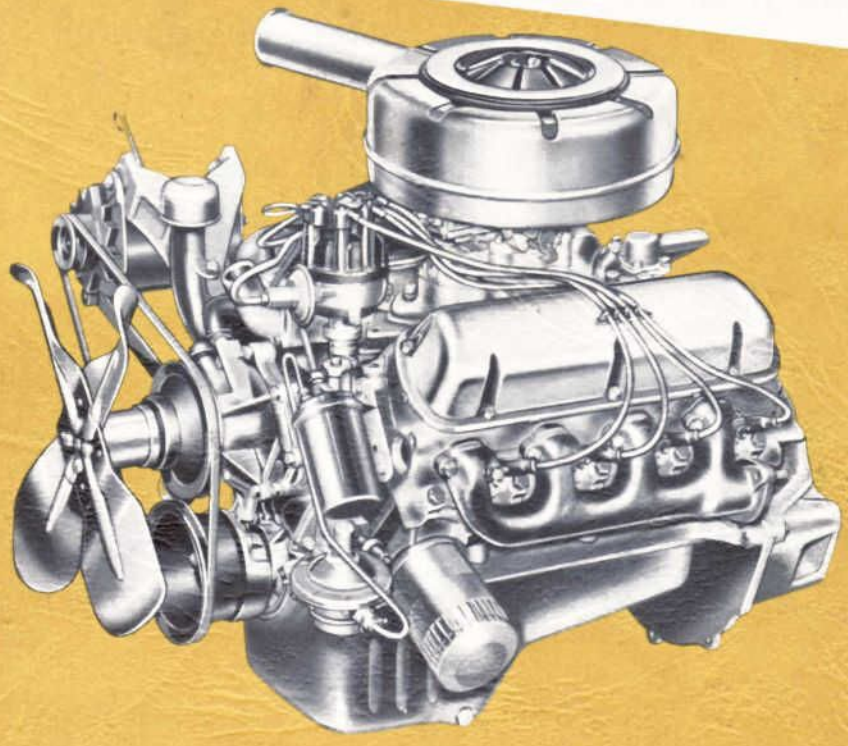
FORD *Service Handbook* 6004



221 V-8 ENGINE

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SERVICE DEPARTMENT
FORD DIVISION
Ford MOTOR COMPANY
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PART 1

IDENTIFICATION

Refer to Table I for identification features of the engine.

TABLE I Identification Features

Patent Plate Symbol	"C"
Engine Prefix	EEU
Engine Identification Number	Stamped into the left front of the cylinder block, near the fuel filter.

The first figure identifies the engine plant

4 — Lima Engine Plant

The second figure indicates the year manufactured

1 — 1961

2 — 1962

The next letter indicates the month

A — January	G — July
B — February	H — August
C — March	J — September
D — April	K — October
E — May	L — November
F — June	M — December

The next figure(s) indicate(s) the date of the month

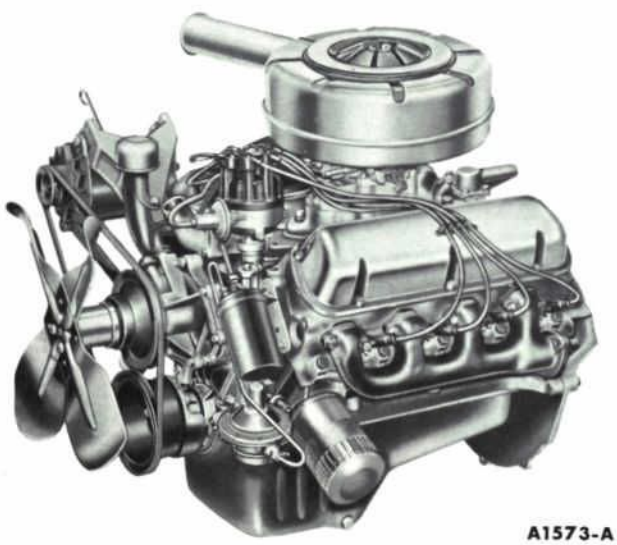

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FIG. 1 — 221 V-8 Engine — 3/4 Left View

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FIG. 2 — 221 V-8 Engine — 3/4 Right View

TABLE I Identification Features (continued)

Low Compression Export Identification	
	Export engines are identified by the letter "X" printed on a round fiber tag attached to the lower generator bracket mounting bolt.
Valve Lifters	Hydraulic
Carburetor	Dual — Ford, with Automatic Choke and Water Heated Spacer
Distributor	Dual Advance — Located at Right Front of Engine
Exhaust	Single
Fuel Required	Regular
Fuel Pump	AC — Located at Left Front of Cylinder Block
Fuel Filter	Cartridge Type — Located at Left Front of Cylinder Head — Replace at 30,000 miles
Air Cleaner	Dry Type
Spark Plugs	18MM tapered seat
Oil Filter	Located at Left Side of Cylinder Block —
Engine Oil Capacity	4 Quarts (Add one quart when changing filter)
Castings	Cylinder Heads, Manifolds, Cylinder Block

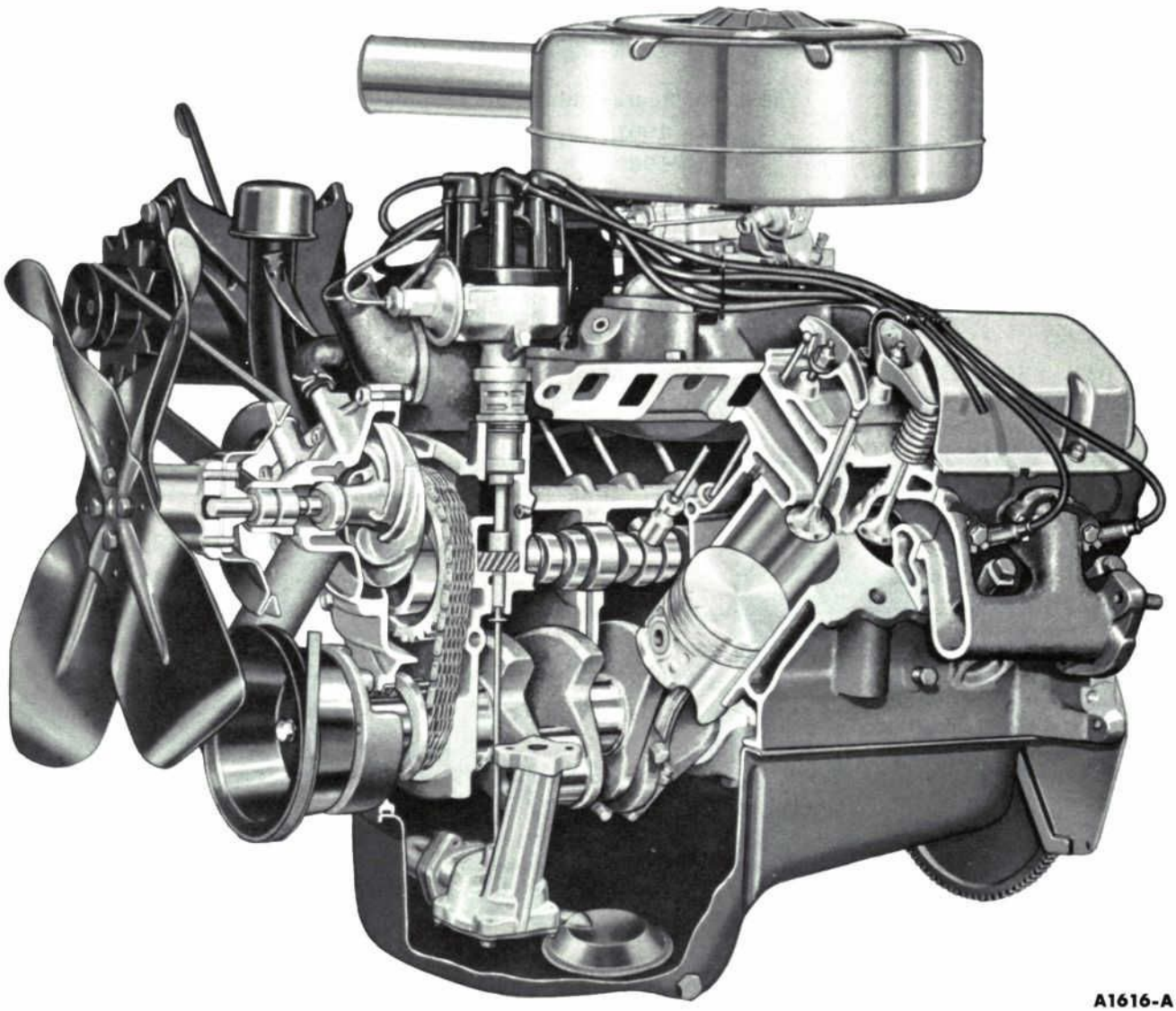

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FIG. 3 — 221 V-8 Engine — Sectional View

PART 2

GENERAL REPAIR

1 ENGINE REMOVAL AND INSTALLATION

The engine removal and installation procedures are for the engine only without the transmission attached. A typical engine installation is shown in Fig. 4.

REMOVAL

1. Drain the cooling system and the crankcase. Remove the oil filter. Remove the hood and the air cleaner. Disconnect the battery ground cable at the cylinder head.

2. Disconnect the radiator upper hose at the coolant outlet housing and the radiator lower hose at the water pump.

On a car with an automatic transmission, disconnect the transmission oil cooler lines at the radiator.

Remove the radiator. Remove the fan, spacer, belt, and pulley.

3. Disconnect the generator wires at the generator. Loosen the generator adjusting bolts to allow the generator to swing down and out of the way.

4. Disconnect the oil pressure sending unit wire at the sending unit, and the flexible fuel line at the fuel tank line. Plug the fuel tank line.

5. Disconnect the accelerator rod at the bellcrank on the intake manifold.

On a car with an automatic transmission, disconnect the throttle valve vacuum line at the intake manifold. Disconnect the manual shift rod at the bellcrank and remove the retracting spring. Disconnect the transmission filler tube bracket at the cylinder block.

On a car with power steering, disconnect the power steering pump bracket from the cylinder head. Remove the drive belt. Wire the power steering pump out of the way and in a position that will prevent the oil from draining out. Disconnect the brake vacuum line at the intake manifold.

6. Disconnect the heater hoses at the water pump and intake manifold. Disconnect the water temperature sending unit wire at the sending unit.

7. Remove the flywheel or converter housing to engine upper bolts.

8. Disconnect the primary wire at the ignition coil and position the wire out of the way. Disconnect the ground strap at the block.

On cars with a vent tube-type crankcase ventilation system, remove the vent tube retaining screws at the intake manifold.

9. Raise the front of the car. Disconnect the starter cable at the starter. Remove the starter and dust seal (and the crankcase vent tube, if so equipped).

10. Disconnect the muffler inlet pipes from the exhaust manifolds. Disconnect the engine support insulators at the brackets on the underbody.

On a car with a manual-shift transmission, remove the remaining flywheel housing to engine bolts. Disconnect the clutch pedal retracting spring. Remove the clutch equalizer bar bracket retaining bolts and remove the clutch release rod at the release lever.

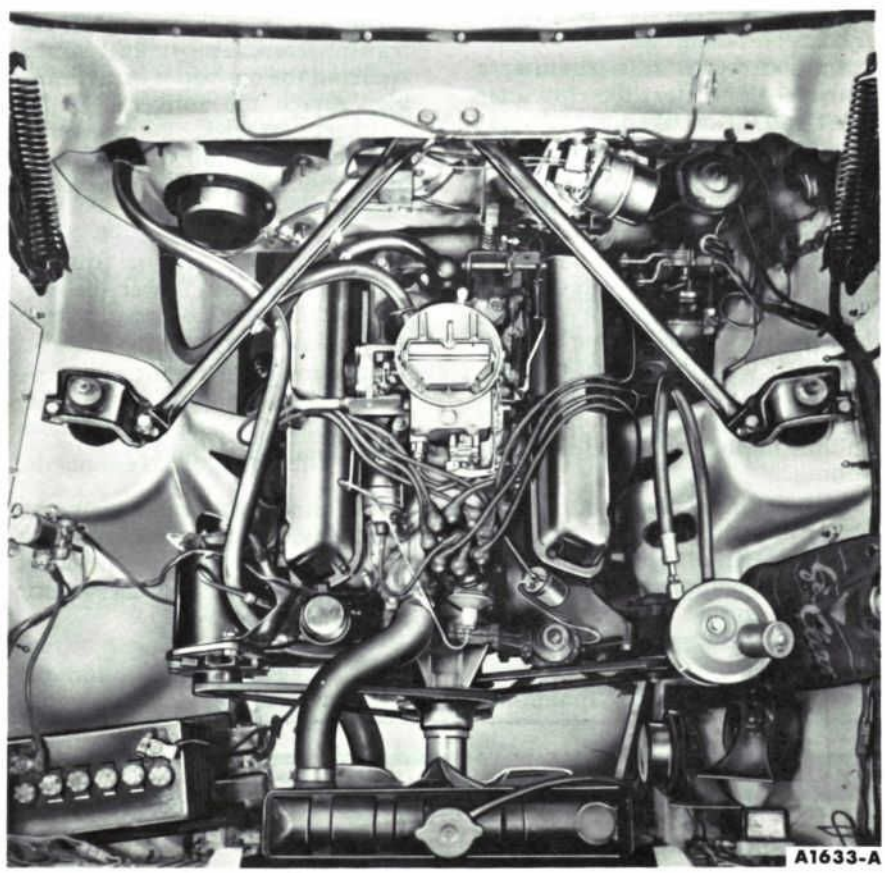


FIG. 4—Typical Engine Installation

On a car with an automatic transmission, remove the converter housing inspection cover. Disconnect the flywheel from the converter. Secure the converter assembly in the housing. Remove the remaining converter housing to engine bolts.

11. Lower the car, then support the transmission. Install the engine left lifting bracket on the front of the left cylinder head, and install the engine right lifting bracket at the rear of the right cylinder head, then attach the engine lifting sling (Fig. 5).

12. Raise the engine slightly and carefully pull it away from the transmission. Lift the engine out of the engine compartment and install it on a work stand (Fig. 6).

INSTALLATION

1. Place a new gasket over the studs of the exhaust manifolds. Attach the engine lifting brackets and sling (Fig. 5) and remove the engine from the work stand.

2. Carefully lower the engine 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 flywheel housing.

On a car with an automatic transmission, start the converter pilot into the crankshaft.

On a car with a manual-shift transmission, start the transmission main drive gear into the clutch disc. It may be necessary to adjust the position of the transmission in relation to the engine if the input shaft will not enter the clutch disc. **If the engine "hangs up" after the shaft enters, turn the crankshaft slowly, with the transmission in gear, until the shaft splines mesh with the clutch disc splines.**

3. Install the flywheel or converter housing upper bolts. Install the engine support insulator to bracket retaining nuts. Disconnect the engine lifting sling and remove the lifting brackets.

4. Raise the front of the car. Connect both exhaust manifolds

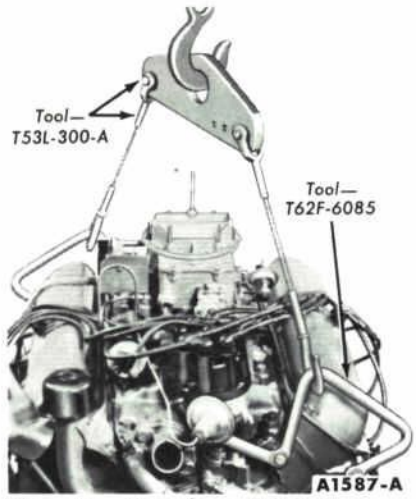


FIG. 5—Engine Lifting Brackets and Sling

to the muffler inlet pipes. Torque the nuts to specifications. Position the dust seal and install the starter (one bolt retains the crankcase vent tube bracket).

On a car with a manual-shift transmission, install the remaining flywheel housing to engine bolts. Connect the clutch release rod. Position the clutch equalizer bar and bracket and install the retaining bolts. Install the clutch pedal retracting spring.

On a car with an automatic transmission, remove the retainer securing the converter in the housing. Attach the converter to the flywheel. Install the converter housing inspection cover. Install the remaining converter housing retaining bolts.

5. Remove the support from the transmission and lower the car. Connect the engine ground strap and coil primary wire.

On cars with a vent tube type crankcase ventilation system, install the vent tube retaining screws at the intake manifold.

6. Connect the water temperature sending unit wire, and the heater hose at the coolant outlet housing. Connect the accelerator rod at the bellcrank.

On a car with an automatic transmission, connect the transmission filler tube bracket. Connect the manual shift rod and install the retracting spring. Connect the throttle valve vacuum line.

FIG. 6—Engine Work Stand

On a car with power steering, install the drive belt and power steering pump bracket. Install the bracket retaining bolts. Adjust the drive belt tension to specifications.

7. Remove the plug from the fuel tank line. Connect the flexible fuel line and the oil pressure sending unit wire.

8. Install the pulley, belt, spacer, and fan. Adjust the belt tension to specifications.

9. Tighten the generator adjusting bolts. Connect the generator wires and the battery ground cable.

10. Install the radiator. Connect the radiator upper and lower hoses.

On a car with an automatic transmission, connect the transmission oil cooler lines.

11. Install the oil filter. Connect the heater hose at the water pump, after bleeding the system. Fill the crankcase with the proper grade and quantity of oil. Operate the engine at fast idle and check all gaskets and hose connections for leaks. Install the air cleaner.

On a car with a manual-shift transmission, adjust the clutch pedal.

12. Install and adjust the hood.

2 IN-CHASSIS REPAIR OPERATIONS

ENGINE FRONT SUPPORT

The front supports are located on each side of the cylinder block (Fig. 7). The rear support is located at the transmission extension housing (Fig. 8). The procedures given apply to either a right or left installation.

REMOVAL

1. Loosen the engine mounting bracket to support bracket retaining bolt from both supports so that the engine can be raised.

If the left support is being removed, remove the oil filter.

2. Remove the support insulator bracket to engine block retaining bolts and lock washers. Raise the engine slightly with a jack and a wood block placed under the oil pan. Remove the engine mounting bracket to underbody retaining bolts and lock washers. Remove the insulator assembly.

3. Remove the rebound insulator retaining nut and lock washer. Separate the rebound insulator and bracket from the compression insulator assembly.

4. Remove the engine mounting bracket to support bracket retaining bolt and lock washer. Remove the compression insulator retaining nuts from the support bracket, then remove the compression insulator and bolt.

INSTALLATION

1. Position the compression insulator and bolt to the support bracket and install the compression insulator assembly retaining nuts. Position the engine mounting bracket to the support bracket and install, but do not tighten, the retaining bolt and lock washer.

2. Position the rebound insulator and bracket to the compression insulator assembly. Install the retaining nut and lock washer. Torque the nut to specifications. Position the insulator assembly to the engine block. Install the support insulator bracket retaining bolts and lock washers. Torque the bolts to specifications.

3. Lower the engine into position and remove the jack and wood block. Position the engine mounting bracket to the underbody and install the bolts and lock washers. Torque the bolts to specifications.

4. Torque the engine mounting bracket to support bracket retaining bolt on both supports to specifications.

If the engine left support was removed, install the oil filter.

ENGINE REAR SUPPORT

REMOVAL

1. Remove the parking brake cable from the clip on the left support bracket. Remove the insulator assembly to extension housing bolts and lock washers. Remove the insulator assembly to support retaining bolt and lock washer.

2. Raise the transmission with a floor jack, then remove the insulator assembly. Remove the support to bracket retaining bolts and spring clips, then remove the support. Remove the support bracket to underbody bolts and remove the bracket.

INSTALLATION

1. Position the support bracket to the underbody. Install and torque the retaining bolts to specifications. Position the support to the brackets and install the bolts and spring clips. Torque the bolts to specifications. Position the insulator assembly to the support and install the bolt and lock washer. Torque the bolt to specifications.

2. Lower the transmission and remove the jack. Install the insulator to extension housing retaining bolts, and lock washers. Torque the bolts to specifications. Install the parking brake cable in the clip on the left support bracket.

INTAKE MANIFOLD

The intake manifold assembly is shown in Fig. 9.

REMOVAL

1. Remove the air cleaner and drain the cooling system.

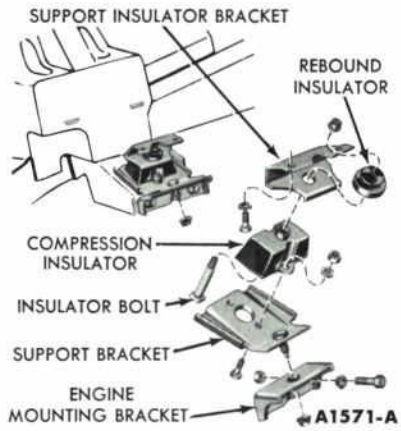


FIG. 7—Engine Front Support

2. Disconnect the accelerator rod at the carburetor. Remove the accelerator retracting spring. Remove the bellcrank assembly from the intake manifold and position it out of the way.

On a car with an automatic transmission, disconnect the throttle valve vacuum line at the intake manifold.

3. Disconnect the high tension lead and wires at the coil. Remove the coil from the intake manifold. Disconnect the battery ground cable. Disconnect the spark plug wires at the spark plugs and remove the wires from the harness brackets on the valve rocker arm covers. Remove the distributor cap and spark plug wire assembly.

4. Remove the carburetor fuel inlet line and the automatic choke heat tube. Disconnect the distributor vacuum line at the carburetor. Remove the distributor hold down bolt and remove the distributor and vacuum line.

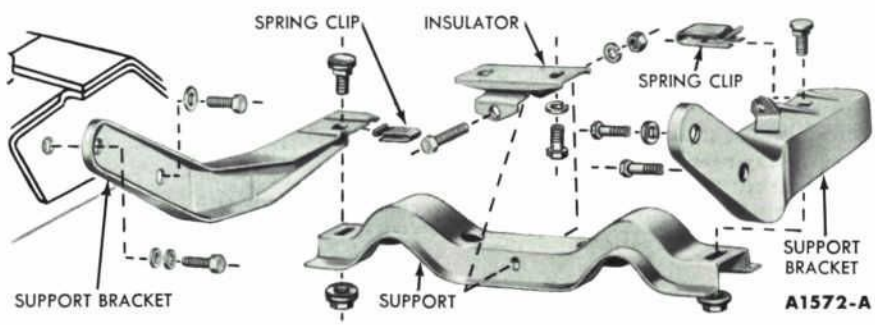


FIG. 8—Engine Rear Support

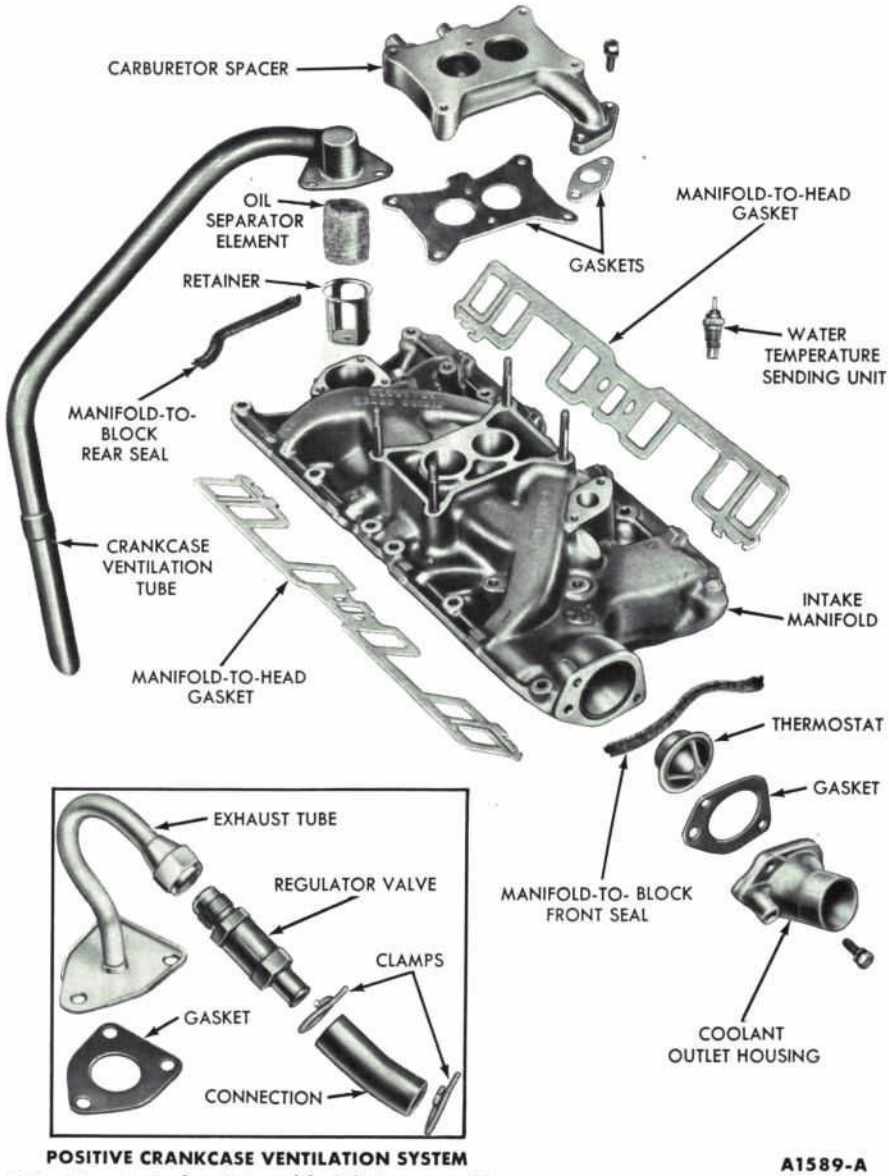


FIG. 9— Intake Manifold Assembly

5. Disconnect the radiator upper hose at the coolant outlet housing, the heater hose at the carburetor spacer, and the water temperature sending unit wire at the sending unit. Loosen the clamp on the water pump bypass hose at the coolant outlet housing and slide the hose off the outlet housing. Remove the crankcase vent tube retaining bolts at the intake manifold. Disconnect the engine ground strap at the cylinder block.

6. Remove the intake manifold and carburetor as an assembly. Remove the intake manifold gaskets and seals.

INSTALLATION

1. Clean the mating surfaces of the intake manifold, cylinder heads, and cylinder block. Coat the cylinder block seal surfaces with oil resistant sealer. Position new seals on the cylinder block and new gaskets on the cylinder heads, with the gasket interlocked with the seal tabs. Be sure the holes in the gaskets are aligned with the holes in the cylinder heads. The correct installation of the gaskets and seals is shown in Fig. 10.

2. Carefully lower the intake manifold into position on the engine. 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.

3. Be sure the holes in the manifold gaskets and manifold are in alignment. Install the manifold retaining bolts. Working from the center to the ends, torque the bolts to specifications.

4. Install the crankcase vent tube retaining bolts. Install the water pump by-pass hose on the coolant outlet housing. Slide the clamp into position and tighten the clamp. Connect the water temperature sending unit wire, the heater hose, and the radiator upper hose. Install the carburetor fuel inlet line and the automatic choke heat tube.

5. Rotate the crankshaft until 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 breaker points open. Install the hold down clamp.

6. Install the distributor cap. Position the spark plug wires in the harness brackets on the valve rocker arm covers and connect

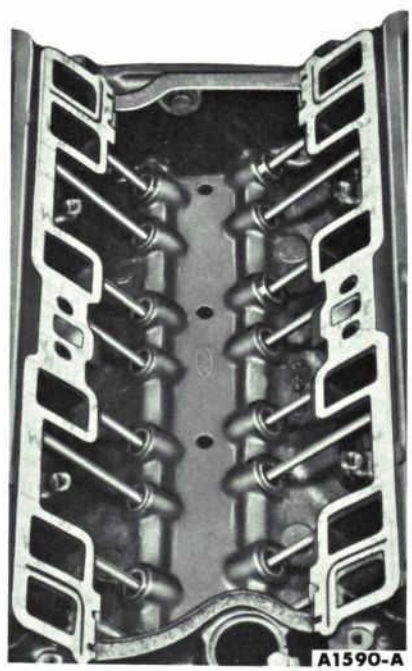


FIG. 10— Intake Manifold Gaskets and Seals Installed

the spark plug wires. Connect the battery ground cable. Install the ignition coil and connect the high tension and coil wires.

7. Install the bellcrank assembly and accelerator retracting spring. Connect the accelerator rod.

On a car with an automatic transmission, connect the throttle valve vacuum line. Fill and bleed the cooling system.

8. Start the engine and adjust the ignition timing. Connect the distributor vacuum line at the carburetor. Operate the engine at fast idle and check all hose connections and gaskets for leaks. Operate the engine until the temperatures have stabilized, adjust the engine idle speed and idle fuel mixture. Adjust the transmission throttle linkage. Install the air cleaner.

DISASSEMBLY

Remove the coolant outlet housing, gasket, thermostat, and the crankcase ventilation oil separator element at the rear top of the manifold. Remove the temperature sending unit, carburetor, spacer, and gaskets.

On an engine with positive crankcase ventilation, remove the exhaust tube, hose connections, and regulator valve.

CLEANING AND INSPECTION

Clean the intake manifold and the crankcase oil separator in a suitable solvent, then dry them with compressed air.

Inspect the manifold for cracks, leaks, 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.

ASSEMBLY

Install the temperature sending unit (coat threads with water resistant sealer), carburetor, spacer, and gaskets. Position the thermostat in the intake manifold. Coat the thermostat gasket with water resistant sealer and position it on the intake manifold. Install the coolant outlet housing. Clean and install the crankcase ventilation oil separator element.

On an engine with positive crankcase ventilation, install the exhaust tube, hose connection, and regulator valve.

EXHAUST MANIFOLDS

REMOVAL

Disconnect the exhaust manifold at the muffler inlet pipe. Remove the automatic choke heat tube from the right exhaust manifold. Remove the retaining bolts and tab washers and remove the exhaust manifold.

INSTALLATION

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

2. Apply graphite grease to the mating surface of the exhaust manifold. Install a new gasket on the muffler inlet pipe studs of the exhaust manifold. Position the exhaust manifold on the cylinder head and install the retaining bolts and tab washers. Working from the center to the ends, torque the bolts to specifications. Lock the bolts by bending one tab of the washer over a flat on the bolt.

3. Position the muffler inlet pipe to the manifold. Install and torque the retaining nuts to specifications. Install the automatic choke heat tube on the right exhaust manifold. Start the engine and check for exhaust leaks.

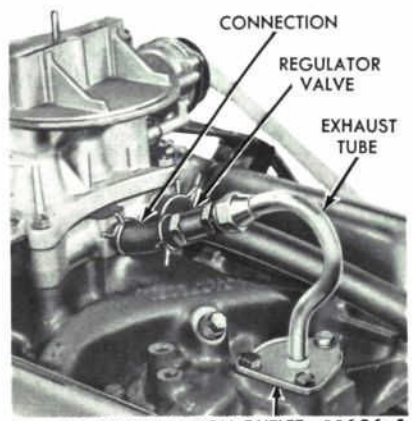


FIG. 11—Regulator Valve and Exhaust Tube

CLEANING AND INSPECTION

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

Clean the mating surfaces of the exhaust manifolds and cylinder heads. On the right exhaust manifold, make sure the automatic choke air inlet and outlet holes are completely open. Clean the maze screen in the passage by pouring cleaning solvent through the passage, then blow out the passage and the automatic choke heat tube with compressed air.

POSITIVE CRANKCASE VENTILATION SYSTEM

REMOVAL

1. Disconnect the crankcase ventilation exhaust tube from the regulator valve assembly. Remove the exhaust tube retaining bolts at the crankcase outlet and remove the exhaust tube and gasket (Fig. 11). Remove the crankcase ventilation oil separator element at the crankcase outlet.

2. Slide the clamps on the hose connection toward the center of the hose. Remove the regulator valve from the hose connection and the hose connection from the carburetor spacer.

INSTALLATION

1. Install the hose connection on the carburetor spacer and the regulator valve in the hose connection. Slide the hose clamps into position.

2. Install the crankcase ventilation oil separator element. Position the exhaust tube and gasket at the crankcase outlet and install the retaining bolts. Connect the exhaust tube to the regulator valve.

REGULATOR VALVE DISASSEMBLY

Place the large hex end of the regulator valve body in a vise. Remove the connector, valve, and spring.

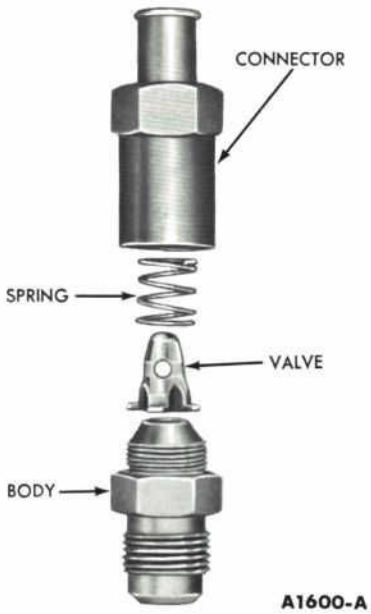


FIG. 12— Regulator Valve Assembly

CLEANING AND INSPECTION

Clean the valve parts and exhaust tube, and crankcase ventilation oil separator elements, in clean carburetor solvent and dry them with compressed air. Clean the rubber hose connections with a low volatility petroleum base solvent and dry with compressed air.

Inspect the valve and valve seat for cracks, nicks, and burrs. Inspect the connector and body for broken or stripped threads.

REGULATOR VALVE ASSEMBLY

Position the spring and valve inside the regulator valve body (Fig. 12). Install the regulator valve connector.

VALVE ROCKER ARM ASSEMBLY

The valve rocker arm assembly is shown in Fig. 13.

REMOVAL

1. Remove the air cleaner. Disconnect the spark plug wires at the spark plugs and remove the wires from the harness brackets on the valve rocker arm covers. Position the wires out of the way.

To remove the right valve rocker arm cover, remove the automatic choke heat tube.

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

3. Remove the valve rocker arm stud nut, fulcrum seat, and rocker arm.

If removal of a rocker arm stud is necessary, remove it with special tool as shown in Fig. 14.

CLEANING AND INSPECTION

Clean all parts thoroughly in solvent and dry with compressed air. Make sure the oil passage in the push rod end of the rocker arm is open.

Check the rocker arm and fulcrum seat for excessive wear, cracks, nicks, or burrs. Check the rocker arm stud and stud nut for stripped or damaged threads.

INSTALLATION

If a rocker arm stud was removed, install a new stud as shown in Fig. 15. If an oversize stud is required, ream the stud bore as necessary.

1. Apply Lubriplate to the top of the valve stem, the valve end of the rocker arm, and the push guide in the cylinder head. Install the valve rocker arm, fulcrum seat, and stud nut.

2. Adjust the valve clearance.

3. Clean the valve rocker arm cover(s) and the cylinder head gasket surface. Apply oil resistant sealer to one side of the new cover gasket(s). Lay the cemented side of the gasket(s) in place in the cover(s), as shown in Fig. 18. Position the cover(s) on the cylinder head(s). Make sure the gasket seats evenly all around the head. Install the bolts. The cover is tightened in two steps. Torque the bolts to specifications. Two minutes later, torque the bolts to the same specifications.

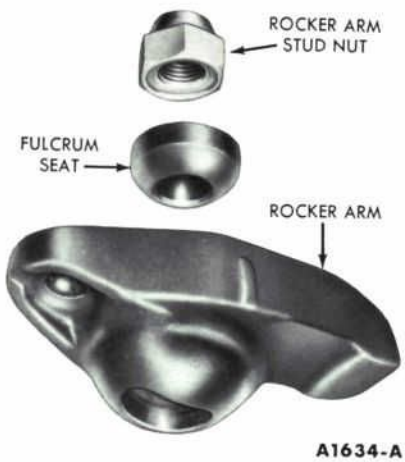


FIG. 13— Valve Rocker Arm Assembly

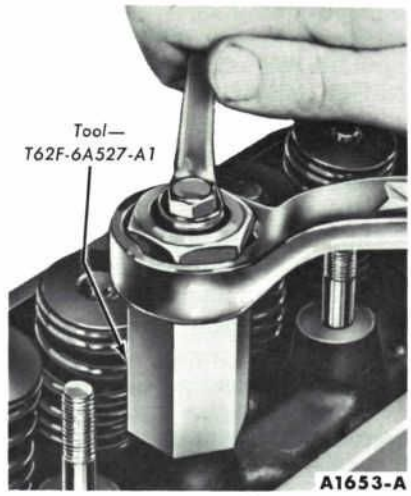


FIG. 14— Removing Rocker Arm Stud

If the right valve rocker arm cover was removed, install the automatic choke heat tube.

4. Install the spark plug wires in the bracket(s) on the valve rocker arm cover(s). Connect the spark plug wires at the spark plugs. Install the air cleaner.

VALVE CLEARANCE ADJUSTMENT

1. Position the crankshaft as outlined in steps 2 and 3. Loosen the rocker arm stud nut until there is end clearance in the push rod,

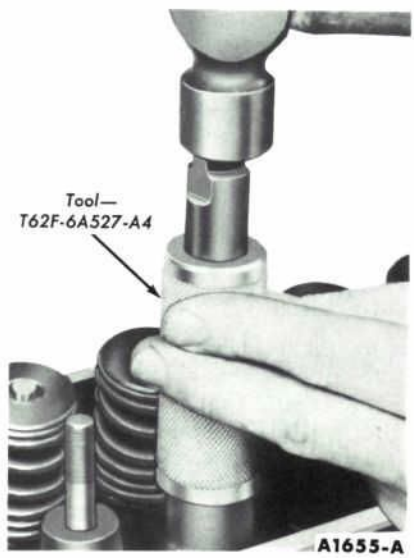


FIG. 15— Installing Rocker Arm Stud

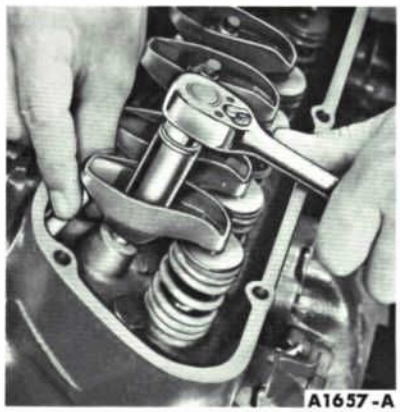


FIG. 16—Valve Clearance Adjustment

then tighten the nut to just remove all the push rod to rocker arm end clearance. This may be determined by rotating and/or moving the push rod with the fingers as the stud nut is tightened (Fig. 16). When the push rod end clearance has been eliminated, tighten the stud nut an additional 2 turns to place the hydraulic lifter plunger in the center of its travel.

2. Rotate the crankshaft until No. 1 piston is on TDC at the end of the compression stroke. With No. 1 piston on TDC, adjust the following valves:

No. 2 Exhaust	No. 1 Intake
No. 5 Exhaust	No. 1 Exhaust
No. 7 Intake	No. 3 Intake
No. 8 Intake	No. 4 Exhaust

3. After these valves have been adjusted, position No. 6 piston on TDC and adjust the following valves:

No. 2 Intake	No. 6 Intake

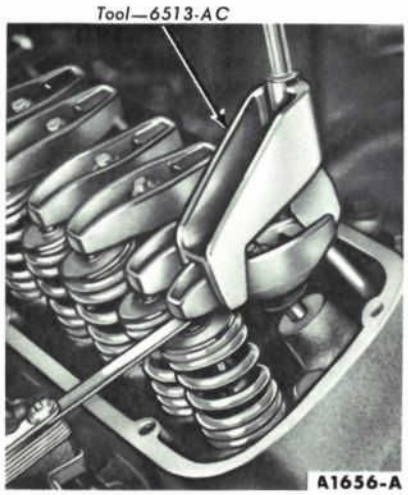


FIG. 17—Valve Clearance Check

FIG. 18—Valve Rocker Arm Cover Gasket Installation

No. 3 Exhaust	No. 6 Exhaust
No. 4 Intake	No. 7 Exhaust
No. 5 Intake	No. 8 Exhaust

The engine should not be cranked or rotated until the hydraulic lifters have had an opportunity to leak down to their normal operating position. The leak-down rate can be accelerated by pressing down on the push rod end of the rocker arm.

The lifters may also be adjusted by positioning each piston at approximate TDC at the end of the compression stroke, in the firing order sequence, and adjusting the affected valves.

4. Operate the engine and check for a noisy lifter(s). If there is a noisy lifter(s), determine which lifter(s) is noisy. When the noisy lifter(s) has been located, use the following procedure:

Follow steps 2 and 3 in the above procedure.

Apply pressure to slowly bleed down the valve lifter until the plunger is completely bottomed (Fig. 17). While holding the valve lifter in the fully collapsed position, check the available clearance between the rocker arm and valve stem tip (Fig. 17). If the clearance is not within specifications, rotate the rocker arm stud nut "clockwise" to decrease the clearance, and "counterclockwise" to increase the clearance. **Normally, one (1) turn of the nut will vary the clearance by 0.066-inch.**

CYLINDER HEADS

The cylinder heads are interchangeable from one cylinder bank to the other.

REMOVAL

1. Remove the intake manifold and carburetor as an assembly.

2. Disconnect the battery ground cable at the cylinder head. Remove the rocker arm cover(s).

On a car with power steering, disconnect the power steering pump bracket from the left cylinder head and remove the drive belt from the pump pulley. Wire the power steering pump out of the way and in a position that will prevent the oil from draining out.

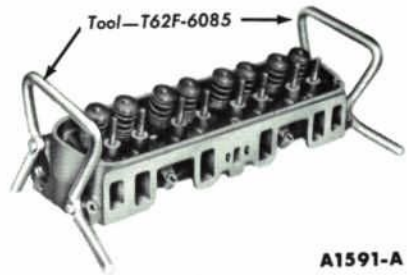


FIG. 19—Cylinder Head Holding Fixtures

3. Disconnect the wires at the generator. Remove the generator mounting bracket bolts and remove the generator and bracket as an assembly. Disconnect the exhaust manifold(s) at the muffler inlet pipe(s).

4. If the cylinder head is not to be disassembled after it is removed, remove it as follows:

Install the cylinder head holding fixtures (Fig. 19). Remove the cylinder head retaining bolts from both ends of the cylinder head and install guide studs (Fig. 20). Remove the remaining cylinder head retaining bolts.

Raise the cylinder head slightly so that the rocker arms can be rotated to the side. Remove the push rods in sequence (Fig. 21). Remove the guide studs and lift the cylinder head off the block. Remove and discard the cylinder head gasket.

5. If the cylinder head is to be disassembled after it is removed, remove the cylinder head as follows:

Loosen the rocker arm stud nuts so that the rocker arms can be rotated to the side. Remove the push rods in sequence (Fig. 21).

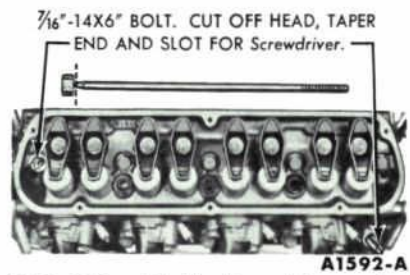


FIG. 20—Cylinder Head Guide Studs

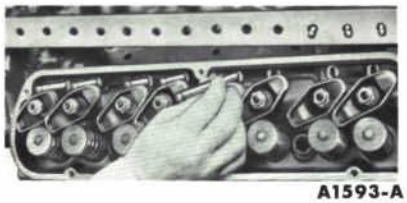

A1593-A

FIG. 21 — Valve Push Rod Removal

Install the cylinder head holding fixtures (Fig. 19). Remove the cylinder head retaining bolts and lift the cylinder head 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. If the cylinder head was removed for a cylinder head gasket replacement, check the flatness of the cylinder head and block gasket surfaces.

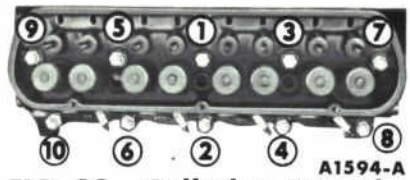
2. If the cylinder head was not disassembled, install the cylinder head as follows:

Position the new cylinder head gasket on the cylinder block. Position the cylinder head to the block and install the guide studs. Raise the cylinder head slightly so that the push rods can be installed in their original locations, with the rocker arms positioned over the push rods. Apply Lubriplate to the valve stem tips, to the valve end of the rocker arm, and the push rod guide in the cylinder head. Coat the cylinder head bolts with water resistant sealer.

Install the two center cylinder head retaining bolts and remove the guide studs and holding fixtures. Install the remaining cylinder head bolts. The cylinder head bolts are tightened in three progressive steps. Torque all the bolts in sequence (Fig. 22) to specifications. **After the cylinder head bolts have been torqued to specifications, the bolts should not be disturbed.**

3. If the cylinder head was disassembled, install the cylinder head as follows:

Position the new cylinder head gasket over the dowels on the cylinder block. Coat the cylinder head bolts with water resistant sealer. Position the cylinder head on the block and install the retaining bolts. Torque the bolts in sequence. Remove the holding fixtures.



A1594-A

FIG. 22 — Cylinder Head Bolt Tightening Sequence

Install the push rods in their original locations. Apply Lubriplate over the valve stem tips, to the valve end of the rocker arm and the push rod guide in the cylinder head. Install the rocker arms. Perform a valve clearance adjustment.

4. Position a new gasket on the studs of the exhaust manifold(s). Connect the exhaust manifold(s) at the muffler inlet pipe(s). Position the generator and bracket and position the drive belt over the pulley. Install the retaining bolts and adjust the drive belt tension to specifications. Connect the generator wires.

5. Connect the battery ground cable. Clean the valve rocker arm cover(s). Apply oil resistant sealer to one side of the new cover gaskets. Lay the cemented side of the gaskets in place in the cover(s) (Fig. 19). Install the valve rocker arm cover(s).

On a car with power steering, install the drive belt and power steering pump bracket. Install the bracket retaining bolts. Adjust the drive belt to specifications. Install the intake manifold and related parts.

DISASSEMBLY

Clean the carbon out of the cylinder head combustion chambers before removing the valves. Compress the valve springs (Fig. 23). Remove the spring retainer locks and release the spring. Remove the spring retainer, spring, stem seal, and valve. Discard the valve stem seals. Identify all valve parts.

If any of the valve rocker arm studs are damaged or worn, remove them (Fig. 14).

CLEANING AND INSPECTION

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. Remove all deposits from the valves with a fine wire brush or buffing wheel. Use cleaning solvent to remove dirt, grease, and other deposits.

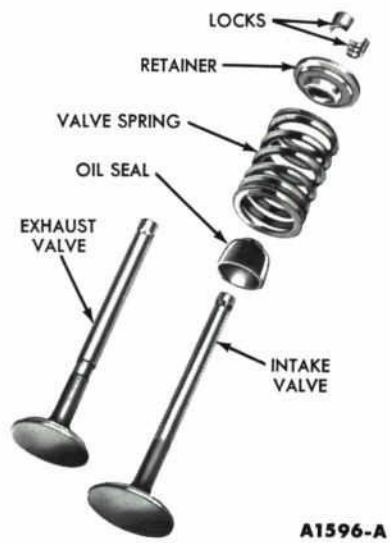
A1595-A

FIG. 23 — Compressing Valve Spring

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

Check the valve rocker arm studs for stripped or broken threads.

Check the flatness of the cylinder head.



A1596-A

FIG. 24 — Valve Assembly

Check the valve seat runout with an accurate gauge. Measure the valve seat width.

The critical inspection points and tolerances of the valves are illustrated in Fig. 24. Inspect the valve face and the edge of the valve head for pits, grooves, scores, or other defects. Inspect the valve stem for a bent condition and the end of the stem for grooves or scores. Check the valve head for signs of burning or erosion, warpage, and cracks. Inspect the valve springs, valve spring retainers, and locks for defects. Check the valve face runout with a special runout gauge.

Check the valve stem to guide clearance of each valve in its respective valve guide.

Check the valve spring pressure to be sure it is within specifications. Weak valve springs cause poor engine performance, therefore, if the pressure of any spring approaches the wear limit, replace the spring. Check each valve spring for squareness.

Clean the push rods in a suitable solvent. Blow out the oil passage in the push rod with compressed air. Check the ends of the push rods for nicks, grooves, roughness, or excessive wear. The push rods can be visually checked for straightness or they can be checked with a dial indicator.

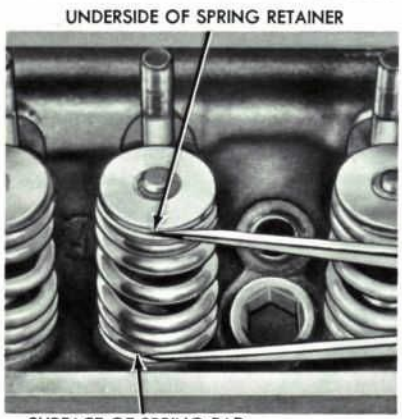


FIG. 25—Valve Spring Assembled Height

ASSEMBLY

1. Install each valve (Fig. 24) in the port from which it was removed or to which it was fitted. Install a new stem seal on the valve. Install the valve spring over the valve, then install the spring retainer. Compress the spring and install the retainer locks (Fig. 23). Install any valve rocker arm studs that were removed (Fig. 15).

2. 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. 25). Check the dividers against a scale. If the assembled height is greater than specifications, install the necessary 0.030-inch thick spacer(s) between the cylinder head spring pad and the valve spring to bring the spring to the recommended height.

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.

VALVE STEM SEAL REPLACEMENT

1. Remove the air cleaner and the valve rocker arm cover. Remove the applicable spark plug.

2. Crank the engine until the applicable piston is on TDC after the compression stroke. Be sure that both valves are closed. **Be sure that the piston is on TDC to prevent the crankshaft from turning when air is applied.** Install an air line with an adapter in the spark plug hole and turn on the air supply.

3. Remove the applicable valve rocker arm stud nut, fulcrum seat, rocker arm, and push rod. Install the stud nut and position the compressor tool as shown in Fig. 26. Compress the valve spring and remove the retainer locks, spring retainer, and valve spring. Remove and discard the valve stem seal (Fig. 27).

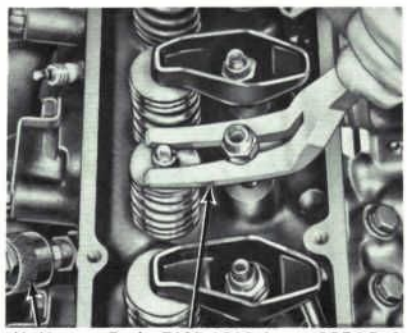


FIG. 26—Compressing Valve Spring

4. Install a new valve stem seal (Fig. 27). Place the spring in position over the valve and install the valve spring retainer. Compress the valve spring and install the valve spring retainer locks. Remove the compressor tool and stud nut. Install the push rod.

5. Apply Lubriplate to the tip of the valve stem, the valve end of the rocker arm, and the push rod guide in the cylinder head. Install the valve rocker arm, fulcrum seat, and stud nut.

6. Adjust the valve clearance. Turn off the air and remove the air line and adapter. Install the spark plug. Clean and install the rocker arm cover. Connect the spark plug wire and install the air cleaner.

FIG. 27—Valve Stem Seal Removal or Installation

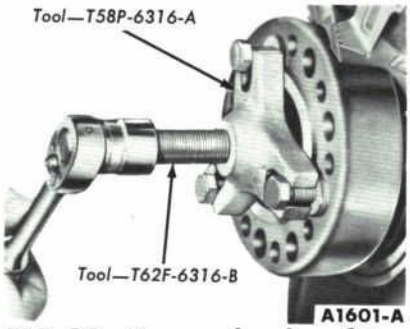


FIG. 28—Crankshaft Adapter Removal

CYLINDER FRONT COVER AND TIMING CHAIN

REMOVAL

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

2. Disconnect the radiator upper hose at the coolant outlet housing and the radiator lower hose at the water pump. Disconnect the heater hose at the water pump. Slide the water pump bypass hose clamp toward the water pump.

3. Loosen the generator mounting bolts at the generator. Remove the generator support bolt at the water pump. Remove the fan, spacer, pulley and drive belt.

On a car with power steering, loosen the drive belt tension and remove the belt.

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

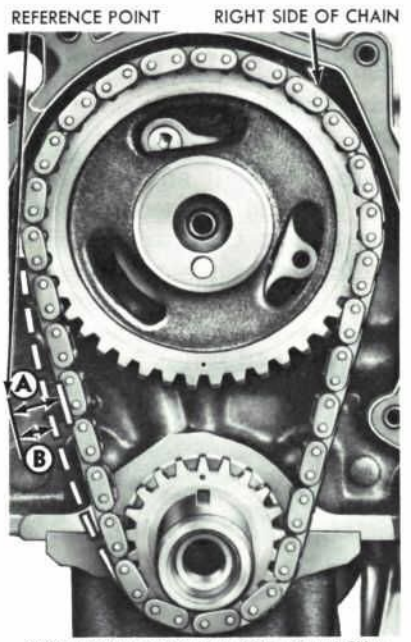


FIG. 29—Timing Chain Deflection

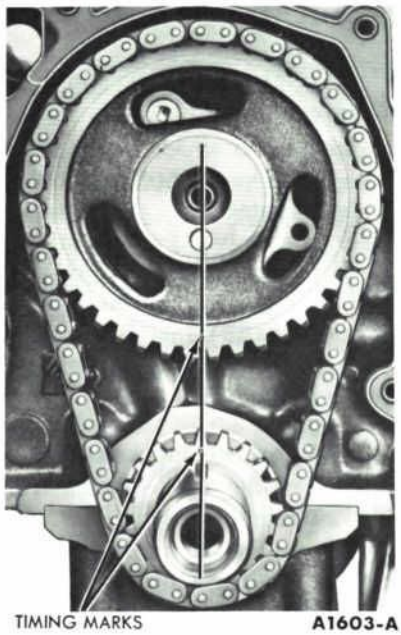


FIG. 30—Aligning Timing Marks

4. Remove the crankshaft pulley from the crankshaft pulley adapter. Remove the cap screw and washer from the end of the crankshaft. Install a puller on the crankshaft pulley adapter (Fig. 28) and remove the adapter.

5. Disconnect the fuel pump outlet line at the fuel pump. Remove the fuel pump retaining bolts and lay the pump to one side with the flexible fuel line still attached.

6. Remove the oil level dipstick. Disconnect the dipstick tube bracket and oil filler tube bracket at the generator mounting bracket. Remove the oil pan to cylinder front cover retaining bolts. Remove the cylinder front cover and water pump as an assembly.

If a new cylinder front cover is to be installed, remove the timing pointer, water pump, and dipstick tube from the old cylinder front cover and install them on the new cover.

7. Discard the cylinder front cover gasket. Remove the crankshaft front oil slinger. Rotate the crankshaft in a clockwise direction (as viewed from the front) to take up the slack on the left side of the timing chain. Establish a reference point on the cylinder block and measure from this point to the chain (Fig. 29). Rotate the crankshaft in the opposite direction to take up the slack on the right side of the chain. 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 1/2 inch, replace the timing chain and/or sprockets.

8. Crank the engine until the timing marks on the sprockets are positioned as shown in Fig. 30. Remove the camshaft sprocket cap screw, washers, and the fuel pump eccentric. Slide both sprockets and the timing chain forward, and remove them as an assembly (Fig. 31).

9. Remove the oil pan and oil pump.

FRONT OIL SEAL REPLACEMENT

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

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

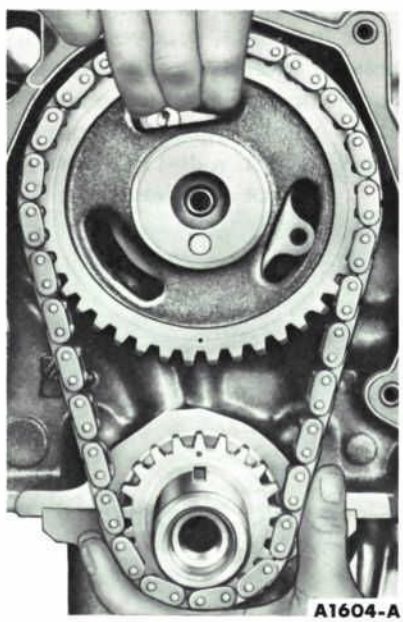


FIG. 31—Timing Chain Removal or Installation

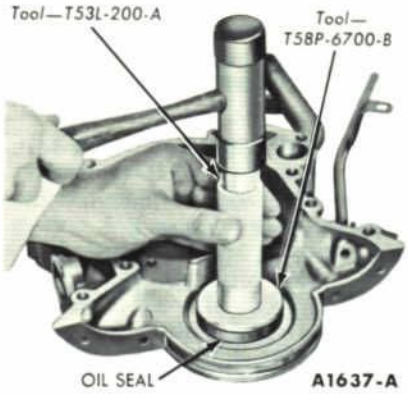


FIG. 32—Oil Seal Installation

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.

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

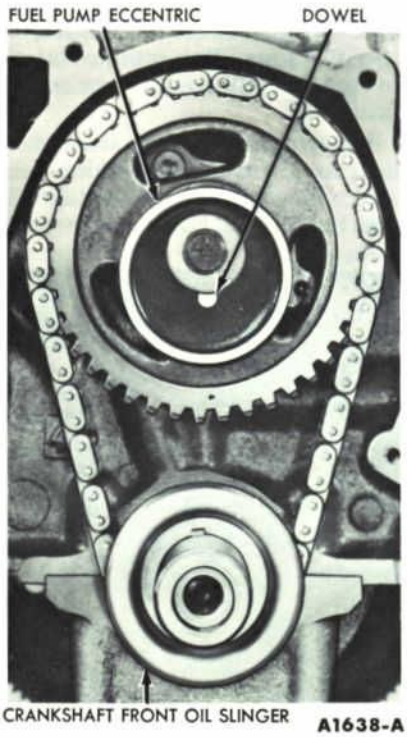


FIG. 33—Fuel Pump Eccentric and Front Oil Slinger Installed

3. Clean the cylinder front cover, oil pan, and the cylinder block gasket surfaces. Coat the gasket surface of the block and cylinder front cover and the cover bolt threads with sealer. Position a new gasket on the block.

4. 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). Coat the threads of the retaining screws with water resistant sealer, then install the screws. While pushing in on the pilot, torque the screws to specifications. Remove the pilot.

5. Line up the crankshaft pulley adapter keyway with the key on the crankshaft. Install the adapter on the crankshaft (Fig. 35). Install the adapter screw and washer. Torque the screw to specifications. Install the crankshaft pulley.

6. Install the oil pump and oil pan. Install the fuel pump, using a new gasket. Connect the fuel pump outlet pipe. Connect the dipstick tube bracket and oil filler tube bracket at the generator mounting bracket. Install the oil level dipstick.

On a car with power steering, install the drive belt and tighten the power steering pump bracket. Adjust the drive belt tension to specifications.

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

7. Install the water pump pulley, drive belt, spacer, and fan. Install the generator support bolt at the water pump. Tighten the generator mounting bolts. Adjust the drive belt tension to specifications.

8. Connect the heater hose and the water pump by-pass hose. Slide the by-pass hose clamp into position. Connect the radiator upper and lower hoses. Connect the battery ground cables.

9. Fill and bleed the cooling system. Fill the crankcase with the proper grade and quantity of engine oil. Operate the engine at fast idle and check for coolant and oil leaks. Check and adjust

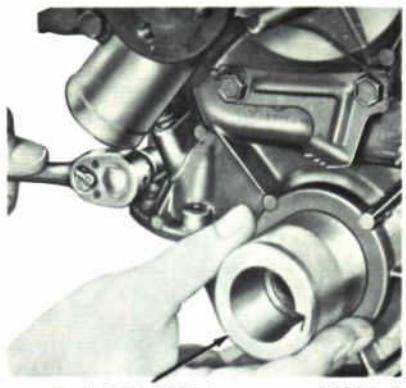


FIG. 34—Cylinder Front Cover Alignment

the ignition timing. Install the air cleaner.

CAMSHAFT

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

REMOVAL

1. Remove the cylinder front cover and timing chain. Disconnect the spark plug wires at the spark plugs and remove the wires from the ignition harness brackets on the valve rocker arm covers. Disconnect the coil high tension lead at the coil. Remove the distributor cap and spark plug wire assembly.

2. Disconnect the ignition coil wires at the coil and remove the coil from the intake manifold. Disconnect the distributor vacuum line at the carburetor. Remove the distributor hold down bolt and clamp and remove the distributor.

3. Disconnect the carburetor fuel inlet line at the carburetor and fuel filter. Remove the fuel line.

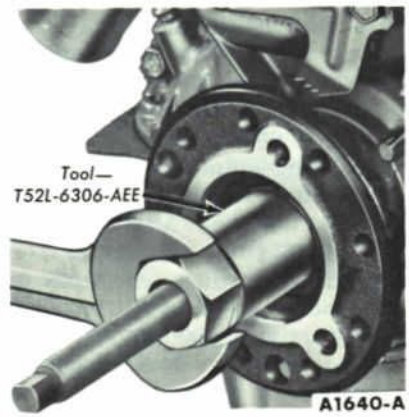


FIG. 35—Crankshaft Adapter Installation

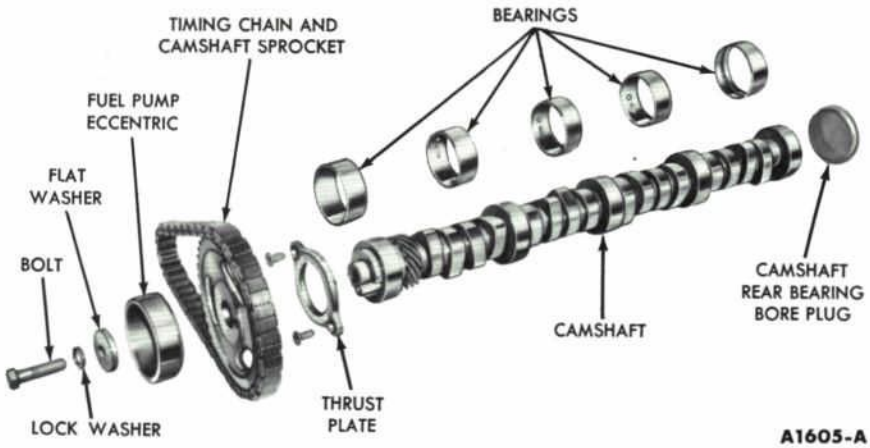


FIG. 36— Camshaft and Related Parts

Disconnect the automatic choke heat tube at the carburetor. Disconnect the heater hose at the carburetor spacer.

On a car with an automatic transmission, disconnect the throttle valve vacuum line at the intake manifold. Disconnect the transmission oil cooler lines at the radiator.

4. Remove the radiator.

5. Disconnect the accelerator rod at the carburetor. Remove the accelerator retracting spring. Remove the bellcrank assembly from the intake manifold and position it out of the way. Disconnect the water temperature sending unit wire at the sending unit and the engine ground strap at the engine. Remove the crankcase vent tube retaining bolts at the intake manifold. Remove the intake manifold and carburetor as an assembly. Remove the intake manifold gaskets and seals.

6. Remove the valve rocker arm covers. Loosen the valve rocker arm stud nuts and rotate the rocker arms to the side. Remove the valve push rods in sequence so that they can be installed in their original locations.

7. Using a magnet, remove the valve lifters and place them in a rack so that they can be installed in their original bores (Fig. 37).

If the valve lifters are stuck in their bores by excessive varnish, etc., it may be necessary to use a plier-type special tool to remove the lifters.

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

CLEANING AND INSPECTION

Clean the camshaft in solvent and wipe dry.

Inspect the camshaft lobes for scoring, and for signs of abnormal wear. Lobe wear characteristics may result in pitting in the general area of the lobe. 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 specifications. The lift of camshaft lobes can only be checked with the camshaft installed in the engine.

Check the distributor drive gear on the camshaft for broken or chipped teeth.

INSTALLATION

1. Oil the camshaft and apply Lubriplate to the lobes. Carefully slide the camshaft through the bearings. Install the camshaft thrust plate.

2. Install the valve lifters in the bores from which they were removed. Install the push rods in their original locations. Apply Lubriplate to the valve stem tips, to the valve end of the rocker arm, and to the push rod guides in the cylinder head. Position the rocker arms over the push rods.

3. Install the intake manifold and related parts.

4. Connect the water temperature sending unit wire and the engine ground strap. Install the bellcrank assembly and the accelerator retracting spring. Connect the accelerator rod.

5. Install the radiator.

On a car with an automatic transmission, connect the transmission oil cooler lines and the throttle valve vacuum line.

6. Connect the heater hose at the spacer. Position and connect the fuel line.

7. Replace the crankshaft front oil seal. Install the timing chain, cylinder front cover, and related parts.

8. 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 breaker points open. Install the hold down clamp. Perform a valve clearance adjustment.

9. Clean the valve rocker arm covers and the cylinder head gasket surface. Apply oil resistant sealer to one side of the new valve rocker arm cover gaskets. Lay the cemented side of the gaskets in place in the covers. Position the covers on the cylinder heads. Make sure the gasket seats evenly all around the head. Install the bolts. The cover is tightened in two steps. Torque the bolts to specifications. Two minutes later, torque the bolts to the same specifications.

10. Install the automatic choke heat tube. Install the ignition coil and connect the wires. Install the distributor cap. Position the spark

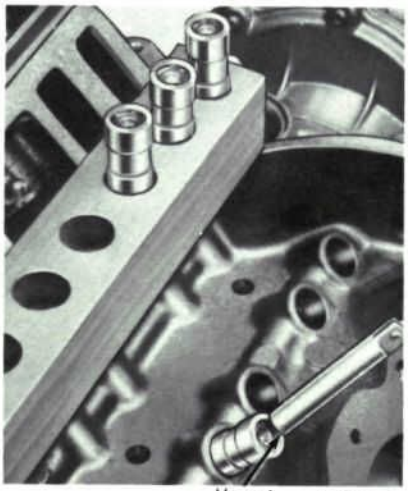


FIG. 37— Valve Lifter Removal

plug wires in the harness brackets on the valve rocker arm covers and connect the spark plug wires. Connect the high tension lead at the coil.

11. Fill and bleed the cooling system. Fill the crankcase with the proper grade and quantity of engine oil. Start the engine and check and adjust the ignition timing. Connect the distributor vacuum line at the carburetor. Operate the engine at fast idle and check all hose connections and gaskets for leaks. Operate the engine until engine temperatures have stabilized, then adjust the engine idle speed and idle fuel mixture. Adjust the transmission throttle linkage. Install the air cleaner.

CAMSHAFT REAR BEARING BORE PLUG REPLACEMENT

1. On a car with a manual-shift transmission, remove the transmission and the clutch pressure plate and disc.

On a car with an automatic transmission, remove the transmission and converter housing.

Remove the flywheel retaining bolts and remove the flywheel.

2. Drill a 1/2-inch hole in the camshaft rear bearing bore plug and pull out the plug (Fig. 38).

3. Clean out the plug bore recess thoroughly and coat the flange of the new plug with water resistant sealer. Install the new camshaft rear bearing bore plug with the flange facing out (Fig. 39) and slightly below the casting surface.

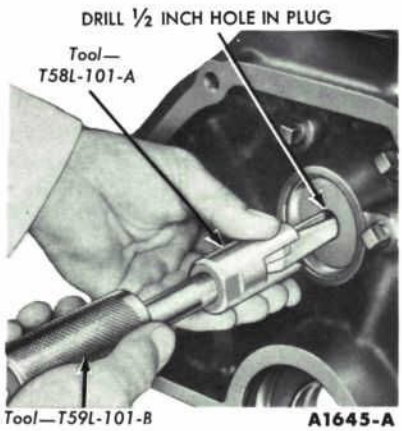


FIG. 38—Camshaft Rear Bearing Bore Plug Removal

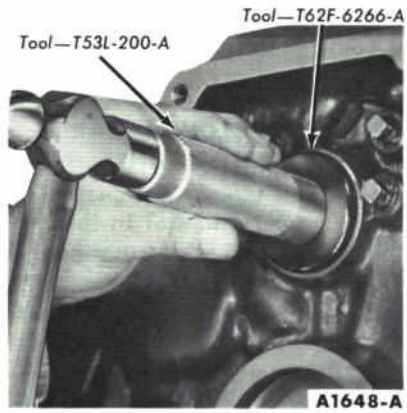


FIG. 39—Camshaft Rear Bearing Bore Plug Installation

4. Install oil resistant sealer on the studs of the retaining bolts. Install the flywheel and torque the retaining bolts to specifications.

On a car with a manual-shift transmission, install the clutch pressure plate and disc, and install the transmission.

On a car with an automatic transmission, install the transmission and the converter housing.

VALVE LIFTER REPLACEMENT

The lifter assemblies should be kept in proper sequence so that they can be installed in their original bores.

1. Remove the intake manifold and related parts.

2. Remove the valve rocker arm covers. Loosen the valve rocker arm stud nuts and rotate the rocker arms to the side. Remove the valve push rods in sequence so that they can be installed in their original locations.

3. Using a magnet, remove the valve lifters and place them in a rack so that they can be installed in their original bores (Fig. 37).

If the valve lifters are stuck in their bores by excessive varnish, etc., it may be necessary to use a plier-type special tool to remove the lifters.

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.

4. Clean and install the valve lifters in the bores from which they were removed.

5. Install the push rods in their original locations. Apply Lubriplate to the valve stem tips, to the valve end of the rocker arm, and to the push rod guide in the cylinder head. Position the valve rocker arms over the push rods and perform a valve clearance adjustment.

6. Install the intake manifold and related parts.

VALVE LIFTER DISASSEMBLY

Each valve lifter is a matched assembly. If the parts of one valve lifter are intermixed with those of another, improper valve operation may result. Disassemble and assemble each valve lifter separately. Keep the 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, metering valve (disc), plunger, and spring.

3. Invert the plunger assembly and remove the check valve retainer by carefully prying up on it with a screwdriver. Remove the check valve (disc or ball check), and spring.

CLEANING AND INSPECTION

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. Test new lifters for free fit in their guide bores.

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

Inspect the parts and discard the entire lifter assembly if any parts show signs of pitting, scoring, galling, or signs of non-rotation. Replace the entire assembly if the plunger is not free in

FIG. 40—Typical Hydraulic Valve Lifter Assembly

the body. The plunger should drop to the bottom of the body by its own weight.

After assembly, 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.

VALVE LIFTER ASSEMBLY

A typical valve lifter assembly is shown in Fig. 40.

1. Place the plunger upside down on a clean work bench. Place the check valve (ball check or disc) in position over the oil hole on the bottom of the plunger. Set the check valve spring on top of the check valve. Position the retainer over the check valve and spring and push the retainer down into place on the plunger.

2. Place the plunger spring, and then the plunger (open end up) into the lifter body.

3. Position the metering valve (disc) in the plunger, and place the push rod cup in the plunger.

4. 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.

CRANKSHAFT LOWER REAR OIL SEAL REPLACEMENT

The upper oil seal in the cylinder block cannot be replaced with the crankshaft installed. The lower seal is replaced as follows:

1. Remove the oil pan and related parts. Remove the rear main bearing cap. Remove and discard the rear oil seat.

2. Clean the rear journal oil seal groove and the mating surfaces of the block and rear main bearing cap. Preform the new seal by hand to the approximate radius of the cap.

3. Insert the seal in the oil seal groove, seating the center of the seal first and allowing the seal to extend equally on both ends. Press the seal down firmly with the thumb at the center of the seal, then press the sides of the seal into the groove working from the ends to the center. Position the seal forming tool as shown in Fig. 41 and complete the seal installation. After installation, cut the ends of the seal flush.

4. Apply a thin coating of oil resistant sealer to the rear main bearing cap at the rear of the top mating surface (Fig. 41). **Do not apply sealer to the area forward of the oil slinger groove.** Install the rear main bearing cap. Torque the cap bolts to specifications.

5. Install the oil pan and related parts.

MAIN AND CONNECTING ROD BEARING REPLACEMENT

MAIN BEARINGS

1. Drain the crankcase. Remove the oil level dipstick. Remove the oil pan. If necessary, remove the oil pump. Remove the spark plugs to permit easy rotation of the crankshaft.

2. **Replace one bearing at a time, leaving the other bearings securely fastened.** Remove the retaining bolts from the main bearing cap to which new bearings are to be installed. Remove the cap and bearing insert.

3. Insert the upper bearing removal tool in the oil hole in the crankshaft. Rotate the crankshaft in the direction of engine rotation to force the bearing out of the cylinder block.

4. Clean the crankshaft journal. Using a special tool in the oil hole in the crankshaft, rotate the crankshaft in the opposite direction of normal engine rotation until the bearing seats itself. Remove the tool.

5. Install the bearing insert in the main bearing cap. Clean the crankshaft journal and the bearing inserts.

6. Support the crankshaft by positioning a small jack so that it will bear against the counterweight adjoining the bearing which is being replaced. The crankshaft is supported so that its weight will not compress the Plastigage and provide an erroneous clearance reading. Check the bearing clearance with Plasti-

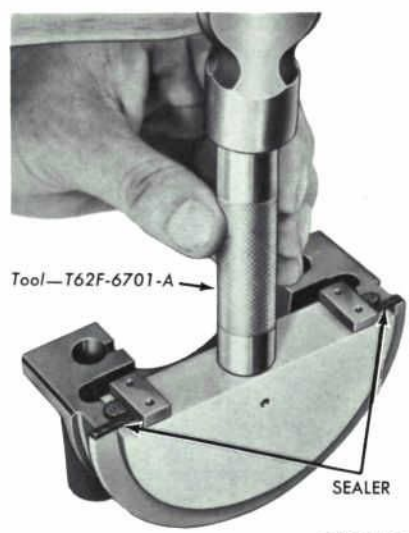


FIG. 41—Seal To Rear Bearing Cap Installation

gage, using the recommended procedure.

7. After the bearing has been checked and found to be satisfactory, apply a light coating of engine oil to the journal and bearings, then install the bearing cap. Torque the bearing cap bolts to specifications. Repeat the procedure for the remaining bearings that require replacement. If the thrust bearing was replaced, align the thrust bearing using the recommended procedure.

8. If the rear main bearing is replaced, replace the lower oil seal in the rear main bearing cap.

9. Clean the oil pump inlet screen and the oil pan, then install the oil pan. Install the oil level dipstick. Fill the crankcase with the proper amount and grade of engine oil. Install the spark plugs. Operate the engine and check for oil leaks and oil pressure.

CONNECTING ROD BEARINGS

1. Follow step 1 under "Main Bearings."

2. Turn the crankshaft until the connecting rod to which the new bearings are to be fitted is down. Remove the connecting rod cap. Push the connecting rod and piston assembly up into the cylinder and remove the bearing inserts from the connecting rod and the connecting rod cap. Be sure the bearing inserts and bearing bore are clean.

3. Clean the crankshaft journal.

4. Fit new bearings with Plastigage, using the recommended procedure.

5. After the bearing clearance has been checked and found to be satisfactory, apply a light coating of engine oil to the journals and bearings. Install the connecting rod cap. Torque the connecting rod cap retaining nuts to specifications.

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

7. Complete the installation procedure by following step 9 under "Main Bearings."

CLEANING AND INSPECTION

Clean the bearing inserts and bearing caps thoroughly.

Inspect each bearing carefully. Bearings that have a scored, chipped, or worn surface should be replaced. The copper lead bearing base may be visible through the bearing overlay, but this does not mean that the bearing is worn. Do not replace the bearing if the bearing clearance is within specifications. Fit new bearings, if necessary.

PISTON AND CONNECTING RODS

REMOVAL

1. Drain the cooling system and crankcase. Remove the air cleaner. Remove the valve rocker arm covers, valve rocker arms, valve push rods, intake manifold, cylinder heads, oil pan, and oil pump.

2. Remove any ridge and/or deposits from the upper end of the cylinder bores using the recommended procedure.

3. Mark all connecting rod caps so that they can be installed in their original locations. Turn the crankshaft until the connecting rod to be removed is down, then remove the connecting rod cap. 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 and cylinder wall when removing the piston and connecting rod.

4. Remove the bearing inserts from the connecting rod cap and install the cap on the connecting rod from which it was removed.

INSTALLATION

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

1. 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 rods and bearing caps 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 cylinder to another, new bearings should be fitted and the connecting rod should be numbered to correspond with the new cylinder number.**

2. Make sure the piston ring gaps are not in alignment with each other, then install a piston ring compressor on the piston and push the piston into the cylinder with a hammer handle until the piston head is slightly below the top of the cylinder (Fig. 42).

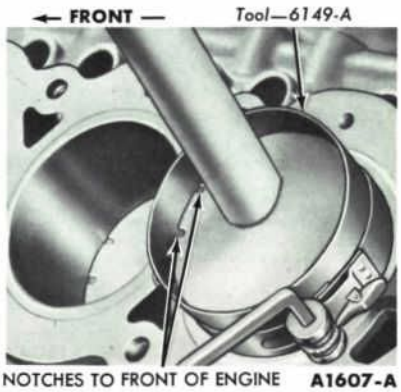


FIG. 42—Piston Installation

Carefully guide the connecting rods to avoid damage to the crankshaft journals. **Install the piston with the indentation notches in the piston toward the front of the engine.** Check the clearance of each bearing, following the recommended procedure. After the bearings have been fitted, apply a light coating of engine oil to the journals and bearings.

3. Turn the crankshaft throw to the bottom of its stroke, then push the piston all the way down until the connecting rod bearing seats firmly on the crankshaft journal. Install the connecting rod cap. Torque the cap nuts to specifications.

4. After the piston and connecting rod assemblies have been installed, check the side clearance between the connecting rods on each crankshaft journal (Fig. 43), to be sure they are within specifications.

5. Clean the oil pump inlet screen and the oil pan and cylinder block gasket surfaces. Install the oil pump and oil pan. Install the cylinder heads, valve push rods, and valve rocker arms. Install the intake manifold and related parts. Check and adjust the valve clearance. Install the valve rocker arm covers. Fill and bleed the cooling system and fill the crankcase with the proper amount and grade of engine oil.

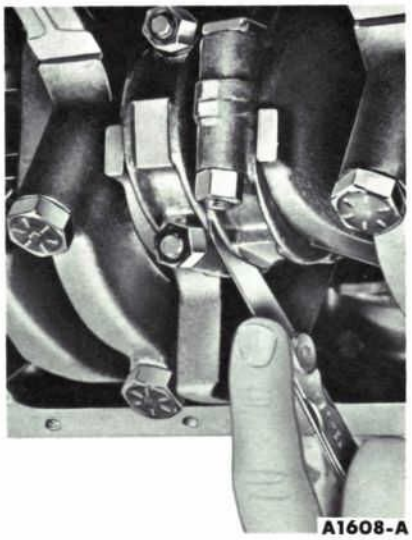


FIG. 43— Connecting Rod Side Clearance

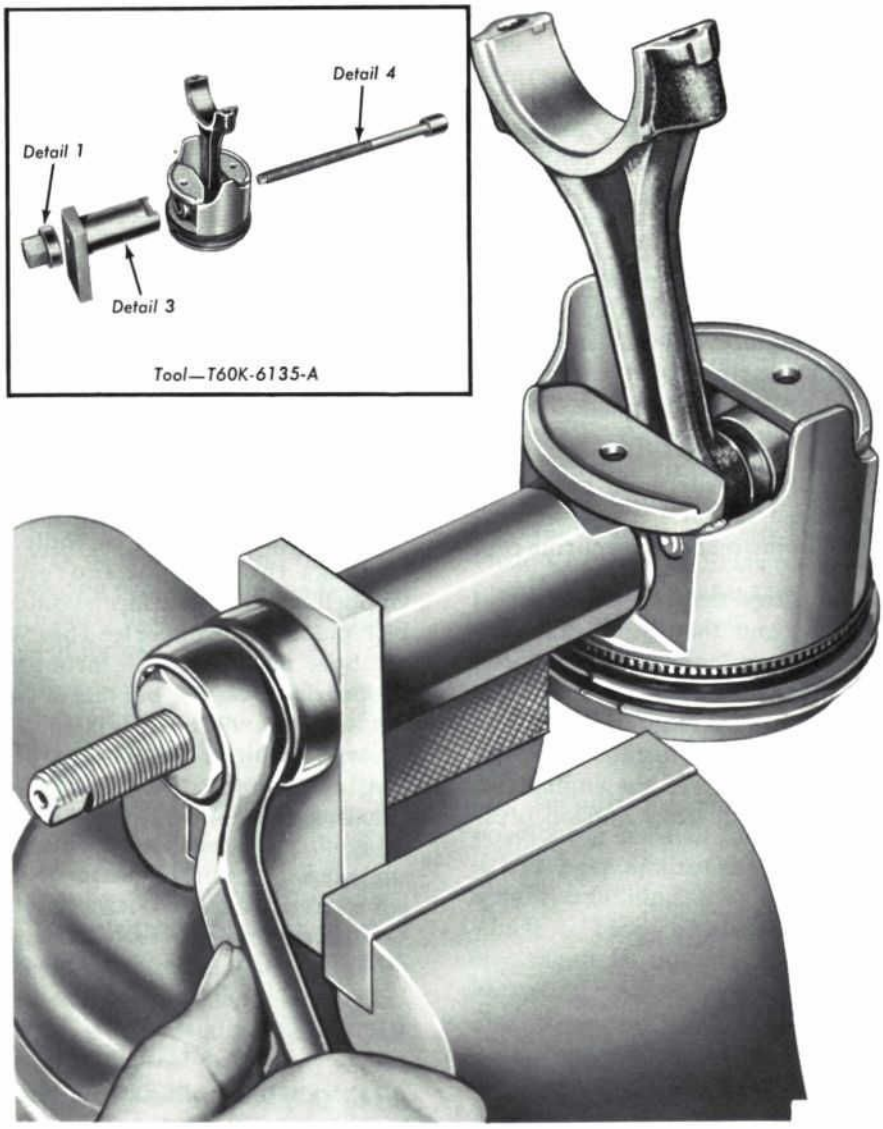


FIG. 44— Piston Pin Removal

6. Operate the engine and check for oil and coolant leaks. Check and adjust the ignition timing. Adjust the engine idle speed and idle fuel mixture. Adjust the transmission throttle linkage. Install the air cleaner.

PISTON AND CONNECTING ROD DISASSEMBLY

Remove the bearing inserts from the connecting rod and cap. Mark the pistons and piston pins to assure assembly with the same connecting rod and installation in the same cylinder from which it was removed. Remove the piston pin from the piston and connecting rod, as shown in Fig. 44. Remove the piston rings.

CONNECTING ROD CLEANING AND INSPECTION

The connecting rods and related parts should be thoroughly 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 cause excessive oil consumption.

Cleaning. Remove the bearings from the connecting 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. 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 ID of the connecting rod piston pin bore and the OD of the piston pin. Replace the connecting rod if the pin bore is not within specifications. Replace the piston pin if the pin is not within specifications.

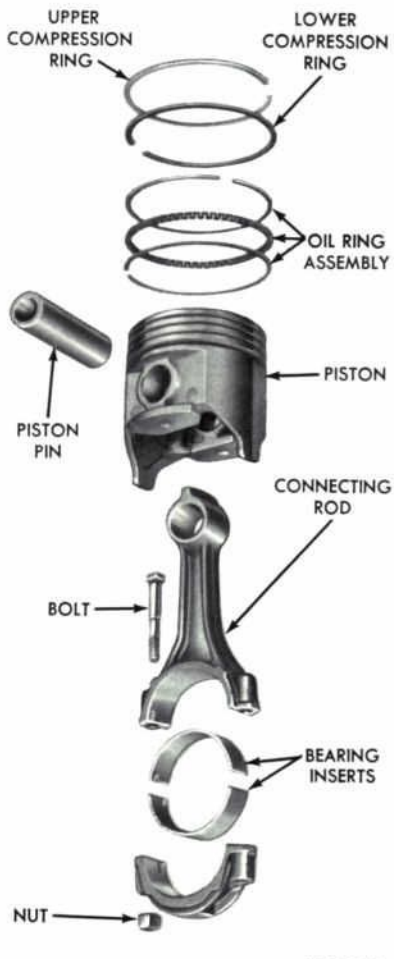


FIG. 45—Piston, Connecting Rod, and Related Parts

Replace defective connecting rod bolts and nuts.

After the connecting rods are assembled to the pistons, 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 is excessive, the connecting rod should be straightened or replaced.

PISTONS, PINS, AND RINGS CLEANING AND INSPECTION

Cleaning. Remove deposits from the piston surfaces. Clean gum or varnish from 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. 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, fractures, and or damage from detonation or pre-ignition.

Check the piston to cylinder bore clearance with a tension scale and ribbon. Check the ring side clearance.

Replace piston pins showing signs of fracture or etching and/or wear. Check the piston pin fit in the piston and connecting rod. Replace the piston pin if the pin is not within specifications.

Replace all rings that are scored, chipped, or cracked. Check the end gap. It is good practice to always install new rings when overhauling the engine. **Rings should not be transferred from one piston to another.**

PISTON AND CONNECTING ROD ASSEMBLY

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

Check the fit of a new piston in the cylinder bore before assembling the piston and piston pin to the connecting rod. The piston pin bore of a connecting rod and the diameter of the piston pin must be within specifications.

1. Lubricate all parts with a thin film of engine oil. **Assemble the piston and connecting rod with the oil squirt hole in the connecting rod and the indentation notches in the piston positioned as shown in Fig. 46.**

2. Start the piston pin in the piston and connecting rod. Draw the piston pin through the piston and connecting rod until the end of the pin seats in Detail 2, Fig. 47.

3. Follow the instructions contained in the piston ring package and install the piston rings. Check the ring side clearance.

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 positioned in the slots provided.

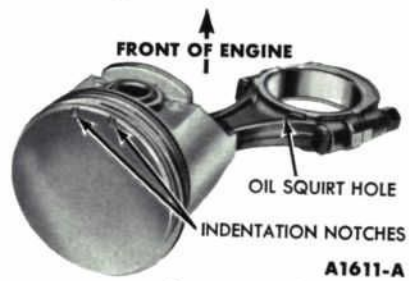


FIG. 46—Piston and Connecting Rod Assembly

FLYWHEEL

REMOVAL

1. On a car with a manual-shift transmission, remove the transmission, and the clutch pres-

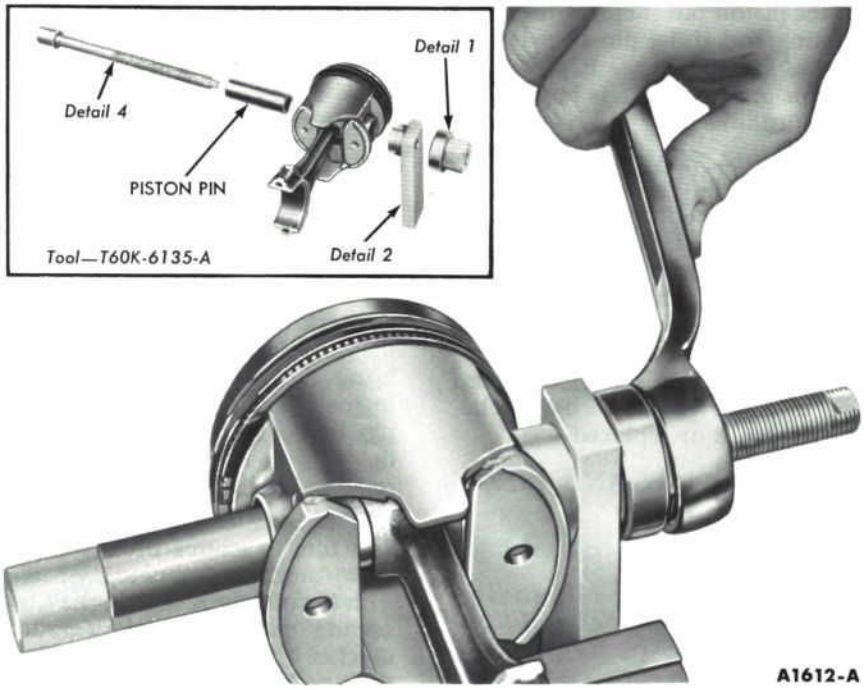


FIG. 47—Piston Pin Installation

sure plate and disc, following the recommended procedures.

On a car with an automatic transmission, remove the transmission and converter housing.

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

CLEANING AND INSPECTION — MANUAL-SHIFT TRANSMISSION

Clean the flywheel in solvent and dry thoroughly.

Inspect the flywheel for cracks, heat checks, or other defects that would make it unfit for further service. Machine the friction surface of the flywheel if it is scored or worn. If it is necessary to remove more than 0.045-inch of stock from the original thickness, replace the flywheel.

Inspect the ring gear for worn, chipped or cracked teeth. If the teeth are damaged, replace the ring gear.

With the flywheel installed on the crankshaft, check the flywheel face runout by installing a dial indicator so that the indicator point bears against the flywheel face. Turn the flywheel, making sure that it is full forward or rearward so that crankshaft end play will not be indicated as flywheel runout.

If the runout exceeds the maximum limit, remove the flywheel and check for burrs between the flywheel and the face of the crankshaft mounting flange. If no burrs exist, check the runout of the crankshaft mounting flange. Replace the flywheel or machine the crankshaft flywheel face, if the mounting flange runout is excessive.

INSTALLATION

1. Coat the threads of the retaining bolts with oil resistant sealer. Position the flywheel on the crankshaft flange and install the retaining bolts. Torque the bolts in sequence across from each other to specifications.

2. On a car with a manual-shift transmission, install the clutch pressure plate and disc, and the transmission.

On a car with an automatic transmission, install the transmission and converter housing.

CLUTCH PILOT BUSHING REPLACEMENT

1. Remove the transmission and clutch pressure plate and disc, following the recommended procedures. Remove the clutch pilot bushing (Fig. 48).

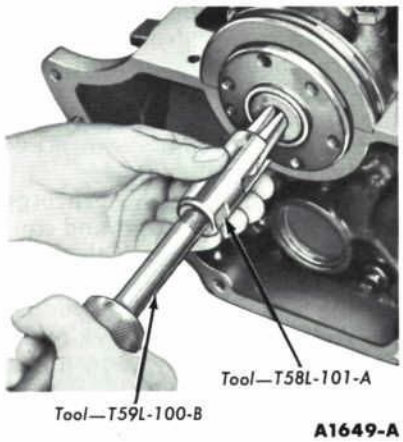


FIG. 48—Clutch Pilot Bushing Removal

2. Coat the pilot bushing bore in the crankshaft with a small quantity of wheel bearing lubricant. Avoid using too much lubricant as it may be thrown onto the clutch disc when the clutch revolves. Install the pilot service bearing (Fig. 49). Install the clutch pressure plate and disc, and the transmission.

OIL FILTER REPLACEMENT

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

2. Coat the gasket on the filter with oil. Clean the filter recess. Place the filter in position on the adapter fitting. Hand tighten the filter until the gasket contacts the

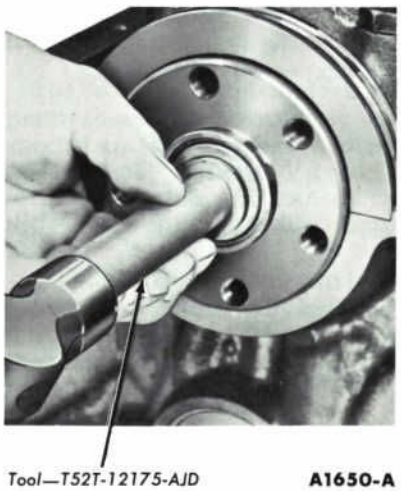


FIG. 49—Clutch Pilot Bearing Installation

adapter face, then advance the filter 1/2 turn.

3. Operate the engine at fast idle and check for oil 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

REMOVAL

1. Drain the crankcase. Remove the oil level dipstick. Remove the cross member retaining nuts and remove the cross member.

2. Remove the oil pan retaining bolts and crank the engine as required to obtain clearance, then remove the oil pan. Remove the oil pump inlet tube and screen assembly.

CLEANING AND INSPECTION

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 solvent and dry thoroughly.

Check the pan for cracks, dents, holes, damaged drain plug threads, and a nicked or warped gasket surface. Repair any damage, or replace the oil pan if repairs cannot be made.

INSTALLATION

1. Clean and install the oil pump inlet tube and screen assembly.

2. Clean the gasket surfaces of the block and oil pan. The oil pan has a two-piece gasket. Coat the block surface and the oil pan gasket surface with sealer. Position the oil pan gaskets on the cylinder block (Fig. 50). Position the oil pan front seal on the cylinder front cover (Fig. 50). **Be sure the tabs on the seal are over the oil pan gasket.** Position the oil pan rear seal on the rear main bearing cap (Fig. 50). **Be sure the tabs on the seal are over the oil pan gasket.**

3. Hold the oil pan in place against the block and install a bolt, finger-tight, on each side of the oil pan. Install the remaining bolts. Torque the bolts from the center outward in each direction to specifications.

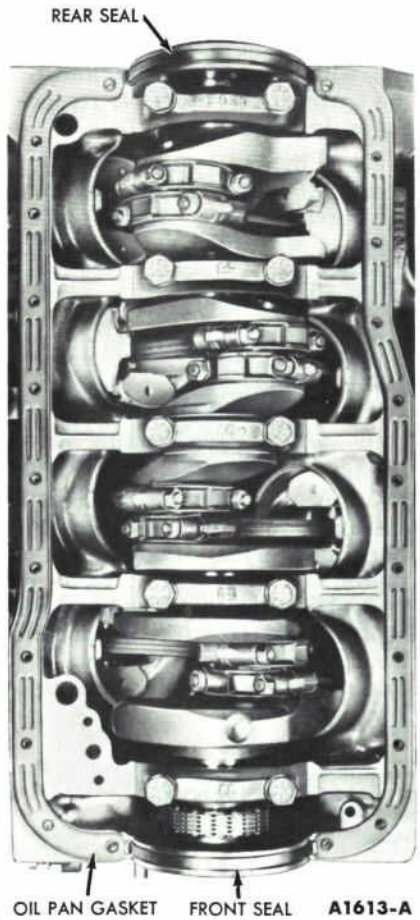


FIG. 50—Oil Pan Gaskets and Seals Installed

4. Position the cross member and install the retaining nuts. Install the oil level dipstick. Fill the crankcase with the proper amount and grade of engine oil. Operate the engine and check for oil leaks.

OIL PUMP

REMOVAL

Remove the oil pan and related parts. Remove the oil pump inlet tube and screen assembly. Remove the oil pump retaining bolts and remove the oil pump, gasket, and intermediate drive shaft.

INSTALLATION

1. 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.

2. Position the intermediate 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.

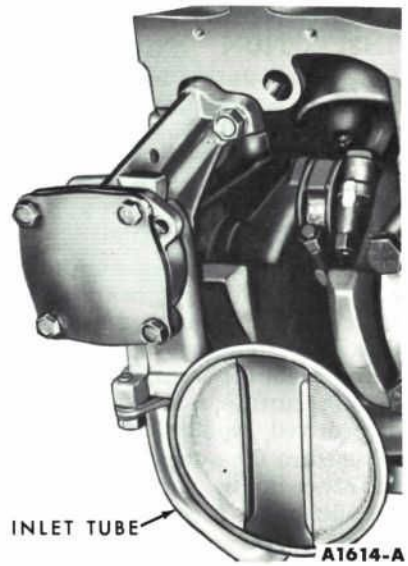


FIG. 51—Oil Pump Inlet Tube Installed

3. Position a new gasket on the pump housing. With the stop properly positioned, insert the intermediate shaft into the oil pump. 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 drive shaft into a new position.** Torque the oil pump retaining screws to specifications.

4. Clean and install the oil pump inlet tube and screen assembly (Fig. 51). Install the oil pan and related parts.

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, then remove the outer race.

3. Insert 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

Wash all parts in solvent and dry thoroughly. Use a brush to clean the inside of the pump body and the pressure relief chamber. Be sure all dirt and chips are removed. Blow out the intake tube screen with compressed air.

Check the inside of the pump body and the outer race and rotor for signs of damage and wear. Check the mating surface of the pump plate for wear. If the plate mating surface is worn, scored, or grooved, replace the plate.

Measure the outer race to body clearance to be sure it is within specifications. Measure the rotor end play clearance. The clearance must be within specifications. The outer race, shaft, and rotor are replaceable only as an assembly.

Check the drive shaft to body clearance. The clearance must be within specifications.

Check the relief valve spring tension. If the spring tension is not within specifications, and/or the spring is defective, replace the spring.

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

ASSEMBLY

The oil pump assembly is shown in Fig. 52.

1. Oil all parts thoroughly. Install the oil pressure relief valve plunger, spring, and a new cap.

2. 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 and torque the cover retaining screws to specifications.

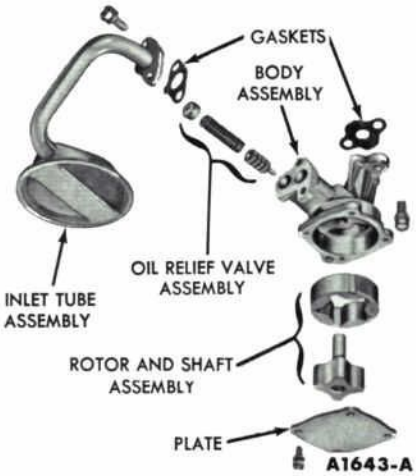


FIG. 52—Oil Pump Assembly

3. Position a new gasket and the oil pump inlet tube on the oil pump and install the retaining bolts.

3 WORK STAND 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 REPLACEMENT

The crankshaft and related parts are shown in Fig. 53.

REMOVAL

1. Disconnect the spark plug wires at the spark plugs and remove the wires from the ignition harness brackets on the valve rocker arm covers. Remove the distributor cap and spark plug wire assembly. Remove the spark plugs to allow easy rotation of the crankshaft.

2. Remove the fuel pump and oil filter. Slide the water pump by-pass hose clamp toward the water pump of the engine. Remove the generator and mounting bracket.

3. Remove the crankshaft pulley from the crankshaft pulley adapter. Remove the cap screw and washer from the end of the crankshaft. Install a puller on the crankshaft pulley adapter (Fig. 28) and remove the adapter. Remove the cylinder front cover and water pump as an assembly.

4. Remove the crankshaft front oil slinger. Check the timing chain deflection and remove the timing chain and sprockets.

5. Invert the engine on the work stand. Remove the clutch pressure plate and disc (manual-shift transmission). Remove the flywheel. Remove the oil pan and gasket. Remove the oil pump.

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

7. Carefully lift the crankshaft out of the block so that the thrust bearing surfaces are not damaged.

CLEANING AND INSPECTION

Handle the crankshaft with care to avoid possible fracture or damage to the finished surfaces.

Clean the crankshaft with solvent, then blow out all oil passages with compressed air.

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.

On engines with a manual-shift transmission, check the fit of the clutch pilot bushing in the bore of the crankshaft. The bushing is pressed into the crankshaft and should not be loose. Inspect the inner surface of the bushing for wear or a bell-mouth condition. Check the ID of the bushing. Replace the bushing if it is worn or damaged.

INSTALLATION

1. Remove the rear journal oil seal from the block and rear main bearing cap. Remove the main bearing inserts from the block and bearing caps. Remove the connecting rod bearing inserts from the connecting rods and caps.

2. If the crankshaft main bearing journals have been refinished

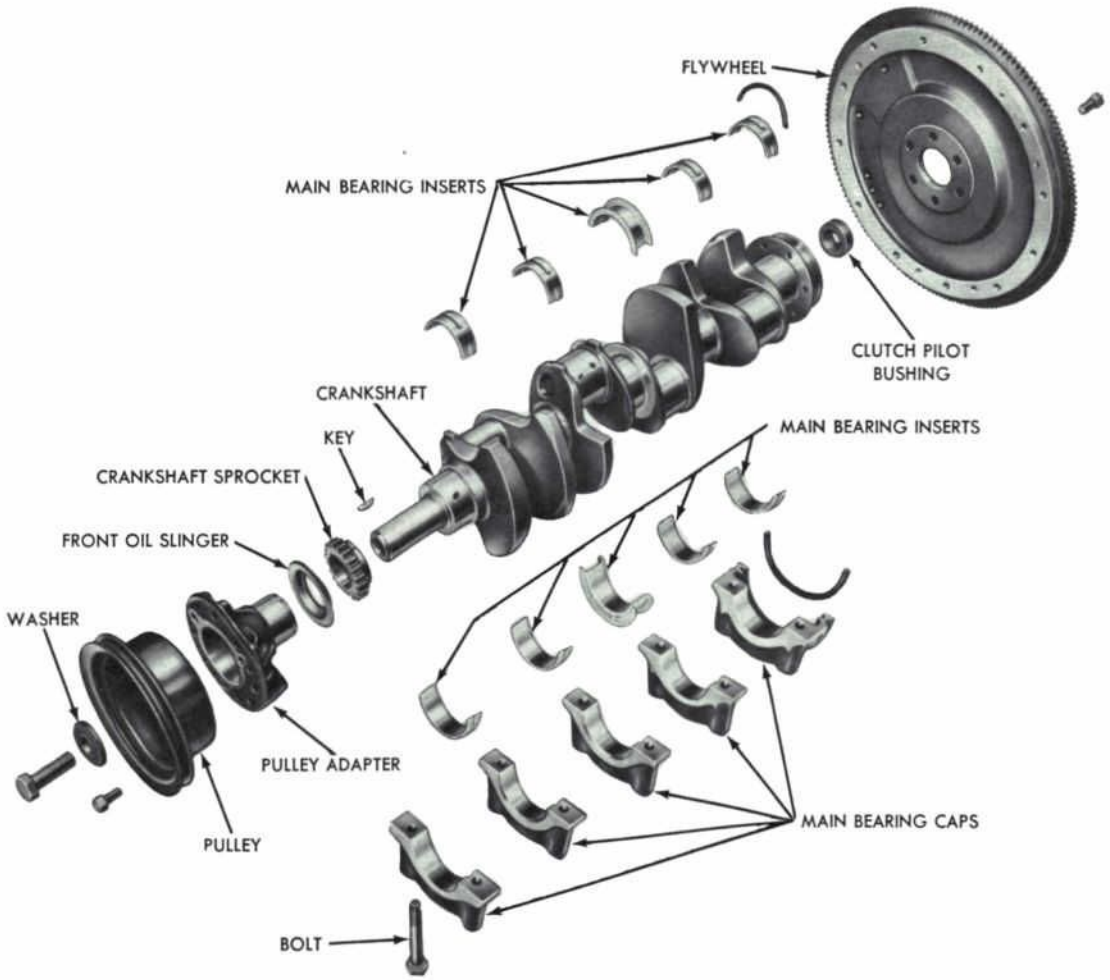


FIG. 53—Crankshaft and Related Parts

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.

3. Place the upper main bearing inserts in position in the bores with the tang fitting in the slot provided. Install the lower main bearing inserts in the bearing caps.

4. Install a new rear journal oil seal in the block (Fig. 54). After installation, cut the ends of the seal flush.

5. Carefully lower the crankshaft into place. **Be careful not to damage the bearing surfaces.** Check the clearance of each main bearing with Plastigage, following the recommended procedure.

6. After the bearings have been fitted, apply a light coating 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. 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.

7. Install the thrust bearing cap with the bolts finger-tight. Pry the crankshaft forward against the thrust surface of the upper half of the bearing (Fig. 55). Hold the crankshaft forward and pry the thrust bearing cap to the rear (Fig. 55). This will align the thrust surfaces of both halves of the bearing. Retain the forward pressure on the crankshaft. Torque the cap bolts to specifications.

8. Force the crankshaft toward the rear of the engine. 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). Zero the dial indicator. Push the crankshaft forward and note the reading on the dial. If the end play exceeds the specified wear limit, replace the thrust bearing. If the end play is less than the specified minimum limit,

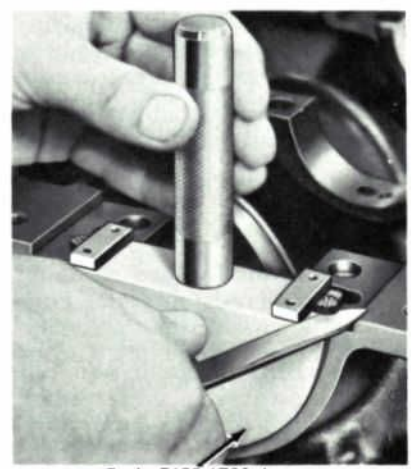


FIG. 54—Seal to Block Installation

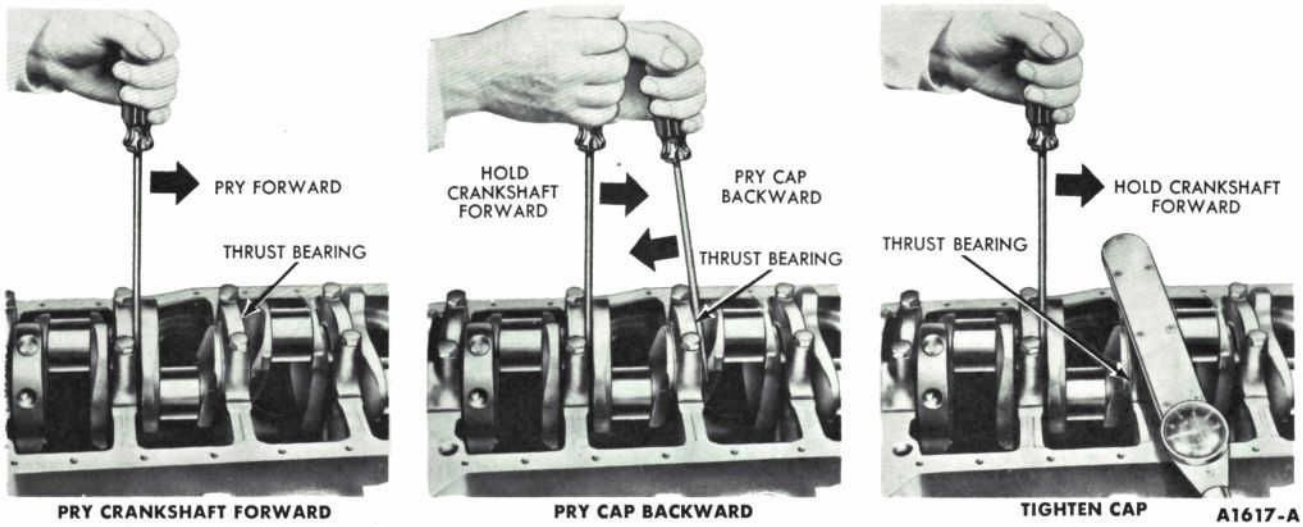


FIG. 55—Thrust Bearing Alignment

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, then recheck the end play to be sure that it is within specifications.

9. Install new bearing inserts in the connecting rods and caps. Check the clearance of each bearing following the recommended procedure. After the connecting rod bearings have been fitted, apply a light coating of engine oil to the journals and bearings. Turn the crankshaft throw to the bottom of its stroke. Push the piston all the way down until the rod bearing seats firmly on the crankshaft journal. Install the connecting rod cap. Torque the retaining nuts to specifications.

10. 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).

11. Clean the oil pan, oil pump, and oil pump screen. Install the oil pump and oil pan.

12. Coat the flywheel retaining bolts with oil resistant sealer. Position the flywheel on the crankshaft. Install the retaining bolts. Torque the bolts to specifications.

On a flywheel for a manual-shift transmission, use a special tool to locate the clutch disc. Install the pressure plate. Tighten the retaining bolts.

13. Install the timing chain and sprockets, cylinder front cover, crankshaft pulley adapter, and crankshaft pulley.

14. Install the oil filter, fuel pump, and connect the fuel lines. Install the generator and mounting bracket. Install the spark plugs, distributor cap, and spark plug wires. Connect the spark plug wires and high tension lead. 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.

REMOVAL

Remove the camshaft, the flywheel, and the crankshaft. Push the pistons to the top of the cylinders. Remove the camshaft rear bearing bore plug. Remove the camshaft bearings (Fig. 57).

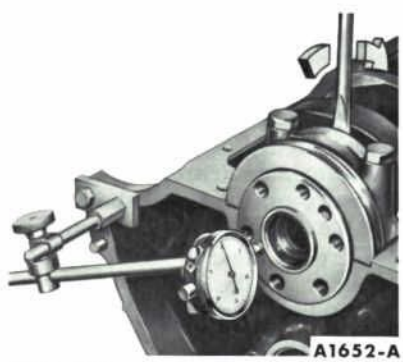


FIG. 56—Crankshaft End Play

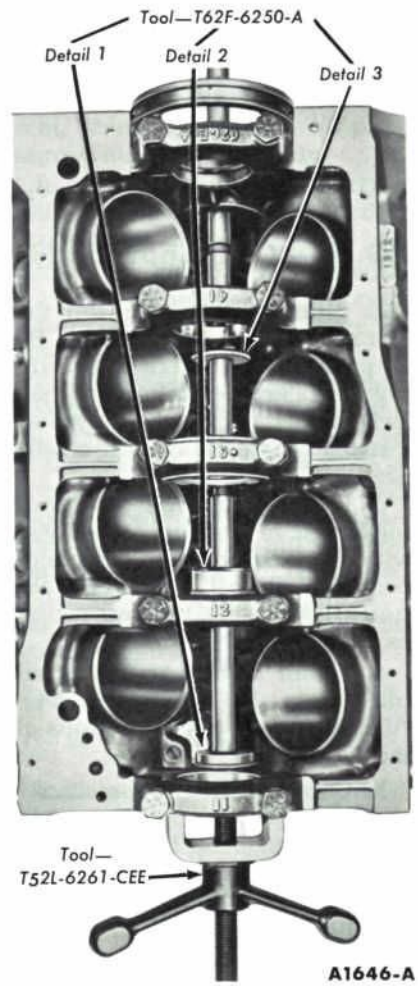


FIG. 57—Camshaft Bearing Replacement

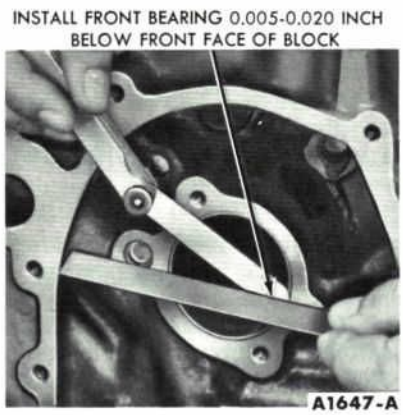


FIG. 58—Camshaft Front Bearing Measurement

INSTALLATION

1. Position the new bearings at the bearing bores, and press them in place with the tool shown in Fig. 57. 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. 58).

2. Clean out the camshaft rear bearing bore plug recess thoroughly. Coat the flange of a new plug with water resistant sealer and install the plug (Fig. 39).

3. Install the camshaft, crankshaft, flywheel, and related parts. Install the engine in the car.

ENGINE DISASSEMBLY

1. Install the engine on the work stand (Fig. 6).

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 and fuel pump outlet line. Remove the fuel pump and discard the gasket. Remove the oil filter.

4. Slide the clamp on the water pump by-pass hose toward the water pump. Remove the automatic choke heat tube. Remove the valve rocker arm covers.

5. Remove the generator and mounting bracket. Remove the ignition coil. Remove the distributor hold down bolt and remove the distributor.

6. Remove the intake manifold retaining bolts. Raise the intake manifold and carefully remove it from the engine. Discard the intake manifold gaskets and seals.

7. Loosen the valve rocker arm stud nuts so that the valve rocker arms can be positioned to one side. Remove the valve push rods in sequence and put them in a rack or holder so that they can be installed in their original locations.

8. Using a magnet, remove the valve lifters and place them in a rack so that they can be installed in their original bores (Fig. 37).

If the valve lifters are stuck in their bores by excessive varnish, etc., it may be necessary to use a plier-type special tool to remove the lifters.

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.

9. Remove the exhaust manifolds and the spark plugs.

10. Install the cylinder head holding fixtures (Fig. 19). Remove the cylinder head bolts and lift the cylinder heads off the block. **Do not pry between the head and the block.** Discard the cylinder head gaskets.

11. Remove the crankshaft pulley from the crankshaft pulley adapter. Remove the cap screw and washer from the end of the crankshaft. Install the puller on the crankshaft pulley adapter (Fig. 28) and remove the adapter.

12. Remove the oil pan to cylinder front cover retaining bolts. Remove the cylinder front cover retaining bolts and remove the cylinder front cover and water pump as an assembly. Discard the gasket and remove the crankshaft front oil slinger.

13. Check the timing chain deflection and remove the timing chain and sprockets. Remove the crankshaft sprocket key.

14. 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.

15. On a flywheel for a manual-shift transmission, remove the clutch pressure plate and disc. Remove the flywheel. Remove the clutch pilot bushing (Fig. 48).

16. Invert the engine. Remove the oil pan and discard the gasket and seals. Remove the oil pump and inlet tube as an assembly. Remove the intermediate drive shaft. Discard the oil pump gasket.

17. **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, then remove the rod cap. Push the connecting rod and piston assembly out of the top of the cylinder with the handle end of a hammer. **Avoid damage to the connecting rod journal or the cylinder wall when removing the piston and rod.**

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

19. Remove the main bearing caps. 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.**

20. Remove the rear journal oil seals from the cylinder block and the rear main bearing cap.

21. Remove the main bearing inserts from the block and bearing caps. Install the main bearing caps in their original locations.

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

23. Remove the camshaft rear bearing bore plug (Fig. 38). Remove the camshaft bearings (Fig. 57).

CYLINDER BLOCK CLEANING AND INSPECTION

CLEANING

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 the passages. Blow out all oil passages, bolt holes, and orifices with compressed air. 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, make a careful check 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 engine 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 flatness of the cylinder block gasket surface.

Replace all expansion type plugs that show signs of leakage.

Inspect the cylinder walls for scoring, roughness, or other signs of wear. Check the cylinder bore for out-of-round and taper by measuring the bore with an accurate gauge, following the instructions of the gauge 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 engine centerline. Refinish cylinders that are deeply scored and/or when out-of-round and/or taper exceeds specified wear limits. If the cylinder walls have minor surface imperfections, but the out-of-round and taper are within specifications, 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 specifications. Use the finest grade of honing stone for this operation.

ENGINE ASSEMBLY

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 into place with the tool shown in Fig. 57. 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. 58).**
4. Clean out the camshaft rear bearing bore plug recess thoroughly. Coat the flange of a new plug with water resistant sealer and install the plug with the flange facing out (Fig. 39). Drive the plug in until it is flush or slightly below the casting surface.
5. Oil the camshaft and apply Lubriplate to all lobes, then carefully slide the camshaft through the bearings.
6. Be sure the rear oil seal grooves are clean. Install a new rear journal oil seal in the cylinder block (Fig. 54). After installation, cut the ends of the seal flush.
7. 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.

8. Install the lower main bearing inserts in the bearing caps.
9. Carefully lower the crankshaft into place. **Be careful not to damage the bearing surfaces.**
10. Check the clearance of each main bearing following the recommended procedure.
11. After the bearings have been fitted, apply a light coating of engine oil to the journals and bearings.
12. Be sure that the oil seal grooves in the rear main bearing cap are clean. Install a new journal seal in the cap (Fig. 41). 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. 41). Do not apply sealer to the area forward of the oil slinger 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.
13. Install the thrust bearing cap and check crankshaft end play following the recommended procedure.
14. Turn the engine on the work stand so that the front end is up.
15. Install the connecting rods and pistons.
16. 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.
17. Lubricate the timing chain and sprockets with engine oil.
18. Install the fuel pump eccentric (Fig. 33), washer, and cap screw. Torque the sprocket cap screw to specifications. Install the crankshaft front oil slinger.
19. Clean the cylinder front cover and the cylinder block gasket surfaces. Install a new crankshaft front oil seal (Fig. 32).
20. Coat the gasket surface of the block and cover, and the cover bolt threads with sealer. Position a new gasket on the block.
21. 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 water pump assembly and pilot over the end of the crankshaft and against the block (Fig. 34).

22. Install the cylinder front cover retaining bolts finger-tight. While pushing in on the pilot, torque the cover bolts to specifications. Remove the pilot.

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

24. Line up the crankshaft pulley adapter keyway with the key on the crankshaft, then install the adapter on the crankshaft (Fig. 35). Install the adapter cap screw and washer. Torque the screw to specifications. Install the crankshaft pulley.

25. Using a new gasket, install the fuel pump.

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

27. Clean the cylinder head and block gasket surfaces. Install the cylinder head gasket over the cylinder head dowels. Place the cylinder head on the engine, then remove the holding fixtures. Coat the cylinder head bolt threads with water resistant sealer, then install the bolts. The cylinder head bolt tightening procedure is performed in three progressive steps. Torque the bolts in sequence (Fig. 22) to specifications. **After the cylinder head bolts have been torqued to specifications, the bolts should not be disturbed.**

28. Coat the mating surfaces of the exhaust manifold with a light film of graphite grease. Position new gaskets over the muffler inlet pipe studs of the exhaust manifolds. 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.

29. Install the spark plugs.

30. Coat the outside of each valve lifter with engine oil to provide initial lubrication. **Do not fill the lifters with oil. The lifters will fill much faster after the engine is started, if they are free of any oil film which may cause an oil seal between the plunger and the lifter body.** Install each lifter in the bore from which it was removed.

31. Install the valve push rods in their original locations. Apply Lubriplate over the valve stem tips, the valve end of the rocker arm and push rod guides in the cylinder head. Install the rocker arms over the push rods. Perform a valve clearance adjustment.

32. Clean the mating surfaces of the intake manifold, cylinder heads, and cylinder block. Coat the intake manifold and cylinder block seal surfaces with oil resistant sealer. Position new seals on the cylinder block and new gaskets on the cylinder heads, with the gasket interlocked with the seal tabs. Be sure the holes in the gaskets are aligned with the holes in the cylinder heads. The correct installation of the gaskets and seals is shown in Fig. 10. Carefully lower the intake manifold on the engine. 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. Be sure the holes in the manifold gaskets and manifold are in alignment, then install the manifold retaining bolts. Working from the center to the ends, torque the bolts to specifications.

33. Install the water pump bypass hose on the coolant outlet housing. Slide the clamp into position and tighten the clamp.

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

35. Install the ignition coil. Position and install the generator and mounting bracket.

36. Clean the valve rocker arm covers and the cylinder head gasket surface. Apply oil resistant sealer to one side of the new cover gaskets. Lay the cemented side of the gaskets in place in the covers. Position the covers on the cylinder heads. Make sure the gasket seats evenly all around the head. Install the valve rocker arm cover retaining bolts. The cover is tightened in two steps. Torque the bolts to specifications. Two minutes later, torque the bolts to the same specifications.

37. Install the automatic choke heat tube. Install the distributor cap. Position the spark plug wires in the brackets on the valve rocker arm covers. Connect the spark plug wires.

38. Connect the carburetor fuel inlet line and pump outlet line.

39. 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.

40. Invert the engine on the work stand. Position the intermediate 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. With the stop properly positioned, insert the intermediate drive shaft into the oil pump. Position a new gasket on the oil pump housing and install the pump and drive 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.** Torque the oil pump retaining screws to specifications.

41. Clean the gasket surface of the block and oil pan. Coat the block surface and the oil pan gasket surface with sealer. Position gaskets on the block. Position a new seal on the cylinder front cover and the rear main bearing cap. Place the oil pan assembly on the block. Install the retaining screws and torque them from the center outward to specifications.

42. Clean the oil filter gasket surface. Coat the gasket on the filter with oil. Place the filter in position in the adapter. Hand tighten the filter until the gasket contacts the adapter face, then advance it 1/2 turn.

43. Install the clutch pilot service bearing (Fig. 49). Coat the retaining bolts with oil resistant sealer. Position the flywheel on the crankshaft and install the retaining bolts. Torque the bolts to specifications.

On a flywheel for a manual-shift transmission, use a special tool to locate the clutch disc. Install the pressure plate.

44. Install the engine in the car. Fill and bleed the cooling system. Fill the crankcase with the proper grade and quantity of engine oil. Operate the engine and check for oil and coolant leaks. Check and adjust the ignition timing. Connect the distributor vacuum line at the distributor. Adjust the engine idle speed, idle fuel mixture, and anti-stall dashpot (if applicable). Adjust the transmission throttle linkage.

PART 3

SPECIFICATIONS AND SPECIAL TOOLS

SERVICE SPECIFICATIONS AND SPECIAL TOOLS

SPECIAL TOOLS

T62F-6085 ..... Cylinder Head Holding Fixture and Engine Lifting Bracket
T62F-6316-B (Screw) } ..... Crankshaft Pulley
T58P-6316-A (Plate) } Adapter Remover
T61P-6019-B ..... Cylinder Front Cover Pilot
T52L-6306-AEE .... Crankshaft Sprocket and Crankshaft Pulley Adapter Replacer
T58P-6700-B ..... Cylinder Block Front Cover Oil Seal Replacer
T62F-6266-A (Adapter) } ..... Camshaft Bearing Bore
T53L-200-A (Handle) } Plug Replacer
T62F-6701-A . Crankshaft Rear Bearing Seal Replacer
T60K-6135-A.. Piston Pin Remover and Replacer Press
T53L-300-A ..... Engine Lifting Sling
T52L-6261-CEE (Puller) } ..... Camshaft Bearing
T62F-6250-A } Remover and Replacer
Detail 1, 2, and 3 (Adapter)
T62F-6565-A ..... Valve Spring Compressor
T52T-6500-DJD ..... Valve Lifter Remover
T58L-101-A ..... Camshaft Rear Bearing Bore Plug Remover
6331 ... Upper Main Bearing Remover and Replacer
6149-A ..... Piston Ring Compressor
T52L-6110-AAD ..... Piston Ring Groove Cleaner
T59L-100-B ..... Clutch Pilot Bushing Puller
T52T-12175-AJD ..... Clutch Pilot Bushing Installer
T58P-7563-A ..... Clutch Disc Locating Tool

GENERAL

Piston Displacement	221 Cu. In.
Compression Ratio	8.7:1
Bore and Stroke	3.50 x 2.87
Taxable Horsepower	39.2
Firing Order	1-5-4-2-6-3-7-8
Engine Idle rpm	
Manual-Shift Transmission	500-525
Automatic Transmission (Drive Range)	475-500
Engine Idle Manifold Vacuum	
Minimum Inches of Mercury @ Specified Engine Neutral Idle rpm (Sea Level)	16
Oil Capacity*	4
*Add one quart extra when changing oil filter.	
Oil Pressure—Hot @ 2000 rpm	35-55 psi
Fuel Requirements †	Regular
†Minimum Octane Required	85

CYLINDER HEAD

		WEAR LIMIT
Gasket Surface Flatness	0.003-inch in any 6 inches 0.006-inch overall	—
Valve Guide Bore Diameter	0.3115-0.3125	NA
Valve Seat Width	0.060-0.080	NA
Valve Seat Angle	45°	NA

VALVE MECHANISM

VALVE LASH WITH LIFTER BLEED CAM		
Intake and Exhaust	0.082-0.152	
VALVE STEM DIAMETER		
(Standard)	0.3100-0.3107	
0.003 Oversize	0.3130-0.3137	
0.015 Oversize	0.3250-0.3257	
0.030 Oversize	0.3400-0.3407	
VALVE FACE ANGLE		
Intake and Exhaust	44°	
VALVE STEM TO VALVE GUIDE CLEARANCE		
Intake	0.0008-0.0025	0.0045
Exhaust	0.0018-0.0035	0.0055
VALVE HEAD DIAMETER		
Intake	1.582-1.597	
Exhaust	1.381-1.396	
Valve Face Runout—Intake and Exhaust	0.0015	0.002
Valve Spring Free Length—Approximate	$2\frac{5}{32}$	
Valve Spring Out-of-square—Maximum	$\frac{1}{16}$	
Valve Spring Pressure—lbs @ Specified Length (Closed)	57-63 @ 1.770	52 @ 1.770
Valve Spring Pressure—lbs @ Specified Length (Open)	161-178 @ 1.380	145 @ 1.380
Valve Spring Assembled Height	$1\frac{3}{4}$-$1\frac{25}{32}$	
Valve Push Rod Runout—Maximum	0.015	NA
Valve Lifter Leak Down Rate	10-80 Seconds	
Valve Lifter Diameter	0.8740-0.8745	
Valve Lifter to Bore Clearance	0.0005-0.0020	0.005

CAMSHAFT AND TIMING CHAIN

Camshaft Journal Diameter...#1	2.0805-2.0815
...#2	2.0655-2.0665
...#3	2.0505-2.0515
...#4	2.0355-2.0365
...#5	2.0205-2.0215

CAMSHAFT AND TIMING CHAIN (Continued)

		WEAR LIMIT
Camshaft Journal to Bearing Clearance	0.001-0.003	0.006
Camshaft Journal Maximum Out-of-Round	0.0005	0.001
Timing Chain Maximum Deflection	0.5	
Camshaft Lobe Lift—Intake and Exhaust	0.2375	0.2325
Camshaft End Play	0.003-0.007	0.012

CAMSHAFT BEARING

Inside Diameter (Assembled)..#1	2.0825-2.0835
..#2	2.0675-2.0685
..#3	2.0525-2.0535
..#4	2.0375-2.0385
..#5	2.0225-2.0235

No. 1 bearing is installed with the front edge 0.005-0.020-inch inside the front face of the cylinder block.

CRANKSHAFT

		WEAR LIMIT
MAIN BEARING JOURNAL DIAMETER		
Coded Red	2.2486-2.2490	
Coded Blue	2.2482-2.2486	
Main Bearing Journal Maximum Runout	0.002	0.003
CONNECTING ROD AND MAIN BEARING JOURNALS		
Maximum Out-of-Round	0.0004	0.0006
Maximum Taper	0.0003 per inch	0.0010
Thrust Bearing Journal Length	1.137-1.139	
Main Bearing Journal Thrust Face Runout	0.001	NA
CONNECTING ROD JOURNAL DIAMETER		
Coded Red	2.1236-2.1240	
Coded Blue	2.1232-2.1236	
CRANKSHAFT FREE END PLAY		
End Play	0.004-0.008	0.012
Assembled Flywheel Clutch Face Maximum Runout	0.010	NA
Assembled Flywheel OD Maximum Runout	0.007	NA

CONNECTING ROD

		WEAR LIMIT
Piston Pin Bushing ID	0.9107-0.9112	
BEARING BORE DIAMETER		
Coded Red	2.2390-2.2394	
Coded Blue	2.2394-2.2398	
Bearing Bore Out-of-Round and Taper—Maximum	0.0004	NA
Connecting Rod Length—Center to Center	5.1535-5.1565	
CONNECTING ROD TWIST		
Maximum Total Difference	0.012	
CONNECTING ROD BEND		
Maximum Total Difference	0.004	
CONNECTING ROD ASSEMBLY—Assembled to Crankshaft		
Side Clearance	0.006-0.016	0.019

CONNECTING ROD BEARING

Bearing to Crankshaft Clearance	0.0009-0.0025	0.0035

PISTON, PISTON PIN, AND PISTON RINGS

		WEAR LIMIT
PISTON DIAMETER		
Color Coded Red	3.4976-3.4982	
Color Coded Blue	3.4988-3.4995	
0.003 Oversize	3.5000-3.5006	
Piston To Bore Clearance—Bottom of Skirt	0.0018-0.0036	0.006
Piston Pin Diameter—Standard	0.9120-0.9123	
Piston Pin Length	3.010-3.030	
Piston Pin to Piston Clearance—Select Fit	0.0001-0.0003	0.0008
PISTON RING WIDTH		
Compression Ring Upper	0.0774-0.0781	
Compression Ring Lower	0.0770-0.0780	
PISTON RING SIDE CLEARANCE		
Compression Ring Upper	0.0019-0.0036	NA
Compression Ring Lower	0.002-0.004	0.006
Oil Ring	Snug	
PISTON RING GAP WIDTH		
Compression Ring—Standard Bore—Upper and Lower	0.010-0.020	
Oil Ring—Standard Bore	0.015-0.055 (Rail)	

CYLINDER BLOCK

		WEAR LIMIT
CYLINDER BORE DIAMETER		
Standard Bore	3.5000-3.5024	
0.003 Oversize	3.5024-3.5036	
CYLINDER BORE OUT-OF-ROUND		
Maximum Out-of-Round	0.001	0.003
CYLINDER BORE TAPER		
Taper	0.001	0.005
MAIN BEARING BORE DIAMETER		
Coded Red	2.4412-2.4416	
Coded Blue	2.4416-2.4420	
Head Gasket Flatness	0.003-inch in any 6 inches 0.006-inch overall	

WATER PUMP

		WEAR LIMIT
Pump to Engine Ratio	1.05:1	
Impeller to Housing Clearance	0.030-0.050	NA
Pulley or Pulley Hub to Housing Face Dimension	5.160	

OIL PUMP

		WEAR LIMIT
Relief Valve Spring Tension Lbs @ Specified Length	11.15-11.75 @ 1.704	NA
Relief Valve Clearance	0.0015-0.0029	NA
Drive Shaft to Housing Bearing Clearance	0.0015-0.0029	NA
Rotor Assembly End Clearance—Pump Installed	0.0011-0.0041	NA
Outer Race to Housing Radial Clearance	0.006-0.012	NA

THERMOSTAT

Start to Open °F—	
Low Temperature Thermostat	155°-162°
Fully Open—Low Temperature Thermostat	182°
Start to Open °F—	
High Temperature Thermostat	174°-181°
Fully Open—High Temperature Thermostat	201°

DRIVE BELT TENSION

WATER PUMP PULLEY AND GENERATOR—Pounds	
New	90-120
Reset	60-90
CRANKSHAFT AND POWER STEERING PUMP PULLEY—Pounds	
New	120-150
Reset	90-120
AIR CONDITIONER COMPRESSOR PULLEY AND FAN PULLEY	
New	120-150
Used	90-120

TORQUE LIMITS—Ft-lbs

Main Bearing Cap Bolts—Oiled Threads	65-75
Cylinder Head Bolts—Oiled Threads	65-70
Oil Pan To Cylinder Block	5/16-18, 9-11
	1/4-20, 7-9
Flywheel to Crankshaft	75-85
MANIFOLDS TO CYLINDER HEADS	
Intake	12-15
Exhaust	13-18
Oil Pump to Cylinder Block	23-28
Oil Pan Drain Plug	15-20
Oil Pump Cover Plate	6-9
Oil Filter Adapter to Cylinder Block	60-100

TORQUE LIMITS—Ft.-lbs. (Continued)

OIL FILTER TO ADAPTER—Hand tighten until gasket contacts adapter face, then advance ½ turn.	
Cylinder Front Cover	12-15
Water Outlet Housing	12-15
Camshaft Sprocket to Camshaft	30-35
Crankshaft Pulley to Crankshaft	70-90
Connecting Rod Nuts	19-24
Camshaft Thrust Plate to Block	6-9
Valve Rocker Arm Cover	3-5
Valve Rocker Arm Adjusting Nut	4.5-10
Fuel Pump to Cylinder Front Cover	23-28
No. 2 Crossmember to Underbody	26-34
ENGINE FRONT SUPPORT	
Support Bracket to Engine	29-39
Insulator Assembly to Support Bracket	15-21
Support Bracket to Body Bracket	41-53
Mounting Bracket to Underbody	26-34
ENGINE REAR SUPPORT	
Insulator to Transmission—Extension	32-42
Insulator to Rear Support	10-15
Rear Support to Mounting Bracket	41-53
Mounting Bracket to Underbody	41-53
Water Pump to Front Cover or Cylinder Block	12-15
Oil Pick-up Tube to Oil Pump	12-15
Crankcase Ventilation Tube to Engine	6-9

TORQUE LIMITS FOR VARIOUS SIZE BOLTS

CAUTION: **If any of the torque limits listed in this table disagree with any of those listed in the preceding tables, the limits listed in the preceding tables prevail.**

Size (Inches)	1/4-20	1/4-28	5/16-18	5/16-24	3/8-16	3/8-24
Torque (Ft-lbs)	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 (Ft-lbs)	45-50	50-60	60-70	70-80	85-95	130-145

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