Workshop Manual

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AQ190, AQ240A

Workshop manual

AQ190A, AQ240A

Contents

Safety Precautions

Introduction

This Workshop Manual contains technical data, descriptions and repair instructions for Volvo Penta products or product versions contained in the contents list. Ensure that the correct workshop literature is being used.

Read the safety information and the Workshop Manual "General Information" and "Repair Instructions" carefully before starting work.

Important

In this book and on the engine you will find the following special warning symbols.

WARNING! If these instructions are not followed there is a danger of personal injury, extensive damage to the product or serious mechanical malfunction.

IMPORTANT! Used to draw your attention to something that can cause damage, product malfunction or damage to property.

NOTE! Used to draw your attention to important information that will facilitate work or operations.

Below is a summary of the risks and safety precautions you should always observe or carry out when operating or servicing the engine.

Immobilize the engine by turning off the power supply to the engine at the main switch (switches) and lock it (them) in the OFF position before starting work. Set up a warning notice at the engine control point or helm.

Generally, all servicing should be carried out with the engine switched off. Some work (carrying out certain adjustments for example) requires the engine to be running. Approaching a running engine is dangerous. Loose clothing or long hair can fasten in rotating parts and cause serious personal injury.
If working in proximity to a running engine, careless movements or a dropped tool can result in personal injury. Avoid burns. Take precautions to avoid hot surfaces (exhausts, turbochargers, charge air pipes and starter elements etc.) and liquids in supply lines and hoses when the engine is running or has been turned off immediately prior to starting work on it. Reinstall all protective parts removed during service operations before starting the engine.

Check that the warning or information decals on the product are always clearly visible. Replace decals that have been damaged or painted over.

Engine with turbocharger: Never start the engine without installing the air cleaner (ACL). The rotating compressor in the Turbo can cause serious personal injury. Foreign objects entering the intake ducts can also cause mechanical damage.

Never use start spray or similar to start the engine. The starter element may cause an explosion in the inlet manifold. Danger of personal injury.

Avoid opening the filler cap for engine coolant system (freshwater cooled engines) when the engine is still hot. Steam or hot coolant can spray out. Open the coolant filler cap carefully and slowly to release pressure before removing the cap completely. Take great care if a cock, plug or engine coolant line must be removed from a hot engine. It is difficult to anticipate in which direction steam or hot coolant can spray out.

Hot oil can cause burns. Avoid skin contact with hot oil. Ensure that the lubrication system is not under pressure before commencing work on it. Never start or operate the engine with the oil filler cap removed, otherwise oil could be ejected.

Stop the engine and close the sea cock before carrying out operations on the engine cooling system.

Only start the engine in a well-ventilated area. If operating the engine in an enclosed space, ensure that exhaust gases and crankcase ventilation emissions are ventilated out of the working area.

⚠ Always use protective goggles where there is a danger of pieces of metal, sparks from grinding, acid or other chemicals being thrown into your eyes. Your eyes are very sensitive, injury can lead to loss of sight!

⚠ Avoid skin contact with oil. Long-term or repeated contact with oil can remove the natural oils from your skin. The result can be irritation, dry skin, eczema and other skin problems. Used oil is more dangerous to health than new oil. Use protective gloves and avoid using oil-soaked clothes and rags. Wash regularly, especially before meals. Use the correct barrier cream to prevent dry skin and to make cleaning your skin easier.

⚠ Most chemicals used in products (engine and transmission oils, glycol, petrol and diesel oil) and workshop chemicals (solvents and paints) are hazardous to health Read the instructions on the product packaging carefully! Always follow safety instructions (using breathing apparatus, protective goggles and gloves for example). Ensure that other personnel are not unwittingly exposed to hazardous substances (by breathing them in for example). Ensure that ventilation is good. Handle used and excess chemicals according to instructions.

⚠ Be extremely careful when tracing leaks in the fuel system and testing fuel injection nozzles. Use protective goggles! The jet ejected from a fuel injection nozzle is under very high pressure, it can penetrate body tissue and cause serious injury There is a danger of blood poisoning.

⚠ All fuels and many chemicals are inflammable. Ensure that a naked flame or sparks cannot ignite fuel or chemicals. Combined with air in certain ratios, petrol, some solvents and hydrogen from batteries are easily inflammable and explosive. Smoking is prohibited! Ensure that ventilation is good and that the necessary safety precautions have been taken before carrying out welding or grinding work. Always have a fire extinguisher to hand in the workplace.

⚠ Store oil and fuel-soaked rags and fuel and oil filters safely. In certain conditions oil-soaked rags can spontaneously ignite. Used fuel and oil filters are environmentally dangerous waste and must be deposited at an approved site for destruction together with used lubricating oil, contaminated fuel, paint remnants, solvent, degreasing agents and waste from washing parts.

⚠ Never allow a naked flame or electric sparks near the batteries. Never smoke in proximity to the batteries. The batteries give off hydrogen gas during charging which when mixed with air can form an explosive gas – oxyhydrogen. This gas is easily ignited and highly volatile. Incorrect connection of the battery can cause a spark which is sufficient to cause an explosion with resulting damage. Do not disturb battery connections when starting the engine (spark risk) and do not lean over batteries.

⚠ Never mix up the positive and negative battery terminals when installing. Incorrect installation can result in serious damage to electrical equipment. Refer to wiring diagrams.

⚠ Always use protective goggles when charging and handling batteries. The battery electrolyte contains extremely corrosive sulfuric acid. If this comes into contact with the skin, wash immediately with soap and plenty of water. If battery acid comes into contact with the eyes, immediately flush with copious amounts of water and obtain medical assistance.

⚠ Turn off the engine and turn off power at main switch(es) before carrying out work on the electrical system.

⚠ Clutch adjustments must be carried out with the engine turned off.

⚠ Use the lifting eyes mounted on the engine/reverse gear when lifting the drive unit.
Always check that lifting equipment is in good condition and has sufficient load capacity to lift the engine (engine weight including reverse gear and any extra equipment installed).

To ensure safe handling and to avoid damaging engine components on top of the engine, use a lifting beam to raise the engine. All chains and cables should run parallel to each other and as perpendicular as possible in relation to the top of the engine.

If extra equipment is installed on the engine altering its center of gravity, a special lifting device is required to achieve the correct balance for safe handling.

Never carry out work on an engine suspended on a hoist.

⚠ Never remove heavy components alone, even where secure lifting equipment such as secured blocks are being used. Even where lifting equipment is being used it is best to carry out the work with two people; one to operate the lifting equipment and the other to ensure that components are not trapped and damaged when being lifted.
When working on-board ensure that there is sufficient space to remove components without danger of injury or damage.

⚠ Components in the electrical system, ignition system (gasoline engines) and fuel system on Volvo Penta products are designed and constructed to minimize the risk of fire and explosion. The engine must not be run in areas where there are explosive materials.

⚠ Always use fuels recommended by Volvo Penta. Refer to the Instruction Book. The use of lower quality fuels can damage the engine. On a diesel engine poor quality fuel can cause the control rod to seize and the engine to overrev with the resulting risk of damage to the engine and personal injury. Poor fuel quality can also lead to higher maintenance costs.

⚠ Observe the following rules when cleaning with high-pressure water jets. Never direct the water jet at seals, rubber hoses or electrical components. Never use a high pressure jet when washing the engine.

General information

About the workshop manual

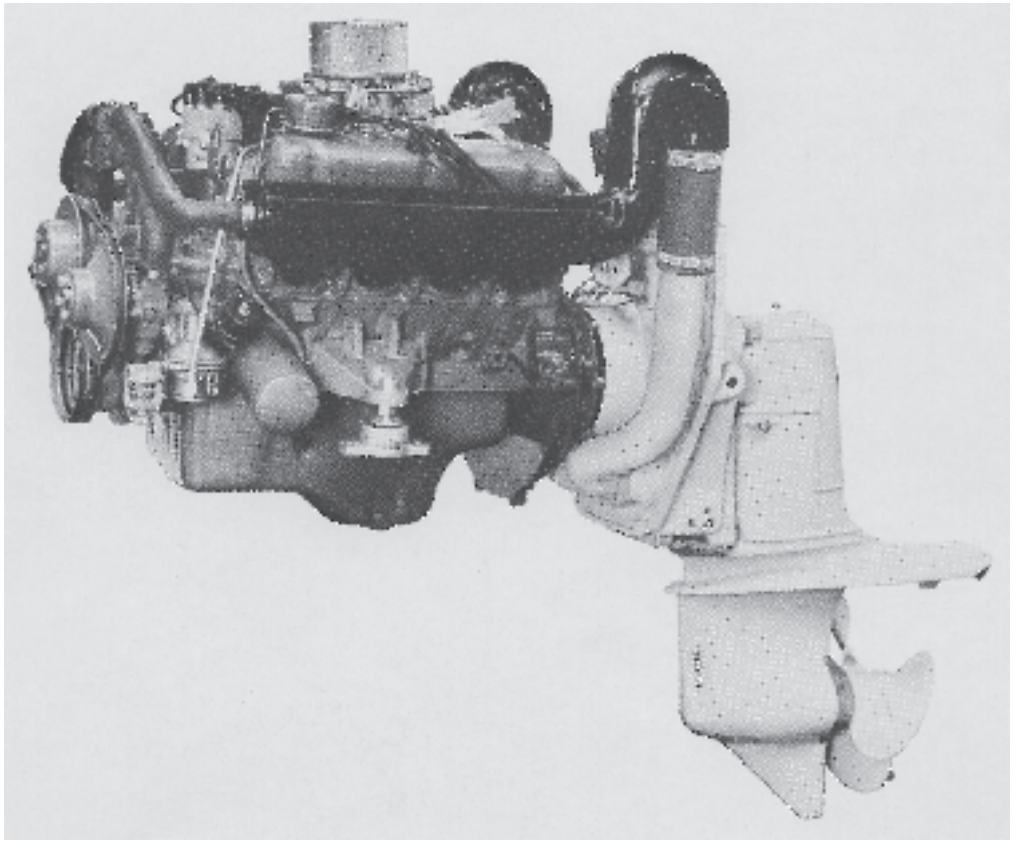
This workshop manual contains technical specification, descriptions and instructions for the standard versions of AQ190, AQ240A. The product designation and number should be given in all correspondence about the product.

This Workshop Manual has been developed primarily for Volvo Penta service workshops and qualified personnel. Persons using this book are assumed to have a grounding in marine drive systems and be able to carry out related mechanical and electrical work.

Volvo Penta is continuously developing their products. We therefore reserve the right to make changes. All the information contained in this book is based on product data available at the time of going to print. Any essential changes or modifications introduced into production or updated or revised service methods introduced after the date of publication will be provided in the form of Service Bulletins.

Replacement parts

Replacement parts for electrical and fuel systems are subject to statutory requirements (US Coast Guard Safety Regulations for example). Volvo Penta Genuine parts meet these requirements. Any type of damage which results from the use of non-original Volvo Penta replacement parts for the product will not be covered under any warranty provided by Volvo Penta.



Repair instructions

The working methods described in the Service Manual apply to work carried out in a workshop. The engine has been removed from the boat and is installed in an engine fixture. Unless otherwise stated reconditioning work which can be carried out with the engine in place follows the same working method.

Warning symbols occurring in the Workshop Manual (for their meaning see *Safety information*)

WARNING!

IMPORTANT!

NOTE!

are not in any way comprehensive since it is impossible to predict every circumstance under which service work or repairs may be carried out. For this reason we can only highlight the risks that can arise when work is carried out incorrectly in a well-equipped workshop using working methods and tools developed by us.

All procedures for which there are Volvo Penta special tools in this Workshop Manual are carried out using these. Special tools are developed to rationalize working methods and make procedures as safe as possible. It is therefore the responsibility of any person using tools or working methods other than the ones recommended by us to ensure that there is no danger of injury, damage or malfunction resulting from these.

In some cases there may be special safety precautions and instructions for the use of tools and chemicals contained in this Workshop Manual. These special instructions should always be followed if there are no separate instructions in the Workshop Manual.

Certain elementary precautions and common sense can prevent most risks arising. A clean workplace and engine eliminates much of the danger of injury and malfunction.

It is of the greatest importance that no dirt or foreign particles get into the fuel system, lubrication system, intake system, turbocharger, bearings and seals when they are being worked on. The result can be malfunction or a shorter operational life.

Our joint responsibility

Each engine consists of many connected systems and components. If a component deviates from its technical specification the environmental impact of an otherwise good engine may be increased significantly. It is therefore vital that wear tolerances are maintained, that systems that can be adjusted are adjusted properly and that Volvo Penta Genuine Parts as used. The engine Maintenance Schedule must be followed.

Some systems, such as the components in the fuel system, require special expertise and special testing equipment for service and maintenance. Some components are sealed at the factory for environmental reasons. No work should be carried out on sealed components except by authorized personnel.

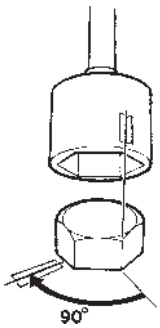
Bear in mind that most chemicals used on boats are harmful to the environment if used incorrectly. Volvo Penta recommends the use of biodegradable degreasing agents for cleaning engine components, unless otherwise stated in a workshop manual. Take special care when working on-board, that oil and waste is taken for destruction and is not accidentally pumped into the environment with bilge water.

Tightening torques

Tightening torques for vital joints that must be tightened with a torque wrench are listed in workshop manual “Technical Data”: “Tightening Torques” and are contained in work descriptions in this Manual. All torques apply for cleaned threads, screw heads and mating surfaces. Torques apply for lightly oiled or dry threads. If lubricants, locking fluid or sealing compound are required for a screwed joint this information will be contained in the work description and in “Tightening Torques” Where no tightening torque is stated for a joint use the general tightening torques according to the tables below. The tightening torques stated are a guide and the joint does not have to be tightened using a torque wrench.

Dimension	**Tightening Torques**	
	Nm	**lbf.ft**
M5	6	4.4
M6	10	7.4
M8	25	18.4
M10	50	36.9
M12	80	59.0
M14	140	103.3

Tightening torques-protractor (angle) tightening



Tightening using both a torque setting and a protractor angle requires that first the recommended torque is applied using a torque wrench and then the recommended angle is added according to the protractor scale. Example: a 90° protractor tightening means that the joint is tightened a further 1/4 turn in one operation after the stated tightening torque has been applied.

Locknuts

Do not re-use lock nuts that have been removed during dismantling as they have reduced service life when re-used – use new nuts when assembling or reinstalling. For lock nuts with a plastic insert such as Nylock® the tightening torque stated in the table is reduced if the Nylock® nut has the same head height as a standard hexagonal nut without plastic insert. Reduce the tightening torque by 25% for bolt size 8 mm or larger. Where Nylock® nuts are higher, or of the same height as a standard hexagonal nut, the tightening torques given in the table apply.

Tolerance classes

Screws and nuts are divided into different strength classes, the class is indicated by the number on the bolt head. A high number indicates stronger material, for example a bolt marked 10-9 indicates a higher tolerance than one marked 8-8. It is therefore important that bolts removed during the disassembly of a bolted joint must be reinstalled in their original position when assembling the joint. If a bolt must be replaced check in the replacement parts catalogue to make sure the correct bolt is used.

Sealants

A number of sealants and locking liquids are used on the engines. The agents have varying properties and are used for different types of jointing strengths, operating temperature ranges, resistance to oil and other chemicals and for the different materials and gap sizes in the engines.

To ensure service work is correctly carried out it is important that the correct sealant and locking fluid type is used on the joint where the agents are required.

In this Volvo Penta Service Manual the user will find that each section where these agents are applied in production states which type was used on the engine.

During service operations use the same agent or an alternative from a different manufacturer.

Make sure that mating surfaces are dry and free from oil, grease, paint and anti-corrosion agent before applying sealant or locking fluid. Always follow the manufacturer's instructions for use regarding; temperature range, curing time and any other instructions for the product.

Two different basic types of agent are used on the engine and these are:

RTV agent (Room temperature vulcanizing). Use for gaskets, sealing gasket joints or coating gaskets. RTV agent is clearly visible when a component has been dismantled; old RTV must be removed before the joint is resealed.

The following RTV agents are mentioned in the Service Manual: Loctite® 574, Volvo Penta 840879-1, Permatex® No. 3, Volvo Penta P/N 1161099-5, Permatex® No. 77. Old sealant can be removed using methylated spirits in all cases.

Anaerobic agents. These agents cure in an absence of air. They are used when two solid parts, for example cast components, are installed face-to-face without a gasket. They are also commonly used to secure plugs, threads in stud bolts, cocks, oil pressure switches and so on. The cured material is glass-like and it is therefore colored to make it visible. Cured anaerobic agents are extremely resistant to solvents and the old agent cannot be removed. When reinstalling the part is carefully degreased and then new sealant is applied.

The following anaerobic agents are mentioned in the Service Manual: Loctite® 572 (white), Loctite® 241 (blue).

NOTE! Loctite® is the registered trademark of Loctite Corporation, Permatex® is the registered trademark of the Permatex Corporation.

Positive closed-type crankcase ventilation system

Compression test

Compression Gauge Check

1. Be sure the oil in the crankcase is at the proper level and the battery is properly charged. Operate 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.
4. 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.
5. 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 within specification if the lowest reading cylinder is within 75 percent of the highest. (See the percentage chart given in Fig. 2.)

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.

1. If compression improves considerably, the piston rings are at fault.
2. If compression does not improve, valves are sticking or seating poorly.
3. 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 (Fig. 2) be used when checking cylinder compression pressures. The chart has been calculated so that the lowest reading number is 75 percent of the highest reading.

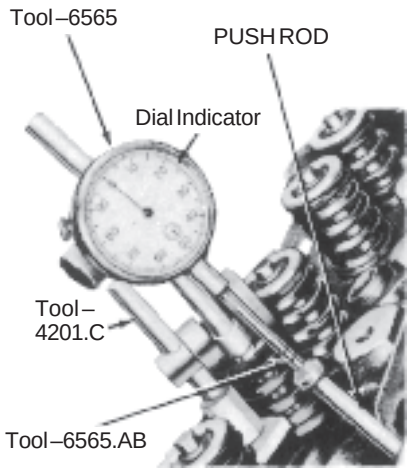


Fig. 3 Testing Camshaft Lobe Lift-Rocker Shaft Mounted Rocker Arms

Example

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

Camshaft lobe lift

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

1. Remove the air cleaner and the valve rocker arm cover(s).
2. On the rocker shaft mounted rocker arms, remove the valve rocker arm shaft(s) assembly as detailed in the pertinent part.

   On the stud mounted rocker arms, remove the rocker arm stud nut, fulcrum seat, oil deflector and rocker arm. Use the adapter for ball-end push rods.
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 (Fig. 3 or 4).
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.

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. 2 Quick Reference Compression Pressure Limit Chart

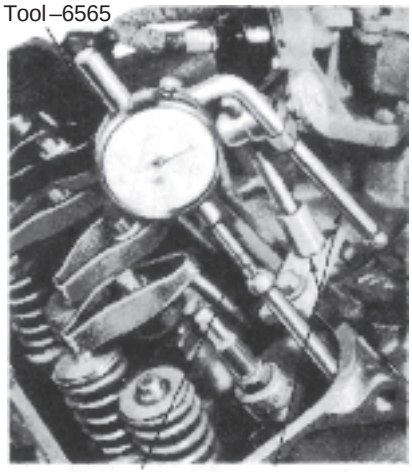


Fig. 4 Testing Camshaft Lobe Lift-Stud Mounted Rocker Arms

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.

On the rocker shaft type mounted rocker arms, install the rocker arm shaft assembly(ies) as detailed in the applicable engine Part.

Install the stud mounted or pedestal mounted rocker arms as detailed in the applicable engine Part. Adjust the valve clearance as detailed in the pertinent Part.

After installing the rocker arms, do not rotate the crankshaft until the hydraulic valve lifters have had sufficient time to bleed down. To do otherwise may cause serious valve damage. Manually bleeding down will reduce the waiting time requirement.

9. Install the valve rocker arm cover(s) and the air cleaner.

Hydraulic valve lifter and hydraulic lash adjuster

Hydraulic valve lifter noise may be caused by improper operating clearance as a result of loose adjusting nuts or improper initial adjustment. Always check rocker arm to valve stem clearance before replacing a valve lifter.

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

Dirt, gum and varnish can keep a check valve from seating and cause a loss of hydraulic pressure. An open valve disc will cause the plunger to force oil back into the valve lifter reservoir during the time the push rod is being lifted and force the valve from its seat. Air bubbles in the lubricating system can be caused by too much oil in the system or too low an oil level. Air may also be drawn into the lubricating system through an opening in a damaged oil pick-up tube. **Air in the system will cause a loss of hydraulic pressure.** Assembled valve lifters can be tested with Tool 6500-E to check the leak down rate. The leak down rate specification is the time in seconds for the plunger to move a specified distance of its travel while under a 50 lb. load. Test the valve lifters as follows:

1. Disassemble and clean the lifter to remove all traces of engine oil.

Lifters cannot be checked with engine oil in them. Only the testing fluid can be used.

2. Place the valve lifter in the tester, with the plunger facing upward. Pour hydraulic tester fluid into the cup to a level that will cover the valve lifter assembly. The fluid can be purchased from the manufacturer of the tester.

Using kerosene or any other fluid will not provide an accurate test.

3. Place the 5/16-inch steel ball provided with the tester in the plunger cap (Fig. 6).

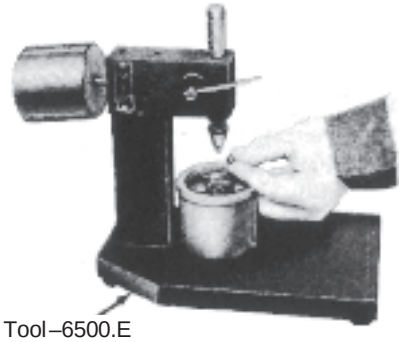


Fig. 6 Placing Steel Ball in Valve Lifter Plunger

4. Adjust the length of the ram (Fig. 7) so that the pointer is 1/16 inch below the starting mark when the ram contacts the valve lifter plunger, to facilitate timing as the pointer passes the Start Timing mark.

   Use the center mark on the pointer scale as the Stop Timing point instead of the original Stop Timing mark at the top of the scale.

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

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

7. A valve lifter that is satisfactory must have a leak-down rate (time in seconds) within the minimum and maximum limits specified.

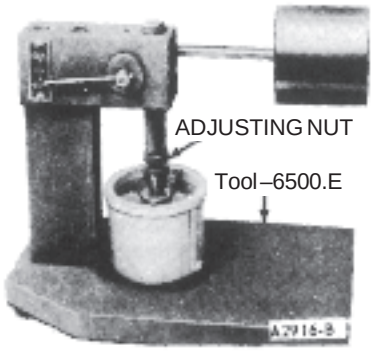


Fig. 7 Adjusting the Ram Length

8. If the valve lifter is not within specifications, replace it with a new lifter. It is not necessary to disassemble and clean new valve lifters before testing, because the oil contained in new lifters is test fluid.

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

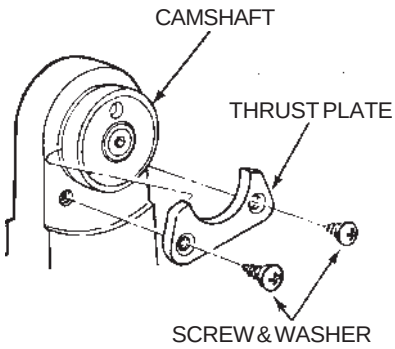
Camshaft end play

On all V-8 engines, prying against the aluminum-nylon camshaft sprocket, **with the valve train load on the camshaft**, can break or damage the sprocket. Therefore, the rocker arm adjusting nuts must be backed off, or the rocker arm and shaft assembly must be loosened sufficiently to free the camshaft. After checking the camshaft end play, adjust the valve clearance.

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 (Figs. 9, 10 and 11). Zero the dial indicator. Position a large screwdriver between the camshaft sprocket or gear and the block. Pull the camshaft forward and release it. Compare the dial indicator reading with specifications. If the end play is excessive, replace the thrust plate.

Remove the dial indicator.

Fig. 8 Cam Shaft Thrust Plate Installation-2300cc



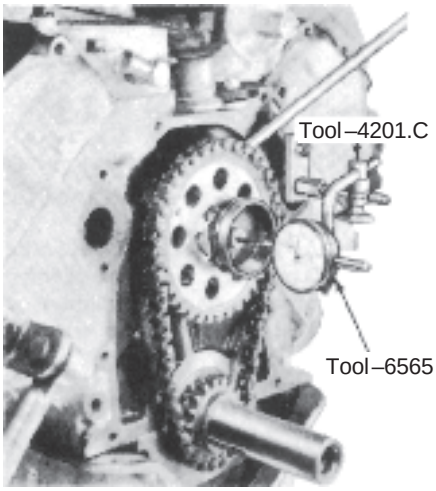


Fig. 9 Checking Camshaft End Play-V-8 Engine

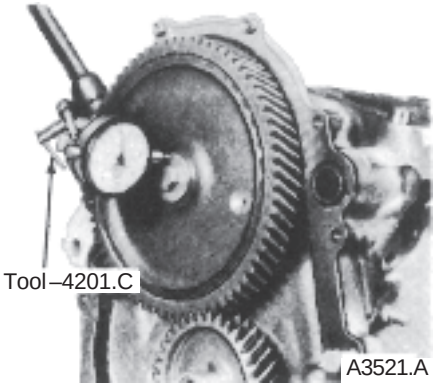


Fig. 10 Checking Camshaft End Play-V-6 Engine

Timing gear runout

Install a dial indicator on the cylinder block as shown in Fig. 13. Hold the camshaft gear against the camshaft thrust plate and zero the indicator. Rotate the crankshaft to turn the camshaft, while holding the camshaft gear against the thrust plate. Check the gear runout through one complete revolution of the camshaft. If the gear runout exceeds specifications, remove it and check for burrs or foreign particles on or between the camshaft and gear joining flanges. Recheck the runout; if it still exceeds specifications, replace the gear.

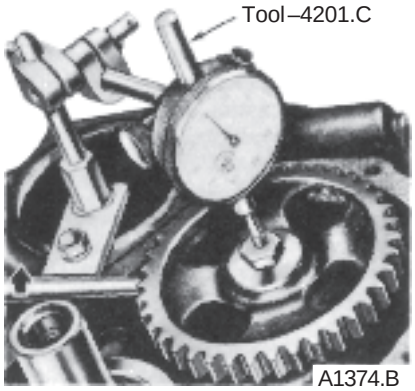


Fig. 11 Checking Camshaft End Play-1-6 Engine

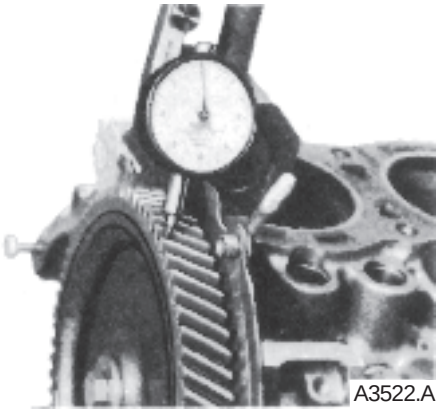


Fig. 12 Checking Timing Gear Backlash

Follow the above procedure to check crankshaft gear runout.

Timing chain deflection

1. Rotate the crankshaft in a counterclockwise direction (as viewed from the front) to take up the slack on the left side of the chain.
2. Establish a reference point on the block and measure from this point to the chain (Fig. 14).
3. Rotate the crankshaft in the opposite direction to take up the slack on the right of the chain. Force the left side of the chain out with the fingers and measure the distance between the reference point and the chain. The deflection is the difference between the two measurements.

If the deflection exceeds specifications, replace the timing chain and sprockets.

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 (Fig. 15).
3. Zero the dial indicator. Push the crankshaft forward and note the reading on the dial.
4. If the end play exceeds the wear limit, replace the thrust bearing. If the end play is less than the minimum limit inspect the thrust bearing faces for scratches, burrs, nicks, or dirt. If the thrust faces are not damaged or dirty, they probably were not aligned properly. Install the thrust bearing and align the faces following the procedure recommended under Main Bearing Replacement in the pertinent engine section. Recheck the end play.

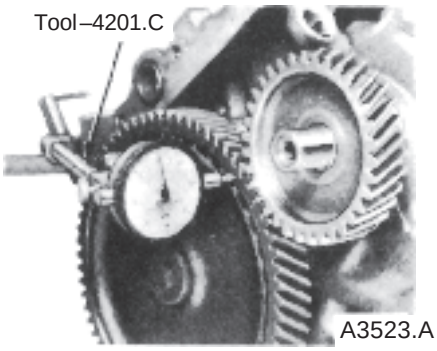


Fig. 13 Checking Timing Gear Runout

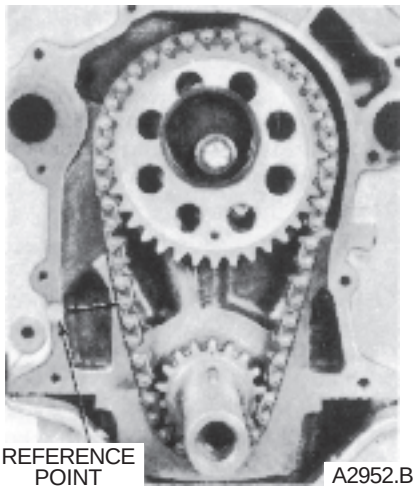


Fig. 14 Checking Timing Chain Deflection-Typical

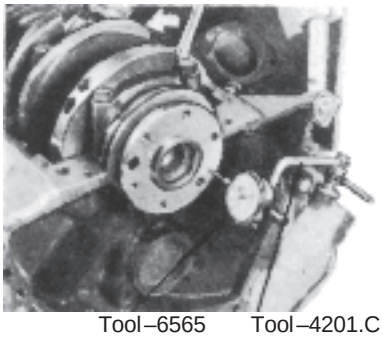


Fig. 15 Checking Crankshaft End Play

Adjustments

Hydraulic valve clearance

The valve arrangement on the left bank is E-I-E-I-E-I-E-I and on the right bank is I-E-I-E-I-E-I-E.

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

Valve stem to valve rocker arm clearance should be within specifications with the hydraulic lifter completely collapsed. Repeated valve reconditioning operations (valve and/or valve seat refacing) will decrease the clearance to the point that if not compensated for, the hydraulic valve lifter will cease to function and the valve will be held open. To determine whether a shorter or a longer push rod is necessary, make the following check:

1. Connect an auxiliary starter switch in the starting circuit. Crank the engine with the ignition switch OFF until the No. 1 piston is on TDC after the compression stroke.
2. With the crankshaft in the positions designated in Steps 3, 4 and 5 position the hydraulic lifter compressor tool on the rocker arm. Slowly apply pressure to bleed down the hydraulic lifter until the plunger is completely bottomed (Fig. 17). Hold the lifter in this position and check the available clearance between the rocker arm and the valve stem tip with a feeler gauge. The feeler gauge width must not exceed 3/8-inch. If the clearance is less than specifications, install a shorter push rod. If the clearance is greater than specifications, install a longer push rod.
3. With the No. 1 piston on TDC at the end of the compression stroke, (POSITION NO. 1 in Fig. 18) check the following valves:
   AQ190
   No. 1 Intake No. 1 Exhaust
   No. 7 Intake No. 5 Exhaust
   No. 8 Intake No. 4 Exhaust
   AQ240
   No. 1 Intake No. 1 Exhaust
   No. 4 Intake No. 3 Exhaust
   No. 8 Intake No. 7 Exhaust

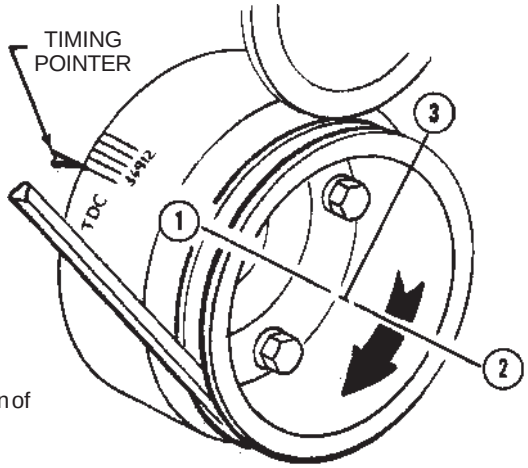


Fig. 18 Position of Crankshaft for Checking and Adjusting Valve Clearance

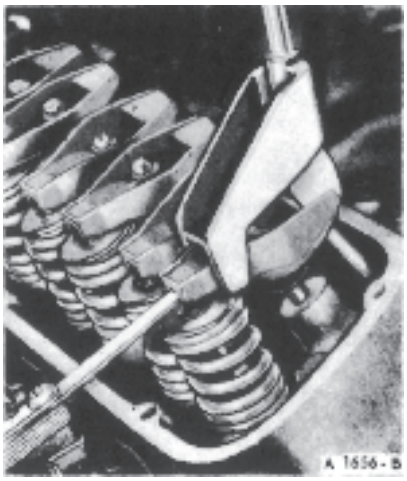


Fig. 17 Checking Valve Clearance-Hydraulic Valve Lifters

4. Rotate the crankshaft to POSITION NO. 2 in Fig. 18 and check the following valves:
   AQ190
   No. 5 Intake No. 2 Exhaust
   No. 4 Intake No. 6 Exhaust
   AQ240
   No. 3 Intake No. 2 Exhaust
   No. 7 Intake No. 6 Exhaust
5. Rotate the crankshaft to POSITION NO. 3 in Fig. 18 and check the following valves:
   AQ190
   No. 2 Intake No. 7 Exhaust
   No. 3 Intake No. 3 Exhaust
   No. 6 Intake No. 8 Exhaust
   AQ240
   No. 2 Intake No. 4 Exhaust
   No. 5 Intake No. 5 Exhaust
   No. 6 Intake No. 8 Exhaust

Engines With Positive Stop Rocker Arm Studs

The positive stop rocker arm stud eliminates the necessity of adjusting the valve clearance. However, to obtain the specified valve lash, it is important that all valve components be in a serviceable condition and installed and torqued properly. **Each stud nut should be removed and inspected for conditions shown in Fig. 19 when adjusting valve clearance.**

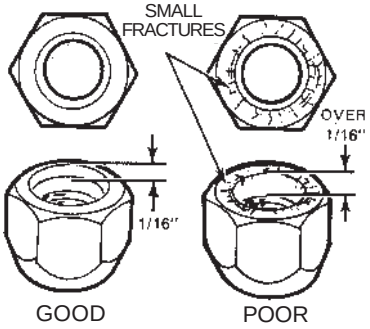


Fig. 19 Inspection of Rocker Arm Stud Nut

6. With the crankshaft in the positions designated in Steps 2, 3 and 4 remove the stud nut and inspect it for conditions shown in Fig. 19.
   Install the stud nuts on the stud and turn the nut clockwise until it contacts the stop. Torque the stud nut to specifications.
7. With the No. 1 piston on TDC at the end of the compression stroke, POSITION NO. 1 in Fig 18, inspect the stud nut and install the stud nut on the following valves:
   AQ190
   No. 1 Intake No. 1 Exhaust
   No. 7 Intake No. 5 Exhaust
   No. 8 Intake No. 4 Exhaust
   AQ240
   No. 1 Intake No. 1 Exhaust
   No. 4 Intake No. 3 Exhaust
   No. 8 Intake No. 7 Exhaust
8. Rotate the crankshaft to POSITION NO. 2 in Fig. 18. Inspect and install the stud nut on the following valves.
   AQ190
   No. 5 Intake No. 2 Exhaust
   No. 4 Intake No. 6 Exhaust
   AQ240
   No. 3 Intake No. 2 Exhaust
   No. 7 Intake No. 6 Exhaust
9. Rotate the crankshaft to POSITION NO. 3 in Fig. 18. Inspect and install the stud nut on the following valves:
   AQ190
   No. 2 Intake No. 7 Exhaust
   No. 3 Intake No. 3 Exhaust
   No. 6 Intake No. 8 Exhaust
   AQ240
   No. 2 Intake No. 4 Exhaust
   No. 5 Intake No. 5 Exhaust
   No. 6 Intake No. 8 Exhaust

Removal and installation

Rocker arm stud nut replacement 302 and 351-W V-8

If the rocker arm stud nut breakaway torque is less than specified, install a new standard stud nut and recheck the breaking torque. Refer to Valve Clearance Adjustment in the applicable Part for the torque procedure.

Rocker arm stud replacement

If it is necessary to remove a rocker arm stud, tool kit T62F-6A527-B is available which contains the following: a stud remover, a 0.006-inch oversize reamer and a 0.015-inch oversize reamer. For 0.010-inch oversize studs, use reamer T66P-6A527-B. To press in replacement studs, use stud replacer T69P-6049-D.

Rocker arm studs that are broken or have damaged threads may be replaced with standard studs. Loose studs in the head may be replaced with 0.006, 0.010 or 0.015-inch oversize studs which are available for service.

Standard and oversize studs can be identified by measuring the stud diameter within 1-1/8 inch from the pilot end of the stud. The stud diameters are:

Standard	0.3714-0.3721
0.006 oversize	0.3774-0.7781
0.010 oversize	0.3814-0.3821
0.015 oversize	0.3864-0.3871

When going from a standard size rocker arm stud to a 0.010 or 0.015-inch oversize stud, always use the 0.006-inch oversize reamer before finish reaming with the 0.010 or 0.015-inch oversize reamer.

1. Position the sleeve of the rocker arm stud remover (Tool T62F-6A527-B) over the stud with the bearing end down. Thread the puller into the sleeve and over the stud until it is fully bottomed. Hold the sleeve with a wrench, then rotate the puller clockwise to remove the stud (Fig. 20).

   If the rocker arm stud was broken off flush with the stud boss, use an easy-out to remove the broken stud following the instructions of the tool manufacturer.
2. If a loose rocker arm stud is being replaced, ream the stud bore using the proper reamer (or reamers in sequence) for the selected oversize stud (Fig. 21). Make sure the metal particles do not enter the valve area. Coat the end of the stud with Lubriplate. Align the stud and installer T69P-6049-D with the stud bore, then tap the sliding driver until it bottoms (Fig. 22). When the installer contacts the stud boss, the stud is installed to its correct height.

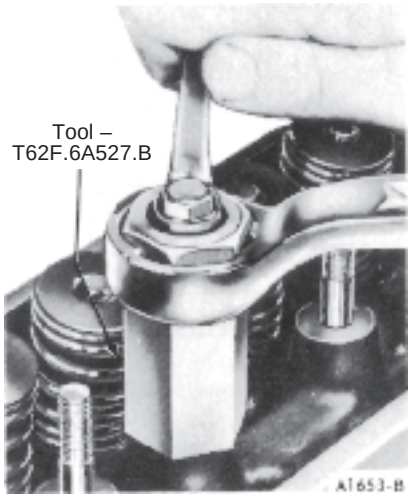


Fig. 20 Removing Rocker Arm Stud

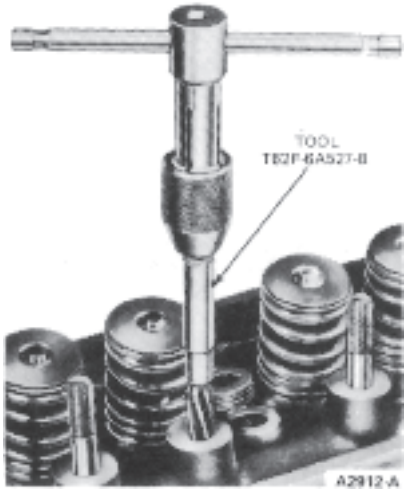


Fig. 21 Reaming Rocker Arm Stud Bore

Installation

Cup-Type

Cup-type core plugs (Fig. 23) are installed with the flanged edge outward. The maximum diameter of this plug is located at the outer edge of the flange. The flange on cup-type plugs flares outward with the largest diameter at the outer (sealing) edge.

It is imperative to install the plug in the machined bore using a properly designed tool. Under no circumstances is the plug to be driven into the bore using a tool that contacts the flange. This method will damage the sealing edge and will result in leakage and/or plug blow out. The flanged (trailing) edge must be below the chamfered edge of the bore to effectively seal the plugged bore. If the core plug replacing tool has a depth seating surface, do not scat the tool against a non-machined (casting) surface.

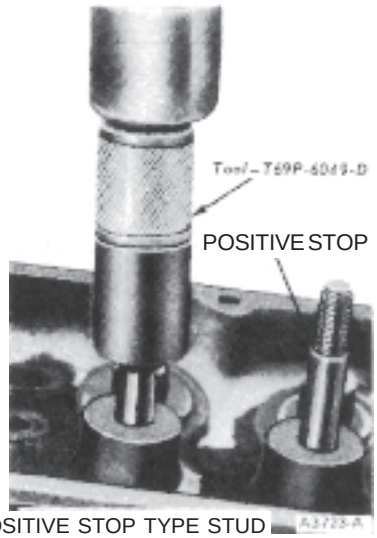


Fig. 22 Installing Rocker Arm Stud

Core plugs

Removal

To remove a large core plug, drill a 1/2-inch hole in the center of the plug and remove with a clutch pilot bearing puller (Tool T59L-100-B and T58L-100A) or pry it out with a large drift punch. On a small core plug, drill a 1/4-inch hole in the center of the plug and pry it out with a small pin punch. Clean and inspect the plug bore.

Prior to installing a core plug the plug bore should be inspected for any damage that would interfere with the proper sealing of the plug. If the bore is damaged it will be necessary to true the surface by boring for the next specified oversize plug.

Oversize (OS) plugs are identified by the OS stamped in the flat located on the cup side of the plug.

Coat the plug and/or bore lightly with an oil-resistant (oil galley) or water-resistant (cooling jacket) sealer and install it following the procedure for cup type or expansion type below:

Expansion-Type

Expansion-type core plugs (Fig. 23) are installed with the flanged edge inward. The maximum diameter of this plug is located at the base of the flange with the flange flaring inward.

It is imperative to push or drive the plug into the machined bore by using a properly designed tool. Under no circumstances is the plug to be driven using a tool that contacts the crowned portion of the plug. This method will expand the plug prior to installation and may damage the plug and/or plug bore. When installed, the trailing (maximum) diameter must be below the chamfered edge of the bore to effectively seal the plugged bore. If the core plug replacing tool has a depth seating surface, do not seat the tool against a non-machined (casting) surface.

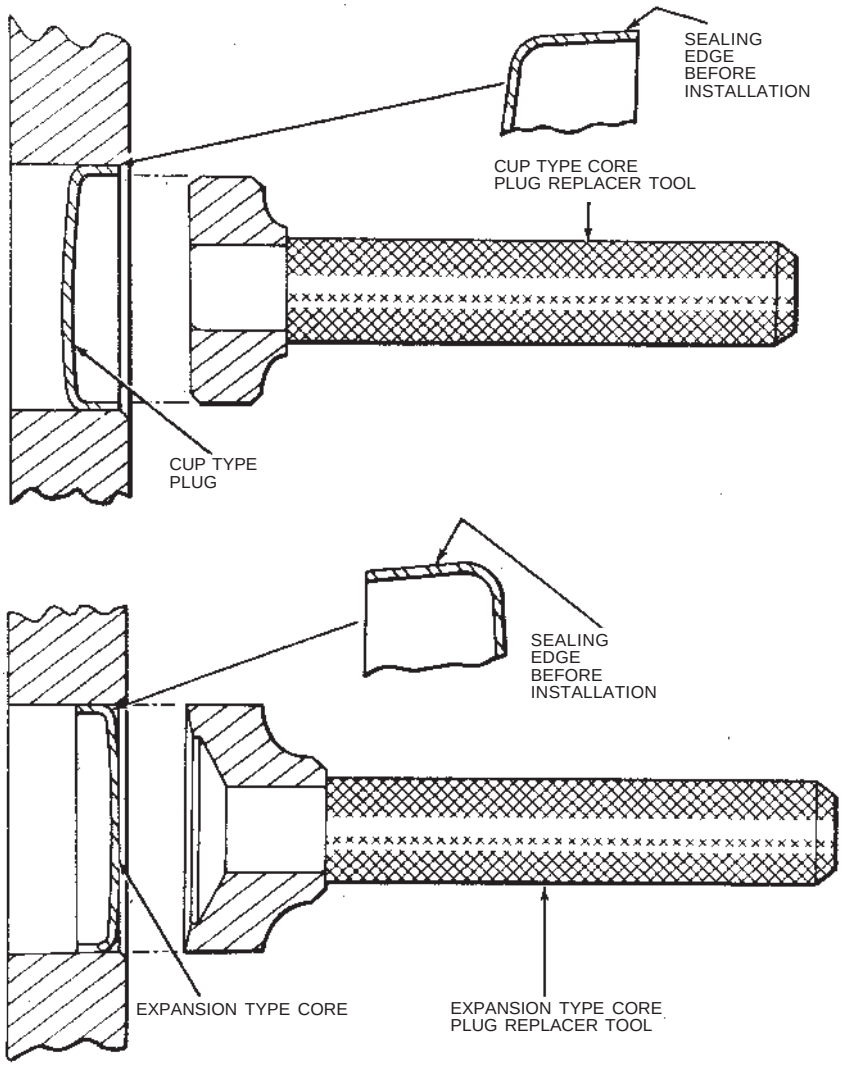


Fig. 23 Typical Core Plugs and Installation Tools

Crankshaft rear oil seal

A split-lip type crankshaft rear oil seal is provided for servicing. The complete seal may be replaced without removing the crankshaft (Fig. 24).

Removal

1. Remove the oil pan and the oil pump (if required).
2. Loosen all the main bearing cap bolts, thereby lowering the crankshaft slightly but not to exceed 1/32 inch.
3. Remove the rear main bearing cap, and remove the oil seal from the bearing cap and cylinder block. On the block half of the seal use a seal removal tool, or install a small metal screw in one end of the seal, and pull on the screw to remove the seal. **Exercise caution to prevent scratching or damaging the crankshaft seal surfaces.**
4. Remove the oil seal retaining pin from the bearing cap if so equipped. **The pin is not used with the split-lip seal.**

Installation

1. Carefully clean the seal grooves in the cap and block with a brush and solvent such as lacquer thinner, chlorothane or tri-chlor-ethylene. Also clean the area where sealer is later to be applied (Fig. 25). Dry the area thoroughly, so no solvent touches the seal.
2. Dip the split lip-type seal halves in the clean engine oil.
3. Carefully install the upper seal (cylinder block) into its groove with undercut side of seal toward the FRONT of the engine (Fig. 24), by rotating it on the seal journal of the crankshaft until approximately 3/8 inch protrudes below the parting surface.

   Be sure no rubber has been shaved from the outside diameter of the seal by the bottom edge of the groove. Do not allow oil to get on the sealer area (Fig. 25).
4. Tighten the bearing cap bolts and torque to specifications.
5. Install the lower seal in the rear main bearing cap with undercut side of seal toward the FRONT of the engine (Fig. 24). Allow the seal to protrude approximately 3/8-inch above the parting surface to mate with the upper seal when the cap is installed.
6. Apply an even 1/16 inch bead of RTV silicone rubber sealer to the areas shown in Fig. 25, following the procedure given in the illustration.
   NOTE: This sealer sets up in 15 minutes. Install the rear main bearing cap. Torque the cap bolts to specifications.
7. Install the oil pump and oil pan. Fill the crankcase with the proper amount and viscosity oil.
8. Operate the engine and check for oil leaks.

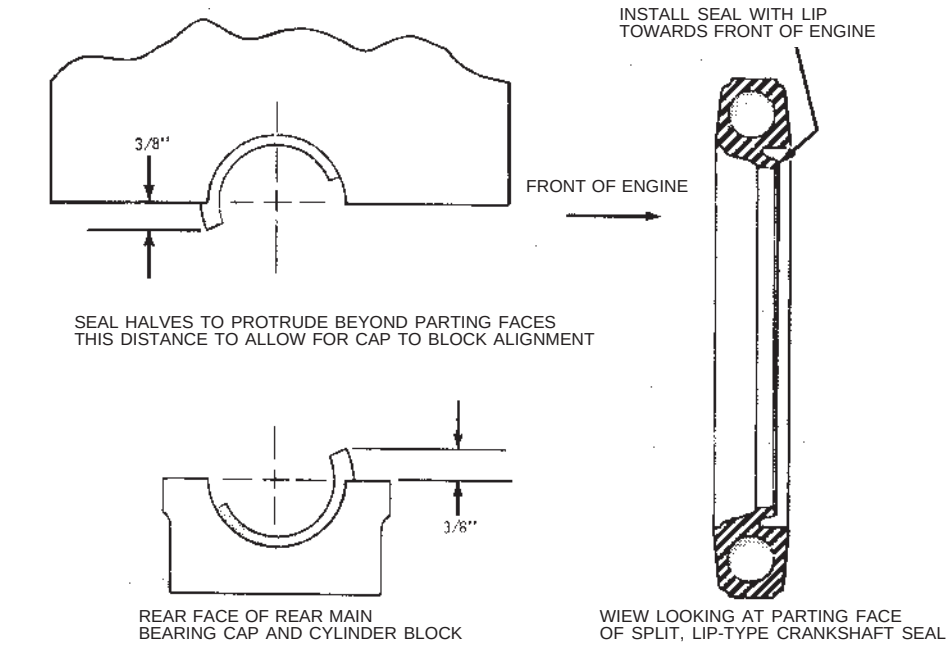


Fig. 24 Installing Crankshaft Rear Oil Seal

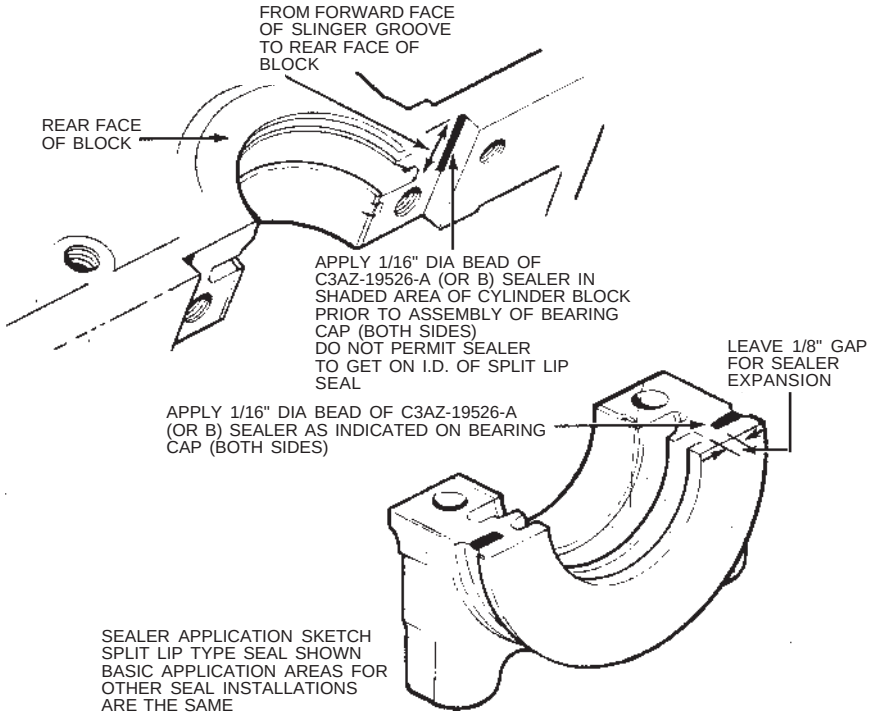


Fig. 25 Applying RTV Sealer To Main Bearing Cop and Block

Overhaul

Cylinder head

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

Reaming Valve Guides

If it becomes necessary to ream a valve guide (Fig. 29) 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 angle 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 (Fig. 30). 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 scat width scale or a machinist scale to measure the seat width (Fig. 31). 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.

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.

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 (Fig. 32), replace the valve as the valve will run too hot in the engine. **The interference angle 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.

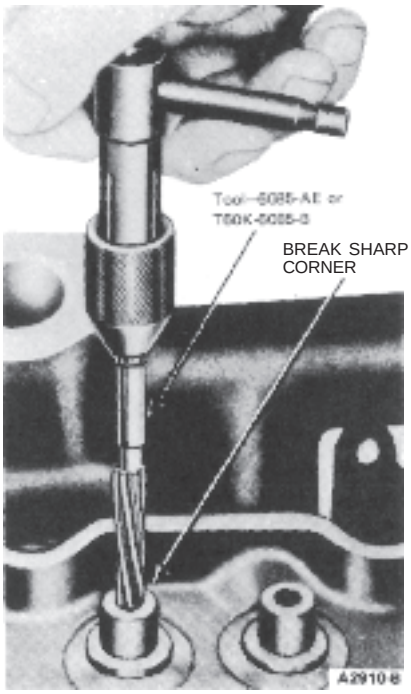


Fig. 29 Reaming Valve Guides-6 Cylinder Shown

Select Fitting Valves

If the valve stem to valve guide clearance exceeds the wear limit, ream the valve guide for the next oversize valve stem. Valves with oversize stem diameters of 0.003, 0.015 and 0.030 inch are available for service for all engines except 2300cc and 2800cc. For these engines, oversize valve stems are available in diameters of 0.008, 0.016, and 0.032 inch oversize. **Always reface the valve seat after the valve guide has been reamed. Refer to Reaming Valve Guides.**

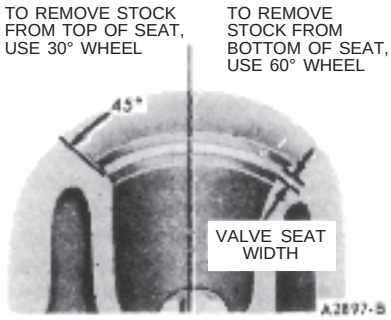


Fig. 30 Refacing Valve Seat

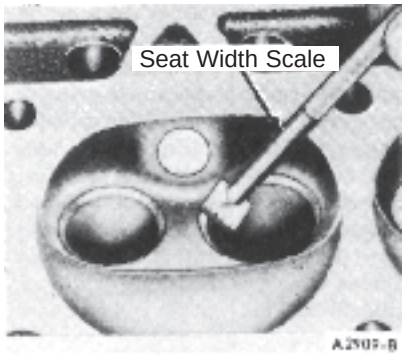


Fig. 31 Checking Valve Seat Width

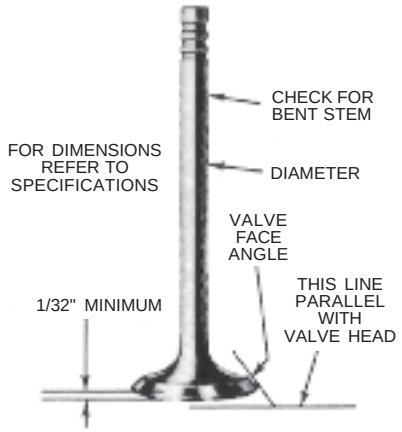


Fig. 32 Critical Valve Dimensions

Camshaft repair

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

Pistons, pins and rings

Fitting Pistons

Pistons are available for service in standard sizes and the oversizes shown in Specification section at the end of each engine Part.

The standard size pistons are color coded red or blue, or have 0.003 OS 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 0.003 OS 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 (within the same grade size) 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). Measure the piston diameter in line with the centerline of the piston pin and at 90 degrees to the piston pin axis.
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

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.

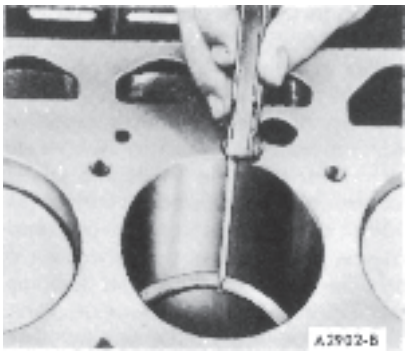


Fig. 33 Checking Piston Ring Gap

3. Push the ring down into the bore area where normal ring wear is not encountered.
4. Use the head of a piston to position the ring in the bore so that the ring is square with the cylinder wall. Use caution to avoid damage to the ring or cylinder bore.

5. Measure the gap between the ends of the ring with a feeler gauge (Fig. 33). If the ring gap is less or greater than the specified limits, try another ring set.
6. Check the ring side clearance of the compression rings with a feeler gauge inserted between the ring and its lower land (Fig. 34). 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.**

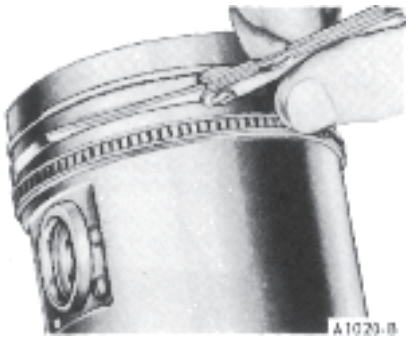


Fig. 34 Checking Piston Ring Side Clearance

Fitting Piston Pins

Install the piston pin, following the procedure under Piston Assembly in the applicable engine part.

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 pick-up 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 one half of a 0.001 or 0.002 inch undersize in combination with a standard bearing to obtain the proper clearance.
2. If fitting a main bearing in the vehicle, **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 (Fig. 3 5).
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, try 0.001 or 0.002 inch undersize bearings 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.

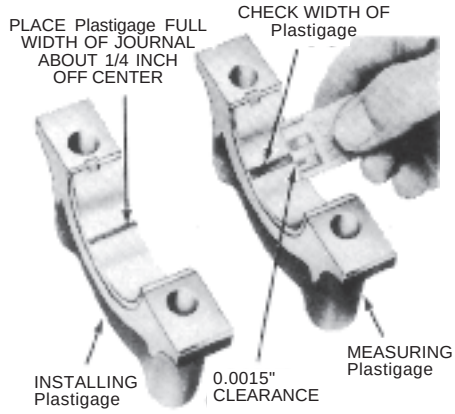


Fig. 35 Installing and Measuring Plastigage

7. After bearing has been fitted, 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.

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. Check the baffle plate on the underside of the manifold if so equipped. The baffle should be securely fastened at all attaching points.

Exhaust Manifolds

Cleaning

Remove all gasket material from the manifolds.

Inspection

Inspect the cylinder head joining flanges of the exhaust manifold(s) 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

Inspect the shaft and the rocker arm bore for nicks, scratches, scores or scuffs. Replace any damaged parts.

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. On stud-mounted rocker arms, check the rocker arm pad, side rails and fulcrum seat for excessive wear, cracks, nicks or burrs. Check the rocker arm stud and nut for stripped or broken threads. On positive stop rocker arm stud nuts, check the shoulder for damage as shown in Fig. 37. Replace all damaged nuts.**

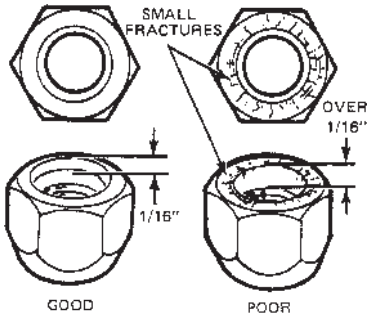


Fig. 37 Positive Stop Rocker Arm Stud Nut

On pedestal mounted rocker arms, check the rocker arm pad and fulcrum scat for excessive wear, cracks, nicks or burrs. Replace all damaged rocker arms.

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. Replace damaged push rods.

The push rods can be visually checked for straightness while they are installed in the engine by rotating them with the valve closed. They also can be checked with a dial indicator (Fig. 38).

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

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. 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.

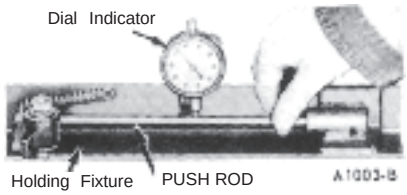


Fig. 38 Checking Push Rod Runout

Inspection

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

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

When a cylinder head is removed because of gasket leaks, check the flatness of the cylinder head gasket surface (Fig. 39) for conformance to specifications. If necessary to refinish the cylinder head gasket surface, **do not plane or grind off more than 0.010 inch.**

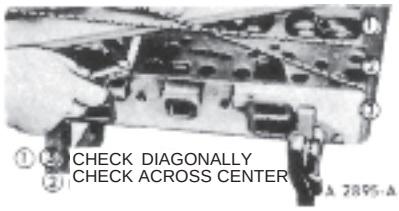


Fig. 39 Typical Cylinder Head Flatness

Check the valve seat runout with an accurate gauge (Fig. 40). 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 (Fig. 30). **Reface any valve seat whose width is not within specifications.**

The critical inspection points of the valves are illustrated in Fig. 32. Refer to the specifications for wear limits.

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 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 Fig. 41 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.

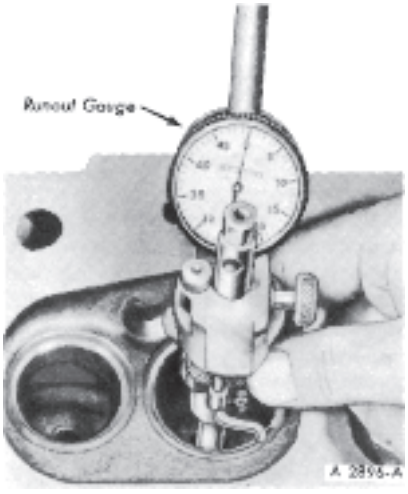


Fig. 40 Checking Valve Seat Runout

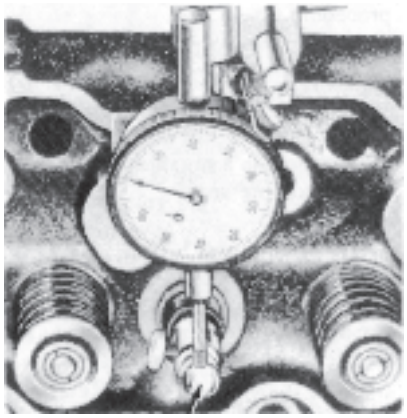


Fig. 41 Checking Valve Stem Clearance

Check the springs for proper pressure (Fig. 42) 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.

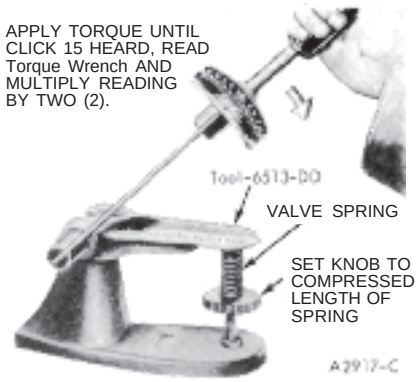


Fig. 42 Checking Valve Spring Pressure

Check each spring for squareness, using a steel square and a flat surface (Fig. 43). 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.

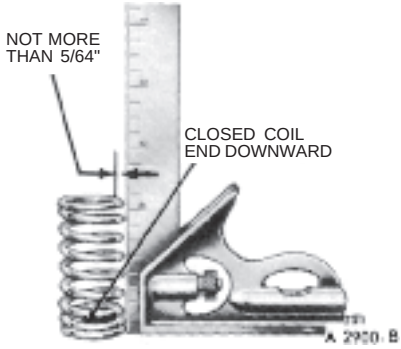


FIG. 43 Checking Valve Spring Squareness

Follow the same procedure to check new valve springs before installation. **Make certain the proper spring (Color coded) is installed. Visually inspect the valve spring retainer to determine if the damper spring coil has been hitting the retainer. This interference will also cause a clicking noise when the engine is operating. The damper spring is properly installed in the valve spring when positioned so that the end of the damper spring bottom coil is 135 degrees counterclockwise from the end of the valve spring lower coil.**

Hydraulic Valve Lifters and Hydraulic Lash Adjusters

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

Cleaning

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

Inspection

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

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

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.

Fuel Pump Eccentric

Cleaning

Clean the fuel pump eccentric in solvent and dry with compressed air.

Inspection

Inspect the fuel pump drive eccentric for scores, nicks and excessive wear. If the eccentric surface is scored, nicked or worn, replace it.

On two-piece designs, inspect inner and outer rings for scoring, nicks, and excessive wear. Replace any part indicating scoring or excessive wear.

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.

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.

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

Measure the outer race to housing clearance (Fig. 44).

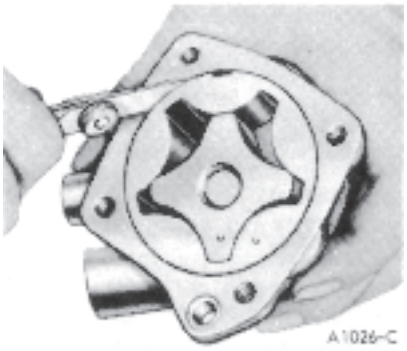


Fig. 44 Checking Outer Race to Housing Clearance

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 (Fig. 45). **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.

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.

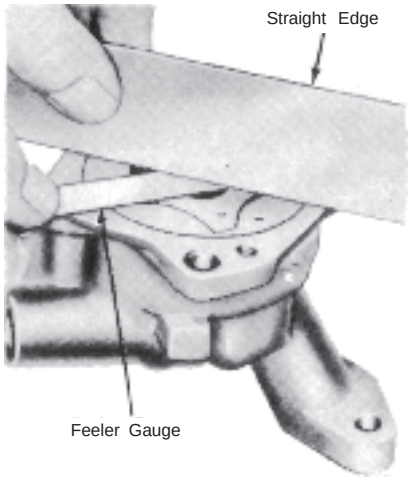


Fig. 45 Checking Rotor End Play

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 0.001 inch oversize piston pin. First, prefit the oversize piston pin to the piston pin bore by reaming or honing the piston to provide 0.0002-0.0004 inch clearance (light slip fit). Then, assemble the piston, piston pin and connecting rod following the procedures for the specific engine being worked on. **It is not necessary to ream or bone 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 (Fig. 46). Make sure the oil ring slots (or holes) are clean.

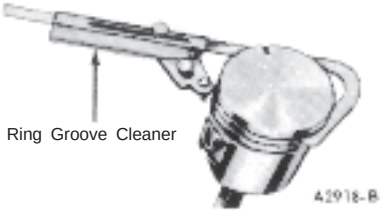


Fig. 46 Cleaning Piston Ring Grooves

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 at the centerline of the piston pin bore and at 90 degrees to the pin bore axis.** 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, in the pertinent engine section.

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.**

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 Fig. 47. 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.

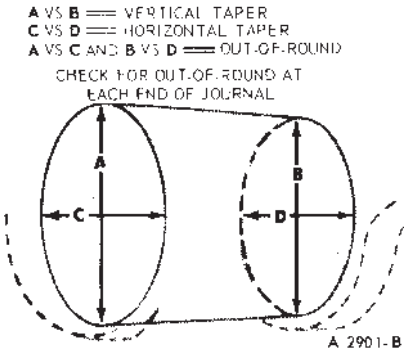


Fig. 48 Crankshaft Journal Measurement

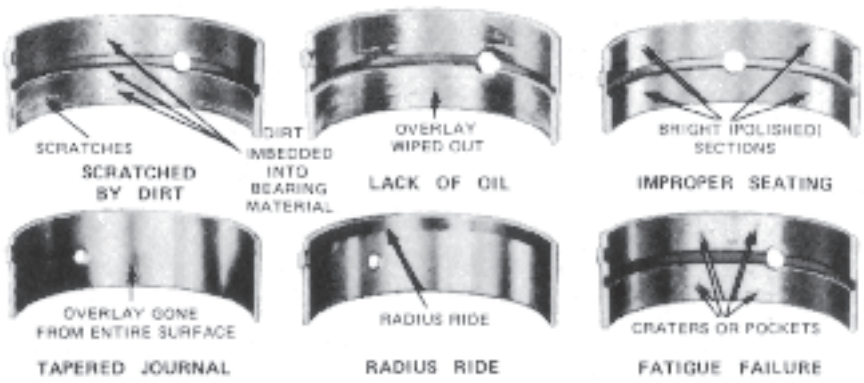


Fig. 47 Typical Bearing Failures

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 (Fig. 48).

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

Crankshaft Vibration Damper and Sleeve

Cleaning

Clean the oil seal contact surface on the crankshaft damper or sleeve with solvent to remove any corrosion, sludge or varnish deposits. Excess deposits that are not readily removed with solvent may be removed with crocus cloth. Use crocus cloth to remove any sharp edges or burrs which might damage the oil seal during installation or cause premature seal wear. **DO not use crocus cloth to the extent that the seal surface becomes polished. A finely polished surface may produce poor sealing or cause premature seal wear.**

Inspection

Inspect the crankshaft damper seal surface for nicks, sharp edges or burrs that might damage the oil seal during installation or cause premature seal wear.

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 all deposits. Thoroughly clean the grooves in the crankshaft bearings and bearing retainers.

Inspection

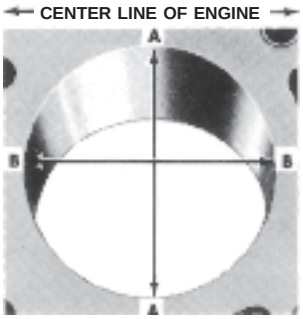
After the block has been thoroughly cleaned, check it for cracks. Minute cracks not visible to the naked eye may be detected by coating the suspected area with a mixture of 25 percent kerosene and 75 percent light engine oil. Wipe the part dry and immediately apply a coating of zinc oxide dissolved in 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 (Fig. 49). **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.



A
At right angle to center line of engine

B
Parallel to center line of engine

1. Out-of-round = Difference between **A** and **B**

2. Taper = Difference between the **A** measurement at top of cylinder bore and the **A** measurement at bottom of cylinder bore.

Fig. 49 Cylinder Bore Out-of-Round and Taper

Removal and installation

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

Refer to Page 19 for Cleaning and Inspection and Engine test procedures.

Engine assembly

Removal

1. Drain the cooling system and the crankcase.
2. Disconnect the battery and alternator ground cables
6. Remove the alternator bolts and position the alternator out of the way.
7. Disconnect the oil pressure sending unit wire from the sending unit, and the flexible fuel line at the fuel tank line. Plug the fuel tank line.
8. Disconnect the accelerator rod from the carburetor.

   Disconnect the transmission filler tube bracket from the cylinder block.
9. Disconnect the water temperature sending unit wire from the sending unit.
10. Remove the flywheel housing to engine upper bolts.
11. Disconnect the primary wire from the ignition coil. Remove the wire harness from the left rocker arm cover and position the wires out of the way. Disconnect the ground strap from the block.
12. Disconnect the starter cable from the starter. Remove the starter.

    Remove the remaining flywheel housing to engine bolts.

Installation

3. Install the flywheel housing upper bolts, making sure that the dowels in the cylinder block engage the flywheel housing.
6. Install the starter and the starter cable.
8. Connect the wiring harness to the left valve rocker arm cover and connect the coil wire.
9. Connect the water temperature sending unit wire.
10. Connect the bellcrank to the intake manifold.
12. Install the pulley, belt, spacer and fan.
13. Position the alternator and install the alternator bolts. Connect the alternator and the battery ground cables. Adjust the belt tension to specifications.

Crankcase ventilation system

Removal

1. Remove the ventilation system air intake hose from the air cleaner and the right valve cover.
2. Remove the air cleaner and intake duct assembly.
3. Disconnect the crankcase vent hose from the carburetor spacer.
4. Pull the regulator valve out of the oil filler cap in the left valve cover.

Installation

1. Insert the regulator valve into the oil filler cap on the left valve cover.
2. Connect the vent hose to the regulator valve; install the hose on the carburetor spacer.
3. Install the air cleaner and intake duct assembly.
4. Install the ventilation system air intake hose to the air cleaner and the right valve cover fitting.
5. Start the engine and check for leaks.

Valve rocker arm cover and rocker arm

The valve rocker arm assembly sequence is shown in Fig. 10.

Removal

1. To remove a valve rocker arm from the right cylinder head, disconnect the automatic choke heat chamber air inlet hose from the inlet tube near the right valve rocker arm cover, if so equipped

   Remove the automatic choke heat tube. Remove the crankcase ventilation fresh air tube from the valve rocker arm cover.
3. Disconnect the spark plug wires from the spark plugs. Do not pull on wire. Remove the wires from the bracket on the valve rocker arm cover(s) and position the wires out of the way.
4. On a left side rocker arm cover, remove the wire harness from the retaining clips. Remove the valve rocker arm cover attaching bolts and remove the cover.
5. Remove the valve rocker arm stud nut, fulcrum seat and rocker arm.

   If removal of the rocker arm stud is necessary, refer to the procedure under Cylinder Head Repairs in Part Page 13.

Installation

All rocker arms and fulcrum seats are to be lubricated with heavy engine oil SE before installation.

1. Apply Lubriplate, or equivalent, to the top of the valve stem and underside of the fulcrum seats.
2. Inspect the stud nut for damage. The chamfer on the nut should not be over 1/16-inch wide. A nut with a chamfer larger than 1/16-inch can cause the valves to be held open.
3. Install the rocker arm, fulcrum seat and stud nut.
4. Clean the valve rocker arm cover(s) and the cylinder head gasket surface(s). Position the valve rocker cover gasket in each cover, making sure that the tabs engage the notches in the cover.
5. Position the cover(s) on the cylinder head(s). Make sure the gasket seats evenly all around the head. Install the bolts and wire loom clips on left hand cover. The cover is tightened in two steps. Torque the bolts to specifications. Two minutes later, torque the bolts to the same specifications.

   Install the crankcase ventilation hoses in the covers. Install the automatic choke heat tube and connect the automatic choke heat chamber air inlet hose at the air cleaner.
6. Install the spark plug wires in the bracket on the valve rocker arm cover(s). Connect the spark plug wires.

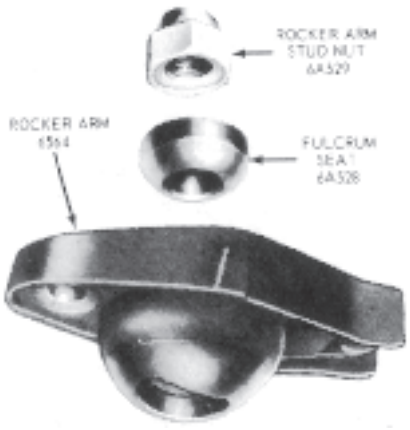


Fig. 10 Valve Rocker Arm-302 and 351-W Engines

Valve spring, retainer and stem seal

Broken valve springs or damaged valve stern seals and retainers may be replaced without removing the cylinder head, provided damage to the valve or valve seat has not occurred.

Removal

1. Make sure the applicable piston is at the top of its stroke to prevent accidental dropping of the valve into the cylinder. Remove the valve rocker arm cover and the applicable spark plug.
2. Install an air line with an adapter in the spark plug hole and turn on the air supply. Failure of the air pressure to hold the valve(s) in the closed position is an indication of valve seat damage and necessitates removal of the cylinder head.
3. Remove the valve rocker arm stud nuts, fulcrum seats, valve rocker arms and push rods from the applicable cylinder.
4. Install the stud nut and position the compressor tool as shown in Fig. 11. Compress the valve spring and remove the retainer locks, sleeve, spring retainer and valve spring.
5. Remove and discard the valve stem seal (Fig. 12).
6. If air pressure has forced the piston to the bottom of the cylinder, any removal of air pressure will allow the valve(s) to fall into the cylinder. A rubber band, tape or string wrapped around the end of the valve stem will prevent this condition and will still allow enough travel to check the valve for binds.

Installation

1. Inspect the valve stem for damage. Rotate the valve and check the valve stem tip for eccentric movement during rotation. Move the valve up and down through normal travel in the valve guide and check the stem for binds. **If the valve has been damaged, it will be necessary to remove the cylinder head for repairs as outlined in Page 17.**
2. If the condition of the valve proved satisfactory, apply heavy engine oil SE to the valve stem and hold the valve in the closed position. Apply the air pressure within the cylinder.

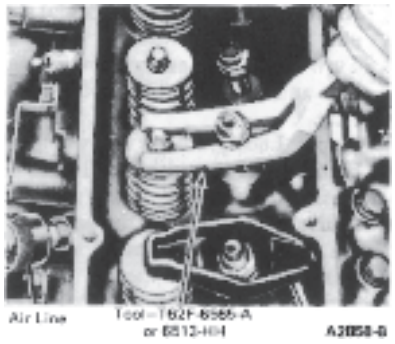


Fig. 11 Compressing Valve

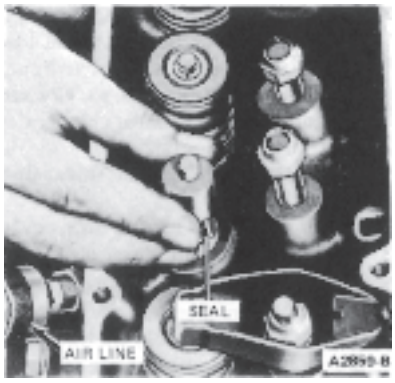


Fig. 12 Removing or Installing Valve Stem Seal

3. Install a new valve stem seal (Fig. 12). Place the spring in position over the valve and install the valve spring retainer and sleeve, if so equipped. Compress the valve spring and install the valve spring retainer locks. Remove the compressor tool and stud nut.
4. Turn off the air and remove the air line and adapter. Install the spark plug.
5. Apply Lubriplate or equivalent on both ends of the push rod. Install the push rod. Apply Lubriplate or equivalent to the tip of the valve stem. On exhaust valves, install the valve stem cap, if so equipped.
6. Apply Lubriplate, or equivalent, to the push rod socket, underside of the fulcrum seat and the valve pad of the rocker arm; then install the valve rocker arms, fulcrum seats and stud nuts.
7. Clean and install the rocker arm cover.

   If the right cover was removed install the automatic choke heat tube (302 only) and the crankcase ventilation hose and fittings. Connect the automatic choke heat chamber air inlet hose (302 only).
8. Install the air cleaner and intake duct assembly.
9. Install the valve rocker arm covers and crankcase ventilation hoses, etc.

Intake manifold

The intake manifold assembly is shown in Fig. 13.

Removal

1. Drain the cooling system. Disconnect the automatic choke heat chamber air inlet hose at the inlet tube near the right valve rocker arm cover.
2. Disconnect the accelerator rod or cable from the carburetor and/or manifold brackets. Remove the accelerator retracting spring.
3. Disconnect the high tension lead and wires from the coil.
5. Disconnect the spark plug wires from the spark plugs using Tool No. T68P-6666-A. Do not pull on the wire. Remove the wires from the harness brackets on the valve rocker arm covers. Remove the distributor cap and spark plug wire assembly. Remove EGR vacuum amplifier at rear of manifold.
6. Remove the carburetor fuel inlet line and the automatic choke heat tube (302 only).
7. Disconnect the distributor vacuum hoses from the distributor. Remove the distributor hold down bolt and remove the distributor.

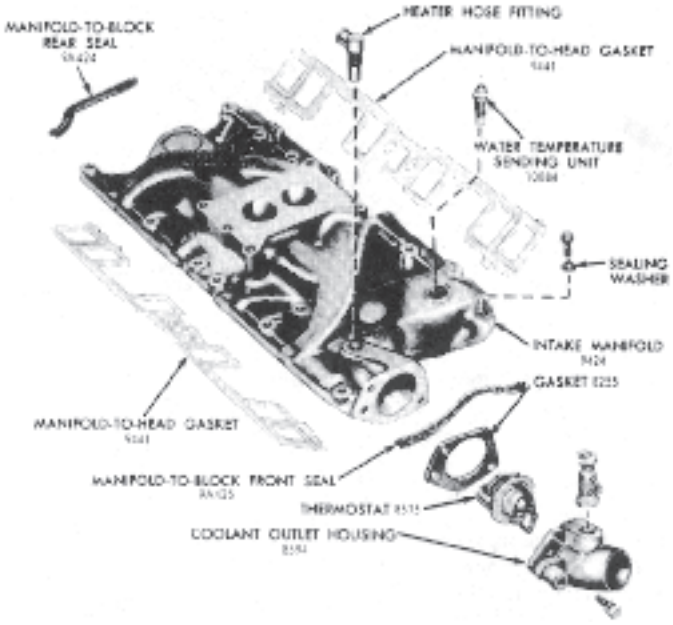


Fig. 13 Typical Intake Manifold Assembly

8. Disconnect the radiator upper hose from the coolant outlet housing, and the water temperature sending unit wire at the sending unit. Disconnect the hose from the intake manifold.
9. Loosen the clamp on the water pump bypass hose at the coolant outlet housing and slide the hose off the outlet housing.
10. Disconnect the crankcase vent hose assembly at the valve rocker arm cover.
12. Remove the intake manifold and carburetor as an assembly. **It may be necessary to pry the intake manifold away from the cylinder head(s). Use caution to avoid possible damage to the gasket sealing surfaces. Remove the intake manifold gaskets and seals. Discard the intake manifold attaching bolt sealing washers.**
13. If the manifold assembly is to be disassembled, identify all vacuum hoses before disconnecting them. Remove the coolant outlet housing, gasket and thermostat. Remove the ignition coil, temperature sending unit, carburetor, spacer and gaskets,

Installation

1. If the intake manifold assembly was disassembled, install the temperature sending unit (threads coated with electrical conductive sealer), ignition coil carburetor, spacer and gaskets.

   Position the thermostat in the coolant outlet housing. Coat the thermostat gasket with water-resistant sealer and position it on the coolant outlet housing. Install the coolant outlet housing.
2. Clean the mating surfaces of the intake manifold, cylinder heads and cylinder block. Use a solvent such as lacquer thinner, chlorothane or tri-chlor-ethylene. Apply a 1/8 inch bead of silicone rubber sealer at the points shown in Fig. 14.

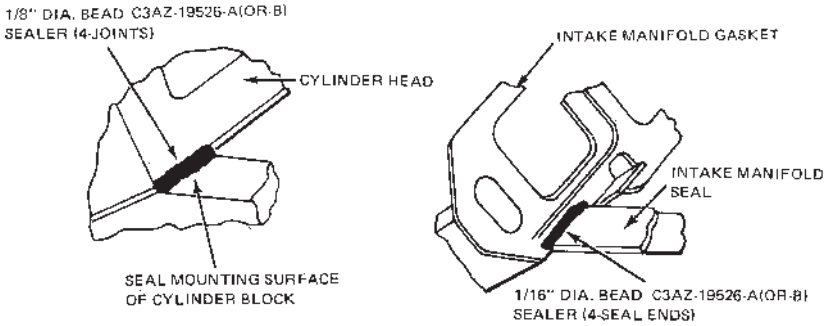


Fig. 14 Typical RTV Sealer Installation-intake Manifold

3. Position new seals on the cylinder block and new gaskets on the cylinder heads with the gaskets interlocked with the seal tabs. Be sure the holes in the gaskets are aligned with the holes in the cylinder heads.

Apply a 1/16 inch bead of the above sealer to the outer end of each intake manifold seal for the full width of the seal (4 places). See Fig. 14.

NOTE: This sealer sets up in 15 minutes, so it is important that assembly be completed promptly. Do not drip any sealer into the engine valley.

4. Carefully lower the intake manifold into position on the cylinder block and cylinder heads. **After the intake manifold is in place, run a finger around the seal area to make sure the seals are in place. If the seals are not in place, remove the intake manifold and position the seals.**

5. Be sure the holes in the manifold gaskets and manifold are in alignment. Install the choke heat stove. Install the intake manifold attaching bolts and nuts. Torque the intake manifold bolts in sequence (Figs. 15 and 16) to specifications.

After completing the remaining assembly steps, operate the engine until it reaches normal operating temperature, then retorque the manifold bolts in sequence to specifications.

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

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

11. Connect the crankcase vent hose. Connect the high tension lead and coil wires.

12. Connect the accelerator rod or cable and retracting spring.

14. Start the engine and check and adjust the ignition timing.

15. Operate the engine at fast idle and check all hose connections and gaskets for leaks. When engine temperatures have stabilized adjust the engine idle speed and idle fuel mixture. Retorque intake manifold bolts to specifications.

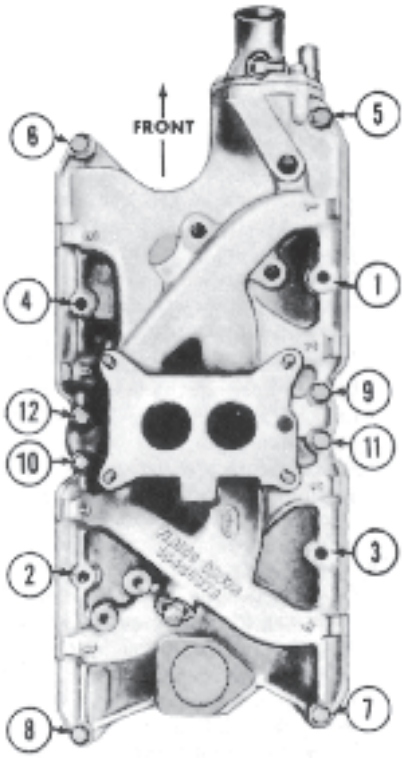


Fig. 15 Intake Manifold Bolts Torque Sequence

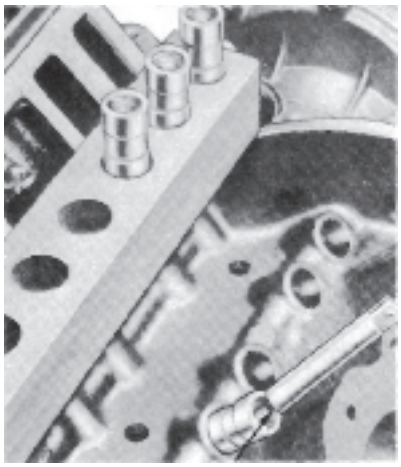


Fig. 17 Removing Valve lifter

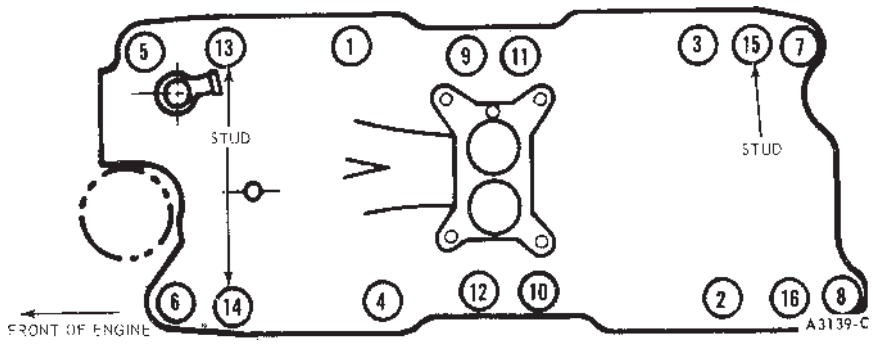


Fig. 16 Intake Manifold Bolts Torque Sequence

Valve lifter

Before replacing a hydraulic valve lifter for noisy operation, be sure the noise is not caused by improperly adjusted valve to rocker arm clearance or by worn rocker arms or push rods.

Removal

1. Remove the intake manifold and related parts by following procedures under Intake Manifold Removal.
2. Remove the crankcase ventilation hoses and fittings from the valve rocker arm covers.
3. Remove the valve rocker arm covers. Loosen the valve rocker arm stud nuts and rotate the rocker arms to the side.
4. Remove the valve push rods and identify them so that they can be installed in their original positions.
5. Using a magnet, remove the valve lifters and place them in a rack so that they can be installed in their original bores (Fig. 17).

   If the valve lifters cannot be removed from their bores due to excessive varnish, etc., it may be necessary to use a plier-type tool (T52T-6500-DJD or 6500-D) or a claw type tool to remove the lifters. Rotate the lifter back and forth to loosen it from the gum or varnish that may have formed on the lifter.

   If necessary to disassemble a lifter, refer to Valve Lifter Disassembly and Assembly.

Installation

Tappets or lifters and bores are to be lubricated with heavy engine oil SE before installation.

1. Clean outside of lifters and install in the bores from which they were removed. If a new lifter(s) is being installed, check the new lifter(s) for a free fit in the bore in which it is to be installed. Lubricate the lifter(s) and bore(s) with heavy engine oil SE before inserting it in the bore.
2. Install the push rods in their original position. Apply Lubriplate or equivalent to the valve stem tips and the push rod ends.
3. Lubricate the rocker arms and fulcrum seats with heavy engine oil SE. Position the rocker arms over the push rods and install stud nuts. Perform a valve clearance adjustment as outlined under Valve Clearance Adjustment-Hydraulic Valve Lifters. Page 12.
4. Install the valve rocker arm covers. Install the crankcase ventilation regulator valve in the valve rocker arm cover.
5. Install the intake manifold and related parts by following procedures under Intake Manifold Installation.

Cylinder heads

If a cylinder head is to be replaced, follow the procedures under Cylinder Head Disassembly and Assembly, and transfer all valves, springs, spark plugs, etc., to the new cylinder head. Clean and inspect all parts, reface the valves, Page 17, and check all assembly clearances before assembling the new or used parts to the new cylinder head.

Removal

1. Remove the intake manifold and carburetor as an assembly following the procedure under Intake Manifold Removal.
2. Remove the rocker arm cover(s).
4. Disconnect the exhaust manifold(s) from the muffler inlet pipe(s).
5. Loosen the rocker arm stud nuts so that the rocker arms can be rotated to the side. Remove the push rods in sequence (Fig. 18) so that they may be installed in their original positions.
6. Install the cylinder head holding fixtures (Fig. 19).

   Remove the cylinder head attaching bolts and lift the cylinder head off the block. If required, remove the exhaust manifolds to gain access to the lower attaching bolts. Remove and discard the cylinder head gasket.

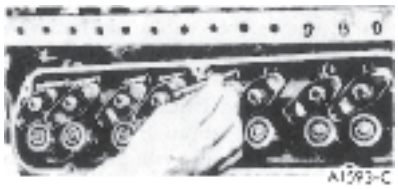


Fig. 18 Removing Valve Push Rod

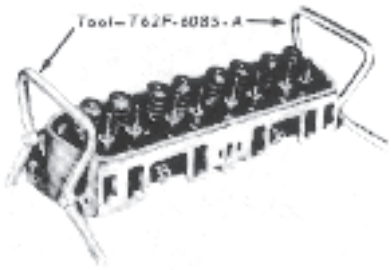


Fig. 19 Cylinder Head Holding Fixture 302 and 352-W

Installation

1. Clean the cylinder head, intake manifold, valve rocker arm cover and cylinder head gasket surfaces. If the cylinder head was removed for a cylinder head gasket replacement, check the flatness of the cylinder head and block gasket surfaces.
2. Position the new cylinder head gasket over the cylinder dowels on the block. Position the cylinder head on the block and install the attaching bolts. Remove the holding fixtures.
3. The cylinder head bolts are tightened in three progressive steps. Torque all the bolts in sequence (Fig. 20) to specifications. When cylinder head bolts have been tightened following this procedure, it is not necessary to retorque the bolts after extended operation. However, the bolts may be checked and retorqued if desired. If removed, install the exhaust manifolds and retorque the attaching bolts to specification.
4. Clean the push rods in a suitable solvent. Blow out the oil passage in the push rod with compressed air. Check the ends of the push rods for nicks, grooves, roughness or excessive wear. Visually check the push rods for straightness or check push rod runout with a dial indicator. If runout exceeds the maximum limit at any point, discard the rod. **Do not attempt to straighten push rods.**
5. Apply Lubriplate or equivalent to both ends of the push rods. Install the push rods in their original positions. Apply Lubriplate or equivalent to the valve stem tips.

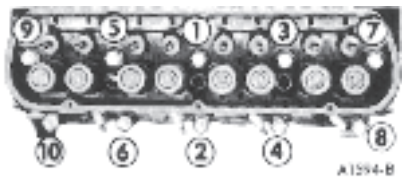


Fig. 20 Cylinder Head Bolt Torque Sequence

6. Install the rocker arms. If all original assembly components are installed, a valve clearance adjustment is not necessary. If any valve train components are replaced, perform a valve clearance adjustment as outlined under Valve Clearance Adjustment-Hydraulic Valve Lifters Page 12.
7. Connect the exhaust manifold(s) at the muffler inlet pipe(s). Tighten the nuts to specifications.
9. Clean the valve rocker arm cover(s). Position the valve rocker cover gasket in each cover, making sure that the tabs engage the notches in the cover. Install the valve rocker arm cover(s).

   The valve rocker cover is tightened in two steps. Tighten the bolts to specifications. Two minutes later retighten bolts to the same specifications.
10. Install the intake manifold and related parts following the procedure under Intake Manifold Installation.

Exhaust manifolds

Removal

1. On a right exhaust manifold, remove the air cleaner and intake duct assembly. Disconnect the automatic choke heat chamber air inlet hose from the inlet tube near the right valve rocker arm cover (302 only).

   Remove the nuts or bolts retaining the heat stove on the exhaust manifold and remove the heat stove.
2. Disconnect the exhaust manifold from the muffler inlet pipe. Remove the attaching nuts and then remove the spark plug wires, spark plugs and heat shields.
3. Remove the attaching bolts and washers and remove the exhaust manifold.

Installation

1. Clean the mating surfaces of the exhaust manifold and cylinder head. Clean the mounting flange of the exhaust manifold and muffler inlet pipe.
2. Position the exhaust manifold on the cylinder head and install the heat shields and the attaching bolts and tab washers. Working from the center to the ends, torque the bolts to specifications. Install the spark plugs and spark plug wires.
3. Position the muffler inlet pipe to the manifold. Install and torque the attaching nuts to specifications.
6. Start the engine and check for exhaust leaks.

Water pump

Removal

1. Drain the cooling system.
2. Remove the air conditioner drive belt and idler pulley bracket if so equipped.

   Remove the alternator drive belt.

   Remove all accessory brackets which attach to the water pump. Remove the water pump pulley.
3. Disconnect the radiator lower hose, heater hose and water pump bypass hose at the water pump.
4. Remove the bolts that attach the pump to the cylinder front cover. Remove the pump and gasket. Discard the gasket.

Installation

1. Remove all gasket material from the mounting surfaces of the cylinder front cover and water pump.
2. Position a new gasket, coated on both sides with sealer, on the cylinder front cover; then install the pump.
3. Install the attaching bolts and torque them to specifications.
4. Connect the radiator hose, heater hose and water pump by-pass hose at the water pump.
5. Install all the accessory brackets which attach to the water pump. Place the water pump pulley on the water pump shaft.

   Adjust the drive belts to the specified belt tension.
8. Operate the engine until normal operating temperatures have been reached and check for leaks.

Cylinder front cover and timing chain

Removal

1. Refer to Water Pump Removal. Perform all steps except removal of the pump. Leave it attached to the front cover.
2. Drain the crankcase.
3. Remove the crankshaft pulley from the crankshaft vibration damper. Remove the damper attaching screw and washer. Install the puller on the crankshaft vibration damper (Fig. 21) and remove the vibration damper.

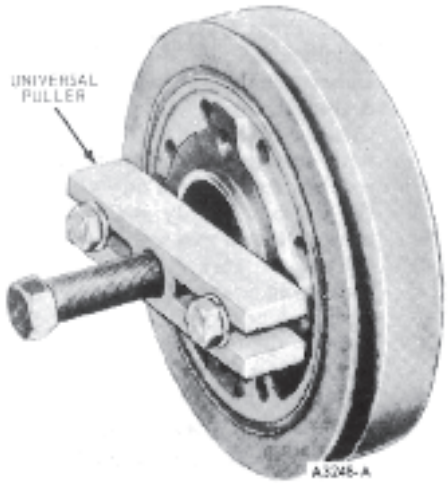


Fig. 21 Removing Crankshaft Vibration Damper

4. Disconnect the fuel pump outlet line from the fuel pump. Remove the fuel pump attaching bolts and lay the pump to one side with the flexible fuel line still attached.
5. Remove the oil level dipstick.
6. Remove the oil pan to cylinder front cover attaching bolts. Use a thin blade knife to cut the oil pan gasket flush with cylinder block face prior to separating the cover from the cylinder block. Remove the cylinder front cover and water pump as an assembly.

   If a new cylinder front cover is to be installed, remove the water pump and dipstick tube from the old cylinder front cover and install them on the new cover.
7. Discard the cylinder front cover gasket. Remove the crankshaft front oil slinger.
8. Check the timing chain deflection (refer to Page 11).
9. Crank the engine until the timing marks on the sprockets are positioned as shown in Fig. 22.
10. Remove the camshaft sprocket cap screw, washers and fuel pump eccentric. Slide both sprockets and the timing chain forward, and remove them as an assembly (Fig. 23).

Installation

1. Position the sprockets and timing chain on the camshaft and crankshaft simultaneously (Fig. 23). Be sure the timing marks on the sprockets are positioned as shown in Fig. 22.
2. Install the fuel pump eccentric, washers and camshaft sprocket cap screw. Torque the sprocket cap screw to specifications. Install the crankshaft front oil slinger (Fig. 24).
3. Clean the cylinder front cover, oil pan and the block gasket surfaces.
4. Install a new oil seal in the cylinder front cover following the procedures under Front Oil Seal Removal and Installation.
5. Lubricate the timing chain with engine oil.
6. Coat the gasket surface of the oil pan with sealer, cut and position the required sections of a new gasket on the oil pan, apply sealer at the corners. Install pan seal as required.

   Coat the gasket surfaces of the block and cover with sealer, and position a new gasket on the block.
7. Position the cylinder front cover on the cylinder block. Use care when installing the cover to avoid seal damage or possible gasket mislocation.
8. Install the cylinder front cover to seal alignment tool into proper position.
9. It may be necessary to force the cover downward to slightly compress the pan gasket. This operation can be facilitated by using a suitable tool at the front cover attaching hole locations.
10. Coat the threads of the attaching screws with oil resistant sealer and install the screws. While pushing in on the alignment tool, tighten the oil pan to cover attaching screws to specifications (Fig. 25). Tighten the cover to block attaching screws to specifications. Remove the pilot.

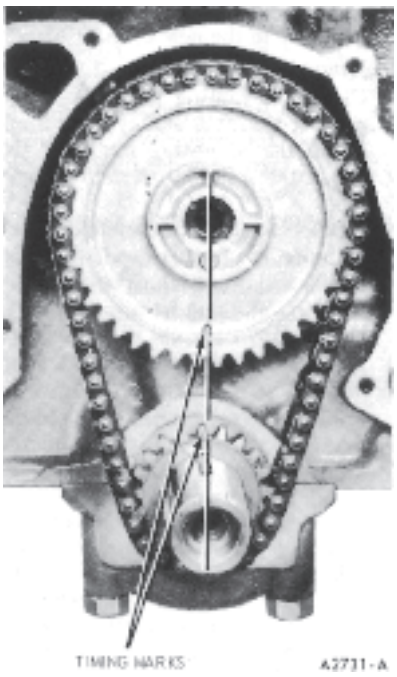


Fig. 22 Aligning Timing Marks

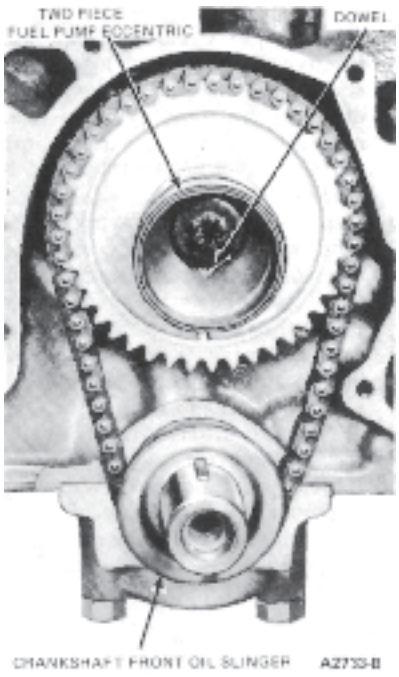


Fig. 24 Fuel Pump Eccentric and Front Oil Slinger Installed

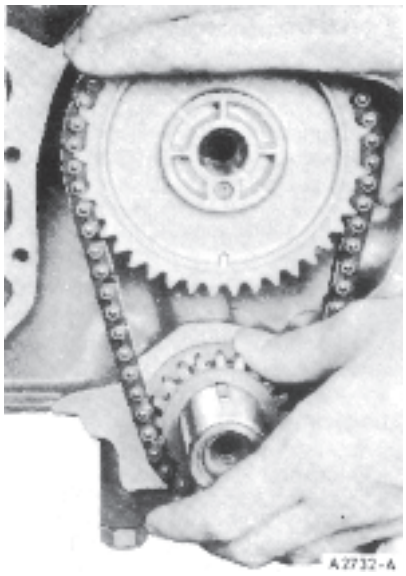


Fig. 23 Removing or Installing Timing Chain

11. Apply Lubriplate or equivalent to the oil seal rubbing surface of the vibration damper inner hub to prevent damage to the seal. Apply a white lead and oil mixture to the front of the crankshaft for damper installation.

12. Line up the crankshaft vibration damper keyway with the key on the crankshaft. Install the vibration damper on the crankshaft (Fig. 26). Install the cap screw and washer. Tighten the screw to specifications. Install the crankshaft pulley.

13. Install the fuel pump using a new gasket. Connect the fuel pump outlet line.

14. Install the oil level dipstick.

15. Refer to Water Pump Installation. Perform all the required steps except installation of the pump.

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

18. Operate the engine at fast idle and check for coolant and oil leaks. Check and adjust the ignition timing.

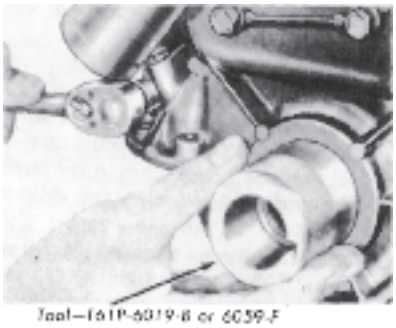


Fig. 25 Aligning Cylinder Front Cover

Front oil seal

Removal

1. Remove the cylinder front cover following the procedure under Cylinder Front Cover and Timing Chain Removal.
2. Drive out the old seal with the pin punch. Clean out the recess in the cover.

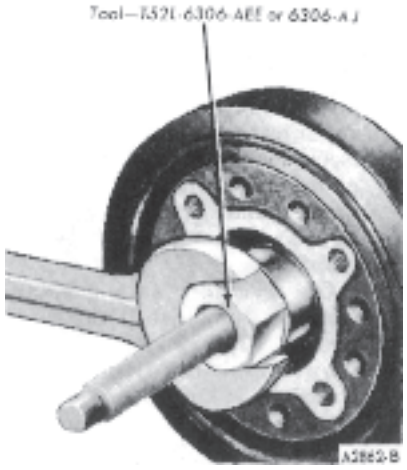


Fig. 26 Installing Crankshaft Vibration Damper

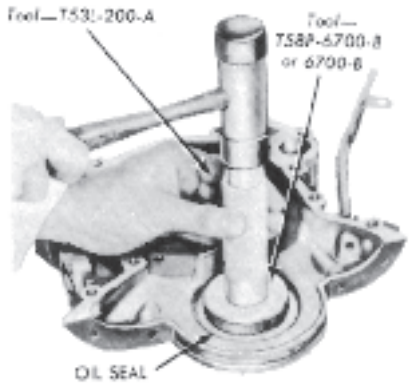


Fig. 27 Installing Crankshaft Front Oil Seal

Installation

1. Coat a new seal with grease, then install the seal in the cover. Drive the seal in until it is fully seated in the recess (Fig. 27). Check the seal after installation to be sure the spring is properly positioned in the seal.
2. Replace the cylinder front cover following the procedure under Cylinder Front Cover and Timing Chain Installation.

Camshaft

The camshaft and related parts are shown in Fig. 28.

Removal

1. Disconnect the upper and lower radiator hoses. Disconnect the transmission oil cooler lines from the radiator, if so equipped. Remove the bolts retaining the fan shroud to the radiator, if so equipped. Remove the radiator.

   On vehicles equipped with air conditioning, remove the bolts which secure the air conditioner and position the condenser out of the way.
2. Remove the cylinder front cover and the timing chain following the procedure under Cylinder Front Cover and Timing Chain Removal.
3. Remove the intake manifold and related parts by following procedures under Intake Manifold Removal.
4. Remove the crankcase ventilation valve and tubes from the valve rocker arm covers. Remove the valve rocker arm covers. Loosen the valve rocker arm stud nuts and rotate the rocker arms to the side.
5. Remove the valve push rods and identify them so that they can be installed in their original positions.
6. Using a magnet, remove the valve lifters and place them in a rack so that they can be installed in their original bores (Fig. 17).

   If necessary to disassemble a lifter, refer to Valve Lifter Disassembly and Assembly.

   If the valve lifters are stuck in their bores by excessive varnish, etc., it may be necessary to use a plier-type tool (T52T-6500-DJD or 6500-D) or a claw type tool to remove the lifters. Rotate the lifter back and forth to loosen it from the gum or varnish that may have formed at the lifter.
7. Remove the camshaft thrust plate Carefully remove the camshaft by pulling toward the front of the engine. **Use caution to avoid damaging the camshaft bearings.**

Installation

1. Oil the camshaft journals with heavy engine oil SE and apply Lubriplate or equivalent to the lobes. Carefully slide the camshaft through the bearings. Install the camshaft thrust plate with groove towards the cylinder block. Check camshaft end play as shown in Page 10.
2. Lubricate the lifters and bores with heavy engine oil SE. Install the valve lifters in the bores from which they were removed.
3. Apply Lubriplate or equivalent to each end of the push rods and install the push rods in their original positions. Apply Lubriplate or equivalent to the valve stem tips. Lubricate the rocker arms and fulcrum seats with heavy engine oil SE. Position the rocker arms over the push rods.
4. Install the intake manifold and related parts by following procedures under Intake Manifold Installation.
5. Connect the water temperature sending unit and the engine ground strap.

6. Connect the accelerator rod and retracting spring.

8. Replace the crankshaft front oil seal following procedures under Front Oil Seal Removal and Installation, Install the timing chain, cylinder front cover and related parts following procedures under Cylinder Front Cover and Timing Chain Installation.

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

11. If any valve train components have been replaced, perform a Valve Clearance Adjustment as outlined under Hydraulic Valve Lifters in Page 12.

12. Clean the valve rocker arm covers and the cylinder head gasket surface. Position the valve rocker cover gasket in each cover, making sure that the tabs engage the notches in the cover.

13. Position the covers on the cylinder heads. Make sure the gasket seats evenly all around the head. Install the bolts. The cover is tightened in two steps. Torque the bolts to specifications. Two minutes later, torque the bolts to the same specifications.

14. Clean and install the crankcase ventilation system.

15. Install the distributor cap. Position the spark plug wires in the harness brackets on the valve rocker arm covers and connect the wires to the plugs. Connect the high tension lead at the coil.

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

17. Start the engine and check and adjust the ignition timing.

18. Operate the engine at fast idle and check all hose connections and gaskets for leaks. When the engine temperature has stabilized adjust the engine idle speed and idle fuel mixture. Retorque intake manifold bolts and nuts.

Flywheel

Removal

3. Remove the flywheel attaching bolts and remove the flywheel.

Installation

1. Coat the threads of the flywheel attaching bolts with oil-resistant sealer. Position the flywheel on the crankshaft flange. Install and torque the bolts in sequence across from each other to specifications.

Clutch pilot bearing

Removal

1. Remove the transmission, clutch pressure plate and disc, following the procedures in Group 16. It is not necessary to remove the flywheel.

2. Remove the pilot bearing and adapter as shown in Fig. 29.

Installation

1. Install the pilot service bearing as shown in Fig. 30; using tool, install new bearing and adapter so the adapter is not cocked.

2. Install the clutch pressure plate, disc and the transmission, following the procedures in Group 16.

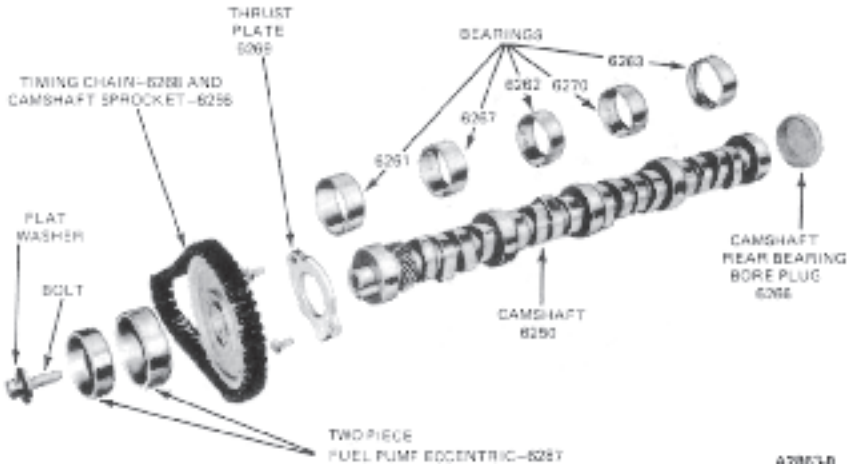


Fig. 28 Camshaft and Related Parts

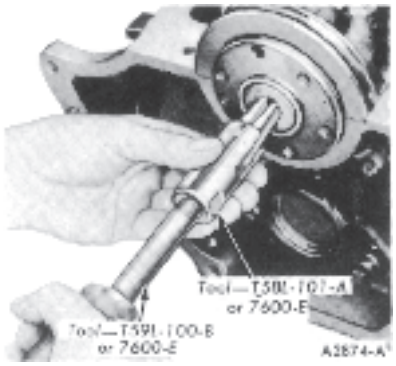


Fig. 29 Removing Clutch Pilot Bearing

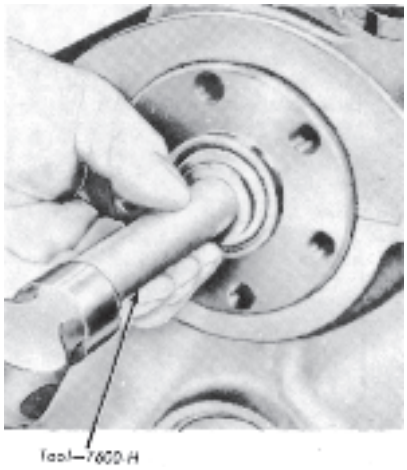


Fig. 30 Installing Clutch Pilot Bearing

Oil pan

Removal

1. Remove the oil level dipstick.
2. Drain the crankcase.
3. Remove the oil pan attaching bolts and position the pan on the crossmember.

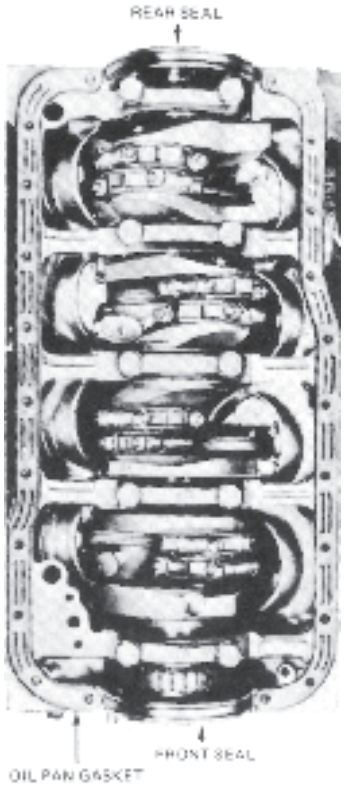


Fig. 31 Oil Pan Gaskets and Seals installed-302 and 351-W Engines

Installation

1. Clean the gasket surfaces of the block and oil pan. The oil pan has a two-piece gasket. Coat the block surface and the oil pan gasket with sealer. Position the oil pan gaskets on the cylinder block (Fig. 31).
2. Position the oil pan front seal on the cylinder front cover. Be sure the tabs on the seal are over the oil pan gasket.
3. Position the oil pan rear seal on the rear main bearing cap (Fig. 31). Be sure the tabs on the seal are over the oil pan gasket.
4. Position the oil pan against the block and install a bolt, finger-tight, on each side of the oil pan. Install the remaining bolts. Tighten the bolts from the center outward in each direction to specifications.
5. Install the oil level dipstick. Fill the crankcase with the proper grade and quantity of engine oil. Start the engine and check for oil leaks.

Camshaft rear bearing bore plug

Removal

2. Remove the flywheel attaching bolts and remove the flywheel. Remove the engine rear cover plate.
3. Remove the bore plug as detailed in Page 13.

Installation

1. Install the bore plug as detailed in Page 13.
2. Coat the flywheel attaching bolts with oil-resistant sealer. Position the engine rear cover plate on the cylinder block dowels. Position the flywheel on the crankshaft flange. Install and torque the attaching bolts in sequence across from each other to specifications.

   On a vehicle with a manual transmission, install the clutch pressure plate, disc and the transmission following the procedures in Group 16.

   On a vehicle with an automatic transmission, install the transmission and converter housing following the procedure in Group 17.

Oil pump

Removal

1. Remove the oil pan and related parts as outlined under Oil Pan Removal.
2. Remove the oil pump inlet tube and screen assembly.
3. Remove the oil pump attaching bolts and remove the oil pump, gasket and intermediate drive shaft.

Installation

1. Prime the oil pump by filling either the inlet or outlet port with engine oil. Rotate the pump shaft to distribute the oil within the pump body.
2. Position the intermediate drive shaft into the distributor socket. With the shaft firmly seated in the distributor socket, the stop on the shaft should touch the roof of the crankcase. Remove the shaft and position the stop as necessary.
3. With the stop properly positioned, insert the intermediate drive shaft into the oil pump. Install the pump and shaft as an assembly. **Do not attempt to force the pump into position if it will not seat readily. The drive shaft hex may be misaligned with the distributor shaft. To align, rotate the intermediate drive shaft into a new position.**

   Torque the oil pump attaching screws to specifications.
4. Clean and install the oil pump inlet tube and screen assembly (Fig. 32).
5. Install the oil pan and related parts as outlined under Oil Pan Installation.

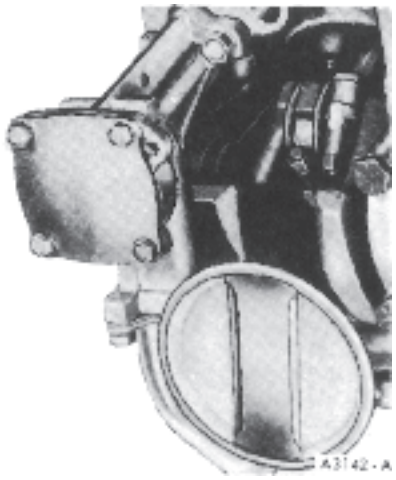


Fig. 32 Oil Pump and Inlet Tube Installed

Crankshaft rear oil seal

Replacement of a crankshaft rear oil seal because of oil leakage requires replacement of both the upper and lower seals. Refer to Crankshaft Rear Oil Seal Replacement in Page 14 for replacement procedures.

Main bearing

The main bearing inserts are selective fit. Refer to procedures under Fitting Main and Connecting Rod Bearings in Page 17.

Removal

1. Drain the crankcase. Remove the oil level dipstick. Remove the oil pan and related parts.
2. Remove the oil pump inlet tube assembly and the oil pump.
3. Replace one bearing at a time, leaving the other bearings securely fastened.

   Remove the main bearing cap to which new bearings are to be installed.
4. Insert the upper bearing removal Tool (Tool 6331) in the oil hole in the crankshaft.
5. Rotate the crankshaft in the direction of the engine rotation to force the bearing out of the block.
6. Clean the crankshaft journals. Inspect the journals and thrust faces (thrust bearing) for nicks, burrs or bearing pick-up that could cause premature bearing wear.
7. If the rear main bearing is being replaced, remove and discard the rear oil seal from the bearing cap.
8. Remove the block half of the rear oil seal following the procedures given under Crankshaft Rear Oil Seal Removal in Page 14.
9. Repeat the above procedure (Steps 3 thru 8) for the remaining bearings to be replaced.

Installation

1. If the rear main bearing is being replaced clean the rear oil seal groove in the block with a brush and the recommended solvent Page 14.
2. Install the block half of the rear oil seal following the procedures given under Crankshaft Rear Oil Seal Installation in Page 14.
3. To install the upper main bearing, place the plain end of the bearing over the shaft on the locking tang side of the block and partially install the bearing so that Tool 6331 can be inserted in the oil hole in the crankshaft. With Tool 633.1 positioned in the oil hole in the crankshaft, rotate the crankshaft in the opposite direction of engine rotation until the bearing seats itself. Remove the tool.
4. Replace the bearing in the cap.
5. Select fit the bearing for proper clearance following procedures under Fitting Main and Connecting Rod Bearings in Page 17.

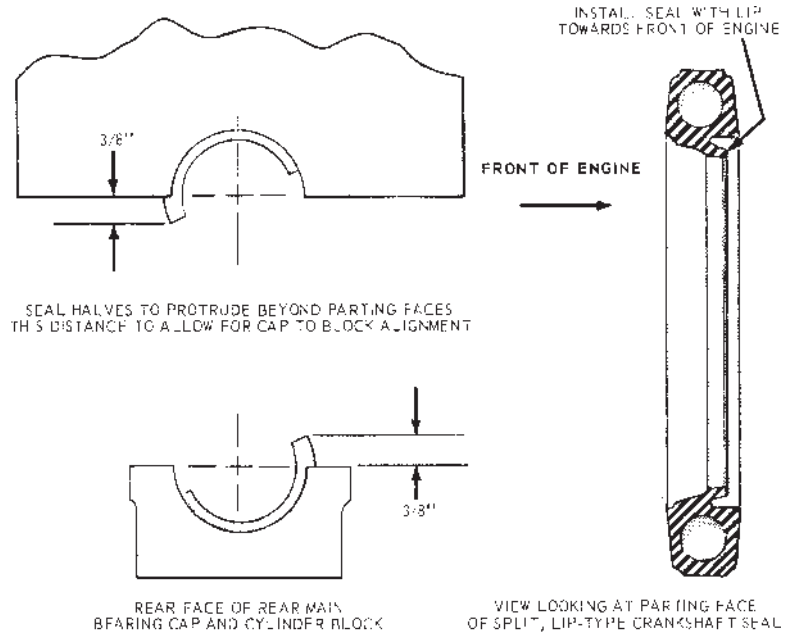


Fig. 33 Installing Crankshaft Rear Oil Seal

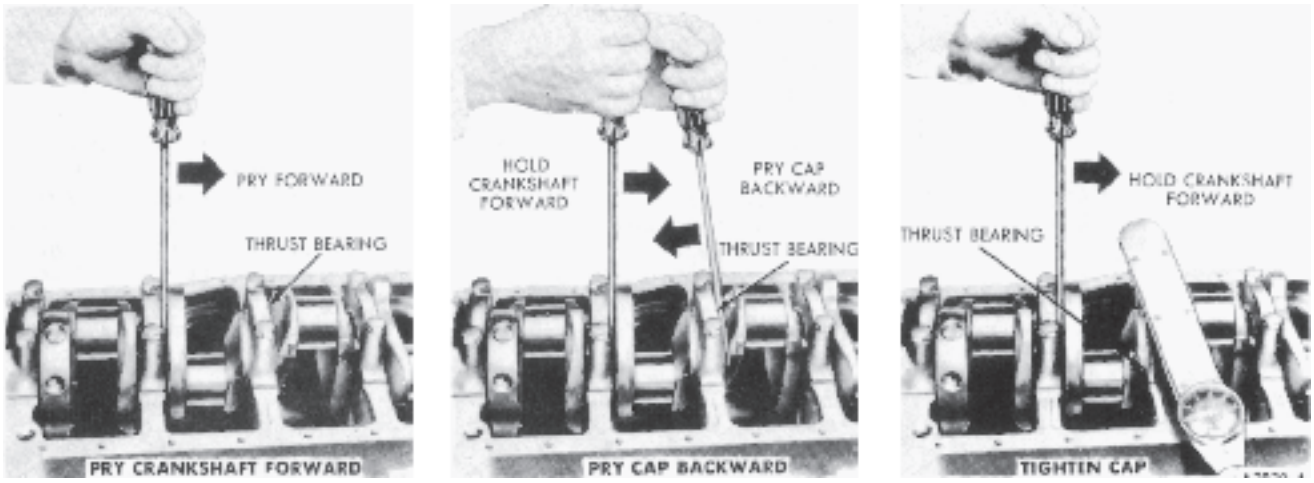


Fig. 34 Aligning Thrust Bearing

6. If the bearing is being replaced on journal number 1, 2 or 4, apply a light coat of engine oil to the journal and bearings and install the bearing cap. Tighten the cap bolts to specifications.
7. If the rear main bearing is being replaced, clean the oil seal groove in the cap, with a brush and recommended solvent Page 14.

   Remove the oil seal retaining pin from the bearing cap, if so equipped. **The pin is not used with the split lip seal.**
8. Install the lower seal in the rear main bearing cap with undercut side of seal toward the FRONT of the engine (Fig. 33); allow the seal to protrude approximately 3/8 inch above the parting surface to mate with the upper seal when the cap is installed.
9. **Refer to Crankshaft Rear Oil Seal Installation - Page 6 - for instructions on use of sealer in installing the main bearing cap.** Lubricate the journal with engine oil and install the rear main bearing cap. Torque the cap bolts to specifications.
10. If the thrust bearing cap (No. 3 main bearing) has been removed, install it as follows:

    Lubricate the journal with engine oil and install the thrust bearing cap with the bolts finger-tight. Pry the crankshaft forward against the thrust surface of the upper half of the bearing (Fig. 34). Hold the crankshaft cap to the rear. This will align the thrust surfaces of both halves of the bearing. Retain the forward pressure on the crankshaft. Torque the cap bolts to specifications.

11. Clean the oil pump inlet tube screen. Prime by filling the inlet opening with oil and rotating the pump shaft until oil emerges from the outlet opening. Install the oil pump and the inlet tube assembly.

12. Position the oil pan gaskets on the oil pan. Position the oil pan front seal on the cylinder front cover. Position the oil pan rear seal on the rear main bearing cap. Install the oil pan and related parts. Install the oil level dipstick.

13. Fill the crankcase. Start the engine and check for oil pressure. Operate the engine at fast idle and check for oil leaks.

Connecting rod bearings

The connecting rod bearings are selective fit. Refer to procedures under Fitting Main and Connecting Rod Bearings in Page 17.

Removal

1. Drain the crankcase. Remove the oil level dipstick. Remove the oil pan and related parts.

2. Remove the oil pump inlet tube assembly and the oil pump.

3. Turn the crankshaft until the connecting rod to which new bearings are to be fitted is down. Remove the connecting rod cap. Remove the bearing inserts from the rod and cap.

Installation

1. Be sure the bearing inserts and the bearing bore in the connecting rod and cap are clean. Foreign material under the inserts will distort the bearing and cause a failure.

2. Clean the crankshaft journal.

3. Install the bearing inserts in the connecting rod and cap with the tangs fitting in the slots provided.

4. Pull the connecting rod assembly down firmly on the crankshaft journal.

5. Select fit the bearing following procedures under Fitting Main and Connecting Rod Bearings in Page 9.

6. After the bearing has been fitted, clean and apply a light coat of engine oil to the journal and bearings. Install the connecting rod cap. Tighten the nuts to specifications.

7. Clean the oil pump inlet tube screen. Prime the pump by filling the inlet opening with oil and rotate the pump shaft until oil emerges from the outlet opening. Install the oil pump and the inlet tube assembly.

8. Position the oil pan gaskets on the oil pan. Position the oil pan front seal on the cylinder front cover. Position the oil pan rear seal on the rear main bearing cap. Install the oil pan and related parts. Install the oil level dipstick.

9. Fill the crankcase. Start the engine and check for oil pressure. Operate the engine at fast idle and check for oil leaks.

Pistons and connecting rods

Removal

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

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

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

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

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

5. Remove the connecting rod nuts and cap.

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

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

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

Installation

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

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

3. Make sure the ring gaps are properly spaced around the circumference of the piston (Fig. 35).

4. Install a piston ring compressor on the piston and push the piston in with a hammer handle until it is slightly below the top of the cylinder (Fig. 36). Be sure to guide the connecting rods to avoid damaging the crankshaft journals. **Install the piston with the indentation notch in the piston head toward the front of the engine.**

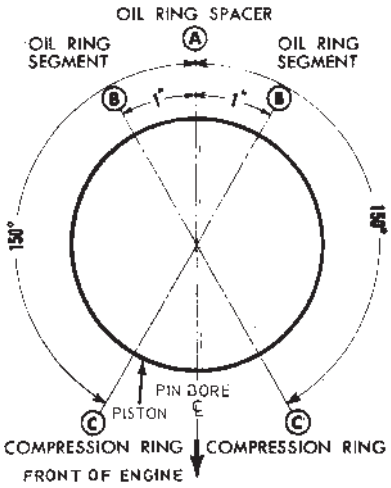


Fig. 35 Piston Ring Spacing

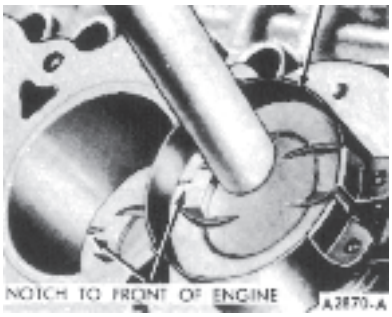


Fig. 36 Installing Piston

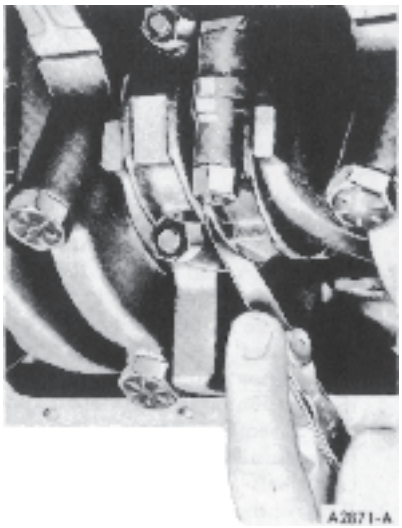


Fig. 37 Checking Connecting Rod Side Clearance

5. Check the clearance of each bearing following the procedure under Fitting Main and Connecting Rod Bearings in Page 17.
6. After the bearings have been fitted, apply a light coat of engine oil to the journals and bearings.
7. Turn the crankshaft throw to the bottom of its stroke. Push the piston all the way down until the connecting rod bearing seats on the crankshaft journal.
8. Install the connecting rod cap. Tighten the nuts to specifications.
9. After the piston and connecting rod assemblies have been installed, check the side clearance between the connecting rods on each crankshaft journal (Fig. 37).
10. Disassemble, clean, and assemble the oil pump. Clean the oil pump inlet tube screen and the oil pan and block gasket surfaces.
11. Prime the oil pump by filling either the inlet port or outlet port with engine oil and rotating the pump shaft to distribute the oil within the housing. Install the oil pump and the oil pan.
12. Install the cylinder heads following procedures under Cylinder Head Installation.
13. Install the intake manifold following procedures under Intake Manifold Installation.
14. Fill the crankcase with the proper grade and quantity of engine oil.
15. Start the engine and check and adjust the ignition timing. Connect the distributor vacuum hoses at the carburetor.
16. Operate the engine at fast idle and check for oil and coolant leaks. When the engine temperature has stabilized adjust the engine idle speed and idle fuel mixture.
17. Install the air cleaner and intake duct assembly.
18. Connect the automatic choke heat chamber air inlet hose.

Crankshaft

The crankshaft and related parts are shown in Fig. 38.

Removal

1. With engine removed and placed on a work stand, disconnect the spark plug wires at the spark plugs and remove the wires from the ignition harness brackets on the valve rocker arm covers. Disconnect the coil to distributor high tension lead at the coil. Remove the distributor cap and spark plug wire assembly. Remove the spark plugs to allow easy rotation of the crankshaft.
2. Remove the fuel pump and oil filter. Slide the water pump by-pass hose clamp toward the water pump. Remove the alternator and mounting brackets.
3. Remove the crankshaft pulley from the crankshaft vibration damper (if so equipped). Remove the cap screw and washer from the end of the crankshaft. Install the pulley on the crankshaft vibration damper (Fig. 21) and remove the damper.
4. Remove the cylinder front cover and water pump as an assembly.
5. Remove the crankshaft front oil slinger. Check the timing chain deflection, then remove the timing chain and sprockets as detailed under Cylinder Front Cover and Timing Chain Removal.

6. Invert the engine on the work stand. Remove the clutch pressure plate and disc (manual-shift transmission). Remove the flywheel and engine rear cover plate. Remove the oil pan and gasket. Remove the oil pump.
7. Make sure all bearing caps (main and connecting rod) are marked so that they can be installed in their original locations.

   Turn the crankshaft until the connecting rod from which the cap is being removed is down, and remove the bearing cap. Push the connecting rod and piston assembly up into the cylinder. Repeat this procedure until all the connecting rod bearing caps are removed.
8. Remove the main bearing caps.
9. Carefully lift the crankshaft out of the block so that the thrust bearing surfaces are not damaged. **Handle the crankshaft with care to avoid possible fracture or damage to the finished surfaces.**

   To refinish journals, dress minor imperfections, etc., refer to Page 16 for instructions.

Installation

1. Remove the rear journal oil seal from the block and rear main bearing cap.
2. Remove the main bearing inserts from the block and bearing caps.
3. Remove the connecting rod bearing inserts from the connecting rods and caps.
4. If the crankshaft main bearing journals have been refinished to a definite undersize, install the correct undersize bearings. Be sure the bearing inserts and bearing bores are clean. Foreign material under the inserts will distort the bearing and cause a failure.
5. Place the upper main bearing inserts in position in the bores with the tang fitting in the slot provided.
6. Install the lower main bearing inserts in the bearing caps.
7. Clean the rear journal oil seal groove and the mating surfaces of the block and rear main bearing cap. Remove the oil seal retainer pin from the rear main bearing seal groove, if so equipped. **The retainer pin is not used with a split lip seal.**
8. Dip the lip seal halves in clean engine oil. Carefully install the seal halves in the block and rear main bearing cap with the undercut sides of the seal toward the FRONT of the engine (Fig. 33) and approximately 3/8 inch protruding above the partial surface.
9. Carefully lower the crankshaft into place. **Be careful not to damage the bearing surfaces.**
10. Check the clearance of each main bearing following the procedure under Fitting Main and Connecting Rod Bearings in Page 17.
11. After the bearings have been fitted, apply a light coat of engine oil to the journals and bearings. Install the rear main bearing cap by following steps 7 thru 9 under Main Bearing Installation. Install all the bearing caps, except the thrust bearing cap (No. 3 bearing). **Be sure that the main bearing caps are installed in their original locations. Torque the bearing cap bolts to specifications.**

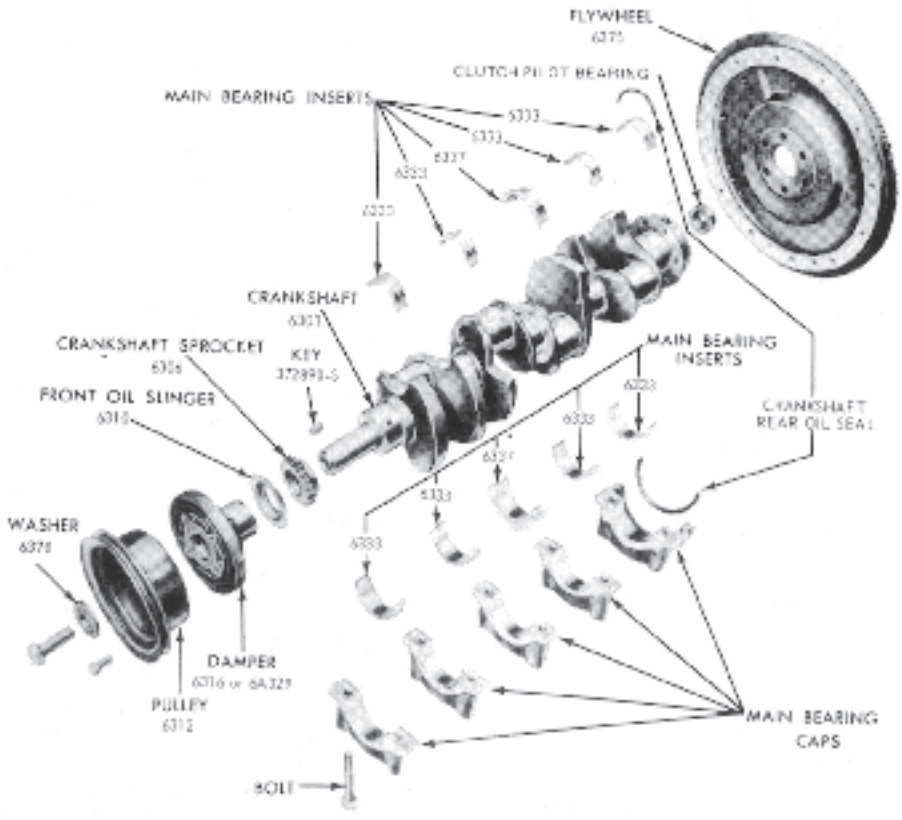


Fig. 38 Crankshaft and Related Parts

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

13. Pry the crankshaft forward against the thrust surface of the upper half of the bearing (Fig. 34).

14. Hold the crankshaft forward and pry the thrust bearing cap to the rear. This will align the thrust surfaces of both halves of the bearing.

15. Retain the forward pressure on the crankshaft. Tighten the cap bolts to specifications.

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

17. Check the crankshaft end play (refer to Page 3,

18. Install new bearing inserts in the connecting rods and caps. Check the clearance of each bearing following the procedure under Fitting Main and Connecting Rod Bearings in Page 9.

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

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

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

22. After the piston and connecting rod assemblies have been installed, check the side clearance between the connecting rods and each connecting rod crankshaft journal (Fig. 37).

23. Install the timing chain and sprockets, cylinder front cover and crankshaft pulley and adapter, following Steps 1 thru 9 under Cylinder Front Cover and Timing Chain Installation.

24. Coat the threads of the flywheel attaching bolts with oil-resistant sealer. Position the flywheel on the crankshaft flange. Install and torque the bolts to specifications.

On a flywheel for a manual-shift transmission, use Tool 6392-N to locate the clutch disc. Install the pressure plate. Tighten the attaching bolts.

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

26. Install the oil filter, fuel pump and connect the fuel lines. Install the alternator, shield and mounting bracket.

27. Install the spark plugs, distributor cap and spark plug wires. Connect the spark plug wires and high tension lead.

28. Install the engine in the vehicle.

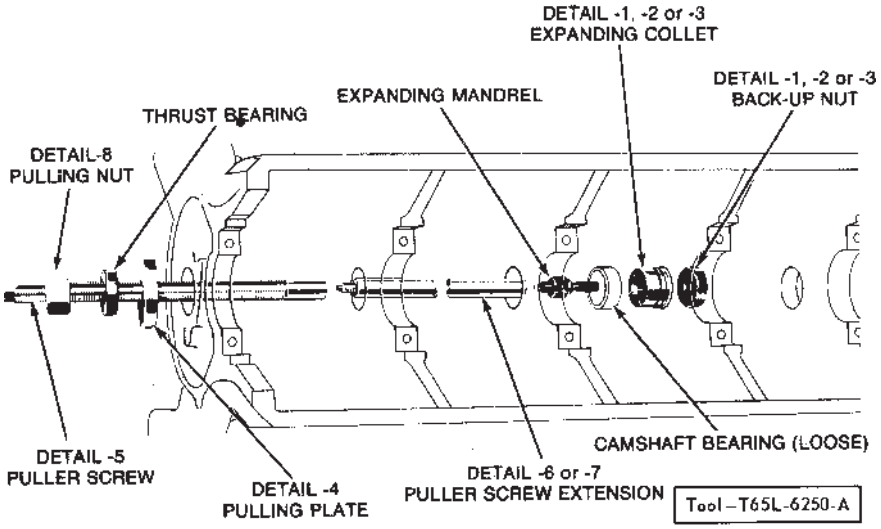


Fig. 39 Camshaft Bearing Replacement

Camshaft bearings

Removal

1. Remove the camshaft, flywheel and crankshaft, following the appropriate procedures in this Section. Push the pistons to the top of the cylinders.
2. Remove the camshaft rear bearing bore plug. Remove the camshaft bearings (Fig. 39).
3. Select the proper size expanding collet and back-up nut and assemble on the expanding mandrel. With the expanding collet collapsed, install the collet assembly in the camshaft bearing, and tighten the back-up nut on the expanding mandrel until the collet fits the camshaft bearing.
4. Assemble the puller screw and extension (if necessary) as shown and install on the expanding mandrel. Wrap a cloth around the threads of the puller screw to protect the front bearing or journal. Tighten the pulling nut against the thrust bearing and pulling plate to remove the camshaft bearing. Be sure to hold a wrench on the end of the puller screw to prevent it from turning.
5. Repeat the procedure for each bearing. To remove the front bearing, install the puller screw from the rear of the cylinder block.

Installation

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

1. Position the new bearings at the bearing bores with the oil holes aligned, and press them in place with the tool shown in Fig. 39. Be sure to center the pulling plate and puller screw to avoid damage to the bearing.

   Failure to use the correct expanding collet can cause severe bearing damage. Be sure the front bearing is installed the specified distance below the front face of the cylinder block (Fig. 40).

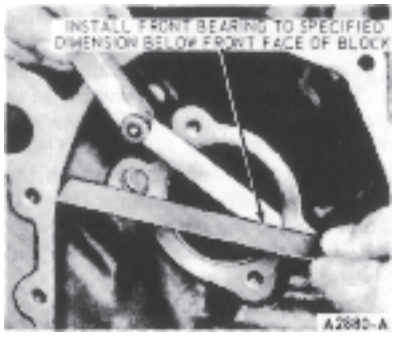


Fig. 40 Camshaft Front Bearing Measurement

2. Install the bore plug as detailed in page 13.
3. Install the camshaft, crankshaft, flywheel and related parts, following the appropriate procedures in this Section, except do not check connecting rod and main bearing clearances as a part of Camshaft Bearing Replacement. Install the engine in the vehicle.

Oil filter

The oil filter assembly is shown in Fig. 41.

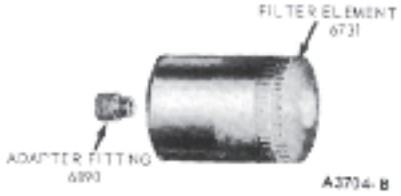


Fig. 41 Cartridge-Type Oil Filter

Removal

1. Place a drip pan under the filter. Unscrew the filter from the adapter fitting and clean the adapter recess and the filter gasket scaling surface.

Installation

1. Coat the gasket on a new filter with oil. Place the new filter in position on the adapter fitting. Hand tighten the filter until the gasket contacts the adapter fact, and 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 leakage. Check the oil level and add oil as required to bring to specified level.

Disassembly and assembly

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

Refer to Page 17 for Cleaning and Inspection procedures.

Valve lifter

The internal parts of each hydraulic valve lifter assembly are matched sets. Do not intermix the parts. Keep the assemblies intact until they are to be cleaned. Valve lifters should always be tested after assembly; refer to the cleaning, inspection and test procedures covered in Page 9.

Disassembly

Disassemble and assemble each lifter separately. Identify the lifter assemblies so they can be installed in their original bores.

1. Grasp the lock ring with needle nose pliers to release it from the groove. It may be necessary to depress the plunger to fully release lock ring.
2. Remove the push rod cup, metering valve (disc) plunger and spring.
3. Remove the plunger assembly, the check valve and the check valve retainer and plunger spring. Carefully remove the plunger spring, the check valve retainer and, the check valve disc from the plunger.

Assembly

Hydraulic lifter assembly is shown in Fig. 42.

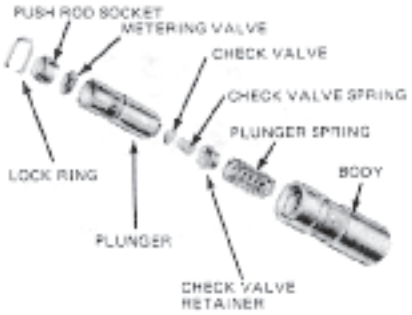


Fig. 42 Hydraulic Valve Lifter Assembly

1. Place the plunger upside down on a clean work bench.
2. Place the check valve (disc or ball check) in position over the oil hole on the bottom of the plunger. Set the check valve spring on top of the check valve (disc or ball check).
3. Position the check valve retainer over the check valve and spring and push the retainer down into place on the plunger.
4. Place the plunger spring, and then the plunger (open end up) into the lifter body.
5. Position the metering valve (disc) in the plunger, and then place the push rod cup in the plunger.

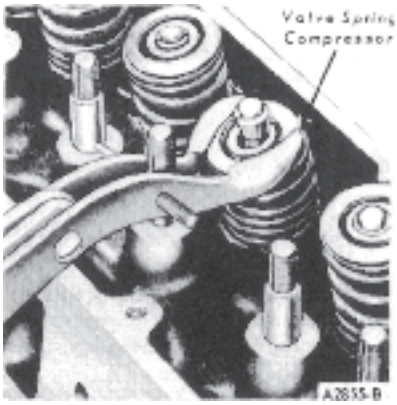


Fig. 43 Compressing Valve Spring

6. Depress the plunger, and position the closed end of the lock ring in the groove of the lifter body. With the plunger still depressed, position the open ends of the lock ring in the groove. Release the plunger, and then depress it again to fully seat the lock ring.
7. Use the hydraulic valve lifter leakdown tester (Page 2) to fill the lifters with test fluid.

Cylinder head

Disassembly

2. Remove the exhaust manifolds (if required) and the spark plugs.
3. Clean the carbon out of the cylinder head combustion chambers before removing the valves.
4. Compress the valve springs (Fig. 43). Remove the spring retainer locks and release the spring.
5. Remove the sleeve, spring retainer, spring, stem seal and valve. Discard the valve stem seals. Identify all valve parts.
6. Clean, inspect and repair the cylinder head as required, or transfer all usable parts to a new cylinder head.

Assembly

All valves, valve stems and valve guides are to be lubricated with heavy oil SE. The valve tips are to have Lubriplate or equivalent applied. The lubricant is to be applied before installation.

1. Install each valve (Fig. 44) in the port from which it was removed or to which it was fitted.
2. Install the valve stem seal and valve spring over the valve and then install the spring retainer. Compress the spring and install the sleeve, if so equipped, and retainer locks (Fig. 44).
3. Measure the assembled height of the valve spring from the surface of the cylinder head spring pad to the underside of the spring retainer with dividers (Fig. 45). Check the dividers against a scale. If the assembled height is greater than specifications, install the necessary 0.030 inch thick spacer(s) between the cylinder head spring pad and the valve spring to bring the assembled height to the recommended height.

   Do not install the spacers unless necessary. Use of spacers in excess of recommendations will result in overstressing the valve springs and overloading the camshaft lobes which could lead to spring breakage and/or worn camshaft lobes.
4. Install the exhaust manifolds (if removed) and the spark plugs.

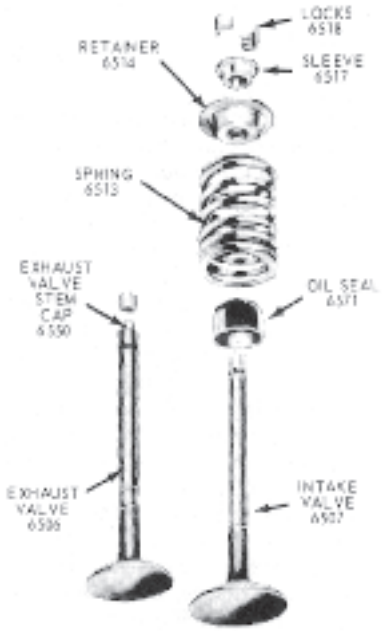


Fig. 44 Valve Assembly-302-2V and 351-W engines

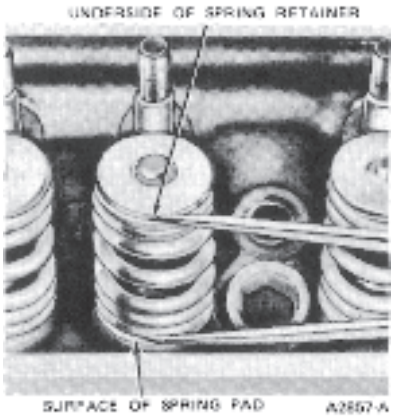


Fig. 45 Valve Spring Assembled Height

Oil pump

Disassembly

1. Remove the oil inlet tube from the oil pump and remove the gasket.
2. Remove the cover attaching screws, then remove the cover. Remove the inner rotor and shaft assembly, then remove the outer race.
3. 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

The oil pump assembly is shown in Fig. 46.

1. Oil all parts thoroughly.
2. Install the oil pressure relief valve plunger, spring and a new cap.
3. Install the outer race and the inner rotor and shaft assembly. **Be sure the dimple (identification mark) on the outer race is on same side as identification mark on rotor. The race rotor and shaft and the outer race are serviced as an assembly. One part should not be replaced without replacing the other.**

   Install the cover and torque the cover attaching screws to specifications.
4. Position a new gasket and the oil inlet tube on the oil pump and install the attaching bolts.

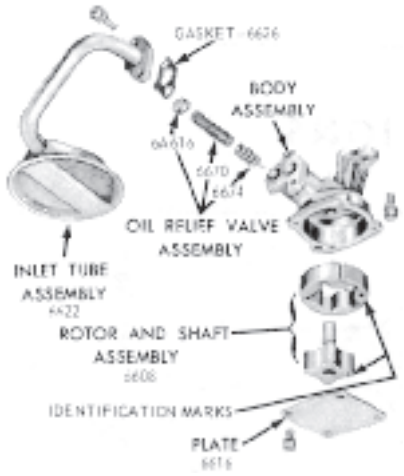


Fig. 46 Oil Pump Assembly

Pistons and connecting rods

Disassembly

1. Remove the bearing inserts from the connecting rod and cap.
2. Mark the pistons to assure assembly with the same rod and installation in the same cylinders from which they were removed.
3. Remove the piston rings. Using an Arbor Press and the tool shown in Fig. 47, press the piston pin from the piston and connecting rod.

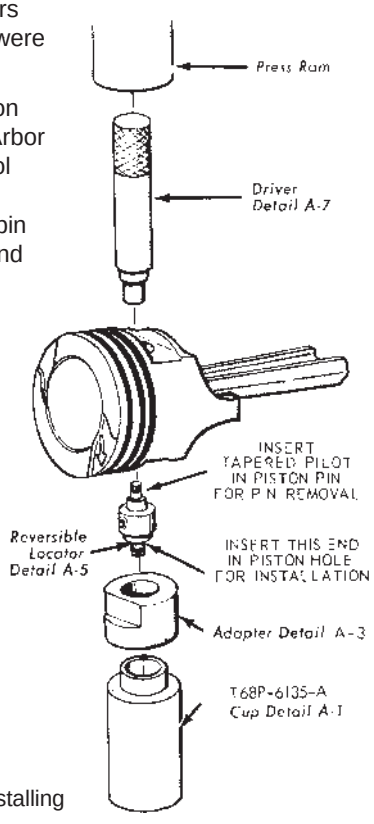


Fig. 47 Removing or Installing Piston Pin

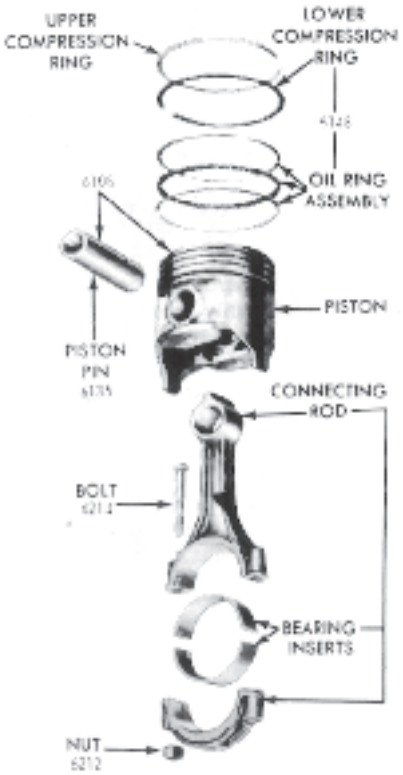


Fig. 48 Piston, Connecting Rod and Related Parts

Assembly

The piston, connecting rod and related parts are shown in Fig. 48. **Check the fit of a new piston in the cylinder bore before assembling the piston and piston pin to the connecting rod.**

The piston pin bore of a connecting rod and the diameter of the piston pin must be within specifications. Refer to specification at end of this part.

1. Apply a light coat of engine oil to all parts. **Assemble the piston to the connecting rod with the cylinder number side of the connecting rod and the indentation notch in the piston positioned as shown in Fig. 49.**

   On replacement connecting rods, install the large chamfered side of the connecting rod bearing bore towards the crankshaft check; facing towards front of engine on right bank rods, and facing towards rear of engine on left bank rods.

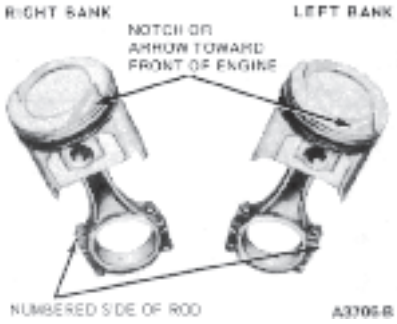


Fig. 49 Correct Piston and Rod Positions

2. Start the piston pin in the piston and connecting rod (this may require a very light tap with a mallet). Using an Arbor Press, press the piston pin through the piston and connecting rod until the pin is centered in the piston (Fig. 47).
3. Check the end gap of all piston rings (Page 16). It must be within specifications. Follow the instructions contained on the piston ring package and install the piston rings.
4. Check the ring side clearance of the compression rings with a feeler gauge inserted between the ring and its lower land (Page 8). 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.**
5. Be sure the bearing inserts and the bearing bore in the connecting rod and cap are clean. Foreign material under the inserts will distort the bearing and cause a failure. install the bearing inserts in the connecting rod and cap with the tangs fitting in the slots provided.

Cylinder assembly

Disassembly

1. Mount the old engine in a work stand and remove all parts not furnished with the new cylinder assembly; following the procedures given in the Removal and Installation Section of this Part.
2. Remove the 4 cylinder head locating dowels and the block drain plugs.
3. Remove the old cylinder assembly from the work stand.

Assembly

1. Clean the gasket and seal surfaces of all serviceable parts and assemblies.
2. Position the new cylinder assembly in a work stand and install the cylinder head locating dowels and block drain plugs.
3. Transfer all serviceable parts removed from the old cylinder assembly, following the procedures given in the Removal and Installation Section of this Part.
4. Check all assembly clearances and correct as necessary.

Cylinder block

Before replacing a cylinder block, determine if it is repairable. If so, make necessary repairs, following the procedures given in Page 20.

Disassembly

1. Completely disassemble the old engine, following the procedures given in the Removal and Installation Section of this Part.
2. Remember to ridge-ream the cylinder bores before removing piston assemblies.
3. Remove the cylinder head locating dowels and the block drain plugs.

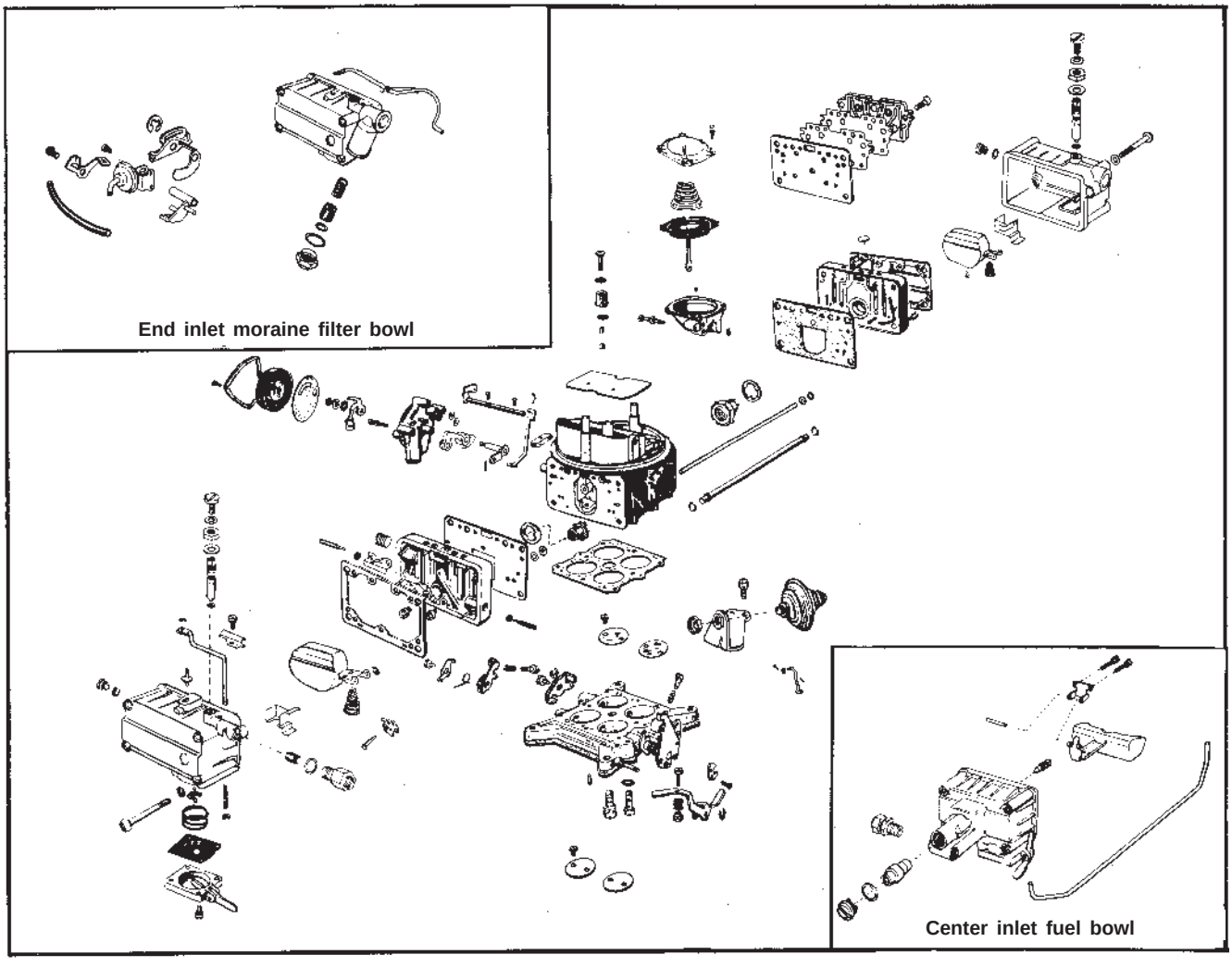
Assembly

1. Clean the gasket and seal surfaces of all serviceable parts and assemblies.
2. Position the new cylinder block in a work stand and install the cylinder head locating dowels and the block drain plugs.
3. Transfer all serviceable parts removed from the old cylinder block, following the procedures given in the Removal and Installation Section of this Part.
4. Check all assembly clearances and correct as necessary.

Carburetor service instructions

Reprinted from **"Holley 2V-4V Marine Maintenance procedures"**

This is a typical view type instruction sheet for different carburetor models, which will show more parts than are required in any one specific model.



Typical view holley carburetor models 4150 & 4160

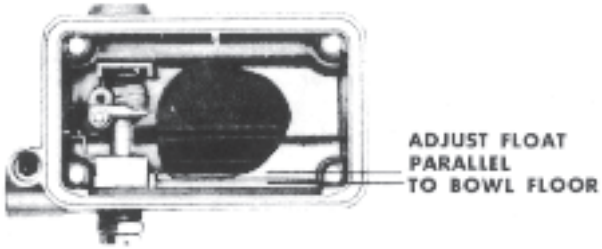
Care and cleaning

To properly overhaul the carburetor, it must be completely disassembled and all parts must be thoroughly cleaned with a commercial carburetor cleaner or solvent. Gaskets, diaphragms, rubber floats, “0” rings, and non-metallic parts must not come in contact with the cleaner solution, to prevent deterioration. Each part must be inspected for wear, deterioration and damage, and all defective parts must be discarded and replaced. The carburetor must then be carefully rebuilt and adjusted.

Float setting

Some carburetors are equipped with fuel bowls which have exterior adjustable needles and seats. The following adjustment procedure will apply to these models:

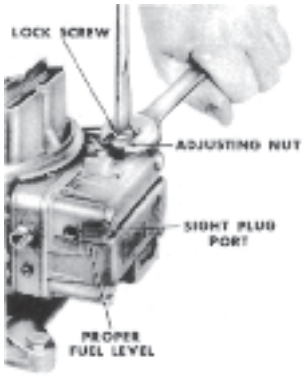
With the float bowl inverted, adjust float parallel to bowl floor. The same setting is required for carburetors incorporating brass floats to obtain a dry setting.



Wet level adjustment after carburetor is installed

With the car on a level surface and the engine running, the fuel level should be on line with the threads at the bottom of sight plug port. (Plus or minus 1/32 inch tolerance.)

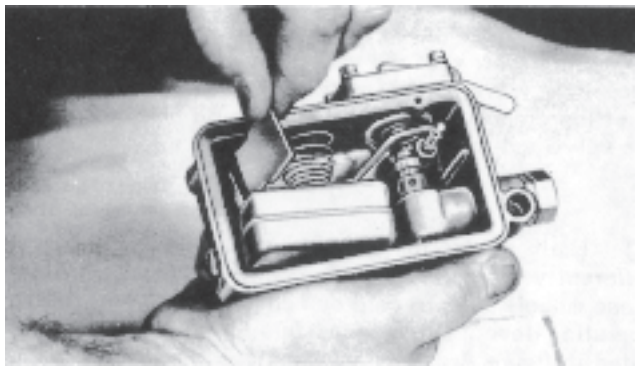
To correct the fuel level, loosen the lock screw and trim the adjusting nut clockwise to lower the fuel level and counter-clockwise to raise the fuel level. Retighten lockscrew while holding adjusting nut. Do not run engine with lockscrew loose.



Float Setting for Non-Adjustable Needle & Seat Carburetors Which Require a Float Gauge

1. Invert Carburetor fuel bowl.
2. Install gauge as shown.
3. Bend float lever tab to bring float setting within limits.

Application	Gauge
Primary side of carburetor	13/16
Secondary side of carburetor	3/4



Adjusting the idle

Seat the idle adjusting needle lightly and back off one full turn. Readjust to proper idle speed and mixture after engine has been brought to operating temperature. (Some applications will have the idle fuel adjustment needle located in the throttle body).

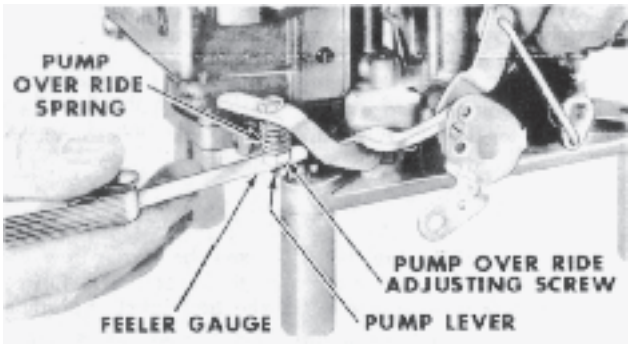
Choke setting

Set choke on center mark, maximum permissible adjustment is two notches either rich or lean. Same procedure to be used for divorced choke applications.

Pump Adjustment

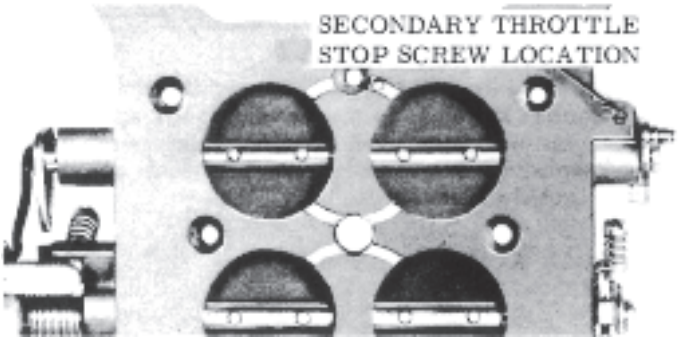
(1) The pump override spring adjustment is checked while holding the throttle in the wide open position and the pump operating lever held in a fully compressed position. The clearance between the adjusting nut and arm of the pump lever should be .015.

(2) After making this adjustment, move the throttle lever from a closed position toward open. Any movement at the throttle lever should be noticed at the pump operating lever. This indicates correct tip-in.



Secondary throttle plate adjustment

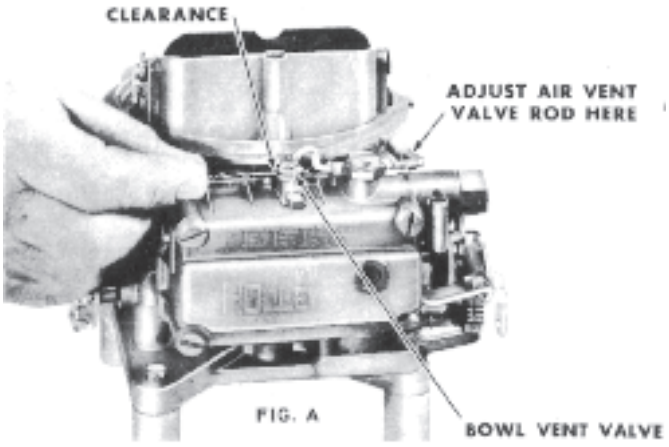
Back the secondary throttle stop screw out until the secondary throttle plates are closed in the bore. Turn the screw in until it touches the stop on the lever, then give it one half additional turn.



Vent valve adjustment

(1) Adjust air vent rod and valve by checking the clearance from valve to seat with a drill with choke open and throttles closed. This clearance should be taken between the valve and the seat and must be .050 to .070.

(2) Early production low inlet fuel bowl models have a different vent rod. The clearance of the air vent valve on these models is corrected by bending the end of the pump operating lever. On later models, bend the rod as indicated in figure A.



Installation instructions for fuel bowl and metering body gaskets

Fuel bowl gasket

The primary fuel bowl gasket must be installed with the accelerator pump passage on the right side of the main jets (Fig. 1).

Fuel bowl screws must be torqued to 40 inch pounds.

Throttle body screws must be torqued to 50 inch pounds.

The carburetor to manifold bolts or nuts must be torqued to 100 inch pounds.

The above screws must be tightened in three stages, crosswise, to arrive at the correct torque.

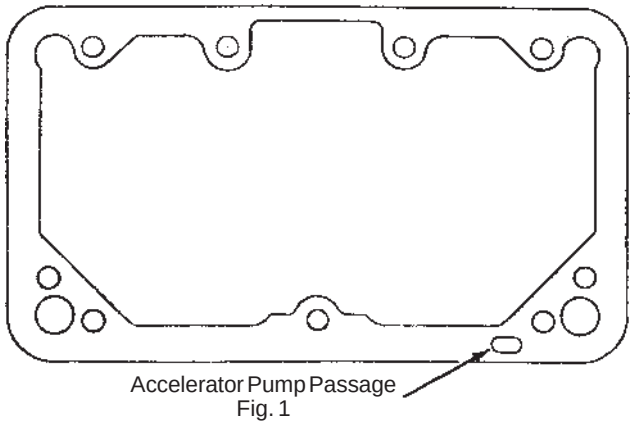


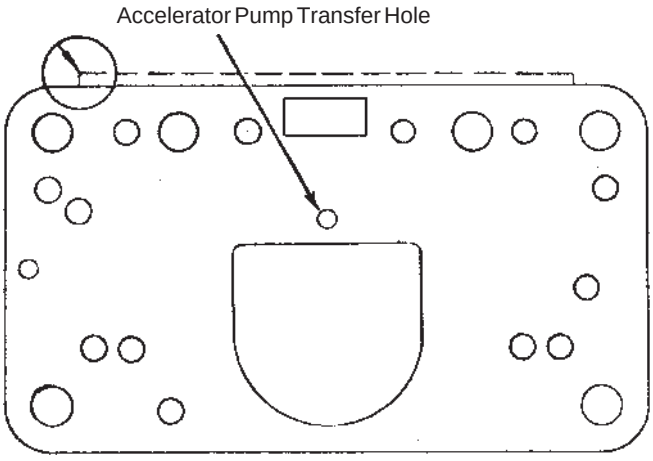
Fig. 1

Primary metering body gaskets

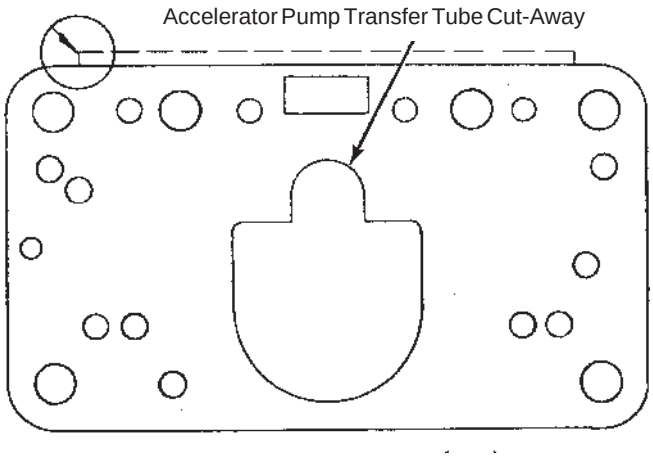
The primary metering body gaskets shown are typical. There are a number of similar gaskets which have different holes and hole locations. Be sure to compare the new gasket with the old gasket being replaced to make sure they have the same number of holes in the proper location (Fig. 2 and Fig. 3).

Some 4160 models use primary metering body gaskets with additional stock in this area. Applications using this gasket have the top bead or lip of the metering body removed. (Fig. 2 and Fig. 3).

Use either primary metering body gasket on secondary side of 4150 models.



Use on Primary without pump transfer tube.
Fig. 2



Use on Primary with pump transfer tube.
Fig. 3

Problem diagnosis

Flooding or leaking carburetor	Cracked carburetor body, or fuel bowl. Defective main body and/or fuel bowl gasket(s). High fuel level or float setting. Fuel inlet needle not seating properly or worn needle and/or seat. Ruptured accelerating pump diaphragm. Excessive fuel pump pressure.	Defective power valve gasket. Ruptured power valve diaphragm. Loose fuel inlet needle valve seat or seat gasket damaged or missing. Sticking and/or restricted float operation. Float tab surface rough. Dirt or foreign material in fuel holds float needle valve open.
Hard starting	Incorrect setting of choke thermostatic spring housing. Improper starting procedure, causing a flooded engine. Improper carburetor fuel level. Improper idle adjustments. Sticking or incorrectly seating fuel inlet needle. Incorrect fuel pump pressure.	Improper carburetor gasket and/or spacer combination. Choke linkage or plate binding. Binding or broken manual choke linkage. Restrictions or air leaks in the choke vacuum or hot air passages. Dirty air cleaner element.
Stalling	**Engine hot or cold** Incorrect idle fuel mixture. Engine idle speed too slow (fast or cold idle adjustments). Dirt, water or ice in fuel filter. Positive crankcase ventilation system malfunctioning or restricted. Fuel lines restricted or leaking air. Fuel tank vent restricted.	Leaking intake manifold or carburetor gaskets. Carburetor icing (cold, wet or humid weather). Incorrect throttle linkage adjustment to carburetor. Clogged air bleeds or idle passages. Defective fuel pump. Excessive looseness of throttle shaft in bore(s) of throttle body.
Rough idle	Improperly adjusted idle mixture screw. Throttle plates and/or throttle shaft bent or damaged. Throttle plates misaligned. Positive crankcase ventilation system malfunctioning or restricted. Idle adjusting needle(s) grooved, worn or otherwise damaged. Idle air bleeds restricted. Idle air or fuel passages restricted. Idle discharge holes restricted. Idle discharge holes not in proper relation to throttle plate(s). Excessive dirt in air cleaner. High or low fuel level or float setting.	Fuel inlet needle not seating properly, or worn needle or seat. Power valve leaking. Restricted air bleeds. Plugged idle fuel channel restrictor. Air leak at carburetor mounting or intake manifold gasket. Plugged main metering jet. Accelerating pump discharge ball check or needle and/or weight not seating properly. Fuel pump pressure too low, or excessive. Fuel siphoning from secondary main fuel system. Restriction in main fuel passage. Air leak below carburetor or at intake manifold gasket.

Poor acceleration	Poor acceleration complaints fall under one of three headings: the engine is sluggish on acceleration, the engine stalls when accelerated, or the engine hesitates or develops a flat spot when accelerated. Poor acceleration is caused by either an excessively lean or rich mixture on acceleration and/or defects or improper adjustments in the ignition system. **A lean mixture on acceleration can be caused by:** Incorrect accelerating pump stroke adjustment. Accelerating pump diaphragm defective. Low fuel pump pressure Sticking fuel inlet needle. Low fuel level or float setting. Restriction in main fuel passage. Air leak between the carburetor and manifold caused by loose mounting bolts or defective gasket. Air leak at the throttle shaft caused by a worn throttle shaft. Accelerating pump fuel inlet valve not seating on acceleration. Restriction in the accelerating pump discharge passage. Accelerating pump discharge valve ball check or weight not coming fully off its seat, or failing to seat properly on the reverse stroke of the pump diaphragm. Air leak at the accelerating pump cover caused by a defective gasket or warped pump cover. Defective power valve spring.	Defective secondary diaphragm. Air leak where secondary vacuum pick-up tube fits into air horn, between air horn and main body, or between the secondary diaphragm housing cover and housing. Secondary throttle plates wedged in barrels. Bent secondary throttle shaft. Secondary throttle plates operating rod binding, or disconnected from secondary diaphragm or secondary throttle lever. Secondary vacuum passage ball check stuck on its seat. Secondary vacuum probe restricted or not properly positioned. Restricted secondary fuel passages. Power valve stuck. **A rich mixture on acceleration can be caused by:** **Broken power valve spring.** **Stuck or improperly adjusted secondary throttle air plates.** High fuel level or float setting. Fuel inlet needle not seating properly or worn needle and/or seat. Malfunctioning automatic choke. Excessively dirty air cleaner. Incorrect accelerating pump stroke adjustment. Power valve leakage. Restricted air bleeds. Worn or damaged main metering jet. Excessive fuel pump pressure.
Inconsistent engine idle speed	Fast idle screw contacting low step of cam at curb idle. Incorrect throttle linkage adjustment to carburetor. Binding or sticking throttle linkage or accelerator pedal. Sticking carburetor throttle shaft.	Excessive looseness of throttle shaft in bores of throttle body. Sticking fuel inlet needle. Defective power valve or gasket. Air leak at carburetor mounting or intake manifold gasket.

Automatic choke slow warm-up, on too often or long	Thermostatic choke setting too rich. Choke linkage sticking or binding.	Incorrect choke linkage adjustment. Choke plate misaligned or binding in air horn.
Surging (cruising speeds to top speeds)	Clogged main jets. Improper size main jets. Low fuel level or float setting. Clogged filter or filter screen	Defective power valve or gasket. Distributor advance incorrect. Low fuel pump pressure or volume.
Reduced top speed	Excessive dirt in air cleaner. Improper size or obstructed main jets. Float setting too high or too low. Fuel pump pressure or volume too high or too low. Power valve spring weak, or power valve restricted. Restricted air bleeds. Restriction in main fuel passages. Throttle plates not fully open. Faulty choke operation. Improper throttle linkage adjustment. Air leak where secondary vacuum pick-up tube fits into air horn and main body, or air leakage between the secondary diaphragm housing cover and housing or the air horn mounting gasket.	Secondary diaphragm return spring too stiff. Secondary throttle plates wedged in barrels. Bent secondary throttle shaft. Secondary throttle plate operating rod binding. Secondary vacuum passage ball check sticking on its seat. Secondary damper linkage sticking. Distributor advance incorrect.

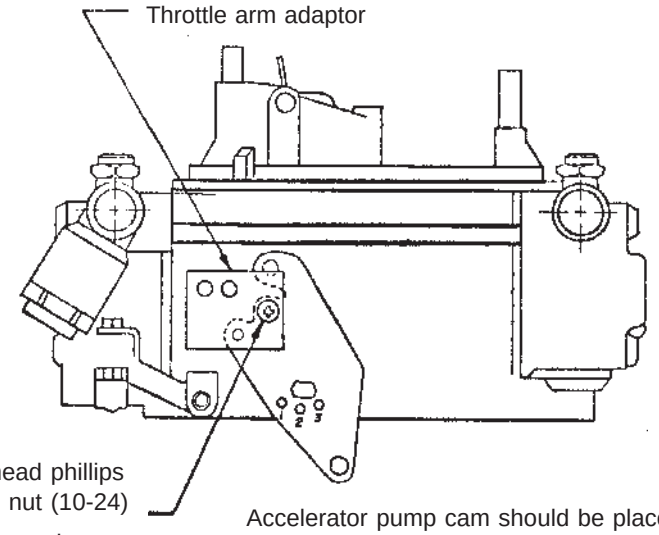
Holley model 4160c specifications

Holley No.	R-6576A
Ford No.	D2JL-E
Bore Primary	1-9/16"
Bore Secondary	1-9/16"
Venturi Primary	1-1/4"
Venturi Secondary	1-5/16"
Main Jet	No. 64
Power Valve	No. 50
Pump Cam Hole Position	No. 1
Pump Override	.015 Min.
Choke Index	3 Notches Lean
Choke Pulldown	.140
Dechoke	.300

Holley model 2300c specifications

Holley No	R-6317-1A
Ford No.	DIFF-9510-LA
Bore	1-1/2"
Venturi	1-3/16"
Main Jet	No. 60
Power Valve	No. 50
Pump Cam Hole Position	No. 2
Pump Override	.015 Min.
Choke Index	3 Notches Lean
Choke Pulldown	.140
Dechoke	.300

Both Carburetors	**Unloader Setting**	**Vacuum Break**	**Auto Choke**	**Initial Idle Mixture**	**Idle Speed RPM**
	.270-.330	.120-.160	3 Notches Lean	1 Turn Open	7



10-24 x 1/2 pan head phillips with locking nylon nut (10-24)

Note: Assembly procedure identical for AQ190 and AQ240 configuration

Accelerator pump cam should be placed in

No. 1 Position AQ190

No. 2 Position AQ240

Specifications

General

Type designation	**AQ190A**	**AQ240A**
Number of cylinder (2 banks, 90° V-form)	8	8
Max output at 70 rev/sec 4200 rev/min	182 hk, (134 kW)	231 hk. (170 kW)
Bore. mm (in.)	101.6 (4.0)	
Stroke, mm (in.)	76.2 (3.0)	88.9 (3.5)
Displacement, dm^3 (cu. in)	4.95 (302)	5.75 (351)
Compression ratio	7.9:1	8.1:1
Compr. press (starter motor MPa (kp/cm^2)	100-110 (10-11) (142-156 p. s. i.)	
Max speed rev/sec	70 (4200 rev/min)	
Idling speed. rev/sec	10.0-10.8 (600-650 rev/min)	
Direction of rotation, viewed from front	Clockwise	
Total weight, engine, rises and outboard drive, approx kg.	405 (890 lb)	1410 (900 lb)
Drive Belt Tensions (lbs.) (5)		

Size	1/4"	Exc. 1/4"
Newly installed Used (1)	50-80	120-160
Up to 10 Min.	40-80 (2)	90-160 (3)
Over 10 Min.	40-60 (2)	75-120 (4)

(1) Read tension immediately after belt is installed, before it stretches or seats in pulley grooves.
(2) If less than 40 pounds, readjust to 40-60 pounds.
(3) If less than 90 pounds, readjust to 90-120 pounds.
(4) If less then 75 pounds, readjust to 90-120 pounds.
(5) A used belt is any in operation for 10 minutes.

Cylinder head

Engine	**AQ190**	**AQ240**
Combustion Chamber Volume	56.7-59.7	58.9-61.9
Valve Guide Bore Diameter (Standard Intake and Exhaust)	0.3433-0.3443	0.3433-0.3443
Valve Seat Width		
Intake	0.060-0.080	0.060-0.080
Exhaust	0060-0.080	0.060-0.090
Valve Seat Angle	45°	45°
Valve Seat Runout (Maximum)	0.0020	0.0020
Valve Arrangement (Front to Rear)	Right I-E-I-E-I-E-I-E	Left E-I-E-I-E-I-E-I
Rocker Arm Stud Bore Dia. Std.	0.3680-0.3695	0.3680-0.3695
Gasket Surface Flatness [1]	0.003 inch In Any 6 Inches 0.006 Overall	

[1)] Head Gasket Surface Finish R.M.S. 60-150

Cooling system

Thermostat limit values °C (°F)	66-80 (119-143) DI MA-8575	

Lubricating system

Oil quality	Service SE	
Oil viscosity	Multigrade Oil SAE 10W-30 or 10W-40	
Oil capacity including oil filter, litres (Imp. qts. /US qts. appr.	5.2 (4.6/5.5)	
Oil capacity excluding cleaner, litres (Imp. qts. /US qts. appr.	4.8 (4.2/5.1)	
Oil capacity between max and min marks approx litre (Imp qts. /US qts.)	1.0 (1.0 qt)	
Oil Pressure-Hot @ 2000 RPM	40-60	40-65

Ignition system

Firing order	1-3-7-2-6-5-4-8	1-3-7-2-6-5-4-8
Ignition distributor, type PRESTOLITE	IBM 7007S	7008S
Basic setting (0-90 r/m)	10° B. T. D. C.	
Ignition distributor, contact gap, mm	0.36-0.48 (0.014-0.019 in)	
Dwell angle	31°	
Spark plugs, type AUTOLITE	ARF-32M	
Spark plugs, electrode gap, mm	0.8-0.9 (0.032-0.036 in)	
Stroboscope setting 70 r/s (4200 r/m)	37°	

Electrical system

Voltage V	12V Negative Earth
Battery capacity, Standard Ah	60
Battery electrolyte specific gravity.	
Fully charged battery	1.275-1.285
When re-charging is necessary	1.230
Alternator	Ford Autolite (DOFF-10300-k)
Output, max.	450 W (38A)
Starter motor, type Ford Motorcraft	D5FF 11001 AA
Output, kW	0.8

Fuel quality

Leaded fuel min	94 octane R. O. N.

Fuel system

Fuel pump, Carter, type	EM D2JL 9350A (M-66 96S)	
Carburetor, Holley, type	D3JL 9510S	D2JL 9510E

Valve rocker arms, push rods and tappets

Engine	AQ190	AQ240
Rocker Arm Lift Ratio	1.61:1	1.61:1
Valve Push Rod (Maximum Runout)	0.015	0.015
Valve Tappet Or Lifter		
Standard Diameter	0.8740-0.8745	0.8740-0.8745
Clearance To Bore[1)]	0.0007-0.0027	0.0007-0.0027
Hydraulic Lifter Leakdown Rate	5-50 Seconds Maximum - Measured at 1/16 Inch plunger travel	
Collapsed Tappet Gap		
Allowable	0.090-0.190	0.115-0.130
Desired	0.106-0.206	0.131-0.181

[1)] Wear Limit – 0.005

Valve springs

Engine	AQ190	AQ240
Valve Spring Pressure Lbs @ Specified length		71-79 @ 1.790 190-210 @ 1.340
Pressure Intake	76-84 @ 1.69 190-210 @ 1.31	
Pressure Exhaust	76-84 @ 1.60 190-210 @ 1.22	
Wear Limit	10% Pressure loss @ Specified Length	
Valve Spring Free Length Approximate		2.06
Intake	1.94	
Exhaust	1.85	
Valve Spring Assembled Height Pad to Retainer		1-49/64-1-13/16
Intake	1-43/64-1-45/64	
Exhaust	1-19/32-1-39/64	
Valve Spring Out-of-Square (Maximum)	5/64 (0.078)	5/64 (0.078)

Valves

Engine	AQ190	AQ240
Valve Stem To Valve Guide Clearance[1)]		
Intake	0.0010-0.0027	0.0010-0.0027
Exhaust	0.0015-0.0032	0.0015-0.0032
Valve Head Diameter		
Intake	1.773-1.791	1.773-1.791
Exhaust	1.442-1.460	1.442-1.460
Valve Face Angle[2)]	44°	44°

[1)] Wear Limit 0.005
[2)] Valve Face Runout – Maximum 0.002.

Valves (Continued)

Engine	AQ190	AQ240
Valve Stem Diameter		
Standard		
Intake	0.3416-0.3423	0.3416-0.3423
Exhaust	0.3411-0.3418	0.3411-0.3418
0.003 Oversize		
Intake	0.3446-0.3453	0.3446-0.3453
Exhaust	0.3441-0.3448	0.3441-0.3448
0.015 Oversize		
Intake	0.3566-0.3573	0.3566-0.3573
Exhaust	0.3561-0.3568	0.3561-0.3568
0.030 Oversize		
Intake	0.3716-0.3723	0.3716-0.3723
Exhaust	0.3711-0.3718	0.3711-0.3718

Camshaft

Engine	AQ190	AQ240
Lobe Lift[1]		
Intake	0.2303	0.2600
Exhaust	0.2375	0.2780
Theoretical Valve Lift		
Intake	0.3707	0.4180
Exhaust	0.3823	0.4480
Camshaft		
End Play[2]	0.001-0.007	0.001-0.007
Camshaft Journal to Bearing Clearance		
Clearance[3]	0.001-0.003	0.001-0.003
Timing Chain Deflection (Maximum)	0.005	0.005

[1] Maximum allowable lobe lift loss (All engines) 0.005
[2] Wear Limit – 0.009
[3] Wear Limit – 0.006.

Camshaft (Continued)

Engine	AQ190	AQ240
Camshaft Journal Diameter Standard[1]		
Bearing No 1	2.0805-2.0815	2.0805-2.0815
Bearing No 2	2.0655-2.0665	2.0655-2.0665
Bearing No 3	2.0505-2.0515	2.0505-2.0515
Bearing No 4	2.0355-2.0365	2.0355-2.0365
Bearing No 5	2.0205-2.0215	2.0205-2.0215
Camshaft Bearings Inside Diameter		
Bearing No 1	2.0825-2.0835	2.0825-2.0835
Bearing No 2	2.0675-2.0685	2.0675-2.0685
Bearing No 3	2.0525-2.0535	2.0525-2.0535
Bearing No 4	2.0375-2.0385	2.0375-2.0385
Bearing No 5	2.0225-2.0235	2.0225-2.0235
Camshaft Bearing Location[2]		
Bearing No 1	0.0050-0.0200	0.0050-0.0200

[1] Camshaft journal maximum runout 0.005
Camshaft journal maximum out-of-round 0.0005
[2] Distance in inches that the front edge of the bearing is installed towards the rear from the front face of the cylinder block.

Basic valve clearance setting

1 1/4-1 1/2 turn down from zero (slight resistance when turning the pushrod).

Approximate oil pan capacities[1]

Engine	AQ190	AQ240
U.S. Measure	3 1/2 Quarts	3 1/2 Quarts
Imperial Measure	4 Quarts	4 Quarts

(1) Add 1/2 quart with filter replacement

Cylinder block

Engine	AQ190	AQ240
Cylinder Bore Diameter[1] [3]	4.0004-4.0052	4.0000-4.0048
Lifter Bore Diameter	0.8752-0.8767	0.8752-0.8767
Main Bearing Bore Diameter	2.4412-2.4420	3.1922-3.1930
Cylinder Block Distributor Shaft Bearing Bore Diameter	0.4525-0.4541	0.5155-0.5171
Head Gasket Surface Flatness[2]	0.003 inch in any 6 inches or 0.006 inch overall	
Crankshaft To Rear Face Of Block Runout TIR Max.	0.010	0.010

[1] Maximum out-of-round 0.0015
Wear Limit 0.005
Cylinder Bore Surface Finish RMS 18-38

[2] Head Gasket Surface Finish RMS 60-150
[3] Maximum Taper 0.001
Wear Limit 0.010

Crankshaft and flywheel

Engine	AQ190	AQ240
Main Bearing Journal Diameter[1]	2.2482-2.2490	2.9994-3.0002
Main Bearing Journal Runout-Maximum[2]	0.002	0.002
Main Bearing Journal Thrust Face Runout	0.001	0.001
Main Bearing Journal Taper Max	0.0006 Per Inch	0.0006 Per Inch
Thrust Bearing Journal Length	1.137-1.139	1.137-1.139
Main Bearing Surface Finish RMS Maximum		
Journal	12	12
Thrust Face	35 Front	25 Rear

[1] Main bearing journal out-of-round maximum 0,0004 (all engines)
[2] Wear Limit – 0.005

Crankshaft and flywheel (Continued)

Engine	AQ190	AQ240
Connecting Rod Journal Diameter[2]	2.1228-2.1236	2.3103-2.3111
Connecting Rod Bearing Journal Maximum Taper	0.0006 Per Inch	0.0006 Per Inch
Crankshaft Free End Play[1]	0.004-0.008	0.004-0.008
Flywheel Clutch Face Runout	0.010	–
Flywheel Ring Gear Lateral Runout Transmission		
Standard	0,030	–
Automatic	0.060	0.060

[1] Wear Limit – 0.012
[2] Connecting rod journal out-of-round maximum 0.0006 (all engines).

Oil pump

Engine	AQ190	AQ240
Rotor-Type Oil Pump Relief Valve Spring Tension Lbs @ Specified Length	10.6-12.2 @ 1 704	18.2-20.2 @ 2.49
Drive Shaft To Housing Bearing Clearance	0.0015-0.0029	0.0015-0.0029
Relief Valve Clearance	0.0015-0.0029	0.0015-0.0029
Rotor Assembly End Clearance	0.001-0.004	0.001-0.004
Outer Race To Housing (Radial Clearance)	0.001-0.013	0.001-0.013

Crankshaft bearings

Engine	AQ190	AQ240
Connecting Rod Bearings		
To Crankshaft Clearance		
Desired	0.0008-0.0015	0.0008-0.0015
Allowable	0.0008-0.0026	0.0008-0.0026
Wall Thickness Standard[1]	0.0572-0.0577	0.0572-0.0577
Main Bearings		
To Crankshaft Clearance		
Desired	No. 1 Bearing 0.0001-0.0005 All Others 0.0005-0.0015	0,0008-0.0015
Allowable	No. 1 Bearing 0.0001-0.0020 All Others 0.0005-0.0024	0.0008-0.0026
Wall Thickness Standard2)	No. 1 Bearing 0.0961-0.0966 All Others 0.0957-0.0962	0.0957-0.0960

[1] 0.002 Undersize ThicknessAdd 0.0010 to Standard Thickness.
[2] 0.002 Undersize ThicknessAdd 0.0010 to Standard Thickness.

Connecting rod

Engine	AQ190	AQ240
Piston Pin Bore Or Rushing ID	0.9104-0.9112	0.9104-0.9112
Connecting Rod Bearing Bore Diameter (1)	2.2390-2.2398	2.2390-2.2398
Connecting Rod Length Center To Center	5.0885-5.0915	5.9545-5.9575
Connecting Rod Alignment Maximum Total Difference (2)		
Twist	0.024	0.024
Bend	0.012	0.012
Connecting Rod Assembly (Assembled To Crankshaft)		
Side Clearance	0.010-0.020	0.010-0.020
Wear Limit	0.023	0.023

1) Connecting rod bearing bore maximum out-of-round and taper (All Engines) 0.0004
2) 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

Engine	AQ190	AQ240
Diameter (1)		
Coded Red	3.9984-3.9990	3.9978-3.9984
Coded Blue	3.9996-4.0002	3.9990-3.9996
0.003 Oversize	4.008-4.0014	4.0002-4.0008
Coded Yellow	4.0020-0.0026	4.0014-4.0020
Piston To Cylinder Bore Clearance	0.0018-4.0026	0.0018-4.0026
Piston Pin Bore Diameter	0.9122-0.9126	0.9124-0.9127
Ring Groove Width		
Upper Compression Ring	0.080-0.081	
Lower Compression Ring	0.080-0.081	
Oil Ring		0.1880-0.1890

1) Measured at the piston pin bore centerline at 90° to the pin bore.

Piston pin

Engine	AQ190	AQ240
Length	3.010-3.040	3.010-3.040
Diameter		
Standard	0.9120-0.9123	0.9120-0.9123
0.001 Oversize	0.9130-0.9133	0.9130-0.9133
To Piston Clearance	0.0002-0.0004	0.0003-0.0005
To Connecting Rod Clearance	Interference Fit	Interference Fit

Piston rings

Engine	AQ190	AQ240
Ring Width/Compression Ring		
Top	0.077-0.078	0.077-0.078
Bottom	0.077-0.078	0.077-0.078
Side Clearance/Compression Ring[1]		
Top	0.002-0.004	0.002-0.004
Bottom	0.002-0.004	0.002-0.004
Side Clearance/Oil Ring		
Ring Gap Width/Compression Ring		
Top	0.010-0.020	0.010-0.020
Bottom	0.010-0.020	0.010-0.020
Ring Gap Width/ Oil Ring[2]	0.015-0.055	0.015-0.055

1) Wear Limit 0.006
2) Steel Rail

Torque limits – FT-LBS

Engine	AQ190	AQ240
Cylinder Head Bolts		
Step 1	55-65	95-105
Step 2	65-72	105-112
Oil Pan to Cylinder	9-11 (5/16 x 18)	9-11 (5/16 x 18)
Block	7-9 (1/4 x 20)	7-9 (1/4 x 20)
Intake Manifold Bolts	23-25	23-25
Exhaust Manifold Bolts	18-24	18-24
Distributor Vacuum Control Valve	15-18	15-18
Flywheel to Crankshaft	75-85	75-85
Main Bearing Cap Bolts	60-70	95-105
Oil Drain Plug	15-25	15-25
EGR Valve to Carburetor Spacer	12-18	12-18
Oil Inlet Tube to Oil Pump	10-15	10-15
Oil Filter Insert to Block	20-30	20-30
Oil Filter to Insert (Cartridge Type)	With grease on gasket surface, hand-tighten until gasket contacts adapter face then tighten 1/2 turn more.	
Camshaft Sprocket to Camshaft	40-45	40-45
Camshaft Thrust Plate to Block	9-12	9-12
Vibration Damper to Crankshaft	70-90	70-90
Crankshaft Pulley to Vibration Damper	35-50	35-50
Connecting Rod Nuts	19-24	40-45
Valve Rocker Arm Cover	3-5	3-5
Fuel Pump to Cylinder Front Cover	19-27	19-27
Rocker Arm Stud Nut	17-23 Ft-Lbs After Nut Contacts Shoulder.	
Alternator Pivot Bolt	45-57	45-57

Miscellaneous torque values

Alternator Bracket to Cylinder Block	15-20	15-20
Alternator Pivot Bolt	45-57	45-57
Alternator Adjusting Arm to Cylinder Block	15-20	15-20
Alternator Adjusting Arm to Alternator	24-40	24-40
Carburetor Mounting Nuts	12-15	12-15
Carburetor Mounting Stud to Intake Manifold	15 max.	15 max.
Fuel Filter to Carburetor	80-100 in-lb	80-100 in-lb

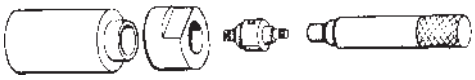
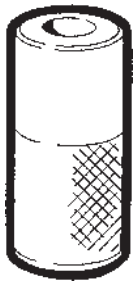
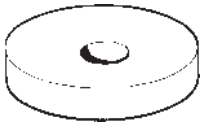
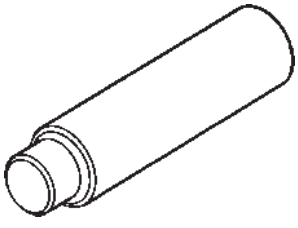
Torque limits for various size bolts-FT-LBS

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

Size (Inches)	1/4-20	5/16-18	3/8-16	7/16-14	1/2-13	9/16-18
Torque (Ft-Lbs)	6-9	12-18	22-32	40-55	55-80	85-120

Note: Oil threads with engine oil unless the threads require oil resistant or water resistant sealer.

Special tools

884584		Valve guide reamer kit
884585		Remover replacer kit, piston pin
884586		Replacer crankshaft, damper
884587		Tool for removing and fittning hydraulic lifter
884588		Rocker arm stud kit
884589		Replacer, rocker stud
884590		Replacer adapter, oil seal
884591		Replacer adapter, core plug
884592		Handle adapter for 884590 and 884591

Notes

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Notes

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