WILLYS

INDUSTRIAL ENGINE

MANUAL and PARTS LIST

Jeep®

4 & 6 CYLINDER INDUSTRIAL ENGINES

INDUSTRIAL ENGINE DIVISION

WILLYS MOTORS, INC.

TOLEDO, OHIO

FORM: IS-1007-R1

MECHANIC'S ENGINE MANUAL

Industrial Type Engines

Industrial Engine Sales

Willys Motors, Inc.

TOLEDO, OHIO

FORM: IS-1007-R1

FOREWORD

In the preparation of this manual covering Willys industrial engines, consideration has been given only to engines as supplied by the Willys Industrial Engine Dept. and to those external components which are standard equipment for those engines.

In OHC, F-Head and L-Head types the Willys engines are supplied either as complete assemblies or as "short" form engines. The "short" engines are composed of the basic engine minus such external components as the distributor, generator, starting motor and some others necessary for operation.

External components may be found on some engines which are not standard with Willys. These have been supplied and installed by other manufacturers on the "short" engine. Information concerning the repair and maintenance of such components must be obtained directly from the manufacturer of the industrial unit. Space limitations prevent coverage of all makes of external components that might be found in use.

Engineering specifications for the OHC, F-Head and L-Head engines will be found at the end of the manual. It is suggested that these specifications be followed closely when making repairs, rebuilding an engine or making adjustments. The close tolerances involved in the original assembly of Willys engines demand precise rebuild, assembly and adjustment. For maximum results consult the specifications.

Duplicate copies of this manual may be ordered from the Industrial Engine Sales Division. The price is $1.50 per copy.

WILLYS MOTORS, INC.
Toledo, Ohio

SECTION I

Preventive Maintenance

Operation and Preventive Maintenance

Correct operating procedure is in itself preventive maintenance. The recommended operating sequence forms the basic pattern of preventive maintenance.

Daily checks of vital systems and units are recommended both as correct operating procedures and preventive maintenance measures.

For maximum efficiency, low cost operation and long life of your engine, particular attention should be given to selecting high quality engine lubricating oil of the correct grade. It is also important that the oil filter and air cleaner receive regular periodic attention and that the level of the cooling solution be correctly maintained to prevent overheating. Keep the fan belt properly adjusted to assure efficient operation of the fan, water pump and generator. Allow the engine to idle sufficiently for warm-up and to assure recirculation of lubricant before putting it to work.

These items are discussed more in detail later in the text. They are mentioned here, however, as an introductory consideration of the factors upon which successful engine operation is dependent.

Pre-Starting Inspection

When a new or rebuilt engine is placed in service, it is suggested that an inspection be made, following the checklist below.

1. Check the oil level in the crankcase. The level is measured by the bayonet type oil level indicator. If the oil level is below the "Full" mark add new oil to the reservoir to bring it to the mark.
2. Check all fuel and oil lines for evidence of leakage or loose connection.
3. Check all wiring connections for security. Check the battery cables and terminals. Make sure that battery cables and ground connections are tightly secured.
4. Check the electrolyte solution in the battery. Add pure distilled water to cells where the level is below the required $\frac{3}{8}$" above the plate level. NOTE: Do not overfill the battery.
5. Check the engine coolant level. If the engine is to be operated in cold weather conditions, check the coolant anti-freeze content with a hydrometer.
6. Check throttle controls for freedom of operation.
7. Check governor controls, if so equipped, for free operation.
8. Check all cylinder head nuts and cap screws for tightness.

Starting the Engine

1. Disengage any gearing, belt pulley drive or other power arrangement connected with the engine.
2. Pull the choke control button out one-fourth the way. This action also opens the throttle slightly.
3. Turn the starter-ignition key to the right to start engine.
4. Pull the choke control button all the way out if the engine fails to start immediately. When it starts push the control in about one-third the way.
5. Set the choke control at the best operating position and as the engine warms up, push it all the way in. Do not run the engine continuously with the choke control out because of fuel waste and the danger of fouling the engine.

Engine Warm-up

When you start the engine, allow it to run at slightly higher than idling speed until operating temperature is achieved. Never put a load on a cold engine. Preliminary warm-up permits lubricant to reach vital bearings and working parts and prevents damage when stress is applied to these units.

Watch the oil pressure indicator. If at any time a drop in pressure is noted stop the engine immediately and investigate the cause of the drop. Continued operation of the engine with inadequate oil pressure may result in serious damage to vital parts.

Engine Temperature Control

During the break-in period of a new or rebuilt engine, one of the greatest dangers is over-heating. There are several possible causes of over-heating, but the basic items for consideration are engine lubrication and coolant circulation.

At the first sign of over-heating, shut the engine down and make a thorough check to determine the cause. Check the temperature gauge frequently.

Temperature of the engine coolant is regulated by a thermostatic valve located in the outlet at the front of the cylinder head. This unit retards the flow of coolant until a predetermined temperature is reached, usually varying between 170° and 180°. When the desired temperature is achieved, the valve opens and free circulation of the coolant through the system begins.

If the thermostat valve becomes faulty and does not open at the correct temperature, the thermostat should be removed and a replacement installed

immediately. In the event, however, that a replacement cannot be made at once, remove the faulty unit, reassemble the hose connection, and run the engine without the thermal control unit until a new one can be obtained.

Continued operation of the engine without the thermostat is harmful, however, because sub-normal coolant temperatures promote the development of sludge and acids harmful to bearings and other internal parts of the engine.

Lubrication

Proper lubrication of your industrial engine is the keystone to its long life and efficient operation.

Lubrication of both types of engine is accomplished by a continuous circulation of oil drawn in through a floating intake located in the crankcase and forced through the system by a rotor type oil pump located externally on the left side of the engine and driven by a spiral gear on the camshaft.

The floating intake does not permit water or dirt that might have accumulated in the bottom of the oil pan to circulate through the system because it draws oil horizontally from the top surface in the pan.

The quantity of oil in the crankcase can be determined by the bayonet type oil level indicator located at the side of the engine. When the level indicator shows the level to be below the "Full" mark add oil to bring it to the required level.

Engine Lubricant

Premium grade, heavy duty oils as produced by any of the major oil companies are recommended for use in your Willys industrial engine. The detergent characteristics of heavy duty oils will keep the engine working parts cleaner, and provide better lubrication than regular engine oils.

Additive compounds in heavy duty oils clean the metal surfaces of lead deposits and soft carbon and provide in the oil greater wetting capacity for more complete lubrication of internal engine parts. In addition to holding harmful elements in suspension, the detergent agents provide greater resistance to oxidation, carbon, varnish and sludge formation. NOTE: Because of its characteristic of holding harmful matter in suspension, heavy duty, high detergent oil will appear to be due for a change

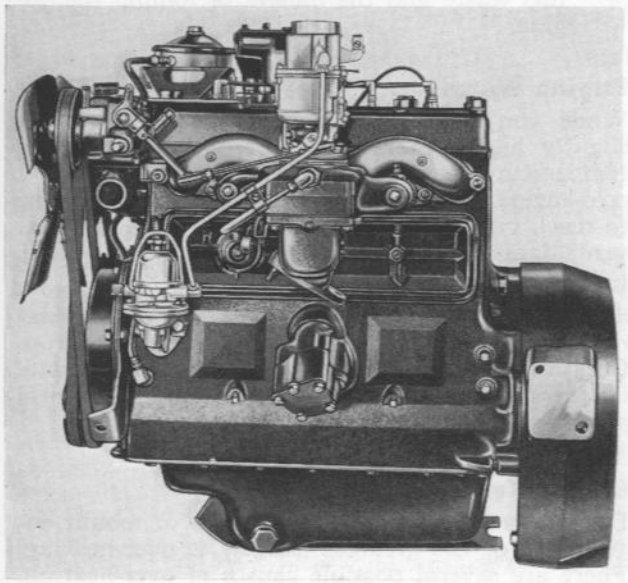

FIG. 1 —THE FOUR CYLINDER L-HEAD TYPE ENGINE — DISTRIBUTOR SIDE.

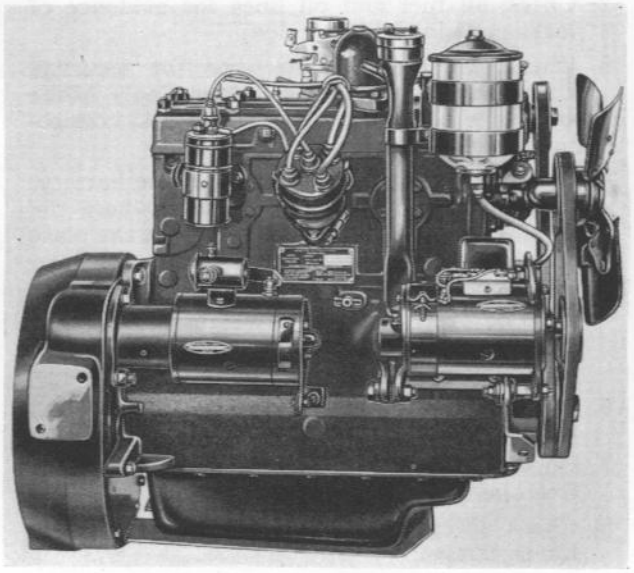

FIG. 2 —THE FOUR CYLINDER L-HEAD TYPE ENGINE — MANIFOLD SIDE.

more rapidly than will ordinary engine oils. Special care should be exercised, therefore, in keeping a record of the running time of an engine when new oil is installed or perfectly good oil may be disposed of before its usefulness expires.

Use the oil selection guide on Page 8 to determine the oil weight to be used to meet climatic conditions prevailing during the engine operation.

Crankcase Oil Level

Daily check should be made of the oil level in the engine crankcase. The oil level indicator rod is located on the right side of the engine. Remove the rod, wipe the oil from it and reinsert the rod in the tube to full depth. Withdraw the rod again and note the oil level. If the level is below the "Full" mark, add oil to bring it up to the mark.

Draining Engine Oil

Engine oil should be changed every 100 hours of operation.

Watch the condition of the oil and should it become fouled by dirt and other foreign matter, drain it off while the engine is warm, preferably after extended operation. The foreign material that might have accumulated in the oil system will be floating in the hot oil and will drain off more easily than if it is allowed to settle as the oil cools. If the oil is allowed to cool the foreign matter will settle in the crankcase and contaminate the new oil that is installed.

At least once a year, preferably in the spring, remove the oil pan and floating oil intake. Wash them thoroughly with a cleaning solution. If operating conditions are severe this servicing may be necessary more often than once a year.

Oil Selection Guide

Select the grade of oil recommended for the temperatures likely to prevail during the engine operation following the change. Use the guide on Page 8 to make your selection.

Above 90 degrees Fahrenheit	SAE 30 or 10W-30
Not lower than 32 degrees	SAE 20 or 20W 10W-30 or 10W-20
As low as 10 degrees above zero Fahrenheit	SAE 20W 10W-30 or 10W-20
As low as 10 degrees below zero Fahrenheit	SAE 10W 10W-30 or 10W-20
Lower than 10 degrees below zero Fahrenheit	SAE 5W or 5W-20

Oil Bath Air Cleaner

The oil bath air cleaner should be removed, thoroughly cleaned and the oil in reservoir changed as often as operating conditions demand. This unit is one of the most vital elements in the engine assembly and must be checked daily or twice daily, depending upon the severity of operating conditions.

Use a long screwdriver or similar instrument in cleaning the filter to dislodge any dirt sticking to the bottom and sides of the intake passage in the body of the cleaner. When the unit is thoroughly cleaned, fill the reservoir to the level mark using the same grade oil currently used in the engine.

Generator Lubrication

Service the generator with a few drops of oil at every 100 hour oil change. Do not over lubricate electrical components.

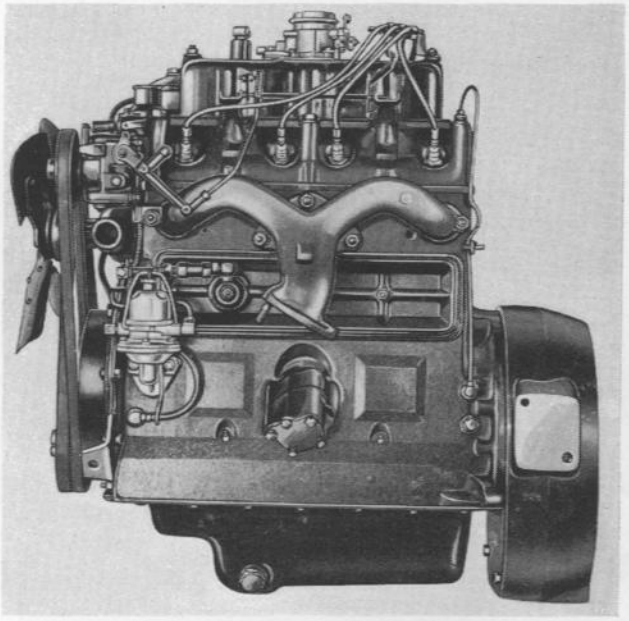

FIG. 3 —THE FOUR CYLINDER F-HEAD TYPE ENGINE — MANIFOLD SIDE.

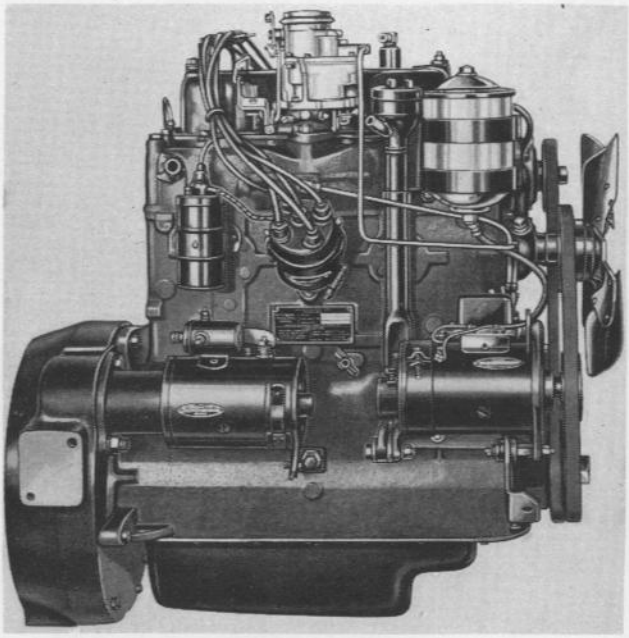

FIG. 4 —THE FOUR CYLINDER F-HEAD TYPE ENGINE — DISTRIBUTOR SIDE.

Distributor Lubrication

Service the distributor with a few drops of engine oil at least at every 100 hour lubrication oil change. Place a few drops of engine oil in the external oiler, and also a few drops on the distributor wick. In addition, place a smear of light grease on the breaker arm cam and a drop of oil on the breaker arm pivot.

Oil Filter

Dismantle the oil filter, clean the housing interior and replace the filter cartridge after every 100 hours operation. On the Tornado OHC engine the full flow oil filter is the throw away type and the complete filter should be replaced. A sound operating rule is to change the oil filter cartridge every time the oil is changed.

In extremely severe operating conditions, the oil filter will have to be serviced more frequently than at every 100 hours.

Pre-Lubricated Components

The starting motor and water pump are lubricated at assembly and require no further servicing for the life of the unit.

Flywheel Bushing

Should the flywheel be removed from the crankshaft or the clutch removed, do not neglect to apply a light coating of chassis grease to the flywheel bushing. This practice is essential and must be accomplished at assembly because of its inaccessibility when the bell housing is installed.

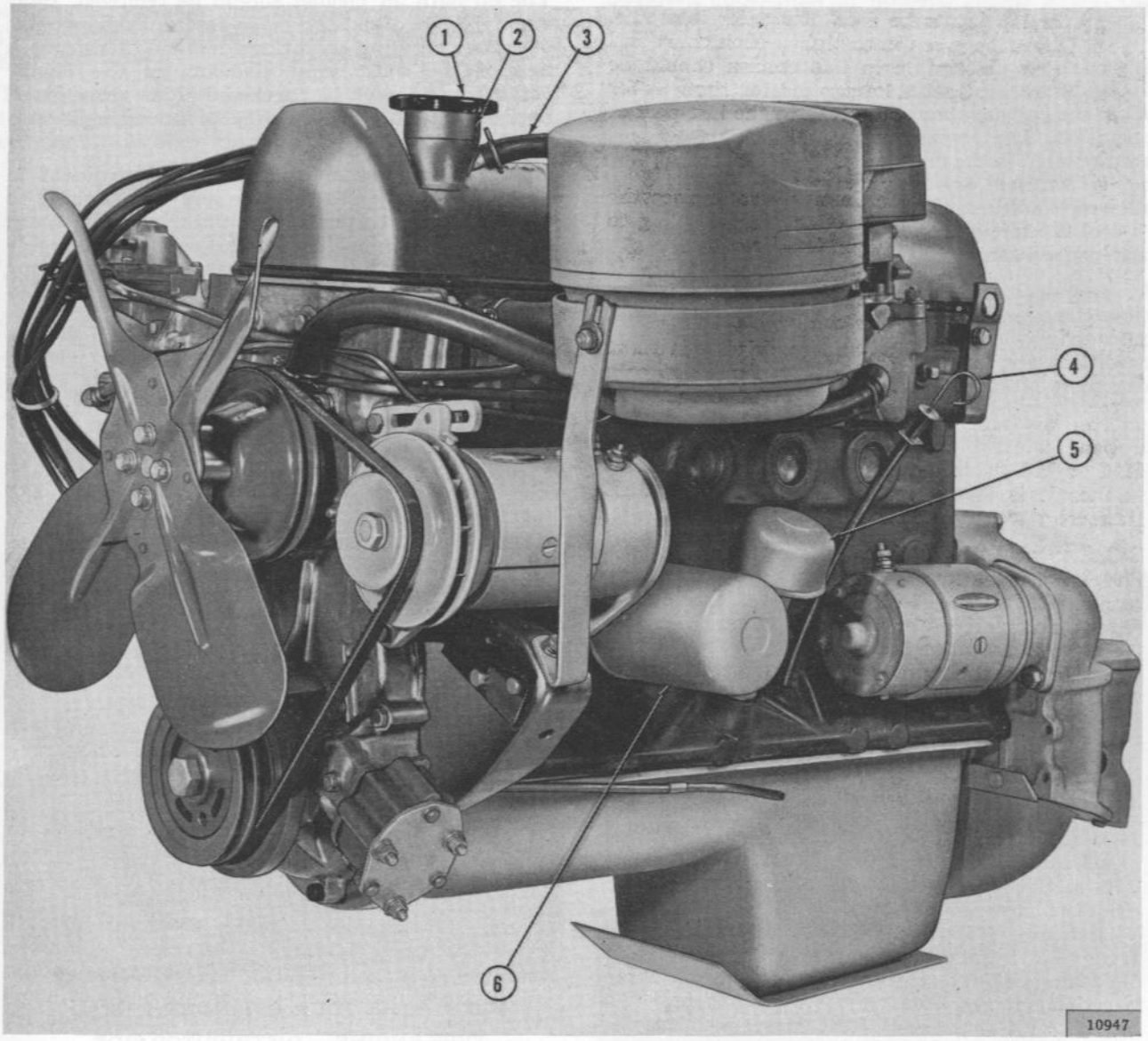

FIG. 4A—THE 6 CYLINDER "TORNADO" OVER HEAD CAM ENGINE—MANIFOLD SIDE

1—Oil Filler Cap
2—Oil Filler Tube
3—Vent Hose
4—Dip Stick
5—Crankcase Breather Cap
6—Oil Filter

SECTION II
Four Cylinder L-Head Engine

The four cylinder L-head engines are basically the same. During the production of the different models, changes have been made to fit the engine to the individual models or to increase performance and efficiency. The changes made during the production of each model as well as general repairs and adjustments are covered in this Manual to assist in properly servicing these models.

In common with all manufacturers some engines are built with oversize cylinder bores or undersize crankshaft journals. These engines are considered standard as parts of the correct sizes are supplied. Before ordering parts or doing any work with the pistons or bearings of a particular engine, it is always wise to check the engine number to determine if over or undersize parts are required. Definite information is given by letters stamped after the engine number. The code covering is given below:

Letter "A"— (10001-A) indicates .010″ (.254 mm.) undersize main and connecting rod bearings.

Letter "B"— (10001-B) indicates .010″ (.254 mm.) oversize cylinder bore.

Letters"AB"— (10001-AB) indicates .010″ (.254 mm.) undersize main and rod bearings and .010″ (.254 mm.) oversize cylinder bore.

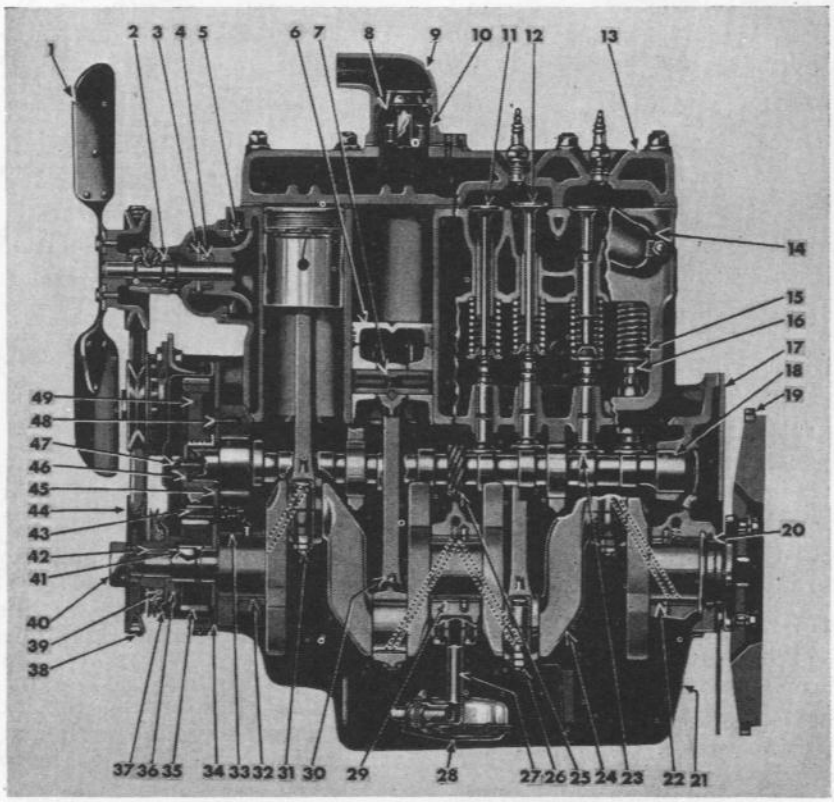

FIG. 5—FOUR CYLINDER L-HEAD ENGINE—SIDE VIEW

1. Fan Assembly
2. Water Pump Bearing & Shaft Assembly
3. Water Pump Seal Washer
4. Water Pump Seal Assembly
5. Water Pump Impeller
6. Piston
7. Piston Pin
8. Thermostat Assembly
9. Water Outlet Elbow
10. Thermostat Retainer
11. Exhaust Valve
12. Inlet Valve
13. Cylinder Head
14. Exhaust Manifold Assembly
15. Valve Spring
16. Valve Tappet Self-Locking Adjusting Screw
17. Engine Plate—Rear
18. Camshaft
19. Flywheel Ring Gear
20. Crankshaft Packing—Rear
21. Crankshaft Bearing Rear Drain Pipe
22. Crankshaft Bearing Rear Lower
23. Valve Tappet
24. Crankshaft
25. Oil Pump & Distributor Drive Gear
26. Connecting Rod Cap Bolt
27. Oil Float Support
28. Oil Float Assembly
29. Crankshaft Bearing Center—Lower
30. Connecting Rod Assembly No. 2
31. Connecting Rod Bolt Lock Nut
32. Crankshaft Bearing Front—Lower
33. Crankshaft Bearing Front—Upper
34. Engine Plate—Front
35. Crankshaft Gear
36. Crankshaft Gear Spacer
37. Crankshaft Oil Slinger
38. Fan Belt
39. Crankshaft Packing—Front End
40. Fan & Generator Drive Pulley Nut
41. Crankshaft Gear Key
42. Fan & Generator Drive Pulley Key
43. Timing Gear Oil Jet
44. Fan & Generator Pulley
45. Camshaft Thrust Plate
46. Camshaft Gear Washer
47. Camshaft Gear Screw
48. Camshaft Thrust Plate Screw
49. Camshaft Gear

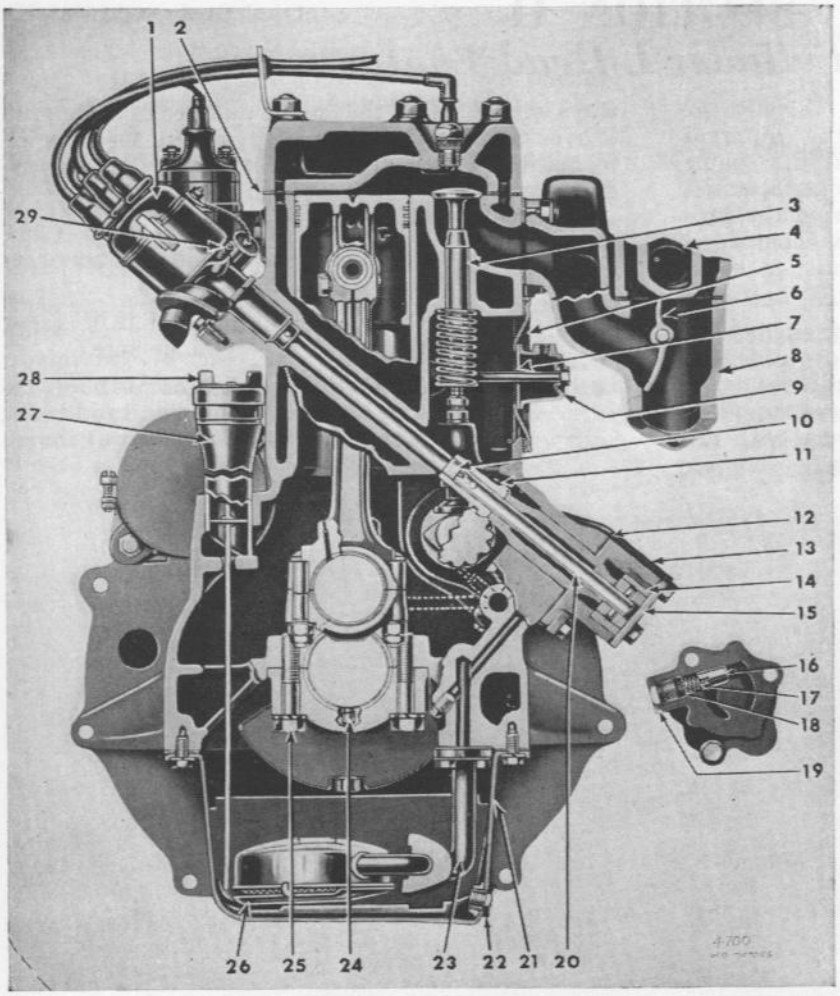

FIG. 6—FOUR CYLINDER L-HEAD ENGINE—END VIEW

1—Ignition Distributor
2—Cylinder Head Gasket
3—Exhaust Valve Guide
4—Intake Manifold
5—Valve Spring Cover
6—Heat Control Valve
7—Crankcase Ventilator Gasket
8—Exhaust Manifold
9—Crankcase Ventilator
10—Distributor Shaft Friction Spring
11—Oil Pump Driven Gear
12—Oil Pump Gasket
13—Oil Pump
14—Oil Pump Rotor
15—Oil Pump Cover
16—Oil Relief Plunger
17—Relief Plunger Spring
18—Relief Valve Shim
19—Relief Plunger Spring Retainer
20—Oil Pump Shaft
21—Oil Pan
22—Drain Plug
23—Oil Float Support
24—Crankshaft Bearing Dowel
25—Bearing Screw
26—Oil Float
27—Oil Filler Tube
28—Oil Filler Cap & Level Indicator
29—Distributor Oiler

Letter "C"— (10001-C) indicates .002″ (.0508 mm.) undersize piston pin.

Letter "D"— (10001-D) indicates .010″ (.254 mm.) undersize main bearing journals only.

Letter "E"— (10001-E) indicates .010″ (.254 mm.), undersize connecting rod bearing journals only.

At the beginning of this section will be found the General Specifications covering the engine as used in the different models. When adjustments are necessary it is recommended that references be made to these specifications so that the proper running tolerances and clearances of all component parts may be maintained.

Engine Tune-up

For best performance and dependability, the engine should have a periodic tune-up every 200 hours. To secure the best results, it is recommended that a definite regular procedure be followed as outlined in Fig. 7. It is essential that the carburetor receive attention as the last of this sequence because it is impossible to satisfactorily service the carburetor until the other units are correctly adjusted.

1. Remove the spark plugs and clean. Adjust the electrode gap to .030″ (.762 mm.) by bending the outer electrode mounted in the plug shell and use a wire gauge to measure the gap.

2. Check the battery, the battery terminals, the negative ground cable and the engine ground strap to be sure that the connections are tight and clean.

3. Remove the distributor cap to clean it and inspect it for cracks and carbon runners. Inspect the points to be sure they are clean and square and adjust them to .020″ (.508 mm.) gap. Check the condenser ground and lead connections.

4. Check the ignition timing.

5. Check the valve tappet clearance. On all models not equipped with rotor type valves, adjust both intake and exhaust valves to .016″ (.4064 mm.) cold. This adjustment supersedes the former adjustment of .014″ (.3556 mm.) for this model engine.

Complete service information is given under the exhaust valve installation of the four cylinder F-head type engine on Page 37 for rotating valves.

6. If equipped with crankcase ventilation, Fig. 45, remove the crankcase ventilator valve from the intake manifold and clean it thoroughly. If this valve should be obstructed the ventilating system will not function and should the valve be stuck open it will be impossible to make the engine idle satisfactorily. See "Crankcase Ventilation", Page 28.

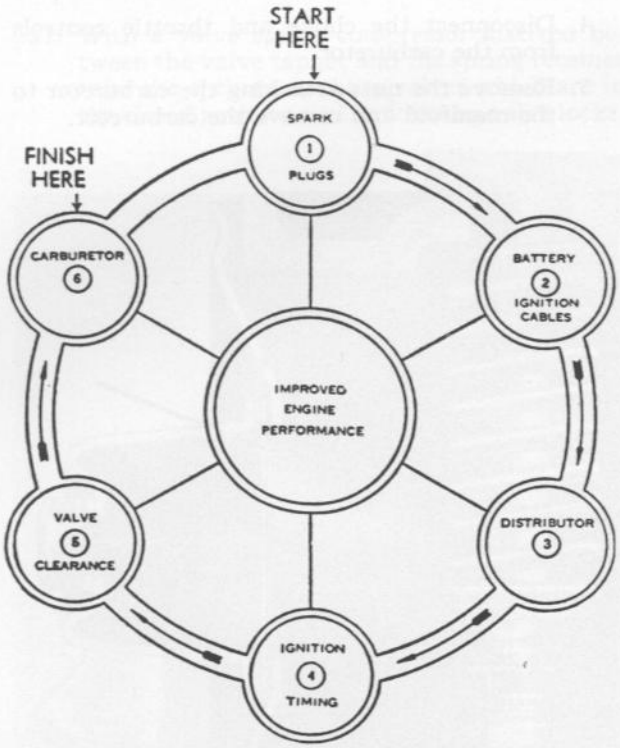

FIG. 7—ENGINE TUNE UP CYCLE

7. Clean the fuel filtering screen and the fuel pump bowl. Check all fuel line connections to guard against leakage.

8. Set the carburetor float level, accelerator pump travel and the metering rod.

9. Start the engine and allow it to run until it is thoroughly warm, then set the carburetor idle screw so the engine will idle at 600 rpm.

10. Adjust the low speed idling valve screw so that the engine will idle smoothly.

Complete information regarding dismantling, cleaning and the adjustment of the Carburetor will be found in the "Fuel" section and that regarding the Distributor and ignition timing in the "Electrical" section.

Locating Engine Trouble

In some cases engine performance is unsatisfactory even after the engine has been carefully tuned and it is known that ignition and carburetion are right. The cause of the trouble usually may be located by the use of vacuum and compression gauges. The use of these gauges has the added advantage that the customer can be shown the cause of the trouble which will result in increased sales and customer satisfaction.

Before using a compression gauge allow the engine to run until normal operating temperature is secured. Remove all the spark plugs and mount the gauge in number one cylinder plug opening. Open the throttle fully and turn the engine with the starting motor until maximum compression reading is shown. Gauge each successive cylinder in the same manner. For satisfactory engine operation the compression must not vary more than 10 lbs. (.703 kg. per sq. cm.) between the cylinders.

The standard compression of this engine is 90-110 P.S.I. (6.3-7.7 kg./sq. cm.) at 185 rpm. Satisfactory engine performance and fuel economy can not be expected if the compression is lower than 90 lbs. (6.3 kg./sq. cm.).

Should the compression readings be low in adjacent cylinders it is possibly caused by a leaking cylinder head gasket.

Uniformly low compression may be caused either by leakage at the valves or at the piston rings or it may possibly be due to incorrect valve timing. Usually if it is due to leakage at the valves it will be impossible to make the engine idle satisfactorily. The true cause of faulty compression and the resulting poor engine performance can usually be determined by using a vacuum gauge.

Connect the gauge to the intake manifold at the windshield wiper fitting. Be sure that there is no leakage at the connection for even a slight leak will result in a false reading. Vacuum readings will vary with altitude above sea level. Below are listed various readings which indicate different engine conditions. These readings should be used to indicate engine condition at sea level and up to 2,000 ft. (609 m.) altitude. At higher points deduct 1 inch (25.4 mm.) vacuum for each 1,000 feet (305 m.) of increased altitude.

With the gauge connected start the engine and set the throttle to give an engine speed of approximately 800 rpm. which is a fast idle speed (standard idle is 600 rpm.). With the engine at operating temperature a steady reading of from 17 to 21 inches (432 to 534 mm.) indicates that the engine is in good condition. As a further check open and close the throttle quickly. If the engine is in normal condition vacuum will drop to 2 inches (50.8 mm.) at wide open throttle and quickly return to about 25 inches (635 mm.) at closed throttle.

Incorrect valve timing will usually be indicated by a steady reading of approximately 10 inches (254 mm.).

Weak valve springs will cause rapid fluctuation of the gauge hand when the engine is raced. Should a valve be sticking at times only, the vacuum will drop 4 or 5 points momentarily when the valve hangs and the fluctuation will resume when the valve operates again. Should a valve be leaking badly the hand will drop 4 or 5 points each time that cylinder operates. A fast fluctuation of the gauge hand between 14 and 19 points indicates that the valve guides are worn.

Leakage at the carburetor gasket, manifold or manifold gasket will be indicated by a steady reading of from 3 to 4 inches (76.2 to 101.6 mm.).

Leakage of compression between the cylinders will show up by the gauge needle drifting regularly between 5 and 19.

A poor carburetor adjustment is generally indicated if the gauge hand moves slowly between 12 and 16.

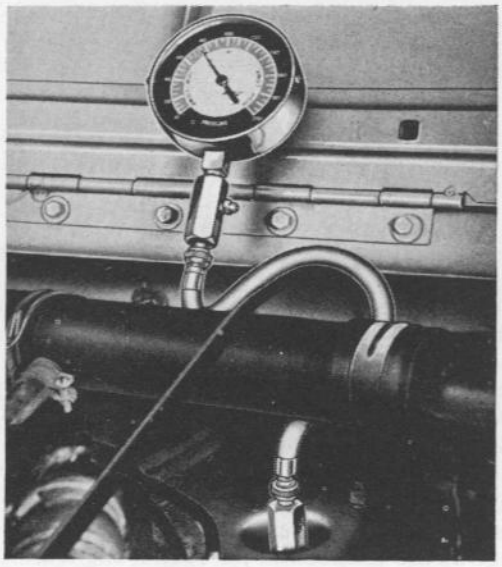

FIG. 8—COMPRESSION AND VACUUM GAUGE

Worn or poorly fitted piston rings or scored pistons and cylinder walls will be indicated by the hand remaining lower than normal or at about 15 points. Some fluctuation will occur should one or two cylinders only be badly scored.

Should the reading be normal when the engine is first started but quickly drop to zero, check the muffler and muffler tail pipe as the exhaust line will probably be nearly clogged.

Grinding Valves

Should tests show that lack of power and poor fuel economy is caused by low compression due to improper seating of the valves, the maximum engine performance can usually be restored by reseating and grinding the valves. Care should be used when valves are ground to maintain factory limits and clearances as only by maintaining these can one expect to get good engine performance.

When it is necessary to grind the valves it will be best to follow the procedure outlined in the following paragraphs.

1. Drain the cooling system by opening the drain cock (on some models a drain plug) at the bottom of the radiator.
2. Remove fuel line from the carburetor to fuel pump.
3. Remove the carburetor air cleaner and the accelerator rod.
4. Disconnect the choke and throttle controls from the carburetor.
5. Remove the nuts attaching the carburetor to the manifold and remove the carburetor.

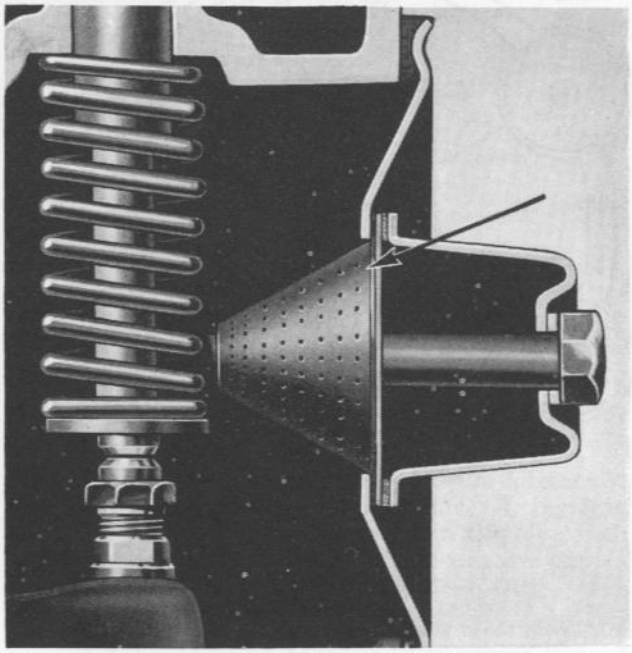

FIG. 9—CRANKCASE VENTILATOR BAFFLE

6. Disconnect the exhaust pipe from the manifold.
7. Remove the crankcase ventilator valve from intake manifold (if so equipped).
8. Remove the manifold attaching nuts and remove the manifolds.
9. Remove the upper radiator hose. Remove the spark plugs. Remove the cylinder head nuts and the temperature gauge bulb, then lift the head from the block. Removal is made easy by using lifting hooks screwed into No. 1 and No. 4 spark plug holes.

CAUTION — Do not use a screw driver, chisel or other sharp instrument to drive between the cylinder head and block to break the head loose from the gasket.

10. On models so equipped, remove the crankcase ventilator tube which extends from the ventilator valve mounted in the intake manifold to an elbow mounted on the valve cover plate. Remove the valve cover plate screws and the valve cover plate. Care should be taken when removing the valve cover not to lose the copper gaskets on each screw. Discard the screen or baffle Fig. 9, when servicing an engine equipped with the crankcase ventilating system — clean and reinstall it if not so equipped. Use cloth to block off the three holes in the valve chamber floor to prevent the valve keys dropping into the crankcase when they are removed.

11. With a valve spring compressor inserted between the valve tappet and the spring retainer raise the springs on those valves which are in the closed position and remove the valve locks.

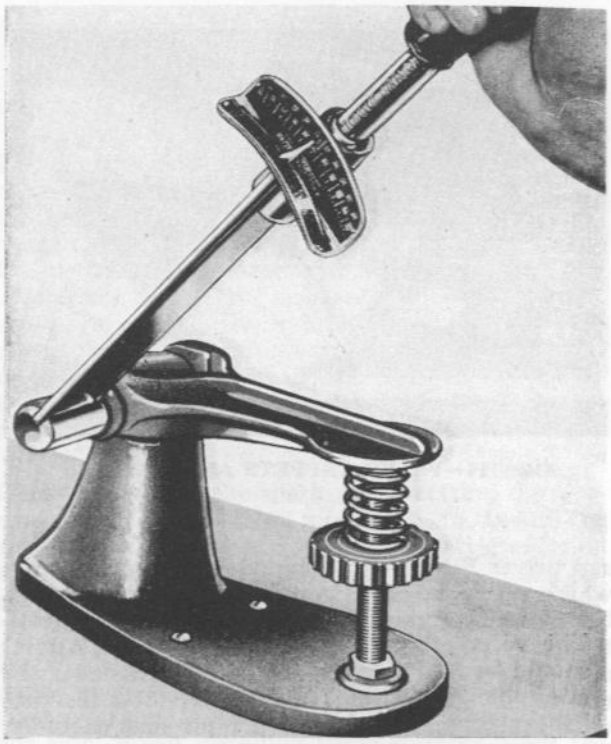

FIG. 10—SPRING TESTING FIXTURE

Turn the crankshaft until those valves which are open are closed and remove the remaining valve locks.

12. Remove the valves and place them in a valve carrying board so they can be identified as to the cylinder from which they are removed. Remove the valve springs. The springs should be washed thoroughly with solvent and examined for damage or corrosion, due to acid etching, which will develop into surface cracks and cause spring failure. The overall free length of each spring should be measured and spring pressure checked on a spring testing fixture as shown in Fig. 10. The free length of the springs is 2 1/2" (63.5 mm.). Should any springs have taken a permanent set showing a reduced free length, they should be discarded.

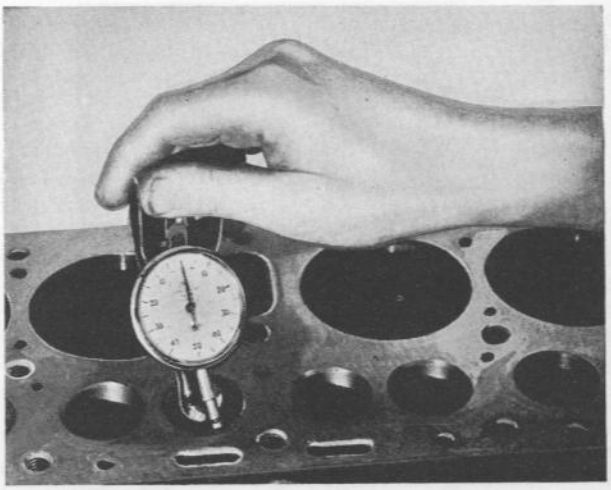

FIG. 11—GAUGING VALVE SEATS

The spring pressure is 50 lbs. (24.04 kg.) at 2 7/64" (53.6 mm.) and 124 lbs. (55.25 kg.) at 1 3/4" (44.4 mm.).

When using the recommended spring checking fixture C-647 shown in Fig. 10, it is necessary to convert the torque wrench reading which is in foot pounds to the static pound pressure of the specifications above. This is accomplished by multiplying the torque wrench reading by two. Thus should the torque wrench reading be 50 foot-pounds the static pressure of the spring will be 100 lbs. Any spring which does not fall within the above specifications or is distorted should be replaced.

13. Clean the carbon from the cylinder head, top of pistons, valve seats and cylinder block.

Clean the valve guides with a wire guide brush; clean the valves on a wire wheel brush, making sure that all carbon is removed from the top and bottom of the heads, as well as the gum which might have accumulated on the stems.

The valve heads should then be refaced at an angle of 45°. It is also usually advisable to reface the seats in the cylinder block and check them with a dial gauge as shown in Fig. 11.

The valve seat should not be out of round more than .002" (.0508 mm.). After reseating touch up the valves to the valve seats with fine valve grinding compound.

Check the clearance between the valve stems and valve guides carefully.

The clearance is .0015" – .00325" (.0381 – .0825 mm.) for the intake and .002" – .00375" (.0508 – .0952 mm.) for the exhaust.

Excessive clearance between the valve stems and guides will cause improper seating and burned valves. When there is too much clearance between the intake valve stem and guide there is a tendency

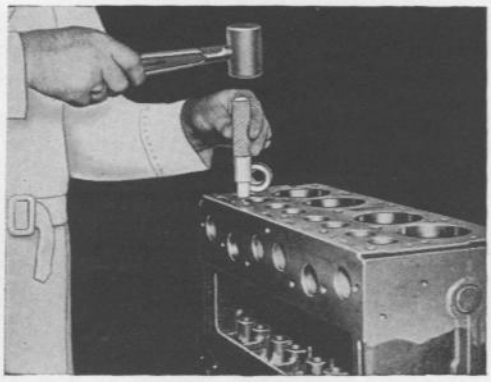

FIG. 12—VALVE GUIDE DRIVER

to draw oil vapor through the guide on the suction stroke causing excessive oil consumption, fouled spark plugs and poor low speed performance.

To check the clearance of the valve stem to the valve guide, take a new valve and place in each valve guide and feel the clearance by moving the valve stem back and forth. If this check shows excessive clearance it will be necessary to replace the valve guide, if not, the valve stem is worn.

Exhaust Valve Seat Insert Replacement

To avoid damaging the block, remove an insert with a tool designed for this purpose. When installing a new insert, make certain the counterbore is clean and smooth. Use an installer tool that will keep the insert in true alignment with the bore. Cool the insert and the installing tool with dry ice for 30 minutes. Immediately after removing a seat insert from the dry ice, position it over the counterbore. Make certain the valve seat is facing out. Drive the insert with the tool until it bottoms in the counterbore. After installation, check the valve seat for concentricity with the valve guide. Grind the valve seat at an angle of 45° and check after grinding with a dial indicator as shown in Fig. 11.

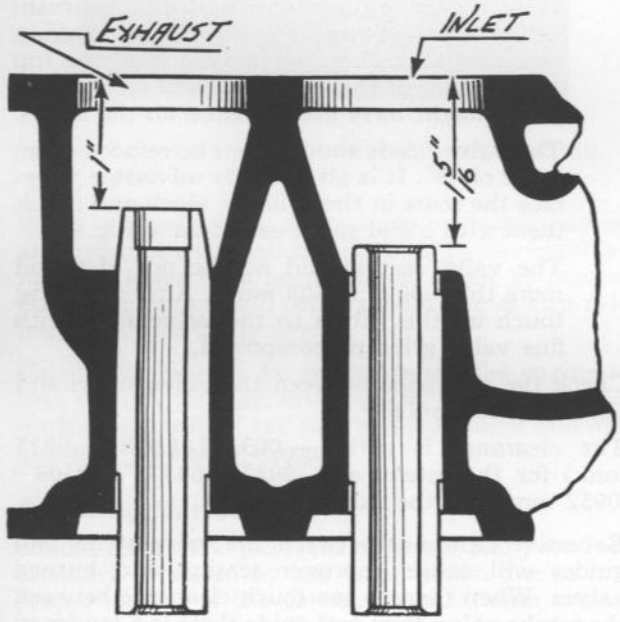

FIG. 13—POSITION OF VALVE GUIDES

Removing and Replacing Valve Guide

Should it be necessary to replace the guides, this installation can best be made by using the driver Tool No. W-177 shown in Fig. 12. The old guides are removed by driving them through the block into the valve compartment. If this driver is not available a suitable puller can be made from a piece of 2″ (50.8 mm.) pipe, 6″ (152.4 mm.) long and 3/8″ (9.525 mm.) bolt 10″ (254 mm.) to 12″ (304.8 mm.) long with a threaded end, a small hexagon nut which will pass through the hole in the cylinder block and a 2″ (50.8 mm.) washer with a 3/8″ (9.525 mm.) hole in it.

When replacing the guides maximum engine performance can only be secured when the top of the exhaust guide is positioned 1″ (2.54 cm.) and that of the intake 1 5/16″ (3.33 cm.) below the top face of the cylinder block as shown in Fig. 13. The standard driver Fig. 12 is equipped with adapter rings which act as stops to correctly locate the guides. Should the standard driver be unavailable a substitute may be made from a piece of 1/2″ (12.7 mm.) round steel 6″ (152.4 mm.) long. Turn down one end to 3/8″ (9.525 mm.) in diameter for a distance of 2″ (50.8 mm.) to form a pilot and shoulder. Should this type driver be used it will be necessary to measure to correctly locate the guides.

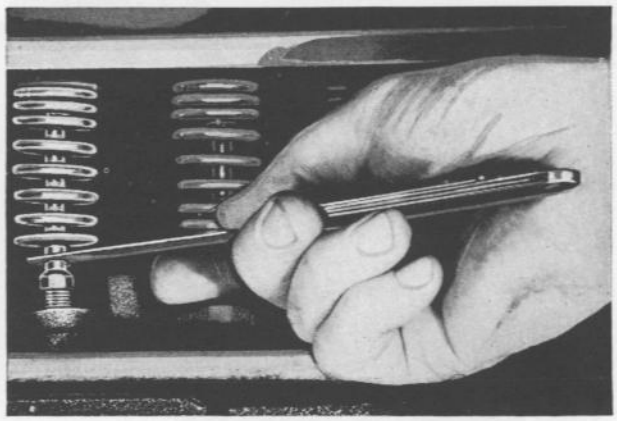

FIG. 14—VALVE TAPPETS AND SPRINGS

The valve tappet clearance in the cylinder block should be .0005″ to .002″ (.0127–.0508 mm.). It is advisable to check the tappet clearance by moving it back and forth in the block. Should the clearance seem to be excessive it might be necessary to install a new one which is supplied .004″ (.1016 mm.) oversize. This operation is covered in the section under "Camshaft and Valve Tappet".

When assembling the valve springs and retainers in the engine make sure that the closed coils of the springs are placed up against the cylinder block as shown in Fig. 14. Install the valves in the same positions from which they were removed. Use a valve spring compressor to raise the valve springs on those

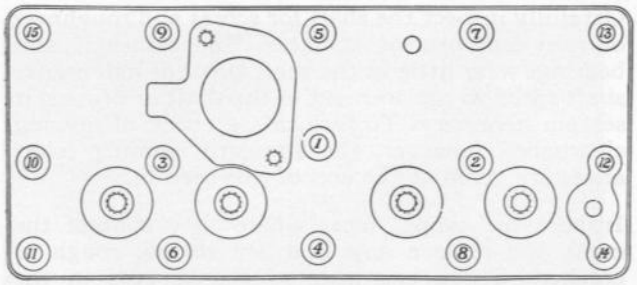

FIG. 15—CYLINDER HEAD TIGHTENING

valves which are in a closed position, and with a valve key inserting tool, insert the valve spring locks. If no inserting tool is available the keys may be held in position by sticking them to the valve stem with grease.

Adjust the valve tappets. This model engine is adjusted .016″ (.4064 mm.) for both intake and exhaust with the engine either hot or cold. (See step 5, "Engine Tune-up", Page 10.)

Remove the cloth blocks from the valve compartment floor openings. Clean the top of the block and pistons of all foreign matter and install the cylinder head gasket without using sealer or other compound. Clean the cylinder head and install it on the cylinder block. Install the air cleaner tube and bracket assembly. Install the cylinder head nuts or cap screws finger tight after which tighten them with a torque wrench in the sequence shown in Fig. 15, 60-70 ft. lbs. (8.3-9.6 kg.-m.) for both stud nuts and screws.

Clean and adjust the spark plugs, setting the electrode gaps at .030″ (.762 mm.), Fig. 16. Install the spark plugs to prevent any foreign matter entering the combustion chambers during the remaining operations.

Install the manifolds with new gaskets. Install the manifold clamp washers noting that on some engines a washer is used having a convex surface on one side. When installing these washers place the convex surface toward the manifold. Install the manifold nuts drawing them up tight. (Torque wrench pull 31-35 lbs. ft.) (4.29–4.83 kg.-m.) Attach the exhaust pipe to the manifold using a new gasket.

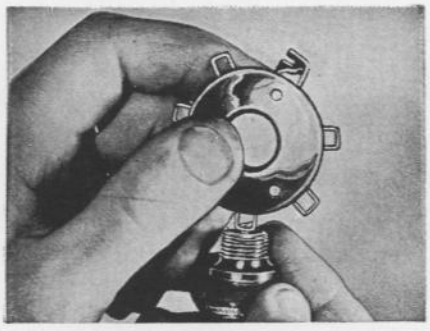

FIG. 16—SETTING SPARK PLUG

On engines equipped with sealed crankcase ventilation, remove the crankcase ventilator valve, Fig. 45, which is mounted on the intake manifold of these engines. Disassemble the valve and clean it thoroughly making sure it is seating. Should the valve opening be blocked the ventilating system will not function and should the valve fail to seat it will be impossible to obtain satisfactory idling of the engine. Reinstall the valve in the manifold.

Overhaul and recondition the carburetor as covered in the "Fuel" section. Install the carburetor on the manifold and attach controls.

Recondition the distributor and set the ignition timing according to instructions under "Distributor" in the "Electrical" section.

Install the upper radiator hose, tighten all hose connections and fill the cooling system. Start the engine and allow it to idle for five or ten minutes, after which, recheck the tappet clearance and retighten the cylinder head.

Cement a new gasket in position on the valve cover plate. Install the cover being sure the copper ring gaskets are placed under the attaching screw heads. Clean the valve chamber ventilator body baffle, Fig. 9 (discard the baffle if engine is equipped with sealed crankcase ventilation), and reinstall with new gaskets. If the engine is equipped with sealed crankcase ventilation, clean and install the ventilator body to ventilator valve tube.

Camshaft and Valve Tappets

The camshaft, Fig. 17, rotates on four bearings. The front bearing is a replaceable steel shell bushing with babbitt face while the other three are precision machined in the cylinder block with no bushings. It is driven by helical cut timing gears, a steel gear being used on the crankshaft and pressed fibre on the camshaft.

The camshaft bearings are lubricated under oil pressure through drilled passages in the crankcase. End thrust of the shaft is carried by a thrust plate bolted to the crankcase. The front bearing is a babbitt lined steel shell pressed into place and staked in to prevent rotation and endwise movement in the crankcase as shown in Fig. 18.

The timing gears are lubricated through a jet threaded into the crankcase which sprays oil from the front main bearing on the tooth contact point of the gears.

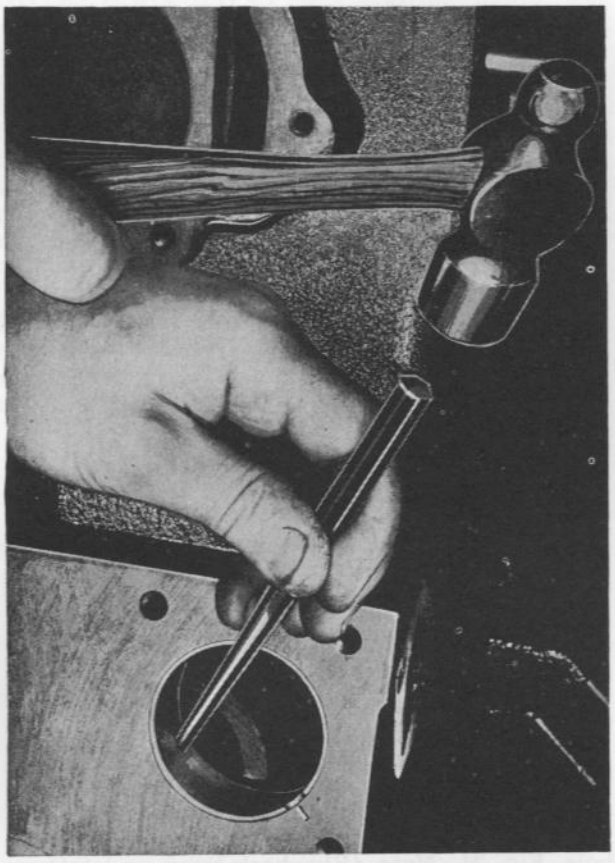

FIG. 18—STAKING CAMSHAFT BEARING

The balance of the assembly is the reverse of disassembly.

Timing Gear Cover and Seal

The timing gear cover is a pressed steel stamping heavily ribbed for strength. The crankshaft oil seal may be braided asbestos impregnated with graphite and oil (see following paragraph). When it is necessary to install a new oil seal, the steel retainer should also be renewed.

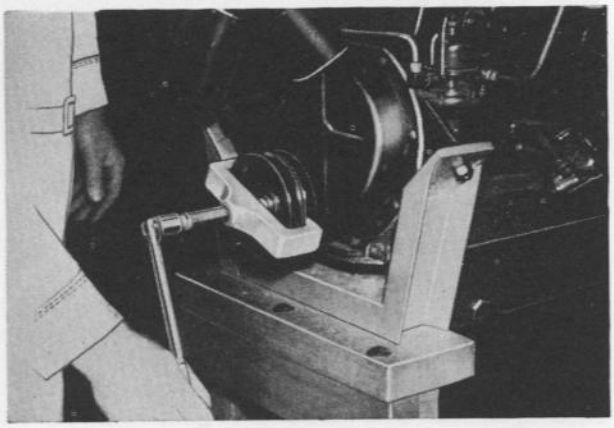

FIG. 19—CRANKSHAFT PULLEY PULLER

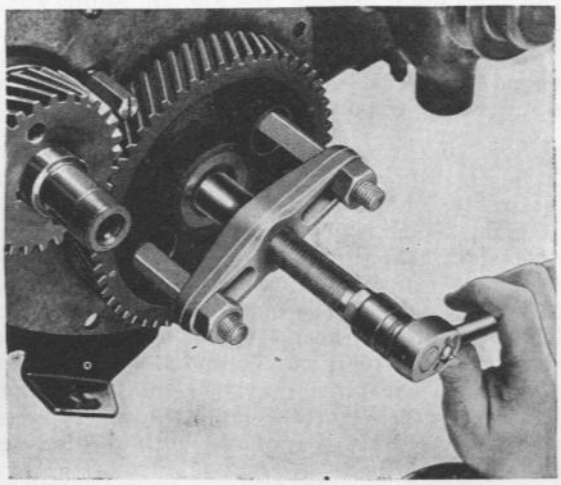

FIG. 20—TIMING GEAR PULLER

A double baffle was added to the timing case cover and the oil seal was changed from braided asbestos to a spring loaded leather seal. The fan pulley hub was also changed to provide a polished surface at the seal contact. This change was made to more effectively prevent dirt and grit entering the engine. This baffled type cover is available for engines equipped with the old cover, however, the assemblies are not interchangeable. Should the cover be removed from an engine which is subjected to excessive dust or dirt do not fail to install the new type cover and pulley.

Camshaft Drive

The camshaft drive is through a helical cut steel gear on the crankshaft and a fibre gear on the camshaft. Lubrication is positive through a jet threaded into the crankcase directly back of the contact teeth of the gears and drilled passages to the front main bearing. When the gears are removed check both the jet and passages to make sure they are clear.

Should it be necessary to replace the timing gears, due attention must be given to both the end float of the shafts and running clearance of the gears.

End float of the crankshaft is controlled by the running clearance between the crankshaft gear and the gear thrust plate. The standard end play is .004″–.008″ (.1016–.2032 mm.) which is adjusted by shims placed between the thrust washer and end

of the front main bearing, see Fig. 26. Shims available are .002″, .004″, .010″ and .030″ (.0508, .1016, .254, .762 mm.) thick. Should the thrust washer be removed be sure that it is reinstalled with the beveled inner edge toward the crankcase.

End float of the camshaft is determined by the running clearance between the camshaft gear and thrust plate. The standard is .003″–.0055″ (.0762–.1397 mm.) which is determined by the thickness of the camshaft gear thrust plate spacer. As a general rule this clearance will vary little through wear or even when a new gear is installed. Should a check indicate too little clearance, place a thin shim between the thrust plate spacer and the shoulder on the camshaft. Clearance may be reduced by dressing off the spacer slightly. Should the spacer be removed make sure it is replaced with the beveled inner edge toward the rear.

End float of both the crankshaft and camshaft can best be measured with a dial indicator.

Standard running tolerance between the gears is .000″ to .002″ (.000 to .0508 mm.) which should be checked with a dial indicator.

When the gears have been removed, it is necessary, when reinstalling them, to retime the valves.

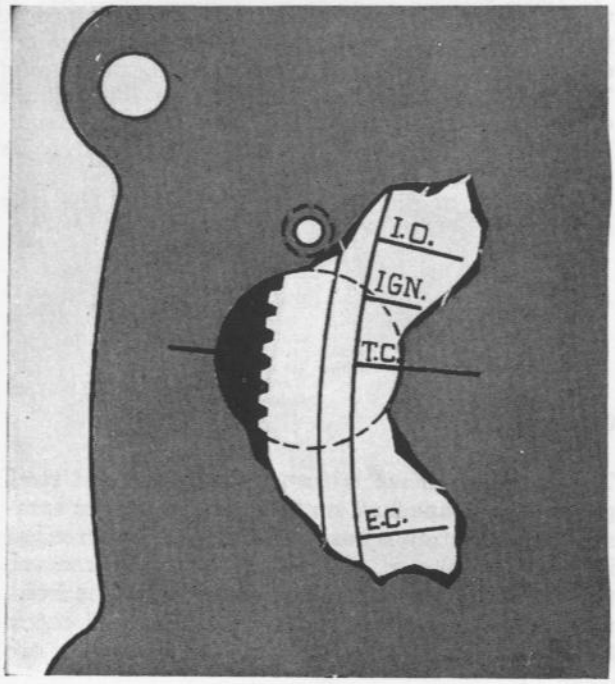

FIG. 21—FLYWHEEL TIMING MARKS
(Early Type Engines)

Valve Timing

To set the timing, install the gears with the shafts positioned so that the timing gear marks are in alignment as shown in Fig. 23.

For timing ignition see the "Electrical" section.

To check valve timing, Fig. 24, carefully adjust the inlet valve tappet for No. 1 cylinder to .020″ (.508 mm.). Rotate the crankshaft clockwise until

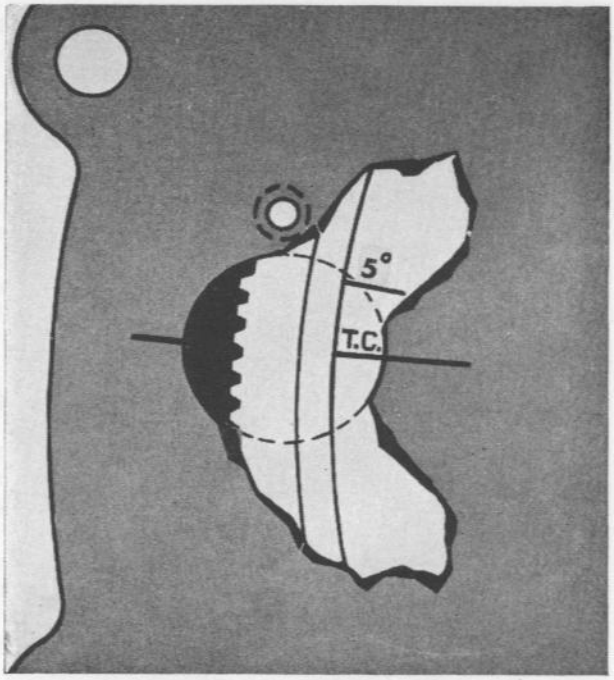

FIG. 22—FLYWHEEL TIMING MARKS
(After CJ-2A Engine No. 175402)

the piston in No. 1 cylinder is ready for the intake stroke as indicated by the flywheel mark "IO" which will be in the center of the timing inspection hole, Fig. 21. Note—Flywheels used on late type engines are not marked to show the "IO" position. Top center is marked and also a 5° before top center position is shown, Fig. 22, for ignition setting. The intake opens 9° before top center. Note the distance between the top center mark and the 5° mark and estimate the 9° or "IO" position. With the crankshaft in this position timing is correct if the tappet is just tight against the valve stem. Do not overlook readjusting the tappet to the running clearance.

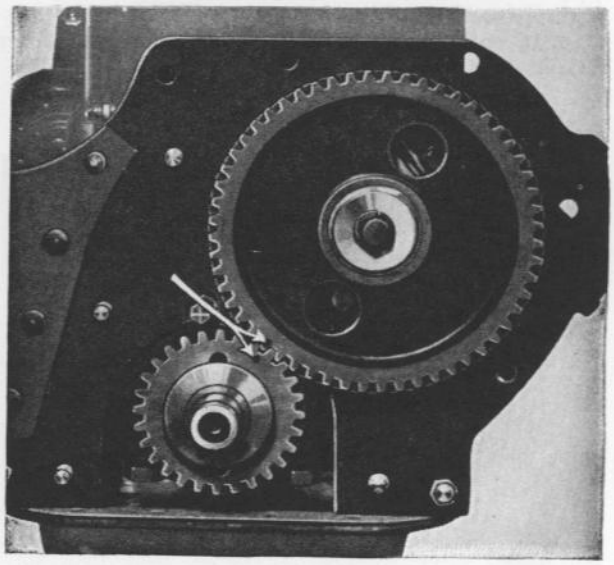

FIG. 23—TIMING GEARS

NOTE: A 4½" (11.43 cm.) starting motor was placed in production of late model 4 cyl. L-head engines. To use the larger starting motor it was necessary to increase the width of the cylinder block flange at the motor mounting. This increased flange width partially covers the location of the flywheel timing mark inspection hole making it impossible to provide an opening for timing purposes. This is not important however, as timing marks are provided on the timing gear cover and crankshaft pulley.

Should it be necessary to install a new cylinder block on an earlier engine equipped with the smaller starting motor it may be necessary to use the timing hole as no other marks are available.

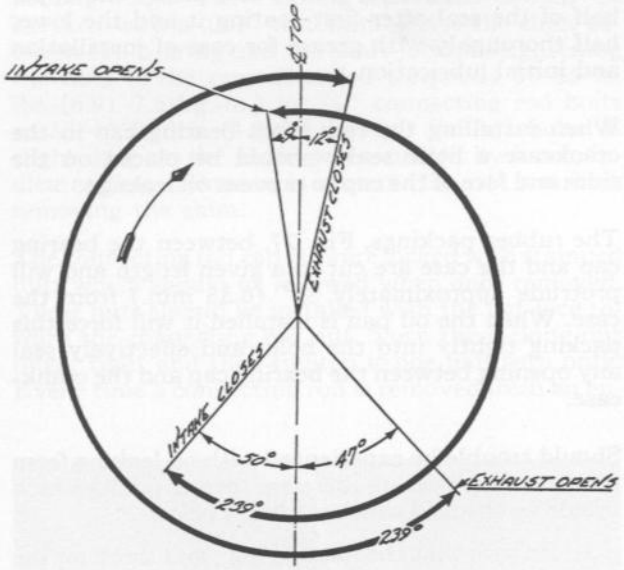

FIG. 24—VALVE TIMING

Should such an installation be made, cut away the flange as required to uncover the timing hole in the engine plate as shown in Fig. 25.

Crankshaft

The crankshaft is of drop forged steel. Crankshafts for this model engine are built with either the four counterweights forged as an integral part of the shaft or with four separately forged counterweights attached to the shaft with a dowel and cap screw. The latter type shaft with removable counterweights is interchangeable with the shaft with integrally forged counterweights if the several points of possible interference listed below are carefully checked when making the installation.

After installation turn the shaft slowly and determine if it clears the pipe plug in the crankcase main oil line at the rear of the oil pump. Should there be insufficient clearance, either install a new slotted headless type plug or grind off and slot the present plug.

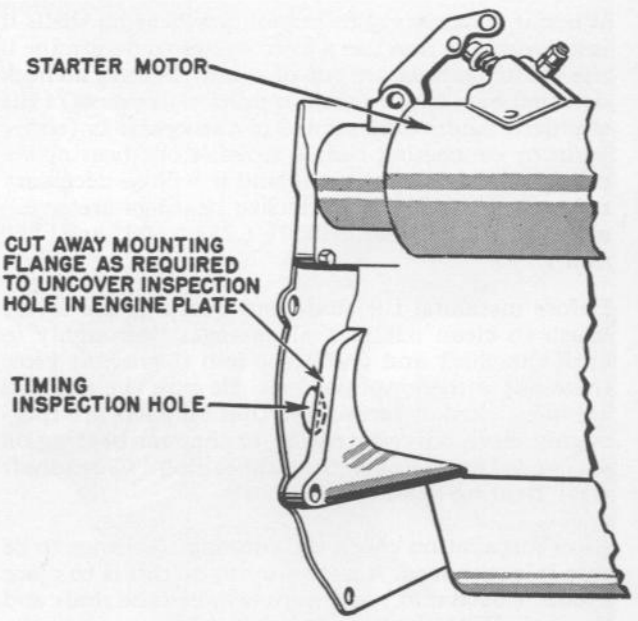

FIG. 25—UNCOVERING TIMING INSPECTION HOLE

After installation of the floating oil intake, check to determine that the crankshaft clears the float when it is up.

Check the clearance of the connecting rod bolt head with the camshaft intake cam for No. 2 cylinder when that cam is toward the crankshaft. If interference is experienced or the clearance is too close, grind off the edge of the bolt head to give about .046" (1.1684 mm.) clearance with the cam.

Before installing the oil pan, it may be necessary to bend the rear main bearing oil return pipe slightly toward the flywheel to clear the rear counterweight.

After installing the oil pan temporarily, check to determine that the front counterweight does not hit the oil pan front end. Should there be interference bend the pan forward to obtain clearance.

For information regarding the crankshaft to flywheel bolts, which are part of the crankshaft kit, refer to the subheading "Flywheel".

The shaft rotates on three steel back babbitt lined bearings with the front bearing taking the thrust. The bearing journal dimensions are given in "Engine Specifications" at the beginning of this section.

Whenever it is necessary to remove the crankshaft or install new crankshaft bearings, the engine must be removed from the frame. Should the flywheel be removed refer to the subheading "Flywheel".

The bearings are made to size and do not require line reaming. The running tolerance is .001"–.0025" (.0254–.0635 mm.). No adjustment is possible and if they require attention they should be replaced.

When it is necessary to install new bearing shells it is advisable to first use a micrometer to determine if the shaft journals are out-of-round. Should a check determine an out-of-round condition in excess of the standard running clearance of the bearings (either main or connecting rod) a satisfactory bearing replacement cannot be made and it will be necessary to regrind the shaft. Undersize bearings are available, .010″, .020″ and .030″ (.254, .508, and .762 mm.).

Before installing the shaft and bearings use a rifle brush to clean out the oil passages thoroughly in both the shaft and crankcase and if possible blow them out with compressed air. Be sure the journals are not nicked or scored and that all parts are thoroughly clean. Give attention to the rear bearing oil seal as outlined under the subheading "Crankshaft Rear Bearing Seal".

After installation check the running clearance to be sure it is standard. A good way to do this is to place a .002″ (.0508 mm.) test shim between the shaft and the shell. With the bearing cap nuts drawn up to the recommended 65-75 ft. lbs. (9.0-10.3 kg.-m.) torque a slight drag of the shaft, when turned by hand proves that the clearance is correct. Do not overlook removing the test shim.

The standard end play of the crankshaft is .004″–.006″ (.1016–.1524 mm.) which is adjusted by shims placed between the crankshaft thrust washer and the face of the front main bearing. This clearance may be checked with feeler gauges as indicated in Fig. 26. To adjust end play it is necessary to remove the crankshaft gear (with a puller) Fig. 20, and the thrust washer. When replacing the washer be sure the side with the inner beveled edge faces the front bearing.

Never file a main bearing cap or install shims between the cap and block as roundness and alignment of the bearings will be destroyed. To maintain accurate alignment in manufacture, the bearing caps are machined as an integral part of the cylinder block. To identify the caps as being part of a given crankcase a daub of paint is placed on the center bearing web and each bearing cap is marked with the same color paint. Use care not to interchange the caps with those from any other engine.

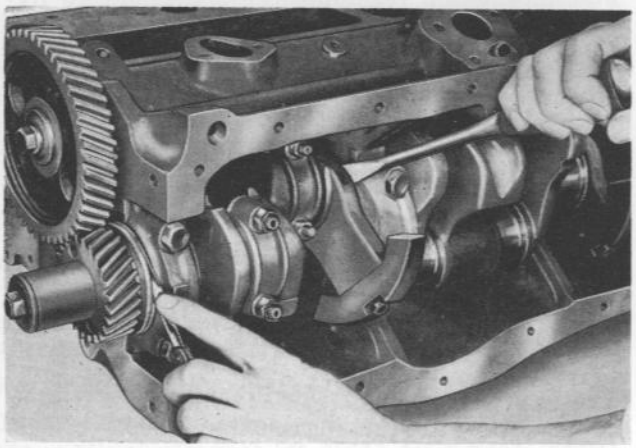

FIG. 26—CHECKING CRANKSHAFT END PLAY

When the crankshaft is removed due attention must be given the rear main bearing oil seal which is discussed in the following paragraphs.

Crankshaft Rear Bearing Seal

A new crankshaft rear bearing seal has been placed in production on all four cylinder engines and can be used as a replacement seal on all four cylinder engines now in use. This new seal is a metal supported rubber lip type, the upper half of which can be readily installed without removing the crankshaft as is necessary when using the rope type packing. To install, remove the rope type packing, clean out the packing groove and install the upper half of the seal after first coating it and the lower half thoroughly with grease for ease of installation and initial lubrication.

When installing the rear main bearing cap in the crankcase a little sealer should be placed on the sides and face of the cap to prevent oil leakage.

The rubber packings, Fig. 27, between the bearing cap and the case are cut to a given length and will protrude approximately ¼″ (6.35 mm.) from the case. When the oil pan is installed it will force this packing tightly into the holes and effectively seal any opening between the bearing cap and the crankcase.

Should trouble be experienced with oil leaking from the rear main bearing there are several points which should be checked which are listed below.

1. Be sure that the identifying paint daub on the bearing cap is the same as that appearing on the centerbearing web.
2. Check the oil return tube to determine that it does not extend up into the oil groove and that the retaining pin is flush with the lower face of the cap.
3. The bearing to crankshaft clearance must not exceed .0029″ (.0736 mm.).
4. Place sealer on the faces of the rear bearing cap from the rear oil groove to the oil seal grooves.
5. Be sure the rubber oil seals extend about ¼″ (6.35 mm.) below the bottom face of the cap.
6. Be sure the oil pan gasket is not leaking.
7. Be sure the crankcase ventilating system (if sealed crankcase type) is operating and remove and discard the ventilator screen or baffle, Fig. 9, mounted on the valve cover plate, The screen or baffle should be cleaned and replaced on engines not equipped with sealed type crankcase ventilation.
8. Check to be sure the oil leak is not at the camshaft rear bearing expansion plug or from a sand hole in the crankcase.

Connecting Rod

The connecting rods are drop forged and are of unusual length, measuring 9.1875″ (23.336 cm.) from center to center. Wrist pins are clamped in the rod. The bearings are of the replaceable shell type.

The connecting rod and piston assemblies are removed and installed through the top of the engine because of the counterweights on the crankshaft.

The standard running clearance of the connecting rod bearings is .0001″ to .0025″ (.0025–.0634 mm.) and the side clearance is .004″ to .010″ (.102–.253 mm.) which may be measured by feeler gauge, Fig. 28.

When installing new shells, align the oil spray holes in the upper shell with the spray holes in the connecting rods. The running clearance should be checked with a .002″ test shim. Place the shim between the bearing and the shaft journal, tightening the nuts to the recommended torque of 50–55 ft. lbs. (6.91–7.6 kg.-m.) for 7/16″ connecting rod bolts or 35–40 ft. lbs. (4.8–5.5 kg.-m.) for 3/8″ bolts. A slight drag on the shaft, when turned by hand, indicates that clearance is correct. Do not overlook removing the shim.

The connecting rod cap nuts are locked with stamped nuts which should be renewed when once removed. These nuts should be installed with the flat face toward the connecting rod nut. Turn the locking nut finger tight and then tighten it one half turn only. Every time a connecting rod is removed from an engine or a new rod is installed it should be checked for alignment on an aligning fixture, Fig. 29.

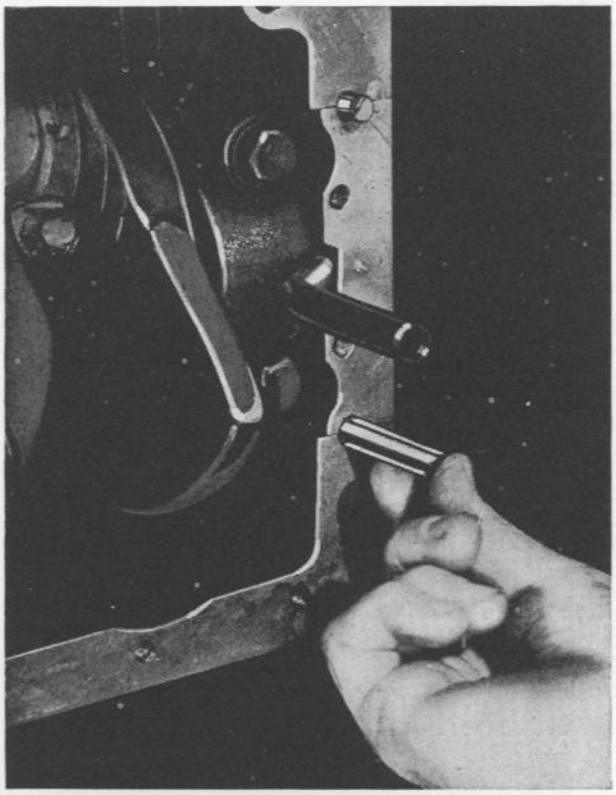

FIG. 27—REAR BEARING CAP PACKING

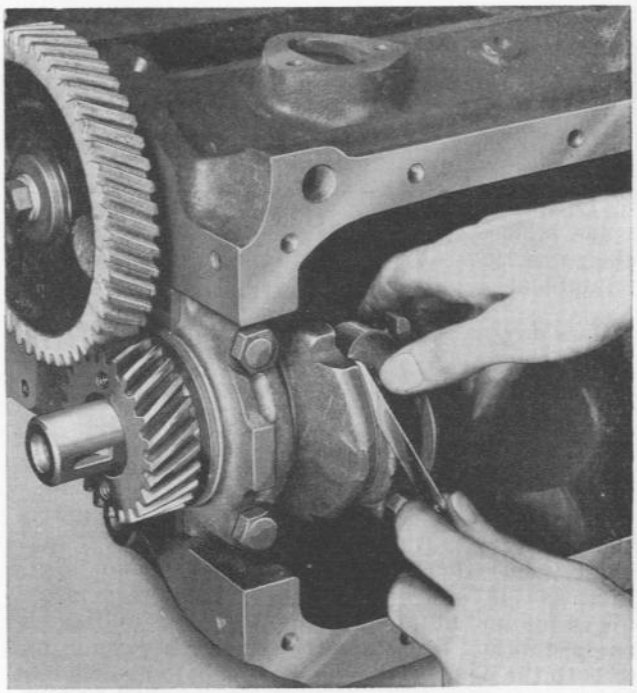

FIG. 28—CONNECTING ROD SIDE PLAY

When straightening the rod, twist or bend in the opposite direction slightly more than the original twist or bend then return the rod to true alignment. The rod will then retain correct alignment.

Longer main bearings with greater wearing surfaces are possible through the use of offset connecting rods. When the rods are installed the offset A, is placed away from the nearest main bearing B. See Fig. 30. The oil spray hole should be on the follow side or away from the camshaft toward the right side of the vehicle. Due to the offset, No. 1 and 2 or No. 3 and 4 connecting rod can not be interchanged for if they are reversed the oil spray hole will be on the wrong side. No. 1 and 3 or No. 2 and 4 can be interchanged.

Pistons

This model engine is equipped with aluminum pistons which are "T" slotted, cam ground, tin plated and have a heat insulation groove above the top ring.

The split skirt aluminum piston is fitted with .003″ (.0762 mm.) clearance. Check this clearance with a .003″ (.0762 mm.) feeler gauge 3/4″ (19.05 mm.) wide which should give 5 to 10 lbs. (2.27–4.54 kg.) pull when being removed, Tool W-173, Fig. 31. The gauge should extend the full length of the piston on the thrust side which is opposite the slot.

Fit the pistons by selection for there are slight differences in diameter due to manufacturing tolerances and limitations.

Pistons are available in the following oversizes: .010″, .020″, .030″, and .040″ (.254, .508, .762 and 1.016 mm.)

NOTE: Effective with engine Serial No. 50705, the piston head thickness was increased from 3/16″ to 1/4″ (4.76-6.35 mm.) to provide greater strength and heat conductivity. Care should be exercised when replacing pistons singly or in sets to procure the correct parts or engine vibration will result due to unbalanced pistons.

Before any attempt is made to fit new pistons, the cylinder bores should be carefully checked for out-of-round and taper. See subheading "Checking Cylinder Bores".

Usually a cylinder hone can be used satisfactorily for installation of a piston up to .005″ (.127 mm.) oversize. If a larger oversize is required the cylinders should be reconditioned with a cylinder boring machine. See "Checking Cylinder Bores" and "Cylinder Boring". Do not try to lap in a new piston using compound because it will ruin the tin plating on the piston and cause a scoring or wiping condition of both the piston and cylinder walls; use a cylinder hone.

All aluminum pistons used have an extra groove directly above the top ring which acts as a heat insulation groove. In operation pressure is built up in this groove, on the power stroke, which acts as a baffle to reduce the passage of oil into the combustion chamber. This groove also distributes heat more evenly and provides better lubrication for the piston rings.

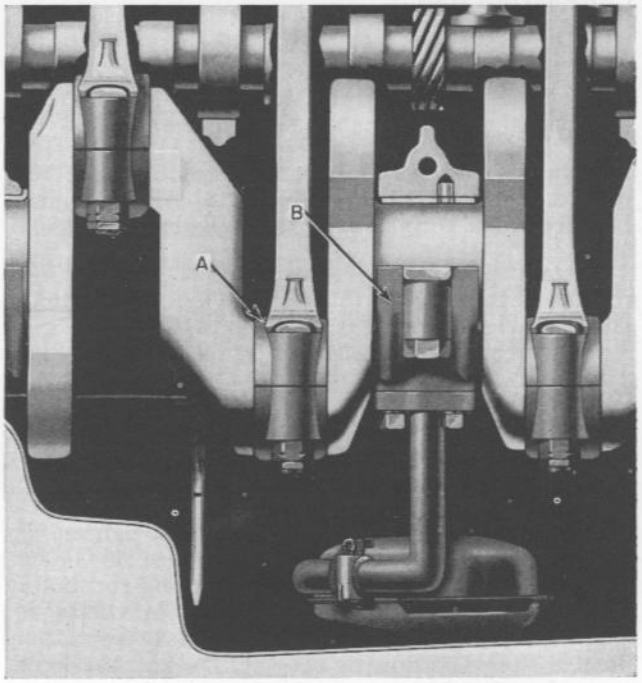

FIG. 30—CONNECTING ROD OFFSET

FIG. 29—CONNECTING ROD ALIGNER

Piston Rings

When installing a new set of piston rings, without reconditioning the cylinder bores, always remove the ridge at the top of the cylinder bore with a reliable ridge reamer, Fig. 32. Use care not to cut below the top of the upper ring position in the bore. It is always advisable to remove the ridge before removing the pistons, keeping the piston tops covered with cloth to prevent the cuttings falling into the

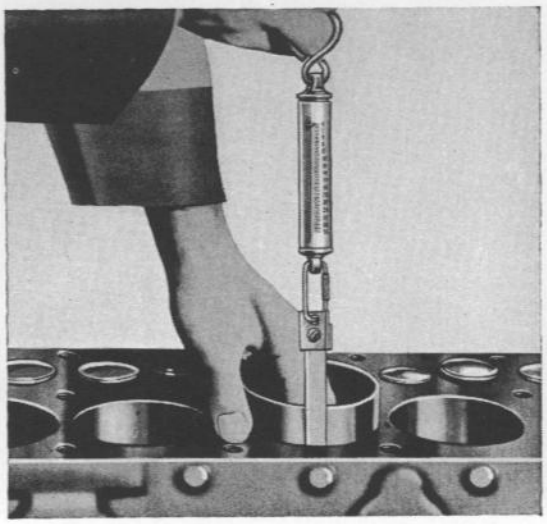

FIG. 31—PISTON FITTING

engine. When the rings are installed stagger the end gaps around the pistons. A ring compressor is essential for rapid assembly.

The width of the compression rings is 3/32" (2.381 mm.) and that of the oil control ring is 3/16" (4.762

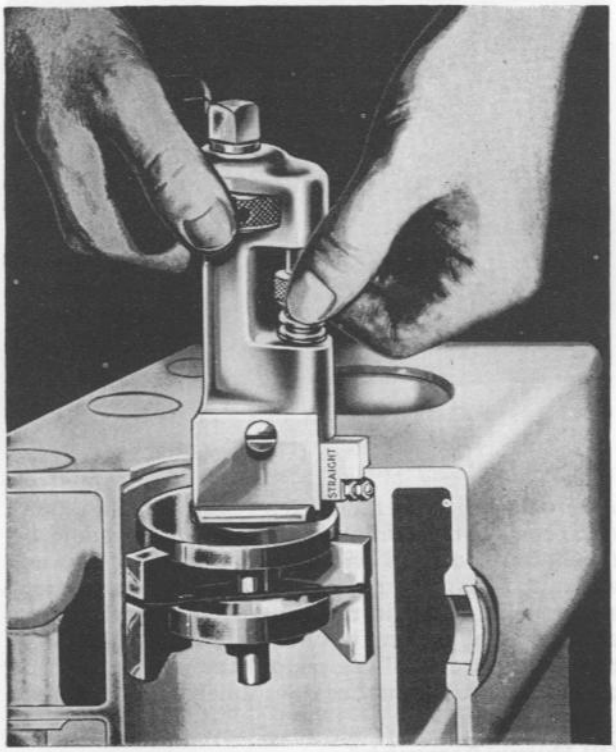

FIG. 32—CYLINDER RIDGE REAMER

mm.). While the compression rings are of the same size they are different in construction and must not by interchanged.

Install these rings as follows:

The upper compression ring has an inside beveled edge which must be installed toward the top.

The face of the lower compression ring is tapered .001" (.0254 mm.). The letters "T" or "T-O-P" on the upper edge indicate how the ring is installed, Fig. 33.

When fitting the rings to the cylinder bores, Fig. 34, the end gap is .008" to .013" (.2032 to .3302 mm.).

The groove clearance, Fig. 35, of the top compression ring is .002" to .004" (.0508 to .1016 mm.). That of the center ring is .0015" to .0035" (.0381 to .0889 mm.) and that of the bottom ring .001" to .0025" (.0254 to .0635 mm.).

Oversize rings which are available for rebored engines are .010", .020", .030" and .040" (.254, .508, .762 and 1.016 mm.). Service type rings should be used when cylinders are not rebored. These rings

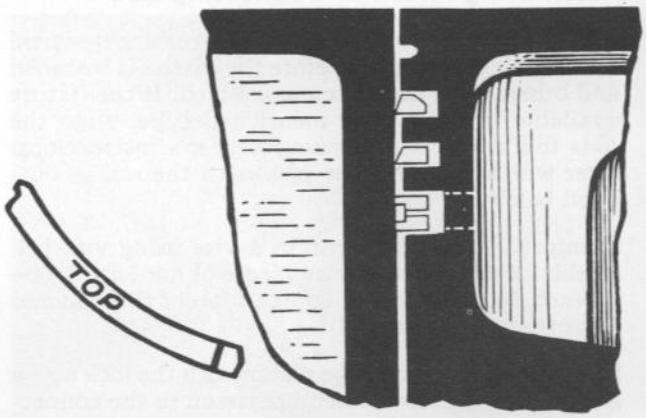

FIG. 33—PISTON RING INSTALLATION

are supplied in the following ranges of oversizes: Standard to .009" (.229 mm.), .010–.019" (.254–.483 mm.), .020"–.029" (.508–.737 mm.), .030"–.039" (.762–.991 mm.) and .040"–.049" (1.016–1.245 mm.).

Piston Pin

The piston pins are anchored in the rods with lock screws and no oversizes are available.

The pins are fitted with a clearance of .0001" (.0025 mm.) to .0005" (.0127 mm.) which is equivalent to a light thumb push fit at room temperature. See Fig. 36.

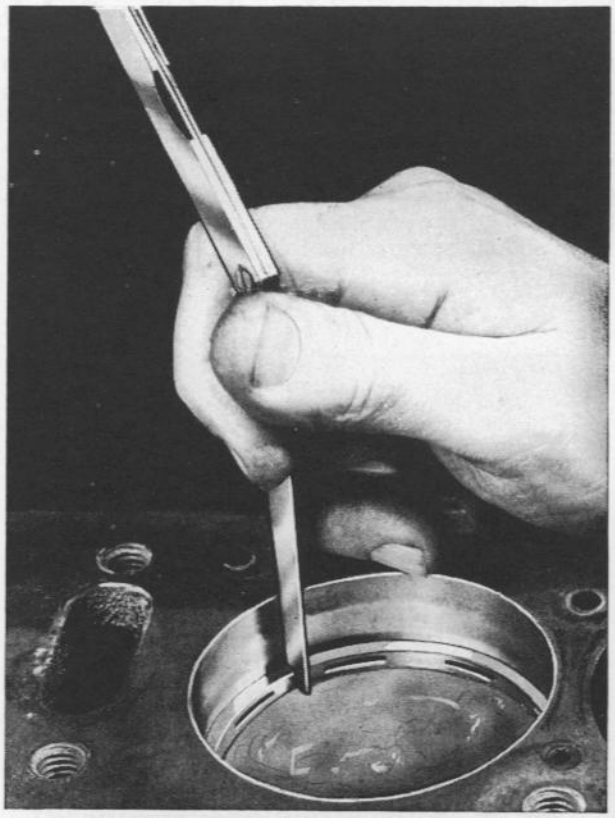

FIG. 34—PISTON RING GAP

Assembling Piston to Connecting Rod

Some connecting rod aligning fixtures are designed for checking alignment before the piston is installed and others with the piston assembled. If the fixture available is of the first mentioned type, align the rods following fixture manufacturer's instructions, after which assemble the piston on the rod as outlined below.

Clamp the connecting rod in a vise using vise jaw shields of soft metal or two pieces of hardwood, one on each side of the rod, approximately three inches from the piston pin end.

Start the piston pin in the piston with the lock screw groove facing down. Assemble piston to the connecting rod with slot No. 2 Fig. 37 in the piston, on the opposite side from the oil spray hole, No. 1 in the bearing end of the connecting rod. Install the piston pin clamp screw.

Should the aligning fixture available require the piston assembled before checking, do not overlook aligning the rods after installing the pistons.

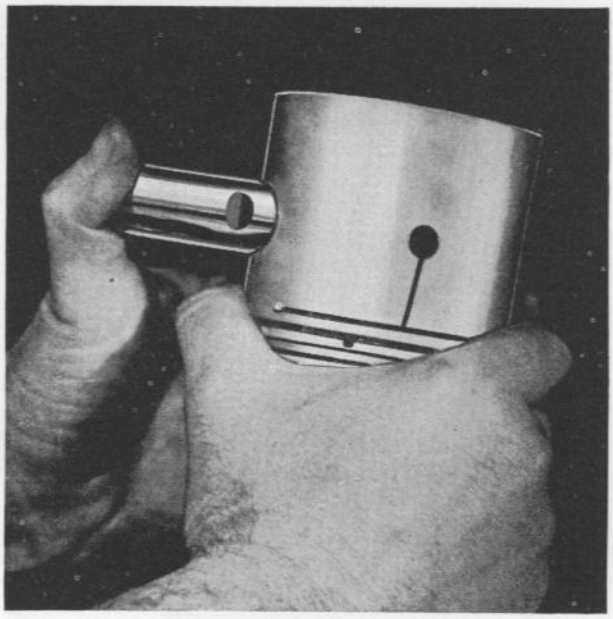

FIG. 36—PISTON PIN FITTING

Checking Cylinder Bores

The best method to check the condition of the cylinder bores to determine if reconditioning is necessary is by the use of a dial gauge.

The gauge hand will instantly and automatically indicate the slightest variation of the cylinder bores. To use this gauge simply insert it in the cylinder bores and move up and down the full length. It is then turned spirally or completely rotated at different points, taking a reading at each point. In this manner all variations in the cylinder bores from top to bottom may be determined.

When cylinders are more than .005″ (.127 mm.) out of true it is best to rebore them. The instructions furnished by the manufacturer of the boring equipment should be carefully followed.

FIG. 35—COMPRESSION RING FITTING

After the cylinders have been rebored within .002″ (.051 mm.) of the final size desired they should be finished or polished with a cylinder hone. Do not attempt to lap them with the piston. In operation, the hone is placed in the cylinder bore and run up and down the full length of the cylinder wall. Follow this procedure until the piston running clearance is correct as outlined under the subheading "Pistons".

Oil Pump Assembly

The oil pump is located externally on the left side of the engine. In operation oil is drawn from the crankcase through the floating oil intake, Fig. 50, No. 3, then passes through a drilled passage in the crankcase to the pump from which it is forced through drilled passages to the crankshaft and camshaft bearings.

Fig. 57, showing the oil circulating system of the four cylinder F-Head engine will also apply to this engine except for the oil line leading to the valve rocker arms.

When it is necessary to remove an oil pump, first remove the distributor cap and note the position of the rotor so that the pump may be reinstalled without disturbing the ignition timing. To install the pump without disturbing the timing, the pump gear must be correctly meshed with the camshaft driving gear to allow engagement of the driving key on the distributor shaft with the pump shaft driving slot, without moving the distributor rotor. Assembly can be made only in one position as the slot and driving key are machined off-center.

Effective with later model engines, a new pump was used in production. Both pumps are similar in type and design except that the later type pump employs an inner and outer rotor within the pump body in place of gears, and, the oil relief valve is

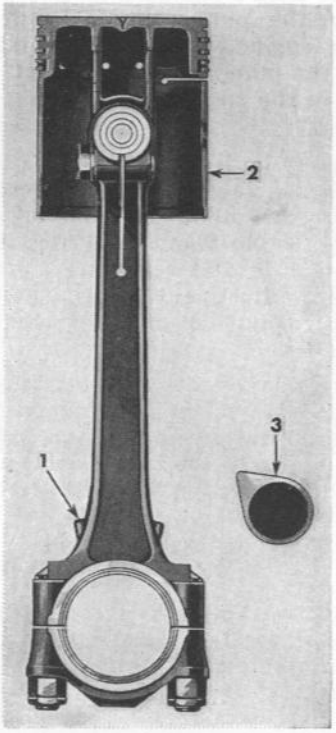

FIG. 37—CONNECTING ROD AND PISTON

mounted on the pump body instead of on the cover. Service information covering the pumps is outlined separately in the following paragraphs.

To disassemble the later type pump Fig. 40 first remove the gear which is retained by straight pin No. 8. It will be necessary to file off one end of the pin before driving it out with a small drift. By removing cover No. 2, the outer rotor and the inner rotor and shaft No. 4 may be removed through the cover opening.

Failure of the pump to operate at full efficiency may usually be traced to excessive end float of the rotors or excessive clearance between the rotors. The clearance between the outer rotor and the pump body should also be checked.

Match the rotors together with one lobe of the inner rotor pushed as far as possible into the notch of the outer rotor. Measure the clearance between the lobes of the rotors as shown in Fig. 38. This clearance should be .010″ (.254 mm.) or less. If more replace both rotors.

Measure the clearance between the outer rotor and the pump body as shown in Fig. 39. Should this clearance exceed .012″ (.305 mm.) the fault is probably in the pump body and it should be replaced.

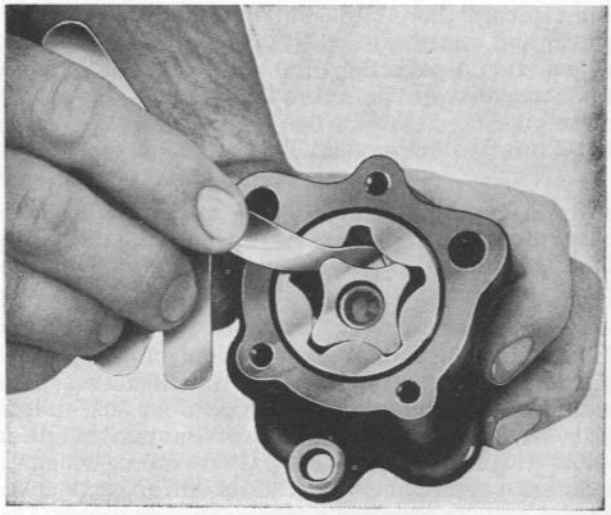

FIG. 38—CHECKING OIL PUMP ROTORS

End float of the rotors is controlled by the thickness of the cover gasket which is made of special material which can be only slightly compressed. Never use other than a standard factory gasket.

Check the cover to be sure the inner surface is not rough or scored and that it is flat within .001″ (.025 mm.) tested with feeler gauges, Fig. 41. Measure the thickness of the rotors which must be within .001″ (.025 mm.) of each other. Assemble the rotors in the pump body and install the cover without the gasket. When the cover screws are tightened to normal tension there should be interference be-

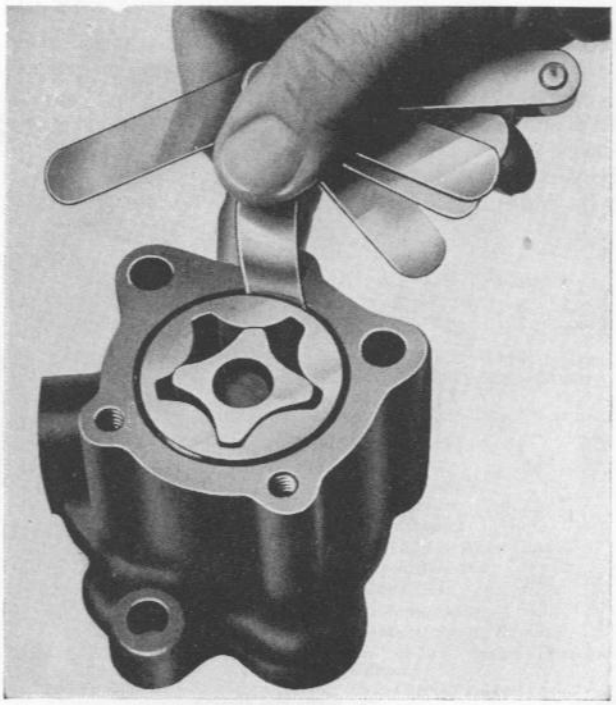

FIG. 39—CHECKING OUTER ROTOR TO OIL PUMP BODY

tween the rotors and the cover making it impossible to turn the pump shaft by hand. Remove the cover and replace it with the gasket in position which should free the rotors and shaft and prove that end float of the rotors is less than the thickness of the gasket when compressed or .004″ (.102 mm.) which is satisfactory.

After assembling the gear on the pump shaft, check the running clearance between the gear and pump body with a feeler gauge. This clearance should be from .003″ to .010″ (.0762–.254 mm.).

The older type pump, Fig. 42, may be disassembled in the same manner as outlined above. The standard end play of the rotor gear is .002″–.005″ (.0508–.127 mm.). End float of the pump shaft is .002″ (.0508 mm.) and .004″ (.1016 mm.) which is secured by selection of parts although an extra cover gasket may be installed to secure this clearance. Do not use other than a standard factory gasket. After disassembly, the pump should be primed before starting the engine. Remove pipe plug No. 3, Fig. 42, and fill the pump housing with oil of the same grade used in the engine.

The pressure of both the pumps is controlled by a similar oil relief valve, Fig. 40, No. 12, and can be altered by installing or removing shims from between retainer No. 9 and the spring. Adding shims increases pressure and removing shims decreases pressure. This adjustment will change the pressure at higher speeds but not at idle speed.

The relief valve opens at a pressure of 35-40 lbs. (2.46-2.81 kg./sq. cm.) at approximately 2000 rpm. Safe minimum pressure is 6 lbs. (.421 kg./sq. cm.) at idle and 20 lbs. (1.406 kg./sq. cm.) at 2000 rpm.

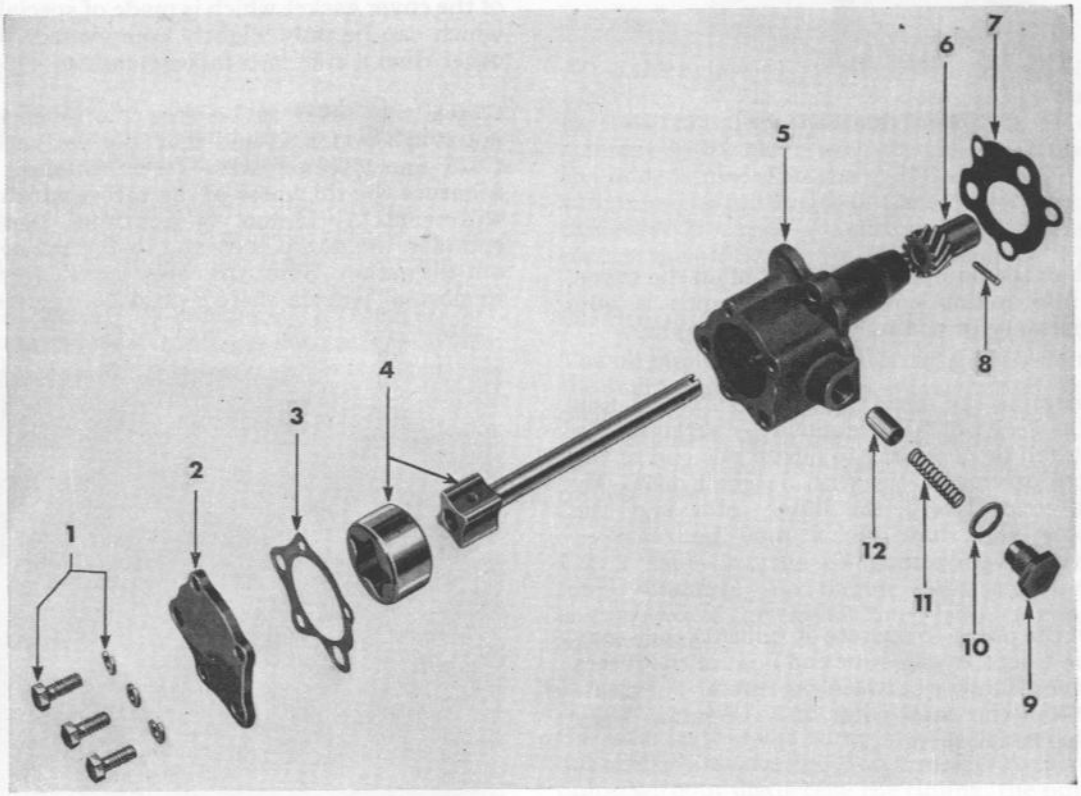

FIG. 40—OIL PUMP—LATE TYPE

1. Cover Screw
2. Cover
3. Cover Gasket
4. Shaft and Rotors
5. Body Assembly
6. Driven Gear
7. Pump Gasket
8. Gear Retaining Pin
9. Relief Valve Retainer
10. Relief Valve Retainer Gasket
11. Relief Valve Spring
12. Relief Valve Plunger

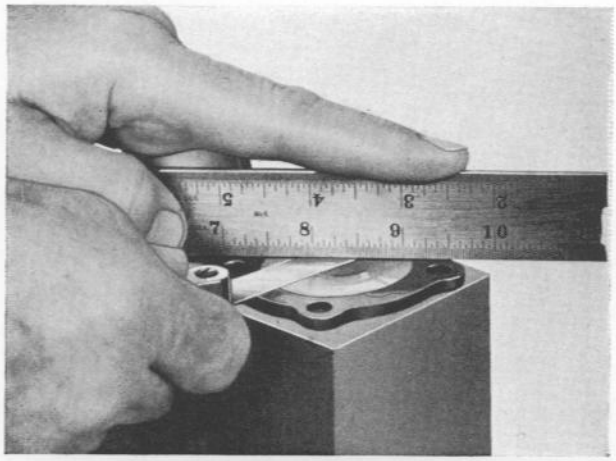

FIG. 41—CHECKING OIL PUMP COVER

Floating Oil Intake

The floating oil intake, Fig. 43, is attached to the crankcase with two screws. The construction of the float and screen causes it to remain on top of the oil, raising and lowering with the amount of oil in the pan.

This construction prevents water or dirt, which may have accumulated in the bottom of the oil pan from circulating because the oil is drawn horizontally from the top surface.

Whenever removed, the float, screen and tube should be cleaned thoroughly to remove any accumulation of dirt, also clean the oil pan.

Fluctuating oil pressure can usually be traced to an air leak between the oil float support and the crankcase. Be sure the float support flange, Figure 43, No. 7, is flat. Clean both the flange and crankcase surfaces thoroughly before installing a new gasket.

Be sure the retaining screws are tight.

The oil pan screw torque wrench reading is 12 – 17 ft. lbs. (1.65 – 2.35 kg.-m.).

Flywheel

NOTE: A new starting motor with an overrunning clutch drive was added to this engine effective with Engine Serial No. 3J-10001. This change made necessary a new flywheel ring gear with 129 teeth replacing the former ring gear with 97 teeth. The flywheels remained unchanged.

The flywheel is attached to the crankshaft with two tapered dowel bolts and four special head bolts. When the flywheel is assembled to the crankshaft be sure the "TC" timing mark is correctly located in relation to No. 1 crank throw. The correct location is indicated by arrows stamped on the flywheel center and on the crankshaft flange which should be installed together. Be sure the crankshaft and flywheel are clean and that there are no nicks or burrs to prevent even seating of the flange. After installation check the runout with a dial indicator attached to the engine plate, Fig. 44. This should not exceed .008″ (.203 mm.) on the outer edge of the rear face. Torque wrench reading 36–40 ft. lbs. (5.0–5.5 kg. m).

When installing a new crankshaft or flywheel replace the tapered dowel bolts with straight snug fitting special bolts furnished with these parts. The crankshaft and flywheel should be assembled in proper relation, then install the straight bolts previously used and tighten securely. Next use a $^{35}/_{64}$″ (13.891 mm.) drill to enlarge the tapered holes. Ream the holes with a $^{9}/_{16}$″ (.5626″) (14.288 mm.) straight reamer and install the two special flywheel bolts Part No. 116295 with nut Part No. 52804 and lockwasher Part No. 52330, instead of the two tapered dowel bolts formerly used. This procedure overcomes the necessity of reaming the special tapered holes.

Oil Pressure Gauge

All models using this engine are equipped with the electric type oil pressure gauge.

A pressure gauge does not indicate the amount of oil in the crankcase but does indicate the approximate pressure under which the oil is circulated in the engine lubricating system. Should the

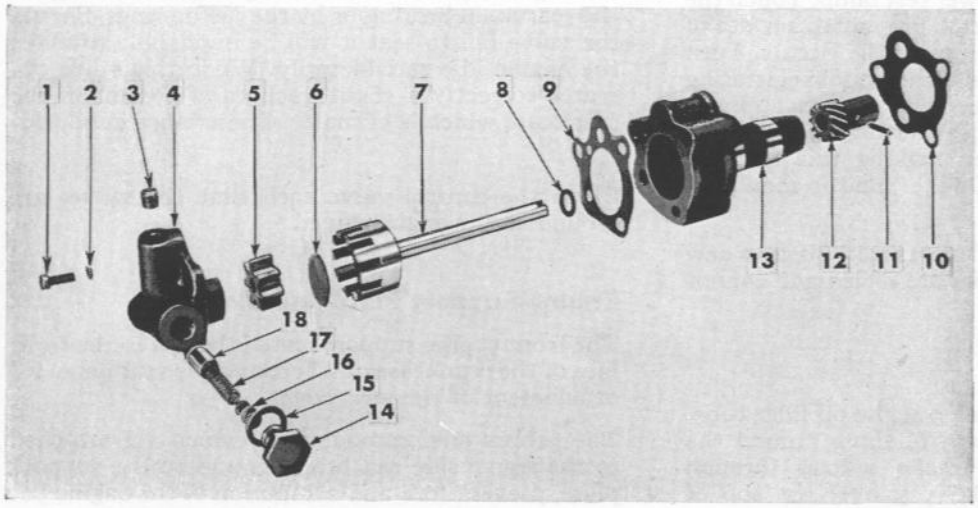

FIG. 42—OIL PUMP—EARLY TYPE

1. Cover to Body Screw
2. Cover to Body Screw Gasket
3. Cover Plug
4. Cover
5. Pinion
6. Rotor Disc
7. Shaft Assembly
8. Shaft Gasket
9. Cover Gasket
10. Oil Pump to Block Gasket
11. Driven Gear Pin
12. Driven Gear
13. Oil Pump Body
14. Oil Relief Spring Retainer
15. Oil Relief Spring Retainer Gasket
16. Relief Spring Shims
17. Relief Plunger Spring
18. Relief Plunger

pressure drop to zero, stop the engine immediately and do not start it until the trouble is corrected. A "sender" is mounted on the left side of the crankcase at an opening in the main oil circulating line. A single wire connects the "sender" to the indicating unit mounted on the instrument panel. Failure to register may indicate no oil, a fault in the oil circulating system or in the gauge units, or a loose or dirty electrical connection.

If a check shows that there is oil in the crankcase and that the electrical circuit is in good condition, disconnect the wire leading to the "sender" at the instrument panel unit and connect in its place one

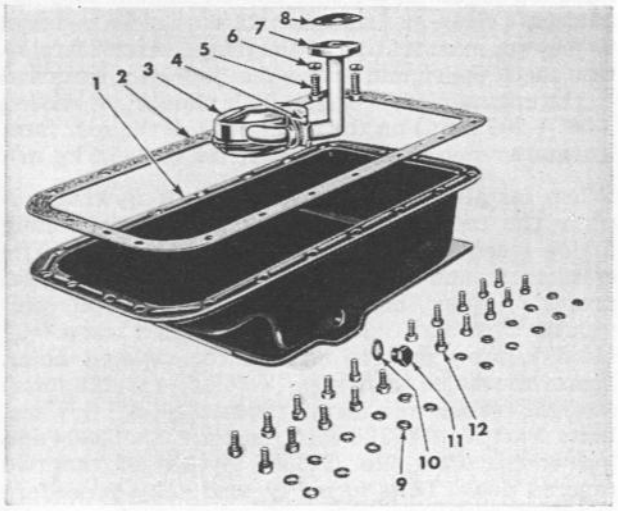

FIG. 43—FLOATING OIL INTAKE AND PAN

1—Oil Pan Assembly	7—Oil Float Support
2—Oil Pan Gasket	8—Oil Float Support Gasket
3—Oil Float	9—Lockwasher
4—Oil Float Support Cotter Pin	10—Drain Plug Gasket
5—Oil Float Support Screw	11—Drain Plug
6—Lockwasher	12—Oil Pan Screw

lead of a 6 volt, 1 candle-power test lamp. Touch the other test lamp lead to a clean, unpainted surface of the instrument panel to complete the circuit. Turn the ignition switch "on" and if the unit is registering correctly, the indicating hand will register approximately three-quarters across the dial. Should the gauge fail to register when making this test the fault is probably in the "Gauge" and it should be replaced.

Should a gauge or "Sender" be at fault, install a new unit because these assemblies are sealed and cannot be repaired.

Oil Filler Tube

Should it be necessary to remove the oil filler tube, loop a piece of iron wire several times around the tube below the top and make a loop through which a pry bar can be used to pry over the top of

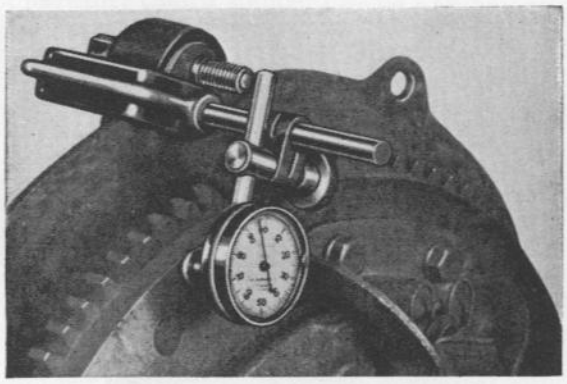

FIG. 44—FLYWHEEL RUNOUT GAUGE

the engine water outlet. Place a pull on the tube, taping it just above where it enters the crankcase. When installing a new tube be sure that the beveled lower end is away from the crankshaft.

Place a piece of hard wood over the top of the tube when installing it to prevent damage to the cap gasket seat.

Crankcase Ventilator

All engines are equipped with positive sealed type crankcase ventilation, Fig. 45, which reduces to a minimum condensation and the formation of sludge. The correct operation of the system depends upon a free flow of air from the air cleaner through the oil filler tube and engine to the control valve mounted in the intake manifold.

Be sure there is no air leakage at the tube connections between the air cleaner and the oil filler tube, and that the oil filler tube cap gasket is in good condition. Always keep the cap locked securely in position.

Be sure that the control valve mounted in the intake manifold operates at all times. Should the valve become clogged with carbon, the ventilation system will not operate and a slight pressure will build up in the engine crankcase which may cause oil leakage at the rear main bearing or by the piston rings. Should the valve fail to seat it will be impossible to make the engine idle satisfactorily. When this valve operates correctly a slight vacuum is present in the crankcase which is of material assistance in oil control.

Clean the control valve each time the valves are ground or the engine tuned.

Engine Support Plate and Mounting

The front engine support plate is bolted to the front face of the crankcase and becomes the rear panel for attachment of the gear cover.

The rubber engine mountings, which are attached to the frame side rail brackets and to the support plate, prevent fore-and-aft motion of the engine yet

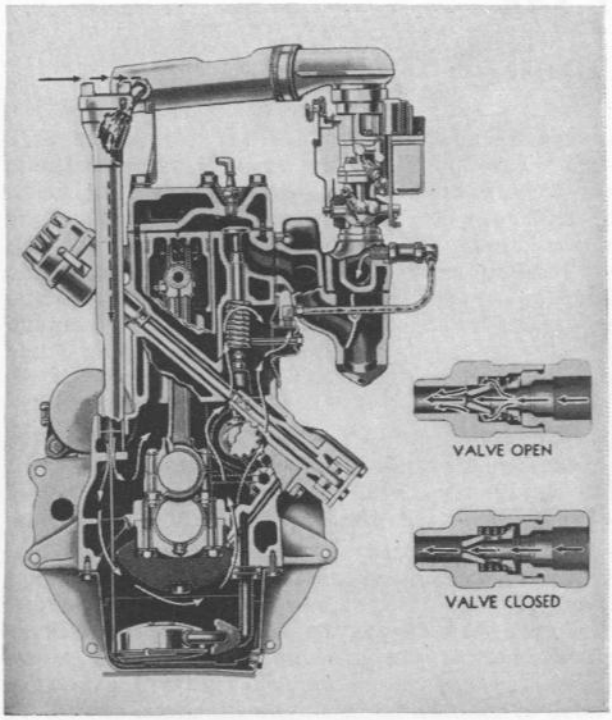

FIG. 45—CRANKCASE VENTILATING SYSTEM

allow free side wise and vertical oscillation which has the effect of neutralizing vibration at the source.

The rubber surfaces of the engine mountings partially insulate the engine from the frame. To bridge this insulation and provide a positive electrical connection for the starting motor and ignition circuits, a ground strap or cable is provided at the right front (on some models left front) engine support. See Fig. 46. The two attaching screws must be kept tight and the connections clean. A loose or

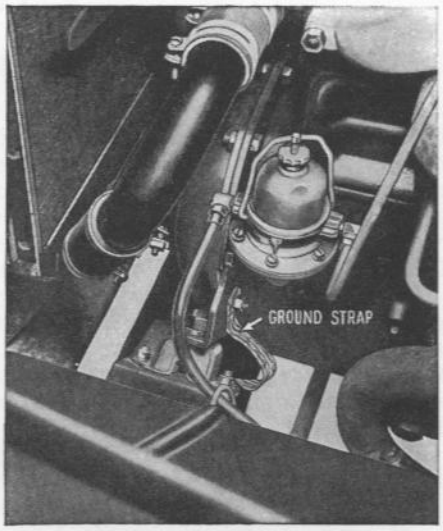

FIG. 46—ENGINE GROUND STRAP

poor connection may result in hard starting of the engine, low charging rate of the generator or sluggish starting motor operation.

The rear engine plate is attached to the rear of the crankcase and provides a means for attachment of the flywheel bell housing.

NOTE: With the adoption of the 4½" starter, a new bell housing and rear engine plate was required. This fact should be borne in mind when ordering replacement parts.

The engine is supported at the frame cross member on a mounting under the bellhousing. The torque wrench reading is 38 – 42 ft. lbs. (5.3 – 5.8 kg.-m.) for the mounting stud nuts.

SECTION III

Four Cylinder F-Head Engine

This engine is of the F-head type which is a combination valve in head and valve in block construction. The large intake valves mounted in the head allows rapid, unobstructed flow of fuel to the combustion chambers through short, water jacketed intake passages. They are operated by push rods through rocker arms in the conventional manner. The exhaust valves are mounted in the block with increased water jacketing to provide better control of heat. They are operated by conventional valve tappets.

This engine is illustrated in Figures 47 and 48.

In the following pages will be found complete information covering disassembly, rebuilding and reassembly of all four cylinder F-head engine units.

In common with all manufacturers, some engines are built with oversize cylinder bores or undersize crankshaft journals. These engines are considered standard as parts of the correct sizes are supplied. Before ordering parts or doing any work with the pistons or bearings of a particular engine, it is important to check the engine serial number to determine if oversize or undersize parts are required. Definite information is given by a letter stamped after the serial number. The letters used and their meaning is given below.

Letter "A" indicates that both the connecting rod and main bearing journals are .010″ (.254 mm.) undersize.

Letter "B" indicates that the cylinder bores are .010″ (.254 mm.) oversize.

Letters "AB" indicate that the bearing journals are .010″ (.254 mm.) undersize and the cylinder bores .010″ (.254 mm.) oversize.

At the beginning of this section, you will find listed the complete specifications covering the engine. When adjustments are necessary, refer to these specifications so that factory clearances are maintained for you cannot expect satisfactory results otherwise.

Engine Tune-up

To secure best performance and dependability, the engine should have a periodic tune-up each 200 hours. To secure the best results, it is recommended that a definite regular procedure be followed. It is essential that the carburetor receive attention at the last of this sequence, as it is impossible to satisfactorily service the carburetor until other units are correctly adjusted.

1. Remove the spark plugs and clean them. Adjust the electrode gaps to .030″ (.762 mm.) by bending the outer electrode mounted in the plug shell and use a wire gauge to measure the gap. If test equipment is available, test both the plugs and the plug cables. The voltage drop of each cable should not exceed 1/10 volt and when taking a milliamp test, the average per cable is six milliamps.
2. Check the battery. This includes cleaning the battery terminals and cable connectors. If corrosion has formed on the terminals, use a strong solution of baking soda and water to remove it. Tighten the terminal screws to assure good connections. Check each cell with a hydrometer which will show a specific gravity of 1.285 if the battery is fully charged and 1.225 when discharged. A variation of 25 points between the cells indicates that the battery requires attention. As a further check, a capacity test may be taken which is made by placing a 300 ampere load on the battery for 15 seconds. The voltage should not drop below 4½ volts. Be sure that the engine ground strap connection, Fig. 46, is tight and clean.
3. Check the engine compression. Use a compression gauge, mounting it successively in each spark plug opening with the balance of the plugs installed. Disconnect the fuel line at the fuel pump to prevent fuel from entering the cylinders. Hold the accelerator wide open and depress the starting motor control, making a note of the gauge reading for each cylinder. Standard compression pressure is 125 pounds at the starting motor speed of 185 rpm. For satisfactory engine operation, compression in all cylinders must be equal within ten pounds with a minimum pressure of 100 pounds.
4. Check the distributor. Remove the cap to clean it thoroughly and inspect it for cracks and carbon runners. Check the shaft for excessive side play. If more than .005″ (.127 mm.), it will be necessary to install new bushings. Check the distributor point spring tension which must be between 17 and 20 ounces. Be sure that the distributor points are clean and make full, square contact. If not correctly aligned, bend the stationary contact bracket slightly to provide alignment. Adjust the points to provide .020″ (.508 mm.) gap. This is accomplished by loosening lock screw, Fig. 49, No. 6, and turning adjusting eccentric screw, No. 7, until correct clearance is secured. Be sure that the fiber block on the breaker arm is resting against the highest point on the cam when the adjustment is made and recheck the gap after locking the adjustment. Check the condenser ground and lead connections.
5. Check the ignition timing. This may best be accomplished with a neon timing light. When using a timing light, be sure to disconnect the vacuum tube from the vacuum control unit mounted on the distributor. In the absence of a timing light, remove No. 1 spark plug and turn the engine over until No. 1 piston is on compression stroke as determined by air being forced out through the spark plug opening.

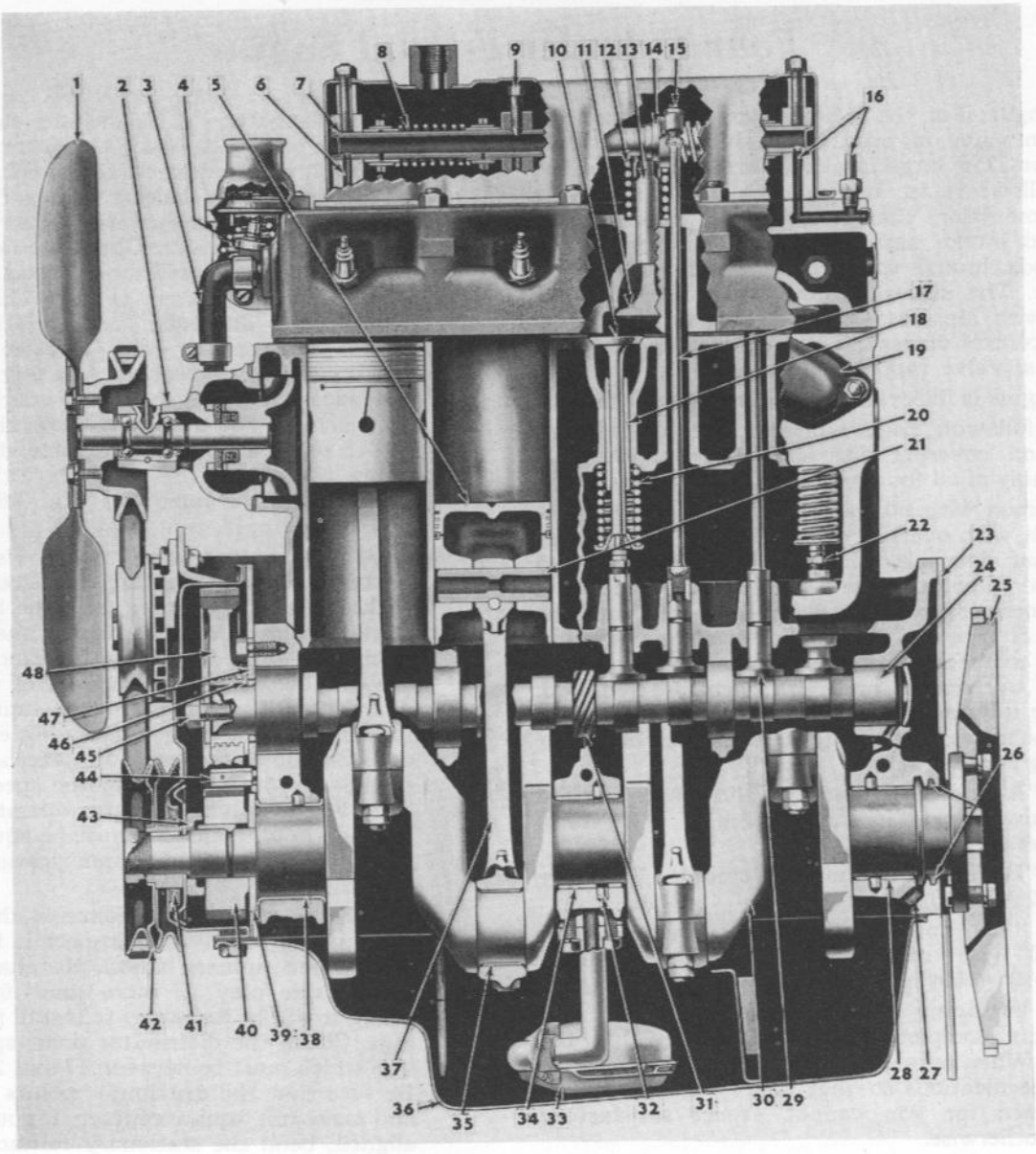

FIG. 47—FOUR CYLINDER F-HEAD ENGINE—SIDE VIEW

1—Fan Assembly
2—Water Pump Assembly
3—Water Bypass Tube
4—Thermostat
5—Piston
6—Oil Return Tube
7—Rocker Arm Shaft
8—Rocker Arm Shaft Spring
9—Rocker Arm Shaft Lock Screw
10—Exhaust Valve
11—Inlet Valve
12—Inlet Valve Spring
13—Inlet Valve Guide
14—Rocker Arm
15—Adjusting Screw
16—Oil Inlet Tube
17—Push Rod
18—Exhaust Valve Guide
19—Exhaust Manifold
20—Exhaust Valve Spring
21—Piston Pin
22—Valve Tappet Adjusting Screw
23—Engine Rear Support Plate
24—Camshaft
25—Flywheel
26—Rear Bearing Oil Seal
27—Oil Return Channel
28—Rear Main Bearing Shell
29—Tappet
30—Crankshaft
31—Oil Pump Drive Gear
32—Main Bearing Dowel
33—Oil Float Assembly
34—Center Main Bearing Shell
35—Connecting Rod Bearing
36—Oil Pan
37—Connecting Rod
38—Front Main Bearing Shell
39—Front Engine Plate
40—Crankshaft Gear
41—Crankshaft Front End Seal
42—Fan and Generator Pulley
43—Crankshaft Gear Spacer
44—Timing Gear Oil Jet
45—Camshaft Gear Screw
46—Camshaft Thrust Plate Spacer
47—Camshaft Thrust Plate
48—Camshaft Gear

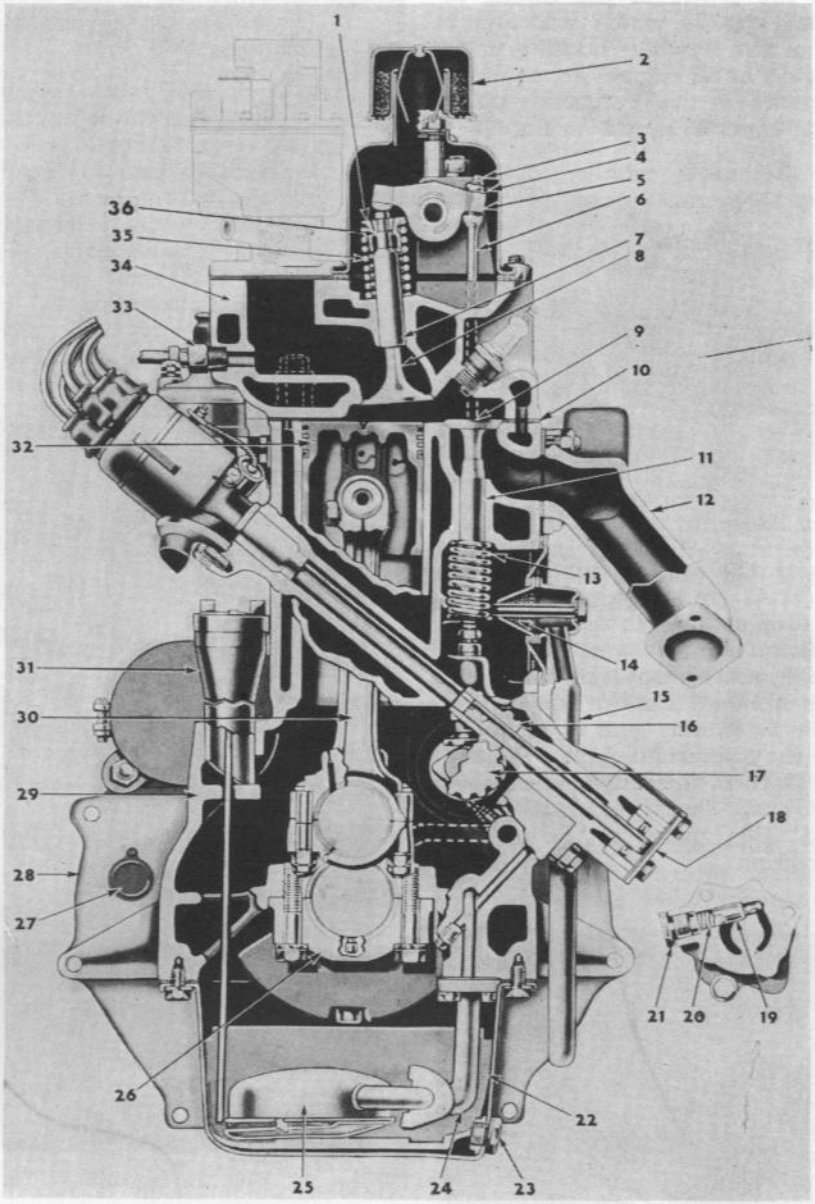

FIG. 48—FOUR CYLINDER F-HEAD ENGINE—END VIEW

1—Inlet Valve Spring Retainer
2—Ventilator
3—Adjusting Screw
4—Adjusting Screw Lock Nut
5—Rocker Arm
6—Push Rod
7—Inlet Valve Guide
8—Inlet Valve
9—Exhaust Valve
10—Cylinder Head Gasket
11—Exhaust Valve Guide
12—Exhaust Manifold
13—Exhaust Valve Spring
14—Crankcase Ventilator Baffle
15—Crankcase Ventilator Tube
16—Oil Pump Gear
17—Camshaft Gear
18—Oil Pump Cover
19—Oil Relief Valve Plunger
20—Oil Relief Valve Spring
21—Oil Relief Valve Spring Retainer
22—Oil Pan
23—Oil Drain Plug
24—Oil Float Support
25—Oil Float Assembly
26—Crankshaft Bearing Cap
27—Timing Mark Cover
28—Engine Support Plate
29—Crankcase
30—Connecting Rod
31—Oil Filler Tube
32—Piston
33—Vacuum Tube
34—Cylinder Head
35—Intake Valve Spring
36—Oil Seal

Turn the engine slowly until the flywheel mark 5° is in the center of the timing inspection opening, Fig. 29, which is located in the right side of the flywheel housing under the starting motor. Later engines are equipped with timing marks on the crankshaft pulley and timing gear cover as shown in Fig. 50.

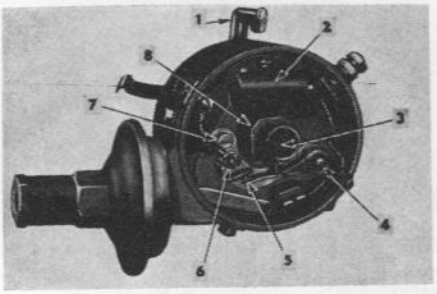

FIG. 49—DISTRIBUTOR

NOTE: Effective with the first production of the 475 series, a 4½" (11.43 cm.) starting motor was used which necessitated changes in the rear engine mounting flange which partially covers the location of the flywheel timing mark inspection hole. As a result, the hole was eliminated and a single raised mark was placed on the timing gear cover to line up with a mark on the crankshaft pulley to locate the "TC" position. In turn, this single raised mark was later replaced by two clearly indented marks; one to locate the 5° BTC position, the other to locate the "TC" position.

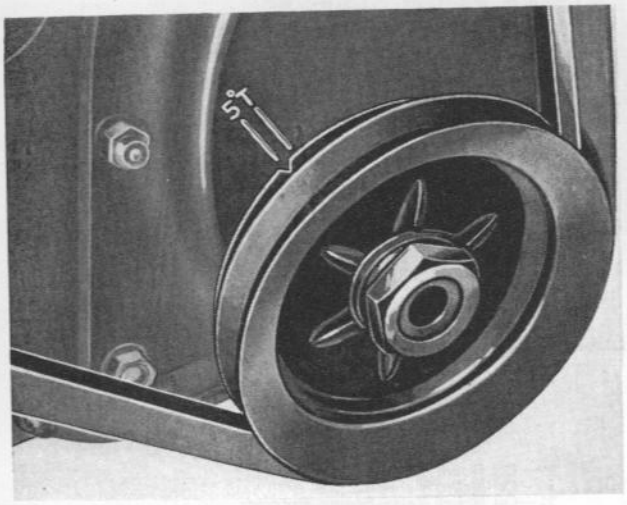

FIG. 50—TIMING MARKS

Either set of marks may be used and both sets will be in alignment when No. 1 piston is correctly positioned to check the timing. When the piston is so positioned, the timing is correctly set if the distributor rotor arm points to No. 1 terminal in the distributor cap and the distributor points are just ready to break. Timing may be altered by loosening the distributor mounting clamp and turning the distributor assembly. Turn it clockwise to advance the timing and counterclockwise to retard it. Do not overtighten the mounting clamp screw.

6. Check the valve tappet clearances. Before making this check run the engine until operating temperature is reached and use a torque wrench to tighten the cylinder head screws to the recommended 60 to 70 ft.-lbs. torque. If the cylinder head is improperly tightened incorrect valve adjustments will be made.
Note that some engines are equipped with conventional type valves while others have the "free" type. Usually the exhaust valves only are of the "free" type. These valves are

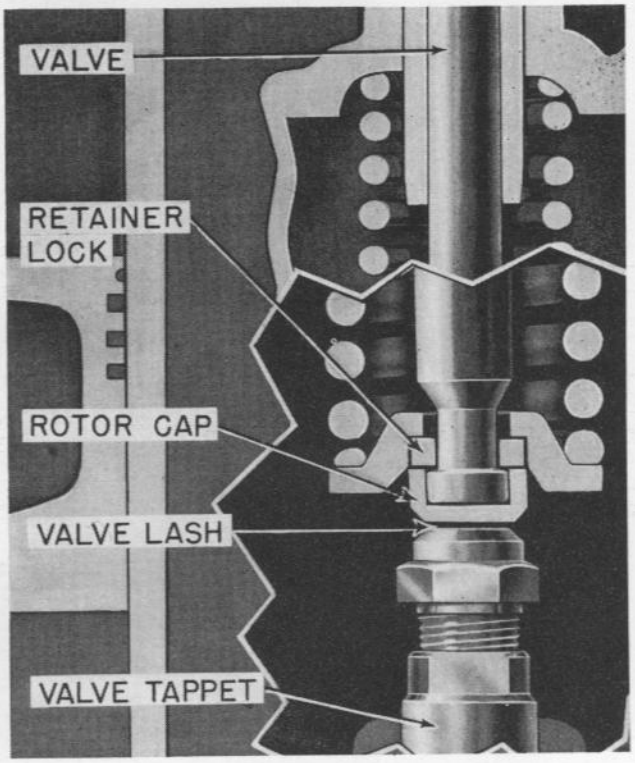

FIG. 51—VALVE WITH ROTOR CAP

equipped with devices which cause the valve stems to rotate in operation. "Free" valve operation of some valves is provided through the use of caps placed over the lower ends of the valve stems as shown in Fig. 51 and others through the use of ball bearings built in the lower spring retainers as shown in Fig. 52. Adjustment of all valves, regardless of type, may be made with the engine either hot or cold.

Adjust the intake valves, with the engine running, to .018" clearance. Adjust all exhaust valves whether of the "free" type or not at .016". Should the "free" type valve having a cap mounted on the lower end as shown in Fig. 51 develop some noise when adjusted at .016" (.406 mm.) the clearance of this type valve only may be reduced to a minimum of .012" (.304 mm).

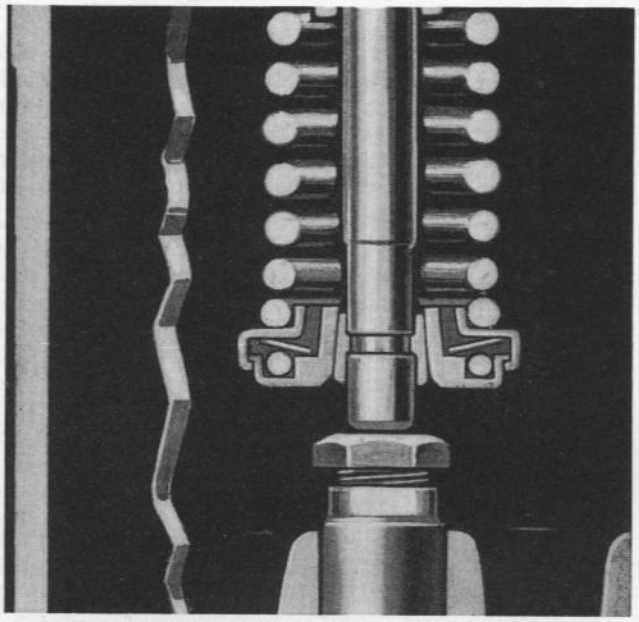

FIG. 52 — VALVE WITH BEARING TYPE ROTATOR

7. Check the fuel system including the air cleaner. Clean the fuel filtering screen and the fuel pump bowl. Check all fuel line connections to guard against leakage. If equipped with an oil bath air cleaner, remove the oil pan, clean it thoroughly and refill to the indicated oil level. Tighten all connections and check for leaks in the air tube.

8. Check the fuel and vacuum pump. Fuel pump pressure is important for low pressure will seriously affect engine operation and too high pressure will cause high fuel consumption and possibly carburetor flooding. Should there be any doubt of normal operation, check the pressure with a gauge as shown in Fig. 238. The minimum pressure is 2½ pounds (1.1339 kilos) at 16 inches (406.40 mm.) above the outlet at an engine speed of 1800 rpm. The maximum pressure is 3¾ pounds (1.700 kilos). See the "Fuel" section for complete information regarding the fuel pump.

9. Check the carburetor.

10. Start the engine and allow it to run until operating temperature is reached. Set the engine idle speed with adjusting screw, No. 1, Fig. 53 to provide the standard idle of 600 rpm. Adjust low speed adjusting screw, No. 2, to provide smooth idle.

Locating Engine Trouble

Occasionally engine performance is unsatisfactory even after the engine has been carefully tuned and it is known that both ignition and carburetion are right. The cause of the trouble usually may be located by using compression and vacuum gauges. No engine can be expected to perform satisfactorily unless the compression is sufficiently high and approximately equal in the cylinders. If performance is unsatisfactory, compression pressures should first be checked. Mount the gauge successively in each spark plug opening with the balance of the plugs installed. Disconnect the fuel line at the fuel pump to prevent fuel from entering the cylinders. Hold the accelerator wide open and depress the starting motor control making a note of the gauge reading for each cylinder. Standard compression is 125 pounds at the starting motor speed of 185 rpm. For satisfactory operation, compression must be equal within 10 pounds and not less than 100 pounds per cylinder.

Uniformly low compression may be caused either by leakage at the valves or at the piston rings or it may possibly be due to incorrect valve timing. Usually if it is due to leakage at the valves, it will be impossible to make the engine idle satisfactorily. The true cause of faulty compression can usually be determined by using a vacuum gauge.

Connect the gauge to intake vacuum at the windshield wiper fitting. Be sure that there is no leakage at the connection, for even a slight leak will result in a false reading.

Vacuum readings will vary with altitude above sea level. Below are listed various readings which indicate different engine conditions. These readings should be used to indicate engine condition at sea level and up to 2000 ft. (609 m.) altitude. At higher points deduct one inch (25.4 mm.) vacuum for each 1000 ft. (305 m.) of increased altitude.

With the gauge connected start the engine and set the throttle to give an engine speed of approximately 800 rpm. which is a fast idle speed (standard idle is 600 rpm.). With the engine at operating temperature a steady reading of from 17 to 21 inches (432 to 534 mm.) indicates that the engine is in good condition. As a further check open and close the throttle quickly. If the engine is in normal condition vacuum will drop to two inches (50.8 mm.) at wide open throttle and quickly return to about 25 inches (635 mm.) at closed throttle.

Incorrect valve timing will usually be indicated by a steady reading of approximately 10 inches (254 mm.).

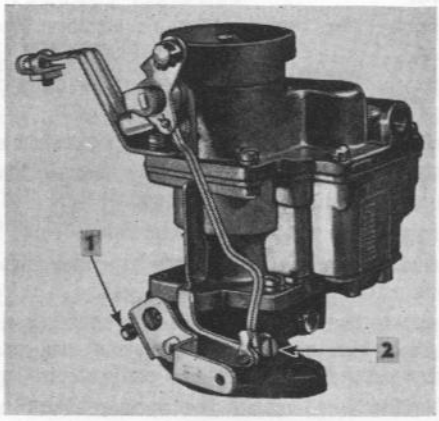

FIG. 53—CARBURETOR

Weak valve springs will cause rapid fluctuation of the gauge hand when the engine is raced. Should a valve be sticking at times only, the vacuum will drop four or five points momentarily when the valve hangs and the fluctuation will resume when the valve operates again. Should a valve be leaking badly the hand will drop four or five points each time that cylinder operates. A fast fluctuation of the gauge hand between 14 and 19 points indicates that the valve guides are worn.

Leakage at the carburetor gasket will be indicated by a steady reading of from three to four inches (76.2 to 101.6 mm.).

Leakage of compression between the cylinders will show up by the gauge needle drifting regularly between 5 and 19.

Poor carburetion is generally indicated if the gauge hand moves slowly between 12 and 16. Worn or poorly fitted piston rings or scored pistons and cylinder walls will be indicated by the hand remaining lower than normal or at about 15 points. Some fluctuation will occur should one or two cylinders only be badly scored.

Should the reading be normal when the engine is first started but quickly drop to zero, check the muffler and muffler tail pipe as the exhaust line will probably be nearly clogged.

Grinding Valves

Should tests show that lack of power and poor fuel economy is caused by low compression due to improper seating of the valves, the maximum engine performance can usually be restored by reseating and grinding the valves. Care should be used when valves are ground to maintain factory limits and clearances as only by maintaining these can one expect to get good engine performance.

When it is necessary to grind the valves it will be best to follow the procedure outlined in the following paragraphs.

1. Drain the cooling system by opening the drain cock at the right lower corner of the radiator.
2. Remove the rocker arm cover.
3. Disconnect the carburetor controls and tubes and remove the carburetor.
4. Disconnect the vacuum booster tube at the head.
5. Remove the rocker arm oil supply line from head.
6. Remove the oil filler tube supporting bracket from the head.
7. Disconnect wire from heat indicator sender.
8. Disconnect the spark plug wires from the plugs and remove the plugs.
9. Remove the upper radiator hose.
10. Remove the water pump by-pass tube from front end of cylinder head.
11. Remove the cylinder head attaching nuts including the one located inside the manifold and reached through the carburetor opening.
12. Lift the head until the rocker arms may be slid to one side and lift out the push rods.
13. Lift the head from the block.
14. Remove the valve cover plate from the side of the block directly back of the exhaust manifold. Use cloth to block off the three holes in the exhaust valve chamber floor to prevent the valve retaining keys falling into the crankcase should they be accidentally dropped.
15. Some engines are equipped with "free" type valves with a ball bearing built as part of the spring retainer as shown in Fig. 52. The procedure of removal and installation is obvious. Other engines are equipped with "free" type exhaust valves as shown in Fig. 51. This valve is of special design at the lower end and is equipped with a rotor cap, which contacts the spring lock as the valve is raised to release the spring pressure allowing the valve to turn when in an open position. Due to the necessary accurate fitting of the cap and valve locks, it is IMPORTANT THAT THE VALVE PARTS BE KEPT TOGETHER AS SETS AND NOT INTERCHANGED. With a valve spring compressor inserted between the valve tappet and spring retainer, raise the springs on the valves which are in a closed position and remove the valve locks. Turn the crankshaft until those valves which are open are closed and remove the remaining locks.
16. Remove the exhaust valves. If of the "free" type, with rotor cap keep all valve parts in sets and correctly identified for return to the same cylinder from which they were removed. Examine the stems of valves which employ the ball bearing type rotator. Wear marks around the circumference of the stem indicates that the valve is rotating satisfactorily. Vertical heavy pressure areas indicate that the valve is not rotating and the rotor bearing built in the lower spring retainer should be examined and replaced if at fault.
17. With a valve spring compressor, remove the intake valves and springs from the head. Identify them for return to the same cylinder from which they were removed.
18. Wash the springs thoroughly in a suitable solvent and examine them for damage or corrosion due to acid etching which might develop into surface cracks to cause failure. Measure the overall free length and check the pressure of each spring, on a spring testing fixture as shown in Fig. 10. The specifications which must be maintained to assure satisfactory operation are given below.

Exhaust Valve Springs

Free length	2½" (63.50 mm.)
With valve closed (compressed to 2 7/64"—53.5781 mm.)	53 lbs. (24.040 kilo.)
With valve open (compressed to 1¾"—44.45 mm.)	120 lbs. (54.430 kilo.)

Intake Valve Springs

Free length	$1\frac{31}{32}$″ (50.0062 mm.)
With valve closed (compressed to $\frac{21}{32}$″—42.0687 mm.)	73 lbs. (33.112 kilo.)
With valve open (compressed to $1\frac{3}{8}$″—34.925 mm.)	160 lbs. (72.574 kilo.)

When using a spring testing fixture, such as the one shown in Fig. 10, it is necessaey to convert the torque wrench reading which is in foot pounds to the static pound pressure of the specifications above. This is accomplished by multiplying the torque wrench reading by two. Thus should the torque wrench reading be 50 foot pounds the static pressure of the spring will be 100 lbs. Any spring which does not fall within the above specification or is distorted should be replaced.

Clean the carbon from the cylinder head, top of pistons, valve seats and cylinder block.

Clean the valve guides with a wire guide brush; clean the valves on a wire wheel brush, making sure that all carbon is removed from the top and bottom of the heads, as well as the gum which might have accumulated on the stems.

Reface both exhaust and intake valves and the valve seats at an angle of 45°.

Note: Each exhaust valve is seated against a seat machined in the block on earlier engines and against an exhaust valve seat insert shrunk into the cylinder block on later engines. Instructions regarding valve seats apply equally to both types of valve seats.

Check each valve seat after grinding with a dial indicator as shown in Fig. 11. The valve seat should not be out-of-round more than .002″ (0,0508 mm.). After reseating, lap the valve to the valve seat with fine valve grinding compound.

Check the clearance between the valve stems and valve guides carefully. Standard intake valve clearance is .0007″ to .0022″ (.01778 mm. to .05588 mm.) and the exhaust valve clearance is .0025″ to .0045″ (.0635 mm. to .1143 mm.).

Excessive clearance between the valve stems and guides will cause improper seating and burned valves. When there is too much clearance between the intale valve stem and guide there is a tendency to draw oil vapor through the guide on the suction stroke causing excessive oil consumption, fouled spark plugs and poor low speed performance.

To check the clearance of the valve stem to the valve guide, take a new valve and place in each valve guide and feel the clearance by moving the valve stem back and forth. If this check shows excessive clearance it will be necessary to replace the valve guide, if not, the valve stem is worn.

Exhaust Valve Seat Insert Replacement

See instruction page 14.

Removing and Replacing Valve Guide

Should it be necessary to replace the guides, use valve guide driver tool W-177, Fig. 12, both to remove the old guides and install the new. If this driver is not available a suitable puller for the exhaust valve guides can be made from a piece of 2″ (50.8 mm.) pipe, 6″ (152.4 mm.) long and a $\frac{3}{8}$″ (9.525 mm.) bolt 10″ (254 mm.) to 12″ (304.8 mm.) long with a threaded end, a small hexagon nut which will pass through the hole in the cylinder block and a 2″ (50.8 mm.) washer with a $\frac{3}{8}$″ (9.525 mm.) hole in it. When using tool W-177 the old exhaust valve guides are driven through the block into the valve compartment.

When replacing the exhaust guides, maximum engine performance can only be secured when the top of exhaust guide is positioned one inch (25.4 mm.) below the top face of the cylinder block as shown in Fig. 54. The standard driver is equipped with an adapter ring which correctly positions the guide. The lower end of the intake guide is positioned flush with the cylinder head casting as shown in Fig. 54.

Should the standard driver be unavailable, a substitute may be made from a piece of $\frac{1}{2}$″ (12.7 mm.) round steel 6″ (152.4 mm.) long. Turn down one end to $\frac{3}{8}$″ (9.525 mm.) in diameter for a distance of 2″ (50.8 mm.) to form a pilot and shoulder. Should this type driver be used, it will be necessary to measure to correctly locate the exhaust valve guides.

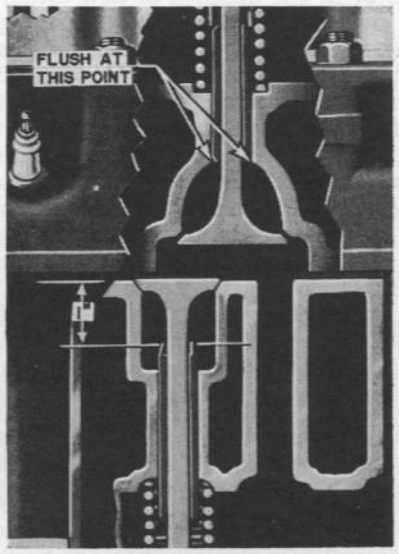

FIG. 54—VALVE GUIDE POSITIONS

Valve Tappet Clearance

Check the clearance of the valve tappets in the cylinder block which should be .0005″-.002″ (.0127-.0508 mm.). Check by moving each tappet back and forth in the block. Should the clearance seem excessive, it might be necessary to replace one or more which are supplied .004″ (.1016 mm.) oversize. This operation is covered in the section under "Camshaft and Valve Tappets."

Valve Installation

Assemble the exhaust valve springs and retainers with the closed coils of the springs placed up to seat in the block. See Fig. 14. Install the valves in the same position from which they were removed. If of the "free" type having caps mounted over the lower ends, be sure that the rotor caps and spring

retainer locks are thoroughly clean and reinstalled on the same valves from which they were originally removed with the worn side of both locks contacting the cap.

The rotor parts when new are made to be interchangeable. When correctly fitted there is from .000″ to .004″ (.000 to .1016 mm.) clearance between the bottom of the valve and the cap when the upper edge of the cap contacts the spring retainer locks as shown in Fig. 51. This clearance is just sufficient to allow the cap to raise the locks, as the valve is opened, to relieve spring pressure and allow the valve to rotate a small fraction of a revolution during each lift cycle. There is some wear of the rotor parts, however, this wear is compensating so that clearance changes little. For this reason it is essential that both the locks and cap be reinstalled on the valve from which they were removed with the worn face of both locks contacting the upper edge of the cap. Should the contact face of the locks be badly worn, install a new cap and new locks or in the absence of new locks, turn the old ones over to provide a new wearing surface. After the valves are installed, turn the engine until each valve is successively wide open. Try each valve for free operation by turning it. If they turn with slight effort, there is sufficient clearance for free operation. Maximum up and down clearance in the cap may be measured by mounting a dial indicating gauge on the valve head and measuring the vertical movement of the valve without compressing the spring. Should there be insufficient clearance to provide free operation, grind a slight amount from the lower end of the valve stem. Should there be too much clearance, lap a small amount from the upper edge of the cap using fine emery cloth placed on a smooth surface.

When installation of the exhaust valves is completed, remove the cloth blocks from the valve compartment floor openings.

Install the intake valves and springs in the cylinder head placing the ends of the springs having closed coils down against the cylinder head.

IMPORTANT: Be sure to install a new rubber oil seal ring on each intake valve stem before installing the retainer locks. With the retainer and spring compressed, position a seal ring on the valve stem just above the lock recess, install the locks and release the spring.

Clean the top of the block and pistons of all foreign matter and install the gasket without using sealer or other compound. Clean the cylinder head and install it on the cylinder block placing a piece of clean wood about 1″ (25.40 mm.) thick between the block and head. Install the intake valve push rods shoving the rocker arms to one side to make the installation. Remove the piece of wood and lower the head until the rocker arm ball ends enter the push rod sockets and then allow the head to seat on the block. Install the cylinder head nuts with the ignition wire clips over the end studs. Tighten the nuts with a torque wrench in the sequence shown in Fig. 55 to 60–70 ft. lbs. (8.3–9.6 kg.-m.) for both stud nuts and screws. Do not overlook installing the cap screw in the intake manifold directly under the carburetor opening.

Clean and adjust the spark plugs, setting the electrode gaps at .030″ (.762 mm.). Install the plugs to prevent any foreign matter entering the combustion chambers during the remaining operations.

Reinstall the water pump by-pass tube and the upper radiator hose. Reinstall the heater tube if so equipped and install the heat indicator wire.

Reconnect the rocker arm oil line and the vacuum booster tube. Reinstall the oil filler tube brace bracket screw.

Recondition the carburetor as outlined in the "Fuel" section. Install the carburetor using a new gasket and connect the throttle and choke controls and the fuel line.

Before starting the engine, which will heat the exhaust manifold, adjust the exhaust valve tappets. If equipped with "free" type valves of the type having caps over the lower ends as shown in Fig. 51, adjust them to .016″ (.406 mm.), although the clearance of this type may be reduced to a minimum of .012″ (.304 mm.) should objectionable noise be present. See step 6, Page 34. If standard type valves or those having ball bearings built into the spring retainers as shown in Fig. 52, adjust them .016″ (.4064 mm.).

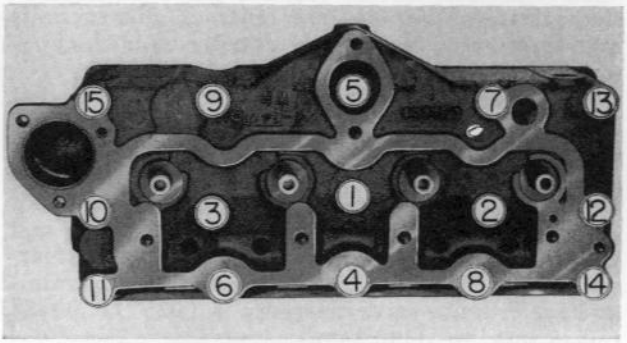

FIG. 55—CYLINDER HEAD TIGHTENING

Set the intake valve rocker arm adjustments sufficiently close to the standard .018″ (.4572 mm.) adjustment to allow the engine to run without any of the valves holding open.

Start the engine and allow it to run until operating temperature is reached, after which check the cylinder head nuts with a torque wrench to be sure that they are tightened to specifications. With the engine operating at idle speed make final adjustment of the rocker arms to .018″ (.4572 mm.) and recheck the exhaust valve adjustments. Install the rocker arm cover using a new gasket. Cement a new gasket on the valve cover plate. Install the cover and ventilator tube using a new gasket back of the tube and new copper ring gaskets under the attaching screw heads.

Recondition the distributor and set the ignition timing according to instructions under "Distributor" in the "Electrical" section.

Reconnect the air cleaner tube and road test the vehicle.

Camshaft and Valve Tappets

The camshaft, Fig. 47, No. 25, rotates on four bearings. The front bearing is a replaceable steel shell bushing with babbitt face while the other three are precision machined in the cylinder block with no bushings. It is driven by helical cut timing gears, a steel gear being used on the crankshaft and pressed fiber on the camshaft.

The camshaft bearings are lubricated under oil pressure through drilled passages in the crankcase. End thrust of the shaft is carried by a thrust plate bolted to the crankcase. The front bearing is a babbitt lined steel shell pressed into place and staked in to prevent rotation and endwise movement in the crankcase as shown in Fig. 18.

The timing gears are lubricated through a jet threaded into the crankcase which sprays oil from the front main bearing on the tooth contact point of the gears.

The valve tappets are lubricated through oil troughs cast in the crankcase. The troughs are filled by oil spray from the connecting rod ends and passages are drilled through the tappet guides to carry the oil to the tappets. A groove cut around the center of the tappet shank carries the oil up and down in the guide.

Removal of Camshaft or Valve Tappet

Drain the radiator and cylinder block, remove the radiator and grille, cylinder head, valves and valve springs. Follow instructions given under heading "Grinding Valves."

Remove the fuel pump and oil pump assemblies.

Remove the oil pan, crankshaft pulley with Puller Tool No. W-175, Fig. 19, fan belt and fan assembly.

Remove the front engine cover and the camshaft gear and thrust plate. The camshaft and crankshaft gears may be readily removed by using the recommended puller, Tool No. W-172, shown in Fig. 20.

Tie the valve tappets up at their highest point of travel with small "C" clamps or spring clip type clothespins. Remove the shaft.

Before removing the tappets, carefully check their clearance in the guides to replace those which have excessive clearance. Oversize available is .004″ (.1016 mm.) which should be fitted with .0005″ to .002″ (.0127 to .0508 mm.) clearance. Remove the tappets and inspect the faces where they contact the cams. Replace any that are scored, rough or cracked.

Carefully inspect the shaft for scores and roughness of cam and bearing surfaces. The camshaft and bearings wear little as the shaft turns at half crankshaft speed so replacement of the shaft or bearing is seldom necessary.

Replacing Camshaft or Valve Tappets

Install the valve tappets and clip them in position. Install the camshaft and the camshaft thrust plate and spacer. Install the valves.

Install the camshaft gear, setting the valve timing as outlined under the heading "Valve Timing." Clean the old gasket from the timing gear cover and cement a new one in position. Examine the oil seal to determine if it is serviceable and replace it if in doubt. Install the cover.

The balance of the assembly is the reverse of disassembly.

Camshaft Drive

Camshaft drive is through helical cut timing gears, a steel gear being used on the crankshaft and a pressed fiber gear on the camshaft. Lubrication is positive through a jet, Fig. 47, No. 46, threaded into the crankcase directly above the gear contact and through a drilled passage to the front main bearing.

Should it be necessary to replace the timing gears, attention must be given to the end float of both the camshaft and crankshaft and to the running clearance of the gears. It is also advisable to check both the jet and oil passage to be sure that they are clear.

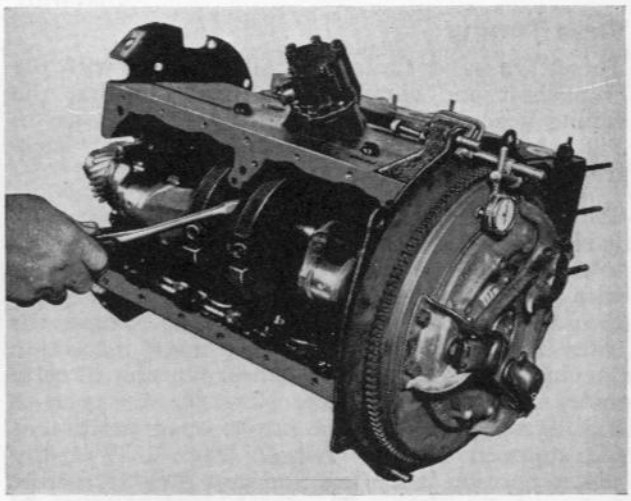

FIG. 56—GAUGING CRANKSHAFT END PLAY

End float of the crankshaft is set by the running clearance between the crankshaft thrust washer and the front face of the front main bearing. The standard end play is .004″ to .006″ (.1016 to .1524 mm.) which is controlled by a shim placed between the thrust washer and the shoulder on the crankshaft. Check the end float with a dial indicator gauge as shown in Fig. 56. If clearance is incorrect, adjustment is made by adding or removing shims. Should the thrust washer be removed, be sure that it is reinstalled with the beveled inner edge toward the crankcase.

End float of the camshaft is determined by the running clearance between the face of the camshaft gear and the thrust plate, Fig. 47, No. 49,

mounted on the crankcase. The standard clearance is .004″ to .007″ (.1016 to .1778 mm.) which is determined by the thickness of the thrust plate spacer and which may best be measured without disassembly by a dial indicator gauge. As a general rule this clearance will change little through wear or even when a new gear is installed. Should a check show too little end float, place a shim of suitable thickness between the gear hub and the spacer. Too much end float may be corrected by dressing off the spacer a suitable amount.

To predetermine the correct end float, if the gear, spacer and thrust plate have been removed, measure the thickness of both the thrust plate and spacer with a micrometer. The thickness of the spacer must be approximately .006″ (.1524 mm.) greater than that of the thrust plate. When this is true and the parts are assembled and drawn tightly together by the gear retaining screw, the end float will be within standard limits. When the spacer is installed, be sure that the inner beveled edge is placed toward the crankcase.

Standard running tolerance between the gears is .000″ to .002″ (.000 to .0508 mm.) which should be checked with a dial indicator.

When the gears have been removed, it is necessary, when reinstalling them, to retime the valves.

Valve Timing

To set the valve timing, install the gears with the crankshaft and camshaft so positioned that the timing gear marks are in alignment as shown in Fig. 23. For timing the ignition, see the "Electrical" section.

To check the valve timing, carefully set the inlet valve rocker arm adjustment for No. 1 cylinder to .026″ (.6604 mm.). Rotate the crankshaft clockwise until the piston in No. 1 cylinder is ready for the intake stroke. To determine this, remove the cover from the flywheel timing mark inspection opening, Fig. 22, in the flywheel housing directly under the starting motor. Note by reference to Fig. 21 that the "IO" or intake open position is not stamped on the flywheel. The "TC" or top center position is marked and also the "5°" before top center position. The intake valve opens 9° before top center. Note the distance between the "TC" and "5°" marks and estimate the intake open position. NOTE: Effective with the first production of the 475 series, a 4½″ (11.43 cm.) starting motor was used which necessitated changes in the rear engine mounting flange which partially covers the location of the flywheel timing mark inspection hole. As a result, the hole was eliminated and a single raised mark was placed on the timing gear cover to line up with a mark on the crankshaft pulley to locate the "TC" position. In turn, this single raised mark was later replaced by two clearly indented marks; one to locate the 5° BTC position, the other to locate the "TC" position. With the crankshaft in this position, timing is correct if the rocker arm is just tight against the valve stem. Do not overlook resetting the rocker arm adjustment to the correct running clearance.

Crankshaft

The crankshaft is of drop forged steel. To better control balance the counterweights are independently forged and attached to the shaft with a dowel and cap screw, which is tack welded for safety.

The flywheel is attached to the crankshaft with tapered dowel bolts, the holes for which are taper reamed at assembly. For information regarding the special crankshaft to flywheel bolts required when a new flywheel or crankshaft is installed, refer to the subheading "Flywheel."

The shaft rotates on three steel back babbitt lined bearings with the front bearing taking the end thrust. The bearing journal dimensions are given in "Engine Specifications" at the beginning of this section.

Whenever it is necessary to remove the crankshaft or install new crankshaft bearings, the engine must be removed from the frame. Should the flywheel be removed refer to the subheading "Flywheel."

The bearings are made to size and do not require line reaming. The running tolerance is .001″ to .0025″ (.0254 to .0635 mm.). No adjustment is possible and if they require attention they should be replaced

When it is necessary to install new bearing shells, it is advisable to first use a micrometer to determine if the shaft journals are out of round. Should a check determine an out of round condition in excess of the standard running clearance of the bearings (either main or connecting rod) a satisfactory bearing replacement cannot be made and it will be necessary to regrind the shaft. Undersize bearings available are .010″, .020″ and .030″ (.2540, .5080 and .7620 mm.).

Before installing the shaft and bearings use a rifle brush to clean out the oil passages thoroughly in both the shaft and crankcase and if possible blow them out with compressed air. Be sure the journals are not nicked or scored and that all parts are thoroughly clean. Give attention to the rear bearing oil seal as outlined under the heading "Crankshaft Rear Bearing Seal."

After installation check the running clearance to be sure it is standard. A good way to do this is to place a .002″ (.0504 mm.) test shim between the shaft and the shell. With the bearing cap nuts drawn up to the recommended 65 – 75 ft. lbs. (8.98 – 10.3 kg.-m.) torque, the shaft should either be locked or there should be a drag when it is turned by hand proving that the clearance is correct. Do not overlook removing the test shim.

The standard end play of the crankshaft is .004″ to .006″ (.1016 to .1524 mm.) which is adjusted by shims placed between the crankshaft thrust washer and the shoulder on the crank. This clearance may be checked with a dial gauge as indicated in Fig. 56. To adjust end play it is necessary to remove the crankshaft gear with a puller, Fig. 20, and the thrust washer. When replacing the washer, be sure the side with the inner beveled edge faces the front bearing.

Never file a main bearing cap or install shims between the cap and block as roundness and alignment of the bearings will be destroyed.

To maintain accurate alignment in manufacture, the bearing caps are machined as an integral part of the cylinder block. To identify the caps as being part of a given crankcase a daub of paint is placed on the center bearing web and each bearing cap is marked with the same color paint. Use care not to interchange the caps with those from any other engine.

When the crankshaft is removed due attention must be given the rear main bearing oil seal which is discussed in the following paragraphs.

Crankshaft Rear Bearing Seal

A new crankshaft rear bearing seal has been placed in production and can be used as a replacement seal on all four cyclinder engines now in use. This new seal is a metal supported rubber lip type, the upper half of which can be readily installed without removing the crankshaft as is necessary when using the old type packing. To install, remove the rope type packing, clean out the packing groove and install the upper half of the seal after first coating it and the lower half thoroughly with grease for ease of installation and initial lubrication.

When installing the rear main bearing cap in the crankcase a little sealer should be placed on the sides and face of the cap to prevent oil leakage.

The rubber packings, Fig. 27, between the bearing cap and the case are cut to a given length and will protrude approximately ¼" (6.35 mm.) from the case. When the oil pan is installed it will force this packing tightly into the holes and effectively seal any opening between the bearing cap and the crankcase.

Should trouble be experienced with oil leaking from the rear main bearing there are several points which should be checked which are listed below.

1. Be sure that the identifying paint daub on the bearing cap is the same as that appearing on the center bearing web.
2. The bearing to crankshaft clearance must not exceed .004" (.1016 mm.).
3. Place sealer on the faces of the rear bearing cap from the rear oil groove to the oil seal grooves.
4. Be sure the rubber oil seals extend about ¼" (6.35 mm.) below the bottom face of the cap.
5. Be sure the oil pan gasket is not leaking.
6. Check to be sure the oil leak is not at the camshaft rear bearing expansion plug or from a sand hole in the crankcase.

Connecting Rod

The connecting rods are drop forged with the wrist pin clamped in the rod. The connecting rod and piston assemblies must be removed through the top of the engine because of the counterweights.

The standard running clearance of the connecting rod bearings is .0005" to .0025" (.0127 to .0635 mm.) and the side clearance is .005" to .009" (.127 to .2286 mm.) which may be measured by a feeler gauge as shown in Fig. 28.

The connecting rod bearings are of the precision shell type which require no fitting. When installing new shells, align the oil spray holes in the upper shell with the spray holes in the connecting rods.

The running clearance should be checked with a .002" (.0508 mm.) test shim. Place the shim between the bearing and the shaft journal, tightening the nuts to the recommended 35-40 lbs. ft. (4.8-5.5 kg. m.) torque. Without the test shim in position, the shaft should turn freely. With the test shim installed, the shaft should either be locked or there should be a heavy drag when it is turned by hand proving that the clearance is correct. Do not overlook removing the shim.

The connecting rod cap nuts are locked with stamped nuts which should be renewed when once removed. These nuts should be installed with the flat face toward the connecting rod nut. Turn the locking nut finger tight and then tighten it one half turn only.

Every time a connecting rod is removed from an engine or a new rod is installed, it should be checked for alignment on an aligning fixture, Fig. 29.

When straightening the rod, twist or bend in the opposite direction slightly more than the original twist or bend, then return the rod to true alignment. The rod will then retain correct alignment.

Longer main bearings with greater wearing surfaces are possible through the use of offset connecting rods. When the rods are installed the offset, Fig. 30, is placed away from the nearest main bearing. The oil spray hole should be on the follow side or away from the camshaft, facing the right side of the vehicle. Due to the offset, No. 1 and 2 or No. 3 and 4 connecting rod cannot be interchanged for if they are reversed, the oil spray hole will be on the wrong side. No. 1 and 3 or No. 2 and 4 can be interchanged.

Pistons

The engine is equipped with aluminum pistons which are "T" slotted, cam ground, tin plated and have a heat insulating groove at the top in which no ring is installed. The pistons are fitted with .003" (.0762 mm.) clearance. To determine this clearance use a .003" (.0762 mm.) feeler gauge ¾" (19.05 mm.) wide which should give five to ten lbs. (2.27-4.54 kg.) pull when removed, Tool W-173 Fig. 31. The gauge should extend the full length of the piston on the thrust side which is opposite the slot. Correct clearances may be secured by selecting pistons of the correct size as there is slight variation in the sizes of standard pistons.

Pistons are available in the following oversizes: .010″, .020″, .030″ and .040″ (.2540, .5080, .7620 and 1.016 mm.).

Before any attempt is made to fit new pistons, the cylinder bores should be carefully checked for out of round and taper. See subheading "Checking Cylinder Bores."

If an oversize piston is required, the cylinders must be reconditioned with a cylinder boring machine. See "Checking Cylinder Bores" and "Cylinder Boring."

NOTE: To provide greater strength and heat conductivity in the F-head engine the piston head thickness was increased from 3/16″ to 1/4″ (4.76 to 6.35 mm.). Care must be exercised in replacing pistons, singly or in sets, to get the correct parts otherwise engine vibration will result due to unbalanced pistons. This change was effective with 473 SW and 4 x 473 SW engine No. 16862; 473 HT and 473-4WD engine No. 13869.

The pistons have an extra groove directly above the top ring which acts as a heat dam or insulating groove. In operation pressure is built up in this groove on the power stroke which acts as a baffle to reduce the passage of oil into the combustion chamber. This groove also provides more even distribution of heat and better lubrication of the piston rings.

Piston Rings

When installing a new set of piston rings without reconditioning the cylinder bores, always remove the ridge at the top of the cylinder bore with a reliable ridge reamer, Fig. 32. Use care not to cut below the top of the upper ring position in the bore. It is always advisable to remove the ridge before removing the pistons, keeping the piston tops covered with cloth to prevent the cuttings falling into the engine. When the rings are installed stagger the end gaps around the pistons. A ring compressor is essential for rapid assembly.

The width of the compression rings is 3/32″ (2.3812 mm.) and that of the oil control ring is 3/16″ (4.7625 mm.). While the compression rings are of the same size, they are different in construction and must not be interchanged. Install these rings as shown in Fig. 33, which is outlined below.

The upper compression ring has an inside beveled edge which must be installed toward the top. The face of the lower compression ring is tapered approximately .001″ (.0254 mm.). The letters "T" or "TOP" on the upper edge indicate how the ring is installed.

When fitting the rings to the cylinder bores, Fig. 34, the end gap is .008″ to .013″ (.2032 to .3302 mm.). The groove clearance, Fig. 35, of the top compression ring is .002″ to .004″ (.0508 to .1016 mm.). That of the center ring is .0015″ to .0035″ (.0381 to .0889 mm.) and that of the bottom ring .001″ to .0025″ (.0254 to .0635 mm.).

When a cylinder has been rebored or honed, standard production rings should be installed. If the cylinders have not been rebored or honed so that there is possibly a slight out of round condition not to exceed .005″ (.1270 mm.), a service type ring must be installed.

Oversize rings which are available for rebored engines are .010″, .020″, .030″ and .040″ (.2540, .5080, .7620 and 1.016 mm.).

Service type rings for use when the cylinders have not been rebored or honed are supplied in the following ranges of oversizes: Standard to .009″, .010″ to .019″, .020″ to .029″, .030″ to .039″ and .040″ to .049″ (.2540 to .4826, .5080 to .7366, .7620 to .9906 and 1.0160 to 1.2446 mm.).

Piston Pin

The piston pins are anchored in the rods with lock screws, and the manufacturer does not recommend the installation of oversize pins for experience has shown that should a pin be worn sufficiently to require replacement, the piston also should be replaced.

The pins are fitted with a clearance of approximately .0001″ to .0005″ (.00254 to .01270 mm.) which is equivalent to a light thumb push fit at room temperature. See Fig. 36.

Assembling Piston to Connecting Rod

Some connecting rod aligning fixtures are designed for checking alignment before the piston is installed and others with the piston assembled. If the fixture available is of the first mentioned type, align the rods following fixture manufacturer's instructions, after which assemble the piston on the rod as outlined below.

Clamp the connecting rod in a vise using vise jaw shields of soft metal or two pieces of hardwood, one on each side of the rod, approximately three inches from the piston pin end.

Start the piston pin in the piston with the lock screw groove facing down. Assemble piston to the connecting rod with slot No. 2, Fig. 37 in the piston, on the opposite side from the oil spray hole, No. 1 in the bearing end of the connecting rod. Install the piston pin clamp screw.

Should the aligning fixture available require the piston assembled before checking, do not overlook aligning the rods after installing the pistons.

Checking Cylinder Bores

The best method to check the condition of the cylinder bores to determine if reconditioning is necessary is by the use of a dial gauge.

The gauge hand will instantly and automatically indicate the slightest variation of the cylinder bores. To use this gauge simply insert it in the cylinder bores and move it up and down the full length. It is then turned spirally or completely rotated at different points, taking a reading at each point. In this manner all variations in the cylinder bores from top to bottom may be determined.

When cylinders are more than .005″ (.1270 mm.) out of true, it is best to rebore them. The instructions furnished by the manufacturer of the boring equipment should be carefully followed.

After the cylinders have been rebored within .002" (.0508 mm.) of the final size desired, they should be finished or polished with a cylinder hone. Do not attempt to lap them with the piston. In operation the hone is placed in the cylinder bore and run up and down the full length of the cylinder wall. Follow this procedure until the piston running clearance is correct as outlined under the subheading "Pistons."

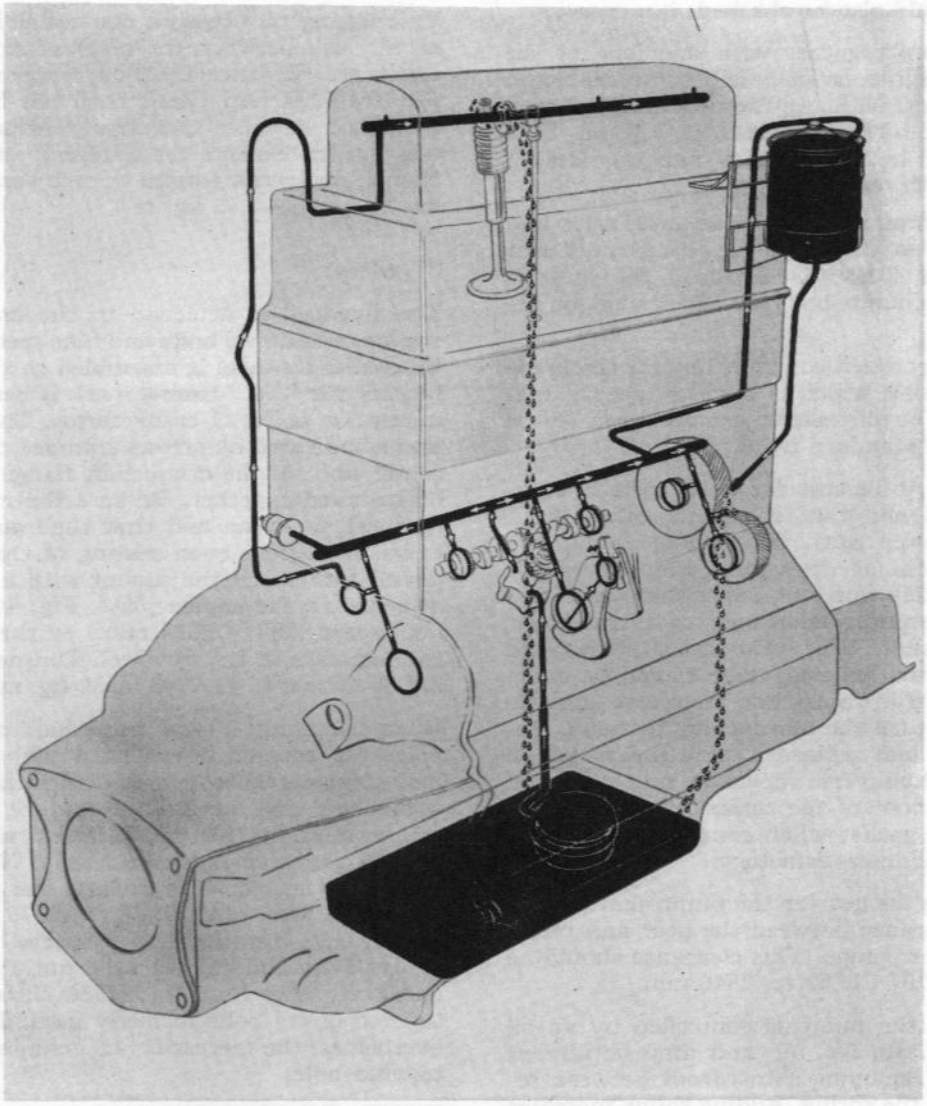

FIG. 57—ENGINE OIL CIRCULATION

Oil Pump Assembly

The oil pump, Fig. 40, is located externally on the left side of the engine. In operation oil is drawn from the crankcase through the floating oil intake, Fig. 43, No. 3, then passes through a drilled passage in the crankcase to the pump from which it is forced through drilled passages to the crankshaft and camshaft bearings. See Fig. 57.

When it is necessary to remove an oil pump, first remove the distributor cover and note the position of the distributing finger so that the pump may be reinstalled without disturbing the ignition timing. To install the pump without disturbing the timing, the pump gear must be correctly meshed with the camshaft driving gear to allow engagement of the driving key on the distributor shaft with the pump shaft driving slot, without moving the distributing finger. Distributor assembly can be made only in one position as the slot and driving key are machined off-center and it is necessary to correctly install the pump to provide this position. Note paragraphs under Installation and Timing for complete information.

The pump employs an inner and outer rotor within the pump body and an oil relief valve is mounted on the pump body which controls oil pressure at higher speeds.

To disassemble the pump, Fig. 40, first remove the gear which is retained by straight pin No. 8. It will be necessary to file off one end of the pin before driving it out with a small drift. By removing the cover No. 2, the outer rotor and the inner rotor and shaft No. 4 may be removed through the cover opening.

Failure of the pump to operate at full efficiency may usually be traced to excessive end float of the rotors or excessive clearance between the rotors. The clearance between the outer rotor and the pump body should also be checked.

Match the rotors together with one lobe of the inner rotor pushed as far as possible into the notch of the outer rotor. Measure the clearance between the lobes of the rotors as shown in Fig. 38. This clearance should be .010″ (.2540 mm.) or less. If more replace both rotors.

Measure the clearance between the outer rotor and the pump body as shown in Fig. 39. Should this clearance exceed .012″ (.3048 mm.) the fault is probably in the pump body and it should be replaced.

End float of the rotors is controlled by the thickness of the cover gasket which is made of special material which can be only slightly compressed. Never use other than a standard factory gasket.

Check the cover to be sure the inner surface is not rough or scored and that it is flat within .001″ (.0254 mm.) tested with feeler gauges, Fig. 41. Measure thickness of the rotors which must be within .001″ (.0254 mm.) of each other. Assemble the rotors in the pump body and install the cover without the gasket. When the cover screws are tightened to normal tension, there should be interference between the rotors and the cover making it impossible to turn the pump shaft by hand. Remove the cover and replace it with the gasket in position which should free the rotors and shaft and prove that end float of the rotors is less than the thickness of the gasket when compressed or .004″ (.1016 mm.) which is satisfactory.

After assembling the gear on the pump shaft, check the running clearance between the gear and pump body with a feeler gauge. This clearance should be from .003″ to .010″ (.0762 to .2540 mm.).

The pressure of the pump is controlled by an oil relief valve, Fig. 40, No. 12, and may be altered by installing or removing shims from between retainer No. 9 and the spring. Adding shims increases pressure and removing shims decreases pressure. This adjustment will change the pressure at higher speeds but not at idle speed.

The pressure at which the oil relief valve opens with standard setting is approximately 35 lbs. (2.46 kg./sq. cm.). Safe minimum pressure is 6 lbs. (.421 kg./sq. cm.) at idle and 20 lbs. (1.406 kg./sq. cm.) at 2000 rpm. (35 mph.) (56 k.).

Floating Oil Intake

The floating oil intake, Fig. 43, is attached to the crankcase with two screws. The construction of the float and screen causes it to remain on top of the oil, raising and lowering with the amount of oil in the pan.

This construction prevents water or dirt, which may have accumulated in the bottom of the oil pan from circulating because the oil is drawn horizontally from the top surface.

Whenever removed, the float, screen and tube should be cleaned thoroughly to prevent any accumulation of dirt, also clean the oil pan.

Fluctuating oil pressure can usually be traced to an air leak between the oil float support and the crankcase. Be sure the float support flange, Fig. 43, No. 7, is flat. Clean both the flange and the crankcase surfaces thoroughly before installing a new gasket. Be sure the retaining screws are tight. The oil pan screw torque wrench reading is 12 – 17 lbs. ft. (1.65 – 2.35 kg. m.)

Flywheel

The flywheel is attached to the crankshaft with two tapered dowel bolts and four special head bolts. When the flywheel is assembled to the crankshaft, be sure the "TC" timing mark is correctly located in relation to No. 1 crank throw. The correct location is indicated by arrows stamped on the flywheel center and on the crankshaft flange which should be installed together. Be sure the crankshaft and flywheel are clean and that there are no nicks or burrs to prevent even seating of the flange. After installation check the runout with a dial indicator attached to the engine plate, Fig. 44. This should not exceed .008″ (.2032 mm.) on the outer edge of the rear face of the flywheel. Torque wrench reading 36-40 lbs. ft. (4.9788-5.532 kg. m.)

When installing a new crankshaft or flywheel replace the tapered dowel bolts with straight snug fitting special bolts furnished with these parts. The crankshaft and flywheel should be assembled in proper relation, then install the straight bolts previously used and tighten securely. Next use a $^{35}/_{64}$″ (13.8887 mm.) drill to enlarge the tapered holes. Ream the holes with a $^{9}/_{16}$″ (14.2875 mm.) straight reamer and install the two special flywheel bolts Willys Part No. 116295 with nut Part No. 52804 and lockwasher Part No. 52330, instead of the two tapered dowel bolts formerly used. This procedure overcomes the necessity of reaming the special tapered holes.

NOTE: Effective with the first production of the 475 series, the 4½″ (11.43 cm.) starting motor which was adopted necessitated a new 129 tooth ring gear replacing the former 124 tooth ring gear.

Oil Pressure Gauge

All power units using the four cylinder F-head engine are equipped with electric type oil pressure gauges. This gauge requires a "sender" mounted on the left rear side of the crankcase at an opening into the main oil circulating line. A single wire connects the "sender" to the indicating unit mounted on the instrument panel.

Should the instrument panel unit fail to indicate pressure in the oil circulating system, stop the engine immediately. Failure to register may indicate no oil, a fault in the oil circulating system or in the gauge units, or loose or dirty electrical connections. See "Oil Pressure Gauge" in the "Electrical" section.

Should a gauge or sender be at fault, install a new unit because the gauges are sealed and cannot be repaired.

Oil Filler Tube

Should it be necessary to remove an oil filler tube of the type mounted on the right side of the engine, loop a piece of iron wire several times around the tube below the top and make a loop through which a pry bar may be used to pry over the top of the engine water outlet. Place a pull on the tube, taping it just above where it enters the crankcase. When installing a new tube be sure that the beveled lower end is away from the crankshaft. Place a piece of hard wood over the top of the tube when installing it to prevent damage to the cap gasket seat.

Engine Support Plate and Mounting

The front engine support is bolted to the front face of the crankcase and becomes the rear panel for attachment of the timing gear cover.

The rear engine plate is attached to the rear of the crankcase and provides a means for attachment of the flywheel bell housing.

NOTE: With the adoption of the 4½" starting motor in series 475 production, a new bell housing, rear engine plate and flywheel ring gear was required.

SECTION IV

Tornado OHC Engine

GENERAL

The 'Jeep' Tornado OHC engine (Fig. 58) is a newly designed, overhead-cam type. Because of its revolutionary design, careful attention should be given to the procedures outlined in this manual to make sure the correct overhaul methods are understood before proceeding.

The engine serial number is stamped on the lower right front of the cylinder block, just behind the ignition coil. As is common in the automotive industry, some engines are manufactured with oversized cylinder bores and/or undersized crankshaft journals. For the Tornado OHC engine, such deviations are indicated by a code suffix to the engine serial number as follows:

A — .010" [0,254 mm] undersized main and connecting rod bearings.
B — .010" [0,254 mm] oversized pistons.
AB — Combination of A and B.

Before ordering parts or doing any work on a particular engine, it is important to check the engine serial number to determine if oversize or undersize parts are required.

Detailed specifications for the Tornado OHC engine are given in the specifications section. When adjustments are necessary, refer to these specifications so that factory clearances may be maintained.

Description

This engine is equipped with an overhead camshaft (10, Fig. 58), and the valves (1 and 19) and valve parts are all mounted entirely on the cylinder head (21). The camshaft, valves, valve springs (4 and 16), rocker arms (6 and 12), and the cylinder head can be removed as an assembly for easy repair or overhaul. The camshaft has only six cams, with the same cam operating the intake and exhaust valve rocker arm for each cylinder. The cylinder block and crankcase are cast integrally, forming a rigid, reinforced unit. The large main bearing caps (24, 30, and 38, Fig. 72) assure rigid support of the main bearings (23, 29 and 39) and the crankshaft (34). Cup-type core plugs (13) are used in the cylinder block (14) to decrease the possiblity of coolant leakage at these points. The engine is equipped with a fully counterbalanced crankshaft supported by four main bearings. Crankshaft end play is controlled by thrust flanges provided on the rear main bearing (23). The engine is pressure lubricated. An oil pump (26, Fig. 58), driven by a helical drive gear (28) on the crankshaft, forces lubricant through drilled passages to efficiently lubricate the main bearings and connecting rod bearings. An external tube (11, Fig. 72) conducts the oil, under pressure, from the cylinder block (14) to the cylinder head (12) to provide lubrication to the cams through the drilled passage in the camshaft (7). An oil passage is cast into the cam bearing support deck (8) to lubricate the camshaft bearings. An oil fitting (45) is provided on the front of the cylinder block to spurt oil on the timing chain (4), crankshaft timing chain sprocket (40) and the oil pump drive gear.

The cylinder block provides a full-length water jacket around each cylinder to provide efficient cooling. Water passages are also provided through the intake manifold (20, Fig. 58) to preheat the incoming fuel mixture and help vaporize the fuel when the engine is cold. The coolant passages in the cylinder head surround the valve and combustion chamber areas to provide proper cooling of the valves. Circulation of the coolant is controlled by a thermostat in the thermostat housing mounted on the intake manifold.

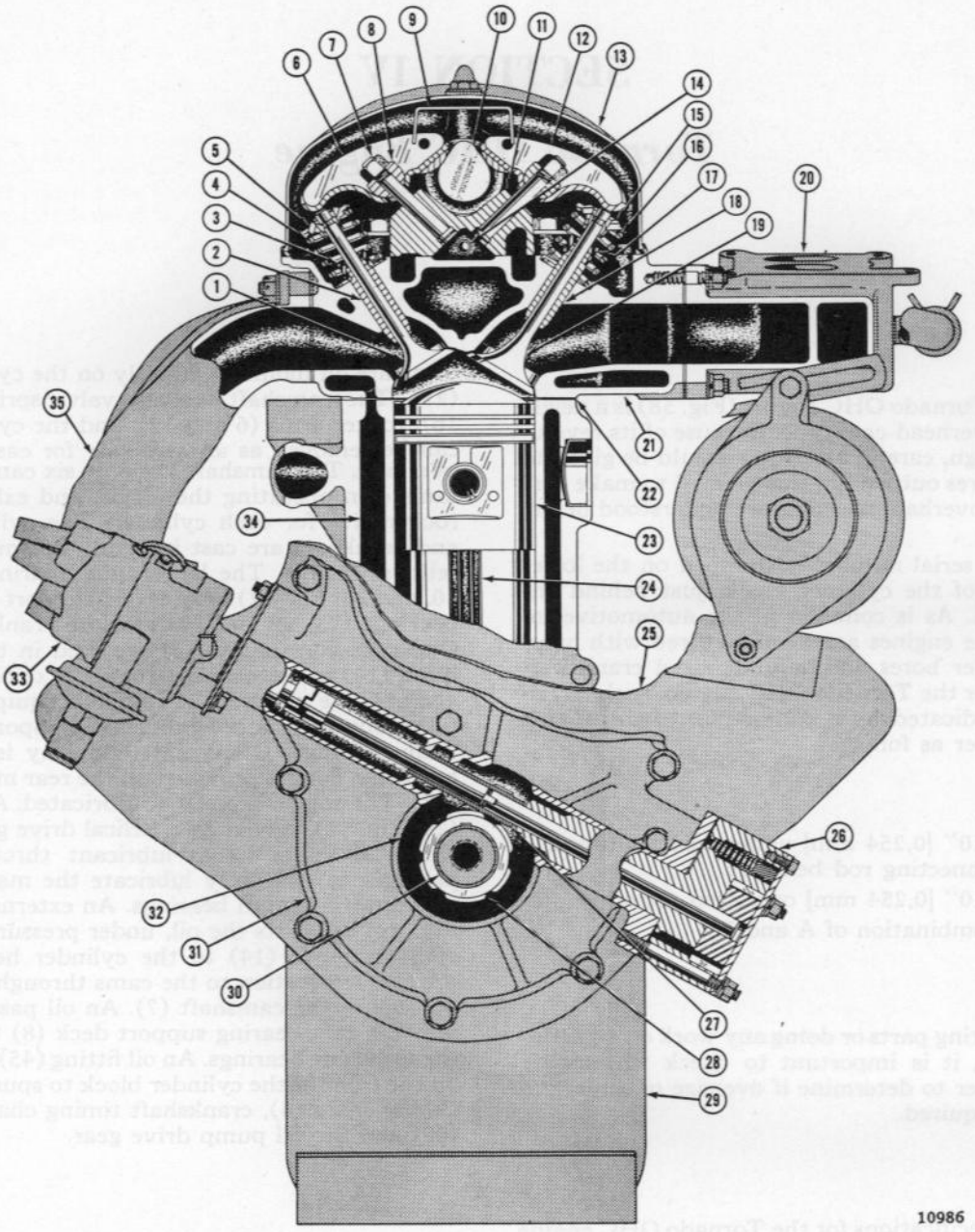

FIG. 58—TORNADO 230 ENGINE—FRONT SECTIONAL VIEW

1—Exhaust Valve
2—Exhaust Valve Guide
3—Valve Guide Seal
4—Valve Spring
5—Exhaust Valve Spring Retainer
6—Rocker Arm
7—Rocker Arm Stud
8—Rocker Arm Ball
9—Rocker Arm Guide
10—Camshaft
11—Cam Bearing Support Deck
12—Intake Rocker Arm
13—Rocker Arm Cover
14—Lubrication Pipe
15—Intake Valve Spring Retainer
16—Valve Spring
17—Valve Guide Seal
18—Intake Valve Guide
19—Intake Valve
20—Intake Manifold
21—Cylinder Head
22—Cylinder Head Gasket
23—Piston
24—Connecting Rod
25—Front Engine Plate
26—Oil Pump
27—Oil Pump Helical Gear
28—Oil Pump Drive Gear
29—Oil Pan
30—Crankshaft
31—Timing Chain Cover
32—Timing Chain Cover Oil Seal
33—Distributor
34—Cylinder Block
35—Exhaust Manifold

Engine Tune-Up

Contents

1. GENERAL

An engine tune-up should be performed at the end of each 250 hours of use, to restore performance and power lost through wear and deterioration resulting from engine use. The tune-up should follow the sequence given below. Correction of items affecting the fuel system should not be attempted until all items affecting compression, ignition, and crankcase ventilation have been satisfactorily checked and any problems corrected.

2. Clean and Check Battery

Inspect battery and cables. If the battery is not satisfactory, install a fully charged battery to allow completion of the tune-up.

a. Check the specific gravity of the electrolyte in each cell of the battery. A hydrometer reading of 1.260 indicates that the battery is fully charged. If the reading is 1.225 or below, the battery needs recharging. If one or more cells is 25 "points" [.025] or more lower than the other cells, this indicates that the cell is shorted, the cell is about to fail, or there is a crack in the battery partition in the case. Unless the battery is repaired or replaced, battery trouble will soon be experienced.

b. Check the electrolyte level in each cell, add distilled water to maintain the solution $\frac{3}{8}$" [9.5 mm] above the plates. Avoid overfilling. Replace the filler caps and tighten securely. It is important to keep the electrolyte level above the plates at all times because plates that are exposed for any length of time will be seriously damaged.

c. Clean the battery terminals and cable connectors. Prepare a strong solution of baking soda and water and brush it around the terminals to remove any corrosion that is present. The cell caps must be tight and their vents sealed to prevent cleaning solution entering the cells; after cleaning, coat the terminals with heavy grease.

d. Inspect the battery cables and replace if badly corroded or frayed. Check tightness of terminal screws to ensure good electrical connections. Check the tightness of the negative ground cable connection at the frame to ensure a good ground connection.

e. Load test the battery. Connect a voltmeter across the battery. Run the starting motor for 15 seconds. If the voltage does not drop below 10 volts on a 12-volt battery, the battery is satisfactory. If the voltage falls below the figure given, yet the specific gravity is above 1.225, the condition of the battery is questionable.

f. Be sure the engine ground strap is tight at both connections. It is connected between the right front lower support bolt and the front engine coil bracket bolt. It these connections are loose or dirty, hard starting or failure to start may result.

3. Clean and Adjust Spark Plugs

Clean, inspect, and gap spark plugs. Do not install spark plugs until completion of compression tests.

a. Use a spark plug cable removing and installing pliers W-274 as shown in Fig. 59 to remove the leads from the spark plugs.

Caution: Pulling on the cables to remove them from the spark plugs will cause internal breaks in the leads and will result in ignition failure. Always use the special tool W-274 to remove the spark plug cables.

b. Using a spark plug wrench, loosen each spark plug one or two turns to break loose any carbon deposits on the plug base.

c. Blow out all carbon and dirt from each spark plug hole with compressed air. If compressed air is not available, temporarily reinstall the spark plug

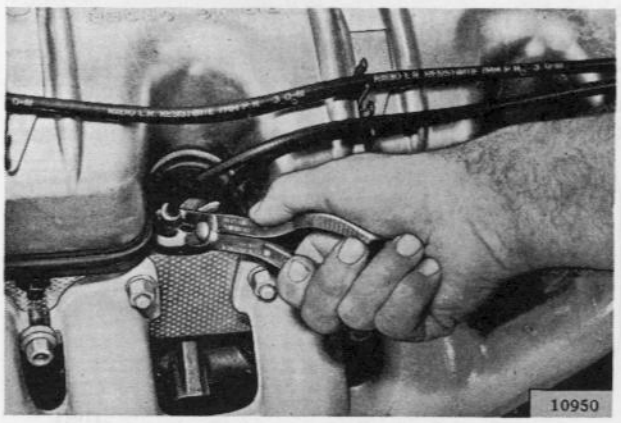

FIG. 59–REMOVING SPARK PLUG WIRE CABLE WITH TOOL W-274

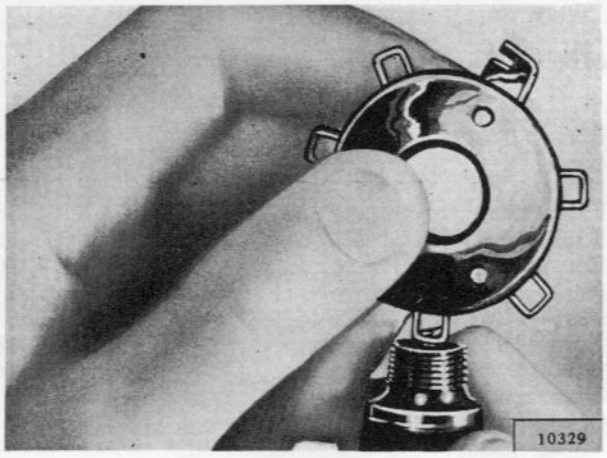

FIG. 60—SETTING SPARK PLUG GAP

cable using the special pliers, start the engine, and accelerate to 1000 rpm. to blow out the carbon and dirt. Stop the engine.

d. Remove the plugs carefully with a spark plug wrench.

e. Inspect the plugs for serviceability. Especially check for burned and eroded electrodes, blistering of porcelain at the firing tip, cracked porcelain, or black deposits and fouling. These conditions indicate that the plugs have not been operating at the correct temperature. Replace bad or worn plugs in sets.

f. Measure the electrode gap of each new or existing plug with a wire gauge as shown in Fig. 60. Adjust each electrode gap to the specified gap by bending the outer electrode mounted in the plug shell.

g. Reinstall plugs. Torque with a wrench to proper setting.

4. Torque Cylinder Head and Manifold

Torque the cylinder head bolts with a torque wrench to 75-80 lbs ft. [10,3-11,0 kgm]. Follow the sequence shown in Fig. 61. Do not overlook tightening the three 5/16 in. nuts, Nos. 15, 16, and 17. Torque these to 15-20 lbs ft [2.07-2.76 kgm]. Torque all intake manifold attaching nuts evenly to 15-20 lbs ft [2.07-2.76 kgm]. Torque all exhaust manifold attaching nuts to 35-40 lbs ft [4.98-5.53 kgm].

5. SERVICE CRANKCASE VENTILATION SYSTEM

This engine model is equipped with a positive crankcase ventilating system that removes the products of combustion from the crankcase at all engine speeds. An improperly operating ventilation system will cause rough idling, power loss, and the formation of sludge and varnish in the engine. Service the system at every tune-up as follows:

a. Disconnect the vent hose (3, Fig. 4A) from the oil filler tube and from the vent valve. Remove the vent valve.

b. Blow out the vent tube with compressed air to make sure it is completely open.

c. Disassemble the vent valve and wash the parts with cleaning solvent; dry thoroughly. Check the parts of the valve for wear and for a distorted spring; replace the valve if the parts are damaged.

d. Reassemble the vent valve and install the valve and hose. When reassembling the valve, make sure that the end coil of the spring is snapped into the groove just under the head of the valve.

e. Check the oil filler cap gasket to make sure it is providing a tight seal of the system.

f. Check the breather cap (5); clean if necessary.

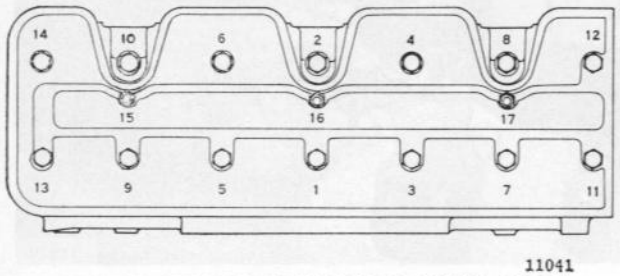

FIG. 61—ENGINE CYLINDER HEAD BOLT TIGHTENING SEQUENCE

6. Check Compression

Take compression readings with a compression gauge, as shown in Fig. 62, at each cylinder while cranking the engine with a starter motor. Allow only four compression strokes at each cylinder and record only the first and fourth readings. Interpret the readings as follows:

a. When pressure quickly comes up to specified pressure and is uniform between all cylinders within 15 psi. [1.054 kg-cm^2], it indicates that the engine is operating normally with satisfactory seating of rings, valves, valve timing, etc.

b. When pressure is low on the first stroke and builds up to less than specified pressure, it indicates compression leakage usually attributable to rings or valves. To determine which is responsible, pour ½ oz. [15 cu cm] of tune-up oil into each cylinder. Allow a few minutes for the oil to leak down past the rings; then again test compression. If compression pressures improve over the first test, the trouble is probably worn piston rings and bores. If compression pressures do not improve, the trouble is probably caused by improper valve seating. If this condition is noticed on only two cylinders that are adjacent, it indicates that there is a possible gasket leak between these cylinders.

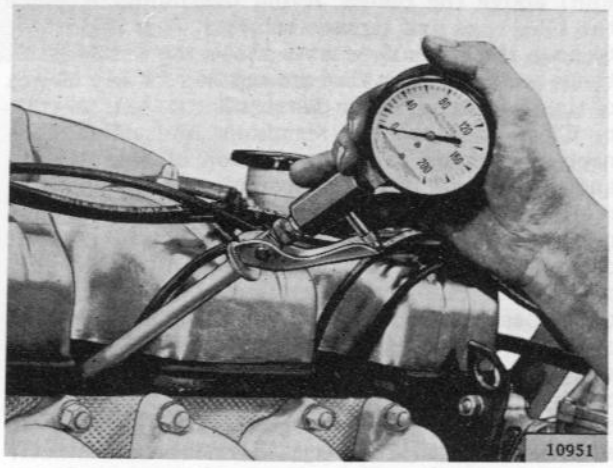

FIG. 62—CHECKING COMPRESSION

If inspection of the spark plugs from these cylinders discloses fouling or surface cracking of electrodes, gasket leakage is probable.

c. When pressure is higher than normal it indicates that carbon deposits in the combustion chamber have reduced the size of the chamber enough to give the effect of a raised compression ratio. This will usually cause pinging under load that cannot be satisfactorily corrected by timing. The carbon must be cleaned out of the engine to correct this trouble.

d. Reinstall the spark plugs. Torque with a wrench to proper setting of 28 to 30 lbs ft.

Advise the vehicle owner if compression is not satisfactory.

7. ROCKER ARM CLEARANCE ADJUSTMENT

Rocker arm clearance adjustment may be made when the engine is either cold or hot. Adjust the rocker arm clearance as follows:

Caution: Do not attempt to remove the rocker arm cover to adjust the rocker arm clearance when the engine is running. Always shut down the engine before removing the rocker arm cover.

a. Remove the rocker arm cover.

b. Turn the engine over until the No. 1 cam nose points down to the 6 o'clock position.

c. Insert a feeler gauge between the rocker arm and the top of the valve stem as shown in Fig. 63. The correct rocker arm clearance for the exhaust valves is .008″ [0,203 mm]. The correct clearance for the intake valves is .006″ [0,152 mm]. Use a socket wrench to adjust the clearance. Turning the rocker arm nut clockwise decreases the clearance; turning the rocker arm nut counterclockwise increases the clearance.

d. Adjust the intake and exhaust valve rocker arms for all six cylinders in this manner, setting cam nose to the 6 o'clock position before adjusting.

e. Install the rocker arm cover.

8. Check Distributor

a. The distributor cap should be inspected for cracks, carbon runners, and evidence of arcing. If any of these conditions exists, the cap should be replaced. Clean any corroded high tension terminals.

b. Inspect the rotor for cracks or evidence of excessive burning at the end of the metal strip. After a distributor rotor has had normal use, the end of the rotor will become burned. If burning is found on top of the rotor, it indicates the rotor is too short and needs replacing. Usually when this condition is found, the distributor cap segment will be burned on the horizontal face and the cap will also need replacing.

c. Check the condenser lead for broken wires or frayed insulation. Clean and tighten the connections on the terminal posts. Be sure the condenser is mounted firmly on the distributor for a good ground connection. Should a condenser tester be available, the capacity should check from .25 to .28 microfarads. In the absence of a tester, check by substituting a new condenser.

d. Examine the distributor points (6, Fig. 64). If they show wear, poor mating, transferred metal, or pitting, then new ones should be installed. Clean the points with a suitable solvent and a stiff-bristled brush.

e. Check the alignment of the points for a full, square contact. If not correctly aligned, bend the stationary contact bracket into proper closing alignment.

f. The contact gap should be set at .020″ [0,508 mm], measured with a wire gauge. Adjustment of the gap is accomplished by loosening the adjusting screw (7) and positioning the stationary contact (8) until correct gap is secured. Be sure that the fiber block on the breaker arm is resting on the highest point on the cam while the adjustment is being made. Recheck the gap after locking the adjustment.

g. Apply a very thin film of cam lubricant to the cam to lessen fiber block wear.

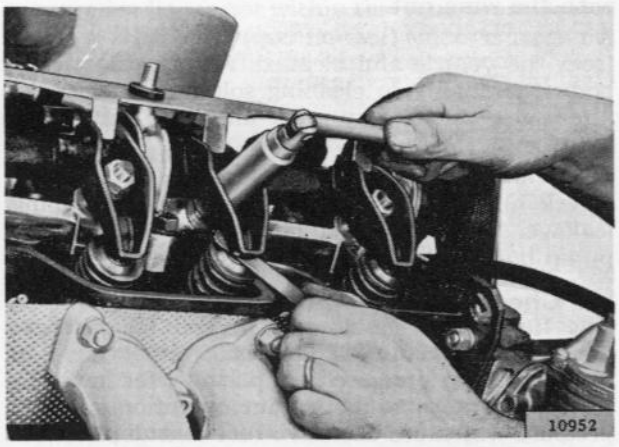

FIG. 63—ADJUSTING VALVE CLEARANCE

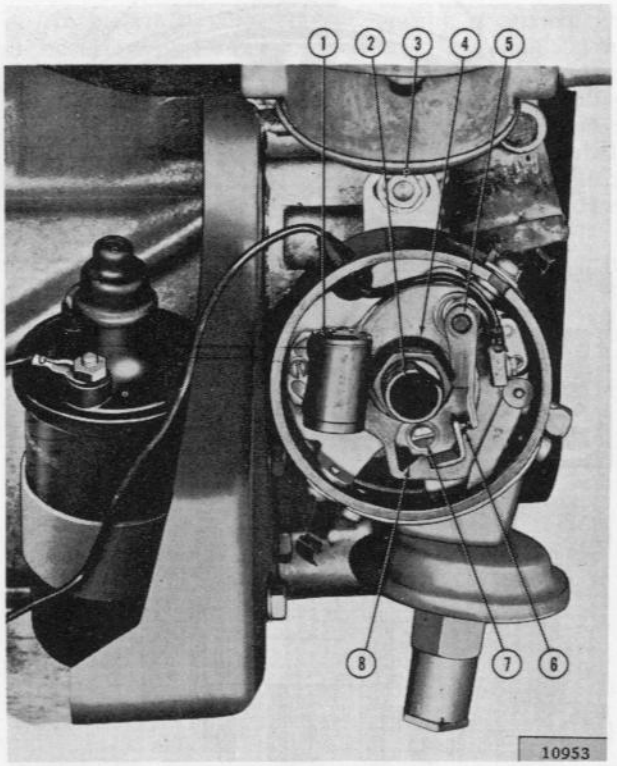

FIG. 64—DISTRIBUTOR

1—Condenser
2—Lubricating Wick
3—Adjusting Nut
4—Breaker Cam
5—Breaker Arm Point
6—Breaker Point
7—Adjusting Screw
8—Stationary Contact

h. Check point contact spring pressure, which should be between 17 and 22 ounces [487 a 625 gr.]. Check with a spring scale hooked on the breaker arm at the contact and pull at right angle to the breaker arm. Make the reading just as the points separate. Adjust the point pressure by loosening the stud holding the end of the contact arm spring and slide the end of the spring in or out as necessary. Retighten the stud and recheck the pressure. Too low a pressure will cause engine missing at high speeds. Too high a pressure will cause rapid wear of the cam, block, and points.

9. Check Ignition Timing

If a neon timing light is available, use it to check ignition timing, following the instructions of the timing light manufacturer.

Note: Always disconnect distributor vacuum line when checking ignition timing. With engine at idle, ignition timing should read 5° BTC. Reconnect vacuum line after completing timing check.

In the absence of a timing light, turn the engine over until No. 1 cam lobe is at the six o'clock position, as shown in Fig. 65. Turn the engine slowly until the 5° mark on the vibration damper is in alignment with the timing pointer as shown in Fig. 13. When the piston is positioned 5° BTC, timing is correctly set if the distributor rotor arm points to No. 1 terminal in the distributor cap and the distributor points are just ready to break. Timing may be altered by loosening the distributor adjustment nut (3, Fig. 64)

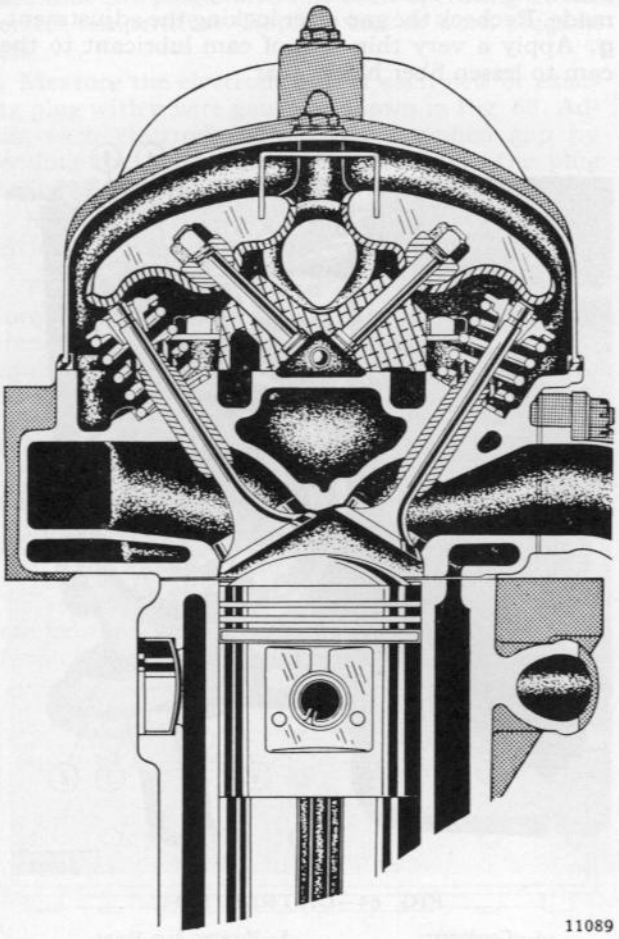

FIG. 65—CAM LOBE AND PISTON IN FIRING POSITION

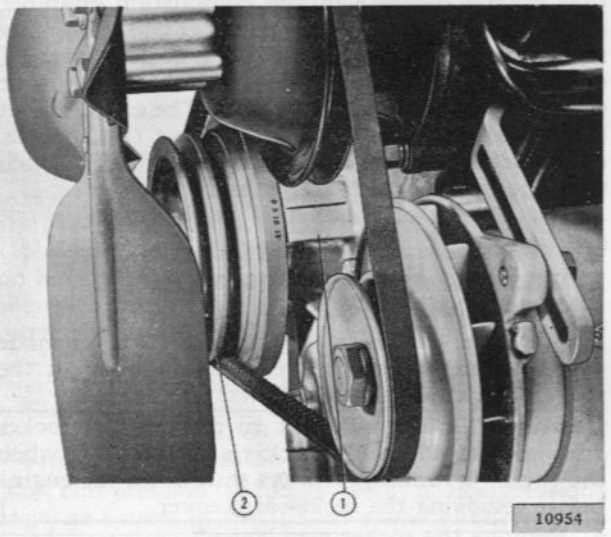

FIG. 66—ENGINE TIMING MARKS

1—Timing Pointer 2—Vibration Damper

with Tool W-272. Turn the distributor clockwise to advance the timing and counterclockwise to retard the timing. Torque the adjusting nut to the specified torque.

10. Check Ignition Wires and Connections

Examine and clean the insulation on all ignition wires and check all connections. Wires should be free from roughness, firm, flexible, and free from minute cracks. Bend wires to check for brittle, cracked, or loose insulation. Because defective insulation will permit crossfiring or missing of the engine, defective wires should be replaced.

11. Service Air Cleaner

To service the air cleaner, unscrew the wingnut under the oil cup and remove the oil cup. Scrape all dirt from inside the oil cup and clean the inside surface with cleaning solution. Refill with new oil of the same viscosity as is recommended for the engine crankcase to the oil level bead and install the cup securely to the cleaner body stud; secure with the wing nut.

Air cleaner body (less oil cup) should be removed from the vehicle and cleaned. Agitate the cleaner body thoroughly in cleaning solution to clean the filtering element. Dry with air hose but do not re-oil.

12. Check Fuel Line and Screens

Check all fuel line connections to guard against leakage. Clean the fuel filtering screen and fuel pump bowl.

13. Check Fuel Pump

The fuel pump should be checked for pressure, volume, and vacuum as follows:

a. Fuel pump pressure is important, for low pressure will seriously affect engine operation and high pressure will cause excessive fuel consumption and possibly flood the carburetor. Should there be any

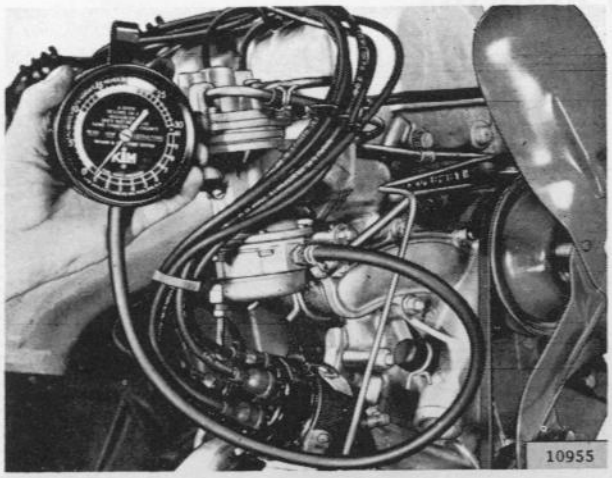

FIG. 67—CHECKING FUEL PUMP PRESSURE

doubt of normal operation, check the pressure with a gauge as shown in Fig. 67, cranking the engine with the starting motor. The minimum and maximum allowable pressures are 3½ psi to 5½ psi [0,246 a 0,386 kg-cm²].

b. Test for volume, as a pump may build up sufficient pressure but fail to produce sufficient volume. Turn down the carburetor line fitting and, with the tank connected, run the engine at 590 to 600 rpm, for one minute, catching the fuel in a calibrated container. At least one quart of fuel should be pumped in this time. If less than one quart is pumped in one minute, the fuel pump is inefficient, the tank line is leaking air, or the fuel supply is restricted.

c. To test the pump for vacuum, disconnect the tank line and connect a vacuum gauge in its place. With the fuel line to the carburetor disconnected, run the engine at 590 to 600 rpm. Observe the vacuum reading. If the gauge indicates less than 10 inches [25.4 cm] of mercury (Hg), the pump is at fault.

d. To check the vacuum pump portion of the fuel pump, disconnect both the manifold and windshield wiper lines from the vacuum pump. Connect a vacuum gauge into the windshield wiper side of the pump. Operate the engine at 800 to 1000 rpm and check the vacuum gauge reading. It should indicate 14 to 19 inches [35 a 48 cm] of mercury (Hg). If the vacuum reading is not within this range, it indicates a pump deficiency which could cause excessive oil consumption or inefficient wiper operation.

14. Check Vacuum

Disconnect the manifold vacuum line from the fuel pump. Install the vacuum gauge onto the line as shown in figure 68 and install the proper adapter. Start the engine. Connect a tachometer from the distributor primary terminal to ground and set the engine speed at 590 to 600 rpm. Observe the vacuum reading and interpret as follows:

a. A steady reading from 14 to 16 inches [35,5 a 40,6 cm] of mercury (Hg) is a normal reading, indicating that valve and spark timing, valve seating, and piston ring sealing are all satisfactory.

b. A steady but below normal reading indicates a condition common to all cylinders, such as a leak

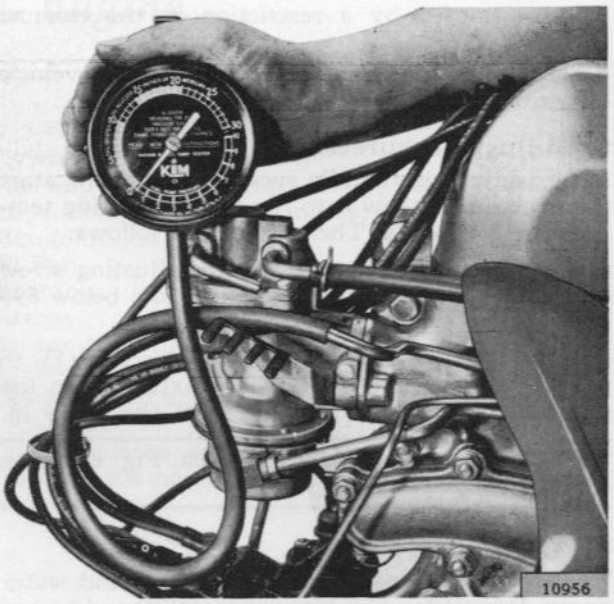

FIG. 68—CHECKING VACUUM

at the carburetor gasket, late ignition or valve timing, or uniform piston ring and bore wear.

c. A slowly fluctuating or drifting reading indicates that the idle mixture is incorrect, and the cause should be looked for in the fuel system.

d. A rhythmic pulsating reading is caused by a condition affecting one or more cylinders, but not all, and indicates leaky valve, gasket blowby, restricted intake port, or an electrical miss.

e. An intermittent pulsating reading is caused by an occasional malfunction, such as a sticking valve (all valves may be erratic in operation if the valve springs are weak), electrical miss caused by insufficient distributor point tension or low coil voltage coupled with inconsistent spark plug gaps or fouled plugs, or dirt in the fuel system finding its way into passages of critical size or valve seats in the carburetor.

f. A normal reading that quickly falls off (with engine running at 2000 rpm) indicates exhaust back

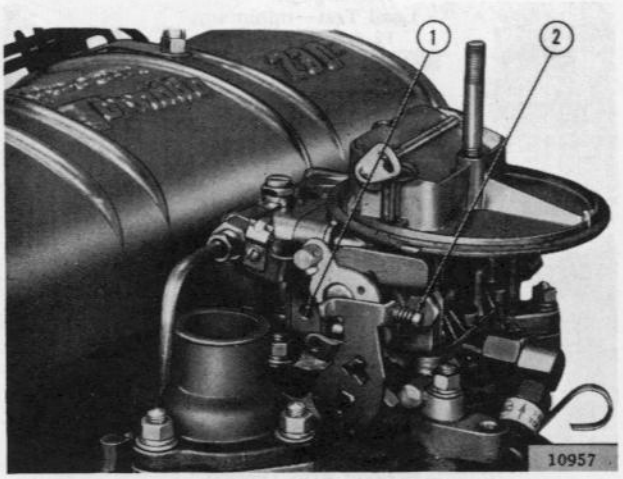

FIG. 69—CARBURETOR

1—Idle Mixture Adjusting Screw
2—Idle Speed Adjusting Screw

pressure caused by a restriction in the exhaust system.

g. Make indicated corrections or advise vehicle owner of engine condition.

15. Adjust Carburetor

Before adjusting the idle speed and mixture, start the engine and allow it to run until operating temperature is reached. Then proceed as follows:

a. Set the engine idle speed with adjusting screw (2, Fig. 69). Do not set the engine idle below 590 rpm.

b. Adjust the idle mixture adjusting screw (1), to provide smooth idle. For richer mixture, turn the screw out; for leaner mixture, turn the screw in.

Note: There are two sides to adjust. Fig. 69 shows one side only.

16. Check Fan Belt

The fan belt drives the fan, generator, and water pump. Inspect fan belt for serviceability and proper tension. Correct tension is obtained when thumb pressure midway between pulleys causes the belt to flex ½" [1¼ cm].

Adjust the fan belt tension by loosening the clamp bolt on the generator brace (3, Fig. 70) and swinging the generator (4) away from the engine until proper belt tension is obtained. Then tighten the clamp bolt.

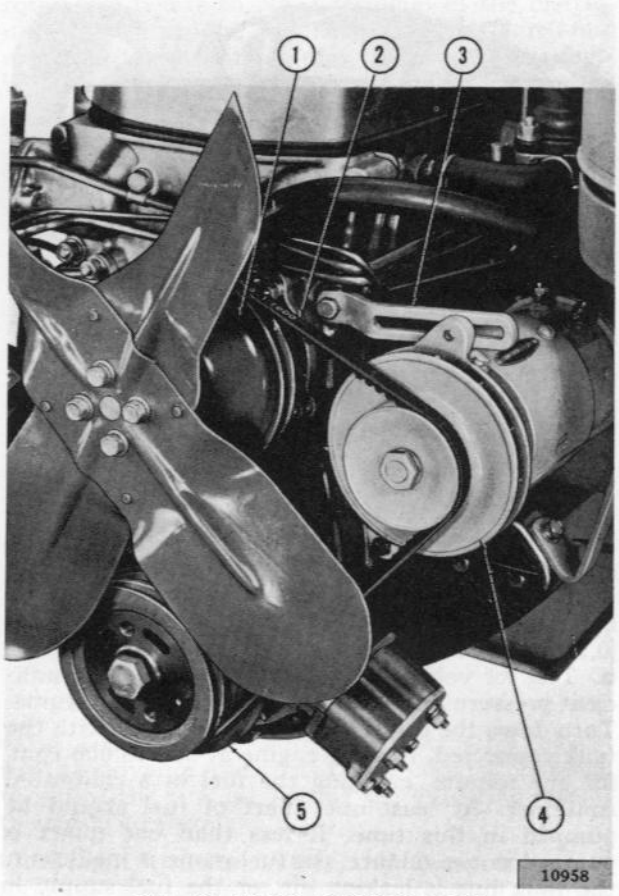

FIG. 70—BELT ADJUSTMENT

1—Fan Pulley
2—Fan Belt
3—Generator Brace
4—Generator
5—Vibration Damper

18 TUNE-UP SPECIFICATIONS

Item	Specification	Metric
BATTERY:		
Voltage	12 volts	
Terminal Ground	Negative	
Specific Gravity:		
Fully Charged	1.260	
Recharge at	1.225	
Load Test—minimum:		
12-volt Battery	10 volts	
SPARK PLUGS:		
Make and Model	AC 5610659 Auto-Lite AE 42 Champion L-7	
Gap	.030"	0,762 mm.
Tightening Torque	20 to 30 lbs-ft.	2,8 a 4,1 Kg-m.
CYLINDER HEAD BOLTS: TORQUE	75-80 lbs-ft.	10,3-11,0 Kg-m.
INTAKE MANIFOLD NUTS: TORQUE	15-20 lbs-ft.	2,07-2,76 Kg-m.
EXHAUST MANIFOLD NUTS: TORQUE	35-40 lbs-ft.	4,98-5,53 Kg-m.
COMPRESSION PRESSURE	145-155 psi.	10,19-10,89 Kg-cm^2
VALVE CLEARANCE:		
Intake	.006"	0,152 mm.
Exhaust	.008"	0,203 mm.
DISTRIBUTOR:		
Breaker Point Gap	.020"	0,508 mm.
Breaker Arm Tension	17 to 22 oz.	482 a 625 gr.
IGNITION TIMING	5° BTC	
Mark Location	Vibration Damper	
ENGINE IDLE SPEED	590 to 600 rpm.	

Tornado OHC Engine

Contents

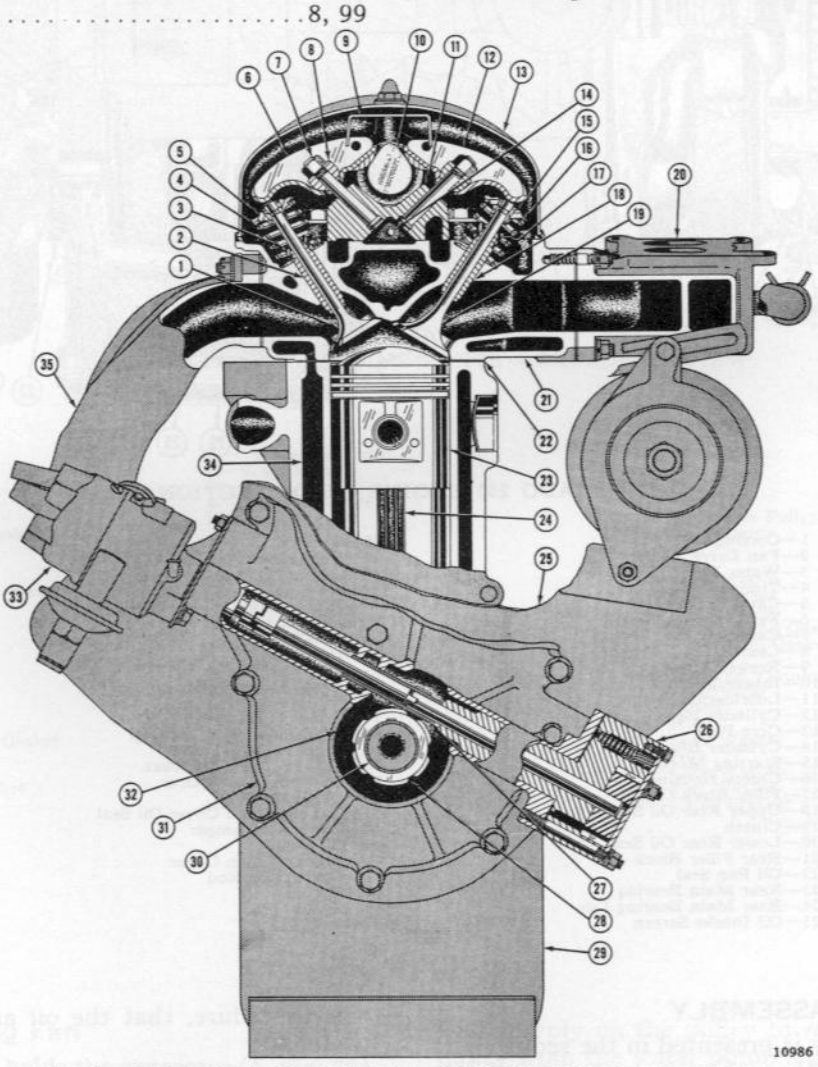

FIG. 71—TORNADO 230 ENGINE—FRONT SECTIONAL VIEW

1—Exhaust Valve
2—Exhaust Valve Guide
3—Valve Guide Seal
4—Valve Spring
5—Exhaust Valve Spring Guide
6—Rocker Arm
7—Rocker Arm Stud
8—Rocker Arm Ball
9—Rocker Arm Guide
10—Camshaft
11—Cam Bearing Support Deck
12—Intake Rocker Arm
13—Rocker Arm Cover
14—Lubrication Pipe
15—Valve Spring Guide
16—Valve Spring
17—Valve Guide Seal
18—Intake Valve Guide
19—Intake Valve
20—Intake Manifold
21—Cylinder Head
22—Cylinder Head Gasket
23—Piston
24—Connecting Rod
25—Front Engine Plate
26—Oil Pump
27—Oil Pump Helical Gear
28—Oil Pump Drive Gear
29—Oil Pan
30—Crankshaft
31—Timing Chain Cover
32—Timing Chain Cover Oil Seal
33—Distributor
34—Cylinder Block
35—Exhaust Manifold

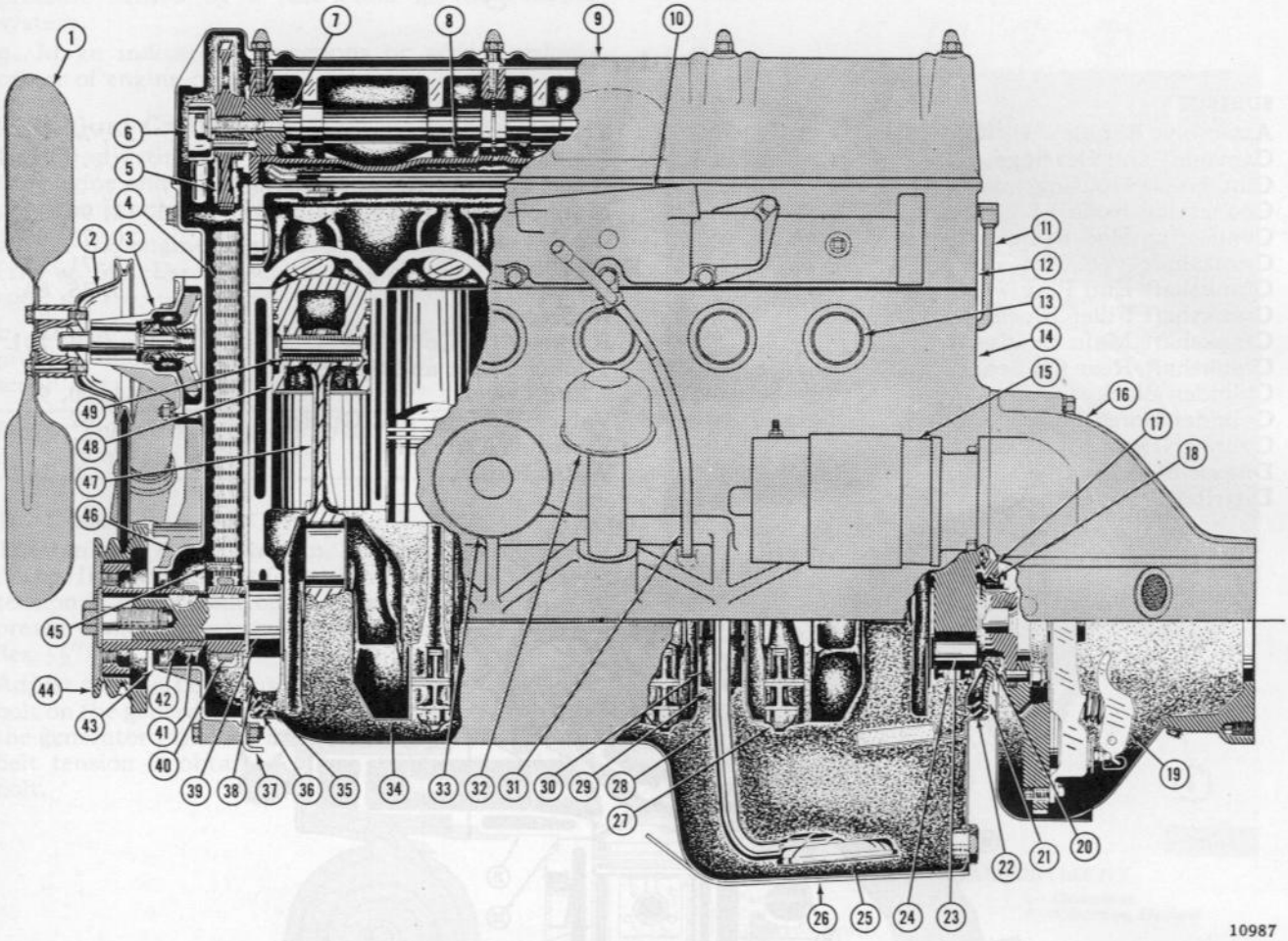

FIG. 72—TORNADO 230 ENGINE—SIDE SECTIONAL VIEW

1—Cooling Fan
2—Fan Drive Pulley
3—Water Pump
4—Timing Chain
5—Camshaft Sprocket
6—Fuel Pump Eccentric
7—Camshaft
8—Cam Bearing Support Deck
9—Rocker Arm Cover
10—Intake Manifold
11—Lubrication Tube
12—Cylinder Head
13—Core Plug
14—Cylinder Block
15—Starting Motor
16—Clutch Housing
17—Filler Block Guard
18—Upper Rear Oil Seal
19—Clutch
20—Lower Rear Oil Seal
21—Rear Filler Block
22—Oil Pan Seal
23—Rear Main Bearing
24—Rear Main Bearing Cap
25—Oil Intake Screen
26—Oil Pan
27—Connecting Rod Bearing Cap
28—Oil Intake Pipe
29—Intermediate Main Bearing Cap Screw
30—Intermediate Main Bearing Cap
31—Dip Stick Guide
32—Breather Cap
33—Oil Filter
34—Crankshaft
35—Front Filler Block
36—Oil Pan Seal
37—Front Engine Plate
38—Front Main Bearing Cap
39—Front Main Bearing
40—Timing Chain Sprocket
41—Oil Pump Drive Gear
42—Oil Slinger
43—Timing Chain Cover Oil Seal
44—Vibration Damper
45—Oil Fitting
46—Timing Chain Cover
47—Connecting Rod
48—Piston
49—Piston Pin

3. ENGINE DISASSEMBLY

Engine disassembly is presented in the sequence to be followed when the engine is to be completely overhauled on an engine stand after removal from the equipment. Most of the operations are also applicable separately with the engine in the equipment, provided that wherever necessary, that part of the engine is first made accessible by removal of accessories and other engine parts.

When disassembly operations are performed with the engine out of the equipment, it is assumed, in this procedure, that the oil and water have been drained.

4. Mounting Engine On Engine Stand

Support the engine with a hoist, using the lifting eyes provided to position the engine on the engine stand. Secure the engine clutch housing to the stand mounting plate with four bolts. Release tension of the hoist cables. Make sure the position lock on the engine stand is tight to prevent the engine from accidentally inverting.

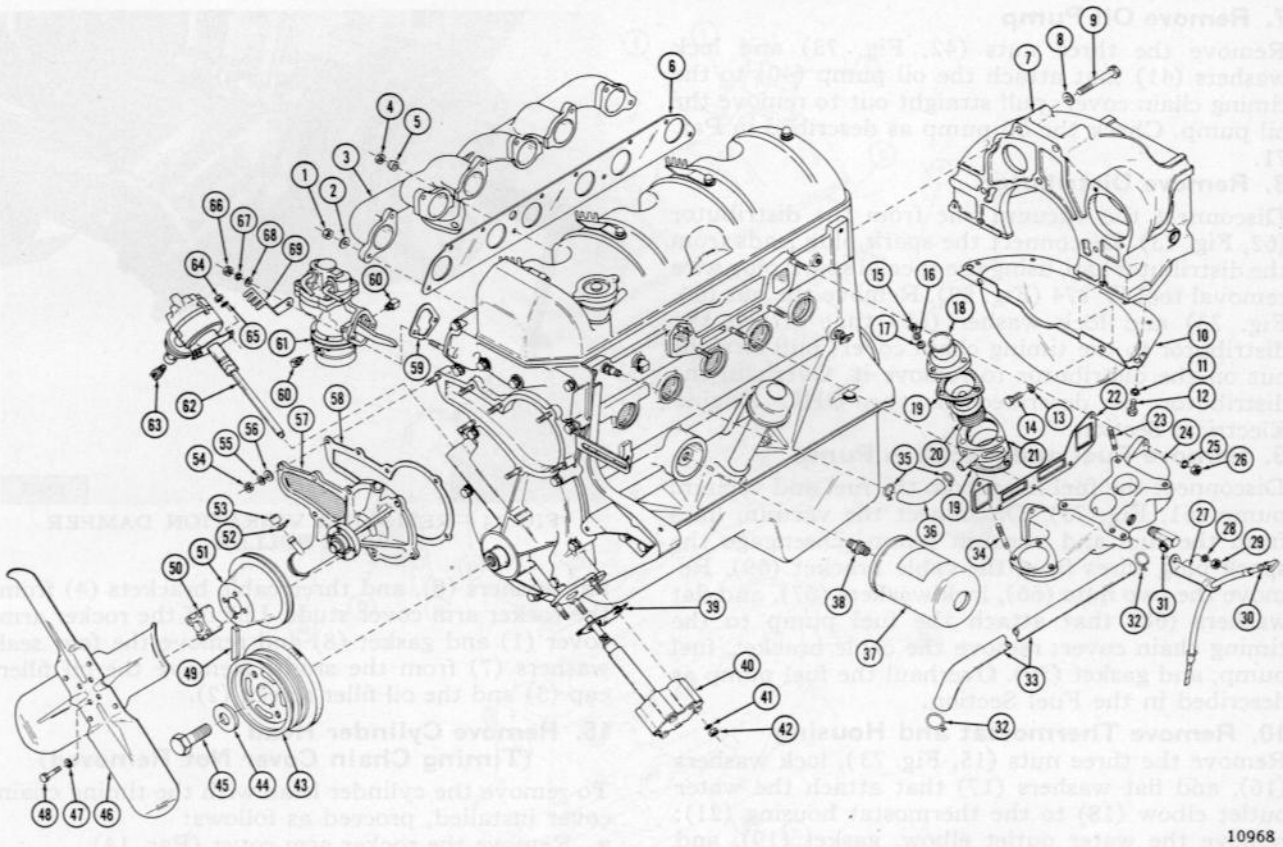

FIG. 73—EXTERNAL ENGINE PARTS—EXPLODED VIEW

1—Nut
2—Flat Washer
3—Exhaust Manifold
4—Nut
5—Retainer
6—Exhaust Manifold Gasket
7—Clutch Housing
8—Lock Washer
9—Bolt
10—Clutch Housing Pan
11—Lock Washer
12—Cap Screw
13—Lock Washer
14—Cap Screw
15—Nut
16—Lock Washer
17—Flat Washer
18—Water Outlet Elbow
19—Water Outlet Elbow Gasket
20—Thermostat
21—Thermostat Housing
22—Intake Manifold Gasket
23—Stud
24—Intake Manifold
25—Lock Washer
26—Nut
27—Dipstick Guide
28—Lock Washer
29—Nut
30—Dipstick
31—Elbow
32—Hose Clamp
33—Water Bypass Hose
34—Stud
35—Hose Clamp
36—Hose
37—Oil Filter
38—Adapter
39—Oil Pump Gasket
40—Oil Pump
41—Lock Washer
42—Nut
43—Vibration Damper
44—Pilot Washer
45—Bolt
46—Cooling Fan
47—Lock Washer
48—Bolt
49—Fan Belt
50—Fan Hub
51—Fan Drive Pulley
52—Hose Clamp
53—Cap
54—Nut
55—Lock Washer
56—Flat Washer
57—Water Pump
58—Water Pump Gasket
59—Fuel Pump Gasket
60—Elbow
61—Fuel and Vacuum Pump
62—Distributor
63—Elbow
64—Nut
65—Lock Washer
66—Nut
67—Lock Washer
68—Flat Washer
69—Cable Bracket

5. Remove Cooling Fan

Loosen the bolt that holds the generator (4, Fig. 70) to the generator brace (3). Loosen the generator bracket mounting bolts and push the generator toward the engine to release fan belt tension; remove the fan belt (2). Remove the four bolts (48, Fig. 73) and lock washers (47) that attach the cooling fan (46), the fan hub (50), and the fan drive pulley (51) to the water pump; remove the fan. Pull sharply on the pulley to remove the hub and pulley from the water pump shaft.

6. REMOVE WATER PUMP

Remove the hose (33, Fig. 73) that connects the water pump and the intake manifold. Remove the seven nuts (54), lock washers (55), and flat washers (56) that attach the water pump (57) to the timing chain cover; remove the water pump and gasket (58).

7. Remove Oil Pump

Remove the three nuts (42, Fig. 73) and lock washers (41) that attach the oil pump (40) to the timing chain cover; pull straight out to remove the oil pump. Check the oil pump as described in Par. 71.

8. Remove Distributor

Disconnect the vacuum line from the distributor (62, Fig. 73). Disconnect the spark plug leads from the distributor cap, using the special spark plug wire removal tool W-274 (Fig. 59). Remove the nut (64, Fig. 73) and lock washer (65) that attach the distributor to the timing chain cover; pull straight out on the distributor to remove it. Overhaul the distributor as described in the OHC Engine Electrical Section.

9. Remove Fuel and Vacuum Pump

Disconnect the fuel lines from the fuel and vacuum pump (61, Fig. 73). Disconnect the vacuum lines from the fuel and vacuum pump. Disengage the spark plug wires from the cable bracket (69). Remove the two nuts (66), lock washers (67), and flat washers (68) that attach the fuel pump to the timing chain cover; remove the cable bracket, fuel pump, and gasket (59). Overhaul the fuel pump as described in the Fuel Section.

10. Remove Thermostat and Housing

Remove the three nuts (15, Fig. 73), lock washers (16), and flat washers (17) that attach the water outlet elbow (18) to the thermostat housing (21); remove the water outlet elbow, gasket (19), and thermostat (20). Remove the two hose clamps (35) and the hose (36) from the thermostat housing and from adapter on the cylinder block. Lift the thermostat housing (21) and gasket (19) from the studs (34) on the intake manifold.

11. Remove Intake Manifold

Remove the two hose clamps (32, Fig. 73) and the water bypass hose (33) from the elbow (31) on the intake manifold (24) and from the water pump (57). Remove the nut (26) and lock washer (25) that attach the intake manifold and the dipstick guide (27) to the lower center stud on the cylinder head. Remove the assembled dipstick (30) and dipstick guide. Remove the four remaining nuts and lock washers that attach the intake manifold to the studs on the cylinder head; remove the manifold and gasket (22).

12. Remove Exhaust Manifold

Remove the eight nuts (1, Fig. 73) and flat washers (2), and the two nuts (4) and retainers (5) that attach the exhaust manifold (3) to the studs on the cylinder head; remove the manifold and gasket (6).

13. Remove Vibration Damper

Remove the bolt (45, Fig. 73) and pilot washer (44) that attach the vibration damper (43) to the crankshaft. Install a vibration damper puller tool C-3732-A as shown in Fig. 74, using the bolts provided. Turn in on the center screw to remove the vibration damper from the crankshaft.

14. Remove Rocker Arm Cover

Disconnect the vent hose (9, Fig. 75) and hose clamps (11) from the oil filler tube and from the vent valve (10). Remove the four cap nuts (5), four

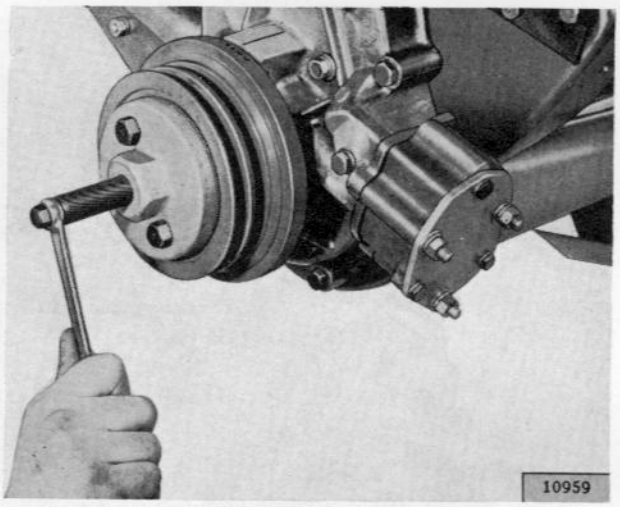

FIG. 74—REMOVING VIBRATION DAMPER WITH PULLER

flat washers (6), and three cable brackets (4) from the rocker arm cover studs. Lift off the rocker arm cover (1) and gasket (8) and remove the four seal washers (7) from the studs. Remove the oil filler cap (3) and the oil filler screen (2).

15. Remove Cylinder Head (Timing Chain Cover Not Removed)

To remove the cylinder head with the timing chain cover installed, proceed as follows:

a. Remove the rocker arm cover (Par. 14).

Caution: When camshaft sprocket is removed from camshaft, make sure that the blade tensioner does not drop out of retainer bracket as blade is free to move vertically in bracket at upper end.

b. Install the camshaft sprocket removal and installation tool W-268 on the rocker arm cover studs as shown in Fig. 76. Fasten with the rocker arm cover nuts. Install the hook of the removal tool in the sprocket and tighten the nut to relieve the tension on the camshaft.

c. Remove the cap screw (40, Fig. 75), lock washer (41), flat washer (42), and fuel pump eccentric (39) from the camshaft sprocket.

d. Pull forward on the camshaft sprocket to remove it from the pilot on the camshaft. With the sprocket still engaged in the timing chain, release the tension on the sprocket removal tool by loosening the nut (1, Fig. 76). Gently allow the sprocket to rest on the bosses in the timing chain cover.

Caution: Do not rotate the crankshaft, when the camshaft sprocket is removed from the camshaft and is resting on the bosses in the timing chain cover. This will severely damage the cover. If the crankshaft is to be rotated at this time, first install camshaft sprocket holding tool W-271. See Par. 25. Do not attempt to remove the camshaft sprocket from the timing chain, since this will upset the crankshaft to camshaft timing.

e. Disconnect the lubrication tube (11, Fig. 19) from the cylinder head and from the block.

f. Remove the three short head bolts (46, Fig. 75) and flat washers (45) and the eleven long head bolts (12) and flat washers (13).

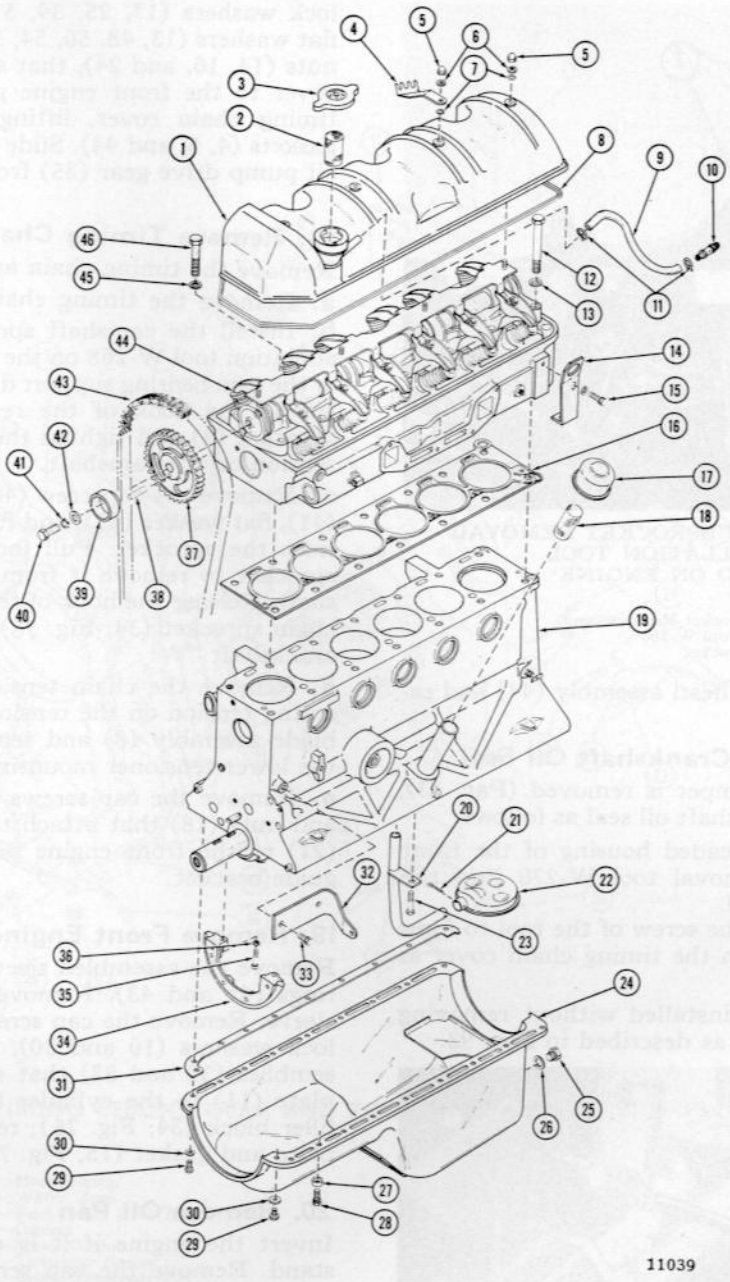

FIG. 75—CYLINDER HEAD AND OIL PAN EXPLODED FROM CYLINDER BLOCK

1—Rocker Arm Cover
2—Oil Filler Screen
3—Oil Filler Cap
4—Cable Bracket
5—Cap Nut
6—Flat Washer
7—Seal Washer
8—Rocker Arm Cover Gasket
9—Vent Hose
10—Vent Valve
11—Hose Clamp
12—Head Bolt
13—Flat Washer
14—Lifting Eye
15—Cap Screw
16—Head Gasket
17—Breather Cap
18—Breather Screen
19—Cylinder Block
20—Oil Intake Pipe Assembly
21—Cotter Pin
22—Oil Intake Screen
23—Main Bearing Bolt
24—Oil Pan
25—Plug
26—Gasket
27—Spacer
28—Cap Screw Assembly
29—Cap Screw
30—Flat Washer
31—Pan Gasket
32—Rear Generator Mounting Bracket
33—Cap Screw
34—Front Filler Block
35—Bolt
36—Washer
37—Camshaft Sprocket
38—Driving Dowel
39—Fuel Pump Eccentric
40—Cap Screw
41—Lock Washer
42—Flat Washer
43—Timing Chain
44—Cylinder Head Assembly
45—Flat Washer
46—Head Bolt

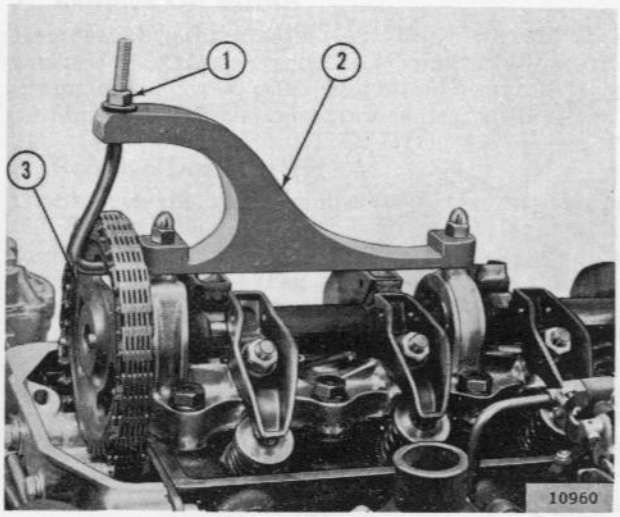

FIG. 76—CAMSHAFT SPROCKET REMOVAL AND INSTALLATION TOOL INSTALLED ON ENGINE

1—Nut
2—Camshaft Sprocket Removal and Installation Tool W-268
3—Camshaft Sprocket

g. Lift off the cylinder head assembly (44) and remove the gasket (16).

16. Removing Front Crankshaft Oil Seal

After the vibration damper is removed (Par. 13), remove the front crankshaft oil seal as follows:

a. Turn the coarse-threaded housing of the front crankshaft oil seal removal tool W-270 into the front crankshaft oil seal.

b. Turn clockwise on the screw of the tool to force the seal from its seat in the timing chain cover as shown in Fig. 77.

c. A new seal can be installed without removing the timing chain cover as described in Par. 93.

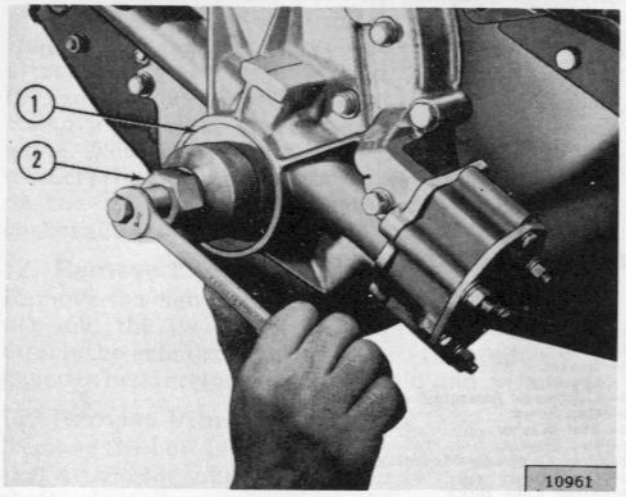

FIG. 77—REMOVING FRONT CRANKSHAFT OIL SEAL

1—Oil Seal
2—W-270 Puller

17. Remove Timing Chain Cover

Remove the hose clamps (1, Fig. 78) and hose (2) from the water port of the timing chain cover (45). Remove the bolts 40, 49, 52, 56, 59, 62, 65, and 67), lock washers (17, 25, 39, 51, 55, 58, 64, and 68), flat washers (13, 48, 50, 54, 57, 61, 63, and 68), and nuts (14, 16, and 24), that secure the timing chain cover to the front engine plate (11); remove the timing chain cover, lifting eye (12), and cover gaskets (4, 5, and 44). Slide the oil slinger (36) and oil pump drive gear (35) from the crankshaft.

18. Remove Timing Chain and Tensioner

Remove the timing chain and tensioner as follows:

a. Remove the timing chain cover (Par. 17).

b. Install the camshaft sprocket removal and installation tool W-268 on the rocker arm cover studs of the cam bearing support deck as shown in Fig.76 . Install the hook of the removal tool (2) in the sprocket (3) and tighten the nut (1) to relieve the tension on the camshaft.

c. Remove the capscrew (40, Fig. 75), lock washer (41), flat washer (42), and fuel pump eccentric (39) from the sprocket. Pull forward on the camshaft sprocket to remove it from the pilot on the camshaft. Release the hook of the tool. Slide the timing chain sprocket (34, Fig. 78) to remove it from the crankshaft.

d. Remove the chain tensioner pin (7) to release spring tension on the tensioner blade. Remove the blade assembly (8) and tensioner spring (6) from the lower tensioner mounting stud.

e. Remove the cap screws (19), flat washers (20), and nuts (18) that attach the chain guide bracket (21) to the front engine plate; remove the chain guide bracket.

19. Remove Front Engine Plate

Remove the assembled sleeve (42, Fig. 78) and O-rings (41 and 43). Remove the O-rings from the sleeve. Remove the cap screws (9 and 31, Fig. 78), lock washers (10 and 30), and the cap screw assemblies (32 and 33) that secure the front engine plate (11) to the cylinder block and to the front filler block (34, Fig. 75); remove the front engine plate and gasket (15, Fig. 78).

20. Remove Oil Pan

Invert the engine if it is mounted on an engine stand. Remove the cap screws (29, Fig. 75), flat washers (30), the cap screw assemblies (28), and spacers (27) that attach the oil pan (24) to the cylinder block; remove the oil pan and gaskets (31).

21. Remove Oil Intake Screen and Pipe

Remove the cotter pin (21, Fig. 75) that attaches the oil intake screen (22) to the oil intake pipe assembly (20); remove the oil intake screen. Remove the main bearing bolt (23) that also attaches the oil intake pipe assembly (23) to the cylinder block; pull straight out to remove the oil intake pipe.

22. Remove Clutch

Remove the cap screws (12 and 14, Fig. 73) and lock washers (11 and 13) that attach the clutch housing pan (10) to the clutch housing; remove the pan. Remove four of the bolts and lock washers that attach the clutch assembly to the flywheel, leaving

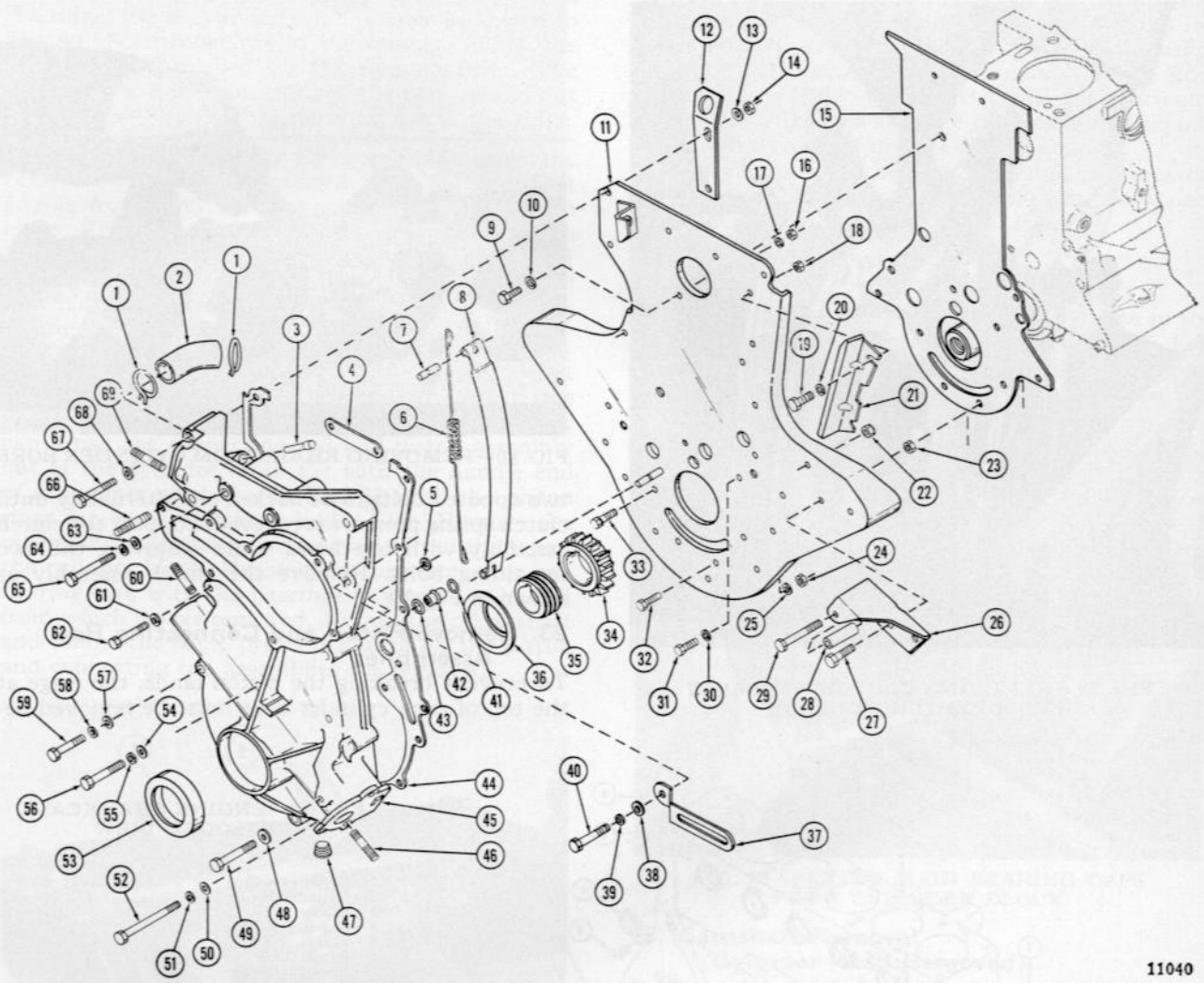

FIG. 78—TIMING CHAIN COVER AND FRONT ENGINE PLATE, EXPLODED VIEW

1—Hose Clamp
2—Water Hose
3—Fuel Pump Push Rod
4—Gasket
5—Small Gasket
6—Tensioner Spring
7—Chain Tensioner Pin
8—Tensioner Blade Assembly
9—Cap Screw
10—Lock Washer
11—Front Engine Plate
12—Lifting Eye
13—Flat Washer
14—Nut
15—Engine Plate Gasket
16—Nut
17—Lock Washer
18—Nut
19—Cap Screw
20—Flat Washer
21—Chain Guide Bracket
22—Nut
23—Nut
24—Nut
25—Lock Washer
26—Generator Mounting Bracket
27—Cap Screw
28—Spacer
29—Bolt
30—Lock Washer
31—Cap Screw
32—Cap Screw Assembly
33—Cap Screw Assembly
34—Timing Chain Sprocket
35—Oil Pump Drive Gear
36—Slinger
37—Generator Brace
38—Flat Washer
39—Lock Washer
40—Bolt
41—O-Ring
42—Sleeve
43—O-Ring
44—Timing Chain Gasket
45—Timing Chain Cover
46—Stud
47—Plug
48—Lock Washer
49—Bolt
50—Flat Washer
51—Lock Washer
52—Bolt
53—Front Crankshaft Oil Seal
54—Flat Washer
55—Lock Washer
56—Bolt
57—Flat Washer
58—Lock Washer
59—Bolt
60—Stud
61—Lock Washer
62—Bolt
63—Flat Washer
64—Lock Washer
65—Bolt
66—Stud
67—Bolt
68—Flat Washer
69—Stud

FIG. 79—REMOVING CLUTCH ASSEMBLY FROM CLUTCH HOUSING

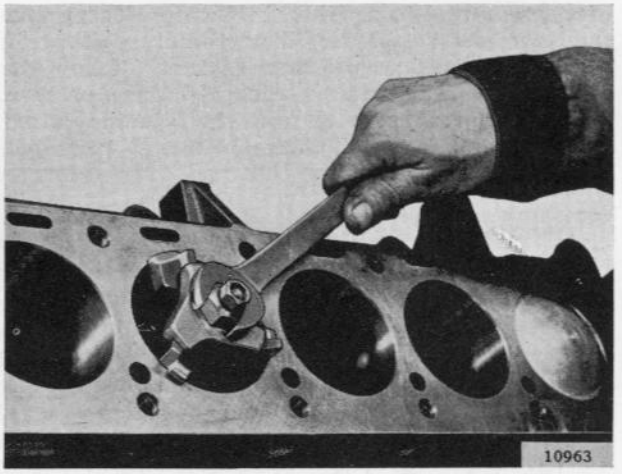

FIG. 80—REMOVING RIDGE FROM CYLINDER BORE

two opposed bolts to be backed out alternately until clutch spring pressure is relieved. Support the clutch assembly with one hand while removing the two remaining bolts. Remove the clutch assembly as shown in Fig. 79.

23. Remove Piston and Connecting Rod Assemblies

To prevent breaking the piston lands, the ridge at the top of each cylinder bore must be removed be-

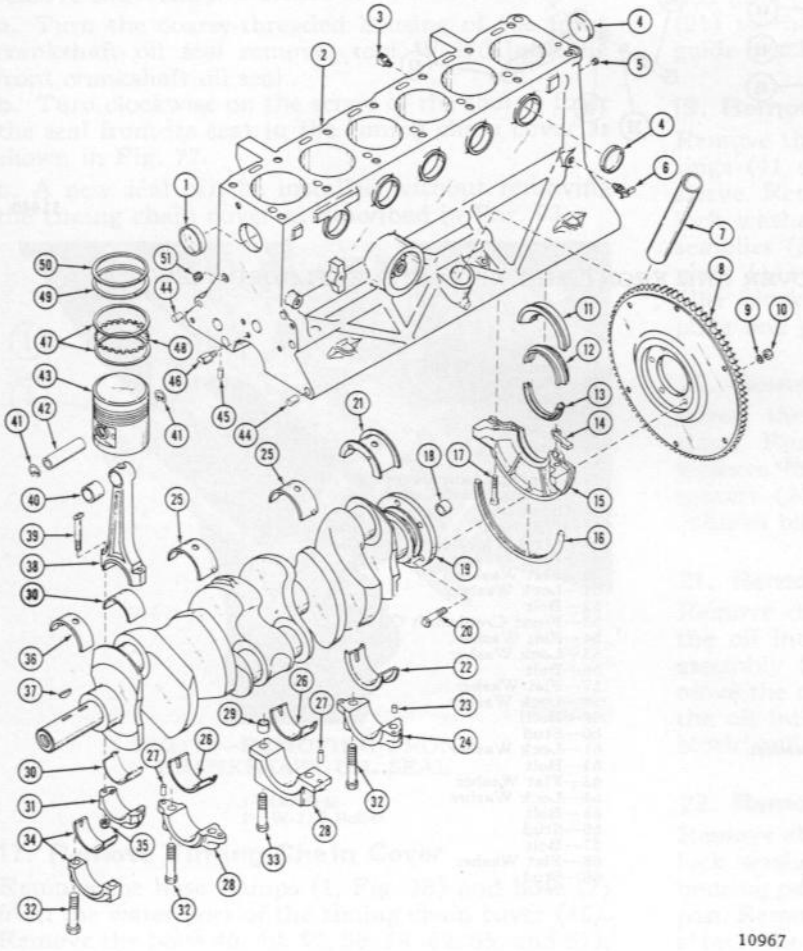

FIG. 81—ENGINE CRANKCASE, EXPLODED VIEW

1—Expansion Plug
2—Cylinder Block
3—Elbow
4—Expansion Plug
5—Plug
6—Drain Cock
7—Breather Tube
8—Flywheel
9—Lock Washer
10—Nut
11—Filler Block Guard
12—Upper Rear Seal
13—Lower Rear Seal
14—Gasket Insert
15—Lower Filler Block
16—Oil Pan Seal
17—Socket Head Machine Screw
18—Pilot Bushing
19—Crankshaft
20—Flywheel Bolt
21—Upper Rear Main Bearing
22—Lower Rear Main Bearing
23—Dowel
24—Rear Main Bearing Cap
25—Upper Intermediate Main Bearing
26—Lower Intermediate Main Bearing
27—Dowel
28—Rear Intermediate Main Bearing Cap
29—Sleeve
30—Crankpin Bearing
31—Connecting Rod Bearing Cap
32—Main Bearing Cap Bolt
33—Special Main Bearing Bolt
34—Lower Front Main Bearing and Cap
35—Self Locking Nut
36—Upper Front Main Bearing
37—Key
38—Connecting Rod
39—Cap Bolt
40—Piston Pin Bushing
41—Retaining Ring
42—Piston Pin
43—Piston
44—Dowel
45—Dowel
46—Oiler
47—Oil Rails
48—Spacer
49—Lower Compression Ring
50—Upper Compression Ring
51—Plug

fore attempting to remove the pistons. To remove the ridge, use a cylinder ridge reamer as shown in Fig. 80. For proper use of the reamer, follow the instructions furnished by the manufacturer. The portion of metal removed from the bore should not extend more than 1/64" [0,396 mm] below the ridge.

Caution: Do not rotate the crankshaft when the camshaft sprocket is removed from the camshaft and is resting on the bosses in the timing chain cover. This will severely damage the timing chain cover. Install camshaft sprocket holding tool W-271 on the cylinder block at the front cylinder head bolt holes and raise the camshaft sprocket off the timing chain cover bosses.

Remove the self-locking nuts (35, Fig. 81) that attach the connecting rod bearing cap (31) to one of the connecting rods (38). Remove the bearing cap. Push the connecting rod and piston assembly out of the cylinder block (2) with the handle end of a hammer as shown in Fig. 82 until the piston rings are free from the cylinder bore. Remove the piston and connecting rod assembly from the top of the cylinder block. Reassemble the connecting rod bearing cap, with the bearings in place, to the rod from which it was removed. Rotate the crankshaft and follow the same procedure until all the piston and connecting rod assemblies are removed.

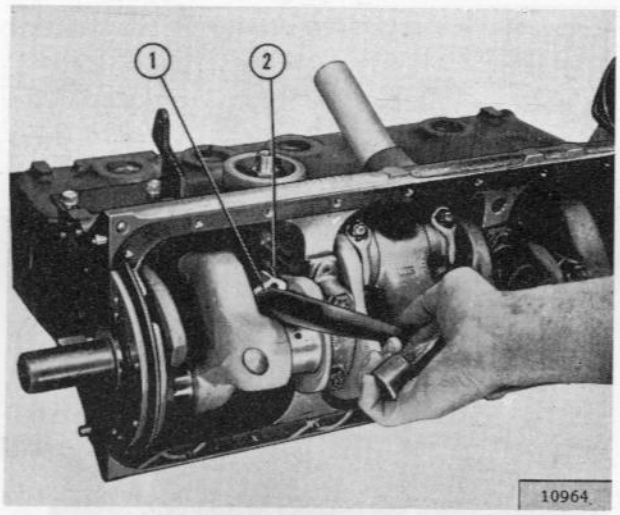

FIG. 82—REMOVING PISTON AND CONNECTING ROD ASSEMBLY
1—Hammer Handle 2—Connecting Rod

24. Remove Crankshaft and Flywheel

Remove the crankshaft and flywheel as follows:

a. Remove the nuts (10, Fig. 81), lockwashers (9) and flywheel bolts (20) that attach the flywheel (8) to the crankshaft (19); remove the flywheel.

b. Remove the two socket head machine screws (17) that attach the rear lower filler block (15) to the cylinder block; remove the oil pan seal, (16) filler block, gasket inserts (14), and lower rear seal (13). Remove the bolts that attach the front filler block (36, Fig. 75) to the cylinder block.

c. Remove the main bearing cap bolts (32 and 33, Fig. 81) that secure the main bearing caps to the cylinder block.

d. Use a bar inserted under the recessed ends of the bearing caps as shown in Fig. 83 to pry the bearing caps from the cylinder block. Be careful not to exert enough pressure to cause damage to the bearing caps or the dowels. Pry alternately, a little at a time, at each end of the bearing caps until each one is free from the dowels. Lift the assembled crankshaft and flywheel from the cylinder block.

e. Install the main bearing caps and bearings on the cylinder block in their original positions to prevent them from becoming mismatched.

24A. Remove Flywheel (Engine in Equipment)

When removing the flywheel with the engine in the vehicle, do not remove the clutch housing (7, Fig. 73). Remove the oil pan (Par. 20) and lower rear filler block (Par. 24-b) to gain access to the flywheel bolts.

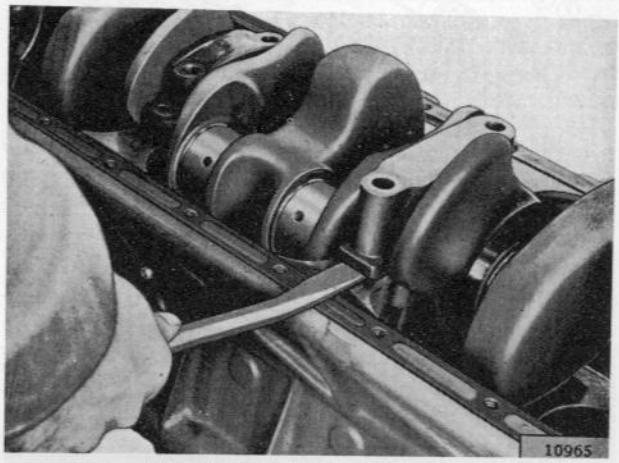

FIG. 83—PRYING MAIN BEARING CAPS FROM CYLINDER BLOCK

25. Camshaft Removal (Cylinder Head Removed)

Remove the camshaft as follows:

a. Lift the rocker arm guide (7, Fig. 84) from the cylinder head assembly. Check the rocker arms (4) to determine which do not have cam tension against them. Turn these parallel to the camshaft. Temporarily install the camshaft sprocket on the camshaft and rotate the camshaft to release tension from the remaining rocker arms. Turn these parallel to the camshaft also. Continue to do this until all rocker arms are out of engagement with the camshaft.

b. Remove the two nuts (1) and lock washers (2) that attach the camshaft retainer (3) to the cam bearing support deck; remove the retainer. Some engines have a shim installed between the retainer and the deck. This shim must be retained and installed at reassembly.

c. Pull forward on the camshaft to remove it from the cam bearing support deck.

d. Remove the three nuts (11), lock washers (12), and flat washers (13) that attach the cam bearing support deck (14) to the cylinder head; remove the cam bearing support deck.

26. Remove Rocker Arms

Remove the nuts that attach the rocker arms (4, Fig. 84) to the rocker arm studs (40); remove the rocker arms and rocker arm balls (5).

Note: The rocker arms can be removed either before or after the removal of the camshaft.

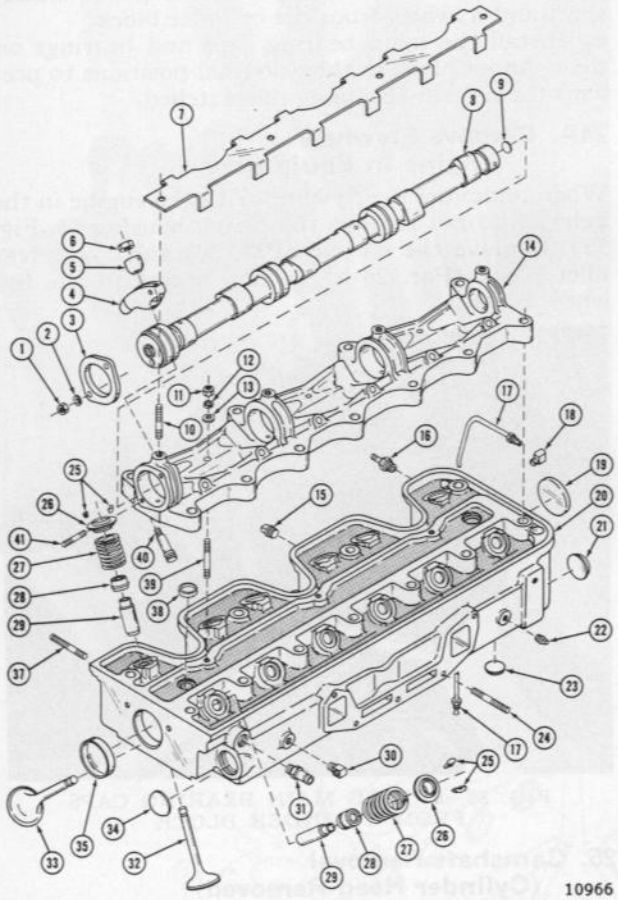

FIG. 84—CYLINDER HEAD, EXPLODED VIEW

1—Nut
2—Lock Washer
3—Camshaft Retainer
4—Rocker Arm
5—Rocker Arm Ball
6—Rocker Arm Nut
7—Rocker Arm Guide
8—Camshaft
9—Plug
10—Stud
11—Nut
12—Lock Washer
13—Flat Washer
14—Cam Bearing Support Deck
15—Plug
16—Temperature Sending Unit
17—Oil Tube
18—Elbow
19—Expansion Plug
20—Cylinder Head
21—Expansion Plug
22—Plug
23—Expansion Plug
24—Stud
25—Valve Lock
26—Valve Spring Retainer
27—Valve Spring
28—Valve Guide Seal
29—Valve Guide
30—Elbow
31—Hose Adapter
32—Exhaust Valve
33—Intake Valve
34—Expansion Plug
35—Expansion Plug
37—Stud
38—Plug
39—Stud
40—Rocker Arm Stud
41—Stud

27. Replacing Valve Springs (Cylinder Head On Engine)

Valve springs may be replaced with the cylinder head on the engine as follows:

a. Install spark plug air pressure adapter W-275 in the spark plug port of the cylinder requiring valve spring replacement. Connect an air line to the adapter.

b. Make sure the piston of that cylinder is on the compression stroke so that both the intake and exhaust valves are closed. Turn on the air pressure to the adapter to hold the valves in postion while the springs are being compressed.

c. Remove the rocker arm and install the valve spring compressor tool W-267 on the rocker arm stud as shown in Fig. 85. Install the rocker arm nut on the stud.

d. Pry on the tool as shown in Fig. 85 to compress the valve spring far enough to remove the valve locks (4); remove the locks, retainer (5) and valve spring (3).

e. Position the new valve spring on the cylinder head, making sure it is properly seated. Position the valve spring retainer on the valve spring and compress the valve spring with the compressor tool. Install the valve locks to retain the valve and spring. Release the air pressure and remove the air pressure adapter.

FIG. 85—COMPRESSING VALVE SPRINGS

1—Valve Spring Compressor Tool W-267
2—Air Hose
3—Rocker Arm Nut
4—Valve Spring
5—Valve Lock
6—Valve Spring Retainer

28. Remove Valves

Remove the valves and attaching parts after removing the cylinder head, as follows:

a. Position the cylinder head on blocks high enough to provide hand clearance under the assembly.

b. Remove valve springs as outlined in Par. 27. Use hand pressure to hold the valve while compressing the spring.

c. Remove and discard the valve guide seal (28) from the top of the valve guide.

d. Remove the remaining 11 valves and valve parts in the same manner. Place the valves in a numbered rack to make sure each valve will be reassembled in the same valve seat from which it was removed. All valve springs, spring retainers, and valve locks are interchangeable.

29. Engine Inspection and Repair

The inspection and repair procedures detailed herein are recommended to be followed when a complete engine overhaul is to be made with the engine out of the vehicle. These instructions can generally be applied separately with the engine in the vehicle. Inspection and repair instructions are included to cover the cylinder block, crankshaft and bearings, connecting rods and bearings, oil pump, valves and rocker arms, pistons and rings, flywheel, timing chain and sprockets, and the camshaft and bearings. In addition, fitting operations for these engine components are included.

Important: Before the inspection and repair procedures listed below are begun, the engine serial number must be checked for the presence of code letters denoting deviations from standard dimensions. Refer to Par. 1.

30. Cylinder Block

The cylinder block must be thoroughly cleaned, inspected and repaired as detailed in the following paragraphs.

31. Cleaning

The cylinder block may be steam cleaned or cleaned with a suitable solvent. A scraper is recommended to remove hard deposits, except on highly finished surfaces. Special attention must be directed to the cleaning of the oil passages, crankcase, and cylinder walls to remove all sludge, dirt and carbon deposits. After cleaning, use air pressure to dry the block thoroughly.

32. Inspection

Examine the cylinder block for minute cracks and fractures. Evidence of rust on the cylinder walls is a good indication of a possible crack in the block. Pressure testing the block will usually indicate the presence of a crack. A pressure test may be made by applying 30 to 60 pounds water and air pressure in the water jackets of the block. With the water jack ports sealed off, a drop in pressure will indicate the presence of a crack.

Note: To make this test the cylinder head must be installed and the inlet and outlet must be sealed tight.

a. Examine all machined surfaces of the cylinder block for burrs and scores. Check cylinder block distortion by placing a straightedge along the length of the cylinder head surface of the block. With a feeler gauge check for clearance between the straightedge and the block as shown in Fig. 86, particularly between adjacent cylinders.

b. Check the cylinder bores for out-of-round and taper to determine whether the bores require honing or reboring. For detail information refer to Par. 34.

c. If main bearing caps are not removed carefully, raising both sides of each cap evenly until free of the dowels, the dowels may be bent. This is especially probable if a pry bar is used, first at one side of the cap and then the opposite, to raise the cap from the cylinder block. Bent main bearing cap dowels can cause misalignment of the bearing cap and resultant rapid bearing wear, necessitating early bearing replacement. Therefore, remove each main bearing cap carefully and if there is any reason to believe any of the dowels may have been bent during bearing cap removal, remove those dowels and install new ones as detailed below.

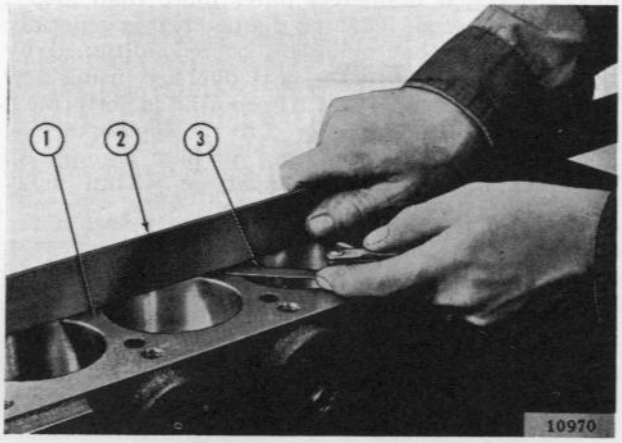

FIG. 86—CHECKING CYLINDER BLOCK FOR DISTORTION

1—Cylinder Block
2—Straightedge
3—Feeler Gauge

33. Cylinder Block Dowel Replacement

Since the hardened dowels must fit tightly to ensure correct cap alignment, gripping them with a tool for removal is sometimes difficult. To simplify the operation, file a notch on each side of the dowel to accommodate a pair of diagonal cutters. Using a piece of bar stock under the diagonals for leverage, work the dowel out of the cylinder block. Before installing a new dowel in the cylinder block make sure the dowel hole is clean. Start the dowel straight in the hole, then tap the dowel lightly with a hammer until it bottoms.

34. Cylinder Bores

The cylinder bores may be reconditioned by honing or reboring. Use oilsoaked rags to protect crankshaft journals and other engine parts from abrasive dust during all reconditioning operations.
Both honing and reboring of the cylinders must be

closely coordinated with fitting the pistons to maintain specified tolerances.

Reboring the cylinders may be accomplished only when adequate facilities and trained or experienced service technicians are available. The engine must be removed from the vehicle and mounted in a suitable level holding fixture.

The amount of material to be removed is determined from the original diameter of the cylinder bores (3.3430″ to 3.3455″) [84,912 a 84,976 mm.] diameter plus the amount of oversized in diameter of the oversized pistons to be fitted.

The largest cylinder bore will determine the oversize to which all cylinders must be rebored, since the size and weight of all pistons must be uniform to maintain proper engine balance. The maximum rebore should not exceed .040″ [1,016 mm.] from standard.

Measure the cylinder diameters by making measurements both parallel to, and at right angles to, crankshaft over entire piston travel and at bottom of cylinder, using a cylinder bore checking gauge as shown in Fig. 87. Proceed as follows:

a. If bores are scored; if out-of-round exceeds .005″ [0,127 mm.]; if diameters differ more than .005″; or if taper exceeds .005″ on diameter, it is generally recommended that cylinders be reconditioned by boring and honing to the next oversize, using new pistons of the proper size. If reboring is performed, all cylinders must be rebored to the same oversize, allowing .0015″ [0,0381 mm.] for final honing. All cylinders bore diameters must be within .002″ [0,0508 mm.] after reconditioning.

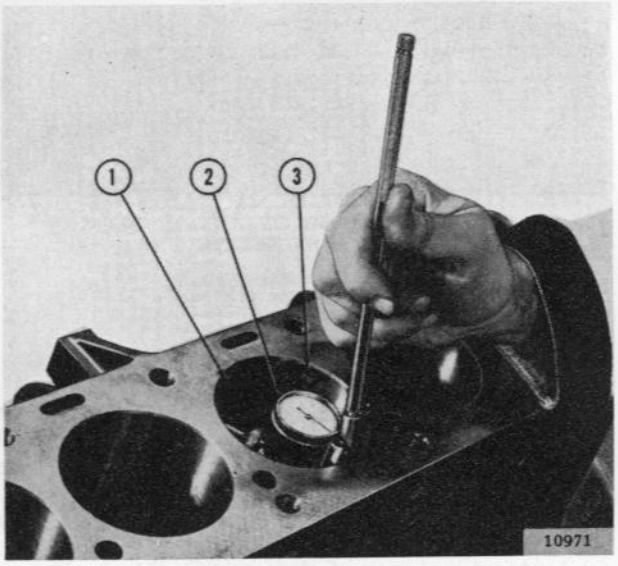

FIG. 87—CHECKING CYLINDER BORE

1—Cylinder Bore
2—Cylinder Bore Checking Gauge
3—Lock Screw

b. If bore measurements are within the above limits, but indicate hollows or waviness, cylinders should be honed with 250 grit stones as shown in Fig. 88. Pump hone up and down in cylinder while it is rotating to produce a satin-finish, diamond cross-hatched pattern approximately 30° with horizontal. Hone only enough to correct waviness.

c. If cylinder bore correction is unnecessary, break the glaze on cylinder walls with a hone with 250 grit stones or with a suitable deglazing tool. Operate the hone or deglazer to obtain diamond cross-hatched pattern, same as above.

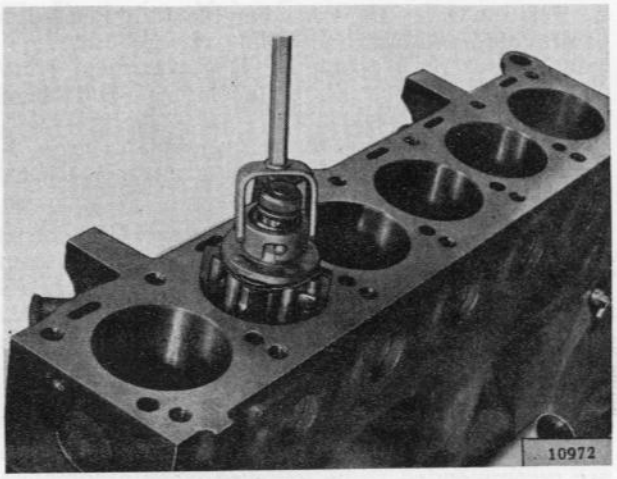

FIG. 88—HONING CYLINDER BORE

d. Regardless of the type of correction on cylinder walls, clean out the bores thoroughly afterwards and apply a light coat of clean engine oil. If cylinders have been rebored or honed heavily, measure cylinder diameters again to ensure proper selection of piston size.

35. Pistons, Rings and Connecting Rods

The pistons and connecting rods were removed from the engine as assemblies. If cylinders were rebored, new oversized pistons and rings will have to be installed as determined at the time cylinders were rebored. Use standard size pistons in cylinder bores up to .009″ [0,029 mm.] oversize measured at bottom of bore. For oversize, use the following chart:

OVERSIZE PISTON APPLICATION CHART

Oversize Piston	Use in Oversize Cylinder Bore Range	Metric
.010″	.010″ to .019″	0,251 a 0,483 mm.
.020″	.020″ to .024″	0,508 a 0,610 mm.
.030″	.030″ to .039″	0,762 a 0,991 mm.
.040″	.040″ to .049″	1,016 a 1,244 mm.

Disassemble pistons and rods by removing piston pin retaining rings as shown in Fig. 89 and pressing

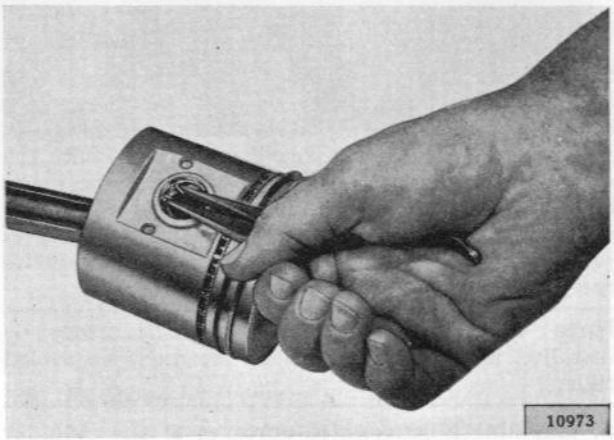

FIG. 89—REMOVING PISTON PIN RETAINING RINGS

out pin. Keep the parts of each assembly identified so they may be installed in the same cylinder from which they were removed. Remove rings from piston. Clean carbon from piston head and clean ring grooves and drain holes.

Use care not to scrape metal from side of grooves nor to make burrs on ring groove surfaces. Check pistons for broken lands, cracks, or worn grooves. Replace piston if necessary, using same size as old piston. Proceed as follows:

a. Check fit of each piston to cylinder bore, when block and pistons are clean and dry and at approximately 70°F [21°C] by using piston fitting gauge and scale C-690 as shown in Fig. 90. Use a .004″ [0,1016 mm.] thickness gauge (½″ wide) [12.7 mm.] if old pistons are to be used. When fitting new pistons, use .0015″ [0,0381 mm.] gauge. The piston is fitted upside down in the block to facilitate the operation, and the gauge must be extend the full length of piston on the thrust side (side opposite slot in piston skirt). Scale should register 5 to 10 pounds [2,26 a 4,53 kg.] pull to remove thickness gauge from between cylinder wall and piston. Excessive pull indicates need for a slightly smaller piston or additional honing of cylinder. Insufficient pull indicates need for fitting a larger piston.

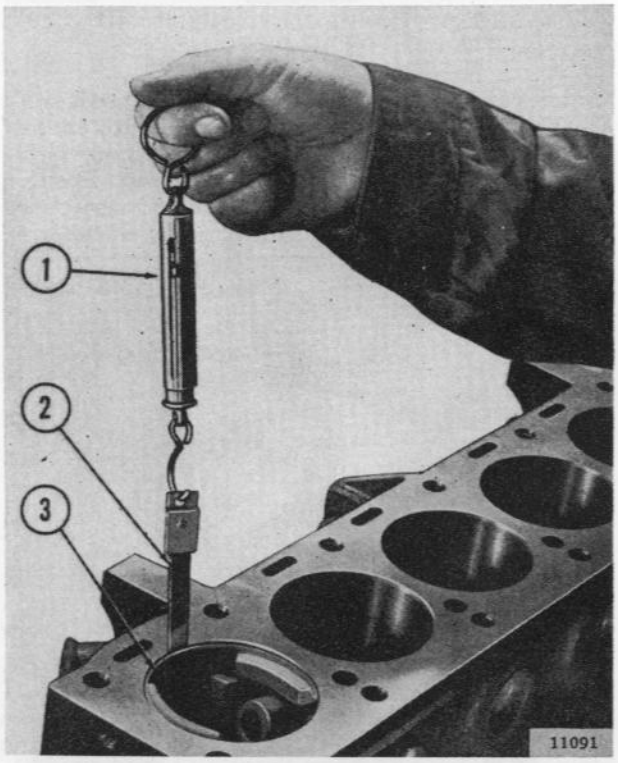

FIG. 90—FITTING PISTON IN CYLINDER BORE

1—Piston Fitting Gauge and Scale, C-690
2—Feeler Gauge
3—Piston

b. Check piston pin fit. The piston pin should be a palm push fit at room temperature.

If the pin is loose, a new pin must be used. It may be necessary to use a .003″ [0,0762 mm.] or a .005″ [0,127 mm.] oversize pin and ream the piston with piston pin reamer DD-82-2 as shown in Fig. 91 to obtain a push fit.

FIG. 91—REAMING PISTON PIN BORE

c. After checking the piston pin fit in the piston, check its fit in the connecting rod bushing. The pin should just slip through the bushing under its own weight. If the pin is too tight, ream the inside diameter of the bushing with piston pin reamer DD-82-2 as shown in Fig. 92 to .8597″ to .8599″ [21,836 a 21,841 mm.] for a standard pin or, if an oversize pin is used, ream the bushing. 003″ to .005″ [0,0762 a 0,127 mm.] oversize. If the pin is too loose, install a new bushing of proper size. The new bushing must be installed with the oil hole aligned with the oil hole in the connecting rod.

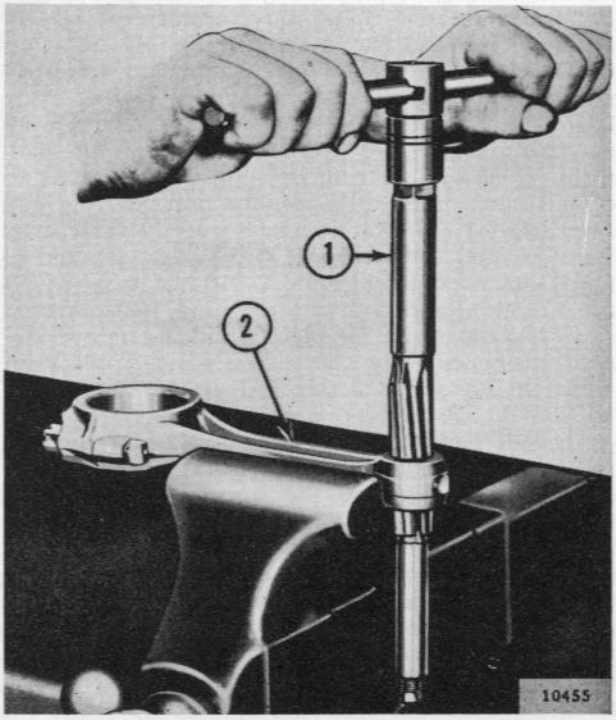

FIG. 92—REAMING CONNECTING ROD BUSHING

1—Reamer, DD-82-2 2—Connecting Rod

d. Assembled piston and rod. Install the piston pin, pushing it in by hand, and install the pin retaining rings.

e. Check width of piston ring grooves, using a new piston ring and feeler gauge as shown in Fig. 93.

FIG. 93—CHECKING PISTON RING SIDE CLEARANCE

RING TO GROOVE CLEARANCES

Upper Compression Ring. . . . .002″ to .0031″ [0,0508 a 0,079 mm.]
Lower Compression Ring. . . . .002″ to .0031″ [0,0508 a 0,079 mm.]

Insert feeler gauge between ring and piston to bottom of groove. Replace piston if ring grooves are not within allowable tolerances.

If a feeler gauge larger than .006″ [0,152 mm.] can be inserted 1/16″ [1,588 mm.] between piston and upper compression ring, groove is worn excessively bell-mouthed and piston should be replaced.

f. Check piston ring end gap by placing compression ring in cylinder bore below ring travel, using head of a piston to push ring in squarely. Minimum end gap must be .010″ [0,254 mm.] for compression rings. If less, place ring in a jig and file ends to obtain minimum gap. Excessive filing or ring gap over .045″ [1,143 mm.] indicates improper size rings were selected. Proper rings in cylinders rebored to usual oversizes should have a .010″ to .020″ [0,254 a 0,508 mm.] end gap without filing. Select piston rings of proper size for installation in the oversize cylinder bores using the Piston Ring Application Chart in Par. 36. Oil ring rail gap must be .015″ to .055″ [0,372 to 1,397 mm.].

g. Install new ring set, using either production replacement rings or oil control rings. Production replacement rings are the same as the original factory installed rings, while oil control ring sets have different components, notably the oil ring spacer. When installing the oil ring spacer for Sealed Power rings, make sure that both the green and orange dot are visible as shown in Fig. 94 at the spacer gap to indicate that the ends have not overlapped. If only one dot is visible, the condition must be corrected. Follow instructions on ring envelopes for proper installation. Use a piston ring tool to install rings on pistons as shown in Fig. 95.

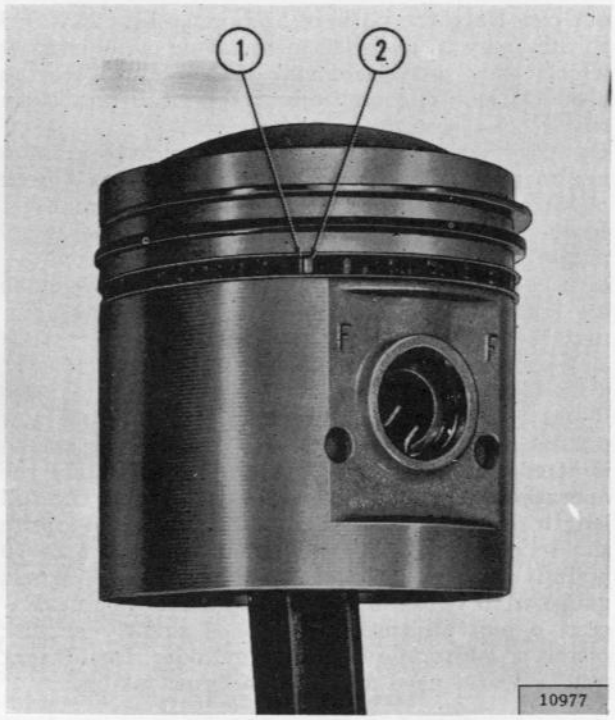

FIG. 94—CORRECTLY ASSEMBLED SEALED POWER PISTON RINGS

Do not expand rings more than necessary to install; also, be careful not to burr the piston with ends of rings. Make sure upper compression ring is installed in groove with correct side up. Position rings so gaps are staggered according to instructions on the envelope.

FIG. 95—INSTALLING RINGS ON PISTON
1—Piston Ring Installing Tool
2—Piston Ring
3—Piston Rings Installed

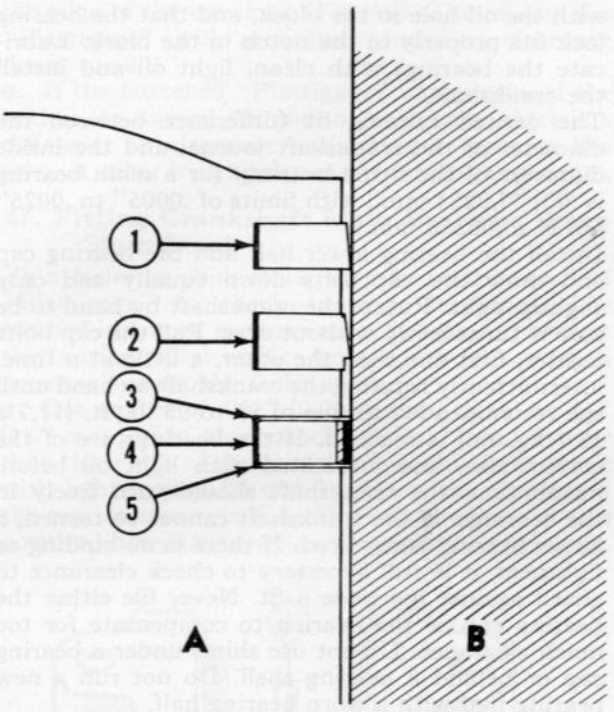

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FIG. 96—PISTONS AND RINGS, ENLARGED CROSS-SECTIONAL VIEW

1—Upper Compression Ring
2—Lower Compression Ring
3—Oil Control Rail
4—Spacer
5—Oil Control Rail

36. Piston Ring Application Chart

Actual Ring Size	Ring Oversize Range	For Best Fit Use in Cyl. Bore Oversize	Ring Gap Fitting
Std.	Std. to .009" [Std. a 0,229 mm.]	Std to .009" [Std. a 0,229 mm.]	No fitting necessary
.020" [0,508 mm.]	.010" to .029" [0,254 a 0,737 mm.]	.010" to .019" [0,254 a 0,483 mm.] .020" to .024" [0,508 a 0,610 mm.]	.007" Gap [0,178 mm.] No fitting necessary
.030" [0,762 mm.]	.030" to .039" [0,762 a 0,991 mm.]	.025" to .029" [0,635 a 0,737 mm.] .030" to .034" [0,762 a 0,863 mm.]	.007" Gap [0,178 mm.] No fitting necessary
.040" [1,016 mm.]	.040" to .049" [1,016 a 1,244 mm.]	.035" to .039" [0,889 a 0,991 mm.] .040" to .049" [1,016 a 1,224 mm.]	.007" Gap [0,178 mm.] No fitting necessary

37. Crankshaft

The crankshaft is machined from a heat treated carbon steel forging and is carefully balanced both dynamically and statically. The main bearing journals and crankpins are efficiently lubricated through the drilled oil gallery and passages in the cylinder block, through which oil is forced under pressure to the main bearings and through the cheeks of the crankshaft to the connecting rod bearings. After machining, the entire crankshaft was treated with Tufftriding process to increase hardness and durability.

While the crankshaft is out of the engine, be very careful when handling it to prevent damage to the connecting rod crankpins and the main bearing journals.

38. Crankshaft Cleaning

Clean out the drilled holes (oil passages) in the crankshaft journals with a small rifle brush or with a piece of wire. Blow out the passages with compressed air after cleaning. Clean the crankshaft thoroughly with a suitable cleaning solvent.

39. Crankshaft Inspection and Repair

Inspect the crankshaft for cracks, alignment, and condition of the crankpins and the main bearing journals. Cracks, misalignment, scored or worn journals and crankpins necessitate crankshaft replacement. Also check the pilot bushing for wear or damage in the rear end of the crankshaft.

Caution: Since the entire crankshaft was treated with a Tufftriding process, it must be reprocessed by the same method after any machining is done on the bearing journals. This is absolutely necessary or crankshaft failure will result.

40. Checking Crankshaft Alignment

To check alignment, mount the crankshaft in the cylinder block with the front and rear bearings in place but the two intermediate bearings removed. With a dial indicator mounted on the crankcase and the indicator button resting on the intermediate bearing journals, one at a time, slowly rotate the crankshaft and note the reading on the indicator dial. Install the two intermediate bearings and remove the front and rear bearings. Then repeat the operation with the dial indicator, checking at the front and rear bearing journals. The maximum allowable run-out is .002" [0,0508 mm.].

41. Checking Main Bearing Journals

Check the crankshaft main bearing journals with a 3" micrometer. The standard journal diameter is 2.3747" to 2.3755" [6,032 a 6,038 cm] for all main bearings. Allowable taper or out-of-round of the journals is .001" [0,0254 mm.].

42. Checking Connecting Rod Crankpins

Check the crankpin diameters with a micrometer to assure they are not out-of-round or tapered more than .001" [0,0254 mm.]. The standard crankpin diameter is 2.0627" to 2.0619" [5,239 a 5,237 cm.].

43. Crankshaft Pilot Bushing

Inspect the crankshaft pilot bushing in the flywheel end of the crankshaft. The pilot bushing may be replaced with the engine in or out of the equipment.

44. Crankshaft Main Bearings

The crankshaft main bearings are steel backed, high lead-copper type which provide long bearing life. They are the replaceable type which, when correctly installed, provide proper clearance without filing, boring, scraping or shimming. Upper and lower bearing halves are retained in position with locks notched on the bearing to fit into corresponding notches in the cylinder block and bearing cap. All four main bearings have the same bore diameter but differ in width; only the two intermediate bearings are the same and interchangeable. Upper and lower halves of each bearing are different, since

the upper halves have the oil supply holes and full-length annular oil grooves. Lower halves have no oil holes and only partial grooves. The bearing halves must be installed in their proper positions. Crankshaft bearings should be replaced as a complete set of four bearings, each bearing consisting of two halves.

The following undersize crankshaft main bearings are available:

.002″ [0,050 mm.]
.010″ [0,254 mm.]
.020″ [0,508 mm.]

The .010″ size is intended for use with a crankshaft that has been turned to this size as standard. There are cases where the crankshaft does not need to be reworked and the slightly undersize bearings can be used.

Bearing sizes are rubber stamped on the back side of each bearing. The rear main bearing has an integral flange to serve as a crankshaft thrust washer.

45. Crankshaft Main Bearing Inspection

The crankshaft journals must be carefully inspected as detailed previously in Par. 41. Worn journals will require undersize bearings. Scored, flaked or worn bearings must be replaced. Bearing wear can be checked by measuring the thickness, which should be .0925″ to .0928″ [2,366 a 2,359 mm.] for standard size bearings.

Measure the main bearing bores, using a telescope gauge and micrometer as shown in Fig. 97. Measure the bores at right angles to the split line and at 45 degrees to the split line. The standard bore diameter is 2.5622″ to 2.5615″ [6,508 a 6,506 cm.]. The bores should not be over .001″ [,0254 mm.] out-of-round or .001″ in taper from end to end. Also, the bores should not be more than .001″ oversize, considering the average diameter of the bore.

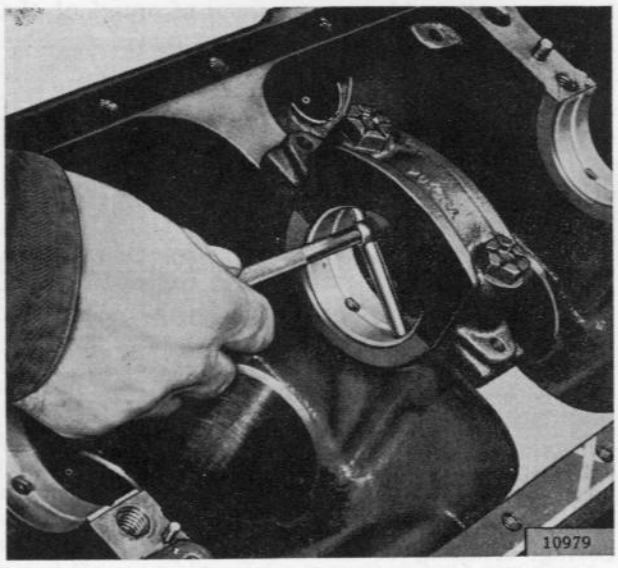

FIG. 97—MEASURING MAIN BEARING BORES

46. Fitting Crankshaft Main Bearings Using Plastigage

After wiping and carefully inspecting the bearing bore, install the proper bearing. See that the oil hole in the bearing upper half registers properly with the oil hole in the block, and that the bearing lock fits properly in the notch in the block. Lubricate the bearings with clean, light oil and install the crankshaft.

The desired running fit (difference between the diameter of the crankshaft journal and the inside diameter of the fitted bearing) for a main bearing is .001″ [,0254 mm.] with limits of .0005″ to .0025″ [,0127 a ,06350 mm.].

Install the bearing lower half and the bearing cap and draw the cap bolts down equally and only slightly tight. Rotate the crankshaft by hand to be sure it turns freely without drag. Pull the cap bolts tighter, first one then the other, a little at a time, intermittently rotating the crankshaft by hand until the recommended torque of 85 to 95 lb./ft. [11,7 a 13,1 kg. m.] is reached. If the bearings are of the correct size, and lubricated with light oil before installation, the crankshaft should turn freely in the bearings. If the crankshaft cannot be turned, a larger bearing is required. If there is no binding or tightness, it is still necessary to check clearance to guard against too loose a fit. Never file either the bearing cap or the bearing to compensate for too much clearance. Do not use shims under a bearing cap or behind a bearing shell. Do not run a new bearing half with a worn bearing half.

The use of "Plastigage" of the proper size to measure .001″ [,0254 mm.] clearance is recommended for checking crankshaft main bearing clearance. The method of checking clearance is as follows:

a. Remove the bearing cap and carefully wipe all oil from the bearing and the journal.

b. Lay a piece of "Plastigage" 1/8″ [3,17 mm.] shorter than the width of the bearing across the journal (lengthwise of the crankshaft).

c. Install the bearing and cap and tighten first one bolt, than the other, a little at a time, to the specified torque. As the bearing tightens down around the journal, the "Plastigage" flattens to a width that indicates the bearing clearance.

d. Remove the cap and measure the width of the flattened "Plastigage", using the scale printed on

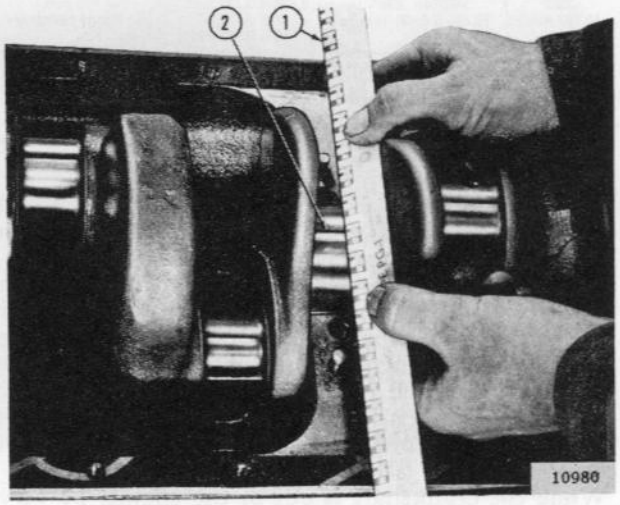

FIG. 98—CHECKING MAIN BEARING CLEARANCE WITH PLASTIGAGE

1—Plastigage Scale
2—Plastigage

the edge of the envelope (Fig. 98). The proper size "Plastigage" will accurately measure clearance down to .001".

e. If the flattened "Plastigage" tapers toward the middle, or toward the end, or both ends, there is a difference in clearance, indicating a taper, a low spot, or other irregularity of the bearing or journal.

47. Fitting Crankshaft Main Bearings Using Shim Stock

Thin feeler or shim stock may be used instead of "Plastigage" to check bearing clearances. The method is simple, but care must be taken to protect the bearing metal surface from injury by too much pressure against the feeler stock.

a. Cut a piece of .001" [0,0254 mm.] thick, by ½" [12,7 mm.] wide, feeler stock ⅛" [3,17 mm.] shorter than the width of the bearing. Coat this feeler stock with light engine oil and lay it on the bearing in the cap, as shown in Fig. 99. With the shim in this position, install the bearing and cap on the crankshaft.

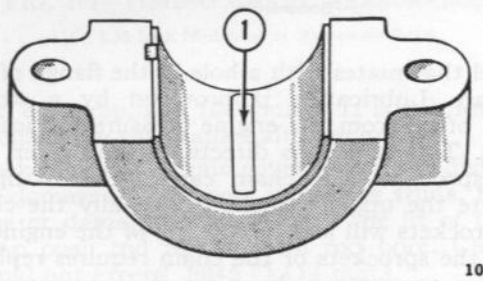

FIG. 99—SHIM STOCK IN POSITION ON MAIN BEARING

1—0.001" Feeler Stock ½" Wide

b. Tighten the bearing cap bolts, first one and then the other, a little at a time, to 85 to 95 lb./ft. torque [11,7 a 13,1 kg. m.].

c. Turn the crankshaft by hand not more than one inch in either direction.

Caution: Turning the crankshaft more may imbed the shim stock in the bearing, giving a false indication of fit and damaging the bearing.

If the bearing clearance is correct, the piece of .001" feeler stock should produce a light to heavy drag. If there is little or no drag, the bearing fit is too loose; if the crankshaft will not turn, there is not enough clearance. In either case another bearing must be selected to provide the proper fit.

d. After the bearing has been correctly fitted, remove the shim stock, wipe the bearing and journal carefully, and apply clean engine oil to the surfaces. Replace the cap and tighten the bolts first one, then the other, a little at a time, to the prescribed torque. Fig. 100 shows the rear main bearing installed. The crankshaft should now turn freely without drag.

48. Connecting Rod Bearings

The connecting rod bearings, like the crankshaft main bearings, are the replaceable type. When correctly installed, the bearings provide proper clearance without filing, boring, scraping, or shimming. Upper and lower bearing halves are retained

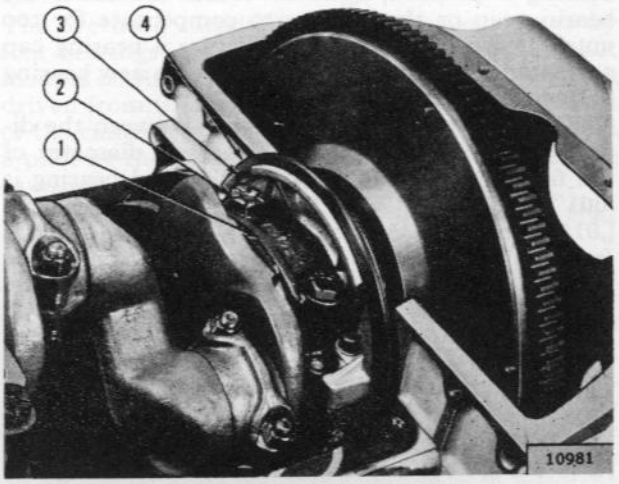

FIG. 100—REAR MAIN BEARING INSTALLATION

1—Rear Main Bearing Cap
2—Bearing Cap Bolt
3—Filler Block
4—Oil Pan Seal

in position with locks notched in the bearing to fit into corresponding notches in the cap and connecting rod. The position of the bearing lock and oil hole in the bearings for numbers 1, 3, and 5 connecting rods is the opposite of those for numbers 2, 4, and 6 and, therefore, they are not interchangeable. Connecting rod bearings should be replaced as a complete set of six bearings, each bearing consisting of two halves.

The following undersize connecting rod bearings are available:

.002" [0,050 mm.]	.012" [0,304 mm.]
.010" [0,254 mm.]	.020" [0,508 mm.]

49. Connecting Rod Bearing Replacement

The bearings are replaced by removing the bearing cap and the upper and lower bearing halves. The new bearings must be installed so that the oil holes align with those in the connecting rod and the locks must fit into the corresponding notches in the rod and cap and seat evenly. Each bearing cap must be installed on the connecting rod from which it was removed, and in the same position.

50. Connecting Rod Bearing Inspection

The crankpins must be carefully inspected as detailed previously in Par. 42. Worn crankpins will require undersize bearings. Scored, flaked or worn bearings must be replaced.

51. Fitting Connecting Rod Bearings

The bearing fit may be roughly checked by shaking the connecting rod by hand, prior to removal of the bearing cap, to determine if it is loose on the crankshaft.

The bearing clearances may be measured with "Plastigage" or shim stock as follows:

After wiping and carefully inspecting the bearing bore, install the proper bearing. See that the oil hole in the bearing upper half registers properly with the oil hole in the connecting rod and the lock fits properly in the notch in the rod. Lubricate the

bearing with clean, light oil. Never file either the bearing cap or the bearing to compensate for too much clearance. Do not shim under a bearing cap or behind a bearing shell. Do not run a new bearing half with a worn half.

The desired running fit (difference between the diameter of the crankpin and the inside diameter of the fitted bearing) for a connecting rod bearing is .001" [,0254 mm.] with limits of .0006" to .0025" [,0152 mm. a ,0635 mm.].

Install the bearing lower half and the connecting rod cap and draw the cap bolt nuts down equally and only slightly tight. Move the connecting rod endwise, one way or the other, on the crankshaft to be sure the bearing is not tight. Pull the nuts tighter, first one then the other, a little at a time, and keep trying the fit of the rod on the crankshaft by hand until recommended torque of 40 to 45 lb./ft. [5,5 a 6,2 kg. m.] is reached. If the bearings are of the correct size, and lubricated with light engine oil before installation, the connecting rod should be easy to slide with the thumbs back and forth parallel to the crankpin. If the connecting rod is tight on the crankshaft, a larger bearing is required. If there is no binding or tightness, it is still necessary to check clearance to guard against too loose a fit.

The use of "Plastigage" or shim stock of the proper size to measure .001" [,0254 mm.] clearance is recommended for checking connecting rod bearing clearances. This is the same material recommended for checking crankshaft main bearings and the method of checking is similar. Refer to Par. 46 and 47. Connecting rod bearings are fitted to the same clearance as the main bearings but the torque specification for connecting rod cap bolt nuts is only 40 to 45 lb./ft. [5,5 a 6,2 kg. m.].

52. Crankshaft End-Play

The end play of the crankshaft is controlled by flanges on the rear main bearing and the machined surface on the number 8 cheek and on the inner side of the oil seal flange of the crankshaft (Fig. 100). Allowable end play is .003" to .007" [,0762 mm. a ,1978 mm.]. If the crankshaft end play is greater than .007", the bearing flange is probably worn, which will necessitate bearing replacement.

53. Checking Crankshaft End-Play

Install the vibration damper bolt and washer. Mount a dial indicator on the front end of the engine with the indicator button against the front end of the vibration damper bolt (Fig. 101). Move the crankshaft endwise to the rear as far as possible and set the indicator dial at zero. Then move the crankshaft forward, prying with a screwdriver as shown. The indicator reading is the total amount of end-play. Remove the dial indicator, cap screw and washer.

54. Timing Chain and Sprocket

The timing chain sprockets are mounted at the front of the crankshaft and at the front of the camshaft, and are connected by a wide, heavy-duty chain which transfers rotation from the crankshaft to the camshaft. The lower sprocket is keyed to the crankshaft. The camshaft sprocket is provided with

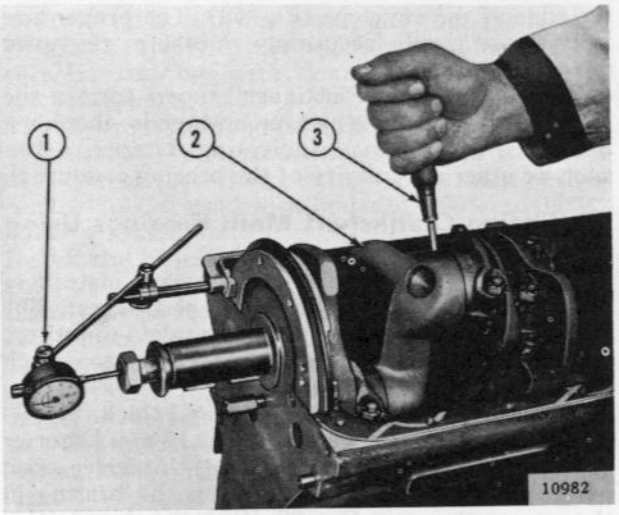

FIG. 101—CHECKING CRANKSHAFT END-PLAY

1—Dial Indicator
2—Crankshaft
3—Screwdriver

a dowel that mates with a hole in the flange of the camshaft. Lubrication is provided by a steady stream of oil from the engine pressure lubrication system. This stream is directed at the chain and lower sprocket. The chain carries the oil up to lubricate the upper sprocket. Normally the chain and sprockets will last for the life of the engine. If one of the sprockets or the chain requires replacement for any reason, however, it is necessary to replace the chain and both sprockets to make sure the proper tolerances are maintained.

55. Inspection and Repair

Check the general condition of both sprockets and chain and inspect for evidence of excessive wear. Replace excessively worn or damaged sprockets or chain.

Check the chain for excessive wear or stretch. When the chain is installed with the chain tensioner in place, measure the distance between the chain sides at the narrowest point (Fig. 102). This distance should be a minimum of 3.38" [8,58 cm.]. If the distance is less than required, the chain has stretched or is worn excessively and must be replaced.

56. Timing Chain Tensioning Device

The timing chain tensioning device maintains a constant pressure against the timing chain to compensate for normal stretch and wear of the chain. Check the contact face of the tensioner blade to make sure the rubber facing material is not worn through. Replace if badly worn. Check the tensioner spring to make sure it is not distorted or elongated.

57. Timing Chain Cover and Oil Seal

The timing chain cover is mounted on the front of the engine to enclose the timing chain mechanism. It also forms an integral part of the water pump body and is provided with a coolant passage to discharge the coolant from the pump. The timing chain cover provides mounting surfaces for the distrib-

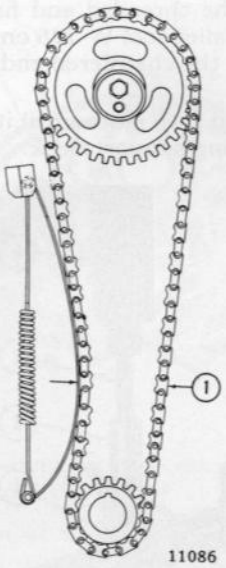

FIG. 102—TIMING CHAIN MEASUREMENT

1—3.38 Inch Minimum at Narrowest Point

utor, oil pump, and fuel pump. It is provided with an oil seal in the crankshaft opening.

Check the timing chain cover for cracks, distortion, and damaged component mounting studs. Replace loose or damaged studs. Check the fit of the fuel pump push rod in the push rod bore. Clearance should not exceed .0045" [,114 mm.].

It is recommended that the front crankshaft oil seal be replaced each time the timing chain cover is removed. Instructions for removing the oil seal are given in Par. 16. Install the front crankshaft oil seal after the timing chain cover is installed. Refer to Par. 93.

58. Vibration Damper

The vibration damper is mounted on the front end of the crankshaft. It is designed to eliminate the torsional vibration set up in the engine. It also serves as a drive pulley for the fan belt. Replace a broken, distorted, or otherwise damaged vibration damper.

59. Camshaft and Bearings

The overhead camshaft (Fig. 103) is supported by four bearings in the cam bearing support deck that mounts on the cylinder head. The camshaft is chain driven from the timing chain sprocket on the front of the camshaft. The camshaft sprocket mounts on a pilot at the front of the camshaft and drives the camshaft through a dowel.

The fuel pump is actuated by an eccentric that mounts on the front of the camshaft sprocket.

The cam bearing support deck is provided with a large oil passage through the center; a ¼" steel tube is inserted in this passage to conduct the lubricating oil to the front of the support deck and to prevent oil drain back when the vehicle is idle. Oil passages are provided in the support deck to lubricate the cam bearings. The oil passage to the rear cam bearing also provides oil under pressure to fill the oil passages in the camshaft to keep the cams lubricated.

60. Camshaft and Bearing Inspection

Clean the camshaft thoroughly with a suitable cleaning solvent. Make sure all oil passages are free. Check the cams for scoring or wear. The cam faces must be prefectly smooth throughout their contact areas. Run out of the camshaft, measured with a dial indicator at the intermediate bearing journals, must not exceed .0005" [0,0127 mm.].

Check the diameter of the camshaft journals with a micrometer. The specified journal diameters are listed below:

CAMSHAFT JOURNAL DIAMETERS

Front	1.9975"-1.9965" [50,7365 mm.-50,7111 mm.]
Front Intermediate	1.8725"-1.8715" [47,5615 mm.-47,5361 mm.]
Rear Intermediate	1.7475"-1.7465" [44,3865 mm.-44,3611 mm.]
Rear	1.3725"-1.3715" [34,8615 mm.-34,8361 mm.]

Check the cam bearing support deck for cracks or distortion. Check the bearing surfaces of the cam bearing deck for visible wear or scoring. Using a telescope gauge and a micrometer, check the in-

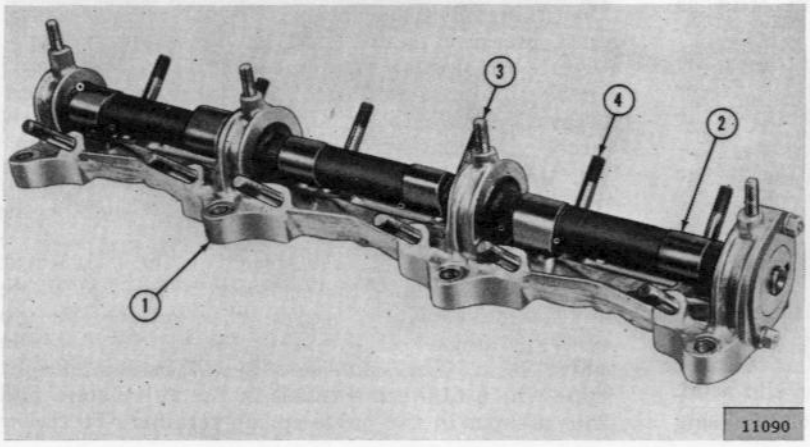

FIG. 103—CAMSHAFT AND CAM BEARING SUPPORT DECK

1—Cam Bearing Support Deck
2—Camshaft
3—Rocker Arm Cover Stud
4—Rocker Arm Stud

ternal diameters of the cam bearing deck bearings as shown in Fig. 104. The specified internal diameters are listed below:

CAM BEARING SUPPORT DECK BORES

Front	1.9995″-2.0005″ [50,7873 mm.-50,8127 mm.]
Front Intermediate	1.8745″-1.8755″ [47,6123 mm.-47,6377 mm.]
Rear Intermediate	1.7495″-1.7505″ [44,4373 mm.-44,4627 mm.]
Rear	1.3745″-1.3755″ [34,9132 mm.-34,9377 mm.]

Compare each journal diameter with the corresponding bearing diameter. If the bearings are defective or permit more than .004″ [,1016 mm.] running clearance, the cam bearing deck and/or the camshaft must be replaced.

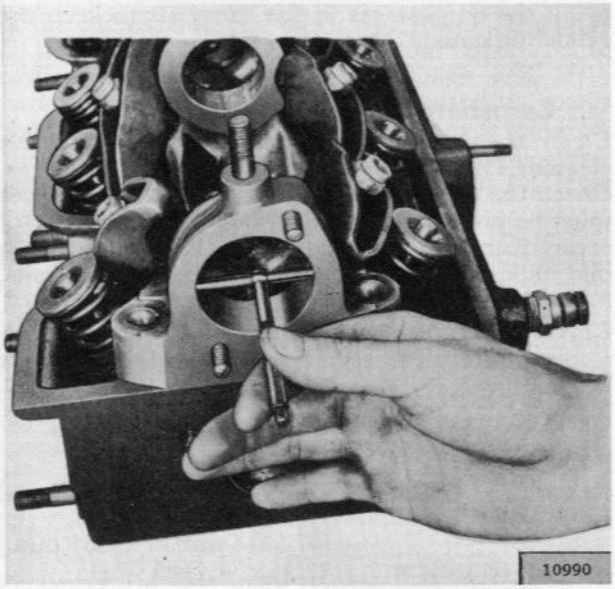

FIG. 104—CHECKING BEARING DIAMETER OF CAM BEARING SUPPORT DECK

61. Replacing Rocker Arm Studs

If any of the rocker arm studs are worn, distorted, or have damaged threads, replace as follows:

a. Position the cam bearing support deck on the bed of an arbor press and position the support of the rocker arm stud remover and installer tool W-266 under the defective rocker arm stud as shown in Fig. 105.

b. Position the guide of the tool on the top of the stud with the chamfered end up. Position the driver in the guide so that the end rests on the top of the stud.

c. Press on the end of the driver to dislodge the rocker arm stud from the cam bearing deck. Make sure the support is properly positioned so that the end of the stud can enter the center bore of the support. Remove the stud.

d. Invert the cam bearing support deck on the bed of the arbor press and install the support of rocker arm stud remover and installer tool W-266 under the deck and aligned with the hole for the stud.

e. Position the new stud in the hole in the bearing deck, starting the threaded end first. Position the guide of the installer tool W-226 on the knurled end of the stud with the chamfered end down, as shown in Fig. 106.

f. Press the stud into place until it is firmly seated in the cam bearing support deck.

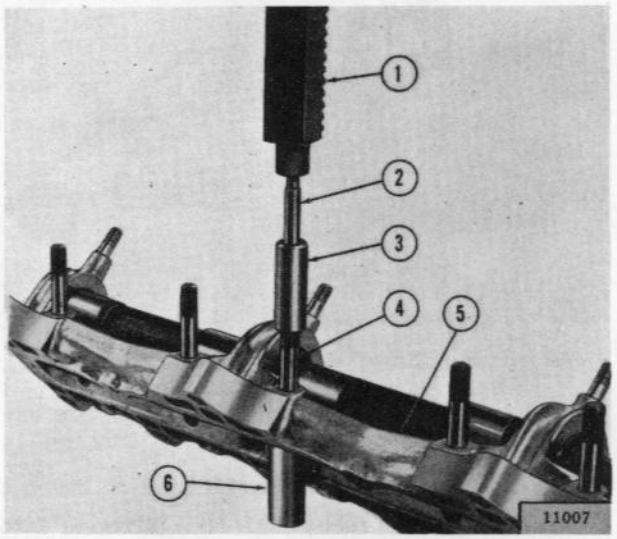

FIG. 105—REMOVING ROCKER ARM STUD FROM BEARING DECK WITH TOOL W-266

1—Arbor Press
2—Driver
3—Guide
4—Rocker Arm Stud
5—Cam Bearing Support Deck
6—Support

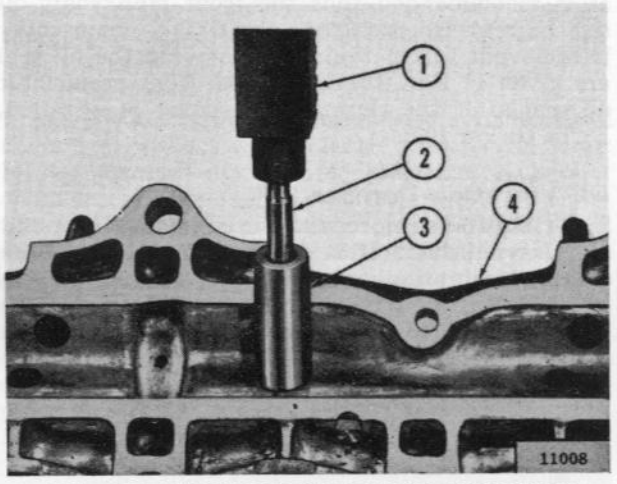

FIG. 106—INSTALLING ROCKER ARM STUD IN BEARING DECK WITH TOOL W-266

1—Arbor Press
2—Driver
3—Guide
4—Cam Bearing Support Deck

62. Valves, Springs, and Guides

The valves, springs, and guides are installed on the cylinder head (Fig. 107) with the valve stems extending up through the head so that the valves seat on the underside of the cylinder head. The valve spring and associated parts are assembled on top of the cylinder head and are locked to the end of the valve stem. The valve retaining lock is the split type which fits into a recess in the valve stem and into a taper in the valve spring retainer. To repair

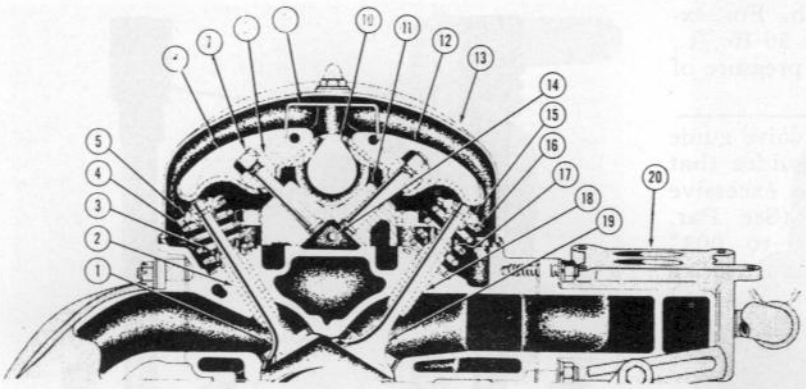

FIG. 107—CUTAWAY VIEW OF VALVES INSTALLED ON HEAD

1—Exhaust Valve
2—Valve Guide
3—Valve Guide Seal
4—Valve Spring
5—Valve Spring Retainer
6—Rocker Arm
7—Rocker Arm Stud
8—Rocker Arm Ball
9—Rocker Arm Guide
10—Camshaft
11—Cam Bearing Support Deck
12—Rocker Arm
13—Rocker Arm Cover
14—Oil Tube
15—Valve Spring Retainer
16—Valve Spring
17—Valve Guide Seal
18—Valve Guide
19—Intake Valve
20—Intake Manifold

or replace the valves, it is necessary to remove the cylinder head from the engine.

63. Inspection of Valves, Springs, and Guides

Clean the valves on a wire wheel, making sure that all carbon is removed from the top and the underside of the heads and that all gum and varnish deposits are removed from the stems.

Polish the valve stems with steel wool or crocus cloth. Visually inspect all valves for warpage, cracks or excessive burning, and discard if any of these conditions exist. Replace any worn, pitted, or corroded valves that cannot be cleaned with a wire brush. Replace any valves when seats are pitted, burned, or corroded so badly that they cannot be cleaned up with a light refacing on a valve refacing machine (Fig. 108).

Replace valves with marks or scoring, or abrasion visible on the stem. Replace any valves with bent stems. This condition will be immediately apparent when the valve is installed in a valve refacing machine.

Check the diameter of the valve stem at two or three different places along the length of the stem, using a micrometer. The stem diameter of the intake valve is .3400″ to .3410″ [8,636 mm. a 8,6614 mm.]. The stem diameter of the exhaust valve is .3385″ to .3395″ [8,5979 mm. a 8,6233 mm.]. Replace valves if the stems are worn.

Wash the valve springs thoroughly in solvent. Visually examine the springs and replace any that are deformed or obviously damaged. Examine for corrosion from moisture or for acid etching which might develop into surface cracks and cause failure. Measure the overall free length of the springs and replace any that are not the standard length of 1.60″ [40,64 mm.] for both intake and exhaust valve springs. Test each spring when compressed to the two different spring lengths given below. These values represent the valve closed and valve open spring lengths. If any spring fails to register spring tension equal to or greater than the minimum load limit in pounds specified for that spring length, replace the spring.

VALVE SPRING TENSION VALUES

Length	Minimum Load
1.26″ [32,004 mm.]	57 lb. [24,494 kg.]
.885″ [22,479 mm.]	130 lb. [66,2536 kg.]

Note: When using a spring checking fixture as shown in Fig. 109, it is necessary to convert the torque reading, which is in pounds-feet, to the static pound pressure specified above, according to the

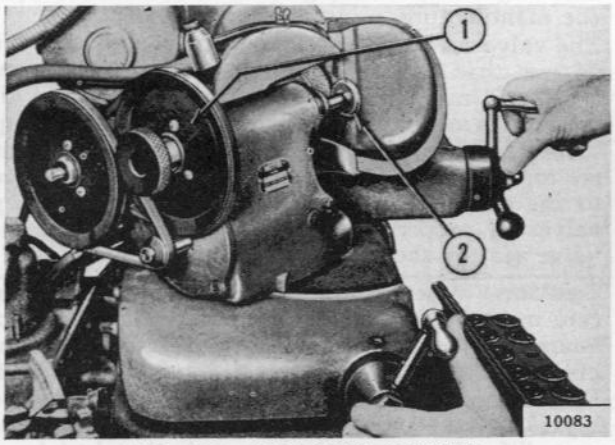

FIG. 108—REFACING VALVES

1—Valve Refacer
2—Valve

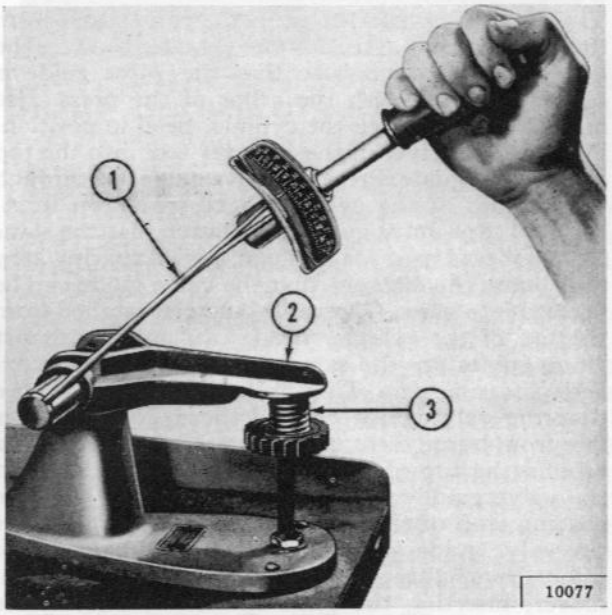

FIG. 109—TESTING VALVE SPRING

1—Torque Wrench
2—Spring Checking Fixture
3—Spring

instructions furnished with the wrench. For example, if the torque wrench reading is 50 lb./ft., and the wrench is 2 ft. long, the static pressure of the spring is 50 x 2 or 100 lbs.

Clean the valve guides with a standard valve guide cleaner or wire brush. Replace valve guides that are damaged or worn enough to cause excessive valve stem-to-valve guide clearance. (See Par. 66.) Standard intake clearance is .001″ to .003″ [,0254 mm. a ,0762 mm.]. Standard exhaust valve clearance is .0025″ to .0045″ [,0835 mm. a ,1143 mm.]. Check the clearance with a plug gage. If this indicates excessive clearance, replace the valve guide.

64. Refacing Valves

Refacing the valves may be accomplished with a valve refacer (Fig. 108). The manufacturer's instructions should be followed when using the refacing equipment.

Reface the valves to an angle of 45 degrees. Take off only the minimum of metal required to clean up the valve faces. If the outer edge of the valve becomes too thin or sharp due to excessive grinding, the valve must be replaced. The valves must be lapped into the valve seats, using a suitable lapping compound, after the valve seats are refaced as described in Par. 67.

65. Cylinder Head Inspection

Inspect the cylinder head for cracks or leaks, damaged or distorted gasket surfaces, damaged valve seats, loose or worn valve guides, damaged threads, loose or damaged studs. Check the area around the core hole expansion plugs for sign of leaking. Refer to Fig. 84 for plug location. Replace any leaking plugs.

66. Valve Guide Replacement

Damaged, loose, or worn valve guides must be replaced. To remove the valve guides, use Valve Guide Remover Tool W-265.

This tool is a mandrel to press the valve guide from the cylinder head. Position the cylinder head on the bed of an arbor press so that the valve guide is squarely in line with the arbor of the press. Use metal blocks to block the cylinder head in position. Position the driver of the remover tool into the top of the valve guide. Press the valve guide out through the bottom of the cylinder head as shown in A, Fig. 110. For valve guide installation, use the same tool that was used for removal, plus a spacing stop that limits the distance that the valve guide can be pressed into place. The valve guide is installed from the top of the cylinder head. Intake and exhaust valve guides are the same and are installed in exactly the same way. To install the guide, make sure that the valve guide bore in the cylinder head is free from burrs, dirt, and carbon, and that the area around the top of the bore is also clean. Position the valve guide on the cylinder head and skip the spacing stop of the valve guide installer tool over the valve guide as shown in B, Fig. 110. Use the same driver that was used as a valve guide remover, inserting the pilot of the driver into the hole in the top of the valve guide. Align the driver squarely with the arbor of the press and press the valve guide into place until the shoulder on the driver strikes the spacing stop. This will provide proper positioning of the guide in the cylinder head. Properly positioned, the top of the valve guide will be .45″ [11,43 mm.] above the machined surface of the cylinder head.

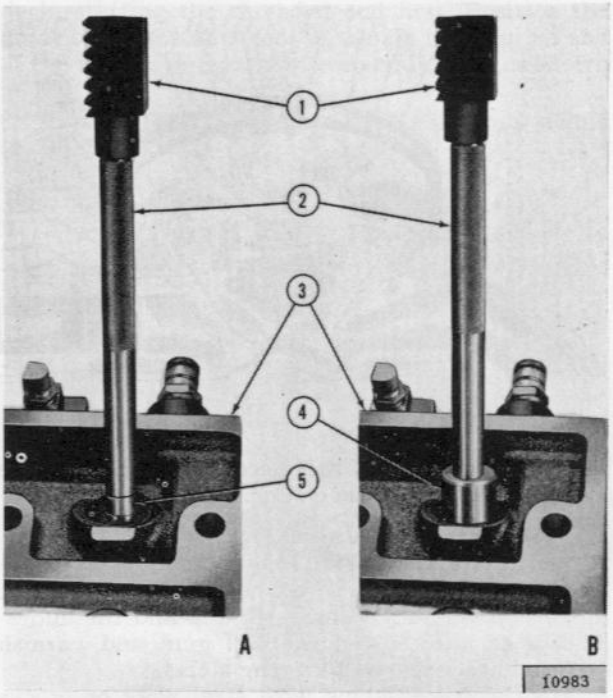

FIG. 110—REMOVING AND INSTALLING VALVE GUIDE FROM CYLINDER HEAD WITH TOOL W-265

1—Arbor Press
2—Driver
3—Cylinder Head
4—Stop
5—Valve Guide

After installing the valve guide, ream the guide to 0.342″ to 0.343″ [8,6868 mm. a 8,7122 mm.].

67. Valve Seat Inspection and Refacing

Inspect the valve seats for cracks, burns, pitting, ridges, or improper angle and reface. During any general engine overhaul it is advisable to reface the valve seats regardless of their condition.

If valve guides are to be replaced, this must be done before refacing the valve seats.

Refacing the valve seats may be accomplished with a 45 degree valve seat grinder in accordance with the manufacturer's instructions (Fig. 111).

The valve seat width after refacing should measure no less than $\frac{5}{64}$″ [1,984 mm.] and no more than $\frac{3}{32}$″ [3,967 mm.]. Fig. 112 shows the valve face dimension. Valve seats that are too wide tend to trap carbon particles that cause seat burning. Seats that are too narrow will not transfer heat from the valve to the coolant as rapidly as is necessary to keep valves in proper operating condition. Check the valve seat as shown in Fig. 113.

Caution: When using valve seat cutting tools, care must be taken to remove only the minimum amount of metal necessary to satisfactorily accomplish that phase of the operation being performed. Excessive removal of material may damage the head beyond repair by factory approved methods, or nullify the reconditioning work that had been accomplished on the valve seat up to that point.

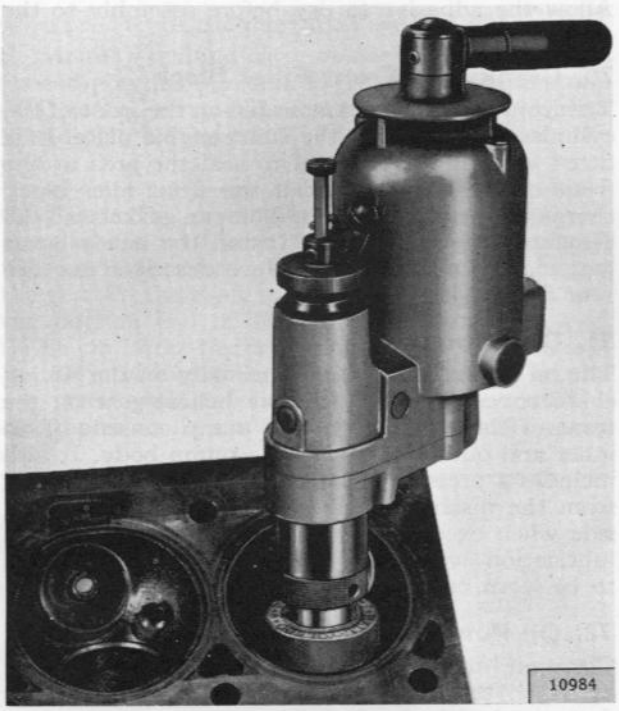

FIG. 111—REFACING VALVE SEATS

A simple check can be made to prove the fit of the valve in the valve seat by spreading a thin film of prussian blue on the valve face and then inserting the valve into the valve seat (Fig. 114). With hand pressure, rotate the valve a quarter of a turn and then remove the valve and observe the transfer of prussian blue to the valve seat. An uneven transfer of prussian blue will indicate an inaccurate valve and valve seat refacing operation.

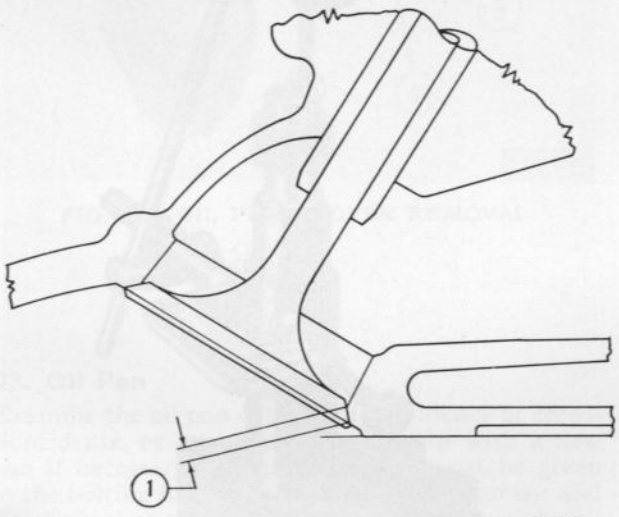

FIG. 112—VALVE SEAT FACE DIMENSIONS

1—1/64" to 3/32"

68. Crankshaft Rear Oil Seal

The rear end of the crankcase is sealed against oil leaks by a seal consisting of the filler block guard (1, Fig. 115), upper seal half (2), two gasket inserts (4), a lower seal half (3), a rear filler block (5), and an oil pan seal (6). The filler block guard is mounted in a recess in the cylinder block. The upper seal half fits into the filler block guard making a rubber-to-metal seal. The inner diameter of the seal has a fabric-faced synthetic rubber sealing surface which engages the crankshaft. The lower seal half is identical to the upper half, and it mounts in the rear filler block. The oil pan seal is cemented to the rear filler block. Dowel pins in the rear filler block align the parts properly during assembly. When the rear filler block is bolted to the crankcase, the gasket inserts are compressed to form a tight seal between the parts of the seal. The gasket inserts, the two seal halves, and the oil pan gasket should be replaced each time the engine is disassembled.

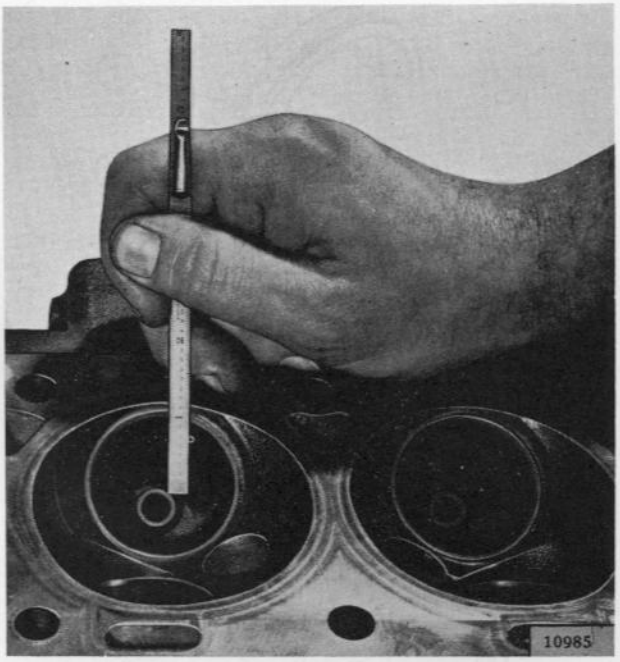

FIG. 113—MEASURING VALVE SEAT FACE

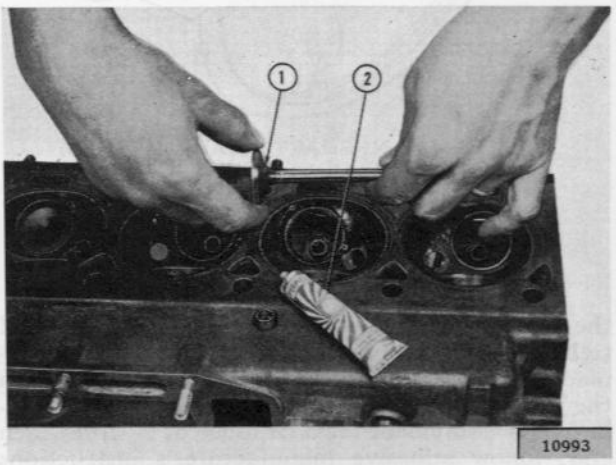

FIG. 114—CHECKING FIT OF VALVE IN VALVE SEAT

1—Valve
2—Prussian Blue

69. Crankshaft Rear Filler Block

Clean rear filler block thoroughly. Remove the oil pan oil seal and the cement used to attach it. Check

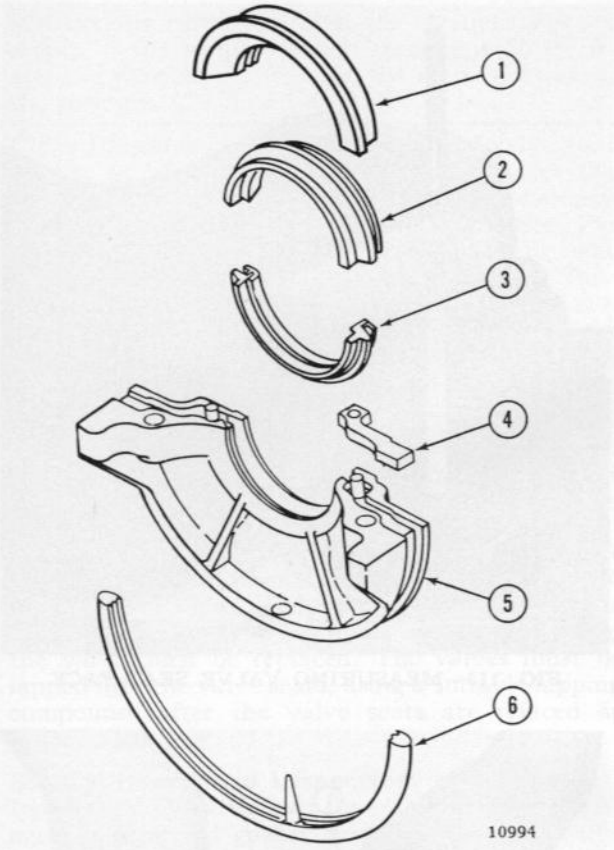

FIG. 115—CRANKSHAFT REAR OIL SEAL, EXPLODED VIEW

1—Filler Block Guard
2—Upper Seal Half
3—Lower Seal Half
4—Gasket Insert
5—Rear Filler Block
6—Oil Pan Seal

the dowel pins to make sure they are straight and tight. Replace the dowel pins if necessary. To replace the oil pan seal, coat the pan seal groove in the filler block with 3M Super Weatherstrip Adhesive or equivalent for a distance of 2″ from each end; follow adhesive manufacturer's instructions carefully. Also coat the pan seal ends for a distance of 2″. Insert the nipple of the pan seal into the hole in the bottom of the filler block. Press the ends into engagement with the cemented portion. When in position, the ends of the pan seal should be 1/16″ below the top of the filler block as shown in Fig. 116.

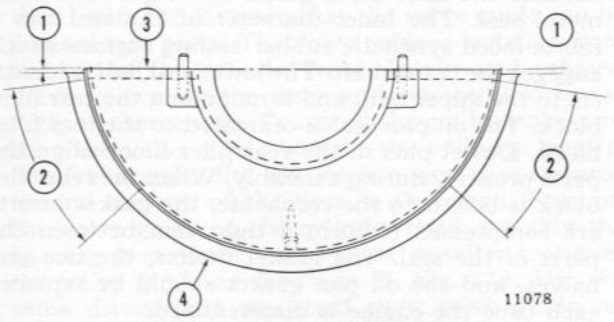

FIG. 116—OIL PAN SEAL ASSEMBLED TO FILLER BLOCK

1—1/16″
2—2″
3—Filler Block
4—Oil Pan Seal

Allow the adhesive to dry before assembly to the engine.

70. Crankshaft Front Filler Block

The front filler block is mounted on the front of the cylinder block and on the front engine plate. It is fitted with an oil pan seal to seal the area at the front of the oil pan. Clean the front filler block thoroughly, removing the old oil pan gasket and the cement used to attach it. Install the new oil pan gasket, following the procedure described for the rear filler block in Par. 69.

71. Oil Pump

The oil pump is mounted externally on the timing chain cover. It is driven by a helical gear on the front of the crankshaft. The pump consists of an inner and outer rotor within a pump body. It also includes a pressure relief valve which opens a port from the discharge side of the pump to the inlet side when excessive pressure builds up within the lubrication system. If inspection shows the pump to be worn or defective, it should be replaced.

72. Oil Pump Inspection

Clean and inspect the oil pump as follows:

a. Wash the exterior of the pump with a cloth dampened with cleaning solvent.

b. Check the entire pump for cracks or leaks.

c. Check the drive gear for cracked, chipped, or

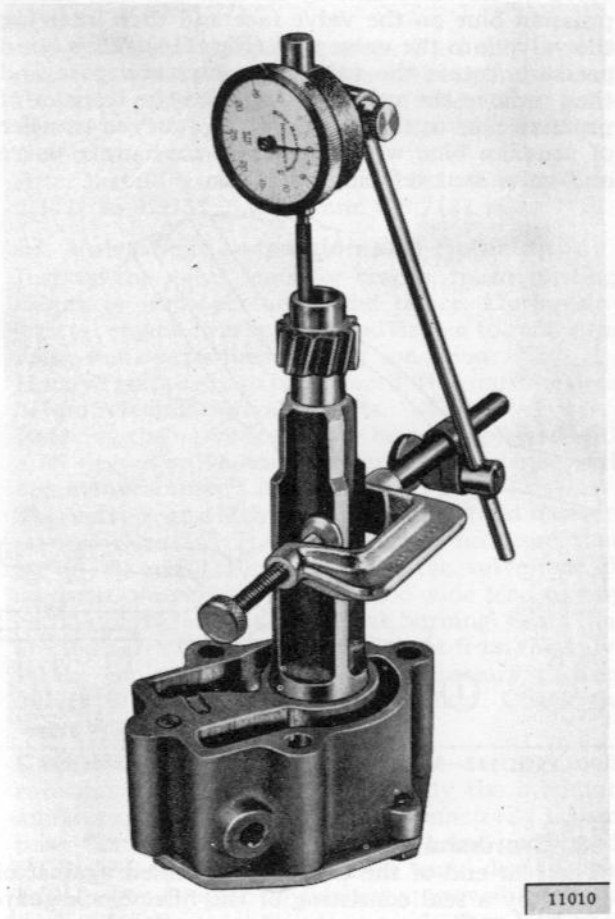

FIG. 117—CHECKING OIL PUMP SHAFT END-PLAY

worn gear teeth. Replace the gear of it is damaged.

d. Mount a dial indicator on the oil pump to check for end-play, as shown in Fig. 117. Move the pump shaft to its extremes and check for total end-play. If end-play exceeds .005″ [,1270 mm.], replace the pump.

Caution: The drive gear is a press fit on the oil pump shaft, and must be removed and replaced with an arbor press. Correct axial positioning of the gear on the shaft is important. When installed, the outside end of the gear hub must be $7\frac{1}{32}$″ [17,86 cm.] from the mounting face of the oil pump. In this position, the centerline of the face of the gear teeth will coincide with the bottom of the distributor shaft slot in the end of the oil pump shaft.

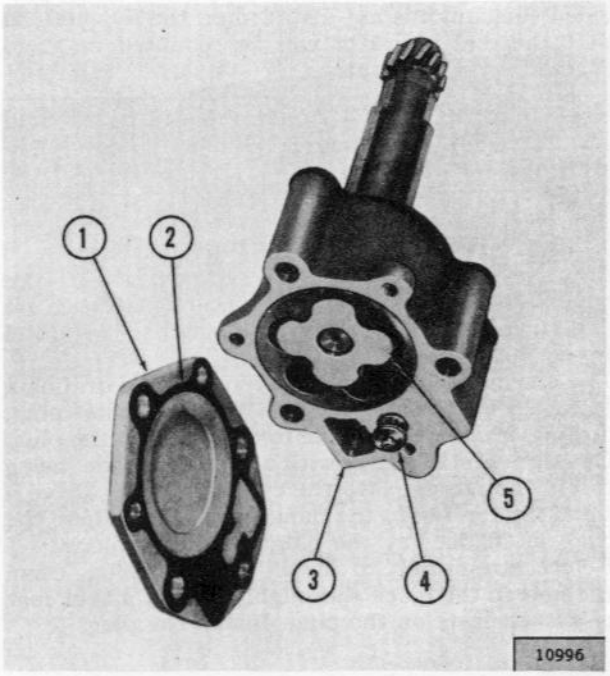

FIG. 118—OIL PUMP COVER REMOVAL

1—Cover
2—Gasket
3—Body
4—Relief Valve
5—Rotor

73. Oil Pan

Examine the oil pan carefully for evidence of corrosion, dents, or other damage. Replace with a new pan if necessary. Special attention must be given to the bolting flange to assure proper alignment and a tight seal at the cylinder block. Whenever the oil pan is removed, replace all gaskets regardless of condition.

74. Flywheel

The flywheel is mounted to the rear flange of the crankshaft. The crankshaft, flywheel, and clutch assembly are statically and dynamically balanced separately and as a unit; therefore, the components should be assembled in their original relative positions to maintain this balance, if possible.

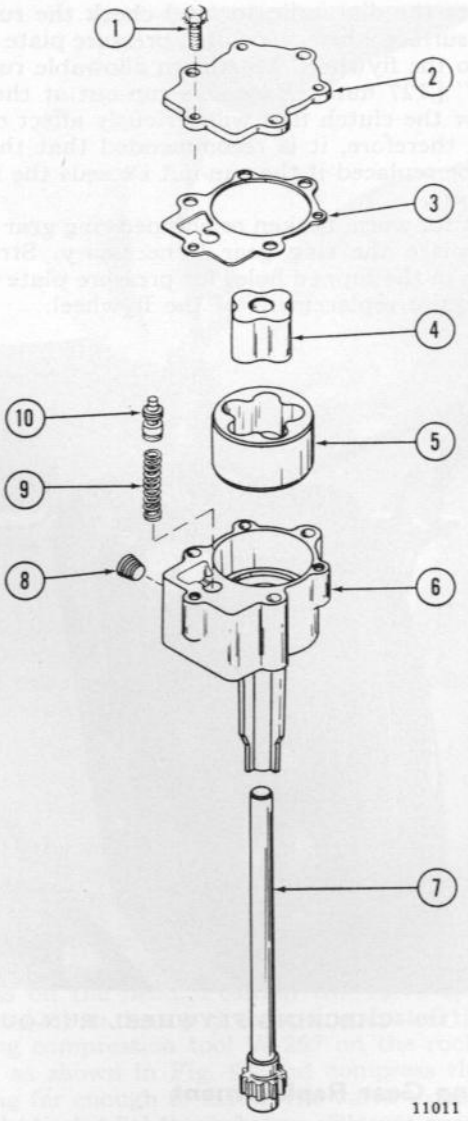

FIG. 119—OIL PUMP, EXPLODED VIEW

1—Sems Screw
2—Cover
3—Cover Gasket
4—Inner Rotor
5—Outer Rotor
6—Pump Body
7—Drive Shaft
8—Plug
9—Relief Valve Spring
10—Relief Valve

75. Flywheel Inspection

Inspection should be done only when assembling the flywheel to the crankshaft when assembling the engine. Clean the flywheel thoroughly with a suitable cleaning solvent and wipe dry. Inspect the clutch face to the flywheel for burned condition, rivet grooves or scuffed condition.

Check the flywheel for run-out, warping, and wear. Mount the flywheel on the crankshaft, with the crankshaft in the cylinder block. Mount a dial indicator with the contact button of the indicator resting against the clutch face of the flywheel (Fig. 120). Set the indicator at zero and rotate the flywheel. Maximum allowable run-out is .005″ [,127 mm.].

Relocate the dial indicator and check the run-out on the surface where the clutch pressure plate cover bolts to the flywheel. Maximum allowable run-out is .005" [,127 mm.]. Excessive run-out at the bolt circle or the clutch face will seriously affect clutch action; therefore, it is recommended that the flywheel be replaced if the run-out exceeds the specified limits.

Inspect for worn, broken or chipped ring gear teeth and replace the ring gear if necessary. Stripped threads in the tapped holes for pressure plate cover will require replacement of the flywheel.

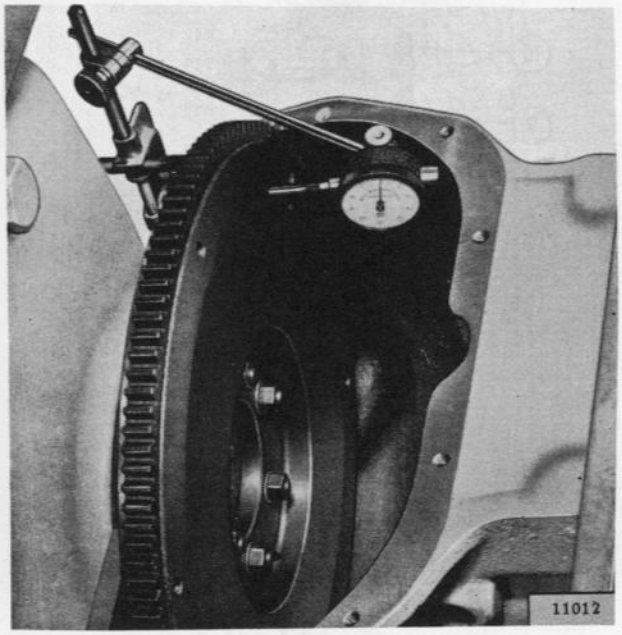

FIG. 120—CHECKING FLYWHEEL RUN-OUT

76. Ring Gear Replacement

To remove the ring gear from the flywheel, drill a 3/8" [9,52 mm.]. hole through the ring gear and cut through any remaining metal with a cold chisel. Remove the ring gear from the flywheel. Thoroughly clean the ring gear surface of the flywheel. Heat the new ring gear evenly to 605°-700°F. [343°-371° C.], and place it on the cold flywheel, making certain that the chamfer on the teeth is opposite the clutch side of the flywheel. Be sure that the ring gear is firmly seated on the flywheel. Allow the ring gear to cool slowly to shrink it onto the flywheel.

77. Clutch Housing

The clutch housing, which encloses the flywheel and clutch, is bolted to the cylinder block. A removable pan, bolted to the bottom of the housing, provides access to the clutch and flywheel. The rear of the housing provides the front support for the transmission.

Examine the housing for cracks and distortion of the machined surfaces. The front face must seat evenly against the cylinder block or engine rear end plate without evidence of warpage. The rear face must be parallel to the front face. Improper alignment will seriously affect the alignment of the power train. In addition, the hole in the rear of the housing, which services as a pilot for the transmission, must be concentric with the crankshaft. With the clutch housing installed, the run-out of the pilot hole and the rear face of the housing can be checked with a dial indicator. Install a clutch plate aligning arbor on the crankshaft pilot bushing, expanding it so that it is tight and will not wobble. Then attach the dial indicator to the arbor with the indicator button resting against the rear face of the clutch housing.

Rotate the flywheel, noting the run-out on the indicator. Maximum allowable run-out is .005" [,127 mm.]. Relocate the dial indicator so that the indicator button will indicate the run-out of the pilot hole in the clutch housing. Rotate the flywheel and note the run-out which should not exceed .006" [,152 mm.].

If desired, a suitable fixture can be made to attach to the flywheel with one of the flywheel bolts, provided the clutch is not installed on the flywheel, so that the dial indicator can be mounted on it to check housing run-out:

Note: Clutch housing run-out should be checked after the clutch housing is installed when assembling the engine.

78. Core Hole Expansion Plugs

Any evidence of coolant leakage around the core hole plugs will require plug replacement. There are five plugs in the left side of the cylinder block and one at the rear (Fig. 121).

The expansion plugs may be removed by drilling a 1/2" [12,7 mm.] hole through the expansion plug, drilling as close as possible to the flange of the plug. Cut through the flange with a hacksaw blade, being careful not to cut into the cylinder block. Drive a small drift between the flange and block where the cut was made. Pry the plug out of the block.

Before attempting to install the new plug, clean the hole in the block thoroughly. Apply a thin coat of gasket paste on the plug. Install the plug.

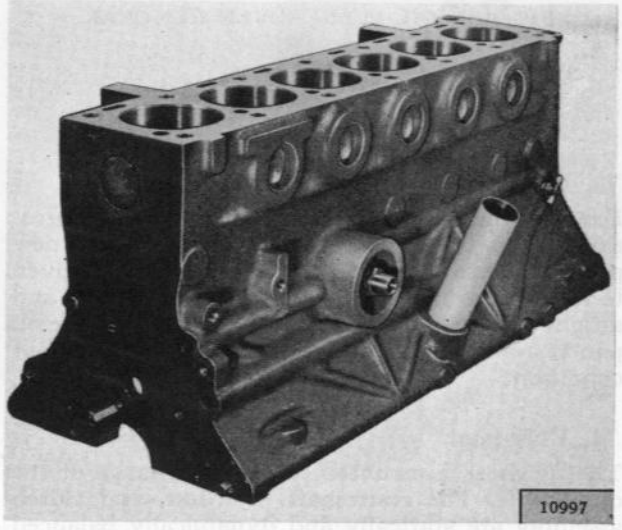

FIG. 121—CORE HOLE EXPANSION PLUGS

79. Engine Assembly

The engine assembly procedure in the following paragraphs is given in the sequence to be followed when the engine is being completely overhauled. Individual inspection, repair, and fitting operations previously detailed are to be performed when necessary throughout the assembly procedure. If a new cylinder block fitted with pistons is used, many of the operations will be unnecessary.

80. Install Valves and Valve Guide Seals

Always use new valve guide seals.

Install the valves and the valve guide seals as follows:

a. Position the cylinder head on blocks high enough to insert the valves from the underside of the head.

b. Apply a light coat of engine oil on the valve stem before assembly. Insert the valve into the valve guide from which it was removed.

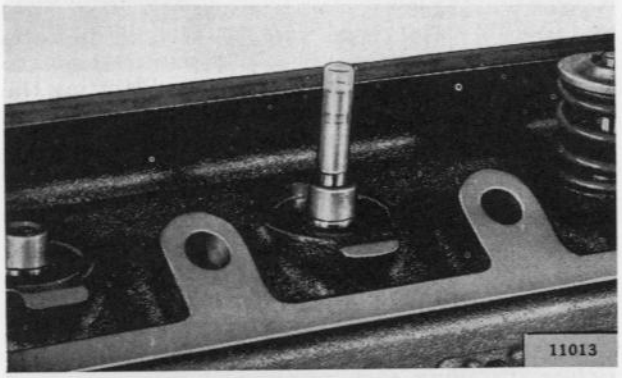

FIG. 122—PLASTIC CAP OF INSTALLER TOOL W-273 POSITIONED ON VALVE STEM

c. Cut off the excess length of the cap. It should extend 1/16" below the groove on the valve stem. Place the plastic cap included in each kit on the top of the valve stem, as shown in Fig. 122, to protect the Teflon insert. Lightly lubricate the cap.

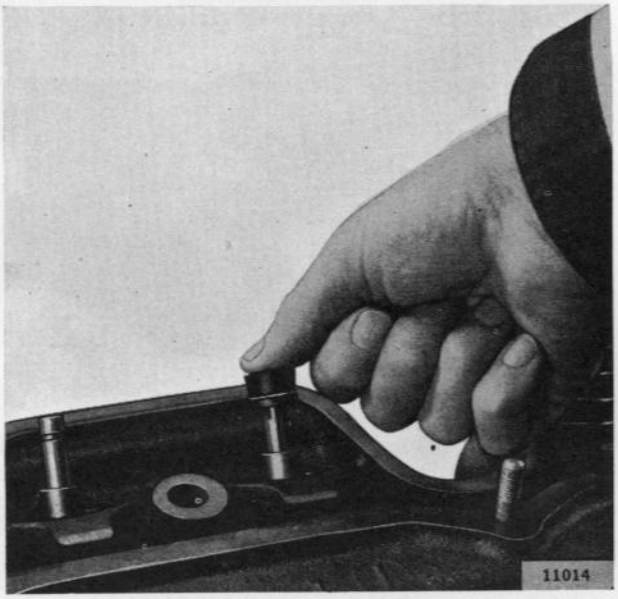

FIG. 123—STARTING VALVE GUIDE SEAL ON VALVE STEM

FIG. 124—SLIDING SEAL DOWN TO VALVE GUIDE

d. Position the valve guide seal squarely on the end of the valve stem and push it down with the thumb until the thumb strikes the top of the plastic cap, as shown in Fig. 123.

e. Use two thumbs, as shown in Fig. 124, to hold the insert in place until the seal touches the top of the valve guide. Remove the plastic cap.

f. Use the valve guide seal installation tool W-273 to push down on the valve guide seal until it is fully seated on the valve guide, as shown in Fig. 125.

g. Position the valve spring (27, Fig. 84) on the cylinder head, making sure it is fully seated in its recess on the head. Position the valve spring retainer (26) on the top of the spring. Install the valve spring compression tool W-267 on the rocker arm stud as shown in Fig. 85 and compress the valve spring far enough to install the valve locks to hold the retainer to the valve stem. Release pressure on

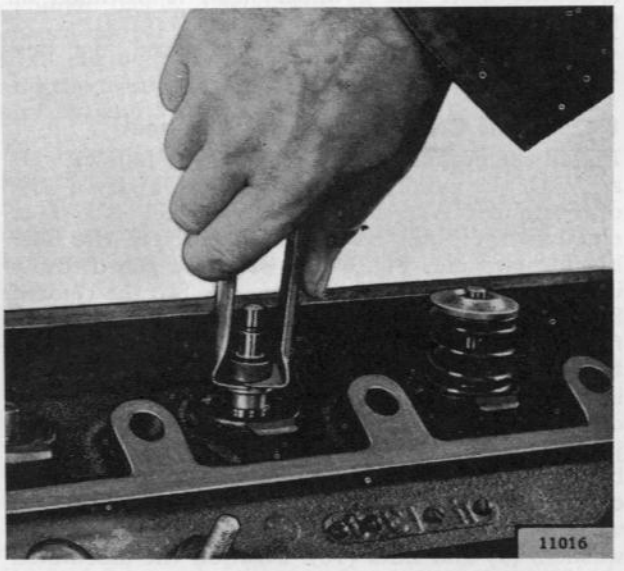

FIG. 125—SEATING SEAL ON VALVE GUIDE WITH INSTALLER TOOL W-273

the valve spring and check that the valve locks seat properly in the groove in the valve stem.

Caution: Take care not to compress the valve springs far enough to damage the valve guide seals during reassembly.

h. Install the remaining 11 valves in the same manner, being sure to install a new valve guide seal on each valve guide.

81. Install Camshaft

Position the cam bearing support deck (14, Fig. 84) on the cylinder head; secure with three nuts (11), lock washers (12), and flat washers (13). Tighten the nuts to specified torque. Lubricate the bearing with engine oil and carefully slide the camshaft into the bearing support deck from the front, being careful not to damage the bearings in the support deck or the journals on the camshaft.

When the camshaft is fully seated, position the retainer (3) on the front of the support deck; secure with two nuts (1) and lock washers (2).

If a shim was installed between the retainer and the support deck before disassembly, this shim must be reinstalled. If the cam bearing support deck is being replaced, the new deck must be inspected to determine if a shim is to be installed at this point. To do this, measure the distance between the centerline of the cam bearing deck front mounting holes and the retainer surface on the deck. If the dimension is .810″ [20,5 mm.], the retainer is to be installed without a shim; .780″ [19,8 mm.], a shim is required.

82. Install Rocker Arms

Position the rocker arm (4, Fig. 84) and the rocker arm ball (5) on the rocker arm stud (40). Install and turn down the rocker arm nut (6) several turns, but do not tighten the nut. Install the remaining 11 rocker arms in the same manner. Straighten each rocker arm on its stud and install the rocker arm guide (7) to hold each in place. Adjust the valve clearance after the cylinder head is installed on the engine.

If the rocker arms are being replaced, use new rocker arms of the latest design.

83. Install Crankshaft and Flywheel

Install the crankshaft and flywheel as follows:

a. With the cylinder block inverted, apply a coat of Permatex Aviation Form-A-Gasket No. 3 or equal to the outer edge and shoulder of the filler block guard (11, Fig. 81). Install the guard firmly in the seat in the cylinder block before the cement hardens. Position the upper rear seal (12) in the filler block guard.

b. Install the upper main bearings (21, 25, and 36) in their seats in the cylinder block. Make sure the oil hole is properly aligned and that the small projection is aligned with its notch. Lubricate the bearings liberally with light engine oil.

c. Install the flywheel (8) on the crankshaft (19) with six flywheel bolts (20), internal tooth lock washers (9) and nuts (10). Position the assembled flywheel and crankshaft on the cylinder block. Lubricate the crankshaft main bearing journals.

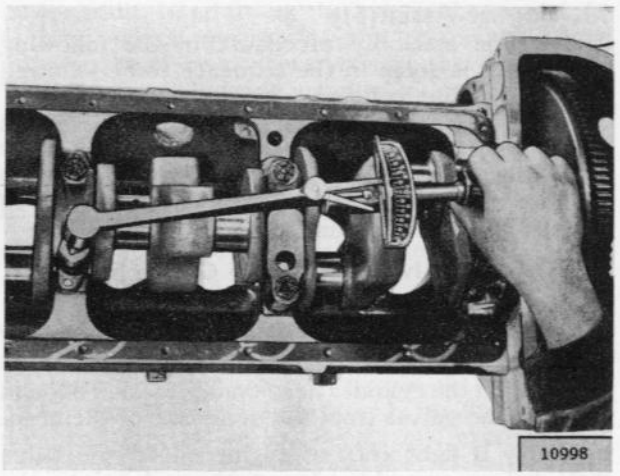

FIG. 126—TIGHTENING MAIN BEARING CAP BOLTS

d. Position the lower main bearings (22, 26, and 34) and bearing caps (24, 28, and 33). Tighten the bolts (32 and 33) on each cap evenly to pull the cap into place without bending the dowels or distorting the bearing caps. Torque the bolts to 85 to 95 lb. ft. [11,8 a 13,1 kg. m] as shown in Fig. 126.

e. Do not install the filler blocks until after the oil pan gaskets are installed on the cylinder block.

f. Rotate the crankshaft. It should spin freely, without binding. If the crankshaft binds, determine and correct the cause of the binding. Refer to Par. 46 or 47 for proper clearance instructions.

84. Install Pistons and Connecting Rods

Before installing each piston and connecting rod assembly in the cylinder block, generously lubricate the entire assembly with clean heavy engine oil. Install each piston and connecting rod assembly in the cylinder to which it was previously fitted. When installing each assembly, rotate the crankshaft so that the crankpin is in the down position. Stagger the ring gaps so that no two gaps are aligned verti-

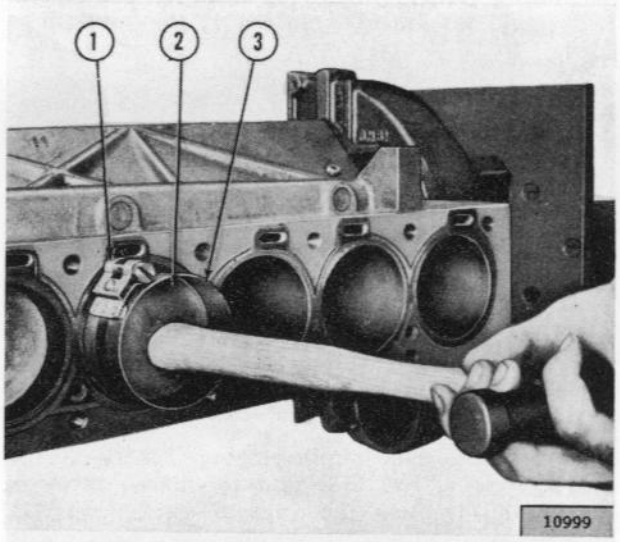

FIG. 127—INSTALLING PISTON AND CONNECTING ROD ASSEMBLY

1—Piston Ring Compressor
2—Piston
3—Hammer Handle

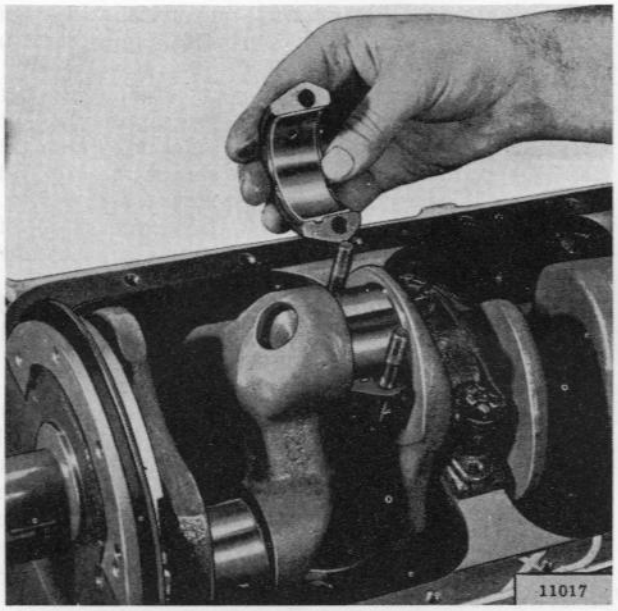

FIG. 128—INSTALLING CONNECTING ROD BEARING CAP

cally. Insert the connecting rod in the cylinder, with the oil spurt hole toward the exhaust side of the cylinder block. Fit a piston ring compressor tightly around the piston. Then, using a hammer handle, gently tap the piston into the cylinder (Fig. 127).

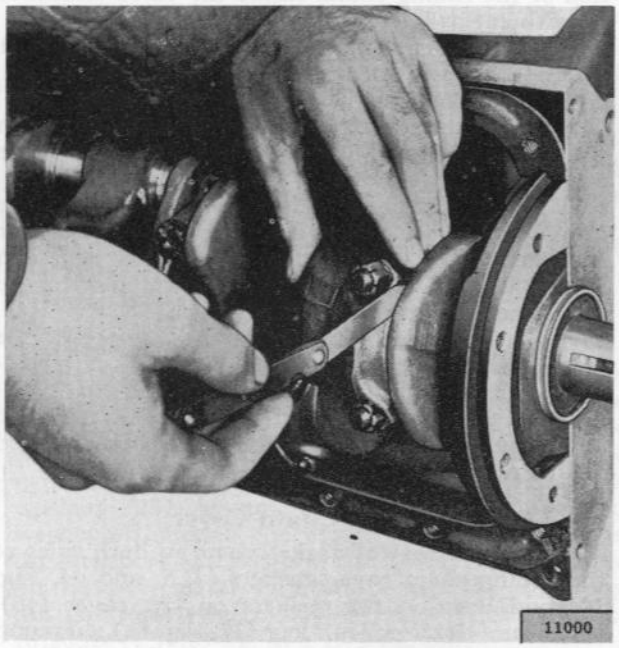

FIG. 129—CHECKING CONNECTING ROD SIDE CLEARANCE

Install the upper crankpin bearing (30, Fig. 81) in the connecting rod (38) and the lower crankpin bearing (30) in the connecting rod bearing cap (31). Lubricate the connecting rod bearing surfaces generously with clean light engine oil and install the bearing cap (Fig. 128). Use new selflocking nuts and tighten to 40-45 lb. ft. torque [5,5 kg. m a 6,2 kg. m]. Refer to Par. 34 and 35 for detailed information in fitting pistons and rings in the cylinder bores. Check the connecting rod side play with a feeler gauge as shown in Fig. 129. Side clearance should be .004″ to .010″ [0,1016 a 0,254 mm.].

85. Install Oil Intake Parts

If the old oil intake pipe (20, Fig. 75) is to be reinstalled, the end that inserts into the port in the cylinder block must be retinned to insure a tight seal. Press the end of the pipe into the port so that the bracket aligns with the main bearing cap bolt (23). Use this bolt to secure the pipe to the cylinder block. Position the oil intake screen (22) on the oil intake pipe; secure with the cotter pin (21).

86. Install Oil Pan

Install the oil pan as follows:

a. Apply a thin coat of non-hardening Permatex over the engine surfaces of the oil pan gaskets (31, Fig. 75); install the gaskets on the cylinder block.

b. Make sure new oil pan seals are installed on the front and rear filler blocks. Install the lower rear seal (13, Fig. 81) in the rear filler block. Position the gasket inserts (14) in the recesses in the filler block. Position the assembled filler block on the cylinder block, making sure the dowels in the filler block squarely engage the holes in the filler block guard. Secure the filler block to the cylinder block with two screws (17). Torque the screws to 12-15 lb. ft. [1,66 a 2,07 kg. m].

c. Position the front filler block (34, Fig. 75) on the crankcase; secure with two bolts.

d. Apply a liberal coating of non-drying Permatex, or equal, to the front and rear filler block seal grooves in the oil pan. Position the oil pan on the cylinder block and install the cap screws (29), flat washers (30), the Sems cap screws (28), and spacers (27). Torque the cap screws to 12 to 15 lbs. ft. [1,66 a 2,07 kg. m].

87. Install Front Engine Plate

Apply a thin coat of gasket paste to both sides of the front end plate gasket (15, Fig. 78). Position the gasket on the front engine plate (11) and position the front engine plate on the front of the cylinder block. The dowels in the cylinder block ensure proper alignment of the plate. Secure the front engine plate to the front of the cylinder block and the front filler block with cap screws (9, 31, 32, and 33) and lock washers (10 and 30).

88. Install Cylinder Head

Install the cylinder head as follows:

a. Make certain that the entire top of the cylinder block assembly and the lower mating surface of the cylinder head are clean. Blow all dirt and carbon from the blind tapped bolt holes in the cylinder block before the cylinder head and gasket are installed.

b. Position the all-metal cylinder head gasket (16, Fig. 75) on the cylinder block so that the coolant ports and vent ports are properly aligned. Use no sealer or other compound on the gasket.

c. Position the cylinder head squarely on the cylinder block, being careful not to damage the gasket. Install the cylinder head bolts. Use a torque wrench to tighten the cylinder head bolts to 75-80 lb. ft. [10,3-11,0 kg. m], following the sequence indicated in Fig. 61.

89. Install Timing Chain Tensioner

Install the timing chain bracket (21, Fig. 78) on the front engine plate (11) with two cap screws (19), flat washers (20) and special seal nuts (18). Position the tensioner blade assembly (8) and spring (6) on the anchor stud on the front engine plate. Bow the blade so that the hook at the upper end of the spring is aligned with the notch in the top of the blade. Insert the chain tensioner pin (7) so that it engages the spring to the blade. Position the top of the tensioner in the bracket on the front engine plate.

90. Install Timing Chain and Sprockets

Install the timing chain and sprockets as follows:

a. Turn over the engine until air starts to blow from the No. 1 spark plug port to indicate that the No. 1 piston is on the compression stroke. Continue to turn over the engine until the keyways in the crankshaft are in the 12 o'clock position to indicate that the No. 1 piston is at top center (Fig. 130.)

b. Temporarily install the camshaft sprocket and turn the camshaft until the nose of the No. 1 cam and the dowel hole on the camshaft are pointing downward to the 6 o'clock position. In this position both valves are closed; this occurs when the associated piston is in the top center position of the compression stroke. Remove the camshaft sprocket.

c. Install the woodruff key in the keyway in the crankshaft nearest the cylinder block. Install the timing chain sprocket removal and installation tool W-286 on the rocker arm cover studs as shown in Fig. 76 .

d. Position the crankshaft timing chain sprocket (34, Fig. 78) and the camshaft timing chain sprocket (37) in opposite ends of the timing chain (43) so that the keyway of the timing chain sprocket is up and the dowel of the camshaft sprocket is down (Fig. 77). Position the parts so that the copper links of the chain are aligned with the timing marks on the sprockets.

e. Lift up the assembled chain and sprockets and slide the timing chain sprocket on the crankshaft so that the sprocket is fully seated.

f. Engage the hook of the camshaft sprocket remover and installer tool in the camshaft sprocket and tighten the nut to tension the chain and pull the mounting hole of the sprocket into alignment with the pilot on the end of the camshaft. Push the sprocket onto the pilot of the camshaft so that the dowel engages the hole in the flange of the camshaft. This may require slight rotation of the crankshaft to secure perfect alignment.

g. Position the fuel pump eccentric (39, Fig. 75) on the camshaft sprocket and install the cap screw (40), lock washer (41), and flat washer (42).

h. Release tension of the special tool and remove the tool from the rocker arm cover studs.

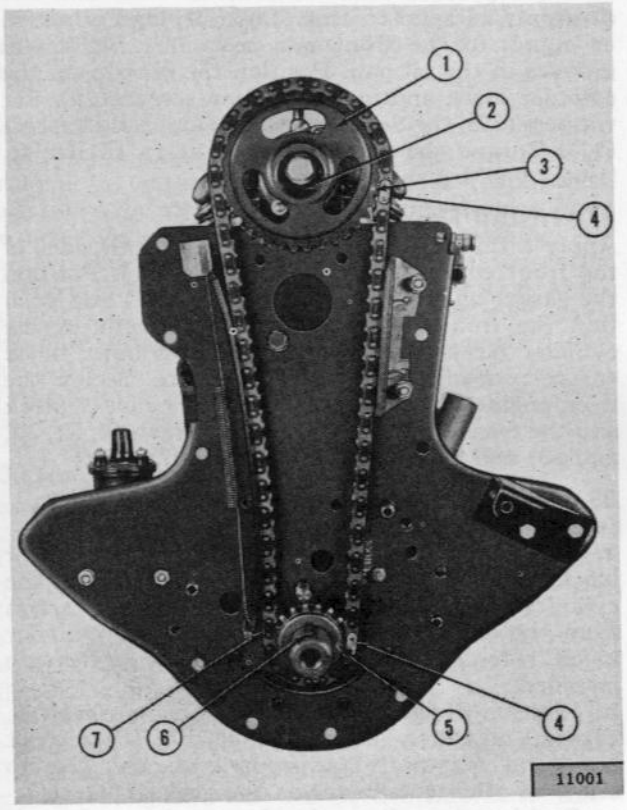

FIG. 130—TIMING CHAIN INSTALLED

1—Camshaft Sprocket
2—Drive Dowel
3—Timing Mark
4—Copper Link
5—Timing Mark
6—Key
7—Timing Chain

91. Valve Clearance Adjustment

Valve clearance adjustment is made after installation of the timing chain. Make the valve clearance adjustment as follows:

a. Rotate the camshaft until the nose of the No. 1 cam points downward to the 6 o'clock position.

b. Turn down the rocker arm nut until a .008" [,2032 mm.] feeler gage can just be inserted between the rocker arm and the top of the valve stem of the exhaust valve as shown in Fig. 63.

c. With the camshaft still in position, move to the intake side of the engine and turn down the rocker arm nut until a .006" [,1524 mm.] feeler gage can just be inserted between the rocker arm and the top of the valve stem of the intake valve.

d. Turn the camshaft over until the nose of the No. 2 cam points downward to the 6 o'clock position. Adjust the valve clearance for the No. 2 cylinder in the manner described above. Continue to adjust until all valve clearances have been adjusted in this manner.

92. Install Timing Chain Cover

Apply a thin coat of gasket paste to both sides of the timing chain cover gaskets (4, 5, and 44, Fig. 78) and position the gaskets on the cover (45). Make sure the Woodruff key (37, Fig. 81), oil pump drive gear (35, Fig. 78), and the oil slinger (36) are both installed on the crankshaft. Assemble the sleeve (42) and O-rings (41 and 43) and install in the oil port in the cylinder block. Lubricate the fuel pump push rod (3) and install it in the timing chain cover. Position the timing chain cover on the front engine plate and secure with the bolts (40, 49, 52, 56, 62, 65, and 67), flat washers (13, 48, 50, 54, 57, 61, 63, and 68), lock washers (17, 25, 39, 51, 55, 58, 64, and 68), and nuts (14, 16, and 24). Be sure to install the lifting eye (12) on the upper right corner

FIG. 131—INSTALLING FRONT CRANKSHAFT OIL SEAL WITH TOOL W-269

of the front engine plate and the generator brace (37) on the upper left of the cover.

93. Install Front Crankshaft Oil Seal

After the timing chain cover is installed, install the front crankshaft oil seal in the timing chain cover. Check the crankshaft to make sure it is free of burrs or sharp projections that could damage the oil seal during installation. Apply a thin coating of sealing compound on the outer edge of the seal and position the seal in the opening so that the seal lip faces toward the inside of the cover. Use the front crankshaft oil seal installing tool W-269 as shown in Fig. 131 to drive the seal in place.

94. Install Exhaust Manifold

Make sure that the mounting surfaces of the cylinder head and exhaust manifold are clean. Position the exhaust manifold gasket (6, Fig. 73) and exhaust manifold (3) on the cylinder head, secure with the two retainers (5), nuts (4), eight lock washers (2) and nuts (1).

95. Install Intake Manifold

Make sure the mounting surfaces of the intake manifold and cylinder head are clean. Position the intake manifold gasket (22, Fig. 73) and the intake manifold (24) on the studs at the intake side of the cylinder head; attach with four nuts (26) and lock washers (25), leaving the lower center nut and washer off. Install the dipstick guide (27) in the dipstick port and position the bracket of the guide on the lower center stud; attach with the remaining nut and lock washer. Torque the nuts to 15 lb. ft. to 20 lb. ft. [2,07 kg. m a 2,77 kg. m].

96. Install Thermostat Housing and Thermostat

Position the thermostat housing gasket (19, Fig. 73) and thermostat housing (21) on the studs at the front of the intake manifold. Install the thermostat (20) and gasket as shown in Fig. 132. The thermostat must be installed before the gasket. Position the water outlet elbow (18) on the thermostat housing and secure with three nuts (15), lock washers (16), and flat washers (17). Connect the hose (36) from the outlet port on the housing to the

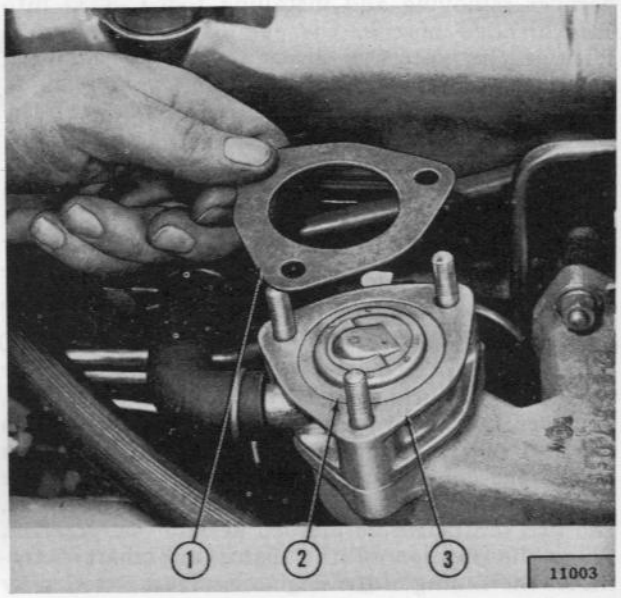

FIG. 132—THERMOSTAT INSTALLATION

1—Gasket
2—Thermostat
3—Thermostat Housing

adapter on the cylinder head with two hose clamps (35).

97. Install Vibration Damper

Install the vibration damper as follows:

a. Install the woodruff key in the keyway on the crankshaft. Make sure the crankshaft, key, and keyway are free of burrs. Align the keyway of the vibration damper with the key and push the vibration damper onto the end of the crankshaft as far as possible.

b. Turn the center post (1, Fig. 133) of vibration

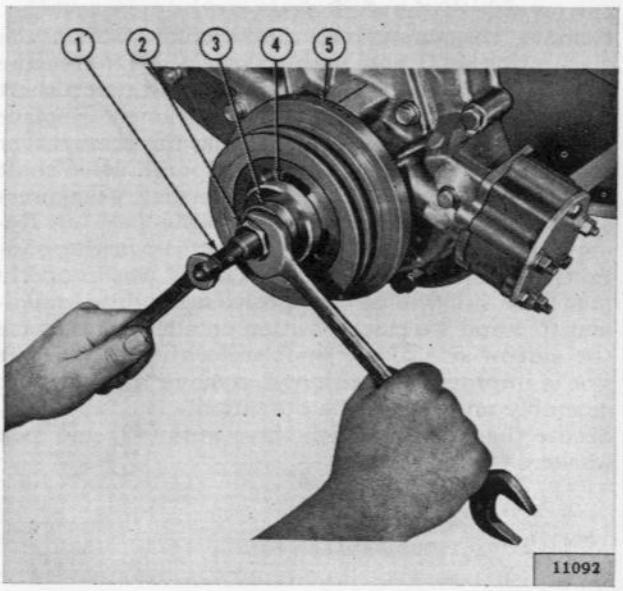

FIG. 133—INSTALLING VIBRATION DAMPER WITH TOOL C-3732-A

1—Center Post
2—Nut
3—Thrust Washer
4—Plate
5—Damper

damper removing and installing tool C-3732 into the threaded bore in the end of the crankshaft. Position the plate (4), thrust washer (3), and nut (2) on the center post.

c. Hold the center post with a wrench and turn the nut into the center post until the vibration damper is fully seated.

d. Back off the nut and turn the center post out of the end of the crankshaft.

e. Install the bolt (45, Fig. 73), and pilot washer (44) to retain the vibration damper. Torque the bolt to 100 lb. ft. to 130 lb. ft. [13,8 a 17,8 kg. m].

98. Install Oil Pump

The oil pump is driven from the crankshaft by means of a helical gear. The distributor, in turn, is driven by the oil pump by means of a tongue on the end of the distributor shaft which engages a slot in the end of the oil pump shaft. Because the tongue and the slot are both machined off center, the two shafts can be meshed in only one position. Since the position of the distributor shaft determines the timing of the engine, and is controlled by the oil pump shaft, the position of the oil pump shaft with respect to the crankshaft is important. Turn the crankshaft until air is blown from the No. 1 spark plug port to indicate that the No. 1 piston is on the compression stroke. Continue to rotate the crankshaft until the pointer on the timing chain cover is aligned with the "O" timing mark on the vibration damper. Install the oil pump mounting gasket (39, Fig. 73) on the oil pump (40) and position the oil pump on the mounting studs on the timing chain cover. Do not install the pump far enough to engage the drive gear with the worm.

Insert a long-blade screwdriver into the distributor shaft opening in the opposite side of the block and engage the slot in the oil pump shaft. Turn the shaft so that the slot is positioned at roughly the 4 and 10 o'clock position on a clock face, with the narrow side of the shaft up.

Remove the screwdriver and, looking down the distributor shaft hole with a flashlight, observe the position of the slot in the end of the oil pump shaft to make certain it is properly positioned. Replace the screwdriver and, while turning the screwdriver counterclockwise to guide the oil pump drive shaft gear into engagement with the camshaft gear, press against the oil pump to force it into position Remove the screwdriver and again observe the position of the slot. If the installation was properly made the slot will be in a position roughly equivalent to 3 and 9 o'clock position on a clock face with the narrow side of the shaft still on the top. If the slot is improperly positioned, remove the oil pump assembly and repeat the operation.

Secure the oil pump with three nuts (42) and lock washers (41).

99. Install Distributor

Make sure that the oil pump shaft has been positioned as described in Par. 98. Rotate the distributor shaft so that the tongue at the end of the shaft will engage the groove in the end of the oil pump shaft. Position the distributor on the timing chain cover so that the tongue engages the groove in the oil pump shaft and install with a nut (64, Fig. 73) and lock washer (65).

100. Install Fuel Pump

Rotate the crankshaft while watching the fuel pump eccentric on the end of the camshaft so that the low part of the eccentric will be adjacent to the fuel pump push rod (3, Fig. 78) in the timing chain cover. Position the fuel pump gasket (59, Fig. 73) on the fuel pump mounting studs, hold the push rod against the eccentric, and position the fuel pump (61) on the studs. The fuel pump spring will offer some resistance to the positioning of the fuel pump. Additional resistance will indicate interference between the fuel pump arm and the push rod. If interference exists, remove the fuel pump and reposition it so that the fuel pump arm is under the end of the push rod. The attaching nuts (66), lock washers (67), and flat washers (68) should be turned down evenly and alternately to prevent cocking of the fuel pump. Be sure to install the cable bracket (69) under the front attaching parts.

101. Install Rocker Arm Cover

Make sure the gasket (8, Fig. 75) is properly mounted on the rocker arm cover (1). Position the four slot washers (7) on the rocker arm studs. Position the rocker arm cover on the cylinder head and secure with four cap nuts (5), and flat washers (6). Install cable brackets (4) between the seal washer and flat washer on the front three studs. Connect the vent hose (9) to the outlet on the oil filler tube and to the vent valve. Install the screen (2) in the filler tube.

102. Install Water Pump and Cooling Fan

Make certain that the water pump mounting surfaces are clean on both the timing chain cover and the water pump. Coat both sides of the water pump gasket (58, Fig. 73) with gasket paste. Position the gasket on the studs on the timing chain cover. Position the water pump on the timing chain cover and secure with seven nuts (54), lock washers (55), and flat washers (56). Torque the nuts to 15 lb. ft. to 20 lb. ft. [2,07 kg. m a 2,77 kg. m].

Position the water pump drive pulley (51), the fan hub (50) and the cooling fan (46) on the hub of the water pump; secure with four bolts (48) and lock washers (47).

SERVICE DIAGNOSIS

Poor Fuel Economy
- Ignition Timing Slow or Spark Advance Stuck
- Carburetor Float High
- Accelerator Pump Not Properly Adjusted
- High Fuel Pump Pressure
- Fuel Leakage
- Leaky Fuel Pump Diaphragm
- Loose Engine Mounting Causing High Fuel Level in Carburetor
- Low Compression
- Valve Sticking
- Spark Plugs Bad
- Spark Plug Cables Bad
- Weak Coil or Condenser
- Improper Valve Clearance
- Carburetor Air Cleaner Dirty
- High Oil Level in Air Cleaner
- Clogged Muffler

Lack of Power
- Low Compression
- Ignition System (Timing Late)
- Improper Functioning Carburetor or Fuel Pump
- Fuel Lines Clogged
- Air Cleaner Restricted
- Engine Temperature High
- Improper Valve Clearance
- Sticking Valves
- Valve Timing Late
- Leaky Gaskets
- Muffler Clogged

Low Compression
- Leaky Valves
- Poor Piston Ring Seal
- Sticking Valves
- Valve Spring Weak or Broken
- Cylinder Scored or Worn
- Valve Clearance Incorrect
- Piston Clearance too Large
- Leaky Cylinder Head Gasket

Burned Valves and Seats
- Sticking Valves or too Loose in Guides
- Improper Timing
- Excessive Carbon Around Valve Head and Seat
- Overheating
- Valve Spring Weak or Broken
- Valve Sticking
- Valve Clearance Incorrect
- Clogged Exhaust System

Valves Sticking
- Warped Valve
- Improper Valve Clearance
- Carbonized or Scored Valve Stems
- Insufficient Clearance Valve Stem to Guide
- Weak or Broken Valve Spring
- Valve Spring Cocked
- Contaminated Oil

Overheating
- Inoperative Cooling System
- Thermostat Inoperative
- Improper Ignition Timing
- Improper Valve Timing
- Excessive Carbon Accumulation
- Fan Belt too Loose
- Clogged Muffler or Bent Exhaust Pipe
- Oil System Failure
- Scored or Leaky Piston Rings

Popping-Spitting-Detonation
- Improper Ignition
- Improper Carburetion
- Excessive Carbon Deposit in Combustion Chambers
- Poor Valve Seating
- Sticking Valves
- Broken Valve Spring
- Valves Adjusted too Close
- Spark Plug Electrodes Burned
- Water or Dirt in Fuel
- Clogged Lines
- Improper Valve Timing

Excessive Oil Consumption
- Piston Rings Stuck in Grooves, Worn or Broken
- Piston Rings Improperly Fitted or Weak
- Piston Ring Oil Return Holes Clogged
- Excessive Clearance, Main and Connecting Rod Bearings
- Oil Leaks at Gaskets or Oil Seals
- Excessive Clearance, Valve Stem to Valve Guide (Intake)
- Cylinder Bores Scored, Out-of-Round or Tapered
- Too Much Clearance, Piston to Cylinder Bore
- Misaligned Connecting Rods
- High Road Speeds or Temperature
- Crankcase Ventilator Not Operating
- Oil Too Thin
- Crankcase Overfilled

Fuel System—4 Cylinder Engines

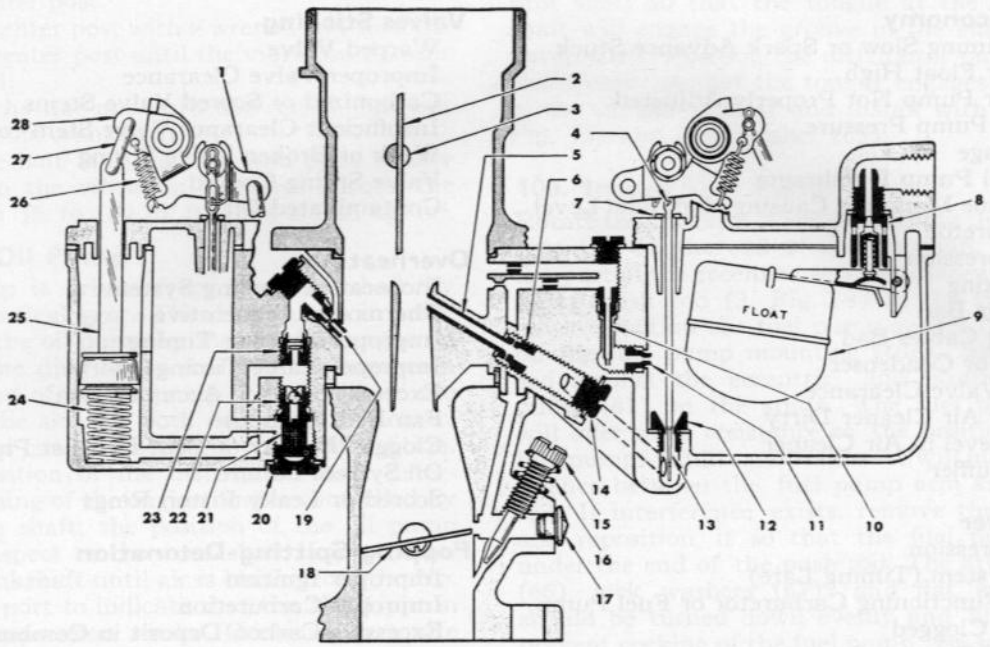

FIG. 134—CARTER CARBURETOR

1. Pump Operating Lever Assembly
2. Choke Valve Assembly
3. Choke Shaft and Lever Assembly
4. Metering Rod Spring
5. Nozzle
6. Nozzle Retaining Plug
7. Metering Rod Disc
8. Needle, Pin, Spring and Seat Assembly
9. Float and Lever Assembly
10. Low Speed Jet Assembly
11. Idle Well Jet
12. Metering Rod Jet and Gasket Assembly
13. Metering Rod
14. Nozzle Passage Plug and Gasket Assembly
15. Idle Adjustment Screw
16. Idle Adjustment Screw Spring
17. Idle Port Rivet Plug
18. Throttle Valve
19. Pump Jet
20. Pump Jet Strainer Nut
21. Pump Jet Strainer
22. Intake Ball Check Assembly
23. Discharge Disc Check Assembly
24. Pump Plunger Spring
25. Pump Plunger and Rod Assembly
26. Pump Arm Spring
27. Pump Connecting Link
28. Pump Arm and Collar Assembly

Carburetor — L Head Engine

The carburetor is of the plain tube type, Fig. 134, with a throttle operated accelerator pump and economizer device. It is a precision instrument designed to deliver the proper fuel and air ratios for all engine speeds. By proper cleaning and replacing all worn parts, the carburetor will function correctly.

The carburetor may be divided into five circuits which are:

1. Float Circuit
2. Low Speed Circuit
3. High Speed Circuit
4. Pump Circuit
5. Choke Circuit

By treating each circuit separately, the diagnosing of trouble and the repair of the carburetor is made much simpler.

Float Circuit or Fuel Level

The float circuit, Fig. 135, is important because it controls the height of the fuel level in the bowl and nozzle. If the fuel level is too high, it will cause trouble in both the low and high speed circuits.

The float bowl, No. 3, acts as a reservoir to hold a constant supply of fuel. The level of the fuel in the bowl is controlled by the float and lever assembly No. 2, float bowl cover No. 4, and the needle valve and seat assembly No. 1.

Low Speed Circuit

The idle or low speed circuit, Fig. 136, controls the supply of fuel to the engine for idle speeds and light load operation up to approximately 1500 rpm. It supplies a small amount of fuel through the entire operating range, gradually decreasing as speed is increased above this speed.

During idle and low speed operation of the engine, fuel flows from the float bowl through the idle well jet No. 7 and the low speed jet No. 8, to the point where it combines with a stream of air entering through by-pass No. 9. The combining of the fuel with the air atomizes or breaks up the fuel into a vapor.

This mixture of air and fuel continues on through the economizer No. 10 until it begins to pass the point where it is further combined with a stream of air coming in through the lower air bleed No. 11. This mixture of fuel and air then flows downward to the idle port chamber and thence into the engine at port No. 12 and also through the idle adjusting screw seat just below. This mixture is richer than the engine requires but when mixed with the air coming past the throttle valve a combustible mixture of the right proportion for idle speeds is formed.

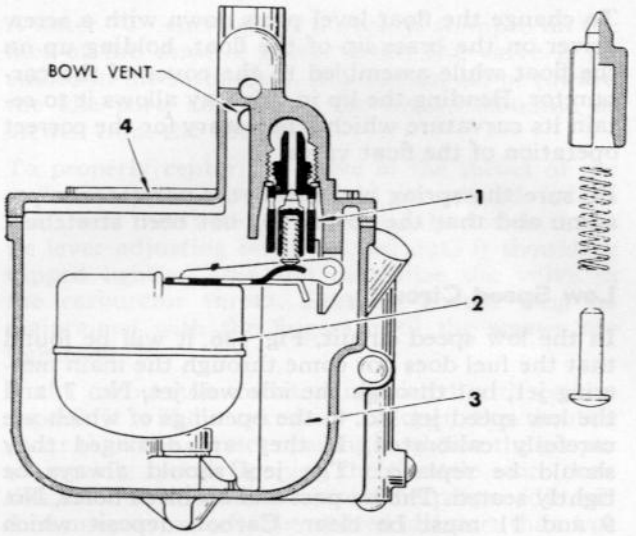

FIG. 135—FLOAT CIRCUIT

The idle port No. 12 is slotted so that, as the throttle valve is opened it will not only allow more air to come in past it, but it will also uncover more of the idle port allowing a greater quantity of fuel and air mixture to enter the intake manifold.

When the idle speed position of the throttle is fixed at 600 rpm., it leaves enough of the slotted port as reserve to cover the range in speed between idle and the time when the high speed system begins to cut in.

The idle adjusting screw No. 13 varies the quantity of the idle mixture.

High Speed Circuit

The high speed circuit, Fig. 137 cuts in as the throttle is opened wide enough for a speed of about 1500 rpm. The velocity of the air flowing down through the carburetor throat creates a pressure slightly less than atmospheric pressure at the tip of the main nozzle, No. 20. Since the fuel in the float bowl is acted upon by atmospheric pressure, the difference in pressure between the two points causes fuel to flow from the bowl through the metering jet and then through the main nozzle into the throat of the carburetor.

At higher speeds the area of the opening between the jet No. 17 and the metering rod No. 16 governs the amount of fuel entering the engine. At wide open throttle only the smallest section of the rod is in the jet.

Acclerating Pump Circuit

As the throttle is opened, the pump plunger and lever are forced downward. This forces fuel from the cylinder, closing intake ball check valve No. 29, Fig. 138, and opening discharge ball check valve No. 30 passing the fuel into the throat of the carburetor through pump jet No. 33.

Pump action is prolonged by the pump arm spring No. 35, because the hole in the pump jet No. 33, restricts the flow of fuel while it is being forced out by the pump. The prolonging of the pump discharge gives the fuel in the high speed circuit sufficient time to flow fast enough to satisfy the demands of the engine.

As the throttle is allowed to return to its original position, the pump plunger is lifted upward. This creates a reduced pressure in the pump cylinder which opens intake ball check valve No. 29 and closes discharge ball check valve No. 30 thereby drawing in a new charge of fuel from the bowl.

Choke Circuit

This circuit Fig. 139 is used only in starting and warming up the engine, by restricting the amount of air allowed to enter the carburetor thereby producing a richer mixture. It consists of a choke shaft and lever assembly No. 39, choke operating lever and spring No. 40, choke valve No. 37, and screws No. 38.

SERVICING AND ADJUSTMENT

Float Circuit

The float circuit is illustrated in Fig. 135.

If the float is loaded with fuel or if the holes for the pins are worn, the carburetor will flood. Poor action of the float needle will occur if the lip of the float bracket is worn. In this event, it should be smoothed with emery cloth.

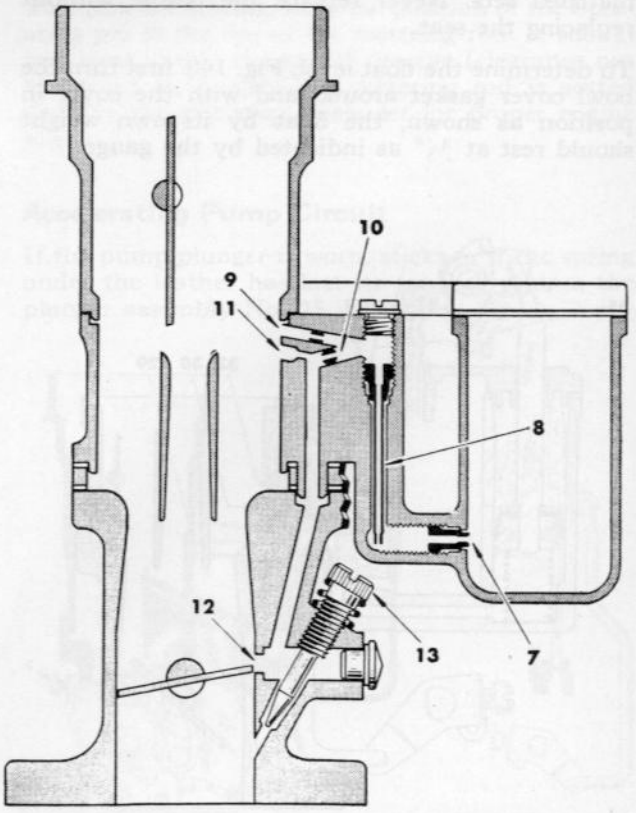

FIG. 136—LOW SPEED CIRCUIT

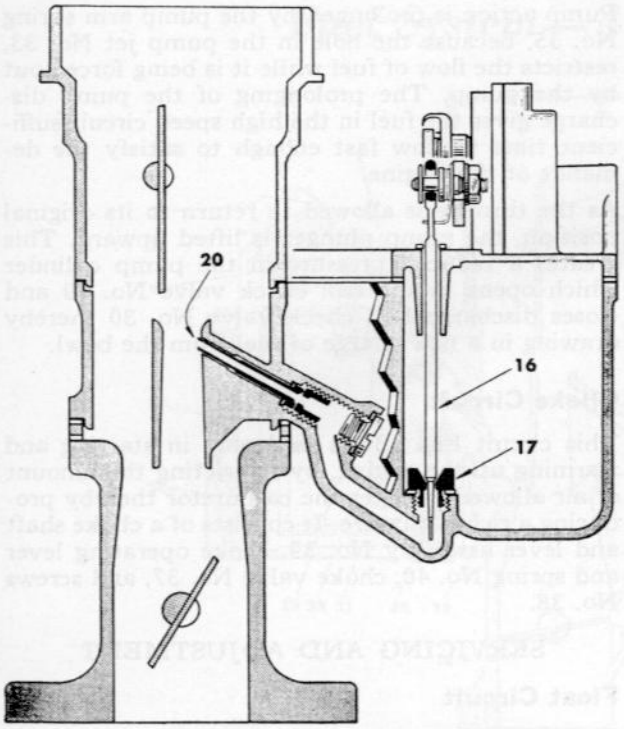

FIG. 137—HIGH SPEED CIRCUIT

The needle and seat may leak because of wear, damage or sticking and will cause the carburetor to flood. Needles and seats are available only in matched sets. Never replace the needle without replacing the seat.

To determine the float level, Fig. 140 first turn the bowl cover gasket around and with the cover in position as shown, the float by its own weight should rest at 3/8" as indicated by the gauge.

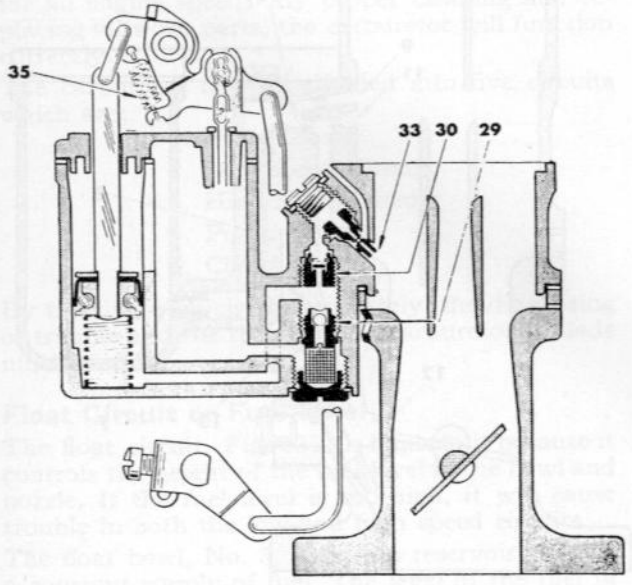

FIG. 138—PUMP CIRCUIT

To change the float level press down with a screw driver on the brass lip of the float, holding up on the float while assembled to the cover of the carburetor. Bending the lip in this way allows it to retain its curvature which is necessary for the correct operation of the float valve.

Be sure the spring and pin in the valve are in position and that the spring has not been stretched.

Low Speed Circuit

In the low speed circuit, Fig. 136, it will be found that the fuel does not come through the main metering jet, but through the idle well jet, No. 7, and the low speed jet No. 8, the openings of which are carefully calibrated. If they are damaged they should be replaced. The jets should always be tightly seated. The by-pass and air bleed holes, No. 9 and 11 must be clear. Carbon deposit which may form in the throat of the carburetor might restrict the air bleed holes to the extent that insufficient air will be supplied to mix the fuel before it reaches the idle port, No. 12.

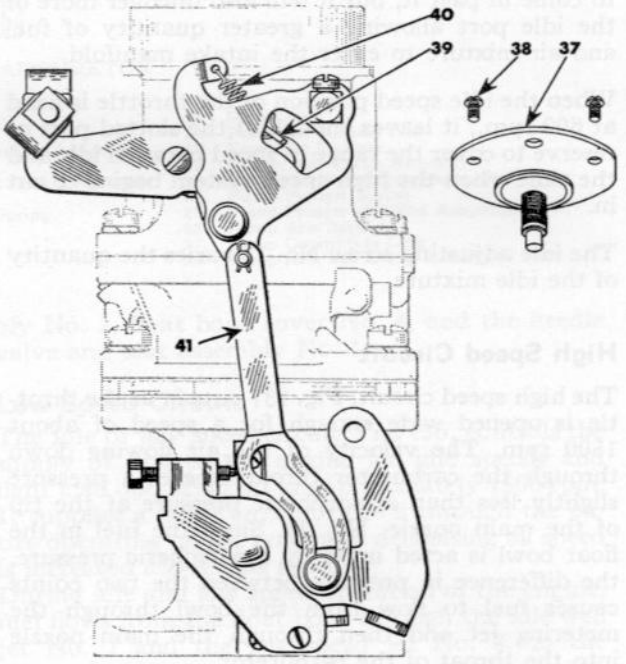

FIG. 139—CHOKE CIRCUIT

This condition will usually be indicated if it is necessary to screw the idle mixture adjusting screw, No. 13, in closer than the minimum limit of 1/2 turn. If the condition is bad, a rolling idle may continue even after the idle mixture adjusting screw is screwed entirely in against the seat. The air bleed holes may be cleaned with a soft copper wire.

The idle port No. 12 must be kept clean and unrestricted. If it is damaged the engine will not perform properly at low speeds and a new body flange will be required.

A letter "C" enclosed by a circle is stamped on the face of the throttle valve. When the valve is installed in the carburetor, this side should be toward the idle port, and facing the intake manifold as viewed from the bottom.

To properly center the valve in the throat of the carburetor, the screws should be started in the shaft, and then with the valve tightly closed (throttle lever adjusting screw backed out) it should be tapped lightly. This will centralize the valve in the carburetor throat. Pressure should then be maintained with the fingers until the screws are tightened.

If the carburetor throat is restricted with carbon deposit it will be necessary to open the throttle wider than the correct opening to obtain the proper engine idle speed. Opening the throttle more than this amount in order to obtain the proper idle will then uncover more of the slotted idle port than was intended. This will result in leaving an insufficient amount of the idle port as a reserve to cover the period between idle and 1500 rpm., where the high speed system begins to cut in. A flat spot on acceleration will result. Clean by scraping with emery cloth.

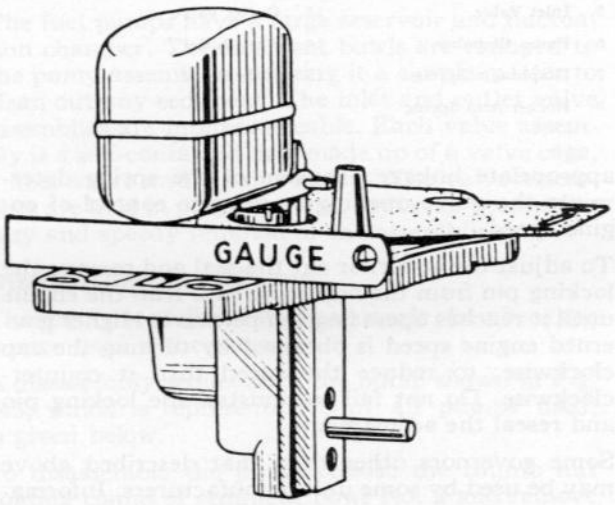

FIG. 140—FLOAT LEVEL SETTING

High Speed Circuit

It is rarely necessary to remove the main nozzle, No. 20, Fig. 137. It can usually be cleaned by removing the plug and blowing it out with compressed air. If it is damaged and requires replacing make sure, upon installation that only one gasket is between the nozzle and the seat.

If the carburetor has been in service for a long time or has been tampered with, it may be found that the metering rod is improperly adjusted or worn. A worn metering rod will have the effect of a rich mixture above 1500 rpm. If the metering rod is worn, the metering rod jet will also be worn and both should be replaced. Before adjusting the metering rod adjust the accelerating pump stroke, for the pump stroke adjustment will change the metering rod setting.

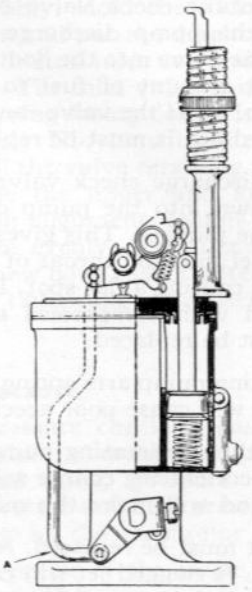

FIG. 141—PUMP TRAVEL GAUGING

To adjust the metering rod, back out throttle lever adjusting screw "C", Fig. 142 and close the throttle tight. Using gauge T-109-26, Fig. 142, (supplied by Carter Carburetor Co.) loosen nut "B" and move pin until it seats in the notch of the gauge. Tighten the nut securely. Remove the gauge and install metering rod with disc, and connect the spring through hole in the metering rod.

To check the setting, note the position of the operating pin in the eye of the metering rod. It should just clear within the top of the eye (clearance not to exceed $\frac{1}{64}$") when the metering rod is seated and the throttle stop screw set for proper engine idle.

Accelerating Pump Circuit

If the pump plunger is worn, sticks or if the spring under the leather has lost its tension, replace the plunger assembly No. 25, Fig. 134.

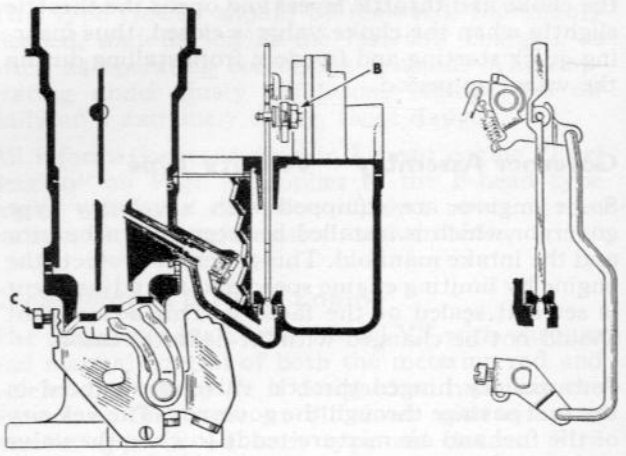

FIG. 142—METERING ROD GAUGING

If the pump intake check valve No. 29, Fig. 138 leaks part of the pump discharge will be forced back through the valve into the float bowl, preventing a sufficient amount of fuel to be discharged from the jet No. 33. If the valve can not be cleaned with compressed air, it must be replaced.

If the pump discharge check valve No. 30 leaks, air will be drawn into the pump cylinder on the up stroke of the plunger. This gives an insufficient discharge of fuel into the throat of the carburetor on acceleration causing a flat spot. If the valve can not be cleaned with compressed air, to prevent leakage, it must be replaced.

If the accelerating pump arm spring No. 35 is weak or damaged, it will cause poor acceleration.

If the hole in the accelerating pump jet No. 33 is too large, the accelerating charge will be allowed to pass too fast and will make the mixture too rich.

An enlarged jet must be replaced. A loose jet gives the same effect. A clogged jet will cause a flat spot on acceleration.

To adjust the pump stroke, pump gauge T-109-117C (supplied by Carter Carburetor Co.) should be used. First back out the throttle adjusting screw "C", Fig. 142 to fully close the throttle. To measure the stroke, place the gauge on top of the bowl cover, Fig. 141, open the throttle wide and measure to the top of the pump plunger rod. Close the throttle tight and measure again. The difference, which is the pump stroke, should be $^{17}/_{64}$". To adjust the stroke bend the throttle connector rod at "A".

IMPORTANT: Always set the pump stroke before setting the metering rod. If set afterwards the metering rod will be thrown out of adjustment.

If the throttle connector rod and throttle shaft arm assembly are worn, it will allow the throttle valve to be opened by the accelerator pedal before the pump jet begins to discharge fuel, resulting in a flat spot. Replace all worn parts because the operation of the metering rod is also affected.

Choke Circuit

The choke connector link No. 41, Fig. 139 connects the choke and throttle levers and opens the throttle slightly when the choke valve is closed, thus insuring quick starting and freedom from stalling during the warm up period.

Governor Assembly — Velocity Type

Some engines are equipped with a velocity type governor which is installed between the carburetor and the intake manifold. This governor protects the engine by limiting engine speed and the adjustment is set and sealed at the factory. This adjustment should not be changed without definite reason.

An auxiliary hinged throttle valve is mounted in the fuel passage through the governor. The velocity of the fuel and air mixture tends to close the valve which is connected to a calibrated spring through appropriate linkage. Tension of the spring determines the valve opening to provide control of engine speed.

To adjust the governor cut the seal and remove the locking pin from the adjusting cap. Run the engine until it reaches operating temperature. Higher governed engine speed is obtained by turning the cap clockwise; to reduce the speed turn it counterclockwise. Do not fail to reinstall the locking pin and reseal the adjustment.

Some governors other than that described above may be used by some unit manufacturers. Information regarding these must be secured directly from such manufacturers.

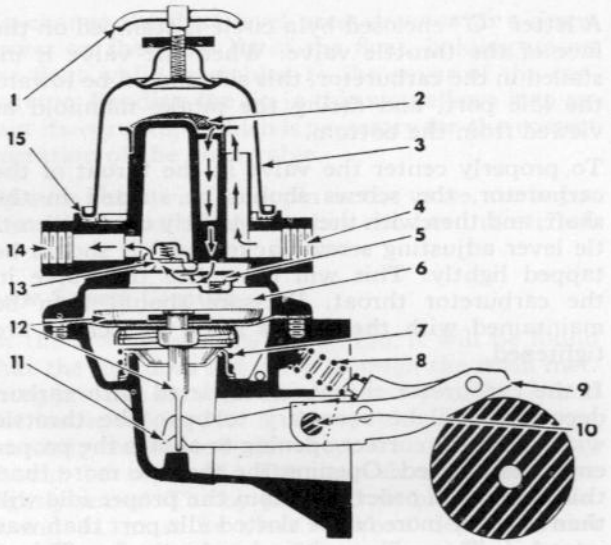

FIG. 143 —FUEL PUMP

1. Strainer Bail and Seat
2. Filtering Screen
3. Bowl
4. Fuel Inlet
5. Inlet Valve
6. Pump Chamber
7. Diaphragm Spring
8. Rocker Arm Spring
9. Rocker Arm
10. Rocker Arm Pin
11. Rocker Arm Link
12. Diaphragm and Pull Rod
13. Outlet Valve
14. Fuel Outlet
15. Body Screw

Governor Assembly — Centrifugal Type

Several different belt driven centrifugal type governors are used. These are all supplied and installed by the unit manufacturers and information concerning them must be secured from the appropriate manufacturer.

Fuel Pump

Industrial engines are equipped with fuel pumps having fuel chambers only.

The principle of operation of all the pumps used is the same and many parts are interchangeable. Differences are external and obvious.

Fig. 143 illustrates the single chamber type fuel pump.

In operation, the rotation of the camshaft eccentric operating arm No. 9, Fig. 143 pivoted at No. 10 pulls the link and diaphragm assembly No. 12 downward about ¼", against spring pressure No. 7 which creates a vacuum in pump chamber No. 6 to provide the suction stroke.

On the suction stroke of the pump, fuel from the tank enters inlet No. 4 into sediment bowl No. 3 and passes through strainer No. 2 and inlet valve No. 5, into pump chamber No. 6. On the return stroke spring pressure No. 7 pushes the diaphragm upward, forcing fuel from chamber No. 6 through outlet valve No. 13 and out through outlet No. 14 to the carburetor.

When the carburetor bowl is full, the float in the carburetor closes the needle valve, thus creating a pressure in pump chamber No. 6. This pressure will hold diaphragm assembly No. 12 down against spring pressure No. 7 where it will remain inoperative until the carburetor requires more fuel and the needle valve opens. Spring No. 8 is merely for the purpose of keeping the rocker arm in constant contact with the eccentric.

The diaphragms are manufactured of several layers of specially treated cloth which is impervious to fuel.

The fuel pumps have a large reservoir and fluctuation chamber. The sediment bowls are clamped to the pump assemblies, making it a simple matter to clean out any sediment. The inlet and outlet valve assemblies are interchangeable. Each valve assembly is a self-contained unit made up of a valve cage, a fiber valve and a valve spring. The valve assemblies are held in place by a valve retainer permitting easy and speedy removal of the assemblies.

Dismantling Fuel Pump

The sequence of dismantling all single chamber type pumps used is the same.

A disassembly sequence of the pump shown in Fig. 143, which is representative of all pumps used, is given below.

To disassemble the pump release the thumb nut holding clamp of sediment bowl No. 3 and remove the bowl. Remove strainer No. 2 from the center tower, remove cork gasket, remove the six screws holding the cover flange to the pump body. Scratch a line across the two castings to assure reassembly in the same position. Lift off the top cover and remove spring No. 8 which holds the rocker arm No. 9 against the camshaft eccentric.

To unhook the diaphragm pull rod No. 12 from the rocker arm link No. 11, press down and away from the rocker arm side of the pump. Remove the oil seal and the washer.

Remove the two screws holding the inlet and outlet valve retainers and remove the retainers.

Wash all parts thoroughly in cleaning solution and examine them for wear or damage.

Assembling Fuel Pump

Install the oil seal (rubber cup) on body followed by the stud washer and spring which fits under the diaphragm assembly. Hold the rocker arm No. 9 down, press down and put the diaphragm assembly No. 12 in place. Install inlet valve assembly No. 5 with new gasket. The inlet valve is installed in the body with the spring facing down. Install the outlet valve assembly No. 13 with the outlet valve spring up. Install the valve retaining plate and two screws. Assemble the upper and lower housings with the marks in alignment. Install the six screws and tighten them evenly. Install cam lever spring No. 8. Install a new bowl gasket, filter screen No. 2 and bowl No. 3 tightening into place with thumb nut.

Fuel Pump Pressure

A fuel pump pressure checking gauge Tool No. C-785, is essential to satisfactorily service fuel pumps. Low fuel pump pressure will seriously affect engine operation and high pressures will often cause fuel leakage by the carburetor inlet valve.

The standard pressure of the single chamber fuel pumps is 4¾ lbs. This pressure is gauged at an elevation of 16" above the pump outlet and at an engine speed of 1800 rpm.

Air Cleaner

Some engines are equipped with a "silencer" dry type air cleaner with a mesh filtering element. These cleaners are clamped directly to the carburetor intake.

Clean and re-oil the filtering element at each 50 hours of engine operation or oftener if the engine is operated under extremely dusty conditions.

To clean the filtering element remove it by loosening the cover wing nut holding it in the assembly. Wash the accumulated dirt from the element by plunging it up and down in the cleaning solution. Dry the unit and re-oil it by dipping in engine oil. Allow the excess oil to drain off before reinstalling on the carburetor.

Some engines are equipped with oil bath type air cleaners. While this type cleaner thoroughly removes all dust from the air before it enters the carburetor it must be serviced at regular intervals for efficient operation.

This type cleaner should be removed, thoroughly cleaned, and the oil in the reservoir changed as often as operating conditions demand. When operating under dusty conditions change the oil daily or if extremely dusty, twice daily.

All information contained in L-head engine "Fuel Section" on Page 83 applies to the F-head type engine with the exception of that covering the carburetor. This information is given below.

Carburetor — F Head Engine

The carburetor is a Carter Model YF with vacuum and manual control of both the metering rod and accelerating pump. It is designed to maintain the correct air-fuel ratio at all times with either a silencer type or oil bath type air cleaner. Five separate circuits are used in the carburetor to con-

trol and vaporize the fuel. A description of the function and operation of each circuit provides an overall description of the carburetor.
Some important changes were made in the carburetor during production. Before disassembling a YF type carburetor refer to heading "Important Carburetor Changes" on Page 96.

Float Circuit

The float circuit Fig. 145 consists of a float, float pin, air horn gasket and the needle and seat assembly. These parts control the fuel level in the carburetor bowl, a supply being maintained for all circuits under all operating conditions.

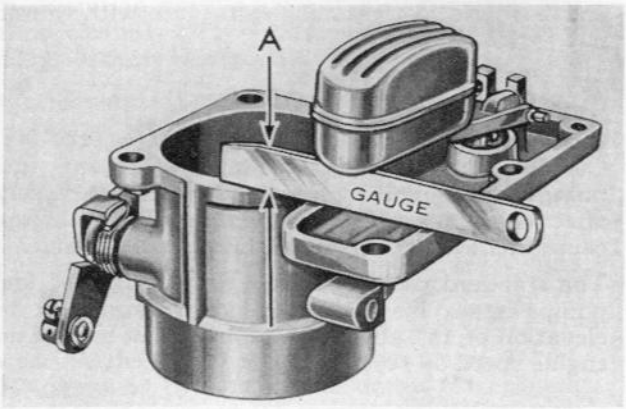

FIG. 144—FLOAT LEVEL GAUGING

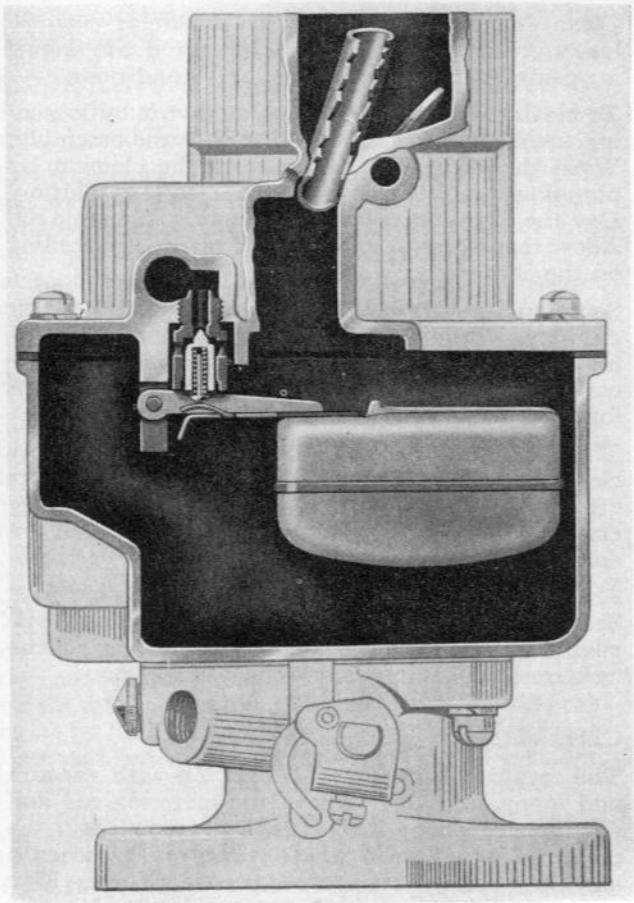

FIG. 145—THE FLOAT CIRCUIT

To prevent float vibration from affecting fuel level the inlet or float valve is spring loaded. Should the needle and seat become worn they must be replaced with a matched set, including the spring, which is the only way they are supplied.
When reinstalling the float be sure to install the float pin with the stop shoulder on the side away from the bore of the carburetor.

Float Adjustment

The float level must be accurately set to insure accurate metering of fuel in both the low and high speed jets. See Fig. 144.
To set the float level remove the bowl cover assembly and invert it as shown in Fig. 144. Remove the bowl cover gasket and allow the weight of the float to rest on the needle and spring. Adjust the level by bending the float arm lip (not the arm) to provide 5/16" clearance between the float and cover as shown by the gauge A, in Fig. 144. Use care that there is no compression of the spring other than that caused by the weight of the float.

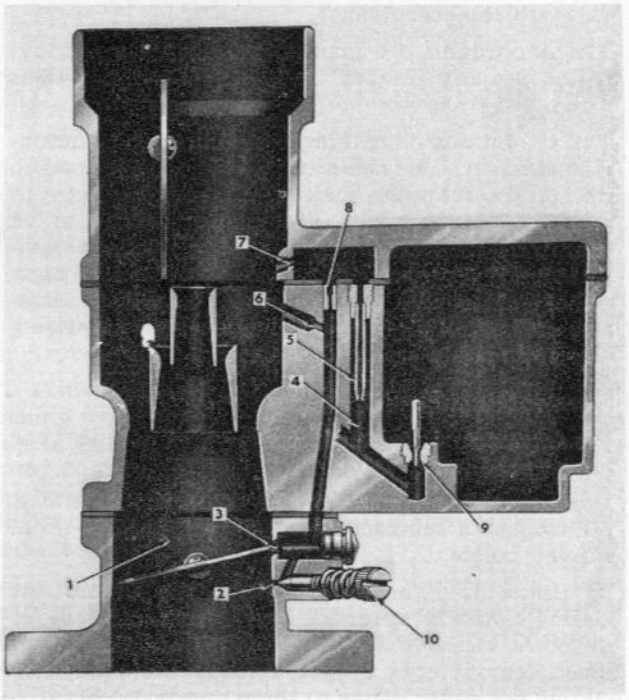

FIG. 146—THE LOW SPEED CIRCUIT

Low Speed Circuit

Fuel for idle and early part throttle operation is metered through the low speed circuit. It is illustrated in Fig. 146.
Liquid fuel enters the idle well No. 4, through the metering rod jet No. 9. Low speed jet No. 5, measures the amount of fuel for idle and early part throttle operation. The air by-pass No. 7, economizer No. 8 and idle air bleed No. 6 are carefully calibrated orifices which serve to break up the liquid fuel and mix it with air as it moves through the passage to the idle port No. 3 and idle adjustment screw port No. 2. Turning the idle adjustment screw No. 10 toward its seat in port No. 2 reduces the quantity of fuel mixture supplied by the idle circuit.

By-pass No. 7, economizer No. 8, idle port No. 3, idle adjustment screw port No. 2 and the bore of the throttle body flange No. 1 must be clean and free of carbon. Obstructions at any of the above points will cause poor low speed engine operation.

Worn or damaged idle adjustment screw No. 10 or low speed jet No. 5 should be replaced.

High Speed Circuit

Fuel for part throttle and full throttle operation is supplied through the high speed circuit, Fig. 147.

The metering rod No. 2 and metering rod jet No. 10 control the amount of fuel admitted through nozzle No. 1 for high speed operation. The lower end of metering rod No. 2 is calibrated in size to accurately meter the fuel required. As the rod is automatically raised and lowered in jet No. 10 the opening in the jet is varied in size to supply fuel proportionate to the requirements through the higher speed and power range. The metering rod is both mechanically and vacuum controlled and is attached to the metering rod arm assembly No. 4.

During part throttle operation, the vacuum in chamber No. 9 pulls the diaphragm assembly No. 8 down holding metering rod arm assembly No. 4 against pump lifter link No. 3. Movement of the metering rod is controlled by pump lifter link No. 3, which is attached to the carburetor throttle shaft. At all times the vacuum in chamber No. 9 is strong enough to overcome the tension of pump diaphragm spring No. 7. Upper pump spring No. 6 serves as a bumper upon deceleration and a delayed action spring on acceleration.

Under any operating condition, when the pump diaphragm spring No. 7 overcomes the vacuum in chamber No. 9, the metering rod No. 2 will move toward the wide open throttle or power position.

Both the nozzle No. 1 and the anti-percolator air bleed are pressed in parts and should not be removed.

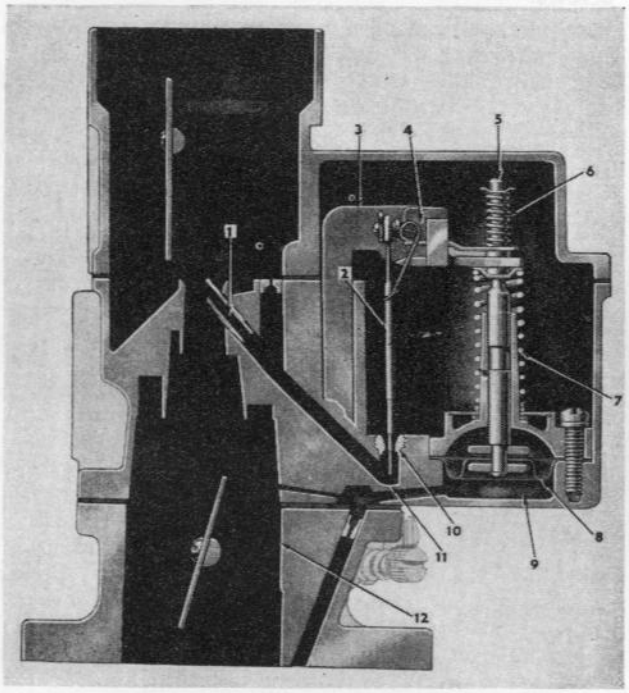

FIG. 147—THE HIGH SPEED CIRCUIT

Metering Rod Adjustment

Metering rod adjustment is important and should be checked each time the carburetor is reassembled. Before adjustment is made be sure that the flat of metering rod arm No. 4 is parallel to the flat of pump lifter link No. 3 as shown in Fig. 147.

With the throttle valve seated in the bore of the carburetor at No. 12, press down on the upper end of diaphragm shaft No. 5 until the diaphragm bottoms in the vacuum chamber. The metering rod should now seat in casting at No. 11 with the metering rod arm flat against the pump lifter link. If the metering rod does not seat in the body casting, or seats before the metering rod arm makes flat contact with the pump lifter link, make adjustment by bending lip on metering rod arm No. 4.

Choke Circuit

It consists of a manually operated choke valve, a fast idle connecting rod and fast idle arm. The choke valve is of the offset spring loaded type to prevent over choking during the starting warm-up period.

When the choke valve is moved to a closed position for starting, Fig. 149, fast idle connector rod A revolves fast idle arm B. This increases the engine idle speed to prevent stalling during the warm-up period. A fast idle connector rod return spring prevents partial closing of the choke valve.

Fast Idle Adjustment

With the choke held in wide open position, lip A, Fig. 149, on fast idle arm should contact the boss on the body casting. Adjust by bending fast idle link at the offset as shown by B.

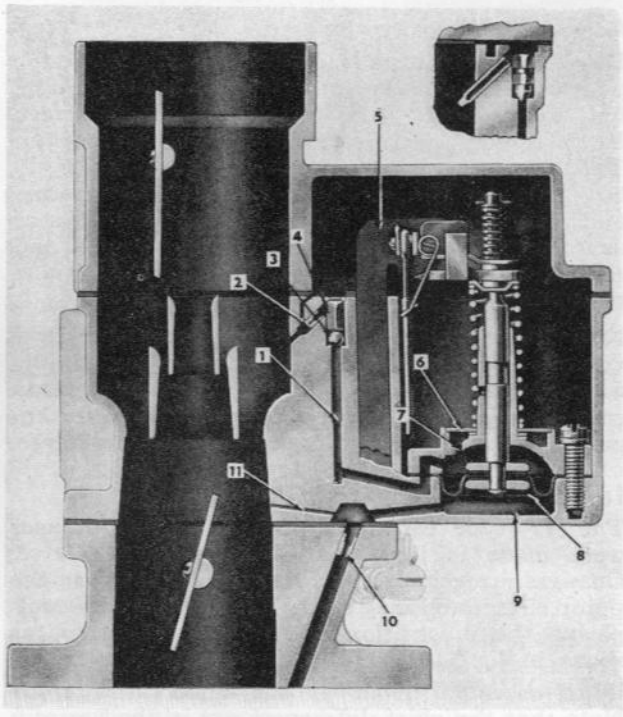

FIG. 148—THE PUMP CIRCUIT

Accelerating Pump Circuit

The accelerator pump circuit, Fig. 148, provides a measured amount of fuel for rapid acceleration and smooth engine operation when the throttle is opened at lower speeds.

In operation vacuum is applied to the underside of diaphragm No. 8 at all times when the engine is running. Lower and more uniform vacuum is provided by vacuum restriction No. 10 and vacuum bleed passage No. 11.

When diaphragm No. 8 is in its maximum down position at low throttle due to high vacuum in chamber No. 9 the chamber above the diaphragm is full of fuel which has been admitted through the screen No. 6 and intake passage No. 7.

When the throttle is opened vacuum drops in chamber No. 9 and diaphragm No. 8 is initially forced upward by the spring on the diaphragm shaft. The upward motion is picked up by accelerator pump lifter No. 5 which is connected to the throttle. This movement forces fuel from the chamber above the diaphragm through discharge pump check valve No. 3 and discharge pump jet No. 2. This auxiliary discharge of fuel supplies engine requirements for quick acceleration and heavy loads. When the throttle is closed the diaphragm is again pulled down by high vacuum and another measured charge of fuel enters the chamber above the diaphragm through intake passage No. 7 to be available for the next cycle of operation.

Pump jet No. 2 is permanently installed and should not be moved.

Pump discharge check No. 3 must seat to prevent air from entering chamber No. 1. Pump discharge retainer No. 4 prevents up-ending of pump discharge check No. 3.

Accelerating Pump Maintenance

If engine acceleration is unsatisfactory, remove the pump diaphragm assembly. Check the diaphragm for wear or damage. Be certain that intake screen No. 6 is not clogged with lint or foreign matter. Then remove pump check retainer ring directly above retainer No. 4 if used, pump check retainer and pump check disk. Pump check disk must seat as a leak will cause poor acceleration. Inspect and replace all worn or damaged parts and clean and blow out all passages with compressed air.

Note that when testing the pump for discharge volume when the carburetor is off the engine only approximately one-half of the maximum pump capacity will be discharged. Vacuum, when the engine is operating, controls the balance of discharge.

Important Carburetor Changes

The YF type carburetor before certain changes were made is illustrated and described above. Changes made in production were primarily in the pump circuit and may readily be identified by comparing the illustration of the original circuit as shown in Fig. 148 with the changed circuit as shown in Fig. 151.

Note that the chief differences are in the use of a ball check valve in place of a disk type at No. 3 in Fig. 148, and the use of twin springs at the top of the pump shaft with the elimination of the large spring on the lower end of the pump shaft.

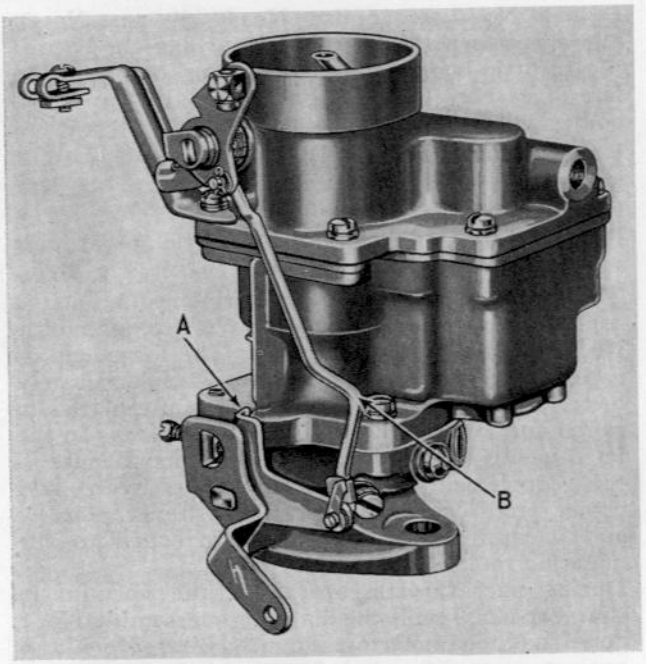

FIG. 149—CARBURETOR FAST IDLE

Basic information given applies to the carburetor either before or after changes have been incorporated.

It is important that these changes be made in all YF type carburetors. Carburetors in which new type parts have **not** been installed may be identified by the fact that a brass identification tag has not been placed under one of the bowl cover retaining screws.

The parts required are inexpensive and are supplied in kit form both by Willys Motors and Carter Carburetor Co. The two kits required are listed below with installation information.

Kit Willys Part No. 119250 (Carter No. 75-807U) consists of the following parts:

No.	W. No.	Carter No.	Part Name
1	804491	11-1616S	Low Speed Jet Assy.
1	119227	61-431	Upper Pump Spring (Outer)
1	119228	61-432	Upper Pump Spring (Inner)
1	119226	75-806	Metering Rod
2	No	Number	Identification Tags

Kit Willys Part No. 119208 (Carter No. 116-27U) consists of the following parts:

No.	W. No.	Carter No.	Part Name
1	119168	116-25	1/8" Aluminum Check Valve
1	119167	221-13	Ball Check Weight
1	119169	63-152	Ball Check Weight Retainer
1	No	Number	1/8" Steel Ball

Both of these kits should be installed at the same time. To make the installation proceed as follows:

Remove the carburetor and clean it thoroughly. Remove the float bowl cover and the accelerating pump assembly. Clean all internal parts, blowing out all jets and passages with compressed air if available.

First install kit 119208. (Carter No. 116-27U.)

Form a new seat as shown in Fig. 150 with stainless steel ball by tapping on the ball. Use 5/32" brass drift No. 1 and a light hammer.

Remove the stainless steel ball and install the 1/8" aluminum ball Willys Part No. 119168 (Carter No. 116-25). Do not tap on the aluminum ball.

Check the ball and seat by pouring a few drops of gasoline in the pump passage on top of the aluminum ball. If a good seat has been formed, liquid gasoline will remain visible in the passage above the aluminum ball for approximately 60 seconds before disappearing.

Install ball check weight, Fig. 151 No. 2, Willys Part No. 119167 (Carter No. 221-13) and retainer. No. 3, Willys Part No. 119169 (Carter No. 63-152).

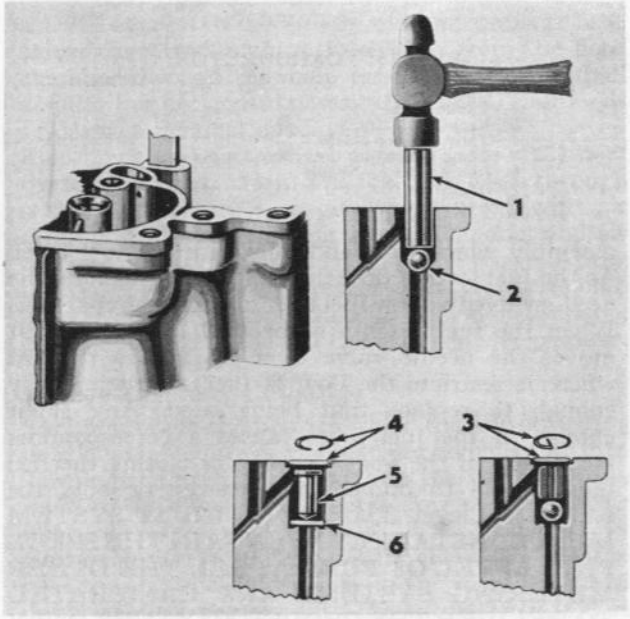

FIG. 150—INSTALLATION OF CHANGE KITS

To install Kit Willys No. 119250 (Carter No. 75-807U):

Be sure that the accelerating pump diaphragm is serviceable and reinstall the pump. When making this installation discard the lower or large pump shaft spring, the spring retaining key and also small spring which is placed over the upper end of the pump shaft. No new lower or large spring is installed. Place upper pump spring inner, Fig. 151 No. 4, Willys Part No. 119228 (Carter Part No. 61-432) as supplied in the kit over the upper end of the pump shaft, followed by pump spring outer. No. 6, Willys Part No. 119227 (Carter Part No. 61-431). Retain both springs in position by lock No. 5 which was used to retain the original single spring. Install new low speed jet assembly, Fig. 158 No. 5, Willys Part No. 804491 (Carter No. 11-1616S), and new metering rod, Willys Part No. 119226 (Carter No. 75-806).

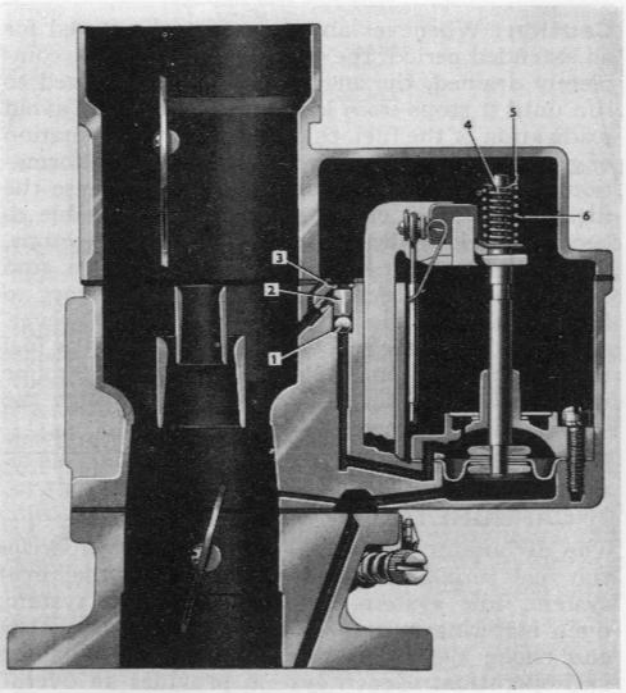

FIG. 151—CARBURETOR WITH KITS INSTALLED

Before reinstalling the float bowl cover, check the float level setting as instructed on Page 94.

When installing the float bowl cover it is best to install a new gasket. Also place one of the identification tags under a cover mounting screw to indicate that the kits have been installed.

Adjust the metering rod as instructed on Page 95.

Fuel System—6 Cylinder OHC Engine

Contents

1. GENERAL

The fuel system consists of the fuel tank, fuel lines, fuel pump, carburetor and air cleaner.

The most important attention necessary to the fuel system is to keep it clean and free from water.

It should be periodically inspected for leaks.

Caution: Whenever an engine is to be stored for an extended period, the fuel system should be completely drained, the engine started and allowed to run until it stops from lack of fuel. This will avoid oxidization of the fuel, that results in the formation of gum in the units of the fuel system. Gum formation is similar to hard varnish and may cause the fuel pump valves or the carburetor float valve to become stuck or the filter screen blocked. Acetone, obtainable in most drug stores, will dissolve gum formation. In extreme cases it will be necessary to disassemble and clean the fuel system; however, often one pint [,6 liter] of acetone placed in the fuel tank with about one gallon [4,5 liters] of gasoline will dissolve any deposits as it passes through the system with the gasoline.

2. CARBURETOR

The carburetor (Fig. 152) controls and vaporizes the fuel through six separate systems: fuel inlet system, idle system, accelerating pump system, main metering system, power enrichment system, and choke system. A description of the function and operation of each system provides an overall description of the carburetor.

For identification, the name "Holley" is cast in the fuel bowl and the part number is stamped on the main body.

3. Fuel Inlet System

The fuel enters the fuel bowl through a filter screen (Fig. 153) and into the fuel valve and seat assembly. The amount of fuel entering the fuel bowl is determined by the space between the top of the movable needle and its seat and also by the pressure from the fuel pump. Movement of the needle in relation to the seat is controlled by the float and lever assembly which rises and falls with the fuel level. As the fuel level drops, the float drops, opening the needle valve to allow fuel to enter the float chamber. When the fuel reaches a specified level, the float moves the needle valve to a position in its seat where it restricts the flow of fuel, admitting only enough to replace that being used. Any slight change in the fuel level causes a corresponding movement of the float, opening or closing the fuel inlet needle to immediately restore or hold the correct fuel level. THIS FUEL INLET SYSTEM MUST CONSTANTLY MAINTAIN THE SPECIFIED LEVEL OF FUEL AS ALL THE OTHER METERING SYSTEMS ARE CALIBRATED TO DELIVER THE PROPER MIXTURE ONLY WHEN THE FUEL IS AT THIS LEVEL.

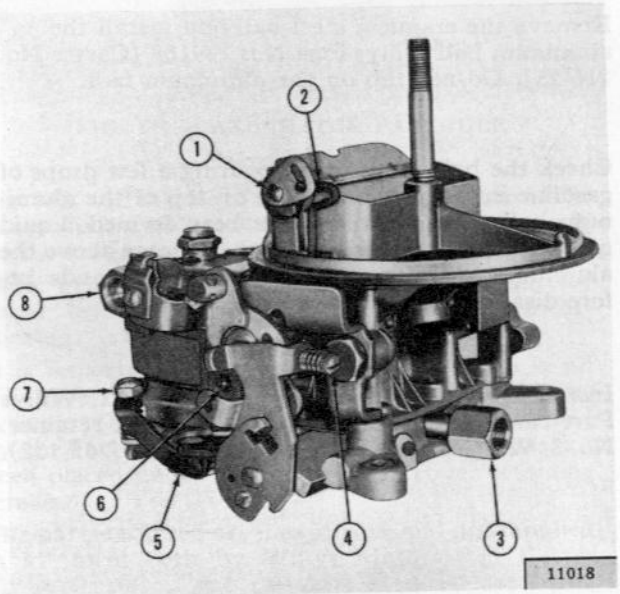

FIG. 152—CARBURETOR

1—Choke Shaft
2—Choke Rod
3—Vacuum Fitting
4—Throttle Stop Screw
5—Pump Operating Lever and Pin Assembly
6—Idle Adjusting Needle
7—Adjusting Nut
8—Fuel Inlet Fitting

A float spring is incorporated under the float to assist in keeping the float in a stable position. The float chamber is vented internally by the vent tube at all times.

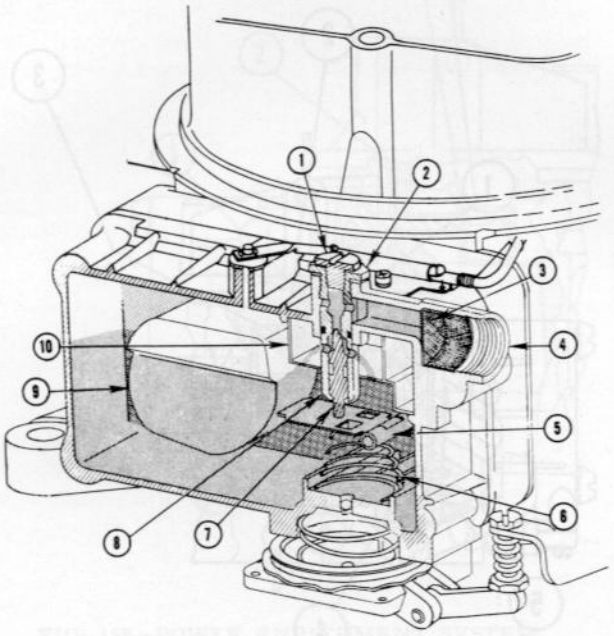

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FIG. 153—FUEL INLET SYSTEM

1—Lock Screw
2—Adjusting Nut
3—Filter Screen
4—Fuel Inlet
5—Float Lever Shaft
6—Float Lever Spring
7—Valve Pin
8—Fuel Inlet Valve
9—Float
10—Baffle

4. Idle System

These carburetors utilize two identical idle systems (Fig. 154), one for each primary barrel. Since the two passages function identically, only one side will be considered. At idle, the normal air pressure in the float chamber causes the fuel to flow through the idle system to the greatly reduced pressure area below the throttle plate. Fuel flows from the float chamber through the main jet, then into the small angular but horizontal passage (idle feed) that leads across to a vertical passage.

Fuel flows up this vertical passage (idle well) past the idle feed restriction. The fuel then flows through a short horizontal passage and is mixed with air coming in from the idle air bleed. This fuel and air mixture flows down another vertical passage. At the bottom of this passage, the fuel-air mixture branches in two directions, one through the idle discharge passage and the other to the idle transfer passage.

a. Idle Discharge Passage

Fuel flows past the pointed tip of the idle adjusting needle which controls the mixture delivered at idle. Turning the needle out increases the volume of the mixture by allowing a greater flow of the fuel-air mixture.

From the idle adjusting needle chamber, the fuel goes through a short passage in the main body and down another passage into the throttle body. The fuel is discharged into the throttle bore below the throttle plate.

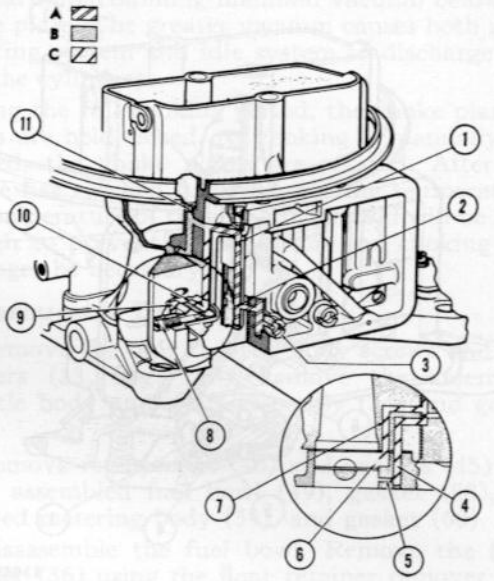

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FIG. 154—IDLE SYSTEM

A—Fuel
B—Air
C—Fuel-Air Mixture
1—Idle Feed Restriction
2—Idle Well
3—Main Jet
4—Idle Discharge Passage
5—Idle Discharge Hole
6—Idle Transfer Slot
7—Idle Transfer Passage
8—Idle Adjusting Needle
9—Idle Discharge Passage
10—Idle Transfer Passage
11—Idle Air Bleed Restriction

b. Idle Transfer Passage

During off-idle operation when the throttle plate is moved slightly, the fuel flows from the metering body into the main body passage and then into the throttle body passage. As the idle transfer slot is exposed to manifold vacuum, fuel is discharged into the throttle bore.

As the throttle plate is opened wider and engine speed increases, the air flow through the carburetor is also increased. This creates an increased vacuum in the venturi to bring the main metering system into operation. The flow from the idle system tapers off as the main metering system begins discharging fuel. The two systems are engineered to provide smooth gradual transition from idle to cruising speeds.

5. Accelerating Pump System

The accelerating pump, Fig. 155, is located in the bottom of the fuel bowl. The pump begins to function when the pump operating lever is actuated by throttle movement. When the throttle is opened, the pump linkage, actuated by a cam on the throttle shaft, forces the pump diaphragm up. As the diaphragm moves up, the pressure forces the pump inlet check ball on its seat, preventing fuel from flowing back into the float chamber. The fuel flows from the short passage in the fuel bowl into the long diagonal passage in the metering body. The fuel passes into the main body and then in the pump discharge chamber. The pressure of the fuel causes the discharge check valve to raise and allows the

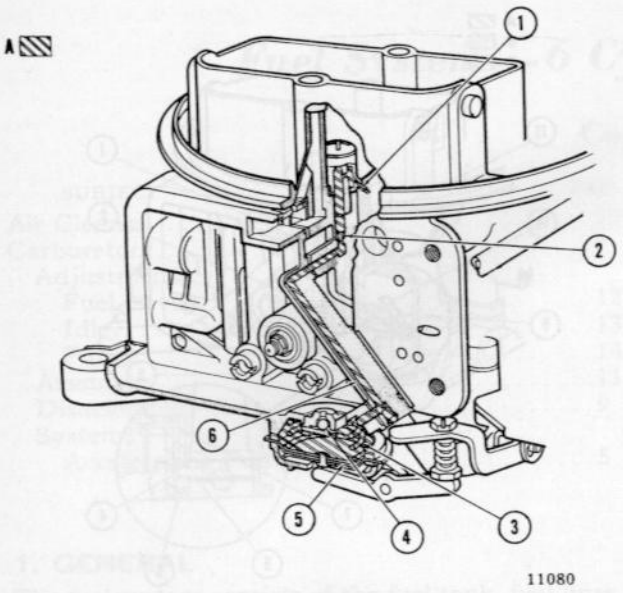

FIG. 155—ACCELERATING PUMP SYSTEM

A—Fuel
1—Discharge Nozzle
2—Pump Discharge Check Valve
3—Diaphragm Return Spring
4—Pump Inlet Check Ball
5—Diaphragm
6—Discharge Passage

fuel to travel into the pump discharge nozzle which directs the fuel down into the venturi. As the throttle is moved toward the closed position, the linkage returns to its original position and the diaphragm spring forces the diaphragm down. As the diaphragm returns to its original position, the pump inlet check ball is moved off its seat and the diaphragm chamber is filled with fuel from the float bowl.

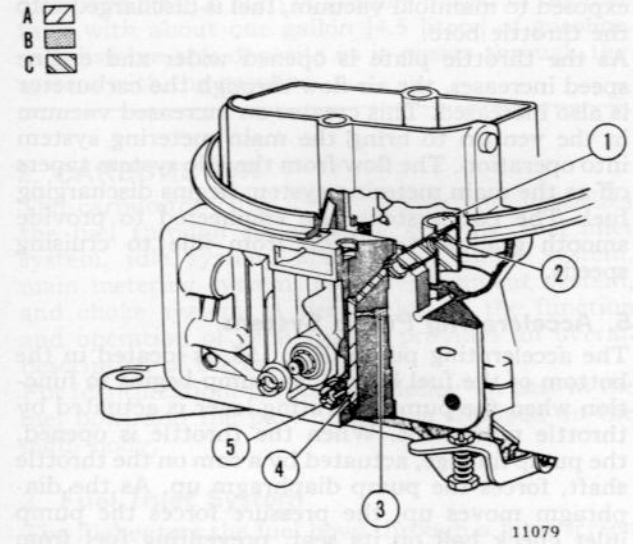

FIG. 156—MAIN METERING SYSTEM—VIEW I

A—Fuel
B—Air
C—Fuel-Air Mixture
1—Booster Venturi
2—Discharge Nozzle
3—Main Well Air Bleed
4—Main Well
5—Main Jet

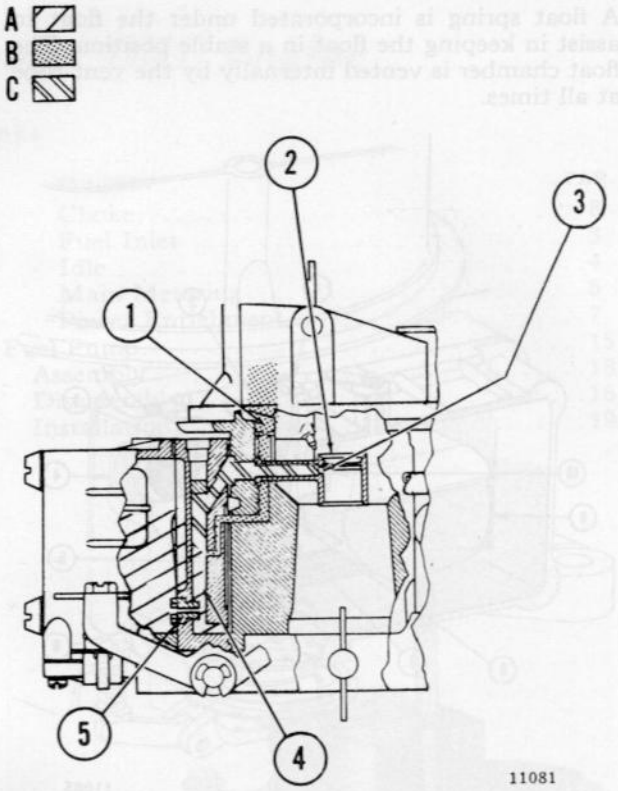

FIG. 157—MAIN METERING SYSTEM—VIEW II

A—Fuel
B—Air
C—Fuel-Air Mixture
1—High Speed Air Bleed
2—Booster Venturi
3—Discharge Nozzle
4—Main Well
5—Main Jet

6. Main Metering System

At normal engine operating speed, the fuel flows from the float chamber through the main jet, Fig. 156, which measures or meters the fuel flow into the bottom of the main well. The fuel moves up the main well past the main well air bleed hole in the side of the well. The mixture of fuel and air moves up the main well and passes into the short horizontal passage leading to the main body, then through the horizontal channel of the discharge nozzle. This fuel is discharged into the booster venturi, and then in the air stream of the carburetor venturi. Filtered air enters through the main metering body by inter-connecting passages. This mixture of fuel and air, being lighter than raw fuel, responds faster to any change in venturi vacuum and vaporizes more readily when discharged into the air stream of the venturi. The throttle plate controls the amount of fuel-air mixture admitted to the intake manifold, regulating the speed and power output of the engine in accordance with throttle position.

7. Power Enrichment System

A vacuum passage in the throttle body transmits manifold vacuum to the power valve chamber in the main body. The power valve, Fig. 158, which is located in the main metering body, is affected by this manifold vacuum. The manifold vacuum, act-

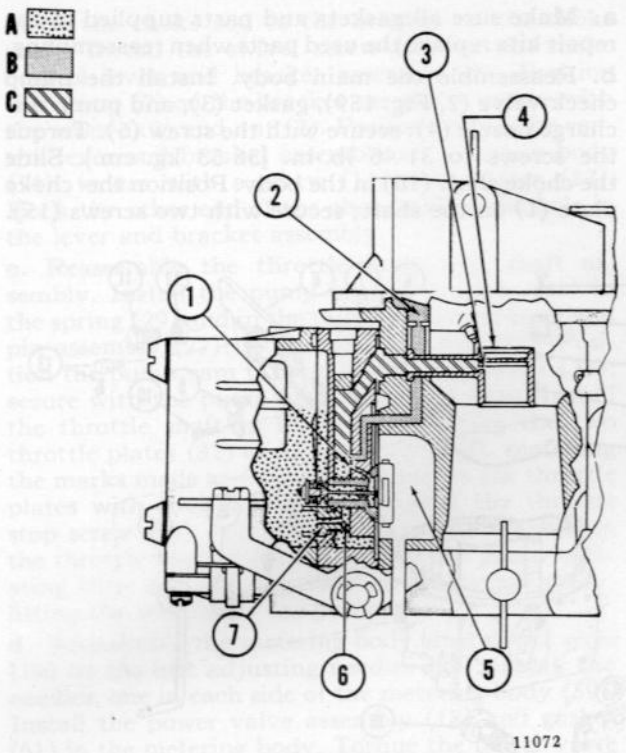

FIG. 158—POWER ENRICHMENT SYSTEM

A—Fuel
B—Air
C—Fuel-Air Mixture
1—Power Valve Restriction
2—High Speed Air Bleed
3—Discharge Nozzle
4—Booster Venturi
5—Manifold Vacuum
6—Main Well
7—Main Jet

ing on the diaphragm at idle or normal load conditions, is strong enough to hold the diaphragm closed, and overcome the tension of the power valve spring. When high power demands place a greater load on the engine and manifold vacuum drops below a predetermined point, the power valve spring overcomes the reduced vacuum, opening the power valve. Fuel flows from the float chamber, through the valve, and out the small holes in the side of the valve through the diagonal restrictions in the main metering body, and then into the main well. In the main well, the fuel joins the fuel flow in the main metering system, enriching the mixture. As engine power demands are reduced, manifold vacuum increases. The increased vacuum acts on the diaphragm, overcoming the tension of the power valve spring. This closes the power valve and shuts off the added supply of fuel which is no longer required.

8. Choke System

The choke system permits a richer fuel-air mixture which is required for starting and operating a cold engine. Most of the vaporized fuel condenses to a liquid on contact with the cold surfaces of the intake manifold. In this liquid form, it burns too slowly and incompletely in the cylinders and will cause stalling and loss of power. The choke plate, which is operated manually, may be closed during the cranking period and partially opened during the warmup, confining manifold vacuum below the choke plate. The greater vacuum causes both main metering system and idle system to discharge fuel into the cylinders.

During the full choking period, the choke plate or plates are held closed. As choking is manually decreased, the choke plates are rotated. After the engine has reached normal operating temperature, the temperature of the intake manifold will be high enough to prevent condensation and choking will no longer be necessary.

9. Carburetor Disassembly

a. Remove the four throttle body screws and lock washers (33, Fig. 159); remove the assembled throttle body and shaft assembly (34) and gasket (21).

b. Remove four screws (46) and gaskets (45); remove assembled fuel bowl (49), gasket (58), assembled metering body (59), and gasket (60).

c. Disassemble the fuel bowl. Remove the float retainer (36) using the float retainer remover tool W-277. Remove the float and hinge assembly (51) and spring (37). Remove the baffle plate (50). Remove the fuel inlet fitting (40), gasket (39), and filter screen (38). Remove the fuel level check plug (48) and gasket (47). Remove the fuel valve seat lock screw (57), gasket (56), adjusting nut (55), gasket (54), fuel inlet valve and seat assembly (53), and seal (52). Remove the four screws (41); remove the fuel pump cover assembly (42), diaphragm assembly (43), and diaphragm return spring (44) from the fuel bowl.

d. Disassemble the metering body. Remove the two main jets (35), using main jet remover and installer tool C-3748. Remove the power valve assembly (18) and power valve body gasket (61), using power valve remover tool W-276. Remove the two idle adjusting needles (20) and seals (19).

e. Disassemble the throttle body and shaft assembly. Lightly scribe both throttle plates as an aid in reassembly. Remove the four throttle plate screws (22); remove the two throttle plates (32). Slide the throttle shaft (23) out of the body; remove the throttle stop screw (25) and spring (24). Remove the pump cam lock screw (26); remove the pump cam (31). Slide off the pump operating lever and pin assembly (27); remove the adjusting nut (30), pump operating screw (28), and spring (29).

f. Disassemble the main body. Remove the screw (11) and washer (12); remove the choke control lever and bracket assembly (8) and choke rod seal (6). Remove the choke control clamp screw (10) and nut (7); remove the clamp (9). Remove the swivel screw (13). Remove the two screws (15); remove the choke plate (1). Slide the choke shaft (16) from the main body; unhook the choke rod. Remove the screw (5), pump discharge nozzle (4), gasket (3), and pump check valve (2).

10. Carburetor Cleaning

Clean all parts except the diaphragm, seals, or leather parts in a cleaning solution. Compressed air should be directed through all passages. Replace all worn or damaged parts.

11. Carburetor Assembly

Caution: The principal screws of the carburetor must be properly torqued with a torque wrench at assembly. Otherwise leaks may occur or the carburetor will not function properly. Proper torque values are given in the following paragraphs. Note that torque values are given in pounds-inches.

a. Make sure all gaskets and parts supplied in the repair kits replace the used parts when reassembling.

b. Reassemble the main body. Install the pump check valve (2, Fig. 159), gasket (3), and pump discharge nozzle (4); secure with the screw (5). Torque the screws to 31-46 lb.-in. [36-53 kg.-cm.]. Slide the choke shaft (16) in the body. Position the choke plate (1) on the shaft; secure with two screws (15).

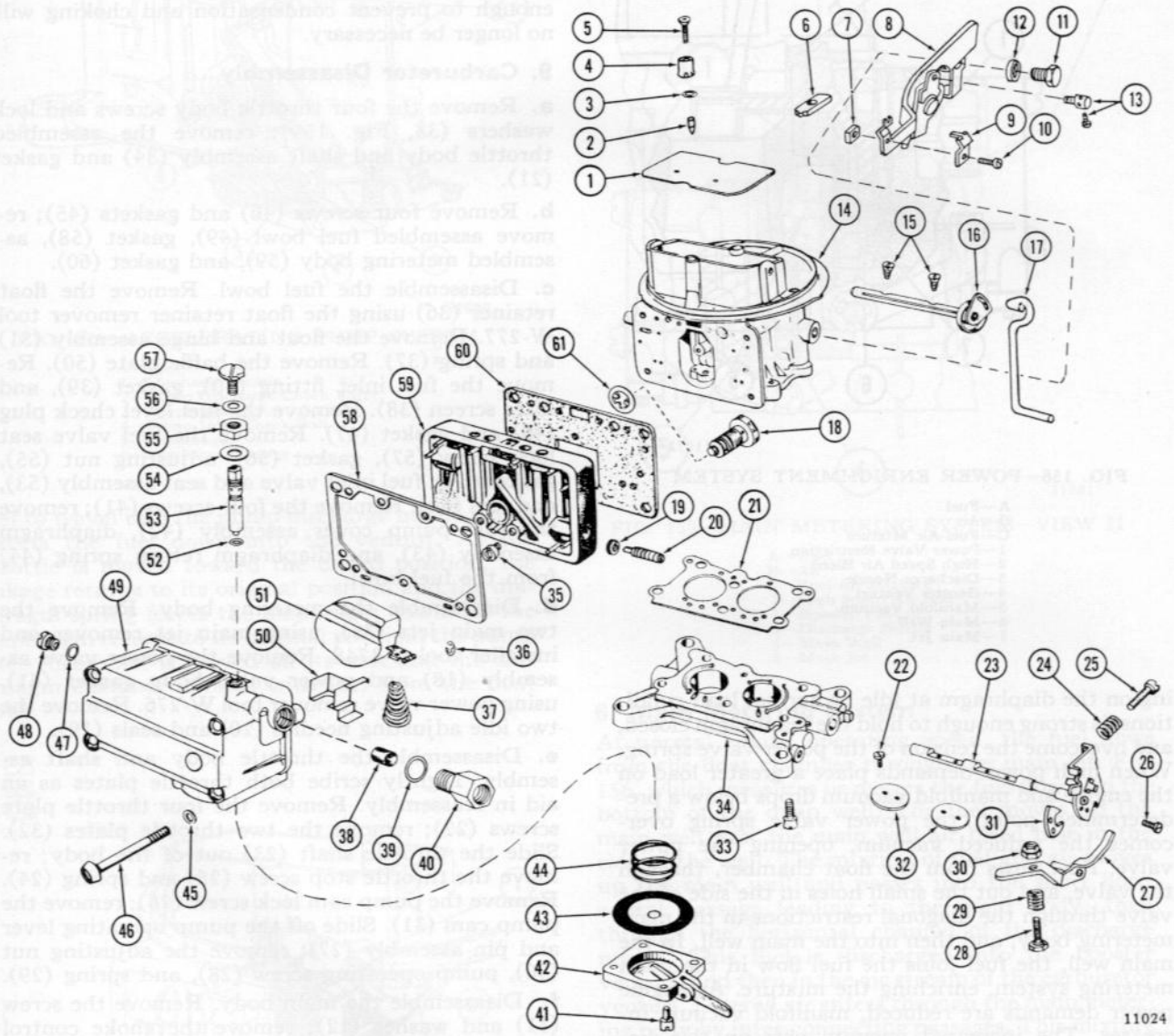

FIG. 159—TYPICAL CARBURETOR, EXPLODED VIEW

1—Choke Plate
2—Pump Check Valve
3—Pump Discharge Nozzle Gasket
4—Pump Discharge Nozzle
5—Pump Discharge Nozzle Screw
6—Choke Rod Seal
7—Choke Wire Clamp Screw Nut
8—Choke Control Lever and Bracket
9—Choke Wire Clamp
10—Choke Wire Clamp Screw
11—Choke Wire Bracket Retainer
12—Choke Wire Bracket Retainer Lock Washer
13—Choke Lever Swivel Screw
14—Main Body
15—Choke Plate Screw
16—Choke Shaft
17—Choke Rod
18—Power Valve Assembly
19—Idle Adjusting Needle Seal
20—Idle Adjusting Needle
21—Throttle Body Gasket
22—Throttle Plate Screw
23—Throttle Lever and Shaft Assembly
24—Throttle Stop Screw Spring
25—Throttle Stop Screw
26—Pump Cam Lock Screw
27—Pump Operating Lever
28—Pump Operating Adjusting Screw
29—Pump Operating Adjusting Screw Spring
30—Adjusting Nut
31—Pump Cam
32—Throttle Plate
33—Throttle Body Screw and Lock Washer
34—Throttle Body
35—Main Jet
36—Float Retainer
37—Float Spring
38—Filter Screen
39—Fuel Inlet Fitting Gasket
40—Fuel Inlet Fitting
41—Fuel Pump Cover Screw
42—Fuel Pump Cover
43—Diaphragm
44—Diaphragm Return Spring
45—Fuel Bowl Screw Gasket
46—Fuel Bowl to Main Body Screw
47—Fuel Level Check Plug Gasket
48—Fuel Level Check Plug
49—Fuel Bowl
50—Baffle Plate
51—Float
52—Fuel Valve Seat "O" Ring
53—Fuel Valve and Seat
54—Fuel Valve Seat Adjusting Nut Gasket
55—Fuel Valve Seat Adjusting Nut
56—Fuel Valve Seat Lock Screw Gasket
57—Fuel Valve Seat Lock Screw
58—Fuel Bowl Gasket
59—Metering Body
60—Metering Body Gasket
61—Power Valve Gasket

Hook the choke rod to the bracket on the choke shaft. Install the swivel screw (13) on the choke control lever and bracket assembly (8). Position the clamp (9) on the bracket assembly; secure with the screw (10) and nut (7). Position the choke control lever and bracket assembly on the main body (14); secure with a screw (11) and washer (12). Hook the other end of the choke rod in the hole in the lever and bracket assembly.

c. Reassemble the throttle body and shaft assembly. Install the pump operating screw (28) in the spring (29) and in the pump operating lever and pin assembly (27); secure with the nut (30). Position the pump cam (31) on the throttle shaft (23); secure with the pump cam lock screw (26). Install the throttle shaft in the body; position the two throttle plates (32) on the throttle shaft, matching the marks made at disassembly; secure the throttle plates with four screws (32). Install the throttle stop screw (25) and spring (24) in the bracket on the throttle shaft. Slide the stud of the pump operating lever and pin assembly in the throttle body, fitting the arm under the pump cam.

d. Reassemble the metering body. Install the seals (19) on the idle adjusting needles (20); install the needles, one in each side of the metering body (59). Install the power valve assembly (18) and gasket (61) in the metering body. Torque the power valve to 160 lb.-in. [174 kg.-cm.]. Install the two main jets (35), using the main jet remover and installer tool C-3748.

e. Reassemble the fuel bowl. Position the diaphragm (43) and diaphragm return spring (44) on the fuel pump cover assembly (42). Install the assembly on the fuel bowl; secure with four screws (41). Torque the screws evenly to 16-22 lb.-in. [18-25 kg.-cm.]. Screw the adjusting nut (55) on the fuel inlet and seat assembly (53). Position the seal (52) and the gasket (54) on the fuel valve and seat assembly; install the assembly in the fuel bowl. Install the gasket (56) and fuel valve seat lock screw (57) in the threaded end of the fuel valve and seat assembly. Install the fuel check plug (48) and gasket (47) in the fuel bowl. Insert the filter screen (38) in the fuel inlet fitting (40); install the assembled fuel inlet fitting and gasket in the fuel bowl. Install the baffle plate (50). Position the spring (37) in the fuel bowl; install the float and hinge assembly over the spring; secure with the float retainer (36).

f. With the lock screw (57) loosened so that the adjusting nut (55) can rotate, turn the assembled fuel bowl upside down. Adjust the position of the adjusting nut until the float lever is parallel with the floor of the fuel bowl. Tighten the lock screw.

g. Position the gasket (60), assembled metering body (59), gasket (58), and assembled fuel bowl (49) on the main body (14); secure with four screws (46) and gaskets (45). Torque the screws to 40-60 lb.-in. [46-69 kg.-cm.].

h. Position the gasket (21) and assembled throttle body (34) on the main body; secure with four throttle body screws and lock washers (33). Torque the screws evenly to 36-49 lb.-in. [41-56 kg.-cm.].

i. When installing the carburetor on the engine, use a new carburetor to manifold gasket of the latest design.

12. Fuel Level Adjustment

a. With the engine mounted level and operating, remove the fuel level check plug (48, Fig. 159). The fuel level should be within $\pm 1/16$" [1,59 mm.] of the bottom line of the check plug port.

b. To adjust the level, loosen the lock screw (57) slightly with a screw driver and turn the adjusting nut with a $5/8$" [15,63 mm.] wrench. Turn the nut clockwise to lower the fuel level, counterclockwise to raise the fuel level ($1/6$ turn equals approximately $1/16$" [1,59 mm.] in fuel level).

c. After adjustment, tighten the lock screw. Operate the engine until the fuel level again stabilizes; recheck the level at the sight plug. Readjust, if necessary, until the correct fuel level is attained.

13. Idle Adjustment

a. Operate the engine on a level surface.

b. Seat the idle adjusting needles (20) and back off one half turn.

Note: Do not seat the idle adjusting needles too tightly as this will groove the tips and prevent a smooth idle, requiring replacement of the idle adjusting needles.

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c. Run the engine at a fast idle until the operating temperature reaches normal. Adjust the throttle stop screw (25, Fig. 159) to idle the engine at the correct rpm.

d. Set the idle adjusting needle to obtain the smoothest running and maximum idle speed. Turn the adjusting needle off over the "high spot" until it again begins to slow down. The setting half way between these two points and slightly on the rich side will result in a satisfactory idle mixture setting. Set both idle needles. Final adjustments may vary slightly from these settings but should not exceed $1/2$ turn difference between screws. If final adjustment increases idle rpm, reset throttle stop screw to specified rpm. Recheck idle adjustment.

14. Pump Override Spring Adjustment

With the throttle held in the wide open position and the pump operating lever and pin assembly (27) held in a fully compressed position, check the clearance between the adjusting screw (28) and the arm of the pump operating lever. The clearance at this point should be .015" [,38 mm.].

15. Fuel and Vacuum Pump

The fuel pump (Fig. 160) is mounted on the upper right side of the engine block. It is operated by its cam lever contacting a push rod operated by an eccentric on the engine camshaft. Upward movement of the pump diaphragm is accomplished by push rod action against the lever which pulls the diaphragm upward and compresses the diaphragm spring. This action induces a low pressure within the fuel chamber, allowing fuel to be forced through the intake valve from the supply tank. As the eccentric continues to rotate, the cam lever allows the diaphragm spring to exert pressure on the diaphragm. This action forces fuel from the fuel chamber through the discharge valve to the carburetor. The cam lever is of one-piece construction, hinged by a full floating pin. One end of the lever contacts the camshaft eccentric push rod and the other end

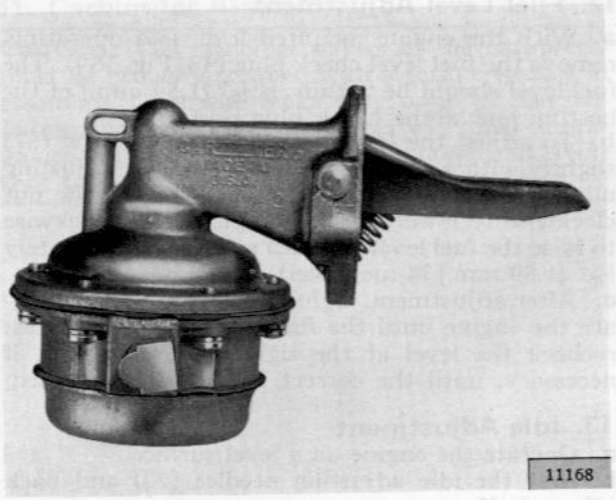

FIG. 160—FUEL PUMP

is connected to the diaphragm shaft so that camshaft action on the lever pulls the diaphragm up, but downward movement of the diaphragm is accomplished only through spring action. The pump delivers the fuel to the carburetor only when the fuel pressure in the outlet line is less than the pressure maintained by the diaphragm spring. If fuel is not needed in the carburetor, the carburetor needle valve is closed by the buoyance of the float, and the pump builds up pressure until it overcomes the tension of the diaphragm spring. This stops the flow of fuel from the pump.

Two air domes are built integrally in the pump, an intake air dome and discharge air dome. A small pocket of air is maintained in the intake side of the pump body. This air is decompressed during the intake stroke, allowing atmospheric pressure on the fuel in the supply tank to force fuel to the pump in a steady flow. This provides a ready supply of fuel to the intake valve at all times. Another pocket of air built into the discharge side of the pump body is sealed from the fuel by a second diaphragm. This eliminates any possibility of air being absorbed by the outgoing fuel. The discharge air domes dampens pulsations in fuel pressure and allows the pump to provide a more constant supply of fuel during the pump intake cycle.

16. Disassembly

Before disassembling the pump, mark the three castings with a file to ensure positioning in the same relation upon assembly. Remove the screws which attach the housing valve to the pump body. Separate the body and housing and remove the diaphragm. Remove the screws attaching the cover to the housing valve. Remove diaphragm and strainer.

17. Cleaning

Clean all metal parts of the fuel and vacuum pump in solvent; brush with a stiff-bristled brush. Drain or blow off solvent with dry, compressed air. Do not remove valves from housings. Check all parts to see that they have not been cracked or broken and that screw threads are not damaged. Refer to Par. C-14 for fuel and vacuum pump testing.

18. Assembly

Position the strainer and new diaphragm and install cover using screws. Hold the cam lever down and position the diaphragm. Fasten the pump body to the housing valve using screws.

19. Fuel Pump Installation

Caution: It has been determined that the timing chain cover, and/or fuel pump mounting flange, can be damaged if the proper procedure for mounting the fuel pump is not followed.

1. Remove the rocker arm cover.
2. Turn the crankshaft until the fuel pump eccentric allows maximum travel of the fuel pump push rod. Position the fuel pump gasket on the timing chain cover studs.
3. Hold the push rod up against the eccentric, then slip the fuel pump into position on the studs. The pump housing should fit snugly against the cover with only enough pressure to overcome resistance of the fuel pump spring. If it does not, there is interference between the fuel pump arm and the push rod. If interference exists, remove the fuel pump and reposition it so that the fuel pump arm is under the end of the push rod.
4. Never try to force the fuel pump into place by tightening the mounting nuts.

20. Air Cleaner

Servicing the air cleaner is covered as part of the periodic lubrication and servicing of the engine. Refer to the instructions in Section I for air cleaner service.

FUEL SYSTEM SPECIFICATIONS

CARBURETOR:	
Make	Holly
Model	2300
Part No.	R-2415-A
Fuel Level Setting	±1/16" [1,59 mm.] from bottom of check plug
FUEL PUMP:	
Make	Carter
Model	MP-3454S
Type	Piston Type Booster
Operating Pressure @ 600 rpm.	3½-5½ psi. [0,25-0,39 kg-cm²]
Fuel Intake Vacuum @ 600 rpm.	10" [25,4 cm.] Hg (mercury) minimum
Vacuum Pump Vacuum @ 800-1000 rpm.	14-19" [35-48 cm.] Hg (mercury) minimum

Electrical System
4 Cylinder Engines

In the following paragraphs will be found information about the battery, distributor, coil, generator, voltage regulator and starting motor. These units, with the connecting wires, make up the engine electrical system. Periodic inspections of these units is highly important, for small faults may be discovered and corrected, which if neglected might develop into expensive repair operations. A quick check at each engine lubrication will provide insurance against such repairs and the resulting costly delays.

Information given below applies only to the standard components supplied by Willys as part of complete engine assemblies. Information of components other than those supplied as original equipment must be obtained from the unit manufacturer.

Battery

The battery acts as a storage reservoir of electrical energy produced by the generator. To store sufficient energy for operation of the electrical system (starter, ignition, etc.) when the generator is not producing, the battery and battery wiring must receive regular attention. The principle attention is to maintain the electrolyte at the correct level, regularly check with a hydrometer and maintain the cable connections tight and clean. Also be sure the battery is held snugly in position to avoid damage due to vibration.

At each engine lubrication check the battery condition with a hydrometer. This practice will result in increased battery life and protection from costly delays due to battery failure.

A hydrometer reading of 1.260 indicates that the battery is fully charged. Should the reading fall below 1.225 it will be necessary to recharge or replace the battery. Unless the cause of the battery discharge is definitely known it is advisable to load test each cell to check for an internal short. A shorted battery will not hold a charge and must be repaired or replaced.

After testing with the hydrometer check the electrolyte level adding distilled water to maintain the solution $\frac{3}{8}$" above the plates. Avoid over filling. Do not fail to replace the filler caps and tighten them securely.

Check the battery cable connections at the battery terminals to be sure they are tight and clean. Copper sulphate which builds up on the terminals may be quickly removed by using a strong solution of baking soda and water. After cleaning, coat the terminals with grease to reduce formation of sulphate. The negative terminal is usually grounded by a cable bolted to the frame. Be sure a good tight connection is made at this point.

An engine ground cable, to connect the engine with the frame, is required if the engine is mounted on rubber insulators. If the terminal connections of this cable are loose or dirty, it will cause hard starting of the engine. Attention should be given to this ground cable, if used, during each inspection, and also at the time the engine is tuned.

Ignition System

The power in an internal combustion engine is derived from burning a fuel and air mixture in the engine cylinders under compression. To ignite these gases a spark is made to jump a small gap in the spark plug within each combustion chamber. The ignition system furnishes this spark. The spark must occur in each cylinder at exactly the proper time and the spark in the various cylinders must follow each other in sequence of firing order. To accomplish this the following units are required:

The battery, which supplies the electrical energy;
The ignition coil, which transforms the battery low-tension current to high-tension current which can jump the spark plug gap in the cylinders under compression;
The distributor, which delivers the spark to the proper cylinders and incorporates the mechanical breaker, which opens and closes the primary circuit at the exact time;
The spark plugs, which provide the gap in the engine cylinders;
The wiring, which connects the various units;
The ignition switch which controls the battery current when it is desired to start or stop the engine.

Distributor

The distributor is mounted on the right side of the engine and is operated by a coupling on the oil pump shaft which is driven by a spiral gear on the camshaft. The spark advance is fully automatic being controlled in some distributors with centrifugal weights only built into the assembly as shown in Fig. 161 and in others by a combination of centrifugal weights and vacuum control.

While some parts of the distributor may be checked or replaced with the unit mounted on the engine it is best to periodically remove it for a thorough check of the following points.

To remove the distributor assembly the following procedure should be followed:

1. Remove high-tension wires from the distributor cap terminal towers, noting the order in which they are assembled to assure correct reassembly. No. 1 spark plug terminal tower in the distributor is the lower right hand tower at the distributor cap spring clip, starting with this tower the wires are installed in a counter-clockwise direction 1-3-4-2 as shown in Fig. 163.
2. Remove the primary lead from the terminal post at the side of the distributor.
3. Unlatch the two distributor cap springs and remove the cap.
4. Note the position of the rotor in relation to the base. This should be remembered to facilitate reinstalling and timing.
5. Remove the screw holding the distributor to the crankcase and lift the assembly from the engine.
6. Wash all parts thoroughly in a suitable cleaning fluid.

Distributor Cap

The distributor cap should be inspected for cracks, carbon runners and evidence of arcing. If any of these conditions exist, a new cap should be installed. Clean any corroded high tension terminals.

Rotor

Inspect the rotor for cracks or evidence of excessive burning at the end of the metal strip.

After a distributor rotor has had normal use the end of the rotor will become burned. If burning is found on top of the rotor, it indicates the rotor is too short and needs replacing. Usually when this condition is found, the distributor cap segment will be burned on the horizontal face and the cap will also need replacing.

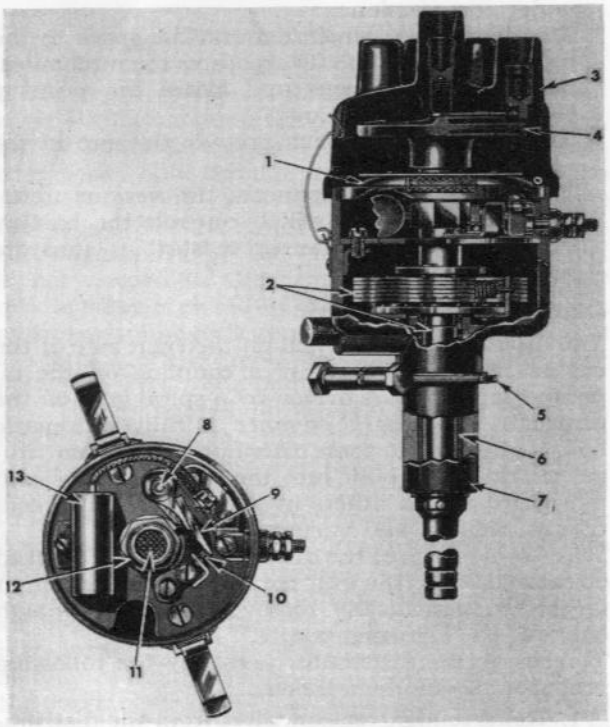

FIG. 161—DISTRIBUTOR

Condenser

The condenser prolongs the life of the distributor points by preventing arcing at the contacts. It also provides a hotter spark by creating a reverse surge of current which rapidly breaks down the magnetic field of the coil by demagnetizing the core. Should the condenser be leaky a weak spark will be experienced.

Check the condenser lead for broken wires or frayed insulation. Clean and tighten the connections on the terminal posts. Be sure the condenser is mounted firmly on the distributor for a good ground connection.

Should a condenser tester be available the condenser capacity should check from .23 to .26 microfarads. In the absence of a tester check by substituting a new condenser.

Distributor Points

The contact points should be clean and not burned or pitted. The contact gap should be set at .020″ measured with a wire gauge. After adjusting, tighten the lock and recheck the gap. If new contacts are installed they should be aligned to make contact at the center of the contact surfaces. Bend the stationary contact bracket to be sure of proper alignment and then recheck the gap.

The contact spring pressure is very important and should be between 17 and 20 ounces. Check with a spring scale hooked on the breaker arm at the contact and pull in a line at right angles to the breaker arm. Make the reading just as the points separate. This pressure should be within the above limits for if it is too low, missing will occur at high speeds and if too high the cam, block and points will wear rapidly. Adjust the point pressure by loosening the stud holding the end of the contact arm spring and slide the end of the spring in or out as necessary. Retighten the stud and recheck the pressure.

Governor Mechanism

The spark advance of some distributors is automatically controlled by a centrifugal governor built in the distributor body and that of others by a combination of centrifugal weights and vacuum control. The centrifugal type governor should be checked for free operation. Hold the governor shaft and turn the cam to the left as far as possible and release it. The cam should immediately return to the original position without drag.

Should a distributor test fixture be available it is best to make a check through the entire advance range, following the instructions of the fixture manufacturer.

Disassembly

If inspection indicates that the distributor should be disassembled for rebuild, proceed as outlined below:

1. Remove the cap.
2. Remove the rotor.
3. Remove the dust cap which is seated in the housing with finger tight press fit.
4. Remove the breaker plate assembly. To do this, remove the two mounting screws and disconnect the strap lead by removing one screw directly above the primary lead terminal on the side of the housing. Rotate the assembly to align the slot in the edge of the breaker plate with the primary lead terminal insulators and screw and lift the assembly from the housing. Removal of condenser and distributor points is obvious.
5. Remove the shaft assembly. To do this, file off the upset end of the pin which is placed through the collar and shaft at the lower end of the housing and drive out the pin with a suitable punch. Remove the collar and washer and pull the shaft from the housing.

6. Should it be necessary to remove the cam assembly, first remove the felt wick from the upper end. Use long nose pliers to compress and remove the spring locking clip located at the bottom of the drilled center opening of the cam and remove the cam.

The balance of disassembly is obvious.

If the shaft and bearings are worn sufficiently to allow .005" or more looseness of the shaft, they must be replaced. Before installing new bearings, soak them in medium grade engine oil and allow them to drain. Wipe all oil from the upper part of the housing. At assembly, apply a film of grease to the upper drive shaft washer and put a small amount of grease in the bearing bore just above the bearings. Lubricate the governor mechanism sparingly with medium grade engine oil. After assembly place 3 to 5 drops of engine oil in the oiler mounted on the side of the housing and 5 drops on the felt located in the center opening of the cam directly below the rotor. Place a very light smear of grease on the cam and 1 drop of oil on the breaker arm pivot.

Before installing the distributor, check the friction spring mounted on the lower end of the drive shaft and replace it if worn or damaged.

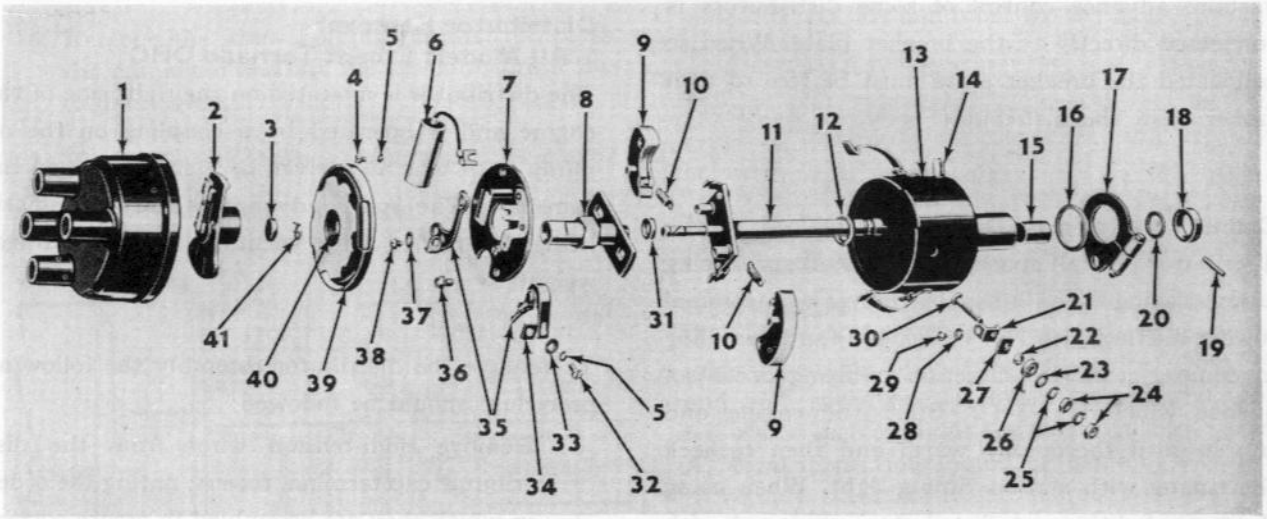

FIG. 162—DISTRIBUTOR—EXPLODED

1. Cap
2. Rotor
3. Cam Oiling Wick
4. Condenser Mounting Screw
5. Lockwasher
6. Condenser
7. Breaker Plate
8. Cam and Stop Plate
9. Governor Weight
10. Governor Spring
11. Drive Shaft
12. Thrust Washer
13. Base
14. Oiler
15. Bearing
16. Advance Arm Thrust Washer
17. Advance Arm
18. Drive Shaft Collar
19. Shaft Collar Rivet
20. Lower Thrust Washer
21. Connector
22. Bushing
23. Terminal Washer
24. Terminal Nut
25. Terminal Lockwasher
26. Insulating Washer
27. Terminal Insulation
28. Connector Lockwasher
29. Connector Screw
30. Terminal Post
31. Cam Spacer
32. Breaker Arm Spring Clip Screw
33. Spring Clip Screw Washer
34. Spring Clip
35. Distributor Points
36. Breaker Plate Screw
37. Washer
38. Locking Screw
39. Plate Seal
40. Felt Washer
41. Snap Ring

Installation and Ignition Timing

If the engine crankshaft has been rotated, with the distributor off, it will be necessary to place No. 1 piston in firing position to correctly install the distributor. To locate this position, some engines have marks placed on the flywheels, and other engines have marks placed on the timing gear covers and crankshaft pulleys. The flywheel marks may be viewed through an opening directly back of the starting motor by loosening the cover and sliding it to one side.

To locate the firing position of No. 1 piston, first remove No. 1 spark plug and turn the engine until No. 1 piston is moving up on the compression stroke as indicated by compression pressure being forced through the spark plug opening. Turn the engine slowly until either mark "5°" is in the center of the flywheel inspection opening or the marks on the crankshaft pulley and timing gear cover are in

Oil the distributor housing where it bears in the cylinder block and install the distributor on the cylinder block. Mount the rotor on distributor shaft and turn the shaft until the rotor points towards No. 1 spark plug terminal tower position (when cap is installed) with the contact points just breaking. See Fig. 163.

Move the rotor back and forth slightly until the driving lug on the end of the shaft enters the slot cut in the oil pump gear and slide the distributor assembly down into place. Rotate the distributor body until the contact points are just breaking. Install the hold-down screw being sure that distributors equipped with vacuum advance are free to turn in the mounting socket. Note that the vacuum advance control of some distributors is connected directly to the breaker plate. When so connected the breaker plate must be free to turn rather than the distributor body.

Connect the primary wire from the coil to the distributor. Install spark plugs. Install spark plug wires, placing them in the distributor cap terminal towers starting with No. 1 (Fig. 163) and installing in counter-clockwise direction in firing order sequence which is 1-3-4-2. Start the engine and run it until thoroughly warm and then recheck the timing with a neon timing light. When using the neon light to set distributors equipped with vacuum advance control it is advisable to disconnect the vacuum tube to make the control inoperative, otherwise the distributor may be advanced slightly, resulting in a false setting. Do not fail to reconnect the tube.

Accelerate the engine and check the automatic advance action by noting the movement of the flywheel or crankcase pulley mark.

NOTE: For low octane gasoline set the timing at top center indicated by "TC" mark on the flywheel.

Distributor Removal — All Models Except Tornado OHC

The distributor is mounted on the right side of the engine and is operated by a coupling on the oil pump shaft which is driven by a spiral gear on the camshaft. The spark advance is fully automatic being controlled by vacuum and centrifugal weights.

To remove the distributor assembly the following procedure should be followed:

1. Remove high-tension wires from the distributor cap terminal towers, noting the order in which they are assembled to assure correct reassembly. No. 1 spark plug terminal tower in the distributor is the lower right hand tower at the distributor cap spring clip, starting with this tower the wires are installed in a counter-clockwise direction 1-3-4-2 on the four cylinder engines as shown in Fig. 164.

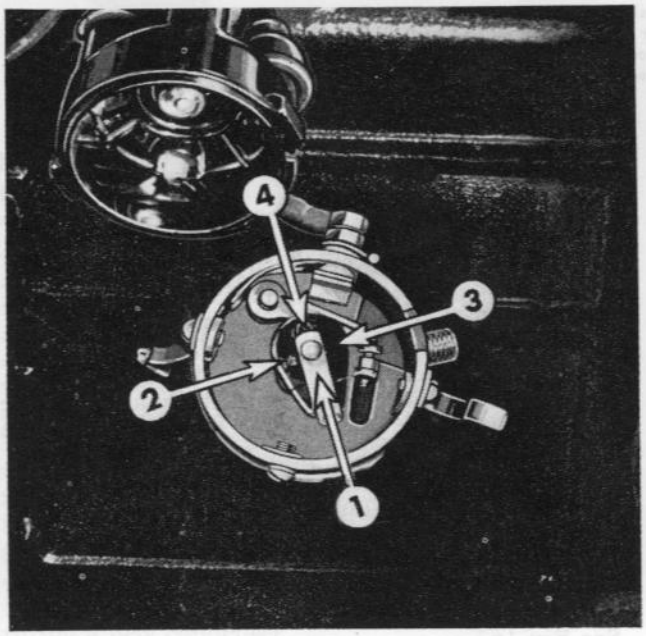

FIG. 163—FIRING POSITIONS

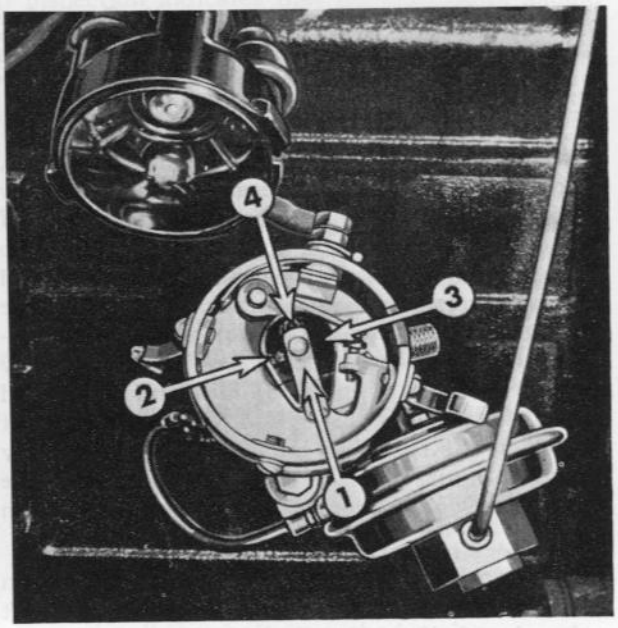

FIG. 164—FIRING POSITIONS — FOUR CYLINDER

2. Remove the primary lead from the terminal post at the side of the distributor.
3. Disconnect the vacuum tube.
4. Unlatch the two distributor cap springs and remove the cap.
5. Note the position of the rotor in relation to the base. This should be remembered to facilitate reinstalling and timing.
6. Remove the screw holding the distributor to the crankcase and lift the assembly from the engine.
7. Wash all parts thoroughly in a suitable cleaning fluid.

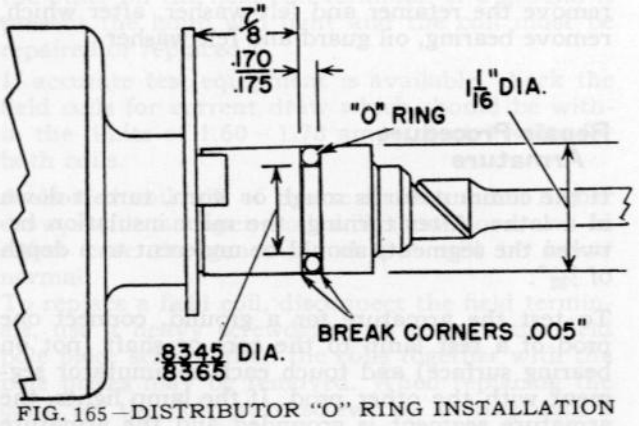

FIG. 165—DISTRIBUTOR "O" RING INSTALLATION

Distributor "O" Ring Installation

A rubber seal "O" ring, Auto-Lite Part No. XA-744W, is being installed on the distributors of vehicles now in production. This "O" ring is to prevent oil leakage around the distributor body shank. For engines where this oil leakage may be present and on which the distributor has no "O" ring, the accompanying illustration, Fig. 165, shows the installation procedure. To install the ring, remove the distributor from the engine and machine a groove in the shank as shown in the illustration. The distributor need not be disassembled as the drive shaft extension can be inserted in the chuck of the lathe. Chuck against the 1/16" diameter shaft. After machining the groove, slip on the "O" ring and reinstall the distributor.

Generator — 6 and 12 Volts

Two types of generators are mostly used on Willys Industrial Engines. One type is a 45 ampere, air cooled, two brush unit. This type generator is used with the conventional control, having the circuit breaker, voltage regulator and current limiting regulator units built into the control unit. Fig. 167.

The other type generator is a 15 ampere, air cooled, three brush unit. This generator is used with a control having only two units — a circuit breaker and a voltage regulator. A current limiting regulator is not used since the maximum generator output is limited by the generator third brush.

Repair and maintenance procedures for both types of generator are the same and are given below.

Generator Maintenance

A periodic inspection should be made of the charging circuit. The interval between these checks will vary depending upon type of service. Dust, dirt and high speed operation are factors which contribute to increased wear of bearings and brushes. A visual inspection should be made of all wiring, to be sure there are no broken or damaged wires. Check all connections to be sure they are tight and clean.

If the commutator is dirty or discolored it can be cleaned by holding a piece of No. 00 sandpaper against it, while it is turning slowly. Blow the sand out of the generator after cleaning. Should the commutator be rough or worn the armature should be removed and the commutator turned and undercut. See heading "Armature."

The brushes should slide freely in their holders. Should they be oil soaked or if they are worn to less than one-half their original length they should be replaced. When new brushes are installed they should be sanded to provide full contact with the commutator. See Fig. 166. Draw a piece of No. 00 sandpaper against the brush contact surface and between the brush and commutator until full contact is secured and blow the dust and sand from the generator. Generators should not be checked for output until the brushes are seated.

Brush spring tension is important. High tension causes rapid brush and commutator wear while low tension causes arcing and reduced output. Test the tension with a spring scale. The tension is 35-53 oz. On the 15 amp. generator, brush spring tension is 26-46 oz.

Dismantling Generator

Due to the fact that the regulator and battery are part of the generator circuit, and the generator output is extremely low when the battery is fully charged, it is advisable to check the generator circuit to determine definitely if the generator is at fault. Should this check prove that no current is passing to the battery, the fault must be localized either in the generator or regulator. Two tests to localize the trouble are given under "Preliminary Inspection", paragraph 2 on page 113.

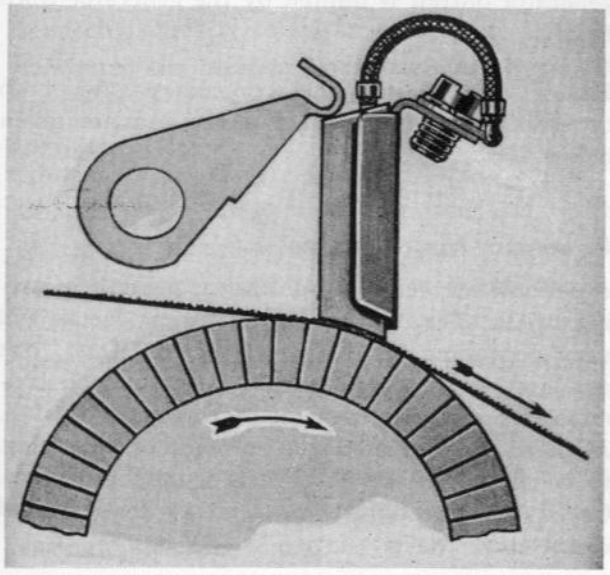

FIG. 166—SANDING GENERATOR BRUSHES

If it is definitely determined that trouble exists within the generator, which necessitates dismantling, remove the generator support bolts which will permit removing the generator assembly from the engine.

The sequence of disassembly of all generators supplied is similar as outlined below.

Remove the generator band and to facilitate removal of the commutator end plate and avoid damage to the brushes, the tension of the springs should be released from the brushes. Use a wire hook to lift the brush springs and at the same time pull the brushes partly out of the brackets and let the springs down against the sides of the brushes to hold them up in the brackets.

Remove the two frame screws in the commutator end plate and remove the end plate assembly.

Next pull the armature and drive head assembly from the generator housing. Remove the generator pulley from the armature by removing the nut and washer. Do not lose the Woodruff key when the pulley is removed. After this, remove the drive end head assembly which includes the oil seal and bearing. To remove the bearing, remove the three screws and lockwashers in the grease retainer and remove the retainer and felt washer, after which, remove bearing, oil guard and felt washer.

Repair Procedure
Armature

If the commutator is rough or worn, turn it down in a lathe. After turning, the mica insulation between the segments should be undercut to a depth of $\frac{1}{32}$".

To test the armature for a ground, connect one prod of a test lamp to the core or shaft (not on bearing surface) and touch each commutator segment with the other prod. If the lamp lights, the armature segment is grounded and the armature must be replaced.

To test for short in armature coils, a growler, Fig. 169, is necessary. Place the armature on the

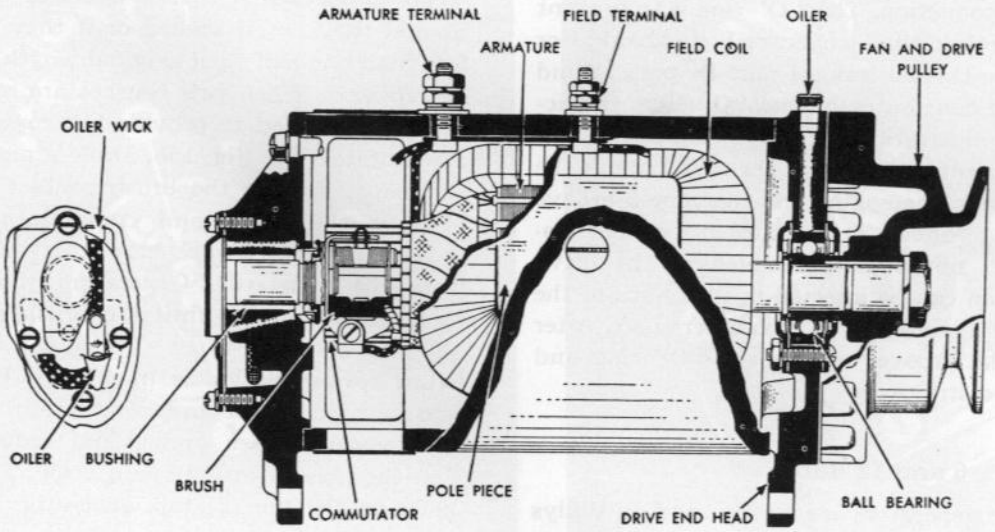

FIG. 167—GENERATOR

growler and lay a thin steel strip on the armature core. The armature is then rotated slowly by hand and if a coil is shorted, the steel strip will vibrate. Should a coil be shorted the armature must be replaced.

If precision test equipment is available, the customary accurate tests can be made in accordance with instructions furnished with the testing equipment.

Brushes

For service information regarding brushes see heading "Generator Maintenance."

Field Coils

Inspect the field coils for chafed wires and using test lamp prods check for both open and grounded circuits. To test for open coil, connect the prods to the two leads from each coil. If the lamp fails to light, the coil is open and must be repaired or replaced.

To test for ground, place one prod on ground and the other on the field coil terminal. If a ground is present the lamp will light and the coil must be repaired or replaced.

If accurate test equipment is available, check the field coils for current draw which should be within the limits of 1.60 – 1.78 amperes at 6 volts for both coils.

A shorted coil will of course show a much higher draw, while an open coil will show no draw. In either case the generator output will be below normal.

To replace a field coil, disconnect the field terminals, use a heavy screwdriver to remove the field pole piece screws, then the coils together with the pole pieces may be removed. When replacing the coils, set the pole piece screws by staking with a center punch.

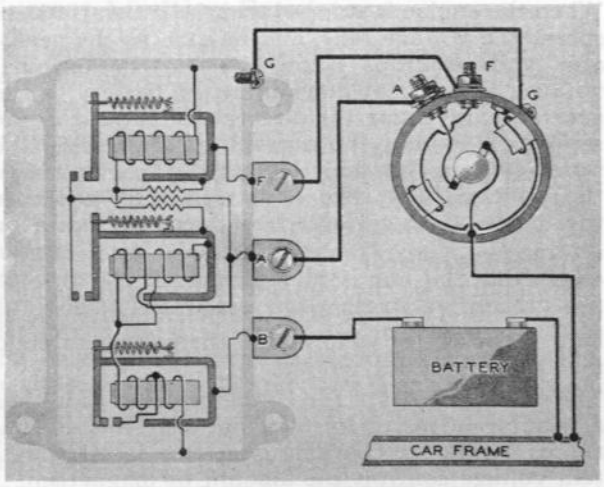

FIG. 168—GENERATOR WIRING DIAGRAM

Brush Holders

With test prods check the insulated brush holder to be sure it is not grounded. Touch the brush holder with one prod and the end plate with the other prod. If the lamp lights, a grounded brush holder is indicated.

Inspect the brush holders for cracks, distortion and improper alignment. The brushes should slide freely and should be in perfect alignment with the commutator segments.

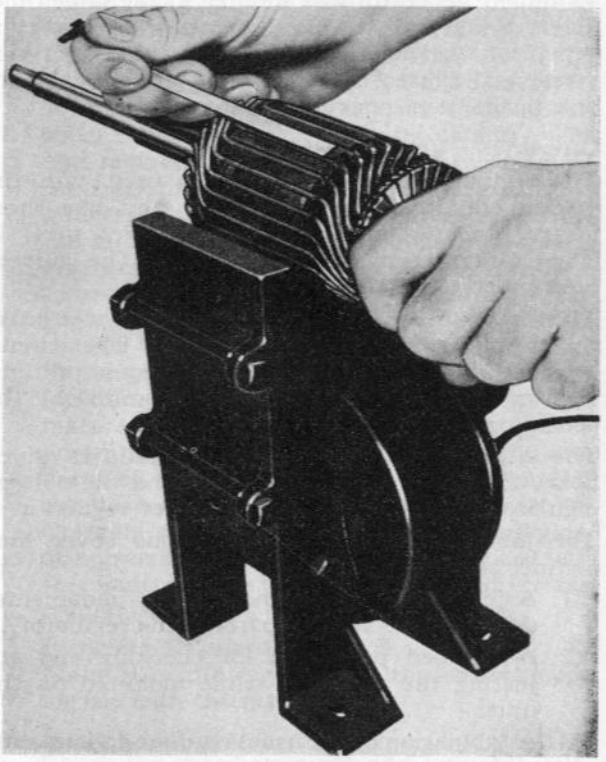

FIG. 169—GROWLER

Reassembling Generator

Install the felt grease retainer and washer in the drive end head. Check the bearing to be sure it is clean and fill it one-half full with a high melting point grease. Install the bearing and also install the inside felt washer and attach the bearing retainer with the lockwashers and screws. Place the drive end head over the front end of the armature shaft. Install the Woodruff key in the armature shaft and install the drive pulley, being sure the key is in position. Secure in position with the washer, nut and cotter pin.

Place the assembly on end so it rests on the pulley with the commutator end up. Then place the generator housing and field coils assembly in position, turning the front end bracket so the dowel pin in the housing enters the hole in the end head. The commutator end plate, including the brushes held in a raised position, should then be placed on the shaft and the field coils connected.

Next install the long frame screws and lower the brushes onto the commutator. If new brushes have been installed, draw a piece of No. 00 sandpaper between the brushes and commutator with the back of the sandpaper against the commutator, Fig. 166. This will properly seat the brushes.

Assembly of the generator is completed by installing the cover band.

When reinstalling the generator on the engine, the bracket bolt torque wrench reading is 31 – 35 ft. lbs.

NOTE: The 45 ampere generator now installed on industrial engines superseded in 1953 a 35 ampere unit. A new voltage regulator for the 45 ampere generator was adopted at the same time. These units must be used in pairs. A new type generator used with an old type regulator, or vice versa, will cause either a loss of ampere capacity or a burned out generator.

Current — Voltage Regulators

The regulator described below is used with the 45 ampere, two brush generator and has three units, Fig. 170, 1. The circuit breaker unit, 2. The voltage regulator unit and, 3. The current limiting regulator unit.

The regulator used with the 15 ampere three brush generator has two units only: 1. The circuit breaker unit and 2. The voltage regulator unit. The maximum generator output is limited by the generator third brush.

The descriptions and testing procedures given below for the circuit breaker unit and the voltage regulator unit apply to both types of regulator.

The following regulator instructions cover four distinct sections as follows:

1. A description of the function and fundamental design of the various parts of the regulator.
2. A detailed procedure for checking and adjusting the regulator while mounted on the unit.
3. A tabulation of the usual regulator complaints with the checks and repairs necessary to eliminate the trouble.
4. Specifications of the unit which are listed at the end of the manual.

Description and Operation

These regulators are used with shunt type generators and have three units each with a separate function to perform. These units, Fig. 170, are the circuit breaker unit, No. 3, the voltage regulator unit No. 1, and the current limiting regulator unit, No. 2.

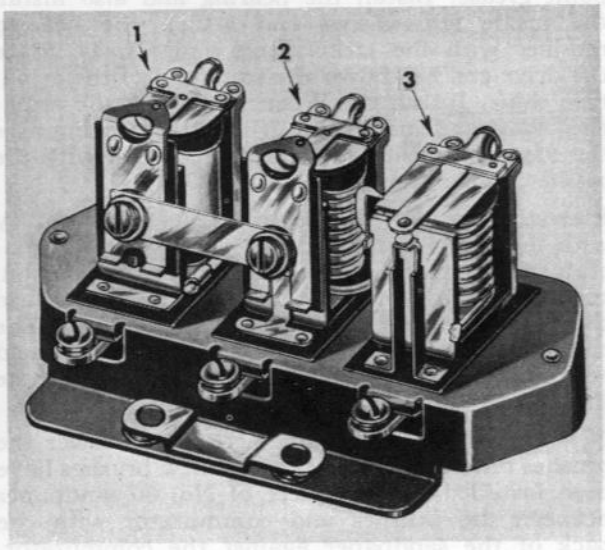

FIG. 170—VOLTAGE REGULATOR

Circuit Breaker

It consists of an electromagnet and a set of contacts. The contacts are mounted with one on a stationary bracket, and the other on a movable armature which is controlled by the electromagnet. The movable contact is mounted on a spring arm so that as the contacts open and close a slight wiping action is produced.

The electromagnet of the circuit breaker has two windings, one, the shunt coil which is connected across the generator output like a voltmeter and the other a series coil connected in series with the generator output like an ammeter. These two coils are wound in the same direction so that when the generator is charging the battery, the magnetism of the series coil increases the total magnetism. When the battery discharges back through the generator, the magnetism of the series coil is reversed and the magnetism of the two coils is opposed. This results in a decreased pull on the armature and spring action opens the contacts.

The sequence of operation of the circuit breaker is as follows:

When the generator is not running, the contacts are open. When the generator is started, the voltage builds up at the armature terminal and in the shunt coil and as soon as it reaches the value for which the circuit breaker is calibrated, there is sufficient magnetism created by the shunt coil to pull down the armature, closing the contacts which automatically connects the generator to the battery. With the contacts thus closed the current in the series coil is flowing from the generator to the battery or in the same direction as the current in the shunt coil, so that the pull on the armature is increased by the magnetism of the series coil.

When the engine is stopped and the generator loses speed, the voltage falls, and as soon as the generator voltage drops below the battery terminal voltage, the current flows from the battery to the generator, reversing the direction of current in the series coil so that the magnetism created by the series coil opposes and reduces the magnetism of the shunt coil. This reduces the pull on the armature to a point where spring action opens the contacts.

Voltage Regulator

The function of the voltage regulator is to hold the generated voltage at a predetermined value as long as the circuit values allow the voltage to build up to the operating voltage.

The electromagnet of the voltage regulator unit has a winding of many turns of fine wire and is connected across the charging circuit so that the system voltage controls the amount of magnetism.

The contacts of the voltage regulator unit are connected in the generator field circuit so that the field circuit is completed through the contacts when they are closed and through a resistor when the contacts are opened.

When the voltage rises to a predetermined value there is sufficient magnetism created by the regu-

lator winding to pull the armature down. This opens the contacts and inserts resistance in the field circuit of the generator thus reducing the field current. The generated voltage immediately drops, which reduces the pull on the armature to the point where the spring closes the contacts. The output again rises and the cycle is repeated.

These cycles occur at high enough frequencies to hold the generated voltage at a constant value and will continue as long as the voltage of the circuit is high enough to keep the voltage regulator unit in operation. With the addition of a current load great enough to lower the battery voltage below the operating voltage of the unit, the contacts will remain closed and the generator will maintain a charging rate as limited by its speed or the current limiting regulator (as limited by the third brush on the 15 amp. generator).

Due to the effect of heat on the operating characteristics of regulator windings it is necessary to compensate for the changes in coil resistance when the regulator is operating under varying temperature conditions. This is accomplished through the use of a nickel iron magnetic by-pass on the voltage regulator unit. This shunt by-passes some of the magnetic flux when the unit is cold and allows most of the flux to act on the armature when the unit is hot. Thus when the coil is hot and not as efficient, the magnetic shunt reduces the amount of flux needed to vibrate the armature.

The compensation is usually more than enough to offset the changes in regulator coil resistance due to heat. The excess compensation allows the regulator to operate at higher voltages under cold operating conditions than under hot conditions. This is necessary as it requires a higher voltage to charge a battery with its internal resistance increased by low temperatures.

Current-Limiting Regulator

The function of the current-limiting regulator is to limit the output of the generator to its maximum safe output.

The electromagnet of the current regulator unit consists of a winding of heavy wire that is connected in series with the generator output. When the generator output reaches a predetermined value, the current in the winding produces enough magnetism to overcome the spring tension and pull the armature down. This opens the contacts and inserts resistance in the field circuit of the generator. With the field current reduced by the resistance, the generator output falls and there is no longer enough magnetism to hold the contacts open. As soon as the spring closes the contacts, the output rises and the cycle is repeated. These cycles occur at high enough frequencies to limit the output to a minimum fluctuation.

Preliminary Inspection

1. Wiring
   Check the wiring to see that it is properly connected to the generator.
2. Generator Performance
   Make sure the generator operates correctly without the regulator in the circuit. Remove the armature and battery leads from the regulator and connect an ammeter between them. Remove the field lead from the regulator and while operating at idle speed touch the field lead to the regulator base. Increase the speed slowly noting the charging rate. DO NOT INCREASE THE OUTPUT ABOVE THE RATED OUTPUT OF THE GENERATOR. If the generator output will not build up inspect the wiring harness for shorts and opens and remove the generator for an overhaul.
   To check the generator circuit when a suitable ammeter is unavailable, Fig. 168, disconnect the ammeter cable at the regulator. Connect one lead of a 6 volt test lamp to the regulator terminal marked "ammeter" and with the engine running, ground the other lead. Should the test light fail to burn there is a fault either in the generator or regulator. To localize the fault, disconnect both the "Field" and "Armature" cables at the generator. Connect a wire from the "Field" terminal to ground and use a 60 watt, 110 volt test lamp to ground the "Armature" terminal. If the generator is charging satisfactorily the test lamp will glow at approximately 1500 rpm. engine speed and the fault will be definitely localized in the regulator.
3. Incorrect Regulator
   Make sure the regulator is the correct type for use with the generator.
4. Battery
   Check the specific gravity and terminal voltage of the battery. If the battery is not up to specifications substitute temporarily for test purposes a fully charged battery of the same type and capacity.
5. High Resistance Connections
   Inspect the wiring between the generator, regulator and battery for broken wires and high resistance connections. Pay special attention to the ground connections at all three units.
   Connect a reliable ammeter with 1 ampere graduations in series with the regulator "B" terminal and the lead removed from this terminal. Run the generator at a medium speed and turn on the lights or accessories until the ammeter shows a 10 ampere charging rate. At this charging rate measure the voltage drop between the following points using an accurate voltmeter graduated in .1 volt divisions. The voltmeter should not show a reading above the maximum noted.

a. Generator "A" terminal to regulator "A" terminal — .1 volt max.
b. Generator "F" terminal to regulator "F" terminal — .05 volt max.
c. Battery terminal to regulator "B" terminal — .1 volt max.
d. Regulator ground screw to generator frame — .03 volt max.

e. Regulator ground screw to battery ground post — .03 volt max.

f. Generator frame to battery ground post — .03 volt max.

Test Procedure

1. Circuit Breaker (End unit — with heavy wire winding)
   Connect a reliable ammeter in series with the regulator "B" terminal and the lead removed from the terminal. Connect an accurate voltmeter from the regulator "A" terminal to the regulator base and place a reliable thermometer near the regulator (about 2 inches from the regulator cover but not touching the regulator).
   Disconnect the field lead from the regulator "F" terminal and insert a variable resistance (3 amp. — 50 ohm capacity) between the lead and the regulator terminal.
   Run the generator at about 1000 generator rpm. Insert all the resistance in the field circuit, then slowly reduce the resistance noting the voltage reading just before the change caused by the closing of the circuit breaker. Increase the charging rate to the figure specified for the regulator being tested then reduce the charging rate by inserting resistance in the field circuit. Note the voltmeter and ammeter reading just before the circuit breaker opens and the ammeter reading drops to zero. The closing voltage and the opening voltage or current should be within the limits specified.
   An accurate method for noting the exact instant of the opening or closing of the circuit breaker is to connect a headphone (2000 ohms or higher) to the battery and armature terminals of the regulator. When the contacts open or close a click will be heard in the headphone.
   To adjust the closing voltage change the armature spring tension by bending the hanger at the lower end of the spring. Increase the spring tension to raise the closing voltage or decrease the tension to lower the voltage. To adjust the opening voltage raise or lower the stationary contact keeping the contacts perfectly aligned. Increasing the contact gap lowers the opening voltage. Change the contact gap by expanding or contracting the stationary contact bracket, keeping the contacts aligned. Do not adjust the gap between the contacts to less than the specified minimum.

2. Voltage Regulator (end unit — with fine wire winding)
   Connect the ammeter as noted above and connect the voltmeter from the regulator "B" terminal to the regulator base. Remove the variable resistance from the field circuit.
   Run the generator at ½ maximum output for 15 minutes to make sure the regulator is at normal operating temperature. Have the cover on the unit during this warm up period and when taking readings.
   Stop the engine then bring it up to approximately 2500 generator rpm. Adjust the amperage to ½ maximum output by turning on lights or accessories and then note the voltmeter reading. This reading should be within the limits specified for the voltage regulator operation. To adjust the operating voltage change the armature spring tension by bending the hanger at the lower end of the armature spring. After each adjustment stop the engine then restart it. Bring it up to speed and adjust the current before taking a reading. In order to obtain an accurate indication of the operation of the voltage regulator unit connect a headphone (2000 ohms or higher) between the "F" terminal and ground to pick up the sound of the opening and closing of the contacts. The clicks should be regular and clear without irregularities or missing. If the tone is not clear and regular remove the regulator cover and inspect the contacts. The contacts should be flat and not burned excessively and should be aligned to make full face contact. If the contacts need cleaning refer to paragraph 4 for the method.

3. Current regulator (center unit — with heavy wire winding)
   Connect the regulator and instruments as described above for the voltage regulator (paragraph 2) and run the generator at approximately 3000 generator rpm. Turn on lights and accessories so that the generator must charge at its maximum rate. The ammeter should show a reading within the limits specified. To adjust the opening amperage change the armature spring tension by bending the hanger at the lower end of the armature spring. After each adjustment stop the engine then restart it. Bring the engine up to speed and take an ammeter reading. Have the cover on the unit when taking readings.
   In order to obtain an accurate indication of the operation of the current regulator unit connect a headphone (2000 ohms or higher) between the regulator "F" terminal and ground to pick up the sound of the opening and closing of the contacts. The clicks should be clear and regular without irregularities or missing. If the tone is not clear and regular remove the regulator cover and inspect the contacts. The contacts should be flat and not burned excessively and should be aligned to make full face contact. If the contacts need cleaning refer to paragraph 4 for the method.

4. Contacts
   Inspect the contacts on all three units. In normal use the contacts will become grayed. If the contacts are burned or dirty or if they are not smooth, file the contacts with a #6 American, Swiss cut, equalling file. Move the file parallel and lengthwise to the armature. File just enough so that the contacts present a smooth surface toward each other. It is not necessary to remove every trace of pitting. After filing, dampen a piece of linen or lintless bond tape in refined carbon tetrachloride and

draw the tape between the contacts. Repeat with a dry piece of tape. Use clean tape for each set of contacts.

5. Recheck
Operate the unit at ½ maximum output for 5 minutes with the cover on the regulator. Repeat the testing procedure for all units as described in paragraphs 1, 2 and 3 above. Be sure cover is on regulator when taking readings.

Quick Checks

Low Charging Rate with a Fully Charged Battery

A fully charged battery and a low charging rate indicates normal regulator operation.

A further check of the regulator operation can be made by using the starting motor for 5 to 10 seconds with the ignition switch in the "off" position. Then start the engine and operate at a generator speed of 2500 to 3000 rpm. The charging rate should rise to its maximum value then taper off to a minimum charge as the battery becomes charged.

High Charging Rate with a Fully Charged Battery

This is usually an indication that the voltage regulator is not operating correctly. The high voltage will cause the battery to gas excessively and will shorten the life of the ignition contacts and, in general, will have a detrimental effect on all connected load.

Connect an ammeter in series with the regulator "B" terminal and the lead removed from the terminal. Run the generator at a medium speed and perform the following operation. After each test is completed reconnect whatever leads have been opened.

1. Operation
Disconnect the field lead at the generator.

Effect
a. Output drops to zero.
b. Output does not drop.

Cause and Remedy
a. Shorted field circuit in regulator or in wiring harness. See test 2.
b. Shorted field circuit in generator. Inspect generator.

2. Operation
Disconnect the field lead at the regulator.

Effect
a. Output drops to zero.
b. Output does not drop.

Cause and Remedy
a. Shorted field in regulator. See test 3.
b. Shorted wiring harness. Repair or replace wiring harness.

3. Operation
Remove the regulator cover and hold the voltage regulator contacts open.

Effect
a. Output drops to zero.
b. Output does not drop.

Cause and Remedy
a. Regulator contacts sticking, regulator out of adjustment or regulator inoperative. Check operation, test 5; check for high resistance, test 4; clean contacts, test 6.
b. Shorted field circuit in the regulator. Clean the regulator contacts and inspect the regulator visually for incorrect wiring between units and shorted leads.

4. Operation
Operate the units at 10 amperes output and measure the voltage drop from the regulator base to the generator frame.

Effect
a. Voltage reading below .03 volts.
b. Voltage reading above .03 volts.

Cause and Remedy
a. Ground circuit O.K. See test 5.
b. Inspect ground circuit for poor connections and eliminate the high resistance. See test 5.

5. Operation
Connect a headphone from the regulator field terminal to the base and hold the current regulator contacts closed.

Effect
a. A steady beat is heard.
b. An unsteady beat is heard.
c. No beat is heard.

Cause and Remedy
a. Voltage regulator operating. Reset regulator as in the operation test on Page 102.
b. Dirty or sticking contacts. Clean contacts as in test 6.
c. Inoperative voltage regulator unit. Adjust regulator operation as in the operation test Page 102. If the regulator cannot be adjusted within limits remove for an overhaul.

6. Clean the voltage regulator contacts with a #6 American Swiss cut equalling file. File lengthwise and parallel to the armature and then clean the contacts with clean linen tape. First draw a piece of tape that has been wet with carbon tetrachloride between the contacts then follow with dry tape. Reset the regulator operation as in the operation test Page 102.

Low Battery and a Low or No Charging Rate

Check all wiring for loose connections, frayed insulation and high resistance connections and correct any fault.

Make sure the generator operates correctly without the regulator in the circuit. Remove the "A" and "B" leads from the regulator and connect an ammeter between them. Remove the field lead from the regulator and while operating at idle speed touch the field lead to the regulator base. Increase the speed slowly noting the charging rate. Do not

increase the output above the rated output of the generator. If the generator output will not build up, inspect the wiring harness for shorts and opens and remove the generator for an overhaul.

Connect an ammeter between the battery lead and the regulator "B" terminal. Connect the field lead to the regulator "F" terminal and connect the armature lead to the regulator "A" terminal. Connect a voltmeter from the regulator "A" terminal to the regulator base. Operate the generator at a medium speed and perform the following tests:

1. Operation
Read the voltmeter.

Effect
a. Voltage builds up.
b. Voltage does not build up.

Cause and Remedy
a. Open series circuit. See test 2.
b. Regulator out of adjustment, field circuit open, grounded series circuit. See test 3.

2. Operation
Remove the regulator cover and with the generator operating at a medium speed hold the circuit breaker contacts closed.

Effect
a. Ammeter shows charge.
b. No generator output.

Cause and Remedy
a. Open circuit breaker shunt winding, incorrect setting of circuit breaker or dirty contacts. Clean contacts and reset circuit breaker as in the operation test on Page 114. If the circuit breaker cannot be set the shunt coil is open and the regulator should be removed for an overhaul.
b. Clean the circuit breaker contacts and try the test again. If there is still no charge the series windings are open and the regulator should be removed for an overhaul.

3. Operation
Run the generator at idle speed and momentarily connect a jumper from the "F" terminal to the regulator base.

Effect
a. Voltage build up.
b. Voltage does not build up.

Cause and Remedy
a. Open field circuit or regulator out of adjustment. See test 4.
b. Grounded series circuit. Remove regulator for an overhaul.

4. Operation
Operate at a medium speed with the jumper removed. Remove the regulator cover and hold the voltage regulator contacts closed.

Effect
a. Voltage builds up.
b. Voltage does not build up.

Cause and Remedy
a. Voltage regulator contacts burned or dirty or incorrect regulator setting. Clean the contacts and adjust the regulator as in the operation test on Page 114.
b. Clean contacts and try again. If the voltage still does not build up. See test 5.

5. Operation
Remove the regulator cover and hold the current regulator contacts closed.

Effect
a. Voltage builds up.
b. Voltage does not build up.

Cause and Remedy
a. Current regulator contacts burned or dirty or incorrect regulator setting. Clean the contacts and adjust the regulator as in the operation test on Page 114.
b. Clean the contacts and perform test 5 again. If the voltage still does not build up remove the regulator for an overhaul.

Starting Motors — 6 and 12 Volts

NOTE: A 4½" starting motor was placed in the production of industrial engines during 1953. The 4" starting motor is still used on some installations however. The service procedures outlined below apply to both starters.

Maintenance Procedure

A periodic inspection should be made of the starting circuit. While the interval between these checks will vary according to the type of service, it should, under normal conditions, be made every 500 hours of operation. At this check the following points should be inspected.

1. Wiring
The starting circuit should be inspected to be sure all connections are clean and tight and that the insulation on the wires is not worn or damaged. The starting circuit should be given a voltage loss test to make sure there is no loss of starting motor efficiency due to high resistance connections. In making this check the voltage loss from the battery terminal to the starting motor terminal should not exceed .30 volts maximum for each 100 amperes. The loss in voltage between the battery ground post and the starting motor frame should not exceed .10 volts maximum for each 100 amperes. If the voltage loss is greater than the above limits the voltage should be measured over each part of the circuit to locate the resistance causing voltage loss.
2. Commutator
If the commutator is dirty or discolored it can be cleaned with 00 sandpaper. Blow the sand out of the motor after cleaning.
Should the commutator be rough or worn the motor should be removed from the engine for cleaning and reconditioning.
3. Brushes
The brushes should slide freely in their holders and make full contact on the commutator. Worn brushes should be replaced.
4. Lubrication
Add 3 to 5 drops of medium engine oil to the oiler in the commutator end cap, if so equipped, at every lubrication. Note that some starting motors are equipped with sealed type bearings at both ends and no lubrication is required.

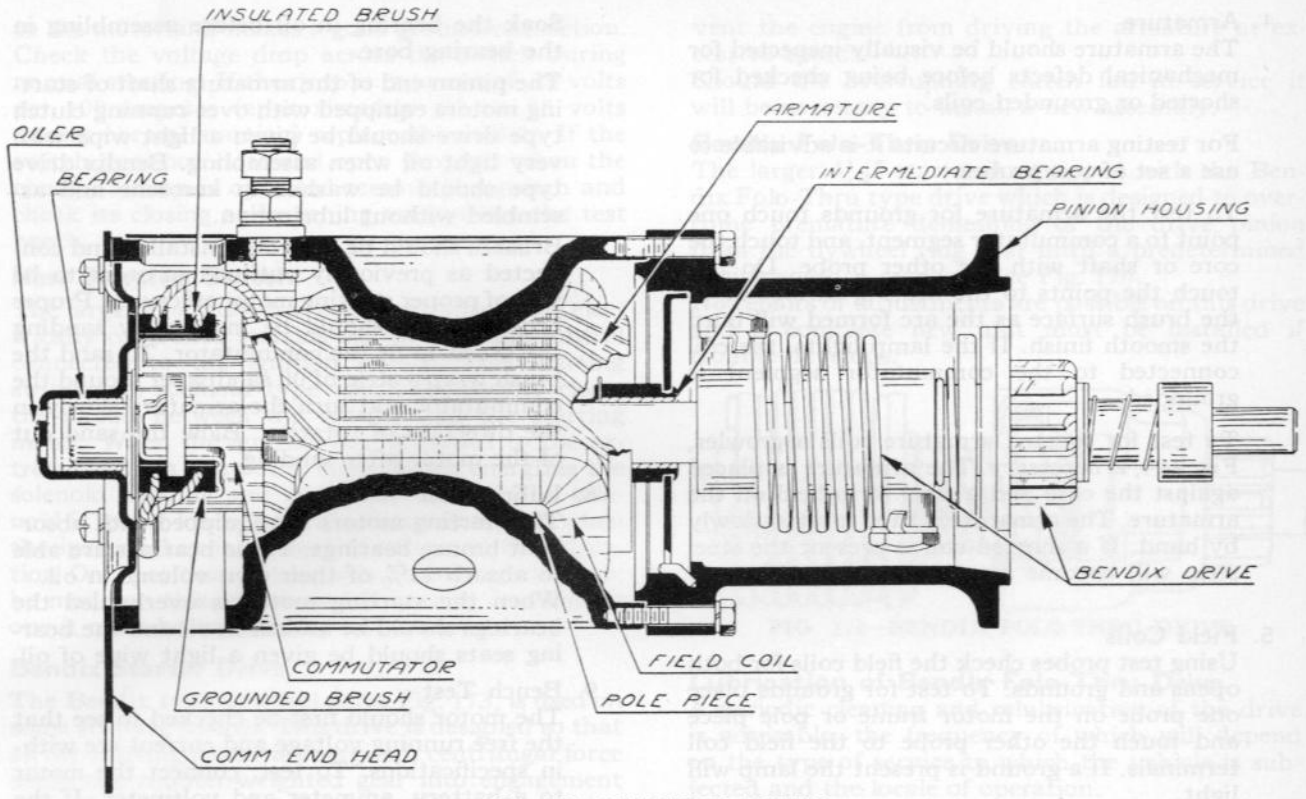

FIG. 171—STARTING MOTOR

Overhaul Procedure

At periodic intervals the starting motor circuit should be thoroughly checked and the moror removed from the engine for cleaning and checking.

1. Disassembly

   To remove the starting motor from the engine disconnect the leads and cover the battery lead with a short piece of hose to prevent short circuiting. Take out the flange bolts holding the motor to the flywheel housing. The motor will then lift off and can be taken to the bench for a complete overhaul.

   Some starting motors are equipped with Bendix type drive while others with the overrunning clutch type with either manual or electrically operated engagement.

   When disassembling the motor, each part should be removed, cleaned and inspected for wear or damage. If so equipped, the Bendix Drive should be cleaned and inspected for wear and a distorted spring. If equipped with the overrunning clutch type drive, the clutch should be thoroughly checked. Bearings should be checked for proper clearance and fit. All insulation should be free of oil and in good condition. The armature, field coils and brushes should be checked for grounds and open circuits.

2. Brushes

   The brushes should slide freely in their holders and make full contact on the commutator. Worn brushes should be replaced.

   When replacing brushes that have the lead riveted to the brush holder the terminal should be unclinched and unsoldered. The new brush lead should be tightly clinched in the terminal then soldered to make a strong, low resistance connection. Brushes that are soldered to the field coil lead should be unsoldered and have the loop in the field coil lead opened. The new brush pigtail should be inserted to its full depth in the loop and then clinched before resoldering. A good soldering job must be done to insure no loss of starting motor efficiency due to a poor contact.

   Brush spring tension should be checked with a spring scale. To check the tension of reaction type brush springs hook the scale under the brush spring near the brush and pull on a line parallel with the side of the brush. Take the reading just as the spring leaves the brush. If the brush spring tension is too low there will be a loss of efficiency due to poor brush contact. If the tension is too great the commutator and brushes will wear excessively and have short life. It is therefore important that the brush spring tension be kept within the limits specified. To change the spring tension twist the spring at the holder with long nosed pliers.

3. Commutator

   Check the commutator for wear and discoloration. If the commutator is only slightly dirty or discolored it can be cleaned with 00 or 000 sandpaper. Blow the sand out of the motor after cleaning the commutator. If the commutator is rough or worn the armature should be removed and the commutator turned down in a lathe.

4. Armature
The armature should be visually inspected for mechanical defects before being checked for shorted or grounded coils.

For testing armature circuits it is advisable to use a set of test probes.

To test the armature for grounds touch one point to a commutator segment, and touch the core or shaft with the other probe. Do not touch the points to the bearing surface or to the brush surface as the arc formed will burn the smooth finish. If the lamp lights, the coil connected to the commutator segment is grounded.

To test for shorted armature coils a growler, Fig. 169, is necessary. The armature is placed against the core and a steel strip held on the armature. The armature is then rotated slowly by hand. If a shorted coil is present the steel strip will become magnetized and vibrate.

5. Field Coils
Using test probes check the field coils for both opens and grounds. To test for grounds place one probe on the motor frame or pole piece and touch the other probe to the field coil terminals. If a ground is present the lamp will light.

To test for open circuits place the probes on the field coil terminal and an insulated brush. If the light does not light the coil is open circuited.

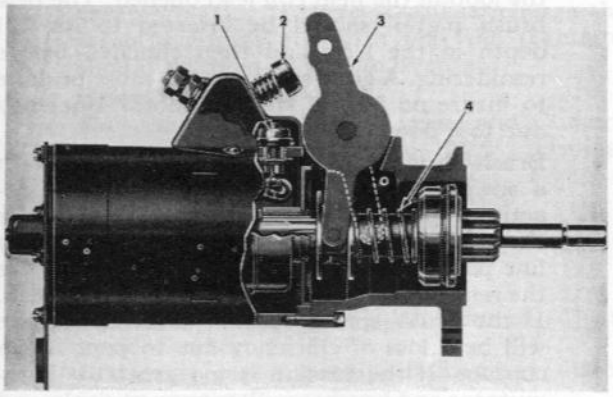

FIG. 172—STARTING MOTOR WITH CLUTCH DRIVE

6. Brush Holder Inspection
Using test probes touch the insulated brush holder with one probe and a convenient ground on the commutator end head with the other probe. If the lamp lights it indicates a grounded brush holder.

7. Assembly of Motor
When assembling absorbent bronze bearings always use the proper arbor as these arbors are designed to give the proper bearing fit. Soak the bearing in oil before assembling in the bearing bore.

The pinion end of the armature shaft of starting motors equipped with over-running clutch type drive should be given a light wipe with very light oil when assembling. Bendix drive type should be washed in kerosene and assembled without lubrication.

Brushes should be correctly installed and connected as previously outlined in order to be sure of proper starting motor efficiency. Proper brush seating should be insured by sanding the brush to fit the commutator. To sand the brush wrap a strip of 00 sandpaper around the commutator and turn the armature slowly in the direction of rotation. Blow the sand out of the motor after sanding.

8. Lubrication
The starting motors are equipped with absorbent bronze bearings. These bearings are able to absorb 25% of their own volume in oil. When the starting motor is overhauled the bearings should be soaked in oil and the bearing seats should be given a light wipe of oil.

9. Bench Test
The motor should first be checked to see that the free running voltage and current are within specifications. To test, connect the motor to a battery, ammeter and voltmeter. If the current is too high check the bearing alignment and end play to make sure there is no binding or interference.

Using a spring scale and torque arm check the stall torque to see that the motor is producing its rated cranking power. The stall torque will be the product of the spring scale reading and the length of the arm in feet. If the torque is not up to specifications check the seating of the brushes on the commutator and the internal connection of the motor for high resistance.

The Bendix should be checked for correct operation. The Bendix pinion should be checked to see that it shifts when the motor is operated under no load.

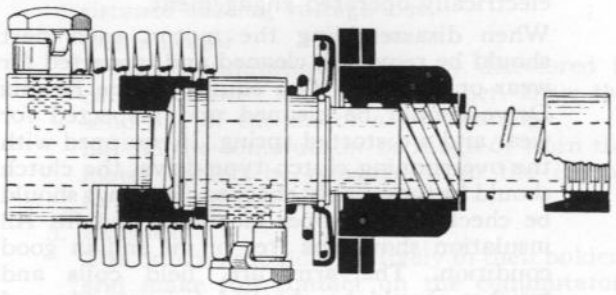

FIG. 173—STARTING MOTOR BENDIX DRIVE

Starting Switch Test

Inspect the control wiring between battery, push button, if so equipped, and switch for breaks, loose terminals and worn insulation. Tighten all connections and make sure the switch is firmly mounted

to the motor and makes a good ground connection. Check the voltage drop across the switch during normal starting. If the drop is in excess of .20 volts per 100 amperes (approximately .50 to .75 volts during normal starting) replace the switch. If the switch does not close and open properly when the control button is operated remove the switch and check its closing and opening voltages on the test bench.

New Starting Switch

The larger 4½" starter is equipped with a new electrically controlled starting switch with the control connected to the ignition switch. This starting switch is a solenoid type which electrically closes the circuit between the battery and the starting motor. When the ignition key is turned to the extreme right, a contact is made which energizes the solenoid winding and closes the circuit. The solenoid is spring loaded and the circuit is opened when the ignition key is allowed to return to the "Ignition On" position. No repairs or adjustments can be made on this switch and if trouble develops in one it must be replaced by a new switch.

Bendix Starter Drive

The Bendix type flywheel drive Fig. 173, is used on some starting motors. This drive is designed so that as the starting motor is energized, centrifugal force sends the counter-weighted gear into engagement with the teeth on the flywheel. When the engine starts and the speed of the engine exceeds the comparable speed of the starting motor, the drive pinion is forced out of engagement with the flywheel.

The Bendix spring absorbs the shock of engagement. There are two types of Bendix drives and springs: right hand and left hand. The type used on these models is of the right hand type.

To determine a right or left hand Bendix drive, turn the drive pinion so the threads on the shaft will show. Hold the end of shaft toward you and note spiral of thread: right hand spiral, right hand drive, left hand spiral, left hand drive.

To determine a right or left hand spring, note the spiral of the coil: if to the right, it is a right hand spring — if to the left, it is a left hand spring.

If the Bendix drive spring shows signs of being distorted, a new spring should be installed.

Do not lubricate the Bendix drive sleeve. Wash it thoroughly with kerosene and install it dry but be sure it is clean.

Overrunning Clutch Drive

Some starting motors used are equipped with the overrunning clutch type drive, Fig. 172. In this drive the clutch and pinion slides on companion splines and the pinion in manually engaged, with the flywheel teeth, by the starting switch control arm before the electrical connection is made at the starting switch. Should the switch control arm fail to completely mesh the pinion, engagement is completed by spring No. 4 (Fig. 172) as soon as the armature starts to rotate. When the engine starts, the flywheel drives the pinion faster than the starting motor armature bringing the overrunning clutch into action to disengage the pinion and prevent the engine from driving the armature at excessive speeds.

Should the overrunning clutch fail in service it will be necessary to install a new assembly.

Bendix Folo-Thru Drive

The larger 4½" starter is equipped with the Bendix Folo-Thru type drive which is designed to overcome premature demeshing of the drive pinion from the flywheel ring gear until a predetermined engine speed is reached. See Fig. 174.

No repairs or adjustments are possible on this drive and a complete new unit must be installed if trouble develops.

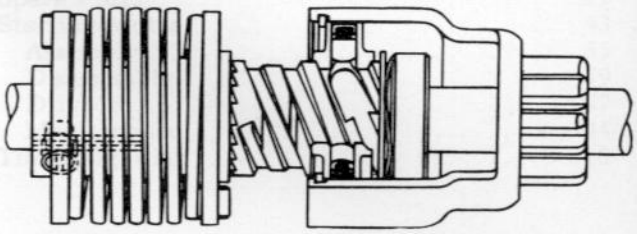

FIG. 174—BENDIX FOLO-THRU DRIVE

Lubrication of Bendix Folo-Thru Drive

A periodic cleaning and relubrication of the drive is advisable, the frequency of which will depend on the type of service to which the vehicle is subjected and the locale of operation.

Remove the starting motor from the engine and take off the outboard housing. The pinion and barrel assembly will be in the demeshed position on the screwshaft. **Do not** move it forward **until after** that portion of the armature shaft ahead of the pinion has been cleaned. If accidentally rotated to the outer end of the screwshaft it will lock in that position and cannot be forced back.

Do not disassemble the drive for any reason.

Do not dip or wash the drive in any cleaning solution.

Do not remove the drive from the armature shaft.

Remove excess oil, grease or foreign matter from the armature shaft by wiping it with a clean cloth. Dampen the cloth with kerosene if necessary. A light film of SAE 10 oil may then be applied to the shaft.

Now rotate the pinion and barrel assembly to the fully extended position, thereby exposing the screwshaft triple threads. Use a cloth dampened with kerosene to wipe them clean. **Do not use gasoline or any commercial cleaner.** If the dirt is thick and gummy, apply the kerosene with a small brush. Tilt the starting motor so that a small amount will run under the control nut. Relubricate with a thin film of SAE 10 oil. Use SAE 5 at extremely low temperatures.

Reassemble the starting motor to the engine with the drive in the extended position. Carefully mesh the pinion with the flywheel ring gear before tightening the starter motor mounting bolts. It may require a slight rotation of the pinion to index it into the ring gear. When the engine starts the drive pinion will automatically demesh from the ring gear and return to its normal position.

ELECTRICAL SYSTEM

Contents

1. GENERAL

The Tornado 230 engine uses a 12-volt electrical system. Make sure a 12-volt battery is provided; and, if the engine is to be used in a vehicle, that 12-volt bulbs and other accessories are provided. Use caution around a 12-volt system as an accidental short circuit is more capable of damaging electrical units.

In the following paragraphs will be found information about the distributor, generator, voltage regulator, and starting motor. These units with their connecting wires make up the electrical system furnished with the engine. To complete the electrical system, it is necessary to furnish a 12-volt battery. Some method of engine ignition control should also be provided.

2. Ignition System

The power in an internal combustion engine is derived from burning a fuel and air mixture in the engine cylinders under compression. To ignite these gases a spark is made to jump a small gap in the spark plug within each combustion chamber.

The ignition system furnishes this spark. The spark must occur in each cylinder at exactly the proper time and the spark in the various cylinders must follow each other in sequence of firing order. To accomplish this, the following units are required:

a. The battery, which supplies the electrical energy;

b. The ignition coil, which transforms the battery low tension current to high tension current which can jump the spark plug gap in the cylinders under compression;

c. The distributor, which delivers the spark to the proper cylinders and incorporates the mechanical breaker, which opens and closes the primary circuit at the exact time;

d. The spark plugs, which provide the gap in the engine cylinders;

e. The wiring, which connects the various units;

f. The ignition switch, which controls the battery current when it is desired to start or stop the engine.

3. Distributor Removal

The distributor is mounted on the right side of the engine and is operated by a coupling on the oil pump shaft which is driven by a worm gear on the crankshaft.

To remove the distributor assembly the following procedure should be followed:

a. Remove high tension wires from the distributor cap terminal towers, noting the order in which they are assembled to ensure correct reassembly. No. 1 spark plug terminal tower is in the 5 o'clock position. Starting with this tower, the wires are installed in a counterclockwise direction in firing order.

b. Remove the primary lead from the terminal post at the side of the distributor.

c. Unlatch the two distributor cap springs and remove the cap.

d. Note the position of the rotor in relation to the base. This should be remembered to facilitate reinstalling and timing.

e. Remove the nut holding the distributor to the timing chain cover; lift the assembly from the engine.

4. Distributor Cap

The distributor cap should be inspected for cracks, carbon runners, and evidence of arcing. If any of these conditions exist, the cap should be replaced. Clean any corroded high tension terminals.

5. Rotor

Inspect the rotor for cracks, or evidence of excessive burning at the end of the metal strip.

After a distributor rotor has had normal use, the end of the rotor will become burned. If burning is found on top of the rotor, it indicates the rotor is too short and needs replacing. Usually when this condition is found, the distributor cap segment will be burned on the horizontal face and the cap will also need replacing.

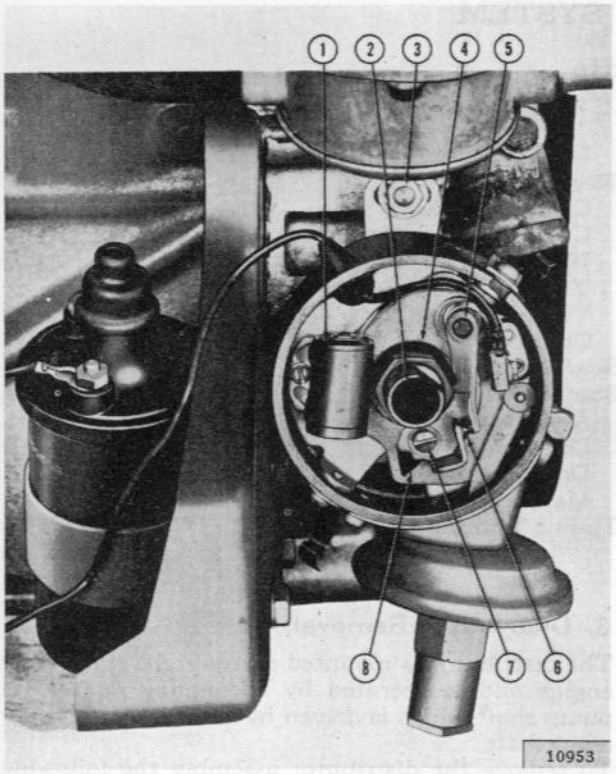

FIG. 175—DISTRIBUTOR

1—Condenser
2—Lubricating Wick
3—Adjusting Nut
4—Breaker Cam
5—Breaker Arm Point
6—Breaker Point
7—Adjusting Screw
8—Stationary Contact

6. Condenser

The condenser prolongs the life of the distributor points by preventing arcing at the contacts. It also provides a hotter spark by creating a reverse surge of current which rapidly breaks down the magnetic field of the coil by demagnetizing the core. Should the condenser be leaky, a weak spark will be experienced.

Check the condenser lead for broken wires or frayed insulation. Clean and tighten the connections on the terminal posts. Be sure the condenser is mounted firmly on the distributor for a good ground connection.

Should a condenser tester be available the condenser capacity should check from .25 to .28 microfarads. In the absence of a tester check by substituting a new condenser.

7. Distributor Points

The contact points should be checked for burning and build-up of metal. If build-up does not exceed 1/64" [about 0,4 mm.] file or grind the points clean, bend into perfect closing alignment.

The contact points should be clean and not burned or pitted. The contact gap should be set at .020" [.508 mm.], measured with a wire gauge. After adjusting, tighten the lock and recheck the gap. If new contacts are installed they should be aligned to make contact at the center of the contact surfaces. Bend the stationary contact bracket to be sure of proper alignment and then recheck the gap. The contact spring pressure is very important and should be between 17 and 22 ounces [.482-.620 kg.]. Check with a spring scale hooked on the breaker arm at the contact and pull in a line at right angles to the breaker arm. Make the reading just as the points separate. This pressure should be within the above limits for if it is too low, missing will occur at high speeds and if too high the cam, block and points will wear rapidly. Adjust the point pressure by loosening the stud holding the end of the contact arm spring and slide the end of the spring in or out as necessary. Retighten the stud and recheck the pressure.

8. Distributor Disassembly

a. Loosen the clips (33, Fig. 176) and remove the distributor cap (1) from the distributor housing (20). Remove the rotor (2) from the drive shaft (12). Remove the terminal screw (5) and washer (6) that secure the low tension lead (36) to the breaker contact plate (7), remove the low tension lead, capacitor lead, and the contact set lead from the terminal. Lift the contact set off the breaker contact plate pivot pin. Remove the screw (39) and washer (38) that secure the capacitor (37) to the contact plate; remove the capacitor. Remove the low tension lead insulating grommet from the distributor housing; remove the low tension lead (36). Remove the advance diaphragm arm retainer clip (4) from the arm pivot pin.

b. Remove the cam felt wick (8), cam retainer clip (9), cam and stop plate (10), and spacer (11) off the drive shaft. Remove the two governor weight springs (35) and governor weights (34) from the governor assembly plate on the drive shaft.

c. Remove two mounting screws (30) washers (31), and clip mountings (32) that secure the cap hold-down clips (33) to the distributor housing; remove the clips. Lift the arm of the advance diaphragm housing (17) off the pivot pin and remove the screw (30) and washer (31); remove the breaker contact plate from the housing.

d. Remove the vacuum tube nipple (13), gasket (14), two spacers (15) and the diaphragm spring (16) from the diaphragm housing (17). Remove the two screws (18) and lockwashers (19) that secure the diaphragm housing to the distributor housing; remove the diaphragm housing.

e. Drive out the coupling rivet (27) that secures the coupling (28) to the drive shaft (12); remove the coupling and thrust washer (22). Remove the drive shaft from the distributor housing.

f. Remove the bolt (24), lockwasher (25), and washer (26) that secure the advance arm (23) to the housing; remove the advance arm. Remove the oiler (29) from the housing.

g. If necessary, press out the two drive shaft bushings (21) from the distributor housing.

h. Clean all metal parts by dipping them in a cleaning solvent; brush with a stiff bristled brush. Drain or blow off cleaning solvent with dry, compressed air.

9. Assembling Distributor

a. Soak two bushings (21), if removed, with clean engine oil and press into position in the housing.

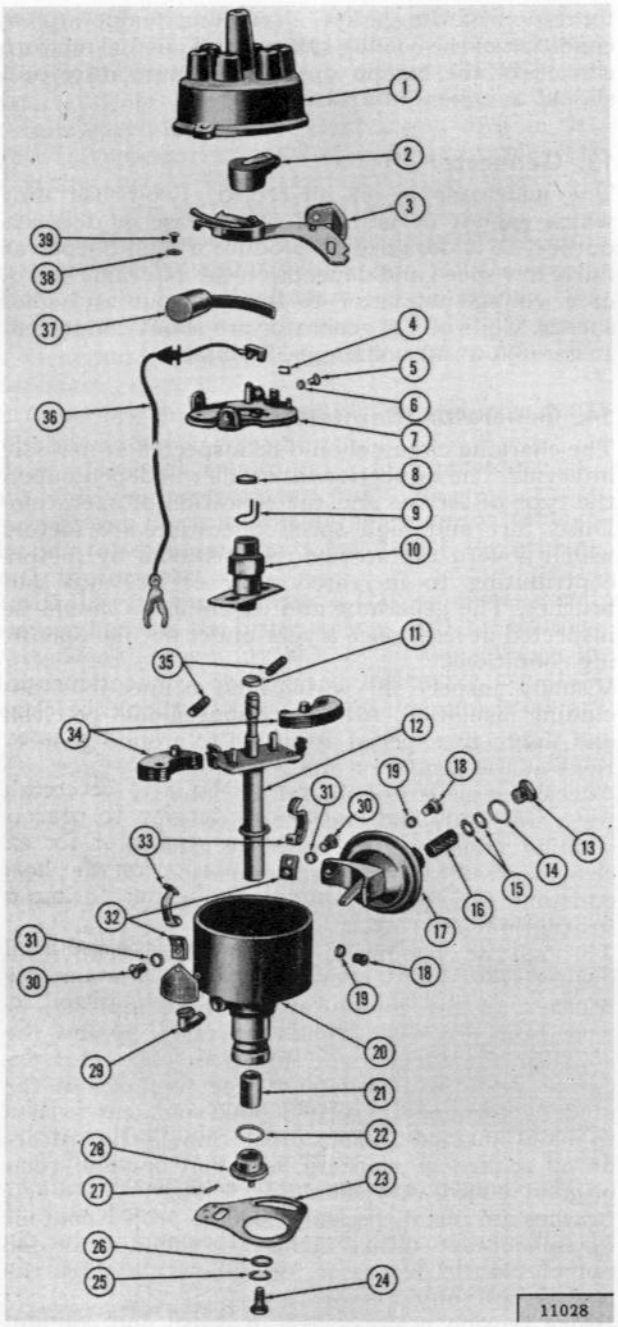

FIG. 176—DISTRIBUTOR

1—Cap
2—Rotor
3—Contact Set
4—Retainer Clip
5—Terminal Screw
6—Washer
7—Breaker Plate
8—Wick
9—Retainer
10—Cam and Stop Plate
11—Spacer
12—Drive Shaft
13—Nipple
14—Gasket
15—Spacers
16—Spring
17—Diaphragm Housing
18—Screw
19—Washer
20—Housing
21—Bushing
22—Thrust Washer
23—Advance Arm
24—Bolt
25—Lock Washer
26—Washer
27—Rivet
28—Coupling
29—Oiler
30—Screw
31—Washer
32—Mounting Clips
33—Holddown Clips
34—Governor Weight
35—Spring
36—Low Tension Lead
37—Capacitor
38—Washer
39—Screw

Press one flush with the top of the bore, the other flush with the bottom.

b. Install the drive shaft oiler (29, Fig. 176 in the distributor housing (20). Mount the advance arm (23) on the housing; secure with a bolt (24), lockwasher (25), and washer (26). After every overhaul and every 50 hours of engine operation, add 3 to 5 drops of oil to the drive shaft oiler.

c. Install the drive shaft (12) in the distributor housing, being careful not to nick or score the bearing inserts. Position the thrust washer (22) and coupling (28) on the drive shaft; secure with the coupling rivet (27). Drive shaft end play, should be measured with a feeler gage; .003" to .010" [,076 a ,254 mm.] end play is allowed. Shaft side play should not exceed .005" [,127 mm.].

d. Install the two governor weights (34) and their springs (35) on the governor assembly plate on the drive shaft. Lubricate the governor mechanism with a few drops of clean engine oil. Install the spacer (11) and the cam and stop plate (10) on the drive shaft; secure with the cam retainer clip (9). Saturate the cam felt wick (8) with clean engine oil and install on top of the cam.

e. Position the two mounting clips (32) and holddown clips (33) on the distributor housing; partially insert the two screws (30), and washers (31). Position the breaker contact plate (7) in the housing; secure with the two clip mounting screws and washers and a third screw and washer.

f. Insert the arm of the advance diaphragm into the opening in the distributor housing. Install the arm on the arm pivot pin in the breaker contact plate; secure with the retainer clip (4). Secure the advance diaphragm housing (17) to the distributor housing with a screw (18) and washer (19). Install the diaphragm spring (16), two spacers (15), gasket (14), and vacuum tube nipple (13) in the diaphragm housing.

g. Insert the low tension lead (36) into the grommet opening in the distributor housing; install the insulating grommet in the housing wall. Position the capacitor (37) on the breaker contact plate; secure with a screw (39) and washer (38). Install the breaker contact set (3) on the breaker plate pivot pin. Connect the contact set lead, the capacitor lead and the low tension lead terminal to the lead mounting terminal with the screw (5) and washer (6). Lubricate the contact set pivot pin with one drop of oil. If the contact set is of nylon construction, do not lubricate. See engine tune-up section for contact adjustment and vacuum advance checking.

10. Setting Ignition Timing

The procedure for setting the ignition timing is given in the engine tune-up section.

11. Distributor Installation

Install the distributor as directed in Par. 99 of the engine section.

12. Spark Plugs

Clean and gap spark plugs as described in the tune-up section. Inspect them for excessive burning and erosion of electrodes, blistering of porcelain at the firing tip, black deposits, or fouling. These

conditions indicate that the plugs have not been operating at the correct temperature.

Note: Prolonged idling just before removing and checking the plugs should be avoided as it may produce false indications.

Spark plug operating temperatures may have been too hot, too cold, or normal as described.

a. At too hot a temperature, the tip of the insulator will show dark spots and blisters after fairly short service. As high-temperature operation is continued, the whole insulator nose will discolor, showing fused and blistered deposits near the electrodes as well as considerable erosion and burning of the electrodes. After extreme service, the porcelain itself may be fused, cracked, and blistered at the tip. The electrodes will show extreme erosion and burning and possibly even surface cracking.

Note: If such cracking appears on certain plugs after fairly short service, it may be caused by water leaks in the associated cylinders.

b. At too cold a temperature plug operation, in the early stages, will result in a dull black sooting of the plug. This condition frequently is found in new vehicles during the break-in period and is no indication of trouble in this case. As the condition progresses, black deposits of oil and carbon build up on the base of the shell and on the insulator until, in extreme cases, the space between insulator and shell may be almost completely filled. Excessive electrode erosion will seldom be found in cases of cold plug operation. These indications can be produced by the use of an excessively rich air-fuel mixture and the carburetor should be checked if this condition is suspected. Fouling will also be caused by leaking rings or intake valve guides that permit excessive oil to reach the combustion chambers. The use of a hotter plug will help burn away some of this fouling but the mechanical condition of the engine should be corrected.

c. In normal temperature operation the plug will accumulate grayish-tan to reddish-brown deposits with fairly uniform discoloration of the insulator nose and slight, localized electrode erosion. If the insulator shows any blotches, blisters, irregular discoloration, etc., look for hot-plug symptoms. Too hot or too cold plug operation may be caused by the use of plugs of other than the specified heat rating but if the plugs are as specified, a hotter or colder plug may be desirable. However, under-or over-heating is usually caused by factors other than the type of spark plugs and the cause should be determined before changing plugs. The design of the engine calls for plugs equivalent to Champion L-71 (as installed in production) though any factor that consistently affects engine operating temperature may cause this requirement to change. Overheating may be caused by insufficient tightening of the plug in the head, which interferes with the flow of heat away from the firing tip. If this is the case, the plug gasket will show very little flattening. Over-tightening, in turn, will produce too easy a heat flow path and result in cold plug operation. This will be evident by excessive flattening and deformation of the gasket. Prevailing temperatures, condition of the cooling system, and air-fuel mixture can effect the engine operating temperature and should be taken into consideration.

13. Generator

The generator is an air-cooled, two-brush unit which cannot be adjusted to increase or decrease output. It is designed to produce a high output at fairly low speed and depends on the external control of a voltage regulator to limit output at higher speeds. Coils of the generator are shunt connected. It is rated at 12 volts and 35 amps.

14. Generator Maintenance

The charging circuit should be inspected at periodic intervals. The inspection intervals will depend upon the type of service and the condition of operation. Dust, dirt and high speed operation are factors which govern the service requirements by factors contributing to increased wear of bearings and brushes. The generator and its circuitry should be inspected at least once a year under normal operating conditions.

Visually inspect all wiring and connections, including insulation. All connections should be clean and tight; give special attention to ground connections at the generator and regulator.

Check the generator mounting bolts to be certain they are tight, and check belt tension to prevent slipping under load. Check the generator for excessive grease and dirt accumulation on the head ends and fan to avoid over-heating due to loss of ventilation.

Through the openings in the commutator end head, inspect the condition of the commutator and the brushes. If the commutator is rough, pitted, or worn, the armature should be removed and the commutator turned and undercut, See Par. 16. Check that the brushes are free to move in the holders and that the springs have sufficient tension to maintain good brush contact. Should the brushes be oil soaked or worn to less than one-half their original length, they should be replaced. When new brushes are installed, sand them to proper contour for full contact surface against the commutator. Do not check the generator for full output until the brushes are fully seated.

Brush tension is important to brush and commutator wear and to arcing of the brushes. Test the spring tension with a spring scale and set to 18 to 36 oz. [0,510 kg. a 1,020 kg.]. Excessive tension causes excessive wear, and insufficient tension causes brush arcing.

Lubricate the generator end heads every 6000 miles [9000 km.] with 3 to 5 drops of SAE 30 oil in the oiler cups.

15. Disassembly

If generator trouble is suspected because of an extremely low charging current, localize the fault before removing the generator for repair. Such fault may be in the regulator, the cables or the battery. See Paragraph 22 of this section for localizing tests. Be sure the wiring and insulation is in good con-

dition and properly connected. To test the wiring and connections electrically, connect an ammeter between the regulator battery terminal and the lead removed from this point. Run the engine at a medium speed (about 2000 RPM) and turn on the lights and accessories for a load of about 10 amperes. With this current load, take a voltage reading with a 10 volt meter between the following points:

a. Generator armature terminals to insulated battery post—.6 volts maximum.

b. Generator field terminals to regulator field terminal—.05 volts maximum.

c. Generator frame to regulator base—.03 volts maximum.

d. Generator frame to battery ground post—.03 volts maximum.

Make additional tests to locate high resistance circuit if higher readings are found in any test. If quite certain the trouble is in the generator, remove the generator support bolts and detach the generator from the engine.

Reach through the openings in the commutator end head and release the brush springs. Lift the brushes away from the commutator to avoid damaging them during removal. (See Fig. 95.) Remove the thru bolts (45) and pull the commutator end head (5) away from the frame (11). To remove the bearing (2), remove the oil retainer (1) and press out the bearing. Remove the oiler (4), and the wick (3), To remove the brushes, remove the screws (6), and lockwashers (7) and slide the brushes (8) out of the brush arms (10). Remove the brush arms from the brush holders in the frame, unhook the brush springs. Pull the armature (44) and drive head (34) from the generator frame. Remove the shaft nut (33) and lockwasher (32) and take the drive pulley and fan assembly off the shaft. Do not lose the woodruff key (43) when the pulley is removed.

To remove the ball bearing, remove the three screws (41), lockwashers (40), the bearing retainer (39) and gasket (38). The bearing (37), retainer (36) and felt washer (35) may now be removed.

16. Armature

If the armature is rough or worn, turn it down in a lathe. The mica should then be undercut to a depth of $\frac{1}{32}$" to $\frac{3}{64}$" [0,8 mm: a 1,2 mm.].

To test the armature for a ground, connect one prod of a test lamp to the core or shaft (not on bearing surface) and touch each commutator segment with the other prod. If the lamp lights. the segment is grounded and the armature must be replaced.

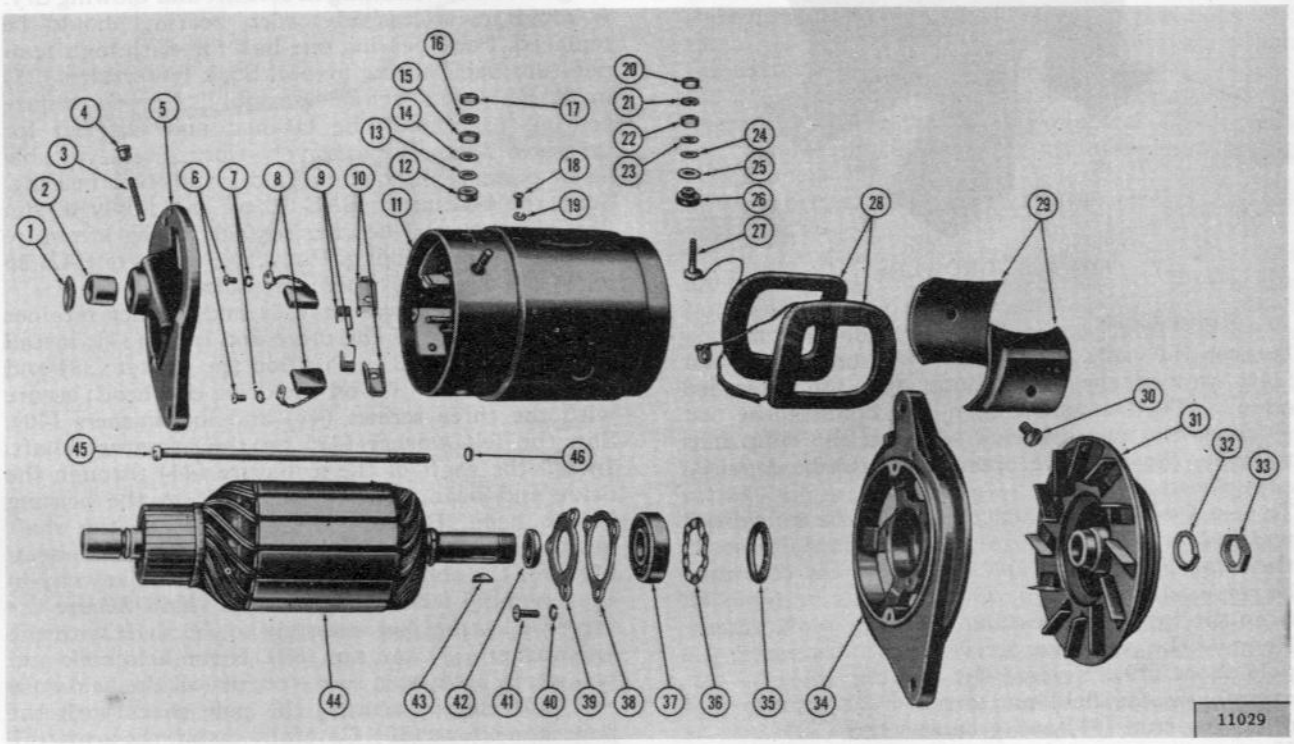

FIG. 177—GENERATOR, EXPLODED VIEW

1—Oil Retainer
2—Bearing
3—Felt Wick
4—Oiler
5—Commutator End Head
6—Brush Lead Screw
7—Lockwasher
8—Brush Set
9—Brush Spring
10—Brush Arm
11—Frame
12—Insulating Bushing
13—Washer
14—Lockwasher
15—Hex Nut
16—Lockwasher
17—Hex Nut
18—Ground Screw
19—Lockwasher
20—Hex Nut
21—Lockwasher
22—Hex Nut
23—Lockwasher
24—Washer
25—Insulating Washer
26—Insulating Bushing
27—Stud
28—Left and Right Field Coil
29—Pole Shoes
30—Pole Shoe Screw
31—Drive Pulley and Fan Assembly
32—Lockwasher
33—Shaft Nut
34—Drive End Head
35—Felt Washer
36—Felt Washer Retainer
37—Ball Bearing
38—Gasket
39—Bearing Retainer
40—Lockwasher
41—Retainer Screw
42—Felt Washer
43—Woodruff Key
44—Armature
45—Thru Bolt
46—Lockwasher

To test for a short in the armature coils, a growler is needed. (See Fig. 178.) Place the armature on the growler and lay a thin strip of steel on the armature core. Rotate the armature slowly by hand and the steel strip will vibrate if a coil is shorted. The armature must be replaced if a coil is shorted.

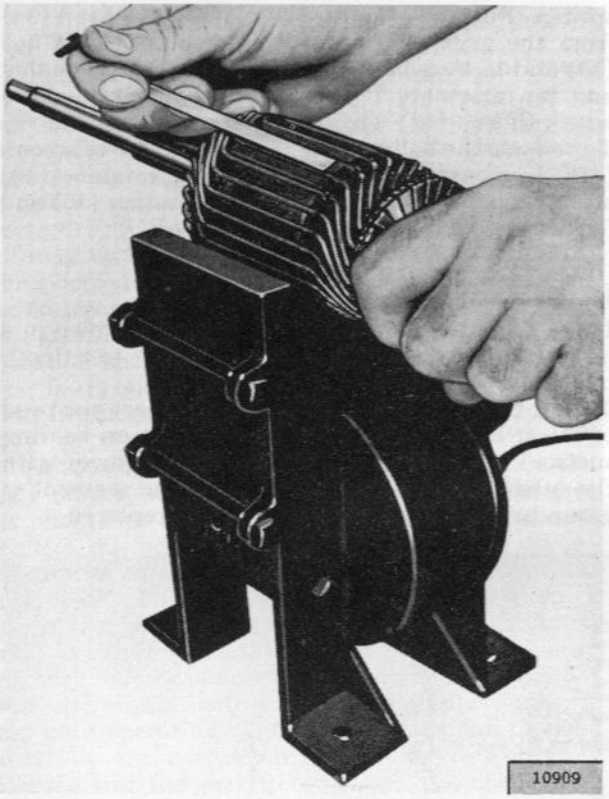

FIG. 178—GROWLER

17. Field Coils

Inspect the coils for chafed wires and using test lamp probes check for both open or grounded circuits. To test for an open coil, connect the test prods to the two coil lead wires. If the lamp fails to light, the coils are open and must be repaired or replaced.

To test for a ground, place one prod on a field coil terminal wire and the other prod on the frame. If the lamp lights, a ground exists and the coil must be repaired or replaced. The coils may be removed from the frame for cleaning, repair or replacement. Remove the pole shoe screws (30) and remove the pole shoes (29). Release the coil terminals by disassembling the field and armature terminals and removing stud (27) and ground screw (18).

If accurate test equipment is available, check the current flow through the coils with 10 volts applied. The current should be 1.6 to 1.7 amperes. A shorted coil will show a much higher current draw and an open coil will show no current draw. In either case the generator output will be below normal.

When reinstalling the field coils, stake the pole shoe screws with a center punch to avoid loosening.

18. Brushes

Service information for the brushes may be found in Paragraph 19.

19. Brush Holders

With the test prods, check the insulated brush holder to be sure it is not grounded. Touch the brush holder with one prod and the end plate with the other prod. If the lamp lights, a brush holder is grounded. When the test probe touches the grounded brush holder, the lamp will light

Inspect the brush holders for distortion or excessive rust. Replace the brush springs if they are excessively burned or rusted. Make sure the brushes slide freely in the holders. If the brushes are oil soaked, charred, or less than one-half their original length, they should be replaced.

Brushes should be reseated for complete surface contact when replaced. Do this by wrapping a piece of 00 sandpaper around the commutator, abrasive side out, beneath the brushes, and rotating it in the same direction it rotates while operating. After sanding, blow the carbon and sandpaper dust out of the generator. Final testing of the generator should allow operation at normal load current for a run-in period before testing for full load output.

20. Generator Assembly

Check ball bearing (37, Fig. 177) for looseness or roughness after cleaning in solvent and blowing dry. A rough or excessively worn bearing should be replaced. Pack bearing one-half full with high temperature ball bearing grease. Soak felt washer (35) in SAE 30 oil before assembly. Porous bronze bearing (2) should be cleaned and checked for excessive wear. If excessively worn, use a suitable arbor press to remove old and install new bearing. Soak the bearing in SAE 30 oil and apply a thin film of oil to the bearing surface of the armature shaft when assembling. Put 3 to 5 drops of SAE 30 oil in the oilers (4) when assembled.

Position the felt washer (35) and washer retainer (36) in the bore of the drive end head (34); install the ball bearing (37). Position the gasket (38) and bearing retainer (39) on the drive end head; secure with the three screws (41) and lockwashers (40). Slip the felt washer (42) on the armature shaft. Install the shaft of the armature (44) through the drive end head, seating the shaft in the bearing in the head. Position the key (43) in the shaft keyway and install the drive pulley and fan assembly over the shaft and key, aligning the keyway in the assembly with the key in the shaft. Secure the drive pulley and fan assembly to the shaft with the lockwasher (32) and nut (33). If the field coils and pole shoes have been removed, install the field coils and pole shoes, securing the pole shoes with the pole shoe screws (30). Carefully install the armature through the frame; making sure that the coils do not scrape. Seat the drive end head on the frame end. Slide the brush arms on the studs in the frame; install the brushes in the brush arms and secure the brush leads with the screws (6) and lockwashers (7). Install the brush springs; seating the brushes on the commutator. If the sleeve bearing (2) has been removed from the commutator end head, press in a new sleeve bearing and install the oil retainer (1). Position the commutator end head on the frame; secure the assembly with the two thru bolts (45) and lockwashers (46).

When installing the generator on the engine, the bracket bolt torque wrench reading is to be 20 to 25 lbs. ft. [2.8 a 3.4 kg.m.].

21. Generator Test Procedure

Connect the generator as shown in figure 179. Using the carbon pile rheostat, adjust the voltage ±10 volts. The motorizing draw should be 3.1 to 3.5 amperes. If motorizing draw is high, fault may be in bearing fit or alignment, or mechanical interference between aramature and pole shoes, or improper end play. Rap the frame sharply with a rawhide hammer to free the armature. Tighten the pole shoes.

Install the generator in a test bench and connect so it is driven at a speed of 1750 maximum rpm. The generator should deliver 15 volts, 16 amperes minimum. Increase the speed to 2300 maximum rpm. The generator should deliver 15 volts at 35 amperes.

Caution: Do not operate at more than 35 amperes for more than a few seconds.

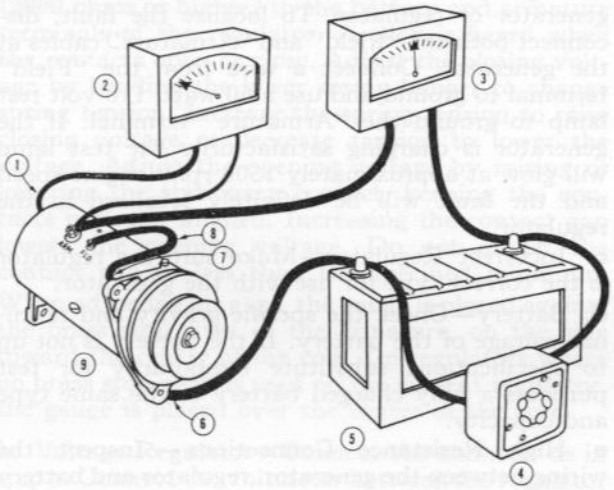

FIG. 179—GENERATOR TEST

1—Ground
2—Voltmeter
3—Ammeter
4—Carbon Pile Rheostat
5—Battery
6—Ground
7—Ground
8—Jumper
9—Generator

22. Current-Voltage Regulators

The regulator (Fig. 180) must match the generator for voltage, current, polarity and common source of manufacture. If this is not done; loss of current capacity or a burned out generator may result.

These regulators are used with shunt type generators and have three units, each with a separate function to perform. These units are the circuit breaker unit, the voltage regulator unit, and a current limiting regulator unit. Each unit is discussed in the following paragraphs.

23. Circuit Breaker

It consists of an electromagnet and a set of contacts. The contacts are mounted with one on a stationary bracket, and the other on a movable armature which is controlled by the electromagnet. The

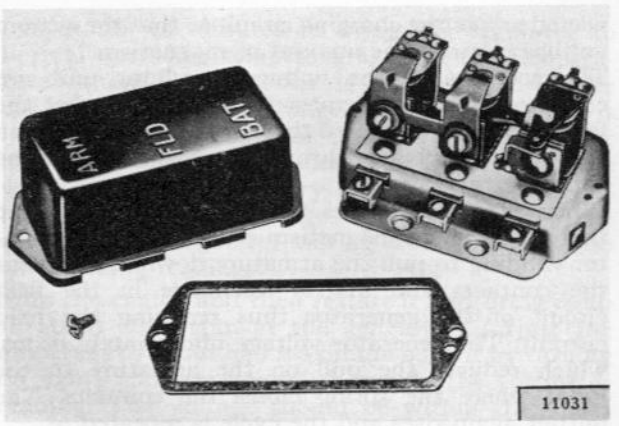

FIG. 180—CURRENT-VOLTAGE REGULATOR

movable contact is mounted on a spring arm so that as the contacts open and close a slight wiping action is produced.

The electromagnet of the circuit breaker has two windings, one, the shunt coil which is connected across the generator output like a voltmeter and the other a series coil connected in series with the generator output like an ammeter. These two coils are wound in the same direction so that when the generator is charging the battery, the magnetism of the series coil increases the total magnetism. When the battery discharges back through the generator, the magnetism of the series coil is reversed and the magnetism of the two coils is opposed. This results in a decreased pull on the armature and spring action opens the contacts.

The sequence of operation of the circuit breaker is as follows:

When the generator is not running, the contacts are open. When the generator is started, the voltage builds up at the armature terminal and in the shunt coil and as soon as it reaches the value for which the circuit breaker is calibrated, there is sufficient magnetism created by the shunt coil to pull down the armature, closing the contacts which automatically connects the generator to the battery. With the contacts thus closed the current in the series coil is flowing from the generator to the battery or in the same direction as the current in the shunt coil, so that the pull on the armature is increased by the magnetism of the series coil.

When the engine is stopped and the generator loses speed, the voltage falls, and as soon as the generator voltage drops below the battery terminal voltage, the current flows from the battery to the generator, reversing the direction of current in the series coil so that the magnetism created by the series coil opposes and reduces the magnetism of the shunt coil. This reduces the pull on the armature to a point where spring action opens the contacts.

24. Voltage Regulator

The function of the voltage regulator is to hold the generated voltage at a predetermined value as long as the circuit values allow the voltage to build up to the operating voltage.

The electromagnet of the voltage regulator unit has a winding of many turns of fine wire and is con-

nected across the charging circuit so that the system voltage controls the amount of magnetism.

The contacts of the voltage regulator unit are connected in the generator field circuit so that the field circuit is completed through the contacts when they are closed and through a resistor when the contacts are opened.

When the voltage rises to a predetermined value there is sufficient magnetism created by the regulator winding to pull the armature down. This opens the contacts and inserts resistance in the field circuit of the generator thus reducing the field current. The generator voltage immediately drops, which reduces the pull on the armature to the point where the spring closes the contacts. The output again rises and the cycle is repeated.

These cycles occur at high enough frequencies to hold the generated voltage at a constant value and will continue as long as the voltage of the circuit is high enough to keep the voltage regulator unit in operation. With the addition of a current load great enough to lower the battery voltage below the operating voltage of the unit, the contacts will remain closed and the generator will maintain a charging rate is limited by its speed or the current limiting regulator.

Due to the effect of heat on the operating characteristics of regulator windings it is necessary to compensate for the changes in coil resistance when the regulator is operating under varying temperature conditions. This is accomplished through the use of a bimetal hinge on the voltage regulator. This design feature limits the initial system voltage when cold, with a resultant reduction in ignition primary current. During the warmup period, this feature materially reduces "blue point" tendencies that occur with high system voltage. In extremely cold temperatures the initial voltage may be several tenths of a volt lower than the cold operating value for the first few minutes of operation. The compensation is usually more than enough to offset changes in the regulator coil resistance. The excess compensation allows the regulator to operate at higher voltages under cold operating conditions. This is necessary because a battery requires higher voltages for charging at low temperatures because of increased internal resistance when cold.

25. Current-Limiting Regulator

The function of the current-limiting regulator is to limit the output of the generator to its maximum safe output.

The electromagnet of the current regulator unit consists of a winding of heavy wire that is connected in series with the generator output. When the generator output reaches a predetermined value, the current in the winding produces enough magnetism to overcome the spring tension and pull the armature down. This opens the contacts and inserts resistance in the field circuit of the generator. With the field current reduced by the resistance, the generator output falls and there is no longer enough magnetism to hold the contacts open. As soon as the spring closes the contacts, the output rises and the cycle is repeated. These cycles occur at high enough frequencies to limit the output to a minimum fluctuation.

26. Preliminary Inspection

a. Wiring—Check the wiring to see that it is properly connected to the generator.

b. Generator Performance—Make sure the generator operates correctly without the regulator in the circuit. Remove the armature and battery leads from the regulator and connect an ammeter between them. Remove the field lead from the regulator and while operating at idle speed touch the field lead to the regulator base. Increase the speed slowly noting the charging rate.

Caution: Do not increase the output above the rated output of the generator.

If the generator output will not build up inspect the wiring harness for shorts and opens and remove the generator for an overhaul. To check the generator circuit when a suitable ammeter is unavailable, disconnect the armature cable at the regulator. Connect one lead of a 6-12v test lamp to the regulator terminal marked "armature" and with the engine running, ground the other lead. Should the test light fail to burn there is a fault either in the generator or regulator. To localize the fault, disconnect both the "Field" and "Armature" cables at the generator. Connect a wire from the "Field" terminal to ground and use a 60 watt, 110 volt test lamp to ground the "Armature" terminal. If the generator is charging satisfactorily the test lamp will glow at approximately 1500 rpm. engine speed and the fault will be definitely localized in the regulator.

c. Incorrect Regulator—Make sure the regulator is the correct type for use with the generator.

d. Battery—Check the specific gravity and terminal voltage of the battery. If the battery is not up to specifications substitute temporarily for test purposes a fully charged battery of the same type and capacity.

e. High Resistance Connections — Inspect the wiring between the generator, regulator and battery for broken wires and high resistance connections. Pay special attention to the ground connections at all three units. Connect a reliable ammeter with 1-ampere graduations in series with the regulator B terminal and the lead removed from this terminal. Run the generator at a medium speed and turn on the lights or accessories until the ammeter shows a 10-ampere charging rate. At this charging rate measure the voltage drop between the following points using an accurate voltmeter graduated in 1-volt divisions. The voltmeter should not show a reading above the maximum noted.

Generator "A" terminal to regulator "A" terminal —.1-volt maximum.

Generator "F" terminal to regulator "F" terminal —.05-volt maximum.

Battery terminal to regulator "B" terminal—.1-volt maximum.

Regulator ground screw to generator frame—.03-volt maximum.

Regulator ground screw to battery ground post —.03-volt maximum.

Generator frame to battery ground post—.03-volt maximum.

27. Test Procedure

a. Circuit Breaker-Connect an ammeter between the regulator B terminal and the wire removed from that terminal as shown in figure 181. Connect a voltmeter between the regulator A terminal and the regulator mounting base. Disconnect the field lead from the regulator F terminal and insert a variable resistance (3 amp. - 50 ohm) between the lead and the regulator terminal. Run the generator at about 8000 rpm. Insert all the resistance in the field circuit, then slowly reduce the resistance, noting the voltage reading just before the change caused by the closing of the circuit breaker. Increase the charging rate to that specified for the regulator under test and then reduce the charging rate by inserting resistance in the field circuit. Note the voltmeter and ammeter readings just before the circuit breaker opens and the ammeter reading drops to zero. The closing voltage and the opening voltage or current should be within the specified limits. An accurate method for noting the exact instant of the opening or closing of the circuit breaker is to connect a headphone (2000 ohms or higher) to the battery and armature terminals of the regulator. A click is heard when the contacts open or close. Adjust the closing voltage by bending the lower spring hanger to change spring tension. Increase the spring tension to raise closing voltage or decrease tension to lower the voltage. Adjust the opening voltage by raising or lowering the stationary contact, keeping the contacts perfectly aligned. Increasing the contact gap lowers the opening voltage. Do not adjust the contact gap to less than the specified minimum. When adjusting air gaps the gauge is placed against the brass stop rivet of the armature, on the side toward the center of the core. On regulators where no brass stop rivet is used on the current regulator, the gauge is placed over the center of the core.

b. Voltage Regulator—Connect the ammeter as in step a. Connect the voltmeter between the regulator B terminal and the regulator base as shown in Fig. 182. Remove the variable resistance from the field circuit. Insert a ¼-ohm fixed resistance in series with the ammeter. Run the generator at half output for 15 minutes to bring the regulator to normal operating temperature. Since the temperature voltage compensation is accomplished by the use of a thin bi-metal hinge, voltage calibration is more sensitive to stray air currents when the cover is removed during adjustment. For this reason more warm-up time is necessary after each trial adjustment to allow the voltage to stabilize. Keep the cover on the regulator during warm-up and also when taking readings.

Stop the engine and then restart it and bring it up to about 2500 rpm at the generator. Adjust the amperage to about half maximum output by turning on lights and accessories, then note the voltmeter reading. The voltage should be within the limits specified for the voltage regulator. To adjust the voltage, change the spring tension by bending the hanger at the lower end of the spring. After each adjustment, stop the engine and restart it, bring it up to speed and adjust the current before taking a reading. To obtain an accurate indication of the opening and closing of the voltage regulator contacts, connect a headphone between the F terminal and ground. Clicks should be regular and clear, without irregularities. If the tone is not clear and regular, remove the cover and inspect the contacts. The contacts should be flat and not excessively burned and should be aligned to be full face contact. If they need cleaning refer to paragraph d for the method.

c. Current Regulator—Connect the regulator and test equipment as in step b. Remove the ¼-ohm fixed resistor from the circuit and connect a carbon pile rheostat across the battery as shown in Fig. 183. With the generator running at about 300 rpm, turn on lights and accessories to require maximum current rate from the generator. Adjust the limiting amperage by changing spring tension. After each adjustment, stop the engine and restart it, bring it up to speed and take a reading. Keep the cover on the regulator when taking the readings. Use a headphone as described in paragraph b to hear the tone of contact operation. Rough and erratic tone indicates the need for contact inspection. If they need cleaning, refer to paragraph d for the method.

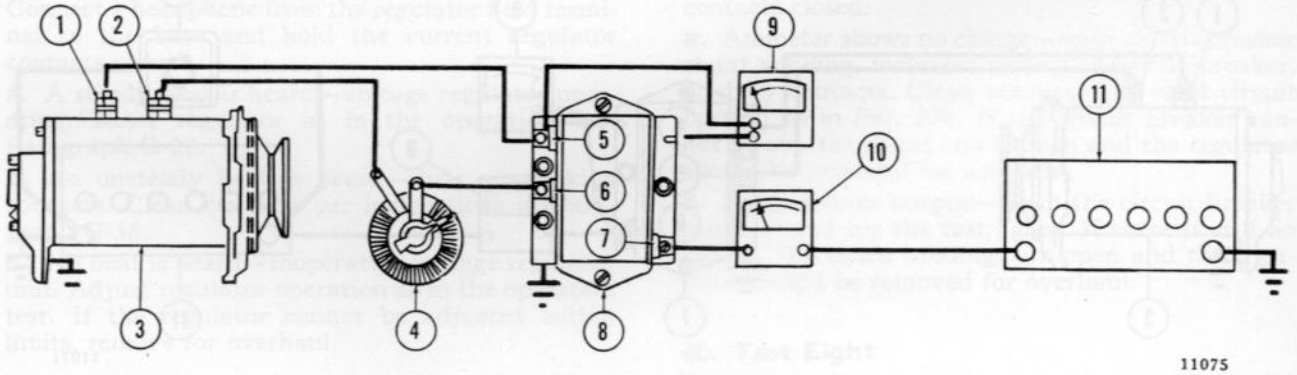

FIG. 181—CIRCUIT BREAKER TEST

1—Armature
2—Field
3—Generator
4—Field Rheostat
5—Armature
6—Field
7—Battery
8—Regulator
9—Voltmeter
10—Ammeter
11—Battery

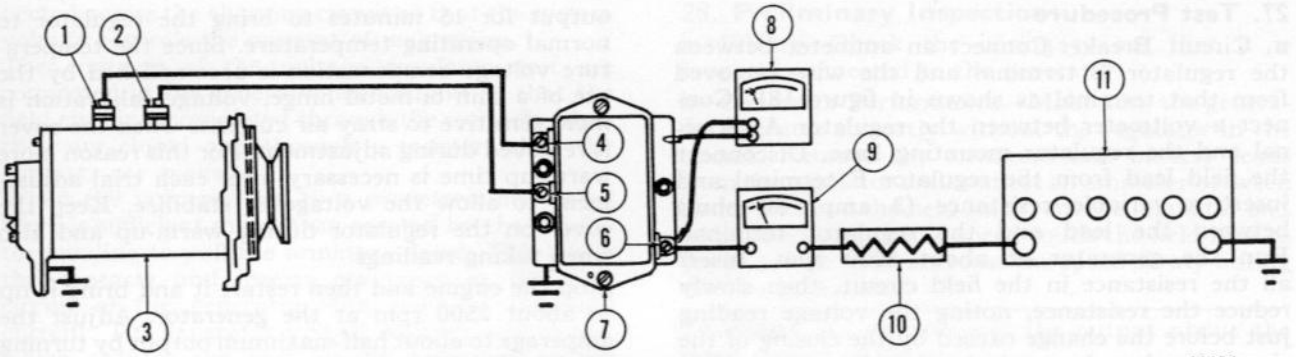

FIG. 182—VOLTAGE REGULATOR TEST

1—Armature
2—Field
3—Generator
4—Armature
5—Field
6—Battery
7—Regulator
8—Voltmeter
9—Ammeter
10—¼ OHM Fixed Resistor
11—Battery

d. Contacts—The regulator contacts, both upper and lower, are tungsten. The voltage regulator and the current regulator stationary contact bracket is combined as one integral part so that the gap adjustments must be made simultaneously. Final adjustment of the contacts may be done by a slight bending of the stationary contact support as required. Inspect the contacts on all three units. The contacts become grayed in normal use. Tungsten contacts normally require no service. If pitted, a #6 American-Swiss Cut equalling file may be used to remove oxides and irregularities. Due to the extreme hardness of tungsten contacts it is virtually impossible to remove all pitting, and is unnecessary to do so. Removal of the oxides normally restores satisfactory operation. After filing, dampen a piece of linen or lintless bond tape in refined carbon tetrachloride and draw the tape between the contacts. Repeat with a dry tape to remove all carbon-tetrachloride. Use a clean tape for each set of contacts.

e. Recheck—Operate the unit at half maximum output for five minutes with the cover on the regulator. Repeat the test procedure for all units as described in a, b, and c above. Be sure the cover is on the regulator when taking readings.

28. QUICK CHECKS

29. Low Charging Rate With a Fully Charged Battery

A fully charged battery and a low charging rate indicates normal regulator operation. A further check of regulator operation can be made by using the starting motor for 5 to 10 seconds with the ignition switched off. Then start the engine and operate the generator at about 2500 rpm. The charging rate should rise to maximum and then taper off to a minimum charge as the battery recovers charge.

30. High Charging Rate with a Fully Charged Battery

This is usually an indication the voltage regulator is not working properly. The high voltage shortens ignition contact life and causes excessive battery gassing. Connect an ammeter in series with the regulator B terminal and the lead removed from that terminal. Run the generator at medium speed and perform the following operations. After each

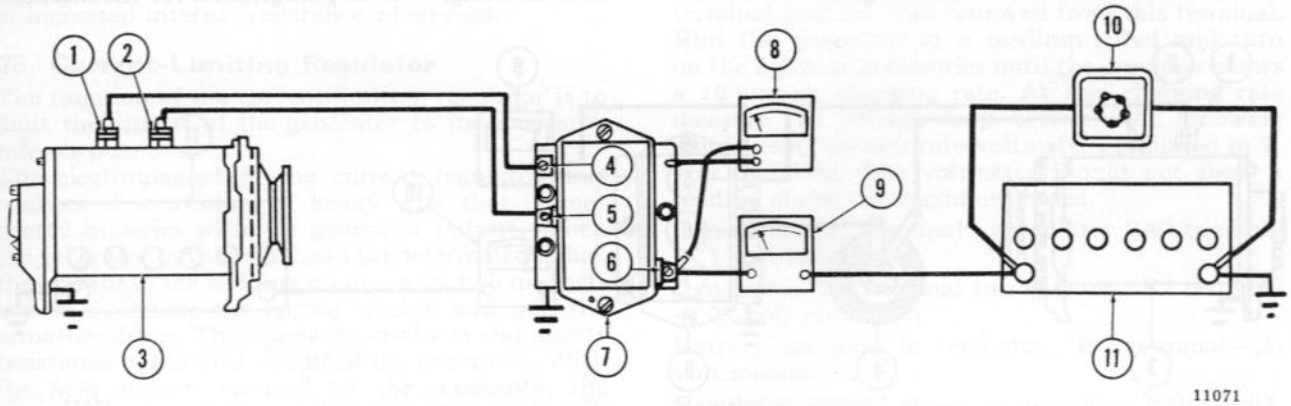

FIG. 183—CURRENT REGULATOR TEST

1—Armature
2—Field
3—Generator
4—Armature
5—Field
6—Battery
7—Regulator
8—Voltmeter
9—Ammeter
10—Carbon Pile Load Rheostat
11—Battery

test is completed, reconnect leads which have been opened.

31. Test One

Disconnect the field lead at the generator.

a. Output drops to zero—shorted field circuit in the regulator or the wiring harness. See test 2.

b. Output does not drop—shorted field circuit in the generator. Inspect the generator.

32. Test Two

Disconnect the field lead at the regulator.

a. Output drops to zero—shorted field in regulator. See test 3.

b. Output does not drop—shorted wiring harness. Repair or replace the wiring harness.

33. Test Three

Remove the regulator cover and hold the voltage regulator contacts open.

a. Output drops to zero—regulator contacts sticking, regulator out of adjustment, or regulator inoperative. Check operation (test 5), check for high resistance (test 4), and clean contacts per Par. 36.

b. Output does not drop—shorted field circuit in the regulator. Clean the regulator contacts and inspect the regulator for incorrect wiring between units and for shorted leads.

34. Test Four

Operate the units at 10 amperes output and measure the voltage drop from the regulator base to the generator frame

a. Voltage reading below .03 volts—ground circuit is satisfactory. See test 5.

b. Voltage reading above .03 volts—inspect the ground circuit for poor connections and eliminate resistance. See test 5.

35. Test Five

Connect a headphone from the regulator field terminal to the base and hold the current regulator contacts closed.

a. A steady beat is heard—voltage regulator operating. Reset regulator as in the operation test Paragraph G-27.

b. An unsteady beat is heard—dirty or sticking contacts. Clean contacts per instructions in Paragraph G-36.

c. No beat is heard—inoperative voltage regulator unit. Adjust regulator operation as in the operation test. If the regulator cannot be adjusted within limits, remove for overhaul.

36. Cleaning of Contacts

Clean the voltage regulator contacts with a #6 American-Swiss cut equalling file. File lengthwise and parallel to the armature and then clean the contacts with clean linen tape. Wet a piece of tape in carbon tetrachloride and draw it between the contacts. Then wipe with a clean dry tape. Reset the regulator operation as in the operation test, Par. 27. When adjusting the air gaps, the gauge is placed against the brass stop rivet of the armature, on the side toward the center of the core. On regulators where no brass stop rivet is used on the current regulator, the gauge is placed over the center of the core.

37. Low Battery and a Low or Zero Charging Rate

Check all wiring for loose connections, frayed insulation and high resistance connections; correct any fault. Make sure the generator operates without the regulator in the circuit. Remove the A and B terminal leads from the regulator and connect an ammeter between them. Remove the field lead from the regulator and touch it to the base while operating at idle speed. Increase the speed slowly, noting the charging rate. Do not exceed the rated output of the generator. If the output does not build up, inspect the wiring harness for shorts and opens. Remove the generator for overhaul if no other fault is found.

Connect an ammeter between the battery lead and the regulator B terminal. Connect the field lead to the regulator F terminal and connect the armature lead to the A terminal. Connect a voltmeter from the regulator A terminal to the base. Operate the generator at a medium speed and perform the following tests:

38. Test Six

Read the voltmeter.

a. Voltage builds up—open series circuit. See test 7.

b. Voltage does not build up—regulator out of adjustment, field circuit open, grounded series circuit. See test 8.

39. Test Seven

Remove the regulator cover and operate the generator at medium speed, holding the circuit breaker contacts closed.

a. Ammeter shows no charge—open circuit breaker shunt winding, incorrect setting of circuit breaker, or dirty contacts. Clean contacts and reset circuit breaker as in Par. 27a. If the circuit breaker cannot be set, the shunt coil is open and the regulator should be removed for overhaul.

b. No generator output—clean the circuit breaker contacts and try the test again. If there is still no charge, the series windings are open and the regulator should be removed for overhaul.

40. Test Eight

Run the generator at idle speed and momentarily connect a jumper from terminal F to the base.

a. Voltage builds up—open field circuit or regulator out of adjustment. See test 9.

b. Voltage does not build up—grounded series circuit. Remove regulator for overhaul.

41. Test Nine

Operate at medium speed with the jumper removed. Remove the regulator cover and hold the voltage regulator contacts closed.

a. Voltage builds up — voltage regulator contacts burned, dirty, or incorrect setting. Clean the contacts and adjust the regulator as in Par. 27.

b. Voltage does not build—clean the contacts and repeat the test. If the voltage still does not build up, see test 10.

42. Test Ten

Remove the regulator cover and hold the current regulator contacts closed.

a. Voltage builds up — current regulator contacts burned or incorrect setting. Clean the contacts and adjust per Par. 27.

b. Voltage does not build up — clean the contacts and repeat the test. If the voltage still does not build up remove the regulator for overhaul.

43. STARTING MOTOR

The starting motor is similar in construction to the generator, but the design of the parts is different because it is necessary for the starting motor to handle a large amount of current for short intervals. Both motor and generator require a frame, field coils, armature, and brushes. Fig. 184 illustrates a typical starting motor, the internal construction of which is representative of the model discussed here.

44. Maintenance Procedure

A periodic inspection should be made of the starting circuit. While the interval between these checks will vary according to the type of service, it should, under normal conditions, be made every 500 hours of operation. At this check the following points should be inspected.

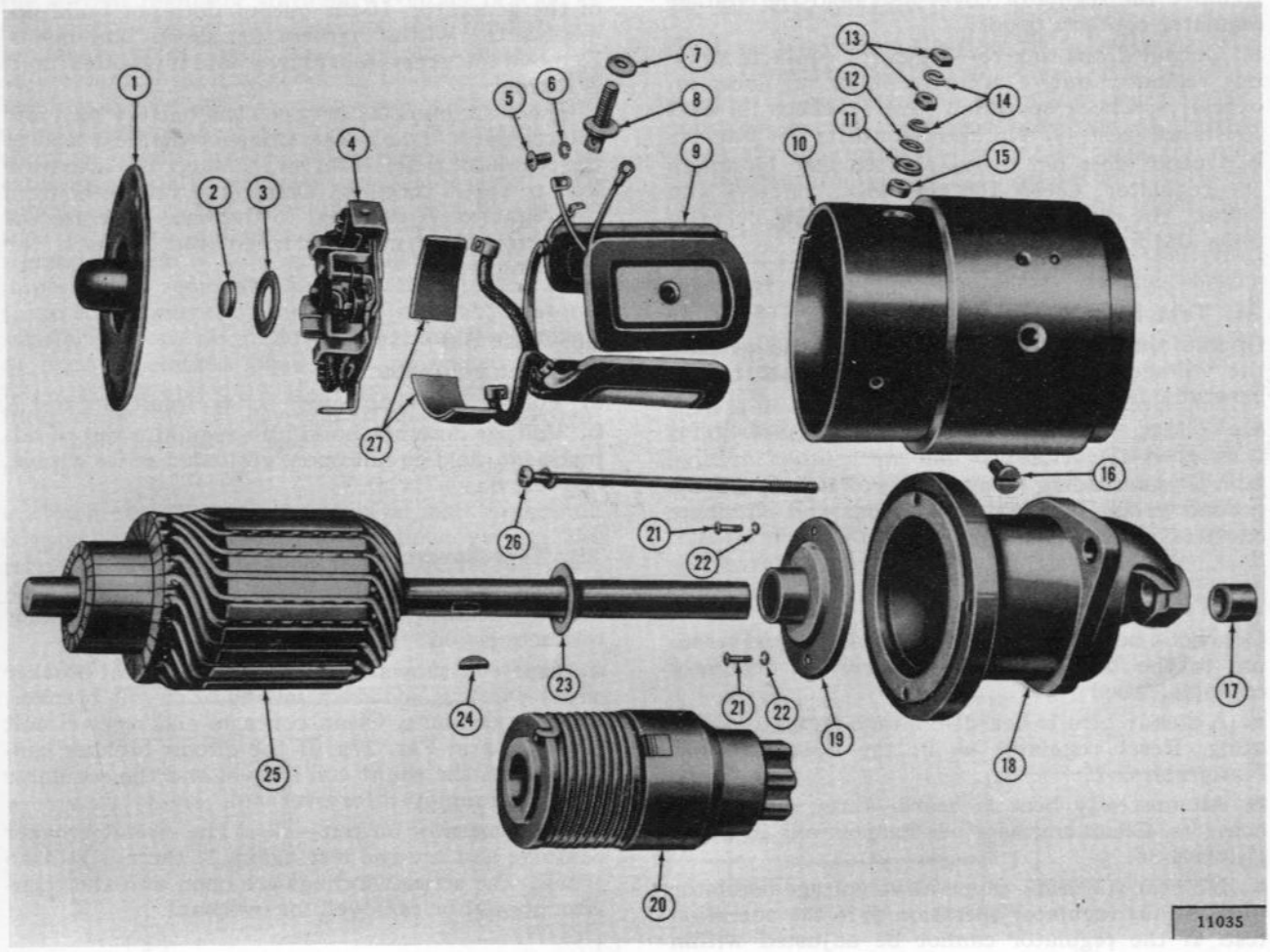

FIG. 184—TYPICAL STARTING MOTOR

1—End Plate
2—Plug
3—Thrust Washer
4—Brush Plate Assembly
5—Screw
6—Lock Washer
7—Insulating Washer
8—Terminal
9—Field Coil and Pole Shoe Set
10—Frame
11—Insulating Washer
12—Washer
13—Nut
14—Lock Washer
15—Insulating Bushing
16—Pole Shoe Screw
17—Sleeve Bearing
18—Drive End Frame
19—Intermediate Bearing
20—Bendix Drive
21—Screw
22—Lock Washer
23—Thrust Washer
24—Key
25—Armature
26—Thru Bolt
27—Insulator

45. Wiring

Inspect the starting circuit to make sure that all connections are clean and tight. Check for worn or damaged insulation on the wires. Perform a voltage-loss test to make sure there is no loss of starting motor efficiency resulting from high resistance connections. Voltage loss from the battery terminal to the starting motor terminal should not exceed .30 volts for each 100 amperes. Voltage loss between the battery ground post and the starting motor frame should not exceed .10 volts for each 100 amperes. If the voltage loss is greater than these limits, measure the voltage loss over each part of the circuit until the resistance causing the voltage loss is located and corrected.

46. Commutator

Sluggish starting motor operation may be caused by a dirty commutator or worn brushes. The commutator on 12-volt starting motors cannot be cleaned while the starting motor is mounted on the engine and it will be necessary to remove it and proceed as for an overhaul. Should the commutator in any starting motor be rough or worn, it should be removed for cleaning and reconditioning.

47. BRUSHES

The brushes should slide freely in their holders and make full contact on the commutator. Worn brushes should be replaced.

48. Overhaul Procedure

At periodic intervals the starting motor circuit should be thoroughly checked and the motor removed from the engine for cleaning and checking.

49. Disassembly

To remove the starting motor from the engine, disconnect the leads and cover the battery lead with a short piece of hose to prevent short circuiting. Remove the flange bolts holding the starting motor to the flywheel housing. Remove the starting motor from the engine.

Each part of the starting motor should be removed, cleaned, and inspected for evidence of wear or damage. The Bendix Drive should be cleaned and inspected for evidence of wear or a distorted spring. Bearings should be checked for proper clearance and fit. All insulation should be free of oil and in good condition. The armature, field coils, and brushes should be checked for good ground and lack of open circuits.

50. Brushes

The brushes should slide freely in their holders and make full contact on the commutator. Worn brushes should be replaced.

Check brush spring tension with a spring scale. Hook the scale under the brush spring near the brush and pull on a line parallel with the side of the brush. Take the reading just as the spring leaves the brush. It is important that the brush spring tension be kept within 32 to 40 oz [,91 a 1.13 kg.]. If the tension is too low, there will be a loss of efficiency from poor brush contact. Too great a tension will cause excessive brush and commutator wear. To change the tension, twist the spring at the holder with long-nosed pliers.

Worn brushes should be replaced.

51. Commutator

Check the commutator for wear and discoloration. If the commutator needs cleaning, use 00 sandpaper and afterward make sure all the sand is removed. If the commutator is rough or worn, it should be turned down in a lathe until all roughness is gone. Remove tool marks by sanding with 00 sandpaper. Undercut the mica segments to a depth of $\frac{1}{32}$" [0,79 mm.] in an undercutting fixture. After undercutting, check the armature on a growler, Fig. 178. The procedure for this check is given in Par. 52.

52. Armature

Visually inspect the armature for mechanical defects before checking for shorted or grounded coils. Use a set of test probes for testing armature circuits. To test the armature for grounds, touch one point of the test probes to a commutator segment and touch the other point to the core or shaft. Do not touch the points to the bearing surface or to the brush surface as the arc formed will burn the smooth finish. If the lamp lights, the coil connected to the commutator segment is grounded.

To test for shorted armature coils, a growler as shown in Fig. 178 is necessary. The armature is placed against the core and a steel strip is held on the armature rotated slowly by hand. If a shorted coil is present, the steel strip will become magnetized and will then vibrate.

53. Field Coils

Using test probes, check the field coils for both ground and open circuits. To test for ground, place one probe on the motor frame or pole piece and touch the other probe to the field coil terminals. If a ground is present, the lamp will light.

To test for open circuits, place the probes on the field coil terminals and on an insulated brush. If the light does not light, the coil is open circuited.

54. Brush Holder Inspection

Using test probes, touch the insulated brush holder with one probe and a convenient ground on the commutator end head with the other probe. If the lamp lights, it indicates a grounded brush holder.

55. Assembly of Starting Motor

When assembling absorbent bronze bearings, always use the proper arbor designed to give the proper bearing fit. Soak the bearing in oil before assembling in the bearing bore.

Brushes should be correctly installed and connected as outlined in Par. 50, in order to be sure of proper starting motor efficiency.

Soak the bearings in oil and give the bearing seats a light coating of oil.

56. Bench Test

Check the starting motor for free-running voltage

and current within specifications. To test, connect the starting motor to a battery, ammeter, and voltmeter. If the current is too high, check the bearing alignment and end play to make sure there is no binding or interference.

Use a spring scale and torque wrench and check the stall torque to see that the motor is producing its rated cranking power. The stall torque will be the product of the spring scale reading and the length of the arm in feet. If the torque is not up to specifications, check the seating of the brushes on the commutator and the internal connection of the starting motor for high resistance.

Check the Bendix Drive for correct operation. The Bendix Drive pinion should shift satisfactorily when the starting motor is operated under no-load condition.

57. Bendix Folo-Thru Drive

The Bendix Folo-Thru drive is designed to overcome premature demeshing of the drive pinion from the flywheel ring gear until a predetermined engine speed is reached. See Fig. 185.

No repairs or adjustments are possible on this drive and a complete new unit must be installed if trouble develops.

58. Lubrication of Folo-Thru Drive

A periodic cleaning and relubrication of the drive is advisable, the frequency of which will depend on the type of service to which the vehicle is subjected and the locale of operation.

Remove the starting motor from the engine and take off the outboard housing. The pinion and barrel assembly will be in the demeshed position on the screwshaft. **Do not** move it forward **until after** that portion of the armature shaft ahead of the pinion has been cleaned. If accidentally rotated to the outer end of the screwshaft it will lock in that position and cannot be forced back.

Do not disassemble the drive for any reason.

Do not dip or wash the drive in any cleaning solution.

Do not remove the drive from the armature shaft.

Remove excess oil, grease or foreign matter from the armature shaft by wiping it with a clean cloth.

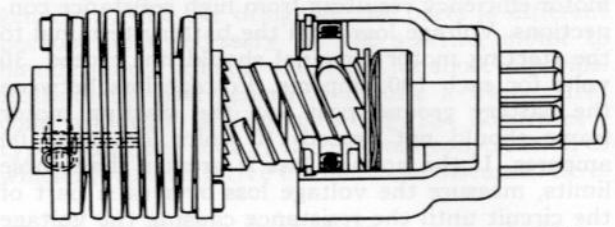

FIG. 185—BENDIX FOLO-THRU DRIVE

Dampen the cloth with kerosene if necessary. A light film of SAE 10 oil may then be applied to the shaft.

Now rotate the pinion and barrel assembly to the fully extended position, thereby exposing the screwshaft triple threads. Use a cloth dampened with kerosene to wipe them clean. **Do not use gasoline or any commercial cleaner.** If the dirt is thick and gummy, apply the kerosene with a small brush. Tilt the starting motor so that a small amount will run under the control nut. Relubricate with a thin film of SAE 10 oil. Use SAE 5 at extremely low temperatures.

Reassemble the starting motor to the engine with the drive in the extended position. Carefully mesh the pinion with the flywheel ring gear before tightening the starting motor mounting bolts. It may require a slight rotation of the pinion to index it into the ring gear. When the engine starts, the drive pinion will automatically demesh from the ring gear and return to its normal position.

SERVICE DIAGNOSIS

SYMPTOMS	PROBABLE REMEDY
Generator:	
Low Charging Rate—	
Dirty Commutator	Clean Commutator
Poor Brush Contact	Repair or Install New Brushes
Regulator Improperly Adjusted	Adjust
High Resistance in Charging Circuit	Clean and Tighten Terminals
Ground Strap Engine to Frame Broken	Replace
Loose or Dirty Terminals	Clean and Tighten
Slipping Generator Belt	Adjust Belt
Worn Out Brushes	Install New Brushes
Weak Brush Spring Tension	Replace
Out of Round Commutator	Repair
Fails To Charge—	
Open Charging Circuit	Correct
Sticking Brushes	Repair or Replace
Dirty or Burned Commutator	Clean Commutator
Grounded Commutator	Replace
Open Circuit in Field	Repair
Weak Soldering on Armature	Repair
Grounded Wiring	Repair
Defective Regulator	Replace Regulator
Too High Charging Rate—	
Regulator Improperly Adjusted	Adjust or Replace
Short in Armature	Replace
Grounded Field-to-regulator Wire	Correct
Shorted Cell in Battery	Replace Battery
Starting Motor:	
Slow Starter Speed—	
Discharged Battery or Shorted Cell	Recharge or Repair
Ground Strap Engine to Frame	Clean Terminals and Tighten
Loose or Dirty Terminals	Clean and Tighten
Dirty Commutator	Clean with No. 00 Sandpaper
Worn Out Brushes	Install New Brushes
Weak Brush Spring Tension	Replace
Poor Brush Contact	Repair or Install New Brushes
Worn Bearings	Replace
Will Not Turn Engine—	
Open Circuit at Starter	Correct
Starter Drive Broken or Stuck	Repair or Replace
Battery Discharged	Recharge Battery
Distributor:	
Hard Starting—	
Distributor Points Burned or Pitted	Clean Points or Replace (Adjust)
Breaker Arm Stuck on Pivot Pin	Clean and Lubricate
Breaker Arm Spring Weak	Replace
Points Improperly Adjusted	Adjust .020"
Spark Plug Points Improperly Set	Adjust .030"
Spark Plug Wire Terminals in Distributor Cap Corroded	Clean
Loose Terminals	Check Circuit
Loose or Dirty Terminals on Ground Strap— Engine to Frame	Clean and Tighten
Condenser Faulty	Replace
Improper Ignition Timing	Set Timing

ELECTRICAL SYSTEM SPECIFICATIONS

GENERATOR (Auto-Lite):	12-Volt
Make	Auto-Lite
Model	GJP-7402-B
Ground Polarity	Negative
Controlled Output	35 amp
Control	CV Regulator
Ratio — Generator to Crankshaft:	
Revolutions	1.75 to 1
Cut-in Engine rpm	758
Rotation — Drive End	Clockwise
Armature End Play	.003″ to .010″ [0,076 a 0,254 mm.]
Brushes	2
Brush Spring Tension	18 to 36 oz. [0,5 a 1 kg.]
Bearing — Drive End	Ball
Bearing — Commutator End	Bronze
Field Coil Draw @ 10 volts	1.6 to 1.7 amp.
Motorizing Draw @ 10 volts	3.1 to 3.5 amp.
Output Test @ 1750 max. RPM	15.0 volts-16 amps.
Output Test @ 2300 max. RPM	15 volts-35 amps.
REGULATOR (Auto-Lite):	12-Volt
Make	Auto-Lite
Model	VBO-4201E-4A
Type	Vibrator
Cutout Relay Closing Voltage @ Generator rpm	12.4 to 12.3 @ 1325
Reverse Current to Open	3 to 5 amp.
Regulated Voltage	14.1 to 14.7
Regulated Current	39 amp. max.
STARTING MOTOR (Auto-Lite):	12-Volt
Make	Auto-Lite
Model	MDY-7021
Rotation — Drive End	Counterclockwise
Brushes	4
Brush Spring Tension	32 to 40 oz. [90.0 a 1100 gr.]
Bearings	3 Bronze
Lock Test:	
Temperature	70°F [21°C.]
Amps. (max.)	405
Volts	4.0
Stall Torque (min.)	9 lb-ft. [1,24 kg-m.]
No Load Test:	
Temperature	70°F. [21°C.]
Amps. (max.)	60
Volts	10
RPM (min.)	4200
Drive:	
Type	Bendix Folo-Thru
Pinion Meshes	Front
Number of Teeth — Pinion	9
DISTRIBUTOR (Auto-Lite):	Auto-Lite
Make	IAT-4411
Model	Centrifugal
Type Advance	1-5-3-6-2-4
Firing Order	.020″ [0,508 mm.]
Breaker Point Gap	17 to 22 oz. [482 a 624 gr.]
Breaker Arm Tension	38°
Cam Angle	7.5 @ 1700 rpm.
Max. Auto Advance	5° @ 15″ [38 cm.] of Mercury (Hg)
Max. Vacuum Advance	.25 to .28 mfd.
Condenser Capacity	

SECTION VII

Specifications

FOUR CYLINDER ENGINES

The following specifications apply to the "L" Head Engine as used in Model CJ-3A and the "F" Head type Engine as used in the current 4 cylinder 'Jeep' vehicles.

General	"L" Head Type	"F" Head Type
Type	4 Cyl. "L"	4 Cyl. "F"
Bore	3 1/8"	3 1/8"
Stroke	4 3/8"	4 3/8"
Displacement	134.2 cu. in.	134.2 cu. in.
SAE Horsepower	15.63	15.63
Maximum Brake Horsepower	60 @ 4000 rpm.	72 @ 4000 rpm.
Maximum Torque	105 @ 2000 rpm.	114 ft. lbs. @ 2000 rpm.
Compression Ratio (Standard)	6.48 to 1	6.9 to 1
Compression Pressure (Cranking speed—wide open throttle)	110 @ 160 rpm.	125 @ 185 rpm.
Cranking Speed	185 rpm.	185 rpm.
Engine Idle	600 rpm.	600 rpm.
Firing Order	1-3-4-2	1-3-4-2
Cylinder Head Material	Cast Iron	Cast Iron
Pistons		
Type	T Slot—Expansion Controlled	T Slot—Expansion Controlled
Weight—Less Rings and Pin (All pistons in one engine should be of equal weight within 1/8 oz.)	12.49 oz.	13.508 oz.
Material	Aluminum Alloy	Aluminum Alloy
Finish	Cam Ground, Tin Plated	Cam Ground, Tin Plated
Length	3.75"	3.75"
Diameter (Near bottom of skirt at right angle to piston pin, but must be selectively fitted to bores)	3.1245-3.1249	3.1245-3.1249
Cylinder Bore:		
Standard Diameter	3.125"-3.127"	3.125"-3.127"
Maximum Advisable Out-of-Round	.005"	.005"
Maximum Advisable Taper	.015"	.015"
Maximum Rebore	.040"	.040"
Clearances:		
Top Land	.017"-.019"	.017"-.019"
Piston Skirt on Thrust Side	5 to 10 lbs. pull on .003" x 3/4" Feeler	5 to 10 lbs. pull on .003" x 3/4" Feeler
Piston Ring Groove Depth:		
Oil	.170"	.161"-.168"
Compression	.160"	.151"-.158"
Piston Ring Groove Width:		
Oil	.1875"-.1885"	.1875"-.1885"
Compression—Upper	.0955"-.0965"	.0955"-.0965"
Compression—Lower	.095"-.096"	.095"-.096"
Piston Pin Hole Bore	.8120"-.8122"	.8120"-.8122"
Piston Rings		
Material	Cast Iron-Chrome Plated	Cast Iron-Chrome Plated
Compression Rings:		
Number per Piston	2	2
Width	3/32"	3/32"
Thickness	.130"-.140"	.144"
Oil Rings:		
Number per Piston	1	1
Width	3/16"	3/16"
Thickness	.135"-.145"	.135"-.145"
Ring Gap	.007"-.023"	.007"-.023"
Side Clearance in Groove:		
Upper Compression Ring	.002"-.004"	.002"-.004"
Lower Compression Ring	.0015"-.0035"	.0015"-.0035"
Oil Ring	.001"-.0025"	.001"-.0025"

FOUR CYLINDER ENGINE—Continued

Connecting Rods, Piston Pins and Bearings		
Connecting Rod:		
Length (Center to Center)	9 3/16"	9 3/16"
Weight	40 oz.	40 oz.
Upper End	Locked in Rod	Locked in Rod
Lower Bearing Material	Steel Backed Babbitt	Steel Backed Babbitt
Type	Replaceable Shells	Replaceable Shells
Diameter	1 15/16"	1 15/16"
Length	1 5/16"	1 5/16"
Clearance	.0005"-.0025"	.0005"-.0025"
End Play	.005"-.009"	.005"-.009"
Piston Pin:		
Type	Locked in Rod	Locked in Rod
Length	2 25/32"	2 25/32"
Diameter	.8117"-.8119"	.8117"-.8119"
Clearance	Push Fit	Push Fit
Crankshaft		
Material	Forged Steel	Forged Steel
Weight	46 1/2 lbs.	46 1/2 lbs.
Thrust Taken at	Front	Front
End Play	.004"-.006"	.004"-.006"
Crankpin Diameter	1 15/16"	1 15/16"
Main Bearing Diameter	2.3341"-2.3331"	2.3341"-2.3331"
Length:		
No. 1	1.927"-1.923"	1.927"-1.923"
No. 2	1.995"-2.005"	1.995"-2.005"
No. 3	1.9375"	1.9375"
Clearance	.0014"-.0029"	.0014"-.0029"
Bearing Material	Steel Backed Babbitt	Steel Backed Babbitt
Type	Replaceable Shells	Replaceable Shells
Vibration Damper	Not Used	Not Used
Camshaft		
Material	Alloy Cast Iron	Alloy Cast Iron
Number of Replaceable Bearings	1—In Front	1—In Front
Drive Type	Gear	Gear
Camshaft Gear	Pressed Fiber—Steel Hub	Pressed Fiber—Steel Hub
Front Bearing	Steel Backed Babbitt	Steel Backed Babbitt
Clearance	.001"-.0025"	.001"-.0025"
Thrust Taken by	Thrust Plate	Thrust Plate
End Play Control	Spacer	Spacer
End Play	.004"-.007"	.004"-.007"
*Bearing Journal Diameters:		
Front	2.188"	2.188"
Front Intermediate	2 1/4"	2 1/4"
Rear	1 3/4"	1 3/4"
Rear Intermediate	2 3/16"	2 3/16"
Valves, Springs and Tappets		
Valve Arrangement	L-Head	F-Head
Valves:		
Material		
Intake	Chrome Nickel 3140	AISI 5150—AISI TS-8150
Exhaust	Stellite or Eatonite	Head 2112 or 2155
Intake Valve:		
Overall Length	5 3/4"	4 25/32"
Overall Head Diameter	1 17/32"	2"
Angle of Seat	45°	45°
Stem Diameter	.3733"-.3738"	.3733"-.3738"
Stem to Guide Clearance	.0015"-.00325"	.0007"-.0022"
Lift	.359"	.260"
Exhaust Valve:		
Overall Length	5 13/16"	5 59/64"
Overall Head Diameter	1 15/32"	1 15/32"
Angle of Seat	45°	45°
Stem Diameter	.3725"	.371"-.372"
Stem to Guide Clearance	.0025"-.0045"	.0025"-.0045"
Lift	.351	.351

*Replaceable bearing used at front Journal only.

FOUR CYLINDER ENGINE—Continued

Valve Springs:		
Intake		
Free Length	2 1/2"	1 31/32"
Spring Pressure—Valve Closed	53 lbs. @ 2 7/64"	73 lbs. @ 1 21/32"
Spring Pressure—Valve Open	120 lbs. @ 1 3/4"	153 lbs. @ 1 13/32"
Exhaust		
Free Length	2 1/2"	2 1/2"
Spring Pressure—Valve Closed	53 lbs. @ 2 7/64"	53 lbs. @ 2 7/64"
Spring Pressure—Valve Open	120 lbs. @ 1 3/4"	120 lbs. @ 1 3/4"
Closed Coil End of Spring	Placed Up	Placed Up
Valve Tappets:		
Overall Length	2 7/8"	2 7/8"
Stem Diameter	.6240"-.6245"	.6240"-.6245"
Clearance to Guide	.0005"-.002"	.0005"-.002"
Adjusting Screw	Self Locking	Self Locking
Operating Tappet Clearance		
Intake	.016"	.018"
Exhaust	.016"	.016"
Tappet Clearance for Timing		
Intake	.020"	.026"
Exhaust	Not Used	Not Used
Intake Valve Opens	9° BTC	9° BTC
Intake Valve Closes	50° ABC	50° ABC
Exhaust Valve Opens	47° BBC	47° BBC
Exhaust Valve Closes	12° ATC	12° ATC
Valve Rotators	Not Used	Thompson on Exhaust Only
Timing Marks	Timing Gear Cover	Timing Gear Cover
Oil Pump		
Type	Internal Rotor	Internal Rotor
Drive from Camshaft	Helical Gears	Helical Gears
Oil Pressure Relief	Plunger Type Valve	Plunger Type Valve
Safe Minimum Pressure	6 lbs. @ Idle 20 lbs. @ 35 mph.	6 lbs. @ Idle 20 lbs. @ 35 mph.
Relief Valve Opens	35-40 lbs.	35-40 lbs.

APPLICATION	TORQUE IN FT.-LBS.
Cylinder Head Stud Nuts	60 — 70
Cylinder Head Screws	60 — 70
Above should be rechecked with engine at operating temperature	
Spark Plugs to Cylinder Head	25 — 33
Main Bearing Caps	65 — 75
7/16" Connecting Rod Cap Bolt Nut	50 — 55
3/8" Connecting Rod Cap Bolt Nut	35 — 45
Pal Nuts (Stamped Locking Nuts)	Finger tight plus 1/4 to 1/3 turn
Rocker Arm Bracket to Head Nut	30 — 35
Piston Pin Lock Bolt	35 — 40
Flywheel to Crankshaft	35 — 41
Camshaft Gear to Camshaft Bolt	30 — 40
Camshaft Thrust Plate Bolts (4 cyl.)	20 — 25
Camshaft Thrust Plate Bolts (6 cyl.)	14 — 20
Oil Pan to Crankcase Screws	12 — 17
Exhaust Manifold	29 — 35
Intake Manifold	29 — 35
Water Outlet Elbow to Cylinder Head	20 — 25
Water Pump to Cylinder Block	12 — 17
Starting Motor Mounting	20 — 25
Generator Bracket	25 — 35

TORNADO OHC ENGINE SPECIFICATIONS

	ENGLISH	METRIC
ENGINE:		
Type	Overhead Camshaft	
Number of Cylinders	6	
Bore	$3^{11}/_{32}$"	84,93 mm.
Stroke	$4^{3}/_{8}$"	111,12 mm.
Piston Displacement	230 cu. in.	4,24 ltr.
Bore Spacing (Center-to-Center)	3.876"	9,846 cm.
Firing Order	1-5-3-6-2-4	
Compression Ratio	8.50:1	
Compression Pressure	145-155 psi.	10,195-10,898 kg^2
Horsepower (SAE)	26.77	
Horsepower (max. brake)	140@ 4000 rpm.	
Torque (max. @ 1750)	210 lb-ft.	29,03 kg-m.
Idle Speed	590 to 600 rpm.	
PISTONS:		
Material	Aluminum Alloy	
Description	Cam Ground, Closed Type	
	Tin Plated	
Clearance Limits:		
Top Land	.0190"-.0255"	4,763-4,923 mm.
Skirt Top	.0007"-.0017"	0,0178-0,04318 mm.
Skirt Bottom	Selective Feeler Fit	
Ring Groove Depth:		
No. 1 and No. 2 Ring	.1875"-.1938"	4,763-4,923 mm.
No. 3 Ring	.1900"-.1963"	4,826-4,986 mm.
Cylinder Bore—Standard:		
—max. out of round	.005"	0,127 mm.
—max. taper	.005"	0,127 mm.
—max. rebore	.040"	1,016 mm.
PISTON RINGS:		
Function:		
No. 1 and No. 2	Compression	
No. 3	Oil	
Material:		
No. 1	Cast Iron,	
	Chrome Plated Face	
No. 2	Cast Iron	
No. 3	2 Steel Rails	
	with Chrome Plated Face	
	Steel Spacer Expander	
Gap:		
No. 1 and No. 2	.010"-.045"	0,254-1,143 mm.
Oil Rail	.015"-.055"	0,372-1,397 mm.
Side Clearance, No. 1 and No. 2	.002"-.0031"	0,0508-0,079 mm.
PISTON PINS:		
Material	SAE 1019 Steel	
Length	2.779"	7,059 cm.
Diameter	.8592"	2,185 cm.
Clearance in Piston	.0002"	0,0051 mm.
Clearance in Rod	.004"-.0008"	0,01016-0,02032 mm.
CONNECTING RODS:		
Material	SAE 1035 Forged Steel	
Weight	29.6 oz.	839,16 gr.
Length (Center-to-Center)	7.000"	17.78 cm.
Bearing:		
Type	Removable	
Material	Steel Backed,	
	Copper-Lead, Tin-Plated	
Overall Length	1.000"	2.54 cm.
Clearance Limits	.0006"-.0025"	0,0125-0,0635 mm.
Nut Torque	40-45 lb-ft.	5,5-6,2 kg-m.
CRANKSHAFT:		
Material	SAE 1045 or 1046	
	Forged Steel	
	Tufftriding	
Hardening Process	Tufftriding	
End Thrust Taken by	Rear Bearing	
End Play	.003"-.007"	0,0762-0,1978 mm.

TORNADO OHC ENGINE SPECIFICATIONS — Continued

	ENGLISH	METRIC
CRANKSHAFT: — Continued		
Main Bearings:		
Type	Removable	.....
Material	Steel-Backed, Copper-Lead, Tin Plated	.....
Clearance	.0005"-.0025"	0,0127-0,0635 mm.
Journal Diameter	2.3747"-2,3755"	6,032-6,038 cm.
Allowable Taper	.001"	0,0254 mm.
Torque	85-95 lb-ft.	11,7-13,1 kg-m.
Crankpin Journal Diameter	2.0619"-2.0627"	5,237-5,239 cm.
Flywheel Runout	.005"	0,127 mm.
CAMSHAFT:		
Location	Overhead Cam	.....
Material	Cast Iron Alloy	.....
Type of Drive	Chain and Sprockets	.....
Journal Diameters:		
Front	1.9975"-1.9965"	50,7365-50,7111 mm.
Front Intermediate	1.8725"-1.8715"	47,5615-47,5361 mm.
Rear Intermediate	1.7475"-1.7465"	44,3865-44,3611 mm.
Rear	1.3725"-1.3715"	34,8615-34,8361 mm.
Bearing Material	Aluminum Alloy SAE 306	.....
Number of Bearings	4	.....
Bearing Diameters:		
Front	1.9995"-2.0005"	50,7873-50,8127 mm.
Front Intermediate	1.8745"-1.8755"	47,6123-47,6377 mm.
Rear Intermediate	1.7495"-1.7505"	44,4373-44,4627 mm.
Rear	1.3745"-1.3755"	34,9132-34,9377 mm.
End Play	.007"-.018"	0,177-0,457 mm.
VALVE SYSTEM:		
Valve Clearance:		
Intake	.008"	0,203 mm.
Exhaust	.008"	0,203 mm.
Timing:		
Intake:		
Opens (°BTC)	15°	.....
Closes (°ABC)	55°	.....
Duration-deg	250°	.....
Exhaust:		
Opens (°BBC)	55°	.....
Closes (°ATC)	15°	.....
Duration-deg	250°	.....
Valve Overlap	30°	.....
Valves:		
Intake:		
Overall Length	4.675"	.....
Head Diameter	1.895"	.....
Angle of Seat	45°	.....
Stem Diameter	.3400"-.3410"	8,636-8,6614 mm.
Stem-to-Guide Clearance	.001"-.003"	0,0254-0,0762 mm.
Exhaust:		
Overall Length	4,485"	11,392 cm.
Head Diameter	1,618"	4,11 cm.
Angle of Seat	45°	.....
Stem Diameter	.3385"-.3395"	8,5979-8,6233 mm.
Stem-to-Guide Clearance	.0025"-.0045"	0,0835-0,1143 mm.
Springs (Intake and Exhaust):		
Free Length	1.60"	40,64 mm.
Pressure @ Length:		
Valve Closed	1.26" @ 57 lb.	3,2004 cm. @ 24,494 kg.
Valve Open	.885" @ 130 lb.	2,2479 cm. @ 66,2536 kg.
LUBRICATION SYSTEM:		
Type of Lubrication:		
Main Bearings	Pressure	.....
Connecting Rods	Pressure	.....
Piston Pins	Splash	.....
Camshaft Bearings	Pressure	.....
Rocker Arms	Splash	.....
Timing Chain Sprockets	Nozzle	.....
Cylinder Walls	Splash	.....
Oil Pump:		
Type	Internal Rotor	.....
Drive	Crankshaft Gear	.....
Normal Oil Pressure	50 psi. @ 2000 rpm.	.....
Oil Intake	Stationary Screen	.....
Oil Filter System	Full Flow	.....

TORNADO OHC ENGINE TORQUE SPECIFICATIONS

	Pounds - Feet	kg-m.
Air Cleaner Mounting Bracket to Air Cleaner Bolt	12-15	1,7-2,1
Air Cleaner Mounting Bracket to Front Engine Plate Bolt	12-15	1,7-2,1
Ballast to Dash Screw	90 in. lb. min.	0,30
Cam Bearing Deck to Cylinder Head Nut	15-20	2,1-2,8
Camshaft Thrust Plate to Cam Bearing Deck Nut	12-15	1,7-2,1
Carburetor to Intake Manifold Nut	12-15	1,7-2,1
Clutch Housing to Cylinder Block Screw	40-50	5,5-6,8
Coil Mounting to Front Engine Plate	12-15	1,7-2,1
Connecting Rod Bolt Cap Nut	40-45	5,5-6,2
Cylinder Head and Cam Bearing Deck to Cylinder Block Bolt	75-80	10,4-11,0
Cylinder Head to Cylinder Block Bolt	75-80	10,4-11,0
Fan to Water Pump Bolt	12-15	1,7-2,1
Filler Block, Front or Rear, to Cylinder Block Screw	12-15	1,7-2,1
Flywheel to Crankshaft Nut	35-40	4,8-5,5
Front Engine Plate to Cylinder Block Screw - 5/16"	12-15	1,7-2,1
Front Engine Plate to Cylinder Block Bolt - 3/8"	15-20	2,1-2,8
Front Engine Plate to Filler Block Screw	12-15	1,7-2,1
Fuel Line, Intake, and Spacer to Oil Pan Screw	12-15	1,7-2,1
Fuel Pump Eccentric and Sprocket to Camshaft Screw	40-45	5,5-6,2
Fuel Pump to Timing Chain Cover Nut	12-15	1,7-2,1
Generator and Bracket to Front Engine Plate Bolt	12-15	1,7-2,1
Generator Bracket to Front Engine Plate Bolt	12-15	1,7-2,1
Generator Strap to Generator Screw	12-15	1,7-2,1
Ignition Coil Terminal Nut	25-30 in. lbs.	0,28-0,34
Ignition Distributor to Timing Chain Cover Nut	12-15	1,7-2,1
Insulator to Engine Support Bracket Bolt	15-20	2,1-2,8
Insulator to Front Engine Plate Nut	25-30	3,4-4,1
Insulator to Transmission Screw	15-20	2,1-2,8
Lifting Eye to Cylinder Head Screw	15-20	2,1-2,8
Main Bearing Cap Bolt	85-85	11,8-13,1
Manifold, Exhaust, to Cylinder Head Nut	35-40	4,8-5,5
Manifold, Intake, to Cylinder Head Nut	15-20	2,1-2,8
Oil Filter Adapter to Cylinder Block	45-50	5,5-6,8
Oil Pan to Cylinder Block Screw	12-15	1,7-2,1
Oil Pump to Timing Chain Cover Nut	12-15	1,7-2,1
Rocker Arm Cover Mounting Nut	12-15	1,7-2,1
Spacer to Frame Crossmember Nut	15-20	2,1-2,8
Spacer to Insulator Bolt	15-20	2,1-2,8
Spark Plug to Cylinder Head	20-30	2,8-4,1
Starter Solenoid to Relay Terminal Nut	25-30 in. lbs.	0,28-0,34
Starting Motor to Clutch Housing Bolt	25-30	3,4-4,1
Timing Chain Cover to Cylinder Block Bolt - 5/16"	12-15	1,7-2,1
Timing Chain Cover to Cylinder Block Bolt - 3/8"	15-20	2,1-2,8
Timing Chain Cover to Cylinder Head Bolt	12-15	1,7-2,1
Timing Chain Guide Bracket to Front Engine Plate Nut	9-12	1,2-1,7
Vibration Damper to Crankshaft Bolt	100-130	13,8-17,9
Voltage Regulator to Splash Apron Screw	5-8	0,69-1,1
Water Outlet Connection to Intake Manifold Nut	12-15	1,7-2,1
Water Pump to Timing Chain Cover Nut	12-15	1,7-2,1

SECTION VIII

PARTS LISTS

4 and 6 Cylinder Industrial Engines

Model F-4, Jeep

Model L-4, Jeep

Tornado OHC 6 Cylinder

Industrial Engine Department
Willys Motors, Inc.
Toledo, Ohio

PROCEDURE FOR ORDER AND RETURN OF PARTS

ORDERING

1. Address all purchase orders and inquiries to the original equipment manufacturer or distributor.
2. All orders must indicate whether parts are to be for resale or remanufacture. If for remanufacture, a Federal Tax Exemption Certificate must accompany your order!
3. All orders must have your terms, shipping instructions, conditions, etc., embodied therein.

RETURNING

In order to eliminate the loss of material returned to this company with consequential delay in the issuance of credits, we ask that you comply with the procedure that follows:

1. Please request specific approval for the return of defective, damaged, surplus, or incorrect parts from the Industrial Engine Department, Willys Motors, Inc., Toledo 1, Ohio. Indicate your purchase order number, invoice number and date received.
2. Upon receipt of the request, a determination will be made as to whether the material is acceptable for return and, if so, you will be advised the location of the department within our plant to which it is to be sent.
3. To be acceptable for return and credit, all material must be tagged "Authorized return — (date of letter) by (name of person authorizing return), (part return), (part number) and (quantity returned)."

We ask that you adhere strictly to this procedure in returning parts. No credits will be issued on returns except on the above basis.

GROUP INDEX

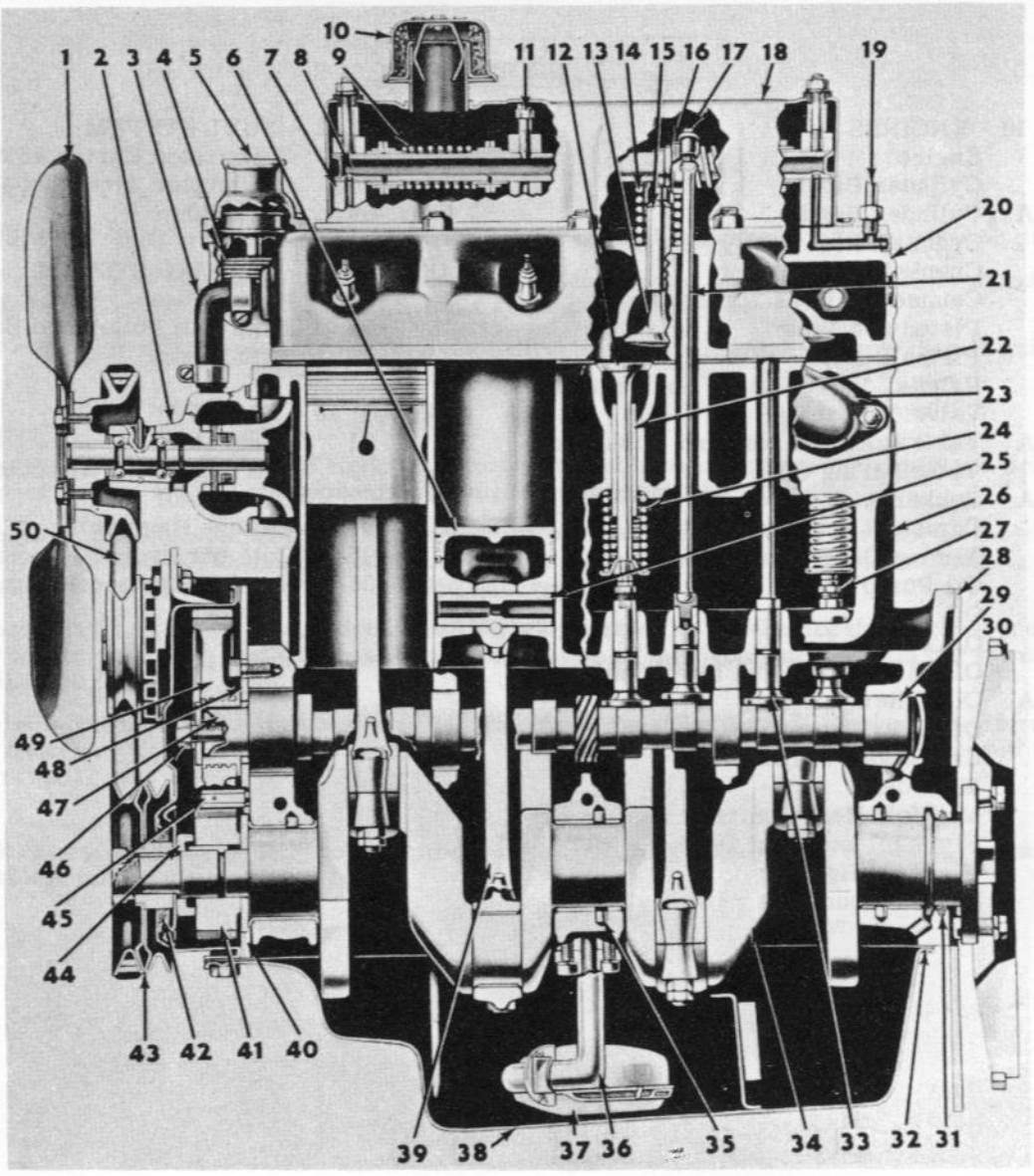

FIG. 180—4F-ENGINE, SIDE SECTION

Ref. No.	Description	Group No.
1	Fan	14-05
2	Pump, water	14-04
3	Hose, by-pass	14-02
4	Thermostat	14-06
5	Fitting, water outlet	10-02A
6	Piston	10-06
7	Bracket, rocker arm shaft	10-09A
8	Shaft & Plug, rocker arm	10-09A
9	Spring, rocker arm shaft	10-09A
10	Cap, breather	10-10A
11	Screw, lock, rocker shaft	10-09A
12	Valve, exhaust	10-08
13	Valve, inlet	10-08
14	Spring, inlet valve	10-08
15	Guide, inlet valve	10-08
16	Arm, rocker	10-09A
17	Screw, adjusting, exhaust valve	10-09
18	Cover, rocker arm	10-10A
19	Tube, oil line	10-17
20	Head, cylinder	10-02A
21	Rod, push, inlet valve	10-09A

4F - ENGINE, SIDE SECTION (Cont'd)

Ref. No.	Description	Group No.
22	Guide, exhaust valve	10-08
23	Manifold, exhaust	10-19
24	Spring, exhaust valve	10-08
25	Pin, piston	10-06
26	Block, cylinder	10-02
27	Screw, adjusting, tappet	10-09
28	Plate, engine, rear	10-23
29	Camshaft	10-11
30	Flywheel Kit	10-21
31	Seal, crankshaft rear, bearing	10-03
32	Packing, crankshaft, cap rear	10-03
33	Tappet, inlet valve	10-09
34	Crankshaft (kit)	10-03
35	Dowel, crankshaft bearing	10-03
36	Support, oil float	10-15
37	Float, oil	10-15
38	Pan, oil	10-14
39	Rod, connecting	10-05
40	Plate, front	10-23
41	Gear, crankshaft	10-11
42	Oil Seal, crankshaft	10-03
43	Pulley	10-03
44	Spacer, crankshaft gear	10-03
45	Jet, oil timing gear	10-02
46	Bolt, gear to camshaft	10-11
47	Spacer, camshaft thrust plate	10-11
48	Plate, thrust, camshaft	10-11
49	Gear, camshaft	10-11
50	Belt, fan and generator	14-05

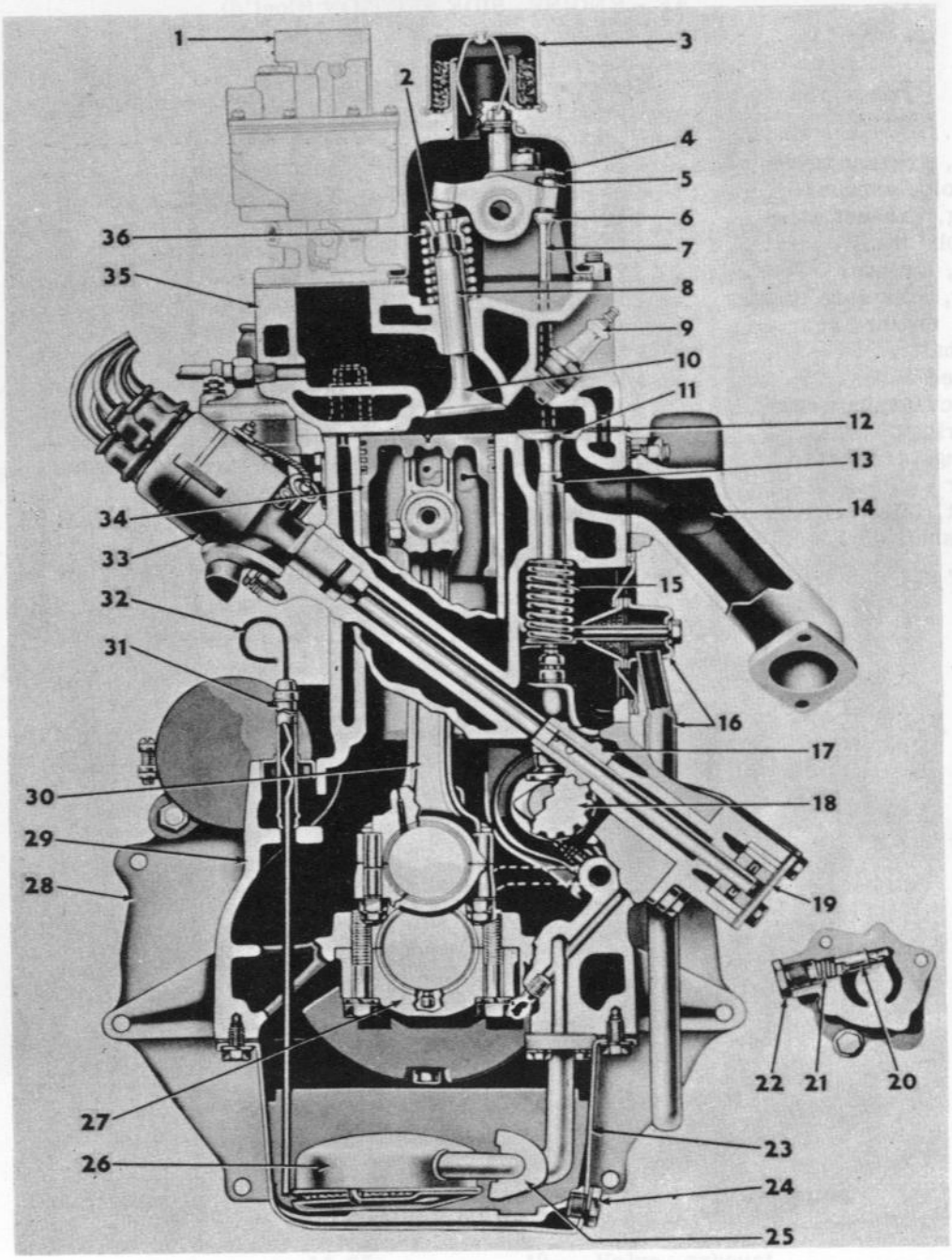

FIG. 181—4F-ENGINE, END SECTION

Ref No.	Description	Group No.	Ref. No.	Description	Group No.
1	Carburetor	12-04	7	Rod, push	10-09A
2	Retainer, inlet valve spring	10-08	8	Guide, inlet valve	10-08
3	Cap, filler	10-16	9	Plug, spark	15-06
4	Screw, adjusting	10-09	10	Valve, inlet	10-08
5	Nut, adjusting screw	10-09	11	Valve, exhaust	10-08
6	Arm, rocker	10-09A	12	Gasket, cylinder head	10-02A

4F - ENGINE, END SECTION (Cont'd)

Ref. No.	Description	Group No.
13	Guide, exhaust valve	10-08
14	Manifold, exhaust	10-19
15	Spring, exhaust valve	10-08
16	Ventilator, crankcase	10-18
17	Gear, driven, oil pump	10-13
18	Camshaft	10-11
19	Pump, oil	10-13
20	Plunger, relief	10-13
21	Spring, relief, plunger	10-13
22	Retainer, relief spring	10-13
23	Pan, oil	10-14
24	Plug, drain, oil pan	10-14
25	Support, oil float	10-15
26	Float, oil	10-15
27	Crankshaft	10-03
28	Plate, engine rear	10-23
29	Block, cylinder	10-02
30	Rod, connecting	10-05
31	Tube, oil level	10-16
32	Rod, oil level	10-16
33	Distributor	15-03
34	Piston	10-06
35	Head, cylinder	10-02A
36	Spring, inlet valve	10-08

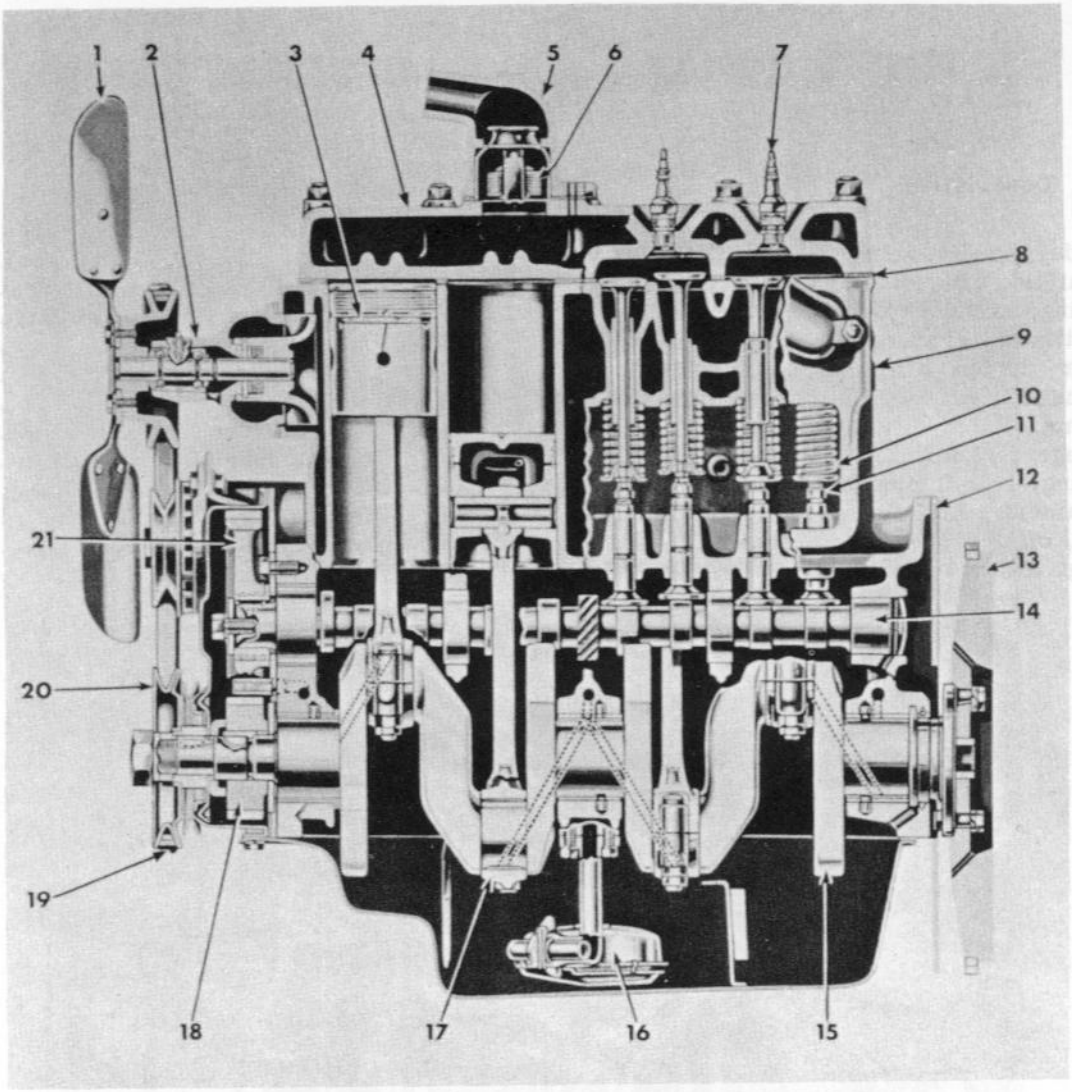

FIG. 182—4L-ENGINE, SIDE SECTION

Ref. No.	Description	Group No.
1	Fan	14-05
2	Pump, water	14-04
3	Piston and Pin	10-06
4	Pin, piston	10-06
5	Elbow, outlet	10-02A
6	Valve, intake	10-08
	Valve, exhaust	10-08
7	Head, cylinder	10-02A
8	Manifold, exhaust	10-19
9	Block, cylinder	10-02
10	Spring, valve	10-08
11	Screw, tappet	10-09
12	Plate, engine, rear	10-23
13	Camshaft	10-11
14	Kit, flywheel	10-21
15	Tappet, valve	10-09
16	Kit, crankshaft	10-03
17	Float, oil	10-15
18	Rod, connecting, No. 1-3	10-05
	Rod, connecting, No. 2-4	10-05
19	Gear, crankshaft	10-03
20	Belt, fan	14-05
21	Nut, crankshaft	10-03
22	Pulley, crankshaft	10-03
23	Plate, engine, front CJ-2A	10-23
	Plate, engine, front CJ-3A	10-23
24	Gear, camshaft	10-11

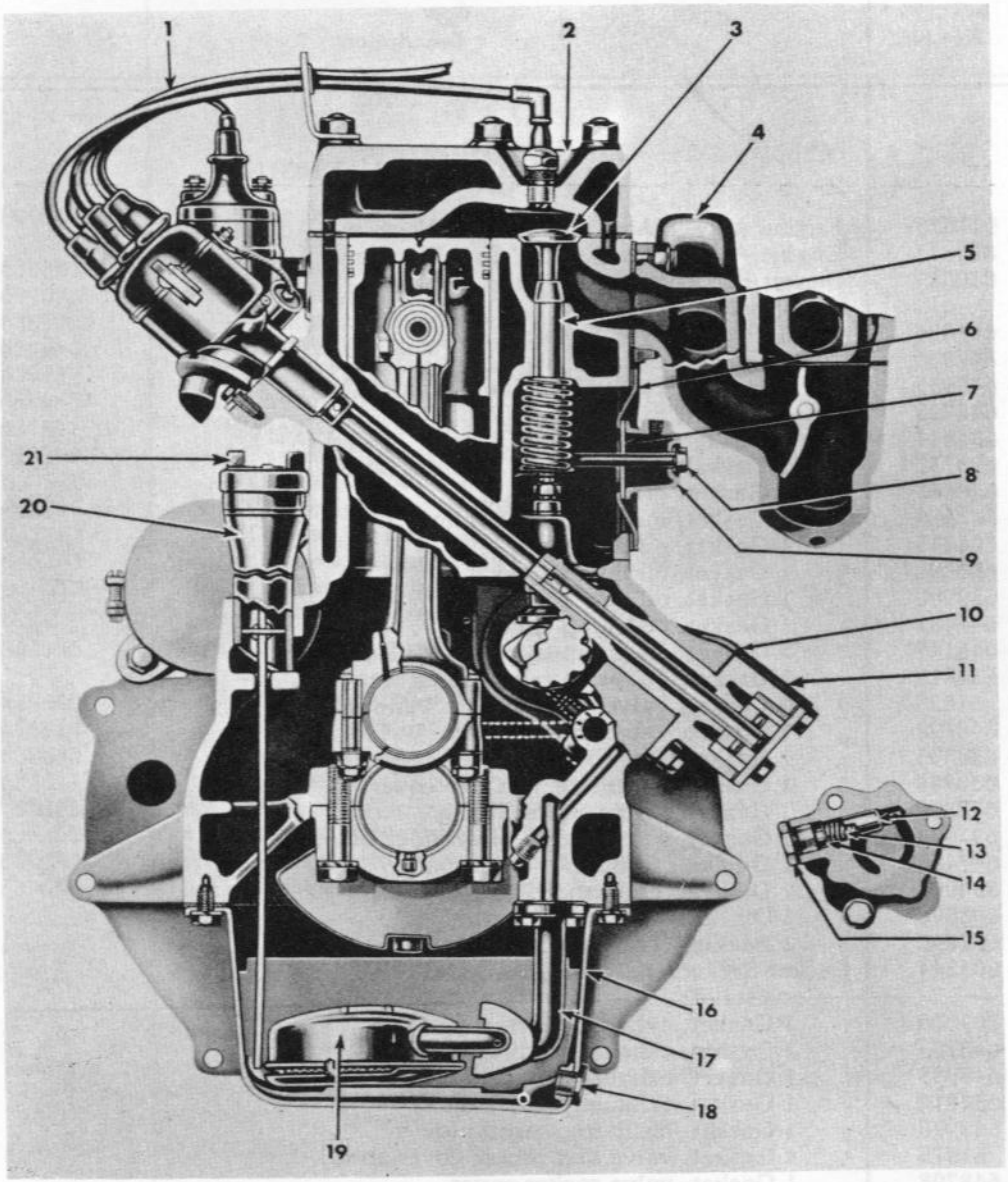

FIG. 183—4L-ENGINE, END SECTION

Ref. No.	Description	Group No.	Ref. No.	Description	Group No.
1	Kit, spark plug, wiring	15-06	10	Body, ventilator	10-18
2	Gasket, cylinder head	10-02A	11	Pump, oil	10-13
3	Piston and Pin, Std.	10-06	12	Pan, oil	10-14
4	Valve, intake	10-08	13	Plug, drain	10-14
	Valve, exhaust	10-08	14	Support, oil float	10-15
5	Head, cylinder	10-02A	15	Float, oil	10-15
6	Guide, intake valve	10-08	16	Kit, crankshaft	10-03
	Guide, exhaust valve	10-08	17	Indicator, oil	10-16
7	Spring, valve	10-08	18	Rod, connecting, No. 1-3	10-05
8	Manifolds, intake and exhaust.	10-19		Rod, connecting, No. 2-4	10-05
9	Screw, valve tappet	10-09	19	Tube, oil filler	10-16

Fig. and Ref. No.	Part No.	Description	4L	4F
		GROUP 10-01—ENGINE		
	911676	Engine Assy. (Short) Incls. Cyl. Block and All Internal Parts	1	
	804811	Engine Assy. (Short) Incls. Cyl. Block and All Internal Parts		1
	810585	Gasket Set, engine overhaul		1
		Consists of:		
	641096	1 Gasket, cylinder block, front		
	807036	1 Gasket, cylinder head		
	648935	1 Gasket, exhaust manifold, center		
	648795	2 Gasket, exhaust manifold, end		
	634814	1 Gasket, exhaust pipe flange		
	638737	2 Gasket, fuel pump to cylinder block		
	630365	1 Gasket, gear cover		
	648970	1 Gasket, insulator, carburetor		
	806515	1 Gasket, oil drain plug		
	630398	1 Gasket, oil float support		
	639980	1 Gasket, oil pan		
	641482	1 Gasket, oil pump cover		
	646147	1 Gasket, oil pump to cylinder block		
	634813	2 Gasket, oil pump relief spring retainer		
	51875	4 Gasket, valve and rocker cover stud		
	648798	1 Gasket, valve rocker cover		
	630305	1 Gasket, valve spring cover		
	630299	1 Gasket, ventilator to valve cover		
	648852	1 Gasket, water outlet fitting		
	637053	1 Gasket, water pump to cylinder block		
	647468	1 Oil Seal, front end, crankshaft		
	800093	2 Oil Seal, crankshaft, rear bearing		
	808098	2 Oil Seal, rocker arm cover		
	637790	2 Packing, crankshaft bearing cup		
	801344	Gasket Set, engine valve job		1
		Consists of:		
	807036	1 Gasket, cylinder head		
	648795	2 Gasket, exhaust manifold (end)		
	648935	1 Gasket, exhaust manifold (center)		
	634814	1 Gasket, exhaust pipe flange		
	648970	1 Gasket, insulator, carburetor		
	51875	4 Gasket, valve and rocker cover stud		
	648798	1 Gasket, valve rocker cover		
	630305	1 Gasket, valve spring cover		
	630299	1 Gasket, ventilator to valve cover		
	648852	1 Gasket, water outlet fitting		

Fig. and Ref. No.	Part No.	Description	4L	4F
		GROUP 10-01—ENGINE (Cont'd)		
	810584	Gasket Set, engine overhaul	1	
		Consists of:		
	630365	1 Gasket, chain cover		
	641096	1 Gasket, cylinder block, front		
	638540	1 Gasket, cylinder head		
	634814	1 Gasket, exhaust pipe flange		
	638737	1 Gasket, fuel pump to cylinder block		
	638640	1 Gasket, intake and exhaust manifold		
	634811	1 Gasket, intake to exhaust manifold		
	630398	1 Gasket, oil float support		
	639980	1 Gasket, oil pan		
	806515	1 Gasket, oil pan drain plug		
	641482	1 Gasket, oil pump cover		
	646147	1 Gasket, oil pump to cylinder block		
	634813	1 Gasket, oil relief spring retainer		
	802030	Gasket Set, engine valve job	1	
		Consists of:		
	638540	1 Gasket, cylinder head		
	634814	1 Gasket, exhaust pipe flange		
	638640	1 Gasket, intake and exhaust manifold		
	634811	1 Gasket, intake to exhaust manifold		
	51875	2 Gasket, valve cover screw		
	630305	1 Gasket, valve spring cover		
	630299	1 Gasket, ventilator to valve cover		
	639650	1 Gasket, water outlet elbow		

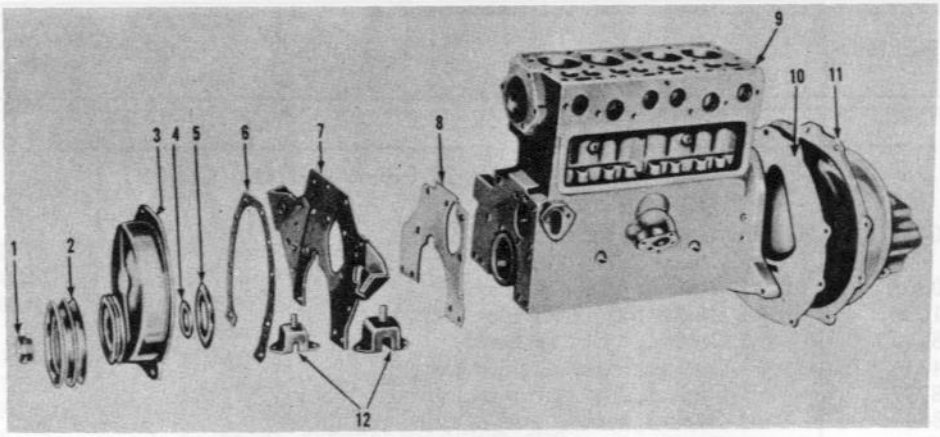

FIG. 184—CYLINDER BLOCK, FLYWHEEL HSG. AND GEAR COVER—4L

Ref. No.	Description	Group No.	Ref. No.	Description	Group No.
1	Nut, crankshaft	10-03	7	Plate, engine front	10-23
2	Pulley, fan drive	10-03	8	Gasket, cylinder block front	10-23
3	Cover, gear	10-12	9	Block and Bearings	10-02
4	Oil seal, crankshaft	10-03	10	Plate, engine, rear	10-23
5	Slinger, oil	10-03	11	Housing, flywheel	10-22
6	Gasket, gear cover	10-12	12	Insulator, front	—

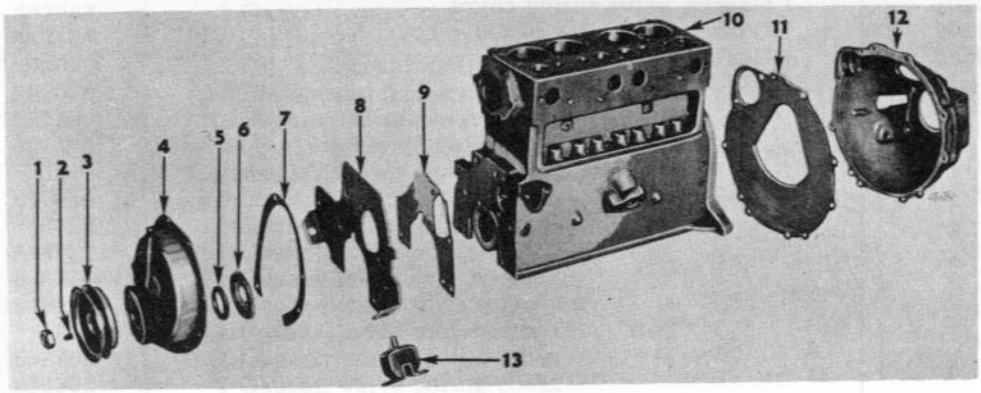

FIG. 185—CYLINDER BLOCK, FLYWHEEL HOUSING AND GEAR COVER—4F

Ref. No.	Description	Group No.	Ref. No.	Description	Group No.
1	Nut, crankshaft	10-03	8	Plate, engine, front (spec. ord.)	—
2	Key	10-03	9	Gasket, cylinder block, front	10-23
3	Pulley, fan drive	10-03	10	Block and bearings	10-02
4	Cover, gear	10-12	11	Plate, engine, rear	10-23
5	Oil Seal, crankshaft	10-03	12	Housing, flywheel (spec. ord.)	—
6	Slinger, oil	10-03	13	Insulator, front	10-23
7	Gasket, gear cover	10-12			

Fig. and Ref. No.	Part No.	Description	4L	4F
		GROUP 10-02—CYLINDER BLOCK		
	918089	Block and Bearings, with piston fitted, cylinder assembly		1
	918014	Block and Bearings, with piston fitted, cylinder assembly	1	
	381519	Screw, bearing cap to crankcase	6	6
	642561	Bolt, hex. hd., 7/16"-14 x 2 3/8" (Bearing caps to cylinder block)	8	8
	GM-120383	Lockwasher, 7/16"	8	8
	A-1126	Cock, drain, cylinder block	1	1
	641050	Jet, oil, timing gear	1	1
	GM-103895	Plug, expansion, 1 1/4"	5	5
	GM-103897	Plug, expansion, 1 3/4" (Camshaft rear bearing)	1	1
	GM-103865	Plug, pipe, 1/8" sq. hd.	3	4
	645256	Plug, pipe, 1/8" slotted (To plug hole for filter in cylinder block)	2	2
	GM-103866	Plug, pipe, 1/4" sq. hd.	1	1
	376373	Plug, pipe, 3/8" countersunk	2	2
	635886	Stud, 1/4" x 1" (Ignition coil to cylinder block)	2	2
	647650	Tube, bypass, cylinder block water pump	1	1
		GROUP 10-02A—CYLINDER HEAD		
	807763	Head, cylinder, (6.48 to 1 Ratio)	1	
186-10	800572	Head, cylinder, assembly (6.9 to 1 Ratio)		1
	801000	Bolt, hex. hd., 7/16"-14 x 1 11/16" (Cylinder head intake manifold to cyl. block)		1
	669118	Washer, flat, special		8
186-20	805730	Bolt, cylinder head, 7/16"-14 x 4 1/4"		14
186-8	GM-137404	Connector, 3/16" inverted flared tube		1
186-17	800293	Fitting, water outlet, cylinder head		1
186-18	673488	Screw and Lockwasher, hex. hd., 5/16"-18 x 7/8"		3
186-11	807036	Gasket, cylinder head		1
186-16	648852	Gasket, water outlet fitting		1
186-12	649720	Nipple, hose, 1/4" pipe		1
186-9	645256	Plug, pipe, slotted hd., 1/8"		2
186-7	GM-103868	Plug, pipe, sq. hd., 1/2"		1
	GM-103195	Stud, carburetor mounting, 3/8"-16 x 1 7/16"		2
	649708	Stud, rocker shaft support, 3/8"-16 x 3 11/16"		4
	638539	Nut, hex. 7/16"-20 } Cylinder head mounting	15	14
	646398	Stud, 7/16"-14 x 4 13/16" }		14
	802548	Stud, 7/16"-14 x 3 3/8" (Cylinder head to cylinder block)	15	
	A-1192	Elbow, water outlet	1	
	GM-122138	Bolt, hex. hd., 3/8"-16 x 1 1/8" } Water outlet elbow to	3	
	GM-120382	Lockwasher, 3/8" } cylinder head	3	
	638540	Gasket, cylinder head	1	
	639650	Gasket, water outlet elbow	1	

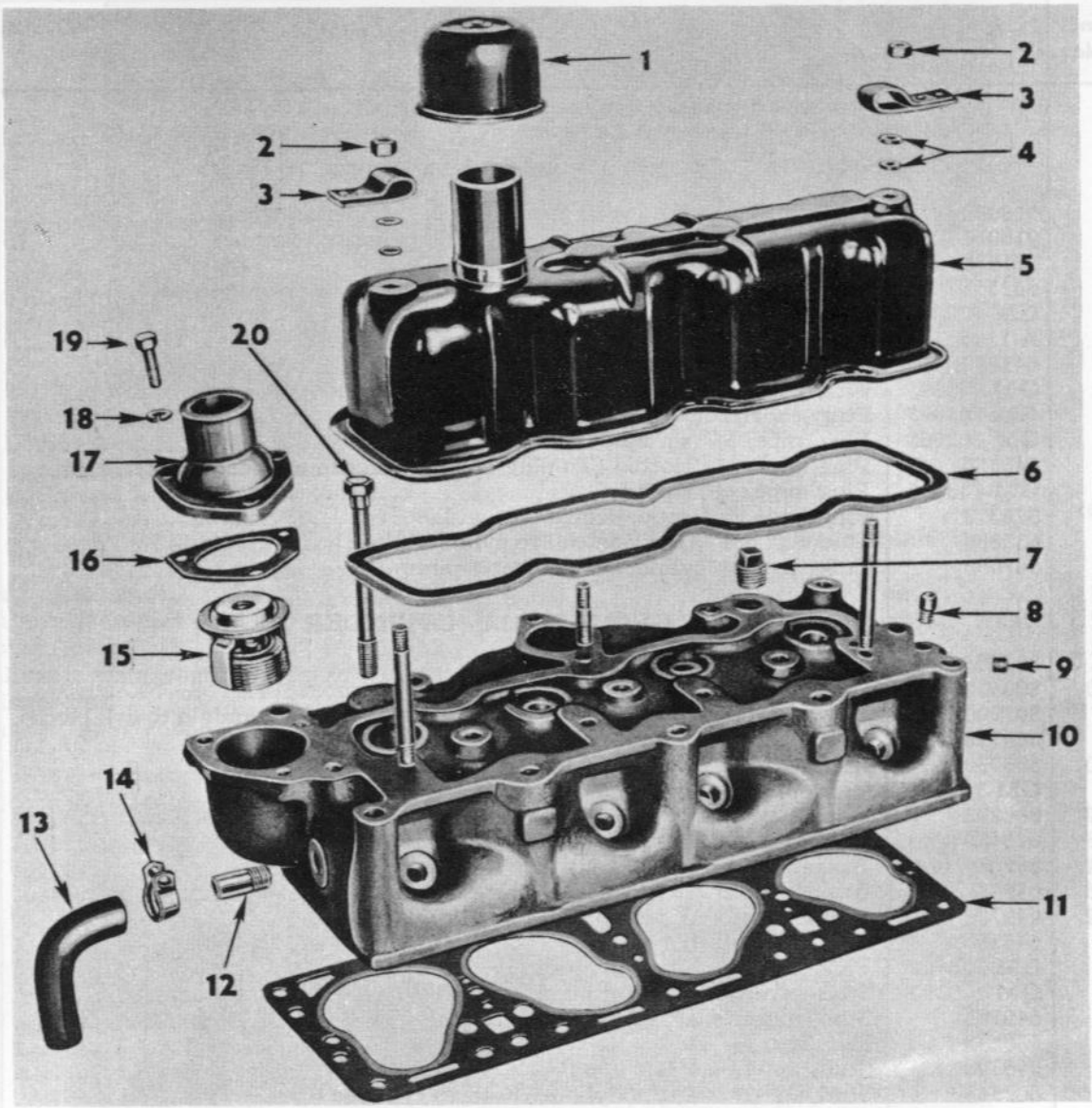

FIG. 186—CYLINDER HEAD AND ROCKER ARM COVER—4F

Ref. No.	Description	Group No.
1	Cap, breather	10-10A
2	Nut, cylinder head stud	10-10A
3	Clip, ignition cable	15-06
4	Washer, cable clip	15-06
5	Cover, rocker arm	10-10A
6	Gasket, rocker arm cover	10-10A
7	Plug, pipe, 1/2"	10-02A
8	Connector, vacuum tube	10-02A
9	Plug, pipe, 1/8" slotted hd.	10-02A
10	Head, cylinder	10-02A
11	Gasket, cylinder hd.	10-02A
12	Nipple, hose	10-02A
13	Hose, by-pass to water pump	14-02
14	Clamp, by-pass hose	14-02
15	Thermostat	14-06
16	Gasket, water, outlet fitting	10-02A
17	Fitting, water outlet	10-02A
18	Lockwasher, outlet fitting (Use assembly)	10-02A
19	Bolt, outlet fitting (Use assembly)	10-02A
20	Bolt, cylinder head 7/16-14 x 4-1/4"	10-02A

Fig. and Ref. No.	Part No.	Description	4L	4F
		GROUP 10-03—CRANKSHAFT		
	381519	Bolt, crankshaft bearing cap	6	6
	GM-120384	Lockwasher, ½″ (Bearing cap to crankshaft bolt)	6	6
187-1	635377	Dowel, crankshaft, bearing	5	5
185-2	GM-124549	Key, woodruff, No. 9 (Pulley to crankshaft)	1	1
187-6	647078	Kit, crankshaft and dowel bolt (Std. size)	1	1
		Consists of:		
	116295	2 Bolt, dowel crankshaft		
	646316	1 Crankshaft		
	GM-114608	2 Lockwasher, dowel bolt		
	GM-114696	2 Nut, dowel bolt		
	A-7696	1 Tag, instruction, crankshaft to flywheel dowel bolt		
184-1	387633	Starting crank nut, crankshaft pulley	1	1
184-4	647468	Oil seal, crankshaft, front end	1	1
	800093	Oil seal, crankshaft, rear bearing	2	2
	637790	Packing, crankshaft bearing cap, rear	2	2
184-2	645623	Pulley, fan drive (5.15″ dia.)	1	1
	646698	Pulley, crankshaft, twin groove	1	1
	811579	Pulley, fan drive (7.54″ dia.)	1	1
187-8	630262	Shim, crankshaft	*	*
184-5	375877	Slinger, crankshaft oil	1	1
187-12	641281	Spacer, crankshaft gear	1	1
187-9	634796	Washer, thrust, crankshaft	1	1
		* Use as required.		
		GROUP 10-04—CRANKSHAFT BEARING		
		NOTE: Connecting Rod Bearing Sets		
		Consists of: (1) Upper and (1) Lower half bearing		
187-2	645160	Bearing Set, crankshaft, front, std. size	1	1
187-3	645161	Bearing Set, crankshaft, center, std. size	1	1
187-4	645162	Bearing Set, crankshaft, rear, std. size	1	1
	804333	Bearing Set, crankshaft, front, .002″ undersize	1	1
	804334	Bearing Set, crankshaft, center, .002″ undersize	1	1
	804335	Bearing Set, crankshaft, rear, .002″ undersize	1	1
	645163	Bearing Set, crankshaft, front, .010″ undersize	1	1
	645164	Bearing Set, crankshaft, center, .010″ undersize	1	1
	645165	Bearing Set, crankshaft, rear, .010″ undersize	1	1
	805242	Bearing Set, crankshaft, front, .012″ undersize	1	1
	805243	Bearing Set, crankshaft, center, .012″ undersize	1	1
	805244	Bearing Set, crankshaft, rear, .012″ undersize	1	1
	645166	Bearing Set, crankshaft, front, .020″ undersize	1	1
	645167	Bearing Set, crankshaft, center, .020″ undersize	1	1
	645168	Bearing Set, crankshaft, rear, .020″ undersize	1	1
	645169	Bearing Set, crankshaft, front, .030″ undersize	1	1
	645170	Bearing Set, crankshaft, center, .030″ undersize	1	1
	645171	Bearing Set, crankshaft, rear, .030″ undersize	1	1

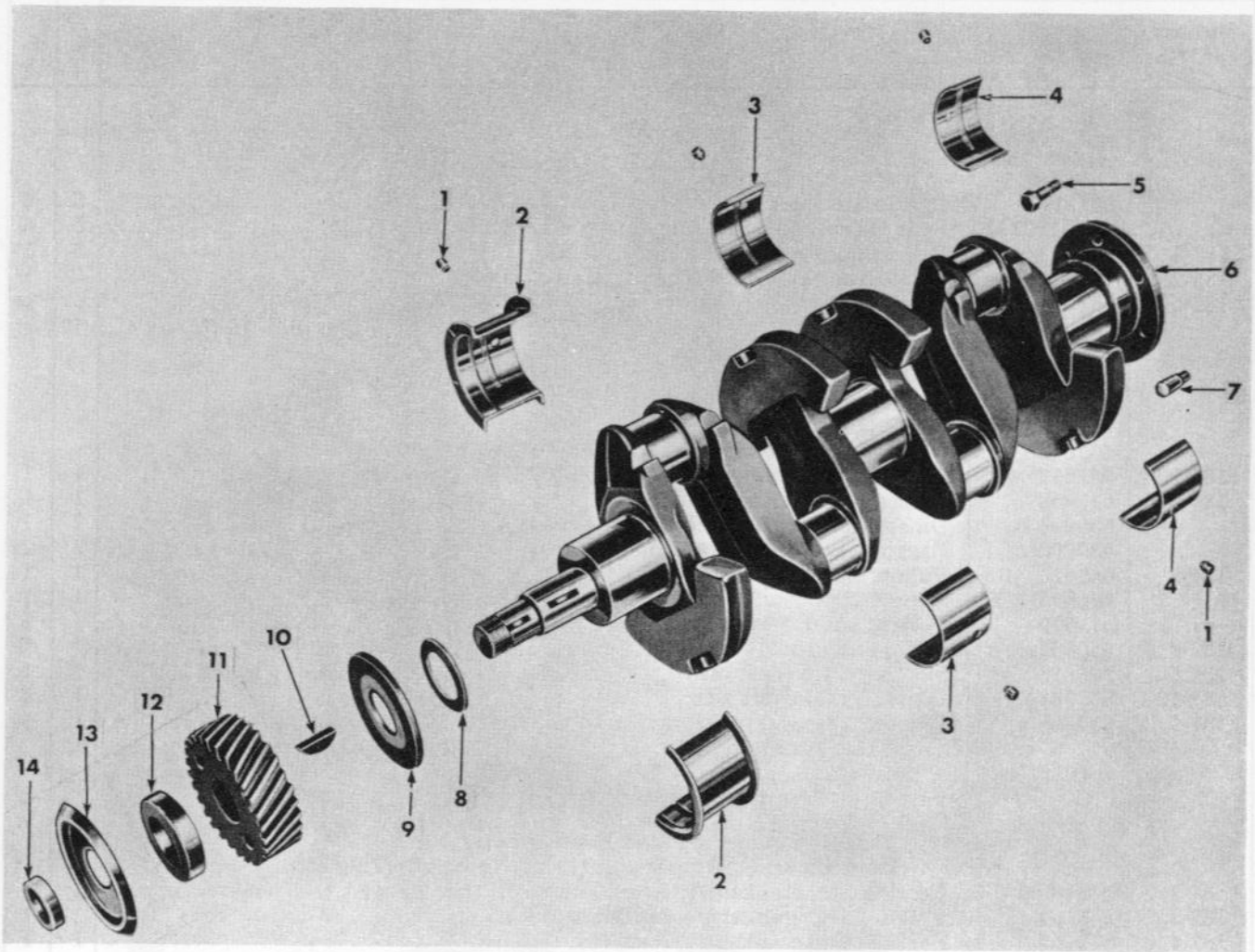

FIG. 187—CRANKSHAFT AND BEARINGS—4L AND 4F

Ref. No.	Description	Group No.	Ref. No.	Description	Group No.
1	Dowel, bearing	10-03	8	Shim, crankshaft	10-03
2	Bearing, front, upper	10-04	9	Washer, thrust	10-03
3	Bearing, center, upper	10-04	10	Key, crankshaft gear	10-03
4	Bearing, rear, upper	10-04	11	Gear, crankshaft	10-11
5	Bolt, flywheel to crankshaft	10-21	12	Spacer, crankshaft gear	10-03
6	Crankshaft	10-03	13	Slinger, oil	10-03
7	Dowel, flywheel to crankshaft	10-21	14	Oil seal	10-03

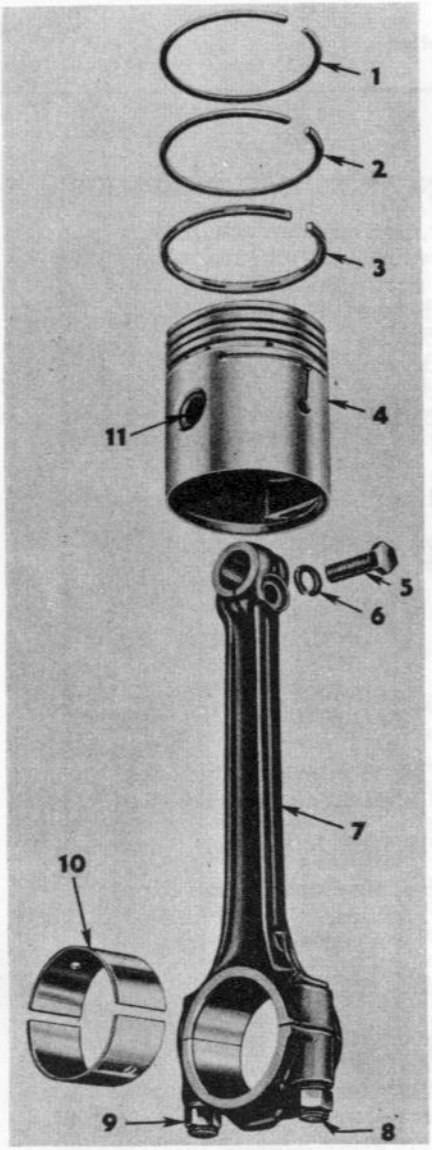

FIG. 188—CONNECTING ROD AND PISTON 4L AND 4F

Ref. No.	Description	Group No.
1	Ring, piston, top groove	10-07
2	Ring, piston, second groove	10-07
3	Ring, piston, third groove	10-07
4	Piston and Pin	10-06
5	Screw, lock, piston pin	10-06
6	Lockwasher, piston pin screw	10-06
7	Rod, connecting	10-05
8	Bolt, connecting rod cap	10-05
9	Nut, connecting rod cap bolt	10-05
10	Bearing Set, connecting rod	10-05
11	Pin, piston	10-06

Fig. and Ref. No.	Part No.	Description	4L	4F
		GROUP 10-05—CONNECTING ROD AND BEARINGS		
188-7	641774	Rod, connecting, No. 1 and 3 cylinder, less bearing, assembly	2	2
188-7	641775	Rod, connecting, No. 2 and 4 cylinders, less bearing, assembly	2	2
188-10	A-7233	Bearing Set, connecting rod, standard size	4	4
	A-6975	Bearing Set, connecting rod, .002″ undersize	4	4
	A-7234	Bearing Set, connecting rod, .010″ undersize	4	4
	805233	Bearing Set, connecting rod, .012″ undersize	4	4
	A-7235	Bearing Set, connecting rod, .020″ undersize	4	4
	A-7236	Bearing Set, connecting rod, .030″ undersize	4	4
188-8	641768	Bolt, connecting rod cap	8	8
188-9	641769	Nut, connecting rod cap bolt	8	8
	GM-107823	Nut, stamped, 3/8″-24 (Connecting rod cap bolt nut lock)	8	8
		GROUP 10-06—PISTON AND PINS		
188-11	636961	Pin, piston	4	4
188-5	632157	Screw, lock piston pin	4	4
188-6	GM-120382	Lockwasher, 3/8″	4	4
188-4	801476	Piston and pin, assembly, std.	4	4
	801537	Piston and pin, assembly, .010″ oversize	4	4
	801538	Piston and pin, assembly, .020″ oversize	4	4
	801539	Piston and pin, assembly, .030″ oversize	4	4
	801540	Piston and pin, assembly, .040″ oversize	4	4
		GROUP 10-07—PISTON RINGS		
		Expander Type with Chrome Plate Compression Rings		
	919194	Ring set, piston, std.-.009″ oversize	1	1
	919195	Ring set, piston, .010-.019″ oversize	1	1
	919196	Ring set, piston, .020-.029″ oversize	1	1
	919197	Ring set, piston, .030-.039″ oversize	1	1
		GROUP 10-08—VALVES, VALVE GUIDES AND SPRINGS		
	802587	Cap, roto, assembly	4	4
	119137	Guide, valve exhaust	4	4
	119136	Guide, valve, inlet	4	
	119138	Guide, valve inlet		4
189-13	375994	Lock, valve spring, retainer		8
189-12	637044	Retainer, engine valve spring	8	
	643334	Lock, exhaust valve spring retainer	16	8
190-12	800986	Oil seal, inlet valve spring retainer		4
190-11	649751	Retainer, inlet valve spring, upper		4
189-11	638636	Spring, exhaust valve	8	4
190-13	800417	Spring, inlet valve		4

Fig. and Ref. No.	Part No.	Description	4L	4F
		GROUP 10-08—VALVES, VALVE GUIDES AND SPRINGS (Cont'd)		
	802639	Valve, exhaust		4
190-15	646421	Valve, inlet		4
	119136	Guide, valve stem, inlet	4	
	119138	Guide, valve stem, inlet		4
	119137	Guide, valve stem, exhaust	4	4
189-10	807342	Valve, engine, exhaust, stellite (928342)	4	4
189-10	807341	Valve, engine, inlet	4	
	806174	Insert, stellite exhaust valve	4	4
		GROUP 10-09—VALVE TAPPETS		
	800550	Tappet, inlet valve (Std.)		4
	919727	Tappet, inlet valve (.004″ oversize)		4
	804772	Tappet assembly, (With adjusting screw) inlet and exhaust (Std.)	8	4
	919703	Tappet assembly (With adjusting screw) inlet and exhaust (.004″ oversize)	8	4
	640020	Screw, tappet adjusting (Self locking type)	8	4
		GROUP 10-09A—VALVE ROCKER ARMS AND PUSH RODS		
190-2	805375	Arm, valve rocker, left, assembly		2
190-7	805376	Arm, valve rocker, right, assembly		2
190-8	802295	Bracket, rocker shaft		4
	641769	Nut, hex., $\frac{3}{8}$″-24, special (Rocker shaft bracket to mounting stud)		4
	800200	Washer, $\frac{3}{8}$″ flat, special		4
	804622	Rod, push, inlet valve		4
190-4	648803	Screw, lock, rocker shaft, $\frac{5}{16}$″-24 x $1\frac{1}{8}$″		2
190-5	805368	Shaft and plug, rocker arm, assembly		1
190-3	649666	Spring, valve rocker shaft		2
		GROUP 10-10—VALVE SPRING COVER		
	630303	Cover, valve spring	1	1
	657087	Cover, exhaust valve spring, assembly		1
	630305	Gasket, valve spring cover	1	1
	51875	Gasket, valve spring cover cap screw	2	2
	645093	Screw, cap valve spring, $\frac{5}{16}$″-18 x $3\frac{11}{16}$″	1	1
	645094	Screw, cap valve spring, $\frac{5}{16}$″-18 x $2\frac{9}{16}$″	1	1
	805476	Stud, valve cover, rear		1
	674993	Washer, spring tension, $\frac{5}{16}$″ (Valve cover cap screw, between cover and gasket washer)	2	2

Fig. and Ref. No.	Part No.	Description	4L	4F
		GROUP 10-10A—ROCKER ARM COVER		
		(Trailing Tube Crank Case Ventilation)		
186-1	701357	Cap, breather assembly		1
186-5	648851	Cover, rocker arm, assembly		1
		(Positive Crankcase Ventilation)		
	908663	Cover, rocker arm, assembly		1
186-2	GM-120368	Nut, hex., 5/16"-24		2
	GM-446363	Washer, plain, 5/16" (Rocker arm cover to valve cover)		2
186-6	648798	Gasket, valve rocker arm cover		1
	906459	Oil seal, rocker arm cover		2
	649709	Stud, rocker arm cover, 5/16"-24 x 2"		2
	808097	Stud, rocker arm cover		2
		GROUP 10-11—CAMSHAFT AND TIMING GEARS		
	641284	Camshaft	1	
189-9	645595	Bushing, camshaft, front	1	1
	800517	Camshaft		1
187-11	641282	Gear, crankshaft (28 teeth)	1	1
189-5	641283	Gear, camshaft (56 teeth)	1	1
189-1	GM-122260	Bolt, hex. hd., 7/16"-14 x 1 1/8" (Gear to camshaft)	1	1
189-2	GM-136857	Lockwasher, 7/16" ext. (Gear to camshaft)	1	1
	GM-124549	Key, woodruff No. 9	2	2
		(1 required camshaft gear to camshaft) (1 required gear to crankshaft)		
189-8	GM-124552	Key, woodruff, No. 13 (Gear to crankshaft)	1	1
189-6	802576	Plate, thrust, camshaft	1	1
190-21	GM-423569	Screw and lockwasher, hex. hd., 3/8"-16 x 3/4"	2	2
189-7	641049	Spacer, camshaft thrust plate	1	1
	642520	Washer, camshaft gear	1	1
		GROUP 10-12—TIMING GEAR COVER		
184-3	643834	Cover, gear assembly	1	1
	GM-123520	Bolt, hex. hd., 3/8"-24 x 3/4"	3	3
	GM-120647	Bolt, hex. hd., 3/8"-24 x 1"	1	1
	GM-271193	Nut and lockwasher, hex., 3/8"-24 (Front cover to engine plate)	4	4
184-6	630365	Gasket, gear cover	1	1
	640185	Plug, nut, 1/4" flared tube	1	1
	375917	Ring, retaining, rear cover packing	1	1
	GM-178551	Lockwasher, 3/8", int. and ext. (Engine ground strap)	2	2
	GM-103195	Stud, 3/8" x 1 7/16"	6	6
	GM-423569	Screw and lockwasher, hex. hd., 3/8"-16 x 3/4" (Front cover engine plate to block)	6	6

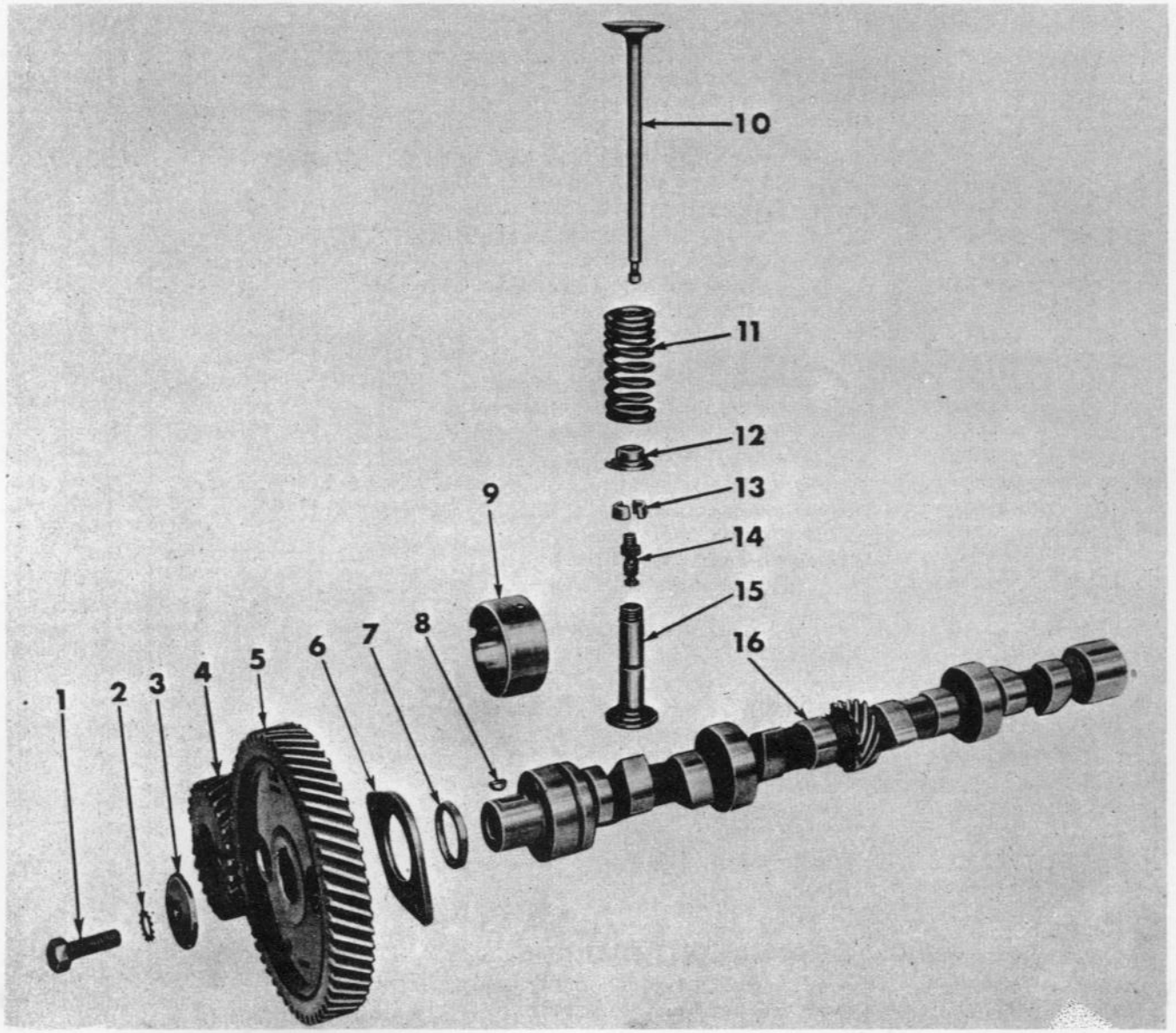

FIG. 189—CAMSHAFT TIMING GEARS AND VALVES—4L

Ref. No.	Description	Group No.
1	Bolt, gear to camshaft	10-11
2	Lockwasher	10-11
3	Washer, camshaft gear	10-11
4	Gear, crankshaft	10-03
5	Gear, camshaft	10-11
6	Plate, thrust	10-11
7	Spacer, thrust plate	10-11
8	Key, camshaft gear	10-11
9	Bushing, camshaft	10-11
10	Valve, intake	10-08
	Valve, exhaust	10-08
11	Spring, valve	10-08
12	Retainer, valve spring	10-08
13	Lock, retainer	10-08
14	Screw, tappet	10-09
15	Tappet	10-09
16	Camshaft	10-11

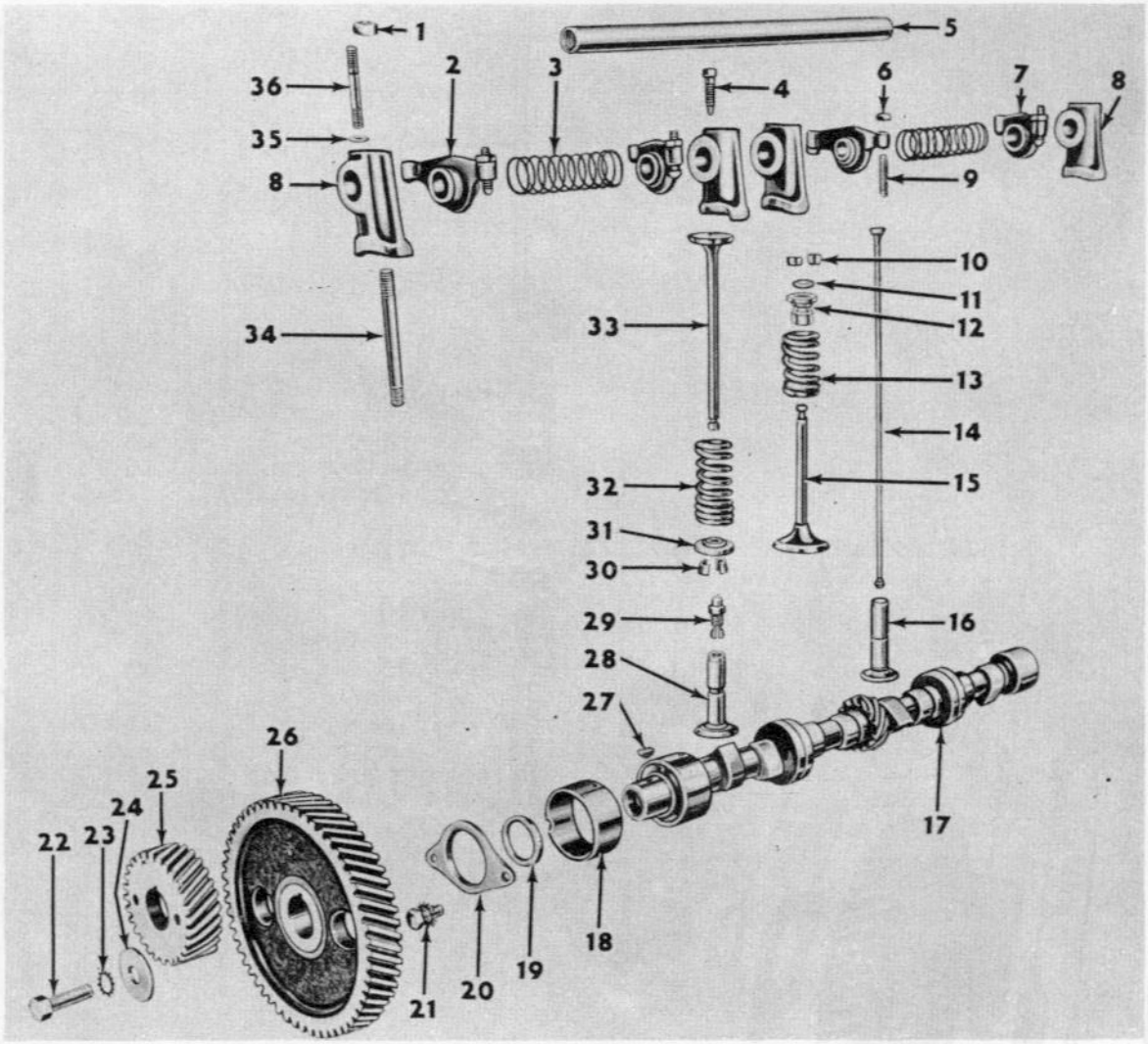

FIG. 190—CAMSHAFT, TIMING GEARS AND VALVES—4F

Ref. No.	Description	Group No.
1	Nut, hex., 5/16"-24	10-10A
2	Arm, rocker, left, assembly	10-09A
3	Spring, rocker arm shaft	10-09A
4	Screw, lock, rocker shaft	10-09A
5	Shaft and Plug, rocker arm	10-09A
6	Nut, hex., 5/16"-24	10-09
7	Arm, rocker, right, assembly	10-09A
8	Bracket, rocker arm, shaft	10-09A
9	Screw, adjusting, inlet valve tappet	10-09
10	Lock, inlet valve spring, upper, retainer	10-08
11	Retainer, inlet valve spring, upper	10-08
12	Oil Seal, inlet valve spring retainer	10-08
13	Spring, inlet valve	10-08
14	Rod, push, inlet valve	10-09A
15	Valve, inlet	10-08
16	Tappet, inlet valve	10-09
17	Camshaft	10-11
18	Bushing, camshaft, front	10-11
19	Spacer, camshaft thrust plate	10-11
20	Plate, thrust, camshaft	10-11
21	Screw, and Lockwasher, thrust plate to block	10-11
22	Bolt, gear to camshaft	10-11
23	Lockwasher, gear to camshaft	10-11
24	Washer, camshaft gear	10-11
25	Gear, crankshaft	10-11
26	Gear, camshaft	10-11
27	Key, woodruff, No. 9	10-11
28	Tappet, exhaust valve	10-09
29	Screw, adjusting, exhaust valve tappet	10-09

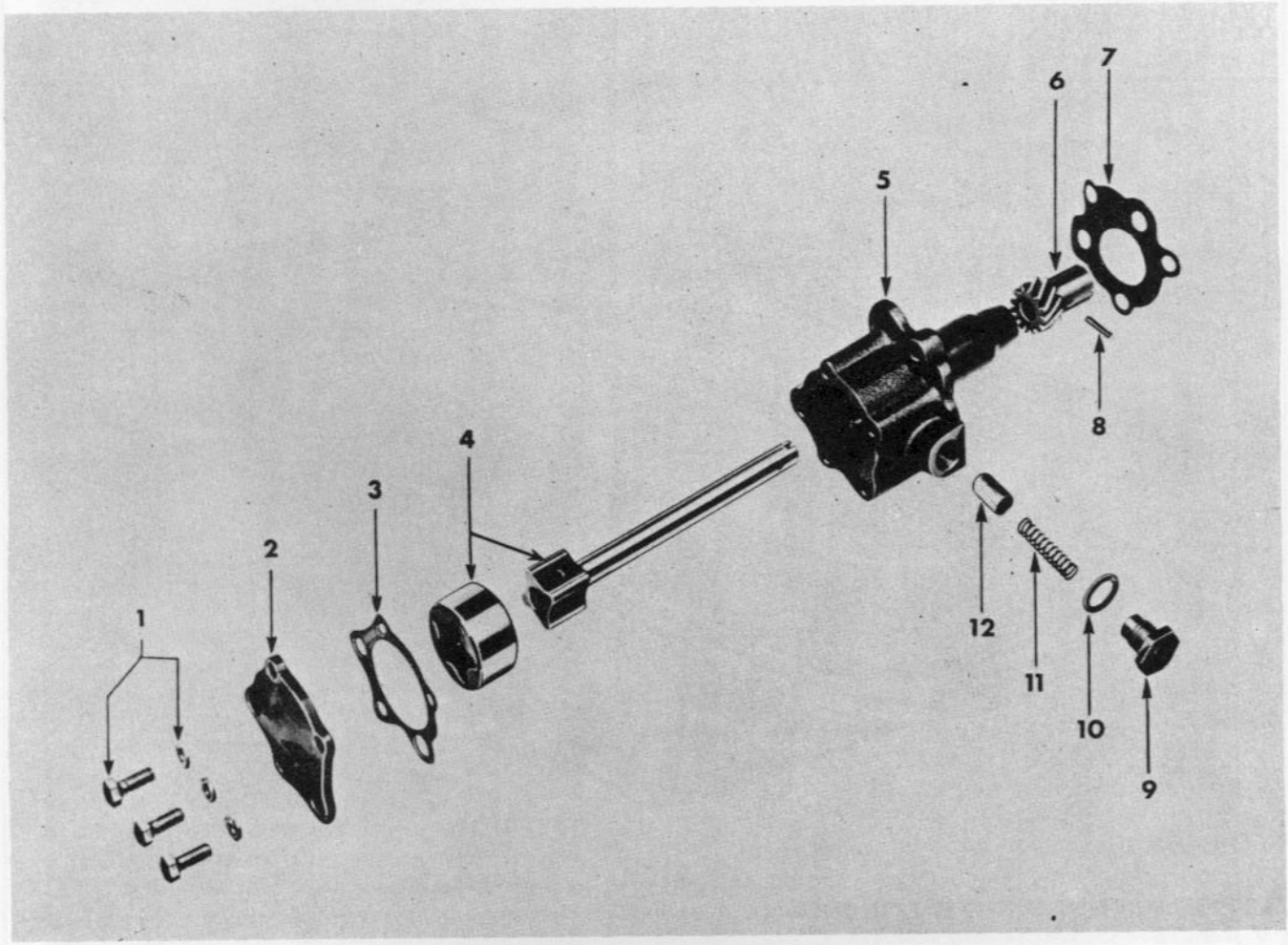

FIG. 191—OIL PUMP—4L AND 4F

Ref. No.	Description	Group No.
1	Screw and Lockwasher	10-13
2	Cover, body	10-13
3	Gasket, cover	10-13
4	Shaft and Rotor	10-13
5	Body	10-13
6	Gear, driven	10-13
7	Gasket, pump to cylinder block	10-13
8	Pin, driven gear	10-13
9	Retainer, oil relief spring	10-13
10	Gasket, oil relief spring retainer	10-13
11	Spring, oil relief plunger	10-13
12	Plunger, oil relief	10-13

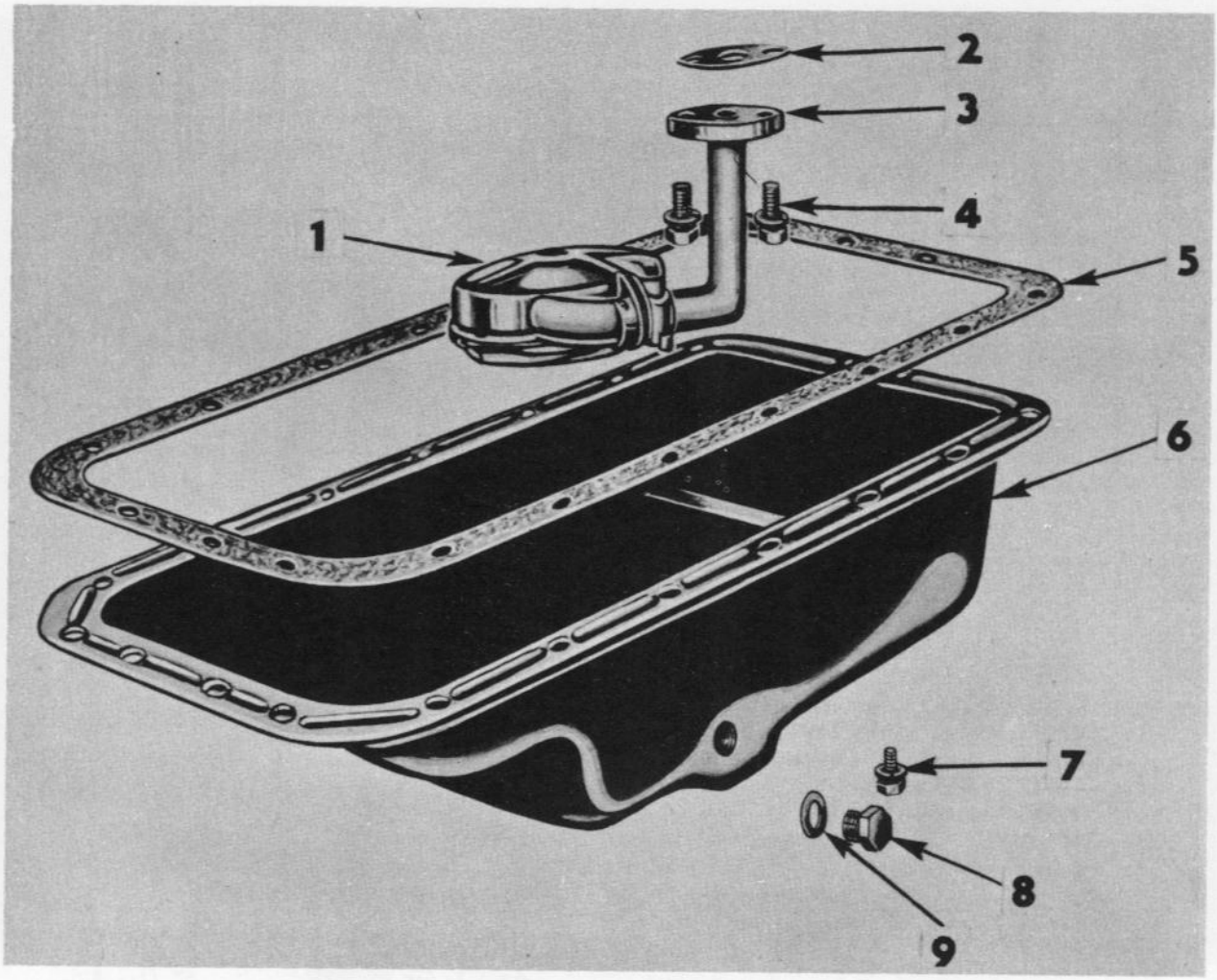

FIG. 192—OIL PAN FLOAT AND SUPPORT—4L AND 4F

Ref. No.	Description	Group No.
1	Float, oil	10-15
2	Gasket, oil float support	10-15
3	Support, oil float	10-15
4	Screw and Lockwasher, hex. hd. 5/16"-18 x 3/4"	10-15
5	Gasket, oil pan	10-14
6	Pan, oil	10-14
7	Screw and Lockwasher, hex. hd. 5/16"-18 x 5/8"	10-14
8	Plug, drain, oil pan	10-14
9	Gasket, oil drain plug	10-14

Fig. and Ref. No.	Part No.	Description	4L	4F
		GROUP 10-13—OIL PUMP		
	804484	Pump, oil, assembly (Cast iron body)	1	1
191-1	GM-431938	Screw and lockwasher, hex. hd., 5/16"-18 x 1" } Oil pump to cylinder block	1	1
	800233	Bolt and lockwasher, hex. hd., 5/16"-18 x 2 1/2" } Oil pump to cylinder block	2	2
191-5	804486	Body, oil pump, assembly (Cast iron)	1	1
191-2	641479	Cover, oil pump body	1	1
191-1	641740	Screw and lockwasher, hex. hd., 1/4"-20 x 5/8"	3	3
191-3	641482	Gasket, oil pump cover	1	1
191-10	634813	Gasket, oil pump relief spring retainer	1	1
191-7	646147	Gasket, oil pump to cylinder block	1	1
191-6	641047	Gear, driven oil pump	1	1
	643362	Kit, repair, oil pump (Eaton pump)	1	1
		Consists of:		
	641482	1 Gasket, cover		
	634813	1 Gasket, oil pump relief spring retainer		
	641047	1 Gear, driven		
	330964	1 Pin, driven gear		
	641742	1 Shaft and rotor (Inner and outer) assembly		
191-8	330964	Pin, oil pump driven gear	1	1
191-12	630518	Plunger, relief, oil pump	1	1
191-9	630390	Retainer, oil pump relief spring	1	1
191-4	641742	Shaft and rotors (Inner and outer) assembly	1	1
191-11	808385	Spring, relief, oil plunger	1	1
	805842	Washer, rectangular	1	1
		GROUP 10-14—OIL PAN		
192-6	A-7238	Pan, oil assembly	1	1
192-7	GM-187527	Screw and lockwasher, hex. hd., 5/16"-18 x 5/8" } Oil pan to cylinder block and gear cover	14	14
	GM-423560	Bolt and lockwasher, hex. hd., 5/16"-18 x 1/2" } Oil pan to cylinder block and gear cover	6	6
192-9	806515	Gasket, oil drain plug	1	1
192-5	639980	Gasket, oil pan	1	1
192-8	639979	Plug, drain, oil pan	1	1
	905595	Plug, drain, oil pan (Magnetic)	1	1
		GROUP 10-15—OIL FLOAT		
192-1	630396	Float, oil, assembly	1	1
	GM-120123	Pin, cotter, 1/8" x 1 1/4" (Oil float to support)	1	1
192-2	630398	Gasket, oil float support	1	1
192-3	630397	Support, oil float	1	1
192-4	GM-451975	Screw and lockwasher, hex. hd., 5/16"-18 x 3/4" (Float support to cylinder block)	2	2

Fig. and Ref. No.	Part No.	Description	4L	4F
		GROUP 10-16—OIL FILLER TUBE AND LEVEL INDICATOR		
		Positive Crankcase Ventilation		
	911417	Tube, assembly, oil filler ($15\frac{31}{32}$" long)	1	
	912947	Tube, assembly, oil filler ($15\frac{31}{32}$" long)		1
	913134	Tube, assembly, oil filler ($18\frac{5}{16}$" long)		1
	926700	Tube, assembly, oil filler ($19\frac{29}{32}$" long)		1
	812119	Tube, assembly, oil filler ($9\frac{5}{16}$" long)	1	1
	912910	Cap and level indicator ($25\frac{1}{4}$" long)	1	1
	812111	Cap and level indicator ($18\frac{9}{16}$" long)	1	1
	807392	Cap and level indicator ($27\frac{19}{32}$" long)		1
	926826	Cap and level indicator ($29\frac{1}{4}$" long)		1
	A-5105	Bracket, filler tube mounting	1	1
		Trailing Tube Crankcase Ventilation		
	804899	Oil level indicator rod		1
	804527	Tube, assembly, indicator rod (Filler cap in Group 10-10A)		1
		GROUP 10-16A—OIL FILTER		
	808042	Filter, assembly, oil	1	1
	800316	Bolt, hex., washer hd., $\frac{5}{16}$"-10 x $\frac{7}{8}$" — Mounting filter to bracket	4	
	800319	Nut, speed, $\frac{5}{16}$"-10 (Thick) (Part of bracket No. 800313) — Mounting filter to bracket	2	
	800320	Nut, speed, $\frac{5}{16}$"-10 (Thin) (Part of bracket No. 800313) — Mounting filter to bracket	2	
	GM-120741	Bolt, hex. hd., $\frac{5}{16}$"-24 x $\frac{3}{4}$" — Mounting filter to bracket		3
	GM-271187	Nut and lockwasher, assembly, $\frac{5}{16}$"-24 — Mounting filter to bracket		4
	GM-120393	Washer, plain, $\frac{5}{16}$" — Mounting filter to bracket		4
	119772	Clamp, filter, body mounting	2	2
	119773	Bolt, mounting clamp	2	2
	119775	Lockwasher, mounting clamp bolt	2	2
	119774	Nut, mounting clamp bolt	2	2
	800313	Bracket, oil filter, assembly, mounting	1	
	802087	Bracket, oil filter, assembly, mounting		1
	GM-431938	Screw and lockwasher, assembly, hex. hd., $\frac{5}{16}$"-18 x 1"		1
	118507	Bolt, oil filter cover	1	1
	909335	Kit, filter element and gasket	1	1
	345961	Grommet, $\frac{13}{32}$", rubber	1	
	647584	Tube, assembly, oil filter, inlet	1	
	647585	Tube, assembly, oil filter, inlet		1
	910290	Tube, assembly, oil filter, outlet	1	1
	GM-128302	Clip, $\frac{1}{2}$", tube	1	1
	GM-137421	Elbow, $\frac{1}{4}$", I. F., 90°	1	1
	808608	Elbow, $\frac{1}{4}$", I. F. x $\frac{1}{8}$", pipe, 45°	1	1

Fig. and Ref. No.	Part No.	Description	4L	4F
		GROUP 10-17—OIL DISTRIBUTION		
	800549	Bracket, oil line clip		1
	GM-9409106	Bolt, hex. hd., and lockwasher, assembly, 1/4"-20 x 1/2" (Bracket to cylinder block)		1
	645539	Clip, 3/16" (Oil line to accelerator cross shaft bracket)		1
	GM-137404	Connector, inverted flared tube, 3/16"		1
	GM-137420	Elbow, 3/16" flared tube (Oil line to cylinder block)		1
	648865	Tube, oil line, crankcase to cylinder head		1
		GROUP 10-18—CRANKCASE VENTILATION		
		Positive Crankcase Ventilation		
	630299	Gasket, ventilator to valve spring cover	1	1
	A-6919	Body, crankcase ventilator, assembly	1	1
	GM-137422	Elbow, pipe, 1/8"	1	
	A-6885	Elbow, pipe, 1/4"	1	
	641083	Tube, crankcase ventilator valve, assembly	1	
	A-6895	Valve, crankcase ventilator, assembly	1	1
	809656	Elbow, 90°, street, 1/8" pipe		1
	810617	Nipple, pipe, reducing, 1/4" x 1/8"		1
	810109	Coupling, pipe, reducing, 1/4" x 1/8"		1
	GM-192466	Nipple, pipe, 1/8" x 1 3/4" long		1
	GM-178910	Tee, 1/4", inverted, flare		1
	640185	Plug, 1/4", inverted, flare		1
	GM-137421	Elbow, 1/4", inverted, flare x 1/8" pipe		1
	908705	Vacuum line		1
	GM-125912	Clip, 1/4", closed		1
		Trailing Tube Crankcase Ventilation		
	630295	Crankcase, ventilator, assembly		1
	630298	Baffle, crankcase, ventilator		1
	630299	Gasket, ventilator to valve spring cover		1
	GM-103877	Plug, 1/8", pipe		1
	GM-125912	Clip, 1/4", closed		1

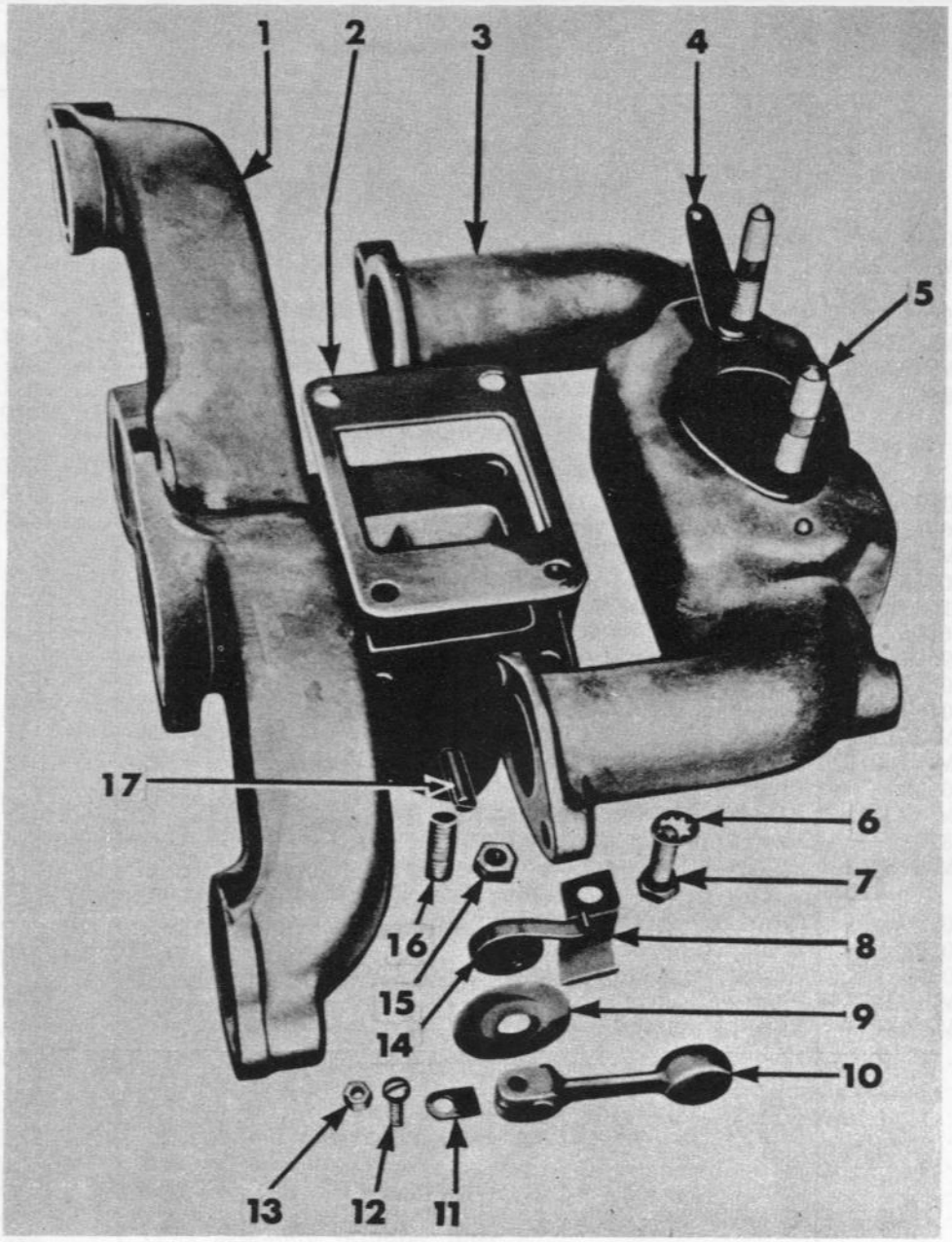

FIG. 193—MANIFOLDS—4L

Ref. No.	Description	Group No.
1	Manifold, exhaust	10-19
2	Gasket	10-19
3	Manifold, intake (for Governor)	10-19
	Manifold, intake (no Governor)	10-19
4	Clip, accelerator spring	12-08
5	Stud (with Governor)	10-19
	Stud (without Governor)	10-19
6	Lockwasher	10-19
7	Bolt	10-19
8	Stop, spring	10-20
9	Washer, spring	10-20
10	Lever, counterweight	10-20
11	Key, lever	10-20
12	Screw, lever	10-20
13	Nut, lever screw	10-20
14	Spring, valve	10-20
15	Nut, exhaust pipe stud	10-19
16	Stud, exhaust pipe	10-19
17	Shaft, valve	10-20

Fig. and Ref. No.	Part No.	Description	4L	4F
		GROUP 10-19—MANIFOLDS		
194-4	648766	Manifold, exhaust, assembly		1
	53287	Nut, hex., 3/8"-24 (Manifold to mounting studs)		5
	GM-120394	Washer, plain, 13/32"		1
194-5	648935	Gasket, exhaust manifold, center		1
194-2	648795	Gasket, exhaust manifold, end		2
	801345	Gasket, set, manifold		1
		Consists of:		
	648935	1 Gasket, exhaust manifold, center		
	648795	2 Gasket, exhaust manifold, end		
194-7	634814	1 Gasket, exhaust pipe flange		
194-6	GM-103196	Stud, 3/8"-16 x 1 9/16"		4
194-3	A-564	Stud, 3/8"-16 x 2 1/8"		2
	645305	Manifold, intake and exhaust, assembly	1	
	638640	Gasket, intake and exhaust, manifold	1	
	634811	Gasket, intake to exhaust	1	
	A-7835	Gasket set, manifold	1	
		Consists of:		
	634814	1 Gasket, exhaust pipe flange		
	638640	1 Gasket, intake and exhaust manifold		
193-2	634811	1 Gasket, intake to exhaust manifold		
193-3	645361	Manifold, intake, assembly	1	
193-1	801826	Manifold, exhaust, assembly	1	
193-7	GM-122017	Bolt, hex. hd., 5/16"-18 x 1"	4	
		GROUP 10-20—MANIFOLD HEAT CONTROL		
	636438	Bearing, heat control valve shaft	2	
193-11	637211	Key, heat control lever	1	
	646089	Kit, valve, heat control, manifold	1	
		Consists of:		
	636438	2 Bearings, valve shaft		
	637211	1 Key, control lever		
	637210	1 Lever, counterweight		
	GM-120910	1 Screw, rd. hd., No. 10-24 x 3/4"		
	GM-120361	1 Nut, hex., No. 10-24		
	637206	1 Shaft, control valve		
	647042	1 Spring, bi-metal		
	639743	1 Stop, bi-metal spring		
	636439	1 Valve, heat control		
	637209	1 Washer, bi-metal spring		
193-10	637210	Lever, counterweight, heat control valve	1	
193-12	GM-120910	Screw, rd. hd., No. 10-24 x 3/4"	1	
193-13	GM-120361	Nut, hex., No. 10-24	1	
193-17	637206	Shaft, heat control valve	1	
193-14	647042	Spring, bi-metal, heat control valve	1	
193-8	639743	Stop, heat control valve spring	1	
	636439	Valve, heat control	1	
193-9	637209	Washer, heat control valve spring	1	

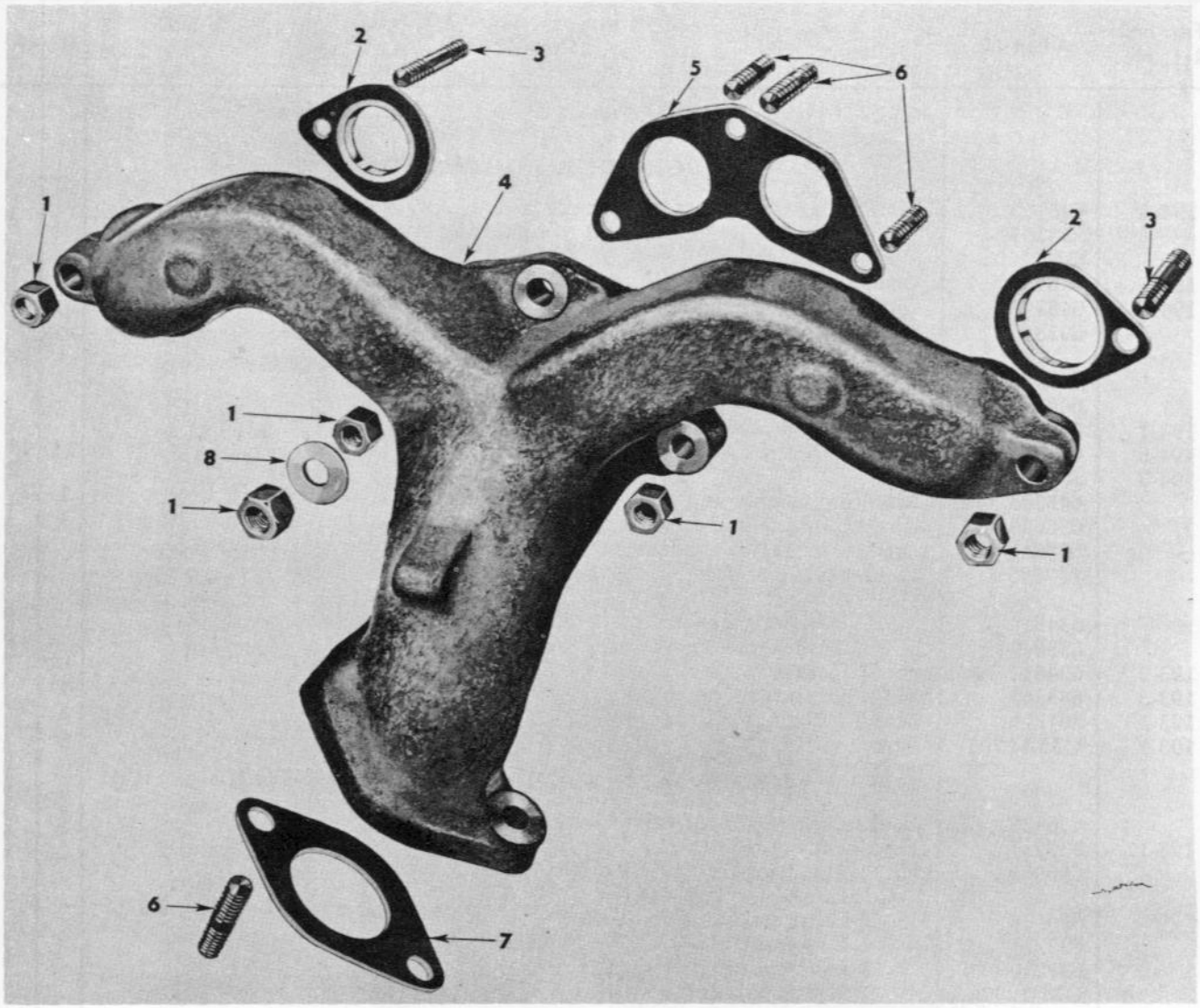

FIG. 194—EXHAUST MANIFOLD—4F

Ref. No.	Description	Group No.	Ref. No.	Description	Group No.
1	Nut, stud	10-19	5	Gasket, center	10-19
2	Gasket, end	10-19	6	Studs 3/8"-16 x 1-9/16"	10-19
3	Studs 3/8"-16 x 2-1/8"	10-19	7	Gasket, exhaust pipe flange	10-19
4	Manifold	10-19	8	Washer, 13/32" plain	10-19

Fig. and Ref. No.	Part No.	Description	4L	4F
		GROUP 10-21—FLYWHEEL AND RING GEAR		
		For Engines Equipped with Solenoid Activated 4½ Starter		
	639578	Bushing, clutch shaft	1	1
187-7	632156	Dowel, flywheel to crankshaft	2	2
	802925	Gear, ring, flywheel (129 teeth)	1	1
	805454	Kit, flywheel and dowel bolt	1	1
		Consists of:		
	804314	1 Flywheel assembly		
	116295	2 Bolt, dowel		
	GM-124934	2 Nut, dowel bolt		
	GM-135629	2 Lockwasher, dowel bolt		
	A-7696	1 Tag, instruction		
187-5	632157	Bolt, hex. hd., ⅜"-24 x 1 5/32"	4	4
	GM-120369	Nut, hex., ⅜"-24 } Flywheel to crankshaft	6	6
	GM-138489	Lockwasher, ⅜"	6	6
		NOTE: Bolt, nut and lockwasher, listed in Flywheel Kit, are for straight doweling of flywheel to crankshaft to eliminate need for special tapered reamer.		
		For Engines Equipped with 4" Bendix Type Starter		
	116295	Bolt, ½"-20 x 1 3/16" (Flywheel to crankshaft dowel)	2	
	639578	Bushing, clutch shaft	1	
	632156	Dowel, flywheel to crankshaft	1	
	635394	Gear, ring, flywheel (97 teeth)	1	
	A-7503	Kit, flywheel and dowel bolt	1	
		Consists of:		
	A-1443	1 Flywheel		
	116295	2 Bolt, dowel		
	GM-114496	2 Nut, dowel bolt		
	GM-135629	2 Lockwasher, dowel bolt nut		
	632157	Bolt, hex. hd., ⅜"-24 x 1 5/8"	4	
	GM-120369	Nut, hex., ⅜"-24 } Flywheel to crankshaft	6	
	GM-138489	Lockwasher, ⅜", ext.	6	
		GROUP 10-22—FLYWHEEL HOUSING		
	630101	Bolt, dowel, ⅜"-24 x 2 1/8"	2	2
	375217	Cover, timing hole, flywheel housing	1	1
	GM-172427	Screw, hex. hd., ¼"-20 x ½"	1	1
	GM-120380	Lockwasher, ¼"	1	1
		GROUP 10-23—ENGINE MOUNTINGS		
184-8	641096	Gasket, cylinder block, front	1	1
	Special order	Plate, engine, front, assembly	1	1
	GM-423569	Bolt, hex. hd., ⅜"-16 x ¾" } Front engine plate to	3	3
		Lockwasher, ⅜", ext. } cylinder block	3	3
184-10	642237	Plate, engine, rear—4 Bendix type starter	1	
184-10	804381	Plate, engine, rear—4½" solenoid type starter	1	1
		SPECIAL NOTE: Front engine plates to be ordered by identifying manufacturer of unit in which Willys Engine is installed.		

Fig. and Ref. No.	Part No.	Description	4L	4F
		GROUP 12-04—CARBURETOR CARTER		
	A-7690	Carburetor assembly (Carter No. 572SA) 1″ bore for E.G.S.	1	
	647744	Carburetor assembly (Carter No. 636SA)	*	
		*Do not furnish—Use Zip Fit replacement carburetor.		
	923806	Zip Fit, replacement carburetor (Carter No. Z-636W)	1	
	116172	Float and lever assembly	1	
	116174	Needle, spring and seat assembly (Fuel inlet)	1	
	116540	Metering rod (std.) (For Carburetor No. 647744)	1	
	116670	Metering rod (1st. lean) (For carburetor No. 647744)	1	
	116660	Metering rod (std.) (For carburetor No. A-7690)	1	
	923804	Zip Kit, Carburetor cleanout (For carburetor No. 647744)	1	
	647745	Kit, repair, carburetor (For carburetor No. 647744)	1	
		Consists of:		
		1 Arm, throttle shaft, assembly		
		1 Check, intake ball, assembly		
		1 Check and plug, discharge disc, assembly		
		1 Clip, clevis, throttle connector rod		
		2 Gasket, body flange		
		1 Gasket, bowl cover		
		1 Gasket, nozzle		
		1 Gasket and baffle, insulator, assembly		
		1 Jet, idle well		
		1 Jet, low speed, assembly		
		1 Jet, pump		
		1 Jet and gasket, metering rod, assembly		
		1 Link, pump connector		
		1 Needle, spring and seat		
		1 Plug, rivet, idle port		
		1 Plunger and rod, pump, assembly		
		1 Rod, metering		
		1 Rod, throttle connector		
		2 Screw, attaching throttle valve		
		4 Spring, pin		
		1 Strainer, check, pump		
	647746	Gasket set, carburetor (For carburetor No. 647744)	1	
		Consists of:		
		2 Gasket, body flange		
		1 Gasket, bowl cover		
		3 Gasket, metering rod jet and plug		
		3 Gasket, needle seat and plug		
		1 Gasket, nozzle		
		1 Gasket, strainer plug		
		1 Gasket and baffle, insulator, assembly		
	806305	Carburetor assembly (Carter No. 938S and 938SA)		**
	920337	Carburetor assembly (Carter No. 938SC)		**
	923995	Carburetor assembly (Carter No. 938SD)		**
		**Do not furnish — Use Zip Fit replacement carburetor.		
	923808	Zip Fit — Replacement Carburetor (Carter No. Z-938W)		1
	117928	Float and lever assembly		1
	118549	Needle, spring and seat assembly (Fuel inlet)		1
	924162	Metering rod — (Std.)		1
	917154	Metering Rod — (1st. lean)		1
		NOTE — For carburetors No. 806305 and No. 920337, do not furnish metering rods. Use field fix kit, to convert to carburetor No. 923995.		
	924161	Kit, carburetor, field fix		1
	923800	Zip Kit, carburetor cleanout		1

Fig. and Ref. No.	Part No.	Description	4L	4F
		GROUP 12-04—CARBURETOR CARTER (Cont'd)		
	808520	Gasket set, carburetor		1
		Consists of:		
	117953	1 Gasket, body flange		
	117954	1 Gasket, bowl cover and air horn		
	648970	1 Gasket, flange		
	116168	1 Gasket, needle seat		
	924160	Kit, carburetor repair (Re-carburation)		1
		Consists of:		
	648970	1 Gasket, flange		
	118549	1 Needle, seat and spring assembly		
	924162	1 Metering rod (Std.)		
	920969	1 Jet, metering rod		
	117953	1 Gasket, body flange		
	117954	1 Gasket, bowl cover and air horn		
	925541	1 Diaphragm assembly		
	119883	1 Gasket, pump lifter		
	920967	1 Needle, pump check		
		Carburetor — Zenith Governator		
	802190	Carburetor assembly with integral governator (2200 r.p.m.)		1
	907846	Carburetor assembly with integral governator (2600 r.p.m.)		1
	119955	Gasket set, carburetor		1
	119943	Kit, carburetor repair		1
	118638	Kit, governor ball bearing		1
		GROUP 12-04A—CARBURETOR ATTACHING PARTS		
	A-6357	Gasket and diffuser, insulator, assembly	1	
	GM-120369	Nut, hex., 3/8"-24, carburetor to manifold stud	2	
	632159	Stud, carburetor to manifold	2	
	GM-137404	Connector, 3/16" inverted flared tube		1
	GM-137421	Elbow, 1/4" tube, 90 degree		1
	648970	Gasket, insulator, carburetor		1
	GM-120369	Nut, hex., 3/8"-24 (Carburetor to manifold)		2
	GM-103865	Plug, pipe, 1/8" sq. hd		1

Fig. and Ref. No.	Part No.	Description	4L	4F
		GROUP 12-09—FUEL PUMP		
	119238	Fuel pump, assembly (AC Spark Plug Div. Type No. 572)	1	1
	640586	Kit, fuel pump, repair	1	1
		Consists of:		
	116695	1 Diaphragm and rod, assembly		
	120594	1 Gasket, bowl		
	116760	2 Gasket, cage		
	120111	1 Gasket, mounting		
	115880	1 Link, rocker arm		
	115870	1 Oil seal, fuel pump		
	116761	1 Pin, rocker arm		
	115654	1 Screen, filtering		
	GM-132696	1 Screw, retainer		
	119959	1 Spring, diaphragm		
	115643	1 Spring, rocker arm		
	919131	2 Valve, assembly		
	116762	1 Washer, pin		
	119257	Fuel pump, assembly, with primer lever (AC type No. 8312)	1	1
	808034	Kit, fuel pump, repair	1	1
		Consists of:		
	116695	1 Diaphragm and pull rod, assembly		
	116694	1 Spring, diaphragm		
	118486	2 Valve, assembly		
	116748	1 Gasket, valve, assembly		
	115880	1 Link, diaphragm operating		
	115654	1 Screen, fuel pump		
	116761	1 Pin, rocker arm		
	116762	1 Washer, rocker arm pin		
	115643	1 Spring, rocker arm		
	120594	1 Gasket, bowl		
	118704	1 Gasket, mounting		
	912017	Fuel pump, assembly (Carter No. M2195S)	1	1
	912018	Kit, fuel pump repair	1	1
		Consists of:		
		1 Diaphragm		
		1 Diaphragm, air dome outlet		
		1 Gasket, flange		
		1 Plug, cam lever pin		

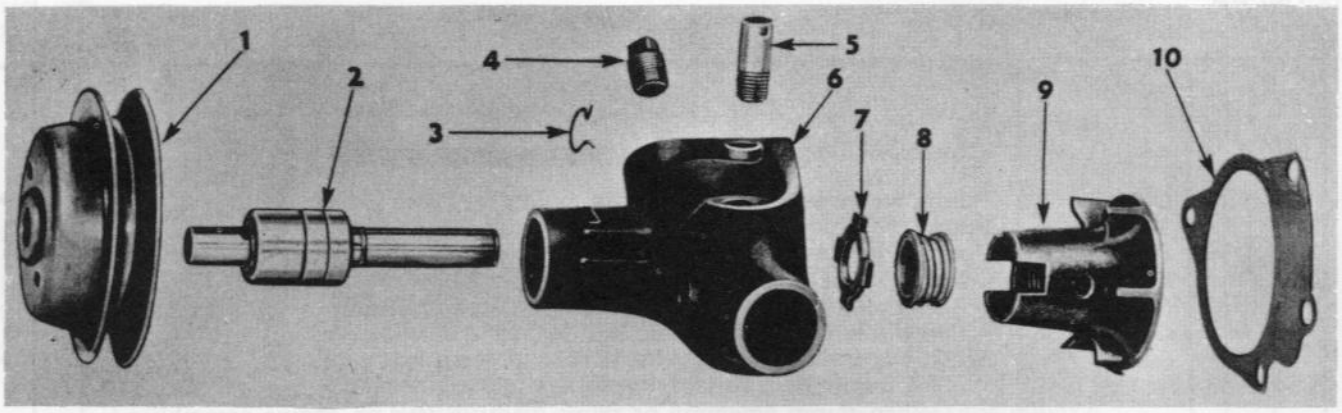

FIG. 195—WATER PUMP—4L AND 4F

Ref. No.	Description	Group No.	Ref. No.	Description	Group No.
1	Pulley	14-05	7	Washer, water pump seal	14-04
2	Bearing and Shaft	14-04	8	Seal, water	14-04
3	Spring	14-04	9	Impeller, water pump	14-04
4	Plug, pipe, 3/8" sq. hd.	14-04	10	Gasket, water pump to cylinder block	14-04
5	Nipple, hose, by-pass	14-04			
6	Body - water pump	14-04			

Fig. and Ref. No.	Part No.	Description	4L	4F
		GROUP 14-04—WATER PUMP		
	649717	Pump, water assembly (4.31″ dia. pulley)	*	*
	808962	Pump, water assembly (4.62″ dia. pulley)	1	1
	800002	Pump, water assembly (Double drive belt pulley)	1	1
	800232	Bolt and lockwasher, hex. hd., 5/16″-18 x 2 1/2″ } Pump to cylinder block	1	1
	673488	Screw and lockwasher, hex. hd., 5/16″-18 x 7/8″ } Pump to cylinder block	2	2
	GM-431938	Screw and lockwasher, hex. hd., 5/16″-18 x 1″ } Pump to cylinder block	1	1
195-6	649718	Body, water pump	*	*
		* 1 required.		
		When pump assembly or pump body is used on engine assemblies that do not have cylinder head water bypass, remove pipe nipple Part No. 649720 from pump assembly No. 649717 and plug hole with 1/4″ pipe plug GM-103866, pump body No. 649718 for this usage must have tapped hole plugged with 1/4″ pipe plug GM-103866.		
195-10	637053	Gasket, water pump to cylinder block	1	1
195-9	639993	Impeller, water pump	1	1
	A-6839	Kit, water pump repair	1	1
		Consists of:		
		1 Gasket, water pump to block		
		1 Seal, water pump assembly		
		1 Shaft, bearing and slinger, water pump assembly		
		1 Spring, water pump bearing retainer		
		1 Washer, water pump seal		
	921476	Kit, water pump impeller	1	1
		Consists of:		
		1 Impeller		
		1 Seal		
		1 Washer		
195-5	649720	Nipple, hose, by-pass 1/4″ pipe	1	1
195-4	GM-103879	Plug, pipe, 3/8″, sq. hd	1	1
	GM-103866	Plug, pipe, 1/4″, sq. hd	1	1
195-8	646732	Seal, water pump, assembly	1	1
195-2	808129	Shaft, bearing and slinger, assembly	1	1
195-3	636298	Spring, water pump bearing retainer	1	1
195-7	640034	Washer, water pump seal	1	1
		GROUP 14-05—FAN, FAN PULLEY AND BELT		
	A-447	Fan, assembly (4 blade)	1	1
	802285	Fan, assembly (Pusher type)	1	1
	GM-9409106	Screw and lockwasher, assembly, hex. hd., 1/4″-20 x 1/2″	4	4
	909558	Spacer (Special fan mounting)	1	1
	GM-121973	Screw, hex. hd., 1/2″-20 x 2 3/4″	4	4
	GM-120380	Lockwasher, 1/4″	4	4
	636299	Pulley, fan and water pump (4.31″ dia.)	1	1
	808736	Pulley, fan and water pump (4.62″ dia.)	1	1
	649721	Pulley, fan and water pump (Double drive belts)	1	1
	913290	Belt, fan and generator drive (5.15″ dia. crankshaft pulley)	1	1
	811733	Belt, fan and generator drive (7.54″ dia. crankshaft pulley)	1	1
	118866	Belt, package, fan and generator drive (Two belts for dual drive)	1	1
		GROUP 14-06—THERMOSTAT		
	812050	Thermostat, assembly	1	1
	639651	Retainer, thermostat	1	

Fig. and Ref. No.	Part No.	Description	4L	4F
		GROUP 15-01—GENERATOR		
		6 Volt Generators		
	649918	Generator assembly (35 amp.) (AL No. GDZ-6001-D)	*	*
	809655	Generator assembly (45 amp.) (AL No. GGW-4801-D)	*	*
	924886	Generator assembly (45 amp.) (AL No. GGW-7404-A)	*	*
		*Replace with Service Generator No. 925045 (Less pulley).		
	925045	Generator assembly (45 amp.) (AL No. GGW-7404S) (Less pulley)	1	1
	812069	Generator assembly (15 amp. enclosed) (AL No. GHD-6001 AC)	**	**
		(Includes Voltage Regulator)		
		**Replace with Service Generator No. 922897 (Less pulley).		
	922897	Generator assembly (15 amp. enclosed) (AL No. GHD-6001 SSN)	1	1
		(Includes Voltage Regulator and less Drive Pulley).		
		Service Components		
		For Generators No. 649918, 809655, 924886 and 925045		
	118432	Pulley, drive	1	1
	118433	Lockwasher, armature shaft, drive end	1	1
	120153	Nut, armature shaft, drive end	1	1
	A-1641	Key, No. 5, Woodruff	1	1
	GM-901203	Bearing, S.A.E. No. 203, Ball	1	1
	118429	Bearing, Abs., Bronze (For Gen. No. 649918)	1	1
	919286	Bearing, Abs., Bronze (For Gen. No. 809655 and 924886)	1	1
	925648	Brush set, for Gen. No. 924886 and 925045	1	1
	118421	Brush set, for Gen. No. 649918	1	1
	120943	Brush set, for Gen. No. 809655	1	1
		For Generator No. 649918		
	120023	Head, assembly, commutator end	1	1
	118434	Head, assembly, drive end	1	1
	118431	Armature, assembly	1	1
		For Generator No. 809655		
	120023	Head, assembly, commutator end	1	1
	118434	Head, assembly, drive end	1	1
	120154	Armature, assembly	1	1
		For Generator No. 924886 and 925045 (Two Piece Frame)		
	925649	Head, assembly, Commutator End	1	1
	925651	Head, assembly, drive end	1	1
	925650	Armature, assembly	1	1
		For Generator No. 812069 and 922897		
	922925	Pulley, drive	1	1
	118433	Lockwasher, armature shaft, drive end	1	1
	120153	Nut, armature shaft, drive end	1	1
	A-1641	Key, No. 5, Woodruff	1	1
	923085	Spacer, drive pulley	1	1
	GM-901203	Bearing, S.A.E. No. 203, Ball	1	1
	118429	Bearing, Abs. Bronze	1	1
	927642	Armature assembly	1	1
	927641	Brush set, service	1	1
	927643	Head assembly, Commutator end	1	1
	927644	Head assembly, drive end	1	1
		12 Volt Generators		
	913095	Generator assembly (30 Amp.) (AL No. GJC-7002-J)	*	*
	923282	Generator assembly (35 Amp.) (AL No. GJP-7202-A)	*	*
	924880	Generator assembly (35 Amp.) (AL No. GJP-7402-A)	*	*
		*Replace with Service Generator No. 925044 (Less Pulley).		
	925044	Generator assembly (35 Amp.) (AL No. GJP-7402-S) (Less drive pulley)	1	1
	926721	Generator assembly (10 Amp. enclosed) (AL No. GJT-7303-J)	**	**
		(Includes voltage regulator)		
		**Replace with Service Generator No. 927651 (Less drive pulley).		

Fig. and Ref. No.	Part No.	Description	4L	4F
		GROUP 15-01—GENERATOR (Cont'd)		
	927651	Generator assembly (10 Amp. enclosed) (AL No. GJT-7303-S) (Includes voltage regulator and less drive pulley).	1	1
		Service Components For Generator Assemblies No. 913095, 923282, 924880 and 925044		
	118432	Pulley, drive	1	1
	118433	Lockwasher, armature shaft, drive end	1	1
	120153	Nut, armature shaft, drive end	1	1
	A-1641	Key, No. 5, Woodruff	1	1
	GM-901203	Bearing, S.A.E., No. 203, Ball	1	1
	919286	Bearing, Abs. Bronze	1	1
	925652	Brush set, service	1	1
	919287	Armature assembly	1	1
		For Generator Assembly No. 913095 and 923282		
	919285	Head assembly, Commutator end	1	1
	919288	Head assembly, drive end	1	1
		For Generator Assembly No. 924880 and 925044		
	925649	Head assembly, commutator end	1	1
	925651	Head assembly, drive end	1	1
		For Generator Assembly No. 926721 and 927651		
	922925	Pulley, drive	1	1
	118433	Lockwasher, armature shaft, drive end	1	1
	120153	Nut, armature shaft, drive end	1	1
	A-1641	Key, No. 5, Woodruff	1	1
	923085	Spacer, drive pulley	1	1
	919286	Bearing, Abs. Bronze	1	1
	GM-901203	Bearing, No. 203, S.A.E.	1	1
	925648	Brush set, service	1	1
	927653	Armature assembly	1	1
	927654	Head assembly, Commutator end	1	1
	927655	Head assembly, drive end	1	1
		Attaching Parts for Generator, 4-Cyl. Engines		
	649927	Brace, generator	1	1
	GM-9409098	Screw and lockwasher, hex. hd., 5/16"-18 x 7/8"	1	1
	GM-446363	Washer, plain, 5/16"	1	1
	GM-120647	Bolt, hex. hd., 3/8"-24 x 1"	1	1
	GM-271193	Nut and lockwasher, hex., 3/8"-24	1	1
	A-1395	Insulator, generator support	2	2
	A-1397	Bolt, generator support insulator — Generator support insulator mounting	2	2
	GM-120368	Nut, hex., 5/16"-24 — Generator support insulator mounting	2	2
	GM-120393	Washer, plain, 5/16" — Generator support insulator mounting	2	2
	GM-120214	Lockwasher — Generator support insulator mounting	2	2
	649925	Support, generator, assembly	1	1
	633949	Bolt, hex. hd., 3/8"-16 x 7/8", special	2	2
	GM-120382	Lockwasher, 3/8" (Support to cylinder block)	2	2
	A-1401	Washer, 24/64" hole	2	2
	A-1396	Washer, 33/64" hole	2	2
		Special Attaching Parts Used With 15 Amp Enclosed Generator		
	805976	Generator support assembly	1	1
	812088	Generator support, insulator bolt	1	1
	GM-120668	Bolt, hex. hd., 3/8"-24 x 1.75"	1	1
	812070	Spacer (Spec.)	1	1

Fig. and Ref. No.	Part No.	Description	4L	4F
		GROUP 15-02—STARTING MOTOR AND ATTACHING PARTS		
		4″ Starting Motor (6 Volt) (Pinion Shaft Bearing in Clutch Housing)		
	A-1245	Starting motor assembly (AL No. MZ-0113)	1	
	A-1568	Armature assembly	1	
	A-1552	Brush set, service	1	
	109445	Spring, brush	4	
	109455	Thrust Washer, 1/32″	2	
	A-1569	Thrust washer spacer	1	
	A-1573	Bendix drive (EBA-46)	1	
	A-1582	Bearing, intermediate	1	
	636734	Bearing, pinion shaft (Mtd. in clutch housing)	1	
	A-1566	Head assembly, commutator end	1	
		4 1/2″ Starting Motor (6 Volt)		
	803867	Starting motor assembly (AL No. MCH-6203) (With commutator head support)	1	1
	925520	Starting motor assembly (AL No. MCH-6215) (Without commutator head support)	1	1
	119605	Armature assembly	1	1
	120201	Brush set, service	1	1
	109445	Spring, brush	4	4
	109455	Thrust washer, 1/32″	a/r	a/r
	117337	Thrust washer, 3/64″	a/r	a/r
	120568	Switch, solenoid starter	1	1
	119597	Bendix drive (AL No. EBB-19) (Eclipse No. A-3281)	1	1
	119833	Bearing, intermediate	1	1
	A-1583	Bearing, pinion housing	1	1
	119609	Pinion housing	1	1
	119604	Head, commutator end, for starter No. 803867 (With support)	1	1
	120677	Head, commutator end, for starter No. 925520 (Without support)	1	1
		4 1/2″ Starting Motor (12 Volt)		
	808623	Starting motor assembly (AL No. MCT-6201) *Replace with starting motor assembly No. 916349.	*	*
	916349	Starting motor assembly (AL No. MDM-6005)	1	1
	919293	Armature assembly	1	1
	919290	Brush set, service	1	1
	922683	Brush holder, insulated	2	2
	922698	Brush holder, grounded	2	2
	922700	Pin, brush holder	2	2
	922699	Spring, brush	2	2
	109455	Thrust washer, 1/32″	a/r	a/r
	117337	Thrust washer, 3/64″	a/r	a/r
	919294	Switch, solenoid starter	1	1
	119597	Bendix drive (AL No. EBB-19) (Eclipse No. A-3281)	1	1
	119833	Bearing, intermediate	1	1
	A-1583	Bearing, pinion housing	1	1
	919295	Pinion housing assembly	1	1
	919291	Head assembly, commutator end	1	1
	924885	Starting motor assembly (AL No. MDU-7004) (Without commutator head support)	1	1
	925549	Starting motor assembly (AL No. MDU-7017) (With commutator head support)	1	1
	925666	Armature assembly	1	1
	925665	Brush set, service	1	1
	925675	Plate assembly, brush holder	1	1
	109455	Thrust washer, 1/32″	a/r	a/r
	117337	Thrust washer, 3/64″	a/r	a/r
	919294	Switch, solenoid starter	1	1
	925667	Bendix drive (AL No. EBB-74) (Eclipse No. 479000)	1	1

Fig. and Ref. No.	Part No.	Description	4L	4F
		GROUP 15-02—STARTER MOTORS & ATTACHING PARTS (Cont'd)		
	119833	Bearing, intermediate	1	1
	A-1583	Bearing, pinion housing	1	1
	925670	Pinion housing assembly	1	1
	925669	Head, commutator end, for starter No. 924885 (Without support)	1	1
	925812	Head, commutator end, for starter No. 925549 (With support)	1	1
	925677	Pin, armature shaft, Bendix drive	1	1
		Starting Motor Attaching Parts		
		For 4″ Starting Motor No. A-1245		
	638646	Support, starting motor	1	
	GM-122126	Bolt, hex. hd., 3/8″-16 x 7/8″ — Support to cylinder block	1	
	GM-120388	Washer, flat, 3/8″ — Support to cylinder block	1	
	GM-120382	Lockwasher, 3/8″ — Support to cylinder block	1	
	GM-123473	Bolt, hex. hd., 5/16″-24 x 5/8″ — Starting motor to support	1	
	GM-446363	Washer, flat, 5/16″ — Starting motor to support	1	
	GM-120214	Lockwasher, 5/16″ — Starting motor to support	1	
	GM-122145	Bolt, hex. hd., 3/8″-16 x 1 1/4″ — Starting motor to rear engine plate and flywheel housing	2	
	GM-120382	Lockwasher, 3/8″ — Starting motor to rear engine plate and flywheel housing	2	
		For 4 1/2″ Starting Motor No. 803867, 808623 and 916349		
	805675	Support, starting motor	1	1
	GM-122126	Bolt, hex. hd., 3/8″-16 x 7/8″ — Support to cylinder block	1	1
	GM-120388	Washer, flat, 3/8″ — Support to cylinder block	1	1
	GM-120382	Lockwasher, 3/8″ — Support to cylinder block	1	1
	GM-9409102	Screw and lockwasher assembly, hex. hd., 5/16″-24 x 3/4″ — Starting motor to support	1	1
	GM-446363	Washer, flat, 5/16″ — Starting motor to support	1	1
	GM-120426	Bolt, hex. hd., 1/2″-13 x 1 1/4″ — Starting motor to rear engine plate and flywheel housing	1	1
	GM-124378	Bolt, hex. hd., 1/2″-20 x 3 1/2″ — Starting motor to rear engine plate and flywheel housing	1	1
	GM-120384	Lockwasher, 1/2″ — Starting motor to rear engine plate and flywheel housing	2	2
	GM-120371	Nut, hex., 1/2″-20 — Starting motor to rear engine plate and flywheel housing	1	1
		For 4 1/2″ Starting Motor No. 925549		
	925555	Support, starting motor	1	1
	GM-9409102	Bolt and lockwasher assy., hex. hd., 5/16″-24 x 3/4″ — Support to starting motor	1	1
	GM-446363	Washer, plain, 5/16″ — Support to starting motor	1	1
	GM-451976	Bolt and lockwasher assembly, hex. hd., 3/8″-16 x 3/4″ (Starting motor to support)	1	1
	GM-120426	Bolt, hex. hd., 1/2″-13 x 1 1/4″ — Starter motor mounting for open flywheel installation	2	2
	GM-120384	Lockwasher, 1/2″ — Starter motor mounting for open flywheel installation	2	2
	GM-120426	Bolt, hex. hd., 1/2″-13 x 1 1/4″ — Starting motor mounting for flywheel housing installation	1	1
	GM-124378	Bolt, hex. hd., 1/2″-13 x 3 1/2″ — Starting motor mounting for flywheel housing installation	1	1
	GM-120384	Lockwasher, 1/2″ — Starting motor mounting for flywheel housing installation	2	2
	GM-120371	Nut, hex., 1/2″-20 — Starting motor mounting for flywheel housing installation	1	1
		For 4 1/2″ Starting Motor No. 924885 (Without Support)		
	GM-120426	Bolt, hex. hd., 1/2″-13 x 1 1/4″ — Mounting starting motor	1	1
	GM-124378	Bolt, hex. hd., 1/2″-13 x 3 1/2″ — Mounting starting motor	1	1
	GM-120384	Lockwasher, 1/2″ — Mounting starting motor	2	2
	GM-120371	Nut, hex., 1/2″-20 — Mounting starting motor	1	1

Fig. and Ref. No.	Part No.	Description	4L	4F
		GROUP 15-03—DISTRIBUTOR		
	909802	Distributor assembly (AL No. IAY-4012)	*	*
		*Replace with distributor assembly No. 923068.		
	923068	Distributor assembly (AL No. IAY-4401)	1	1
	801174	Distributor and vacuum control assembly (AL No. IAT-4008)	**	**
		**Replace with distributor and vacuum control assembly No. 923069.		
	923069	Distributor and vacuum control assembly (AL No. IAT-4405)	1	1
		Service Components and Attaching Parts		
	118415	Arm, advance	1	1
	118343	Cap assembly, distributor	1	1
	923392	Rotor	1	1
	917128	Condenser package	1	1
	923146	Contact set, breaker	1	1
	GM-121867	Bolt, hex. hd., 1/4"-20 x 9/16" } Distributor to cylinder block	1	1
	GM-120392	Washer, plain, 1/4" } Distributor to cylinder block	1	1
	GM-120380	Lockwasher, 1/4" } Distributor to cylinder block	1	1
	637615	Spring, friction, distributor shaft	1	1
		GROUP 15-04—VOLTAGE REGULATOR		
		6 Volt System		
	800396	Voltage and current regulator assembly (AL No. VRP-6003A)	*	*
		*Replace with voltage and current regulator No. 923048.		
	923048	Voltage and current regulator assembly (AL No. VBO-4601G)	1	1
		For generator No. 649918		
	809654	Voltage and current regulator assembly (AL No. VBE-6105A)	**	**
		**Replace with voltage and current regulator No. 923131.		
	923131	Voltage and current regulator assembly (AL No. VBO-4601C)	1	1
		For generator No. 809655 and 925045		
	924644	Voltage regulator (AL No. VBP-5601B)	1	1
		For enclosed type generator No. 812069 and No. 922897.		
		12 Volt System		
	913097	Voltage and current regulator assembly (AL No. VRX 6009B)	*	*
		*Replace with voltage and current regulator No. 923130.		
	923130	Voltage and current regulator assembly (AL No. VBO-4201E)	1	1
		For Generator Assemblies No. 913095, 923282, 924880 and 925044		
	927656	Voltage regulator (AL No. VBP-6201B)	1	1
		For enclosed type generator No. 926721 and No. 927651.		
		GROUP 15-05—COIL WIRING AND ATTACHING PARTS		
	913098	Coil, ignition, assembly (12 Volt)	1	1
	649712	Coil, ignition, assembly (6 Volt)	1	1
	635886	Stud, mounting, ignition coil, 1/4"-20 x 1"	2	2
	807271	Nut and lockwasher, hex. 1/4"-28	2	2
	631105	Washer, 1/4" special (Coil to cylinder head)	2	2
	A-5083	Cable, ignition coil, primary	1	1
	642133	Cable, ignition coil, secondary	1	1
	393594	Tip, ignition cable, distributor and secondary	2	2

Fig. and Ref. No.	Part No.	Description	4L	4F
		GROUP 15-06—SPARK PLUGS AND WIRES		
	347002	Bushing, rubber, 11/16″ hole	1	
	640289	Cable, ignition, spark plug No. 1, assembly	1	
	640290	Cable, ignition, spark plug No. 2, assembly	1	
	640291	Cable, ignition, spark plug No. 3 and 4	2	
	640587	Kit, spark plug and coil wires	1	
		Consists of:		
	640292	1 Cable, secondary, coil		
	640289	1 Cable, spark plug, No. 1		
	640290	1 Cable, spark plug, No. 2		
	640291	2 Cable, spark plug, No. 3 and No. 4		
	804492	Plug with gasket, spark, assembly (Champion J-8 or Auto-Lite A-7)	4	4
	393594	Seal, weather, spark plug cables distributor end	6	6
	805383	Clip, ignition cable, upper		1
	805384	Clip, ignition cable, lower		1
	808419	Ignition, cable bracket		1
	807026	Cable, ignition, spark plug, No. 1		1
	807027	Cable, ignition, spark plug, No. 2 and 3		2
	807028	Cable, ignition, spark plug, No. 4		1
	GM-120393	Washer, plain, 5/16″ (Cables to rocker arm cover studs)		2
	807029	Kit, ignition spark plug cable		1
		Consists of:		
	642133	1 Cable, secondary, ignition coil, assembly		
	807026	1 Cable, spark plug, No. 1, assembly		
	807027	2 Cable, spark plug, No. 2 and 3 assembly		
	807028	1 Cable, spark plug, No. 4 assembly		

Tornado OHC 6 Cylinder Engine

GROUP INDEX

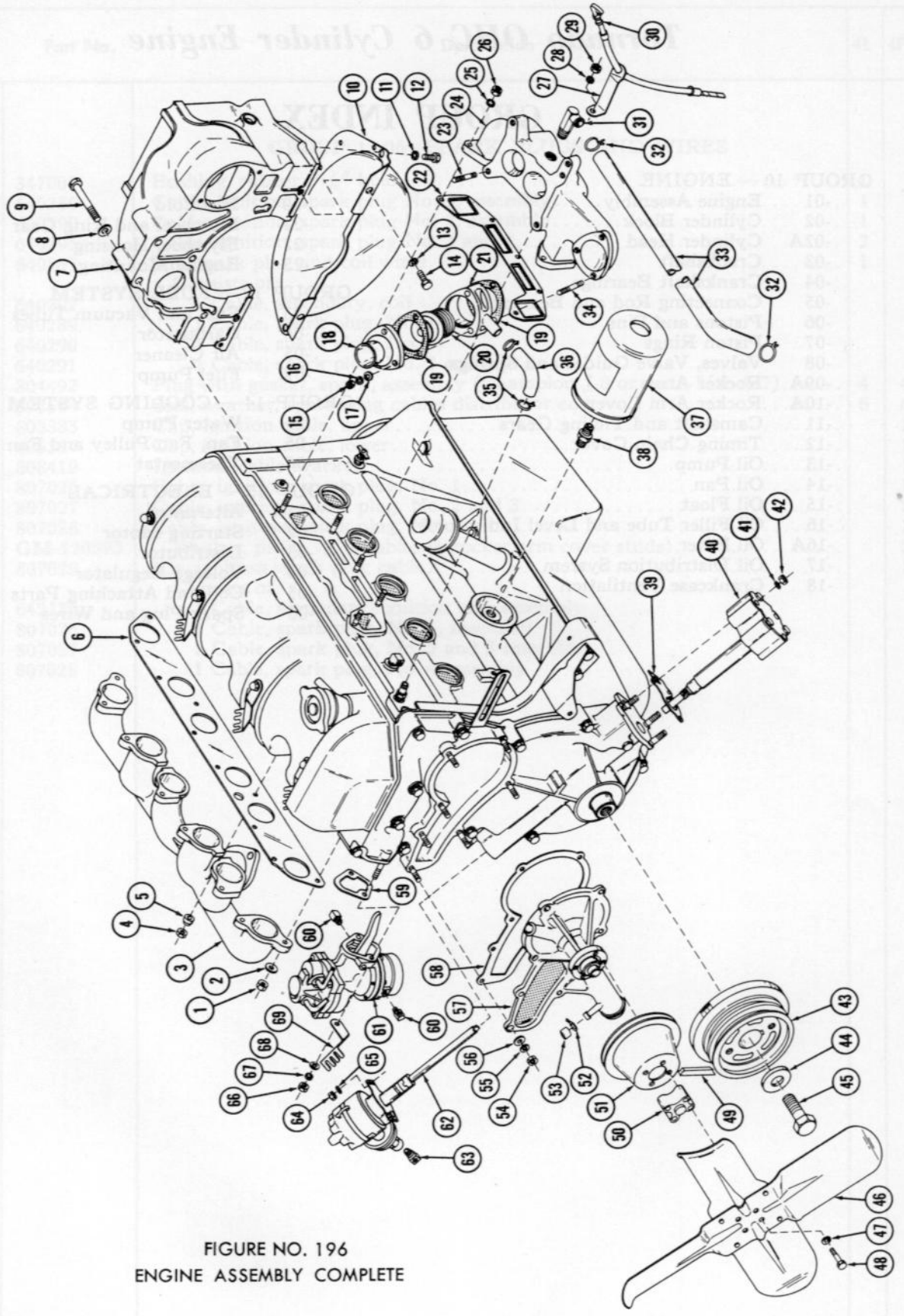

FIGURE NO. 196
ENGINE ASSEMBLY COMPLETE

FIGURE NO. 196
ENGINE ASSEMBLY COMPLETE

Ref. No.	Description	Group No.
1	Nut, hex., 3/8"—24	10-19
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4	Nut, hex., 3/8"—24	10-19
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11	Part of number 12	
12	Bolt and Lockwasher, hex., hd., 5/16"—18 x 1/2"	10-22
13	Part of number 14	
14	Bolt and Lockwasher, hex. hd., 5/16"—20 x 5/8"	10-22
15	Nut, hex., 5/16"—24	10-19
16	Lockwasher, 5/16"	10-19
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18	Elbow, water outlet	10-19
19	Gasket, water outlet elbow	10-19
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23	Stud, 5/16"—18 x 24 x 1 3/4"	12-04
24	Manifold, intake	10-19
25	Lockwasher, 5/16"	10-19
26	Nut, hex., 5/16"—24	10-19
27	Tube, oil level indicator guide (Includes Bracket)	10-16
28	Lockwasher, 5/16"	10-19
29	Nut, hex., 5/16"—24	10-19
30	Indicator, oil level	10-16
31	Elbow, heater hose water by-pass	10-19
32	Clamp, hose water by-pass	10-19
33	Hose, water by-pass	10-19
34	Stud, 5/16" x 2 5/8"	10-19
35	Clamp, hose (Spacer to cylinder head)	10-19
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37	Filter, oil, assembly	10-16A
38	Adapter, oil filter	10-16A
39	Gasket, oil pump to chain cover	10-13
40	Pump, oil, assembly	10-13
41	Lockwasher, 5/16"	10-13
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43	Damper, vibration and fan drive	10-03
44	Washer, special	10-03
45	Bolt, hex. hd., 3/4"—16 x 2"	10-03
46	Fan, assembly	14-05
47	Lockwasher, 5/16" (Part of No. 48)	
48	Bolt and Lockwasher, hex. hd., 5/16"—18 x 2 1/2"	14-05
49	Belt, drive fan and alternator	14-05
50	Spacer, fan	14-05
51	Pulley, water pump	14-05
52	Clamp, hose	10-19
53	Cap, water pump (Not Serviced)	
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55	Lockwasher, 5/16"	14-04
56	Washer, plain, 5/16"	14-04
57	Pump, water, assembly	14-04
58	Gasket, water pump	14-04
59	Gasket, fuel pump to chain cover	12-09
60	Elbow, 5/16" inverted flared tube	12-09
61	Pump, fuel and vacuum, assembly	12-09
62	Distributor, ignition	15-03
63	Elbow, inverted flared tube	15-03
64	Nut, hex., 5/16"—24	15-03
65	Lockwasher, 5/16"	15-03
66	Nut, hex., 5/16"—24	12-09
67	Lockwasher, 5/16"	12-09
68	Washer, plain, 5/16"	12-09
69	Bracket, cable, fuel pump	15-06

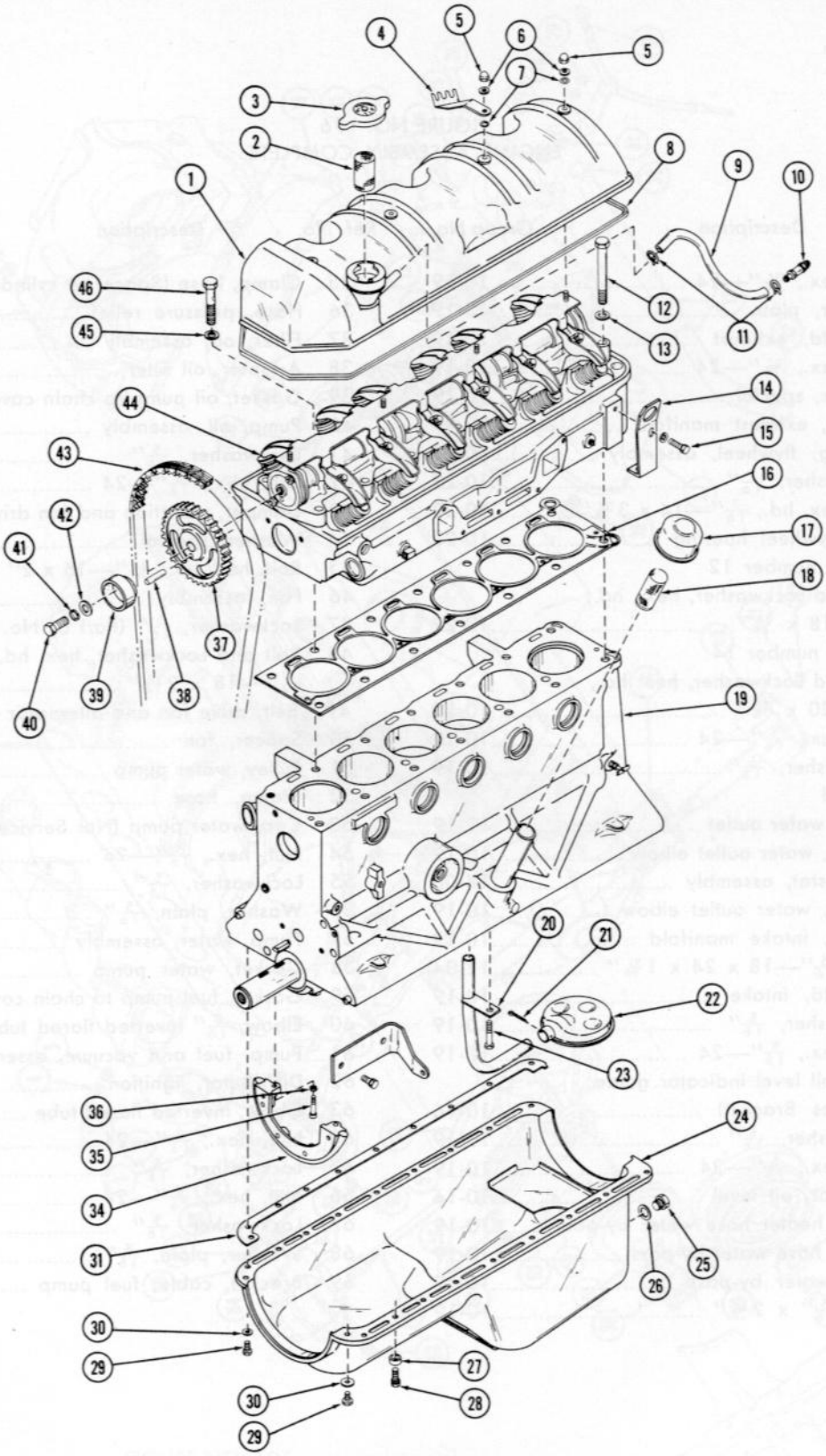

FIGURE NO. 197
CYLINDER BLOCK, TIMING CHAIN, SPROCKET,
ROCKER COVER AND OIL PAN

FIGURE NO. 197
CYLINDER BLOCK, TIMING CHAIN, SPROCKET, ROCKER COVER AND OIL PAN

Ref. No.	Description	Group No.
1	Cover, rocker arm	10-10A
2	Screen, oil filler cap tube	10-10A
3	Cap, oil filler, assembly	10-10A
4	Bracket, cable, rocker cover	15-06
5	Nut, crown, 3/8"—24	10-10A
6	Washer, plain, 3/8"	10-10A
7	Seal, oil, rocker cover	10-10A
8	Gasket, rocker cover	10-10A
9	Hose, oil filler tube to carburetor	10-18
10	Valve, crankcase ventilator	10-18
11	Clamp	10-18
12	Bolt, cylinder head, 5 1/2" long	10-02A
13	Washer, cylinder head	10-02A
14	Eye, lift, rear	10-23
15	Bolt and lockwasher, hex. hd., 3/8"—16 x 3/4"	10-23
16	Gasket, cylinder head	10-02A
17	Cap, crankcase ventilation breather	10-18
18	Screen, crankcase ventilation breather	10-18
19	Block with pistons fitted cylinder, assembly	10-02
20	Tube and bracket, suction, assembly	10-15
21	Pin, cotter, 3/32" x 1"	10-15
22	Screen, oil intake, assembly	10-15
23	Not Serviced	
24	Pan, oil, assembly	10-14
25	Plug, oil pan drain	10-14
26	Gasket, drain plug	10-14
27	Spacer	12-03
28	Screw and lockwasher, hex. hd., 5/16"—18 x 1"	10-14
29	Screw and lockwasher, hex. hd., 5/16"—18 x 3/4"	10-14
30	Washer, plain, 5/16"	10-14
31	Gasket, oil pan side	10-14
34	Block, filler front bearing, assembly	10-03
35	Screw and lockwasher, hex. hd., 5/16"—18 x 7/8"	10-03
36	Part of number 35	
37	Sprocket, camshaft, assembly	10-11
38	Pin, dowel (Camshaft sprocket)	10-11
39	Eccentric, fuel pump	10-11
40	Screw, 1/2"—20 x 1 7/8"	10-11
41	Lockwasher, 1/2"	10-11
42	Washer, plain, 1/2"	10-11
43	Chain, timing	10-11
44	Head, cylinder, assembly	10-02A
45	Washer, cylinder head	10-02A
46	Bolt, cylinder head, 2 1/4" long	10-02A

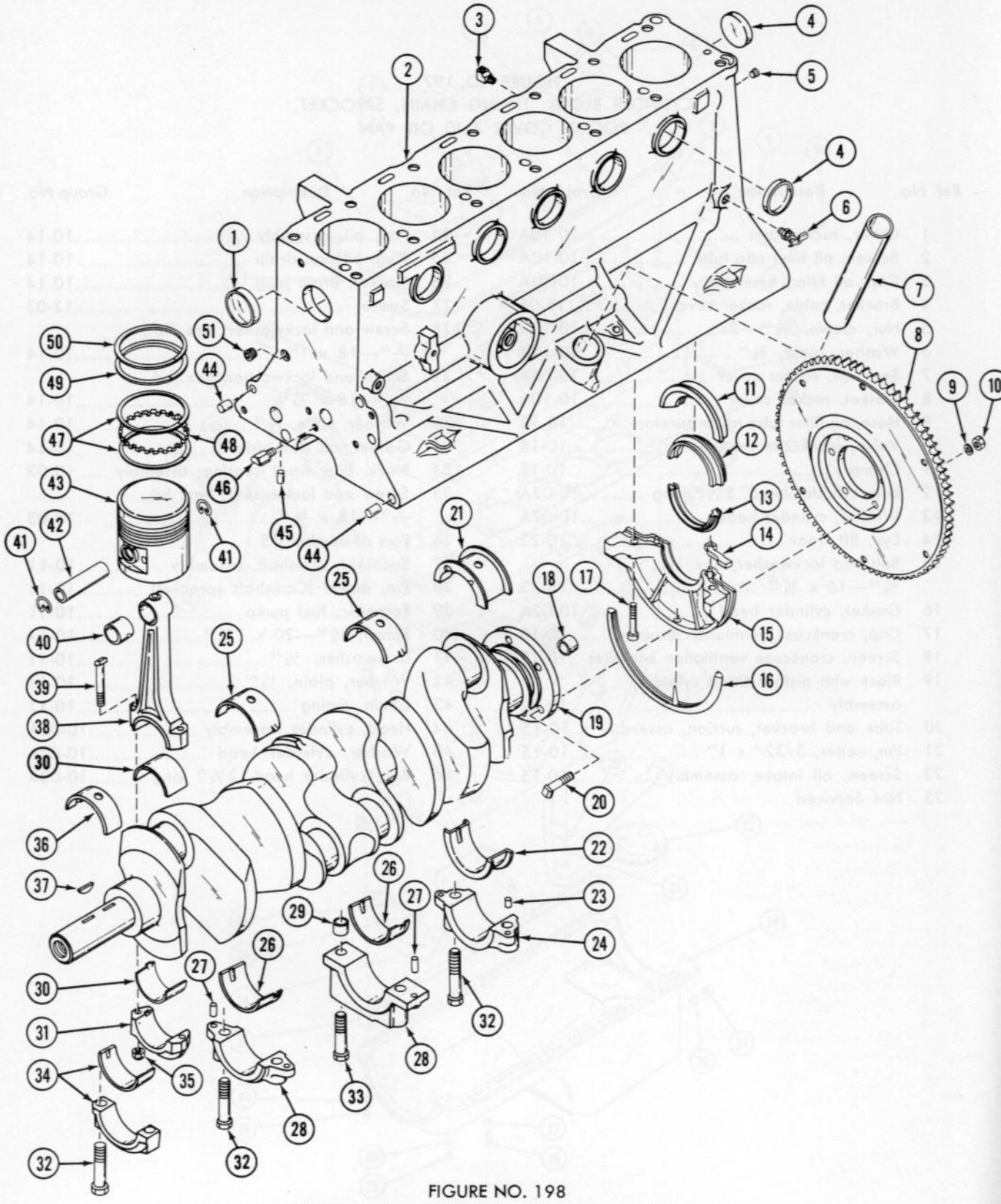

FIGURE NO. 198
CRANKSHAFT, BEARINGS, CONNECTING RODS,
PISTONS AND RINGS

FIGURE NO. 198
CRANKSHAFT, BEARINGS, CONNECTING RODS, PISTONS AND RINGS

Ref. No.	Description	Group No.
1	Plug, expansion, 1 3/4"	10-02
2	Block, with pistons fitted, cylinder, assembly	10-02
3	Elbow, 90 degree special	10-02
4	Plug, expansion, 1 5/8" (Water Jacket)	10-02
5	Plug, pipe, 1/4"	10-02
6	Cock, drain cylinder block	10-02
7	Tube, crankcase ventilation breather	10-18
8	Flywheel and Ring Gear, assembly	10-21
9	Lockwasher, 3/8"	10-21
10	Nut, hex., 3/8"—24	10-21
11	Kit, rear bearing oil seal	10-03
12	Oil Seal, crankshaft, rear	10-03
13	Oil Seal, crankshaft, rear	10-03
14	Gasket, filler block, rear bearing	10-03
15	Kit, rear bearing oil seal	10-03
16	Gasket, filler block oil pan end	10-03
17	Screw and Lockwasher, hex. hd., 5/16"—18 x 7/8"	10-03
18	Bushing, crankshaft pilot	10-03
19	Crankshaft, assembly	10-03
20	Bolt, flywheel	10-21
21	Bearing Set, crankshaft, No. 4	10-04
22	Bearing Set, crankshaft, No. 4	10-04
23	Dowel, rear cap	10-02
24	Not Serviced	
25	Bearing Set, crankshaft, No. 2 and 3	10-04
26	Bearing Set, crankshaft, No. 2 and 3	10-04
27	Dowel, front and rear intermediate	10-02
28	Not Serviced	
29	Ring, dowel, rear intermediate bearing	10-02
30	Bearing Set, connecting rod	10-05
31	Not Serviced	
32	Screw, bearing cap, front, intermediate and rear	10-02
33	Screw, bearing cap, crankshaft rear intermediate	10-02
34	Bearing Set, crankshaft, No. 1	10-04
35	Nut, connecting rod cap bolt	10-05
36	Bearing Set, crankshaft, No. 1	10-04
37	Key, Woodruff, No. 15	10-03
38	Rod, connecting	10-05
39	Bolt, connecting rod cap	10-05
40	Bushing, piston pin	10-06
41	Retainer, piston pin	10-06
42	Pin, piston	10-06
43	Piston and Pin, assembly	10-06
44	Sleeve, dowel	10-02
45	Dowel, cap front bearing	10-02
46	Oiler, timing chain and gear	10-02
47	Ring Set, piston	10-07
48	Ring Set, piston	10-07
49	Ring Set, piston	10-07
50	Ring Set, piston	10-07
51	Plug, pipe, 1/4"	10-02

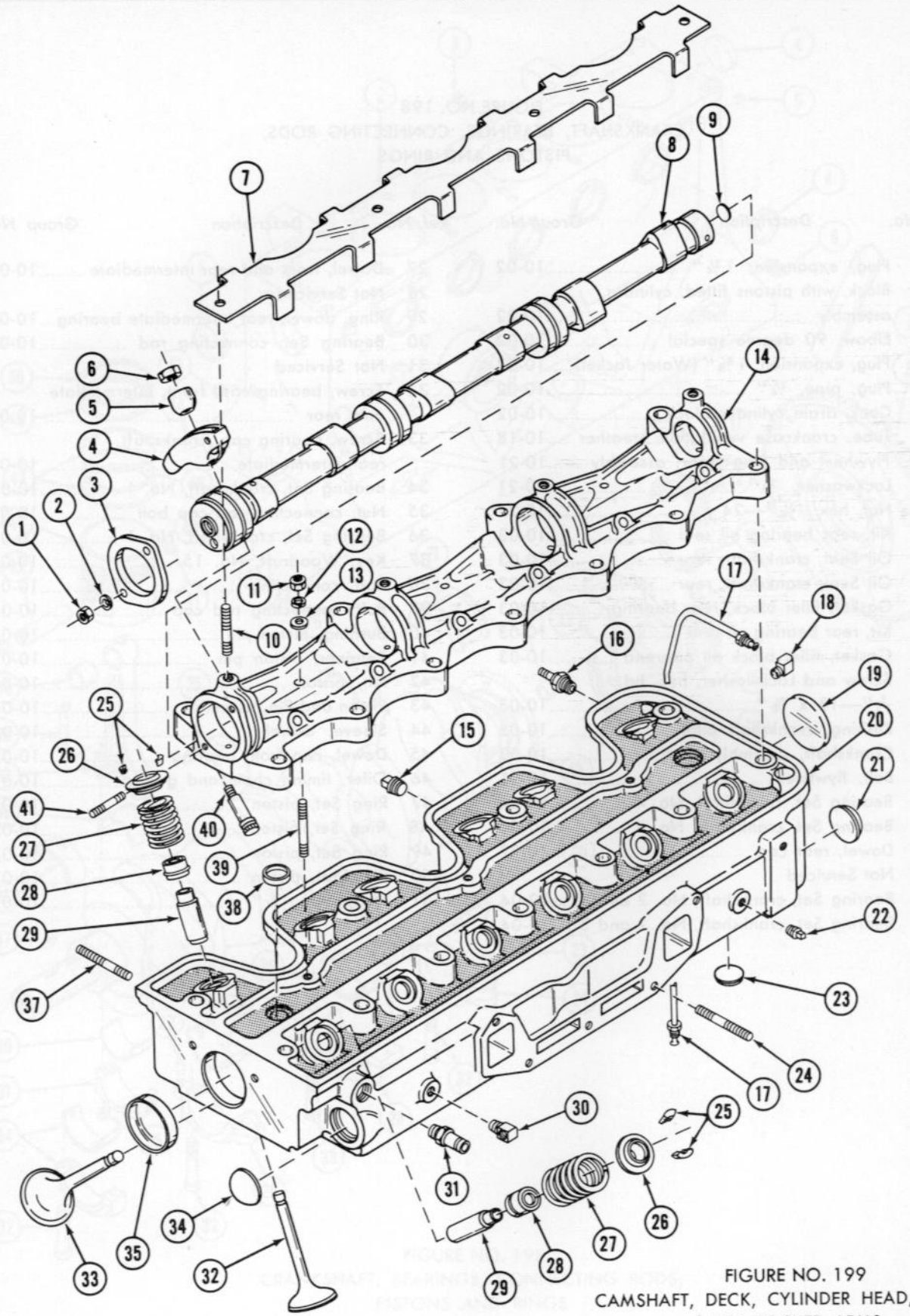

FIGURE NO. 199
CAMSHAFT, DECK, CYLINDER HEAD, VALVES AND ROCKER ARMS

FIGURE NO. 199
CAMSHAFT, DECK, CYLINDER HEAD, VALVES AND ROCKER ARMS

Ref. No.	Description	Group No.
1	Nut, hex., 5/16"—24	10-11
2	Lockwasher, 5/16"	10-11
3	Plate, thrust camshaft	10-11
4	Arm, rocker, assembly	10-09A
5	Ball, rocker arm	10-09A
6	Nut, adjusting, rocker arm	10-09A
7	Guide, rocker arm	10-09A
8	Camshaft	10-11
9	Plug, camshaft, 9/16"	10-11
10	Stud, rocker cover, 3/8"—24 x 1 1/2"	10-10A
11	Nut, hex., 5/16"—24	10-11
12	Lockwasher, 5/16"	10-11
13	Washer, plain, 5/16"	10-11
14	Deck, bearing cam, assembly	10-11
15	Plug, pipe, sq. hd., 3/8" (Heater Connection)	10-02A
16	Plug, heater indicator	16-01
17	Tube, oil camshaft	10-17
18	Elbow, 5/16", flared tube	10-02A
19	Plug, expansion, 1 5/8" (Water Jacket)	10-02A
20	Head, cylinder, assembly	10-02A
21	Plug, expansion, 1 3/8"	10-02A
22	Plug, pipe, 1/4" sq. hd.	10-02A
23	Plug, expansion, 1"	10-02A
24	Stud, 5/16"—18 x 24 x 1 3/4" (Intake Manifold)	10-19
25	Lock, valve spring retainer	10-08
26	Retainer, valve spring	10-08
27	Spring, valve	10-08
28	Kit, valve stem seals	10-08
29	Guide, valve stem	10-08
30	Elbow, outlet side	10-02A
31	Nipple, hose	10-02A
32	Valve, exhaust	10-08
33	Valve, inlet	10-08
34	Plug, expansion, 1 3/8"	10-02A
35	Plug, cup type	10-02A
37	Stud, 3/8"—16 x 24 x 1 7/8" (Exhaust Manifold)	10-19
38	Plug, cup type, 1 5/16" dia.	10-02A
39	Stud, 5/16"—18 x 24 x 1 9/16"	10-11
40	Stud, rocker arm	10-09A
41	Stud, thrust plate, 5/16"—24 x 1 1/8"	10-11

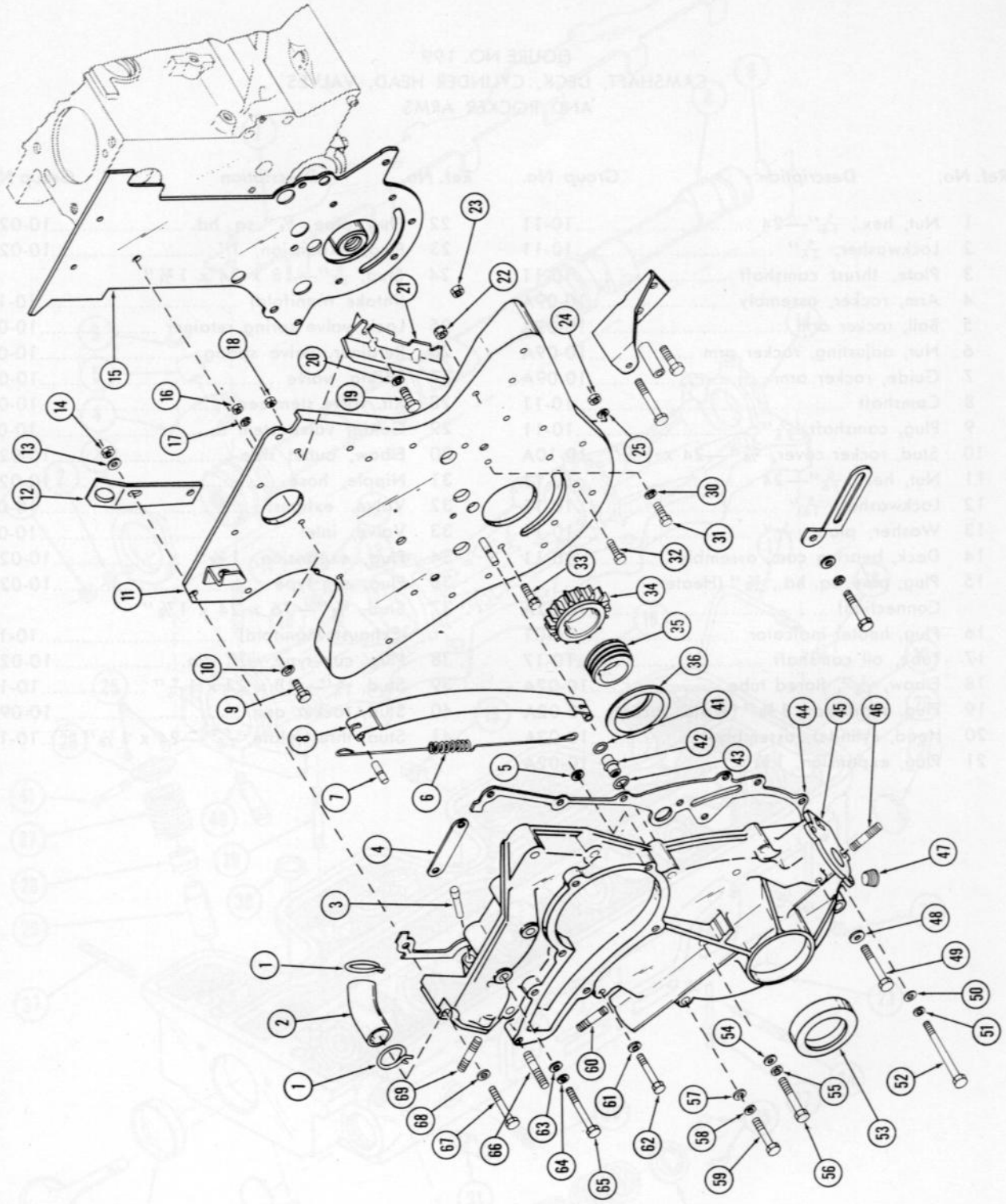

FIGURE NO. 200
TIMING CHAIN COVER AND FRONT
ENGINE PLATE

FIGURE NO. 200
TIMING CHAIN COVER AND FRONT ENGINE PLATE

Ref. No.	Description	Group No.
1	Clamp, hose, 1 7/8" I.D.	14-04
2	Hose, water pump outlet to block	14-04
3	Rod, push, fuel pump	12-09
4	Gasket Set, chain cover	10-12
5	Deleted	
6	Spring, timing chain tension blade	10-11
7	Pin, timing chain tension blade	10-11
8	Tensioner and pad, assembly	10-11
9	Bolt	
10	Lockwasher	
11	Plate, engine, front, assembly	10-23
12	Eye, lift, front	10-23
13	Lockwasher	
14	Nut, hex., 3/8"—16	10-12
15	Gasket, engine plate, front	10-23
16	Nut	
17	Lockwasher	
18	Nut, special, 5/16"—24	10-11
19	Bolt, hex. hd., 5/16"—24 x 7/8"	10-11
20	Washer, plain, 5/16"	10-11
21	Bracket, timing chain guide	10-11
22	Nut, huglock, 5/16"—24	
23	Nut, huglock, 5/16"—24	
24	Nut	
25	Lockwasher	
30	Lockwasher	
31	Bolt	
32	Bolt	
33	Bolt	
34	Sprocket, crankshaft	10-03
35	Gear, drive, oil pump and distributor	10-03
36	Thrower, oil crankshaft, front	10-03
41	Seal, washer	10-12
42	Sleeve, cover to block	10-12
43	Seal, washer	10-12
44	Gasket Set, chain cover	10-12
45	Cover, timing chain	10-12
46	Stud, 5/16"—24 x 3 1/4"	10-12
47	Plug, pipe, 3/8" (Recessed head)	10-12
48	Lockwasher, 3/8"	10-12
49	Bolt, hex. hd., 3/8"—16 x 1 1/2"	10-12
50	Washer, plain, 5/16"	10-12
51	Lockwasher, 5/16"	10-12
52	Bolt, hex. hd., 5/16"—18 x 4"	10-12
53	Seal, oil, front	10-12
54	Washer	
55	Lockwasher	
56	Bolt	
57	Deleted	
58	Deleted	
59	Deleted	
60	Stud, 5/16"—24 x 3 1/4"	10-12
61	Lockwasher, 3/8"	10-12
62	Bolt, hex. hd., 3/8"—16 x 2 1/4"	10-12
63	Deleted	
64	Lockwasher, 5/16"	
65	Bolt, hex. hd., 5/16"—18 x 3"	10-12
66	Stud, 5/16"—24 x 1 1/2" (Water pump)	10-12
67	Bolt	
68	Lockwasher	
69	Stud, 5/16"—24 x 3/4"	10-12

Fig. and Ref. No.	Part No.	Description	No. Req'd.
		GROUP 10-01—ENGINE	
		Complete engines may be obtained by specifying compression ratio, the type of Clutch, Transmission, Carburetor, allowing a lead time of approximately thirty (30) days after receipt of order.	
		(See Block Assemblies Group 10-02)	
	930187	Gasket Set, engine overhaul	1
		Consists of:	
	930188	1 Gasket Set, engine valve job	
	925957	1 Gasket Set, oil pan	
	925957	Gasket Set, oil pan	1
		Consists of:	
	806515	1 Gasket, drain plug	
	925795	2 Gasket, filler block, oil pan end	
	925116	2 Gasket, filler block, rear bearing	
	931498	2 Gasket, oil pan, side	
		1 Installation, instruction	
	921039	2 Oil Seal, crankshaft, rear	
	930188	Gasket Set, engine valve job	1
		Consists of:	
	926092	1 Gasket, carburetor to intake manifold	
	930769	1 Gasket, cylinder head	
	926027	1 Gasket, exhaust manifold to head	
	K-745608	1 Gasket, exhaust manifold to exhaust pipe	
	K-706163	1 Gasket, fuel pump to chain cover	
	926055	1 Gasket, intake manifold to cylinder head	
	932649	1 Gasket, oil pump	
	928211	1 Gasket, rocker cover	
	931682	1 Gasket Set, timing chain cover	
	648852	1 Gasket, water outlet elbow	
	926038	1 Gasket, water pump	
	906459	4 Oil Seal, rocker cover to cam deck studs	
	929687	2 Seal, cover to cylinder block sleeve	
	K-706165	1 Seal, oil, crankshaft, front	
		GROUP 10-02—CYLINDER BLOCK	
	932729	Block, cylinder, assembly	1
		(Includes bearings, connecting rods, crankshaft, and pistons with rings fitted)	
1-19	930184	Block, with pistons fitted cylinder, assembly	1
3-6	A-1126	Cock, drain, cylinder block	1
3-23	K-701415	Dowel, front intermediate, rear intermediate, rear cap crankshaft	5
3-45	K-709327	Dowel, front bearing cap, crankshaft	2
3-3	930248	Elbow, 90° special	1
3-46	931633	Oiler, timing chain and gear	1
3-5	K-706180	Plug, pipe, $\frac{1}{4}$", cylinder block oil header	2
3-4	K-733598	Plug, expansion, $1\frac{5}{8}$" (Water Jacket)	1
3-1	907879	Plug, expansion, $1\frac{3}{4}$"	1
3-29	K-701414	Ring, dowel, rear intermediate bearing	1
3-32	K-735979	Screw, bearing cap, crankshaft, front, intermediate and rear	6
3-33	K-735980	Screw, bearing cap, crankshaft, rear intermediate	2
3-44	926195	Sleeve, dowel	1
		GROUP 10-02A—CYLINDER HEAD	
1-44	930183	Head, cylinder assembly	1
1-12	926089	Bolt, cylinder head, $5\frac{1}{2}$" long	11
1-46	926090	Bolt, cylinder head, $2\frac{1}{4}$" long	3
4-18	GM-137422	Elbow, $\frac{5}{16}$" flared tube	1
4-30	931549	Elbow, outlet, side	1
1-16	930769	Gasket, cylinder head	1
4-31	675015	Nipple, hose (Water pressure relief from outlet elbow spacer)	1

Fig. and Ref. No.	Part No.	Description	No. Req'd.
		GROUP 10-02A—CYLINDER HEAD (Cont'd)	
	GM-137398	Nut, inverted flared tube, 5/16" (Use with GM-9409263)	1
4-35	928863	Plug, cup type	1
4-38	930160	Plug, cup type 15/16" dia.	2
4-23	GM-116447	Plug, expansion, 1"	2
4-21	GM-117923	Plug, expansion, 1 3/8"	2
4-19	K-733598	Plug, expansion, 1 5/8" (Water Jacket)	1
	GM-9409263	Plug, inverted flared tube, 5/16" (To plug inverted fitting hole when vacuum booster line is not used)	1
4-22	GM-143933	Plug, pipe, 1/4" sq. hd.	1
4-15	GM-103879	Plug, pipe sq. hd., 3/8" (Heater connection)	1
1-13	930856	Washer, cylinder head	14
		GROUP 10-03—CRANKSHAFT	
3-19	926097	Crankshaft, assembly	1
1-34	929728	Block, filler, front bearing, assembly	1
1-35	GM-9409098	Screw and lockwasher, hex. hd., 5/16"-18 x 7/8" (Front bearing filler block to cylinder block)	2
3-18	K-729521	Bushing, crankshaft pilot	1
2-43	931170	Damper, vibration and fan drive, assembly	1
2-45	GM-428811	Bolt, hex. hd., 3/4"-16 x 2" } Vibration damper to crankshaft	1
2-44	K-735826	Washer, special } Vibration damper to crankshaft	1
5-35	926051	Gear, drive, oil pump and distributor (Also Group 15-03)	1
3-37	GM-113782	Key, Woodruff, No. 15 (Crankshaft sprocket and fan drive pulley to crankshaft)	2
3-11	925958	Kit, rear bearing oil seal	1
		Consists of:	
		1 Block filler, rear bearing oil seal	
3-16	925795	2 Gasket, filler block, oil pan end	
3-14	925116	2 Gasket, filler block, rear bearing	
	931498	2 Gasket, oil pan	
		1 Guard, rear bearing oil seal	
		1 Installation, instructions	
	GM-120214	2 Lockwasher, 5/16" (Rear filler block)	
3-12	921039	2 Oil Seal, crankshaft, rear	
	GM-138223	2 Screw, 5/16"-18 x 1 1/4" (Rear filler block)	
5-34	926013	Sprocket, crankshaft	1
5-36	926052	Thrower, oil, crankshaft front	1
		GROUP 10-04—CRANKSHAFT BEARING	
		NOTE: Crankshaft Bearing Sets consists of: (1) Upper and (1) Lower Half Bearing	
3-34	930189	Bearing Set, crankshaft No. 1 standard size	1
3-25	930190	Bearing Set, crankshaft No. 2 and 3 standard size	2
3-21	930191	Bearing Set, crankshaft No. 4 standard size	1
	930192	Bearing Set, crankshaft No. 1 .002" undersize	1
	930193	Bearing Set, crankshaft No. 2 and 3 .002" undersize	2
	930194	Bearing Set, crankshaft No. 4 .002" undersize	1
	930195	Bearing Set, crankshaft No. 1 .010" undersize	1
	930196	Bearing Set, crankshaft No. 2 and 3 .010" undersize	2
	930197	Bearing Set, crankshaft No. 4 .010" undersize	1
	930198	Bearing Set, crankshaft No. 1 .012" undersize	1
	930199	Bearing Set, crankshaft No. 2 and 3 .012" undersize	2
	930200	Bearing Set, crankshaft No. 4 .012" undersize	1
	930201	Bearing Set, crankshaft No. 1 .020" undersize	1
	930202	Bearing Set, crankshaft No. 2 and 3 .020" undersize	2
	930203	Bearing Set, crankshaft No. 4 .020" undersize	1

Fig. and Ref. No.	Part No.	Description	No. Req'd.
		GROUP 10-05—CONNECTING RODS AND BEARINGS	
		NOTE: Connecting Rod Bearing Set consists of: (1) Upper and (1) Lower Half Bearing	
3-38	928973	Rod, connecting, assembly (Cylinders 1-3-5)	3
	928974	Rod, connecting, assembly (Cylinders 2-4-6)	3
3-30	930204	Bearing Set, connecting rod, standard (Cylinders 1-3-5)	3
	930205	Bearing Set, connecting rod, standard (Cylinders 2-4-6)	3
	930206	Bearing Set, connecting rod, .002″ undersize (Cylinders 1-3-5)	3
	930207	Bearing Set, connecting rod, .002″ undersize (Cylinders 2-4-6)	3
	930208	Bearing Set, connecting rod, .010″ undersize (Cylinders 1-3-5)	3
	930209	Bearing Set, connecting rod, .010″ undersize (Cylinders 2-4-6)	3
	930210	Bearing Set, connecting rod, .012″ undersize (Cylinders 1-3-5)	3
	930211	Bearing Set, connecting rod, .012″ undersize (Cylinders 2-4-6)	3
	930212	Bearing Set, connecting rod, .020″ undersize (Cylinders 1-3-5)	3
	930213	Bearing Set, connecting rod, .020″ undersize (Cylinders 2-4-6)	3
3-39	K-711058	Bolt, connecting rod cap	12
3-35	K-711057	Nut, connecting rod cap bolt	12
		GROUP 10-06—PISTONS AND PINS	
3-43	926076	Piston and pin, assembly, standard	6
	930214	Piston and pin, assembly, .010″ oversize	6
	930215	Piston and pin, assembly, .020″ oversize	6
	930216	Piston and pin, assembly, .030″ oversize	6
	930217	Piston and pin, assembly, .040″ oversize	6
3-40	K-701331	Bushing, piston pin	6
3-42	K-732597	Pin, piston (Standard)	6
3-41	K-711932	Retainer, piston pin	12
		GROUP 10-07—PISTON RINGS	
3-47	930218	Ring Set, piston standard	1
	930219	Ring Set, piston .010″ oversize	1
	930220	Ring Set, piston .020″ oversize	1
	930221	Ring Set, piston .030″ oversize	1
	930222	Ring Set, piston .040″ oversize	1
		GROUP 10-08—VALVES, VALVE GUIDES AND SPRINGS	
4-29	930225	Guide, valve, stem, .0005″ oversize	12
4-28	931396	Kit, valve, stem seals	1
4-25	643334	Lock, valve, spring retainer	24
4-26	926222	Retainer, valve, spring	12
4-27	933019	Spring, valve	12
4-32	926216	Valve, exhaust	6
4-33	926215	Valve, inlet	6
		GROUP 10-09A—ROCKER ARMS	
4-4	926232	Arm, rocker, assembly	12
4-5	929423	Ball, rocker arm	12
4-7	928572	Guide, rocker arm	1
4-6	930943	Nut, adjusting, rocker arm	12
4-40	930875	Stud, rocker arm	12
		GROUP 10-10A—ROCKER ARM COVER	
1-1	928201	Cover, rocker arm	1
1-5	GM-131675	Nut, crown 3/8″-24 } Rocker cover mounting	4
1-6	GM-120394	Washer, plain 3/8″ } Rocker cover mounting	4
1-3	930291	Cap, oil filler, assembly	1

Fig. and Ref. No.	Part No.	Description	No. Req'd.
		GROUP 10-10A—ROCKER ARM COVER (Cont'd)	
1-8	928211	Gasket, rocker cover	1
1-2	929682	Screen, oil filler cap tube	1
1-7	906459	Seal, oil, rocker cover	4
4-10	928887	Stud, rocker cover 3/8"-24 x 1 1/2"	4
	928860	Tube and extension, oil filler and ventilator	1
		GROUP 10-11—CAMSHAFT AND TIMING GEARS	
4-8	932959	Camshaft	1
5-21	930288	Bracket, timing chain guide assembly	1
5-19	GM-120213	Bolt, hex. hd., 5/16"-24 x 7/8" — Timing chain bracket guide assembly to front engine plate	2
5-18	931562	Nut, special, 5/16"-24 — Timing chain bracket guide assembly to front engine plate	2
5-20	GM-120393	Washer, plain, 5/16" — Timing chain bracket guide assembly to front engine plate	2
1-43	926002	Chain, timing	1
4-14	930223	Deck, bearing cam, assembly	1
4-12	GM-120214	Lockwasher, 5/16" — Cam bearing deck to cylinder head studs	3
4-11	GM-120368	Nut, hex., 5/16"-24 — Cam bearing deck to cylinder head studs	3
4-13	GM-120386	Washer, plain, 5/16" — Cam bearing deck to cylinder head studs	3
1-39	929041	Eccentric, fuel pump	1
	931633	Oiler, timing chain and gear	1
1-38	GM-141246	Pin, dowel (Camshaft sprocket)	1
5-7	928664	Pin, timing chain, tension blade	1
4-3	926064	Plate, thrust, camshaft	1
4-2	GM-120214	Lockwasher, 5/16" — Plate to deck	2
4-1	GM-120368	Nut, hex., 5/16"-24 — Plate to deck	2
4-41	928884	Stud, thrust plate 5/16"-24 x 1 1/8" — Plate to deck	2
4-9	GM-111174	Plug, 9/16" (Camshaft)	1
5-6	928667	Spring, timing chain tension blade	1
1-37	926157	Sprocket, camshaft, assembly	1
1-41	GM-120384	Lockwasher, 1/2" — Sprocket to camshaft	1
1-40	GM-123899	Screw, 1/2"-20 x 1 7/8" — Sprocket to camshaft	1
1-42	808961	Washer, plain, 1/2" — Sprocket to camshaft	1
	928884	Stud, self tapping (Distributor)	1
4-39	949783	Stud, 5/16"-18-24 x 1 9/16" (Deck, bearing cam)	3
5-8	931210	Tensioner and pad, assembly	1
	931221	Tube, oil, cam bearing deck	1
	932052	Clip, oil tube to deck	1
		GROUP 10-12—TIMING CHAIN COVER	
5-45	928281	Cover, timing chain	1
5-49	GM-120918	Bolt, hex. hd., 3/8"-16 x 1 1/2" — Chain cover to front engine plate	4
5-62	GM-122188	Bolt, hex. hd., 3/8"-16 x 2 1/4" — Chain cover to front engine plate	7
5-48	GM-120382	Lockwasher, 3/8" — Chain cover to front engine plate	11
5-14	GM-120377	Nut, hex., 3/8"-16 — Chain cover to front engine plate	11
5-65	GM-122089	Bolt, hex. hd., 5/16"-18 x 3" — Chain cover to cylinder head	2
	GM-120214	Lockwasher, 5/16" — Chain cover to cylinder head	2
	GM-122077	Bolt, hex. hd., 5/16"-18 x 2 1/2" — Cover to block thru dowel sleeve and across oil passage	3
	GM-120214	Lockwasher, 5/16" — Cover to block thru dowel sleeve and across oil passage	3
	GM-120393	Washer, plain, 5/16" — Cover to block thru dowel sleeve and across oil passage	3
5-52	GM-178429	Bolt, hex. hd., 5/16"-18 x 4" — Chain cover to block thru dowel sleeve at oil pump	1
5-51	GM-120214	Lockwasher, 5/16" — Chain cover to block thru dowel sleeve at oil pump	1
5-50	GM-120393	Washer, plain, 5/16" — Chain cover to block thru dowel sleeve at oil pump	1
5-4	931682	Gasket Set, chain cover	1
5-47	GM-444698	Plug, pipe, 3/8" (Recessed head)	2
5-53	K-706165	Seal, oil front	1
5-41	929687	Seal, washer	2
5-42	930790	Sleeve, cover to block	1

Fig. and Ref. No.	Part No.	Description	No. Req'd.
		GROUP 10-12—TIMING CHAIN COVER (Cont'd)	
	949783	Stud, 5/16"-18-24 x 1 9/16" (Deck bearing cam)	3
5-69	930903	Stud, (Fuel pump) 5/16"-24 x 1 3/4"	2
5-46	928734	Stud, 5/16"-24 x 3 1/4" (Oil Pump)	3
5-66	928737	Stud, (Water pump) 5/16"-24 x 1 1/2"	7
	928884	Stud, self tapping (Distributor) 5/16"-24 x 1 1/8"	1
		GROUP 10-13—OIL PUMP	
2-40	928929	Pump, oil assembly	1
2-41	GM-120214	Lockwasher, 5/16" — Oil pump to chain cover	3
2-42	GM-120368	Nut, 5/16"-24 — Oil pump to chain cover	3
	GM-120393	Washer, plain, 5/16" — Oil pump to chain cover	3
	931582	Cover, oil pump	1
	931580	Gasket, cover, oil pump	1
2-39	932649	Gasket, oil pump to chain cover	1
	930987	Gear, oil pump, drive	1
	931581	Screw, oil pump, cover attaching	3
	930829	Set, gear and pinion, oil pump	1
	930828	Shaft and gear, oil pump drive	1
	931579	Spring, relief valve	1
	928734	Stud, 5/16"-24 x 3 1/4" (Oil pump)	3
	931578	Valve, relief, oil pump	1
		GROUP 10-14—OIL PAN	
1-24	K-733541	Pan, oil, assembly	1
1-29	931635	Screw and lockwasher, hex. hd., 5/16"-18 x 3/4" — Oil pan to cylinder block	17
1-28	680440	Screw and lockwasher, hex. hd., 5/16"-18 x 1" — Oil pan to cylinder block	1
1-30	GM-120393	Washer, plain, 5/16" — Oil pan to cylinder block	17
	680440	Bolt and lockwasher, hex. hd., 5/16"-18 x 1" — Oil pan bolt left side	1
	669842	Spacer — Oil pan bolt left side	1
	GM-120393	Washer, plain, 5/16" — Oil pan bolt 2nd from rear	1
	925957	Gasket Set, oil pan	1
		Consists of:	
1-26	806515	1 Gasket, drain plug	
	925795	2 Gasket, filler block, oil pan end	
	925116	2 Gasket, filler block, rear bearing	
1-31	931498	2 Gasket, oil pan, side	
		1 Installation, instruction	
	921039	2 Oil seal, crankshaft, rear	
1-25	639979	Plug, oil pan drain	1
		GROUP 10-15—OIL FLOAT	
1-22	926083	Screen, oil intake, assembly	1
1-21	GM-121224	Pin, cotter 3/32" x 1" (Screen to suction tube)	1
1-20	929891	Tube and bracket, suction, assembly	1
		GROUP 10-16—OIL FILLER TUBE AND LEVEL INDICATOR	
	930291	Cap, oil filler, assembly	1
2-30	930537	Indicator, oil level	1
	929682	Screen, oil filler cap tube	1
2-27	930272	Tube, oil level indicator guide	1
	928860	Tube and extension, oil filler and ventilator	1
		GROUP 10-16A—OIL FILTER	
2-37	927787	Filter, oil, assembly	1
2-38	929406	Adapter, oil, filter	1

Fig. and Ref. No.	Part No.	Description	No. Req'd.
		GROUP 10-17—OIL DISTRIBUTION SYSTEM	
4-17	928954	Tube, oil, camshaft	1
		GROUP 10-18—CRANKCASE VENTILATION	
1-17	930365	Cap, crankcase ventilation breather (On block)	1
1-11	GM-272847	Clamp	2
1-9	931542	Hose, oil filler tube to carburetor	1
1-18	929682	Screen, crankcase ventilation breather	1
3-7	928862	Tube, crankcase ventilation breather (On block)	1
1-10	930929	Valve, crankcase ventilator	1
		GROUP 10-19—MANIFOLD	
2-3	933035	Manifold, exhaust, assembly (Use with automatic choke)	1
	933022	Manifold, exhaust	1
2-1	53287	Nut, hex., 3/8"-24 } Exhaust manifold to cylinder head	10
2-2	K-731960	Washer, plain } Exhaust manifold to cylinder head	8
2-5	K-711824	Washer, special } Exhaust manifold to cylinder head	2
2-24	933703	Manifold, intake	1
2-25	GM-120214	Lockwasher, 5/16" } Intake manifold to cylinder head	5
2-26	GM-120368	Nut, hex., 5/16"-24 } Intake manifold to cylinder head	5
	GM-120393	Washer, plain, 5/16" } Intake manifold to cylinder head	3
2-32	GM-272850	Clamp, hose, water by-pass	2
2-35	GM-272851	Clamp, hose (Water outlet elbow spacer to cylinder head)	2
2-31	951614	Elbow, heater hose, water by-pass	1
2-18	800293	Elbow, water outlet	1
2-16	GM-120214	Lockwasher, 5/16" } Elbow to manifold	3
2-15	GM-120368	Nut, hex., 5/16"-24 } Elbow to manifold	3
2-6	926027	Gasket, exhaust manifold	1
2-22	926055	Gasket, intake manifold	1
2-19	648852	Gasket, water outlet elbow	2
2-36	930261	Hose, pressure relief (Water outlet elbow spacer to cylinder head)	1
2-33	926139	Hose, water by-pass (Intake manifold to water pump)	1
2-21	929019	Spacer, water outlet elbow	1
4-37	926156	Stud, 3/8"-16 x 24 x 1 7/8"	8
	915270	Stud, 3/8" x 2 1/8" (Exhaust manifold)	2
4-25	915271	Stud, 5/16"-18 x 24 x 1 3/4" (Intake manifold)	5
2-34	924331	Stud, 5/16" x 2 5/8" (Water outlet elbow)	3
		GROUP 10-21—FLYWHEEL AND RING GEAR	
	930833	Flywheel and ring gear, assembly	1
3-20	932674	Bolt, flywheel } Flywheel to crankshaft	6
3-9	GM-138542	Lockwasher, internal tooth, 3/8" } Flywheel to crankshaft	6
3-10	641769	Nut, hex., 3/8"-24 } Flywheel to crankshaft	6
	930684	Gear, ring, flywheel	1
		GROUP 10-22—FLYWHEEL HOUSING	
2-7	930375	Housing, flywheel, assembly (Heavy duty)	1
	K-734137	Bolt, dowel } Flywheel housing to cylinder block	2
	GM-179859	Bolt, hex. hd., 7/16"-14 x 1 1/8" } Flywheel housing to cylinder block	1
2-9	GM-187151	Bolt, hex. hd., 7/16"-14 x 3 3/8" } Flywheel housing to cylinder block	2
2-8	GM-120383	Lockwasher, 7/16" } Flywheel housing to cylinder block	5
	931410	Bushing, flywheel housing	2
2-10	K-731456	Pan, flywheel housing	1
2-12	GM-423560	Bolt and lockwasher, hex. hd., 5/16"-18 x 1/2" } Flywheel housing pan to flywheel housing	2
2-14	GM-186493	Bolt and lockwasher, hex. hd., 5/16"-20 x 5/8" } Flywheel housing pan to flywheel housing	4
	K-727588	Plug, button, vent type (Screen)	3

Fig. and Ref. No.	Part No.	Description	No. Req'd.
		GROUP 10-23—ENGINE MOUNTING	
5-12	928727	Eye, lift, front (Mounts with chain cover bolts)	1
1-14	928728	Eye, left, rear	1
1-15	GM-451976	Bolt and lockwasher, hex. hd., 3/8"-16 x 3/4" } Eye lift	1
	GM-120394	Washer, plain, 3/8" } to cylinder head	1
5-15	928844	Gasket, engine plate, front	1
	932954	Insulator, engine support front	2
	GM-120383	Lockwasher, 7/16" } Insulator to	2
	GM-271501	Nut, hex., 7/16"-14 } front engine plate	2
	GM-120647	Bolt, hex. hd., 3/8"-24 x 1"	3
	GM-121615	Bolt, hex. hd., 3/8"-24 x 1 1/4" Insulator and ground strap	1
	GM-271193	Nut, hex., 3/8"-24 to engine and support brackets	4
	GM-120394	Washer, plain, 3/8"	4
	928567	Insulator, engine support, rear, assembly	1
	GM-122145	Bolt and lockwasher, hex. hd., 3/8"-16 x 1 1/4"	2
	928464	Support, front engine, P.D. and Cab	2
	GM-181636	Bolt, hex. hd., 3/8"-24 x 7/8"	6
	GM-120382	Lockwasher, 3/8" Engine support	6
	GM-120369	Nut, hex., 3/8"-24 to frame	6
	GM-120394	Washer, plain, 3/8"	6
	928665	Pin, anchor	1
5-11	926001	Plate, engine front, assembly	1
	GM-451975	Bolt and lockwasher, 5/16"-18 x 3/4" } Front engine plate	2
	GM-9409098	Bolt and lockwasher, 5/16"-18 x 7/8" } to filler block	2
	930681	Bolt, hex. hd., 3/8"-16 x 5/8"	1
	GM-122007	Bolt, hex. hd., 5/16"-18 x 3/4" Front	1
	GM-138542	Lockwasher, 3/8" engine plate	1
	GM-120214	Lockwasher, 5/16" to block	1
	GM-451975	Screw and lockwasher, hex. hd., 5/16"-18 x 3/4"	1

Fig. and Ref. No.	Part No.	Description	No. Req'd.
		GROUP 12-03 FUEL AND VACUUM TUBES	
	GM-272844	Clamp, hose, 9/16" (Fuel tank to fuel pump)	4
	GM-192107	Clip, closed, 5/16" (Fuel line to water pump stud)	1
	928874	Extension, fuel line (Fuel pump to hose)	1
	928850	Hose, connecting (Fuel line to fuel pump)	2
	928911	Tube, carburetor to fuel pump	1
		GROUP 12-04—CARBURETOR	
	926091	Carburetor, assembly (Holley #R-2415-A)	1
	GM-120214	Lockwasher, 5/16" (Carburetor to manifold)	4
	GM-120368	Nut, hex., 5/16"-24 (Carburetor to manifold)	4
1-23	915271	Stud, 5/16"-18-24 x 1 3/4" (Carburetor to manifold)	4
	GM-120393	Washer, plain, 5/16" (Carburetor to manifold)	4
	930182	Diaphragm, accelerator pump	1
	931574	Elbow, reducing	1
	926092	Gasket, carburetor, flange	1
	930176	Gasket Set, carburetor (For carburetor 926091 Holley #R-2415-A)	1
		Consists of:	
		1 Gasket, adjusting nut, fuel valve seat	
		1 Gasket, fitting, fuel inlet	
		1 Gasket, flange	
		1 Gasket, fuel bowl	
		1 Gasket, fuel level check plug	
		1 Gasket, lock screw, fuel valve seat	
		1 Gasket, metering body	
		1 Gasket, power body	
		2 Gasket, pump discharge nozzle	
		4 Gasket, screw, fuel bowl	
		1 Gasket, throttle body	
		1 "O" ring, fuel valve seat	
		2 Seal, adjusting needle	
	930178	Jet, carburetor metering (Standard)	1
	930179	Jet, carburetor metering (Second lean)	1
	930180	Jet, carburetor metering (Fourth lean)	1
	930175	Kit, repair carburetor (Clean out) (For carburetor 926091 Holley #R-2415-A)	1
		Consists of:	
		1 Diaphragm, assembly	
		1 Gasket, flange	
		1 Gasket, fuel bowl	
		4 Gasket, fuel bowl screw	
		1 Gasket, fuel inlet fitting	
		1 Gasket, fuel level check plug	
		1 Gasket, metering body	
		1 Gasket, power body	
		2 Gasket, pump discharge nozzle	
		1 Gasket, throttle body	
	930177	1 Needle, valve and seat, assembly	
		2 Seal, adjusting needle	
	930181	1 Valve, power, assembly	

Fig. and Ref. No.	Part No.	Description	No. Req'd.
		GROUP 12-04—CARBURETOR (Cont'd)	
	930174	Kit, repair carburetor (Major) (For carburetor 926091 Holley #R-2415-A) Consists of:	1
		1 Diaphragm, assembly	
	930176	1 Gasket Set, carburetor	
	932652	2 Needle, idle adjusting	
		1 Needle, valve and seat, assembly	
	932650	1 Nozzle, pump discharge	
		1 Retainer, float	
		2 Screw, choke valve	
		4 Screw, throttle valve	
		1 Valve, power	
	932651	1 Valve, pump check	
	918893	Stud, special, 9/16" x 3/4"-3-3/8" (Air cleaner to carburetor)	1
	930182	Diaphragm, accelerator pump	1
	931574	Elbow, reducing	1
	926092	Gasket, carburetor flange	1
	933617	Gasket Set, carburetor (For carburetor 933170 Holley #2640)	1
	930178	Jet, carburetor metering (Standard)	1
	930179	Jet, carburetor metering (Second lean)	1
	930180	Jet, carburetor metering (Fourth lean)	1
	933619	Kit, carburetor, choke (For carburetor 933170 Holley #2640)	1
	933618	Kit, repair carburetor (Clean out) (For carburetor 933170 Holley #2640)	1
	933616	Kit, repair carburetor (Major) (For carburetor 933170 Holley #2640)	1
	932652	Needle, idle adjusting	2
	930177	Needle, valve and seat, assembly	1
	932650	Nozzle, pump discharge	1
	918893	Stud, special 5/16" x 2 7/8" (Air cleaner to carburetor)	1
	933511	Stud, 9/16" x 3/4"-4 5/8" (Air cleaner to carburetor)	1
	933360	Tube, fresh air automatic choke (Exhaust manifold to carburetor)	1
	933194	Tube and loom, automatic choke, assembly	1
	930181	Valve, power, assembly	1
	932651	Valve, pump check	1
		GROUP 12-05—AIR CLEANER	
	932710	Cleaner, air, dry type (Use with dual throat carburetor)	1
	933488	Cleaner, air, oil bath (Use with dual throat carburetor)	1
	931996	Cleaner, air, oil bath (Use with single throat carburetor)	1
	931750	Cover, air cleaner (For 932710)	1
	931751	Element, air cleaner (For 932710)	1
	GM-219217	Nut, wing, 5/16"-24	1
		GROUP 12-09—FUEL PUMP	
2-61	930144	Pump, fuel, assembly	1
2-67	GM-120214	Lockwasher, 5/16" } Fuel pump to chain cover	2
2-66	GM-120368	Nut, hex. hd., 5/16"-24 } Fuel pump to chain cover	2
2-68	GM-120393	Washer, plain, 5/16" } Fuel pump to chain cover	2
	GM-179148	Clip, closed (Vacuum line to chain cover)	1
2-60	GM-137422	Elbow, 5/16" inverted flared tube	2
2-59	K-706163	Gasket, fuel pump	1
	933548	Kit, repair, fuel pump	1
5-3	929017	Rod, push, fuel pump	1
	930903	Stud, (Fuel pump) 5/16"-24 x 1 3/4"	2
		Use With Automatic Choke	
	933170	Carburetor, assembly (With automatic choke) (Holley #2540)	1
	GM-120214	Lockwasher, 5/16" } Carburetor to manifold	4
	GM-120368	Nut, hex. hd., 5/16"-24 } Carburetor to manifold	4
	915271	Stud, 5/16"-18-24 x 1 3/4" } Carburetor to manifold	4
	GM-120393	Washer, plain, 5/16" } Carburetor to manifold	4
	933362	Bracket, support, automatic choke tubes	1

Fig. and Ref. No.	Part No.	Description	No. Req'd.
		GROUP 14-04—WATER PUMP	
2-57	926044	Pump, water assembly	1
2-55	GM-120214	Lockwasher, 5/16" — Water pump to chain cover	7
2-54	GM-120368	Nut, hex., 5/16"-24 — Water pump to chain cover	7
2-56	GM-120393	Washer, plain, 5/16" — Water pump to chain cover	7
5-1	GM-272861	Clamp, hose, 1 7/8" I.D.	2
2-58	926038	Gasket, water pump	1
5-2	930068	Hose, water pump outlet to block	1
	928737	Stud, (Water pump) 5/16"-24 x 1 1/2"	7
		GROUP 14-05—FAN, FAN PULLEY AND BELT	
2-46	908696	Fan, assembly	1
2-48	800232	Bolt and lockwasher, hex. hd., 5/16"-18 x 2 1/2"	4
2-50	929300	Spacer, fan (Water pump pulley and fan blade assembly and spacer to water pump hub)	1
2-49	930045	Belt, drive, fan and alternator	1
	929646	Belt, "V" type (Use with power steering) (44 1/2" long)	1
2-51	K-733798	Pulley, water pump	1
		GROUP 14-06—THERMOSTAT	
2-20	812050	Thermostat, assembly	1
	905594	Thermostat, assembly (High temp.)	1

Fig. and Ref. No.	Part No.	Description	No. Req'd.
		GROUP 15-01A—ALTERNATOR	
	933037	Alternator, assembly (35 Amp.) (12 Volt) (Motorola)	1
	933139	Alternator, assembly (40 Amp.) (12 Volt) (Motorola)	1
	GM-124186	Bolt, hex. hd., 1/2"-20 x 2 3/4" — Alternator to bracket and front engine plate	1
	GM-190171	Nut, elastic stop, 1/2"-20 — Alternator to bracket and front engine plate	1
	933100	Bracket, alternator, support	1
	GM-123798	Bolt, hex. hd., 5/16"-24 x 1 3/4" — Alternator support bracket to engine plate	1
	GM-124094	Bolt, hex. hd., 5/16"-24 x 2 1/2" — Alternator support bracket to engine plate	2
	GM-120214	Lockwasher, 5/16" — Alternator support bracket to engine plate	3
	GM-120368	Nut, hex. hd., 5/16"-24 — Alternator support bracket to engine plate	3
	933101	Strap, adjusting, alternator	1
	GM-423561	Screw and lockwasher, 5/16"-18 x 7/8" — Strap to alternator	1
	GM-120393	Washer, plain, 5/16" — Strap to alternator	1
	933669	Nut	1
	933694	Nut, hex. hd., No. 10-24	7
	933693	Nut, hex. hd., No. 10-24	2
	933688	Nut, square	4
	933664	Pulley	1
	933676	Retainer, front bearing	1
	933677	Retainer, rear bearing	1
	933668	Rotor, assembly (For 35 Amp. 933037 alternator)	1
	933679	Rotor, assembly (For 40 Amp. 933139 alternator)	1
	933674	Screw, No. 8- x 1/2"	2
	933689	Sleeve, insulating (For 35 Amp. 933037 alternator)	2
	933690	Sleeve, insulating (For 40 Amp. 933139 alternator)	2
	933667	Spacer	1
	933680	Stator, assembly (For 35 Amp. 933037 alternator)	1
	933681	Stator, assembly (For 40 Amp. 933139 alternator)	1
	933692	Washer, insulating (For 40 Amp. 933139 alternator)	1
	933691	Washer, insulating, 13/64" x 3/4"	5
		GROUP 15-02—STARTING MOTOR	
	932095	Motor, starting assembly	1
	GM-122267	Bolt, hex. hd., 7/16"-14 x 1 1/4" — Starting motor to rear engine plate and bell housing	2
	GM-136857	Lockwasher, 7/16" — Starting motor to rear engine plate and bell housing	2
	931985	Cable, solenoid to starting motor, assembly	1
	916462	Switch, solenoid, starter assembly (12 volt)	1
	GM-191985	Screw, and lockwasher, assembly, 1/4"-20 x 1/2" (Solenoid to dash and toe riser reinforcement)	2
	GM-120368	Nut, hex. hd., 5/16"-24 — Starter solenoid switch terminal	2
	GM-138538	Lockwasher, 5/16" — Starter solenoid switch terminal	2
	GM-120614	Nut, hex. hd., No. 10-32 — Starter solenoid to switch, relay terminal	1
	GM-138479	Lockwasher, No. 10 — Starter solenoid to switch, relay terminal	1
		Serviceable Components of 932095—Starting Motor	
	931669	Armature (12 volt) assembly	1
	119833	Bearing, intermediate, assembly	1
	931672	Bushing, pinion housing	1
	931670	Drive, bendix	1
	931665	Frame and field, assembly	1
	925669	Head, commutator, assembly	1
	931671	Housing, pinion, assembly	1
	931667	Package, field coil and brush set	1
	925677	Pin, armature shaft, drive end	1
	925675	Plate, brush, assembly	1
	925665	Set, brushes	1
	109455	Washer, thrust, 1/32"	*
	177337	Washer, thrust, 3/64"	*
		(*) As required.	

Fig. and Ref. No.	Part No.	Description	No. Req'd.
		GROUP 15-03—DISTRIBUTOR	
	931852	Distributor, assembly	
	GM-120214	Lockwasher, 5/16"	1
	GM-120368	Nut, hex. hd., 5/16"-24 } Distributor to chain cover	1
	GM-120393	Washer, plain, 5/16"	1
	929096	Clip, vacuum tube to fuel line	1
	GM-137420	Elbow, inverted flared tube, 90°	2
		(1 Vacuum tube connector)	2
		(1 Vacuum tube to elbow in cylinder head)	
	926051	Gear, drive, oil pump and distributor (Also Group 10-03)	1
	931545	Tube, vacuum, assembly (Distributor to carburetor)	1
		Serviceable Components of 931852 Distributor	
	931673	Arm, advance	1
	931674	Cap, distributor, assembly	1
	931666	Condenser, package	1
	931678	Extension, shaft, flexible	1
	931680	Pin, coupling, drive shaft	1
	931679	Rotor	1
	119842	Seal "O" ring	1
	923391	Set, contact, breaker	1
	931675	Vacuum, chamber	1
		GROUP 15-04—VOLTAGE REGULATOR	
	933038	Regulator, voltage, assembly (12 volt)	1
	GM-454787	Screw and lockwasher, No. 10-32 x 1/2" (Voltage regulator to splash apron)	3
		GROUP 15-05—COIL AND ATTACHING PARTS	
	929992	Ballast, ignition coil (12 volt)	1
	699614	Screw, No. 14-10 x 1/2"	1
	929993	Coil and bracket, ignition, assembly (12 volt)	1
	GM-120741	Bolt, hex. hd., 5/16"-24 x 3/4" } Coil	2
	GM-271187	Nut and lockwasher, 5/16"-24 } mounting	2
	GM-120217	Lockwasher, No. 10 (Coil wire to stud)	2
	GM-120614	Nut, hex. hd., No. 10-32 (Coil wire to stud)	2
		GROUP 15-06—SPARK PLUG AND WIRES	
	929800	Bracket, cable, fuel pump	1
	929799	Bracket, cable, rocker cover	3
	930224	Kit, ignition, spark plug cables	1
		Consists of:	
	926174	1 Cable, secondary, ignition coil, assembly	
	926168	1 Cable, spark plug, No. 1 assembly	
	926169	1 Cable, spark plug, No. 2 assembly	
	926170	1 Cable, spark plug, No. 3 assembly	
	926171	1 Cable, spark plug, No. 4 assembly	
	926172	1 Cable, spark plug, No. 5 assembly	
	926173	1 Cable, spark plug, No. 6 assembly	
	929735	Plug with gasket, spark, assembly	6

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