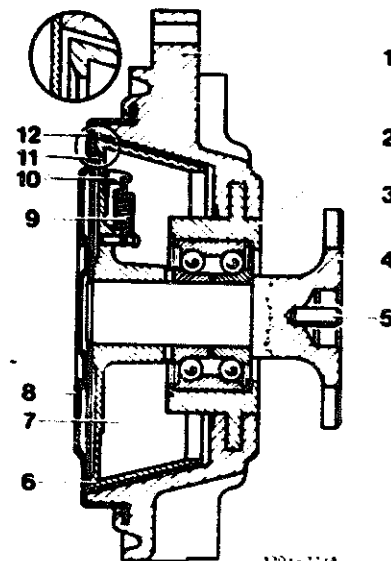
605 589 00 25 00

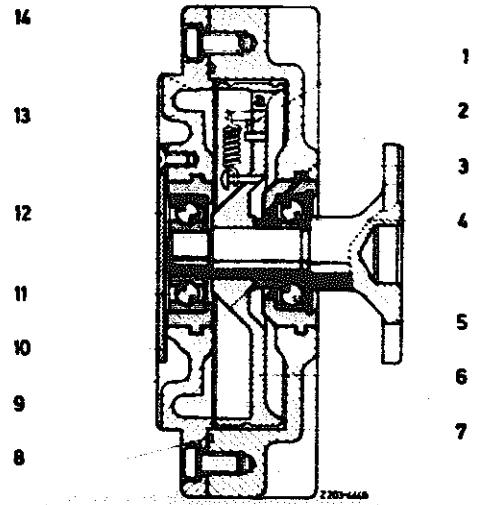
Note

A modified viscofan clutch is installed since February 1979, starting engine end No. 005889, chassis end No. 005779. The coolant pump and the coolant pump housing were also changed.

Viscofan clutch 2nd version

5 Notched pin





Viscofan clutch 1st version

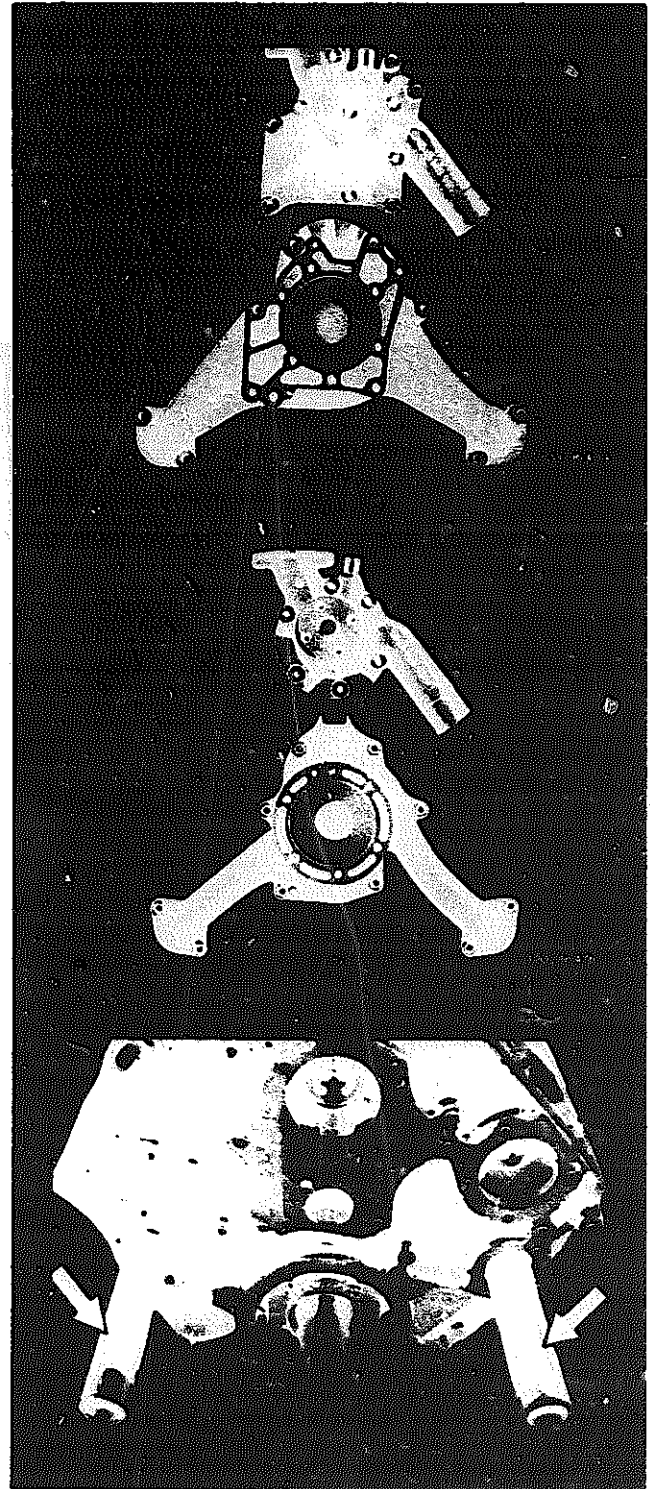
The modified viscofan clutch 116 200 01 22 can be attached only to modified coolant pump with housing.

Coolant pump and housing starting engine end No. 005889

Coolant pump and housing up to engine end No. 005888

The coolant distributing pipes (arrows) are no longer installed starting engine end No. 001915.

On engines up to engine end No. 001914 be sure to remove coolant distributing pipes during repair jobs.

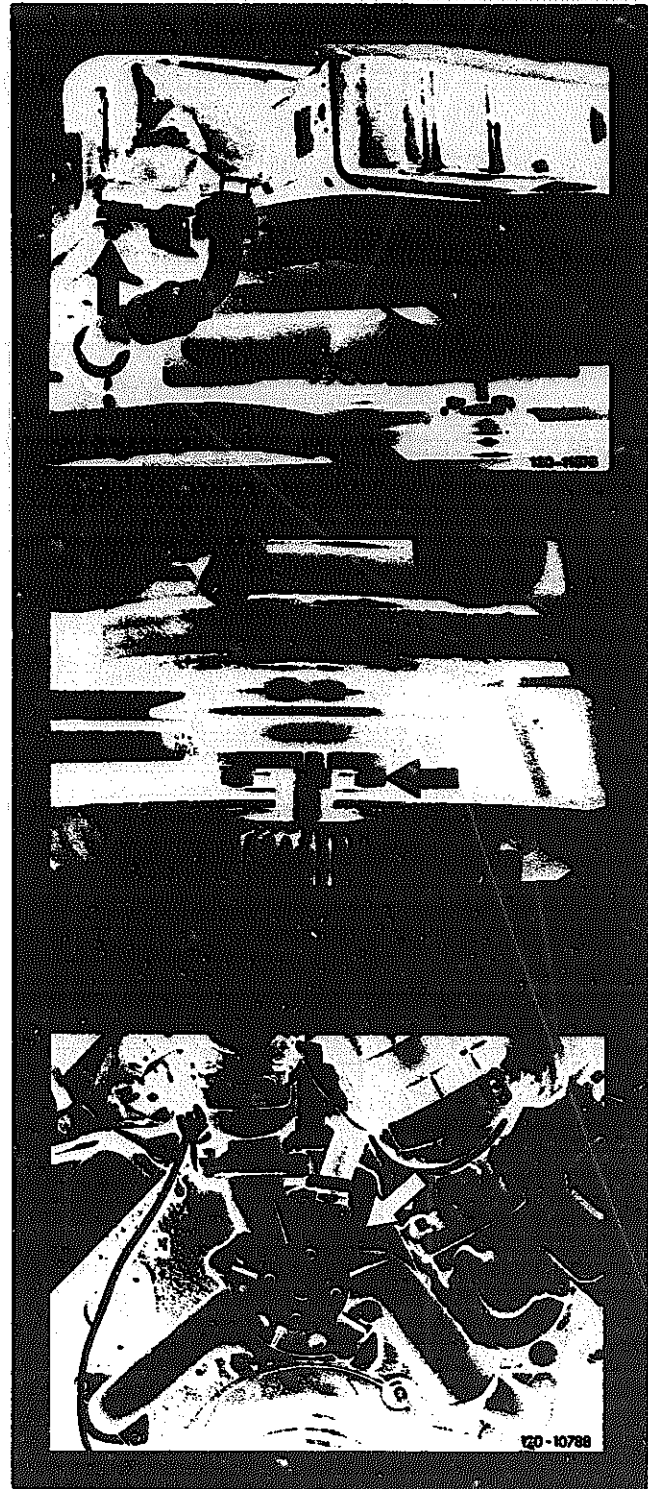


Removing

- 1 Drain coolant (20-010).
- 2 Loosen upper coolant hose.
- 3 Loosen V-belt A at power steering pump (13-340).
- 4 Disconnect upper oil line at air oil cooler and plug openings with plastic caps.
- 5 Loosen radiator shell.

- 6 Unscrew visco fan clutch and take it away together with the radiator shell upward.
- 7 Take pulley off of coolant pump.
- 8 Loosen and pull heater hose and lower coolant hose off of coolant pump.

- 9 Unscrew thermostat housing at coolant pump.
- 10 Unscrew the six bolts on the bearing housing (arrow) and remove coolant pump.



Installing

After replacing the gaskets and seals, installation is in reverse sequence. Pay attention to different lengths of bolts.

- 11 Add coolant (20-010).
- 12 Check cooling system for leaks.

20-225 Sealing coolant pump

Special tool

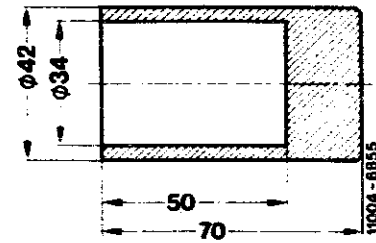
Impeller extractor



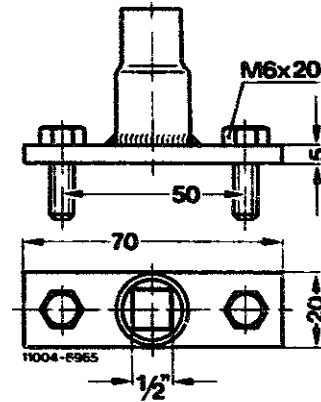
100 589 15 33 00

Self-made tools

Installer sleeve

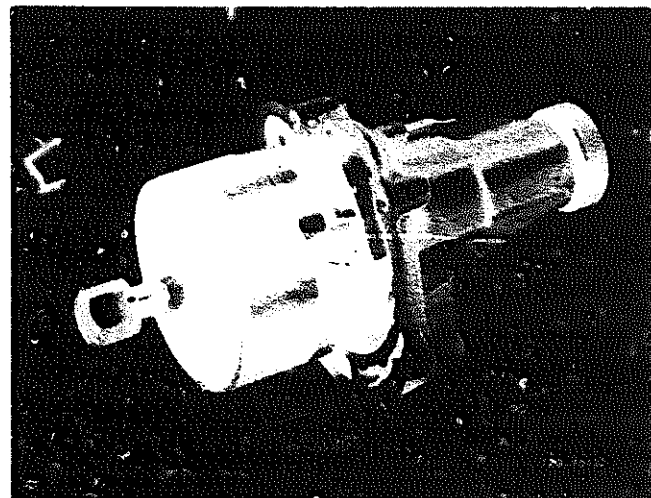


Impeller tightness tester



Disassembling

- 1 Pull off impeller.



2 Press sliding seal ring out of bearing housing.

3 Press counterring out of impeller.

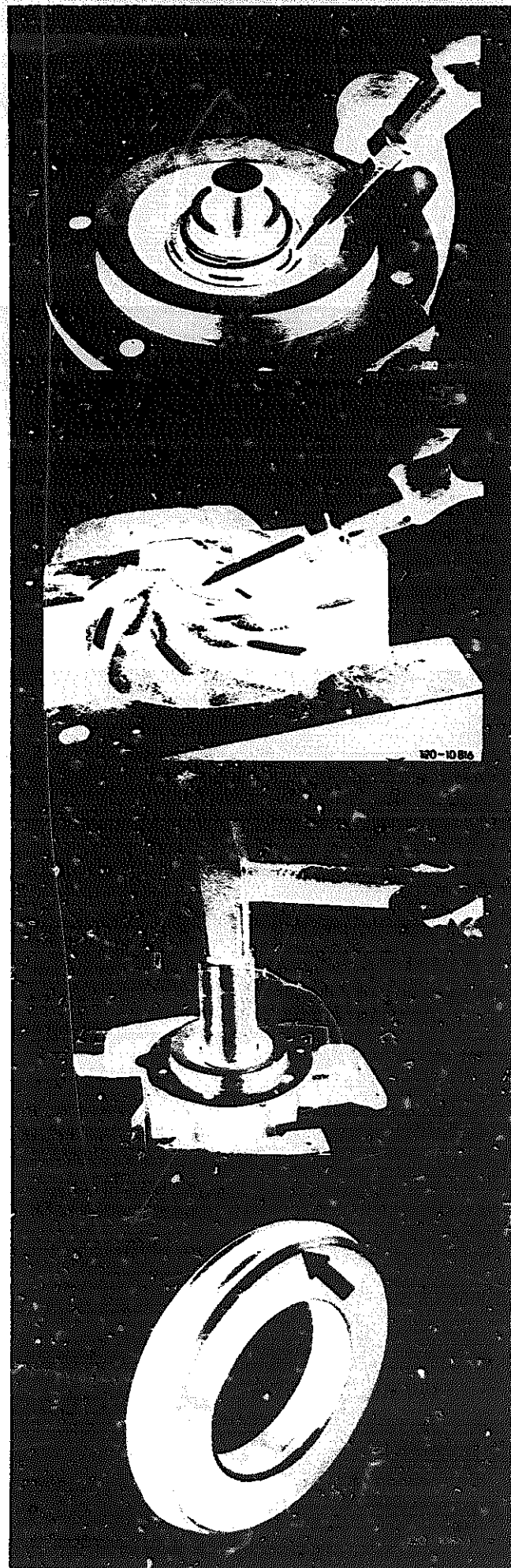
Assembling

4 Apply a light coat of sealing compound to brass casing of sliding seal ring and drive or press the sliding seal ring into the bearing housing.

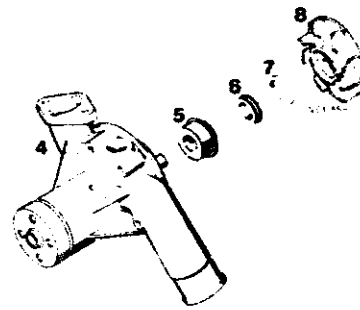
Attention!

Only use bearing housing, and not coolant pump shaft, as a support.

5 Coat O-ring on counterring with brake cylinder paste and press it with its chamfered side forward (arrow) into the thoroughly cleaned impeller.



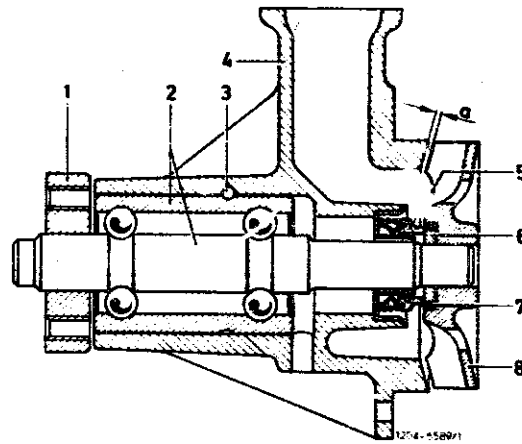
6 Clean sealing surfaces of counterring (6) and sliding seal ring (5) of dust with a chamois.



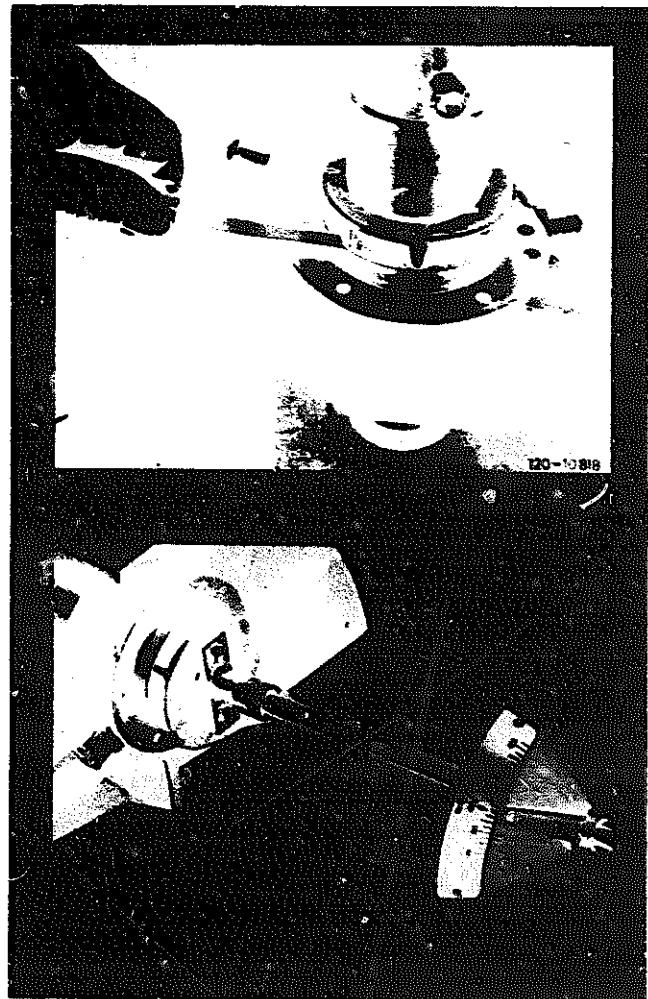
- 4 Bearing housing
- 5 Sliding seal ring
- 6 Counterring
- 7 O-ring
- 8 Impeller

7 Install impeller; watch distance „a”.

- 1 Fan hub
 - 2 Coolant pump shaft with compact bearing
 - 3 Key
 - 4 Bearing housing
 - 5 Sliding seal ring
 - 6 Counterring
 - 7 O-ring
 - 8 Impeller
- a = 1.0 ^{+0.2} / _{-0.1}



8 Check distance „a” with a feeler gauge.



9 Check tightness of impeller with a torque of 35 Nm (3.5 kpm).

20-230 Removing and installing coolant pump housing

Tightening torques	Nm	(kpm)
Radiator drain plug	6-10	(0.6-1)
Coolant pump housing to crankcase	25-30	(2.5-3)
Visco fan clutch to coolant pump hub	25	(2.5)
Thermostat housing to coolant pump bearing housing	23	(2.3)

Coolant capacity

Cooling system with heater	approx. 16 ltr.
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Special tools

Tester for cooling system and radiator cap



001 589 48 21 00

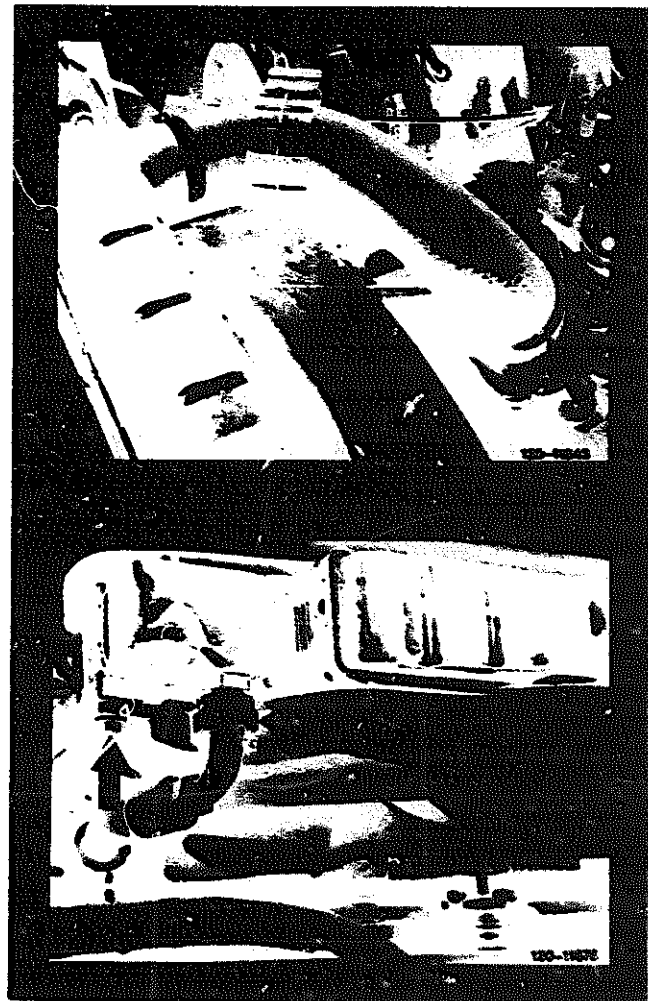
Double connection for radiator and expansion tank closing test



000 589 73 63 00

Removing

- 1 Drain coolant (20-010).
- 2 Remove upper coolant hose.
- 3 Loosen V-belt "A" at power steering pump (13-340).
- 4 Disconnect upper oil line at air oil cooler and plug openings with plastic caps.
- 5 Unscrew radiator shell.



6 Unscrew visco fan clutch and remove together with radiator shell upward.

7 Loosen and take heater nose and lower coolant hose from water pump.

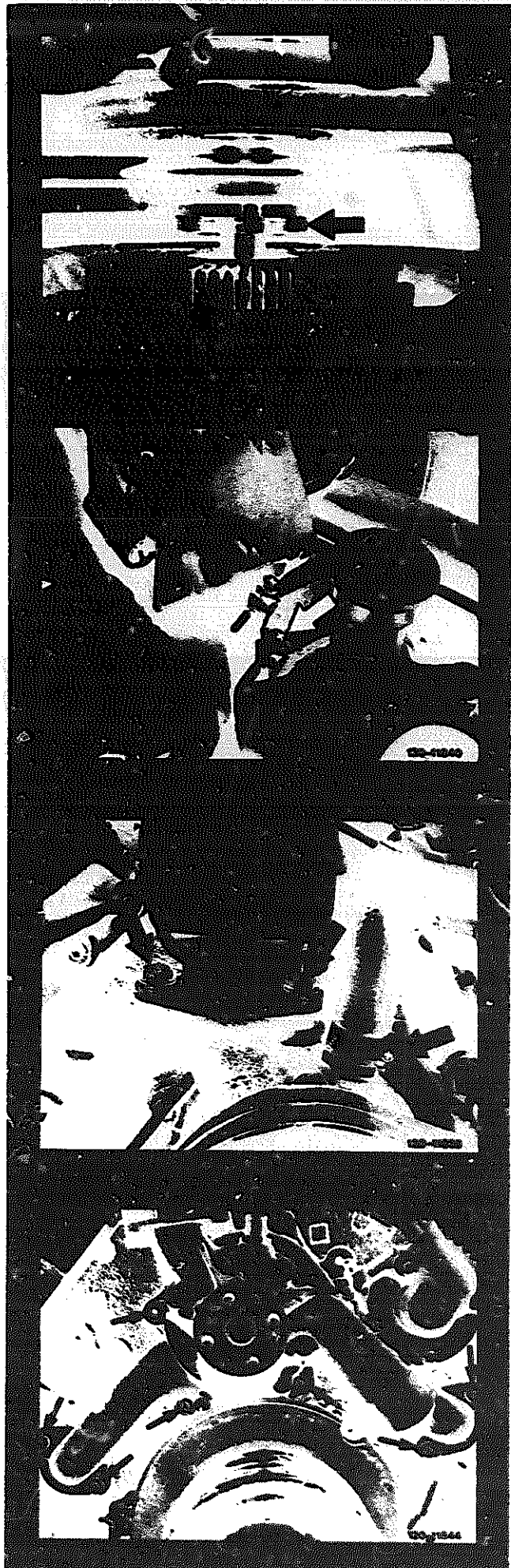
8 Loosen thermostat housing at upper connecting hose.

9 Unscrew thermostat housing at coolant pump.

10 Unscrew coolant pump housing mounting bolts and remove coolant pump housing upward at an angle.

Installing

11 Installation is in reverse sequence.



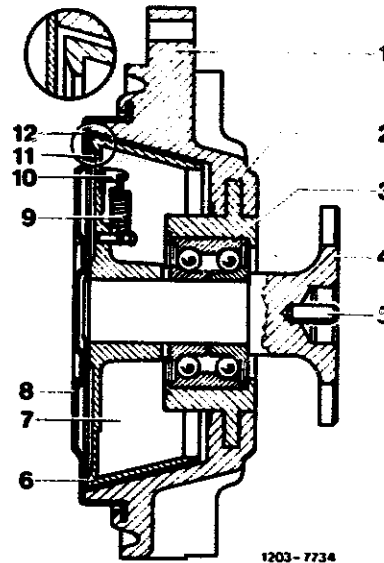
Operation

With this viscofan clutch the fan speed depends on the engine speed.

Up to an engine speed of about 3500 rpm the fan will run proportional to the engine speed, whereby a fan speed of about 1900 rpm resulting from the belt drive ratio and visco clutch slip is not exceeded.

As the engine speed increases further the fan speed will drop to about 1000 rpm and is about 1200 rpm at maximum engine speed.

This control is performed by a spring-loaded valve lever (10), which closes bore (11) because of centrifugal force and interrupts the transmitting fluid circuit.



2nd version starting engine end No. 005889

- | | |
|-------------------------|-------------------|
| 1 Housing | 7 Storage chamber |
| 2 Bearing bushing | 8 Closing cap |
| 3 Inclined ball bearing | 9 Closing spring |
| 4 Flange shaft | 10 Closing lever |
| 5 Notched pin | 11 Feed bore |
| 6 Primary disc | 12 Working gap |

Checking switching-off

Increase engine speed slowly. Fan speed must drop, which is heard clearly, at maximal 3500 rpm.

Checking switching-on

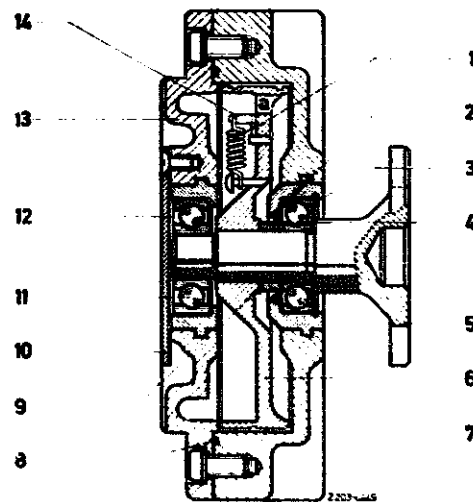
Increase engine speed slowly to about 4000 rpm and hold for about 2 minutes. Slow down engine speed gradually. At the latest at 2450 rpm it must be heard that the fan switches on.

Repairing

A defective visco fan clutch cannot be repaired with normal workshop equipment. It must be replaced by a new clutch.

Note

A modified viscofan clutch is installed since February 1979, starting engine end No. 005889, chassis end No. 00577. The modified viscofan clutch can only be attached to the simultaneously modified coolant pump with coolant pump housing.



1st version up to engine end No. 005888

- | | |
|-----------------------|------------------------|
| 1 Draw spring | 9 Spacing ring |
| 2 Sealing ring | 10 Gasket |
| 3 Locking ring | 11 Radial ball bearing |
| 4 Radial ball bearing | 12 Cover plate |
| 5 Crankshaft | 13 Cap |
| 6 Primary disc | 14 Closing lever |
| 7 Basic body | Bore |
| 8 O-ring | |

20-420 Removing and installing radiator

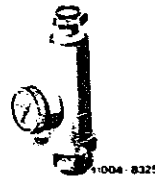
Tightening torques	Nm	(kpm)
Radiator drain plug	6-10	(0.6-1)
Oil cooler drain plug (install without seal)	30-35	(3-3.5)
Oil hose couplings (counterhold)	20-30	(2-3)

Capacities

Oil cooler	approx. 0.5 ltr.
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Special tools

Tester for cooling system and radiator cap



001 589 48 21 00

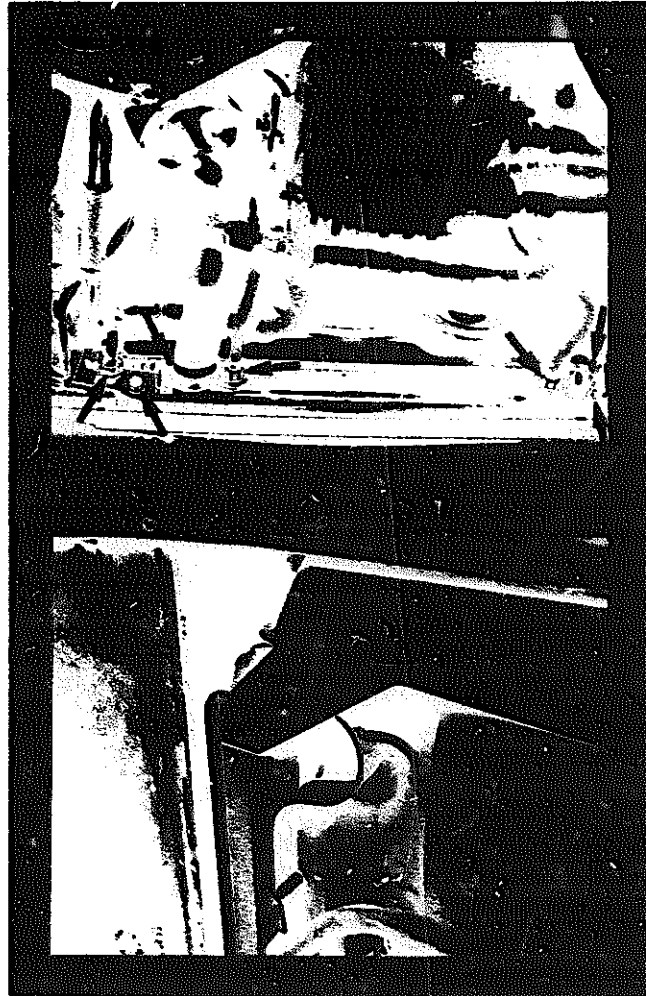
Double connection for radiator and expansion tank closing test



000 589 73 63 00

Removing

- 1 Drain radiator of coolant and oil cooler of oil.
- 2 Disconnect upper and lower coolant hoses as well as supply and return hoses to tank at radiator.
- 3 Unscrew hoses for oil cooler and transmission oil cooler, and plug with plastic caps.
- 4 Unscrew radiator shell at top, pull out of bottom holder and place it over the fan.
- 5 Press left and right brackets outward (arrow) and remove radiator upward.



installing

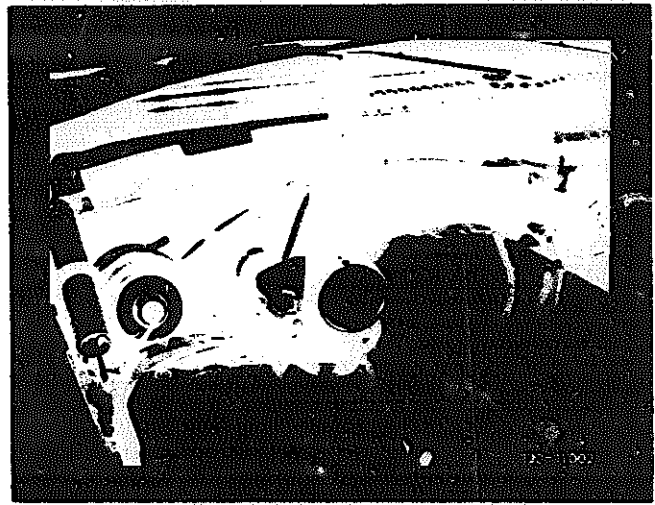
Installation is in reverse sequence.

6 Add coolant (20-010).

7 Check cooling system for leaks.

Note: The drain plug on the air oil cooler is installed without a seal.

After installation of radiator clean arch of air guide plate underneath radiator from oil and water.

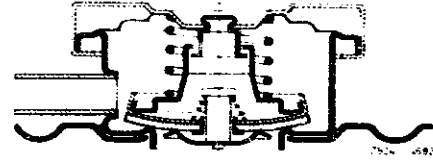


20-430 Checking expansion tank closing cap

Closing cap

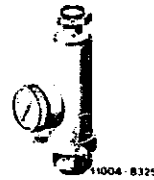
Pressure relief valve opens at $1.0 \begin{smallmatrix} +0.15 \\ -0.1 \end{smallmatrix}$ bar gauge pressure

Vacuum valve starts opening at 0.1 bar vacuum



Special tools

Tester for cooling system and radiator cap



001 589 48 21 00

Double connection for radiator and expansion tank closing test



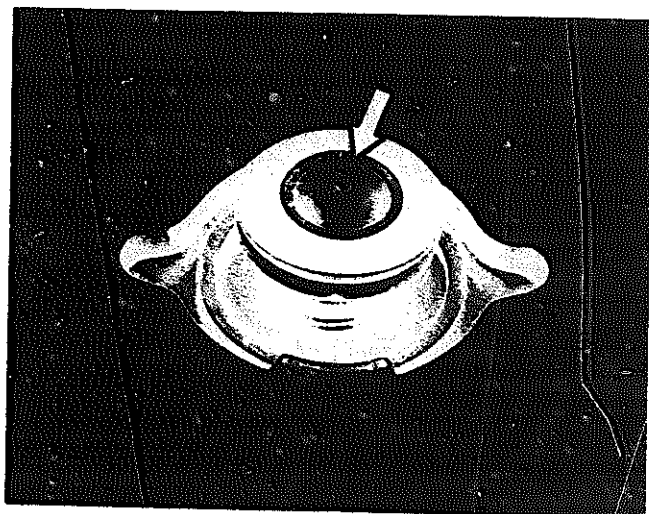
000 589 73 63 00

Checking pressure relief valve

- 1 Attach double connection on leak tester by means of holding clips.
- 2 Place closing cap on double connection.
- 3 Check opening pressure by pumping.

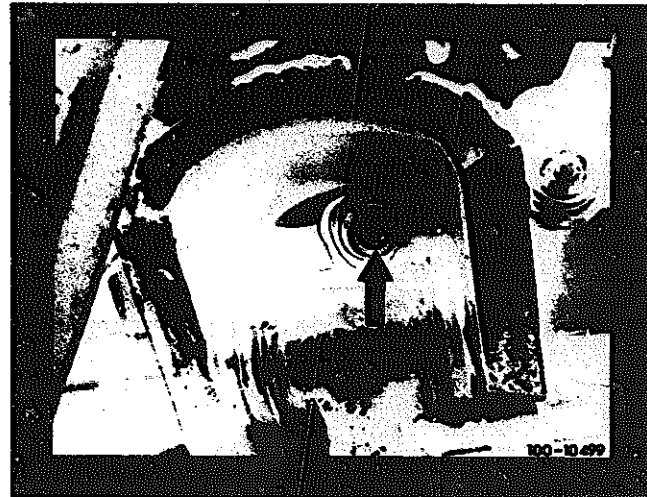
Checking vacuum valve

Vacuum valve (arrow) should rest against rubber seal, lifting-off should be easy, valve should spring back when released.



Engine mounting front

1 Unscrew fastening bolt for engine carrier on engine mount (arrow).



2 Unscrew engine damper at bottom.

3 Lift engine with pit lift against oil pan.

Note: Use wooden support to avoid damaging oil pan.

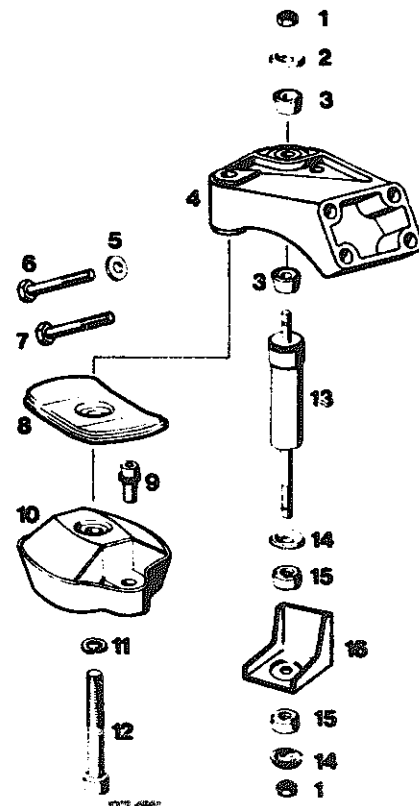
4 Unscrew engine mounting on cross member and remove.

5 For installation proceed vice versa.

6 Tighten fastening screw to 75 Nm (7.5 kpm).

Attention!

Check regulating shaft for correct function.



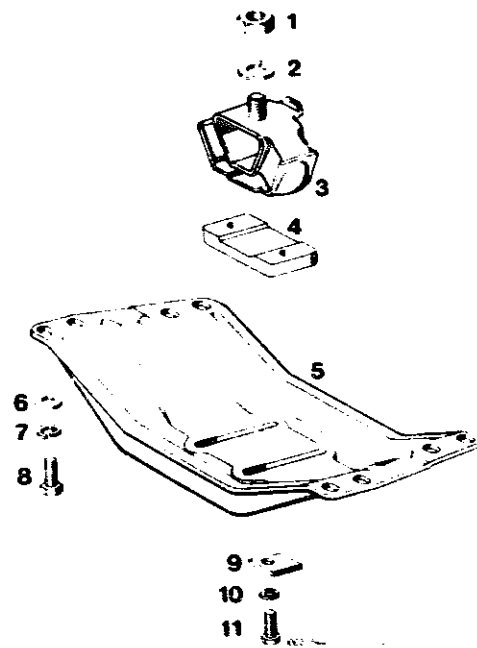
- | | |
|-------------------------------------|---------------------------------------|
| 1 Nut | 9 Combination screw M 8 x 18 |
| 2 Plate spring 115 241 07 12 (30 ø) | 10 Engine mounting |
| 3 Rubber buffer 115 241 17 65 | 11 Snap ring 12 |
| 4 Engine mounting | 12 Fastening screw M 12 x 40 |
| 5 Washer A 8 | 13 Engine shock absorber |
| 6 Screw M 8 x 60 (3 each) | 14 Plate springs 106 241 00 12 (26 ø) |
| 7 Screw M 8 x 75 (1 each) | 15 Rubber buffer 108 241 00 65 |
| 8 Shielding plate | 16 Retainer on side member |

Engine mounting rear

Attention!

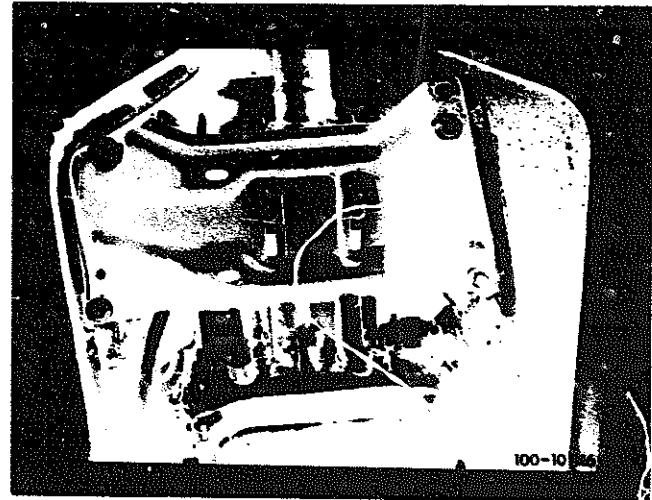
For removal of engine mounting (3), the engine carrier (5) is not screwed off.

Observe correct installation position of shim (4).



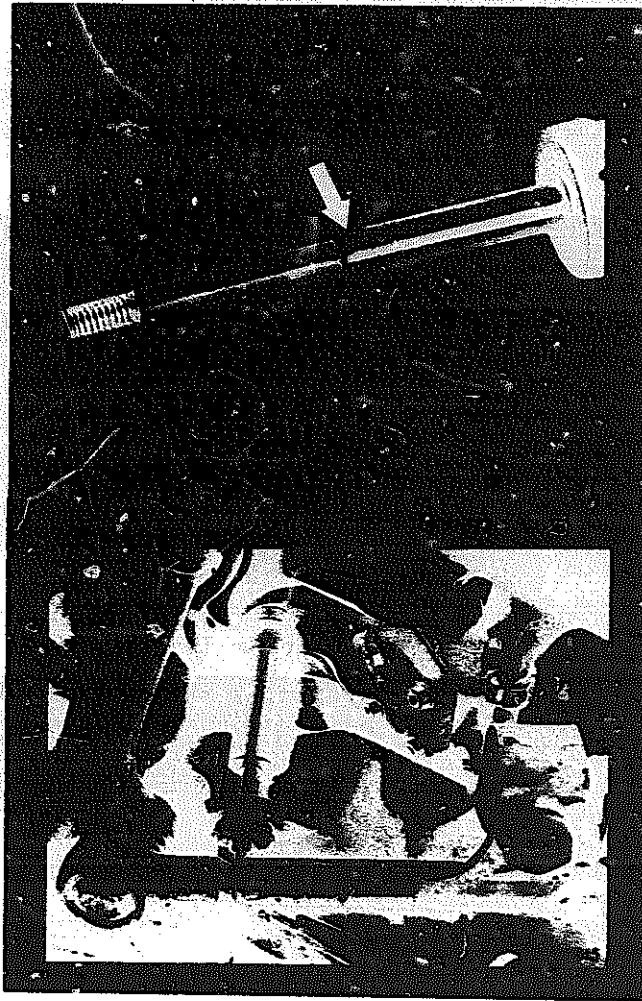
- | | |
|-------------------|--------------|
| 1 Nut M 12x1.5 | 6 Washer |
| 2 Spring washer | 7 Snap ring |
| 3 Engine mounting | 8 Screw |
| 4 Shim | 9 Shim |
| 5 Engine carrier | 10 Snap ring |
| | 11 Screw |

Note: Screw engine mounting to engine carrier free of tension.



Note

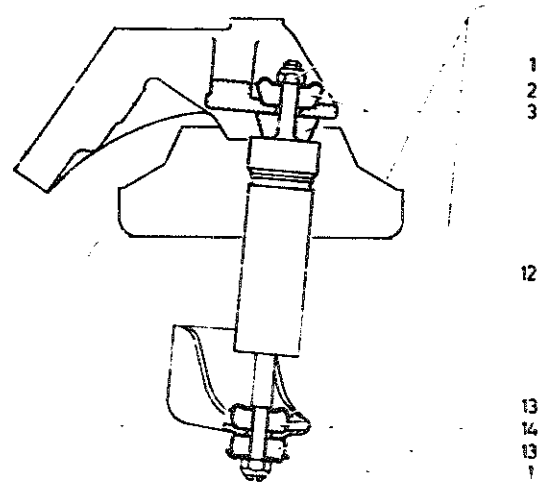
For loosening and tightening lower hex. nut apply counterhold to piston rod at flats (arrow) provided for this purpose.



Engine damper left and right

- 1 Loosen hex. nuts (1) top and bottom.
- 2 Compress engine damper and remove.
- 3 For installation proceed vice versa.

Note: Observe different plate springs and rubber buffers.



- | | |
|-----------------|------------------|
| 1 Nut | 12 Engine damper |
| 2 Plate spring | 13 Plate spring |
| 3 Rubber buffer | 14 Rubber buffer |

Programmed repairs engine 100.985 Mechanical

* Job No. of flat rate unit (AW) or standard text and flat rates data.

01 Engine removal and installation, cylinder crankcase, cylinder head, engine breather

Complaint:

Oil leaks at cylinder head hood seal

Cause/remedy:

Studs come to rest inside cap nut, but no pressure is exerted against cylinder head hood seal.

Check and correct screw-in standout of studs (should be max. = 20.4 mm).

Complaint:

Righthand cylinder head hood seal moving inwards and developing oil leaks.

Cause/remedy:

Hoses at idle speed air distributor and engine breather are contracting and interrupting engine breathing.

Mount new, reinforced hoses available as standard starting engine end No. 003786. Part No. 100 094 11 91, 100 094 12 91, 100 094 13 91, 100 094 02 82, 116 090 01 82.

Complaint:

Oil leaks at oil pan rear.

Cause/remedy:

The three rear threaded bores for fastening oil pan are drilled through into oil chamber. Mount screws with sealing compound.

Complaint:

Cylinder head gasket damaged.

Cause/remedy:

To prevent pinking damage on cylinder head gaskets starting engine end No. 000595 to 001 202¹⁾, the cylinder head gaskets (Elring; 100 016 24 20 (left) and 100 016 25 20 (right) had to be replaced by cylinder head gasket (Reinz) 100 016 21 20 (left) and 100 016 23 20 (right) within scope of an action up to the end of 1976.

¹⁾ Except engine end No.:

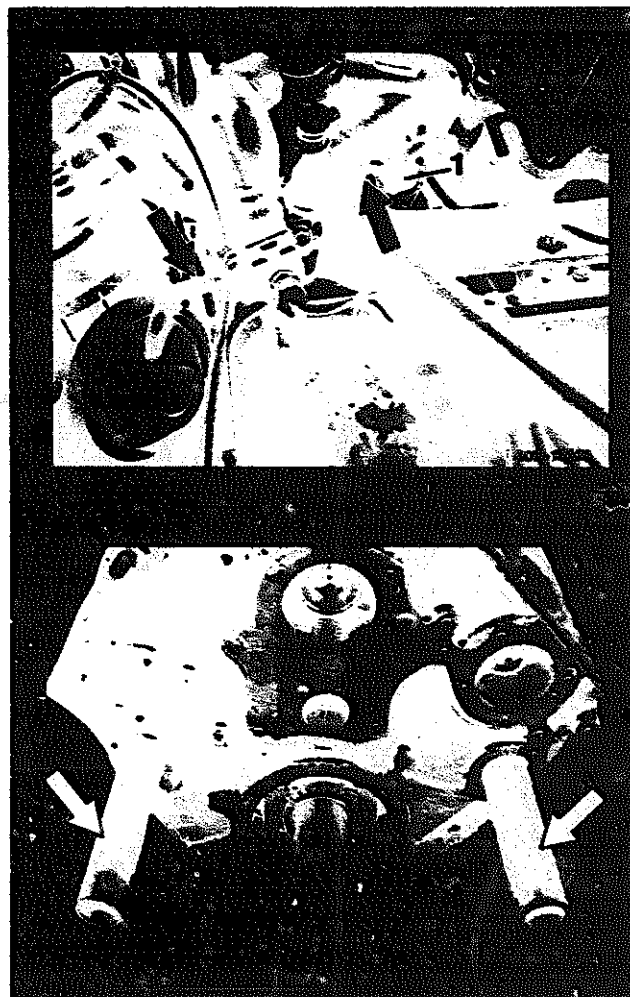
000892	001094-001095	001131
000899	001098	001133-001141
000934	001103	001143-001159
000958	001105-001108	001161-001167
000980	001110-001111	001169-001172
001023	001113-001115	001174-001179
001043	001117	001181-002001
001050	001120	
001083-001085	001127-001128	

In this connection, starting engine end No. 000001 to 001451, a thermo valve (1) for shutting-off the vacuum advance of the ignition distributor at temperatures above 65 °C (149 °F) had to be installed into intake manifold.

Starting engine end No. 001 452 the depth of the piston cavity had to be changed from 2.65 mm to 3.9 mm, as a result of which the pinking boundary has been improved. ($\epsilon = 8.4$, formerly $\epsilon = 8.8$).

As an intermediate version, starting engine end No. 001340 to 001451, pistons with cavities 2.95 mm deep were installed ($\epsilon = 8.6$).

Coolant distributing pipes (arrows) were installed up to engine 001915. During repair jobs, particularly in connection with cylinder head gasket damage caused by overheating, these pipes must be removed since they are obstructing the coolant circuit by distortion.



03 Crank assembly

Complaint:

Rear crankshaft radial sealing ring leaking.

Cause/remedy:

Damaged, worn sealing ring running surface cannot be repaired. Crankshaft must be renewed.

Complaint:

Ring gear damaged by starting into engine coming to a stop

Cause/remedy:

Install ignition starter switch 116 462 00 93 with larger repeat-turning angle (standard since August 1978).

18 Engine lubrication, engine oil cooling

Complaint:

Oil pressure at idle not above 0.3 bar. At approx. 2500 rpm not until 2.5 to 3.0 bar.

Cause/remedy:

Bushing for ignition distributor drive on shaft seizing. Bushing rotates in crankcase. Measure basic bore for bushing in crankcase. Nominal: 28.000–28.021 mm. If max. dimension is exceeded, renew crankshaft housing (in this connection refer to job No. 05–434).

This film replaces microfilm No. 07 102 2009 02.

Below is a survey of revisions and additions in keywords. They are already known from service informations published at an earlier date. National versions (AUS) and (USA) are included.

	Job. no.	Coordinates
<p>Checking intermediate flange during installation not only for concentric running, but also for axial runout.</p> <p>Respective job number:</p>		
Installation and centering of intermediate flange	01-220	N 2 - P 2
<p>Different cylinder heads between standard version and (AUS) (USA)</p> <p>Cylinder head bolts of different lengths: Starting engine no. 001285 with spacing sleeve 13 mm high. If not used, damage to cylinder crankcase may result.</p> <p>Respective job number:</p>		
Removal and installation of cylinder head	01-415	G 3 - F 4
<p>Minimum dia. of necked-down shaft of connecting rod bolts increased from 7.7 to 8 mm.</p> <p>Respective job number:</p>		
Checking, renewing and tightening connecting rod bolts	03-310	L 4 - O 4
<p>Simplified renewal of valve guides.</p> <p>Respective job number:</p>		
Checking and renewing valve guides	05-285	E 11 - J 11
<p>Measuring instrument for tensioning V-belts newly included (known from SI E 174).</p> <p>Respective job numbers:</p>		
Information concerning renewing and tensioning of V-belts	13-335	E 14 - H 14
Renewing and tensioning V-belts	13-340	H 14 - P 14

2nd version oil pressure relief valve added.

Respective job No.

Removal and installation of oil pressure relief valve in oil pump 18-215 L 15 - O 15

Reinforced coolant pump and viscofan clutch 2nd version added
(known from SI 20/13).

Water distribution pipes are omitted starting engine no. 001 915. On former engines,
remove within scope of repair jobs.

Respective job number:

Removal and installation of coolant pump 20-210 G 15 - L 15

Programmed repairs newly included D 18 - H 18

01 Engine removal and installation, cylinder crankcase, cylinder head, engine breather

Engine	Job. no.	Coordinates
Checking compression pressure	01-010	B 1 - C 1
Checking cylinders for leaks	015	D 1 - F 1
Evaluating cylinder bores	020	G 1 - H 1
Measuring oil consumption	025	H 1 - J 1
Removing and installing engine (oil capacity)	030	K 1 - C 2
Engine breather - operation	040	D 2 - E 2
 Cylinder crankcase		
Measuring, boring and honing cylinder bores	110	E 2 - F 2
Facing cylinder crankcase parting surface	120	G 2 - H 2
 Front crankcase cover and intermediate flange		
Removal and installation of front crankcase cover	215	H 2 - M 2
Installation and centering of intermediate flange	220	N 2 - P 2
 Oil pan		
Complete removal and installation of oil pan	310	A 3 - F 3
 Cylinder head		
Removing and installing cylinder head	415	G 3 - F 4
Facing cylinder head parting surface	418	G 4 - J 4
Pressure testing cylinder head	420	K 4 - L 4

03 Crank assembly

Crankshaft, connecting rod and pistons		
Checking, renewing and tightening of connecting rod bolts	03-310	L 4 - O 4
Repairing and squaring connecting rods	313	O 4 - C 5
Removal and installation of piston	316	D 5 - L 5
Checking and reconditioning crankshaft	318	L 5 - C 6
Mounting of crankshaft	320	D 6 - O 6
Replacing front crankshaft radial sealing ring	324	O 6 - B 7
Replacing rear crankshaft radial sealing ring	327	B 7 - E 7
Removal and installation of hub, vibration damper and pulley	342	E 7 - L 7
Checking and correcting TDC transmitter adjustment	345	L 7 - P 7
Removing and installing crankshaft sprocket	350	A 8 - E 8
 Driven plate and ring gear		
Removing and installing driven plate	410	E 8 - F 8
Replacing ring gear	430	G 8 - H 8

05 Engine timing, valves

Camshaft, rocker arms and valves

Checking and replacing hydraulic valve clearance compensating element	05-211	H 8 - L 8
Checking and correcting basic setting of hydraulic valve clearance compensating elements	213	L 8 - P 8
Checking and adjusting camshaft timing	215	A 9 - F 9
Removing and installing camshaft	220	G 9 - P 9
Grinding camshaft bearing journals	225	A 10 - C 10
Removing and installing rocker arms	230	D 10 - F 10
Removing and installing of valve springs	250	G 10 - L 10
Checking valve springs	260	L 10 - M 10
Replacing valve stem seals	270	N 10 - P 10
Checking and machining valves	280	A 11 - E 11
Checking and machining valve guides	285	E 11 - J 11
Replacing valve seat inserts	290	K 11 - M 11
Machining valve seat inserts	291	N 11 - B 12

Timing chain, chain tensioner, tensioning and slide rails

Removing and installing chain tensioner	310	B 12 - F 12
Replacing timing chain	320	G 12 - L 12
Removing and installing tensioning rail	330	L 12 - O 12
Removing and installing sliding rails	340	O 12 - C 13

Drive for oil pump, ignition distributor and hydraulic oil pump

Removing and installing intermediate sprocket for ignition distributor drive	434	D 13 - F 13
Removing and installing intermediate sprocket for hydraulic oil pump drive	436	G 13 - L 13
Removing and installing guide sprocket	440	L 13 - E 14

13 Belt drives

Belt drives

Information concerning replacing and tensioning of V-belts	13-335	E 14 - H 14
Replacing and tensioning V-belts	340	H 14 - P 14

18 Engine lubrication, engine oil cooling

Oil circuit

Oil circuit, oil pressure, pressure relief valves and oil filter	18-005	A 15 - C 15
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Oil filter

Checking thermostat in oil filter	120	D 15 - E 15
Removing and installing thermostat in oil filter upper section	125	E 15 - F 15

Oil pump

Removing and installing oil pump	210	G 15 - L 15
Removing and installing oil pressure relief valve in oil pump	215	L 15 - O 15

20 Engine cooling, coolant hoses, radiator

Cooling system

Coolant circuit and engine cooling	20-005	O 15 - C 16
Draining and filling coolant-antifreeze chart	010	D 16 - H 16
Cleaning cooling system	015	H 16 - L 16
A. De-oiling		H 16 - J 16
B. De-calcifying, de-rusting		H 16 - L 16

Coolant pump

Removing and installing coolant pump	210	L 16 - P 16
Sealing coolant pump	225	A 17 - E 17
Removing and installing coolant pump housing	230	E 17 - H 17

Viscofan clutch

Viscofan clutch (speed-controlled)	320	H 17 - J 17
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Radiator

Removing and installing radiator	420	K 17 - M 17
Checking expansion tank closing cap	430	N 17 - O 17

22 Engine suspension

Engine suspension

Removal and installation of engine mounting	22-210	O 17 - B 18
Removal and installation of engine damper	240	B 18 - C 18

Programmed repairs		D 18 - H 18
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Revisions		H 18 - L 18
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