ENGINE

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DESCRIPTION AND OPERATION

ENGINE CONSTRUCTION

Engine Usage

The 1.9 liter engine is standard equipment on all 1973 Opel 1900, Manta and GT models. This engine has a compression ratio of 7.6:1 and operates on "regular" low lead grade fuel.

Engine Construction

The *cylinder head* is made of high-grade chromium grey cast iron. The valve guides are cast intergal with the head. The overhead camshaft is supported in four bearings in the cylinder head.

Location of the valve seats in ***combustion chamber*** is above the center of cylinder bore. The spark plug is positioned in the center and near the highest point of combustion chamber. This arrangement provides for short flame travel, uniform combustion and **good** cold start prop&ties. ***Exhaust valves*** **have seat** inserts of highly heat and water resisting material. The head surface is alumetized and so are the seats of the *inlet valves* Alumetizing makes the valve heads non- scaling and promotes long life. All engines have "roto-caps".

The forged, five main bearing crankshaft has large-diameter main and connecting rod bearing journals with considerable overlap for vibration-free operation. Tri-metal bearing shells are used for main and connecting rod bearings. The crankshaft end play is controlled by the rear main bearing.

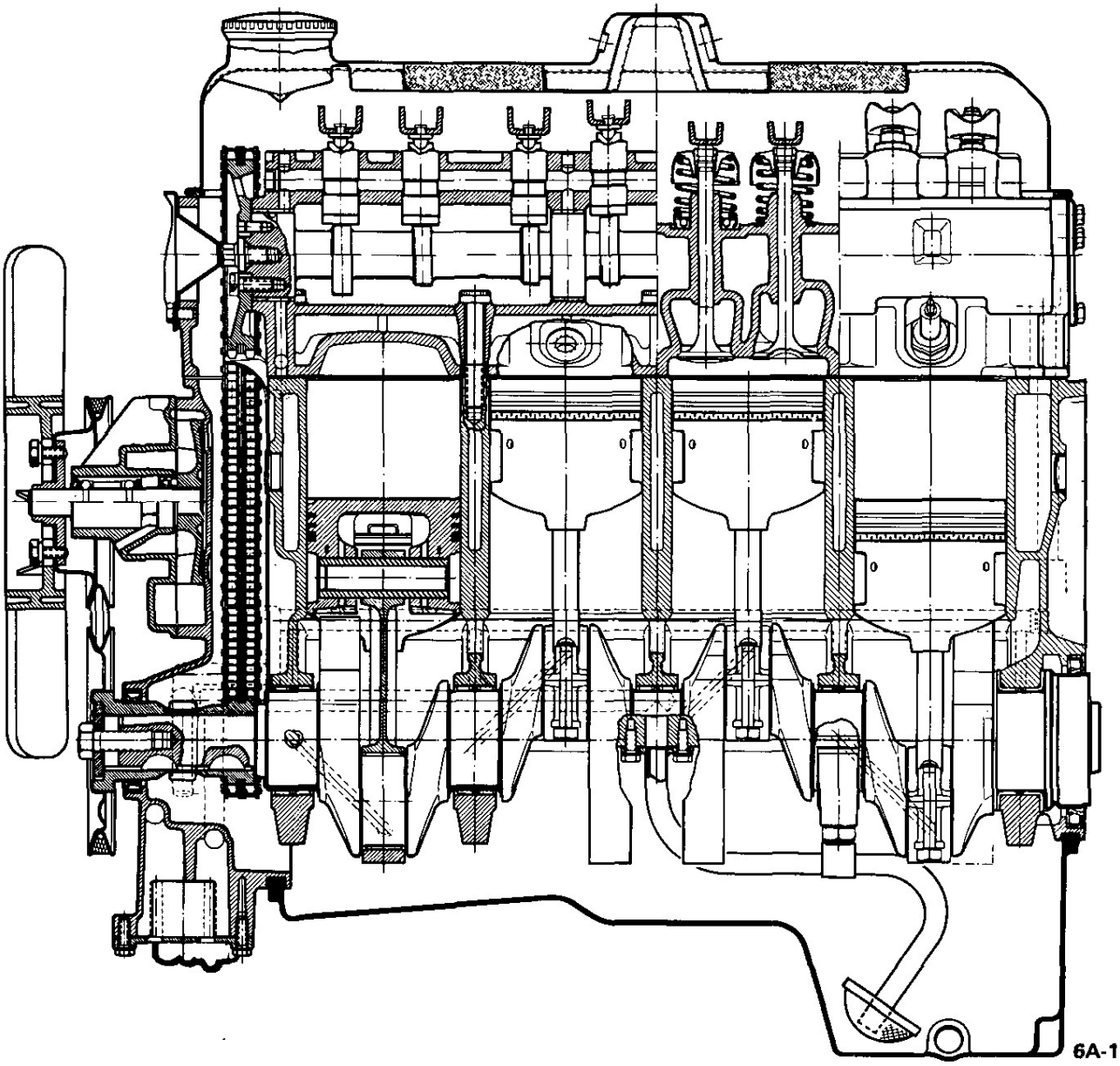


Figure 6A-1 Side Cross Section View of Engine

This engine has full skirt "Autothermic" type pistons with two horizontal slots in oil control ring groove, which partly separate head and skirt to maintain good contact with the cylinder walls throughout the entire temperature range.

The camshaft located in the cylinder head is an important design feature of the new power units. This arrangement permits an extremely rigid valve train which accounts for precise valve timing. The grey cast iron camshaft has induction hardened bearing journals and cams. Installation of camshaft is facilated by each diameter of the four bearings and journals being slightly smaller than the preceding.

Camshaft end play is controlled at forward end by the camshaft front bearing seat outer face in one direction, and by the front bearing cover in the other direction. A nylon bolt in camshaft forward end serves to adjust end clearance.

The camshaft is driven by an endless *Duplex roller* chain. The crankshaft double sprocket and pulley arc held by one key. The camshaft sprocket is fixed with a guide pin and attached with 3 bolts.

Inside the timing case, a long damper block is provided on the driving side of the chain and a shorter, curved spring plate tensioner on the non-driving side. Both have wear-resistant and oil-proof synthetic rubber slipper pads. The self adjusting *chain* tensioner located on driving side of chain at right

hand side above crankshaft sprocket, has a plunger head with oil- proof and wear-resistant synthetic rubber pad, which is pressed against chain by both spring and oil pressure.

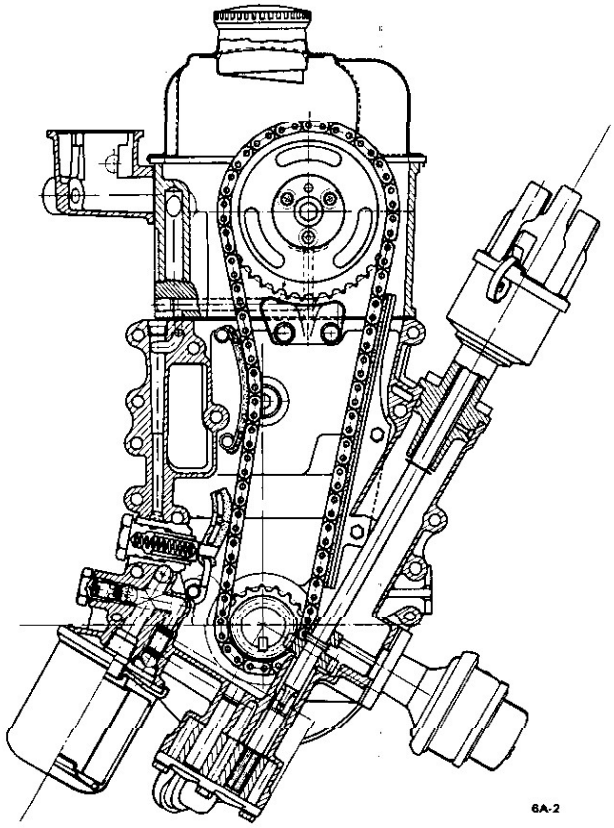


Figure 6A-2 Sectional View. Timing System

The top end of the short, light-weight *hydraulic valve lifters* is provided with a cup in which tits the ball end of a stud engaged in an elongated hole in rocker arm, thus maintaining transverse alignment of the rocker arm.

The *rocker arm* is a steel stamping and pivots on a ball secured by a self-locking nut on a stud screwed into the cylinder head. This arrangement permits easy valve clearance adjustment. All valves have oil seals installed between valve spring and cap.

The *fuel pump* is located at bottom left-hand side of timing case and operated by, a cam integral with distributor drive gear riveted to distributor drive shaft.

The aluminum alloy cast *intake manifold* with smooth walls provide better charge of cylinders, especially at high engine RPM. It is a four-port manifold, i.e. there are separating walls between all arms, one for each cylinder. An adapter for crankcase ventilation hose leading to rocker arm cover is arranged on front portion of intake manifold.

Hot exhaust gases are used for heating a vaporization plate located at bend of intake manifold below carburetor and communicating with its tinned underside with the interior of the exhaust manifold to ensure that only vaporized fuel reaches the cylinders.

LUBRICATION SYSTEM AND OIL PUMP

The engine is lubricated by a forced feed system

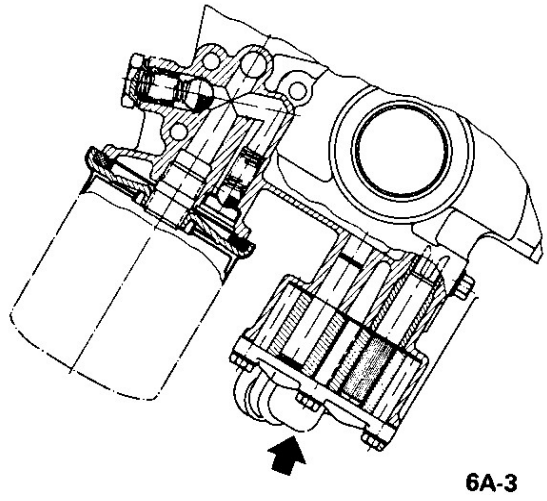


Figure 6A-3 Oil Pump Pressure Relief Valve

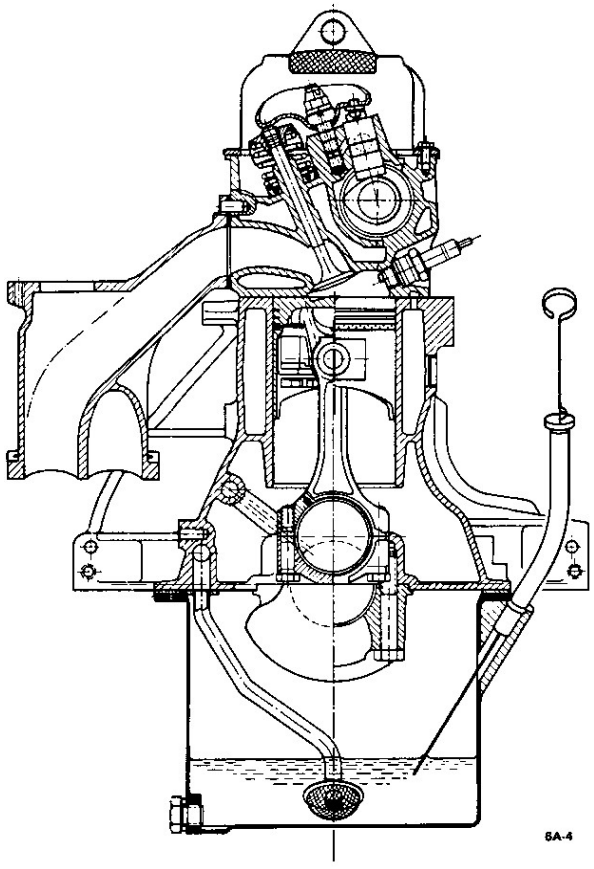


Figure 6A-4 Rear Cross Sectional View

incorporating a gear-type pump driven by the distributor shaft. The pump body forms 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 of the oil pan.

The oil pump pressure relief valve is located in the engine oil pump cover. See Figure 6A-3. The pressure relief valve serves to feed surplus oil back into the suction passage should the required oil pressure be exceeded. The old oil pressure relief valve which is located above the oil filter is inoperative. A heavier spring has been installed to keep the valve seated at all times.

The oil filter is of the full flow type. With it in parallel is a by-pass system controlled by a valve in the timing chain cover above the oil filter which ensures oil circulation directly to 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 Nos. 2, 3 and 4 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 oil under pressure.

Surplus oil collects at end of cylinder head and returns through a passage to the crankcase. A calibrated squirt hole in connecting rod big end bearing sprays 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.

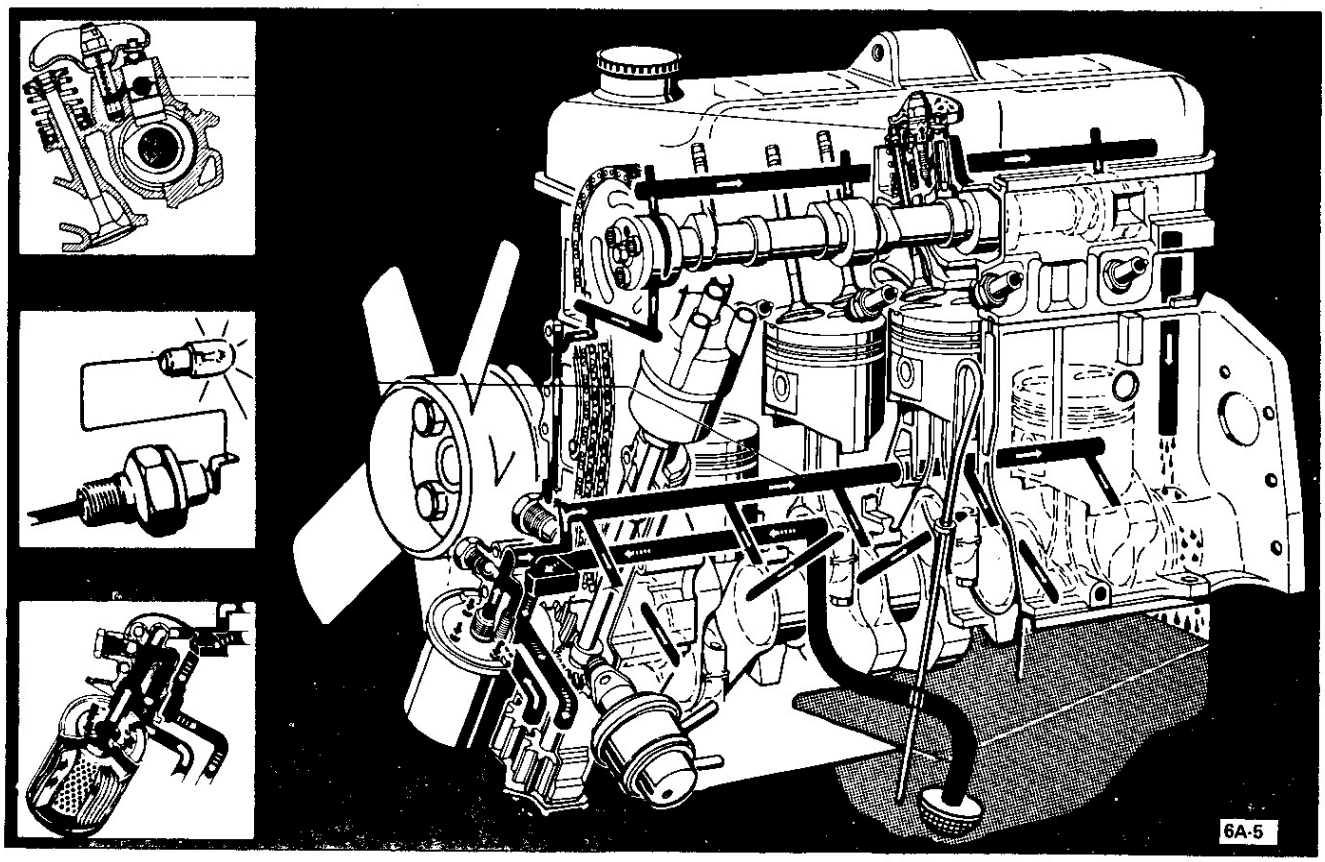


Figure 6A-5 Engine Lubrication System

DIAGNOSIS

EXCESSIVE OIL CONSUMPTION

Condition	Correction
External Oil Leaks at: Rocker Arm Covers Crankcase Front Cover Oil Pan and Gasket	Tighten attaching bolts. If leaks persist, remove cover (or pan), check sealing surfaces for burrs or scoring, replace gasket, and seal bolts with silastic sealer or equivalent. Make sure oil level is not overfull.
Improper Reading of Dip-Stick	Car may not be level when taking r Insufficient oil "drain-back" time after stopping engine (three minutes must be allowed). Dip-stick may not be completely pushed down against stop. Dipstick may be bent.
Oil Viscosity Too Light	Use recommended SAE viscosity for prevailing temperatures.
Continuous High-Speed Driving	At speeds above 60 mph, increased sumption can be expected with any Inform customer of this fact.
High-Speed Driving Following Normal Slow Speed City Driving	When principal use of automobile i city driving, crankcase dilution f condensation occurs. High speed a temperatures will remove water, resulting in what appears to be rapid lowering of oil level. Inform customer of this fact.
Piston Rings Not "Broken In"	Allow engine to accumulate at leas 4,000 miles before attempting any engine disassembly to correct for oil consumption.

NOISY VALVES AND LIFTERS

The noise level of the valve mechanism cannot be properly judged where the engine is below operating temperature when the hood is raised, or when the valve rocker arm covers are removed.

Before attempting to judge valve noise level, the engine must be thoroughly warmed up (at least 20 minutes of operation at 1200 to 1500 RPM) to stabilize oil and coolant temperatures and bring all engine parts to a normal state of expansion. When the engine is warmed up, listen for engine noise while sitting in the driver's seat with the hood closed. Run the engine at idle and at various higher speeds.

If the preceding check indicates valve mechanism is abnormally noisy, remove the rocker arm cover so that the various conditions that cause noise may be checked. A piece of heater hose of convenient length may be used to pick out the particular valves or valve linkages that are causing abnormal noise. With the engine running at a speed where the noise is pronounced; hold the end of hose to an ear and hold other end about 1/2 inch from point of contact between rocker arm and valve stem. Mark or record the noisy valves for investigation of following causes:

1. ***Sticking, Warped, or Eccentric Valves, Worn Guides*** Sticking valves will cause irregular engine operation or missing on a low speed pull and will usually cause intermittent noise.

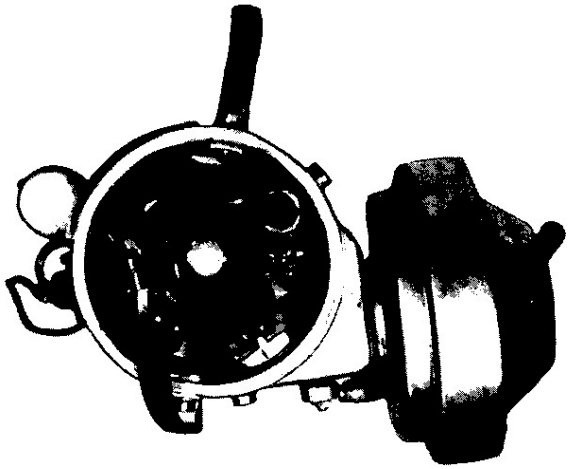
Pour penetrating oil over the valve spring cap and allow it to drain down the valve stem. Apply pressure to the one side of the valve spring and then the other, and then rotate the valve spring about 1/2 turn. If these operations affect the valve noise, it may be assumed that valves should be reconditioned.

2. ***Worn or Scored Parts in the Valve Train*** Inspect rocker arms, push rod ends for scoring. Check push rods for bends, valve lifters, and camshaft surfaces for scoring. Replace faulty parts.

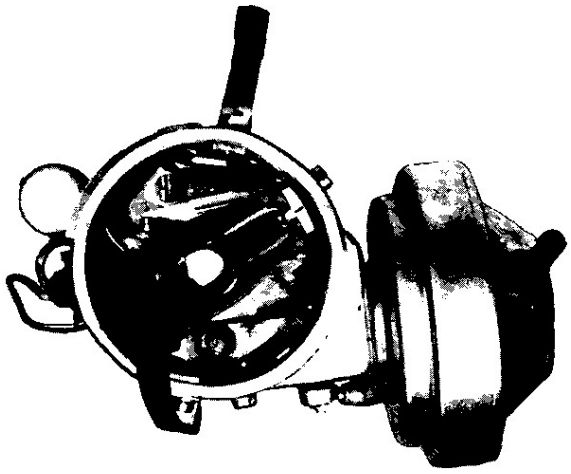
MAINTENANCE AND ADJUSTMENTS

VALVE LIFTER ADJUSTMENT

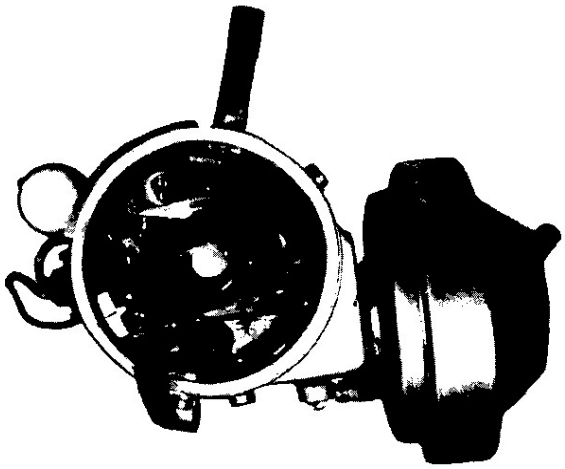
Perform hydraulic valve lifter adjustment with the engine off. It makes no difference whether the engine is cold or is at operating temperature. Set piston of the respective cylinder to upper top center on the firing stroke. This can be accomplished by removing the distributor cap and observing the rotor. Check position of the rotor and follow spark path for the rotor tip through the distributor cap, high tension wire to spark plug. This determines which cylinder is at upper top center on the firing stroke. Adjust the hydraulic lifters of the two valves for that cylinder at this time. When they are adjusted, turn engine so that another cylinder is at upper top center on the firing stroke and adjust the two valve lifters for that cylinder. Repeat process until all valves are adjusted. See Figure 6A-6 for correct rotor position for each cylinder.



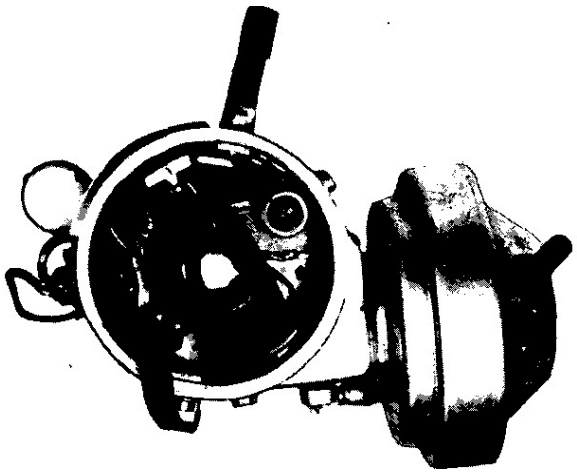
CORRECT ROTOR POSITION TO ADJUST VALVES ON CYLINDER NO. 1



CORRECT ROTOR POSITION TO ADJUST VALVES ON CYLINDER NO. II



CORRECT ROTOR POSITION TO ADJUST VALVES ON CYLINDER NO. III



CORRECT ROTOR POSITION TO ADJUST VALVES ON CYLINDER NO. IV

6A-6

Figure 6A-6 Rotor Positions for Valve Lifter Adjustment

Actual adjustment is made by backing off adjusting nut at the rocker arm until clearance exists between the valve stem, rocker arm, and lifter. Then slowly tighten adjusting nut until clearance is eliminated. When clearance is eliminated, turn adjusting nut one full turn (clockwise). This positions the hydraulic piston of the hydraulic lifter mid-point in its total available travel, and no further adjustment is required.

MAJOR REPAIR

ENGINE ASSEMBLY REMOVAL AND INSTALLATION

Removal (Opel 1900 and Manta)'

The engine assembly on the Opel 1900 and Manta can be removed together with the transmission through the top of the engine compartment.

1. Remove hood (scribe hood hinge to hood mounting location).
2. Disconnect battery negative cable.
3. Drain coolant at lower radiator hose.
4. Remove upper and lower radiator hoses.
5. Remove radiator and fan shroud.
6. Disconnect heater hoses.
7. Disconnect brake booster vacuum hose.
8. Remove air cleaner.
9. Disconnect electrical connections and accelerator linkage.
10. Remove console.
11. Remove shift lever boot, plate, and shift lever.
12. Raise car on hoist.
13. Disconnect fuel line at pump.
14. Remove front stone shield.
15. Disconnect speedo-cable, back-up light switch, and clutch cable.
16. Remove drive shaft.
17. Disconnect exhaust pipe and bell housing support.
18. Disconnect transmission support. See Figure 6A-7.
19. Remove engine mount bolts. See Figure 6A-8.
20. Attach hoist chains.
21. Lift engine and transmission assembly out of car.

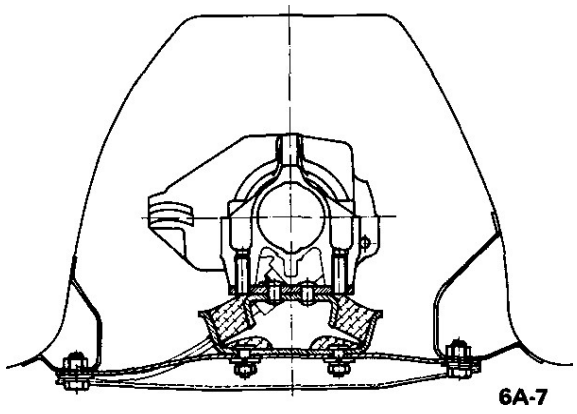


Figure 6A-7 Transmission Support Bolts . Opel 1900 and Manta Series

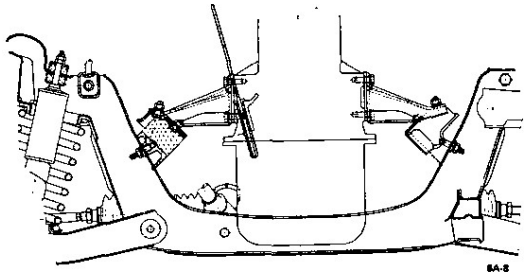
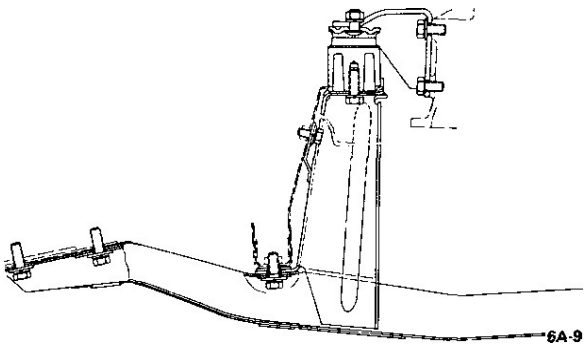


Figure 6A-8 Engine Mount Bolts ▪ Opel 1900 and Manta Series

Removal (GT)

The removal and installation of the 1.9 liter engine is only possible towards the floor and from below respectively.



Fig, 6A-9 Left Front Engine Suspension with Cross Member (GT)

The engine **does not rest on** the front suspension cross member as in the Opel 1900 and Manta but on a separate cross member. On removal and installation of the engine the front suspension cross member need not be detached.

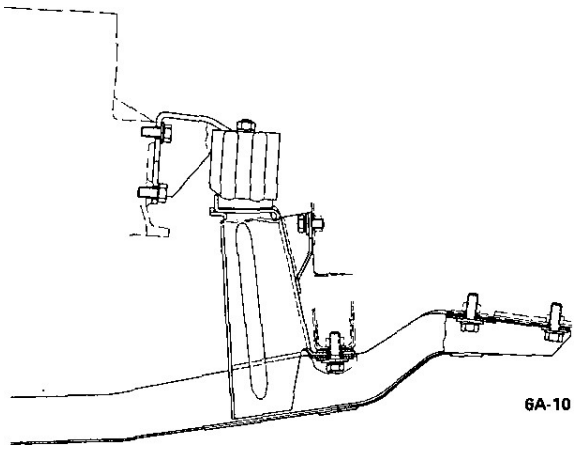


Fig. 6A-10 Right Front Engine Suspension with Cross Member (GT)

1. Disconnect battery negative cable,

2. Remove air cleaner.

3. Drain radiator coolant by disconnecting lower radiator hose. Disconnect upper radiator hose. See Figure 6A-11. Radiator need not be disconnected.

4. Disconnect all electrical connections:

a. Coil wire to distributor.

b. Wires from alternator. Remove unit and bracket.

c. Battery positive cable at starter switch.

d. Oil pressure switch wires at cylinder block.

e. Wires from starter solenoid.

5. Remove vacuum hoses at tee mounted to intake manifold. Remove tee from manifold to avoid interference during engine lowering.

6. Remove throttle linkage and carburetor.

7. Disconnect heater hoses.

8. Disconnect water valve bracket to manifold,

9. Remove gear shift lever.

10. Using suitable equipment lift up engine so that front engine mounts are somewhat relieved.

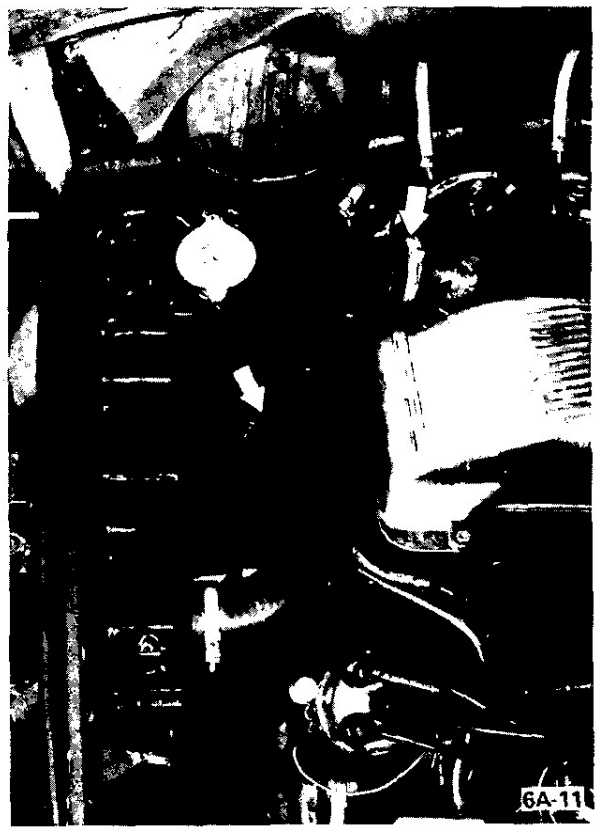


Figure 6A-11 Radiator Hose Clamp Location

11. Raise vehicle, both front and rear end. A two post axle type hoist is recommended for this operation.

12. Disconnect fuel line at fuel pump and plug. Be sure fuel line is disconnected from any engine and transmission clips.

13. Disconnect speedometer cable from transmission.

14. Disconnect clutch cable.

15. Disconnect drive shaft at rear universal joint and remove.

16. Disconnect exhaust at manifold.

17. Remove tailpipe and muffler hangers.

18. Remove ground strap from engine to side rail.

19. Detach transmission cross member from transmission and frame. See Figure 6A-12.

20. Detach engine cross member from engine and frame.

21. Carefully lower engine **and** transmission and remove from underneath vehicle.

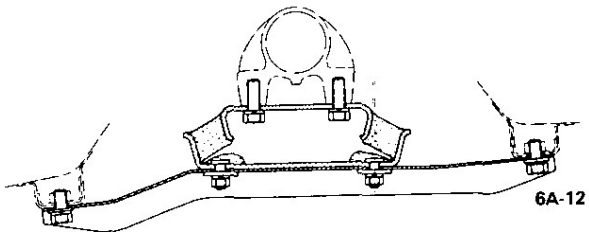


Fig. 6A-12 Transmission Cross Member

Installation (Opel 1900 and Manta)

1. Lower engine and transmission assembly into car.

2. Install components as removed in steps 1 through 19 above.

Installation (GT)

1. Install bell housing, transmission and starter.

2. Using suitable equipment raise assembly into vehicle.

3. Install components as removed in steps 1 thru 21.

ENGINE OIL PAN REMOVAL AND INSTALLATION

Removal (Opel 1900 and Manta)

To remove the engine oil pan, a device similar to the one illustrated in Figure 6A-14 can be made and used to support the front of the engine. This particular device was made up using hardwood, bolts, and chain.

1. Assemble chains to engine.

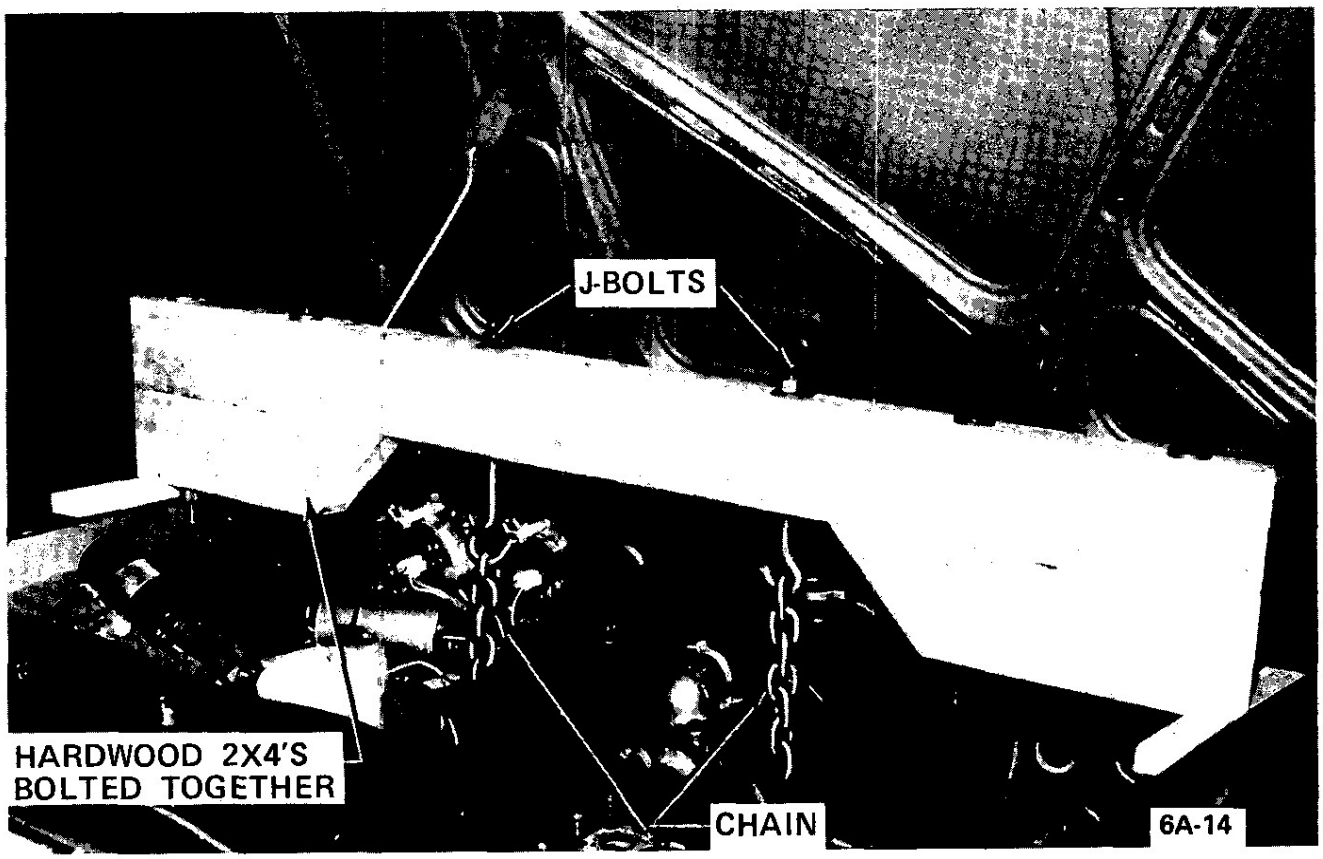


Figure 6A-14 Engine Support Tool - Opel 1900 and Manta.

a. Attach left chain to alternator support rear bolt.

b. Bolt right chain to existing threaded hole at lower right front of engine.

2. Assemble loose ends of chain to support device J-bolts and adjust to remove engine weight from motor mounts.

3. Remove the two motor mount bracket to motor mount retaining nuts.

4. Remove the two front suspension to frame rail bolt retaining nuts.

5. Remove nut and bolt at lower end of steering shaft U-joint.

6. With a floor jack under the center of the front suspension cross member, raise car high enough for wheels and suspension assembly to be rolled from under car.

7. Position jack stands under both front jack brackets on underbody to support car in this position.

8. Remove both front cross member support to frame attaching bolts.

9. Remove brake pipe to brake hose retaining clips at frame rails and disconnect brake hose from brake pipes. Use an absorbent material or suitable container for the brake fluid that will drain out.

10. Lower the front suspension assembly and remove from under car.

11. Drain engine oil and remove oil pan and gasket.

Installation (Opel 1900 and Manta)

1. Apply a light bead of sealer to the clean sealing surfaces of the oil pan and affix a new gasket.

2. Bolt oil pan and gasket assembly to engine block.

3. Roll front suspension and floor jack under car and raise into position careful to pilot the cross member to frame rail attaching bolts and steering shaft to their respective locations.

4. Install cross member support to frame attaching bolts and torque to 22 lb.ft.

5. Connect brake hose to brake pipes and install retaining clips.

6. Bleed front brake system. Maintain brake fluid level.

7. Remove jack stands and lower car.

8. Install suspension to frame rail bolt retaining nuts.

9. Release and remove engine supporting device.

10. Install motor mount bracket to motor mount retaining nuts.

11. Install steering shaft U-joint lower bolt and nut.

12. Replace engine oil.

Removal (GT Series)

1. Support engine in vehicle using Tool J-23375. See Figure 6A- 15.

Figure 6A-15 Engine Holding Fixture

Install tool by removing upper engine mount nut and installing fixture. Replace nut and tighten. The engine will now be supported by the tool, between the frame rails. The front suspension need not be removed on GT Models.

2. Drain oil.

3. Remove oil pan bolts and remove oil.

Installation (GT Series)

1. Replace oil pan and bolts.

2. Remove engine holding fixture and replace engine mounts.

3. Replace engine oil.

INTAKE AND EXHAUST MANIFOLD REMOVAL AND INSTALLATION

Removal

1. Disconnect battery.

2. Remove air cleaner.

3. Disconnect throttle linkage at carburetor.

4. Disconnect vacuum advance line at carburetor.

5. Remove fuel line at carburetor inlet.

6. Remove positive crankcase ventilation hose at rocker arm cover.

7. Disconnect E.G.R. lines from carburetor and intake manifold.

8. Disconnect exhaust pipe.

9. Remove six bolts attaching manifold assembly to cylinder head and remove manifold and carburetor as an assembly. Discard manifold gasket.

To separate intake and exhaust, manifold, remove carburetor and four bolts using Tool J-23016, attaching intake manifold to exhaust manifold. Always install a new manifold intermediate gasket when the manifolds are separated.

Installation

1. Install new manifold gasket and place manifold in position.

2. Install manifold bolts. New manifold to cylinder head gasket must be installed whenever a manifold is removed.

3. When installing the manifold, start with the No. 1 and No. 2 bolts. See Figure 6A-16. Gradually tighten both bolts until snug. Then continue with the rest of the bolts in the sequence illustrated in Figure 6A-16. Torque bolts to 33 lb. ft.

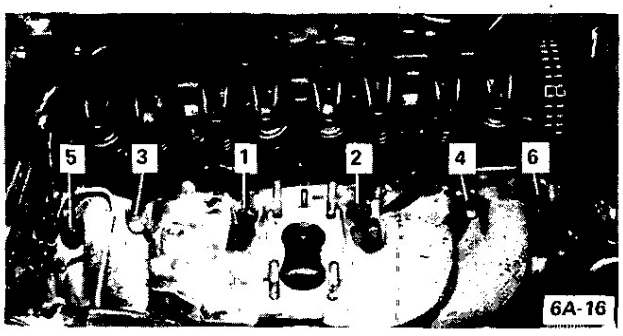


Figure 6A-16 Manifold Bolt Tightening Sequence

4. Connect parts removed in Steps 1 thru 8 above.

CYLINDER HEAD REMOVAL AND INSTALLATION

Removal

1. Drain coolant from radiator and block. Loosen drain plug on right side of engine to avoid coolant entering into cylinder bores. Drain plug is located on the right rear of cylinder block above oil pressure switch.

2. Remove hoses from thermostat housing. Collect coolant as it contains anti-freeze.

3. Remove 6 intake and exhaust manifold attaching bolts and swing assembly aside.

4. Remove spark plug wires from plugs.

5. Remove bracket bolt holding spark plug wires away from cylinder head.

6. Remove rocker arm cover.

7. Remove 10 cylinder head bolts using 12 MM serrated drive J-22915, and 2 cylinder head to timing chain cover bolts with a 6MM hex head wrench. See Figure 6A-17.

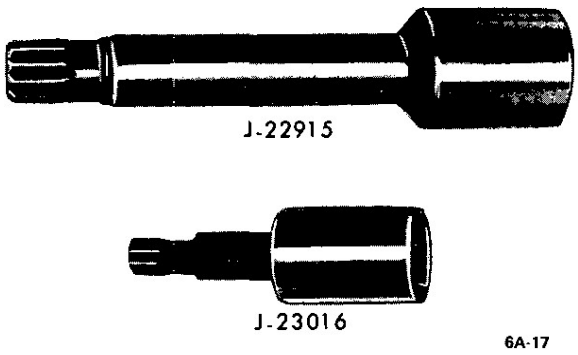


Figure 6A-17 Serrated Bits

8. Remove three bolts attaching plate to front of cylinder head.

9. Remove plastic screw from end of camshaft.

10. Remove 3 bolts attaching camshaft sprocket to cylinder head. Slide sprocket off of camshaft and remove head. Place head on bench supported at each end by a block of wood to prevent damage to valves.

Installation

1. Install in reverse procedure to removal, paying particular attention to the following:

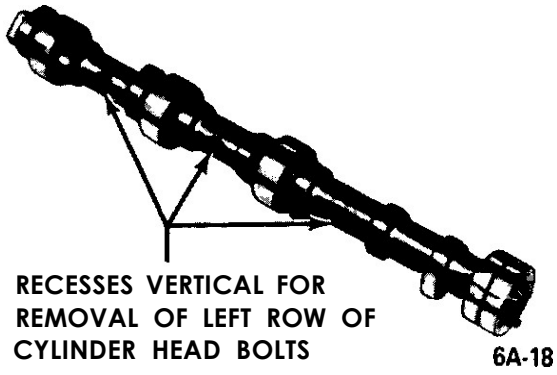
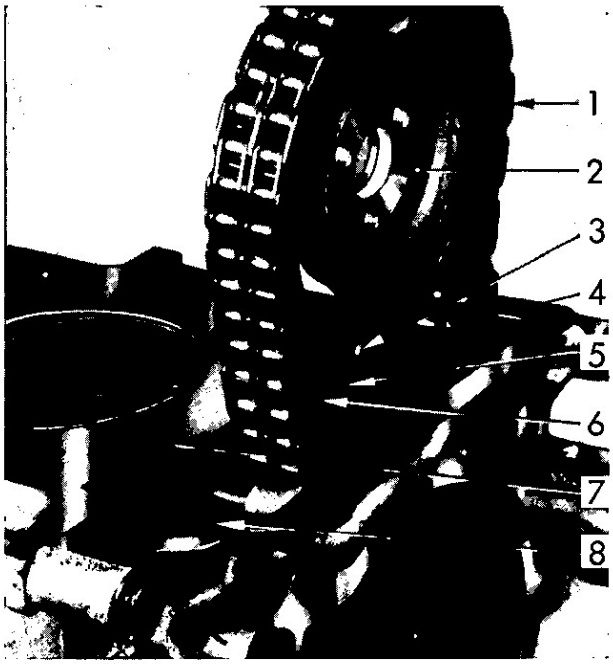


Figure 6A-18 Recesses in Camshaft

2. Clean piston tops and combustion chambers. Thoroughly clean all gasket surfaces on the cylinder block and cylinder head.

3. Lightly lubricate cylinder walls with engine oil. Install coolant passage rubber gasket ring in timing case. See Figure 6A-19.



1. TIMING CHAIN
2. CAMSHAFT SPROCKET
3. SPROCKET TIMING MARK
4. TIMING CASE
5. SUPPORT TIMING MARK
6. SUPPORT
7. CYLINDER BLOCK
6. RUBBER GASKET RING

6A-19

Figure 6A-19 Coolant Passage Rubber Gasket Ring in Timing Case

4. Apply silastic sealer or equivalent to both sides of the cylinder head gasket where the gasket mates with the timing chain cover, place new cylinder head gasket onto cylinder block.

5. Install cylinder head. Be careful to place head squarely over guide pins.

Rotate camshaft so that recesses are in vertical position to allow installation of left row of bolts.

6. Install 10 head bolts. Tighten the bolts a little at a time in the sequence shown in Figure 6A-20. Give bolts a final torque in the same sequence. Torque to 72 lb. ft. (cylinder head cold). Use same procedure for cylinder head to timing chain cover bolts with final torque at 17 lb.ft. See Figure 6A-20. These torques apply to lightly oiled threads.

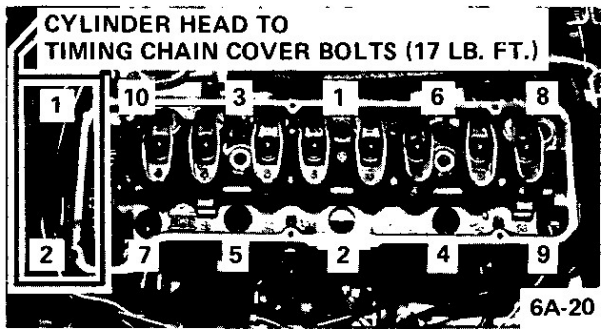


Figure 6A-20 Cylinder Head Bolt Tightening sequence

7. Slide camshaft sprocket with assembled chain onto camshaft and guide pin and fasten with bolts. Install nylon adjusting screw. After sprocket has been attached to camshaft, recheck alignment to see that chain has not slipped. Close front access hole.

8. Check camshaft end clearance between cover and nylon screw with feeler gauge. Clearance should be .004" - .008" Excess clearance can be eliminated by carefully readjusting cover with a suitable drift.

Reconditioning Valves and Guides

1. Remove cylinder head. Place on clean surface. Place head on bench supported at each end by a block of wood to prevent damage to valves.

2. Using suitable spring compressor, such as J-8062, compress valve spring and remove cap retainers. Release tool and remove spring and cap. See Figure 6A-21.

3. Remove valves. Place valves in numerical order so that they can be reinstalled in original location.

4. Remove all carbon from combustion chambers, piston heads, and valves. When using scrapers or

wire brushes for removing carbon, avoid scratching valve seats and valve faces. A soft wire brush such as J-8089 is suitable for this purpose.

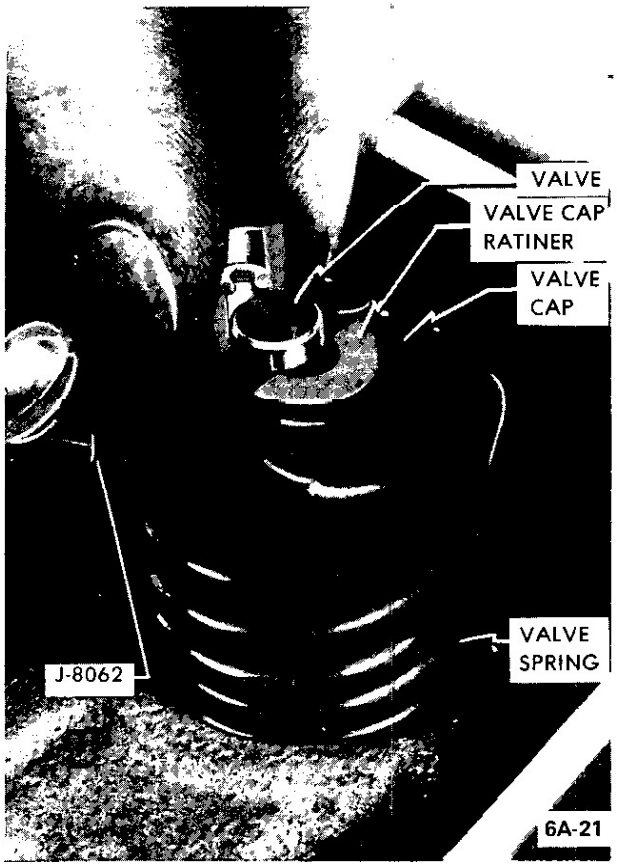


Figure 6A-21 Removing Valve Cap Retainers

5. Clean carbon and gum deposits from valve guide bores.

6. Inspect valve faces and seats for pits, burned spots or other evidences of poor seating. If a valve head must be ground until the outer edge is sharp in order to true up the face,discard the valve because the sharp edge will run too hot.

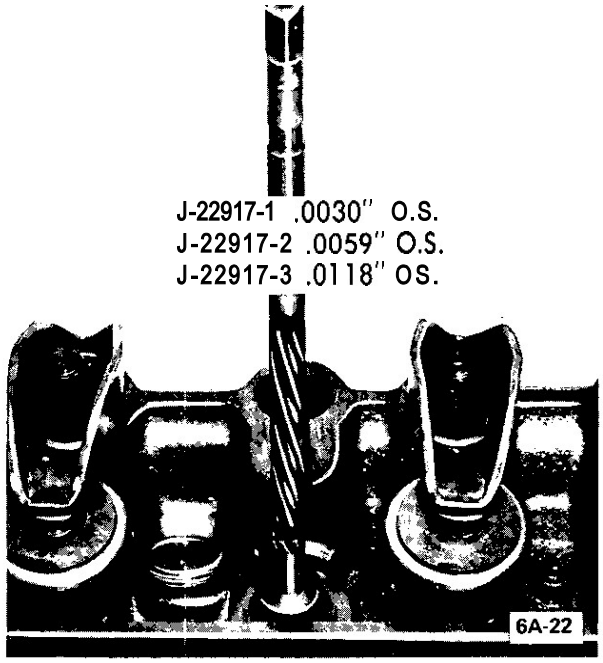


Figure 6A-22 Reaming Valve Guide

SIZE IN.		VALVE GUIDE DIA. IN.	CORRESPONDING VALVE STEM DIA.		OVERSIZE MARK
			INTAKE VALVE IN.	EXHAUST VALVE IN.	
PRODUCTION	STANDARD	.3553 - .3562	.3538 - .3543	.3524 .3528	–
PRODUCTION AND SERVICE	OVERSIZE .0030	.3582 .3592	.3567 .3572	.3553 .3559	1
	OVERSIZE .0059	.3615 - .3622	.3597 .3602	.3583 .3588	2
SERVICE	OVERSIZE .0118	.3671 .3681	.3656 - .3661	.3642 .3647	A

6A-2:

Figure 6A-23 Valve Guides and Corresponding Valves

New inlet valves must not be refaced or lapped with grinding compound. The correct angle for the intake and exhaust valve head is 44 degrees.

7. Inspect valve guides. Worn or pitted guides can be reamed to accept valves with oversize stems. Oversize valves are occasionally used in production. Oversize valves are marked " 1 " "2" or "A" and are stamped into the valve stem end and also stamped near spark plug hole. See Figure 6A-22.

8. Reseat valve seats in cylinder head in the following sequence:

Intake

With 45 degrees cutter, remove burnt structure until a metallic bright seat is obtained. Lightly coat valve head with red lead, insert it into guide and turn it under light pressure several times back and forth. Thereby a contact pattern is obtained and the seat width can be measured. If valve does not seat perfectly all around, lightly recut valve seat to the established seat width of .049" - .059" with 30 degrees correction cutter.

Exhaust

The directions for reconditioning intake valve seats apply in principle also to exhaust valve seat reconditioning with the exception that the valve seat width should be .063-.073 in. and different cutters are employed.

NOTE: *: Use* **new** *valve seals whenever valves are reconditioned.*

9. Lube valves with engine oil and reinstall valves, valve springs, caps and cap retainers using J-8062. Install valve spring with closely wound coils toward cylinder head. See Figure 6A-24.

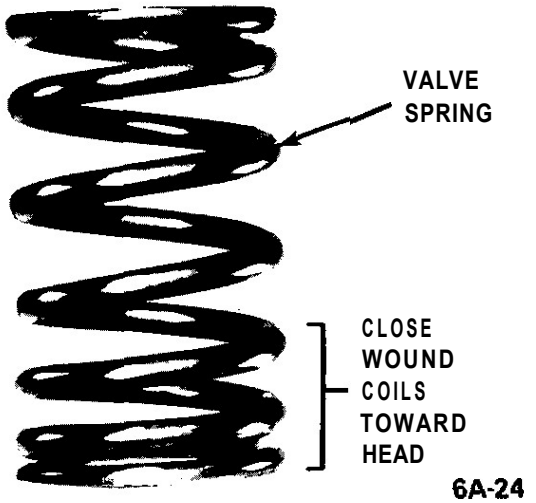


Figure 6A-24 Valve Spring

10. Install cylinder head.

11. Adjust valve clearance. See MAINTENANCE AND ADJUSTMENTS.

Replacing Rocker Arm Studs

1. When replacing rocker arm studs become necessary, remove air cleaner, rocker arm cover and rocker arm.

NOTE: ***The rocker arm studs are screwed into the cylinder head. A tapered part of the stem serves to a void stud loosening.***

2. Attach vise grip pliers to stud being removed and remove from cylinder head.

3. Screw in new stud. Seat tapered part of stud by striking stud end with a rubber hammer.

4. Place two turned down rocker arm nuts on threaded part of stud.

5. Torque stud into cylinder head to 29 lb.ft.

Valve Lifter Service

The valve lifters can be removed after removing rocker arm cover and **rocker arms.**

No oversize lifters have been released due to the insignificant wear of the valve lifters and cylinder head guides.

Amply oil respective parts and install in reverse sequence to removal.

Carry out hydraulic valve lifter adjustment as outlined in MAINTENANCE AND ADJUSTMENTS.

CONNECTING ROD BEARINGS

A connecting rod bearing consists of two halves or shells which are alike and interchangeable in rod and cap. When the shells are placed in rod and cap the ends extend slightly beyond the parting surfaces so that when rod bolts are tightened the shells will be clamped tightly in place to insure positive seating and to prevent turning. The ends of shells must never be tiled flush with parting surface of rod or cap.

If a precision type connecting rod bearing becomes noisy or is worn so that clearance on crankpin is excessive, a new bearing of proper size must be selected and installed since no provision is made for adjustment. Under no circumstances **should the connecting** rod or cap be filed to adjust the bearing clearance.

Inspection of Connecting Rod Bearings and Crankshaft Journals

Remove oil pan.

After removal of oil pan, disconnect two connecting rods at a time from crankshaft and inspect the bearings and crankpin journals. While turning crankshaft it is necessary to temporarily reconnect the rods to crankshaft to avoid possibility of damaging the journals through contact with loose rods.

If connecting rod bearings are chipped or scored they should be replaced. If bearings are in good physical condition check for proper clearance on crankpins as described under, checking clearance and selecting replacement connecting rod bearings.

If crankpin journals are scored or ridged, the crankshaft must be replaced, or reground for undersize bearings, to insure satisfactory life of connecting rod bearings. Slight roughness may be polished out with fine grit polishing cloth thoroughly wetted with engine oil. Burrs may be honed off with a fine oil stone.

Use an outside micrometer to check crankpins for out- of-round. If crankpins are more than .002" out- of- round, satisfactory life of new bearings cannot be expected.

Checking Clearance and Selecting Replacement Connecting Rod Bearings

Service **bearings** are furnished in standard size and several undersizes. The clearance of connecting rod (and crankshaft) bearings may be checked by use of Plastigage, Type PG-1 (green), or equivalent, which is soluble in oil.

1. Remove connecting rod cap with bearing shell. Wipe off oil from bearing and crankpin journal, also blow oil out of hole in crankshaft.

2. Place a piece of the plastic-type gauge material lengthwise along the bottom center of the lower bearing shell (Figure 6A-25, view A), then install cap **with** shell and tighten nuts to 36 lb. ft. Do not turn crankshaft with gauge type material in bearing.

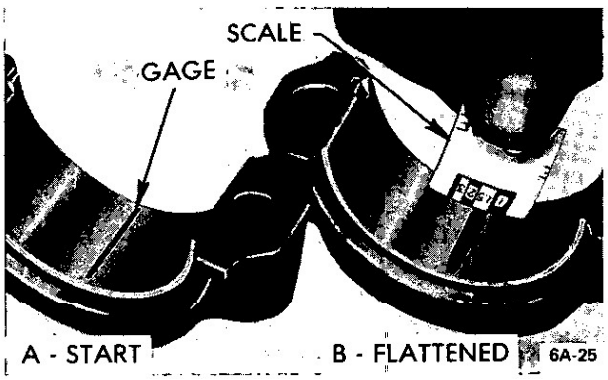


Figure 6A-25 Checking Bearing Clearance With Plastic-Type Gauge

3. Remove bearing cap with bearing shell, the flattened piece of gauge will be found adhering to either the bearing shell or the crankpin. Do not remove it.

4. Using the scale printed on the envelope, measure the flattened piece of gauge at its widest point. The **number** within the graduation which closely corresponds to the width of the gauge, indicates the bearing clearance in thousandths of an inch. See Figure 6A-25, View B.

5. The desired clearance with a new bearing is .0006"- .0025". If bearing has been in service it is advisable to install a new bearing if the clearance exceeds .003", however if bearing is in good condition and is not being checked because of bearing noise, it is not necessary to replace the bearing.

6. After the proper size bearing has been selected, clean off the gauge, oil thoroughly, reinstall cap with bearing shell and tighten nuts to 36 lb. ft.

CRANKSHAFT BEARINGS AND SEALS

Replacement of Crankshaft Bearings

A crankshaft bearing consists of two halves or shells which are identical and are interchangeable in cap and crankcase. All crankshaft bearings except the rear main **bearing** are identical. The crankshaft end **thrust** is taken up the rear (No. 5) main bearing.

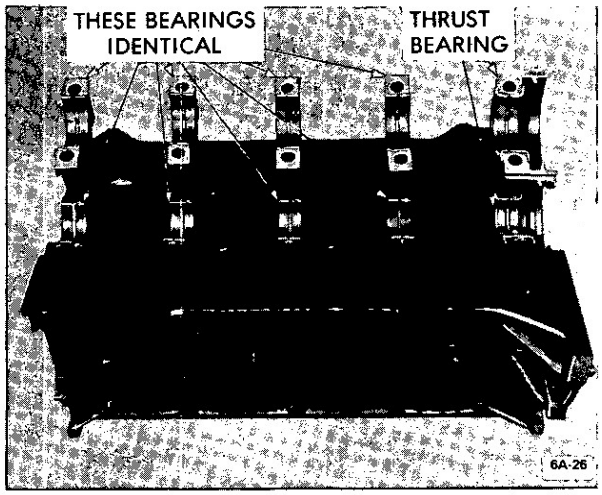


Figure 6A-26 Engine Crankshaft Bearings

When the shells are placed in crankcase and bearing cap, the ends extend slightly beyond the parting surfaces so that when cap bolts are tightened the shells will be clamped tightly in place to insure positive

seating and to prevent turning. The *ends of shells must never be tiled flush with parting surface of crankcase or bearing cap.*

Crankshaft bearings are the precision type which do not require reaming to size. Shims are not provided for adjustment since worn bearings are readily replaced with new bearings of proper size. Bearings for service replacement are furnished in standard size and undersizes. ***Under no circumstances should crankshaft bearing caps be filed to adjust for wear in old bearings.***

After removal of oil pan, pipe and screen assembly, perform the following removal, inspection and installation operations on each crankshaft bearing in turn so that the crankshaft will be well supported by the other bearings.

If crankshaft has been removed to check straightness the following procedure is suggested. Rest crankshaft on "V-blocks" at number one and number live main bearing journals. Check indicator runout at No. 3 main bearing journal. Total indicator reading should not exceed .0012".

1. Since any service condition which affects the crankshaft bearings may also affect the connecting rod bearings, it is advisable to inspect connecting rod bearings first. If crankpins are worn to the extent that crankshaft should be replaced or reground, replacement of crankshaft bearings only will not be satisfactory.

If replacement of cylinder block or crankshaft is required, always check main bearing clearance with plastic-type gauge to obtain specified limits.

2. Remove one bearing cap, then clean and inspect lower bearing shell and the crankshaft journal. If journal surface is scored or ridged, the crankshaft must be replaced or reground to insure satisfactory operation with new bearings. Slight roughness may be polished out with tine grit polishing cloth thoroughly wetted with engine oil, and burrs may be honed off with a tine stone.

3. If condition of lower bearing shell and crankshaft journal is satisfactory, check the bearing clearance with a plastic-type gauge.

4. When checking a crankshaft bearing with plastic-type gauging material, turn crankshaft so that oil hole is up to avoid dripping of oil on the gauge material. Place paper shims in lower halves of adjacent bearings and tighten cap bolts to take the weight of crankshaft off *the lower shell of beating being checked.*

5. If bearing clearance exceeds .003", it is advisable to install a new bearing; however, if bearing is in good condition and *is* not being checked because of bearing noise, it is not necessary to replace the bearing.

6. Loosen all crankshaft bearing cap bolts 1/2 turn, and remove cap of bearing to be replaced.

7. Remove upper bearing shell by inserting Bearing Shell Remover and Installer J-8080 in oil hole in crankshaft, then slowly turning crankshaft so that the tool rotates the shell out of place by pushing against the end without the tang. See Figure 6A-27.

When turning crankshaft with rear bearing cap removed hold oil seal to prevent it from rotating out of position in crankcase.

8. The crankshaft journal cannot be measured with an outside micrometer when shaft is in place; however, when upper bearing shell is removed the journal may be checked for out-of-round by using a special crankshaft caliper and inside micrometer.

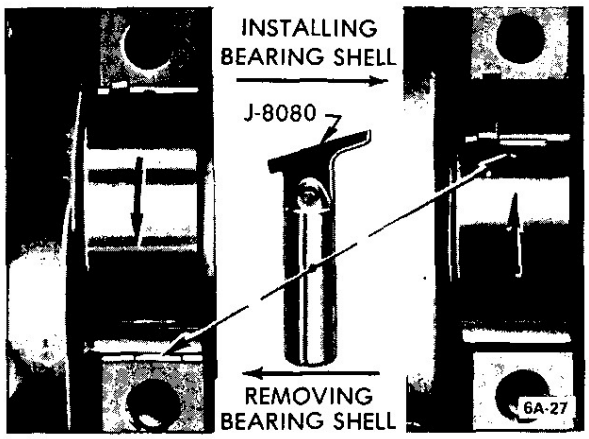


Figure 6A-27 Removing and Installing Crankshaft Bearing Upper Shell

The caliper should not be applied to journal in line with oil hole.

If crankshaft journal is more than .0012" out-of-round, the crankshaft should be replaced since the full mileage cannot be expected from bearings used with an excessively out-of-round crankshaft.

9. Before installation of bearing shells make sure that crankshaft journal and the bearing seats in crankcase and cap are thoroughly cleaned.

10. Coat inside surface of upper bearing shell with engine oil and place shell against crankshaft journal so that tang on shell will engage notch in crankcase when shell is rotated into place.

11. Rotate bearing shell into place as far as possible by hand, then insert Installer J-8080 in crankshaft oil hole and rotate crankshaft to push shell into place. Bearing shell should move into place with very little

pressure. If heavy pressure is required, shell was not started squarely and will be distorted if force into place.

12. Place lower bearing shell in bearing cap, then check clearance with plastic-type gauge, as previously described.

13. The desired clearance with a new bearing is .0009" to .0025". If this clearance cannot be obtained with a standard size bearing, insert an undersize bearing and check again with plastic-type gauge material.

14. When the proper size bearing has been selected, clean out all plastic gauge material, oil the lower shell and reinstall bearing cap. Clean the bolt holes and lube bolts, then torque cap bolts to 72 lb. ft. The crankshaft should turn freely at flywheel rim; however, a very slight drag is permissible if an undersize bearing is used.

15. If the thrust bearing shell is disturbed or replaced it is necessary to line up the thrust surfaces of the bearing shell before the cap bolts are tightened. To do this, move the crankshaft fore and aft the limit of its travel several times (last movement fore) with the thrust bearing cap bolts finger tight.

16. After bearing is installed and tested, loosen all bearing cap bolts 1/2 turn and continue with other bearings. When bearings have been installed and tested, tighten all bearing cap bolts to 72 lb. ft.

17. Replace rear bearing oil seals.

18. Install pipe and screen assembly and oil pan.

Installation of Rear Bearing Oil Seals (Engine in Vehicle)

1. Remove transmission, bell housing and clutch. Refer to appropriate section for removal procedures.

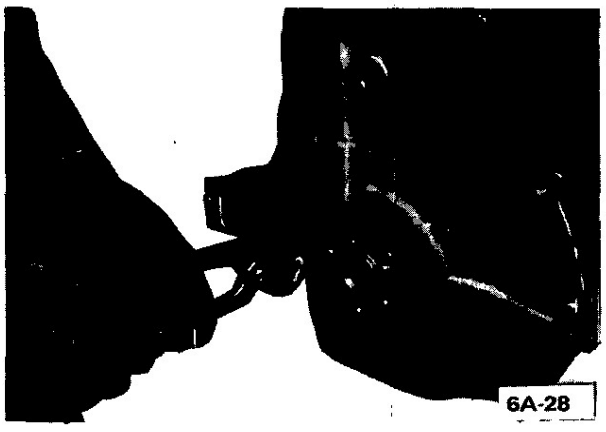


Figure 6A-28 Removing Rear Main Oil Seal

2. Remove flywheel.

3. Punch a hole into oil seal and screw in a sheet metal screw and pull out oil seal. See Figure 6A-28.

4. To insure proper sealing, lubricate seal with a suitable protective grease and install on taper ring J-22928. Turn seal to ensure lip of seal is not turned back. See Figure 6A-27.

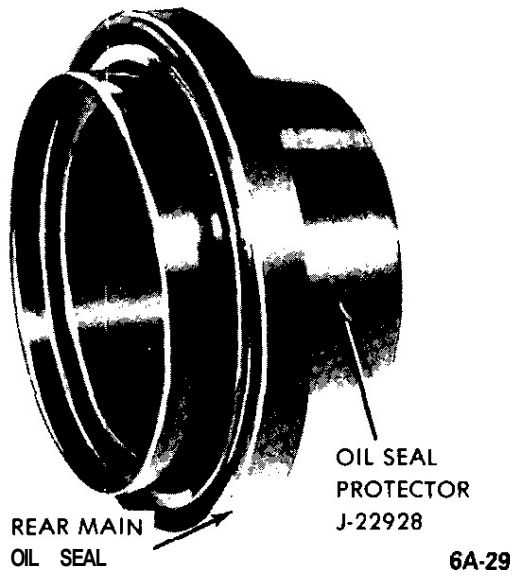


Figure 6A-29 Installing Oil Seal on Tool J-22928

5. Place tapered ring with oil seal on crankshaft flange and move lip of seal over rear of crankshaft. Be careful not to tilt seal.

Figure 6A-30 Installing Rear Main Bearing Oil Seal

6. Drive in oil seal using Tool J-22928-2. See Figure 6A-30.

7. Install flywheel, clutch, bell housing and transmis-

sion. When replacing flywheel use new bolts and torque to 43 lb.ft.

PISTON, RINGS AND CONNECTING RODS

Removal and Disassembly of Piston and Rod Assemblies

1. Drain oil.

2. Remove oil pan.

3. Remove cylinder head.

4. Examine the cylinder bores above the ring travel. If bores are worn so a ridge exists, remove the ridges with a ridge reamer to avoid damaging rings or cracking ring lands in pistons during removal.

5. Mark the cylinder number on all pistons, connecting rods and caps. Starting at the front end of the crankcase, the cylinders are numbered l-2-3-4,

6. Remove cap and bearing shell from number 1 connecting rod.

7. Push the piston and rod assembly up and out of top cylinder. Then reinstall cap and bearing shell on rod.

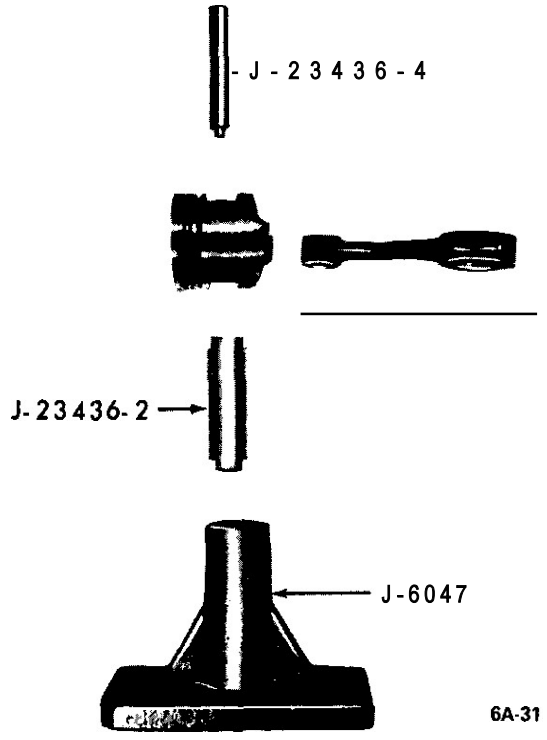


Figure 6A-3 1 Piston Pin Removal Tool Layout - 1 .9 Engine

8. Remove other rod and piston assemblies in the same manner.

9. Remove compression rings and oil rings.

10. Remove piston pin in following manner:

a. Position base support J-6047 on hydraulic press.

b. Place tool J-23436-2 in base support with large diameter bore facing upward. See Figure 6A-31.

c. Position piston and rod assembly on tool J-23436-2 making certain the pin is aligned on tool.

d. Position tool J-23436-4 in opposite end of piston pin and press pin out.

Inspection of Cylinder Bores

Inspect cylinder walls for scoring, roughness, or ridges which indicate excessive wear. Check cylinder bores for taper and out-of-round with an accurate cylinder gage at top, middle and bottom of bore, both parallel and at right angles to the centerline of the engine. The diameter of the cylinder bores at any point may be measured with an inside micrometer or by setting the cylinder gauge dial at "0" and measuring across the gauge contact points with outside micrometer while the gauge is at the same "0" setting.

If a cylinder bore is moderately rough or slightly scored but is not out-of-round or tapered, it is possible to repair the bore by honing to accept a standard service piston. If cylinder bore is very rough or deeply scored, it may be necessary to rebore the cylinder to fit an oversize piston in order to insure satisfactory results.

If a cylinder bore is tapered .0005" or more, or is out-of-round .0005" or more, it is advisable to hone or rebore for the smallest possible oversize piston and rings.

Visual Inspection of Pistons, Rings, and Pins

Clean carbon from piston surfaces and under side of piston heads. Clean carbon from ring grooves with a suitable tool and remove any gum or varnish from piston skirts with suitable solvent.

Carefully examine pistons for rough or scored bearing surfaces, cracks in skirt, head cracked or broken ring lands, and chipping or uneven wear which would cause rings to seat improperly or have excessive clearance in ring grooves. Damaged or faulty pistons should be replaced.

Fitting Pistons to Cylinders

The pistons are cam ground, which means that the

diameter at the right angle to the piston pin is greater than the diameter parallel to the piston pin. When a piston is checked for size, it must be measured with micrometers applied to the skirt at points 90 degrees to the piston pin. See Figure 6A-32. The piston should be measured (for fitting purposes) 2 1/2 inches below the top of piston.

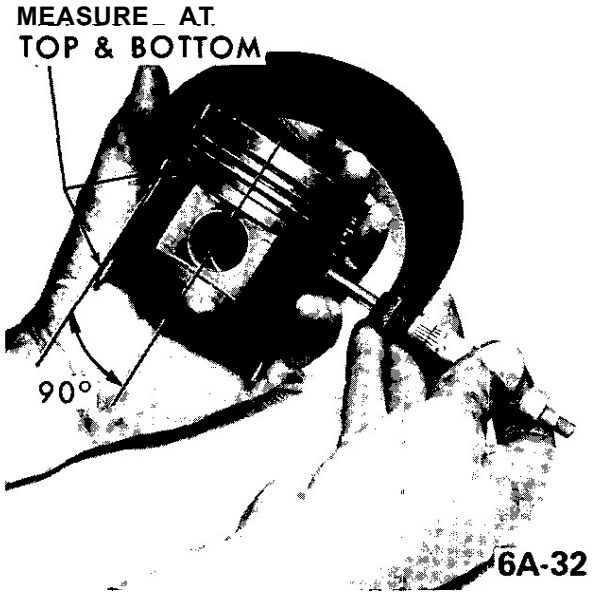


Figure 6A-32 Measuring Piston

Inspect bearing surfaces of piston pins. Check for wear by measuring worn and unworn surfaces with micrometers. Rough or worn pins should be replaced. Check fit of piston pins in piston bosses. Occasionally pins will be found tight due to gum or varnish deposits. This may be corrected by removing the deposit with a suitable solvent. If piston bosses are worn out-of-round or oversize, the piston and pin assembly must be replaced. Oversize pins are not practical because the pin is a press fit *in* the *connecting* rod. Piston pins must tit the piston with .0004" to .0007" clearance.

Examine all piston rings for scores, chips or cracks. Check compression rings for tension by comparing with new rings. Check gap of compression rings by placing rings in bore at bottom of ring travel. Measure gap with feeler gage. Gap should be between .011" and .021". If gaps are excessive (over .021") it indicates the rings have worn considerably and should be replaced.

No attempt should be made to cut down oversize pistons to fit cylinder bores. This practice will destroy the surface treatment and affect the weight. The smallest possible oversize service pistons should be used and the cylinder bores should be honed to size for proper clearance.

1. Before installing piston, piston rings, or reboring cylinders, observe the following:

Cylinder bores may not be the same size. Standard replacement piston sizes are in the midpoint of the cylinder bore size range. Therefore, it may be necessary to hone cylinders for correct piston tit. Out-of-round on cylinder bore must not exceed .0005" maximum with a taper of not over .0005".

Before the honing or reboring operation is started, measure all new pistons with micrometer contacting at points exactly 90 degrees to piston pin (Figure 6A-32) then select the smallest piston for the first fitting. The slight variation usually found between pistons in ***a set*** may provide for correction if the first piston has excessive clearance.

If wear of cylinder does not exceed .005" honing is recommended for truing the bore. If wear or out-of-round exceeds these limits, the bore should be trued up with a fly cutter boring **bar** and then finish honed.

When reboring cylinders, all crankshaft bearing caps must be in place and tightened to proper torque to avoid distortion of bores in final assembly. Always be certain the crankshaft is out of the way of the boring cutter when boring each cylinder. When making the final cut with boring bar, leave .001" on the diameter for finish honing to give the required clearance specified.

When honing cylinders, use clean sharp stones of proper grade for the required amount of metal to be removed, in accordance with instructions of the hone manufacturer. Dull or dirty stones cut unevenly and generate excessive heat. When using coarse or medium grade stones use care to leave sufficient metal so that all stone marks may be removed with the fine stones used for finishing in order to maintain proper clearance.

When finish honing, pass the hone through the entire length of cylinder at the rate of approximately 60 cycles per minute. This should produce the desired 45 degree cross hatch pattern on cylinder walls which will insure maximum ring life and minimum oil consumption.

It is of the greatest importance that refinished cylinder bores have not over .0005" out-of-round or tapered. Each bore must be final honed to remove all stone or cutter marks and provide a smooth surface. **During** final honing, each piston must be fitted individually to the bore in which it will be installed and should be marked to insure correct installation.

After final honing and before the piston is checked for fit, each cylinder bore must be ***thoroughly*** washed to remove all traces of abrasive and then dried. The dry bore should then be brushed clean with a power-driven fibre brush. If all traces of abrasive are not removed, rapid wear of new pistons and rings will result. Fit new pistons in the following manner:

2.. Expand a telescope gage to fit the cylinder bore at right angles to the piston pin 2-1/2″ from top. See Figure 6A-33.

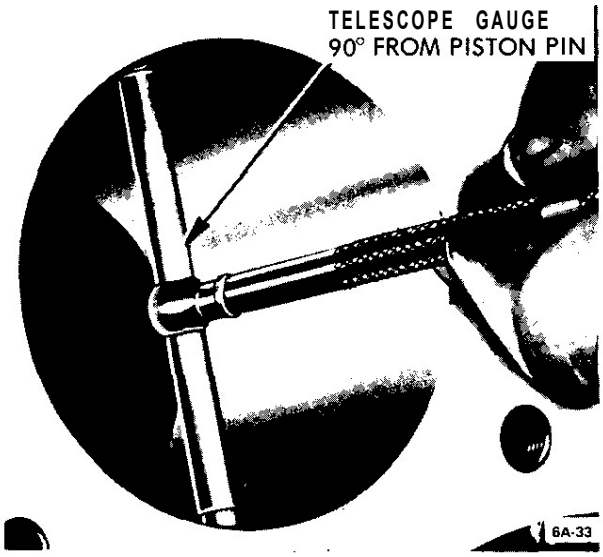


Figure 6A-33 Checking Cylinder Bores

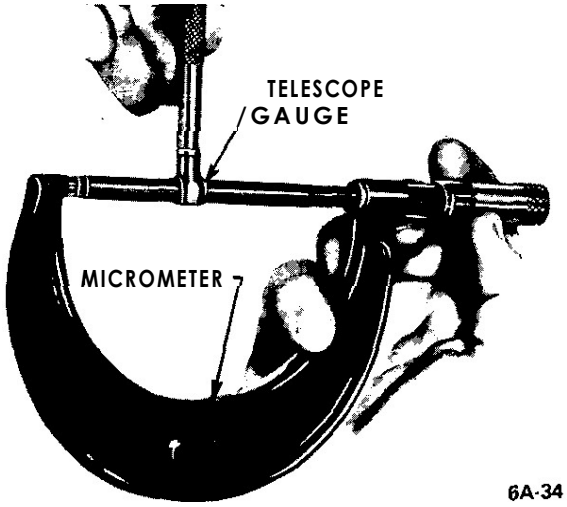


Figure 6A-34 Measuring Telescope Gage

3. Measure the piston to be installed. See Figure 6A-32. The piston must be measured at right angles to the piston pin 2-1/2″ below the top of piston. The piston must be between .0008″ and .0012″ smaller than the cylinder bore.

Both block and piston must be at approximately the same temperature when measurements are made or expansion errors will occur. A dif.ference of 10 degrees F between parts is sufficient to produce a variation of .0005″.

Fitting New Piston Rings

When new piston rings are installed without reboring cylinders, the glazed cylinder walls should be slightly dulled without increasing the bore diameter by means of the finest grade honing stones.

New piston rings must be checked for clearance in piston grooves and for gap in cylinder bores; however, the flexible oil rings are not checked for gap. The cylinder bores and piston grooves must be clean, dry, and free of carbon and burrs.

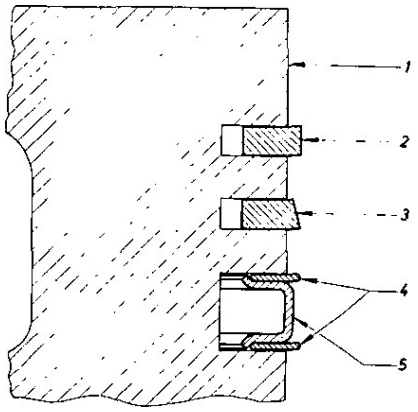
To check the end gap of compression rings, place the ring in the cylinder in which it will be used and square it in the bore by tapping with the lower end of a piston. Measure the gap with feeler gages.

Piston ring end gap should be .014″ - .022″ (top) and .014″ - .022″ (2nd) and the oil ring end gap should be .015″ - .055″.

If gap is less than specified, file the ends of rings carefully with a smooth tile to obtain proper gap.

Install piston rings as follows:

1. Upper ring is chrome plated and can be installed either way up. Number two (2) ring has to be installed with the marking "top" up. Oil ring can be installed either way up. See Figure 6A-35.

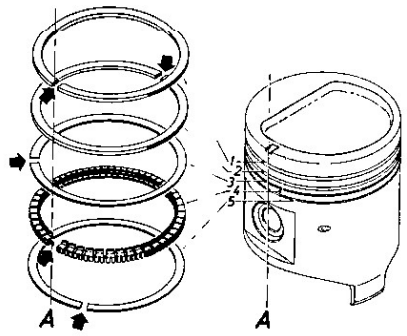


1. PISTON
2. NO. 1 COMPRESSION RING - INSTALLED WITH EITHER SIDE UP.
3. NO. 2 COMPRESSION RING - INSTALLED WITH "TOP" MARKING TOWARDS THE TOP.
4. UPPER AND LOWER STEEL BAND RING - INSTALLED WITH EITHER SIDE UP.
5. INTERMEDIATED RING - INSTALLED WITH EITHER SIDE UP.

6A-35

Figure 6A-35 Arrangement of Piston Rings

2. Install piston rings so gaps are positioned as shown in Figure 6A-36.



1. NO. 1 COMPRESSION - GAP IN FRONT
2. NO. 2 COMPRESSION - GAP IN REAR
3. UPPER STEEL BAND - 1 - 2 IN. TOWARDS THE LEFT OF INTERMEDIATE RING GAP
4. INTERMEDIATE RING - GAP IN FRONT
5. LOWER STEEL BAND - 1 - 2 IN. TOWARDS THE RIGHT OF INTERMEDIATE RING GAP.

"A" VERTICAL LINE FOR PISTON AND RINGS, FRONT

6A-36

Figure 6A-36 Location of Piston Ring Gaps

With rings installed on piston, check clearance in grooves by inserting feeler gages between each ring and its *lower* land. Any wear that occurs forms a step at inner portion of the lower land. If the piston grooves have worn to the extent that relatively high steps exist on the lower lands, the piston should be replaced since steps will interfere with the operation of new rings causing ring clearances to become excessive. Piston rings are not furnished in oversize widths to compensate for ring groove wear.

When fitting new rings to new pistons, the side clearance of the compression rings should be .0024" - .0034" (top) and .0013" - .0024" (2nd), and the oil ring clearance should be .0013" - .0024".

Assembly of Piston and Connecting Rod

NOTE: Connecting rods may be out of alignment due to shipping or handling. Always check a new rod before installing piston and pin.

Inspect piston pin bores and piston pins for wear. Piston pin bores and piston pins must be free of varnish or scuffing when being measured. The piston pin should be measured with a micrometer and the piston pin bore should be measured with a dial bore gage or an inside micrometer. If clearance is in excess of the .001" wear limit, the piston and piston pin assembly should be replaced.

1. Lubricate piston pin holes in piston and connecting rod to facilitate installation of pin.

2. Install pin in following manner:

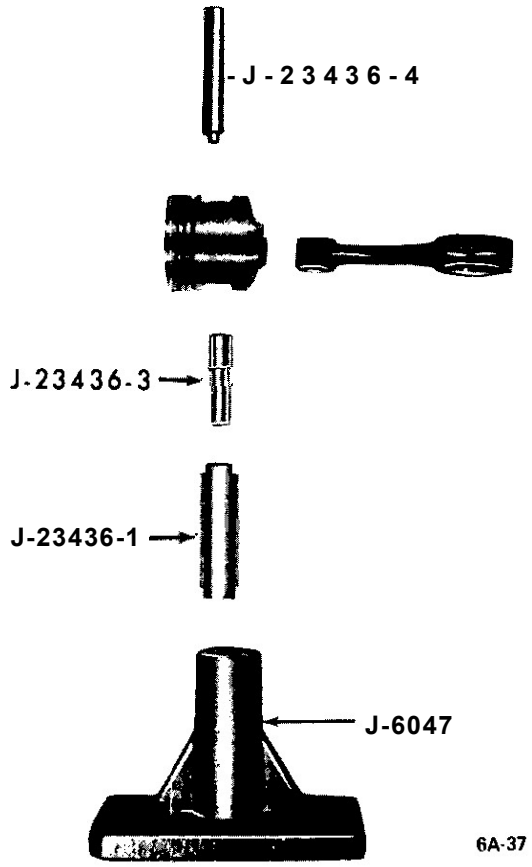
a. Position base support J-6047 on hydraulic press.

b. Place tool J-23436-1 in support J-6047 with small diameter bore facing upward.

c. Place small end of tool J-23436-3 in bore of tool J-23436-1.

d. Position piston, rod, and pin guide J-23436-3.

e. Line up pin on piston, and using tool J-23436-4 press pin into piston. See Figure 6A-37.



6A-37

Figure 6A-37 Piston Pin Installation Tool Layout - 1.9 Engine

3. Remove installer from connecting rod and piston assembly and check piston for freedom of movement on piston pin.

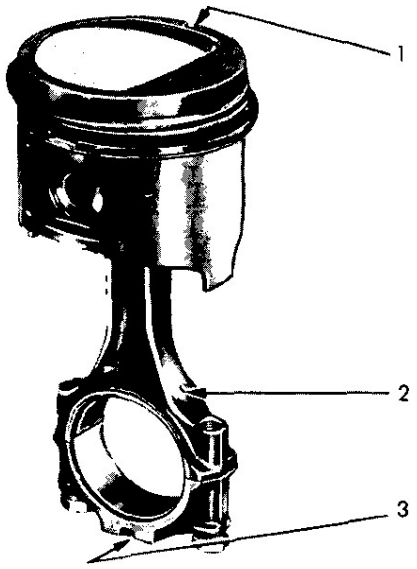
4. Make sure cylinder bores, pistons, connecting rod bearings and crankshaft journals are absolutely clean, then coat all bearing surfaces with engine oil.

5. Before installation of a piston and rod assembly in its bore, position the crankpin straight down.

6. Remove connecting rod cap.

7. Make sure the gap in the oil ring rails and the gaps of the compression rings are positioned correctly.

8. Lubricate the piston and rings and install in bore



1. NOTCH IN PISTON HEAD POINTING TOWARD THE FRONT
2. OIL HOLE IN CONNECTING ROD POINTING TOWARD THE RIGHT (MANIFOLD SIDE)
3. NOTCH IN CONNECTING ROD CAP POINTING TOWARD THE REAR

6A-38

Figure 6A-38 Piston and Rod Assembly

by compressing the rings with a "wrap around" compressor.

9. Select a new connecting rod bearing, if necessary. Otherwise install cap with bearing lower shell on rod and tighten bolt nuts to 36 lb.ft. torque.

10. Install all other piston and rod assemblies in same manner. When piston and rod assemblies are prop erly installed, the oil spurt holes in the connecting rods will be facing right.

11. Check end clearance between connecting rods in each crankpin using feeler gages. Clearance should be between .0043" and .0095".

12. Install cylinder head. Torque 10 cylinder head bolts to 72 lb.ft (cold), and 2 cylinder head to timing chain cover bolts to 17 lb.ft.

13. Install new oil pan gasket by first installing flange gasket with tabs in slots in rear main bearing cap and engine front cover. Then install rubber strips in grooves in rear main bearing cap and engine front cover. Install oil pan, torquing bolts to 5 lb.ft.

14. Install (Opel 1900 and Manta) front suspension assembly. (GT) Install engine suspension cross member.

After installation of new pistons and rings, care should be used in starting the engine and in running it for the first hour. Avoid high speeds until the parts have had a reasonable amount of break-in so that scuffing will not occur.

TIMING CHAIN COVER AND TIMING CHAIN

Timing Chain Cover Removal

1. Support engine in vehicle as outlined under Engine Oil Pan Removal and Installation.

2. Remove radiator and shroud assembly

3. Remove cylinder head.

4. Remove alternator belt and remove alternator mounting bracket.

5. Remove fuel pump

6. Remove ignition distributor.

7. Remove chain tensioner assembly out of timing cover.

8. Remove crankshaft pulley bolt and remove pulley.

9. Remove water pump assembly.

10. Remove oil pan

11. Remove timing chain cover bolts. One bolt is covered by the water pump. See Figure 6A-39.

12. Pull off sprockets with chain. Put a paint mark

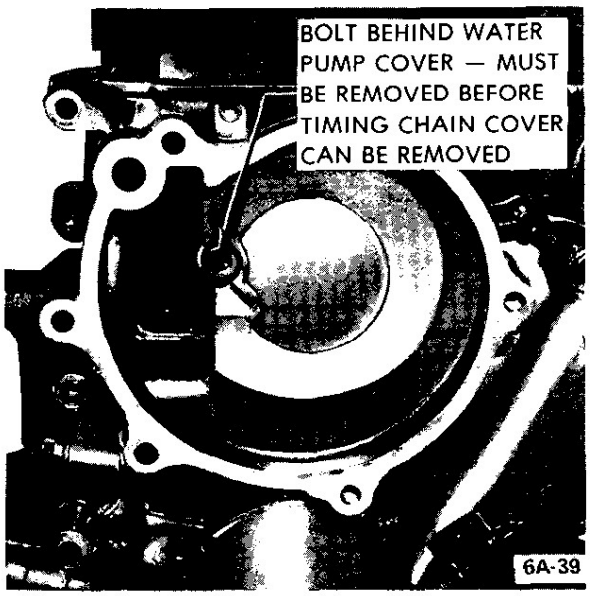


Figure 6A-39 Bolt Behind Water Pump

on front side of timing chain to permit reinstallation in original position.

Timing Chain Cover and Timing Chain installation

Reinstall timing chain cover by reversing removal procedures, pay particular attention to the following points.

1. Clean all parts, check for wear and replace as required. The Parts Department supplies either the two sprockets complete with chain or the chain alone. It is not permissible to replace sprockets alone. The chain tensioner is, with the, exception of the tensioner body, only available as a complete unit.

2. Turn crankshaft so that key for sprocket is on top and vertical. Assemble chain', with camshaft sprocket, then put chain on crankshaft sprocket already installed. Be sure paint dot on chain is in front so that chain moves in same direction as prior to disassembly.

3. Make sure camshaft sprocket mark is in alignment with mark on support and chain in parallel with damper block.

4. To install new timing case oil seal, drive out oil seal from the rear using a drift. Coat circumference of oil seal sparingly with suitable sealer and press seal in, using tool J-22924. Take care not to damage timing case. See Figure 6A-40.

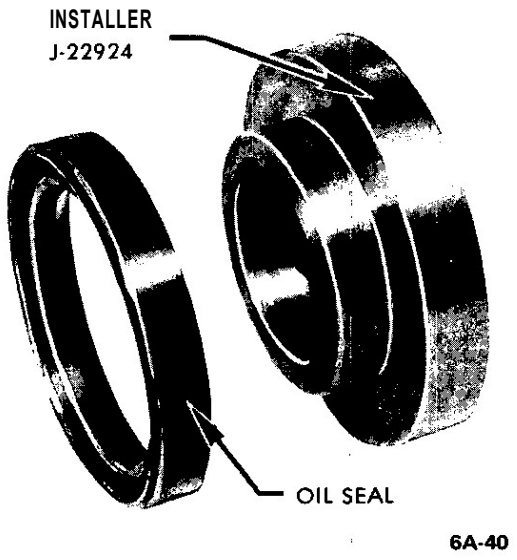


Figure 6A-40 Installing Timing Cover Oil Seal on Protector

It is not necessary to use crankshaft bolt to install seal when cover is off engine.

5. Inspect chain tensioner for proper operation and reusability.

6. Install timing case rubber gaskets to cylinder block. Stick on with grease as necessary. Gaskets will somewhat overlap with oil pan gasket.

7. Position timing cover onto guide pin in upper left corner of cylinder block and insert centering bolt through timing chain cover into lower right corner of cylinder block. See Figure 6A-40A. No sealing is required.

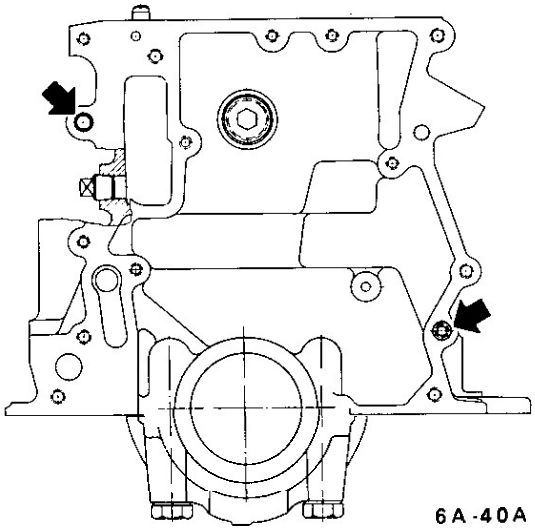


Figure 6A-40A Installing Timing Chain Cover

8. Install cylinder head

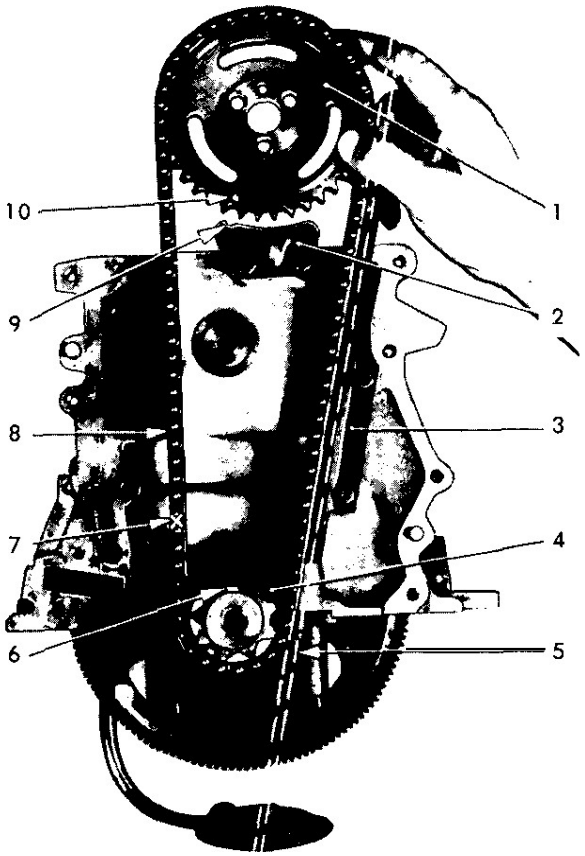
After sprocket has been attached to camshaft, recheck alignment to see that chain has not slipped. At this time both No. 1 and No. 4 pistons will be at TDC position. No. 4 piston will be in tiring position and No. 1 piston up on exhaust stroke. To time engine to fire on No. 1 cylinder, rotate crankshaft 360 degrees. This will position the timing mark 180 degrees from original alignment of camshaft sprocket and support bracket, and will completely close No. 1 intake and exhaust valves. Also, the timing mark on the flywheel (ball) and cylinder block (pointer) will coincide. See Figure 6A-41.

Replacing Timing Cover Oil Seal (Engine Installed)

1. Remove fan belts.

2. Remove crankshaft pulley bolt and remove pulley.

3. Insert screwdriver behind seal and rest screwdriver on crankshaft pin. Pry out oil seal.



1. CAMSHAFT SPROCKET
2. CAMSHAFT SPROCKET SUPPORT
3. LONG DAMPER BLOCK
4. CRANKSHAFT SPROCKET
5. CHAIN AND DAMPER BLOCK IN PARALLEL
6. CRANKSHAFT KEY
7. PAINT MARK ON FRONT
8. TIMING CHAIN
9. MARK ON CAMSHAFT SPROCKET SUPPORT
10. MARK ON CAMSHAFT SPROCKET

6A-41

Figure 6A-4 1 Valve Timing Marks

4. Lubricate new oil seal and place on installer J-22924.

5. Place installer J-22924 on crankshaft. Using crankshaft bolt and washer install seal into cover. See Figure 6A-42.

6. Install crankshaft pulley, bolt and washer. Torque bolt to 72 lb.ft.

7. Install belts and torque to proper tension 45 lb.ft.

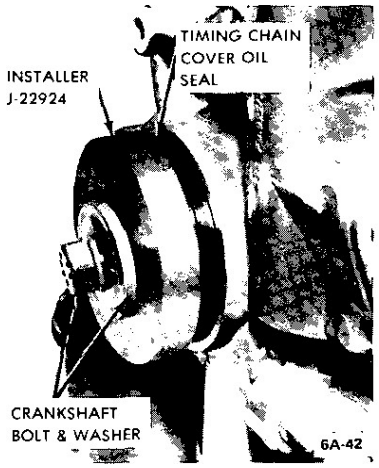


Figure 6A-42 Installing Timing Chain Cover Oil Seal

Replacing Distributor Drive Gear On Crankshaft

1. Remove fan belt.

2. Remove fuel pump. Plug end of fuel line with a suitable stop.

3. Remove spark plug wires, distributor hold down clamp. Remove distributor.

4. Turn crankshaft so key is on top.

5. Pry oil seal out of timing chain cover.

6. Insert a screwdriver through opening for fuel pump and push out distributor drive gear, which has a push tit on crankshaft, through oil seal seat in timing cover.

7. Install new gear. Be sure key tits in keyway. When installing components, use new gaskets as required.

8. Install new oil seal.

9. Connect parts removed in steps 1 thru 3.

CAMSHAFT

Removal

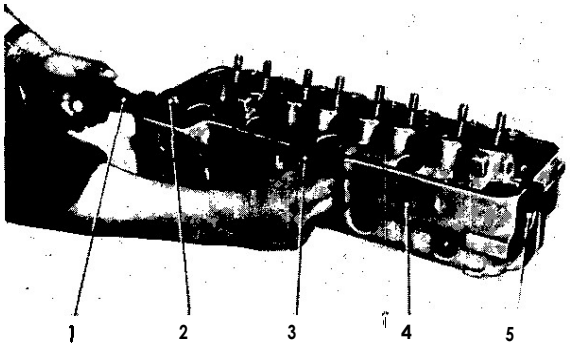
1. Remove cylinder head.

2. Loosen self-locking rocker arm nuts and swing rocker arms off valve lifters.

3. Remove valve lifter. Place lifters in a suitable holding fixture so that they may be reinstalled in original position.

4. Remove cover from access hole on left side and

rear of cylinder head. Remove camshaft toward front, supporting camshaft with one hand through access hole and taking care not to damage bearing surfaces. See Figure 6A-43.



1. CAMSHAFT
2. FRONT ACCESS HOLE
3. LATERAL ACCESS HOLE
4. CYLINDER HEAD
5. REAR ACCESS HOLE

6A-43

Figure 6A-43 Removing Camshaft

Installation

1. Liberally lubricate camshaft journals and install camshaft from front into cylinder head. Support shaft through access hole in left side of head to prevent damaging bearings.

2. Reinstall valve lifters, rocker arms and self- locking rocker arm nuts.

3. Install rear and side access plates.

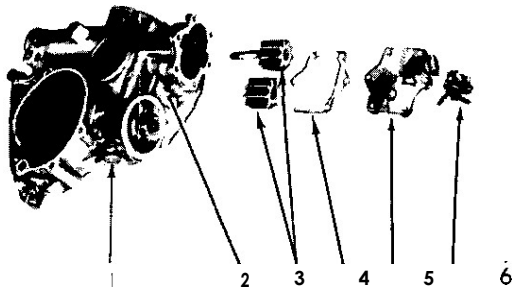
4. Reinstall cylinder head.

OIL PUMP COVER AND GEARS

Removal and Installation of Oil Pump Cover and Gears

1. Remove screws attaching oil pump cover assembly to timing chain cover. Remove cover assembly and slide out oil pump gears. See Figure 6A-44.

2. Wash off gears and inspect for wear, scoring, etc. Replace any gears not found serviceable. Discard pump covers scored by gear action. If pump housing or distributor drive shaft bushing are worn (this is only possible after a long service life), the timing case together with all exchangeable pump parts have to be discarded.



1. OLD PRESSURE RELIEF VALVE ASSEMBLY
2. TIMING CASE
3. OIL PUMP GEARS
4. COVER GASKET
5. COVER & VALVE ASSEMBLY
6. COVER ATTACHING SCREWS

6A-44

Figure 6A-44 Oil Pump Components

In isolated cases, timing cases are installed in production having .008 in. oversize bores for pump gears and shafts. Oversize bores may exist either for one or both gears; these timing cases are identified by the number "0.2" stamped into pump flange on left and-/or right-hand side. Oversize replacement gears should be selected according to Part Catalog specifications.

3. Liberally lubricate spindles and gear teeth and use new cover gasket. Install oil pump cover.

If new gears are installed, their end clearance in a dry pump housing should be checked with a straight edge and a feeler gauge. The gears must not protrude more than .004 in. over pump housing. See Figure 6A-45.

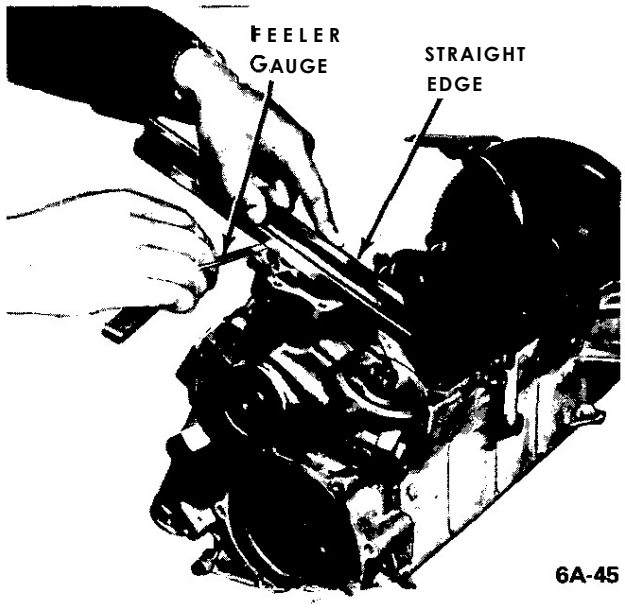


Figure 6A-45 Checking Oil Pump Gear End Clearance

With feeler gauge, check gear backlash. It should be between .004 in. and .008 in. See Figure 6A-46.

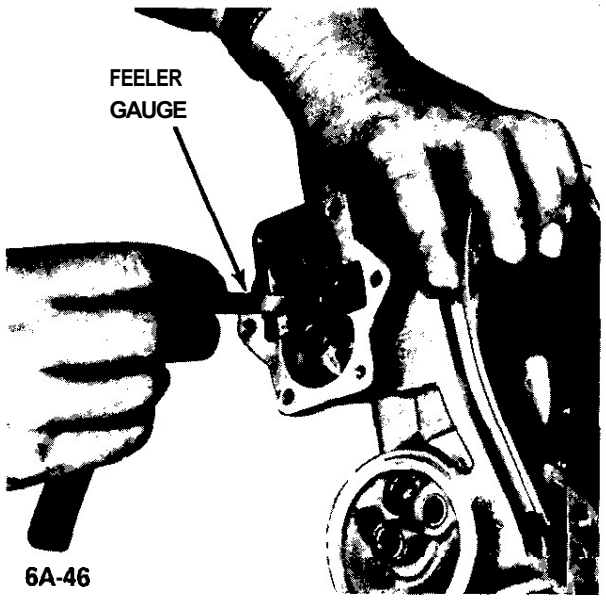


Figure 6A-46 Measuring Oil Pump Gear Backlash

Checking Oil Pump Relief Valve For Proper Functioning

1. Unscrew plug and check spring and relief valve plunger in oil pump cover for dirt particles and free operation. If required, carefully clean plunger and seat. Pressure relief plunger sticking as a result of foreign material or sludge build-up in the oil pump cover can cause loss of oil pressure.

Removal and Inspection of Oil Pump Pipe and Screen Assembly

1. Remove oil pan.

2. Clean oil pan. Make sure the gasket surfaces and pan and block are clean.

3. Remove (2) bolts holding pipe and screen assembly to cylinder block. See Figure 6A-47.

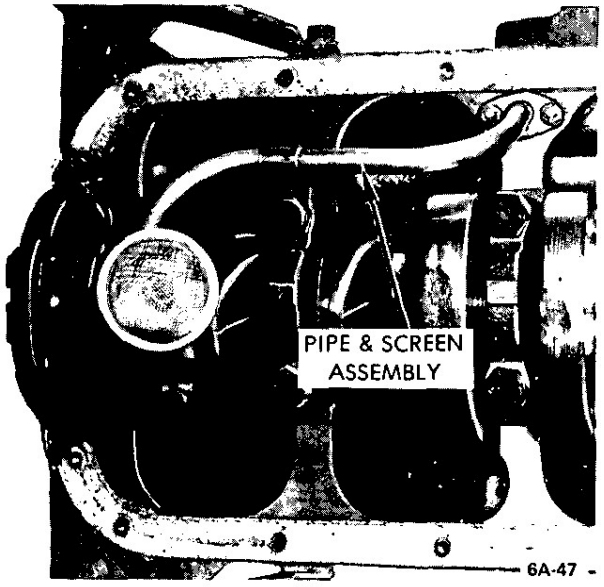


Figure 6A-47 Installation of Pipe and Screen Assembly

4. Clean the screen and housing thoroughly in solvent and blow dry with air stream.

Installation of Oil Pump and Screen Assembly

Install by reversing removal procedures, paying particular attention to the following points.

1. Make sure oil pump pipe flange gasket surface of block is smooth and free of dirt.

2. Use a new gasket and install assembly.

3. Tighten pan bolts evenly. Do not over-tighten. Torque to 5 lb. ft.

SPECIFICATIONS

BOLT TORQUE SPECIFICATIONS

Use a reliable torque wrench to tighten all parts listed, to insure proper tightness without straining or distorting parts. These specifications are for clean and lightly-lubricated threads only; dry or dirty threads produce increased friction which prevents accurate measurement of tightness.

Part	Torque Lb.Ft.
Connecting Rod Bolts	36
Crankshaft Main Bearing Bolts	72
Flywheel to Crankshaft Attaching Bolts	43
Cylinder Head Attaching Bolts	Cold 72 -Warm 58
Camshaft Sprocket Attaching Bolts	18
Generator Bracket to Cylinder Block Attaching Bolts	29
Generator Bracket to Timing Case Attaching Bolts	29
Crankshaft Pulley Attaching Bolts	72
Rocker Arm Stud in Cylinder Head	29
Spark Plugs	30
Clutch Housing to Cylinder Block Attaching Bolts	36
Timing Case to Cylinder Block Attaching Bolts	14
Water Pump to Timing Case Attaching Bolts	11
Engine Support to Cylinder Block Attaching Bolts	40
Rear Engine Suspension to Transmission Rear Bearing Retainer Bolts	22
Transmission to Clutch Housing Attaching Bolts	29
Starter to Clutch Housing Attaching Bolts	40
Support to Starter Attaching Nut	4
Intake and Exhaust Manifold to Cylinder Head Attaching Bolts	33

Unless Otherwise Noted:	
10 MM Bolt (15 MM Head)	30
8 MM Bolt (13 MM Head)	15
6 MM Bolt (10 MM Head)	30 Lb.In.

GENERAL SPECIFICATIONS

Type - No. of Cylinders	In line 4
Valve Arrangement	In head
Bore and Stroke	3.66 x 2.75
Piston Displacement Cu. In.	115.8
Compression Ratio	7.6:1
Octane Requirement	Regular - Low Lead
Firing Order	1-3-4-2
Cylinder Block Material	Cast Iron
Crankshaft Bearings Number and Type In-Metal Babbitts	5 Removable Steel Backed
Bearing Which Takes End Thrust	5
Connecting Rod Bearing Material	Steel Backed Tri-Metal Babbitts
Piston Material and Surface	Aluminum Alloy, Lead Coated
Piston Pin Offset	.031 In. to the Right
Compression Rings Material and Surface Treatment	
No. 1	Chrome-plated, Cast Iron - Rectangular
No. 2	Cast Iron - Tapered
Oil Ring	Chrome-plated, Cast Iron
Location of All Piston Rings	Above Piston Pin
Camshaft Material	Alloy Cast Iron
Camshaft Drive	Chain
Number and Type of Camshaft Bearings	4 Steel-Backed Babbitt
Valve Lifter Type	Hydraulic
Oiling System Type	Circulating High Pressure
Oil supplied to:	
Bearing Surfaces, Crankshaft, Camshaft and Connecting Rods	Pressure
Piston, Pins	Vapor
Cylinder Walls	Nozzle Spray
Rocker Arms	Pressure
Oil Reservoir Capacity - Quarts	3 1/4 With Dry Filter
Oil Filter - Type	Throw Away Element

Cooling System - Type ..... Liquid Cooling With Circulating Pump
Filler Cap Type - Pressure ..... 13.2-15.2 PSI
Water Temperature Control ..... Thermostat and Bypass
Thermostat Open At ..... 189 F.
Cooling System Capacity ..... 6 Qts.
Fan Drive ..... Water Pump Shaft

ENGINE DIMENSIONS AND FITS

Cylinder, Crankcase, Pistons, Cylinder Head, Valves

Cylinder Bore Limits for Standard Size Pistons:
Size 1 3.659-3.660 In.
Size 2 3.661-3.663 In.
Size 3 3.664-3.668 In.
Cylinder Bore Limits for Oversize Pistons, .02 In. Oversize ..... 3.679-3.681 In.
Max. Permissible Cylinder Bore Out-of-Roundness ..... .0005 In.
Max. Permissible Cylinder Bore Taper ..... .0005 In.
Piston Clearance, Nominal (on skirt bottom) ..... .0014 In.
No. 1 Compression Ring Side Clearance in Piston Groove ..... .0024-.0034 In.
No. 2 Compression Ring Side Clearance in Piston Groove ..... .0013-.0024 In.
Oil Control Ring Side Clearance in Piston Groove ..... .0013-.0024 In.
Piston Ring Gap:
No. 1 Compression Ring ..... .014-.022 In.
No. 2 Compression Ring ..... .014-.022 In.
Oil Control Ring ..... .015-.055 In.
Piston Pin in Connecting Rod ..... Press Fit

	Intake	Exhaust
Valve Spring Pressure Valve Closed	1.57 In. at 93 Lbs.	1.36 In. at 97 Lbs.
Valve Open	1.18 In. at 182 Lbs.	.96 In. at 180 Lbs.
Valve Stem Diameters Standard Size	.3538-.3543 In.	.3524-.3528 In.
.003 In. Oversize	.3567-.3572 In.	.3553-.3559 In.
.0059 In. Oversze	.3597-.3602 In.	.3583-.3588 In.
.O 1 18 In. Oversize	.3656-.3661 In.	.3642-.3647 In.
Valve Length, Nominal	4.843 In.	4.92 In.
Valve Head Diameter	1.574 In.	1.34 In.

Valve Guide Bores in Cylinder Head (Intake and Exhaust)
Standard Size ..... .3553-.3562 In.
.003 in Oversize ..... .3582-.3592 In.
.006 in Oversize ..... .3615-.3622 In.
.0118 in Oversize ..... .3671-.3681 In.
Valve Stem Clearance
Intake ..... .001-.0029 In.
Exhaust ..... .0039 In.
Max. Permissible Head to Stem Runout
Intake ..... .0016 In.
Exhaust ..... .0019 In.

Valve Seat and Correction Angle in Cylinder Head	
Intake	
Valve Seat Angle	45"
Outer Correction	30"
Exhaust	
Valve Seat Angle	45"
Outer Correction	30"
Valve Face Angle	44°
Valve Seat Width in Cylinder Head	
Intake	.049-.059 In.
Exhaust	.063-.073 In.
Valve Head Contact Area	Aim at Centricity
Valve Clearance at 176°F. Coolant and 140°F. to 176" Oil Temperature	
Intake and Exhaust	Zero Plus One Turn

Cranking Mechanism

Max. Permissible Out-of-Roundness of Connecting Rod Bearing Journals	.0002 In.
Max. Permissible Taper of Connecting Rod and Crankshaft Bearing Journals	.0004 In.
Max. Permissible Radial Runout of Center Main Bearing Journals When Supported in End Bearings	.0012 In.
Max. 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.
Max. Permissible Runout of Crankshaft to Flywheel Contact Area	.0008 In.
Crankshaft End Play	.0017-.0061 In.
Main Bearing Clearance	.0009-.0025 In.
Connecting Rod Bearing Clearance	.0006-.0025 In.
Connecting Rod End Play on Bearing Journal	.0043-.0095 In.
Connecting Rod Bearing Length	.7785-.7992 In.
Crankshaft Thrust Bearing Length	1.08 In.

Valve Mechanism

Camshaft Bearing Clearance	.001-.003 In.
Camshaft End Play	.004-.008 In.
Max. Permissible Radial Runout of Camshaft Center Bearing - Camshaft Supported in Outer Bearings	.001 In.
Valve Lifter Clearance in Cylinder Head Bore	.0003-.0013 In.

Engine Lubricating System

Oil Pump Gear Backlash	.004-.008 In.
Oil Pump Gear End Play in Housing	Gears Protruding Over Edge of Housing: Not More Than .004 In.
Clearance of Spindle in Bore of Oil Pump Driven Gear	.0003-.0015 In.
Clearance Between Oil Pump Drive Gear and Bushing	.00035-.0015 In.
Oil Pump Relief Valve Spring Pressure at a Spring Length of .8 In.	.44-.66 Lbs.

	CRANKSHAFT MAIN BEARING JOURNALS			CONNECTING ROD BEARING JOURNALS, (ALL)		CONNECTING ROD WIDTH, (ALL)
	NO. 1, 2, 3 & 4 BEARING DIAMETER	BEARING NO. 5 (PILOT BEARING) WIDTH	BEARING NO. 5 (PILOT BEARING) DIAMETER	WIDTH	DIAMETER	
AVAILABLE SIZES OF CONNECTING ROD AND CRANKSHAFT BEARING SHELLS AS WELL AS CONNECTING RODS.	INCHES	INCHES	INCHES	INCHES	INCHES	INCHES
DIMENSIONS FOR STANDARD (PRODUCTION) SIZE CRANKSHAFT. USE OPEL BEARING PART NOS. 618036, 618710, 622711.	2.2832 ± .003	1.0819 ± .0012	2.2832 ± .0003	.9858 ± .0015	2.0464 ± .0003	.9789 ± .0010
DIMENSIONS FOR GRINDING CRANKSHAFTS FOR USE WITH .010 INCH UNDERSIZE BEARINGS. USE OPEL BEARING PART NOS. 618161, 618735, 622941.	2.2733 ± .0002	1.0898 ± .0012	2.2733 ± .0002	.9858 ± .0015	2.0366 ± .0003	.9789 ± .0010
DIMENSIONS FOR GRINDING CRANKSHAFTS FOR USE WITH .020 INCH UNDERSIZE BEARINGS. USE OPEL BEARING PART NOS. 618310, 618760, 622779.	2.2635 ± .0002	1.0977 ± .0012	2.2635 ± .0002	.9937 ± .0016	2.0267 ± .0003	.9867 ± .0010

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