	16	16 S	19 S	19 US
Engine type	In line engine with camshaft in head			
Number of cycles	4			
Number of cylinders	4			
Bore	3.35 in. (85 mm)		3.66 in. (93 mm)	
Stroke	2.75 in. (69.8 mm)			
Piston displacement, actual	96.62 cu.in.(1584 cm^3)		115.72 cu.in.(1897 cm^3)	
Piston displacement, taxable	95.53 cu.in.(1566 cm^3)		114.38 cu.in.(1875 cm^3)	
Output				
GMC-Test 20 HP/RPM	79/5600	92/5800	102/5400	90/5200
DIN 70 020 PS/RPM	68/5200	80/5200	90/5100	78/4800
Torque				
GMC-Test 20 ft.lbs./RPM	89.5/3400	95/4200	115/2800-3400	111/3400
DIN 70 020 kpm/RPM	11/3400	12/3800	14.9/2500-3100	13.9/2600
Compression ratio	8.2	9.5	9.0	7.6
Spark plugs, Bosch	W 200 T 35	W 200 T 30	W 200 T 35	
Spark plugs, A C	42 FS	41.2 XLS	42 FS	42 FS
Spark plug gap	.028 - .031 in. (0.7 - 0.8 mm)			
Dwell angle	47 - 53°) at a min. breaker point gap			
Dwell time	53 - 59 %) of .016 in. (0.40 mm)			
Firing order	1 - 3 - 4 - 2			
Engine oil fill, Initial fill	6.8 pts. (3.2 ltrs.)			
Engine oil fill, Without oil filter element replacement	5.7 pts. (2.7 ltrs.)			
Engine oil fill, With oil filter element replacement	6.3 pts. (3 ltrs.)			
Carburetor	Standard PDSI Manual	Two barrels DIDTA Automatic	Two barrels DIDTA Automatic	Two barrels DIDTA Automatic
Choke valve				
Engine idle rpm. Synchromesh transmission	700 - 750	800 - 850	800-850	850 - 900
Engine idle rpm. Automatic transmission in "N"	-	750 - 800	750 - 800	800 - 850
Clutch	Single plate, dry disc			
Clutch pedal free travel	0			
Cooling system	Water circulated by maintenance-free centrifugal pump.			
Lubrication	Pressure feed by gear type pump, full flow type oil filter			
Valve clearance with engine at operating temperature, Intake	.012 in. (0.30 mm)			0
Valve clearance with engine at operating temperature, Exhaust	.012 in. (0.30 mm)			0

6

	Technical Specifications	Check with:
Cylinder Head, Valves		
Adjusting spark plug gap	.028 - .031 in. (0.7 - 0.8 mm)	Feeler gauge
Ignition timing	Pointer at inspection hole to marking on flywheel.	Timing light and tachometer
Valve clearance with engine at operating temperature Intake and axhauste	.012 in. (0.30 mm) 0 on US engines	Feeler gauge
Adjusting hydro-valve lifter (on US engine only, engine not running)	When clearance in valve control mechanism is just eliminated, tighten rocker arm adjusting nut 1 turn	
Valve spring pressure Intake valve closed Intake valve open Exhaust valve closed Exhaust valve open	 88.2 - 81.6 lbs. (40 - 37 kp) 66.1 - 153.2 lbs.(30 - 69.5 kp) 76.1 - 71.7 lbs. (34.5-32.5 kp) 54 - 157 lbs. (24.5 - 71.2 kp)	Spring scale
Valve dimensions (intake) Stem diameter Standard size .003 in.(0.075 mm) oversize .0059 in.(0.15 mm) oversize .0118 in.(0.30 mm) oversize Total length Valve head diameter	 .3538-.3543 in.(8.987-9.000 mm) .3567-.3572 in.(9.062-9.075 mm) .3597-.3602 in.(9.137-9.150 mm) .3656-.3661 in.(9.287-9.300 mm) 4.843 in. (123 mm) 1.574 in. (40 mm)	 Micrometer Vernier caliper
Valve dimensions (exhaust) Stem diameter Standard size .003 in.(0.075 mm) oversize .0059 in.(0.15 mm) oversize .0118 in.(0.30 mm) oversize Total length Valve head diameter	 .3524-.3528 in.(8.952-8.965 mm) .3553-.3559 in.(9.027-9.040 mm) .3583-.3588 in.(9.102-9.115 mm) .3642-.3647 in.(9.252-9.265 mm) 5.021 in. (125 mm) 1.338 in. (34 mm)	 Micrometer Vernier caliper
Valve stem clearance Intake Exhaust	 .001-.0025 in.(0.025-0.063 mm) .0024-.0039 in. (0.060-0.098 mm)	Micrometer

	Technical Specifications	Check with:
Max. permissible head to stem runout Intake Exhaust	 .0016 in. (0.04 mm) .0019 in. (0.05 mm)	
Valve seat and correction angle in cylinder head Intake and exhaust Valve seat angle Outer correction angle	 45° 30°	
Valve face angle	44°	
Valve seat width in cylinder head Intake Exhaust	 .049-.059 in. (1.25 - 1.50 mm) .063-.073 in. (1.60 - 1.85 mm)	
Valve head contact area	Aim at centricity	
Valve stem bores in cylinder head (Intake and exhaust) Standard size .003 in. (0.075 mm) oversize .006 in. (0.150 mm) oversize .0118 in. (0.300 mm) oversize	 .3553-.3562 in. (9.025-9.050 mm) .3582-.3592 in. (9.100-9.125 mm) .3615-.3622 in. (9.175-9.200 mm) .3671-.3681 in. (9.325-9.350 mm)	Inside caliper

Cylinder Block And Pistons

Cylinder bore	Refer to table "Grinding Dimensions"	
Permissible cylinder bore out-of-roundness	.0005 in. (0.013 mm)	Inside caliper
Permissible cylinder bore taper	.0005 in. (0.013 mm)	Inside caliper
Piston clearance, nominal	.0012 in. (0.03 mm)	Inside caliper
Piston size	Refer to table "Grinding Dimensions"	
Piston ring gap on 16 and 16 S-engine No. 1 compression ring No. 2 compression ring Oil control ring	 .0118-.0177 in. (0.30 - 0.45 mm) .0118-.0177 in. (0.30 - 0.45 mm) .0150-.0551 in. (0.38 -1.4 mm)	Feeler gauge, ring installed in groove

	Technical Specifications	Check with:
Piston ring gap on 19 S and US-engine No.1 compression ring No.2 compression ring Oil control ring	 .0138-.0217 in.(0.35 - 0.55 mm) .0138-.0217 in. (0.35 - 0.55 mm) .0150-.0551 in. (0.38 - 1.40 mm)	 Feeler gauge, ring installed in groove
Piston pin in piston	Selective fit	

Cranking Mechanism

Crankshaft grinding dimensions	Refer to table "Grinding Dimensions"	
Permissible out-of-roundness of connecting rod bearing journals	.0002 in. (0.006 mm)	Micrometer
Permissible taper of connecting rod and crankshaft bearing journals	.0004 in. (0.01 mm)	Dial gauge
Permissible radial runout of center main bearing journals when supported in end bearings	.0012 in. (0.03 mm)	Dial gauge
Permissible unparallelism of connecting rod bearing journals when crankshaft is placed in V-blocks so that main bearing journals next to each other are supported	.0005 in. (0.012 mm)	Dial gauge
Permissible runout of crankshaft to flywheel contact area	.0008 in. (0.02 mm)	Dial gauge
Crankshaft end play	.0017-.0061 in.(0.043-0.156 mm)	Dial gauge
Main bearing clearance	.0009-.0025 in. (0.023-0.064 mm)	Dial gauge Micrometer
Connecting rod bearing clearance	.0006-.0024 in. (0.015-0.061 mm)	Dial gauge Micrometer
Connecting rod end play on bearing journals	.0043-.0095 in.(0.11-0.24 mm)	Feeler gauge

	Technical Specifications	Check with:
Weight difference of connecting rods without pistons and bearing shells within an engine	.28 oz. (8 g)	Scale
Fitting ring gear onto flywheel	Heat ring gear to 356°F - 446°F (180 - 230°C)	
Permissible lateral runout of ring gear to flywheel	.0197 in. (0.5 mm)	Dial gauge

Valve Mechanism

Camshaft grinding dimensions and pertaining camshaft bearing diameter	Refer to table in this group	Micrometer Inside caliper
Camshaft end play	.004 -.008 in. (0.1-0.2 mm)	Feeler gauge
Permissible radial runout of camshaft center bearing - camshaft supported in outer bearings	.001 in. (0.025 mm)	Dial gauge

Engine Lubrication

Oil pump gear backlash	.004 - .008 in. (0.10 - 0.20 mm)	Feeler gauge
Oil pump gear end play in housing	0 - .004 in. (0 - 0.10 mm)	Straight-edge Feeler gauge

Clutch

Clutch pedal free travel	0	
Permissible lateral runout of clutch contacting area on installed flywheel with a diameter of 8 in. (200 mm)	.0039 in. (0.1 mm)	Dial gauge
Permissible clutch disc lateral runout (reading taken at edge of disc)	.016 in. (0.4 mm)	Dial gauge
Permissible clutch disc thickness including spread after installation of new linings	.35 in. (9 mm)	Vernier caliper

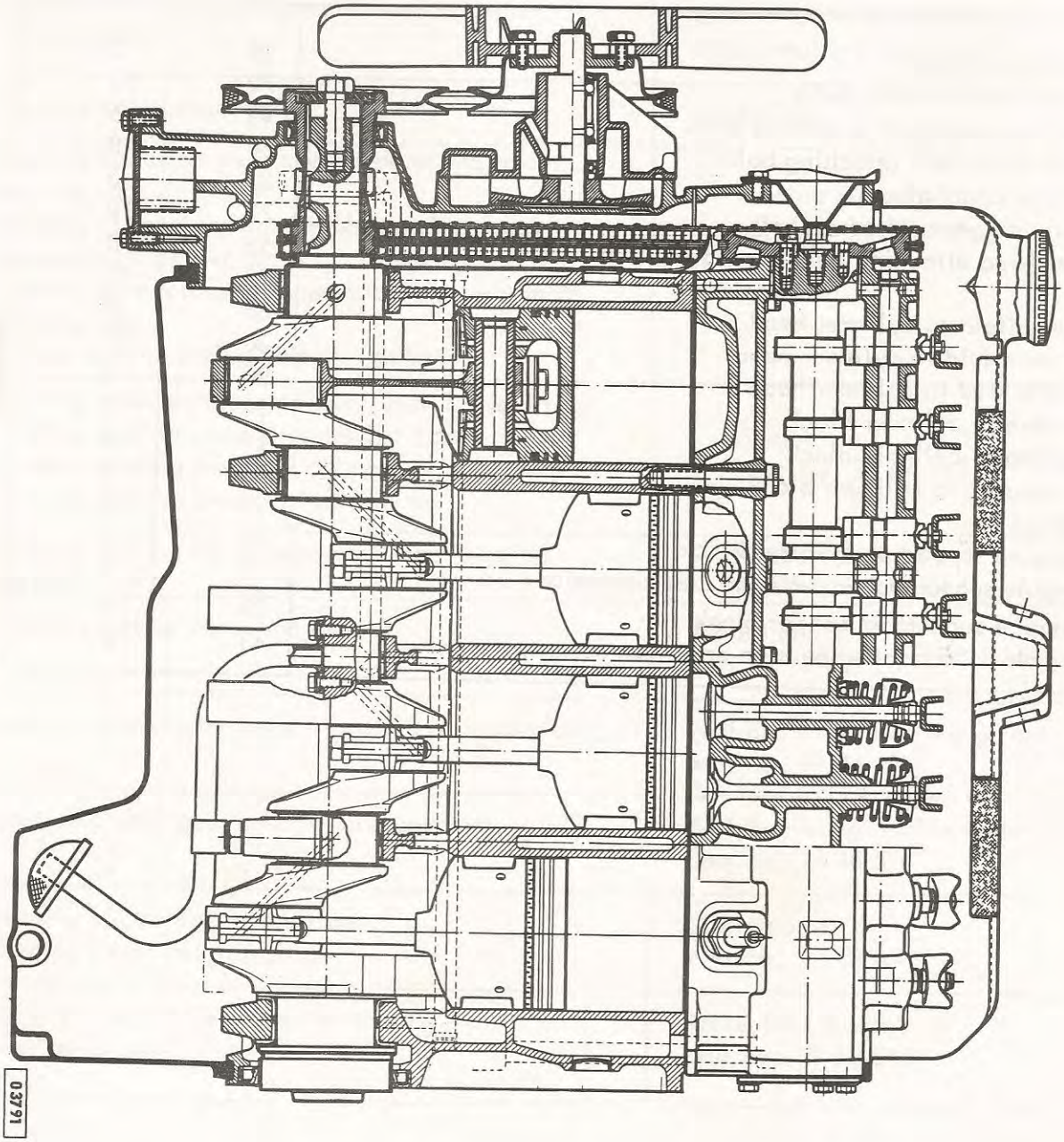
Oils, Grease, Sealers

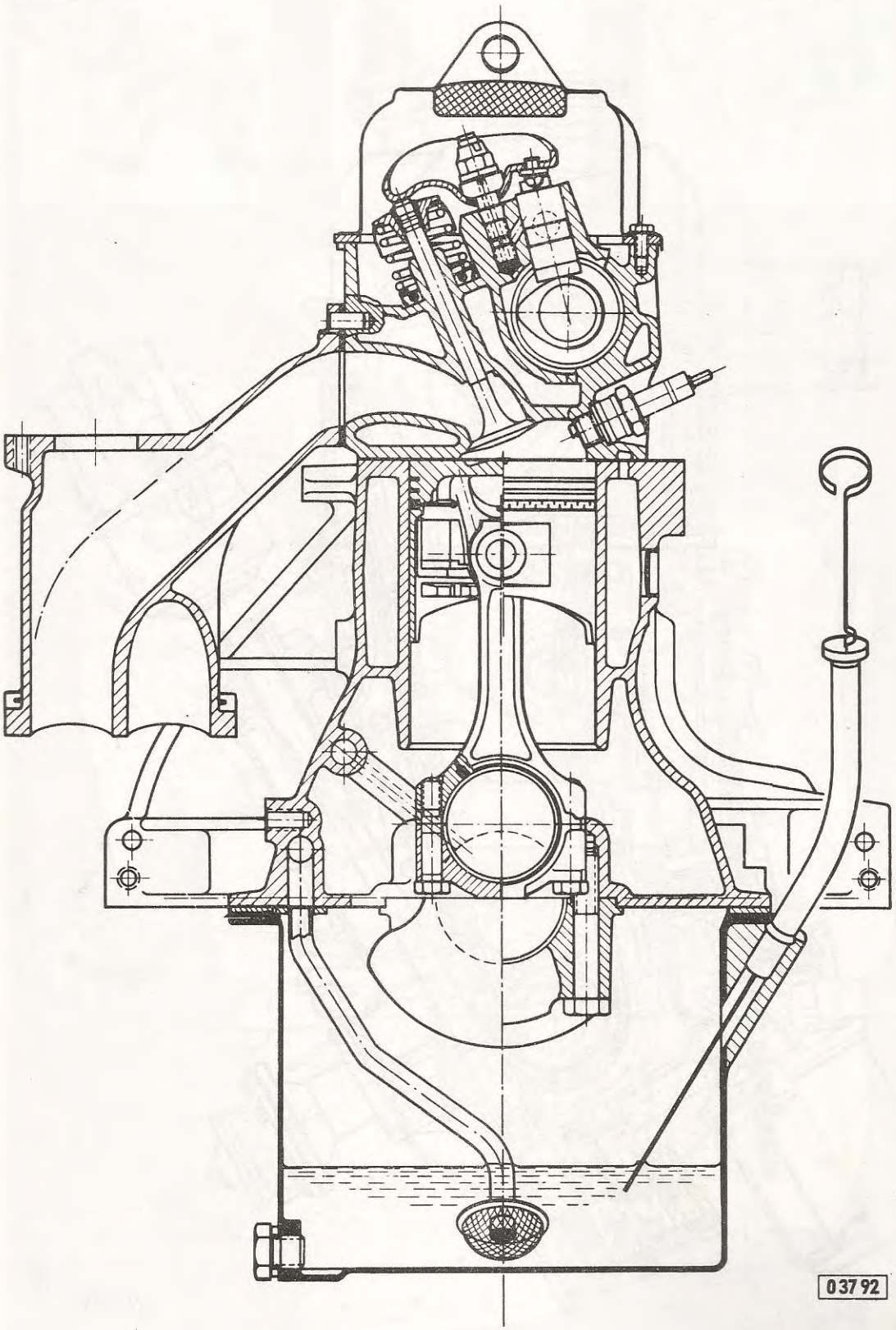
Engine oil for normal outside temperatures	GM 4745-M-SAE 20 for service MS or multi-viscosity oil
Engine oil for prevailing temperatures below 15°F (-10°C)	GM 4745-M-SAE 10 for service MS or multi-viscosity oil.
Coating valve stems	Engine oil
Coating contacting surface inside of rear main bearing cap Coating oil pan cork and rubber gasket areas contacting cylinder block Coating contacting surfaces outside of rear main bearing cap Filling butting ends of oil pan gasket	Sealing compound part no. 15 03 294
Coating outer surface of timing case oil seal ring Coating sealing area for camshaft cover Coating sealing areas for oil pump suction tube Coating sealing areas for water pump	Sealer part no. 15 04 167
Coating sealing lip of rear crankshaft bearing oil seal	Protective grease part no. 19 48 814
Oiling cylinder walls and pistons	Adhesive oil part no. 19 49 950
Coating clutch gear needle bearing in crankshaft	Ball and roller bearing grease part no. 19 46 254
Coating clutch gear bushing in crankshaft	Molybdenum disulfide paste part no. 19 48 524
Coating clutch disc hub splines Coating thrust bearing guide	Sliding paste part no. 19 48 564
Coating sealing lip of crankshaft rear main bearing oil seal	Protective grease part no. 19 48 814

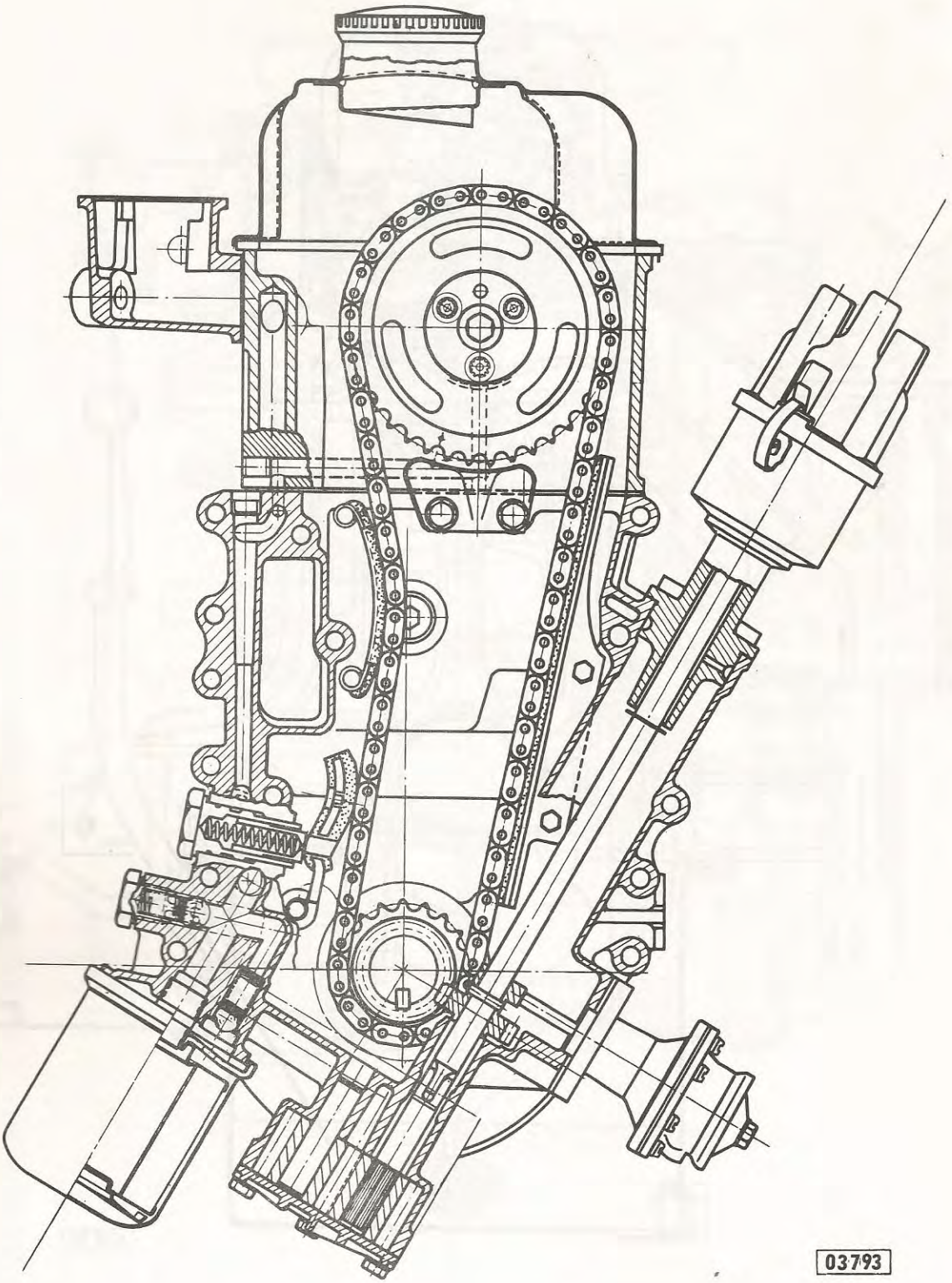
Revised page

Torque Specifications

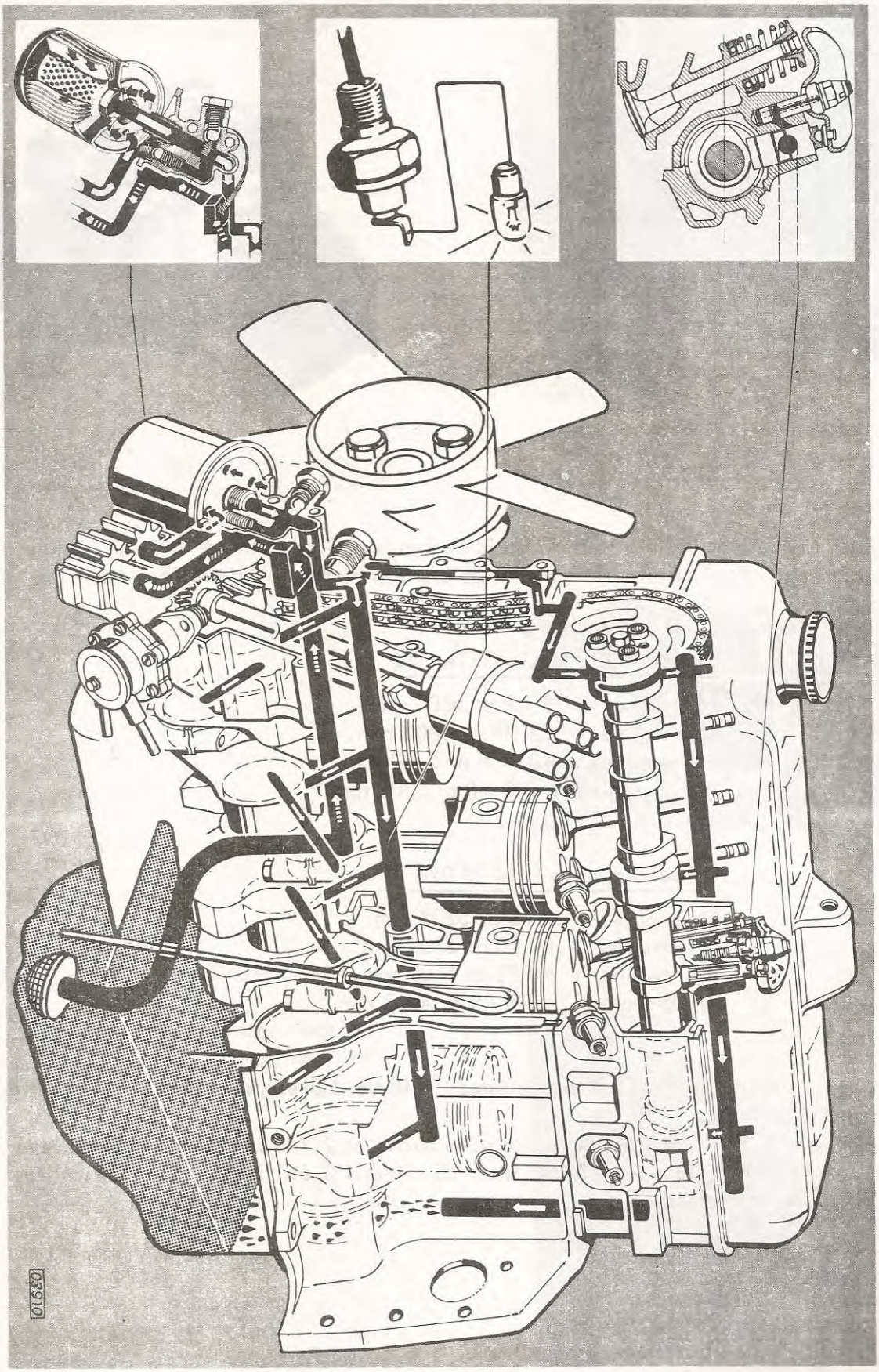
	ft. lbs.	Kpm
Connecting rod bolts	36	5
Crankshaft main bearing bolts	72	10
Flywheel to crankshaft attaching bolts	43	6
Pulley to crankshaft attaching bolts	58	8
Sprocket to camshaft	22	3
Harmonic balancer to crankshaft	72	10
Cylinder head attaching bolts: operating temperature	58	8
cold	72	10
Intake manifold to cylinder head	36	5
Exhaust manifold to cylinder head	36	5
Rocker arm stud in cylinder head	29	4
Timing case to cylinder block	14	2
Water pump to cylinder block	14	2
Clutch housing to cylinder block	36	5
Spark plugs	29	4
Front engine support to cylinder block	29	4
Rear engine support to transmission case extension	22	3
Front engine support to damper block	29	4
Damper block to front suspension cross member attachment	43	6


03791

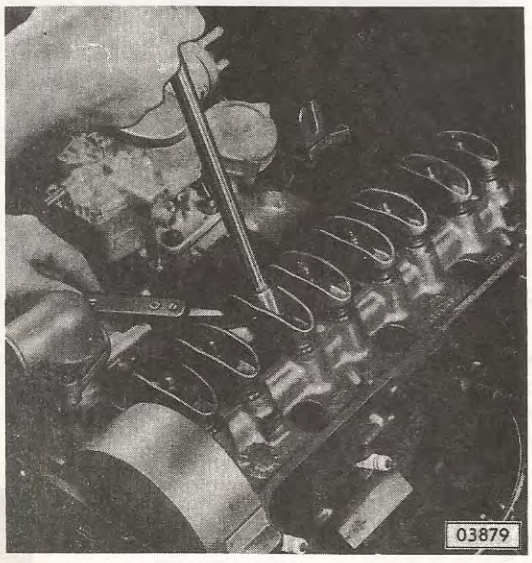

03792



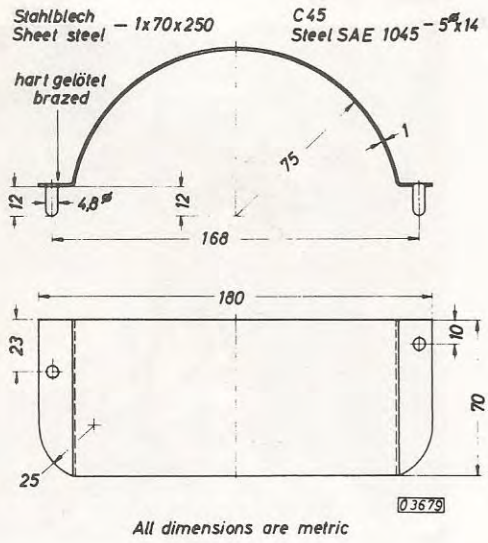
03793


D3910

Adjusting Valve Clearance



With engine at operating temperature (160° F = 80° C coolant and 140° - 160° F = 60° - 80° C oil temperature) adjust intake and exhaust valve clearance while engine is running to .012 in. (0.30 mm) by turning rocker arm nut. Feeler gauge should slide with a drag.



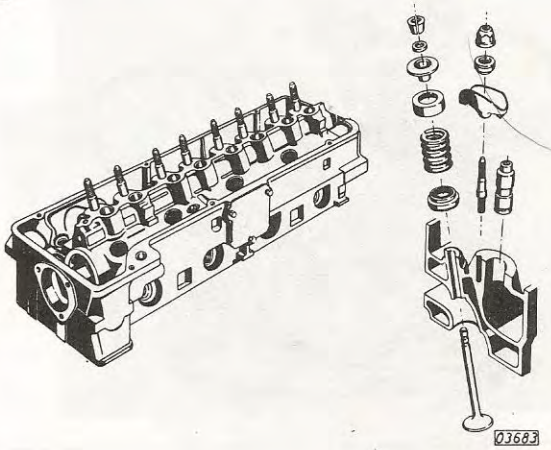
All dimensions are metric

Deflect splash oil of timing chain with a protective metal sheet to be made up in own repairshop according to the dimensions given in the drawing. This metal sheet can also be obtained from Messrs. Matra-Werke under No. 0/58.

Button cork gasket onto rocker arm cover - do not cement it to cover.

- Cylinder head removed-

Check evenness of cylinder head sealing area on a surface plate or with a straight-edge and a feeler gauge. Permissible unevenness at its total length = .002 in. (0.05 mm).



In order to obtain a proper and gas-tight valve seat, the intake and exhaust valves may be lapped with a fine-grained lapping compound.

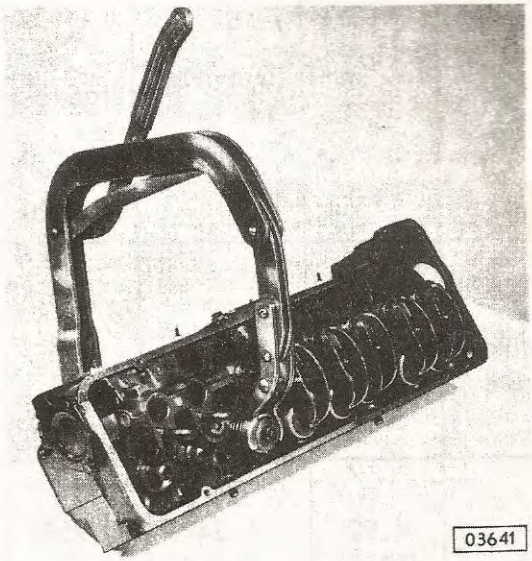
As long as no cratering in the valve head is noticable the valve may be reworked by regrinding.
Make sure that the upper valve edge does not become too thin as the edge would otherwise burn quickly. Such valves have to be replaced.

Worn valve guides do not warrant a concentric valve seat. They have to be reamed to the next oversize and new valves have to be installed.

The valve head angle is 44° and the valve seat angle 45°.

The oversize markings 1, 2 and A are rolled into valve stam end.

Remove valves using tool MW 111-
For proper installation mark installation position of individual parts.

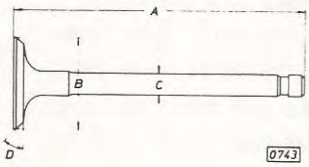


Valves

Concentricity of valve head to stem should not exceed:

Intake valve = .003 in. (0.08 mm)
Exhaust valve = .002 in. (0.05 mm)

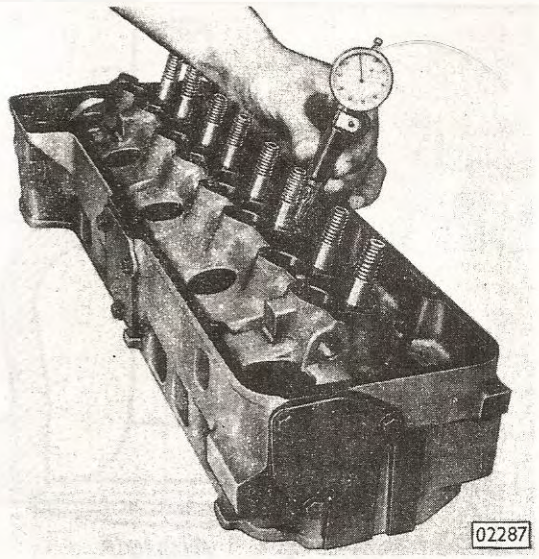
Valve Dimensions



	A in. (mm)	B Diameter in. (mm)	C Diameter in in. (mm) Standard size without marking	.003 (0.075) oversize 1	.006 (0.150) oversize 2	.0118 (0.300) oversize A	D
Intake valve	4.84 (123)	1.57 (40)	.3538 (8.987) to .3543 (9.000)	.3568 (9.062) to .3573 (9.075)	.3597 (9.137) to .3602 (9.150)	.3656 (9.287) to .3661 (9.300)	44°
Exhaust valve	4.92 (125)	1.34 (34)	.3524 (8.952) to .3530 (8.965)	.3554 (9.027) to .3559 (9.040)	.3583 (9.102) to .3589 (9.115)	.3643 (9.252) to .3648 (9.265)	44°
Valve stem bore	-	-	.3553 (9.025) to .3562 (9.050)	.3582 (9.100) to .3592 (9.125)	.3615 (9.175) to .3622 (9.200)	.3671 (9.325) to .3681 (9.350)	-

Oversize 1 and 2 for Production and Service
Oversize A for Service only

Check valve guides for wear, using dial gauge and inside caliper.



In case of wear ream guides to the next oversize. Oversize valves may also be installed in production. An oversize mark is then stamped near spark plug hole. In case of doubt measure guide. After reaming guides, cross out identification marks with a chisel and remark with the new size.

Ream guides always from the outside of cylinder head, so that the more accurate bore is attained on the side of the valve head.

For reconditioning use the following cutters:

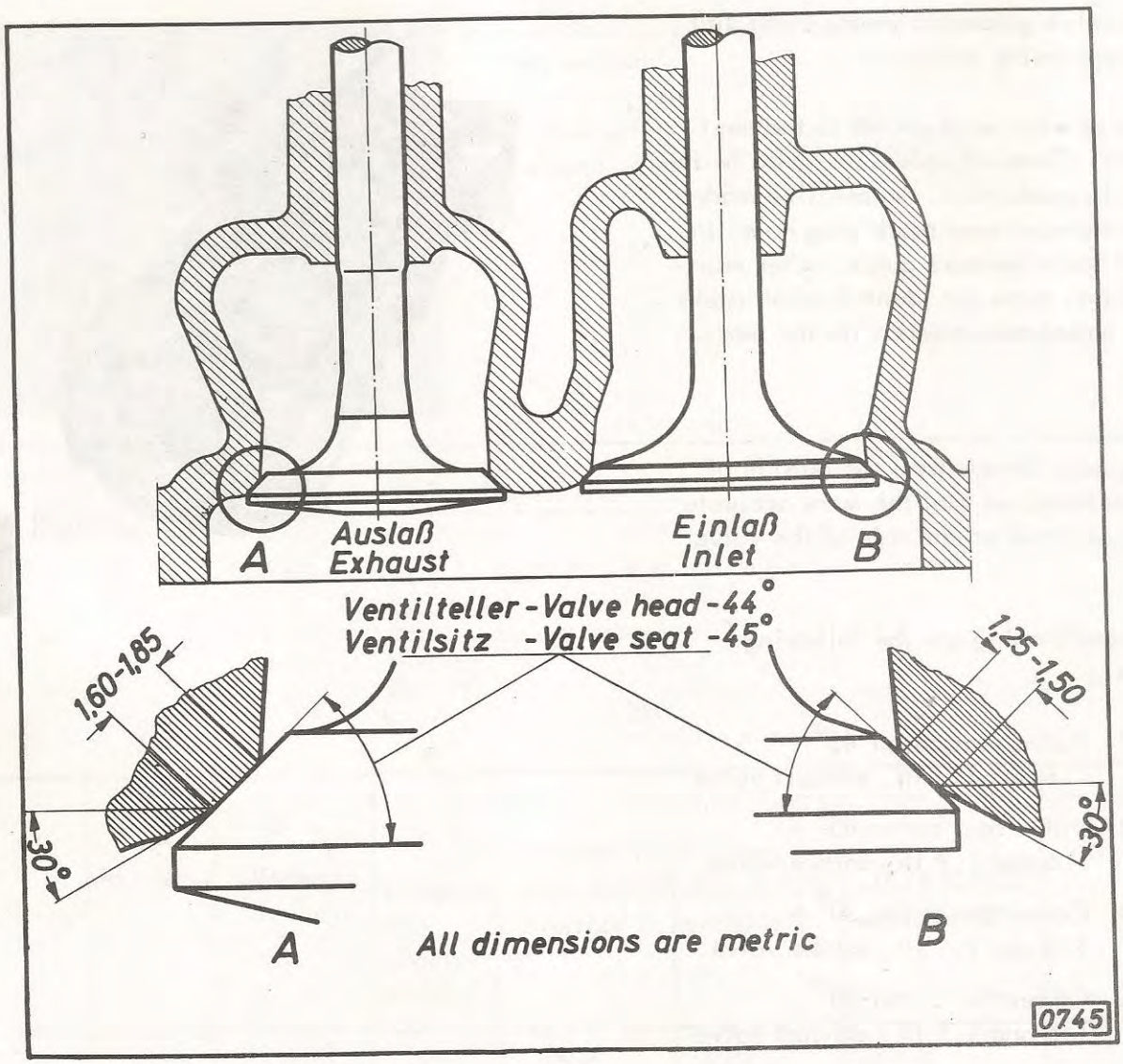
S-1092 Valve seat cutter 45° - 1.6 and 1.9 ltr. exhaust valve

S-1302 Valve seat cutter 45° - 1.6 and 1.9 ltr. intake valve

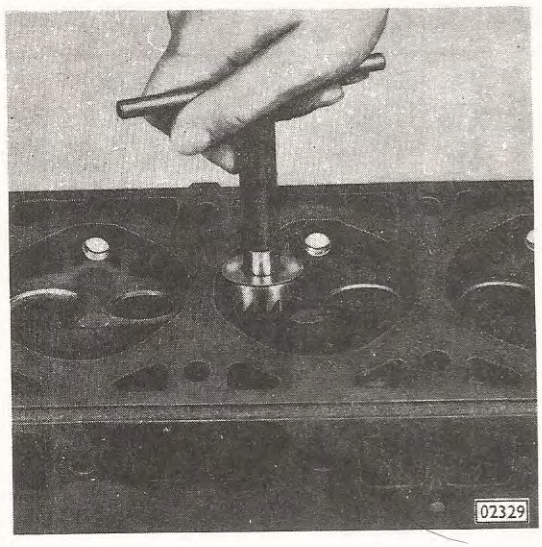
S-1303 Correction cutter 30° - 1.6 and 1.9 ltr. intake valve

S-1304 Correction cutter 30° - 1.6 and 1.9 ltr. exhaust valve

Start cutting with a 45° cutter at valve seat - material removal should be limited to a minimum - and with a 30° correction cutter cut to specified seat width. Apply read lead to valve head and check contact pattern. If required, recut valve seat.



Vertically apply uniform pressure to cutters so that a concentric valve seat without chatter marks is obtained.



For checking valves for proper seat, coat valve head with red lead, insert valve into guide and turn it under light pressure several times back and forth.

If the valve is properly seated, the read lead adheres evenly distributed to the valve seat.

Though as a rule a compression tight valve fit can be obtained, if valve seat is properly cut, the quality of the seat can be improved by lapping valve.

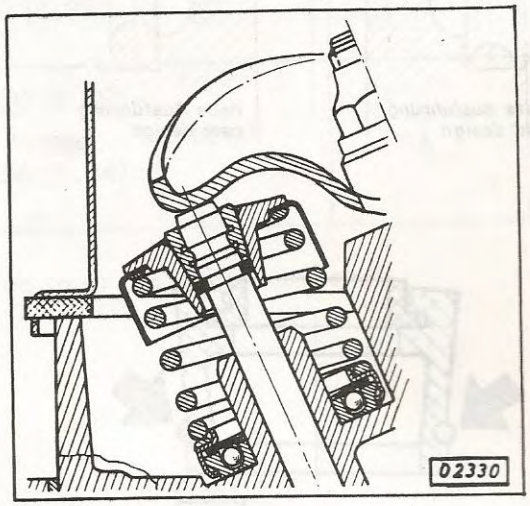
For lapping use only fine-grained lapping compound.

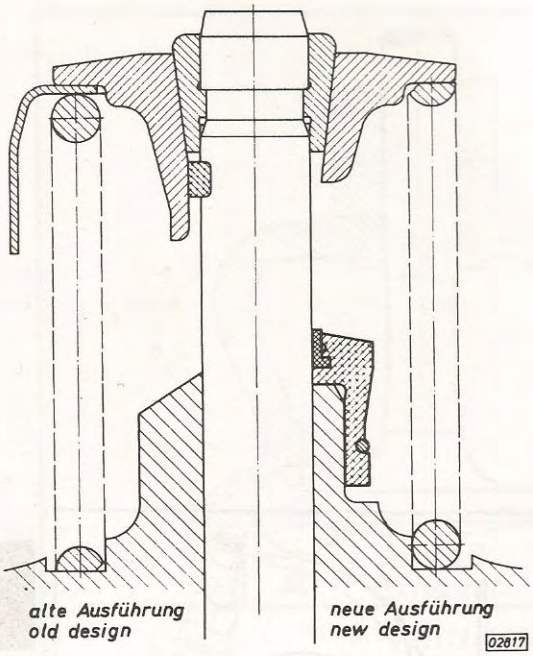
In order to evenly distribute the lapping compound film on the valve seat, rhythmically lift valve off seat during lapping operation.

After lapping carefully clean valves and valve seats from lapping compound remnants.

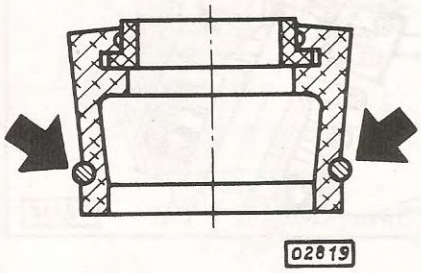
Coat valves with engine oil and install them into cylinder head. Make sure oil seal ring and oil deflector are properly seated. The narrow windings of the valve springs must show towards cylinder head.

The exhaust valves are provided with "roto-caps".



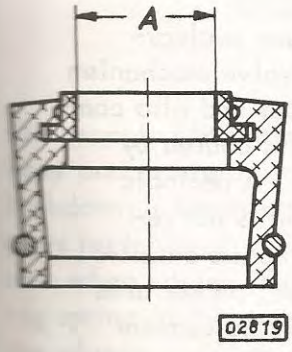


The right side of the illustration shows the valve stem oil seal of the 1.9 ltr. US-engine in installed condition (applies to intake valves only).



The Parts and Accessories Department supplies three versions of the oil seal according to the different valve stem diameters - standard and oversizes.

The different valve stem oil seals can be distinguished by colored rings.



Valve stem oil seals				Valves
		Dimension A Diameter in in. (mm) 1.9 ltr.	Color of ring	
Production and Service Oversizes	.0030 in. (0.075 mm)	.338 (8.59) to .344 (8.74)	white	Standard and over-size 1
	.0059 in. (0.150 mm)	.344 (8.74) to .350 (8.89)	yellow	Oversize 2
Service Oversize	.0118 in. (0.300 mm)	.350 (8.89) to .356 (9.04)	black	Oversize A

The oversize markings of the valves 1, 2 or A are rolled in at the valve stem end.

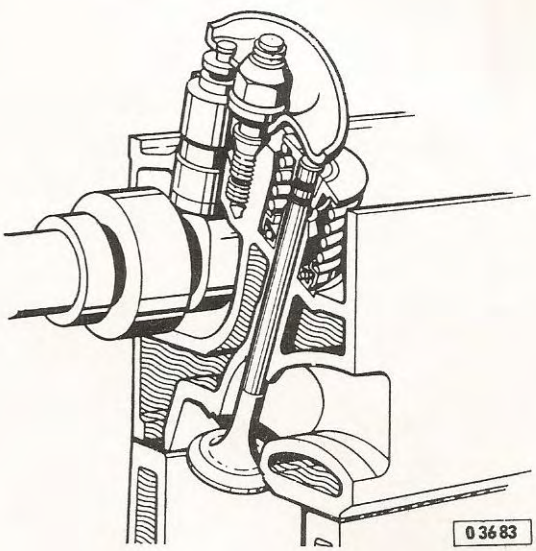
6

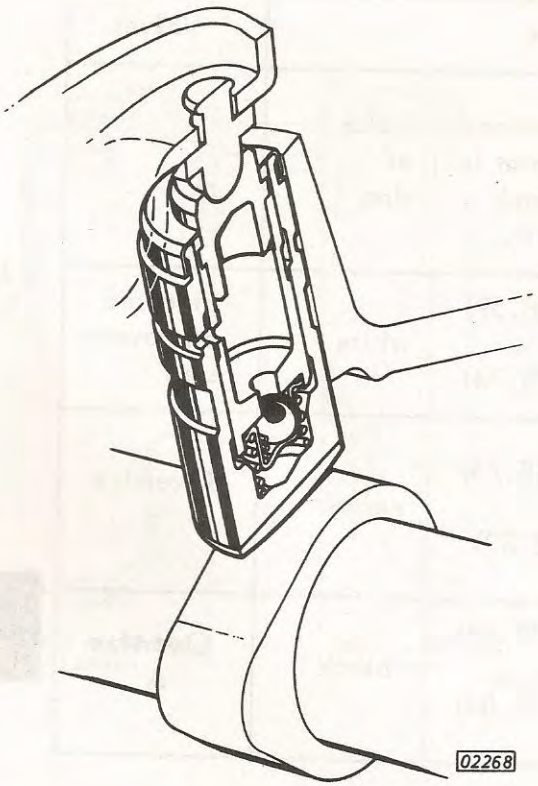
Valve Lifters

Due to insignificant wear of valve lifter and guide, no oversizes have been released.

Valve lifter guides with pitting marks can be smoothened with fine emery cloth, at the same time replacing valve lifter.

On reinstallation amply apply oil.

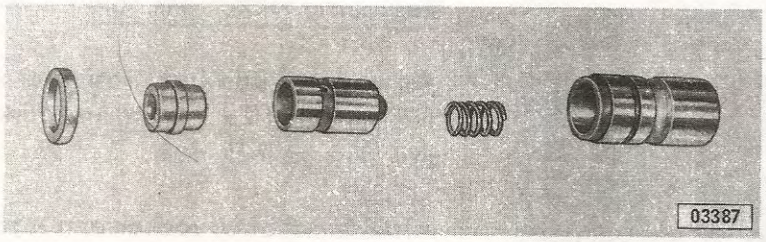




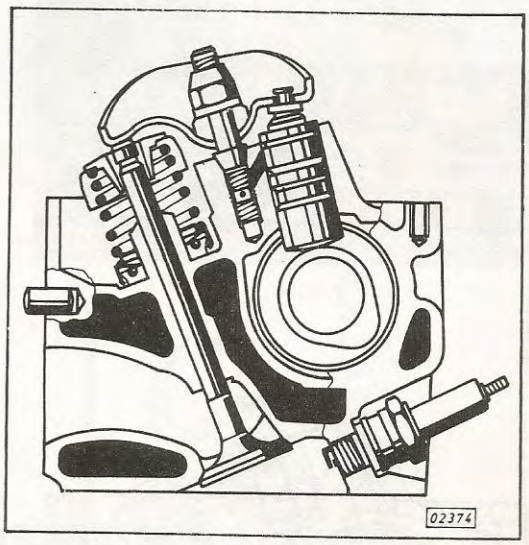
US-vehicles are equipped with 1.9 ltr. engines only. They are provided with a camshaft supported in four places, hydro-valve lifters and a modified valve stem oil seal (intake valves only).

The hydro-valve lifters ensure a clearance-free operation of the valve mechanism under all operating conditions and also compensate the changes in length caused by thermal expansion and wear. A periodic valve clearance readjustment is not required. Only after engine repairs entailing removal of cylinder head, rocker arms or hydro-valve lifters a basic adjustment has to be carried out.

The hydro-valve lifter consists in the main of the lifter body and a plunger. The wear resistant cam contact area on the body is sintered. The body is provided with grooves and bores through which oil is fed into the interior of the plunger. As soon as the interior of the plunger is filled with oil, the ball retaining valve of the plunger opens so that oil can also enter the pressure chamber below the plunger. When the camshaft lifts up the valve lifter, a pressure is exerted onto plunger by the valve spring of the respective valve causing a higher pressure in the pressure chamber than in the upper cavity, entailing the immediate closing of the ball retaining valve. By this means *the valves operate without any clearance.*



Oil escaping between plunger and lifter body and returning to the oil sump - this leakdown is necessary and desired - is always replenished due to the constant pressure when engine is running. A compensating spring in the pressure chamber above the plunger supports clearance-free valve operation.

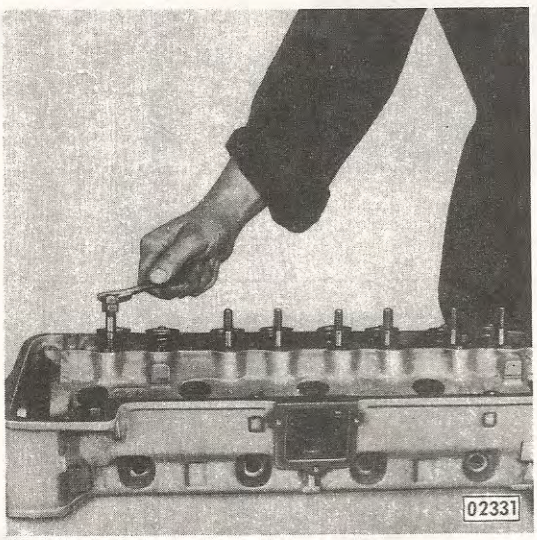


Hydro-valve lifter adjustment

Carry out hydro-valve lifter adjustment with engine not running. It makes no difference whether the engine is cold or has operating temperature. Set piston of the respective cylinder to U.D.C. It is advisable to adjust lifters in the firing order.

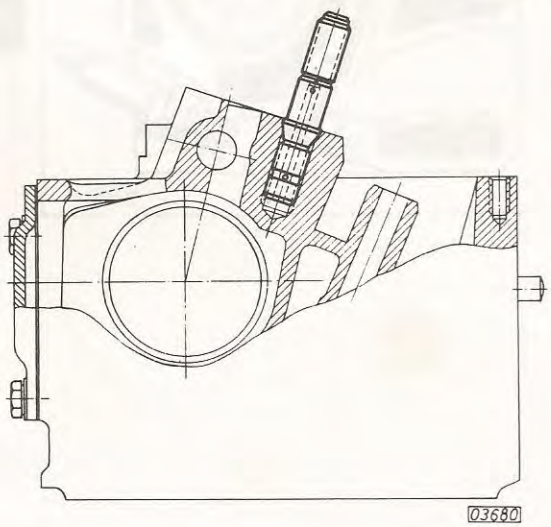
Back off adjusting nut at the rocker arm until a clearance exists. Then tighten adjusting nut until any clearances between valve, rocker arm and lifter are eliminated. Screw in adjusting nut one full turn. The valve clearance is now adjusted and no readjustment is required.

Replacing rocker arm stud



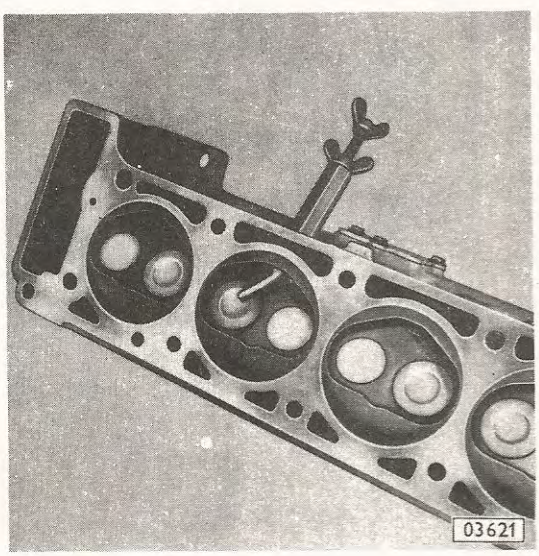
For removal and installation of stud use two nuts M 10 x 1 or two reworked rocker arm nuts as lock nuts.

After removal of rocker arm screw in new stud, seat tapered part with a rubber hammer stroke onto stud end and torque stud to 29 ft. lbs. (4 kpm).



If after a short period of operation the valve clearance has abnormally changed, check stud tightness and retighten to specified torque.

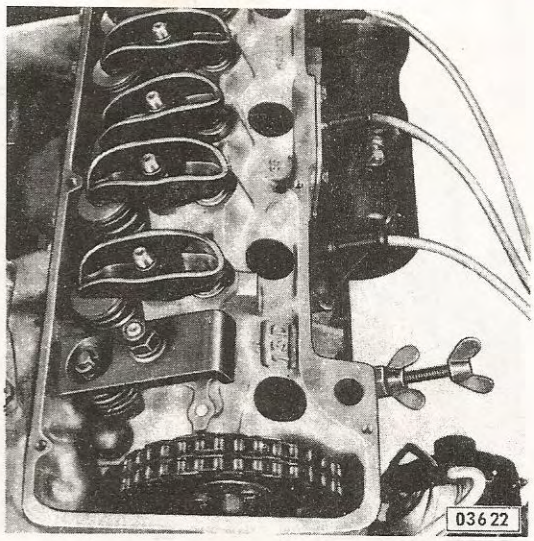
Replacing valve springs



Remove and install rocker arm cover.

Screw tool S-1230 into spark plug hole. Thereby the piston must be positioned somewhat below U.D.C. Turn hooked end until it presses against valve head and secure with wing nut.

With the aid of tool S-1298 remove valve spring.



To avoid damage to the oil seal ring, first compress spring together with oil deflector and valve seat and then place oil seal ring in valve stem groove. This applies only to 16, 16 S and 19 S-engine. As far as the valve stem oil seals for 19 US-engines are concerned refer to page 06-45.