ENGINE

GROUP 8

PART 8-1 GENERAL ENGINE SERVICE

This part covers engine diagnosis, testing, adjustment and repair procedures. In addition, the cleaning and inspection procedures are covered.

For engine removal, disassembly, assembly, installation and major repair procedures, refer to the pertinent part of this group.

The engine identification tag is attached to the engine with the ignition coil mounting bracket bolt. The symbol code (Fig. 1) identifies each engine for determining parts usage; i.e., engine cubic inch displacement and model year. The change level and engine code number determine if parts are peculiar to a specific engine.

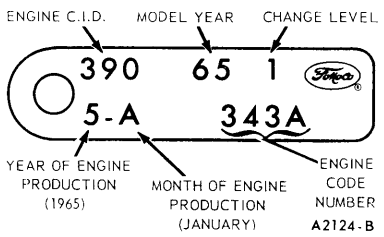

FIG. 1—Engine Identification Tag

1 DIAGNOSIS AND TESTING

DIAGNOSIS

Engine performance complaints usually fall under one of the basic headings listed in the "Diagnosis Guide." When a particular trouble can not be traced to a definite cause by a simple check, the possible items that could be at fault are listed in the order of their probable occurrence. Check the items in the order listed. For example, under "Poor Acceleration," the ignition system is listed as a probable cause of the trouble. All the ignition system items that affect acceleration are listed. Check all these items before proceeding to the next probable cause.

For diagnosis of transistor ignition system malfunctions, refer to Group 9.

DIAGNOSIS GUIDE

ENGINE WILL NOT CRANK	The cause of this trouble is usually in the starting system (Group 14). If the starting system is not at fault, check for hydrostatic lock or a seized engine as follows: Remove the spark plugs; then attempt to crank the engine with the starter. If the engine cranks, it indicates that water is leaking into the cylinders. Remove the cylinder head(s) and inspect the gasket(s) and/or head(s) for cracks. Examine the cylinder block for cracks.	

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DIAGNOSIS GUIDE (Continued)

ENGINE CRANKS NORMALLY, BUT WILL NOT START	Check the fuel supply. If there is sufficient fuel in the tank, the cause of the trouble probably lies in either the ignition or the fuel system. To determine which system is at fault, perform the following test: Disconnect a spark plug wire. Check the spark intensity at the end of the wire by installing a terminal adapter in the end of the wire. Then hold the adapter approximately 3/16 inch from the exhaust manifold and crank the engine. **IF THERE IS NO SPARK OR A WEAK SPARK AT THE SPARK PLUGS** The cause of the trouble is in the ignition system. **Disconnect the brown lead ("I" terminal) and the red and blue lead ("S" terminal) at the starter relay.** Install an auxiliary starter switch between the battery and "S" terminals of the starter relay. To determine if the cause of the trouble is in the primary or the secondary circuit, remove the coil high tension lead from the top of the distributor, **and hold it approximately 3/16 inch from the cylinder head.** With the ignition on, crank the engine and check for a spark. If the spark at the coil high tension lead is good, the cause of the trouble is probably in the distributor cap, rotor or spark plug wires. If there is no spark or a weak spark at the coil high tension lead, the cause of the trouble is probably in the primary circuit, coil to distributor high tension lead, or the coil. **IF THERE IS A GOOD SPARK AT THE SPARK PLUGS** Check the spark plugs. If the spark plugs are not at fault, check the following items:	**AUTOMATIC CHOKE** Check the position of the choke plate. If the engine is hot, the plate should be open. If the plate is not open, the engine will load up due to the excessively rich mixture and will not start. If the engine is cold, the plate should be closed. If the plate is not operating properly, check the following items: The choke linkage for binding. The fast idle cam linkage for binding. Thermostatic spring housing adjustment. **FUEL SUPPLY AT THE CARBURETOR** Work the throttle by hand several times. Each time the throttle is actuated, fuel should spurt from the accelerating pump discharge nozzle. If fuel is discharged by the accelerating pump, the engine is probably flooded, or there is water in the fuel system, or an engine mechanical item is at fault. If fuel is not discharged by the accelerating pump, disconnect the carburetor fuel inlet line at the carburetor. Use a suitable container to catch the fuel. Crank the engine to see if fuel is reaching the carburetor. If fuel is not reaching the carburetor, check: The fuel filter. The fuel pump. The carburetor fuel inlet line for obstructions. The fuel pump flexible inlet line for a collapsed condition. The fuel tank line for obstructions. The fuel tank vented cap. If fuel is reaching the carburetor, check: The fuel inlet system including the fuel inlet needle and seat assembly and float assembly. **ENGINE** Mechanical failure in camshaft drive.
ENGINE STARTS, BUT FAILS TO KEEP RUNNING	**FUEL SYSTEM** Idle fuel mixture needles not properly adjusted. Engine idle speed set too low. The choke not operating properly. Float setting incorrect. Fuel inlet system not operating properly. Dirt or water in the fuel lines or in the fuel filter. Carburetor icing.	Fuel pump defective. Check for dirt in the carburetor not allowing fuel to enter or be discharged from the idle system. **IGNITION SYSTEM** Defective spark plugs. Leakage in the high tension wiring. Open circuit in primary resistance wire. Breaker points not properly adjusted.

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DIAGNOSIS GUIDE (Continued)

ENGINE RUNS, BUT MISSES	Determine if the miss is steady or erratic and at what speed the miss occurs by operating the engine at various speeds under load. **MISSES STEADILY AT ALL SPEEDS** Isolate the miss by operating the engine with one cylinder not firing. This is done by operating the engine with the ignition wire removed from one spark plug at a time, until all cylinders have been checked. Ground the spark plug wire removed. If the engine speed changes when a particular cylinder is shorted out, that cylinder was delivering power before being shorted out. If no change in the engine operation is evident, the miss was caused by that cylinder not delivering power before being shorted out. In this case, check the: **IGNITION SYSTEM** If the miss is isolated in a particular cylinder, perform a spark test on the ignition lead of that cylinder. If a good spark does not occur, the trouble is in the secondary circuit of the system. Check the spark plug wire and the distributor cap. If a good spark occurs, check the spark plug. If the spark plug is not at fault, a mechanical component of the engine is probably at fault. **ENGINE** Intake manifold gasket leak. Perform a manifold vacuum test or a compression test to determine which mechanical component of the engine is at fault. **MISSES ERRATICALLY AT ALL SPEEDS** **EXHAUST SYSTEM** Exhaust system restricted. **IGNITION SYSTEM** Defective breaker points, condenser, secondary wiring, coil or spark plugs. High tension leakage across the coil, rotor or distributor cap. Defective ignition switch. **FUEL SYSTEM** Float setting incorrect. Fuel inlet system not operating properly. Dirt or water in the fuel lines or carburetor. Restricted fuel filter. **COOLING SYSTEM** Check the cooling system for internal leakage and/or a condition that prevents the engine from reaching normal operating temperature. **ENGINE** Perform a manifold vacuum test or a compression test to determine which mechanical component of the engine is at fault. **MISSES AT IDLE ONLY** **FUEL SYSTEM** Idle fuel mixture needles not properly adjusted. Restriction in idle fuel system. **IGNITION SYSTEM** Excessive play in the distributor shaft. Worn distributor cam. Defective coil, condenser, breaker points, rotor, ignition wiring or spark plugs. **ENGINE** Perform a manifold vacuum test or a compression test to determine which mechanical component of the engine is at fault. **MISSES AT HIGH SPEED ONLY** **FUEL SYSTEM** Power valve or passages clogged or damaged. Low or erratic fuel pump pressure. Fuel inlet system not operating properly. Restricted fuel filter. Restricted main fuel system. Positive crankcase ventilation system restricted or valve not operating properly. **COOLING SYSTEM** Engine overheating. **IGNITION SYSTEM** Defective spark plugs. **ENGINE** Perform a manifold vacuum test or a compression test to determine which mechanical component of the engine is at fault.

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DIAGNOSIS GUIDE (Continued)

ROUGH ENGINE IDLE	**FUEL SYSTEM** Engine idle speed set too low. Idle fuel mixture needles not properly adjusted. Idle compensator malfunction. Float setting incorrect. Air leaks between the carburetor, spacer, and the manifold and/or fittings. Power valve leaking fuel. Idle fuel system air bleeds or fuel passages restricted. Fuel bleeding from the accelerating pump discharge nozzles. Secondary throttle plates not closing. Improper secondary throttle plate stop adjustment. Leaking fuel pump, lines or fittings.	**IGNITION SYSTEM** Improperly adjusted or defective breaker points. Fouled or improperly adjusted spark plugs. Incorrect ignition timing. Spark plug misfiring. **ENGINE** Loose engine mounting bolts or worn engine support insulator. Cylinder head bolts not properly torqued. Positive crankcase ventilation regulator valve defective or a restricted ventilation system. Worn camshaft lobes. Perform a manifold vacuum test and/or compression test to determine which mechanical component is at fault.
POOR ACCELERATION	**IGNITION SYSTEM** Incorrect ignition timing. Fouled or improperly adjusted spark plugs. Improperly adjusted or defective breaker points. Distributor not advancing properly. **FUEL SYSTEM** Accelerating pump malfunction. Float setting incorrect. Throttle linkage not properly adjusted. Accelerating pump stroke not properly adjusted. Leaky power valve, gaskets or accelerating pump diaphragm.	Dirt or corrosion in accelerating system. Distributor vacuum passages in the carburetor blocked. Restricted fuel filter. **BRAKES** Improper adjustment – too tight. **TRANSMISSION** Improper band adjustment. Converter One-Way Clutch. **ENGINE** Perform a manifold vacuum test and/or compression test to determine which mechanical component of the engine is at fault.
ENGINE DOES NOT DEVELOP FULL POWER OR HAS POOR HIGH SPEED PERFORMANCE	**FUEL SYSTEM** Restricted air cleaner. Restricted fuel filter. Clogged or undersize main jets and/or low float setting. Clogged or undersize secondary jets. Power valve or passages clogged or damaged. Fuel pump pressure incorrect. Distributor vacuum passage in the carburetor blocked. Secondary throttle plates not opening. Automatic choke malfunctioning or improperly adjusted. **IGNITION SYSTEM** Ignition timing not properly adjusted.	Defective coil, condenser or rotor. Distributor not advancing properly. Excessive play in the distributor shaft. Distributor cam worn. Fouled or improperly adjusted spark plugs, or spark plugs or incorrect heat range. Improperly adjusted or defective breaker points. **EXHAUST SYSTEM** Restriction in system. **COOLING SYSTEM** Thermostat inoperative or of incorrect heat range. Thermostat installed incorrectly. Check the cooling system for in-

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DIAGNOSIS GUIDE (Continued)

ENGINE DOES NOT DEVELOP FULL POWER OR HAS POOR HIGH SPEED PERFORMANCE (Continued)	ternal leakage and/or for a condition that prevents the engine from reaching normal operating temperature. **ENGINE** Positive crankcase ventilation system and/or regulator valve not operating properly. Perform a manifold vacuum test	or a compression test to determine which mechanical component of the engine is at fault. One or more camshaft lobes worn beyond wear limit. Worn valve guides. **TRANSMISSION** Improper band adjustment (automatic transmission).
EXCESSIVE FUEL CONSUMPTION	Determine the actual fuel consumption with test equipment installed in the car. If the test indicates that the fuel consumption is not excessive, demonstrate to the owner how improper driving habits will affect fuel consumption. If the test indicates that the fuel consumption is excessive, make a preliminary check of the following items before proceeding to the fuel and ignition systems. **PRELIMINARY CHECKS** **CHASSIS ITEMS** Check: Tires for proper pressure. Front wheel alignment. Brake adjustment. **EXHAUST SYSTEM** Check for restriction in system. **ODOMETER** Check calibration. **IGNITION SYSTEM** Check: Distributor breaker points. Ignition timing. **ENGINE** Positive crankcase ventilation regulator valve defective or restricted ventilation system. **FINAL CHECKS** **FUEL SYSTEM** Check: Fuel pump pressure.	Engine idle speed. Idle fuel mixture needles for proper adjustment. Automatic choke for proper operation. Fast idle speed screw for proper adjustment. Accelerating pump stroke adjustment. Anti-stall dashpot for proper adjustment. Air cleaner for restrictions. Float setting or fuel level. Jets for wear and/or damage. Power valve operation. Air bleeds for obstructions. Accelerating pump discharge nozzles for siphoning. Accelerator linkage for binds. Choke adjustment. **IGNITION SYSTEM** Check: Spark plug condition and adjustment. Distributor spark advance operation. Initial ignition timing. **ENGINE** Perform a manifold vacuum test or a compression test to determine which mechanical component of the engine is at fault. **COOLING SYSTEM** Check thermostat operation and heat range. **TRANSMISSION** Check band adjustment (automatic transmission).
ENGINE OVERHEATS	**TEMPERATURE SENDING UNIT AND GAUGE** Unit or gauge defective or not indicating correct temperature, or constant voltage regulator defective. **ENGINE** Cylinder head bolts not properly	torqued. Incorrect valve clearance. Low oil level or incorrect viscosity oil used. Perform a manifold vacuum test or a compression test to determine which mechanical component of the engine is at fault.

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DIAGNOSIS GUIDE (Continued)

ENGINE OVERHEATS (Continued)	**COOLING SYSTEM** Insufficient coolant. Cooling system leaks. Drive belt tension incorrect. Radiator fins obstructed. Thermostat defective. Thermostat improperly installed. Cooling system passages blocked. Water pump inoperative.	Faulty fan drive clutch. **IGNITION SYSTEM** Incorrect ignition timing. **EXHAUST SYSTEM** Restrictions in system. **BRAKES** Improper adjustment – too tight.
LOSS OF COOLANT	**COOLING SYSTEM** Leaking radiator or water pump. Loose or damaged hose connections. Radiator cap defective. Overheating. **ENGINE** Cylinder head gasket defective.	Intake manifold to cylinder head gasket defective. Cylinder head or intake manifold bolts not properly torqued. Cylinder block core plugs leaking. Temperature sending unit leaking. Cracked cylinder head or block, or warped cylinder head or block gasket surface.
ENGINE FAILS TO REACH NORMAL OPERATING TEMPERATURE	**TEMPERATURE SENDING UNIT AND GAUGE** Unit or gauge defective or not indicating correct temperature, or constant voltage regulator defective.	**COOLING SYSTEM** Thermostat inoperative or of incorrect heat range.
NOISY HYDRAULIC VALVE LIFTER	A noisy valve lifter can be located by operating the engine at idle speed and placing a finger on the face of the valve spring retainer. If the lifter is not functioning properly, a shock will be felt when the valve seats. Another method of identifying a noisy lifter is by the use of a piece of hose. With the engine operating at idle speed, place one end of the hose near the end of the valve stem and the other end to the ear and listen for a metallic noise. Repeat this procedure on each intake and exhaust valve until the noisy lifter(s) has been located. The most common causes of hydraulic valve lifter troubles are dirt, gum, varnish, carbon deposits and air bubbles. Dirt in the lifter assembly can prevent the disc valve from seating, or it may become lodged between the plunger and body surfaces. In either case, the lifter becomes inoperative due to failure to "pump-up," or because the internal parts are no longer free to function properly. When dirt is found to be responsible for lifter malfunction, remove the lifter assembly and thoroughly clean it. Recommended engine oil and filter change intervals should be followed to minimize lifter problems caused by dirt (Group 19).	Deposits of gum and varnish cause similar conditions to exist which may result in lifter malfunction. If these conditions are found to be present, the lifter should be disassembled and cleaned in solvent to remove all traces of deposits. Air bubbles in the lubricating oil, caused by an excessively high or low oil level, may likewise cause lifter malfunction. A damaged oil pick-up tube may allow air to be drawn into the lubricating system. Check for engine oil aeration as follows: Check the engine oil level to be sure it is within specification and correct as required. **Be sure the correct engine oil dipstick is being used.** Operate the engine at approximately 1200 rpm until normal operating temperature is reached. Stop the engine and remove the oil pressure sending unit. Install a fitting in this opening with a petcock-type valve that will permit attachment of a ¼- to ⅜-inch diameter hose of sufficient length to direct the oil discharge into the oil filler pipe. Close the valve. Start the engine and operate it at approximately 500 rpm for a minimum of 5 minutes; then, open the valve slightly to permit a steady dis-

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DIAGNOSIS GUIDE (Continued)

NOISY HYDRAULIC VALVE LIFTER (Continued)	charge of oil. Check the oil flow for air bubbles. Increase the engine speed to approximately 1000 rpm and check for air bubbles in the oil. **To facilitate checking for air bubbles, direct the oil flow over white paper or through a piece of transparent tube. The engine should not be operated at excessive speeds or for extended periods with the oil bleed attached.** If oil aeration is evident, remove the oil pan for further test and/or inspection of the oil pump intake system. Perform corrective action as required to remove air from the lubricating oil.

TESTING

CAMSHAFT LOBE LIFT

Check the lift of each lobe in consecutive order and make a note of the readings.

1. Remove the air cleaner and the valve rocker arm cover(s). Remove the valve rocker arm shaft assembly(lies). Install a solid tappet-type push rod in the push rod bore of the camshaft lobe to be checked, or use the adapter for ball-end push rods shown in Fig. 2.

2. Make sure the push rod is in the valve lifter socket. Install a dial indicator in such a manner as to have the actuating point of the indicator in the push rod socket and in the same plane as the push rod movement (Fig. 2).

3. **Disconnect the brown lead ("I" terminal) and the red and blue lead ("S" terminal) at the starter relay.** Install an auxiliary starter switch between the battery and "S" terminals of the starter relay. **Crank the engine with the ignition switch "OFF".**

"Bump" the crankshaft over until the valve lifter rests on the base circle of the cam. **At this point the push rod is in its lowest position.**

4. Zero the dial indicator. Continue to rotate the crankshaft slowly until the push rod is in the fully raised position.

5. Compare the total lift recorded on the indicator with specifications.

6. To check the accuracy of the original indicator reading, continue to rotate the crankshaft until the indicator reads zero. **If the camshaft reading on any lobe is below specified wear limits, the camshaft and the valve lifters operating on the worn lobes must be replaced.**

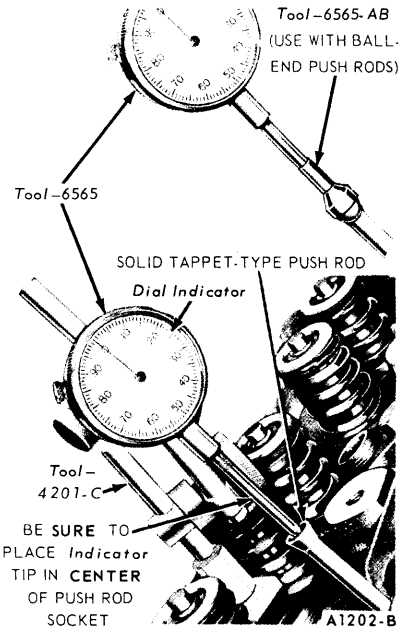

FIG. 2—Camshaft Lobe Lift

TABLE 1—Manifold Vacuum Gauge Readings

Gauge Reading	Engine Condition
18 inches or over.	Normal.
Low and steady.	Loss of power in all cylinders possibly caused by late ignition or valve timing, or loss of compression due to leakage around the piston rings.
Very low.	Intake manifold, carburetor spacer or cylinder head gasket leak.
Needle fluctuates steadily as speed increases.	A partial or complete loss of power in one or more cylinders caused by a leaking valve, cylinder head or intake manifold gasket, a defect in the ignition system, or a weak valve spring.
Gradual drop in reading at engine idle.	Excessive back pressure in the exhaust system.
Intermittent fluctuation.	An occasional loss of power possibly caused by a defect in the ignition system or a sticking valve.
Slow fluctuation or drifting of the needle.	Improper idle mixture adjustment or carburetor, spacer or intake manifold gasket leak, or crankcase ventilation system restricted.

7. Remove the dial indicator and the auxiliary starter switch.

8. Install the valve rocker arm shaft assembly(ies). Install the valve rocker arm cover and the air cleaner.

MANIFOLD VACUUM TEST

A manifold vacuum test aids in determining the condition of an engine and also in helping to locate the cause of poor engine performance. To check manifold vacuum:

1. Operate the engine for a minimum of 30 minutes at 1200 rpm or until the engine is at normal operating temperature.

2. Remove the plug or power brake line at the rear of the intake manifold (front of crankcase ventilation outlet), and install an accurate, sensitive, vacuum gauge.

3. Operate the engine at the recommended idle rpm, with the transmission selector lever in neutral.

4. Check the vacuum reading on the gauge.

Test Conclusions. Manifold vac-

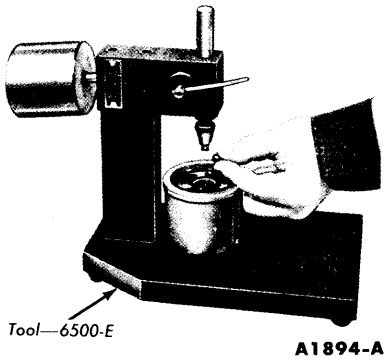

FIG. 3—Placing Steel Ball in Valve Lifter Plunger

uum is affected by the carburetor adjustment, valve timing, ignition timing, the condition of the valves, cylinder compression and leakage of the manifold, carburetor, carburetor spacer or cylinder head gaskets, or a restricted crankcase ventilation system.

Because abnormal gauge readings may indicate that more than one of the above factors are at fault, exercise caution in analyzing an abnormal reading. For example, if the vacuum is low, the correction of one item may increase the vacuum enough so as to indicate that the trouble has been corrected. It is important, therefore, that each cause of an abnormal reading be investigated and further tests conducted,

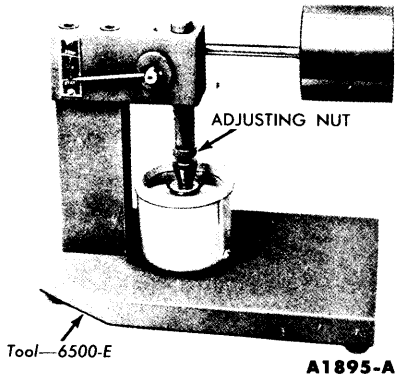

FIG. 4—Adjusting the Ram Length

where necessary, in order to arrive at the correct diagnosis of the trouble.

Table 1 lists various types of readings and their possible causes.

Allowance should be made for the effect of altitude on the gauge reading. The engine vacuum will decrease with an increase in altitude.

COMPRESSION TEST

1. Be sure the crankcase oil is at the proper level.

2. Be sure the battery is properly charged. Operate the engine for a minimum of 30 minutes at 1200 rpm or until the engine is at normal operating temperature. Turn the ignition switch off; then remove all the spark plugs. Remove the coil high tension lead from the distributor cap and ground it against the engine.

3. Set the primary throttle plates and choke plate in the wide open position.

4. Install a compression gauge in No. 1 cylinder.

5. Using an auxiliary starter switch, crank the engine a minimum of 5 pumping strokes and record the highest reading.

Disconnect the brown lead ("I" terminal) and the red and blue lead ("S" terminal) at the starter relay. Install an auxiliary starter switch between the battery and "S" terminals of the starter relay. **Crank the engine with the ignition switch "OFF".**

Note the number of compression strokes required to obtain the highest reading.

6. Repeat the test on each cylinder, cranking the engine the same number of times for each cylinder as was required to obtain the highest reading on the No. 1 cylinder.

Test Conclusions. A variation of ± 20 psi from specified pressure is satisfactory. However, the compression of all cylinders should be uniform within 20 psi.

A reading of more than the allowable tolerance above normal indicates excessive deposits in the cylinder.

A reading of more than the allowable tolerance below normal indicates leakage at the cylinder head gasket, piston rings or valves.

A low, even compression in two adjacent cylinders indicates a cylinder head gasket leak. This should be checked before condemning the rings or valves.

To determine whether the rings or the valves are at fault, squirt the equivalent of a tablespoon of heavy oil into the combustion chamber. Crank the engine to distribute the oil and repeat the compression test. The oil will temporarily seal leakage past the rings. If approximately the same reading is obtained, the rings are satisfactory, but the valves are leaking. If the compression has increased substantially over the original reading, there is leakage past the rings.

During a compression test, if the pressure fails to climb steadily and remains the same during the first two successive strokes, but climbs higher on the succeeding strokes, or fails to climb during the entire test, it indicates a sticking valve.

HYDRAULIC VALVE LIFTER TESTS

Dirt, deposits of gum and varnish and air bubbles in the lubricating oil can cause hydraulic valve lifter failure or malfunction.

Dirt, gum and varnish can keep a check valve from seating and cause a loss of hydraulic pressure. An open valve disc will cause the plunger to force oil back into the valve lifter reservoir during the time the push rod is being lifted to force the valve from its seat.

Air bubbles in the lubricating system can be caused by too much oil in the system or too low an oil level. Air may also be drawn into the lubricating system through an opening in a damaged oil pick-up tube. **Air in the hydraulic system can cause a loss of hydraulic pressure.**

Assembled valve lifters can be tested with tool 6500-E to check the leak down rate. The leak down rate specification (for gauging purposes) is 10-50 seconds at 50 lbs. load. Plunger travel is 0.125 inch. Test the valve lifters as follows:

1. Place the valve lifter in the tester, with the plunger facing upward. Pour hydraulic tester fluid into the cup to a level that will cover the valve lifter assembly. **The fluid can be purchased from the manufacturer of the tester. Do not use kerosene, for it will not provide an accurate test.**

2. Place a 5/16-inch steel ball in the plunger cup (Fig. 3).

3. Adjust the length of the ram so that the pointer is in line with the starting mark when the ram contacts the valve lifter plunger (Fig. 4).

4. Work the valve lifter plunger up and down until the lifter fills with fluid and all traces of air bubbles have disappeared.

5. Allow the ram and weight to force the valve lifter plunger downward. Measure the exact time it takes for the pointer to travel from the "Start Timing" to the "Stop Timing" marks of the tester.

6. A valve lifter that is satisfactory must take at least 10 seconds, but not more than 50 seconds, to leak down.

7. If the valve lifter is not within specifications, disassemble the lifter and clean and inspect it as outlined in Section 3. Assemble the lifter and test the lifter again. If it does not meet specifications, replace it with a new lifter. **Always test a new lifter before installing it in the engine.**

8. Remove the fluid from the cup and bleed the fluid from the lifter by working the plunger up and down. **This step will aid in depressing the lifter plungers when checking the valve clearance.**

FLYWHEEL RUNOUT AUTOMATIC TRANSMISSION

Remove the spark plugs.

Install a dial indicator so that the indicator point rests on the face of the ring gear midway between the mounting bolt circle and gear teeth.

Push the flywheel and crankshaft forward as far as possible to prevent crankshaft end play from being indicated as flywheel runout.

Set the indicator dial on the "zero" mark. Turn the flywheel one complete revolution while observing the total indicator reading (T.I.R.). If the T.I.R. exceeds specifications, the starter ring gear or flywheel and ring gear assembly must be replaced.

Install the dial indicator so that the point rests on a tooth of the ring gear, and check the outside diameter (O.D.) of the assembled flywheel and ring gear. **For this check, carefully adjust the indicator on the gear tooth so that the indicator point is near the extreme limit of its travel. This will prevent the indicator point from catching between the gear teeth as the flywheel is turned.** Set the indicator dial on the "zero" mark and slowly turn the flywheel through one revolution while observing the total indicator reading. The T.I.R. must be within specifications, or the ring gear must be replaced.

2 COMMON ADJUSTMENTS AND REPAIRS

VALVE CLEARANCE

A 0.060-inch shorter push rod or a 0.060-inch longer push rod are available for service to provide a means of compensating for dimensional changes in the valve mechanism. Refer to the Master Parts List or the specifications for the pertinent color code.

Valve stem to valve rocker arm clearance should be within specifications with the hydraulic lifter completely collapsed. Repeated valve reconditioning operations (valve and/or valve seat refacing) will decrease this clearance to the point that if not compensated for, the hydraulic valve lifter will cease to function.

To determine whether a shorter or a longer push rod is necessary, make the following check:

1. **Disconnect the brown lead ("I" terminal) and the red and blue lead ("S" terminal) at the starter relay.** Install an auxiliary starter switch between the battery and "S" terminals of the starter relay. **Crank the engine with the ignition switch "OFF".**

2. **Position the crankshaft as outlined in steps 6 and 7.**

3. Position the hydraulic lifter compressor tool on the rocker arm and slowly apply pressure to bleed down the hydraulic lifter until the plunger is completely bottomed (Fig. 5). Hold the lifter in the fully collapsed position.

4. Insert the correct end of the clearance gauge between the valve stem and the rocker arm.

5. If the first step of the gauge enters, a standard length push rod may be used.

If the first step of the gauge does not enter, replace the standard push rod with a 0.060-inch shorter service push rod.

If the second step of the gauge enters, the operating range of the lifter is excessive. This indicates that the incorrect push rod has been installed or severe wear has occurred at the push rod ends, rocker arm, or valve stem. In this case, it will be necessary to determine the area of discrepancy and the incorrect or defective part(s) should be replaced.

If all the valve train components except the push rod are within limits, install a 0.060-inch longer push rod.

6. Rotate the crankshaft until No. 1 piston is on TDC at the end of the compression stroke, and check the following valves:

No. 1 Intake	No. 1 Exhaust
No. 3 Intake	No. 4 Exhaust
No. 7 Intake	No. 5 Exhaust
No. 8 Intake	No. 8 Exhaust

7. Position No. 6 piston on TDC and check the following valves:

No. 2 Intake	No. 2 Exhaust
No. 4 Intake	No. 3 Exhaust
No. 5 Intake	No. 6 Exhaust
No. 6 Intake	No. 7 Exhaust

When compressing the valve spring to remove push rods, be sure the piston in the individual cylinder is below TDC to avoid contact between the valve and the piston.

To replace a push rod, it will be necessary to remove the valve rocker arm shaft assembly following the procedures in Part 8-2, Section 3.

Upon replacement of a valve push rod and/or valve rocker arm shaft assembly, the engine should not be cranked or rotated until the hydraulic valve lifters have had an opportunity to leak down to their normal operating position. The leak down rate can be accelerated by using the tool shown in Fig. 5 on the valve rocker arm and applying pressure in a direction to collapse the lifter.

VALVE ROCKER ARM SHAFT ASSEMBLY

Dress up minor surface defects on the rocker arm shaft and in the rocker arm bore with a hone.

If the pad at the valve end of the rocker arm has a grooved radius, replace the rocker arm. **Do not at-**

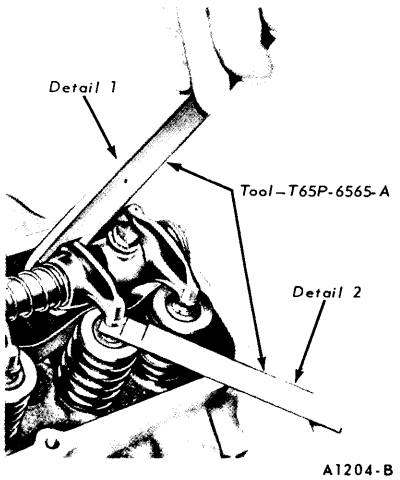

FIG. 5—Valve Clearance

tempt to true this surface by grinding.

PUSH RODS

Following the procedures in Section 3 under "Push Rod Inspection," check the push rods for straightness.

If the runout exceeds the maximum limit at any point, discard the rod. **Do not attempt to straighten push rods.**

CYLINDER HEADS

Replace the head if it is cracked. **Do not plane or grind more than 0.010 inch from the cylinder head gasket surface.** Remove all burrs or scratches with an oil stone.

REAMING VALVE GUIDES

If it becomes necessary to ream a valve guide (Fig. 6) to install a valve with an oversize stem, a reaming kit is available which contains the following reamer and pilot combinations: a 0.003-inch and O.S. reamer with a standard diameter pilot, a 0.015-inch O.S. reamer with a 0.003-inch O.S. pilot, and a 0.030-inch reamer with a 0.015-inch O.S. pilot.

When going from a standard size valve to an oversize valve, always use the reamers in sequence. **Always reface the valve seat after the valve guide has been reamed.**

REFACING VALVE SEATS

Refacing of the valve seats should be closely coordinated with the refacing of the valve face so that the finished seat and valve face will be concentric and the specified interference fit will be maintained. This is important so that the valve and seat will have a compression-tight fit. Be sure that the refacer grinding wheels are properly dressed.

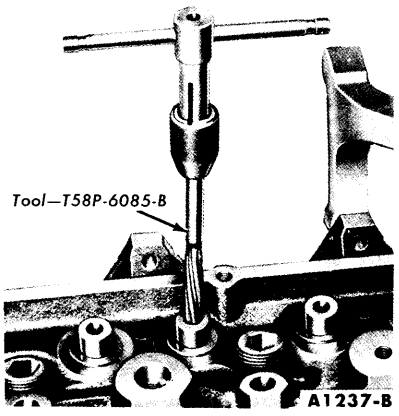

FIG. 6—Reaming Valve Guides

Grind the valve seats to a true 45° angle (Fig. 7). Remove only enough stock to clean up pits and grooves or to correct the valve seat runout. After the seat has been refaced, measure the seat width (Fig. 8). Narrow the seat, if necessary, to bring it within limits.

If the valve seat width exceeds the maximum limit, remove enough stock from the top edge and/or bottom edge of the seat to reduce the width to specifications.

On the valve seats, use a 60° angle grinding wheel to remove stock from the bottom of the seats (raise the seats) and use a 30° angle wheel to remove stock from the top of the seats (lower the seats).

The finished valve seat should contact the approximate center of the valve face. It is good practice to determine where the valve seat contacts the face. To do this, coat the seat with Prussian blue; then set the valve in place. Rotate the valve with light pressure. If the blue is transferred to the center of the valve face, the contact is satisfactory. If the blue is transferred to the top edge of the valve face, lower the valve seat. If the blue is transferred to the bottom edge of the valve face, raise the valve seat.

VALVES

For inspection procedures refer to Section 3.

Valve defects, such as minor pits, grooves, etc, may be removed. Discard valves that are severely damaged, or if the face runout or stem clearance exceed specifications.

Discard any defective part of the valve assembly.

REFACING VALVES

The valve refacing operation should be closely coordinated with the valve seat refacing operation so that the finished angles of the valve face and of the valve seat will be to specifications and will provide a compression-tight fit. Be sure that the refacer grinding wheels are properly dressed.

If the valve face runout is excessive and/or to remove pits and grooves, reface the valves to a true 44° angle. Remove only enough stock to correct the runout or to clean up the pits and grooves. If the edge of the valve head is less than 1/32 inch thick after grinding, replace the valve as the valve will run too hot in the engine. **The interference fit of the valve and seat should not be lapped out.**

Remove all grooves or score marks from the end of the valve stem; then chamfer as necessary. Do not remove more than 0.010 inch from the stem.

If the valve and/or valve seat has been refaced, it will be necessary to check the clearance between the rocker arm pad and the valve stem with the valve train assembly installed in the engine.

SELECT FITTING VALVES

If the valve stem to valve guide clearance exceeds the wear limit, ream the valve guide for the next oversize valve stem. Valves with oversize stem diameters of 0.003, 0.015 and 0.030 inch are available for service. **Always reface the valve seat after the valve guide has been reamed.** Refer to "Reaming Valve Guides."

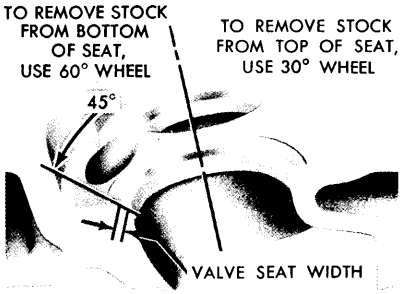

FIG. 7—Valve Seat Refacing

CAMSHAFT

Remove light scuffs, scores or nicks from the camshaft machined surfaces with a smooth oil stone.

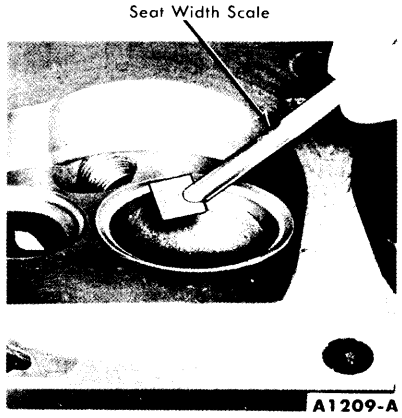

FIG. 8—Checking Valve Seat Width

CRANKSHAFT

Dress minor imperfections with an oil stone. Reface severely marred journals.

If the journals exceed the wear limit, they should be refinished to size for the next undersize bearing.

REFINISHING JOURNALS

Refinish the journal to give the proper clearance with the next undersize bearing. If the journal will not "clean up" to give the proper clearance with the maximum undersize bearing available, replace the crankshaft.

Always reproduce the same journal shoulder radius that existed originally. Too small a radius will result in fatigue failure of the crankshaft. Too large a radius will result in bearing failure due to radius ride of the bearing.

After refinishing the journals, chamfer the oil holes, then polish the journal with a No. 320 grit polishing cloth and engine oil. Crocus cloth may be used also as a polishing agent.

PISTONS, PINS AND RINGS

FITTING PISTONS

Pistons are available for service in standard sizes and 0.020, 0.030 and 0.040 inch oversizes.

The standard-size pistons are color coded "red" or "blue" on the dome. Refer to the specifications for the standard-size piston dimensions. Piston pins and retainers are provided with new pistons.

Follow the procedures in Section 3 to measure the piston O.D. and cylinder bore. The dimensions should be within specifications, and the piston to bore clearance (bore I.D. minus piston O.D.) must be within the specified limits.

Then, check the piston fit in the bore with a feeler gauge and spring scale, following the procedure in steps 1 thru 7 below.

If the piston clearance is greater than the maximum limit, recheck calculations to be sure that the proper size piston has been selected, check for a damaged piston; then try a new piston.

If the clearance is less than the minimum limit, recheck calculations before trying another piston. If none can be fitted, refinish the cylinder for the next size piston available.

When a piston has been fitted, mark it for assembly in the cylinder to which it was fitted.

If the taper and out-of-round conditions of the cylinder bore are within limits, new piston rings will give satisfactory service provided the piston clearance in the cylinder bore is within specified limits. If the new rings are to be installed in a used cylinder that has not been refinished, remove the cylinder wall "glaze." Be sure to clean the cylinder bore thoroughly, following the procedures in Section 3.

To fit a piston:

1. Calculate the size piston to be used by taking a cylinder bore check, following the procedures in Section 3.

2. Select the proper size piston to provide the desired clearance (Refer to the specifications).

3. Make sure the piston and cylinder block are at room temperature (70°F). **After any refinishing operation allow the cylinder bore to cool, and make sure the piston and bore are clean and dry before the piston fit is checked.**

To check the measured fit of piston to cylinder bore, use a feeler gauge and tension scale following the procedure in steps 4-7 below. **This procedure must not be used to overrule the calculated fit determined from measuring the piston and cylinder bore (Section 3).**

4. Attach a tension scale to the end of a feeler gauge ribbon that is free of dents or burrs. The feeler ribbon should be ½-inch wide and of one of the thicknesses listed in Fig. 9.

5. Position the ribbon in the cyl-

PISTON CLEARANCE

RIBBON 0.0015 THICK & 0.500 WIDE		RIBBON 0.002 THICK & 0.500 WIDE		RIBBON 0.0035 THICK & 0.500 WIDE		RIBBON 0.006 THICK & 0.500 WIDE	
Ribbon Pull Lbs.	Clearance Inches	Ribbon Pull Lbs.	Clearance Inches	Ribbon Pull Lbs.	Clearance Inches	Ribbon Pull Lbs.	Clearance Inches
13	—	13	—	13	0.0012	13	0.0038
12	—	12	—	12	0.0014	12	0.0040
11	—	11	—	11	0.0016	11	0.0041
10	—	10	—	10	0.0018	10	0.0043
9	—	9	0.0002	9	0.0021	9	0.0045
8	—	8	0.0005	8	0.0023	8	0.0047
7	0.0002	7	0.0007	7	0.0025	7	0.0049
6	0.0004	6	0.0010	6	0.0027	6	0.0050
5	0.0007	5	0.0012	5	0.0030	5	0.0057
4	0.0009	4	0.0015	4	0.0032	4	0.0059
3	0.0012	3	0.0017	3	0.0033	3	0.0060
2	0.0015	2	0.0020	2	0.0036	2	0.0062
1	0.0017	1	0.0022	1	0.0038	1	0.0063
0	0.0020	0	0.0025	0	0.0040	0	0.0065

A1930-A

FIG. 9—Piston Clearance Chart

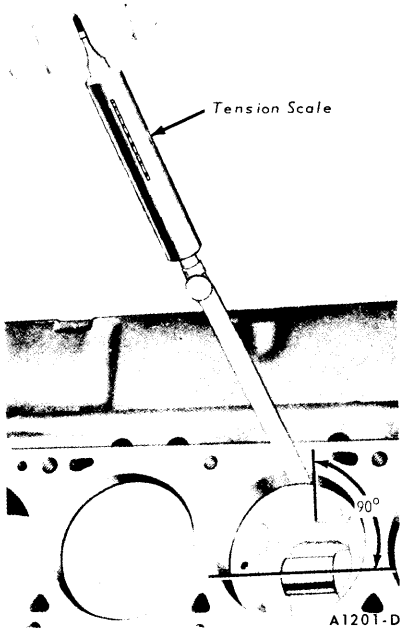

FIG. 10—Checking Piston Fit

inder bore so that it extends the entire length of the piston at 90° from the piston pin location.

6. Invert the piston and install it in the bore so that the end of the piston is about 1½ inches below the top of the cylinder block and the piston pin is parallel to the crankshaft axis.

7. Hold the piston and slowly pull the scale in a straight line with the ribbon, noting the pull required to remove the feeler ribbon (Fig. 10).

Compare the required pull with Fig. 9 to determine the piston clearance.

FITTING PISTON RINGS

1. Select the proper ring set for the size piston to be used.

2. Position the ring in the cylinder bore in which it is going to be used.

3. Push the ring down into the bore area where normal ring wear is not encountered.

4. Use the head of a piston to position the ring in the bore so that the ring is square with the cylinder wall. **Use caution to avoid damage to the ring or cylinder bore.**

5. Measure the gap between the ends of the ring with a feeler gauge (Fig. 11). If the ring gap is less or greater than the specified limits, try another ring set.

6. Check the ring side clearance of the compression rings with a feeler gauge inserted between the ring and its lower land (Fig. 12). The gauge should slide freely around the entire ring circumference without binding. Any wear that occurs will form a step at the inner portion of the lower land. **If the lower lands have high steps, the piston should be replaced.**

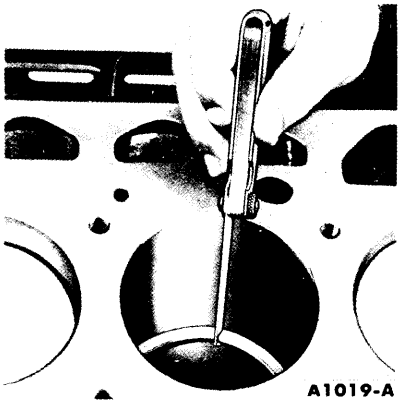

FIG. 11—Typical Piston Ring Gap

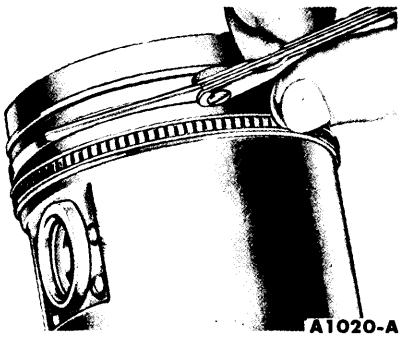

FIG. 12—Ring Side Clearance

FITTING PISTON PINS

The piston pin should be a light thumb press fit at normal temperature (70°F). Standard piston pins are color coded green. Pins of 0.001-inch oversize (color coded blue) and 0.002-inch oversize (color coded yellow) are available.

If the pin hole in the piston must be reamed or honed, use precision honing equipment or an expansion-type piloted reamer.

If a reamer is used, place the reamer in a vise and revolve the piston around the reamer. Set the reamer to the size of the pin bore; then expand the reamer slightly and trial ream the pin bore. Take a light cut. Use a pilot sleeve of the nearest size to maintain alignment of the bores.

Check the hole size, using the new piston pin. If the bore is small, expand the reamer slightly and make another cut. Repeat the procedure until the proper fit is obtained. Check the piston pin for fit in the respective rod bushing. If necessary, ream or hone the bushing to fit the pin.

Install the piston pin in the piston and rod. Install a new retainer at each end of the pin to hold it in place. Make sure the retainers are properly seated in their grooves.

CYLINDER BLOCK

REFINISHING CYLINDER WALLS

Honing is recommended for refinishing cylinder walls only when the walls have minor imperfections, such as light scuffs, scratches, etc. The grade of hone to be used is determined by the amount of metal to be removed. Follow the instructions of the hone manufacturer. If coarse stones are used to start the honing operation, leave enough material so that all hone marks can be removed with the finishing hone which is used to obtain the proper piston clearance.

Cylinder walls that are severely marred and/or worn beyond the specified limits should be refinished. Before any cylinder is refinished, all main bearing caps must be in place and tightened to the proper torque so that the crankshaft bearing bores will not become distorted from the refinishing operation.

Refinish only the cylinder or cylinders that require it. **All pistons are the same weight, both standard and oversize; therefore, various sizes of pistons can be used without upsetting engine balance.**

Refinish the cylinder with the most wear first to determine the maximum oversize. If the cylinder will not clean up when refinished for the maximum oversize piston recommended, replace the block.

Refinish the cylinder to within approximately 0.0015 inch of the required oversize diameter. This will allow enough stock for the final step of honing so that the correct surface finish and pattern are obtained. Use clean sharp hones of No. 180-220 grit for this operation.

For the proper use of the refinishing equipment, follow the instructions of the manufacturer. Only experienced personnel should be allowed to perform this work.

After the final operation in either of the two refinishing methods described and prior to checking the piston fit, thoroughly clean and oil the cylinder walls, following the procedure in Section 3. Check the piston fit, following the procedures in this section and Section 3. Mark the pistons to correspond to the cylinders in which they are to be installed. When the refinishing of all cylinders that require it has been completed and all pistons fitted, thoroughly clean the entire block to remove all particles from the bearing bores, oil passages, cylinder head bolt holes, etc. Coat the cylinder walls with oil.

3 CLEANING AND INSPECTION

The cleaning and inspection procedures in this section are for a complete engine overhaul; therefore, for partial engine overhaul or parts replacement follow the pertinent cleaning or inspection procedure.

INTAKE MANIFOLD

CLEANING

Remove all gasket material from the machined surfaces of the manifold. Clean the manifold in a suitable solvent, and dry with compressed air.

INSPECTION

Inspect the manifold for cracks, damaged gasket surfaces, or other defects that would make it unfit for further service. Replace all studs that are stripped or otherwise damaged. **Remove all filings and foreign matter that may have entered the manifold as a result of repairs.**

Check the baffle plate on the underside of the manifold; it should be securely fastened to all retaining points.

EXHAUST MANIFOLDS

CLEANING

Remove all gasket material from the manifolds.

On the right exhaust manifold, clean out the automatic choke air heat chamber. Make sure the air inlet passage is completely open and the cover does not leak. Blow out the automatic choke air heat tube and air inlet tube with compressed air.

INSPECTION

Inspect the manifolds for cracks, damaged gasket surfaces, or other defects that would make them unfit for further service.

VALVE ROCKER ARM SHAFT ASSEMBLY

CLEANING

Clean all the parts thoroughly. Make sure all oil passages are open. If necessary, remove the plugs from both ends of the rocker arm shaft to thoroughly clean the shaft passages.

INSPECTION

Check the clearance between each rocker arm and the shaft by checking the ID of the rocker arm bore and the OD of the shaft. If the clearance between any rocker arm and the shaft exceeds the wear limit, replace the shaft and/or the rocker arm. Inspect the shaft and the rocker arm bore for nicks, scratches, scores or scuffs.

Inspect the pad at the valve end of the rocker arms for indications of scuffing or abnormal wear. If the pad is grooved, replace the rocker arm. **Do not attempt to true this surface by grinding.**

Check for broken locating springs.

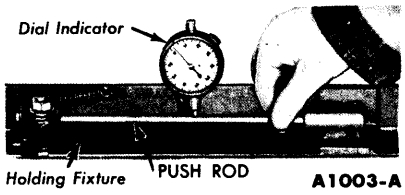

FIG. 13—Push Rod Runout

PUSH RODS

INSPECTION

Check the ends of the push rods for nicks, grooves, roughness or excessive wear.

The push rods can be visually checked for straightness while they are installed in the engine by rotating them with the valve closed. They also can be checked with a dial indicator (Fig. 13).

CYLINDER HEADS

CLEANING

With the valves installed to protect the valve seats, remove deposits from the combustion chambers and valve heads with a scraper and a wire brush. **Be careful not to damage the cylinder head gasket surface.** After the valves are removed, clean the valve guide bores with a valve guide cleaning tool. Use cleaning solvent to remove dirt, grease and other deposits. Clean all bolt holes; be sure the oil transfer passage is clean.

Remove all deposits from the valves with a fine wire brush or buffing wheel.

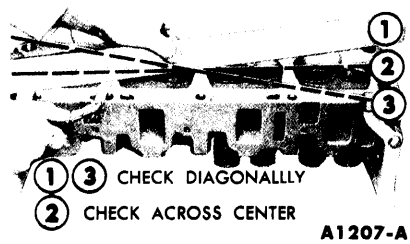

FIG. 14—Cylinder Head Flatness

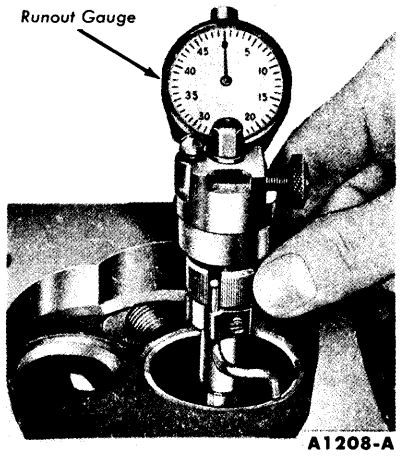

FIG. 15—Valve Seat Runout

INSPECTION

Check the cylinder head for cracks, and inspect the gasket surface for burrs and nicks. Replace the head if it is cracked.

The following inspection procedures are for a cylinder head that is to be completely overhauled. For individual repair operations, use only the pertinent inspection procedure.

Cylinder Head Flatness. When a cylinder head is removed because of gasket leaks, check the flatness of the cylinder head gasket surface (Fig. 14) for conformance to specifications. If necessary to refinish the cylinder head gasket surface, **do not plane or grind off more than 0.010 inch.**

Valve Seat Runout. Check the valve seat runout with an accurate gauge (Fig. 15). Follow the instructions of the gauge manufacturer. If the runout exceeds the wear limit, reface the valve and valve seat.

Valve Seat Width. Measure the valve seat width (Fig. 8). Reface the valve seats if the width is not within specifications.

Valves. The critical inspection points and tolerances of the valves are illustrated in Fig. 16. Refer to the specifications for the wear limits.

Inspect the valve face and the edge of the valve head for pits, grooves, scores or other defects. Inspect the stem for a bent condition and the end of the stem for grooves or scores. Check the valve head for signs of burning, erosion, warpage and cracking. Defects, such as minor

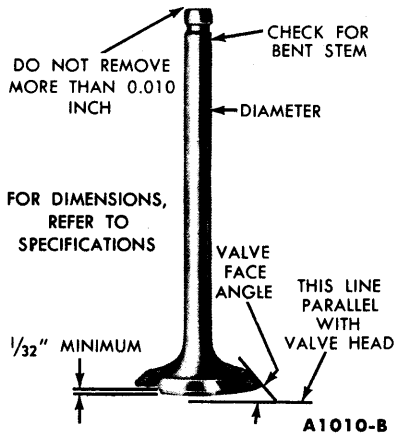

FIG. 16—Critical Valve Tolerances

pits, grooves, etc., may be removed. Discard valves that are severely damaged.

Inspect the valve springs, valve spring retainers, locks and sleeves for defects. Discard any visually defective parts.

Valve Face Runout. Check the valve face runout as shown in Fig. 17. The valve face runout should not exceed the specified limits. If the runout exceeds the wear limit, the valve should be replaced or refaced as outlined under "Refacing Valves" in this section.

Valve Stem Clearance. Check the valve stem to valve guide clearance of each valve in its respective valve guide with the tool shown in Fig. 18 or its equivalent. Use a flat-end indicator point.

Valve Spring Pressure. Check the spring for proper pressure (Fig. 19). Do not remove the damper spring when checking the pressure. Weak valve springs cause poor engine performance; therefore, if the

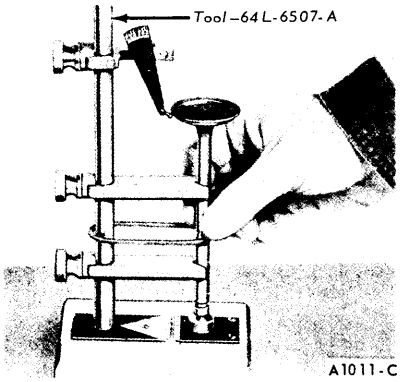

FIG. 17—Valve Face Runout

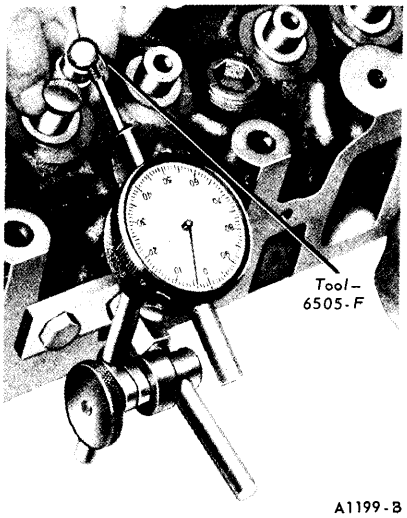

FIG. 18—Valve Stem Clearance

pressure of any spring exceeds the wear limit, replace the spring.

Valve Springs. Check each spring for squareness, using a steel square and a surface plate (Fig. 20). Stand the spring and square on end on the surface plate. Slide the spring up to the square. Revolve the spring slowly and observe the space between the top coil of the spring and the square. If the spring is out of square more than 1/16 inch, replace it.

Follow the same procedure to check new valve springs before installation.

Make certain the proper spring (color coded) is installed.

Visually inspect the valve spring retainer to determine if the damper spring coil has been hitting the retainer. This interference will also cause a clicking noise when the engine is operating. The damper spring is properly installed in the valve spring when positioned so that the end of the damper spring bottom

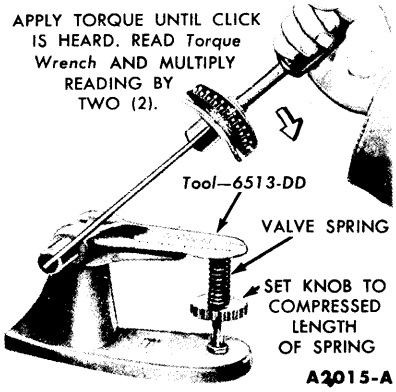

FIG. 19—Valve Spring Pressure

coil is 135° counterclockwise from the end of the valve spring lower coil.

HYDRAULIC VALVE LIFTERS

The valve lifter assemblies should be kept in proper sequence so that they can be installed in their original position. Inspect and test each lifter separately so as not to intermix the internal parts. **If any part of the lifter assembly needs replacing, replace the entire assembly.**

CLEANING

Thoroughly clean all the parts in clean solvent and wipe them with a clean, lint-free cloth.

INSPECTION

Inspect the parts and discard the entire lifter assembly if any part shows pitting, scoring, galling, or evidence of non-rotation. Replace the entire assembly if the plunger is not free in the body. The plunger should drop to the bottom of the body by its own weight.

Assemble the lifter assembly and check for freeness of operation by pressing down on the push rod cup. The lifters can also be checked with a hydraulic tester to test the leak down rate. Follow the instructions of the test unit manufacturer or the procedure in Section 1.

TIMING CHAIN AND SPROCKETS

CLEANING AND INSPECTION

Clean all parts in solvent and dry them with compressed air. Inspect the chain for broken links. Inspect the sprockets for cracks, and worn or damaged teeth. **Replace all the components of the timing chain and sprocket assembly if any one item needs replacement.**

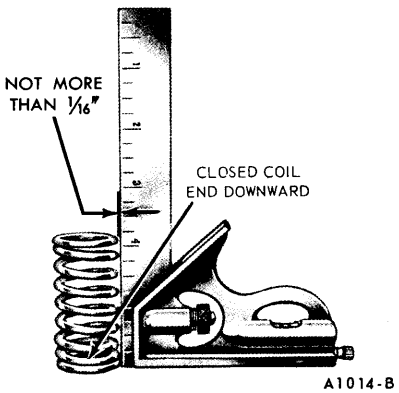

FIG. 20—Valve Spring Squareness

CAMSHAFT

CLEANING AND INSPECTION

Clean the camshaft in solvent and wipe it dry. Inspect the camshaft lobes for scoring and signs of abnormal wear. Lobe wear characteristics may result in pitting in the general area of the lobe toe. This pitting is not detrimental to the operation of the camshaft; therefore, the camshaft should not be replaced until the lobe lift loss has exceeded 0.005 inch.

The lift of camshaft lobes can be checked with the camshaft installed in the engine or on centers. Refer to "Camshaft Lobe Lift."

Check the distributor drive gear for broken or chipped teeth.

CRANKSHAFT

CLEANING

Handle the crankshaft with care to avoid possible fractures or damage to the finished surfaces. Clean the crankshaft with solvent; then blow out all oil passages with compressed air.

INSPECTION

Inspect main and connecting rod journals for cracks, scratches, grooves or scores.

Measure the diameter of each journal in at least four places to determine out-of-round, taper, or undersize condition (Fig. 21).

FLYWHEEL—AUTOMATIC TRANSMISSION

INSPECTION

Inspect the flywheel for cracks or other defects that would make it unfit for further service. Inspect the starter ring gear for worn, chipped or cracked teeth. If the teeth are damaged, replace the starter ring gear.

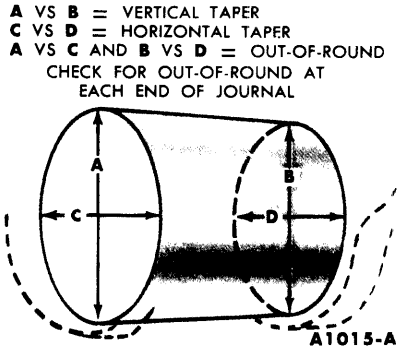

FIG. 21—Crankshaft Journal Measurements

With the flywheel installed on the crankshaft, check the gear face runout and outside diameter runout of the flywheel (refer to Section 1 for the proper procedure).

CONNECTING RODS

CLEANING

Remove the bearings from the rod and cap. Identify the bearings if they are to be used again. Clean the connecting rod in solvent, including the rod bore and the back of the inserts. **Do not use a caustic cleaning solution.** Blow out all passages with compressed air.

INSPECTION

The connecting rods and related parts should be carefully inspected and checked for conformance to specifications. Various forms of engine wear caused by these parts can be readily identified.

A shiny surface on the pin boss side of the piston usually indicates that a connecting rod is bent or the piston pin hole is not in proper relation to the piston skirt and ring grooves.

Abnormal connecting rod bearing wear can be caused by either a bent connecting rod, an improperly machined crankpin, or a tapered connecting rod bore.

Twisted connecting rods will not create an easily identifiable wear pattern, but badly twisted rods will disturb the action of the entire piston, rings and connecting rod assembly and may be the cause of excessive oil consumption.

Inspect the connecting rods for signs of fractures and the bearing bores for out-of-round and taper. If the bore exceeds the recommended limits and/or if the connecting rod is fractured, it should be replaced.

Check the piston pin to connecting rod bushing clearance. Replace the connecting rod if the bushing is so worn that it can not be reamed or honed for an oversize pin.

Replace defective connecting rod nuts and bolts.

Check the connecting rods for bend or twist on a suitable alignment fixture. Follow the instructions of the fixture manufacturer. If the bend and/or twist exceeds specifications, the connecting rod must be straightened or replaced.

PISTONS, PINS AND RINGS

CLEANING

Remove deposits from the piston surfaces. Clean gum or varnish from

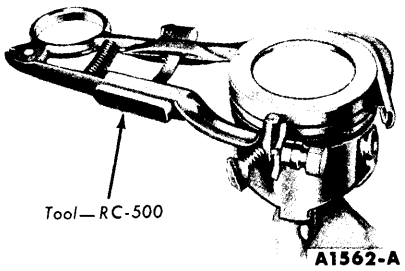

FIG. 22—Cleaning Ring Grooves—Typical

the piston skirt, piston pins and rings with solvent. **Do not use a caustic cleaning solution or a wire brush to clean pistons.** Clean the ring grooves with a ring groove cleaner such as shown in Fig. 22. Make sure the oil ring slots (or holes) are clean.

INSPECTION

Carefully inspect the pistons for fractures at the ring lands, skirts and pin bosses, and for scuffed, rough or scored skirts. If the lower inner portion of the ring grooves have high steps, replace the piston. The step will interfere with ring operation and cause excessive ring side clearance.

Spongy, eroded areas near the edge of the top of the piston are usually caused by detonation or pre-ignition. A shiny surface on the thrust surface of the piston, offset from the centerline between the piston pin holes, can be caused by a bent connecting rod. Replace pistons that show signs of excessive wear, wavy ring lands or fractures or damage from detonation or pre-ignition.

Check the piston to cylinder bore clearance by measuring the piston and bore diameters. Refer to the specifications for the proper clearance. Refer to "Cylinder Block Inspection" for the bore measurement procedure. **Measure the O.D. of the piston with micrometers at the centerline of the piston pin bore and at 90° to the pin bore axis.** Install the piston(s) and recheck the clearance with a tension scale and ribbon, following the procedure under "Fitting Pistons." Check the ring side clearance following the procedure under "Fitting Piston Rings."

Replace piston pins showing signs of fracture, etching or wear. Check the piston pin fit in the piston and rod (Section 2).

Replace all rings that are scored, chipped or cracked. Check the end gap and side clearance (Section 3). It is good practice to always install new rings when overhauling the engine. **Rings should not be transferred from one piston to another regardless of mileage.**

MAIN AND CONNECTING ROD BEARINGS

CLEANING

Clean the bearing inserts and caps thoroughly in solvent, and dry them with compressed air. **Do not scrape gum or varnish deposits from bearing shells.**

INSPECTION

Inspect each bearing carefully. Bearings that have a scored, chipped or worn surface should be replaced. Typical examples of bearing failures and their causes are shown in Fig. 23. The copper lead bearing base may be visible through the bearing overlay. This does not mean that the bearing is worn. It is not necessary to replace the bearing if the bearing clearance is within recommended limits. Check the clearance of bearings that appear to be satisfactory with Plastigage. Fit new bearings following the recommended procedure (Part 8-2).

CYLINDER BLOCK

CLEANING

After any cylinder bore repair operation, such as honing or deglazing, clean the bore(s) with soap or detergent and water. **Then, thoroughly rinse the bore(s) with clean water to remove the soap or detergent, and wipe the bore(s) dry with a clean, lint-free cloth. Finally, wipe the bore(s) with a clean cloth dipped in engine oil. If these procedures are not followed, rusting of the cylinder bore(s) may occur.**

If the engine is disassembled, thoroughly clean the block in solvent. Remove old gasket material from all machined surfaces. Remove all pipe plugs which seal oil passages; then clean out all the passages. Blow out all passages, bolt holes, etc., with compressed air. **Be sure the jiggle pin in the main oil gallery front plug operates freely.**

Make sure the threads in the cylinder head bolt holes are clean. Dirt in the threads may cause binding and result in a false torque reading. Use a tap to true-up threads and to remove any deposits.

INSPECTION

After the block has been thoroughly cleaned, check it for cracks. Minute cracks not visible to the naked eye may be detected by coating the suspected area with a mixture of 25% kerosene and 75% light motor oil. Wipe the part dry and immediately apply a coating of zinc oxide dissolved in wood alcohol. If cracks are present, the coating will become discolored at the defective area. Replace the block if it is cracked.

Check all machined gasket surfaces for burrs, nicks, scratches and scores. Remove minor imperfections with an oil stone. Check the cylinder block for flatness of the cylinder head gasket surface following the procedure and specifications recommended for the cylinder head. The cylinder block can be machined to bring the cylinder head gasket surface within the flatness specifications, **but do not exceed 0.010 inch stock removal.**

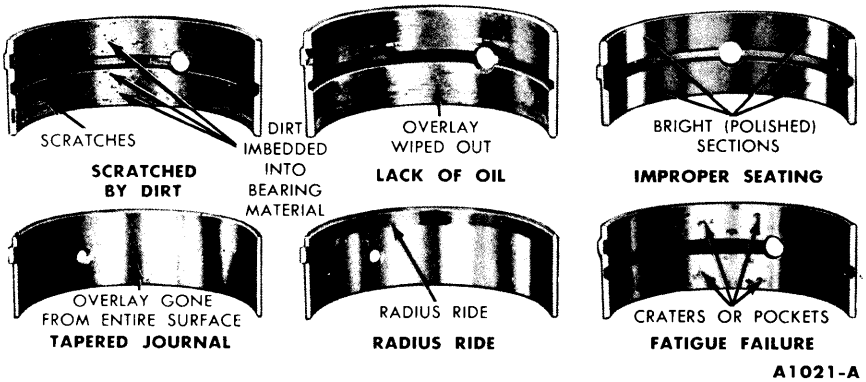

FIG. 23—Typical Bearing Failures

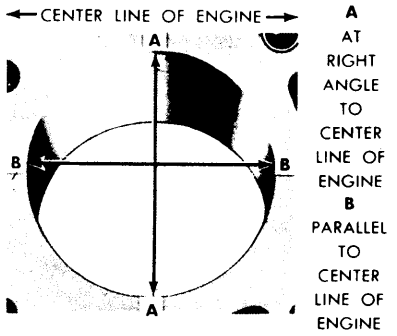

FIG. 24—Cylinder Bore Out-of-Round and Taper

Replace all expansion-type plugs that show evidence of leakage.

Inspect the cylinder walls for scoring, roughness, or other signs of wear. Check the cylinder bore for out-of-round and taper. Measure the bore with an accurate bore gauge following the instructions of the manufacturer. Measure the diameter of each cylinder bore at the top, middle and bottom with the gauge placed at right angles and parallel to the centerline of the engine (Fig. 24).

Refinish cylinders that are deeply scored and/or when out-of-round and/or taper exceed the wear limits.

If the cylinder walls have minor surface imperfections, but the out-of-round and taper are within limits, it may be possible to remove the imperfections by honing the cylinder walls and installing new service piston rings providing the piston clearance is within specified limits. Use the finest grade of honing stone for this operation.

OIL PAN

CLEANING

Scrape any dirt or metal particles from the inside of the pan. Scrape all old gasket material from the gasket surface. Wash the pan in a solvent and dry it thoroughly. Be sure all foreign particles are removed from below the baffle plate.

INSPECTION

Check the pan for cracks, holes, damaged drain plug threads, a loose baffle, and a nicked or warped gasket surface.

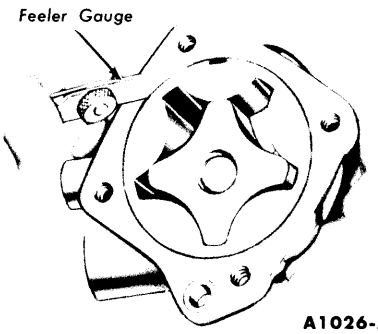

FIG. 25—Outer Race to Housing Clearance—Typical Oil Pump

Repair any damage, or replace the pan if repairs cannot be made.

OIL PUMP

CLEANING

Wash all parts in a solvent and dry them thoroughly with compressed air. Use a brush to clean the inside of the pump housing and the pressure relief valve chamber. Be sure all dirt and metal particles are removed.

INSPECTION

Refer to the specifications for clearances and wear limits.

Check the inside of the pump housing and the outer race and rotor for damage or excessive wear.

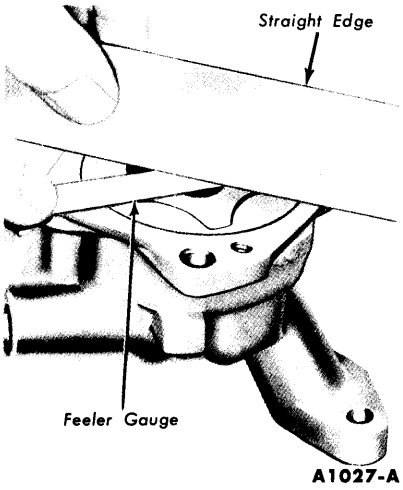

FIG. 26—Rotor End Play—Typical Oil Pump

Check the mating surface of the pump cover for wear. If the cover mating surface is worn, scored or grooved, replace the cover.

Measure the outer race to housing clearance (Fig. 25).

With the rotor assembly installed in the housing, place a straight edge over the rotor assembly and the housing. Measure the rotor end play clearance between the straight edge and the rotor and outer race (Fig. 26).

The outer race, shaft and rotor are replaceable only as an assembly.

Check the drive shaft to housing bearing clearance by measuring the OD of the shaft and the ID of the housing bearing.

Inspect the relief valve spring for a collapsed or worn condition. Check the relief valve spring tension. If the spring tension is not within specifications or the spring is defective, replace the spring.

Check the relief valve piston for scores and free operation in the bore.

CRANKCASE VENTILATION SYSTEM

Refer to Group 19 for the correct mileage interval for maintenance.

CLEANING

Do not attempt to clean the crankcase regulator valve.

Clean the crankcase ventilation system connection on the carburetor spacer by probing the inlet nipple with a flexible wire or bottle brush.

Clean the rubber hose with a low-volatility, petroleum-base solvent and dry with compressed air.

PART 8-2 390 V-8 ENGINE

1 DESCRIPTION AND OPERATION

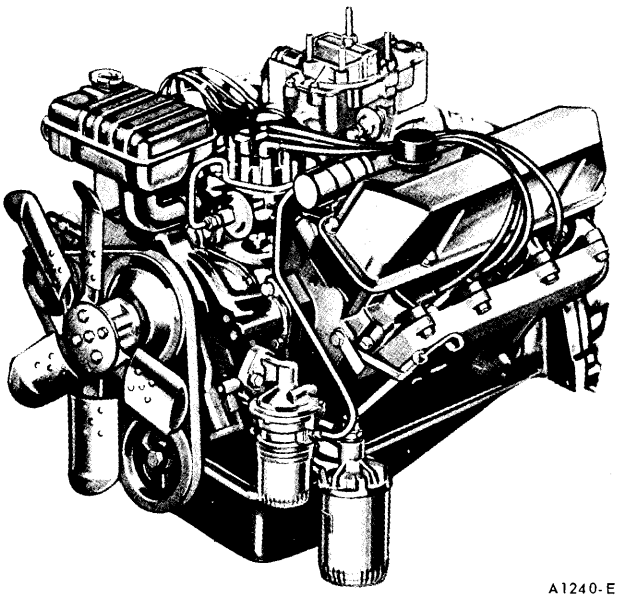

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FIG. 1—Typical ¾ Left Front View

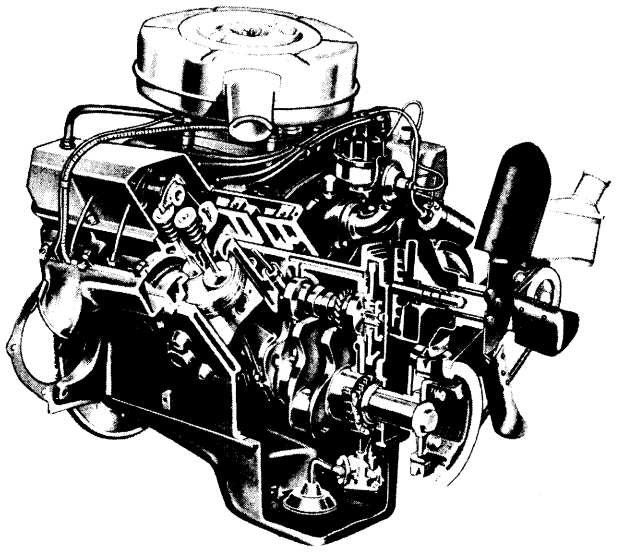

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FIG. 2—Typical ¾ Right Front Sectional View

The Thunderbird 390 Special V-8 engine (Figs. 1, 2 and 3) has a 4.05-inch bore and a 3.78-inch stroke and a total piston displacement of 390 cubic inches. It has a compression ratio of 10.1:1. The warranty plate identification symbol for the engine is "Z."

An engine identification tag is attached to the ignition coil bracket; refer to Part 8-1, Section 1.

MANIFOLDS

An engine coolant heated spacer is located between the carburetor and the intake manifold (Fig. 4). The coolant flows from the front of the engine through the spacer inlet hose and into the carburetor coolant spacer. The coolant circulates through the spacer and flows into the heater inlet hose and into the heater. Exhaust gases provide the initial heat necessary to assist in vaporizing the incoming fuel mixture.

The intake manifold has two sets of fuel passages, each with its own separate inlet connection to the carburetor (Fig. 5). The right barrels of the carburetor feed Nos. 1, 4, 6 and 7 cylinders and the left barrels feed Nos. 2, 3, 5 and 8 cylinders.

The distributor is mounted at the left front of the intake manifold.

Warm air for the automatic choke is drawn from the heat chamber of the right exhaust manifold (Fig. 6).

CYLINDER HEADS

The cylinder head assemblies contain the valves and the valve rocker

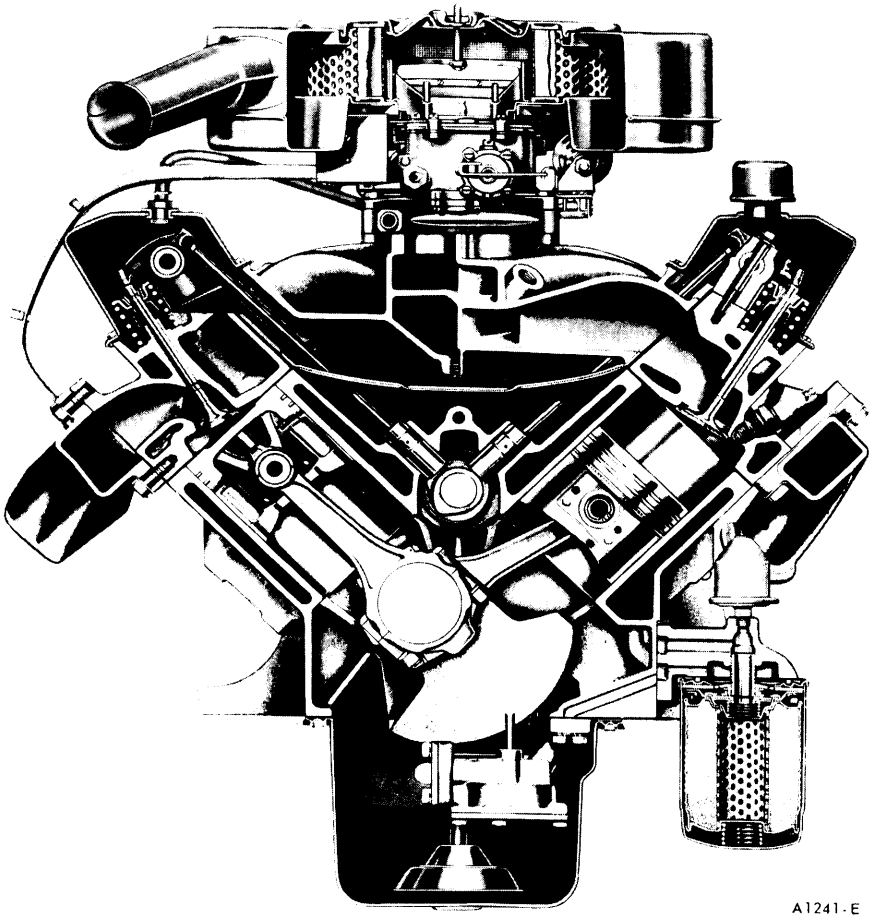

FIG. 3—Typical Front Sectional View

arm shaft assembly. The combustion chambers are machined in the head. Valve guides are an integral part of the head. The valves are arranged from front to rear on both banks E-I-E-I-I-E-I-E (Fig. 7).

CYLINDER BLOCK

The cylinders are numbered from front to rear, on the right bank 1, 2, 3 and 4 and on the left bank 5, 6, 7 and 8. The firing order is 1-5-4-2-6-3-7-8.

The oil pump, mounted inside the oil pan at the front, is driven by the distributor through an intermediate drive shaft.

The crankshaft is supported by five main bearings. Crankshaft end thrust is controlled by the flanges of the No. 3 main bearing.

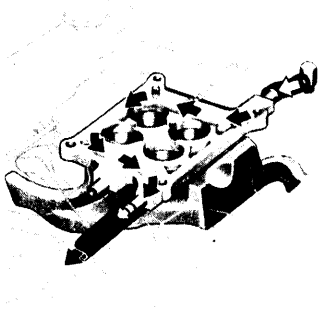

FIG. 4—Engine Coolant-Heated Spacer Passages

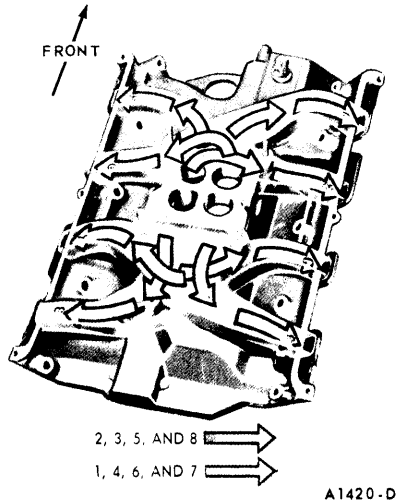

FIG. 5—Intake Manifold Fuel Passages

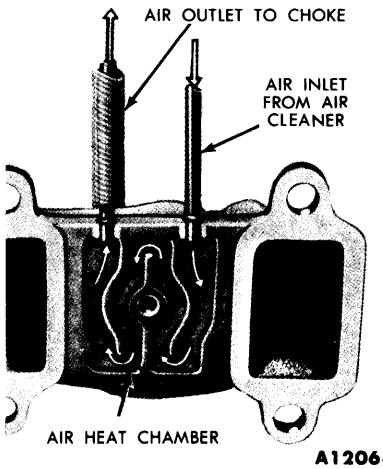

FIG. 6—Automatic Choke Heat Chamber

The pistons have two compression rings and one oil control ring. The top compression ring is chrome-plated and the lower compression ring is phosphate-coated. The oil control ring assembly consists of a serrated spring and two chrome-plated steel rails.

VALVE TRAIN

The intake and exhaust valve assemblies are the rotating-type which rotate slightly each time the valve opens and closes.

The push rods are solid steel with oil cushioned sockets.

The camshaft is supported by five bearings pressed into the block. It is driven by a sprocket and timing chain in mesh with a sprocket on the crankshaft. Camshaft thrust is controlled by a thrust plate bolted to the front of the cylinder block. An eccentric, bolted to the front end of the camshaft, operates the fuel pump.

Hydraulic valve lifters are used in the engine. The valve lifters are housed in bores located in the cylinder block valve lifter chamber. The valve lifters operate directly on the camshaft lobes, thereby transmitting the thrust of the camshaft lobes, by the means of hydraulic pressure, to the push rods which actuate the valve train. Figure 8 shows the various components and operation of a hydraulic lifter.

When either an exhaust valve or

FIG. 7—Valve Port Arrangement

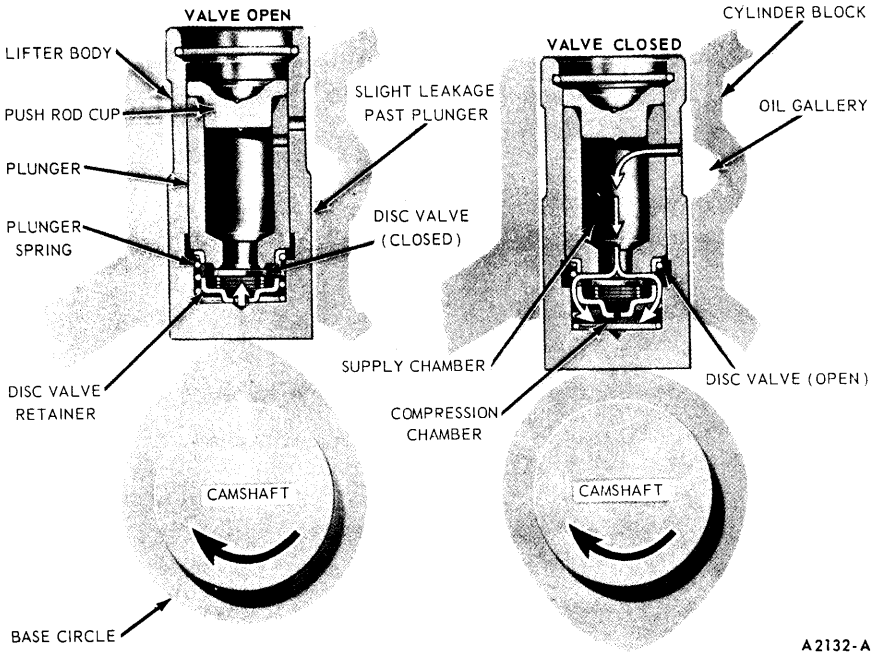

FIG. 8—Typical Hydraulic Valve Lifter Operation

an intake valve is closed, the actuating valve lifter is on the base circle (lowest position) of the camshaft lobe.

When the valve lifter is in this position, the lifter plunger spring expands. This action forces the lifter plunger and valve push rod upward, forcing the valve end of the rocker arm to maintain solid contact with the valve (zero valve lash). In this position, the oil hole in the lifter body and plunger is indexed with the oil gallery in the cylinder block.

As the lifter plunger moves upward, the volume of the compression chamber is increased, resulting in reduced oil pressure in the compression chamber. Therefore, to equalize the resulting pressure differential between the supply chamber and the compression chamber, the disc valve moves off its seat and permits oil to flow from the supply chamber to the compression chamber. When the compression chamber becomes filled with oil, the pressures in the two chambers are equalized. The oil flow ceases and the disc valve spring seats the disc valve and closes the disc valve port.

As the camshaft rotates, the lifter assembly is raised by the camshaft lobe. This increases the push rod force against the lifter plunger and hydraulic pressure immediately builds up in the compression chamber until it acts as a solid member of the valve operating mechanism. The lifter then becomes a hydraulic ram which forces the valve in the cylinder head to open. During this period, a slight leakage of oil past the plunger occurs (calibrated leak down rate).

As the high point of the camshaft lobe rotates and passes by the foot of the valve lifter, the valve in the cylinder head seats and the valve lifter assembly is forced downward. Reduced force on the lifter plunger at this time relieves the pressure on the lifter plunger and it is free to be moved upward by the plunger spring. This action allows oil to flow once again through the indexed oil holes in the lifter body and plunger.

The operating cycle is completed for each revolution of the camshaft. Zero clearance (lash) in the valve train mechanism is maintained at all times by the hydraulic force and expansion of the plunger spring between the lifter body and plunger.

LUBRICATION SYSTEM

Oil from the oil pan sump, located in the front of the oil pan, is forced through the pressure-type lubrication system (Fig. 9) by a rotor oil pump. A spring-loaded relief valve in the pump limits the maximum pressure of the system. Oil relieved by the valve is directed back to the intake side of the pump.

All the oil discharged by the pump passes through a full flow-type filter before it enters the engine. The filter is mounted in a vertical position at the lower left front of the engine. A relief valve in the filter permits oil to by-pass the filter element if it becomes clogged.

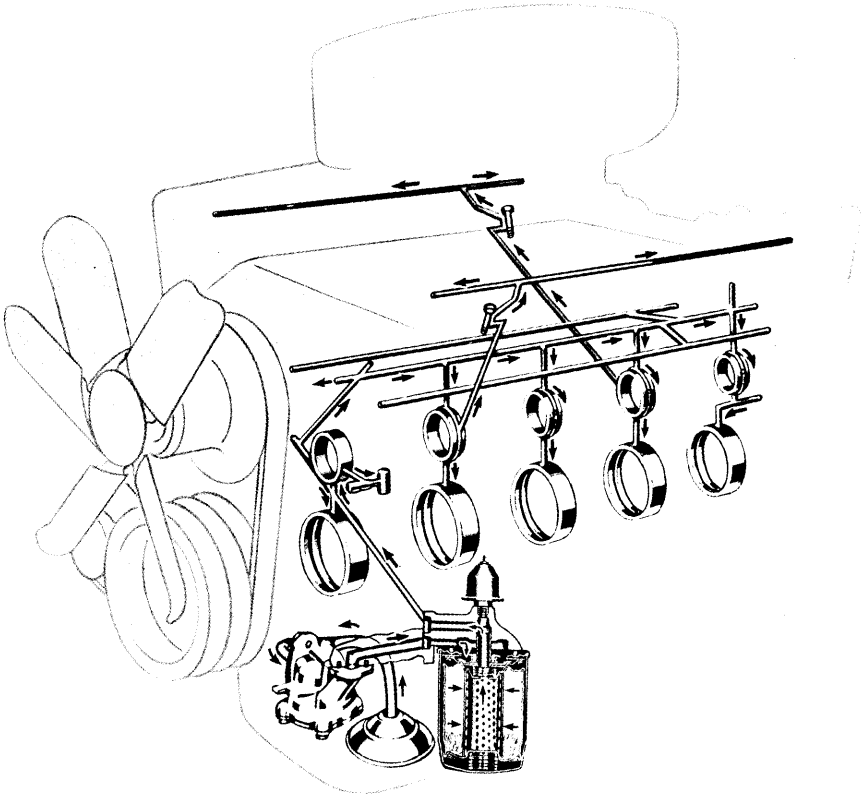

FIG. 9—Lubrication System

From the filter, the oil flows into the main oil gallery which is located in the center of the valve push rod chamber floor. The oil gallery supplies oil to each individual camshaft bearing, through drilled passages in the block. Passages are drilled from each camshaft bearing to each main bearing. The camshaft No. 1 bearing feeds No. 1 main bearing, and the camshaft No. 2 bearing feeds No. 2 main bearing, etc. The oil then flows through notches or grooves in the main bearings to lubricate the crankshaft journals. A jiggle pin in the main oil gallery front plug allows any air that may be trapped in the oil to escape. The timing chain and sprockets are splash lubricated by oil from the jiggle pin.

The crankshaft is drilled from the main bearings to the connecting rod bearings.

A small groove is located in the connecting rod at the mating face where the cap contacts the connecting rod. This groove is used as an oil squirt hole for cylinder wall lubrication. Oil from the connecting rod squirt hole lubricates the opposite cylinder wall. For example, the No. 1 connecting rod oils No. 5 cylinder, etc. As the crankshaft turns, the hole in the connecting rod bearing aligns with the hole in the journal causing a direct squirt of oil onto the cylinder wall.

Oil passages are drilled from the main oil gallery to each valve lifter oil gallery. Oil from here feeds the valve lifter assemblies. A reservoir at each valve lifter bore boss traps oil so that oil is available for valve lifter lubrication as soon as the engine starts.

An oil passage is drilled from the camshaft No. 2 bearing web to the left cylinder head between Nos. 5 and 6 cylinders to lubricate the valve rocker arm shaft assembly (Fig. 10). The oil passage in the cylinder head is drilled from the cylinder head bolt bore to the No. 2 valve rocker arm shaft support.

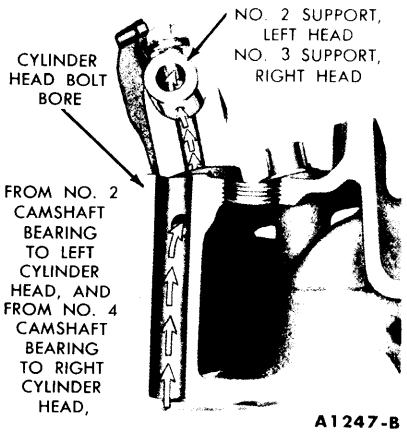

FIG. 10—Valve Rocker Arm Shaft Lubrication

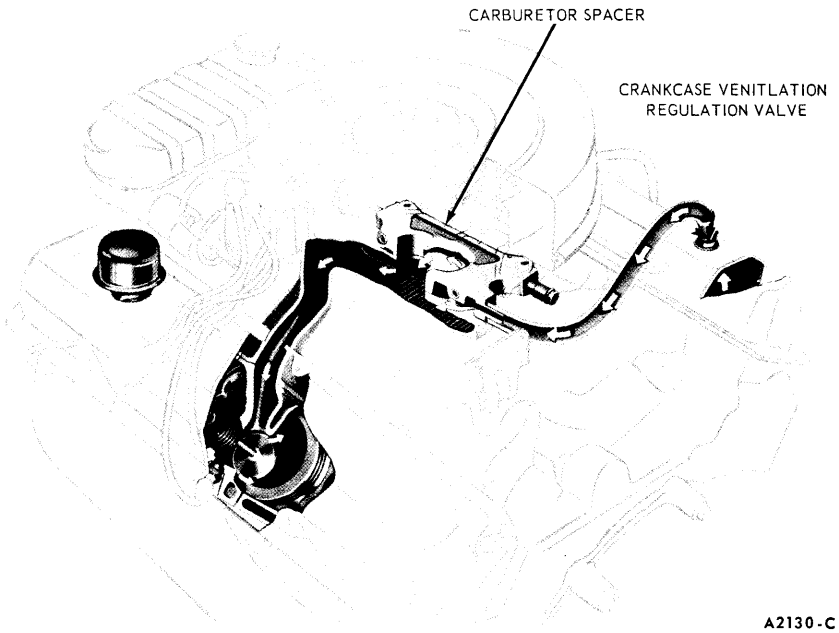

FIG. 11—Positive Crankcase Ventilation System

The oil flows through the valve rocker arm shaft through drilled holes in each valve rocker arm to lubricate the bushing and both ends of the valve rocker arm. The excess oil spirals down the rotating push rods and lubricates the push rod seats. The right valve rocker arm shaft assembly is similarly lubricated from No. 4 camshaft bearing via the No. 3 valve rocker arm shaft support.

A baffle located under the valve rocker arm shaft assembly shields the valve stems from oil splash. Excess oil is returned to the oil pan through drain-back holes located at

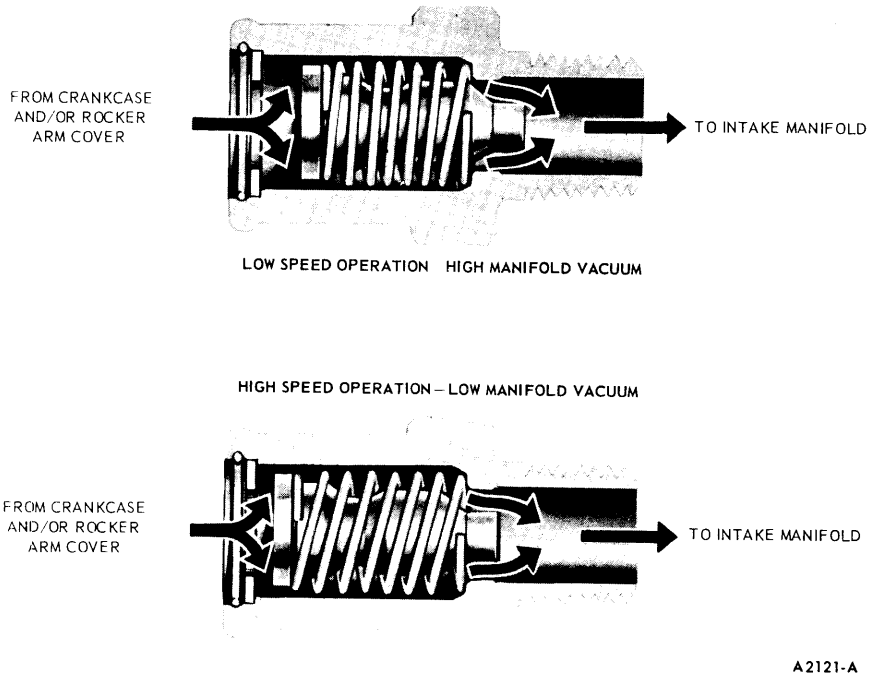

FIG. 12—Positive Crankcase Ventilation Regulator Valve Operation

each end of the cylinder head and in the push rod chamber floor.

POSITIVE CRANKCASE VENTILATION SYSTEM

Ventilating air enters the engine through the oil filler tube cap (breather cap) on the left rocker cover (Fig. 11).

On a closed crankcase ventilation system, the breather cap is sealed and connected to the air cleaner by a hose. Thus, the crankcase receives air from the air cleaner.

On closed crankcase ventilation systems, if the system becomes restricted, a back-flow condition will occur, thereby venting the crankcase gases into the air cleaner silencing chamber.

A slight vacuum is maintained in the engine crankcase due to a restriction (metering hole) in the breather cap and by the amount of air flow through the regulator valve. A baffle plate, located under the intake manifold, directs a portion of the ventilating air to the front of the crankcase and into the cylinder front cover. The baffle plate, aided by the turbulent pressures of the crankcase, circulates air throughout the valve push rod chamber and the crankcase. The ventilating air flows into the right valve rocker arm cover from the valve push rod chamber. From the valve rocker arm cover, the ventilating air passes through the crankcase ventilation regulator valve and into the carburetor spacer through a connecting hose. The carburetor spacer disperses the air, laden with crankcase vapors, into the intake manifold below the carburetor.

The amount of regulator valve opening or restriction is governed by intake manifold vacuum pressure (Fig. 12).

During idle, the high intake manifold vacuum overcomes the spring pressure and moves the valve to the "Low Speed Operation" position (Fig. 12). With the valve in this low flow position, the ventilating air passes between the valve (jiggle pin) and the outlet port. In this position there is minimum ventilation, but it never completely seals off the air flow.

As engine speed increases, and manifold vacuum decreases, the valve spring forces the valve to the full open position (Fig. 12). This increases the flow of ventilating air.

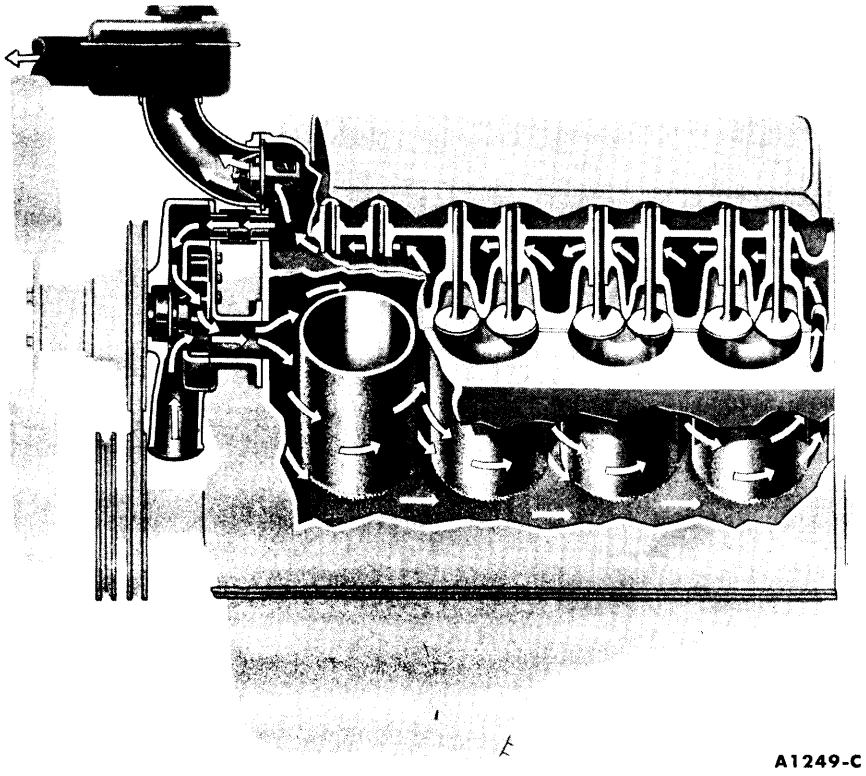

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FIG. 13—Typical Cooling System

COOLING SYSTEM

The coolant is drawn from the bottom of the radiator by the water pump which delivers the coolant to the cylinder block (Fig. 13).

The coolant travels through cored passages to cool the entire length of each cylinder wall. Upon reaching the rear of the cylinder block, the coolant is directed upward into the cylinder heads where it cools the combustion chambers, valves, and valve seats on its return to the front of the engine.

The coolant from each cylinder head flows through the water passages in the intake manifold and past the water thermostat, if it is open, into the radiator supply tank. If the thermostat is closed, a small portion of the coolant is returned to the water pump for recirculation. The entire system is pressurized to 12-15 psi.

2 IN-CAR ADJUSTMENTS AND REPAIRS

ENGINE SUPPORTS

The front supports are located on each side of the cylinder block and the rear support is located at the transmission extension housing (Fig. 14).

FRONT SUPPORT INSULATOR

The engine front support is shown in Fig. 14.

Removal

1. Position a jack and wood block under the engine oil pan, and raise the engine sufficiently to unload the engine front support insulators.

2. Remove the insulator assembly to engine retaining bolts and lock washers. Remove the insulator assembly to intermediate support bracket retaining nuts and washers on both engine supports.

3. Raise the engine about 1 inch and remove the right side insulator

assembly. Remove the assembly nuts and separate the insulator from the intermediate support bracket.

4. On the left side engine support, move the insulator and intermediate support bracket forward, and remove the assembly nuts. Separate the insulator and intermediate support bracket, and remove them from the engine compartment.

Installation

1. On a left side engine support, position the insulator and intermediate support bracket between the engine and frame crossmember. Assemble the insulator and support bracket and torque the nuts to specifications.

2. On a right side engine support, assemble the support insulator to the intermediate support bracket, and torque the nuts to specifications.

3. Position the insulator assembly(lies) to the engine and install the retaining bolts and lock washers. Torque the retaining bolts to specifications.

4. Lower the engine and install the insulator assembly to intermediate support bracket retaining nut and washer on both supports. Torque the retaining nuts to specifications.

REAR SUPPORT INSULATOR

The engine rear support is shown in Fig. 14.

Removal

1. Position a jack under the transmission extension housing. Remove the insulator assembly to support bracket retaining bolt and nut. Remove the insulator retainer bolts and lock washers.

2. Raise the transmission extension housing slightly to gain clearance and remove the insulator assembly and retainer.

3. If necessary, remove the support bracket to end bracket retaining bolts, washers and nuts. Remove the support bracket.

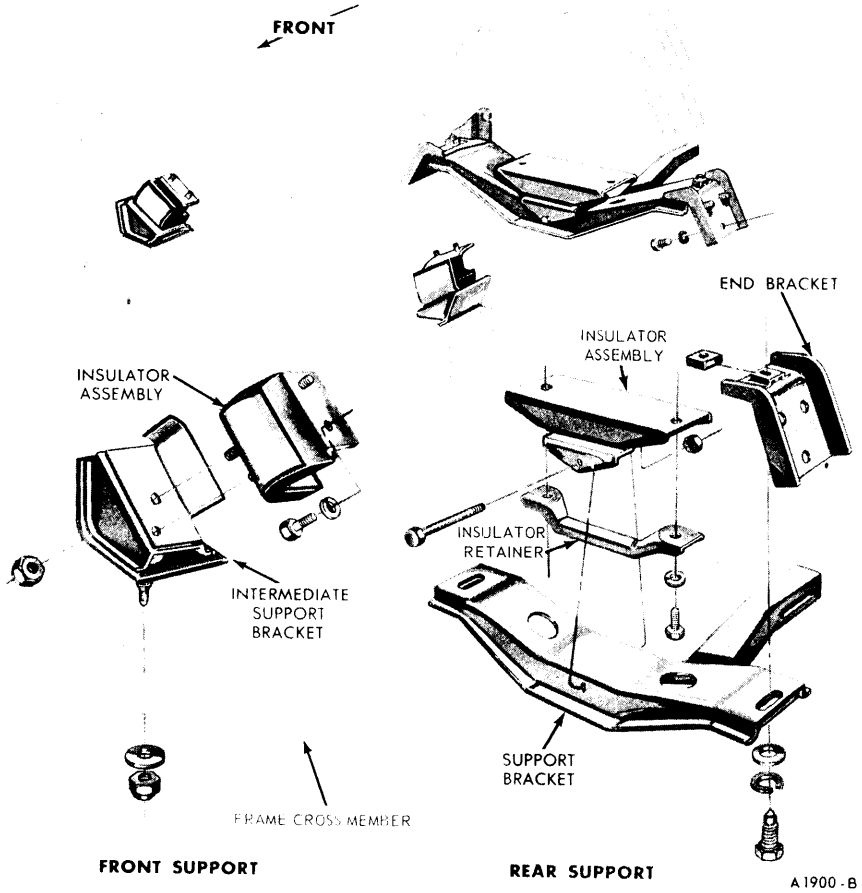


FIG. 14—Engine Front and Rear Supports

4. If necessary, remove the end bracket to floor pan reinforcement retaining bolts and lock washers. Remove the end bracket.

Installation

1. If the end brackets were removed, position the end bracket to the floor pan reinforcement and install the retaining bolts and lock washers. Torque the bolts to specifications.

2. If the support bracket was removed, position the support bracket to the end brackets and install the retaining bolts, lock washers and nuts. Torque the bolts to specifications.

3. Position the insulator assembly and insulator retainer to the transmission extension housing and install the insulator retainer bolts and lock washers. Torque the bolts to specifications.

4. Lower the transmission extension housing and install the support assembly to support bracket retaining bolt and nut. Torque the bolt to specifications. Remove the jack.

VALVE ROCKER ARM SHAFT ASSEMBLY

REMOVAL

1. Disconnect the automatic choke heat chamber air inlet tube and remove the air cleaner.

2. Disconnect the spark plug wires at the spark plugs. Remove the wires from the bracket on the valve rocker arm cover(s) and position the wires out of the way.

To remove the right valve rocker arm cover, remove the carburetor choke air heat tube. Remove the crankcase ventilation regulator valve.

To remove the left valve rocker arm cover, disconnect the brake booster vacuum line and position the line out of the way.

3. Remove the valve rocker arm cover(s).

If the left cover is removed, position the wire loom out of the way.

4. Starting at the No. 4 cylinder, loosen the right valve rocker arm shaft support bolts in sequence, two turns at a time. After the bolts are all loosened, remove the valve rocker arm shaft assembly and the oil baffle plate. Starting at the No. 5 cylinder, follow the same procedure on the left valve rocker arm shaft support bolts. **This procedure must be followed to avoid damage to the valve mechanism.**

FIG. 15—Typical Installation Identification Mark—Rocker Arm Shaft Assembly

INSTALLATION

1. Apply Lubriplate to the pad end of the rocker arms, to the tip of the valve stems, and to both ends of the push rods.
2. Crank the engine until the No. 1 piston is on TDC at the end of the compression stroke.
3. Rotate the crankshaft damper an additional 45° (identified by "XX" on the damper).
4. Position the baffle plate and the valve rocker arm shaft assembly(ies) on the cylinder head(s) with the valve push rods in place and the rocker shaft support bolts finger-tight. **Be sure the shaft is positioned so that the oil holes are to the bottom. Also, the identification notch (Fig. 15) must be downward and toward the front on the right bank, or toward the rear on the left bank.**
5. Starting at the No. 4 cylinder, tighten the bolts in sequence, two turns at a time, until the supports fully contact the cylinder head. Torque the bolts in sequence to specifications.
6. Starting at the No. 5 cylinder, follow the same procedure for the left valve rocker arm shaft support bolts. The additional time consumed in this procedure will permit the hydraulic lifters to leak down. This will minimize the possibility of bending the push rods, valves or rocker arms. **Be sure that the hydraulic lifters have leaked down to their normal operating position before cranking the engine. This is necessary in order to avoid possible damage to the valves, push rods or valve rocker arms.**
7. Check the valve clearances and correct if necessary (Part 8-1, Section 2).
8. Clean the valve rocker arm cover(s). Apply oil-resistant sealer to one side of new cover gasket(s). Lay the cemented side of the gasket(s) in place in the cover(s).
9. Position the cover(s) on the cylinder head(s). Make sure the gasket seats evenly all around the head. Install the bolts (and the wire loom clamps on the left cover). The cover is tightened in two steps. First, torque the bolts to specifications. Two minutes later, torque the bolts to the same specifications.

If the left cover was removed, connect the brake booster vacuum line.

If the right cover was removed, install the carburetor choke air heat tube. Install the crankcase ventilation regulator valve in the rocker cover.

10. Connect the spark plug wires. Install the air cleaner and connect the automatic choke heat chamber air inlet tube.

DISASSEMBLY

1. Remove the cotter pins from each end of the valve rocker arm shaft. Remove the flat washer and spring washer from each end of the shaft.
2. Slide the rocker arms, springs and supports off the shaft. Be sure to identify all the parts.
3. If it is necessary to remove the plugs from each end of the shaft, drill a hole in one plug. Insert a steel rod through the drilled plug and knock out the plug on the opposite end. Working from the open end, knock out the remaining plug.

CLEANING AND INSPECTION

Refer to Part 8-1, Section 3 for the cleaning and inspection procedures.

REPAIRS

Refer to Part 8-1, Section 2 for the repair procedures.

ASSEMBLY

1. Oil all the moving parts with engine oil. Apply Lubriplate to the pad of the valve rocker arms.
2. If the plugs were removed from the ends of the shaft, use a blunt tool

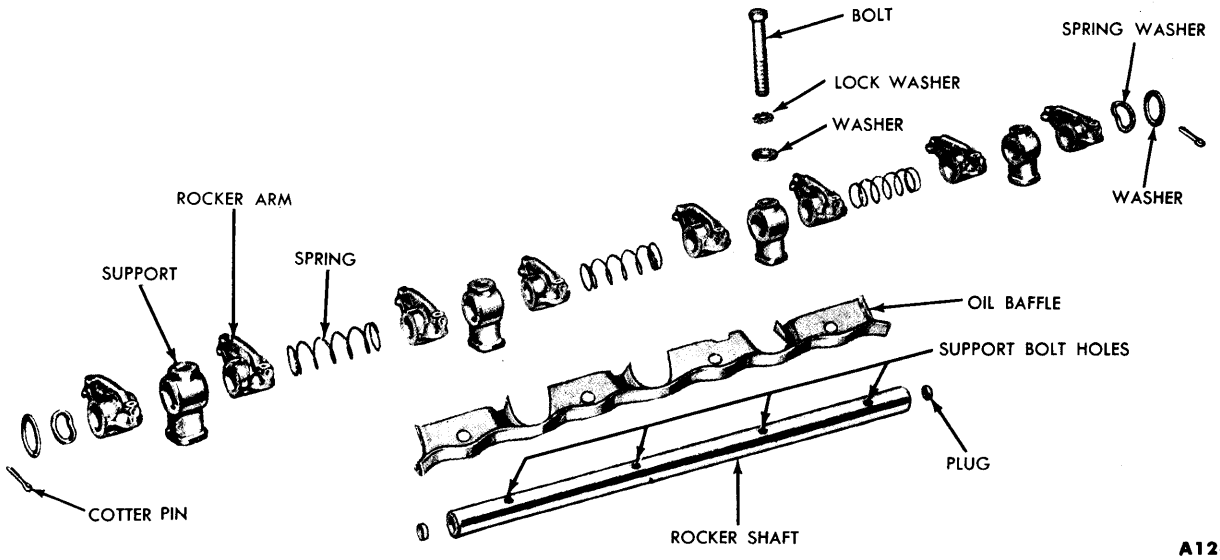


FIG. 16—Valve Rocker Arm Shaft Assembly

or large diameter pin punch, and install a plug, cup side out, in each end of the rocker arm shaft.

3. Install the rocker arms, supports and springs in the order shown in Fig. 16. **Be sure the oil holes in the shaft are facing downward.**

When properly assembled, the identification notch (Fig. 15) on the right rocker shaft assembly must be facing downward and toward the front of the engine. On the left rocker shaft assembly, the notch is downward and toward the rear. Complete the assembly by installing the remaining flat washer and spring washer and install the cotter pin.

INTAKE MANIFOLD REMOVAL

1. Drain the cooling system. Disconnect the automatic choke heat chamber air inlet tube and remove the air cleaner.

2. Disconnect the accelerator rod at the carburetor. Remove the accelerator cross shaft bracket from the intake manifold and position it out of the way.

3. Remove the carburetor fuel inlet line and the automatic choke air heat tube. Disconnect the brake booster vacuum line at the intake manifold and at the flexible hose. Remove the vacuum line.

4. Disconnect the coil high tension lead and the coil wires at the coil. Disconnect the oil pressure sending unit wire at the sending unit. Remove the wire loom from the retaining clips on the left valve rocker arm cover and position it out of the way.

5. Disconnect the spark plug wires at the spark plugs and remove the wires from the ignition harness brackets on the valve rocker arm covers.

6. Remove the distributor cap and spark plug wire assembly. Disconnect the distributor vacuum line at the distributor.

7. Remove the distributor hold-down bolt and clamp. Remove the distributor.

8. Disconnect the radiator upper hose at the radiator supply tank; then remove the supply tank. Disconnect the water temperature sending unit wire at the sending unit. Disconnect the heater hose at the carburetor spacer and the heater hose at the automatic choke housing. Position the hoses out of the way.

On a car with an air conditioner, disconnect the heater hoses at the intake manifold and at the "T" connector in the heater hose to the water pump.

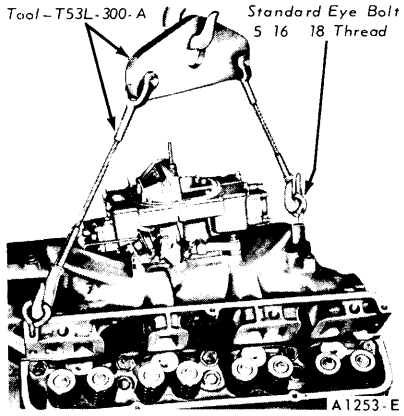


FIG. 17—Intake Manifold Removal or Installation

9. Slide the clamp on the water pump bypass hose toward the water pump.

10. Remove the valve rocker arm covers.

11. Refer to "Valve Rocker Arm Shaft Assembly Removal," and remove the valve rocker arm shaft assembly by following steps 4 and 5.

12. Remove the valve push rods in sequence.

13. Remove the intake manifold retaining bolts.

14. Install standard eye bolts with 5/16-18 threads in the left front and right rear rocker arm cover screw holes. Attach the engine lifting sling (Fig. 17).

15. Raise the intake manifold and carefully remove it and radiator supply tank as an assembly. **It may be necessary to pry the intake manifold away from the cylinder head(s).** Remove the intake manifold gaskets and seals.

16. If the manifold is to be disassembled, remove the radiator supply tank, thermostat and gasket. Remove the heater hose and fitting. Remove the carburetor, spacer and gasket. Remove the coolant temperature sending unit.

CLEANING AND INSPECTION

Refer to Part 8-1, Section 3 for the cleaning and inspection procedures.

INSTALLATION

The intake manifold assembly is shown in Fig. 18.

1. If the intake manifold was disassembled, install the carburetor, spacer and gasket. Coat the thermostat gasket and heater hose fitting

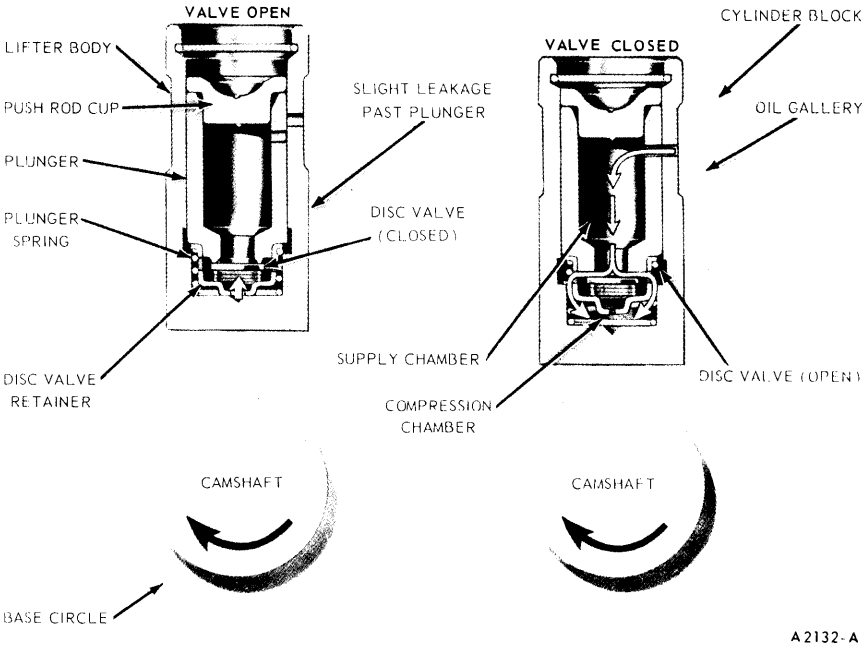


FIG. 18—Typical Intake Manifold Assembly

with water-resistant sealer. Install the heater hose and fitting. Coat the coolant temperature sending unit with electrical-conductive sealer and install it in the intake manifold. Position the thermostat gasket on the intake manifold. Install the thermostat and radiator supply tank.

2. Clean the mating surfaces of the intake manifold, cylinder heads and cylinder block. Use a suitable solvent to remove all traces of oil.

3. Coat the cylinder block seal surfaces with a quick-setting seal adhesive. Apply a non-hardening sealer to the mating lines of the cylinder heads and cylinder block.

4. Position new seals on the cylinder block and new gaskets on the cylinder heads. **Be sure the seals are properly positioned during installation as the adhesive sticks to the seals immediately on contact.** Position the manifold gasket slots over the end tabs on the seals. Coat these four connections with a non-hardening sealer. Be sure the holes in the gaskets are aligned with the holes in the cylinder heads.

5. Install the eye bolts in the intake manifold and attach the engine lifting sling. Carefully lower the intake manifold on the engine (Fig. 17) and at the same time engage the coolant outlet nipple with the water pump bypass hose.

6. Position the intake manifold by inserting the distributor in place. **After the intake manifold is in place, run a finger around the seal area to make sure the seals are in place. If the seals are not in place, remove the intake manifold and reposition the seals.**

7. Be sure the holes in the manifold gaskets and manifold are in alignment. **Apply a non-hardening, oil-resistant sealer under the head of each bolt,** and install the manifold retaining bolts. Torque the bolts to specifications in sequence as shown in Fig. 19.

8. Remove the distributor.

9. Remove the engine lifting sling and eye bolts.

10. Slide the water pump bypass hose clamp into position. Connect the water temperature sending unit, and the radiator upper hose. Install the heater hose on the automatic choke housing and connect the heater hose to the carburetor spacer.

11. On a car with an air conditioner, connect the heater hoses at the intake manifold and at the "T" connector in the heater hose to the water pump.

12. Apply Lubriplate to both ends of the push rods. Install the push rods in their original bores, positioning the lower ends of the rods in the lifter cups. Refer to "Valve Rocker Arm Shaft Assembly Installation," and install the valve rocker arm shaft assembly by following steps 1 thru 7.

13. Rotate the crankshaft damper until the No. 1 piston is on TDC at the end of the compression stroke. Position the distributor in the block with the rotor at the No. 1 firing position and the points open. Install the hold down clamp.

14. Install the valve rocker arm covers; refer to steps 8 and 9 under Valve Rocker Arm Shaft Assembly Installation.

15. Connect the brake booster vacuum line and the flexible hose.

16. Install the carburetor fuel inlet line and connect the distributor vacuum line. Install the automatic choke air heat tube.

17. Install the distributor cap. Connect the spark plug wires. Install the wire loom in the retaining clips on the left valve rocker arm cover.

18. Connect the oil pressure sending unit wire, coil high tension lead, coil primary wire, and coolant temperature sending unit wire.

19. Install the accelerator cross shaft bracket. Connect the accelerator rod.

20. Fill and bleed cooling system.

21. Start the engine and check and adjust the ignition timing. Operate the engine until engine temperatures have stabilized, and adjust the engine idle speed and idle fuel mixture.

22. Adjust the transmission control linkage. Install the air cleaner and connect the automatic choke heat chamber air inlet tube.

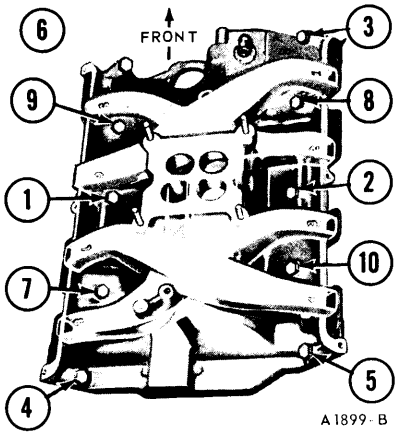


FIG. 19—Intake Manifold Torque Sequence

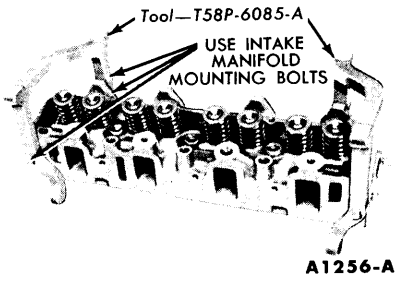


FIG. 20—Cylinder Head Holding Fixtures

EXHAUST MANIFOLD

REMOVAL

1. On a right exhaust manifold, disconnect the automatic choke heat chamber air inlet tube at the carburetor. Remove the air cleaner. Remove the automatic choke air heat tube and air inlet tube.

2. On a left exhaust manifold, disconnect the power steering pump bracket from the cylinder block and move it out of the way. Position the pump so that the oil will not drain out. Disconnect the power steering hose bracket and position the hoses out of the way. Remove the dipstick and tube assembly.

3. Disconnect the exhaust manifold at the muffler inlet pipe. Remove the retaining bolts and tab washers and remove the exhaust manifolds.

CLEANING AND INSPECTION

Refer to Part 8-1, Section 3 for the cleaning and inspection procedures.

INSTALLATION

1. Clean the mating surfaces of the exhaust manifold(s) and cylinder head(s). Scrape the gasket material from the mounting flange of the exhaust manifold and muffler inlet pipe.

2. Apply graphite grease to the mating surface(s) of the exhaust manifold(s) and cylinder head(s).

3. Position the exhaust manifold(s) on the cylinder head(s) and install the retaining bolts and tab washers. Working from the center to the ends torque the retaining bolts to specifications. Lock the bolts by bending one tab of the washer over a flat on the bolt.

4. On a left exhaust manifold, install the dipstick and tube assembly.

Use oil-resistant sealer on the dipstick tube threads. Position the power steering pump bracket on the cylinder block and install the retaining bolts. Adjust the belt tension. Position the hoses and install the power steering hose bracket.

5. On a right exhaust manifold, install the automatic choke air heat tube and air inlet tube on the right exhaust manifold.

6. Position a new gasket on the muffler inlet pipe(s) and connect the exhaust manifold(s) to the inlet pipe(s). Install and torque the retaining nuts to specifications.

7. Install the air cleaner and connect the automatic choke heat chamber air inlet tube.

POSITIVE CRANKCASE VENTILATION SYSTEM

REMOVAL

1. Remove the carburetor air cleaner. Remove the vent hose.

2. Grasp the crankcase ventilation regulator valve and pull it straight upwards and out of the grommet in the right valve rocker arm cover.

3. Use a hose clamp tool to slide both hose clamps off the ends of the inlet hose. Remove the inlet hose from the carburetor spacer, and separate the hose from the regulator valve.

CLEANING AND INSPECTION

Refer to Part 8-1, Section 3 for cleaning and inspection procedures on the inlet hose, carburetor spacer and oil filler tube breather cap. **Do not clean the regulator valve.**

INSTALLATION

1. Install the inlet hose and hose clamp on the regulator valve. Position the hose clamp.

2. Install the inlet hose and hose clamp on the carburetor spacer inlet nipple. Position the hose clamp.

3. Install the crankcase ventilation regulator valve in the right valve rocker arm cover. Install the air cleaner and vent hose.

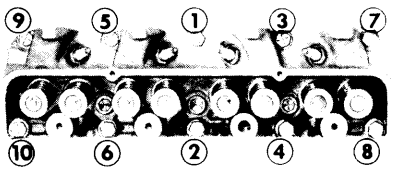


FIG. 21—Cylinder Head Bolt Torque Sequence

CYLINDER HEADS

REMOVAL

If a cylinder head is to be replaced, follow the procedures under "Cylinder Head Disassembly and Assembly," and transfer all valves, springs, spark plugs, etc., to the new cylinder head. Clean and inspect all parts and reface the valves (refer to Part 8-1) before assembling the used parts to the new cylinder head.

1. Remove the intake manifold, carburetor and radiator supply tank as an assembly following the procedure under "Intake Manifold Removal."

2. Disconnect the exhaust manifolds at the muffler inlet pipes.

If the left cylinder head is to be removed, remove the ignition coil and engine identification tag, and remove the power steering pump mounting bolt from the cylinder head.

3. Remove the cylinder head bolts. Install the cylinder head holding fixtures (Fig. 20).

4. Lift the cylinder heads off the block. **Do not pry between the head and the block.** Remove and discard the cylinder head gasket.

INSTALLATION

1. Clean the cylinder head and cylinder block gasket surfaces.

2. Inspect the cylinder head, following the procedures in Part 8-1, Section 3.

3. Apply cylinder head gasket sealer to both sides of a new gasket. Guided by the word "FRONT" on the gasket, install the gasket over the cylinder head dowels.

4. Place the cylinder head on the engine and remove the holding fixtures.

On the left cylinder head, install the ignition coil, engine identification tag, and the power steering pump mounting bolt.

5. Install the cylinder head bolts. The cylinder head bolts are tightened in three progressive steps. Torque all the bolts in sequence (Fig. 21) to 70 ft-lbs; then torque them to 80 ft-lbs, and finally torque to specifications. **After the cylinder head bolts have been torqued to specifications, the bolts should not be disturbed.**

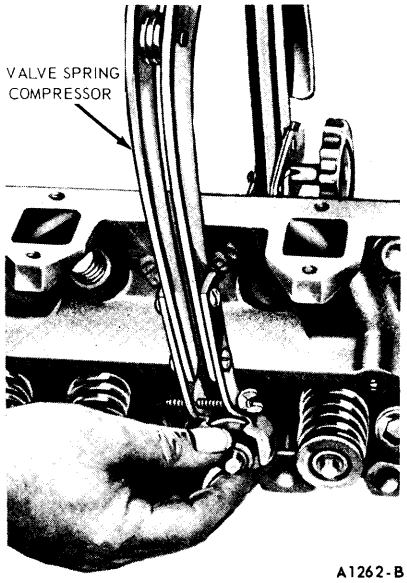


FIG. 22—Compressing Valve Spring—On Bench

6. Position new gaskets on the muffler inlet pipes. Connect the exhaust manifolds to the muffler inlet pipes. Torque the nuts to specifications.

7. Install the intake manifold and related parts following the procedure under "Intake Manifold" Installation."

DISASSEMBLY

1. Remove the spark plugs. Clean the carbon out of the cylinder head combustion chambers before removing the valves.

2. Remove the exhaust manifolds.

3. Compress the valve springs (Fig. 22). Remove the spring retainer locks and release the spring.

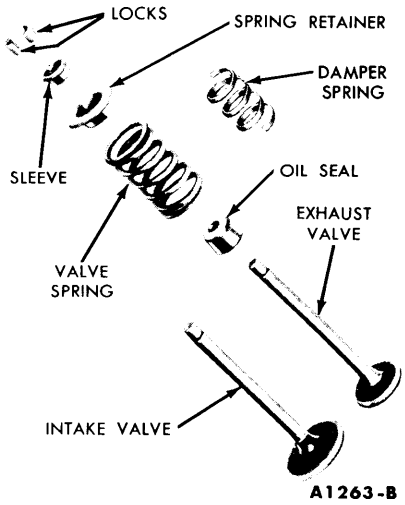


FIG. 23—Valve Assembly

Inspect the valve springs removal to determine if the damper spring(s) is intertwined with the valve spring(s). If this condition exists, replace all defective or worn components (refer to inspection procedures in Part 8-1, Section 3).

4. Remove the sleeve, spring retainer, spring (and damper spring if applicable), stem seal and valve. Discard the valve stem seals. Identify all valve parts.

CLEANING AND INSPECTION

Refer to Part 8-1, Section 3 for the cleaning and inspection procedures.

REPAIRS

Cylinder head repair procedures and checks such as valve and valve seat refacing, cylinder head flatness checks, etc., are covered in Part 8-1, Sections 2 and 3.

ASSEMBLY

1. Install each valve (Fig. 23) in the port from which it was removed or to which it was fitted. Install a new stem seal on the valve. **The exhaust valve stem seal is approximately 0.025 inch shorter in overall height than the intake valve stem seal; therefore, be sure the seals are installed on the proper valves.**

2. Install the valve spring (closed coils downward) over the valve, and install the spring retainer and sleeve. **Make sure the damper spring is installed in the valve spring so that the coil end of the damper spring is 135° counterclockwise from the coil end of the valve spring.**

3. Compress the spring and install the retainer locks (Fig. 22).

4. Measure the assembled height of the valve spring from the surface of the cylinder head spring pad to the underside of the spring retainer with dividers (Fig. 24). Check the dividers against a scale. If the assembled height is greater than specified, install the necessary 0.030-inch thick spacer(s) between the cylinder head spring pad and the valve spring to bring the assembled height to the recommended specifications.

Do not install spacers unless necessary. Use of spacers in excess of recommendations will result in overstressing the valve springs and overloading the camshaft lobes which could lead to spring breakage and worn camshaft lobes.

5. Install the exhaust manifolds.

6. Install the spark plugs.

VALVE SPRING, RETAINER AND STEM SEAL REPLACEMENT

Broken valve springs, or defective valve stem seals and retainers may be replaced without the need of removing the cylinder head, providing damage to the valve or valve seat has not occurred.

1. Disconnect the automatic choke heat chamber air inlet tube and remove the air cleaner. Remove the valve rocker arm cover(s), following steps 2 and 3 under "Valve Rocker Arm Shaft Assembly Removal."

2. Remove the applicable spark plug. **Disconnect the brown lead ("I" terminal) and the red and blue lead ("S" terminal) at the starter relay.** Install an auxiliary starter switch between the battery and "S" terminals of the starter relay. **Crank the engine with the ignition switch "OFF".**

Crank the engine until the piston of the affected cylinder is on the power stroke.

3. Loosen the valve rocker arm support bolts evenly and alternately, two turns at a time, until the valve spring tension has been released. Remove the push rod(s) of the valve(s) to be serviced.

4. Tighten the valve rocker arm support bolts evenly and alternately, two turns at a time, until they are snug. Push the rocker arm to one side and secure it in this position (Fig. 25). If an end valve is to be worked on, it will be necessary to remove the rocker arm from the shaft.

5. Install an air adapter in the spark plug hole and connect the air supply hose to the adapter. Turn on the air supply. **Air pressure may turn the crankshaft until the piston reaches the bottom of its stroke.**

6. Compress the valve spring and remove the valve retainer locks from the valve (Fig. 26). **If air pressure fails to hold the valve in the closed position during this operation, it can be presumed that the valve is**

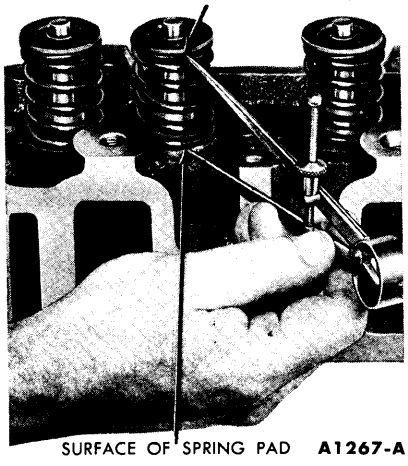


FIG. 24—Valve Spring Assembled Height

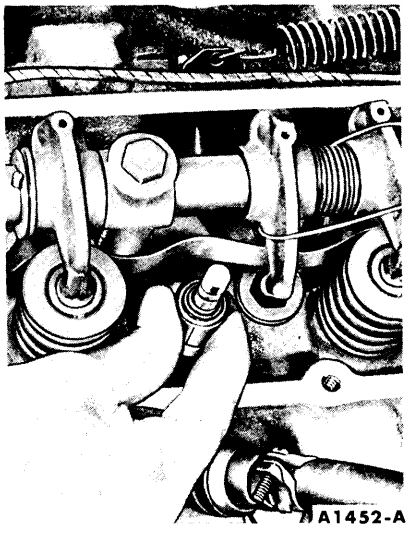


FIG. 25—Valve Stem Seal Removal

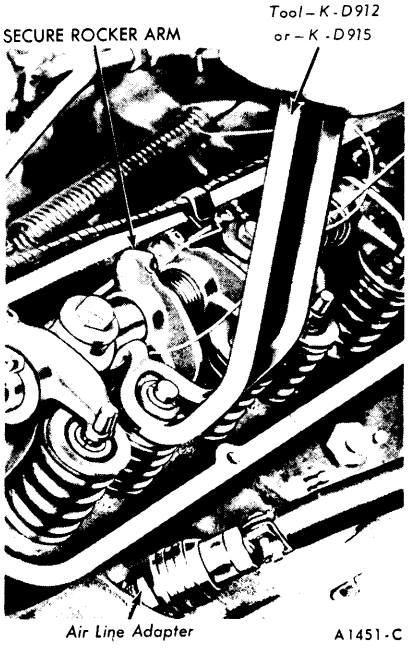


FIG. 26—Compressing Valve Spring—In Chassis

not seating or is damaged. If this condition occurs, remove the cylinder head for further inspection.

7. Remove the valve spring and related parts. Remove the valve stem seal (Fig. 25). **If air pressure has forced the piston to the bottom of the cylinder, any removal of air pressure will allow the valve(s) to fall into the cylinder. A rubber band, tape or string wrapped around the end of the valve stem will prevent this condition and still allow enough travel to check the valve for binds.**

8. Inspect the valve stem for damage. Rotate the valve and check the valve stem tip for eccentric movement during rotation. Move the valve up and down through normal travel in the valve guide and check the stem for binds. **If the valve has been damaged, it will be necessary to remove the cylinder head for repairs as outlined in Part 8-1, Section 2.**

9. If the condition of the valve proved satisfactory, hold the valve in the closed position and apply the air pressure within the cylinder

10. Inspect the valve stem seal for a cracked, torn or brittle condition, and replace it if necessary. Install the seal on the valve stem. **The exhaust valve stem seal is approximately 0.025 inch shorter in overall height than the intake valve stem seal; therefore, be sure the proper seal is installed.**

11. Install the valve springs, retainer and sleeve over the valve stem. **Make sure the valve damper spring is installed in the valve spring so that the coil end of the damper spring is 135° counterclockwise from the coil end of the valve spring.**

12. Compress the valve spring (Fig. 26) and install the valve retainer locks. Tap the valve stem tip with a soft mallet to make certain that the retainer locks are properly seated.

13. Remove the air line and adapter. Install the spark plug. Remove the wire securing the valve rocker arm and slide the rocker arm in position. Install the end rocker arm(s), if they were removed.

14. Loosen the valve rocker arm support bolts evenly and alternately, two turns at a time, until spring tension is removed. Apply Lubriplate to both ends of the push rod. Position the push rod within the rocker arm socket and the valve lifter seat.

15. Tighten the rocker arm shaft support bolts evenly and alternately, two turns at a time, until they are snug. Torque the bolts to specifications.

16. Remove the remote control starter switch. Install the high tension lead wire in the ignition coil terminal.

17. Install the spark plug wires. Check the valve clearances and correct if necessary (Part 8-1, Section 2).

18. Install the valve rocker arm cover(s), following steps 8 and 9 under "Valve Rocker Arm Shaft Assembly Installation."

19. Install the air cleaner and connect the automatic choke heat chamber air inlet tube.

CRANKSHAFT DAMPER REPLACEMENT

To remove the crankshaft damper, refer to steps 5, 6 and 7 under "Cylinder Front Cover and Timing Chain Removal," except do not remove the water pump. Install the crankshaft damper following the procedures in steps 7, 8, 9, 12 and 13 under "Cylinder Front Cover and Timing Chain Installation."

CYLINDER FRONT COVER AND TIMING CHAIN

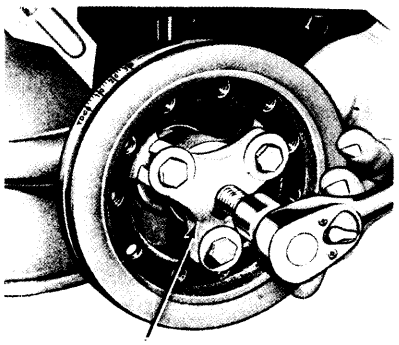
REMOVAL

1. Drain the cooling system and and crankcase. Disconnect the battery ground cable.

2. Disconnect the radiator upper hose at the radiator supply tank. Disconnect the radiator lower hose at the water pump.

3. Disconnect the transmission oil cooler lines at the radiator. Remove the radiator.

4. Disconnect the heater hose at the water pump. Slide the water pump bypass hose clamp toward the engine.



Tool-T58P-6316-A or-B or 6306-AJ A1257-D

FIG. 27—Crankshaft Damper Removal

5. Disconnect the power steering pump bracket from the water pump and remove the drive belt. Wire the power steering pump assembly to the left side of the car in a position that will prevent the oil from draining out.

On a car with an air conditioner, remove the compressor drive belt.

6. Loosen the alternator mounting bolts at the alternator. Remove the drive belt. Remove the alternator support bolt at the water pump. Remove the water pump, drive belt adjusting arm, pulley and fan as an assembly.

7. Remove the cap screw and washer from the end of the crankshaft. Remove the power steering pulley from the crankshaft damper. Install the puller on the crankshaft damper (Fig. 27) and remove the damper.

8. Disconnect the carburetor fuel inlet line at the fuel pump.

9. Remove the fuel pump retaining bolts and lay the pump to one side with the flexible fuel line still attached.

10. Remove the crankshaft sleeve as shown in Fig. 28.

11. Remove the screws fastening the cylinder front cover to the block. Remove the cylinder front cover.

On a car with an air conditioner, the compressor brackets are retained by cylinder front cover screws.

12. Discard the cylinder front cover gasket. Remove the oil slinger.

13. Rotate the crankshaft in a clockwise direction (as viewed from the front) to take up the slack on the left side of the chain.

14. Establish a reference point on the block and measure from this point to the chain (Fig. 29).

15. Rotate the crankshaft in the opposite direction to take up the slack on the right side of the chain.

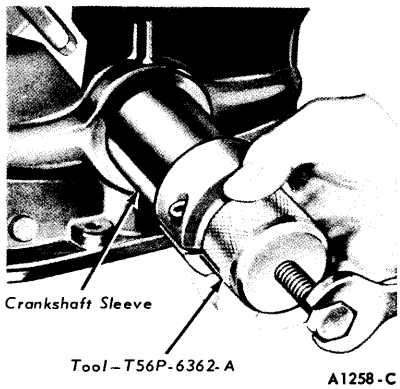


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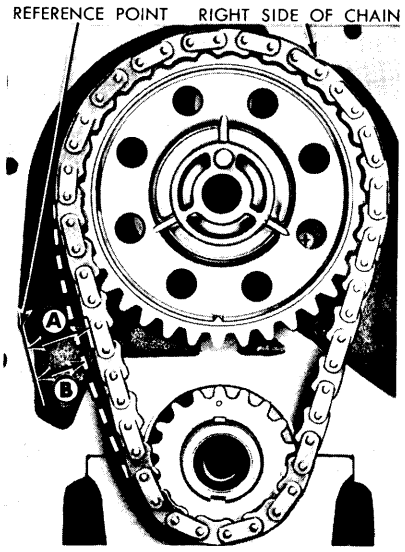
FIG. 28—Crankshaft Sleeve Removal



TAKE UP SLACK ON LEFT SIDE, ESTABLISH REFERENCE POINT. MEASURE DISTANCE **A**. TAKE UP SLACK ON RIGHT SIDE. FORCE LEFT SIDE OUT. MEASURE DISTANCE **B**. DEFLECTION IS **A** MINUS **B**. A1284-C

FIG. 29—Timing Chain Deflection

Force the left side of the chain out with the fingers and measure the distance between the reference point and the chain. The deflection is the difference between the two measurements.

If the deflection exceeds ½ inch, replace the timing chain and/or sprockets.

16. Crank the engine until the timing marks on the sprockets are positioned as shown in Fig. 30.

17. Remove the camshaft sprocket cap screw and the fuel pump eccentric.

18. Slide both sprockets and the timing chain forward, and remove the sprockets and timing chain as an assembly (Fig. 31).

19. Remove the oil pan and oil pump screen, following the procedure under "Oil Pan Removal."

FRONT OIL SEAL REPLACEMENT

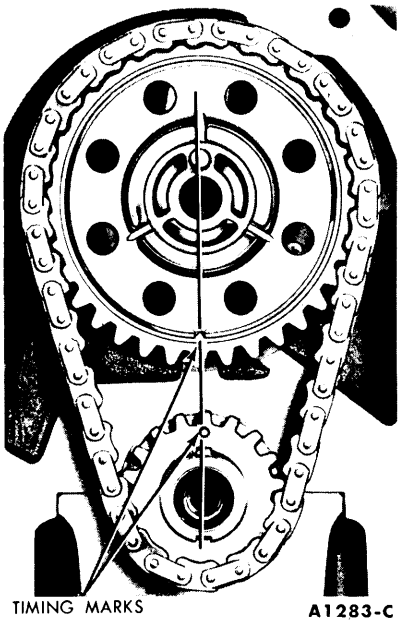
It is good practice to replace the oil seal each time the cylinder front cover is removed.

1. Drive out the old seal with a pin punch. Clean out the recess in the cover.

2. Coat a new seal with grease; then install the seal (Fig. 32). Drive the seal in until it is fully seated in the recess. Check the seal after installation to be sure the spring is properly positioned in the seal.

INSTALLATION

1. Position the sprockets and timing chain on the camshaft and crankshaft (Fig. 31). Be sure the timing marks on the sprockets are positioned as shown in Fig. 30.



A1283-C

FIG. 30—Aligning Timing Marks

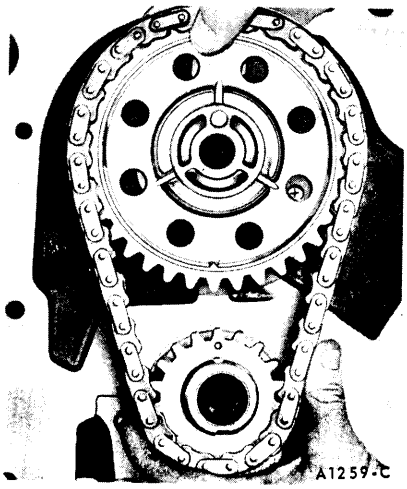


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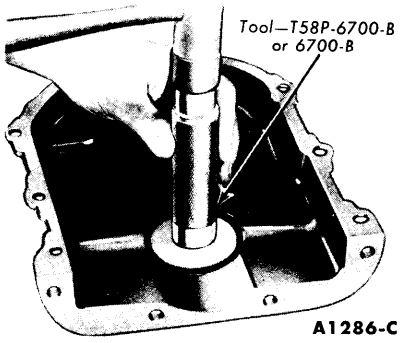
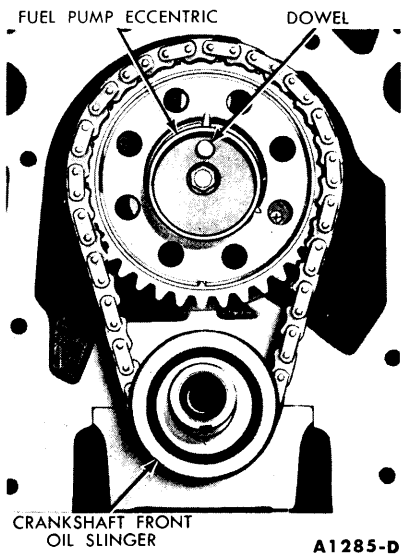
FIG. 31—Timing Chain Removal or Installation



A1286-C

FIG. 32—Oil Seal Installation



A1285-D

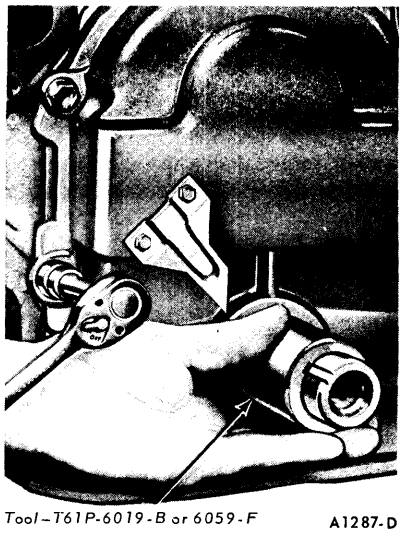
FIG. 33—Fuel Pump Eccentric and Front Oil Slinger Installed

2. Install the fuel pump eccentric and the camshaft sprocket cap screw (Fig. 33). Torque the sprocket cap screw to specifications. Install the crankshaft front oil slinger.

3. Clean the cylinder front cover, oil pan and cylinder block gasket surfaces.

4. Coat the gasket surface of the block and cover and the cover bolt threads with sealer. Position a new gasket on the block.

5. Lubricate and install the alignment pilot tool on the cylinder front cover so that the keyway in the pilot



A1287-D

FIG. 34—Cylinder Front Cover Alignment

aligns with the key in the crankshaft. Position the cover and pilot over the end of the crankshaft and against the block (Fig. 34). Install the retaining screws.

On a car with an air conditioner, position the compressor bracket on the cylinder front cover, and install the retaining screws finger-tight.

While pushing in on the pilot, torque the screws to specifications. Remove the pilot.

6. Install the crankshaft sleeve.

7. Lubricate the hub and line up the damper keyway with the key on the crankshaft. Install the damper on the crankshaft (Fig. 35).

8. Install the power steering pump pulley on the damper. Torque the screws to specifications.

9. Install the damper cap screw and washer, and torque the screw to specifications.

10. Clean the oil pan and the oil pump screen. Install the oil pump screen and oil pan following the procedure under "Oil pan and Oil Pump Installation."

11. Clean the water pump gasket surfaces. Coat new gaskets with sealer and position the gaskets on the block. Install the water pump, pulley, fan and alternator adjusting arm as an assembly.

12. Install and adjust the alternator drive belt(s).

On a car with an air conditioner, install and adjust the drive belt.

13. Install the power steering pump drive belt and attach the pump bracket to the water pump. Adjust the drive belt tension.

14. Install the fuel pump, using a new gasket.

15. Connect the carburetor fuel inlet line. Connect the heater hose. Slide the water pump bypass tube clamp forward on the tube.

16. Install the radiator and support as an assembly. Connect the radiator lower hose at the water pump and the radiator upper hose at the radiator supply tank. Connect the battery ground cable. Connect the transmission oil cooler lines.

17. Fill and bleed the cooling system. Fill the crankcase with the proper grade and quantity of engine oil.

18. Operate the engine at fast idle and check for coolant and oil leaks. Adjust the ignition timing. Install the air cleaner and connect the automatic choke heat chamber air inlet tube.

CLEANING AND INSPECTION

Refer to Part 8-1, Section 3 for the cleaning and inspection procedures.

CAMSHAFT

The camshaft and related parts are shown in Fig. 36.

REMOVAL

1. Remove the cylinder front cover following steps 1 thru 12 under "Cylinder Front Cover and Timing Chain Removal."

2. Refer to "Valve Rocker Arm Shaft Assembly Removal" and remove the valve rocker arm covers and the valve rocker arm shaft assemblies.

3. Disconnect the coil high tension lead at the coil. Remove the distributor cap and spark plug wire assembly. Disconnect the distributor vacuum line at the distributor. Remove the distributor hold down bolt and clamp. Remove the distributor.

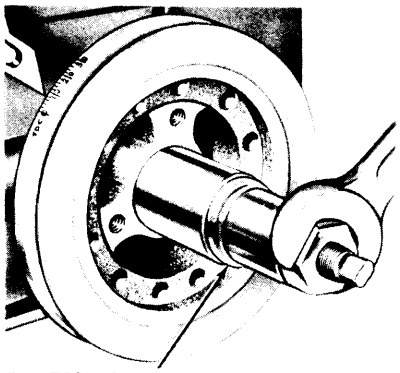


FIG. 35—Crankshaft Damper Installation

4. Remove the valve push rods in sequence and place them in a rack so that they can be installed in their original positions.

5. Position an inspection light through a push rod opening and into the valve push rod valley (Fig. 37). Remove the valve lifters or tappets with a magnet through the push rod openings. In some cases it will be necessary to transfer the lifter or tappet over to an adjoining push rod opening in order to remove it. Place the lifters or tappets in a rack so that they can be installed in their original positions.

6. Remove the oil pan and oil pump screen by following the procedure under "Oil Pan Removal."

7. Install a dial indicator so that the indicator point is on the camshaft sprocket retaining screw. Push the camshaft toward the rear of the engine and set the dial indicator on zero. Pull the camshaft forward and release it. Compare the indicator reading with the specifications. If the end play is excessive, check the spacer for correct installation before it is removed. **The side of the spacer having a chamfer on the ID must be against the camshaft front journal.** If the spacer is installed correctly, replace the thrust plate.

8. Remove the dial indicator. Remove the timing chain and sprockets following steps 13 thru 18 under

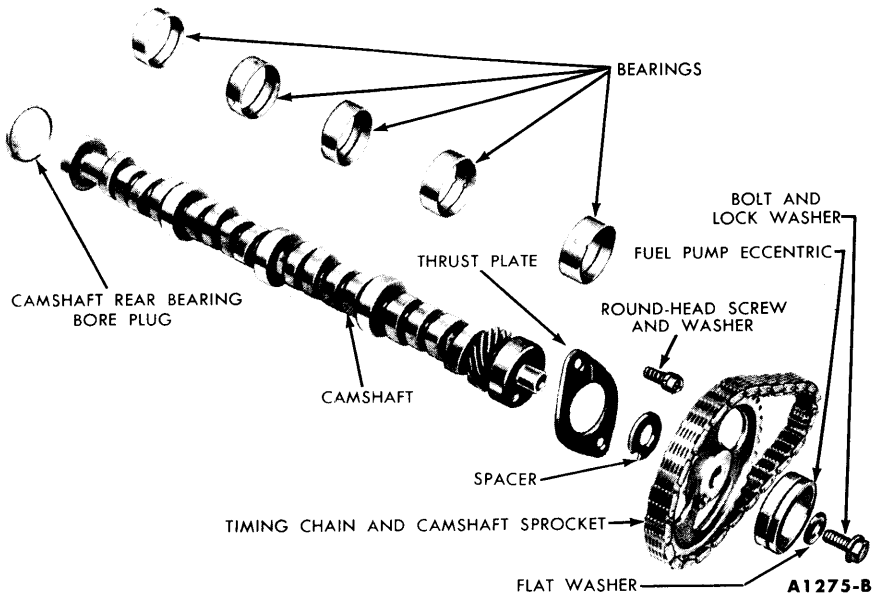


FIG. 36—Camshaft and Related Parts

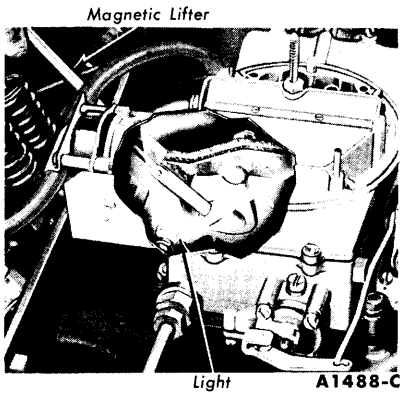


FIG. 37—Hydraulic Valve Lifter Removal—Intake Manifold Installed

"Cylinder Front Cover and Timing Chain Removal."

9. Remove the camshaft thrust plate and spacer. Carefully remove the camshaft by pulling it toward the front of the engine. **Use caution to avoid damaging the camshaft bearings.**

CLEANING AND INSPECTION

Refer to Part 8-1, Section 3 for the cleaning and inspection procedures.

REPAIRS

Refer to Part 8-1, Section 2 for the repair procedure.

INSTALLATION

1. Oil the camshaft and apply Lubriplate to the lobes. Carefully slide the camshaft through the bearings. Install the thrust plate and spacer. **The chamfered ID of the spacer must be toward the camshaft front journal. Be sure the thrust plate oil groove is up and toward the front (next to camshaft sprocket).**

2. Follow the procedure in step 7 of "Camshaft Removal" and check the camshaft end play.

3. Position the sprockets and timing chain on the camshaft and crankshaft (Fig. 31) with the timing marks on the sprockets aligned as shown in Fig. 30.

4. Install the fuel pump eccentric and the camshaft sprocket cap screw (Fig. 33). Torque the sprocket cap screw to specifications. Install the front oil slinger.

5. Replace the crankshaft front oil seal. Install the cylinder front cover, crankshaft damper and related parts following steps 3 thru 16 under "Cylinder Front Cover and Timing Chain Installation."

6. With the No. 1 piston on TDC at the end of the compression stroke, position the distributor in the block with the rotor at the No. 1 firing position and the points open. Install the hold down clamp.

7. Install the distributor cap. Connect the coil high tension lead.

8. Install the valve lifters in the bores from which they were removed. Install the push rods in their original positions.

9. Refer to "Valve Rocker Arm Shaft Assembly Installation" and install the valve rocker arm shaft assembly following steps 1 thru 9.

10. Fill and bleed the cooling system. Fill the crankcase with the proper grade and quantity of engine oil.

11. Start the engine and check and adjust the ignition timing. Connect the distributor vacuum line. Operate the engine at fast idle and check all hose connections and gaskets for leaks.

CAMSHAFT REAR BEARING BORE PLUG REPLACEMENT

1. Remove the transmission and converter housing by following the procedure in Part 7-2.

2. Remove the flywheel retaining bolts and remove the flywheel.

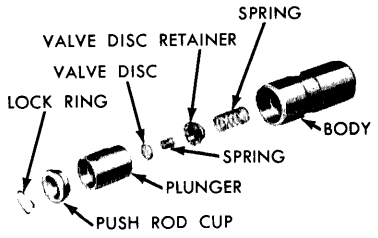
3. Drill a ½-inch hole in the camshaft rear bearing bore plug and use tool T-7600-E to remove the plug.

4. Clean out the plug bore recess thoroughly.

5. Coat the flange of a new plug with oil-resistant sealer and install it with the flange facing inward (Fig. 59).

6. Install the flywheel.

7. Install the transmission and converter housing by following the procedure in Part 7-2.



NOTE: PLUNGER AND BODY ARE MATCHED SELECTIVE FIT SETS DO NOT MISMATE PAIRS.

A1835-A

FIG. 38—Typical Hydraulic Valve Lifter Assembly

HYDRAULIC VALVE LIFTER REPLACEMENT

The following procedure is applicable for removing one or all of the valve lifters. This procedure can not be used if the valve lifters are stuck in their bores by excessive varnish, etc. In this case, it will be necessary to remove the intake manifold. After the intake manifold has been removed, remove the valve lifters.

1. Refer to "Valve Rocker Arm Shaft Assembly Removal" and remove the valve rocker arm covers and the valve rocker arm shaft assemblies by following steps 1 thru 4. Remove the push rods and place them in a rack so they can be installed in the same location from which they were removed.

2. Position an inspection light through a push rod opening and into the valve push rod valley (Fig. 37). Remove the valve lifters with a magnet through the push rod openings. In some cases, it will be necessary to transfer the lifter over to an adjoining push rod opening in order to remove it. Place the lifters in a rack so that they can be installed in their original positions.

The internal parts of each hydraulic valve lifter assembly are matched sets. Do not intermix the parts. Keep the assemblies intact until they are to be cleaned.

3. Install the push rods. Install the new (or cleaned) hydraulic valve lifters through the push rod openings with a magnet (Fig. 37).

4. Refer to "Valve Rocker Arm Shaft Assembly Installation" and install the valve rocker arm shaft assemblies and covers by following steps 1 thru 10.

HYDRAULIC VALVE LIFTER DISASSEMBLY

Each valve lifter is a matched assembly. If the parts of one lifter are intermixed with those of another, improper valve operation may result. Disassemble and assemble each lifter separately. Keep the lifter assemblies in proper sequence so that they can be installed in their original bores.

1. Grasp the lock ring with needle nose pliers to release it from the groove. It may be necessary to depress the plunger to fully release the lock ring.

2. Remove the push rod cup, plunger and spring.

3. Invert the plunger assembly and remove the disc valve retainer by

carefully prying up on it with a screw driver. Remove the disc valve and spring.

CLEANING AND INSPECTION

Refer to Part 8-1, Section 3 for the cleaning and inspection procedures.

HYDRAULIC VALVE LIFTER ASSEMBLY

A typical hydraulic valve lifter assembly is shown in Fig. 38.

1. Place the plunger upside down on a clean work bench.
2. Place the disc valve in position over the oil hole on the bottom of the plunger. Set the disc valve spring on top of the disc.
3. Position the disc valve retainer over the disc and spring, and push the retainer down into place on the plunger.
4. Place the plunger spring and then the plunger (open end up) into the lifter body.
5. Place the push rod seat in the plunger.
6. Depress the plunger, and position the closed end of the lock ring in the groove of the lifter body. With the plunger still depressed, position the open ends of the lock ring in the groove. Release the plunger, then depress it again to fully seat the lock ring.

TESTING

Refer to Part 8-1, Section 1 for the testing procedures.

CRANKSHAFT REAR OIL SEAL REPLACEMENT

Replacement of a crankshaft rear oil seal requires replacement of both the upper and lower seals. Remove the engine; then remove the crankshaft and replace the seals following the procedure under "Crankshaft Removal and Installation" (Section 4).

MAIN AND CONNECTING ROD BEARING REPLACEMENT

The main and connecting rod bearing inserts are selective fit. **Do not file or lap bearing caps or use shims to obtain the proper bearing clearance.**

Selective fit bearings are available for service in standard sizes only. Standard bearings are divided into two sizes and are identified by a daub of red or blue paint. Refer to the Parts Catalog for the available sizes. **Red marked bearings increase the clearance; blue marked bearings decrease the clearance.** Undersize bearings, which are not selective fit, are available for use on journals that have been refinished.

MAIN BEARING REPLACEMENT

1. Drain the crankcase. Remove the oil level dipstick. Remove the oil pan and oil pump. Remove the spark plugs to allow easy rotation of the crankshaft.
2. **Replace one bearing at a time leaving the other bearing securely fastened.** Remove the main bearing cap to which new bearings are to be installed.
3. Insert the upper bearing removal tool (tool 6331) in the oil hole in the crankshaft.
4. Rotate the crankshaft in the direction of engine rotation to force the bearing out of the block.
5. Clean the crankshaft journal and bearing inserts. **When replacing standard bearings with new bearings, it is good practice to first try to obtain the proper clearance with two blue bearing halves.**
6. To install the upper main bearing, place the plain end of the bearing over the shaft on the locking tang side of the block and partially install the bearing so that tool 6331 can be inserted in the oil hole in the crankshaft. With tool 6331 positioned in the oil hole in the crankshaft, rotate the crankshaft in the opposite direction of engine rotation until the bearing seats itself. Remove the tool.
7. Replace the cap bearing.
8. Support the crankshaft so that its weight will not compress the Plastigage and provide an erroneous reading. Position a small jack so that it will bear against the counterweight adjoining the bearing which is being checked.
9. Place a piece of Plastigage on the bearing surface the full width of the bearing cap and about ¼ inch off center (Fig. 39).
10. Install the cap and torque the bolts to specifications. **Do not turn the crankshaft while the Plastigage is in place. When checking the width of the Plastigage, check at the widest point in order to get the minimum clearance. Check at the narrowest point in order to get the maximum clearance. The difference between the two readings is the taper.**
11. If the clearance is less than the specified limits, try two red bearing halves or a combination of red and blue depending upon the condition. If the standard bearings do not bring the clearance within the desired limits, refinish the crankshaft journal. Then install undersize bearings.
12. After the bearing has been checked and found to be satisfactory, apply a light coat of engine oil to the journal and bearings; then install the bearing cap. Torque the cap bolts to specifications.
13. Repeat the procedure for the

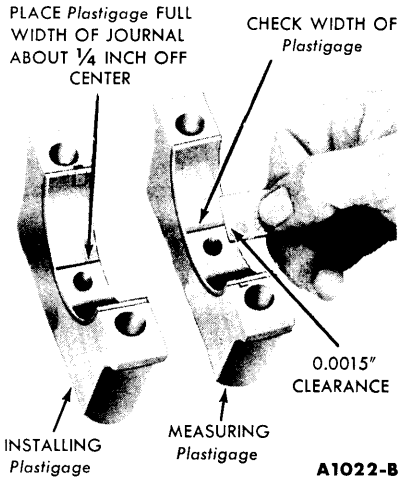


FIG. 39—Installing and Measuring Plastigage—Engine in Chassis

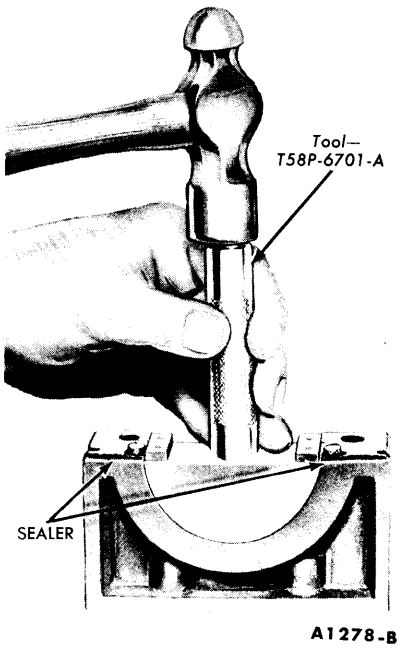


FIG. 40—Seal to Rear Bearing Cap Installation

remaining bearings that require replacement.

14. If the rear main bearing is replaced, remove the rear main bearing cap. Remove and discard the rear seal and side seals.

15. Clean the rear journal oil seal groove.

16. Install a new rear journal oil seal in the rear main bearing cap (Fig. 40). After installation, cut the ends of the seals flush.

17. Apply a thin coating of oil-resistant sealer to the rear main bearing cap at the rear of the top mating surface (Fig. 40). **Do not apply sealer to the area forward of the side seal groove.** Install the rear main bearing cap. Torque the cap bolts to specifications.

18. Dip the side seals in light engine oil; then immediately install them in the grooves. **Do not use sealer on the side seals. The seals are designed to expand when dipped in oil. Using sealer may retard this expansion.** It may be necessary to tap the seals into place for the last ½ inch of travel. Do not cut the seal projecting ends.

19. Check the retainer side seals for leaks by squirting a few drops of oil into the parting lines between the rear main bearing cap and the cylinder block from the outside. Blow compressed air against the seals from the inside of the block. If air bubbles appear in the oil, it indicates possible oil leakage. **This test should not be performed on newly installed seals until sufficient time has been allowed for the seals to expand into the seal grooves.**

20. Disassemble, clean and assemble the oil pump.

21. Install the oil pump and oil pan. Install the oil level dipstick. Fill the crankcase with the proper amount and viscosity oil. Install the spark plugs.

22. Operate the engine and check for oil leaks.

CONNECTING ROD BEARING REPLACEMENT

1. Follow step 1 under "Main Bearing Replacement."

2. Turn the crankshaft until the connecting rod to which new bearings are to be fitted is down.

3. Remove the connecting rod cap. Push the connecting rod up into the cylinder and remove the bearing insert from the rod and cap.

4. Follow step 5 under "Main Bearing Replacement."

5. Install the new bearings in the connecting rod and cap. Pull the connecting rod assembly down firmly on the crankshaft journal.

6. Place a piece of Plastigage on the lower bearing surface, the full width of the cap and about ¼ inch off-center.

7. Install the cap and torque the connecting rod nuts to specifications. **Do not turn the crankshaft while the Plastigage is in place.**

8. Remove the cap; then, using the Plastigage scale, check the width of the Plastigage following steps 9 thru 11 under "Main Bearing Replacement."

9. After the bearing clearance has been checked and found to be satisfactory, apply a light coat of engine oil to the journal and bearings. Install the connecting rod cap.

10. Repeat the procedure for the remaining connecting rods that require new bearings.

11. Follow steps 20, 21 and 22 under "Main Bearing Replacement."

CLEANING AND INSPECTION

Refer to Part 8-1, Section 3 for the cleaning and inspection procedures.

PISTON AND CONNECTING ROD ASSEMBLY

REMOVAL

1. Drain the cooling system and the crankcase. Remove the intake manifold, cylinder heads, oil pan and oil pump following the procedures in this section.

2. Remove any ridge and/or deposits from the upper end of the cylinder bores as follows:

Turn the crankshaft until the piston to be removed is at the bottom of its travel and place a cloth on the piston head to collect the cuttings. Remove any ridge and/or deposits from the upper end of the cylinder bores. Remove the cylinder ridge with a ridge cutter. Follow the instructions furnished by the tool manufacturer. **Never cut into the ring travel area in excess of 1/32 inch when removing ridges.**

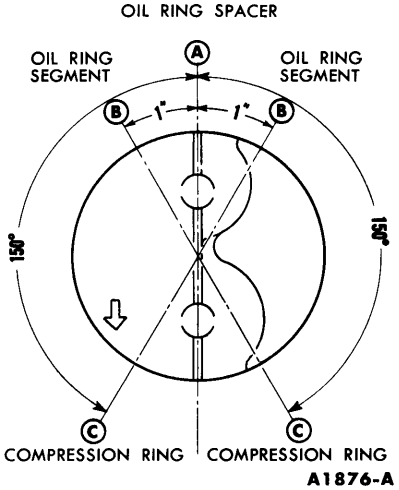


FIG. 41—Piston Ring Gap Spacing

3. Make sure all connecting rod caps are marked so that they can be installed in their original locations.

4. Turn the crankshaft until the connecting rod being removed is down.

5. Remove the connecting rod cap.

6. Push the connecting rod and piston assembly out the top of the cylinder with the handle end of a hammer. **Avoid damage to the crankshaft journal or the cylinder wall when removing the piston and rod.**

7. Remove the bearing inserts from the connecting rod and cap.

8. Install the cap on the connecting rod from which it was removed.

INSTALLATION

1. If new piston rings are to be installed, remove the cylinder wall glaze. Follow the instructions of the tool manufacturer.

2. Oil the piston rings, pistons and cylinder walls with light engine oil. **Be sure to install the pistons in the same cylinders from which they were removed or to which they were fitted. The connecting rod and bearing cap are numbered from 1 to 4 in the right bank and from 5 to 8 in the left bank, beginning at the front of the engine. The numbers on the connecting rod and bearing cap must be on the same side when installed in the cylinder bore. If a connecting rod is ever transposed from one block or cylinder to another, new bearings should be fitted, and the connecting rod should be numbered to correspond with the new cylinder number.**

3. Make sure the ring gaps are properly spaced around the circumference of the piston (Fig. 41).

4. Install a piston ring compressor on the piston and push the piston in with a hammer handle until it is slightly below the top of the cylinder (Fig. 42). Be sure to guide the connecting rods to avoid damaging the

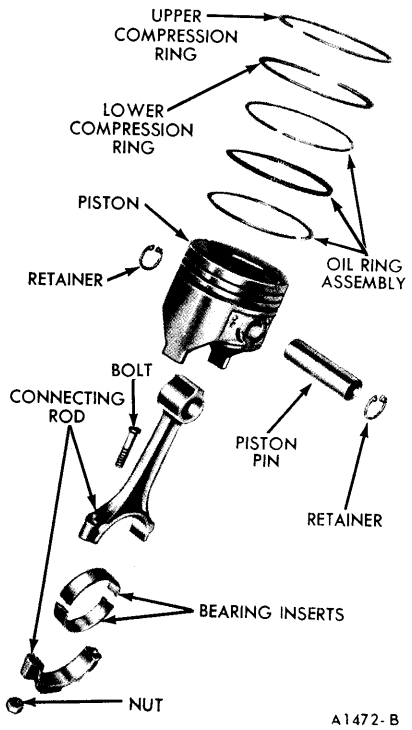


FIG. 45—Piston, Connecting Rod and Related Parts

2. Coat the gasket on the new filter with oil. Place the filter in position on the adapter (Fig. 48). Hand tighten the filter until the gasket contacts the adapter face. Then advance it ½-turn.

3. Operate the engine at fast idle and check for leaks. If oil leaks are evident, perform the necessary repairs to correct the leakage. Check the oil level and fill the crankcase if necessary.

OIL PAN AND OIL PUMP

REMOVAL

1. Drain the crankcase and remove the oil level dipstick.

2. Remove the oil pan retaining screws and lower the oil pan to the cross member. Position the crankshaft so that the counterweight will clear the oil pan.

3. Remove the oil pump retaining bolts and place the oil pump, inlet tube screen and intermediate drive shaft in the oil pan. Remove the oil pan and oil pump. Remove the inlet tube and screen assembly from the oil pump. Discard the gasket. Clean the oil pump inlet tube and screen.

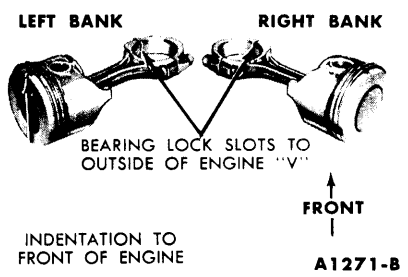


FIG. 46—Connecting Rod and Piston Assembly

CLEANING AND INSPECTION

Refer to Part 8-1, Section 3 for the cleaning and inspection procedures.

INSTALLATION

1. Clean the oil pan and cylinder block gasket surfaces. Position a new gasket on the oil pan.

2. Position a new oil pump inlet tube gasket on the oil pump and install the inlet tube and screen. Prime the oil pump by filling either the inlet or outlet port with engine oil. Rotate the pump shaft to distribute the oil within the pump body.

3. Place the oil pump in the oil pan and position the oil pan on the cross member. Position a new oil pump gasket on the cylinder block. Insert the intermediate drive shaft into the oil pump housing and install the oil pump and shaft as an assembly (Fig. 49). **Do not attempt to force the pump into position if it will not seat readily. The drive shaft hex may be misaligned with the distributor shaft. To align, rotate the intermediate shaft into a new position.** Torque the oil pump retaining screws to specifications.

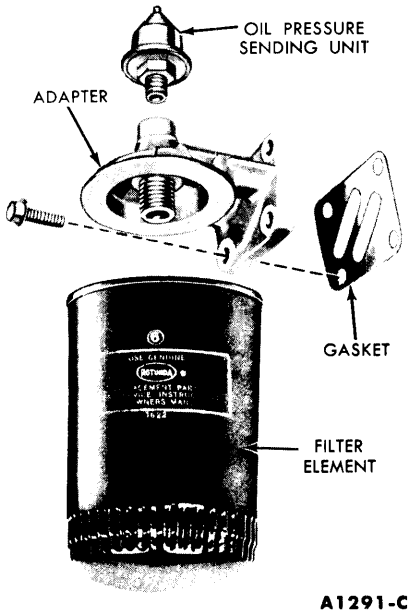


FIG. 47—Rotunda Oil Filter Assembly

FIG. 48—Rotunda Oil Filter Replacement

4. Hold the oil pan in place against the cylinder block and install a retaining screw on each side of the oil pan. **Install the oil pan sealer bolts that retain the oil pan to the rear main bearing cap.** Install the remaining screws and torque them, from the center outward, to specifications.

5. Replace the engine oil filter. Fill the crankcase with the proper grade and quantity of engine oil. Operate the engine and check for leaks.

FIG. 49—Oil Pump and Inlet Tube Installed

crankshaft journals. **Install the piston with the indentation in the piston head toward the front of the engine.**

5. Check the clearance of each bearing following the procedure under "Connecting Rod Bearing Replacement."

6. After the bearings have been fitted, apply a light coat of engine oil to the journals and bearings.

7. Turn the crankshaft throw to the bottom of its stroke. Push the piston all the way down until the connecting rod bearing seats on the crankshaft journal.

8. Install the connecting rod cap. Torque the nuts to specifications.

9. After the piston and connecting rod assemblies have been installed, check the side clearance between the connecting rods on each crankshaft journal (Fig. 43).

10. Disassemble, clean and assemble the oil pump. Clean the oil pump inlet tube screen and the oil pan and block gasket surfaces.

11. Prime the oil pump by filling either the inlet port or outlet port with engine oil and rotating the pump shaft to distribute the oil within the housing. Install the oil pump and the oil pan.

12. Install the cylinder heads by following steps 1 thru 6 under "Cylinder Head Installation."

13. Refer to "Intake Manifold Installation" and install the intake manifold by following steps 2 through 19.

14. Fill and bleed the cooling system. Fill the crankcase with the proper grade and quantity of engine oil.

15. Operate the engine and check for oil and coolant leaks. Check and adjust the ignition timing. Adjust the engine idle speed and fuel mixture.

16. Install the air cleaner and connect the automatic choke heat chamber air inlet tube.

DISASSEMBLY

1. Mark the pistons and pins to assure assembly with the same rod and installation in the same cylinder from which they were removed.

2. Remove the piston rings. Remove the piston pin retainers. Drive the pin out of the piston and connecting rod (Fig. 44). Discard the retainers.

CLEANING AND INSPECTION

Refer to Part 8-1, Section 3 for the cleaning and inspection procedures.

REPAIRS

Refer to Part 8-1, Section 2 for the repair procedures.

ASSEMBLY

The piston, connecting rod and related parts are shown in Fig. 45.

1. Lubricate all parts with light engine oil. Position the connecting rod in the piston and push the pin into place. Assemble the piston and connecting rod as shown in Fig. 46.

2. Install new piston pin retainers in the piston. Follow the insrtuctions contained on the piston ring package and install the piston rings.

3. Check the ring side clearance of the compression rings with a feeler gauge (step 6 under "Fitting Piston Rings" in Part 8-1, Section 2).

Be sure the piston ring gaps are properly spaced (Fig. 41).

4. Be sure the bearing inserts and the bearing bore in the connecting rod and cap are clean. Foreign material under the inserts may distort the bearing and cause a failure. Install the bearing inserts in the connecting rod and cap with the tangs fitting in the slots provided.

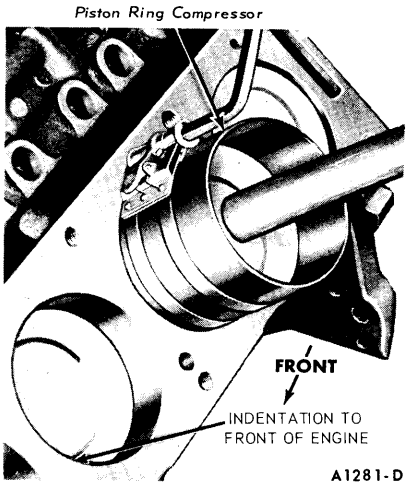


FIG. 42—Piston Installation

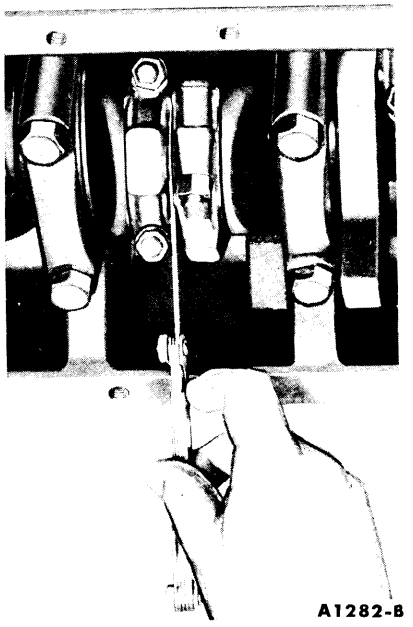


FIG. 43—Connecting Rod Side Clearance

FLYWHEEL

REMOVAL

1. Disconnect the transmission from the engine and slide it to the rear as outlined in Part 7-2.

2. Remove the flywheel retaining bolts and remove the flywheel.

INSPECTION

Refer to Part 8-1, Section 3 for the inspection procedure.

INSTALLATION

1. Install the flywheel on the crankshaft flange and install the retaining bolts. Torque the bolts in sequence across from each other to specifications.

2. Check the flywheel runout, following the procedure in Part 8-1, Section 1.

3. Connect the transmission to the engine as outlined in Part 7-2.

OIL FILTER REPLACEMENT

The Rotunda oil filter assembly is shown in Fig. 47.

1. Place a drip pan under the filter. Unscrew the filter from the adapter fitting. Clean the adapter filter recess.

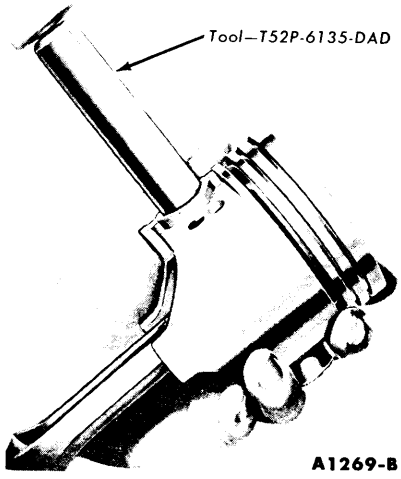


FIG. 44—Piston Pin Removal

OIL PUMP DISASSEMBLY

1. Remove the oil inlet tube from the oil pump and remove the gasket.
2. Remove the cover retaining screws, then remove the cover. Remove the inner rotor and shaft assembly and the outer race.
3. Remove the staking marks at the relief valve chamber cap. Drill a hole in the relief valve chamber cap, and install a self-threading sheet metal screw of the proper diameter into the oil pressure relief valve chamber cap and pull the cap out of the chamber. Remove the spring and plunger.

CLEANING AND INSPECTION

Refer to Part 8-1, Section 3 for the cleaning and inspection procedures.

OIL PUMP ASSEMBLY

The oil pump assembly is shown in Fig. 50.

1. Oil all parts thoroughly.
2. Install the oil pressure relief valve plunger, spring and a new cap. Stake the cap.
3. Install the outer race, and the inner rotor and shaft assembly. **The inner rotor and shaft, and the outer race are serviced as an assembly. One part should not be replaced without replacing the other.** Install the cover. Torque the cover retaining screws to specifications.
4. Position a new gasket and the oil inlet tube on the oil pump and install the retaining bolts.

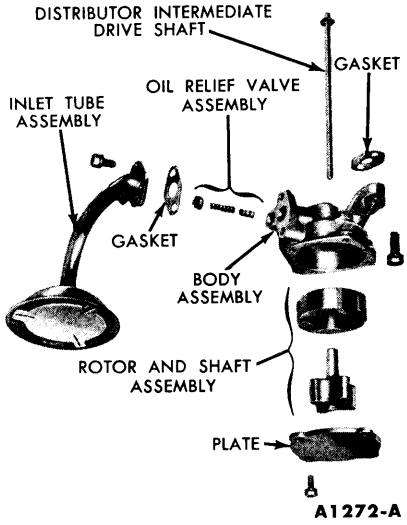


FIG. 50—Oil Pump Assembly

3 ENGINE REMOVAL AND INSTALLATION

The procedures given are for the engine without the transmission attached.

REMOVAL

1. Drain the cooling system and the crankcase. Remove the hood. Disconnect the automatic choke heat chamber air inlet tube and remove the air cleaner.
2. Disconnect the radiator upper hose at the radiator supply tank and the radiator lower hose at the water pump.
3. Disconnect the transmission oil cooler lines at the radiator. Remove the radiator and support as an assembly.
4. Disconnect the battery ground cable at the alternator mounting bracket. Remove the ignition coil and engine identification tag.
5. Disconnect the oil pressure sending unit wire at the sending unit and the flexible fuel line at the fuel tank line.
6. Remove the wire loom from the clips on the left valve rocker arm cover and position the wires out of the way.
7. Disconnect the accelerator rod at the carburetor. Remove the accelerator retracting spring. Remove the accelerator cross shaft bracket from the intake manifold and position it out of the way.
8. Disconnect the power steering pump bracket from the water pump; then wire the power steering pump to the hood left hinge in a position that will prevent the oil from draining out.
9. Disconnect the power brake line at the intake manifold and at the flexible line. Release the line from the brackets on the left valve rocker arm cover and remove the line.

   On a car with an air conditioner, disconnect the magnetic clutch wire. Isolate the compressor.
10. Remove the heater hose from the automatic choke housing and disconnect it at the water pump. Disconnect the heater hose at the carburetor spacer. Position the heater hoses out of the way.

    On a car with an air conditioner, disconnect the heater hoses at the intake manifold and at the "T" connector in the heater hose to the water pump.
11. Disconnect the alternator wires at the alternator (Part 13-2).
12. Disconnect the coolant temperature sending unit wire at the sending unit.
13. Remove the engine ground strap. Remove the starter cable retaining bracket from the alternator mounting bracket.
14. Raise the front of the car.
15. Remove the No. 2 cross member to underbody brace on the right side to provide clearance for starter removal. Remove the starter and dust seal and the transmission fluid filler tube bracket.
16. Disconnect the muffler inlet pipes from the exhaust manifolds. Remove the engine intermediate support bracket to cross member retaining nut on the right and left engine front supports.
17. Remove the converter housing lower access cover and the cover assembly. Remove the flywheel to converter nuts. Secure the converter assembly in the housing. Remove the converter housing to engine lower bolts, and remove the oil cooler lines retaining clamp from the engine block.
18. Lower the car and support the transmission. Remove the converter housing upper retaining bolts. Remove the front fender to upper dash braces.
19. Install the engine left lifting bracket on the front of the left cylinder head where the coil mounts. Install the engine right lifting bracket at the rear of the right cylinder head. Attach the engine lifting sling (Fig. 51).
20. Raise the engine slightly and carefully pull it from the transmission.
21. Lift the engine out of the engine compartment and install it on a work stand.

INSTALLATION

1. Place a new gasket on the muffler inlet pipes.
2. Attach the engine lifting brackets and sling (Fig. 51). Remove the engine from the work stand.

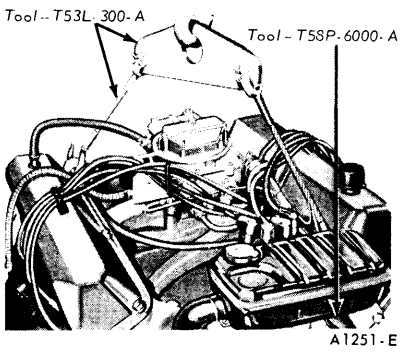


FIG. 51—Engine Lifting Brackets and Sling

3. Lower the engine carefully into the engine compartment. Make sure the exhaust manifolds are properly aligned with the muffler inlet pipes and the dowels in the block engage the holes in the converter housing. Start the converter pilot into the crankshaft.

4. Install the front fender to upper dash braces. Install the converter housing upper bolts. Torque the bolts to specifications.

5. Start the engine intermediate support bracket to cross member retaining nut on the right and left engine front supports. Disconnect the engine lifting sling and remove the lifting brackets.

6. Raise the front of the car. Install the converter housing lower retaining bolts. Torque the bolts to specifications.

7. Remove the retainer securing the converter in the housing. Install the flywheel to converter lock washers and nuts. Torque the nuts to specifications. Install the converter lower access plate and the housing cover assembly. Install the oil cooler lines retaining clamp.

8. Torque the engine intermediate support bracket to cross member retaining nuts to specifications.

9. Connect both exhaust manifolds to the muffler inlet pipes. Torque the nuts to specifications.

10. Position the dust seal and install the starter and the transmission fluid filler tube bracket. Install the No. 2 cross member to underbody brace.

11. Remove the support from the transmission and lower the car.

12. Connect the alternator wires (Part 13-2).

13. Connect the water temperature sending unit wire.

14. Connect the engine ground strap. Install the starter cable retaining clamp.

15. Connect the flexible fuel line and the oil pressure sending unit wire.

16. Install the ignition coil and engine identification tag. Connect the coil primary and high tension wires.

17. Position the wire loom in the retaining clips on the left valve rocker arm cover.

18. Install the accelerator cross shaft bracket and the accelerator retracting spring. Connect the accelerator rod.

19. Connect the power steering pump bracket to the water pump.

20. Connect the power brake line to the intake manifold and to the flexible line. Install the line in the retaining clips on the left valve rocker arm cover.

On a car with an air conditioner, connect the magnetic clutch wire and the compressor lines.

21. Install the radiator and support as an assembly. Connect the radiator upper and lower hoses. Connect the transmission oil cooler lines.

22. Install the heater hose on the automatic choke housing. Connect the heater hose at the carburetor spacer.

On a car with an air conditioner, connect the heater hose at the intake manifold.

23. Fill and bleed the cooling system. Connect the heater hose at the water pump.

On a car with an air conditioner, connect the heater hose at the "T" connector in the heater hose to the water pump.

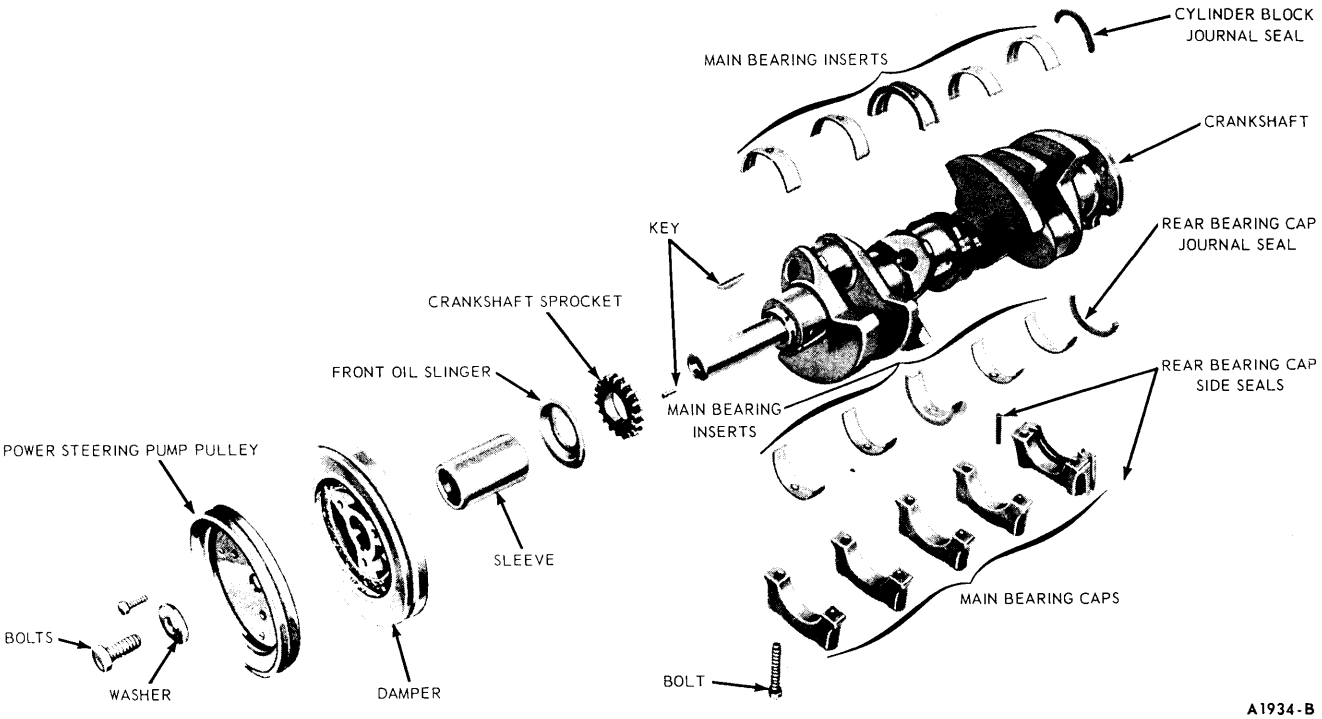


FIG. 52—Typical Crankshaft and Related Parts

24. Fill the crankcase with the proper grade and quantity of engine oil.

25. Operate the engine at fast idle and check all gaskets and hose connections for leaks.

26. Adjust the transmission control linkage. Adjust the accelerator linkage. Install the air cleaner and connect the automatic choke heat chamber air inlet tube.

27. Install and adjust the hood.

4 MAJOR REPAIR OPERATIONS

To perform the operations in this section, it will be necessary to remove the engine from the car and install it on a work stand.

CRANKSHAFT

The crankshaft and related parts are shown in Fig. 52.

REMOVAL

1. Remove the alternator adjusting arm bracket bolt from the alternator and the upper support bracket bolt at the water pump. Remove the spark plugs to allow easy rotation of the crankshaft.

2. Remove the fuel pump. Slide the water pump bypass hose clamp toward the rear of the engine. Remove the water pump and fan as an assembly.

3. Remove the crankshaft damper cap screw and washer. Remove the power steering pump pulley. Install the puller on the damper (Fig. 27) and remove the damper.

4. Remove the crankshaft sleeve as shown in Fig. 28.

5. Remove the cylinder front cover.

6. Remove the crankshaft front oil slinger. Check the timing chain deflection, then remove the timing chain and sprockets by following the applicable steps under "Cylinder Front Cover Removal."

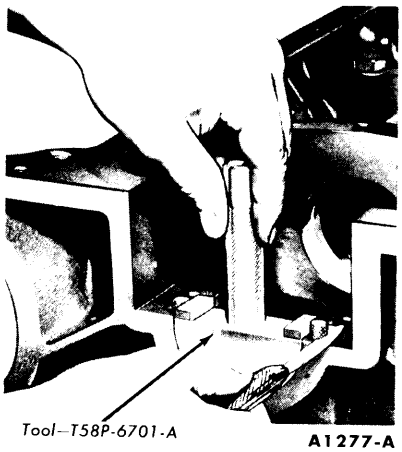


FIG. 53—Seal to Block Installation

7. Invert the engine on the work stand. Remove the flywheel. Remove the oil pan and gasket. Remove the oil pump.

8. **Make sure all bearing caps (main and connecting rod) are marked so that they can be installed in their original locations.** Remove the connecting rod bearing caps. Turn the crankshaft until the connecting rod from which the cap is being removed is down and remove the cap. Push the connecting rod and piston assembly up into the cylinder.

9. Remove the main bearing caps.

10. Carefully lift the crankshaft out of the block so that the thrust bearing surfaces are not damaged. **Handle the crankshaft with care to avoid possible fracture or damage to the finished surfaces.**

CLEANING AND INSPECTION

Refer to Part 8-1, Section 3 for the cleaning and inspection procedures.

REPAIRS

To refinish journals, dress minor imperfections, etc., refer to Part 8-1, Section 2.

INSTALLATION

1. Remove the rear journal oil seal from the block and rear main bearing cap. Remove the rear main bearing cap to block side seals.

2. Remove the main bearing inserts from the block and bearing caps.

3. Remove the connecting rod bearing inserts from the connecting rods and caps.

4. If the crankshaft main bearing journals have been refinished to a definite undersize, install the correct undersize bearings. Be sure the bearing inserts and bearing bores are clean. Foreign material under the inserts may distort the bearing and cause a failure.

5. Place the upper main bearing inserts in position in the bores with the tang fitting in the slot provided.

6. Install the lower main bearing inserts in the bearing caps.

7. Install a new rear journal oil seal in the block (Fig. 53). After installation, cut the ends of the seals flush. **It is very important that the seal be cut flush with the surface of the cylinder block. This prevents rough edges which may project from the groove and lodge between the bearing cap and cylinder block.**

8. Carefully lower the crankshaft into place. **Be careful not to damage the bearing surfaces.**

9. Check the clearance of each main bearing as follows:

Place a piece of Plastigage on the crankshaft journal the full width of the journal and about ¼ inch off center (Fig. 54). Follow steps 10 and 11 under "Main Bearing Replacement" in Part 8-2, Section 2.

10. After the bearings have been fitted, apply a light coat of engine oil to the journals and bearings. Install a new seal in the rear main bearing cap and install the rear main bearing cap by following steps 15 thru 19 under "Main Bearing Replacement" in Part 8-2, Section 2. Install all the bearing caps, except the thrust bearing cap (No. 3 bearing). **Be sure that the main bearing caps are installed in their original locations.** Torque the bearing cap bolts to specifications.

11. Install the thrust bearing cap with the bolts finger-tight.

12. Pry the crankshaft forward against the thrust surface of the upper half of the bearing (Fig. 55).

13. Hold the crankshaft forward and pry the thrust bearing cap to the

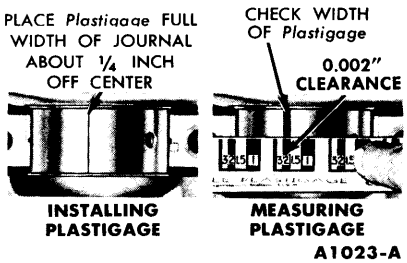


FIG. 54—Installing and Measuring Plastigage—Engine on Work Stand

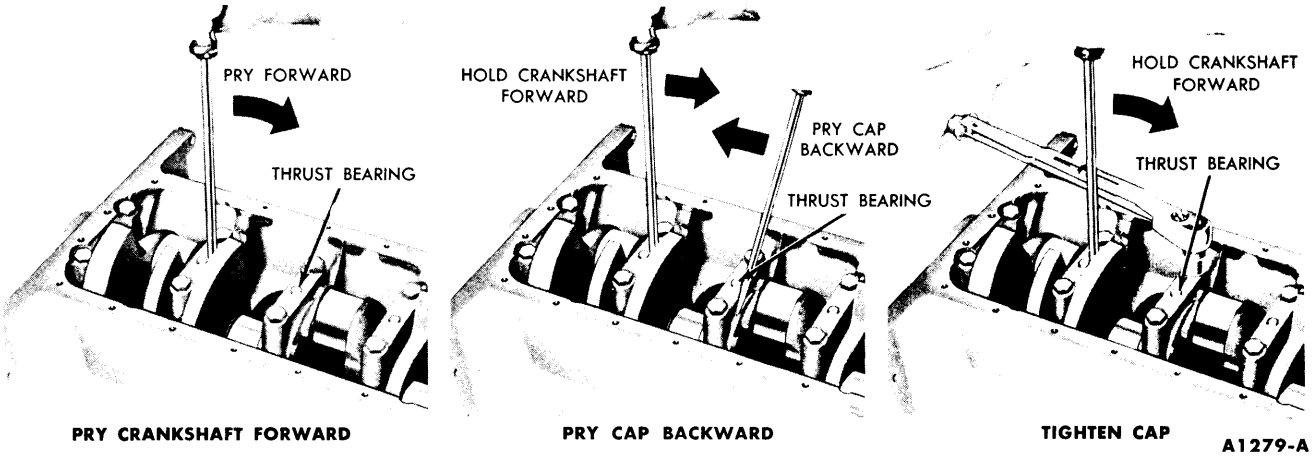


FIG. 55—Thrust Bearing Alignment

rear (Fig. 55). This will align the thrust surfaces of both halves of the bearing.

14. Retain the forward pressure on the crankshaft. Torque the cap bolts to specifications (Fig. 55).

15. Force the crankshaft toward the rear of the engine.

16. Install a dial indicator so that the contact point rests against the crankshaft flange and the indicator axis is parallel to the crankshaft axis (Fig. 56).

17. Zero the dial indicator. Push the crankshaft forward and note the reading on the dial.

18. If the end play exceeds the wear limit, replace the thrust bearing. If the end play is less than the minimum limit, inspect the thrust bearing faces for scratches, burrs, nicks or dirt. If the thrust faces are not defective or dirty, they probably were not aligned properly. Install the thrust bearing and align the faces, following the recommended procedure (steps 11, 12, 13 and 14). Then check the end play.

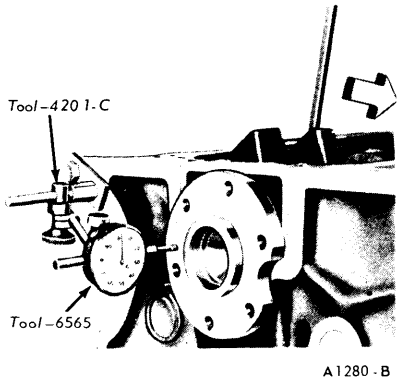


FIG. 56—Crankshaft End Play

19. Install new bearing inserts in the connecting rods and caps. Check the clearance of each bearing following the procedure under "Main Bearing Replacement."

20. After the connecting rod bearings have been fitted, apply a light coat of engine oil to the journals and bearings.

21. Turn the crankshaft throw to the bottom of its stroke. Push the piston all the way down until the rod bearing seats on the crankshaft journal.

22. Install the connecting rod cap. Torque the nuts to specifications.

23. After the piston and connecting rod assemblies have been installed, check the side clearance between the connecting rods on each connecting rod crankshaft journal (Fig. 43).

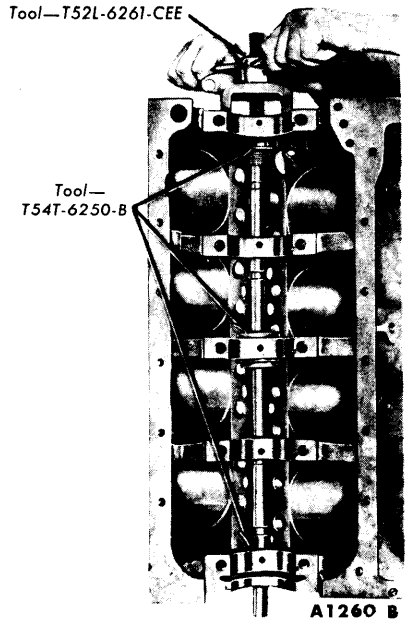


FIG. 57—Camshaft Bearing Replacement

24. Position the flywheel on the crankshaft. Install the retaining bolts. Torque the bolts to specifications.

25. Install the timing chain and sprockets, cylinder front cover and crankshaft damper, following steps 1 thru 9 under "Cylinder Front Cover Installation."

26. Clean the oil pan, oil pump and oil pump inlet screen. Prime the oil pump by filling either the inlet or outlet port with engine oil and rotating the pump shaft to distribute oil within the housing. Install the oil pump and oil pan, following the procedures under "Oil Pan and Oil Pump Installation."

27. Install the oil filter, fuel pump and carburetor fuel inlet line. Install the alternator. Install the spark plugs.

28. Install the engine in the car.

CAMSHAFT BEARING REPLACEMENT

Camshaft bearings are available pre-finished to size for standard and 0.015-inch undersize journal diameters. The bearings are not interchangeable from one bore to another.

1. Remove the camshaft, flywheel and crankshaft, following the appropriate procedures in Section 2 or Section 4. Push the pistons to the top of the cylinders.

2. Remove the camshaft rear bearing bore plug. Remove the camshaft bearings (Figs. 57 or 58).

If the camshaft bearings are being removed with the tool shown in Fig. 58, the following procedure will apply: Select the proper size expanding

collet and back-up nut assemble on expanding mandrel. With the expanding collet collapsed, install the collet assembly in the camshaft bearing, and tighten the back-up nut on the expanding mandrel until the collet fits the camshaft bearing. Assemble the puller screw and extension (if necessary) as shown and install on the expanding mandrel. Tighten the pulling nut against the thrust bearing and pulling plate to remove the camshaft bearing. To remove the front bearing, install the puller screw from the rear of the cylinder block.

3. Position the new bearings at the bearing bores, and press them in place with the tool shown in Fig. 57 or Fig. 58. Align the oil holes in the bearings with the oil holes in the cylinder block when the bearings are installed. **Be sure the front bearing is installed 0.005-0.020 inch below the front face of the cylinder block (Fig. 59).**

4. Clean out the camshaft rear bearing bore plug recess thoroughly. Coat the flange of a new plug with oil-resistant sealer and install the plug (Fig. 60) with the flange edge of the plug facing inward.

5. Install the camshaft, crankshaft, flywheel and related parts, following the appropriate procedures in Section 2 or Section 4, except do not check connecting rod and main bearing clearances as a part of "Camshaft Bearing Replacement." Install the engine in the car.

CYLINDER ASSEMBLY REPLACEMENT

DISASSEMBLY

Follow steps 1 thru 11, 13 thru 20, and 24 thru 26 under "Engine Disassembly." Remove 4 cylinder head dowels from the cylinder block. Remove the cylinder block drain plugs, and remove the cylinder assembly from the work stand.

CLEANING

Clean the gasket and seal surfaces of all parts and assemblies (refer to Part 8-1, Section 3).

ASSEMBLY

Install the replacement cylinder block assembly on a work stand. Install the cylinder block drain plugs and cylinder head dowels. Transfer all parts removed from the old cylinder assembly to the new cylinder assembly, following the procedures in steps 21 thru 34 and 41 thru 62 under "Engine Assembly."

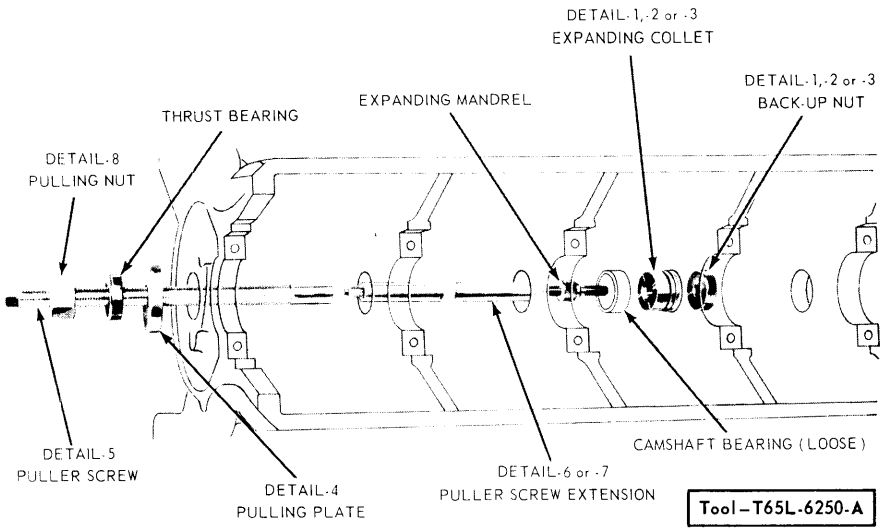


FIG. 58—Typical Camshaft Bearing Replacement

ENGINE DISASSEMBLY

1. Install the engine on the work stand.

2. Remove the distributor cap and spark plug wire assembly.

3. Disconnect the distributor vacuum line at the distributor. Remove the carburetor fuel inlet line. Remove the fuel pump and discard the gasket.

4. Slide the clamp on the water pump bypass hose toward the water pump. Remove the automatic choke air heat tube and air inlet tube. Remove the valve rocker arm covers and crankcase ventilation tube.

Starting at the No. 4 cylinder, loosen the right rocker arm shaft support bolts in sequence, two turns at a time. After the bolts are all loosened, remove the valve rocker arm shaft assembly and the oil baffle plate. Starting at the No. 5 cylinder, follow the same procedure on the left valve rocker arm shaft support bolts.

5. Remove the valve push rods in sequence and put them in a rack so that they can be installed in their original bore.

6. Remove the distributor hold down bolt and clamp and remove the distributor.

7. Remove the intake manifold retaining bolts.

8. Install standard eye bolts with $\frac{7}{16}$-18 threads in the left front and right rear rocker arm cover screw holes and attach the engine lifting sling (Fig. 51).

9. Raise the intake manifold and carefully remove it from the engine. Discard the intake manifold gaskets and seals.

10. Remove the baffle plate from the valve push rod chamber floor by prying up on the baffle with a screw driver (Fig. 61).

11. Lift the valve lifters from the cylinder block and place them in a rack so that they can be installed in their original bore (Fig. 62). **The internal parts of each hydraulic valve lifter assembly are matched sets. Do not intermix the parts. Keep the assemblies intact until they are to be cleaned.**

12. Remove the exhaust manifolds and the spark plugs. Remove the automatic choke air chamber cover from the right exhaust manifold.

13. Remove the cylinder head bolts and install the cylinder head

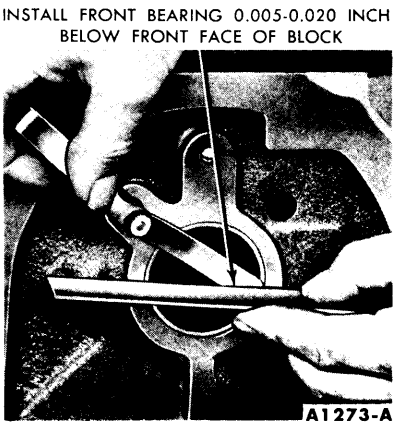


FIG. 59—Camshaft Front Bearing Measurement

holding fixtures (Fig. 20).

14. Lift the cylinder heads off the block. **Do not pry between the head and the block.** Discard the cylinder head gaskets.

15. Remove the oil filter. Remove the oil filter adapter assembly and oil pressure sending unit as an assembly. Discard the gasket.

16. Remove the alternator, brackets and drive belts.

17. Remove the water pump, pulley and fan as an assembly.

18. Remove the power steering pulley. Remove the crankshaft damper (Fig. 27).

19. Remove the crankshaft sleeve as shown in Fig. 28.

20. Remove the cylinder front cover. Discard the gasket. Remove the crankshaft front oil slinger.

21. Check the timing chain deflection by following steps 13, 14 and 15 under "Cylinder Front Cover and Timing Chain Removal."

22. Remove the camshaft sprocket cap screw and the fuel pump eccentric. Remove the crankshaft sprocket key. Remove the sprockets and timing chain as an assembly (Fig. 31).

23. Remove any ridge and/or carbon deposits from the upper end of the cylinder bores. Move the piston to the bottom of its travel and place a cloth on the piston head to collect the cuttings. Remove the cylinder ridge with a ridge cutter. Follow the instructions furnished by the tool manufacturer. **Never cut into the ring travel area in excess of 1/32 inch when removing ridges.** After the ridge has been removed, remove the cutter from the cylinder bore.

24. Remove the flywheel.

25. Invert the engine. Remove the oil pan. Discard the gasket.

26. Remove the oil pump and inlet tube as an assembly. Remove the oil pump drive shaft. Discard the oil pump gasket.

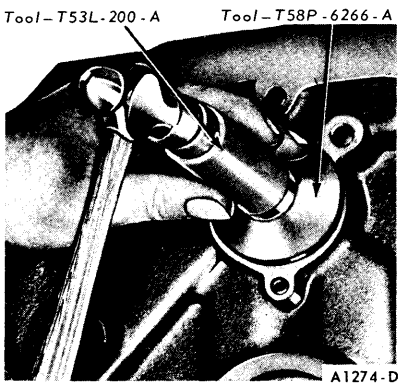


FIG. 60—Camshaft Rear Bearing Bore Plug Installation

27. Make sure all connecting rods and caps are marked so that they can be installed in their original locations. Turn the crankshaft until the connecting rod being removed is down. Remove the rod cap.

28. Push the connecting rod and piston assembly out the top of the cylinder with the handle end of a hammer. **Avoid damage to the crankpin or the cylinder wall when removing the piston and rod.**

29. Remove the bearing inserts from the connecting rods and caps. Install the rod caps on the connecting rods from which they were removed.

30. Remove the main bearing caps.

31. Carefully lift the crankshaft out of the cylinder block so that the thrust bearing surfaces are not damaged. **Handle the crankshaft with care to avoid possible fracture or damage to the finished surfaces.**

32. Remove the rear journal oil seal from the block and rear bearing cap, and remove the cap to block side seals.

33. Remove the main bearing inserts from the block and bearing caps. Install the main bearing caps in their original positions.

34. Carefully remove the camshaft by pulling it toward the front of the engine. Use caution to avoid damaging the journals and lobes.

35. Remove the camshaft rear bearing bore plug. Remove the camshaft bearings (Fig. 57).

CLEANING AND INSPECTION

For cleaning and inspection procedures, refer to Part 8-1, Section 3.

ENGINE ASSEMBLY

If the cylinder block is to be replaced, transfer the cylinder head dowels and cylinder block drain plugs to the new cylinder block.

1. Remove the glaze from the cylinder bores by following the instructions of the tool manufacturer.

2. Invert the engine on the work stand.

3. Position the new camshaft bearings at the bearing bores, and press them in place with the tool shown in Fig. 57 or Fig. 58. Align the oil holes in the cylinder block when the bearings are installed. **Be sure the camshaft front bearing is installed 0.005-0.020 inch below the front face of the cylinder block (Fig. 59).**

4. Check the oil passage that feeds the rocker arm shafts for obstructions by squirting oil into the opening on each cylinder bank and observing the flow through the oil holes at Nos. 2 and 4 bearings.

5. Clean out the camshaft rear bearing bore plug recess thoroughly.

6. Coat the flange of a new plug with oil-resistant sealer and install it with the flange facing inward (Fig. 60). Drive the plug in until it is flush or slightly below the casting surface.

7. Oil the camshaft and apply Lubriplate to all lobes; then carefully slide it through the bearings.

8. Be sure that the rear oil seal grooves are clean. Install a new rear journal oil seal in the block (Fig. 53). After installation, cut the ends of the seals flush.

9. If the crankshaft main bearing journals have been refinished to a definite undersize, install the correct undersize bearings. Be sure the bearing inserts and bearing bores are clean. Foreign material under the inserts may distort the bearing and cause a failure.

Place the upper main bearing inserts in position in the bore with the tang fitting in the slot provided.

10. Install the lower main bearing inserts in the bearing caps.

11. Carefully lower the crankshaft into place. **Be careful not to damage the bearing surfaces.**

12. Check the clearance of each main bearing following the procedure under "Main Bearing Replacement."

13. After the bearings have been fitted, apply a light coat of engine oil to the journals and bearings.

14. Be sure that the oil seal grooves in the rear main bearing cap are clean. Install a new journal seal in the cap (Fig. 40). After installation, cut the ends of the seal flush. Apply a thin coating of oil-resistant sealer to the rear main bearing cap at the rear of the top mating surface (Fig. 40). **Do not apply sealer to the area forward of the side seal groove.** Install the rear main bearing cap and the remainder of the caps, except the thrust bearing cap (No. 3 bearing). **Be sure that the main bearing caps are installed in their original locations.** Torque the bearing cap bolts to specifications.

15. Install the thrust bearing cap and check crankshaft end play by following steps 11 thru 18 under "Crankshaft Installation."

16. Turn the engine on the work

collet and back-up nut assemble on expanding mandrel. With the expanding collet collapsed, install the collet assembly in the camshaft bearing, and tighten the back-up nut on the expanding mandrel until the collet fits the camshaft bearing. Assemble the puller screw and extension (if necessary) as shown and install on the expanding mandrel. Tighten the pulling nut against the thrust bearing and pulling plate to remove the camshaft bearing. To remove the front bearing, install the puller screw from the rear of the cylinder block.

3. Position the new bearings at crankshaft front oil slinger.

21. Clean the cylinder front cover and the cylinder block gasket surfaces. Install a new crankshaft front oil seal (Fig. 32).

22. Coat the gasket surface of the block and cover and the cover bolt threads with sealer. Position a new gasket on the block.

23. Install the alignment pilot tool on the cylinder front cover so that the keyway in the pilot aligns with the key in the crankshaft. Position the cover and pilot over the end of the crankshaft and against the block (Fig. 34).

24. Install the cylinder front cover bolts finger-tight. Position the alternator support bracket and the alternator adjusting arm bracket; then install the bolts (on a car equipped with an air conditioner, connect the compressor and brackets to the cylinder front cover). While pushing in on the pilot, torque the cover bolts to specifications. Remove the pilot

25. Lubricate the crankshaft with a white lead and oil mixture and lubricate the oil seal rubbing surface

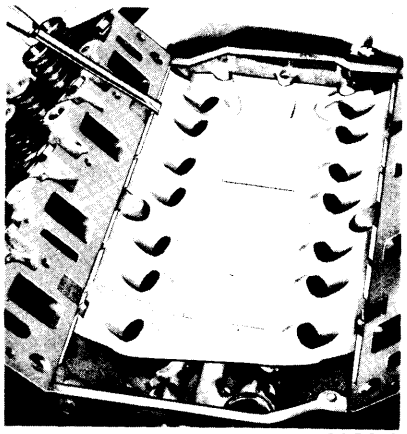


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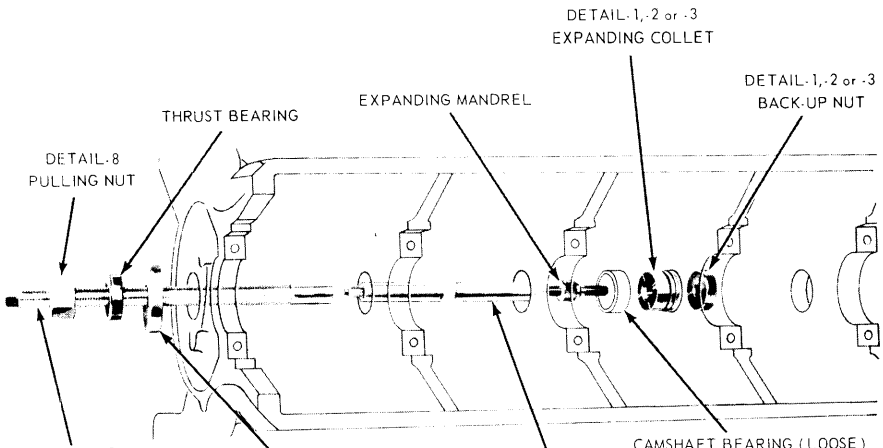
FIG. 61—Baffle Plate Removal



fuel pump. Install the alternator, brackets and drive belts.

31. Turn the engine on the work stand so that the top of the engine is up.

32. Clean the cylinder head and block gasket surfaces. Apply sealer to both sides of a new gasket. Guided by the word "FRONT" on the gasket install the head gasket over the cylinder head dowels.

33. Place the cylinder head on the engine and remove the holding fixtures. Coat the head bolt threads with water-resistant sealer and install the bolts.

34. The cylinder head bolt tightening procedure is performed in three progressive steps. Torque the bolts in sequence (Fig. 21) to 70 ft-lbs, then to 80 ft-lbs, and finally to specifications. **After the cylinder head bolts have been torqued to specifications, the bolts should not be disturbed.**

35. Coat the mating surfaces of the exhaust manifold with a light film of graphite grease.

36. Using a new gasket, install the automatic choke air chamber cover on the right exhaust manifold. **Be sure the cover is securely fastened.**

37. Position a new gasket over the muffler inlet pipe studs of the exhaust manifolds.

38. Position the exhaust manifolds on the cylinder heads and install the retaining bolts and tab washers. Torque the retaining bolts to specifications, working from the center to the ends. Lock the bolts by bending one tab of the washer over a flat on the bolt.

39. Install the spark plugs.

40. Install the baffle plate in the valve push rod chamber. Position one side of the baffle plate and press the other side into place.

inder block and new gaskets on the cylinder heads. Position the gasket slots in the end tabs over the ribs on the seals. Be sure the holes in

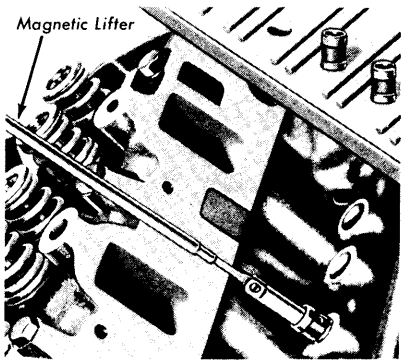


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FIG. 62—Valve Lifter Removal—Intake Manifold Removed

the gaskets are aligned with the holes in the cylinder heads.

45. Install the eye bolts in the intake manifold and attach the engine lifting sling and carefully lower the intake manifold on the engine (Fig. 17).

46. Position the intake manifold by inserting the distributor in place. **After the intake manifold is in place, run a finger around the seal area to make sure the seals are in place. If the seals are not in place, remove the intake manifold and position the seals.**

47. Start the water pump bypass hose on the intake manifold.

48. Be sure the holes in the manifold gaskets and manifold are in alignment. Install the manifold retaining bolts and torque them to specifications, in sequence as shown in Fig. 19.

49. Remove the distributor and the engine lifting sling and eye bolts.

50. Refer to "Valve Rocker Arm

Shaft Assembly Installation" and install the valve rocker arm shaft assembly by following steps 1 thru 6.

51. Install the automatic choke air heat tube and air inlet tube.

52. Rotate the crankshaft damper until the No. 1 piston is on TDC then position the distributor in the block with the rotor at the No. 1 firing position and the points open. Install the hold down clamp.

53. Connect the distributor vacuum line. Install the distributor cap. Install the valve rocker arm covers.

54. Connect the spark plug wires. Install the carburetor fuel inlet line.

55. Invert the engine on the work stand. Position the oil pump drive shaft into the distributor socket. With the shaft firmly seated in the distributor socket, the stop on the shaft should touch the roof of the crankcase. Remove the shaft and position the stop as necessary.

56. With the stop properly positioned, insert the oil pump drive shaft into the oil pump.

57. Prime the oil pump by filling either the inlet or outlet port with engine oil. Rotate the pump shaft to distribute the oil within the pump body.

58. Position a new gasket on the pump housing and install the pump and shaft as an assembly. **Do not attempt to force the pump into position if it will not seat readily. The drive shaft hex may be misaligned with the distributor shaft. To align, rotate the intermediate shaft into a new position.**

59. Install the oil pan assembly on the block following the procedure under "Oil Pan and Oil Pump Installation." Install the retaining screws and torque them from the center outward to specifications.

60. Position the flywheel on the crankshaft and install the retaining bolts. Torque the bolts alternately to specifications.

61. Clean the oil filter adapter gasket surfaces. Apply sealer to a new adapter gasket and install the adapter assembly and gasket.

62. Clean the adapter filter recess. Coat the gasket on a new filter with oil. Place the filter in position on the adapter. Hand tighten the filter until the gasket contacts the adapter face, and then advance it ½-turn.

63. Install the engine in the car. Operate the engine and check for oil and coolant leaks. Check the ignition timing, and adjust the engine idle speed, idle fuel mixture and anti-stall dashpot.

64. Adjust the transmission control linkage.

PART 8-3 SPECIFICATIONS

NOTE: All specifications are given in inches unless otherwise noted.

GENERAL ENGINE

MODEL PREFIX	EES
PISTON DISPLACEMENT—Cubic Inches	390
COMPRESSION RATIO	10.1:1
BRAKE HORSEPOWER @ Specified rpm	300 @ 4600
TORQUE—Ft-lbs @ Specified rpm	427 @ 2800
BORE AND STROKE	4.05 x 3.784
COMPRESSION PRESSURE—psi	
Sea Level @ Cranking Speed	170-210
Tolerance Between Cylinders	20
TAXABLE HORSEPOWER	52.49
FIRING ORDER	1-5-4-2-6-3-7-8
VALVE ARRANGEMENT—Front to Rear	E-I-E-I-I-E-I-E
ENGINE IDLE RPM*	475-500
*Refer to Group 10, Part 10-1, Section 2 for proper procedure in setting idle speed.	
ENGINE IDLE MANIFOLD VACUUM—Minimum Inches of Mercury @ Specified Engine Neutral Idle rpm—Sea Level	18
INITIAL IGNITION TIMING—BTDC*	6°
*For altitude operation, and/or to obtain optimum engine performance and fuel economy, the initial ignition timing may be advanced 5° over the "normal" setting. No further improvement in engine performance or fuel economy will be achieved by advancing beyond this point. Advance the timing progressively until engine detonation (spark knock) is evident under actual road test acceleration. Retard the timing until the detonation (spark knock) is eliminated. If the individual requirements of the car and/or the use of sub-standard fuels dictate, the initial timing may have to be retarded from the recommended setting to eliminate detonation (spark knock). If retarding is necessary, it should be done progressively and not to exceed 2° BTDC.	
CRANKCASE OIL CAPACITY	
U.S. Measure	6 quarts*
Imperial Measure	5 quarts*
*Includes one quart with filter replacement.	
OIL PRESSURE—psi hot @ 2000 rpm	35-55

CYLINDER HEAD

GASKET SURFACE FLATNESS	
0.003 inch in any 6 inches or 0.006 inch overall.	
VALVE GUIDE BORE DIAMETER—Standard	
Intake and Exhaust	0.3728-0.3735
VALVE SEAT WIDTH	
Intake	0.060-0.080
Exhaust	0.070-0.090
VALVE SEAT ANGLE	
Intake and Exhaust	45°
VALVE SEAT RUNOUT—Maximum	0.002
COMBUSTION CHAMBER VOLUME—CC	73.1-76.1

VALVE MECHANISM

VALVE CLEARANCE*	0.050-0.150
*Clearance specified is obtained at the valve stem tip with the hydraulic valve lifter collapsed.	
VALVE STEM DIAMETER	
Standard	
Intake and Exhaust	0.3711-0.3718
0.003 Oversize	
Intake and Exhaust	0.3741-0.3748
0.015 Oversize	
Intake and Exhaust	0.3861-0.3868
0.030 Oversize	
Intake and Exhaust	0.4011-0.4018
VALVE STEM TO VALVE GUIDE CLEARANCE	
Intake	0.0010-0.0024—Wear Limit 0.0045
Exhaust	0.0010-0.0024—Wear Limit 0.0055
VALVE HEAD DIAMETER	
Intake	2.022-2.037
Exhaust	1.551-1.566
VALVE FACE ANGLE	
Intake and Exhaust	44°
VALVE FACE RUNOUT—Maximum	
Intake and Exhaust	0.002
VALVE SPRING APPROXIMATE FREE LENGTH	2.15
VALVE SPRING MAXIMUM OUT-OF-SQUARE	0.072
VALVE SPRING PRESSURE (LBS.) @ SPECIFIED LENGTH	
Intake and Exhaust	74-84 @ 1.820
	Wear Limit 67 @ 1.820
	190-208 @ 1.420
	Wear Limit 171 @ 1.420
VALVE SPRING ASSEMBLED HEIGHT	
Pad to Underside of Retainer	$1\frac{13}{16}$-$1\frac{27}{32}$
VALVE PUSH ROD RUNOUT	0.025
VALVE LIFTER STANDARD DIAMETER	0.8740-0.8745
VALVE LIFTER TO LIFTER BORE CLEARANCE	0.0005-0.0020
	Wear Limit 0.005
VALVE LIFTER LEAK DOWN RATE—Wear Limit	10-50 Seconds
ROCKER ARM TO ROCKER SHAFT CLEARANCE	0.0035-0.055
	Wear Limit 0.0065
ROCKER ARM SHAFT OUTSIDE DIAMETER	0.8385-0.8395
ROCKER ARM BORE DIAMETER	0.843-0.844
ROCKER ARM LIFT RATIO	1.73:1

CAMSHAFT AND TIMING CHAIN

CAMSHAFT END PLAY	0.001-0.007 Wear Limit 0.012
CAMSHAFT JOURNAL STANDARD DIAMETER	2.1238-2.1248
CAMSHAFT JOURNAL MAXIMUM OUT-OF-ROUND	0.001
CAMSHAFT JOURNAL RUNOUT—Maximum	0.005
CAMSHAFT JOURNAL TO BEARING CLEARANCE	0.001-0.003 Wear Limit 0.006
CAMSHAFT LOBE LIFT	
Intake and Exhaust	0.2316 Wear Limit 0.2266
VALVE LIFTER LIFT	
Intake (Opens)	0.002 @ 26° BTDC
Intake (Closes)	0.004 @ 64° ABDC
Exhaust (Opens)	0.002 @ 67° BBDC
Exhaust (Closes)	0.004 @ 23° ATDC
SPROCKET CONTACT FACE RUNOUT	
Maximum	0.002
ASSEMBLED SPROCKET CONTACT FACE RUNOUT	
Maximum	0.006
TIMING CHAIN DEFLECTION	0.5

CAMSHAFT BEARINGS

INSIDE DIAMETER	2.1258-2.1268
LOCATION IN RELATION TO FRONT FACE OF BLOCK CAM BEARING BORE—NO. 1 BEARING ONLY—BELOW	0.005-0.020

CRANKSHAFT

MAIN BEARING JOURNAL STANDARD DIAMETER	
Coded Red	2.7488-2.7492
Coded Blue	2.7484-2.7488
MAIN BEARING JOURNAL MAXIMUM RUNOUT	0.002 Wear Limit 0.003
CONNECTING ROD AND MAIN BEARING JOURNAL MAXIMUM OUT-OF-ROUND	0.0004
CONNECTING ROD AND MAIN BEARING JOURNAL TAPER	0.0003 per inch
THRUST BEARING JOURNAL LENGTH	1.124-1.126
MAIN BEARING JOURNAL THRUST FACE RUNOUT	0.001
CONNECTING ROD JOURNAL DIAMETER	
Coded Red	2.4384-2.4388
Coded Blue	2.4380-2.4384
CRANKSHAFT FREE END PLAY	0.004-0.010 Wear Limit 0.014
ASSEMBLED FLYWHEEL OUTSIDE (Radial) RUNOUT—MAXIMUM	0.020
ASSEMBLED FLYWHEEL RING GEAR (Lateral) RUNOUT—MAXIMUM	0.037
ASSEMBLED SPROCKET FACE RUNOUT—MAXIMUM	0.006
SPROCKET CONTACT FACE RUNOUT—MAXIMUM	0.001

CRANKSHAFT MAIN BEARINGS

JOURNAL CLEARANCE—No. 1 and 3	0.0007-0.0031
No. 2, 4 and 5	0.0005-0.0028
WALL THICKNESS	
Coded Red	0.0953-0.0958
Coded Blue	0.0957-0.0962
0.002 Undersize	0.0967-0.0972

CONNECTING ROD

PISTON PIN BUSHING INSIDE DIAMETER	0.9752-0.9755
PISTON PIN BUSHING MAXIMUM OUT-OF-ROUND	0.0004
PISTON PIN BUSHING MAXIMUM TAPER	0.0003
BEARING BORE DIAMETER	
Coded Red	2.5907-2.5911
Coded Blue	2.5911-2.5915
BEARING BORE OUT-OF-ROUND AND TAPER	
Maximum	0.0004
CENTER-TO-CENTER LENGTH	6.486-6.490
TWIST TOTAL DIFFERENCE—Maximum	0.012
BEND TOTAL DIFFERENCE—Maximum	0.004
CONNECTING ROD ASSEMBLY—Assembled to Crankshaft	
Side Clearance	0.006-0.016 Wear Limit 0.019

CONNECTING ROD BEARINGS

BEARING TO CRANKSHAFT CLEARANCE	0.0007-0.0028
WALL THICKNESS	
Coded Red	0.07515-0.07565
Coded Blue	0.07555-0.07605
0.002 Undersize	0.07655-0.07705

PISTON

PISTON DIAMETER*	
Coded Red	4.0477-4.0483
Coded Blue	4.0489-4.0495
0.003 Oversize	4.0501-4.0507
*Measured at the piston pin bore centerline at 90° to the bore.	
PISTON TO CYLINDER BORE CLEARANCE	0.0015-0.0023
PISTON PIN BORE DIAMETER	0.9752-0.9755
RING GROOVE WIDTH	
Upper Compression Ring	0.0805-0.0815
Lower Compression Ring	0.0960-0.0970
Oil Ring	0.188-0.189

PISTON PIN

PISTON PIN DIAMETER	
Standard	0.9750-0.9753
0.001 Oversize	0.9760-0.9763
0.002 Oversize	0.9770-0.9773
PISTON PIN LENGTH	3.156-3.170
PISTON PIN TO PISTON CLEARANCE	0.0001-0.0003 Wear Limit 0.0008
PISTON PIN TO CONNECTING ROD BUSHING CLEARANCE	0.0001-0.0005 Wear Limit 0.001

PISTON RINGS

RING WIDTH	
Upper Compression Ring	0.0774-0.0781
Lower Compression Ring	0.0930-0.0940
RING SIDE CLEARANCE	
Upper Compression Ring	0.0024-0.0041 Wear Limit 0.006
Lower Compression Ring	0.002-0.004 Wear Limit 0.006
Oil Ring	Snug
RING GAP WIDTH—Standard Bore	
Upper and Lower Compression Rings	0.010-0.020
Oil Ring (Steel Rail)	0.015-0.066

CYLINDER BLOCK

CYLINDER BORE DIAMETER	
Standard	4.0500-4.0524
0.003 Oversize	4.0524-4.0536
CYLINDER BORE MAXIMUM OUT-OF-ROUND	0.001 Wear Limit 0.005
CYLINDER BORE MAXIMUM TAPER	0.001 Wear Limit 0.010
HEAD GASKET SURFACE FLATNESS 0.003 inch in any 6 inches or 0.006 inch overall.	

OIL PUMP

RELIEF VALVE SPRING TENSION – Lbs @ Specified Length	9.0-9.6–1.53 inches
RELIEF VALVE CLEARANCE	0.0015-0.0029
DRIVE SHAFT TO HOUSING BEARING CLEARANCE	0.0015-0.0029
ROTOR ASSEMBLY END CLEARANCE– Pump Assembled	0.0011-0.0041
OUTER RACE TO HOUSING RADIAL CLEARANCE	0.006-0.012

TORQUE LIMITS (Ft-Lbs)

MAIN BEARING CAP BOLTS—Oiled Threads	95-105
CYLINDER HEAD BOLTS	80-90
OIL PAN TO CYLINDER BLOCK	9-11
OIL PAN DRAIN PLUG	15-20
MANIFOLDS TO CYLINDER HEAD	
Intake	32-35
Exhaust	12-18

MANIFOLDS TO CYLINDER HEAD—(Continued)

FLYWHEEL TO CRANKSHAFT	75-85
OIL PUMP TO CYLINDER BLOCK	20-25
OIL PICK-UP TUBE TO OIL PUMP	12-15
OIL PUMP COVER PLATE	6-9
OIL FILTER ADAPTER TO CYLINDER BLOCK	12-15
CYLINDER FRONT COVER	12-15
WATER OUTLET HOUSING	12-15
WATER PUMP TO CYLINDER BLOCK	20-25
CAMSHAFT SPROCKET TO CAMSHAFT	35-45
CAMSHAFT THRUST PLATE TO BLOCK	12-15
DAMPER TO CRANKSHAFT	70-90
CONNECTING ROD NUTS	40-45
VALVE ROCKER ARM COVER	4-7
VALVE ROCKER SHAFT SUPPORT TO CYLINDER HEAD	40-45
FUEL PUMP TO CYLINDER FRONT COVER	20-25
ENGINE SUPPORTS	
Front Insulator to Engine	35-50
Front Insulator to Support	20-30
Front Insulator to Intermediate Bracket	45-60
Intermediate Bracket to Cross Member	45-60
Support Retainer to Extension Housing	40-50
Support to End Bracket	40-50
End Bracket to Floor Pan Reinforcement	20-30

STANDARD TORQUE LIMITS FOR VARIOUS SIZE BOLTS

CAUTION: Special torque limits listed in the preceding tables should be used in preference to these standard limits wherever they apply.

Size (Inches)	1/4-20	1/4-28	5/16-18	5/16-24	3/8-16	3/8-24
Torque (Foot-Pounds)	6-9	6-9	12-15	15-18	23-28	30-35
Size (Inches)	7/16-14	7/16-20	1/2-13	1/2-20	9/16-18	5/8-18
Torque (Foot-Pounds)	45-50	50-60	60-70	70-80	85-95	130-145

SPECIAL TOOLS

Description	Ford Tool No.	Former No.
Hub Bearing Cup (Inner and Outer) Replacer Kit	T53L-200-A	
Engine Lifting Sling	T53L-300-A	6000-BA
Piston Ring Groove Cleaner		RC-500
Valve Spring Compressor		K-D915
Differential Backlash and Runout Gauge, with Universal Bracket		
Dial Indicator and Bracket	TOOL-4201-C	
Engine Lifting Bracket	T58P-6000-A	6000-BD
Cylinder Front Cover Pilot	T61P-6019-B	6059-F
Cylinder Head Holding Fixture	T58P-6085-A	6085-M
Valve Guide Reamer Kit	T58P-6085-B	6085-H
Piston Pin Remover	T52P-6135-DAD	
Piston Ring Compressor	TOOL-6149-A	
Camshaft Bearing Remover and Replacer Adapter	T65L-6250-A	T54T-6250-B T52L-6261-CEE
Camshaft Bearing Bore Plug Replacer Adapter	T58P-6266-A	
Crankshaft Damper and Sprocket Replacer	T52L-6306-AEE	
Crankshaft Damper Remover	T58P-6316-B	6306-AJ

Description	Ford Tool No.	Former No.
Upper Main Bearing Insert Remover and Replacer	TOOL-6331	
Crankshaft Pulley Spacer Remover	T56P-6362-A	
Hydraulic Tappet Leakdown Tester	TOOL-6500-E	6500-E
Valve Stem Clearance Checking Tool	TOOL-6505-F	8680-A
Tru-Valve Gauge	T64L-6507-A	
Valve Spring Compressor	TOOL-6513-DD	6513-EE
Cam Lift and Push Rod Stroke Dial Indicator	TOOL-6565	
Cup Shaped Adapter to TOOL 6565	TOOL-6565-AB	
Rocker Arm to Valve Stem Clearance Gauge	T58P-6565-A	
Rocker Arm to Valve Stem Clearance Gauge (Use with T58P-6565-A)	T65P-6565-A	
Cylinder Block Front Cover Oil Seal Replacer Adapter	T58P-6700-B	6700-B
Crankshaft Rear Bearing Seal Replacer	T58P-6701-A	6701-C
Cylinder Head Bolt Torque Sequence Tool (Typical)		S-8683
Impact Slide Hammer	T59L-100-B	T-7600-E
Puller Attachment	T58L-101-A	T-7600-E