Workshop Manual

928

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Structure of the Workshop Manual

This Workshop Manual describes all of the important operations for which special instructions are required to ensure proper completion.This manual is essential for shop foremen and mechanics who need this information to keep the vehicles in safe operating condition. The basic safety rules, of course, also apply to all repairs on vehicles, without exception.

Breakdown of the Workshop Manual

1. Overview of repair groups
2. Record sheet for supplements
3. List of contents
4. Technical data
5. Repair groups

Breakdown of the repair groups

1. Table of tightening torques
2. Special tools required
3. Exploded diagrams
4. Legends for the exploded diagrams
5. Notes on assembly/application of special tools
6. Diagnosis for the repair groups

The Workshop Manual will be updated regularly by means of supplements which must be filed immediately to maintain the usefulness of the manual. Appropriate entries must be made in the record sheet to prove that the manual is complete.

The content of this Workshop Manual will be supplemented with Technical Information Bulletins, which will be integrated into the manual from time to time.

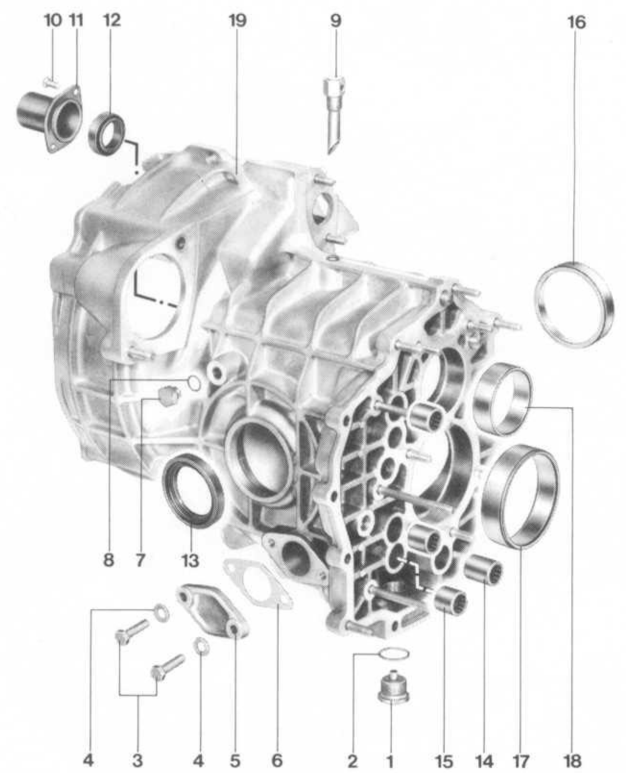
Descriptions of design and function can be found in the service training course reference material.

Printed in Germany - XXII, 1989

Layout of the exploded diagram

(A) 34 (B) Manual Transmission, Controls, Case (C) 911 Carrera 4

Disassembling and assembling transmission



34 - 128 (D)

Disassembling and assembling transmission (E)

Printed in Germany - VII, 1988 (F)

(C) 911 Carrera 4 (B) Manual Transmission, Controls, Case (A) 34

(G) (H) Note when:

No	Description	Qty.	Removing	Installing
1	Screw plug	1		Clean, tighten with 30 Nm
2	Sealing ring	1		Replace
3	Hexagon head screw	2		Tighten with 23 Nm (17 ftlb)
4	Washer	2		
5	Flange	1		
6	Seal	1		Replace
7	Screw plug	1		Tighten with 23 Nm (17 ftlb)
8	Sealing ring	1		Replace
9	Breather	1		Tighten with 35 Nm (26 ftlb). Observe installation position
10	Fillister head screw	2		Tighten with 10 Nm (7 ftlb)
11	Guide tube	1		
12	Rotary shaft seal	1		Only install after assembling the gear set (also refer to Page 34-113)
13	Rotary shaft seal	1		Drive into position with Special Tool 9252. Pack space between sealing lips with Klüber Silubrin Grease S
14	Spherical sleeve	1	Pull out with a suitable internal puller (e.g. Schrem 14-20)	Press in with Special Tool 9254

Disassembling and assembling transmission (E)

Printed in Germany - VII, 1988 (F)

34 - 129 (D)

A - Repair group, numbers
B - Repair groups, text
C - Type of vehicle to repaired
D - Page number
E - Operation
F - Impressum, supplement number, year of printing
G - Diagram item number in the order of disassembling
H - Special notes to be observed when installing or removing

The notes on assembly/application of special tools which are given after the exploded diagram are always arranged in the order of text → diagram.

This workshop manual describes all of the important operations for which special instructions are required to assure proper completion. This manual is essential for the shop foremen and mechanics, who need this information to keep the vehicles in a safe operating condition. The basic safety rules, of course, also apply to repairs on vehicles without exception.

The information is grouped according to repair numbers which are identical to the first two digits of the repair time and warranty code.

The repair group index, an alphabetical index and the register table are quick guides to find information in the manual.

Descriptions of design and function can be found in the service training course reference material.

This workshop manual will be kept up to date with workshop bulletins, which will be made part of the manual from time to time. We recommend that these workshop bulletins be filed in the special folder provided for this purpose.

SUPPLEMENT TO 928 REPAIR MANUAL
(XVIII)

Information Sheet - Extension of the 928 Repair Manual to 7 Volumes

Overview of Repair Manual Volumes:

Volume	I	= Drive Unit
Volume	I - A	= Drive Unit
Volume	II	= Drive Train
Volume	III	= Drive Train
Volume	IV	= Chassis, Heating, Air Conditioning
Volume	V	= Bodywork, Car Electrics
Volume	VI	= Car Electrics (Circuit Diagrams)
Volume	VII	= Car Electrics (Circuit Diagrams, '88 Models Onward)

Please file the pages in the volumes of the Repair Manual as follows:

1. Please file pages 20 - 1 to 28 - 71 of the original Volume I - Drive Unit in the new Volume I-A - Drive Unit.

2. The new Volume VII Car Electrics (Circuit Diagrams, '88 Models Onward) contains pages 97 - 281 to 97 - 305.

List of Repair Groups

Printed in Germany – XXVII, 1991

Engine, cylinder head, valves

Printed in Germany - XXVII, 1991

Printed in Germany – XXVII, 1991

Page

Engine, Lubrication

Engine, Cooling

Printed in Germany – XXVII, 1991

NEW INTERNATIONAL UNIT SYSTEM

The "Legislation Concerning Units of Measurement" was passed in the Federal Republic of Germany on July 5, 1970. The new units have to be applied in official and business transactions by the end of the allocated transition period on December 31, 1977 (some even earlier).

The new units are derived from the international system of basic units.

Basic Units

Factor	Unit	
	Name	Symbol
Length	Meter	m
Mass	Kilogram	kg
Time	Second	s
Electric strength of current	Ampere	A
Temperature	Kelvin	K
Intensity of light	Candela	cd
Substance quantity	Mol	mol

Decimal multiples and parts of units can be made by adding prefixes in front of the unit symbols.

Prefixes

Power of ten	Prefix	Prefix Symbol
10^{12}	Tera	T
10^{9}	Giga	G
10^{6}	Mega	M
10^{3}	Kilo	k
10^{2}	Hecto	h
10	Deka	da
10^{-1}	Deci	d
10^{-2}	Centi	c
10^{-3}	Milli	m
10^{-6}	Micro	μ
10^{-9}	Nano	n
10^{-12}	Pico	p

Examples:

1. Unit m (meter). By adding prefix k (kilo) we have km (kilometer = 1,000 m).

2. Unit s (second). By adding prefix m (milli) we have ms (millisecond = 1/1000 s).

The following list is a survey of important units used frequently in motor vehicle repair operations.

List of Units

Factor	Basic Unit	Other Acceptable Units	Remarks
Length	m	µm, mm, cm, dm, km etc.	No longer acceptable: µ for 0.001 mm
			0.001 mm = 1 µm
Area	m^2	mm^2, cm^2, dm^2 etc.	No longer acceptable: qm, qmm, qcm etc.
Volume	m^3	mm^3, cm^3, dm^3 etc. l, ml, cl etc.	No longer acceptable: cbm, cmm, ccm etc., ltr., Ltr.
			$1\ l = 1\ dm^3$
Plane angle	rad (radiant)	° (degree) ' (minute) " (second)	1 rad = 1 m/m $1^\circ = \pi/180$ rad $1^\circ = 60'$ $1' = 60''$
			" not acceptable for inch
Solid angle	sr (steradiant)	m^2/m^2	$1\ sr = 1\ m^2/m^2$
Mass	kg	g, mg, dag etc. t, kt, Mt etc.	No longer acceptable: pound, hundredweight, double-hundredweight
			1 t = 1000 kg
			Weight is given in kg

Factor	Basic Unit	Other Acceptable Units	Remarks
Density	kg/m^3	kg/dm^3, kg/l, g/cm^3 etc.	No longer acceptable: specific weight
Time	s	min (minute) h (hour) d (day) a (year)	3h = 3 hours 3^h = 3 o'clock For time data, e.g. $3^h 40^m 20^s$ min can be abbreviated in m
			No longer acceptable: Sec., sec., hr.
Volumetric flow (flow rate)	m^3/s	cm^3/min 1/s, 1/h etc.	
Frequency	Hz (Hertz)	kHz, MHz etc.	1 Hz = 1/s
Speed of revolvement	1/s s^{-1}	1/min min^{-1}	No longer acceptable: U/min, Upm
Speed of travel	m/s	km/h	
Acceleration	m/s^2		g (acceleration of fall) $g \approx 9.81\ m/s^2$
Force	N (Newton)	kN, MN etc.	No longer acceptable: p, kp, Mp, dyn
			$1\ N = 1\ kg\ m/s^2$ $1\ kp - 9\ 81\ N \approx 10\ N$
Pressure	N/m^2 Pa (Pascal)	bar, mbar etc.	No longer acceptable: kp/cm^2, atm, at, ata, atü, atu, mmHg, Torr, m Ws
			Pressure or vacuum must be specified, e.g.: 2 atü $\approx$ 2 bar pressure = 3 bar 0,4 atu $\approx$ 0.4 vacuum = 6 bar 5 ata $\approx$ 5 bar

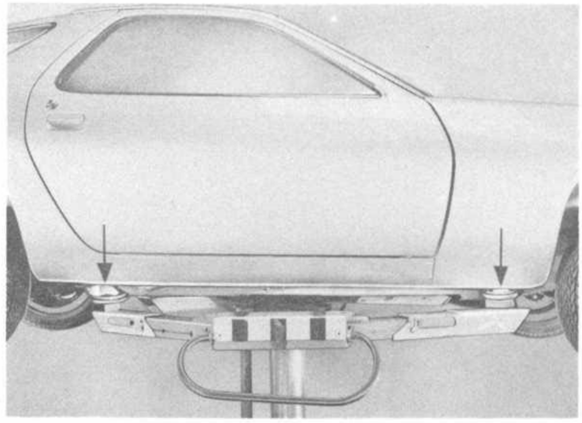
Factor	Basic Unit	Other Acceptable Units	Remarks
			$1\ N/m^2 = 1\ Pa$ $1\ mbar = 100\ Pa$ $1\ bar \approx 1\ kp/cm^2 = 1\ at$ $1\ bar = 750\ Torr$
Mechanical stress (strength)	N/m^2	N/m^2	No longer acceptable: kp/cm^2, kp/mm^2
Dynamic viscosity	Pa s	mPa s, µPa s	No longer acceptable: P (Poise), cP, kg s/m^2, dyn s/cm^2 $1\ Pa\ s = 10\ P$ $\approx 0.1\ kg\ s/m^2$
Kinematic viscosity	m^2/s 1	cm^2/s, mm^2/s	No longer acceptable: St (Stokes), cSt, E (Engler degree) $1\ cm^2/s = 1\ St$
Torque	Nm	Ncm, Nmm	No longer acceptable: kpm, kpcm, etc. $1\ Nm \approx 0.1\ kpm$ $1\ Nm = 1\ kgm^2/s^2$
Work, energy, heat quantity	J (Joule)	mJ, kJ etc. Nm, kWh, Ws	No longer acceptable: kpm, erg, cal, kcal, PSh, We (thermal unit) 1 J = 1 Nm = 1 Ws $1\ J \approx 0.1\ kpm$ $1\ cal = 1\ WE \approx 4.19\ J$ $1\ PSh \approx 0.736\ kWh$
Specific fuel consumption	kg/kWh	g/kWh, kg/J	No longer acceptable: g/PSh, kg/PSh
Power	W (watt)	mW, kW etc.	No longer acceptable: PS $1\ PS \approx 0.736\ kW$

Factor	Basic Unit	Other Acceptable Units	Remarks
Weight coefficient	kg/W	kg/kW	No longer acceptable: kg/PS
Temperature	K (Kelvin)	^{o}C	No longer acceptable: ^{o}K (degrees Kelvin), grd. (temperature difference) 1^{o} C = 1 K
Electric current strength	A (ampere)	μA, mA etc.	
Electric voltage	V (volt)	μV, mV, etc.	1 V = 1 W/A
Electric resistance	Ω (Ohm)	mΩ , kΩ etc.	1 Ω = 1 V/A
Electric charge, electrical quantity	C (Coulomb)	Ah, As	1 C = 1 As
Electric capacitance	F (Farad)	pF, μF, mF	1 F = 1 C/V
Sound level	phon	dB (decibel)	
Light flux	lm (Lumen)		1 lm = 1 cd sr
Light intensity	lx (Lux)		1 lx = 1 lm/m^2

LIFTING CAR

1. Lifting with hoist

Only use lift points shown.

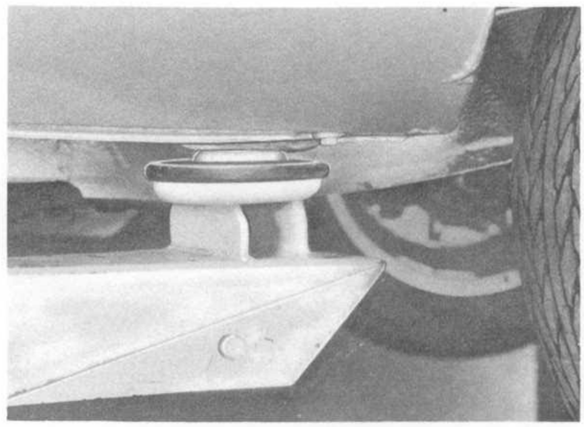


Caution

When driving car on hoist platform, make sure that there is sufficient space between hoist and car.

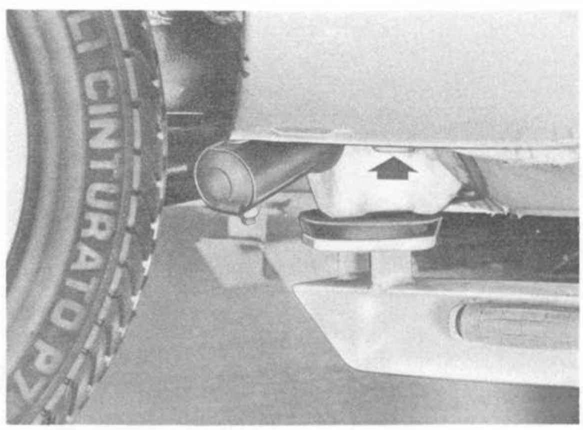
Front

On car jack pick-up point.



Rear

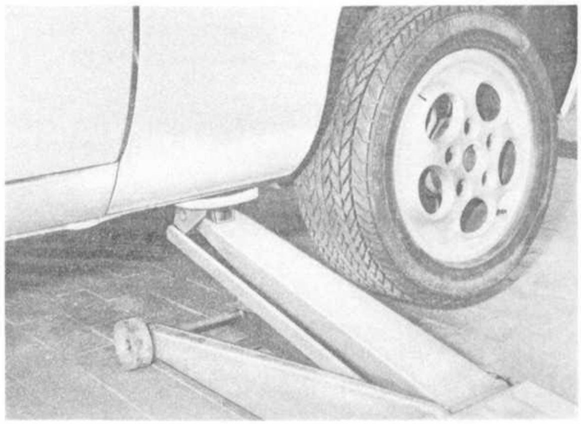
On rear axle control arm bracket.



2. Lifting with floor jack

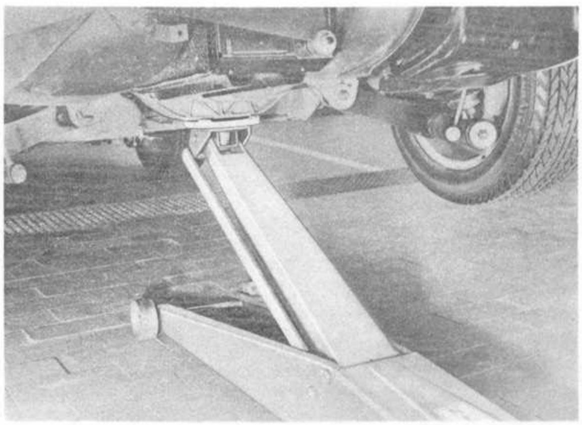
Side

Front or rear on pick-up points for car jack. Use an appropriate piece of wood between jack lifting plate and pick-up point.



Rear

On cross member for rear axle control arm.



Note

Never raise car on engine oil pan or transmission, since this could cause serious damage.

TECHNICAL DATA

(Adjusting specifications and wear limits are listed in each individual repair group.)

Note: USA values in brackets.

Engine

Internal engin code		M 28/03 w/man. trans. M 28/04 w/auto. trans.
No. of cylinders		8
Bore	mm/in.	95.0/3.74
Stroke	mm/in.	78.9/3.11
Displacement (actual)	$cm^3/in.^3$	4474/272.97
Compression ratio		8.5 : 1
Max. engine power, DIN 70020	kW/HP	169/230
Net power, SAE J 245	kW/HP	164/219
at engine speed	rpm	5250
Max. torque, DIN 70020	Nm/kpm	343/35.0
Net torque, SAE J 245	Nm/ft lbs	333/245
at engine speed	rpm	3600
Max. specific power output,		
DIN 70020	kW/l / HP/l	40/54
SAE J 245	kW/l / HP/l	38/51
Engine speed limit (by electronic cut-off of fuel pumps)		6300 ± 200
Engine weight (dry)	kg/lb	260/573

Engine Design

Type		8 cylinder, 4 stroke, internal combustion V-engine
Crankcase		Two-piece, cast light alloy, without cylinder liners
Crankshaft		Forged steel, 5 bearings
Connecting rods		Forged sintered steel
Pistons		Cast ligth alloy, chrome plated or iron coated bearing surfaces

Camshaft		Cast steel, runs in camshaft housing without bearing shells
Camshaft drive		Toothed belt and tensioning roller
Cylinder head		Aluminum
Valve arrangement		1 intake, 1 exhaust, overhead, in-line
Valve train		By overhead camshaft and hydraulic cam followers
Timing (1 mm lift, zero valve clearance)	Int. opens	8° ATDC
	Int. closes	55° ABDC
	Exh. opens	38° BBDC
	Exh. closes	2° BTDC
Valve clearance		Automatic hydraulic adjustment
Engine Cooling		Closed cooling system, mechanical fan with viscous coupling (electric fan and thermo switch for air conditioning)
Engine Lubrication		Pressure lubricating system with sickle type pump
Oil filter		Full flow
Oil pressure at 5000 rpm		Approx. 5 bar at 80 to 100° C/176 to 212° F oil temperature
Oil pressure indication		Indicator lamp and pressure gage
Oil consumption	1/1000 km qt/600 mi.	Approx. 1.5
Exhaust System		Double pipes up to catalytic converter, intermediate and main mufflers
Emission control		EGR, air pump
Heating		Warm water heater with heat exchanger and blower
Fuel System		CIS (continuous) fuel injection
Fuel supply		2 elec. delivery pumps, connected in series

Fuel octane requirement	RON/MON/CLC	91/84/87

Electrical System

Battery voltage	V	12
Battery capacity	Ah	66
Battery capacity (optional)	Ah	88
Alternator output	A/W	90/1260
Ignition (breakerless)		Transitorized/coil ignition
Firing order		1 - 3 - 7 - 2 - 6 - 5 - 4 - 8
Basic ignition setting		31^{o} BTDC at 3000 rpm with vacuum hose disconnected
Spark plugs		Bosch W 145 T 30 Beru 145/14/3 A
Spark plug gap	mm/in.	0.7 + 0.1/0.028 + 0.004

Transmission	Rear-mounted (5-speed manual transmission) combined with final drive. Connected to front-mounted engine/clutch by central tube.
Clutch	Double disc, diaphragm spring dry clutch
Pressure plate	MFZ 2/215 Ks ph
Body Type	Coupe with integral steel body, 2 doors, rear lid and retractable headlights. Aluminum hood, doors and bolted front fenders. (sliding roof optional)

Dimensions

(at total permissible weight)

Length		mm/in.	4462/175.67
Width		mm/in.	1836/72.28
Height		mm/in.	1311/51.61
Wheelbase		mm/in.	2500/98.43
Track			
front at curb weight		mm/in.	1545/60.82
at total weight		mm/in.	1551/61.06
rear at curb weight		mm/in.	1514/59.60
at total weight		mm/in.	1530/60.23
Ground clearance		mm/in.	119/4.69
Overhang angle	front		22^{o}
	rear		18^{o} 30'

Weights

Curb weight without options			Man. trans.	Auto. trans.
	Front	kg/lb	745/1642	745/1642
	Rear	kg/lb	745/1642	785/1731
	Total	kg/lb	1490/3285	1530/3373
Curb weight with options			Man. trans.	Auto. trans.
	Front	kg/lb	765/1686	765/1686
	Rear	kg/lb	765/1686	795/1753
	Total	kg/lb	1530/3373	1560/3492
Max. axle load,	front	kg/lb	900/1984	
	rear	kg/lb	1000/2200	
Max. total weight		kg/lb	1870/4123	
Max. roof load, including roof rack		kg/lb	35/77	
Max. trailer load				
	without trailer brakes	kg/lb	750/1653 (up to grades of 16 %)	
	with trailer brakes	kg/lb	1600/3527 (up to grades of 16 %)	
Max. towing weight		kg/lb	3470/7650	
Max. tongue weight		kg/lb	50/110	

Filling Capacities

Engine oil		HD oils to API classification SD or SE, viscosity: summer SAE 30, winter SAE 20, at continuous temperatures between - 15° C and 0° C SAE 20 W 20, or SAE 10 W for continuous temperatures below - 15° C. (multi-grade oils: 15 W 50 or 20 W 50 when approved).
Engine oil change	1 tr/qt	Approx. 6.5/6.85 (level on dipstick is important)
Engine coolant	1 tr/qt	Approx. 16/17
Transmission oil		Hypoid oil SAE 90 to MIL-L 2105 B. API classifiaction GL 5.
Transmission and differential	1 tr/qt	Approx. 3.8/4
Fuel tank	1 tr/gal.	Approx. 86/22,5, of which 11 liters 2,9 gal. for reserve
Brake fluid reservoir	1 tr/qt	Approx. 0.2/0.2
Windshield washer and headlight cleaner reservoir	1 tr/qt	Approx. 8/8,5 (water)
Cleaning solution reservoir	1 tr/qt	Approx. 0.6/0.6

Performance

		(with 5-speed transmission)
Top speed	km/h / mph	above 230 / 144
Acceleration 0 - 100 km/h, 0 - 62 mph	s	6.8
1000 m from standing start	s	27.0
Power to weight	kg/kW / kg/HP	8.3 / 6.0

Hill Climbing

		(with 5-speed transmission)
1st gear	%	71
2nd gear	%	41
3rd gear	%	28
4th gear	%	18
5th gear	%	11

TECHNICAL DATA - 1980, 1981, 1982 Models

(Adjusting specifications and wear limits are listed in each individual repair group.)

Engine

Internal engine code		M 28/13, automatic M 28/14 from 1981: M 28/15, automatic M 28/16
No. of cylinders		8
Bore	mm/in.	95.0/3.74
Stroke	mm/in.	78.9/3.11
Displacement (actual)	$cm^3/in.^3$	4474/272.97
Displacement (rounded off)	cm^3	4420
Compression ratio		9.0 : 1
Max. engine power, DIN 70020	kW/HP	170/231
Net power, SAE J 245	kW/HP	165/220
at engine speed	rpm	5250 (5500)
Max. torque, DIN 70020	Nm/kpm	360/36.7
Net torque, SAE J 245	Nm/ft. lbs.	348/265
at engine speed	rpm	4000
Max. specific power output, DIN 70020	kW/1 / HP/1	38/52
SAE J 245	kW/1 / HP/1	37/49
Engine speed limit		without
Engine weight (dry)	kg/lb	245/540

Engine Design

Type	8 cylinder, 4 stroke, internal combustion V-engine
Crankcase	Two-piece, cast light alloy, without cylinder liners
Crankshaft	Forged steel, 5 bearings
Connecting rods	Forged sintered steel
Pistons	Cast light alloy, chrome plated or iron coated bearing surfaces

Camshaft		Cast steel, runs in camshaft housing without bearing shells
Camshaft drive		Toothed belt and tensioning roller
Cylinder head		Light alloy
Valve arrangement		1 intake, 1 exhaust, overhead, in-line
Valve timing		By overhead camshaft and hydraulic cam followers
Timing (1 mm lift, zero valve clearance)		Intake opens 12^{o} after TDC Intake closes 48^{o} after BDC Exhaust opens 32^{o} before BDC Exhaust closes 6^{o} before TDC
Valve clearance		Automatic hydraulic adjustment
Engine Cooling		Closed cooling system, mechanical fan with viscous coupling (electric fan and thermo switch for cars with air conditioner)
Engine Lubrication		Pressure lubricating system with sickle type pump
Oil filter		Full flow
Oil pressure at 5000 rpm		Approx. 5 bar at 80 to 100^{o} C/176 to 212^{o} F oil temperature
Oil pressure indication		Indicator lamp and pressure gauge
Oil consumption	1/1000 km qt/600 mi.	Approx. 1.5
Exhaust System		Twin pipes up to catalytic converter, then single pipe to center and final mufflers
Emission control		Oxygen sensor with 3-way catalytic converter ; from 1981 additional secondary air injection
Heating		Warm water heater with heat exchanger and blower
Fuel System		AFC (Air Flow Controlled) fuel injection
Fuel supply		Electric delivery pump

Fuel octane requirement RON/MON/CLC		91, 84, 87 leadfree

Electrical System

Battery voltage	V	12
Battery capacity	Ah	66
Battery capacity (optional)	Ah	88
Alternator output	A/W	90/1260
Ignition (breakerless)		Transistorized coil ignition
Firing order		1-3-7-2-6-5-4-8

Transmission

Front-mounted engine, rear-mounted transmission, bolted to a rigid, central tube to make up a rigid drive unit/transaxle. Front-mounted engine, clutch, torsion drive shaft to transmission running in rigid, central tube, rear-mounted transmission and final drive unit, double constant velocity joints, rear wheels

Clutch

Double-plate, diaphragm spring, dry clutch (pull-to-release type) on engine side

Automatic transmission

Hydraulic torque converter, stall ratio **approx. 2.0 : 1**

Body Type

Coupe with integral steel body, 2 doors, rear lid and retractable headlights. Aluminum hood, doors and bolted front fenders. (sliding roof optional)

Dimensions

Length	mm/in.	4462/175.67
Width	mm/in.	1836/72.28
Height (at DIN curb-weight)	mm/in.	1282/50.47
Wheelbase (in designed position)	mm/in.	2500/98.43
Track :		
front at curb weight	mm/in.	1549/60.98
at total weight	mm/in.	1552/61.10
rear at curb weight	mm/in.	1521/59.88
at total weight	mm/in.	1529/60.20
Ground clearance at total weight	mm/in.	120/4.72
Bed clearance at total weight	mm/in.	40/1.57
Overhang angle		
front at total weight		20^{o}
rear at total weight		16^{o}

Weights

Curb weight without extra equipment		
front	kg/lb	745/1643
rear	kg/lb	745/1643
total	kg/lb	1520/3351 1535/3385 automatics
Max. curb weight with extra equipment	kg/lb	1540/3395
Max. axle load		
front	kg/lb	900/1984
rear	kg/lb	1000/2200
Max. total weight	kg/lb	1870/4123
Max. roof load	kg/lb	35/77 - from 1982: 75/165 with •Porsche roof transport system

Capacities

Engine oil		Quality HD oils to API classification SE. For all year operation multigrade oils of viscosity SAE 15 W-50 or 20 W-50 (latter oil not for constant temperatures below - 15° C/+5°F). Emergency use of single grade HD oil to API classifications SE or SF and in fact SAE 30 for summer and SAE 20 for winter (only for constant temperatures below + 5° C/+ 41° F).
Engine oil volume	ltr /qt	Approx. 7.5/8.5 (level on dipstick is important)
Engine coolant	ltr /qt	Approx. 16/17
Transmission oil		Hypoid oil SAE 75 W-90 to MIL-L 2105 B, API classification GL 5
Transmission and differential	ltr /qt	Approx. 3.8/4
Fuel tank	ltr /gal.	Approx. 86/22.5 of which about 8 liters/2.1 in reserve
Brake fluid reservoir	ltr /qt	Approx. 0.2/0.2
Reservoir for windshield washer and headlight cleaner	ltr /qt	Approx. 6/6.4 (water)
Reservoir for cleaning solution	ltr /qt	Approx. 0.6/0.6

Performance

		Manuals	Automatics
Top speed	km/h / mph	230/143	225/140
Acceleration from 0 to 100 km/h (0 to 60 mph)	s	7.5	8.5
1000 m from standing start	s	28.0	29.0
1/4 mile from standing start	s	15.5	16.0
Power to weight	kg/kW / kg/HP	8.9/6.6	9.2/6.8

Hill Climbing

1st gear	%	62	39
2nd gear	%	41	21
3rd gear	%	28	11
4th gear	%	18	
5th gear	%	11	

TECHNICAL DATA – Type 928 S

(Adjusting specifications and wear limits are listed in each individual repair group).

Engine

Internal engine code		M 28/19, automatics M 28/20
No. of cylinders		8
Bore	mm/in.	97.0/3.82
Stroke	mm/in.	78.9/3.11
Displacement (actual)	$cm^3/in.^3$	4664/284.60
Displacement (rounded off)	cm^3	4608
Compression ratio		9.3 : 1
Max. engine power, DIN 70020 Net power, SAE J 1349 at engine speed	kW/HP kw/HP rpm	178/242 174/234 5250
Max. torque, DIN 70020 Net torque, SAE J 1349 at engine speed	Nm/kpm Nm/ft.lbs. rpm	365/37,2 357/263 4000
Max. specific power output, DIN 70020 SAE J 1349	 kW/l HP/l kw/l HP/l	 38/52 37/50
Speed limit through ignition cut-off at	 rpm	 without
Engine weight (dry)	kg	261

Engine Design

Type	8 cylinder, 4 stroke, internal combustion V-engine
Crankcase	Two-piece, cast light alloy without cylinder liners
Crankshaft	Forged steel, 5 bearings
Connecting rods	Forged sintered steel
Pistons	Cast light alloy, chrome plated or iron coated bearing surfaces

Camshaft		Cast steel, running in camshaft housing without bearing shells
Camshaft drive		Toothed belt and tensioning roller
Cylinder head		Light alloy
Valve arrangement		1 intake, 1 exhaust, overhead, in-line
Valve timing		By overhead camshaft and hydraulic cam followers
Timing (1 mm lift, zero valve clearance)		Intake opens 11° ATDC Intake closes 46° ABDC Exhaust opens 25° BBDC Exhaust closes 2° ATDC
Valve clearance		Automatic hydr. adjustment
Engine Cooling		Closed cooling system, mechanical fan with visco coupling (also electric fan and thermo switch for cars with air conditioner)
Engine Lubrication		Pressure lubricating system with sickle type pump
Oil filter		Full flow
Oil pressure at 5000 rpm		Approx. 5 bar at 80 to 100° oil temperature
Oil pressure indication		Indicator lamp and pressure gauge
Oil consumption	l/1000 km	Approx. 1.5
Exhaust System		Double pipes up to catalytic converter, then single pipe in and out of intermediate muffler, double pipes in final muffler
Emission control		Oxygen sensor with 3-way catalytic converter and secondary air injection
Heating		Warm water heater with heat exchanger and blower
Fuel System		AFC (Air Flow Controlled) Fuel injection
Fuel supply		1 electric delivery pump

Fuel octane requirement	RON	91 leadfree

Electrics

Degree of shielding		ECE R 10 and 72/245/EC
Battery voltage	V	12
Battery capacity	Ah	88
Alternator output	A/W	90/1260
Ignition (breakerless)		Transistor coil ignition
Firing order		1 - 3 - 7 - 2 - 6 - 5 - 4 - 8

Transmission

Front-mounted engine, rear-mounted transmission, bolted to a connecting tube to make up a rigid drive unit = transaxle.
Front-mounted engine, clutch, torsional elastic drive shaft to transmission running in connecting tube, rear-mounted transmission/final drive unit, double joints, rear wheels

Clutch	Double-plate, diaphragm spring, dry clutch in pulled version and arranged on engine side
Automatic transmission	Hydraulic torque converter, moving off conversion ratio approx. 2.0 : 1

Body Type

Coupe with integral steel body, 2 doors, tailgate and retractable headlights. Aluminum hood, doors and bolted front fenders (optional with sliding roof)

Dimensions

Length	mm/in.	4462/175.67
Width	mm/in.	1836/72.28
Height (at DIN curbweight)	mm/in.	1282/50.47
Wheelbase (in designed position)	mm/in.	2500/98.43
Track width:		
front at curbweight	mm/in.	1549/60.98
at total weight	mm/in.	1552/61.10
rear at curbweight	mm/in.	1521/59.88
at total weight	mm/in.	1529/60.20
Ground clearance	mm/in.	120/4.72
Bed clearance	mm/in.	40/1.57
Overhand angle to DIN		
front		15^{o} - 22^{o} without front spoiler
rear		19.6^{o}

Weights

Curbweight without extra equipment		
front	kg	725
rear	kg	725
total	kg	1450
Curbweight with extra equipment up to	kg	1520, 1535 automatics
Max. axle load		
front	kg	900
rear	kg	1000
Max. total weight	kg	1870
Max. roof load	kg	75 with Porsche roof transport system
Max. trailer load		
without trailer brakes	kg	750 (for grades up to 12 %)
with trailer brakes	kg	1600 (for grades up to 12 %)
Max. towing weight	kg	3470
Max. tongue weight	kg	50

Filling Capacities

Engine oil		Quality HD multi-grade pils of API classification SE or SF. Single-grade oils may only be used when multi-grade oils are not available and operating conditions are normal.
Engine oil volume	l	Approx. 7.5 (level on dipstick is important)
Engine coolant	l	Approx. 16
Transmission oil		Hypoid oil SAE 75 W-90 to MIL-L 2105 B, API classification GL 5
Oil volume for transmission and differential	l	Approx. 3.8
Fuel tank	l	Approx. 86, of which 8 liters in reserve
Brake fluid tank	l	Approx. 0.2
Tank for windshield washer and headlight cleaner	l	Approx. 6 (water)
Tank for cleaning solution	l	Approx. 0.6

Performance

		Manual	Automatic
Top speed	km/h / mph	235/146	230/143
Acceleration from 0 to 100 km/h (0 to 60 mph)	s	6.8	7.2
1000 m from standing start	s	27.5	28.2
1/4 mile from standing start	s	15.2	15.5
Power to weight			
DIN 70020	kg/kW/kg/HP	8.5/6.3	
SAE J 1349	kg/kW/kg/HP	8.7/6.5	8.8/6.6

Hill Climbing

1st gear	%	61	52
2nd gear	%	39.5	30.5
3rd gear	%	25	14.5
4th gear	%	16	7.5
5th gear	%	9.5	

TECHNICAL DATA – TYPE 928 S – 1984/'85/'86 Models

(Adjusting specifications and wear limits are listed in each individual repair group.)

Note: USA values are in brackets.

Engine

Internal engine code		M 28/21, Automatic M 28/22 (USA, Japan, Canada M 28/19, Automatic M 28/20)
Bore	mm/in.	97.0/3.82
Stroke	mm/in.	78.9/3.11
Displacement (actual)	$cm^3/in.^3$	4664/284.60
Displacement (rounded off)	cm^3	4632
Compression ratio		10.4 : 1 (9.3 : 1)
Max. engine power 80/1269/EC	kW/HP	228/310 (178/242)
Net power, SAE J 1349	kW/HP	174/234
at engine speed	rpm	5900 (5250)
Max. torque, 80/1269/EC	Nm/kpm	400/40.7 (365/37.2)
Net torque, SAE J 1349	Nm/ft. lbs.	357/263
at engine speed	rpm	4100 (4000)
Max. specific power output		
DIN 70020	kW/l / HP/l	49/67 (38/52)
SAE J 1349	kW/l / HP/l	37/50
Speed limit by stopping fuel feed	rpm	6400 (USA, without)
Engine weight (dry)	kg	261

Engine Design

Type	8 cylinder, 4 stroke, internal combustion V-engine
Crankcase	Two-piece, light alloy, without cylinder liners
Crankshaft	Forged sintered steel, 5 bearings
Connecting rods	Forged sintered steel
Pistons	Cast light alloy, chrome plated or iron coated bearing surfaces
Cylinders	Light alloy

Camshaft		Cast steel, runs in camshaft housing without bearing shells
Camshaft drive		Toothed belt
Cylinder head		Light alloy
Valve arrangement		1 intake, 1 exhaust, overhead, in-line
Valve timing		By overhead camshafts and hydraulic cam followers
Timing (1 mm lift, zero valve clearance)		Intake opens 6° ATDC (11° ATDC) Intake closes 54° ABDC (46° ABDC) Exhaust opens 43° BBDC (25° BBDC) Exhaust closes 4° BTDC (2° ATDC)
Valve clearance		Automatic hydraulic adjustment
Engine Cooling		Closed cooling system, mechanical fan with viscous coupling (additional series connected electric fan and thermo switch for cars with air conditioner)
Engine Lubrication		Pressure lubricating system with sickle type pump
Oil filter		Full flow
Oil pressure at 5,000 rpm		Approx. 5 bar at 80 to 100 °C/176 to 212 °F oil temperature
Oil pressure indication		Indicator lamp and pressure gauge
Oil consumption	l/1000 km	Up to 1.5
Exhaust System		Twin pipes entire length; primary, center and final mufflers (twin pipes up to catalytic converter, then single pipe in and out of center muffler, twin pipes in final muffler)
Emission Control		(USA, oxygen sensor with 3-way catalytic converter and secondary air injection)
Heating		Warm water heater with heat exchanger and blower
Fuel System		LH-Jetronic (L-Jetronic)
Fuel supply		1 electric delivery pump

Printed in Germany

Fuel octane requirement	RON	98 (91 leadfree)	
Fuel consumption to DIN 70030/1		Manual	Automatic
at constant 90 km/h	l/100 km	8.7	8.6
at constant 120 km/h	l/100 km	10.2	10.5
EC city test	l/100 km	19.2	16.7

Electrical System

Interference suppression		ECE-R 10 and 72/245/EC
Battery voltage	V	12
Battery capacity	Ah	88
Alternator output	A/W	90/1260
Ignition		Electronic ignition, breakerless
Firing order		1–3–7–2–6–5–4–8

Transmission

Front-mounted engine, rear-mounted transmission, bolted to a rigid, central tube to make up a rigid drive unit/transaxle.
Front-mounted engine, clutch, torsion drive shaft to transmission running in rigid, central tube, rear-mounted transmission and final drive unit, double constant velocity joints, rear wheels

Clutch: Double-plate, diaphragm spring, dry clutch (pull-to-release type) on engine side

Automatic transmission: Hydraulic torque converter, stall ratio approx. 2.0 : 1 (2.12 : 1)

Body Type

Coupe with integral steel body, 2 doors, rear lid and retractable headlights; aluminum engine hood, doors and bolted front fenders (sliding roof optional)

Dimensions

Length	mm/in.	4447/175.08 (4462/175.67)
Width	mm/in.	1836/72.28
Height (at DIN curbweight)	mm/in.	1282/50.47
Wheelbase (in designed position)	mm/in.	2500/98.43
Track at DIN curbweight		
Front	mm/in.	1549/60.98
Rear	mm/in.	1521/59.88
Ground clearance	mm/in.	120/4.72
Bed clearance	mm/in.	40/1.57
Overhang angle to DIN		
Front		15 – 22° without front spoiler (20°)
Rear		19.6°

Weights – DIN 70020 –

Curbweight		
Front	kg	750 – 770 (760 – 780)
Rear	kg	750 – 770 (760 – 780)
Total	kg	1500 with manual transmission 1540 with automatic transmission (1520 – 1560)
Max. axle load		
Front	kg	900
Rear	kg	1100 (1000)
Max. total weight	kg	1870
Max. roof load	kg	35 75 with Porsche roof transport system
Max. trailer load		
Without brakes	kg	750
With brakes	kg	1600
Max. car/trailer weight	kg	3470
Max. drawbar load	kg	75

Capacities

Engine oil		Quality HD multigrade oils to API classification SE or SF according to plant approval list. Emergency use of single grade oils only when multigrade oils are not available and operating conditions are normal.	
Engine oil volume	ltr.	Approx. 7.5 (level on dipstick is important)	
Engine coolant	ltr.	Approx. 16	
Transmission oil		Hypoid oil SAE 75 W-90 to MIL-L 2105 B, API classification GL 5	
Transmission oil volume for manual transmission with differential	ltr.	Approx. 3.8	
Fuel tank	ltr.	Approx. 86, of which approx. 8 liters in reserve	
Brake fluid reservoir	ltr.	Approx. 0.2	
Washing fluid reservoir for headlights and windshield	ltr.	Approx. 9 (water)	
Cleaning solution reservoir	ltr.	Approx. 0.6	

Performance

		Manuals	Automatics
Top speed	km/h / mph	255/158 (235/146)	250/155 (230/143)
Acceleration from 0 to 100 km/h (0 to 60 mph)	sec.	6.2 (6.8)	6.7 (7.2)
1,000 mtr. from standing start	sec.	25.6 (27.5)	26.3 (28.2)
1/4 mile from standing start	sec.	(15.2)	(15.5)

Hill Climbing

		Manuals	Automatics
1st gear	%	* 93 (61)	65.4 (52)
2nd gear	%	49.8 (39.5)	37.4 (30.5)
3rd gear	%	31.5 (25)	18.1 (14.5)
4th gear	%	20.7 (16)	8.9 (7.5)
5th gear	%	12.7 (9.5)	

* engine orientated

Changes (values) in the model '85/'86 year

Battery capacity	Ah	72	'86 models onward
Alternator/output	A/W	115/1610	'85 models onward
Weights - to DIN 70020 -			'85 models onward
Curb weight			
Front	kg	795	
Rear	kg	735 - 755	
Total	kg	1530 Manual transmission 1550 Automatic transmission	
Per. axle load front	kg	920	
Per. total weight	kg	1890	
Per. total weight with trailer	kg	3490	
Transmission oil capacity with differential - manual transmission	L	approx. 4.5	'86 models onward
Reservoir for windscreen and headlamp wash system	L	approx. 7.5 (water)	'86 models onward

TECHNICAL DATA - 928 S - '85/'86 models (32-valve engines)

(Adjustment specifications and wear limits are listed in the individual repair groups).

Engine

Internal engine code		Manual transmission M 28/43 Automatic transmission M 28/44 USA, Canada, Japan
Bore	mm/in.	100/3.94
Stroke	mm/in.	78.9/3.11
Displacement (actual)	cc/in.^{3}	4957/302.5
Displacement (rounded down)	cc	4898
Compression ratio		10.10 : 1
Max. power 80/1269/EC (Net power, SAE J 1349) at engine speed	kW/HP kW/HP rpm	215/292 215/288 5750
Max. torque 80/1269/EC (Net torque, SAE J 1349) at engine speed	Nm/kpm Nm/lbft rpm	410/42 410/302 2700
Max. specific power, DIN 70020 (SAE J 1349)	kW/L/HP/L kW/L/HP/L	43.4/59.0 43/58.2
Fuel cut-off to limit engine speed at	rpm	6400
Engine weight (dry)	kg	264

Changes (values) in the '85/'86 model year (32-valve engines)

Valve arrangement	2 intake, 2 exhaust, overhead V
Valve actuation	2 overhead camshafts and hydraulic bucket tappets
Camshaft drive	Toothed belt and internal chain
Timing (1 mm lift, zero play)	Intake opens 11 degrees before TDC Intake closes 50 degrees after BDC Exhaust opens 30 degrees before BDC Exhaust closes 5 degrees before TDC
Fuel octane rating	RON/MON 96/86, unleaded

PERFORMANCE

		Manual trans.	Automatic trans.
Maximum speed	km/h (mph)	250 155	242 150
Acceleration:			
0 - 100 km/h	s	6.3	6.8
0 - 100 mph	s	13.8	15.7
0 - 60 mph	s	6.1	6.6
Kilometer from standing start	s	25.8	26.8
1/4 mile from standing start	s	14.2	14.9

CLIMBING PERFORMANCE

		Manual trans.	Automatic trans.
1st gear	%	62.4	57.3
2nd gear	%	43.2	33.0
3rd gear	%	28.1	17.2
4th gear	%	19.2	8.9
5th gear	%	10.7	-

TECHNICAL DATA - 928 S - '86 models (32-valve engines)

(Adjustment specifications and wear limits are listed in the individual repair groups).

Engine

Internal engine code		Manual transmission M 28/45 Automatic transmission M 28/46 Australia, Germany, Austria, Switzerland
Bore	mm/in.	100/3.94
Stroke	mm/in.	78.9/3.11
Displacement (actual)	$cc/in.^3$	4957/302.5
Displacement (rounded down)	cc	4898
Compression ratio		9.3 : 1
Max. power 80/1269/EC	kW/HP	212/288
at engine speed	rpm	5750
Max. torque 80/1269/EC	Nm/kpm	400/40.8
at engine speed	rpm	2700
Max. specific power, DIN 70020	kW/L/HP/L	42.8/58.1
Fuel cut-off to limit engine speed at	rpm	6394
Engine weight (dry)	kg	264

Changes (values) in the '86 model year (32-valve engines)

Valve arrangement	2 intake, 2 exhaust, overhead V
Valve actuation	2 overhead camshafts and hydraulic bucket tappets
Camshaft drive	Toothed belt and internal chain
Timing (1 mm lift, zero play)	Intake opens 11 degrees before TDC Intake closes 50 degrees after BDC Exhaust opens 30 degrees before BDC Exhaust closes 5 degrees before TDC
Fuel octane rating	RON/MON 91/82, unleaded

PERFORMANCE

		Manual trans.	Automatic trans.
Maximum speed	km/h	252	247
	(mph)	157	154
Acceleration:			
0 - 100 km/h	s	6.2	6.7
0 - 100 mph	s	14.3	14.4
Kilometer from standing start	s	25.6	26.3

CLIMBING PERFORMANCE

		Manual trans.	Automatic trans.
1st gear	%	62.5	62.3
2nd gear	%	48.8	38.3
3rd gear	%	31.8	20.1
4th gear	%	22.2	11.9
5th gear	%	14.8	-

TECHNICAL DATA - 928 S - '87/88 models

(Adjustment specifications and wear limits are listed in the individual repair groups).

Note: USA values are stated in parentheses

Engine

Internal engine code		Manual transmission M 28/41 Automatic transmission M 28/42 Worldwide	
Bore	mm/in.	100/3.94	
Stroke	mm/in.	78.9/3.11	
Displacement (actual)	cc/in.^{3}	4957/302.5	
Displacement (rounded down)	cc	4898	
Compression ratio		10.0 : 1	
			Australia
Max. power 80/1269/EC	kW/HP	235/320	221/300
(Net power, SAE J 1349)	kW/HP	235/316	221/296
at engine speed	rpm	6000	
Max. torque 80/1269/EC	Nm/kpm	430/43.9	420/42.8
(Net torque, SAE J 1349)	Nm/lbft	430/316.9	
at engine speed	rpm	3000	
Max. specific power, DIN 70020	kW/L/HP/L	47.4/64.6	44.6/60.5
(SAE J 1349)	kW/L/HP/L	47.4/63.7	
Fuel cut-off to limit engine speed at	rpm	6600	
Engine weight (dry)	kg	264	

Changes (values) in model year '87/88

Valve arrangement		2 intake, 2 exhaust, overhead V	
Valve actuation		2 overhead camshafts and hydraulic bucket tappets	
Camshaft drive		Toothed belt and internal chain	
Timing (1 mm lift, zero play)		Intake opens	11 degrees after TDC
		Intake closes	36 degrees after BDC
		Exhaust opens	17 degrees before BDC
		Exhaust closes	2 degrees before TDC
Fuel octane rating	RON/MON	95/85 unleaded	
		Australia 91/82 unleaded	
Blower drive		Double electric fans	
Clutch		Single-plate dry clutch with diaphragm spring, extended, mounted on engine	
DIMENSIONS		(Curb weight to DIN)	
Length	mm/in.	4520/177.95 (4523/178.07)	
Track:			with rims
Front	mm/in.	1551/61.06	7 J x 16
Rear	mm/in.	1546/60.9	8 J x 16
Overhang angle:			
Rear		14.1 degrees	

PERFORMANCE

		Manual trans.	Manual trans. Australia	Automatic trans.	Automatic trans. Australia
Maximum speed	km/h (mph)	270 168	265 165	265 165	260 162
Acceleration:					
0 - 100 km/h	sec	5.9	6.0	6.3	6.6
0 - 60 mph	sec	5.7	5.7	6.0	6.3
Kilometer from standing start	sec	25.4	25.4	25.9	26.2
1/4 mile from standing start	sec	14.2	14.1	14.5	14.7

WEIGHTS (to DIN 700 20)

Curb weight:		Manual trans.	Automatic trans.
Front	kg	820	820
Rear	kg/lbs	760/770	780/790
Total	kg/lbs	1580/1590	1600/1610
Total per. weight	kg/lbs	1920/1900	

CLIMBING PERFORMANCE

		Manual trans.	Manual trans. Australia	Automatic trans.	Automatic trans. Australia
1st gear	%	63	62	63	63
2nd gear	%	54	47	47	39
3rd gear	%	34	29	25	20
4th gear	%	23	20	15	11
5th gear	%	15	12	-	-

Technical data - Type 928 GT - Model 89

(Adjustment and wear values are contained in respective repair groups)

Note: USA values are given in brackets

Drive assembly

Internal engine designation		Manual gearbox M 28.47
Bore	mm/in.	100 (3.94)
Stroke	mm/in.	78.9 (3.11)
Displacement (actual)	$cm^3/in.^3$	4957 (302.5)
Displacement (rounded down)	cm^3	4898
Compresion ratio		10.0 : 1
Max. engine power,		
80/1269/EWG	kW/HP	243 / 330
(Net Power, SAE J 1349)	kW/HP	243 (326)
at engine speed	rpm	6200
Max. torque		
80/1269/EWG	Nm/kpm	430 / 43.9
(Net Torque, SAE J 1349)	Nm/lb ft	430 (317)
at engine speed	rpm	4100
Max. specific output		
DIN 70020	kW/l/PS/l	49.0 / 66.6
(SAE J 1349)	kW/l/HP/l	49.0 (65,8)
Speed limitation by		
fuel interruption	rpm	6800
Idling speed	rpm	775 ± 25
Motor weight (dry)	kg	264

Printed in Germany - XXIV, 1989

Technical Data - Type 928 GTS - 1992 Model Year

(Adjustment values and wear limits are included in the relevant Repair Groups)

Note: U.S. values are given in brackets

Power Unit

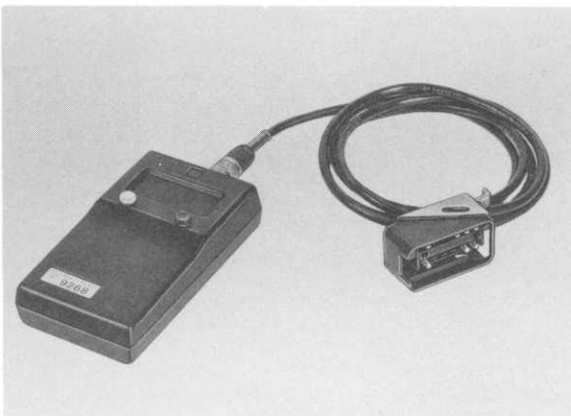
Internal engine designation		Manual transmission M 28.49 Automatic transmission M 28.50
Bore	mm (in.)	100 (3,94)
Stroke	mm (in.)	85,9 (3,38)
Displacement (actual)	c.c.(cu.in.)	5397 (329.3)
Octane requirements	RON/MON	98/88
Compression ratio		10.4 : 1
Max. engine power		
80/1269/EEC	kW/HP	257 / 350
(Net Power, SAE J 1349)	kW (HP)	257 (345)
at engine speed	rpm	5,700
Max. torque		
80/1269 EWG	Nm/kpm (ftlb)	500 / 51 (369)
(Net Torque, SAE J 1349)	Nm (ftlb)	500 (369)
at engine speed	rpm	4,250
Max. liter output		
DIN 70020	kW/l / HP/l	46,3 / 63
(SAE J 1349)	kW/l (HP/l)	46,3 (68,4)
Torque limitation via		
fuel cutoff	rpm	6,600
Idle speed	rpm	675 ± 25
Engine weight (dry)	kg	266

Printed in Germany - XXVII, 1991

LH / EZK control unit error diagnosis

LH/EZK control unit error diagnosis
928 S 4 as from Model 88.

The LH/EZK control unit is capable of self-diagnosis as from model year 88. That is to say that the control unit is capable of detecting, storing and displaying system errors. An amended part number identifies the control unit capable of diagnosis. A special developed diagnostic tester (special tool No. 9268) is then used to read out the error memory and to test specific components and control signals of the fuel and ignition system.



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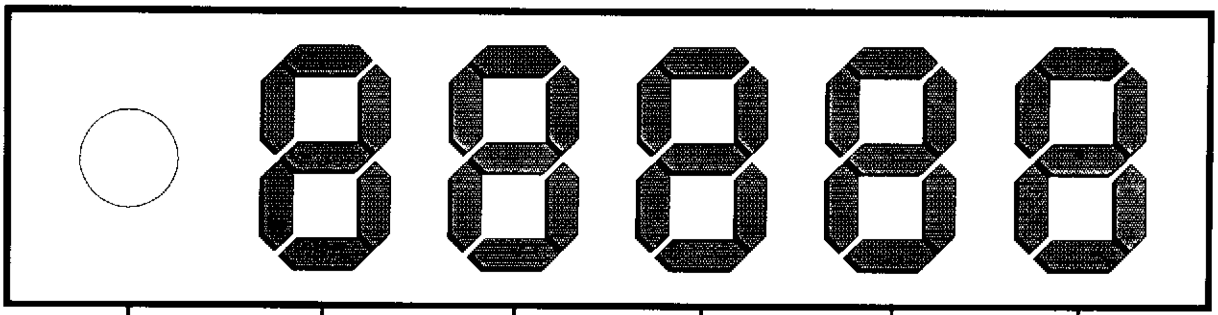
Important: Do not disconnect the battery or the connector of the DME control unit before diagnosis as otherwise the error memory will be erased.

Display



LED

Control unit identifikation

1 = LH / DME
2 = EZK

Error code test code

Diagnosis mode

1 = Continuous error
2 = Occasionally occuring error
3 = Actuator/input signal testing
4 = System adaption
5 = No error

Function-display

○	**LED off**	Test sequence terminated /ignition off
◐	**Flashing LED**	Error code / test code
●	**LED on**	Ignition on

Connection in the 928 S 4

The diagnosis socket in the 928 S 4 is located on the retaining plate of the EZK control unit.

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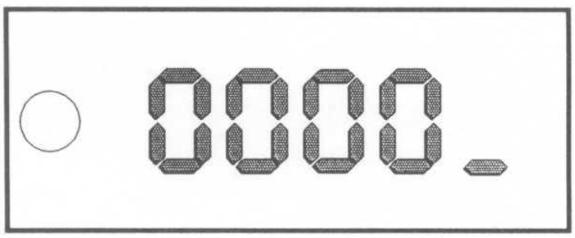
Ignition off

After connecting the tester, the following display must appear.

Display:



If this is not the case, check the tester terminals and/or the power supply to the diagnosis socket in the car by referring to the circuit diagram.

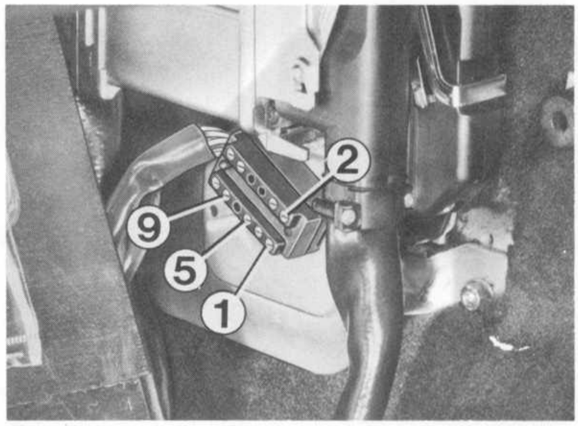
Diagnosis socket in the car

Pin 1 = Terminal 15

Pin 2 = Terminal 31

Pin 5 = Terminal 30

Pin 9 = Hall generator



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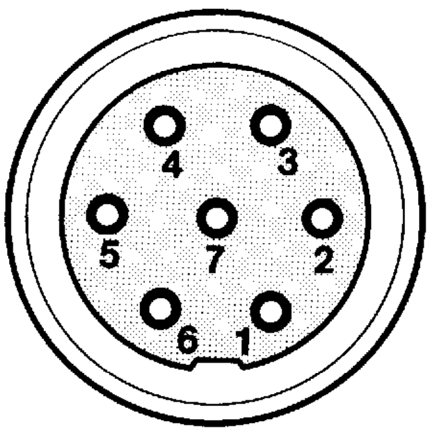
Tester cable

Diagnosis plug		Round plug
Pin 1	→	Pin 4
Pin 2	→	Pin 1
Pin 3	→	Pin 7
Pin 4	→	Pin 6
Pin 5	→	Pin 2
Pin 6		Unused
Pin 7		Unused
Pin 8		Unused
Pin 9		Unused
Pin 10		Unused
Pin 11	→	Pin 5
Pin 12	→	Pin 3



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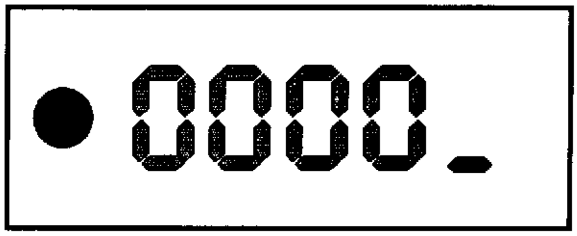
Switch on the ignition

Display:



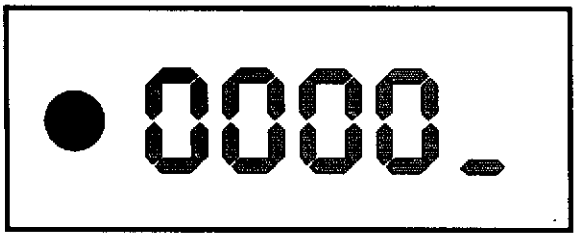
The ignition must not be switched off during the entire error diagnosis procedure.

Starting error diagnosis

Condition:

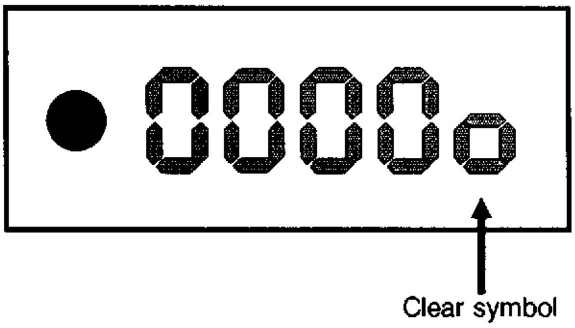
Engine off
Ignition on

Display:



Press the *green* key until the clear symbol appears on the function display.

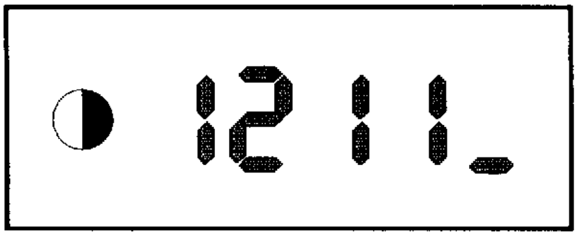
Display:



The diagnosis sequence for the LH control unit takes place first followed by that of the EZK control unit.

If an error is displayed– make a note of the error (e.g. 1211).

Display:

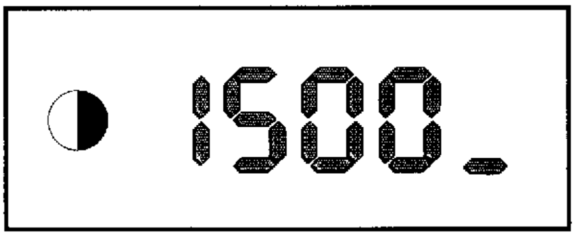


The error is displayed until the *green* key is pressed again on the tester. The next error code is then displayed, if applicable.

This must be repeated until 1000 appears on the display.

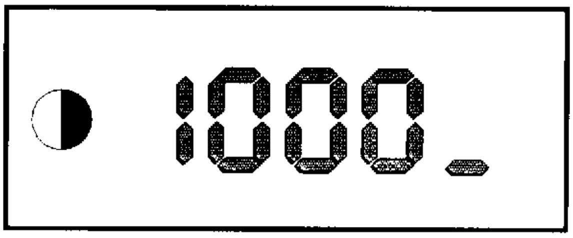
If there is no error, the following display appears.

Display:



Press the *green* key until the clear symbol appears on the function display. The following display must then appear.

Display:



This shows that diagnosis of the DME control unit has been terminated.

If one or several errors (max. 3 in the LH control unit and max. 5 in the EZK control unit) has/have been displayed, the error memory must be reset, see Chapter "Resetting the error memory".

Functional check of actuator and input signals

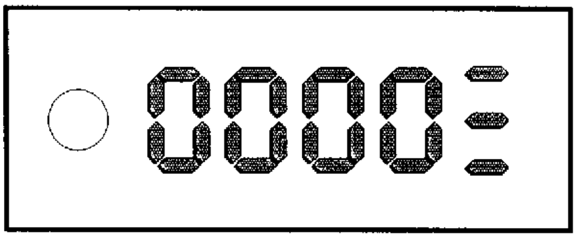
A functional check of actuator and input signals can be carried out independent of an error diagnosis. This functional check tests individual components or electrical signals with respect to their function or signal path. Functions are triggered by the diagnosis tester. During the functional check of components, these must be heard or felt to operate and it is therefore possible to determine whether they are in proper electrical working order or whether they are defective. An error display by the tester is not possible in this mode but the tester will detect faulty input signals or wiring connections.

Starting actuator and input signal functional check.

Ignition off

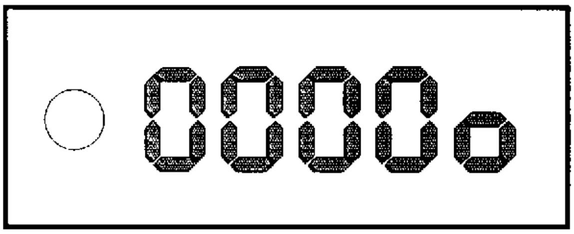
Press the *yellow* key repeatedly until the function symbol (see display) appears on the function display.

Display:



Press the *green* key until the clear symbol appears on the function display.

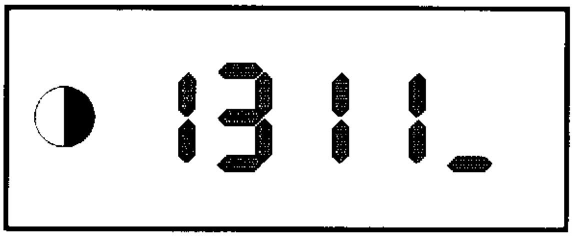
Display:



Switch on the ignition within 8 seconds.

The first testing step is activated and the injection valves are actuated.

Display:



The injection valves must all be heard or felt to operate.

Note:

There may be starting difficulties in later attempts to start the engine because a slight residual amount of fuel is injected during this testing step.

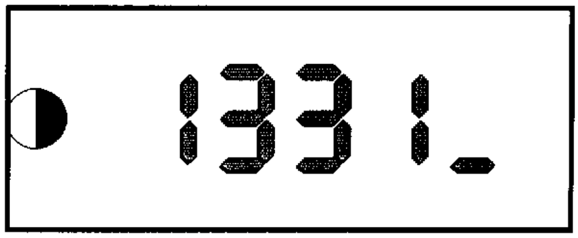
The testing steps remain in operation until the *green* key is pressed again on the tester and the clear symbol appears.

The next testing step is initiated by pressing the *green* key again.

Refer to the test code list for the sequence of testing steps.

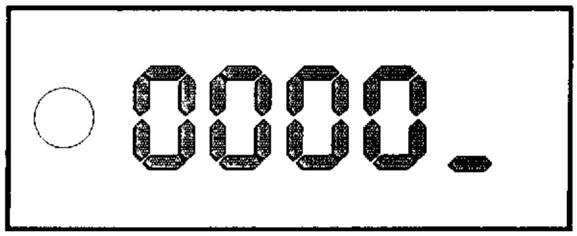
After testing step "speed signal from EZK to LH control unit", additional controls must be operated on the car to check the input signals.

Display:



Operate the starter motor for approx. 5 seconds. The LED on the tester will go out shortly afterwards and the following display will appear.

Display:



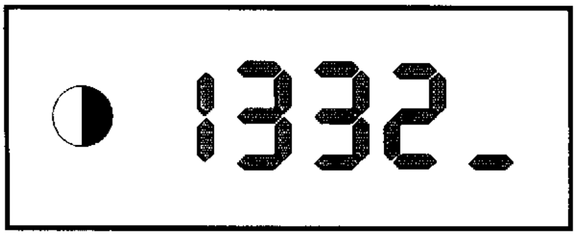
Note:

The ignition must not be switched off after the starting procedure.

If the 0000 display does not appear, there is an error (check with reference to the circuit diagram). It is possible to move on to the next testing step at any time. To do this, press the *green* key until the clear symbol appears.

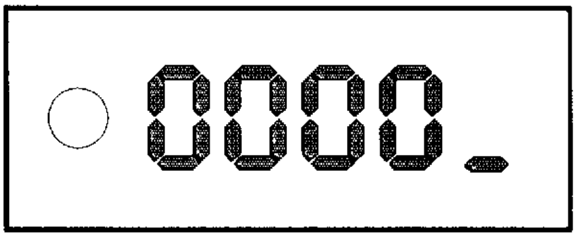
Initiate the idle contact testing step.

Display:



Press the accelerator pedal slightly. After approx. 20 mm, the LED must go out and the following display must appear.

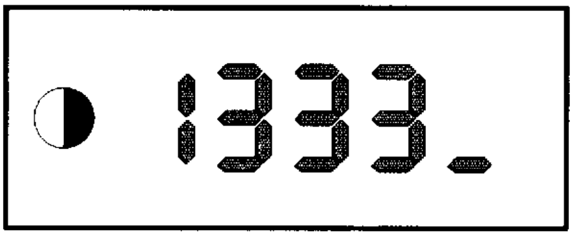
Display:



If this is not the case, there is a fault in the area of the idle contact (see idle contact trouble-shooting).

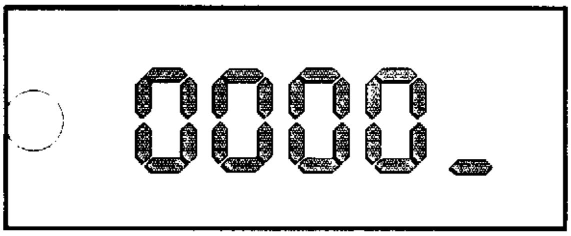
Initiate the full load contact testing step.

Display:



Press the accelerator pedal down slowly until the full load position has been reached. At the same time, the LED must go out and the following display will appear.

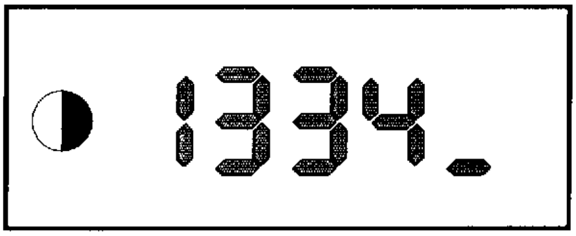
Display:



If this is not the case, there is a fault in the area of the full load contact (see full load contact trouble-shooting).

Initiate the testing step for air-conditioning control to the LH control unit (terminal 15).

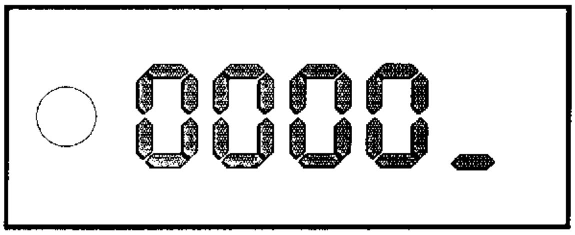
Display:



Set the air-distribution slide switch to up / down.

Switch on the air-conditioning system briefly (AC pushbutton). The LED must go out and the following display will appear.

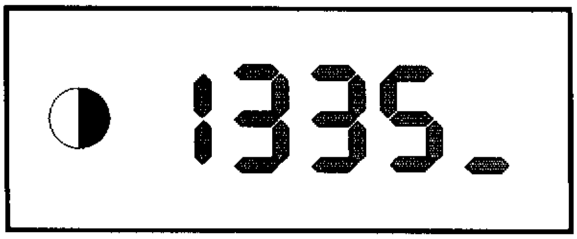
Display:



If this is not the case, there may be a fault in the area of the air- conditioning system's wiring. In the event of an error, check with reference to the circuit diagram.

Initiate the testing step for the air-conditioning control to the LH control unit (terminal 14).

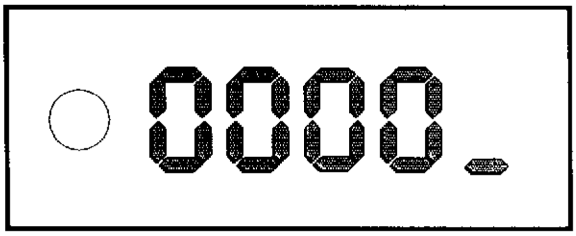
Display:



Set the air distribution slide switch to up / down.

Switch on the air-conditioning system briefly (AC pushbutton). The LED must go out and the following display will appear.

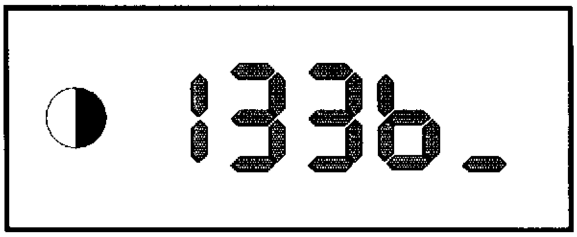
Display:



If this is not the case, there may be a fault in the wiring. In the event of an error, check with reference to the circuit diagram.

Initiate the testing step for speed reduction on automatic vehicles.

Display:



Note:

This testing step does not apply to vehicles with manual gearboxes.
Press the *green* key until the clear symbol appears.

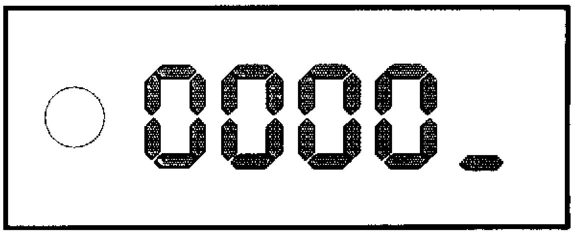
After a short period, the display 1000 will appear, i.e. output terminated.

Switch off the ignition

The functional check of actuator and input signals is thus terminated.

Move the selector lever from the P or N position to a drive position. The LED must go out and the following display will appear.

Display:



In the event of an error, check with reference to the circuit diagram.

Press the *green* key until the clear symbol appears. After a short period the display 1000 will appear, i.e. output terminated.

Switch off the ignition

The functional check of actuator and input signals is thus terminated.

Printed in Germany – XX, 1988

Test code list

Test code	Components
1311	Injection valves
1321	Rotary idle controller
1322	Solenoid valve - tank bleeding
1323	Resonance flap
1331	Speed signal from EZK to LH -control unit
1332	Idle contact
1333	Full load contact
1334	Air-conditioning control to the LH control unit terminal 15
1335	Air-conditioning control to the LH control unit terminal 14
1336	Idle speed reduction for vehicles with automatic transmission

System adaption

System adaption can be carried out with the tester. That is to say that the electronic idle control in the LH control unit is adapted to the actual air throughput and to the current condition of the engine.

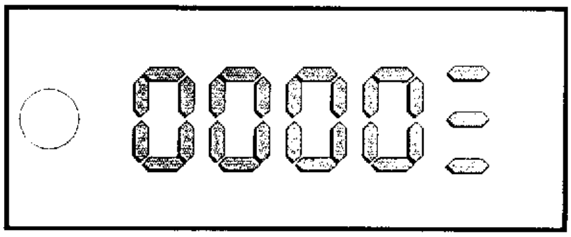
Note:

The engine must be at operating temperature for system adaption and all consumers must be switched off. The idle contact must also be functionable.

Ignition off

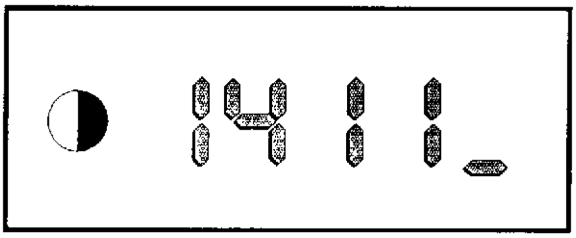
Press the *yellow* key repeatedly until the function symbol appears on the function display.

Display:



Press the *green* key until the clear symbol appears on the function display. Start the engine within 8 seconds. Allow the engine to idle until the system adaption code appears.

Display:



The engine must now idle for at least 30 seconds.

System adaption is then terminated.

Ignition off

Knock detection

An error diagnosis must be carried out before knock detection is performed to guarantee that there is no electrical fault in the area of the knock control and knock sensors.

Knock detection should only be carried out if the customer has complained of poor performance or excessive consumption, for instance.

Condition

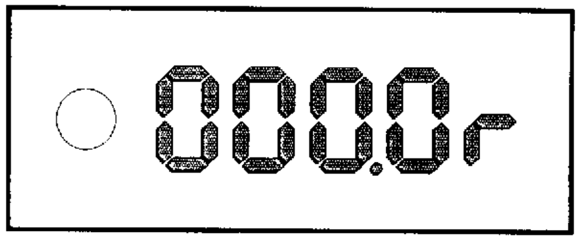
The engine must be at operating temperature during the test. The test must be carried out during a test drive or on the roller test stand.

Knock detection

Engine at operating temperature

While the engine is running, press the *yellow* and *green* keys simultaneously until the knock detection function symbol appears on the function display.

Display:



The tester is now in knock detection mode.

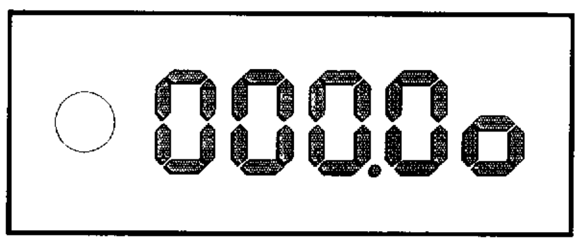
Note:

Normal driving is a prerequisite for the test drive (roller test stand).

Start the test drive (roller test stand).

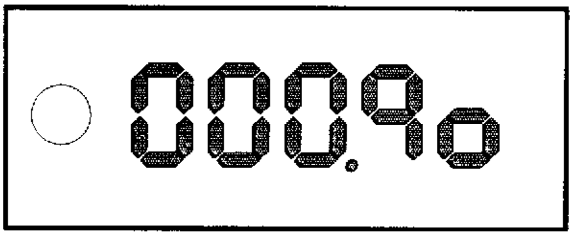
Press the *green* key until the clear symbol appears on the function display.

Display:



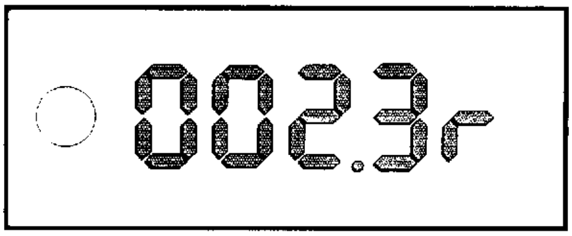
The tester is now active. If knocking occurs, this will be indicated by the tester, e.g.:

Display:



The function display will change to "r" after 10 000 ignition firings have elapsed.

Display:



Counting is now terminated.

The number of knocks is displayed in "per mil". 23 knocks have been counted in this example.

Knock detection must be carried out until the function display switches over from the clear symbol to the knock detection symbol.

This is always the case after 10 000 ignitions have taken place. All occurring knocks are added up and displayed as the end result.

To restart knock detection, press the *green* key until the clear symbol appears again.

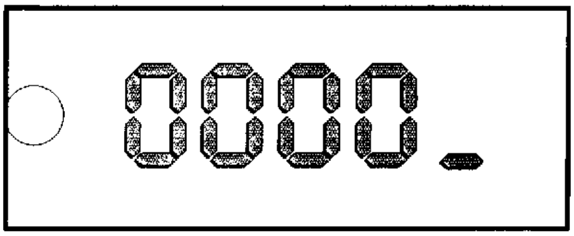
A knock display of > 5.0 (50) indicates a fault.

Possible faults:

Defective bucket tappets
Connecting rod damage
Damage to the crankshaft drive

Press the *green* and *yellow* keys simultaneously to leave knock detection mode, until the following display appears.

Display:



Trouble-shooting

LH control unit

Diagnosis using the tester can only indicate the error path but not a defective component.

Note:

The entire error memory must be read out before trouble-shooting.

Error code 1111

The supply voltage is too low < 10 V or too high > 16 V.

Possible causes of inadequate supply voltage.

Battery exhausted

Poor contact to the grounding strap

Poor contact in the control unit

A defective regulator may be the cause of excessive supply voltage.

Printed in Germany – XX, 1988

Error code 1112

This error code indicates a fault in the area of the idle contact.

Possible faults:

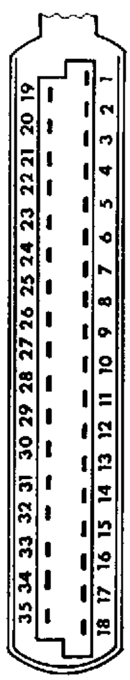
Short-circuit to ground
Switch stuck

Testing the idle contact

Ignition off

Disconnect the plugs from the EZK control unit and from the LH control unit.

Connect an ohmmeter between terminal 2 and terminal 5 on the LH control unit plug.



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Display:

Throttle valve closed: $R < 10\ \Omega$

Throttle valve open: $R = \infty\ \Omega$

Switchover must occur even if the throttle valve is only slightly open (approx. 1°).

In the event of an error, check with reference to the circuit diagram.

Error code 1113

This error code indicates a fault in the area of the full load contact.

Possible faults

Short-circuit to ground
Switch stuck

Testing the full load contact

Ignition off

Disconnect the plugs from the EZK control unit and from the LH control unit.

Connect an ohmmeter between terminal 3 and terminal 5 on the LH control unit plug.

Display:

Throttle valve closed: $R = \infty\ \Omega$

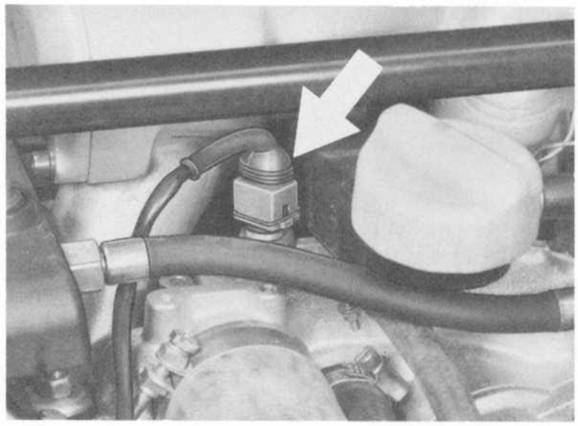
Throttle valve open: $R < 10\ \Omega$

The switching point must be just before full load.

In the event of an error, check with reference to the circuit diagram.

Error code 1114

This error code indicates a fault in the area of the engine temperature sensor.



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Possible faults

Short-circuit to ground
Short-circuit to positive
Break in the circuit
Defective engine temperature sensor

Testing the engine temperature sensor

Ignition off

Disconnect plugs from the EZK control unit and the LH control unit.

Connect an ohmmeter between terminal 13 and terminal 5 on the LH control unit plug.

Display:

32°F	=	4400 Ω -	6800 Ω
59 - 86°F	=	1400 Ω -	3600 Ω
104°F	=	1000 Ω -	1300 Ω
176°F	=	250 Ω -	290 Ω
212°F	=	100 Ω -	210 Ω

If these values are not achieved during this testing step, measurement must be carried out directly on the engine temperature sensor.

Note:

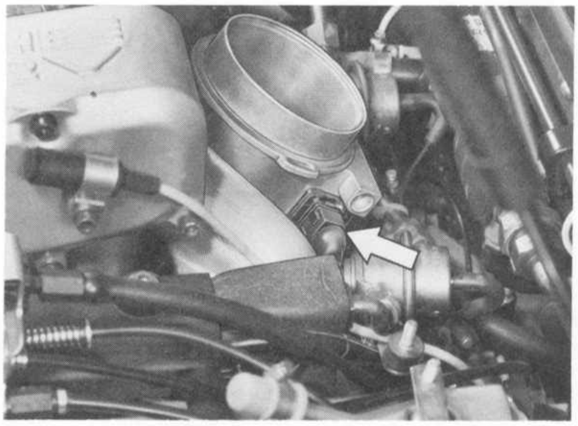
When measuring the resistance of the engine temperature sensor, always measure between the contact lug and the housing, as this contains two temperature sensors, independent of one another.

The engine temperature sensor makes the mixture richer for cold or hot start.

In the event of an error, check with reference to the circuit diagram.

Error code 1121

This error code indicates a fault in the area of the air-flow sensor.



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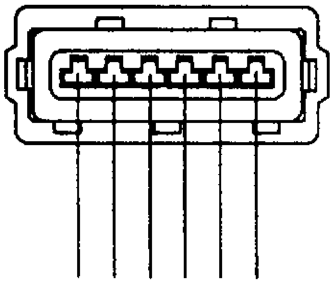
Checking the voltage supply to the air-flow sensor:

Ignition off

Disconnect the plug to the air-flow sensor.

Connect terminals 17 and 21 of the disconnected LH control unit plug.

It must be possible to measure the battery voltage between terminal 2 (positive) and terminal 4 (ground) of the disconnected air-flow sensor plug.



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If the battery voltage display does not appear, check the cable harness and plug connections with reference to the circuit diagram.

Functional check of the hot-wire signal

Plug the connector into the air-flow senor. Remove LH relay (XXV) and press terminal 30 and terminal 87 into the relay socket.

It must be possible to measure a voltage between terminals 6 and 7 on the disconnected LH control unit plug.

Display: ≈ 1.5 V - 1.8 V

Blow onto the hot-wire in the air-flow sensor and observe the voltmeter.

Display: ≈ 1.5 V - 5 V

Functional check of the hot-wire self-cleaning process

Allow the engine to run with integrated, connected air-flow sensor.

Condition:

Engine temperature > 140°F

Increase speed to above 2000 rpm.

Turn off the engine, i.e. ignition off. After approx. 4 seconds, the hot-wire must glow for approx. 1 second (self-cleaning function).

Error code 1122

This error code indicates a fault in the area of the rotary idle controller.

Note:

A functional check can be carried out using the actuator and input signal functional check.

In the event of an error, check the cable harness with reference to the circuit diagram.

Error code 1123

This error code indicates that the Lambda control has detected that the mixture is too rich.

Possible causes for too rich a mixture

System pressure too high

No partial vacuum at the pressure regulator

Injection valve does not close

Blockage in the return line to the fuel tank

Misfiring

Short-circuit to positive, Lambda probe

Error code 1124

This error code indicates that the Lambda control has detected that the mixture is too lean.

Possible causes for too lean a mixture

Short-circuit to ground, Lambda probe

Air infiltration on the intake side

Air infiltration on the exhaust side before the Lambda probe

Injection valve does not open

Fuel pressure too low

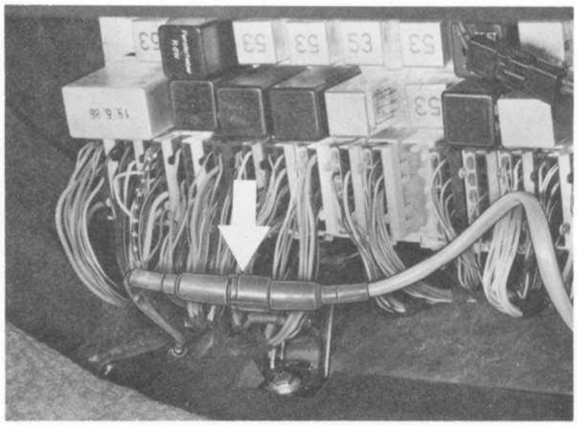
Error code 1125

This error code indicates a fault in the area of the Lambda probe.

Possible faults:

Short-circuit to ground
Short-circuit to positive
Break in the circuit

Testing the Lambda probe signal



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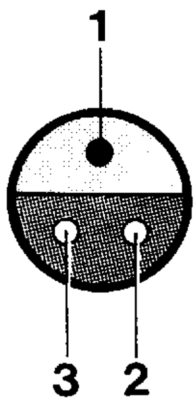
Disconnect the Lambda probe plug

Note:

Only use a digital voltmeter to measure the voltage of the Lambda probe, or use a comparable measuring device with an internal resistance (Ri) of not less than 10 MΩ.

Measure the voltage between pin 1 and ground.



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The voltage will be in the range of approx. 150 mV - 900 mV , according to the mixture composition.

Check the cable harness to the LH control unit with reference to the circuit diagram.

Error code list for the LH control unit

Error code	Error path
1500	No fault
1000	Output terminated
1111	Supply voltage too low / high
1112	Idle contact
1113	Full load contact
1114	Engine temperature sensor
1121	Air-flow sensor
1122	Rotary idle controller
1123	Lambda control detects too rich a mixture
1124	Lambda control detects too lean a mixture
1125	Lambda probe

The digit 2 may also appear in the second error code digit position (e.g. 1211) indicating "sporadic error", i.e. an occasionally occurring fault.

This does not apply to error code 1000 and 1500.

Trouble-shooting, EZK control unit

Diagnosis using the tester can only indicate the error path, but not a defective component.

Note:

The entire error memory must be read out before trouble-shooting.

Error code 2112

This error code indicates a fault in the area of the idle contact.

Possible faults:

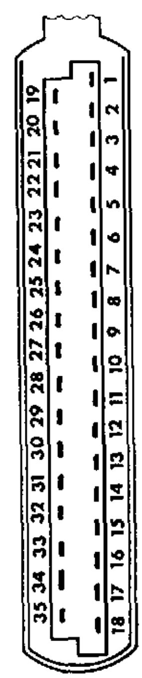
Short-circuit to ground
Switch stuck

Testing the idle contact

Ignition off

Disconnect the plugs from the EZK control unit and the LH control unit.

Connect an ohmmeter between terminal 8 and terminal 18 of the EZK control unit plug.



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Display:

Throttle valve closed: R < 10 Ω

Throttle valve open: R = ∞ Ω

Switchover must occur even if the throttle valve is only slightly open (approx. 1°).

Error code 2113

This error code indicates a fault in the area of the full load contact.

Possible faults:

Short-circuit to ground
Switch stuck

Testing the full load contact.

Ignition off

Disconnect the plugs from the EZK control unit and the LH control unit.

Connect an ohmmeter between terminal 26 and terminal 18 of the EZK control unit plug.

Display:

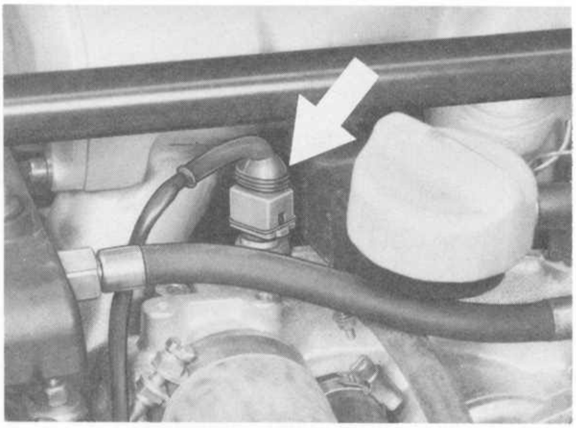
Throttle valve closed: R = ∞ Ω

Throttle valve open: R = 10 Ω

The switching point must be just before full load.

Error code 2114

This error code indicates a fault in the area of the engine temperature sensor.



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Possible faults

Short-circuit to ground
Short-circuit to positive
Break in the circuit
Defective engine temperature sensor

Testing the engine temperature sensor

Ignition off

Disconnect the plugs from the EZK control unit and the LH control unit.

Connect an ohmmeter between terminal 19 and terminal 18 of the EZK control unit.

Display:

32°F	=	4400 Ω - 6800 Ω
59 - 86°F	=	1400 Ω - 3600 Ω
104°F	=	1000 Ω - 1300 Ω
176°F	=	250 Ω - 290 Ω
212°F	=	100 Ω - 210 Ω

If these values are not achieved during this testing step, measurement must be carried out directly on the engine temperature sensor.

Note:

Always measure the resistance of the engine temperature sensor between the contact lug and the housing as this contains two temperature sensors, independent from one another.

The engine temperature sensor advances the spark angle when the engine is cold for improved running.

Error code 2115

This error code does not clearly determine whether the fault is in the area of the full load contact or in the area of the idle contact.

More detailed information is then given by error code 2112 or 2113.

Error code 2121

This error code indicates a fault in the area of the load signal (e.g. partial load) between the LH control unit and the EZK control unit.

Possible faults

Break in the circuit
Short-circuit to ground

If this load signal is not received by the EZK control unit, ignition is retarded in the partial load area and full load area.

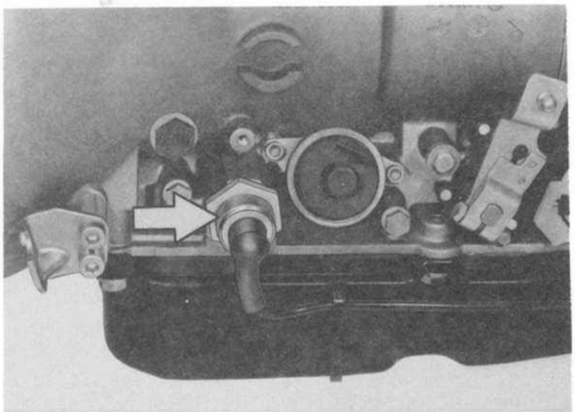
Control value for an intact load signal

3000 1/min 32° before TDC ± 4°

In the event of a fault, check the cable harness with reference to the circuit diagram.

Error code 2126

This error code indicates a fault in the area of the transmission safeguard switch.



Possible faults

Switch defective
Short-circuit to ground

Trouble-shooting:

See repair manual, checking the transmission safeguard switch, Page 28 - 70.

Error code 2131 and error code 2132

These error codes indicate a fault in the area of the knock sensors.

Error code 2131	Knock sensor 1
Error code 2132	Knock sensor 2

Error testing of the knock sensors is an active error test, i.e. the error test is carried out while driving.

If there is a fault, first check the wiring for short-circuit to ground, short-circuit to positive and continuity, with reference to the circuit diagram, before replacing knock sensors.

Error code 2133

This error code indicates a fault in the control unit.

If this error code appears, replace the EZK control unit.

Error code 2134

This error code indicates a fault in the area of the Hall generator signal.

Possible faults:

Short-circuit to ground
Break in the circuit

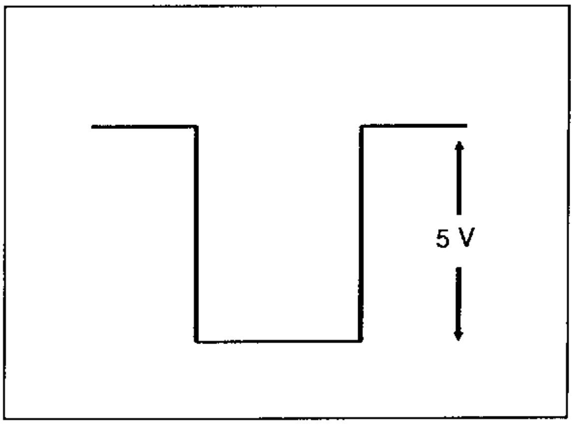
Testing the Hall generator signal

Disconnect the plug from the EZK control unit.

Connect an oscilloscope to terminal 22 and terminal 4 of the EZK plug.

Operate the starter motor

The following image must appear on the oscilloscope.



If this is not the case, carry out the test on the Hall generator directly.

If the Hall generator is defective, the control unit retards the ignition by approx. 6° for all cylinders in the upper partial load or full load areas.

Error code 2141

This error code indicates a fault in the control unit.

If this error code appears, replace the EZK control unit.

Error code list for the EZK control unit

Error code	Error path
2500	No fault
2000	Output terminated
2112	Idle contact
2113	Full load contact
2114	Engine temperature sensor
2115	Idle/full load contact
2121	Load signal from the LH control unit
2126	Transmission safeguard switch
2131	Knock sensor I
2132	Knock sensor II
2133	Knock control in the control unit
2134	Hall generator signal
2141	EZK control unit

The digit 2 may also appear in the second error code digit position (e.g. 2212), indicating "sporadic error", i.e. an occasionally occurring fault.

This does not apply to error code 1000 and 1500.

Resetting the error memory

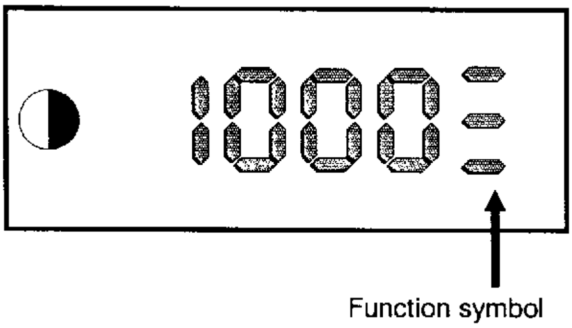
The error memories of the LH control unit and the EZK control unit must each be reset individually.

Once error diagnosis has been terminated for the LH or EZK control units, this is indicated by error code 1000 for the LH control unit or 2000 for the EZK control unit.

It is only possible to reset the error memories when this error code has appeared. Proceed as follows:

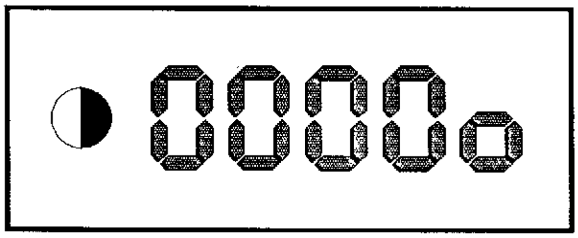
Press the *yellow* key repeatedly until the function symbol (see display) appears on the function display.

Display:



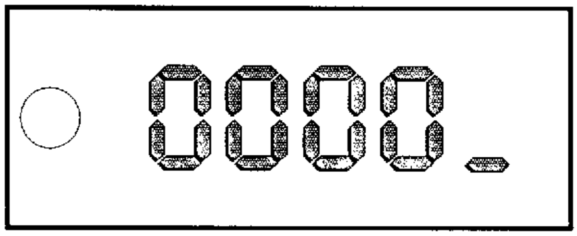
Press the *green* key until the clear signal appears on the function display.

Display:



The error memory has been reset when the LED goes out and the function display changes to 0000.

Display:



Note:

A test drive must be made after resetting the error memory

Observe the following conditions for this:

1. The engine must be at operating temperature, i.e. at least 176°F.

2. The duration of the test drive (minimum 6 minutes)

3. At the end of the test drive, run the engine for at least 60 seconds without opening the throttle valve.

   After the test drive, read out the error memory once again.

Printed in Germany – XX, 1988

Operating conditions for start of diagnosis

Systems	Ignition on Engine standing still	Engine running
928 S4 / 928 GT 928 GTS (5,4 l)		
LH-Jetronic	yes	to n < 2500 rpm
EZK	yes	to n < 2600 rpm
ABS / lock	yes	no
Airbag	yes	yes
Alarm system	yes	yes
RDK	yes	yes

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Operating Instructions for System Tester 9288

1. General information

1.1 Application

The Systemtester 9288 (BOSCH KTS 301) is a microprocessor-controlled self-diagnosis tester.

All systems which have a diagnosis interface as per ISO Standard can be tested with this tester. The following tests are possible:

- Reading out the fault memory
- Testing of the actuators
- Testing the circuit inputs
- System adaptation
- Engine-knock detection
- Sensor and status checks, tire-pressure monitoring (RDK)

The Systemtester 9288 is a high-quality piece of electronic equipment. In order to prevent damage to the equipment as a result of improper use, please read the information in the operating instructions carefully and comply with it.

In addition, the instructions (specifications) of the vehicle manufacturer are also to be observed.

If the tester should fail, check the following points before sending it in for repair:

1. Has the tester been operated incorrectly?
2. Is the battery sufficiently charged?
3. Is the adapter cable OK?
   (Please note when checking the adapter cable that a highly sensitive electronic matching circuit is installed in the vicinity of the 19-pole plug).

1.2 Construction (Fig. 1)

No.	Description	Function	Remarks
1	LCD indicator	Dot matrix 5 x 8 4 lines each with 20 characters Foreign languages possible Illumination	If the Systemtester 9288 is switched on without the program module, following the self-test the tester switches off automatically and informs the user that the program module is not fitted.
2	Keyboard	Keys 1, 2, 3 = Selection key Keys < > = Previous page/next page Key H = Help menu, e.g.: Illumination, Screens stored, Control-unit overview, Setting up printer, Switching off unit Key N = Return to the next higher program level following termination of a test sequence or, during a test sequence, return to the last display Key ⇨ = Storing indication Key ⇦ = Playing back stored reading	Switching on: = Press any key Switching off: (automatic) = 180 s after last depression of a key or if no data stream flows across the serial interface. The last field in the top right-hand corner is filled completely, this means that this is a stored figure and not an actual, real-life figure.
3	Power supply	Fitted accumulator with NiCd batteries. The Systemtester 9288 must be switched off during the initial battery charging process. Charging time > 8 hours	Discharged upon delivery. Following charge: Operating time: 4–8 hours without scale illumination 1–2 hours with scale illumination
	If the voltage is not sufficient, "Charge battery" appears on the display. If this is not done, the unit switches itself off.	Connection to vehicle battery by means of vehicle-specific adapter lead (see 1.4)	Connection through ISO-interface Charging voltage supply
		Battery charger (accessory)	For test operation and for charging the NiCd batteries.
4	Connection for input and output devices	Connection facility for Printer e.g. Epson, IBM, Hewlett Packard (HP)	The Systemtester 9288 transmits data with the following configurations: 8 data bits / 1 start bit / 1 stop bit / No parity (for printer matching)
5	Connection for vehicle specific adapter lead	Reading out the data	Input for flashing-code support
6	Plug-in programme module (see also Figure 2) ⚠ C-MOS ! Do not touch plug !	Operating system LCD drive Keyboard Interface communication Computations and data conversions	Plug in module: remove rubber protector, insert module fully.

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1.3 Battery charger run off mains voltage (Figure 3)

– Accessory –

Item 1 Charger with connecting cable, 1.5 m long

Item 2 8-pin AMP plug

1.4 Vehicle-specific adapter cable

Porsche No. 000 721 928.81

1.5 Connecting lead (Figure 4)

– Self-fabrication –

for printer, programme load station or similar unit.

For interface-trunk assignment, see manual of corresponding unit.

Printer cable for standard D 25
BOSCH No. 1 684 465 193

Printer cable for EPSON
BOSCH No. 1 684 465 194

2. Connection

The following points must be observed:

- No gear must be engaged on the vehicle (Automatic transmission in position N - P) – Danger of Accident !
- **ALL** work on the vehicle must only be carried out with the ignition switched off.

After having connected the vehicle-specific adapter cable, the instructions listed under "3" are displayed on the Systemtester 9288:

2.1 Charging with the battery charger (Fig. 3)

Connecting the Systemtester 9288 to the battery charger. (Fig. 1, pos. 5).

2.2 Diagnosis

Connecting the Systemtester 9288 to the diagnosis plug in the vehicle by means of the vehicle-specific adapter cable.

Switch on the tester and proceed according to the instructions displayed.

3. Testing

Scope of module:

Guidance through the menu, communication with the ECU, reading out the error memory and selection of the "Help" menus, actuator diagnosis, circuit inputs and system adaptation, engine-knock detection, sensor and event check for the tire-pressure monitor (RDK).

3.1 Reading-out the error memory

Connect the Systemtester 9288 (see 2.)
Switch on the Systemtester,
(possible with every key!)
Display:

```
PORSCHE
Eprom modul        eng
Mod. intro.   xx.xx.xx
```

If a specific instruction does not appear in a display, it is always possible to proceed by pressing the button >.

Due to the fact that the Systemtester 9288 can store error displays (see Chapter 3.7), the following display will appear if errors have been stored in the image memory:

```
Stored displays
erased ?
1 = yes
3 = no
```

Key 3

Display:

```
Print out
displays:          H

continue:          >
```

H = Help menu (see 3.6) or key 1

Display:

```
Vehicle types
1 = 944 S
2 = 911 Carrera 4
3 = 928 S 4
```

Selection of the vehicle type with key 1, 2 or 3.

After the vehicle type has been selected, the following instruction appears:

```
Connect adapter
cable to veh. plug.
Ignition "ON".
After completion:  >
```

The following then appears:

```
Wait for
Data

Break off test:    N
```

After a short pause, the Systemtester 9288 reports all the systems that are installed in the particular vehicle. If a system is preceded by " ≠ ", this means that at least 1 error is stored in that particular system.

Examples:

```
Installed systems
1 = ≠ LH
2 = ≠ EZK
3 =   RDK
```

The particular system can be selected by means of key 1, 2 or 3.

After selection (for instance with key 1), the following display appears:

```
LH
System:  L01 LH-JET
Ser. No.:  92861812313
RB. No.:  0280002507
```

After pressing the key >, a selection menu is displayed:

```
Menu
1 = Fault memory
2 = Drive links
3 = Input signals    >
```

```
< Menu
1 = System adaptation
```

In the example – press key 1. There then follows the display of the number of errors which are stored (if any).

```
Number of
faults

→ 2 ←
```

Proceed with key >

```
Additional info to
every display with
key 1
continue:            >
```

Proceed with key >

Error output:

```
1: Engine
temperature sensor 2
Short to ground
not present
```

If key 1 is pressed instead of the > key, the corresponding error code display appears (the last two digits of the flashing code).

```
Fault code: – 14 –
```

Proceed with key >

Further errors are displayed (if they exist):

```
2: Idle contact

Short to ground
present
```

If key 1 is pressed instead of key > the corresponding error-code display appears (the last two digits of the flashing code).

```
Fault code: – 12 –
```

After the last displayed error, the following instruction appears:

```
Repair fault accord-
ing to repair
instructions
Continue:            >
```

Proceed with key >

```
Fault repaired ?
1 = yes
3 = no
```

Return to display "No. of errors" with key 3.

Proceed with key 1:

```
Fault memory
1 = Erase
3 = Do not erase
```

If key 3 is pressed:
= Return to menu "error memory".

The error memory is not erased!

Proceed with key 1:

```
Fault memory
has been cleared

Return:              N
```

The test scope "Read-out error memory" is terminated at this point.

3.2 Actuator diagnosis

If an actuator is selected, this is triggered by the ECU so that it can be checked for correct functioning.

The various actuators components are gone through one after the other and are selected with the > key.

Operate the Systemtester 9288 as described under 3.1 until the following menu display appears:

```
Menu
1 = Fault memory
2 = Drive links
3 = Input signals    >
```

After pressing key 2, the display for the first actuator appears:

```
Injector
to activate
1 = Start
Continue:            >
```

If key > is pressed, the next actuator is selected.

Pressing key 1 results in the following instruction:

```
Can injectors be
heard / felt ?
1 = yes
3 = no
```


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Key 1 selects the next actuator (e.g. idle actuator). Following instruction:

```
Repair fault accord-
ing to repair
instructions
Continue:          >
```

After pressing key >, the following display appears:

```
Injector
to activate
1 = Start
Continue:          >
```

Proceed with key 1

```
Can injectors be
heard / felt ?
1 = yes
3 = no
```

Proceed with key 1 to the next actuator.

```
Idle stabilizer
to activate
1 = Start
Continue:          >
```

Proceed with key 1

```
Can idle stabilizer
be heard / felt ?
1 = yes
3 = no
```

By pressing key 1, the next actuator is selected. After pressing key 3, the next instruction appears:

```
Repair fault accord-
ing to repair
instructions
Continue:          >
```

Proceed with key >

```
Idle stabilizer
to activate
1 = Start
Continue:          >
```

After pressing key 1, the following display appears:

```
Can idle stabilizer
be heard / felt ?
1 = yes
3 = no
```

By pressing key 1, the next actuator is selected. The actuators are selected one after the other and triggered until the following display appears:

```
Drive link test
completed

Return:            N
```

By pressing the key N, the operator is returned to the menu.

3.3 Circuit inputs

In addition to the actuators, the Systemtester 9288 can also check circuit inputs. To this end, operate the Systemtester 9288 in accordance with 3.1 until this menu display appears:

```
   Menu
1 = Fault memory
2 = Drive links
3 = Input signals    >
```

Press key 3

```
Idle contact
1 = Start

Continue:            >
```

By pressing key > the next circuit input is selected.

The next display appears when key 1 is pressed.

```
Activate accl. pedal
Idle contact
– closed –
Continue:            >
```

Operate the accelerator pedal, the following display appears:

```
Activate accl. pedal
Idle contact
– open –
Continue:            >
```

The next circuit input is selected by pressing key >. Repeat until this display appears:

```
Input signals
testing completed

Return:              N
```

Press key N for return to menu

3.4 System adaptation

When the function "System adaptation" is triggered, the ECU registers the basic air requirement of the engine.

To this end, operate the Systemtester 9288 as per 3.1 until the following menu display appears:

```
   Menu
1 = Fault memory
2 = Drive links
3 = Input signals    >
```

Proceed with key >

```
<  Menu
1 = System adaptation
```


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Proceed with key 1

Prerequisite: Eng. at oper. temp. with all consumers and ignition off.

Proceed with key >

System adaptation 1 = Start	
Return:	N

If key N is pressed
= return to menu.
If key 1 is pressed:

Start engine !

Following engine start there appears:

System is being adapted Please wait !

After approx. 30 secs there appears:

System adaptation completed	
Return:	N

If it is impossible to carry out system adaptation (idle contact not closed, or defective), the following display appears:

No system adaptation possible Idle contact ?	
Return:	N

After completion of the system adaptation, return to the menu with key N.

3.5 Engine-knock registration

The engine-knock registration function can only be triggered through the EZK or DME control unit.

To this end, operate the Systemtester 9288 as described in 3.1 until the following display appears:

Installed systems
1 = # LH
2 = # EZK
3 = RDK

The particular system can be selected by means of key 1, 2 or 3. For instance with key 2 the following display appears:

EZK System: E01EZK Ser. No.: 92861812415 RB. No.: 0227400154

Proceed with key >
The following menu display appears:

< Menu 1 = Fault memory 2 = Knock registration

Proceed with key 2

Condition: Engine at operating temperature >

Proceed with key >

< Start knock registration before test drive >

Proceed with key >

< A normal test drive is a pre- requisite >

Proceed with key >

< Stop the test drive only if the display with the no. of knocks comes on.

Proceed with key >

Knock registration 1 = Start	
Return:	N

Pressing key 1 activates the engine-knock counter:

Knock registration in progress Please wait!

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The knock counter registers 10,000 ignitions before the display with the actual number of combustion "knocks" appears.

```
Number
Knocks:        xxx
Combustion:    xxxxx
Continue:          >
```

Proceed with key >

```
Knock registration
completed

Return:            N
```

If knock registration is impossible (due to lack of engine-speed signal), the following display appears:

```
No knock regist-
ration possible.
RPM signal ?
Return:            N
```

Following completion of the knock registration test, return to the menu with key N.

3.6 Help menu

The "Help" menu can be selected from every display by pressing key H. Return to the initial display with key N.

```
   Help menu
1 = Illumination
2 = Display stored
3 = Ctrl. unit chart   >
```

Proceed, for instance with key 1:

Key 1:

The scale illumination is switched on and the tester returns to the previous display.

Or with key 2:

```
Data display stored
1 = Print
2 = Clear
```

Proceed with key 1
Stored displays are printed out (If printer connected).

Proceed with key 2
Stored displays are erased.

With the "Help" menu, for instance

```
   Help menu
1 = Illumination
2 = Display stored
3 = Crtl. unit chart   >
```

if the key > is pressed, a further section of the "Help" menu is displayed:

```
<  Help menu
1 = Printer setting
2 = Switch off equip.
3 = Baud Rate
```

Proceed for instance with key 1

```
Printer setting
1 = IBM
2 = HP Quiet Jet
3 = EPSON
```

The selection of the printer results in the tester being set up for the printer type in question.

3.7 Store measurement displays (Key ⇨)

Using key ⇨, all displays can be stored manually.

The following displays are stored automatically:

- ECU-Identity
- Installed systems
- All existing errors

When the memory limit is reached, the following instruction is displayed:

```
Data display mem.
full !

Return:            N
```

3.8 Show stored measurement displays (Key ⇦)

Using the keys < or >, the stored displays for the selected system can be shown.

The stored displays can be called up by means of the ⇦ key.

The system selection (LH - EZK - RDK) takes place with the keys 1, 2 or 3.

4. Service and wear parts (BOSCH)

Fig.	BOSCH Part No.	Designation	Comment
1/3	1 687 335 002	NC-battery	
4/1	1 684 483 152	Plug	
4/2	1 684 485 170	Socket	9pole
4/3	1 680 552 005	Screwed cap	
	1 684 465 193	Printer cable (Standard D 25)	
	1 684 465 194	Printer cable (EPSON)	

4.1 Service parts (Porsche)

Designation	Porsche Part No.	Special tool No.
Systemtester 9288	000.721.928.80	9288
Adapter cable	000.721.928.81	9288/1
Battery charger	000.721.928.82	9288/2
Module (D)	000.721.928.84	9288/4
Module (GB/USA)	000.721.928.85	9288/5
Module (F)	000.721.928.86	9288/6
Module (I)	000.721.928.87	9288/7
Module (E)	000.721.928.88	9288/8

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TOLERANCES AND WEAR LIMITS

		When Installed (new)	Wear Limit
Cooling System			
Coolant thermostat	Opening temperature	81 - 85° C	
Radiator Cap			
High pressure valve	Opening pressure	0.9 - 1.15 bar	
Low pressure valve	Opening pressure	0.07 - 0.12 bar	
Oil Circuit			
Oil consumption	ltr/1000 km		ca. 1.5
Oil pressure at 80° C oil temperature and at 5000 rpm	Pressure	5 bar	
Oil dipstick			
Upper mark	Oil volume	7.5 ltr	
Lower mark	Oil volume	6.0 ltr	
Oil pump			
Clearance	Axial play	0.080 - 0.120	
	Radial play	0.060 - 0.088	
Valve Timing			
Camshaft bore	Inside dia.	$60.5^{+0.03}_{-0}$	
Camshaft	Diameter	$60.5^{-0.03}_{-0.045}$	
Camshaft	Axial play	0.10 - 0.18	
Bucket tappet bore	Inside dia.	$38^{+0.010}_{+0.038}$	
Bucket tappet	Diameter	$38^{-0.018}_{-0.034}$	
Camshaft	Runout	0.02	
Cylinder Head and Valves			
Bearing surface	Distortion		max. 0.08
Valve seat:			
Intake	Width	1.7	
Exhaust	Width	2.0	
Intake	Seat angle	45°	
Exhaust	Seat angle	45°	
Outer correction angle		30°	
Inner correction angle		60°	
Valve guides:			
Intake and exhaust	Inside dia.	9 + 0.015	
Valve stem:			
Intake	Diameter	8.97 - 0.012	
Exhaust	Diameter	8.95 - 0.012	

			When Installed (new)	Wear Limit
Valve guide/valve stem	Clearance			
Intake				0.80
Exhaust				0.80
Compression			8 bar and more	6. 5 bar

Pistons and Connecting Rods

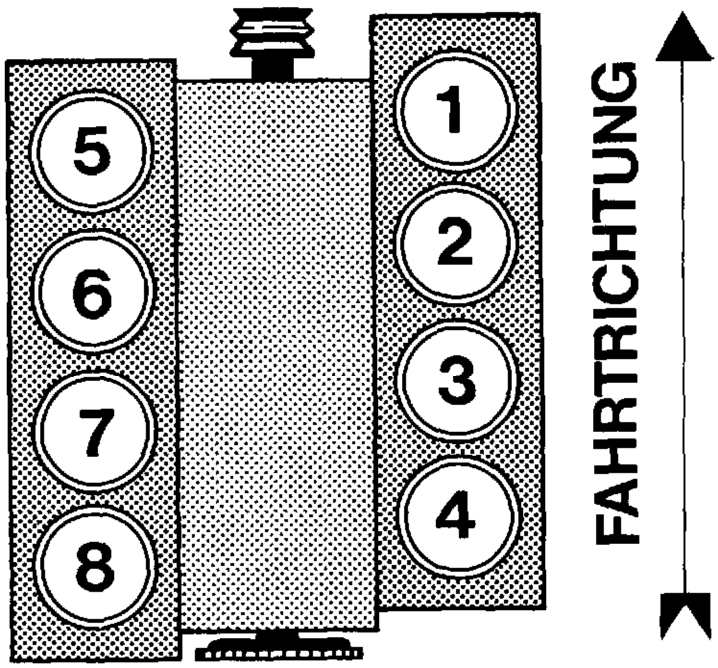
Cylinder/piston	Clearance		0. 024 - 0. 048		ca. 0, 080
			Mahle	KS	
Piston rings	Side clearance	Groove 1	0. 06 - 0. 102	0. 05 - 0. 082	
		Groove 2	0. 04 - 0. 072	0. 05 - 0. 082	
		Groove 3	0. 013 - 0. 127	0. 023 - 0. 137	
Piston rings	End clearance		Groove 1 = 0. 20 to 0. 40 Groove 2 = 0. 20 to 0. 40 Groove 3 = 0. 40 to 1. 40		

Conrod bushing	Diameter	$24^{+0.018}_{+0.028}$	
Piston pin	Diameter	24 - 0. 004	
Conrod bushing/piston pin	Radial play	0. 018 - 0. 032	

Crankshaft and Engine Block

Crankshaft (measured on 2nd, 3rd or 4th bearings, 1st and 5th bearings running in vees)	Runout	0, 04 - 0, 06	max. 0, 08
Conrod bearing journal	Diameter	51. 971 - 51. 990	
Conrod bearing/crankshaft	Radial play	0. 034 - 0. 092	
	Axial play	0. 100 - 0. 400	
Crankshaft bearing journal	Diameter	69. 971 - 69. 990	
Crankshaft bearing/crankshaft	Radial play	0. 020 - 0. 098	
Crankshaft bearing/crankshaft	Axial play	0. 110 - 0. 312	
Cylinder bore	Out-of-true	0. 010	0. 020

DESIGNATION OF CYLINDERS



ENGINE TORQUE SPECIFICATIONS

Location	Tightening Specifications	Torque Nm (ftlb)	Threads
Main bearing	3 steps: 1st step 2nd step 3rd step	20 (14) 40 (29) 60 + 5 (43 + 3.6)	M 12 x 1.5
Crankcase with "X" next to case number and all crankcases with closed main bearing bushing, bearing 1		75 + 5 (54 + 3.6)	
Main bearing	2 steps: 1st step 2nd step	20 (14) 40 + 5 (29 + 3.6)	M 10
Crankcase with "X" next to case number and all crankcases with closed main bearing bushing, bearing 1		50 + 5 (36 + 3.6)	
Oil pump	2 steps: 1st step 2nd step	15 (11) 20 (14)	M 8
Conrod nut with smooth bearing surface		58 + 5 (42 + 3.6)	M 10 x 1.25
Conrod nut with ribbed bearing surface		75 (54)	M 10 x 1.25
Cylinder head	A) Pre-loading cylinder head gasket 1st step 2nd step 3rd step	 20 (14) 50 (36) 85 (61)	M 12 x 1.5
	B) Gasket left in preloaded condition 30 minutes		
	C) Final tightening: Nuts unscrewed one after the other by 1/4 turn and then tightened. See note on page 15 - 7	85 (61)	
	New tightening instructions for changed cylinder head gasket: Part No. 928.104.361.02 Cyl. 1 – 4 Part No. 928.104.362.02 Cyl. 5 – 8 Part No. 928.104.371.09 Cyl. 1 – 4		

Location	Tightening Procedures	Torque Nm (ftlb)	Thread
	New tightening procedure for cylinder head gasket: ET-No. 928.104.372.09 Cyl. 5 - 8		
	from following engine numbers onward:		
	80 C 0260 M 28/09 80 C 5269 M 28/10 82 C 0713 M 28/11 82 C 5782 M 28/12 81 C 1037 M 28/15 81 C 6398 M 28/16 80 C 8051 M 28/17 80 C 9155 M 28/18		
	1st step 2nd step 3rd step	20 (14.6) 50 (36.5) 90 (65.7)	
Cylinder head studs	torquing by angle of rotation:		
	1st step 2nd step 3rd step 4th Step Only in conjunction with new stud bolt	20 90°of rotation 90°of rotation 90°of rotation	
	Recognizable by:		
	Color:ochre (galvanized, yellow passivated)		
	Thread: longer and with cylinder head gasket		
	928.104.361.02/362.02 928.104.371.09/372.09		

Location	Tightening Specifications	Torque Nm (kpm)	Threads
Camshaft housing to cylinder head		20 (2.0)	M 8
Plug on camshaft housing		40 (4.0)	M 18 x 1.5
Camshaft		45 (4.5) 65 (6.5)	M 10 (8.8) M 10 (10.9)
Spark plugs		25 to 30 (2.5 to 3.0)	
Flywheel		90 (9.0)	M 10 x 1.25
Pulley		295 (29.5)	M 18 x 1.5
Oil drain plug		60 (6.0) 50 (5.0)	M 22 x 1.5 M 20 x 1.5
Thermostat housing plug		80 (8.0)	M 48 x 1.5
Oil pressure sensor		35 (3.5)	M 18 x 1.5
Pressure relief valve plug		40 (4.0)	M 18 x 1.5
Bypass valve adapter		70 (7.0)	M 24 x 1.5
Water drain plug in engine block		35 (3.5)	M 12 x 1.5
Radiator water drain plug		1,5(0,2)	M 10
Adapter to radiator to engine		70 (7.0) 70 (7.0)	
Oil hose to adapter on crankcase upper section		70 (7.0)	M 26 x 1.5
Oil hose to adapter on radiator		70 (7.0)	M 26 x 1.5
Temperature switch on radiator		40 (4.0)	

Location	Tightening Specifications	Torque Nm (kpm)	Threads
Coolant thermostat housing to engine	Two steps: 1st step 2nd step	10 (1.0) 20 + 2 (2.0 + 0.2)	M 8
Coolant temperature transmitter		25 – 30 (2.5 – 3.0)	
Air Injection:			
Adapter on cylinder head		40 (4.0)	
Check valve		55 (5.5)	
Oxygen sensor air line		30 (3.0) 55 (5.5)	 M 18 x 1.5
Exhaust gas test nut on catalytic converter		30 (3.0)	M 14 x 1.5
Exhaust gas test plug on catalytic converter		15 (1.5)	M 8 x 1
Temperature sensor II to thermostat housing		12 (1.2)	
Temperature valve to connector		max. 15 (1.5)	M 10 x 1
CO test line to exhaust manifold		25 (2.5)	
All other bolts and nuts:			
M 6		6 + 2 (0.6 + 0.2)	
M 8		20 + 2 (2.0 + 0.2)	
M 10		40 + 5 (4.0 + 0.5)	

Engine tightening torques (32-valve engine)

Location	Thread	Tightening torque Nm (ftlb)	
Main bearing bolts	M 12 x 1.5	1st stage	30 (22)
		2nd stage	55 (41)
		3rd stage	75 +5 (55 +4)
Main bearing bolts	M 10	1st stage	20 (15)
		2nd stage	50 + 5 (37 + 4)
Oil pump bolts	M 8	1st stage	15 (11)
		2nd stage	20 (15)
Connecting rod bolts Verbusrip nut	M 10 x 1.25	75 (55)	
928 GTS (5.4 l) Engine Type M 28.49/50 Connecting rod bolts (forged con-rods) Verbusrip nut	M 10 x 1.25	25 + 90° tightening angle	
Cylinder head **studs**		1st stage	20 (15)
		2nd stage	90° torque angle
		3rd stage	90° torque angle
		4th stage	90° torque angle
Cylinder head **hexagon head bolts**		1st stage	20 (15)
		2nd stage	90° torque angle
		3rd stage	90° torque angle
Camshaft bearing saddles to cylinder head	M 6 M 8	10 (7) 20 (15)	
Hex socket head bolts for chain tensioner	M 6	10 (7)	
Banjo bolt / chain tensioner	M 8 x 1	10 (7)	
Check valve / chain tensioner	M 10 x 1	15 (11)	
Camshaft bolt union	M 10 x 1.5	65 (48)	
Cylinder head cover	M 6	10 (7)	
Spark plugs	M 14 x 1.25	25 to 30 (18 to 22)	
Flywheel bolts	M 10 x 1.25	1st stage	40 (30)
		2nd stage	90 (66)

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Location	Thread	Tightening torque Nm (ftlb)	
Pulley bolts	M 18 x 1.5	295 (218)	
Oil drain plug	M 20 x 1.5	50 (37)	
Thermostat housing plug	M 48 x 1.5	80 (59)	
Oil pressure sender	M 18 x 1.5	35 (26)	
Pressure release valve plug	M 18 x 1.5	40 (30)	
Short-circuit valve screw-in flange	M 24 x 1.5	70 (52)	
Cylinder block drain plug	M 12 x 1.5	35 (26)	
Radiator drain plug	M 10	1.5 (1)	
Screw-in flange to radiator to engine		70 (52) 70 (52)	
Oil hose to screw-in flange at upper crankcase section	M 26 x 1.5	70 (52)	
at coolant radiator	M 26 x 1.5	70 (52)	
Temperature switch to coolant radiator		40 (30)	
Regulator housing for coolant circuit to engine	M 8	1st stage 2nd stage	10 (7) 20 + 2 (15 + 1)
Temp. sender unit - coolant temperature		25 - 30 (18 - 22)	
Check valve		55 (41)	
Air line		30 (22)	
Oxygen sensor	M 18 x 1.5	55 (41)	
Exhaust gas takeoff plug to catalytic converter	M 8 x 1	15 (11)	
Temp. sensor NTC II to regulator housing		12 (9)	

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Location	Thread	Tightening torque Nm (ftlb)
Knock sensor bolt union	M 8	20 (15), without washer
Knock sensor bolt union as of Engine No. M 28.42 81 M 51771 M 28.47 85 M 01112 928 GTS (5.4 l) engine type M 28.49/50	M 8	20 (15), original screw (micro-seal type) without washer
Intake rail mounting	M 8	15 (11)
Hall sender mounting	M 6	8 (6)
CO branch line mounting to exhaust manifold		25 (18)
All other nuts and bolts		
M 6 M 8 M 10		8 + 2 (6 +1) 20 + 2 (15 +1) 40 − 5 (30 +4)

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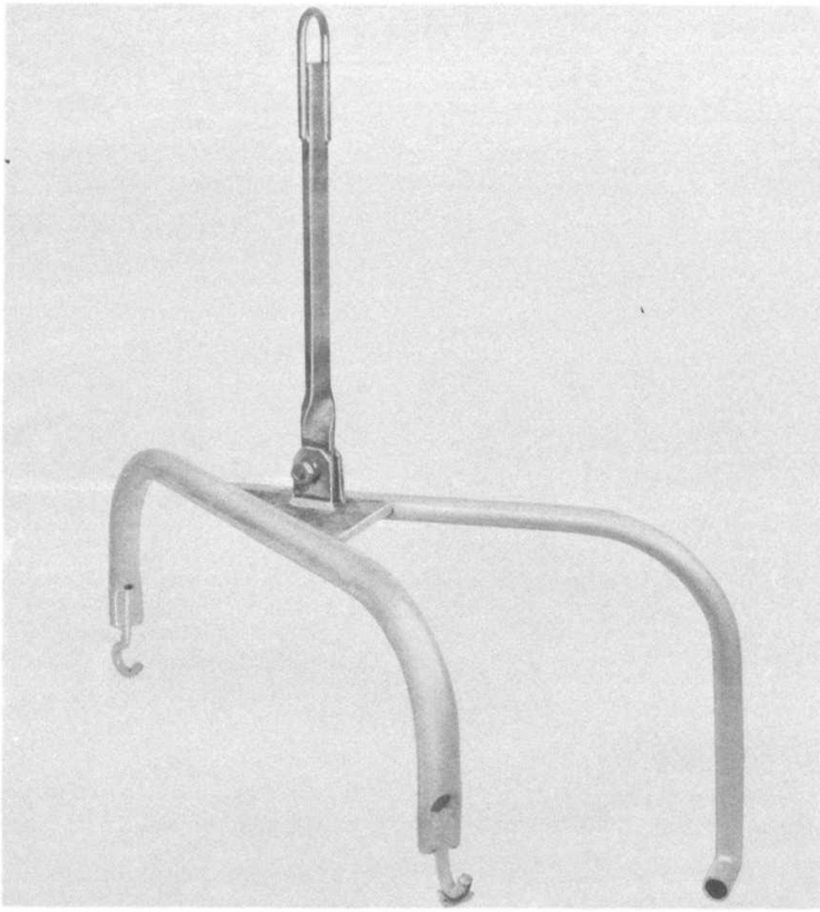
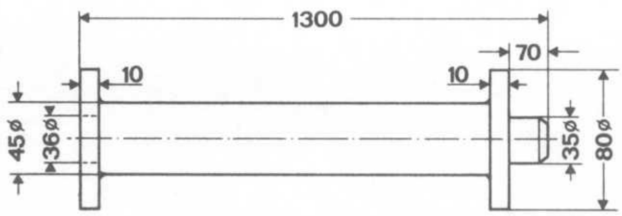
TOOLS





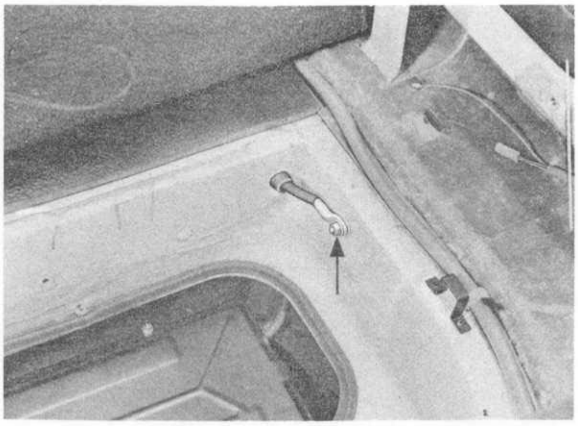
No.	Description	Special Tool	Remarks
1	Adapter for removal and installation of engine	9137	Used in conjunction with shop hoist

REMOVING AND INSTALLING ENGINE

Removing

1. Use fender and bumper protective covers.

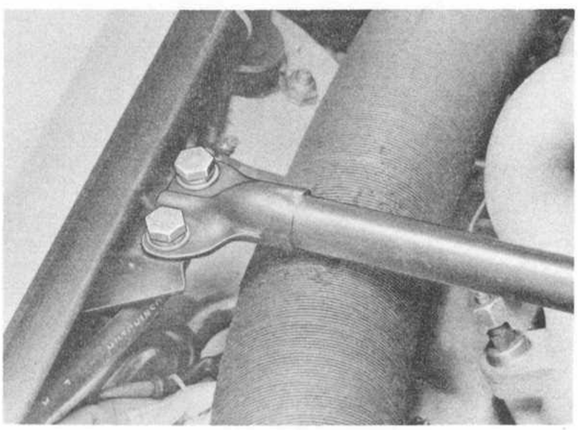
2. Disconnect battery ground cable at spare wheel well.



3. Loosen and remove engine compartment cross brace.

Note

Car must stand on its wheels when cross brace is removed or installed.



4. Set up hoist and align with specified pick-up points on car, but do not raise car.

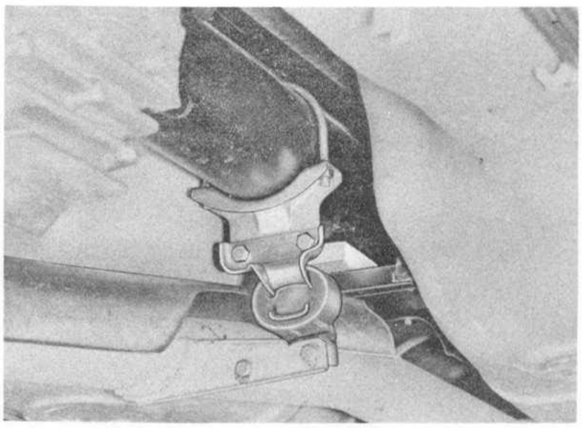
5. Detach windshield washer hoses and engine compartment light wires.

6. Disconnect engine hood supports at top, loosen engine hood bolts and remove engine hood.

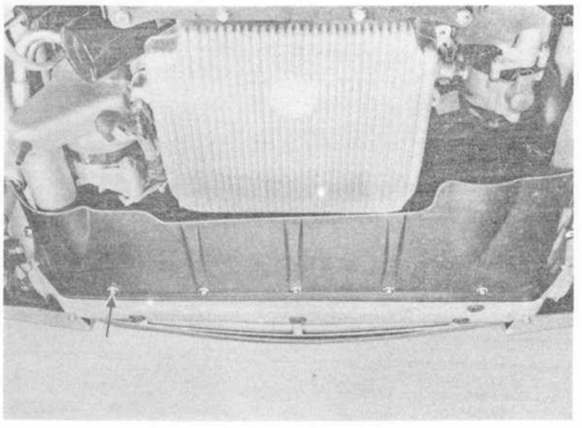
7. Remove cap from coolant expansion tank.

8. Remove air intake hoses and entire air cleaner assembly.

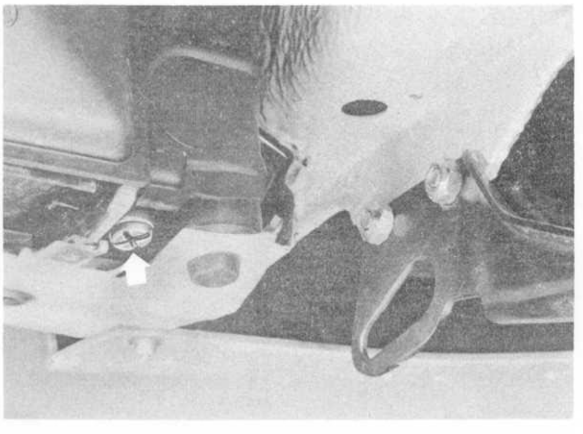
9. Raise car. Place piece of wood (locally manufactured) on central tube and rear tunnel brace.



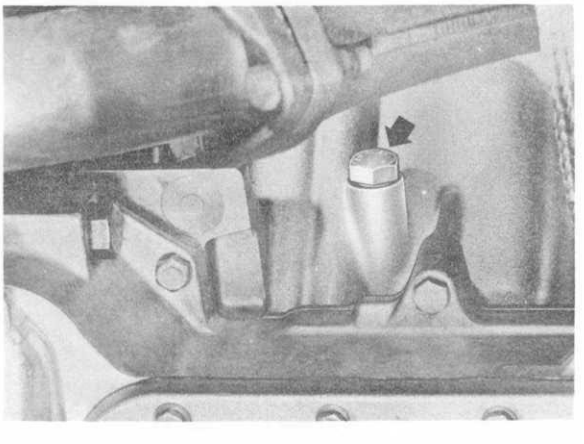
10. Detach splash shield at bottom.



11. Drain coolant from radiator.

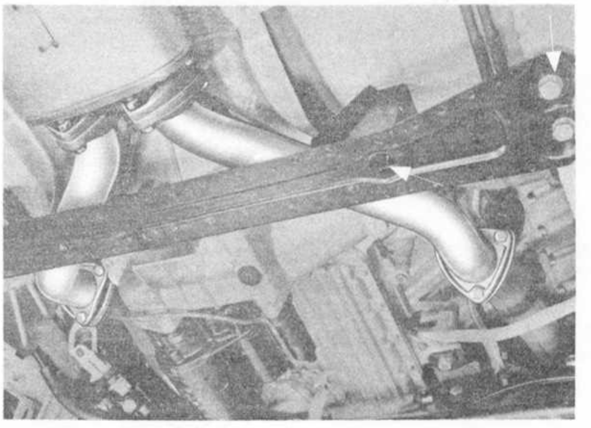


Remove water drain plugs on left and right side of crankcase.

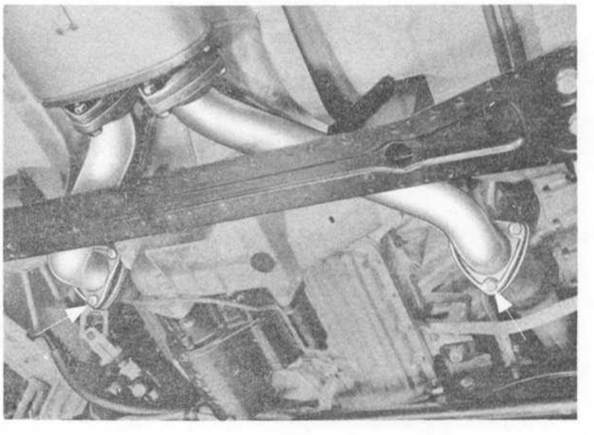


12. Drain engine oil.

13. Remove lower body brace.



14. Detach exhaust pipes at exhaust manifolds and heat shields on left and right sides.



15. Detach ground cable at body.

16. Install and tighten oil drain plug to specified torque.

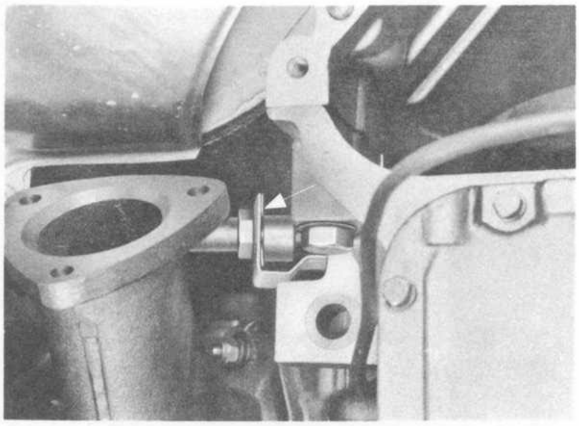
17. Install and tighten coolant drain plugs to specified torque.

18. Unscrew clutch slave cylinder at clutch housing and remove with line connected.

Note

Do not operate clutch pedal.

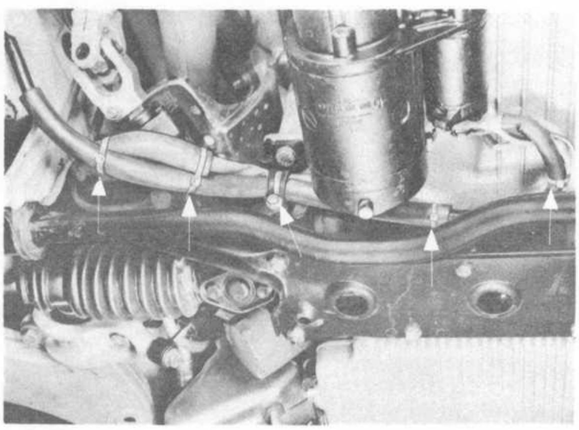
19. Remove mounting strap for pressure line to slave cylinder.



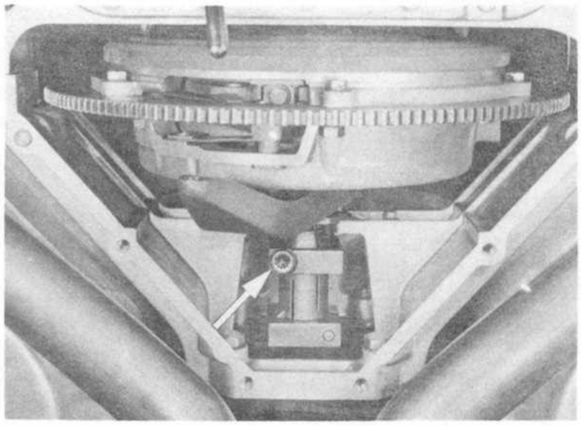
20. Disconnect wires on starter.

21. Remove clutch housing cover with starter. Disconnect release lever at ball pin by pressing release lever down in direction of clutch.

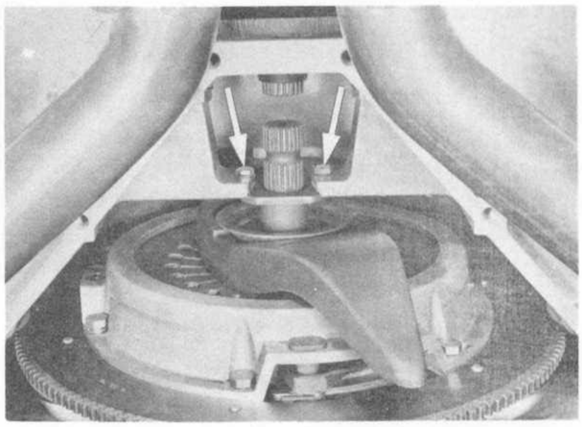
22. Open clamps for starter wires on steering cross member.



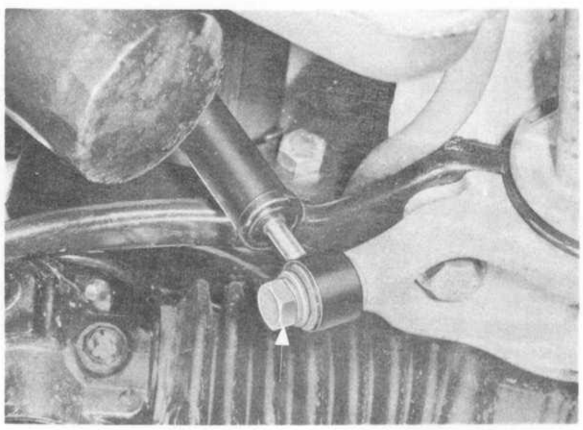
23. Remove socket head bolts and slide back clamping sleeve on drive shaft.



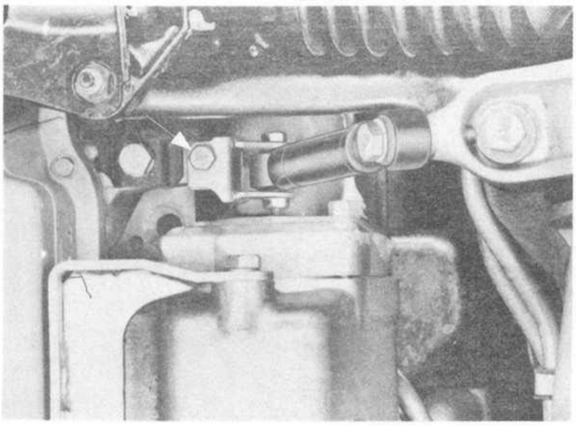
24. Unscrew throwout bearing sleeve mounting bolts and push sleeve in direction of clutch.



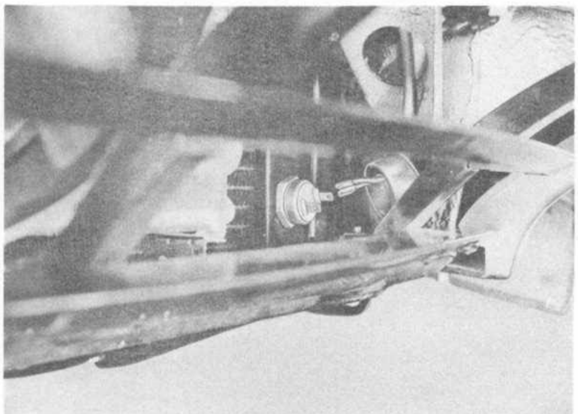
25. Disconnect left and right engine shock absorbers at control arms.



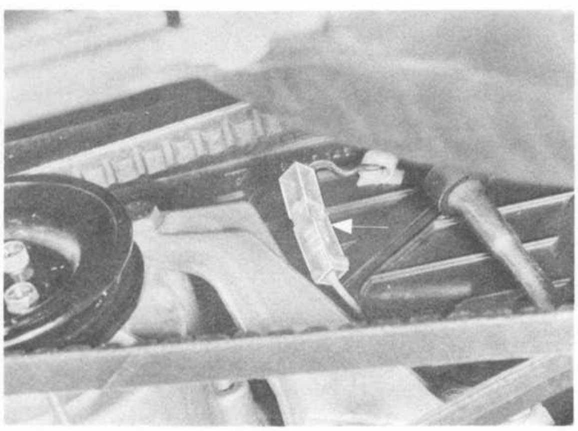
26. Detach engine shock absorbers with left and right mounts.



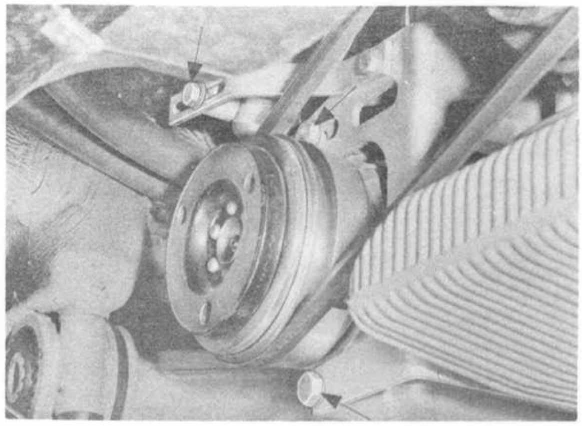
27. Cars with air conditioning: Detach temperature switch wires on radiator.

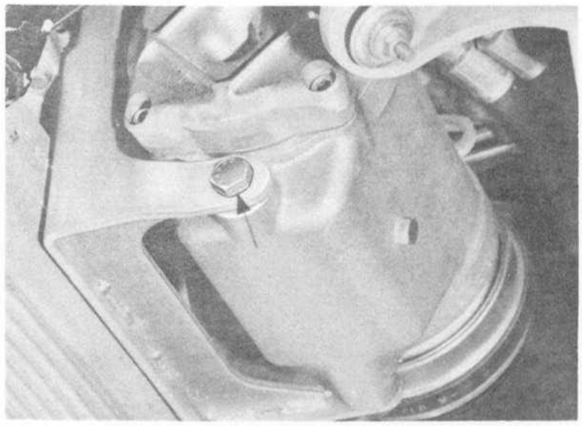


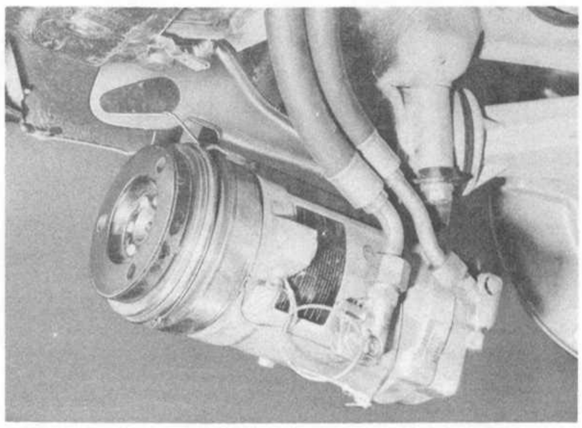
Disconnect plug leading to compressor (on right drive belt cover).



28. Loosen compressor, remove from console and suspend it with the hoses connected.



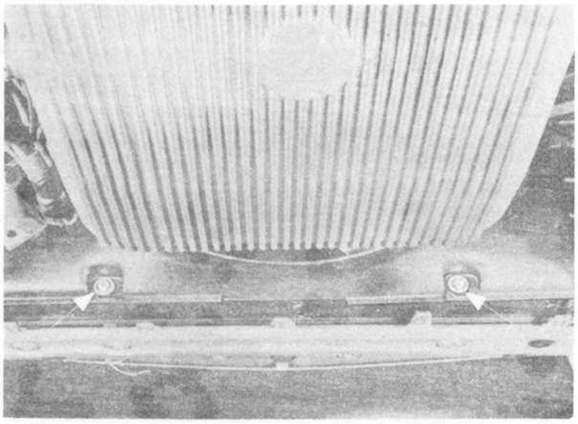




29. Loosen and remove air pump filter housing.

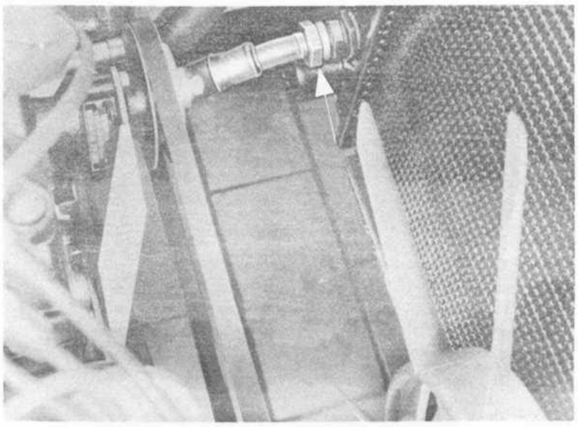
30. Detach alternator cooling hose.

31. Loosen lower fan shroud at radiator and remove.



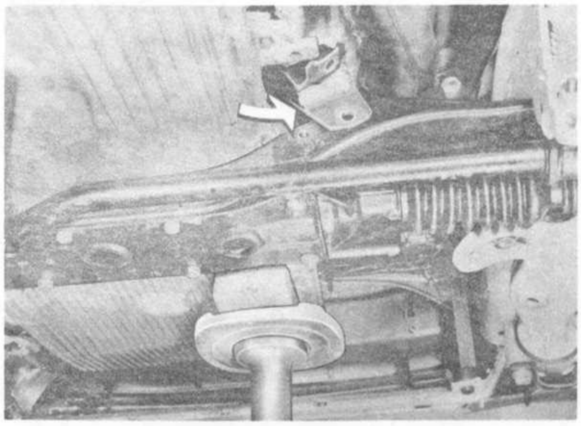
32. Detach all coolant hoses at radiator.

33. Detach bottom oil hose at radiator.



34. Remove engine mounts separately by applying a lifting force from one side to engine with a hydraulic jack, locally manufactured pad and an appropriate piece of wood on the oil pan, loosening the bolts, lifting the engine and removing the engine mounts.

Place engine on front cross member carefully. Remove second mount accordingly.



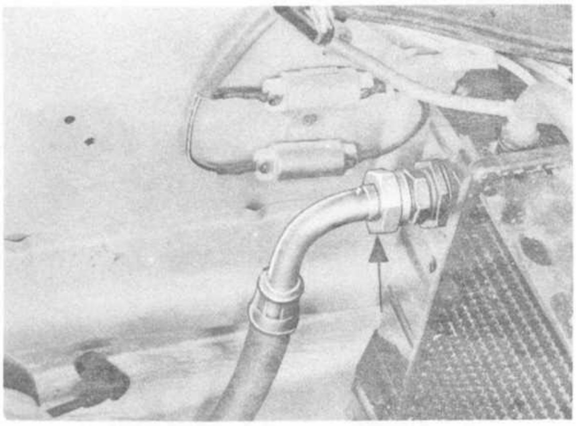
35. Remove clutch/engine mounting bolts.

36. Lower car.

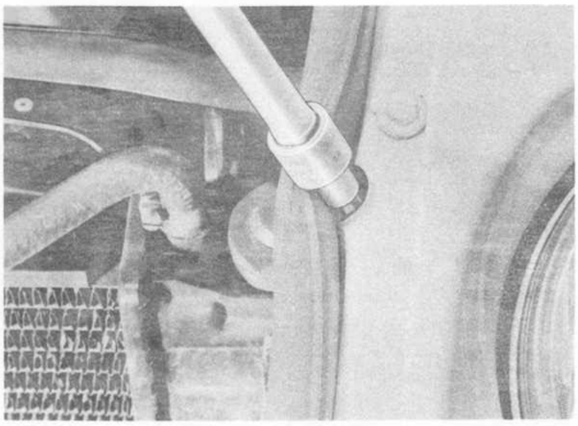
37. Loosen and detach vent hose at T-adaptor for radiator and thermostat housing.

38. Loosen and detach coolant hoses at thermostat housing.

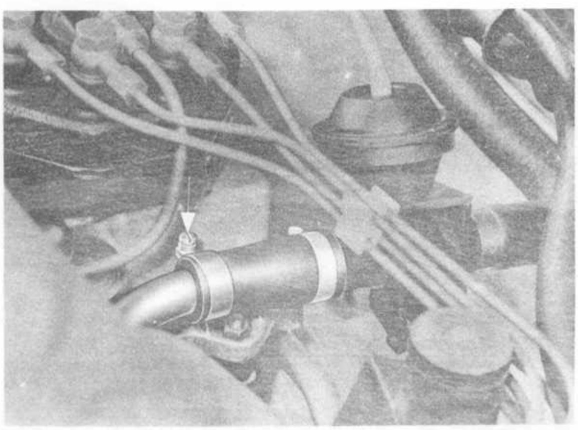
39. Detach upper oil hose at radiator while counterholding.



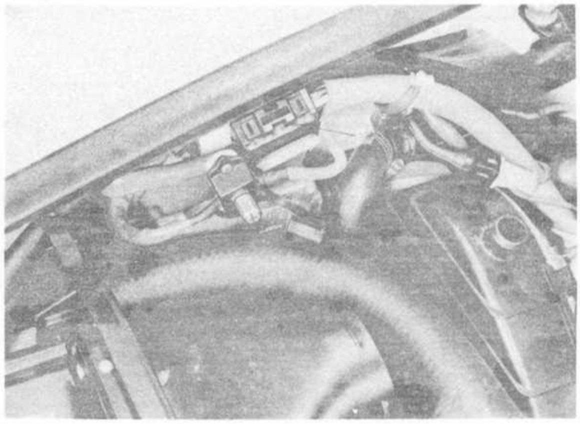
40. Loosen top radiator mountings and lift out radiator carefully.



41. Open hose clamp and remove hose between heater valve and neck.



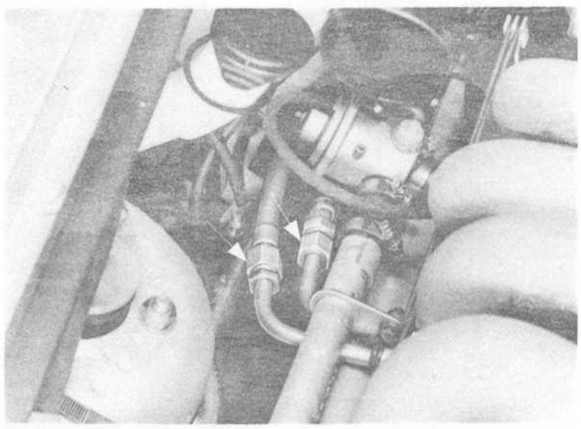
42. Disconnect B + wire, plug of transmitter wire to distributor and plug for engine wire harness.



43. Remove control unit.

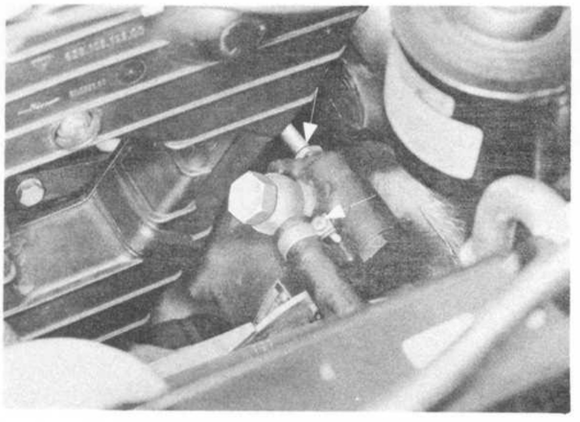
44. Detach ignition coil and place aside.

45. Detach fuel feed and return lines while counterholding.



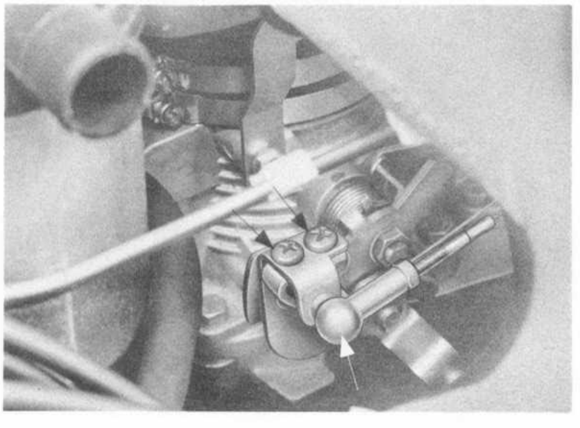
46. Detach hydraulic line at power steering pump.

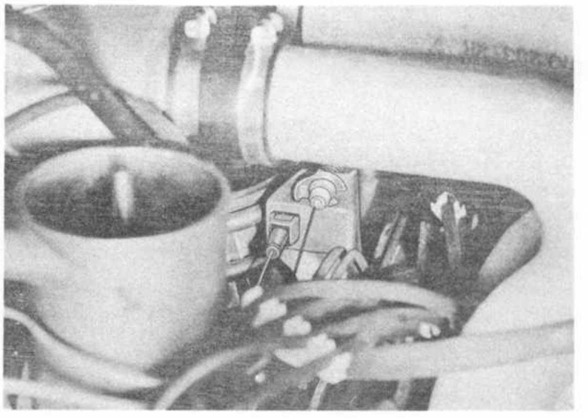
47. Detach oil hoses at supply tank of power steering pump, drain oil and remove tank.



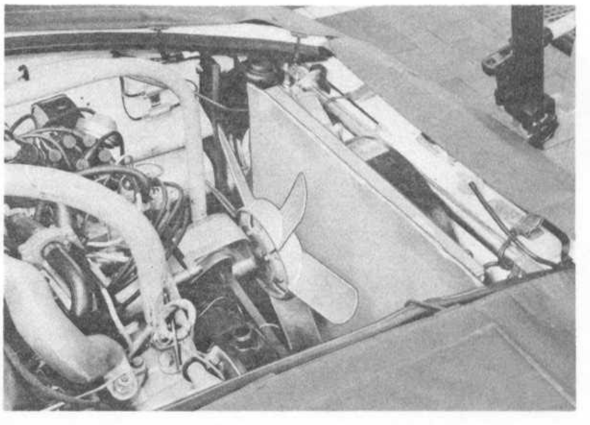
48. Detach brake booster vacuum hose at manifold.

49. Disconnect operating cable for accelerator pedal and cruise control, remove holder and clamp, and place cables outside.





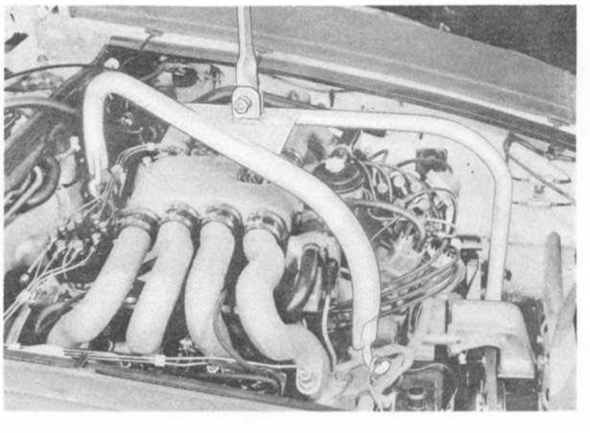
50. Be sure to cover condenser on cars with air conditioning to prevent damage when removing and installing (e.g. with a wood board).



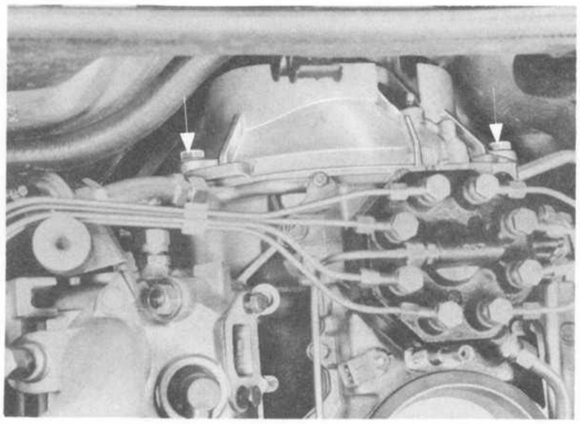
51. Engage adapter 9137 (in conjunction with floor hoist) in the eyelets provided for this purpose. Raise adapter until tight on engine.

Note

This requires that car stands on its wheels.

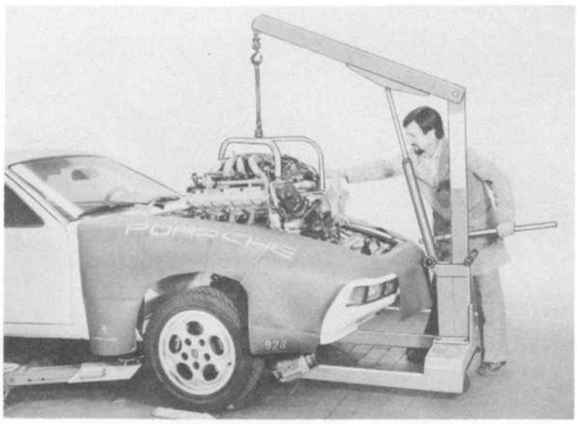


52. Unscrew top engine block/clutch housing mounting bolts.



53. Pull engine forward carefully and remove central shaft I with guide tube.

54. Lift out engine.



Installing

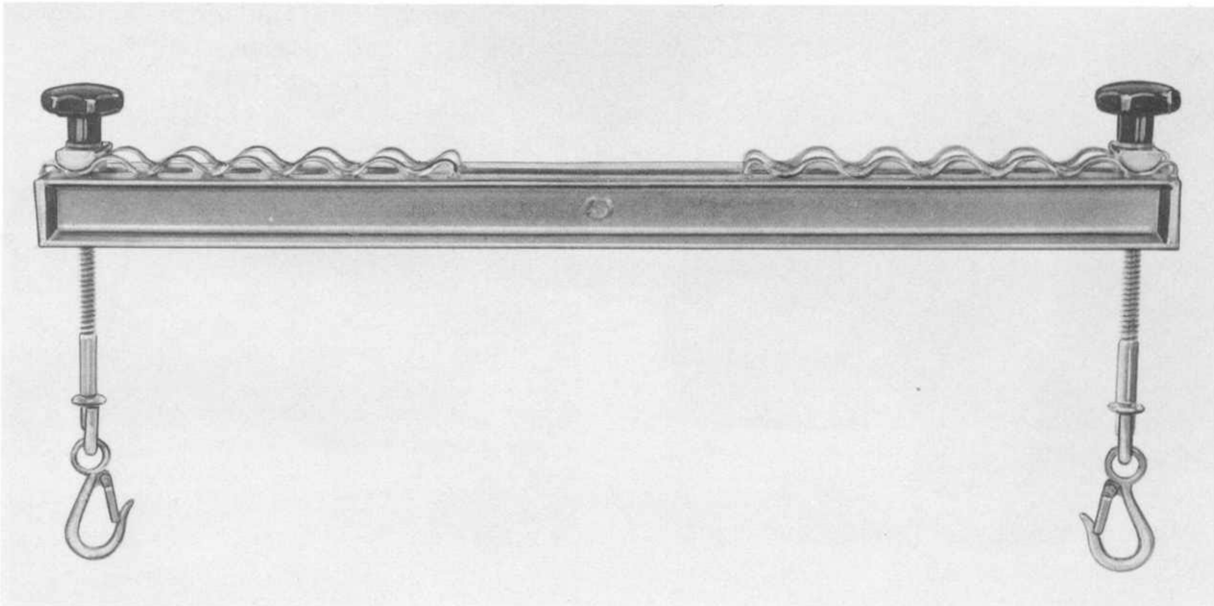
Note the following for installation.

1. Tighten nuts and bolts to specified torques.
2. Add coolant until level is at edge of filler opening (position-heater lever at "warm").
3. Run engine to operating temperature and check coolant level, adding more coolant if necessary.

   Coolant level must reach center of expansion tank.

ENGINE; REMOVING AND INSTALLING

(32-VALVE ENGINES) TOOLS



No.	Designation	Special Tool	Remarks
	Engine lifting tackle	3033	VW Special tool

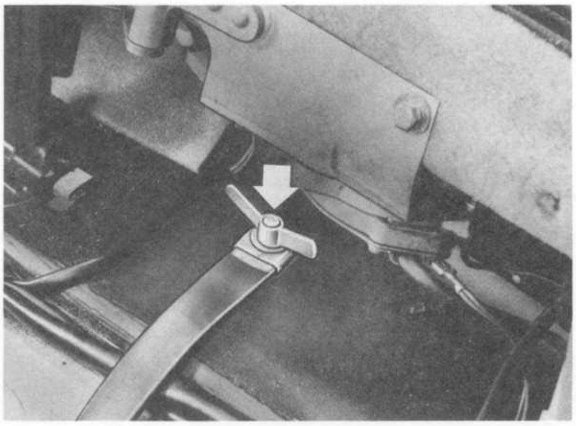
Please note:

If necessary, use a commercially available carabiner (650 kg load-bearing capacity) to attach engine lifting tackle to workshop hoist.

ENGINE, REMOVING AND INSTALLING
(32-VALVE ENGINES)

R e m o v a l

1.Disconnect ground lead to battery behind tool plate.



2.Place cover over fender and bumper.

3.Unbolt and remove cross member.

N o t e

Vehicle must be standing on its wheels. Cross member is tensioned.

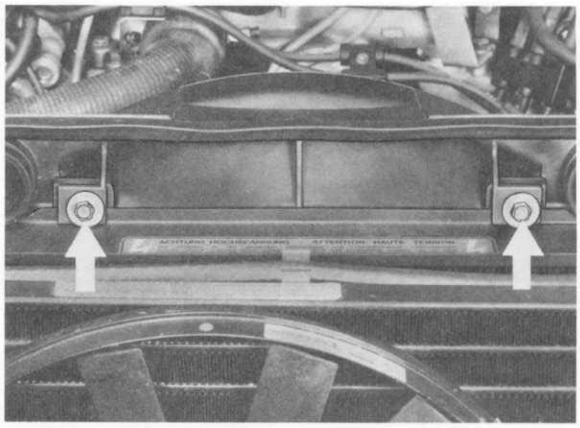
4.Position lifting platform and engage vehicle jacking points.

5.Disconnect hoses for windscreen washer, heated spray nozzles and cable for engine compartment light.

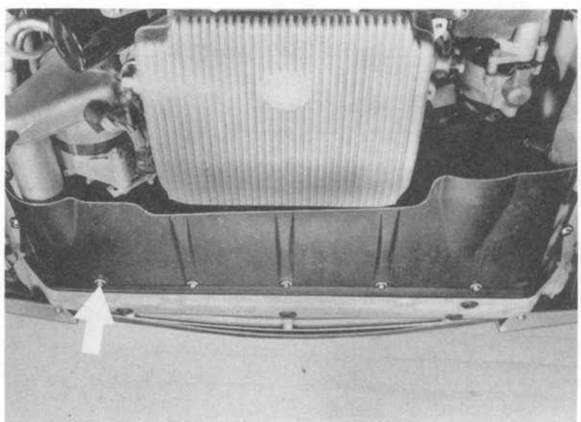
6.Unhook accelerator spring retaining clamp at bottom, unscrew hood mounts and lift off hood.

7.Remove air intake hoses and air filter housing as a unit.

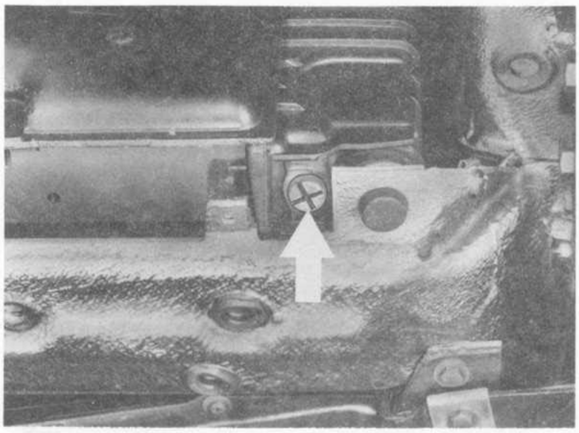
8.Open cap of cooling water expansion tank and remove top of air deflector from cooler.



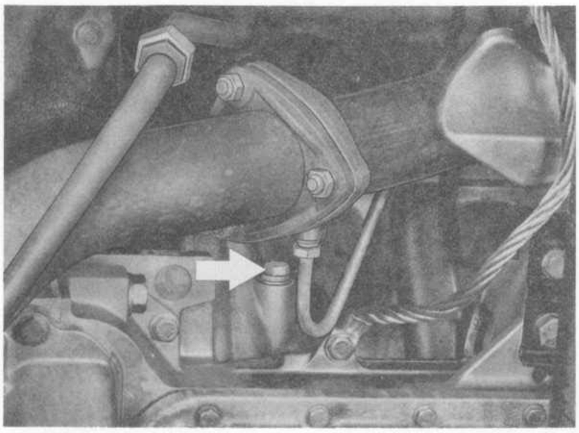
9.Raise vehicle and remove oil pan guard.



10.Drain cooler. (Catch coolant in suitable container).



11.Unscrew water drain plugs on left and right of crank-case upper half.

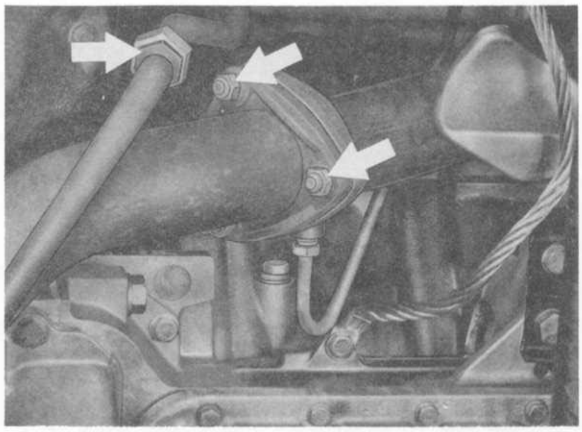


12.Drain engine oil. (Only if engine is to be overhauled.)

13.Disconnect exhaust flanges on left and right of exhaust manifold and unscrew air injector.

N o t e

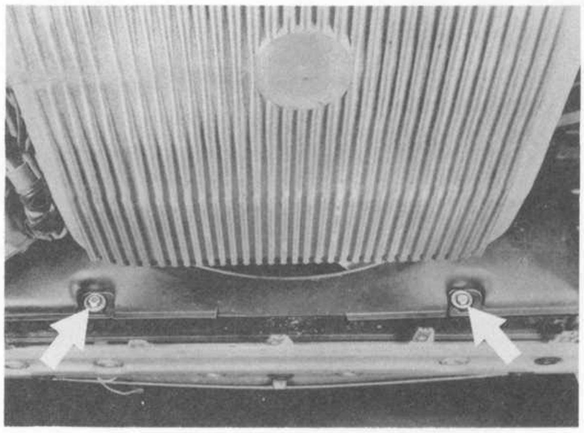
Wrap a piece of wire around exhaust system behind junction and attach to cross member.



14.Disconnect body-engine ground connection at engine.

15.Replace cooler drain plug and tighten to specified torque, 1.5 Nm (0.2 kpm).

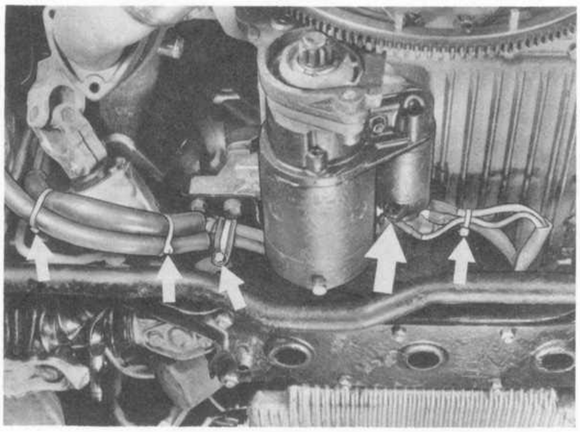
16.Remove bottom section of air deflector from cooler.



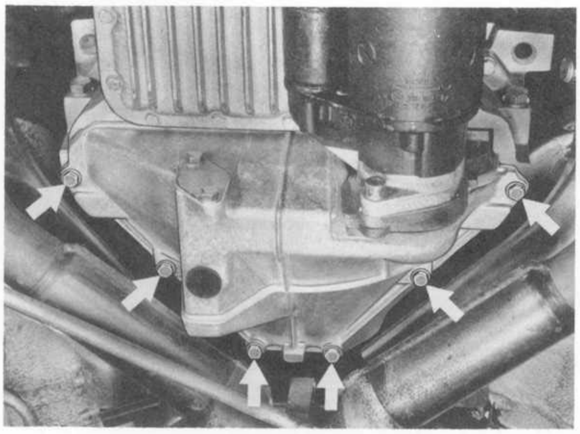
17. Pull air hose off alternator.

18. Disconnect cable from starter.

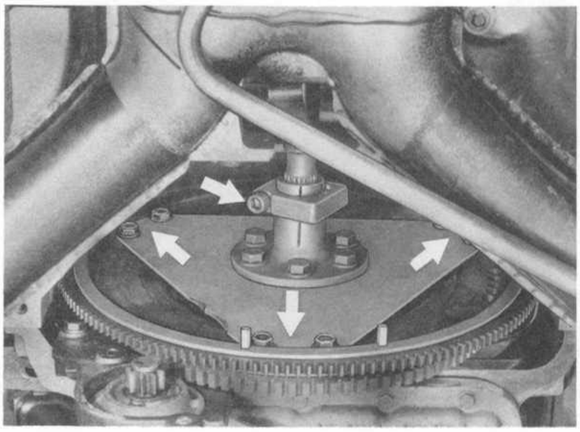
19. Detach clamps for starter cable from steering transverse and pull alternator cable thru toward front of vehicle.



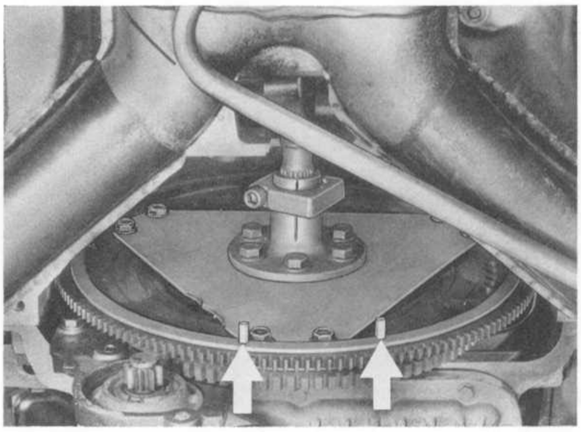
20. Remove cover from clutch housing.



21. Unscrew bolts holding driving plate, unscrew pan head screw of bearing sleeve, push driven plate back along central shaft.



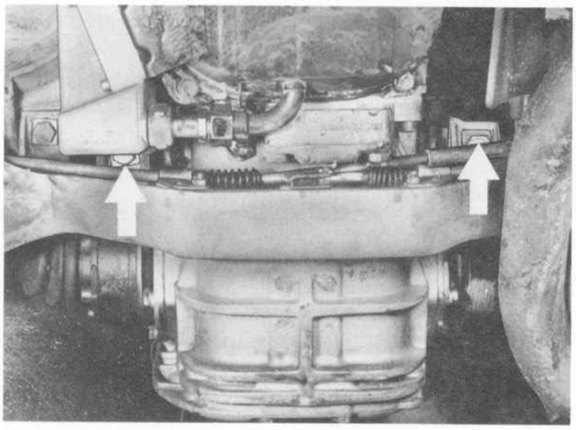
22. The pins for the oil temperature sensor must point downward before engine can be removed.



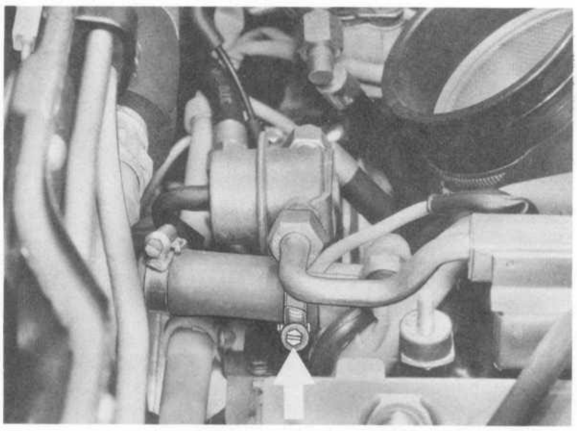
Note:

The clutch must be removed completely for vehicles from Model 87, engine type M 28.41 onwards. Refer to the Workshop Manual, Page 30 - 6b.

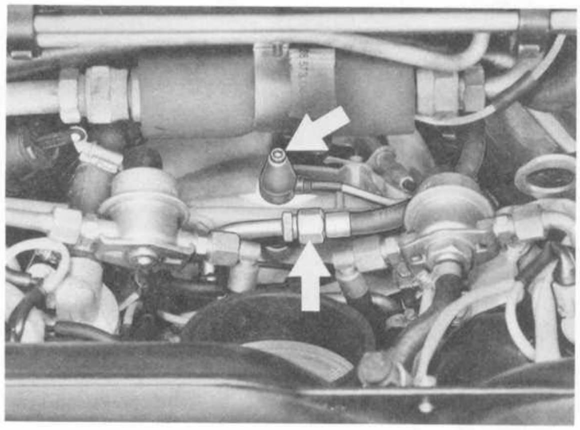
23.Remove both transmission mount bolts.



24.Disconnect hose from heating regulator and pipe stub on engine and remove. Pull underpressure line for automatic transmission from underpressure distributor.

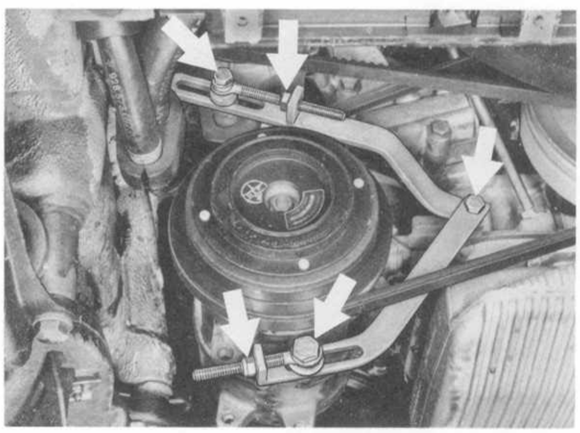


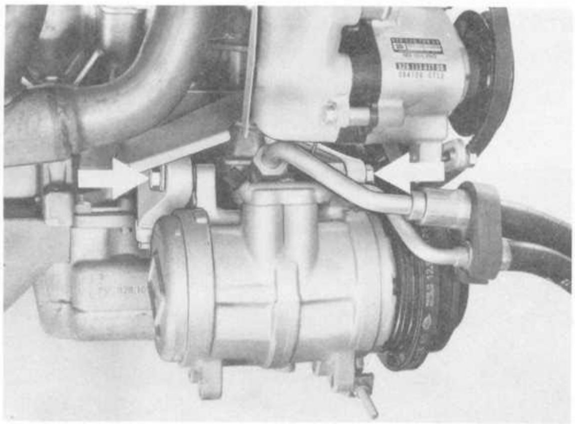
25.Disconnect and remove oil temperature sensor. Disconnect fuel return line while countering nut with second open-ended wrench.



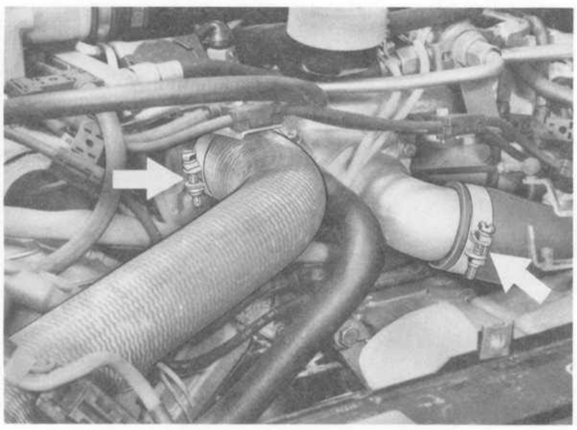
26.Unscrew bolts for clutch housing-engine housing top and bottom (e.g. jointed socket wrench) and push transmission toward rear (approx. 5 - 6 mm).

27.Disconnect air conditioner compressor plug connector, remove compressor from bracket and hang on one side with hoses in place.

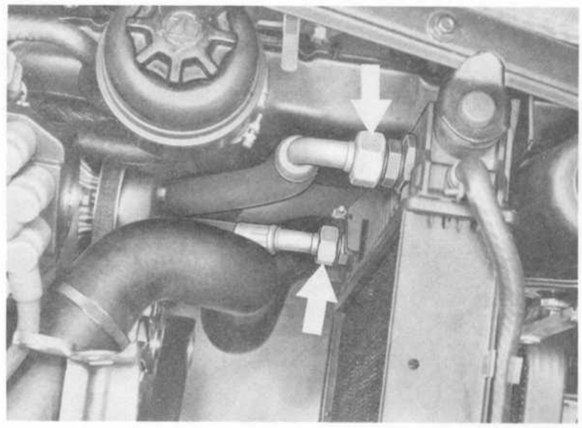




28. Detach both coolant hoses from cooler at regulator housing and remove.

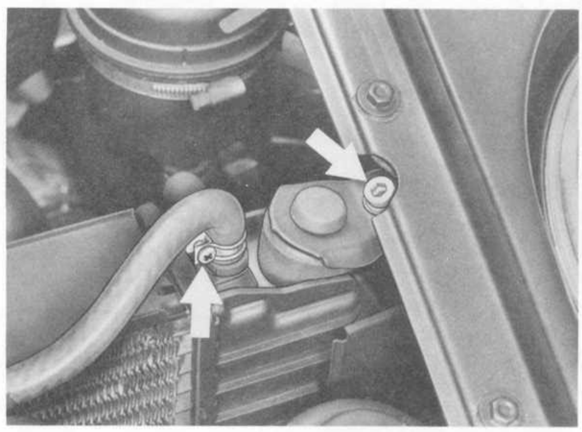


29. Detach oil hoses for engine cooling and ATF cooling from top and bottom of cooler, countering with second open-ended wrench.

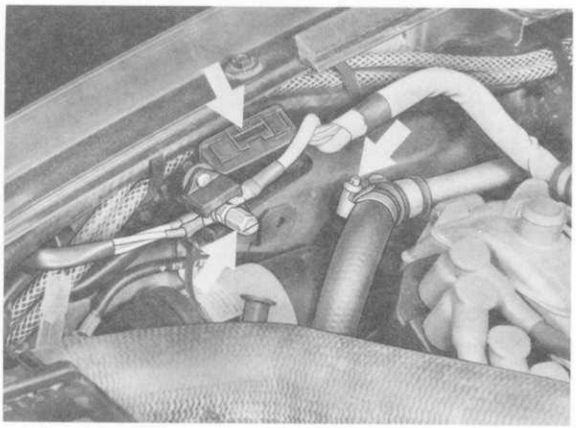


30. Disconnect cable from temperature switch at bottom left of cooler.

31. Disconnect bleed hose from top left of cooler, unscrew cooler attachment and lift cooler carefully up out of engine compartment.

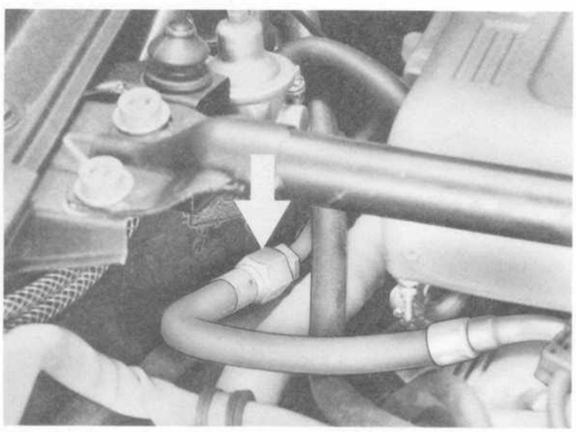


32. Disconnect coolant filler hose from cooler tube at front right, and remove. Disconnect multiplug and B+ terminal.



33. Disconnect bleed hose from cooling water expansion tank at engine and remove.

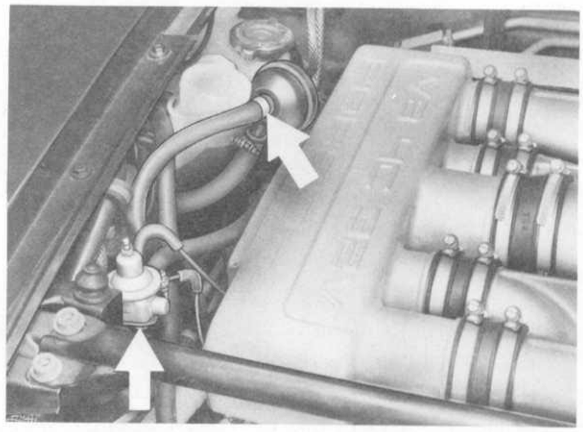
34. Disconnect fuel supply line, countering with second open-ended wrench.



35. Disconnect ignition leads on both sides from distributor cover, remove both ignition coils from bracket and lay to one side.

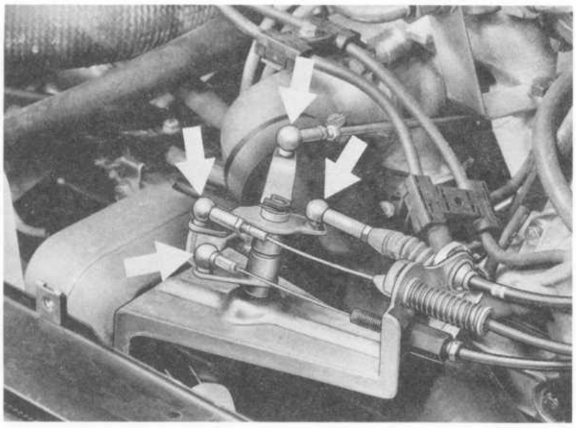
36. Detach filter housing from air pump.

37. Remove scavenging valve from holder. Disconnect hose from air-bleed valve and remove. Disconnect underpressure hose from EZF control unit.



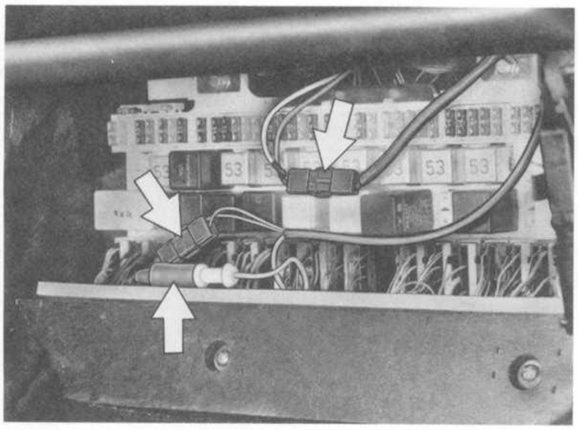
38. Disconnect underpressure hose from brake servo unit and remove.

39.Disengage actuating cables for throttle, cruise control and control cable for automatic transmission. Remove safety devices and clamp from bracket and lay cables over fender.

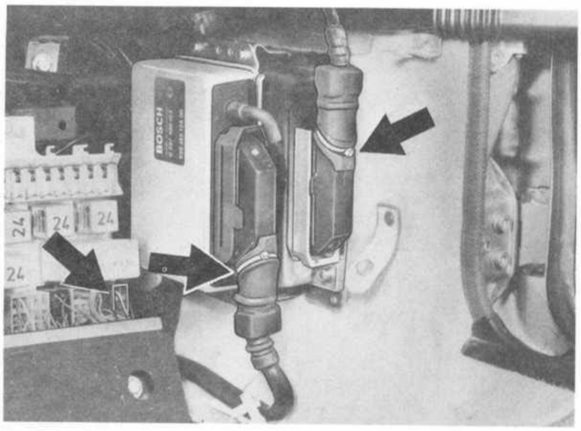


40.Disconnect oil hoses from servo pump reservoir, drain oil and catch in suitable container. Disconnect hose clamp from reservoir and remove reservoir.

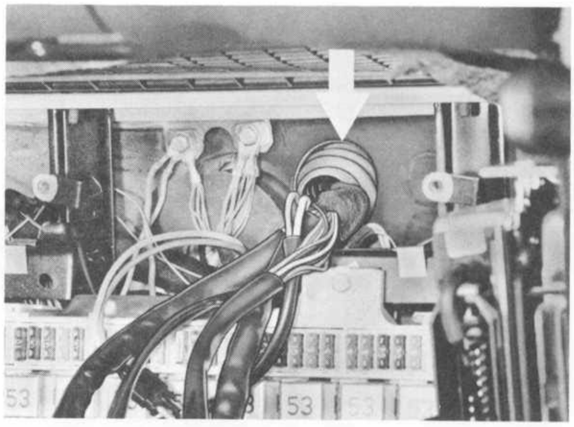
41.Remove cover of central electrics unit. Disconnect plug-type connectors for Lambda probe, probe heating and electronic ignition.



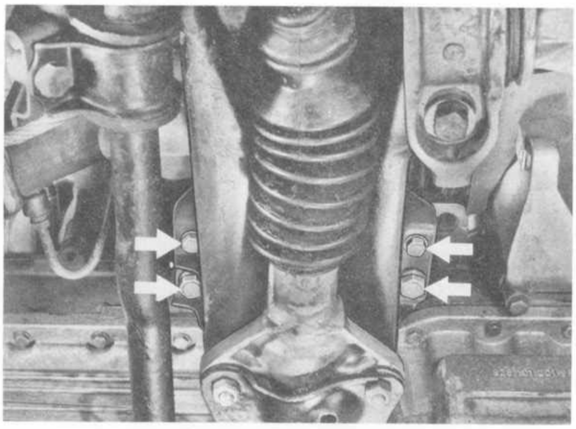
42.Disconnect multiplugs from EZF and LH control units, together with multiplug at right of central electrics unit.



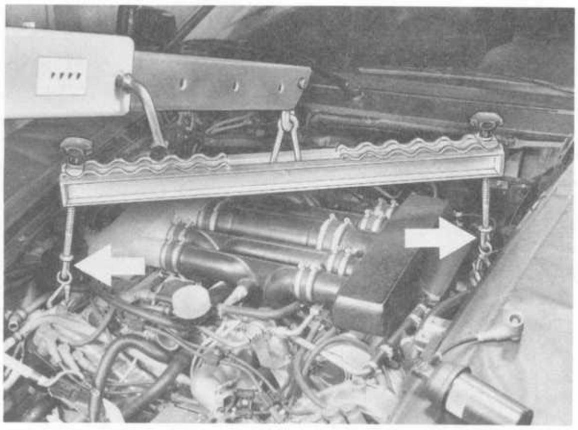
43.Push rubber sleeve out of holder into engine compartment.



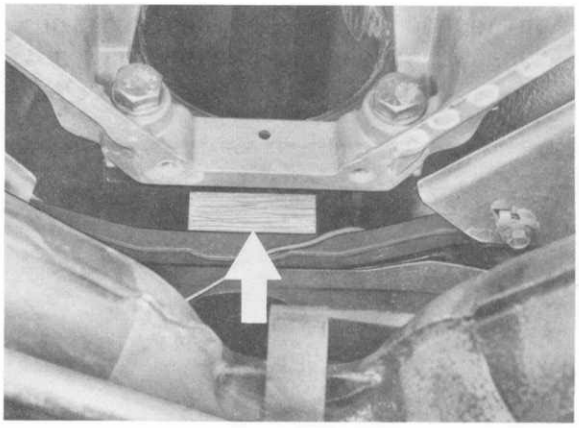
44.Unscrew left-hand and right-hand mount bolts in underside of engine brace.



45.Attach VW 3033 lifting tackle mounted on workshop hoist (e.g. Bilstein K 750 H) to eyes and slightly tension lifting tackle.



46.Place wooden block (improvised) between central pipe and cross member.



47.Tilt engine carefully toward front, lifting slightly. Once engine housing and clutch housing separate, engine can be hoisted out of vehicle.

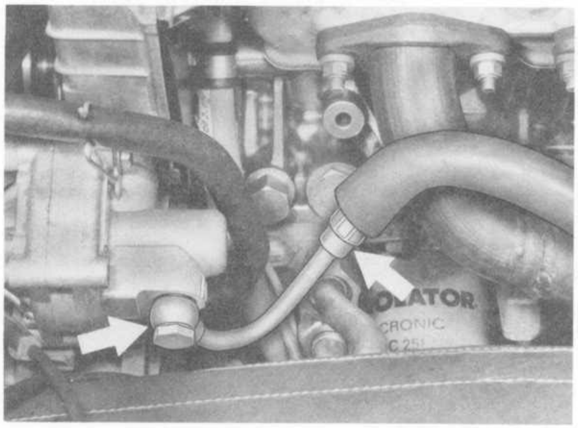
N o t e

Care must be taken to ensure that the cable bundle from the central electrics unit is paid out as the engine is lifted clear of the vehicle.

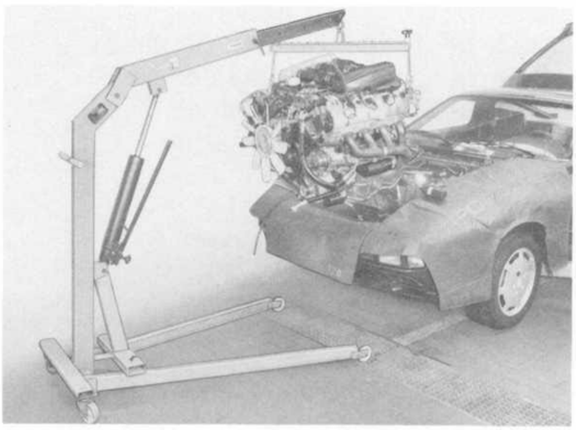
48.Disconnect delivery hose from servo pump and remove.

N o t e

Mark position of delivery hose before disconnecting.



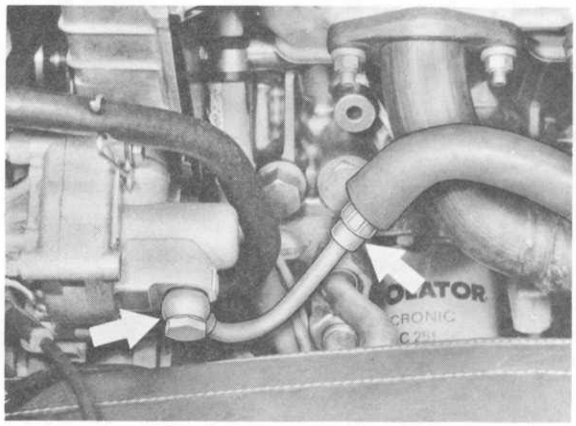
49.Lift engine clear of vehicle.



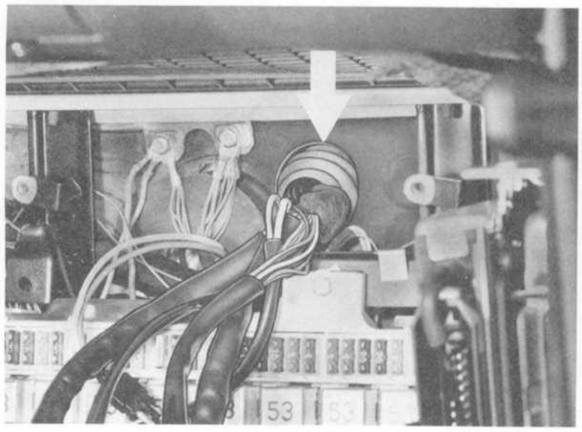
I n s t a l l a t i o n

Note the following:

1.Push transmission to rear. Place wooden block (improvised, 25 mm thick) between drive shaft casing and cross member. Connect the servo pump delivery line before installing the engine. (Note mounting position).



2.Insert cable bundle of central electrics.



3. Lower the engine onto the hydraulic mounts. Detach lifting bar and workshop hoist.

4. Use a car jack to raise the clutch housing and transaxle and bring the engine to its installation position.

Note

To avoid placing the driver plate of the flywheel under strain, start by fitting the driver plate to the flywheel using the six bolts and only tighten the pan-head screw of the clamping sleeve afterwards.
Tightening torque: 80 Nm

5. Top up coolant level to lip. Set heater lever to "warm".

6. Run the engine until it reaches its operating temperature, check engine oil and coolant levels, top up if necessary. The coolant level should lie near the middle of the expansion tank.

7. Fill hydraulic steering fluid reservoir and bleed the steering system.

8. Top up the ATF in the transmission.

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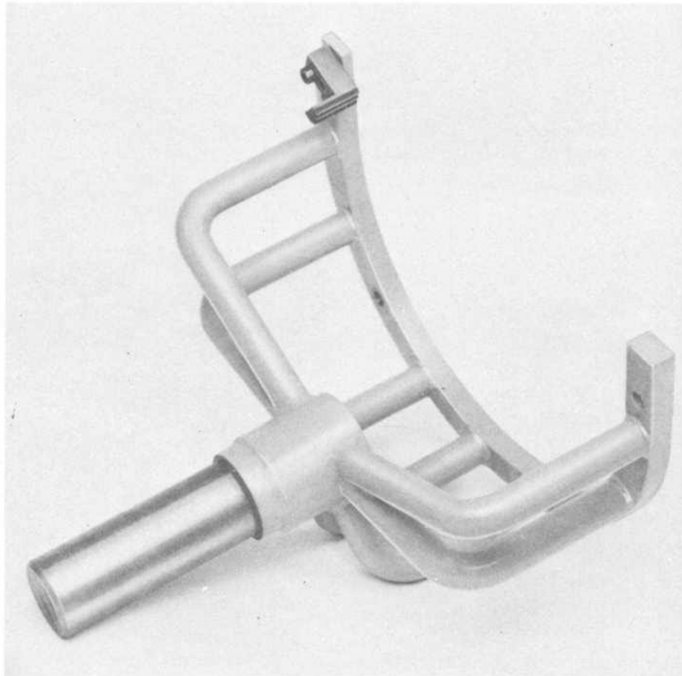
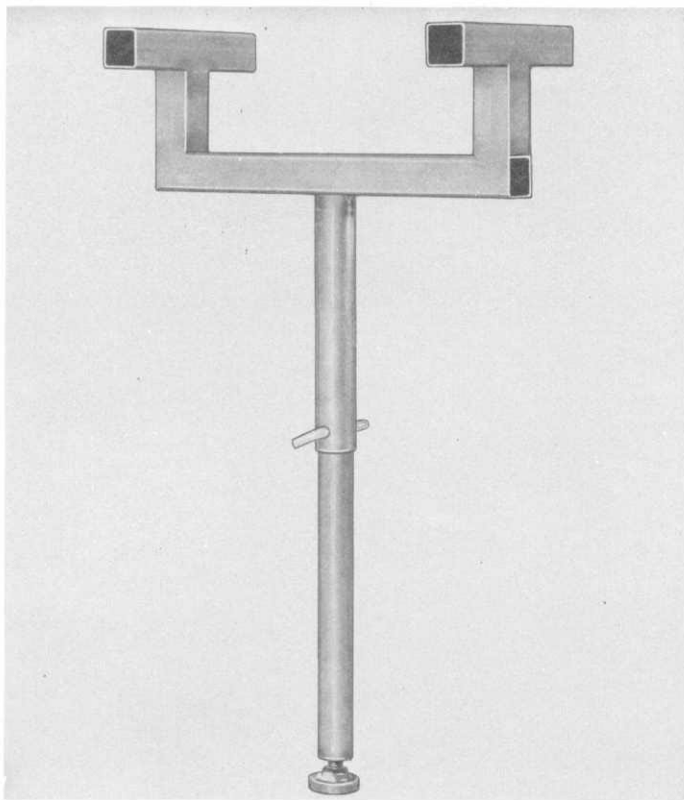
TOOLS

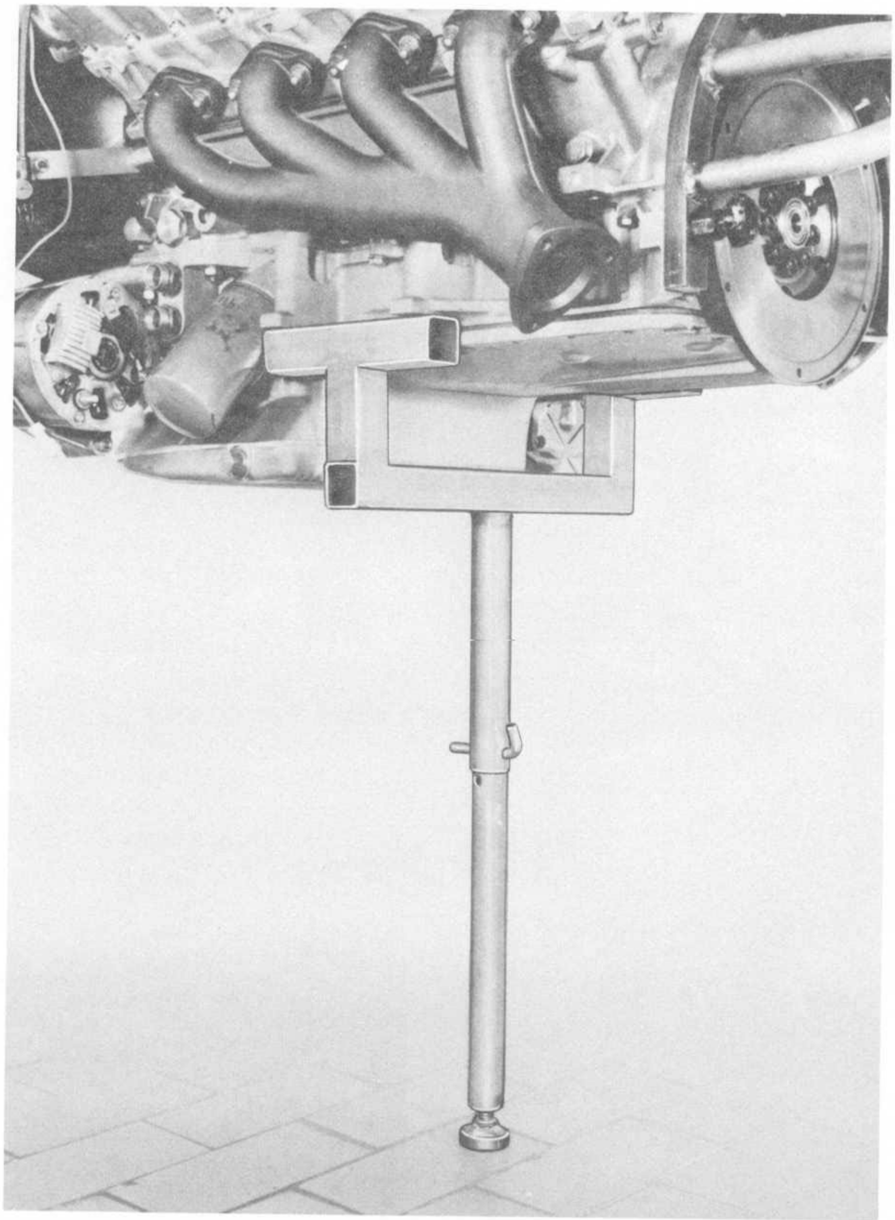




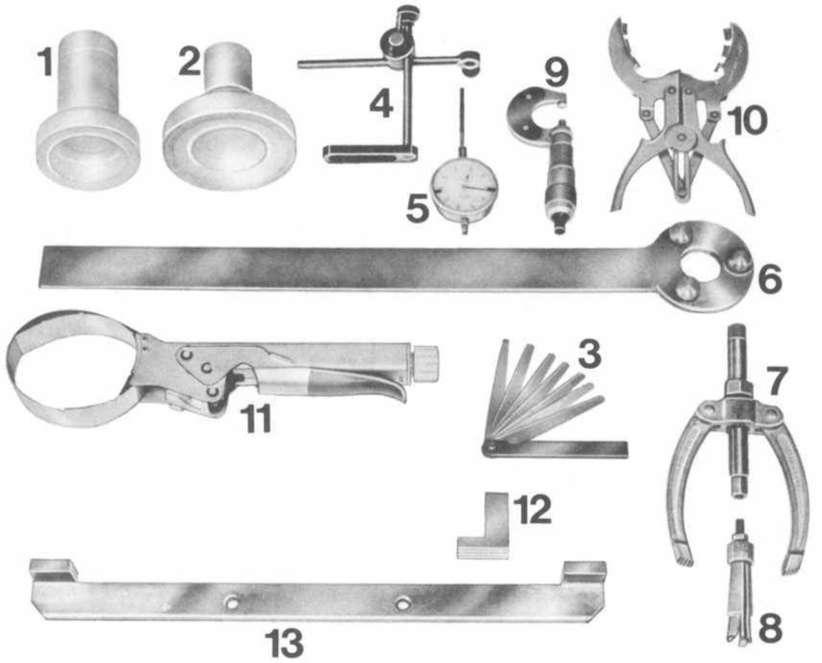
No.	Description	Special Tool	Remarks
1	Engine holder	9127	
2	Engine support	9128	

USING ENGINE SUPPORT (SPECIAL TOOL 9128)

We recommend using the engine support as from the state "cylinder heads installed" when assembling the engine.

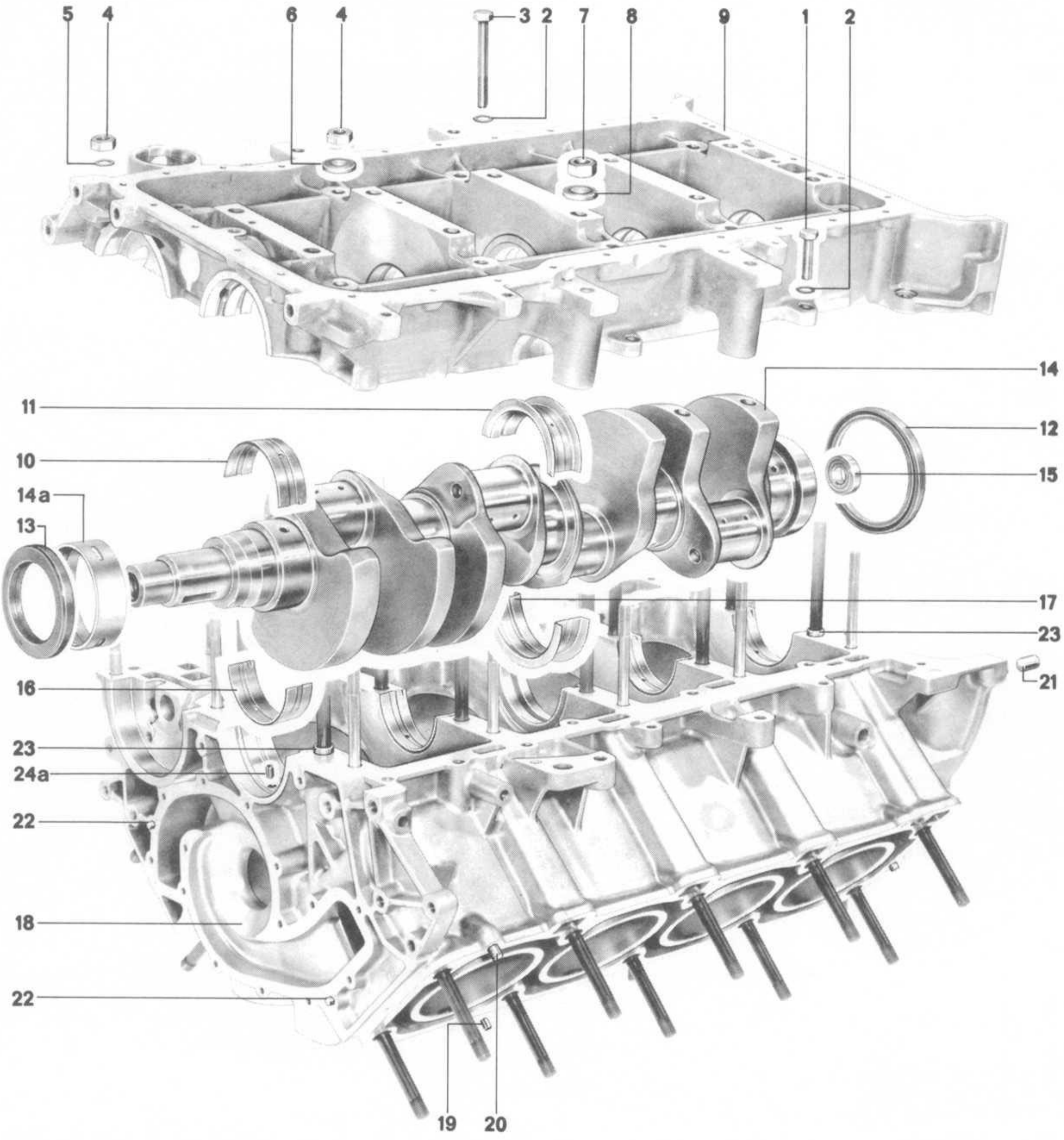


TOOLS



No.	Description	Special Tool	Remarks
1	Crankshaft oil seal extractor (pully end)	9125	
2	Crankshaft oil seal extractor (flywheel end)	9126	
3	Feeler gage		Standard
4	Dial gage holder	VW 387	
5	Dial gage		Standard
6	Holder (for loosening oil pump drive gear)	9157	
7	Puller spindle	US 1039	
8	Internal extractor		Standard, e. g. Kukko No. 21/2 (14.5 to 18.5 mm)
9	Micrometer		Standard
10	Piston ring pliers		Standard
11	Piston ring compressor	US 1008 A	
12	Toothed segment	Part of 9127	
13	Flywheel holder	9130	

DISASSEMBLING AND ASSEMBLING CRANKCASE AND CRANKSHAFT



No.	Description	Qty.	Note When: Removing	Note When: Installing	Special Instructions
1	Bolt M 8 x 30	6			
2	Washer B 8	16			
3	Bolt M 8 x 65	10			
4	Nut M 10 (plastic coated threads)	10		Always replace	
5	Washer	2			
6	Washer	10			
7	Nut M 12 x 1.5 (plastic coated threads)	10		Always replace	
8	Washer	10			
9	Crankcase lower section	1		Clean sealing surface to remove grease	
10	Main bearing shell half	4		Lubricate	
11	Thrust bearing half (bearing 3)	1		Lubricate	
12	Shaft seal (flywheel end)	1		Replace	
13	Shaft seal (pulley end)	1		Replace	
14	Crankshaft	1		Check end and radial play	
14a	Closed main bearing shell, bearing 1	1		Lubricate, make sure bearing engages in pin	
15	Grooved ball bearing	1	Pull out with Kukko	Check, replacing if necessary	
16	Main bearing shell half	4		Lubricate	

No.	Description	Qty.	Note When: Removing	Installing	Special Instructions
17	Thrust bearing shell half (bearing 3)	1		Lubricate	
18	Crankcase upper section	1		Clean sealing surface to remove grease	
19	Key	2		Install facing forward	
20	Dowel pin	4			
21	Dowel pin	2			
22	Dowel pin	2			
23	Dowel sleeve	2			
24	Key since 1982 models	1		Position correctly	

SEALING UPPER AND LOWER CRANKCASE SECTIONS

Note

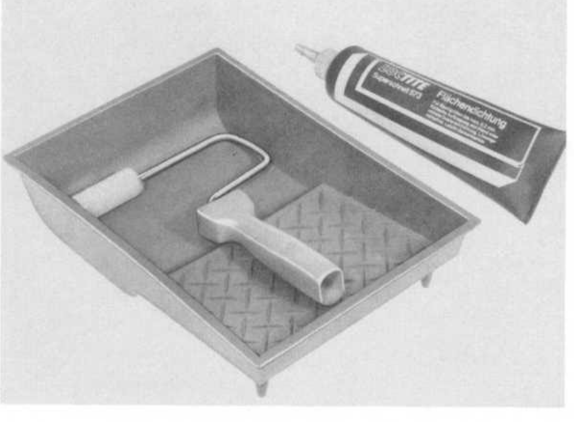
Only Loctite 574 (orange) should be used as a sealant. Loctite 574 will dry only in conjunction with metal and exclusion of air. After applying a coat of sealant the bolts should be installed and tightened no later than 10 minutes, since the sealant on the metal will start to dry.

Removing Old Sealant

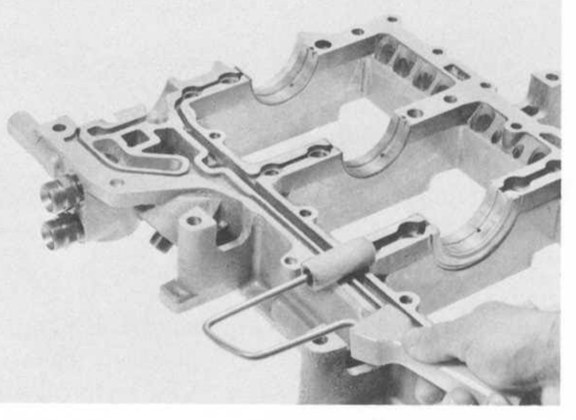
The old sealant does not have to be removed for repairs. It is only necessary to remove grease from the surface, so that after the cleaning solution has dried the new coat of sealant can be applied. The new Loctite will dissolve the old sealant in the surface finish and dry again after assembling.
We recommend a fine steel brush or Loctite remover 80646 for removing old sealant, if this is ever necessary.

Applying Sealant

1. We recommend a short-pile velour roller for application by hand. A tray will also be required for the sealant and should have a rough edge to scrape excess sealant from the roller.



2. Roll on a very thin coat of sealant with a velour roller.

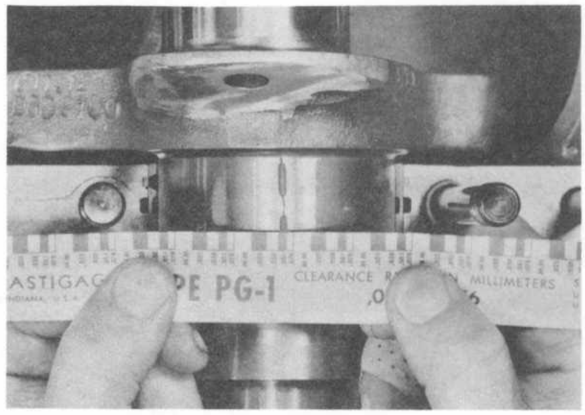


CHECKING CRANKSHAFT BEARING CLEARANCE

The "Plastigage" method is a simple way of checking bearing clearance.

Plastigage is available in three different sizes for measuring ranges from 0.025 to 0.23 mm.

Type	Color	Measuring Range
PG-1	green	0.025 to 0.075 mm
PR-1	red	0.05 to 0.15 mm
PB-1	blue	0.10 to 0.23 mm



Checking Radial Clearance

1. Remove crankcase lower section.

2. Remove oil from bearing shell and bearing journal.

3. Place Plastigage having width of bearing on crankshaft journal in axial direction. Install crankcase lower section carefully and tighten to specified torque.

Note

Do not turn crankshaft while measuring.

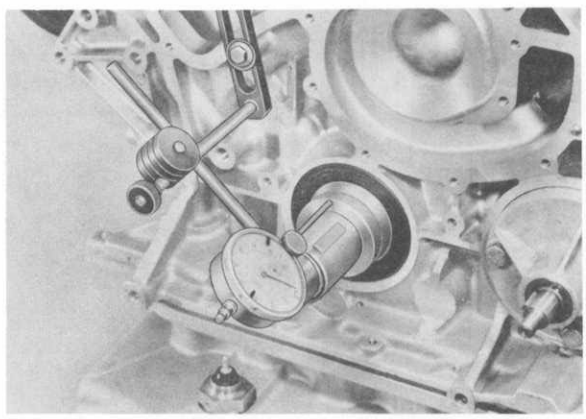
4. Remove crankcase lower section. Read width of flattened Plastigage from measuring scale. Corresponding value on measuring scale equals the bearing clearance.

Play of new bearings:	0.020 to 0.098 mm
Wear limit:	0.16 mm

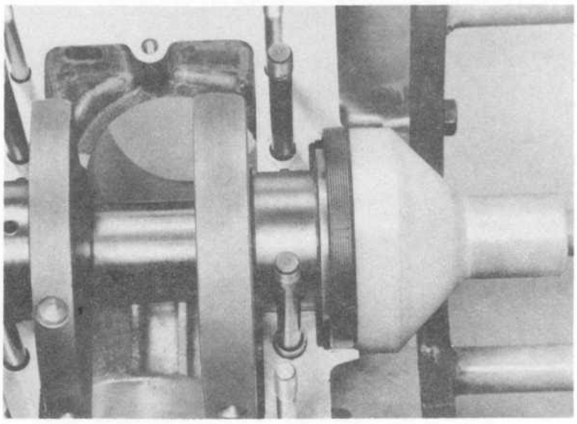
Checking End Play

Use Special Tool VW 387 to check end play.

Play of new bearings:	0.110 to 0.312 mm
Wear limit:	0.40 mm

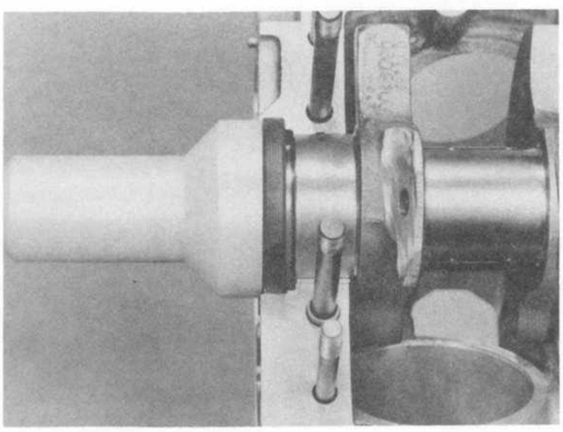


INSTALLING CRANKSHAFT SEAL (FLYWHEEL END)



Align seal with Special Tool 9126.

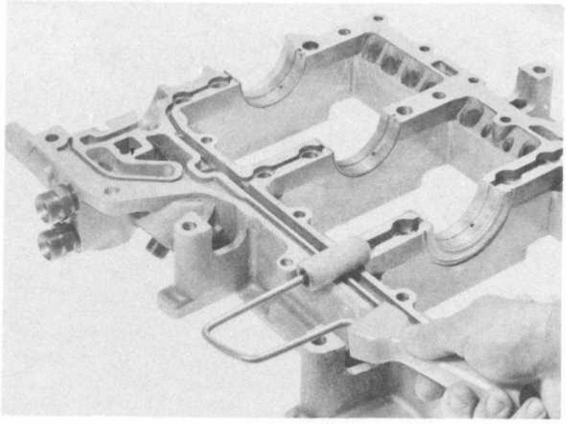
INSTALLING CRANKSHAFT SEAL (PULLEY END)



Align seal with Special Tool 9125.

INSTALLING UPPER AND LOWER CRANKCASE SECTIONS

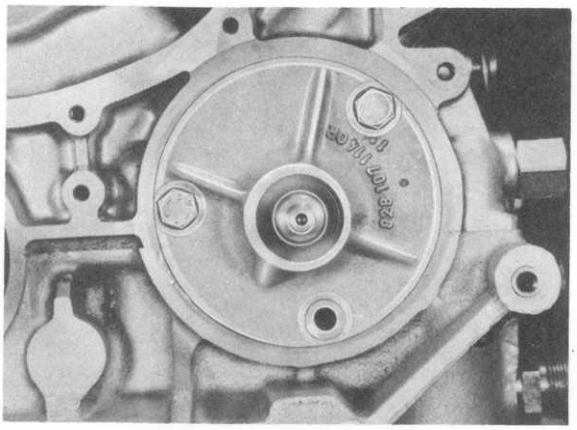
1. Apply a thin coat of Loctite 573 on crankcase lower section.



2. Install crankcase lower section.

3. Install mounting nuts by hand.

4. Install oil pump body, tightening first both upper bolts to specified torque.

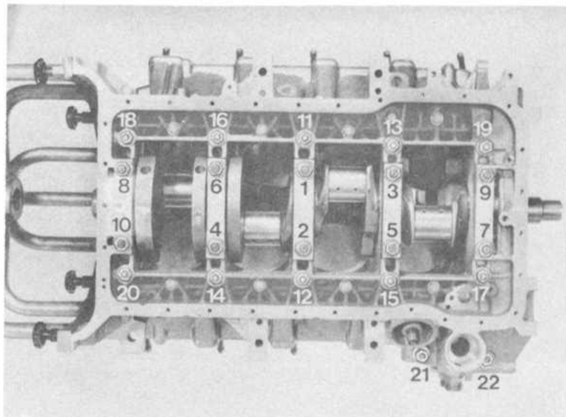


Note

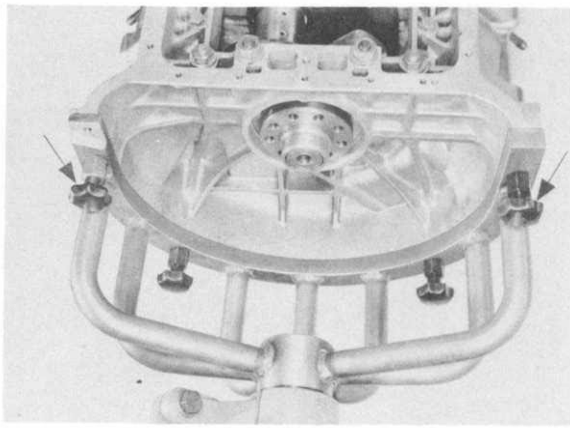
This is how crankcase upper and lower sections are located in longitudinal direction.

5. Tighten mounting nuts to final torque. See page 10 - 03 for specified torques and instructions.

Tighten to sequence.



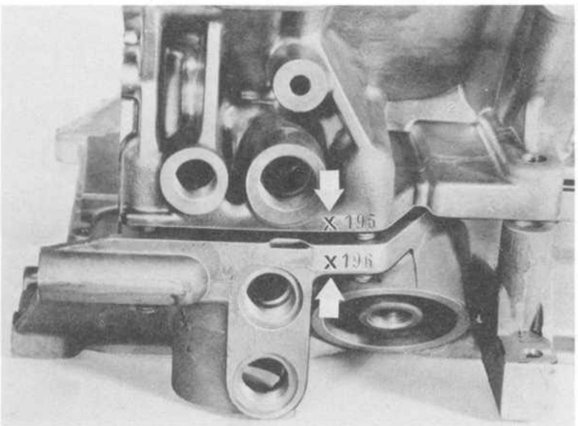
6. Mount upper section on engine holder after tightening nuts.



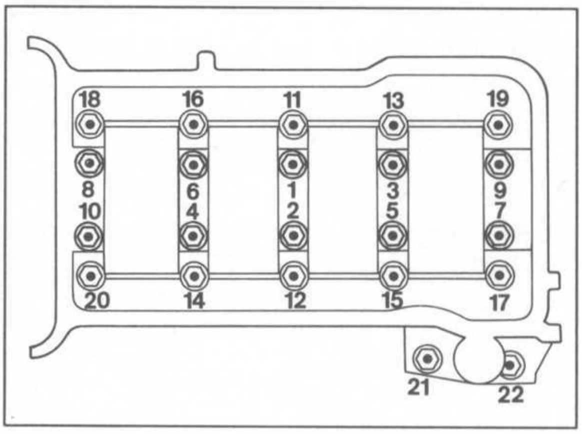
7. Remove oil pump body.

Assembly note

On crankcases that have an "X" embossed next to the housing number and on crankcases with a closed main-bearing bushing (bearing 1), the specified tightening torque of the studs has been modified.
As of Model Year '85, the matching number was extended to four digits, and the "X" embossed ahead of the number was therefore deleted.



Tightening sequence - tightening torque



1325-13

Tightening sequence:

Number 1...10 in 3 steps:
M 12 x 1.5 thread

1st step 30 Nm (22 ftlb.)
2nd step 55 Nm (41 ftlb.)
3rd step 75 + 5 Nm (55 + 4 ftlb.)

Number 11...22 in 2 steps:
M 10 thread

1st step 20 Nm (15 ftlb.)
2nd step 50 + 5 Nm (37 + 4 ftlb.)

Note

As of Model Year '92, hexagon head bolts are used to assemble the two crankcase sections.

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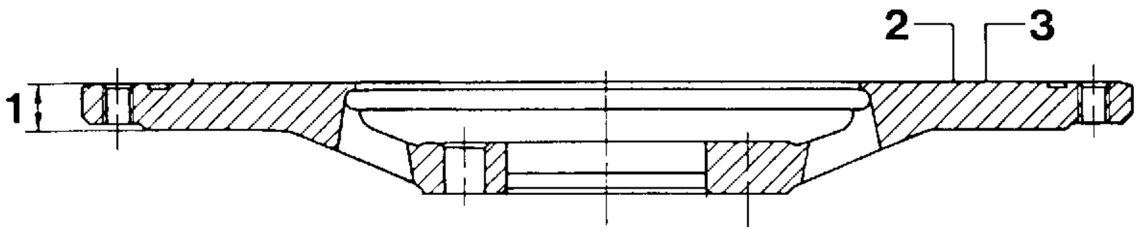
MACHINING FLYWHEEL

The bearing surface for the drive plate on the flywheel can be machined in a lathe when seriously scored or burnt.

The metal removal should be kept as small as possible.
Wear limit for flywheel thickness: 11.8 mm.



1 = Wear limit 11.8 mm

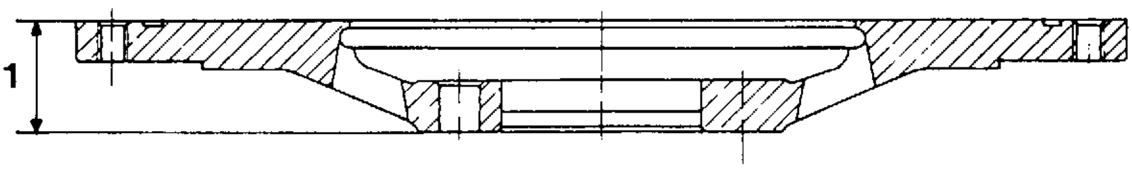
2 = Smallest possible metal removal

3 = Max. runout 0.05 mm

Bearing surface machining specifications:

Surface finish + waviness = 0.008 mm.

MACHINING FLYWHEEL – Beginning with 1984 Models
Engine Type M 28.21

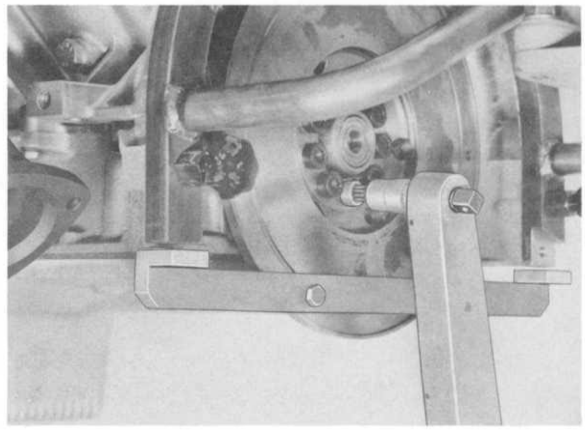


1 = Wear limit 27.5 mm

Removing and installing flywheel

Removing

Mount Special Toll 9130 on flywheel with two hex. head bolts and loosen Phillips screws.



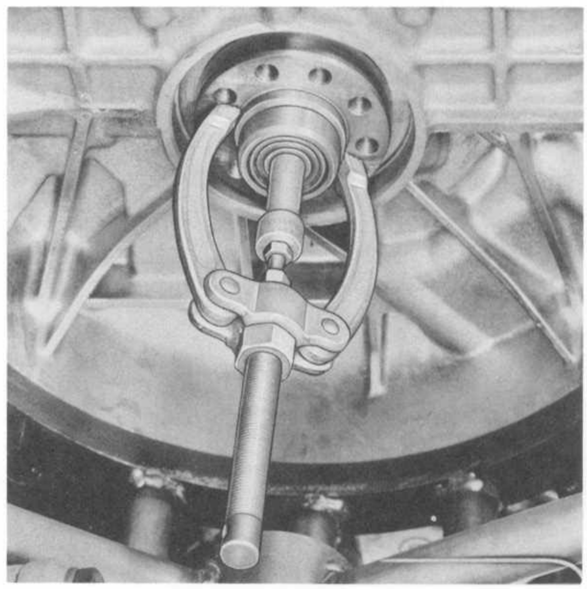
Installing

Align marks on flywheel (cast boss) and crankshaft (punch mark).

Tighten multi-tooth bolts in two stages.

1st stage	40 Nm (30 ftlb)
2nd stage	90 Nm (66 ftlb)

Removing and installing grooved ball bearing



Removing

Pull out grooved ball bearing with an internal extractor, e.g. Kukko 21/2 (14.5 to 18.5 mm).

Installing

Drive bearing in to stop with a suitable mandrel.

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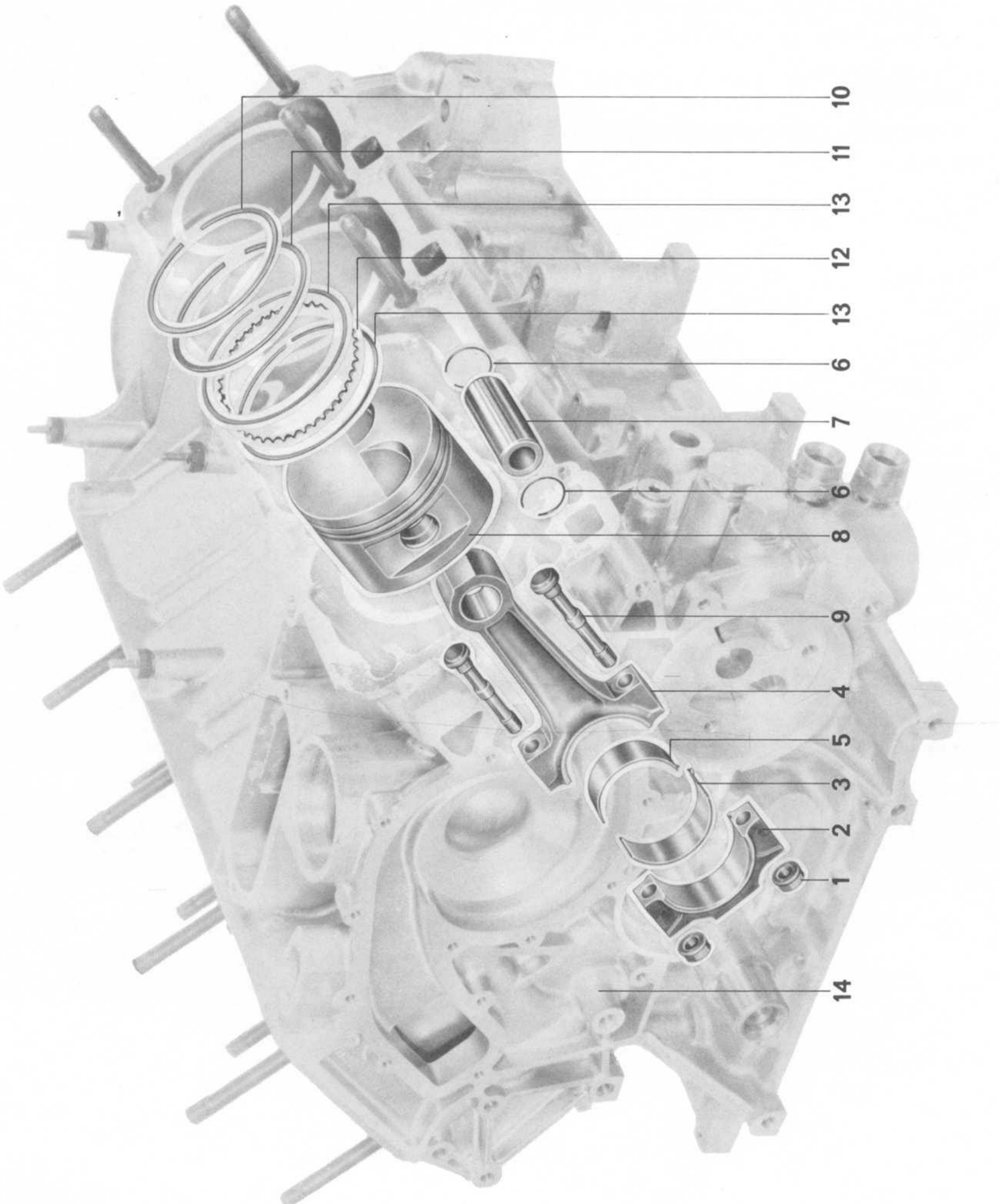
10
11
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14

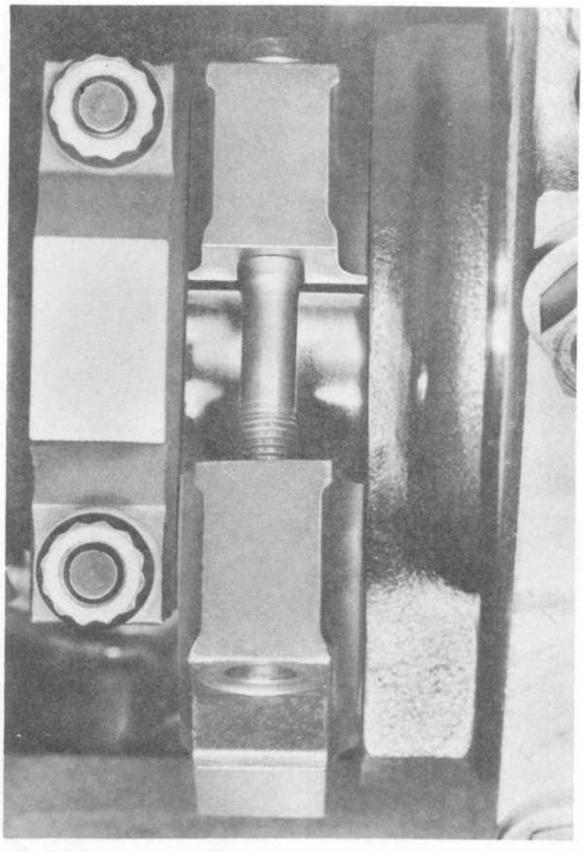
No.	Description	Qty.	Note When: Removing	Installing
1	Connecting rod nut	16		Replace, tighten to specified torque. Lubricate threads and bearing surface
2	Connecting rod cap	8		Note pairing code
3	Bearing shell	8		Always replace worn bearing shells
4	Connecting rod	8		Check for distortion and parallel deviation. Make sure that narrow side with small chamfer faces neighboring connecting rod. Wide side with large chamfer faces crankshaft cheek
5	Bearing shell	8		Always replace worn bearing shells
6	Circlip	16	Pry out	Position correctly
7	Piston pin	8		Heat piston to approx. 60° C/140° F if hard to install, lubricate slightly
8	Piston	8		Lubricate slightly. Position correctly. Note tolerance group
9	Connecting rod bolt	16		
10	Piston ring Groove 1 Tapered face	8		
11	Piston ring Groove 2 Tapered face scraper ring	8		

No.	Description	Qty.	Note When: Removing	Installing
12	Oil ring spring Groove 3	8		Install oil ring springs first, then oil rings. Check to ensure that ends of springs butt against each other.
13	Oil ring Groove 3	16		
14	Crankcase upper section	1		Check cylinder bores

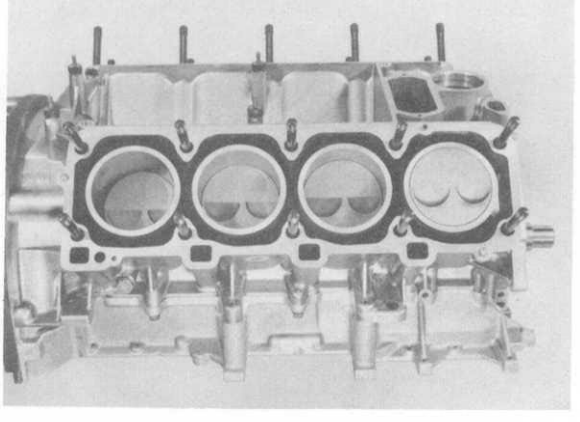
INSTALLING PISTON AND CONNECTING ROD

Installed Position of Connecting Rods

The narrow side with a small chamfer must face neighboring connecting rod; wide side with large chamfer is aligned with crank.



Make sure that piston is positioned correctly when pre-assembling the connecting rod and piston. Piston must be installed that rounded surfaces of valve pockets face down.



Installing Piston with Connecting Rod

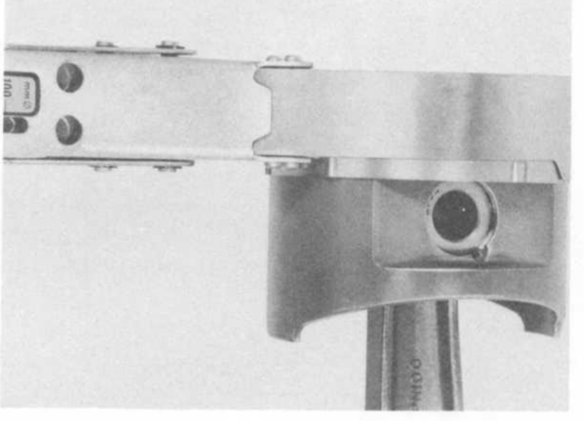
1. Install both upper piston rings that their gaps are offset by 120^o.

2. Install three-piece oil scraper ring as follows.

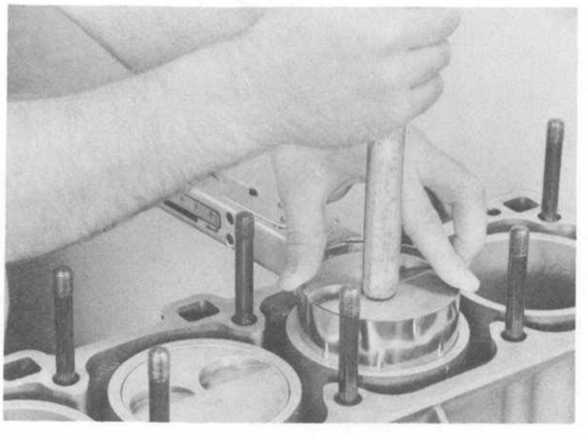
   Spring offset to steel band by approx. 45^o and steel band offset to steel band by at least 90^o.

3. Lubricate piston and cylinder bore slightly.

4. Apply piston ring compressor.



5. Install piston with connecting rod in cylinder bore and knock into cylinder by applying light knocks from hammer's handle and applying firm pressure to edge of compressor.



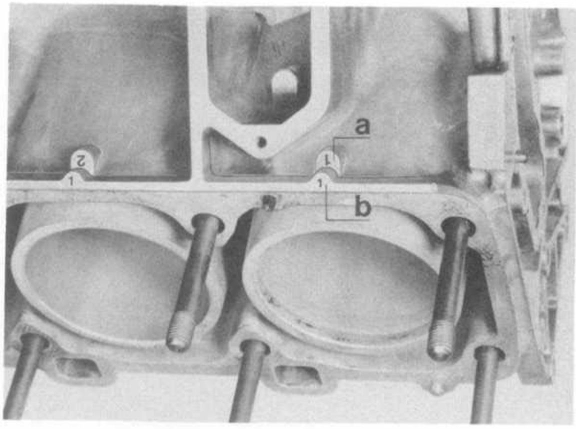
Note

Installation must be performed carefully and with feeling. If too much resistance is encountered, interrupt installing procedures, check rings and start again.

Tolerance Group of Pistons and Cylinders

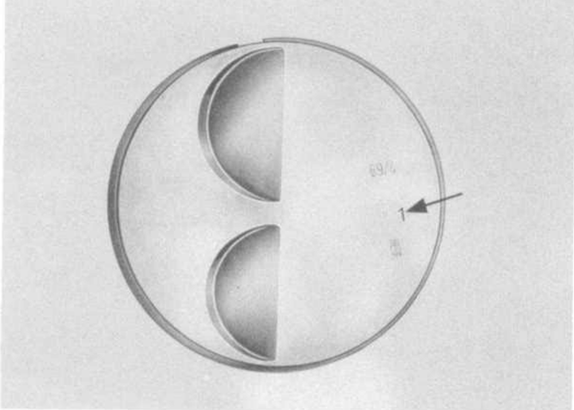
1. Only match pistons and cylinders having the same tolerance group.

2. Note cylinder marks on engine block.



a = Cylinder mark (arrangement)
b = Tolerance group

3. Note piston marks on piston skirt.



Note

Different tolerance groups could be used in one engine.

Checking Connecting Rod Radial Play

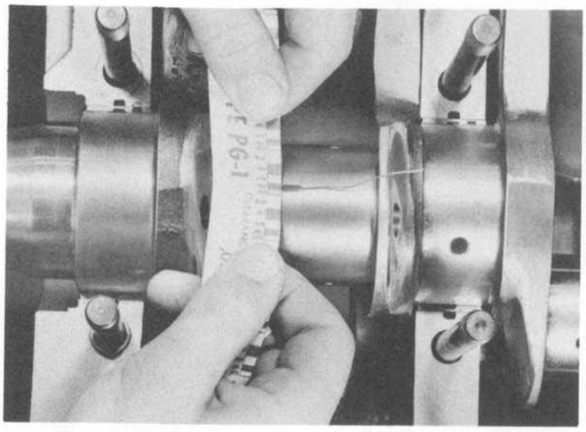
1. Remove connecting rod cap, clean bearing shell and connecting rod bearing journal to remove oil. Place Plastigage having width of bearing on crankshaft journal in axial direction. Install bearing cap carefully and tighten to specified torque.

Note

Do not turn crankshaft while measuring.

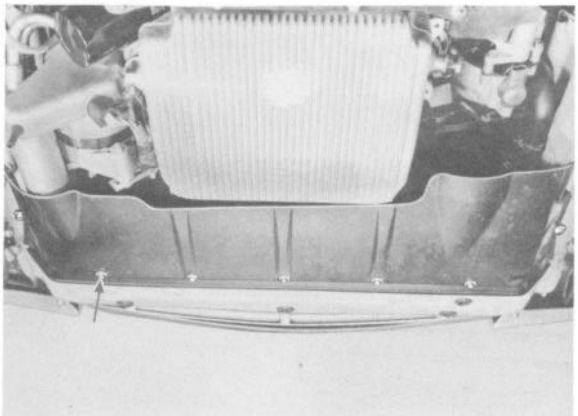
2. Remove connecting rod cap. Width of flattened Plastigage is read off of measuring scale which corresponds with bearing play.

New bearing play: 0.02 - 0.07 mm
Wear limit: 0.10 mm

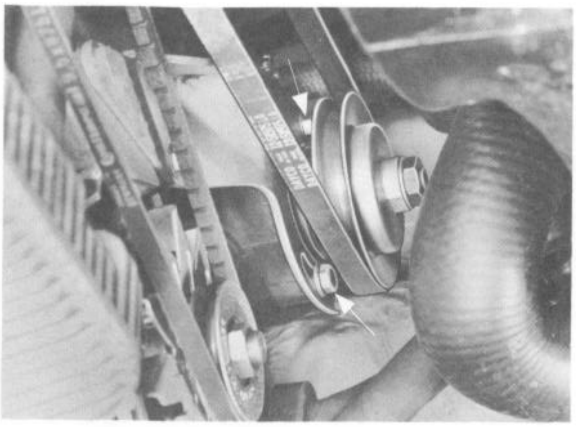


REPLACING BELTS FOR ALTERNATOR AND POWER STEERING PUMP

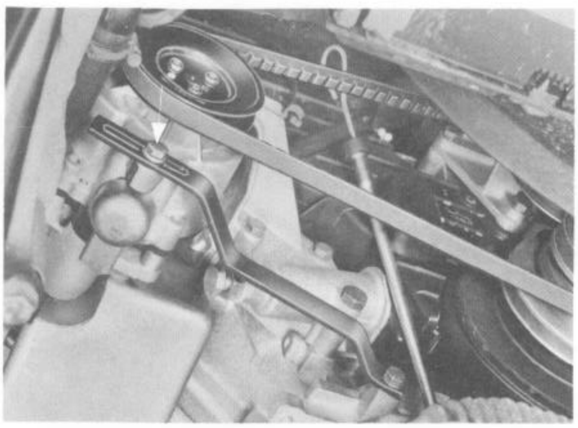
1. Remove engine guard.



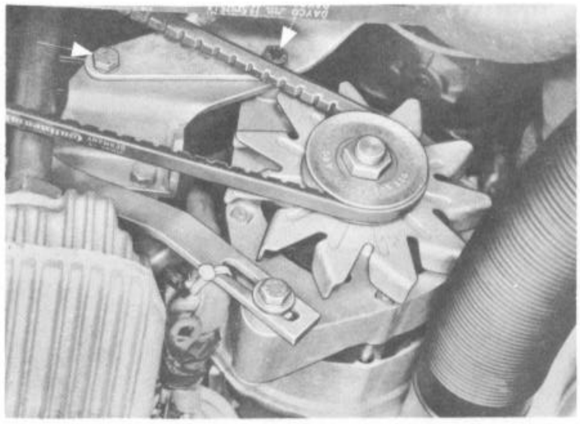
2. Loosen power steering pump bolts, swing pump in and remove belt.



3. Loosen auxiliary air pump bolt, swing pump in and remove belt.



4. Loosen alternator bolt, swing alternator in (if necessary, detach alternator vent cover) and remove belt.



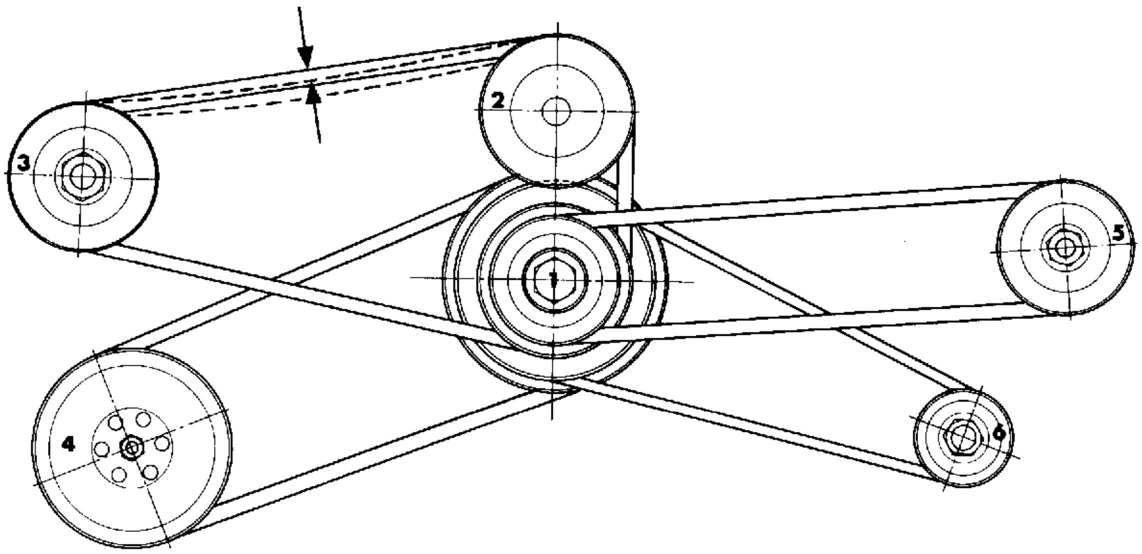
5. Tighten belts.

CHECKING AND CORRECTING BELT TIGHTNESS

Note

The tightness of all belts is checked by applying thumb pressure to belt at point midway between two pulleys.

Belts must give by approx. 10 mm.



1 - Crankshaft

2 - Fan

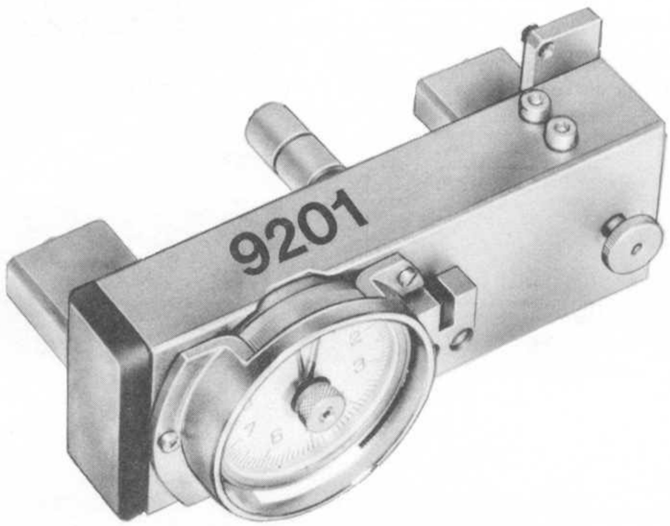
3 - Auxiliary air pump

4 - Air conditioner compressor

5 - Power steering pump

6 - Alternator

TOOLS

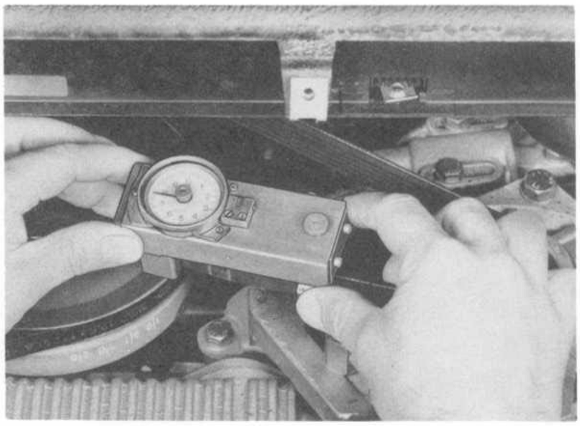


No.	Designation	Special Tool	Remarks
	Tester for belt tension	9201	

CHECKING AND ADJUSTING TENSION OF ALTERNATOR POLY-RIB BELT

'82 MODELS ONWARD

Checking



1. Prepare Special Tool 9201 for the check. Remove locking pin from Special Tool and push measuring pin opposite locking pin out as far as it will go. Align drag needle with measuring needle.

2. Push Special Tool on to belt (sliding shoe on smooth surface). Slowly press measuring button (arrowed) in until locking pin is felt to engage and read value from dial.

Settings:

New belt:	9.2
Used belt:	8.4 + 0.8

If necessary, adjust belt tension.

Remark:

The new Poly-rib belts in used '85 models onward (32-valve engines) have 6 ribs (previously 5).

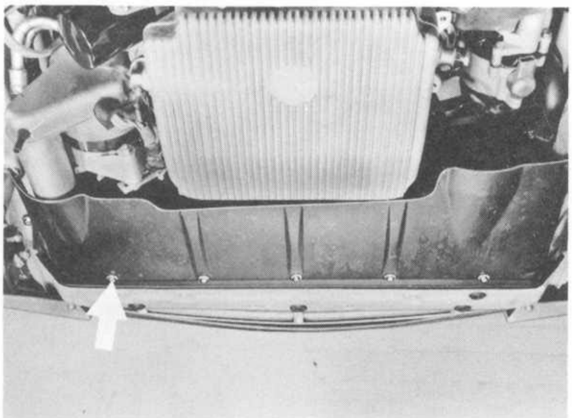
Note:

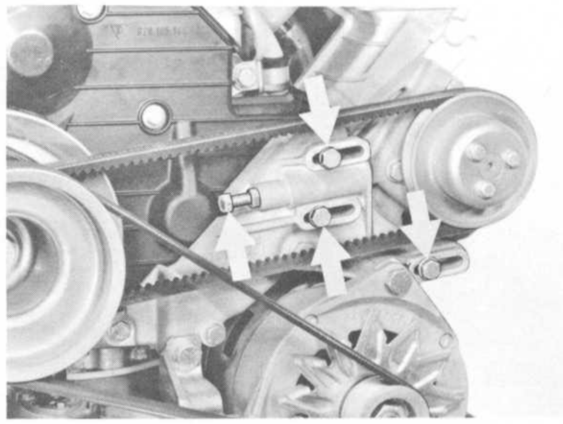
1. Contact must be established between the entire surface of the sliding shoe and the belt. While the measurement is being taken, do not allow the Special Tool to turn or its position on the belt to change.

2. The lower tolerance limit of a used belt should be set with the belt cold (room temperature approx. 20°C) and the upper tolerance limit with the belt warm.

REPLACING DRIVE BELTS FOR ALTERNATOR, POWER PUMP, AIR PUMP AND AIR CONDITIONER COMPRESSOR (32 VALVE ENGINE)

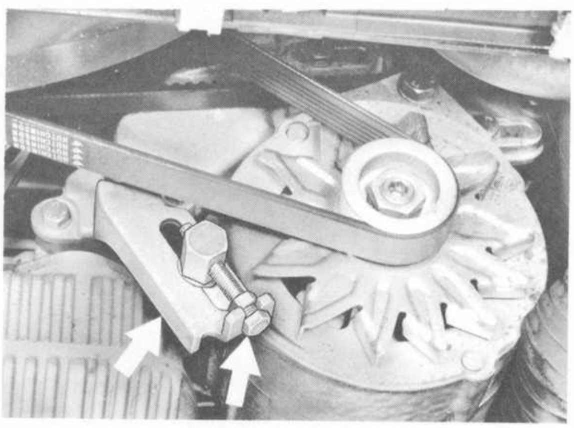
1. Remove engine splash guard.





2. Unscrew both nuts and adjusting bolt for alternator. Swing in alternator, if necessary unscrew cowl, and take off polyrib drive belt.

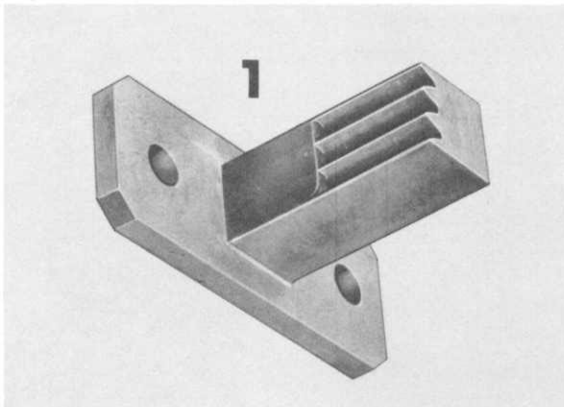
4. Unscrew adjusting nut and bolt on air pump, swing in pump and take off drive belt. Same procedures are necessary for the a/c compressor.

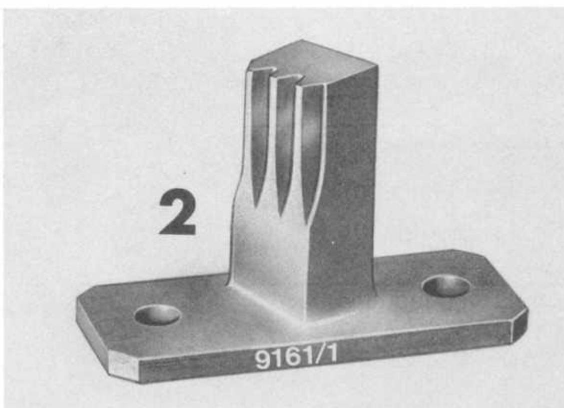


3. Unscrew lock nut and bolts on power pump, push in pump and take off drive belt.

5. Install and adjust new drive belts.

TOOLS

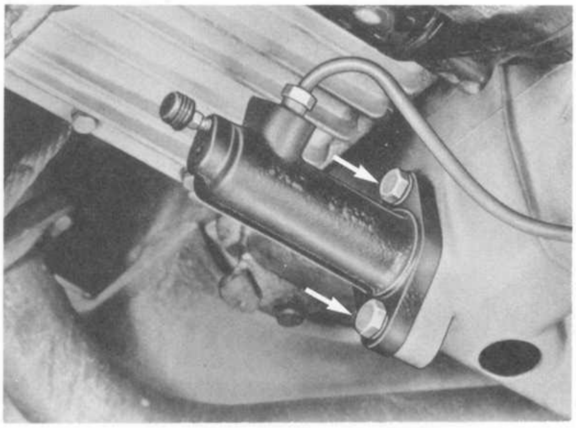




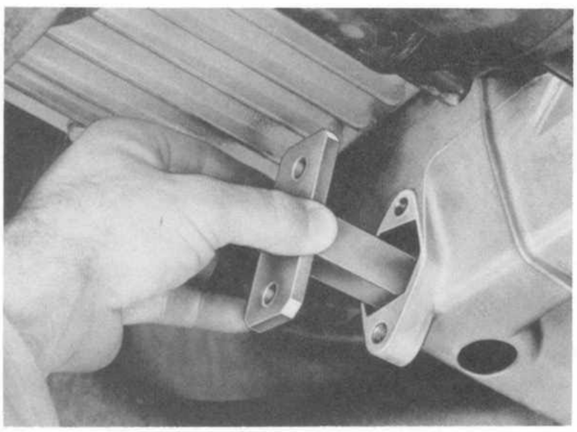
No.	Description	Special Tool	Remarks
1	Flywheel stop	9161	
2	Flywheel stop beginning with 1983 models	9161/1	In conjunction with new cover on clutch housing, starter mounted on clutch housing

STOPPING FLYWHEEL FOR ASSEMBLY JOBS

1. Unscrew clutch slave cylinder and remove with line connected.



2. Guide in special tool and mount with standard bolts.



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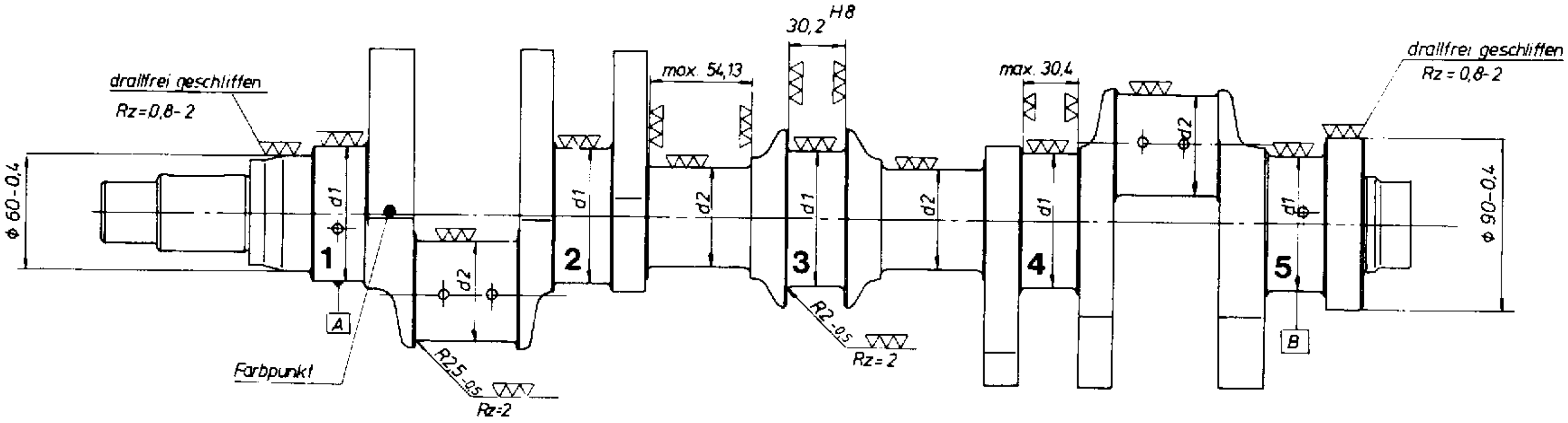
CRANKSHAFT (Standard and Machined Sizes)

Size	Crankcase Bore Dia.	Crankshaft Bearing Journal Dia. d 1	Crankshaft Connecting rod Journal Dia. d 2	Thrust Bearing Width
Standard	Standard 75.000...75.019 Oversize 75.250...75.269	69.971...69.990	51.971...51.990	max. 30.08 *
- 0.25		69.721...69.740	51.721...41.740	
- 0.50		69.471...69.490	51.471...51.490	
- 0.75		69.221...69.240	51.221...51.240	

* Thrust bearing 3
Machined size: 30.200 . . . 30.239



Only grind crankshaft oil seal surfaces as much as necessary. Otherwise, if necessary, polish to 0.8 . . . 2 microns.

After grinding, chamfer oil bores to a radius of 0.5 mm. Break sharp edges to a radius of 0.2 to 0.5 mm.

Color Codes for Machined Sizes

1st undersize	blue paint dot
2nd undersize	green paint dot

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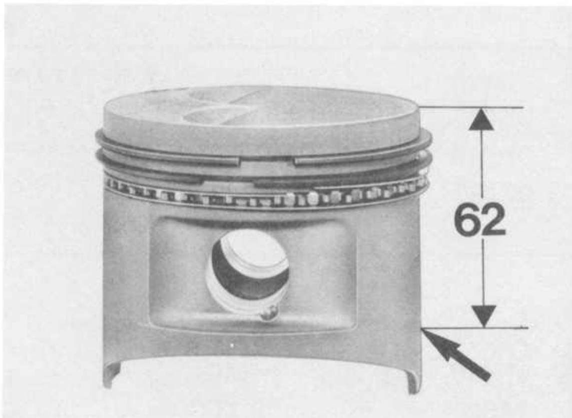
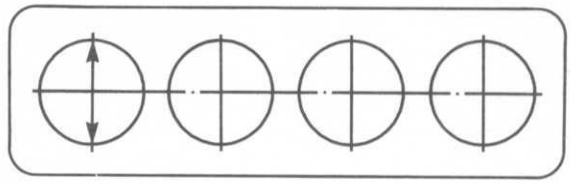
Checking pistons and cylinder bores





Repair size	Piston dia. (mm) Mahle	Piston dia. (mm) Kolbenschmidt		Cylinder bore (mm)		Tolerance group identification
Standard	94.960	94.964		95.000		0
	94.970	94.974	± 0.007	95.010	± 0.005	1
	94.980	94.984		95.020		2
1st oversize	95.460	95.464		95.500		0 KD 1
	95.470	95.474	±0.007	95.510	±0.005	1 KD 1
	95.480	95.484		95.520		2 KD 1

Checking the pistons

Measure approx. 62 mm from piston crown, 90 deg. offset to piston pin axis.

Checking the cylinder bores

Measure approx. 62 mm from upper edge of cylinder bore in transverse direction of cylinder block.
Prior to measuring, fit crankcase bottom section and tighten to specified torque.

Note

It is recommended that the stocks of the relevant piston tolerance group are checked before machining the cylinders. If necessary, hone to the piston size available.
In some cases, certain tolerance groups may be in short supply.

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Engine Type M 28.11/12 (928 S)

Repair size	Piston dia. (mm) Mahle			Cylinder bore (mm)		Tolerance group identification
		as of 4.82				
Standard	96,960	96,965		97,000		0
	96,970	96,975	± 0,005	97,010	± 0,005	1
	96,980	96,985		97,020		2
1st oversize	97,460	97,465		97,500		0 KD 1
	97,470	97,475	± 0,005	97,510	± 0,005	1 KD 1
	97,480	97,485		97,520		2 KD 1

Engine Type M 28.19/20 (USA)

Repair size	Piston dia. Kolbenschmidt		Cylinder bore (mm)		Tolerance group identification
Standard	96,975		97,000		0
	96,985	± 0,007	97,010	± 0,005	1
	96,995		97,020		2
1st oversize	97,475		97,500		0 KD 1
	97,485	± 0,007	97,510	± 0,005	1 KD 1
	97,495		97,520		2 KD 1

Note

It is recommended that the stocks of the relevant piston tolerance group are checked before machining the cylinders. If necessary, hone to the piston size available.
In some cases, certain tolerance groups may be in short supply.

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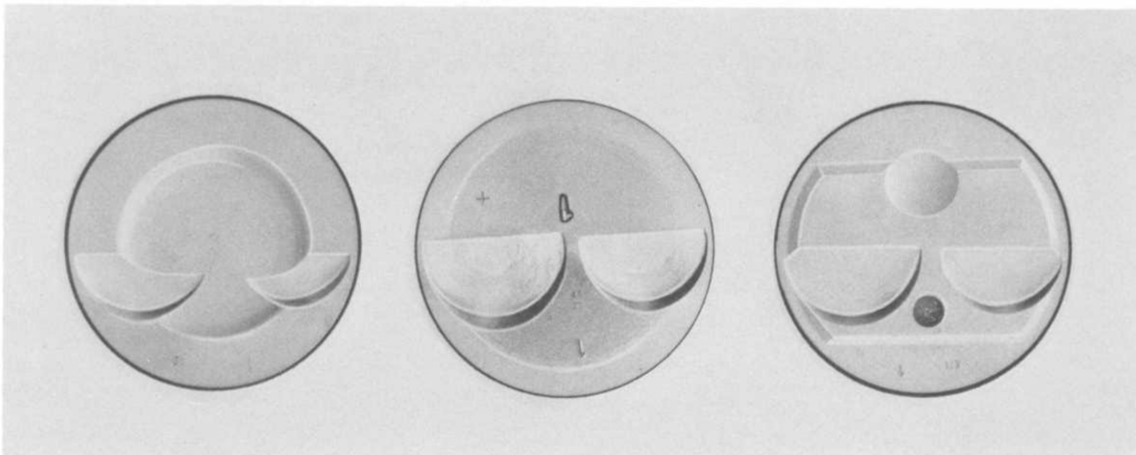
PISTON ARRANGEMENT – 1980/1981/1982/1983 Models



Engine M 28/13 and M 28/14
M 28/19 and M 28/20
USA, Canada, Japan
Compression ratio 9 : 1
95 mm diameter (M 28/13, M 28/14)
97 mm diameter (M 28/19, M 28/20)

Engine M 28/11 and M 28/12

Europe and Rest of World
Compression ratio 10 : 1
97 mm diameter

Engine M 28/09 and M 28/10

Europe and Rest of World
Compression ratio 10 : 1
95 mm diameter

Piston Weight Tolerances

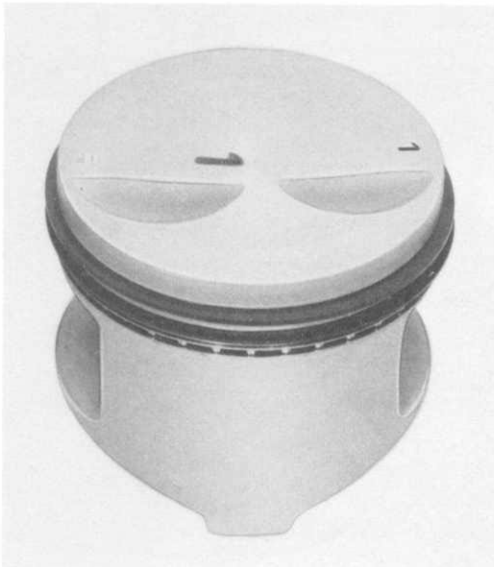
Since 1980 models pistons and piston pins are paired according to weight. Pistons are weighed with components (piston pins, piston rings, circlips).

Piston pins must always remain in the corresponding pistons and must not be mixed up within a set of pistons for one engine. This is important when disassembling and assembling an engine and pistons must be marked if necessary.

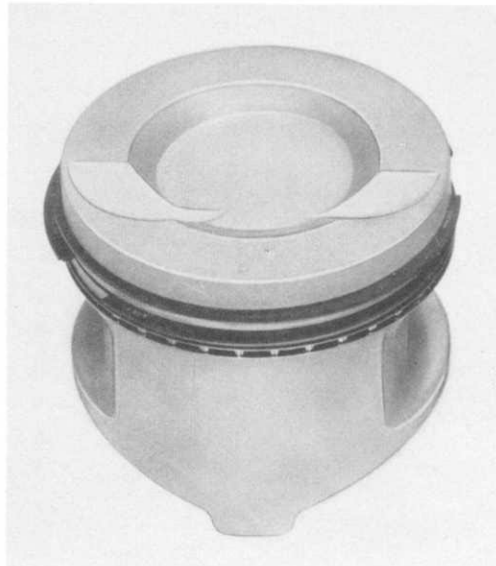
If pistons and pins are mixed up, they must be rearranged by checking the total weight.

Weight = 722 g
Permissible tolerance = $\pm$ 4 g

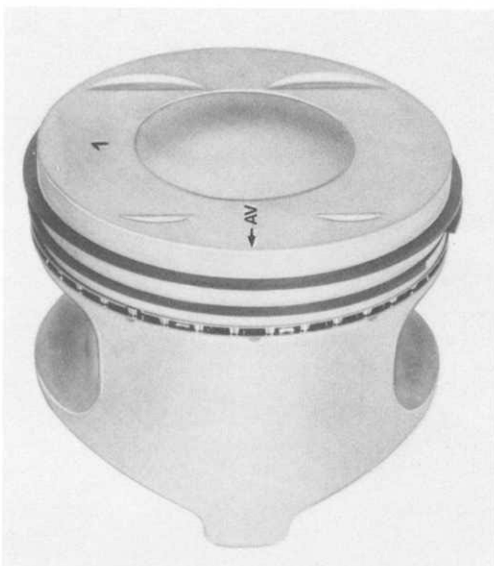
PISTON SIZES, 84/85/86 MODELS ONWARD



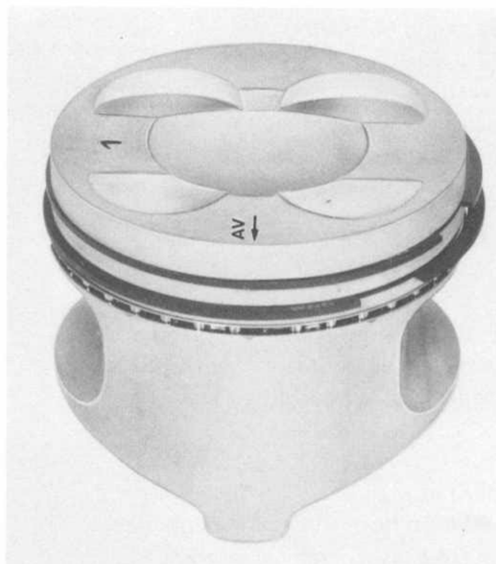
Engine M 28. 21/22, Europe and all other countries, compression ratio 10.4 : 1
Nominal diameter - 97.0 mm



Engine M 28. 21/22, Sweden, Switzerland and Australia, compression ratio 9.3 : 1
Nominal diameter - 97.0 mm



(32-VALVE ENGINES)
Engine M 28. 43/44 USA, Canada and Japan, Compression ratio 10.0 : 1
Nominal diameter - 100.0 mm



Engine M 28. 45/46 Australia, Germany, Austria and Switzerland, Compression 9.3 : 1
Nominal diameter 100.0 mm

NOTES FOR INSTALLING PISTONS
(32-VALVE ENGINES)

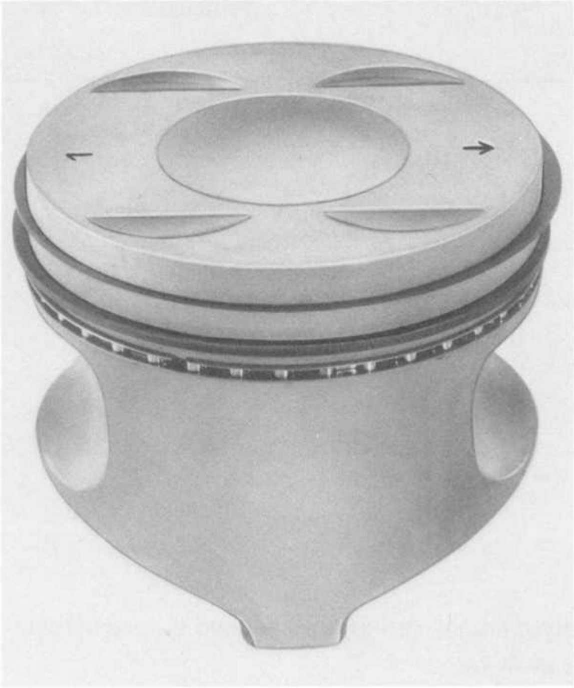
1. The "AV ⟶ " (exhaust valve) inscribed on the base of the piston indicates the installation position (arrow toward exhaust side). When pre-assembling pistons, check that the connecting rods are in the correct installation position.

N o t e :

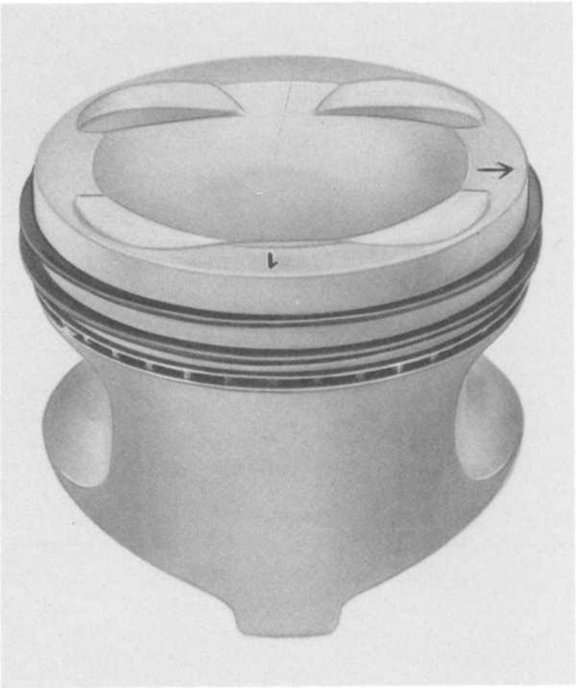
Modifed installation position for pistons as of engine numbers:

M 28.43 as of 81 G 00594 - 00622
M 28.44 as of 81 G 06311 - 06378

The valve cutouts for the valves are of equal size on both sides. The installation position is indicated by an arrow which points toward the belt pulley.



PISTONS, 87 MODELS ONWARD



M 28. 41/42 engines, worldwide
Compression ratio: 10.0 : 1
Nominal dia. 100.00 mm

The valve cutouts for the valves are the same size on both sides. The installation position is indicated by an arrow which points toward the belt pulley.

Checking pistons and cylinder bores (32-valve engine)

Engine Type M 28.43/44/45/46

Repair size	Piston dia. (mm) Kolbenschmidt	Cylinder bore (mm)	Tolerance group identification
Standard	99,975	100,000	0
	99,985 ± 0,007	100,010 ± 0,005	1
	99,995	100,020	2
1st oversize	100,475	100,500	1 0
	100,485 ± 0,007	100,510 ± 0,005	1 1
	100,495	100,520	1 2

Engine Type M 28.41/42/47

Repair size	Piston dia. (mm) Kolbenschmidt	Cylinder bore (mm)	Tolerance group identification
Standard	99,980	100,000	0
	99,990 ± 0,007	100,010 ± 0,005	1
	100,000	100,020	2
1st oversize	100,480	100,500	1 0
	100,490 ± 0,007	100,510 ± 0,005	1 1
	100,500	100,520	1 2

Note

It is recommended that the stocks of the relevant piston tolerance group are checked before machining the cylinders. If necessary, hone to the piston size available.
In some cases, certain tolerance groups may be in short supply.

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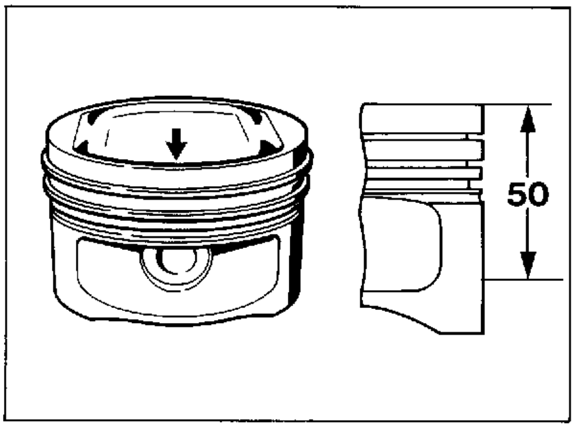
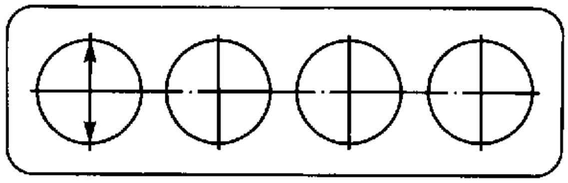
Checking pistons and cylinder bores - Type 928 GTS (5,4 l)

Engine Type M 28.49/50





Repair size	Piston dia. (mm) Kolbenschmidt	Cyilinder bore (mm)	Tolerance group identification
Standard	99,980	100,000	0
	99,990 ± 0,007	100,010 ± 0,005	1
	100,000	100,020	2
1st oversize	100,480	100,500	I 0
	100,490 ± 0,007	100,510 ± 0,005	I 1
	100,500	100,520	I 2

Checking the pistons

Measure approx. 50 mm from piston crown, 90 deg. offset to piston pin axis.

Checking the cylinder bores

Measure approx. 50 mm from upper edge of cylinder bore in transverse direction of cylinder block.
Prior to measuring, fit crankcase bottom section and tighten to specified torque.

Note

It is recommended that the stocks of the relevant piston tolerance group are checked before machining the cylinders. If necessary, hone to the piston size available.
In some cases, certain tolerance groups may be in short supply.

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REMACHINING CYLINDER BORES IN THE CRANKCASE TOP HALF

The crankcase top half is made of an aluminum alloy which contains minute particles of pure silicon.

In order to give the cylinder the proper surface qualities, the cylinder bores must be machined until the silicon particles protrude from the aluminum so that the pistons and rings only make contact with the silicon.

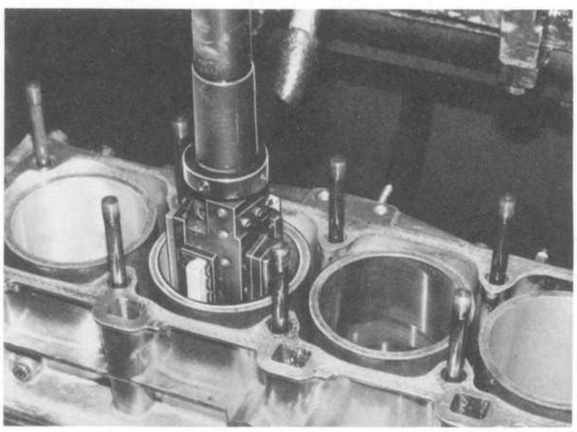
If it is necessary to remachine the cylinder bores, they can be regenerated with the SUMMEN CK - 10 / CV - 616 cylinder borer, so that oversize pistons can be installed.

Individual cylinder bores can be remachined as required, as the oversize pistons are of the same weight as the standard pistons.

Always check that pistons of the correct size are in stock before machining the cylinder, and if necessary, machine the cylinder to suit the size of piston available. Bottlenecks may arise in the delivery of individual tolerance groups.

The following operations are required:

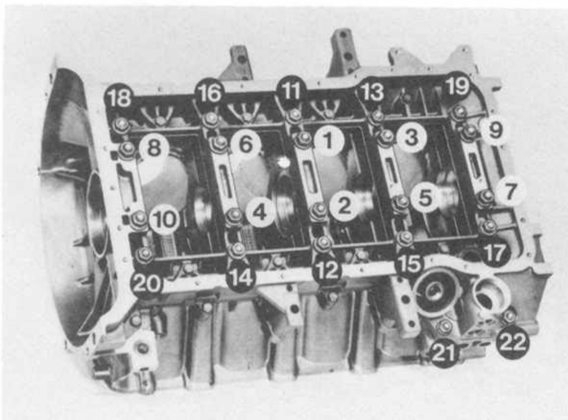
Rough-milling to 0.1 mm less than final size.
Dressing to 0.02 mm less than final size.
Polishing to final size
Lapping with Sunnen silicone compound.



ASSEMBLY INSTRUCTIONS

It is essential to tighten the bearing stud in bolts which hold the two halves of the crankcase together before machining.

Torqueing procedure	Tightening torque in Nm (ftlb)	Thread
3 Steps: 1st step	20 (14.6)	M 12 x 1.5
2nd step	40 (29.2)	
3rd step	75 (54.7)	
2 Steps: 1st step	20 (14.6)	M 10
2nd step	50 (36.5)	
	20 (14.6)	M 8



Tools

Drill	CK - 10 with filter CV - 616 " "
Grinding head	CK - 3000 or CK - 2600
Grinding oil	MB - 30 or MAN - 845
Felt inlay	C30 - F 85 1 Set
Silicone compound	AN - 30
Storage box for felt inlays	AN - 35 stone holder set
Set of stone holders for felt inlays instead of grindstones	CK - 3035 A 1 Set
Set of stone holders for grindstones for 3 different types of stone	CK - 3035 A 3 Set
Set of felt holders instead of guide shoe	CK - 3130 A 1 Set
Rough-milling set	C30 - J55 ++ shorten to 70 mm long
Finishing set	C30 - J84 ++ shorten to 70 mm long
Polishing set	C30 - C03 - 81

H o n i n g

Remove the upper guide shoe for all honing and lapping processes.

The excess must be removed from the bronze strip of main guide shoe No. 3 until the strip is flush with the guide shoe - base.

M a c h i n e S e t t i n g s

Rough milling - see settings in column 1 of table.

Finishing - see settings in column 2 of table.

Polishing - see settings in column 3 of table.

Lapping - to lay bare the silicon crystals.

1.Adjust the machine to the settings in column 4 of the test sheet.

2.Remove all abrasive particles from previous honing with filtered honing oil.

3.Wipe the cylinder bores dry and apply a thin coating of thoroughly mixed silicone compound.

N o t e

If the silicone compound is too thick, it can be thinned by adding fresh honing oil and mixing thoroughly.

4.Holders with felt strips are now set into the grinding head instead of the guide shoes and honing stones.

Use a setting gauge to adjust the head to the cylinder diameter in the same way as when working with guide rails and honing stones.

5.Soak the felt in filtered honing oil and apply a coating of silicone compound.

6.Turn off the supply of grinding oil, the cylinders are lapped without grinding oil.

M a c h i n e t h e c y l i n d e r s a s f o l l o w s :

Move the grinding head into the bore. Turn the adjusting wheel anti-clockwise until the felt strips touch the bore. Start the machine and continue turning the handwheel anti-clockwise until the load gauge shows approx. 20 - 30 %.

Set the advance wheel scale to 20.

The machine will switch off automatically after approx. 80 seconds. The cylinder surface is now matt and dull.

Before starting on the next cylinder apply another coating of silicone compound to the felt.

N o t e :

If the holders with the felt inlays are not in use, they must be kept in the storage box so as to remain absolutely clean.

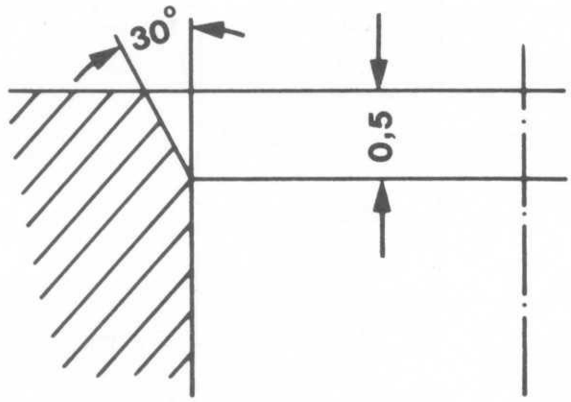
Never re-use the silicone compound.

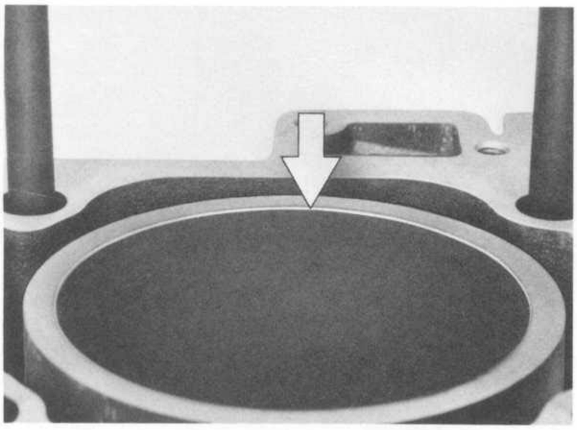
Machining cylinders with SUNNEN - 10 / CV 616 honer

E.g. Cylinder diameter Standard 100.00 mm	A	B	C	D
Cylinder diameter 1st oversize 100.50 mm	100.40 mm	100.48 mm	100.50 mm	100.50 mm
Cylinder length 145 mm				
Type of honing head	CK-3000 or CK-2600	dto.	dto.	dto.
Lift scale for stone length	70 mm	70 mm	70 mm	70 mm
Reading on scale	160 mm	160 mm	160 mm	125 mm
Speed in rpm	125 CK/CV	125 CK/CV	125 CK/CV	185 CK 230 CV
Strokes per min.	49 CK/57 CV	49 CK/57 CV	49 CK/57CV	73CK/80CV
Advance	5	4	3	2
Stone protruding by at top	21 mm	21 mm	21 mm	2 mm
Roughing stone	C 30 - J 55			
Finishing stone		C 30 - J 84		
Polishing stone			C 30-C03-81	
Felt stone				C30-F 85
Display %	30 - 40	30 - 40	20 - 30	20 - 30
Material removed	0.07 mm/	0.03 mm/	0.01 mm/	approx. 20 strokes
Advance wheel setting	10 strokes	10 strokes	10 strokes	80 sec. running time
Surface roughness	Approx. 7 - 8 my	Approx. 2 my	Approx. 0.6 - 0.8 my	Approx. 1-2 my

A=1st roughing to dia. B=finishing to dia. C=polishing to dia. D=Lapping

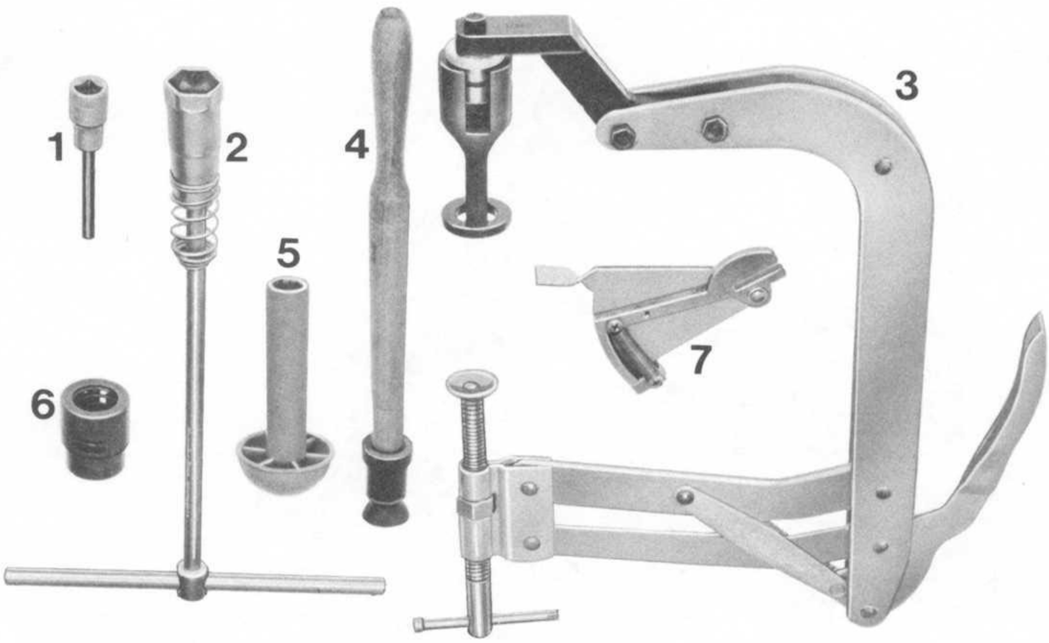
Once honing is finished, the upper 0.5 mm of the remachined cylin- der bores must be champfered to 30°.



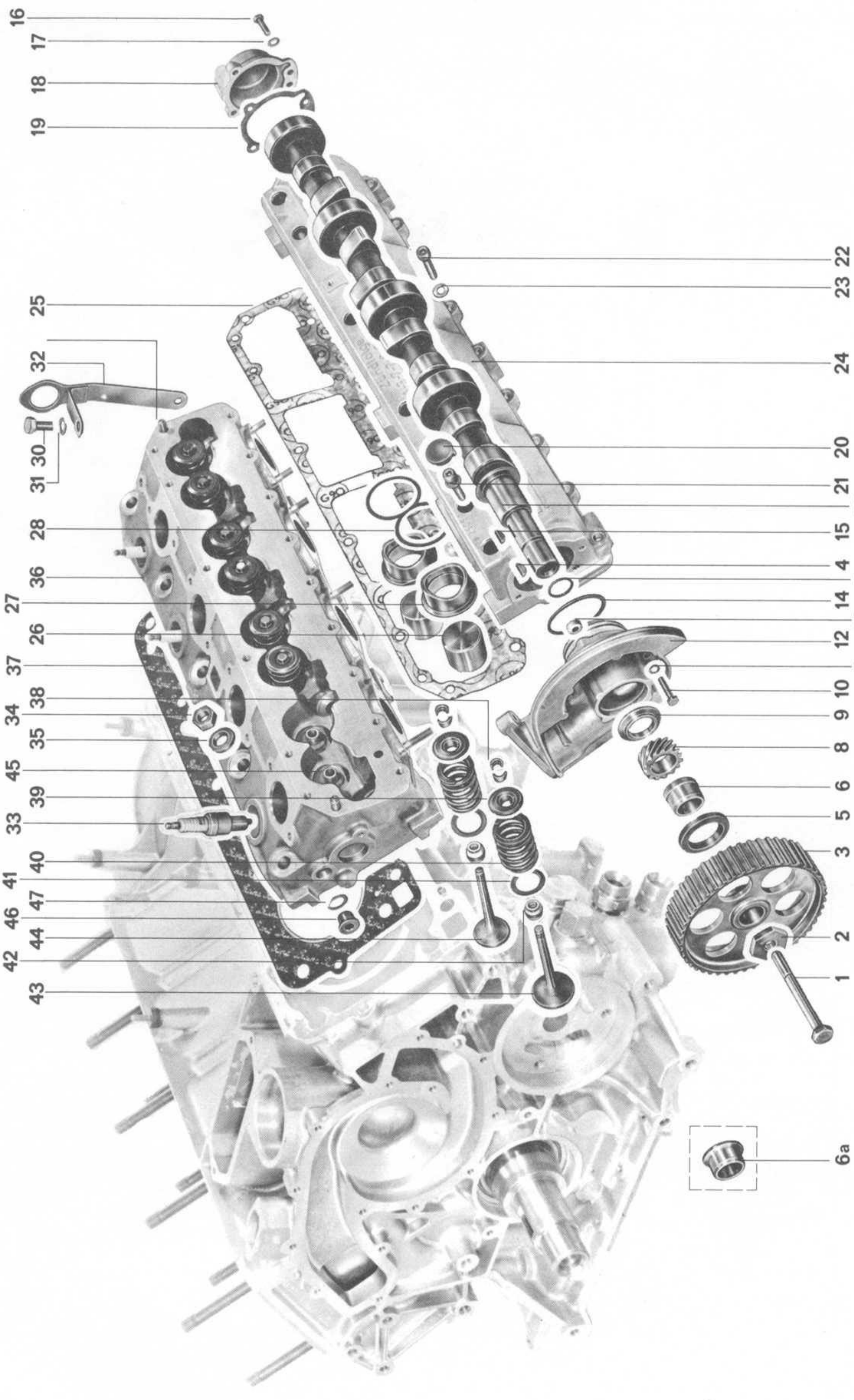


Before reassembly, thoroughly clean both halves of the crankcase so as to remove all trace of abrasive par- ticles and silicone paste.

TOOLS



No.	Description	Special Tool	Remarks
1	Wrench socket	9133	
2	Spark plug wrench	-	Standard, e.g. Hazet 767 - 1
3	Valve spring compressor	US 1020 or P 200 a	
4	Valve grinder	-	Standard
5	Thrust plate for installation of valve shaft seal	10 - 101	
6	Valve spring adjuster	9138	
7	Toothed belt tightness tester	9131	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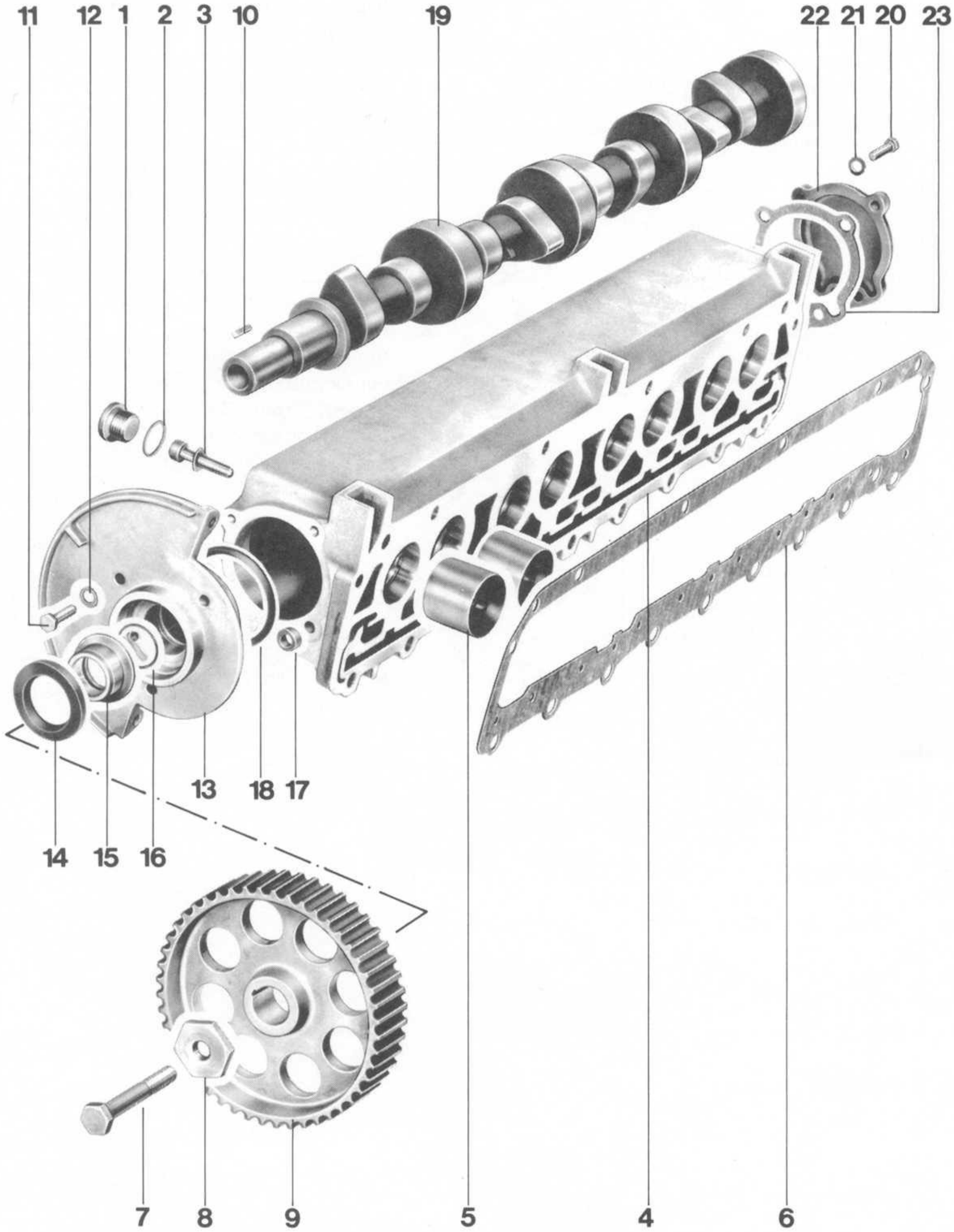
No.	Description	Qty.	Note When Removing	Note When Installing	Special Instructions
1	Bolt	2		Tighten to specified torque	
2	Washer	2			
3	Camshaft sprocket	2		Watch position when installing camshaft drive	
4	Woodruff key	2			
5	Camshaft oil seal	2		Replace, drive in to stop	
6	Spacer	1			
6a	Spacer	1		Install on camshaft right side	
7	O-ring	2		Replace, lubricate slightly	
8	Distributor drive gear	1			
9	Spacer	1			
10	Bolt	6			
11	Washer	6			
12	Bearing carrier	1			
13	Seal	2		Replace	
14	O-ring	2		Replace, lubricate slightly	
15	Woodruff key	1			
16	Bolt	6			
17	Washer	6			
18	End cover	2			
19	Gasket	2		Replace	

No.	Description	Qty.	Note When Removing	Note When Installing	Special Instructions
20	Plug	12	First remove lockplates, not shown (two)	Replace	
21	Bolt with washers	12			
22	Bolt	18			
23	Washer	18			
24	Camshaft housing	2			
25	Gasket	2		Replace, position correctly (do not cover oil feed bore)	
26	Hydraulic valve lifter	16	Position so that oil bore faces up	Check	
27	Lifter sleeve	16	Do not mix up lifters and sleeves		
28	Gasket	8		Replace	
29	Left camshaft	1		Note marks (on rear camshaft bearing) right side (cyl. 1 - 4) 155 ... left side (cyl. 5 - 8) 156 ...	
30	Bolt	2			
31	Washer	2			
32	Lifting eye	1			
33	Spark plug	8			
34	Nut	20		Tighten to specified torque	

No.	Description	Qty.	Note When: Removing	Note When: Installing	Special Instructions
35	Washer	20			
36	Cylinder head	2			
37	Left gasket	1		Replace, position correctly	
38	Valve keeper	32		Position correctly	
39	Spring retainer	16			Note different versions (see page 15 - 8 d)
40	Outer valve spring	16		Position correctly. Springs with red dot face down and springs with green dot face up (to tappets). From 3.81 (928 S) springs with white dot face down or up.	
	Inner valve spring from 1980 models	16			
	Valve spring disc from 1980 models	16			Note different versions (see page 15 - 8 d)
41	Shim	X	Note quantity	Measure again if necessary	
42	Valve stem seal	16		Always replace	
43	Intake valve	8			
44	Exhaust valve	8			
45	Valve guide	16			
46	Plug	2			
47	Seal	2		Replace	
48	Dowel pin	4			

DISASSEMBLING AND ASSEMBLING VALVE DRIVE

Camshaft Housing for Cylinder Bank 1 – 4
Beginning with 1979 Models

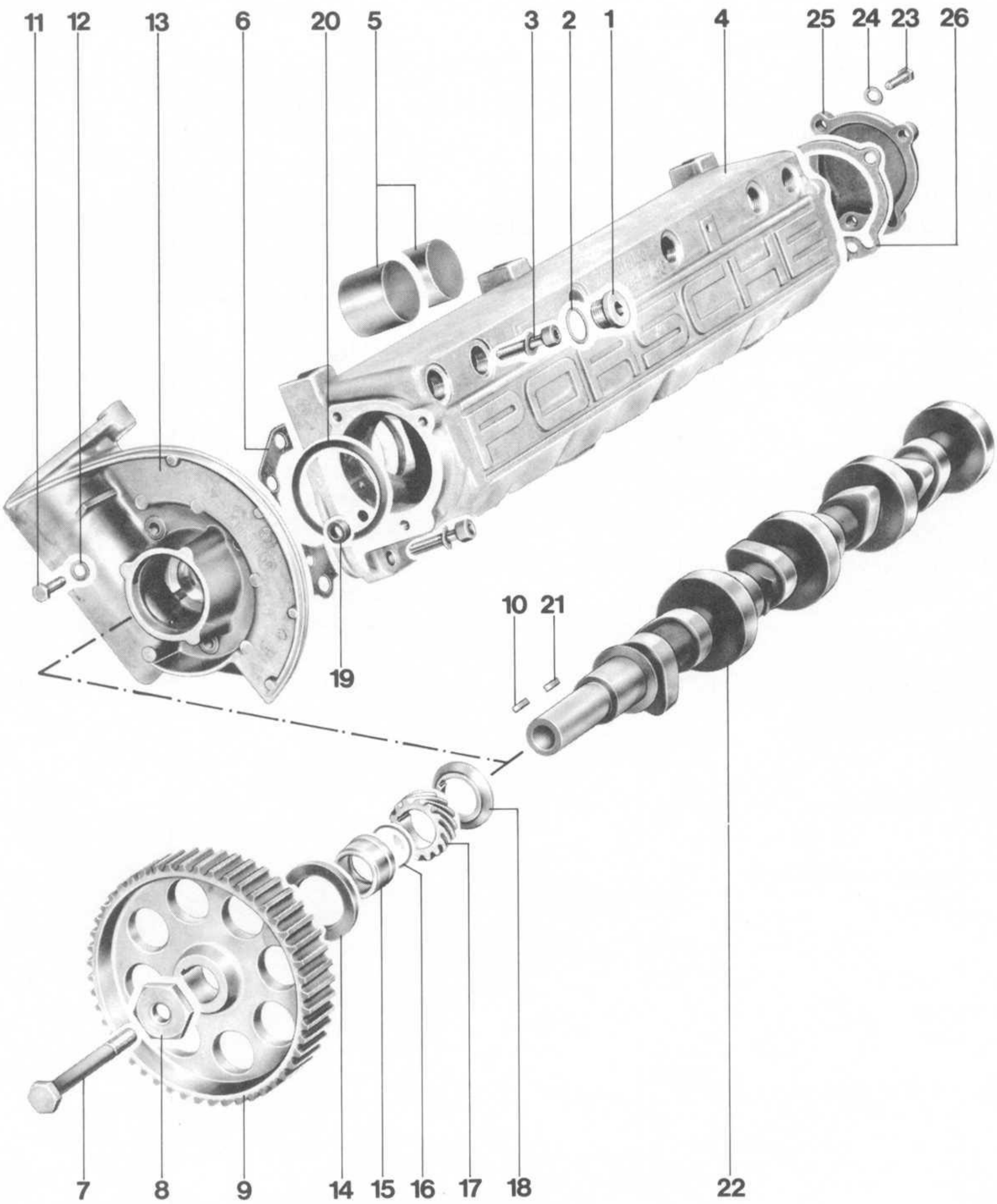


No.	Description	Qty.	Note When: Removing	Note When: Installing	Special Instructions
1	Plug M 18 x 1.5	6		Torque: 40 Nm (29 ftlb)	
2	Seal A 18 x 22	6		Replace	
3	Screw with attached washer M 8 x 35	15		Torque: 20 Nm (14 ftlb)	
4	Camshaft housing	1			
5	Hydraulic valve lifter	8	Do not mix up; store so that oil bores face up		
6	Gasket for camshaft housing	1		Always replace, TOP faces up when installed	
7	Bolt M 10 x 70	1		Torque: 65 Nm (47 ftlb); hold hexagon washer with wrench	
8	Hexagon washer	1		Position correctly, flat surface faces sprocket	
9	Camshaft sprocket	1		Check position when installing drive belt	See page 15 - 14
10	Woodruff key	1			
11	Bolt M 6 x 25	3			
12	Washer A 6.4	3			
13	Camshaft bearing	1			

No.	Description	Qty.	Note When: Removing	Note When: Installing	Special Instructions
14	Shaft seal	1		Replace, give sealing lip a light coat of oil, install together with spacer and drive in flush	
15	Spacer	1			
16	O-ring 23 x 2	1		Replace	
17	Seal	1			
18	O-ring	1		Replace	
19	Camshaft	1		Lubricate bearing surfaces with oil, check mark (on rear camshaft bearing)	
20	Bolt M 6 x 22	3			
21	Washer	3			
22	Cover	1			
23	Cork gasket	1		Replace	

DISASSEMBLING AND ASSEMBLING VALVE DRIVE

Camshaft Housing Cylinder Bank 5 – 8
Beginning with 1979 Model



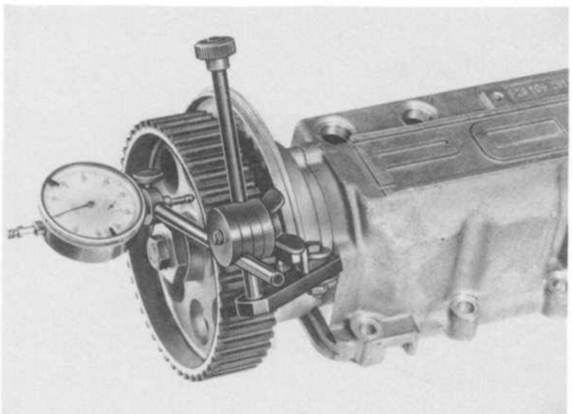
No.	Description	Qty.	Note When: Removing	Note When: Installing	Special Instructions
1	Plug M 18 x 1.5	6		Torque: 40 Nm	
2	Seal A 18 x 22	6		Replace	
3	Screw with attached washer M 8 x 35	15		Torque: 20 Nm	
4	Camshaft housing	1			
5	Hydraulic valve lifter	8	Do not mix up; store that oil bore faces up		
6	Gasket for camshaft housing	1		Always replace; TOP faces up when installed	
7	Bolt M 10 x 95	1		Torque: 65 Nm; hold on washer with hexagon	
8	Washer with hexagon	1		Position correctly, flat surface faces sprocket	
9	Camshaft sprocket	1		Check position when mounting toothed belt	See page 15 - 14
10	Woodruff key	1			
11	Bolt M 6 x 25	3			
12	Washer A 6.4	3			
13	Flange bearing	1			

No.	Description	Qty.	Note When: Removing	Note When: Installing	Special Instructions
14	Shaft seal	1		Replace; give sealing lip a light coat of oil, install together with spacer and drive in flush	
15	Spacer	1			
16	O-ring 23 x 2	1		Replace	
17	Sprocket for distributor	1			
18	Spacer	1		Position correctly	
19	Seal	1		Replace	
20	O-ring	1		Replace	
21	Woodruff key	1			
22	Camshaft	1		Lubricate bearing surfaces with oil; check mark (on rear camshaft bearing)	
23	Bolt M 6 x 22	3			
24	Washer A 6.4	3			
25	Cover	1			
26	Cork gasket	1		Replace	

CHECKING AXIAL PLAY OF CAMSHAFT

Check axial play in conjunction with dial gauge holder VW 387.

New Part Play:	0.09 – 0.12 mm
Wear Limit:	0.20 mm



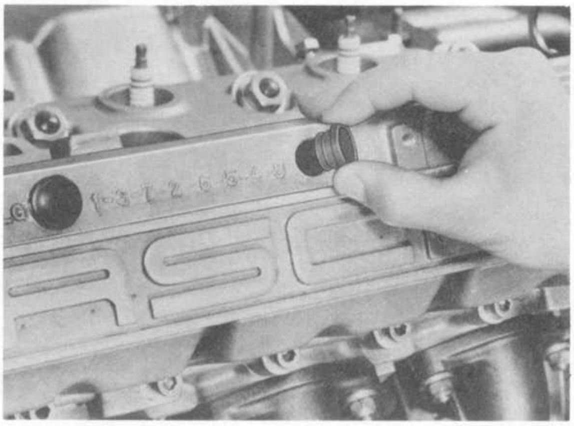
If necessary, replace flange bearing and/or camshaft bearing cover.

Type	Right Camshaft Cyl. Bank 1 – 4	Code Located on Rear Face of Camshaft
928 all 1978, 1979 models		
M 28.01/02/03/04	928.105.155.07	155.07
928 all 1980, 1981, 1982 models		
M 28.09/10/13/14/15/16	928.105.173.01	173.01
928 S R. o. W. 1980, 1981, 1982, 1983 models		
M 28.11/12	928.105.187.03	187.03
928 S USA, Japan, Canada 1980, 1981, 1982, 1983 models		
M 28.19/20	928.105.203.00	203.00
928 S R. o. W. 1984 models		
M 28.21/22	928.105.211.00	211.00
928 S USA, Japan, Canada 1984 models		
M 28.19/20	928.105.203.00	203.00

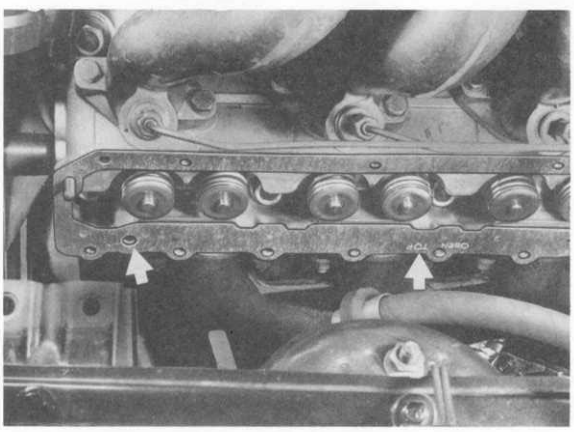
Left Camshaft Cyl. Bank 5 – 8	Code Located on Rear Face of Camshaft	Timing with 1 mm Lift and Zero Clearance
928.105.156.07	156.07	Intake opens 8° ATDC Intake closes 55° ABDC Exhaust opens 38° BBDC Exhaust closes 2° BTDC
928.105.174.01	174.01	Intake opens 12° ATDC Intake closes 48° ABDC Exhaust opens 32° BBDC Exhaust closes 6° BTDC
928.105.188.03	188.03	Intake opens 9° ATDC Intake closes 52° ABDC Exhaust opens 37° BBDC Exhaust closes 2° BTDC
928.105.204.00	204.00	Intake opens 11° ATDC Intake closes 46° ABDC Exhaust opens 25° BBDC Exhaust closes 2° ATDC
928.105.212.00	212.00	Intake opens 6° ATDC Intake closes 54° ABDC Exhaust opens 43° BBDC Exhaust closes 4° BTDC
928.105.204.00	204.00	Intake opens 11° ATDC Intake closes 46° ABDC Exhaust opens 25° BBDC Exhaust closes 2° ATDC

DISASSEMBLING AND ASSEMBLING VALVE TRAIN

Camshaft Housing



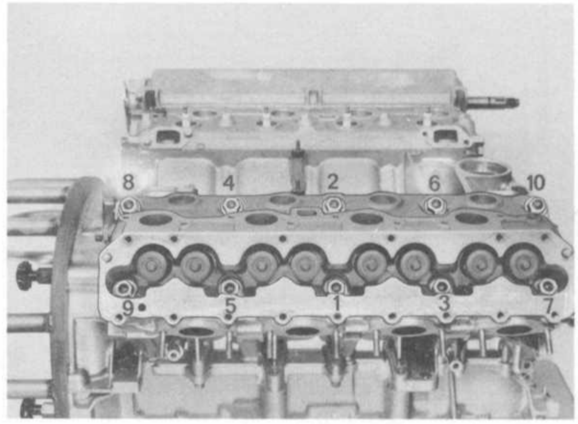
Lubricate plugs lightly and install by hand. For engine with aluminum plugs the torque is 40 Nm. Use new seals.



Note installed position of camshaft housing gasket. Camshaft oil bore must be clear (arrow).

Installing Cylinder Head

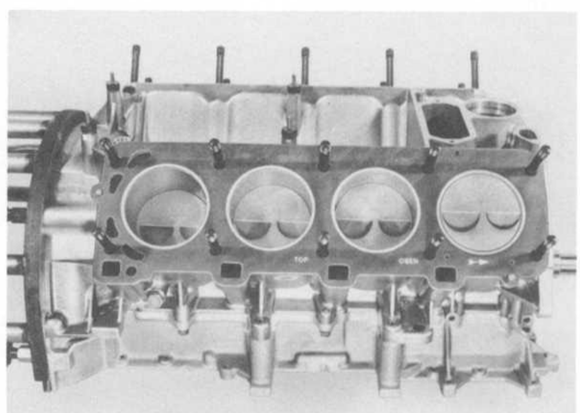
The cylinder head can be removed from an engine in the car.



Tightening sequence: see figure
Loosening sequence: opposite

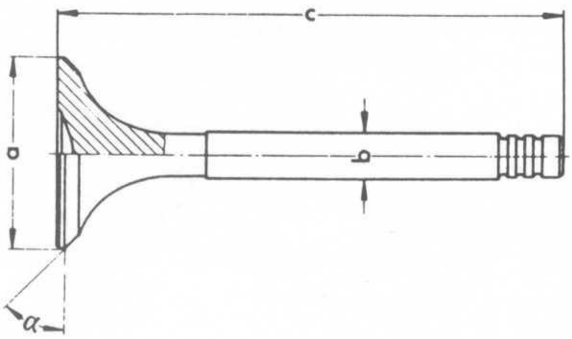
Note

Never use any lubricant for the installation of cylinder head nuts and washers. Only the threads of the studs must be given a light coat of engine oil.
Washer must not turn when tightening cylinder head nuts! Control by making paint marks if necessary. On the repair sector the washer can be made reusable by roughening the bearing surface facing the cylinder head with a rough grain sandpaper.



Position of installed cylinder head gasket.
Watch marks, "TOP" and arrow, when installing.
Arrow faces forward (see figure).

Valve Sizes



Valve Sizes 928

Distance	Intake	Exhaust
a	43.00 mm	38.00 mm
b	8.97 mm	8.95 mm
c	110.50 mm	110.90 mm
α	45°	45°

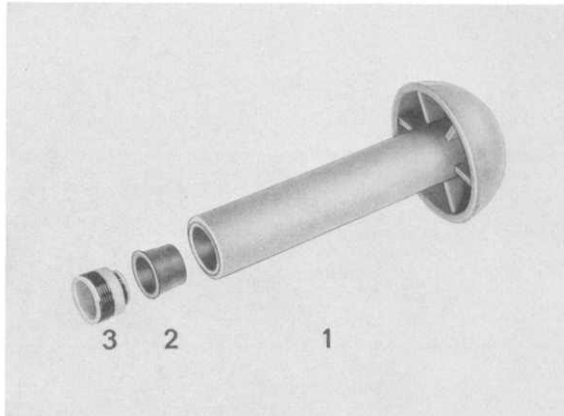
Valve Sizes 928 S

Distance	Intake	Exhaust
a	45.00 mm	40.00 mm
b	8.97 mm	8.95 mm
c	110.50 mm	110.90 mm
α	45°	45°

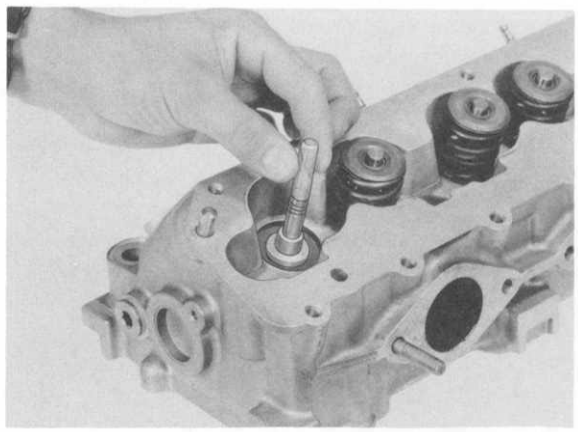
Removing and Installing Valve Stem Seal
(cylinder head removed)

Pull off valve stem seals with Special Tool 3047

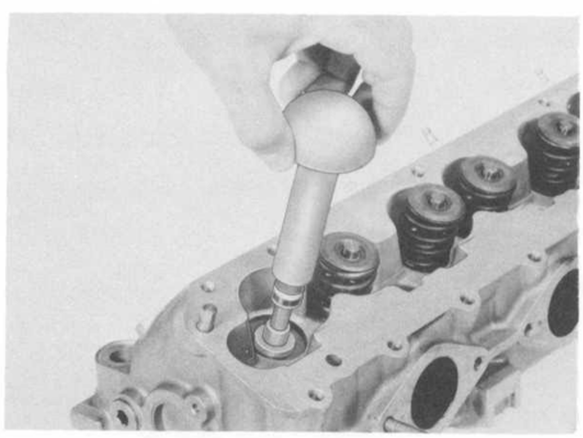
1 - Pressure pad to install valve stem seal
2 - Valve stem seal 924 as intermediate part
3 - Original valve stem seal



Shorten plastic sleeve from Type 924 by approx. 10 mm and place on valve stem.



Lubricate valve stem seal and push on to valve guide carefully with the pressure pad.

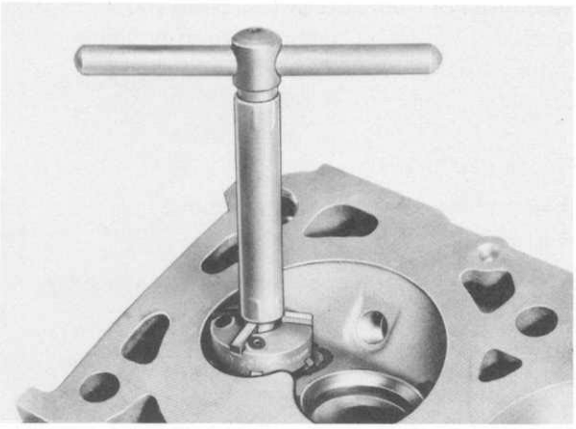


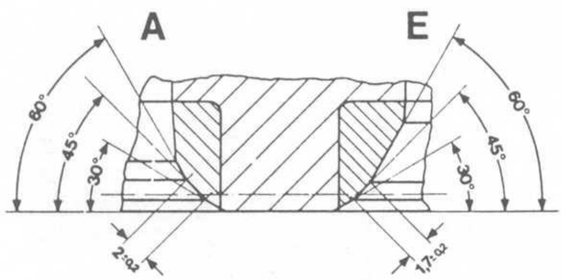
Plastic Sleeve Source: Cartool
Alfred-Brehm-Str. 5
D-8070 Ingolstadt/Donau

Machining valve seats

Note

Before refacing the valve seats, check dimension "A" to avoid carrying out work that may be unnecessary if the wear limit has been exceeded.

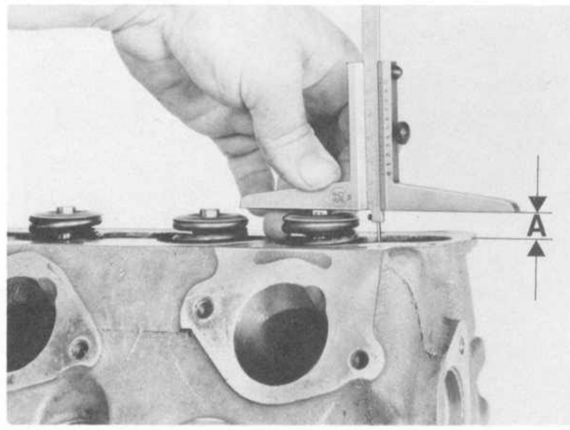




Valve seats may be machined down to the wear limit "A" = 14,5 mm
(size new 13.65 ± 0.45).

Check with a new valve.
Distance "A" must not be exceeded, as otherwise the function of the hydraulic valve tappet would not be assured.

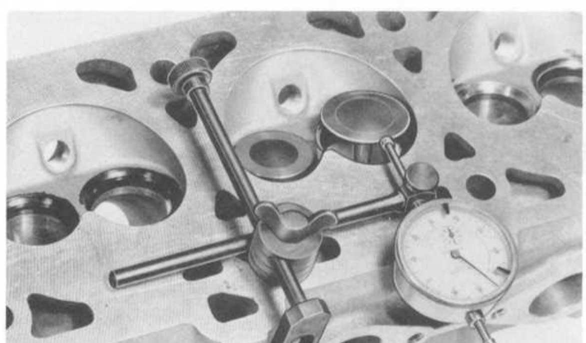
Remove no more than the absolute minimum amount of metal in order to prevent premature wear.



Checking valve guides

1. Remove deposits with a cleaning reamer.

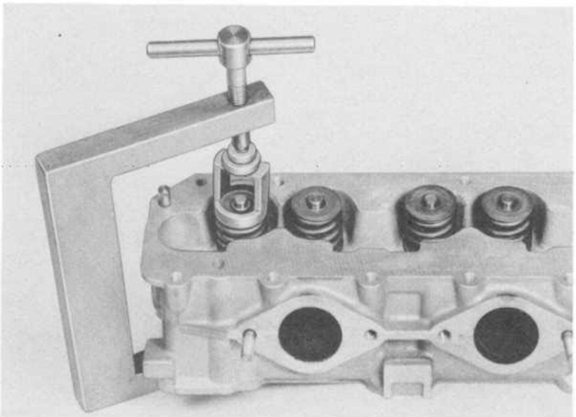
2. Place new valve in valve guide and check that valve stem end is flush with cylinder head/camshaft housing mating face.



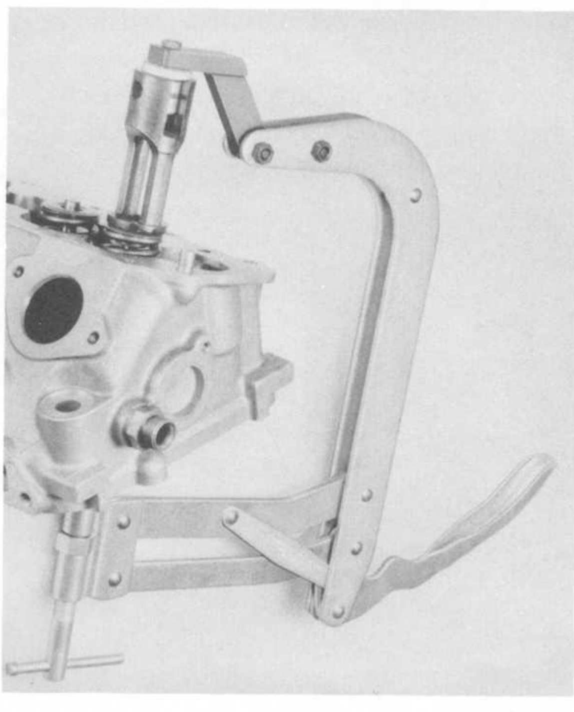
3. Check clearance with dial gage holder VW 387 and dial gage.
   Wear limit = 0.80 mm.

Printed in Germany – XXVII, 1991

Removing and Installing Valve Springs



Remove and install valve springs with P 200 a.



Remove and install valve springs with US 1020 (only applicable for USA).

Checking Installed Length of Valve Springs

1. Install Special Tool 9138 with shims belonging to a pertinent valve, spring retainer and both keepers.

2. Read distance from Special Tool 9138 and, if necessary, correct by adding or removing shims. Shims are available in thicknesses of 0.5 and 1.0 mm.

928 Models 1978/1979

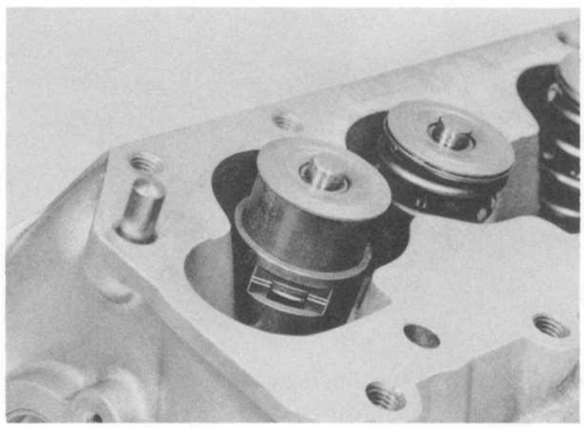
Intake valve	39.6 + 0.5 mm
Exhaust valve	38.6 + 0.5 mm

928 Models 1980

Intake valve	38.2 ± 0.3 mm
Exhaust valve	38.2 ± 0.3 mm

928 S

Intake valve	38.5 + 0.5 mm
Exhaust valve	37.5 + 0.5 mm



Example: 928 Models 1980

Special Tool 9138 shows 38.6 mm. In this case install one more 0.5 mm shim.

Example: 928 S (Exhaust Valve)

Special Tool 9138 shows 38.6 mm. In this case install additional 1.0 mm shims.

CHECKING INSTALLED LENGTH OF VALVE SPRINGS
928 S Beginning with 3.81

Valve Springs

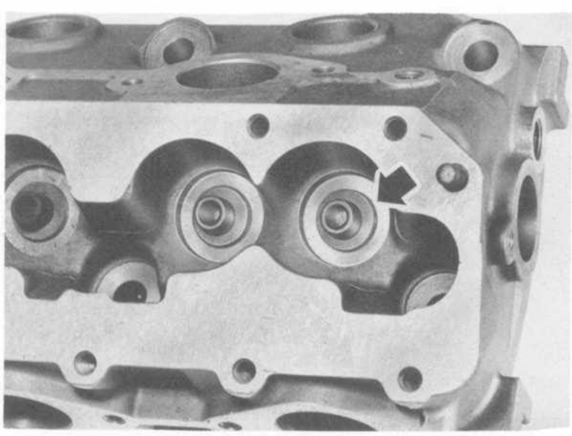
Valve springs sets with progressive outside springs on both sides (formerly only one side) were introduced beginning with

Engine No. 821 0516 M 28/11 or
821 5503 M 28/12 Automatics.

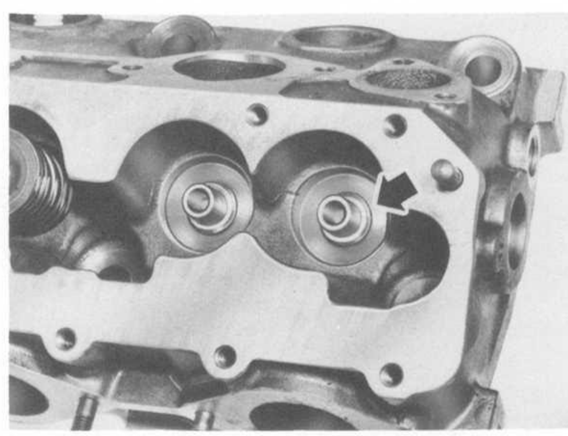
This change made it necessary to have large valve spring bearing surfaces on the cylinder heads.

Old

New



Old Version



New Version

The new cylinder heads can be installed in pairs on older engines or only on one engine side together with the old version. The progressive valve springs with accessories must always be used on the new cylinder heads on both sides.

Old valve springs, discs, stem seals, guides and washers are still availabe.

Installed Length of 928 S Valve Springs with 1 White Stripe Beginning with 3.81

Note:
Use Special Tool 9138/1.

	New Valve Springs – White Dot –
Intake valve	41.5 + 0.5 mm
Exhaust valve	40.5 + 0.5 mm

Installed Length of 928 S Valve Springs with 2 or 3 White Stripes Beginning with 3.82

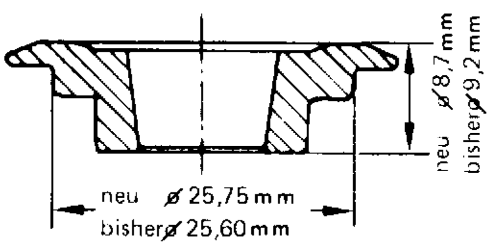
	New Valve Springs – 1 or 2 White Stripes –
Intake valve	41.0 + 0.5 mm
Exhaust valve	40.0 + 0.5 mm

New installed lengths are not given on Special Tool 9138/1 "Valve Spring Adjuster", so that when reaching "41.5 or 40.5 mm" one more 0.5 mm shim has to be added.

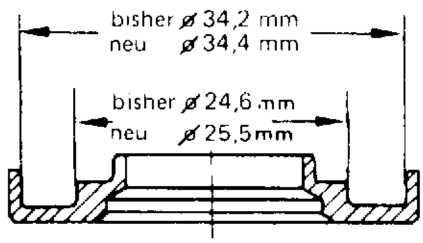
Note:

New valve springs with 2 or 3 white stripes may only be used together with new spring retainers and guides.

Spring Retainer

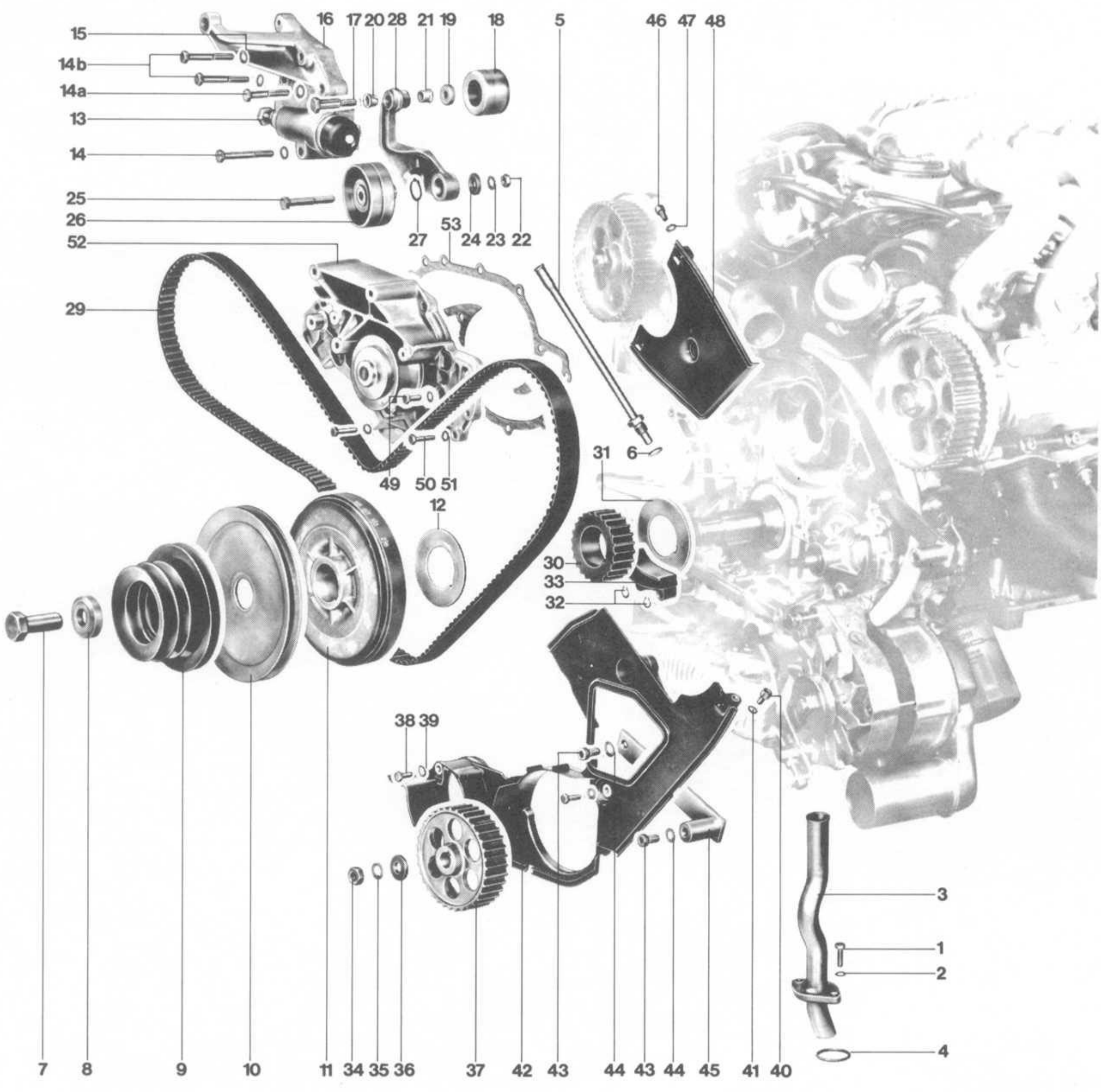


Guide Disc



REMOVING AND INSTALLING CAMSHAFT DRIVE BELT AND WATER PUMP

REMOVING AND INSTALLING CAMSHAFT DRIVE BELT AND WATER PUMP



No.	Description	Qty.	Note When: Removing	Note When: Installing	Special Instructions
1	Bolt M 6 x 20	2			
2	Washer	2			
3	Oil tube	1			
4	Seal	1		Replace	
5	Guide tube for oil dipstick	1			
6	Seal 14 x 18, aluminum	1		Replace	
7	Bolt	1			
8	Thrust washer	1			
9	Pulley	1			
10	Pulley	1			
11	Vibration damper	1			
12	Collar washer	1			
13	Adjusting screw	1			
14	Bolt M 8 x 62	1			
14a	Bolt M 8 x 45	1		Install with Loctite 574	
14b	Bolt M 8 x 55	2			
15	Washer	4			
16	Tensioning roller housing	1			see Page 15-24
17	Shaft bolt	1			
18	Roller	1		Check for easy movement, turning by hand. Roller must turn easily without restriction at any point	

No.	Description	Qty.	Note When: Removing	Installing	Special Instructions
19	Washer	1			
20	Nylon bushing	1		Check, replacing if necessary	
21	Nylon bushing	1		Check, replacing if necessary	
22	Nut	1			
23	Washer	1			
24	Washer 9 x 25 x 3,5	1			
25	Bolt M 8 x 55	1			
26	Tensioning roller	1		Check for easy movement, turning by hand. Tensioning roller must turn easily and without restriction at any point.	
27	Circlip 20 x 1.75	1		Position correctly	
28	Tensioning roller carrier	1			
29	Camshaft drive belt	1		Check, replacing if necessary	
30	Sprocket	1			
31	Collar washer	1			
32	Circlip 8 x 0.8	2			
33	Slide	1			
34	Nut M 10	1			
35	Washer	1			
36	Washer 10.5	1			
37	Oil pump sprocket	1			
38	Bolt	2			
39	Washer	2			

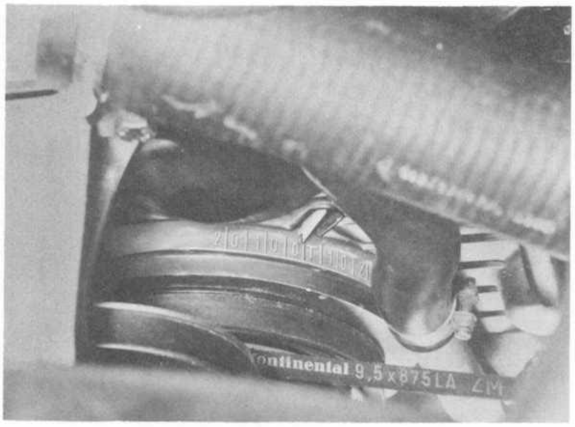
No.	Description	Qty.	Note When: Removing	Note When: Installing	Special Instructions
40	Bolt M 6 x 12	1			
41	Washer	1			
42	Camshaft drive belt cover	1			
43	Bolt	2			
44	Washer	2			
45	Pump brace	1			
46	Bolt M 6 x 12	2			
47	Washer	2			
48	Camshaft drive belt cover	1			
49	Bolt M 6 x 20	5		Install in recess of housing	
50	Bolt M 6 x 25	8			
51	Washer	13			
52	Housing with water pump	1			
53	Gasket	1		Replace	

INSTALLING CAMSHAFT DRIVE BELT AND ADJUSTING TIMING

Note:
Make sure new drive belts are retightened after driving car approx. 1,000 km.

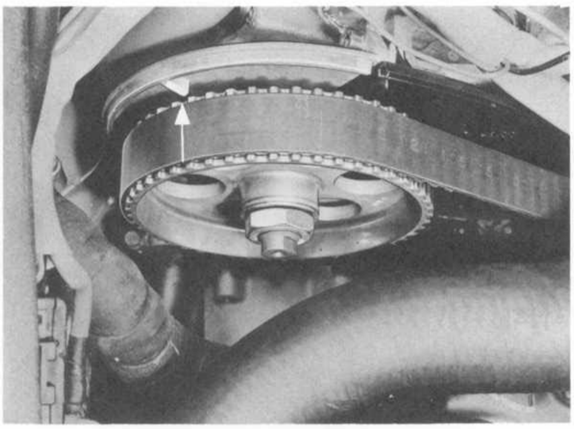
Installing Camshaft Drive Belt

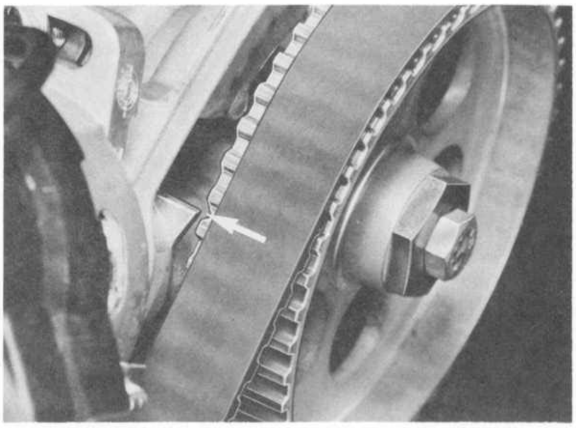
1. Line up TDC mark on vibration damper with red indicator on cover by turning crankshaft clockwise.



Note:
Vibration damper must be removed again for installation of the camshaft drive belt afterwards.

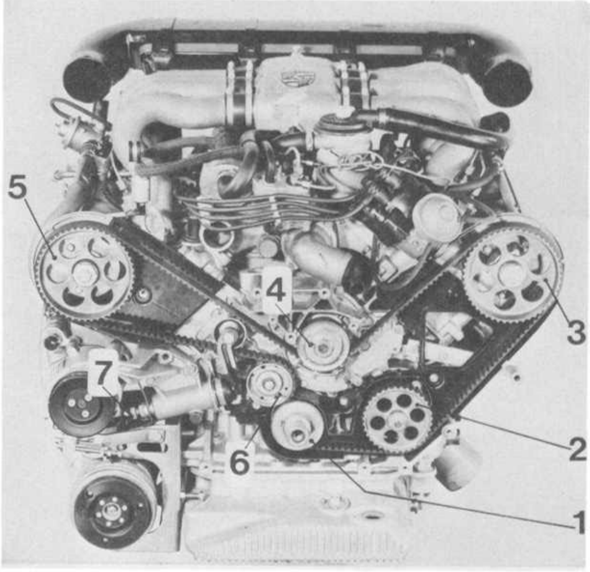
2. Turn both camshafts until notches in both camshaft sprockets are aligned with marks cast on the camshaft bearing caps.





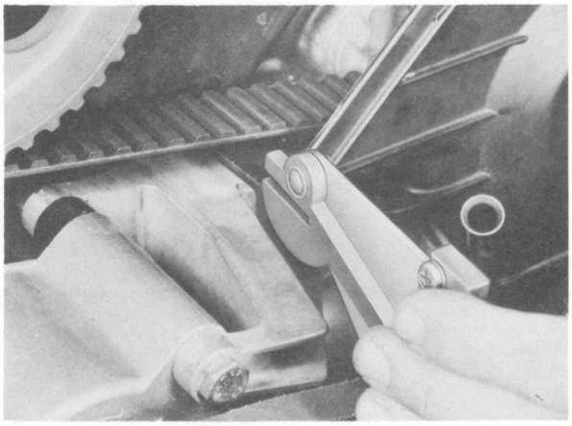
3. Install camshaft drive belt, always pre-loaded by hand, in the following order.

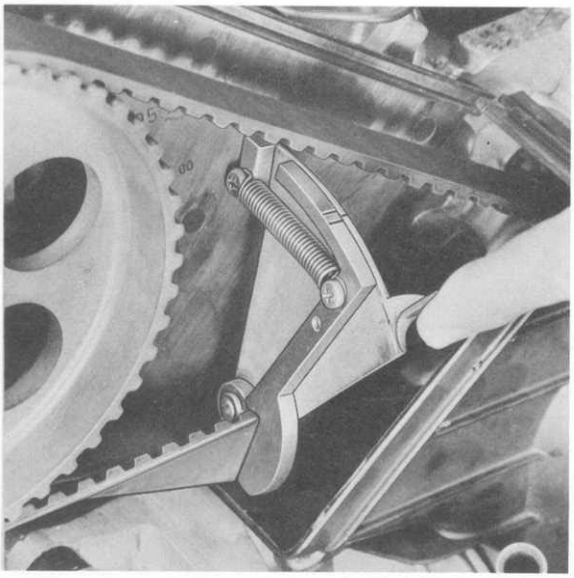
   First on sprocket (1), oil pump sprocket (2), then over sprocket (3) of left camshaft (cyl. 5 through 8), bottom of water pump sprocket (4) and on sprocket (5) of cyl. 1 through 4, and finally over camshaft drive belt tensioning roller (6).



Note:
Should the teeth of a hand-tightened camshaft drive belt not match the sprocket pitch accurately enough, turn pertinent camshaft sprocket counterclockwise carefully until teeth match.

4. Tighten camshaft drive belt to specifications with special tool 9131.





5. Turn engine clockwise two turns to align red indicator and TDC mark.

Note:

Never turn engine anticlockwise, since this could destroy the camshaft drive belt tensioner.

6. Check position of marks.

7. Now tighten camshaft drive belt again.

8. Turn engine clockwise two turns to align red indicator and TDC mark.

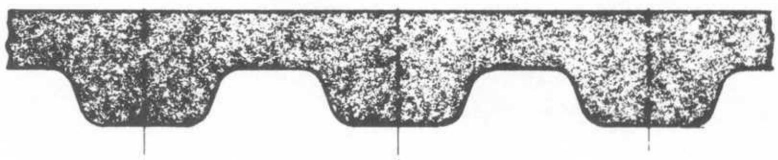
9. Recheck.

TOOTHED DRIVE BELTS WITH HTD TEETH
Beginning with 1983 Models

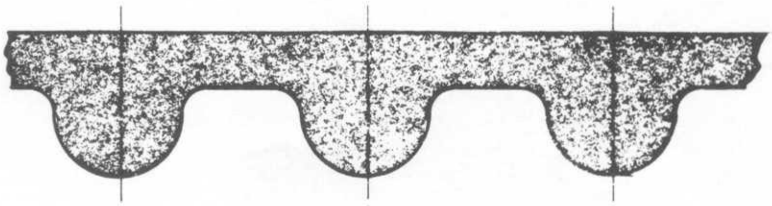
Note:

The shape of teeth on drive belts for camshaft sprockets, oil pump sprocket and crankshaft sprocket has been changed to High Torque Drive (HTD).

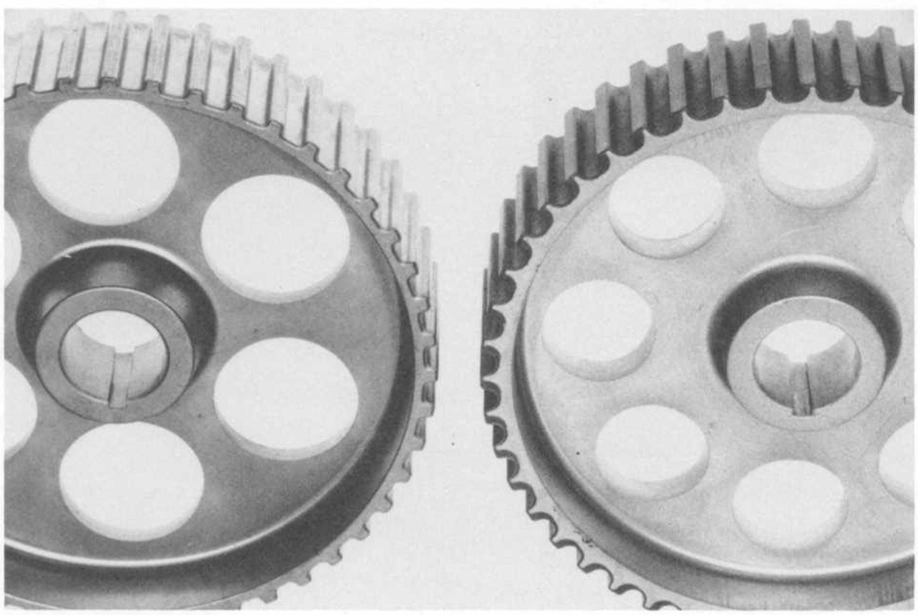
Old Tooth Shape



HTD Tooth Shape



Old Camshaft Sprocket HTD Camshaft Sprocket

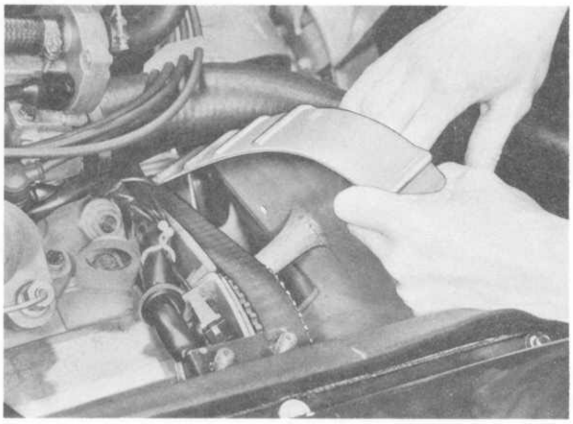


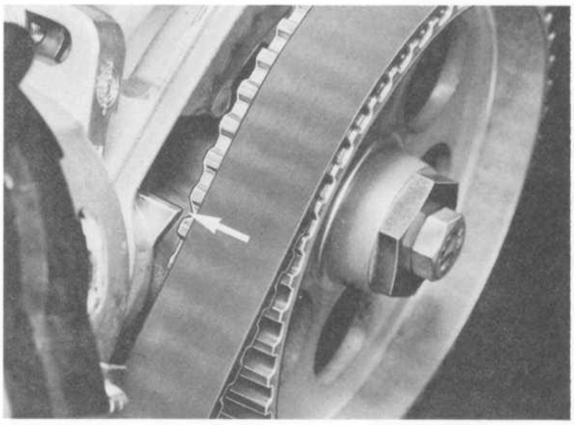
Note: New HTD drive belts can also be used on older engines, if above mentioned sprockets with new tooth shape are used at same time.
Sprockets with different teeth shape should never be mixed.

CHECKING AND ADJUSTING DRIVE BELT

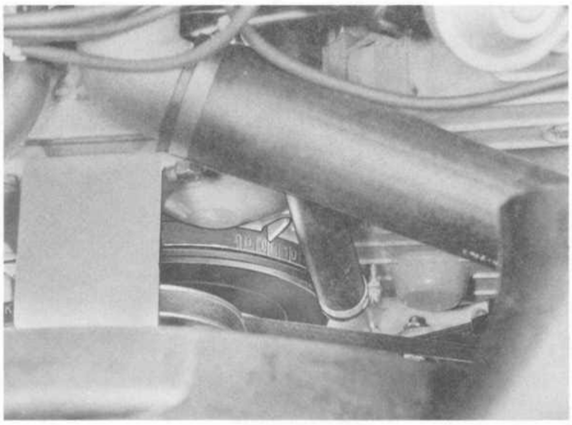
Checking

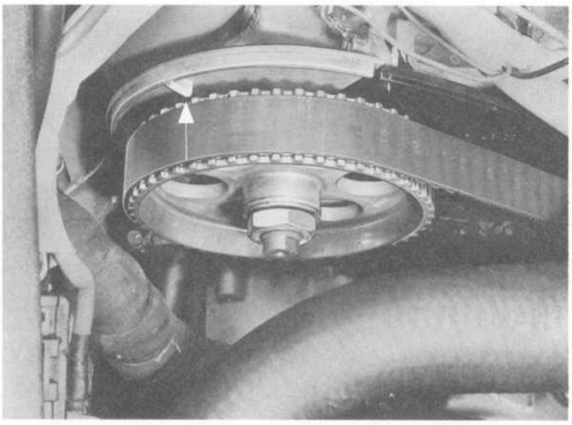
1. Loosen and remove drive belt cover upper sections on both sides.





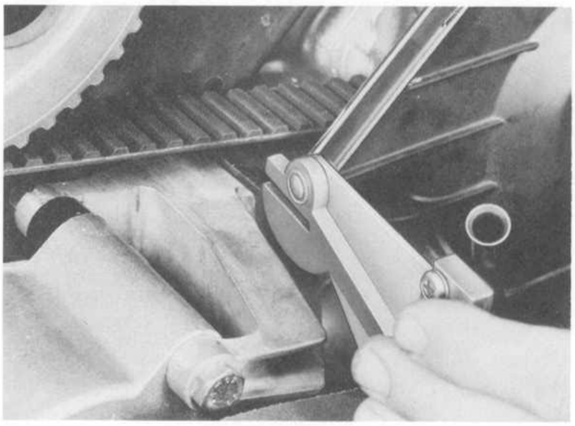
2. Turn engine in direction of rotation to TDC (cylinder 1). In this position marks on camshaft sprockets must be aligned with marks on flange bearings.

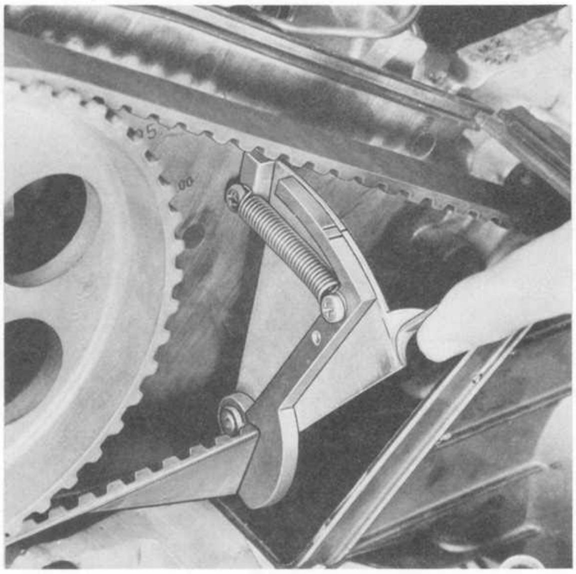




3. Turn engine two more turns until TDC mark is reached again and check drive belt for damage and wear at the same time.

4. Check drive belt tightness between tension roller and camshaft sprocket on relaxed section of belt with Special Tool 9131.
   Drive belt tightness is correct when right mark is between both left marks and special tool rests on rear drive belt cover. (Engine must be positioned for this test as described in point 2.)

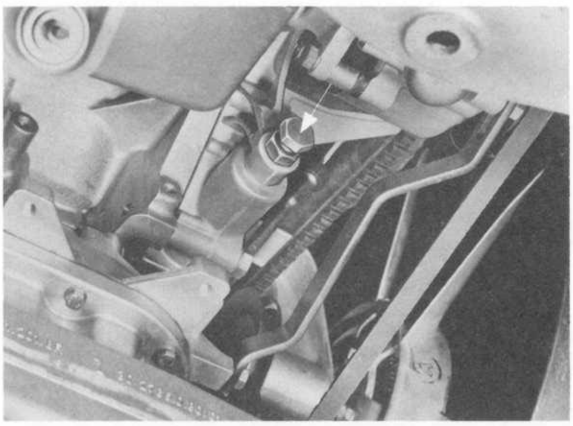




Adjusting

Note

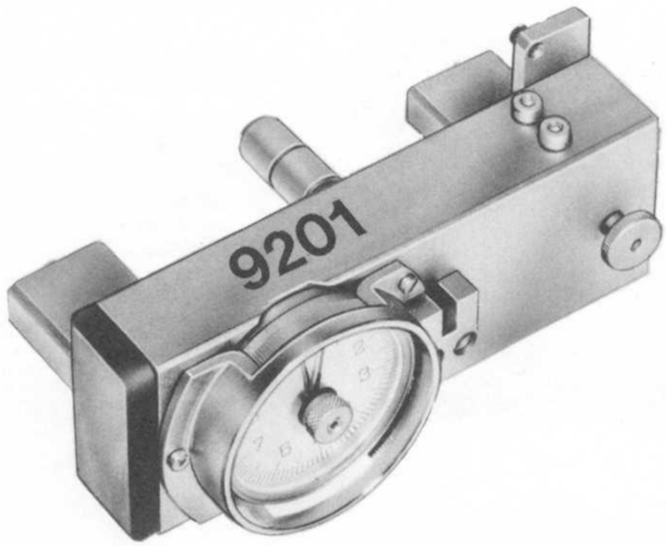
Drive belt adjusting screw is located on bottom of engine at front right-hand side.



Loosen locknut of adjusting screw and turn adjusting screw until drive belt tightness is correct. Tighten locknut. Turn engine two turns and recheck tightness of drive belt.

Screw tightened – tightens belt
Screw loosened – loosens belt

TOOLS

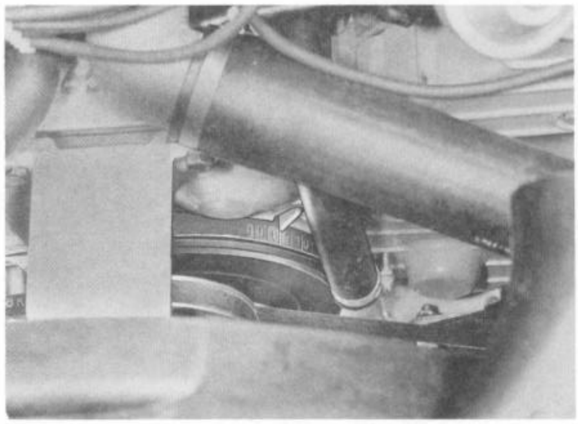


No.	Description	Special Tool	Remarks
1	Belt tightness tester	9201	

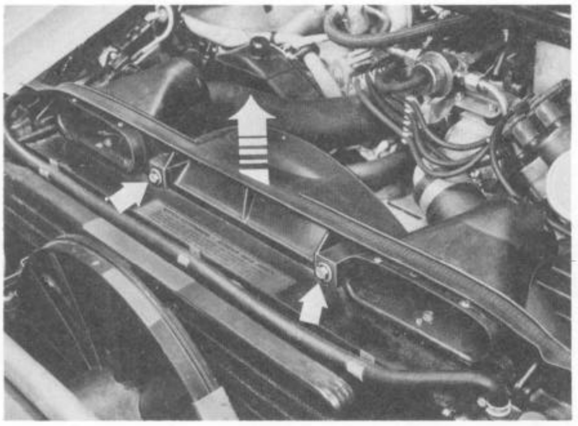
CHECKING AND ADJUSTING DRIVE BELT

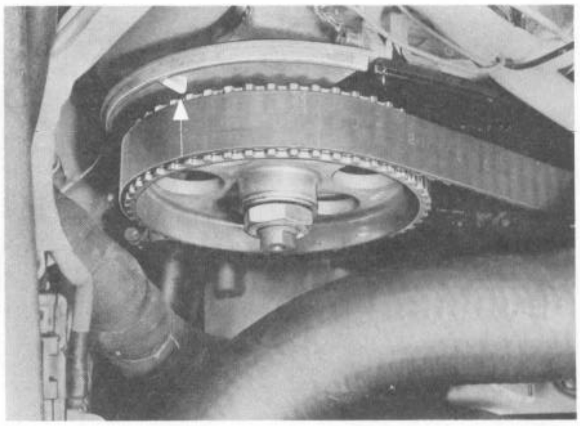
Checking

1. Remove air guide hoses.

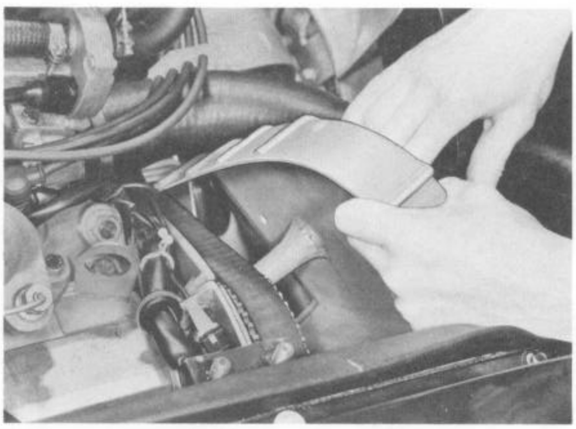


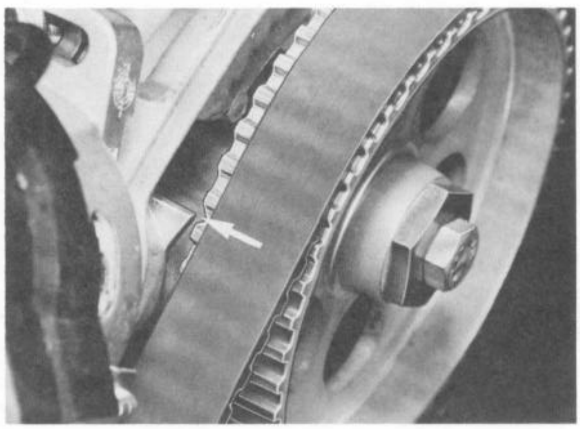
2. Unscrew two hexagon head metal screws and remove air guide upper section from above.





3. Unscrew drive belt guard upper section on both sides and remove.

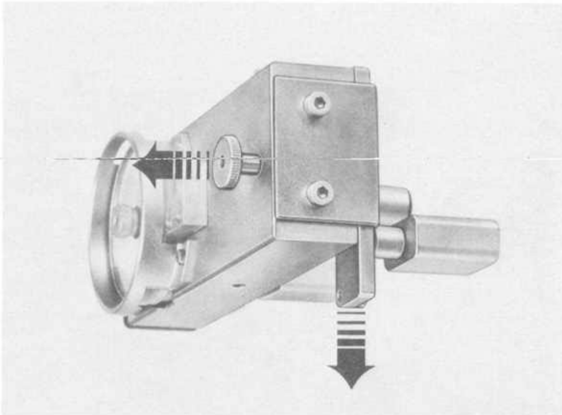




4. Turn engine in direction of rotation to TDC (cylinder 1). In this position marks on camshaft sprockets should conform with marks on flange bearings.

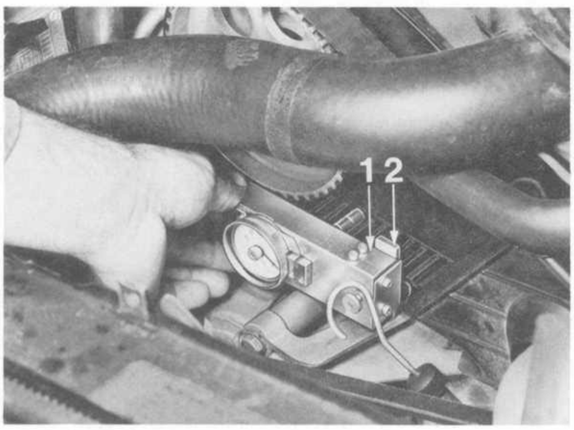
5. Turn engine two more turns until TDC mark is reached again and check drive belt for damage and wear at same time.

6. Prepare Special Tool 9201 for checking. Pull out lockpin on special tool and slide out gauge pin opposite the lockpin fully. Line up maximum indicator with gauge indicator.



7. Slide special tool on to relaxed section of drive belt (sliding shoes on smooth surface, rollers in tooth gap).

8. Press down tester on case (arrow 1) slowly until gauge button (arrow 2) resting on the air pump bracket engages.



Line up maximum indicator with gauge indicator (in anticlockwise direction).

Read value while keeping the tester free of tension, i. e. horizontal to the drive belt.
Tester must not contact plastic cover.

N o t e :

Sliding shoes must rest on belt with their complete surface. The special tool must not be turned or moved on the belt while checking.

9. Pull out lockpin to have the gauge button disengage again.

I m p o r t a n t :

This test requires the engine in the position described in point 4.

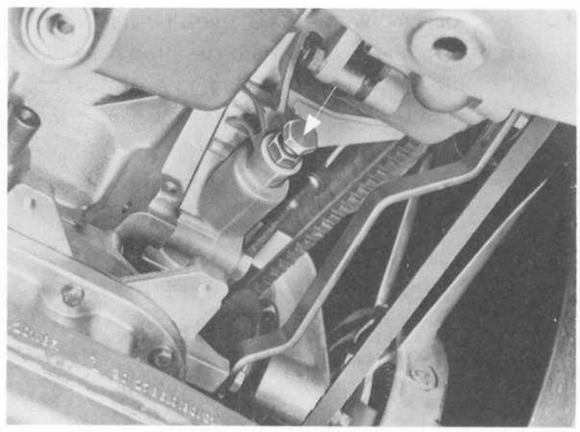
Repeat test one or two times!

Adjusting value: 4.5 scale units.

Correct belt tightness if necessary.

A d j u s t i n g

The drive belt adjusting screw is located on bottom of engine at front right.



Loosen nut on adjusting screw and turn adjusting screw until the drive belt tightness is correct. Tighten nut again. Turn engine two more turns and recheck drive belt tightness.

Tightening screw = tightening belt

Loosening screw = loosening belt

Note

Never turn engine anticlockwise, since drive belt could jump out if its tightness is insufficient.

Machining the cylinder head mating surface

Checking the cylinder head for distortion

Check the sealing surface of the cylinder head for distortion using a feeler gauge and straightedge.

Distortion limit of mating surface: 0.05 mm. Warped cylinder heads may be repaired by machining the mating surface. Admissible distortion after machining: 0.03 mm

Machining the cylinder heads

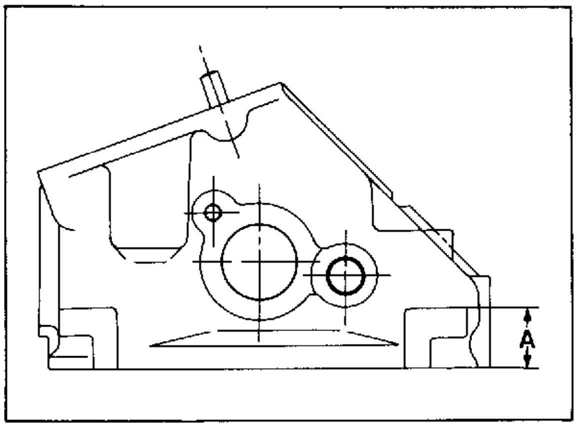
As a rule, both cylinder heads must be machined by the same amount to ensure correct seating of the regulator housing.

Machine sealing surface of the cylinder head only until a straight surface is obtained. Max. wear limit: 23.6 mm.

Note for machining of the sealing surface:
Max. roughness = 0.015 mm

If machining causes the actual value to be below the tolerance applicable to new parts, use a 1.4 mm thick cylinder head gasket (available from the parts service) when fitting the cylinder head.

New-part size A = 24 ± 0.1 mm
Wear limit A = 23.6 mm



Note

When machining the sealing surface facing the combustion chamber, also check the mating surface on the camshaft end and machine if required.
Admissible distortion of camshaft mating surface
when checking: 0.1 mm
after machining: 0.03 mm
Before machining the mating surface facing the camshaft housing, check dimension "A" to avoid unnecessary work.
Plug oil passage of check valve before machining. Remove roll pins.

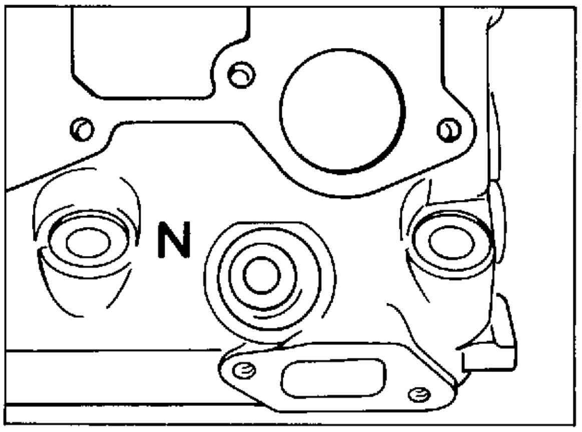
Cylinder head refacing dimensions and identification

New dimension	: 24 ± 0.1 mm
Gasket	: 1.1 mm
Identification	: none
Refacing dimension	: 23.8 to 23.6 mm
Gasket	: 1.4 mm
Identification	: N

Identification: N

Engrave at cylinder 1 and 4 as well as 5 and 8, respectively.

Height of "N" character: 10 mm



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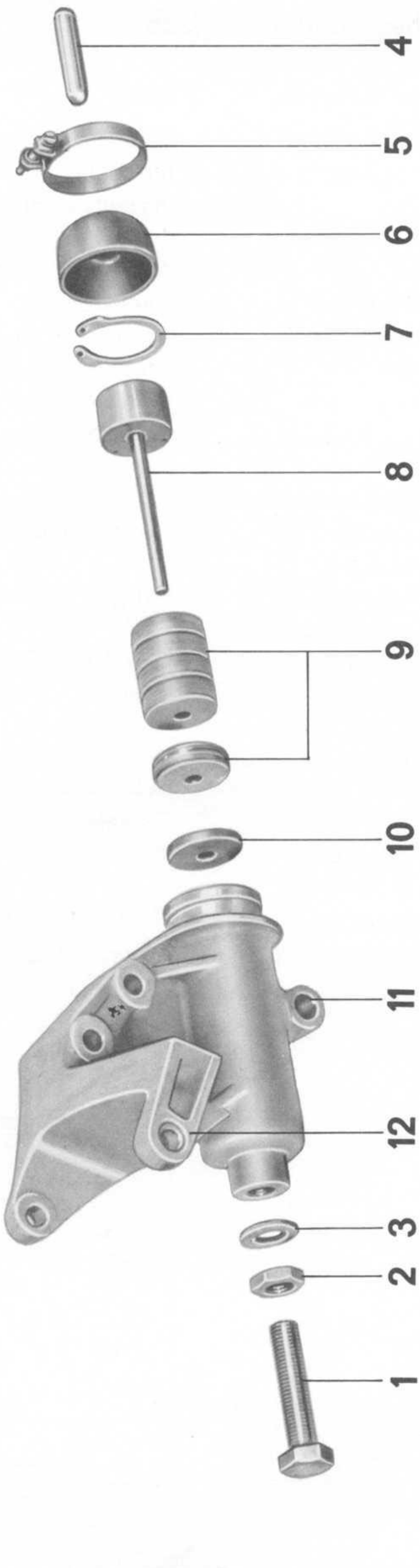
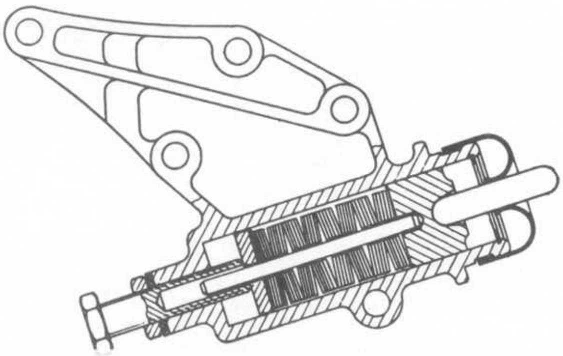
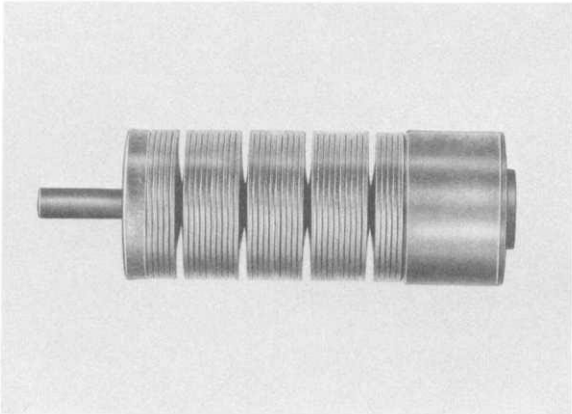

4
5
6
7
8
9
10
11
12
3
2
1

No.	Description	Qty.	Note When Removing	Note When Installing	Special Instructions
1	Adjusting screw	1			
2	Nut M 12 x 1.5	1		Lock after adjusting	
3	Unitec circlip	1		Check, replacing if necessary	
4	Push rod	1			
5	Hose clamp	1			
6	Bellow	1		Check, replacing if necessary	
7	Circlip	1	Position correctly		
8	Piston	1			
9	Bimetal plate (8 plate sets of 5 each, coated alternately) (7 plate sets of 5 each, coated alternately)	40 35		Watch arrangement	see page 15 - 12
10	Support disc	1			
11	Tensioning roller housing	1		Fill one third of housing with transmission oil SAE 90	
12	Key	1			

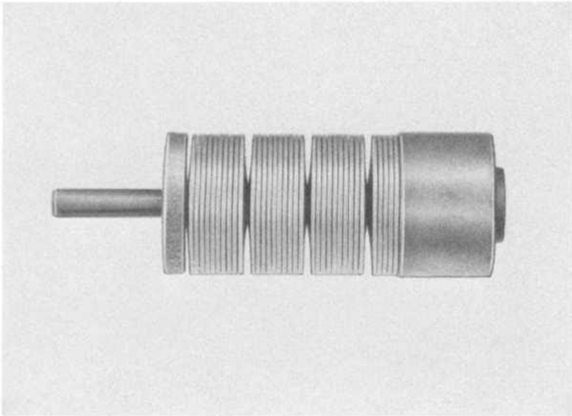
INSTALLATION NOTES

Arrangement of Bimetal Plate Sets for Tensioning Roller





Install 8 plate sets of 5 each with coated surface alternately.



Install 7 plate sets of 5 each with coated surface alternately.

Note

Use correct adjusting screw to match number of plate sets.
8 plate sets = adjusting screw 928.105.075.00
7 plate sets = adjusting screw 928.105.075.01

Installing Tensioning Roller Housing

1. Fill one third of housing with SAE 90 transmission oil.

2. Hold housing at an angle and slide in entire piston with bimetal plate sets and support disc.

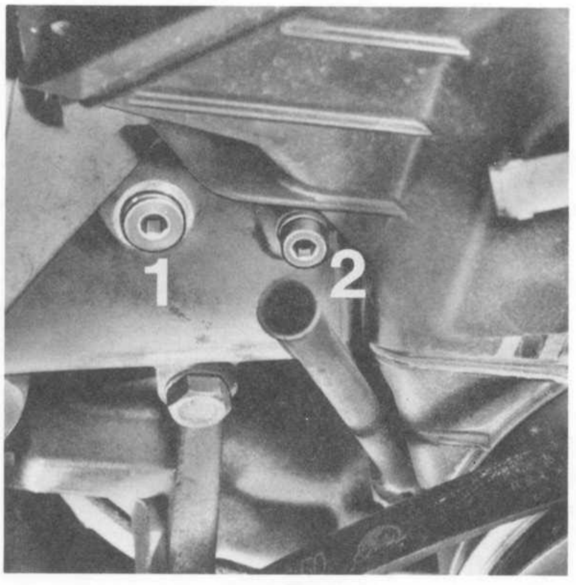
3. Push piston in housing until oil leaves the discharging bore and piston is felt to be against the stop.

4. Oil level should reach upper edge of tensioning roller housing. Add oil while holding the tensioning roller housing upright, if necessary.

BLEEDING TENSIONING ROLLER HOUSING (TOOTHED BELT TENSIONER)

1. Tighten toothed belt as specified.

2. Remove oil filler plug (1) and bleeder screw (2).

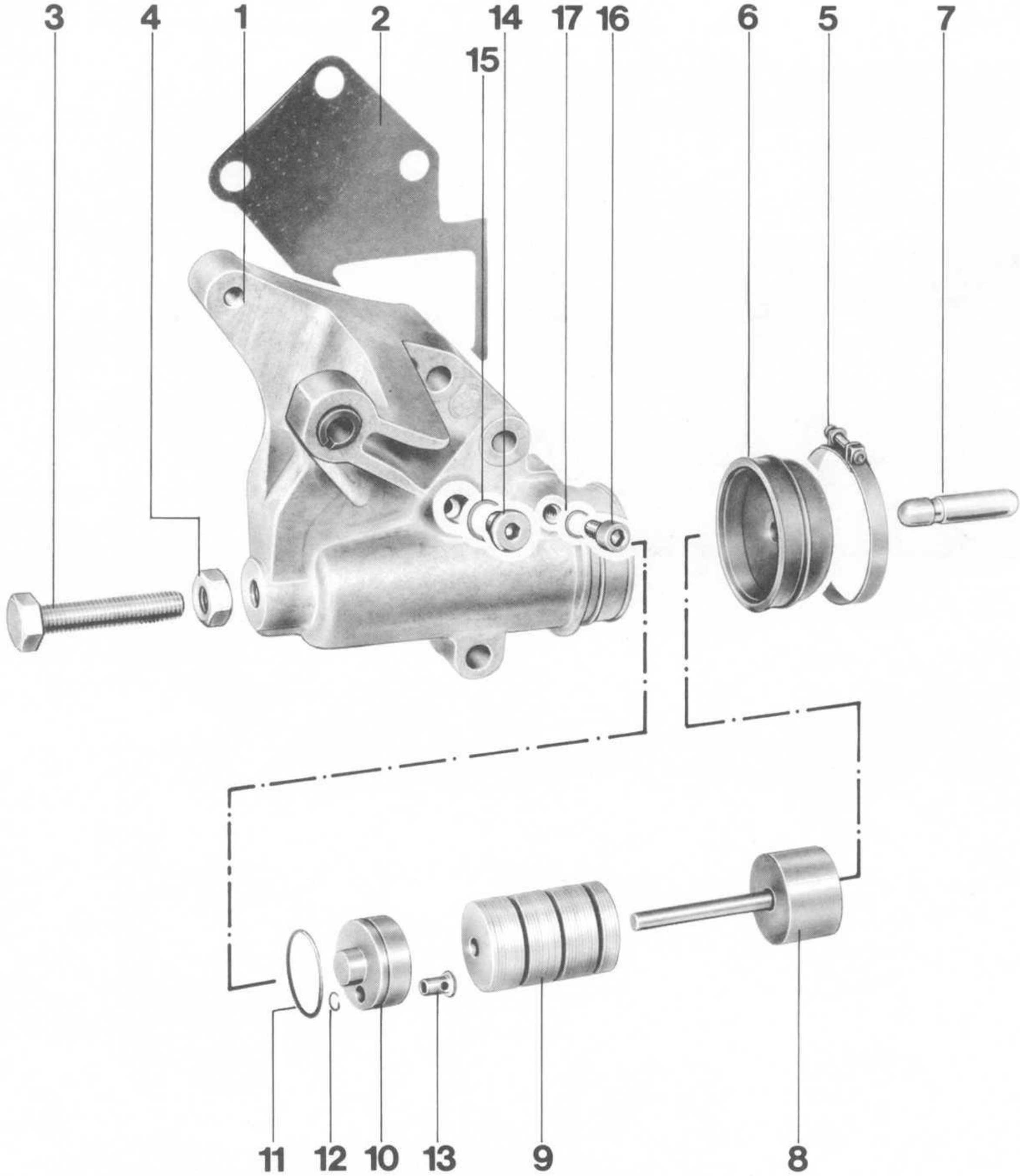


3. Pour oil from oil can into oil filler opening, slowly, until oil runs out of bleeder screw bore.

4. Screw in and tighten oil filler plug and bleeder screw.

DISASSEMBLING AND ASSEMBLING TENSIONING ROLLER HOUSING

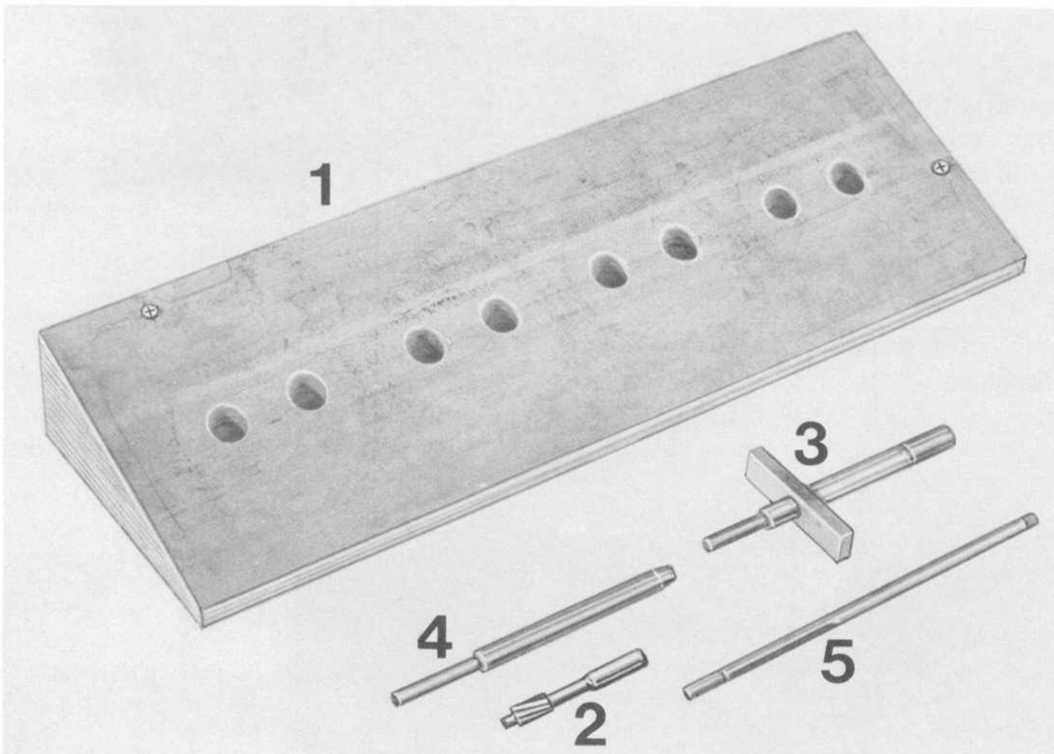
Beginning with 1983 Models



No.	Description	Qty.	Note When: Removing	Installing	Special Instructions
1	Tensioning roller housing	1		Lubricate guide sleeve with oil	
2	Gasket	1		Replace	
3	Adjusting screw	1			
4	Nut M 12 x 1.5	1		Lock nut after adjusting, while holding adjusting screw	
5	Hose clamp	1			
6	Dust cover	1			
7	Push rod	1		Install in dust cover while still removed; make sure of correct fit in groove	
8	Piston	1			
9	Bimetal disc set	35		7 sets of 5 each, coated alternately	
10	Valve carrier	1			
11	O-ring 27.5 x 1.5	1		Replace	
12	Snap ring	1		Position correctly	
13	Valve	1		Check that valve carrier moves easily	
14	Oil filler plug M 10 x 1	1			
15	Seal A 10 x 13.5	1		Replace	
16	Bleeder screw M 6 x 10	1			
17	Seal A 6.5 x 9.5	1		Replace	

REPLACING VALVE GUIDES

TOOLS



No.	Description	Special Tool	Remarks
1	Pressing out base	9220	
2	Countersink	9220/1	
3	Pressure pad	9221	
4	Driver	9224	
5	Reamer	3015	

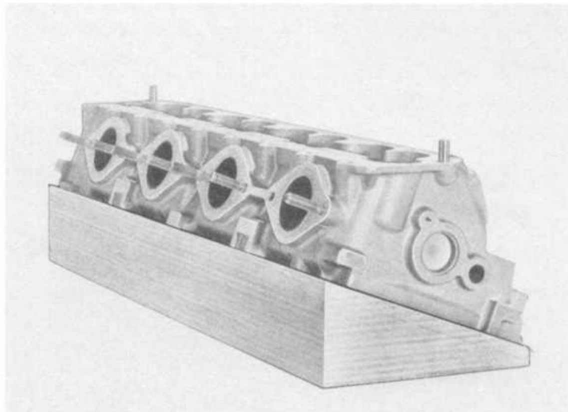
REPLACING VALVE GUIDES

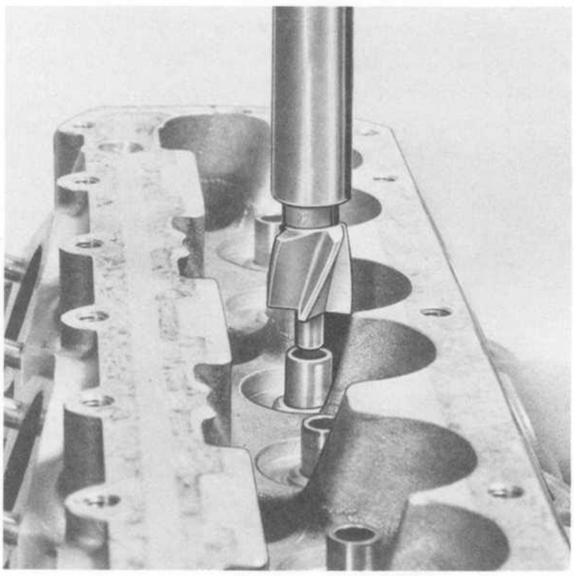
1. Clean and inspect cylinder head. Cylinder heads are not suitable for replacement of valve guides, if their valve seats and sealing surfaces can no longer be machined.

2. Machine off protruding valve guides from the camshaft side with a countersink, Special Tool 9220/1, until guides are flush with the cylinder head.

Note:

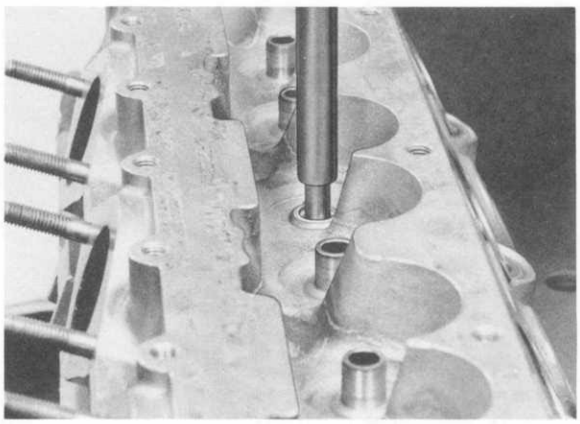
Be careful not to damage guide collar for spring retainers.



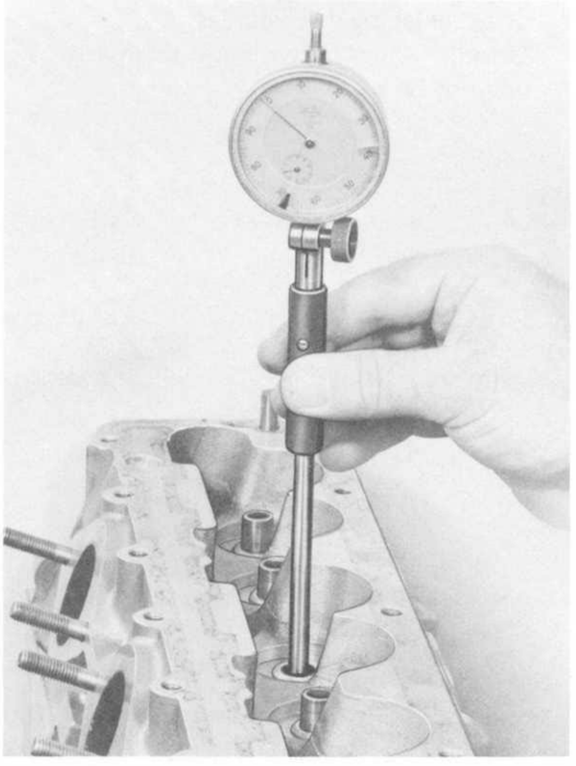


3. Place cylinder head on Special Tool 9220.

4. Loosen valve guides from camshaft end with brief hammer knocks on Special Tool 9224 and press out rest of guides toward combustion side with a press.



5. Check bores in cylinder head with an internal gauge.



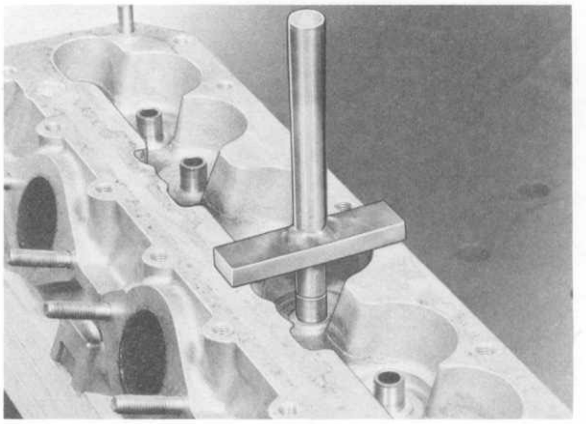
6. Grind off service valve guide, Part No. 928 104 328 52 (13.27 mm outside dia.), accordingly.

   Press-fit for intake and exhaust valve guides must be 0.06 to 0.08 mm.

Example:

Measured bore diameter in cylinder head = 13.01 mm. Outside diameter of service valve guide ground accordingly to 13.07 . . . 13.09 mm.

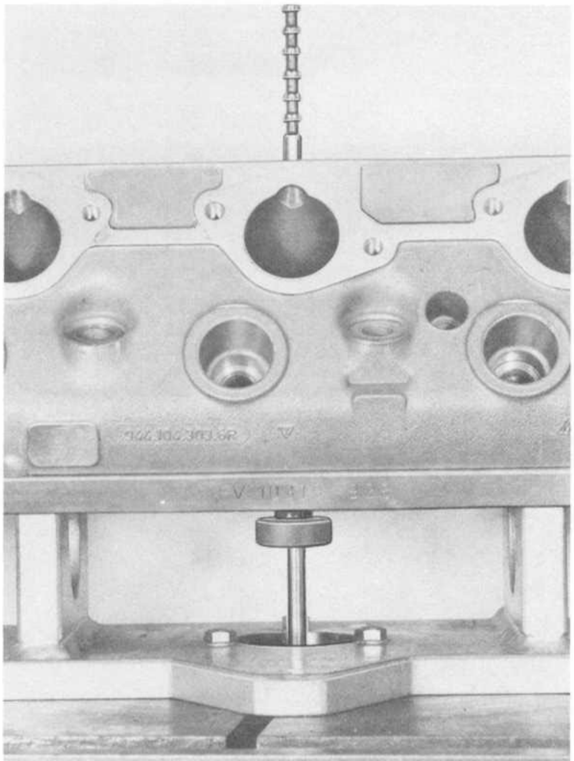
7. Coat valve guides with tallow, insert with a light knock, align and press into cylinder head against stop from camshaft side with Special Tool 9221.



Note:

If pertinent workshop equipment is available, valve guides can be chilled in liquid air and pressed into a cylinder head heated to 190 °C/375 °F.
Cylinder head may be kept at temperature of 190 °C/375 °F for max. 90 minutes.

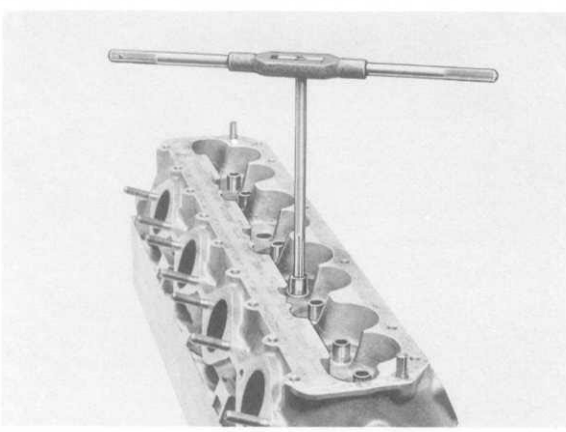
8. Ream out valve guides to size 9.00 – 9.015 (9 H 7) with a reamer.



9. If absolutely necessary, valve guides can be reamed out with Special Tool 3015.

   Procedures:

   Always ream out valve guides with "petroleum" as a lubricant. Back out reamer frequently to remove burrs. Check reamed bore with limit gauge P 206 and, if necessary, ream out bore again with a dry reamer.



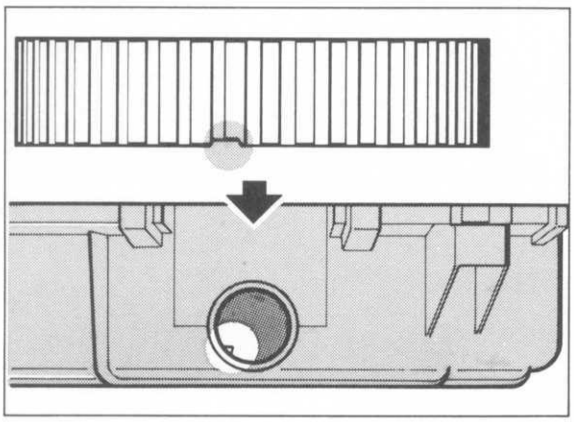
10. Valve seat inserts must be machined after replacing valve guides. Grinding in valves with grinding paste will not be sufficient.

CHECKING TDC MARKS ON CAMSHAFT SPROCKETS
(Do not remove toothed belt cover)

'86 MODELS ONWARD

ENGINE TYPE M 28. 21/22
M 28. 43/44/45/46/41/42

The covers fitted as of model year '86 have cast noses at the air-bleed ports for the intake hoses; with the crankshaft at the ignition TDC for cylinder no.1, these noses must be aligned with the recesses in the camshaft sprockets.



Note:

Maintenance (toothed belt)

During servicing (job: toothed belt), it is not necessary to remove the left-hand toothed-belt cover to check that the setting is correct.

TOOLS (32 VALVE ENGINE)

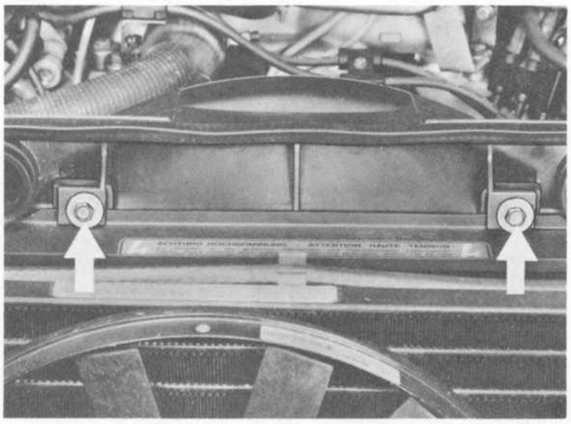
No.	Description	Special Tool	Remarks
	Belt tightness tester	9201	

CHECKING AND ADJUSTING TOOTHED BELT (32 VALVE ENGINE)

Checking

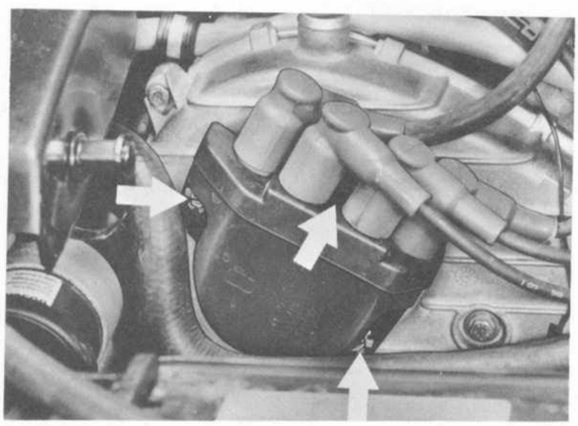
1. Remove air guide hoses.

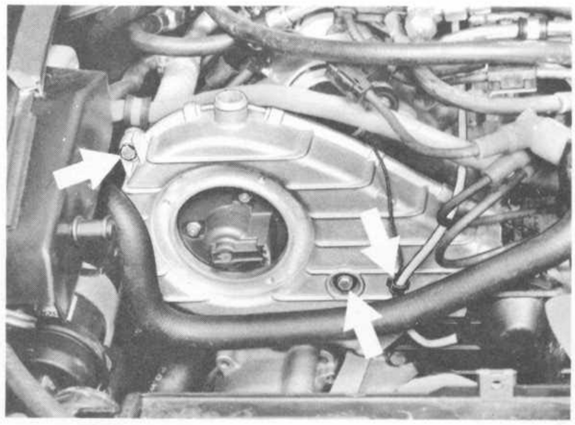
2. Unscrew two self-tapping screws and take off upper air guide section from above.



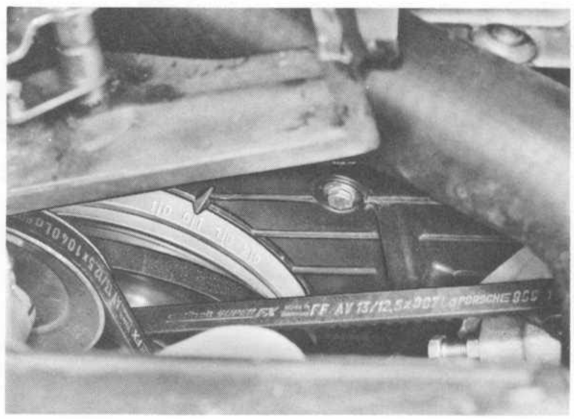
3. Unscrew and take off distributor caps and toothed belt cover upper section on righthand side.

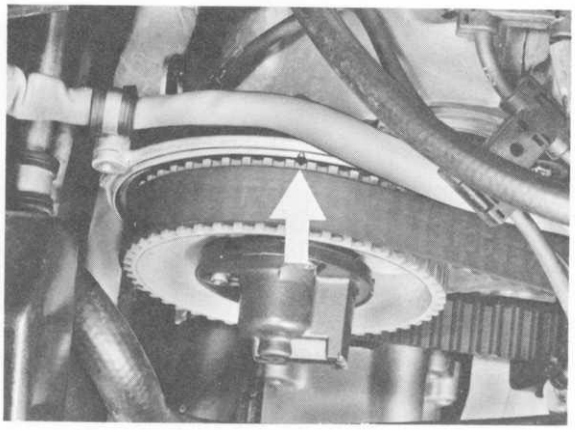
4. Unscrew and push toothed belt cover upper section on lefthand side forward.

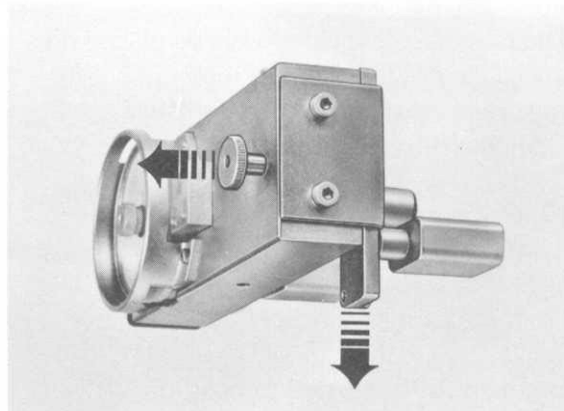


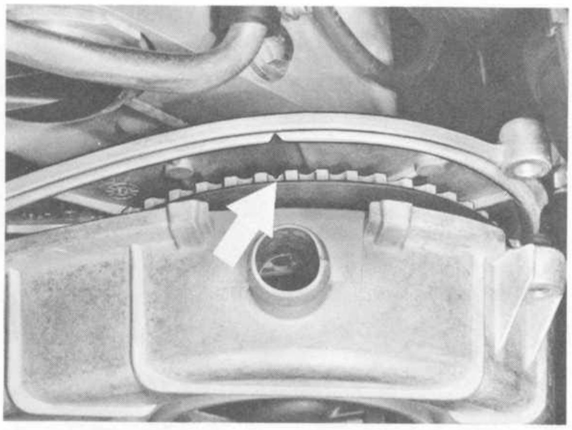


5. Turn engine in direction of rotation to TDC (cyl. 1). Marks on camshaft and flange bearings must be aligned in this position.







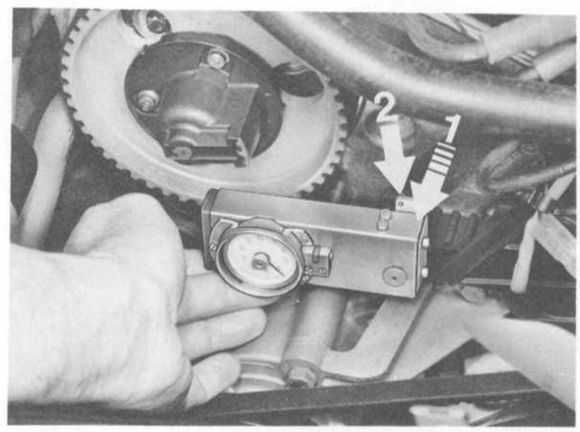


6. Turn engine two more turns until TDC mark is reached again and then continue turning while checking toothed belt for wear and damage.

7. Prepare Special Tool 9201 for checking. Pull out lock pin on special tool and move testing pin opposite the lock pin to starting position. Place drag needle on gauge needle.

8. Slide special tool on released belt section of toothed belt (sliding shoe on smooth surface, roller must fit in tooth gap).

9. Press down tester on housing (arrow 1) slowly until gauge tip resting on air pump bracket (arrow 2) engages.



Read test value without tension in tester, i.e. tester must be kept horizontal to the toothed belt. Tester must not rest on the plastic cover.

Sliding shoes must rest on belt with their entire surface. Special tool must not be turned or moved on the belt during the entire checking procedures.

Note

The drag needle must always be placed on the gauge needle after the lock pin has engaged to exclude erroneous gauge readings (turn anticlockwise).

10. Pull out lock pin to have gauge tip disengage.

Important

Engine must be turned to position described in point 5 for this test.

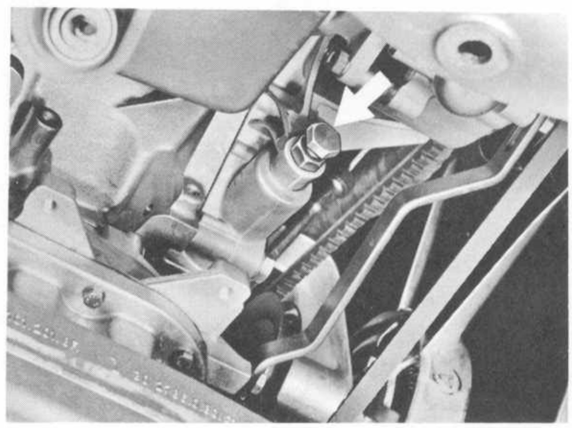
Repeat test one or two for checking!

Adjusting value: 5.0 + 0.3.

Correct belt tightness if necessary.

Adjusting

The toothed belt adjusting screw is located on bottom of engine at front righthand side.



Loosen lock nut of adjusting screw and turn adjusting screw until correct toothed belt tightness is reached. Tighten lock nut. Turn engine two more turns and recheck belt tightness.

Screw tightened - belt tightened.

Screw loosened - belt loosened

Note

Never turn engine anticlockwise, because toothed belt could jump off if tightness were insufficient.

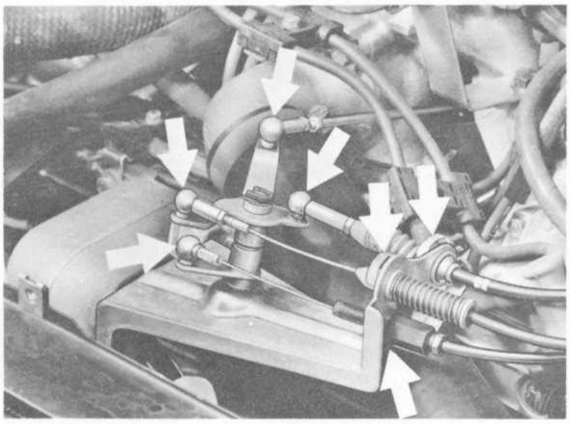
REPLACING TOOTHED BELT (32 VALVE ENGINE)

1. Remove air cleaner intake hoses.

2. Unscrew air guide on radiator at top and bottom, and remove.

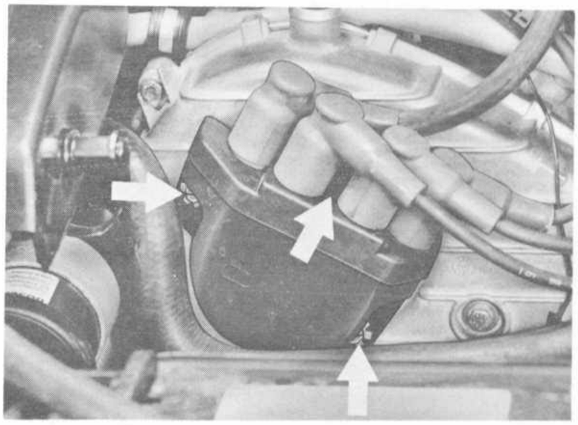
3. Loosen and take off drive belts for alternator, power pump, air pump and air conditioner compressor.

4. Disconnect cables for throttle, cruise control and automatic transmission. Remove retainers and clamp on console and place cables outside.



5. Loosen and remove fan console on engine.

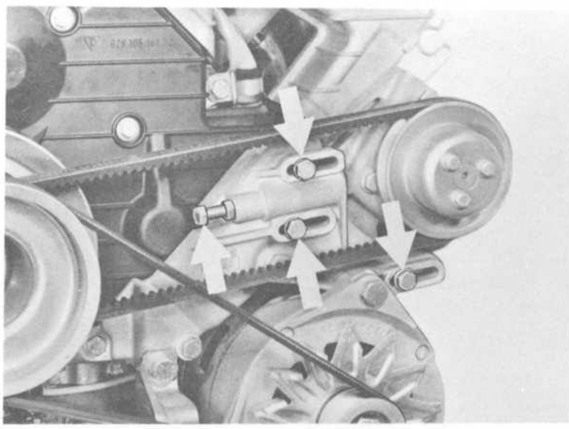
6. Pull off left and right ignition leads on distributor cap. Unscrew and place distributor cap aside.



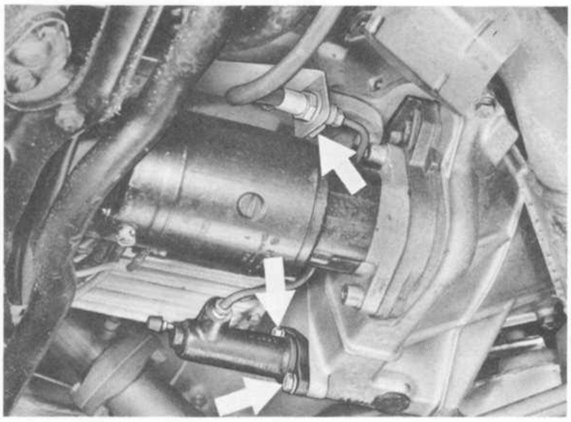
7. Take off both distributor rotors. Disconnect plugs for A/C compressor and toothed belt tightness indicator.

8. Unscrew toothed belt cover upper section on both sides and take off righthand upper section.

9. Unscrew power pump on console and let it hang down on its hoses.



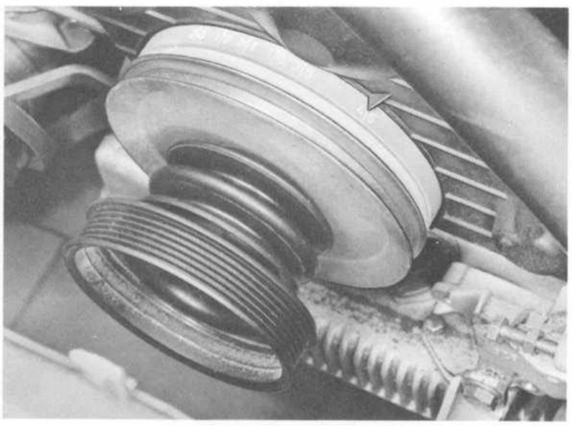
10. Remove clutch slave cylinder. Take off clamp on clutch hose holder and remove push rod. Let cylinder with connected line hang down.



Note

Never operate clutch pedal after removing the slave cylinder.

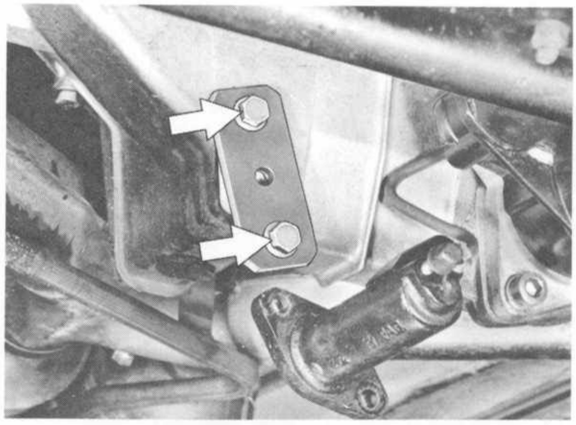
11. Align mark for 45° before TDC (cyl. 1) on vibration damper with red needle by turning crankshaft clockwise.



Note

Camshafts may be turned without damaging the valves after aligning the 45° mark.

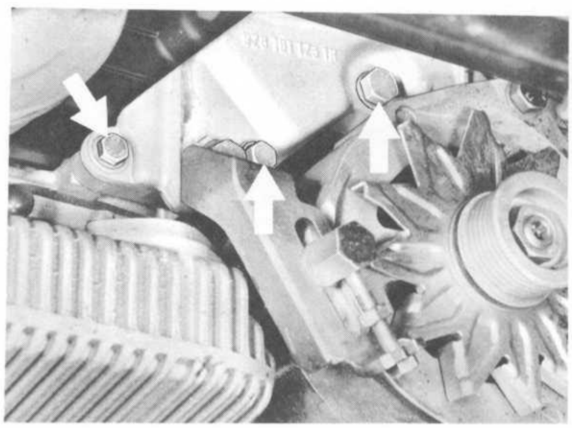
12. Mount Special Tool 9161 / 1 with original screws to hold the crankshaft.



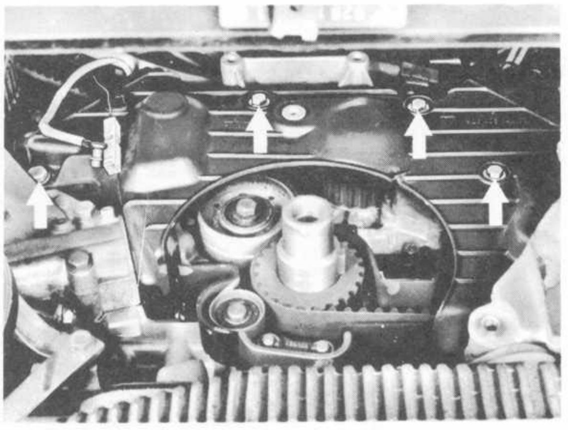
13. Unscrew bolt (wrench size 27 mm) on crankshaft and take off both pulleys, vibration damper and collar.

14. Loosen and unscrew guide tube for oil dipstick.

15. Unscrew console with alternator on engine.

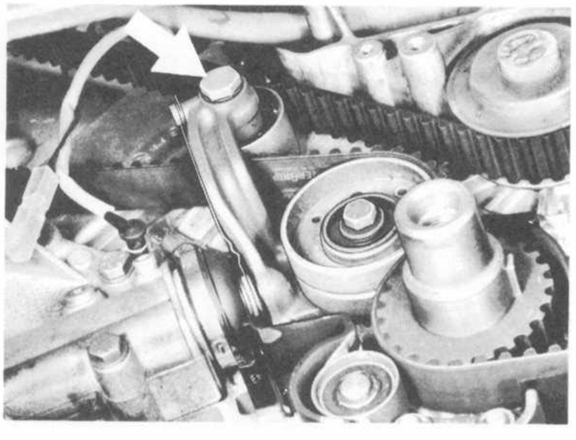


16. Undo center toothed belt cover, remove left-hand upper section and center toothed belt cover.



17. Slacken toothed belt by turning toothed-belt tensioner.

18. Unbolt and remove tensioning roller bracket.



19. Remove toothed-belt from right-hand side over cylinder 1 - 4 camshaft sprocket, water-pump sprocket, cylinder 5 - 8 camshaft sprocket, oil-pump sprocket and crankshaft sprocket.

Installing

1. Installation of toothed belt is the reverse of the above sequence.

2. Turn camshafts to mark and hold firmly in this position.

3. Then turn engine in direction of rotation to ignition TDC (cyl. no. 1).

Note

Damage may be caused to the valves if the camschafts move suddenly.

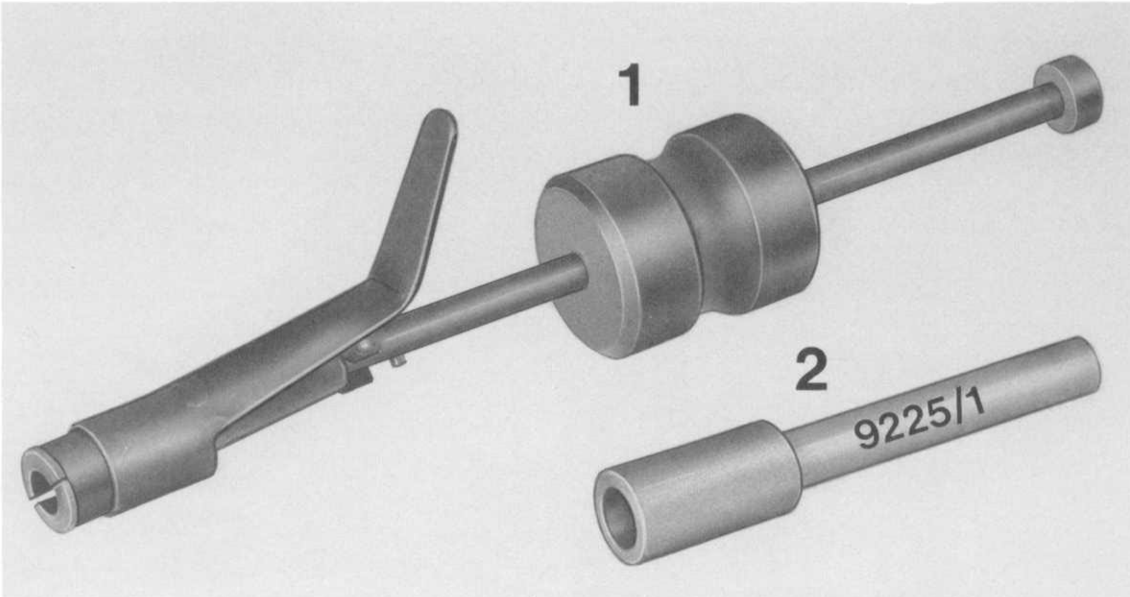
4 Once the toothed belt is in position, adjust the settings. See page 15 - 101 to 15 - 104.

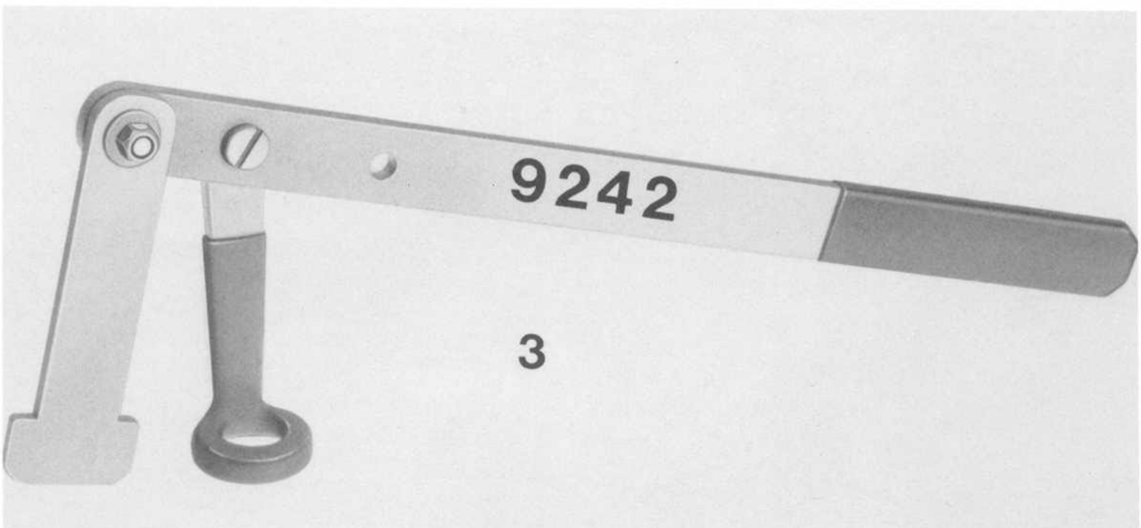
Special note on toothed belt and drive belt

As a rule, make sure the toothed belt and drive belt are **not kinked** during assembly, packing and storage. Improper handling may cause preliminary damage to the camshaft toothed belt that may be the cause for incipient damage.

Printed in Germany – XXXI, 1993

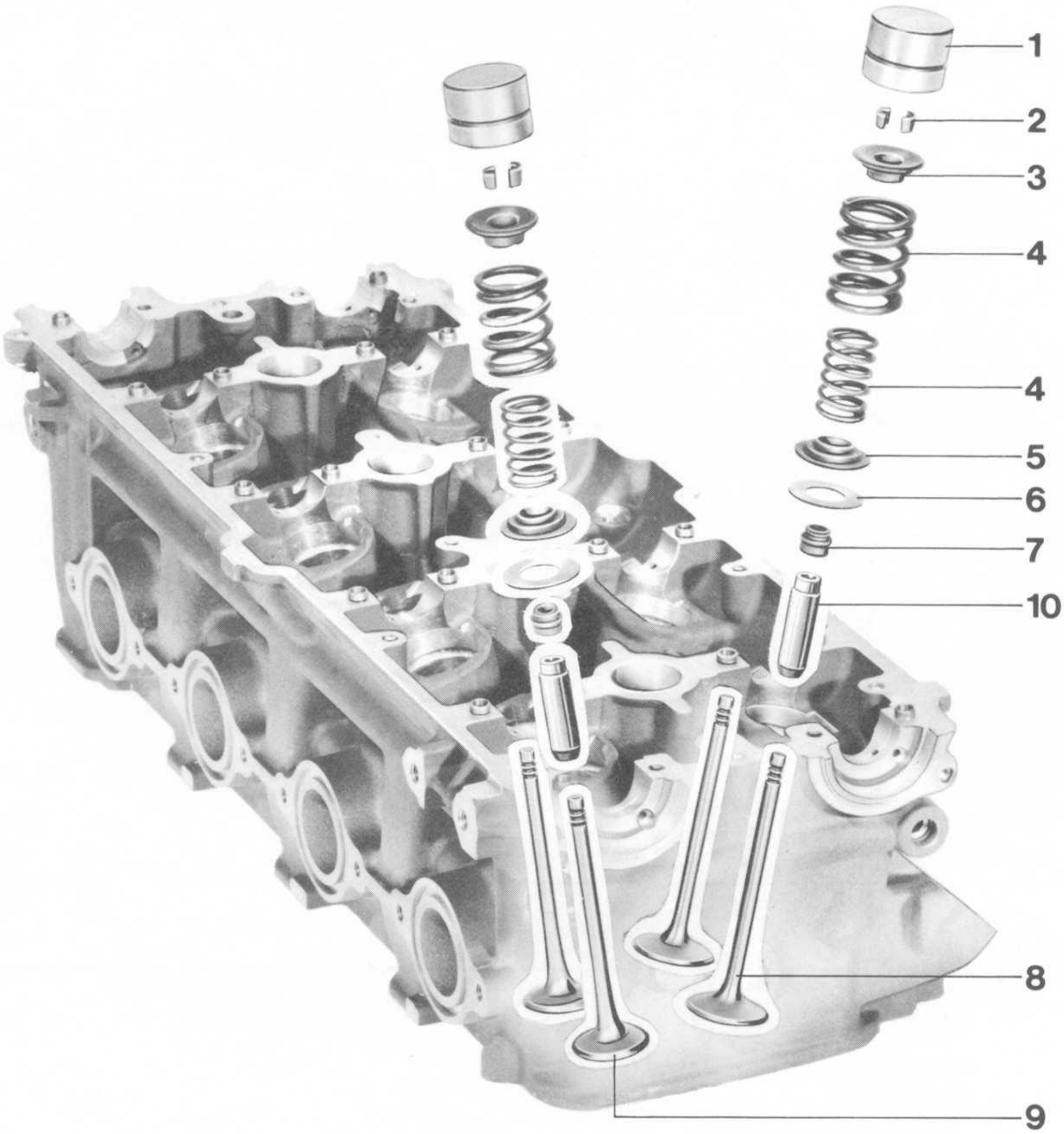
TOOLS - CYLINDER HEAD (32-VALVE ENGINES)





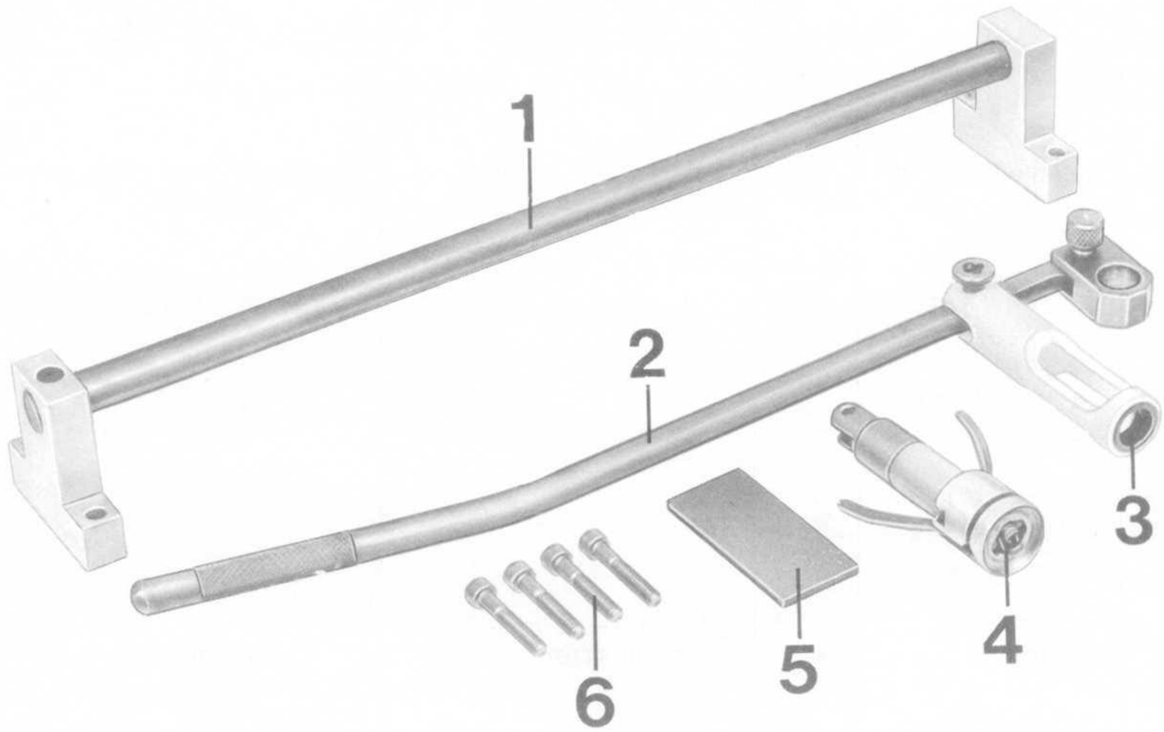
No.	Designation	Special Tool	Remarks
1	Puller for valve stem seals	9237	
2	Press-in tool for valve stem seals	9225/1	
3	Valve spring installation device	9242	or US 1020 + US 1020/1

DISASSEMBLING AND ASSEMBLING CYLINDER HEAD (32-VALVE ENGINES)



No.	Description	Qty.	Note When: Removing	Installing
1	Hydraulic valve tapet	16	Remove with the aid of a magnet, do not mix up	Oil
2	Conical valve keeper	32		Check that seating is correct
3	Spring plate	16		
4	Valve spring set	16		
5	Valve spring retainer	16		
6	Washer	X	Note number	Redetermine if necessary
7	Valve stem seal	16		Always renew, press in with press-in tool, Special Tool 9225/1, oil sealing lip
8	Intake valve	8		Oil valve stem
9	Exhaust valve	8		Oil valve stem
10	Valve guide	16		

TOOLS - CYLINDER HEAD (32-VALVE ENGINES)



No.	Description	Special Tool	Remarks
1	Assembly bridge		Supplier: Sauer Hamburg
2	Lever		" "
3	Magnetic disassembly head		" "
4	Assembly head		" "
5	Base		Improvised tool
6	Bolts		Commercially available M 8 x 40

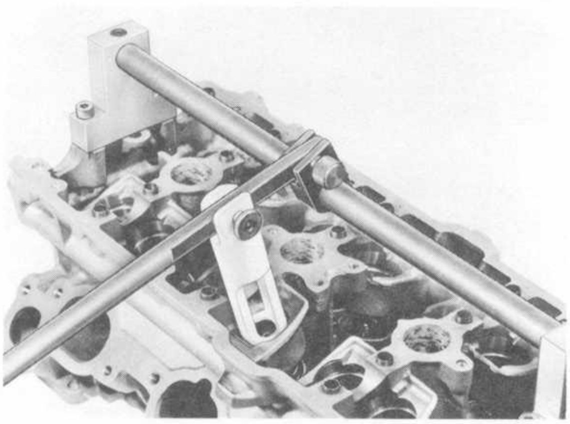
NOTE ON ASSEMBLY (32-VALVE ENGINES)

REMOVING AND INSTALLING VALVE SPRINGS WITH SPECIAL TOOL MADE BY SAUER

1. Improvise a set of 4 bases from wood or hard rubber for the valves. Length 90 mm, width 40 mm, thickness 6 mm.

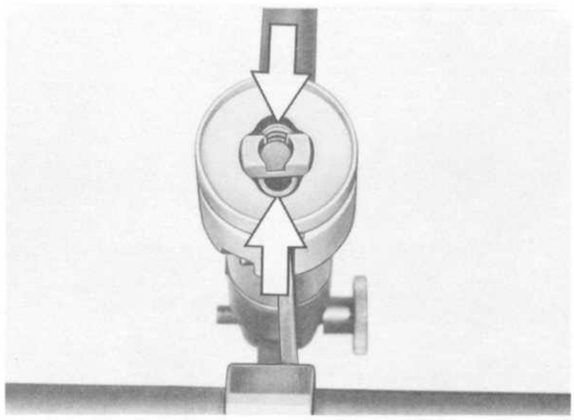
2. Position assembly bridge on cylinder head. Use a clamp to secure cylinder head to bench and prevent it tilting.

3. Attach magnetic disassembly head to lever. Compress valve spring in cylinder head and use a small screwdriver to pry taper valve keepers from valve stem.

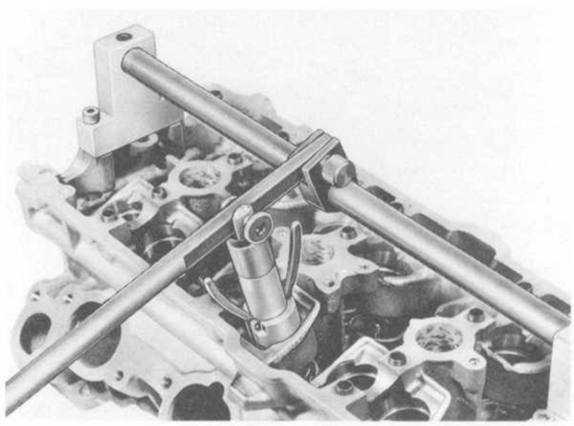


4. Use the magnetic disassembly head to withdraw all the valve spring parts.

5. Attach assembly head to lever. Press clamping arms together and insert taper valve keepers in assembly head.



6. Place washer, valve spring stop, valve spring and valve spring plate in cylinder head and compress with assembly head. Engage taper valve keepers by moving lever up and down slightly. This action automatically positions the taper valve keepers correctly.



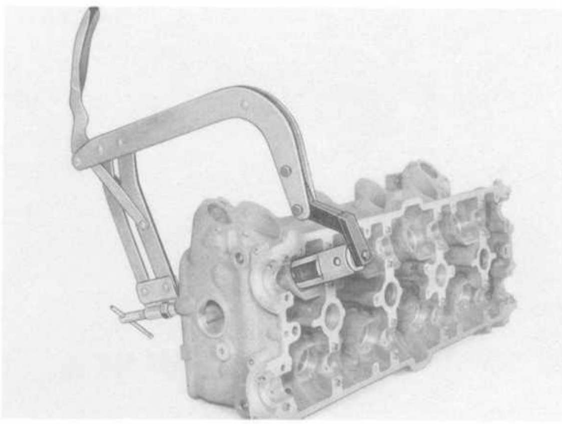
7. When the taper valve keepers are engaged, the clamping arms of the assembly head point out.

NOTES ON ASSEMBLY (32-VALVE ENGINES)

REMOVING AND INSTALLING VALVE SPRINGS

Cylinder head removed

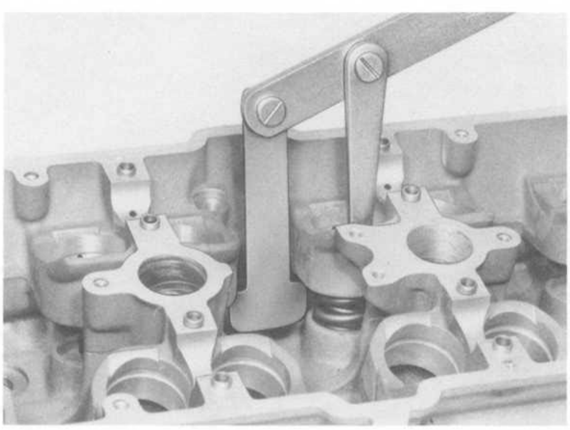
Remove and install valve springs with USA 1020 + US 1020/1.



REMOVING AND INSTALLING VALVE SPRINGS

Cylinder head installed

Remove and install valve springs with Special Tool 9242.

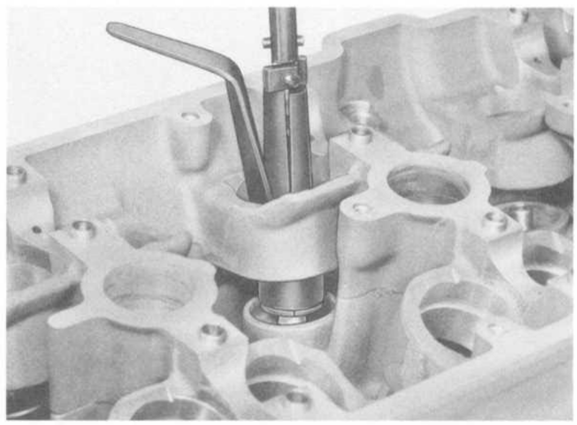


REMOVING AND INSTALLING VALVE STEM SEAL

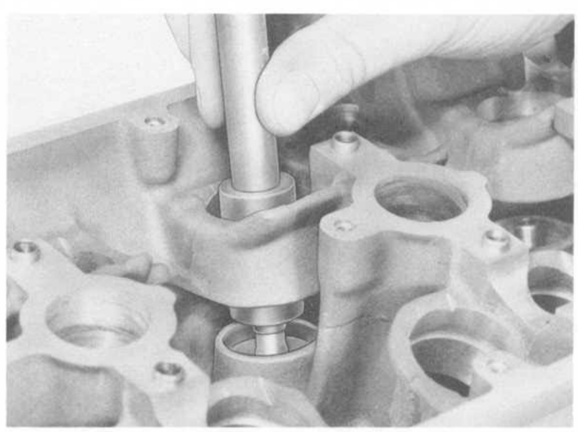
'85/'86 MODELS ONWARD

ENGINE TYPE M 28. 43/44/45/46

Pull off valve stem seal with Special Tool 9237.



Oil valve stem and install valve. Push assembly sleeve over valve stem. Oil sealing lip of valve stem seal and position on assembly sleeve. Using Special Tool 9225/1 carefully and gently press seal onto valve guide until it is seated.

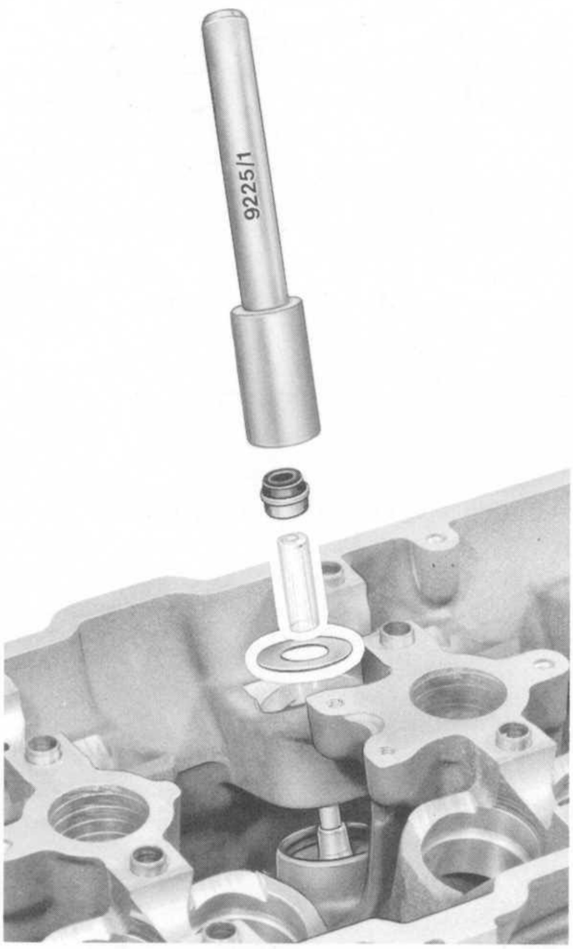


INSTALLING VALVE STEM SEAL
'87 MODELS ONWARD

ENGINE TYPE M 28. 41/42

Note:

It is essential to place a 1 mm washer on the cylinder-head mating face before installing the valve stem seal.



1. Oil valve stem and install valve. Place 1 mm thick washer on the cylinder-head mating face. Push assembly sleeve over valve stem. Oil sealing lip of valve stem seal and position on assembly sleeve. Using Special Tool 9225/1, push seal carefully and gently onto valve guide until seated.

2. The valve stem seal is correctly seated when Special Tool 9225/1 and washer make contact.

Note:

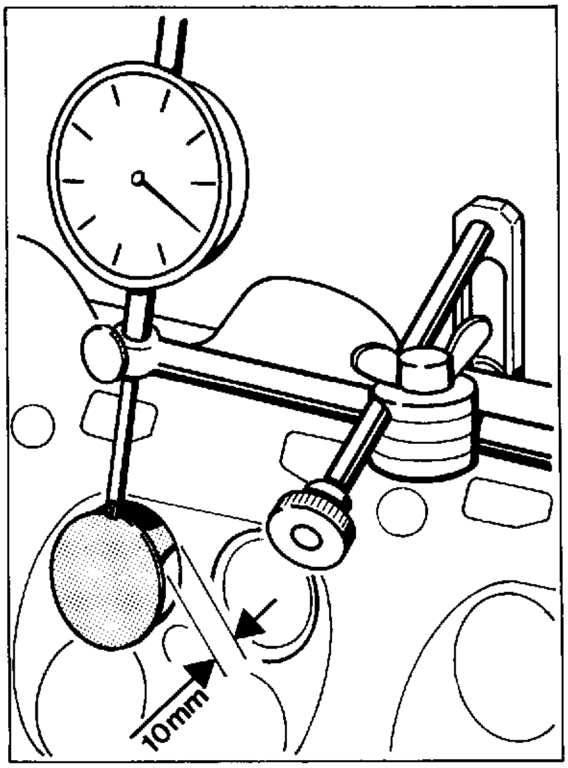
The assembly sleeves are available as spare parts.

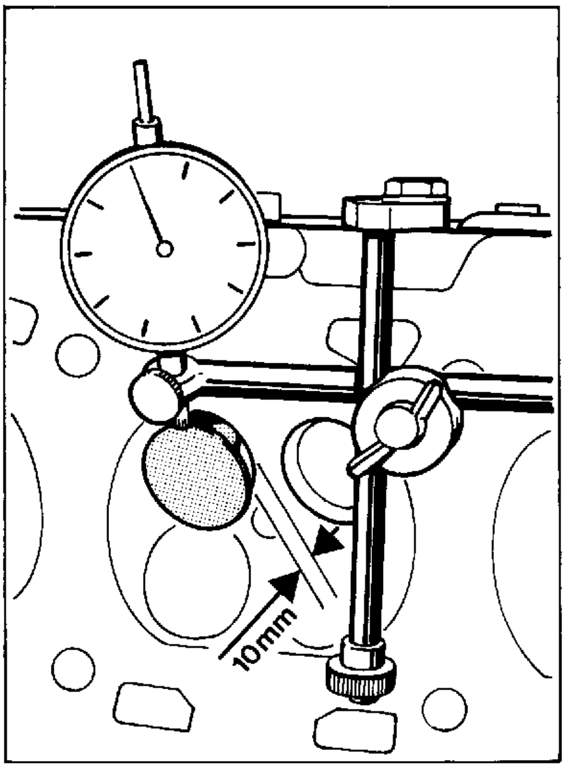
CHECKING VALVE GUIDES (32-VALVE ENGINES)

1.Clean valve guides thoroughly.

2.Use a new valve to measure the rocker clearance.

3.Attach dial-gage holder VW 387 to cylinder head. Align dial gage parallel to valve head.

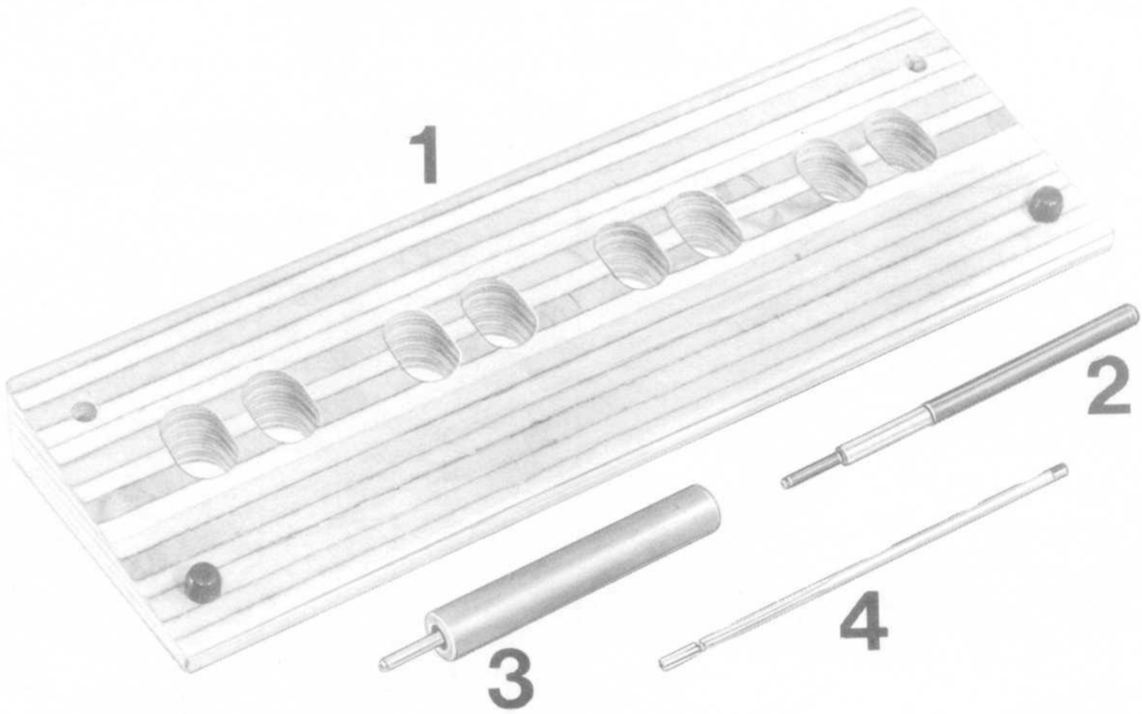




4.Measure rocker play at 10 mm valve lift (distance between valve head and valve seat). Wear limit for intake and exhaust valve guides = 0.80 mm.

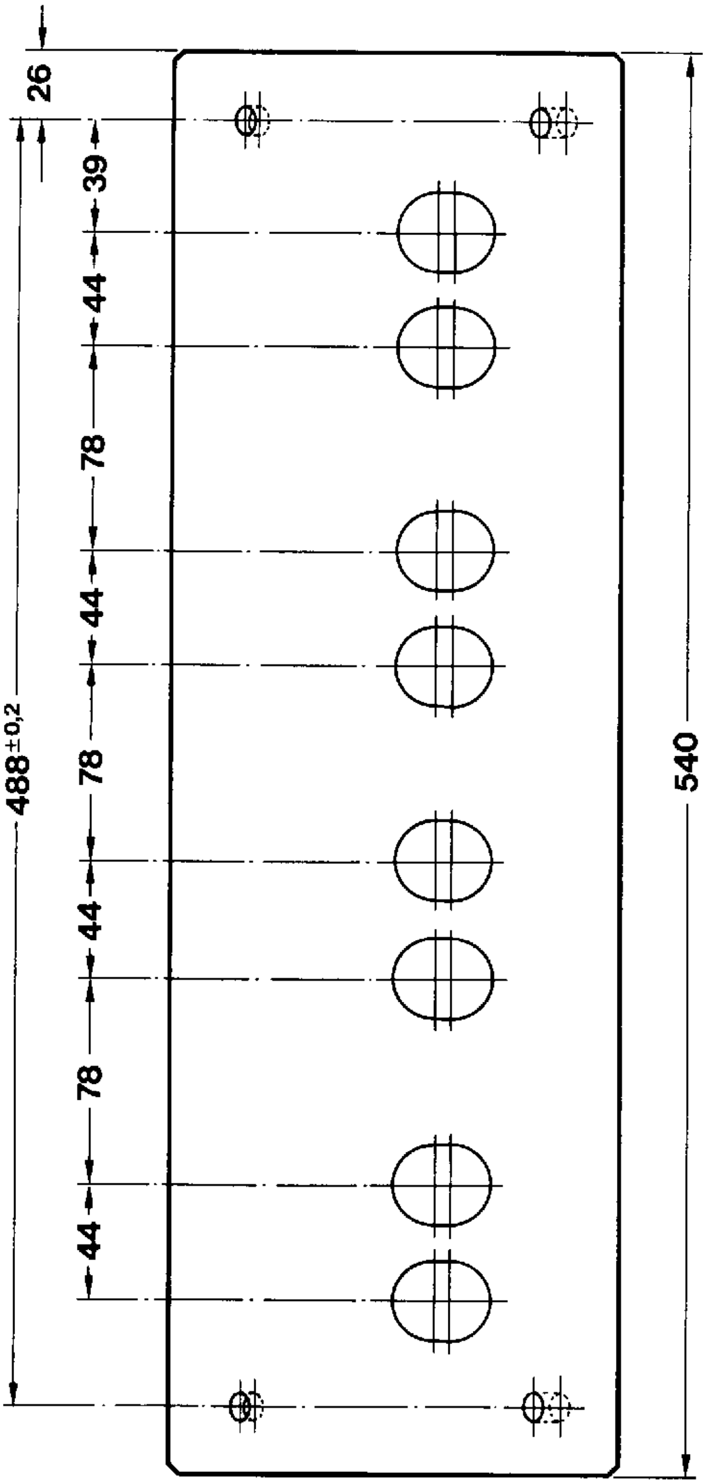
REPLACING VALVE GUIDES

TOOLS

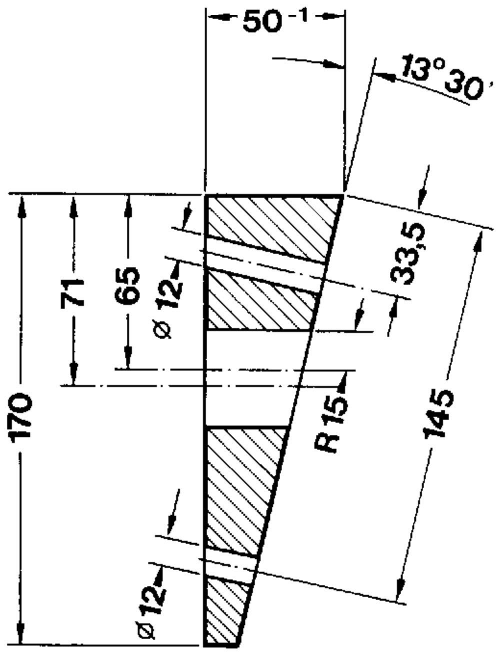


No.	Description	Special Tool	Remarks
1	Press-out base		See drawing
2	Thrust piece		" "
3	Thrust piece		" "
4	Reamer	3120	VW Special Tool

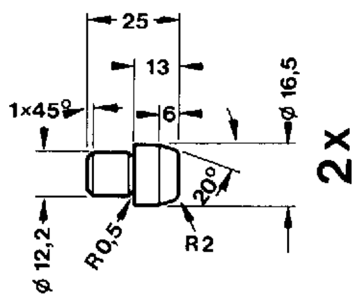
DRAWING:
Press-out device for valve guides



Material: wood



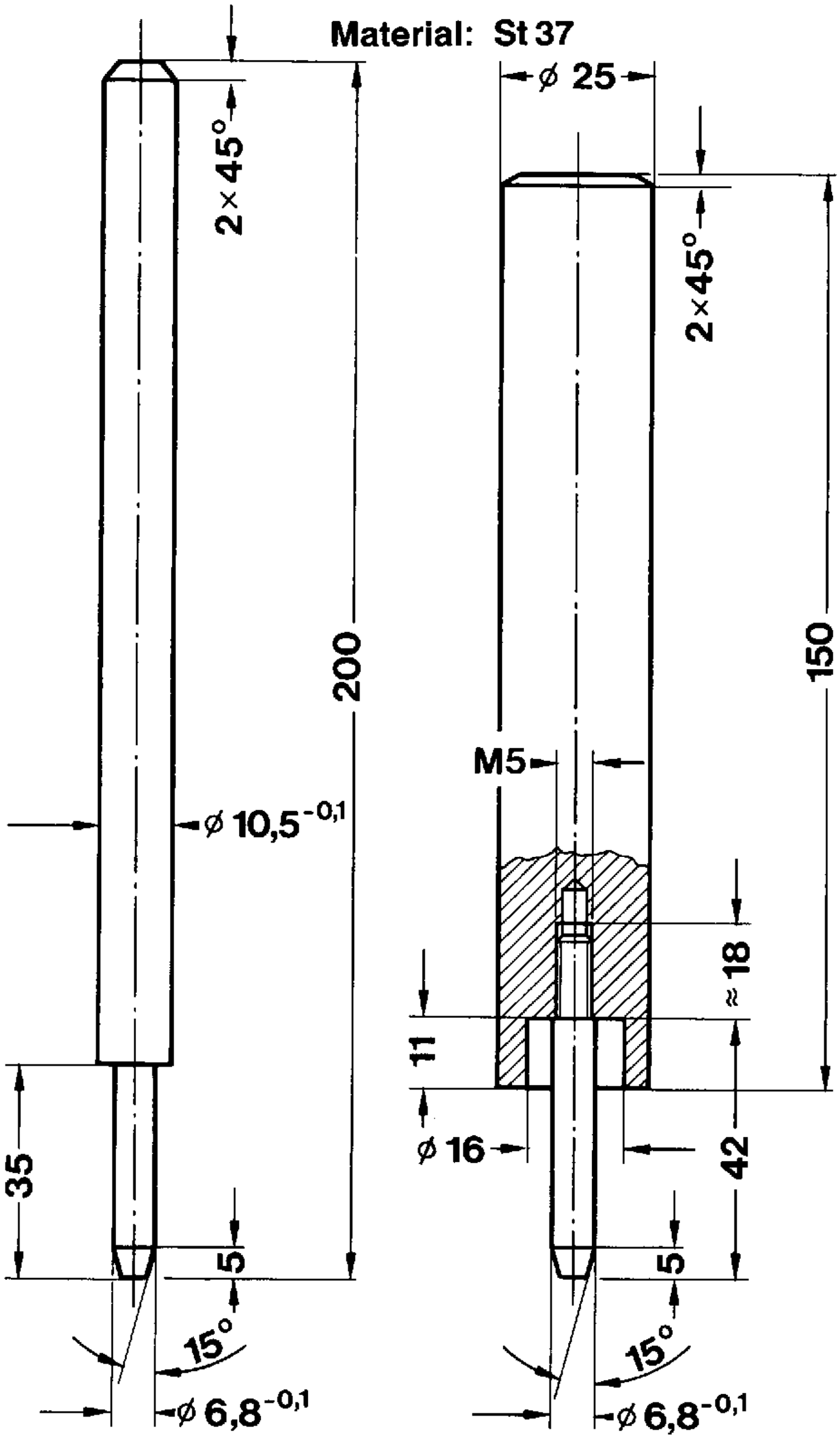
Material: St 37



DRAWING:

Thrust piece for pressing out valve guide

Thrust piece for pressing in valve guide

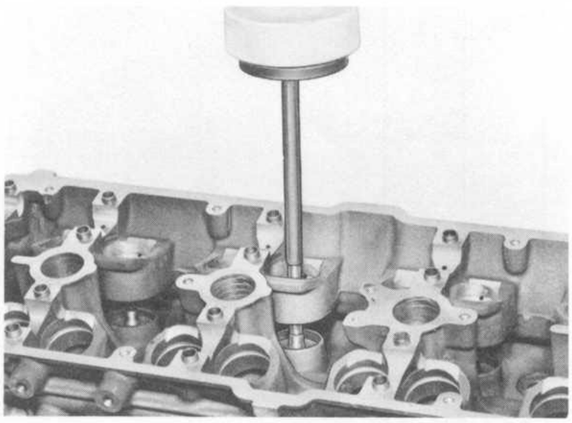


REPLACING VALVE GUIDES

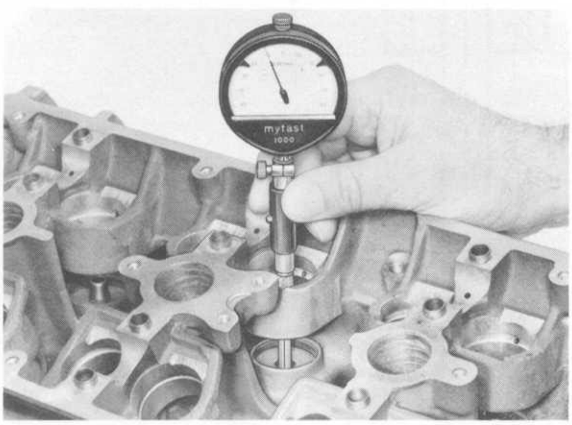
1. Clean cylinder head and check. If the valve seats or mating faces of the cylinder heads cannot be remachined, the cylinder heads are not suitable for replacement valve guides.

2. Position cylinder head on press-out base.

3. Working from the camshaft side to the combustion-chamber side, press out valve guides with a press.



4. Use internal calipers to measure bores in cylinder head.



5. Machine KD valve guide, part no. 944 104 327 51 (external diameter 11.26 mm) to correct size.

   Loading must be 0.06 - 0.08 mm for both intake and exhaust valve guides.

Example:

Bore in cylinder head measured 11.020 mm. Machine outside diameter of KD valve guide to 11.080 or 11.10 mm.

Note:

Replacing valve guides, ENGINE TYPE M 28. 41/42, '87 MODELS ONWARD

It is essential to place a 1 mm thick washer on the cylinder-head mating face before installing the valve guide.

6. Heat cylinder head to 170°C. Coat valve guides with talcum powder, tap lightly into position, align and, using a thrust piece and working from the camshaft side, press into cylinder head until seated.

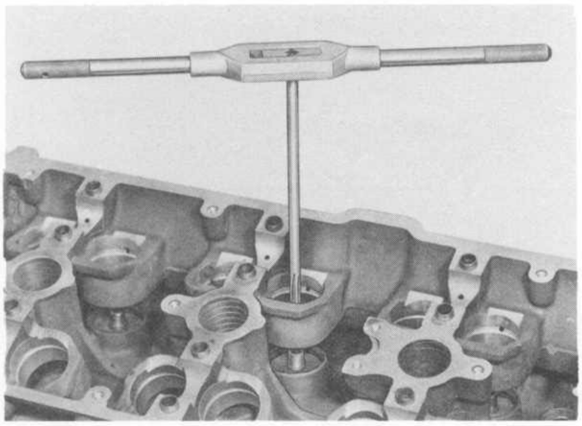
   Caution:

Do not maintain the temperature of 170°C for more than a maximum of 90 minutes.

7. Roughen valve guides with Special Tool 3120.

Proceed as follows:

It is essential to use petroleum as a lubricant when roughening valve guides. During this operation, withdraw reamer frequently to remove chips. Once bore has been reamed, finish with dry reamer.



8. The valve-seat rings must be remachined when the valve guides have been replaced. It is not sufficient to grind in the valves with grinding paste.

Note:

Distinguishing feature, cylinder head

'85/'86 models M 28.43/44/45/46	'87 models onward M 28.41/42
Bearing bridge attachment, M 6	M 8
Exhaust manifold attachment 2-bolt flange	3-bolt flange

Machining cylinder-head mating face (32-valve engines)

Checking the cylinder head for distortion

Check the sealing surface of the cylinder head for distortion using a feeler gauge straightedge.

Distortion limit of mating surface: 0.05 mm

Cylinder heads with distorted mating faces can be remachined and reused. Admissible distortion after machining: 0.03 mm.

Machining cylinder heads

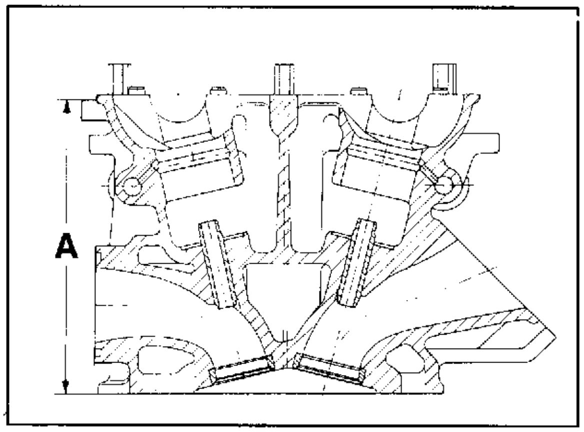
As a rule, both cylinder heads must be machined by the same amount to ensure correct seating of the regulator housing.

Machine sealing surface of the cylinder head only until a straight surface is obtained. Max. wear limit: 146.6 mm.

Note for machining of the sealing surface: Max. roughness = 0.015 mm

If machining causes the actual value to be below the tolerance applicable to new parts, use a 1.4 mm thick cylinder head gasket (available from the parts service) when fitting the cylinder head.

New-part size A = 147 ± 0.1 mm
Wear limit A = 146.6 mm



1126-15

Cylinder head refacing dimensions and identification

New dimension	: 147 ± 0.1 mm
Gasket	: 1.1 mm
Identification	: none
Refacing dimension	: 146.8 to 146.6 mm
Gasket	: 1.4 mm
Identification	: N

Identification: "N"

Engrave on exhaust side between cylinder 2 and 3 as well as 6 and 7, respectively, on the casting lug below the cylinder head cover sealing surface.

Height of "N" character: 6 mm

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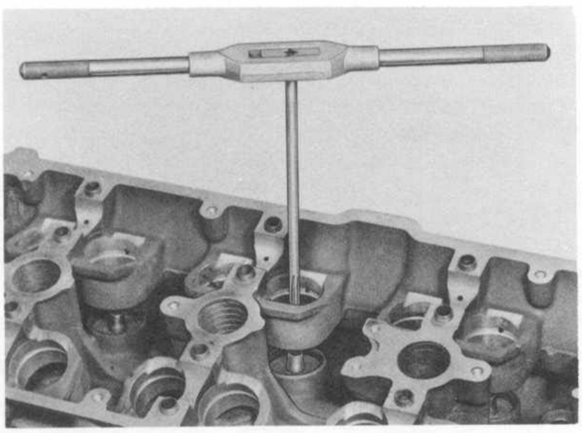
7. Roughen valve guides with Special Tool 3120.

Proceed as follows:

It is essential to use petroleum as a lubricant when roughening valve guides. During this operation, withdraw reamer frequently to remove chips. Once bore has been reamed, finish with dry reamer.



8. The valve-seat rings must be remachined when the valve guides have been replaced. It is not sufficient to grind in the valves with grinding paste.

Note:

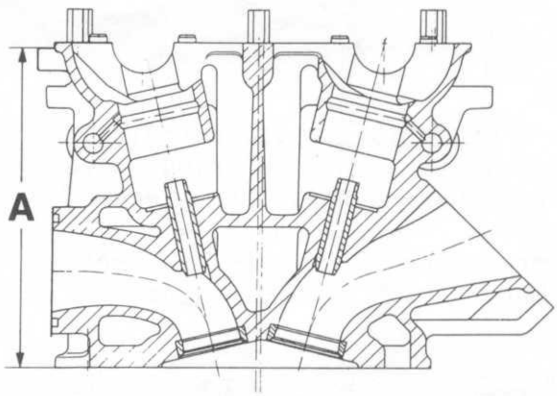
Distinguishing feature, cylinder head

'85/'86 models M 28.43/44/45/46	'87 models onward M 28.41/42
Bearing bridge attachment, M 6	M 8
Exhaust manifold attachment 2-bolt flange	3-bolt flange

Machining cylinder-head mating face (32-valve engines)

Checking the cylinder head for distortion

Check the sealing surface of the cylinder head for distortion using a feeler gauge straightedge.

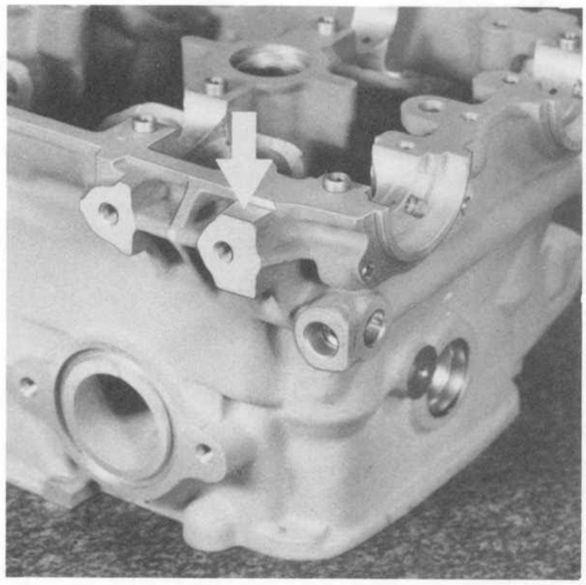


Distortion limit of mating surface: 0,05 mm

Cylinder heads with distorted mating faces can be remachined and reused. Admissible distortion after machining: 0.03 mm.

Machining cylinder heads

As a rule, both cylinder heads must be machined by the same amount to ensure correct seating of the regulator housing.



Machine sealing surface of the cylinder head only until a straight surface is obtained.
Max. wear limit: 146,6 mm.

Note for machining of the sealing surface:
Max. roughness = 0.015 mm

If machining causes the actual value to be below the tolerance applicable to new parts, use a 1.4 mm thick cylinder head gasket (available from the parts service) when fitting the cylinder head.

New-part size A = 147 ± 0.1 mm
Wear limit A = 146.6 mm

OLD PAGE BUT THIS PICTURE MIGHT BE USEFUL

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CS cylinder head seals as from Model 89

Thicker cylinder head seals **(CS cylinder head seals)** must be fitted to compensate for the removed material when facing the cylinder heads.

The CS cylinder head seals can be recognized by means of the changed part numbers.

These cylinder head seals can also be installed in 4-valve engines as from Model 85.

The reworking tolerances have **not** changed as a result.

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CHECKING VALVE SEAT WEAR LIMIT

Note:

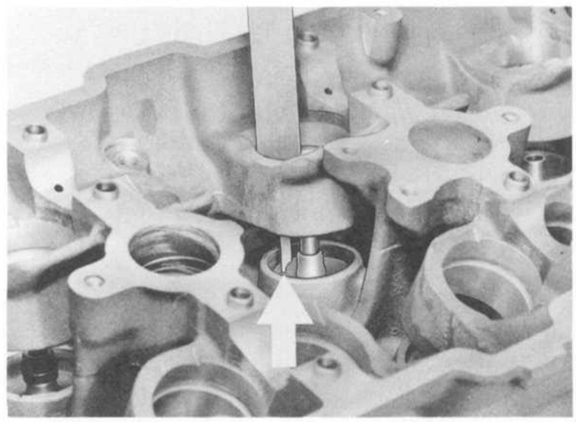
Distinguishing feature, cylinder head

'85/'86 models M 28.43/44/45/46	'87 models onward M 28.41/42
Bearing bridge attachment M 6	M 8
Exhaust manifold attachment, 2-bolt flange	3-bolt flange

1. The valve seats of the 4-valve-per-cylinder heads can be machined. Do not machine past the wear limit, as otherwise the function of the hydraulic valve tappets is no longer assured.

Size worn	Intake valve	Exhaust valve
'85/'86 mod.	43.0 mm	42.1 mm
'87 mod.	44.4 mm	43.4 mm

2. Use the valve to be installed and measure from the end of the valve stem to the contact face of the valve spring stop in the cylinder head.



3. While measuring, hold the valve firmly against the valve seat.

CHECKING AND MACHINING VALVE SEATS (32-VALVE ENGINES)

Visual inspection

1. Check that valve seat is tight in cylinder head.

2. Check contact pattern. If valve does not contact entire area of valve seat, the seat must be machined slighty.

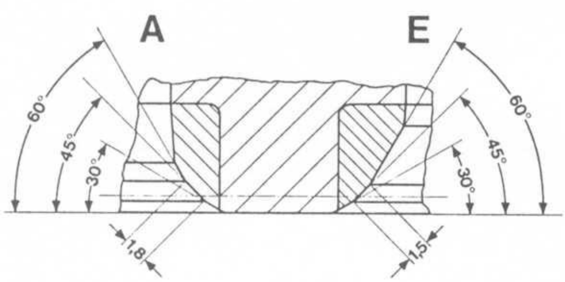
Machining

1. Valve seat may be machined with, for example, a Neway valve grinder or a Hunger valve-seat machining tool.

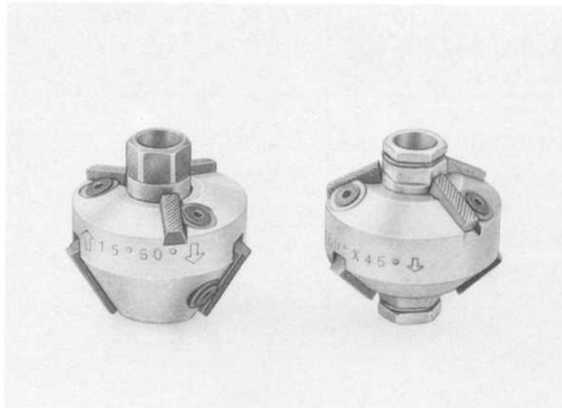
2. Machine the valve seats with a 45° valve reseating tool. Afterwards, machine the face to the specified face width with a 60° reseating tool. It is no longer necessary to finish with a 30° reseating tool.

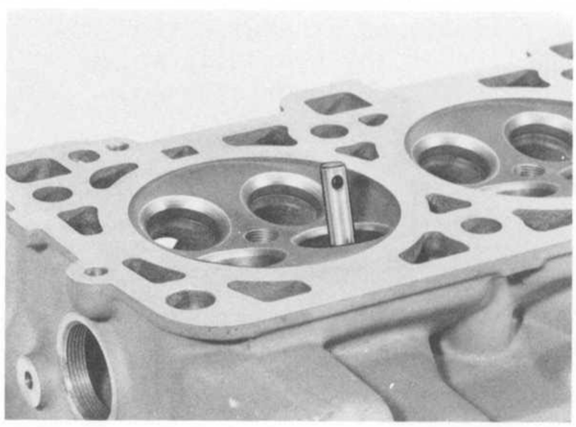
Intake-valve face width 1.5 mm

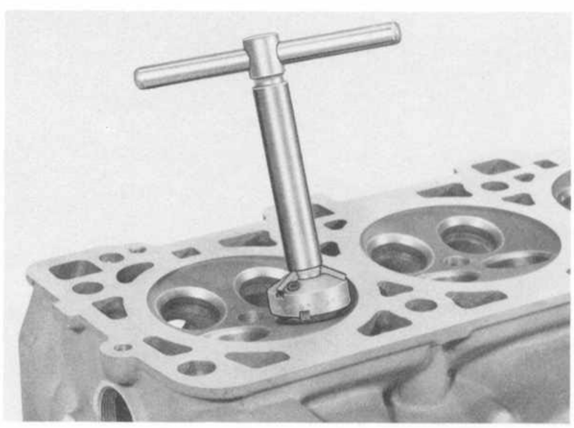
Exhaust-valve face width 1.8 mm



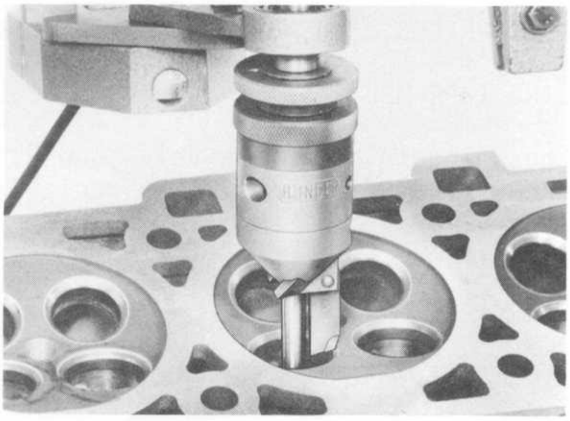
3. Valve reseating tools, e.g.
Neway 234 45°
Neway 213 60°





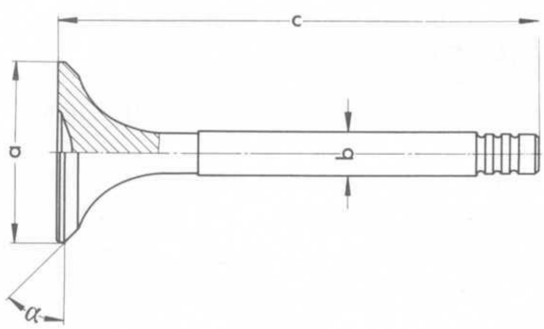


4. Valve reseating tool, e.g. Hunger VDSNL 1/45 I.K.



5. After the valve seats have been machined, use a grinding paste to lightly grind in valve seats. Check contact pattern of valve seat surface.

VALVE DIMENSIONS



VALVE DIMENSIONS 928 S

'85/'86 MODELS ONWARD

ENGINE TYPE M 28. 43/44/45/46

Dim.	Intake	Exhaust
a	35 mm	32 mm
b	6.97 mm	6.94 mm
c	112.2 mm	111.2 mm
α	45°	45°

VALVE DIMENSIONS 928 S

'87 MODELS ONWARD

ENGINE TYPE M.28 41/42

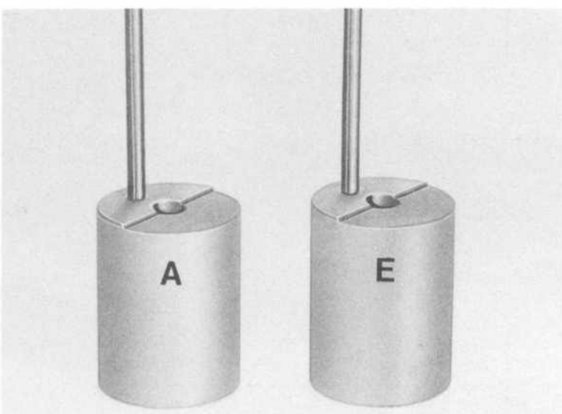
Dim.	Intake	Exhaust
a	37 mm	33 mm
b	6.97 mm	6.94 mm
c	114.7 mm	113.7 mm
α	45°	45°

CHECKING AND ADJUSTING INSTALLATION LENGTH OF VALVE SPRINGS (32-VALVE ENGINES)

VALVE SPRINGS, '85 MODELS ONWARD

ENGINE TYPE M28.43/44

1. Check length of intake-valve and exhaust-valve springs with Special Tool 9240.



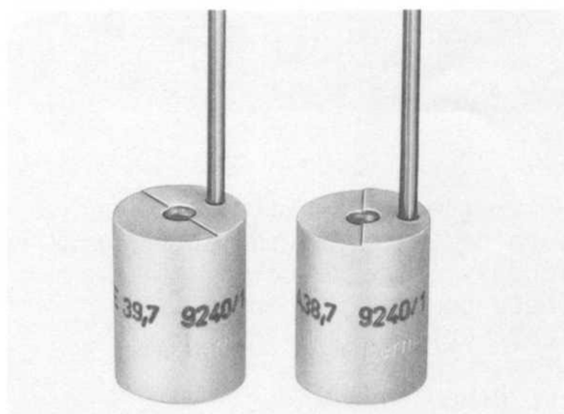
Measuring tools with installation length marked:

Intake	42.6 + 0.5 mm
Exhaust	41.6 + 0.5 mm

VALVE SPRINGS, '86 MODELS ONWARD

ENGINE TYPE M28. 45/46

2. Check length of intake-valve and exhaust-valve springs with Special Tool 9240/1.



Measuring tools with installation length marked:

Intake	39.7 + 0.5 mm
Exhaust	38.7 + 0.5 mm

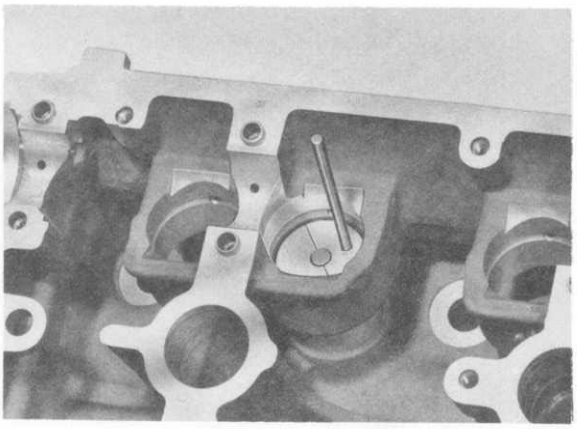
VALVE SPRINGS, '87 MODELS ONWARD

ENGINE TYPE M28. 41/42

Note:

Do not use Special Tool 9240 or 9240/1 to measure the installation length of valve springs as of model year '87. Checking and adjusting length of valve springs, see page 15 - 116 b.

3. Install valve and hold against valve seat. Once installed, the end of the valve stem should be between the end of the upper edge and the offset surface of the special tool. If the valve stem protrudes beyond the upper edge of the special tool, install shims to take up the excess. 0.5 mm thick shims are available.



4. Do not mix up the valves after adjustment.

Valve spring	85 models	86/86 models
Free length		
Outer spring	40.00 mm	43.5 mm
Wire dia.		
Outer spring	4.1 mm	3.6 mm
Inner spring	2.9 mm	2.7 mm

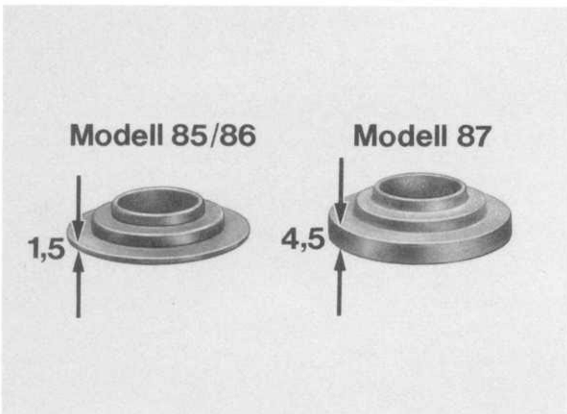
CHECKING AND ADJUSTING INSTALLATION LENGTH OF VALVE SPRINGS (32-VALVE ENGINES)

VALVE SPRINGS, '87 MODELS ONWARD

ENGINE TYPE M 28. 41/42

Note:

It is essential to ensure that the correct valve springs are installed in cars of the various model years.



TOOLS (IMPROVISED)

Valve spring plate SP No. 944.105.467.03

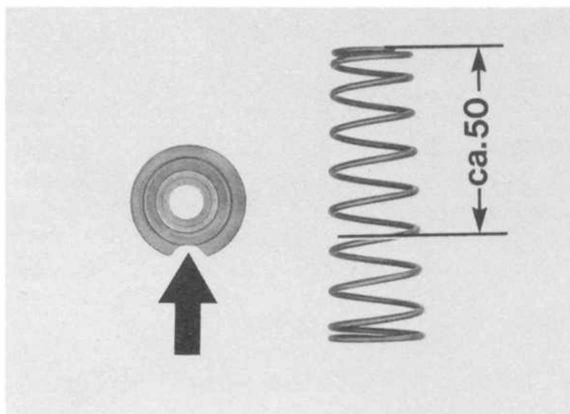
Secondary spring SP No. 928.107.171.01

Note:

When selecting the valve spring plate (improvised) it is essential to ensure that the valve spring plate is 2.0 + 0.2 mm thick.

1. Grind a face approx. 10 mm broad on valve spring plate. Install spring plate for measurement only.

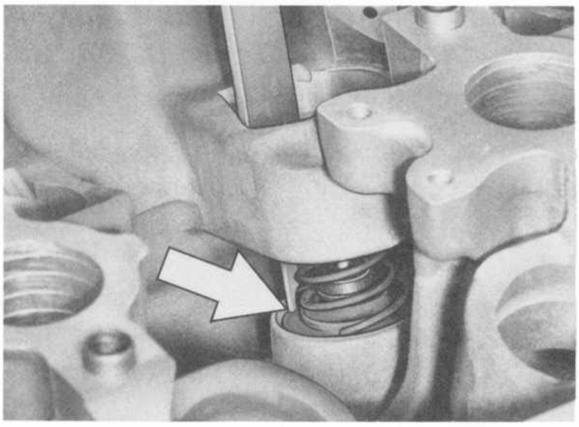
2. To facilitate installation shorten secondary spring to approx. 50 mm.



3. Install valve and press against valve seat. Install plate, valve spring retainer, secondary spring and spring plate with ground surface.

4. Install conical valve keepers with Special Tool 9242.

5. Using a depth gage, measure from surface of valve spring plate vertically through gap to outer spring bearing surface.



Installation length

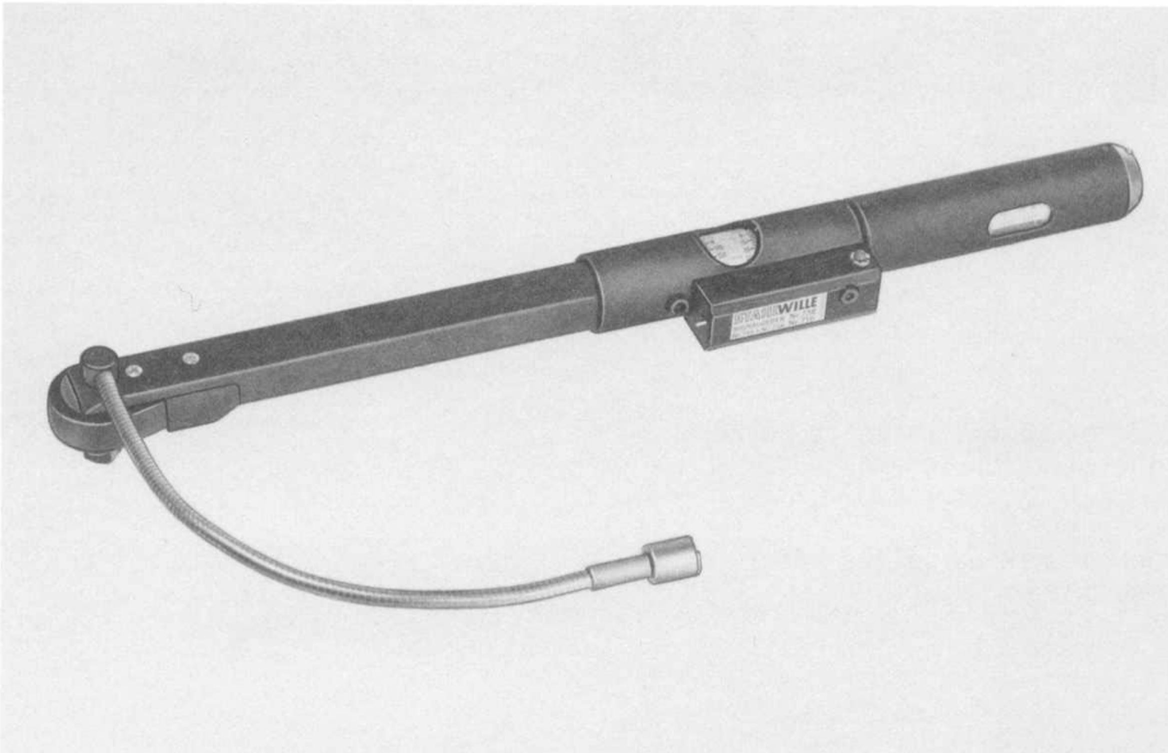
I n t a k e 35.5 + 0.5 mm

E x h a u s t 34.5 + 0.5 mm

6. Add or remove shims to correct installation length.

7. Do not mix up valves after measuring.

TOOLS - INSTALLING CYLINDER HEAD (32-VALVE ENGINE)
TORQUING BY ANGLE OF ROTATION



No.	Description	Special tools	Remarks
	Angle of rotation meter		commercially available, e.g. Stahlwille No. 715/20

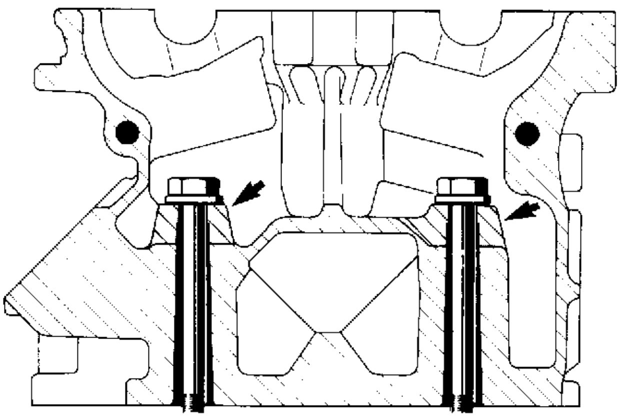
Modifications to the cylinder head (32 valve)

From Model 89
Engine type M 28.41/42

Note

Only the reinforced cylinder heads will be available as spare parts for all vehicles from Model 87 onwards. The unfinished part number, in the casting, is 928.104.413.2R

1. The cylinder head has been reinforced by 20 mm in the area of the bearing surfaces for the cylinder head bolts (arrow).



88-509

2. **The new 20 mm longer hexagon head bolts must be used for assembly.**

3. **New bolt length**
   M 12 x 199
   M 12 x 149

The tightening sequence remains unchanged.

1st stage	20 Nm (15 ft. lb.)
2nd stage	90° torque angle
3rd stage	90° torque angle

Note

If oil and water have been mixed, the cylinder heads must be subjected to a thorough visual inspection (hairline cracks). The cooling system must also be checked for leaks. Use test unit VW 1274 above the expansion tank for the leak test (max. 1 bar). The camshaft covers must be removed for visual inspection.

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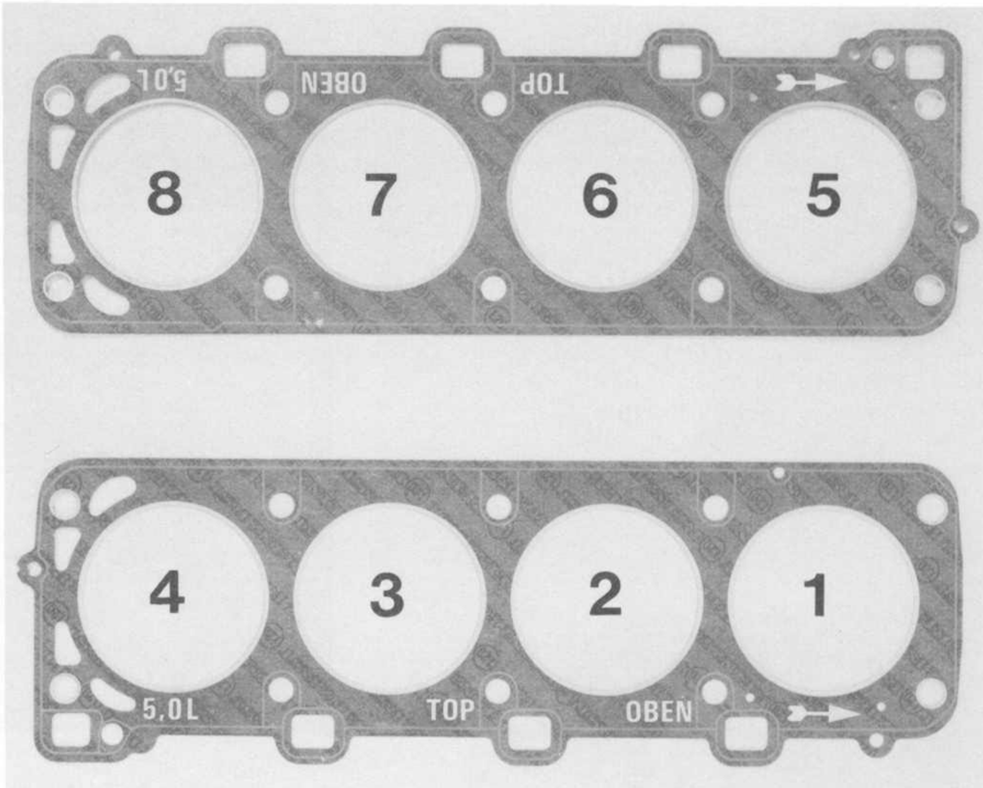
CYLINDER HEAD, INSTALLING (32-VALVE ENGINES)
Cylinder head attached by means of threaded studs

N o t e

The cylinder head can only be installed with the engine removed from the vehicle.

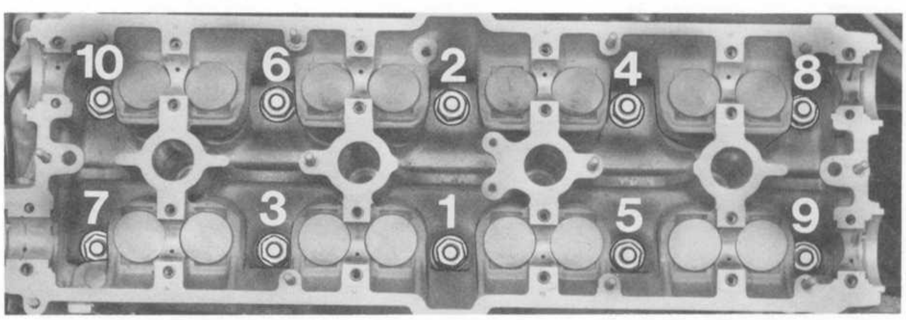
1. Place cylinder head gasket in correct position.



2. Install cylinder head

Torquing sequence (4 steps)
see Fig.
Sequence for removal: reverse

1st step	20 Nm
2nd step	90° of rotation
3rd step	90° of rotation
4th step	90° of rotation



INSTALLING CYLINDER HEAD (32 VALVE ENGINE)
Hexagon cylinder-head bolts

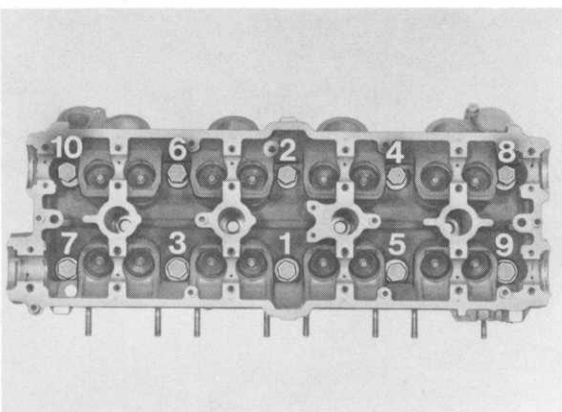
Note:

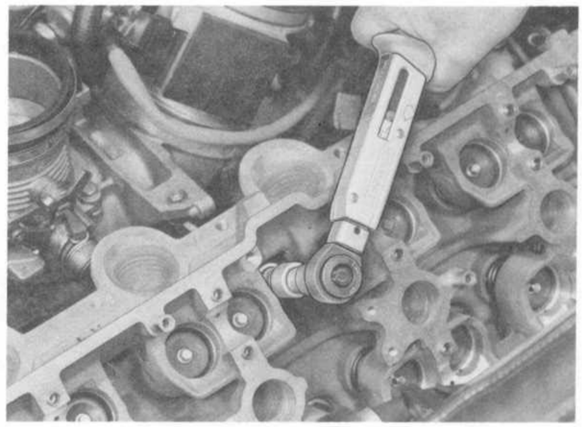
The cylinder head can also be installed with the engine in place. If both cylinder heads are to be removed and installed, it is advisable to remove the engine first.

1. Place cylinder-head gasket in position right way round.

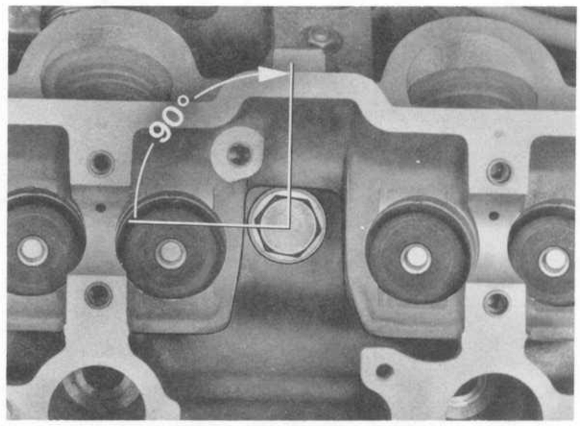
2. Install cylinder head
   Torquing sequence:
   (3 stages)
   Removal sequence:
   reverse order

1st stage	20 Nm (15 ftlb)
2nd stage	90° of turn
3rd stage	90° of turn





1st stage 20 Nm (15 ftlb)

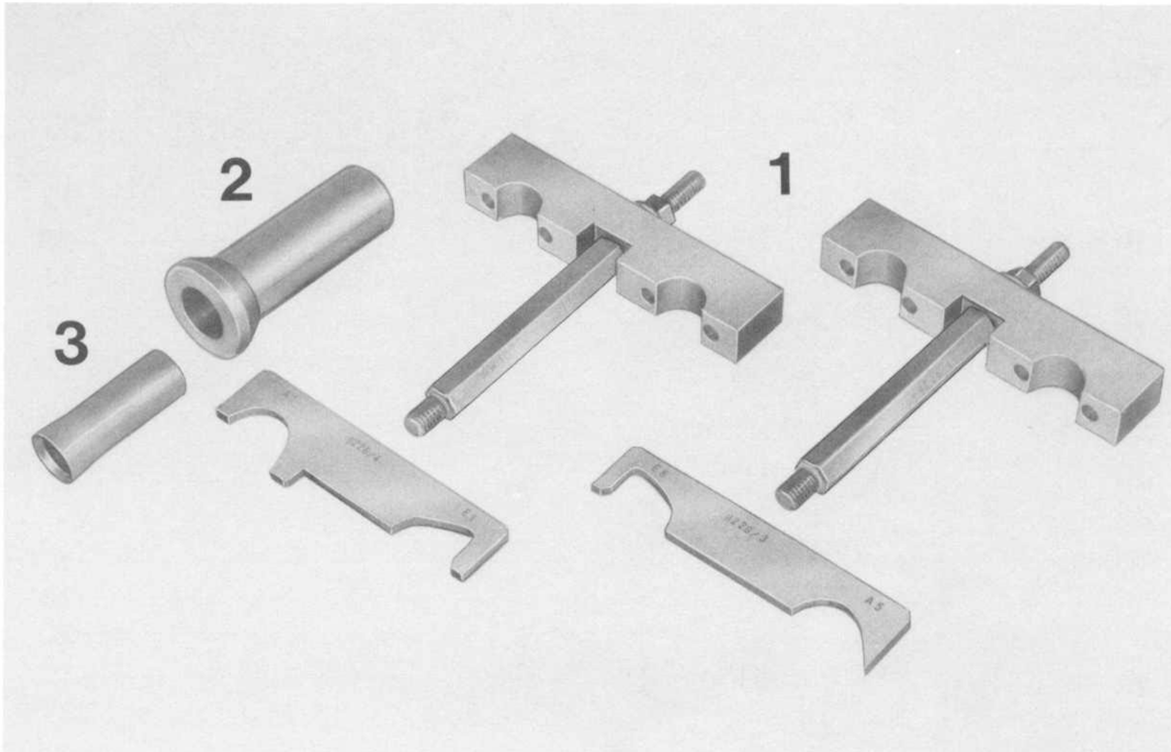


2nd stage 90° of turn
3rd stage 90° of turn

Note:

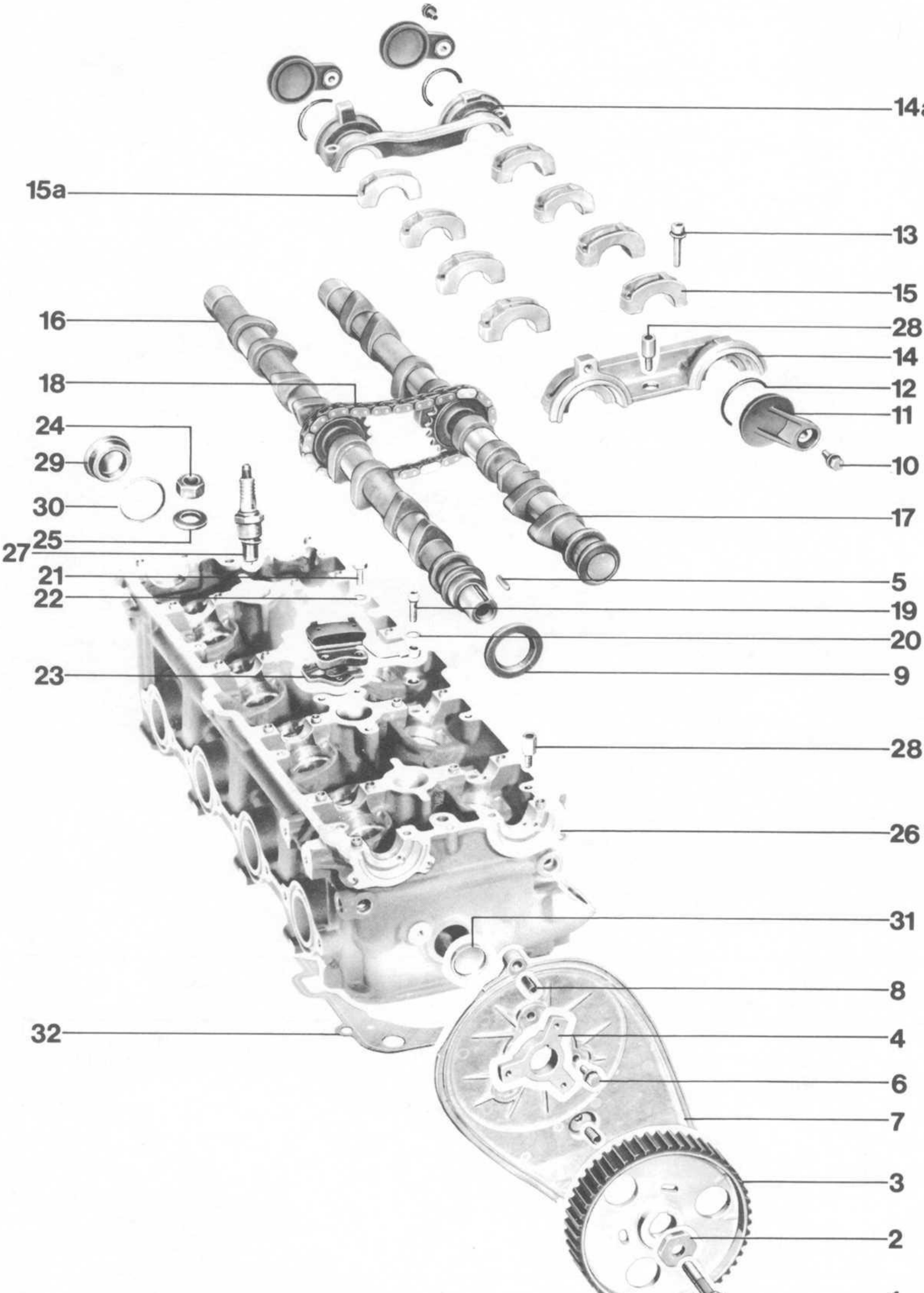
As a rule, do not use lubricant when installing the cylinder-head nuts or hex bolts and washers. It is only necessary to apply a light coat of engine oil to the stud bolts or hex bolts.

TOOLS - DISASSEMBLING AND ASSEMBLING VALVE DRIVE (32-VALVE ENGINE)



No.	Description	Special Tools	Remarks
1	Set of tools for installing camshaft	9226 or 9248	for 85/86 models for 87 models
2	Pressure piece for seal ring	9234	
3	Drift for seal ring	9233	

DISASSEMBLING AND ASSEMBLING VALVE DRIVE (32 VALVE ENGINE)



No.	Description	Qty.	Note When Removing	Note When Installing	Special Instructions
1	Bolt	1		Torque: 65 Nm (47 ftlb); hold on washer with hexagon	
2	Washer	1			
3	Camshaft sprocket	1			
4	Hub	1			
5	Woodruff key	1			
6	Bolt M 6 x 18	3			
7	Rear toothed belt cover	1			
8	Dowel sleeve	2			
9	Shaft seal	1		Always replace. First oil sealing lip and then drive in seal with 9233 and 9234.	
10	Bolt with attached washer	3			
11	Plug	3			
12	Seal	3		Replace	
13	Bolt M 6 x 30 with attached washer	24		Torque: 10 Nm (7 ftlb)	
14	Front bearing bridge	1		Check code. Coat with Loctite 574.	

No.	Description	Qty.	Note When Removing	Note When Installing	Special Instructions
14 a	Rear bearing bridge	1		Check code. Coat with Loctite 574	
15	Bearing cap for intake camshaft	4		Check code and pairing number.	
15 a	Bearing cap for exhaust camshaft	4		Check code and pairing number.	
16	Exhaust camshaft	1		Oil bearing surfaces. Check code.	
17	Intake camshaft	1		Oil bearing surfaces. Check code.	
18	Timing chain	1		Check relation to camshafts.	
19	Hollow bolt with check valve	2			
20	Aluminum washer	1		Replace	
21	Bolt	2			
22	Washer	2			
23	Chain tensioner	1			
24	Nut	10			
25	Washer	10			

No.	Description	Qty.	Note When Removing	Note When Installing	Special Instructions
26	Cylinder head	1			
27	Spark plug	4		Torque: 25 to 30 Nm (18 to 22 ftlb). Coat threads with Molykote HTP Paste.	
28	Threaded insert	12			
29	Plug	1			
30	Round seal	1		Replace, if necessary.	
31	Plug	1		Install with Loctite 270.	
32	Cylinder head gasket	1		Always replace	

Camshaft Installation	USA, Canada and Japan	Australia, Switzerland, Austria and West Germany	Worldwide
Engine type 928 S 85/86/87 models (32-valve engines)	M 28.43 M 28.44	M 28.45 M 28.46	M 28.41 M 28.42
Right-hand camshaft Cylinder bank 1-4 Intake shaft Exhaust shaft	928.105.291.04 928.105.293.04	928.105.291.04 928.105.293.04	928.105.291.09 928.105.293.09
Identification code on rear end face	291.04 293.04	291.04 293.04	291.09 293.09
Left-hand camshaft Cylinder bank 5-8 Intake shaft Exhaust shaft	928.105.292.04 928.105.294.02	928.105.292.04 928.105.294.02	928.105.292.09 294.08
Identification code on rear end face	292.04 294.02	292.04 294.02	292.09 294.08
Valve timing, 1 mm lift, zero play			
Intake opens °CS	11° after TDC	11° after TDC	11° after TDC
Intake closes °CS	50° after BDC	50° after BDC	36° after BDC
Exhaust opens °CS	30° before BDC	30° before BDC	17° before BDC
Exhaust closes °CS	5° before TDC	5° before TDC	2° before TDC

Camshaft installation type 928 S4 - 928 GTS (5,4 l)

Camshaft Installation	World-wide model 88 onward	World-wide model 92 onward
	Engine type 928 S M 28.41/42	**Enginetype 928 GTS (5,4 l) M. 28.49/50**
Camshaft, right Cylinder bank 1 - 4		
Intake shaft	928.105.271.00	928.105.271.03
Exhaust shaft	928.105.273.00	928.105.273.03
Identification code on the rear End face	271.00 273.00	271.03 273.03
Camshaft, left Cylinder bank 5 - 8		
Intake shaft	928.105.272.00	928.105.272.03
Exhaust shaft	928.105.274.00	928.105.274.03
Identification code on the rear end face	272.00 274.00	272.03 274.03
Valve timing, 1 mm stroke, zero play		
Intake opens	11° CS after TDC	13° CS after TDC
Intake closes	36° CF after BDC	61° CS after BDC
Exhaust opens	17° CS before BDC	28° CS before BDC
Exhaust closes	2° CS before TDC	12° CS before TDC

Note

The camshafts of 87 and 88 models may be combined for installation.

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REMOVING AND INSTALLING CAMSHAFTS (32 VALVE ENGINE)

1. Unscrew and remove cross member.

Note

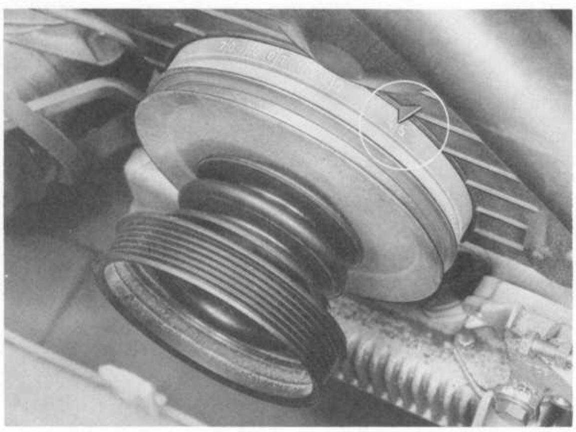
Car standing on its own wheels. Cross member has tension.

2. Remove air intake hoses and complete air cleaner.

3. Loosen hose clamps on intake air distributor and take off intake air distributor.

4. Remove distributor cover, distributor rotor, toothed belt upper section and cylinder head cover.

5. Turn crankshaft clockwise to align the 45° before TDC mark (cylinder no. 1) on vibration damper with cast boss of middle toothed belt cover.



Note

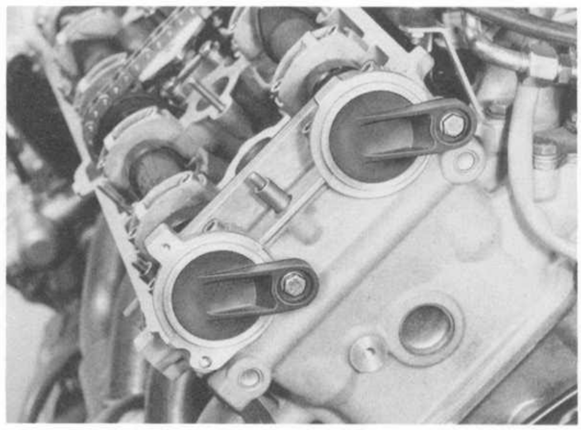
At the 45° mark camshafts can be turned without damaging the valves.

6. Loosen toothed belt with the toothed belt tensioner and take toothed belt off of camshaft sprocket.

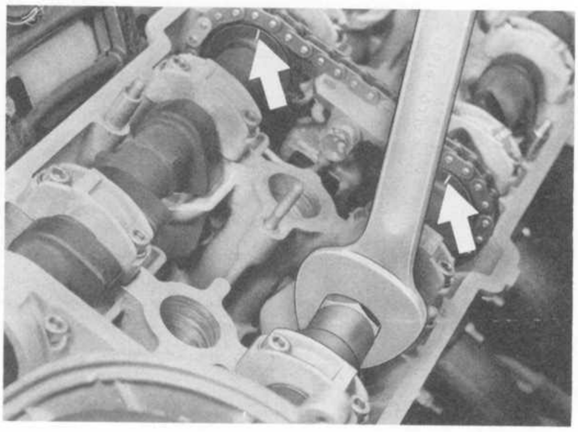
7. Unscrew camshaft bolt and take sprocket, drive hub and woodruff key off of exhaust camshaft.

8. Unscrew and take off rear toothed belt cover.

9. Loosen and remove camshaft seals.



10. Set marks on camshafts to face up by turning exhaust camshaft with a 27 mm open - end wrench.

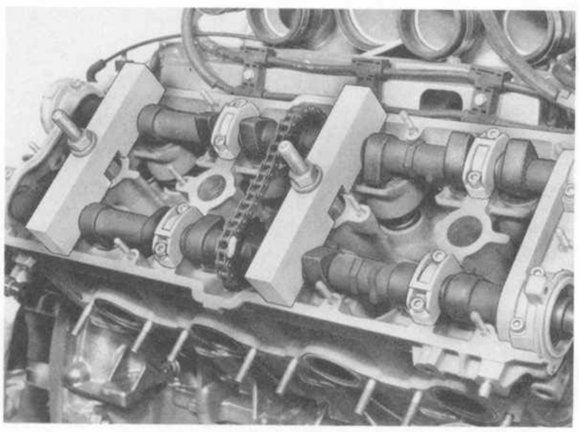


11. Unscrew and remove chain tensioner.

Note

Chain tensioner piston has spring force. Compress piston for removal and hold together with a suitable piece of wire after removing.

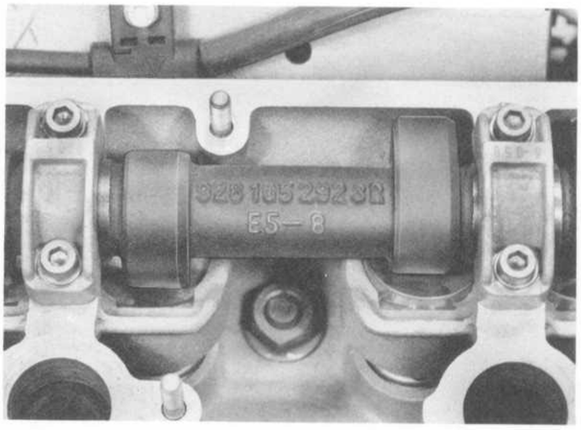
12. Hold both camshafts in bearings with Special Tool 9226. Unscrew and remove all other bearing bridges and bearing caps.

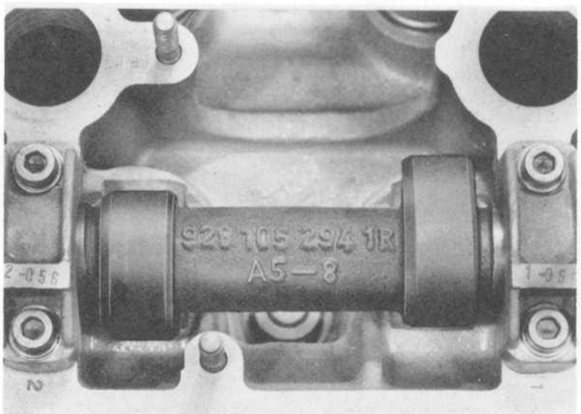


13. Release special tool uniformly and remove both camshafts with chain carefully.

Installing

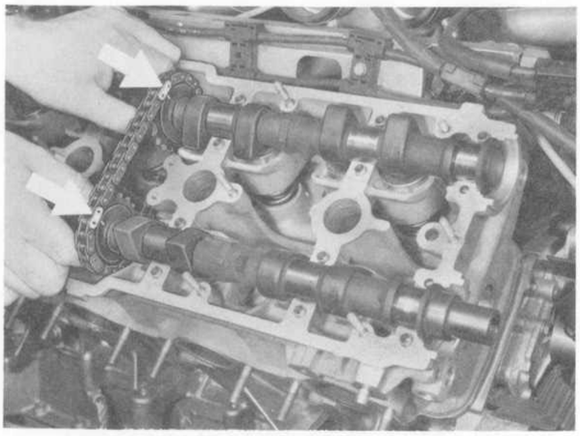
14. Place intake camshaft and exhaust camshaft in timing chain.



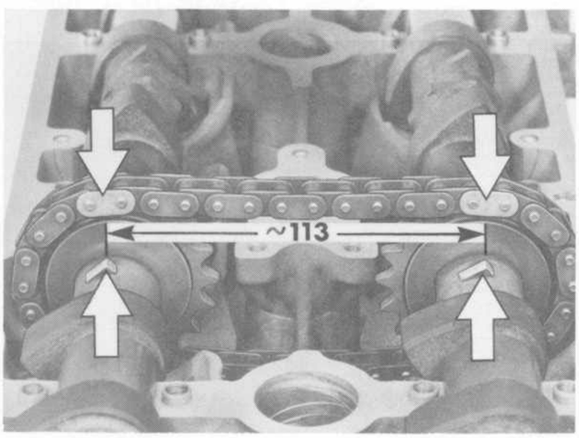


Adjusting

Place both camshafts in timing chain such that the marks of the camshafts or the cast noses are aligned with marked chain links. Lubricate bearing surfaces with oil and carefully place timing chain in bearings.



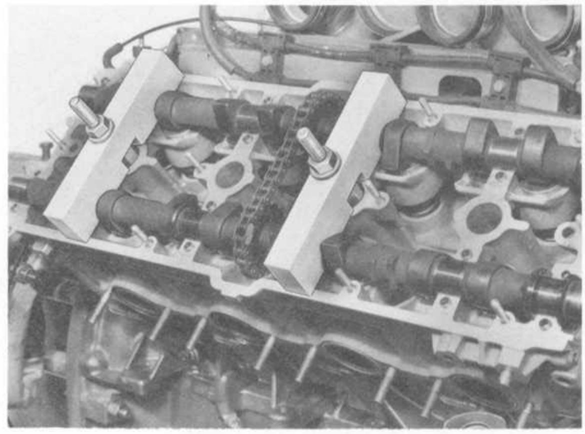
The distance between the markings on the inlet and outlet camshafts is 7 outer links of the chain, and/or aprox. 113 mm spacing between the cast lugs.



Note:

The crankshaft must be at the 45° before ignition TDC (cylinder 1) mark so that the valves do not contact the piston crown.

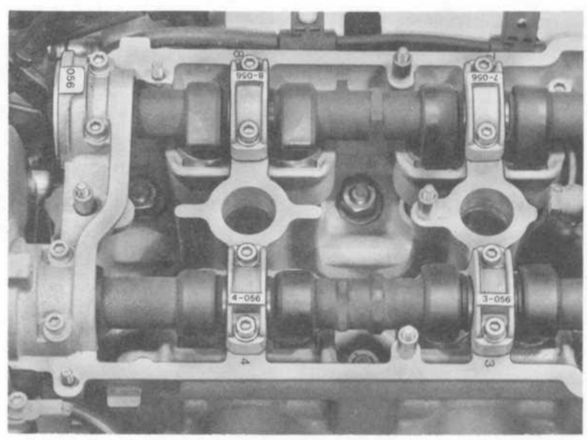
15. Secure camshafts in cylinder head with Special Tool 9226.

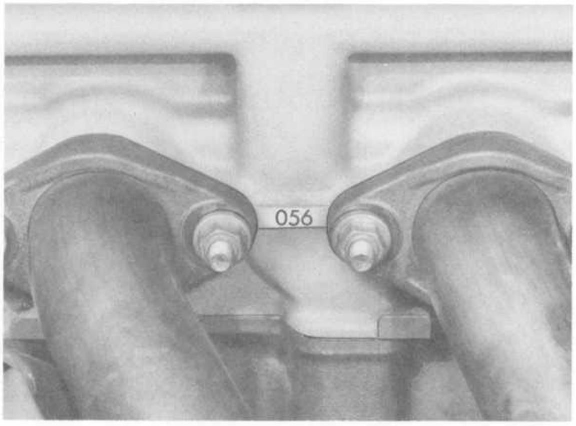


16. Install bearing bridges and bearing covers of camshafts. Bearing bridges and covers are machined with the cylinder head and must always be installed together. Note identifier and pairing code.

Tightening torque of bearing bridge and covers M 6 10 Nm (7 ftlb)

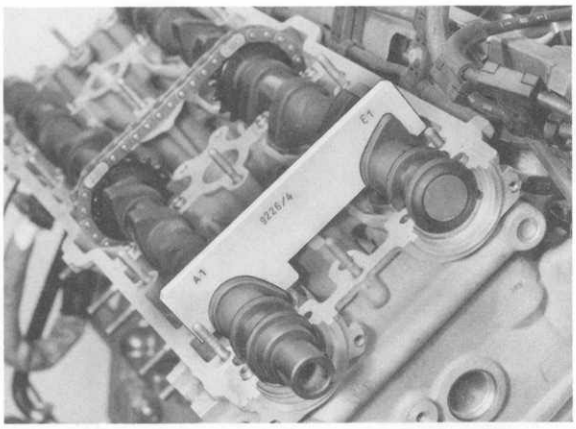
M 8 20 Nm (14 ftlb)

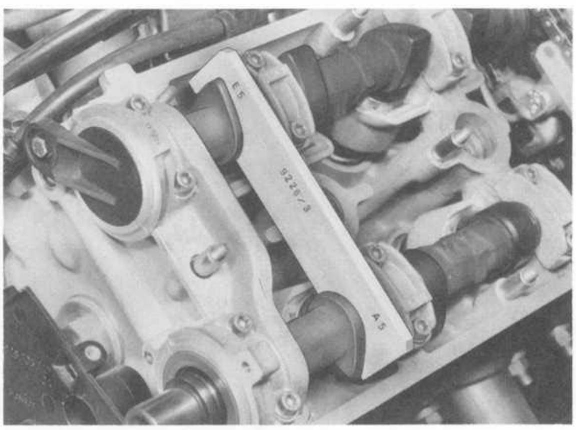




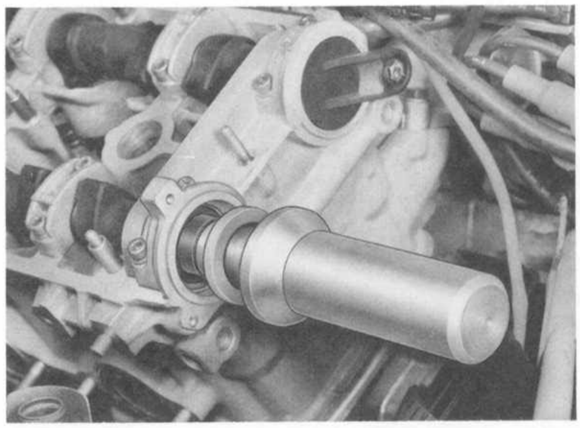
17. Apply Loctite 674 to mating surfaces of front and rear double-bearing bridges.

18. Recheck camshaft correlation with gage from Special Tool Set 9226.





19. Use Special Tool assembly sleeve 9233 and pressure piece 9234 to drive in sealing ring on the camshaft input side. Oil sealing lip before assembly.



N o t e

The camshaft adjustment gauges for cylinders 1 and 5 are discontinued as from model year 87, engine type M 28. 41/42

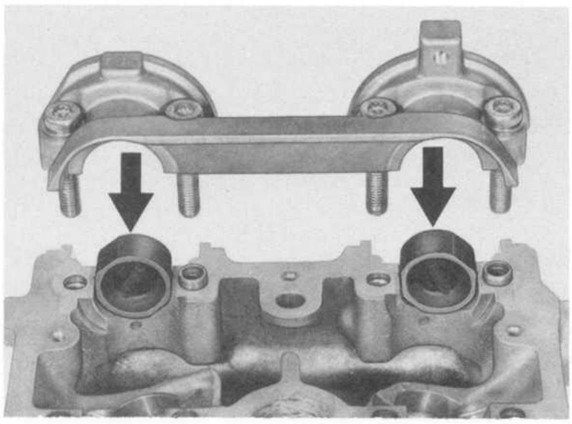
2. The timing chains must always be replaced after a toothed belt has failed, if the pistons have caused damage to the valves. Sprockets and chain tensioners must be subjected to a thorough visual inspection.

Installing camshaft seal

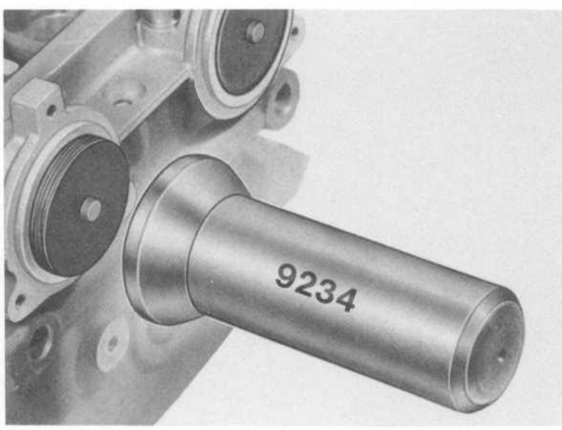
87 models onward

Engine type M 28.41/42/47/49/50

1. Place sealing washers (lock pins M 28.49/50 as of MY '92) into bearing seats and fit bearing saddle with Loctite 574. Tightening torque: 20 Nm (15 ftlb)



2. After torquing the bearing bridge, install sealing cover with the aid of Special Tool 9234.



85 models onward

Engine types M 28.43/44/45/46/41/42/47/49/50

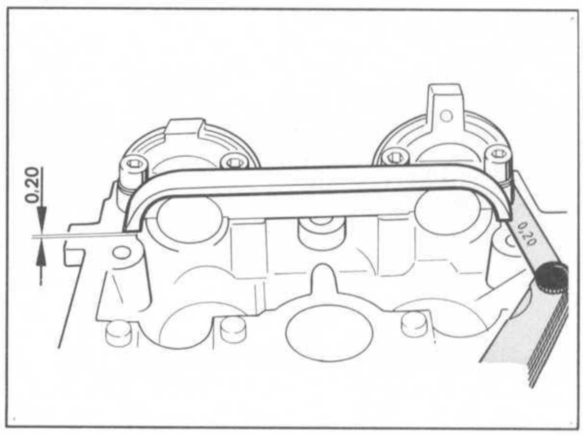
Engine installed

Note

If the sealing cover of an engine as of model year 85 (32 valve engines) leaks with the engine installed, the procedure for installing the cover is as follwos:

1. Place camshafts and sealing washers in bearing.

2. Apply Loctite 574 to bearing bridge and install. Place a 0.20 mm feeler gauge between bearing bridge and cylinder head and tighten bolts slightly by hand.



3. Apply a light film of oil to sealing cover and press on by hand. Tighten bearing bridge to specified torque.

M 6 bearing bridge	10 Nm (7.5 ftlb) Mod. 85/86
M 8 bearing bridge	20 Nm (15 ftlb) from Mod. 87

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REMOVING AND INSTALLING CHAIN TENSIONER FOR CAMSHAFTS

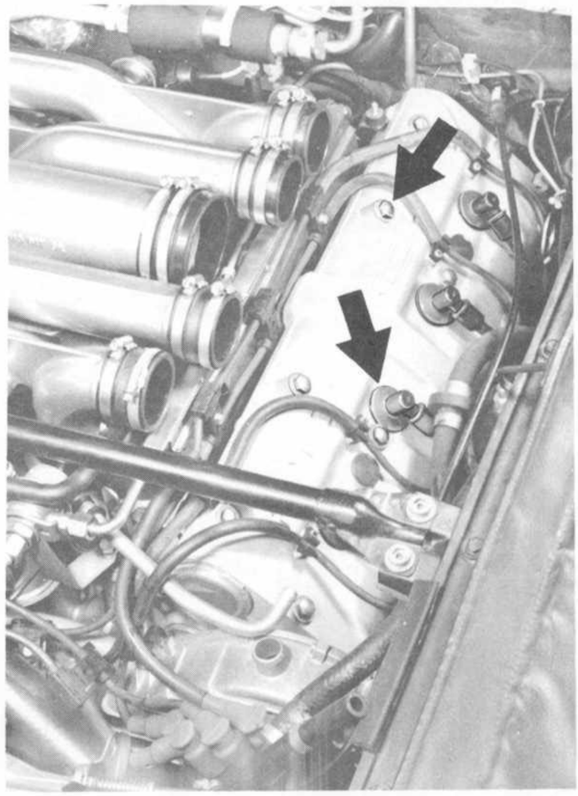
1. Unscrew and remove cross strut.

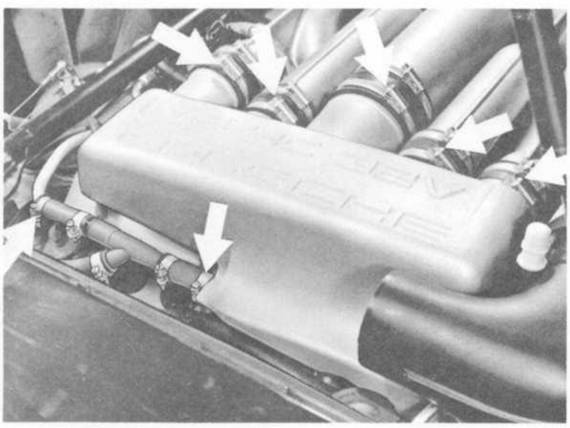
Note

Car must be on its wheels - cross strut has tension.

2. Remove air intake hoses and complete air cleaner.

3. Loosen hose clamps on intake air distributor and vacuum pipe. Pull off and lay suction pump aside. Loosen hose clamps on intake air distributor and intake pipe, and take off intake air distributor.





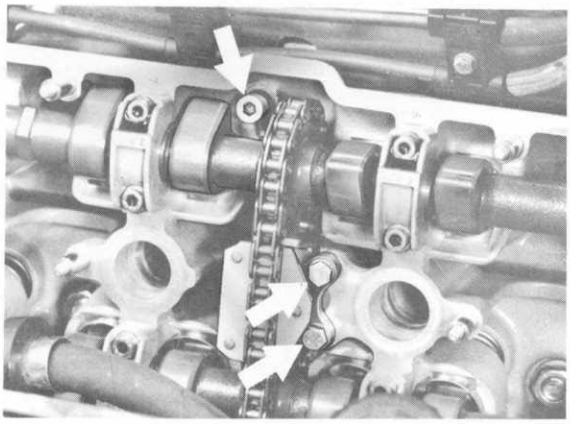
4. Unscrew suspension eye on engine only at rear left.

5. Pull off spark plug connectors and take ignition leads out of holder on cylinder head cover. Unscrew and remove cylinder head cover.

Note

Note that some bolts are with and some without a seal when unscrewing the cylinder head cover.

6. Unscrew and remove hollow union bolt with check valve on cylinder head. A seal is only used underneath the bolt head. Unscrew and remove chain tensioner on cylinder head.



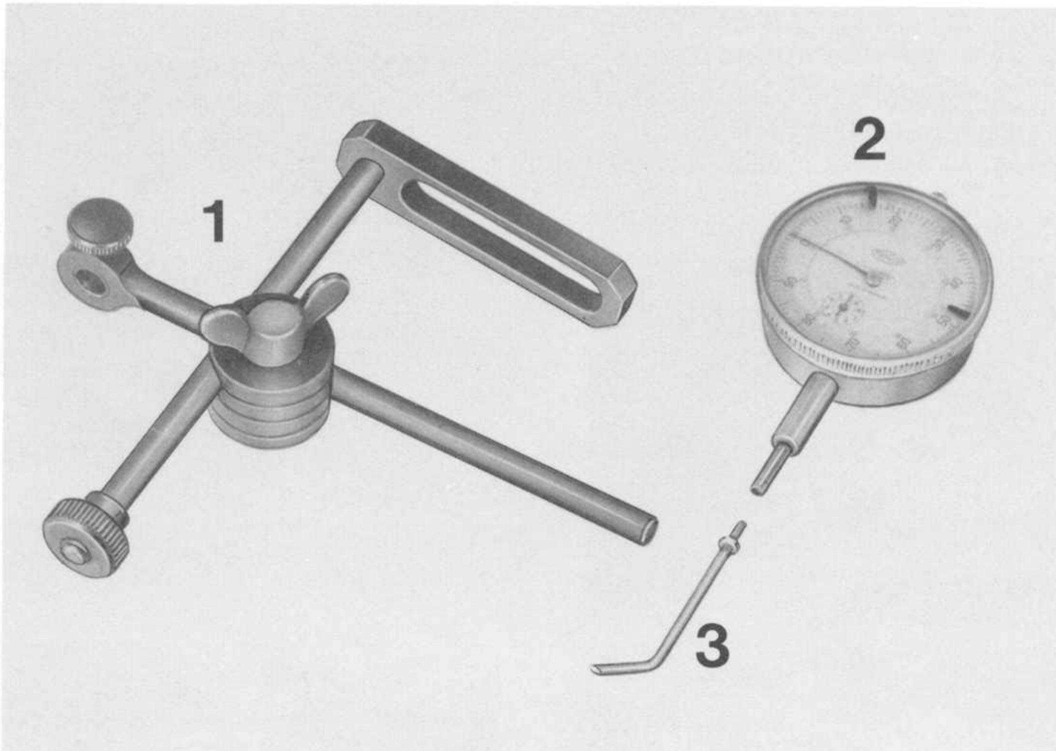
Note

Chain tensioner piston has spring force. Compress piston when removing and bind together with a suitable piece of wire after removing.

Chain tensioner piston on righthand side for cylinders 1 to 4 presses the chain up; on lefthand side for cylinders 5 to 8 down.

Tighten chain tensioner with specified torque after installation.

TOOLS FOR CAMSHAFT ADJUSTMENT (32-VALVE ENGINES)



No.	Designation	Special tool	Remarks
1	Gauge holder	VW 387	
2	Gauge		commercially available
3	Gauge inset	9232	

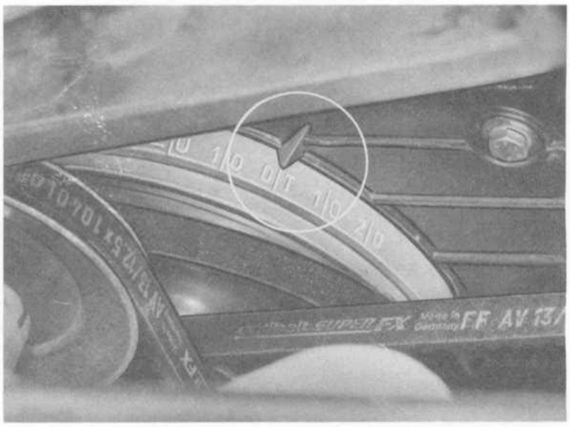
CHECKING AND ADJUSTING CAMSHAFT SETTING, 85/86 MODELS ONWARD

ENGINE TYPE M28. 43/44/45/46

P r e c o n d i t i o n :

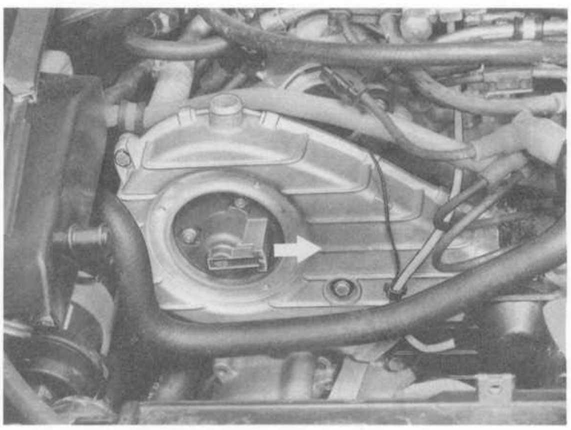
Timing belt tensioned as specified.
Specification: 5.0 + 0.3 scale gradations.

1. Turn engine in direction of rotation to TDC (cylinder No. 1).

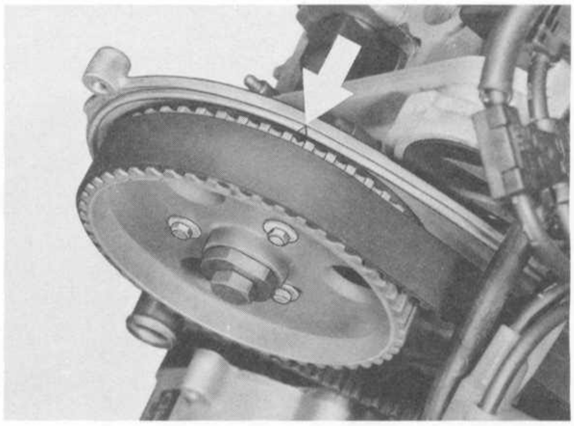


N o t e :

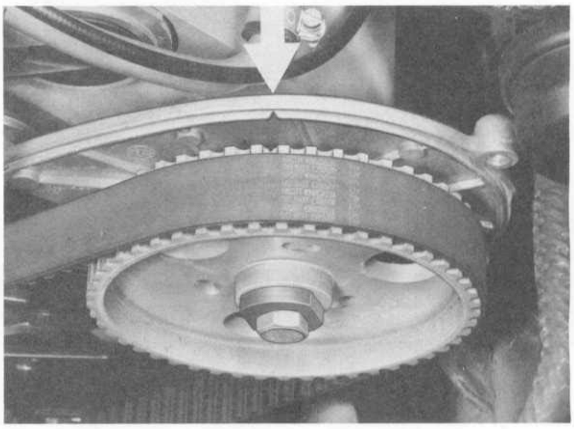
Both distributor fingers point left in forward direction of travel.



2. In this position, the marks on the camshaft gears and the flange bearings must also be aligned.

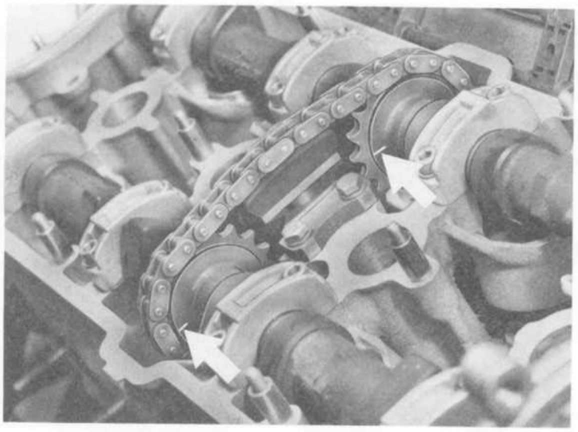


Cylinder bank 1-4

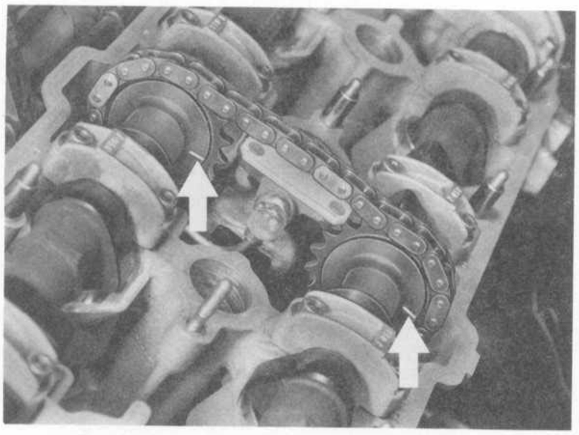


Cylinder bank 5-8

3. At the same time, check the marks (older engines) or noses (newer engines) on the camshafts.
Both marks point toward exhaust side.

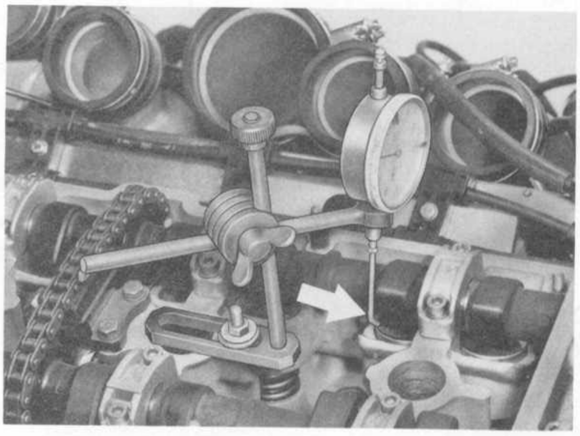


Cylinder bank 1 - 4



Cylinder bank 5 - 8

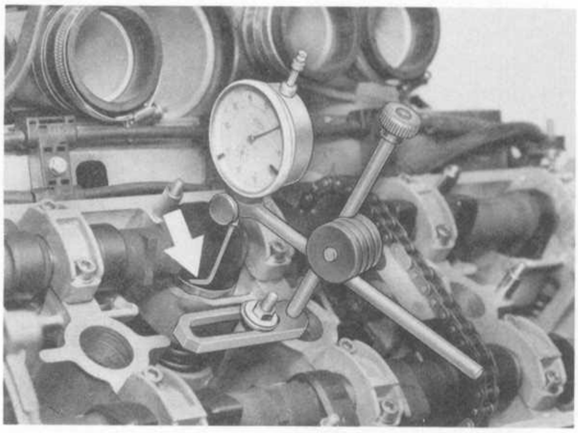
4. Mount gauge with holder VW 387 on cylinder head. Set gauge to 0 with 5 mm pretension on hydraulic tappet of cylinder 1 intake valve.



Cylinder bank 1 - 4

Correct setting 1.6 ± 0.1 mm

Place gauge on hydraulic tappet of cylinder 6 intake valve.

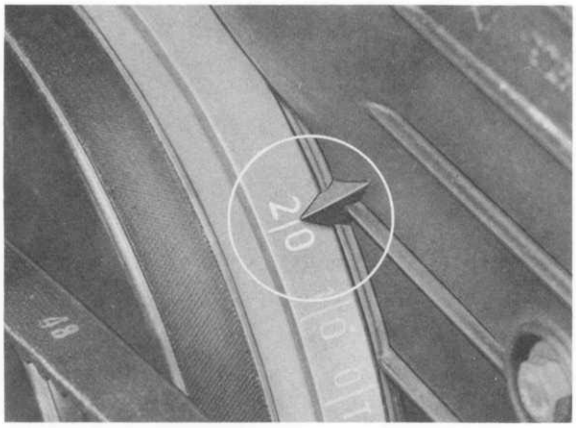


Cylinder bank 5 - 8
Specified value: 2.0 ± 0.1 mm

N o t e

The gauge must be aligned perpendicular to the intake valve.

5. Turn the crankshaft on past TDC (cylinder 1) while observing gauge. Continue turning engine until the lift is 1.6 ± 0.1 mm. The 20° (after TDC, cylinder 6) mark must now be aligned with the index mark on the camshaft drive belt cover.

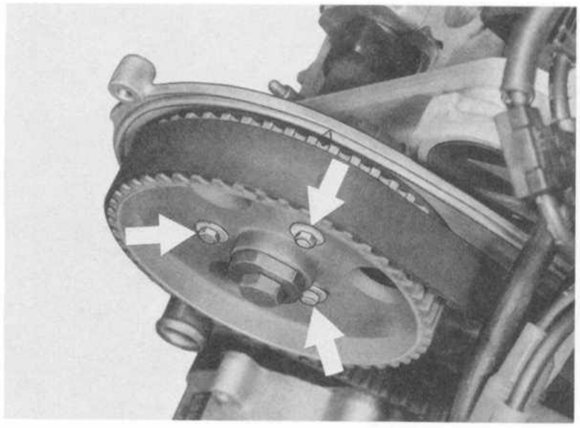


6. If the components are not aligned, proceed as follows:

A d j u s t i n g

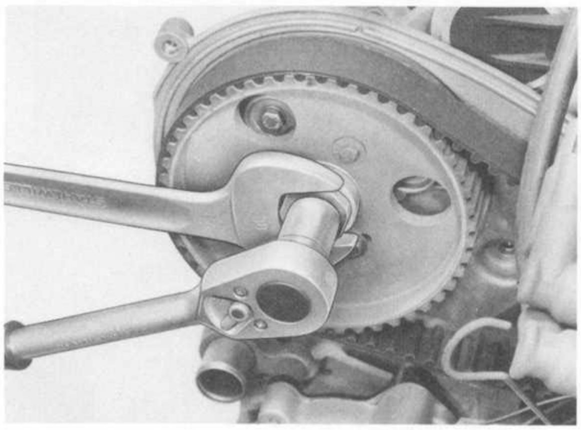
Cylinder bank 1 - 4

1. Install 3 extra M5 x 15 bolts to hold camshaft wheel, so as to prevent the camshaft wheel or camshaft turning when the retaining bolts are slackened.



2. Turn crankshaft in its usual direction of rotation until the gauge shows a lift of 1.6 ± 0.1 mm.

3. Slacken camshaft retaining bolts, bolts <u>must</u> be countered. Slacken provisional M 5 bolts.



CHECKING AND ADJUSTING CAMSHAFT SETTING

87 MODELS ONWARD

ENGINE TYPE M 28. 41/42

N o t e :

Installation of new camshafts in type M 28. 41/42 engines as of model year 87 has changed the valve timing. The new camshafts are recognizable because they have no rear journals.

A d j u s t i n g

Cylinder bank 1-4

Testing and adjusting specification: 1.8 ± 0.1 mm

Cylinder bank 5-8

Testing and adjusting specification: 2.0 ± 0.1 mm

Adjustment of the camshafts follows the same sequence as described on p. 15 - 134.

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4. Turn crankshaft until cylinder No. 6 is at 20° after TDC.

5. Block camshaft gears by installing 3 M 5 x 15 auxiliary bolts then tightening M 10 bolt to 65 Nm (47 ftlb).

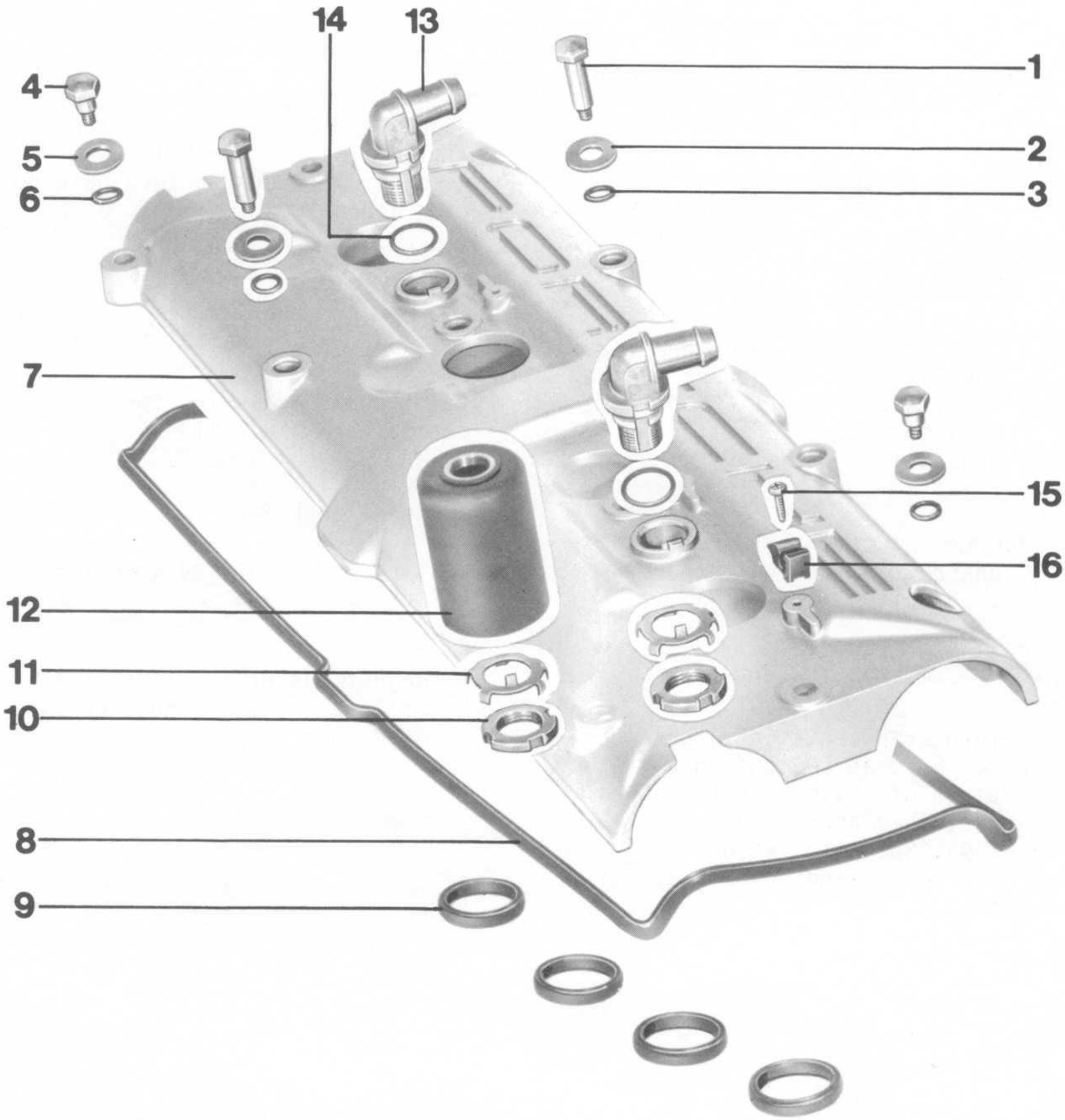
6. Turn crankshaft through 2 more revolutions and recheck setting. Specified value: 1.6 + 0.1 mm, cylinder No. 6 20° after TDC. Readjust if necessary.

7. Once adjustment is completed, unscrew and remove temporary M 5 x 15 bolt.

Cylinder bank 5-8

8. Turn crankshaft until cylinder No. 6 is at TDC and check settings of cylinder bank 5-8 as described above (cylinder bank 1-4). Specified value 2.0 ± 0.1 mm, cylinder No. 1 20° after TDC.

CYLINDER HEAD COVER, DISASSEMBLING AND REASSEMBLING (32-VALVE ENGINES)



No.	Designation	Qty.	Note when: Removing	Installing
1	Screw	9		
2	Washer	9		
3	Gasket	9		
4	Screw	3		
5	Washer	3		
6	Gasket	3		
7	Cylinder head cover	1		
8	Seal	1		
9	Gasket	4		
10	Locknut	2		
11	Guard	2		
12	Oil separator	1		
13	Connection stub	2		Connection stub on oil separator with throttle 6.5 mm
14	O - ring	2		
15	Screw	4		
16	Ignition lead holder	4		

928 S_4 CLUB SPORT-Version

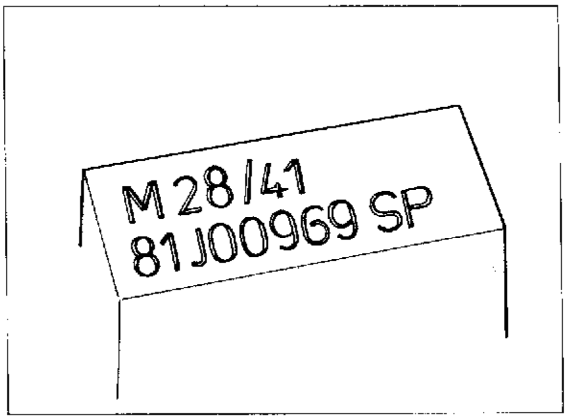
Identification, scope of modification, test and adjustment values

As from Model 88

Engine type M28.41 CLUB SPORT

Note

The identification code "SP" has been embossed as a suffix to the serial number.



62/15

Scope of modification, engine

- New camshafts with different valve-timing adjustment.
- EZK control unit (see Page 28 - 73).
- LH control unit (see Page 28 - 73).
- Idle speed: 775 rpm
- Modified middle and rear silencer with 2 end pipes.
- Lighter air-conditioning compressor.

Camshaft assignment for Club Sport and GT version

Camshaft assignment	Worldwide as from Mod. 88		Worldwide as from Mod. 89
Engine type	**928 S 4** **M 28.41 Club Sport**		**928 GT** **M 28.47**
Camshaft, right Cylinder bank 1...4			
Intake shaft	928.105.291.06	or	928.105.271.01
Exhaust shaft	928.105.293.06	or	928.105.273.01
Identification on the rear face surface	291.06 293.06		271.01 273.01
Camshaft, left Cylinder bank 5...8			
Intake shaft	928.105.292.06	or	928.105.272.01
Exhaust shaft	928.105.294.05	or	928.105.274.01
Identification on the rear face surface	292.06 294.05		272.01 274.01
Timings, 1 mm stroke, zero play			
Intake opens	3° crank angle after TDC		3° crank angle after TDC
Intake closes	42° crank angle after BDC		42° crank angle after BDC.
Exhaust opens	30° crank angle before BDC		30° crank angle before BDC
Exhaust closes	5° crank angle before TDC		5° crank angle before TDC

Note

The camshaft designs may be installed in mixed configuration.

The **camshaft adjustment gauges** for cylinders 1 and 5 can be used again for the camshafts for the engine types M 28.41 Club Sport or M 28.47, as described on Page 15-128.

Printed in Germany - XXIV, 1989

Checking and adjusting the camshaft setting, Club Sport and GT version

As from Model 88, Club Sport Version

Engine type M 28.41 CLUB SPORT

Note

The timings have changed as a result of installation of new camshafts as from Model 88 for the engine type M 28.41 Club Sport.

Adjustment

Cylinder bank 1 - 4
Testing and adjustment value: **2.8 ± 0.1 mm**

Cylinder bank 5 - 8
Testing and adjustment value: **3.1 ± 0.1 mm**

Camshaft adjustment is performed in the same order as described on Page 15 - 134.

As from Model 89, GT version

Engine type M 28.47

Note

The same camshafts as in engine type M 28.41 Club Sport are installed in the engine type M 28.47 as from Model 89. The setting has not changed.

Adjustment

Cylinder bank 1 - 4
Testing and adjustment value: **2.8 ± 0.1 mm**

Cylinder bank 5 - 8
Testing and adjustment value: **3.1 ± 0.1 mm**

Camshaft adjustment takes place in the same order as described on Page 15 - 134.

Printed in Germany – XXIV, 1989

Checking and adjusting camshaft setting, Type 928 GTS (5,4 l)

As of MY '92

Engine Type M 28.49/50

Note

Along with the introduction of new camshafts as of MY '92 for engine type M 28.49/50 928 GTS, the camshaft timing was changed.

Adjusting

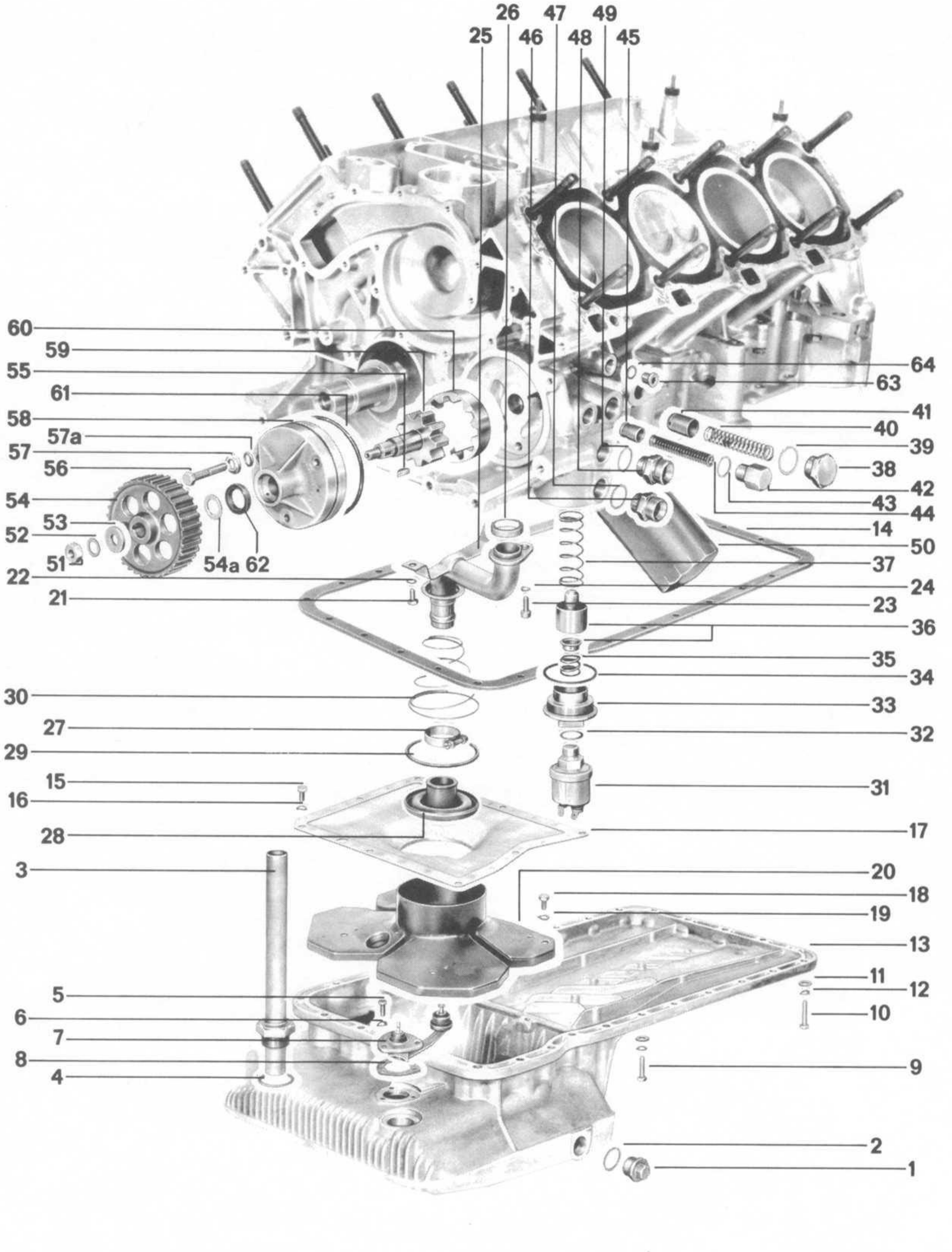
Cylinder bank 1...4
Checking and setting dimension:
1.83 ±0.1 mm

Cylinder bank 5...8
Checking and setting dimension:
2.08 ±0.1 mm

To adjust the camshafts, proceed in the order described on page 15 - 134.

Printed in Germany – XXVII, 1991

REMOVING AND INSTALLING LUBRICATING SYSTEM PARTS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No.	Description	Qty.	Note When Removing	Note When Installing	Special Instructions
1	Magnetic plug	1		Tighten to specified torque	
2	Seal	1		Replace	
3	Pipe	1			
4	Seal	1		Replace	
5	Bolt	3			
6	Washer	3			
7	Oil level supply switch	1			
8	Gasket	1		Replace	
9	Bolt	5		Install at depressions of oil pan	
10	Bolt	25			
11	Washer	30			
12	Washer	30			
13	Oil pan	1		Check	
14	Oil pan gasket	1		Replace	
15	Bolt	8			
16	Washer	8			
17	Oil filter screen	1		Check	
18	Bolt	4		Use Loctite 270 or 271	
19	Washer	4			
20	Oil pan insert	1		Check	
21	Bolt	2			
22	Washer	2			
23	Socket head bolt	1			

No.	Description	Qty.	Note When Removing	Note When Installing	Special Instructions
24	Washer	1			
25	Oil intake tube	1		Check	
26	Gasket	1		Replace	
27	Hose clamp	1			
28	Rubber sleeve	1		Check for damage, replace if necessary	
29	Spring support disc	1		Position correctly	
30	Spring	1			
31	Oil pressure sender	1			
32	Seal	1		Replace	
33	Plug	1		Tighten to specified torque	
34	Seal	1		Replace	
35	Thermostat spring	1			
36	Thermostat insert	1			
37	Thermostat spring	1			
38	Plug	1			
39	Seal	1		Replace	
40	Spring	1			
41	Bypass valve piston	1	Check for wear		
42	Plug	1			
43	Seal	1		Replace	
44	Spring	1			
45	Pressure relief valve piston	1	Check for wear		
46	Adaptor	1			

No.	Description	Qty.	Note When Removing	Note When Installing	Special Instructions
47	Seal	1		Replace	
48	Adapter	1			
49	Seal	1		Replace	
50	Oil filter	1	Loosen with standard strap, e. g. Hazet 2171-2		
51	Nut	1			
52	Washer	1			
53	Washer	1			
54	Oil pump gear	1			
54a	Shim 22 x 16 x 1	1		Only use together with light alloy gear	
55	Woodruff key	1			
56	Bolt	3			
57	Washer	3			
57 a	Round cord seal	3			
58	Oil pump housing	1			
59	Inner rotor	1		Lubricate	
60	Outer rotor	1		Lubricate, chamfered side must be inside of oil pump body (facing forward)	
61	O-ring	1		Replace	
62	Shaft seal	1		Replace, drive into oil pump body flush. Install with 9195, see page 17 - 6 a	
63	Plug for oil bores	1			
64	Seal	1		Replace	

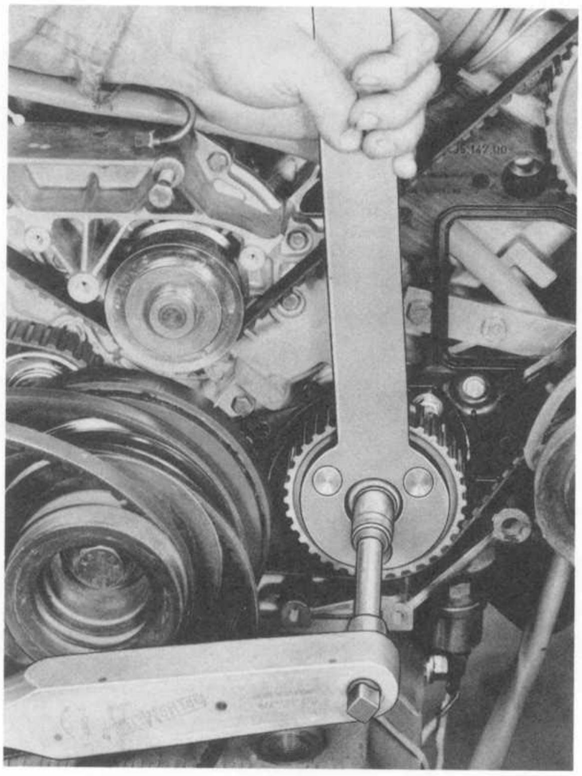
ASSEMBLY INSTRUCTIONS
OIL PUMP, REMOVING AND INSTALLING

Removing

1. Lock oil pump drive wheel with special tool 9157, unscrew retaining nuts and pull off drive wheel.

Note

Use special tool 9157/1 to lock oil pump drive wheels with HTD tooth shape (83 models onward).



2. Unscrew the oil pump mounting bolts and remove oil pump.

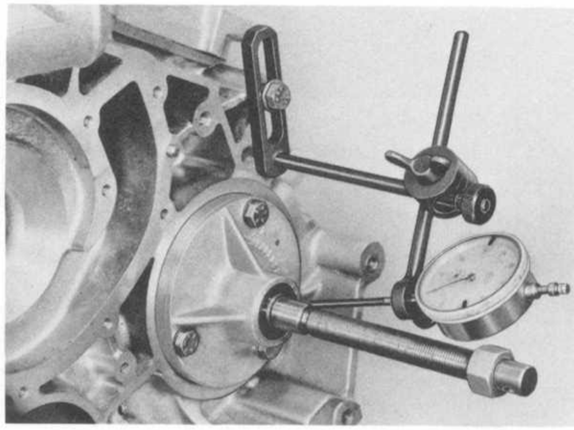
Installing

Note

Measure axial play before installation. The measurement must be carried out with the pump dry, in other words without oil.

1. Use gauge holder VW 387 and threaded section to measure axial play.

   Axial play 0.08 to 0.12 mm



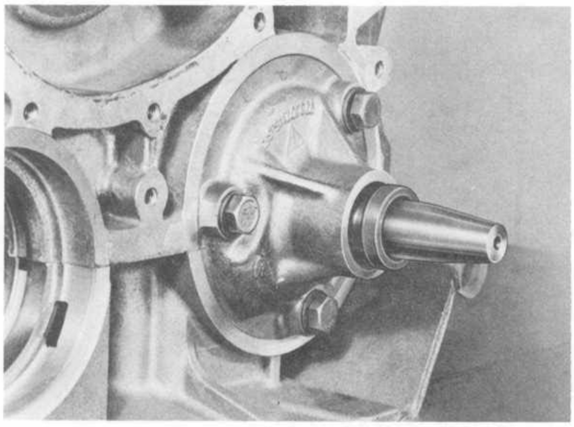
2. If necessary, remove inner rotor.

   Size 21 $^{-0.080}_{-0.095}$ mm

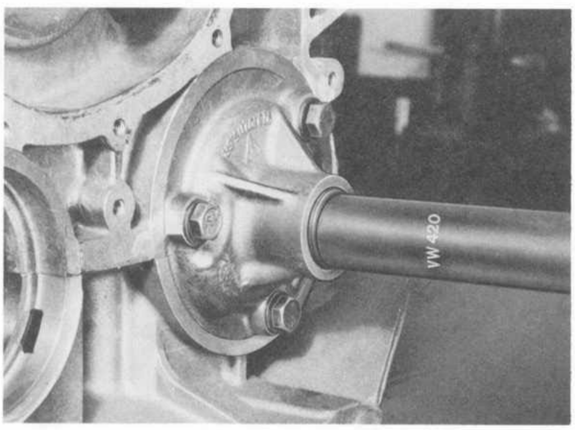
3. When installing a replacement oil pump, do not remove transport fixture until mounting bolts have been tightened.

REPLACING SHAFT SEAL FOR OIL PUMP

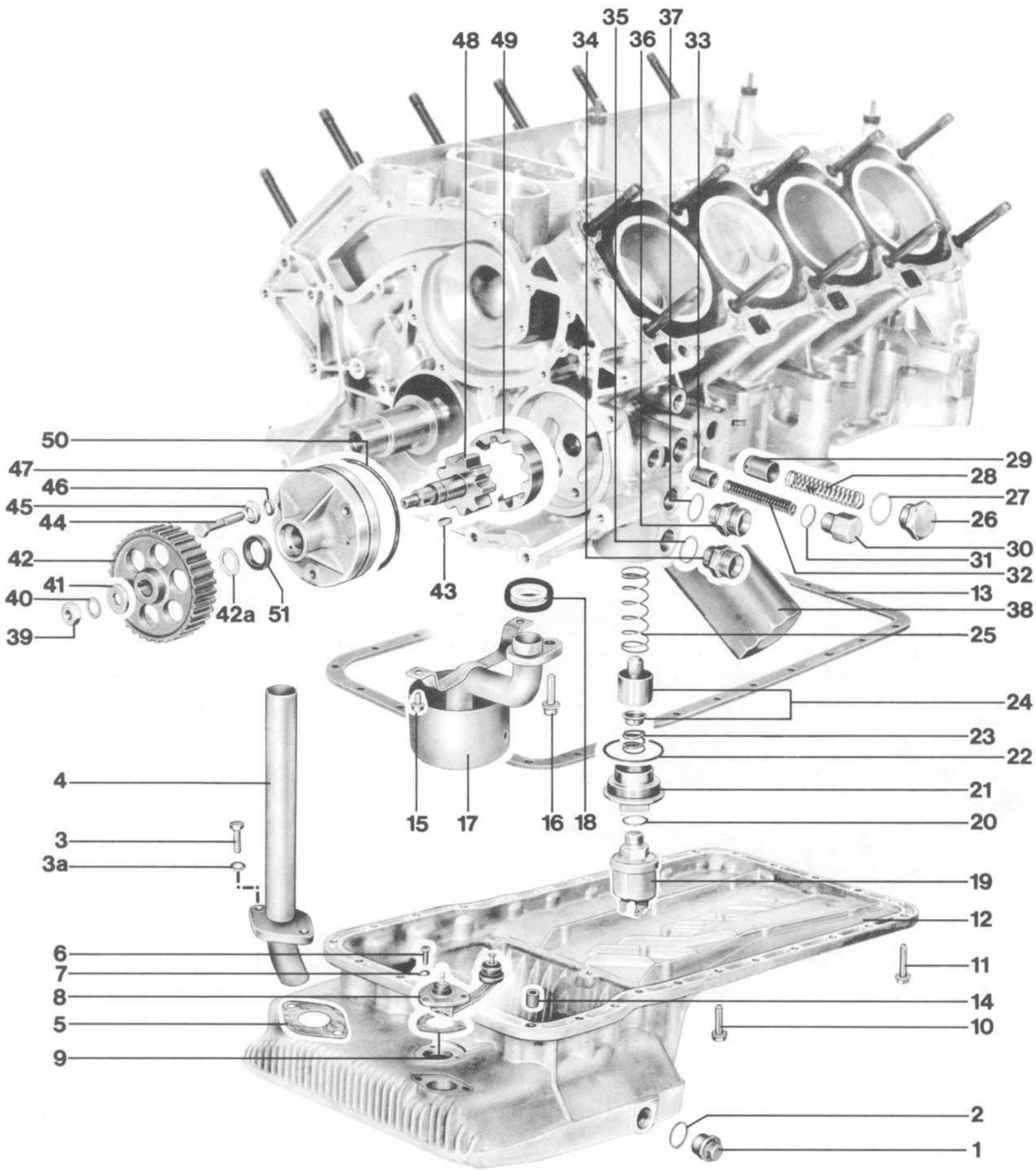
1. Lubricate sealing lip with oil and slide seal over Special Tool 9195 on to the drive shaft inner race.



2. Knock in seal flush with a suitable pressure pad, e. g. VW 420.



LUBRICATION SYSTEM COMPONENTS, REMOVING AND INSTALLING, 83 MODELS ONWARD



No.	Designation	Qty.	Note when: Removing	Installing
1	Magnetic plug	1		tighten plug to correct torque setting.
2	Gasket	1		fit replacement
3	Hex bolt M 6 x 20	2		
3a	Washer	2		
4	Tube	1		
5	Seal	1		fit replacement
6	Hex bolt M 5 x 12	3		
7	Spring washer	3		
8	Oil level switch	1		
9	Seal	1		fit replacement
10	Hex bolt M 6 x 25 with washer	5		install in oil pan recesses
11	Hex bolt M 6 x 28 with washer	25		
12	Oil pan	1		check
13	Oil pan seal	1		fit replacement
14	Centering sleeve (rubber)	2		

No.	Designation	Qty.	Note when: Removing	Installing
15	Hex bolt M 6 x 12 with washer	2		
16	Allen bolt M 8 x 30 with washer	1		
17	Oil intake tube	1		check
18	Gasket	1		fit replacement
19	Oil pres- sure sensor	1		
20	Gasket	1		fit replacement
21	Threaded plug	1		tighten to correct torque setting
22	Gasket	1		fit replacement
23	Spring for thermostat	1		
24	Regulator insert	1		
25	Spring for thermostat	1		
26	Threaded plug	1		
27	Gasket	1		fit replacement
28	Pressure spring	1		
29	Plunger for bypass valve	1	check for wear	
30	Threaded plug	1		

No.	Designation	Qty.	Note when: Removing	Installing
31	Gasket	1		fit replacement
32	Pressure spring	1		
33	Piston for pressure release valve	1	check for wear	
34	Screw connector	1		
35	Gasket	1		fit replacement
36	Screw connector	1		
37	Gasket	1		fit replacement
38	Oil filter	1	use commercially available oil filter remover, e.g. Hazet 2171-2	
39	Hex nut	1		
40	Spring washer	1		
41	Washer	1		
42	Toothed wheel for oil pump	1		
42a	Shim ring 22 x 16 x 1	1		only install with light alloy toothed wheel
43	Woodruff key	1		
44	Hex bolt M 8 x 45	3		
45	Washer	3		

No.	Designation	Qty.	Note when: Removing	Installing
46	Sealing ring	3		fit replacement
47	Oil pump body	1		
48	Inner rotor	1		oil
49	Outer rotor	1		oil, install with chamfered side in oil pump body (in forward direction of travel)
50	O-Ring	1		fit replacement
51	Shaft seal	1		fit replacement, use drift 9195 to fit seal flush with oil pump body, see p. 17 - 6a

Note

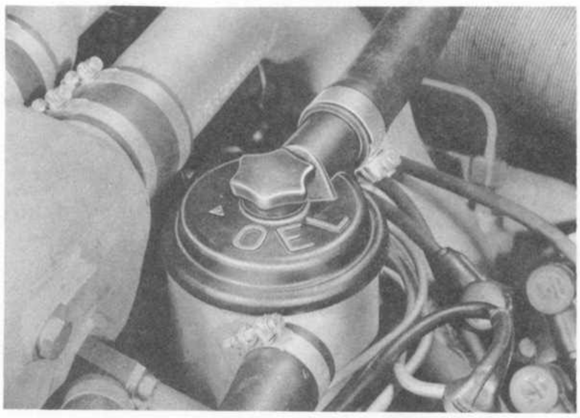
The **short-circuiting valve,** Nos. 26 to 29, is **deleted** on the engines for the 1991 MY. The crankcase is no longer machined at the respective valve location. Exchange engines with **new** crankcases are also supplied **without** short circuiting valve.

Printed in Germany – XXIX, 1992

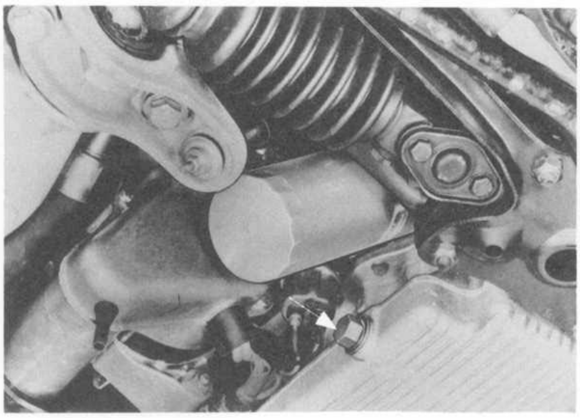
CHANGING ENGINE OIL AND ENGINE OIL FILTER

Requirement:
Engine at operating temperature.

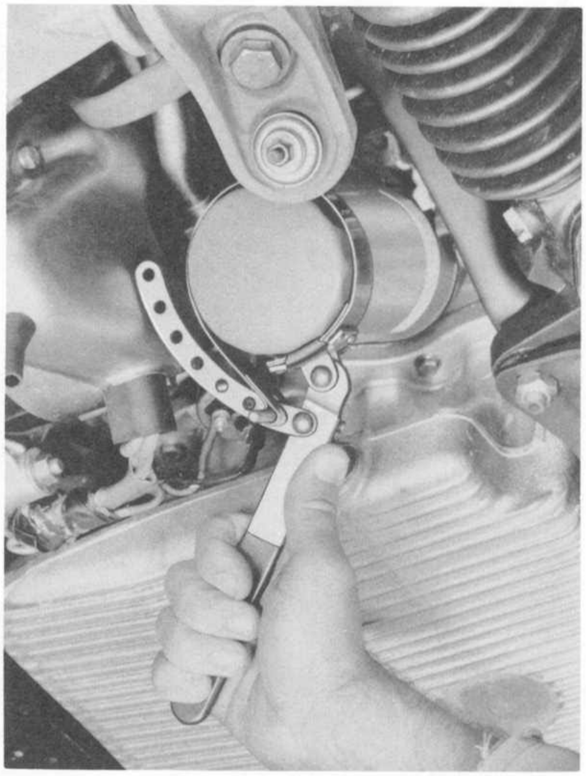
1. Loosen and remove oil filler cap.



2. Remove oil drain plug from oil pan and drain engine oil.



3. Loosen oil filter with a standard strap wrench, or US 4462.



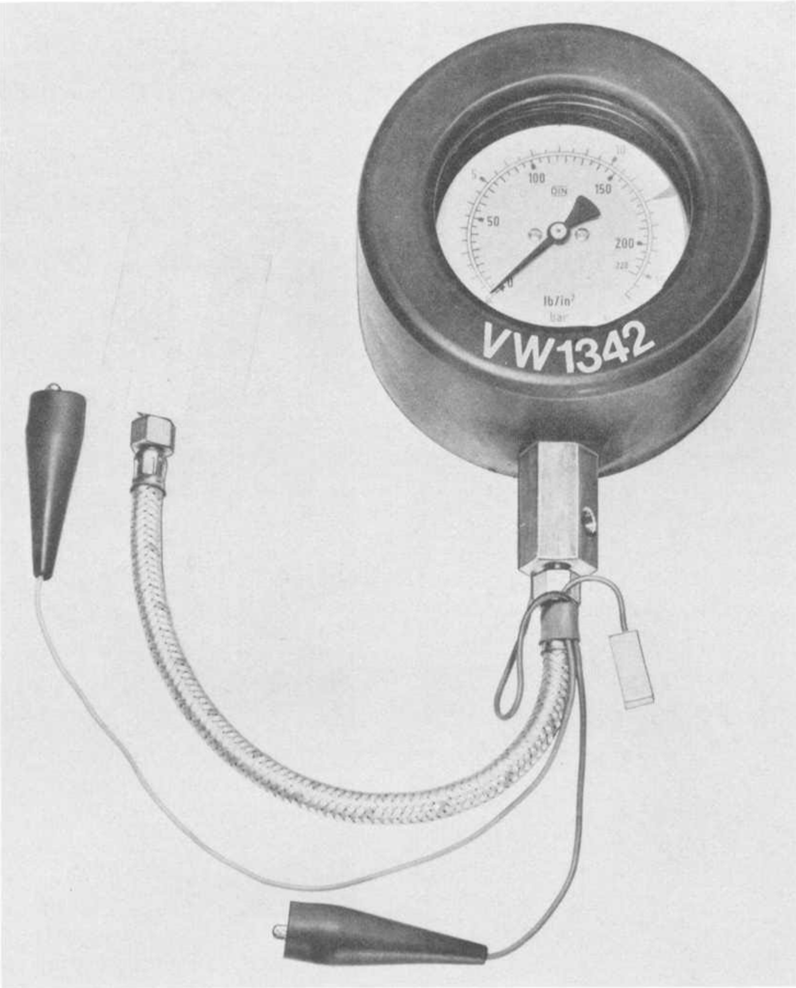
4. Clean drain plug. Replace seal. Tighten drain plug to 4.0 + 0.3 (29 + 2 ft lb).

5. Lubricate gasket on oil filter slightly, install by hand until gasket contacts surface and then tighten one more turn.

6. Add engine oil, run engine to operating temperature and check for leaks.

7. Check oil level on stopped engine.

TOOLS



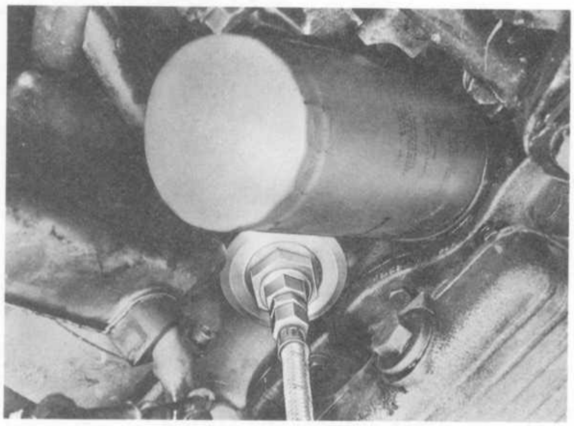
No.	Description	Special Tool	Remarks
1	Oil pressure tester	VW 1342	

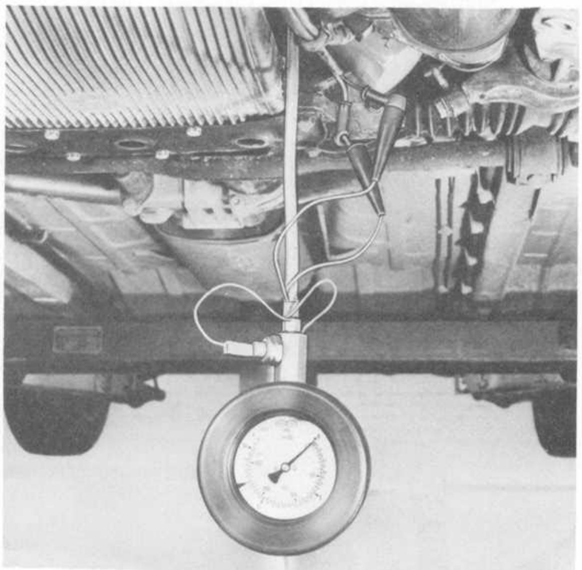
CHECKING OIL PRESSURE

1. Drain engine oil.

2. Remove oil filter and oil pressure sensor.

3. Screw oil pressure tester VW 1342 in conjunction with M 10 x 1 adapter, Part No. 999.105.013.02, and M 10 x 1 / M 18 x 1.5 adapter, Part No. 901.101.175.01, in plug opening for oil thermostat housing in place of the oil pressure sensor. Mount oil filter and add oil.





4. Run engine to operating temperature (about 80°C/176°F).

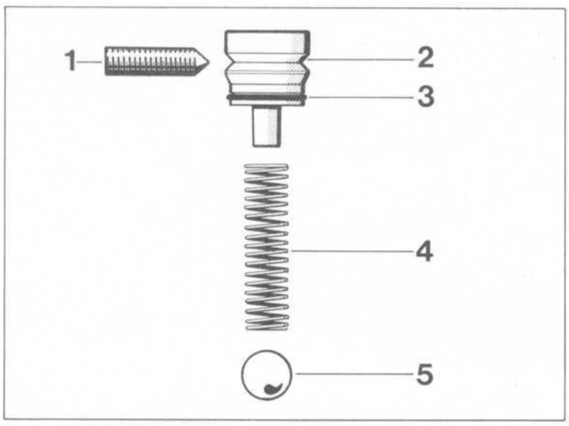
5. Have a second person raise the engine speed to 4000 rpm.

6. Read oil pressure on tester. Value must be higher than 5 bar (73 psi).

CLEANING OIL CHECK VALVE FOR HYDRAULIC VALVE TAPPETS

Note:

The oil check valve prevents the oil from flowing back out of the cylinder head, thus assuring operation of the hydraulic valve tappets. If the valve tappets chatter as the engine turns over just after starting, it is essential to clean the check valve.



1 - Threaded rod

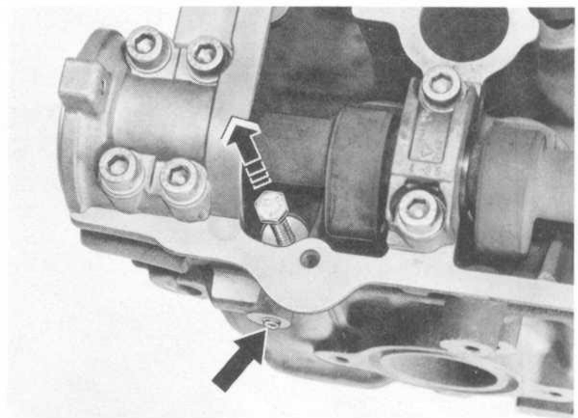
2 - Spring guide

3 - O-ring

4 - Compression spring

5 - Ball

1. Remove cylinder-head cover. Screw a hex bolt, e.g. M 6 x 40 down into spring guide. Slacken threaded rod 2 turns and lift out valve guide.



2. Use a magnet to withdraw compression spring and ball. Thoroughly clean ball seat, ball, compression spring and oil duct. The ball seat remains in the cylinder head and great care must be taken to ensure that it is not damaged.

3. Replace O-ring before installation. Tightening torque for threaded rod 3.5 Nm (2.8 ftlb).

Cleaning the complete engine-oil system following engine failure (bearing failure)

Note

This cleaning sequence is only intended to given pointers as to where chips may be found. The actual scope of work involved must be determined individually for each engine failure.

Replace the following parts:

- Hydraulic valve tappets

- Chain tensioner

- Oil filter

The following parts must be dismantled, checked and cleaned thoroughly:

- Oil pump

- Thermostat housing

- Bypass valve

- Release valve

- Oil retension valve in the cylinder head
  See Page 17 - 10

The following parts must be cleaned thoroughly and/or rinsed several times:

Note:

All oil feeder holes may be flushed thoroughly with a commercially available oil - gasoline syringe and benzine.

- Oil sump

- Oil inlet pipe

- Crankcase

- Crankshaft

- Cylinder heads

- Camshaft housing

- Oil lines

- Oil filler pipe

- Oil cooler in the radiator

Change oil filter and engine oil after approx. 500 km running time.

Note:

Following an engine failure, the complete intake system must be checked for foreign bodies and/or oil and cleaned before assembly.

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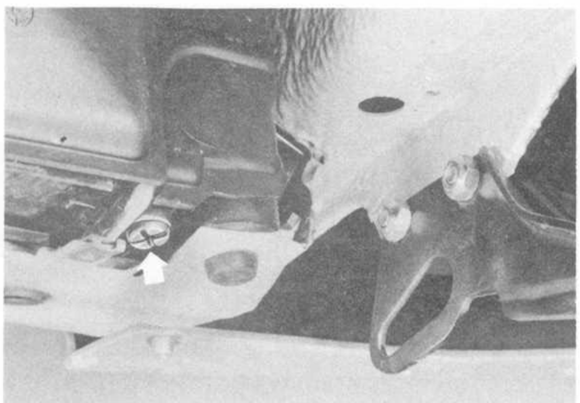
CHANGING COOLANT AND BLEEDING COOLING SYSTEM

Requirement:
Engine cool for draining coolant.

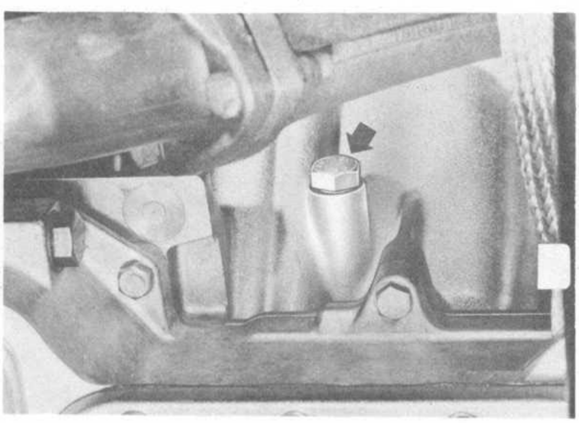
1. Set heater lever at "warm" and run engine briefly.

2. Take off cap on expansion tank.

3. Unscrew drain plug on radiator and catch coolant.



4. Unscrew coolant drain plugs on left and right-hand sides of crankcase and catch coolant.



5. Replace seals for drain plugs on crankcase and O-ring for drain plug on radiator.

Torques:
Radiator plug - 1.5 to 2.0 Nm (13 to 17 in. lb)
Crankcase plug - 45 to 50 Nm (33 to 36 ft lb)

6. Add coolant until level reaches edge of filler opening (heater lever must be at "warm").

7. Run engine to operating temperature and check coolant level, adding more if necessary.

Coolant level must reach center of expansion tank.

COOLANT MIXING TABLE

Protection to	Antifreeze	Water	Antifreeze	Water
- 25° C/- 13° F	40 %	60 %	6.4 ltr./6.8 US qt	9.6 ltr./10.1 US qt
- 30° C/- 22° F	45 %	55 %	7.2 ltr./7.6 US qt	8.8 ltr./9.3 US qt
- 35° C/- 31° F	50 %	50 %	8.0 ltr./8.5 US qt	8.0 ltr./8.5 US qt

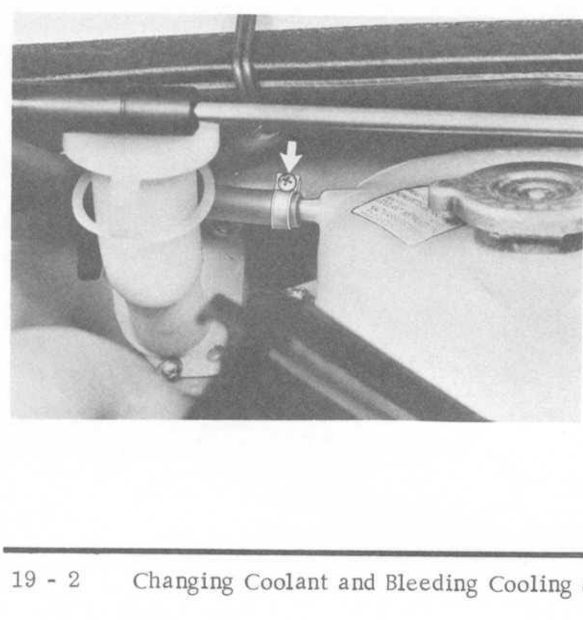
CHECKING COOLING SYSTEM FOR LEAKS

Note

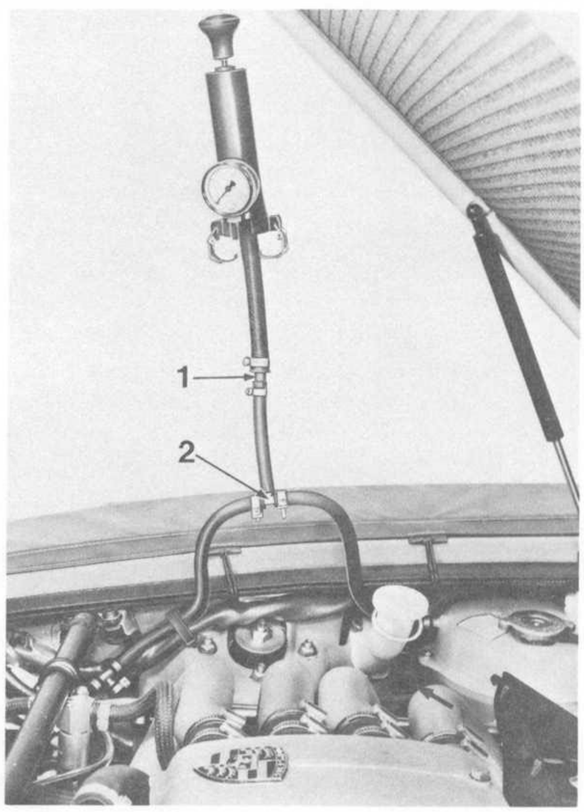
Engine must be cold for leak test.

Check coolant and warm water hoses for proper routing, porosity, swelling, tears and cafe. Replace damaged hoses.

1. Detach hose from radiator to expansion tank at expansion tank.

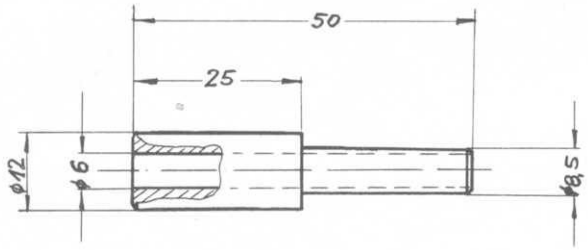


2. Connect tester VW 1274 with separate T-adapter and pertinent hoses ahead of the expansion tank.



1 - Adapter
2 - T-adapter

3. An adapter (made locally) will be required to connect the tester on the T-adapter.



Material: steel pipe St 35 12 x 3

4. Build up about 1 bar pressure in cooling system by pumping. Pressure valve in cap must open between 0.9 and 1.15 bar.

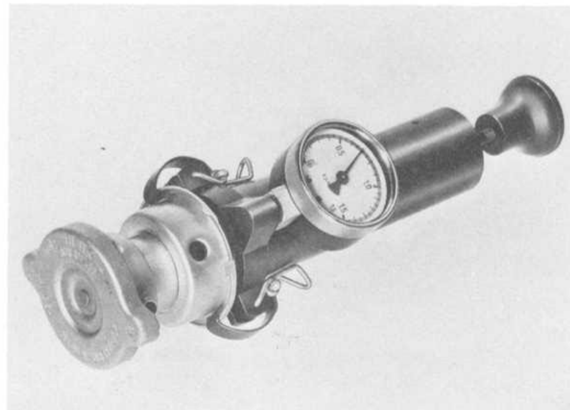
5. Visually inspect the following parts for leaks.

Engine block:	Water pump
	Cylinder head gasket
	Thermostat housing
	Hose connections
	Cylinder head mounting studs
Radiator:	Bleeder neck
	Water drain plug
	Hose connections
	Oil cooler cap
	Temperature switch or
	Plug
Heater:	Hose connections

CHECKING COOLANT SYSTEM CAP

1. Mount cap on tester.

2. Produce pressure with hand pump. Pressure valve should open between 0.9 and 1.15 bar.

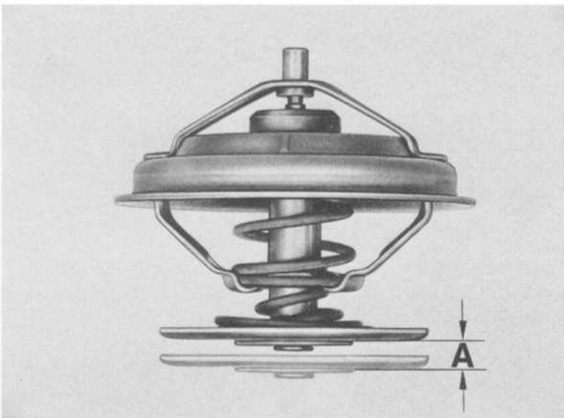


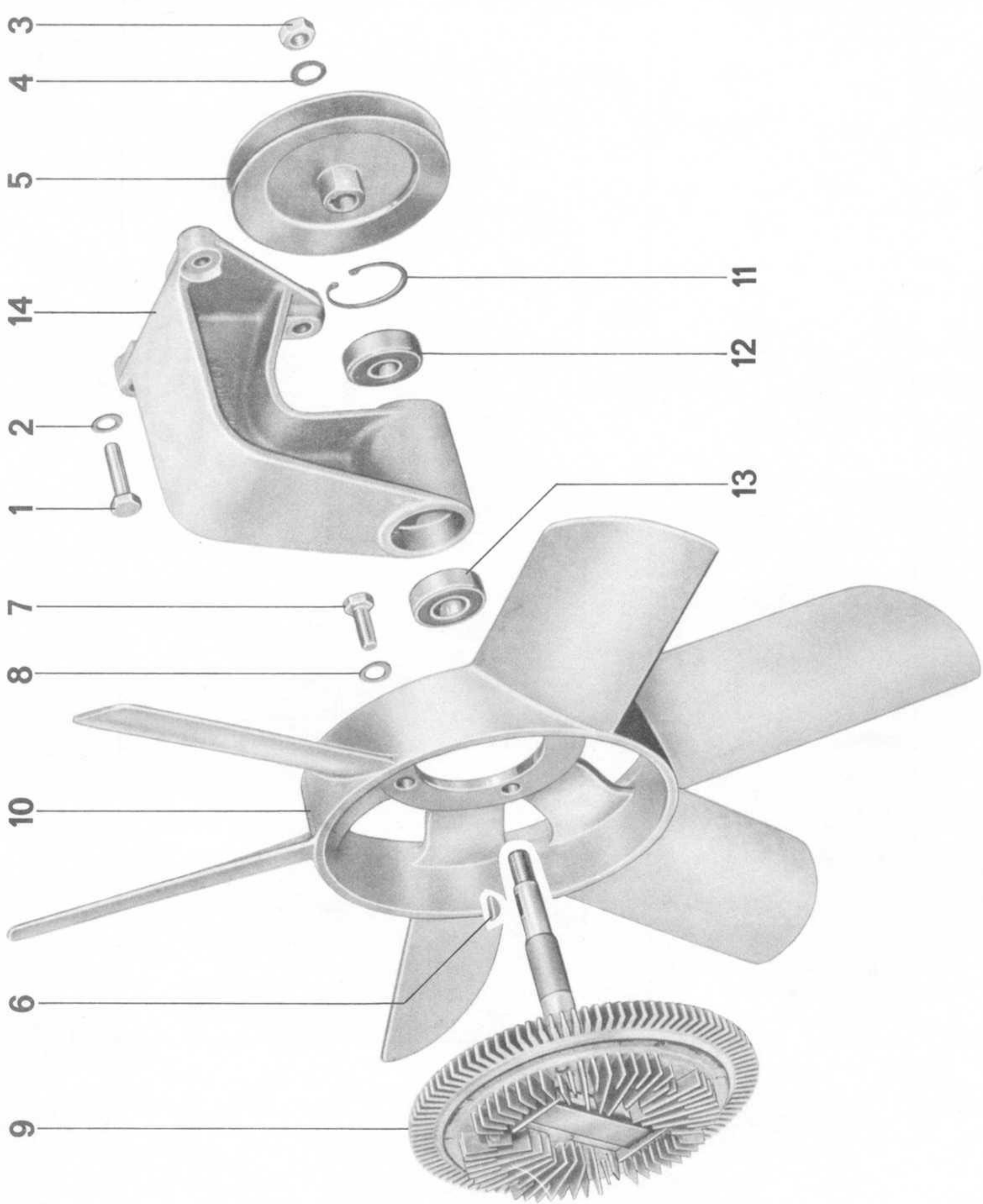
CHECKING COOLANT THERMOSTAT

Heat coolant thermostat in a water bath.

Begins to open: approx. $83 \pm 2^\circ$
Ends: approx. 98°

Opening travel (distance A): at least 8 mm.

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6
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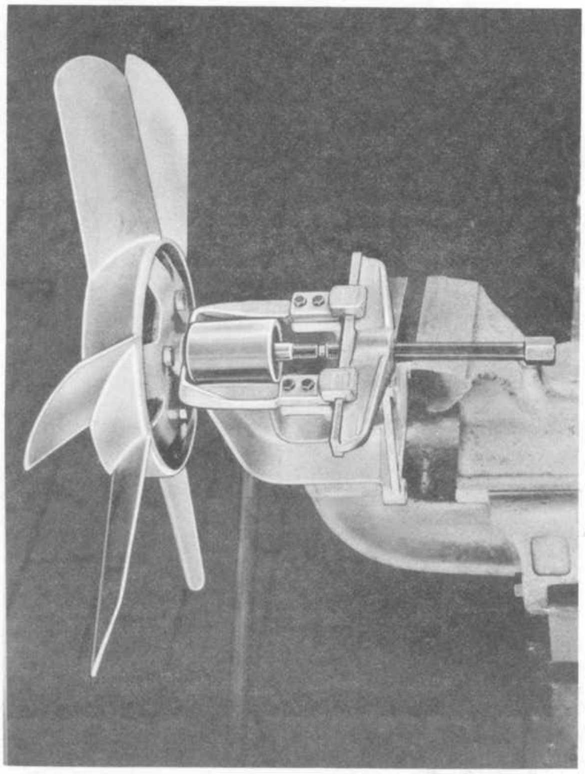
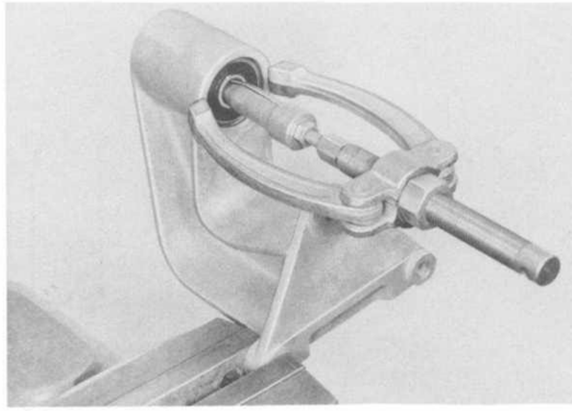
13

No.	Description	Qty.	Note When Removing	Note When Installing	Special Instructions
1	Bolt	3			
2	Washer	3			
3	Nut	1			
4	Washer	1			
5	Pulley	1	Pull off	Check runout	
6	Woodruff key	1			
7	Bolt	4			
8	Washer	4			
9	Viscuous coupling	1	Press off, store so that shaft is horizontal or inclined no more than 45^{0}	Coat seats for ball bearings on shaft with Loctite 270 or 271	
10	Fan	1			
11	Circlip	1		Position correctly	
12	Ball bearing (small diameter inner race)	1	Pull out with, e.g., Kukko internal extractor No. 21/1 (12 - 14.5 mm)	Check, replace if necessary. Drive in with suitable mandrel	
13	Ball bearing (large diameter inner race)	1	Pull out with, e.g., Kukko internal extractor No. 21/2 (14.5 - 18.5 mm)	Check, replace if necessary. Drive in with suitable mandrel	
14	Fan carrier	1		Check	

DISASSEMBLING AND ASSEMBLING VISCUOUS FAN

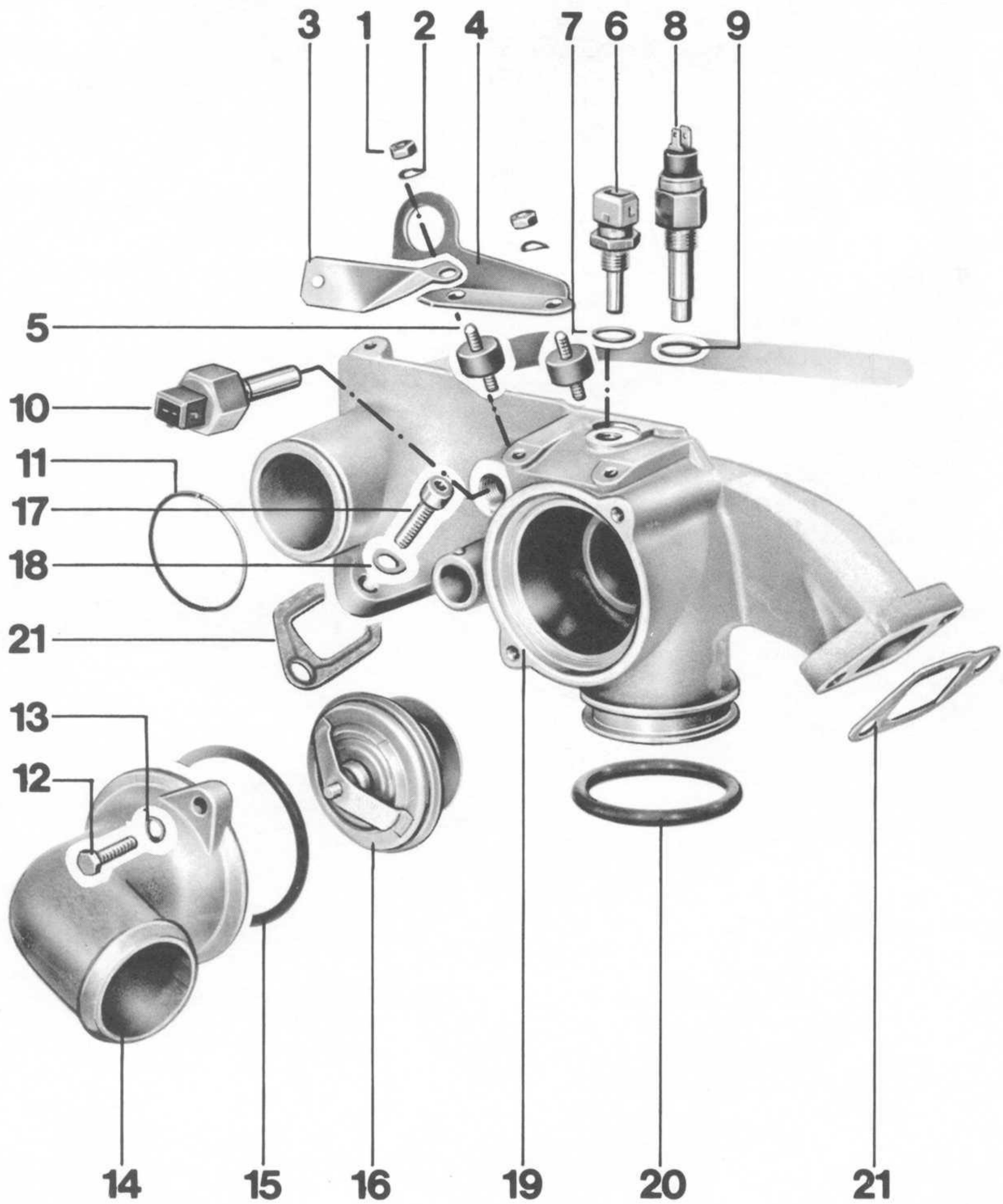


Pull off viscuous coupling with a double-arm extractor, e.g. Kukko 20/10 (width: 120 mm, depth: 100 mm).



Pull out grooved ball bearings with an internal extractor, e.g. Kukko.

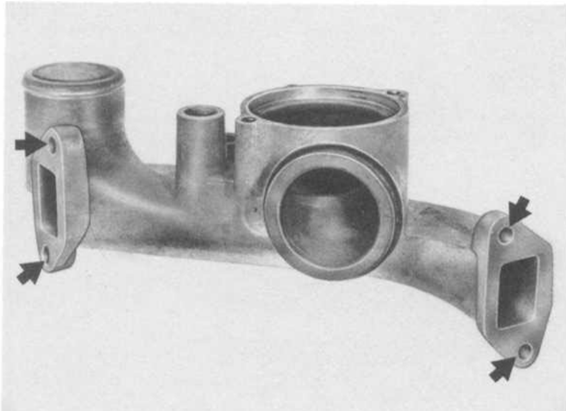
DISASSEMBLING AND ASSEMBLING THERMOSTAT HOUSING
FOR COOLING SYSTEM (AFC)



No.	Description	Qty.	Note When: Removing	Installing	Special Instructions
1	Nut M 6	2			
2	Washer	2			
3	Ignition cable holder	1			
4	Pressure damper holder	1			
5	Rubber/metal mount	2		Check, replacing if necessary	
6	Temperature switch II	1			
7	Seal	1		Replace	
8	Temperature sensor	1			
9	Seal A 14 x 18	1		Replace	
10	Temperature time switch (for cold start valve)	1			
11	Retaining	1			
12	Bolt M 6 x 25	2			
13	Washer B 6	2			
14	Cover for thermostat housing	1			
15	Round seal	1		Replace	
16	Thermostat insert	1			
17	Bolt M 8 x 30	4			
18	Washer A 8.4	4			
19	Thermostat housing	1			
20	O-ring 53 x 7	1		Replace	
21	Gasket	2		Replace	

Note:

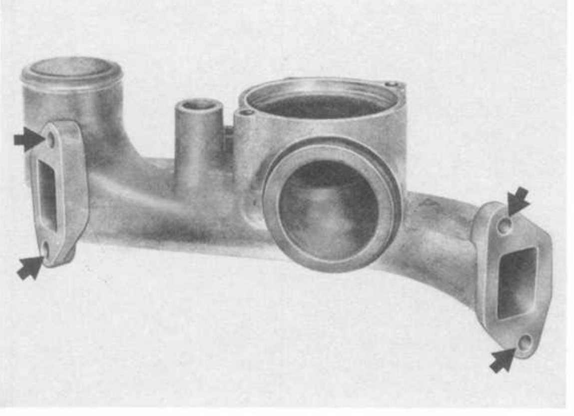
If cylinder heads had been machined or ground, check that thermostat housing fits correctly afterwards. It must not be installed with tension. If necessary, correct by machining mounting bores.



No.	Description	Qty.	Note When Removing	Note When Installing	Special Instructions
1	Electric air valve	1			
2	Hose clamp	1			
3	Hose	1			
4	Bolt	2			
5	Washer	2			
6	Throttle bypass valve	1			
7	Bolt	2			
8	Washer	2			
9	Holder	1			
10	Warm-up control	1			
11	Temperature sensor (coolant)	1			
12	Seal	1		Replace	
13	Temp. time switch for cold start valve	1			
14	Retainer	1			
15	Bolt	2			
16	Washer B 6	2			
17	Cover for governor housing	1			
18	Round seal	1		Replace	
19	Thermostat insert	1			see page 19 - 2 b
20	Bolt	2			
21	Washer A 8,4	2			
22	Governor housing	1			
23	O-ring 53 x 7	1		Replace	
24	Gasket	2		Replace	

NOTE

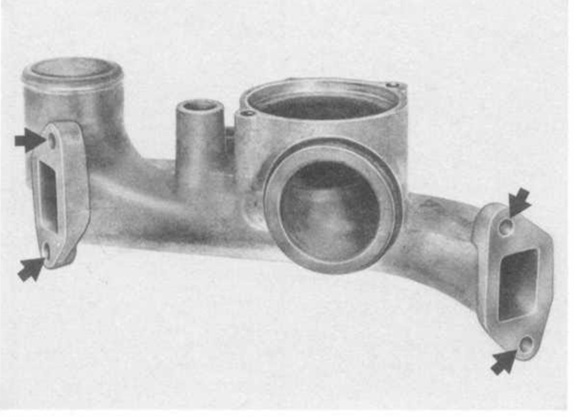
If cylinder heads had been machined or ground, check that thermostat housing fits correctly afterwards. It must not be installed with tension. If necessary, correct by machining mounting bores.



No.	Description	Qty.	Note When Removing	Note When Installing	Special Instructions
1	Electric air valve	1			
2	Hose clamp	1			
3	Hose	1			
4	Bolt	2			
5	Washer	2			
6	Throttle bypass valve	1			
7	Bolt	2			
8	Washer	2			
9	Holder	1			
10	Warm-up control	1			
11	Temperature sensor (coolant)	1			
12	Seal	1		Replace	
13	Temp. time switch for cold start valve	1			
14	Retainer	1			
15	Bolt	2			
16	Washer B 6	2			
17	Cover for governor housing	1			
18	Round seal	1		Replace	
19	Thermostat insert	1			see page 19 - 2 b
20	Bolt	2			
21	Washer A 8,4	2			
22	Governor housing	1			
23	O-ring 53 x 7	1		Replace	
24	Gasket	2		Replace	

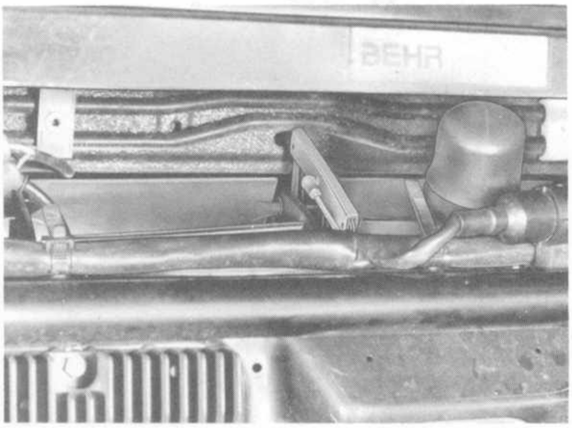
NOTE

If cylinder heads had been machined or ground, check that thermostat housing fits correctly afterwards. It must not be installed with tension. If necessary, correct by machining mounting bores.



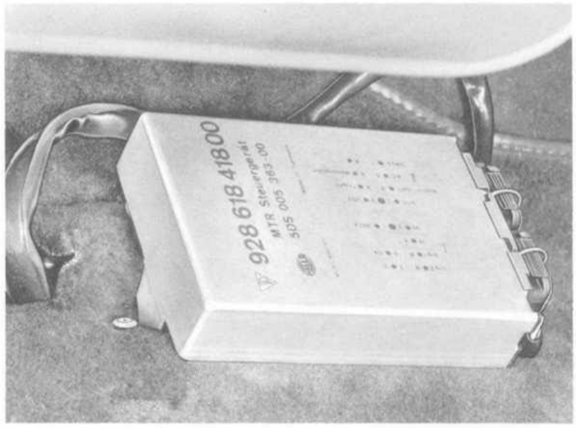
COOLING-AIR FLAP CONTROL,'87 MODELS ONWARD

The cooling air which enters through the new front air dam is regulated from the radiator intake by cooling air control flaps actuated by an electric positioning motor.

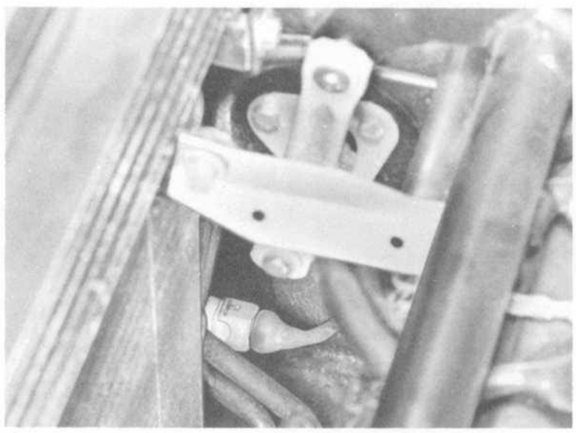


The flaps are positioned by a linkage connected to the positioning motor crank. The crank position which corresponds to the flap position is stored mechanically on a control disk integrated in the positioning motor. (0%, 30%, 100%).

The control unit for the flaps and cooling-air control is positioned beside the passenger seat.

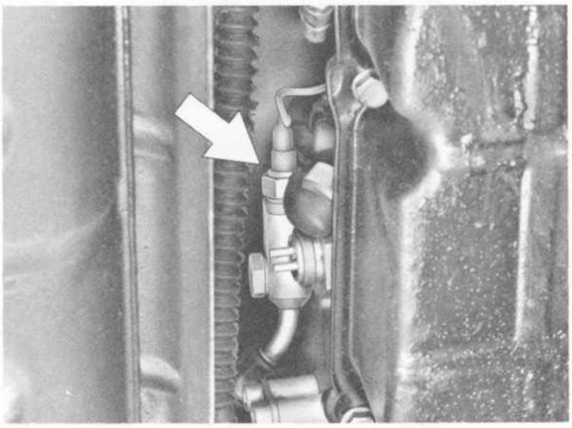


Cooling-water temperature sender



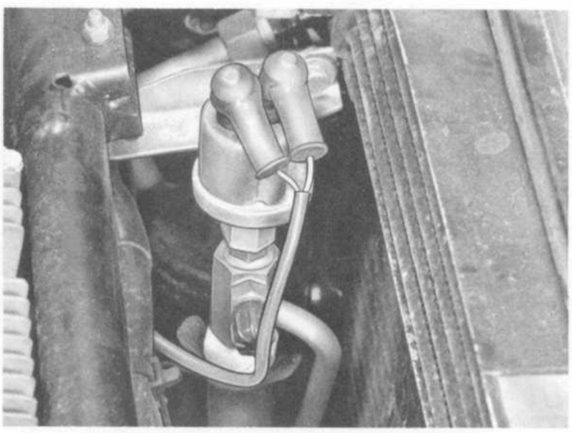
Tightening torque: 30 Nm (22 ftlb)

Temperature switch, automatic transmission



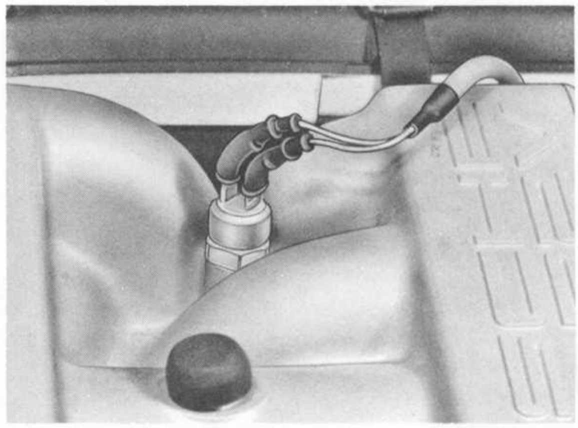
Tightening torque: 30 Nm (22 ftlb)

Pressure sender, Frigen



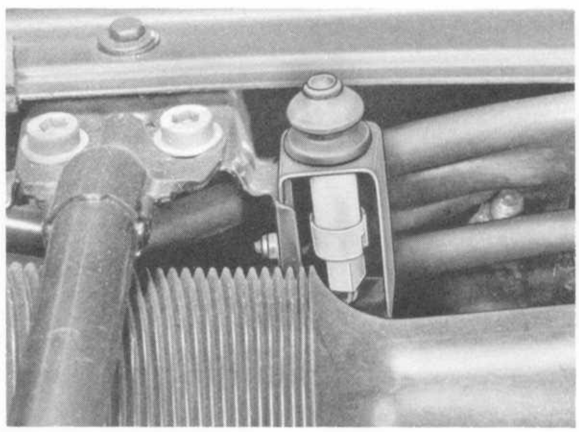
Tightening torque: 30 Nm (22 ftlb)
M 4 nut : 1 Nm (0.7 ftlb)

Temperature switch, intake

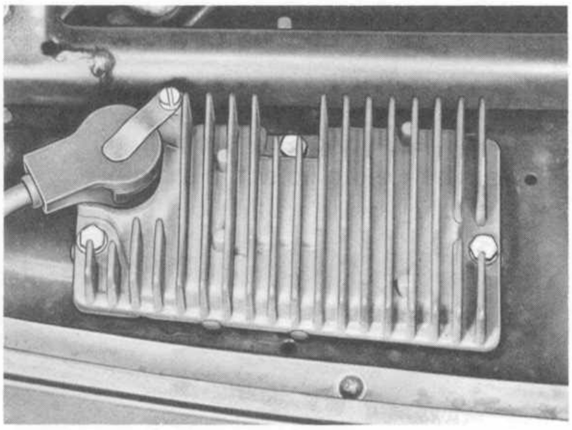


Tightening torque: 40 Nm (30 ftlb)

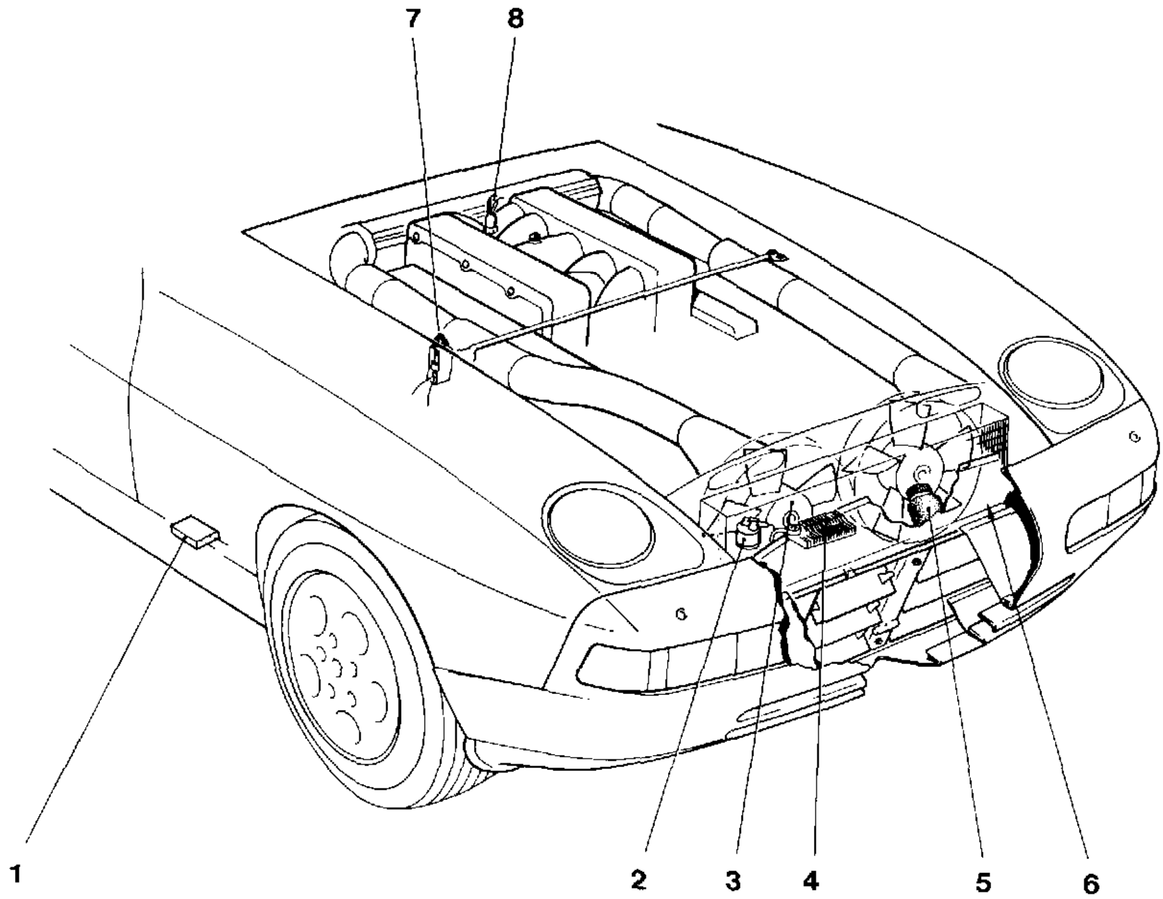
Engine-compartment lid switch



The output stage receives a square signal from the control unit. The output stage contains two mutually independent output-stage modules with separate protective circuits: each module controls a separate cooler fan.



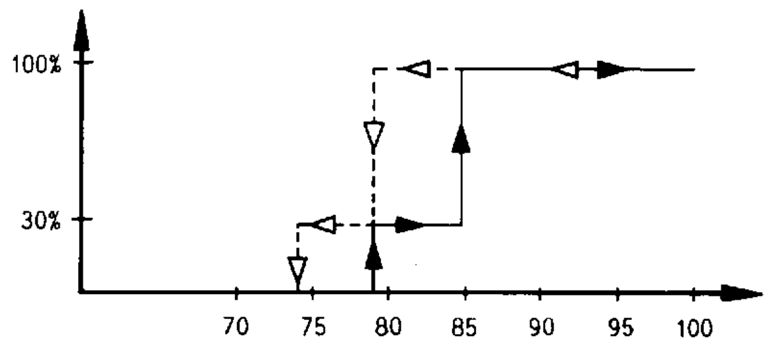
If a fault occurs, the cooling-air flaps are opened to the 100% setting and the intact fan operates at full speed, while the faulty fan is switched off. A check is made approx.every 20 seconds to ascertain whether the fault persists.



1. Control unit
2. Pressure sender, Frigen
3. Engine fan
4. Output stage
5. Flap positioning motor
6. Temperature sender, cooling water
7. Engine-compartment lid switch
8. Temperature switch, intake

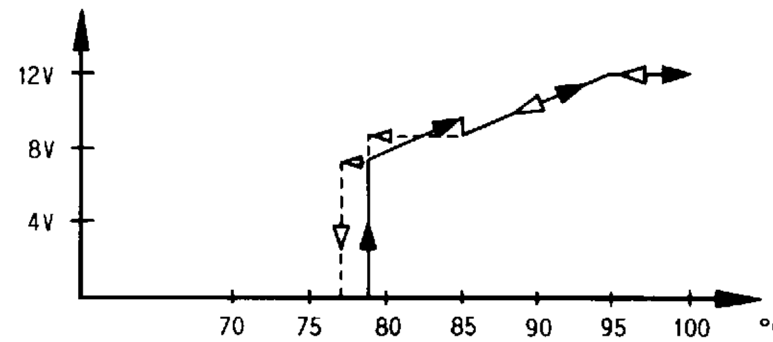
Temperature sender, cooling water

Flap position



Cooling water

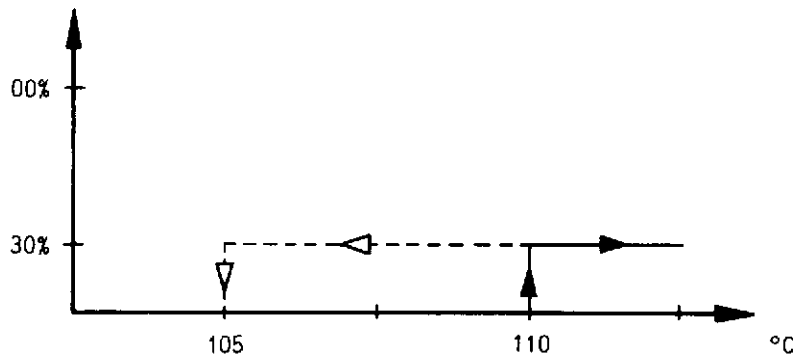
Fan voltage



Cooling water

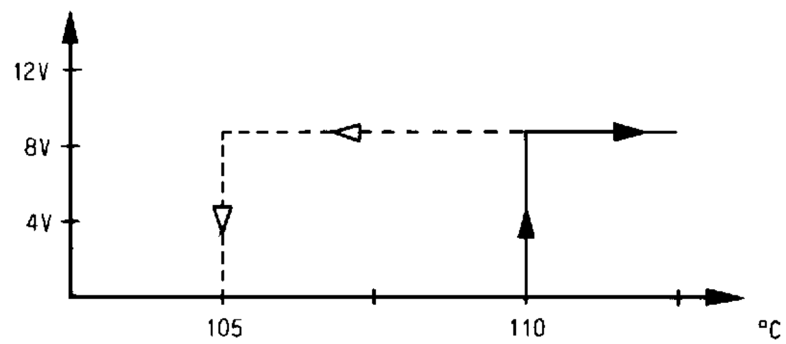
Temperature switch, automatic transmission

Flap position



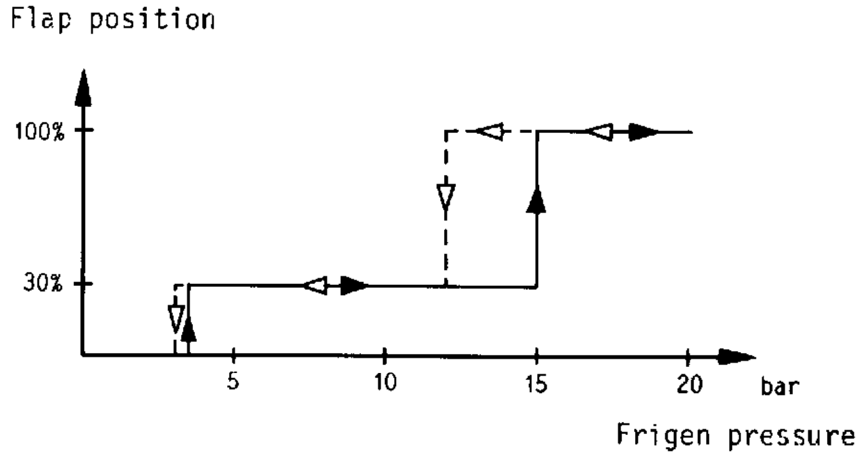
Temperature switch, automatic transmission

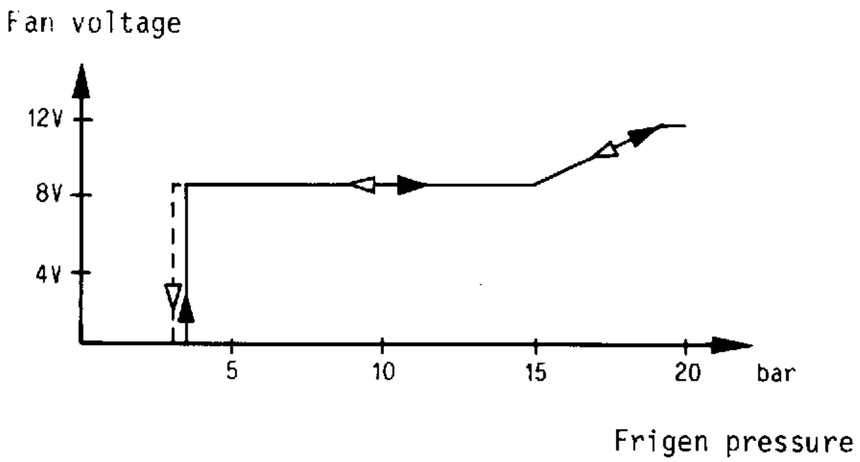
Fan voltage



Temperature switch, automatic transmission

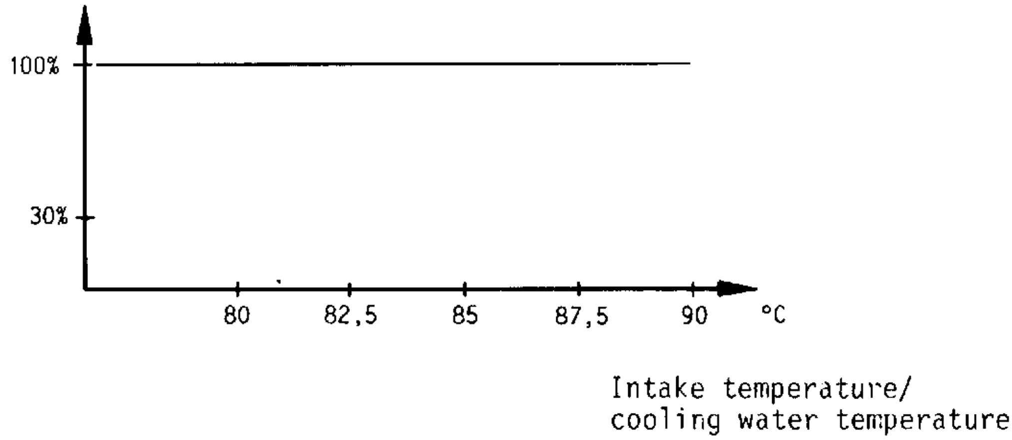
Pressure sender, Frigen



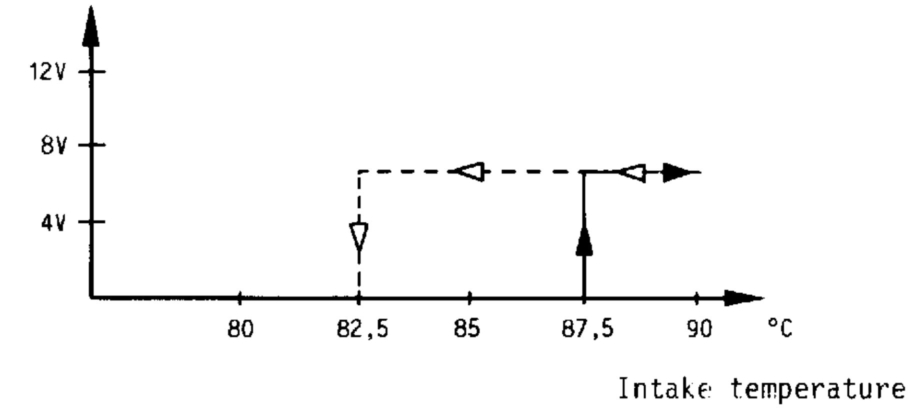


Run-on

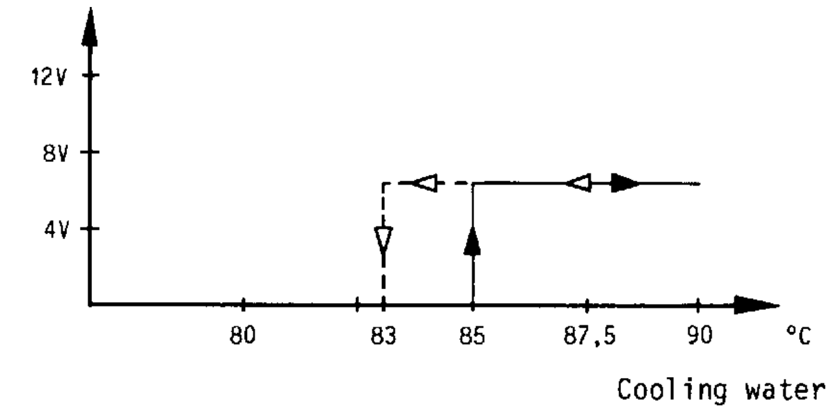
Flap position



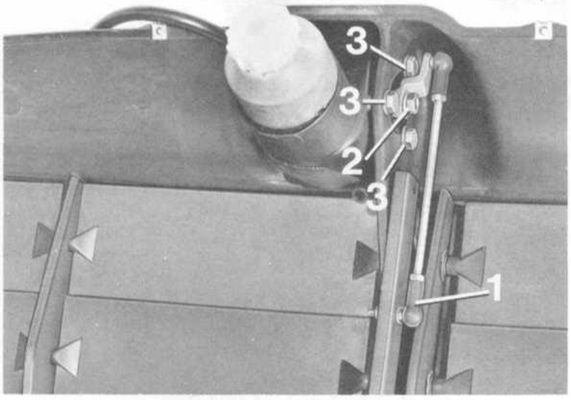
Fan voltage



Fan voltage



REMOVING COOLING-AIR FLAP MOTOR



1.) Detach actuating linkage at ball joint (1).

2.) Remove nut from drive axle (2).

3.) Remove three nuts holding flap-positioning motor (3).

4.) Disconnect connector at joint.

INSTALLING

When installing, ensure that engine temperature is less than 74°C.

1.) Re-connect connector

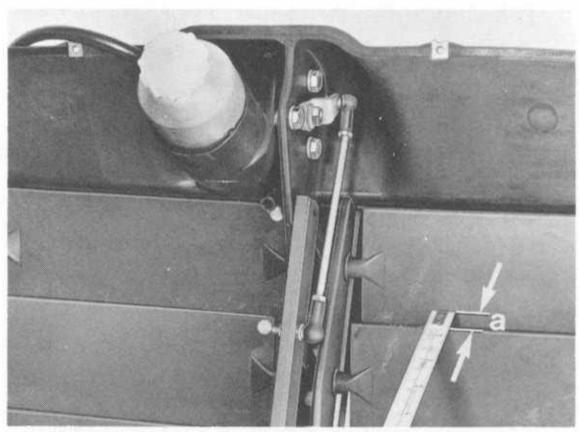
2.) Switch ignition on.
Flap positioning motor moves to 0% position.

3.) Tighten securing nuts (3 nuts).

4.) Set adjusting arm so that the air flaps are in the 0% position when the actuating rod is installed.

5.) Press AC button
The positioning motor moves to the 30% position.

6.) Check distance a
a = 16.5 ± 2 mm.



The 100% position is set off the 0% or 30% position.

REMOVING AND INSTALLING FANS

1.) Disconnect battery.

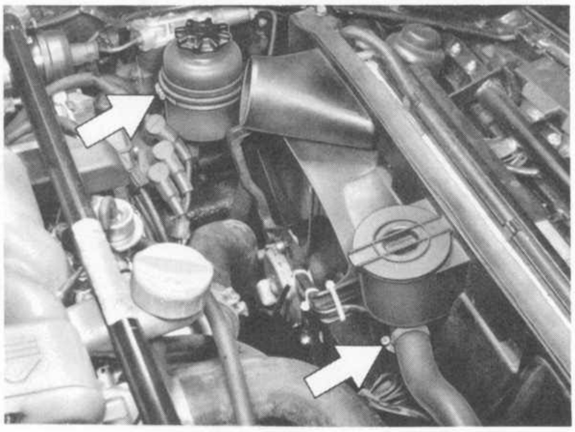
2.) Remove both mounting bolts.

3.) Cut cable holders.

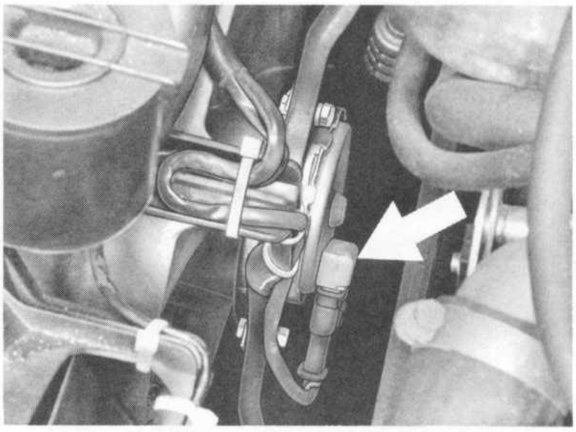
4.) Remove plugs from fans.

5.) Remove hose clamp from air filter (auxiliary air pump).

6.) Remove hose clamp from oil reservoir (servo oil).



When installing fans, ensure that plugs are in correct positions.

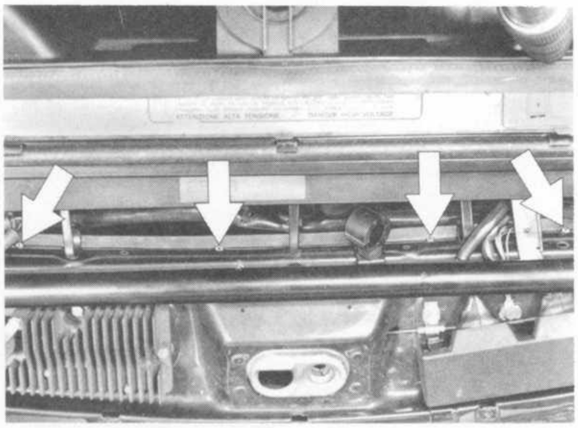


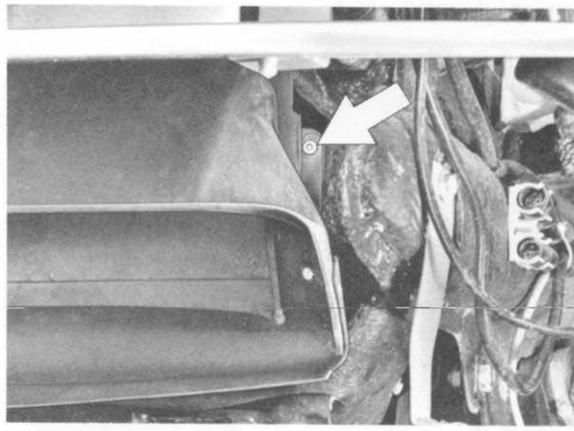
REMOVING AND INSTALLING COOLING-AIR FLAPS

Removing and installing front air dam: see Repair Group 66.

Removing and installing PU part: see Repair Group 63.

Remove securing bolts.

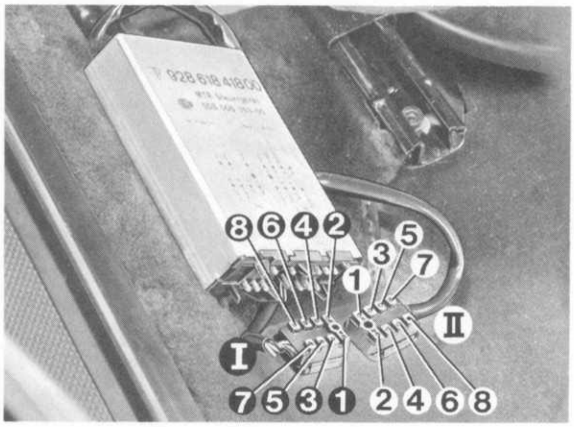




Disconnect plug of flap positioning motor at coupling.

TROUBLESHOOTING

Disconnect plug I and plug II from control unit.



1.) Test voltage supply

Connect voltmeter to pin 2 (plus) and pin 7 (minus) of plug I

Reading: battery voltage

2.) Connect voltmeter to pin 4 (plus) and pin 7 (ground) of plug I

Ignition on

Reading: battery voltage

Ignition off

Reading: 0 V

Function test of AC button

Connect voltmeter to pin 7 (ground) of plug I and pin 5 (plus) of plug II

Ignition on

Press AC button

Set the air-distribution slide switch to up/down.

Reading: battery voltage

Function-testing the individual senders with an ohmmeter.

1.) Temperature sender, cooling water

A resistance of between 1000 ohm and 4000 ohm, depending on engine temperature, should be measurable between pin 1 of plug II and pin 7 of plug I.

Reading:

60°C = 3862 ohm ± 150 ohm
85°C = 1582 ohm ± 54 ohm
100°C = 967 ohm ± 36 ohm

2.) Pressure sender, Frigen

Pin 4, plug II and pin 7, plug I.
Resistance is between 20 ohm and 150 ohm, depending on Frigen pressure.

Reading.

1.5 bar = 22 ohm ± 4 ohm
5 bar = 53 ohm ± 4 ohm
10 bar = 92 ohm ± 5 ohm
15 bar =125 ohm ± 5 ohm

3.) Engine-compartment lid switch

Pin 6, plug II and pin 7, plug I

Engine-compartment lid closed

Reading: ∞ ohm

Engine-compartment lid open

Reading: 0 ohm - 20 ohm

4.) Temperature switch intake/ automatic transmission

Pin 3, plug II and pin 7, plug I

Intake temperature > 87.5°C

Reading: 0 ohm

Intake temperature < 82.5°C

Reading: ∞ ohm

Temperature switch, automatic transmission

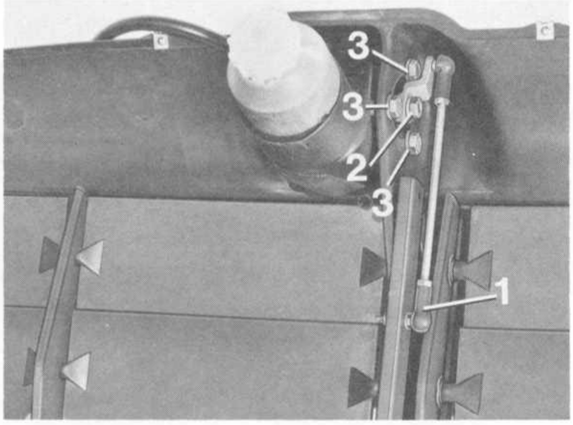
> 110°C reading: 0 ohm
< 105°C reading: ∞ ohm

If the values stated are not reached, the sender in question is defective.

Function-testing the flap positioning motor

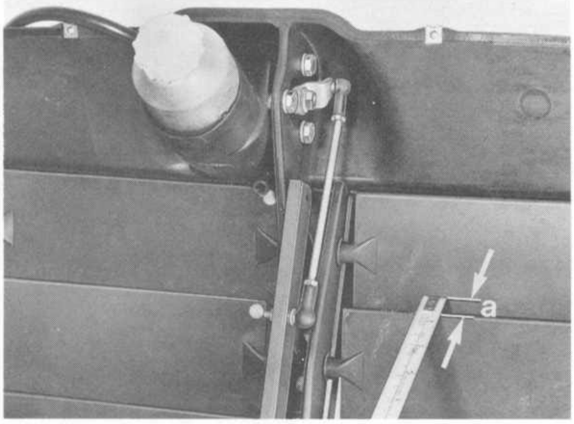
With a length of cable, connect pin 7 (ground) of plug I to pin 5 (0%) of plug I (approx. 2 - 4 seconds).

The flap positioning motor moves to the 0% position.



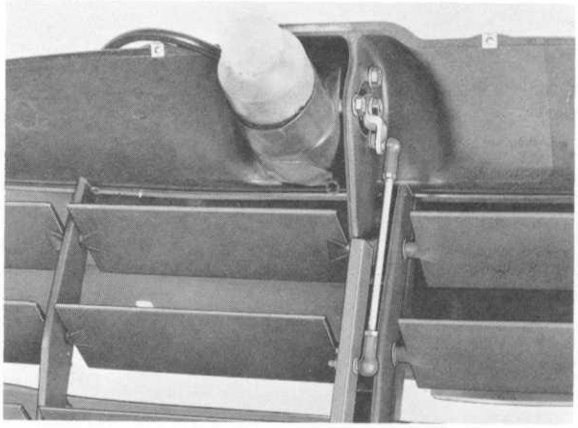
Connect pin 7, plug I and pin 2, plug II (approx. 2 - 4 seconds).

The flap positioning motor moves to the 30% position.



Connect pin 7, plug I and pin 1 (100%) (approx. 2 - 4 seconds).

The flap positioning motor moves to the 100% position.



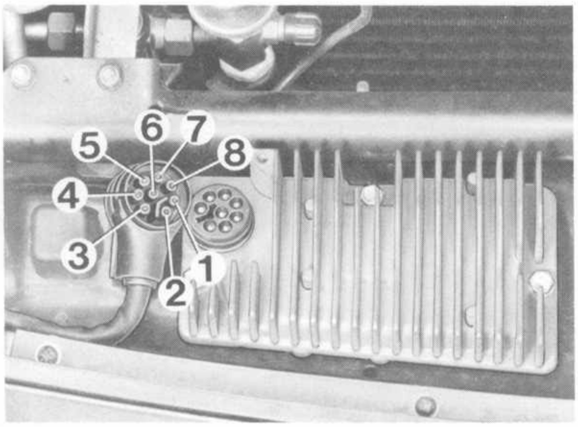
If the flap positioning motor fails to assume one of the positions stated, use an ohmmeter to check the conductivity of the control unit - flap positioning motor wire harness.

If the wire harness is OK the flap positioning motor is defective.

Function-testing the output stage

1.) Plugs I and II must be connected to the control unit.

2.) Checking voltage supply.



Connect voltmeter to pin 3 (ground) and pin 4 (plus) of the fan output-stage plug connector.

Reading: battery voltage

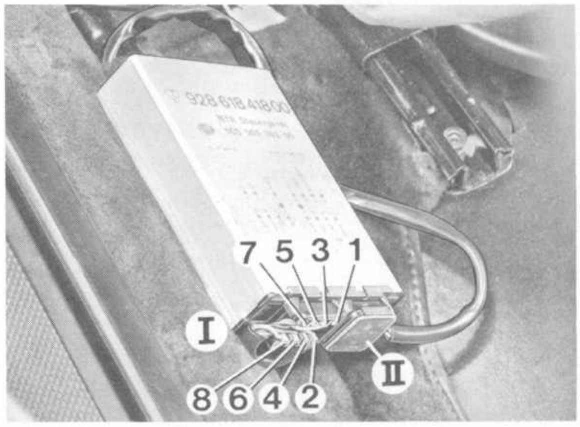
3.) Connect voltmeter to pin 3 (ground) and pin 2 (plus).

Ignition on

Reading: battery voltage

4.) Function-testing the control signal of the output stage.

Reconnect output-stage plug connector. Remove cover from plug I of control unit.



Engine temperature < 79°C(175°F)

Measure the voltage with an analog voltmeter with an external resistance (Ri) 100 kOhm.

Pin 7, plug I (ground) and pin 6 (plus).

Ignition on

Press AC button

Set the air-distribution slide switch to up/down.

Reading: approx. 7 V

Pin 7, plug I (ground) and pin 8 (plus).

Ignition on

Press AC button

Set the air-distribution slide switch to up/down.

Reading: approx. 7 V

If both fans refuse to operate when the AC button is pressed while the ignition is on, the output stage is defective.