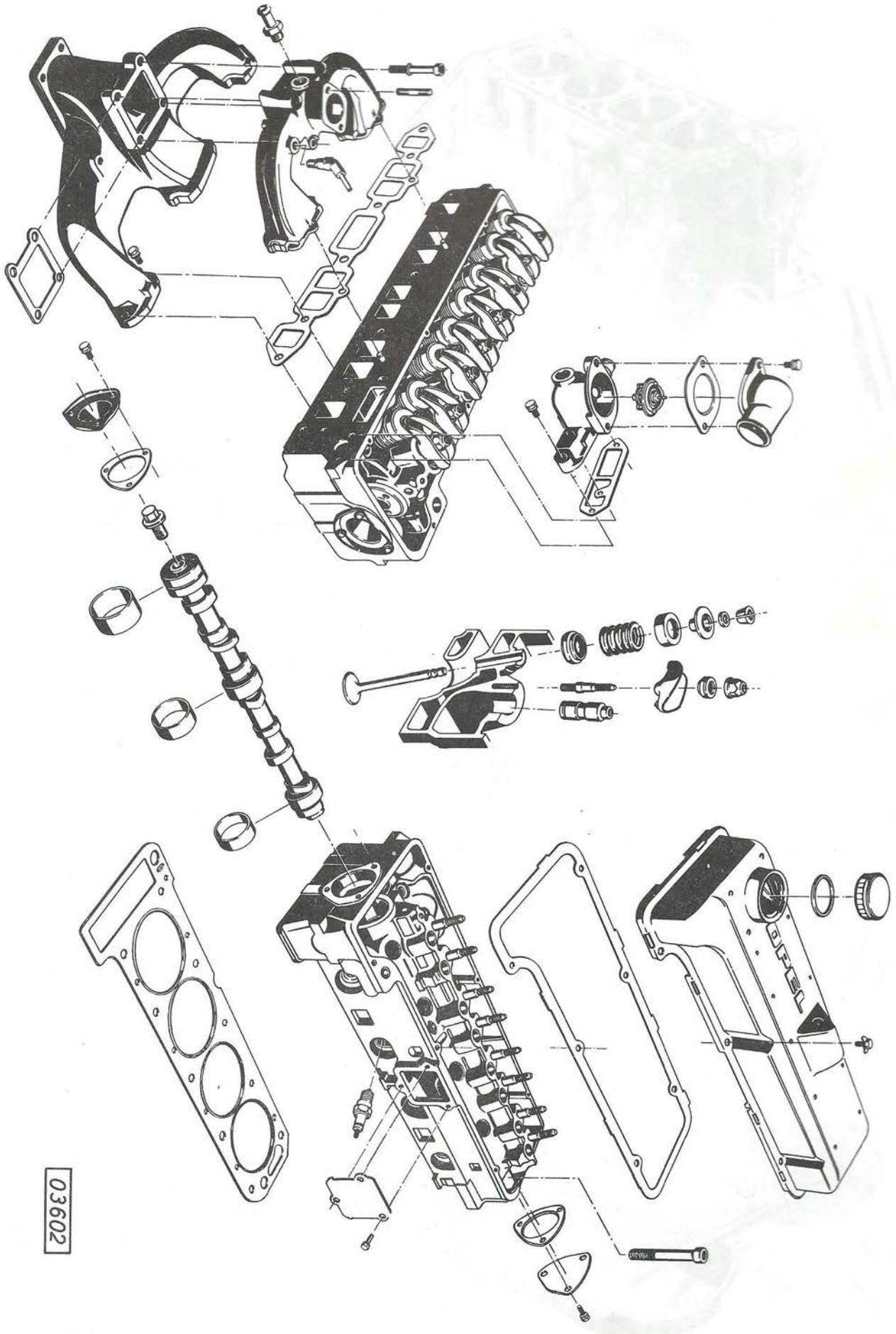
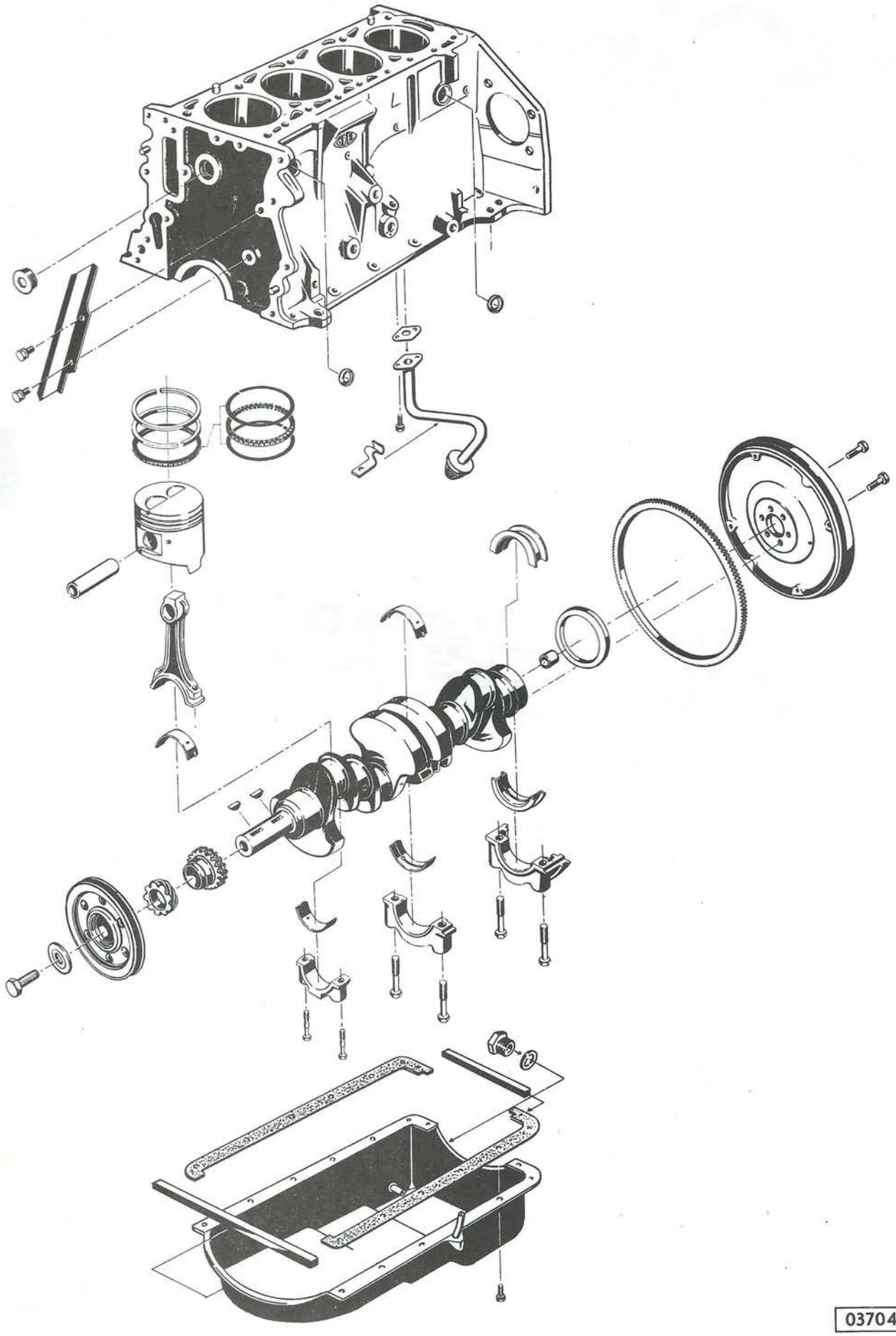
GROUP 6

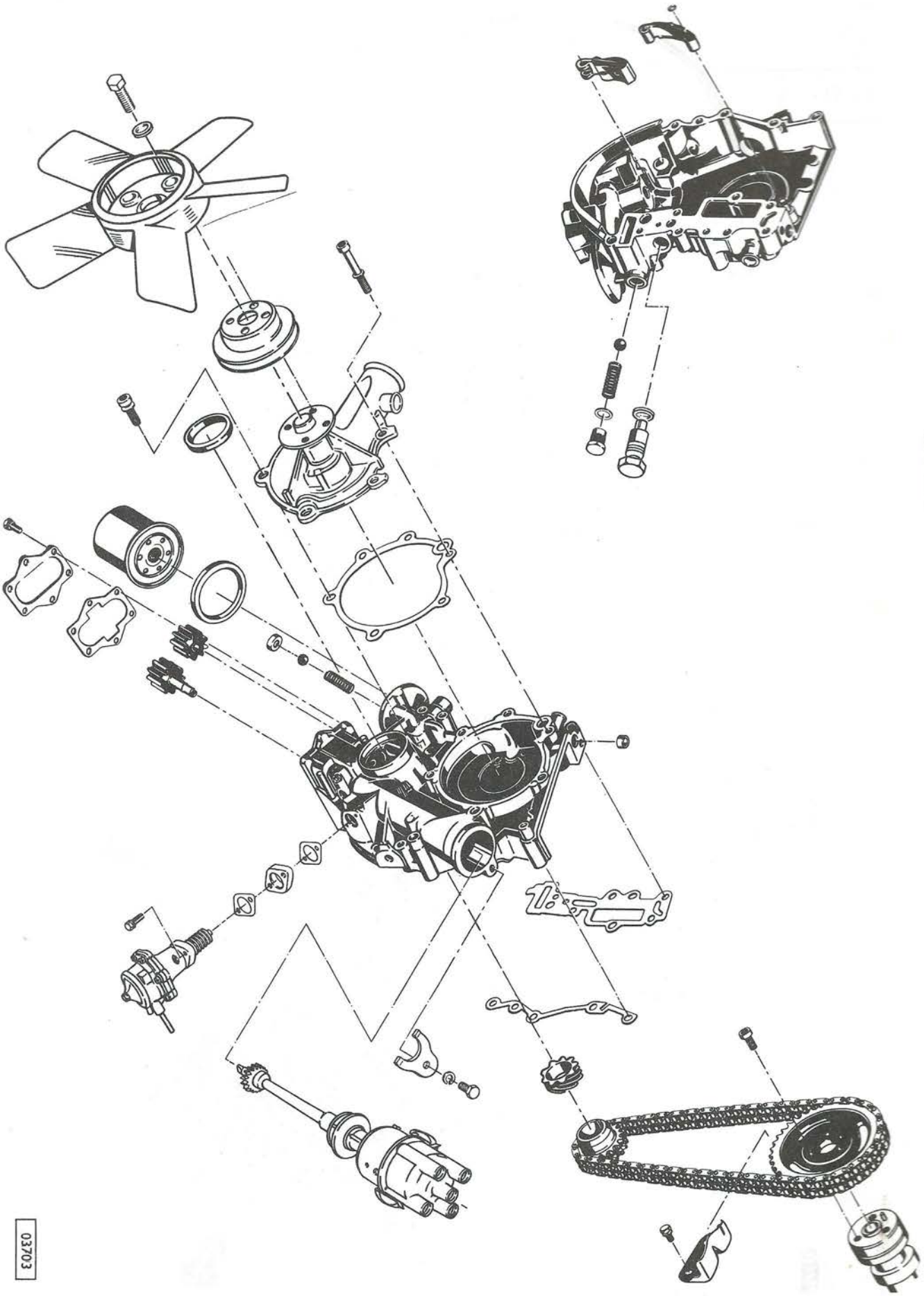
ENGINE AND CLUTCH



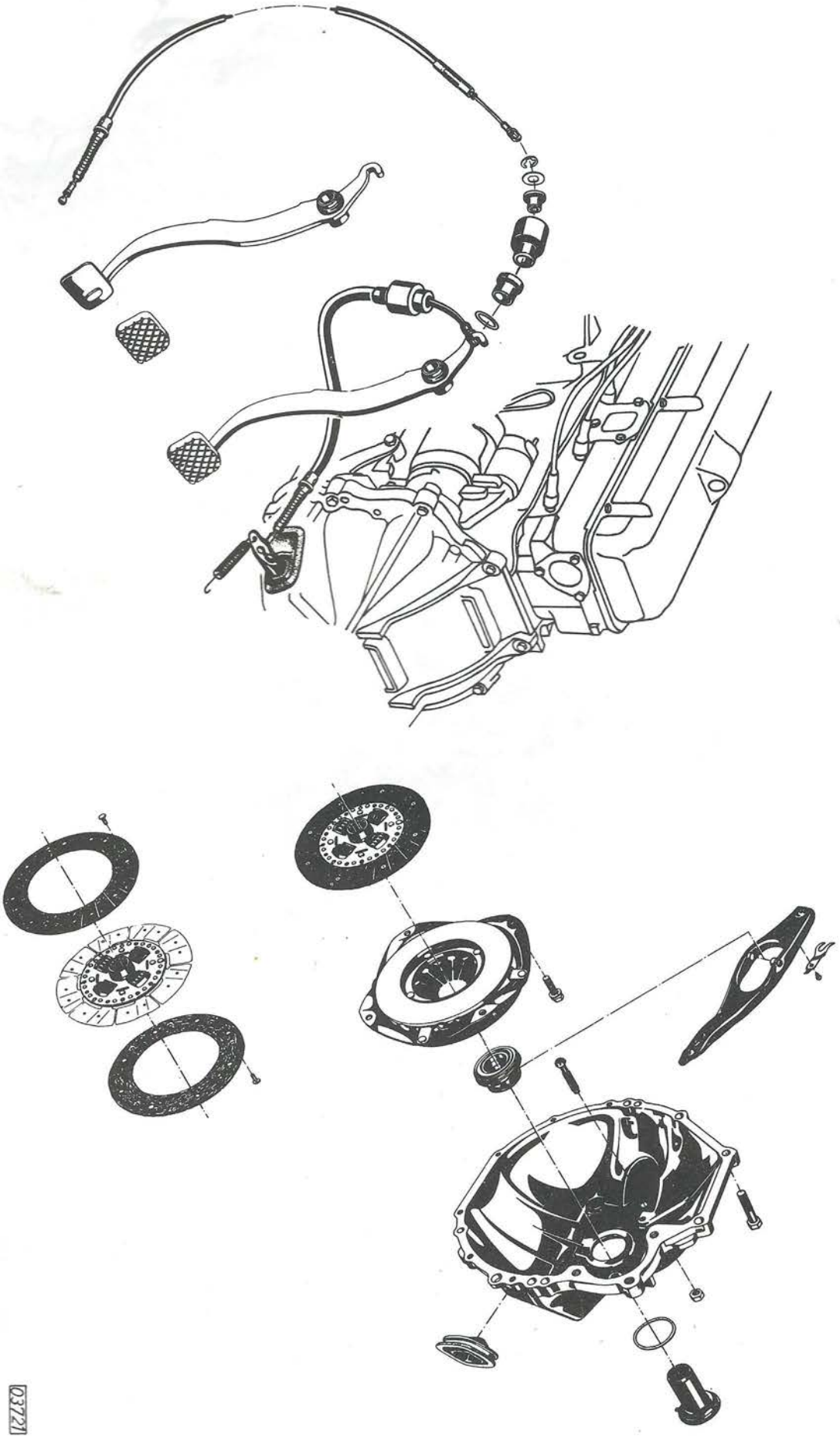
03602



03704



03703



037221

	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.)			
Without oil filter element replacement	5.7 pts. (2.7 ltrs.)			
With oil filter element replacement	6.3 pts. (3 ltrs.)			
Carburetor	Standard PDSI	Two barrels DIDTA	Two barrels DIDTA	Two barrels DIDTA
Choke valve	Manual	Automatic	Automatic	Automatic
Engine idle rpm.				
Synchromesh transmission	700 - 750	800 - 850	800-850	850 - 900
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
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

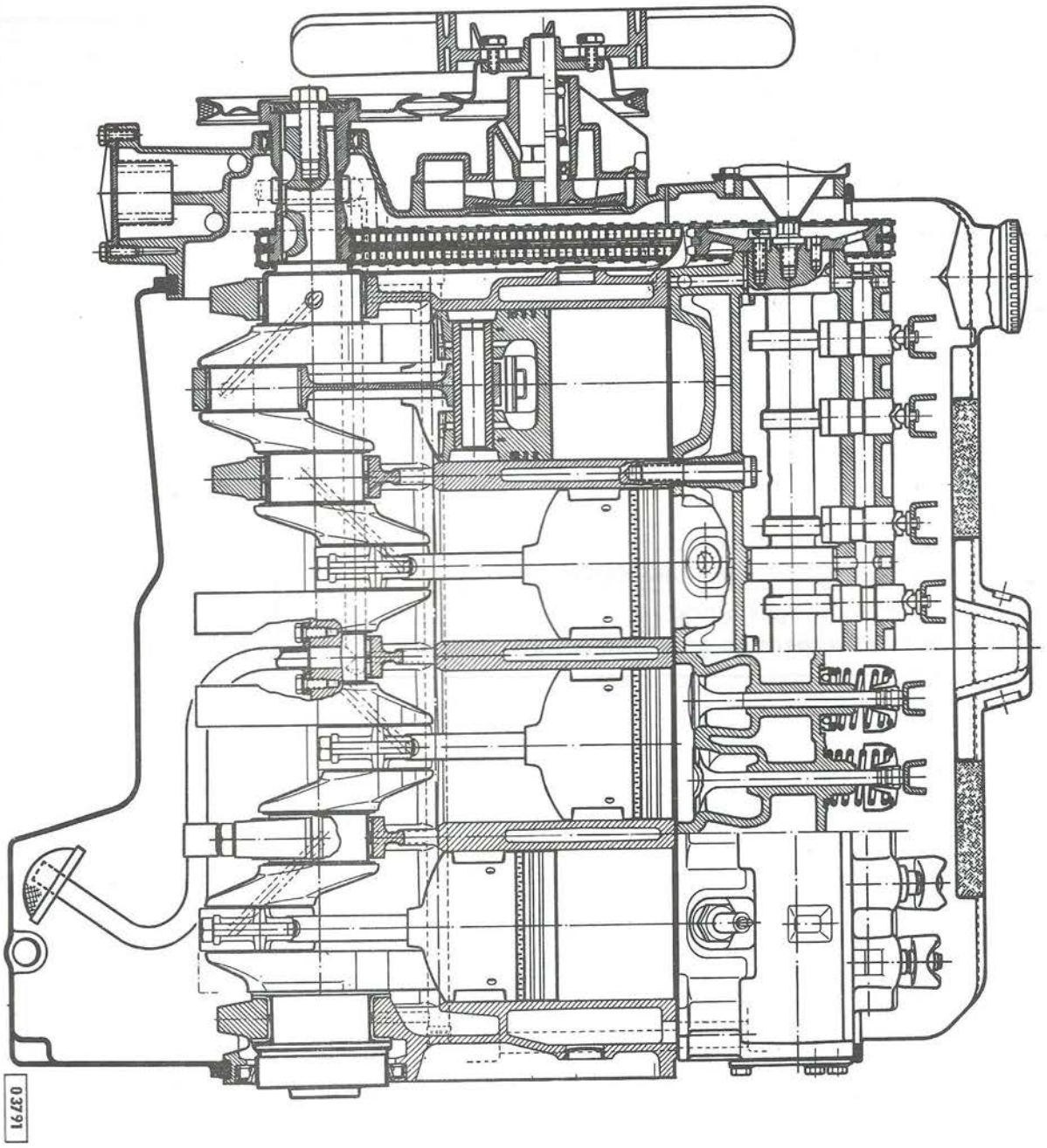
Clutch pedal free travel	0	
Permissible lateral runout of clutch contacting area on installed flywheel with a diameter of 8 in. (200 mm)	.0039 in. (0.1 mm)	Dial gauge
Permissible clutch disc lateral runout (reading taken at edge of disc)	.016 in. (0.4 mm)	Dial gauge
Permissible clutch disc thickness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

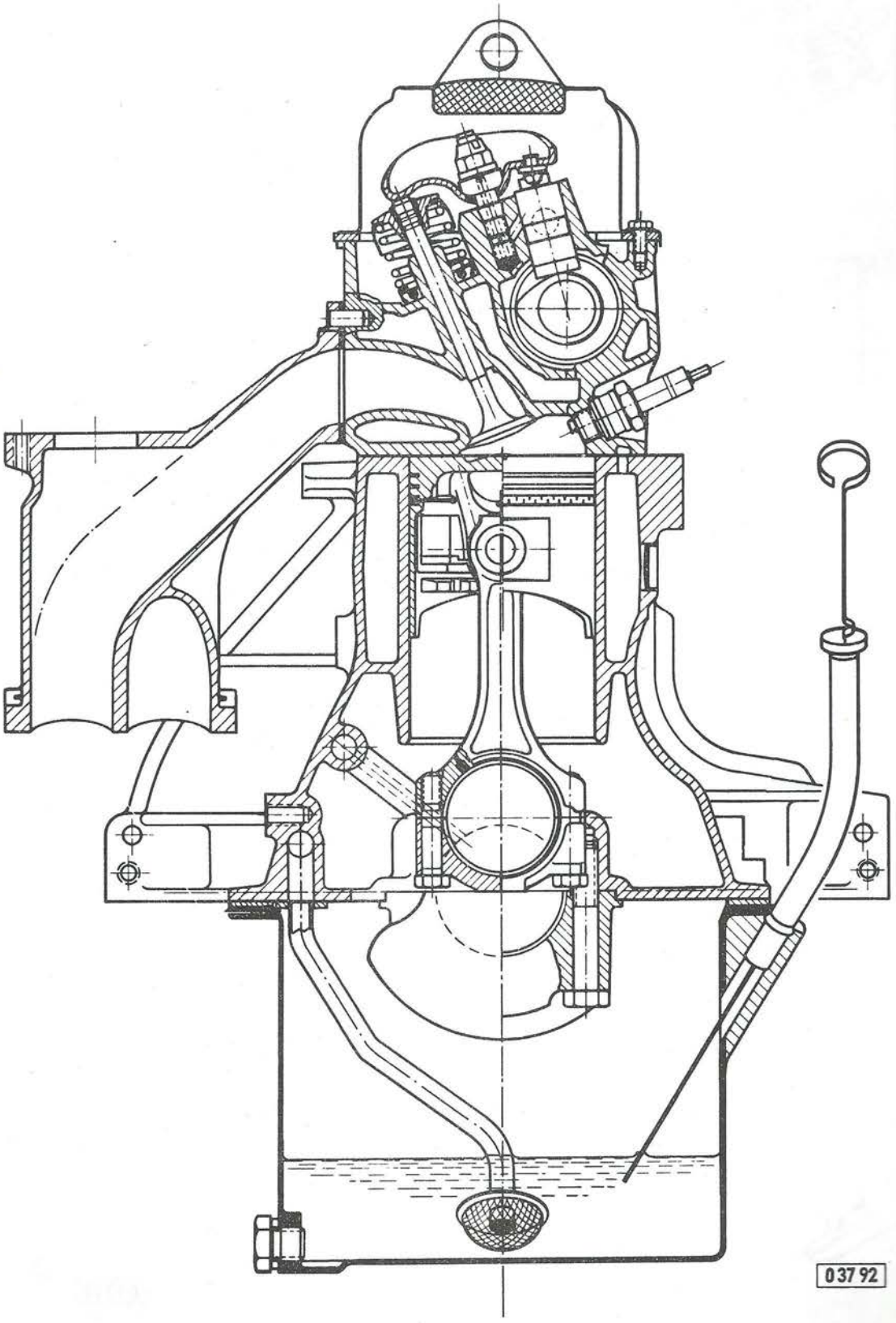
Oils, Grease, Sealers

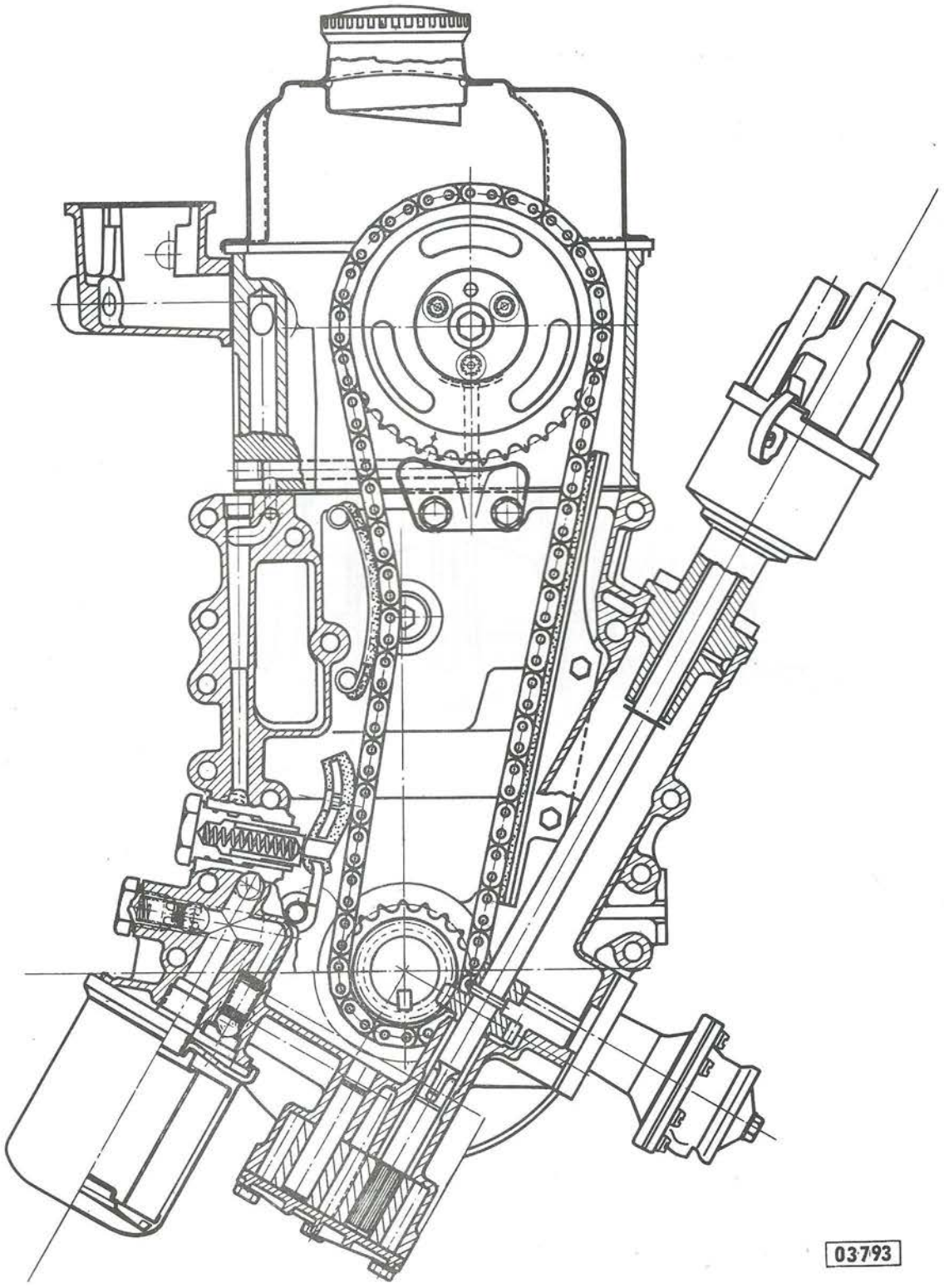
Engine oil for normal outside temperatures	GM 4745-M-SAE 20 for service MS or multi-viscosity oil
Engine oil for prevailing temperatures below 15°F (-10°C)	GM 4745-M-SAE 10 for service MS or multi-viscosity oil.
Coating valve stems	Engine oil
Coating contacting surface inside of rear main bearing cap 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

Torque Specifications

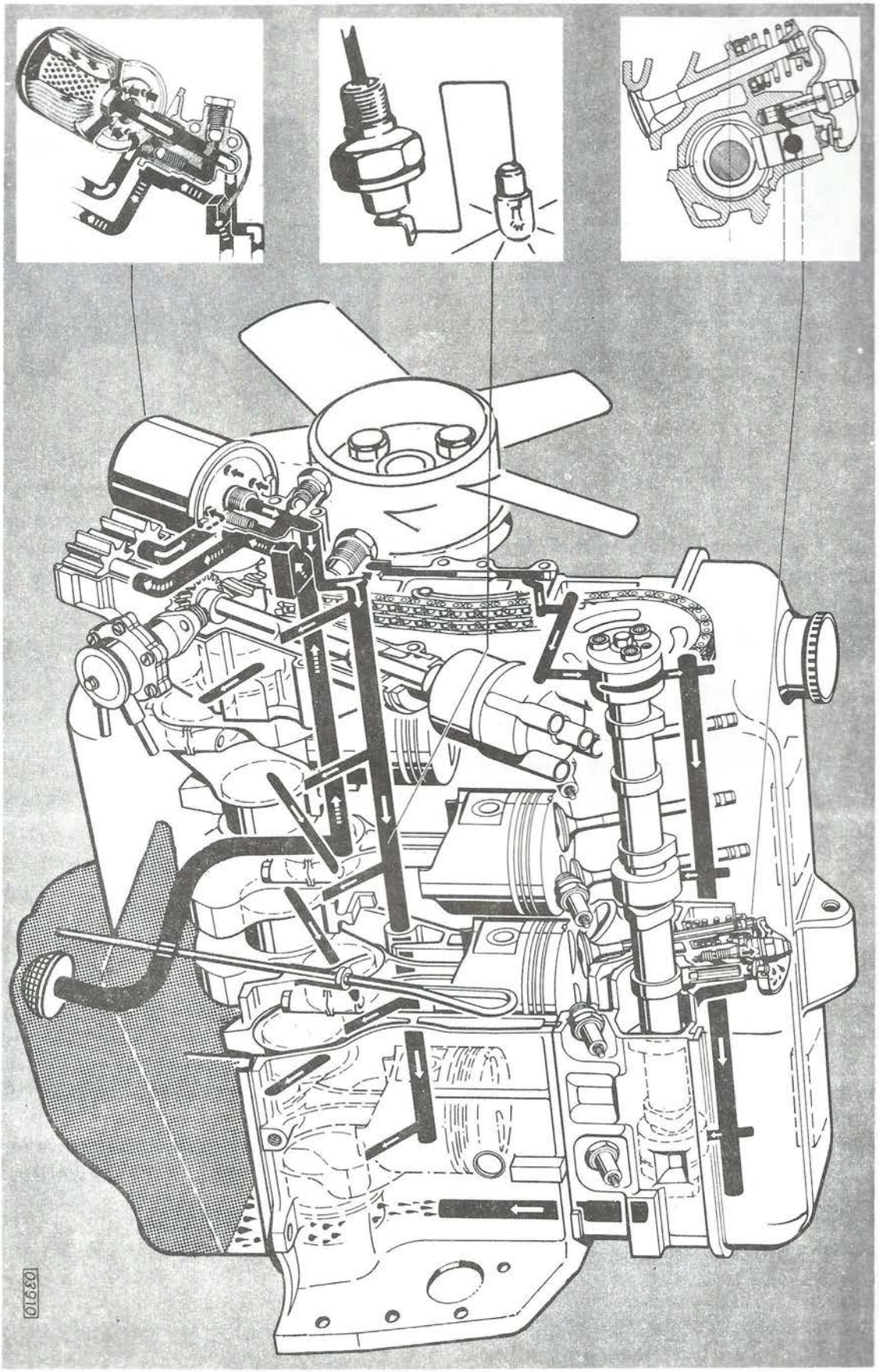
	ft. lbs.	Kpm
Connecting rod bolts	36	5
Crankshaft main bearing bolts	72	10
Flywheel to crankshaft attaching bolts	43	6
Pulley to crankshaft attaching bolts	58	8
Sprocket to camshaft	22	3
Harmonic balancer to crankshaft	72	10
Cylinder head attaching bolts: operating temperature	58	8
cold	72	10
Intake 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

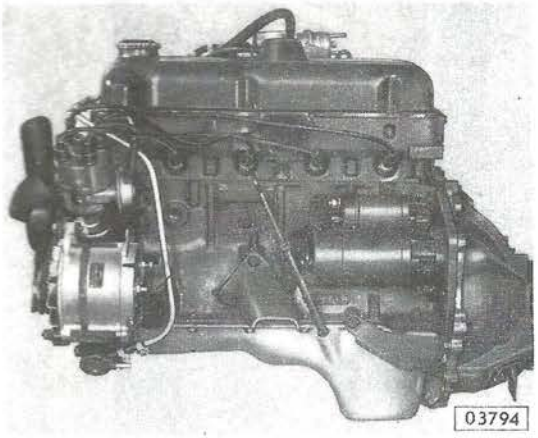

03791

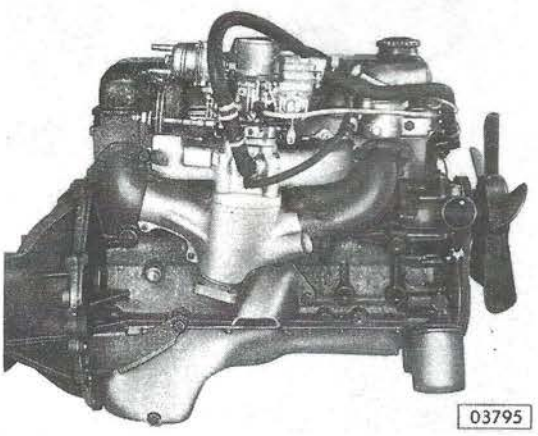

037 92



03793


03910





The engines to be installed are in their basic design identical to the 4-cylinder engines with cam in head. Four different engine types are optionally installed. They have the following output:

HP according to GMC-Test 20

16-engine = 79 HP at 5600 rpm.
16S-engine = 92 HP at 5800 rpm.
19S-engine = 102 HP at 5400 rpm.
19 US-engine = 90 HP at 5200 rpm.

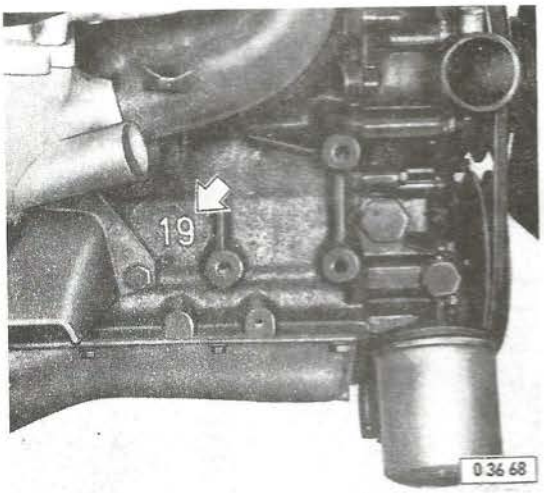
PS according to DIN 70 020

16-engine = 68 PS at 5200 rpm.
16S-engine = 80 PS at 5400 rpm.
19S-engine = 90 PS at 5100 rpm.
19 US-engine = 78 PS at 4800 rpm.

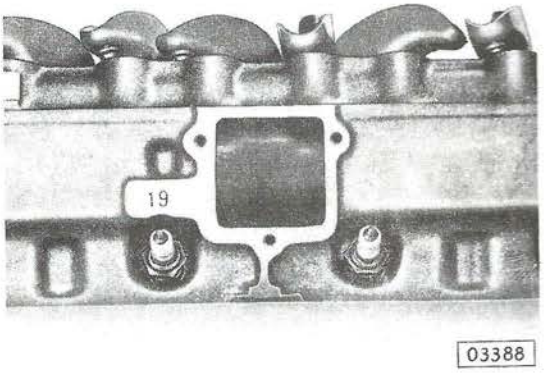
Vehicles to be shipped to the USA are equipped with the US-engine only.

The 1.6 ltr. and 1.9 ltr. engines have the same stroke of 2.748 in. (69.8 mm), however different cylinder bore diameters (3.346 in. = 85 mm and 3.661 in. = 93 mm) as well as different compression ratios.

The cylinder block is marked by the number "16" or "19" embossed on left and right side.

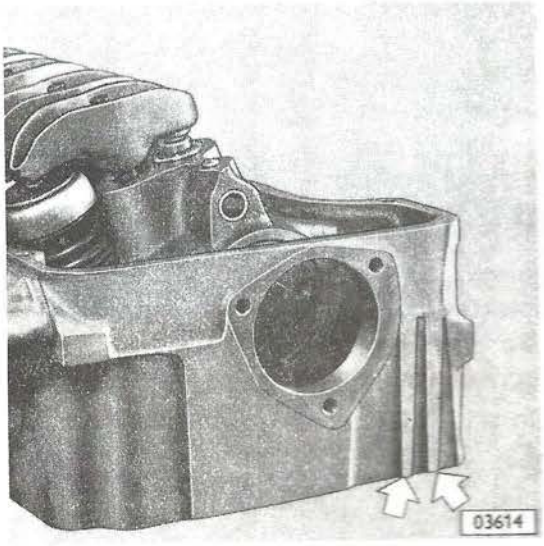


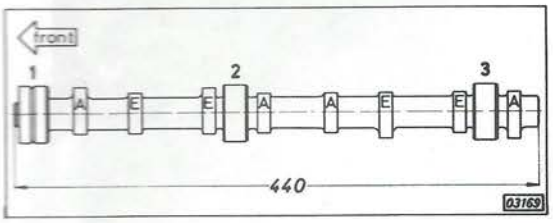
On installation of a new cylinder head attention has to be paid to the marking near the cover (see illustration)



or the vertical ribs of cylinder head face.

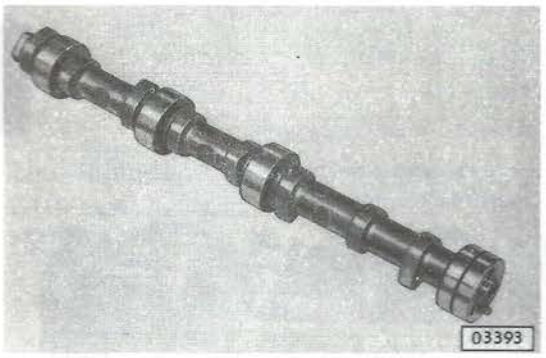
Without rib = 1.6 ltr. cylinder head
Three ribs = 1.6 ltr. S cylinder head
Two ribs = 1.9 ltr. S and US cylinder head



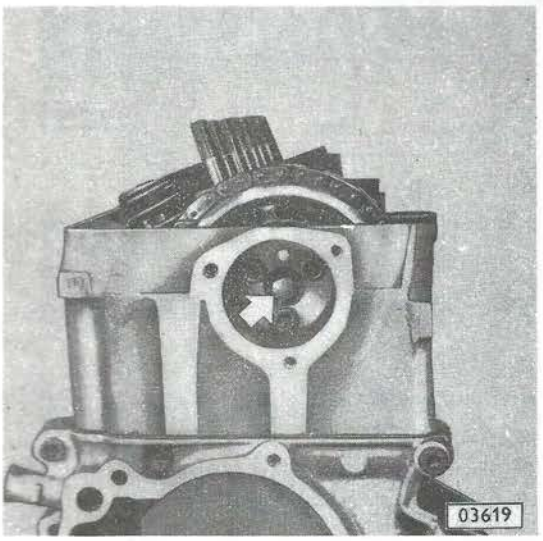


The cylinder head bolts are arranged so as to form a square framing each cylinder bore, this makes 10 bolts in all. The cylinder head is centered on cylinder block by two guide pins.

The engines 16, 16 S and 19 S are equipped with the same camshaft. It is arranged in the cylinder head and supported in three places. Installation of the camshaft is facilitated by each diameter of the three bearings being slightly smaller than the preceding.

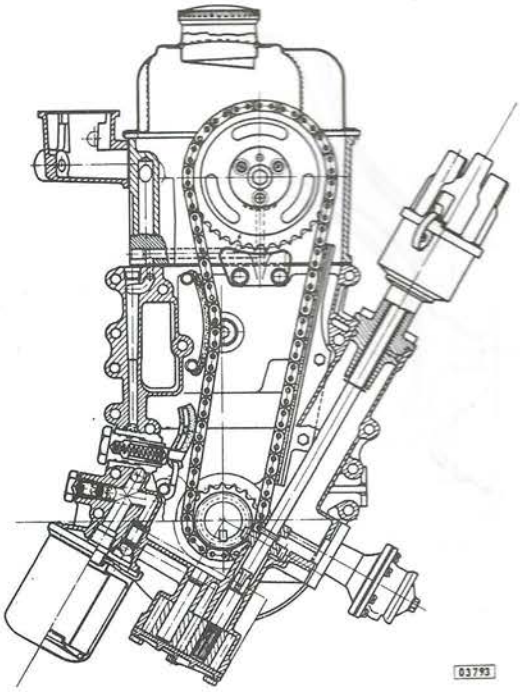


The cylinder head of the 1.9 ltr. US engines is equipped with a camshaft supported in four places.

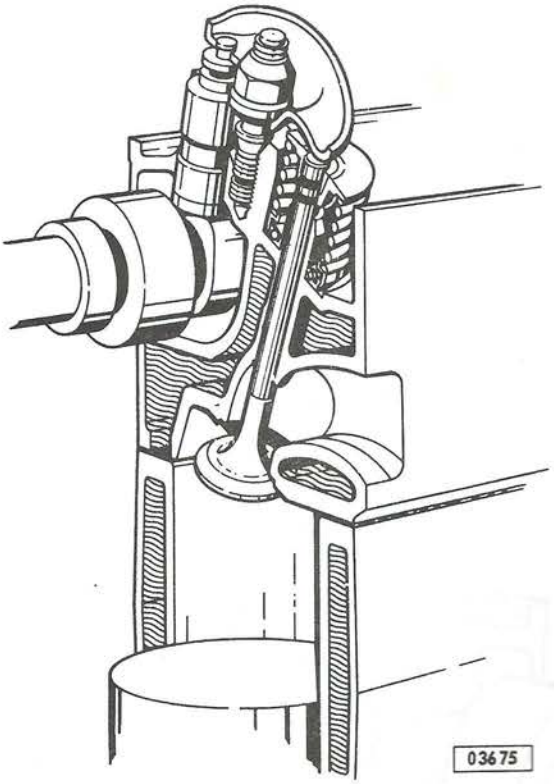


A nylon bolt in camshaft forward end serves to adjust end clearance.

The camshaft is driven by an endless Duplex roller chain. The chain is guided in the timing case by a short and a long slide. A chain tensioner provides a tight and clearance-free seat of the chain. Both slides have wear-resistant and oil-proof synthetic slipper pads.



Exhaust valves have seats of highly heat and wear resisting material. The head surface is alutized. Alutizing makes valve heads non-scaling and promotes long life. All engines have "roto-caps".

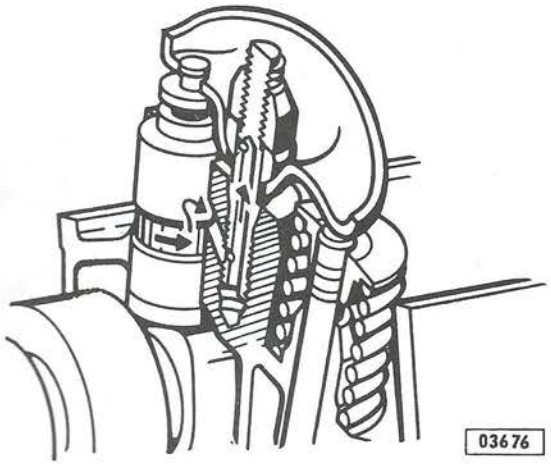


The head surface of the intake valves is no longer alutized. For this reason, the intake and exhaust valves may be lapped with a fine-grained lapping compound.

The engine is lubricated by a forced feed system incorporating a gear-type pump driven by the distributor shaft. The pump body is part of the timing case. A passage cast in cylinder block and a suction pipe connect the pump to the screen cover assembly in the sump.

Pump pressure relief valve and oil filter by-pass valve are also positioned in timing case. The pressure relief valve serves to feed surplus oil back into the suction passage should the required oil pressure be exceeded. The oil filter is of the full flow type. With it in parallel is a by-pass system controlled by a valve which ensures oil circulation directly to the lubrication points, if element becomes clogged by dirt or oil is too thick to pass through. Only when oil flow through element is unrestricted, the by-pass valve will close and filtered oil is fed to the engine.

Oil flow through the engine is as follows:
The oil pump draws oil from the sump through the screen and pumps it through drilled passages in timing case to the full flow filter. From there it passes to the cylinder block main oil gallery with a branch in timing case to no.1 camshaft bearing. Drilled passages lead from the oil gallery to crankshaft main bearings and in the crankshaft from main bearings to connecting rod bearings. The camshaft front journal has a crescent shaped groove which controls the oil supply to cylinder head oil gallery.



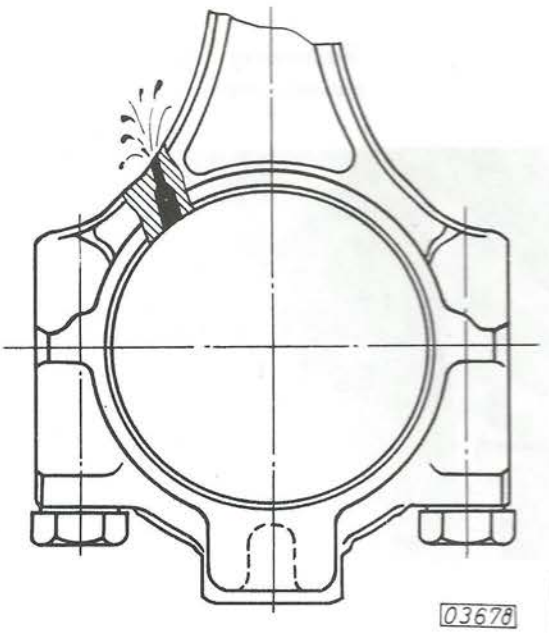
The cylinder head oil gallery delivers oil under pressure to all valve lifters, to no. 2 and 3 camshaft bearings, and to rocker arm seats. An additionally drilled passage connects the valve lifter circular groove with circular groove of rocker arm stud from where the oil is directed upwards through a drilled passage to the rocker arm seat. The cams are lubricated by splash oil. Susplus oil collects at end of cylinder head and returns through a passage to the crankcase.

A squirt hole in connecting rod big end bearing splashes oil against right-hand side of cylinder wall. Additional cylinder wall and piston pin lubrication is through oil splash from crankshaft.

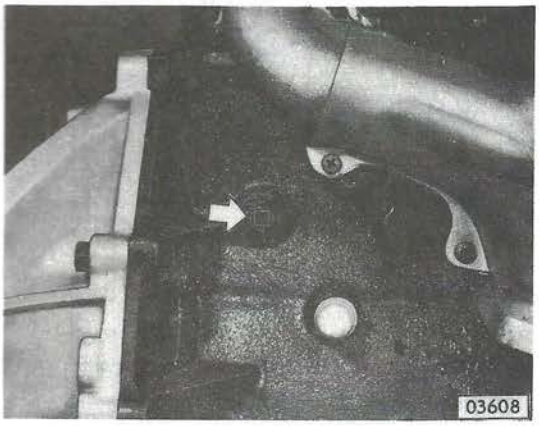
A jet in timing case projects oil against oil pump drive and the timing chain receives lubrication from above the chain tensioner.

The cooling system is of the conventional pressurized type, a centrifugal pump combined with the timing case serves to circulate the coolant. When the thermostat is closed, the coolant will return to the pump via a by-pass for swift and uniform warming up of the engine. Only when the engine has reached normal operating temperature, the coolant circulates through the radiator.

The heater system branches off the cooling system ahead of the thermostat in flow direction so that the heater is in operation before engine has reached full operating temperature.



Removing Engine Together With Clutch And Transmission



Detach ground strap from battery.

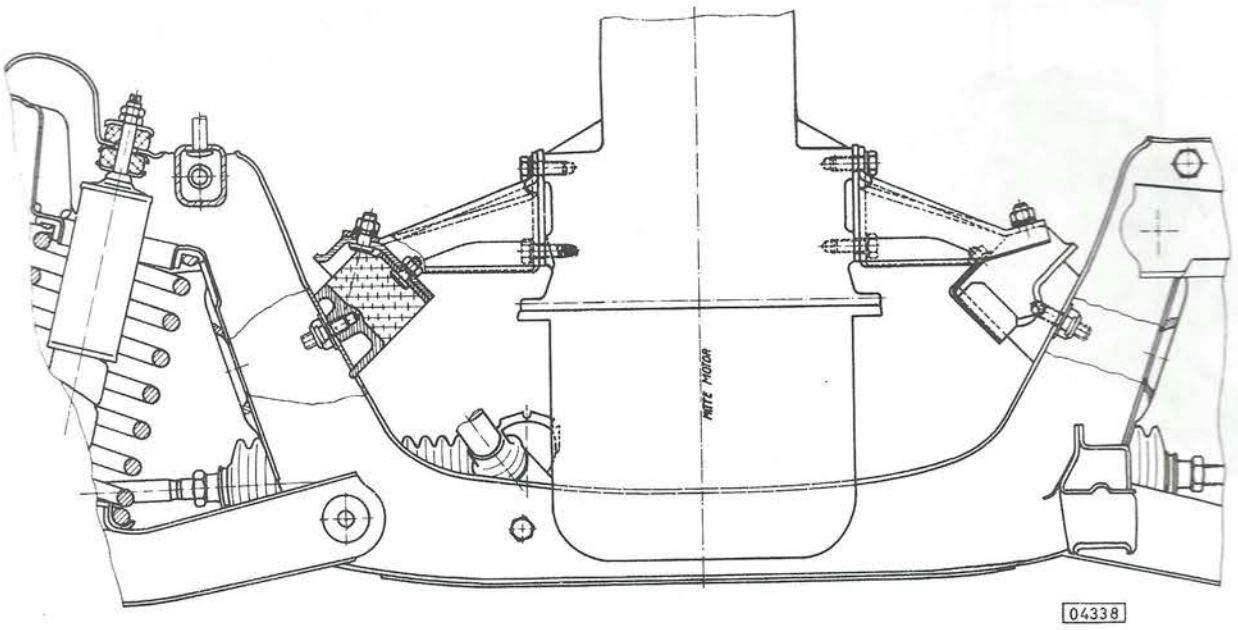
Remove engine hood (refer to respective operation in group 11).

Remove air cleaner.

Drain coolant. To do this, remove drain plug with 9 mm square articulated socket wrench MW 113.

Remove radiator. Pull off both radiator hoses - lower hose first - and collect coolant. Remove lower attaching bolt and pull out radiator towards the top.

Detach all linkages, pipes, hoses, cables and bowden control wires from engine or aggregates.



Unscrew nuts from threaded bolts of the engine support to damper block attachments.

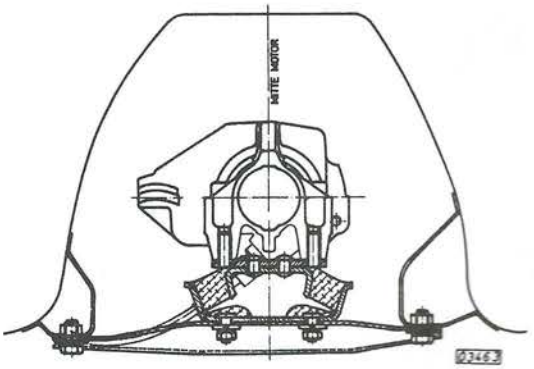
Jack up front and rear end of vehicle.

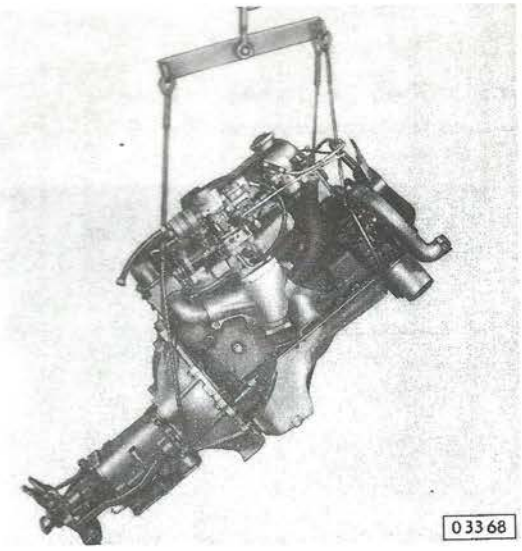
Remove propeller shaft and slip sealing sleeve SW-191 onto transmission mainshaft to avoid oil loss. On vehicles with automatic transmission use sealing sleeve S-1279.

Unscrew exhaust pipe from manifold.

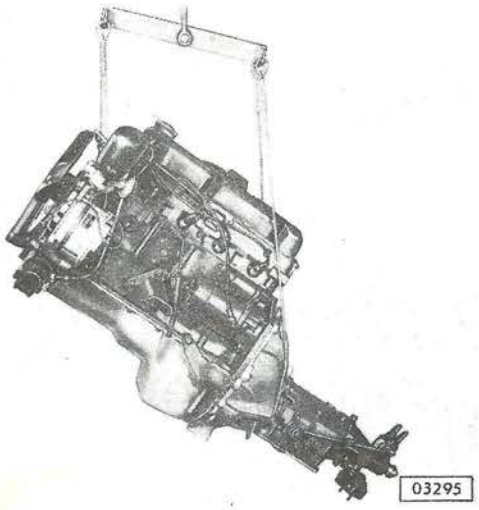
Remove gearshift lever (refer to respective operation in group 7).

Place jack below transmission and unscrew rear engine mount.





Place cables of engine lifter S-1220 around engine as shown in the illustration - short cable (59 in. = 1.50 m) in front and long cable (78.7 in. = 2 m) in the rear. Hook cables into hooks of engine lifter S-1220 and attach lifter to hoist. Ensure that no engine parts are damaged by cables.



Lift engine so that engine supports clear the damper blocks. Bring engine in an inclined position and remove it from engine compartment.

Prior to reinstallation of engine check all attaching parts for reusability (cracks, breaks).

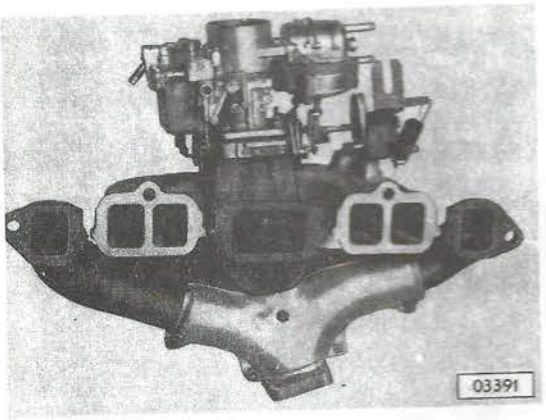
Tighten by hand all engine attaching bolts and nuts. Rock engine so that it is positioned free of stress and tighten bolts and nuts.

Torque nuts of front engine suspension support to damper block attachments to 29 ft. lbs. (4 kpm).

Torque rear engine mount to transmission case extension to 22 ft. lbs. (3 kpm).

Replacing Gasket Between Intake And Exhaust Manifold And Cylinder Head

Remove air cleaner, unhook carburetor bowden control wire and pull off all lines leading to the carburetor.



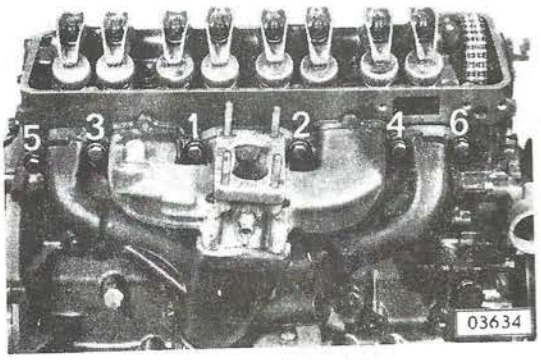
With a 15-mm box wrench unscrew exhaust manifold support from engine block and with a 13-mm articulated socket head wrench from exhaust manifold.

Screw manifold attaching bolts out of cylinder head. Then remove exhaust and intake manifold together with carburetor from cylinder head.

Attach manifolds together with new gasket to cylinder head.

Note

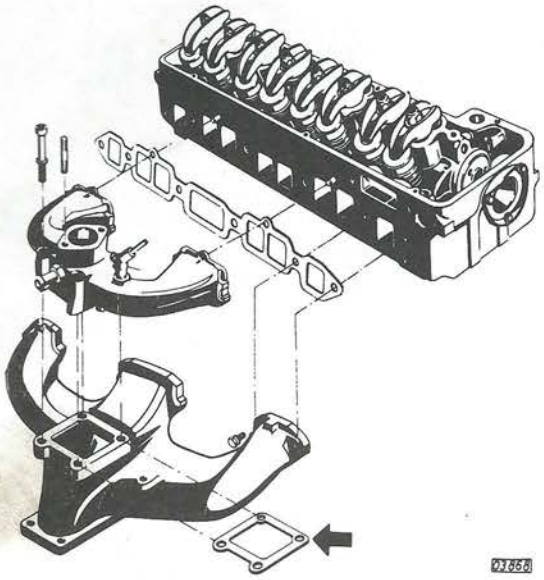
Add a thinner washer to both manifold outer attaching bolts and a somewhat thicker washer to the four inner attaching bolts.



Tighten attaching bolts in the sequence shown in the illustration to a torque of 36 ft. lbs. (5 kpm). Coat bolts with colloidal graphite grease.

Retighten attaching bolts in cold condition after engine had reached operating condition.

Replacing Manifold Intermediate Gasket



Remove air cleaner, unhook carburetor bowden control wire and pull off all lines leading to the carburetor.

Unscrew exhaust pipe from manifold using a 13 mm articulated socket head wrench.

Unscrew manifold attaching bolts out of cylinder head and remove intake and exhaust manifold together with carburetor from cylinder head.
Unscrew carburetor from intake manifold and intake manifold from exhaust manifold.

Using a new intermediate gasket, bolt together both manifolds only fingertight. Align exhaust and intake manifold so that proper sealing is obtained. To do this, evenly tighten assembly with its cleaned contacting areas without gasket to cylinder head. Tighten also assembly bolts.

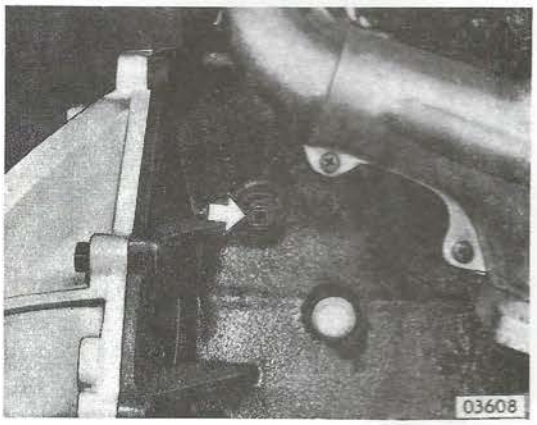
Remove manifold assembly and install with new gasket. Torque attaching bolts to 36 ft. lbs. (5 kpm).

Reinstall carburetor and all detached parts in reverse sequence to removal.

Retighten attaching bolts in cold condition after engine had reached operating temperature.

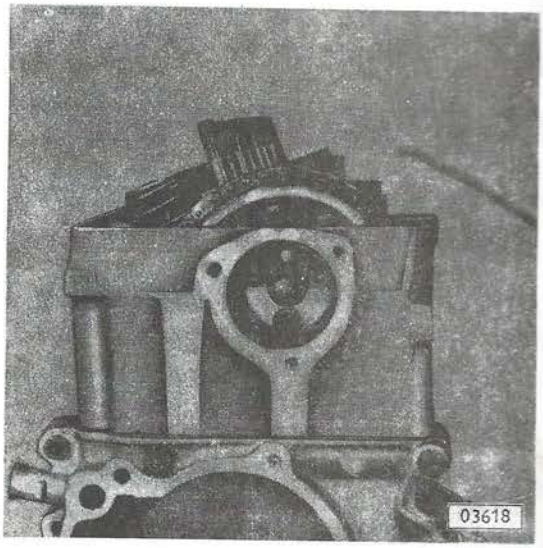
Drain coolant. To do this, unscrew drain plug, using 9 mm square articulated socket head wrench MW 113.

Unscrew exhaust pipe flange from manifold, using 13 mm articulated socket head wrench.

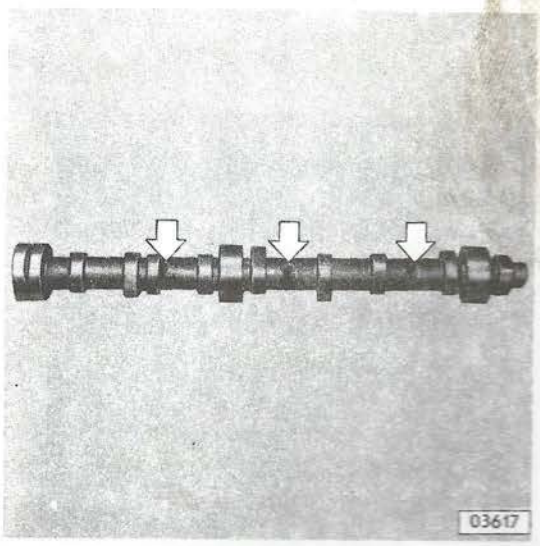


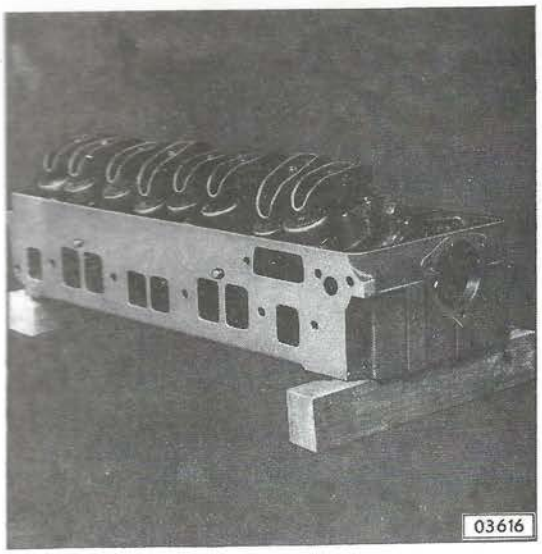
Unscrew front cover from cylinder head and sprocket from camshaft.

For sprocket removal use serrated socket head wrench MW 81.



With serrated socket head wrench MW 110 remove cylinder head bolts. Rotate camshaft so that recesses are in vertical position to allow removal of left-hand row of bolts.



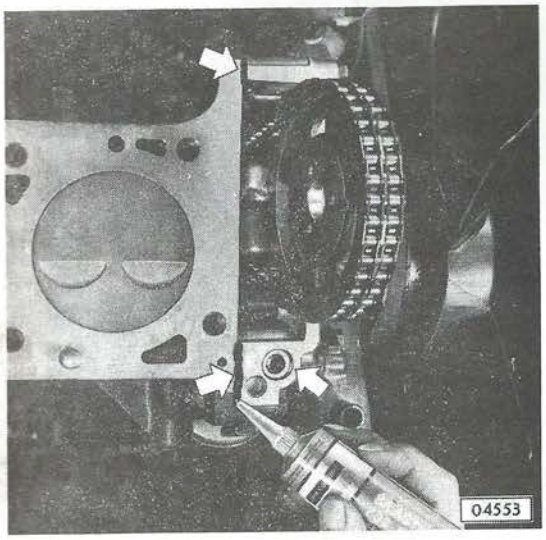


Always use two suitable wooden blocks to support cylinder head, if it is placed on work bench assembled with camshaft and valves. Otherwise valves held open by camshaft would touch work bench and valve shafts may get distorted.

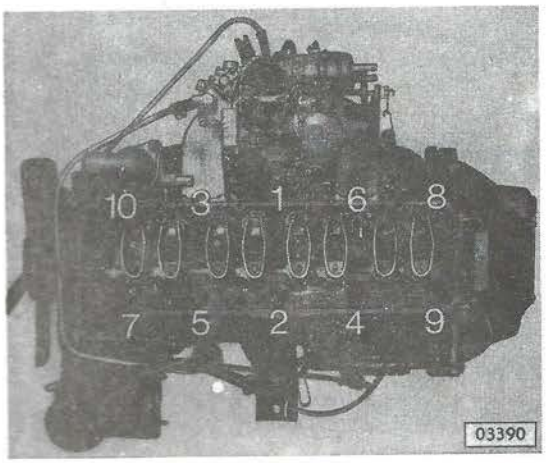
Clean piston heads combustion chambers and all sealing areas.

Lightly oil cylinder walls. Install coolant passage gasket in timing case.

Apply an approx .12 in. (3 mm) thick worm of sealing compound catalog no. 15 03 294, between timing case and engine block.



Prior to installation of cylinder head rotate crankshaft so that all pistons are positioned below U.D.C. When rotating crankshaft back and forth later on for attachment of cramshaft sprocket, it is absolutely necessary to loosen the adjusting nuts of the open valves so that valves do not touch piston heads.



Place new cylinder head gasket without sealer, compensating gasket downwards, onto cylinder block. Install cylinder head assembly and tighten bolts on cold engine in the sequence shown in the illustration to a torque of 72 ft. lbs. (10 kpm), using tool MW 110.

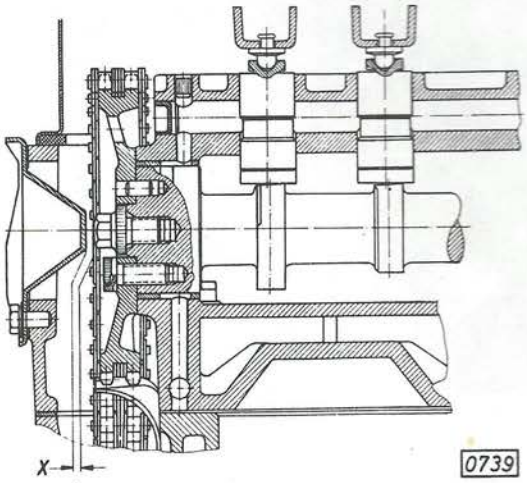
After 600 miles/1000 km retighten cylinder head bolt on cold engine to 72 ft. lbs. (10 kpm) and on engine with operating temperature to 58 ft. lbs. (8 kpm).

When retightening bolts, take into consideration that the initial resistance of a bolt to be retightened as per torque wrench, is higher than the actually existing torque. Only after overcoming this resistance the specified value will be obtained. This fact is quite often the reason for improperly tightened cylinder head bolts which leads to leakages.

When retightening cylinder head bolts, first loosen bolts somewhat and then tighten to the specified value in a single operation, observing tightening sequence.

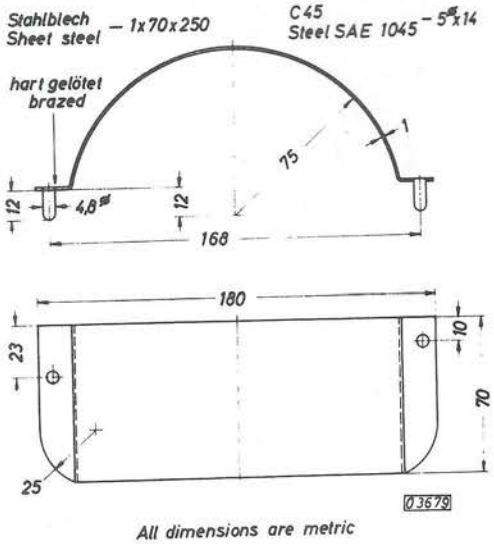
Install camshaft sprocket, using serrated socket head wrench adapter MW 81. The end clearance X between butting face of cover and bolt should be .004 - .008 in. (0.1 - 0.2 mm). Check with feeler gauge. Excessive clearance can be eliminated by caulking cover accordingly.

To do this, remove cover.



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

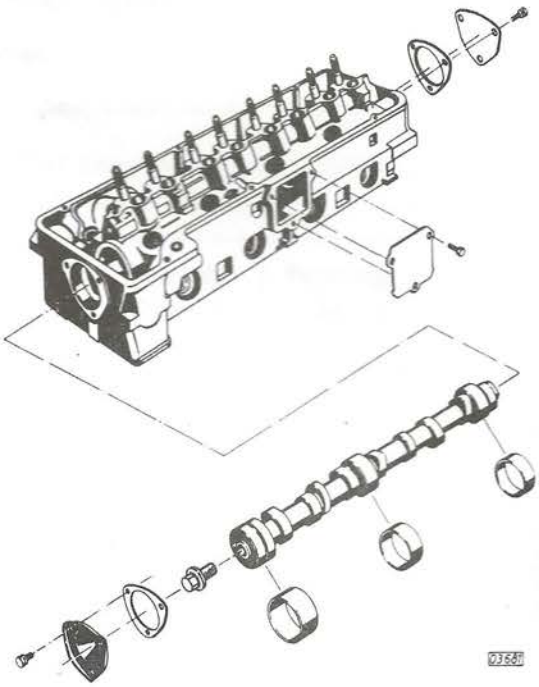
Deflect splash oil of timing chain with a protective metal sheet to be made up in own repairshop according to the dimensions given in the drawing. This metal sheet can also be obtained from Messrs. Matra-Werke under No. 0/58.

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

Replacing Camshaft

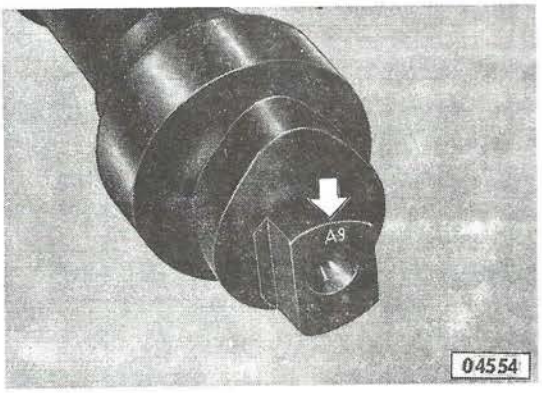
Remove and install cylinder head.

Unscrew rocker arms and lateral access hole cover. Remove valve lifters. Carefully remove camshaft towards the front supporting camshaft with one hand through lateral access hole. Take care not to damage bushings.



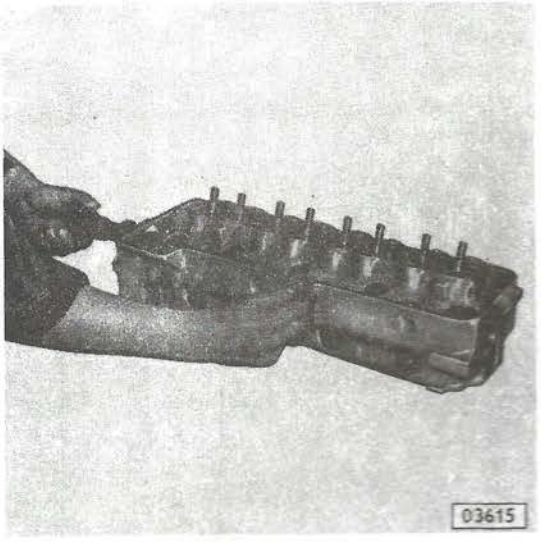
On installation of a new camshaft pay attention to marking on camshaft rear face.

Model	Marking
16, 16 S, 19 S	A
19 US	B



Liberally lubricate journals of new camshaft and from front towards the rear install camshaft into cylinder head. Support shaft through lateral access hole to prevent damaging bushings.

Camshafts with .004 in. (0.1 mm) undersize installed in production are marked with a violet paint dot between the 4th and 5th cam. The cylinder heads with .004 in. (0.1 mm) undersize are also marked with a violet paint dot at the first camshaft bearing.



The Parts and Accessories Department supplies camshaft bearings for journals with .02 in. (0.5 mm) undersize only thereby providing replacement possibilities for all permissible dimensions (refer to respective table). If the required equipment is on hand, the desired bearing size can be made up in own repairshop.

When pressing in bearings, ensure that the oil bores in bushings coincide with the oil passages in cylinder head.

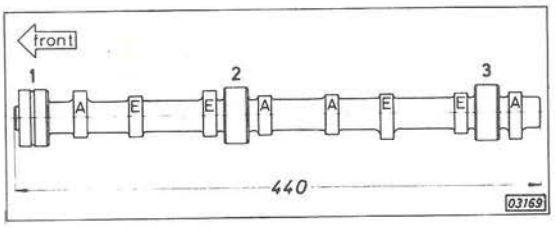
The bearings have to be bored to standard or undersize (refer to table) according to journal size. After boring thoroughly clean all oil passages from metal chips.

Camshaft journal diameters and bearing inner diameters

1.6 - 1.6 S - 1.9 S - engines

	Grind camshaft journals to in. (mm) diameter			After pressing in, bore bearings to in. (mm) diameter		
	Journal No. 1	Journal No. 2	Journal No. 3	Bearing No. 1	Bearing No. 2	Bearing No. 3
Standard size (Production)	1.926 (48.935) to 1.927 (48.950)	1.916 (48.685) to 1.917 (48.700)	1.906 (48.435) to 1.907 (48.450)	1.930 (49.020) to 1.931 (49.045)	1.920 (48.770) to 1.921 (48.795)	1.910 (48.520) to 1.911 (48.545)
.004 in. (0.1 mm) undersize (Production)	1.922 (48.835) to 1.923 (48.850)	1.921 (48.585) to 1.913 (48.600)	1.903 (48.335) to 1.904 (48.350)	1.926 (48.920) to 1.927 (48.945)	1.916 (48.670) to 1.917 (48.695)	1.906 (48.420) to 1.907 (48.445)
.02 in. (0.5 mm) undersize (Service)	1.906 (48.435) to 1.907 (48.450)	1.897 (48.185) to 1.898 (48.200)	1.926 (48.935) to 1.927 (48.950)	1.910 (48.520) to 1.911 (48.545)	1.900 (48.270) to 1.901 (48.295)	1.891 (48.020) to 1.892 (48.045)

	Camshaft journal diameters and bearing inner diameters 1.9 Ltr. US - engines							
	Grind camshaft journals to in. (mm) diameter				After pressing in, bore bearings to in. (mm) diameter			
	Journal No. 1	Journal No. 2	Journal No. 3	Journal No. 4	Bearing No. 1	Bearing No. 2	Bearing No. 3	Bearing No. 4
Standard size (Production)	1.926 (48.935) to 1.927 (48.950)	1.916 (48.685) to 1.917 (48.700)	1.911 (48.560) to 1.912 (48.575)	1.906 (48.435) to 1.907 (48.450)	1.930 (49.020) to 1.931 (49.045)	1.920 (48.770) to 1.921 (48.795)	1.915 (48.645) to 1.916 (48.670)	1.910 (48.520) to 1.911 (48.545)
.004 in. (0.1 mm) undersize (Production)	1.922 (48.835) to 1.923 (48.850)	1.921 (48.585) to 1.913 (48.600)	1.907 (48.460) to 1.908 (48.475)	1.903 (48.335) to 1.904 (48.350)	1.926 (48.920) to 1.927 (48.945)	1.916 (48.670) to 1.917 (48.695)	1.911 (48.545) to 1.912 (48.570)	1.906 (48.420) to 1.907 (48.445)
.02 in. (0.5 mm) undersize (Service)	1.906 (48.435) to 1.907 (48.450)	1.897 (48.185) to 1.898 (48.200)	1.892 (48.060) to 1.893 (48.075)	1.926 (47.935) to 1.927 (47.950)	1.910 (48.520) to 1.911 (48.545)	1.900 (48.270) to 1.901 (48.295)	1.895 (48.145) to 1.896 (48.170)	1.891 (48.020) to 1.892 (48.045)



The camshaft journals and bearings are consecutively numbered from front (water pump side) to the rear. The camshaft of the US-engines is supported in four places.

For checking center bearing journal run-out place camshaft in centers of a lathe. Runout must not exceed .0010 in. (0.025 mm).

Liberally lubricate camshaft journals and install camshaft from front towards the rear into cylinder head. Support shaft by hand through lateral access hole to prevent damaging bearings.

Install complemented cylinder head.

Replacing Sprockets And Timing Chain

Remove and install engine.

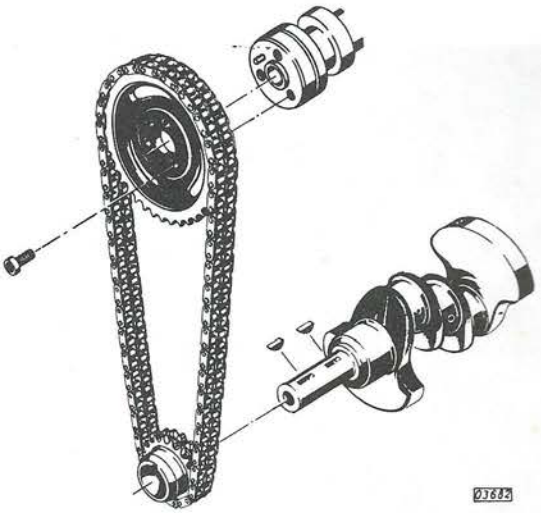
Remove and install cylinder head.

Remove and install generator and bracket.

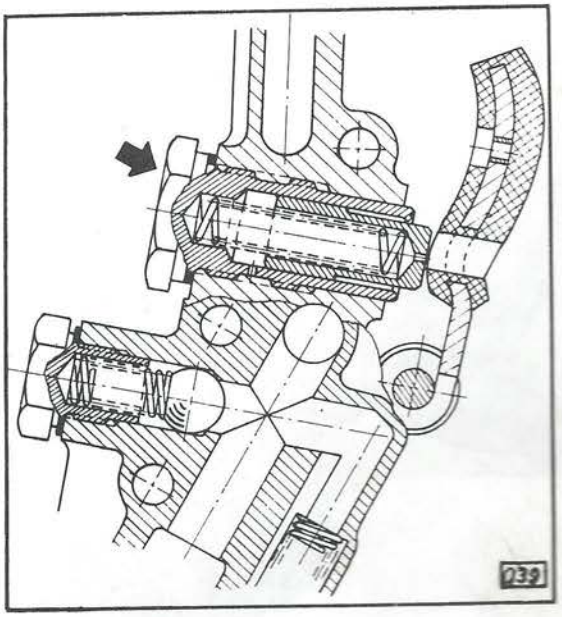
Remove and install crankshaft pulley.

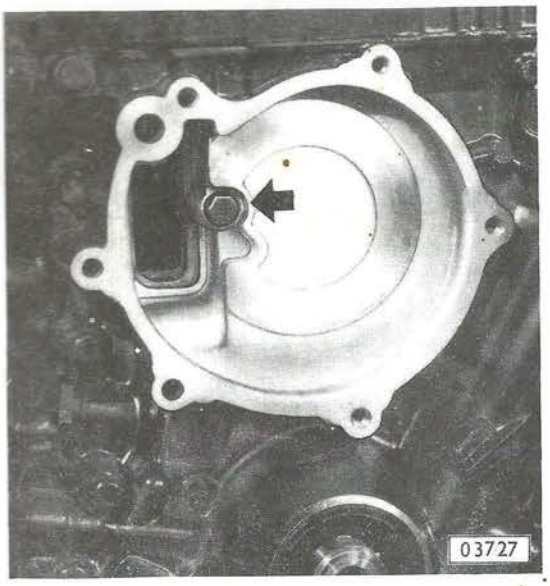
Remove and install water pump.

Remove and install oil pan.

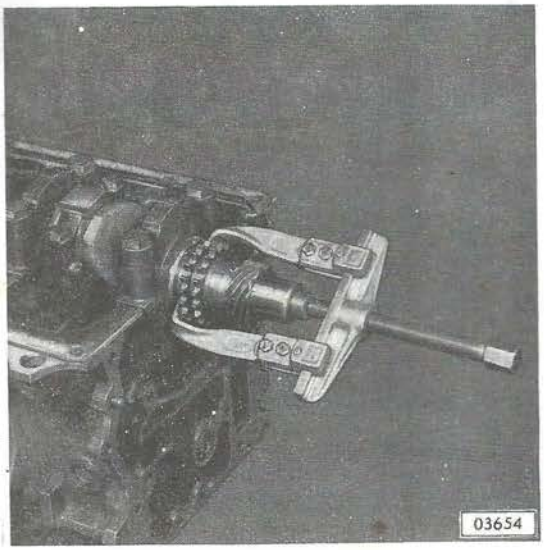


Remove chain tensioner.





Unscrew timing case. Do not forget bolt covered by water pump.

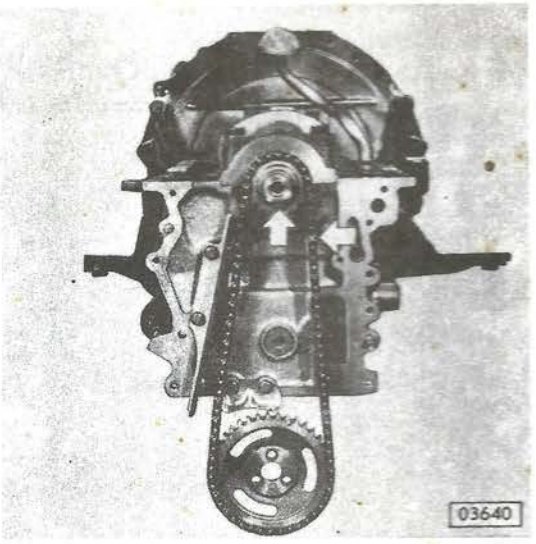


Remove chain and crankshaft sprocket. If required, use Kukko puller No. 20-1 together with thrust piece. If timing chain is to be reused, mark installation position.

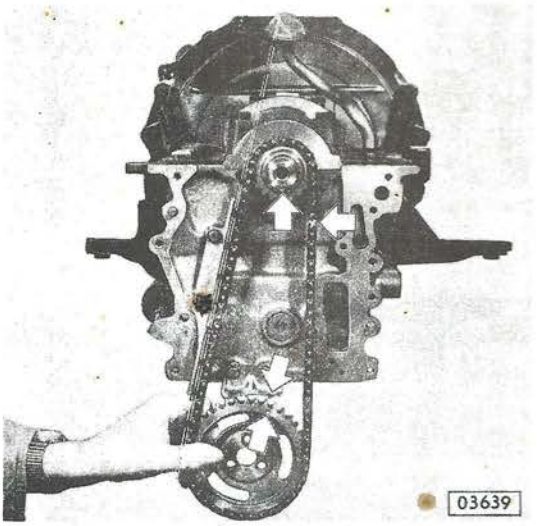
With a suitable sleeve drive sprocket onto camshaft journal paying attention that key is properly seated.

Clean all parts, check them for wear and replace, if necessary. The Parts and Accessories Department supplies the timing chain and sprockets as a set or the chain as an individual part. It is not permissible to replace individual sprockets. They are, therefore, not obtainable as individual parts.

Turn crankshaft so that sprocket key is on top and vertical as shown in the illustration. Assemble timing chain parts. Pay attention to paint marking made on removal of chain.



Make sure cramshaft sprocket mark is in alignment with mark on support and chain is in parallel with slipper pad. After sprocket has been fixed to camshaft, recheck alignment.



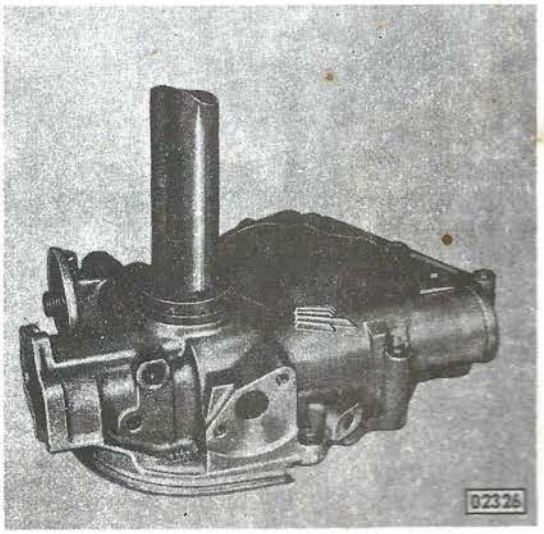
With tool S-1305 press new seal ring into timing case paying attention that timing case is not damaged. Lightly coat seal ring seat with sealer, part No. 15 04 167.

Slip timing chain spring plate and slipper pad onto dowel pins in timing case and secure spring plate with snap ring.

Install all other parts in reverse sequence to removal.

Adjust valve clearance.

Set ignition timing.

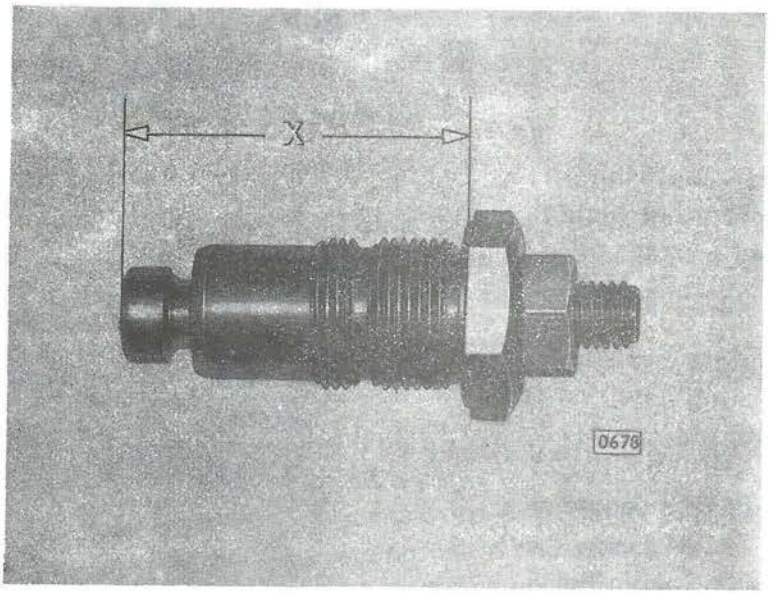


Checking Chain Tensioner For Proper Operation

If chain noises are encountered which indicate that chain tensioner is not properly working, check its operation with tool SW-287.

For checking slacken back thrust bolt and in place of the removed chain tensioner screw in tool without seal ring. By screwing in thrust bolt with a screwdriver lightly tension timing chain and in this position secure thrust bolt with lock nut.

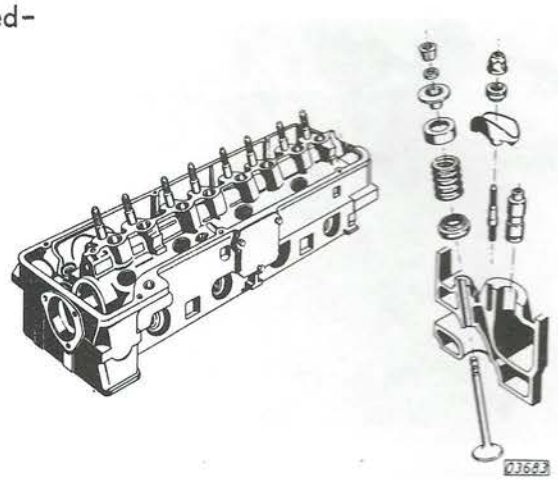
Remove tool, measure dimension X with a vernier caliper and compare with same dimension on chain tensioner - without seal ring. The established control dimension X must be at least .08 in. (2mm) smaller than the comparison dimension at the chain tensioner. If this value is not obtained , which is possible due to chain lengthening after longer periods of operation, reduce height of chain tensioner hexagon head on a lathe accordingly.



Overhauling Cylinder Head

- 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.

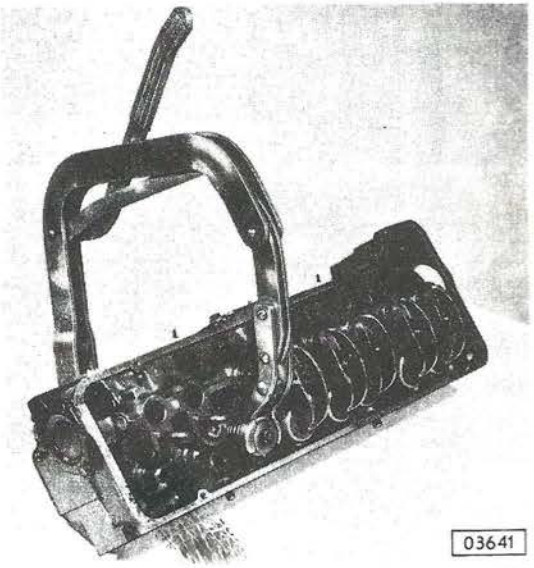
As long as no cratering in the valve head is noticable the valve may be reworked by regrinding.
Make sure that the upper valve edge does not become too thin as the edge would otherwise burn quickly. Such valves have to be replaced.

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°.

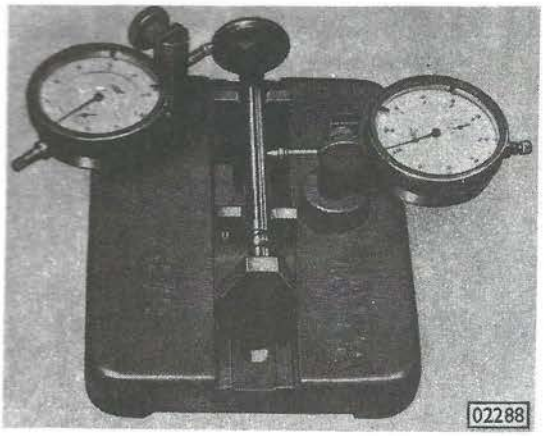
The oversize markings 1, 2 and A are rolled into valve stam end.

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



6

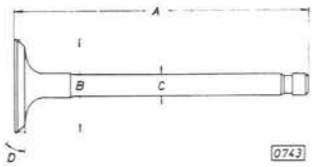
Valves



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:

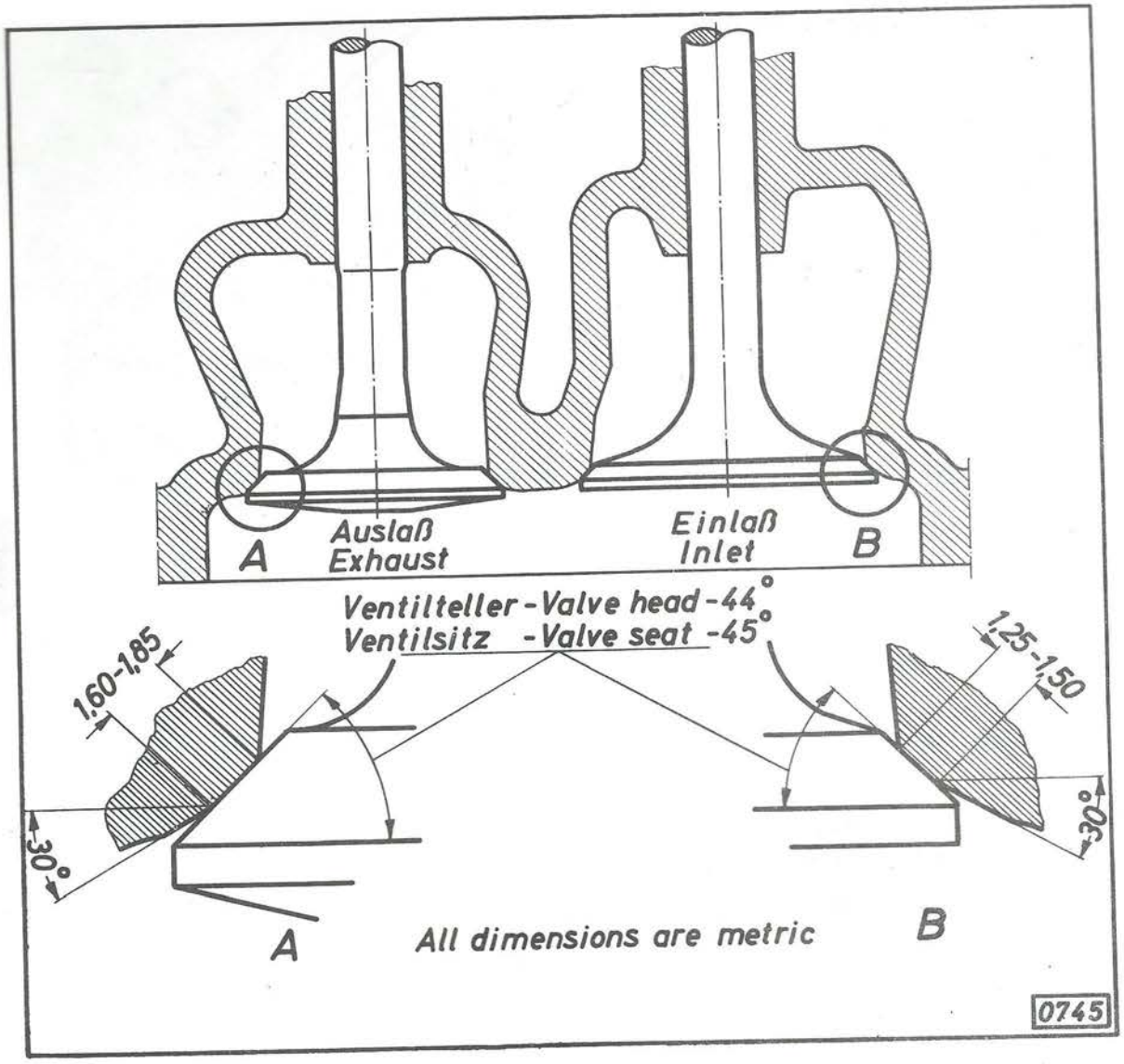
S-1092 Valve seat cutter 45° - 1.6 and 1.9 ltr. exhaust valve

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

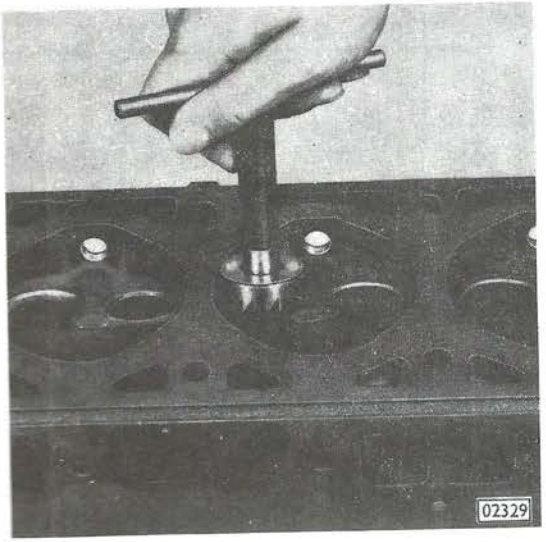
S-1303 Correction cutter 30° - 1.6 and 1.9 ltr. intake valve

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.

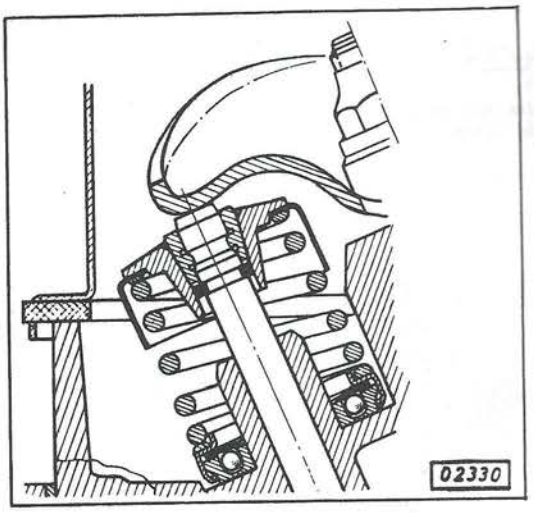
For lapping use only fine-grained lapping compound.

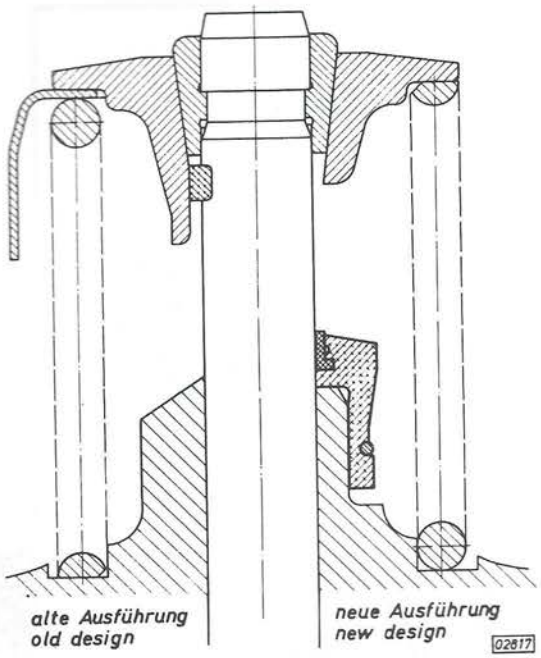
In order to evenly distribute the lapping compound film on the valve seat, rhythmically lift valve off seat during lapping operation.

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

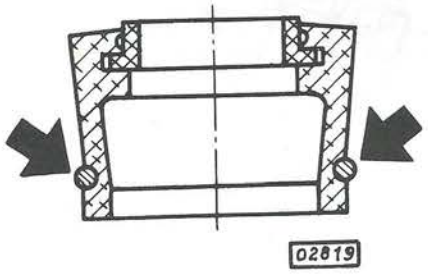
Coat valves with engine oil and install them into cylinder head. Make sure oil seal ring and oil deflector are properly seated. The narrow windings of the valve springs must show towards cylinder head.

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



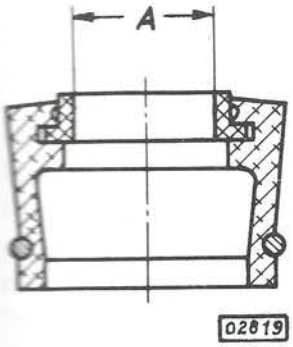


The right side of the illustration shows the valve stem oil seal of the 1.9 ltr. US-engine in installed condition (applies to intake valves only).



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

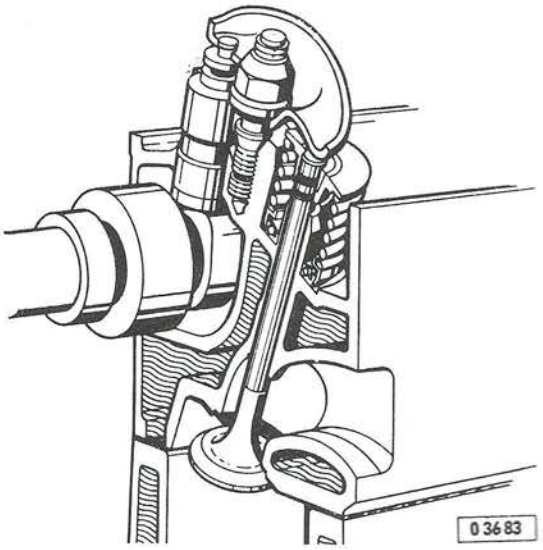
The oversize markings of the valves 1, 2 or A are rolled in at the valve stem end.

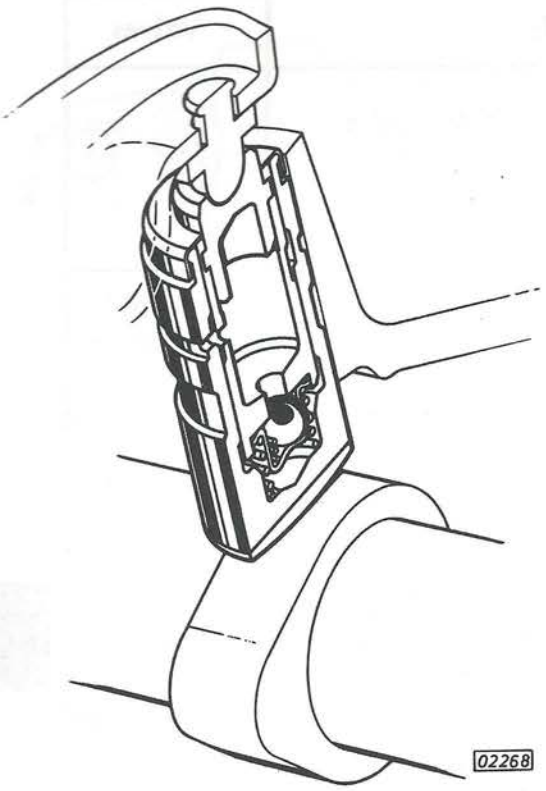
Valve Lifters

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.

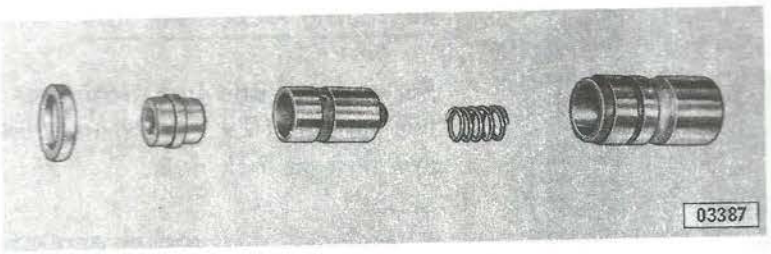




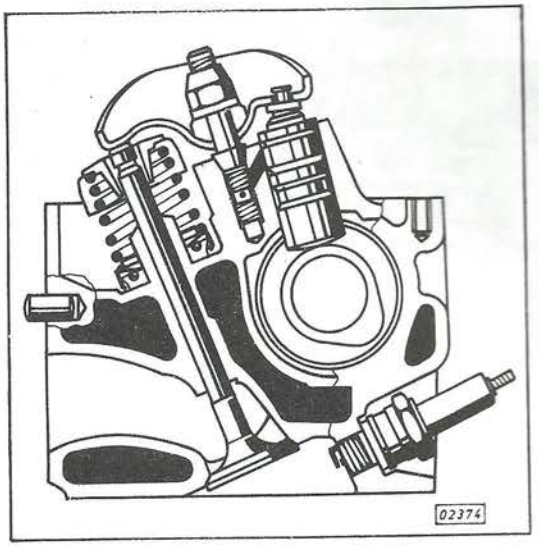
US-vehicles are equipped with 1.9 ltr. engines only. They are provided with a camshaft supported in four places, hydro-valve lifters and a modified valve stem oil seal (intake valves only).

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.

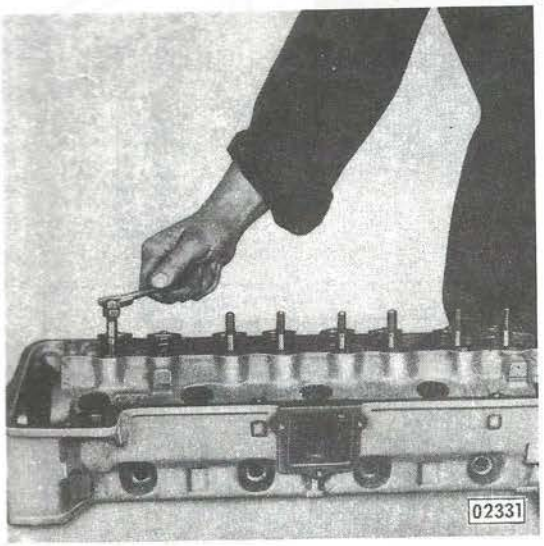


Hydro-valve lifter adjustment

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.

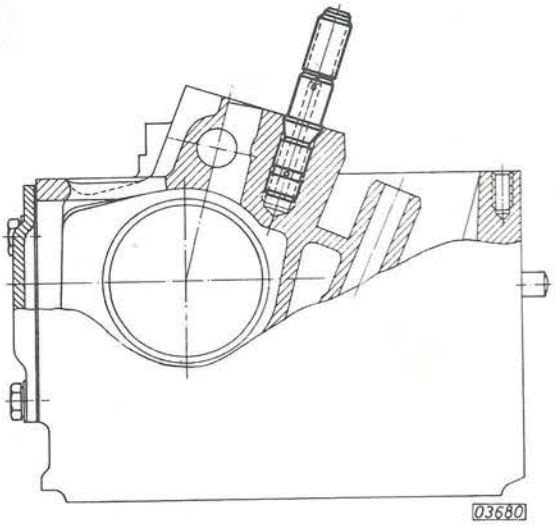
Back off adjusting nut at the rocker arm until a clearance exists. Then tighten adjusting nut until any clearances between valve, rocker arm and lifter are eliminated. Screw in adjusting nut one full turn. The valve clearance is now adjusted and no readjustment is required.

Replacing rocker arm stud



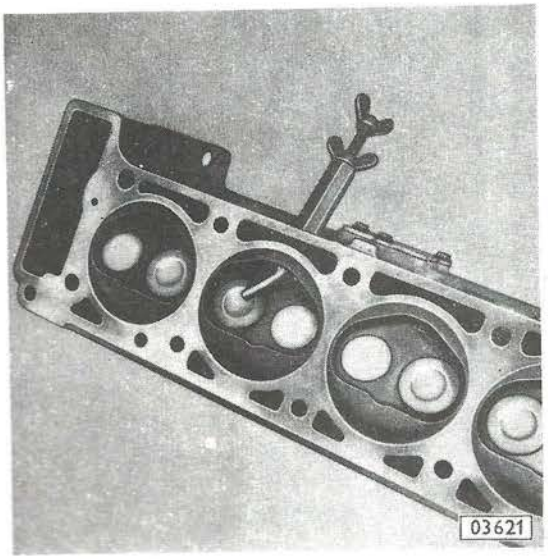
For removal and installation of stud use two nuts M 10 x 1 or two reworked rocker arm nuts as lock nuts.

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.

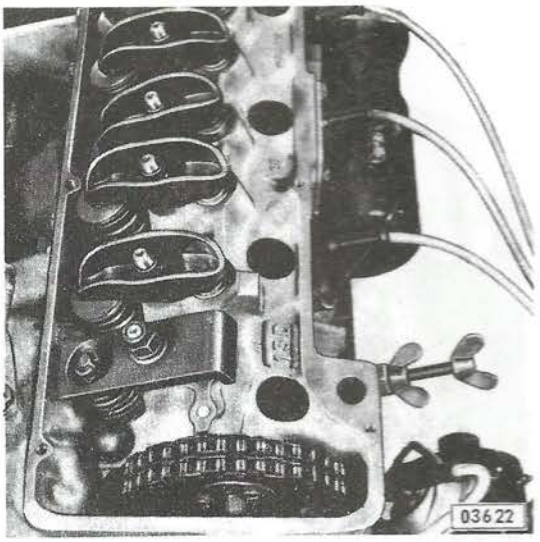
Replacing valve springs



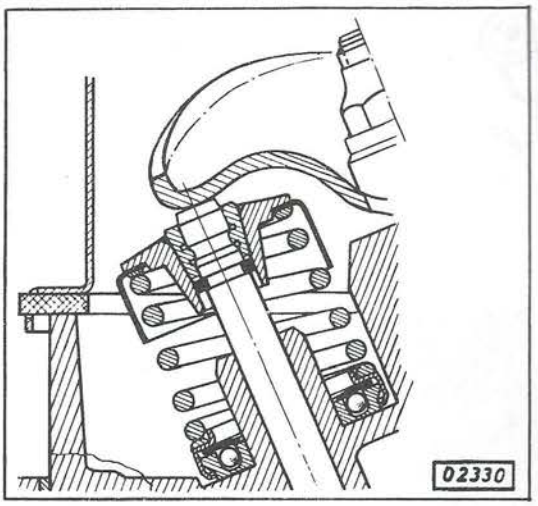
Remove and install rocker arm cover.

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.

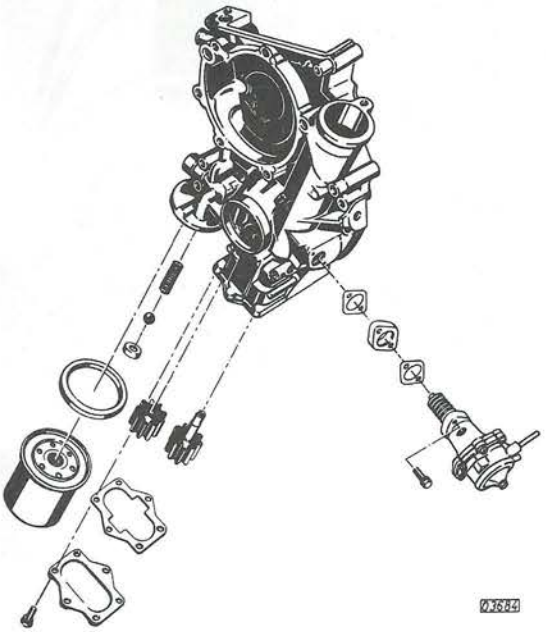
With the aid of tool S-1298 remove valve spring.

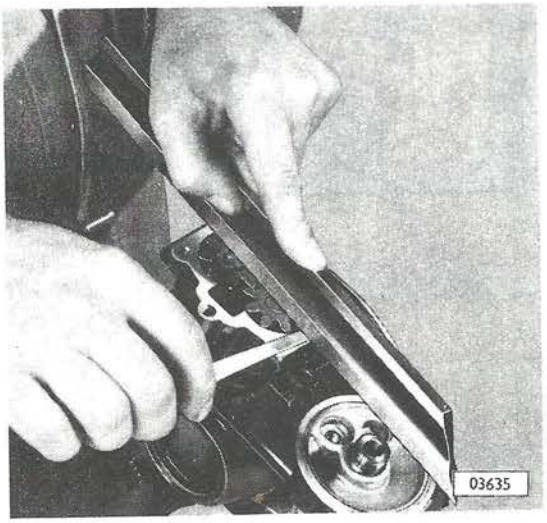


To avoid damage to the oil seal ring, first compress spring together with oil deflector and valve seat and then place oil seal ring in valve stem groove. This applies only to 16, 16 S and 19 S-engine. As far as the valve stem oil seals for 19 US-engines are concerned refer to page 06-45.



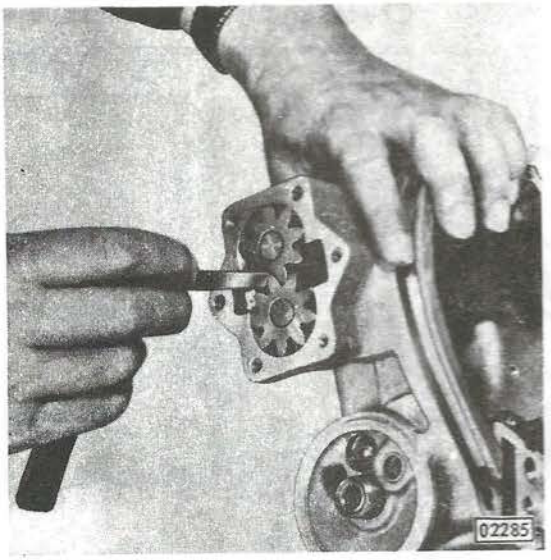
Overhauling Oil Pump





Check end clearance of gears. To do this, individually place gears without oil into pump and measure end clearance using a straightedge and a feeler gauge. Permissible clearance exists, if gear faces protrude 0 to .004 in. (0.10 mm) over cover contacting surface. Pump cover worn by gears must be replaced.

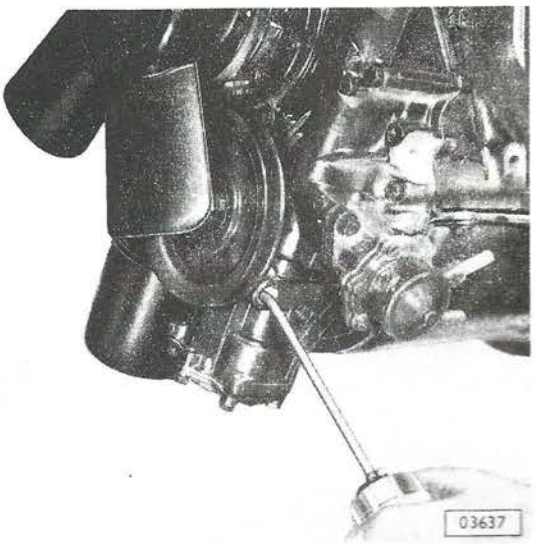
With feeler gauge check gear backlash. It should be between .004 in. (0.10 mm) and .008 in. (0.20 mm).



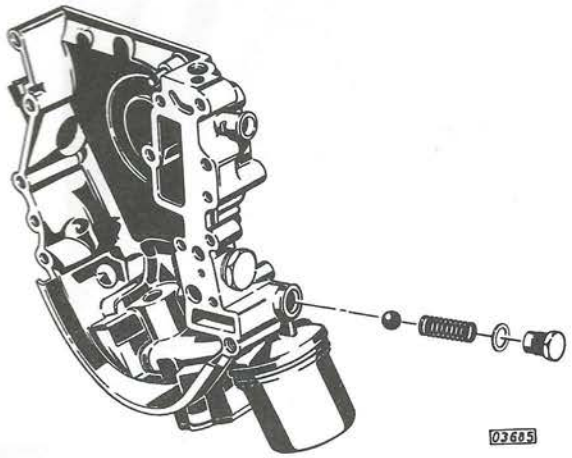
When overhauling oil pump, it has to be borne in mind that in individual cases timing cases are installed in production in which the bores for gears and shafts have .008 in. (0.2 mm) oversize. This may apply to both gears but also to one gear. Such an oversize can be identified by a "02" which is stamped into the straight web of the pump housing on the right or left side or on the right and left side.

Liberally oil gears and install them together with cover and new gasket.

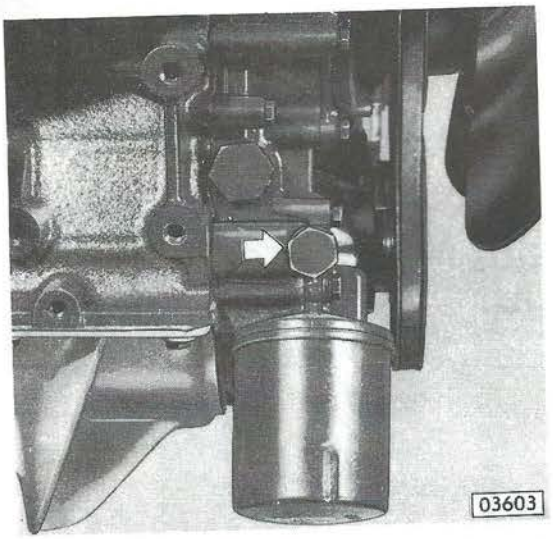
Remove plug from oil pump housing and prior to starting engine fill pump with engine oil.



Checking Oil Pump Pressure Regulator Valve For Proper Operation

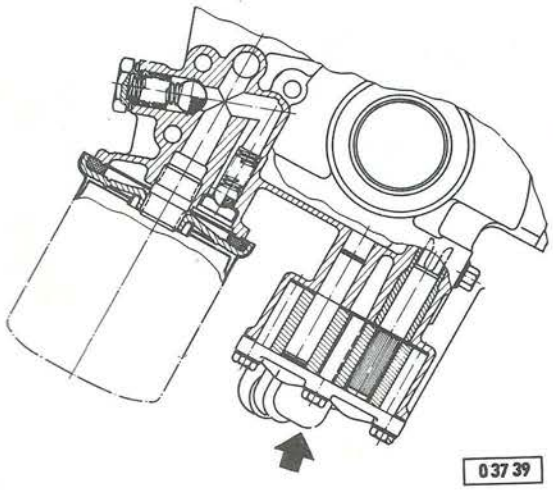


In case of symptoms caused by insufficient oil pressure - oil pressure indicator lamp lights up - always check oil pump pressure regulator valve for proper operation.



Unscrew plug and check spring and valve ball for free operation and dirt particles. If required, clean and free valve ball.

On assembly lightly tap ball - old or new one - onto ball seat, using a brass drift, to allow ball to seat itself properly.



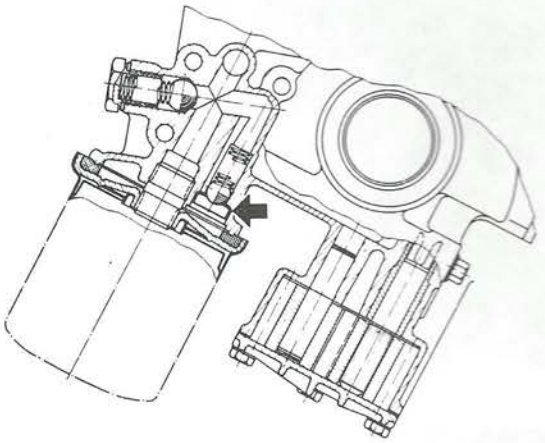
The oil pump pressure regulator valve of the 1.9 ltr. US-engines is located in the oil pump cover. If the oil pump cover was removed, make sure on reinstallation that the plug points to vehicle rear end.

Replacing Oil Filter Pressure Relief Valve

Remove and install oil filter element.

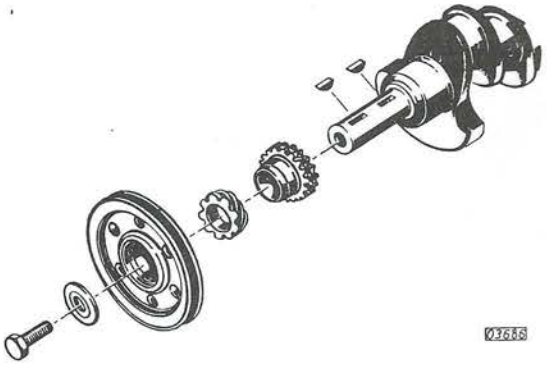
With a suitable drift remove valve sleeve located below attaching flange. Make sure that sealing area for filter element is not damaged.

Clean bore and passage with compressed air. Insert new spring and valve ball and with a suitable drift drive in new valve sleeve so that open sleeve side faces downwards.



03677

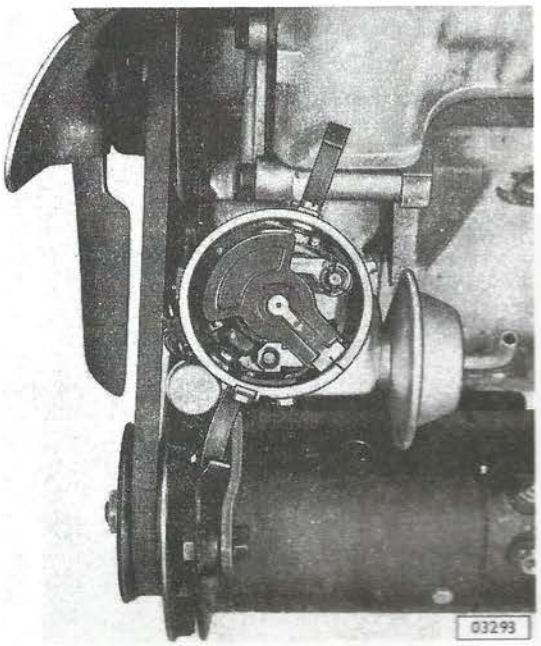
Replacing Distributor Drive Gear



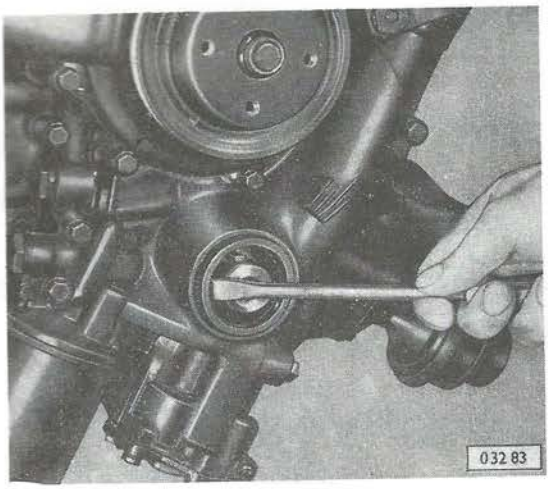
03668

Remove distributor cap and condenser plate.

Turn crankshaft until notch on rotor tip aligns with notch on distributor housing.

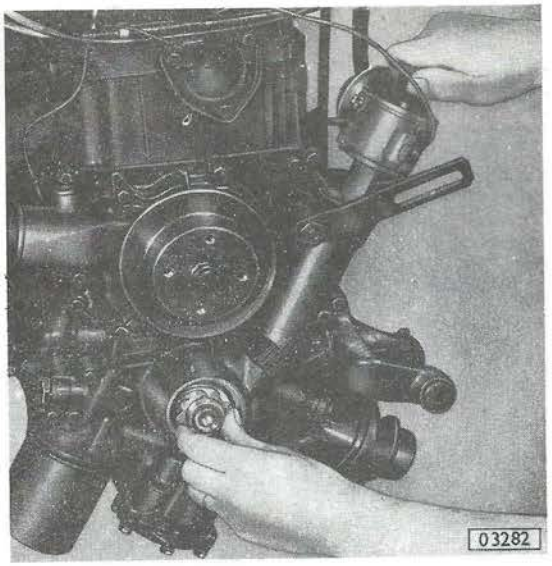


03293



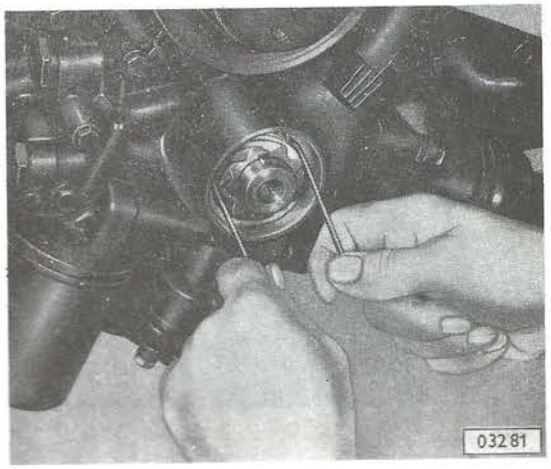
Remove crankshaft pulley.

With a screwdriver remove oil seal from timing case. Oil seal cannot be reused and has to be replaced.



By turning rotor of distributor counter-clockwise push helical gear on crankshaft journal outward, so that it can be pulled out by hand (helical gear has a sliding fit).

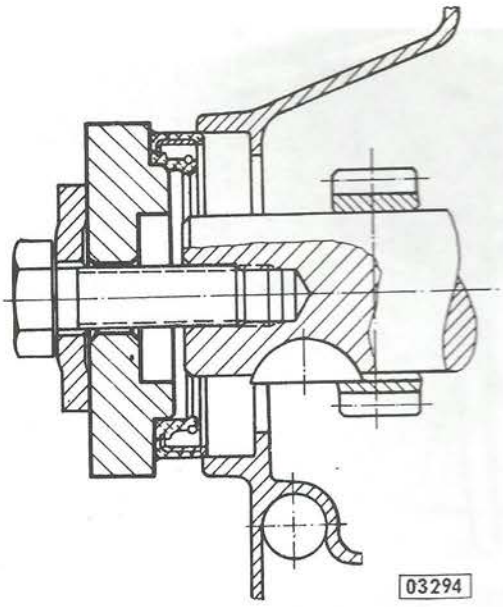
Should it not be possible to move the helical gear by turning the rotor, prepare two hooks from 3 mm welding rod bending them at one end approx. 5 mm at right angles. With these hooks pull helical gear off crankshaft journal.



As soon as the helical gear is no longer in mesh with the distributor driven gear, leave distributor rotor in this position (for easier installation). After installation of the new helical gear the distributor rotor must be in the same position as before, i.e. the notch on the rotor tip must be in alignment with the notch on distributor housing. Should this initial position not be obtained, remove helical gear from its seat again and stagger distributor driven gear one tooth by turning rotor accordingly. Check as to whether proper position has been obtained.

After oiling sealing lip, install new oil seal with tool S-1305 into timing case. Use bolt and washer for attaching crankshaft pulley.

Lightly coat outside surfaces with sealer, part No. 15 04 167, prior to installation.



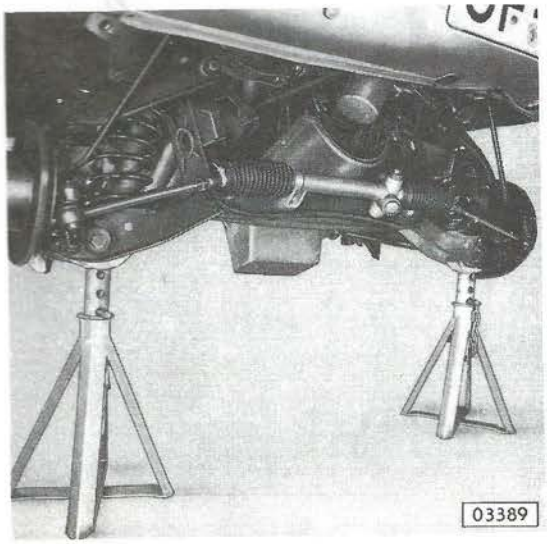
The further installation of removed parts has to be carried out in reverse sequence to removal.

Check ignition timing and adjust, if necessary.

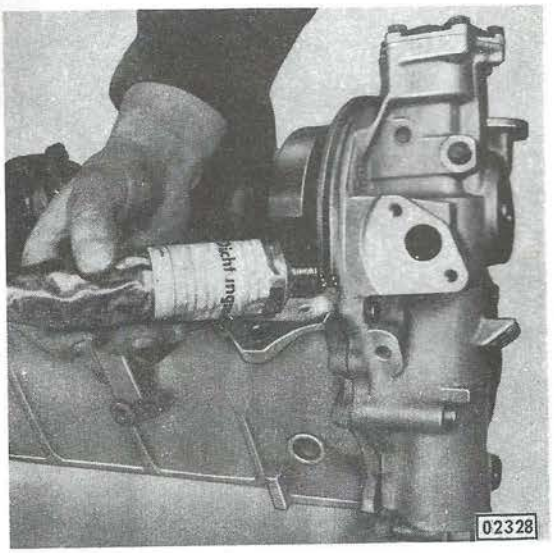
Replacing Oil Pan Gasket

With engine lifter S-1244 and short cable (approx. 59 in. = 1.50 m long) lift engine so that the front engine damper blocks are somewhat relieved.

Remove all linkages, cables, pipes, hoses, bowden control wires and adjoining parts which hinder detachment of front suspension crossmember (refer also to group 3). Let down crossmember so that the upper attaching bolts (left and right) are still inserted approx. .4 in. (1 cm) in frame. Pay attention to brake hoses.

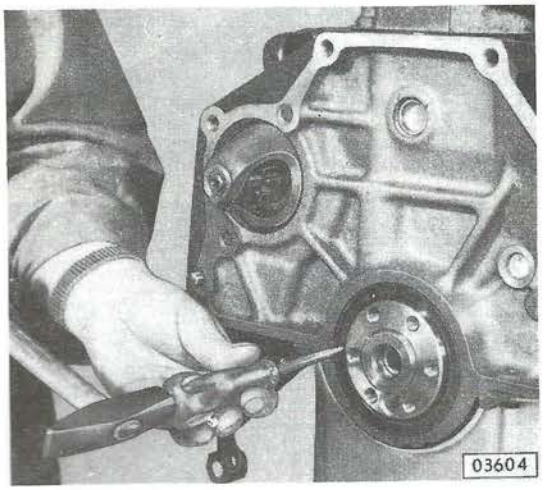


In this position support front suspension crossmember with stands and remove oil pan.



Prior to reinstallation of oil pan coat contacting surfaces of oil pan cork gaskets and rubber strips on cylinder block side with sealing compound, part No. 15 03 161, and install cork gaskets. Fill gaps at the gasket ends with sealing compound, part No. 15 04 402, and place rubber strips into grooves. Install oil pan.

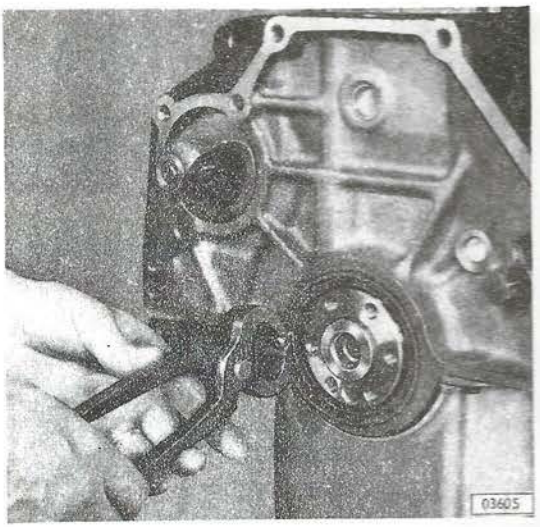
Replacing Crankshaft Rear Main Bearing Oil Seal



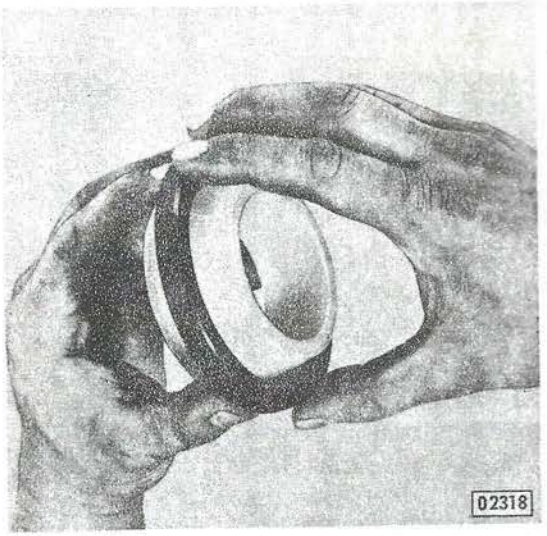
Remove and install flywheel.

With a suitable drift punch a hole into center of oil seal.

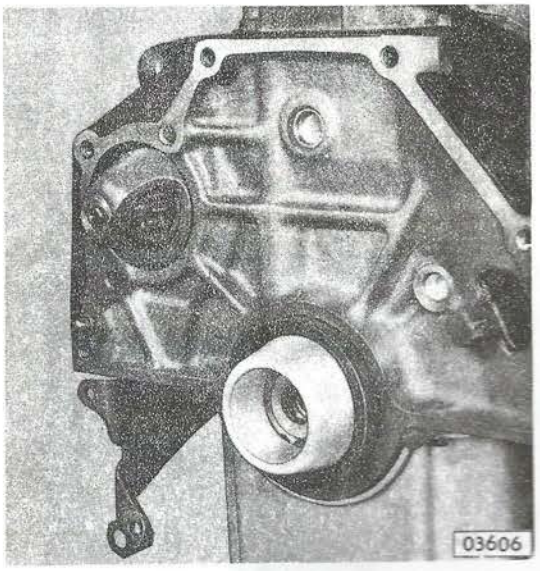
Screw a suitable sheet metal screw into oil seal and with pliers pull out oil seal.

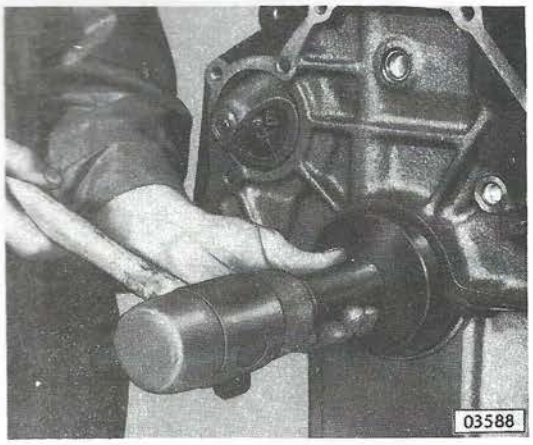


Slide new oil seal with lip coated with protective grease, part No. 19 48 814, with open side onto tapered ring of tool S-1296. Turn oil seal to avoid that lip is folded back and tension spring is pushed out.



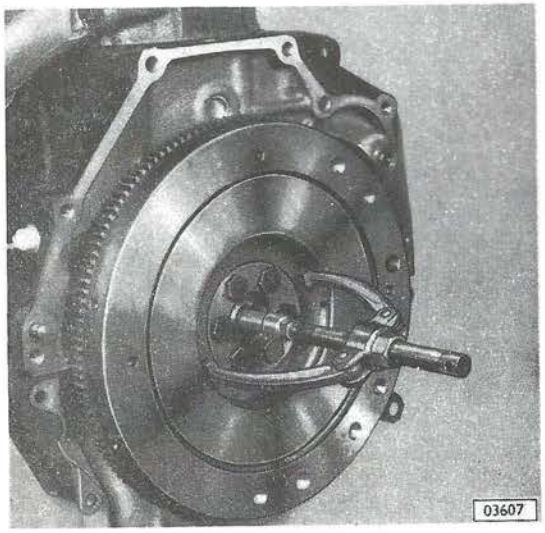
Place tapered ring with oil seal on crankshaft journal, snugly push oil seal over journal and remove tapered ring.





Drive in waved oil seal using tool S-1296.

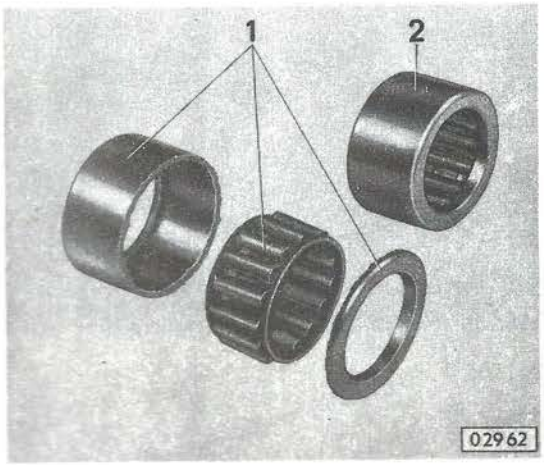
Replacing Clutch Gear Needle Bearing In Crankshaft



Remove clutch (refer to respective operation in this group).

Remove clutch gear needle bearing, using Kukko puller No. 22-1 and adapter No. 21/2.

When pulling out needle bearing with aforementioned tools, the possibility exists that the bearing will be destroyed. Because of a too tight press fit the shoulder at the bearing sleeve face may tear off so that only the needle bearing cage can be removed while the bearing sleeve remains in the bore.



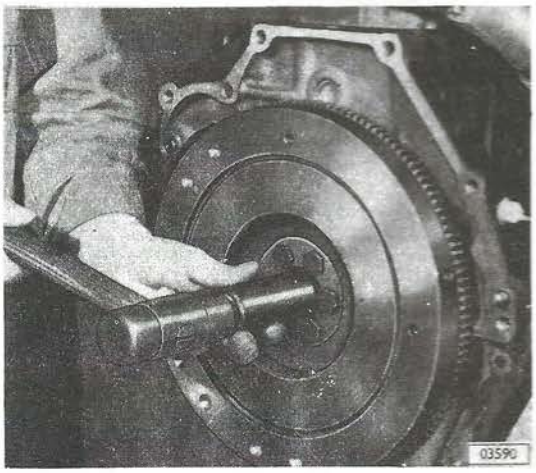
1 Destroyed bearing
2 New bearing

In such a case the needle bearing sleeve has to be pulled out of the bore with the Kukko puller adapter No. 21/3.

Should it not be possible to insert the puller adapter No. 21/3 through the bearing sleeve, grind puller claws accordingly.

Drive in new needle bearing using tool S-1296 and pertaining spacer ring. Proper seat of bearing is warranted by tool.

Lightly coat needle bearing with ball and roller bearing grease, part No. 19 46 254.



Note

Crankshafts with a .039 in. (1 mm) oversize bore are provided with a bushing instead of the needle bearing. Remove and install this bushing in the same way as the needle bearing - refer also to "Crankshaft".

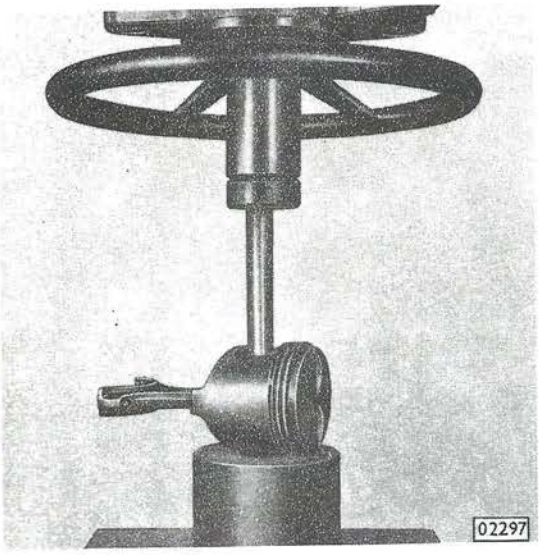
Replacing Pistons

03636

Remove and install engine.
Remove and install oil pan.
Remove and install cylinder head.
Unscrew connecting rod bearing cap and remove piston together with connecting rod towards the top out of cylinder.

Observe original installation position of piston.

Notch in piston head must point towards the front, oil squirt hole towards manifold side and notch in connecting rod bearing cap towards the rear.



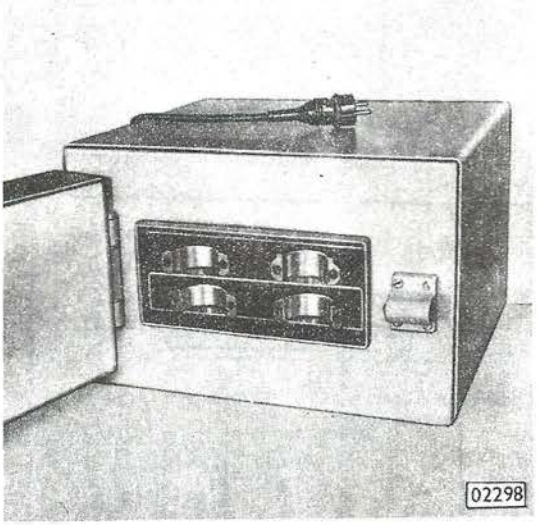
02297

In cold condition press out piston pin, using tool S-1297 and a suitable support. Piston cannot be reused.

Connecting rods and pistons are supplied separately. They have to be assembled in own repairshop. Use electric oven MW 101 or a heating plate available on the market (1500 - 2000 Watts) for heating connecting rod to the required installation temperature of 536° F (280° C).

The 1.9 ltr. US-engine is equipped with trough-type pistons. Because of the semi-circular recess in piston head a compression ratio of 7.6 : 1 is obtained.

If an electric oven is on hand, heat connecting rods to specified installation temperature, which takes about 30 minutes.

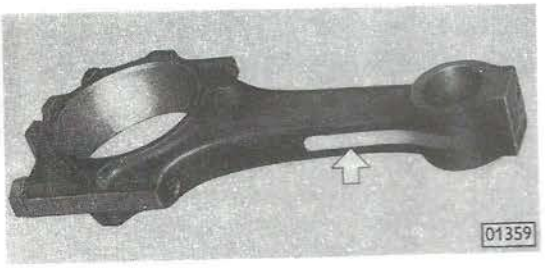


If connecting rods are to be heated up with a heating plate, determine the required installation temperature of 536° F (280° C) with temperature measuring crayons, obtainable in packages with twelve crayons under the designation

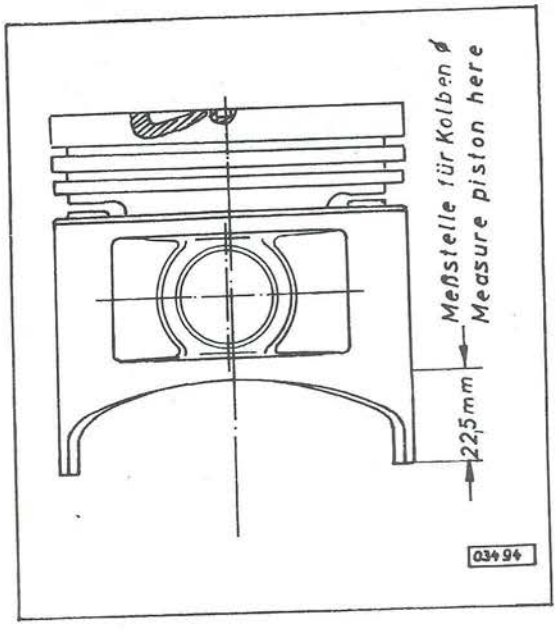
Thermochrom-Stifte
No. 2815/280
from Messrs. A. W. Faber Castell

Stein bei Nürnberg
Western Germany

With the crayon a coloring substance is applied to the piston pin eye as well as the upper part of the connecting rod shaft. With its upper eye the connecting rod is then placed onto the heating plate. In order to obtain a quick and even heat flow, it has to be made sure that the eye surface planely rests on heating plate. For this purpose support opposite connecting rod end with a suitable block. To shorten the warm up period, it is advisable to place a fireproof clay onto connecting rod eye.



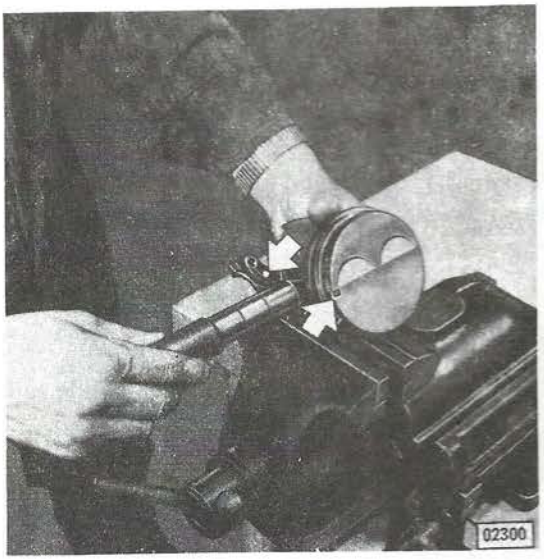
As soon as the connecting rod eye has reached a temperature of 536° F (280° C) the applied coloring substance is getting black indicating the desired assembling temperature. The color line should not change color over its entire length but only up to the beginning of the connecting rod shaft.



Select new piston according to table "Cylinder And Piston Dimensions".

Pistons, the size of which can no longer be identified, have to be measured with a micrometer at a distance of .88 in. (22.5 mm) from piston lower end at right angles to the piston axis.

When connecting rod has reached specified temperature, clamp it into a vise. Place guide pin and installer of tool S-1297 into piston pin lubricated with engine oil and insert into piston bore. Assemble piston with connecting rod so that the aforementioned installation positions are adhered to. Slide piston into connecting rod eye until shoulder of installation arbor hits piston skirt.



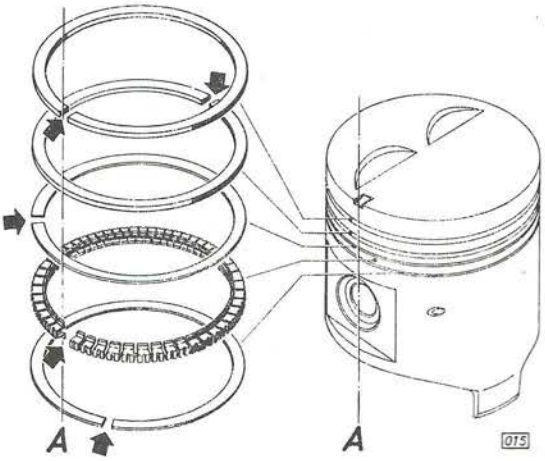
The connecting rod cools down rapidly. In order to obtain a proper fit of piston pin in connecting rod eye, it is therefore essential that piston pin is quickly pushed in. A correction of piston pin seat after connecting rod has cooled down is not possible without running the risk of piston distortion.

The Parts and Accessories Department supplies only connecting rods of the highest weight group. Variations in weight can be corrected by grinding material off the two projections on connecting rod bearing cap.

The weight variation of the individual connecting rods of an engine must not exceed .28 oz. (8 g).

Prior to installation of pistons into cylinders - use piston ring compressor - amply provide pistons and cylinder walls with adhesive oil, part No. 19 40 950, and turn them so that

a) intermediate ring gap is in front
b) gaps of steel band rings are located 1-2 in. (25 - 50 mm) towards the left and right of the intermediate ring gap
c) gap of lower compression ring is offset 180° to the intermediate ring gap. The gap of the upper compression ring is in front.

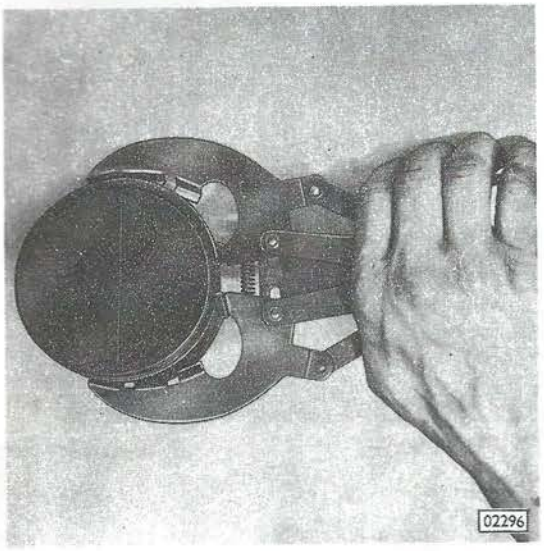


Install connecting rod and piston assembly into cylinder, using a piston ring compressor available on the market.

Use new connecting rod bolts and torque them to 36 ft. lbs. (5 kpm).

Replacing. Piston Rings

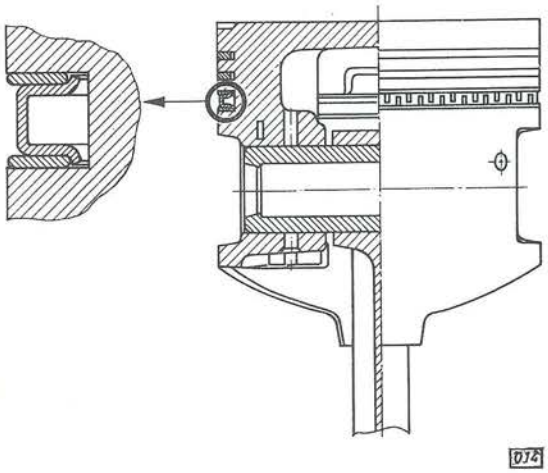
- Piston removed -



Remove and install piston rings, using piston ring pliers (except oil control ring).

Decarbonize piston grooves using a piece of discarded piston ring.

On installation make sure that "Top" marking on center ring points upwards.

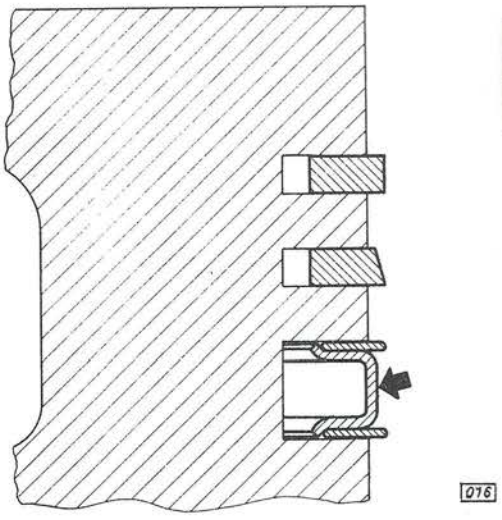


A PC-ring is used as oil control ring in lower piston ring groove.

On removal of PC-rings with combination plier individually grip first steel band rings at their end and spirally pull them downwards out of ring groove. Then remove intermediate ring.

On installation first place intermediate ring into groove, making sure that ring gaps are not superjacent. Then, one after the other, spirally install upper and lower steel band ring, reversing removal operation.

Check PC-ring combination for jamming. It should have a spring-tight seat.



Piston ring gap	Engines	
	16, 16 S	19 S, 19 US
Upper ring	.0118 - .0177 in. (0.30 - 0.45 mm)	.0138 - .0217 in. (0.35 - 0.55 mm)
Center ring	.0118 - .0177 in. (0.30 - 0.45 mm)	.0138 - .0217 in. (0.35 - 0.55 mm)
Lower ring	.0150 - .0551 in. (0.38 - 1.40 mm)	.0150 - .0551 in. (0.38 - 1.40 mm)

Pistons with index number "0.4" and higher are provided with oversize piston rings. On replacement of piston rings select them according to Parts Catalog specifications.

Measure piston ring gap with piston ring placed in cylinder, using a feeler gauge.

Engines : 16 and 16 S				
Size	Cylinder		Piston	
	Cylinder bore diameter in. (mm)	Index number for cylinder bore on crankcase	Pertaining piston diameter Service in. (mm)	Index number on piston head Service
Production sizes	3.3445 (84.95)	5	3.3437 (84.93)	6
	3.3449 (84.96)	6	3.3437 (84.93)	6
	3.3453 (84.97)	7	3.3445 (84.95)	8
	3.3457 (84.98)	8	3.3445 (84.95)	8
	3.3461 (84.99)	99	3.3453 (84.97)	00
	3.3465 (85.00)	00	3.3453 (84.97)	00
	3.3468 (85.01)	01	3.3461 (84.99)	02
	3.3472 (85.02)	02	3.3461 (84.99)	02
	3.3476 (85.03)	03	3.3468 (85.01)	04
	3.3480 (85.04)	04	3.3468 (85.01)	04
	3.3484 (85.05)	05	3.3476 (85.03)	06
	3.3488 (85.06)	06	3.3476 (85.03)	06
	3.3492 (85.07)	07	3.3484 (85.05)	08
	3.3496 (85.08)	08	3.3484 (85.05)	08
	3.3500 (85.09)	09	3.3484 (85.05)	08
Oversize .020 in. (0.5 mm)	3.3650 (85.47)	85.47	3.3638 (85.44)	85.44 7 + 05 +)
	3.3653 (85.48)	85.48	3.3642 (85.45)	85.45 8 + 05
	3.3657 (85.49)	85.49	3.3646 (85.46)	85.46 9 + 05
	3.3661 (85.50)	85.50	3.3650 (85.47)	85.47 0 + 05
Oversize .039 in. (1 mm)	3.3846 (85.97)	85.97	3.3835 (85.94)	85.94 7 + 10
	3.3850 (85.98)	85.98	3.3839 (85.95)	85.95 8 + 10
	3.3854 (85.99)	85.99	3.3842 (85.96)	85.96 9 + 10
	3.3858 (86.00)	86.00	3.3846 (85.97)	85.97 0 + 10

Production pistons after index No. "04" are provided with oversize piston rings.

Oversize pistons are marked with the complete piston dimension and an index number +)

Cylinder Grinding And Piston Dimensions

Engines : 19 S and 19 US				
Size	Cylinder		Piston	
	Cylinder bore diameter in. (mm)	Index number for cylinder bore on crankcase	Pertaining piston diameter Service in. (mm)	Index number on piston head Service
Production sizes	3.6594 (92.95)	5	3.6587 (92.93)	6
	3.6598 (92.96)	6	3.6587 (92.93)	6
	3.6602 (92.97)	7	3.6594 (92.95)	8
	3.6606 (92.98)	8	3.6594 (92.95)	8
	3.6610 (92.99)	9	3.6602 (92.97)	0
	3.6614 (93.00)	0	3.6602 (92.97)	0
	3.6618 (93.01)	1	3.6610 (92.99)	02
	3.6622 (93.02)	2	3.6610 (92.99)	02
	3.6626 (93.03)	3	3.6618 (93.01)	04
	3.6630 (93.04)	04	3.6618 (93.01)	04
	3.6634 (93.05)	05	3.6626 (93.03)	06
	3.6638 (93.06)	06	3.6626 (93.03)	06
	3.6642 (93.07)	07	3.6634 (93.05)	08
	3.6646 (93.08)	08	3.6634 (93.05)	08
	3.6650 (93.09)	09	3.6634 (93.05)	08
Oversize .020 in. (0.5 mm)	3.6799 (93.47)	93.47	3.6787 (93.44)	93.44 7 + 05 +)
	3.6803 (93.48)	93.48	3.6791 (93.45)	93.45 8 + 05
	3.6807 (93.49)	93.49	3.6795 (93.46)	93.46 9 + 05
	3.6811 (93.50)	93.50	3.6799 (93.47)	93.47 0 + 05

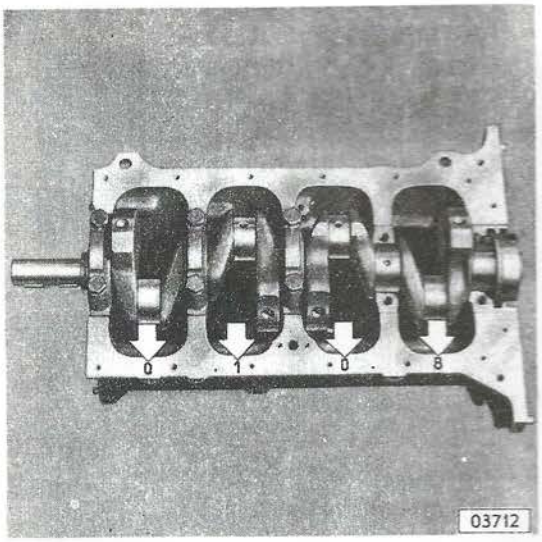
Production pistons after index No. "04" are provided with oversize piston rings.

Oversize pistons are marked with the complete piston dimension and an index number +).

Uniform piston clearances exist on production engines and short blocks as well as cylinder blocks with pistons, i. e. assembled at factory. According to the obtainable piston sizes a varying piston clearance has to be taken into consideration for service repairs.

When reconditioning cylinder bores cancel original index number on crankcase sealing surface and stamp new index number according to table "Cylinder Grinding And Piston Dimensions" into sealing surface.

Piston and cylinder bore must have the same index number.



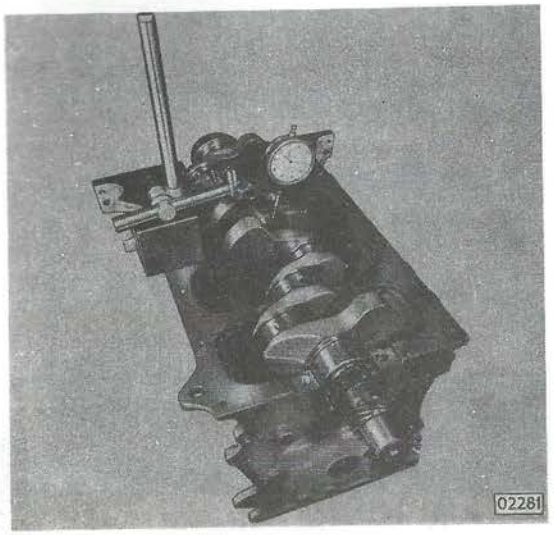
Piston installation clearance 16, 16 S, 19 S and 19 US

Production: .0012 in. (0.03 mm)

Service: .0008 in. - .0012 in. (0.02 - 0.03 mm)

For cylinder blocks with index number "0.9" : .0016 in. (0.04 mm)

Crankshaft



Check crankshaft for runout. Permissible runout should not exceed .001 in. (0.03 mm). To do this, remove center bearing shells so that crankshaft rests in front and rear main bearing shells. Check runout with dial gauge.

Measure main and connecting rod bearing journals with a micrometer. Permissible out-of-roundness = .0002 in. (0.006 mm). Permissible taper = .0004 in. (0.010 mm). Permissible end clearance of crankshaft = .0017 - .0061 in. (0.043 - 0.156 mm).

If bearing journals are no longer in proper condition, grind crankshaft according to the following table considering the obtainable undersize bearing shells. When doing this, pay attention to the fact that .0098 in. (0.25 mm) undersize crankshafts may already be installed in production. These crankshafts are paint marked on a web as follows:

blue = undersize for main bearing journal
yellow = undersize for connecting rod bearing journal
blue / yellow = undersize for both journals

Measure main and connecting rod bearing clearances with "Plastigage".

Permissible main bearing clearance =
.0009 - .0025 in. (0.023 - 0.064 mm)

Permissible connecting rod bearing clearance =
.0006 - .0024 in. (0.015 - 0.061 mm)

"Plastigage" is a measuring device consisting of a plastic thread with exactly calibrated diameter. A piece of thread the width of the bearing is cut off and is placed axially between journal and bearing shell. By tightening bearing cap bolts - pay attention to specified torque - the thread is flattened to a certain width, depending on the bearing clearance. After removal of the bearing cap the width of the deformed thread, adhering either to journal or to bearing shell can be measured to determine promptly the bearing clearance. For this purpose a measuring scale which has inch as well as millimeter values is furnished with the "Plastigage" set and attention must be paid to get the figures not mixed up. A possible oval or taper wear of the bearing journal can also be determined readily and exactly by this method.

"Plastigage" is obtainable for various measuring ranges from

Messrs. Ern K.G.

4 Düsseldorf
Corneliusstr. 65/67

For Opel engines the following type, which is also the ordering number, is normally sufficient:

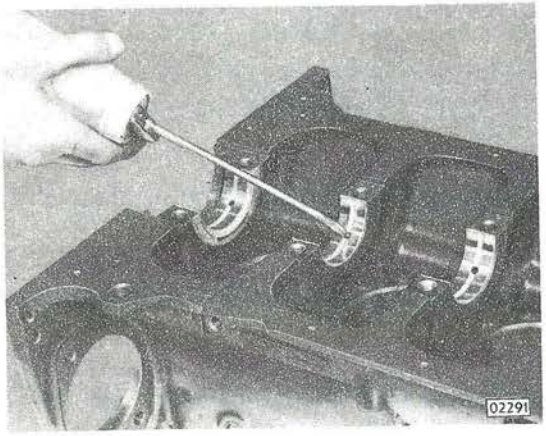
Type : PG-1 Color: green
Measuring range: .001 - .003 in.
(0.025 - 0.075 mm)

An original set "Plastigage", consisting of 12 packages with one measuring thread each permits approximately 150 individual measurements.

"Plastigage" may also be used to measure exactly and speedily various other kinds of clearances by the method explained above. Detailed instructions on proper usage are included in each set.

When grinding crankshaft journals to the next undersize and using new bearing shells observe crankshaft grinding dimensions according to table.

Crankshafts with .039 in. (1 mm) oversize bores are marked with the letter "A" at the face of the flywheel spigot. For the oversize bores use bearing bushings instead of the needle bearings. Install bushings with tool S-1296 without spacer ring. Lightly coat bushing with molybdenum disulfide paste, part No. 19 48 524.

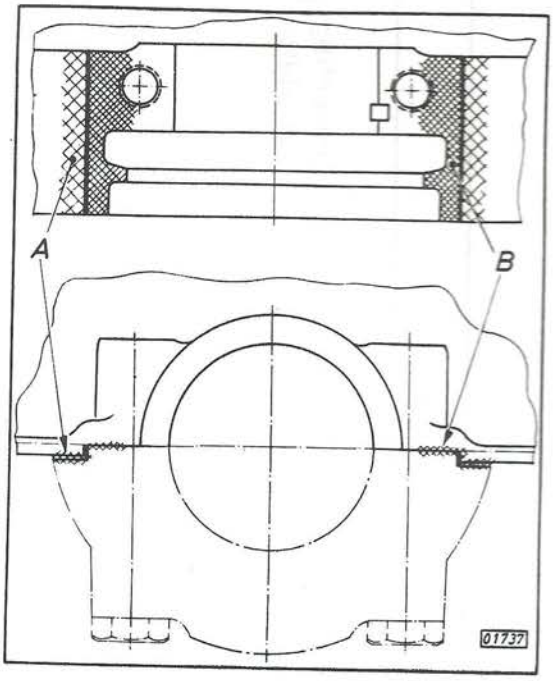


Prior to installation of crankshaft fill oil gallery of cylinder block with engine oil.

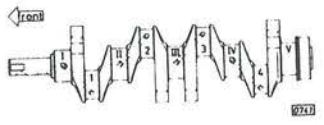
Seat crankshaft with a few rubber hammer blows.

Amply oil bearing journals and torque bearing cap bolts to 72 ft. lbs. (10 kpm).

In order to prevent leakages at the rear main bearing carefully coat sealing areas "A" and "B" shown in the drawing with sealing compound part No. 15 03 294.



Crankshaft Grinding Dimensions

16, 16 S, 19 S and 19 US - engines						
	Crankshaft bearing journals			Connecting rod bearing journals all		Connecting rod width +) all
	No. I thru IV	No. V Pilot bearing				
	Diameter in. (mm)	Width in. (mm)	Diameter in. (mm)	Width in. (mm)	Diameter in. (mm)	in. (mm)
	Standard size					
	2.2829 (57.987) to 2.2835 (58.000)	1.0807 (27.450) to 1.0831 (27.512)	2.2829 (57.987) to 2.2835 (58.000)	.9843 (25.000) to .9874 (25.080)	2.0461 (51.971) to 2.0467 (51.987)	.9779 (24.838) to .97999 (24.890)
	.0099 in. (0.25 mm) undersize for Production and Service					
A = Crankshaft bearing shell diameter .0099 in. (0.25 mm) undersize	2.2731 (57.737) to 2.2736 (57.750) use A	1.0886 (27.650) to 1.0910 (27.712) use B	2.2731 (57.737) to 2.2736 (57.750) use A	.9843 (25.000) to .9874 (25.080)	2.0363 (51.721) to 2.0369 (51.737) use C	.9779 (24.838) to .9799 (24.890)
B = Bearing shell width for bearing V .0079 in. (0.2 mm) oversize						
C = Connecting rod bearing shell diameter .0099 in. (0.25 mm) undersize						

.0197 in. (0.5 mm) undersize for Service						
A = Crankshaft bearing shell diameter .0197 in. (0.5 mm) undersize B = Bearing shell width for bearing V .0157 in. (0.4 mm) oversize C = Connecting rod bearing shell diameter .0197 in. (0.5 mm) undersize D = Connecting rod width .0079 in. (0.2 mm) oversize	2.2633 (57.487) to 2.2638 (57.500) use A	1.0965 (27.850) to 1.0989 (27.912) use B	2.2633 (57.487) to 2.2638 (57.500) use A	.9921 (25.200) to .9953 (25.280)	2.0264 (51.471) to 2.0270 (51.487) use C	.9857 (25.038) to .9878 (25.090) use D