MASTER Packard SERVICEMAN

TRAINING PROGRAM

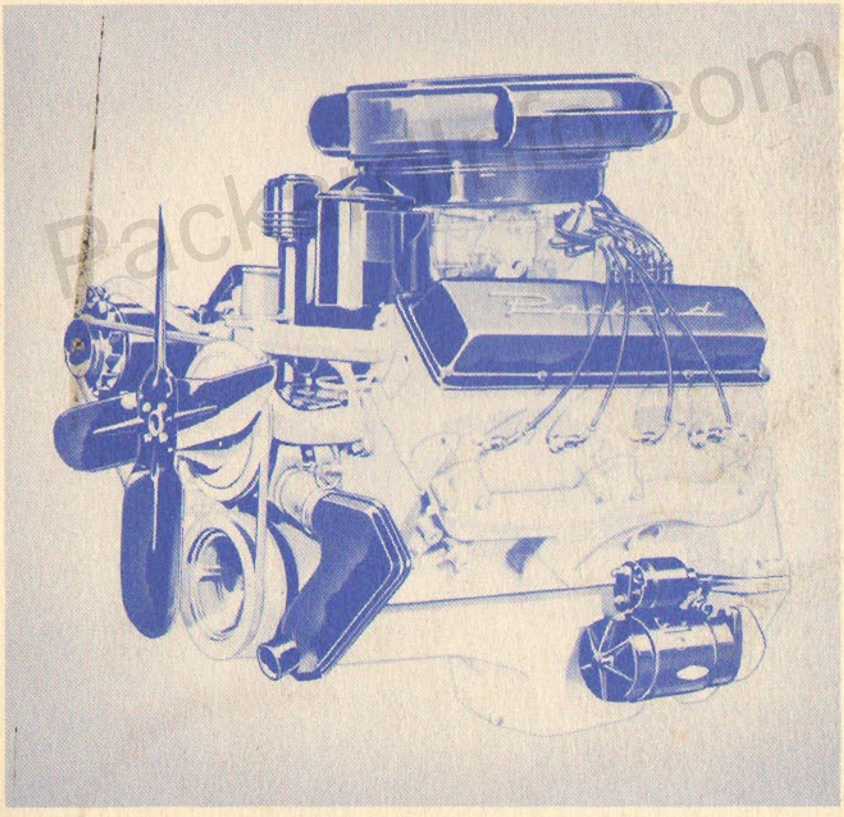
Serviceman's Training Book

THE 55TH SERIES

CLIPPER—PACKARD V-8 ENGINES

with

TEST PROCEDURES—TROUBLE SHOOTING



STUDEBAKER-PACKARD CORPORATION

DETROIT 32, MICHIGAN

CONTENTS

ENGINE

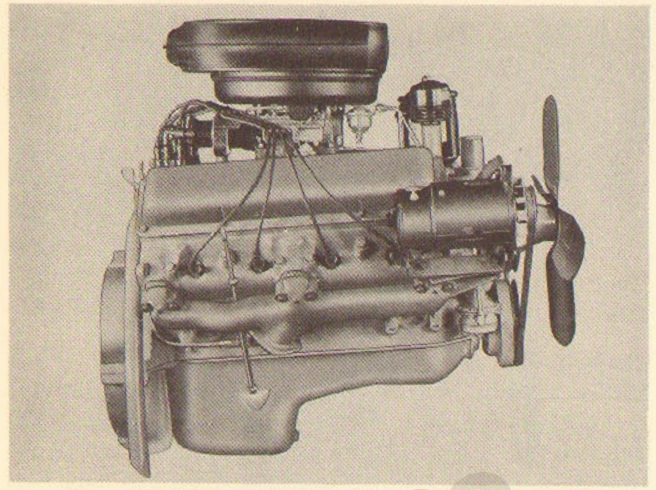


Figure 1—Right Side View—Packard V-8 Engine

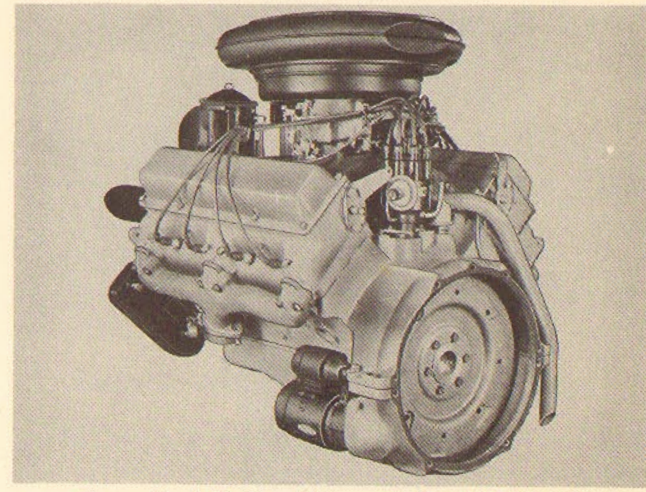


Figure 2—Left Rear View—Packard V-8 Engine

DESCRIPTION

The Packard V-8 valve-in-head engines are built in two sizes. The engine used on the 5540 (Clipper Deluxe and Super) has a displacement of 320 cubic inches with a 3 3/16″ bore and 3½″ stroke. The compression ratio is 8.5 to 1. The larger engine is used on models 5560 and 5580 (Clipper Custom and Packard Line) and has a displacement of 352 cubic inches with a 4″ bore and 3½″ stroke. The compression ratio is 8.5 to 1.

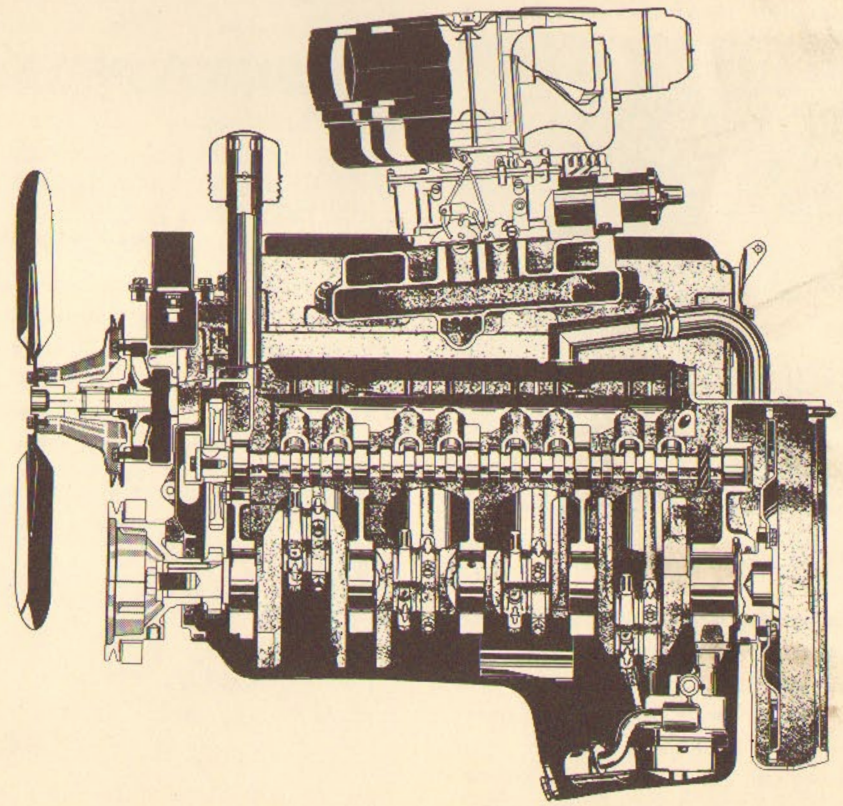


Figure 3—Longitudinal Section View—Packard V-8 Engine

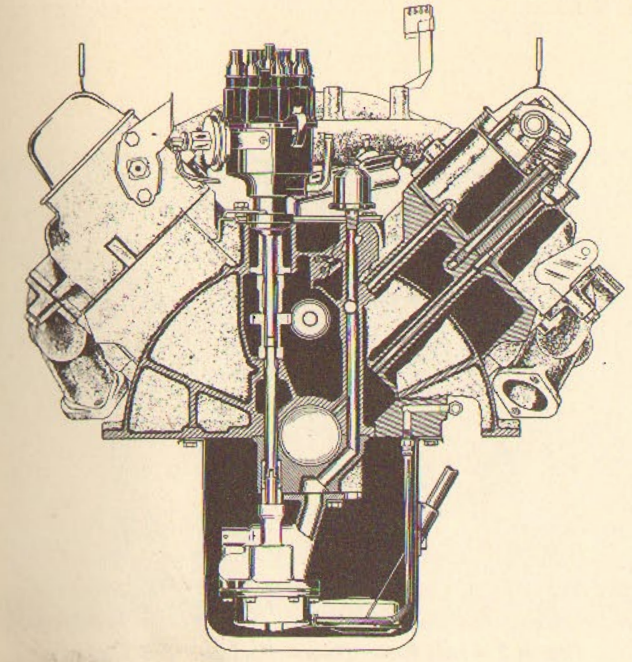


Figure 4—Transverse Rear View

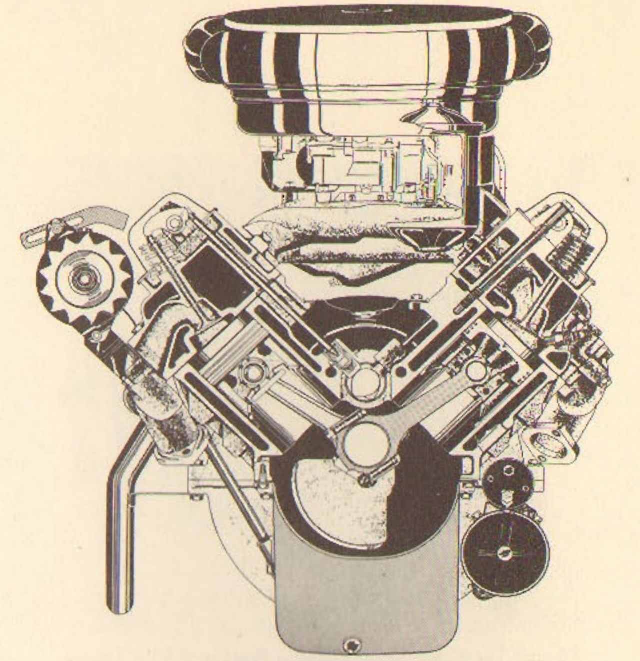


Figure 6—Transverse Front View

The cylinder block is a 90° type cast integral with the crankcase in a casting of fine iron alloy. The crankcase walls are reinforced by five rugged and heavily ribbed webs which support the crankshaft main bearings.

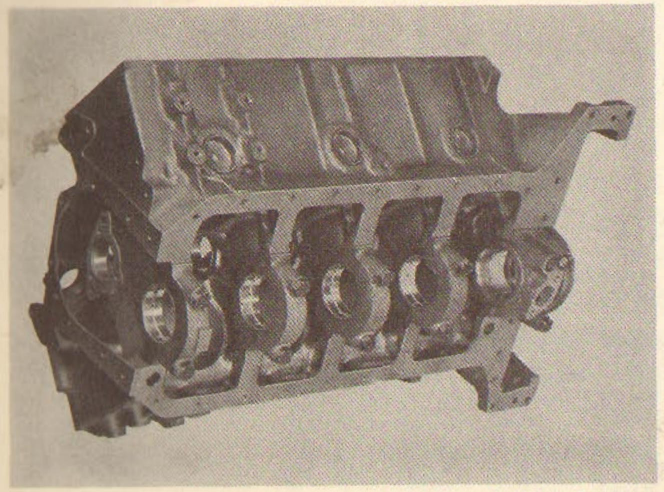


Figure 5—Cylinder Block

The camshaft is an iron alloy precision casting, with the cams cast as an integral part of the camshaft. The contour or the shape of the cams is designed to give the valves the longest period of wide opening and quiet valve operation. Five steel-backed precision type babbitt bearings support the camshaft in the block. The camshaft is driven by a silent chain and sprockets.

The crankshaft is a steel precision casting with six integral counterweights, and operates on five precision bearings, with a total main bearing area of 44.46 sq. in. The crankshaft end thrust is taken by the rear (No. 5) main bearing.

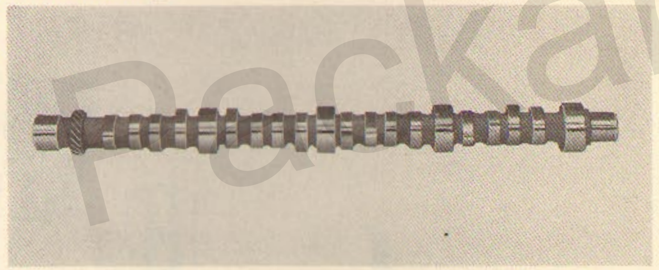


Figure 7—Camshaft

The cylinder heads used on the Packard V-8 engine are an iron alloy of rigid construction. The combustion chamber of "elliptic" or "parabolic" shape has many advantages over other combustion chamber designs. The cylinder heads are symmetrically designed so that the left head is interchangeable with the right head.

The valve guides are integral with the cylinder head. Four oversized reamers are made available for servicing worn valve guides.

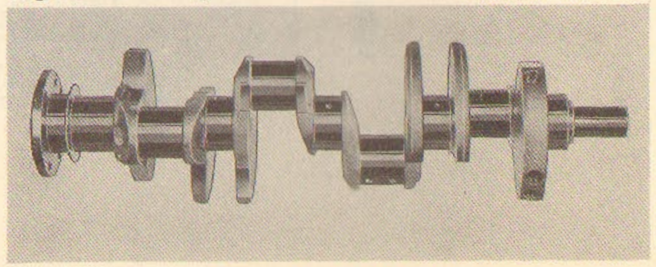


Figure 8—Crankshaft

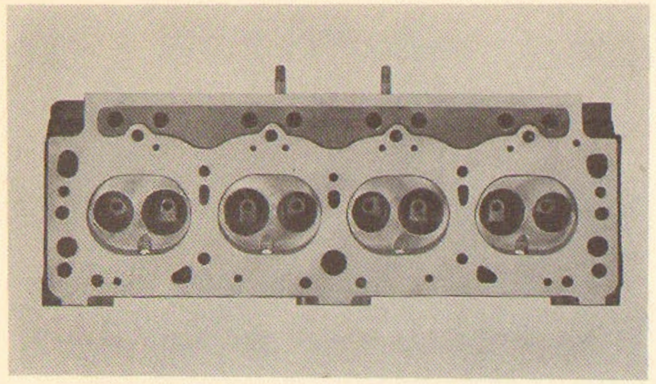


Figure 9—Cylinder Head

Valves with oversized stems are available for service.

The intake valves are made of Silichrome steel, hardened and tempered all over. The exhaust valves of flexible head design are made of high grade Austenitic Steel, which readily conforms to the shape of the seat and is highly resistant to burning and pitting. Neoprene valve spring seals are fitted to both intake and exhaust valve spring seats to control the amount of oil permitted to lubricate the valve stems and integral guides.

The hydraulic tappet assembly is of a stub type and contains a seat for the lightweight tubular valve push rods. The rocker assembly consists of a tubular shaft with short, sturdy rocker levers.

The connecting rods are drop-forged of high grade manganese steel, and are of sturdy "I" beam construction. Balancing lugs are provided at each end of the connecting rod assembly. A precisely metered, milled groove located at the split line bearing end of the connecting rod provides adequate lubrication for the cylinder wall. The connecting rod bearings are the removable type, made of thin steel shells lined with a lead babbitt alloy material. A hard-rolled bronze bearing in the upper end is provided as a bearing for the piston pin. The connecting rod caps are numbered and must match with the number on the rods.

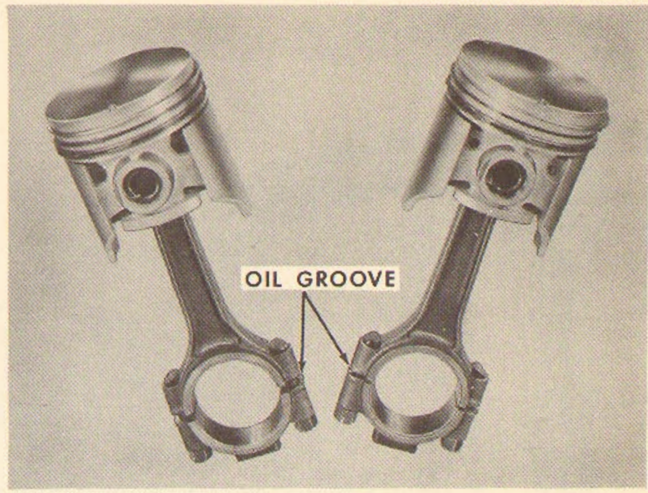


Figure 10—Connecting Rod and Piston Assembly

When installing the connecting rods the numbered side must face towards the outside of the block and the metered oil groove towards the camshaft.

The pistons are the aluminum alloy slipper type, cam ground, and have steel struts to control expansion. The surfaces of the pistons are tin plated to provide an ideal bearing material. Three piston rings are used on each piston above the piston pin—two compression rings in the two upper grooves and one special type oil ring in the bottom groove. The top compression ring is chrome plated.

The pistons are numbered from 1 to 8 for installation in the respective cylinders. When installing the piston assembly in the engine the -F- stamping on the side of the piston must face forward. Oversize pistons are available for service.

COOLING SYSTEM

The radiator is of a tube and fin type and has a square, broad frontal area which exposes more fins and tubes to the oncoming air while driving. The radiator tanks are of a lock seam joint construction which gives greater strength at the soldered joint.

A centrifugal water pump with a single inlet discharges into an equalizing outlet manifold with dual outlets, feeding a balanced flow to both cylinder banks. The coolant passes around each individual cylinder barrel to passages in the rear portion of the block, where it crosses into the cylinder head and reverses its direction. It flows through generous passages around the combustion chambers, valve ports and valve guides and returns to the radiator through an outlet at the forward end of the cylinder heads and through a water outlet manifold cast integrally with the pump body.

A 167° capsule type thermostat, whose operation is unaffected by cooling system pressures, is located in a housing at the center of the water outlet manifold.

A 12 PSI radiator pressure valve cap is used which is designed to raise the boiling point of the coolant and permit somewhat higher engine operating temperatures without any loss from boiling. The pressure radiator cap should be inspected frequently to avoid

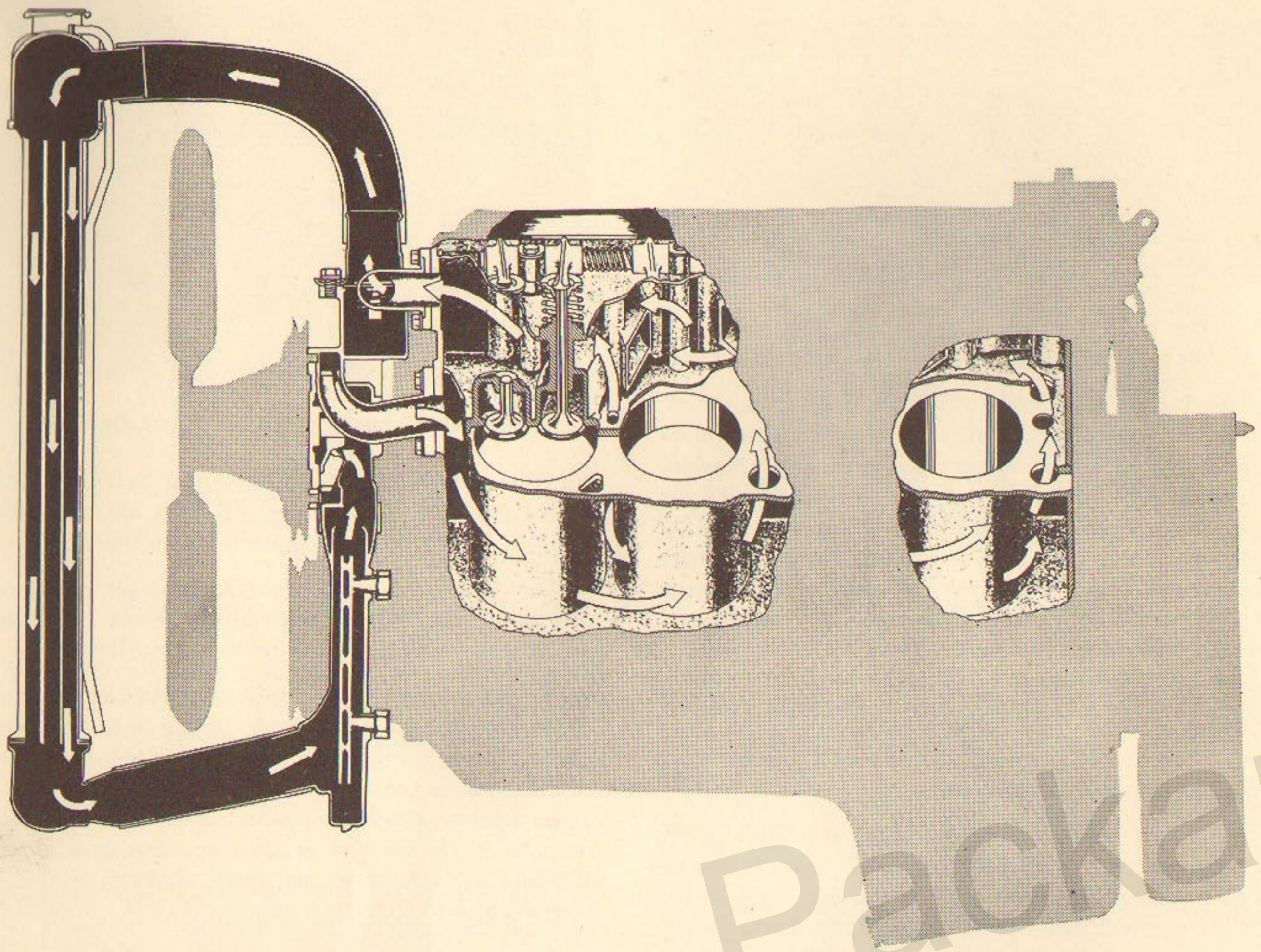


Figure 11—Cooling System

possible damage to the cooling system. If the pressure and vacuum valves in the cap are not opening and closing properly the cap should be replaced.

For the cooling system to maintain its efficiency the system must be leak-tight and kept free from rust and corrosion.

Rust proofing of the cooling system in the winter can be accomplished through the use of a permanent type anti-freeze containing inhibitors. When anti-freeze is used, drain the cooling system in the spring after freezing weather is past; flush the system thoroughly and refill with water, adding Packard rust preventative.

CRANKCASE VENTILATION

The crankcase ventilating system provides air circulation through the engine crankcase, to prevent crankcase condensation which causes oil dilution and sludge in the engine.

Ventilating air enters the crankcase through the oil filler cap. It is drawn down into the front of the crankcase, and after passing to the rear, enters the valve tappet compartment. The air then circulates forward in the valve tappet compartment and out through a hole at the rear of the upper valve tappet cover. It is drawn out through the tappet cover breather tube.

The filter element in the oil filler cap is not replaceable. The oil filler cap should be serviced by washing in clean kerosene or solvent, draining thoroughly, and coating with clean engine oil.

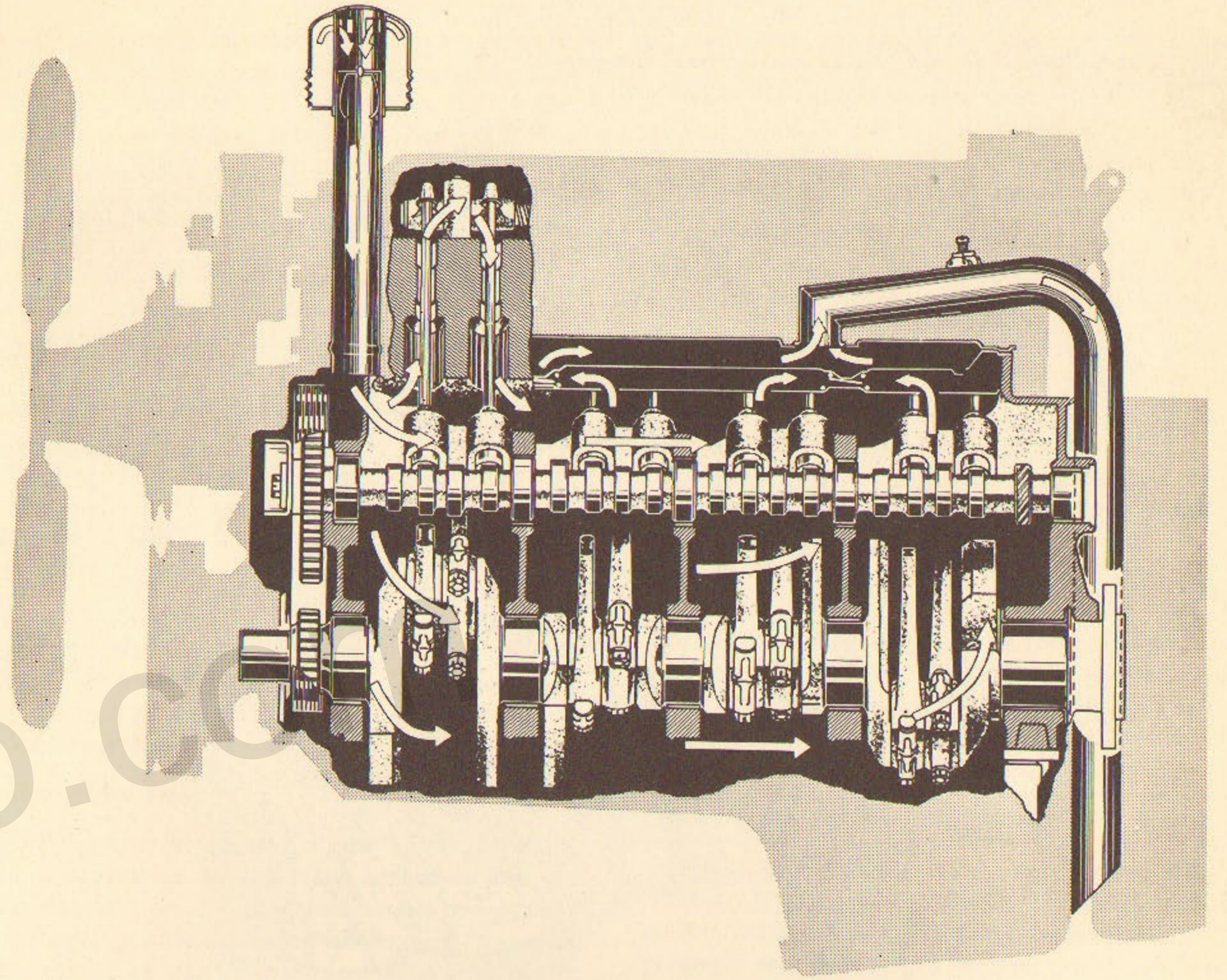


Figure 12—Crankcase Ventilation

OILING SYSTEM

All vital moving parts of the Packard V-8 engine are pressure lubricated. Oil enters the pump through a floating strainer and is directed to two longitudinal main oil galleries drilled and extending the full length of both cylinder banks. The oil galleries are sealed at the rear end by two plugs and at the front by the camshaft retainer plate.

Crankcase Main Bearing Lubrication

Oil pressure to the crankshaft main bearings is supplied from the two main oil galleries through drilled passages in the main bearing webs. Nos. 1, 3, and 5 main bearings receive oil from the right bank oil gallery, while Nos. 2 and 4 main bearings receive oil pressure from the left bank oil gallery.

Camshaft Lubrication

Metering holes drilled in the main bearing inserts and lined up with drilled passages in the main bearing webs, supply lubrication to Nos. 1, 2, 3, and 4 camshaft bearings. The No. 5 camshaft bearing receives lubrication direct from the main oil gallery through a drilled passage at the rear of the cylinder block.

Connecting Rod Bearing Lubrication

The connecting rod bearings and journals are lubricated through drilled passages in the crankshaft from the main bearing journals.

Cylinder Walls and Piston Lubrication

Cylinder walls and pistons are lubricated by splash and spray from the oil forced through the small notched orifice provided between the contact surfaces of the connecting rod and cap. On every revolution of the crankshaft, the small milled groove lines up, or will register, with a hole in the connecting rod crankshaft journal.

The piston pins are lubricated by oil spray deflected from the cylinder walls.

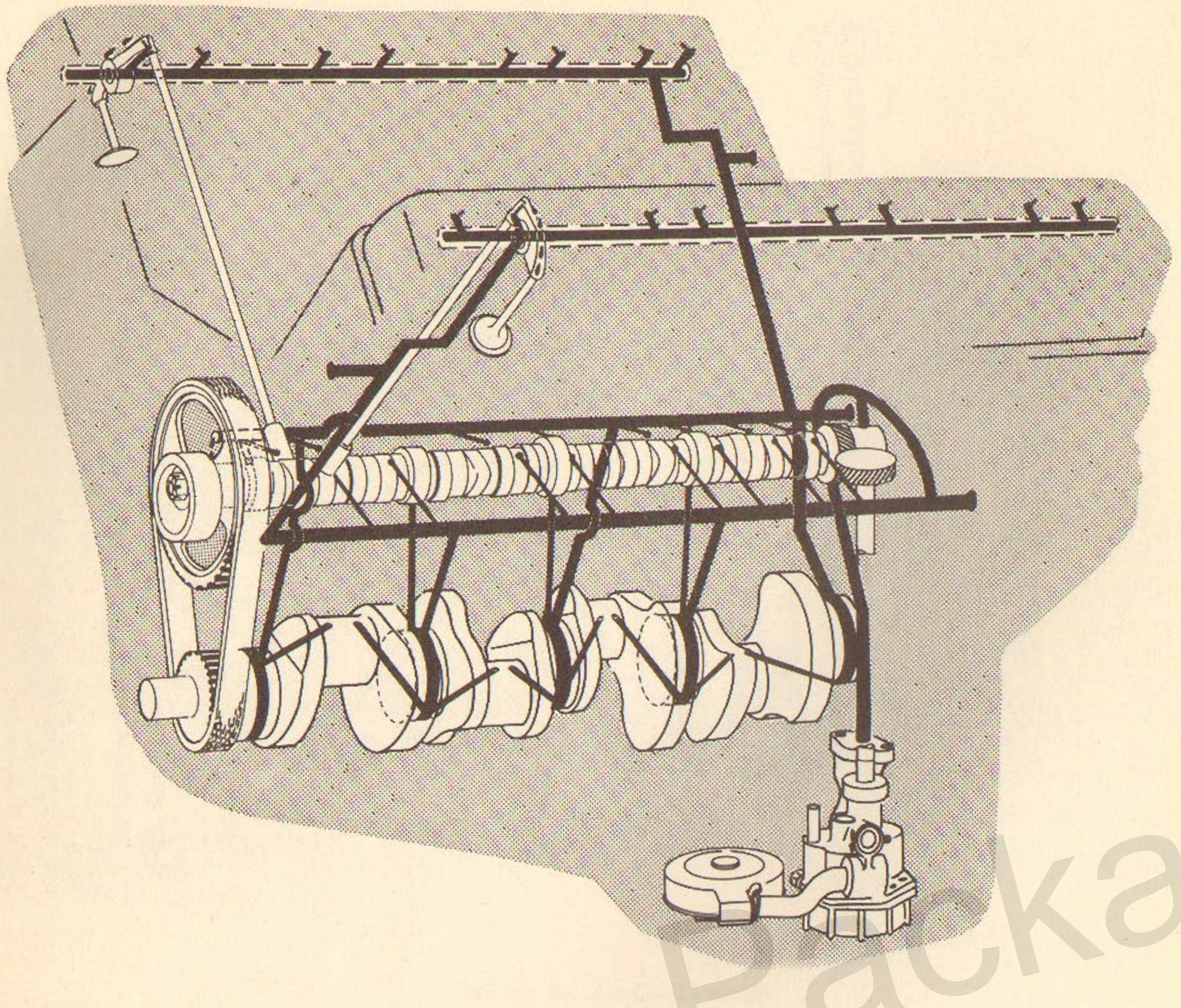


Figure 13—Oiling System

Timing Chain and Sprocket Lubrication

Timing chain, sprockets and fuel pump eccentric cam receive lubrication from the right bank oil gallery by means of a small milled groove and spray hole in the camshaft retainer plate.

Hydraulic Tappets

The hydraulic tappets receive pressure lubrication from the main oil galleries through connecting passages in the cylinder block. Oil around the tappets enters the tappet body to the check valve and plunger through a metered hole and annular groove.

Rocker Levers and Shaft

Pressure lubrication to the rocker shafts is supplied from the main oil galleries up through a drilled passage in the cylinder block which mates with a passage in the cylinder head. The passage in the cylinder head leads the oil around the relieved shank on the cylinder head bolt to the rocker lever shaft bracket. A passage in the bracket directs the oil into the hollow rocker lever shaft. The shaft on the right bank gets oil through the rear mounting bracket, while the shaft on the left bank gets oil through the front bracket. The hollow rocker lever shafts also function as oil galleries to supply oil to the rocker levers.

Drilled passages in the rocker levers furnish lubrication to the push rod sockets and valve stems. Overflow oil from the valve train drains down into the crankcase through drain holes provided in the cylinder head and block. The drain hole for the right bank is at the front, while the drain hole for the left bank is at the rear of the cylinder head.

Distributor Shaft Bearing Lubrication

The distributor drive gear lubrication is accomplished by splash, while the distributor shaft bearings are lubricated by gravity feed.

ENGINE TUNE-UP

Periodic engine tune-ups and inspections will maintain engine performance at maximum economy and efficiency. The tune-up and inspection operations described in this manual should be helpful to the mechanic as a guide to systematic and thorough checking and tuning procedures.

The Packard Owner should be informed of the importance of this maintenance service in keeping his engine performance at peak efficiency.

Minor Tune-Up

Spark Plugs: Clean the spark plugs by sand blasting and wipe off porcelain. Inspect the electrodes and file them to provide a clean flat surface. Adjust gap to .035" by bending the outer electrode. Check with a round feeler gauge. Install spark plugs using new gaskets and torque-tighten to 26-30 lbs. ft.

Dirty spark plugs or those with burned or worn electrodes require as much as 40% more voltage to fire them. Too wide a plug gap may reduce power or cause a miss on acceleration. Too narrow a plug gap may cause uneven engine idle.

Compression Test

With the engine at normal operating temperature, make a compression test of each cylinder, first removing all of the spark plugs and setting the throttle in the full open position. Use the starter motor to crank engine through at least four compression strokes for each cylinder, noting the reading on the first as well as on the final stroke.

Pressure should build up quickly and evenly to a minimum of 120 PSI at 150 RPM. Variation between the highest and lowest reading cylinder should not exceed 10 pounds.

Lower than specified compression pressures could indicate cylinder, ring, valve, or gasket trouble. Higher than specified compression pressures usually indicate excessive carbon deposits in the combustion chamber.

Compression troubles must be corrected before engine performance can be restored by tuning.

Distributor Contact Points

Inspect the distributor contact points. If points are pitted, burnt or excessively corroded a new set of points should be installed. Proper installation of a new set of contact points requires alignment and adjustment.

With the breaker arm rubbing block resting on the cam lobe of the breaker cam, adjust the breaker gap to .016".

Inspect the Delco-Remy distributor for excessive play, or wobble, in the vacuum advance plate. Inspect the distributor cap and rotor for cracks and corroded, burnt, or worn radial contacts. Inspect the lead wires for breakage or damaged installation. Inspect the Manifold Heat Control Valve.

Ignition Timing

Start the engine and warm to normal operating temperature. With the engine running at idle speed, direct the high tension timing light to timing marks on the vibration damper. Adjust distributor position until ignition occurs at 6° B.T.D.C.

Fuel Pump Sediment Bowl

Remove fuel pump bowl and screen and wash thoroughly in cleaning solvent. Reassemble bowl and screen, using a new gasket and making sure that it is properly seated. Tighten all fuel pump connections.

Carburetor Adjustment

With the engine warmed up to operating temperature, adjust the carburetor idle mixture, using a vacuum gauge to obtain a smooth idle. Adjust the throttle lever stop screw so the engine will idle at 425-475 RPM in neutral.

Carburetor Air Cleaner

Remove the oil bath air cleaner and drain the oil from the reservoir and flush with solvent. Flush the filter element and allow to drain.

Fill the reservoir to level with engine oil (SAE 50 in summer and SAE 20 in winter).

PERFORMANCE INSPECTION

The following tests should be made using suitable equipment after a motor tune-up, to determine the operating efficiency of components and systems vital to the over-all performance of the vehicle's power plant.

If unsatisfactory test results are obtained, the unit or system giving unsatisfactory results should be tested in detail as explained in the electrical section of this manual.

Cranking Voltage Test: Connect a jumper lead from distributor primary post to ground to prevent engine from starting. Connect a voltmeter to battery side of ballast resistor and to ground. Turn Ignition Switch ON and crank engine. Read cranking voltage on Voltmeter while observing Cranking Speed. Remove jumper lead.

Test Results

Voltmeter reads 9.6 volts or more and cranking speed is normal indicates: battery, starter, cables, switch and ignition circuit to coil operating satisfactorily.

Voltmeter reads less than 9.6 volts indicates: weak battery; defective cables, connections, switch or starter; defective ignition circuit to coil.

Cranking speed below normal indicates: excessive resistance in cables, or starting motor; excessive mechanical drag in engine.

Uneven cranking speed indicates: uneven compression.

Distributor Resistance Test: Calibrate Dwell Meter and connect Dwell Meter leads to distributor terminal of coil and to ground. Turn Ignition Switch ON and read Dwell Meter.

Test Results

Meter Reading within Black Bar on Dwell Scale indicates: primary circuit from coil through distributor to ground in normal condition.

Meter Reading Zero indicates: distributor points are open. Pump engine with starter until points close, and then take reading.

Meter Reading Not within Black Bar indicates: high resistance present in wire from coil, at internal or external distributor connections, at contact points, or in the distributor mounting.

Note: Excessive resistance must be eliminated before continuing with tests on tune-up.

Dwell Test: Recalibrate Dwell Meter to Set Line, then set switch to 8-lobe position. Start engine, run at idle speed, and read Dwell Meter.

Test Results

Dwell Meter reads 26° to 33° Delco; 27°±2° Auto-Lite indicates: point gap and point dwell relationship normal.

Dwell reading not within specifications indicates: wrong point assembly, point rubbing block defective or misaligned, or distributor cam worn.

Dwell Variation Test: With the Dwell Meter connected the same as for Dwell Test, change engine speed from idle to 1500 RPM and back to idle while observing Dwell Meter.

Test Results

Dwell reading remains the same from idle to 1500 RPM and back to idle indicates: distributor in good mechanical condition.

Dwell reading varies in excess of 2° from idle to 1500 RPM and back to idle indicates: worn distributor shaft, bushings, or breaker plate.

Ignition Timing and Advance Tests: Connect leads of Electronic Distributor tester to car battery and connect pick-up to No. 1 spark plug, set tester switches to ON and timing positions. With engine running at 400 RPM or less, direct power light to timing marks on vibration damper. Adjust distributor position until ignition occurs at 6° B.T.D.C.

Set engine speed to 400 RPM or less, and adjust tester advance control until timing mark is again aligned with pointer. Read degrees of timing advance on tester meter.

Test Results

Total advance reading within range 50° to 52° at 4200 RPM indicates: mechanical and vacuum advance mechanisms operating properly.

Total advance reading not within specified range indicates: faulty mechanical or vacuum advance mechanism.

Position of timing mark not steady during either timing or advance test indicates: pitted or misaligned distributor points, improper distributor point spring tension, worn or loose vacuum breaker plate, worn distributor shaft or bushings.

Charging Voltage Test: Set engine speed at 1500 RPM and connect voltmeter leads to battery side of ballast resistor and to ground. After pointer stops moving read voltage.

Test Results

Voltmeter reading between 13.8 and 14.8 indicates: charging system and voltage regulator operating normally.

Voltmeter reads below 13.5 V indicates: defective generator or generator drive, defective or misadjusted voltage regulator, high resistance in charging circuits.

Voltmeter reads above 14.8 V indicates: defective or misadjusted voltage regulator, high resistance in regulator ground circuit, or grounded field circuit.

Secondary Resistance and Polarity Test: With engine stopped, connect jumper lead from generator armature terminal to ground. Start engine and adjust speed to 1500 RPM. Set selector switch of Volts Ignition Tester to Secondary Resistance position and connect red test lead to ground. Touch black test lead to each spark plug in turn and observe reading on Secondary Resistance Scale of meter.

Test Results

All readings showing minimum of 4 indicates: secondary circuit is in normal condition.

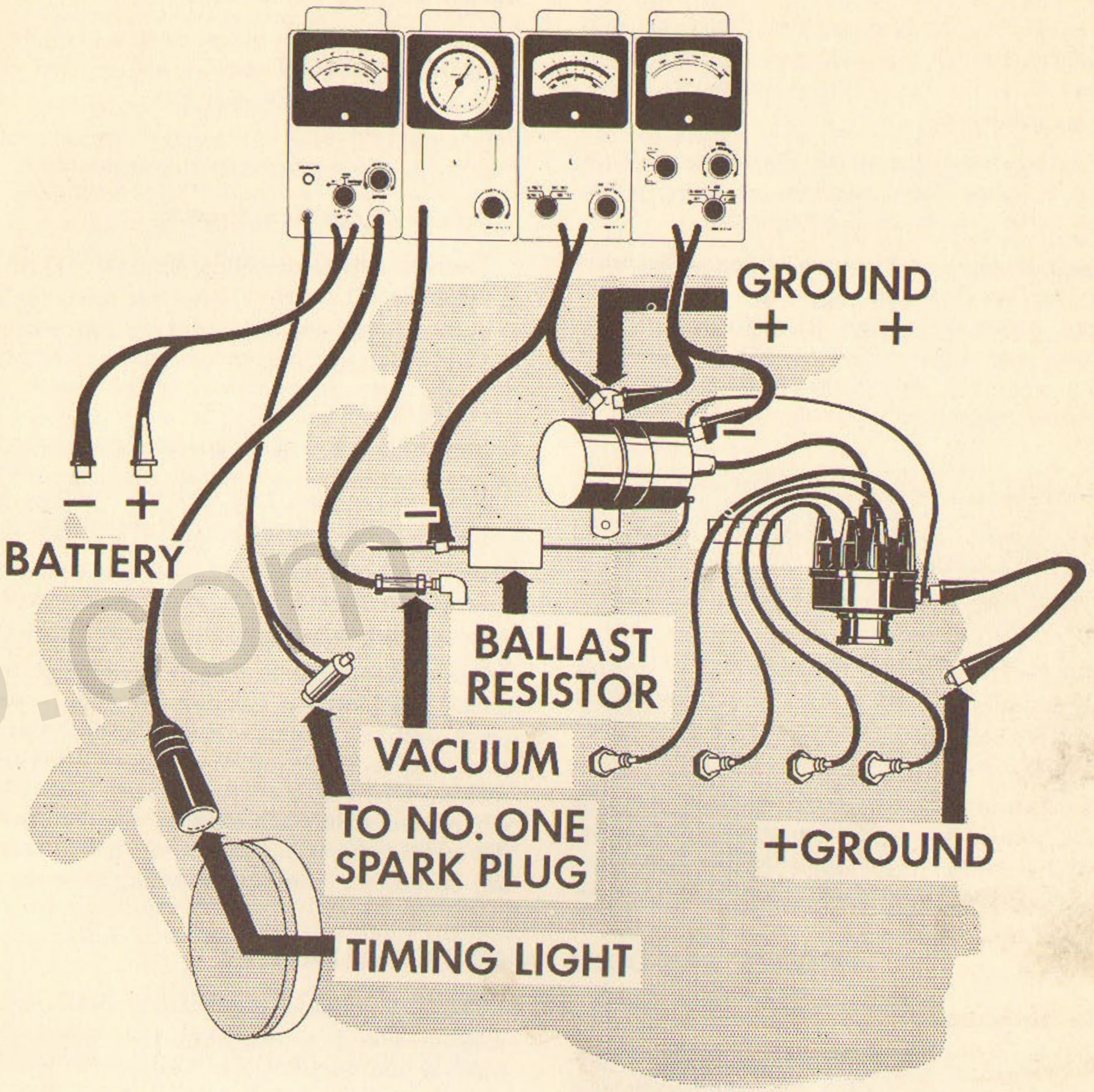


Figure 14—Performance Inspection Wiring Hook-Up

All readings lower than 4 indicates: corroded coil tower terminal, poorly connected or broken coil wire, center cap electrode burned, or burned rotor tip.

One or more readings lower than 4 indicates: broken or poorly connected spark plug wires, burned or corroded cap terminals.

Any excessive readings . . . from two or more plugs adjacent in firing order indicates: cross-fire occurring between the plug cables or in distributor cap.

Meter reads off scale to left with red test clip grounded indicates: coil polarity is reversed due to coil primary wires connected in a reverse order, wrong coil, or vehicle battery connected in reverse.

Ignition Output and Secondary Leakage Test: With engine stopped, connect jumper lead from generator armature terminal to ground. Start engine and adjust speed to 1500 RPM. Set selector switch of Volts-Ignition Tester to Ignition Test position and connect one tester lead to each primary terminal of coil. Adjust tester Calibrator until meter reads to 8 cyl. set line. Lift off any one spark plug wire and note reading on Ignition Test Scale of meter. (To check insulation of all wires and all portions of distributor cap for cracks and carbon tracks, repeat test at each spark plug wire.)

Test Results

Meter reads in Good (Blue) Band when each plug wire is lifted off indicates: good ignition output and secondary insulation.

All readings low or Ignition Test Calibrator cannot be adjusted to set line indicates: high resistance in primary circuit, defective distributor points, defective coil or condenser.

Low readings only when certain plug wires are lifted off indicates: defective insulation on those wires, cracks or carbon tracks in distributor cap.

Idle Speed, Mixture and Vacuum: Connect Tachometer and Vacuum Gauge to engine and run engine at idle speed. Adjust carburetor idle mixture until both Tachometer and Vacuum Gauge indicate engine is operating smoothly. Adjust the throttle lever stop screw so the engine will idle at 425-275 RPM in neutral.

Test Results

Engine running smoothly at specified idle RPM, vacuum reading between 18 and 21 inches and steady indicates: engine, ignition system and fuel system operating normally.

Vacuum reading less than 15 inches H.G. but steady indicates: late ignition timing, low compression, valves improperly seated, excessive mechanical drag in the engine.

Vacuum abnormally unsteady indicates: improper carburetor idle mixture, distributor points spacing, spark plug gapping, choke adjustment, valve adjustment, poor plug or carburetor condition, manifold air leaks, defective valves or uneven compression.

Major Engine Tune-Up

The major engine tune-up consists of all the operations in the "Minor Engine Tune-Up" plus the additional operations outlined below:

Clean and tighten the battery terminals and add water to the electrolyte if necessary.

Tighten all electrical connections.

Torque-tighten the cylinder head bolts to the proper specifications.

Torque-tighten the exhaust and intake manifold cap screws and nuts.

Adjust fan belt.

Clean and adjust carburetor automatic choke.

Make an exhaust gas analysis covering the idle system, main metering system, accelerating system.

(If the performance of the carburetor is non-standard, it should be removed and reconditioned, under a separate operation.)

Road test the car so that the engine performance under actual driving conditions can be tested. Note particularly the engine idle, acceleration and over-all performance. While the car is being road tested, make a safety check of the operation of brakes, steering, windshield wipers and horn. Check the operation of the turn indicator signal and all lights. Recommend any necessary repairs found during the road test.

ENGINE REMOVAL AND INSTALLATION

Engine Removal

Remove drain plug and drain engine oil pan. Remove hood assembly. Drain cooling system and remove radiator core. Remove water pump and manifold assembly. Disconnect heater hose at cylinder head (if car is so equipped). Disconnect and remove battery. Remove air cleaner.

Remove coil, bracket, distributor cap and ignition wiring as an assembly. Remove carburetor assembly. Disconnect power brake vacuum line at power cylinder (if car is so equipped). Disconnect vacuum hose at windshield wiper motor. Disconnect flexible fuel pump line. Remove generator assembly. Disconnect wire leads to water temperature and oil pressure indicator sending units. Disconnect engine ground wire at dash. Remove the screws at power steering pump bracket (if car is so equipped) and place the pump pressure lines and hose assembly out of the way. Remove valve tappet cover vent tube. Remove starting motor and flywheel housing lower cover. Disconnect exhaust pipe from the exhaust manifold.

Drain the transmission oil pan and remove transmission filler tube assembly. Disconnect oil cooler lines at the transmission. Loosen the transmission rear support bracket, *but do not remove bolts.* Support the transmission using a block of wood and a jack. Disconnect the throttle valve control linkage at transmission.

Remove the converter clutch housing to flywheel retaining nuts. Remove the bell housing to flywheel housing cap screws. Disconnect front motor supports at frame. Install a flexible lifting cable or rope around intake manifold and attach a chain fall or hoist. Clamp or wire the converter to the transmission case to keep the converter from sliding out of the transmission. Raise engine and slide forward to clear transmission and lift out of the chassis.

On cars equipped with standard transmission and overdrive, the transmission and overdrive should first be removed. (Note: The engine and transmission can be removed as an assembly by removing the front fenders and grille assembly.)

Installation of Engine

To install the engine, attach a cable or rope under the intake manifold, hoist the engine and lower into car, carefully guiding the engine so that the pilot on the converter clutch housing will enter the bore in the crankshaft, while at the same time the four studs on the clutch housing enter the holes in the flywheel. Install the front engine support insulator bolts and torque tighten to 55-60 lbs. ft. Unhook the hoist and remove the cable or rope from the intake manifold.

Remove the clamp or wire holding the converter to the bell housing and install the four converter to flywheel retaining nuts. Install the bell housing to flywheel housing bolts and torque tighten the bolts to 25 to 30 ft. lbs. Tighten the four converter to flywheel retaining nuts to 25 to 30 ft. lbs. torque. Remove the jack from under the transmission and tighten the rear transmission support bolts. Install flywheel housing lower cover, starter motor, and valve tappet cover vent tube. Connect transmission throttle valve control linkage and adjust linkage correctly. Connect exhaust pipe to manifold.

(Install power steering pump assembly if car is so equipped and tighten drive belt to specifications. See power steering section.) Install generator, and tighten drive belt to specifications. (See electrical section.)

Connect engine ground wire to dash, and connect wire leads to water temperature and oil pressure indicator sending units. Connect flexible fuel pump line, and vacuum hose to windshield wiper motor. Connect power brake vacuum line, (if car is so equipped). Install coil, bracket, distributor cap and ignition wiring. Install carburetor assembly and con nect up linkage and vacuum line. Install batter and air cleaner. Install water pump and manifol assembly and radiator core. Connect heater hose an tighten all hose connections.

Fill cooling system. Fill transmission with oi Service engine with oil. Set ignition timing. Adjus carburetor idle. Install hood assembly. Road test th car for satisfactory engine performance.

Note: To install the engine stand mounting Bar J-5957, it will be necessary to remove the right bank exhaust manifold, right front motor support insulation, and the oil level indicator tube assembly. Mount the bar at right side using the 4 threaded holes for the motor mount and the 4 special bolts supplied. The block is held at the rear of the bar by a clamp. See Fig. 15.

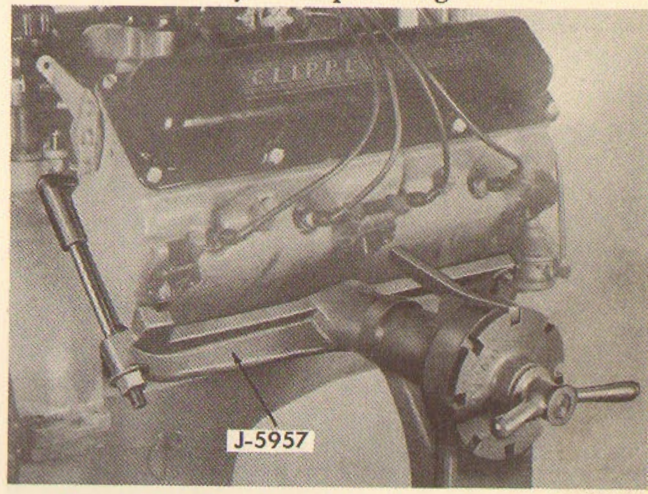


Figure 15—Engine Mounted on Reconditioning Stand

CRANKSHAFT REMOVAL AND INSTALLATION

Crankshaft Removal (Engine Removed)

After the engine is removed and placed on the engine stand, remove the engine oil pan.

To remove engine vibration damper assembly, use vibration damper remover J-5992. Remove vibration damper retainer screw and washer. Install the center adapter J-5992-2 in threads in the end of the crankshaft. Install screw assembly J-5992-3 in remover body J-5992-1 and remove the damper. Figure 16.

Note: If cars are equipped with power steering and/or air conditioning, it will be necessary to remove the drive pulleys before the vibration damper remover can be installed. The pulleys can be pried off after the retainer screw has been removed.

Remove fuel pump, engine gear cover, chain and camshaft sprockets by following the procedure outlined under Camshaft Removal. (See Page 25)

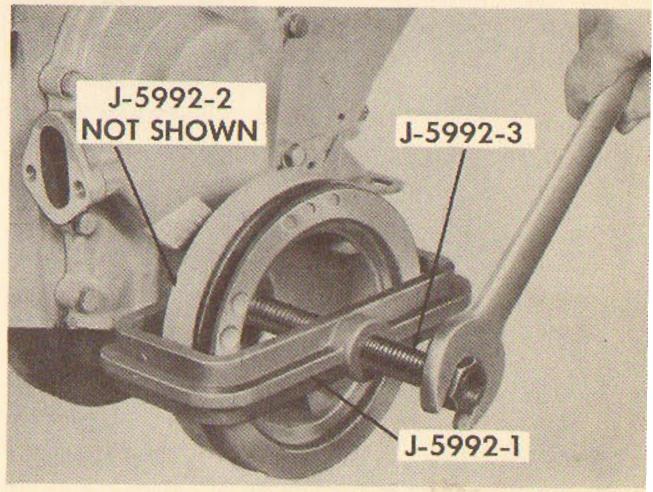


Figure 16—Pulling Vibration Damper

Disconnect vacuum pump line at side of crankcase Remove the two oil pump attaching screws and remove the oil and vacuum pump and strainer assemblies

Remove all connecting rod bearing caps and the lower bearing halves, and push connecting rods and piston assemblies up into cylinder bore so that they will not interfere with removing and replacing the crankshaft. Remove the main bearing caps and lift out the crankshaft and flywheel assembly. If necessary, the flywheel can be removed by removing the six screws attaching the flywheel to the flange on the crankshaft.

Crankshaft Installation (Engine Removed)

When installing a new crankshaft always use new oil seals and main and connecting rod bearing inserts.

Check all crankshaft journals for scratches and burrs. Be sure all oil passages are free from dirt.

Install a new crankshaft rear oil seal in the provided groove in the crankcase upper half, using crankshaft rear oil seal installer J-3048-A. Apply Lubriplate in the groove of the crankcase. Start the seal in the groove with fingers, and use the installer tool and hammer to drive the seal in place. With the tool still in place, trim off the ends of the seal flush with the surface of the block.

Install the oil seal in the rear main bearing cap in the same manner. See Figures 17 and 18.

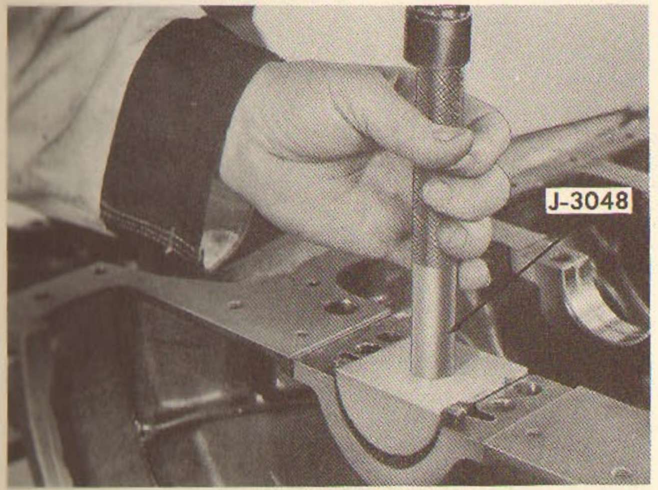


Figure 17—Installing Rear Main Bearing Oil Seal in Cylinder Block

Install the new upper halves of the bearings in the crankcase bores. Be sure they are properly seated, with the ear of each bearing properly located in its machined notch in the bearing bore. Lubricate all the bearings with clean engine oil. Install the crankshaft by carefully lowering into the bearings. Install bearings in the bearing caps so that respective numbers correspond with the numbers on the crankcase, and the word "*front*" faces towards the front of the engine.

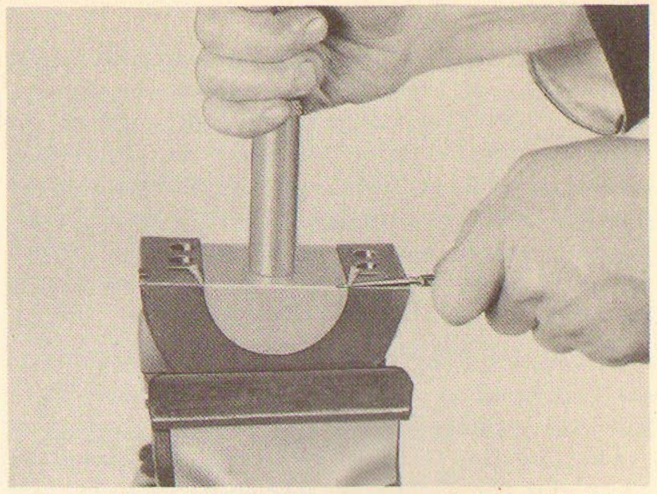


Figure 18—Installing Oil Seal in Rear Main Bearing Cap

Install the attaching screws and torque tighten to 90-95 ft. lbs.

Check the free rotation of the crankshaft, and the crankshaft end play.

Checking Crankshaft End Play

Fasten a dial indicator at the rear of the engine to bear on the crankshaft. Apply pressure forward and rearward on the crankshaft, and take the reading. The

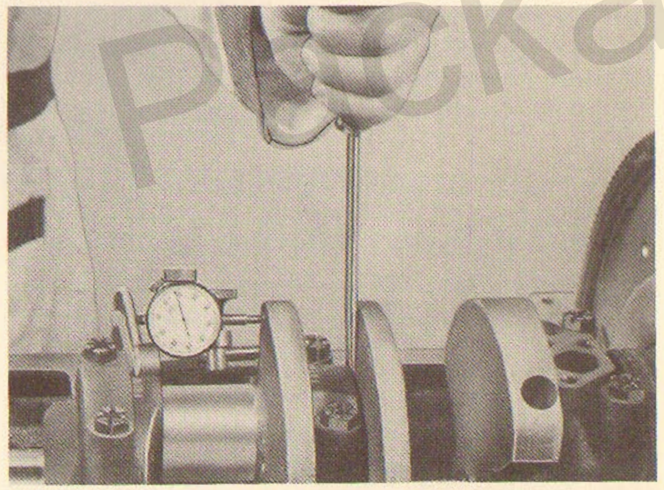


Figure 19—Checking Crankshaft End Play

crankshaft end play should be .0035″ to .0085″. End thrust is taken by the No. 5 rear main bearing. Figure 19.

A cast iron flywheel with a pressed-on steel starter gear is used with conventional clutch and transmission, while a pressed steel flywheel with a welded-on starter gear is used with Ultramatic. When installing the flywheel, check the cap screw threads and the threads in the crankshaft flange to be sure no burrs or

dirt are on the contacting surfaces. Figure 20. Torque tighten the flywheel self locking cap screw to 55 to 60 ft. lbs.

Install new bearings in the connecting rods and caps, and install caps on respective connecting rods. Torque tighten to 40-45 lbs. ft.

Install timing chain and sprockets. First rotate engine crankshaft to position No. 1 piston on firing stroke. Line up and center the timing marks on the sprockets and install the chain and sprockets.

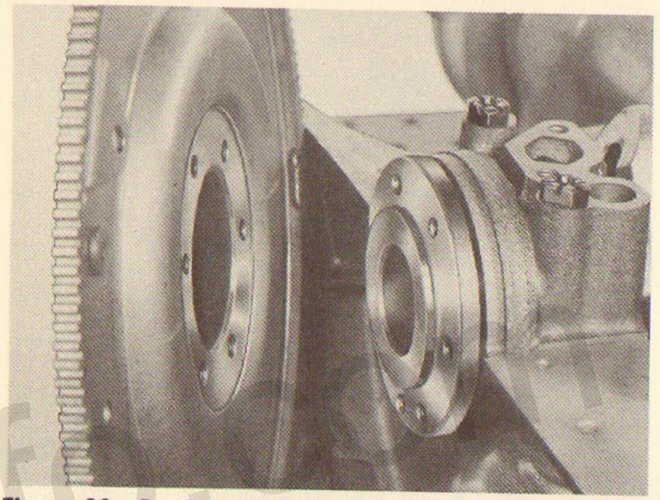


Figure 20—Be Sure Surfaces Are Clean When Installing Flywheel

Install fuel pump drive eccentric, and crankshaft oil slinger. Install a new oil seal in the chain case gear cover, and a new gasket and install cover, but do not tighten cover screws until after installing vibration damper.

Installation of Vibration Damper Assembly

To install engine vibration damper assembly, lubricate the oil seal in the gear cover, and position the damper over the crankshaft and start it in place by tapping with a rawhide hammer.

To complete the installation, the vibration damper installer J-5992 must be used. Assemble the installer by placing the ¾″ nut on the screw assembly J-5992-3, and slide the spacer J-5992-4 over the screw assembly. Start the screw in the end of the crankshaft and tighten until it bottoms in the threads. With one end of the spacer against the damper, turn the nut on the screw until the vibration damper hub bottoms the crankshaft oil slinger against a shoulder on the crankshaft. Install the vibration damper retainer washer and screw. Torque tighten the retainer screw to 130-150 ft. lbs. See Figure 21.

Complete the tightening of the screws in the gear cover, and install fuel pump. Install oil and vacuum pump assembly, and torque tighten the screws to 25-30 ft. lbs.

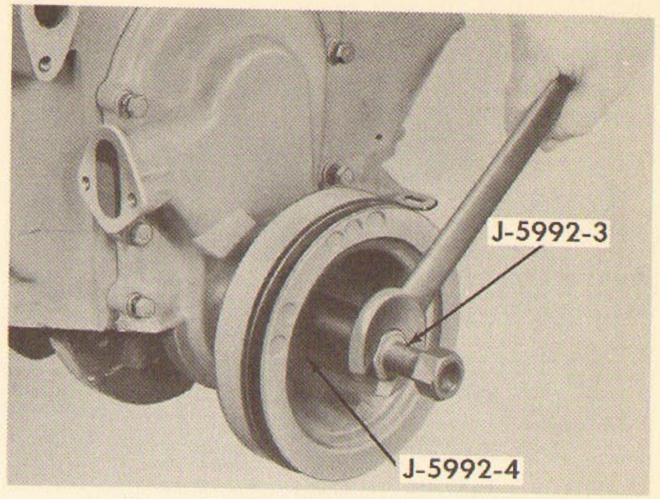


Figure 21—Installing Vibration Damper

Install engine oil pan, using a new gasket set. Be sure that the two end gaskets are properly seated in their grooves.

Note: The engine vibration damper assembly can be removed with the engine in car, by removing the radiator core and fan.

Checking Main and Connecting Rod Bearing Clearance

The Plastigage method can be used to measure the clearance between the main bearings and journals and clearance between the connecting rod bearing and crankpin.

Be sure the crankshaft bearing journals and bearing surfaces are clean from dirt. Place a piece of Plastigage the full width of the bearing surface on the crankshaft journal. Install the bearing cap and tighten the bearing cap bolts, to recommended torque.

Remove the bearing cap and insert, but do not disturb the plastigage. Compare width of the flattened plastigage at its widest point with the scale printed on the plastigage container. See Figure 22.

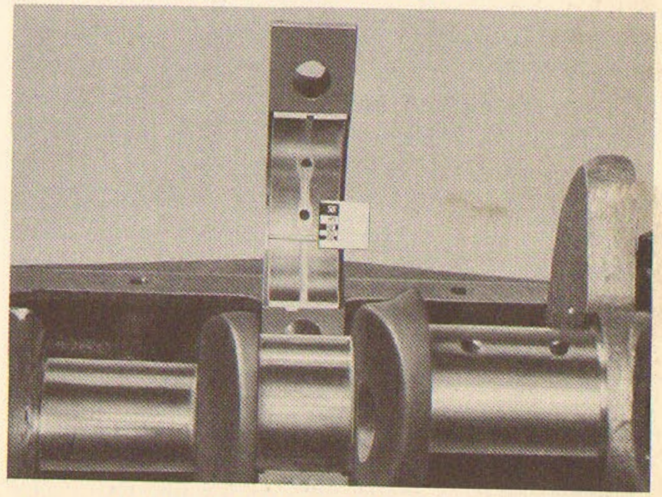


Figure 22—Checking Bearing Clearance with Plastigage

The reading indicates the bearing clearance in thousands of inch. Clearance for both connecting rod and crankshaft main bearings should be .0005″ to .0025″.

When making this check with the engine in car it will be necessary to set a jack under the crankshaft to take the weight off the bearing cap.

Removing and Replacing Crankshaft Main Bearing Upper Halves (Engine in Car)

The front four main bearing inserts are interchangeable, upper or lower. To remove the upper bearing half, use a flattened cotter pin in the oil hole in the crankshaft journal. Rotate crankshaft counterclockwise to remove the upper bearing half. To install, place new upper bearing half on crankshaft journal with the ear lined up with the notch in the bearing bore and rotate crankshaft clockwise. Figure 23.

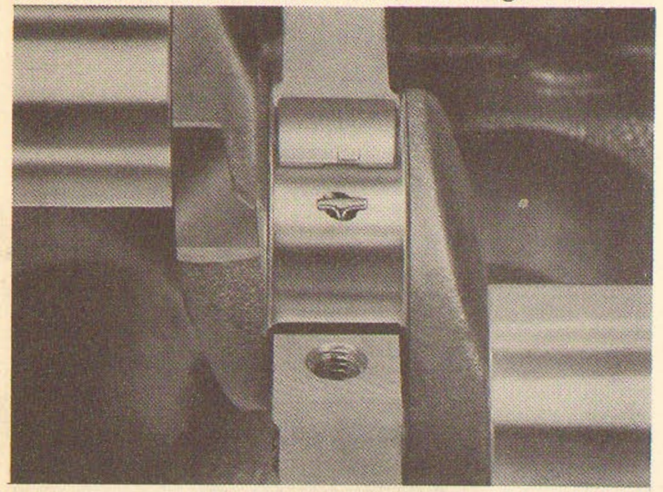


Figure 23—Installing Main Bearing Upper Halves

Crankshaft Removal (Engine in Car)

Remove transmission as outlined in the transmission section of this manual.

Drain the cooling system. Remove radiator core and top splasher. Drain and remove engine oil pan. Remove water pump and manifold assembly. Remove vibration damper assembly. Remove fuel pump. Remove gear cover and chain and sprockets. Remove oil and vacuum pump assembly. Remove spark plugs. Disconnect connecting rods, and push pistons assemblies up into cylinder bores so that the crankshaft can be removed without interfering with the connecting rods.

Remove front and rear main bearing caps. Support the crankshaft at the front and rear journals and remove the three intermediate main bearing caps. Carefully lower the crankshaft and flywheel assembly.

Installation of Crankshaft (Engine in Car)

Install new crankshaft rear oil seals in the upper crankcase and rear main bearing cap. Raise crankshaft into position and support. Install main bearing caps. Install connecting rods on crankshaft. Torque tighten all the main and connecting rod bolts to specified torque. Install new front crankshaft oil seal in engine gear cover. Install chain and sprockets, "being sure that the 'O' marks line up". Install fuel pump drive eccentric, crankshaft oil slinger and gear cover, using a new gasket on the gear cover. See Fig. 24.

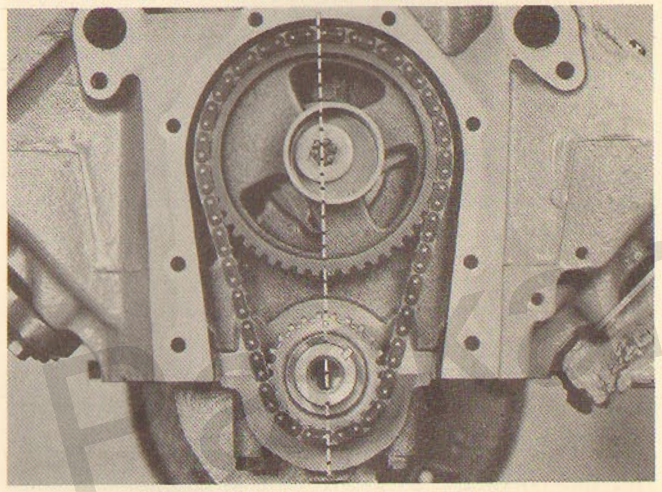


Figure 24—Line up the "O" Marks

Install vibration damper and fuel pump. Install water pump and manifold assembly. Install radiator core and top splasher. Install oil and vacuum pump assembly. Install engine oil pan. Install transmission. Fill cooling system with coolant, and service engine with oil. Install spark plugs and start engine. Set ignition timing and adjust engine idle. Road test car for performance.

PISTONS, PINS, RINGS

Removal of Engine Oil Pan

Drain the engine oil. Remove the screws attaching the steering idler lever to the frame and lower steering linkage.

Remove engine oil level indicator. On cars not equipped with the dual exhaust system the crossover exhaust pipe from left to right banks will have to be removed; on cars with dual exhaust, remove left exhaust pipe. Remove the starter motor and flywheel lower housing. Remove attaching screws and washers and remove oil pan.

Pistons

All pistons in the Packard V-8 engines are the aluminum alloy slipper-type pistons, are cam ground and have steel struts to control expansion and provide uniform clearance through all engine operating temperatures. The bearing surface is treated and tin plated. After the oil pan is removed the piston and connecting rod assembly can be removed from the top of the cylinder block. Figure 25.

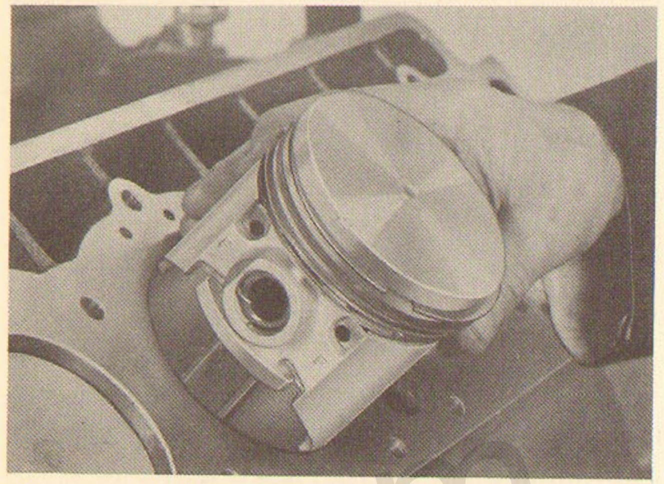


Figure 25—Removing Piston and Connecting Rod Assembly

Removing Ridge at Top of the Cylinder Bore

Before pistons are taken out it is necessary to remove any cylinder ridge at the top of the worn cylinder. Failure to do this may result in breaking the rings or damaging the ring land on the piston.

Note: Position and set the ridge reamer in the cylinder bore so it cannot cut down into the ring travel more than $\frac{1}{32}''$. For best results use a good standard make of ridge reamer. Figure 26.

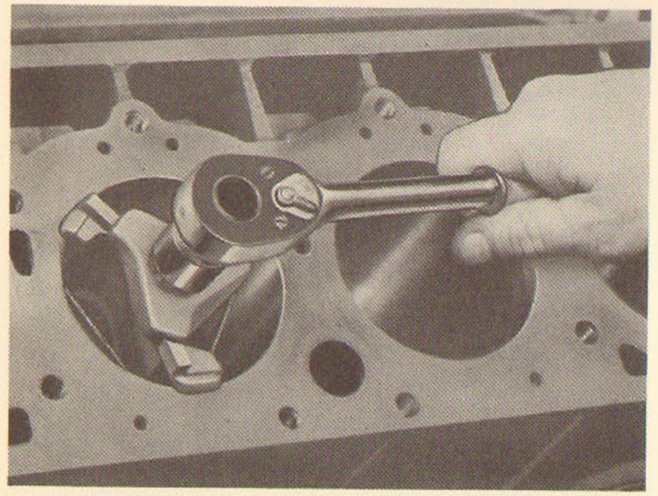


Figure 26—Removing Cylinder Bore Ridge

After the pistons and connecting rod assemblies are removed, wash in clean solvent. Dry the pistons with compressed air. Remove the piston rings from the piston, using piston ring expander K.M.O. 297R for the $3\frac{13}{16}''$ bore and K.M.O. 297V for the 4″ bore. Figure 27.

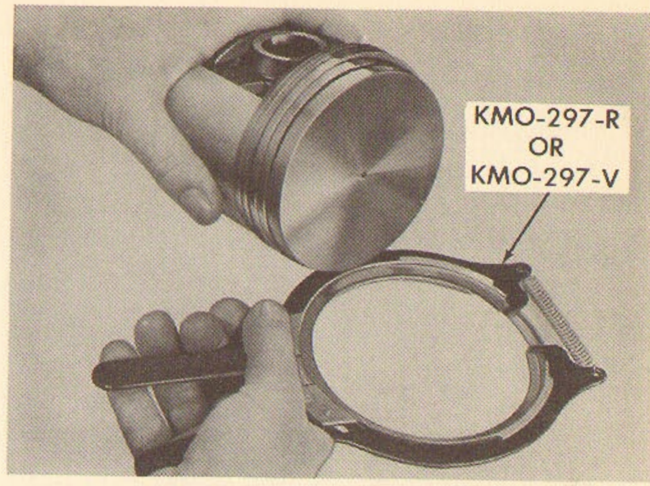


Figure 27—Removing or Installing Piston Rings

Inspect the pistons for cracked or worn ring lands, scores and corrosion. If the piston ring lands are worn or cracked, new pistons should be installed.

Measure the cylinder wall taper and out-of-round wear, using cylinder checking gauge K.M.O. 913. If the taper does not exceed .006″ and out-of-round does not exceed .003″ a new set of service rings can be installed with satisfactory results.

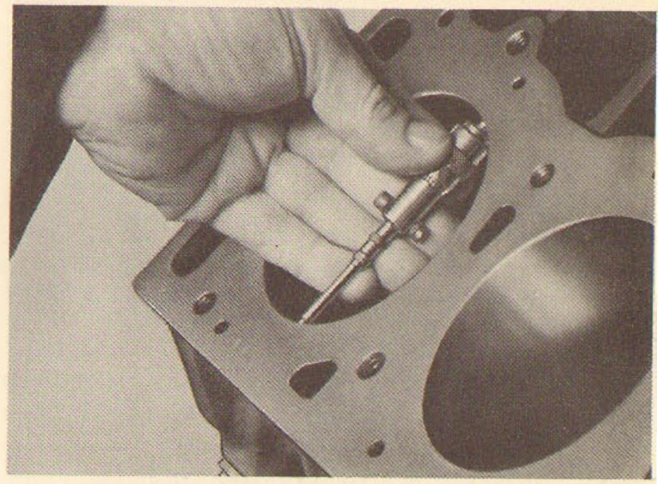


Figure 28—Measuring Cylinder Bore Wear

Measure the cylinder bore wear as shown in Figure 28 and record the measurement found at the point of greatest wear. Next, using a 3-4″ outside micrometer, measure the piston diameter at right angle to the piston pin. Figure 29. Subtract the piston measurement, and if the measurement is greater than .006″ the cylinders should be reconditioned and new pistons installed. (Oversize pistons are furnished in .010″, .020″, .030″ oversize.)

When reboring the cylinders they should be rebored to within .0015″ of the required oversize diameter, and then the cylinders should be honed to obtain the exact clearance.

A good reboring job will show a measurement of not *more than .0005" taper and not more than .0005" out-of-round.*

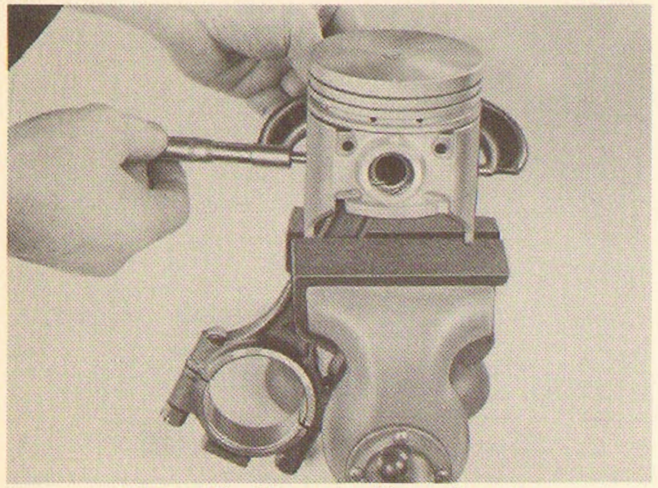


Figure 29—Measuring Piston Diameter

Caution: When reconditioning the cylinder walls the crankshaft and bearing crankpins should be covered to prevent cuttings, chips, and abrasives from getting into the oil passages. After the reconditioning is completed, the engine crankcase and crankshaft should be *thoroughly* cleaned of all foreign matter and particles. The cylinder walls should be cleaned, and all dust particles removed with the use of a clean rag soaked with engine oil.

Piston Fit in Reconditioned Cylinders

The slipper-type skirt pistons are cam ground, and machined to allow clearances of .021" at top land, .001"-.0015" at top of skirt and .001"-.0015" at bottom of skirt.

The pistons should be fitted to the cylinder bore with the greatest of accuracy. Clearance should be measured between the bottom of the skirt at right angle to the piston pin and the cylinder wall, and should fall within the limits of .001" to .0015".

The fitting should be done at normal room temperature (70°F.). All pistons should be selectively fitted to the individual cylinders, and then marked with the respective cylinder number. The clearance between the piston and cylinder bore can be checked by using a .0015" feeler gauge ½" wide and long enough to extend down into the cylinder bore the full length of the piston.

Place the feeler gauge against the side of the cylinder wall and insert the piston, without rings, in an inverted position in the cylinder bore. Push the piston down until the bottom of the skirt is slightly below the top of the cylinder block, with the piston pin bore parallel to crankshaft. Figure 30. Pull out the feeler gauge with a spring scale. Observe the reading on the scale when the feeler gauge is being withdrawn. The amount of pull necessary to withdraw the feeler gauge should be 6 to 11 lbs. *If the scale reading is not within these limits select another piston. Do not machine new pistons as the tin plating would be destroyed.*

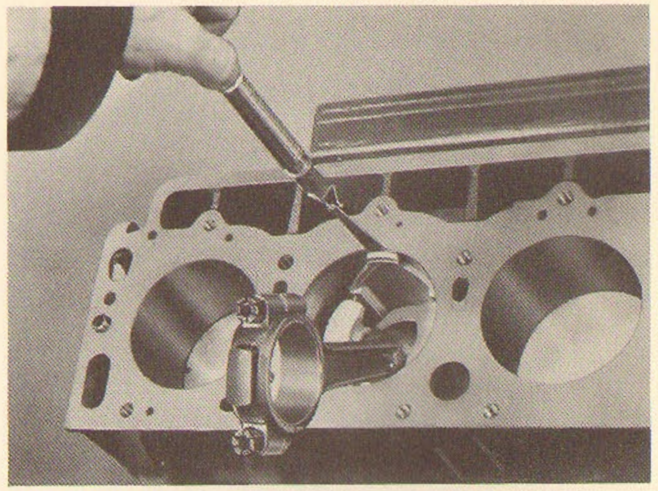


Figure 30—Checking Piston to Cylinder Fit

Piston Pin Fit in the Piston

Piston pins are available in standard and oversizes of .003" and .006". The piston pins should be fitted to a hand push fit after the piston has been heated in water to a temperature of 160°. When pistons are reamed or honed to accommodate oversize piston pins, care should be exercised to avoid removing an excessive amount of stock in the piston pin holes during the honing operation.

Piston Pin Bushing Replacement

A thin split type bronze bushing is used that must be expanded tightly into the bushing bore before it can be successfully reamed. If the bushing is not burnished or expanded into the rod, it may become loose, resulting in a burned-out bushing or scored piston pin.

After pressing the old bushing out of the rod, using an arbor press and remover tool, install a new bushing,

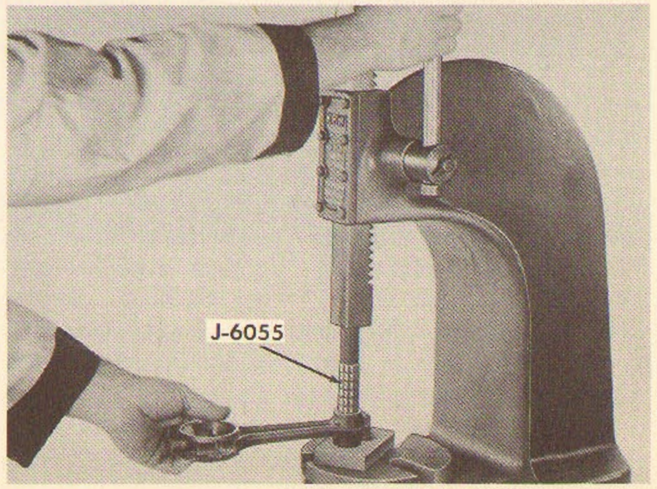


Figure 31—Burnishing Piston Pin Bushing

using the installer tool so that the bushing is flush with both sides of the rod.

Position burnishing tool J-6055 in the bushing. Then, applying the plate of the tool under the end of the rod, push the burnisher through the bushing. Figure 31.

Piston Pin Fit in the Connecting Rod

After the bushing has been burnished, and before reaming the piston pin bushing, the oil hole in the bushing should be drilled, using a 3/16" drill. Using a reamer or hone, fit the pin in the rod. The fit of the pin in the rod may be checked by inserting the pin in the rod and then holding the pin in a vise, using lead jaws to prevent damaging the pin. Place the rod in a horizontal position where it should slowly fall downward of its own weight. Figure 32.

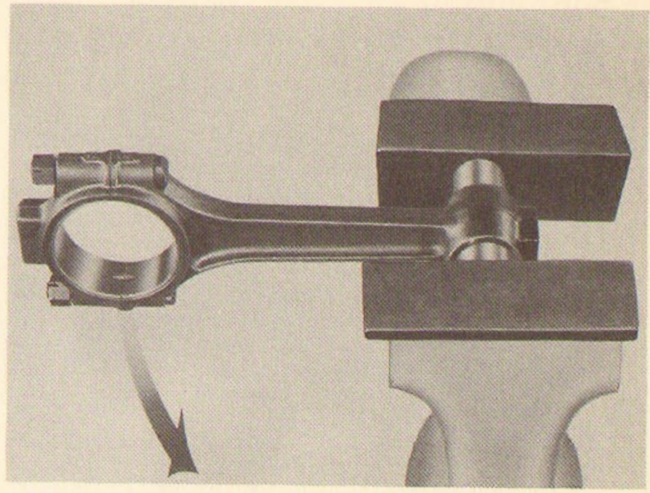


Figure 32—Checking Pin Fit in Connecting Rod

CONNECTING ROD ALIGNMENT

It is important that the connecting rods be in proper alignment before being installed in the engine.

To check the connecting rod alignment, use the connecting rod aligning jig J-3210-A and the connecting rod bending bar HM-3-12. Remove the bearing inserts, install the bearing cap and piston pin, and place the rod on the aligning fixture. Place the V block on the pin and move the arbor and rod toward the face plate. Figure 33.

The four pins in the face of the 'V' block are used to indicate a bent or twisted rod. If the two pins in a horizontal line at the top of the block contact the face plate and the lower pins do not, the rod is cocked or bent. If the two lower pins rest against the plate and the upper pins are away from the plate, the rod is bent in the opposite direction.

The pins in a vertical line on each side of the block may be used to check a twisted rod. If two pins in a vertical line contact the face plate and the other two pins do not, the connecting rod is twisted. When the rod is straight and no twist exists, all four pins in the 'V' block will contact the face plate of the aligning jig.

Note: When correcting a twisted rod, always bend the rod beyond the straight position and then bend back until straight, so as to relieve the strains that are set up by bending. If this is not done, the rod may not remain straight after it is installed in the engine.

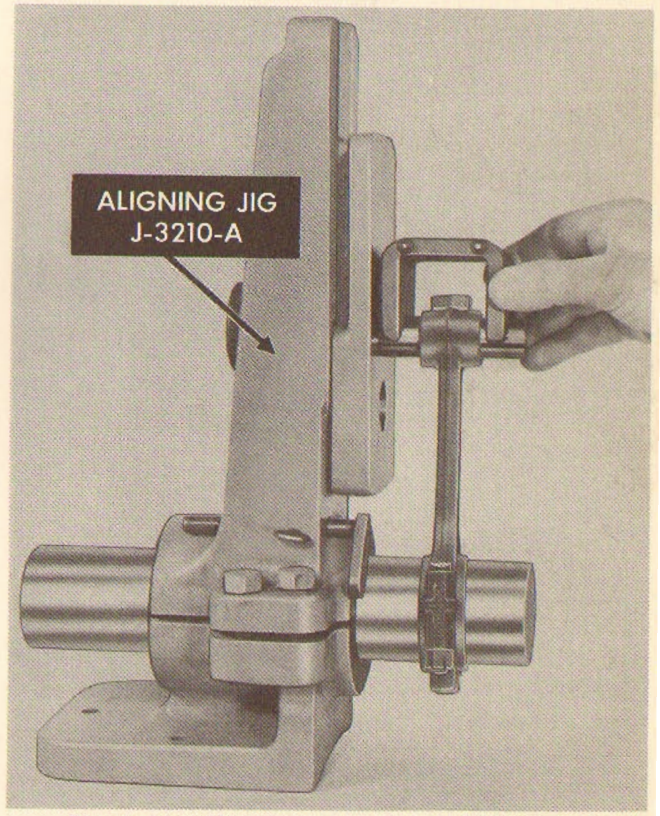


Figure 33—Checking Connecting Rod Alignment

ASSEMBLING CONNECTING RODS IN PISTON

To assemble the connecting rod in the piston, position the connecting rod in its respective piston so that when the assembly is installed in the engine the stamping 'F' on the face of the piston, and the small notch on the top edge of the piston, will be facing to the front of the engine, and the milled oil groove in the rod cap will be up and inward towards the camshaft. See Figure 34.

Note: *Heat piston in water to 160°F. when assembling pin in rod and piston.*

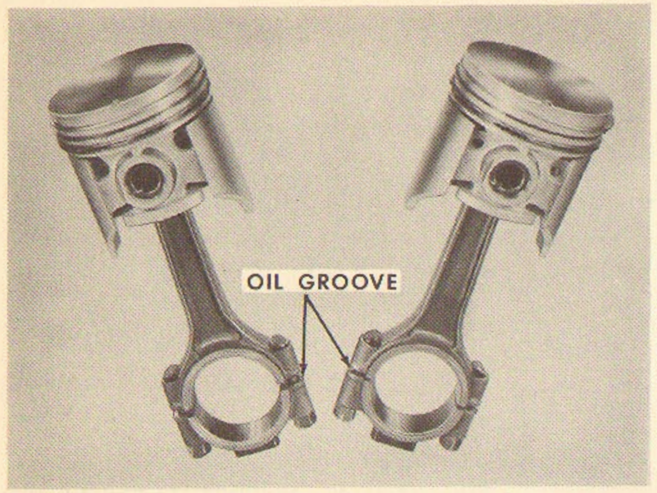


Figure 34—Position of Oil Groove to Mark on Piston

Piston Pin Lock Installation

After the piston pin has been installed in the rod and piston, the steel lock ring should be securely installed and seated in the groove in the piston boss. See Figure 35.

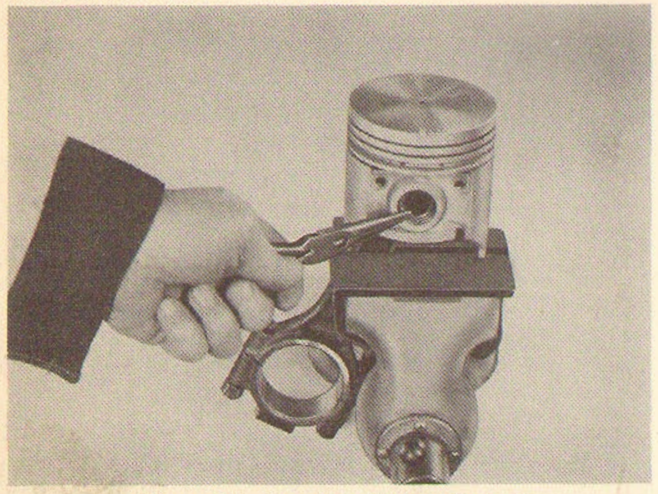


Figure 35—Installing Piston Pin Lock

Piston Ring Installation

The two compression rings and single oil ring are located above the piston pin. The upper compression ring is chrome coated. The lower compression ring is Ferrox coated. The uncoated oil (bottom) ring is ventilated with wide slots separating the narrow faces.

It is important that the piston rings be the correct size in diameter to assure correct ring-to-cylinder wall pressure. When cylinders have been rebored oversize, pistons and rings of corresponding size must be used.

Check the clearance between the ring and top land. When installing new piston rings they should always be checked for side clearance in the piston groove. See Figure 36. The side clearance is .0015″ to .005″. The ring should be free enough to rotate in groove of own weight.

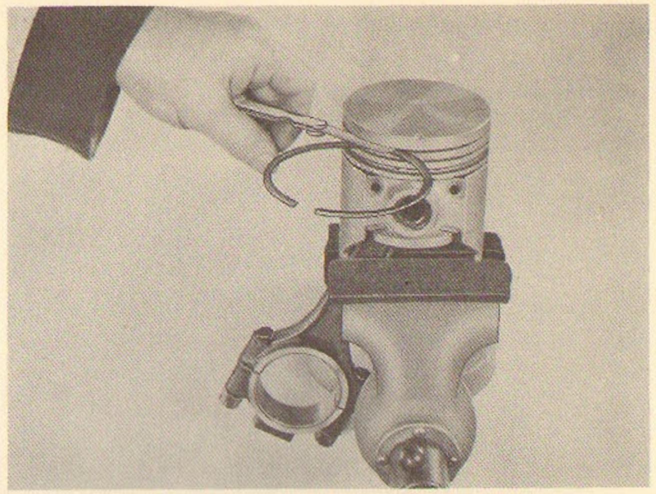


Figure 36—Measuring Piston Ring Side Clearance

Checking Piston Ring Gap

The piston ring gap should always be checked in the lower or less worn portion of the cylinder bore. Insert the ring in the cylinder and, using the head of a piston to align the rings, push the ring down in the lower portion of the cylinder bore. Then check the gap with a feeler gauge as shown in Figure 37. The ring gaps should be .015″ on the $3\frac{13}{16}$″ bore and .018″ on the 4″ bore.

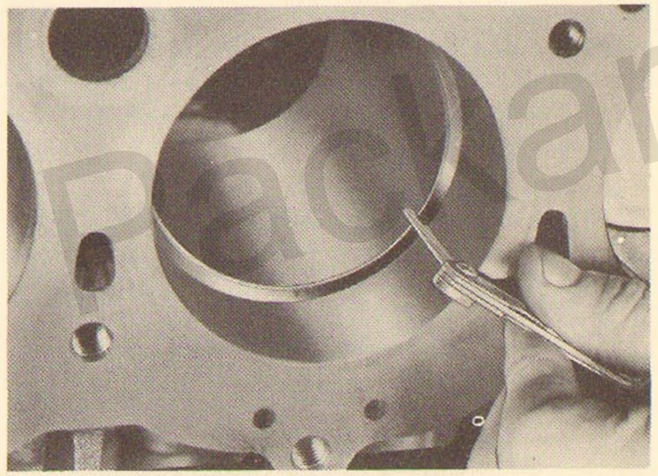


Figure 37—Checking Piston Ring Cap

When the rings are installed on the pistons, the piston ring expander tool should be used to prevent over-expanding or twisting the rings.

Install the oil ring expanding spring with the gap opposite camshaft side of piston. Install oil ring in bottom groove. Install the two top compression rings with the chrome ring in the top groove and with mark "Top" toward top of piston.

Note: *The inside groove on the compression rings must always be installed up.*

Place gap of top compression ring and oil ring towards camshaft side of piston (both banks). Place gap of second ring opposite camshaft side of piston (both banks). All gaps should be midway between piston pin bosses.

ENGINE

Installation of Piston and Connecting Rod Assembly

The connecting rods are attached to the crankshaft in pairs. The rods are numbered. Starting from the front of the engine the odd numbers are in the left bank, and even numbers in the right bank.

When installed in the engine, numbers on the rods are down and facing away from the block. The milled oil groove in the connecting rod cap, for lubricating the cylinder walls, is on the opposite side of the rod from the numbers, and when rods are installed in the engine the milled oil groove is up and inward towards the camshaft. (New service rods are not numbered, but are interchangeable in either bank on both engines.)

Rotate crankshaft until the bearing throw is in position for assembly of pistons 1-2 then 7-8; 3-4; 5-6.

Install the connecting rod bearing upper half into the connecting rod. Be sure the ear of the bearing enters the notched groove. Install connecting rod bolt guide J-6071 on the bolts to retain the bearing half in rod. See Figure 38.

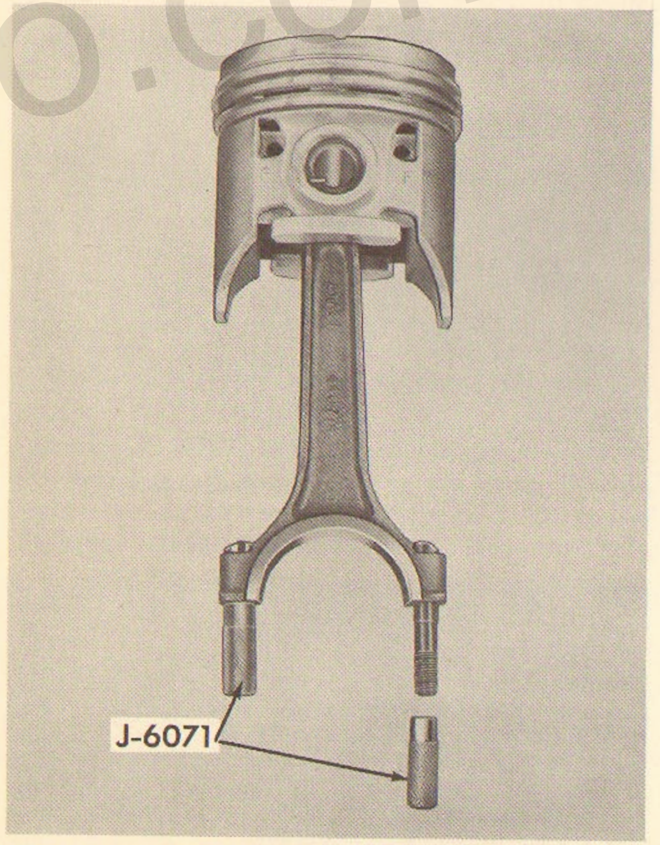


Figure 38—Connecting Rod Bolt Protector

Lubricate the entire piston assembly in caster oil or clean heavy engine oil. Lubricate the bearing half. Space the ring gaps in their proper positions on the piston. Place the piston installing tool J-5952 or J-5569 on piston and install piston and rod in cylinder bore with the notch on the piston toward the front. See Figure 39.

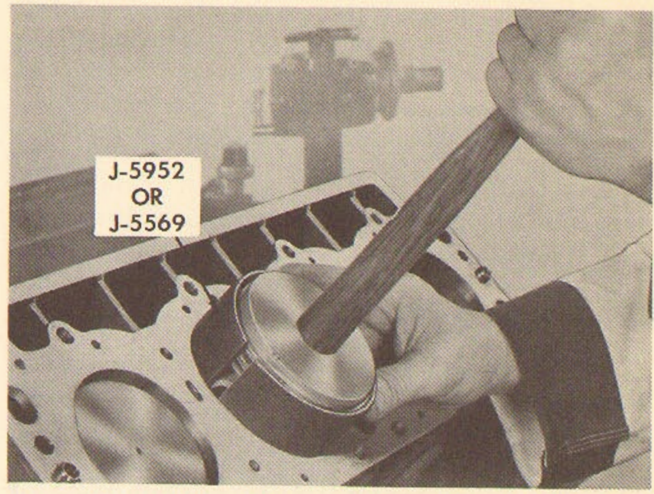


Figure 39—Installing Piston and Connecting Rod Assembly

Gently tap the piston down in the cylinder and position the connecting rod on the crankshaft. Remove the two connecting rod bolt guides and install the connecting rod cap and bearing over the connecting rod bolts, being sure the numbered side of cap corresponds with the number on the side of rod, and that the milled oil groove is towards camshaft. Install connecting rod bolt nuts and torque tighten to 40 to 45 ft. lbs.

Check connecting rod end play for .003″ to .0011″ (two rods). See Figure 40.

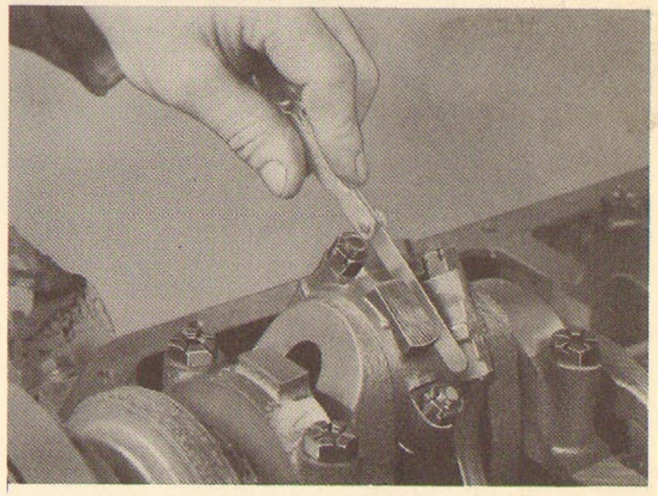


Figure 40—Checking Connecting Rod End Play

Caution: Use new connecting rod nuts if the old ones fit loosely on the connecting rod bolt thread. The nut is the self-locking type, and a new one is recommended if there is any doubt of a proper fit.

Install oil pump and vacuum pump assembly, and engine oil pan.

Installation of Engine Oil Pan

Using a new gasket set place the two side gaskets on the oil pan, holding them in place with cotton cord or cement. Install the two end gaskets in the rear main bearing cap and bottom of the gear cover, being sure they are in place and properly seated. Install the oil pan and start the attaching screws. Tighten the two longer screws at the front and rear ends of the oil pan before tightening the other screws.

Torque tighten oil pan screw 15 to 18 ft. lbs. Install steering idler lever bracket to side of frame. Install engine oil level indicator. Install flywheel lower housing. Install starter motor and exhaust pipe. Install and tighten oil pan drain plug and service engine with oil.

Install cylinder heads as outlined under "Servicing Valves, Guides, and Tappets." Set ignition timing and adjust engine idle.

Starting and Operating a Reconditioned Engine

Start the engine and operate it at approximately 1200 RPM or the equivalent of 25 to 30 MPH, and maintain this speed until the engine temperature reaches 160 to 180 degrees Fahrenheit.

The common practice of starting a reconditioned engine and letting it idle slowly has resulted in a high percentage of piston ring failures. At idle speeds, insufficient engine oil is sprayed onto the cylinder walls, pistons, and rings to lubricate them properly during the break-in period. The recommended speed of 1200 RPM will insure lubrication to these moving parts and will prevent scuffing during this critical period.

SERVICING THE VALVES, GUIDES AND TAPPETS

Removal of Cylinder Head

Drain the cooling system at the radiator drain cock. Remove generator (right bank) or remove fan belt (left bank). Remove the fan, water pump, and manifold assembly. See Figure 41.

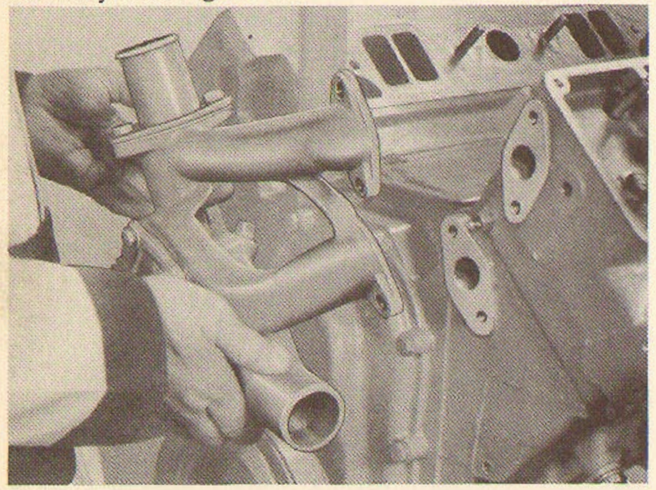


Figure 41—Removing Water Pump and Manifold Assembly

Remove the air cleaner. Remove the ignition coil and bracket, disconnect the ignition cables, and place the coil and wiring out of the way. Remove the carburetor and intake manifold assembly. Figure 42.

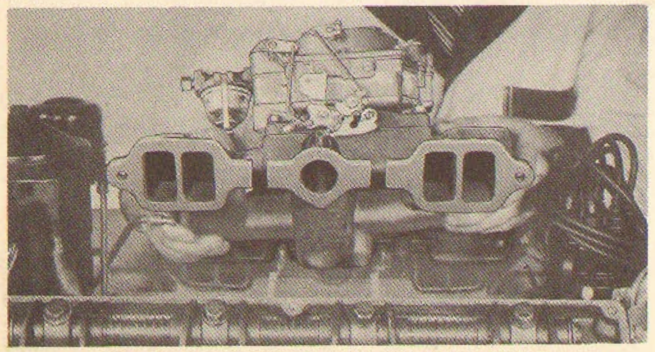


Figure 42—Removing Carburetor and Manifold Assembly

Remove the valve cover. Remove the four bolts attaching the rocker lever shaft to the cylinder head and lift off the rocker lever shaft assembly. Figure 43.

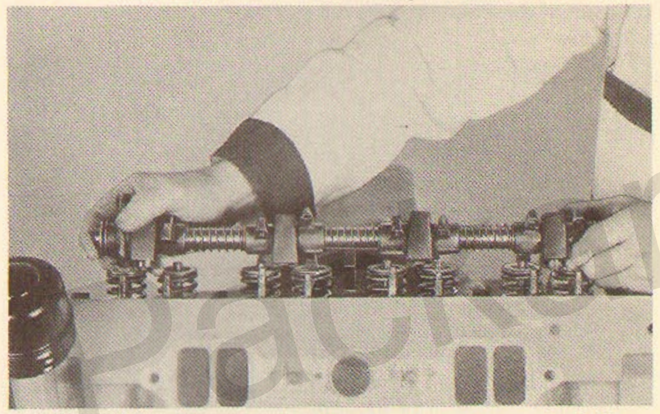


Figure 43—Removing Valve Rocker Lever and Shaft Assembly

Disconnect the exhaust manifold from the exhaust pipe. Remove the cylinder head bolts. Install the cylinder head lifter J-4159 in the front and rear spark plug holes and lift off the cylinder head. Figure 44.

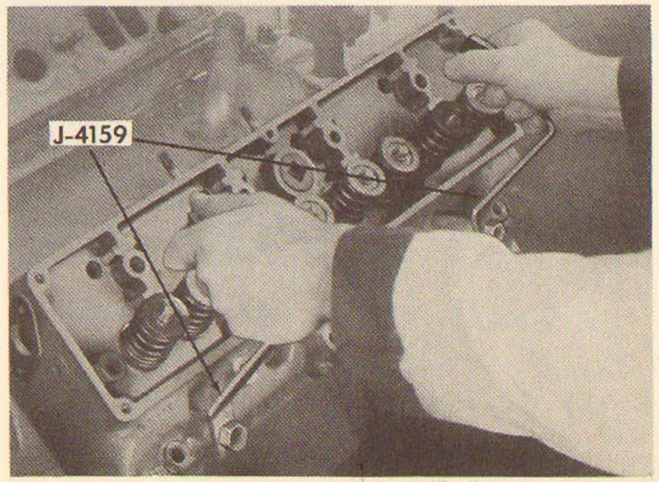


Figure 44—Removing Cylinder Head

Note: To remove right bank cylinder head it will be necessary to remove the heater if car is so equipped. The oil level indicator will also have to be removed.

On cars equipped with Twin Ultramatic Transmissions the filler tube assembly will have to be removed. On removing the left bank head the oil filter and bracket will have to be loosened from the cylinder head. On cars equipped with Power Steering the bracket bolts will have to be removed and the pump and hose assembly moved out of the way.

Removing and Checking Valve Springs

With the cylinder head removed, place the cylinder head in the Valve Spring Compressor J-5988.

Note: To place the cylinder head in the Valve Spring Compressor J-5988 it will be necessary to remove the exhaust manifold, throttle cross-shaft bracket, and water temperature indicator sending unit.

Compress the spring and remove the two valve spring locks, valve spring seat and spring. See Figure 45.

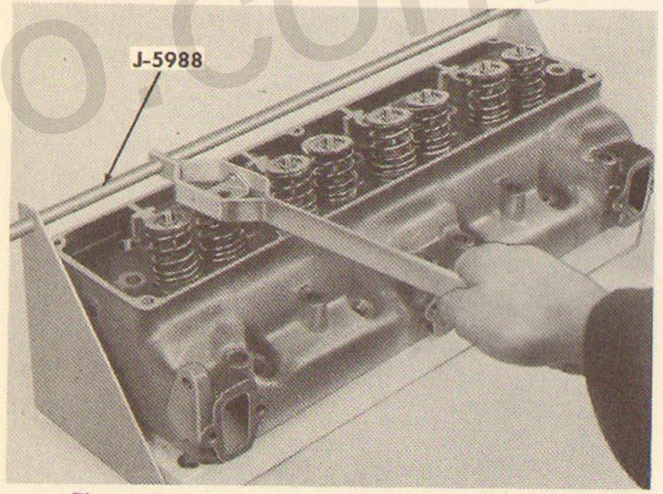


Figure 45—Removing Valve Springs and Valves

Check all springs and if signs of rust, the springs should be replaced. Using a valve spring tester check the valve spring pressure, the pressures are the same on both intake and exhaust. 78 to 86 lbs. at 1¾" (Valve closed)—158 to 172 lbs. at 1⅜" (Valve open).

When installing the valve springs, assemble the end with the two closely wound coils against the cylinder head.

Refacing the Valves

The use of a wet type valve refacer is recommended. The equipment should be checked periodically for accuracy.

The grinding wheel should be dressed and trued up before attempting to use it. Set the graduated swivel for the proper valve seat angle—intake valve seat angle 30°, exhaust valve seat angle 45°. Figure 46.

When refacing the valves take a very light cut to insure a smooth surface on the face of the valve. After refacing the valves check the thickness of the valve head edge and if less than $\frac{1}{32}$" the valve should be replaced.

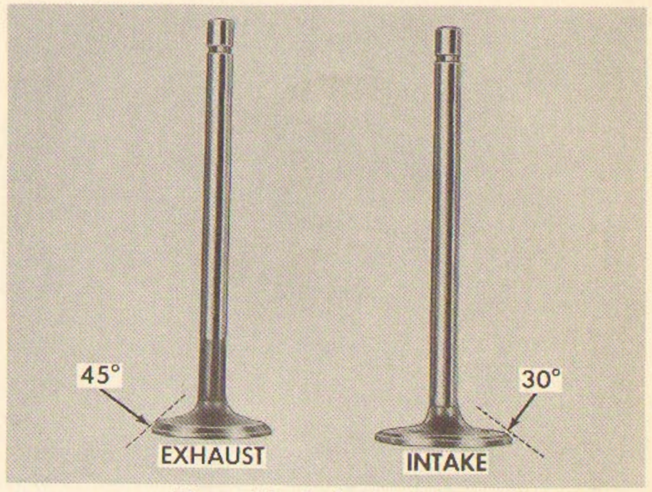


Figure 46—Refacing Valves

Check the valve stem ends. If cupped or pitted, face off the ends and re-chamfer if necessary. Never remove more than .010".

Reaming Valve Guides

The valve guides are integral with the cylinder head and are not replaceable. When the valve stem and guide clearance becomes excessive, the guide bores in the cylinder head will have to be reamed and valves with oversize stems installed. Valves are available in .003", .010", .020", .030" oversizes.

Four special oversized reamers are available in Valve Guide Set J-6042 which will provide the desired clearance of .001" to .002" between the inlet valve stem and guide and .002" to .003" between the exhaust valve stem and guide. See Figure 47.

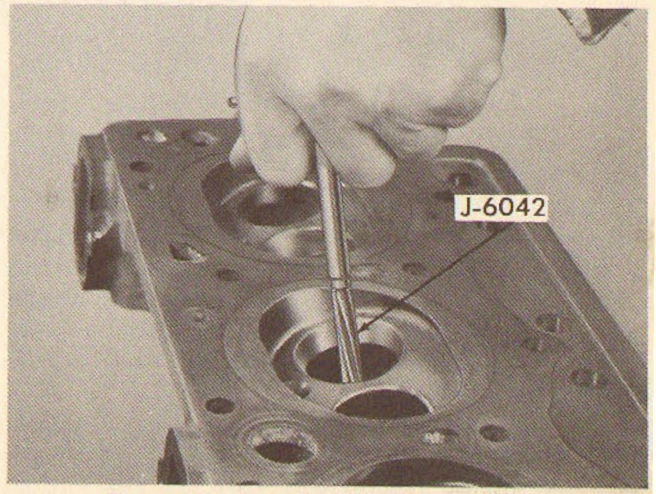


Figure 47—Reaming Valve Stem Guide

After the valves have been removed from the head, clean the valve stems and guides. Carefully inspect the valve stems and guides for scores and wear. Check the valve stem to guide clearance by placing each valve in its respective guide bore, and measuring the side-to-side play *crosswise* to the cylinder head. See Figure 48.

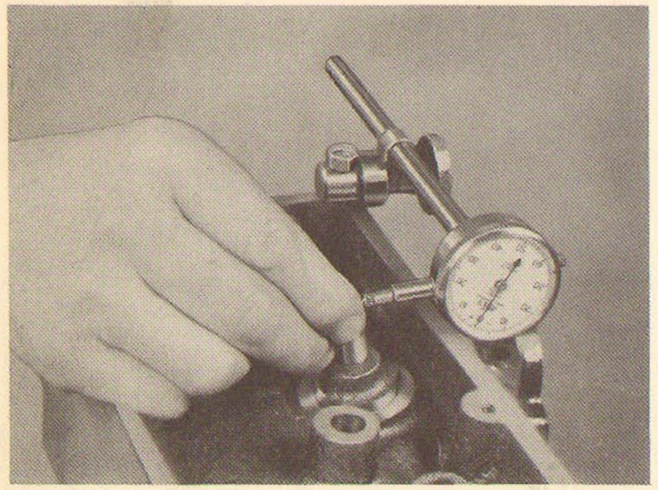


Figure 48—Valve Stem to Guide Clearance

This can be done by the use of a dial indicator or narrow strips of feeler gauge material placed between the valve stem and guide bore. If the clearance is greater than .004″ on the intake and .005″ on the exhaust the guides should be reamed and oversized valves installed.

Select the desired oversize valve and the proper pilot and reamer to be used.

Refacing Valve Seats in Cylinder Head

Reface each valve seat using a reliable and accurate power valve seat refacer. The grinding wheels of the refacer should be accurately dressed to the proper angles. The intake valve seat should be ground to 30° angle. The exhaust valve seat should be ground to 45° angle. See Figure 49.

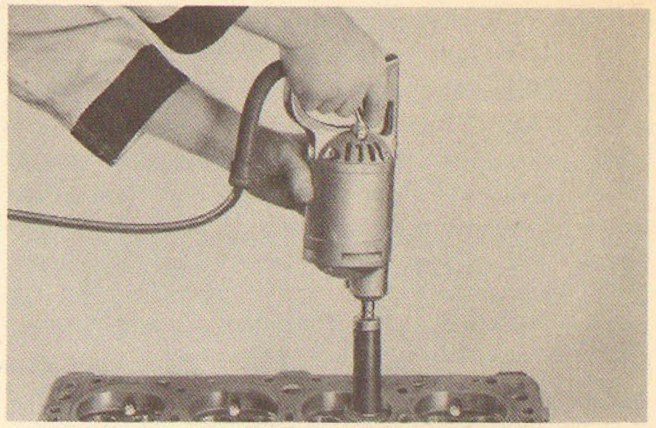


Figure 49—Refacing Valve Seat in Cylinder Head

The intake valve seat width is $\frac{3}{64}$″. The exhaust valve seat width is $\frac{5}{64}$″, being wider than the intake seat for the purpose of cooling the exhaust valve head. If the valve seat is too wide when reconditioned it should be narrowed by using the proper angle stones 15° at the top and 75° at the bottom of the valve seat.

Checking Valve Seat Run-Out

Check the valve seat run-out with an accurate gauge. Run-out should not exceed .002″ total indicator reading. Figure 50.

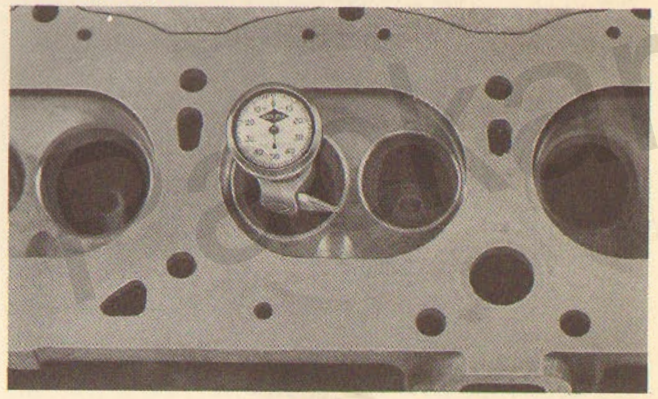


Figure 50—Checking Valve Seat Runout

CYLINDER HEAD INSTALLATION

Be sure the head is free from carbon and other foreign matter. Inspect the milled gasket contact surface of the cylinder head and install a new cylinder head gasket. The gaskets are interchangeable from right to left bank, but are marked for the proper side up. Coat the gasket with a light film of Perfect Seal No. 5. Two dowels are provided on the top of the cylinder block to hold the gasket in place and to pilot the cylinder head. (These dowels are drilled and also provide a return for the surplus oil in the rocker lever chambers.) See Figure 51.

Using the cylinder head lifter tool, install the head in place over the dowels. Install the flat washers on the cylinder head bolts and start the five medium length bolts in the center holes of the head. Install

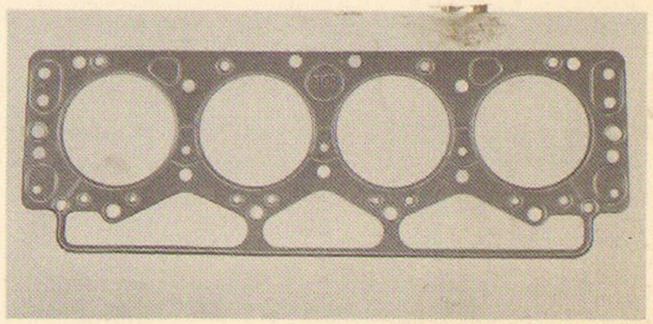


Figure 51—Install Gaskets "TOP" as Marked

the valve push rods, being sure they engage in the sockets in the valve lifters, and carefully install the valve rocker lever shaft assembly. The two end rocker shaft mounting brackets are doweled to line up with

the bosses on the cylinder head. Use the four longest cylinder head bolts and tighten them equally, and at the same time place the push rods in their respective sockets in the rocker levers. Install the short cylinder head bolts along the lower edge of the cylinder head and tighten all bolts in sequence shown in Figure 52.

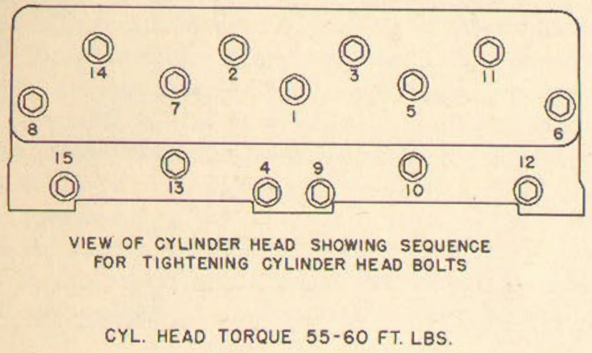


Figure 52—Torque Tightening Sequence

Torque tighten cylinder head bolts to 55 to 60 ft. lbs. Figure 53.

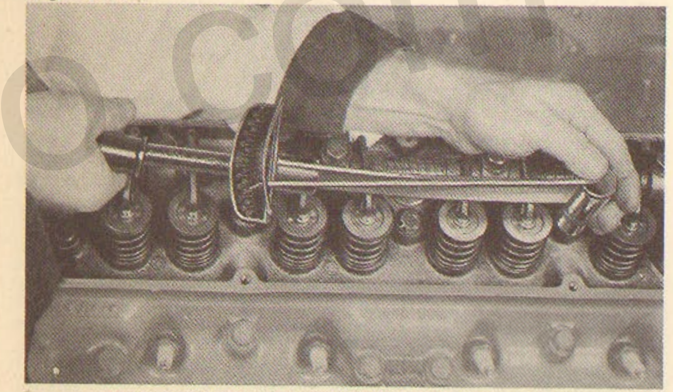


Figure 53—Torque Tighten Cylinder Head

Connect the exhaust pipe to the manifold. Using new gaskets, install the carburetor and manifold assembly, and connect up the throttle linkage and vacuum line. Install the ignition coil and wiring. Install the water pump and manifold assembly using new gaskets. Install generator, and/or fan belt, and adjust fan belt to proper tension. Install valve covers, and air cleaner. Adjust carburetor idle.

Checking Valve Tappet Clearance

The valve tappet clearance or dry lash must be checked *with no oil in the compression chamber of the tappet and the plunger completely bottomed. The tappet must be on the base circle of the cam.*

With the piston on the compression stroke and both valves closed, press downward on the push rod end of the rocker lever to compress the plunger spring and force the plunger to its bottom position. While still holding down on the rocker lever, measure the lash. The clearance between the valve stem end and rocker lever tip should be .050″ to .210″. Figure 54.

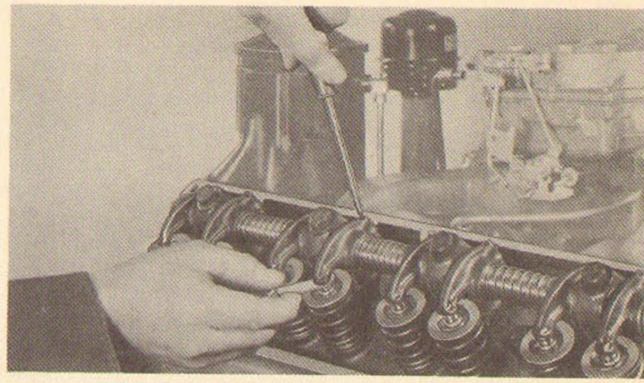


Figure 54—Checking Valve Tappet Lash

When the tappets have not been removed for servic ing, the lash can be checked by rotating the engin until the valve is open and allow to stand for severa minutes. The valve spring load will cause the tappe to leak down and force the tappet downward. Wit the plunger in this position, hold down on the rocke lever to keep the plunger spring compressed an rotate engine until the valve is closed, then check th clearance.

Removing Hydraulic Tappet Assembly

The hydraulic tappets can be removed from th engine crankcase with the use of the Valve Tappe Remover J-5962 or a wire hook. See Figure 55.

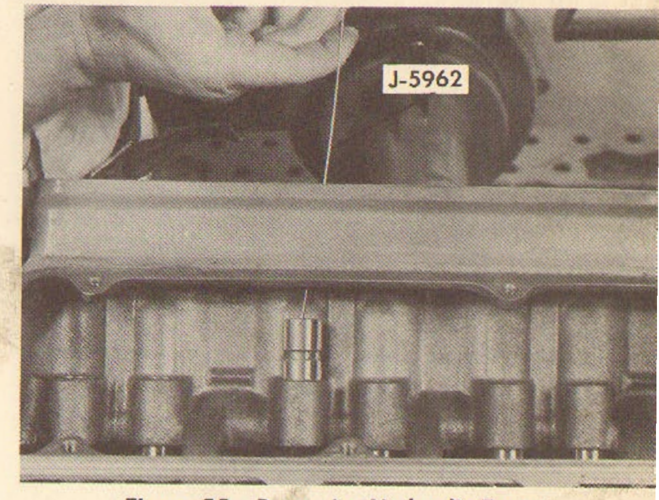


Figure 55—Removing Hydraulic Tappet

Hydraulic Tappet Assembly

The hydraulic tappets are of a stub type with an integral flat check valve and coil spring. The tappet assembly consists of a body, plunger spring, retainer check valve coil spring, flat check valve, plunger, push rod socket and snap ring. See Figure 56.

The hydraulic tappet is a fairly simple positive action unit. Oil supplied to the hollow plunger feeds down through the check valve which admits the exact amount of oil lost due to leakdown for each lift cycle, thus keeping the compression space replenished.

Servicing Hydraulic Tappets

Hydraulic tappets should be serviced when they are definitely noisy and when the engine is overhauled. A *loud* clicking noise is usually the result of the plunger's being stuck below its normal operating position; or the check valve may not be sealing due to dirt or a damaged seat. A *light* clicking noise indicates that the plunger is operating only slightly below its normal position due to a slight leakage of the check valve or plunger. *Intermittent* noise is the result of chips or dirt. When all tappets are noisy, the usual cause is an insufficient supply of oil reaching the tappets. Dirt, chips and varnish generally cause only a few of the units to become noisy at any one time.

Before disassembling the tappets they should be washed in clean solvent to remove the excess oil and soften any gum deposits. The tappets should be taken apart and serviced one at a time, to avoid mixing the plungers and bodies. *This is very important, as these parts are selectively fitted to give a predetermined leakage of oil (called leakdown) under load.*

Tappet Disassembly

Press down on the valve push rod socket and use a pair of needle nosed pliers to remove the lock ring. Remove the push rod socket, plunger, and the plunger spring. Remove the check valve assembly from the plunger, being careful not to lose the small flat valve and coil spring.

Cleaning Tappets

Using a suitable container and clean solvent, thoroughly wash all parts and remove any varnish or gum condition from the plunger and inside of the tappet body. Inspect plunger and the walls of the body for scratches.

Note: If the plunger or body is scratched the complete unit will have to be replaced as the plunger from one tappet body cannot be used in another body.

Try the plunger for fit in the body. If the check valve assembly was removed from the plunger, inspect the flat check valve, spring and seat. After all parts have been washed and inspected, reassemble as shown in Figure 56. The lock ring can be installed in the same manner in which it was removed.

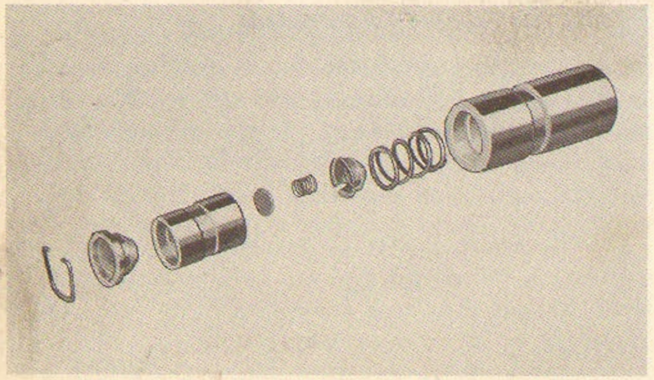


Figure 56—Hydraulic Tappet, Disassembled

Testing Hydraulic Tappets

Use a clean container deep enough to cover the tappet assembly (in an upright position). Fill the container with clean kerosene. Remove the push rod socket and place the tappet in the kerosene in an upright position, allowing it to fill up. Remove the tappet and replace the push rod socket. Place the tappet assembly between the jaws of the checking tool J-5978. Check the leakdown by depressing the tool. A decided resistance should be noticed. If the plunger collapses immediately, the tappet should be inspected again, or replaced with a new one. Fig. 57.

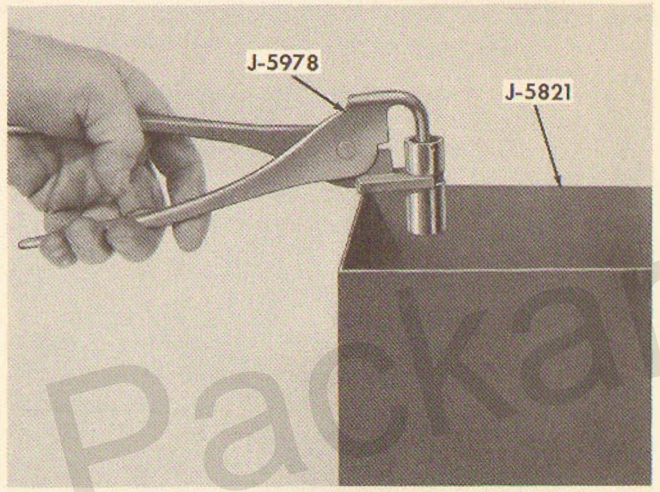


Figure 57—Testing Hydraulic Tappet

Valve Rocker Levers and Shaft Assembly

After the rocker lever shaft assembly has been removed it can be disassembled by removing the cotter pins, and flat and wave washers from the end of the shaft. Remove rocker levers, springs and supports from the shaft, keeping all parts in order so they can be replaced in the original position, unless new parts are needed.

Clean and inspect all parts, making sure that all oil holes are open. Inspect the shaft and rocker levers for wear. Inspect the rocker lever radius at valve stem end, and if worn replace the rocker lever. Inspect the plugs for being tight in the end of the rocker shaft.

Note: When assembling the rocker lever shaft, the shaft must be assembled with the grooved oil hole in the downward position, or facing the cylinder head. Figure 58.

There is a left and right rocker lever *and if reversed in assembly they will not properly contact the valve stem.*

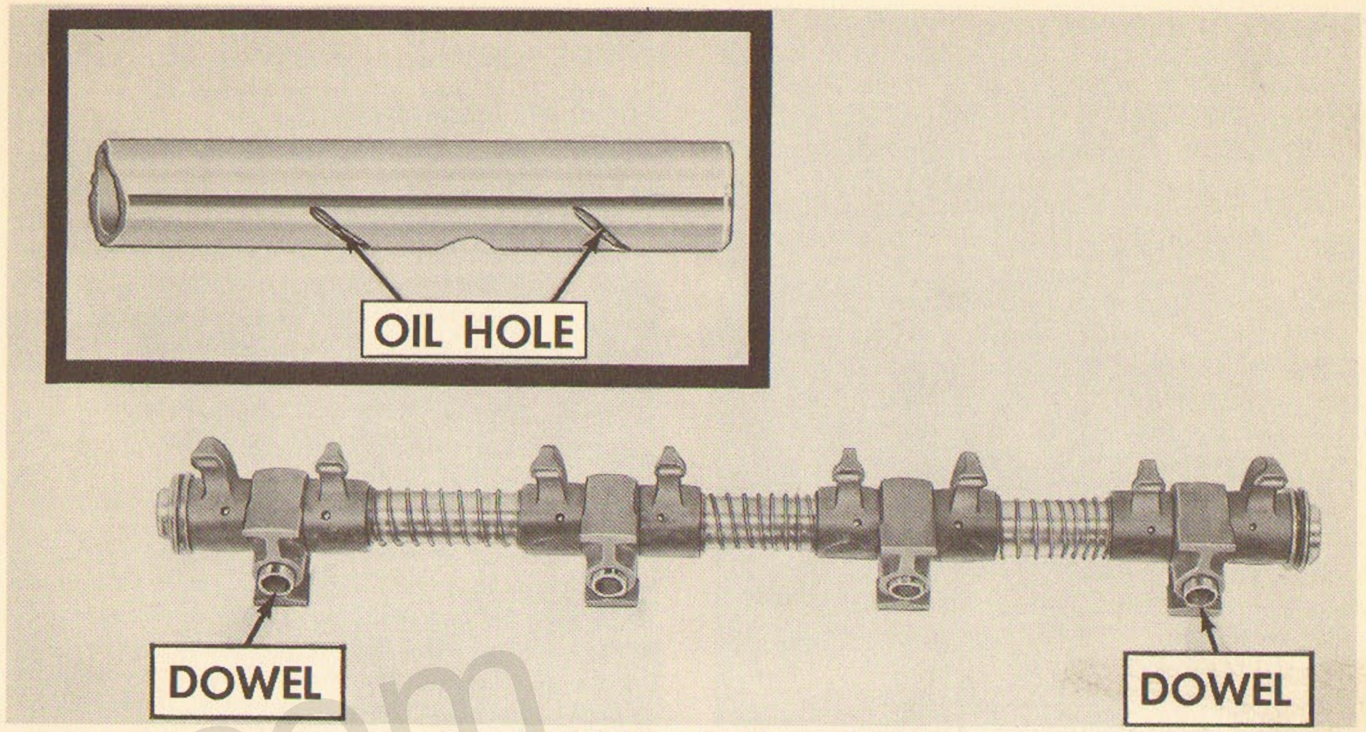


Figure 58—Installing Rocker Lever and Shaft

CAMSHAFT REMOVAL AND INSTALLATION

Engine in Car

To remove the camshaft, drain the radiator, disconnect the hose connections and remove the radiator core. Remove fan, water pump and manifold assembly, and fuel pump assembly. Remove air cleaner, ignition coil, carburetor and intake manifold. Remove vacuum line to the distributor, disconnect ignition cables and place out of the way. Remove and replace distributor as outlined on page 29.

In the following sequence, remove valve rocker covers, the four rocker lever shaft mounting bracket bolts, both banks, and lift off the rocker lever shaft assemblies. Remove the upper valve tappet cover and breather tube. See Figure 59. Then remove the lower valve tappet cover. Remove push rods and place them in the valve train stand J-5709. Remove tappets, placing them in the hydraulic tappet container J-5982, keeping them in sequence of removal. See Figure 60.

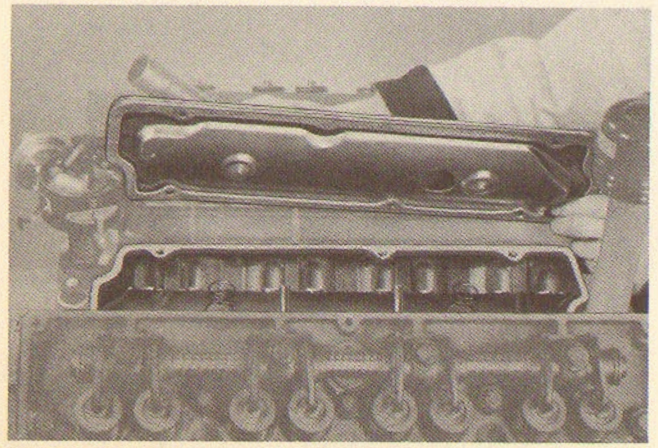


Figure 59—Upper Valve Tappet Cover

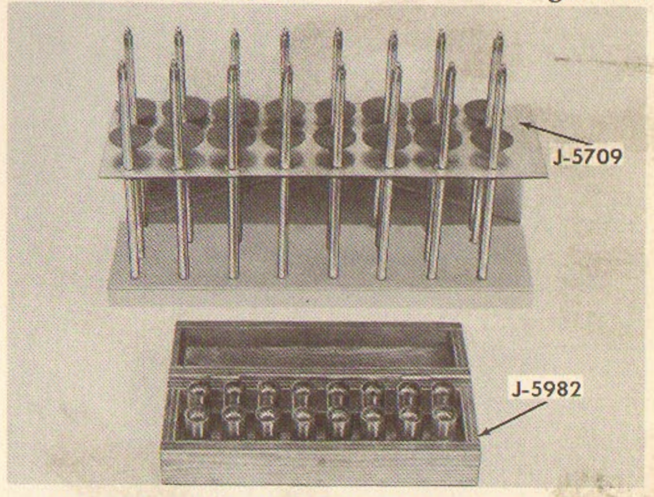


Figure 60—Valve, Push Rod and Tappet Container

Using a 1⅙″ socket and extension handle, remove the vibration damper screw and washer. Install the crankshaft vibration damper removing and replacing tool J-5992, and remove damper assembly. (On cars equipped with Power Steering or Air Conditioning, the pulleys will have to be removed before attaching the damper puller.)

Drain the engine oil and remove oil pan. Remove the screws at the front of the chain case cover and remove the cover. Pry off the oil slinger from the end of the crankshaft. Remove the screw holding the fuel pump drive eccentric at the front end of the camshaft and remove the eccentric. Rotate the engine to line up the timing marks on the crankshaft and camshaft sprockets. Remove the sprockets by alternately prying on them and slide the chain and sprocket assembly off the camshaft and crankshaft.

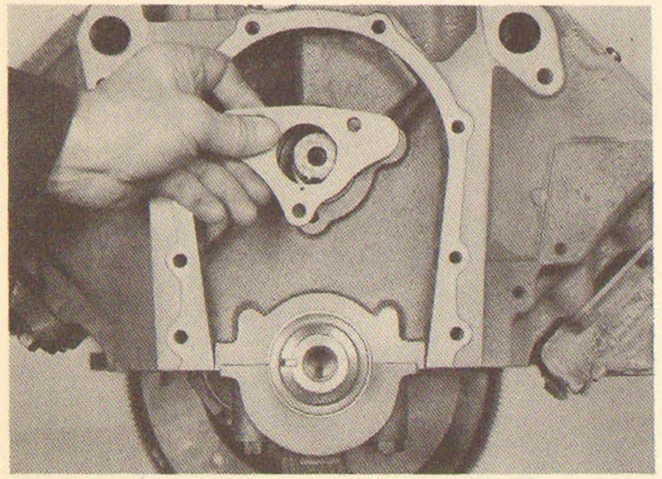


Figure 61—Removing or Installing Camshaft Retainer Plate

Remove the three camshaft retainer plate screws and remove the plate and lift out the camshaft spacer. Figures 61 and 62. Carefully pull the camshaft forward into the radiator grille far enough so it will clear the engine block, taking precautions not to damage the camshaft and bearings.

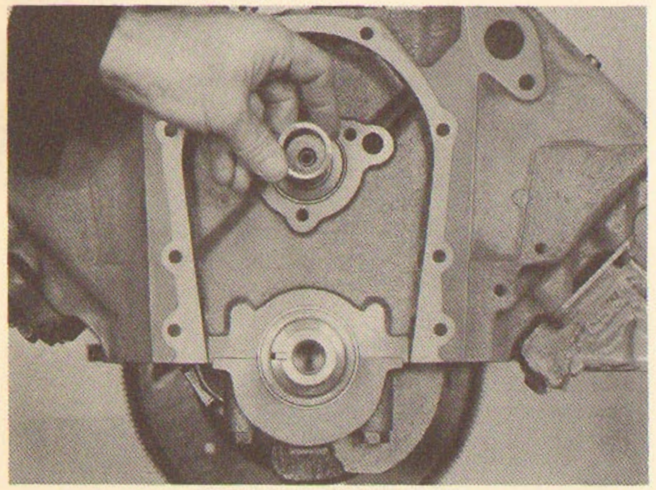


Figure 62— Removing or Installing Camshaft Spacer

Camshaft Bearings

The five steel-backed, precison-type, babbit-lined camshaft bearings are the same on both V-8 engines. The bearings are lined up with corresponding oil holes and pressed into the crankcase. Each bearing has a different diameter bore to correspond with the reduced diameter on the camshaft iournals. The running clearance between the camshaft and bearings is .0005″ to .0045″.

Camshaft Inspections

After cleaning the camshaft, inspect the cam lobes and journals for wear, scores, pits and proper alignment. The inspection can be made by placing the camshaft between centers, or resting the two end journals on V-blocks. A dial indicator should be mounted over the center line of the camshaft with the pointer contacting the shaft. Rotate camshaft, and if the eccentricity of the intermediate bearing journals is more than .002″ the camshaft will have to be straightened or replaced. The cam base circle run-out should not exceed .002″.

The cam heel wear can be checked with a micrometer. First, measure from *the cam base circle over the top of the lobe,* and then measure across *the cam base circle diameter.* The difference in the measurement will be the cam lobe lift. The cam lobe lift is .233″ on both the intake and exhaust.

Installation of Camshaft

Lubricate the camshaft bearing surfaces with clean engine oil and carefully install the camshaft in the engine crankcase. Figure 63. Center the camshaft retainer plate over the camshaft spacer and torque tighten the retainer plate screws to 15—18 ft. lbs. Check the camshaft for free rotation and end play, camshaft end play is. 004″—.006″.

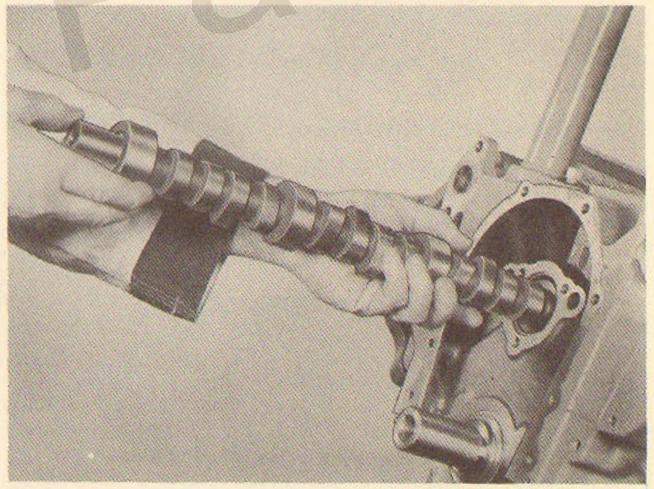


Figure 63—Installing Camshaft

Installation of Chain and Sprockets

Install camshaft and crankshaft sprocket keys *being sure they are* properly *seated in the key ways.* Rotate engine crankshaft to bring No. 1 cylinder to firing position. Slide the crankshaft sprocket part way on the

end of the crankshaft, and assemble the camshaft sprocket in the chain, locating and lining up the 'O' marks on the sprockets in line with crankshaft and camshaft centers. Position the chain on the crankshaft sprocket and start the camshaft sprocket on the camshaft. Using a rawhide hammer alternately tap both sprockets in their proper positions. Figure 64.

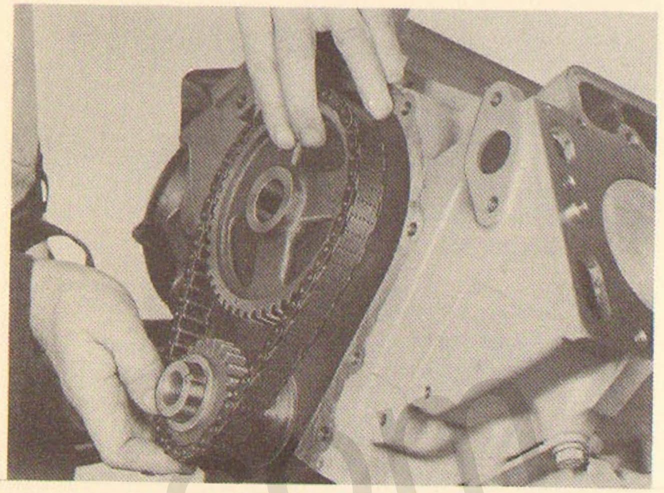


Figure 64—Installing Chain and Sprockets

Note: The camshaft sprocket will have to be installed about 1/16″ beyond a position flush with the camshaft end, to enable the installation of the fuel pump drive eccentric.

After the chain and sprockets are installed the 'O' marks should line up or otherwise the valve timing will not be correct.

Install fuel pump drive eccentric. Position the fuel pump drive eccentric on the camshaft and align with the camshaft key. Install the retainer washer and bolt and torque tighten the bolt to 25—30 ft. lbs. Figure 65.

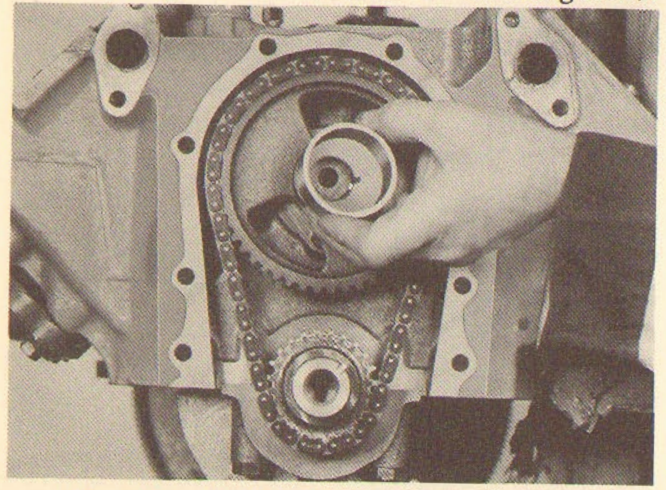


Figure 65—Installing Fuel Pump Drive Eccentric

Install crankshaft oil slinger. See Figure 66. Position the oil slinger on the end of the crankshaft and key with the cupped side forward.

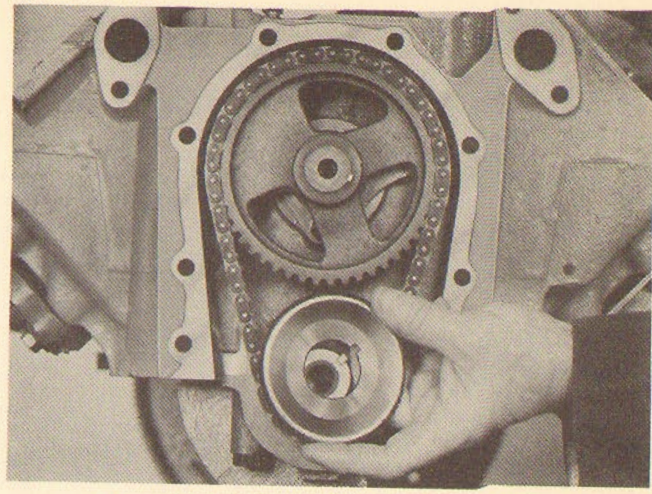


Figure 66—Installing Crankshaft Oil Slinger

Installing Crankshaft Front Oil Seal

Drive out the old seal using a punch and hammer. Be careful not to damage the cover. Place the new oil seal in position in the gear cover and press in place, using the installer tool, J-5983. Figure 67.

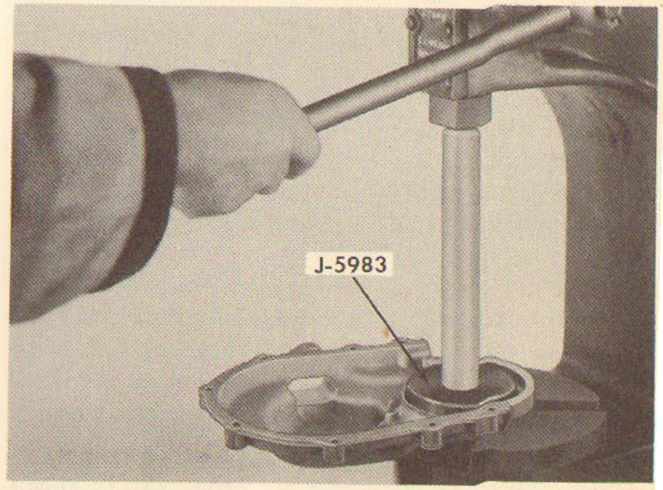


Figure 67—Crankshaft Front Oil Seal

Installation of Gear Case Cover

Using a new case cover gasket, install gear cover in place and start the cap screws in the threads, but do not tighten. Lubricate the oil seal in the cover, and install the vibration damper assembly, using the hub on the damper as a pilot to align the gear cover. See Figure 68. After damper is installed complete the installation of the cover screws and torque tighten to 15-18 ft. lbs.

Install engine oil pan. Use a new gasket set and install oil pan and fill oil pan with oil. Install fuel pump, water pump and manifold assembly, using new gaskets. Install generator adjusting strap and fan, and adjust fan belt to specifications.

Install the valve tappets in the block. Install push rods and rocker lever shaft assemblies, being sure that the push rods are in the sockets both in the valve

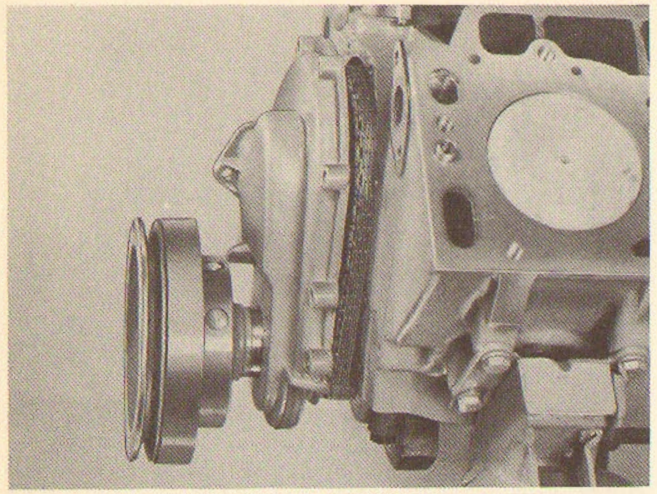


Figure 68—Installing Gear Case Cover

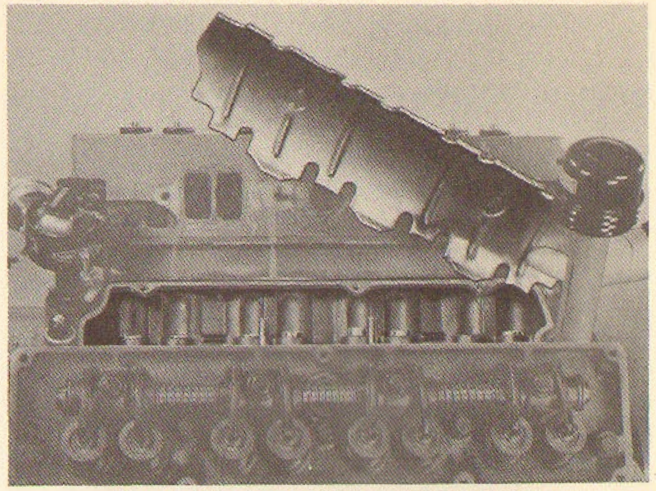


Figure 69—Lower Valve Tappet Cover

tappets and rocker levers. Torque-tighten rocker lever bracket bolts 55—60 ft. lbs. Install the lower valve tappet baffle cover. Use a new gasket and install the upper valve tappet cover and breather tube. See Figure 69.

Install intake manifold, carburetor assembly and air cleaner. Connect up vacuum line to distributor and heater tube to automatic choke. Install valve covers always using a new gasket. Install ignition coil and bracket assembly and connect up the ignition cables.

Install the radiator, being sure to tighten all connections. Fill cooling system. Reset ignition timing and carburetor idle.

VALVE TIMING

Valve timing is a means for determining whether the crankshaft sprocket and the camshaft sprocket are in proper relationship with each other. Both the camshaft and crankshaft sprockets are stamped with a letter 'O' to be used for setting the timing of the camshaft and valves during timing chain installation. The 'O' marks should be together and aligned through the center of the sprockets when the chain is installed.

If either sprocket is off one tooth in relation to the other, the opening and closing cycle of the valves will be advanced or retarded and the valves will be timed improperly.

To determine if the valve timing is correct, rotate engine crankshaft to bring No. 6 piston up on compression stroke. Note the mark on the vibration damper, and stop turning the engine just before the mark reaches the 15° timing indicator mark on the chain case cover.

With the valve cover removed, left bank, attach a dial indicator to the flange on the cylinder head at No. 1 cylinder, front left bank, and rest the point of the indicator on the milled surface end of the intake rocker lever. Figure 70.

With the valve clearance lash zero continue to rotate engine crankshaft until the mark on the damper is at the 14° BTDC timing mark on the chain case cover. At this point the exhaust valve on No. 1 cylinder will be closing and the intake valve should just begin to open.

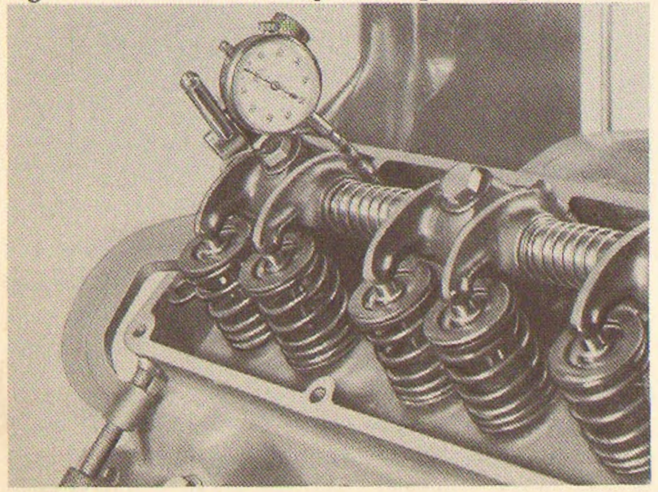


Figure 70—Valve Timing

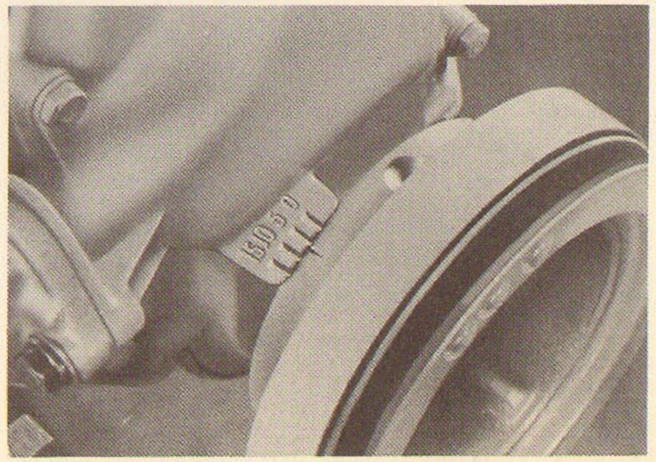


Figure 71—Timing Indicator Marks

To compensate for any leak down in the hydraulic tappet a feeler gauge can be used to maintain zero lash.

Note: The maximum deflection of the timing chain is ½". If deflection is more than this, it will cause a variation in the valve timing.

Installation of Distributor

When removing and installing the camshaft the position of the distributor usually is disturbed.

To install the distributor, rotate engine crankshaft until No. 1 cylinder (front left bank) is approximately 6° before TDC on the firing stroke. Figure 71. Place the gasket on the distributor shaft. Then, with the distributor cap removed, insert the distributor to engage the oil pump drive shaft by turning the distributor rotor. See Figure 72.

Select the proper tooth so that when the distributor gear is in full mesh with the camshaft gear the rotor will be pointing toward the right bank and slightly to the rear. On the Delco distributor the rotor position for No. 1 terminal is 30° rearward from the transverse line, and on the Auto-Lite distributor, 37° rearward. See Figure 73.

After the distributor is in its bottom position, install the retainer clamp, washer and screw. Connect the vacuum advance tube and wire lead. Install the distributor cap and snap the lever spring hooks in place on the cap. For final timing, see the "*Ignition*" section of this manual.

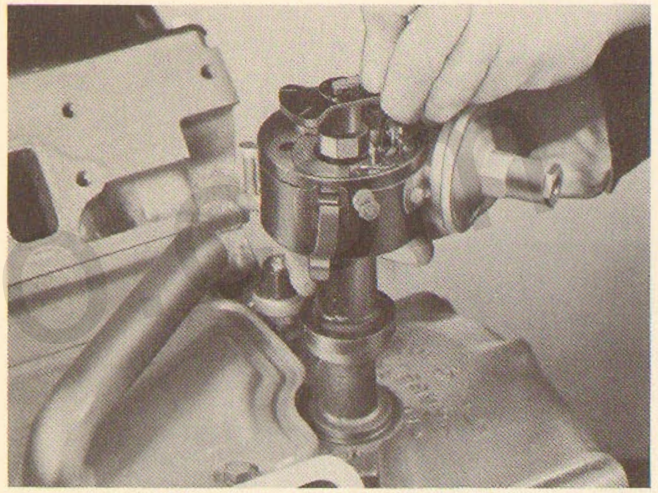


Figure 72—Installing Distributor

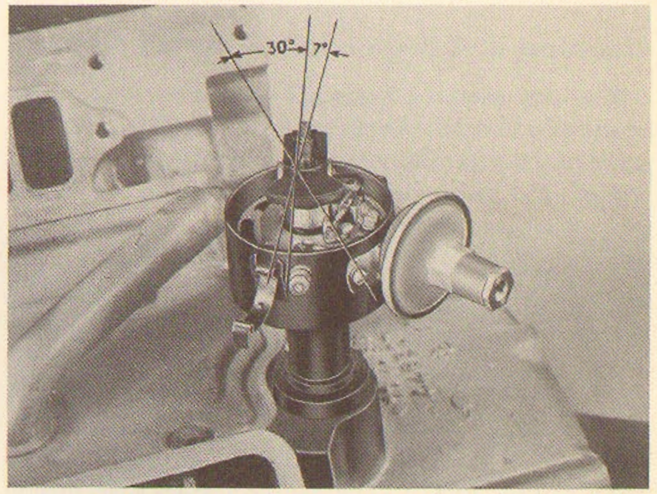


Figure 73—Position of Rotor on Number One Terminal

OIL AND VACUUM PUMP ASSEMBLY

The oil pump is a gear type, driven through the distributor drive and camshaft gears.

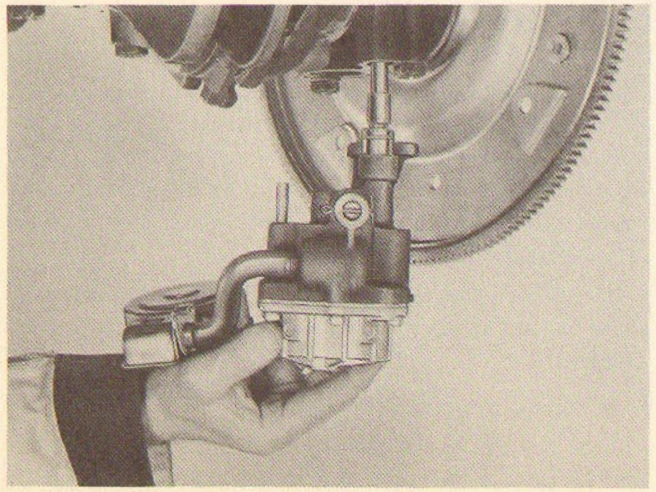


Figure 74—Removing Oil Pump, Vacuum Pump, and Strainer Assembly

Removal of Oil Pump Assembly

Remove the engine oil pan. Disconnect the vacuum pump line to the crankcase. Remove the two screws attaching the oil pump to the rear main bearing cap and remove the oil pump, vacuum pump and strainer assembly. See Figure 74.

Disassembly of Oil Pump Assembly

Remove the six screws attaching the vacuum pump to the oil pump body and lift off the vacuum pump assembly. See Figure 75.

Care should be taken not to lose the small hexagonal drive. Remove the idle gear. Remove the pin from the sleeve on the shaft and drive off sleeve. Remove the upper and lower oil pump driving shaft and gear. Press the shaft out of the driving gear, if necessary.

If necessary to replace the float assembly the suction tube can be unscrewed from the pump body.

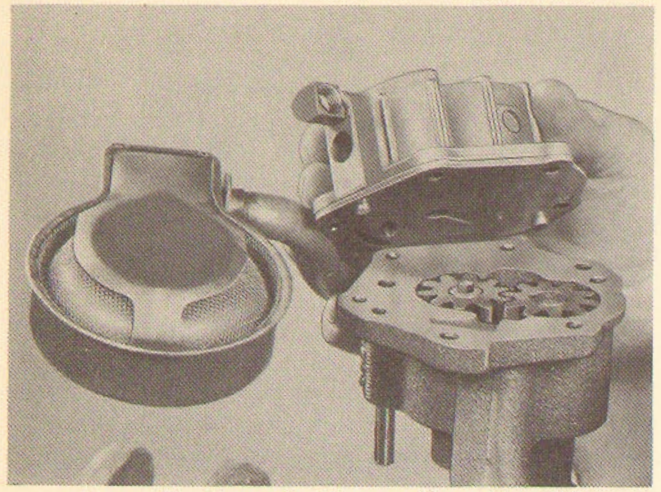


Figure 75—Removing Vacuum Pump Assembly

Cleaning and Inspection

Wash all parts in cleaning solvent and dry with compressed air. Inspect the float for leaks. Inspect strainer. Inspect the pump shaft and gears for wear scores, and pits. Check the clearance between the gears and pump body. See Figure 76.

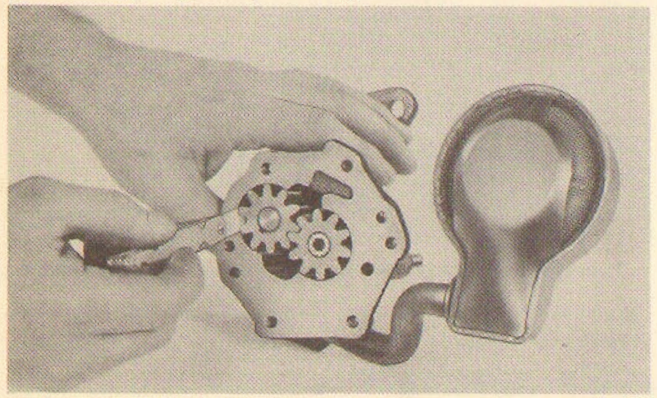


Figure 76—Checking Clearance Between Gears and Oil Pump Body

The clearance should not exceed .005″. Check the end clearance of the gears. Figure 77. The end clearance of the gears should not exceed .003″. Check the

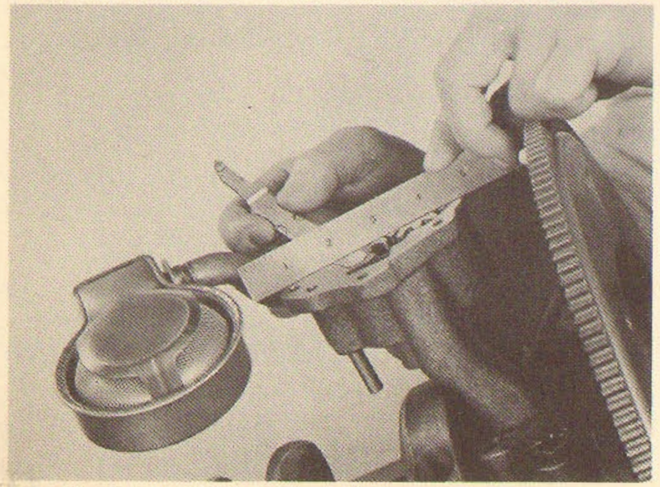


Figure 77—Checking End Clearance of Gears

shaft clearance in the pump body. This clearance should not exceed .003″. Inspect the pressure relief valve piston for scores which might cause leaks or binding in the pump.

Inspect the relief valve spring. The free length of the relief valve spring is approximately $3\frac{19}{64}$″. When compressed to $1\frac{3}{8}$″, pressure should be 9 to 9.5 lbs.

Inspect vacuum pump cover plate for wear. If worn, dress down on a surface plate.

Assembly of Oil Pump

If the float and suction tube was removed from the pump body, special care should be taken when installing them to see that the suction tube is tight in the threads in the pump body, and that the float is properly positioned.

The vacuum pump must be removed from the oil pump body in order to measure the float position. When the float is in proper position there should be ¾″ between the surface of the pump body and float. See Figure 78.

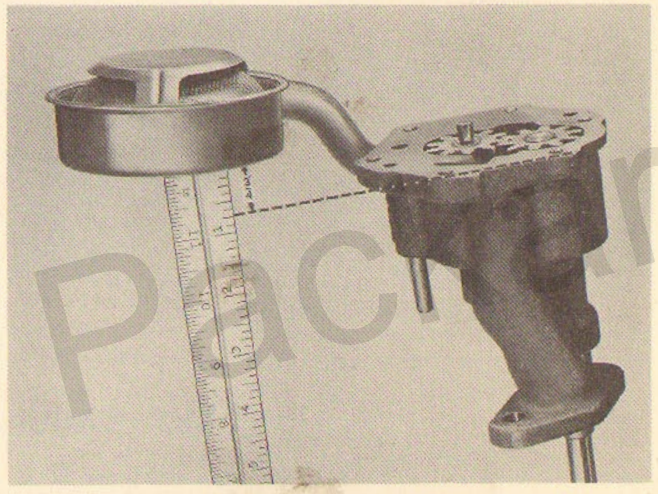


Figure 78—Checking Position of Float Assembly

Caution: When positioning the float, do not unscrew the tube to position the float, but continue one more turn.

Install key in pump shaft keyway and press driving gear on shaft until flush with bottom of gear. Install upper and lower shafts and gear in pump body. Install sleeve on the shafts. Install pin in the sleeve and stake both ends of pin. Install idle gear. Install hexagonal drive in end of idle gear.

Position the vacuum pump on the oil pump body to line up the dowel pins and install vacuum pump assembly.

Installing the Oil Pump

Start the oil pump driving shaft in the hole of the rear main bearing cap and turn the shaft to engage the mating end on the distributor shaft. Start the two screws and lock washers and torque-tighten the

screws to 25—30 ft. lbs. Connect the vacuum pump line to crankcase. Install engine oil pan, using a new gasket set. (Oil pump pressure, should be 10 lbs. at idle and 45 to 50 lbs. at 2800 RPM.)

Servicing Vacuum Pump Assembly

The vacuum pump is serviced as an assembly only, and should be replaced in the event of failure.

After the engine oil pan has been removed the vacuum pump can be removed by disconnecting the vacuum line at the crankcase and removing the six screws and lockwashers attaching the vacuum pump to the oil pump. After the vacuum pump is removed the oil pump idle gear can fall out of the oil pump body.

Note: When installing the vacuum pump be sure the hexagonal drive is in place in the idle gear, and that the vacuum pump cover makes a good contact with the mating surface of the oil pump body.

If the vacuum pump is disassembled for cleaning purposes caution should be taken not to lose any of the small parts. See Figure 79.

The vacuum pump is connected in series with the engine vacuum line at the windshield wiper motor. A check valve assembly is provided in the vacuum pump line to control the vacuum to the windshield wiper motor when the engine vacuum is lowered.

The check valve is mounted at a fitting on the right, and lower rear side of the crankcase, and consists of a spring loaded flat valve and a screen. The check valve assembly can be removed and disassembled for cleaning.

Vacuum Pump Test

Connect a vacuum gauge in the vacuum pump line and start engine. (Vacuum should be a minimum of 20 inches of mercury at 1800 RPM.)

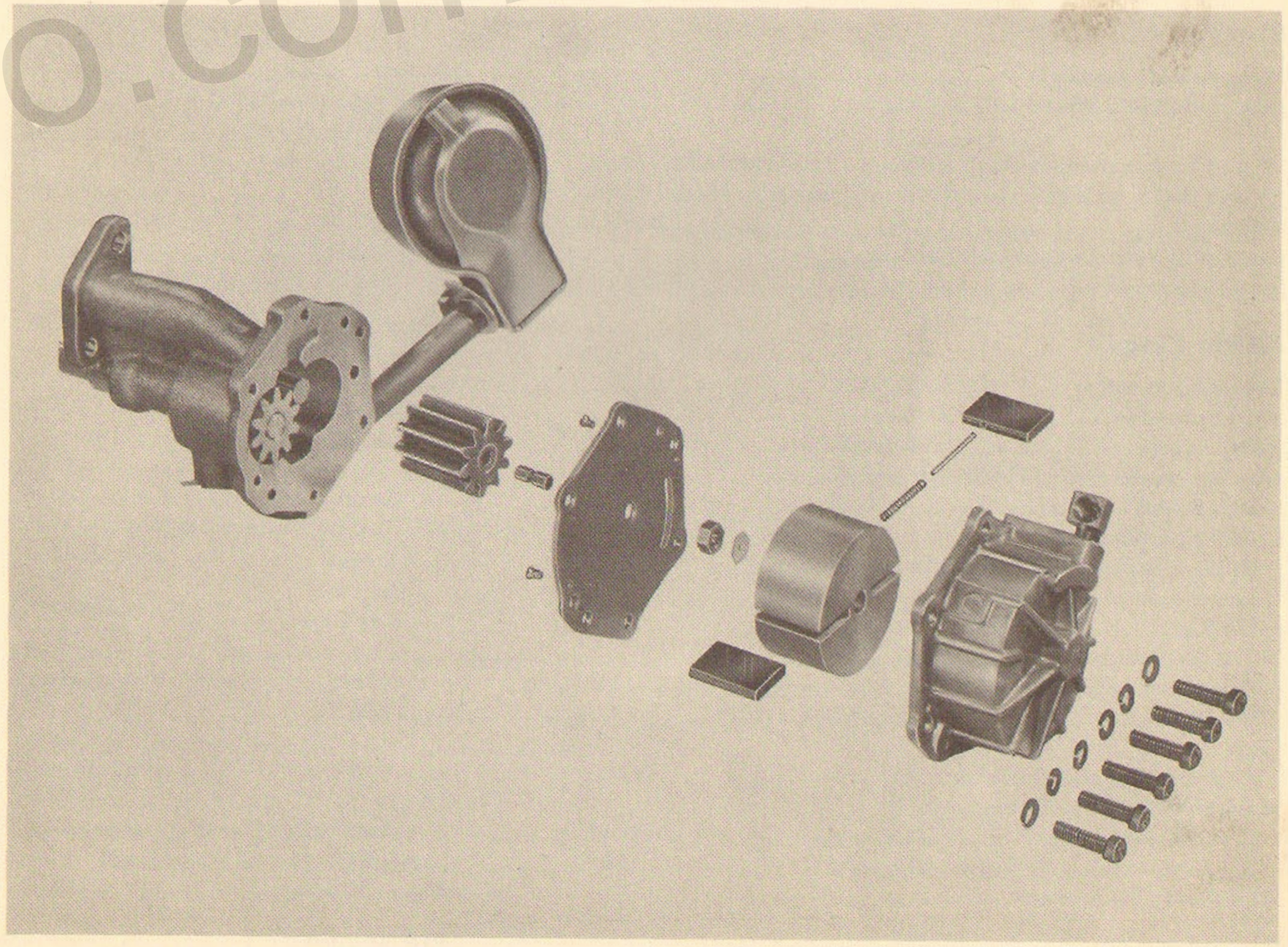


Figure 79—Vacuum Pump Disassembled

ENGINE SPECIFICATIONS

MODEL	5540	5560	5580
General			
Type		Overhead Valve V-8, 90°	
Cylinders, Head Material		Cast Iron	
Bore and Stroke	3.1825″ x 3.5″	4″ x 3.5″	4″ x 3.5″
Piston Displacement, cu. in.	320	352	352
Numbering System			
Left Bank (All models)		1-3-5-7	
Right Bank (All models)		2-4-6-8	
Firing Order (All models)		1-8-4-3-6-5-7-2	
Compression Ratio			
Standard Head	8.5:1	8.5:1	8.5:1
Optional Head	No	No	Yes
Number of Mounting Points			
Front	2	2	2
Rear	1	1	1
Horsepower			
Rated (taxable)	46.5	51.2	51.2
Developed at 4600 RPM	225	245	260*
Torque at 2400-2800 RPM	325	355	355**

Pistons

Material (All models)		Aluminum Alloy	
Description and Finish (All models)		Cam Ground, Autothermic Flat Head, Slipper Type Skirt, Tin Plated	

* 275 Horsepower at 4800 RPM on Caribbean Model 5588.
** 355 lbs. ft. at 2400-3200 RPM on Caribbean Model 5588.

Weight	22.293 oz.	24.763 oz.	24.763 oz.
Clearance, Skirt Bottom (All models)		.001″-.0015″	
Ring Groove Depth	.2035″	.213″	.213″
Piston Rings			
Type (All models)			
Compression		Taper Face Compression	
Oil		Ventilated, Wide Slot	
Number above Piston Pin (All models)		3	
Material (All models)		Iron	
Coating (All models)			
Upper Compression Ring		Chrome	
Lower Compression Ring		Ferrox	
Oil Ring		None or Blued	
Width (All models)			
Compression Rings		.078″	
Oil Ring		.186″	
Gap			
Compression and Oil Rings	.015″	.018″	.018″
Maximum Wall Thickness			
Compression Rings	.191″	.200″	.200″
Oil Ring	.160″	.166″	.166″
Expanders (All models)		Under Oil Ring	
Piston Pins		**(All Models)**	
Material		Alloy Steel, Heat Treated	
Length		3.250″	

ENGINE SPECIFICATIONS—Continued

MODEL	5540	5560	5580
Diameter		.9803″	
Type		Floating	
Bushing		In Rod	
Material (bushing)		Bronze	
Clearance			
In Piston		.0000″-.0002″ with Piston @ 70°-160°F.	
In Rod		.0000″-.0004″	
Direction Offset in Piston		.0625″ Toward Major Thrust Side	
Connecting Rods		**(All Models)**	
Material		Steel Forging	
Weight		1 lb., 10.688 oz.	
Length (center to center)		6.7182″	
Bearing			
Material		Steel-backed Babbitt	
Type		Removable	
Effective Length		.939″	
Clearance		.0005″ to .0025″	
End Play		.003″-.011″ (two rods)	
Crankshaft			
Material (All models)		Cast—Steel	
Weight (All models)		55 lbs.	
Vibration Damper Type (All models)		Rubber Floated	
End Thrust taken by Bearing (All models)		No. 5—Rear Main	
Crankshaft End Play (All models)		.0035″-.0085″	
Main Bearing			
Material		Babbitt Nos. 1-2-3-4 Copper-Lead, No. 5 Babbitt	
Type (cast-in or removable) (All models)		Removable Steel Backed	
Clearance (All models)		.0005″ to .0025″	
Journal dia. & bearing effective length. (All models)			
No. 1		2.4990″ x .950″	
No. 2		2.4990″ x .950″	
No. 3		2.4990″ x .950″	
No. 4		2.4990″ x .950″	
No. 5		2.4990″ x 1.736″	
Connecting Rod Crankpin Journal Diameter (All models)		2.250″	
Camshaft		**(All Models)**	
Material		Cast Iron Alloy	
Bearings			
Material		Steel-backed Babbitt	
Number		5	
Type of Drive			
Chain		Chain	
Crankshaft Gear or Sprocket Material		Steel, Heat Treated	
Camshaft Gear or Sprocket Material		Cast Alloy Iron	
Timing Chain			
Make		Morse	
No. of Links		64	
Width		1.000″	
Pitch		.375″	

ENGINE SPECIFICATIONS—Continued

MODEL	5540	5560	5580
Valve System		**(All Models)**	
Hydraulic Lifters		Yes	
Rocker Ratio		1.6 to 1	
Operating tappet clearance			
Intake		Automatic Take-up	
Exhaust		Automatic Take-up	
Timing Marks		On Vibration Damper & Camshaft Chain Cover	
Timing			
Intake			
Opens (°BTC)		14° B.T.D.C.	
Closes (°ABC)		56° B.T.D.C.	
Exhaust			
Opens (°BBC)		52° B.T.D.C.	
Closes (°ATC)		18° B.T.D.C.	
Intake			
Material		Silichrome Steel	
Overall Length		5.712"	
Actual overall head dia.		1.937"	
Angle of Seat		30° (Nominal)	
Stem Diameter		.3725"	
Stem to Guide Clearance		Selected for .001"-.002"	
Lift		.374"	
Outer spring press. and length			
Valve Closed		78 to 86 lbs. @ 1.750"	
Valve Open		158 to 172 lbs. @ 1.375"	
Exhaust			
Material		Austenitic Steel	
Overall Length		5.690"	
Actual overall head dia.		1.687"	
Angle of seat		45° (Nominal)	
Stem Diameter		.3715"	
Stem to Guide Clearance		Selected for .002"-.003"	
Lift		.374"	
Outer Spring Press. and Length			
Valve Closed		78 to 86 lbs. @ 1.750"	
Valve Open		158 to 172 lbs. @ 1.375"	
Lubrication System			
Type of Lubrication			
Main Bearings		Pressure	
Connecting Rods		Pressure	
Piston Pins		Oil Mist	
Camshaft Bearings		Pressure	
Tappets		Pressure	
Timing Gear or Chain		Pressure Jet	
Cylinder Walls		Pressure Jet	
Oil Pump Type		Gear	
Normal Oil Pressure		45-50 PSI @ 2800 RPM	
Oil Pressure Gage Type		Electric	
Type Oil Intake		Floating	
Oil Filter Type		Partial Flow (Optional)	Partial Flow
Capacity of Crankcase, less Filter—Refill		5 Quarts	

ENGINE SPECIFICATIONS—Continued

MODEL	5540	5560	5580
Oil Grade Recommended (SAE viscosity and Temperature Range)		Not Lower than + 32°F.—SAE 20 or 20W As Low as —10°F.—SAE 10W Below —10°F.—SAE 5W	
Oil Type Recommended		ML, MM, or MS Depending on Vehicle Operation	

TORQUE SPECIFICATIONS

FUNCTION	THREAD SIZE	TORQUE FT. LBS.	TORQUE IN. LBS.
Camshaft Driving Chain Cover Screw	5/16-18	15-18	
Camshaft Fuel Pump Eccentric Retainer Bolt	3/8-16	25-30	
Camshaft Thrust Plate Bolt	5/16-18	15-18	
Carburetor Assembly to Manifold Nut	5/16-24	15-18	
Carburetor Fuel Inlet Connector (Brass)	1/8-27	8-10	
Carburetor Fuel Inlet Connector Flared Inverted (Brass)	1/8-27	8-10	
Connecting Rod Bolt Nut	3/8-24	40-45	
Crankshaft Bearing Cap #1-2-3-4 Screw	1/2-13	90-95	
Crankshaft Bearing Cap #5	1/2-13	90-95	
Crankshaft Pulley	3/4-16	130-150	
Cylinder (Oil Filter Drain) Plug	1/8-27	8-10	
Cylinder Head Bolt	7/16-14	55-60	
Cylinder Head Core Hole Plug	1 x 11	45-50	
Cylinder Head Oil Gallery Plug	1/8-27	8-10	
Cylinder Head Water Outlet Cover (Rear) Screw	3/8-16	25-30	
Cylinder Oil Passage Plug	1/4 sq. hd. (pipe)	10-15	
Cylinder Water Jacket Drain Plug	1/8-27	8-10	
Distributor Hold Down Clamp Screw	5/16-18	15-18	
Fan Pulley Screw	1/4-28		90-100
Flywheel Assembly Screw	7/16-20	55-60	
Flywheel Cover to Cylinder Screw	3/8-16	25-30	
Fuel Pump Assembly Screw	3/8-16	25-30	
Fuel Pump to Gasoline Filter Tube Assembly Connector 5/16 Flared Tube Inverted	1/8-27	8-10	
Fuel Pump to Gasoline Filter Tube Assembly Connector Elbow 90° Flared Tube Inverted	1/8-27	8-10	
Fuel Pump Elbow (Gasoline Inlet) 90° 1/8 Street	1/8-27	8-10	
Gasoline Filter Assembly Connector 5/16 Flared Tube Inverted	1/8-27	8-10	
Generator Assembly Nut	5/16-24	15-18	
Generator Adjusting Strap Screw	5/16-18	15-18	
Generator Bracket Screw	5/16-18	15-18	
Ignition Coil Screw Attaching	5/16-18	15-18	
Ignition Spark Plug	14 MM	26-30	
Manifold (Exhaust) to Cylinder Head Screw	3/8-16	25-30	
Manifold (Intake) to Cylinder Head Screw	3/8-16	25-30	
Manifold (Intake) Stud Nut	3/8-24	25-30	
Oil Pan Assembly Screw and Lockwasher	5/16-18	15-18	
Oil Pan Drain Plug	5/8-18	25-30	
Oil and Vacuum Pump Oil Strainer Assembly Screw	3/8-16	25-30	
Starter Motor Assembly Screw	7/16-14	55-60	
Manifold (Intake) to Carburetor Stud	5/16-18	15-18	
Timing Indicator Screw RH Cross Recess Tapping	1/4-20		90-100
Vacuum Pump & Cover Plate Assembly Screw (to Oil Pump)	1/4-20		90-100
Valve Cover Assembly Screw & Lockwasher Assembly (Split)	5/16-18	15-18	

TORQUE SPECIFICATIONS—Continued

FUNCTION	THREAD SIZE	TORQUE FT. LBS.	TORQUE IN. LBS.
Valve Tappet Cover and Baffle (Upper) Assembly Screw & Lockwasher	5/16-18	15-18	
Vibration Damper Assembly Screw	3/4-16	130-150	
Motor Water Pump Assembly Screw	3/8-16	25-30	
Water Pump Body Plug	3/8-18	10-12	
Water Pump Cover Screw	5/16-18	15-18	
Water Pump Water Outlet Flange	3/8-16	25-30	
Water Temperature Sending Unit (Cylinder Head)	1/4-18	10-15	
Vacuum Pump to Cylinder Connector 1/4 Inverted	1/8-27	8-10	
Motor Mount (Front) to Frame Bolt	7/16-20	55-60	
Motor Mount (Front) to Cylinder Bracket (Right and Left)	3/8-16	25-30	
Motor Mount (Rear) to Transmission Bolt	1/2-13	65-75	
Motor Mount (Rear) to Transmission Bolt	3/8-16	25-30	
Motor Mount (Rear) Stud Nut	3/8-24	25-30	
Motor Mount (Rear) Bracket (to "X" Member) Bolt	3/8-24	25-30	

ENGINE TROUBLE SHOOTING

CONDITION	POSSIBLE CAUSE
1. Starting motor will not crank the engine.	(a) Run down or dead battery. (b) Faulty starting motor.
2. Starting motor will crank the engine, but engine fails to start.	(a) Low battery. (b) Faulty starting motor. (c) Low compression, due to valves being stuck open or not seating. Worn piston rings not sealing. Faulty cylinder head gasket. (d) Climatic control improperly adjusted.
3. Engine fails to start. (Open primary circuit)	(a) Burned or oxidized contact points. (b) Primary circuit resistance unit burnt or open. (c) Contact points incorrectly adjusted, not closing to permit contact. (d) Contact arm binding on the pivot post, preventing closing of the contact points. (e) Contact arm spring weak or broken. (f) Contact arm distorted or bent. (g) Dirt or foreign matter on the contact points. (h) Primary lead connection loose at the distributor or coil. (i) Primary windings in the coil broken. (j) Open ignition switch circuit.

ENGINE TROUBLE SHOOTING—Continued

CONDITION	POSSIBLE CAUSE
4. Engine fails to start. (Grounded primary circuit) **Caution: A grounded coil primary winding, a grounded ignition switch, or a grounded switch to coil primary lead will cause excessive current flow and in most cases will cause wires to burn.**	(a) Contact points incorrectly adjusted, not opening. (b) Contact points not opening, due to worn insulator block (rubbing block) on the contact arm. (c) Faulty insulating bushing in the contact arm. (d) Cracked or faulty insulator at the distributor primary terminal. (e) Grounded condenser. (f) Distributor to coil primary lead grounded. (g) Primary winding of the ignition coil grounded.
5. Engine fails to start. (Faulty secondary circuit) **To further check the secondary circuit, remove one of the spark plug cables from the spark plug and hold the terminal about 1/4 inch from the cylinder head. A sharp blue-white spark approximately one sixteenth of an inch wide should occur regularly while the engine is being cranked. If a good sharp spark occurs, check the spark plugs, timing, carburetion, and compression for cause of failure to start. If no spark occurs, or if the spark is thin and weak, the ignition secondary circuit is most likely at fault.**	(a) Dirty or corroded connections of the secondary coil to distributor cable. A broken or faulty secondary cable from the coil to the distributor cap. (b) A cracked distributor cap or a burned carbon track from the distributor cap center terminal to the distributor housing. (c) Broken contact on the rotor, cracked or grounded rotor. (d) Open secondary circuit in the coil. (e) Open condenser, or under capacity condenser. (f) Broken or burned out radio suppressor in the distributor cap.
6. Engine fails to start. **If the ignition, timing, and spark plugs are correct, the most probable cause is an over-supply or insufficient supply of fuel. First, check for flooded engine.** **Note: A flooded engine can often be cleared of excess fuel vapors by holding the throttle wide open while starting the engine. The "unloader" is provided to hold the choke open, to clear the excess fuel vapors, if the engine becomes flooded during the starting period. After the engine starts, close the throttle gradually as the engine speeds up.**	(a) Choke valve not operating properly or climatic control improperly set. (b) Carburetor unloader linkage improperly set. (c) Float level set too high. (d) Dirty, worn, or faulty needle valve and seat. (e) Float sticking, or rubbing against side of the fuel bowl. (f) Leak in the float, allowing the float to become "logged." (g) Fuel pump pressure too great.
7. Engine fails to start. Insufficient supply of fuel.	(a) Needle stuck in the seat, due to gum in the fuel. (b) Float out of adjustment. (c) Clogged gasoline inlet screen at the carburetor. (d) Fuel pump faulty or of insufficient capacity. (e) Fuel pump strainer clogged. (f) Fuel pump bowl gasket faulty. (g) Flexible hose from the fuel line to the fuel pump, twisted, deteriorated, or restricted. (h) Fuel lines to the fuel tank clogged, kinked, restricted, or leaking. (i) Vent in the fuel tank filler cap closed or restricted.

CONDITION	POSSIBLE CAUSE
8. Hard starting when engine is hot.	(a) Leaky carburetor needle valve and seat.
This condition is usually caused by an over-supply of fuel. Very rarely, an ignition coil may lose its efficiency when it is hot and cause ignition failure.	(b) Choke valve sticking, or climatic control improperly set.
	(c) Carburetor main discharge nozzles not seating or loose.
	(d) Faulty ignition coil.
9. Hard starting when engine is cold.	(a) Battery capacity insufficient, or faulty battery.
Any of the conditions enumerated under groups 2, 3, 4, 5, 6, and 7 (Engine fails to start), also may cause hard starting in cold weather.	(b) Faulty starting motor.
	(c) Choke not operating properly, or climatic control improperly adjusted.
	(d) Crankcase oil too heavy. (In winter.)
	(e) Water in the fuel will freeze in cold weather and restrict the supply of fuel.
10. Burnt ignition contact points.	(a) High voltage in the electrical system will cause the contacts to burn, forming a blue scale on the contact surfaces.
	(b) Primary circuit resistance unit shorted.
	(c) Loose condenser lead at the breaker arm terminal bracket or excessive resistance in the condenser.
	(d) An UNDER capacity condenser will cause material transfer build-up on the positive (+) contact (bracket). An OVER capacity condenser will cause material transfer build-up on the negative (—) contact (breaker arm).
	(e) Contacts set too close.
	(f) Oil on the contact points will cause them to pit and burn. This condition is generally indicated by the contacts burning black.
11. Miss in the engine at all speeds.	(a) Fouled spark plugs or broken insulators.
	(b) Faulty spark plug cables.
	(c) Burned or pitted ignition points.
	(d) Incorrect ignition contact point gap.
	(e) Faulty condenser.

CONDITION	POSSIBLE CAUSE
	(f) Blown cylinder head gasket between cylinders. This condition can be noted when the miss occurs in two adjacent cylinders.
	(g) Sticking valves or broken valve spring.
	(h) Leak at inlet manifold gaskets.
	(i) Carburetor faulty or out of adjustment.
12. Miss in engine on acceleration or hard pull.	(a) Faulty spark plug or plugs.
	(b) Crack in the distributor cap.
	(c) Faulty ignition cables.
	(d) Burned or pitted contact points.
	(e) Loose connection in the primary circuit or broken distributor ground lead (pigtail lead).
	(f) Faulty carburetion or compression.
13. Miss or skip in engine on idle.	(a) Faulty spark plugs or gap too small.
	(b) Dirty or corroded secondary circuit connections or faulty ignition cables.
	(c) Cracked or faulty distributor cap. Radial contacts in the cap burned or worn.
	(d) Faulty carburetion or compression.
14. Loss of power. Loss of top speed.	(a) Ignition timing incorrect.
	(b) Centrifugal governor advance not operating properly.
	(c) Vacuum advance not operating properly.
	(d) Ignition contact points burned and pitted.
	(e) Faulty spark plugs.
	(f) Faulty ignition cables.
	(g) Faulty ignition coil.
	(h) Faulty carburetion or compression.
15. Detonation (Spark Knock)	(a) Ignition timing incorrect.
	(b) Centrifugal governor advance not operating properly.
	(c) Vacuum advance not operating properly.

CONDITION	POSSIBLE CAUSE
	(d) Faulty spark plugs.
	(e) Low octane fuel, faulty carburetion, faulty cooling, and carbon formation in combustion chamber can cause detonation.
	(f) Metal protrusion into combustion chamber.
16. Carburetor flooding or leaking.	(a) Leak in the float allowing the float to become "logged." High float level. Stopped up vent hole.
	(b) Bowl cover not sealing or faulty bowl gasket. (Bowl cover warped or bent.)
	(c) Worn needle and seat where you can see or feel a ridge on the needle. Sticky needle.
	(d) Gum, dirt, or foreign matter between the needle and seat, not allowing needle shut off.
	(e) Float pin worn or the holes in the float bracket for the float pin worn egg shaped. This will cause the float to "bobble."
	(f) Cracked castings or passage plugs or parts not sealing gasoline tight in the casting.
	(g) High fuel pump pressure.
17. Lean on idle. (Miss or skip on idle)	(a) Improper adjustment.
	(b) Restricted metering hole in the low speed jet. Economizer hole in the casting restricted. Restriction in the passage in the casting from the low speed jet to the port hole and idle adjusting screw.
	Port hole restricted.
	Hole restricted in the casting where the idle screw seats.
	(c) Air leak in flange gasket or manifold gasket.
	(d) Idle screw burred.
18. Rich on idle. (Roll or loading-up on idle)	(a) Improper adjustment.
	(b) Worn or too large metering hole in the low speed jet.
	Low speed jet not seated in the casting.
	Air bleed or by-pass hole in the casting restricted with carbon.

CONDITION	POSSIBLE CAUSE
	Idle port damaged.
	Idle screw damaged so as to prevent adjustment.
19. Lean condition. (Loss of power, detonation, sluggish engine.)	(a) Low fuel pump pressure.
	(b) Restriction in the gas line connection to the needle seat. This many not allow sufficient gasoline to enter the bowl for high speed driving.
	(c) Low float level.
	(d) Restricted vent hole in the bowl cover.
	Restriction between the metering rod and jet.
	Improper metering rod setting or parts that operating metering rod worn (bowl cover, pump arm, throttle rod, throttle shaft arm.)
	If the above parts are worn, the different steps of the metering rod will not pull out at the proper time.
	Wrong metering rod (too large in diameter) or metering hole too small in metering rod jet (wrong parts).
	Restriction in the casting from metering rod jet to nozzle.
20. Rich condition. (Loading up at all speeds, excessive fuel consumption, black smoke from tail pipe.)	(a) High fuel pump pressure.
	(b) High float level.
	(c) Metering rod spring disconnected from the metering rod.
	(d) Worn metering rod and jet. Metering jet loose in the casting.
	Bent metering rod.
	(e) Choke valve stuck in the air horn causing carburetor to be partly choked.
	Choke not operating properly.
	(f) Air cleaner dirty or clogged up.
21. Lean on acceleration. (Flat spot or hesitation on acceleration.)	(a) Weak plunger spring.
	Worn or dried out plunger leather or weak pump spring.
	Damaged or cracked plunger leather.
	Wrong plunger assembly.
	Intake or discharge check not seated in the casting.
	Leaking or sticking intake or discharge check.
	Pump passages in the casting restricted.
	Pump jets restricted or not seated in the casting.
	Pump not adjusted properly.

CONDITION	POSSIBLE CAUSE
	(b) Worn accelerating pump linkage.
22. Too rich on warm-up (Loading up during warm-up period.)	(a) Choke valve or shaft binds in the air horn. Choke piston binds or is stuck. (b) Choke air strainer gauge covered with dirt, preventing hot air from reaching the thermostatic coil. Leak in the thermostat housing gasket. (c) Leak in the hot air tube from the stove to the thermostat housing.
23. Faulty engine performance. Roughness, loss of power, excessive fuel consumption.	(a) Carburetor flange loose or faulty gasket. (b) Restricted air cleaner, oil bath air cleaner too full, or excessive accumulation of sediment. Excessive accumulation of sediment will raise the oil level and have the same effect as too much oil in oil bath air cleaner. (c) Throttle linkage that is worn or improperly adjusted. (d) Restricted fuel line. A restriction in the fuel line may result in an apparent vapor lock action, or a definite cut-off in the supply of fuel.
24. Back firing at the carburetor. Engine back-firing through the carburetor while the engine is cold is caused by the late burning of the mixture in the cylinder, due to the improper fuel-air ratio. The late burning ignites the incoming charge, causing an explosion in the inlet manifold and carburetor. This can be corrected by the proper setting of the climatic control. However, continued back-firing after the engine is warm should be corrected after checking and locating one of the following possible causes.	(a) Spark plug cables crossed in the distributor cap. (b) Late ignition timing. (c) Incorrect valve timing. (d) Improperly seating valves. (e) Dirt or obstructed fuel lines. (f) Dirt or water in the fuel pump bowl. (g) Inlet manifold air leaks. (h) Poor grade of motor fuel. (i) Worn, faulty, or improper type spark plugs.
25. Fouled spark plugs.	(a) Worn piston rings. (b) Worn, tapered, or out-of-round cylinders. (c) Excessive piston clearance. (d) Excessively rich mixture due to flooding carburetor. (e) Spark plugs of the incorrect type. (f) Spark plug gap too narrow causing missing at idle.
26. Burnt spark plugs.	(a) Spark plugs of the incorrect type. (b) Lean mixture caused by a faulty carburetor. (c) Late ignition timing. (d) Engine overheated due to worn water pump or restriction in the cooling system.

CONDITION	POSSIBLE CAUSE
27. Abnormal oil consumption. **Before deciding that worn or clogged piston rings or worn cylinders are the cause of excessive oil consumption, do not overlook the possibility of oil leaks. Slow leaks can be located by operating the engine with a piece of clean paper spread under the crankcase.** **If the exhaust is smoking and if the spark plugs foul up, this is an indication that the oil is being burned in the cylinders. The oil may be pumping past the pistons and rings, or it may be drawn in along the valve stems. Another common cause of excessive oil consumption is too great oil level, causing the crankshaft to dip and emulsify the excessive oil, throwing it up into the cylinders.**	(a) Excessive amount of oil in the crankcase. (b) Oil leak at the rear main bearing. (c) Oil leak at the crankshaft front oil seal. (d) Oil leaks around the engine oil pan. (e) Oil leaks around the timing chain case cover. (f) Worn, scored, or carbon clogged piston rings. (g) Excessive taper or out-of-round in the cylinder walls. (h) Excessive piston clearance. (i) Excessive clearance between the inlet valve stems and guides. Damaged or improperly installed valve stem oil seal.
28. Low oil pressure. **An indication of no oil pressure is a sure sign of either insufficient oil in the crank-case, a clogged oil screen, or a broken oil pump inlet line. The normal oil pressure at moderate speeds should be approximately 45 psi. Pressure of less than 30 psi indicates that the engine oiling system should be carefully inspected.** **10 to 15 psi is satisfactory pressure at idle.**	(a) Insufficient supply of oil. (b) Incorrect grade of engine oil. (c) Badly diluted engine oil. (d) Air leak in the oil pump inlet line. (e) A clogged oil inlet screen. (f) Worn or faulty oil pump gears. (g) Oil pressure relief valve not seating properly. (h) Worn or loose crankshaft main or connecting rod bearings.
29. High oil pressure. **The oil pressure should not exceed 50 psi except momentarily when a cold engine is started. Excessive high oil pressure is not desirable since it affects all the units which depend on a regulated oil pressure.**	(a) Engine oil too heavy. (b) Relief valve may be sticking or may be stuck open. (c) Obstruction or restriction in the oil distributing line.
30. Crankshaft knocks. **These noises are usually detected as a heavy, dull, metallic knock, which will either increase in sound level or frequency as the engine speed and load is increased. A crankshaft main bearing knock is most noticeable during acceleration at higher speeds. A most common cause of crankshaft main knock is excessive clearance at one or more of the main bearings. By alternately grounding out each spark plug, the approximate location of the loose main bearing may be determined.** **Excessive crankshaft end play causes sharper noise or rap, which occurs at irregular intervals. In severe cases the noise may be increased or decreased by releasing and engaging the clutch.**	(a) Insufficient oil supply. (b) Low oil pressure. (c) Badly diluted engine oil. (d) Excessive main bearing clearance. (e) Excessive crankshaft end play. (f) Eccentric, worn, or out-of-round main bearing journals. (g) Main bearing misalignment. (h) Loose engine flywheel. (i) Loose vibration damper on the front end of the crankshaft.

ENGINE TROUBLE SHOOTING—Continued

CONDITION	POSSIBLE CAUSE
31. Connecting rod bearing knocks. **Connecting rod noises are usually a light rap or clatter of much less intensity than main bearing knocks. The noise is most audible when the engine speed is increased. Connecting rod bearing knocks can best be located by grounding out each of the spark plugs, one at a time. These noises should not be confused with piston or piston pin knocks.**	(a) Insufficient oil supply. (b) Low oil pressure. (c) Badly diluted engine oil. (d) Excessive bearing clearance on the crank pin. (e) Out-of-round or tapered crank pin journals. (f) Misaligned connecting rods.
32. Piston noises. **The most common piston noise is known as the "piston slap," due to the piston rocking from side to side in the cylinder. "Piston slap" is usually a hollow, bell-like sound. "Piston slap" is most audible when driving under engine speed.** **Accelerating the engine at low speed under heavy load. Slight piston slap that occurs with a cold engine and disappears after the engine is warmed up does not warrant reconditioning the cylinders and installing new pistons.**	
33. Piston pin knock. **The most common piston pin knock is the result of excessive piston pin clearance. This knock is characterized by a sharp, metallic, double knock, sounding like shaking marbles in a metal container, and is generally most audible when the engine is idling. Interference or rubbing between the upper end of the connecting rod and the piston pin boss is very difficult to diagnose and may be mistaken for a tappet noise or a connecting rod bearing knock.**	(a) Excessive piston pin clearance in the piston boss. (b) Excessive piston pin clearance in the bushing. (c) Bushings loose in the connecting rod. (d) Interference or rubbing between the connecting rod and the piston pin boss.
34. Valve and tappet noises. **Noisy valve action has a metallic, sharp, clicking noise, occurring at regular intervals. It may be faulty hydraulic valve tappet units.**	(a) Faulty or dirty hydraulic tappet units. (b) Weak or broken valve springs. (c) Excessive valve stem to guide clearance.
35. Detonation or spark knock. **Detonation or spark knock is caused by pre-ignition. Preignition is caused by an incandescent particle of carbon or metal in the combustion chambers. The mixture is ignited prematurely while the piston is coming up on the compression stroke. The pre-ignition will cause a heavy explosion on the piston at the wrong time, causing the piston, the connecting rod, and the other engine parts to vibrate, resulting in a sound which is known as detonation, or spark knock.**	(a) Carbon deposits on the piston head and in the combustion chamber. (b) Ignition timing too early. (c) Incorrect automatic advance mechanism in the distributor. (d) Octane rating of the fuel too low. (e) Old or stale fuel. (f) Extremely lean carburetor mixture. (g) Spark plugs of the incorrect heat range.

ENGINE TROUBLE SHOOTING—Continued

CONDITION	POSSIBLE CAUSE
35. Detonation or spark knock. (continued) **Detonation can also be caused by a fuel of the wrong octane rating, which burns too rapidly, resulting in a sudden and abnormally high pressure against the piston on the downward stroke. Detonation has a metallic, ringing sound which is commonly known as a "ping". Detonation is most audible when the engine is pulling under heavy load, accelerating rapidly, or is pulling while overheated.**	(h) Carbon on the spark plugs or burnt porcelains. (i) Cylinder head gasket edge projecting into the combustion chamber. (j) Hot valves resulting from: 1. Insufficient tappet clearance. 2. Valves of the wrong type metal. 3. Improper setting of the valves. 4. Thin edged valves. 5. Cracked, burnt, or warped valve heads. (k) Engine overheating caused by faulty cooling system operation. (l) Protruding, sharp, metallic edge in the combustion chamber.
36. Vibration originating at the engine.	(a) Misfiring or rough engine. (b) Unequal compression of cylinders. (c) Engine support loose on the engine block. (d) Unbalanced crankshaft or flywheel.
37. Vibration originating from outside the engine. **Throbbing sounds and vibration originating outside the engine often telegraph along the propeller shaft and seem to originate in the engine.**	(a) Transmission rattle caused by transmission and overdrive oil too light. (b) Clutch driven plate grease-soaked. (c) Low friction lag clutch driven plate on an overdrive equipped car. (d) Bent propeller shaft. (e) Propeller shaft out of balance. (f) Wheels out of balance.
38. Uncommon engine noises.	(a) Flywheel loose on the crankshaft. (b) Vibration damper loose on the crankshaft. (c) Fallen object in the exhaust passage or inner pipe in the muffler. (d) Loose exhaust pipe flange at manifold. (e) Loose engine accessory, such as the generator, air cleaner, etc.

NOTES

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