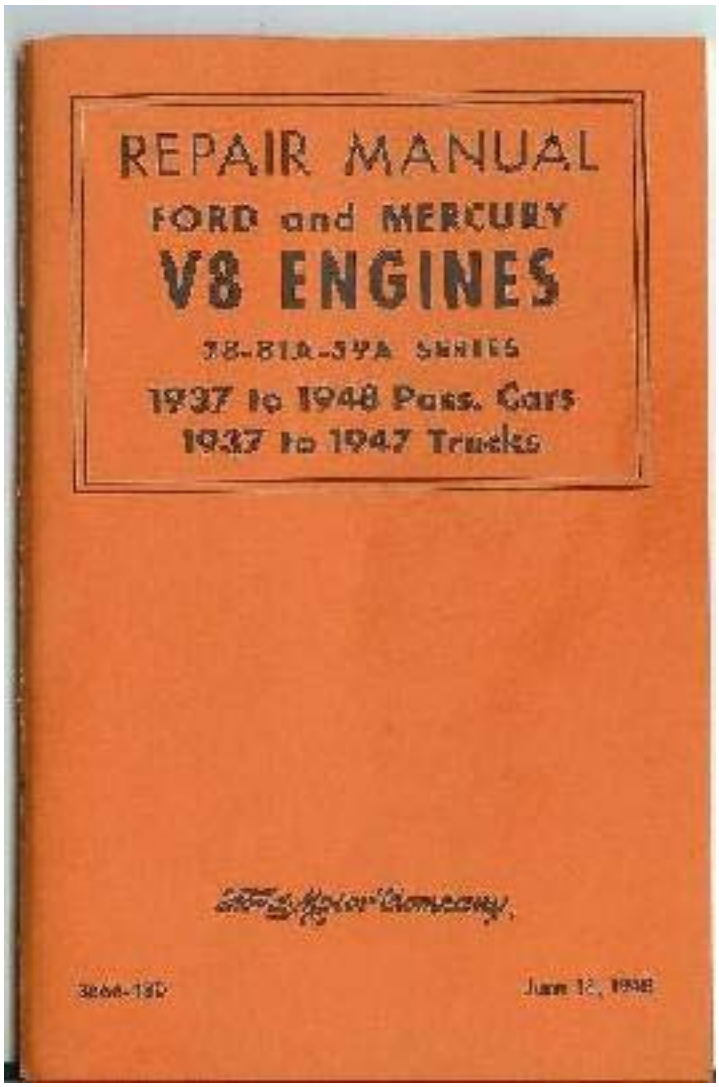
REPAIR MANUAL
FORD and MERCURY
V8 ENGINES
38-81A-39A SERIES
1937 to 1948 Pass. Cars
1937 to 1947 Trucks
Ford Motor Company
3866-1SD
June 12, 1948

FOREWORD

This book contains information and instructions for the overhaul or repair of the Ford and Mercury V-8 engines (except 60 H.P.) built during 1937 through 1948 inclusive. Due to the differences in the various models of cars and trucks using these engines, no attempt has been made in this book to cover the procedures necessary to remove the engine from the vehicle. The instructions and procedures start with the engine already removed from the vehicle.

This book applies to any of these engines, since their construction is identical except for sizes. Each Chapter is divided into sections as shown in the Table of Contents. Chapter IV gives fits, tolerances, and wear limits in tabulated form. Maximum clearances are included since it is possible for two parts, either of which is satisfactory for further use when considered alone, to have excessive clearance when used together.

Throughout this book, on the first page of each Chapter, a list of the major subjects in the Chapter is given, each with an assigned section number.

In the Inspection and Repair Chapter, each section contains complete inspection instructions, with wear limits which clearly point out when a part should be reworked or replaced.

Numbers appearing in the various illustrations in bold type are basic part numbers. When ordering parts from your authorized dealer by these numbers, specify the year and model number of the vehicle.

This book is intended to be used as a guide for anyone working on any of these engines, and it gives procedures for the complete repair of the engine. Where limited repairs only are to be made, follow just those portions of the book that apply to the particular engine being worked on. This is a Repair Manual rather than a Reconditioner's Manual, and some acceptable repair practices would not be acceptable reconditioning practices. In this book the word "repair" is used to indicate "restore to good working condition" and not to a "like new" condition.

FORD MOTOR COMPANY
Service Department

3666-48D

CONTENTS

3666-48D

112. ACCESSORY REMOVAL.

The first step in the disassembly of the engine is the removal of the accessories.

a. Remove Carburetor. Loosen the clamp screw at the bottom of the air cleaner and lift the cleaner from the carburetor (fig. 1). Disconnect and remove the fuel line from the carburetor and fuel pump. Remove the three nuts and washers that hold the carburetor to the intake manifold, and remove the carburetor from the intake manifold.

b. Remove Fuel Pump. Remove the two nuts and flat washers that hold the fuel pump and its adapter to the intake manifold and remove the fuel pump and adapter as a unit from the intake manifold (fig. 1). Lift out the fuel pump push rod from the intake manifold.

c. Remove Fans. Two types of fans have been used; bracket mounted fans and pulley mounted fans. The procedure for their removal is contained in subparagraphs (1) and (2) below.

(1) *BRACKET MOUNTED FANS.* On engines having the fan attached to the generator mounting bracket, remove the two fan pulley nuts and washers that hold the fan and pulley assembly to the generator mounting bracket, and remove the fan belt and fan and pulley assembly from the generator mounting bracket.

(2) *PULLEY MOUNTED FANS.* On engines having the fan attached to the crankshaft pulley or the generator pulley, remove the cap screws that hold the fan to the pulley and remove the fan from the pulley.

d. Remove Generator. Remove the generator support bracket nut from the stud and remove the generator belt from the generator. Remove the generator from the intake manifold.

e. Remove Spark Plug Wires and Conduits and Spark Plugs. Remove the spark plug wires from the spark plugs. Remove the cap screws that hold each spark plug wire conduit to the intake manifold (fig. 3). Remove the distributor cap bail from each cap and remove the caps from the distributor. On the one-cap type distributor, release the clips from the cap, and remove the cap. Remove the

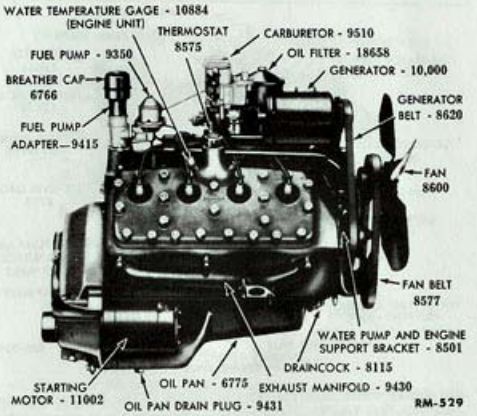

Fig. 2—Engine, Right Side View

spark plug wires and conduits from the intake manifold. Remove the eight spark plugs.

f. Remove Distributor and Coil. Two types of distributors have been used; the one-cap type and the two-cap type.

(1) *ONE-CAP TYPE DISTRIBUTOR.* Disconnect all wires from the coil (fig. 3). Remove the two cap screws that hold the coil to the coil bracket on the intake manifold, and remove the coil from the bracket. Remove the two cap screws that hold the distributor to the cylinder front cover, and remove the distributor.

(2) *TWO-CAP TYPE DISTRIBUTOR.* Disconnect the wire from the coil. Disconnect the vacuum line from the distributor. Remove the three cap screws that hold the distributor to the cylinder front cover, and remove the distributor.

g. Remove Oil Filter. Disconnect the oil return line and oil intake line from the oil filter (fig. 3). Remove the three nuts that hold the filter to the cylinder head, and remove the filter.

h. Remove Starting Motor. Remove the cap screw which secures the starting motor bracket to the oil pan. Loosen the two

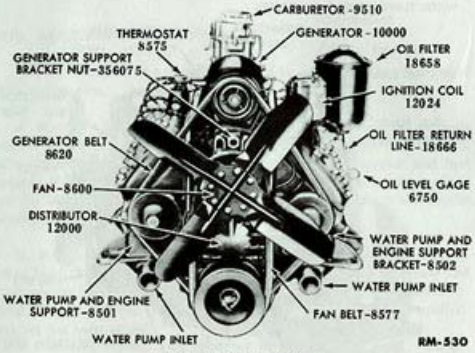

Fig. 3—Engine, Front View

cap screws which hold the starting motor to the flywheel housing until they are free from the housing. Remove the starting motor.

i. Remove Intake Manifold. Remove the cap screws that hold the intake manifold to the cylinder block, and remove the intake manifold (fig. 4).

j. Remove Water Pumps. Remove the four cap screws that hold each water pump to the cylinder block, and remove the water pumps from the cylinder block.

NOTE: *One of these screws is accessible for removal through the pump inlet opening.*

k. Remove Oil Pan. Remove the cap screws from the oil pan, and remove the oil pan from the cylinder block.

l. Remove Pressure Plate and Clutch Disk. Press the end of one clutch release lever down, and insert a wooden block approximately $\frac{3}{8}$ inch thick between the lever and the pressure plate. Repeat this operation for each lever. This will relieve the tension on the pressure plate (fig. 61). Remove the cap screws from the pressure plate cover, and remove the pressure plate and clutch disk from the flywheel.

NOTE: *On liquamatic drive engines, the pressure plate and clutch disk are removed from the fluid coupling in the same manner.*

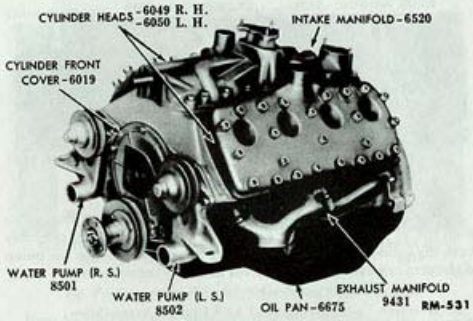

Fig. 4—Engine, Stripped

m. Remove Flywheel. Remove the lock wire, cap screws, and flywheel dowel retainer from the flywheel. Using a soft hammer, lightly tap the flywheel on first one side and then the other until it comes loose from the crankshaft. Lift the flywheel from the crankshaft.

NOTE: *On liquamatic drive engines, the fluid coupling is removed from the crankshaft flange by removing the screws located between the coupling and cylinder block.*

113. ENGINE DISASSEMBLY.

This section contains instructions for the complete disassembly of the stripped engine.

a. Remove Cylinder Heads. Remove the nuts from each cylinder head, and remove each cylinder head and gasket from the cylinder block (fig. 4). To remove cylinder heads that have become corroded to the studs, remove the studs that are corroded, using a stud puller that does not injure the threads on the studs (fig. 5).

b. Remove Cylinder Front Cover. Remove the cap screws that hold the cylinder front cover to the cylinder block, and remove the front cover from the cylinder block (fig. 4).

c. Remove Exhaust Manifolds. Remove the cap screws that hold each exhaust manifold to the cylinder block and remove the two manifolds (fig. 4).

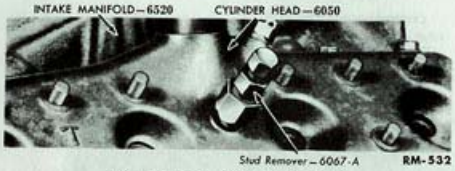

Fig. 5—Removing Cylinder Head Stud

d. Remove Oil Pump. Remove the lock wire and cap screw from the oil pump mounting flange, and remove the pump assembly from the cylinder block (fig. 6). It may be necessary to jar the pump slightly to remove it from its recess in the cylinder block.

e. Remove Connecting Rod and Piston Assemblies.

NOTE: *If a deep ridge is present at the top of the cylinder bores, it should be removed before attempting to remove pistons.*

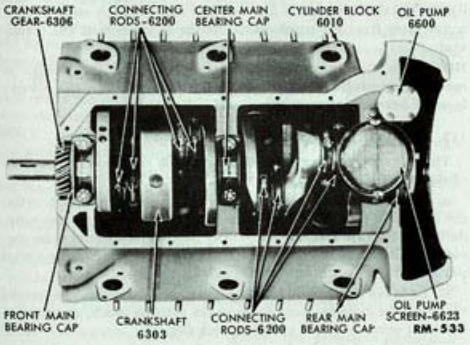

Fig. 6—Under Side of Engine With Oil Pan Removed

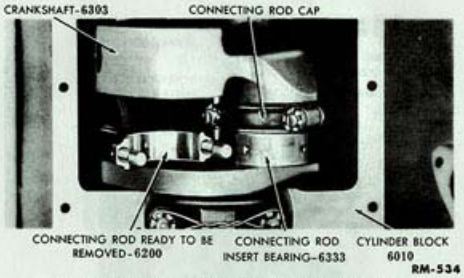

Fig. 7—Connecting Rod and Piston Ready to be Removed

Remove the two cotter pins and nuts from the connecting rod. Tap on the connecting rod bolt with a brass hammer until the connecting rod cap is free from the connecting rod. Lift the cap off the connecting rod. Push the piston and connecting rod out of the cylinder block, using a hammer handle, being careful that the connecting rod bolts do not scratch the bearing (fig. 7). Remove the connecting rod bearings. As each bearing is removed, install a small piece of masking tape at the forward end of each half, numbering the bearing removed from the front crankpin number 1, the second bearing number 2, etc., (fig. 8). This will permit the bearings to be reinstalled in the same way and on the same crankpin during reassembly, if they are to be reused.

Fig. 8—Identification Marks on the Connecting Rod Bearings

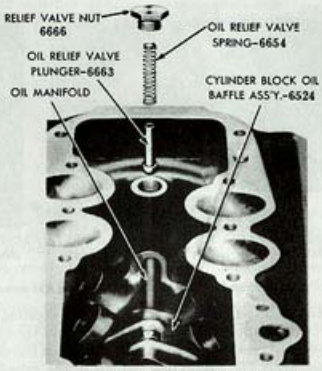

Fig. 9—Oil Relief Valve, Disassembled

f. Remove Oil Pump Drive Cover and Idler Gear. Remove the lock wire and the cap screws that hold the oil pump drive cover to the cylinder block. Remove the oil pump drive cover, gasket, and oil pump idler gear from the cylinder block.

g. Remove Oil Baffles. Place a screwdriver under each of the oil baffles and pry its mounting clamp off the oil manifold. Remove the two oil baffle assemblies from the cylinder block (fig. 9).

h. Remove Valve Assemblies and Push Rods. Insert the valve lifter in the notches in the valve guide bushing and pull the valve guide bushing down as shown in fig. 10, and remove the valve guide retainer. Repeat the above operation on all the valves that are in a closed position. Turn the crankshaft until all the valves that were open are closed. Repeat the above procedure and remove the remaining valve guide retainers.

NOTE: ***If the valve guide bushings are tight in the block and cannot be pulled down with the valve lifter, compress the valve spring with the lifter and remove the spring retainer from the valve stem. Raise the valve up and, using a driver that drives the two halves of the bushing straight down, drive the bushings***

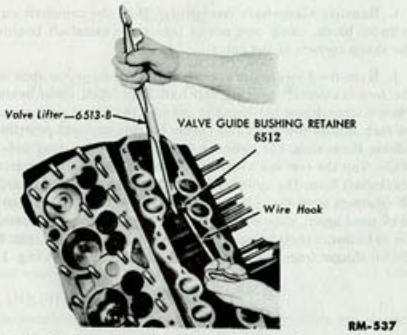

Fig. 10—Removing Valve Guide Bushing Retainer

down until the retainer can be removed from the bushing. The valve and bushing assembly can then be removed from the block with a bar-type valve lifter.

As the valves are removed, tag or otherwise identify them as to the cylinders and valve port from which they were removed. Lift the push rods from the cylinder block and tag or otherwise identify them as to the cylinder and push rod bore from which they were removed.

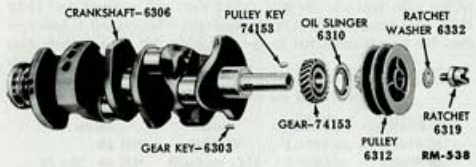

Fig. 11—Crankshaft Assembly, Disassembled

i. Remove Camshaft Assembly. Slide the camshaft out of the cylinder block, using care not to injure the camshaft bearings with the sharp corners of the cams.

j. Remove Crankshaft Assembly. Remove the lock wire and the two crankshaft bearing cap nuts from each main bearing cap. Place a screwdriver between the cylinder block and the boss provided on each side of the front and center bearing cap and pry the caps to release them from the cylinder block. Lift the bearing caps off the studs. Tap the rear main bearing cap off with a soft hammer. Lift the crankshaft from the cylinder block. Remove the main bearings and oil retainers from the cylinder block (fig. 6). If the main bearings are to be used again, they must be marked upon removal in such a manner as to insure their being reassembled in the same positions. Remove the oil slinger from the forward end of the crankshaft (fig. 11).

Chapter

II

INSPECTION AND REPAIR

121. CRANKSHAFT AND FLYWHEEL.

The disassembled crankshaft and flywheel assemblies are shown in figs. 11 and 13.

a. Crankshaft. Thoroughly clean the crankshaft, including clean out all the drilled holes in the journals with a rifle brush or a piece of wire. Replace the crankshaft flange dowels if they are damaged. Replace a crankshaft gear that has chipped, broken or worn teeth (subpar. (2) below). If the main journals or the crankpin journals are grooved or scored, the crankshaft must be replaced or remachined (subpar. (1) below). Light scores or scratches can be honed, then polished with No. 320 grit polishing paper. Measure each journal diameter at at least four places to determine size, out-of-round, and taper. Remachine any journals that are out-of-round more than 0.0015 inch. Remachine journals that taper more than 0.001 inch (subpar. (1) below). Journals that are worn evenly with less than 0.001 inch taper or less than 0.0015 inch out-of-round need not be reground if the available bearings will provide not more than 0.003 inch clearance for the main bearings or not more than 0.005 inch clearance for the crankpin bearings.

(1) *REMACHINING.* The original maximum diameter of crankshaft journals for the various engines are as follows:

MODEL	YEAR	MAIN JOURNALS	CRANKPIN JOURNALS
85 HP	1937-38	2.3990 in.	1.9990 in.
85 and 90 HP	Starting 1939	2.4990 in.	1.9990 in.
95 and 100 HP	Starting 1939	2.4990 in.	2.1390 in.

Subtract the amount of undersize of the bearings to be used from the

Fig. 12—Removing Crankshaft Gear

original size (shown above) and remachine the crankshaft by grinding to this new size, then polish with #320 grit polishing paper, removing not more than 0.0009 inch from the diameter.

(2) *CRANKSHAFT GEAR REPLACEMENT.* Remove the crankshaft gear with a puller that pulls the gear evenly (fig. 12). Remove the crankshaft gear Woodruff key. To install the crankshaft gear, tap the crankshaft gear Woodruff key into the crankshaft, and press the gear on the crankshaft.

b. Flywheel. Wash the flywheel thoroughly. Replace or reface a flywheel (fig. 13) that has an excessively worn or scored friction face. Replace a flywheel ring gear that is cracked, chipped or has excessively worn teeth (subpar. (1) below). Replace the clutch pilot bearing if it is excessively worn or does not revolve freely and smoothly (subpar. (2) below).

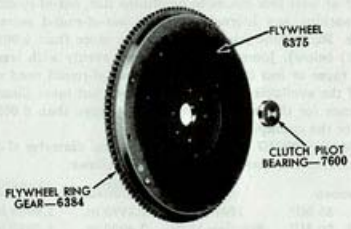

Fig. 13—Flywheel and Clutch Pilot Bearing (Truck)

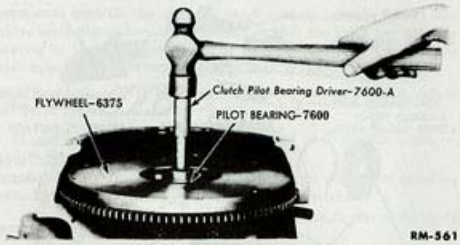

Fig. 14—Replacing Pilot Bearing

NOTE: ***If the engine is equipped with liquamatic drive, it will be necessary to replace the fluid coupling unit if it leaks oil or if the ring gear is damaged. If the clutch friction surface on the flywheel is worn or scored, the flywheel must be replaced or refaced.***

(1) *FLYWHEEL RING GEAR REPLACEMENT.* Drill a $^{17}/_{32}$-inch hole nearly through the flywheel ring gear on the engine side of the gear. Hit the remaining portion of the ring gear with a chisel until it separates and lift the ring gear off the flywheel. Clean the ring gear recess on the flywheel. Heat the ring gear evenly to 360°F. and place it on the cold flywheel, making sure it is firmly seated in the recess of the flywheel.

(2) *REFACE FLYWHEEL.* Remove just enough material from the clutch friction surface to obtain a smooth flat surface parallel with the flywheel mounting flange. The same amount of material must also be removed from that portion of the flywheel to which the clutch pressure plate is attached. If the thickness of the flywheel, measured between the friction surface and the flywheel mounting flange, is reduced to less than 0.855 inch in order to obtain a smooth flat surface, the flywheel must be discarded.

NOTE: ***The flywheel used in connection with liquamatic drive can also be refaced if required, providing its thickness is not reduced more than 0.015 inch.***

(3) *PILOT BEARING REPLACEMENT.* Drive the pilot bearing out of the flywheel (figs. 13 and 14). Install the pilot bearing with the open side of the bearing toward the engine side of the flywheel, using a driver (fig. 14) that applies pressure to the outer race of the bearing.

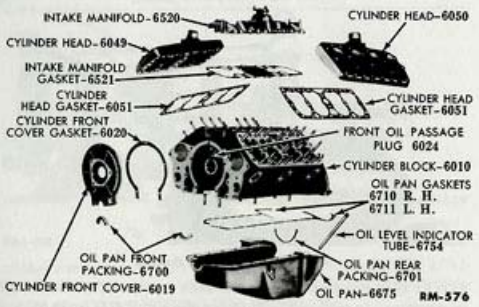

Fig. 15—Cylinder Block, Heads, Intake Manifold, Oil Pan, Front Cover and Seals, and Oil Level Gauge Tube

122. CYLINDER BLOCK.

Strip off the old gaskets from all the surfaces of the cylinder block. Remove the oil relief valve nut, spring, and valve from the cylinder block (fig. 9). Remove the two oil passage plugs, one at the front (fig. 15) and one at the rear end of the cylinder block. Run a rifle brush or a ¼-inch rod through the oil manifold to loosen any carbon or sludge that might have collected in the oil manifold. Blow out the oil manifold passages with compressed air. Coat the oil passage plug threads with thread sealer and install them in the block.

NOTE: ***Do not coat the threads in the block with sealer.***

a. Inspection. After the cylinder block has been thoroughly cleaned, inspection should cover the following seven procedures:

(1) *CRACKS.* If the valve springs in the block are corroded or rusted or there is an excessive amount of sludge in the valve chamber, it is an indication that the block might be cracked and should be checked thoroughly. Check the block at the flywheel housing for cracks around the dowel pins. Replace the block if it is cracked.

(2) *STUDS.* Replace damaged or broken studs (par. e below).

(3) *CAMSHAFT BEARINGS.* Replace the camshaft bearings if they are scored or if the inside diameters of the bearings measure more than 1.7985 inches (par. f below).

(4) *VALVE SEATS.* Replace any valve seat insert that is cracked

or that is loose in the cylinder block (par. g below). Reface any valve seats where there is any indication that the valve has not been seating or if new guides are to be installed or if the width of the seat measures more than 0.125 inch (par. h below).

NOTE: ***If the engine has been completely disassembled, reface all valve seats.***

(5) *CYLINDER BORES.* Inspection of the cylinder bores involves four accurate measurements.

(*a*) MEASUREMENTS. The fastest, accurate method of checking cylinders is with a telescope gauge and micrometer.

(*1*) Measure the diameter of the cylinder lengthwise of the block at the deepest point of the ring wear.

(*2*) Measure the diameter of the cylinder lengthwise of the block at the bottom of the cylinder.

(*3*) Measure the diameter of the cylinder crosswise of the block at the deepest point of the ring wear.

(*4*) Measure the diameter of the cylinder crosswise of the block at the bottom cylinder.

(*b*) DIAGNOSIS. An accurate diagnosis of the cylinder bore must take into account taper, out-of-round, and wear.

(*1*) TAPER. A comparison of readings (1) with (*2*) and a comparison of (*3*) with (*4*) above will indicate the taper. If the taper exceeds 0.006 inch, rebore the cylinder to the next oversize for which pistons are available.

(*2*) OUT-OF-ROUND. A comparison of the readings (*1*) with (*3*) and a comparison of (*2*) with (*4*) will indicate the out-of-round of the cylinders. If the cylinder is out-of-round 0.003 inch and a true cylinder wall cannot be obtained by honing to 0.005 inch oversize, the cylinder must be rebored and honed to the correct size for the oversize pistons which are available.

(*3*) WEAR. A comparison of readings (*1*) or (*2*) with the original diameter of the cylinder will establish the amount of wear. Standard or rebored cylinders having from 0.003 inch to 0.005 inch wear must have the ridge at the top of the cylinders removed, and must be honed or rebored to the correct size for the available oversize pistons. If cylinders are worn more than 0.005 inch, the cylinder block must be rebored and honed to the correct size for the available oversize pistons. If the cylinder walls are excessively worn or scored and a true cylinder wall cannot be obtained to accommodate the largest oversize piston available, cylinders can be rebored to accommodate a cast-iron sleeve (par. e below).

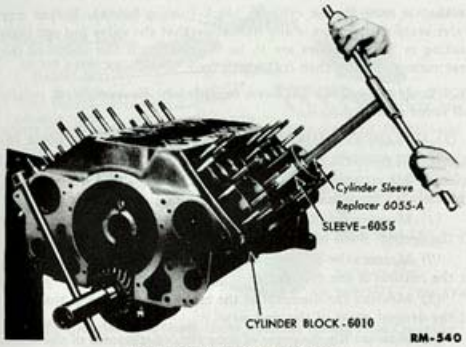

Fig. 16—Installing Cylinder Sleeve

(6) *OIL RELIEF VALVE.* If the oil pump to be used with the engine is not equipped with a relief valve (fig. 41), replace the cylinder block relief valve spring if its tension is less than 43 ounces or more than 50 ounces when the length of the spring is compressed to 1.380 inches. Install the valve, spring, and the valve nut in the cylinder block.

If the oil pump to be used with the engine is equipped with a relief valve (fig. 42), replace the cylinder block relief valve spring if its tension is less than 78 ounces or more than 87 ounces when the length of the spring is compressed to 1.380 inches. Install the valve, spring, and valve nut in the cylinder block.

(7) *FUEL PUMP PUSH ROD BUSHING.*

NOTE: ***These bushings wear out-of-round, and should a bushing wear through, it will permit oil to escape from the main oil passage, making it almost impossible to build up or maintain sufficient oil pressure.***

Check the bushing for wear, using a new fuel pump push rod as a gauge. While the clearance at this point is not critical, if the bushing is worn excessively, it must be replaced (par. i below).

b. Steel Sleeve Replacement. Remove the sleeves from the cylinder block, using a puller that pulls the sleeve evenly. Install new sleeves, using a replacer that provides an even pull on the sleeve with-

out distorting it (fig. 16). After the sleeves are installed, use a piston (without rings) or a plug gauge in the cylinder to determine if the sleeve was properly installed. If the piston or plug gauge has a tendency to stick, the sleeve was buckled during installation. Remove the damaged sleeve and install a new sleeve, and recheck it.

c. Cast-Iron Sleeve Installation. Rebore the cylinder 0.0012 inch smaller than the outside diameter of the cast-iron sleeve to be used so as to establish the correct press fit. Counterbore the cylinder at the top to the correct size to accommodate the flange at the top of the sleeve. Press a new sleeve into the cylinder bore. New Cast-iron sleeves are manufactured with a finished cylinder bore to fit a standard size piston and do not require honing.

d. Cylinder Reboring and Honing. Make sure the gasket surface at the top of the cylinder block is free from carbon, old pieces of gasket and that it is thoroughly clean before attaching the boring bar. Rebore each cylinder 0.0015 inch under the size required for the oversize piston to be used, leaving the 0.0015 inch for honing. A No. 220-L grit hone is recommended, and the honing operation requires the removing of just enough material to obtain the correct clearance for the piston to be used in that particular bore. When fitting pistons, clean the cylinder walls and pistons thoroughly. Use a tension scale and thickness gauge as outlined in section 123. Pistons must be kept with the cylinder block and each piston marked indicating the cylinder number to which it has been fitted.

e. Stud Replacement. Remove all damaged studs with a standard stud puller. To remove a broken stud, indent the end of the broken stud exactly in the center with a center punch. With a small drill, drill into the broken stud to a depth of approximately two-thirds of the length of the remaining portion of the stud, then follow up with a larger drill. The larger drill selected must leave a wall thicker than the depth of the threads. Select an extractor (EZ-Out) of the proper size and insert it into the drilled hole, and screw out the remaining part of the broken stud. Install a new stud with a stud driver. Drive all studs until no threads show at the bottom of the stud.

f. Camshaft Bearing Replacement. Remove the camshaft bearings with a puller that draws the bearing out evenly (fig. 17). Install the camshaft bearings with a replacer which is equipped with a pilot to guide the bearings, as shown in fig. 18. When installing the camshaft bearings, make sure that the oil hole in the bearing is in

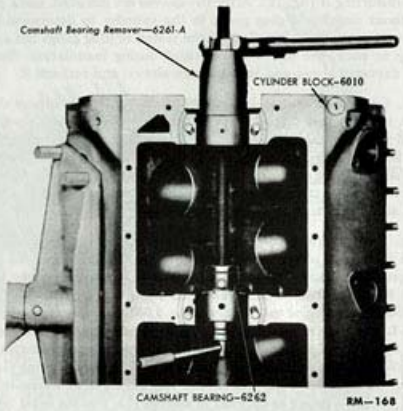

Fig. 17—Removing Camshaft Bearing

line with the oil hole in the cylinder block. Replacement bearings are supplied to the correct size and do not require reaming.

g. Valve Seat Insert Replacement. Remove the valve seat insert, being careful not to damage the cylinder block. If the counterbore is worn, remachine it to obtain a 0.0015-inch to 0.0030-inch press fit on the replacement insert. Make sure the counterbore is clean. Pack the new insert in dry ice for at least 15 minutes and drive the insert in place in the counterbore, using a driver that assures the insert going into place evenly. Reface the valve seat insert (par. **h.** below).

h. Valve Seat Refacing. Reface each valve seat with a 90-degree (included angle) valve seat grinding wheel or valve seat cutter until the face of the seat is "cleaned up" and free from pits or nicks. If a valve seat cutter is used, it will be necessary to lap the valves into the seat (section 124). The time ordinarily required to lap the valves is saved by using an eccentric-type valve seat grinder with which the grinding wheel contacts only one portion of the seat at any given time. If the grinder, including the pilot, is in good condition and the

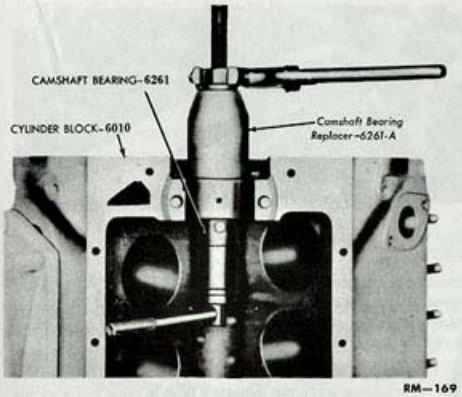

Fig. 18—Replacing Camshaft Bearing

grinding wheel is kept sharp and properly dressed, it ordinarily is not necessary to lap the valves into the seats. After refacing, the width of the valve seat should not be more than 0.125 inch, measured across the face of the seat (fig. 19). If the seat is too wide, remove just enough stock from the top and/or bottom of the seat to reduce the width to 0.062 inch. Use a 120-degree (included angle) valve seat cutter for removing stock from the top of the seat and a 60-degree (included angle) cutter for removing stock from the bottom of the seat.

i. Fuel Pump Push Rod Bushing Replacement. Drive the fuel pump push rod bushing from the cylinder block. Using a suitable driver, drive the new bushing in place so that the top of the bushing is flush with the casting. Reaming the bushing after installation is not required.

123. PISTONS AND CONNECTING RODS.

To disassemble the piston and connecting rod, remove the piston rings with a piston ring expander. Remove the two piston pin retainers (fig. 20), and push the piston pin out of the piston. Scrape the

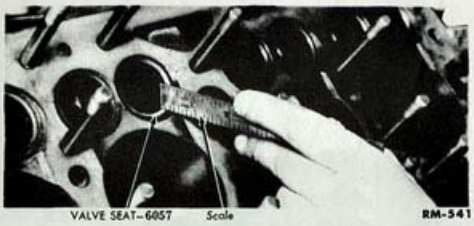

Fig. 19—Measuring Width of Valve Seat

carbon from the piston ring grooves and also from the top of the pistons. Clean any carbon and sludge from the oil holes in the oil ring groove. Make sure the oil holes in the piston end of the connecting rod are open. Clean all parts thoroughly.

a. Inspection. Usually the type of wear, or the condition of one of the reciprocating parts, can indicate a fault in other reciprocating parts, i.e. a bent connecting rod could result in unusual wear, on either or both, the piston or the connecting rod bearing.

(1) *PISTONS.* If the cylinder bores have been honed or rebored (sec. 122), new pistons will already have been selected to fit the new diameter. If the cylinders have not been honed or rebored, or if the original size has been reestablished by means of sleeves (sec. 122), pistons must be selected for each bore (subpar. (*a*) below). Discard pistons which are cracked, scored, damaged or have burned spots.

(*a*) FITTING PISTONS. To check the clearance of a piston in a cylinder bore, use a thickness gauge ½ inch wide and long enough to cover the entire length of a piston and attach it to a tension scale. Place the gauge on the side of the piston bore and push the piston in the cylinder so that the side of the piston, which is 90 degrees (right angle) from the piston pin hole, is against the thickness gauge. Withdraw the gauge and observe the reading on the tension scale (fig. 25). The thickness of the gauge to be used and the pounds pull for the various combinations of pistons and cylinder bores are as follows:

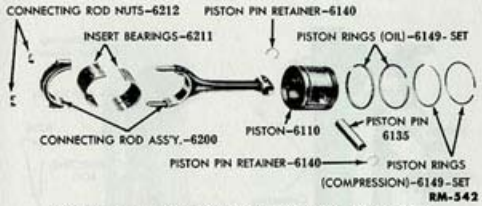

Fig. 20—Connecting Rod and Piston Assembly, Disassembled

Cylinder Bore and Piston Combinations	Steel Piston GAUGE THICKNESS	Steel Piston PULL POUNDS	Aluminum Piston GAUGE THICKNESS	Aluminum Piston PULL POUNDS
New steel sleeve—new piston	0.003	6-10	0.003	6-10
Worn steel sleeve—new piston	0.004	6-10	0.004	6-10
Worn steel sleeve—worn piston	0.005	6-10	0.005	6-10
New plain bore—new piston	0.0025	6-10	0.002	6-10
Worn plain bore—new piston	0.004	6-10	0.004	6-10
Worn plain bore—worn piston	0.005	6-10	0.005	6-10

(*b*) PISTON PIN BORES. Use a new piston pin as a gauge, and insert it in the piston pin bore. If the pin falls through by its own weight, the pin bore is excessively worn and must be reamed and burnished or honed to accommodate an oversize piston pin (par. e below).

(*c*) PISTON RING GROOVES. Check the width of the ring grooves with a new piston ring and a thickness gauge (fig. 24). Discard a piston if the clearance between the ring and the piston exceeds 0.004 inch.

(2) *PISTON PINS.* Replace piston pins that have become worn and measure to less than 0.749 inch.

(3) *CONNECTING RODS.* Replace connecting rods which have damaged studs. If the connecting rod crankpin bore is worn 0.0015 inch or more over the original size, it must be replaced, or rehoned to accommodate the available oversize bearings, or remachined to standard size where equipment is available.

NOTE: ***If the size of the crankpin bore of one connecting rod is changed, it will be necessary to change the size of the other rod used on the same crankpin so that both may be used on the same size bearing.***

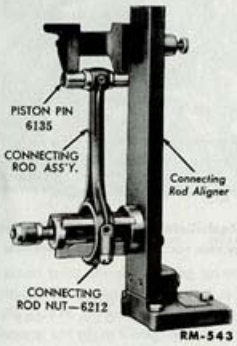

Fig. 21—Checking Connecting Rod for Bend

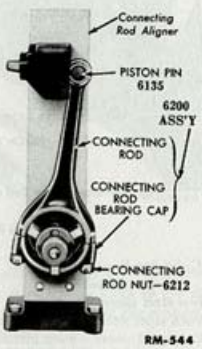

Fig. 22—Checking Connecting Rod for Twist

The original diameter of the connecting rod bore is 2.2195 to 2.2200 inches for the 85 horsepower and 90 horsepower engines, and 2.3597 to 2.3603 inches for the 95 horsepower and 100 horsepower engines. To check the piston pin bushing for wear, use a new piston pin as a gauge. If any looseness is felt, rebush the connecting rod (par. c below) or fit an oversize piston pin to both the connecting rod and the piston (par. b below). Check the connecting rods for being bent or twisted. Bent or twisted connecting rods must be alined (figs. 21 and 22). Select two connecting rods, each having the same diameter bore for each crankpin. Where possible, use the original connecting rod for each cylinder. If any of the old rods are used in a different cylinder, file off the old number. Number each rod and cap as follows: Use $\frac{3}{32}$-inch steel stamps for numbering the connecting rods and cap. Rods to be used on cylinders on the right bank are stamped "R" on the forward side of the right-hand stud boss. Rods to be used on cylinders on the left bank are stamped "L" on the forward side of the left hand stud boss. The cylinder number is stamped either following or below the number. The same letter and number are stamped on the cap so that the rod and cap numbers are alongside of each other when the cap is in place.

Fig. 23—Measuring Connecting Rod Bearing for Wear

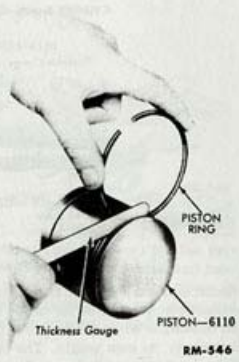

Fig. 24—Checking Ring Groove Width

NOTE: *Right or left is as viewed from the driver's seat with the engine in its normal operating position.*

(4) *CONNECTING ROD BEARINGS.* Replace connecting rod bearings that are worn, pitted, scored, or discolored (due to overheating). Bearings otherwise satisfactory but with small pits need not be replaced, unless the pits extend to the side of the bearing and oil might be bypassed to the side, in which case the bearing must be replaced. Place a plug gauge or a round piece of accurately ground or rolled bar stock on the inside surface of the bearing and measure the thickness of the two pieces (fig. 23). Deduct the thickness of the bar stock from the reading obtained to determine the thickness of the connecting rod insert bearing. Replace each connecting rod bearing that measures less than 0.1085 inch thick.

b. Fitting Oversize Piston Pins.

NOTE: *This procedure applies only when piston pins are to be fitted to old pistons. When new pistons are used, the connecting rod bushings must be replaced if the old bushing does not provide the correct fit for a standard piston pin (par. c. below).*

If a connecting rod bushing or a piston pin hole is worn and its inside diameter does not measure more than 0.7535 inch, it can be

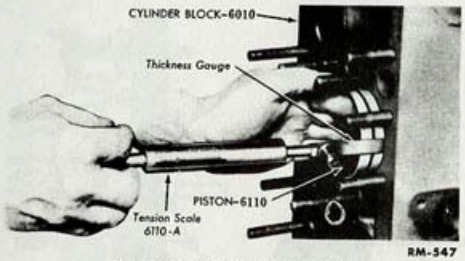

Fig. 25—Fitting Piston to Cylinder Bore

reamed and burnished or honed to fit a 0.001 inch or a 0.002 inch oversize piston pin. The correct fit for a piston pin in the connecting rod bushing is when the pin to be used will pass slowly through the bushing by its own weight. The correct fit for a piston pin in the piston is when it can be inserted in the piston by a light push by hand with the piston temperature at approximately 70 degrees.

c. Connecting Rod Bushing Replacement. Drive the bushing from the connecting rod with a suitable driver. Press a new bushing into the connecting rod. Drill the four oil holes in the bushing to the same size as the holes in the connecting rod. Ream and burnish or hone the bushing to 0.7505 inch. Check the alinement of the connecting rod, correcting any misalinement (figs. 21 and 22).

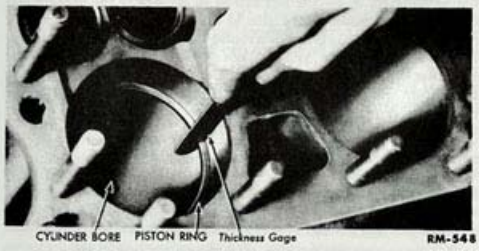

Fig. 26—Measuring Ring Gap with Thickness Gauge

Fig. 27—Installing Piston Ring on Piston

d. Assemble Piston, Piston Pin, and Connecting Rod. Install the piston which was previously fitted (par e above) for the particular cylinder to the connecting rod previously selected and having the number of that cylinder (par. a above). Hold the piston in place on the connecting rod. Install a piston pin in the piston and connecting rod, and install a piston pin retainer on each side of the piston pin bore groove in the piston.

e. Fitting and Installing Piston Rings. Place a new piston ring in the cylinder and press it about halfway down into the cylinder bore with the bottom of a piston so the ring will be square with the cylinder wall. Measure the ring end gap with a thickness gage (fig. 26). If the gap is less than 0.012 inch, remove the ring. Place it in a jig and file it with a fine cut file until the correct gap (0.012 to 0.017 inch) is established. If the gap exceeds 0.017 inch, an oversize ring must be used. Roll the new piston ring around its groove in the piston. The ring should roll freely and not have a clearance of less than 0.0015 inch or more than 0.004 inch. Install the piston ring on the pistons with a piston ring expander (fig. 27). Repeat the entire above procedure for each piston ring.

124. CAMSHAFT AND VALVE MECHANISM.

Two types of camshafts have been used; the press-on type, shown in fig. 29, and the bolt-on type, shown in fig. 31.

a. Camshaft Inspection and Repair. Clean the camshaft and timing gear thoroughly. Replace a camshaft that has excessively scored or damaged cams or worn, corroded, scored, or discolored journals. Replace a camshaft if any of the journals measure less than 1.7955 inches. Replace a camshaft gear that is visibly worn, broken, or has chipped teeth (par. e below). Replace an oil pump drive

Fig. 28—Removing Camshaft Gear (Press-on Type)

gear if it is worn, chipped, or has been slipping on the camshaft (par. d below).

(1) *CAMSHAFT GEAR REPLACEMENT.* Instructions for replacing both types of camshaft gears are given in subparagraphs (*a*) and (*b*) below.

(*a*) PRESSED-ON TYPE. Press the camshaft gear off the camshaft (fig. 28). Press a new gear on the camshaft (fig. 30) making sure that the mark on the camshaft is in line with the mark on the camshaft gear within $\frac{1}{64}$ inch.

(*b*) BOLT-ON TYPE. Straighten the four tabs on the camshaft gear locking ring (fig. 31). Remove the four cap screws and locking ring. Lift the camshaft gear from the camshaft. To install the camshaft gear, place it on the camshaft and install the locking ring and the four cap screws. Bend the tabs on the locking ring down onto the cap screws.

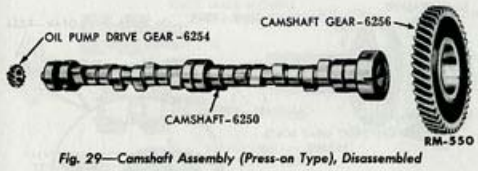

Fig. 29—Camshaft Assembly (Press-on Type), Disassembled

(2) *OIL PUMP DRIVE GEAR REPLACEMENT.*

NOTE: *Later design camshafts are provided with a flat surface on the one side of that portion of the shaft on which the oil pump drive gear is installed (fig. 31). Later design oil pump drive gears are also provided with a similar flat (fig. 31). These*

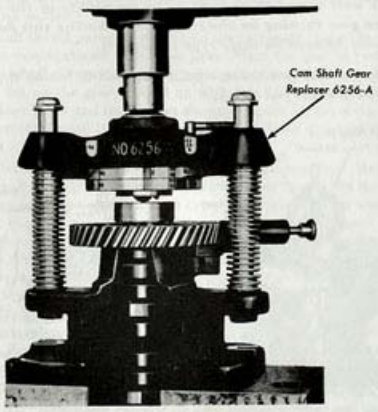

Fig. 30—Replacing Camshaft Gear (Press-on Type)

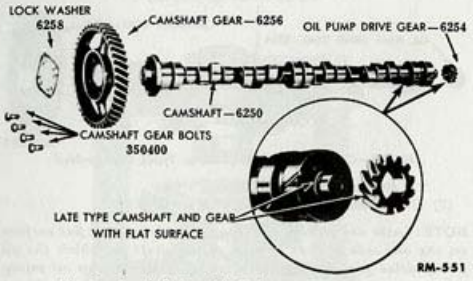

Fig. 31—Camshaft Assembly (Bolt-on Type), Disassembled

flats were added to eliminate the possibility of the oil pump drive gear turning on the shaft. Gears having this flat surface cannot be used on early type camshafts.

Remove the gear, using a puller that will fit behind the gear and exert a straight pull (fig. 32).

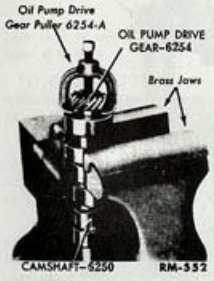

Fig. 32—Removing Oil Pump Drive Gear From Camshaft

Fig. 33—Replacing Oil Pump Drive Gear on Camshaft

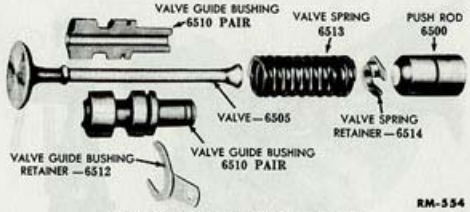

Fig. 34—Valve Assembly, Disassembled

NOTE: ***On early design camshafts which do not have enough clearance for a puller, it will be necessary to place the camshaft in a vise equipped with brass jaws and drive a blunt chisel between the camshaft and the side of the gear, first on one side then on the other, until the sufficient clearance is obtained to install the puller.***

To install the oil pump drive gear on the camshaft, place the camshaft in a vise equipped with brass jaws. Place the gear in position on the camshaft. If working on a late design camshaft and gear, make sure the flat on the gear is lined up with the flat on the camshaft. Using a fiber block and hammer as shown in figure 33, drive the gear on the camshaft until it is firmly seated against the shoulder of the camshaft.

b. Valve Push Rods. Clean the push rods thoroughly. Replace push rods (fig. 34) if the diameter is worn to less than 0.998 inch, or if they are scored or cracked. Cast type push rods showing wear on the ends may be resurfaced at either, or both, ends. Pressed steel type push rods may be resurfaced at the bottom end only. Replace any push rods that are less than 1.710 inches long after resurfacing.

c. Valves, Guides, and Springs. Hold the valve assembly in the hand and compress the valve spring as shown in figure 35. Lift one-half of the valve guide bushing from the assembly. Remove the other half of the valve guide bushing and the spring and spring retainer (fig. 34). **Keep the two halves of each valve guide together in pairs.** Scrape the carbon off the valve heads and stems. Clean the valves, springs, and valve guide bushings.

WARNING: ***Don't use caustic or any material that will injure the protective coat of paint on the valve springs. This paint is necessary to protect the spring from crankcase moisture.***

RM-555

Fig. 35—Compressing Valve Spring by Hand

RM-556

Fig. 36—Checking Valve Spring Tension

(1) *VALVES.*

NOTE: ***Any new valves that are to be used will be used as intake valves in order to keep intake valve guide clearance to a minimum.***

Replace valves that have bent or scored stems. Repalce any valves the stems of which are worn to less than 0.3065 inch. Any valves the stems of which measure more than 0.3090 inch are probably satisfactory for use as intake valves. Stems measuring more than 0.3065 inch are satisfactory for use as exhaust valves. Reface pitted, corroded, or burned valves. Replace valves that are pitted, burned, or warped that will not clean up with a light cut of the grinding wheel. If a cutter was used to reface the valve seats in the cylinder block, lap each valve into its seat.

(2) *VALVE SPRINGS.* Replace the valve spring if it has lost its protective coating of paint, or if the tension is less than 30 pounds or is more than 40 pounds when compressed to 2 1/4 inches (fig. 36).

(3) *VALVE GUIDES.*

NOTE: ***Any new valve guides that are to be used will be used as intake valve guides in order to keep the intake valve guide clearance to a minimum.***

Using a valve with a stem diameter of 0.311 inch as a gage, place the valve in each half of the valve guide bushing and measure each

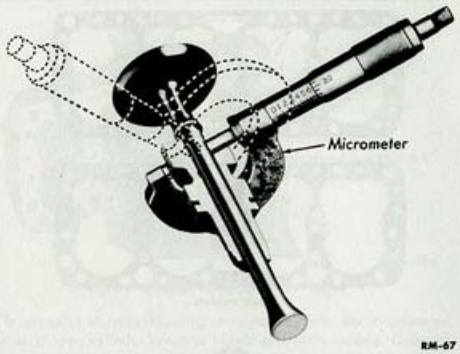

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Fig. 37—Checking Valve Guide Bushing for Wear

side with a micrometer, as shown in figure 37. Replace both halves of any valve guide bushing if the measurement is less than 0.6665 inch. Select guides for each valve, measuring each half with the valve with which it is to be used. Any new guides being used and the old guides having the least wear will be used with the intake valves. Any guide and valve combination measuring more than 0.666 inch is satisfactory for exhaust valves.

To assemble the valve assembly, place the valve spring retainer and spring on the valve, and slide both halves of the valve guide bushing in place.

125. CYLINDER HEADS AND CYLINDER FRONT COVER.

Instructions for the inspection and repair of both the 41T and 59A styles of cylinder heads are given in par. a. below.

a. Cylinder Head. Replace a cracked cylinder head or a head that the gasket surface is warped 1/16 inch or more over the full length of the head. Replace the head if the threads in the spark plug holes and the water temperature gage holes are stripped. Repair any threads that are not stripped but are otherwise damaged (subpar. (1) below). Cylinder heads with the basic part number prefix 41T and 59A have an improvement which provides better cooling (fig. 38).

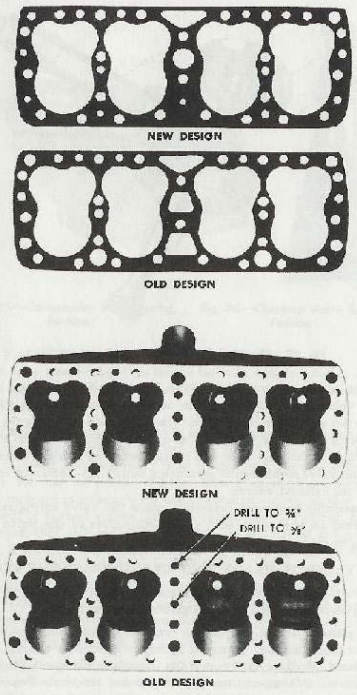

Fig. 38—Cylinder Heads and Gaskets (Old Style 41T and New Style 59A)

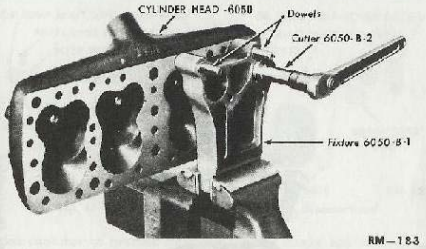

Fig. 39—Cylinder Head Cutter and Fixture

It is advisable when overhauling an engine to make modifications on the early type cylinder heads to obtain this extra cooling. Cylinder blocks the basic part numbers of which have a prefix 41A for the 85- and 90-horsepower engines or 59A for the 90- or 100-horsepower engines have the valve ports located 0.090 inch farther from the center line of the block than did the early type blocks. This late type block is supplied for all service requirements. In order to use old type cylinder heads on these blocks, it will be necessary to enlarge the combustion chamber and enlarge the water holes in the heads as outlined under cylinder head modifications (subpar. (2) and (3) below).

(1) *REPAIR.* If threads are damaged in any of the spark plug holes or the water temperature gage holes, clean up the threads with the correct size tap.

(2) *MODIFICATIONS FOR BETTER COOLING.* The 1/16-inch water hole in the center of the top edge of the head between Nos. 4 and 5 valves is to be increased from 7/16 inch to 3/4 inch (fig. 38), and the water hole in the center of the head between Nos. 2 and 3 cylinder bores is to be increased from 1/16 inch to 5/8 inch (fig. 38).

NOTE: ***These heads will require different cylinder head gaskets after reworking.***

(3) *MODIFICATIONS FOR USING EARLY TYPE HEADS ON LATE TYPE CYLINDER BLOCKS TO PROVIDE CLEARANCE FOR VALVES.* Place the cylinder head over the dowels on one side of the fixture (fig. 39), and secure the head to the fixture with the bolt provided. This will locate the head for enlarging the combus-

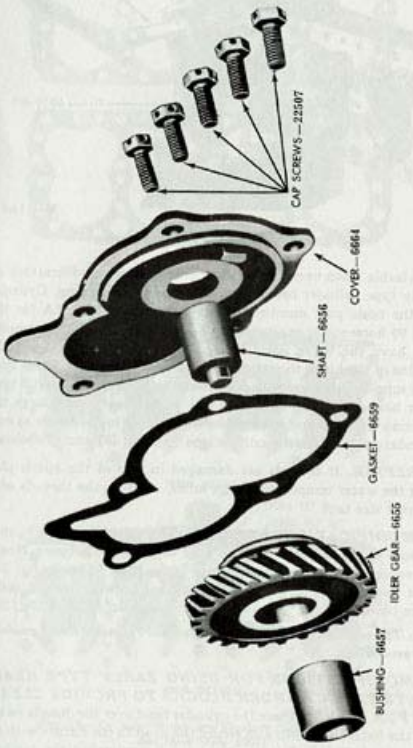

Fig. 40—Oil Pump Drive Cover, Idler Gear, Bushing and Shaft, Disassembled

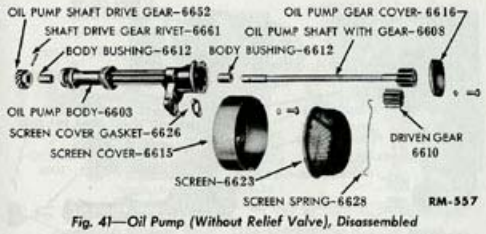

Fig. 41—Oil Pump (Without Relief Valve), Disassembled

tion chamber to provide clearance for one intake and one exhaust valve. Insert the cutter in one of the cutter guides, and cut away the material at the edge of the combustion chamber the full depth of the combustion chamber. Place the cutter in the other guide and proceed in the same manner. Place the cylinder head over the same dowel and in position so that the chamber over two more valves can be enlarged. The remaining chambers can be enlarged by placing the cylinder head over the dowel on the other side of the fixture and proceeding in the same manner.

b. Cylinder Front Cover. Check the gasket surface of the cover for nicks and for damaged threaded holes in the cover, and make repairs as required. Replace a cover if the camshaft thrust surface of the cover is scored.

126. OIL PUMP AND OIL PUMP DRIVE.

To disassemble the oil pump, remove the screen spring (retainer wire) and remove the screen from the screen cover (fig. 41). Remove the two cap screws that hold the screen cover to the oil pump body, and remove the screen cover and gasket from the pump body. On pumps having an oil relief valve (fig. 42), remove the lock wire from the relief valve nut and remove the relief valve nut spring and plunger from the pump body. Remove the pump cover and oil pump driven gear. Clean all parts thoroughly. Blow out all oil passages in the pump body with compressed air.

a. Inspection. Replace the oil relief valve spring if its tension is less than 78 ounces or more than 87 ounces when its length is compressed to 1.380 inches. Replace the oil pump driven gear if it is worn or has broken teeth. Replace the driven gear shaft if it shows evidence of wear. Replace the oil pump body if it is cracked or broken.

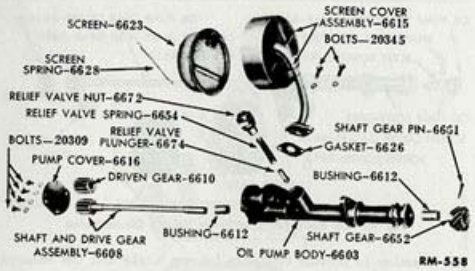

Fig. 42—Oil Pump (With Relief Valve), Disassembled

Replace the oil pump shaft drive gear if it is worn or has broken teeth. Holding the pump body in one hand, push the shaft gear first to one side then to the opposite side. If the movement is greater than 0.005 inch, replace the bushing (subpar. (1) and (2) below).

(1) *REMOVE SHAFT.* Drive the pin out of the oil pump shaft gear and press the gear off the shaft (fig. 43). Remove the shaft from the oil pump body. Replace the shaft if the gear is worn, or if the shaft is bent, or if the bearing surface of the shaft measures less than 0.497 inch diameter.

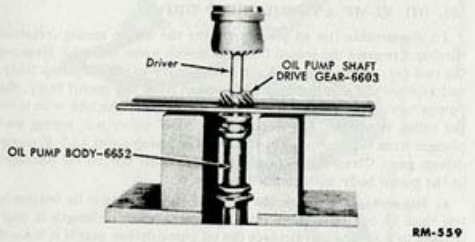

Fig. 43—Removing Oil Pump Shaft Gear From Shaft

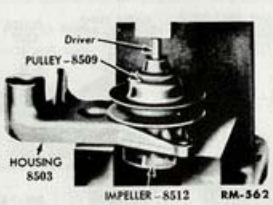

Fig. 44—Removing Pulley From Pump Shaft (Bushing Type)

Fig. 45—Removing Shaft From Impeller (Bushing Type)

(2) *REPLACE BUSHINGS.* If the bushings measure more than 0.502 inch diameter, drive them out of the housing, using a suitable driver. Press the new bushings in place in the housing, and line ream them to 0.500 inch.

(3) *REPLACE DRIVEN GEAR SHAFT.* If the driven gear shaft is worn and measures less than 0.434 inch, drive it from the oil pump body and press a new shaft in place, making sure the lower end of the shaft will clear the oil pump cover when it is installed.

(4) *INSTALL OIL PUMP SHAFT.* Install the shaft in the oil pump body. Position the shaft drive gear on the end of the shaft with the hub side of the gear down and the pin hole in the gear at right angle to the hole (if any) already in the shaft. Press the gear onto the shaft until an end play of 0.017 inch is established. Drill a $\frac{5}{32}$-inch hole through the shaft in line with the hole in the gear. Install a $\frac{5}{32}$-inch pin through the gear and the shaft and peen both ends of the pin.

b. Assembly. Install the oil pump driven gear on the shaft. Place the oil pump cover in position on the oil pump and install the lock washers and cap screws. Making sure the screen cover gasket surface on the pump body is free from dirt, install the gasket and screen cover on the pump body, and install the two lock washers and cap screws that hold the screen cover to the pump body. Place the screen into the screen cover and install the screen spring (retainer wire). On pumps having an oil relief valve, attach the relief valve spring to the plunger and insert them in the pump body. Install the relief valve nut and lock with wire.

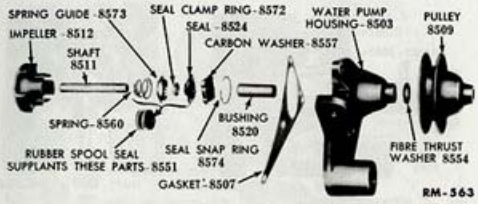

Fig. 46—Water Pump (Bushing Type), Disassembled

127. WATER PUMP.

Two types of water pumps are in use; the bushing type, as shown in fig. 46, and the ball bearing type, as shown in fig. 55.

a. Bushing Type. To disassemble the bushing type, block up the water pump, as shown in figure 44, and press the water pump pulley off the water pump shaft. Remove the fiber thrust washer, impeller, and shaft from the water pump housing. Remove the snap ring from the impeller and remove the carbon washer, rubber seal, seal clamp ring, spring guide, and spring from the impeller and shaft (fig. 46). Clean all parts thoroughly.

(1) *INSPECTION.* Replace a water pump housing that is cracked or damaged in any way. Replace a water pump pulley if it is cracked or damaged. Replace an impeller that is cracked or has damaged or broken fins (subpar. (2) below). Replace a bent pump shaft or one on

Fig. 47—Pressing Shaft Into Impeller (Bushing Type)

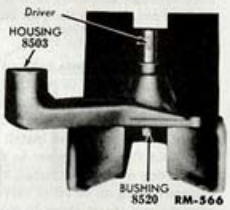

Fig. 48—Removing Bushing From Water Pump Housing

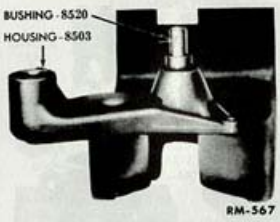

Fig. 49—Pressing Bushing Into Water Pump Housing

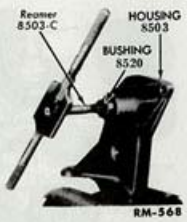

Fig. 50—Reaming Water Pump Bushing

which the bearing surface is worn to less than 0.498 inch (subpar. (2) below). Replace a water pump bushing if it is scored or if the inside diameter of the bushing measures more than 0.502 inch (subpar. (3) below). Replace the rubber seal or carbon washer if it is scored or worn. Replace a seal spring if it is corroded or rusted. If the seal is the rubber-spool type and it is worn, replace it (fig. 46).

(2) *SHAFT OR IMPELLER REPLACEMENT.* Place the impeller in a press, as shown in fig. 45, and press the shaft out of the impeller. To install a shaft into the impeller, place the impeller in a press, as shown in fig. 47, and press the shaft into the impeller until the shaft is flush with the end of the impeller.

(3) *WATER PUMP BUSHING REPLACEMENT.* Place the water pump housing in a press and press the bushing out of the housing (fig. 48). Press a new bushing into the housing (fig. 49), until the end of the bushing is flush with the end of the housing. Place the shaft and impeller into the housing and, if the shaft does not go in the bushing freely, ream the bushing to 0.500 inch (fig. 50).

(4) *ASSEMBLY.* Install the spring, spring guide seal, carbon washer, and snap ring on the shaft and into the impeller. If the rubber-spool type seal is to be used, install the rubber-spool seal, carbon washer, and seal snap ring into the impeller. Install the shaft and impeller into the water pump housing. Place the fiber thrust washer on the shaft and press the pulley on the shaft until it is flush with the shaft (fig. 51).

b. Ball Bearing Type. To disassemble the ball bearing type, place the water pump in a press and press the pulley off the shaft (fig. 52). Turn the pump over and press the shaft and bearing out of

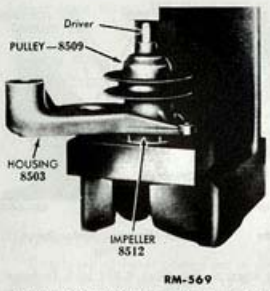

Fig. 51—Pressing Pulley on Water Pump Shaft (Bushing Type)

Fig. 52—Pressing Pulley Off Water Pump Shaft (Ball Bearing Type)

the impeller and housing (fig. 53). Remove the water pump seal snap ring from the impeller, and remove the carbon washer, seal clamp ring, spring guide, and spring from the impeller (fig. 55). Clean all parts thoroughly.

(1) *INSPECTION*. Replace a water pump housing if it is cracked or damaged. Replace a water pump pulley if it is cracked or damaged. Replace a pump shaft and bearing if the bearing has a tendency to stick when it is turned or if it has excessive side or end play. Replace the rubber seal or carbon washer if it is scored or worn. Replace a spring if it is rusted or corroded. If the seal is the rubber-spool type and it is worn, replace it (fig. 55).

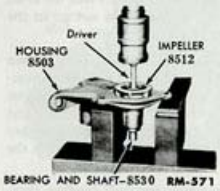

Fig. 53—Pressing Water Pump Impeller Off Shaft (Ball Bearing Type)

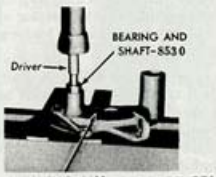

Fig. 54—Pressing Shaft and Bearing Into Pump Housing (Ball Bearing Type)

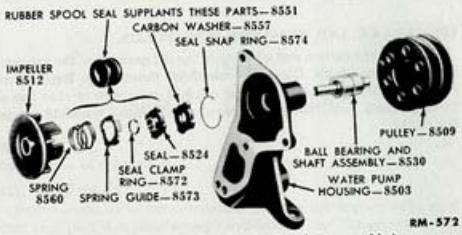

Fig. 55—Water Pump (Ball Bearing Type), Disassembled

(2) *ASSEMBLY*. If the rubber-disk type seal is used, install the pump spring. Place the clamp ring on the pump seal (disk type), and install the spring guide, seal, carbon washer and snap ring into the impeller. If the rubber-spool type seal is to be used, place the rubber-spool type seal, carbon washer, and snap ring into the impeller.

Press the shaft and bearing into the housing with the long part of the shaft entering the housing (fig. 54). Press the pulley on the shaft until the pulley is flush with the end of the shaft (fig. 56). Press the impeller onto the shaft until it is flush with the end of the shaft (fig. 57).

128. OIL PAN.

Clean the oil pan thoroughly. Replace an oil pan that has stripped threads in the drain plug hole or one which is badly dented or distorted.

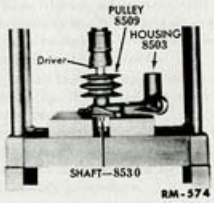

Fig. 56—Pressing Pulley on Water Pump Shaft (Ball Bearing Type)

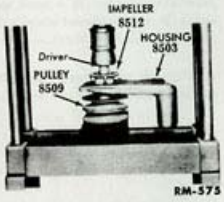

Fig. 57—Pressing Impeller on Water Pump Shaft (Ball Bearing Type)

129. INTAKE AND EXHAUST MANIFOLDS.

Scrape all the carbon and all parts of the old gaskets off the exhaust and intake manifolds. Clean the manifolds thoroughly. Replace an intake or exhaust manifold that is cracked or broken or that has a through sand hole. Replace broken or damaged manifold studs (sec. 122).

Chapter

III

ASSEMBLY OF ENGINE

131. ASSEMBLY.

Before assembly of the component parts of the engine, make sure that each part is in satisfactory condition for use. (Chapter II.)

a. Install Crankshaft. Select main bearing liners of the correct thickness to establish a clearance of 0.000 inch to 0.003 inch. If the wear on the crankshaft is such that the clearance cannot be obtained with the bearing liners available, it will be necessary to remachine the crankshaft to the next undersize for which bearings are available (section 121). Select a rear main bearing of the correct length between flanges to obtain crankshaft end play from 0.002 inch to 0.008 inch.

NOTE: *If a cylinder block (part number prefix 41A) having a main bearing bore of 2.670 inches to 2.671 inches is to be used with a 1937 or 1938 crankshaft, use special bearing liners having a larger outside diameter of the correct thickness to obtain the correct bearing clearance. In addition to the above combination, a small percentage of cylinder blocks were manufactured with a 0.015-inch oversize main bearing bore. These blocks can be identified by the letters "ERP" stamped on the gasket surface for the oil pan at the front left-hand side of the engine. These blocks, when new, will also have a metal tag attached, indicating the block has an oversize main bearing bore. Bearing liners having an 0.015 inch oversize outside diameter are required for these blocks.*

Install the three upper halves of the main bearings in the cylinder block (fig. 58). Install the lower halves of the main bearings in the main bearing caps.

NOTE: *If the old main bearings are being reused, assemble them in the cylinder block and bearing caps in their original position as indicated by the markings made during the disassembly procedure.*

Coat the upper and lower rear main bearing oil seal retainers with shellac and install the upper half of the retainer in the cylinder block. Engines built since April 1, 1944 have the lower oil seal retainer

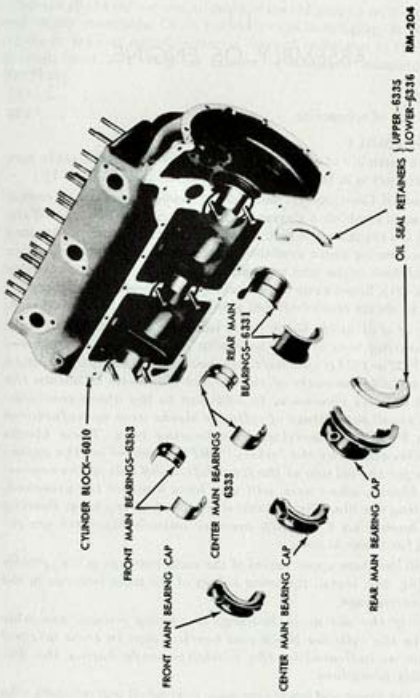

Fig. 58—Cylinder Block, Main Bearings and Caps, and Oil Seal Retainers, Disassembled

Fig. 59—Measuring Crankshaft End Play

integral with the cap. On earlier engines, install the lower half of the retainer in the rear main bearing cap. Oil the main bearing inserts with a light coat of oil. Install the oil slinger on the forward end of the crankshaft (page 13, fig. 11). Place the crankshaft in the cylinder block and install the main bearing caps on the cylinder block. Install the main bearing cap nuts and tighten them to from 75 to 80 foot-pounds. Pry the crankshaft forward and insert a feeler gage between the crankshaft and rear main bearing (fig. 59). If the clearance exceeds 0.008 inch, select a bearing with a thicker flange or if the clearance is less than 0.002 inch, select a bearing with a thinner flange. Lock all the main bearing nuts with wire.

b. Install Oil Pump Drive Cover and Idler Gear. Slide the oil pump idler gear on the shaft, and place the oil pump drive cover, gear, and gasket in place on the cylinder block. Install the cap screws and locking wire.

c. Install Flywheel. Place the flywheel in position on the crankshaft. Install the dowel retainer and cap screws on the flywheel, and tighten the cap screws to from 65 to 70 foot-pounds. Check the flywheel for run-out with a dial indicator (fig. 60). If the run-out is more than 0.005 inch, make certain there is no foreign matter or burs between the flywheel and the crankshaft. Recheck the flywheel for run-out, and if there is still a run-out of more than 0.005 inch, take off the flywheel, turn it 180 degrees, and install it again. If there is still a run-out of more than 0.005 inch, the flywheel must be replaced or resurfaced. Lock the cap screws with wire. Pack the pilot bearing

Fig. 60—Checking Flywheel Run-out With Dial Indicator

Fig. 61—Installing Clutch Disk and Pressure Plate

with a short fiber sodium soap grease having a melting point of not less than 300° F.

NOTE: *If the engine is equipped with liquamatic drive, position the fluid coupling on the crankshaft flange and install the cap screws.*

d. Install Clutch Disk and Pressure Plate. Block the three clutch levers down as shown in figure 61. Hold the clutch disk in place and install either a clutch shaft or a clutch pilot tool into the clutch disk and pilot bearing (fig. 61). Place the clutch pressure plate on the flywheel, and install and tighten the cap screws and lock washers. Remove the blocks that hold the clutch release levers. Remove the clutch pilot tool.

e. Install Camshaft Assembly. Slide the camshaft into the cylinder block, making sure the timing mark on the camshaft gear is in line with the timing mark on the crankshaft gear (fig. 62).

f. Install Push Rods and Valve Assemblies. Place a push rod in each push rod bore. If any of the push rods are tight in the bore, select a push rod which will slip into the bore by its own weight.
NOTE: *If the cylinder block or the valves are new, do not use push rods which have been refaced.*

Turn the camshaft until No. 1 push rod is resting on the heel of the cam (fig. 63). Install No. 1 valve assembly in No. 1 valve port. Pull the valve guide bushing down with a bar type valve lifter, and insert a valve guide bushing retainer in the bushing (fig. 64). Upon removal of the valve lifter, be sure that the retainer is seated in the slot of both halves of the valve guide bushing (fig. 64). Check the clearance

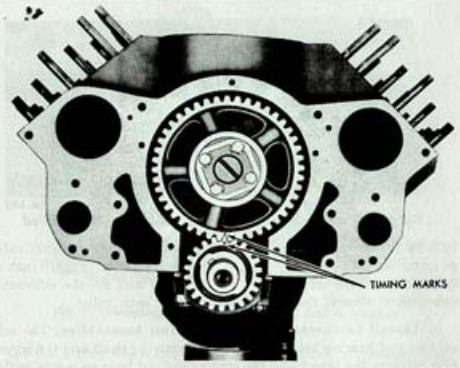

Fig. 62—Timing Marks

between the push rod and the end of the valve stem with a thickness gage (fig. 65). If the clearance is more than 0.012 inch for the intake or 0.016 inch for the exhaust, select a longer valve or reface the valve or valve seat to lower the valve. If the clearance is less than 0.010

Fig. 63—Push Rod on Heel of Cam

Fig. 64—Installing Valve Guide Bushing Retainer

Fig. 65—Checking Clearance Between Valve Stem and Push Rod

inch for the intake or 0.014 inch for the exhaust, select a shorter valve or grind the lower end of the stem until a clearance of 0.010 inch to 0.012 inch for the intake and 0.014 to 0.016 inch for the exhaust is established. Repeat the above operation for each valve.

g. Install Connecting Rod and Piston Assemblies. The connecting rod bearing total clearance between the shaft and the insert, and between the insert and the connecting rod bore on a new engine is 0.0015 inch to 0.0035 inch. Parts must be selected to obtain a total clearance not to exceed 0.005 inch when old parts are used. If previous inspection indicates any wear under the specified limits on the crankpin journals, connecting rod bearings or the bore of the connecting rod, a combination of these worn parts may exceed the allowable clearance of 0.005 inch. Follow whichever of the following conditions that apply.

(1) *CRANKPIN AND ROD WITHIN MANUFACTURING LIMITS.* If the crankpin and connecting rod bores are within manufacturing limits, use standard size bearings.

(2) *CRANKPINS UNDERSIZE, ROD BORES WITHIN WEAR LIMITS.* If the crankpins have been reground or are worn more than 0.0015 inch undersize and the connecting rod bores are within the wear limits, use a bearing with its outside diameter standard and its inside diameter undersize as required.

(3) *CRANKPIN BORE OVERSIZE.* If a connecting rod bore has been reground oversize, select a bearing having the correct inside diameter of the crankpin and the correct outside diameter for the oversize connecting rod bore. It will be necessary to use this rod on the same crankpin with a second rod of the same oversize.

NOTE: ***Before installation, select the piston assemblies for each cylinder as outlined in section 123.***

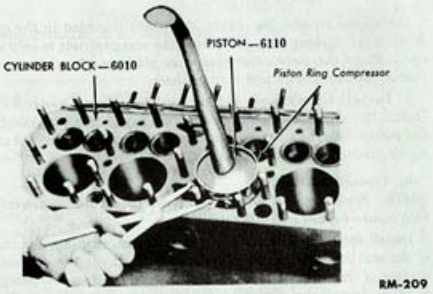

Fig. 66—Installing Piston and Connecting Rod Assemblies in Cylinder Bore

Oil the piston rings. Oil the two halves of No. 1 connecting rod bearing and place them on the crankpin. If the old bearings are used, install them on the original crankpin from which they were removed. Place piston and connecting rod assembly marked R-1 in No. 1 cylinder in the right-hand bank with the connecting rod and piston assembly number facing toward the front of the engine. Use a piston ring compressor on the piston rings and tap the piston down into the cylinder with the end of a hammer handle (fig. 66). Position the connecting rod on the crankpin and install the bearing cap on the connecting rod, making sure the number on the connecting rod is facing toward the front of the engine. Install, but do not completely tighten, the nuts. Place the piston and connecting rod assembly marked L-1 in No. 1 cylinder in the left-hand bank in the same manner and attach the connecting rod to the crankpin. Repeat the above operation, installing the remaining connecting rod and piston assemblies. Tighten the connecting rod nuts to from 35 to 40 foot-pounds, and install cotter pins in each connecting rod.

NOTE: ***If self-locking nuts are used on the connecting rod studs, they are to be tightened to from 40 to 45 foot-pounds.***

h. Install Oil Pump. Place the oil pump assembly in position in the cylinder block, and install the cap screw and locking wire.

i. Install Cylinder Front Cover.

NOTE: ***Soak new cylinder front cover oil seals (part 6700) in the oil for approximately two hours before installation.***

Install the oil seal (fig. 15) in the recess provided in the cylinder front cover, making sure the ends of the seal protrude evenly at both ends. Place the cover and gasket in place on the cylinder block. Install the cap screws and lock washers.

j. Install Crankshaft Pulley and Starting Crank Ratchet. Install the crankshaft pulley Woodruff key in the crankshaft. Tap the pulley onto the crankshaft and install the flat washer and starting crank ratchet on the crankshaft.

k. Install Oil Pan.

NOTE: *Soak new oil pan front seals in oil for approximately two hours before installation.*

Install the oil pan front seal in the oil pan, making sure the ends of the seal protrude evenly at both ends. Coat the bottom machined surface of the cylinder block with grease, and set the oil pan gaskets in place. Install the oil pan rear cork packing in the recess provided in the rear main bearing cap (fig. 58). Place the oil pan in position on the cylinder block and install the cap screws and lock washers.

l. Install Water Pumps. Hold a water pump and gasket in position on the cylinder block. Install the cap screws and lock washers in the pump, and tighten the cap screws.

NOTE: *One of the cap screws is installed through the pump inlet opening.*

Repeat the above procedure on the other water pump.

m. Install Cylinder Heads. Cylinder blocks having a basic part number prefix 41A or 59A can be identified by oblong water passages on the gasket surface just above the valves. These water passages on blocks previous to 1945 were round. Cylinder heads having basic part number prefix 41T or 59A can be identified by the prefix 41T or 59A cast on the top of the heads. Refer to the chart below for selecting the correct cylinder head gaskets for the various cylinder blocks and heads.

To install the cylinder head, place a gasket on each bank of cylinders. Making sure no foreign matter is on the gasket surfaces, place the cylinder head on each bank of cylinders. Install and tighten the cylinder head nuts to from 50 to 60 foot-pounds.

n. Install Intake Manifold. Place the intake manifold gasket on the cylinder block. Making sure there is no foreign matter in the valve chamber, place the intake manifold on the cylinder block, and install the lock washers and cap screws, and tighten all the cap screws except the four cap screws that hold the two spark plug wire conduits to the intake manifold.

CYLINDER HEADS	CYLINDER BLOCK				
	78-6010 85 and 90 HP 1937	85 and 90 HP 1938-42	95 and 100 HP 1939-44	41A-6010 90 HP Starting 1945	59A-6010 100 HP Starting 1945
77-6050-A	40-6051B *70-6051B				
78-6050-B	40-6051B *70-6051B	40-6051B *70-6051B (1938 only)			
81A-6049 A or B 81A-6050 A or B 81T-6049, 81T-6050		91A-6051 *91B-6051	59A-6051 *59B-6051		
81A-6049 A or B 81A-6050 A or B 81T-6049, 81T-6050 Reworked for better cooling (par. 125)		41A-6051 *41B-6051	59A-6051 *59B-6051		
81A-6049 A or B 81A-6050 A or B 81T-6049, 81T-6050 Reworked for better cooling and combustion chamber enlarged (par. 125)				41A-6051 *41B-6051	
99T-6049, 99T-6050 29A-6049, 29A-6050			09A-6051 *09B-6051		
99T-6049, 99T-6050 29A-6049, 29A-6050 Reworked for better cooling (par. 125)			59A-6051 *59B-6051		
99T-6049, 99T-6050 29A-6049, 29A-6050 Reworked for better cooling and combustion chamber enlarged (par. 125)					59A-6051 *59B-6051
†41T-6050				41A-6051	
59A-6050 B				41A-6051	59A-6051 *59B-6051

*For use on Bus
†Used on 90 HP with Steel Sleeve when used in Truck

Fig. 67—Cylinder Head and Gasket Table

o. Install Exhaust Manifolds. Place the right and left exhaust manifolds and gaskets in position on the sides of the cylinder block. Coat the threads of the exhaust manifold cap screws with graphite, and install the lock washers and cap screws.

132. INSTALLATION OF ACCESSORIES.

The following instructions are based on the assumption that the various accessories are in good working order. Overhaul or repair the various accessories before installation if required.

a. Install Starting Motor. Hold the starting motor in position on the flywheel housing, and tighten the two long bolts which secure it to the housing. Install and tighten the cap screws that hold the starting motor bracket to the oil pan.

b. Install Spark Plugs. Sand blast clean the spark plugs and set the gaps to 0.025 inch. Install the eight spark plugs and gaskets in the cylinder heads, and carefully tighten the spark plugs to from 24 to 28 foot-pounds.

c. Install Fuel Pump and Adapter. Install the fuel pump push rod in the cylinder block.

WARNING: ***Replace the push rod if its length is worn to less than 8.870 inches.***

Install the fuel pump adapter gasket on the intake manifold. Install the fuel pump and adapter on the intake manifold. Install the lock washers and nuts on the fuel pump, and tighten the nuts.

d. Install Carburetor. Place the carburetor gasket in position on the intake manifold, and install the carburetor on the intake manifold. Install the lock washers and nuts on the carburetor studs, and tighten the nuts. Connect the fuel line to the carburetor and fuel pump.

e. Install Generator. Place the generator on the intake manifold and install, but do not tighten the generator mounting bracket nut.

f. Install Belts and Fan. To install the bracket mounted fan, position the generator belt on the crankshaft, water pump, and generator pulleys. Place the fan and bracket assembly in position on the generator mounting bracket, and install, but do not tighten, the two cap screws which hold the fan and bracket assembly to the generator mounting bracket. Install the fan belt on the fan and crankshaft pulleys. Raise the generator up until a total movement of 1 inch of the belt is possible at a point midway between the generator and water pump pulleys. Tighten the generator support bracket nut. Raise the fan and bracket assembly up until a total movement of 1 inch of the belt is possible at a point midway between the fan pulley and the crankshaft pulley. Tighten the fan bracket assembly cap screws.

To install the generator pulley mounted fan, install the generator belt on the crankshaft water pump and generator pulleys. Raise the generator up until a 1 inch total movement of the belt is possible at a point midway between the generator pulley and the water pump pulley. Tighten the generator support bracket nut. Place the fan in position on the pulley, and install the cap screws that hold the fan to the pulley.

g. Install Distributor and Coil. Make sure the distributor is in good condition with the points properly spaced and the timing set before installation.

(1) *ONE CAP OR FLAT TYPE.* Install a new gasket on the distributor and place the distributor on the cylinder front cover, making sure the tang on the distributor shaft is in line with the offset slot in the end of the camshaft. Install the two cap screws that hold the distributor to the cylinder front cover. Install the vacuum line on the cylinder front cover and intake manifold. Place the coil bracket in position on the intake manifold, and install the two cap screws that hold the bracket to the manifold. Place the coil in position on the bracket, and install the two screws that hold the coil to the bracket.

(2) *TWO CAP TYPE.* Install a new gasket on the distributor, and place the distributor and coil in position on the cylinder front cover. Making sure the tang on the distributor shaft is in line with the offset slot in the end of the camshaft, install the three cap screws and lock washers. Install the vacuum line on the distributor and intake manifold.

h. Install Distributor Caps and Spark Plug Wires and Conduits. To install the one cap or flat type place the spark plug wires and conduits (one on each side) in position on the intake manifold, and install the two cap screws that hold the conduit bracket to the intake manifold. Position the distributor cap on the distributor, and fasten it with the two clips on the distributor.

To install the two cap type, install the two spark plug wire conduits and wires on the intake manifold (one on each side), and install the cap screws that hold the conduit brackets to the intake manifold. Install the distributor caps on the distributor and clamp the distributor cap bail on the caps.

i. Install Oil Filter. Make sure the filter has been cleaned and a new filter element has been installed. Place the oil filter in position on the cylinder head and install the three cylinder head nuts that hold the filter to the cylinder head. Connect the oil return line to the filter and oil pan. Connect the filter intake line to the filter and to the fitting on the flywheel housing.

Chapter IV
FITS AND TOLERANCES

141. DEFINITION OF FITS.

The table of fits and tolerances (sec. 142) gives the original clearance established between various parts at the time of manufacture, as well as wear and limit clearances that indicate to what point the clearance may increase before the parts must be replaced. These clearances are based on the parts involved all being at 70° F. The following definitions of the various types of fits are given to assist in arriving at the correct amount of clearance between parts not included in section 142, as well as to give a better appreciation of why the various tolerances must be adhered to. Generally speaking, all bores are made to a standard size (so standard reamers, plug gages, etc. may be used) with a plus tolerance. The maximum size of the male parts is usually a standard size less the minimum clearance required for the type of fit desired. The minimum size for male parts is the maximum size minus the tolerance.

a. Wring Fit. A wring fit is the type of fit required between a bore and a plug gage, when using the plug gage, to determine the inside diameter of the bore. With a wring fit, it is necessary to turn or wring the plug gage or part to force it through the bore. This type of fit does not provide space for a film of oil.

b. Slip Fit. A slip fit exists when the male part is slightly smaller than the female part and involves less clearance than a running fit (par. e below). An example of the minimum allowable clearance for a slip fit would be a piston pin that, from its own weight, would pass slowly through the connecting rod bushing (bushing and pin both in a vertical position). In most cases (except where only a limited movement of the parts is involved) slip fits are specified when, due to anticipated expansion (par. f below) of the female part, enough additional clearance will result to change this type of fit to a running fit (par. e below) and provide adequate clearance for a film of oil.

c. Running Fit. A running fit is a fit providing enough clearance for a continuous film of oil between the two parts. A running fit usually requires 0.001 inch for oil film plus a minimum of 0.001 inch for each 1 inch of diameter (par. f below).

d. Press Fit. A press fit is one that requires force to enter the male part into the bore. Accepted practice for press fits is to have the male part larger by 0.001 inch for each inch of diameter than the bore into which it is to be pressed.

e. Shrink Fit. Generally speaking, a shrink fit is tighter than a press fit. The amount of the shrink ranging from 0.001 inch to 0.002 inch for each 1 inch of diameter and in some cases even more. The parts having a press fit may be assembled either by force or by the shrink method. There are two methods of shrinking two parts together, either one of which may be used (both may be used in some instances). One method involves expansion of the female member by heating. The other method involves contracting the male member by chilling with dry ice or liquid air.

f. Effect of Expansion on Fits. Allowances are made in establishing fits on parts that are exposed to higher temperature in order to provide for the anticipated expansion of the part during operation and still provide adequate clearance for the type of fit required. Allowances must also be made for unequal expansion of dissimilar materials. Absolute minimum allowance for expansion of parts exposed to flame or exhaust gases (pistons, piston rings, and valves) is 0.001 inch for each 1 inch of diameter or length. In anticipating the expansion of a piston to make allowances for the additional clearance required in the cylinder, 0.001 inch for each 1 inch of diameter is added. In anticipating the expansion of a piston ring, to make allowances for the additional gap required between the ends of the piston ring, 0.001 inch for each linear inch of the part is added.

142. FITS AND TOLERANCES.

FIT LOCATION NAME	ORIGINAL FIT TOLERANCES	FIT WEAR LIMIT	TYPE OF FIT
CYLINDER BLOCK			
Cylinder bore out-of-round	—	0.003 in.	—
Cylinder bore taper or maximum wear	—	0.006 in.	—
Clearance between camshaft and bearing	0.001 in. to 0.002 in.	0.004 in.	Running
Clearance between push rod and push rod bore	0.0005 in. to 0.0015 in.	0.005 in.	—
CONNECTING ROD AND PISTON ASSEMBLY			
Connecting rod bearing end play	0.003 in. to 0.007 in.	0.010 in.	—

FIT LOCATION NAME	ORIGINAL FIT TOLERANCES	FIT WEAR LIMIT	TYPE OF FIT
Connecting rod side clearance for two rods	0.006 in. to 0.014 in.	0.020 in.	—
Piston pin clearance in connecting rod	0.0002 in. to 0.0005 in.	0.0015 in.	Slip
Piston pin clearance in piston:			
Steel	0.0003 in. to 0.0009 in.	0.0015 in.	Slip (light-push)
Aluminum	0.0001 in. to 0.0002 in.	0.0015 in.	Slip (light-push)
Piston and cylinder	6 pounds to 12 pounds pull with a thickness gage 0.003 in. and ½ in. wide	6 pounds to 10 pounds pull with a thickness gage 0.005 in. and ½ in. wide	—
Top piston ring to groove side clearance	0.0015 in. to 0.0030 in.	0.004 in.	—
Balance of piston ring to groove side clearance	0.0010 in. to 0.0025 in.	0.0035 in.	—
Piston ring end gap	0.012 in. to 0.017 in.	0.035 in.	—
VALVES			
Stem to guide clearance (exhaust)	0.0025 in. to 0.0045 in.	0.006 in.	Running
Stem to guide clearance (intake)	0.0015 in. to 0.0035 in.	0.005 in.	Running
Valve seat angle	45 degrees	—	—
Spring tension at 2.125 in.	36 to 40 lbs.	30 lbs.	—
Clearance between valve stem and push rod (exhaust)	0.014 in. to 0.016 in.	0.014 in. to 0.016 in.	—
Clearance between valve stem and push rod (intake)	0.010 in. to 0.012 in.	0.010 in. to 0.012 in.	—
OIL PUMPS			
Clearance between driven gear and shaft	0.002 in. to 0.0035 in.	0.005 in.	Running
Clearance between oil pump body bushing and shaft	0.001 in. to 0.003 in.	0.005 in.	Running

FIT LOCATION NAME	ORIGINAL FIT TOLERANCES	FIT WEAR LIMIT	TYPE OF FIT
Clearance between oil pump drive idler gear bushing and shaft	0.001 in. to 0.003 in.	0.005 in.	Running
CRANKSHAFT			
Crankshaft end play	0.002 in. to 0.006 in.	0.008 in.	—
Main bearing clearance	0.0005 in. to 0.003 in.	0.005 in.	Running
Crankpin to connecting rod clearance	0.0015 in. to 0.0035 in.	0.005 in.	Running and Floating
OIL RELIEF VALVE SPRINGS			
Spring tension at 1.380 in.:			
In cylinder blocks only	43 ounces to 50 ounces	43 ounces	—
In cylinder block and oil pump	78 ounces to 87 ounces	78 ounces	—
FUEL PUMP PUSH ROD			
Wear on fuel pump push rod length	—	0.006 in.	Running
WATER PUMP (BUSHING TYPE)			
Clearance between water pump shaft and bushing	0.001 in. to 0.002 in.	0.005 in.	—

143. TORQUE WRENCH READINGS.

Main bearing nuts	75 to 80 ft lbs
Connecting rod castellated nuts	35 to 40 ft lbs
Connecting rod self-locking nuts	40 to 45 ft lbs
Cylinder head nuts (cast iron heads)	50 to 60 ft lbs
Cylinder head nuts (aluminum heads)	35 to 40 ft lbs
Flywheel cap screws	65 to 70 ft lbs
Spark plugs (Cast iron heads)	24 to 28 ft lbs