11 Engine

			Page
Specifications			11-0/3
11 00	005	Diagnosis with BMW Program Tester	00/1
	039	Checking Compression of all Cylinders	00/23
	050	Removing and Installing Engine	00/23
11 12	000	Removing and Installing Cylinder Head Cover	12/1
	100	Removing and Installing Cylinder Head	12/1
	161	Replacing Cylinder Head (No Installation Parts)	12/5
	591	Replacing Valve Guide	12/6
	607	Machining Valve Seat Inserts and Valves	12/7
	719	Grinding Cylinder Head Sealing Surface	12/7
11 13	000	Removing and Installing Oil Pan	13/1
11 14	100	Removing and Installing/Sealing Upper Timing Case Cover	14/1
	120	Removing and Installing/Sealing Upper and Lower Timing Case Covers	14/1
	141	Replacing Radial Seal in Timing Case Cover	14/3
	611	Replacing Radial Seal in End Cover	14/4
11 21	000	Removing and Installing Crankshaft	21/1
	501	Replacing Crankshaft	21/2
	571	Replacing Needle Bearing Race in Crankshaft	21/4
11 22	000	Removing and Installing Flywheel	22/1
	051	Replacing Torque Converter Drive Shell	22/1
	541	Replacing Starter Gear Ring	22/2
11 24	501	Replacing One Connecting Rod	24/1
	601	Replacing One Connecting Rod Bush	24/1
11 25	000	Removing and Installing all Pistons	25/1
	651	Replacing Piston Rings of One Piston	25/2
11 31	000	Removing and Installing Camshaft	31/1
	051	Replacing Timing Chain	31/2
	061	Replacing Set of Timing Gears	31/4
	090	Removing and Installing Chain Tensioner Piston	31/5
	581	Replacing Tensioning Rail	31/6
	591	Replacing Guide Rail	31/6
11 33	020	Removing and Installing Rocker Arm Shafts	33/1
	031	Replacing All Rocker Arms	33/2
11 34	004	Adjusting Valve Clearance	34/1
	509	Checking All Valves for Leaks	34/1
	550	Removing and Installing Valves	34/1
11 41	000	Removing and Installing Oil Pump	41/1
	151	Replacing Oil Pump Roller Drive Chain	41/1
	512	Disassembling and Assembling Oil Pump	41/2
11 42	020	Removing and Installing Full Flow Oil Filter	42/1
	021	Replacing Full Flow Oil Filter	42/1
11 51	000	Removing and Installing Water Pump	51/1
	502	Disassembling and Assembling Water Pump	51/1
11 52	000	Removing and Installing Fan	52/1
11 53	000	Removing and Installing Coolant Thermostat	53/1
	080	Replacing Temperature Sensor	53/1
11 61	050	Removing and Installing Trap with Throttle Housing	61/1
	051	Replacing Trap	61/3
	290	Removing and Installing Intake Adapters	61/3
	420	Removing and Installing All Intake Manifolds	61/4
11 70	009	Checking Function of EGR System	70/1
11 71	020	Removing and Installing EGR Filter	71/1
	501	Replacing EGR Valve	71/2
11 72	000	Replacing Air Pump	72/1
	501	Replacing Booster Blowoff Valve	72/1
	511	Replacing Check Valve	72/2

		Page
11 74 051	Replacing Thermo Valve	74/1
071	Replacing Timing Valve	74/1
501	Replacing Pressure Converter	74/1
11 75 000	Removing and Installing EGR Reactor	75/1
030	Replacing Exhaust Manifold	75/1
530	Replacing Air Injection Tubes	75/2

Engine — SPECIFICATIONS

Model		320 i	320 i A
Bore	mm(in.)		89 (3.504)
Stroke	mm(in.)		80 (3.150)
Bore / stroke ratio			0.90
Effective displacement	$cm^3(in.^3)$		1990 (121.4)
Compression ratio			8.1 : 1
Max. power output	kW (DIN HP)	81 (110)	77 (105)[2]
	at rpm		5800
Max. continuous speed	rpm		6000
Max. top speed	rpm		6400
Max. torque	Nm/mkp(ft. lbs.)	155/15.5 (112)	150/15.0 (108.5)[2]
	at rpm		3750
Compression pressure	bar(psi)	good, above:	10.5 (150)
		normal:	9.5 ... 10.5 (135 ... 150)
		poor, below:	9.0 (130)
Testing specifications		Check with a calibrated compression pressure tester, battery fully charged, engine at operating temperature, throttle wide open and at starter speed.	

Engine Lubrication

Lubricating system	Circulating oil lubrication with full flow oil filter, rotor oil pump (EATON) with chain drive off of crankshaft. Pressure valve in filtered oil circuit.
Oil filter	One-way, full-flow, throw-away-type filter cartridge

1) Also refer to Page 11-0/19.

2) California version.

Model		320 i	320 i A
Continuation of Engine Lubrication			
High pressure safety valve (opens)	bar(psi)		2.2 ± 0.3 (31 ± 4)
Oil pump design			rotor pump (Eaton system)
Oil pressure indicator lamp (ON)	bar(psi)		below 0.2 ... 0.5 (3 ... 7)
Oil filling capacity	ltr(pts.)		$4.0^{+0.25}$ ($8.5^{+0.5}$) with filter replacement
Max. oil consumption[1]	ltr(pts.)/100 KM		0.15 (0.3)
Oil grades			branded heavy duty oils for internal combustion engines
Viscosity for outside temperatures:		Single-grade Oil	Multi-grade Oil
chiefly above + 30°C (+85°F)		SAE 40	SAE 20 W 50
all year above -10°C (+15°F)		SAE 30	SAE 20 W 40 SAE 20 W 50
chiefly below + 10°C (+50°F)		SAE 20	SAE 10 W 30 SAE 10 W 40 SAE 10 W 50 SAE 15 W 50
Oil Pump			
Oil pressure at idle speed	bar(psi)		0.8 ... 1.2 (11 ... 17)
Oil pressure at 4000 rpm	bar(psi)		about 4.0 (57)
Safety valve opening pressure	bar(psi)		4.12 ... 4.5 (58.5 ... 64)
Safety valve spring length, relaxed	mm(in.)		68 (2.677)
Outer rotor/pump body radial play	mm(in.)		$0.1^{+0.05}$ ($0.004^{+0.002}$)
Rotor outside diameter	mm(in.)		$57.1_{-0.025}$ ($2.248_{-0.001}$)
Body inside diameter	mm(in.)		57.2 + 0.025 (2.252 + 0.001)

1) Also refer to Page 11-0/19.

Model		320 i	320 i A
Continuation of Oil Pump			
Rotor height	mm(in.)		$16\ ^{-\ 0.015}_{-\ 0.045}$ $(0.6299\ ^{-\ 0.0006}_{-\ 0.0017})$
Body depth	mm(in.)		$16\ ^{+\ 0.050}_{+\ 0.020}$ $(0.6299\ ^{+\ 0.0019}_{+\ 0.0007})$
Rotor (inner and outer)/pump body axial play	mm(in.)		0.035 ... 0.095 (0.0014 ... 0.0037)
Inner rotor/outer rotor gap	mm(in.)		0.12 ... 0.20 (0.005 ... 0.008)
Max. wear depth in cover	mm(in.)		0.05 (0.002)
Distance betw. body wall/gear bearing surface on hub	mm(in.)		42.7 ± 0.1 (1.681 ± 0.004)
Rotor oil pump drive			single roller chain 3/8" x 5/32"
Number of links			46
Number of sprocket teeth for oil pump drive	Z_1		18
	Z_2		27
Valve Clearance			
Intake and exhaust valve (max. coolant temp. $35^{\circ}C/95^{\circ}F$)	mm(in.)		0.15 ... 0.20 (0.006 ... 0.008)[1]
Valve clearance adjustment			by way of cams on rocker arms
Adjusting sequence		Dead Center Position Cyl. No.	Valve Overlapping Cyl. No.
		1	= 4
		3	= 2
		4	= 1
		2	= 3

1) 0.20 ... 0.25 mm (0.008 ... 0.010") at operating temperature (thermostat open).

SPECIFICATIONS

Model			320 i	320 i A
Valve Timing			with 0.5 mm (0.020 inch) clearance between cam base circle and rocker arm contact surface	
Intake opens	°	on crankshaft	4 BTDC	
Intake closes	°	on crankshaft	52 ABDC	
Exhaust opens	°	on crankshaft	52 BBDC	
Exhaust closes	°	on crankshaft	4 ATDC	
Total timing (values in ref. to cst.)	°	on crankshaft	236	
			with 0.28 mm (0.011 inch) clearance between cam base circle and rocker arm contact surface	
Intake opens	°	on crankshaft	18 BTDC	
Intake closes	°	on crankshaft	66 ABDC	
Exhaust opens	°	on crankshaft	66 BBDC	
Exhaust closes	°	on crankshaft	18 ATDC	
Intake cycle	°	on crankshaft	264	
Exhaust cycle	°	on crankshaft	264	
Valve Drive Train				
Valve operation			via light alloy rocker arms with chill cast pads and overhead camshaft	
Camshaft drive			double roller chain with automatic oil-damped chain tensioner with anti-recoil device	
Timing chain			3/8" x 7/32"	
Roller diameter		mm(in.)	6.35 (0.250)	
Number of links			94	
Valves				
Total valve length, intake		mm(in.)	103.8 ± 0.2 (4.087 ± 0.008)	
exhaust		mm(in.)	103.8 ± 0.2 (4.087 ± 0.008)	

Model			320 i	320 i A
Continuation of Valves				
Head diameter	Intake	mm(in.)		$46\ ^{0}_{-0.160}$ ($1.811\ ^{0}_{-0.006}$)
	Exhaust	mm(in.)		$38\ ^{0}_{-0.160}$ ($1.496\ ^{0}_{-0.006}$)
Stem diameter	Intake	mm(in.)		$8\ ^{-0.025}_{-0.040}$ ($0.3149\ ^{-0.0010}_{-0.0015}$)
	Exhaust	mm(in.)		$8\ ^{-0.040}_{-0.055}$ ($0.3149\ ^{-0.0015}_{-0.0020}$)
Valve head rim thickness when new	Intake	mm(in.)		1.5 ± 0.15 (0.059 ± 0.006)
	Exhaust	mm(in.)		2.0 ± 0.10 (0.079 ± 0.004)
Valve head rim regrind thickness	Intake	mm(in.)		1.0 ± 0.15 (0.039 ± 0.006)
	Exhaust	mm(in.)		1.5 ± 0.10 (0.059 ± 0.004)
Valve seat angle	Intake			$45^{0}\ 30' + 20'$
	Exhaust			$45^{0}\ 30' + 20'$
Valve seat/stem runout	Intake	mm(in.)		0.02 (0.0008)
	Exhaust	mm(in.)		0.02 (0.0008)
Valve clearance (radial)	Intake	mm(in.)		0.025 ... 0.055 (0.0010 ... 0.0020)
	Exhaust	mm(in.)		0.040 ... 0.070 (0.0015 ... 0.0030)
Max. wear allowance		mm(in.)		0.15 (0.006)
Valve Seat Inserts				
Outside diameter	Intake	mm(in.)		$47.15\ ^{-0.009}_{-0.025}$ ($1.8563\ ^{-0.0003}_{-0.0010}$)
	Exhaust	mm(in.)		$40.15\ ^{-0.009}_{-0.025}$ ($1.5807\ ^{-0.0003}_{-0.0010}$)

Model			320 i	320 i A
Continuation of Valve Seat Inserts				
Oversizes [1]	Intake	mm(in.)		$47.35\ ^{-0.009}_{-0.025}$ ($1.8642\ ^{-0.0003}_{-0.0010}$)
				$47.55\ ^{-0.009}_{-0.025}$ ($1.8720\ ^{-0.0003}_{-0.0010}$)
	Exhaust	mm(in.)		$40.35\ ^{-0.009}_{-0.025}$ ($1.5886\ ^{-0.0003}_{-0.0010}$)
				$40.55\ ^{-0.009}_{-0.025}$ ($1.5964\ ^{-0.0003}_{-0.0010}$)
Valve seat insert bore in cyl. head [1]	Intake	mm(in.)		$47.00\ ^{+0.025}_{0}$ ($1.8504\ ^{+0.0010}_{0}$)
	Exhaust	mm(in.)		$40.00\ ^{+0.025}_{0}$ ($1.5748\ ^{0.0010}_{0}$)
Shrink fit [2]		mm(in.)		0.10 ... 0.15 (0.004 ... 0.006)
Valve seat angle				45^{0}
Outer correction angle				15^{0}
Valve Seat Width	Intake	mm(in.)		1.50 ... 2.10 (0.059 ... 0.083)
	Exhaust	mm(in.)		1.55 ... 2.05 (0.061 ... 0.081)
Valve Guides				
Overall length		mm(in.)		52 (2.047)
Outside diameter		mm(in.)		$14\ ^{+0.044}_{+0.033}$ ($0.5512\ ^{+0.0017}_{+0.0013}$)
Oversize diameter		mm(in.)		14.1/14.2/14.3 (0.555/0.559/0.563)
Inside valve guide diameter in cylinder head		mm(in.)		$8\ ^{+0.015}_{0}$ ($0.3149\ ^{+0.0006}_{0}$)

1) Note shrink fit size for oversize bore in cylinder head!

2) Heat cylinder head to about 200^{0} C/390^{0} F; freeze valve seat insert to about - 70^{0} C/- 94^{0} F.

Engine		SPECIFICATIONS	
Model		320 i	320 i A
Continuation of Valve Guides			
Bore diameter in cylinder head	mm(in.)	$14\ ^{0}_{-0.018}$ ($0.5512\ ^{0}_{-0.0007}$)	
Oversize diameter	mm(in.)	14.1/14.2/14.3 (0.555/0.559/0.563)	
Valve guide projection in cylinder head	mm(in.)	15.0 ± 0.5 (0.590 ± 0.020)	
Shrink fit in cylinder head	mm(in.)	0.018 ... 0.044 (0.0007 ... 0.0017)	
Cylinder head heating temperature	°C(°F)	220 ... 250 (410 ... 480)	
Valve Springs			
Identification		1)	
Wire gauge diameter	mm(in.)	4.25 (0.167)	
Outer coil diameter	mm(in.)	31.90 ± 0.2 (1.256 ± 0.008)	
Spring length, relaxed	mm(in.)	about 43.5 or 46 (1.712 or 1.811) 2)	
Spring force kp (lbs)/testing length mm (in.)	kp(lbs)/mm(in.)	29 ± 1.16 (64 ± 2.5)/37.6 (1.480)	70 ± 2.8 (154 ± 6)/28.5 (1.122)
Rocker Arms			
Rocker arm bore without bush	mm(in.)	$18.0\ ^{+0.018}_{0}$ ($0.7087\ ^{+0.0007}_{0}$)	
Rocker arm bush bore diameter in rocker arm	mm(in.)	$15.5\ ^{+0.018}_{0}$ ($0.6102\ ^{+0.0007}_{0}$)	
Bore diameter in cylinder head	mm(in.)	$15.5\ ^{+0.043}_{0}$ ($0.6102\ ^{+0.0017}_{0}$)	
Rocker arm shaft diameter	mm(in.)	$15.5\ ^{-0.016}_{-0.034}$ ($0.6102\ ^{-0.0006}_{-0.0013}$)	
Rocker arm shaft clearance in cylinder head	mm(in.)	0.016 ... 0.077 (0.0006 ... 0.0030)	
Rocker arm moving clearance	mm(in.)	0.016 ... 0.052 (0.0006 ... 0.0020)	

1) Green, yellow or white color code depending on make (below when installed).

2) Depending on make (same spring force of 29 ± 1.16 kp/64 ± 2.5 lbs. for installed distance of 37.6 mm/1.480").

Model			320 i				320 i A
Camshaft							
Camshaft bearing seat diameter		mm(in.)	$35\ ^{-0.025}_{-0.041}$				$35\ ^{-0.025}_{-0.041}$ (1.3779 $^{-0.0010}_{-0.0016}$)/42 $^{-0.025}_{-0.041}$ (1.6535 $^{-0.0010}_{-0.0016}$)/43 $^{-0.025}_{-0.041}$ (1.6929 $^{-0.0010}_{-0.0016}$)
Bore diameter in cylinder head		mm(in.)	$35\ ^{+0.034}_{+0.009}$				$35\ ^{+0.034}_{+0.009}$ (1.3779 $^{+0.0013}_{+0.0003}$)/42 $^{+0.034}_{+0.009}$ (1.6535 $^{+0.0013}_{+0.0003}$)/43 $^{+0.034}_{+0.009}$ (1.6929 $^{+0.0013}_{+0.0003}$)
Running clearance (radial)		mm(in.)	0.034 ... 0.075 (0.0013 ... 0.0029)				
Axial clearance		mm(in.)	0.02 ... 0.13 (0.0008 ... 0.0051)				
Max. radial run-out of distributor worm wheel		mm(in.)	0.025 (0.0010)				
Cam base circle diameter		mm(in.)	26.7612 (1.0536)				
Cam lift		mm(in.)	7.0267 $\pm$ 0.080 (0.2766 $\pm$ 0.0031)				
Chain Tensioner							
Piston length		mm(in.)	62 (2.441)				
Tensioning rail spring length, relaxed		mm(in.)	155.5 (6.122)				
Wire gauge diameter		mm(in.)	1 $\pm$ 0.015 (0.0394 $\pm$ 0.0006)				
Crankshaft							
Bearing bore diameter in engine block	red	mm(in.)	$60\ ^{+0.010}_{0}$				$60\ ^{+0.010}_{0}$ (2.3622 $^{+0.0004}_{0}$)
	blue	mm(in.)	$60\ ^{+0.010}_{+0.019}$				$60\ ^{+0.010}_{+0.019}$ (2.3622 $^{+0.0004}_{+0.0007}$)
Grinding Stages			Standard	Stage 1	Stage 2	Stage 3	Tolerance
Main bearing journal diameter	red	mm(in.)	55.00 (2.1653)	54.75 (2.1555)	54.50 (2.1456)	54.25 (2.1358)	$^{-0.010}_{-0.020}$ (-0.0004 / -0.0008)
	blue	mm(in.)	55.00 (2.1653)	54.75 (2.1555)	54.50 (2.1456)	54.25 (2.1358)	$^{-0.020}_{-0.029}$ (-0.0008 / -0.0011)

Model		320 i		320 i A		
Continuation of Crankshaft						
Grinding Stages		**Original**	**Stage 1**	**Stage 2**	**Stage 3**	**Tolerance**
Bearing shell thickness, red	mm(in.)	2.500 (0.0984)	2.625 (0.1033)	2.750 (0.1082)	2.875 (0.1132)	- 0.010 (0.0004) - 0.020 (0.0008)
blue	mm(in.)	2.510 (0.0988)	2.635 (0.1037)	2.760 (0.1086)	2.885 (0.1136)	- 0.010 (0.0004) - 0.020 (0.0008)
Radial bearing play, red	mm(in.)	0.030 ... 0.070 (0.0012 ... 0.0027)				
blue	mm(in.)	0.030 ... 0.068 (0.0012 ... 0.0026)				
Locating bearing width	mm(in.)	30.00 (1.1811)	30.20 (1.1890)	30.40 (1.1968)	30.60 (1.2047)	+ 0.064 (0.0025) + 0.025 (0.0009)
Grinding Stages		**Original**	**Stage 1**	**Stage 2**	**Stage 3**	**Tolerance**
Connecting rod journal diameter	mm(in.)	48.00 (1.8898)[1]	47.75 (1.8799)	47.50 (1.8700)	47.25 (1.8602)	- 0.009 (0.0003) - 0.025 (0.0009)
Max. crankshaft imbalance (dynamic w/o flywheel)	gcm	50				
Axial crankshaft play	mm(in.)	0.085 ... 0.174 (0.0033 ... 0.0068)				
Max. runout at center main journal (crankshaft running on outer journals)	mm(in.)	0.1 (0.0039)				
Max. radial runout at 25 mm (0.984") and 22 mm (0.866") dia. journals (for sprocket and pulley) in relation to main bearing journals	mm(in.)	0.05 (0.0019)				
Crankshaft throw	mm(in.)	80 ± 0.1 (3.150 ± 0.004)				
Max. surface roughness at journals	Rt (microns)	2.0				
Connecting Rods						
Total length (between big and small end centers)	mm(in.)	135 ± 0.1 (5.315 ± 0.004)				

1) Also $48.00 \begin{smallmatrix} -0.034 \\ -0.050 \end{smallmatrix}$ mm ($1.8898 \begin{smallmatrix} -0.0013 \\ -0.0020 \end{smallmatrix}$ in.).

Model		320 i	320 i A
Continuation of Connecting Rods			
Small end conrod bore diameter	mm(in.)		$24\ ^{+0.021}_{0}$ ($0.9449\ ^{+0.0008}_{0}$)
Outside conrod bush diameter	mm(in.)		24.060 ... 24.100 (0.9472 ... 0.9488)
Inside conrod bush diameter	mm(in.)		$22\ ^{+0.010}_{+0.005}$ ($0.8661\ ^{+0.0004}_{+0.0002}$)
Conrod bearing bore diameter	mm(in.)		$52\ ^{+0.015}_{0}$ ($2.0472\ ^{+0.0006}_{0}$)
Grinding Stages		Original	Stage 1 / Stage 2 / Stage 3 / Stage 4
Bearing shell thickness	mm(in.)	1.983 ... 1.993 (.0780 ... .0784)	1.995 ... 2.005 (.0785 ... .0789) / 2.108 ... 2.118 (.0830 ... .0834) / 2.233 ... 2.243 (.0879 ... .0883) / 2.358 ... 2.368 (.0928 ... .0932)
Radial bearing play	mm(in.)		0.023 ... 0.078 (0.0009 ... 0.0031)
Max. deviation from parallel of conrod bores with bearing shells at distance of 150 mm/5.905"	mm(in.)		0.04 (0.0015)
Max. displacement to one side	°		0° 30'
Max. deviation in weight between 4 connecting rods of one engine	g		± 4
Large end	g		± 2
Small end	g		± 2
Cylinders			
Standard bore diameter	mm(in.)		89.015 ± 0.005 (3.5045 ± 0.0002)
Intermediate bore diameter	mm(in.)		89.095 ± 0.005 (3.5077 ± 0.0002)
1st oversize bore diameter	mm(in.)		89.265 ± 0.005 (3.5144 ± 0.0002)
2nd oversize bore diameter	mm(in.)		89.515 ± 0.005 (3.5242 ± 0.0002)

Engine — SPECIFICATIONS

Model			320 i	320 i A
Continuation of Cylinders				
Surface finish		Rt (microns)		3 ... 4
Max. cylinder bore out-of-true		mm(in.)		0.01 (0.0004)
Max. cylinder bore conicity		mm(in.)		0.01 (0.0004)
Max. deviation of cylinder centerline from bearing bore perpendicular		o		0^{o} 0.5'
Max. total wear clearance at piston and cylinder		mm(in.)		0.10 ... 0.15 (0.0039 ... 0.0059)
Pistons				
Weight class				+ or - stamped
Standard piston diameter		mm(in.)		88.97 (3.5027)
Intermediate size diameter		mm(in.)		89.05 (3.5059)
1st oversize diameter (+ 0.25 mm/0.010")		mm(in.)		89.22 (3.5126)
2nd oversize diameter (+ 0.50 mm/0.020")		mm(in.)		89.47 (3.5224)
Piston clearance (installed)		mm(in.)		0.045 (0.0018)
Max. difference in weight between all pistons of one engine		g		9 ... 10
Piston Rings				
1st groove (plain compression ring)	Height	mm(in.)		$1.75\ ^{-0.010}_{-0.022}$ ($0.0689\ ^{-0.0004}_{-0.0009}$)
	End gap	mm(in.)		0.30 ... 0.45 (0.0118 ... 0.0177)
	Clearance	mm(in.)		0.06 ... 0.092 (0.0024 ... 0.0036)

Model				320 i	320 i A
Continuation of Piston Rings					
2nd groove (taper face ring) 3)	Height	mm(in.)			$2.00\ ^{-0.010}_{-0.022}$ ($0.0787\ ^{-0.0004}_{-0.0009}$)
	End gap	mm(in.)			0.20 ... 0.40 (0.008 ... 0.016)
	Clearance	mm(in.)	KS pistons:		0.040 ... 0.072 (0.0016 ... 0.0028)
			Mahle pistons:		0.030 ... 0.062 (0.0012 ... 0.0024)
3rd groove (bevelled ring) 3)	Height	mm(in.)			$4.00\ ^{-0.010}_{-0.022}$ ($0.1575\ ^{-0.0004}_{-0.0009}$)
	End gap	mm(in.)			0.25 ... 0.50 (0.010 ... 0.020)
	Clearance	mm(in.)	KS pistons:		0.030 ... 0.062 (0.0012 ... 0.0024)
			Mahle pistons:		0.020 ... 0.052 (0.0008 ... 0.0020)
Piston Pins					
Piston pin offset from piston centerline		mm(in.)			1.0 (was 1.5) (0.039) (was 0.059)
Piston pin diameter / color code white		mm(in.)			$22\ ^{0}_{-0.003}$ ($0.8661\ ^{0}_{-0.0001}$)
color code black		mm(in.)			$22\ ^{-0.003}_{-0.006}$ ($0.8661\ ^{-0.0001}_{-0.0002}$)
Piston pin bore diameter in boss		mm(in.)			$22\ ^{-0.004}_{0}$ ($0.8661\ ^{-0.0001}_{0}$)
Piston pin clearance in piston 1)		mm(in.)			0.002 ... 0.006 (0.00008 ... 0.00024) 2)
Piston pin clearance in conrod bush					
color code white		mm(in.)			0.005 ... 0.013 (0.0002 ... 0.0005)
color code black		mm(in.)			0.008 ... 0.016 (0.0003 ... 0.0006)

1) Only replace pistons and piston pins together. Pistons and piston pins are matched.

2) 0.001 ... 0.005 mm (0.00004 ... 0.00020") for Mahle pistons.

3) Not to German (DIN) Standards; special version for BMW.

Engine — SPECIFICATIONS

Model		320 i	320 i A
Thermostat			
Starts to open	°C (°F)		80 ± 1.5 (175 ± 2.5)
Min. full opening	mm(in.) at °		8 (0.315) 94 ... 95
Water Pump			
Gap between body and impeller	mm(in.)		1 ± 0.2 (0.039 ± 0.008)
Flywheel			
Max. unbalance, static	gcm	15	-
dynamic	gcm	-	15
Max. lateral runout measured at 92 mm/3.622" dia.	mm(in.)		0.03 (0.001)
220 mm/8.661" dia.	mm(in.)		0.1 (0.004) 1)
Max. friction surface machining	mm(in.)		0.4 + 0.1 (0.016 + 0.004) 1)
Min. friction surface thickness	mm(in.)		14.5 (0.571) 1)
Engine Exhaust Gas Emission Control			
Exhaust Gas Filter			
Flow rate Q	$m^3(ft^3)/h$		13 ± 0.5 (459 ± 18)
at pressure	bar (psi)		0.4 (6)

1) Not applicable to models with an automatic transmission.

Engine — SPECIFICATIONS

Model		320 i		320 i A
EGR Valve (blue) - with pressure converter -				
Make			Pierburg	
Model designation			PE 20 279	
Double-vane Air Pump				
Make			Saginaw	
Max. continuous speed	rpm		5,000	
V-belt			$9.5 \times 775 \,^{+2}_{-4}$ ($0.374 \times 30.5 \,^{+0.08}_{+0.16}$)	
Blow-off Valve				
Make			Pierburg	
Model designation			PE 20 140	
Blowing-off starts	bar(psi)		0.4 ± 0.05 (6 ± 1)	
Check Valve				
Make		Pierburg	or	General Motors Deutschland GmbH
Model designation		PE 20 141	or	7975/679
Thermo Valve				
Make		Pierburg	or	Texas Instruments
Model designation		PE 20 276	or	23 VT 51 AB - 17
Color of top section		green		blue
Opens	^{o}C (^{o}F)		43 ± 3 (109 ± 5)	
Closes	^{o}C (^{o}F)		33 ± 3 (91 ± 5)	

Engine — SPECIFICATIONS

Model		320 i	320 i A
Thermo Timing Valve (electric)			
Make			Pierburg
Model designation			PE 20 277
Voltage rating		V	12
Max. operating voltage		V	7 ... 16.5
Resistance at 25 ± 5° C/77 ± 8° F		ohms	6.5 ± 4
Vacuum Control			
Make			Bosch
Model designation			0 280 160 305
Auxiliary Air Valve			
Make			Bosch
Model designation			0 280 160 400
Reactor			
Make			Zeuner-Stärker 1)

1) Only applicable to California version models.

Model	320 i	320 i A

Torque Specifications in Nm / kpm (ft. lbs.)

Engine to transmission	M 8	25 ... 27 / 2.5 ... 2.7	(18 ... 19)	
	M 10	47 ... 51 / 4.7 ... 5.1	(34 ... 37)	
Carrier to engine, left	M 8 x 20	22 ... 24 / 2.2 ... 2.4	(16 ... 17)	
right	M 10 x 18	43 ... 48 / 4.3 ... 4.8	(31 ... 35)	
Holder to carrier, left	M 8 x 20	25 ... 28 / 2.5 ... 2.8	(18 ... 20)	
Rubber mount nuts	M 10	43 ... 48 / 4.3 ... 4.8	(31 ... 35)	
Engine damper nut	M 6	10 ... 11 / 1.0 ... 1.1	(7 ... 8)	
Cyl. head bolts crosswise from center in three steps	1st Step	35 ... 45 / 3.5 ... 4.5	(25 ... 32)	
	2nd Step	60 ... 65 / 6.0 ... 6.5	(43 ... 47)	
	3rd Step	68 ... 72 / 6.8 ... 7.2	(49 ... 52)	
Main bearing caps		58 ... 63 / 5.8 ... 6.3	(42 ... 45)	
Connecting rod bolts	12.9 DIN 267	52 ... 57 / 5.2 ... 5.7	(38 ... 41)	
Flywheel to crankshaft 2)		100 ... 115/ 10 ... 11.5	(72 ... 83)	
Chain tensioner plug		30 ... 40 / 3.0 ... 4.0	(22 ... 29)	
Rocker arm clamping screw		9 ... 11 / 0.9 ... 1.1	(6.5 ... 8)	
Safety valve plug on oil pump body		25 ... 30 / 2.5 ... 3.0	(18 ... 22)	
Oil drain plug		60 ... 65 / 6.0 ... 6.5	(43 ... 47)	
Full flow oil filter (cold engine)		24 ... 26 / 2.4 ... 2.6	(17 ... 19)	
Clutch to flywheel		22 ... 24 / 2.2 ... 2.4	(16 ... 17)	
Oil pan to crankcase and timing case cover		9 ... 11 / 0.9 ... 1.1	(6.5 ... 8)	
Camshaft lubrication oil line hollow bolt		11 ... 13 / 1.1 ... 1.3	(8 ... 9)	
Pulley to crankshaft		140 ... 150/ 14 ... 15	(101 ... 108)	
Spark plugs		25 ... 30 / 2.5 ... 3.0	(18 ... 22)	
Fuel pump		10 ... 14 / 1.0 ... 1.4	(7 ... 10)	
Timing case cover, upper and lower		9 ... 11 / 0.9 ... 1.1	(6.5 ... 8)	
Distributor flange to cylinder head	M 8	23 ... 27 / 2.3 ... 2.7	(17 ... 19)	
	M 6	9 ... 11 / 0.9 ... 1.1	(6.5 ... 8)	
Exhaust manifold to cyl. head nut		30 ... 33 / 3.0 ... 3.3	(22 ... 24)	
Injection valve coupling nuts		25 /	2.5 (18)	
Thermo valve	Pierburg	15 /	1.5 (11)	
	Texas Instruments	10 /	1.0 (7)	
Double-vane air pump mtg. bolts	M 8	41.4 /	4.14 (30)	
Rocker arm cams		9 ... 11 / 0.9 ... 1.1	(6.5 ... 8)	
Temperature sensor		20 ... 25 / 2.0 ... 2.5	(14 ... 18)	
Oil pressure switch		30 ... 35 / 3.0 ... 3.5	(22 ... 25)	
Backup light switch		6 ... 10 / 0.6 ... 1.0	(4 ... 7)	

1) On cold engine (max. 35° C/95° F).

2) Install with Loctite Type 270 and Activator N.

Determining Oil Consumption

Oil consumption measurements can be made after car has been driven about 7,500 km (4,500 miles).
This distance is necessary before the oil consumption will have stabilized itself.
Engine must not leak oil.
Drain engine oil at operating temperature.
Remove and drain oil filter housing.
Replace filter cartridge or throw-away-type filter.
Fill engine with new oil.
Drive car under normal operating conditions until oil level has sunk to lower mark on oil dipstick. Any measurements taken between 500 and 1,000 km (300 and 600 miles) will not be exact, because from experience we all know that the first half liter (pint) will be consumed more quickly than the rest.
Max. oil consumption is 0.15 liter/100 km (approx. 1600 miles/pint).

Possible Causes for Excessive Oil Consumption

1. Engine is not yet broken in.
2. Valve stem seals damaged.
3. Pistons seized.
4. Piston rings installed incorrectly, broken or worn.
5. Excessive clearance between valve stem and valve guide.

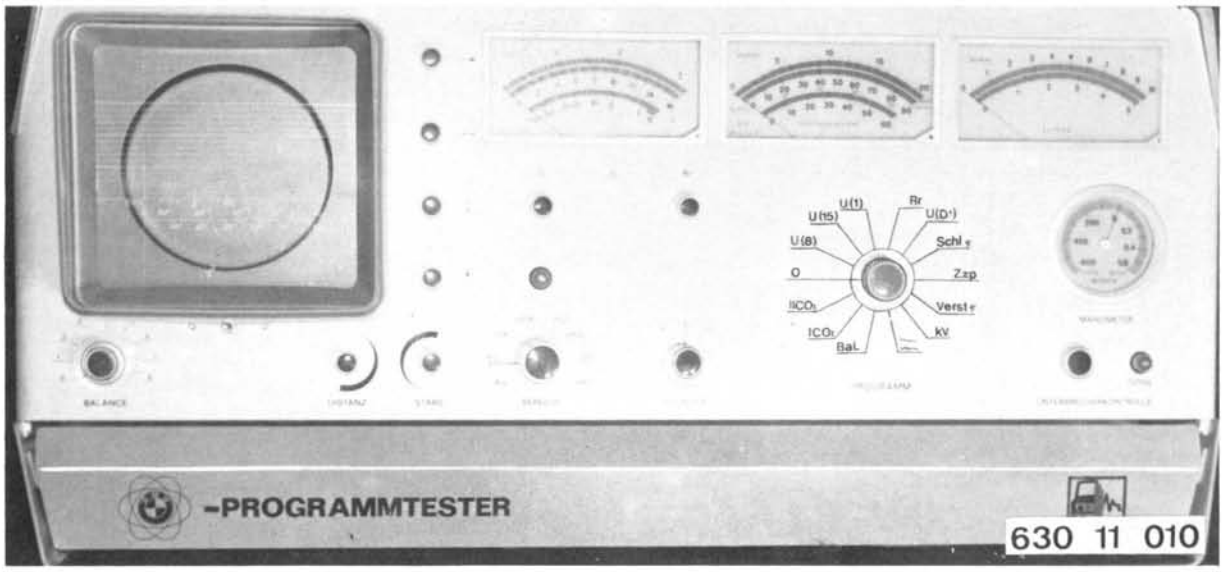
Determining Fuel Consumption According To German Industrial Standard DIN 70 030

Car's fuel injection and ignition timing settings [1] must be standard.
Tire size must agree with data in vehicle's registration papers.
Correct tire pressures to specifications.
Release brakes completely.
Engine must have been operated for at least 7,500 km (4,500 miles) and be at operating temperature.
For fuel consumption test car's weight must be half that between maximum total weight and curbweight.
The speed must be kept as constantly as possible and about 3/4 of the maximum possible speed over the entire test stretch. Testing speed should never exceed 110 KPH (68 MPH).
The test stretch chosen should have a level as possible surface, dry and about 10 km (6 miles) long, which must be driven in both directions. Uphill and downhill gradients up to 1.5 % are permissible.
The air temperature must be between + 10 and 30° C (+ 50 and 86° F) and the wind velocity can be a maximum of 3 meter (ca. 10 feet) per second.
The car's fuel tank is filled with a commercial branded premium grade fuel.

The fuel consumption is measured with a standard tester or by the following formula, whereby 10 % is added to cover any unfavorable conditions.

$$\frac{\text{Consumed fuel} \times 100}{\text{driven km}} = \text{Normal fuel consumption}$$

1) See Specifications

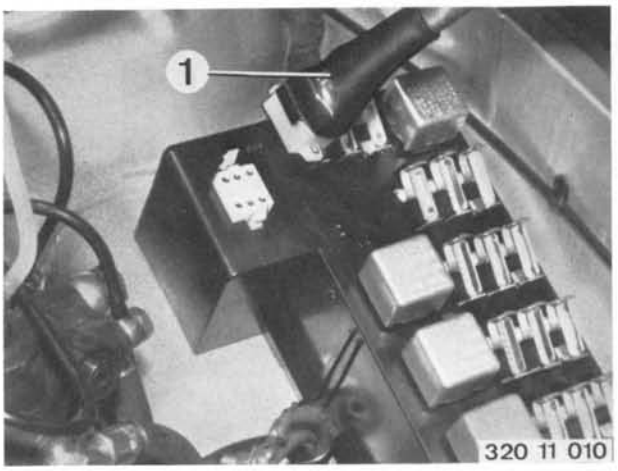


11 00 005 Diagnosis with BMW Program Tester

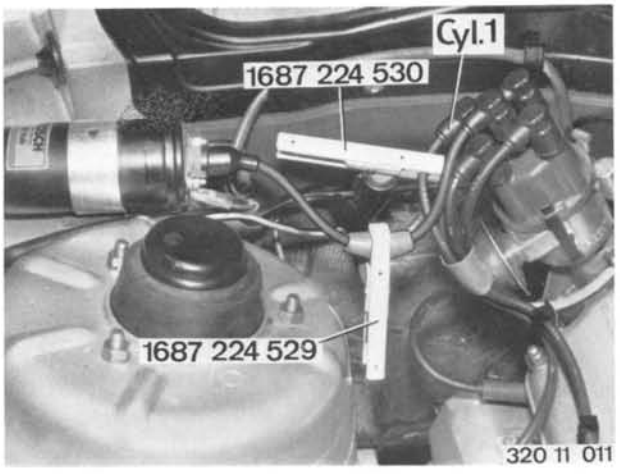
Switch Position	Item Tested	Page
	Connecting Program Tester	11-00/3
U (B +)	Battery Voltage without Power Consumers	00/4
U (15)	Voltage at Ignition Coil Terminal 15	00/4
	a) Ignition Coil Static Current	
	b) When Starting	
U (1)	Voltage Drop at Contact Breakers and Plugs	00/4
Rr	Capacitor - Distributor	00/5
U (D +)	Alternator and Regulator	00/6
Schl	Dwell Angle	00/8
	Cam Displacement - Distributor	00/8
	Contact Breaker Points	00/9
	Ignition Coil Polarity	00/9
	Capacitor - Distributor	00/10
Zzp	Ignition Timing	00/10
Verst	Centrifugal Ignition Control	00/11
	Vacuum Ignition Control	00/11
KV	Oscillograph Display Adjustments (Basic Trace)	00/12
	Ignition Voltage / High Tension Insulation	00/13
	Comparative Display of Cylinders	00/16
Bal.	Balancing Cylinder Display	00/17
I CO %	Exhaust Gas % by Volume / Engine Idle Speed	00/18
Test Values		00/19

Connecting Program Tester

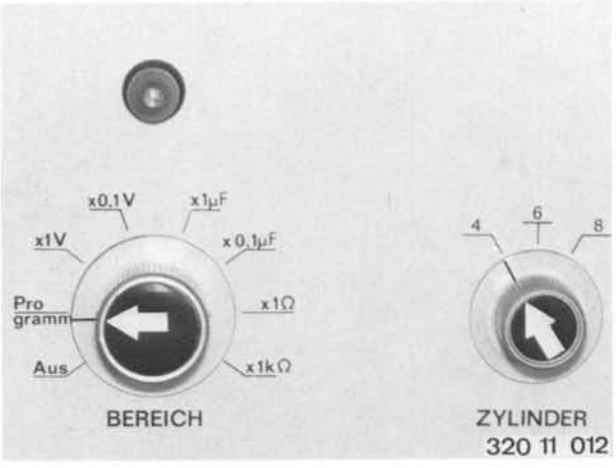
Connect BMW Program Tester to 220 volts power supply, and test leads, manual remote control and stroboscope light to program tester.



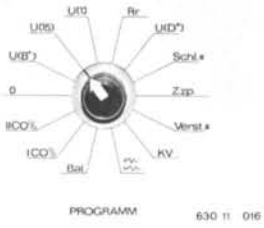
Connect high tension detector clips.
Detector clip 1 687 224 529 to cyl. 1 lead and
530 to ignition coil/
distributor lead.



Set selector switch at program.
Tester is ready for use when yellow indicator lamp is on. If not, check 1 ampere fuse above main power supply cord.
Set cylinder selector switch at 4.



Switch Position U (B+)
16 volt scale

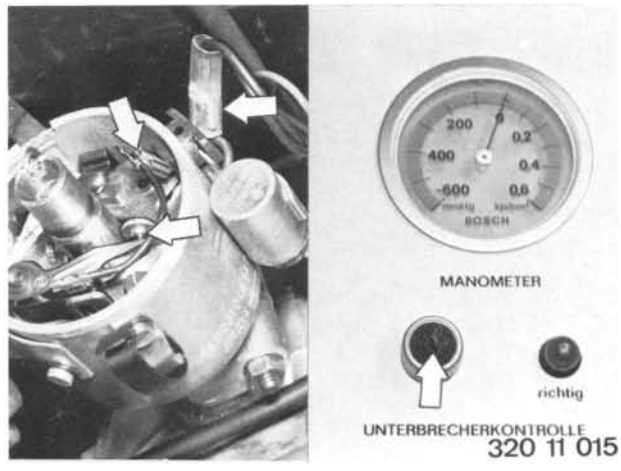


Switch Position U (15)
16 volt scale

Switch Position U (1)
1.6 volt scale

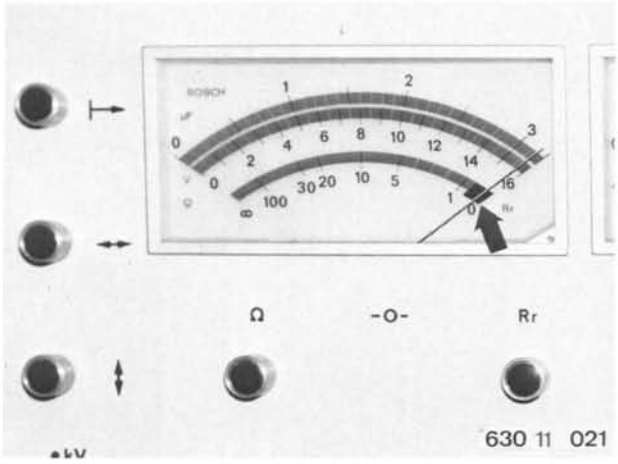
Check battery voltage 1) with consumers off. Engine stopped, ignition turned off.

Turn on ignition at ignition switch.
Don't turn on ignition with manual remote control.
a) Min. coil current at term. 15: 11 volts.
b) Start engine at ignition switch. Min. voltage while operating starter motor: 9 volts.



Ignition turned off.
Press contact breaker control switch. Green lamp must be on. If not, operate starter until green indicator lamp is on.
Read voltage drop 1).
If maximum specifications are exceeded, check contact breaker points and plugs.

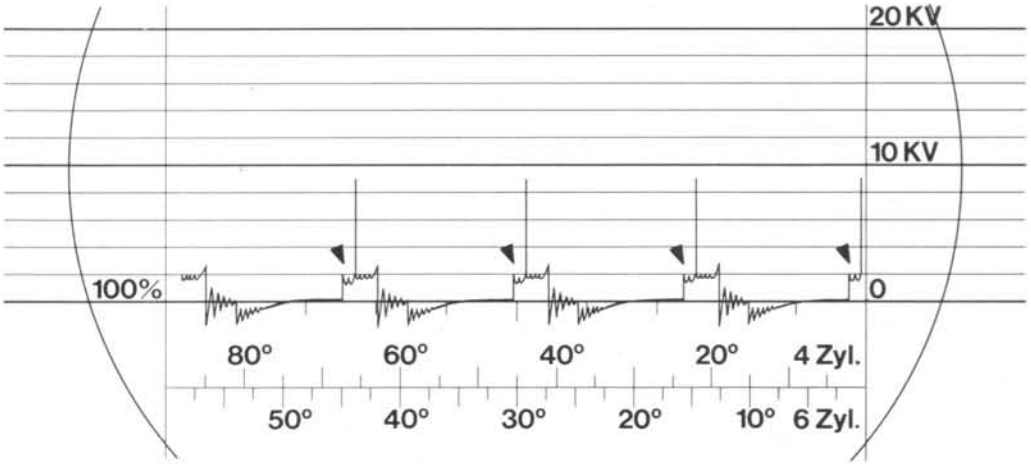
1) See Specifications



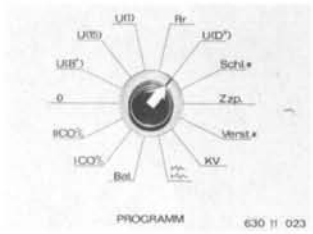
Switch Position Rr
Rr scale

Capacitor Series Resistance
Ignition turned off.

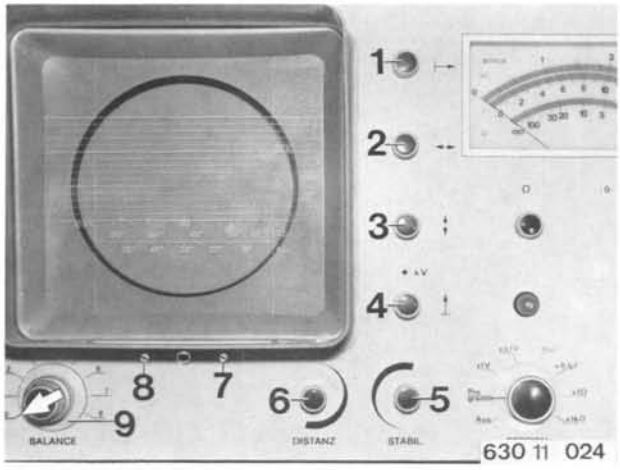
Detach wire from contact breaker point and wire 1 from plug.
Hold wire 1 against ground and set needle at lower edge (0) of Rr scale with Rr rotary switch knob.
Connect wire 1 to plug.
Capacitor is good, if needle points within the wide range.



Caution! Capacitor series resistance will retard the ignition timing.
The defect must be found and corrected before adjusting the ignition timing.



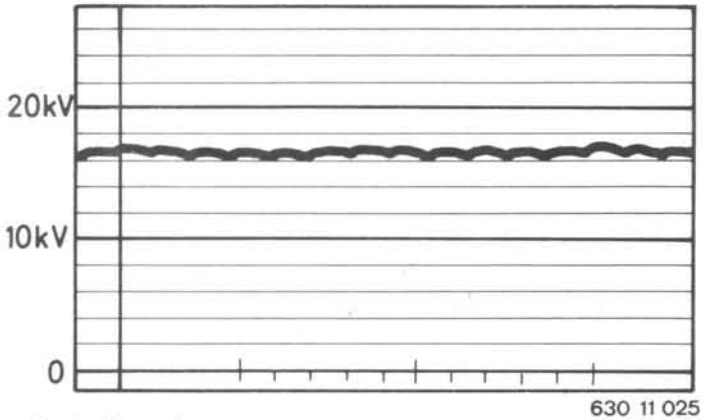
Switch Position U (D +)
2000 RPM scale



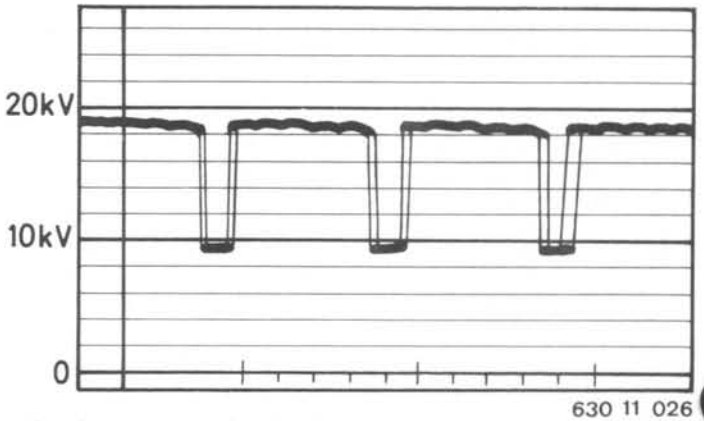
Set balance switch (9) at 0.
Turn distance rotary switch knob (6) to left stop.
Adjust image width between 0 and 60° with rotary switch knobs (2) and (1).

Adjust image to zero line (3).
Adjust stable rotary switch knob (5) with engine running at speed of 900 rpm until the upper harmonic waves remain constant.
Turn rotary switch knob (4) until the upper harmonic wave is about 5 mm (0.2 in.).

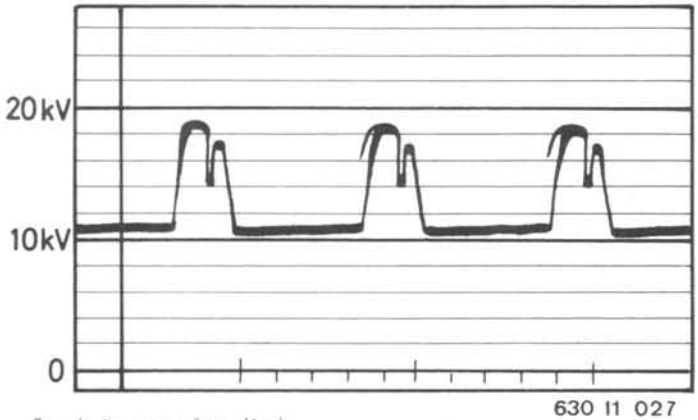
Caution! Only adjust the image.focus (8) and image brightness (7) if absolutely necessary!



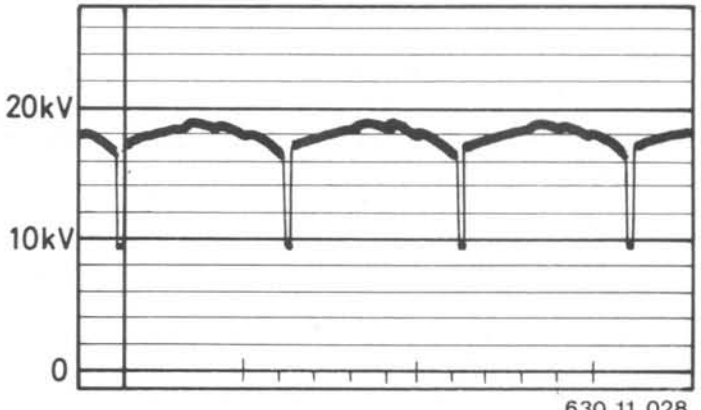
Good alternator.
Switch on headlights to prevent superposition of the oscillograph image.



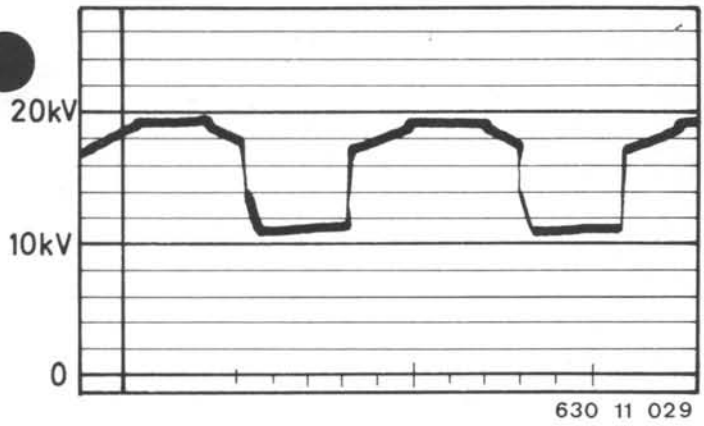
Break in one exciter diode.



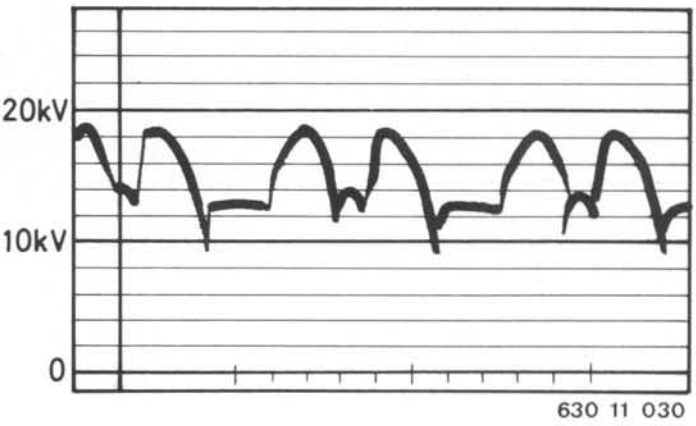
Break in one plus diode.



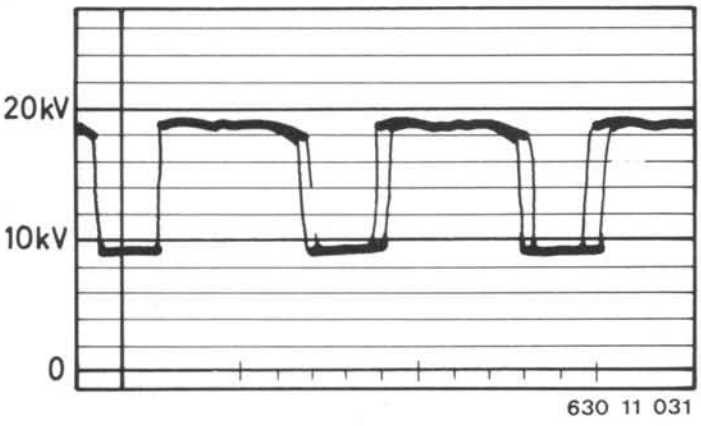
Break in one minus diode.



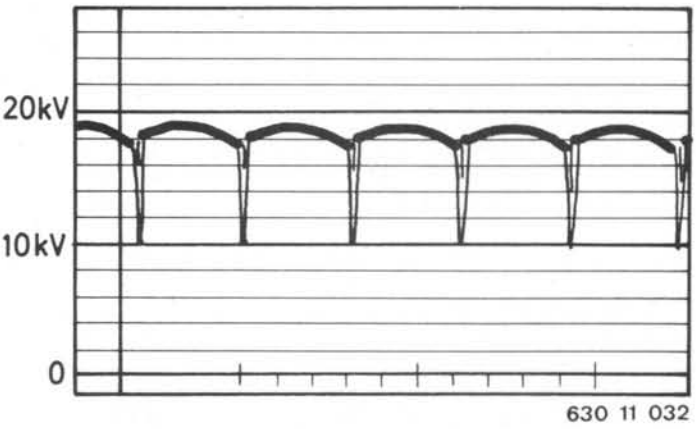
Short circuit in one exciter diode.



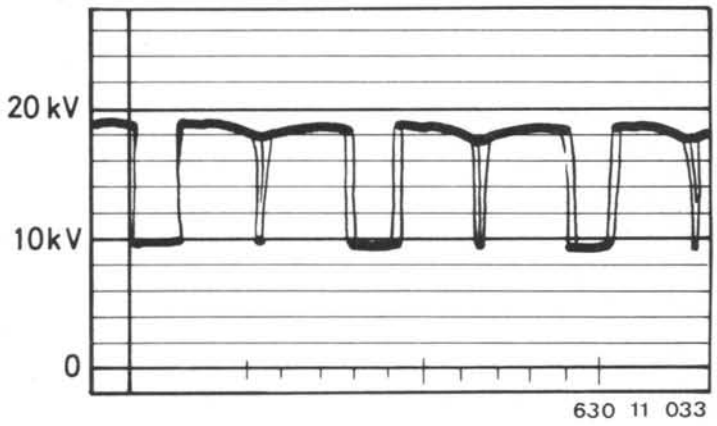
Short circuit in one plus diode.



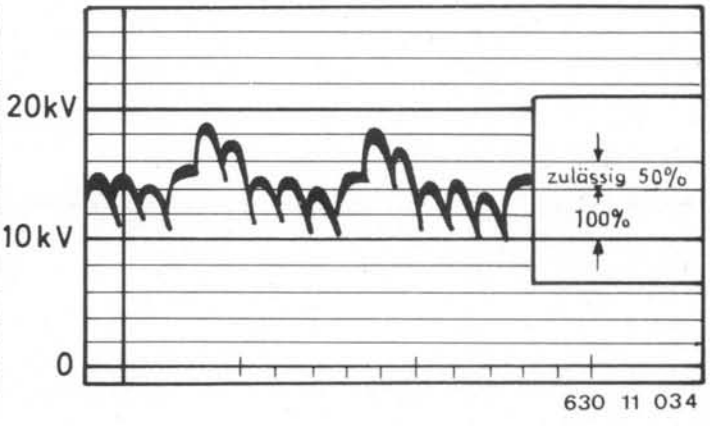
Short circuit in one minus diode.



Phase error.



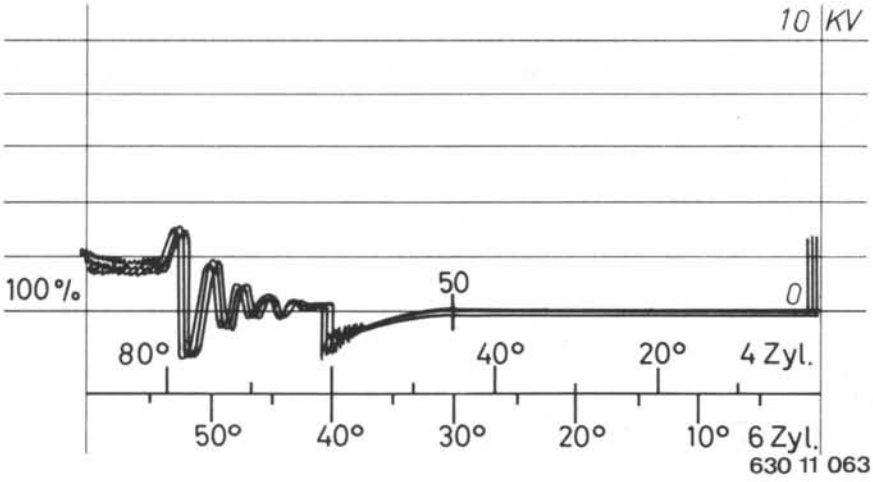
Phase error and short circuited minus diode.



Diodes with altered characteristic.

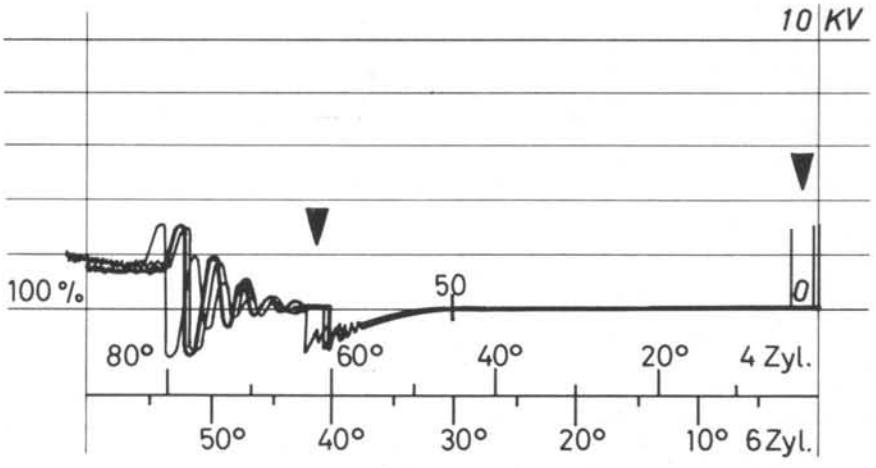
Caution! Deviations below 50 % are still acceptable. If deviations are greater than this, the defective diode must be replaced.

Switch Position Dwell Angle
Engine speed 2000 RPM



630 11 063

Dwell angle 59 ... 65°.
Adjust dwell angle to smallest value.
This oscillograph shows a correctly adjusted dwell angle.



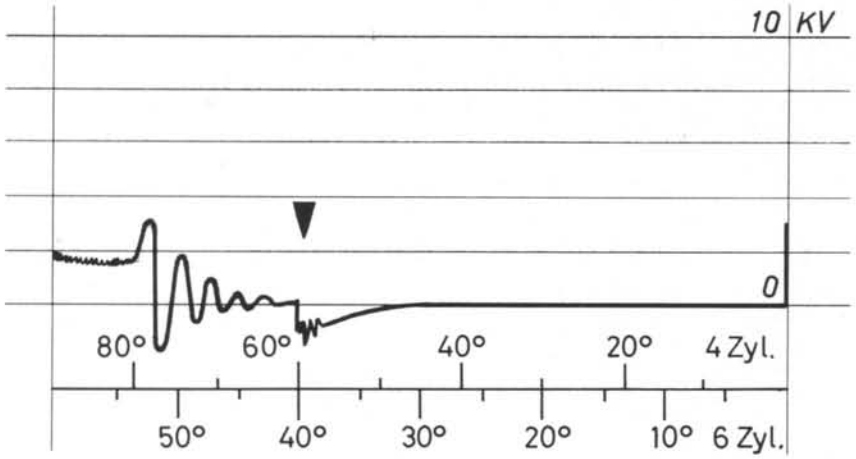
630 11 037

Distributor Cam Displacement

The ignition patterns of all cylinders are superimposed.
The distributor's accuracy will determine the regularity of the successive ignition patterns.

The amount of cam displacement[1)] can be read off of the scale in degrees.
Worn cams, a worn distributor shaft or a loose contact breaker plate will cause alterations in dwell angle and ignition timing intervals.
Replace distributor - 12 11 060.

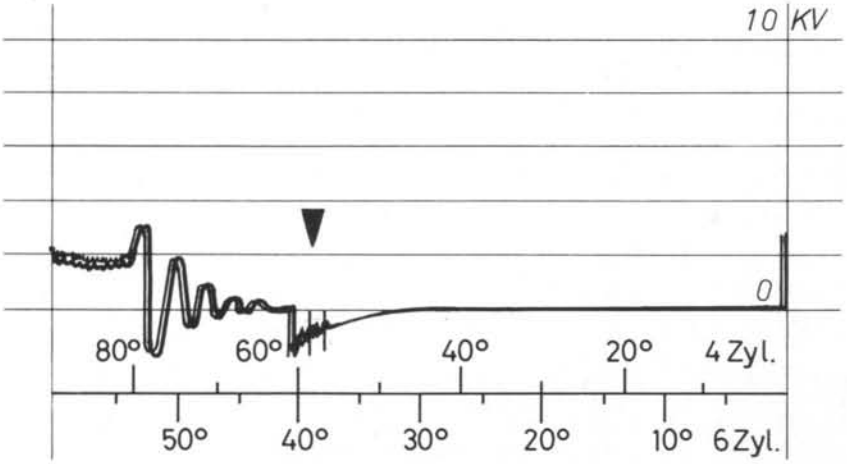
1) See Program Test Sheet



630 11 038

Dirty and Burnt Contact Breaker Points

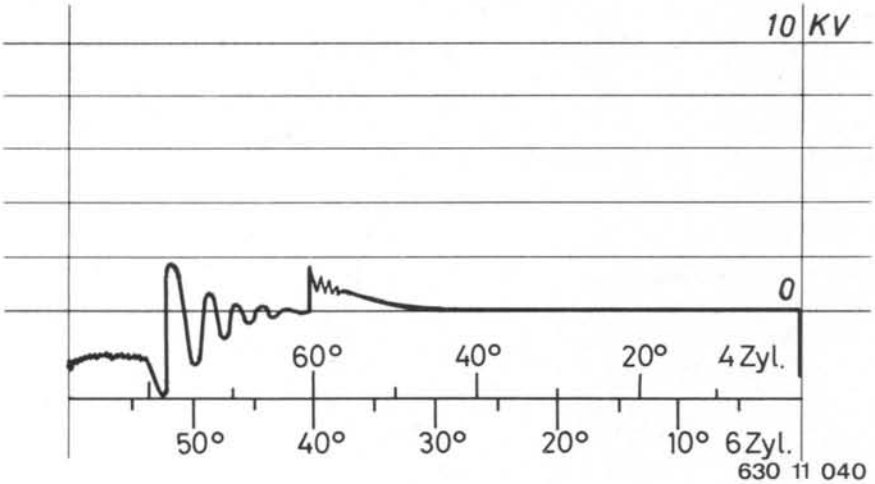
The oscillograph shows this fault by a deformation of the initial dwell phase.
Replace contact breaker points.



630 11 039

Contact Chatter

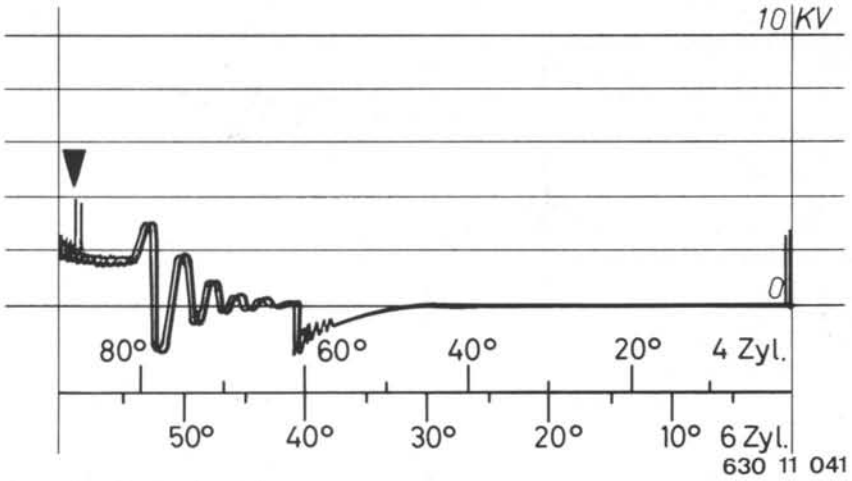
The contact breaker arm will bounce after closing and thus produce another break.
Replace contact breaker points.



630 11 040

Incorrect Ignition Coil Polarity

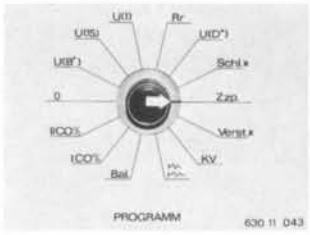
Wires have been mixed up at ignition coil terminals 15 (+) and 1 (-).
Correct wire connections. This refers to the car's wires and not those of the test lead.



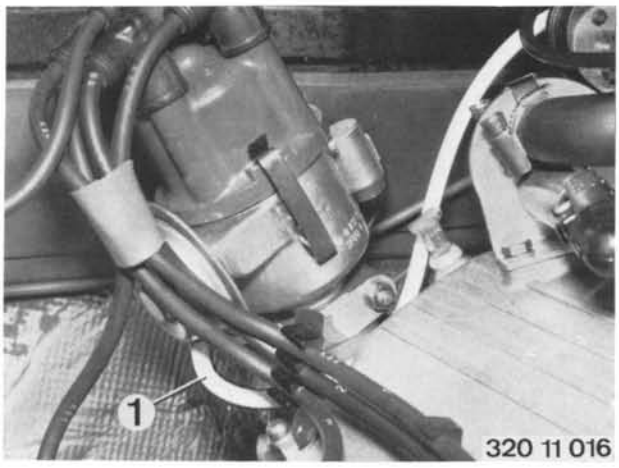
Capacitor Series Resistance

Capacitor series resistance will cause arcing at the contact breaker points, which turn blue, and the erosion of metal from one contact breaker point to the other.

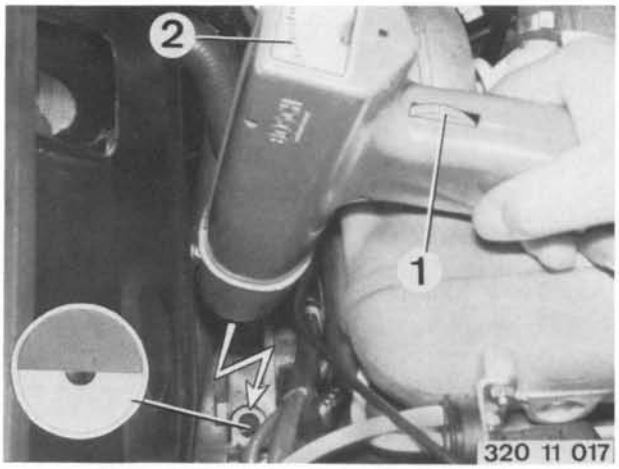
Caution! Capacitor series resistance will retard the ignition timing. It is essential to correct this defect before adjusting the ignition timing. Replace capacitor and contact breaker points.



Switch Position Ignition Timing
2000 RPM scale



Engine at operating temperature.
Detach vacuum hose (1) at distributor.
Boost engine speed - 2200 RPM 49 State Version
2400 RPM California Version



Turn off timing angle indicator with thumbwheel (1) on stroboscope light (off stop). Needle on instrument (2) points to 0.
Aim stroboscope light at ball mark[1] on flywheel.
Loosen distributor and turn appropriately.

Caution! Note changes in engine speed while adjusting ignition timing. The ignition timing is correct when center of ball can be seen at edge of inspection hole.

1) Long pin for automatic transmission.

Switch Position Timing Angle

Centrifugal Ignition Control[1)]
Engine at operating temperature.
Detach vacuum hose (1).
Perform centrifugal ignition control curve.

Turn thumbwheel (1) on stroboscope light until TDC mark on flywheel aligns with edge of inspection hole. Read timing angle 1) in degrees on crankshaft at scale (2). Replace distributor if far off of specifications.

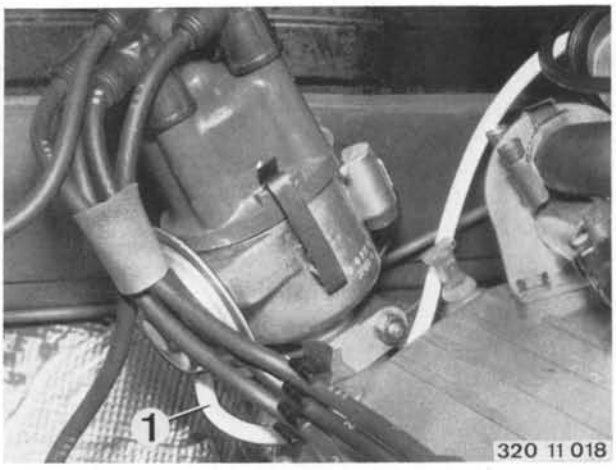
Vacuum Ignition Control[1)]
Connect control valve (3) between vacuum box (4) and timing valve (5).
Connection (6) to vacuum pressure gauge.
Shut control valve (3).

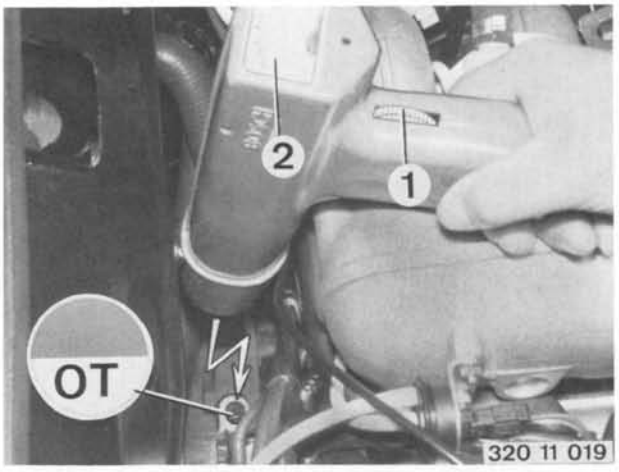
Adjust engine speed at highest vacuum value. Turn thumbwheel (1) on stroboscope light until TDC mark on flywheel aligns with edge of inspection hole. Open control valve for vacuum tester slowly. If TDC mark wanders toward retarded ignition, vacuum ignition control end has been reached.
Correct change in engine speed.
Turn thumbwheel (1) on stroboscope until TDC mark on flywheel aligns with edge of inspection hole.
Read timing angle, e.g. 31^{0}.

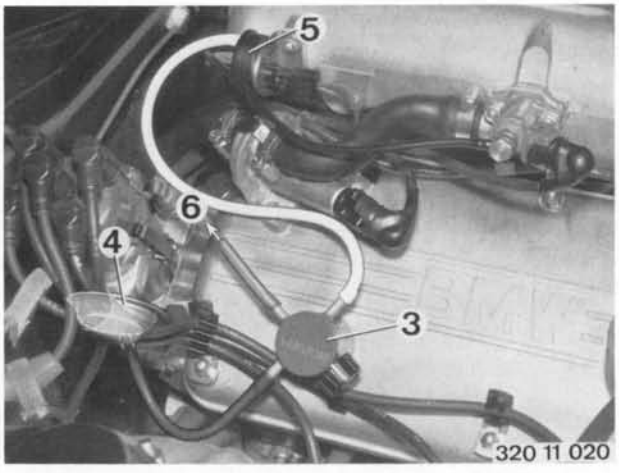
Example:
Angle with control valve shut 41^{0}.
Angle with control valve open 31^{0}.
Vacuum ignition control angle 10^{0}.
Shut control valve slowly until TDC mark wanders toward advanced ignition. The vacuum shown at this stage is used for start of vacuum ignition control.

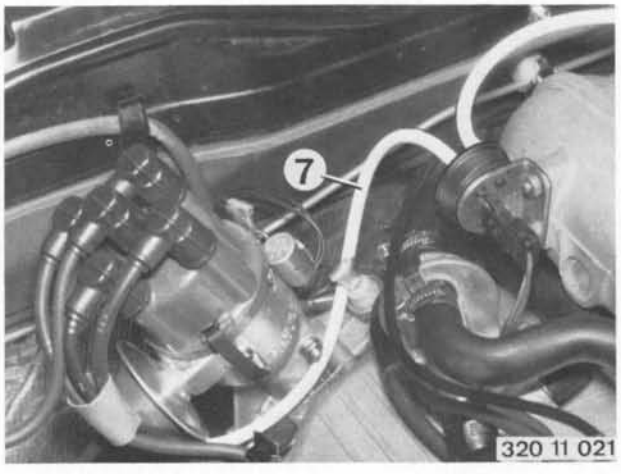
Timing valve must be shut on cold engine and during warm-up phase.
Turning on ignition will heat timing valve continuously.
Test: cold engine.
Detach hose (7).
Start engine.
No vacuum should be felt at timing valve.
Test: warm engine.
Detach hose (7).
Timing valve is good, if engine speed rises by about 200 rpm.

1) See Test Sheet - 11-00/19

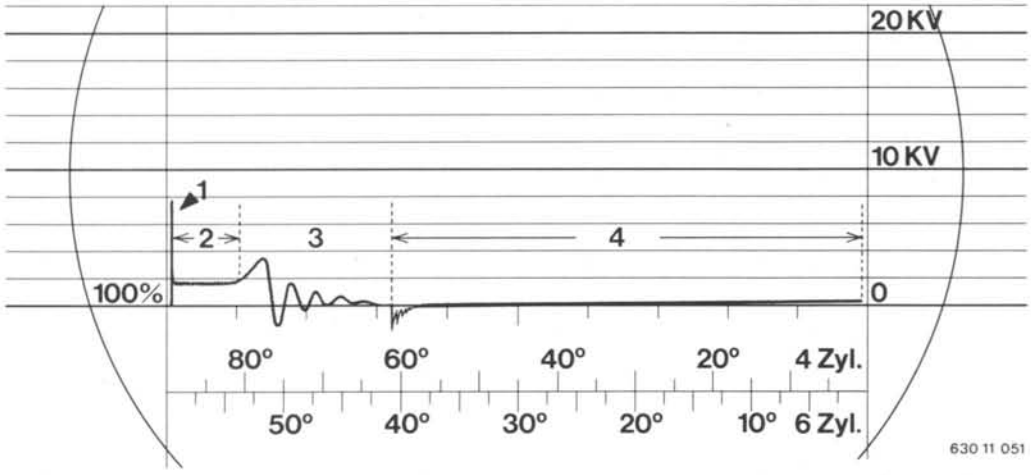








Switch Position KV
Engine speed
9000 RPM scale
1200 ... 1400 RPM



Basic Image E X T E R N A L

This oscillograph shows the ignition voltage pattern for one engine cylinder, if the ignition system is good.

Ignition Voltage Peak (1)

The ignition voltage peak is produced at the moment when the contact breaker points open.

Combustion Voltage Line (2)

The combustion voltage line shows the further progress of the ignition spark, which continues to glow for a brief period.

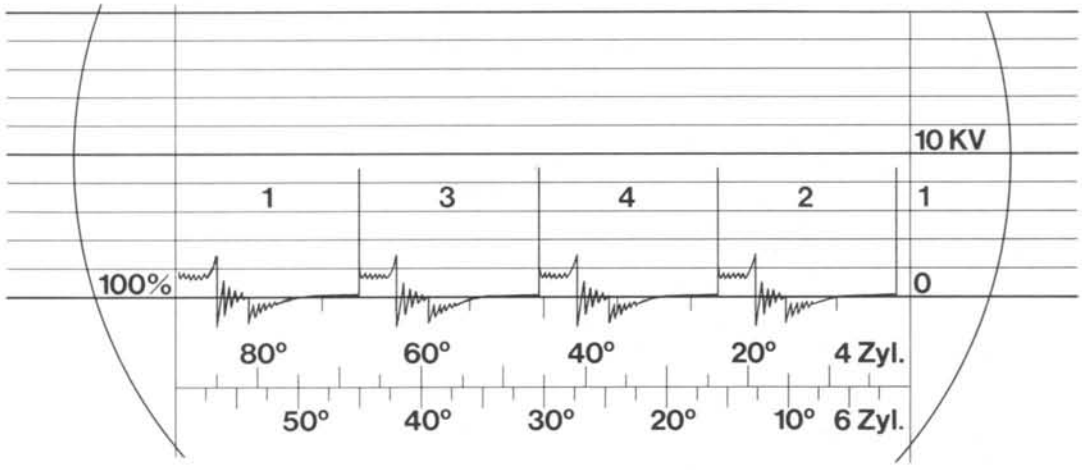
Dying Out Phase (3)

This phase clearly shows how the ignition spark is broken off and dies away.

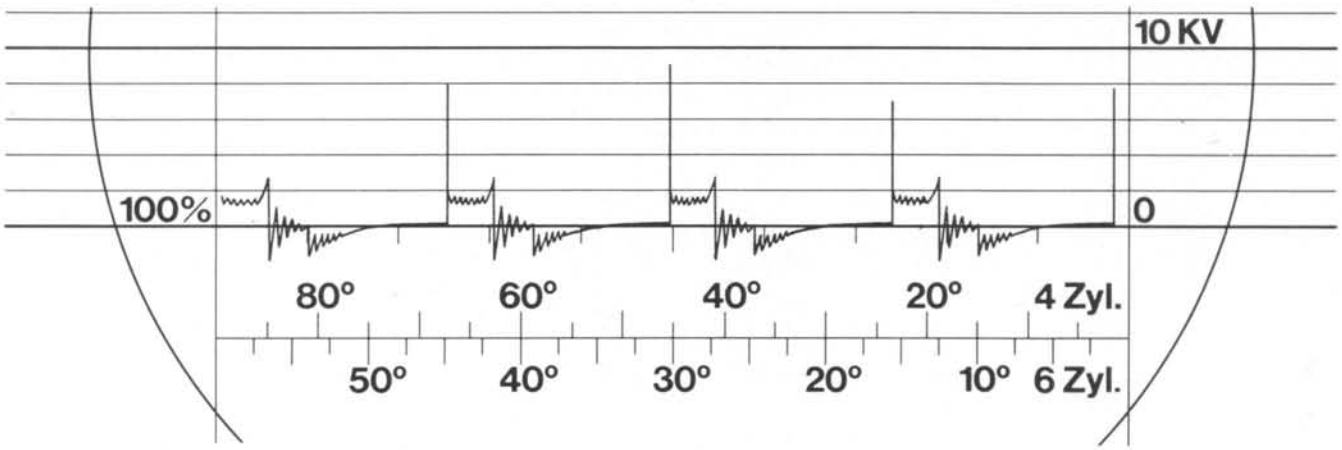
Closing Period (4)

The contact breaker points are closed. Thus the name of this period.

All deviations from basic image mean faults in ignition system!



General view of an ignition system in good condition.
Cylinders are shown on screen in firing order.
Only ignition voltage peak of cylinder number 1 is at far right.



Differences in Ignition Voltage

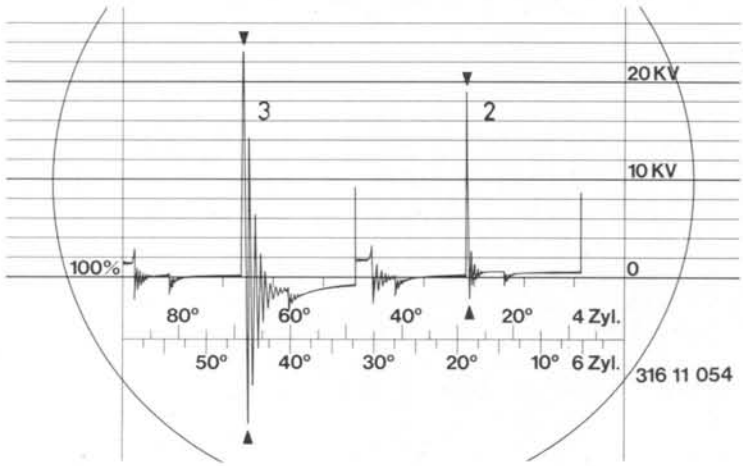
Turn rotary switch knob KV to left stop.

Ignition voltage is measured in KV with an oscilloscope. More important than the amount of ignition voltage, is the uniformity for all cylinders. Differences up to 3 KV are acceptable.

If differences are greater than this, check the following.

Factors Affecting Ignition Voltage Requirement	Ignition Voltage Too High Cause	Ignition Voltage Too Low Cause
b) Electrode gap [1)]	Large	Small
c) Compression	High	Low
d) Fuel/air mixture	Lean	Correct
e) Ignition spark polarity	Incorrect	Correct (negative ignition pulse)
f) Electrode (engine) temperature	Low	High
g) Electrode material 1)	Unsuitable alloys	Specially selected alloys
h) Electrode shape 1)	Round	Sharp-edged
i) Electrode condition 1)	Burnt	New
k) Ignition timing	Retarded	Advanced
l) Ignition cable	Break	-
m) Spark gap in distributor	Large	-

1) Determined by spark plugs.

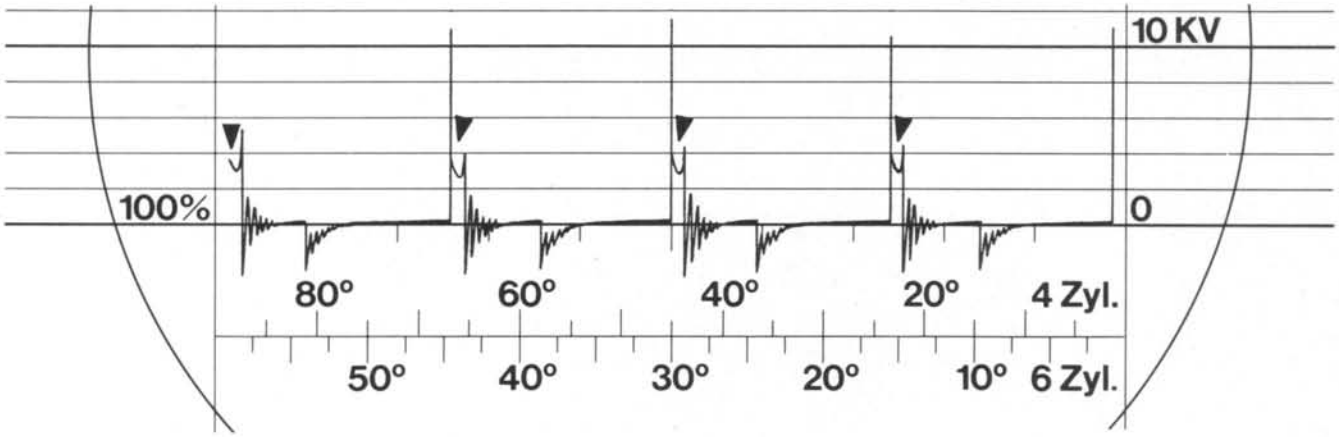


Critical Insulation Test

This requires pulling off one each spark plug connector one after the other.

Cylinder 3 insulation in good condition.

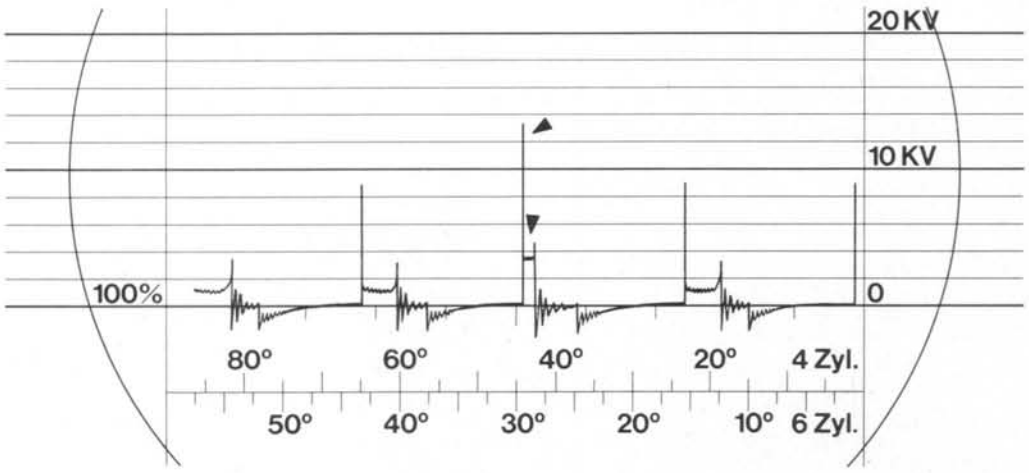
Cylinder 2 insulation defective.



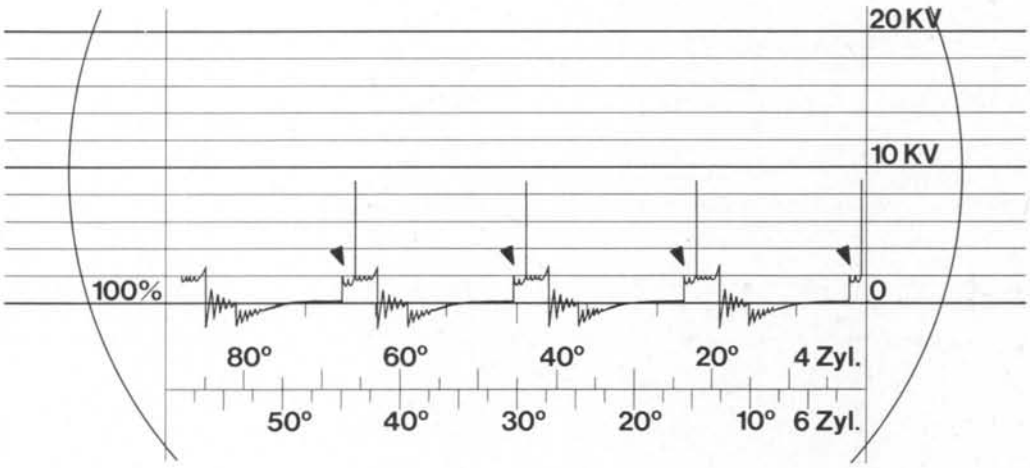
Faults On All Cylinders

Suppressor resistors between ignition coil, distributor or distributor rotor with too much resistance. Combustion voltage line is at an angle and narrower than usual.

Excessive resistance will be noticed when driving the car by way of poor acceleration and inadequate engine power.



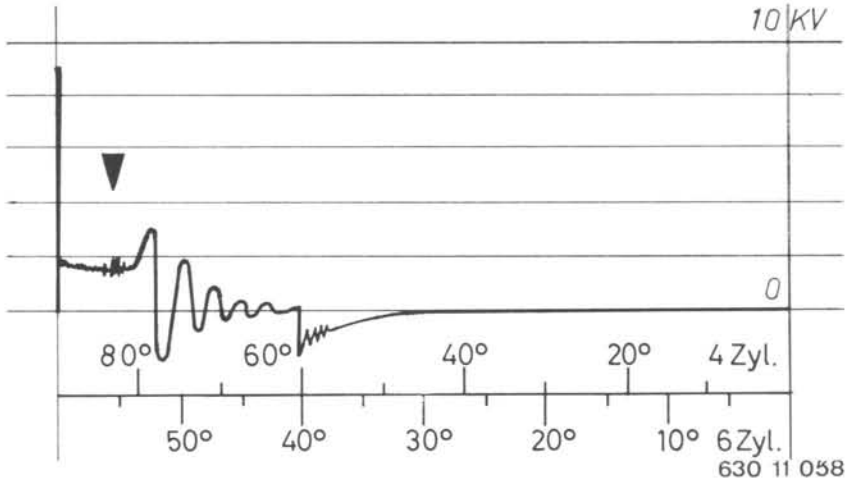
Fault on one ignition cable, spark plug connector or suppressor cap.



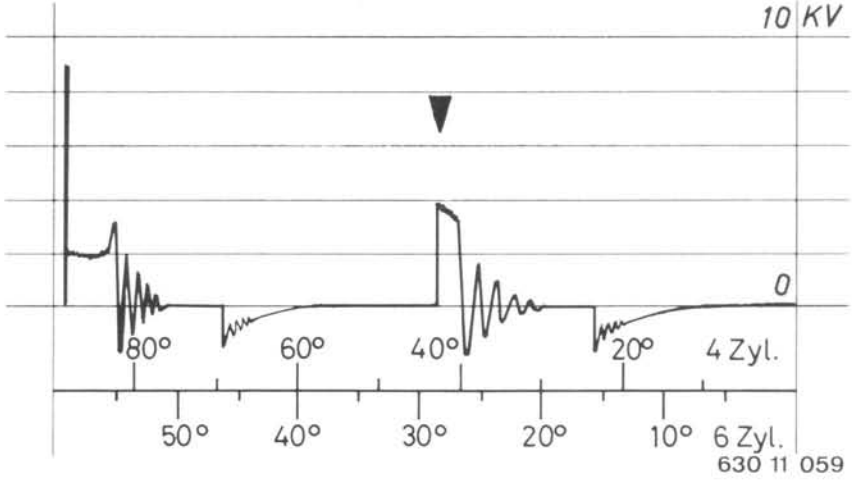
Capacitor Series Resistance

Caution! Capacitor series resistance will retard the ignition timing. This fault must be found and corrected before adjusting the ignition timing.

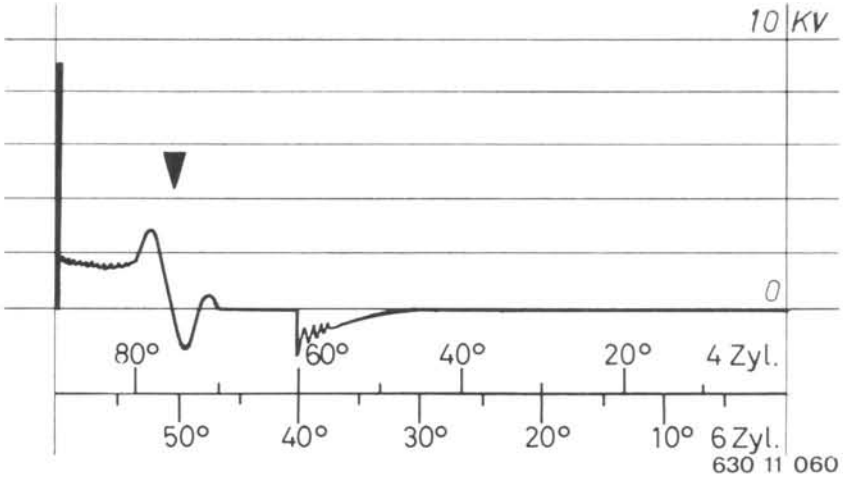
Turn rotary switch knob — to the right until basic image for 1st cylinder appears separately on the screen.
Now turn rotary switch knob —— to the left slowly and check the images in the sequence of firing order (1-3-4-2).



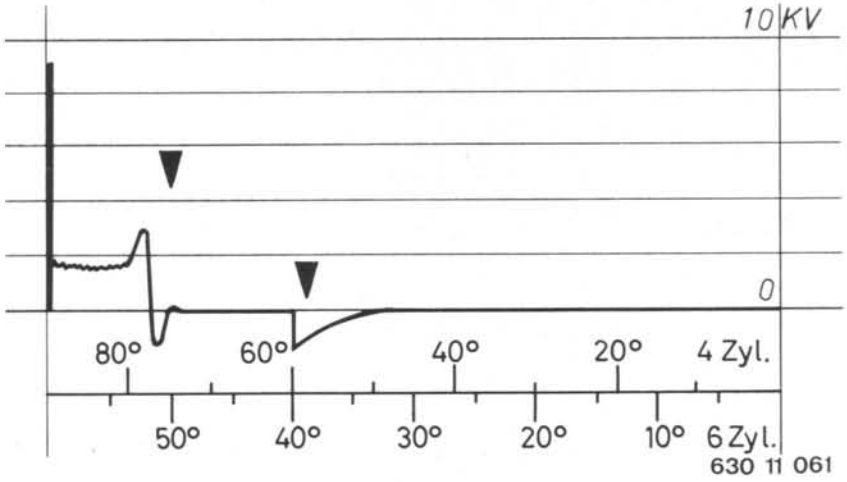
If spark plugs are heavily contaminated, the combustion voltage line will appear thicker than usual and will be superimposed by oscillations.



If spark plugs are severely leaded, the ignition current will stray via the electrically conductive lead deposits when the engine is warm. This in turn will cause misfiring.



Distributor capacitor will be shorted against ground, if insulation resistance is below 2 K-ohms. Engine will stop running, if there is a complete short-to-ground.

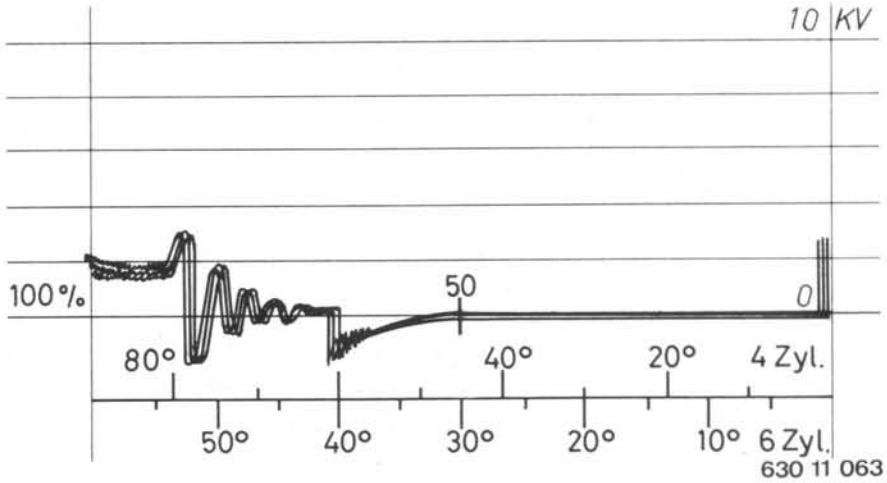


Short in Ignition Coil Primary Winding

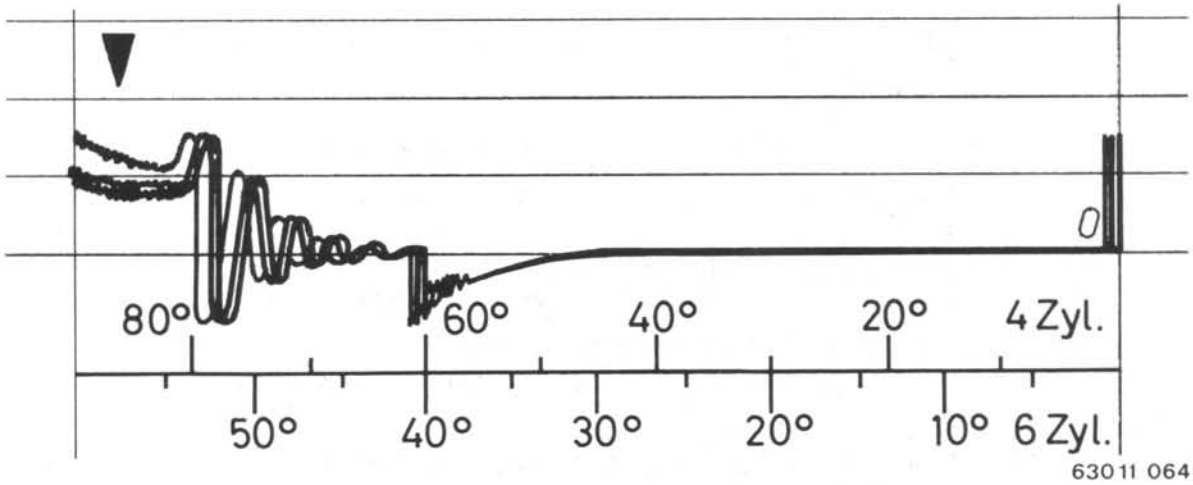
Turn back rotary switch knobs — and —— to their initial positions (cylinders 1 through 4 between 0 and 60°).

9000 RPM scale

Engine speed ca. 1200 ... 1400 RPM

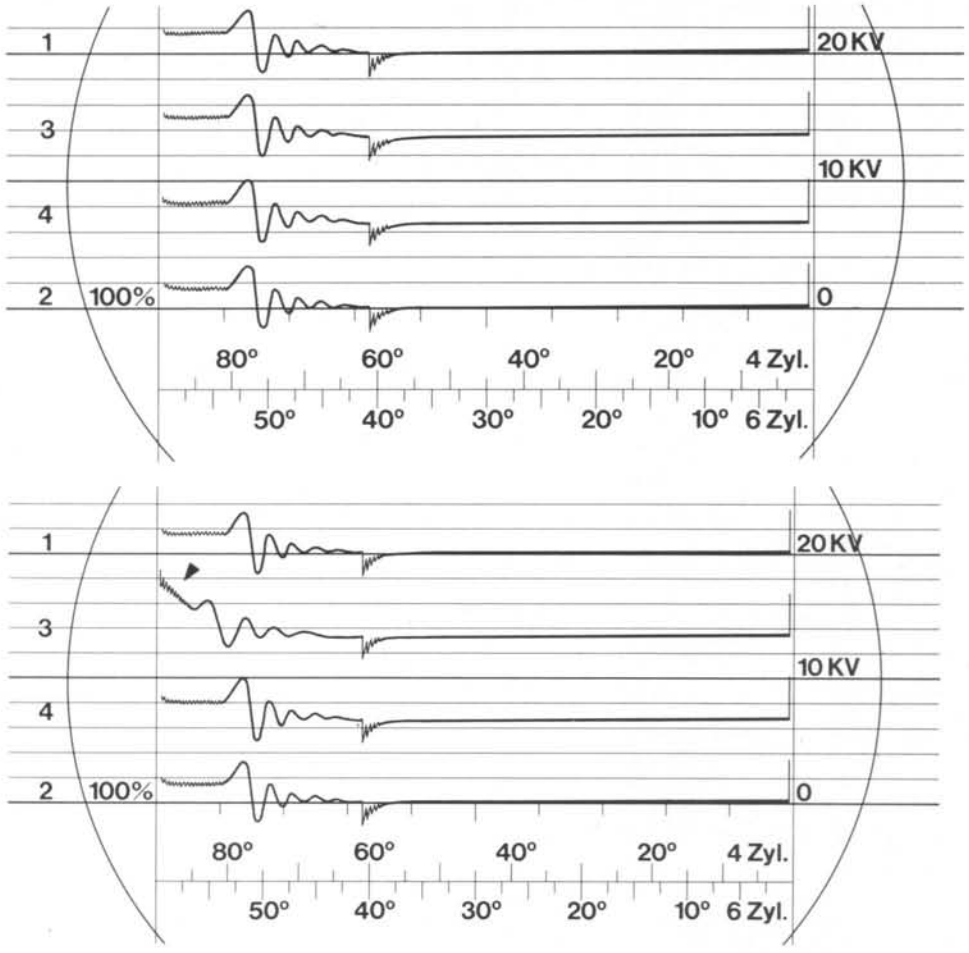


The ignition patterns of all cylinders are superimposed for comparison with each other.



This oscillograph shows that a suppressor resistor for one cylinder is defective.

Set balance switch at 0.
Turn distance rotary switch knob to the right until all cylinders appear on the screen.
The cylinder patterns are superimposed in sequence of firing order to make comparisons.

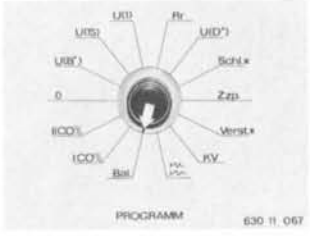


Excessive suppressor resistance at cylinder 3.

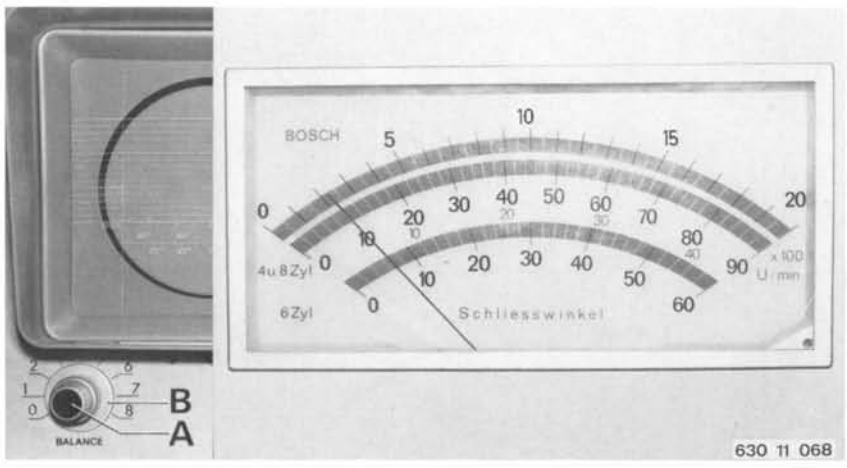
Power Output Comparison of Cylinders

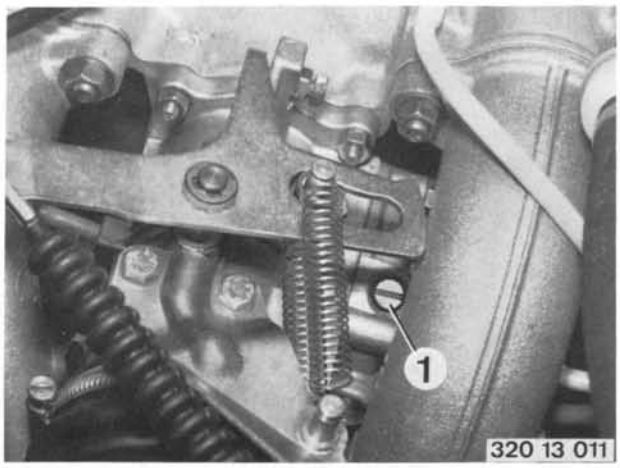
Caution! This test requires perfect carburetor, ignition timing and valve clearance settings.

Adjust cylinders with selector switch (A) one after the other in sequence of firing order, and short circuit each cylinder by pressing button (B). Read speed drop on scale. Speed drops should be as uniform as possible and about 100 RPM per cylinder. Check compression, if speed drop is inadequate.



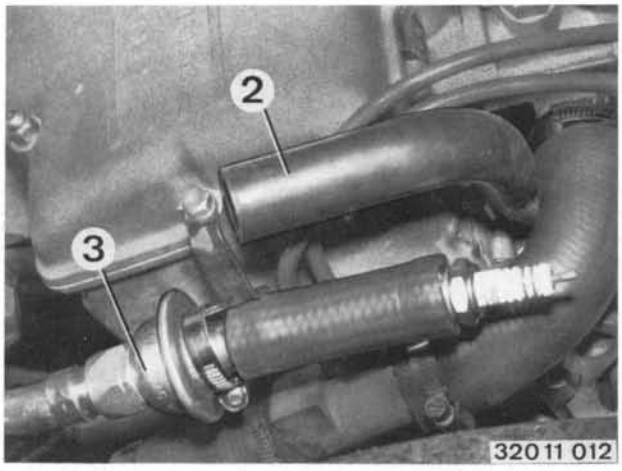
Switch Position Balance
2000 RPM scale
Engine speed 1500 RPM



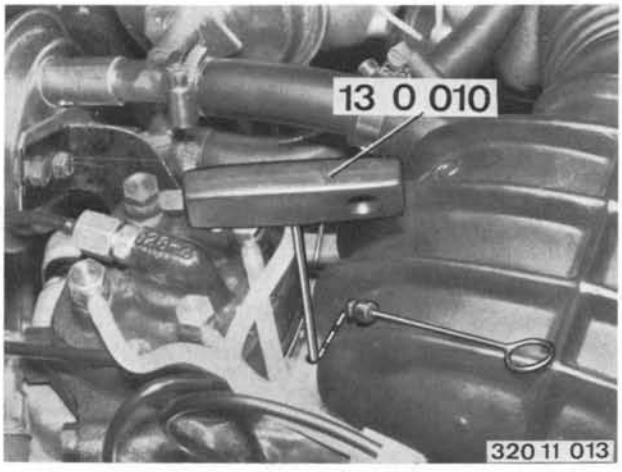


Exhaust Gas % by Volume / Adjusting Engine Idle Speed

Requirements for all adjustments:
Engine at operating temperature, i.e. min. oil temperature 60° C/140° F.
Correct ignition timing and valve clearance.
Air filter cartridge in good condition.
CO tester at operating temperature and calibrated.
Adjust engine idle speed to 900 ± 50 rpm with screw (1).



Detach hose (2) at check valve.
Plug check valve (3).



Remove plug from fuel distributor.
Adjust CO level with adjusting wrench 13 0 010.
Max. 2.0 % by volume for 49 State Version
Max. 3.5 % by volume for California Version

Caution! Never accelerate while making adjustments. Refer to Troubleshooting on Page 13-50/9, if CO level cannot be adjusted to specifications at an idle speed free of misfiring.

Switch Pos.	Item Tested	Specification
U (B +)	Battery voltage without power consuming equipment	min. 11.8 volts
U (15)	Voltage at ignition coil terminal 15	
	a) at ignition coil static current	min. 10.8 volts
	b) while starting	min. 9.0 volts
U (1)	Voltage drop at contact breakers and plugs	max. 0.3 volts
Rr	Capacitor series resistance	within Rr range
U (D+)	Alternator	
	a) voltage at D +	13.5 ... 14.6 volts
	b) checked with oscilloscope at 900 rpm	see Page 11-00/6
Schl.	Dwell angle	59^0 ... 65^0
∢	Contact opening	min. 0.35 mm (0.014 in.)
	Cam displacement checked with oscilloscope at 2000 rpm	max. 3^0
Zzp.	Ignition timing[1] 25^0 BTDC (without vacuum ignition control, engine at operating temp.)	2200 rpm for 49 State Version 2400 rpm for California Version
Verst.	Centrifugal ignition control	1000 rpm 1^0
∢	(without vacuum ignition control, engine at operating temp.) stroboscope lamp aimed at TDC mark	1500 rpm 10^0 - 15^0
		2000 rpm 15^0 - 24^0
	Distributor No. 0 231 170 214	2500 rpm 20^0 - 27^0
		3000 rpm 24^0 - 31^0
		3500 rpm 27^0 - 34^0
		4000 rpm 31^0 - 38^0 end
	Vacuum retarded ignition control	begins 70 - 100 Torr ends 170 - 210 Torr range 16^0 on crankshaft
	Retarded ignition control at idle speed Engine speed boosted with hose disconnected	approx. 200 rpm
kV	Ignition voltage at 1200 ... 1400 rpm	6 ... 11 kV
	Differences in ignition voltage of individual cylinders	2 ... 3 kV
	Increase when accelerating	2 ... 3 kV
	Ignition coil idle voltage (plug connectors pulled off)	min. 18 kV
Bal.	Output comparison of cylinders at 1000 rpm	engine speed must be as constant as possible
ICO %	Exhaust gas test at 900 ± 50 rpm (no air injection)	max. 2.0 % by Vol. for 49 States max. 2.5 ... 3.5 % by Volume for California
	Fuel pump pressure - delivery pressure (system pressure)	4.5 ... 5.2 bar (64 ... 74 psi)

1) Ball mark for manual transmissions
Long pin for automatic transmissions

Auxiliary Test

Voltage resistance and capacitance tests can also be made with test lead via range switch. These tests can be made at any program switch position; this will not impede the other program - except the voltmeter.

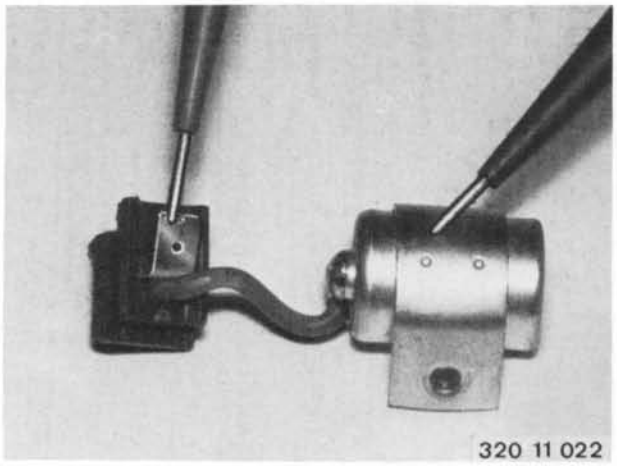
Voltage Test

Set range switch at X 1 V or X 0.1 V depending on test range.

Test lead connections: red clip to +
black clip to -

Capacitance Test

Set range switch at X 1 micron or X 0.1 micron depending on test range.

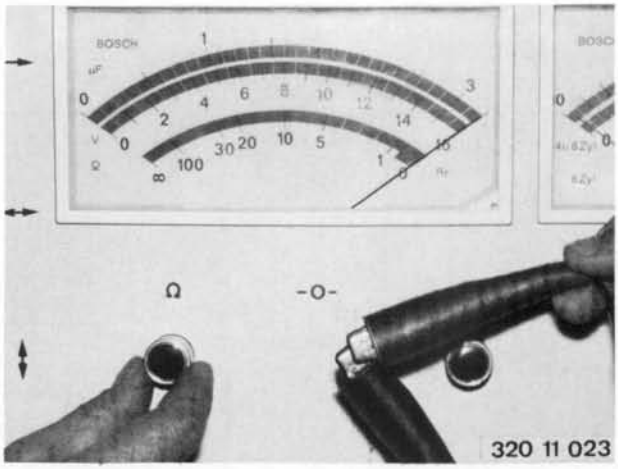


Caution! For capacitance tests never short circuit or supply voltage to test terminals. Built-in capacitors must be disconnected before testing.
Connect capacitor between clips of test lead. Read test value 1) on instrument.

Note! Capacitors, which were not used for a long time or are new, must be charged and discharged before testing. Otherwise the series resistance that is shown will be too high and will disappear immediately after being put in operation.

Resistance Tests

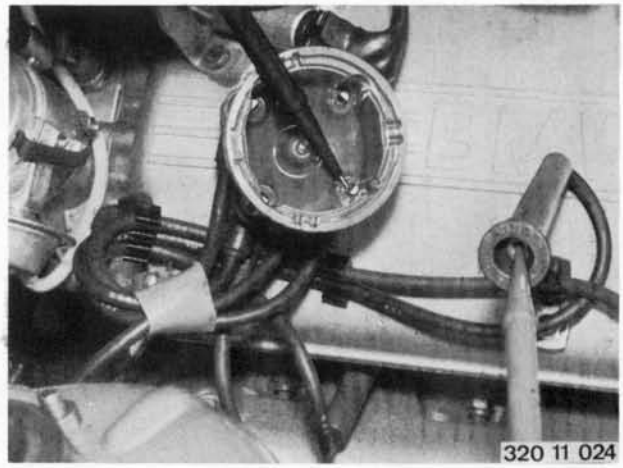
Set range switch at X 1 ohm or X 1 K-ohm depending on test range.
Calibrate the applied test range before each test.
Short circuit test terminals.
Set needle of instrument at 0 (bottom scale) with rotary switch knob ohm.



Connect resistor[1)] between clips of test lead and read amount of resistance.
The degree of insulation is so much better, the higher the insulation resistance. Normally the instrument needle in test range X 1 K-ohm will deflect completely when insulation is perfect, i.e. infinite resistance.

Caution!

Never supply voltage to test terminals.
0.25 ampere fuse on front of tester, right-hand side.



1) See Test Values

Test Values for Auxiliary Test

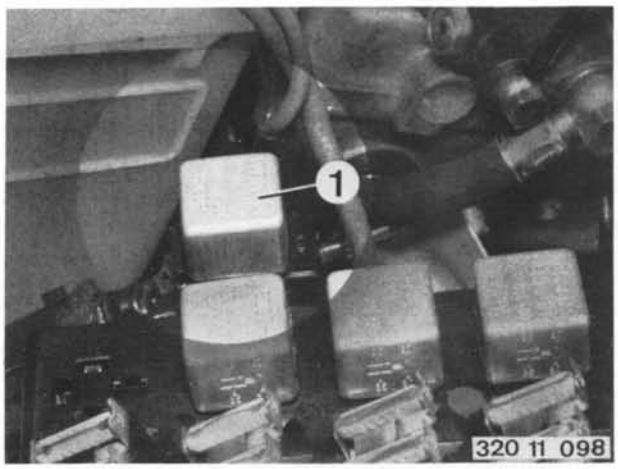
Charge Condition			min. 12.2 volts
Charge Condition	Acid Density g/cm^3	Idle Speed Voltage Per Cell Volts	Battery Voltage Without Power Consuming Equip. Volts
Full	1.28	2.12 ... 2.13	12.72 ... 12.78
Half	1.20	2.05	12.3
Dead	1.12	1.97 ... 1.98	11.82 ... 11.88

Voltage at ignition coil terminal 15		
a) at ignition coil static current		min. 11.0 volts
b) while starting		min. 9.0 volts
Voltage drop at contact breakers and plugs		max. 0.3 volts
Voltage at alternator D +		13.5 ... 14.6 volts
Voltage drop B + to starter 30		max. 0.5 volts
B + to ignition coil 15 or series resistor input		max. 0.4 volts
B - to engine ground		max. 0.5 volts
Suppressor resistance[1]		
Distributor rotor		5 K-ohm $\pm$ 25 %
Suppressor cap in distributor cap		1 K-ohm $\pm$ 25 %
Plug connectors		1.4 K-ohm $\pm$ 25 %
Distributor capacitor[1]	No. 1 237 330 295	0.18 ... 0.22 micron ohm
Insulation resistance		min. 200 K-ohm
Ignition coil[1]	Bosch No. 0221 119 017 KW 12 V	1.7 ... 2.1 K-ohm
Cable series resistance		0.9 K-ohm

[1] Values at + 20° C (+ 68° F).

11 00 039 CHECKING COMPRESSION OF ALL CYLINDERS

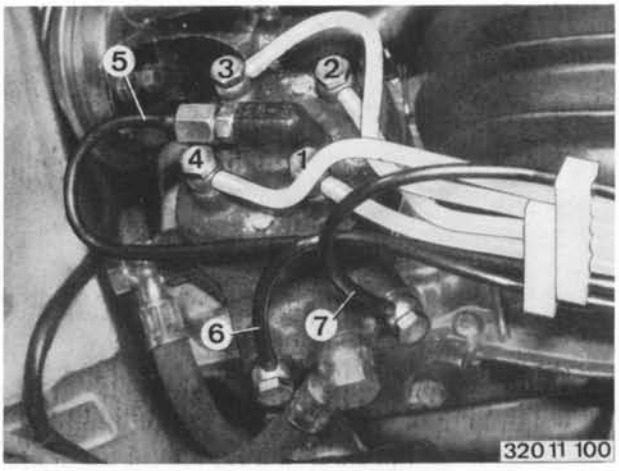
Caution! Disconnect starting relay (1) to prevent flooding the cylinders with fuel from injection valves each time the starter is operated.



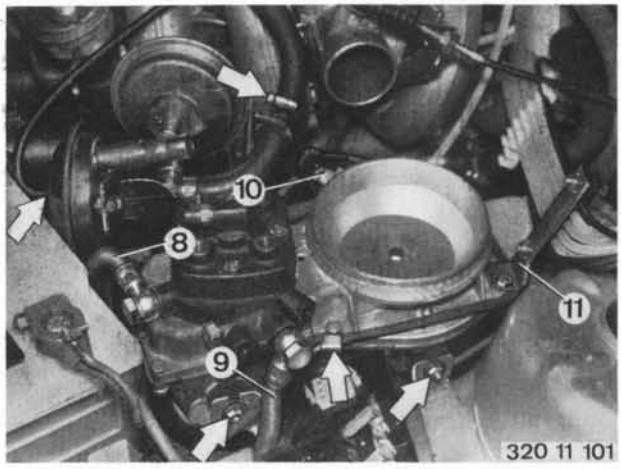
Remove spark plugs.
Check compression pressure [1].

11 00 050 REMOVING AND INSTALLING ENGINE

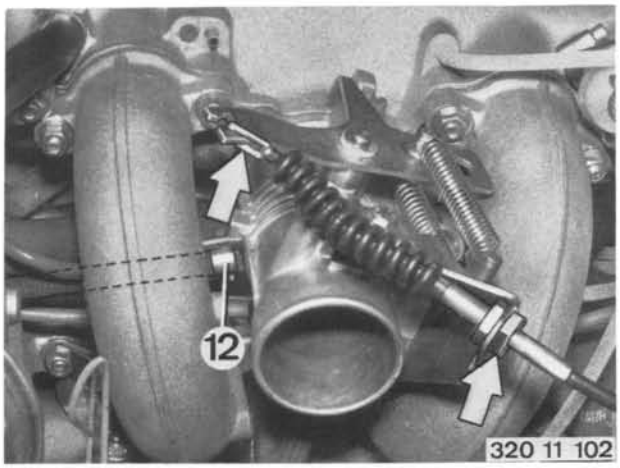
Remove transmission - 23 00 020.
Remove radiator - 17 11 000.
Take off intake cowl.
Disconnect wires to injection valves 1 ... 4.
Installation Note! Check seals and replace if necessary.
Detach fuel lines (5 ... 7).
Installation Note! Line (5 and 6) to warm-up sensor
Line (7) to cold start valve



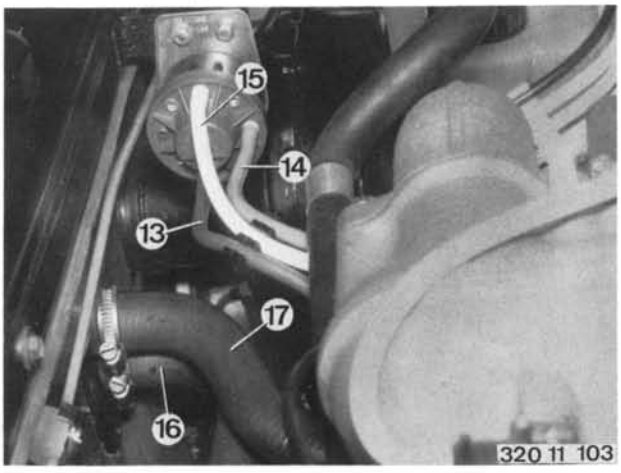
Detach fuel feed and return hoses (8 and 9).
Installation Note! Hose (8) to fuel filter outlet
Hose (9) to fuel tank
Pull plug (10) off of air-flow sensor and lift harness out of holders.
Detach vacuum hoses.
Disconnect holder (11) on air-flow sensor.
Detach mixture control unit at wheelhouse and remove from above.



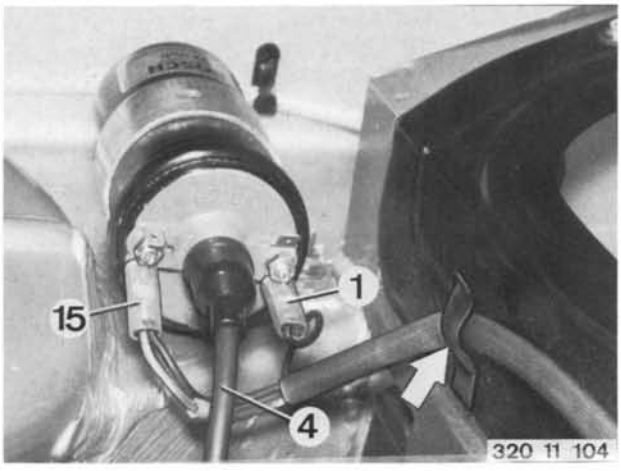
1) See Specifications



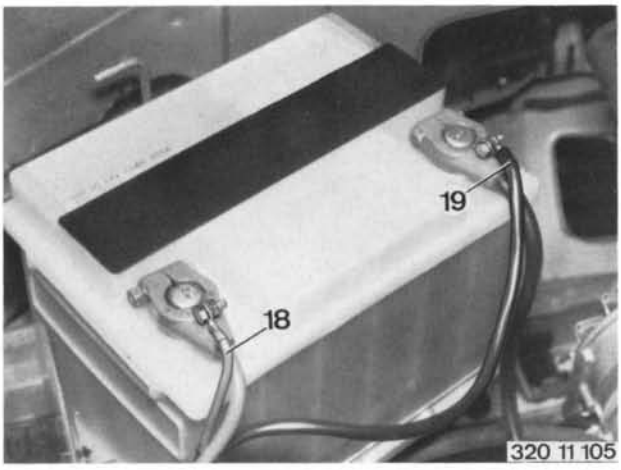
Detach accelerator cable and take off of counter-holder.
Installation Note! Adjust accelerator cable (see 35 41 520).
Detach hose (12) at throttle housing.



Detach hoses (13 ... 15) at pressure converter.
Installation Note! Hose (13) red
Hose (14) blue
Hose (15) white
Detach warm water hoses (16 and 17).
Caution! Be careful not to mix up hoses.
Hose (16) down from cylinder head.
Hose (17) to return line.

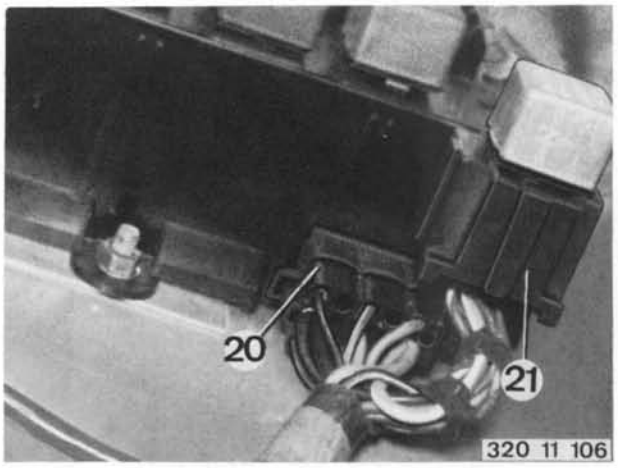


Disconnect wires 4, 1 and 15 at ignition coil.
Installation Note! black - terminal 1
green - terminal 15
Take harness out of holders on wheelhouse.

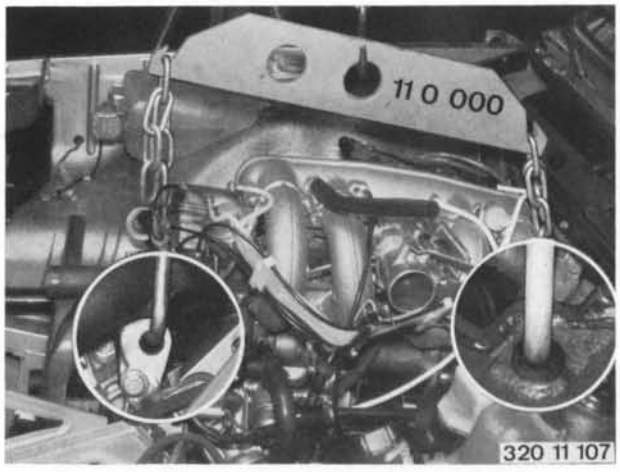


Detach wire (18) at minus line and wire (19) at plus line.
Remove battery.

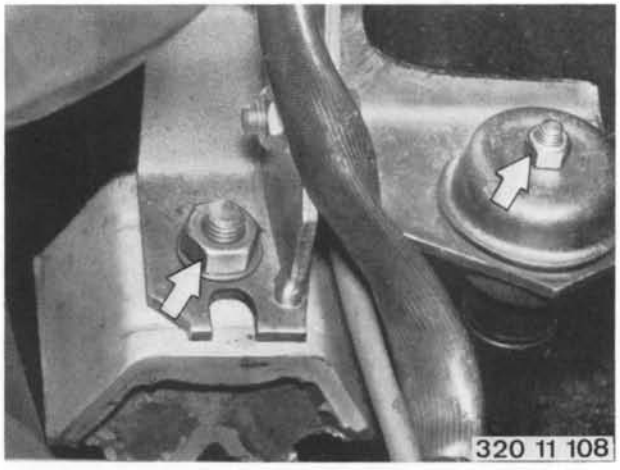
Remove cover.
Pull off or lift out central electrics plug (20) and plug (21).
Take harness out of holders on wheelhouse.



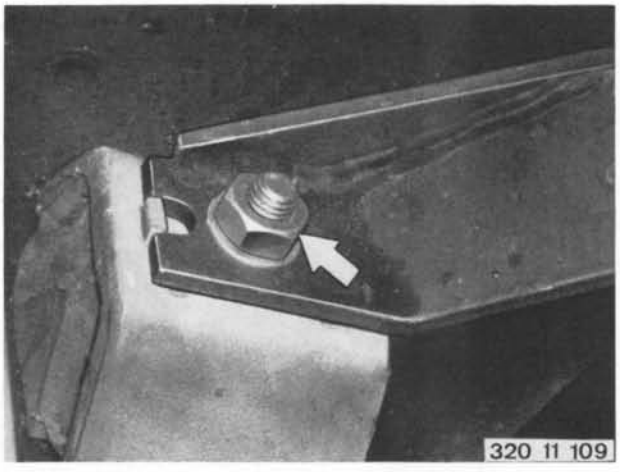
Connect engine to front and rear of engine lifter 11 0 000.

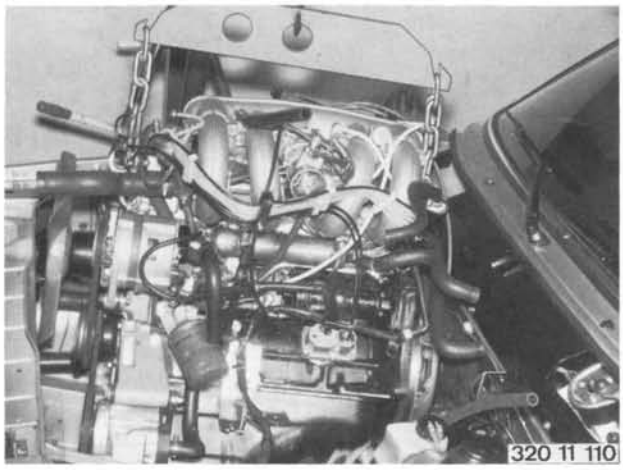


Detach left engine mount.
Detach upper engine damper.



Detach right engine mount.

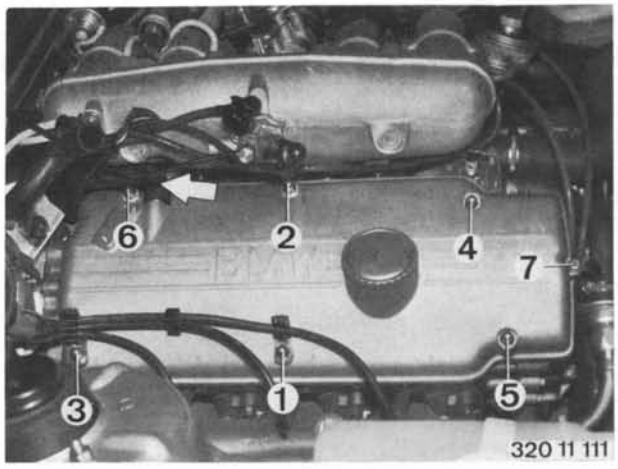




Lift out engine.

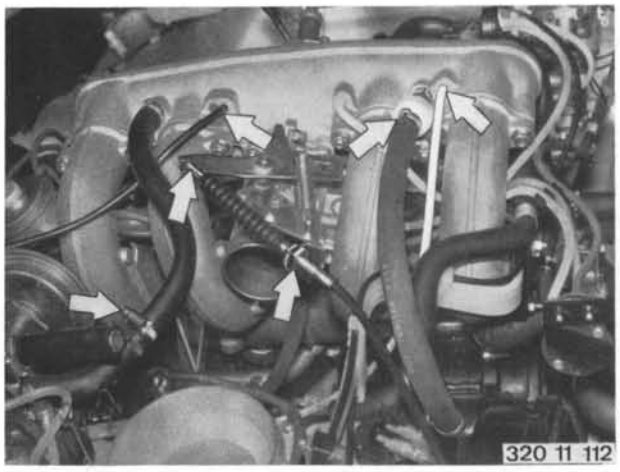
11 12 000 REMOVING AND INSTALLING CYLINDER HEAD COVER

Take auxiliary air valve off of cylinder head cover.
Detach vent hose.
Remove cylinder head cover.
Installation Note! Tighten nuts and bolts in sequence 1 ... 7.



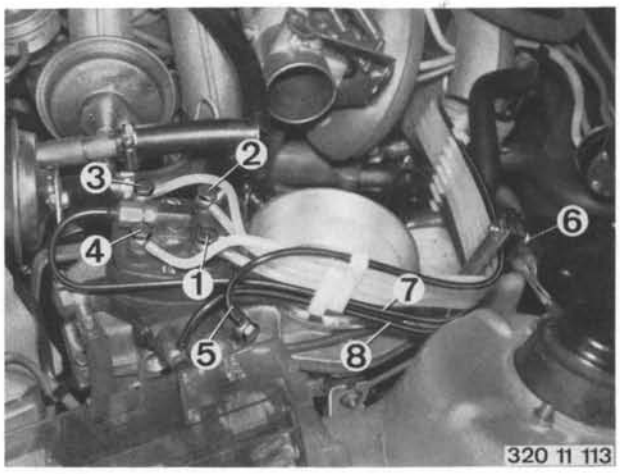
11 12 100 REMOVING AND INSTALLING CYLINDER HEAD

Open engine hood.
Cover side section (protective covers).
Detach minus line at battery.
Drain coolant.
Installation Note! Set heater lever at "warm" before refilling cooling system. Pour in water and tighten radiator cap by turning it to stop II. Heat coolant to 80° C (176° F). Bleed cooling system after thermostat has opened.
Check coolant level and screw on radiator cap to stop II.

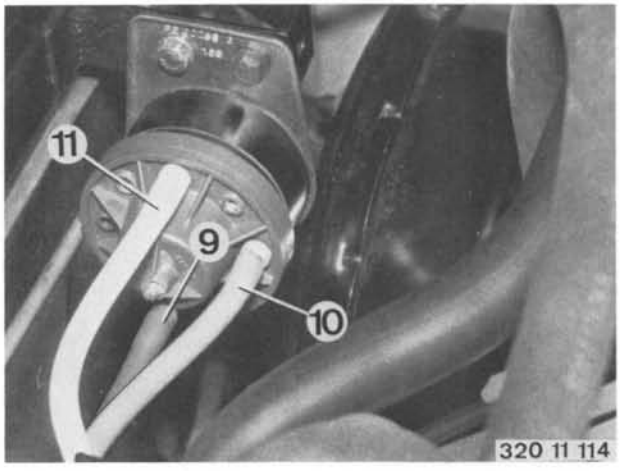


Remove intake cowl.
Detach vacuum hoses.
Detach accelerator cable and take it out of counter-holder.
Installation Note! Adjust accelerator cable (see 35 41 420).

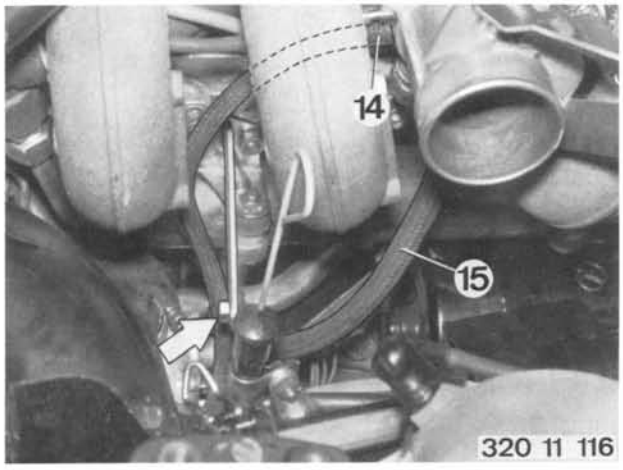
Detach wires to injection valves 1 ... 4.
Installation Note! Check seals and replace when necessary.
Detach wire (5) and holder (6).
Lift wires (7 and 8) out of holder.



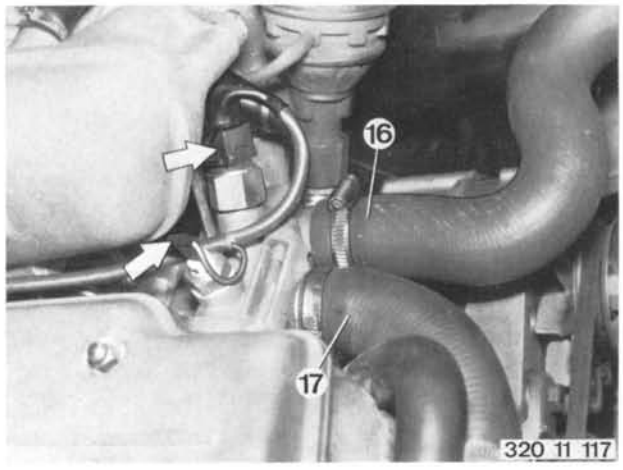
Detach pressure converter hoses (9 ... 11).
Installation Note! Hose (9) red
Hose (10) blue
Hose (11) white



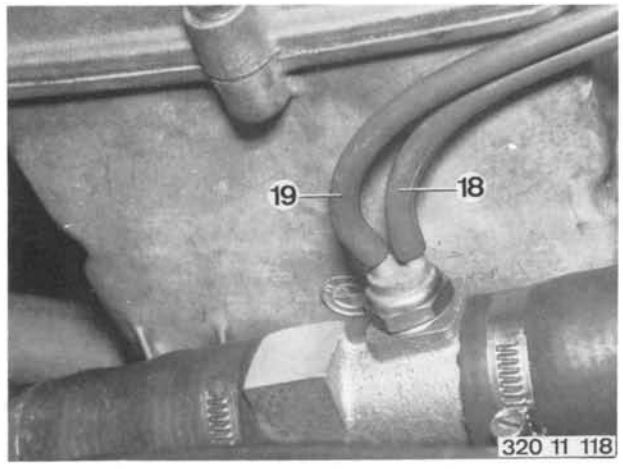
Detach warm water hoses (12 and 13) at cylinder head and crankcase.
Detach holders.



Detach hoses (14 and 15) at throttle housings.
Remove oil dipstick clamp.

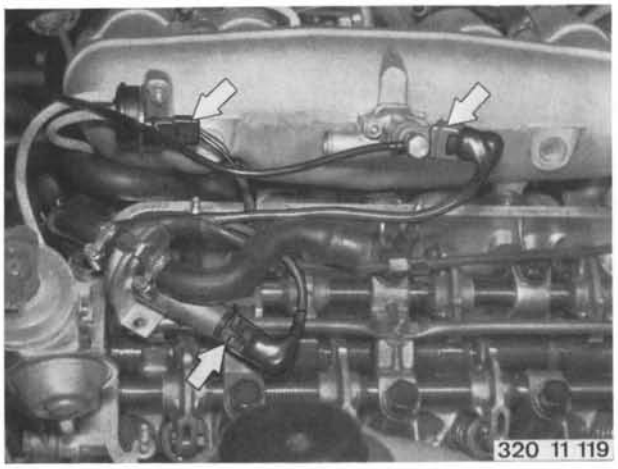


Remove warm water hoses (16 and 17).
Disconnect wires and plugs at temperature sensor and temperature timing switch.



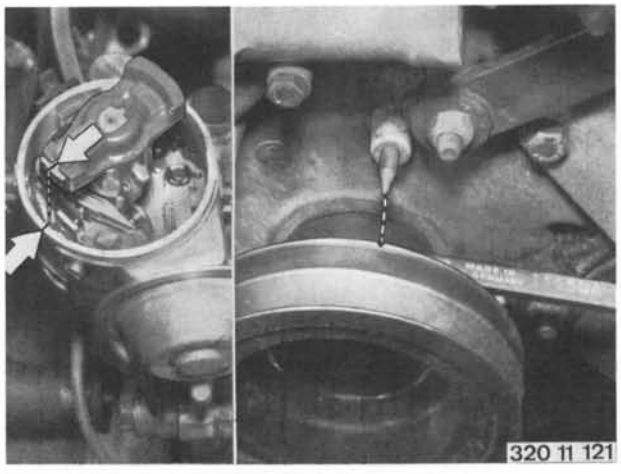
Detach hoses (18 and 19) at thermo valve.
Installation Note! Hose (18) outer to throttle housings
Hose (19) center to EGR valve

Remove upper timing case cover - 11 14 100.
Disconnect plug connectors and ignition coil wire 4.
Remove distributor cap.
Pull plugs off of cold start valve, auxiliary air valve and timing valve.

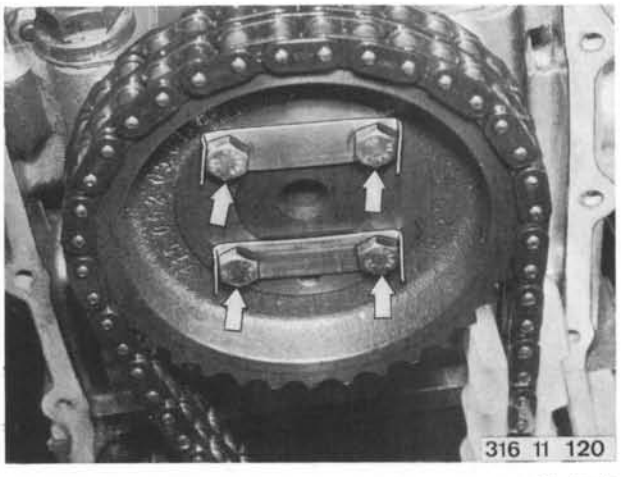


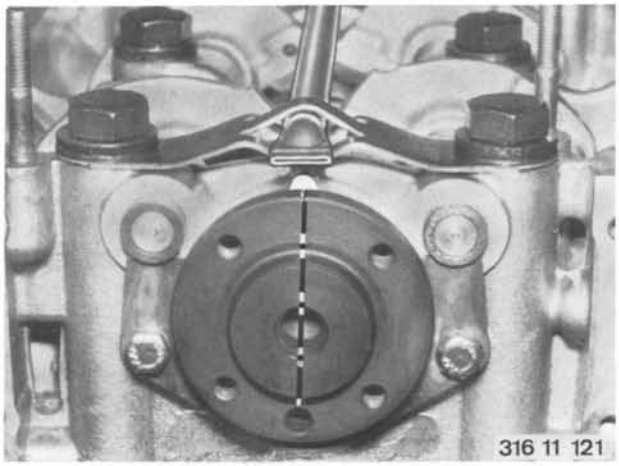
Disconnect wire 1 at distributor and wire at oil pressure switch.
Take harness out of holder.

Set piston of cylinder 1 at TDC.
Distributor rotor points to notch in distributor housing.
Indicator points to notch in pulley.

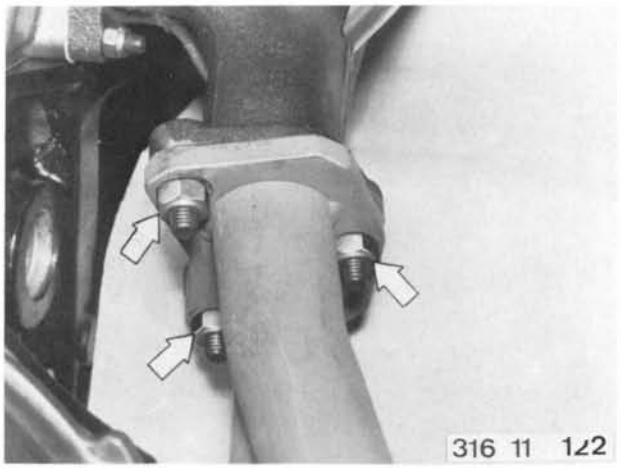


Remove chain tensioner piston - 11 31 090.
Open lockplates.
Remove sprocket.





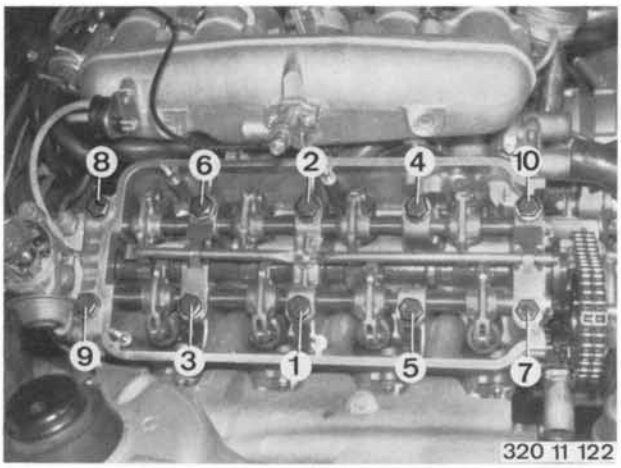
Installation Note! Install timing chain that bore for dowel pin faces down. Notch in camshaft flange must align with cast tab on cylinder head.



Detach exhaust pipe at exhaust manifold and holder on transmission.
Installation Note! Check gaskets and replace when necessary.

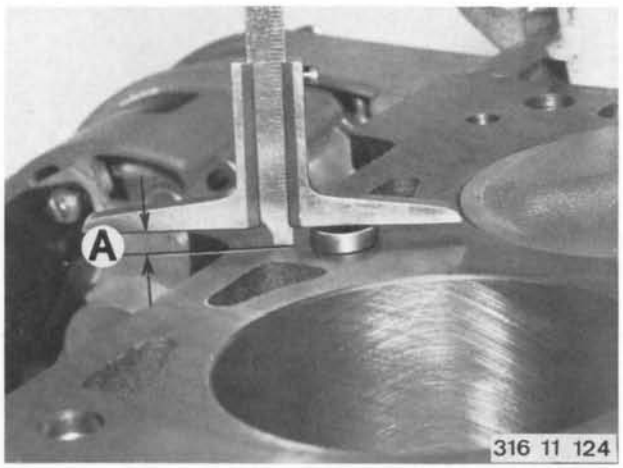
Loosen cylinder head bolts and remove cylinder head.
Installation Note! Tighten bolts in three steps one after the other in sequence 1 ... 10. 1)
Run engine to operating temperature. After trial run let engine cool down to 35° C (95° F).
Tighten cylinder head bolts to final torque 1).

Caution! Tighten cylinder head bolts again after 1000 km (600 miles).



Installation Notes! Check projection of dowel sleeves for cylinder head and its gasket with a depth gauge.
Max. projection (A) is 5 mm (0.2 in.).

Caution! If there is oil in the blind holes, the bolts cannot apply sufficient pressure against the cylinder head even though specified torque is used. Besides the crankcase could crack.
Always install a new cylinder head gasket.
Clean cylinder head bolts and apply light coat of oil.
Clean mating surfaces on cylinder head and crankcase thoroughly.
Installation Note! Only use cylinder head gaskets from manufacturer, since coolant flow openings must be exact.
Installation Note! Coat timing case mating surface with Atmosit or Curil K 2.
Grind down cylinder head surface if necessary - 11 12 719.
Adjust valve clearance - 11 34 004.
Adjust engine idle speed - 13 00 004.

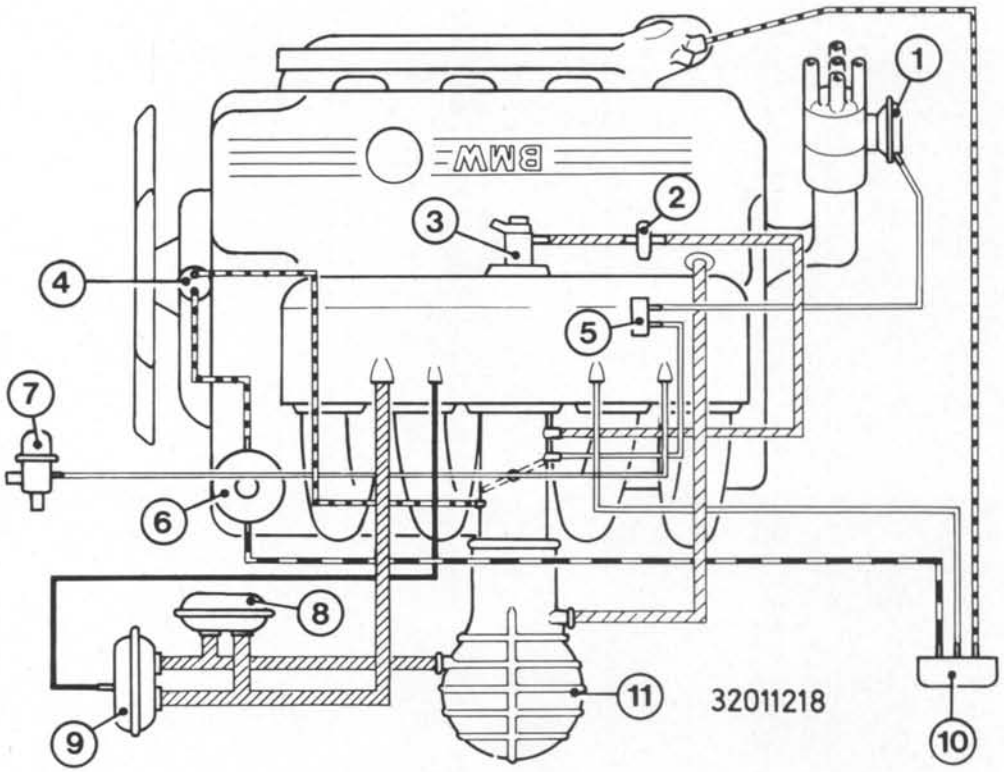


1) See Specifications

Hose Location Layout

1 Distributor
2 Auxiliary air valve
3 Cold start valve
4 Thermo valve
5 Timing valve
6 EGR valve
7 Blow-off valve
8 Auxiliary air valve
9 Vacuum limiter
10 Pressure converter
11 Intake cowl

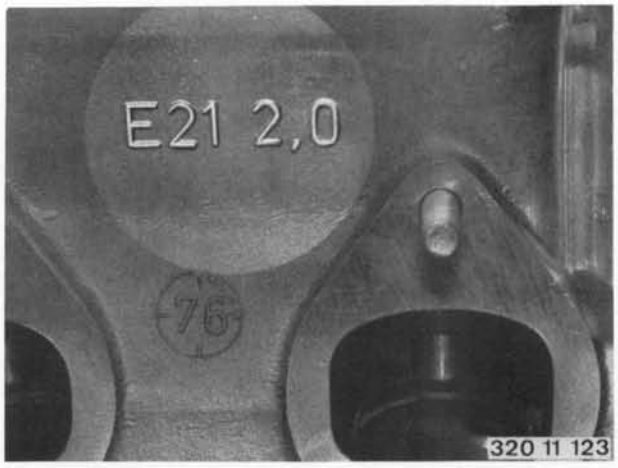
red
white
blue
black



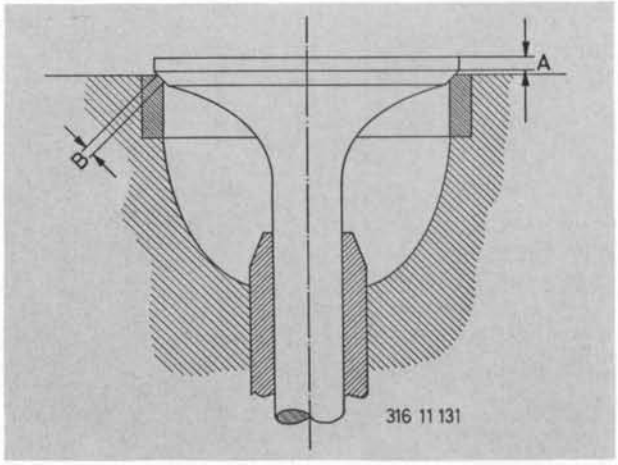
11 12 161 REPLACING CYLINDER HEAD
(No Installation Parts)

Remove cylinder head - 11 12 100.
Remove valves - 11 34 550.

Caution! Only use cylinder heads with double semi-spherical combustion chambers. Code E 21-2.0 on left-hand side.



Check valves.
Note minimum head edge thickness[1] and valve seat angle B. Replace valve, if minimum valve head edge thickness cannot be held.
Grind valves.
Install valves and gasoline test them for leaks - 11 34 509.
Take attachments off of old head and install on new head.

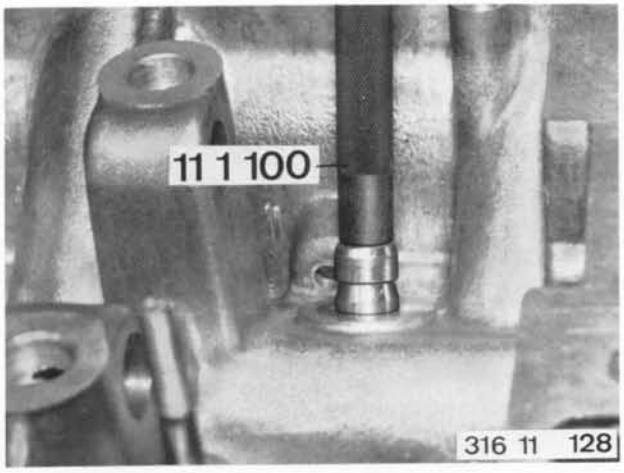


1) See Specifications

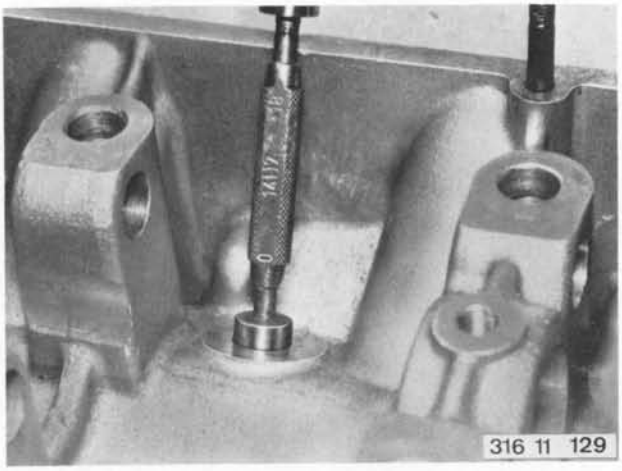
11 12 591 REPLACING VALVE GUIDES

- Valves Removed -

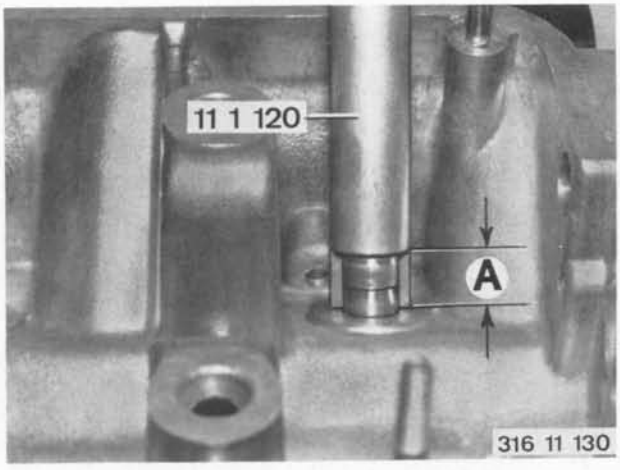
Check valve guides[1] for wear.



If maximum wear limits are exceeded, drive out cold valve guide into combustion chamber with mandrel 11 1 100.



Check bore in cylinder head. If permissible diameter is exceeded, ream bore and install an oversize valve guide 1).



Heat cylinder head[1].
Press valve guide into combustion chamber toward camshaft end.
Taper groove faces camshaft end.

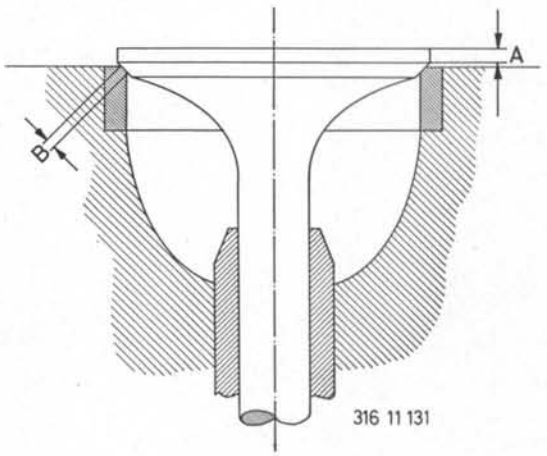
Caution! Bore in mandrel 11 1 120 determines installation depth A of 15 - 0.5 mm (0.591 - 0.020").
Ream valve guide to specified inside diameter 1).

1) See Specifications

11 12 607 MACHINING VALVE SEATS AND VALVES

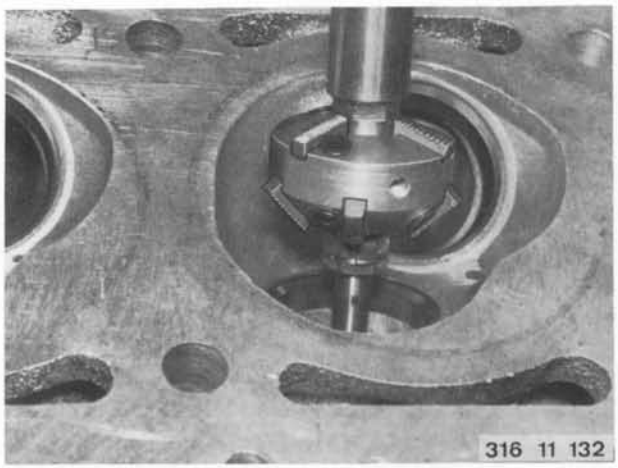
- Valves Removed -

Note minimum valve head edge thickness A[1] and valve seat angle B.
Replace valve, if minimum valve head edge thickness cannot be held.



Machine valve seats.
Machined valve seats may not have chatter marks.

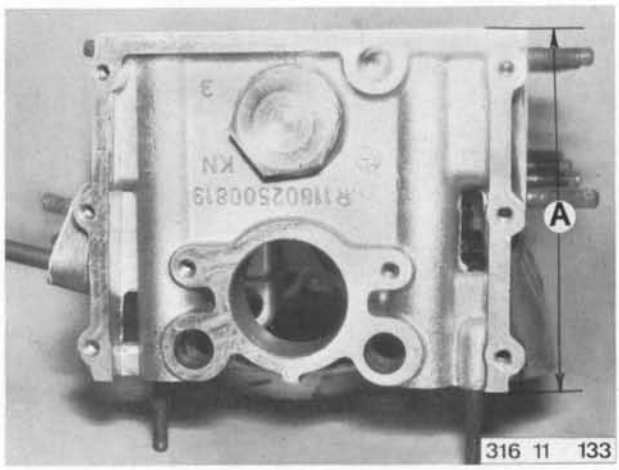
Installation Note! Check valves for leaks with gasoline test - 11 34 509.



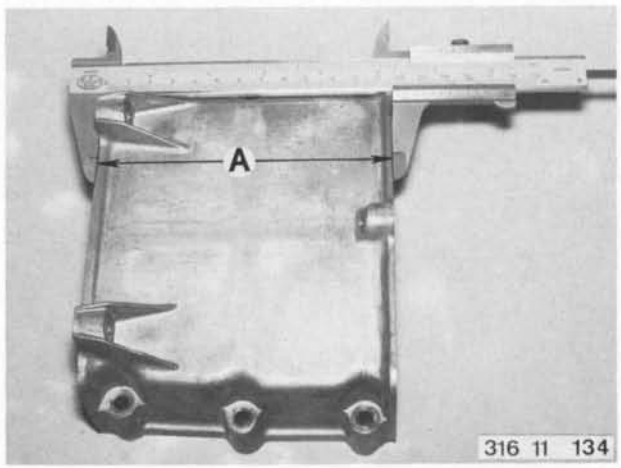
11 12 719 GRINDING CYLINDER HEAD SEALING SURFACE

- Valves Removed -

When machining cylinder head sealing surface more than 0.3 mm (0.012 in.) may not be removed from total thickness A - 129 ± 0.1 mm (5.079 ± 0.004") - of original cylinder head size.



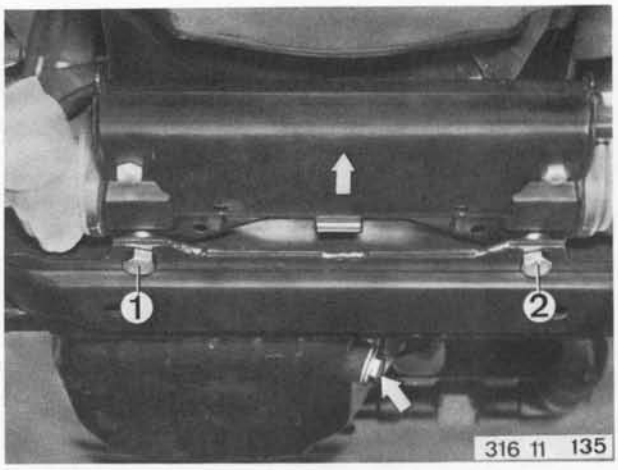
This requires machining upper timing case cover accordingly.



1) See Specifications

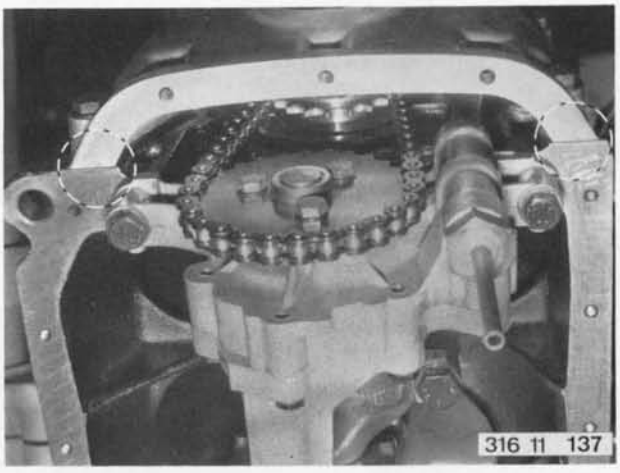
11 13 000 REMOVING AND INSTALLING OIL PAN

Loosen bolts (1 and 2).
Pull steering off of front axle carrier.
Drain engine oil.
Detach oil pan.



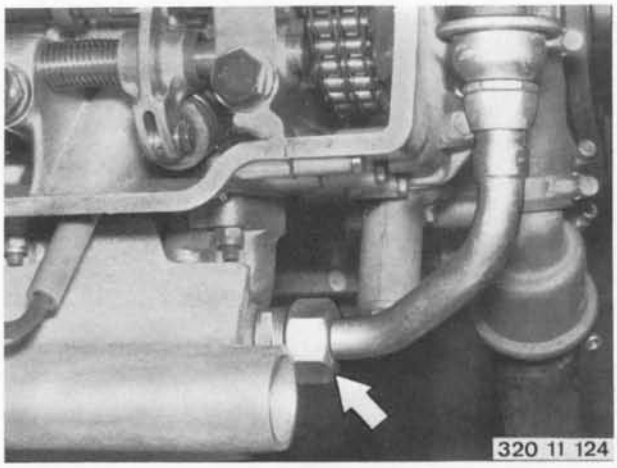
Swing down oil pan.
Turn crankshaft and remove oil pan toward front.

Installation Note! Clean sealing surfaces.
Coat mating surfaces at timing case cover and end cover with Atmosit or Curil K 2.



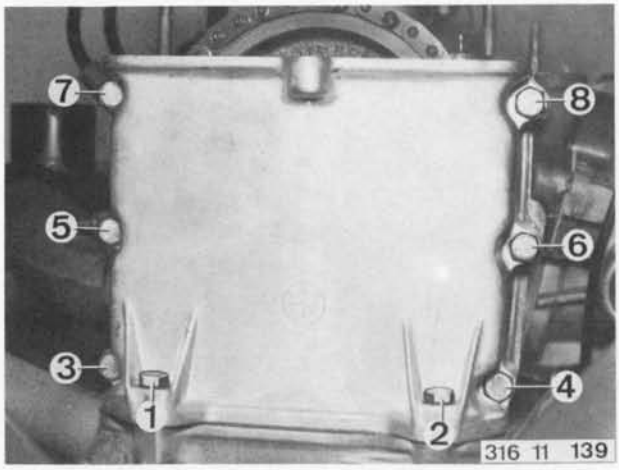
11 14 100 REMOVING AND INSTALLING/SEALING UPPER TIMING CASE COVER

Remove cylinder head cover - 11 12 000.
Detach pipe at exhaust manifold.



Detach timing case cover.

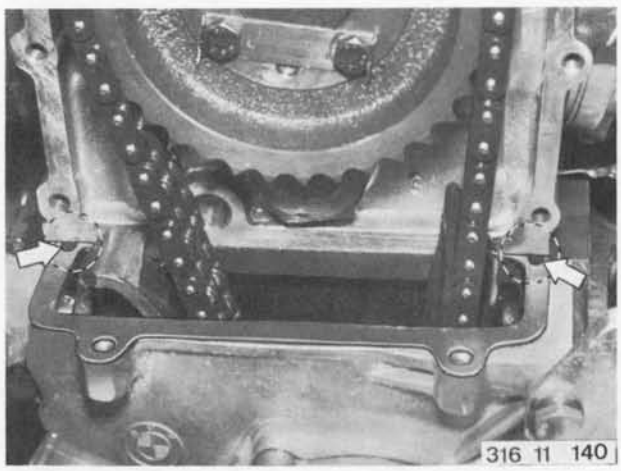
Installation Note! Tighten bolts 1 and 2 slightly. Then tighten screws 3 through 8 in sequence and finally screws 1 and 2 to specifications.



To improve the seal between cylinder head and timing case cover, two additional bores have been made on the cylinder head gasket.

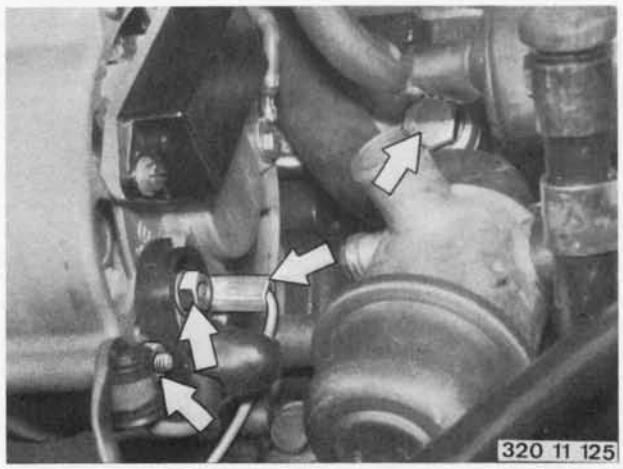
Caution! Fill bores with Dirko sealing compound before installation of timing case cover.

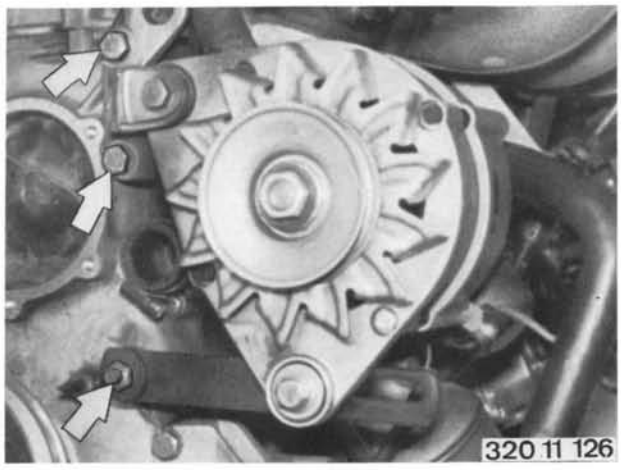
If cylinder head gasket is without bores, apply a coat of Atmosit or Curil K 2 to mating surfaces between cylinder head and timing case cover.
If cylinder head gasket is damaged, remove cylinder head (see 11 12 100) and replace gasket.



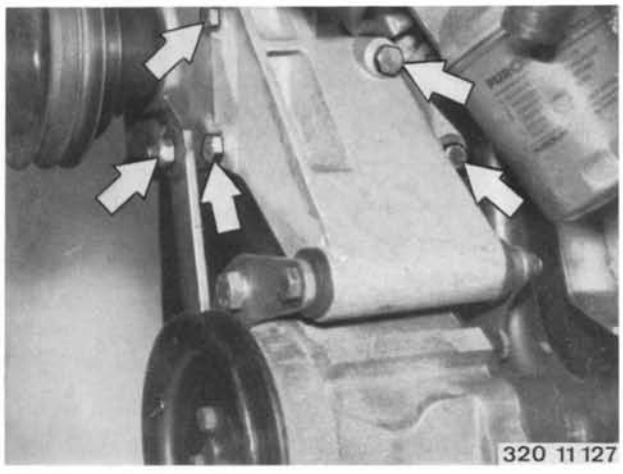
11 14 120 REMOVING AND INSTALLING/SEALING UPPER AND LOWER TIMING CASE COVERS

Disconnect battery ground strap.
Remove water pump - 11 51 000.
Remove upper timing case cover - 11 14 100.
Remove chain tensioner piston - 11 31 090.
Detach wires at alternator.
Loosen bolt on crankcase.



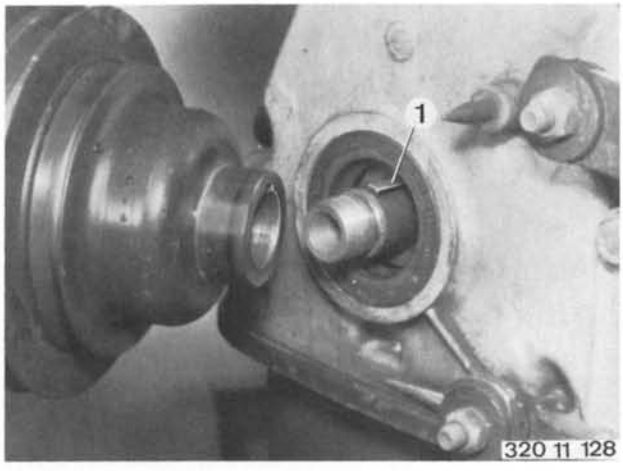


Remove alternator with holder and tensioning bar.



Remove air pump with holder and tensioning bar.

Remove guard.
Lock starter gear ring with Special Tool 11 2 100.



Loosen pulley nut[1)].
Pull off pulley.

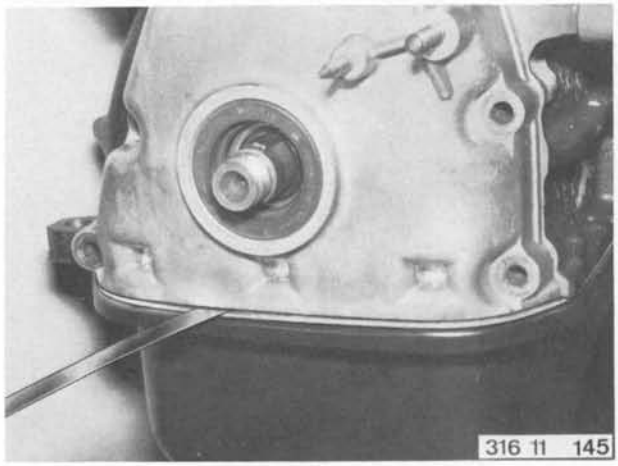
Installation Note! If hub is seriously worn, install seal that its sealing lip rests in front of or behind wear groove.

Make sure that woodruff key (1) is positioned correctly.

1) See Specifications for specified torque.

Remove bolts on timing housing cover and front of oil pan.
Loosen all other bolts of oil pan.

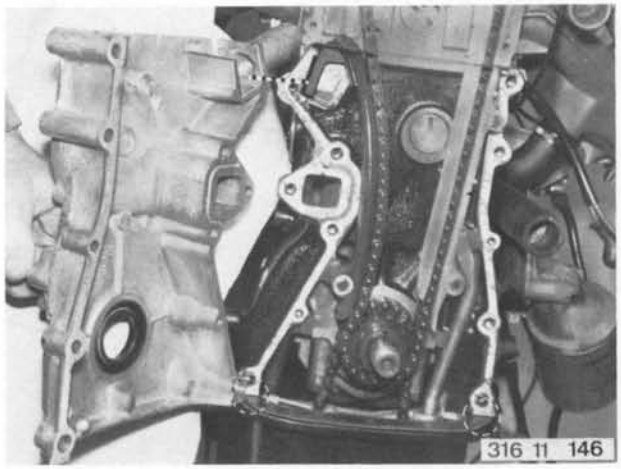
Caution! Use knife to carefully separate oil pan gasket from timing housing cover.



Remove timing housing cover.

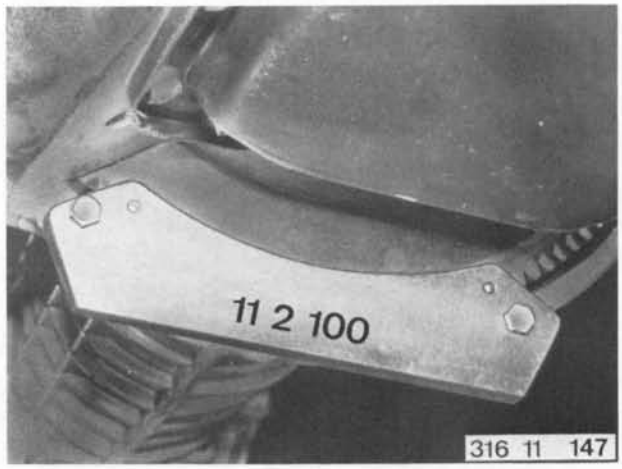
Installation Note! Coat mating surfaces between oil pan and crankcase with Atmosit or Curil K 2.

Caution! Tensioner piston take-up land must be in oil pocket.
If oil pan gasket is damaged, remove oil pan (see 11 13 000) and replace gasket.

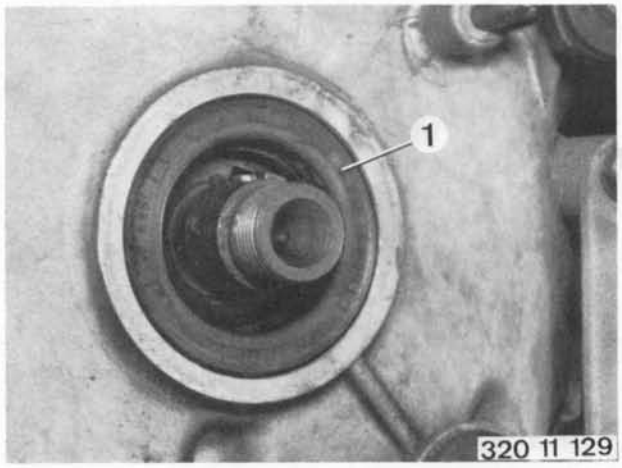


11 14 141 REPLACING RADIAL SEAL IN TIMING HOUSING COVER

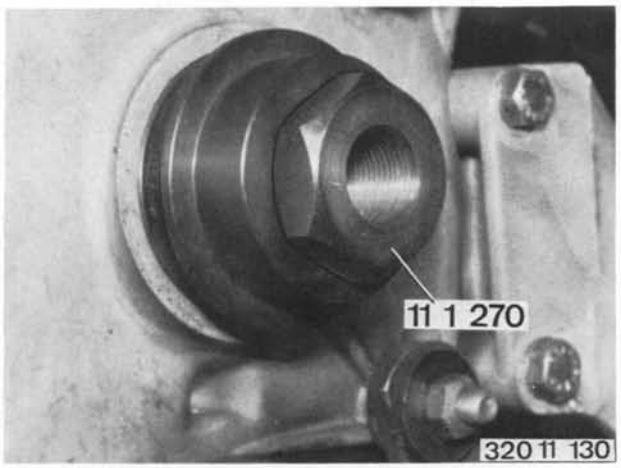
Take fan housing off of radiator.
Loosen alternator.
Remove v-belt.
Remove guard.
Lock starter gear ring with Special Tool 11 2 100.



Loosen pulley nut[1].
Pull off pulley.
Lift out radial seal (1).

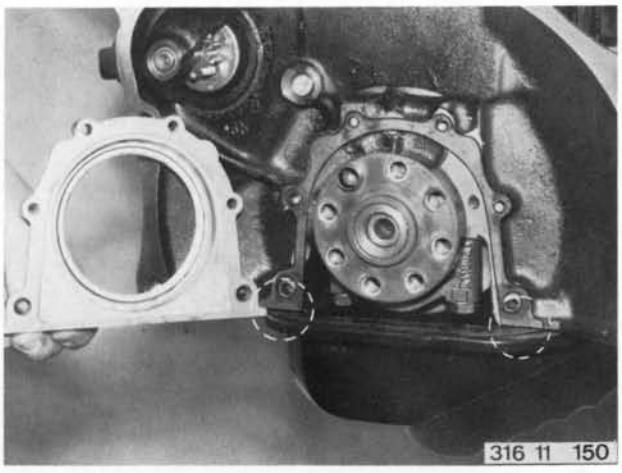


1) See Specifications for specified torque.



Fill radial seal with grease.
Install radial seal with Special Tool 11 1 270.

Installation Note! If hub is seriously worn, install seal that its sealing lip is in front of or behind the wear groove.

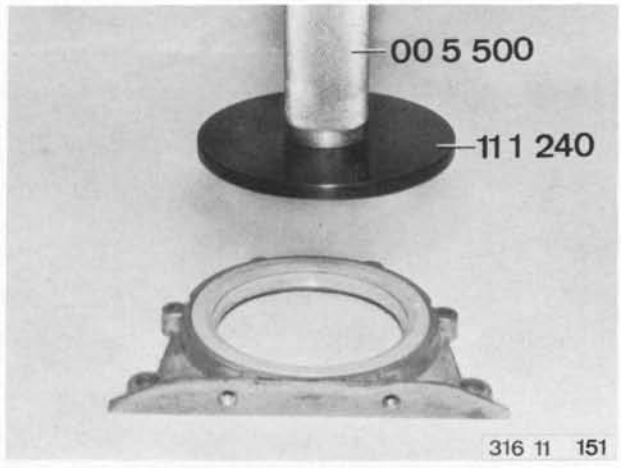


11 14 611 REPLACING RADIAL SEAL IN END COVER

- Flywheel Removed -

Loosen rear oil pan bolts partially.
Separate gasket carefully with a knife in area of end cover/oil pan mating surface.
Remove end cover.
Press radial seal out of end cover.

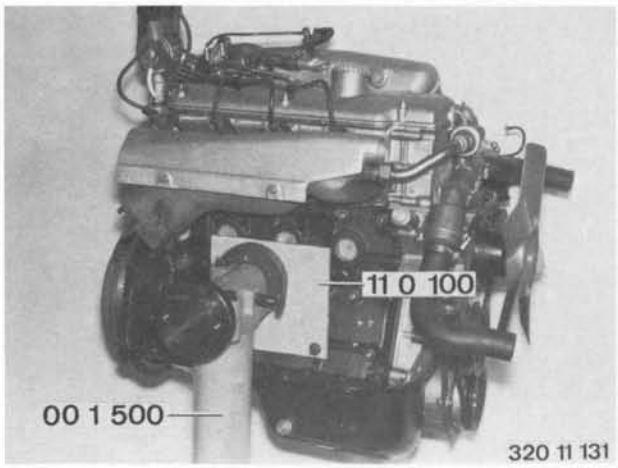
Installation Note! Coat end cover/oil pan mating surfaces with Atmosit or Curil K 2.
If oil pan gasket is damaged, remove oil pan (see 11 13 000) and replace gasket.



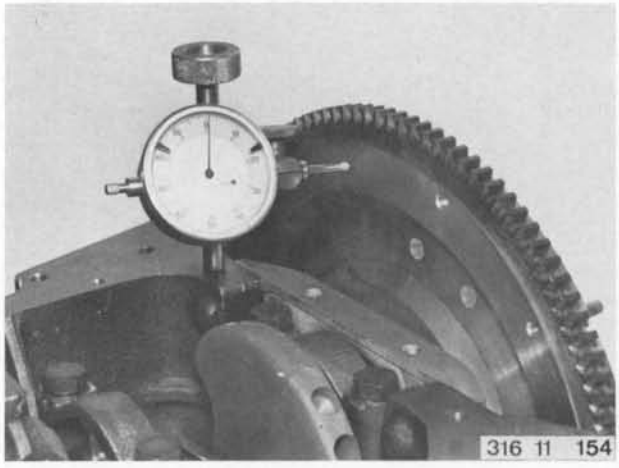
Fill cavity between sealing lips with grease.
Install radial seal with Special Tools 11 1 240 and 00 5 500.

11 21 000 REMOVING AND INSTALLING CRANKSHAFT

Remove engine - 11 00 050.
Remove engine suspension.
Bolt crankcase to Special Tool 00 1 500 with Special Tool 11 0 100.

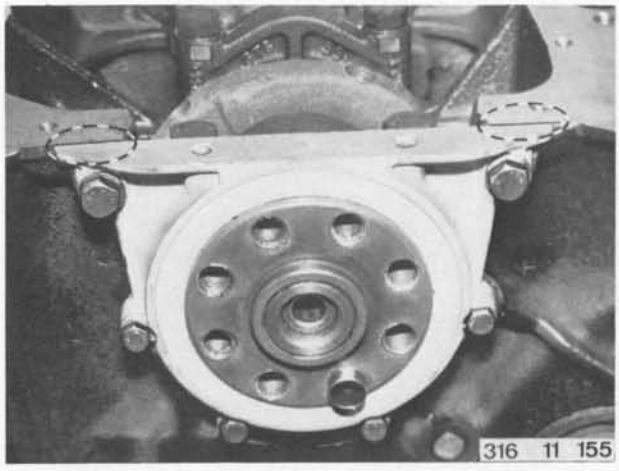


Detach clutch - 21 21 000.
Remove timing chain - 11 31 051.
Detach oil pump - 11 41 000.
Before removing crankshaft check axial play[1].
Check main bearings if maximum permissible axial play is exceeded.

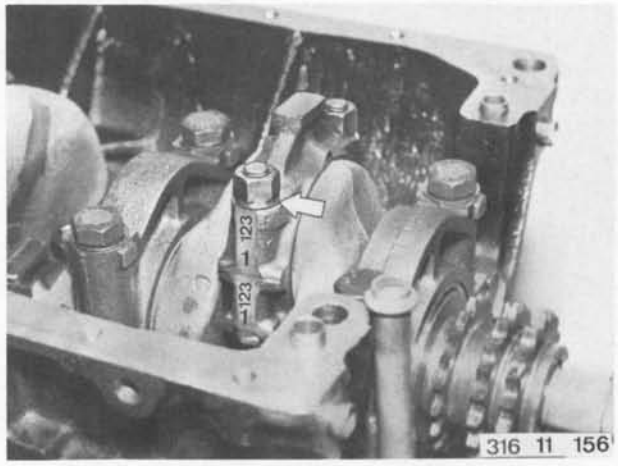


Remove flywheel - 11 22 000.
Remove end cover.

Installation Note! Coat end cover/oil pan mating surface with Atmosit or Curil K 2.



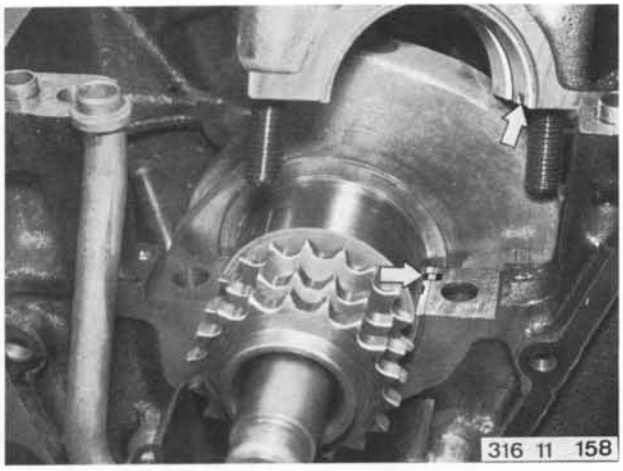
Mark connecting rods and bearing caps to pertinent cylinders.
Connecting rod 1 is at sprocket end.
Remove conrod bearing caps in BDC position.
Machining figures must always be on same side.
Narrow collar of nut faces bearing cap.



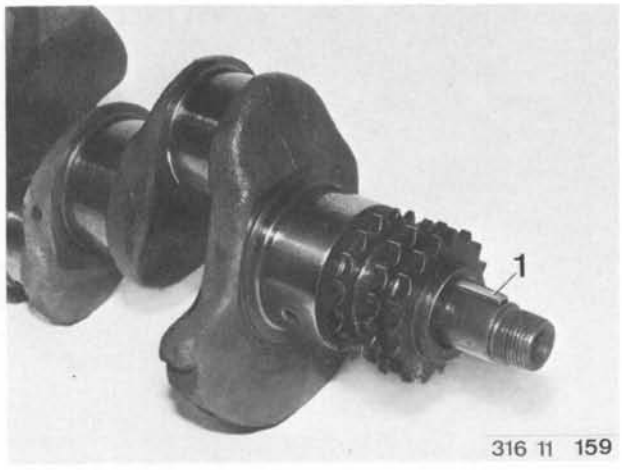
1) See Specifications

Mark bearing caps.
Remove crankshaft bearing caps.
Lift out crankshaft.

Installation Note! Don't mix up bearing caps.
Bearing cap 1 is at sprocket end.
Bearing 3 is locating bearing.

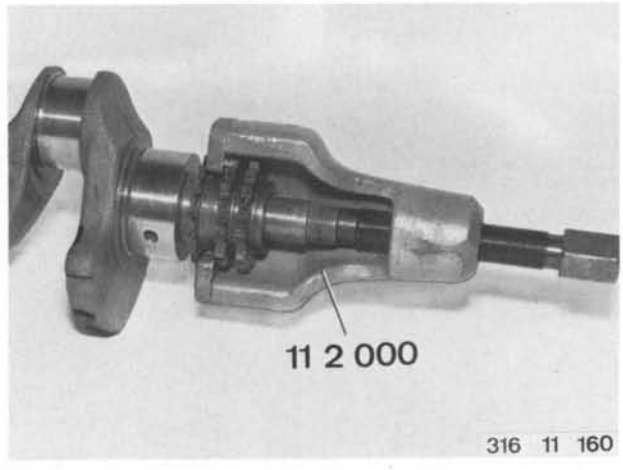


Installation Note! Install crankshaft bearing caps that groove is against groove.



11 21 501 REPLACING CRANKSHAFT
- Crankshaft Removed -

Remove woodruff key (1).



Extract sprocket with Special Tool 11 2 000.

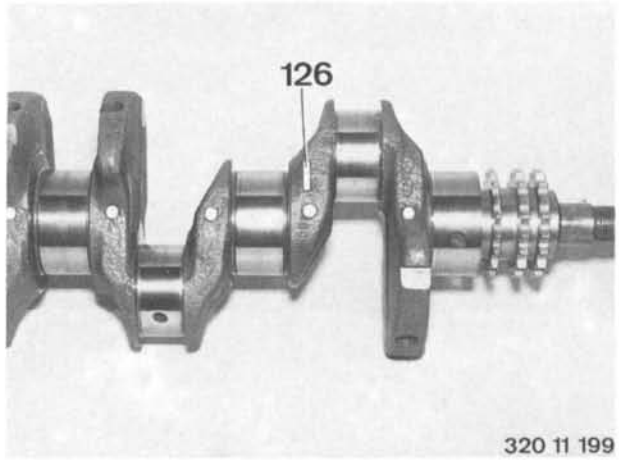
Installation Note! Heat sprocket.

Crankshaft identification marks:
Forging number on crankpin web.

BMW 320 i
1 252 126 or only 126
320 i A

Replace needle bearing race - 11 21 571.

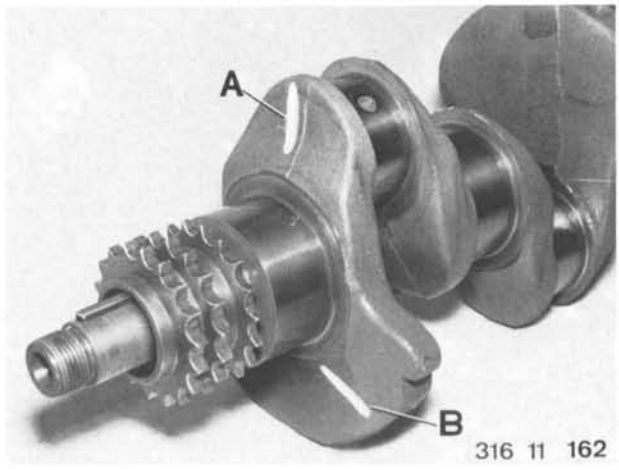
Crankshaft identification:
One red or blue dot of paint on sides of counterweights means standard size 1).



320 11 199

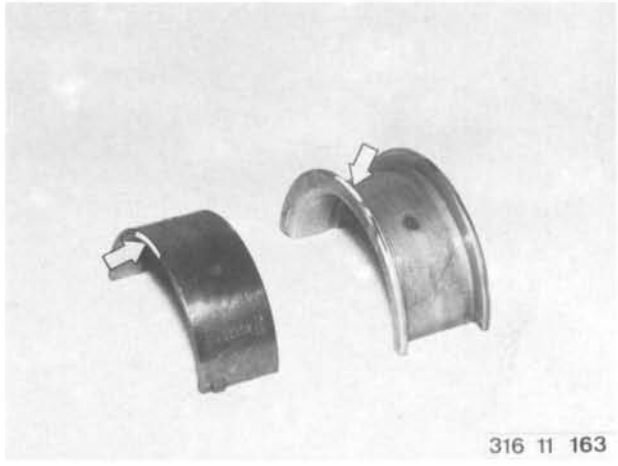
Ground crankshafts are marked with paint stripes.
Conrod Journals (A)
1 paint stripe Stage 1 1)
2 paint stripes Stage 2 1)
3 paint stripes Stage 3 1)
Main Bearing Journals (B)
1 paint stripe Stage 1 1)
2 paint stripes Stage 2 1)
3 paint stripes Stage 3 1)

Caution! Crankshaft is "tenifer" treated and should only be ground at the factory.



316 11 162

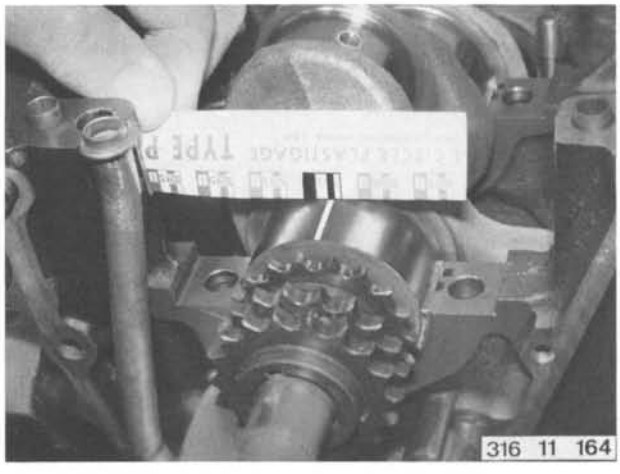
Always install bearing shells matching the particular bearing journal diameter, i.e. bearing shells must be marked with the same red or blue paint as on crankshaft.


316 11 163

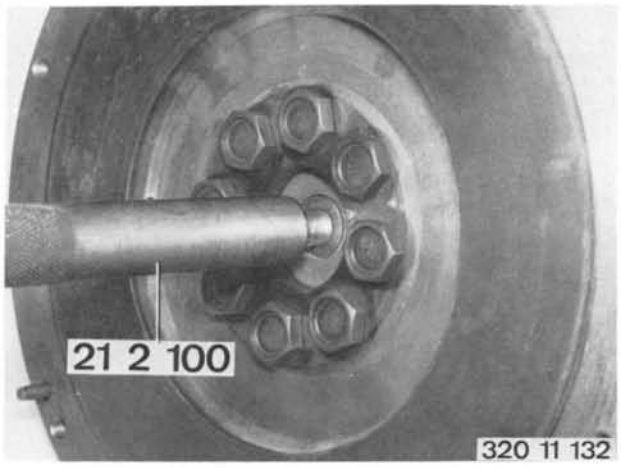
Check bearing play 1) with "plastigage".
Plastigage is available in three diameters.

Type	Color	Measuring Range
PG-1	green	0.025 ... 0.075 (.0010 ... .0030")
PR-1	red	0.050 ... 0.150 (.0020 ... .0060")
PB-1	blue	0.100 ... 0.230 (.0040 ... .0090")

a) Measure each bearing separately.
b) Bearing surface dry of oil.
c) Crankshaft at TDC for measuring.
d) Bearing cap at specified torque 1).
e) Don't turn crankshaft while measuring.
f) Read bearing play 1) on width of flattened plastigage with help of scale supplied.


316 11 164

1) See Specifications

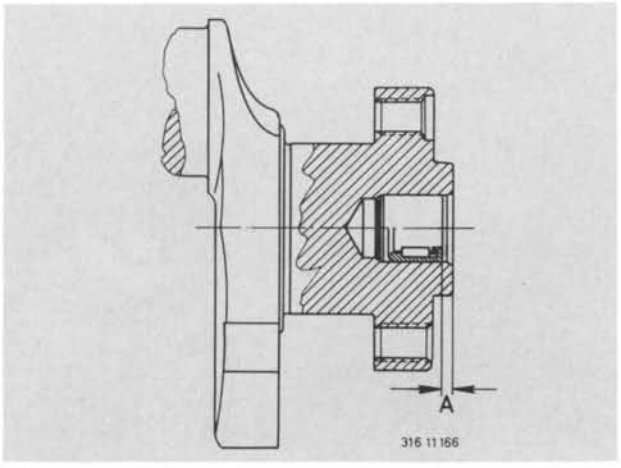


11 21 571 REPLACING NEEDLE BEARING RACE IN CRANKSHAFT

- Clutch Removed -

Fill bore in crankshaft with a kneadable compound (Terostat or similar).
Drive out needle bearing race with Special Tool 21 2 100.

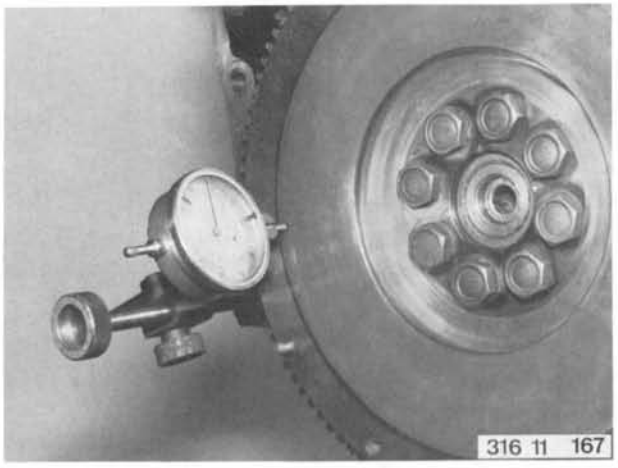
Installation Note! Install new needle bearing race with open end facing flywheel.



Drive in needle bearing race with appropriate mandrel.
Keep distance A of 3 mm (0.118 in.).
Fill needle bearing race with a branded multi-purpose grease.

11 22 000 REMOVING AND INSTALLING FLYWHEEL

Remove clutch - 21 21 000.
Check flywheel's axial play [1].

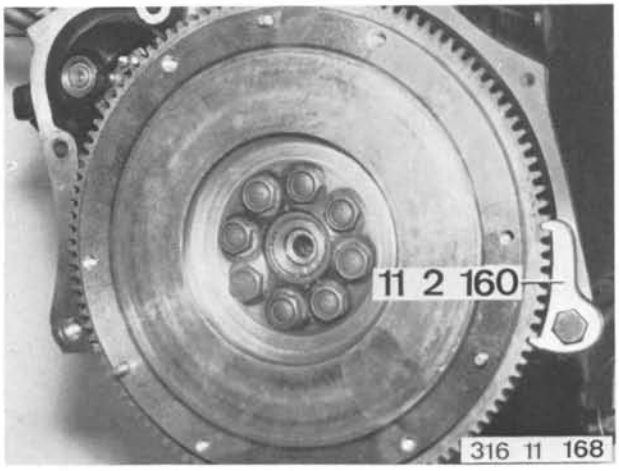


Lock flywheel with Special Tool 11 2 160.
Unscrew stretch bolts.

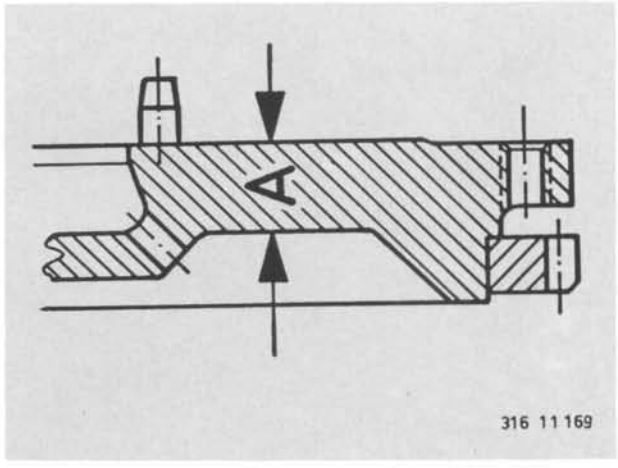
Caution! Replace stretch bolts and install with Loctite Code No. 270.

Clean threaded bores thoroughly.
Remove flywheel.

Installation Note! Note length and pitch of bolts.



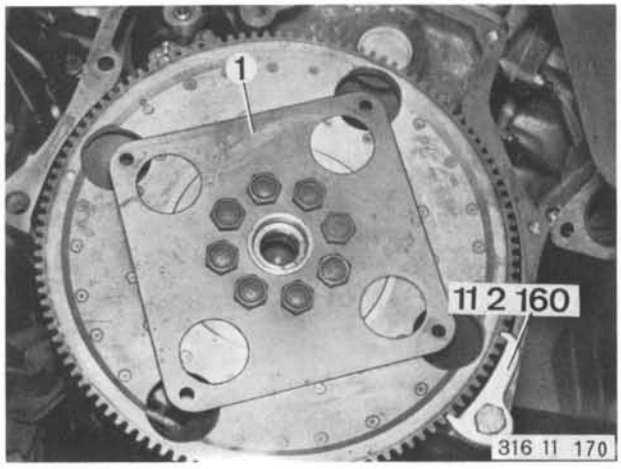
Installation Notes! Friction surface can be ground. But wall thickness within friction area may not be ground to less than 13.5 mm (0.531 in.) 1). See A.



11 22 051 REPLACING TORQUE CONVERTER DRIVE SHELL

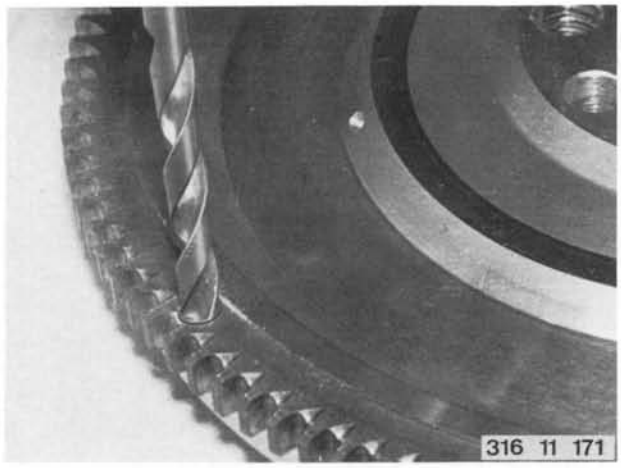
Remove transmission - 24 00 020.
Lock flywheel with Special Tool 11 2 160.
Unscrew stretch bolts.
Replace drive shell (1).

Installation Note! Replace stretch bolts and install with Loctite Code No. 270.
Clean threaded bores thoroughly.

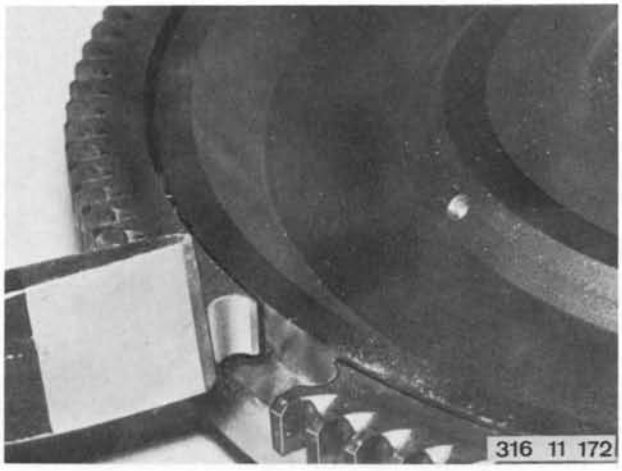


1) See Specifications

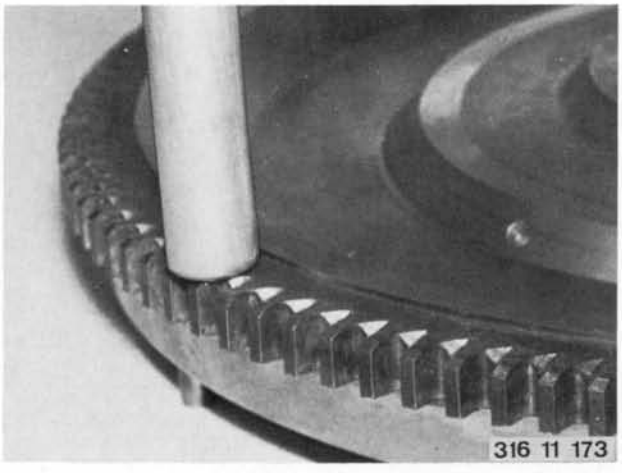
11 22 541 REPLACING STARTER GEAR RING



To facilitate removal of gear ring, drill a 6.5 mm (1/4 in.) diameter hole approx. 8 mm (0.315 in.) deep immediately below a tooth gap.



Split ring gear at drilled hole with a chisel.

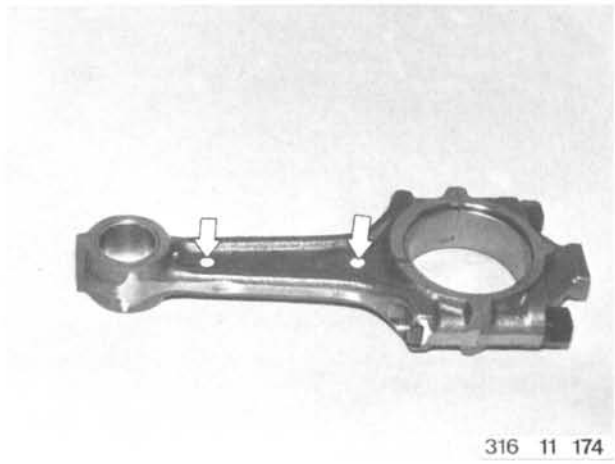


Installation Note! Heat new starter gear ring to 200 ... 230° C (395 ... 445° F).
Check with thermocolor pencil.
Chamfered side of teeth faces engine.
Use brass mandrel to drive on starter gear ring until it fits snugly.

11 24 501 REPLACING ONE CONNECTING ROD

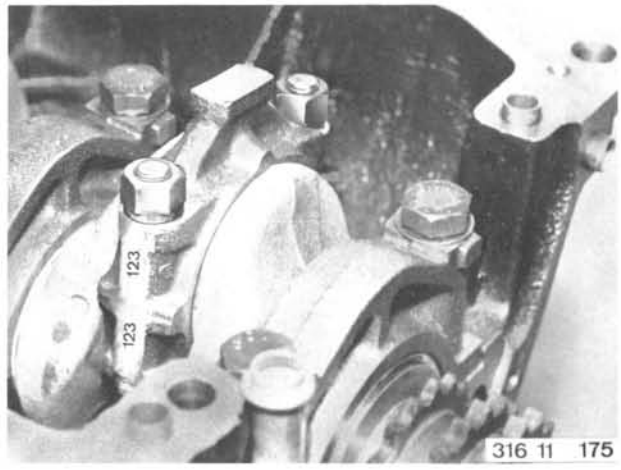
- Piston Removed -

Caution! Install connecting rods of same weight class in an engine so that the total tolerance is within $\pm$ 4 grams (without bearing shells).
A paint mark indicates the weight class. If paint mark cannot be found, remove a second connecting rod to compare weight.



316 11 174

Install conrod bearing shells in connecting rod.
Place plastigage on crankshaft bearing journal dried of oil.
Bolt connecting rod on crankshaft.
Machining figures must face in same direction.
Oil bore in conrod big end faces timing chain.

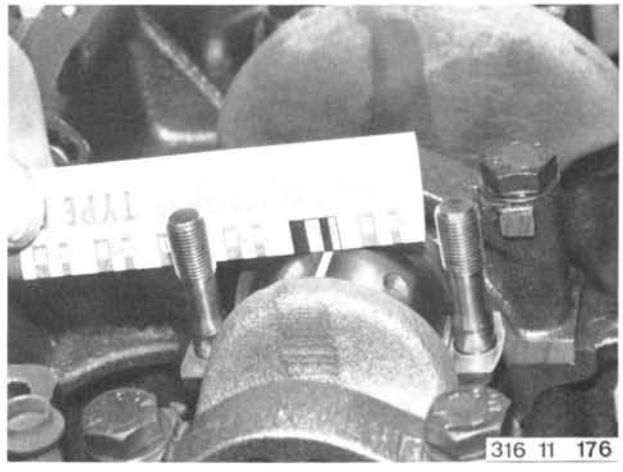


316 11 175

Bolt bearing cap to specified torque[1].

Caution! Don't turn crankshaft or conrod.
Remove bearing cap.
Read bearing play 1) on width of flattened plastigage with help of scale supplied.
Plastigage is available in three diameters.

Type	Color	Measuring Range
PG-1	green	0.025 ... 0.075 mm (.001 ... .003")
PR-1	red	0.050 ... 0.150 mm (.002 ... .006")
PB-1	blue	0.100 ... 0.230 mm (.004 ... .009")



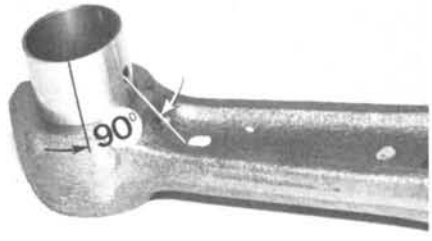
316 11 176

11 24 601 REPLACING ONE CONROD BUSHING

- Connecting Rod Removed -

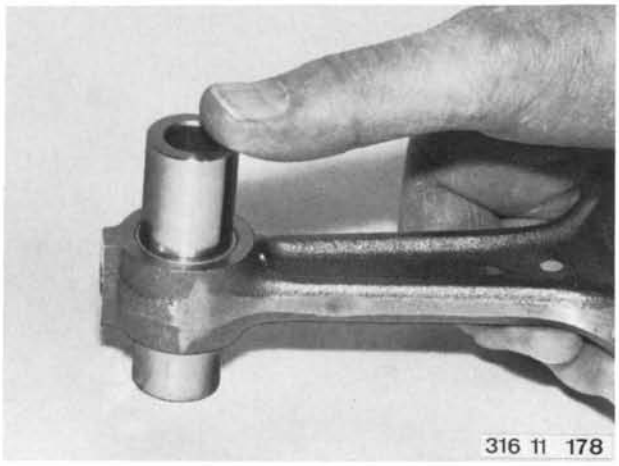
Connecting rods with machined small end bushings can be ordered from Parts Department.
Press out old bushing.

Installation Note! Press in new small end bushing that its end gap is at 90° angle to oil bore.

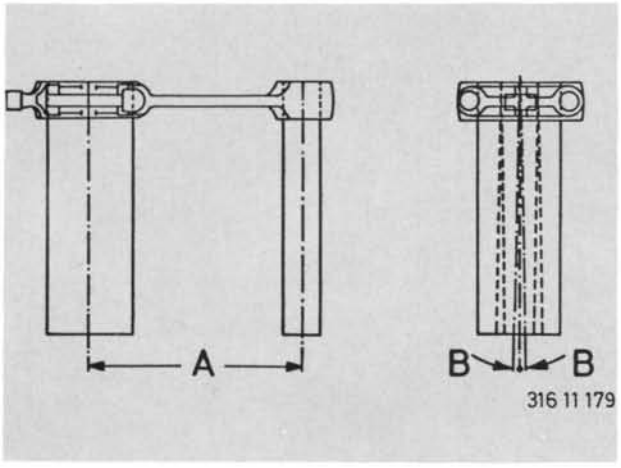


316 11 177

1) See Specifications



Drill, clean and deburr oil bores.
Ream open small end bushing 1).
Piston pin must slide through small end bushing under slight pressure.



Check connecting rod for deviation from parallel (A) and maximum permissible displacement (B), and correct if necessary.

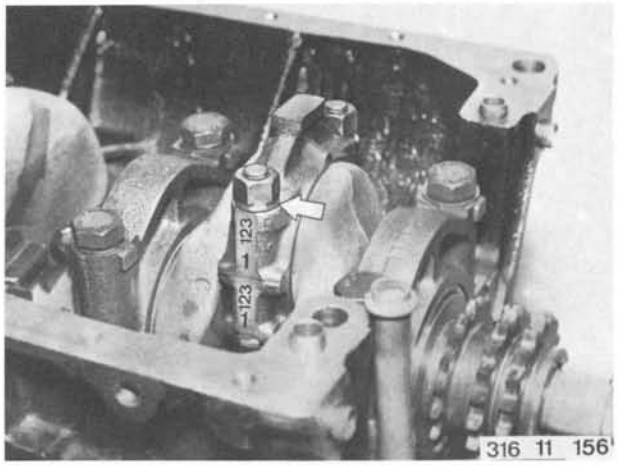
A = $150^{\ -0.04}$ mm ($5.906^{\ -0.002}$ in.)

B = 0° 30'

1) See Specifications for piston pin play.

11 25 000 REMOVING AND INSTALLING ALL PISTONS

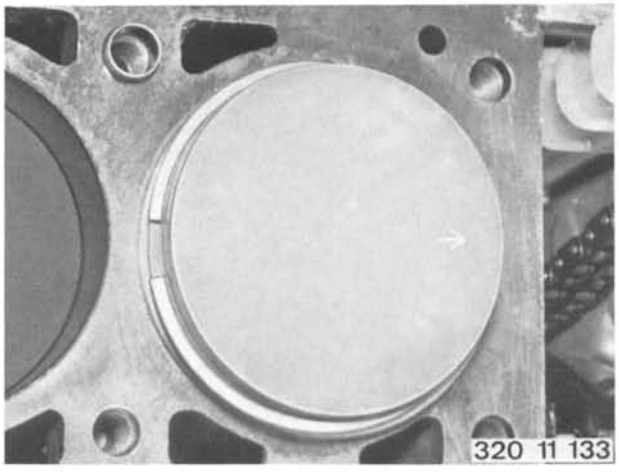
Remove engine - 11 00 050.
Remove cylinder head - 11 12 100.
Remove oil pan - 11 13 000.
Mark connecting rods and bearing caps to matching cylinders.
Connecting rod 1 is at sprocket end.
Remove conrod bearing caps in BDC position.
Machining figures must always face in same direction.
Narrow collar of nuts faces bearing cap.



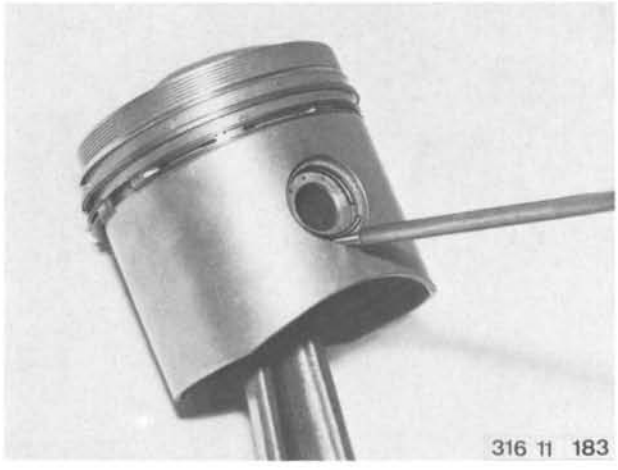
316 11 156

Press up piston and connecting rod to remove.

Installation Note! Offset piston ring end gaps to each other by 180°.
Arrow on piston crown faces timing chain.


320 11 133

Remove circlip.
Press out piston pin.

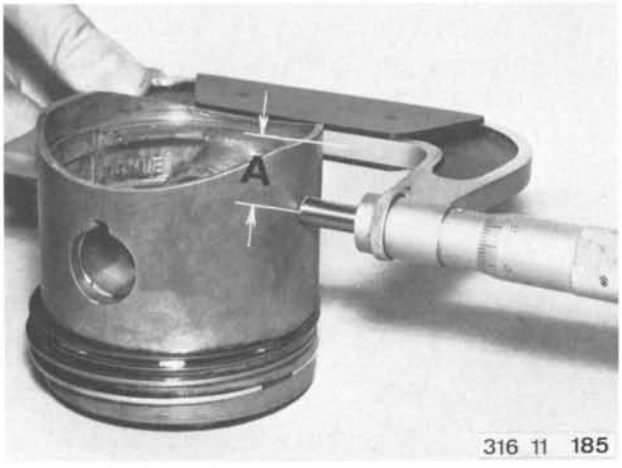

316 11 183

Installation Note! Oil bore in conrod's small end faces same way as arrow on piston crown.

Caution! Only install pistons of same make and weight class 1).
Weight class is stamped with + or - on piston crown.
Check piston play 1).

320 11 134

1) See Specifications



Check piston installed clearance [1].
Measuring Point A for Mahle Pistons

BMW 320 i)
320 i A) 15.8 mm (0.622 in.)

Measuring Point A for KS Pistons

BMW 320 i)
320 i A) 23.45 mm (0.923 in.)

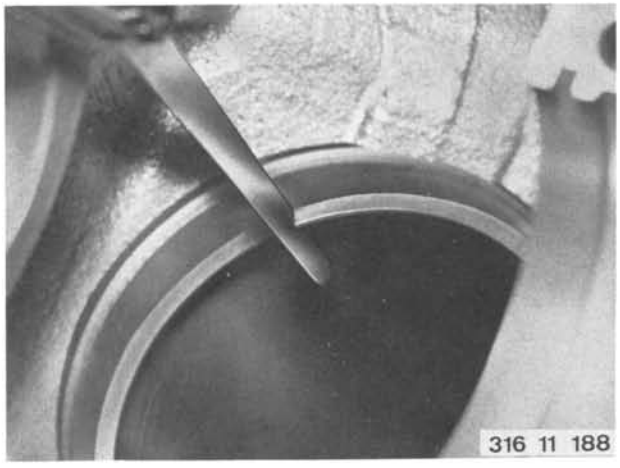
Piston Identification:

BMW 320 i)
320 i A) A = 31.2 ± 0.1 mm (1.228 ± 0.004 in.)
Epsilon = 8.1

11 25 651 REPLACING PISTON RINGS OF ONE PISTON

- Piston Removed -

Measure flank clearance [1] of piston rings in grooves.

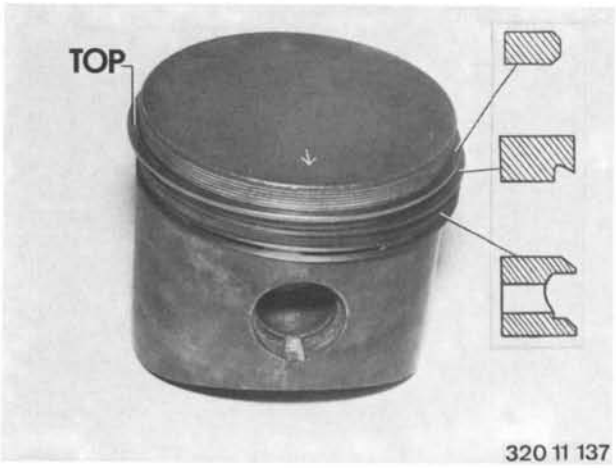


Remove piston rings and check end gap [1].

1) See Specifications

Installation Note! Install piston rings with "TOP" facing piston crown.

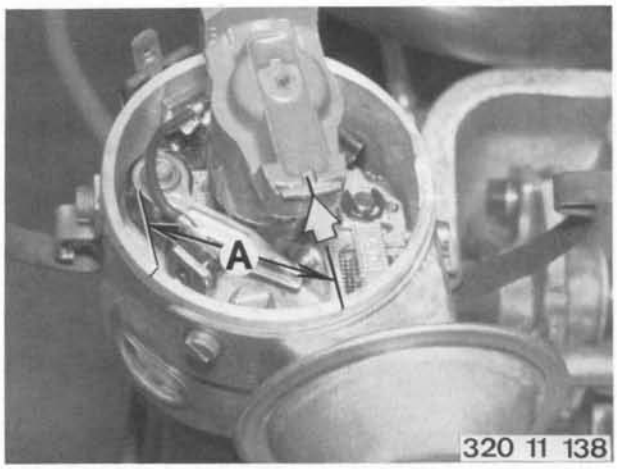
1 Plain compression ring
2 Taper face ring
3 Bevelled ring



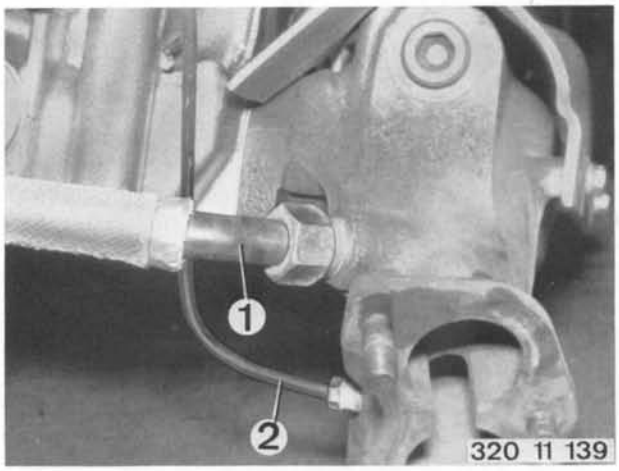
11 31 000 REMOVING AND INSTALLING CAMSHAFT

Remove cylinder head - 11 12 100.
Loosen clamping screw and pull out distributor.

Installation Note! Turn distributor rotor counter-clockwise by about 3.5 cm (1.4 in.) (A) from notch in distributor housing.
Guide distributor drive into camshaft drive.
Install distributor in correct position.
Vacuum box faces exhaust manifold.
Adjust ignition timing - 12 11 004.

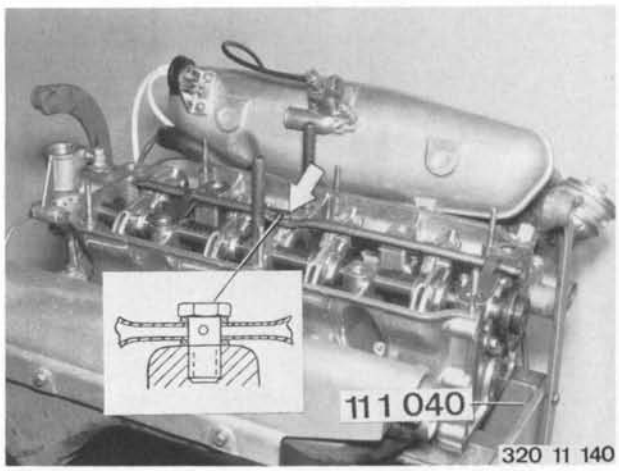


Detach lines (1 and 2) at exhaust manifold.



Mount cylinder head on Special Tool 11 1 040.
Detach oil line.

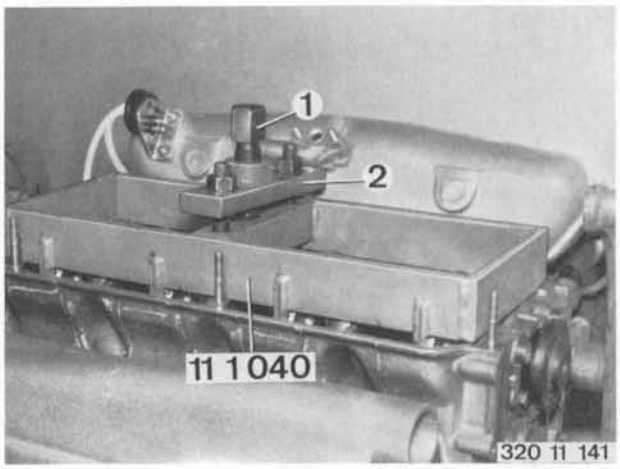
Installation Note! Note position of oil seals.

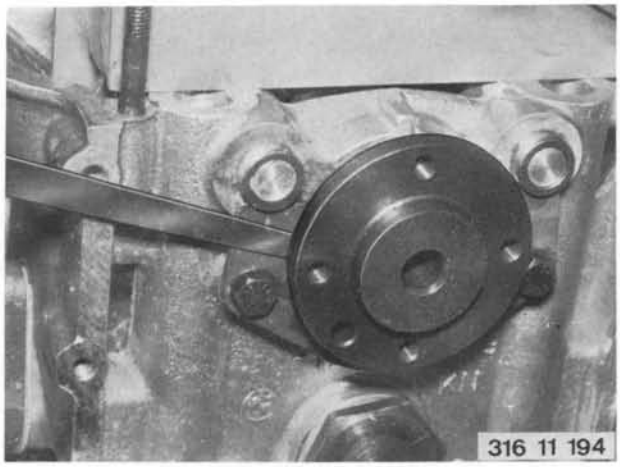


Remove cold start valve.
Adjust cam to maximum valve clearance.
Install Special Tool 11 1 040 and preload rocker arms.

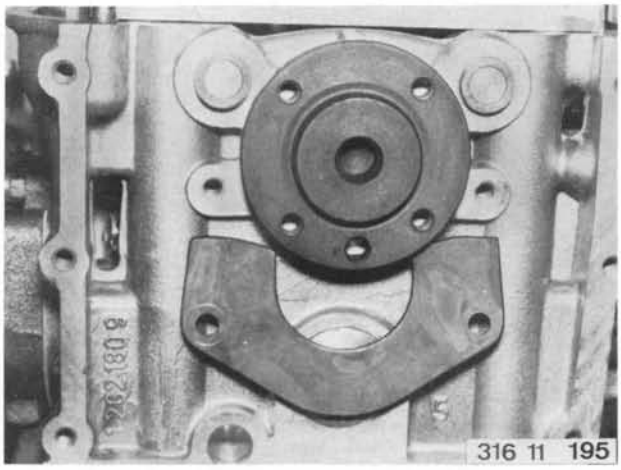
Caution! Clamping screw (1) is off center.
To prevent contact between valve heads, install tensioning bracket (2) that short end faces exhaust manifold.

Installation Note! Adjust valve clearance.



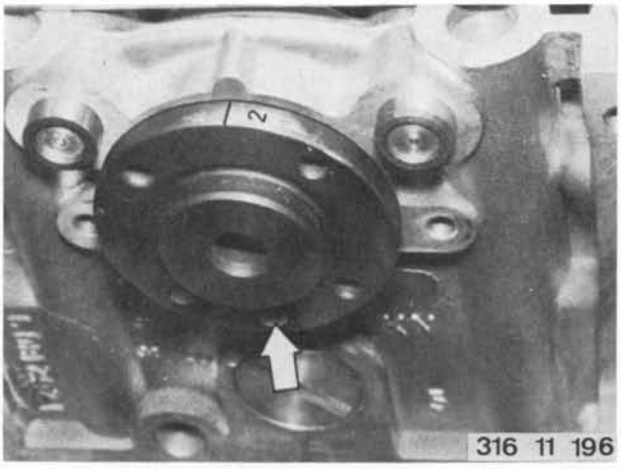


Check axial play[1] between guide plate and camshaft.



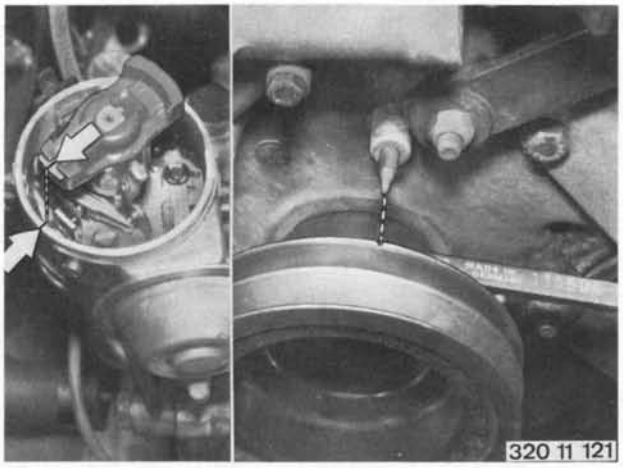
Remove guide plate.
Pull out camshaft carefully.

Installation Note! If guide plate has been installed properly, camshaft must turn easily.



Notch in flange aligns with cast tab on cylinder head.
Bore for dowel pin faces down.

Camshaft Identification:
2 264° standard version

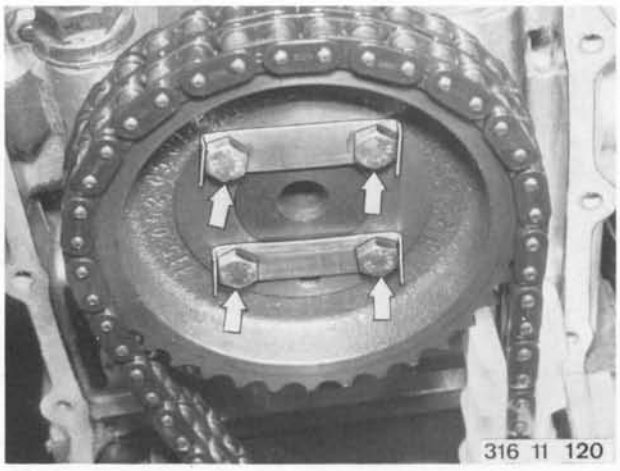


11 31 051 REPLACING TIMING CHAIN

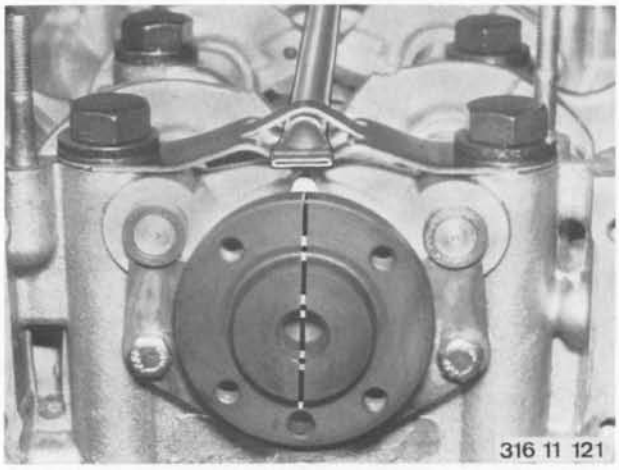
Timing chain is pre-stretched. No replacements are necessary before 50,000 km (30,000 miles).
If chain noise is not normal, check chain tensioner piston - 11 31 090.
Remove distributor cap.
Set piston of cylinder number 1 at TDC.
Distributor rotor faces notch in distributor housing.
Indicator's point faces notch in pulley

1) See Specifications

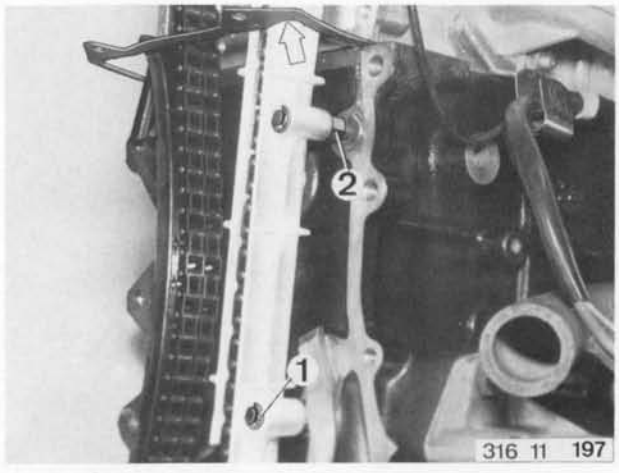
Remove upper and lower timing case covers - 11 14 120.
Open lockplates.
Remove sprocket.



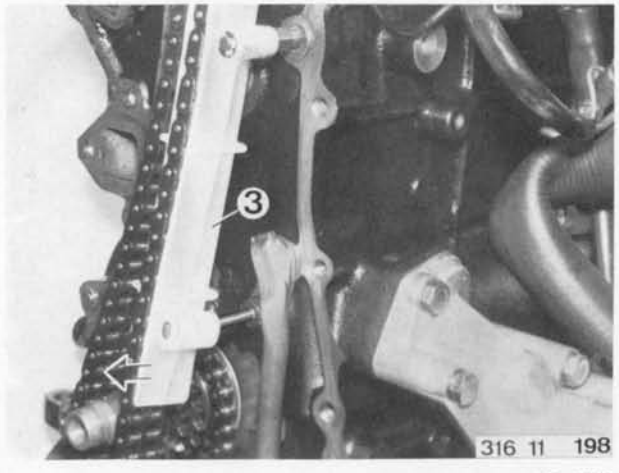
Installation Note! Install chain that bore for dowel pin faces down. Notch in camshaft flange aligns with cast tab on cylinder head.

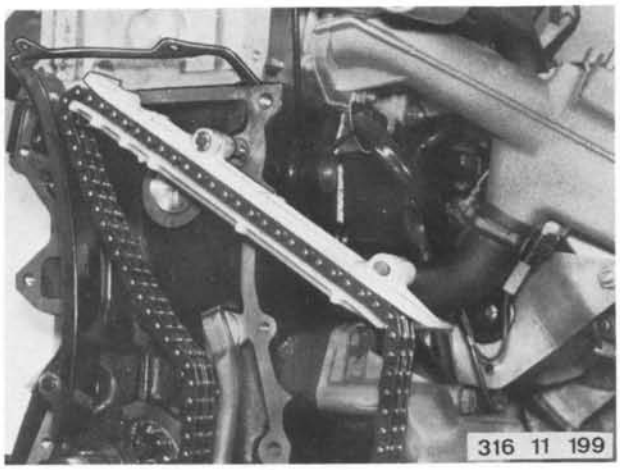


Remove circlip (1).
Unscrew pivot pin (2) until guide rail rests on cylinder head gasket.

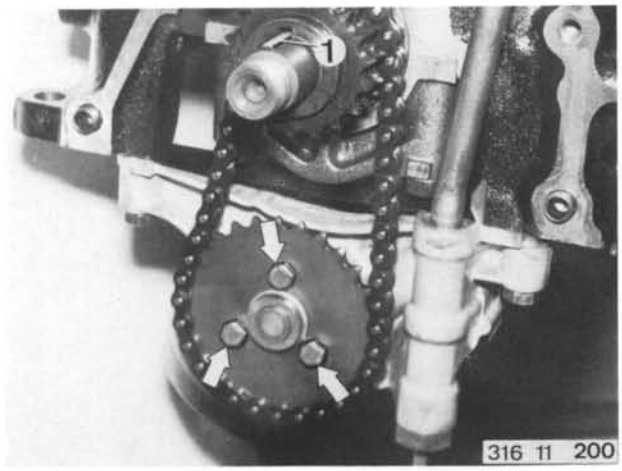


Remove timing chain from sprocket and crankshaft.
Remove guide rail (3) by pulling down and swinging to the right.



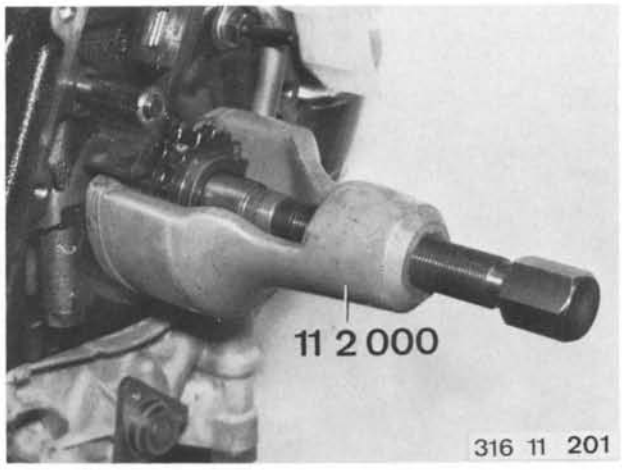


Take timing chain off of guide rail.
Check timing chain sprockets and replace if necessary - 11 31 061.



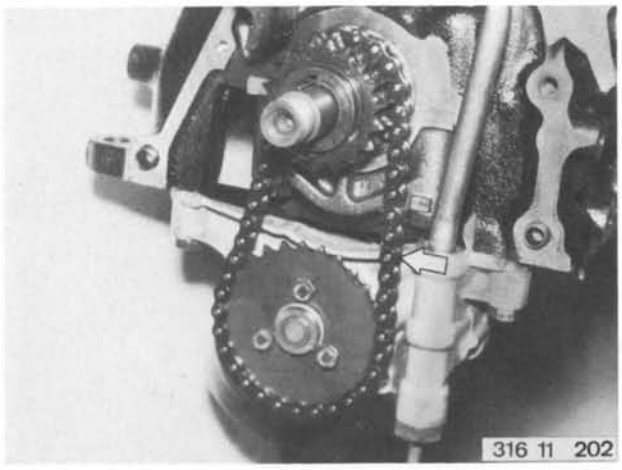
11 31 061 REPLACING SET OF TIMING CHAIN SPROCKETS

Remove timing chain - 11 31 051.
Remove oil pan - 11 13 000.
Take sprocket off of oil pump.
Remove woodruff key (1).
Take off chain.



Extract sprocket with Special Tool 11 2 000.

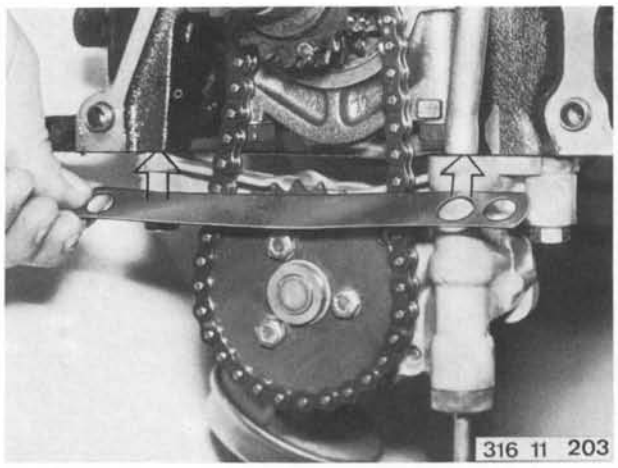
Installation Note! Heat sprocket.



Installation Note! Chain tension is correct, if chain gives under slight thumb pressure.
Two timing chains are available for this purpose.
Color Code: red = normal length
green = extra long

If chain tension is not correct when using either of both chain lengths, use shims of appropriate thickness.

Caution! Note position of oil bore in shim.

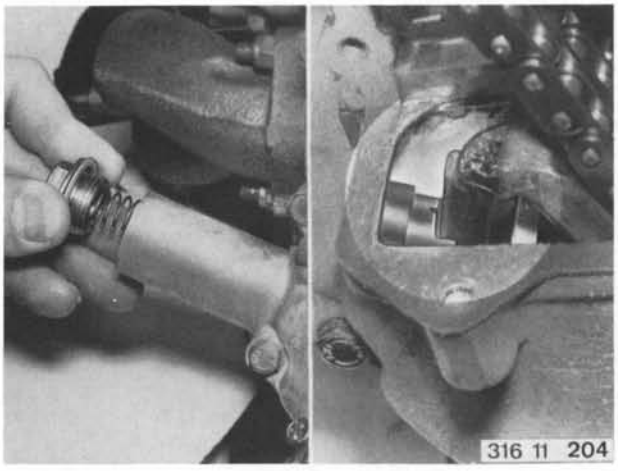


11 31 090 REMOVING AND INSTALLING CHAIN TENSIONER PISTON

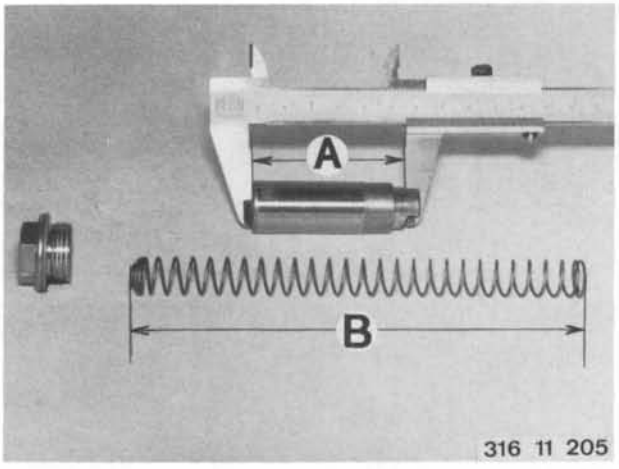
Unscrew plug.

Caution! Strong spring pressure.
Remove spring and piston.

Installation Note! Piston opening must take end of tensioning rail.

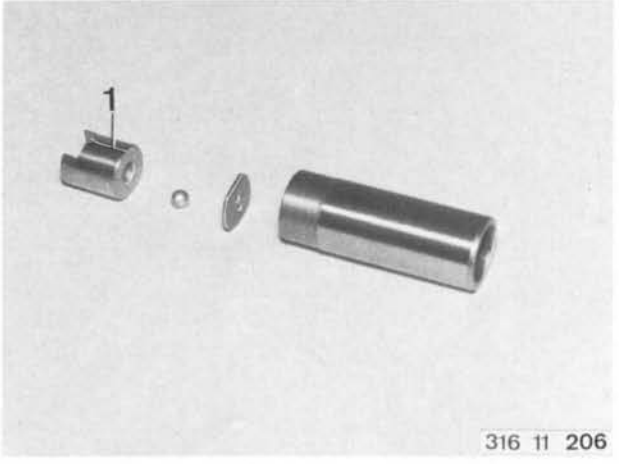


Installation Note! Check installed piston distance A and relaxed spring length B 1).
Conical end of spring faces plug.

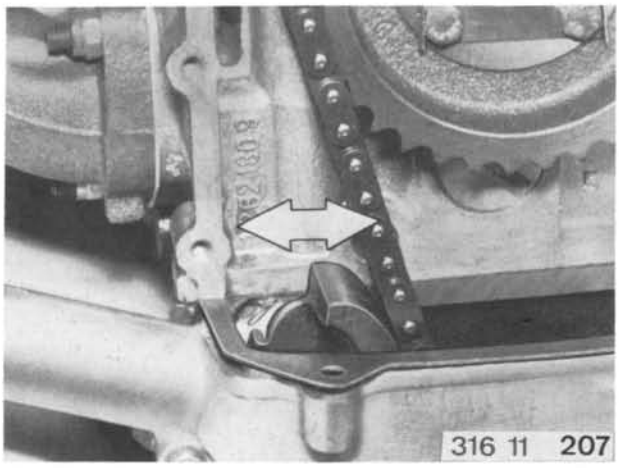


Check vent slots (1) for plugging with compressed air.
Press out valve and clean slots, if they are plugged.

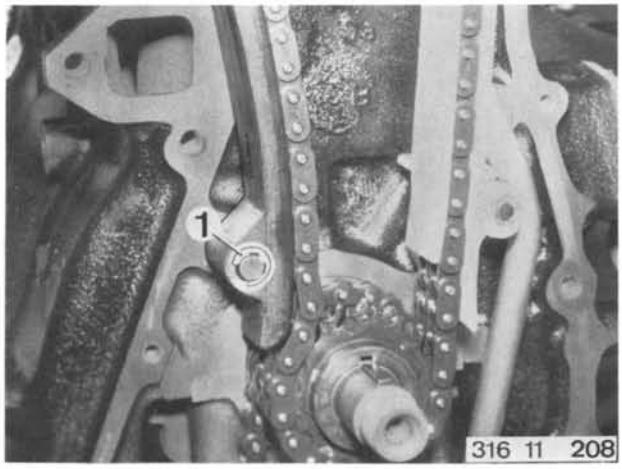
Installation Note!
Don't cover vent slots (1) with perforated disc.



1) See Specifications



To bleed piston, remove cylinder head cover - 11 12 000.
Install piston and spring.
Install plug and tighten only slightly.
Fill oil pocket with engine oil.
Move tensioning rail back and forth with screwdriver until oil runs out at plug.
The following could be causing unusual chain noise.
a) Piston bled insufficiently.
b) Piston seized.
c) Vent slots plugged.
d) Ball valve in piston malfunctions.
e) Spring pressure too high or too low.
f) Installed piston distance incorrect.
g) Tensioning rail without axial play on pivot pin.

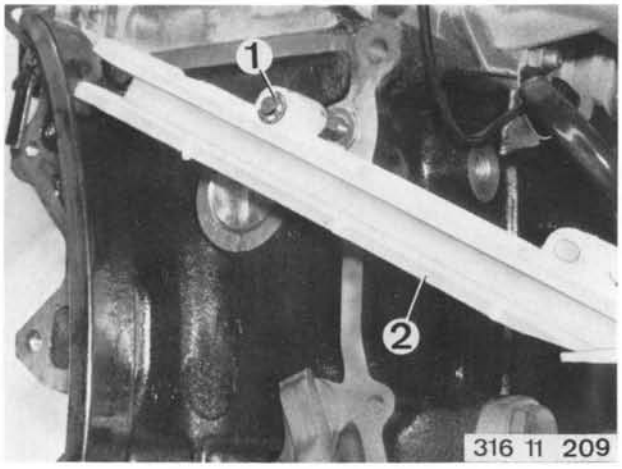


11 31 581 REPLACING TENSIONING RAIL

- Lower Timing Case Cover Removed -

Remove circlip (1).
Remove tensioning rail.

Installation Note! Tensioning rail pivot must move freely and have axial play.



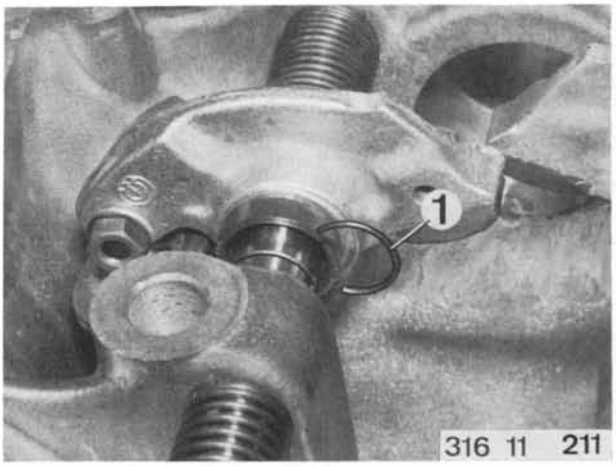
11 31 591 REPLACING GUIDE RAIL

- Timing Chain Removed -

Remove circlip (1).
Remove guide rail (2).

11 33 020 REMOVING AND INSTALLING ROCKER ARM SHAFT

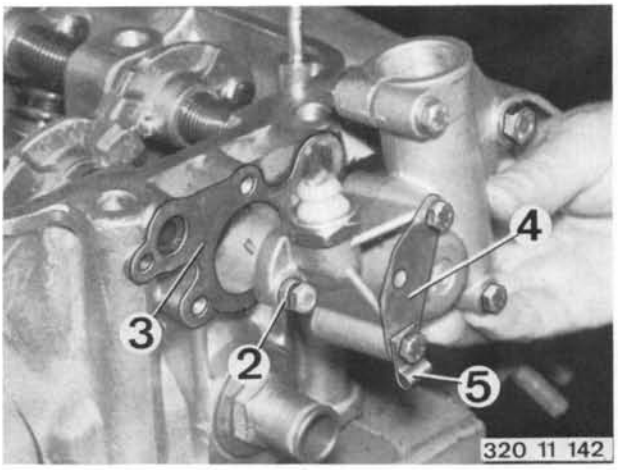
Remove camshaft - 11 31 000.
Slide back thrust ring and rocker arm.
Remove circlip (1).



Remove distributor flange.

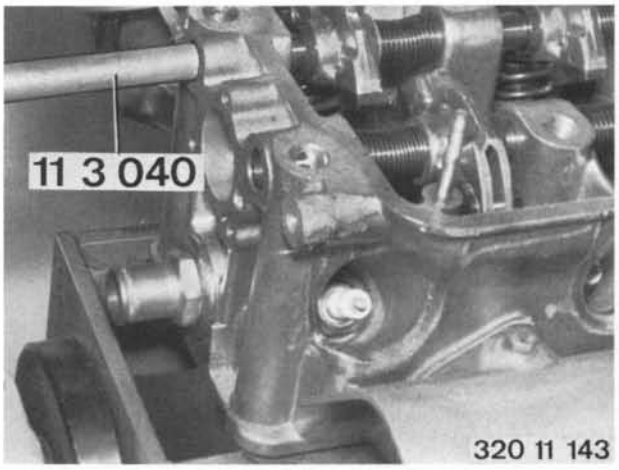
Installation Note! Note self-sealing washer (2).
Only use Cobritol gaskets (3).

Secure holder (4) and clamp (5).

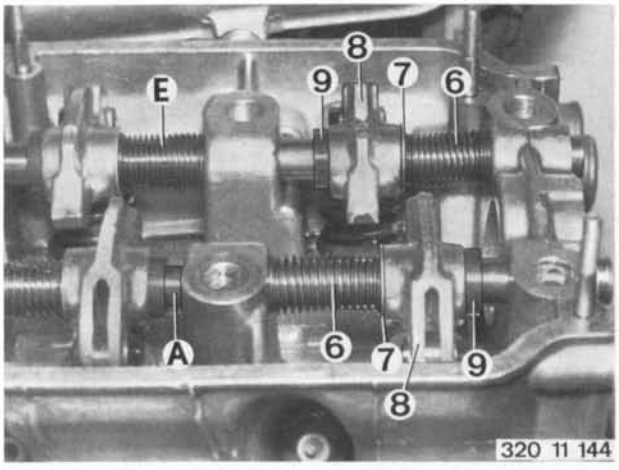


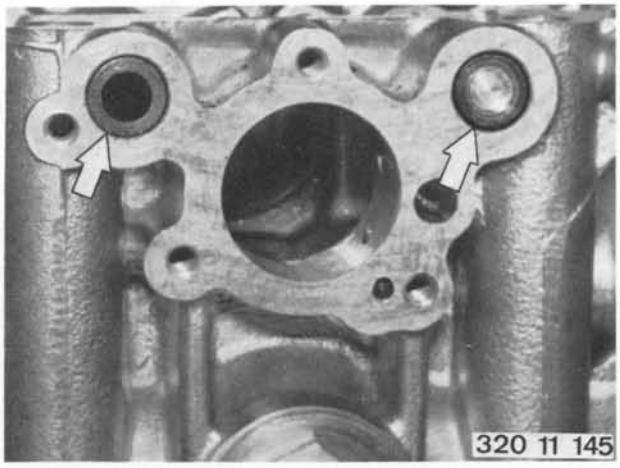
Drive out rocker arm shafts with Special Tool 11 3 040.

Installation Note! Replace worn shafts and rocker arms.

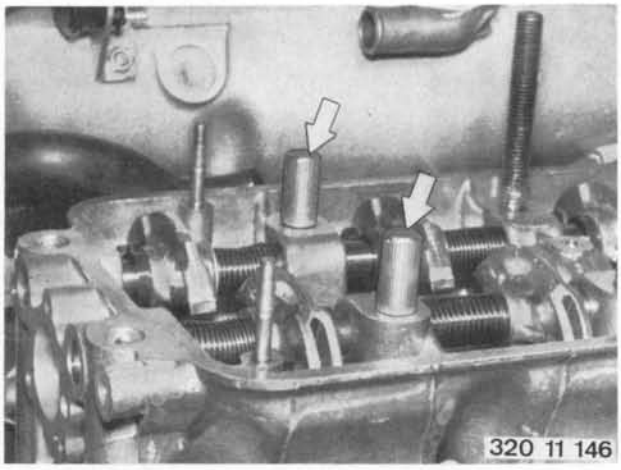


Spring (6), washer (7), rocker arm (8) and thrust ring (9).
A = Exhaust side
E = Intake side

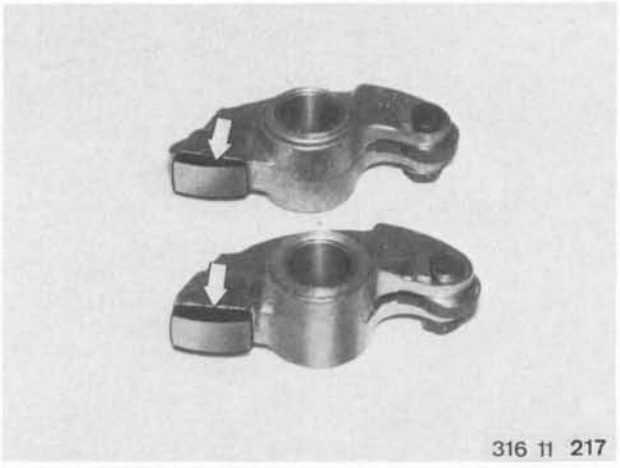




Caution! Rocker arm shaft on intake side is open to the back.
Rocker arm shaft on exhaust side must be closed.
Install loose or missing plugs with Loctite Code No. 270.

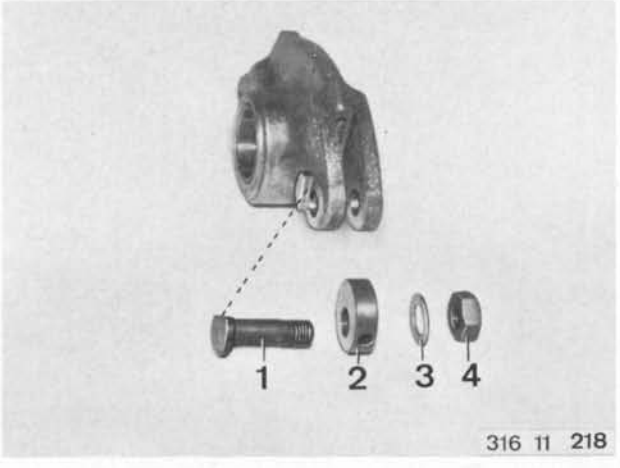


Installation Note! Align rocker arm shafts that cylinder head bolts fit in openings.
Install dowel pins.



11 33 031 REPLACING ALL ROCKER ARMS

Remove rocker arm shafts - 11 33 020.
Replace worn rocker arms or rocker arms with loose contact pads.
Loose contact pads will be heard as excessively loud valve noise.

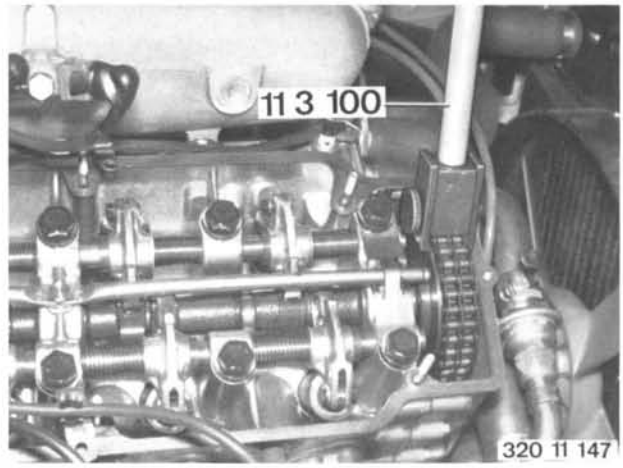


Install old set screw (1), cam (2), washer (3) and nut (4) on new rocker arm.
Replace a worn cam.

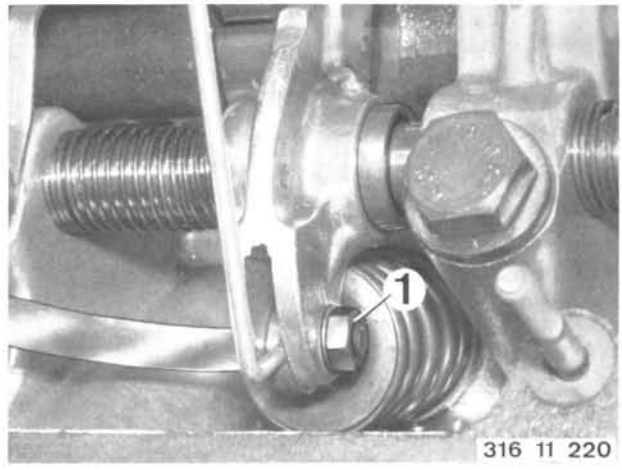
Caution! Set screw and nut have M 6 x 0.75 fine threads.
Bevelled side of set screw faces tab on rocker arm.

11 34 004 ADJUSTING VALVE CLEARANCE

Remove cylinder head cover - 11 12 000.
To adjust valve clearance turn engine with Special Tool 11 3 100.



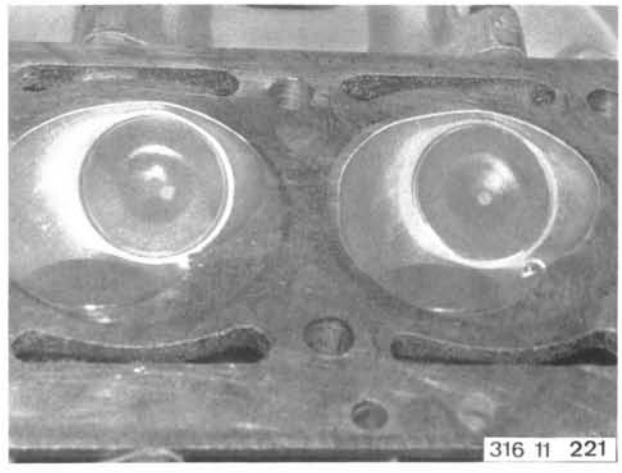
Adjusting sequence[1] is same as firing order of 1-3-4-2 at top dead center (TDC) of compression stroke.
After loosening nut (1) between valve and cam adjust valve clearance 1).



Caution! Never measure or adjust valve clearance between contact pad and cam.

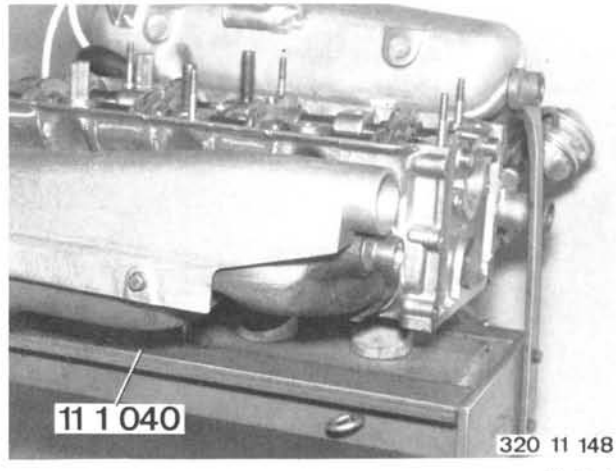
11 34 509 CHECKING ALL VALVES FOR LEAKS
- Camshaft Removed -

Spark plugs remain installed.
Fill combustion chamber with gasoline.
If gasoline flows past valve heads, valves must be machined - see 11 12 607.

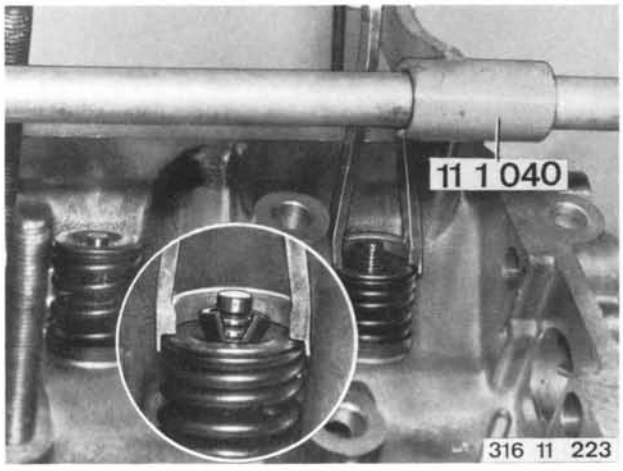


11 34 550 REMOVING AND INSTALLING VALVES
- Rocker Arm Shafts Removed -

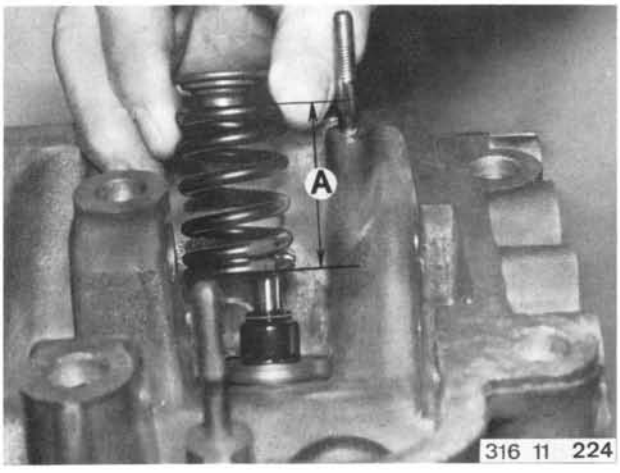
Place piece of wood in Special Tool 11 1 040.
Mount cylinder head.



1) See Specifications

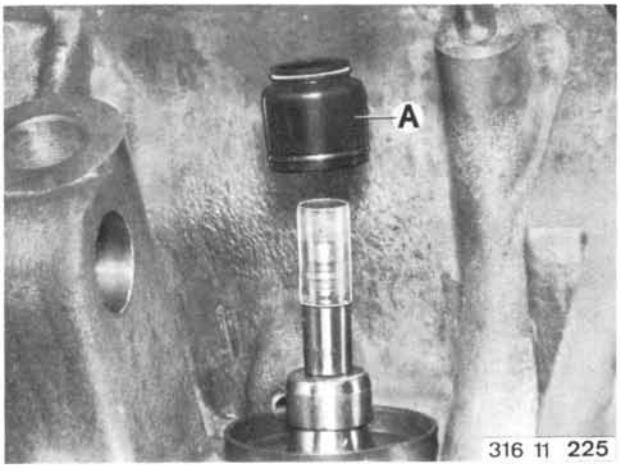


Press down valve springs with Special Tool 11 1 040 and remove valve poppet.



Remove spring retainer and springs.

Installation Note! Only install green marked springs.
Determine relaxed spring length A[1].



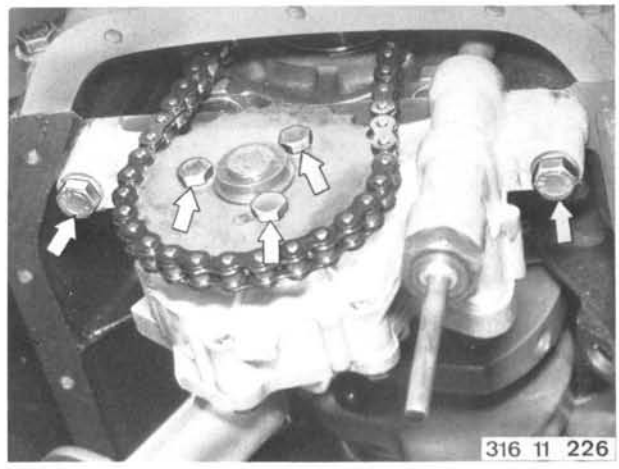
Deburr valve stem to avoid damage to valve stem seal and valve guide.
Replace damaged valve stem seals (A) to prevent excessive oil consumption.

Installation Note! Wind cellophane tape around grooves before installation of valve shaft seals.

1) See Specifications

11 41 000 REMOVING AND INSTALLING OIL PUMP

Remove oil pan - 11 13 000.
Loosen sprocket.
Open lockplates.
Detach oil pump.


316 11 226

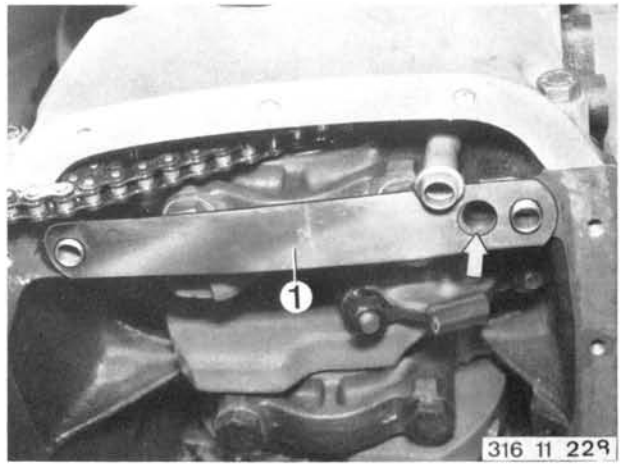
Remove oil pump.

Caution! Note location of o-ring between housing and pressure safety line.


316 11 227

Installation Note! Adjust chain tension with shims (1) that chain will give under slight thumb pressure.

Caution! Note location of oil bore in shim.

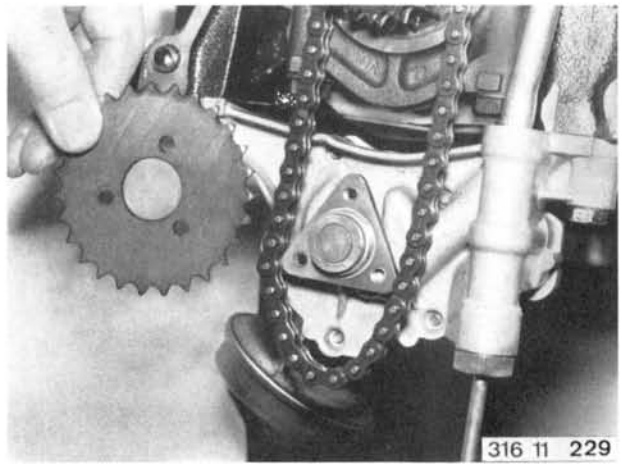


316 11 228

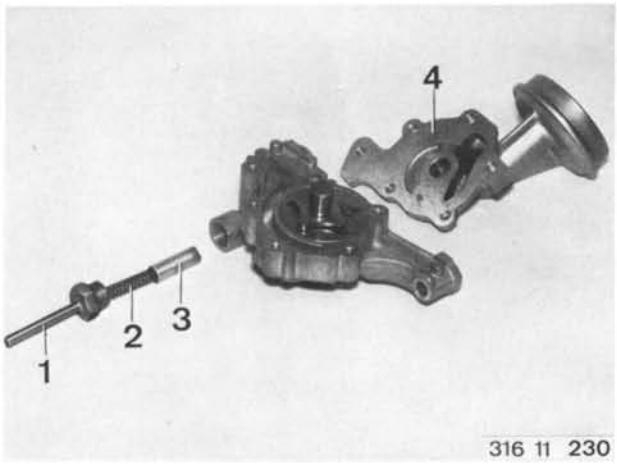
11 41 151 REPLACING OIL PUMP DRIVE ROLLER CHAIN

Remove oil pan - 11 13 000.
Remove timing chain - 11 31 051.
Remove sprocket from oil pump.
Take off roller chain.

Installation Note! Adjust chain tension, see removal of oil pump - 11 41 000.


316 11 229

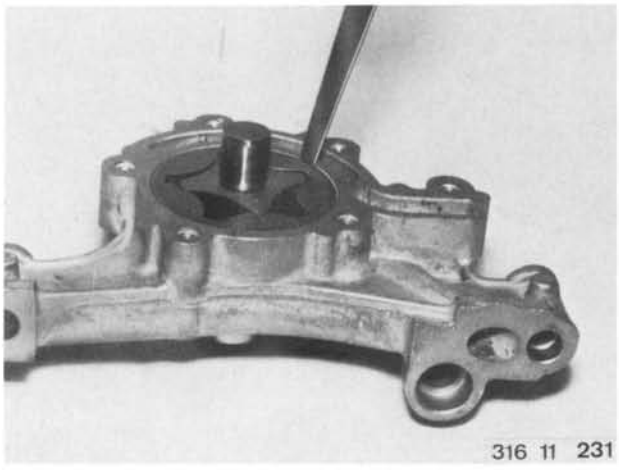
11 41 512 DISASSEMBLING AND ASSEMBLING OIL PUMP



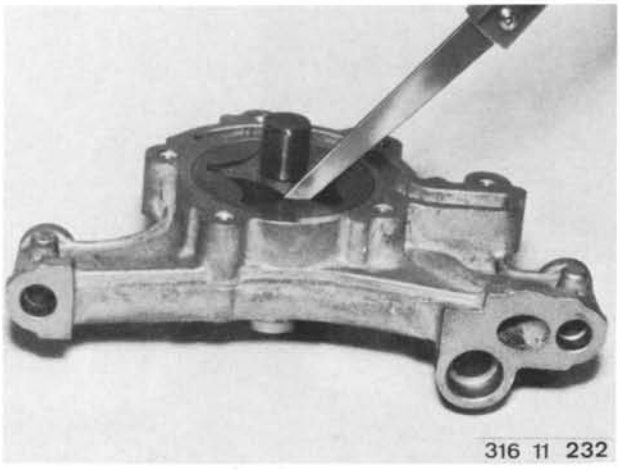
316 11 230

Unscrew part (1).
Remove spring (2) and piston (3).

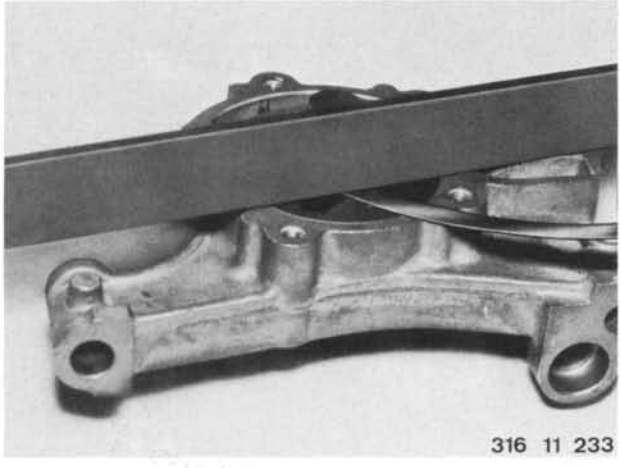
Caution! Never alter relaxed spring length[1].
Remove oil pump cover (4).


316 11 231

Check play[1] between outer rotor and pump body. If play exceeds maximum specifications, replace pump body.


316 11 232

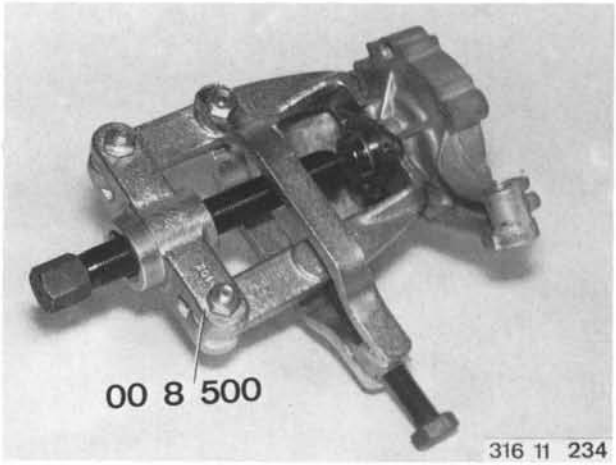
Check gap[1] between inner and outer rotors.
If gap exceeds maximum specifications, replace inner and outer rotors.


316 11 233

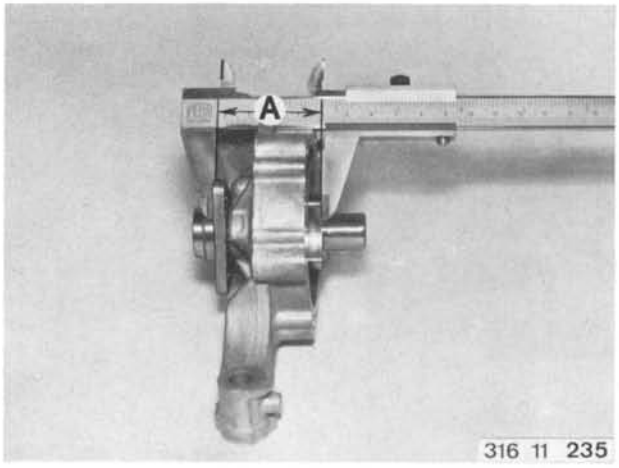
Check play[1] between rotor sealing surface and pump body.
Replace pump body, if play exceeds maximum specifications.

1) See Specifications

Extract hub with Kukko 00 8 500. Don't press off.



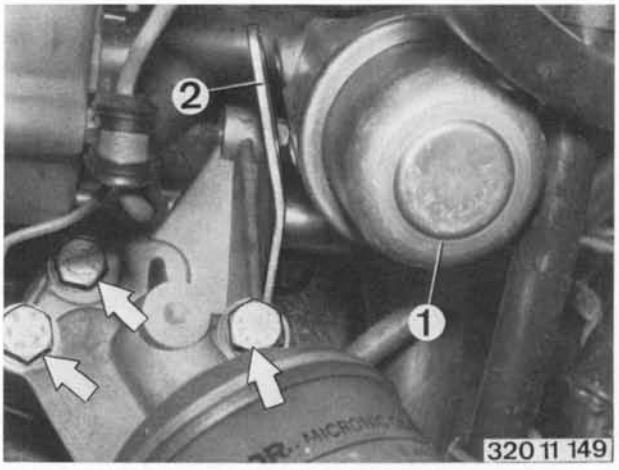
Installation Note! Note distance of flange to inner rotor.
A = 42.7 ± 0.1 mm (1.681 ± 0.004 in.)



11 42 020 REMOVING AND INSTALLING FULL FLOW OIL FILTER

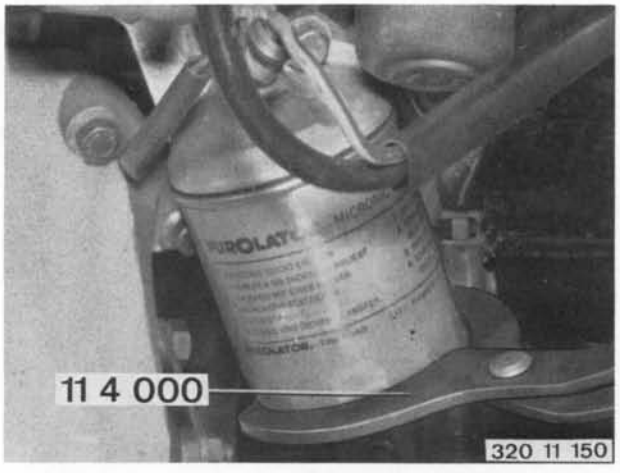
Take blow-off valve (1) off of holder (2).
Take full flow oil filter off of engine block.

Installation Note! Replace gasket.



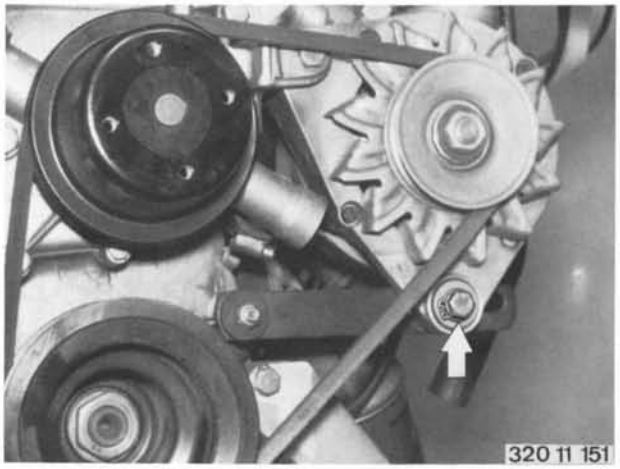
11 42 021 REPLACING FULL FLOW OIL FILTER

Unscrew oil filter with Special Tool 11 4 000.



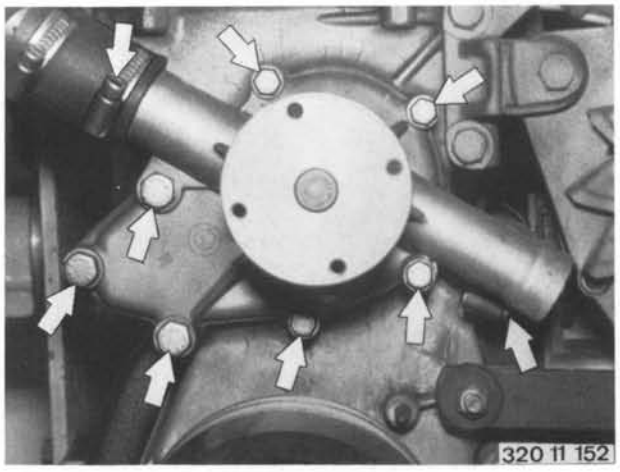
11 51 000 REMOVING AND INSTALLING WATER PUMP

Remove fan - 11 52 000.
Loosen alternator.
Remove pulley and v-belt.



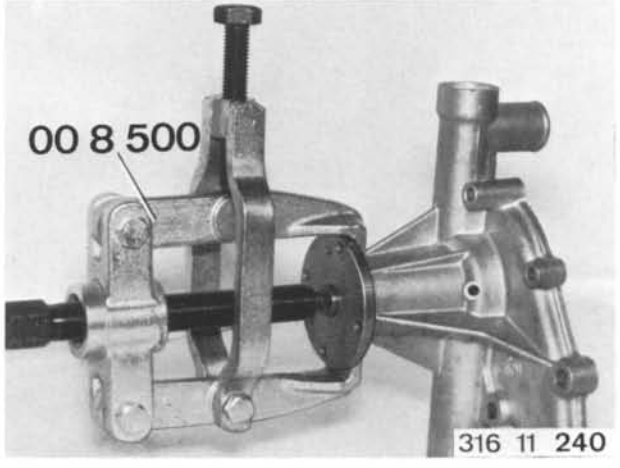
Loosen hose clamps.
Remove water pump.

Installation Note! Replace gasket.

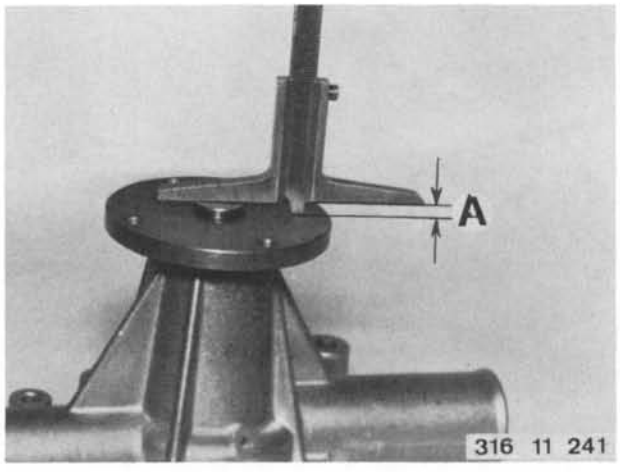


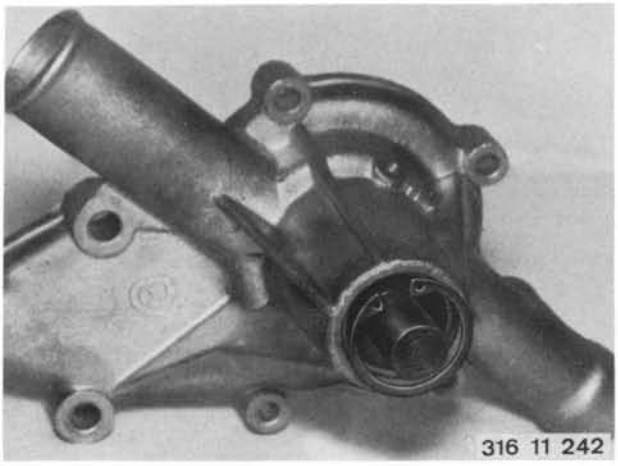
11 51 502 DISASSEMBLING AND ASSEMBLING WATER PUMP

Extract hub with Kukko 00 8 500.

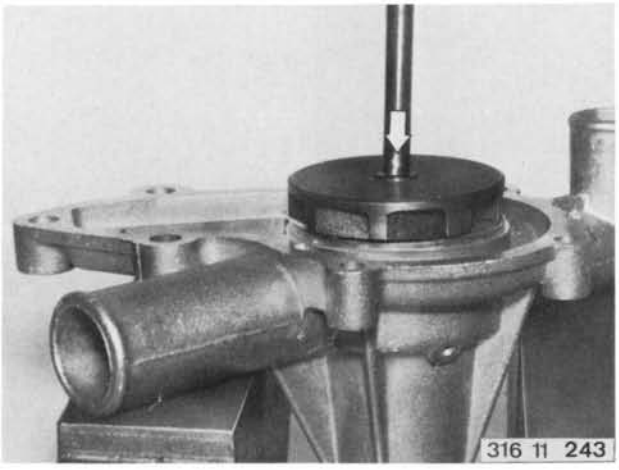


Installation Note! Distance A = $3^{+0.5}$ mm or ($0.118^{+0.020}$ in.).

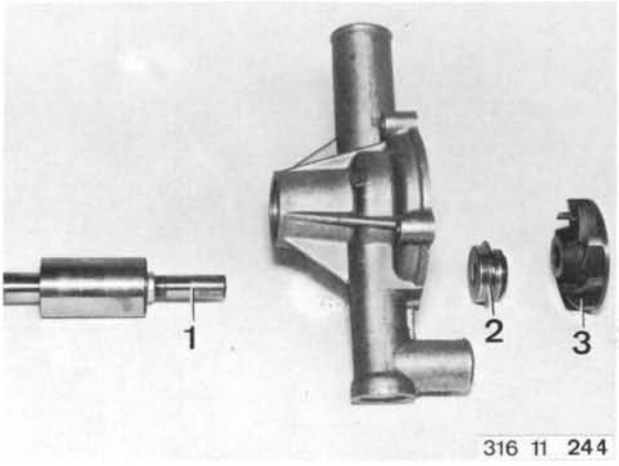




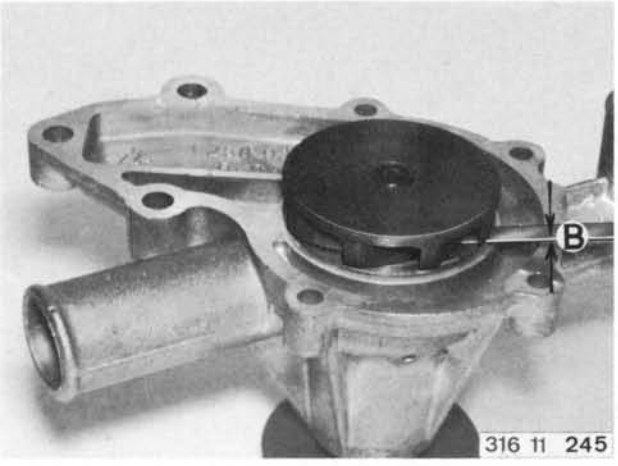
Remove circlip.



Press impeller off of shaft and water pump bearing out of body.



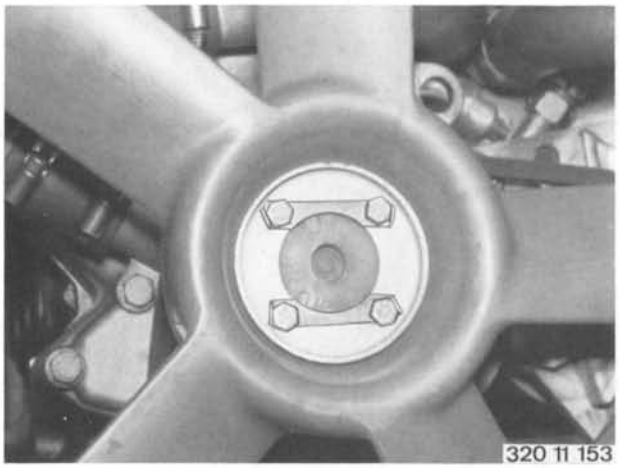
Replace bearing (1) and shaft seal (2).
Check impeller (3) and replace if necessary.



Installation Note! Install impeller with Loctite Code No. 270.
Keep distance B = $1^{+0.2}$ mm ($.039^{+.008}$ in.).
Installation pressure about 440 kp (970 lbs.) or about 500 kp (1100 lbs.) for new part.

11 52 000 REMOVING AND INSTALLING FAN

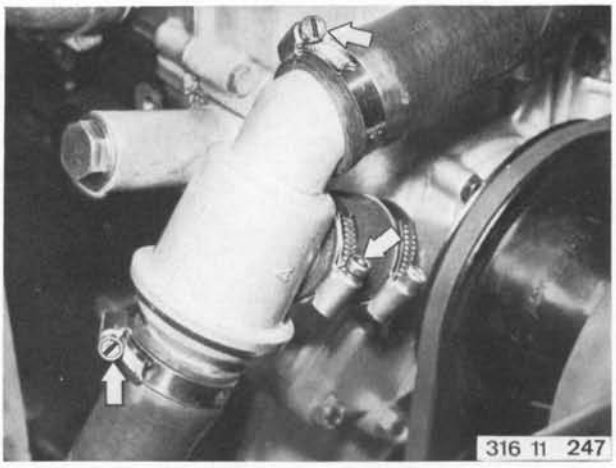
Remove radiator - 17 11 000.
Open lockplates.
Remove fan.



11 53 000 REMOVING AND INSTALLING COOLANT THERMOSTAT

Drain coolant.
Loosen hose clamps.
Remove thermostat.
Starts to open at 80° C (176° F).

Installation Note! Bleed cooling system.
Set heater lever at "warm" before filling cooling system again.
Pour in water and tighten radiator cap by turning to catch II. Heat coolant to 80° C (176° F). Turn radiator cap to catch I for bleeding after thermostat has opened.
In so doing squeeze upper and lower elbow hoses by hand several times to affect a pumping action, so that any air can escape through the radiator.
Check coolant level and turn radiator cap to catch II.



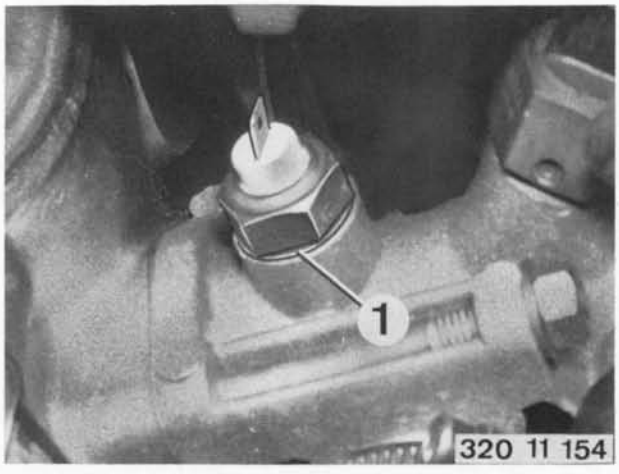
Checking Thermostat:
Hang thermostat in container filled with water and heat water.
Check opening action and opening travel with steel ruler.
Opening travel = 8 ± 1 mm (0.315 ± 0.039 in.).

11 53 080 REPLACING TEMPERATURE SENSOR

Detach wires.
Unscrew sensor from branch flange.

Installation Note! Check gasket (1) and replace, if necessary.

Add coolant.



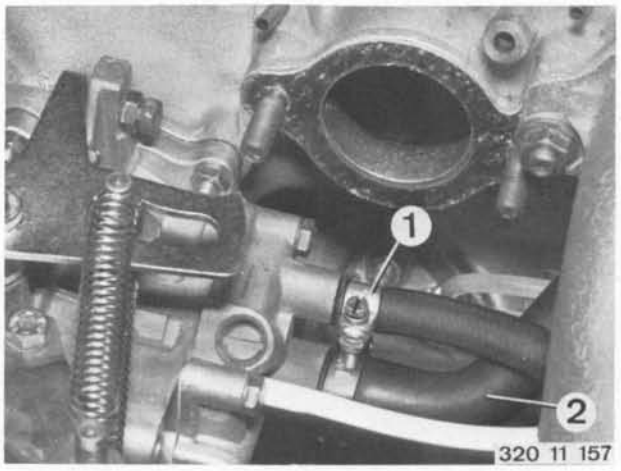
11 61 050 REMOVING AND INSTALLING TRAP WITH THROTTLE HOUSINGS

Remove intake cowl.
Detach accelerator cable and take off of counter-holder.

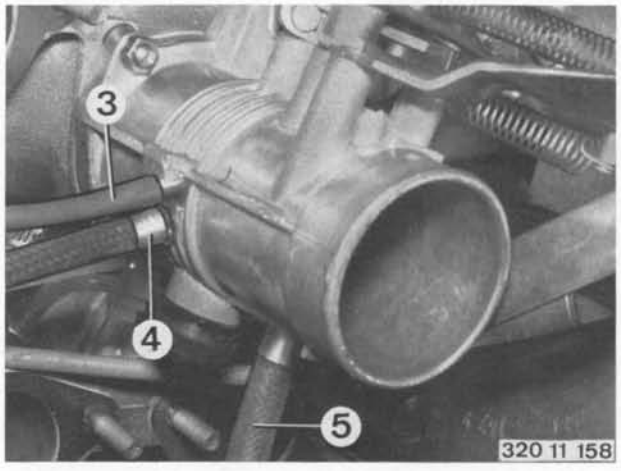
Installation Note! Adjust accelerator cable (see 35 41 420).
Detach or pull vacuum hoses off of trap.

Remove injection line holder from intake manifold 4.

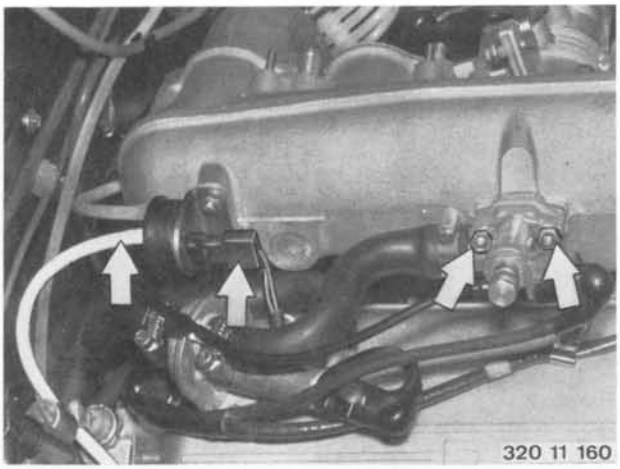
Remove intake manifold of cylinder 3.
Detach hoses (1 and 2).



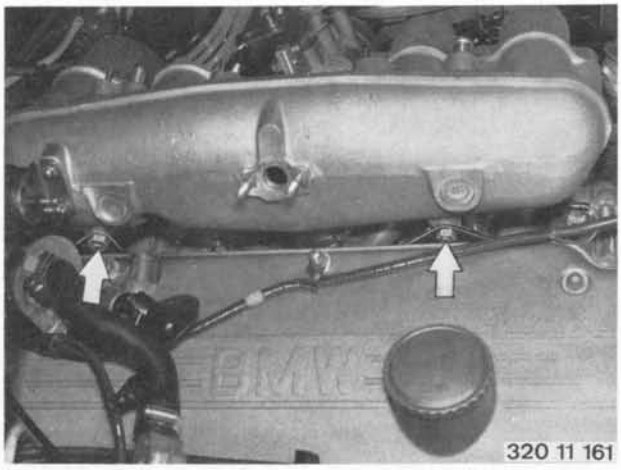
Detach hoses (3 ... 5).



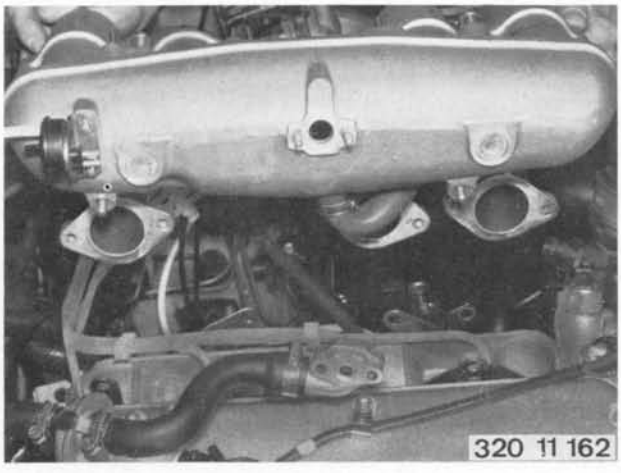
Detach hoses at EGR valve.
Disconnect plugs at temperature timing switch.



Take cold start valve off of trap.
Disconnect plugs and vacuum hose at timing valve.



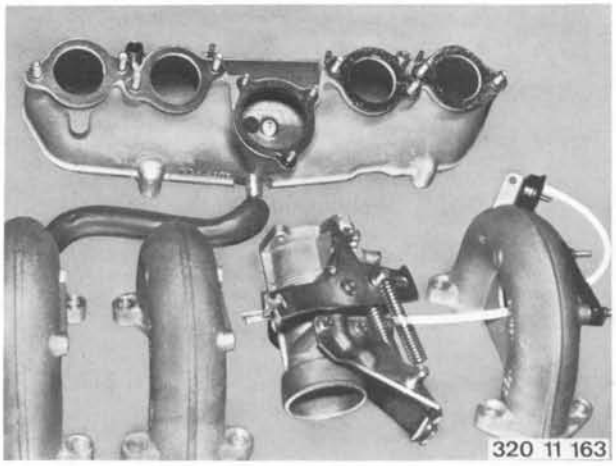
Detach trap at supporting brackets.



Detach remaining intake pipes at intake .
Pull off and remove trap.
Check gaskets and replace, if necessary.

11 61 051 REPLACING TRAP

Remove trap - 11 61 050.
Install old throttle housings, intake pipes, timing valve and air hose on new trap.
Replace gaskets.



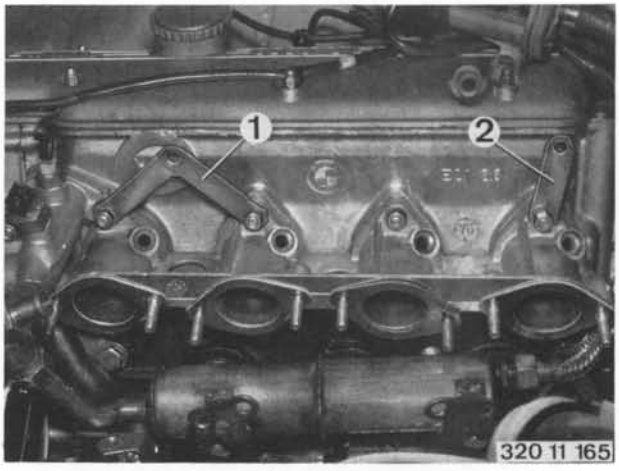
11 61 290 REMOVING AND INSTALLING INTAKE MANIFOLD

Remove trap - 11 61 050.
Lift out injection valves 1 ... 4.

Installation Note! Check seals and replace, if necessary.

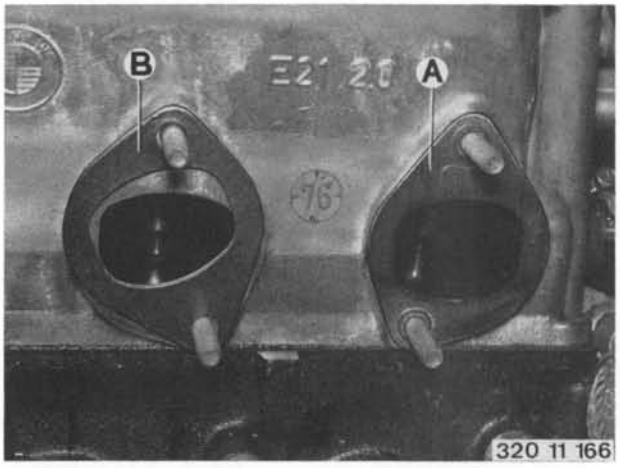
Take intake manifold off of cylinder head, including branch flange.

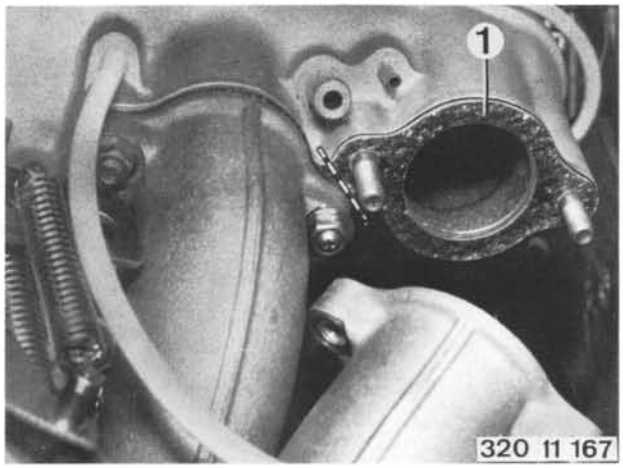
Installation Note! Also secure holders (1 and 2).



Replace gaskets.

Caution! Gaskets are off-center.
Gasket (A) is correct - gasket (B) is wrong.





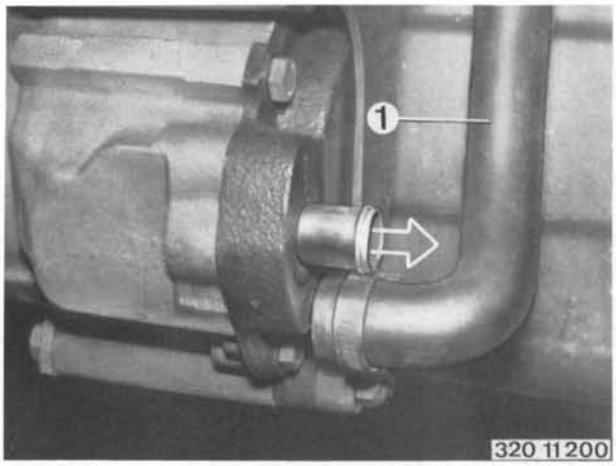
11 61 420 REMOVING AND INSTALLING ALL INTAKE PIPES

Take intake pipes off of trap and intake manifold.
Loosen holder for fuel injection lines on intake pipe 4.
Replace gaskets.
If only one intake pipe is removed, cut off gasket (1) behind staybolt.

11 70 009 CHECKING FUNCTION OF EGR SYSTEM

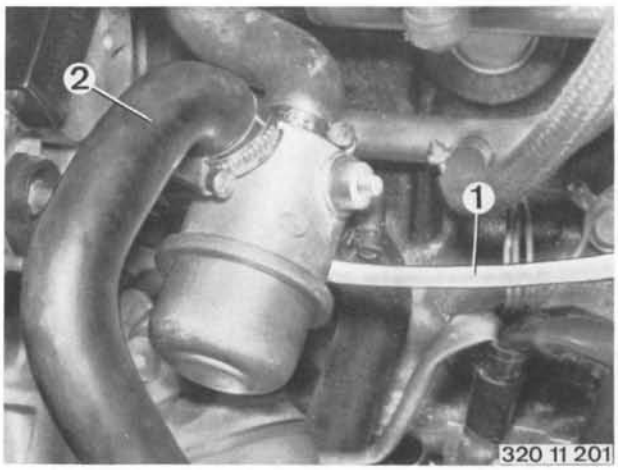
A) Air Pump

Detach hose (1).
Start engine.
Air pump is good, if air flow velocity increases as engine speed increases.
If air flow velocity does not increase,
- check v-belt tightness,
- air pump movement or possibly check valve for leaks.



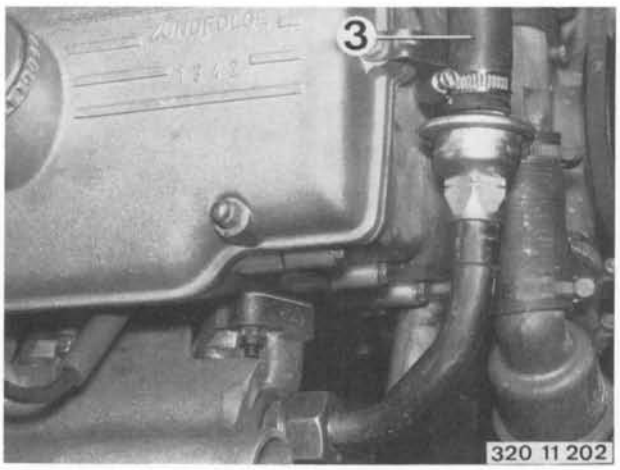
B) Blow-off Valve

The blow-off valve prevents
1. backfiring when releasing accelerator pedal and
2. overloading of air pump.
Ref. 1: When coasting valve must blow off via hose (2) every 3 ± 1.5 seconds.
Ref. 2: Safety valve must open at 0.35 bar (5 psi).
Detach vacuum hose (1) at blow-off valve.
Suction must be felt at end of vacuum hose (1) when engine is running.
Blow-off valve is good, if air is blown off through hose (2) when connecting hose (1).



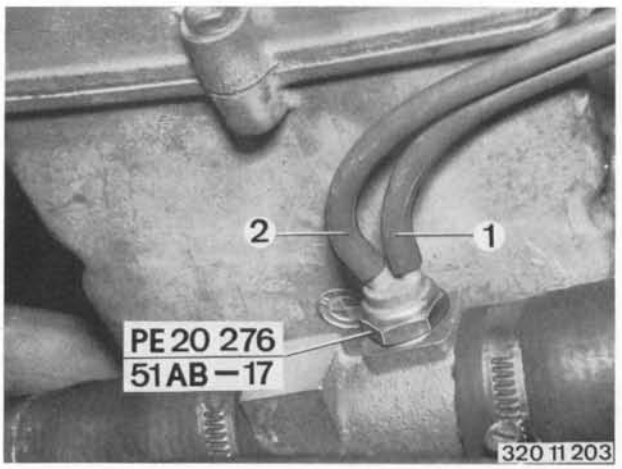
C) Check Valve

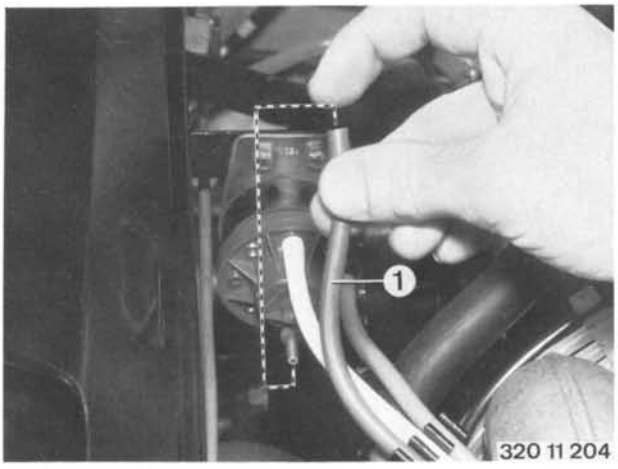
Detach hose (3) at blow-off valve and blow in air.
Air flow must be toward exhaust manifold.
When drawing in air valve must shut.



D) Thermo Valve

Detach hose (1) at throttle housing and hose (2) at EGR valve, and blow in air.
Thermo valve shut at coolant temperatures up to $+ 33^{0}$ C ($+ 91^{0}$ F) and open from $+ 43^{0}$ C ($+ 109^{0}$ F).
Only use thermo valves PE 20 276 or 51 AB - 17.

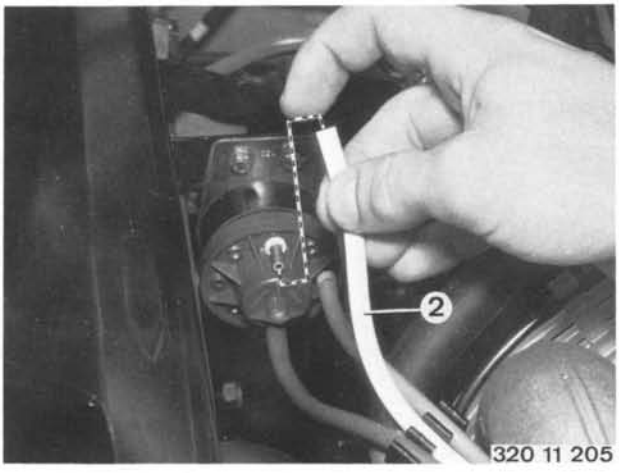




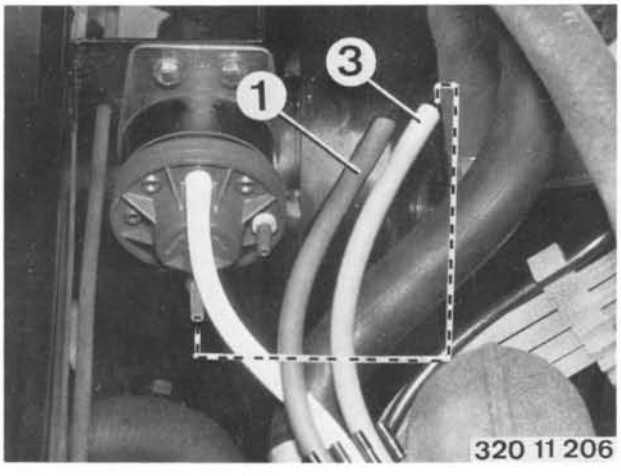
E) Pressure Converter

Engine must run for all tests.

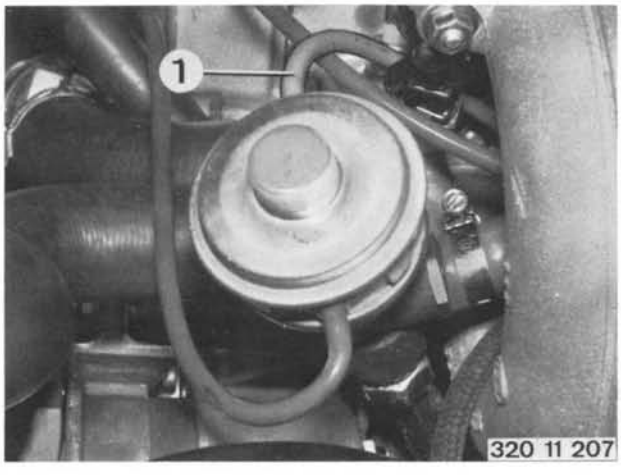
a) Exhaust Gas Counter Pressure/Control Pressure
Detach red hose (1) at pressure converter.
Counterpressure must be felt with finger.



b) Intake Manifold Vacuum
Detach white hose (2) at pressure converter and check for vacuum with finger. There must be vacuum.



c) Regulating Pressure
Detach red hose (1) and blue hose (3).
Feel blue pressure converter connection with finger for vacuum. Replace pressure converter, if there is no vacuum.

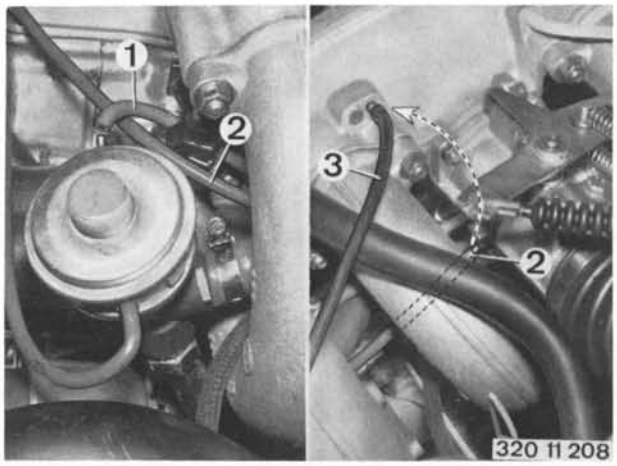


F) EGR Valve

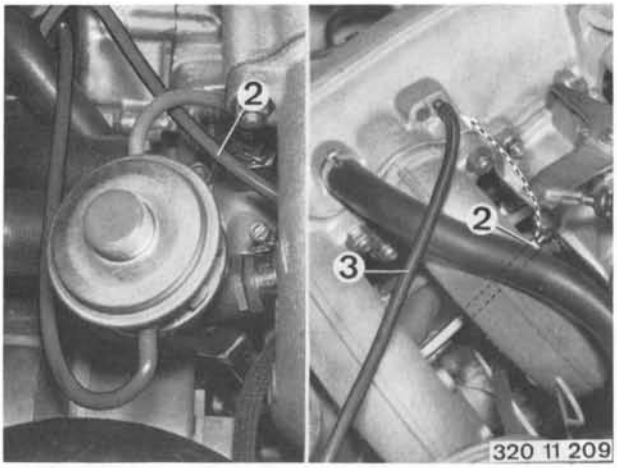
Engine must run for all tests.

a) Detach blue hose (1) at EGR valve.
Don't plug connection or hose.
Engine speed should not change.
Engine speed drops:
- Throttle gap too large at idle speed
- EGR valve will not close

b) Detach blue hose (1) at EGR valve and black hose (3) at header.
Detach red hose (2) at throttle housing and connect to header.
Engine speed must drop considerably.
Engine speed does not drop:
- Replace EGR valve.

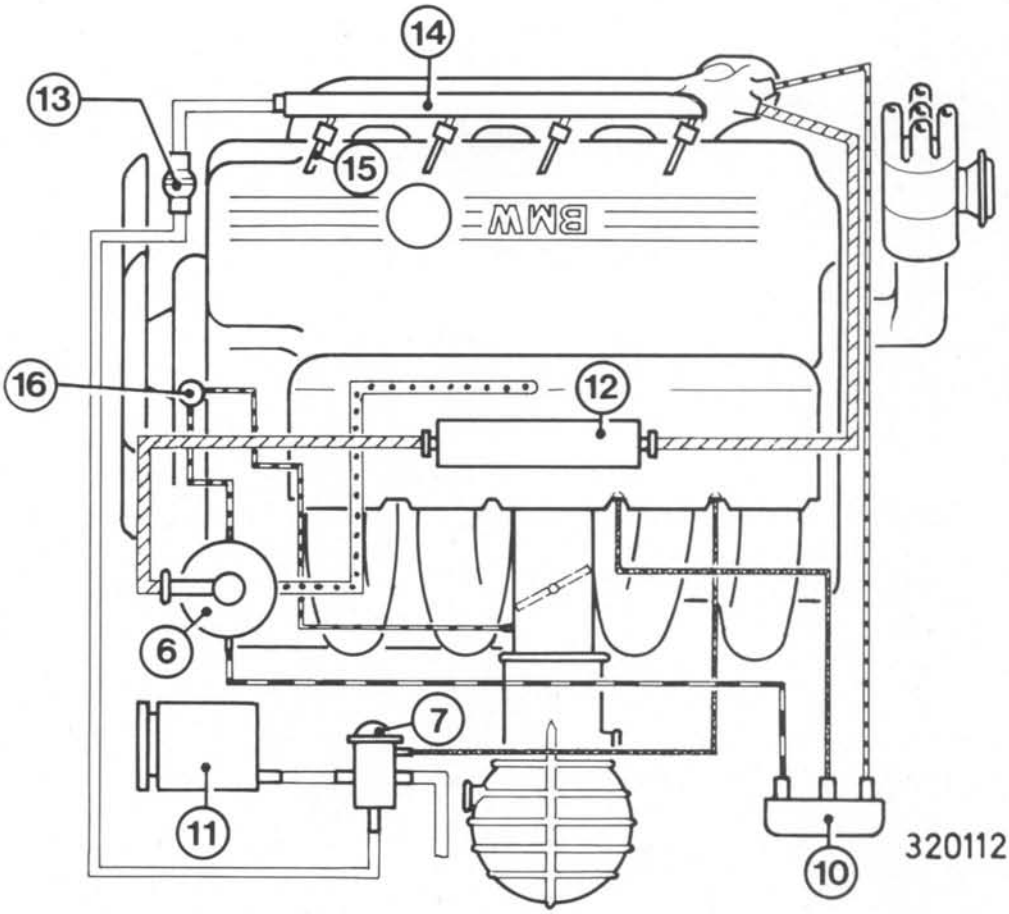


c) Detach black hose (3) at header.
Detach red hose (2) at thermo valve and connect to header.
Engine speed should not drop.
Engine speed drops:
- EGR valve will not close
- Pressure converter defective



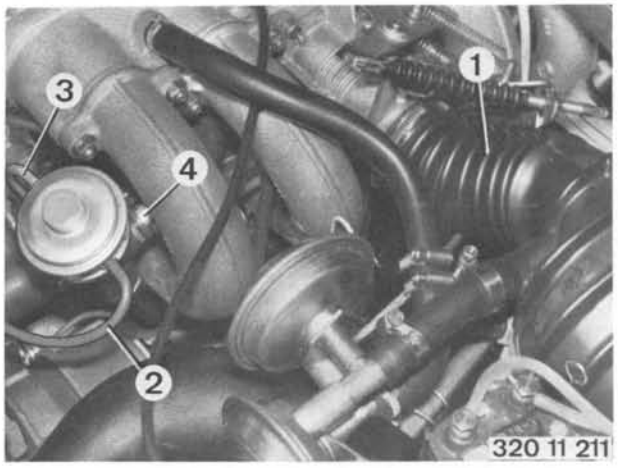
EGR System Layout

6 EGR valve
7 Blow-off valve
10 Pressure converter
11 Air pump
12 EGR filter
13 Check valve
14 Manairox manifold
15 Injection tube
16 Thermo valve
red
blue
white



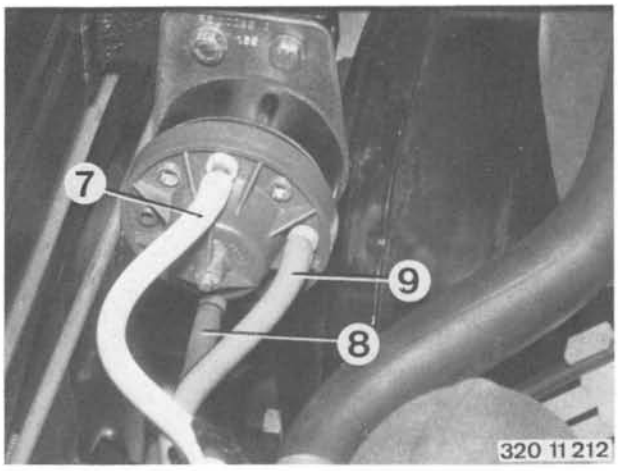
11 71 020 REMOVING AND INSTALLING EGR FILTER

Replace EGR filter every 25,000 miles.
Remove intake cowl (1).
Detach hoses at EGR valve.
2 to thermo valve
3 to pressure converter
4 to header



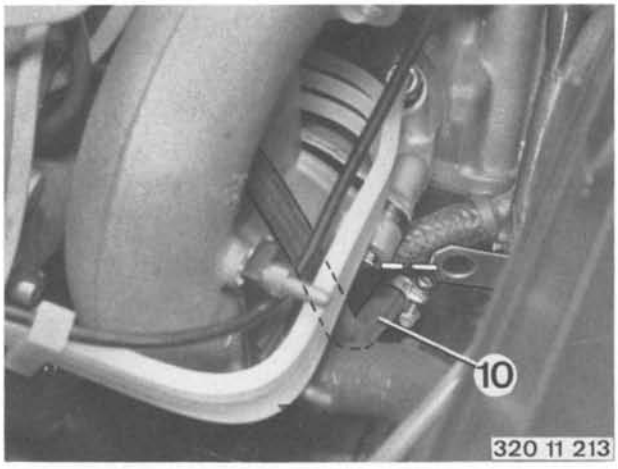
Detach holder on intake manifold.
Detach vacuum hoses at pressure converter.
Remove intake pipe of cylinder 4.

Installation Note! Connect hoses to pressure converter that colors match.
7 white
8 blue
9 red

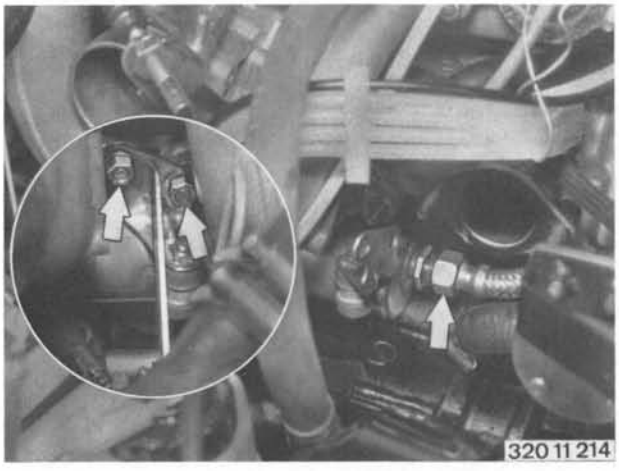


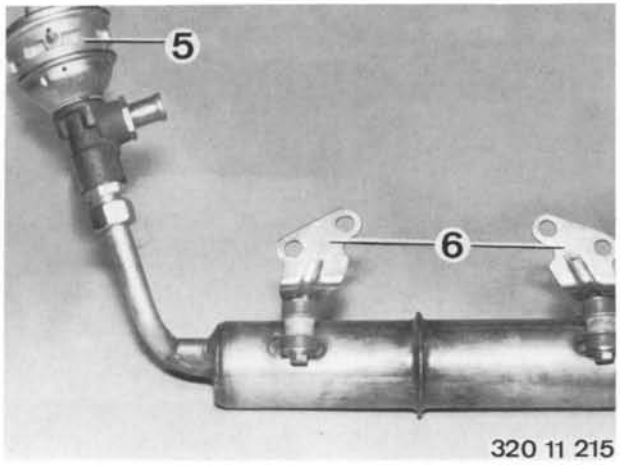
Detach hose (10) for throttle housing heating.

Installation Note! Secure harness holder on intake manifold.

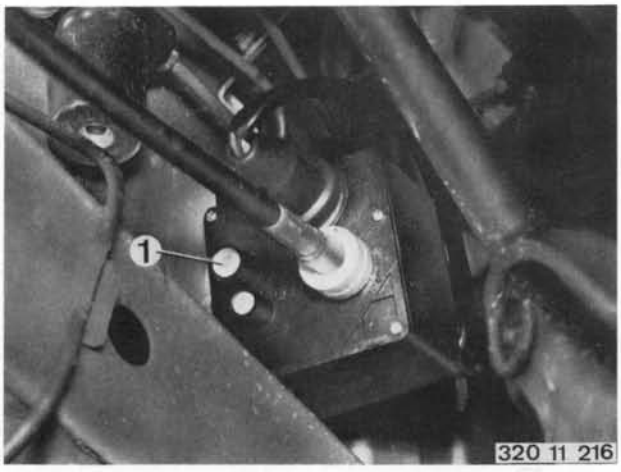


Remove holder on intake manifold and guide tube for oil dipstick.
Loosen EGR filter fasteners.
Remove EGR filter.

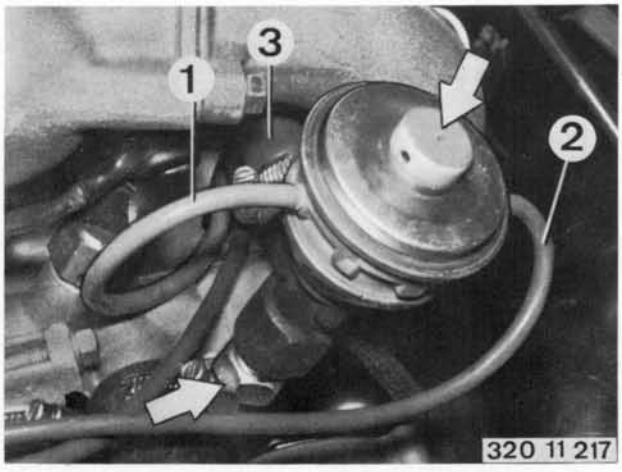




Install EGR valve (5) and holder (6).



After finishing replacement of filter press in contact (1) on intermittent switch again.



11 71 501 REPLACING EGR VALVE

Identification: Blue dot = 49 State Version
Red dot = California Version

Detach vacuum hoses (1 and 2).

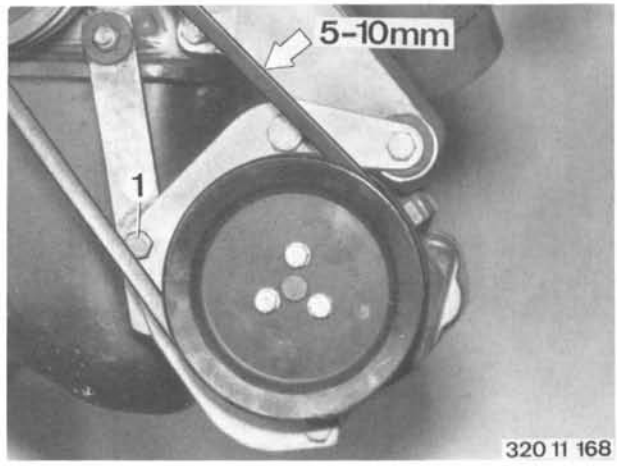
Installation Note! Blue hose (1) to pressure converter.
Red hose (2) to thermo valve.

Detach air hose (3).
Take EGR valve off of line.

11 72 000 REPLACING AIR PUMP

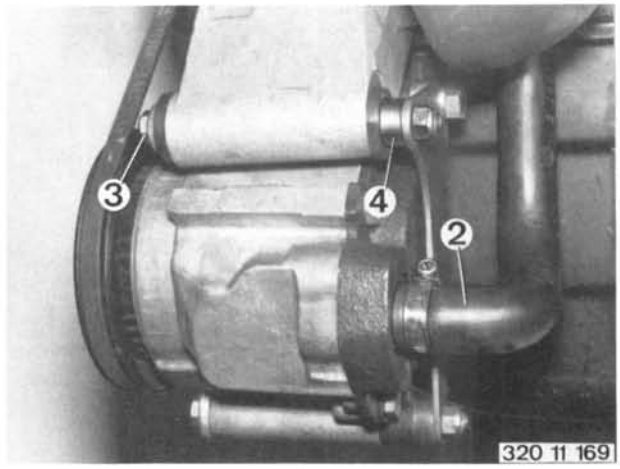
Remove screw (1).

Installation Note! Adjust belt tightness.
Belt must give by 5 ... 10 mm (0.197 ... 0.394 in.).

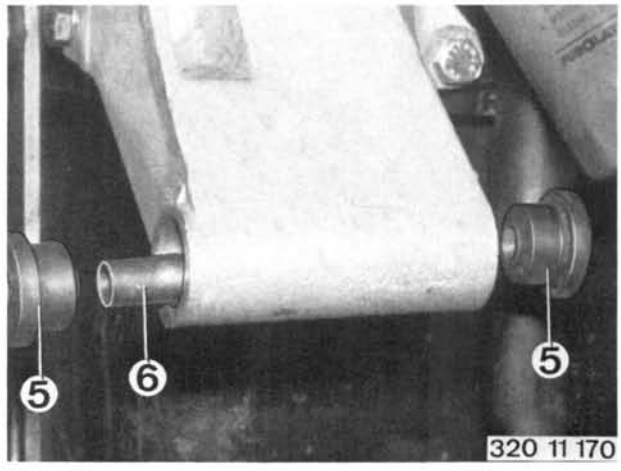


Detach hose (2).
Remove screw (3).

Caution! Spacer (4).
Remove air pump.

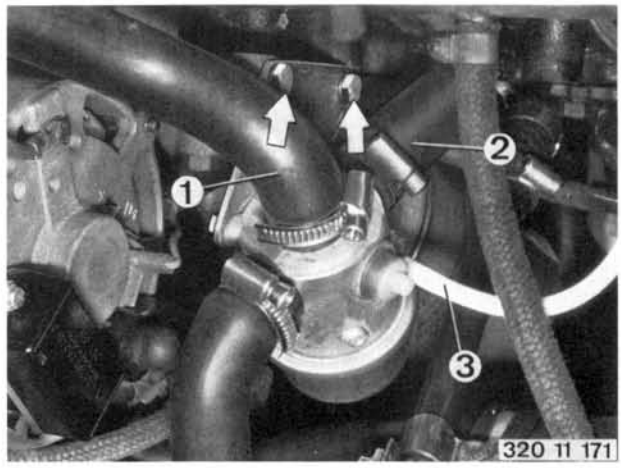


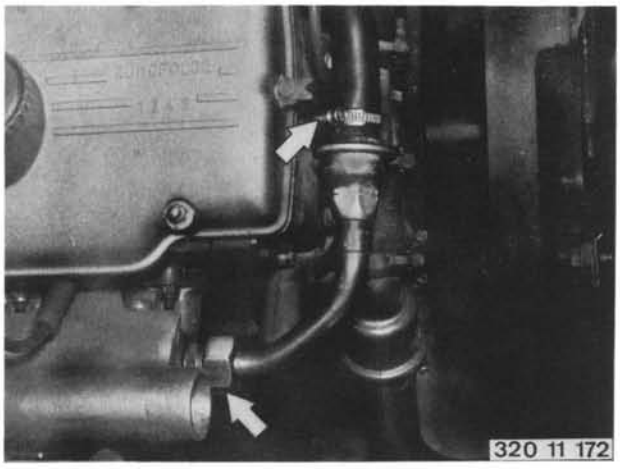
Installation Note! Check bearing sleeves (5) and replace, if necessary.
Spacer (6).



11 72 501 REPLACING BLOW-OFF VALVE

Remove intake cowl and intake neck.
Detach hoses (1 and 2).
Detach vacuum hose (3).
Take blow-off valve off of oil filter housing.





11 72 511 REPLACING CHECK VALVE

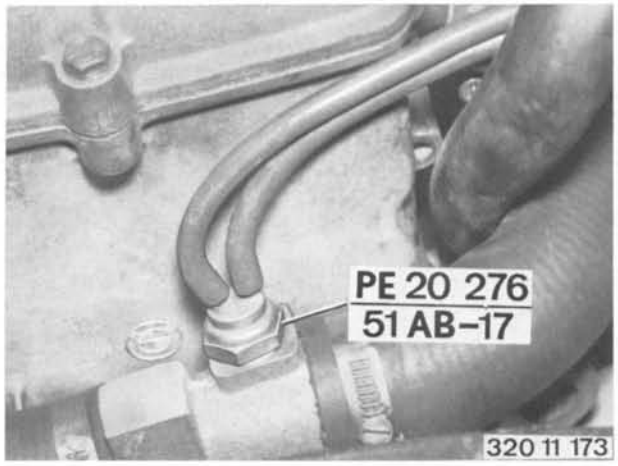
Loosen coupling nut on exhaust manifold.
Remove hose clamp.
Remove check valve.

11 74 051 REPLACING THERMO VALVE

Detach vacuum hoses.
Remove thermo valve.
Replace gasket.

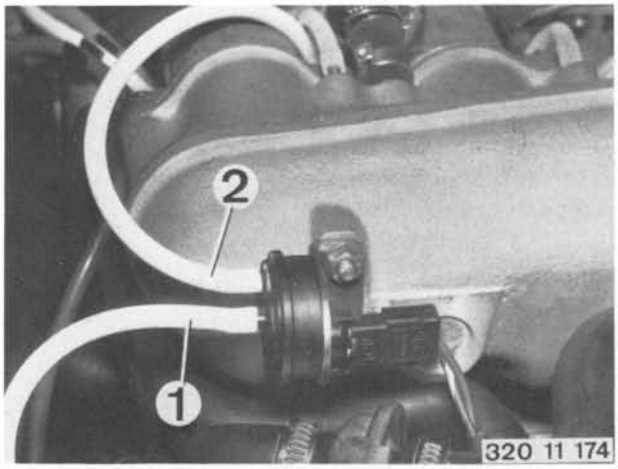
Installation Note! Add coolant and bleed cooling system - 17 11 000.

Caution! Only use thermo valves with designation PE 20 276 (green upper part) or 51 AB-17 (blue upper part, green dot of paint).



11 74 071 REPLACING TIMING VALVE

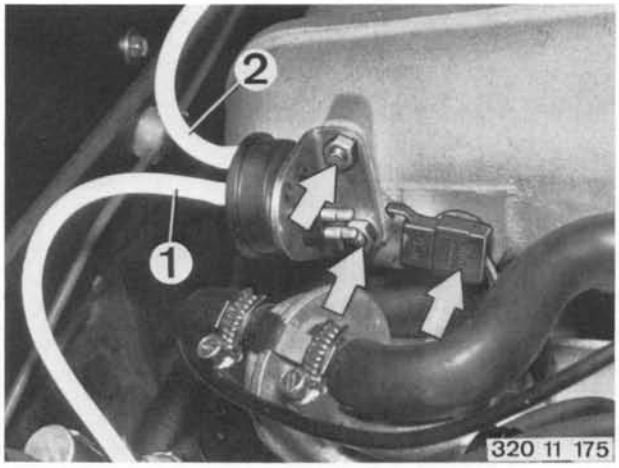
Timing valve is shut when engine is cold or in warm-up phase.
Turning on ignition heats timing valve continuously.
Cold Engine Test:
Detach hose (1).
Start engine.
No vacuum should be felt at timing valve.
Warm Engine Test:
Detach hose (2).
Timing valve is good, if engine speed increases by about 200 rpm.



Disconnect plugs.
Detach hoses (1 and 2).

Installation Note! Hose (1) to distributor vacuum box.
Hose (2) to throttle housing.

Take timing valve off of header.

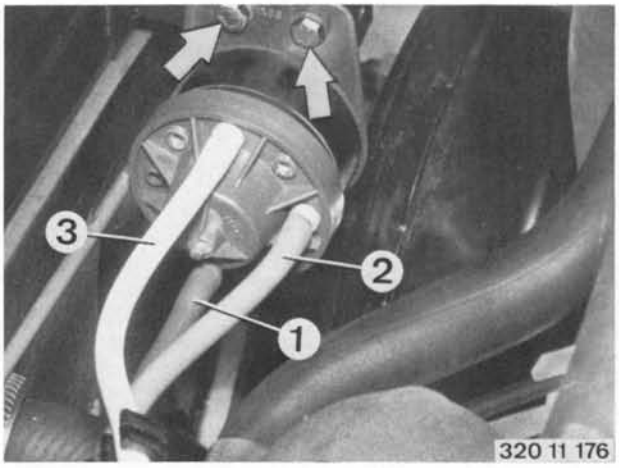


11 74 501 REPLACING PRESSURE CONVERTER

Detach vacuum hoses.

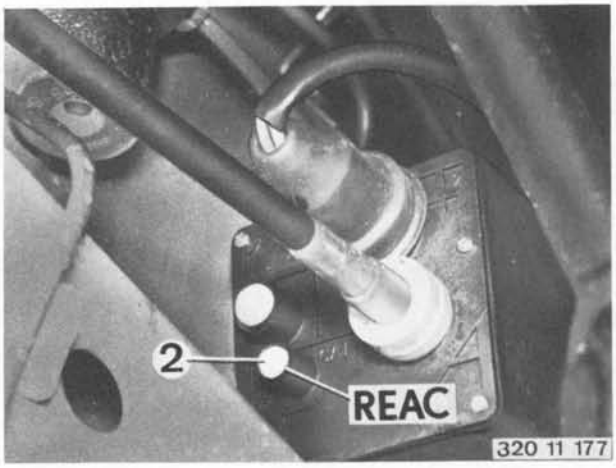
Installation Note! Hose (1) red
Hose (2) blue
Hose (3) white

Take pressure converter off of holder.

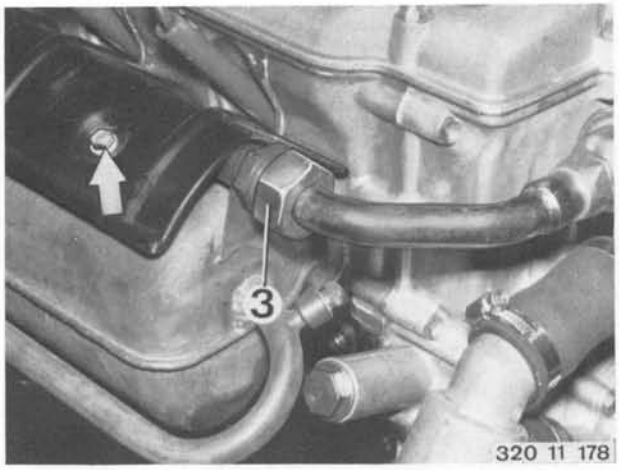


11 75 000 REMOVING AND INSTALLING EGR REACTOR

The reactor functions on the principle of self-ignition and must be checked for cracks and burns every 25,000 miles.
This requires removal of guard.
The time for inspection is released by an interval switch and shown on instrument panel.
Press in contact (2) on interval switch after completion of inspection or replacement of reactor.

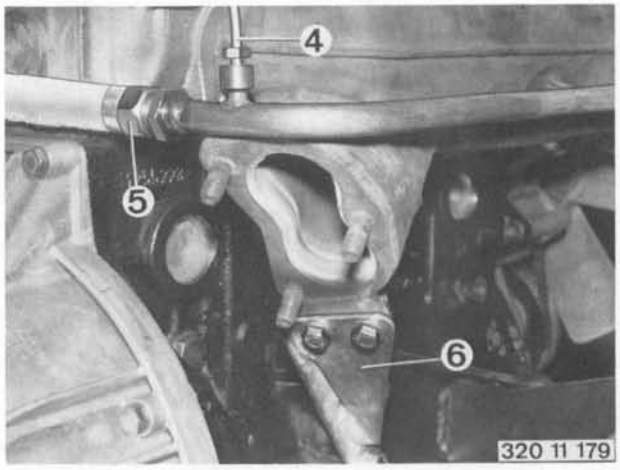


Detach exhaust pipe at reactor.
Remove guard.
Loosen fastener (3).



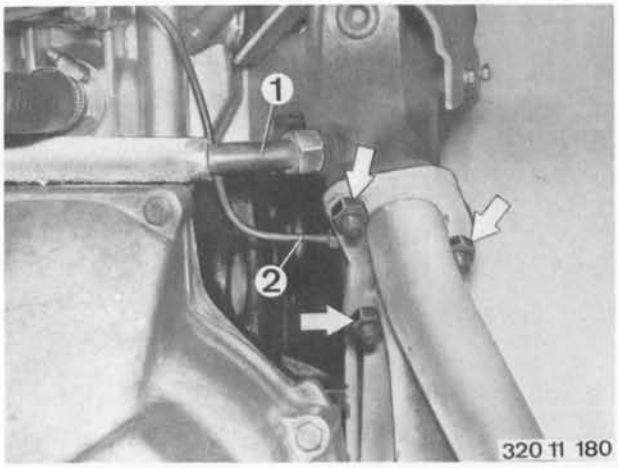
Remove counterpressure line (4), pipe (5) to EGR valve and support (6).
Detach reactor at cylinder head.

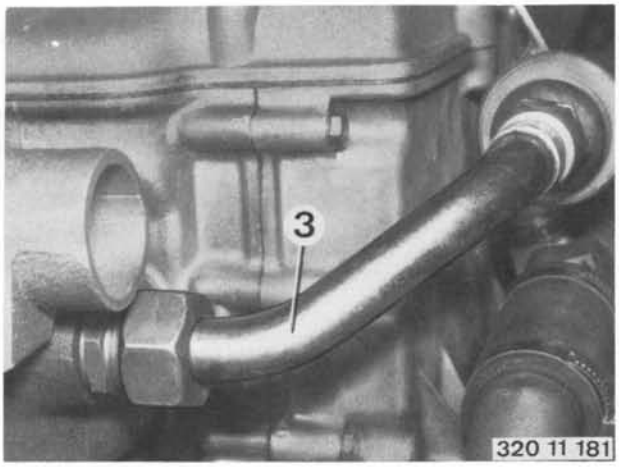
Installation Note! Check gaskets and replace, if necessary.



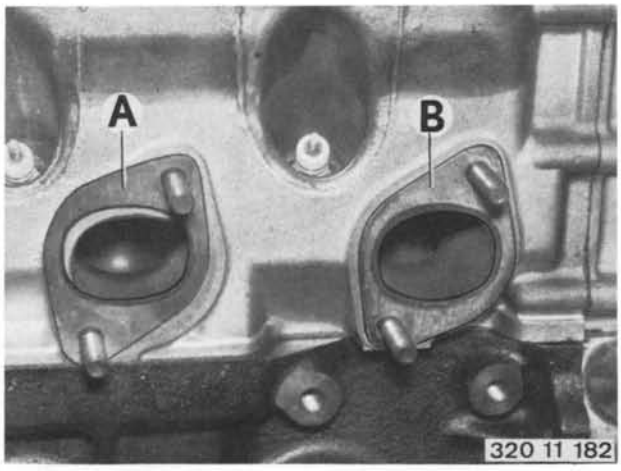
11 75 030 REPLACING EXHAUST MANIFOLD

Detach exhaust pipe at exhaust manifold.
Detach recirculation lines (1 and 2).



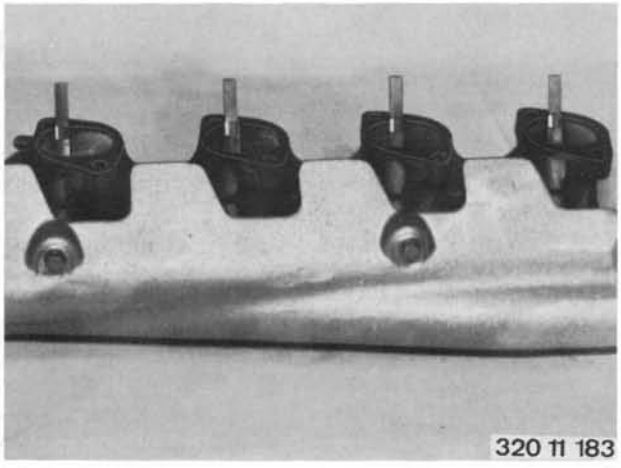


Detach air line (3).



Remove guard.
Detach exhaust manifold at cylinder head.

Installation Note! Note location of gaskets.
Gasket (A) = correct, gasket (B) = wrong.
Replace damaged staybolts and install with Loctite Code No. 270.



11 75 530 REPLACING INJECTION TUBES

Remove exhaust manifold - 11 75 030.
Unscrew injection tubes.

Installation Note! Screw in injection tubes until they have a tight fit.