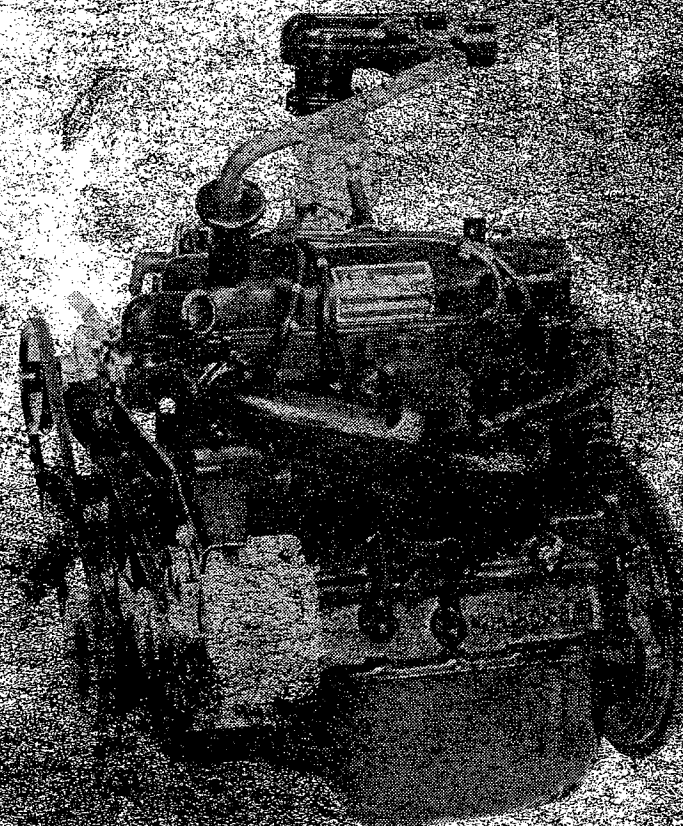




2274E

67 CID — 1100 C.C.
98 CID — 1600 C.C.
ENGINE SERVICE MANUAL



Introduction

This Shop Manual provides the Service Technician with information for the proper servicing of the Ford 67 and 98 CID Industrial Engines.

In general, this manual covers the servicing of the engine and associated standard equipment. In many cases, engines are supplied with accessories and equipment that are unique to the application. If service information is ever required on such unique accessories or equipment, it is suggested that the Industrial Engine Operations of Ford Motor Company be contacted. The proper information will either be forwarded or the Service Technician will be advised where it can be obtained.

The information in this manual is grouped in sections according to the type of work being performed. The various sections are indicated in the Index. In addition, each section is subdivided to include topics such as diagnosis and testing, cleaning and inspection, overhaul, removal and installation procedures, disassembly and assembly procedures, and service specifications.

Industrial Engine Operations
Ford Parts and Service Division
P.O. Box 3080
Livonia, Michigan 48151

The descriptions and specifications contained in this manual were in effect at the time the book was released for printing. Ford Motor Company reserves the right to discontinue models at any time, or change specifications or design, without notice and without incurring obligation.

67 AND 98 CID GASOLINE ENGINES

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PART 1 Basic Engine

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IDENTIFICATION

An Identification Decal (Fig. 1) is affixed to the left side of the rocker cover of the engine. The decal contains the engine serial number which identifies this unit from all others. Next is the engine displacement which determines the engine specifications, then the model number and S.O. or special options which determines the parts or components required on this unit. Use all the numbers when seeking information or ordering replacement parts for this engine.

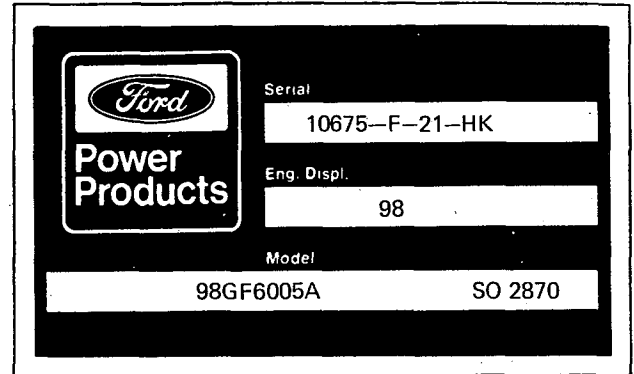


FIG. 1 Identification Decal

DESCRIPTION

The 67 and 98 CID engines (Fig. 2) are a four cylinder, in-line, overhead valve unit operating on the four stroke cycle with cross-flow cylinder head and bowl-in-piston combustion chambers.

The cylinder bores are machined directly in the cast iron cylinder block, which is cast integral with the upper half of the crankcase, and are provided with full length water jacketing.

The cast iron crankshaft runs in five large diameter main bearings fitted with steel-backed copper/lead or lead/bronze bearing liners.

End-play and thrust are controlled by half-thrust washers located in the cylinder block on either side of the center main bearing.

Seals pressed in the front cover and the rear oil seal carrier prevent oil leaks from the front and rear of the crankshaft. The front seal runs on the pulley hub while the rear seal runs on the crankshaft flange itself.

The connecting rods are H section forgings having separate rod caps attached by two bolts and located by hollow dowel pins. Connecting rod bearing liners are steel-backed copper/lead or aluminum/tin. The piston pin ends have steel-backed bronze bushings.

Solid skirt aluminum alloy pistons with two compression and one oil control ring situated above the piston pin bore are used. The combustion chamber is machined in the piston crown. The piston pins are fully floating and are retained in position by eyelet type snap rings installed in grooves at each end of the piston pin bore.

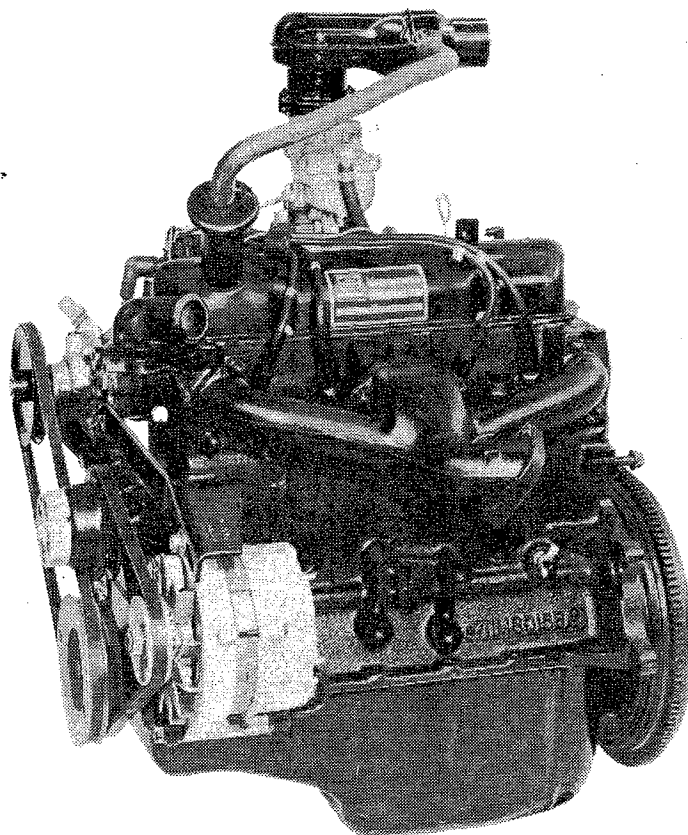
The camshaft is driven at half engine speed by a single row chain and sprockets from the crankshaft. This timing chain is automatically tensioned by a snail cam, bearing against a pivoted tensioner arm. A gear and an eccentric, machined integral with the camshaft, drive the distributor, oil pump and the fuel pump. A thrust plate is bolted to the cylinder block front face and located between the front bearing journal and the sprocket flange that retains the camshaft.

Overhead valves are mounted perpendicular to the cast iron cylinder head in integral valve guides and are operated by rocker arms, push rods and tappets from the camshaft. The rocker arms are mounted on a shaft supported by four mounting posts bolted to the cylinder head. Valve clearances are adjusted by means of self-locking screws provided in the rocker arms.

A cast iron flywheel is mounted on the crankshaft flange. The drive for the starter motor is provided by a steel ring gear shrunk onto the flywheel.

The oil pan is a steel stamping and has a sump for the lubricating oil. The engine lubrication system is the force feed type incorporating a full flow oil filter. The oil pump, which is mounted externally on the engine, is an eccentric bi-rotor type. The pump incorporates a non-adjustable plunger type relief valve.

An oil filler cap is located in the rocker cover. Crankcase ventilation is controlled by a positive-type closed system.



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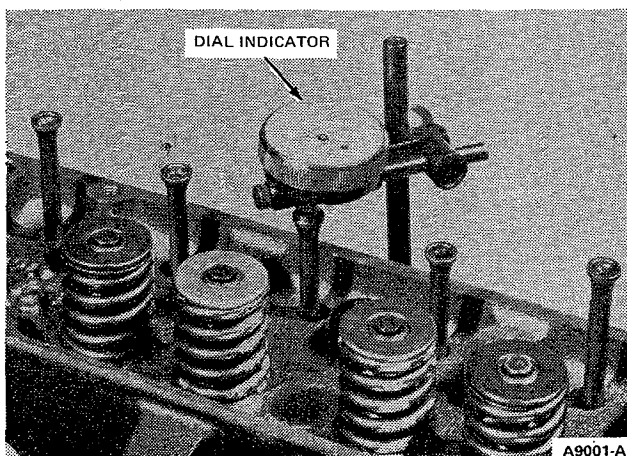
FIG. 2 98 CID (1600cc) Engine

DIAGNOSIS AND TESTING

CAMSHAFT LOBE LIFT

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

1. Remove the air cleaner and the valve rocker arm cover.
2. Remove the valve rocker arm shaft assembly as detailed in the pertinent section.
3. Make sure the push rod is in the valve lifter socket. Install a dial indicator in such a manner as to have the ball socket adapter of the indicator on the end of the push rod and in the same plane as the push rod movement (Figure 3).



A9001-A

FIG. 3 Testing Camshaft Lobe Lift

4. Connect an auxiliary starter switch in the starting circuit. Crank the engine with the ignition switch OFF. Bump the crankshaft over until the tappet or lifter is on the base circle of the camshaft lobe. At this point, the push rod will be in its lowest position.
5. Zero the dial indicator. Continue to rotate the crankshaft slowly until the push rod is in the fully raised position (highest indicator reading).
6. Compare the total lift recorded on the indicator with specifications.
7. To check the accuracy of the original indicator reading, continue to rotate the crankshaft until the indicator reads zero. **If the lift on any lobe is below specified wear limits, the camshaft and the valve lifters operating on the worn lobe(s) must be replaced.**
8. Remove the dial indicator and auxiliary starter switch.
9. Install the rocker arm shaft assembly as detailed under Removal and Installation.
10. Install the valve rocker arm cover and the air cleaner.

COMPRESSION TEST

COMPRESSION GAUGE CHECK

1. Be sure the crankcase is at the proper level and the battery is properly charged. Operate the engine for a minimum of 30 minutes at 1200 rpm or until the engine is at normal operating temperature. Turn the ignition switch off; then remove all the spark plugs.
2. Set the carburetor throttle plates and choke plate in the wide open position.
3. Install a compression gauge in No. 1 cylinder.

- Install an auxiliary starter switch in the starting circuit. Using the auxiliary starter switch, crank the engine (with the ignition switch off) at least five compression strokes and record the highest reading.
Note the approximate number of compression strokes required to obtain the highest reading.
- Repeat the test on each cylinder as was required to obtain the highest reading on the No. 1 cylinder.

TEST CONCLUSION

The indicated compression pressures are considered normal if the lowest reading cylinder is within 75% of the highest. Refer to the following example and (Figure 4).

Seventy-five percent of 140, the highest cylinder reading, is 105. Therefore, cylinder No. 7 being less than 75% of cylinder No. 3 indicates an improperly seated valve or worn or broken piston rings.

If one, or more, cylinders read low, squirt approximately one (1) tablespoon of engine oil on top of the pistons in the low reading cylinders. Repeat compression pressure check on these cylinders.

- If compression improves considerably, the piston rings are at fault.
- If compression does not improve, valves are sticking or seating poorly.
- If two adjacent cylinders indicate low compression pressures and squirting oil on the pistons does not increase the compression, the cause may be a cylinder head gasket leak between the cylinders. Engine oil and/or coolant in the cylinders could result from this problem.

It is recommended the following quick reference chart be used when checking cylinder compression pressures. The chart has been calculated so that the lowest reading number is 75% of the highest reading.

EXAMPLE

After checking the compression pressures in all cylinders, it was found that the highest reading obtained was 196 psi. The lowest pressure reading was 155 psi. The engine is within specifications and the compression is considered satisfactory.

POSITIVE CLOSED-TYPE VENTILATION SYSTEM

A malfunctioning closed crankcase ventilation system may be indicated by loping or rough engine idle. Do not attempt to compensate for this idle condition by disconnecting the crankcase ventilation system and making carburetor adjustments. **The removal of the crankcase ventilation system from the engine will adversely affect the fuel economy and engine ventilation with resultant shortening of engine life.** To determine whether the loping or rough idle condition is caused by a malfunctioning crankcase ventilation system, perform either of the following tests.

AIR INTAKE TEST

This test is performed with the crankcase ventilation tester C8AZ-6B627-A (Figure 5) which is operated by the engine vacuum through the oil fill opening. Follow the procedures described below to install the tester and check the crankcase ventilation system for faulty operation.

- With the engine at normal operating temperature, remove the oil filler cap.
- Hold the tester C8AZ-6B627-A over the opening in the valve cover. Make sure that the surface is flat to form a seal between the cover and tester. If the cover is distorted, shape it as required to make an air tight seal. An air leak between the cover and tester will render the tester inoperative.
- Start the engine and allow it to operate at the recommended idle speed.
- Hold the tester over the oil filler cap opening making sure that there is a positive seal between the tester and cover.
- If the ball settles in the **Good** (green) area, the system is functioning properly. If the ball settles in the **Repair** (red) area, clean or replace the malfunctioning components as required.
- Repeat the test after repairs are made to make sure that the crankcase ventilation system is operating satisfactorily.

Clean or replace the malfunctioning components as required. Repeat the test to ensure that the crankcase ventilation system is operating satisfactorily.

Maximum PSI	Minimum PSI	Maximum PSI	Minimum PSI	Maximum PSI	Minimum PSI
134	101	174	131	214	160
136	102	176	132	216	162
138	104	178	133	218	163
140	105	180	135	220	165
142	107	182	136	222	166
144	108	184	138	224	168
146	110	186	140	226	169
148	111	188	141	228	171
150	113	190	142	230	172
152	114	192	144	232	174
154	115	194	145	234	175
156	117	196	147	236	177
158	118	198	148	238	178
160	120	200	150	240	180
162	121	202	151	242	181
164	123	204	153	244	183
166	124	206	154	246	184
168	126	208	156	248	186
170	127	210	157	250	187
172	129	212	158		

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FIG. 4 Quick Reference Compression Pressure-Limit Chart

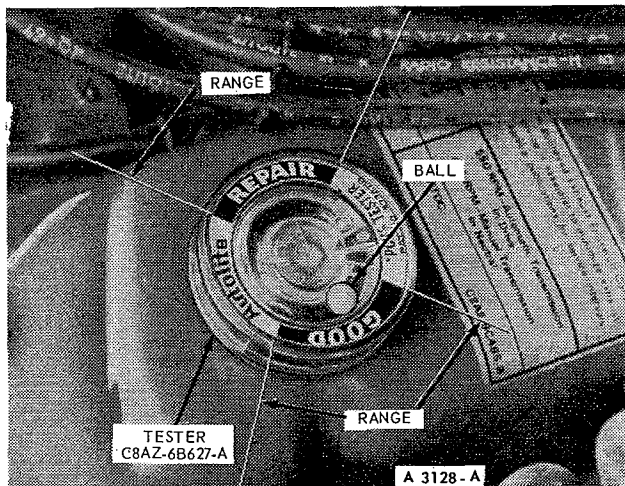


FIG. 5 Crankcase Ventilation System Tester

CRANKCASE VENTILATION REGULATOR VALVE TEST

Install a known good regulator valve (PCV) in the crankcase ventilation system.

Start the engine and compare the engine idle condition to the prior idle condition.

If the idle condition is found to be satisfactory, use the new regulator valve and clean the hoses, fittings, etc.

If the loping or rough idle condition remains when the good regulator valve is installed, the crankcase ventilation system for restriction at the intake manifold or carburetor spacer. If the system is not restricted, further engine component diagnosis will have to be conducted to find the malfunction.

CRANKSHAFT END PLAY

1. Force the crankshaft toward the rear of the engine.
2. Install a dial indicator so that the contact point rests against the crankshaft flange and the indicator axis is parallel to the crankshaft axis (Figure 6).
3. Zero the dial indicator. Push the crankshaft forward and note the reading on the dial.

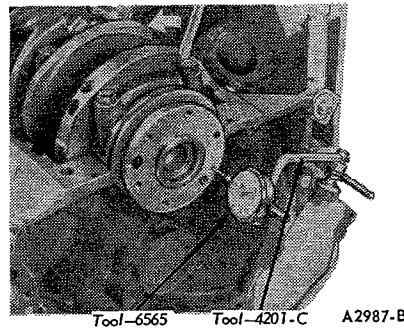


FIG. 6 Checking Crankshaft End Play

4. If the end play exceeds the wear limit, replace the thrust washers. If the end play is less than the minimum limit inspect the thrust bearing faces for scratches, burrs, nicks, or dirt.

FLYWHEEL FACE RUNOUT

Install a dial indicator so that the indicator point bears against the flywheel face. Turn the flywheel making sure that it is full forward or rearward so that crankshaft end play will not be indicated as flywheel runout.

If the clutch face runout exceeds specifications, remove the flywheel and check for burrs between the flywheel and the face of the crankshaft mounting flange. If no burrs exist, check the runout of the crankshaft mounting flange. Replace the flywheel or machine the crankshaft-flywheel mounting face sufficiently to true up the surface if the mounting flange runout exceeds specifications. Replace it or reinstall it on the flywheel.

CAMSHAFT END PLAY

Push the camshaft toward the rear of the engine. Install a dial indicator so that the indicator point is on the camshaft sprocket attaching screw or gear hub. Zero the dial indicator. Position a large screwdriver between the camshaft sprocket and the cylinder head. Pull the camshaft forward and release it. Compare the dial indicator reading with specifications. If the end play is excessive, replace the thrust plate retaining the camshaft. Remove the dial indicator.

OVERHAUL

CYLINDER HEAD

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

REAMING VALVE GUIDES

If it becomes necessary to ream a valve guide (Figure 7) to install a valve with an oversize stem, a reaming kit is available which contains the following reamer and pilot combinations: a 0.003-inch OS reamer with a standard diameter pilot, a 0.015-inch OS reamer with a 0.003-inch OS pilot, and a 0.030-inch reamer with a 0.015-inch OS pilot.

When going from a standard size valve to an oversize valve always use the reamer in sequence. **Always reface the valve seat after the valve guide has been reamed, and use a suitable scraper to break the sharp corner (ID) at the top of the valve guide.**

REFACING VALVE SEATS

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

Grind the valve seats of all engines to a true 45 degree angle (Figure 8). Remove only enough stock to clean up pits and grooves or to correct the valve seat runout. After the seat has been refaced, use a seat width scale or a machinist scale to measure the seat width (Figure 9). Narrow the seat, if necessary, to bring it within specifications.

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

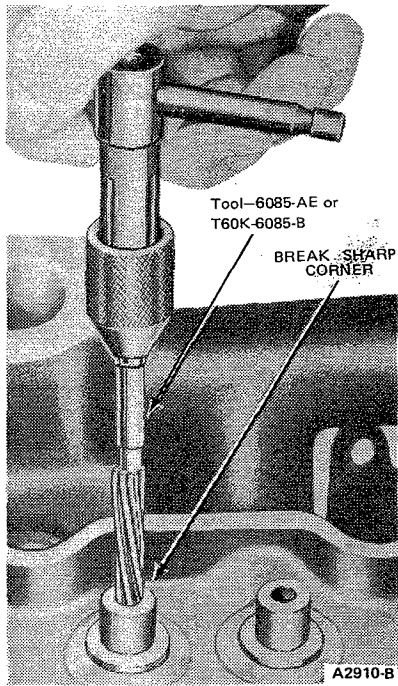


FIG. 7 Reaming Valve Guides

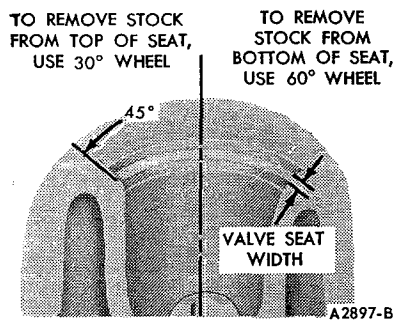


FIG. 8 Refacing Valve Seat

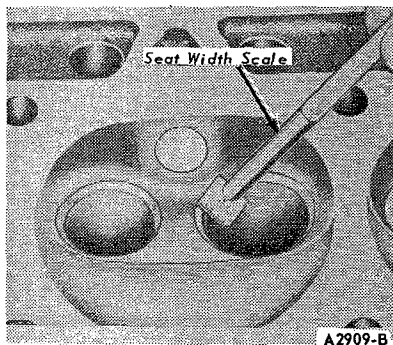


FIG. 9 Checking Valve Seat Width

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

The finished valve seat should contact the approximate center of the valve face. It is good practice to determine where the valve seat contacts the face. To do this, coat the seat with Prussian blue and set the valve in place. Rotate the

valve with light pressure. If the blue is transferred to the center of the valve face, the contact is satisfactory. If the blue is transferred to the top edge of the valve face, lower the valve seat. If the blue is transferred to the bottom edge of the valve face, raise the valve seat.

VALVES

Minor pits, grooves, etc., may be removed. Discard valves that are severely damaged, if the face runout cannot be corrected by refinishing or stem clearance exceeds specifications. Discard any excessively worn or damaged valve train parts.

REFACING VALVES

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

Under no circumstances should the faces of aluminized intake valves be ground or the valves lapped in as this will remove the diffused aluminum coating and reduce the valves wear and heat resistant properties. If the valve faces are worn or pitted it will be necessary to install new valves and to resurface the valve seats or, alternatively, lap the seats using dummy valves. The exhaust valves may be lapped in or the faces ground if required.

If the valve face runout is excessive and/or to remove pits and grooves, reface the valves to a true 44 degree angle. Remove only enough stock to correct the runout or to clean up the pits and grooves. If the edge of the valve head is less than 1/32 inch thick after grinding (Figure 10), replace the valve as the valve will run too hot in the engine. **The interference fit of the valve and seat should not be lapped out. Remove all grooves or score marks from the end of the valve stem, and chamfer it as necessary. Do not remove more than 0.010 inch from the end of the valve stem.**

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

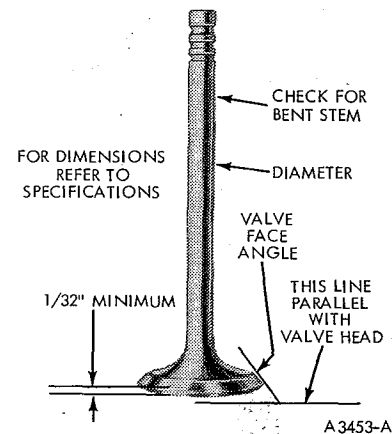


FIG. 10 Critical Valve Dimensions

SELECT FITTING VALVES

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

CAMSHAFT REPAIR

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

CRANKSHAFT

Dress minor scores with an oil stone. If the journals are severely marred or exceed the wear limit, they should be refinished to size for the next undersize bearing.

REFINISHING JOURNALS

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

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

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

FITTING MAIN OR CONNECTING ROD BEARINGS WITH PLASTIGAGE

1. Clean crankshaft journals. Inspect journals and thrust faces (thrust bearing) for nicks, burrs or bearing pickup that would cause premature bearing wear. **When replacing standard bearings with new bearings, it is good practice to fit the bearing to minimum specified clearance.** If the desired clearance cannot be obtained with a standard bearing, try a 0.002 inch undersize in combination with a standard bearing to obtain the proper clearance.
2. If fitting a main bearing in the chassis, position a jack under counterweight adjoining bearing which is being checked. Support crankshaft with jack so its weight will not compress Plastigage and provide an erroneous reading.
3. Place a piece of Plastigage on bearing surface across full width of bearing cap and about 1/4 inch off center (Figure 11).

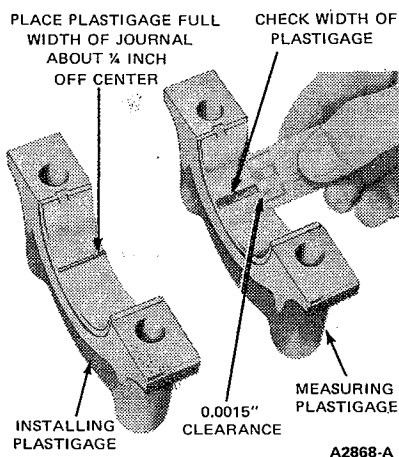


FIG. 11 Installing and Measuring Plastigage

4. Install cap and torque bolts to specifications. Do not turn crankshaft while Plastigage is in place.
5. Remove cap. Using Plastigage scale, check width of Plastigage at widest point to get minimum clearance. Check at narrowest point to get maximum clearance. Difference between readings is taper of journals.

6. If clearance exceeds specified limits, on the connecting rod bearings, try a 0.002 inch undersize bearing in combination with the standard bearings. Bearing clearance must be within specified limits. If 0.002 undersize main bearings are used on more than one journal, be sure they are all installed in cylinder block side of bearing. If standard and 0.002 inch undersize bearings do not bring clearance within desired limits, refinish crankshaft journal, then install undersize bearings.
7. After bearing has been fitted, remove Plastigage, apply light coat of engine oil to journal and bearings. Install bearing cap. Torque cap bolts to specifications.
8. Repeat procedure for remaining bearings that require replacement.

PISTONS, PINS AND RINGS

FITTING PISTONS

Pistons are available for service in standard sizes and the oversizes shown in the specifications.

The standard size pistons are color coded red or blue, or have .0025 O.S. stamped on the dome. Refer to the Specifications for standard size piston dimensions.

Measure the cylinder bore and select the piston to assure the proper clearance. When the bore diameter is in the lower one third of the specified range, a red piston should be used. When the bore diameter is in the middle one third a blue piston should be used. When the bore diameter is in the upper one third, the 0.0025 O.S. piston should be used.

Measure the piston diameter to ensure that the specified clearance is obtained. It may be necessary periodically to use another piston (red or blue) that is either slightly larger or smaller to achieve the specified clearance. **If none can be fitted, refinish the cylinder to provide the proper clearance for the piston. When a piston has been fitted, mark it for assembly in the cylinder to which it was fitted. If the taper, out-of-round and piston to cylinder bore clearance conditions of the cylinder bore are within specified limits, new piston rings will give satisfactory service. If new rings are to be installed in a used cylinder that has not been refinished, remove the cylinder wall glaze (Refer to Cylinder Block, Refinishing Cylinder Walls). Be sure to clean the cylinder bore thoroughly.**

1. Calculate the size piston to be used by taking a cylinder bore check. Follow the procedures outlined under Cleaning and Inspection.
2. Select the proper size piston to provide the desired clearance (refer to the specifications). The piston should be measured 2-1/4 inches below the dome and at 90° to the piston pin bore.
3. Make sure the piston and cylinder block are at room temperature (70 degrees F.). **After any refinishing operation allow the cylinder bore to cool, and make sure the piston and bore are clean and dry before the piston fit is checked.**

FITTING PISTON RINGS

Three piston rings are fitted, two compression and one oil control ring. The lower compression ring is stepped externally to the bottom face and the upper ring is chrome plate and tapered on the O.D. Both rings are marked **top** and must be fitted correctly. The upper ring, when new, has a reddish brown compound on the outer edge. On no account must this compound be removed. The oil control rings have narrow ring lands and may be fitted either way.

1. Select the proper ring set for the size cylinder bore.
2. Position the ring in the cylinder bore in which it is going to be used.
3. Push the ring down into the bore area where normal ring wear is not encountered.

4. Use the head of a piston to position the ring in the bore so that the ring is square with the cylinder wall. Use caution to avoid damage to the ring or cylinder bore.
5. Measure the gap between the ends of the ring with a feeler gauge (Figure 12). If the ring gap is less or greater than the specified limits, try another ring set.
6. Check the ring side clearance of the compression rings with a feeler gauge inserted between the ring and its lower land (Figure 13). The gauge should slide freely around the entire ring circumference without binding. Any wear that occurs will form a step at the inner portion of the lower land. If the lower lands have high steps, the piston should be replaced.

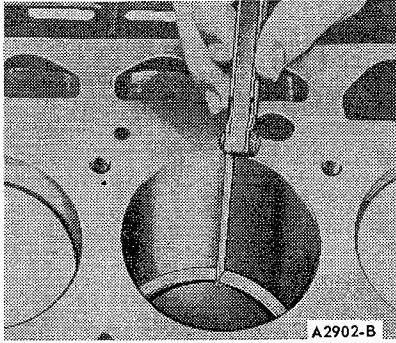


FIG. 12 Checking Piston Ring Gap

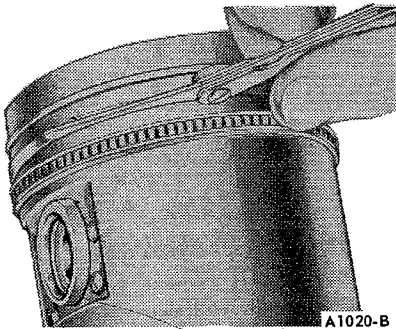


FIG. 13 Checking Piston Ring Side Clearance

FITTING PISTON PINS

The piston pins are selected to give the correct fit in the piston pin bore and bushing in the connecting rod. Pistons are only supplied in service complete with the piston pin, to ensure the correct fit. The piston pins should not be interchanged.

VALVE ROCKER ARM AND/OR SHAFT ASSEMBLY

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

If the pad at the valve end of the rocker arm has a grooved radius, replace the rocker arm. Do not attempt to true this surface by grinding.

PUSH RODS

Following the procedures under Push Rod Inspection, check the push rods for straightness.

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

CYLINDER BLOCK

REFINISHING CYLINDER WALLS

Honing is recommended for refinishing cylinder walls only when the walls have minor scuffs or scratches, or for fitting pistons to the specified clearance. The grade of hone to be used is determined by the amount of metal to be removed. Follow the instructions of the hone manufacturer. If coarse stones are used to start the honing operation, leave enough material so that all hone marks can be removed with the finishing hone which is used to obtain the proper piston clearance. Cylinder walls that are severely marred and/or worn beyond the specified limits should be refinished. Before any cylinder is refinished, all main bearing caps must be in place and tightened to the proper torque so that the crankshaft bearing bores will not become distorted from the refinishing operation. Refinish only the cylinder or cylinders that require it. All pistons are the same weight, both standard and oversize; therefore, various sizes of pistons can be used without upsetting engine balance. Refinish the cylinder with the most wear first to determine the maximum oversize. If the cylinder will not clean up when refinished for the maximum oversize piston recommended, replace the block. Refinish the cylinder to within approximately 0.0015 inch of the required oversize diameter. This will allow enough stock for the final step of honing so that the correct surface finish and pattern are obtained. For the proper use of the refinishing equipment follow the instructions of the manufacturer. Only experienced personnel should be allowed to perform this work. Use a motor-driven, spring pressure-type hone at a speed of 300-500 rpm. Hones of grit sizes 180-220 will normally provide the desired bore surface finish of 15/32 RMS. When honing the cylinder bores use a lubricant mixture of equal parts of kerosene and SAE No. 20 motor oil. Operate the hone in such a way to produce a cross-hatch finish on the cylinder bore. The cross-hatch pattern should be at an angle of approximately 30 degrees to the cylinder bore. After the final operation in either of the two refinishing methods described and prior to checking the piston fit, thoroughly clean and oil the cylinder walls. Mark the pistons to correspond to the cylinders in which they are to be installed. When the refinishing of all cylinders that require it has been completed and all pistons are fitted, thoroughly clean the entire block and oil the cylinder walls.

REPAIRING SAND HOLES OR POROUS ENGINE CASTINGS

Porosity or sand hole(s) which will cause oil seepage or leakage can occur with modern casting processes. A complete inspection of engine and transmission should be made. If the leak is attributed to the porous condition of the cylinder block or sand hole(s), repairs can be made with metallic plastic (part No. C6AZ-19554-A). Do not repair cracks with this material. Repairs with this metallic plastic must be confined to those cast iron engine component surfaces where the inner wall surface is not exposed to engine coolant pressure or oil pressure, for example:

1. Cylinder block surfaces extending along the length of the block, upward from the oil pan rail to the cylinder water jacket but not including machined areas.
2. Lower rear face of the cylinder block.
3. Intake manifold casting.
4. Cylinder head, along the rocker arm cover gasket surface.

The following procedure should be used to repair porous areas or sand holes in cast iron.

- a. Clean the surface to be repaired by grinding or rotary filing to a clean bright metal surface. Chamfer or undercut the hole or porosity to a greater depth than the rest of the cleaned surface. Solid metal must sur-

round the hole. Openings larger than 1/4 inch should not be repaired using metallic plastic. Openings in excess of 1/4 inch can be drilled, tapped and plugged using common tools. Clean the repair area thoroughly. Metallic plastic will not stick to a dirty or oily surface.

- b. Mix the metallic plastic base and hardener as directed on the container. Stir thoroughly until uniform.
- c. Apply the repair mixture with a suitable clean tool, (putty knife, wood spoon, etc.) forcing the epoxy into

the hole or porosity.

- d. Allow the repair mixture to harden. This can be accomplished by two methods, heat cure with a 250 degree watt lamp placed 10 inches from the repaired surface, or air dry for 10-12 hours at temperatures above 50 degrees F.
- e. Sand or grind the repaired area to blend with the general contour of the surrounding surface.
- f. Paint the surface to match the rest of the block.

CLEANING AND INSPECTION

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

INTAKE MANIFOLD

Cleaning

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

Inspection

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

EXHAUST MANIFOLDS

Cleaning

Remove all gasket material from the manifolds.

Inspection

Inspect the cylinder head joining flanges of the exhaust manifold for evidence of exhaust gas leaks.

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

VALVE ROCKER ARM AND/OR SHAFT ASSEMBLY

Cleaning

Clean all the parts thoroughly. Make sure all oil passages are open.

Make sure the oil passage in the push rod end of the rocker arm is open.

Inspection

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

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

Check the adjusting nut(s) torque. If not within specifications, replace the nut(s). Check the rocker arm pad and

fulcrum seat for excessive wear, cracks, nicks or burrs.

PUSH RODS

Cleaning

Clean the push rods in a suitable solvent. Blow out the oil passage in the push rod with compressed air.

Inspection

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

The push rods can be visually checked for straightness while they are installed in the engine by rotating them with the valve closed. They also can be checked with a dial indicator (Figure 14).

If the push rod is visibly bent, it should be replaced.

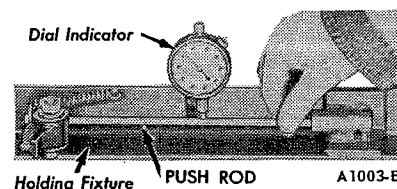


FIG. 14 Checking Push Rod Runout

CYLINDER HEADS

Cleaning

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

Inspection

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

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

When a cylinder head is removed because of gasket leaks, check the flatness of the cylinder head gasket surface (Figure 15) for conformance to specifications. If necessary to refinish the cylinder head gasket surface, **do not plane or grind off more than 0.010 inch.**

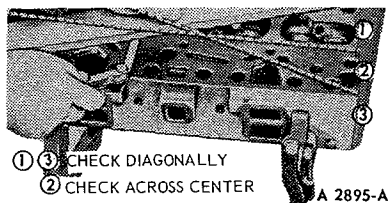


FIG. 15 Typical Cylinder Head Flatness

Check the valve seat runout with an accurate gauge (Figure 16). Follow the instructions of the gauge manufacturer. If the runout exceeds the wear limit, reface the valve and valve seat. Measure the valve seat width (Figure 9). Reface any valve seat whose width is **not within specifications**.

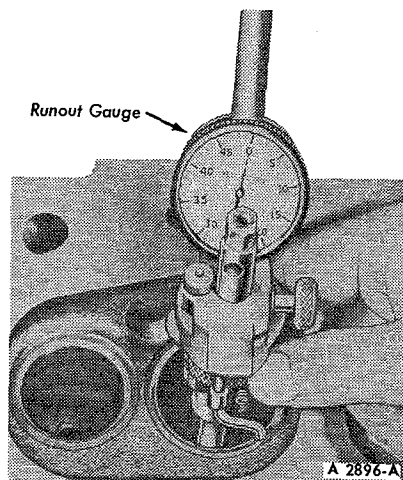
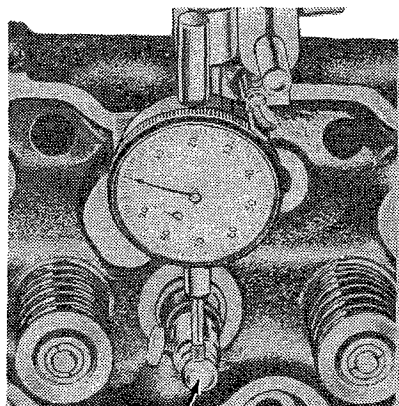


FIG. 16 Checking Valve Seat Runout

Inspect the valve face and the edge of the valve head for pits, grooves, scores or other damage. Inspect the stem for a bent condition and the end of the valve head for pits, grooves, scores or other wear. Inspect the stem for a bent condition and the end of the stem for grooves or scores. Check the valve head for signs of burning, erosion, warpage and cracking. Minor pits, grooves, etc., may be removed. Discard valves that are severely damaged.

Inspect the valve spring, valve spring retainers, locks



TOOL 6505-E 302, 351M AND 400 CID
TOOL 6505-F 460 CID
TOOL 6505-G 200 AND 250 CID

A 3131-D

FIG. 17 Checking Valve Stem Clearance

and sleeves for wear or damage. Discard any visually damaged parts.

Check the valve stem to valve guide clearance of each valve in its respective valve guide with the tool shown in Figure 17 or its equivalent. Use a flat end indicator point.

Install the tool on the valve stem until it is fully seated, and tighten the knurled set screw firmly. Permit the valve to drop away from its seat until the tool contacts the upper surface of the valve guide.

Position the dial indicator with its flat tip against the center portion of the tool's spherical section at approximately 90 degrees to the valve stem axis. Move the tool back and forth in line with the indicator stem. Take a reading on the dial indicator without removing the tool from the valve guide upper surface. Divide the reading by two, the division factor for the tool.

Check the springs for proper pressure (Figure 18) at the specified spring lengths. (Tool 6513-DD.) **Manually rotating the valve spring assemblies while installed in the engine, must not be used to determine good and/or bad valve springs.** Weak valve springs cause poor engine performance. Replace any spring not within specifications.

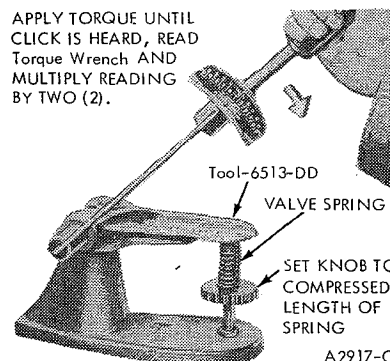


FIG. 18 Checking Valve Spring Pressure

Check each spring for squareness, using a steel square and a flat surface (Figure 19). Stand the spring and square on end on the flat surface. Slide the spring up to the square. Revolve the spring slowly and observe the space between the top coil of the spring and the square. The out-of-square limits are 5/64 inch.

Follow the same procedure to check new valve springs before installation. **Make certain the proper spring (color coded) is installed.**

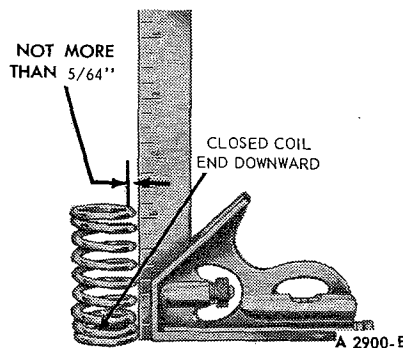


FIG. 19 Checking Valve Spring Squareness

TAPPETS Cleaning

Thoroughly clean the tappets in cleaning solvent and wipe them with a clean lint-free cloth.

Inspection

Check the tappets for wear or scores. Check the bottom end of tappet to make sure that it has a slight convex. Replace tappets that are scored, worn, or if the bottom is not smooth. If the bottom surface is worn flat, it may be used with the original camshaft only.

TIMING CHAIN AND SPROCKETS

Cleaning

Clean all parts in solvent and dry them with compressed air.

Lubricate the timing chain with engine oil before installing it on the sprockets.

Inspection

Inspect the chain for broken links. Inspect the sprockets for cracks and worn or damaged teeth. Replace all the components of the timing chain and sprocket assembly, if any one item needs replacement.

CAMSHAFT

Cleaning and Inspection

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

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

Check the distributor drive gear for broken or chipped teeth. Replace the camshaft if this condition exists.

CRANKSHAFT

Cleaning

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

Inspection

Inspect the main and connecting rod journals for cracks, scratches, grooves or scores. Inspect the crankshaft oil seal surface for nicks, sharp edges or burrs that might damage the oil seal during installation or cause premature seal wear.

Measure the diameter of each journal in at least four places to determine an out-of-round, taper or undersize condition (Figure 20).

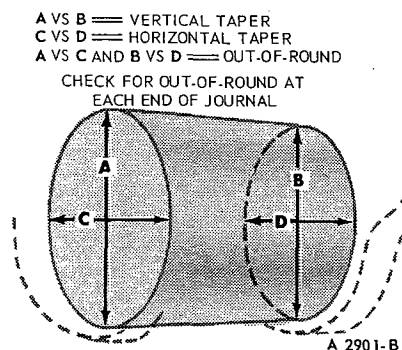


FIG. 20 Crankshaft Journal Measurement

On engines used with a manual shift transmission, check the fit of the clutch pilot bushing in the bore of the crankshaft. The bushing is pressed into the crankshaft and should not be loose. Inspect the inner surface of the bushing for wear or a bell-mouth condition. Check the ID of the bushing (Figure 21). Replace the bushing if it is worn or damaged or the ID is not within specifications.

Inspect the pilot bearing (ball bearing) when so equipped, for roughness, evidence of overheating or loss of lubricant. Replace it if any of these conditions are found.

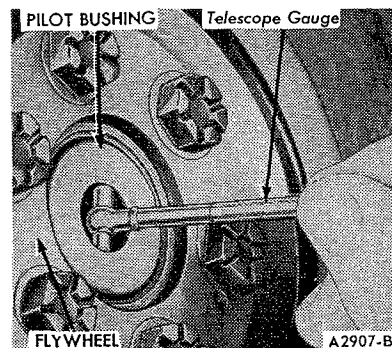


FIG. 21 Checking Clutch Pilot Bushing Wear

FLYWHEEL

Inspection

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

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

With the flywheel installed on the crankshaft, check the flywheel face runout, following the procedure under Diagnosis and Testing.

CONNECTING RODS

Cleaning

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

Inspection

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

A shiny surface on either pin boss side of the piston usually indicates that a connecting rod is bent.

Abnormal connecting rod bearing wear can be caused by either a bent connecting rod, worn or damaged crankpin, or a tapered connecting rod bore.

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

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

rod piston pin bore. If the pin bore in the connecting rod is larger than specifications, install a 0.002 inch oversize piston pin. First, prefit the oversize piston pin to the piston pin bore by reaming or honing the piston. Then, assemble the piston, piston pin and connecting rod following the procedures for assembly. **It is not necessary to ream or hone the pin bore in the connecting rod. Replace damaged connecting rod nuts and bolts. Check the connecting rods for bend or twist on a suitable alignment fixture. Follow the instructions of the fixture manufacturer. If the bend and/or twist exceeds specifications, the connecting rod must be straightened or replaced.**

PISTONS, PINS AND RINGS

Cleaning

Remove deposits from the piston surfaces. Clean gum or varnish from the piston skirt, piston pins and rings with solvent. **Do not use a caustic cleaning solution or a wire brush to clean pistons.**

Clean the ring grooves with a ring groove cleaner (Figure 22). Make sure the oil ring slots (or holes) are clean.

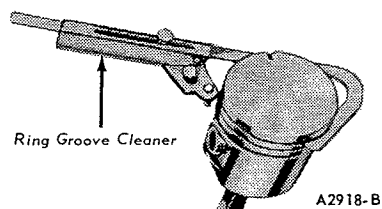


FIG. 22 Cleaning Piston Ring Grooves

Inspection

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

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

Check the piston to cylinder bore clearance by measuring the piston and bore diameters. Refer to the specifications for the proper clearance. Refer to Cylinder Block Inspection for the bore measurement procedure. **Measure the OD of the piston with micrometers approximately 2-1/4 inches below the dome and at 90 degrees to the piston pin bore.** Check the ring side clearance following the procedure under Fitting Piston Rings in this section.

Replace piston pins showing signs of fracture, etching or wear. Check the piston pin fit in the piston and rod. Refer to Piston and Connecting Rod Assembly.

Check the OD of the piston pin and the ID of the pin bore in the piston. Replace any piston pin or piston that is not within specifications.

Replace all rings that are scored, broken, chipped or cracked. Check the end gap and side clearance. **Rings should not be transferred from one piston to another regardless of mileage or hours.**

MAIN AND CONNECTING ROD BEARINGS

Cleaning

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

Inspection

Inspect each bearing carefully. Bearings that have a scored, chipped, or worn surface should be replaced. Typical examples of unsatisfactory bearings and their causes are shown in Figure 23. The copper lead bearing base may be visible through the bearing overlay. This does not mean that the bearing is worn. It is not necessary to replace the bearing if the bearing clearance is within recommended limits. Check the clearance of bearings that appear to be satisfactory with Plastigage as detailed under Main and Connecting Rod Bearings.

CYLINDER BLOCK

Cleaning

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

If the engine is disassembled, thoroughly clean the block with solvent. Remove old gasket material from all machined surfaces. Remove all pipe plugs that seal oil passages; then clean out all the passages. Blow out all passages, bolt holes, etc., with compressed air. Make sure the threads in the cylinder head bolt holes are clean. Dirt in the threads may cause binding and result in a false torque reading. Use a tap to true up threads and to remove any deposits. Thoroughly clean the grooves in the crankshaft bearings and bearing retainers.

Inspection

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

Check all machined gasket surfaces for burrs, nicks, scratches and scores. Remove minor imperfections with an oil stone.

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

Inspect the cylinder walls for scoring, roughness, or other signs of wear. Check the cylinder bore for out-of-round and taper. Measure the bore with an accurate bore gauge following the instructions of the manufacturer. Measure the diameter of each cylinder bore at the top, middle and bottom with the gauge placed at right angles and parallel to the centerline of the engine (Figure 24). **Use only the measurements obtained at 90 degrees to the engine centerline when calculating the piston to cylinder bore clearance.**

Refinish cylinders that are deeply scored and/or when out-of-round and/or taper exceed the wear limits. If the cylinder walls have minor surface imperfections, but the out-of-round and taper are within limits, it may be possible to remove the imperfections by honing the cylinder walls and installing new service piston rings providing the piston clearance is within specified limits.

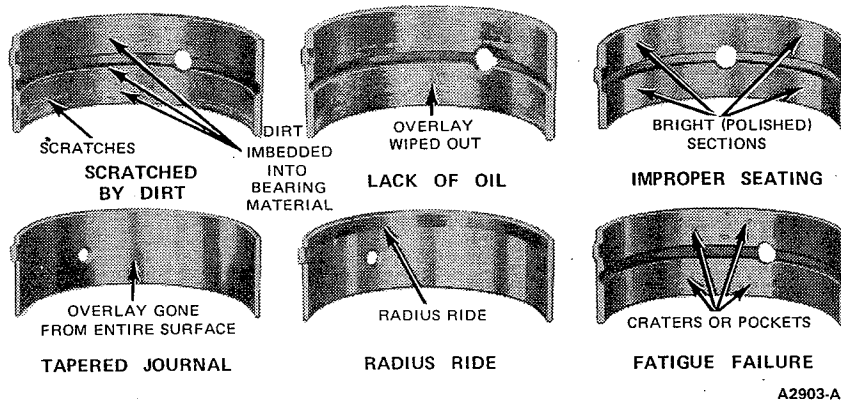


FIG. 23 Typical Bearing Failures

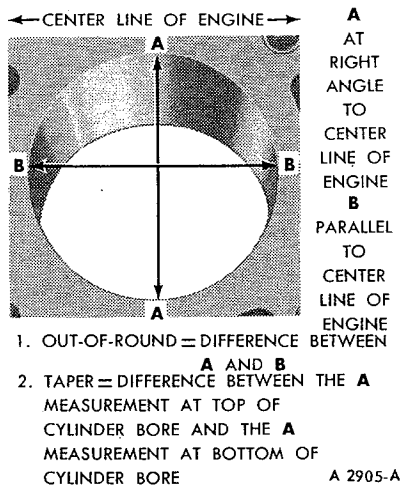


FIG. 24 Cylinder Bore Out-of-Round and Taper

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

Measure the outer race to housing clearance (Figure 25). Then check the clearance between the outer race and the rotor lobes (Figure 26).

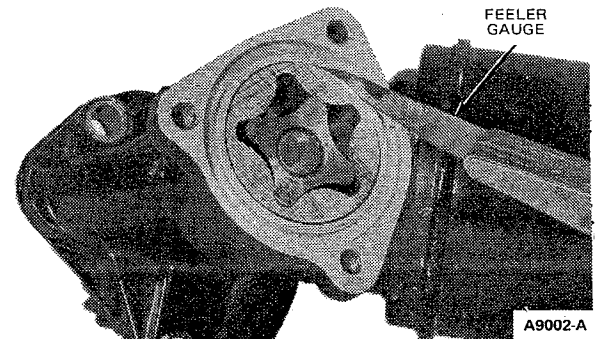


FIG. 25 Checking Outer Race to Housing Clearance

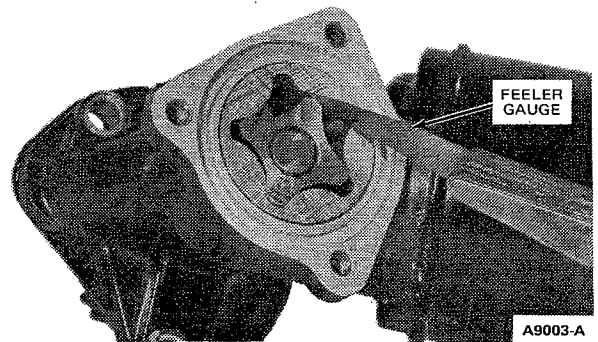


FIG. 26 Checking Rotor Lobes to Outer Race Clearance

OIL PAN

Cleaning

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

Inspection

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

Inspect for damage (uneven surface) at the bolt holes caused by over-torquing the bolts. Straighten surfaces as required. Repair any damage, or replace the pan if repairs cannot be made satisfactorily.

OIL PUMP

Cleaning

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

Inspection

Refer to the specifications for clearances and wear limits.

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

With the rotor assembly installed in the housing, place a straight edge over the rotor assembly and the housing. Measure the clearance (rotor end play) between the straight edge and the rotor and outer race (Figure 27). **The outer race, shaft and rotor are replaceable only as an assembly.** Check the drive shaft to housing bearing clearance by measuring the OD of the shaft and the ID of the housing bearing. Inspect the relief valve spring for a collapsed or worn condition. Check the relief valve spring tension. If the spring tension is not within specifications and/or the spring is worn or damaged, replace the spring. Check the relief valve piston for scores and free operation in the bore.

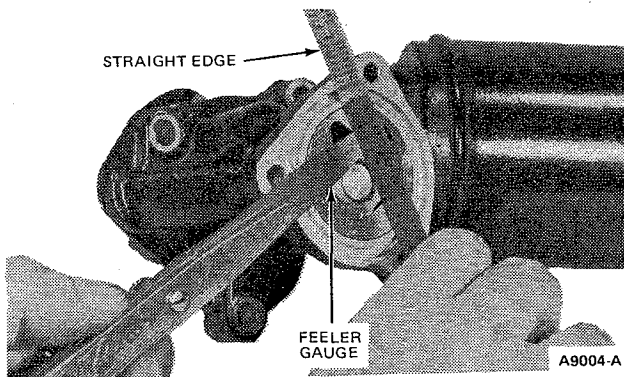


FIG. 27 Checking Rotor End Play

REMOVAL AND INSTALLATION

VALVE ROCKER ARM COVER, ROCKER ARM AND/OR SHAFT

Removal

1. Remove the air cleaner or air horn from the carburetor.
2. Disconnect the spark plug leads, remove them from the clip on the rocker cover and position aside.
3. Remove the rocker cover attaching screws, remove the rocker cover and discard the gasket.
4. Remove the rocker arm shaft attaching bolts evenly and lift off the rocker arm shaft assembly (Figure 28).

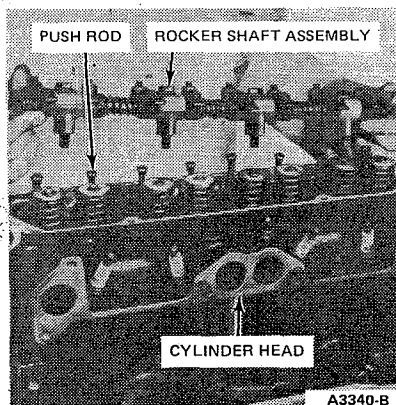


FIG. 28 Removing or Installing Rocker Arm Assembly

5. Remove the cotter pin from one end of the shaft and slip the flat washer, crimped washer and second flat washer off the shaft. The rocker arm shaft supports, rocker arms and springs can now be removed from the shaft.
6. Remove the plugs from the rocker shaft ends by drilling a hole in one plug. Insert a long rod through the drilled plug and knock the opposite plug out of the shaft. Remove the drilled plug in the same manner.
7. Clean the component parts of the shaft assembly in any suitable degreasing fluid.

Installation

1. Refit new plugs to the rocker shaft ends.
2. Assemble the rocker arm shaft. **The bolt hole in the rocker arm shaft support must be on the same side as the adjusting screw in the rocker arm. The rocker arms are right and left handed, the rocker pads being inclined towards the support.** Install the cotter pins with the heads upwards and bend over the legs to secure.
3. Lubricate the valve stem tips, rocker arm pads and the

POSITIVE CLOSED-TYPE CRANKCASE VENTILATION SYSTEM

Cleaning

Do not attempt to clean the crankcase ventilation regulator valve; it should be replaced at the specified maintenance interval. The oil filler cap and oil separator should be cleaned at the proper mileage interval. Remove the cap and the oil separator and wash them in a low volatility, petroleum base solvent. Shake the cap dry and install them. Clean the crankcase ventilation system connection(s) on the intake manifold by probing with a flexible wire or bottle brush. Clean the hoses, fittings, tubes and associated hardware with a low volatility, petroleum base solvent and dry with compressed air.

- push rod ends with Lubriplate or equivalent. Position the rocker shaft assembly on the cylinder head (Figure 28) engaging the push rods with the adjusting screws. Install and tighten the bolts evenly to specifications.
4. Adjust the valve clearance to specifications.
5. Ensure that the mating surfaces on the cylinder head and rocker cover are free from all traces of the old gasket material.
6. Position the rocker cover and gasket on the cylinder head and secure with the attaching screws. Torque the screws to specifications.
7. Locate the spark plug leads in the rocker cover clip and re-connect them to their respective plugs.
8. Install the air cleaner.

VALVE PUSH ROD

Removal

1. Remove the rocker shaft bolts evenly and lift off the rocker arm shaft assembly.
2. Remove the push rods from their locations and keep them in their correct order.

Installation

1. Lubricate both ends of the push rods with Lubriplate or equivalent and install them in their respective bores.
2. Lubricate the valve stem tips and the rocker arm pads with Lubriplate or equivalent and position the rocker arm shaft assembly on the cylinder head, engaging the push rods with the adjusting screws. Tighten the bolts evenly to specifications.
3. Adjust the valve lifters to specifications.

INTAKE MANIFOLD

Removal

1. Partially drain the cooling system.
2. Remove the air cleaner.
3. Disconnect the throttle rod from the carburetor throttle lever.
4. Disconnect the fuel line and the distributor vacuum line from the carburetor.
5. Disconnect the water outlet hose and the crankcase ventilation hose from the intake manifold.
6. Disconnect external resistor wires. Remove mounting bolt and remove resistor.
7. Remove coil mounting bolt and position coil out of the way.
8. Remove the attaching nut and bolts and remove the intake manifold.

9. Remove the gasket.
10. If a new manifold is to be installed, transfer all necessary components to the new manifold.

Installation

1. Apply a water resistant sealer to both sides of the gasket around the water port and position it on the cylinder head.
2. Install the intake manifold and tighten the nuts and bolts evenly to specifications.
3. Connect the water hose and the crankcase ventilation hose to the intake manifold.
4. Connect the distributor vacuum line and the fuel supply line to the carburetor.
5. Connect the throttle rod.
6. Position coil to intake manifold and install mounting bolt.
7. Position external resistor, dipstick tube and fuel filter bracket to intake manifold and install retaining bolt.
8. Install the air cleaner.
9. Refill the cooling system with the recommended coolant.

EXHAUST MANIFOLD

Removal

1. Remove the two nuts attaching the manifold to the muffler pipe flange and separate the joint.
2. Remove the bolts and nuts attaching the exhaust manifold to the cylinder head and discard the gaskets.
3. Clean all mating surfaces of gasket material.

Installation

1. Position the center gasket on the studs, ensuring that it is the correct way up and locate the manifold on the studs.
2. Position the other gaskets between the manifold flanges and cylinder head, fit the nuts and bolts and tighten evenly to specifications.
3. Position the two manifold and muffler pipe flanges together and secure with two nuts.
4. Start engine and check for leaks.

CYLINDER HEAD

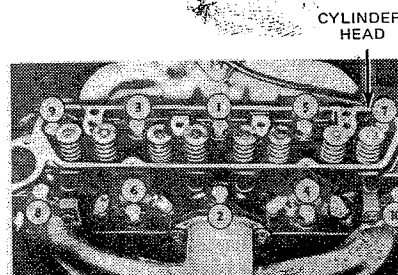
Removal

1. Remove the air cleaner or air horn from the carburetor.
2. Disconnect the fuel line at the fuel pump and carburetor.
3. Drain the coolant.
4. Disconnect the spark plug leads, remove them from the clip on the rocker cover and position out of the way.
5. Disconnect the water outlet and crankcase ventilation hoses at the intake manifold.
6. Disconnect the wire from the temperature gauge sending unit (if so equipped).
7. Detach the exhaust pipe and move clear of the cylinder head.
8. Disconnect the throttle rod, choke cable and the distributor vacuum advance hose from the carburetor.
9. Disconnect the throttle linkage at the governor and position out of the way.
10. Remove the governor mounting bolts to cylinder head and remove governor.
11. Remove alternator adjusting bracket mounting bolt to cylinder head.
12. Disconnect resistor wires. Remove mounting bolt and remove resistor.
13. Remove coil mounting bolt and position coil out of the way.
14. Remove the thermostat housing, pull to one side and remove the thermostat.
15. Remove the rocker arm cover and gasket.

16. Remove the rocker arm shaft bolts evenly and lift off the rocker arm shaft assembly.
17. Lift out the push rods from their locations and keep them in their correct order.
18. Remove the cylinder head bolts and lift off the cylinder head and gasket. **Do not lay the cylinder head flat on its face as damage to the spark plugs or gasket surface can occur.**

Installation

1. Clean all gasket material from the mating surfaces and position the cylinder head gasket on the cylinder block using pilot studs.
2. Position the cylinder head, remove pilot studs and install the cylinder head bolts. Tighten the bolts down evenly in sequence (Figure 29) and in three steps to specifications.



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FIG. 29 Cylinder Head Bolt Tightening Sequence

3. Lubricate both ends of the push rods with Lubriplate or equivalent and install them in their respective bores.
4. Install the rocker arm shaft assembly to the cylinder head, locating the push rods on the adjusting screws. Tighten the bolts evenly to specifications.
5. Adjust the valve clearances.
6. Connect the exhaust pipe.
7. Connect the distributor vacuum advance line, the throttle rod, and choke cable to the carburetor.
8. Connect the wire to the temperature gauge sender unit.
9. Connect the water outlet and crankcase ventilation hoses to the intake manifold.
10. Locate the thermostat in its bore in the cylinder head and install the gasket and thermostat housing.
11. Refill the cooling system.
12. Position governor and mounting bracket to cylinder head and install bolts.
13. Loosen governor adjusting bolts and position drive belt to governor. Adjust belt to specification and tighten bolts.
14. Connect the throttle linkage to the governor.
15. Install the alternator bracket mounting bolt to cylinder head.
16. Position coil to intake manifold and install mounting bolt.
17. Position external resistor, dipstick tube and fuel filter bracket to intake manifold and install retaining bolt.
18. Connect the ignition wires to the spark plugs in the correct firing order.
19. Readjust the valve clearances to specification.
20. Install the rocker arm cover.
21. Install the air cleaner to the carburetor.
22. Adjust the carburetor idle speed and mixture settings.

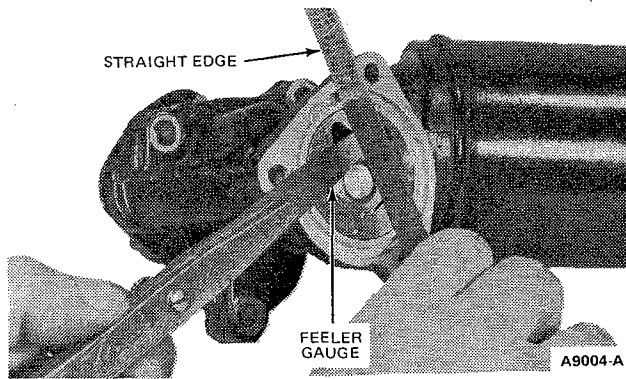


FIG. 27 Checking Rotor End Play

REMOVAL AND INSTALLATION

VALVE ROCKER ARM COVER, ROCKER ARM AND/OR SHAFT

Removal

1. Remove the air cleaner or air horn from the carburetor.
2. Disconnect the spark plug leads, remove them from the clip on the rocker cover and position aside.
3. Remove the rocker cover attaching screws, remove the rocker cover and discard the gasket.
4. Remove the rocker arm shaft attaching bolts evenly and lift off the rocker arm shaft assembly (Figure 28).

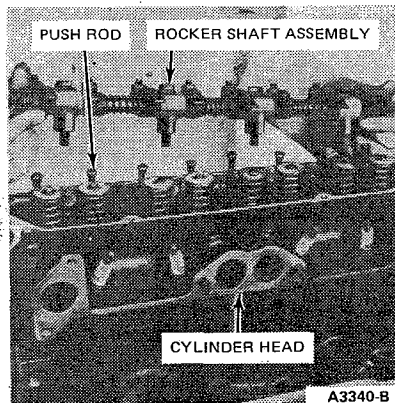


FIG. 28 Removing or Installing Rocker Arm Assembly

5. Remove the cotter pin from one end of the shaft and slip the flat washer, crimped washer and second flat washer off the shaft. The rocker arm shaft supports, rocker arms and springs can now be removed from the shaft.
6. Remove the plugs from the rocker shaft ends by drilling a hole in one plug. Insert a long rod through the drilled plug and knock the opposite plug out of the shaft. Remove the drilled plug in the same manner.
7. Clean the component parts of the shaft assembly in any suitable degreasing fluid.

Installation

1. Refit new plugs to the rocker shaft ends.
2. Assemble the rocker arm shaft. **The bolt hole in the rocker arm shaft support must be on the same side as the adjusting screw in the rocker arm. The rocker arms are right and left handed, the rocker pads being inclined towards the support.** Install the cotter pins with the heads upwards and bend over the legs to secure.
3. Lubricate the valve stem tips, rocker arm pads and the

POSITIVE CLOSED-TYPE CRANKCASE VENTILATION SYSTEM

Cleaning

Do not attempt to clean the crankcase ventilation regulator valve; it should be replaced at the specified maintenance interval. The oil filler cap and oil separator should be cleaned at the proper mileage interval. Remove the cap and the oil separator and wash them in a low volatility, petroleum base solvent. Shake the cap dry and install them. Clean the crankcase ventilation system connection(s) on the intake manifold by probing with a flexible wire or bottle brush. Clean the hoses, fittings, tubes and associated hardware with a low volatility, petroleum base solvent and dry with compressed air.

- push rod ends with Lubriplate or equivalent. Position the rocker shaft assembly on the cylinder head (Figure 28) engaging the push rods with the adjusting screws. Install and tighten the bolts evenly to specifications.
4. Adjust the valve clearance to specifications.
5. Ensure that the mating surfaces on the cylinder head and rocker cover are free from all traces of the old gasket material.
6. Position the rocker cover and gasket on the cylinder head and secure with the attaching screws. Torque the screws to specifications.
7. Locate the spark plug leads in the rocker cover clip and re-connect them to their respective plugs.
8. Install the air cleaner.

VALVE PUSH ROD

Removal

1. Remove the rocker shaft bolts evenly and lift off the rocker arm shaft assembly.
2. Remove the push rods from their locations and keep them in their correct order.

Installation

1. Lubricate both ends of the push rods with Lubriplate or equivalent and install them in their respective bores.
2. Lubricate the valve stem tips and the rocker arm pads with Lubriplate or equivalent and position the rocker arm shaft assembly on the cylinder head, engaging the push rods with the adjusting screws. Tighten the bolts evenly to specifications.
3. Adjust the valve lifters to specifications.

INTAKE MANIFOLD

Removal

1. Partially drain the cooling system.
2. Remove the air cleaner.
3. Disconnect the throttle rod from the carburetor throttle lever.
4. Disconnect the fuel line and the distributor vacuum line from the carburetor.
5. Disconnect the water outlet hose and the crankcase ventilation hose from the intake manifold.
6. Disconnect external resistor wires. Remove mounting bolt and remove resistor.
7. Remove coil mounting bolt and position coil out of the way.
8. Remove the attaching nut and bolts and remove the intake manifold.

9. Remove the gasket.
10. If a new manifold is to be installed, transfer all necessary components to the new manifold.

Installation

1. Apply a water resistant sealer to both sides of the gasket around the water port and position it on the cylinder head.
2. Install the intake manifold and tighten the nuts and bolts evenly to specifications.
3. Connect the water hose and the crankcase ventilation hose to the intake manifold.
4. Connect the distributor vacuum line and the fuel supply line to the carburetor.
5. Connect the throttle rod.
6. Position coil to intake manifold and install mounting bolt.
7. Position external resistor, dipstick tube and fuel filter bracket to intake manifold and install retaining bolt.
8. Install the air cleaner.
9. Refill the cooling system with the recommended coolant.

EXHAUST MANIFOLD

Removal

1. Remove the two nuts attaching the manifold to the muffler pipe flange and separate the joint.
2. Remove the bolts and nuts attaching the exhaust manifold to the cylinder head and discard the gaskets.
3. Clean all mating surfaces of gasket material.

Installation

1. Position the center gasket on the studs, ensuring that it is the correct way up and locate the manifold on the studs.
2. Position the other gaskets between the manifold flanges and cylinder head, fit the nuts and bolts and tighten evenly to specifications.
3. Position the two manifold and muffler pipe flanges together and secure with two nuts.
4. Start engine and check for leaks.

CYLINDER HEAD

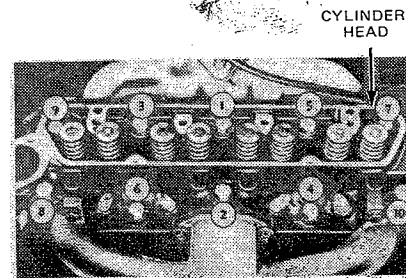
Removal

1. Remove the air cleaner or air horn from the carburetor.
2. Disconnect the fuel line at the fuel pump and carburetor.
3. Drain the coolant.
4. Disconnect the spark plug leads, remove them from the clip on the rocker cover and position out of the way.
5. Disconnect the water outlet and crankcase ventilation hoses at the intake manifold.
6. Disconnect the wire from the temperature gauge sending unit (if so equipped).
7. Detach the exhaust pipe and move clear of the cylinder head.
8. Disconnect the throttle rod, choke cable and the distributor vacuum advance hose from the carburetor.
9. Disconnect the throttle linkage at the governor and position out of the way.
10. Remove the governor mounting bolts to cylinder head and remove governor.
11. Remove alternator adjusting bracket mounting bolt to cylinder head.
12. Disconnect resistor wires. Remove mounting bolt and remove resistor.
13. Remove coil mounting bolt and position coil out of the way.
14. Remove the thermostat housing, pull to one side and remove the thermostat.
15. Remove the rocker arm cover and gasket.

16. Remove the rocker arm shaft bolts evenly and lift off the rocker arm shaft assembly.
17. Lift out the push rods from their locations and keep them in their correct order.
18. Remove the cylinder head bolts and lift off the cylinder head and gasket. **Do not lay the cylinder head flat on its face as damage to the spark plugs or gasket surface can occur.**

Installation

1. Clean all gasket material from the mating surfaces and position the cylinder head gasket on the cylinder block using pilot studs.
2. Position the cylinder head, remove pilot studs and install the cylinder head bolts. Tighten the bolts down evenly in sequence (Figure 29) and in three steps to specifications.



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FIG. 29 Cylinder Head Bolt Tightening Sequence

3. Lubricate both ends of the push rods with Lubriplate or equivalent and install them in their respective bores.
4. Install the rocker arm shaft assembly to the cylinder head, locating the push rods on the adjusting screws. Tighten the bolts evenly to specifications.
5. Adjust the valve clearances.
6. Connect the exhaust pipe.
7. Connect the distributor vacuum advance line, the throttle rod, and choke cable to the carburetor.
8. Connect the wire to the temperature gauge sender unit.
9. Connect the water outlet and crankcase ventilation hoses to the intake manifold.
10. Locate the thermostat in its bore in the cylinder head and install the gasket and thermostat housing.
11. Refill the cooling system.
12. Position governor and mounting bracket to cylinder head and install bolts.
13. Loosen governor adjusting bolts and position drive belt to governor. Adjust belt to specification and tighten bolts.
14. Connect the throttle linkage to the governor.
15. Install the alternator bracket mounting bolt to cylinder head.
16. Position coil to intake manifold and install mounting bolt.
17. Position external resistor, dipstick tube and fuel filter bracket to intake manifold and install retaining bolt.
18. Connect the ignition wires to the spark plugs in the correct firing order.
19. Readjust the valve clearances to specification.
20. Install the rocker arm cover.
21. Install the air cleaner to the carburetor.
22. Adjust the carburetor idle speed and mixture settings.

VALVE SPRING, RETAINER AND STEM SEAL CYLINDER HEAD REMOVED

Removal

1. Remove the exhaust manifold and the spark plugs.
2. Compress the valve spring with a valve spring compressor. Remove the valve spring retainer locks, release the spring and remove the spring and retainer.
3. Remove the seal and withdraw the valve.

Installation

1. Install the valve and a new valve stem seal to the stem.
2. Position the valve spring and retainer over the valve stem.
3. Compress the valve spring. Locate the retainer locks in the valve stem grooves and slowly release the spring compressor to engage the collets in the retainer tappets.

CYLINDER HEAD INSTALLED

Removal

1. Remove the air cleaner or air horn from the carburetor.
2. Disconnect the spark plug leads, remove them from the clip on the rocker cover and position out of the way.
3. Remove the rocker arm cover and gasket.
4. Remove the rocker arm shaft bolts evenly and lift off the rocker arm shaft assembly.
5. Lift the pushrods from their locations and keep them in their correct order.
6. Remove the spark plugs.
7. Suitably support the appropriate valve (Figure 30) with air pressure.
8. Compress the valve spring, using Tool No. T70P-6049-A. Remove the valve spring retainer locks. Release the spring compressor, remove the valve spring, retainer and the valve stem oil seal.

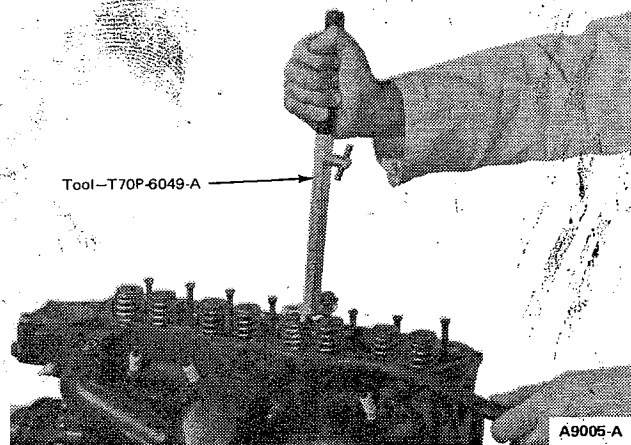


FIG. 30 Compressing Valve Spring — In-Chassis

Installation

1. Install a new valve stem seal over the valve stem.
2. Position the valve spring and retainer over the valve stem.
3. Compress the valve spring using Tool No. T70P-6049-A. Position the valve spring retainer locks in the valve stem grooves and slowly release the spring to engage the locks in the retainer. Remove the air hose and adaptor.
4. Lubricate both ends of the push rods with Lubriplate or equivalent and install them in their respective bores. Install the rocker arm shaft assembly to the cylinder head, locating the push rods on the adjusting screws. Tighten the bolts evenly to specifications.

5. Adjust valve clearances to specification.
6. Install the rocker arm cover.
7. Install the spark plugs and connect the ignition wires to the spark plugs in the correct firing order.
8. Start the engine and run until engine reaches normal operating temperature.
9. Disconnect the ignition wires from spark plugs and remove the rocker arm cover.
10. Readjust the valve clearances (hot) to specifications.
11. Install the rocker cover with a new gasket and torque the attaching screws to specification.
12. Locate the spark plug leads in the rocker cover clip and reconnect them to their respective plugs.
13. Install the air cleaner assembly to the carburetor.

WATER PUMP

Removal

1. Drain the cooling system.
2. Loosen the governor adjusting bolts and remove drive belt.
3. Loosen the alternator adjusting and mounting bolts. Pivot the alternator towards the engine and remove the drive belt.
4. Remove the fan and pulley attaching bolts. Remove the fan and pulley.
5. Loosen the clamps and remove the lower hose from the water pump.
6. Disconnect the manifold water hose from the water pump.
7. Remove bolts securing water pump to cylinder block and remove the pump and gasket.

Installation

1. Make sure that the mating faces of cylinder block and pump are clean.
2. If new pump is being installed, transfer water hose connection to new pump.
3. Position the pump and gasket on the cylinder block and secure with the attaching bolts.
4. Connect the manifold water hose to the water pump and tighten clamp.
5. Position lower hose on water pump and tighten the clamp.
6. Position the pulley and fan and secure with bolts. Torque the bolts to specification.
7. Position drive belt over crankshaft, fan and alternator pulley and adjust the belt tension to specifications using Tool No. T63L-8620-A. Tighten the alternator mounting and adjusting bolt to specifications.
8. Position the governor drive belt to governor and fan pulley. Adjust the belt to specification. Tighten adjusting bolts.
9. Refill radiator and install cap. Start the engine and check for leaks.

CYLINDER FRONT COVER AND TIMING CHAIN, OR CRANKSHAFT SPROCKETS

Removal

1. Drain the engine coolant by opening the drain cock on the radiator and removing the drain plug in the cylinder block.
2. Disconnect the radiator hoses at the engine.
3. Remove the radiator.
4. Remove the governor and fan belts and then remove the fan and the water pump pulley.
5. Remove the water pump.
6. Remove the crankshaft pulley, using a suitable puller.

7. Remove the oil pan to cylinder front cover attaching bolts. Use a thin knife to cut the oil pan gasket flush with cylinder block face prior to separating the cover from the cylinder block. Remove the front cover.
8. Remove the crankshaft oil slinger. Remove the camshaft sprocket retainer and bolts.
9. Remove the timing chain tensioner arm. Remove the camshaft sprocket, and disconnect the timing chain.
10. If crankshaft sprocket is to be removed, use tool No. T64P-3590-F (Figure 31).

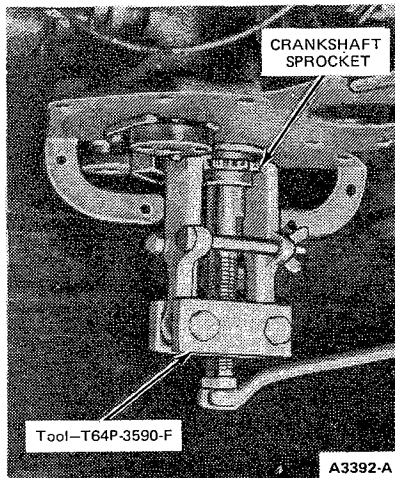


FIG. 31 Removing Crankshaft Sprocket

Installation

1. If crankshaft sprocket was removed, install using replacer tool No. T70P-6150 (Figure 32).
2. Position the timing chain over the camshaft and crankshaft sprockets so that the timing marks are aligned when the sprocket is installed (Figure 33). Tighten the bolts to specification, then bend up the locking tabs.

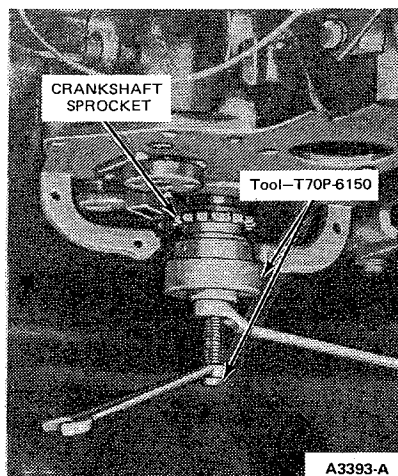


FIG. 32 Installing Crankshaft Sprocket

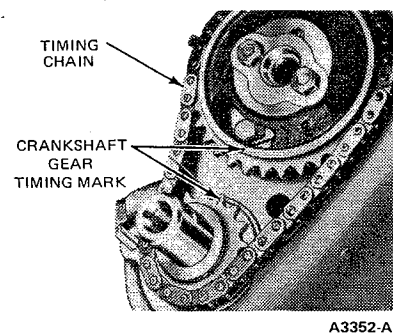


FIG. 33 Valve Timing Marks

3. Locate the tensioner arm on the pivot pin while holding the tensioner cam in the released position.
4. Install the oil slinger on the crankshaft. Install the camshaft sprocket retainer and bolts. Torque the bolts to specifications. Install the timing chain tensioner.
5. Position the gasket, portions of oil pan gasket, if necessary, and the end seal on the front cover with an oil resistant sealer at the ends. Align the cover in position with Tool No. T70P-6150 (Figure 34). Tighten the attaching bolts evenly to specification and remove the aligner tool. Tighten the oil pan bolts to specification.
6. Position the crankshaft pulley aligning the pulley slot with the crankshaft key. Tighten the attaching bolt to specifications.
7. Install the water pump and torque the attaching bolts to specification.
8. Install the water pump pulley and fan. Install the governor and fan belts and adjust the tension of the belts to specifications using Tool T63L-8620-A.
9. Install the radiator.
10. Install the radiator upper and lower hoses and tighten the clips.
11. Refill the radiator.
12. Start engine and check for oil and water leaks.

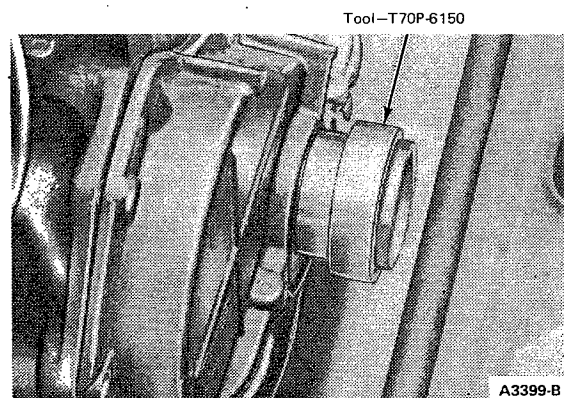


FIG. 34 Aligning Front Cover Oil Seal

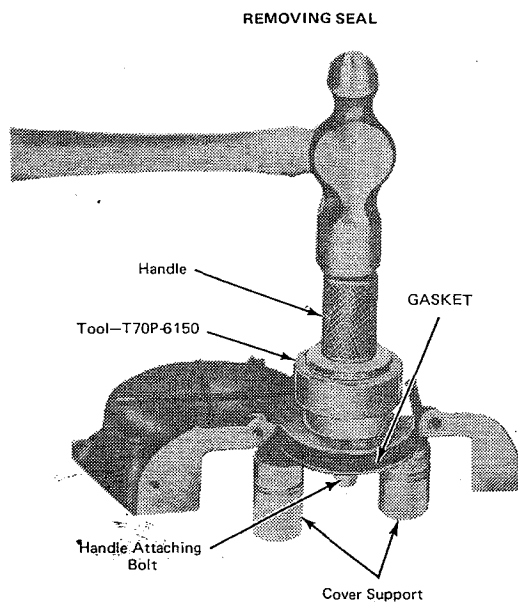
FRONT OIL SEAL

Removal

The oil seal can be removed, after first removing the front cover and driving the seal out from the rear.

Installation

1. Drive a new seal into the housing with Tool T70P-6150 (Figure 35), while supporting the cover around the seal.
2. When fitting the cover it is important that the oil seal is aligned concentrically with the crankshaft and pulley boss with Tool No. T70P-6150 (Figure 34).



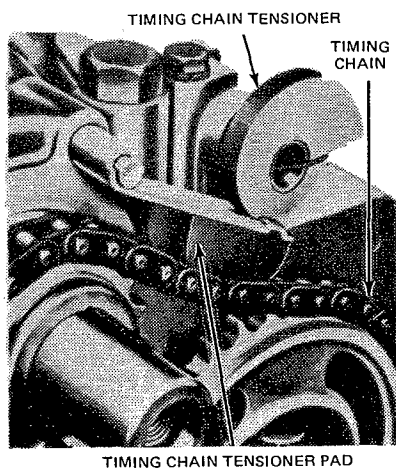
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FIG. 35 Installing Front Cover Oil Seal

TIMING CHAIN TENSIONER

Removal

1. Remove the cylinder front cover and oil pan.
2. Remove the timing chain tensioner and tensioner arm by removing the two attaching bolts (Figure 36).



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FIG. 36 Timing Chain Tensioner

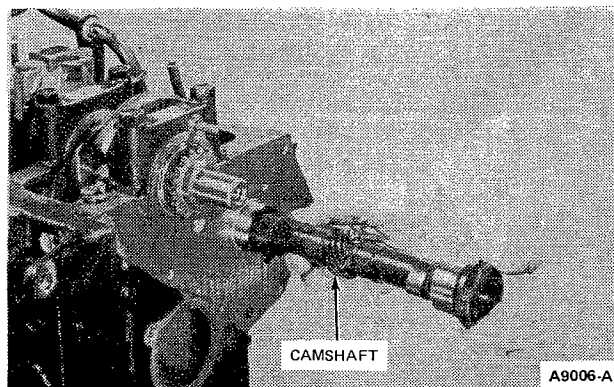
Installation

1. Locate the tensioner arm on the pivot pin.
2. Position the tensioner and replace the two bolts.
3. Replace the cylinder front cover and oil pan.

CAMSHAFT AND/OR VALVE LIFTERS

Removal

1. Remove the engine assembly and mount the engine on a stand. Drain the crankcase.
2. Disconnect the fuel line at the fuel pump.
3. Loosen the alternator and governor adjustment bolts and remove the belts.
4. Remove the fan and water pump pulley.
5. Remove the oil and fuel pumps from the cylinder block.
6. Disconnect the spark plug wires from the plugs and remove the cover. Clean all gasket material from rocker arm cover and cylinder head.
7. Remove the rocker arm cover attaching screws and rocker cover. Remove the distributor from the cylinder block.
8. Remove the rocker arm shaft support bolts evenly and lift off the rocker arm shaft.
9. Lift the push rods from their locations in the cylinder block, taking care to keep them in their correct order.
10. Invert the engine on the stand and remove the oil pan and gaskets.
11. Remove the crankshaft pulley, the front cover and oil slinger.
12. Remove the timing chain tensioner assembly.
13. Remove the camshaft sprocket and timing chain.
14. With the engine inverted, remove the camshaft thrust plate and remove the camshaft (Figure 37).



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FIG. 37 Removing Camshaft

15. If necessary, remove the tappets from their locations in the cylinder block and keep them in the correct order.

Installation

1. Install a new front cover oil seal, using Tool No. T70P-6150 (Figure 35).
2. Install the tappets, if removed.
3. Install the camshaft and fit the thrust plate in the camshaft groove. Tighten the attaching bolts to specification and bend up the locking tabs.
4. Check the camshaft end play.
5. Locate the timing chain on the camshaft sprocket and fit the camshaft sprocket with the timing mark aligned with the one on the crankshaft sprocket. Tighten the attaching bolts to specification and bend up the locking tabs.

6. Locate the tensioner arm on the pivot pin and install the timing chain tensioner.
7. Install the oil slinger on the crankshaft.
8. Position the gasket on the front cover with an oil resistant sealer at the ends, align the front cover with Tool No. T70P-6150 and tighten the bolts evenly to specification before removing the aligner.
9. Position a new gasket on the block flange using an oil resistant sealer compound at each end. Position the end seals chamfered ends into the groove, again using an oil resistant sealer at the ends and refit the oil pan. Tighten the oil pan bolts to the correct torque, **FOLLOWING FIRST THE ALPHABETICAL, THEN THE NUMERICAL SEQUENCES SHOWN IN Figure 38.**
10. Install the dipstick.
11. Install the crankshaft pulley aligning the pulley slot with the crankshaft key. Tighten the pulley attaching bolt to specification.
12. Right the engine on stand. Install and time the distributor.
13. Position a new gasket on the oil pump mounting flange and install the oil pump and filter assembly. Tighten the attaching bolts to specification.
14. Position a new gasket to the fuel pump flange and insert the rocker arm through the slot in the block wall so that the arm lies on the camshaft eccentric. Secure the fuel pump to the cylinder block with two washers and bolts, tightening the bolts evenly to specifications.
15. Lubricate push rod ends, valve stem tips and rocker pads with Lubriplate or equivalent. Install the push rods in their respective bores and install the rocker arm shaft assembly, making sure that the cupped ends of the push rods engage the adjusting screws. Tighten the rocker arm shaft attaching bolts evenly to specification.
16. Adjust the valve clearances to specification.
17. Connect the distributor vacuum advance line to the carburetor.
18. Install the water pump pulley and fan. Position the alternator and drive belts on the pulley and adjust the belt governor tension to specifications. Connect the fuel line from the carburetor to the fuel pump.
19. Install distributor cap and connect wires to spark plugs.
20. Remove engine from stand.
21. Install the engine assembly in the vehicle.
22. Start the engine and check for oil and water leaks.
23. Readjust the valve clearances (hot) to specification.
24. Install the rocker arm cover and a new gasket and secure with attaching screws and torque to specifications.
25. Install the air cleaner assembly.
26. Start engine, adjust the ignition timing, if necessary.
27. Adjust the carburetor idle speed and fuel-air mixture to specifications.

FLYWHEEL RING GEAR

The flywheel ring gear is located in a retention groove and can be removed by cutting between two adjacent teeth with a hack saw and splitting the gear with a chisel. In no circumstances should pressure be applied in an attempt to remove the ring gear for repositioning on the flywheel.

When installing the ring gear it must be heated evenly to a temperature not to exceed 600 degrees F. or the ring gear wear resistant properties will be destroyed. If the ring gear is heated by a direct flame place the ring gear on a bed of fire bricks and then play the flame in a circular motion onto the bricks about 1-1/2 inches from the inside of the gear until it reaches the required temperature. The correct temperature can be detected by using a special type of temperature sensitive crayon, or alternatively by polishing a section of

the ring gear and heating until it turns dark blue. Fit the ring gear with the chamfers on the leading faces of the gear teeth relative to the direction of rotation. Allow the ring gear to cool naturally in air. **Do not quench.**

OIL PAN

Removal

1. Drain the crankcase.
2. Remove the oil level dipstick.
3. Remove the three bolts and remove the starter motor.
4. Remove the oil pan attaching bolts and remove the pan and gasket.

Installation

1. Clean the oil pump inlet tube and screen assembly.
2. Clean the gasket surfaces of the block and oil pan. Be sure to clean the seal retainer grooves in the cylinder front cover and the rear seal retainer. The oil pan has a two-piece gasket. Coat the block surface and the oil pan gasket surface with oil-resistant sealer. Position the oil pan gaskets on the cylinder block.
3. Position the end seals with the chamfered ends into the grooves, again using an oil resistant sealer. Position the oil pan and tighten the bolts evenly to specifications following first the alphabetical, then the numerical sequences shown in Figure 38.



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FIG. 38 Oil Pan Bolts Tightening Sequence

4. Clean and install the starter motor, securing it with the three bolts.
5. Refill the oil pan with the correct grade of engine oil and install the dipstick.
6. Start the engine and check for oil leaks.

OIL PUMP

The oil pump and filter assembly is bolted to the right side of the cylinder block and can be removed with the engine in place.

Removal

1. Place a drain pan under the oil pump.
2. Remove the three bolts attaching the oil pump and filter assembly and withdraw the assembly (Figure 39).
3. Separate the oil filter from the oil pump.

Installation

1. Position the oil filter to the oil pump assembly.
2. Ensure the mating surfaces are clean of old gasket material, then install the oil pump and filter assembly on the cylinder block, using a new gasket together with an oil resistant sealer and secure with the three bolts. Tighten the bolts to specifications.
3. Check the oil level and add oil if necessary.
4. Start the engine and check for oil leaks.

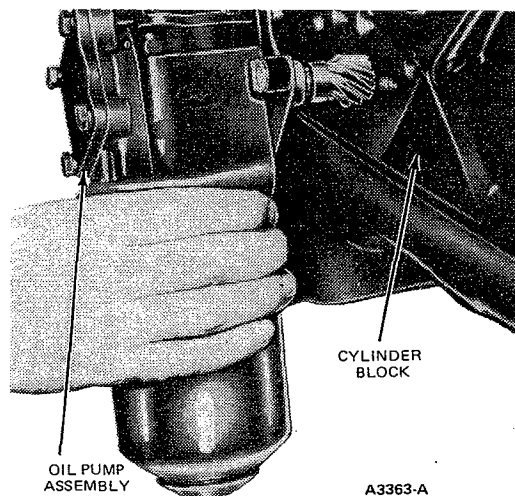


FIG. 39 Removing Oil Pump

CRANKSHAFT REAR OIL SEAL

1. Remove the pressure plate bolts evenly and remove the pressure plate and clutch disc.
2. Remove the flywheel.
3. Remove the oil pan and gaskets.
4. Remove the rear oil seal carrier and remove the seal.

Installation

1. Install a new crankshaft rear oil seal using Tool No. T70P-6165 (Figure 40).

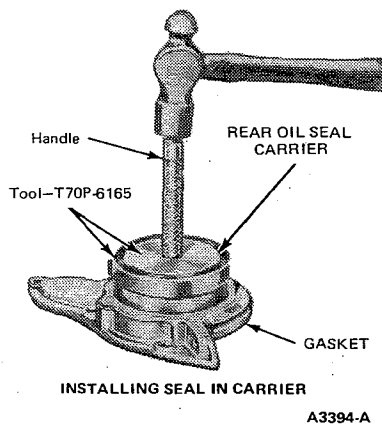


FIG. 40 Installing Crankshaft Rear Oil Seal

2. Position a new gasket on the rear oil seal carrier, using an oil resistant sealer compound at the ends, and fit the carrier to the block rear face using aligner Tool No. T70P-6165. Tighten the bolts evenly to specifications and remove the aligner.
3. Position new gaskets on the block flange using oil resistant sealer at each end. Position the end seals with the chamfered ends into the grooves, again using an oil resistant sealer and refit the oil pan. Tighten the bolts to the correct torque and in sequence.
4. Locate the flywheel squarely upon the crankshaft flange. Tighten the bolts evenly to specifications.
5. Install the clutch disc and pressure plate.

MAIN BEARINGS

Removal

1. Remove main bearing caps and thrust washers. Keep the caps in order so they can be installed in their original positions.
2. Remove upper bearing liners from the cylinder block and the lower bearing liners from the caps.
3. Check caps and journals for damage.
4. Install new upper bearing liners in the cylinder block, and new lower bearing liners in the bearing caps.
5. Make sure that the journals and bearings are free from dirt and abrasive particles.
6. Fit the bearings using Plastigage as detailed in General Engine Service.

Installation

1. Clean off the journals and liners.
2. Install the crankshaft thrust washers.
3. Oil the bearing surfaces and install the bearing caps in their original positions, tightening the bolts to specification.

CONNECTING ROD BEARINGS

Removal

1. Turn the crankshaft to allow removal of number one connecting rod cap. Partially remove the connecting rod bolts two or three turns and tap them to release the cap. Completely remove the bolts and remove the cap. Keep them in order so they can be installed in their original positions.
2. Remove the upper connecting rod bearing from the connecting rod and the lower bearing from the connecting rod cap.

Installation

1. Install the upper and lower bearing liners in their appropriate locations.
2. Measure the bearing clearances using Plastigage as detailed in General Engine Service.
3. Install the connecting rod caps on the connecting rods in their original positions and tighten the bolts to specifications.

PISTONS AND CONNECTING RODS

Removal

1. Drain the engine oil.
2. Drain the cooling system.
3. Disconnect the battery.
4. Disconnect the spark plug leads and position out of the way.
5. Disconnect the water outlet and crankcase ventilation hoses at the intake manifold.
6. Disconnect the wire from the temperature gauge sending unit (if so equipped).
7. Detach the exhaust pipe and move clear of the cylinder head.
8. Disconnect the throttle rod, choke cable and the distributor vacuum advance hose from the carburetor.
9. Disconnect the throttle linkage at the governor and position out of the way.
10. Remove the governor mounting bolts to cylinder head and remove governor.
11. Remove alternator adjusting bracket mounting bolt to cylinder head.
12. Disconnect resistor wires. Remove mounting bolt and remove resistor.
13. Remove coil mounting bolt and position coil out of the way.

14. Remove the thermostat housing, pull to one side and remove the thermostat.
15. Remove the rocker arm cover and gasket.
16. Remove the rocker arm shaft bolts evenly and lift off the rocker arm shaft assembly.
17. Lift out the push rods from their locations and keep them in their correct order.
18. Remove the cylinder head bolts and lift off the cylinder head and gasket. **Do not lay the cylinder head flat on its face as damage to the spark plugs or gasket surface can occur.**
19. Remove the starter motor and oil pan.
20. Clean the oil pan and cylinder block faces and remove the end seals.
21. Partially remove the bearing cap bolts several turns and tap them to release the cap. Completely remove the bolts and remove the bearing cap. Keep them in order so they can be installed in their original positions. Push the piston and connecting rod out of the bore and remove the assembly.

Piston Selection

Installation

1. Position the bearing liners in the connecting rods and end caps. Turn the crankshaft as necessary to fit each connecting rod to the crank, but do not fit the end cap.
2. Measure the bearing clearances using the Plastigage method as detailed in the Overhaul Section.
3. Clean all bearing surfaces of Plastigage material. If necessary, select new bearing liners to give the correct clearances.
4. Install the connecting rods on the crank and tighten the connecting rod bolts to specifications.
5. Position a new gasket on the block flange, using oil resistant sealer at each end. Install the end seals, with the chamfered ends into the grooves, again using an oil resistant sealer.
6. Install the oil pan and tighten the bolts evenly to the correct torque following first the alphabetical, then the numerical sequences shown in Figure 38.
7. Clean and install the starter motor, securing it with the two bolts.
8. Clean all gasket material from the mating surfaces and position the cylinder head gasket on the cylinder block using pilot studs.
9. Position the cylinder head, remove pilot studs and install the cylinder head bolts. Tighten the bolts down evenly in sequence (Figure 29) and in three steps to specifications.
10. Lubricate both ends of the push rods with Lubriplate or equivalent and install them in their respective bores.
11. Install the rocker arm shaft assembly to the cylinder head, locating the push rods on the adjusting screws. Tighten the bolts evenly to specifications.
12. Adjust the valve clearances.
13. Connect the exhaust pipe.
14. Connect the distributor vacuum advance line, the throttle rod, and choke cable to the carburetor.
15. Connect the wire to the temperature gauge sender unit.
16. Connect the water outlet hoses and crankcase ventilation hose to the intake manifold.
17. Locate the thermostat in its bore in the cylinder head and install the gasket and thermostat housing.
18. Refill the cooling system.
19. Connect the ignition wires to the spark plugs in the correct firing order.
20. Readjust the valve clearances to specification.
21. Install the rocker arm cover.
22. Refill the oil pan with the correct grade of oil.

23. Install the air cleaner to the carburetor.
24. Adjust the carburetor idle speed and mixture settings.

CRANKSHAFT

Removal

1. Remove the engine from the vehicle and mount it in an engine stand.
2. Remove the clutch disc and pressure plate.
3. Remove the flywheel from the crankshaft.
4. Loosen the alternator and governor belt adjusting bolts and remove the drive belts.
5. Remove the pulley from the front of the crankshaft.
6. Remove the cylinder front cover.
7. Slide the oil slinger off the shaft (Figure 41). Remove the timing chain tensioner and timing chain, then remove the crankshaft sprocket from the crankshaft with Tool No. T64P-3590-F.
8. Invert engine, remove oil pan and oil inlet tube and screen.
9. Remove the four connecting rod bearing caps and keep them in order so that they will be installed on the rods from which they were removed.
10. Remove the five main bearing caps and keep them in order so that they may be installed in their original positions.
11. Carefully lift the crankshaft from the cylinder block.

Installation

1. Place the lubricated main bearing liners in the cylinder block. Install the crankshaft and check the bearing clearance using the Plastigage method as detailed in the Overhaul Section and torque the main bearing caps on their respective journals to specification.
2. Check the crankshaft end play (Figure 6).
3. Install the correct thickness of thrust washers to establish the specified end play (Figure 41A).
4. Fit the connecting rod bearing using the Plastigage method.
5. Install the correct connecting rod caps in their original positions and torque the cap bolts to specification.
6. Install the oil inlet tube and screen.
7. Install the crankshaft sprocket and timing chain making sure that the timing marks are in alignment.
8. Install the oil slinger, timing chain tensioner and cylinder front cover. Install the crankshaft pulley (Figure 43).
9. Install the oil pan and new gaskets. Tighten the oil pan attaching bolts to specification following first the alphabetical, then the numerical sequence shown in Figure 38.

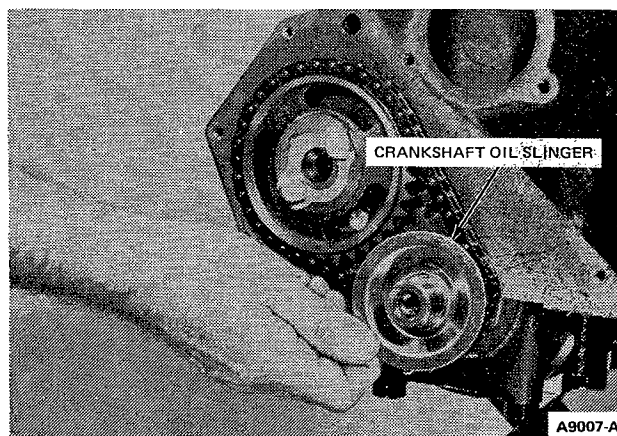


FIG. 41 Crankshaft Oil Slinger

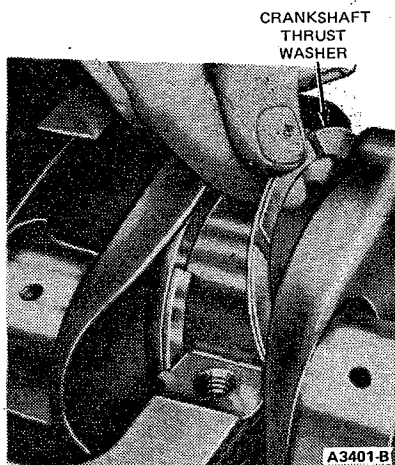


Fig. 41A Crankshaft End Play

10. Right engine and install alternator and governor drive belts. Adjust belts to specified tension. Tighten adjusting bolts.
11. Install the flywheel, clutch disc and pressure plate.
12. Remove engine from stand.
13. Install the engine in vehicle.
14. Fill the crankcase and the cooling systems to the correct level with the specified oil and coolant. Start the engine and check for oil and water leaks.

CAMSHAFT BEARINGS

The service bearings for the camshaft are pre-sized and require no machining after installation. When one bearing requires replacement it is advisable to replace all three, as camshaft alignment may be affected if only one bearing is changed.

The camshaft front and rear bearings are both approximately 3/4 inch wide, the front one having an additional oil hole for the rocker arm shaft oil feed, and the center bearing approximately 5/8 inch wide. Install the bearings using a replacer in addition to the adapters previously used. Make sure that the oil holes in the bearings and cylinder block are correctly aligned before installation and that the splits in the bearings are upwards and outwards at 45 degrees to the vertical.

Removal

Remove camshaft following the appropriate procedures in this section.

1. Remove the flywheel.
2. Remove the crankshaft rear oil seal carrier.
3. Remove the camshaft bearings.

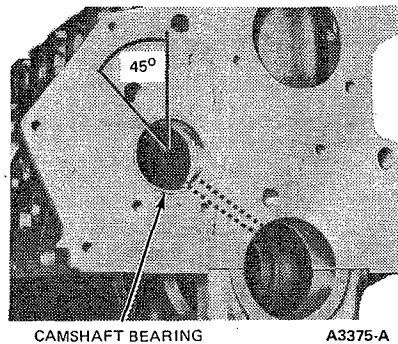


FIG. 42 Camshaft Bearing Position

4. Check all the oil passages to make sure that they are clear. Apply an oil resistant sealer to the oil gallery plugs prior to installation.

Installation

1. Install new camshaft bearings. Make sure that the oil holes in the bearings and cylinder block are aligned. The splits in the bearings should be upwards and outwards at 45 degrees to the vertical (Figure 42).
2. Install a new crankshaft rear oil seal using Tool No. T70P-6165 (Figure 40).
3. Position a new gasket to the rear oil seal carrier using an oil resistant sealer at the ends. Install the carrier on the cylinder block and tighten the bolts evenly to specification.
4. Locate the flywheel squarely on the crankshaft flange. Tighten the attaching bolts to specification.
5. Install the camshaft and related parts following the appropriate procedures in this section.

OIL FILTER

Removal

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

Installation

1. Coat the gasket on the replacement filter with oil. Position the filter on the adapter fitting. Hand tighten the filter until the gasket contacts the adapter face, then advance it 1/2 turn.
2. Operate the engine at fast idle, and check for oil leaks. If oil leaks are evident, perform the necessary repairs to correct the leakage. Check the oil level and fill the crankcase as required.

DISASSEMBLY AND ASSEMBLY

When installing nuts or bolts that must be torqued (refer to the torque specifications), oil the threads with light weight engine oil. **Do not oil threads that require oil-resistant or water-resistant sealer.**

ENGINE ASSEMBLY

Disassembly

1. Mount the engine on a stand and drain crankcase.
2. Disconnect the fuel line at the fuel pump and carburetor.
3. Disconnect the spark plug leads, remove them from the clip on the rocker cover and position out of the way.
4. Disconnect the water outlet and crankcase ventilation hoses at the intake manifold.
5. Disconnect the wire from the temperature gauge-sending unit (if so equipped).
6. Disconnect the throttle rod, and the distributor vacuum advance hose from the carburetor.
7. Remove the governor mounting bolts to cylinder head. Remove governor and drive belts.
8. Remove alternator adjusting bracket mounting bolt to cylinder head.
9. Disconnect resistor wires. Remove mounting bolt and remove resistor, fuel filter and bracket, dipstick and tube.
10. Disconnect coil wires, remove mounting bolt and remove coil.
11. Remove the thermostat housing and thermostat.
12. Remove the rocker arm cover and gasket.
13. Remove the rocker arm shaft bolts evenly and lift off the rocker arm shaft assembly.
14. Lift out the push rods from their locations and keep them in their correct order.
15. Remove the cylinder head bolts and lift off the cylinder head and gasket. Do not lay the cylinder head flat on its face as damage to the spark plugs or gasket surface can occur.
16. Remove the fuel pump and oil pump.
17. Remove the bolt securing the oil separator to the cylinder block and remove the separator.
18. Remove the distributor and secondary wiring.
19. Remove fan, spacer, pulley and alternator belt.
20. Remove the alternator mounting and adjusting bracket bolts. Remove alternator.
21. Remove crankshaft pulley.
22. Remove the water pump, front cover and crankshaft oil slinger.
23. Remove any ridge and/or carbon deposits from the upper end of the cylinder bores. Move the piston to the bottom of its travel and place a cloth on the piston head to collect the cuttings. Remove the cylinder ridge with a ridge cutter. Follow the instructions furnished by the tool manufacturer. **Never cut into the ring travel area in excess of 1/32 inch when removing ridge.**
24. Invert the engine on the stand and remove the oil pan and gaskets.
25. Remove the oil pick up tube retaining bolt and remove the assembly. Remove the oil return tube.
26. Remove the flywheel and rear engine plate.
27. Remove the rear bearing retainer.
28. Remove the timing chain tensioner.
29. Remove the camshaft sprocket and timing chain.
30. Remove the camshaft thrust plate and the camshaft. Remove the tappets keeping them in their correct order.
31. Make sure all connecting rods and caps are marked so that they can be installed in their original locations. Partially loosen the connecting rod bolts several turns

- and tap them to release the bearing caps. Remove the bolts completely and remove the caps. Push the pistons out of the bores and remove the assemblies (Figure 43).
32. Remove the main bearing caps bolts evenly and lift off each cap. Lift out the crankshaft and handle with care to avoid possible fracture or damage to finished surfaces.
33. Remove the main bearings from block and cap. Remove the thrust washers.
34. Disassemble the piston and connecting rod assemblies. Remove the piston rings and the two piston pin snap rings. Push the piston pin out of each piston.
35. Remove the coolant drain plug and oil pressure sending unit from the block.
36. Remove the block from the stand.

Assembly

1. Mount the block in the stand inverted.
2. Install the coolant drain plug and oil pressure sending unit.
3. Place the upper main bearing inserts in position in the bore with the tang fitting in the slot provided.
4. Install the lower main bearing inserts in the bearing caps.
5. Carefully lower the crankshaft into place. **Be careful not to damage the bearing surfaces.** Check the clearance of each main bearing following the procedures in the Overhaul Section.
6. Install the thrust washers to the center main. Apply a light coat of oil to the journals and bearings. Install the main bearing caps. Tighten the main bearing cap bolts evenly to specifications and check crankshaft rotation.
7. Check the crankshaft end-play.
8. Install the tappets into their respective bores.
9. Oil the camshaft journals with heavy SE engine oil and apply Lubriplate or equivalent to all lobes and then carefully slide it through the bearings.
10. Position the camshaft thrust plate and tighten the attaching bolts to specifications. Check the camshaft end play. Bend the locking tabs to secure the bolts.
11. Install the camshaft sprocket and timing chain aligning the timing marks on the camshaft and crankshaft sprockets (Figure 45). Tighten the attaching bolts to specification and bend up the locking plate tabs.
12. Position the timing chain tensioner arm on the pivot pin and install the tensioner (Figure 46).
13. Install a new oil seal to the front cover using Tool No. T70P-6150 (Figure 47).
14. Install the oil slinger on the crankshaft and position the front cover gasket in place using oil resistant sealer. Locate the front cover, aligning the seal to the crankshaft with Tool No. T70P-6150. Tighten the bolts evenly to specification and remove the aligner tool.
15. Install a new oil seal in the rear oil seal carrier using Tool No. T70P-6165 (Figure 48).
16. Position a new gasket on the rear oil seal carrier using oil resistant sealer. Secure the carrier to the cylinder block. Tighten the bolts evenly to specification.
17. Assemble the respective pistons to their connecting rods. Be sure the word "front" on the rod on the arrow on the top of the piston face the same side (Figure 49). Push the piston pin into the piston and rod and install the two piston pin snap rings.
18. Install the rings on the piston starting with the oil ring, then the second compression ring and the top compression ring. Position the gaps as shown in Figure 50.

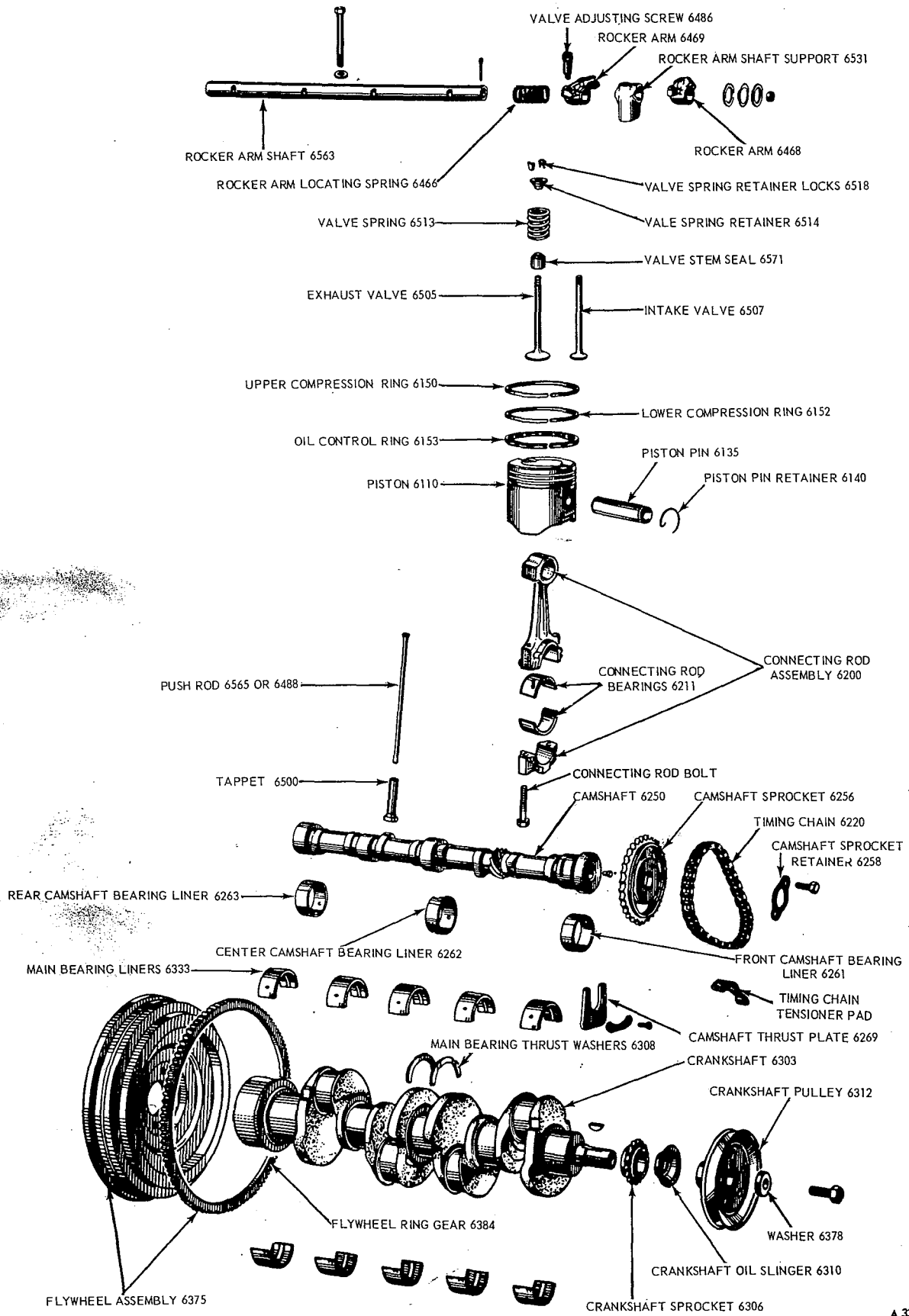
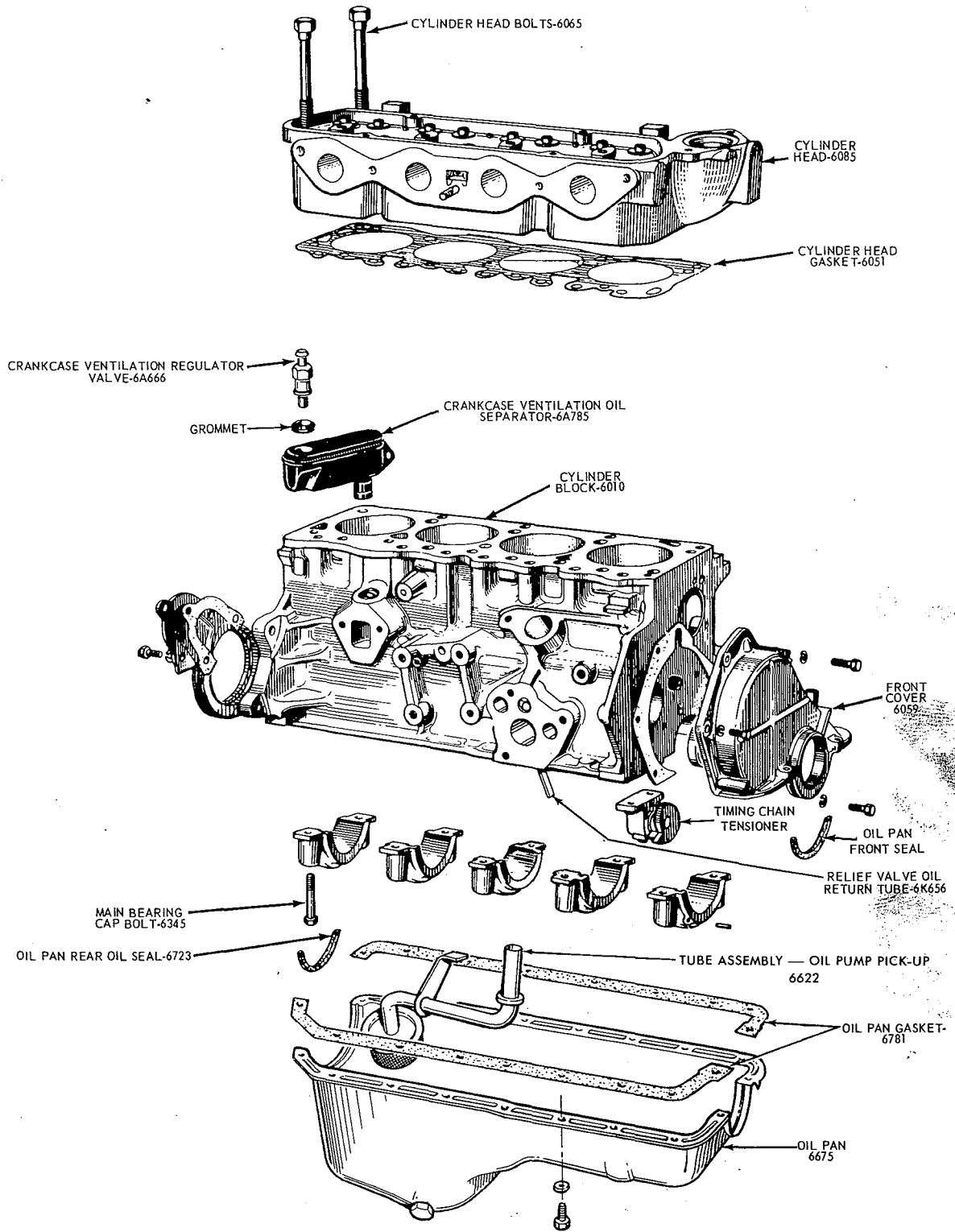
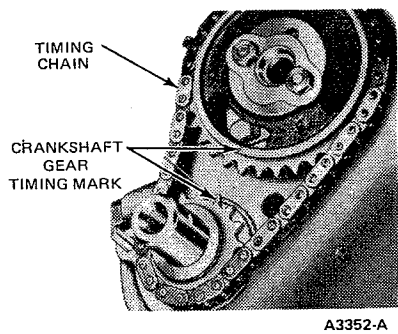


FIG. 43 Engine Internal Parts Disassembled



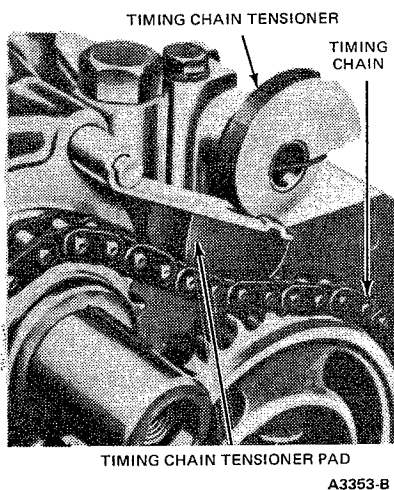
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FIG. 44 Engine Exterior Parts Disassembled



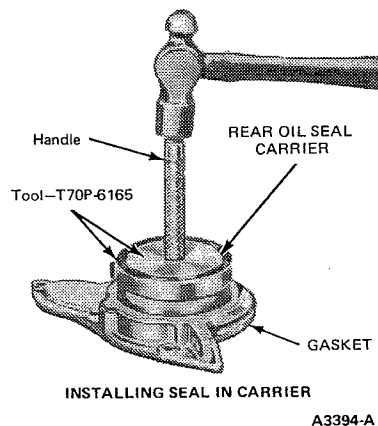
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FIG. 45 Camshaft Sprocket and Timing Chain Aligning Marks



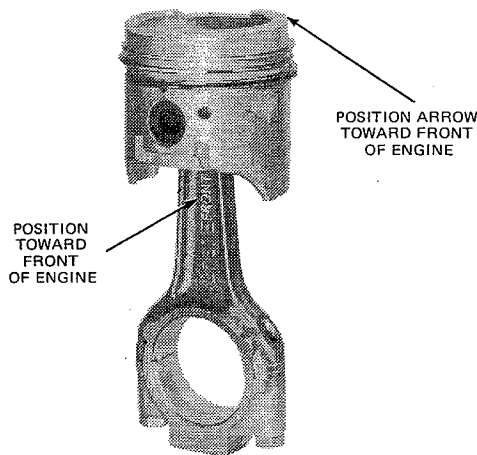
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FIG. 46 Timing Chain Tensioner



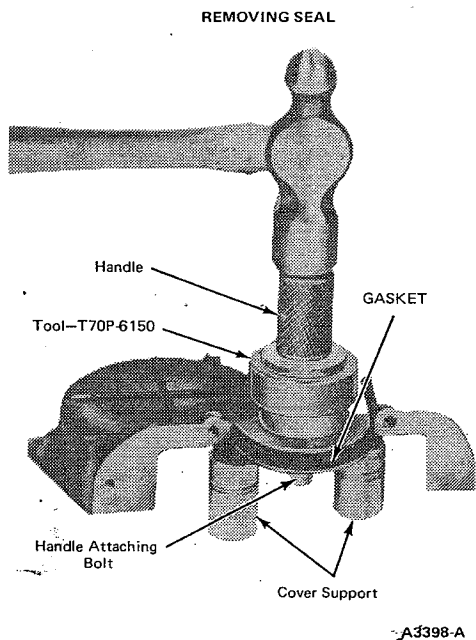
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FIG. 48 Installing Crankshaft Rear Oil Seal



A9008-A

FIG. 49 Connecting Rod and Piston Assembly



A3398-A

FIG. 47 Installing Front Cover Oil Seal

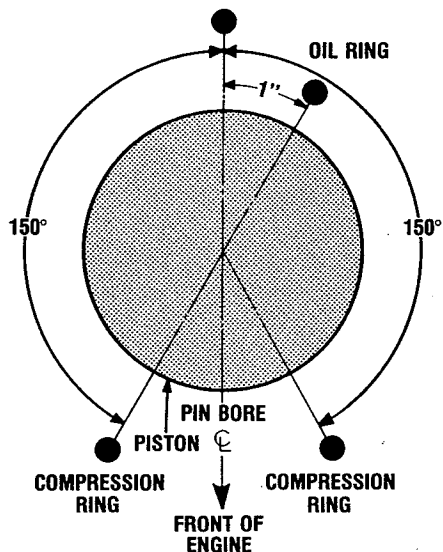
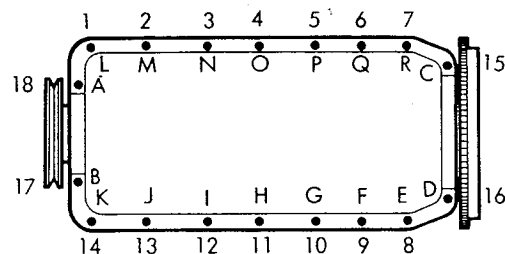


FIG. 50 Piston Ring Cap Spacing

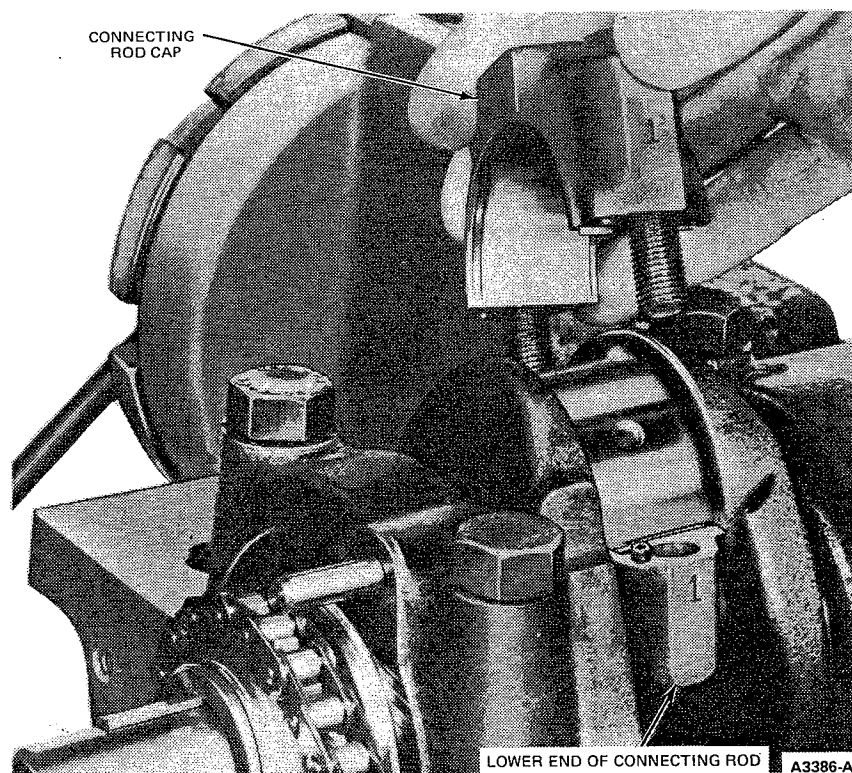
19. Rotate the engine in the stand so that the front end is up. Oil the piston rings and cylinder bores with engine oil. Compress the rings using a universal piston ring compressor. Install the piston and connecting rod assemblies into their respective bores with the arrow on top of the piston pointing toward the front of the block.
20. Install the connecting rod bearings and check the clearances as detailed in the Overhaul Section.
21. Oil the bearings and journals with engine oil and install the connecting rod bearing caps (Figure 51). Tighten the bolts to specification. Check the connecting rod side clearance.
22. Rotate the engine to the inverted position. Replace the oil pump inlet tube and screen and the oil return tube. Press the tubes to the full depth of the counterbored holes. Install the inlet tube retaining bolt.
23. Position the flywheel squarely on the crankshaft flange. Tighten the attaching bolts evenly to specification.
24. Install the crankshaft pulley and torque the bolt to specification.
25. Coat the block surface and the oil pan gasket surface with oil resistant sealer. Position the oil pan gaskets on the cylinder block. Position the end seals with the chamfered ends into the grooves, again using an oil resistant sealer at the mating areas. Position the oil pan and tighten the bolts evenly to specification following first the alphabetical, then the numerical sequences shown in Figure 52.
26. Right the engine in the stand. Position a new gasket on the water pump and install the pump on the block.



A 3360-B

FIG. 52 Oil Pan Bolts Tightening Sequence

27. Position the alternator and brackets to the block and install mounting bolts.
28. Install and time the distributor.
29. Position the oil separator to the block and install the retaining bolt.
30. Position a new oil pump mounting gasket to the block using oil resistant sealer. Position the pump to the block, install the mounting bolts and torque to specifications.
31. Position a new gasket to the fuel pump flange and insert the rocker arm through the slot in the block so that the arm lies on the camshaft lobe. Install the mounting bolts and tighten evenly to specification.
32. Position the cylinder head gasket on the cylinder block using pilot studs.



A3386-A

FIG. 51 Installing Connecting Rod Caps

33. Position the cylinder head, remove the pilot studs and install the cylinder bolts. Tighten the bolts down evenly in sequence (Figure 53) and in three steps to specification.

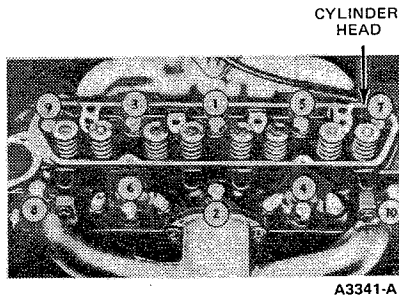


FIG. 53 Cylinder Head Bolt Tightening Sequence

34. Lubricate both ends of the push rods with Lubriplate or equivalent and install them in their respective bores.
35. Install the rocker arm shaft assembly to the cylinder head, locating the push rods on the adjusting screws. Tighten the bolts evenly to specification. Adjust the valve clearances. Install the rocker cover.
36. Locate the thermostat in its bore in the cylinder head and install the gasket and thermostat housing. Connect the wire to the temperature gauge sending unit.
37. Position the coil to the intake manifold and install mounting bolt. Connect primary wires to coil.
38. Install dipstick and tube. Position dipstick tube bracket, fuel filter and bracket and resistor to intake manifold and install mounting bolt. Connect coil wire to resistor.
39. Position governor to cylinder head and install mounting bolts.
40. Connect the throttle rod, and distributor vacuum advance hose to the carburetor.
41. Connect the water outlet and crankcase ventilation hoses at the intake manifold.
42. Install the distributor cap, position leads into clip on rocker cover and connect the leads to the spark plugs.
43. Connect the fuel line at the fuel pump and carburetor.
44. Install remaining alternator adjusting arm mounting bolts to cylinder head. Loosen alternator and governor adjusting bolts.
45. Install water pump pulley, spacer and fan. Install alternator and governor drive belts. Adjust both belts to specifications.
46. Remove engine from stand.

CYLINDER HEAD

Disassembly

1. Remove the exhaust manifold and the spark plugs.
2. Remove the intake manifold.
3. Remove deposits from the combustion chambers and valve heads with a scraper and a wire brush before removing the valves. **Be careful not to scratch the gasket surfaces.**
4. Compress the valve springs. Remove the valve spring retainer locks and release the spring. Remove the spring

retainer, spring, valve stem seal and valve. Discard the valve stem seals. Identify all valve parts. Refer to the Overhaul Section for repair procedures.

Assembly

1. Lubricate the valve guides and valve stems with engine oil. Apply Lubriplate or equivalent to the tips of the valve stems.
2. Install each valve in the valve guide from which it was removed or to which it was fitted. Install a new stem seal on the valve. Install the valve spring, valve spring retainer, compress the spring and install the retainer locks.
3. Measure the assembled height of the assembled valve spring from the surface of the cylinder head spring pad to the underside of the spring retainer. If the assembled height is greater than specification, install the necessary spacer between the cylinder head spring pad and the valve spring to bring the assembled height to the recommended dimension. **Do not install spacers unless necessary. Use of spacers in excess of recommendations will result in overstressing the valve springs and overloading the camshaft lobes which would lead to spring breakage and/or worn camshaft lobes.**

OIL PUMP

Disassembly

1. Remove the filter.
2. Remove the end plate and withdraw the rubber O-ring from the groove in the pump body.
3. If it is necessary to replace the rotor assembly, remove the outer rotor, then drive out the retaining pin securing the gear to the shaft and pull off the gear.
4. Remove the inner rotor and shaft.
5. Drill a small hole and insert a self-threading sheet metal screw of the proper diameter into the oil pressure relief valve chamber cap and pull the cap out of the chamber. Remove the spring and plunger.

Assembly

1. Oil all parts thoroughly.
2. Install the oil pressure relief valve plunger, spring and new cap.
3. Install the inner rotor and shaft assembly in the pump body. Press the gear onto the shaft supporting the shaft at the rotor end on a suitable spacer, until the far end of the gear teeth are 2-1/4 inches (57.15mm) from the mounting flange. If a new shaft and/or gear are used, drill a 1/8 inch (3.175mm) hole at right angles to the shaft through the gear shoulder 1-5/16 inches (33.338mm) from the mounting flange. Replace the gear retaining pin and peen over the ends securely.
4. Install the outer rotor with its chamfered side facing inward toward the pump body.
5. Place a new rubber O-ring in the groove in the pump body. Position the end plate with the machined face toward the rotors and install the retaining bolts.
6. Coat the gasket on the oil filter with engine oil. Position the filter to the pump housing. Hand tighten the filter until the gasket contacts the face, then advance it 1/2 turn.

PART 2 Ignition System

COMPONENT INDEX	Page	COMPONENT INDEX	Page
IDENTIFICATION	2-01	REMOVAL AND INSTALLATION	
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DIAGNOSIS AND TESTING		Spark Plug Wire	2-07
Spark Intensity Tests	2-02	Spark Plugs	2-07
Ignition System Tests	2-02	Distributor	2-08
Distributor Tests — On Vehicle	2-03	Breaker Plate and/or	
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ADJUSTMENTS		CLEANING AND INSPECTION	
Breaker Points and/or Condenser	2-05	Spark Plugs	2-10
Ignition Timing	2-06	Distributor	2-10

IDENTIFICATION

The distributor identification number is stamped on the distributor housing. The basic part number for distributors is 12100. To procure replacement parts, it is necessary to know the part number prefix and suffix (Figure 1).

Always refer to the Parts Catalog for parts usage and interchangeability before replacing a distributor or a component part for a distributor.

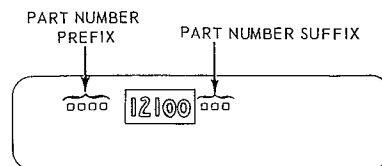


FIG. 1 Distributor Identification

DESCRIPTION

The distributor is located on the right side of the engine. It is equipped with a vacuum and a centrifugal advance unit to control ignition timing. The vacuum advance governs the ignition timing (spark advance) during low engine speeds, or low engine loadings. The centrifugal advance, in combination with the vacuum advance, controls the ignition timing at higher engine speeds or heavy engine loadings to provide the correct ignition timing for maximum engine performance.

The diaphragm is connected to the movable breaker plate by a link. An increase in vacuum will move the diaphragm against the advance diaphragm spring tension, causing the movable breaker plate to pivot opposite the distributor rotation. Thus, ignition timing is advanced, and this is calculated to occur during normal roadload operation, but not during deceleration or idle.

The ignition system consists of a primary (low voltage) and a secondary (high voltage) circuit (Figure 2).

The primary circuit consists of the:

1. Battery.
2. Ignition switch.
3. Primary circuit resistor.
4. Primary windings of the ignition coil.
5. Breaker points.
6. Condenser.

The secondary circuit consists of the:

1. Secondary windings of the ignition coil.
2. Distributor rotor.
3. Distributor cap.
4. High tension (spark plug) wires.
5. Spark plugs.

When the breaker points are closed, current flows from the battery through the ignition switch to the primary wind-

ings in the coil, then to ground through the closed breaker points. When the breaker points open, the magnetic field built up in the primary windings of the coil moves through the secondary windings of the coil, producing high voltage. **High voltage is produced each time the breaker points open.** The high voltage flows through the coil high tension lead to the distributor cap where the rotor distributes it to one of the spark plug terminals in the distributor cap. This process is repeated for every power stroke of the engine.

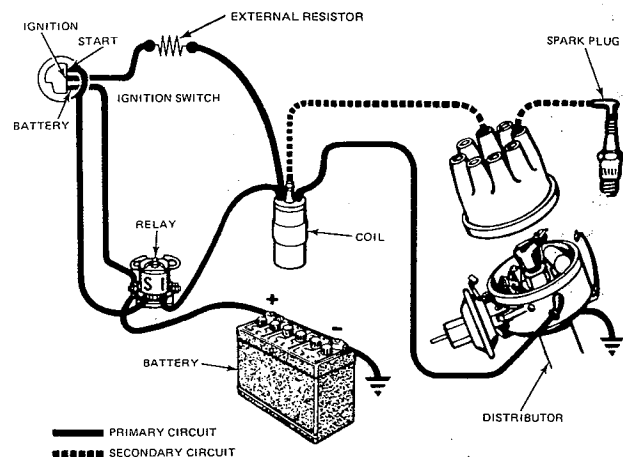


FIG. 2 Typical Conventional Ignition System Circuits

DIAGNOSIS AND TESTING

Ignition systems troubles are caused by a failure in the primary and/or the secondary circuit; incorrect ignition timing; or incorrect distributor advance. Circuit failures may be caused by shorts, corroded or dirty terminals, loose connections, defective wire insulation, cracked distributor cap or rotor, defective distributor points, fouled spark plugs, or by improper dwell angle.

If engine starting or operating trouble is attributed to the ignition system, start the engine and verify the complaint. On engines that will not start, be sure there is gasoline in the fuel tank and that fuel is reaching the carburetor. Then locate the ignition system problem by an oscilloscope test or by a spark intensity test.

SPARK INTENSITY TESTS

Trouble Isolation

1. Connect auxiliary starter switch in the starting circuit.
2. Remove the coil high tension lead from the distributor cap.
3. Turn on the ignition switch.
4. While holding the high tension lead approximately 3/16 inch from the cylinder head or any other good ground, crank the engine with an auxiliary starter switch.

If the spark is good, the trouble lies in the secondary circuit.

If there is no spark or a weak spark, the trouble is in the primary circuit, coil to distributor high tension lead, or the coil.

Primary Circuit

A breakdown or energy loss in the primary circuit can be caused by: defective primary wiring, or loose or corroded terminals; burned, shorted, sticking or improperly adjusted breaker points; an open or shorted coil; or condenser.

A complete test of the primary circuit consists of checking the circuit from the coil to ground, and the starting ignition circuit.

Excessive voltage drop in the primary circuit will reduce the secondary output of the ignition coil, resulting in hard starting and poor performance.

To isolate a trouble in the primary circuit, use a voltmeter and perform the following tests; Battery to Coil; Starting Ignition Circuit; Coil to Ground; or Breaker Points.

Secondary Circuit

A breakdown or energy loss in the secondary circuit can be caused by: fouled or improperly adjusted spark plugs; defective high tension wiring or high tension leakage across the coil, distributor cap or rotor resulting from an accumulation of dirt.

To check the spark intensity at the spark plugs, thereby isolating an ignition problem to a particular cylinder, proceed as follows:

1. Disconnect a spark plug wire. **Check the spark intensity of one wire at a time.**
2. Install a terminal adapter in the terminal of the wire to be checked. Hold the adapter approximately 3/16 inch from the exhaust manifold and crank the engine, using an auxiliary starter switch. The spark should jump the gap regularly.
3. If the spark intensity of all the wires is satisfactory, the coil, condenser, rotor, distributor cap and the secondary wires are probably satisfactory.

If the spark is good at only some wires, check the resistance of those particular leads.

If the spark is equal at all wires, but weak or intermittent, check the coil, distributor cap and the coil to distributor high

tension wire. The wire should be clean and bright on the conducting ends, and on the coil tower and distributor sockets. The wire should fit snugly and be bottomed in the sockets.

IGNITION SYSTEM TESTS

Battery to Coil Voltmeter Test

1. Connect the voltmeter leads as shown in Figure 3.

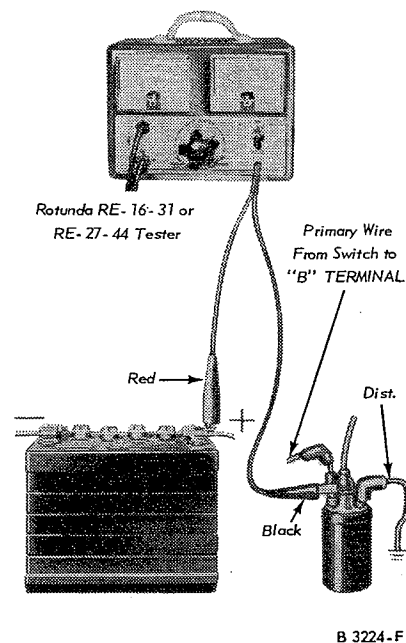


FIG. 3 Battery-to-Coil and Starting Ignition Circuit Test

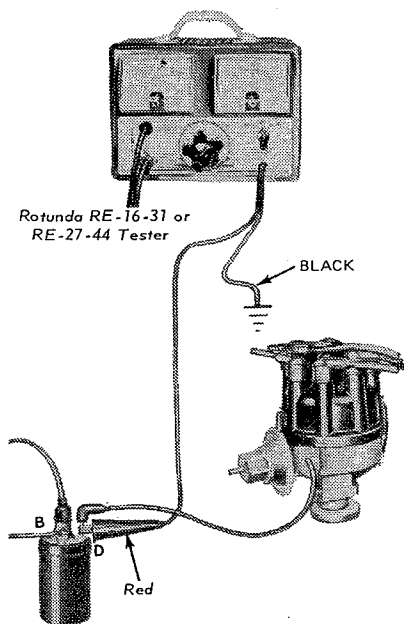
2. Connect a jumper wire to the distributor terminal of the coil to a good ground on the distributor housing.
3. Turn the lights and accessories off.
4. Turn the ignition switch on.
5. If the voltmeter reading is between 4.5 and 6.9 volts, the primary circuit from the battery to the coil is satisfactory.
6. If the voltmeter reading is greater than 6.9 volts, check the following:
 - The battery and cables for loose connections or corrosion
 - The primary insulation, broken strands, and loose or corroded terminals
 - If the voltmeter reading is less than 4.5 volts the ignition resistor should be replaced
 - Check the starter-relay-to-ignition switch for damage.

Starting Ignition Circuit Voltmeter Test

1. Connect the voltmeter leads as shown in Figure 3.
2. Disconnect and ground the coil to distributor high tension lead at the distributor.
3. With the ignition switch off, crank the engine with an auxiliary starter switch while observing the voltage drop.
4. If the voltage drop is 0.4 volt or less, the starting ignition circuit is satisfactory.
5. If the voltage drop is greater than 0.4 volt, clean and tighten the terminals in the circuit or replace the wiring as necessary.

Coil to Ground Voltmeter Test

1. Connect the voltmeter leads as shown in Figure 4.



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FIG. 4 Coil to Ground Test

2. Close the breaker points.
3. Turn all lights and accessories off.
4. Turn the ignition switch on.
5. If the voltmeter reading is 0.25 volt or less, the primary circuit from coil to ground is satisfactory.
6. If the voltmeter reading is greater than 0.25 volt, test the voltage drop between each of the following:
 - The coil and the breaker point connections of the coil to distributor primary wire.
 - The movable breaker point and the breaker plate.
 - The breaker plate and the distributor housing.
 - The distributor housing and engine ground.
7. Turn the ignition switch off. Disconnect the voltmeter leads.

Coil Test

Check the coil on a coil tester following the manufacturer's instructions. Check for ohms resistance both primary and secondary. Also check the amperage draw both with the engine idling and stopped. These checks should all fall within specifications.

Secondary (High Tension) Wires Resistance Test

The secondary wires include the wires connecting the distributor cap to the spark plugs and the wire connecting the center terminal of the distributor cap to the center terminal of the ignition coil.

These wires are the radio resistance-type which filter out the high frequency electrical impulses that are the source of ignition noise interference. The resistance of each wire should not exceed 5000 ohms per inch. **When checking the resistance of the wires or setting ignition timing, do not puncture the wires with a probe. The probe may cause a separation in the conductor.**

When removing the wires from the spark plugs, grasp and twist the moulded cap, then pull the cap off the spark plug by hand only. Do not pull on the wire because the wire

connection inside the cap may become separated or the insulator may be damaged.

To check the spark intensity at the spark plugs, proceed as follows:

1. Disconnect a spark plug wire. **Check the spark intensity of one wire at a time.**
2. Install a terminal adapter in the terminal of the wire to be checked. Hold the adapter approximately 3/16 inch from the exhaust manifold and crank the engine, using an auxiliary starter switch. The spark should jump the gap regularly.
3. If the spark intensity of all the wires is satisfactory, the coil, condenser, rotor, distributor cap and the secondary wires are probably satisfactory.
 - If the spark is good at only some wires, check the resistance of those particular leads.
 - If the spark is equal at all wires, but weak or intermittent, check the coil, distributor cap and the coil to distributor secondary (high tension) wires.

Spark Plug Test

Inspect, clean, file the electrodes and gap the plugs. After the proper gap is obtained, check the plugs on a testing machine. Compare the sparking efficiency of the cleaned and gapped plug with a new plug. Replace the plug if it fails to meet 70 percent of the new plug performance.

DISTRIBUTOR TESTS — ON VEHICLE

Test Connections

1. Disconnect the distributor primary wire at the coil. Connect a short jumper wire to the DIST terminal of the coil and the distributor primary wire. Connect the red lead to the jumper wire.
2. Connect the black lead to a good ground on the engine.

Dwell Angle Check

1. Disconnect the distributor vacuum line. Connect the tester.
2. Turn the test control knob to the set position.
3. Adjust the set control knob until the needle on the dwell meter lines up with the set line.
4. Start the engine and let it idle.
5. Turn the cylinder selector to the figure corresponding to the number of lobes on the cam of the distributor.
6. Read the dwell angle on the dwell meter and compare the reading to specifications.
7. Turn off the engine.
8. If the dwell angle was below the specified amount, the breaker point gap is too wide. If the dwell angle was above the specified amount, the breaker point gap is too close.

If the dwell is to specifications, turn the test selector knob to the OFF position and disconnect the tester leads and jumper wire; then connect the distributor vacuum line.

Dwell Angle Adjustment

If the dwell angle is not within specifications, proceed as follows:

1. Remove the coil high tension lead from the distributor and ground it.
2. Remove the distributor cap and place it out of the way. Remove the rotor.
3. Connect an auxiliary starter switch in the circuit.
4. Loosen the breaker point attaching screw near the breaker point contacts.
5. With the ignition on, crank the engine with an auxiliary

starter switch and adjust the gap to specifications.

6. Release the auxiliary starter switch and tighten the breaker point attaching screw.
7. Since the adjustment may have changed when the attaching screw was tightened, crank the engine again with the auxiliary starter switch and check the dwell. When the dwell is properly adjusted, remove the jumper wire, auxiliary starter switch and tester leads and install the rotor, distributor cap, coil high tension lead and starter relay wires. Connect the distributor vacuum line.

DISTRIBUTOR TESTS — OFF VEHICLE

The following instructions indicate the general principles to be followed for testing the distributor on a tester. The method of testing, however, may vary for machines of different manufacture. For specific instructions refer to the equipment manufacturer's handbook.

1. Mount the distributor on the tester. Check that the distributor is free to rotate.
2. Make the necessary electrical connections and zero the instrument if required.
3. Tighten the drive chuck to the distributor drive shaft securely.
4. Rotate the drive chuck by hand to make sure the distributor shaft turns freely and then tighten the locking screw on the distributor support arm.
5. Connect the Synchronograph test lead to the primary lead wire of the distributor.

Breaker Point Resistance

1. Turn the test selector to the position for checking resistance.
2. Rotate the chuck by hand until the distributor breaker contacts are closed.
3. The pointer on the cam angle meter should read in the OK zone of the meter scale. If the meter pointer does not fall in the OK zone, there is excessive resistance caused by a faulty contact across the distributor points, a damaged primary lead, or a poorly grounded base plate. A faulty contact across the distributor points indicates improper spring tension or burned or pitted points.

Insulation and Leakage

1. Turn the test selector to the cam angle position and rotate the chuck by hand until the distributor breaker contacts are open.
2. The cam angle meter should show a zero reading. If a zero reading is not obtained, a short circuit to ground exists.

A short could be caused by poor primary wire insulation, a shorted condenser or a short between the breaker arm and breaker plate.

Mechanical Operation

1. Manually check the advance mechanism by turning the rotor in the direction of distributor rotation and then

releasing it. The rotor will return to its original position if the mechanism has freedom of movement and the springs are in good condition.

2. Make the necessary connections for the stroboscopic timing light or sparking protractor. (Refer to equipment manufacturer's handbook).
3. Adjust the speed control to vary the distributor speed between 400 and 4000 engine rpm, or at the maximum speed of the engine on which the distributor is used. Erratic or then faint flashes of light preceding the regular flashes as the speed of rotation is increased can be due to weak breaker arm spring tension or binding of the breaker arm on the pivot pin.
4. Operate the distributor at approximately 2500 engine rpm and move the protractor scale so that the zero degree mark on the scale is opposite one of the neon flashes. The balance of all the flashes should come within 1 degree, plus or minus, evenly around the protractor scale. A variation larger than 1 degree or erratic or wandering flashes may be caused by a worn cam or distributor shaft or a bent distributor shaft.

Dwell Angle

1. Disconnect and plug the distributor vacuum line.
2. Turn the test selector switch to the correct cam angle position and operate the distributor at approximately 1000 engine rpm.
3. Adjust the breaker point gap until the dwell angle is to specifications. Unplug and connect the distributor vacuum line.

Breaker Plate Wear

A worn breaker plate on the distributor will usually cause the breaker point gap and contact dwell to be erratic as engine speed and load conditions are varied.

Adjust the test set to 0 degree advance, 0 inches vacuum, and 100 rpm. Adjust the dwell angle to 26 degrees. Apply vacuum to the distributor diaphragm and increase it very slowly while observing the indicated dwell angle. The maximum dwell angle variation should not exceed 4 degrees when going from zero to maximum vacuum at constant rpm. If the dwell angle variation exceeds this limit, there is excessive wear.

Distributor Spark Advance Test

The spark advance is checked to determine if the ignition timing advances in proper relation to engine speed and load.

Check the contact dwell. If the contact dwell is not within specifications, adjust the breaker points.

Check the breaker arm spring tension and adjust it or replace the points as necessary.

The dual advance distributor has two independently operated spark advance systems. Each system is adjusted separately. **Adjust the centrifugal advance before adjusting the vacuum advance.**

ADJUSTMENTS

Accurate ignition system adjustments are of great importance in the proper operation and performance of the engine.

After any adjustment of ignition timing and distributor point dwell, check the distributor automatic advance for proper operation.

Centrifugal Advance

1. Operate the distributor in the direction of rotation and adjust the speed to the initial rpm setting listed in the specifications. Move the protractor scale so that one of the flashes lines up with the zero degree mark.
2. Slowly increase the rpm to the setting specified for the first advance reading listed in the specifications.

If the correct advance is not indicated at this rpm, stop the distributor and bend one spring adjustment bracket to change its tension (Figure 5). Bend the adjustment bracket away from the distributor shaft to decrease advance (increase spring tension) and toward the shaft to increase advance (decrease spring tension). After the adjustment is made, identify the bracket so as not to repeat the adjustment on the same spring.

3. After an adjustment has been made to one spring, check the minimum advance point again.
4. Operate the distributor at the specified rpm to give an advance just below the maximum. If this advance is not to specifications, stop the distributor and bend the other spring bracket to obtain the correct advance.
5. Check the advance at all rpm settings listed in the specification booklet. Operate the distributor both up and down the rpm range.

Vacuum Advance

1. Connect the test set vacuum line to the fitting on the diaphragm.
2. Set the test set at 0 degree advance, 0 vacuum, and at 1000 rpm.
3. Check the advance at the vacuum settings given in the specifications.

Do not change the original rpm setting when going to a different vacuum setting. If the other settings are not within limits, there is incorrect spring tension, leakage in the vacuum chamber and/or line.

To check the diaphragm for leakage:

Install the distributor tester. Do not connect the vacuum line to the distributor.

Adjust the vacuum pressure of distributor tester to obtain 25 inches of Hg or slightly less. Hold your hand over the end of the tester's vacuum hose and note the reading obtained. **Do not exceed 25 inches Hg.**

If the reading is 25 inches Hg or less, connect the tester's vacuum line to the vacuum fitting on the diaphragm to be tested without changing any of the adjustments.

The gauge reading should not be less than it was above. If it is less, the diaphragm is leaking and should be replaced.

BREAKER POINTS AND/OR CONDENSER

Breaker Point Alignment

The breaker points must be accurately aligned and stroke squarely to assure normal breaker point life. Misalignment of these breaker point surfaces can cause premature wear, overheating and pitting.

1. Turn the cam so that the breaker points are closed, then check the alignment of the points (Figure 6).

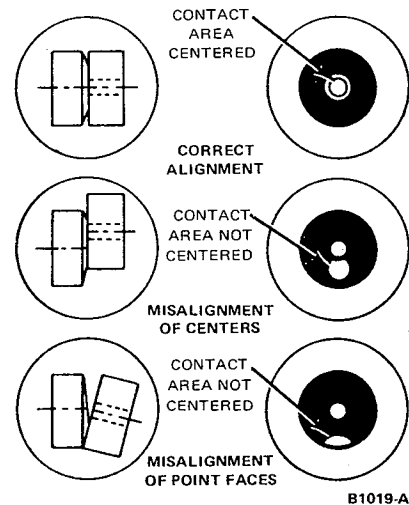


FIG. 6 Checking Breaker Point Alignment

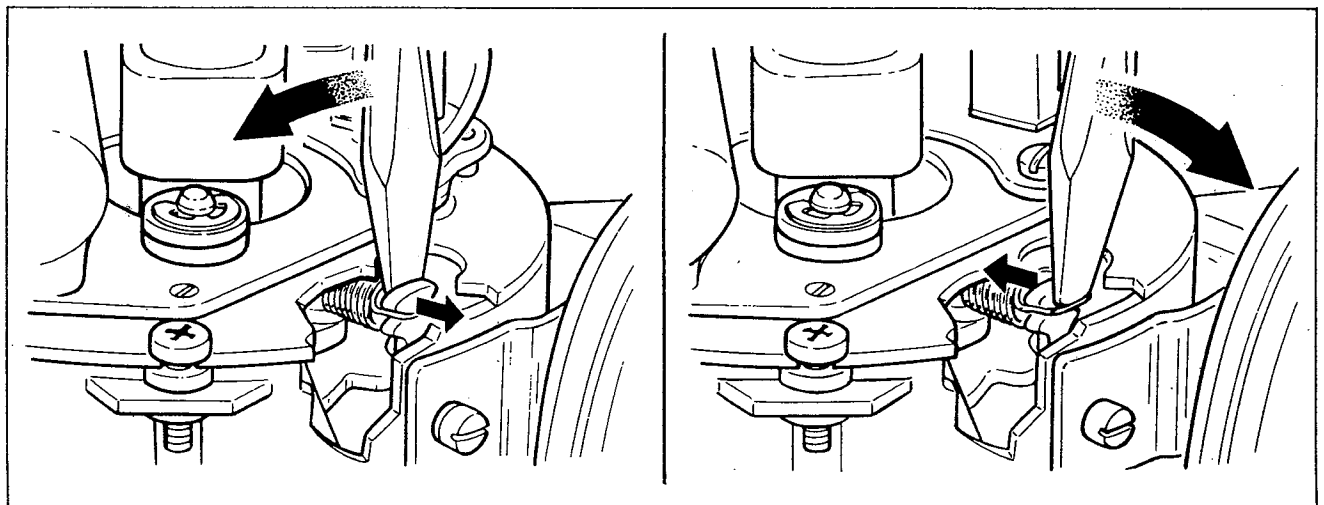
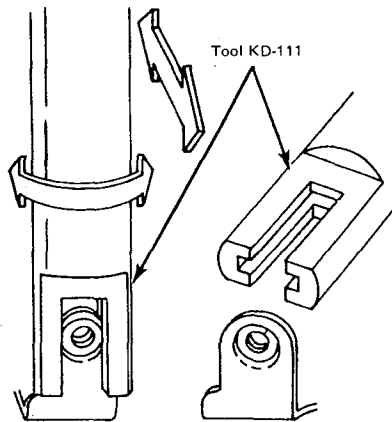


FIG. 5 Centrifugal Advance Adjustment

If the distributor is on the engine, close the points by proceeding as follows:

1. With the ignition switch off, crank the engine by using an auxiliary starter switch.
2. Using the tool shown (Figure 7) and exerting **very light pressure**, align the breaker point bracket. **Do not bend the breaker arm.**
3. After the breaker points have been properly aligned, adjust the breaker point gap.



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FIG. 7 Using Alignment Tool

Breaker Point Gap Adjustment

A scope, a dwell meter, or a feeler gauge can be used to check the gap of new breaker points.

A scope or a dwell meter should be used to check the gap of used breaker points. Due to the roughness of used points, it is not advisable to use a feeler gauge to check the gap.

To check and adjust the breaker points with a feeler gauge:

1. Check and adjust the breaker point alignment.
2. Rotate the distributor until the rubbing block rests on the peak of a cam lobe.

If the distributor is on the engine, place the rubbing block on the peak of the cam by proceeding as follows:

Crank the engine with an auxiliary starter switch.

Insert the correct thickness blade of a clean feeler gauge between the breaker points (Figure 8). Adjust the points to the correct gap and tighten the screws.

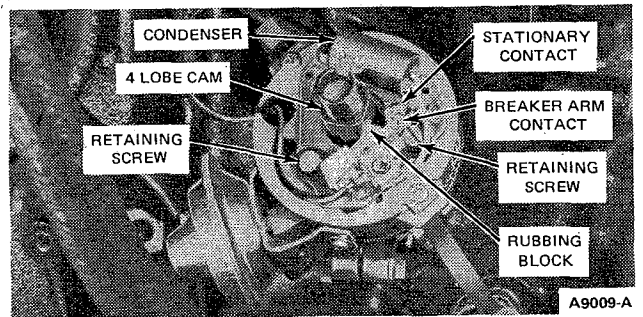


FIG. 8 Adjusting New Breaker Point Gap

Clean the cam, then apply a light film of distributor cam lubricant (C4AZ-19D530-A) to the cam when new points are installed. **Do not use engine oil to lubricate the distributor cam.** Set the ignition timing.

Also, set the contact dwell to the low setting.

To check and adjust the breaker points with a scope or a dwell meter, refer to the manufacturer's instructions.

IGNITION TIMING

Timing Mark Locations

The timing marks and their locations are illustrated in Figure 9.

For checking and adjusting the ignition timing with a scope refer to the scope manufacturer's instructions. To check and adjust the timing with a timing light, proceed as follows:

Initial Ignition Timing

1. Clean and mark the specified timing mark with chalk or white paint.
2. Disconnect the vacuum line and plug the disconnected vacuum line.
3. Connect a timing light to the No. 1 cylinder spark plug wire. Connect a tachometer to the engine.
4. Start the engine and reduce the idle speed to 600 rpm to be sure that the centrifugal advance is not operating. Adjust the initial ignition timing to specifications by rotating the distributor in the proper direction.
5. Check the centrifugal advance for proper operation by starting the engine and accelerating it to approximately 2000 rpm. If the ignition timing advances, the centrifugal

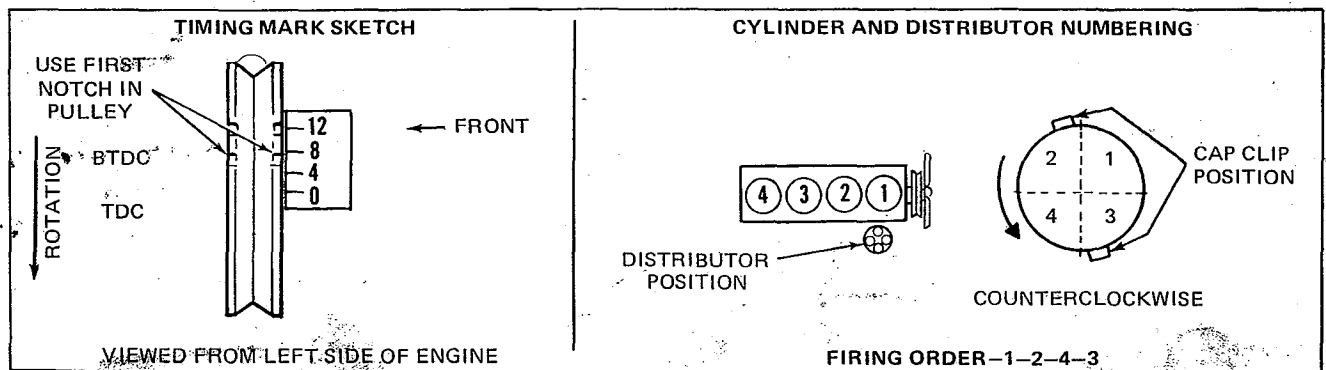


FIG. 9 Engine Timing and Cylinder Firing Order

advance mechanism is functioning properly. Note the engine speed when the advance begins and the amount of total advance. Stop the engine.

- Unplug the vacuum line and connect it to the distributor vacuum advance unit. Start the engine and accelerate it to approximately 2000 rpm. Note the engine speed when the advance begins and the total amount of advance.

Advance of the ignition timing should begin sooner and advance farther than when checking the centrifugal advance alone. Stop the engine.

- If the vacuum advance is not functioning properly, remove the distributor and check it on a distributor tester. Replace the diaphragm unit if the vacuum portion is out of calibration.

REMOVAL AND INSTALLATION

BREAKER POINTS AND/OR CONDENSER

Removal

- Remove the distributor cap and rotor.
- Disconnect the primary and the condenser wires from the breaker point terminal.
- Remove the breaker point assembly and condenser attaching screws. Lift the breaker point assembly and condenser out of the distributor.

Installation

- Clean the distributor cam thoroughly.
- Apply a light film of distributor cam lubricant C4AZ-19D500-A on the cam. **Do not use any type of oil.**
- Place the breaker point assembly and the condenser in position and install the attaching screws.
- Align and adjust the breaker points.
- Connect the primary and condenser wires to the breaker point terminal.
- Install the rotor and the distributor cap.

SPARK PLUG WIRE

When removing the wires from the spark plugs, grasp, twist and pull the moulded cap by hand only. Do not pull on the wires because the wire connection inside the cap may become separated or the boot may be damaged.

Removal

- Disconnect the wires from the spark plugs and distributor cap.
- Lift the wires from the clip on the valve rocker arm cover and remove the wires.
- Remove the coil high tension lead.

Installation

- Insert each wire in the proper socket of the distributor cap (Figure 10). Be sure the wires are forced all the way down into their sockets.
- Remove the wire retaining bracket from the old spark plug wire set and install it on the new set in the same relative position. Install the wires in the clip on the valve rocker arm cover. Connect the wires to the proper spark plugs. Install the coil high tension lead.

SPARK PLUGS

Removal

- Disconnect the wire from each spark plug by grasping, twisting and then pulling the moulded cap of the wire only. **Do not pull on the wire because the wire connection inside the cap may become separated or the weatherseal may be damaged.**
- After loosening each spark plug one or two turns, clean the area around each spark plug port with compressed air, then remove the spark plugs.

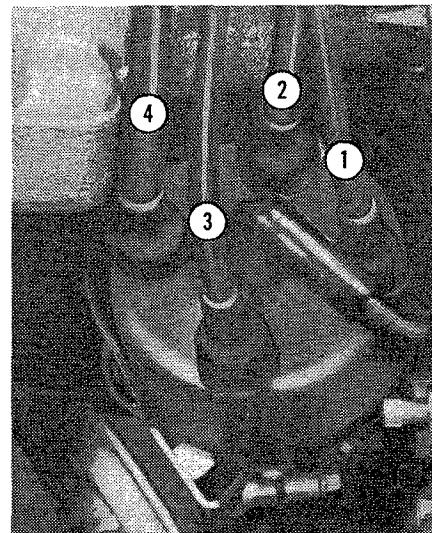


FIG. 10 Distributor Cap

After cleaning, the electrodes must be dressed with a small file to obtain flat parallel surfaces on both the center and side electrodes (Figure 11). Set the spark plug gap to specifications by bending the ground electrode (Figure 12); all spark plugs new or used should have the gap checked and reset as required.

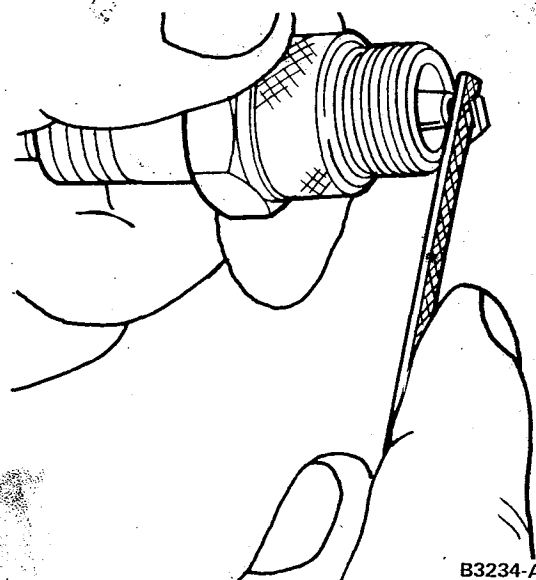


FIG. 11 Filing Spark Plug Electrode

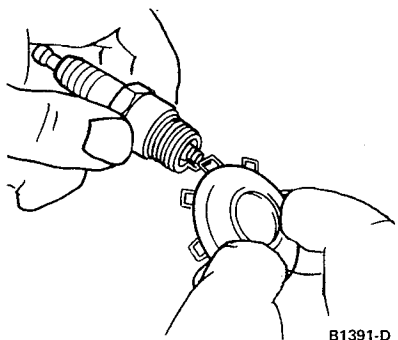


FIG. 12 Checking and Setting Spark Plug Gap

Installation

1. Install the spark plugs and torque each plug to specification.
2. Connect the spark plug wires.

DISTRIBUTOR

Removal

1. Remove the distributor cap.
2. Disconnect the vacuum line from the distributor.
3. Scribe a mark on the distributor body and the cylinder block indicating the position of the body in the block, and scribe another mark on the distributor body indicating the position of the rotor. These marks can be used as guides when installing the distributor in a correctly timed engine providing the crankshaft has not been turned while the distributor is removed.
4. Remove the bolt attaching the distributor to the engine and carefully remove the distributor.

Installation

1. Align the scribe marks previously made on the distributor body, cylinder block and rotor. Install the distributor.
2. If the crankshaft was rotated while the distributor was removed, the engine must be timed as follows:
3. Turn the engine crankshaft until the appropriate timing mark on the timing cover is in line with the notch on the crankshaft pulley as the No. 1 piston comes up on the compression stroke.
4. With the vacuum advance unit pointing to the rear of the engine position the rotor to point to No. 2 spark plug (Figure 13).

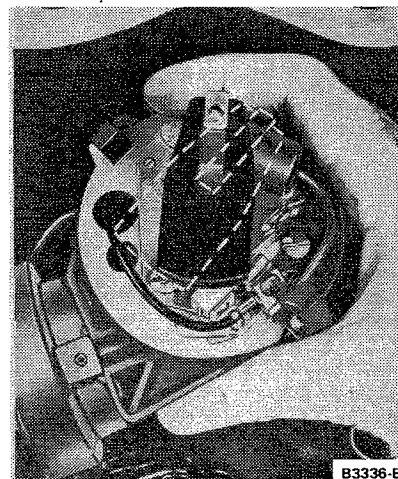


FIG. 13 Installing Distributor

5. Insert the distributor and, as the gears mesh, the rotor should rotate slightly. If necessary re-position the clamp, without turning the distributor, so that the hole is in line with the one in the cylinder block. Install the attaching bolt and tighten.

BREAKER PLATE AND/OR SUB-PLATE REMOVAL

Removal

1. Remove the distributor cap and the rotor.
2. Remove the breaker points from the plate (Figure 14).
3. Remove the C-clip that secures the vacuum advance arm to the plate.
4. Remove the two sub-plate attaching screws and lift the plate and wire from the housing.

Installation

1. Position the plate and wire in the housing and secure it with the two attaching screws.
2. Secure the vacuum advance arm to the plate with the C-clip.
3. Install the breaker points and rotor. Adjust the breaker point spacing to specification.
4. Install the rotor and the distributor cap.

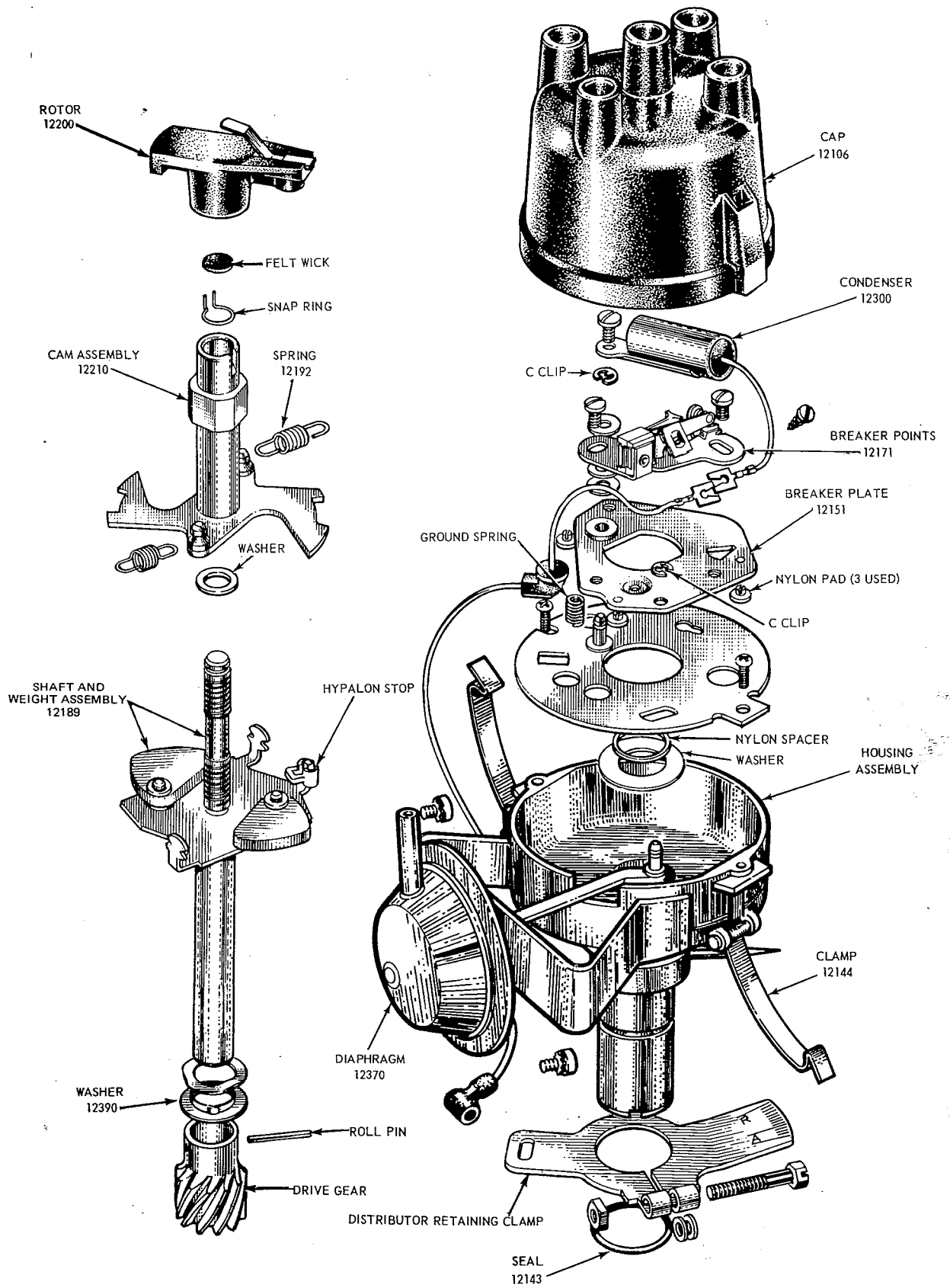


FIG. 14 Distributor — Disassembled

CLEANING AND INSPECTION

SPARK PLUGS

Examine the firing of the spark plugs, noting the type of deposits and the degree of electrode erosion. Refer to Figure 15 for the various types of spark plug fouling and their causes.

Clean the plugs on a sand blast cleaner, following the manufacturer's instructions. **Do not prolong the use of the abrasive blast as it will erode the insulator and electrode.**

Examine the plug carefully for cracked or broken insulators, badly pitted electrodes, and other signs of failure. Replace as required.

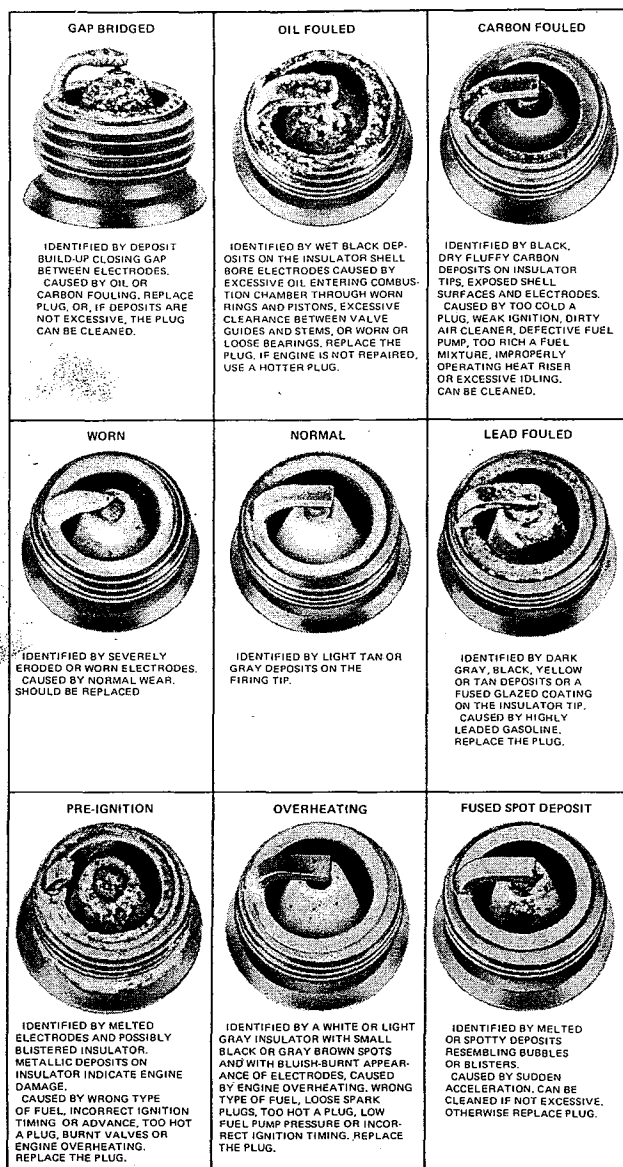


FIG. 15 Spark Plug Inspection

DISTRIBUTOR

Soak all parts of the distributor assembly (except the condenser, breaker point assembly, lubricating wick, vacuum diaphragm, distributor base oil seal and electrical wiring) in a mild cleaning solvent or mineral spirits. Do not use a harsh cleaning solution. Wipe all parts that cannot be immersed in a solvent with a clean dry cloth.

After foreign deposits have been loosened by soaking, scrub the parts with a soft bristle brush. **Do not use a wire brush, file, or other abrasive object.** Dry the parts with compressed air.

Inspect the distributor cam lobes for scoring and signs of wear. If any lobe is scored or worn, replace the distributor.

Inspect the breaker plate assembly for signs of distortion, wear or damage. Replace the breaker plate assembly if it is damaged.

Inspect all electrical wiring for fraying, breaks, etc. and replace any that is not in good condition.

Check the distributor base for cracks or other damage.

Check the diaphragm housing, bracket, and rod for damage. Check the vacuum line damage. Test the diaphragm for leakage as explained under Distributor Test. Replace all defective parts.

The breaker point assembly consists of the stationary point bracket assembly, breaker arm and the primary wire terminal.

Breaker points should be inspected, cleaned and adjusted as necessary. Breaker points can be cleaned with chloroform and a stiff bristle brush. Replace the breaker point assembly if the contacts are badly burned or excessive metal transfer between the points is evident (Figure 16). Metal transfer is considered excessive when it equals or exceeds the gap setting specifications.

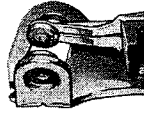

CONDITION	CAUSED BY
 <p>BURNED</p>	<p>Incorrect voltage regulator setting. Radio condenser installed to the distributor side of the coil.</p>
 <p>EXCESSIVE METAL TRANSFER OR PITTING</p>	<p>Incorrect alignment. Incorrect voltage regulator setting. Radio condenser installed to the distributor side of the coil. Ignition condenser of improper capacity. Extended operation of the engine at speeds other than normal.</p>

FIG. 16 Breaker Point Inspection

Distributor Cap

Clean the distributor cap with a soft bristle brush and mild cleaning solvent or mineral spirits. Dry the cap with compressed air. Inspect the cap for cracks, burned contacts, broken carbon button, carbon tracks or dirt or corrosion in the sockets. Replace the cap if it is damaged.

Rotor

Clean the rotor with a soft bristle brush and mild cleaning solvent or mineral spirits. Dry the rotor with compressed air. Inspect the rotor for being broke, cracked, having carbon tracks, or burning. Replace the rotor if it is corroded or damaged.

Secondary Wiring

Wipe the wires with a damp cloth and check for breaks or cracked insulation. Inspect the terminals and boots for looseness or corrosion. Replace any wires that are not in good condition.

Coil

Wipe the coil with a damp cloth and check for any cracks or other defects.

PART 3 Fuel System

COMPONENT INDEX	Page	COMPONENT INDEX	Page
IDENTIFICATION	3-01	Idle Speed	3-03
DESCRIPTION	3-01	Fuel Level (Float Level)	3-03
DIAGNOSIS AND TESTING		REMOVAL AND INSTALLATION	
Pressure Test	3-02	Carburetor	3-03
Capacity (Volume) Test	3-02	Fuel Pump	3-03
ADJUSTMENTS		DISASSEMBLY AND ASSEMBLY	
Idle Fuel Mixture and		Carburetor	3-04

IDENTIFICATION

The carburetor identification tag is attached to the upper body of the carburetor. The basic part number for all carburetors is 9510. To procure replacement parts, it is necessary to know the part number prefix and suffix.

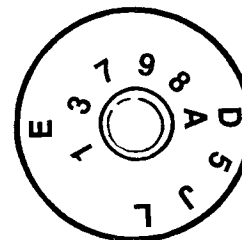


FIG. 1 Carburetor Identification

DESCRIPTION

The fuel system includes a single action fuel pump operated by a lobe on the camshaft. It is a permanently sealed unit and is not repairable.

The fuel filter is the disposable in-line type located in the line between the fuel pump and carburetor.

The carburetor is a Bendix single venturi, downdraft design.

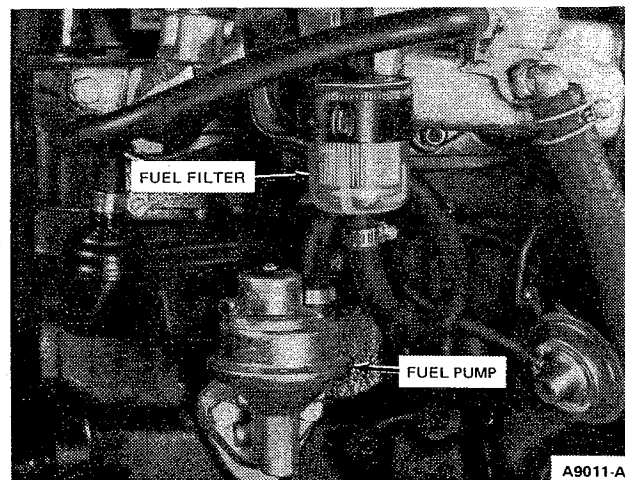


FIG. 2 Fuel Pump and Filter

DIAGNOSIS AND TESTING

To determine that the fuel pump is in satisfactory operating condition, tests for both fuel pump pressure and fuel pump capacity (volume) should be performed.

The tests are performed with the fuel pump installed on the engine and the engine at normal operating temperature at idle speed.

Before the tests, make sure the replaceable fuel filter has been changed within the recommended maintenance mileage interval. When in doubt, install a new filter.

PRESSURE TEST

Refer to the fuel pump specification in this Part, and note the fuel pump pressure and capacity (volume) design tolerances.

1. Remove the air cleaner assembly. Disconnect the fuel inlet line or the fuel filter at the carburetor. Use care to prevent combustion due to fuel spillage.
2. Connect a pressure gauge, a restrictor and a flexible hose (Figure 3) between the fuel filter and the carburetor.

NOTE: Inside diameter of smallest passage in test flow circuit must not be smaller than .220.

3. Position the flexible fuel outlet hose and the restrictor so the fuel can be discharged into a suitable, graduated container (Figure 3).
4. Before taking a pressure reading operate the engine at

the specified idle rpm and vent the system into the container by opening the hose restrictor momentarily.

5. Close the hose restrictor, allow the pressure to stabilize, and note the reading. Refer to the Specifications Section in this Part.

If the pump pressure is not within specifications, and the fuel lines and filter are in satisfactory condition, the pump is defective and should be replaced.

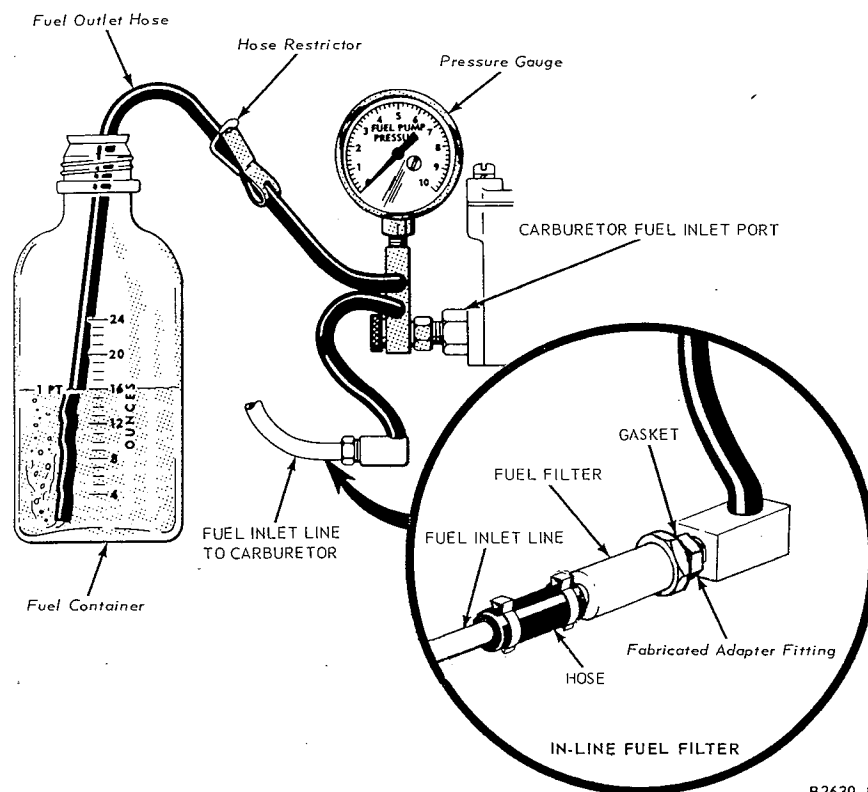
If the pump pressure is within specifications, perform the tests for fuel capacity (volume).

CAPACITY (VOLUME) TEST

With the fuel pump pressure within specifications, test the capacity (volume) as follows:

1. Operate the engine at the specified idle rpm.
2. Open the hose restrictor and expel the fuel into the container (Figure 3), while observing the time required to expel one pint. Close the restrictor. One pint or more of fuel should be expelled within the specified time limit.

If the pump volume is below specifications, repeat the test using an auxiliary fuel supply and a new fuel filter. If the pump volume meets specifications while using the auxiliary fuel supply, check for a restriction in the fuel supply from the tank and for the tank not venting properly.



B2630-B

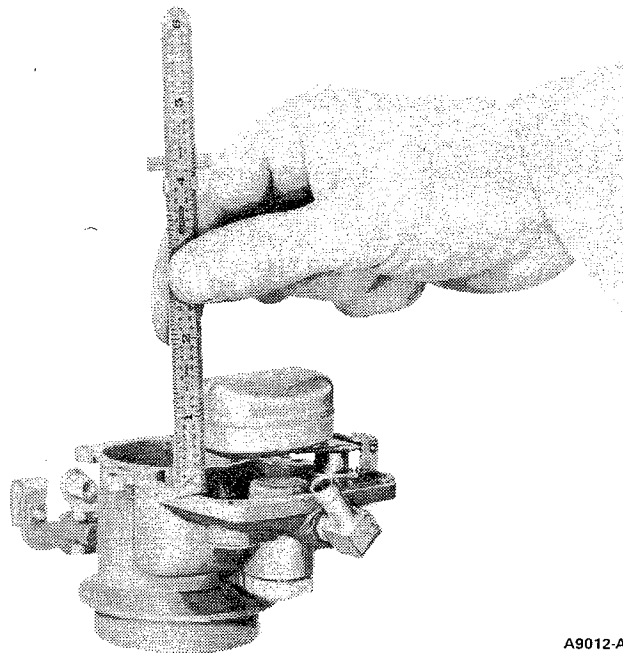
FIG. 3 Typical Fuel Pump Pressure and Capacity Test Equipment

ADJUSTMENTS

IDLE FUEL MIXTURE AND IDLE SPEED

The idle fuel mixture and idle speed adjustment screws are the only external adjusting items on this carburetor. To adjust the idle fuel mixture and idle speed, proceed as follows:

1. Remove the air cleaner. Operate the engine at a fast idle speed until normal operating temperature is reached.



A9012-A

FIG. 4 Float Level

2. Disengage any load on the engine.
3. Set the throttle at minimum speed. Be sure the throttle linkage does not control the idle speed. The idle speed adjustment screw must contact the throttle lever.
4. Turn the idle speed adjusting screw either in or out to obtain 700 rpm.
5. Turn the idle mixture adjustment screw inward until the engine speed begins to drop due to a lean mixture. Next turn the screw outward until the engine speed begins to drop due to a too rich mixture. Then turn the screw inward to a point between these two extremes to obtain maximum engine smoothness and rpm.
6. Set the idle speed to the smoothest point within the range of 700-850 rpm.
7. Recheck idle mixture adjustment and reset if needed.

FUEL LEVEL (FLOAT LEVEL)

1. Disconnect the choke cable.
2. Remove the screws attaching the air intake body to the fuel bowl assembly.
3. Raise the air intake body slightly and loosen the gasket from the fuel bowl, then lift the air intake and gasket clear of the fuel bowl.
4. Invert the air intake body and remove the gasket.
5. With the air intake body inverted, and only the weight of the float assembly pressing against the inlet needle and seat, measure the vertical distance from the air intake body gasket surface to the top of the float (Figure 4).
6. Bend the float arm as necessary to adjust the float to the proper dimension.
7. Place the gasket on the fuel bowl and position the air intake body. Install the retaining screws. Tighten the screws evenly and securely.
8. Connect the choke cable.

REMOVAL AND INSTALLATION

CARBURETOR

Removal

1. Remove the air cleaner.
2. Disconnect the fuel inlet line and distributor vacuum hose.
3. Disconnect the carburetor throttle linkage. Disconnect choke cable.
4. Remove carburetor retaining nuts and lift off carburetor.
5. Remove and discard carburetor gasket.

Installation

1. Install new carburetor gasket and mount carburetor. Secure with retaining nuts.
2. Connect throttle linkage and the choke cable. Check operation of throttle and choke for full travel.

3. Connect fuel line and distributor vacuum line.

4. Start engine and adjust idle speed and idle fuel mixture.
5. Install the air cleaner.

FUEL PUMP

Removal

1. Disconnect the fuel inlet and outlet lines at the fuel pump.
2. Remove fuel pump retaining screws. Lift off pump and gasket.

Installation

1. Place new gasket on pump and position pump on cylinder block. Install retaining screws.
2. Connect fuel inlet and outlet lines.

DISASSEMBLY AND ASSEMBLY

CARBURETOR

The procedure applies to the Zenith 13366 series carburetor (Figure 6). Figure 5 is keyed to Figure 6 and identifies the parts and special Zenith tools required.

DISASSEMBLY AND REMOVAL OF AIR INTAKE BODY

1. Remove the large hex plug (15) and fiber washer (16) from the top of the air intake assembly (14).
2. Remove the six screws (18) and lockwashers which attach the air intake assembly to the fuel bowl assembly.
3. Raise the air intake assembly slightly and loosen the gasket from the fuel bowl, then lift the air intake with gasket clear of the fuel bowl. Use care not to damage the float (26).

DISASSEMBLY OF AIR INTAKE BODY

1. Invert the air intake body and remove gasket (28) from the air intake.
2. Press a small screwdriver against the float axle (27) to push axle from the slotted side of hinge bracket, then remove the float assembly (26) and fuel valve needle (part of 22).
3. Remove fuel valve seat (22) and fiber washer (23) from the air intake, using C161-85 wrench or wide blade screwdriver.
4. Mark choke bracket and choke lever positions to insure correct reassembly and then remove choke parts as follows:
 - a. If choke plate screw is riveted, file off the threaded end flat and remove the screw (1) and choke plate (2).
 - b. Pull out the choke shaft and lever assembly (7.)
 - c. Remove the choke bracket screw (9) and choke bracket (13).

SEPARATE FUEL BOWL AND THROTTLE BODY

1. Loosen the main jet plug (53).
2. Loosen the nut for the pump lever assembly (60), using tool C161-25.
3. Remove the two screws (48) and lockwashers which attach the fuel bowl assembly to the throttle body assembly.
4. Separate the fuel bowl from the throttle body enough to remove the nut (60) and washer (61).
5. Remove the link-pump lever (58) from the throttle shaft (67).
6. Remove the fuel bowl from the throttle body.
7. Remove the venturi (50) and gasket (54).

DISASSEMBLY OF FUEL BOWL

1. Remove the line-pump lever (58) from the accelerating actuator shaft assembly (29) by sliding it out.
2. Remove the idle jet (34) from the top surface of the fuel bowl (46).
3. Remove the well vent (39) from top surface of the fuel bowl, using C161-80 wrench.
4. Remove the main jet (40) and fiber washer (41) from inside bottom of the fuel bowl.
5. Remove main jet plug (53) and washer (52), then remove main discharge jet (51), using C161-1 wrench.
6. Remove check valve from the fuel bowl as follows:
 - a. Turn back the ears of the pump check valve (38),

located in the pump cylinder. Turn fuel bowl over and allow check valve disc to fall out.

- b. Insert tapered end of check valve tool C161-5 into the check valve and screw down (counterclockwise) until tool is firmly fastened into check valve body. Then raise sliding weight up sharply against the stop bar a few times to remove check valve body.
- c. Remove the air vent check valve (30) from passage in top surface of the fuel bowl by inserting the tapered thread end of check valve tool C161-5 into the check valve and screwing down (counterclockwise) until tool is firmly fastened to check valve. Then raise sliding weight up sharply against the stop bar a few times to remove check valve.
- d. Turn the fuel bowl over and allow the ball (33), weight (32), and retainer washer (31) to fall out.

NOTE: DO NOT attempt to remove the channel bushing (47) or nozzle bushing as these parts are pressed in at the factory and need not be removed to service the carburetor.

7. Remove the fuel bowl drain plug (45).
8. Remove the channel plugs as follows:
 - a. Remove the four lead channel plugs (44) and the accelerating jet channel plug (36) by first making a center punch mark in center of the plugs.
 - b. Drill a No. 46 hole in center of plugs, being careful not to drill through the plugs into the casting.

NOTE: The accelerating jet channel plug is drilled at the factory in some cases to receive the plug extractor.

- c. Insert tapered thread end of plug extractor tool C161-21 into holes just drilled and screw down (counterclockwise) until tool is firmly fastened into plug. Then strike opposite end of tool sharply with light hammer to draw plugs out of casting.

NOTE: The threaded tip of the extractor tool can easily be broken off unless the casting and tool are held firmly and the extractor is driven away from the casting without tipping. For accelerating channel plug removal, use plug extractor C161-15.

- d. Remove corrosion, dirt and gum from the four passages, using a 1/8 inch drill with the cutting tip ground blunt to avoid damaging the casting.

DISASSEMBLY OF THROTTLE BODY

1. File riveted ends of the throttle plate screws (55) flat and then remove the two throttle plate screws, throttle plate (56), and throttle shaft and lever assembly (67).

NOTE: Use caution to avoid scarring throttle body bore or throttle plate. DO NOT attempt to remove the idle port plug from the side of the throttle body.

2. Remove the idle adjusting needle (20) and spring (21) from side of the throttle body.

INSPECTION AND CLEANING

Inspect all parts and replace any that are damaged or worn. Clean the carburetor using Ford Carburetor Cleaner, C000-19535-B.

NOTE: DO NOT attempt to clean non-metal parts in the carburetor cleaning solution.

Blow out passages and channels in the castings using compressed air. It is recommended to reverse the air flow through each passage to insure the removal of all particles of dirt. NEVER USE A WIRE OR DRILL TO CLEAN OUT THE JETS.

ASSEMBLY**ASSEMBLY OF AIR INTAKE BODY**

1. Place choke plate (2) in the air intake assembly with poppet valve toward gasket surface. (Applies to units where choke plate includes poppet valve.)
2. Insert the choke shaft and lever assembly (7) and close the choke. Spring of poppet valve should face air entrance.
3. With the choke plate closed, align hole in shaft with hole in choke plate. Lever should point toward bracket.
4. Center the choke plate in closed position and tighten the choke plate screw (1).

NOTE: DO NOT attempt to rivet threaded end of screw.

As an alternate method use a loctite type of screw lock, or equivalent.

5. Install a new fuel valve seat (22) and fiber washer (23), using C161-85 wrench.
6. Install fuel valve needle in seat (22), followed by float assembly (26) and float axle (27).

NOTE: Press float axle into center position from opposite of slotted side.

7. Invert the air intake assembly. With float lever resting on fuel valve needle, measure distance from machined surface of air intake body to top center of float. This dimension should be 1.484 inch. To increase or decrease distance between float and machined surface of air intake, use long-nosed pliers and bend float lever close to float body.

ASSEMBLY OF FUEL BOWL

1. Drive each of the four lead ball plugs (44) into plug channels until each plug is flush with surface of casting, using tool C161-19.

NOTE: Only one or two light blows are required to seal a lead ball plug in the channel. Avoid driving plugs in too deep, or fuel passages may become blocked.

2. Install the accelerating jet channel plug (36) and drive it into place with a light hammer.
3. Install a new accelerating pump check valve (38) in bottom of the pump cylinder, using tool C161-53, as follows:

- a. Place the check valve on formed end of tool and press firmly into counterbored area.

NOTE: Both pump and air vent check valves are identical.

- b. Turn the fuel bowl assembly upside down and start the check valve tool into pump cylinder with guide bar in pump rod passage. Press hard to start check valve into its seat.
- c. Invert the fuel bowl assembly, hold firmly in hand, and drive the check valve into its seat with a few sharp blows, using a light hammer. Be sure that the check valve bottoms completely.
4. Install the idle jet (34) in top surface of the fuel bowl (no gasket required).
5. Install the pump refill check valve ball (33), weight (32), retainer washer (31), and air vent check valve (30) as follows:
 - a. Drop the steel ball into vertical passage next to accelerating jet (37) in top surface of the fuel bowl assembly.
 - b. Drop the square weight (32) in on top of ball, then place brass retainer washer (31) in check valve counterbore on top of the weight.
 - c. Start the air vent check valve (30) evenly into counterbore on top of the retainer washer with finger pressure. Flat head of valve must face top surface of fuel bowl casting.

drive the check valve into place as far as the tool will permit.

NOTE: Check valve must seat evenly and must not be cocked at an angle.

6. Install the main jet (40) with fiber washer (41) in bottom of the fuel bowl and seat firmly with screwdriver.

NOTE: If carburetor includes an adjustable main jet, it will not have a main jet in the fuel bowl.

7. Install the main discharge jet (51) in passage in outside bottom of the fuel bowl, using C161-1 wrench.
8. Install the main jet plug (53) with fiber washer (52) in passage at outside bottom of the fuel bowl.
9. Install the well vent jet (39) in top surface of the fuel bowl assembly, using C161-80 wrench (no gasket required).
10. Install the accelerating pump piston and rod assembly (29) in the pump cylinder.

NOTE: The hair pin retainer should be installed in the same groove it was in originally. The pump guide rod has two grooves at the upper end to determine the length of the pump stroke. When a quarter stroke is required, the hair pin retainer is installed in the upper groove; and for half stroke, the bottom groove.

CHECK PUMP ACTION

To check the action of the accelerating pump, proceed as follows:

- a. Fill the carburetor fuel bowl with gasoline.
- b. Force the pump piston downward in the pump cylinder and note if the air vent check valve (30) leaks.
- c. Repeat this operation, noting if the pump check valve (38) leaks, allowing gasoline to be forced back into the fuel bowl through the channel leading from bottom of pump cylinder to the fuel bowl.
- d. Again, repeat operation and observe the discharge of fuel at the accelerating jet (37).

NOTE: Always make this check to insure that the accelerating pump is functioning properly.

ASSEMBLY OF THROTTLE BODY

NOTE: If the fit of the throttle shaft is sloppy in the throttle body, it will be necessary to either replace the throttle body and shaft assembly, or install new throttle shaft bushings to return the fit to factory specifications. A poorly fitting throttle shaft upsets the idle of the engine. DO NOT attempt to replace the throttle shaft bushings in the field unless the following tools are available: Counterbore Reamer, C161-73-2; Shaft Line Reamer, C161-71-3; and Bushing Drive, C161-72-3. The long shaft bushing is C9-56; the short shaft bushing is C9-55.

1. Install the throttle shaft and lever assembly (67) and throttle plate (56) in the throttle body (57).
2. Back out the throttle stop screw (66) and place the throttle body assembly on a bench with mounting flange side up.
3. Starting with the throttle shaft facing downward, rotate shaft so that threaded ends of hole face the idle port plug.
4. Insert the throttle plate in the throttle shaft (short side first). Center throttle plate and then rotate shaft counterclockwise to close.
5. Turn the throttle body over and start the screws (55) into the shaft, leaving screws loose. Make sure beveled sides of plate are next to throttle body bore. Tap the plate lightly to center it and then tighten the screws.

NOTE: DO NOT attempt to rivet threaded ends of screws. Use a loctite type of screw lock for the locking method.

6. Install the idle adjusting needle (20) and spring (21).

ASSEMBLY OF THROTTLE BODY, FUEL BOWL AND AIR INTAKE

1. Place venturi (50) in position in the fuel bowl assembly.
NOTE: The notch in the venturi fits over the discharge arm of the fuel bowl.
2. Place the throttle body to fuel bowl gasket (54) in position around the venturi.
NOTE: One hole in the gasket is reinforced with a metal ring. The idle channel bushing in the fuel bowl assembly should pass through this ring.
3. Install the pump lever (58), lockwasher (61), and nut (60), using C161-25 wrench.
NOTE: Pump lever should be mounted on throttle shaft so that the pump link hole is under the pump rod, and the lever is pointing upward when throttle is closed.

4. Assemble the throttle body to the fuel bowl assembly with two screws (48) and lockwashers (49).
5. Place the air intake gasket (28) on the fuel bowl and assemble air intake assembly to fuel bowl assembly with six screws (18) and lockwashers. Tighten the screws evenly and securely.
6. Install the large hex plug (15) in the top of the fuel bowl cover.
7. Hold the throttle lever in a closed position and turn throttle stop screw IN just to the point of contact with throttle body stop, then turn the screw IN 1½ additional turns as a preliminary adjustment.

PARTS LIST FOR 13366 SERIES CARBURETORS

* Reference Number	Part Name	* Reference Number	Part Name
1	Screw - choke plate	36	Plug - accelerating jet channel
2	Plate - choke	37	Jet - accelerating
7	Shaft and lever - choke	38	Valve - pump check
8	Screw - choke lever swivel	39	Jet - well vent
9	Screw - bracket assembly	40	Jet - main
11	Screw - tube clamp	41	Washer - main jet
12	Nut - tube clamp screw	44	Lead shot - channel plug
13	Bracket - choke	45	Plug - bowl drain
14	Body - air intake	46	Bowl - fuel
15	Plug - filter	47	Bushing - idle channel
16	Washer - filter plug	48	Screw - bowl to throttle body
17	Element - filter	50	Venturi
18	Screw - bowl to intake	51	Jet - discharge
20	Needle - idle adjusting	52	Washer - main passage plug
21	Spring - idle adjusting needle	53	Plug - main passage
22	Valve and seat - fuel	54	Gasket - bowl to body
23	Washer - fuel valve seat	55	Screw - throttle plate
26	Float	56	Plate - throttle
27	Axle - float	57	Body - throttle
28	Gasket - bowl to intake	58	Link - pump lever
29	Pump	60	Nut - pump lever assembly
30	Valve - air vent check	61	Lockwasher - pump lever
31	Retainer - weight	64	Lever - throttle
32	Weight - check ball	66	Screw - throttle stop
33	Ball - refill check	67	Shaft and lever - throttle
34	Jet - idle	69	Gasket - flange

*Used to identify parts on Fig. 6.

SPECIAL ZENITH TOOLS REQUIRED

C161-1	Main Discharge Wrench	C161-21	Extractor Tool (lead ball plug removal)
C161-5	Check Valve Tool	C161-53	Check Valve Tool (to assemble)
C161-15	Extractor Tool (channel plug removal)	C161-80	Well Vent Wrench
C161-19	Channel Plug Driver	C161-85	Fuel Valve Seat Wrench

FIG. 5

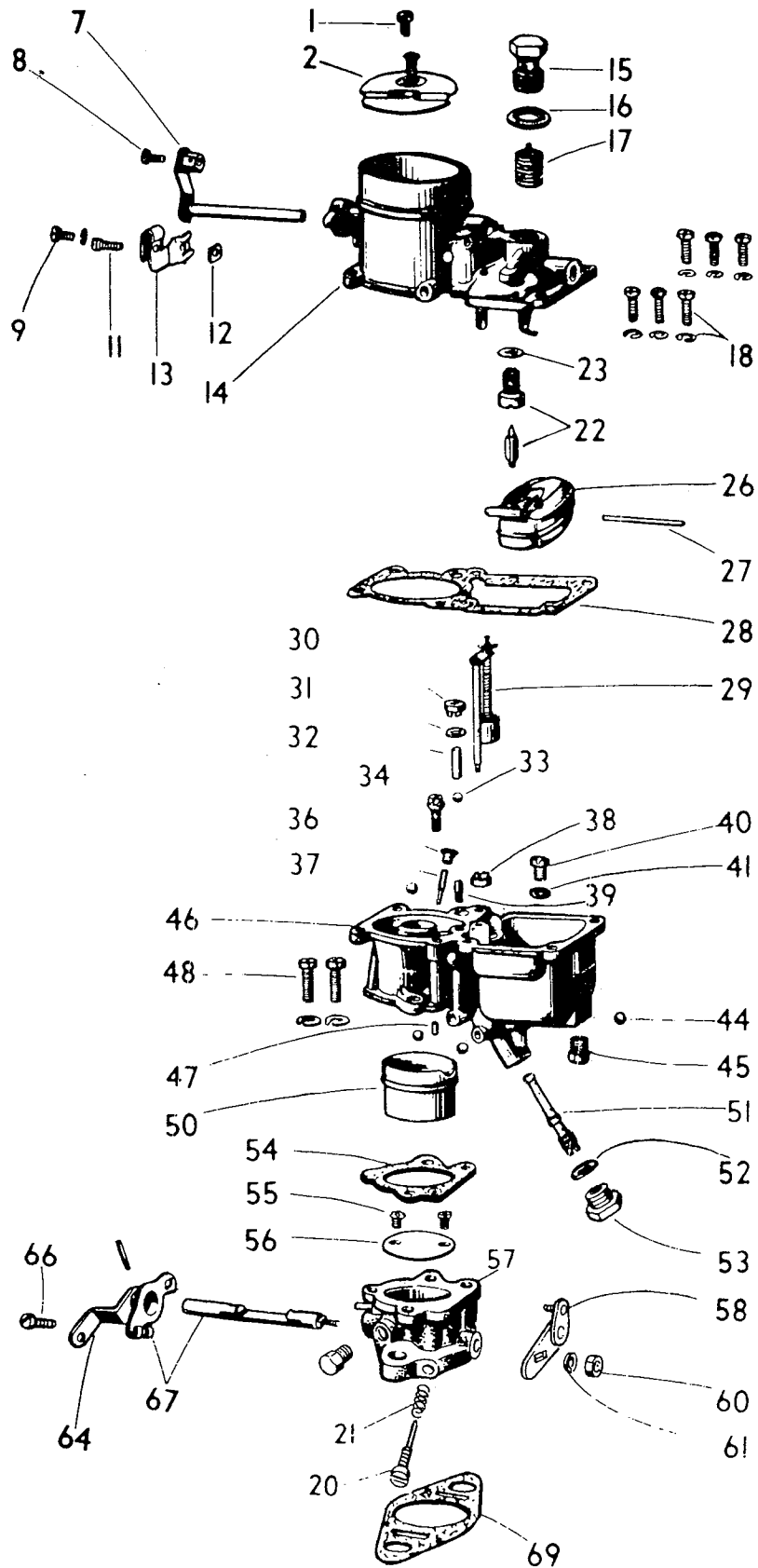


FIG. 6 Zenith 13366 Series Carburetors (Models 228 SAX9) (Typical)

PART 4 Charging System

COMPONENT INDEX	Page	COMPONENT INDEX	Page
DESCRIPTION AND OPERATION		ADJUSTMENTS	
Alternator	4-01	Belt Adjustments	4-06
DIAGNOSING AND TESTING		REMOVAL AND INSTALLATION	4-07
On Vehicle Tests	4-02	OVERHAUL	4-07
Bench Tests	4-05		

DESCRIPTION AND OPERATION

ALTERNATOR

The Alternator charging system is a negative ground system, and consists of an alternator, a regulator, a charge indicator, a storage battery, and associated wiring.

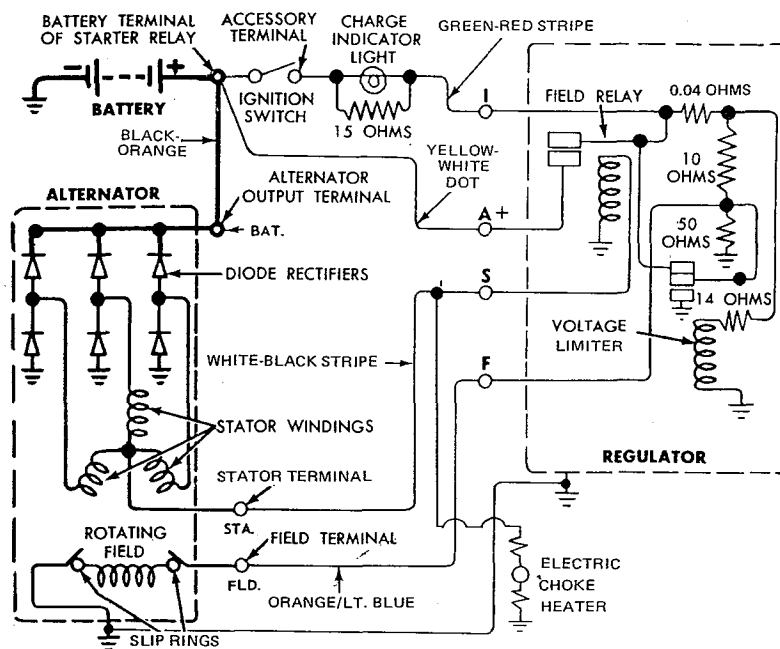
The alternator is belt driven from the engine. Current is supplied from the alternator-regulator system to the rotating field of the alternator through two brushes to two slip rings.

The alternator produces power in the form of alternating current. The alternating current is rectified to direct current by six diodes. The alternator regulator automatically adjusts the alternator field current to maintain the alternator output voltage within prescribed limits to correctly charge the battery.

If a charge indicator lamp is used in the charging system (Figure 1), the system operation is as follows: When the ignition switch is turned ON, a small electrical current flows through the lamp filament (turning the lamp ON) and

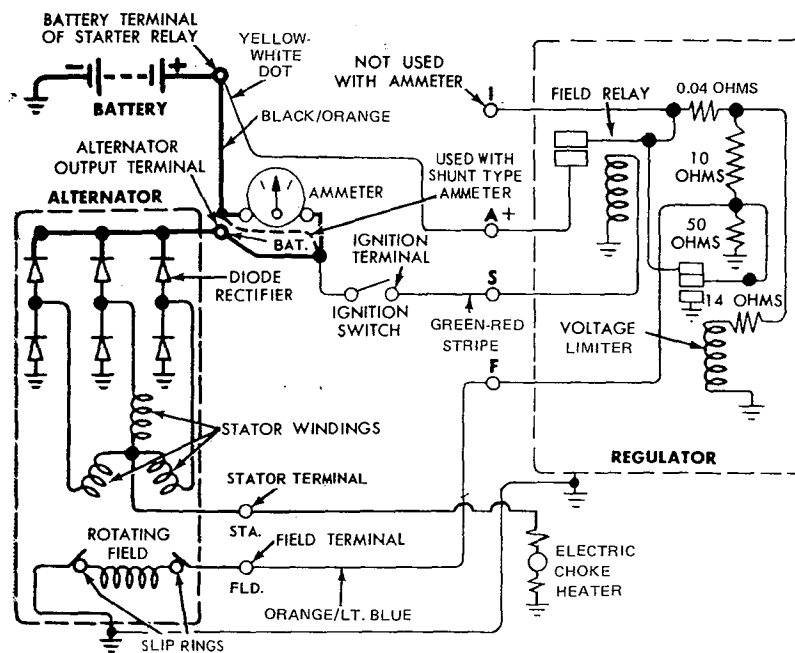
through the alternator regulator to the alternator field. When the engine is started, the alternator field rotates and produces a voltage in the stator winding. When the voltage at the alternator stator terminal reaches about 3 volts, the regulator field relay closes. This puts the same voltage potential on both sides of the charge indicator lamp causing it to go out. When the field relay has closed, current passes through the regulator A terminal and is metered to the alternator field.

If an ammeter is used in the charging system (Figure 2), the regulator I terminal and the alternator stator terminal are not used. When the ignition switch is turned ON, the field relay closes and electrical current passes through the regulator A terminal and is metered to the alternator field. When the engine is started, the alternator field rotates causing the alternator to operate. The ammeter indicates current flow into (charge) or out of (discharge) the vehicle battery.



J1210-L

FIG. 1 Alternator Charging System — Indicator Light



J1205-K

FIG. 2 Alternator Charging System — Ammeter

DIAGNOSING AND TESTING

Certain tests outlined are illustrated in the schematic and in pictorial form. The schematic illustrates the internal connections of the Rotunda equipment so these connections can be duplicated when this equipment is not available. The various circuits involved in the tests can be selected by means of switches without the necessity of changing connections when the illustrated equipment is used. This reduces the time required to test units and circuits on the vehicle.

Where applicable, the tests are divided into On The Vehicle and On the Test Bench procedures. Either procedure can be followed depending on the equipment available for the tests.

Troubleshooting or diagnosis is required before actual repairs can be made in the electrical system. Even where an obvious fault makes the replacement of a unit necessary, you must still find out why the unit failed. When a trouble is diagnosed correctly, unnecessary repairs are prevented, the time the vehicle is out of service will be decreased, and the repairs that are made will be permanent.

ON VEHICLE TESTS

Before performing charging system tests on the vehicle, note the complaint such as: slow cranking, battery dead or using an excessive amount of water, top of battery wet, ammeter shows charge at all times and/or no charge, alternator warning lamp does not come on and/or never goes out. This information will aid in isolating the part of the system causing the problem. The battery must be in proper state of charge (at least 1.200 specific gravity).

Visual Inspection

1. Check the battery posts and battery cable terminals for clean and tight connections. Remove the battery cables (if corroded), clean and install them securely.
2. Check for clean and tight wiring connections at the alternator, regulator and engine.
3. Check the alternator belt tension and tighten to specification (if necessary).

INDICATOR LIGHT-ALTERNATOR CHARGING SYSTEM

Normal Charge Indicator

With Ignition switch off . . . Alternator lamp is off.

With Ignition switch on (engine not running) . . . Alternator lamp is on.

With Ignition switch on (engine running) . . . Alternator lamp is off.

1. If the charge indicator lamp does not come on with the ignition key in the ON position and the engine not running, check the I wiring circuit for an open circuit or burned out charge indicator lamp (ignition switch to regulator I terminal).
2. If the charge indicator light does not come on, disconnect the wiring plug connector at the regulator and connect a jumper wire from the I terminal of the regulator wiring plug to the negative battery post cable clamp.
3. The charge indicator lamp should go on with the ignition key turned to the ON position.
4. If the charge indicator bulb does not go on, check the bulb for continuity and replace (if burned out).

5. If the bulb is not burned out, an open circuit exists between the ignition switch and the regulator.

A good indication of a problem in the I wiring circuit (ignition switch to regulator I terminal) will show when the charge indicator light goes out with high engine rpm. This is caused by an open circuit in the 15 ohm resistor wire (connected in parallel with the indicator light) generally at the terminal point (either end of the resistor wire).

AMMETER-ALTERNATOR CHARGING SYSTEM

Normal Charge Indicator

With ignition switch off and no electrical load . . . Ammeter should show 0 or center scale.

With ignition switch on engine running . . . Needle deflects towards charge and returns toward center scale in two steps (fully charged battery).

With ignition switch off and lights on . . . Ammeter should show between 0 and discharge scale.

Tests Using a Voltmeter

When performing charging system tests with a voltmeter, turn OFF all lights and electrical components. Place the transmission in neutral and apply the parking brake. The battery must be charged to at least 1.200 specific gravity before starting the test.

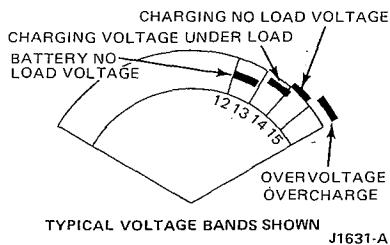


FIG. 3 Voltmeter Test Scale

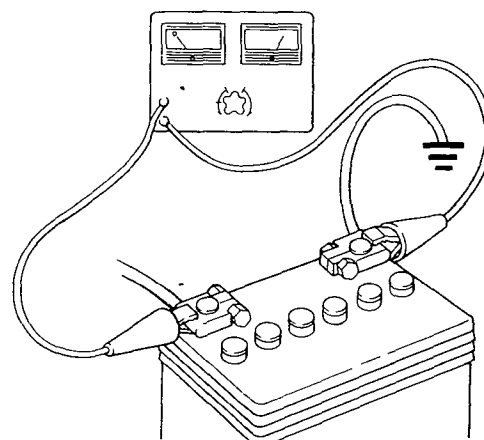
Voltmeter Test Procedure

1. Connect the negative lead of the voltmeter to the negative battery cable clamp (not bolt or nut), and the positive lead of the voltmeter to the positive battery cable clamp (not bolt or nut) (Figure 4).
2. Record the battery voltage reading shown on the voltmeter scale.
3. Connect the red lead of a tachometer to the distributor terminal of the coil and the black tachometer lead to a good ground.
4. Then, start the engine and operate the engine at approximately 1500 rpm. With no other electrical load the voltmeter reading should increase 1 volt and not exceed 2 volts above the first recorded battery voltage reading. The reading should be taken when the voltmeter needle stops moving.
5. With the engine running, turn on all the electric equipment.
6. Increase the engine speed to 2000 rpm. The voltmeter should indicate a minimum of 0.5 volt above the first recorded battery voltage (Figure 3).

If the above tests indicate proper voltage readings, the charging system is operating normally. Proceed to Test Results if a problem still exists.

Test Results

1. If the voltmeter reading indicates over voltage (more than 2.0 volts above battery voltage), stop the engine and check the ground connections between the regulator and



VOLTMETER CONNECTIONS - TO BATTERY

K2628-A

FIG. 4 Voltmeter-to-Battery Connections

alternator and/or regulator to engine. Clean and tighten connections securely and repeat the Voltmeter Test Procedure.

2. If over voltage condition still exists, disconnect the regulator wiring plug from the regulator and repeat the Voltmeter Test Procedure.
3. If over voltage condition disappears (voltmeter reads battery voltage), replace voltage regulator and repeat the voltmeter test procedure.
4. If over voltage still exists with the regulator wiring plug disconnected, repair the short in the wiring harness between the alternator and regulator. Then, replace the regulator and connect the regulator wiring plug to the regulator and repeat the Voltmeter Test Procedure.
5. If the voltmeter reading does not increase (one volt), check for the presence of battery voltage at the alternator BAT terminal and the regulator A terminal. Repair the wiring if no voltage is present at these terminals, and repeat the Voltmeter Test Procedure.
6. If the voltmeter reading does not increase one volt above battery voltage, proceed to the next step before performing other tests, the field circuit (regulator plug to alternator) must be checked for a grounding condition. If the field circuit is grounded and the jumper wire is used as a check at the regulator wiring plug from the A to F terminals (Figure 5), excessive current will cause heat damage to the regulator wiring plug terminals and may burn the jumper wire (Figure 5). Also, if the field circuit was grounded, the connector wire inside the regulator will be burned open and an under voltage condition will result.
8. The field circuit should be checked with the regulator wiring plug disconnected and an ohmmeter connected from the F terminal of the regulator wiring plug to the battery ground. The ohmmeter should indicate between 4 and 250 ohms (Figure 6).
9. A check for the regulator burned-open wire is made by connecting an ohmmeter from the I to F terminals of the regulator (Figure 7). The reading should indicate 0 (no resistance). If the reading indicates approximately 10 ohms, the connector wire inside the regulator is open. **The field circuit grounded condition must be found and repaired before installing a new regulator.**

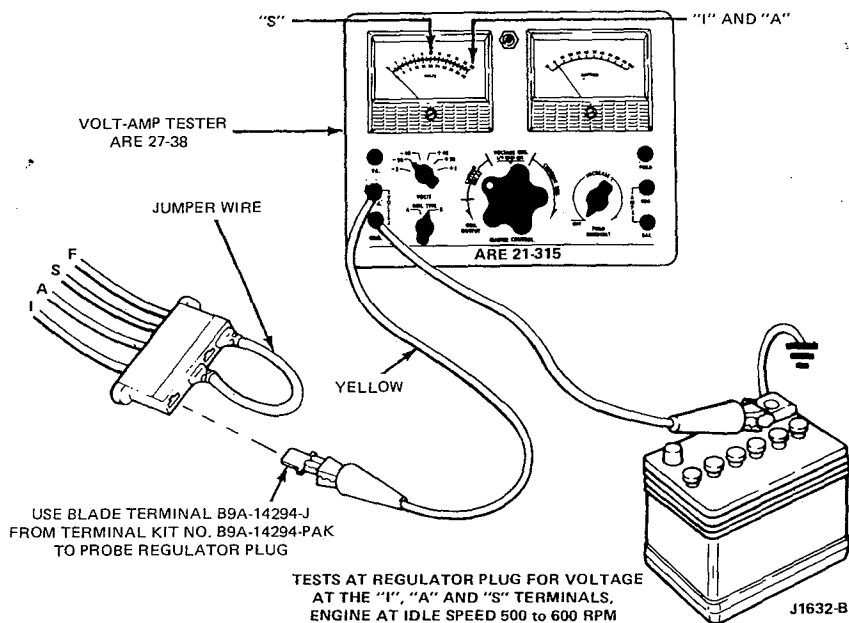


FIG. 5 Regulator Plug Voltage Tests

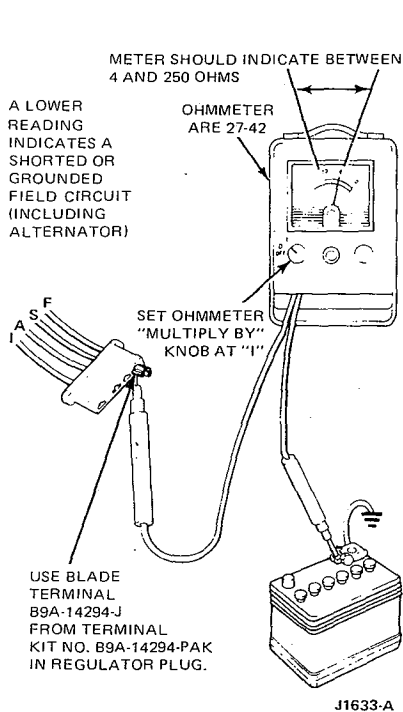


FIG. 6 Field Circuit Test

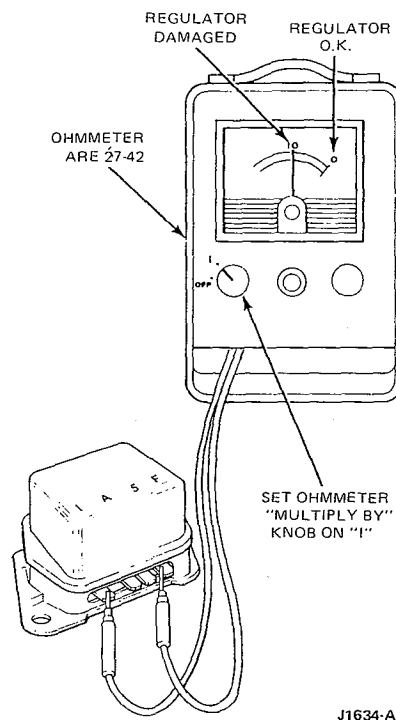


FIG. 7 Regulator Burned-Open Connector Wire Test

Field Circuit and Alternator Tests

1. If the field circuit is satisfactory, disconnect the regulator wiring plug at the regulator and connect the jumper wire from the A to the F terminals on the regulator wiring plug (Figure 5).
2. Repeat the Voltmeter Test Procedure.
3. If the Voltmeter Test Procedure still indicates a problem (under voltage), remove the jumper wire from the regulator plug and leave the plug disconnected from the regulator. Then, connect a jumper wire to the FLD and BAT terminals on the alternator (Figure 8).
4. Repeat the Voltmeter Test Procedure.
5. If the Voltmeter Test results are now satisfactory, repair the wiring harness from the alternator to the regulator. Then, **remove the jumper wire at the alternator** and connect the regulator wiring plug to the regulator.
6. Repeat the Voltmeter Test Procedure, to be sure the charging system is operating normally.
7. If the Voltmeter Test results still indicate (under voltage), repair or replace the alternator. With the jumper wire removed, connect the wiring to the alternator and regulator.
8. Repeat the Voltmeter Test Procedure.

Regulator I and S Circuit Tests**S — Circuit with Ammeter**

1. Connect the positive lead of the voltmeter to the S terminal of the regulator wiring plug (Figure 5). Then, turn the ignition switch to the ON position. Do not start the engine.
2. The voltmeter reading should indicate battery voltage.
3. If there is no voltage reading, disconnect the positive voltmeter lead from the positive battery clamp and repair the S wire lead from the ignition switch to the regulator wiring plug.
4. Connect the positive voltmeter lead to the positive battery cable terminal, connect regulator wiring plug to regulator and repeat the Voltmeter Test Procedure.

S and I Circuit — With Indicator Light

1. Disconnect the regulator wiring plug and install a jumper wire between the A and F terminals.
2. With the engine idling, connect the positive lead of the voltmeter to the S terminal and then to the I terminal of the regulator wiring plug (Figure 5). The voltage of the S circuit should read approximately 1/2 of the I circuit.
3. If no voltage is present, repair the alternator or the wiring circuit at fault. Reconnect the positive voltmeter lead to the positive battery cable terminal.
4. If the above circuit tests are satisfactory, install a new regulator.
5. Then, remove the jumper wire from the regulator wiring plug and connect the wiring plug to the regulator. Repeat the Voltmeter Test Procedure.

Diode Test — On Vehicle

1. Disconnect voltage regulator wiring plug.
2. Connect a jumper between "A" and "F" terminal of voltage regulator wiring plug.

3. Connect voltmeter to battery cable clamps.
4. Start engine — let engine run at idle.
5. Read and record voltmeter reading.
6. Move positive voltmeter lead to "S" terminal in voltage regulator wiring plug.
7. Note voltmeter reading.

Test Results

1. If voltmeter reads 1/2 of battery voltage, diodes are okay.
2. If voltmeter reads approximately 1.5 volts, alternator has shorted **negative** diode, or a grounded stator winding.
3. If voltmeter reads approximately 1.5 volts less than battery voltage, alternator has shorted **positive** diode.
4. If voltmeter reads about 1.0 to 1.5 volts less than 1/2 battery voltage, alternator has an **open positive** diode.
5. If voltmeter reads about 1.0 to 1.5 volts more than 1/2 battery voltage, alternator has an **open negative** diode.

BENCH TESTS**RECTIFIER SHORT OR GROUNDED AND STATOR GROUNDED TEST — ON BENCH**

These tests are performed with an ARE 27-42 ohmmeter. Set the Multiply By knob at 10, and calibrate the ohmmeter as directed inside the instrument cover.

Contact one ohmmeter probe to the alternator BAT terminal and the other probe to the STA terminal. Then, reverse the ohmmeter probes and repeat the test. A reading of about 60 ohms should be obtained in one direction and no needle movement with the probes reversed. A reading in both directions indicates a bad positive diode, a grounded positive diode plate or a grounded BAT terminal.

Perform the same test using the STA and GND (ground) terminals of the alternator. A reading in both directions indicates either a bad negative diode, a grounded stator

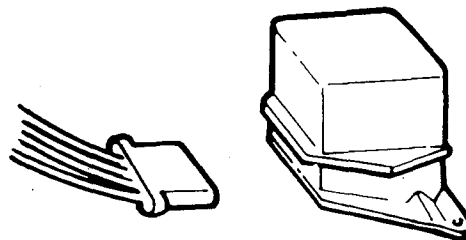
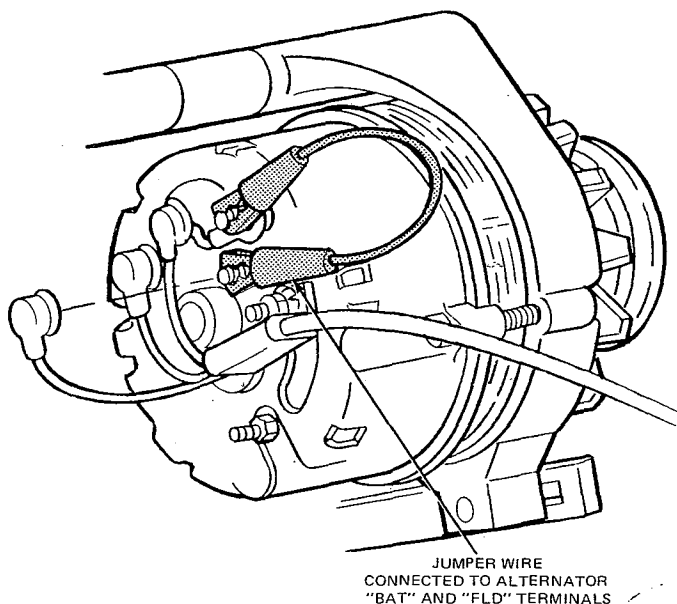


FIG. 8 Jumper Wire Connections

winding, a grounded stator terminal, a grounded positive diode plate, or a grounded BAT terminal.

Infinite readings (no needle movement) in all four probe positions in the preceding tests indicates an open STA terminal lead connection inside the alternator.

FIELD OPEN OR SHORT CIRCUIT TEST — ON BENCH

This test is performed with an ohmmeter (Tool ARE 27-42). Set the ohmmeter Multiply By knob at 1 and calibrate the ohmmeter as directed inside the instrument cover.

Contact the alternator field terminal with one probe and the ground terminal with the other probe. Then, spin the alternator pulley. The ohmmeter reading should be between 4 and 250 ohms, and should fluctuate while the pulley is turning. An infinite reading (no meter movement) indicates an open brush lead, worn or struck brushes, or a bad rotor assembly. An ohmmeter reading less than 4 ohms indicates a grounded brush assembly, a grounded field terminal or a bad rotor.

DIODE TEST — ON BENCH

Remove the rectifier assembly from the alternator as outlined under Disassembly. Set the ohmmeter Multiply By knob at 10 and calibrate the meter as directed inside the cover.

To test one set of diodes, contact one probe to the terminal bolt as shown in Figure 9 and contact each of the three stator lead terminals with the other probe. Reverse the probes and repeat the test. All diodes should show a low reading of about 60 ohms in one direction, and an infinite reading (no needle movement) with the probes reversed. Repeat the preceding tests for the other set of diodes except that the other terminal screw is used.

If the meter readings are not as specified, replace the rectifier assembly.

STATOR COIL OPEN OR GROUNDED TEST — ON BENCH

These tests are made to determine if the stator coil is operating properly. Disassemble the stator from the alternator as outlined under Disassembly.

Set the ARE 27-42 ohmmeter Multiply By knob at 1, and calibrate the meter as directed inside the cover. Connect the ohmmeter probes between each pair of stator leads (3 different ways). The ohmmeter must show equal readings for each pair of stator leads. Replace the stator if the readings are not the same.

Set the ARE 27-42 ohmmeter Multiply By knob at 1000. Connect the ohmmeter probes to one of the stator leads and to the stator laminated core. Be sure that the probe makes a good electrical connection with the stator core. The meter should show an infinite reading (no meter movement). If the meter does not indicate an infinite reading (no meter movement), the stator winding is shorted to the core and must be replaced. Repeat this test for each of the stator leads.

ROTOR OPEN OR SHORT CIRCUIT TEST — ON BENCH

Disassemble the front housing and rotor from the rear housing and stator as outlined under Disassembly. Set the ohmmeter (ARE 27-42) Multiply By knob at 1 and calibrate the meter as directed inside the ohmmeter cover.

Contact each ohmmeter probe to a rotor slip ring. The meter reading should be 4 or 5 ohms. A higher reading indicates a damaged slip ring solder connection or a broken wire. A lower reading indicates a shorted wire or slip ring. Replace the rotor if it is damaged cannot be repaired.

Contact one ohmmeter probe to a slip ring and the other probe to the rotor shaft. The meter reading should be infinite (no deflection). A reading other than infinite indicates the rotor is shorted to the shaft. Inspect the slip ring soldered terminals to be sure they are not bent and touching the rotor shaft, or that excess solder is grounding the rotor coil connections to the shaft. Replace the rotor if it is shorted and cannot be repaired.

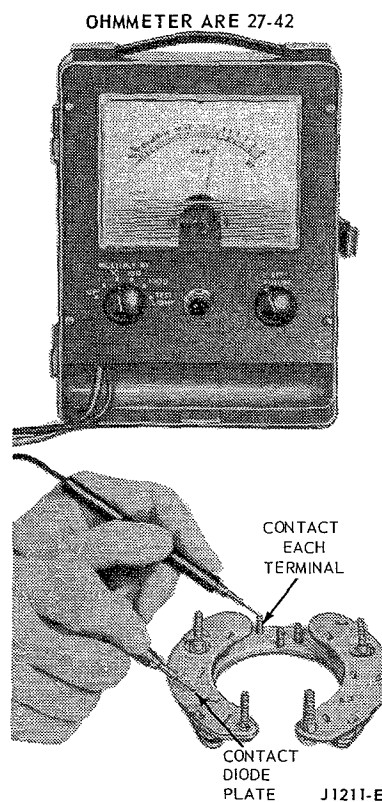


FIG. 9 Diode Test — Rear Terminal Alternator

ADJUSTMENTS

BELT ADJUSTMENTS

1. Check the belt tension with Tool T63L-8620-A. The belt should be within specifications (Specifications Section).
2. If the belt is not within specification, loosen the alternator mounting bolt to a snug position and loosen the adjusting arm bolts.
3. Apply pressure on the alternator front housing only and tighten the adjusting arm to alternator bolt.
4. Check the belt tension using Tool T63L-8620-A. Adjust the belt for specified tension.
5. Tighten all mounting bolts.

REMOVAL AND INSTALLATION

Removal

1. Disconnect the battery ground cable.
2. Loosen the alternator mounting bolts and remove the adjustment arm-to-alternator attaching bolt.
3. Remove the electrical connectors from the alternator.
4. Disengage the alternator belt. Remove the alternator mounting bolt, and remove the alternator.

Installation

1. Install the alternator wiring harness. Position the alternator to the engine, and install the spacer (if used) and the alternator mounting bolt. Tighten the bolt only finger tight.
2. Install the adjustment arm-to-alternator attaching bolt.
3. Position the belt on the pulley and adjust the belt tension using Tool T63L-8620-A. Apply pressure on the alternator front housing only, when tightening the belt. Tighten the adjusting arm bolt and the mounting bolt.
4. Connect the battery ground cable.

OVERHAUL

Disassembly

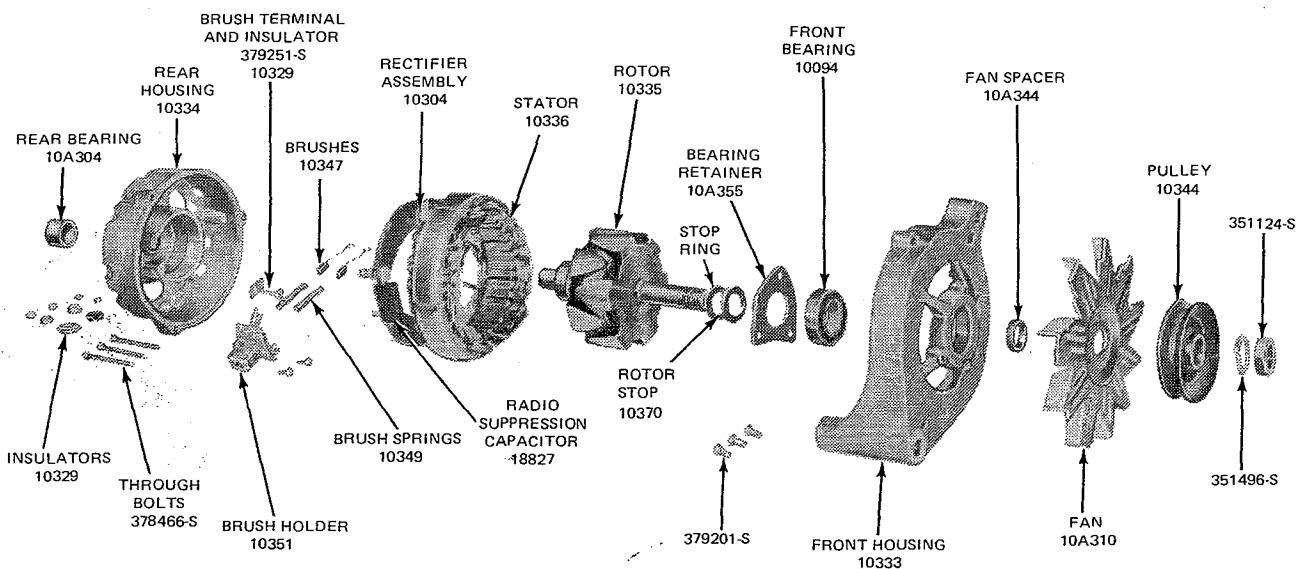
Figure 10 shows a disassembled view of the alternator.

1. Mark both end housings and the stator with a scribe mark for assembly.
2. Remove the three housing through bolts.
3. Separate the front housing and rotor from the stator and rear housing.
4. Remove all the nuts and insulators from the rear housing and remove the rear housing from the stator and rectifier assembly.
5. Remove the brush holder mounting screws and remove the holder, brushes, brush springs, insulator and terminal.
6. If replacement is necessary, press the bearing from the rear housing supporting the housing on the inner boss.
7. If the rectifier assembly is being replaced, unsolder the stator leads from rectifier terminals, and separate the

stator from the rectifier assembly. Use a 100-watt soldering iron.

8. Original production alternators will have one of three types of rectifier assembly circuit boards (Figure 11); one has the circuit board spaced away from the diode plates with the diodes exposed. Another type is a single circuit board with built-in diodes. The third type circuit board has built-in diodes with an additional booster diode plate containing two diodes. This circuit board is used only in the 61-ampere alternator.

If the alternator rectifier has an exposed board, remove the screws from the rectifier by rotating the bolt heads 1/4 turn clockwise to unlock them and then remove the screws (Figure 11). Push the stator terminal straight out on a rectifier with the diodes built into the circuit board (Figure 11). Avoid turning the screw while removing, to make certain that the straight knurl will engage the in-



J1166-K

FIG. 10 Disassembled Alternator

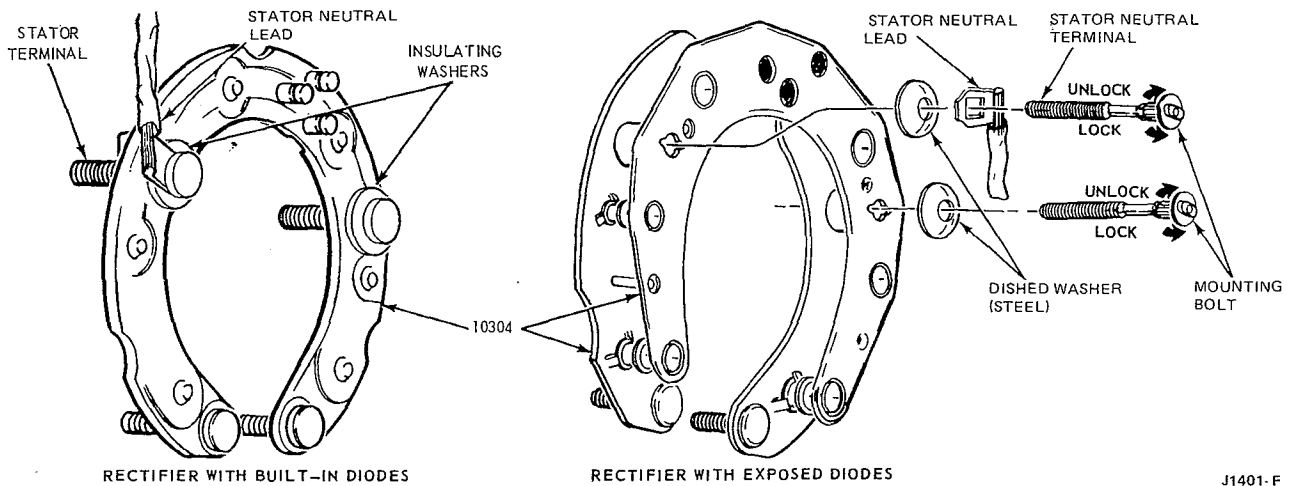


FIG. 11 Rectifier Assembly

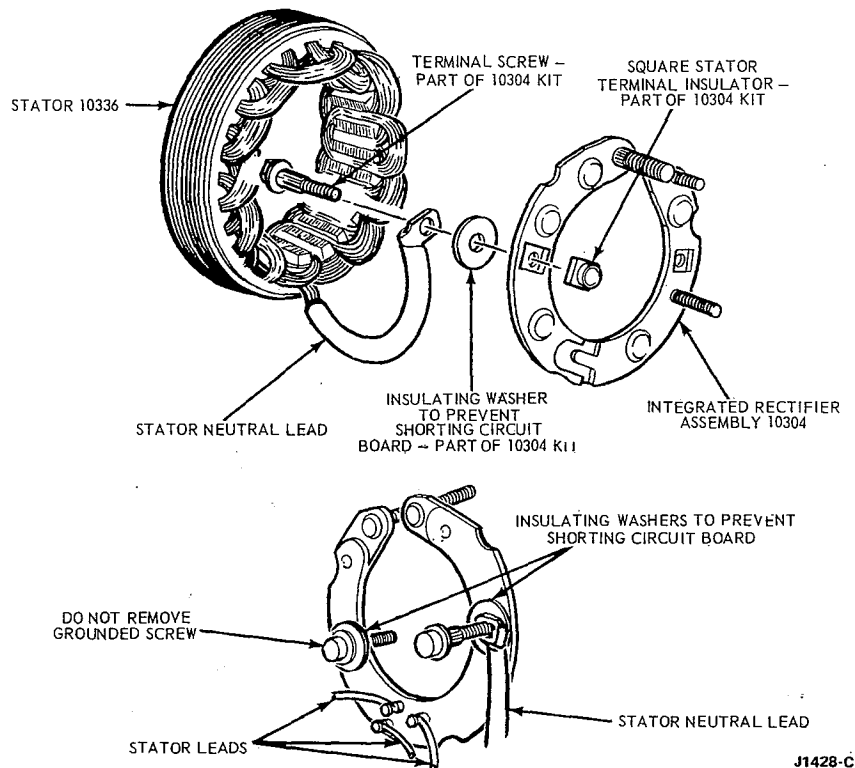


FIG. 12 Stator Terminal Installation — Integral Rectifier Circuit Board

ulators when installing. Do not remove the grounded screw (Figure 12).

9. Remove the drive pulley nut with the tool shown in Figure 13; then, pull the lock washer, pulley, fan, fan spacer, rotor and rotor stop from the rotor shaft.
10. Remove the three screws that hold the front end bearing retainer, and remove the retainer. If the bearing is damaged or has lost its lubricant, support the housing close to the bearing boss, and press out the old bearing from the housing.
11. Perform a diode test and a field open or short circuit test (Refer to Testing in this Part).

Assembly

1. The rotor, stator and bearings must not be cleaned with solvent. Wipe these parts off with a clean cloth.
2. Press the front bearing in the front housing bearing boss (put pressure on the bearing outer race only), and install the bearing retainer (Figure 10).
3. If the stop-ring on the rotor drive shaft was damaged, install a new stop-ring. Push the new ring on the shaft and into the groove. **Do not open the ring with snap ring pliers as permanent damage will result.**
4. Position the rotor stop on the drive shaft with the recessed side against the stop-ring.

- Position the front housing, fan, spacer, fan, pulley and lock washer on the drive shaft and install the retaining nut. Tighten the retaining nut with the tool shown in Figure 13 to the specified torque.

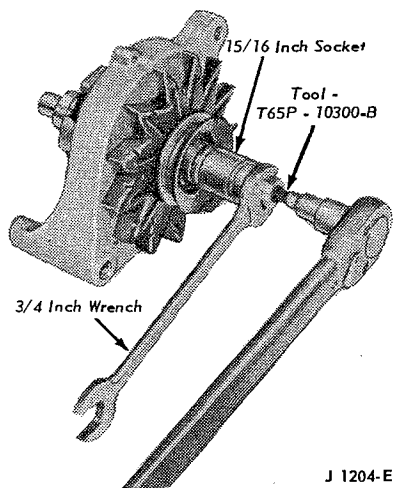


FIG. 13 Pulley Removal

- If the rear housing bearing was removed, support the housing on the inner boss and press in a new bearing flush with the outer end surface.
- Place the brush springs, brushes, brush terminal and terminal insulator in the brush holder and hold the brushes in position by inserting a piece of stiff wire in the brush holder as shown in Figure 14.
- Position the brush holder assembly in the rear housing and install the mounting screws. Position the brush leads in the brush holder as shown in Figure 15.
- Wrap the three stator winding leads around the rectifier terminals and solder them. Use a 100-watt soldering iron and rosin-core solder. Position the stator neutral lead eyelet on the stator terminal screw and install the screw in the rectifier assembly (Figure 16).
- For a rectifier with the diodes exposed, insert the special screws through the wire lug, dished washers and circuit board (Figure 11). Turn them 1/4 turn coun-

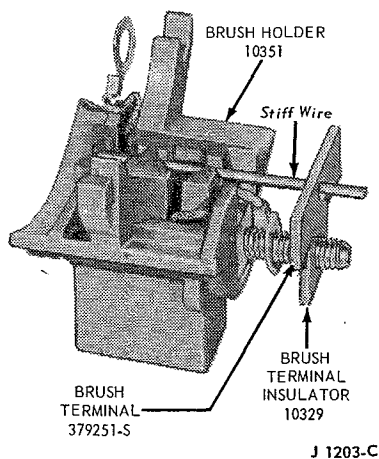


FIG. 14 Brush Holder Assembly

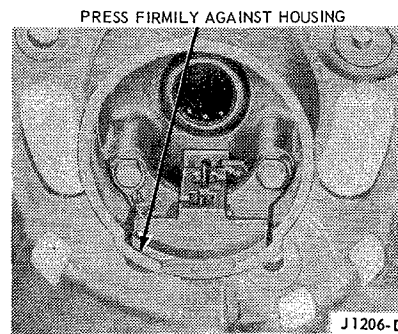


FIG. 15 Brush Lead Positions

terclockwise to lock them. For single circuit boards with built-in diodes, insert the screws straight through the wire lug, insulating washer and rectifier into the insulator (Figure 12).

The dished washers are to be used only on the circuit board with exposed diodes (Figure 11). If they are used on the single circuit board, a short circuit will occur. A flat insulating washer is to be used between the stator terminal and the board, when a single circuit board is used (Figure 12).

- Position the radio noise suppression capacitor on the rectifier terminals. On the circuit board with exposed diodes, install the STA and BAT terminal insulators (Figure 16). On the single circuit board, position the square hole in the rectifier assembly (Figure 12). Position the BAT terminal insulator (Figure 17) on the BAT terminal.

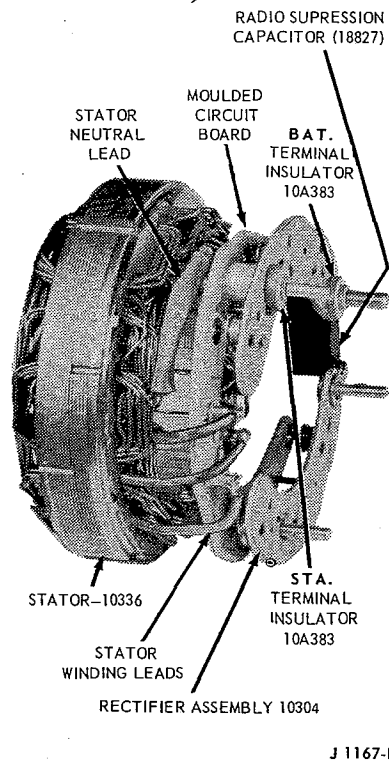


FIG. 16 Stator Lead Connections

Position the stator and rectifier assembly in the rear housing. Make certain that all terminal insulators are seated properly in their recesses. Position the STA (black), BAT (red), and FLD (orange) insulators, on the terminal bolts, and install the retaining nuts (Figure 18).

12. Wipe the rear end bearing surface of the rotor shaft with a clean lint-free rag.
13. Position the rear housing and stator assembly over the rotor and align the scribe marks made during disassembly. Seat the machined portion of the stator core into the step in both end housings. Install the housing through bolts. Remove the brush retracting wire, and put a daub of water-proof cement over the hole to seal it.

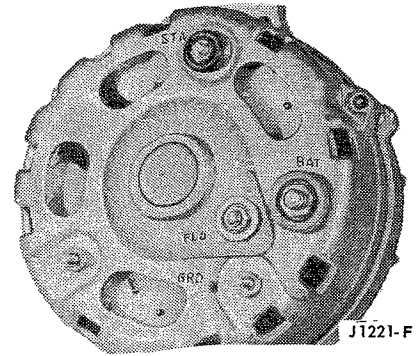


FIG. 18 Alternator Terminal Locations

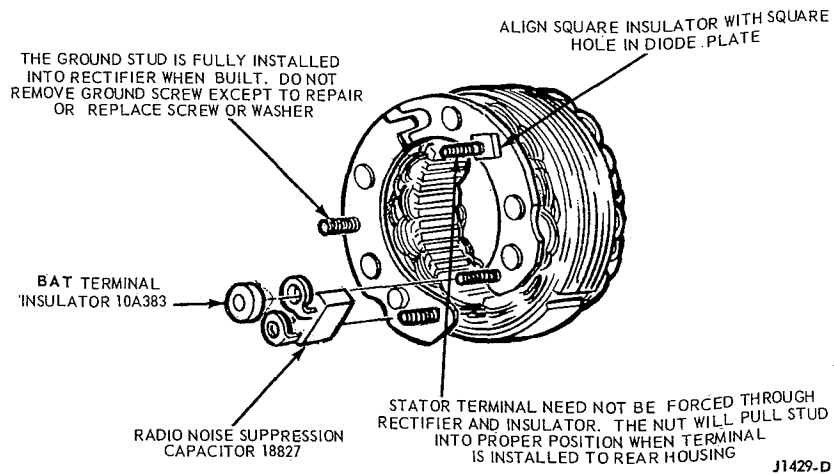


FIG. 17 Terminal Insulators — Fiber-Glass Circuit Board

PART 5 Starting System

COMPONENT INDEX	Page	COMPONENT INDEX	Page
DESCRIPTION	5-01	REMOVAL AND INSTALLATION	5-04
OPERATION	5-01	OVERHAUL	
TESTING		Disassembly	5-04
Road Service	5-01	Cleaning and Inspection	5-05
On Vehicle Testing	5-02	Brush Replacement	5-05
Bench Tests	5-02	Assembly	5-05

DESCRIPTION

The starter is a four pole, four brush motor with a series field and a solenoid operated roller clutch drive.

This starter motor features a face-type moulded commutator assembly on the end face of the armature.

A fully insulated brush holder assembly consisting of wedge shaped brushes and coil type springs assembled into a plastic moulded brushbox is riveted to the brush end plate. The brushes are provided with a keyway to ensure correct fitting, and the springs are held captive in the moulded brushbox.

The end play is controlled at the commutator end by a

thrust plate and a required number of shims, which are assembled on the armature shaft extension and held in place by a cotter pin.

The solenoid assembly is mounted to a flange on the starter drive housing. The entire shift lever mechanism and the solenoid plunger are enclosed in the drive housing, thus protecting them from exposure to dirt and road splash.

The solenoid incorporates two windings, a pull-in winding and a hold-in winding. Together they provide sufficient magnetic attraction to pull the solenoid plunger into the solenoid.

OPERATION

Engine cranking occurs when the starter solenoid on the starter is energized through the starter control (ignition) switch. When energized, the solenoid shifts the starting motor pinion into mesh with the engine flywheel ring gear.

Simultaneously, the main contacts of the solenoid are closed and battery current is directed to the starting motor causing the armature to rotate.

After the engine starts, the starter drive is disengaged when the ignition switch is returned from the start to the on

or run position. This opens the circuit to the starter solenoid and the solenoid return spring causes the shift lever to disengage the starter drive from the engine flywheel ring gear.

The starting motor is protected from excessive speed by an overrunning clutch incorporated in the starter drive assembly. The overrunning clutch permits the drive pinion gear to rotate faster than the armature thus disengaging itself from the engine flywheel ring gear when the engine starts.

TESTING

ROAD SERVICE

On road service calls, connect a booster battery to the system for cases of a starter that will not crank the engine or a starter that cranks the engine very slowly. If the starter does not turn the engine over, even with the booster battery attached, refer to the following tests. **Be certain that correct battery polarity is observed when using a booster battery; positive to positive, and negative to negative connection of the auxiliary cables.**

ON VEHICLE TESTING

STARTER CRANKING CIRCUIT TEST

These tests will determine whether or not there is excessive resistance in the cranking circuit. Make each test connection as shown in Figure 1. While cranking the engine, observe the voltage drop reading for each test. **Disconnect and ground the high tension lead from the ignition coil to prevent the engine from starting. Connect a remote control switch between the battery terminal of the starter relay and**

the S terminal of the relay.

The voltage drop in the circuit will be indicated by the voltmeter (0 to 2 volt range). Maximum allowable voltage drop should be:

1. With the voltmeter negative lead connected to the starter terminal and the positive lead connected to the battery positive terminal (Figure 1, connection No. 1) 0.5 volt.
2. With the voltmeter negative lead connected to the starter terminal and the positive lead connected to the battery terminal of the starter solenoid (Figure 1, connection No. 2) 0.3 volt.
3. With the voltmeter negative lead connected to the battery terminal of the starter solenoid and the positive lead connected to the positive terminal of the battery (Figure 1, connection No. 3) 0.2 volt.
4. With the voltmeter negative lead connected to the negative terminal of the battery and the positive lead connected to the engine ground (Figure 1, connection No. 4) 0.1 volt.

STARTER LOAD TEST

Connect the test equipment as shown in Figure 2. Be sure that no current is flowing through the ammeter and heavy-duty carbon pile rheostat portion of the circuit (rheostat at maximum counterclockwise position).

Crank the engine with the ignition OFF, and determine the exact reading on the voltmeter. This test is accomplished by disconnecting and grounding the high tension lead from the ignition coil, and by connecting a jumper from the battery terminal of the starter solenoid to the ignition switch S terminal of the solenoid.

Stop cranking the engine, and reduce the resistance of the carbon pile until the voltmeter indicates the same reading as that obtained while the starter cranked the engine. The ammeter will indicate the starter current draw under load.

STARTER SOLENOID TEST

If the solenoid does not pull in, in the Starter Load Test, measure the voltage between the starter-mounted solenoid switch terminal and ground with the ignition switch closed.

If the voltage is 10 or more volts, a worn or damaged solenoid is indicated. Remove the starter assembly for solenoid replacement.

BENCH TESTS

STARTER NO-LOAD TEST

The starter no-load test will uncover such faults as open or shorted windings, rubbing armature, and bent armature shaft. The starter can be tested, at no-load, on the test bench only.

Make the test connections as shown in Figure 3. The starter will run at no-load. Be sure that no current is flowing through the ammeter (rheostat at maximum counterclockwise position). Determine the exact reading on the voltmeter.

Disconnect the starter from the battery, and reduce the resistance of the rheostat until the voltmeter indicates the same reading as that obtained while the starter was running. The ammeter will indicate the starter no-load current draw.

ARMATURE OPEN CIRCUIT TEST

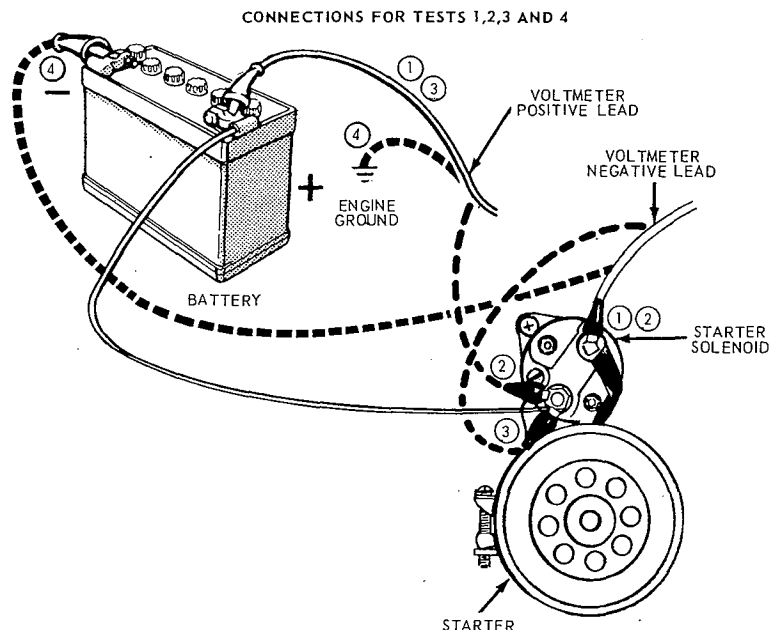
An open circuit armature may sometimes be detected by examining the commutator for evidence of burning. A spot burned on the commutator is caused by an arc formed every time the commutator segment, connected to the open circuit winding, passes under a brush.

ARMATURE AND FIELD GROUNDED CIRCUIT TEST

This test will determine if the winding insulation has failed, permitting a conductor to touch the frame or armature core.

To determine if the armature windings are grounded, make the connections as shown in Figure 4. If the volt meter indicates any voltage, the windings are grounded.

Grounded field windings can be detected by first disconnecting the grounded end of the winding where it terminates at the frame, then making the connections as shown in Figure 5. If the voltmeter indicates any voltage, the field windings are grounded.



J1413-B

FIG. 1 Starter Cranking Circuit Test

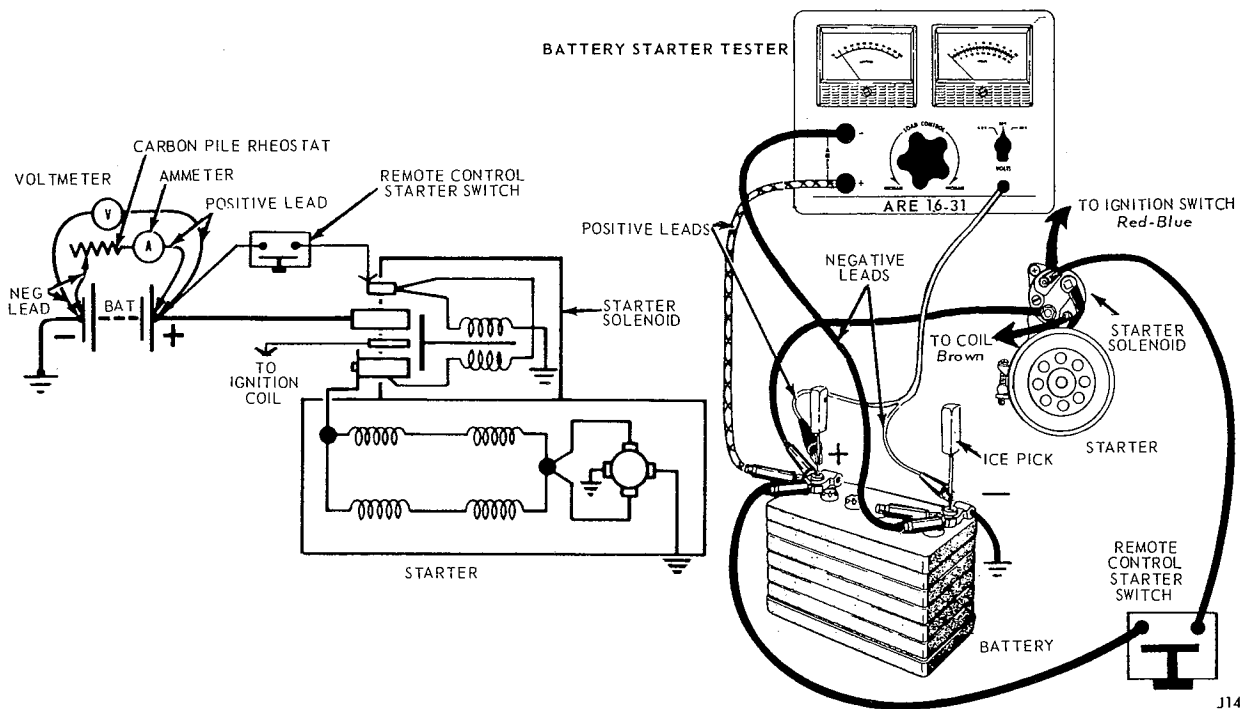


FIG. 2 Starter Load Test

J1415-B

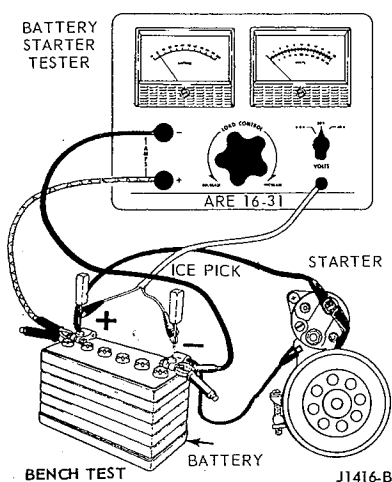


FIG. 3 Starter No-Load Test on Test Bench

J1416-B

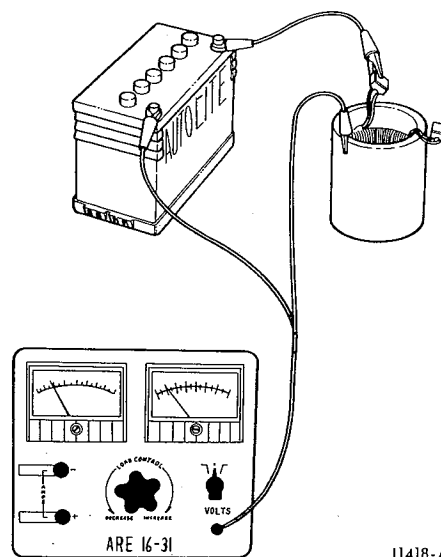


FIG. 5 Field Grounded Circuit Test

J1418-A

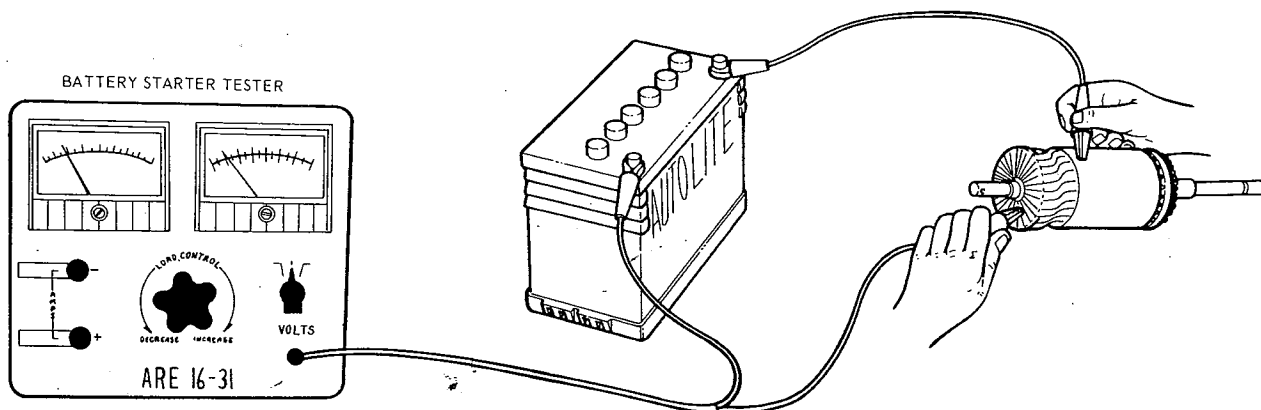


FIG. 4 Armature Grounded Circuit Test

J1417-A

REMOVAL AND INSTALLATION

REMOVAL

1. Disconnect the battery ground cable.
2. Disconnect the cable and wires at the terminals on the solenoid. Remove the two bolts attaching the steering idler arm to the frame.
3. Remove the starter mounting bolts and remove the starter assembly.

INSTALLATION

1. Position the starter assembly to the starter mounting plate and start the mounting bolts.
2. Snug the starting motor mounting bolts while holding the starter squarely against the mounting surface and fully inserted into the pilot hole. Torque the mounting bolts.
3. Connect the cable and wires to the terminals on the solenoid. Tighten the battery cable nut.

OVERHAUL

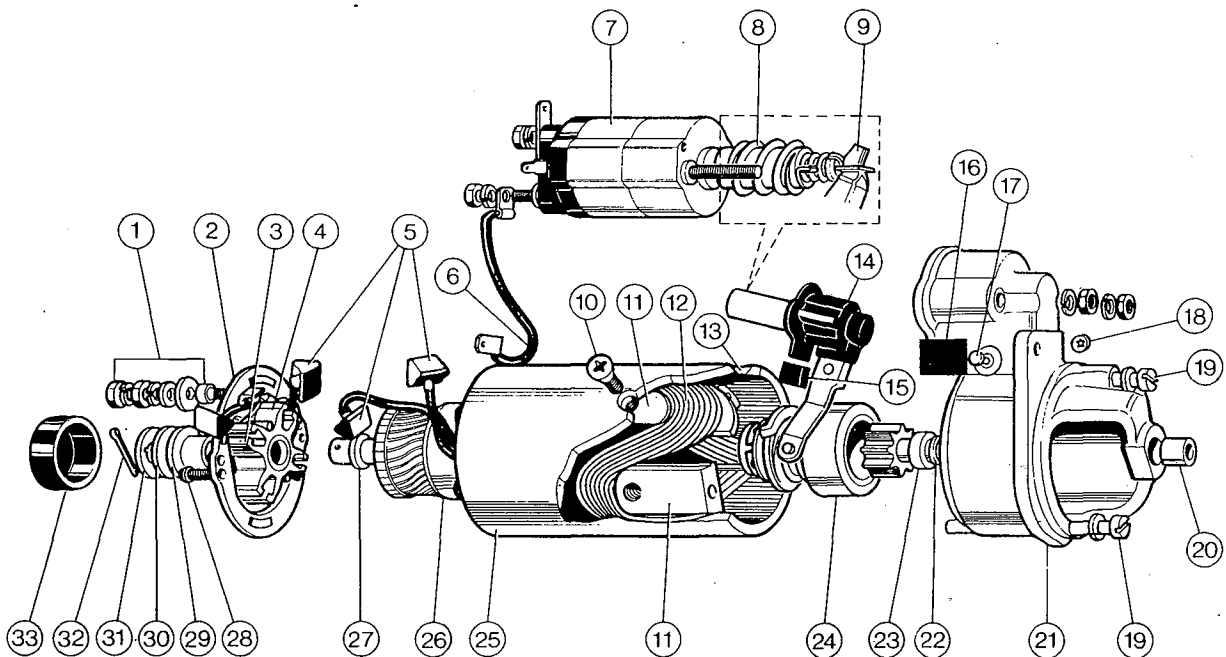
DISASSEMBLY

1. Remove the connector link between the solenoid and the motor (Figure 6).
2. Remove the nuts and washer which retain the solenoid to the drive end housing.
3. Remove the main part of the solenoid. Remove the rubber seal, the plunger and return spring assembly by

lifting it from the top of the shift fork.

NOTE: The solenoid plunger is matched to the main part of the solenoid and is not interchangeable separately.

4. Remove the rubber sealing block from between the drive end housing and the frame.
5. Remove the retaining clip from the groove in the shift



B/26/2

Fig.2.

- | | | |
|--|----------------------------------|---|
| 1. Terminal nuts and washers | 13. Field to ground connection | 25. Frame |
| 2. Commutator end plate | 14. Rubber seal | 26. Armature |
| 3. Brush housing | 15. Rubber dust pad | 27. Thrust washer |
| 4. Brush springs | 16. Rubber dust cover. | 28. Commutator end plate retaining screws (2) |
| 5. Brushes | 17. Pivot pin | 29. Bearing bushing |
| 6. Connector link, solenoid to starter | 18. Retaining clip | 30. Thrust plate |
| 7. Solenoid unit | 19. Housing retaining screws (2) | 31. Shim washer |
| 8. Return spring | 20. Bearing bushing | 32. Cotter pin |
| 9. Shift fork | 21. Drive end housing | 33. Dust cover |
| 10. Pole screw | 22. Stop ring | |
| 11. Pole shoe | 23. Thrust collar. | |
| 12. Field coils | 24. Drive assembly | |

FIG. 6 Solenoid Actuated Starter

- fork pivot pin and remove the pin.
- Remove the drive end housing retaining nuts and washers and remove the housing from the frame and studs.
 - Lift the shift fork off the drive assembly.
 - Remove the dust cover, cotter pin, shim washer and thrust plate from the armature shaft extension at the commutator end. Remove the armature, complete with the internal thrust washer and drive assembly, through the drive end of the starter frame.
 - Remove the thrust washer from the commutator end of the armature shaft.
 - Remove the drive stop ring, thrust collar and slide the drive assembly off the armature shaft.
 - Remove the two brush end plate retaining screws and part the end plate from the frame. Disengage the field winding brushes from the brush holder and then completely remove the end plate from the frame.

CLEANING AND INSPECTION

- Do not wash the drive because the solvent will wash out the lubricant, causing the drive to slip. Use a brush or compressed air to clean the drive, field coils, armature, commutator, armature shaft front end plate, and rear end housing. Wash all other parts in solvent and dry the parts.
- Inspect the armature windings for broken or burned insulation and unsoldered connections.
- Check the armature for open circuits and grounds.
- Inspect the armature shaft and the two bearings for scoring and excessive wear. If the commutator is rough, turn it.
- Check the brush holders for broken springs and the insulated brush holder for shorts to ground. Tighten any rivets that may be loose. Replace the brushes if worn off 5/16 inch (8.0mm) in length.

- Check the brush spring tension. Replace the springs if the tension is not within specified limits.
- Inspect the field coils for burned or broken insulation and continuity. Check the field brush connections and lead insulation. A brush kit is available. All other assemblies are to be replaced rather than repaired.
- Examine the wear pattern on the starter drive teeth. The pinion teeth must penetrate to a depth greater than 1/2 the ring gear tooth depth (Figure 7), to eliminate premature ring gear and starter drive failure.
- Replace starter drives and ring gears with milled, pitted or broken teeth or that show evidence of inadequate engagement (Figure 7).

BRUSH REPLACEMENT

- Cut the two brush leads away from the terminal post. Use a file or hacksaw and make a groove in the head of the terminal sufficiently deep to accommodate the new brush leads. Solder the brush leads into the terminal groove.
- Cut the remaining two brush leads about 1/4 inch (6.3mm) from the joint of the field winding. Solder the new brush leads to the ends of the original brush leads.

Be sure the insulated sleeving on the new brush leads provides the maximum coverage consistent with satisfactory soldering.

ASSEMBLY

- Apply a small amount of lubriplate on the armature shaft splines. Install the drive assembly on the armature shaft, install the thrust collar and stop ring (Figure 6).
- Install the thrust washer on the commutator end of the armature shaft.
- While holding the brush end plate in the proper position near the starter frame, install the brushes in the brush holder. Then, position the brush end plate to the starter frame and install the retaining screws.

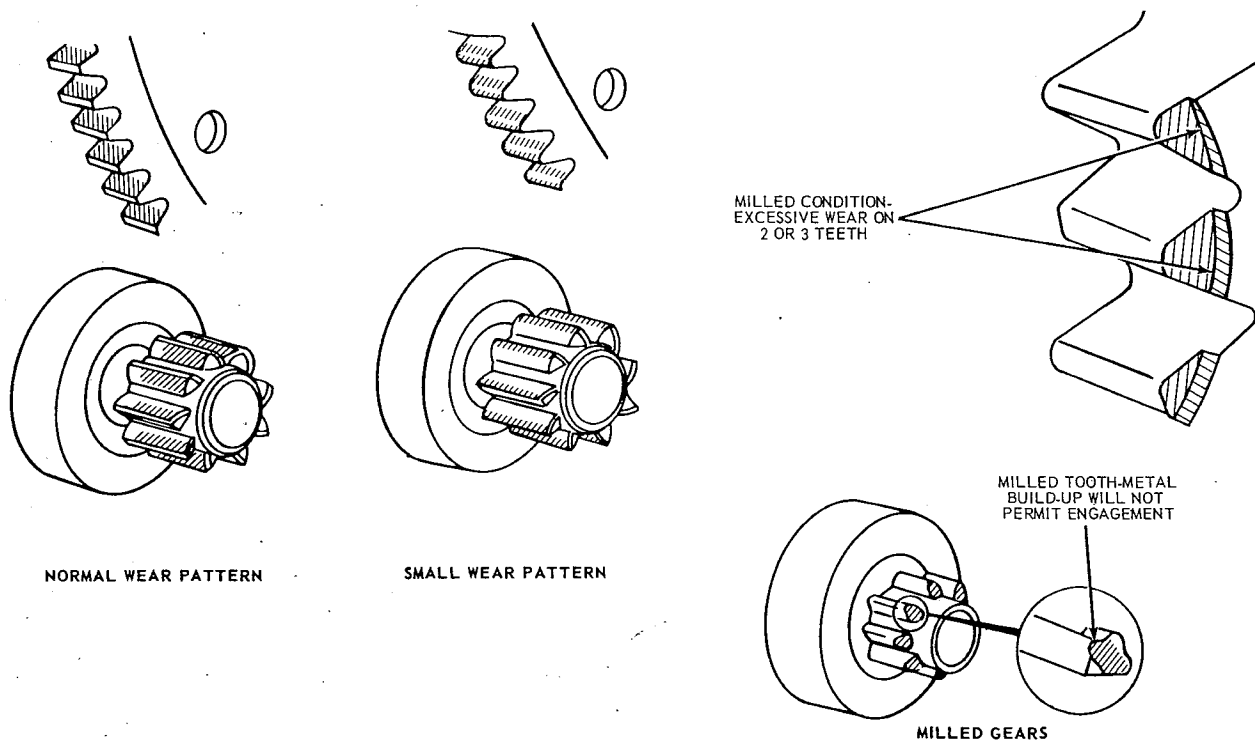


FIG. 7 Pinion and Ring Gear Wear Patterns

4. Apply a small amount of lubriplate to the internal thrust washer and install the armature, complete with drive assembly, through the drive end of the starter frame. Install the thrust plate, shim washer and cotter pin to the armature shaft extension. Check the end play of the commutator. It can be controlled by the number of shim washers (usually one or two). Install the dust cover.
 5. Install the rubber seal, plunger and return spring assembly to the top of the shift fork. Position the shift fork to the drive assembly.
 6. Position the drive end housing over the studs and to the frame. Install the retaining washers and nuts.
 7. Position the pivot pin to the housing and shift fork and install the retaining clip.
 8. Install the rubber sealing block between the drive end housing and the frame.
 9. Position the main part of the solenoid over the plunger and to the drive end housing. Install the retaining washers and nuts.
 10. Install the connecting link between the solenoid and the motor.
-

PART 6 Governors

COMPONENT INDEX	Page	COMPONENT INDEX	Page
DESCRIPTION AND OPERATION	6-01	RPM Adjustments	6-02
ADJUSTMENTS		Removal and Installation	6-03
Preliminary Checks	6-02		

DESCRIPTION AND OPERATION

The Hoof and Pierce mechanical flyweight type governors are used on these engines (Figures 1 and 2). They are mounted on the left front of the engine and are belt driven from the engine accessory pulley.

A direct mechanical linkage from the governor throttle control arm to the carburetor throttle lever limits carburetor action to the governor setting. As the engine speed in-

creases, the rotation of the governor shaft increases. Centrifugal force causes the weights to move outward as the rotation of the governor shaft increases. However, a spring retards or limits the movement of the weights until centrifugal force overcomes the spring tension. At this time the weights are forced outward closing the throttle plates through the linkage to the throttle shaft.

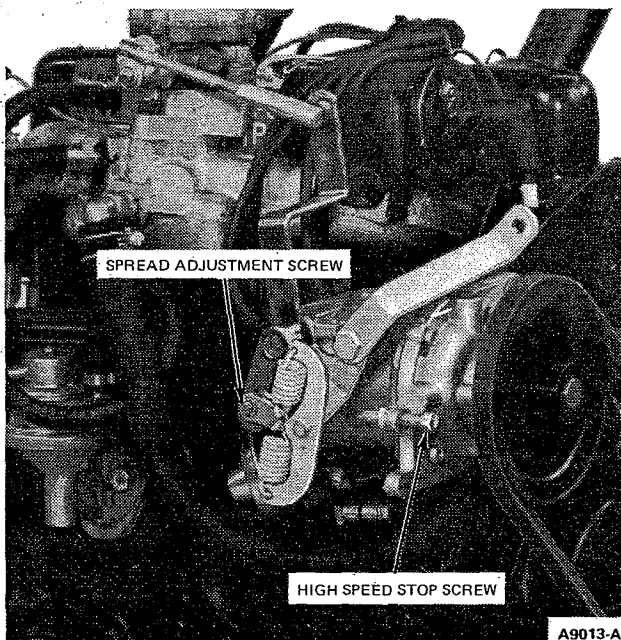


FIG. 1 Hoof Governor

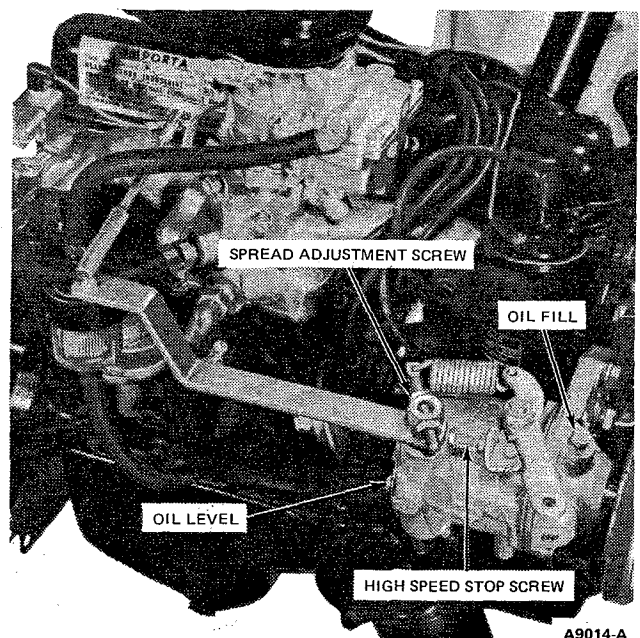


FIG. 2 Pierce Governor

ADJUSTMENTS

PRELIMINARY CHECKS

Three preliminary checks must be made on the mechanical governor before attempting any repair adjustments. These are the governor oil level, drive belt tension and the throttle control rod length.

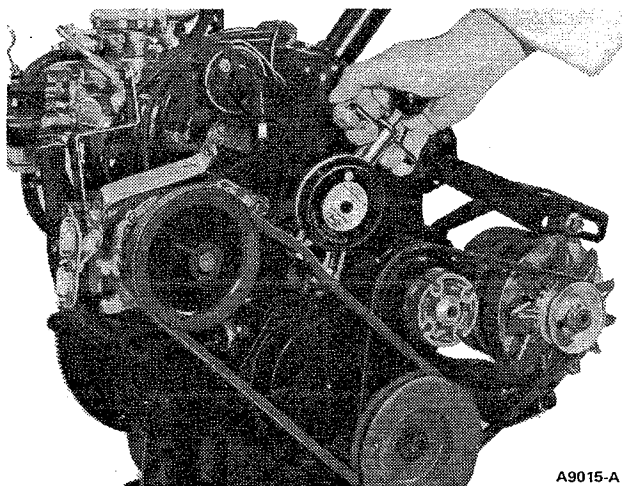
OIL LEVEL

Remove the oil level plug. If oil drips out the level is full. If oil doesn't drip out, remove the oil fill plug and add 10W-30 or 10W-40 engine oil into the fill hole until it starts dripping out oil level hole. Install the oil level and oil fill plugs.

BELT TENSION

Belt tension should be checked on a cold belt only.

1. Install the belt tension tool on the drive belt (Figure 3) and check the tension.
2. If adjustment is required, loosen the governor adjusting bolts and move the governor until the correct tension is obtained.
3. Remove the gauge. Tighten the governor adjusting bolts. Install the tension gauge and recheck the belt tension.



A9015-A

FIG. 3 Belt Tension

THROTTLE CONTROL ROD

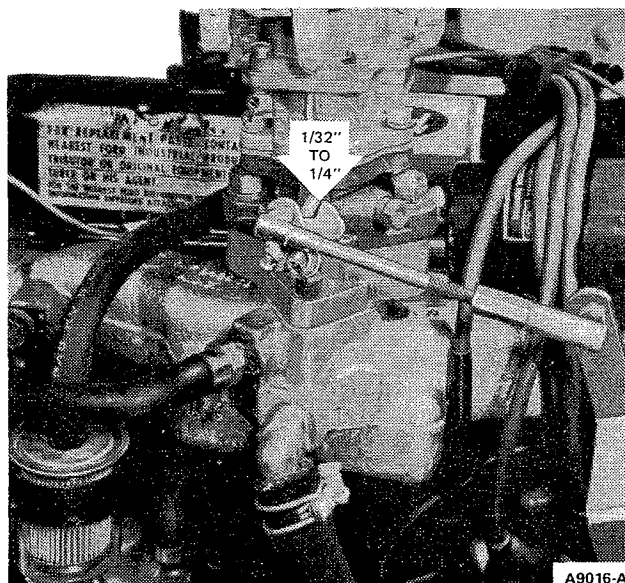
1. Manually move the governor throttle lever to the maximum open throttle with spring tension on the governor.
2. Check the gap between the carburetor throttle shaft lever and its maximum open position stop (Figure 4). It should be 1/32 to 1/4 inch wide.
3. If adjustment is necessary, loosen the control rod ball joint lock nuts, remove the rod from the carburetor throttle lever and adjust the length of the rod with the ball joints.
4. Install the throttle control rod on the carburetor throttle lever and recheck the gap. Tighten the lock nuts.

RPM ADJUSTMENTS

HIGH SPEED

First attach a tachometer to the engine, then run the engine until it reaches normal operating temperature.

1. Loosen the locknut on the high-speed stop screw.
2. Disengage engine load.



A9016-A

FIG. 4 Throttle Control Rod

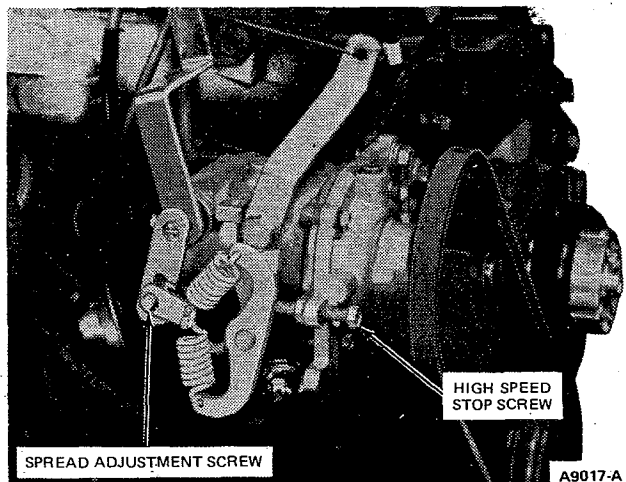
3. Slowly pull the throttle to desired maximum engine speed.
4. Adjust the high-speed stop screw on the governor to attain the desired maximum engine speed.
5. Tighten the locknut.

SPREAD OR SENSITIVITY

Proper governor operation requires a difference between full-load and no-load governed speed. Too small an rpm spread between the two speeds will cause governor hunting and surging. Too large a spread will cause low response. For this governor, normal rpm spread is 5 to 10 percent.

INCREASE SPREAD — HOOF GOVERNOR

1. With the engine running under no-load at maximum governed speed, loosen the rpm spread adjusting lock nut (Figure 5) and turn the adjusting screw counterclockwise until engine speed decreases 150 rpm; then tighten the



A9017-A

FIG. 5 Hoof Spread Adjustment

lock nut.

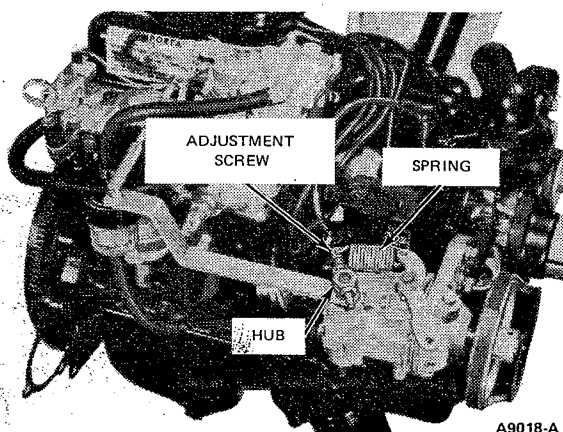
2. Recheck governor operation under full-load and no-load conditions to determine if operation is stabilized and sensitivity is satisfactory.
3. Readjust the governor high-speed stop screw to maintain the correct high-speed under load.

DECREASE SPREAD — HOOF GOVERNOR

1. Run the engine under no-load at maximum governed speed, loosen the rpm spread lock nut and turn the adjusting screw clockwise until engine speed increases one hundred fifty rpm.
2. Recheck governor operation under load and no-load conditions.
3. Readjust the governor high-speed stop screw to maintain the correct high-speed under load.

INCREASE SPREAD — PIERCE GOVERNOR

1. With the engine running under no-load at maximum governed speed, loosen the lock nuts and adjust the screw (Figure 6) to move the spring away from the lever hub.



A9018-A

FIG. 6 Pierce Spread Adjustment

Tighten the lock nuts.

2. Recheck governor operation under full-load and no-load conditions to determine if operation is stabilized and sensitivity is satisfactory.
3. Readjust the governor high-speed stop screw to maintain the correct high-speed under load.

DECREASE SPREAD — PIERCE GOVERNOR

1. With the engine under no-load at maximum governed speed, loosen the lock nuts and adjust the screw to move the spring nearer the lever hub. Tighten the lock nuts.
2. Recheck governor operation under load and no-load conditions.
3. Readjust the governor high-speed stop screw to maintain the correct high-speed under load.

LOW SPEED

1. Attach a tachometer and move the hand throttle, or variable speed lever, to the closed position.
2. Adjust the carburetor idle speed screw to obtain the desired idle speed.

NO-LOAD SURGE

The no-load surge adjustment is set at the factory and rarely requires adjustment. If necessary, this adjustment can be used to prevent hunting and surging at no-load speeds, provided the rpm spread adjustment is set properly.

1. Make the adjustment with the tachometer installed. Increase the engine speed with the hand throttle or variable speed lever to 75 rpm lower than the maximum no-load desired control rpm.
2. Loosen the no-load surge adjustment screw locknut and turn the screw inward until the rpm increases to the desired control rpm.

CAUTION: Do not turn the screw in all the way. It will interfere with proper governor operation and prevent the governor from returning the engine to idle speed.

3. Readjust the governor high-speed stop screw to maintain the correct high-speed under load.

REMOVAL AND INSTALLATION

REMOVAL

1. Disconnect hand throttle connection at governor variable speed lever.
2. Disconnect governor to carburetor throttle control rod at governor.
3. Loosen governor mounting nuts and bolts and move governor towards engine to loosen drive belt.
4. Remove drive belt from governor pulley.
5. Remove governor to bracket attaching bolts and remove governor.

INSTALLATION

1. Position the governor to the mounting bracket and install the attaching bolts snugly.
2. Position drive belt to governor pulley and move the governor away from the engine to tighten the belt. Tighten the attaching bolts.
3. Adjust the belt tension.
4. Connect the governor to carburetor throttle control rod. Adjust the rod as described previously.
5. Connect hand throttle cable to governor variable speed lever. Adjust cable as necessary to permit operation from idle to maximum speed.

PART 7 Cooling

COMPONENT INDEX	Page	COMPONENT INDEX	Page
Description and Operation	7-01	Drive Belt	7-01
ADJUSTMENTS		Belt Tension	7-01

DESCRIPTION AND OPERATION

The system is of the full flow type with a centrifugal pump (Figure 1). The thermostat, located in the cylinder, controls the flow through the system maintaining the proper temperature.

The coolant flow is from the bottom of the radiator to the pump which delivers it to the cylinder block. It then flows through the cored passages to cool the entire length of each cylinder wall. Upon reaching the rear of the cylinder block, the coolant is directed upward into the cylinder head where it cools the combustion chambers, valves and valve seats.

The coolant from the cylinder head flows past the thermostat, if it is open, through the coolant outlet housing and into the top of the radiator.

Another passage in the head routes the warm coolant through the intake manifold to help atomize the fuel mixture, and then through a hose to the inlet of the water pump.

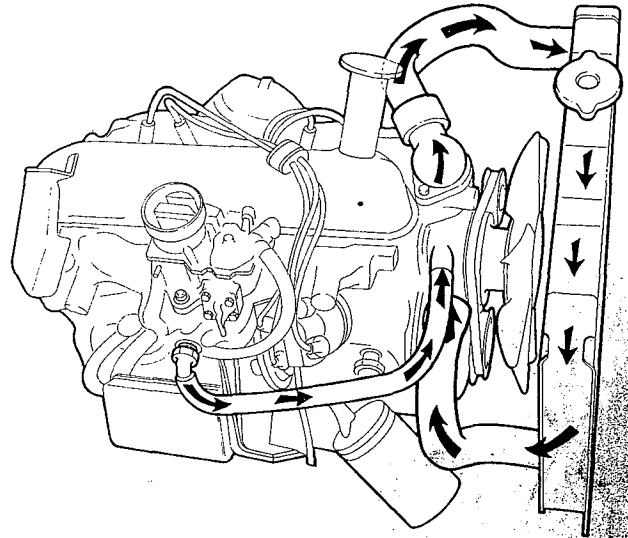


FIG. 1 Cooling System

ADJUSTMENTS

DRIVE BELT

The fan drive belt should be properly adjusted at all times. A loose drive belt can cause improper alternator, fan and water pump operation. A belt that is too tight places a severe strain on the water pump and the alternator bearings.

A properly tensioned drive belt minimizes noise and also prolongs the service life of the belt. Therefore, it is recommended that a belt tension gauge be used to check and adjust the belt tension. **Any belt that has been operated for a minimum of 10 minutes is considered a used belt, and when adjusted, it must be adjusted to the used tension shown in the specifications.**

BELT TENSION

1. Install the belt tension tool on the drive belt (Figure 2) and check the tension.
2. If adjustment is necessary, loosen the alternator mounting and adjusting arm bolts. Move the alternator toward or away from the engine until the correct tension is obtained. Remove the gauge.
3. Tighten the alternator adjusting arm and mounting bolts. Install the tension gauge and recheck the belt tension.

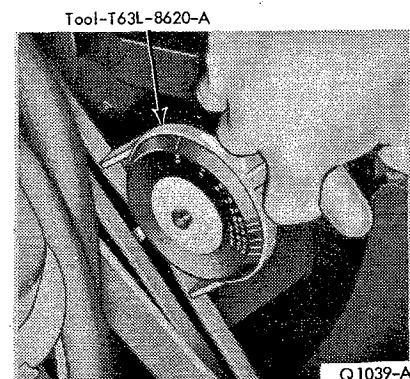


FIG. 2 Belt Tensioning

PART 8 Specifications

All specifications are given in inches with millimeters in parenthesis.

GENERAL

67 CID (1100cc)	
98 CID (1600cc)	
Compression Ratio	8:1
Bore	3.188 (80.98)
Stroke — 67	2.098 (53.29)
98	3.056 (77.62)
Firing Order	1-2-4-3
Oil Capacity with Filter (Approx.)	3.5 Qt. (3.311 liters)

CYLINDER HEADS

Gasket Surface Flatness	.0015 (.0375)
	in any 12 inches (304.8)
Valve Guide Bore Diameter	.3113-.3125 (7.907-7.938)
Valve Guide replacement	
Bushing Bore Diameter	.4383-.4391 (11.113-11.153)
Valve Seat Width — Intake	.0625 (1.59)
Exhaust	.0781 (1.98)
Valve Seat Angle	45°
Valve Seat Insert Exhaust	
Inside Diameter	1.2680-1.2685
Depth	.2175-.2225
Valve Seat Insert Exhaust	
I.D.	1.2680-1.2685 (32.207-32.220)
Depth (LPG only)	.2175-.2225 (5.521-5.652)

VALVE MECHANISM

Lash Intake — Cold	.008 (.20)
Exhaust — Cold	.022 (.56)
Stem Diameter — Intake	.3098-.3105 (7.868-7.886)
Exhaust	.3089-.3096 (7.846-7.863)
Oversize .003 (.076) Intake	.3128-.3135 (7.944-7.962)
Exhaust	.3119-.3126 (7.922-7.939)
Oversize .015 (.38) Intake	.3248-.3255 (8.248-8.266)
Exhaust	.3239-.3246 (8.226-8.243)
Stem to Guide Clearance Intake	.0008-.0027 (.020-.068)
Exhaust	.0017-.0036 (.043-.091)
Length — All	4.181-4.165 (106.2-105.8)
Head Diameter	
Intake 67	1.425-1.415 (36.197-35.937)
98	1.507-1.550 (39.60-39.40)
Exhaust 67	1.244-1.232 (31.60-31.30)
98	1.340-1.330 (34.00-33.80)
Seat Angle	44½°-45°
Face Runout — Wear Limit	.002 (.05)
Spring Free Length	1.48 (37.6)
Spring Assembled Height	
Pad to Retainer	1.263 (32.08)
Spring Load at Assembled Height	44-49 lbs. (19.96-22.23 Kg)
Push Rod Diameter — 67	.218-.222 (5.59-5.64)
98	.250-.254 (6.35-6.45)
Length 67	6.49-6.52 (164.8-165.6)
98	7.63-7.66 (193.8-194.6)
Max. Runout	.012 (.300)
Tappet — Length	1.85 (47.0)
Stem Diameter	.4360-.4365 (11.072-11.085)
Block Bore	.437-.438 (11.10-11.12)
Clearance to Block	.0005-.002 (.013-.05)

VALVE MECHANISM (Cont.)

Rocker Shaft — Diameter .....	.623-.624 (15.83-15.85)
Rocker Bore .....	.625-.6265 (15.88-15.913)
Shaft Clearance in Rocker .....	.001-.0035 (.03-.089)
Rocker Arm Ratio	1.54:1

CAMSHAFT

Journal Diameter	1.5597-1.5605 (39.617-39.637)
Bearing — I.D.	1.5615-1.5620 (39.662-39.675)
Length Front & Rear	20.79 (20.13)
Center	0.68 (17.31)
Clearance .....	.001-.0023 (.025-.058)
Bore for Bearing	1.6885-1.6895 (42.888-42.913)
Oversize Bearing	
O/S on OD Standard ID .....	.020 (.513)
End Play .....	.0024-.075 (.061-.192)
Thrust Plate Thickness .....	.1755-.1775 (4.458-4.509)
Valve Timing —	
Inlet Opens — °BTDC	17 — 21
Inlet Closes — °ABDC	51 — 55
Exhaust Opens — °BBDC	51 — 70
Exhaust Closes — °ATDC	17 — 22
Inlet cam lift	0.2108 (5.3548) — 0.2356 (5.9851)
Exhaust cam lift	0.2176 (5.5276) — 0.2321 (5.8943)

CRANKSHAFT

Main Bearing Journal Diameter	2.1253-2.1261 <i>2.1253 - 2.1261 STD</i> (53.983-53.749)
Main Bearing Clearance .....	.0005-.002 (.013-.051)
Rod Bearing Journal Diameter	1.9332-1.9336 <i>1.9370</i> (49.20-49.21)
Rod Bearing Clearance .....	.0005-.002 (.013-.051)
Main & Rod Bearing Journal —	
Max. Taper .....	.0003 (.008)
Max. Out-of-Round .....	.0004 (.010)
Crankshaft End Play .....	.003-.011 (.08-.28)
Bearing Wall Thickness — Standard .....	.0719-.0722 (1.788-1.796)
For Every .002 (.051) Undersized Thickness	
Add .001 (.026) to Standard Thickness	

CONNECTING ROD

Piston Pin Bushing I.D. ....	.8121-.8125 (20.627-20.638)
Connecting Rod Bearing Bore	2.0825-2.0830 (52.90-52.91)
Connecting Rod Length Center to Center	
67	4.324-4.326 (109.83-109.88)
98	4.133-4.135 (104.98-105.03)
Side Clearance .....	.004-.010 (.10-.25)
Max. Twist or Bend .....	.004 (.10)
Pin bushing and crankshaft bearing bore must be parallel and in the same vertical plane within the specified total difference at ends of 8-inch long bar measured 4 inches on each side of rod.	

PISTON

Diameter	3.1853-3.1877
Piston to Bore Clearance .....	.0013-.0019 (.033-.048)
(Measured 90° to pin centerline and at bottom of pin)	
Clearance between Deck and Piston Crown at TDC	
67 .....	.005-.023 (.13-.58)
98 .....	.025-.043 (.63-1.09)

PISTON PIN

Diameter .....	.8119-.8123 (20.622-20.632)
Interference Fit in Piston .....	.0001-.0003 (.003-.008)
Clearance in Rod Bushing .....	.0001-.0003 (.003-.008)

PISTON RINGS

Top Compression Ring Width	.077-.078 (1.96-1.98)
Bottom Compression Ring Width	.077-.078 (1.96-1.98)
Top Compression Ring Side Clearance	.0016-.0036 (.041-.091)
Bottom Compression Ring Side Clearance	.0016-.0036 (.041-.091)
Compression Ring Side Clearance — Wear Limit	.006 (.152)
Oil Ring Width	.155-.156 (3.94-3.96)
Oil Ring Side Clearance	.0018-.0038 (.046-.097)
Oil Ring Side Clearance — Wear Limit	.007 (.178)
Top Compression Ring — Std. Bore — Ring Gap	.009-.014 (.23-.36)
Bottom Compression Ring — Std. Bore — Ring Gap	.009-.014 (.23-.36)
Oil Ring — Std. Bore — Ring Gap Width	.009-.014 (.23-.36)

CYLINDER BLOCK

Cylinder Bore Diameter	3.1869-3.1893 (80.948-81.008)
Cylinder Bore Out-of-Round — Max.	.0005 (.013)
Taper — Max.	.001 (.025)
Tappet Bore Diameter	.516-.517 (13.11-13.13)
Main Bearing Bore Diameter	2.2710-2.2715 (57.683-15.696)
Height, Pan Surface to Deck	
67	7.224-7.229 (183.49-183.62)
98	8.326-8.331 (211.48-211.61)
Gasket Surface Flatness	.0015 (.0381) in any 12 inches (304.8)

LUBRICATION

Oil Pressure — Hot @ 2000 RPM	35-40 PSI (240-275K _n /m ²)
Oil Pump — Rotor Assembly End Clearance	.001-.004 (.025-.102)
Outer Race to Housing Clearance	.005-.0075 (.13-.195)
Clearance Between Inner & Outer Rotors	.006 (.160)

IGNITION SYSTEM

Distributor Point Gap	.025 (.64)
Dwell Angle	38°-40°
Firing Order	1-2-4-3
Rotation	Counterclockwise
Initial Timing — BTC	6°
End Play	Preload
Spark Plugs	AGR-22
Plug Gap	.023 (.58)
Coil — Primary Resistance (Ohms)	1.40-1.54 (75°F)
Secondary Resistance (Ohms)	7600-8800 (75°F)
Primary External Resistor (Ohms)	1.30-1.40 (75°F)
Condenser — (Micro Farads)	0.21-0.25

DISTRIBUTOR ADVANCE CHARACTERISTICS

Vacuum Advance — set the test stand to 0° at 1000 rpm and 0 inches of Mercury.

Vacuum (Inches of Mercury)	Advance (Distributor Degrees)
5	0 — 1¼
6	0 — 3
7	1¾ — 4¾
9	4¾ — 7¾
11	7 — 10
13	8¾ — 11¾
14 and above	9 — 12

Centrifugal Advance — set test stand to 0° at 250 distributor rpm and 0 inches of Mercury.

Distributor rpm	Advance (Distributor Degrees)
500 and below	0
700	½ — 2½
900	2¾ — 4¾
1100	4½ — 6½
1400	6½ — 8½
1700	8¾ — 10¾
2000	10 — 12
2350 and above	12½ — 14¼

FUEL SYSTEM

Float Level 1½ inches (38.1)
 Pump Pressure 3.5-5.0 psi (24.5-34.3 kNm²)

STARTER

Solenoid Actuated Starter Motor				Starter Brushes	
Dia. In. Inches (Metric)	Current Draw Under Normal Load (Amps)	Normal Engine Cranking Speed (rpm) @70°F.	No. Load (Amps)	Wear Limit In Inches (Metric)	Spring Tension (Ounces Force)
3½ (88.9)	135-250	140-180	65	5/16 (.8)	28

TORQUE SPECIFICATIONS

Item	Torque Ft-Lb	Nm.
Camshaft Sprocket to Camshaft Bolt	12-15	16-20
Camshaft Thrust Plate Bolts	2.5-3.5	3.4-4.7
Connecting Rod Bolts	30-35	41-47
Cylinder Head Bolts	Step 1 — 20-30	27-41
	Step 2 — 50-55	68-75
	Step 3 — 65-70	88-95
Crankshaft Pulley Bolt	24-28	33-38
Crankcase Ventilation Adaptor to Manifold	8-12	11-20
Cylinder Front Cover Bolts	5-7	7-9.5
Carburetor Attaching Nuts	12-15	16-20
Chain Tension Support to Cylinder Block	5-7	7-9.5
Distributor to Cylinder Block	5-7	7-9.5
Distributor Clamp	25-30	34-4.7
Exhaust Manifold to Cylinder Head Nuts	15-18	20-24
Separator Clamping Bolt	6-9	8-12
Flywheel to Crankshaft Bolts	50-55	68-75
Fuel Pump to Cylinder Block	12-15	16-20
Alternator Mounting to Cylinder Block Bolts	20-25	27-34
Intake Manifold to Cylinder Head Nuts	15-18	20-24
Main Bearing Cap Bolts	65-70	88-95
Oil Pump to Cylinder Block	12-15	16-20
Oil Drain Plug	20-25	27-34
Oil Pan to Cylinder Block Bolts	6-8	8-11

TORQUE SPECIFICATIONS (Cont.)

Item	Torque Ft-Lb	Nm.
Oil Pump Cover to Oil Pump Bolts	5-7	7-9.5
Rear Oil Seal Retainer to Cylinder Block	12-15	16-20
Rocker Cover to Cylinder Head Screws	2.5-3.5	3.4-4.7
Rocker Shaft Support Bolt	25-30	34-41
Spark Plug to Cylinder Head	22-28	30-38
Water Outlet Connection to Cylinder Head	12-15	16-20
Water Pump to Cylinder Block	5-7	7-9.5
Water Pump to Cylinder Block	12-15	16-20
Oil Filter	½ turn after initial setting	

Bolts & Nuts	Torque Ft-Lb	Mm.
1/4-20	5-7	7-9.5
5/16-18	12-15	16-20
5/16-24	12-15	16-20
3/8-16	17-22	23-30
3/8-24	22-27	30-37
7/16-14	30-35	41-47
7/16-20	40-45	55-61
1/2-13	45-50	61-68
1/2-20	50-60	68-81
9/16-12	60-70	81-95
9/16-18	65-75	88-102
5/8-11	75-85	102-116
5/8-18	100-110	135-150

For non-critical and not otherwise mentioned applications, the above general assembly torques will apply.

BELT TENSION

All Except Governor

New 140 Lbs.

Used 110 Lbs.

Governor

New 70 Lbs.

Used 50 Lbs.

Any belt that has operated for ten minutes or more is considered a used belt.

SPECIAL SERVICE TOOLS

T64P-3590-F

Puller

T70P-6049-A

Compressor — Valve Spring

T70P-6150

Installer — Aligner — Front Cover Seal

T70P-6165

Installer — Crankshaft Rear Seal

T70P-6250

Remover — Installer — Camshaft Bearings

Tool — 6505-G

Valve Stem Clearance Checking Tool

Tool — 6513-DD

Valve Spring Tester

C8AZ-6B627-A

Crankcase Ventilation System Tester

T63L-8620-A

Belt Tension Gauge

TROUBLESHOOTING

HARD STARTING

- Battery condition
- Battery cables
- Battery size
- Fuel supply restricted
- Fuel quality
- Ignition system
- Choke operation
- Engine load connected
- Starter
- Starter solenoid
- Engine compression low

ENGINE DOES NOT DEVELOP FULL POWER

- Air intake system restricted
- Exhaust restricted
- Maximum governor rpm setting low
- Ignition timing
- Ignition system
- Compression low
- Carburetor not opening fully or too rich or lean
- Camshaft timing
- Excessive friction in engine or power train
- Engine application

ENGINE EMITS EXCESSIVE SMOKE

WHITE SMOKE — Fuel is not burning or water in combustion chamber.

- Water in combustion chamber
- Incorrect timing
- Poor cylinder compression
- Cold engine

BLUE SMOKE — Lubricating oil in combustion chamber.

- Valve guides worn
- Rings worn
- Piston(s) damaged
- Oil-bath air cleaner allowing oil in intake

BLACK SMOKE — Incomplete combustion

- Clogged air intake system
- Type of fuel used
- Cold engine
- Restricted exhaust
- Excessive engine load

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144
2657