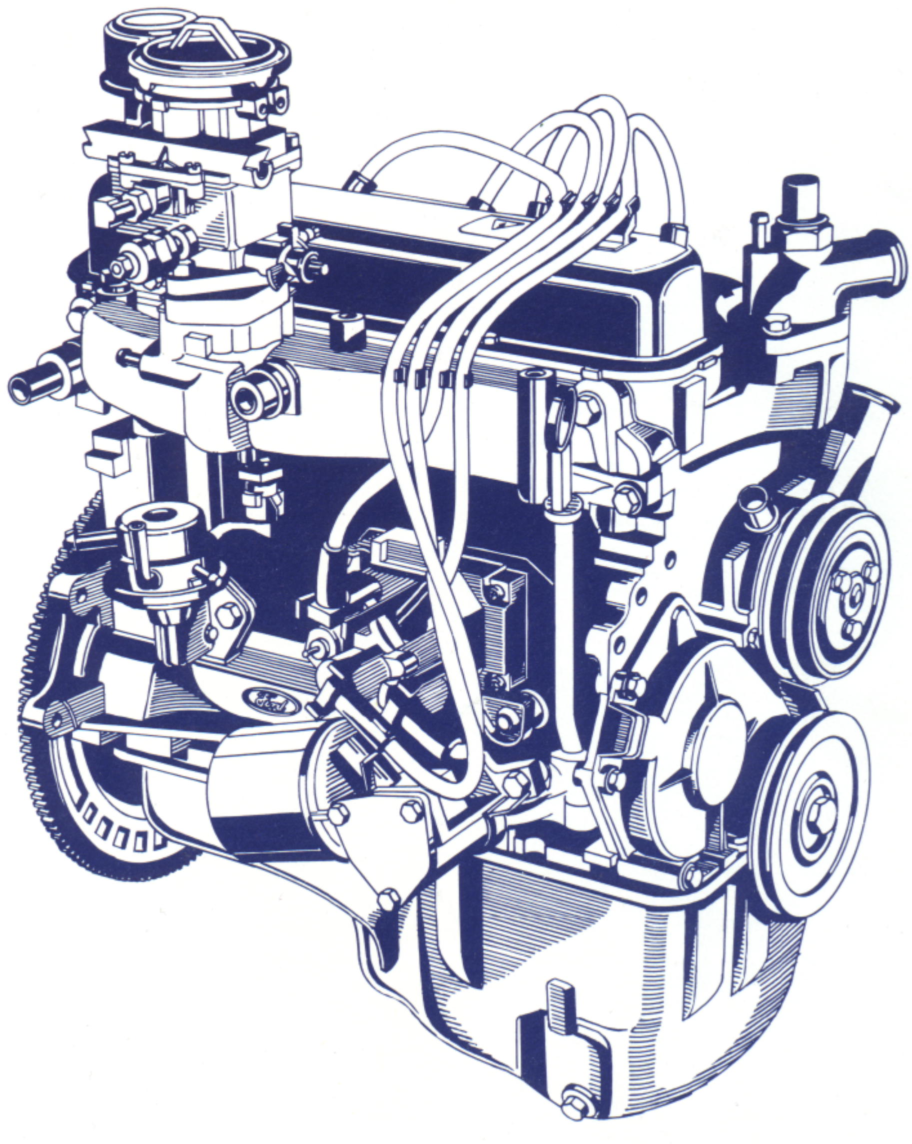
Ford Power Products

VSG-411/413 ENGINE SERVICE MANUAL



FPPO-194-264
REVISED OCT. '89

IMPORTANT SAFETY NOTICE

Appropriate service methods and proper repair procedures are essential for the safe, reliable operation of all motor vehicles as well as the personal safety of the individual doing the work. This Shop Manual provides general directions for accomplishing service and repair work with tested, effective techniques. Following them will help assure reliability.

There are numerous variations in procedures, techniques, tools and parts for servicing vehicles, as well as in the skill of the individual doing the work. This Manual cannot possibly anticipate all such variations and provide advice or cautions as to each. Accordingly, anyone who departs from the instructions provided in the Manual must first establish that he compromises neither his personal safety nor the vehicle integrity by his choice of methods, tools or parts.

NOTES, CAUTIONS, AND WARNINGS

As you read through the procedures, you will come across NOTES, CAUTIONS, and WARNINGS. Each one is there for a specific purpose. NOTES give you added information that will help you to complete a particular procedure. CAUTIONS are given to prevent you from making an error that could damage the engine. WARNINGS remind you to be especially careful in those areas where carelessness can cause personal injury. The following list contains some general WARNINGS that you should follow when you work on an engine.

- Always wear safety glasses for eye protection.
- Use safety stands whenever a procedure requires you to be under the unit.
- Be sure that the ignition switch is always in the OFF position, unless otherwise required by the procedure.
- Set the parking brake when working on a vehicle. If you have an automatic transmission, set it in PARK unless instructed otherwise for specific operation. If you have a manual transmission, it should be in REVERSE (engine OFF) or NEUTRAL (engine ON) unless instructed otherwise for a specific operation. Place wood blocks (4″ x 4″ or larger) to the front and rear surfaces of the tires to provide further restraint from inadvertent vehicle movement.
- Operate the engine only in a well-ventilated area to avoid the danger of carbon monoxide.
- Keep yourself and your clothing away from moving parts, when the engine is running, especially the fan and belts.
- To prevent serious burns, avoid contact with hot metal parts such as the radiator, exhaust manifold, tail pipe, catalytic converter and muffler.
- Do not smoke while working on the vehicle.
- To avoid injury, always remove rings, watches, loose hanging jewelry, and loose clothing before beginning to work on a vehicle. Tie long hair securely behind the head.
- Keep hands and other objects clear of the radiator fan blades. Electric cooling fans can start to operate at any time by an increase in underhood temperatures, even though the ignition is in the OFF position. Therefore, care should be taken to ensure that the electric cooling fan is completely disconnected when working under the hood.

Introduction

This Service Manual provides the service technician with information for the proper servicing of the Valencia Industrial Engine.

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

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

Where the terms "Right" or "Left" occur in this publication, they refer to the respective sides of the engine when viewed from the rear or flywheel end.

Pistons and valves are numbered from the front or timing cover end of the engine commencing at Number 1.

FORD MOTOR COMPANY
FORD POWER PRODUCTS OPERATIONS
FORD PARTS AND SERVICE DIVISION
3000 SCHAEFER ROAD
DEARBORN, MICHIGAN 48121

Note: The recommendations and suggestions contained in this publication are made to assist the distributor in improving his distributorship parts and/or service department operations. These recommendations and suggestions do not supersede or override the provisions of the Warranty and Policy Manual and in any cases where there may be a conflict, the provisions of the Warranty and Policy Manual shall govern.

Litho in U.S.A. **Rev. October, 1989**

VSG GASOLINE ENGINE

PART 1 Basic Engine

IDENTIFICATION

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

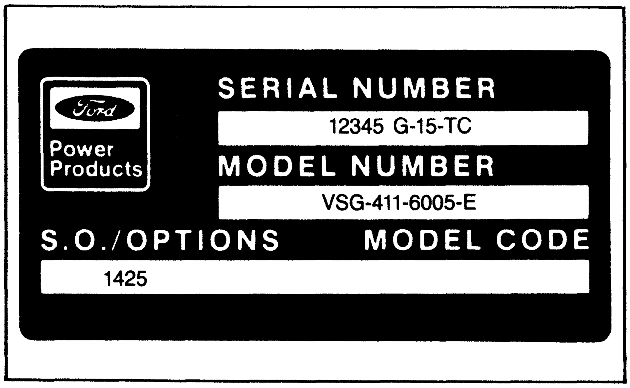


FIG. 1 Identification Decal

Identification of the cylinder block and therefore of the basic engine type can be made by reference to the stampings on the left rear top edge of the cylinder block (Figure 2).

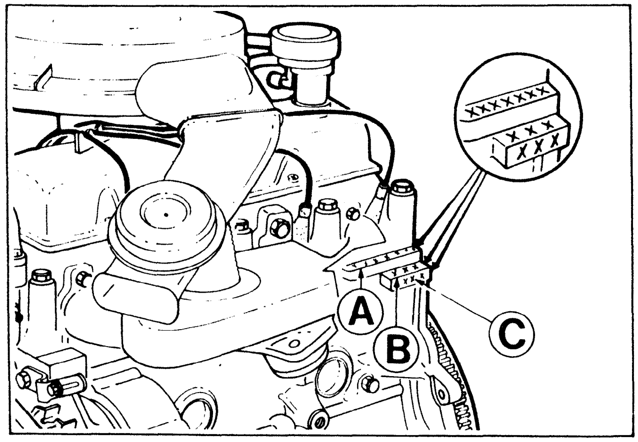


FIG. 2 A — Serial Number
B — Engine Code
C — Engine Build Date

The engine code will begin with a "G." This will indicate that it is a 1.1 liter engine.

The engine build date follows the corporate system. Example: "4K26". The first number indicates the year. The letter indicates the month in alphabetical sequence, A January, B February, etc. omitting I. The last two numbers are the day of the month.

DESCRIPTION

The engine is a water-cooled, 4 cylinder, 4 stroke, in-line gasoline engine. The cylinder head in which the combustion chambers are located is of a cross-flow type, the fresh fuel/air mixture is drawn in on one side and burnt gases are passed into the exhaust system on the opposite side.

The valves are suspended in the cylinder head and are operated by means of tappets, pushrods and rocker arms.

The valves are disposed in an alternating pattern in the cylinder head starting with an exhaust valve by the thermostat housing.

The three-bearing camshaft is located on the right side of the cylinder block and driven by roller chain from the crankshaft.

The common driving gear shared by the distributor and oil pump is located behind the second cam on the camshaft, the eccentric cam driving the fuel pump is located between the sixth and seventh cams.

The oil pump is bolted onto the outside of the cylinder block below the distributor. The full-flow oil filter is angled downwards and mounted directly on the oil pump.

The crankshaft is mounted in three or five bearings (see section 8). The crankshaft end play is determined by thrust half rings at the center main bearing.

The front crankshaft journal is sealed by means of an oil seal installed in the timing cover.

The rear crankshaft journal is sealed by means of an oil seal pressed into an oil seal carrier.

The timing cover has cast ignition timing degree marks or a TDC reference pointer. A notch on the crankshaft belt pulley is used in conjunction with either the degree or TDC reference points when installing the distributor and checking timing. They are visible on the front, left side of the engine.

The spark plugs have a tapered seat without a sealing ring.

Engine Ventilation, Figure 4.

The ventilation system consists of an oil filler cap with two connecting hoses, one of which passes to the inlet manifold and the other to the air cleaner.

The result is a closed ventilation system in which the fumes from the crankcase pass back via the inlet manifold into the cylinders for combustion.

Gas flow is regulated by a calibrated orifice in the oil filler cap.

Lubrication circuit, Figure 5.

An eccentric twin-rotor oil pump draws oil via a strainer from the sump and forces it into the full-flow oil filter.

Oil pressure is regulated by a relief valve inside the pump. The filtered oil passes through the center of the filter element, then along a short passage (right hand side of the engine) to the oil pressure switch and through a transverse bore to the main oil gallery (left hand side of the engine).

The crankshaft main bearings are fed directly from the main oil gallery and the camshaft bearings are linked, in turn for their lubrication with the front, center and rear main bearings. Each of the rod journals are supplied with oil by the nearest main bearing through oblique passages.

An oil hole in the connecting rod ensures splash lubrication of the piston pins and the trailing side of the cylinders. Timing chain and sprockets are also lubricated via a splash hole. The camshaft front bearing journal has a machined groove through which oil is intermittently forced to the rocker shaft (via passages in cylinder block and cylinder head).

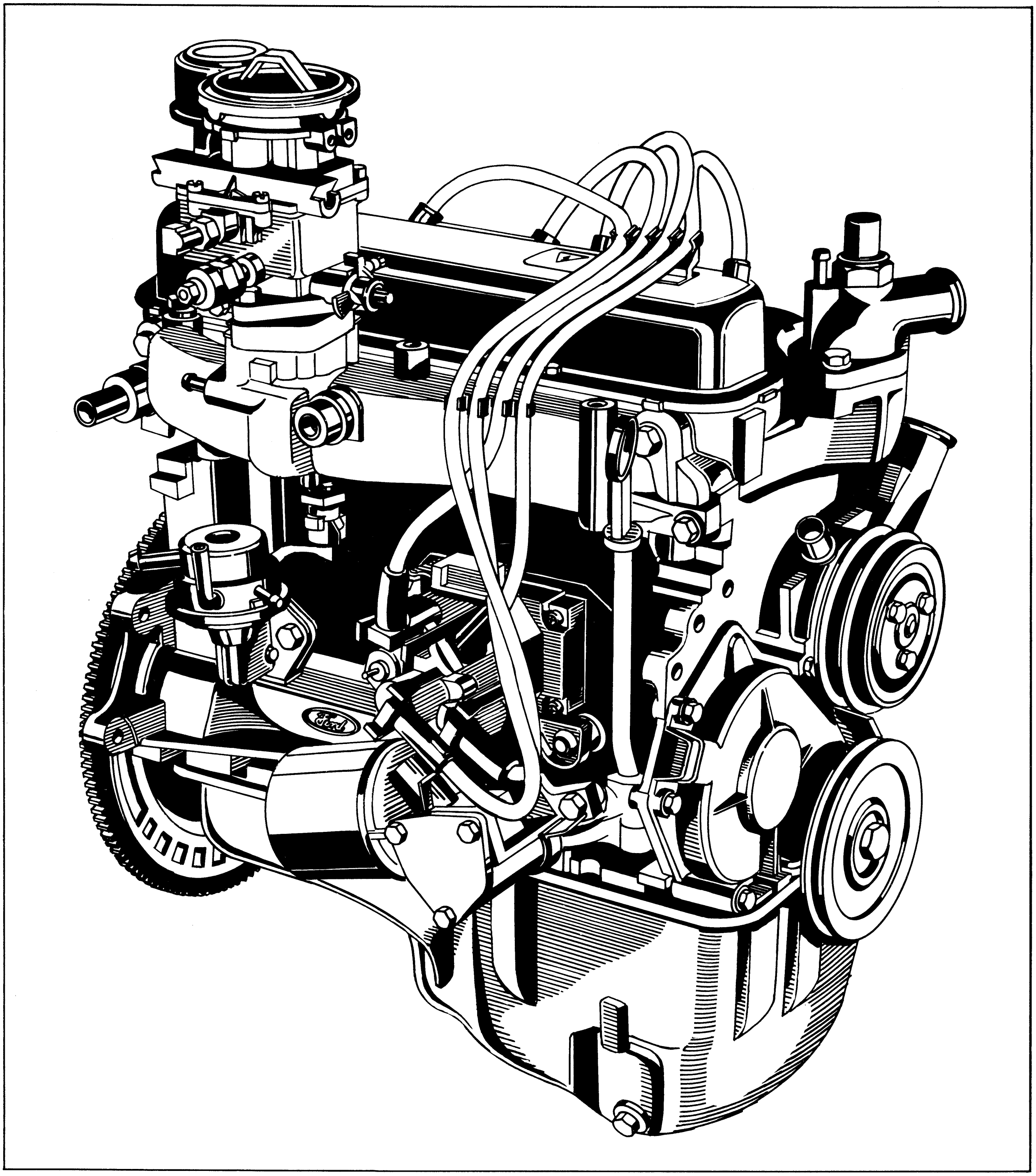


FIG. 3 VSG-411 Sectional View

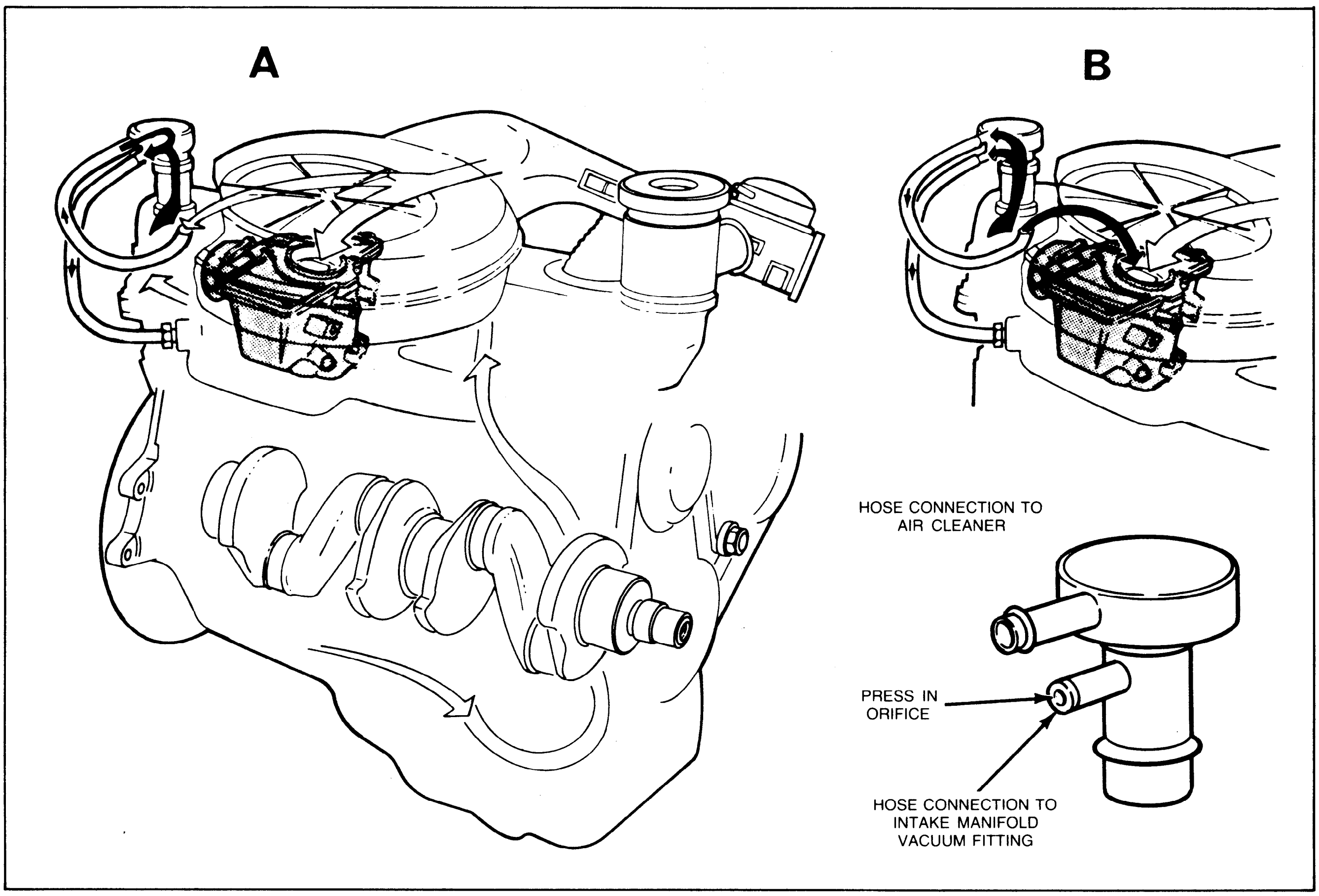


FIG. 4 Engine Ventilation System
A — Ventilation at Idle Speed and Half Throttle
B — Ventilation at Full Throttle

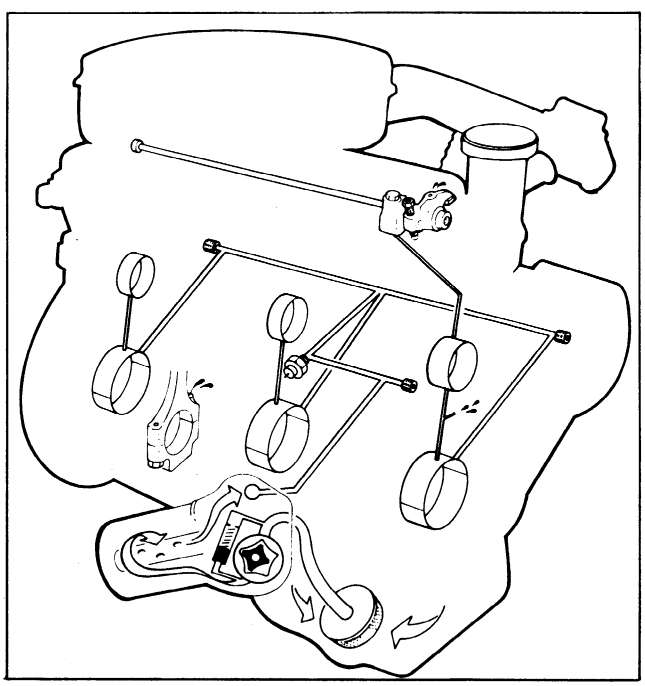


FIG. 5 Lubrication Circuit

DIAGNOSIS AND TESTING

CAMSHAFT LOBE LIFT

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

1. Remove the air cleaner and the valve rocker arm cover.
2. Remove the valve rocker arm shaft assembly as detailed in the pertinent section.
3. Make sure the push rod is in the valve lifter socket. Install a dial indicator in such a manner as to have the ball socket adapter of the indicator on the end of the push rod and in the same plane as the push rod movement (Figure 6).

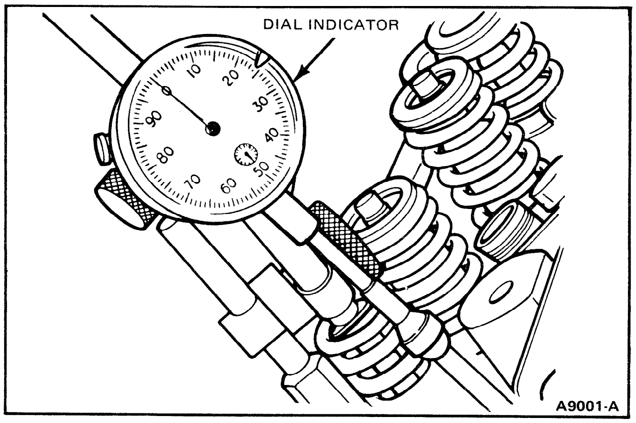


FIG. 6 Testing Camshaft Lobe Lift

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

COMPRESSION TEST

COMPRESSION GAUGE CHECK

1. Be sure the crankcase is at the proper level and the battery is properly charged. Operate the engine for a minimum of 30 minutes at 1200 rpm or until the engine is at normal operating temperature. Turn the ignition switch off; then remove all the spark plugs.
2. Set the carburetor throttle plates and choke plate in the wide open position.
3. Install a compression gauge in No. 1 cylinder.
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 normal if the lowest reading cylinder is within 75% of the highest. Refer to the following example and Figure 7.

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

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

1. If compresison 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 be used when checking cylinder compression pressures. The chart has been calculated so that the lowest reading number is 75% of the highest reading.

EXAMPLE

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

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

FLYWHEEL FACE RUNOUT

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

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

CAMSHAFT END PLAY

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

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		

FIG. 7 Quick Reference Compression Pressure Limit Chart CA1005-A

OVERHAUL

CYLINDER HEAD

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

REAMING VALVE GUIDES

If it becomes necessary to ream the valve guide (Figure 8), 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.**

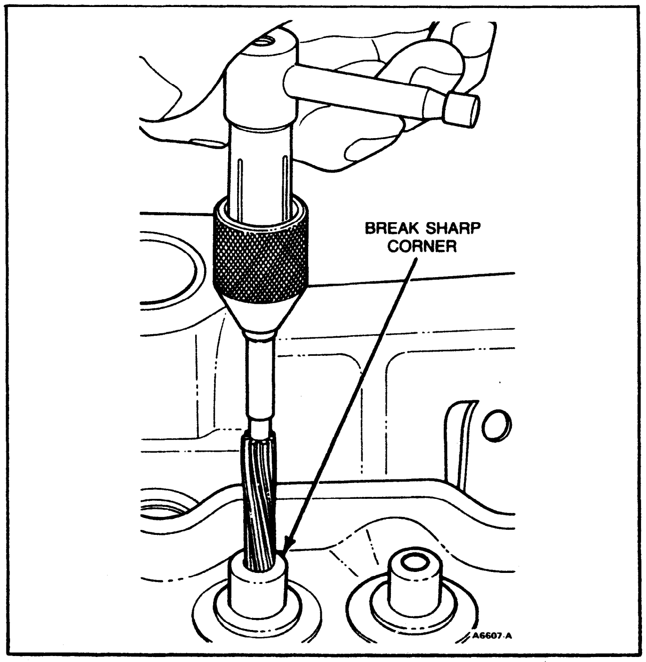


FIG. 8 Reaming Valve Guides

REFACING VALVE SEATS

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

Grind the valve seats to a true 45 degree angle (Figure 9). Remove only enough stock to clean up pits and grooves or to correct the valve seat runout. After the seat has been refaced, use a seat width scale or a machinist scale to measure the seat width (Figure 10). Narrow the seat, if necessary, to bring it within specifications.

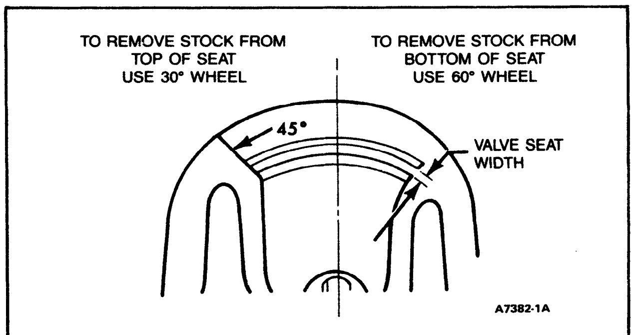


FIG. 9 Refacing Valve Seat

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.

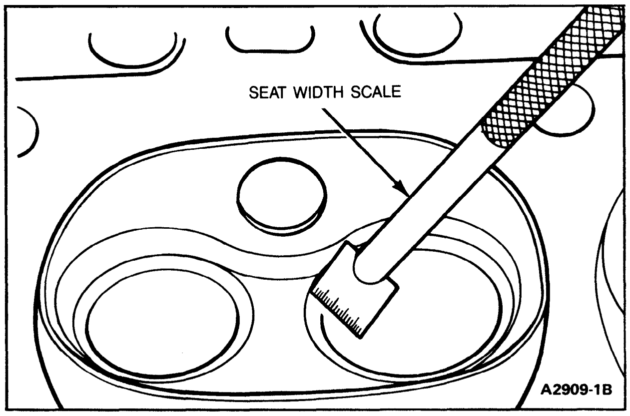


FIG. 10 Checking Valve Seat Width

VALVES

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

REFACING VALVES

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

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

If the valve face runout is excessive and/or to remove pits and grooves, reface the valves to a true 44 degree angle. Remove only enough stock to correct the runout or to clean up the pits and grooves. If the edge of the valve head is less than 1/32 inch thick after grinding (Figure 11), replace the valve as the valve will run too hot in the engine. **The interference fit of the valve and seat should not be lapped out. Remove all grooves or score marks from the end of the valve stem, and chamfer it as necessary. Do not remove more than 0.010 inch from the end of the valve stem.**

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

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 diameter are available for service. **Always reface the valve seat after the guide has been reamed. Refer to Reaming Valve Guides.**

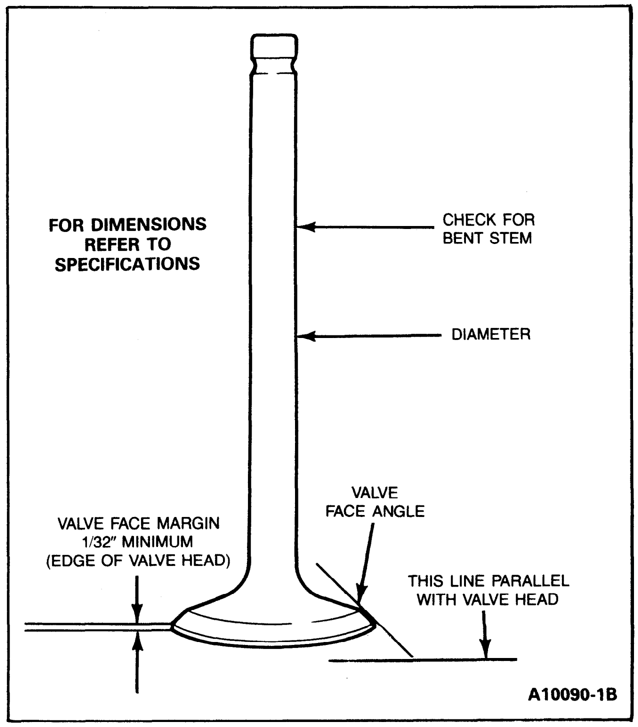


FIG. 11 Critical Valve Dimensions

CAMSHAFT REPAIR

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

CRANKSHAFT

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

REFINISHING JOURNALS

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

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

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

FITTING MAIN OR CONNECTING ROD BEARINGS WITH PLASTIGAGE

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

3. Place a piece of Plastigage on bearing surface across full width of bearing cap and about 1/4 inch off center (Figure 12).
4. Install cap and torque bolts to specifications. Do not turn crankshaft while Plastigage is in place.
5. Remove cap. Using Plastigage scale, check width of Plastigage at widest point to get minimum clearance. Check at narrowest point to get maximum clearance. Difference between readings is taper of journals.
6. If clearance exceeds specified limits on the connecting rod bearings, try a 0.002 inch undersize bearing in combination with the standard bearings. Bearing clearance must be within specified limits. If 0.002 undersize main bearings are used on more than one journal, be sure they are all installed in cylinder block side of bearing. If standard and 0.002 inch undersize bearings do not bring clearance within desired limits, refinish crankshaft journal, then install undersize bearings.
7. After bearing has been fitted, remove Plastigage, apply light coat of engine oil to journal and bearings. Install bearing cap. Torque cap bolts to specifications.
8. Repeat procedure for remaining bearings that require replacement.

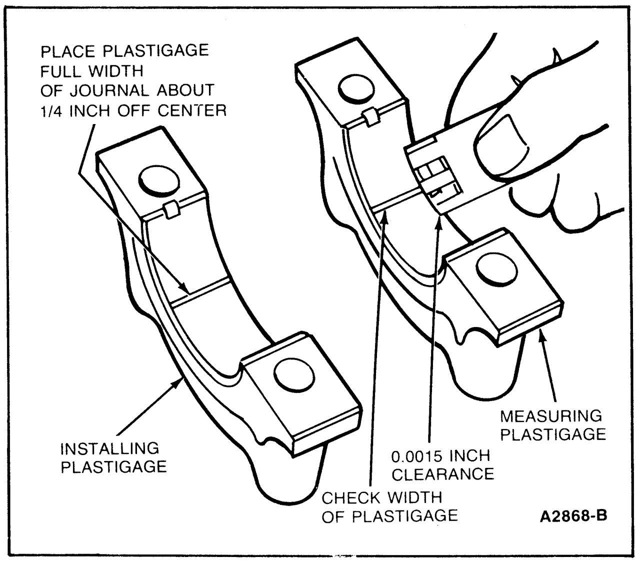


FIG. 12 Installing and Measuring Plastigage

PISTONS, PINS AND RINGS

FITTING PISTONS

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

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

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

FITTING PISTON RINGS

Three piston rings are fitted, two compression and one oil control ring.

1. Select the proper ring set for the size cylinder bore.
2. Position the ring in the cylinder bore in which it is going to be used.
3. Push the ring down into the bore area where normal ring wear is not encountered.
4. Use the head of a piston to position the ring in the bore so that the ring is square with the cylinder wall. **Use caution to avoid damage to the ring or cylinder bore.**
5. Measure the gap between the ends of the ring with a feeler gauge (Figure 13). If the ring gap is less or greater than the specified limits, try another ring set.

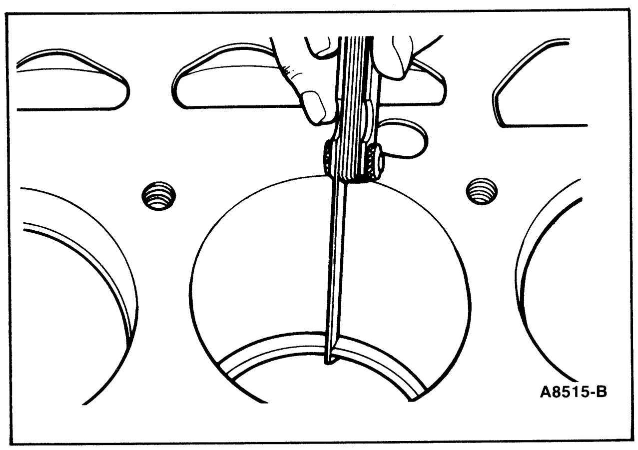


FIG. 13 Checking Piston Ring Gap

6. Check the ring side clearance of the compression rings with a feeler gauge inserted between the ring and its lower land (Figure 14). 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.**

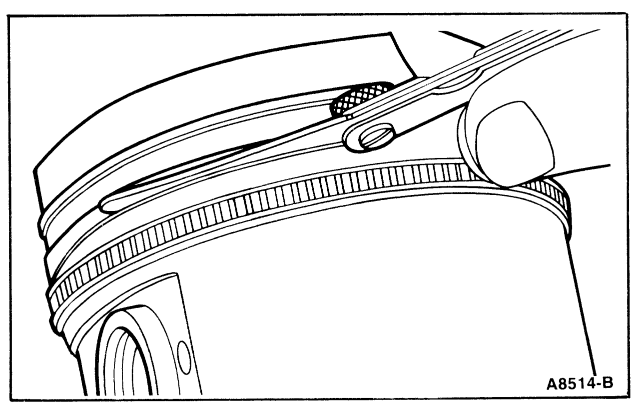


FIG. 14 Checking Piston Ring Side Clearance

FITTING PISTON PINS

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

VALVE ROCKER ARM AND/OR SHAFT ASSEMBLY

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

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

PUSH RODS

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

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

CYLINDER BLOCK

REFINISHING CYLINDER WALLS

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

REPAIRING SAND HOLES OR POROUS ENGINE CASTINGS

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

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

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

a. Clean the surface to be repaired by grinding or rotary filing to a clean bright metal surface. Chamfer or undercut the hole or porosity to a greater depth than the rest of the cleaned surface. Solid metal must surround the hole. Openings larger than 1/4 inch should not be repaired using metallic plastic. Openings in excess of 1/4 inch can be drilled, tapped and plugged using common tools. Clean the repair area thoroughly. Metallic plastic will not stick to a dirty or oily surface.
b. Mix the metallic plastic base and hardener as directed on the container. Stir thoroughly until uniform.
c. Apply the repair mixture with a suitable clean tool, (putty knife, wood spoon, etc.) forcing the epoxy into the hole or porosity.
d. Allow the repair mixture to harden. This can be accomplished by two methods, heat cure with a 250 degree lamp placed 10 inches from the repaired surface, or air dry for 10-12 hours at temperatures above 50 degrees F.
e. Sand or grind the repaired area to blend with the general contour of the surrounding surface.
f. Paint the surface to match the rest of the block.

CLEANING AND INSPECTION

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

INTAKE MANIFOLD

Cleaning

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

Inspection

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

EXHAUST MANIFOLDS

Cleaning

Remove all gasket material from the manifolds.

Inspection

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

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

VALVE ROCKER ARM AND/OR SHAFT ASSEMBLY

Cleaning

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

Make sure the oil passage in the rocker arm is open.

Inspection

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

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

Check the adjusting nut(s) torque. If not within specifications, replace the nut(s). Check the rocker arm pad and fulcrum seat for excessive wear, cracks, nicks or burrs.

PUSH RODS

Cleaning

Clean the push rods in a suitable solvent. Blow dry the pushrod with compressed air.

Inspection

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

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

If the push rod is visibly bent, 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 with a valve guide cleaning tool. Use cleaning solvent to remove dirt, grease and other deposits. Clean all bolt holes. Remove all deposits from the valves with a fine wire brush or buffing wheel.

Inspection

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

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

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

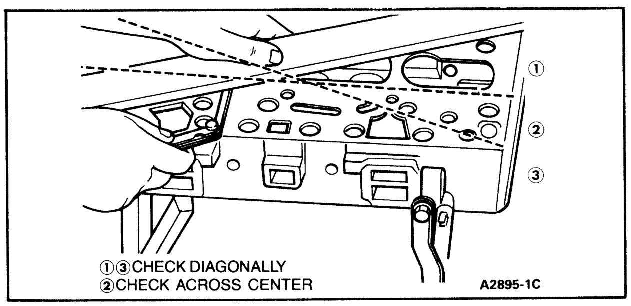


FIG. 15 Typical Cylinder Head Flatness

Check the valve seat runout with an accurate gauge (Figure 16). Follow the instructions of the gauge manufacturer. If the runout exceeds the wear limit, reface the valve and valve seat. Measure the valve seat width (Figure 10). Reface any valve seat whose width **is not within specifications**.

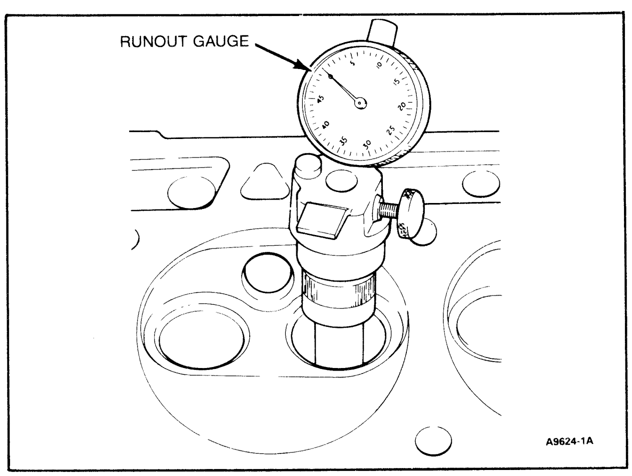


FIG. 16 Checking Valve Seat Runout

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

Inspect the valve spring, valve spring retainers, locks and sleeves for wear or damage. Discard any visually damaged parts.

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

With the cylinder head gasket face up, slide a new standard intake or exhaust valve into the valve guide to be checked until the tip of the valve stem is flush with the top of the valve guide.

Mount a dial test indicator on the cylinder head by the valve to be checked (Figure 17).

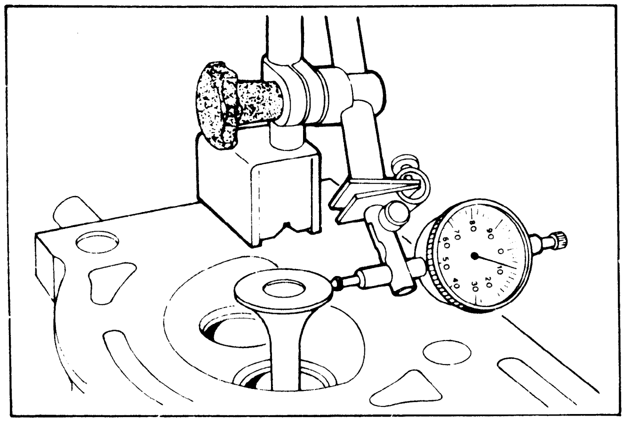


FIG. 17 Checking Valve Stem Clearance

Position the plunger of the dial test indicator on the edge of the valve head and measure the valve head movement by applying lateral pressure to the valve. If the valve head movement is greater than the values given below, the valve guide in question must be reamed using the appropriate reamer, and a new oversize valve installed.

Maximum permissible valve head movement values for the above test procedure:

Intake valve	0.50 mm (0.020 in.)
Exhaust valve	0.60 mm (0.024 in.)

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

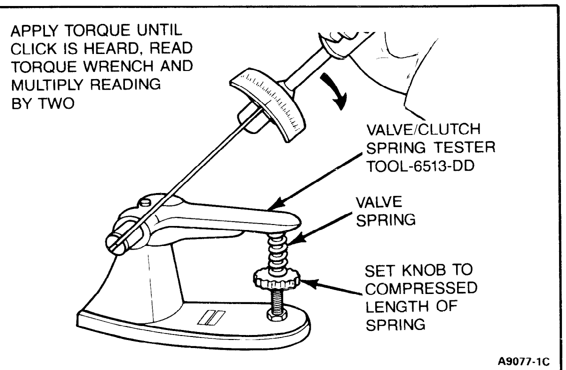


FIG. 18 Checking Valve Spring Pressure

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

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

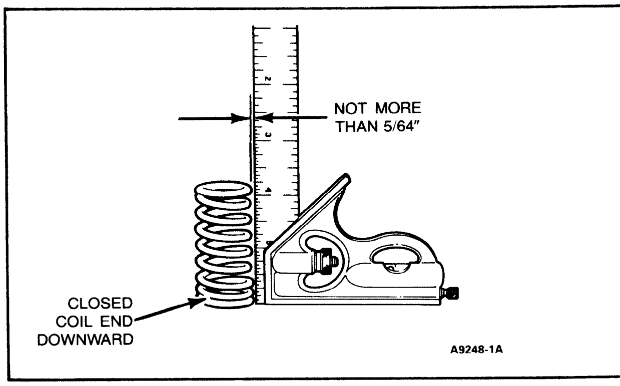


FIG. 19 Checking Valve Spring Squareness

TAPPETS

Cleaning

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

Inspection

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

TIMING CHAIN AND SPROCKETS

Cleaning

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

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

Inspection

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

CAMSHAFT

Cleaning

Clean the camshaft in solvent and wipe it dry.

Inspection

Inspect the camshaft lobes for scoring and signs of abnormal wear. Lobe pitting except in the general area of the lobe toe is not detrimental to the operation of the camshaft; therefore, the camshaft should not be replaced unless the lobe lift loss has exceeded specifications or pitting has occurred in the lobe lift area.

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

To measure the camshaft lobe lift proceed as follows:

1. Measure distance between the major (A-A) and minor (B-B) diameters of each cam lobe with a Vernier caliper and record the readings, Figure 20. The difference in the readings on each cam diameter is the lobe lift.

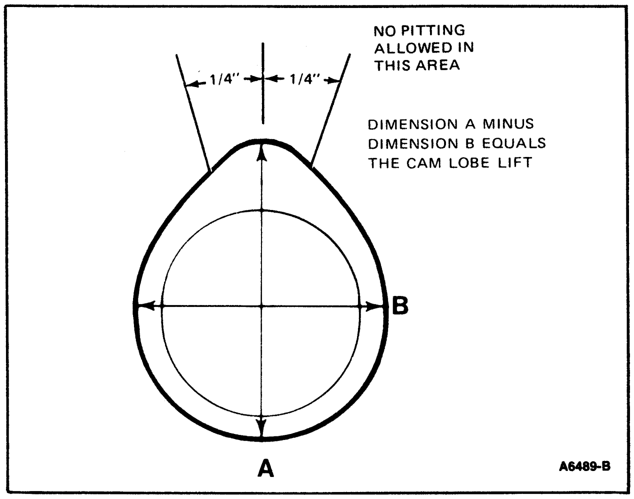


FIG. 20 Camshaft Lobe Lift Measurement — Camshaft Removed

2. If the readings do not meet specification, replace the camshaft.

CAMSHAFT BORES

Inspection

Check camshaft bores for size, taper, roundness, runout, and finish. If any of these dimensions exceeds the limits given in Specifications, install new camshaft bearings.

CRANKSHAFT

Cleaning

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

Inspection

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

Measure the diameter of each journal in at least four places to determine an out-of-round, taper or undersize condition (Figure 21).

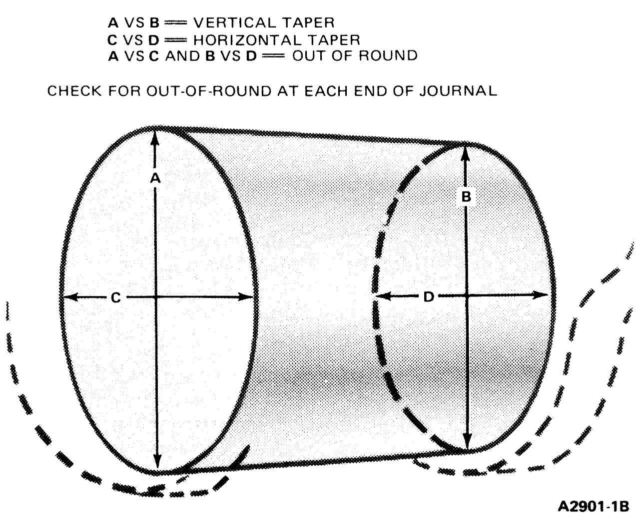


FIG. 21 Crankshaft Journal Measurement

FLYWHEEL

Inspection

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

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

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

CONNECTING RODS

Cleaning

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

Inspection

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

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

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

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

Inspect the connecting rods for signs of fractures and the bearing bores for out-of-round and taper. If the bore exceeds the recommended limits and/or if the connecting rod is fractured, it should be replaced. Check the ID of the connecting rod piston pin bore. If the pin bore in the connecting rod is larger than specifications, install a 0.002 inch oversize piston pin. First, prefit the oversize piston pin to the piston pin bore by reaming or honing the piston. Then, assemble the piston, piston pin and connecting rod following the procedures for assembly. **It is not necessary to ream or hone the pin bore in the connecting rod. Replace damaged connecting rod nuts and bolts. Check the connecting rods for bend or twist on a suitable alignment fixture. Follow the instructions of the fixture manufacturer. If the bend and/or twist exceeds specifications, the connecting rod must be straightened or replaced.**

PISTONS, PINS AND RINGS

Cleaning

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

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

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.

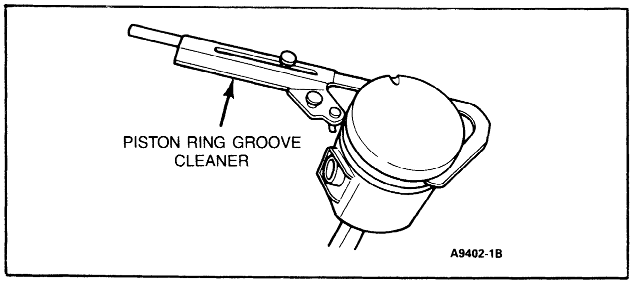


FIG. 22 Cleaning Piston Ring Grooves

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

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

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

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

MAIN AND CONNECTING ROD BEARINGS

Cleaning

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

Inspection

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

CYLINDER BLOCK

Cleaning

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

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

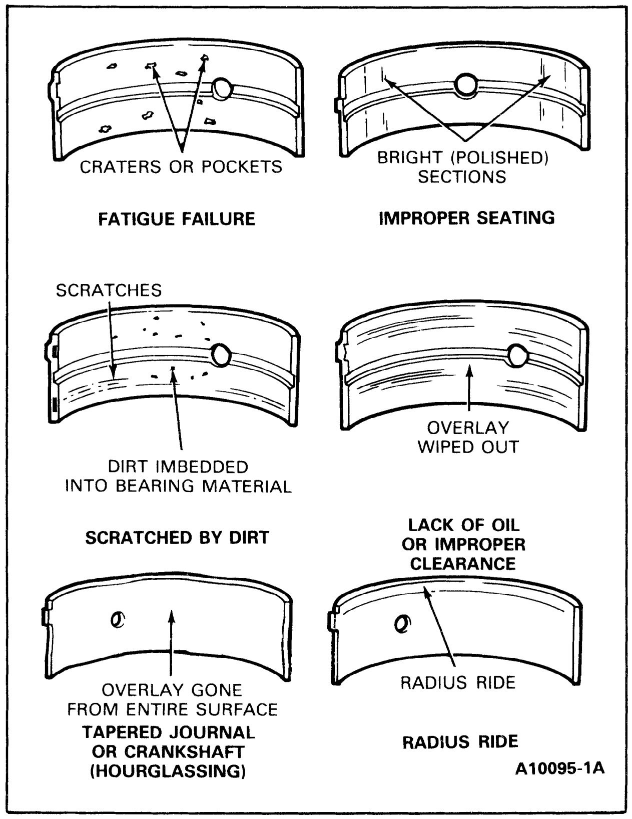


FIG. 23 Typical Bearing Failures

Inspection

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

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

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

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

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

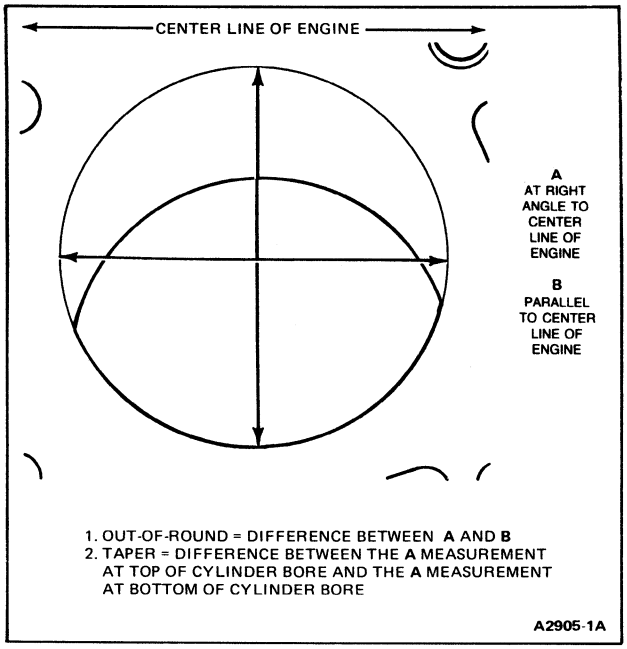


FIG. 24 Cylinder Bore Out-of-Round and Taper

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

With the rotor assembly installed in the housing, place a straight edge over the rotor assembly and the housing. Measure the clearance (rotor end play) between the straight edge and the rotor and outer race (Figure 27). **The outer race, shaft and rotor are replaceable only as an assembly.** Check the drive shaft to housing bearing clearance by measuring the OD of the shaft and the ID of the housing bearing. Inspect the relief valve spring for a collapsed or worn condition. Check the relief valve spring tension. If the spring is worn or damaged, replace the spring. Check the relief valve piston for scores and free operation in the bore.

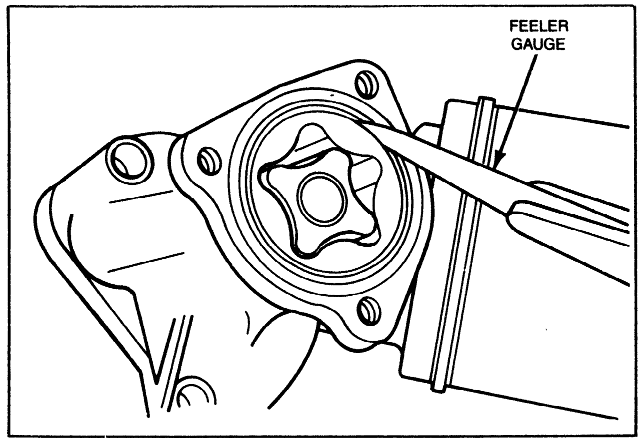


FIG. 25 Checking Outer Race to Housing Clearance

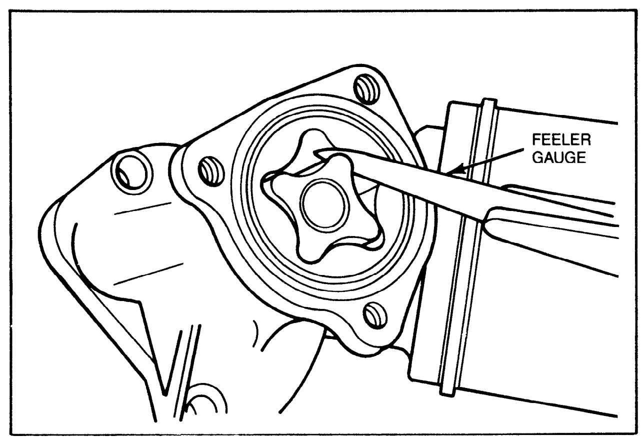


FIG. 26 Checking Rotor Lobes to Outer Race Clearance

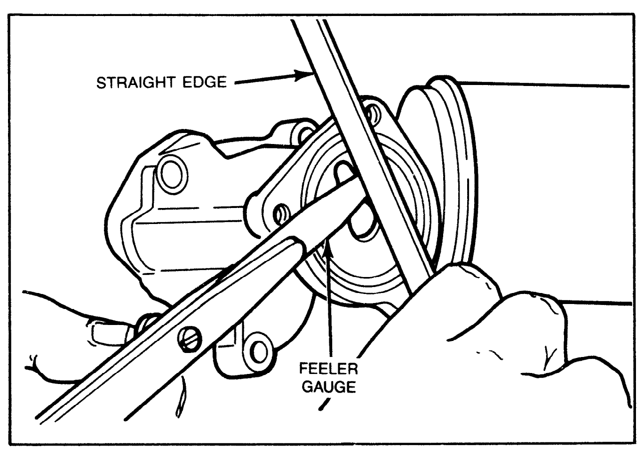


FIG. 27 Checking Rotor End Play

REMOVAL AND INSTALLATION

VALVE ROCKER ARM COVER, ROCKER ARM AND/OR SHAFT

Removal

1. Remove the air cleaner from the carburetor.
2. Disconnect the spark plug leads, remove them from the clip on the rocker cover and position aside.
3. Remove the rocker cover attaching screws, remove the rocker cover and discard the gasket.
4. Remove the rocker arm shaft attaching bolts evenly and lift off the rocker arm shaft assembly.
5. Remove the cotter pin from one end of the shaft and slip the flat washer, crimped washer and second flat washer off the shaft. The rocker arm shaft supports, rocker arms and springs can now be removed from the shaft.
6. Remove the plugs from the rocker shaft ends by drilling a hole in one plug. Insert a long rod through the drilled plug and knock the opposite plug out of the shaft. Remove the drilled plug in the same manner.
7. Clean the component parts of the shaft assembly in any suitable degreasing fluid.

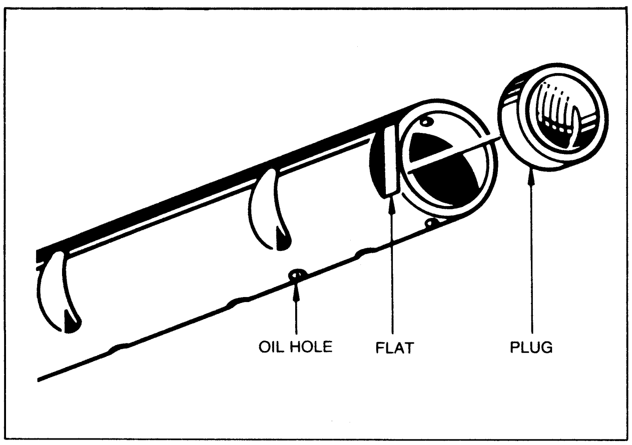


FIG. 28 Front End of Rocker Shaft

Installation

1. Refit new plugs to the rocker shaft ends.
2. Assemble the rocker arm shaft. **The bolt hole in the rocker arm shaft support must be on the same side as the adjusting screw in the rocker arm. The oil holes must point downward and the flat on the shaft to the front of engine. The rocker arms are right and left handed, the rocker pads being inclined towards the support.** Install the cotter pins with the heads upwards and bend over the legs to secure.
3. Lubricate the valve stem tips, rocker arm pads and the push rod ends with Lubriplate or equivalent. Position the rocker shaft assembly on the cylinder head engaging the push rods with the adjusting screws. Install and tighten the bolts evenly to specifications.
4. Adjust the valve clearance to specifications.
5. Ensure that the mating surfaces on the cylinder head and rocker cover are free from all traces of the old gasket material.
6. Position the rocker cover and gasket on the cylinder head and secure with the attaching screws. Torque the screws to specifications.
7. Locate the spark plug leads in the rocker cover clip and reconnect them to their respective plugs.
8. Install the air cleaner.

INTAKE MANIFOLD

Removal

1. Partially drain the cooling system.
2. Remove the air cleaner.
3. Disconnect the throttle rod from the carburetor throttle lever.
4. Disconnect the fuel line and the distributor vacuum line from the carburetor.
5. Disconnect the water outlet hose and the crankcase ventilation hose from the intake manifold.
6. Remove the attaching nut and bolts and remove the intake manifold.
7. Remove the gasket.
8. If a new manifold is to be installed, transfer all necessary components to the new manifold.

Installation

1. Apply a water resistant sealer to both sides of the gasket around the water port and position it on the cylinder head.
2. Install the intake manifold and tighten the nuts and bolts evenly to specifications.
3. Connect the water hose and the crankcase ventilation hose to the intake manifold.
4. Connect the distributor vacuum line and the fuel supply line to the carburetor.
5. Connect the throttle rod.
6. Install the air cleaner.
7. Refill the cooling system with the recommended coolant.

EXHAUST MANIFOLD

Removal

1. Remove the exhaust pipe retaining nuts and exhaust pipe.
2. Remove the eight exhaust manifold retaining nuts.
3. Remove the exhaust manifold.
4. Remove the four exhaust gaskets and discard them.

Installation

1. Install four new exhaust manifold gaskets onto the studs.
2. Install the exhaust manifold and torque the nuts to specification in the sequence shown in Figure 28a.
3. Install the exhaust pipe and torque the retaining nuts to specification.

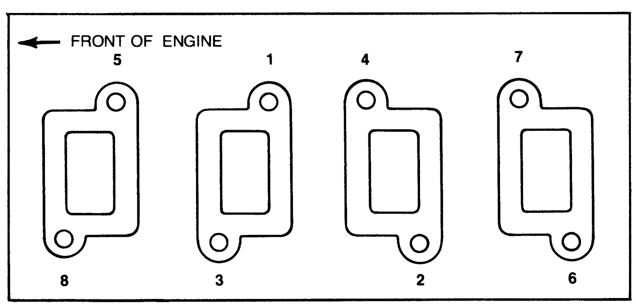


FIG. 28a Exhaust Manifold Torque Sequence

CYLINDER HEAD

Removal

1. Remove the air cleaner.
2. Disconnect the fuel line at the fuel pump and carburetor.
3. Drain the coolant.
4. Disconnect the spark plug leads, remove them from the clip on the rocker cover and position out of the way.
5. Disconnect the water outlet and crankcase ventilation hoses at the intake manifold.

REMOVAL AND INSTALLATION

VALVE ROCKER ARM COVER, ROCKER ARM AND/OR SHAFT

Removal

1. Remove the air cleaner from the carburetor.
2. Disconnect the spark plug leads, remove them from the clip on the rocker cover and position aside.
3. Remove the rocker cover attaching screws, remove the rocker cover and discard the gasket.
4. Remove the rocker arm shaft attaching bolts evenly and lift off the rocker arm shaft assembly.
5. Remove the cotter pin from one end of the shaft and slip the flat washer, crimped washer and second flat washer off the shaft. The rocker arm shaft supports, rocker arms and springs can now be removed from the shaft.
6. Remove the plugs from the rocker shaft ends by drilling a hole in one plug. Insert a long rod through the drilled plug and knock the opposite plug out of the shaft. Remove the drilled plug in the same manner.
7. Clean the component parts of the shaft assembly in any suitable degreasing fluid.

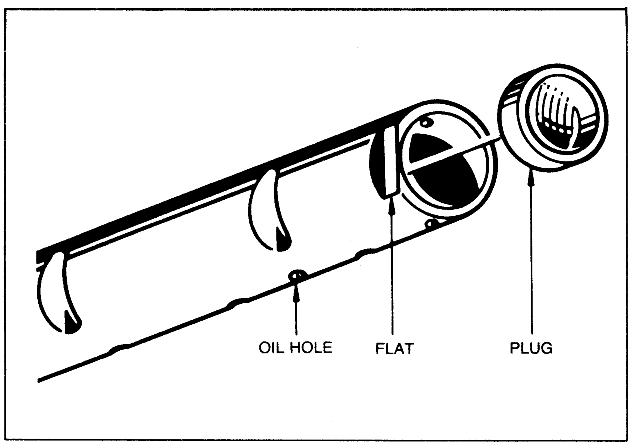


FIG. 28 Front End of Rocker Shaft

Installation

1. Refit new plugs to the rocker shaft ends.
2. Assemble the rocker arm shaft. **The bolt hole in the rocker arm shaft support must be on the same side as the adjusting screw in the rocker arm. The oil holes must point downward and the flat on the shaft to the front of engine. The rocker arms are right and left handed, the rocker pads being inclined towards the support.** Install the cotter pins with the heads upwards and bend over the legs to secure.
3. Lubricate the valve stem tips, rocker arm pads and the push rod ends with Lubriplate or equivalent. Position the rocker shaft assembly on the cylinder head engaging the push rods with the adjusting screws. Install and tighten the bolts evenly to specifications.
4. Adjust the valve clearance to specifications.
5. Ensure that the mating surfaces on the cylinder head and rocker cover are free from all traces of the old gasket material.
6. Position the rocker cover and gasket on the cylinder head and secure with the attaching screws. Torque the screws to specifications.
7. Locate the spark plug leads in the rocker cover clip and reconnect them to their respective plugs.
8. Install the air cleaner.

INTAKE MANIFOLD

Removal

1. Partially drain the cooling system.
2. Remove the air cleaner.
3. Disconnect the throttle rod from the carburetor throttle lever.
4. Disconnect the fuel line and the distributor vacuum line from the carburetor.
5. Disconnect the water outlet hose and the crankcase ventilation hose from the intake manifold.
6. Remove the attaching nut and bolts and remove the intake manifold.
7. Remove the gasket.
8. If a new manifold is to be installed, transfer all necessary components to the new manifold.

Installation

1. Apply a water resistant sealer to both sides of the gasket around the water port and position it on the cylinder head.
2. Install the intake manifold and tighten the nuts and bolts evenly to specifications.
3. Connect the water hose and the crankcase ventilation hose to the intake manifold.
4. Connect the distributor vacuum line and the fuel supply line to the carburetor.
5. Connect the throttle rod.
6. Install the air cleaner.
7. Refill the cooling system with the recommended coolant.

EXHAUST MANIFOLD

Removal

1. Remove the exhaust pipe retaining nuts and exhaust pipe.
2. Remove the eight exhaust manifold retaining nuts.
3. Remove the exhaust manifold.
4. Remove the four exhaust gaskets and discard them.

Installation

1. Install four new exhaust manifold gaskets onto the studs.
2. Install the exhaust manifold and torque the nuts to specification in the sequence shown in Figure 28a.
3. Install the exhaust pipe and torque the retaining nuts to specification.

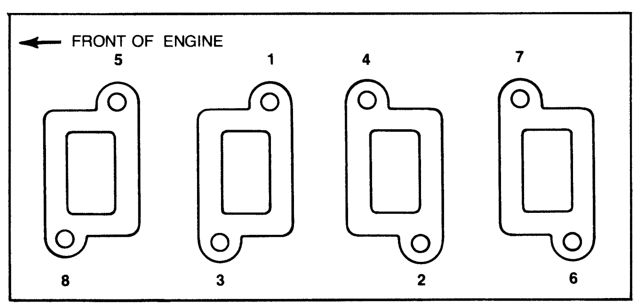


FIG. 28a Exhaust Manifold Torque Sequence

CYLINDER HEAD

Removal

1. Remove the air cleaner.
2. Disconnect the fuel line at the fuel pump and carburetor.
3. Drain the coolant.
4. Disconnect the spark plug leads, remove them from the clip on the rocker cover and position out of the way.
5. Disconnect the water outlet and crankcase ventilation hoses at the intake manifold.

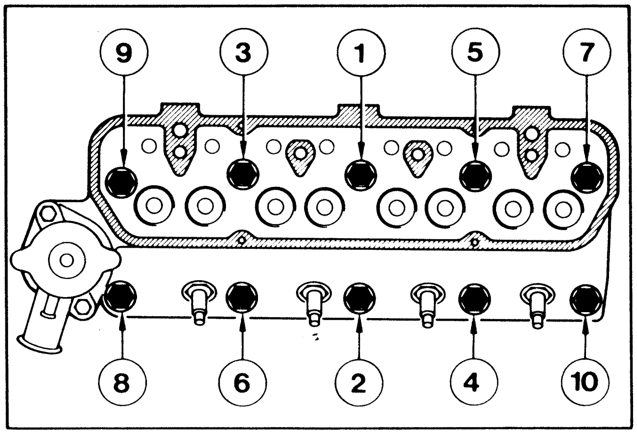


FIG. 29 Cylinder Head Bolt Tightening Sequence

6. Disconnect the wire from the temperature gauge sending unit.
7. Detach the exhaust pipe.
8. Disconnect the throttle rod, choke cable and the distributor vacuum advance hose from the carburetor.
9. Disconnect the throttle linkage at the governor and position out of the way.
10. Remove the governor mounting bolts and remove governor.
11. Remove the thermostat housing, pull to one side and remove the thermostat.
12. Remove the rocker arm cover and gasket.
13. Remove the rocker arm shaft bolts evenly and lift off the rocker arm shaft assembly.
14. Lift out the push rods from their locations and keep them in their correct order.
15. Remove the cylinder head bolts and lift off the cylinder head and gasket. **Do not lay the cylinder head flat on its face as damage to the spark plugs or gasket surface can occur.**

Installation

1. Clean all gasket material from the mating surfaces and position the cylinder head gasket on the cylinder block using pilot studs.
2. Position the cylinder head, remove pilot studs and install the cylinder head bolts. Tighten the bolts down evenly in sequence (Figure 29) and in four steps to specifications.
3. Lubricate both ends of the push rods with Lubriplate or equivalent and install them in their respective bores.
4. Install the rocker arm shaft assembly to the cylinder head, locating the push rods on the adjusting screws. Tighten the bolts evenly to specifications.
5. Adjust the valve clearances.
6. Install the rocker arm cover.
7. Connect the exhaust pipe.
8. Connect the distributor vacuum advance line, the throttle rod, and choke cable to the carburetor.
9. Connect the wire to the temperature gauge sender unit.
10. Connect the water outlet and crankcase ventilation hoses to the intake manifold.
11. Locate the thermostat in its bore in the cylinder head and install the gasket and thermostat housing.
12. Refill the cooling system.
13. Position governor and mounting bracket to cylinder head and install bolts.
14. Loosen governor adjusting bolts and position drive belt to governor. Adjust belt to specification and tighten bolts.
15. Connect the throttle linkage to the governor.
16. Install the alternator bracket mounting bolt to cylinder head.
17. Connect the ignition wires to the spark plugs in the correct firing order.
18. Install the air cleaner to the carburetor.

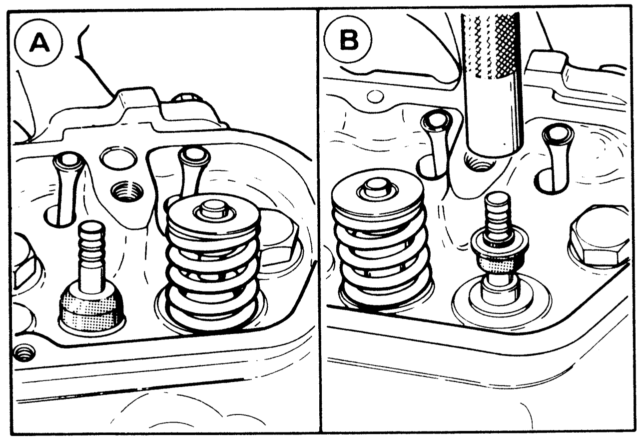


FIG. 30 A — Exhaust Valve Seal
B — Intake Valve Seal

19. Adjust the carburetor idle speed and mixture settings.
20. Check governor operation, adjust as required.

VALVE SPRING, RETAINER AND STEM SEAL

CYLINDER HEAD REMOVED

Removal

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

Installation

Lubricate all valves, valve stems and valve guides with heavy engine oil, SAE 50 weight.

1. Install each valve in the valve guide hole from which it was removed or to which a new valve is to be used.
2. Cover the valve grooves with plastic tape, slide the new seal onto the valve stem, remove the tape. NOTE: The exhaust valves are fitted with umbrella type seals. The intake valves have the "positive" guide mounted seals which must be pressed on with a special service tool (Figure 30). "Positive" type seals may only be installed on intake valves not having the Ford oval on the stem.
3. Install valve spring and damper assembly over the valve, then install spring retainer. Compress spring and install retainer key locks.
4. Measure the assembled height of the valve spring from the underside of the spring to the underside of the spring retainer. If the assembled height is not within specification, valve spring load loss may be excessive. Shim spring to specification.

CYLINDER HEAD INSTALLED

Removal

1. Remove the air cleaner.
2. Disconnect the spark plug leads, remove them from the clip on the rocker cover and position out of the way.
3. Remove the rocker arm cover and gasket.
4. Remove the rocker arm shaft bolts evenly and lift off the rocker arm shaft assembly.
5. Lift the push rods from their locations and keep them in their correct order.
6. Remove the spark plugs.
7. Suitably support the appropriate valve with air pressure.
8. Compress the valve spring, using special service tool (Figure 31). Remove the valve spring retainer locks. Release the spring compressor, remove the valve spring retainer and the valve stem oil seal.

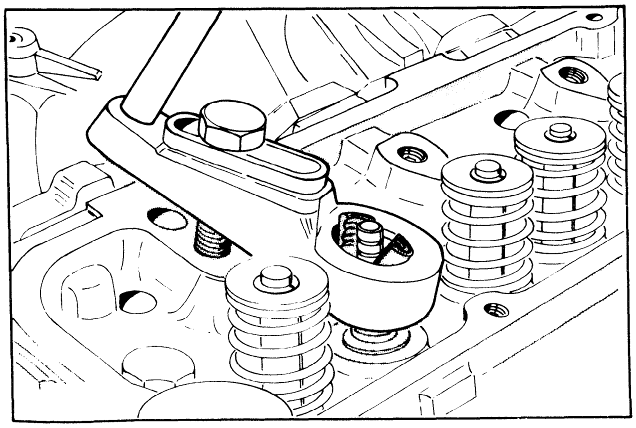


FIG. 31 Valve Spring Compressing Tool

Installation

1. Cover the valve grooves with plastic tape, slide the new seal onto the valve stem, remove the tape. NOTE: The exhaust valves are fitted with umbrella type seals. The intake valves have the "positive" guide mounted seals which must be pressed on with a special service tool (Figure 30).
2. Position the valve spring and retainer over the valve stem.
3. Compress the valve spring using the special service tool. Position the valve spring retainer locks in the valve stem grooves and slowly release the spring to engage the locks in the retainer. Remove the air hose and adapter.
4. Lubricate both ends of the push rods with Lubriplate or equivalent and install them in their respective bores. Install the rocker arm shaft assembly to the cylinder head, locating the push rods on the adjusting screws. Tighten the bolts evenly to specifications.
5. Adjust valve clearances to specification.
6. Install the rocker cover with a new gasket and torque the attaching screws to specification.
7. Install the spark plugs.
8. Locate the spark plug leads in the rocker cover clip and reconnect them to their respective plugs.
9. Install the air cleaner assembly.

WATER PUMP

Removal

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

Installation

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

CYLINDER FRONT COVER AND TIMING CHAIN, OR CRANKSHAFT SPROCKETS

Removal

1. Drain the engine coolant by opening the drain cock on the radiator and removing the drain plug in the cylinder block.
2. Disconnect the radiator hoses at the engine.
3. Remove the radiator.
4. Remove the governor and fan belts and then remove the fan and the water pump pulley.
5. Remove the water pump.
6. Remove the crankshaft pulley.
7. Remove the oil pan to cylinder front cover and front cover to block attaching bolts. Use a thin knife to cut the oil pan gasket flush with cylinder block face prior to separating the cover from the cylinder block. Remove the front cover.
8. Remove the crankshaft oil slinger. Remove the camshaft sprocket retainer and bolts.
9. Remove the timing chain tensioner arm. Remove the camshaft sprocket, and disconnect the timing chain.
10. If crankshaft sprocket is to be removed, use a standard two-jaw puller (Figure 32).

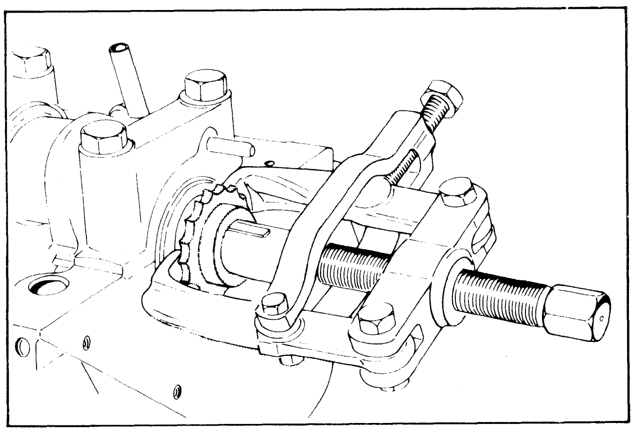


FIG. 32 Removing Crankshaft Sprocket

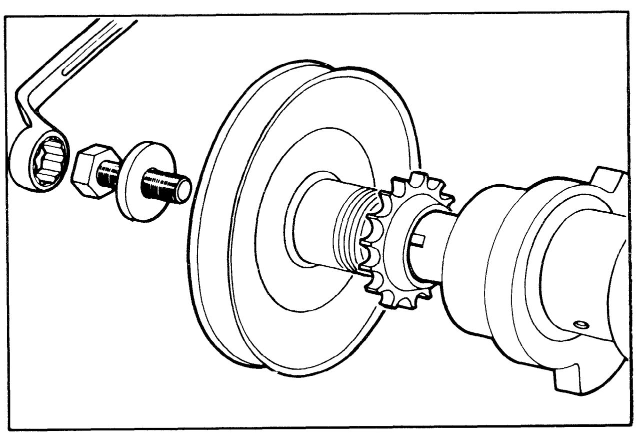


FIG. 33 Installing Crankshaft Sprocket

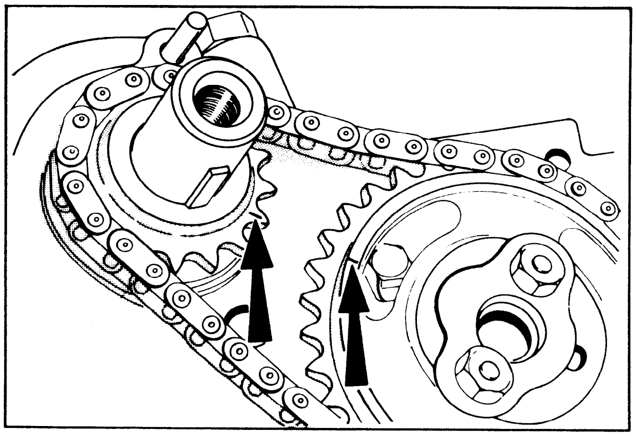


FIG. 34 Timing Marks

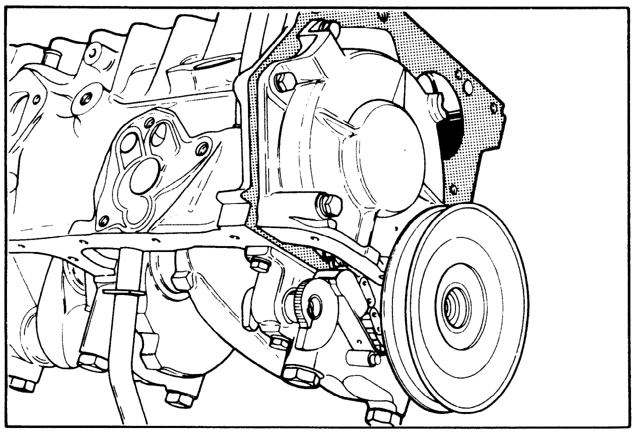


FIG. 35 Aligning Front Cover and Seal

Installation

1. If crankshaft sprocket was removed, install using the pulley, bolt and washer. The timing mark on the sprocket must face the end of the crankshaft.
2. Position the timing chain over the camshaft and crankshaft sprockets so that the timing marks are aligned when the sprocket is installed (Figure 34). **The number 4 cylinder is on top dead center when using the gear marks as reference.** Tighten the bolts to specification, then bend up the locking tabs.
3. Locate the tensioner arm on the pivot pin while holding the tensioner cam in the released position.
4. Install the oil slinger on the crankshaft.
5. Position the gasket, portions of oil pan gasket, if necessary, and the end seal on the front cover with an oil resistant sealer at the ends. Install the front cover and align the seal by installing the crankshaft pulley (Figure 35). Tighten the attaching bolts evenly to specification.
6. Install and torque crankshaft pulley retaining bolt.
7. Install the water pump and torque the attaching bolts to specification.
8. Install the water pump pulley and fan. Install the governor and fan belts and adjust the tension of the belts to specifications using Tool T63L-8620-A.
9. Install the radiator.
10. Install the radiator upper and lower hoses and tighten the clamps.
11. Refill the radiator.
12. Start engine and check for oil and water leaks.

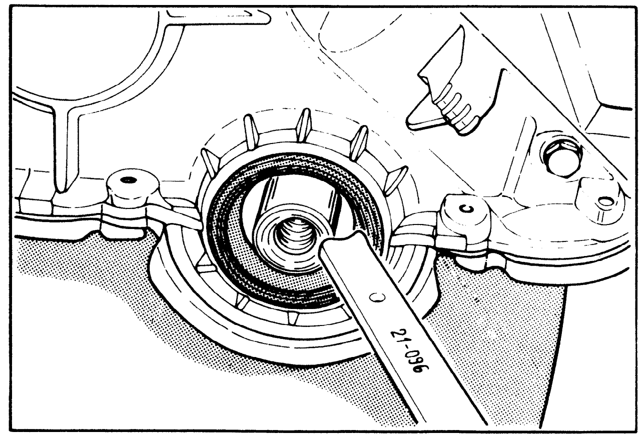


FIG. 36 Removing Front Cover Oil Seal

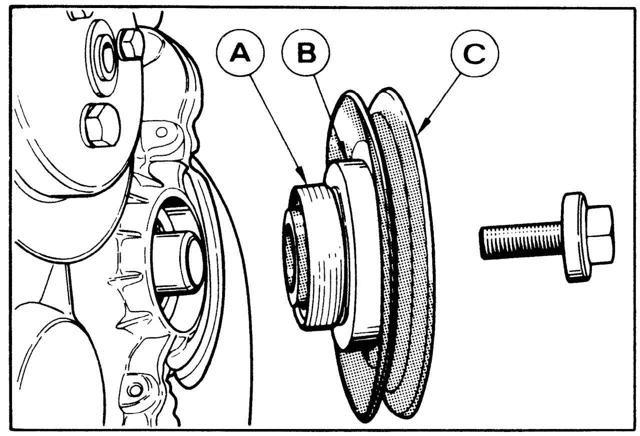


FIG. 37 Front Oil Seal Installation
A — Seal B — Tool 21-046
C — Crankshaft Pulley

ADJUSTING VALVE CLEARANCES

1. Only turn the crankshaft belt pulley clockwise while adjusting the valve clearances and start by aligning the mark on the belt pulley with the "O" mark on the front cover.
2. If belt pulley is now turned to and fro slightly, valves of cylinder No. 1 or 4 will be rocking, i.e., the two rockers and push rods move in opposite directions.
3. When valves in cylinder No. 4 are rocking, No. 1 cylinder valve clearances should be adjusted.
4. Then rotate belt pulley a further half turn. In this position valves of cylinder No. 3 will rock and valve clearances of cylinder No. 2 can be adjusted and so on according to firing order. (See Technical Data for settings.)

Cylinder No. 4 rocking — adjust cylinder No. 1
Cylinder No. 3 rocking — adjust cylinder No. 2
Cylinder No. 1 rocking — adjust cylinder No. 4
Cylinder No. 2 rocking — adjust cylinder No. 3

CRANKSHAFT FRONT OIL SEAL

Removal

1. Loosen alternator and adjusting bracket bolts and remove fan belt.
2. Remove crankshaft pulley bolt and remove pulley by hand.
3. Remove oil seal from front cover using special service tool (21-096). NOTE: Use short end of tool on this seal (Figure 36).

Installation

1. Lubricate the sealing lip of the new seal with engine oil and push new seal into front cover using tool 21-046, crankshaft pulley, bolt and washer (Figure 37).
2. Remove special service tool and reinstall crankshaft pulley. Torque bolt to specification.
3. Install fan belt and adjust the tension of the belts to specification using Tool T63L-8620-A. Tighten alternator and adjusting bracket bolts.

CAMSHAFT AND/OR VALVE LIFTERS

Removal

1. Remove the engine assembly and mount the engine on a stand. Drain the crankcase.
2. Disconnect the fuel line at the fuel pump.
3. Loosen the alternator and governor adjustment bolts and remove the belts.
4. Remove the fan and water pump pulley.
5. Remove the oil and fuel pumps from the cylinder block.
6. Disconnect the spark plug wires from the plugs and remove the distributor from the cylinder block.
7. Remove the rocker arm cover attaching screws and rocker cover. Clean all gasket material from rocker arm cover and cylinder head.
8. Remove the rocker arm shaft support bolts evenly and lift off the rocker arm shaft.
9. Lift the push rods from their locations in the cylinder block, taking care to keep them in their correct order.
10. Invert the engine on the stand and remove the oil pan and gaskets.
11. Remove the crankshaft pulley, the front cover and oil slinger.
12. Remove the timing chain tensioner assembly.
13. Remove the camshaft sprocket and timing chain.
14. With the engine inverted, remove the camshaft thrust plate and remove the camshaft (Figure 38).
15. If necessary, remove the tappets from their locations in the cylinder block and keep them in the correct order.

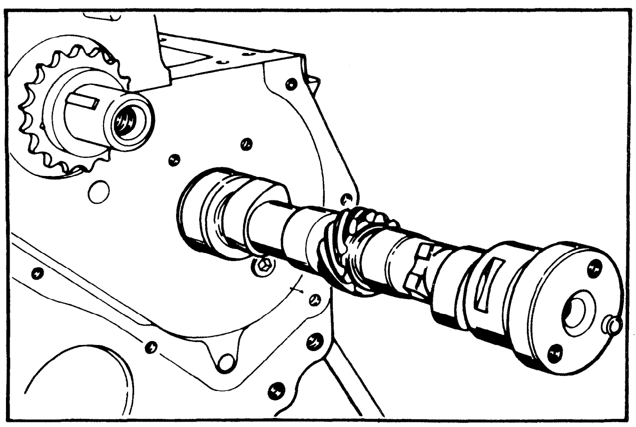


FIG. 38 Camshaft Removal

Installation

1. Install a new front cover oil seal, using Tool 21-046.
2. Install the tappets, if removed.
3. Install the camshaft and fit the thrust plate in the camshaft groove. Tighten the attaching bolts to specification and bend up the locking tabs.
4. Check the camshaft end play.
5. Locate the timing chain on the camshaft sprocket and install the camshaft sprocket with the timing mark aligned with the one on the crankshaft sprocket. Tighten the attaching bolts to specification and bend up the locking tabs.
6. Locate the tensioner arm on the pivot pin and install the timing chain tensioner.
7. Install the oil slinger on the crankshaft.
8. Position the gasket on the front cover with an oil resistant sealer at the ends, align the front cover with the crankshaft pulley and tighten the bolts evenly to specification.
9. Position a new gasket on the block flange using an oil resistant sealer compound at each end. Position the end seals chamfered ends into the groove, again using an oil resistant sealer at the ends and install the oil pan. Tighten the oil pan bolts to the correct torque, FOLLOWING FIRST THE ALPHABETICAL, THEN THE NUMERICAL SEQUENCES SHOWN IN Figure 39.
10. Install the dipstick.
11. Install the crankshaft pulley aligning the pulley slot with the crankshaft key. Tighten the pulley attaching bolt to specification.

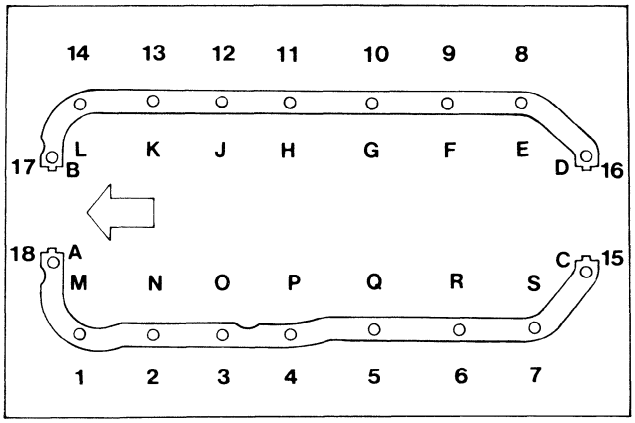


FIG. 39 Oil Pan Bolt Tightening Sequence

12. Right the engine on stand. Install and time the distributor.
13. Position a new gasket on the oil pump mounting flange and install the oil pump and filter assembly. Tighten the attaching bolts to specification.
14. Position a new gasket to the fuel pump flange and insert the rocker arm through the slot in the block wall so that the arm lies on the camshaft eccentric. Secure the fuel pump to the cylinder block with two washers and bolts, tightening the bolts evenly to specifications.
15. Lubricate push rod ends, valve stem tips and rocker pads with Lubriplate or equivalent. Install the push rods in their respective bores and install the rocker arm shaft assembly, making sure that the cupped ends of the push rods engage the adjusting screws. Tighten the rocker arm shaft attaching bolts evenly to specification.
16. Adjust the valve clearances to specification.
17. Install the rocker arm cover and a new gasket and secure with attaching screws and torque to specifications.
18. Install the distributor and connect the vacuum advance line to the carburetor.
19. Install distributor cap and connect wires to spark plugs.
20. Install the water pump pulley and fan. Position the alternator and governor drive belts on the pulley and adjust the belt tension to specifications. Connect the fuel line from the carburetor to the fuel pump.
21. Remove engine from stand.
22. Install the engine assembly in the unit.
23. Start the engine and check for oil and water leaks.
24. Install the air cleaner assembly.
25. Start engine, adjust the ignition timing, if necessary.

26. Adjust the carburetor idle speed and fuel-air mixture to specifications. Check governor operation.

CAMSHAFT BEARINGS

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

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

Removal

Remove camshaft following the appropriate procedures in this section.

1. Remove the flywheel.
2. Remove the crankshaft rear oil seal carrier.
3. Remove the camshaft bearings.
4. Check all the oil passages to make sure that they are clear. Apply an oil resistant sealer to the oil gallery plugs prior to installation.

Installation

1. Install new camshaft bearings. Make sure that the oil holes in the bearings and cylinder block are aligned. The splits in the bearings should be upwards and outwards at 45 degrees to the vertical (Figure 40).
2. Install a new crankshaft rear oil seal using Tool 21-059A.
3. Position a new gasket to the rear oil seal carrier using an oil resistant sealer at the ends. Install the carrier on the cylinder block and tighten the bolts evenly to specification.
4. Locate the flywheel squarely on the crankshaft flange. Tighten the attaching bolts to specification.
5. Install the camshaft and related parts following the appropriate procedures in this section.

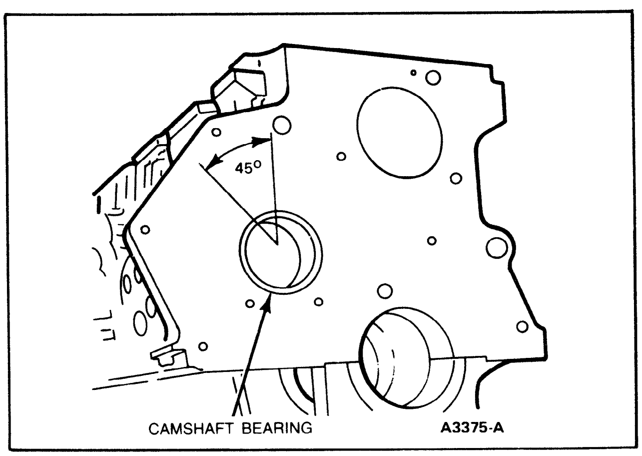


FIG. 40 Camshaft Bearing Position

OIL PUMP

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

Removal

1. Place a drain pan under the oil pump.
2. Remove the oil filter from the oil pump.
3. Remove the three bolts attaching the oil pump and remove the assembly.

Installation

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

OIL PAN

Removal

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

Installation

1. Clean the oil pump inlet tube and screen assembly.
2. Clean the gasket surfaces of the block and oil pan. Be sure to clean the seal retainer grooves in the cylinder front cover and the rear seal retainer. The oil pan has a two-piece gasket. Coat the block surface and the oil pan gasket surface with oil-resistant sealer. Position the oil pan gaskets on the cylinder block.
3. Position the end seals with the chamfered ends into the grooves, again using an oil resistant sealer. Position the oil pan and tighten the bolts evenly to specifications following first the alphabetical, then the numerical sequences shown in Figure 39.
4. Clean and install the starter motor, securing it with the three bolts.
5. Refill the oil pan with the correct grade of engine oil and install the dipstick.
6. Start the engine and check for oil leaks.

FLYWHEEL RING GEAR

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

When installing the ring gear it must be heated evenly to a temperature of 260 to 280°C (500-535°F). Do not exceed 290°C (554°F) as the ring gear wear resistant properties will be destroyed. If the ring gear is to be heated by direct flame, place the ring gear on a metal plate approximately 2 to 3 mm (.079-.118 in.) thick and heat plate from below in the area of the ring gear (Figure 41) until it reaches the required temperature. The correct temperature can be detected by using a special type of temperature sensitive crayon. Fit the ring gear with the chamfers on the leading faces of the gear teeth relative to the direction of rotation. Allow the ring gear to cool naturally in air. **Do not quench.**

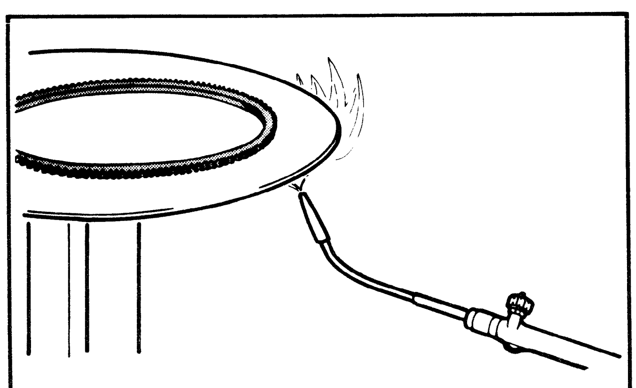


FIG. 41 Heating Ring Gear

CRANKSHAFT REAR OIL SEAL

Removal

1. Remove the P.T.O. or transmission clutch & pressure plate.
2. Remove the flywheel.
3. Remove the rear oil seal using tool 21-096 (Figure 42).

Installation

1. Lubricate the sealing lip of the new seal with engine oil and push new seal into seal carrier using tool 21-059A.
2. Locate the flywheel squarely on the crankshaft flange. Tighten the bolts evenly to specification.
3. Install the P.T.O. or transmission, clutch and pressure plate.

PISTONS AND CONNECTING RODS

Removal

1. Drain the cooling system and the crankcase.
2. Refer to Cylinder Head Removal in this Section and remove the cylinder head and related parts.
3. Remove the oil pan following the procedure under Oil Pan Removal in this Section.
4. Turn the crankshaft until the piston to be removed is at the bottom of the stroke and place a cloth on the piston dome to collect the cuttings. Remove any ridge and/or deposits from the upper end of the cylinder bore with a ridge cutter. Follow the instructions furnished by the tool manufacturer. **Never cut into the ring travel area in excess of 0.74mm (1/32 inch) when removing ridges.**
5. Make sure all the connecting rod caps are marked so that they can be installed in their original positions. Remove the connecting rod 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.

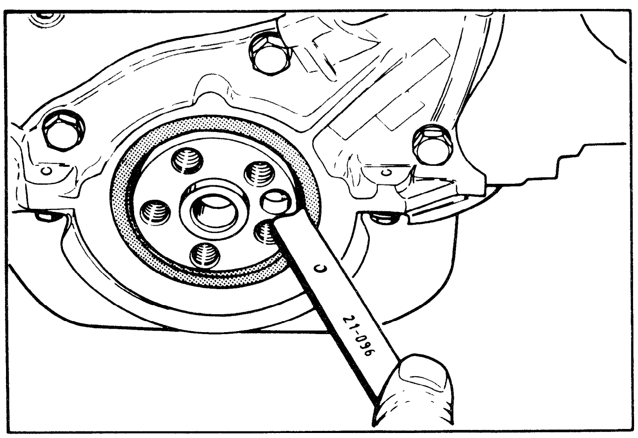


FIG. 42 Rear Crankshaft Oil Seal Removal

Installation

1. Refer to Cylinder Block — Refinishing in this Section.
2. Oil the piston rings, pistons and cylinder walls with light engine oil.
3. **Be sure to install the pistons in the same cylinders from which they were removed or to which they were fitted.** The connecting rods and bearing caps are numbered from 1 to 4 beginning at the front of the engine. The number on the connecting rod and bearing cap must be on the same side of rod when installing in the cylinder bore. If a connecting rod is ever transferred from one cylinder block to another or from one cylinder to another, new bearings should be fitted and the connecting rod should be re-numbered to correspond with the new cylinder number.
4. Make sure the ring gaps are properly spaced around the circumference of the piston (Figure 43). Oil the rings, then install a piston ring compressor on the piston. Make sure that the arrow in the dome of piston is toward the front, then push the piston into its bore with the handle end of a hammer until it is slightly below the top of the cylinder (Figure 44). Be sure to guide the connecting rods to avoid damaging the crankshaft journals.
5. Check the clearance of each bearing following the procedure under Overhaul in this section.
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, then push the piston all the way down until the connecting rod bearing seats on the crankshaft journal. Install the connecting rod cap. Tighten the nuts to specification.
8. After the piston and connecting rod assemblies have been installed, check the connecting rod side clearance on each crankshaft journal.
9. Install the oil pan and related parts. Follow procedures in this Section.
10. Refer to Cylinder Head Installation and install the cylinder head and related parts. Adjust the valve clearance as described in this Section.

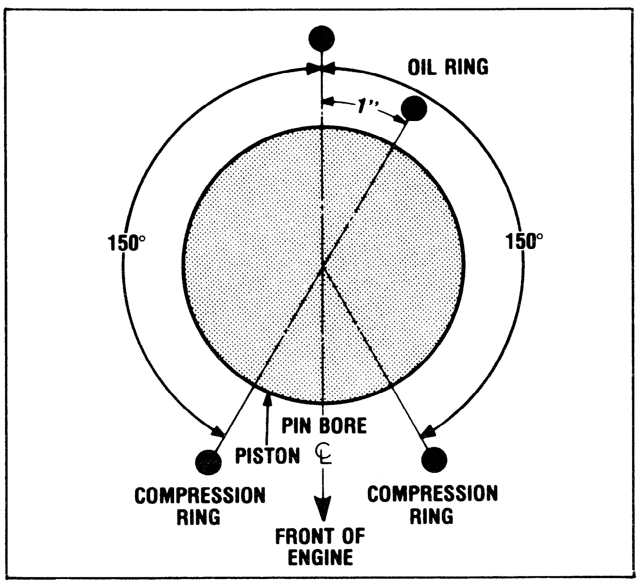


FIG. 43 Piston Ring Cap Spacing

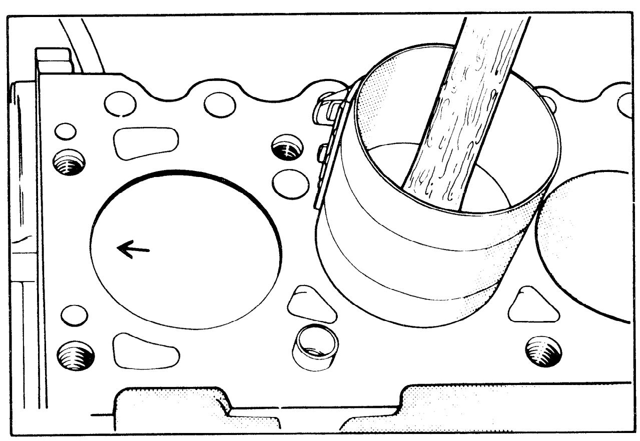


FIG. 44 Piston Installation

11. Fill and bleed the cooling system. Fill the crankcase.
12. Start the engine and check for oil pressure. Operate the engine at fast idle and check for oil and coolant leaks.
13. Operate the engine until engine temperatures have stabilized. Check and adjust the ignition timing. Adjust the engine idle speed and fuel mixture to the specifications.

OIL FILTER

Removal

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

Installation

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

DISASSEMBLY AND ASSEMBLY

ENGINE ASSEMBLY

Disassembly

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

Assembly

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

Start the assembly by examining the block and crankshaft to determine the bearings to be used. The block with standard main bearing bores is unmarked. With 0.38mm (0.015 in.) oversized main bearing bores, the bearing caps are marked with white paint (Figure 45).

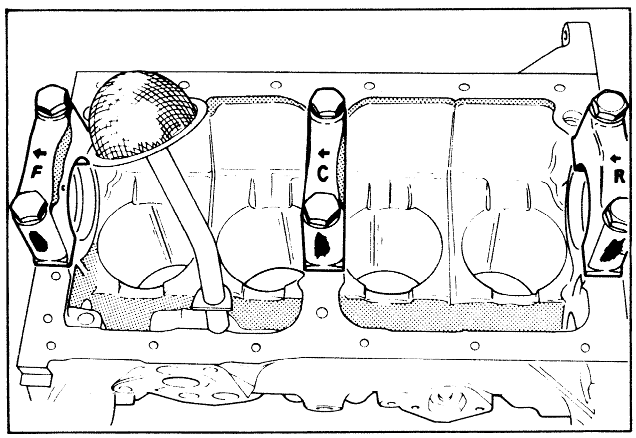


FIG. 45 Main Bearing Cap Markings

The crankshaft main bearing journals of standard diameter came in 2 size categories and are either unmarked or have a yellow paint mark on the first counterweight (Figure 46). See specifications for dimensions.

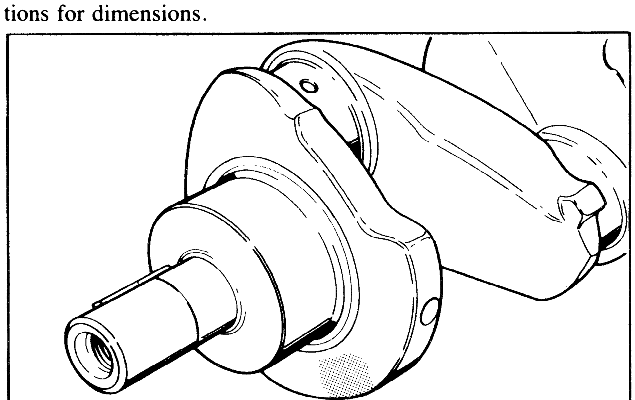


FIG. 46 Main Bearing Journal Markings

The standard diameter connecting rod journals are unmarked. Where the connecting rod journals are 0.25 mm (.010 in.) undersize, the crankshaft is marked with a green paint spot on the web next to the connecting rod bearing journal number one, as shown in Figure 47.

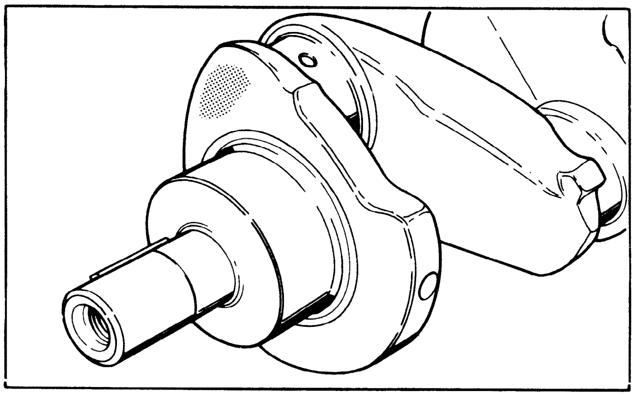


FIG. 47 Connecting Rod Journal Markings

The standard main bearing and connecting rod bearing inserts have no color marking. Bearing inserts for undersize (u/s) crankshafts or oversize (o/s) cylinder blocks have corresponding inscriptions on the back.

When new bearing inserts are selected they should be measured to ensure that they are the appropriate size. Be sure that the specified tolerances are adhered to by measuring bearing journals and block bores individually with the bearing inserts installed.

1. Mount the block in the stand inverted.
2. Install the coolant drain plug and oil pressure sending unit.
3. Place the upper main bearing inserts in position in the bore with the tang fitting in the slot provided.
4. Install the lower main bearing inserts in the bearing caps.
5. Carefully lower the crankshaft into place. **Be careful not to damage the bearing surfaces.** Check the clearance of each main bearing following the procedures in the Overhaul Section.
6. Install the thrust washers to the center main. Apply a light coat of oil to the journals and bearings. Install the main bearing caps. Tighten the main bearing cap bolts evenly to specifications and check crankshaft rotation.
7. Check the crankshaft end play.
8. Install the tappets into their respective bores.
9. Oil the camshaft journals with heavy engine oil and apply Lubriplate or equivalent to all lobes and then carefully slide it through the bearings.
10. Position the camshaft thrust plate and tighten the attaching bolts to specifications. Check the camshaft end play. Bend the locking tabs to secure the bolts.
11. Install the camshaft sprocket and timing chain aligning the timing marks on the camshaft and crankshaft sprockets (Figure 34). Tighten the attaching bolts to specification and bend up the locking plate tabs.
12. Position the timing chain tensioner arm on the pivot pin and install the tensioner (Figure 48).
13. Install a new oil seal to the front cover using tool 21-046.
14. Install the oil slinger on the crankshaft and position the front cover gasket in place using oil resistant sealer. Locate the front cover, aligning the seal to the crankshaft with pulley (Figure 35). Tighten the bolts evenly to specification.
15. Install a new oil seal in the rear oil seal carrier using tool 21-059A.
16. Position a new gasket on the rear oil seal carrier using oil resistant sealer. Secure the carrier to the cylinder block. Tighten the bolts evenly to specification.

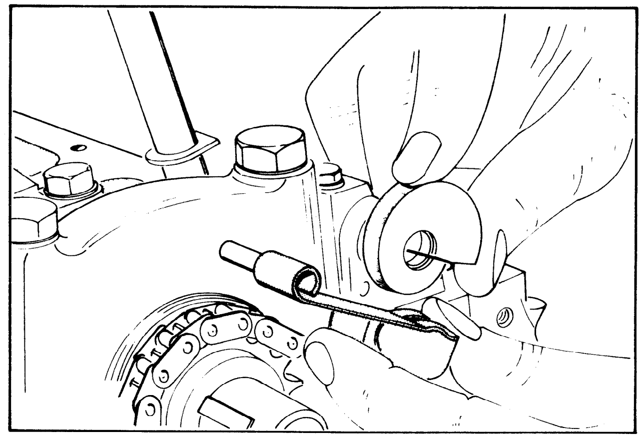


FIG. 48 Installing Timing Chain Tensioner

17. Assemble the respective pistons to their connecting rods. Be sure the "F" or "front" on the rod and the arrow on the top of the piston face the same side (Figure 49). Push the piston pin into the piston and rod and install the two piston pin snap rings on service pistons only.

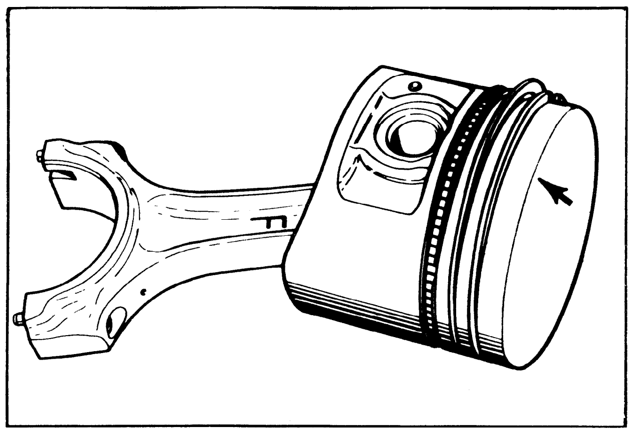


FIG. 49 Connecting Rod and Piston Assembly

18. Install the rings on the piston starting with the oil ring, then the second compression ring and the top compression ring. Position the gaps as shown in Figure 43.
19. Rotate the engine in the stand so that the front end is up. Oil the piston rings and cylinder bores with engine oil. Compress the rings using a universal piston ring compressor. Install the piston and connecting rod assemblies into their respective bores with the arrow on top of the piston pointing toward the front of the block.
20. Install the connecting rod bearings and check the clearances as detailed in the Overhaul Section.
21. Oil the bearings and journals with engine oil and install the connecting rod bearing caps. Tighten the bolts to specification. Check the connecting rod side clearance.
22. Rotate the engine to the inverted position. Replace the oil pump pick up tube and screen. Press the tubes to the full depth of the counterbored holes.
23. Position the flywheel squarely on the crankshaft flange. Tighten the attaching bolts evenly to specification.

24. Install the crankshaft pulley and torque the bolt to specification.
25. Coat the block surface and the oil pan gasket surface with oil resistant sealer. Position the oil pan gaskets on the cylinder block. Position the end seals with the chamfered ends into the grooves, again using an oil resistant sealer at the mating areas. Position the oil pan and tighten the bolts evenly to specification following first the alphabetical, then the numerical sequences shown in Figure 50.

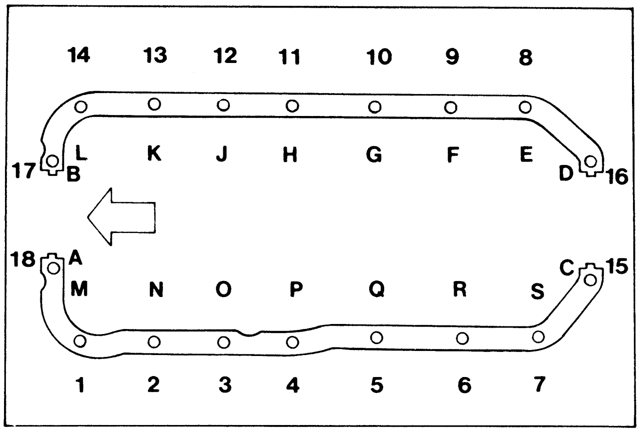


FIG. 50 Oil Pan Bolt Tightening Sequence

26. Right the engine in the stand. Position a new gasket on the water pump and install the pump on the block.
27. Position the alternator and brackets to the block and install mounting bolts.
28. Install and time the distributor.
29. Position a new oil pump mounting gasket to the block using oil resistant sealer. Position the pump to the block, install the mounting bolts and torque to specifications.
30. Position a new gasket to the fuel pump flange and insert the rocker arm through the slot in the block so that the arm lies on the camshaft lobe. Install the mounting bolts and tighten evenly to specification.
31. Position the cylinder head gasket on the cylinder block using pilot studs.
32. Position the cylinder head, remove the pilot studs and install the cylinder bolts. Tighten the bolts down evenly in sequence (Figure 51) and in three steps to specification.
33. Lubricate both ends of the push rods with Lubriplate or equivalent and install them in their respective bores.
34. Install the rocker arm shaft assembly to the cylinder head, locating the push rods on the adjusting screws. Tighten the bolts evenly to specification. Adjust the valve clearances. Install the rocker cover.
35. Locate the thermostat in its bore in the cylinder head and install the gasket and thermostat housing. Connect the wire to the temperature gauge sending unit. Connect primary wires to coil.
36. Install dipstick and tube.
37. Position governor and install mounting bolts.
38. Connect the throttle rod, and distributor vacuum advance hose to the carburetor.
39. Connect the water outlet and crankcase ventilation hoses at the intake manifold.

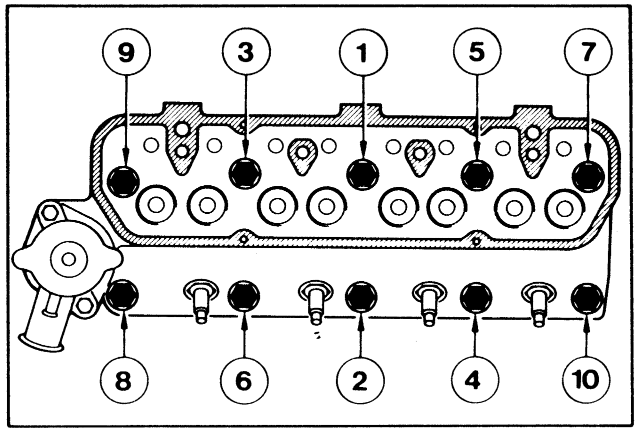


FIG. 51 Cylinder Head Bolt Tightening Sequence

40. Install the distributor cap, position leads into clip on rocker cover and connect the leads to the spark plugs.
41. Connect the fuel line at the fuel pump and carburetor.
42. Install remaining alternator adjusting arm mounting bolts. Loosen alternator and governor adjusting bolts.
43. Install water pump pulley, spacer and fan. Install alternator and governor drive belts. Adjust both belts to specifications.
44. Remove engine from stand.

OIL PUMP

Disassembly

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

Assembly

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

PART 2 Ignition System — Breaker Point

IDENTIFICATION

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

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

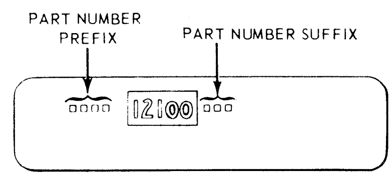


FIG. 1 Distributor Identification

DESCRIPTION

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

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

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

The primary circuit consists of the:

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

The secondary circuit consists of the:

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

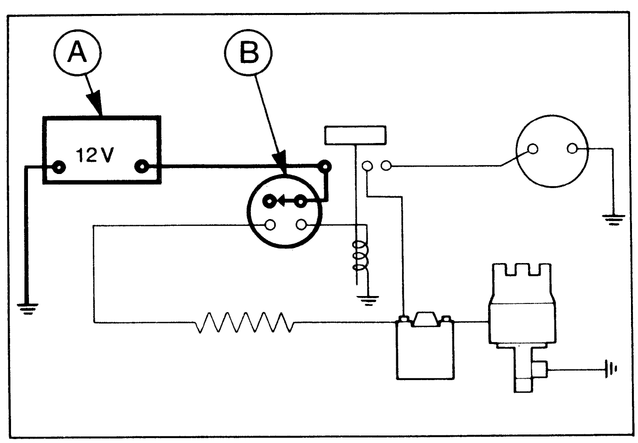


FIG. 2 Ignition System Circuit
A — Battery
B — Ignition Switch (Off Position)

The ignition system is of the ballast resistor type and uses a seven volt coil. Under normal operating conditions the 12 volt feed to the coil is reduced by a ballast resistor wire to seven volts (Figure 3).

During starting, however, the ballast resistor wire is by-passed allowing full available battery voltage to be fed to the coil. This ensures that during cold starting, when the starter motor current draw would be high, sufficient voltage is still available at the coil to produce a powerful spark (Figure 4).

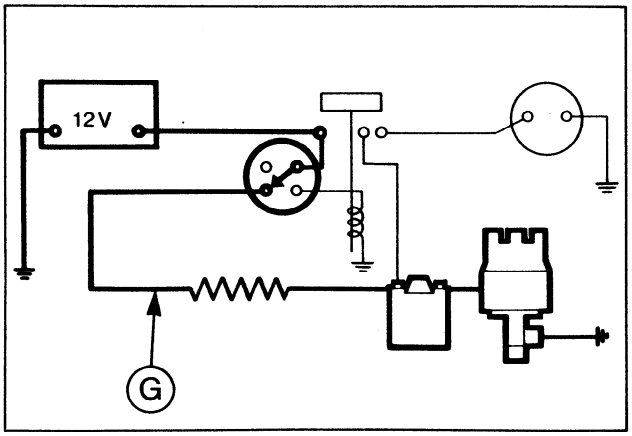


FIG. 3 Ignition Switch in the "On" Position
G — Ballast Resistor

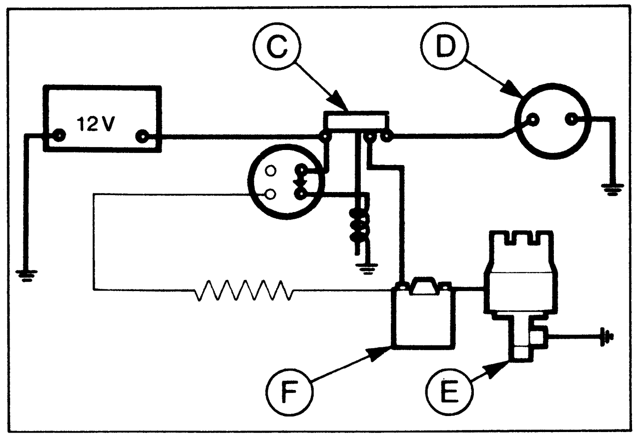


FIG. 4 Ignition Switch in the "Start" Position
C — Starter Solenoid E — Distributor
D — Starter Motor F — Ignition Coil

DIAGNOSIS AND TESTING

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

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

SPARK INTENSITY TESTS

Trouble Isolation

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

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

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

Primary Circuit

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

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

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

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

Secondary Circuit

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

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

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

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

If the spark is equal at all wires, but weak or intermittent, check the coil, distributor cap and the coil to distributor high tension wire. The wire should be clean and bright on the conducting ends, and on the coil tower and distributor sockets. The wire should fit snugly and be bottomed in the sockets.

IGNITION SYSTEM TESTS

Battery to Coil Voltmeter Test

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

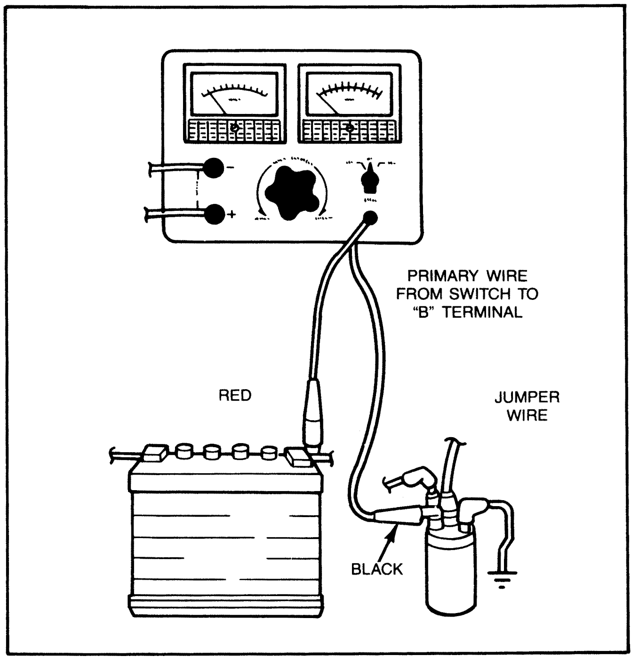


FIG. 5 Battery-to-Coil and Starting Ignition Circuit Test

Starting Ignition Circuit Voltmeter Test

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

Coil to Ground Voltmeter Test

1. Connect the voltmeter leads as shown in Figure 6.

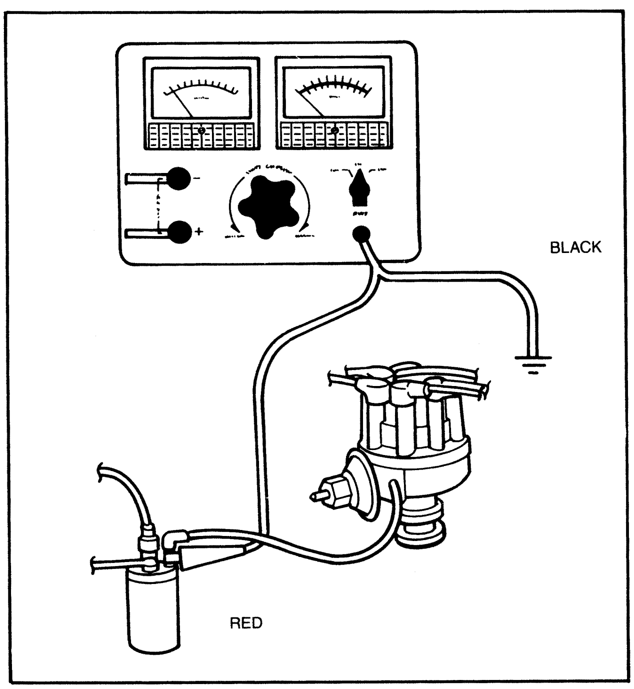


FIG. 6 Coil to Ground Test

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

Coil Test

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

Secondary (High Tension) Wires Resistance Test

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

These wires are the radio resistance-type which filter out the high frequency electrical impulses that are the source of ignition noise interference. The resistance of each wire should not exceed 23,000 ohms. **When checking the resistance of the wires or setting ignition timing, do not puncture the wires with a probe. The probe may cause a separation in the conductor**.

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

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

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

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

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

Spark Plug Test

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

DISTRIBUTOR TESTS — ON ENGINE

Test Connections

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

Dwell Angle Check

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

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

Initial Timing Check

Manually turn engine to locate timing notch on crankshaft pulley and, using a piece of chalk, highlight notch (Figure 7). Connect timing light to engine as per manufacturer's instructions, start engine and allow to idle at specified idle speed. Disconnect and plug vacuum hose and check ignition timing. Refer to specifications. Adjust as required.

Do not disconnect timing light or reconnect vacuum hose at this stage.

Distributor Spark Advance Test

To carry out ignition advance checks, the timing light must be of the type that includes an advance meter.

With timing light still connected, restart engine and hold at 2000 rpm. Adjust timing light to bring crankshaft notch back to initial timing mark and note mechanical advance on timing light meter. Reconnect vacuum advance hose and adjust timing light to bring crankshaft notch back to initial timing mark. The meter will measure total advance. To obtain a vacuum advance figure, subtract mechanical advance figure from total.

When investigating ignition problems a more detailed check of the advance characteristic may be required at varying engine rpm and vacuums. This can be done with a tachometer and vacuum pump.

1. Connect pump directly to distributor (Figure 8).
2. Start engine and adjust idle to 1000 rpm.
3. Adjust timing light to bring crankshaft notch back to TDC and note mechanical advance.
4. Pump vacuum to required figure (refer to specifications), readjust timing light and note advance.

To calculate vacuum advance, subtract mechanical advance obtained in step 3 from total advance obtained in step 4.

5. Repeat step 4 at varying vacuum figures.
6. Remove vacuum pump and check mechanical advance at varying engine rpm.

Figures quoted in the Specification Section do not include the initial static advance.

7. Reconnect vacuum advance hose.

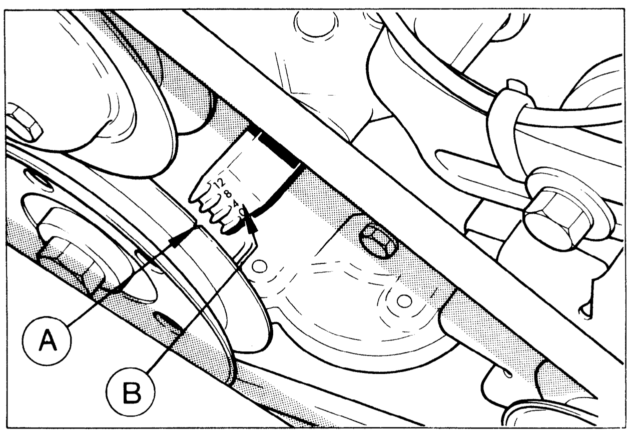


FIG. 7 Timing Marks
A — T.D.C. Notch on Crankshaft Pulley
B — Timing Marks on Front Cover

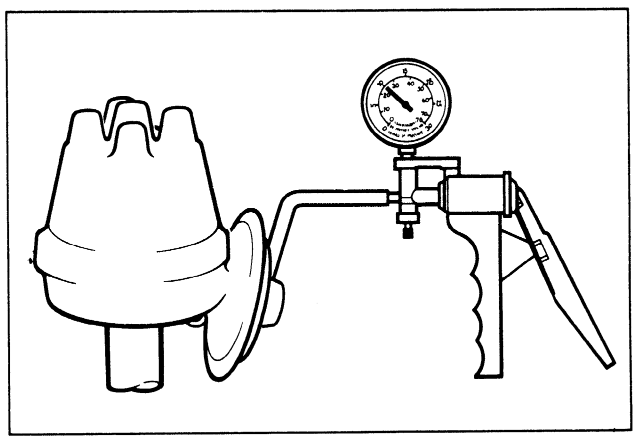


FIG. 8 Vacuum Pump Connected to Distributor

ADJUSTMENTS

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

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

Breaker Point Alignment

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

1. Turn the cam so that the breaker points are closed, then check the alignment of the points.
2. Using a tool and exerting **very light pressure**, align the stationary point bracket. **Do not bend the movable arm.**
3. After the breaker points have been properly aligned, adjust the breaker point gap.

Dwell Angle/Breaker Point Gap Adjustment

Check and adjust dwell angle (breaker point gap) as follows:

1. Connect a dwell meter to engine as per manufacturer's instructions and start engine.
2. Record dwell angle at idle and at 2,000 rpm. Check dwell angle and variation in the Specification Section.
3. To adjust, stop engine, remove distributor cap and position to one side, remove rotor.
4. With ignition on, crank engine with starter. Loosen retaining screw and adjust breaker points. Tighten retaining screw.
5. Recheck dwell at idle and 2,000 rpm.

An alternative method for adjusting dwell angle is by using feeler gauges.

This method is less accurate than that detailed above but is satisfactory as long as breaker points are in good condition and care is taken when adjusting.

Manually turn engine until the rubbing block rests on top of cam (Figure 9). Adjust points to give gap as specified in Specification Section. Tighten retaining screw. Turn engine over to the opposite cam (180°) and recheck gap.

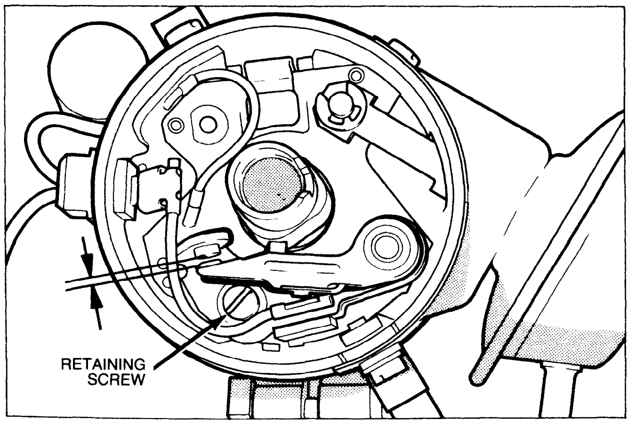


FIG. 9 Breaker Points

Initial Ignition Timing

The timing marks and their locations are illustrated in Figure 10.

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

1. Clean and mark the specified timing mark with chalk or white paint.
2. Disconnect the vacuum line and plug the disconnected vacuum line.
3. Connect a timing light to the No. 1 cylinder spark plug wire. Connect a tachometer to the engine.
4. Start the engine and reduce the idle speed to 600 rpm to be sure that the centrifugal advance is not operating.
5. Direct the timing on the timing marks. The light should flash just as the notch on the pulley lines up between the 4 and 8. Check specifications for correct initial ignition timing.
6. If the timing is not to specification, loosen the distributor retaining bolt and rotate the distributor body until the marks are in line.

   Ignition timing is advanced by clockwise rotation of the distributor body, while counterclockwise rotation retards timing.
7. Tighten distributor retaining bolt and connect vacuum hose.

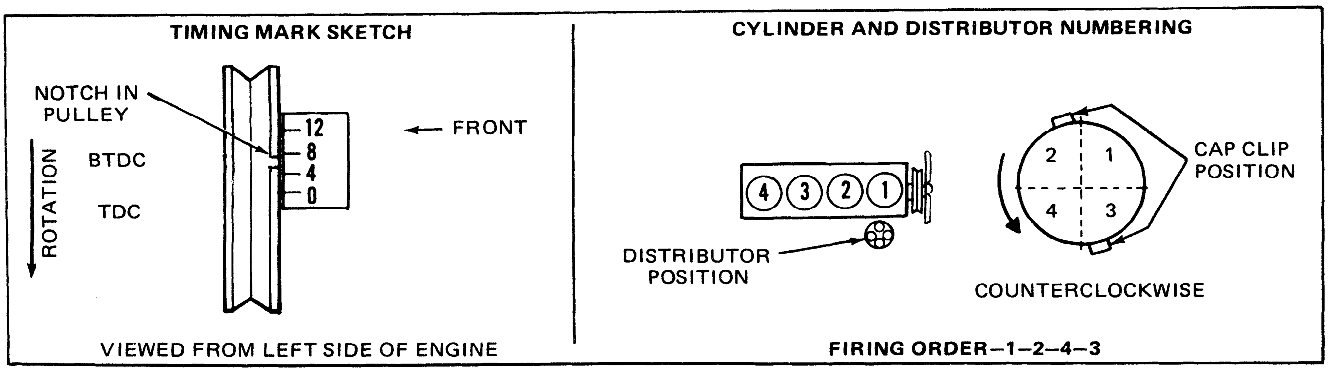


FIG. 10 Engine Timing and Cylinder Firing Order

REMOVAL AND INSTALLATION

All components above the base plate, the breaker points, condenser, vacuum diaphragm unit, rotor and cap are serviced individually. However, components located beneath the base plate, the advance weights and springs are not available. It will be found that the base plate is sealed in the casing and should not be removed.

BREAKER POINTS AND/OR CONDENSER

Removal

1. Remove the distributor cap and rotor.
2. Disconnect the breaker point primary lead from the condenser terminal (Figure 11).
3. Remove the breaker point retaining screw and remove the assembly.
4. Disconnect primary lead from coil. Remove condenser retaining screw and remove condenser and terminal assembly.

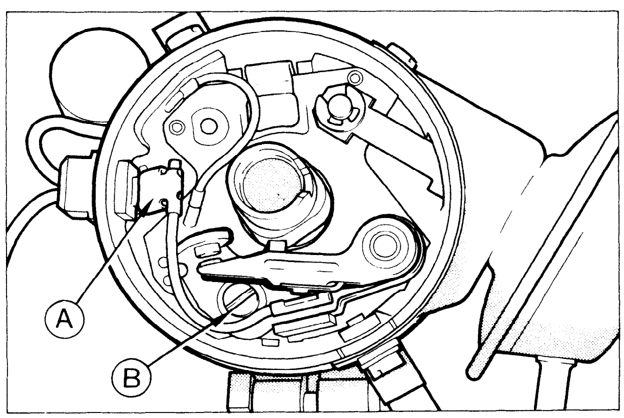


FIG. 11 Breaker Points
A — Primary Lead
B — Retaining Screw

Installation

1. Clean the distributor cam thoroughly.
2. Apply a light film of distributor cam lubricant C4AZ-19D530-A on the cam. **Do not use any type of oil.**
3. Apply a few drops of oil to the distributor oil felt.
4. Position the breaker points in the distributor and install retaining screw.
5. Position condenser and terminal assembly to distributor and install retaining screw.
6. Connect primary wire to coil and breaker point primary lead to condenser terminal.
7. Install rotor and distributor cap.

SPARK PLUG WIRE

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

Removal

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

Installation

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

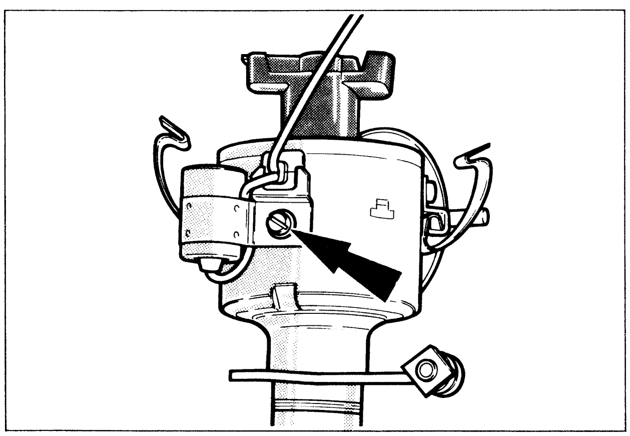


FIG. 12 Condenser Assembly

SPARK PLUGS

Removal

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

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

Installation

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

DISTRIBUTOR

Removal

1. Remove the distributor cap and position clear of distributor.
2. Disconnect the vacuum line from the distributor.
3. Disconnect primary lead from the coil.
4. Position engine at TDC on No. 1 cylinder. The notch (TDC) on the crankshaft pulley should be lined up with the 0 mark (TDC) on the front cover and the rotor should be lined up with the scribe mark on the distributor housing (Figure 13).
5. Remove distributor retaining bolt and remove distributor. Mark rotor position on distributor housing to assist in installation.

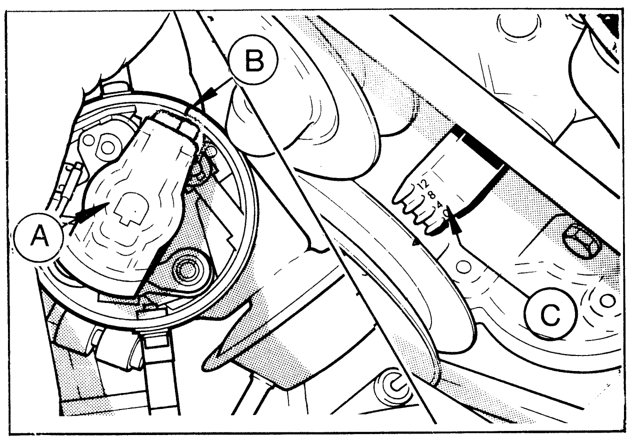


FIG. 13 Rotor Location
A — Rotor
B — Scribe Mark
C — Timing Marks

Installation

1. Check that the engine is at TDC on No. 1 cylinder.
2. Align rotor with mark made on distributor housing.
3. Install distributor into block and install retaining bolt. Rotor should be aligned with scribe mark at this time (Figure 13).
4. Install distributor cap and connect primary lead to coil.
5. Check and adjust initial ignition timing.

NOTE: If timing cannot be adjusted with retaining bolt, position bolt in center of slot and tighten. Loosen distributor clamp retaining bolt (Figure 14) and adjust initial timing to specification. Tighten clamp retaining bolt. DO NOT OVER-TIGHTEN (25-30 inch pounds torque).

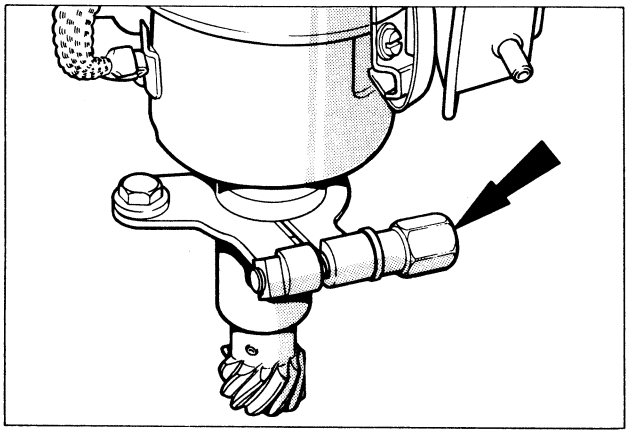


FIG. 14 Distributor Clamp Retaining Bolt

VACUUM DIAPHRAGM

Removal

1. Remove distributor cap and rotor arm.
2. Remove clip retaining vacuum actuating lever to pivot pin, remove two screws and detach unit from distributor body.

Installation

1. Lubricate pivot pin with distributor cam lubricant C4AZ-19D530-A.
2. Slide diaphragm unit actuating lever onto pivot pin, position unit to housing and install two retaining screws.
3. Install clip to pivot pin.
4. Install rotor and distributor cap.

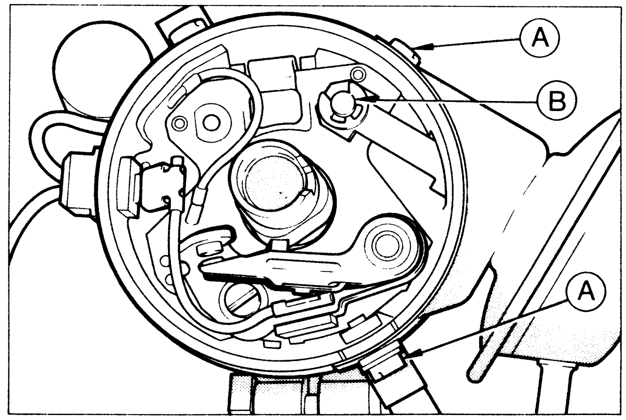


FIG. 15 Vacuum Diaphragm Removal
A — Retaining Screws
B — Pivot Pin Clip

CLEANING AND INSPECTION

SPARK PLUGS

Examine the spark plug for cracked ceramic insulator and condition of firing end. Refer to Figure 16 for various conditions and actions.

DISTRIBUTOR

Clean distributor using compressed air.

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

Inspect the breaker plate assembly for signs of distortion, wear or damage.

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

Check the distributor base for cracks or other damage.

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

Inspect the breaker points. Replace the breaker point assembly if the contacts are badly burned or excessive metal transfer between the points is evident.

DISTRIBUTOR CAP AND ROTOR

Wipe the distributor cap and rotor with a clean cloth dampened with soap and water. Remove any soap film and dry with compressed air.

Examine for cracks, carbon tracking, dirt or missing carbon button in cap. Replace as necessary. Review Distributor Cap and Rotor Installation and Removal.

IGNITION WIRES

Without removing wires, inspect for visible damage such as cuts, pinches, cracked or torn boots. Replace as necessary.

IGNITION COIL

Wipe coil tower with a clean cloth dampened with soap and water. Remove any soap film and dry with compressed air. Inspect for cracks, carbon tracking and dirt.

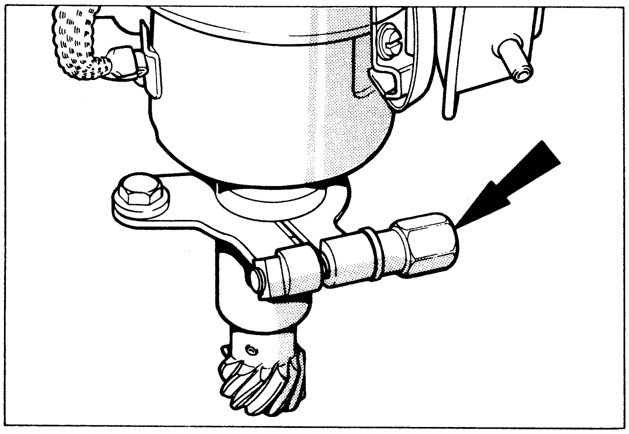


FIG. 14 Distributor Clamp Retaining Bolt

VACUUM DIAPHRAGM

Removal

1. Remove distributor cap and rotor arm.
2. Remove clip retaining vacuum actuating lever to pivot pin, remove two screws and detach unit from distributor body.

Installation

1. Lubricate pivot pin with distributor cam lubricant C4AZ-19D530-A.
2. Slide diaphragm unit actuating lever onto pivot pin, position unit to housing and install two retaining screws.
3. Install clip to pivot pin.
4. Install rotor and distributor cap.

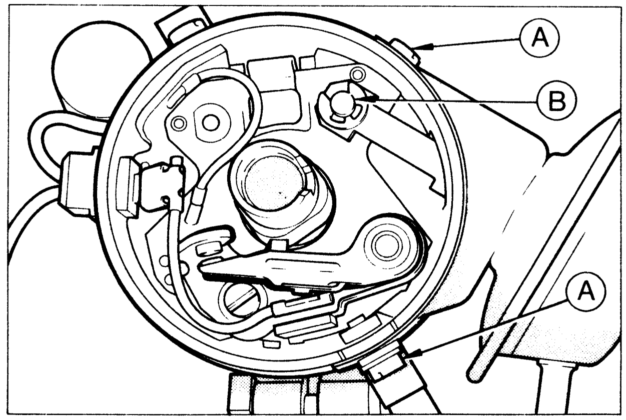


FIG. 15 Vacuum Diaphragm Removal
A — Retaining Screws
B — Pivot Pin Clip

CLEANING AND INSPECTION

SPARK PLUGS

Examine the spark plug for cracked ceramic insulator and condition of firing end. Refer to Figure 16 for various conditions and actions.

DISTRIBUTOR

Clean distributor using compressed air.

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

Inspect the breaker plate assembly for signs of distortion, wear or damage.

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

Check the distributor base for cracks or other damage.

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

Inspect the breaker points. Replace the breaker point assembly if the contacts are badly burned or excessive metal transfer between the points is evident.

DISTRIBUTOR CAP AND ROTOR

Wipe the distributor cap and rotor with a clean cloth dampened with soap and water. Remove any soap film and dry with compressed air.

Examine for cracks, carbon tracking, dirt or missing carbon button in cap. Replace as necessary. Review Distributor Cap and Rotor Installation and Removal.

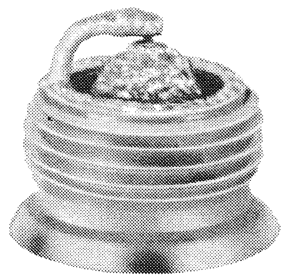
IGNITION WIRES

Without removing wires, inspect for visible damage such as cuts, pinches, cracked or torn boots. Replace as necessary.

IGNITION COIL

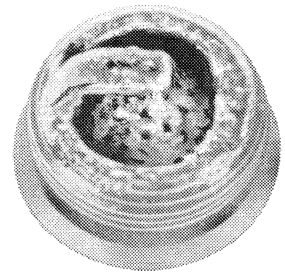
Wipe coil tower with a clean cloth dampened with soap and water. Remove any soap film and dry with compressed air. Inspect for cracks, carbon tracking and dirt.

GAP BRIDGED



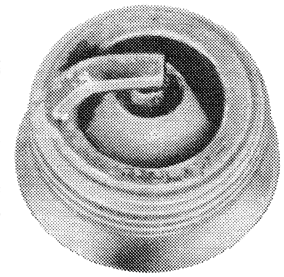
IDENTIFIED BY DEPOSIT BUILD-UP CLOSING GAP BETWEEN ELECTRODES.
CAUSED BY OIL OR CARBON FOULING. REPLACE PLUG, OR, IF DEPOSITS ARE NOT EXCESSIVE, THE PLUG CAN BE CLEANED.

OIL FOULED



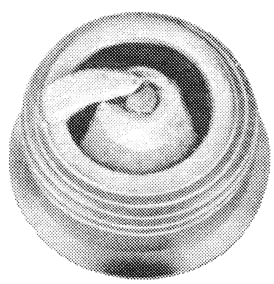
IDENTIFIED BY WET BLACK DEPOSITS ON THE INSULATOR SHELL BORE ELECTRODES CAUSED BY EXCESSIVE OIL ENTERING COMBUSTION CHAMBER THROUGH WORN RINGS AND PISTONS, EXCESSIVE CLEARANCE BETWEEN VALVE GUIDES AND STEMS, OR WORN OR LOOSE BEARINGS. REPLACE THE PLUG. IF ENGINE IS NOT REPAIRED, USE A HOTTER PLUG.

CARBON FOULED



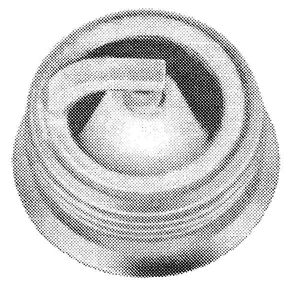
IDENTIFIED BY BLACK, DRY FLUFFY CARBON DEPOSITS ON INSULATOR TIPS, EXPOSED SHELL SURFACES AND ELECTRODES.
CAUSED BY TOO COLD A PLUG, WEAK IGNITION, DIRTY AIR CLEANER, DEFECTIVE FUEL PUMP, TOO RICH A FUEL MIXTURE, IMPROPERLY OPERATING HEAT RISER OR EXCESSIVE IDLING. CAN BE CLEANED.

WORN



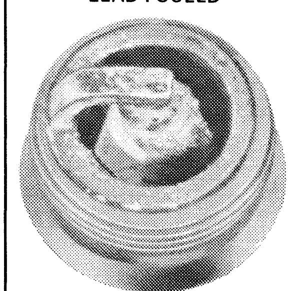
IDENTIFIED BY SEVERELY ERODED OR WORN ELECTRODES.
CAUSED BY NORMAL WEAR. SHOULD BE REPLACED

NORMAL



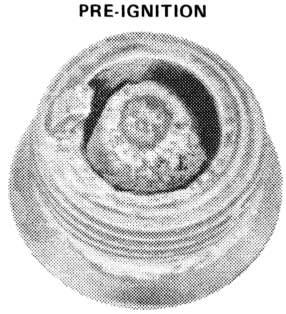
IDENTIFIED BY LIGHT TAN OR GRAY DEPOSITS ON THE FIRING TIP.

LEAD FOULED



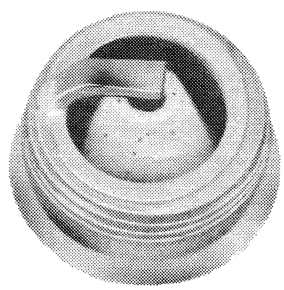
IDENTIFIED BY DARK GRAY, BLACK, YELLOW OR TAN DEPOSITS OR A FUSED GLAZED COATING ON THE INSULATOR TIP.
CAUSED BY HIGHLY LEADED GASOLINE. REPLACE THE PLUG.

PRE-IGNITION



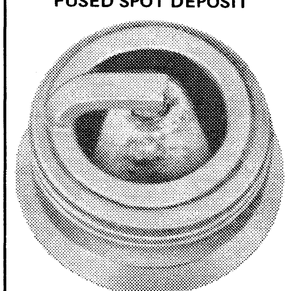
IDENTIFIED BY MELTED ELECTRODES AND POSSIBLY BLISTERED INSULATOR. METALLIC DEPOSITS ON INSULATOR INDICATE ENGINE DAMAGE.
CAUSED BY WRONG TYPE OF FUEL, INCORRECT IGNITION TIMING OR ADVANCE, TOO HOT A PLUG, BURNT VALVES OR ENGINE OVERHEATING. REPLACE THE PLUG.

OVERHEATING



IDENTIFIED BY A WHITE OR LIGHT GRAY INSULATOR WITH SMALL BLACK OR GRAY BROWN SPOTS AND WITH BLUISH-BURNT APPEARANCE OF ELECTRODES, CAUSED BY ENGINE OVERHEATING. WRONG TYPE OF FUEL, LOOSE SPARK PLUGS, TOO HOT A PLUG, LOW FUEL PUMP PRESSURE OR INCORRECT IGNITION TIMING. REPLACE THE PLUG.

FUSED SPOT DEPOSIT



IDENTIFIED BY MELTED OR SPOTTY DEPOSITS RESEMBLING BUBBLES OR BLISTERS.
CAUSED BY SUDDEN ACCELERATION. CAN BE CLEANED IF NOT EXCESSIVE. OTHERWISE REPLACE PLUG.

B3235-B

FIG. 16 Spark Plug Inspection

PART 2A — Ignition System — Solid State

IDENTIFICATION

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

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

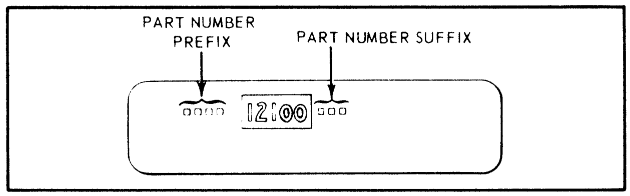


FIG. 1 Distributor Identification

DESCRIPTION

The solid state ignition is the breakerless type. The distributor is located on the right side of the engine. It is equipped with a vacuum and a centrifugal advance unit to control ignition timing. It has a stator and trigger wheel that sends a signal to the TFI electronic amplifier module which is located on the distributor housing. The module switches the primary circuit, in the coil, on and off controlling the secondary current to the spark plugs.

Notice that the primary circuit to the coil (Fig. 2) does not have a ballast resistor. The coil is supplied with battery voltage at all times. The module is energized by a circuit from the ignition switch.

When the trigger wheel arms are between the stator pick-up arms, the module will switch on. This allows current to flow from the battery, through the ignition switch to the primary winding of the coil. From the coil the current flows through the module circuits to ground through the distributor body.

When a trigger wheel arm is directly opposite a stator arm (Fig. 3), the voltage induced in the trigger coil will change from a positive to a negative voltage. This change over will trigger a circuit in the module, which switches OFF the ignition coil primary circuit. This results in the collapse of the ignition coil magnetic field which generates the high voltage required to fire the plugs.

The solid state ignition system uses a high output coil. It can be identified by the safety cover on the top. The cover would allow the coil to fail safely in the unlikely event of a module malfunction in which coil current is left on permanently.

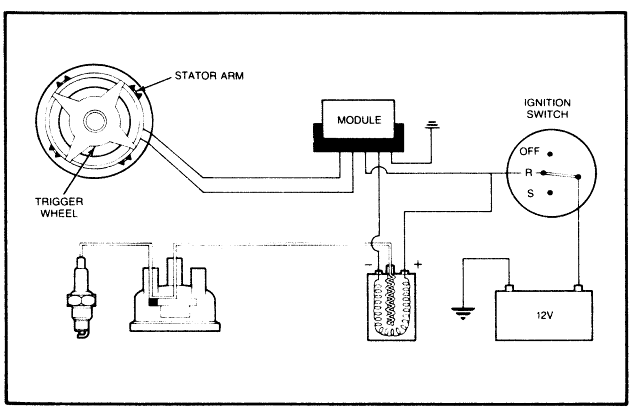


FIG. 2

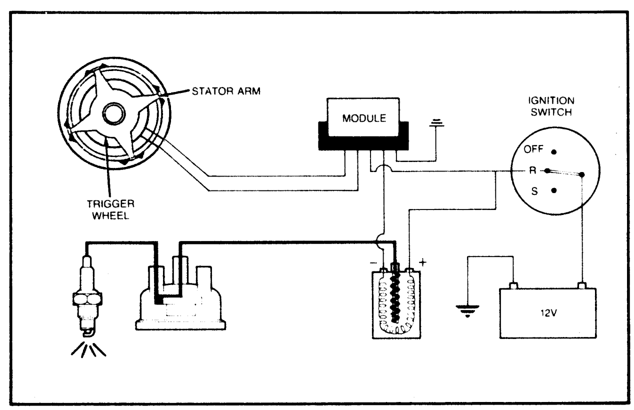


FIG. 3

DIAGNOSIS AND TESTING

Ignition system troubles are caused by a failure in the primary and/or the secondary circuit, incorrect ignition timing, or incorrect distributor advance. Circuit failures may be caused by shorts, corroded or dirty terminals, loose connections, cracked distributor cap or rotor, fouled spark plugs, inoperative trigger coil or module.

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

TROUBLE ISOLATION

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

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

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

PRIMARY CIRCUIT

A breakdown or energy loss in the primary circuit can be caused by: defective primary wiring, or loose or corroded terminals, open or shorted ignition or trigger coil, or inoperative module

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

To isolate a trouble in the primary circuit, perform the test shown in the diagnostic chart (Fig. 4).

SECONDARY CIRCUIT

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

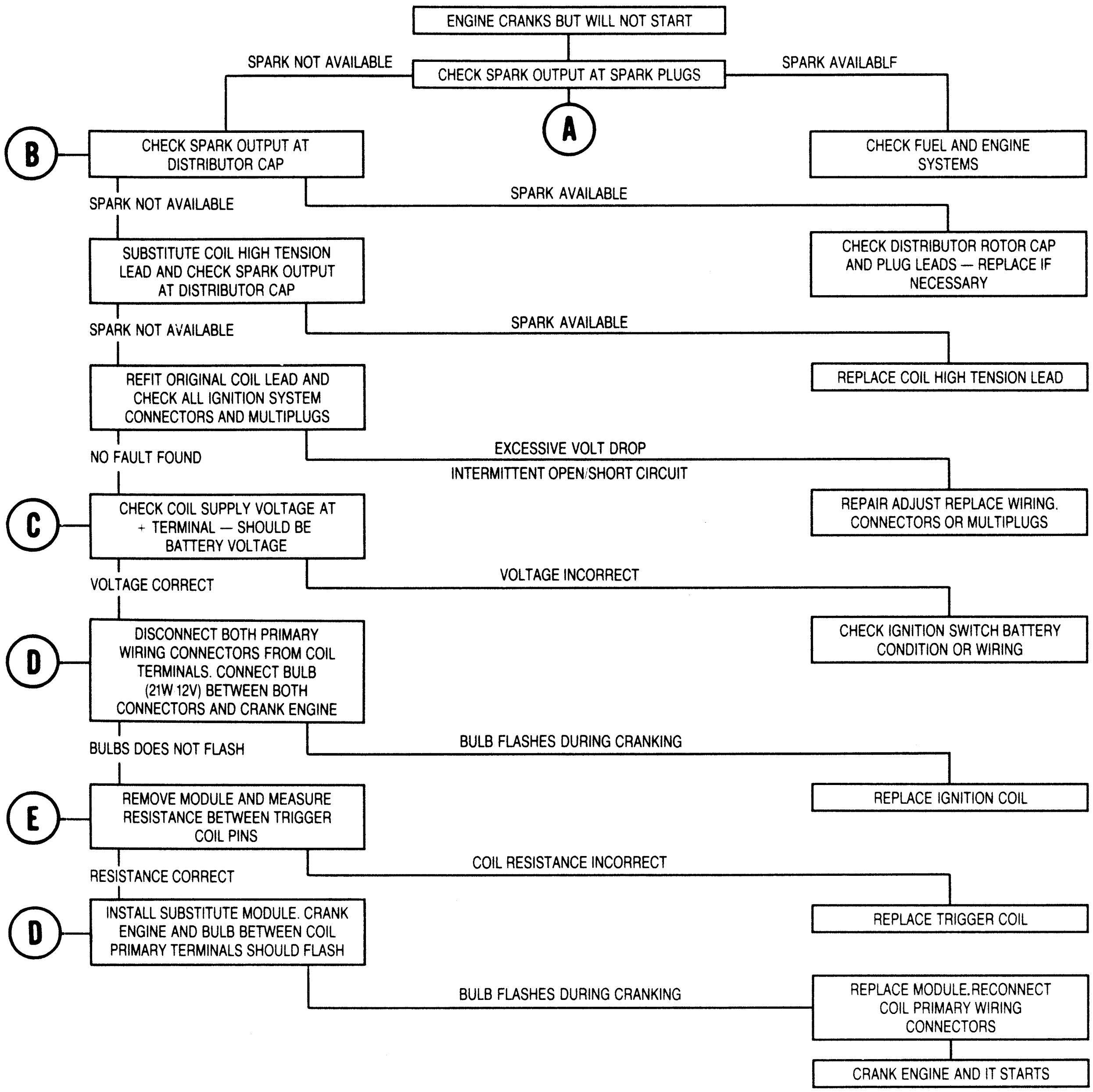
To check the spark intensity at the spark plugs, thereby isolating an ignition problem to a particular cylinder, proceed as follows:

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

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

These wires are the radio resistance-type which filter out the high frequency electrical impulses that are the source of ignition noise interference. The resistance of each wire should not exceed 23,000 ohms. **When checking the resistance of the wires or setting ignition timing, do not puncture the wires with a probe. The probe may cause a separation in the conductor**.

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


ENGINE CRANKS BUT WILL NOT START
CHECK SPARK OUTPUT AT SPARK PLUGS
SPARK NOT AVAILABLE
SPARK AVAILABLF
A
CHECK FUEL AND ENGINE SYSTEMS
B
CHECK SPARK OUTPUT AT DISTRIBUTOR CAP
SPARK NOT AVAILABLE
SPARK AVAILABLE
CHECK DISTRIBUTOR ROTOR CAP AND PLUG LEADS — REPLACE IF NECESSARY
SUBSTITUTE COIL HIGH TENSION LEAD AND CHECK SPARK OUTPUT AT DISTRIBUTOR CAP
SPARK NOT AVAILABLE
SPARK AVAILABLE
REPLACE COIL HIGH TENSION LEAD
REFIT ORIGINAL COIL LEAD AND CHECK ALL IGNITION SYSTEM CONNECTORS AND MULTIPLUGS
NO FAULT FOUND
EXCESSIVE VOLT DROP
INTERMITTENT OPEN/SHORT CIRCUIT
REPAIR ADJUST REPLACE WIRING. CONNECTORS OR MULTIPLUGS
C
CHECK COIL SUPPLY VOLTAGE AT + TERMINAL — SHOULD BE BATTERY VOLTAGE
VOLTAGE CORRECT
VOLTAGE INCORRECT
CHECK IGNITION SWITCH BATTERY CONDITION OR WIRING
D
DISCONNECT BOTH PRIMARY WIRING CONNECTORS FROM COIL TERMINALS. CONNECT BULB (21W 12V) BETWEEN BOTH CONNECTORS AND CRANK ENGINE
BULBS DOES NOT FLASH
BULB FLASHES DURING CRANKING
REPLACE IGNITION COIL
E
REMOVE MODULE AND MEASURE RESISTANCE BETWEEN TRIGGER COIL PINS
RESISTANCE CORRECT
COIL RESISTANCE INCORRECT
REPLACE TRIGGER COIL
D
INSTALL SUBSTITUTE MODULE. CRANK ENGINE AND BULB BETWEEN COIL PRIMARY TERMINALS SHOULD FLASH
BULB FLASHES DURING CRANKING
REPLACE MODULE.RECONNECT COIL PRIMARY WIRING CONNECTORS
CRANK ENGINE AND IT STARTS

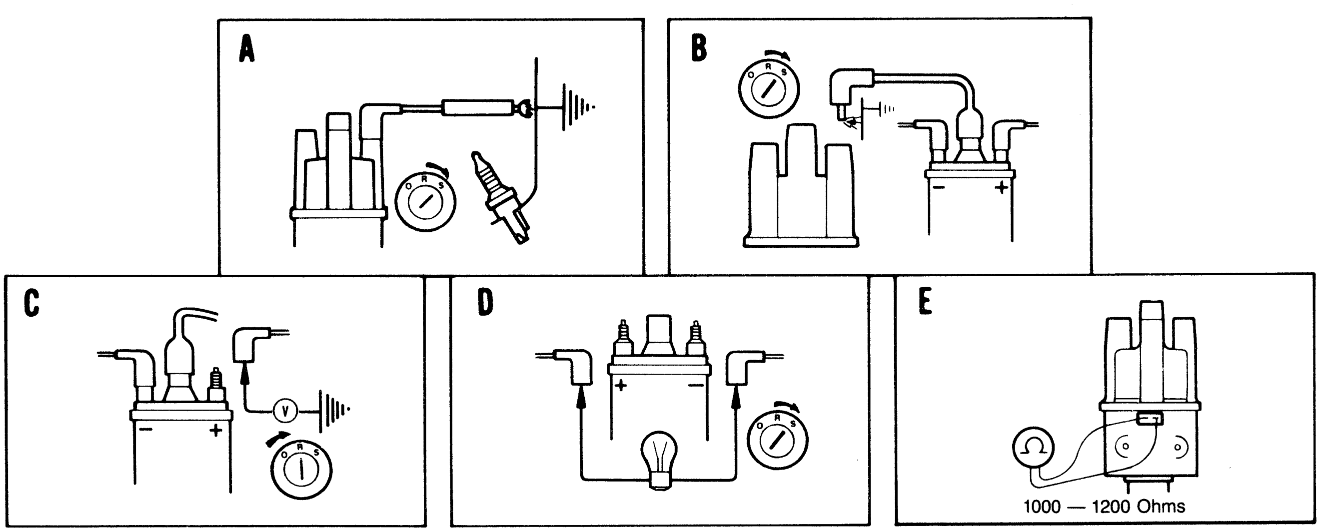

A
B
C
D
E
1000 — 1200 Ohms

FIG. 4

INITIAL TIMING CHECK

Manually turn engine to locate timing notch on crankshaft pulley and, using a piece of chalk, highlight notch (Figure 5). Connect timing light to engine as per manufacturer's instructions, start engine and allow to idle at specified idle speed. Disconnect and plug vacuum hose and check ignition timing. Refer to specifications. Adjust as required.

Do not disconnect timing light or reconnect vacuum hose at this stage.

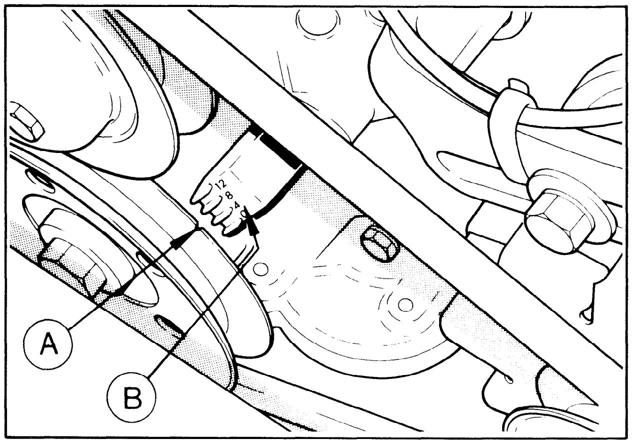


FIG. 5 Timing Marks
A — T.D.C. Notch on Crankshaft Pulley
B — Timing Marks on Front Cover

DISTRIBUTOR SPARK ADVANCE TEST

To carry out ignition advance checks, the timing light must be of the type that includes an advance meter.

With timing light still connected, restart engine and hold at 2000 rpm. Adjust timing light to bring crankshaft notch back to initial timing mark and note mechanical advance on timing light meter. Reconnect vacuum advance hose and adjust timing light to bring crankshaft notch back to initial timing mark. The meter will measure total advance. To obtain a vacuum advance figure, subtract mechanical advance figure from total.

When investigating ignition problems a more detailed check of the advance characteristic may be required at varying engine rpm and vacuums. This can be done with a tachometer and vacuum pump.

1. Connect pump directly to distributor (Figure 6).
2. Start engine and adjust idle to 1000 rpm.
3. Adjust timing light to bring crankshaft notch back to TDC and note mechanical advance.
4. Pump vacuum to required figure (refer to specifications), readjust timing light and note advance.

To calculate vacuum advance, subtract mechanical advance obtained in step 3 from total advance obtained in step 4.

5. Repeat step 4 at varying vacuum figures.
6. Remove vacuum pump and check mechanical advance at varying engine rpm.

Figures quoted in the Specification Section do not include the initial static advance.

7. Reconnect vacuum advance hose.

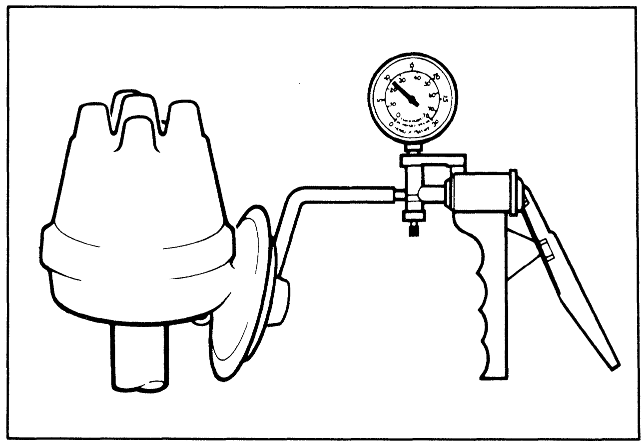


FIG. 6 Vacuum Pump Connected to Distributor

ADJUSTMENTS

INITIAL IGNITION TIMING

The timing marks and their locations are illustrated in Figure 7.

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

1. Clean and mark the specified timing mark with chalk or white paint.
2. Disconnect the vacuum line and plug the disconnected vacuum line.
3. Connect a timing light to the No. 1 cylinder spark plug wire. Connect a tachometer to the engine.
4. Start the engine and reduce the idle speed to 600 rpm to be sure that the centrifugal advance is not operating.
5. Direct the timing on the timing marks. The light should flash just as the notch on the pulley lines up between the 4 and 8. Check specifications for correct initial ignition timing.
6. If the timing is not to specification, loosen the distributor retaining bolt and rotate the distributor body until the marks are in line.

   Ignition timing is advanced by clockwise rotation of the distributor body, while counterclockwise rotation retards timing.
7. Tighten distributor retaining bolt and connect vacuum hose.

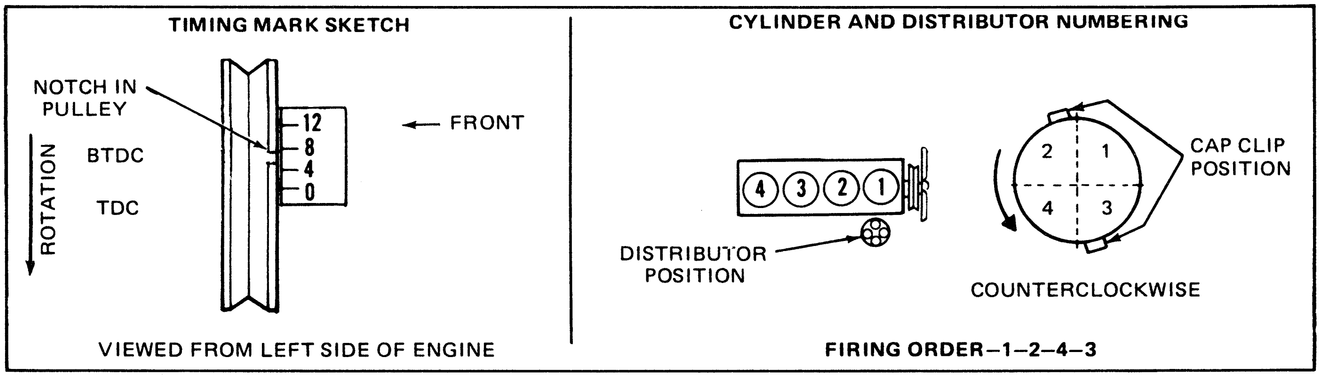


FIG. 7 Engine Timing and Cylinder Firing Order

REMOVAL AND INSTALLATION

DISTRIBUTOR

REMOVAL

1. Remove the distributor cap and position clear of distributor.
2. Disconnect the vacuum line from the distributor.
3. Disconnect primary lead from the coil.
4. Position engine at TDC on No. 1 cylinder. The notch (TDC) on the crankshaft pulley should be lined up with the 0 mark (TDC) on the front cover and the rotor should be lined up with the scribe mark on the distributor housing (Figure 8).
5. Remove distributor retaining bolt and remove distributor. Mark rotor position on distributor housing to assist in installation.

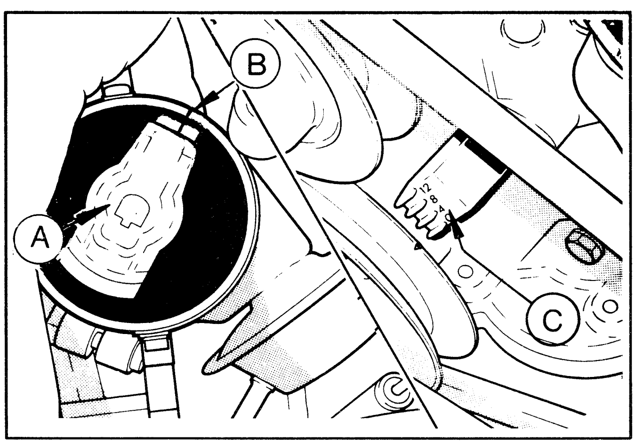


FIG. 8 Rotor Location
A — Rotor
B — Scribe Mark
C — Timing Marks

INSTALLATION

1. Check that the engine is at TDC on No. 1 cylinder.
2. Align rotor with mark made on distributor housing.
3. Install distributor into block and install retaining bolt. Rotor should be aligned with scribe mark at this time (Figure 8).
4. Install distributor cap and connect primary lead to coil.
5. Check and adjust initial ignition timing.
NOTE: If timing cannot be adjusted with retaining bolt, position bolt in center of slot and tighten. Loosen distributor clamp retaining bolt (Figure 9) and adjust initial timing to specification. Tighten clamp retaining bolt. DO NOT OVER-TIGHTEN (25-30 inch pounds torque).

SPARK PLUGS

REMOVAL

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

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

INSTALLATION

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

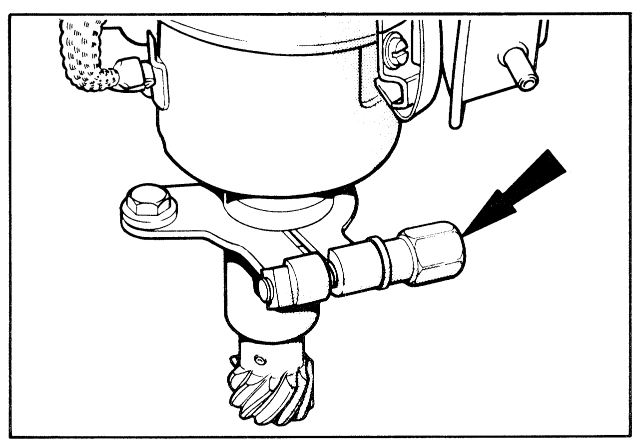


FIG. 9 Distributor Clamp Retaining Bolt

VACUUM DIAPHRAGM

REMOVAL

1. Remove distributor cap, rotor and shield.
2. Remove two screws and gently pull unit from distributor body and downward.

INSTALLATION

1. Lubricate end of actuating lever with distributor cam lubricant C4AZ-19D530-A.
2. Rotate stator clockwise and hold in this position. Slide diaphragm unit actuating lever onto pivot pin (Figure 10), position unit to housing and install two retaining screws.
3. Install shield, rotor and distributor cap.

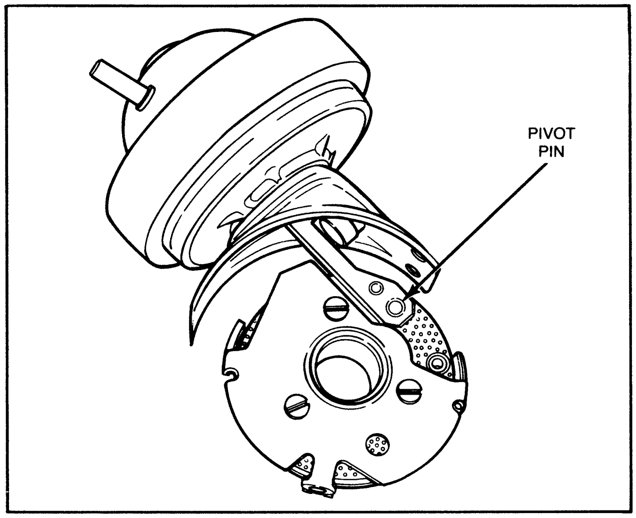


FIG. 10 Vacuum Diaphragm Pivot Pin

CLEANING AND INSPECTION

SPARK PLUGS

Examine the spark plug for cracked ceramic insulator and condition of firing end. Refer to Figure 11 for various conditions and actions.

DISTRIBUTOR

Clean distributor using compressed air.

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

Check the distributor base for cracks or other damage.

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

DISTRIBUTOR CAP AND ROTOR

Wipe the distributor cap and rotor with a clean cloth dampened with soap and water. Remove any soap film and dry with compressed air.

Examine for cracks, carbon tracking, dirt or missing carbon button in cap. Replace as necessary. Review Distributor Cap and Rotor Installation and Removal.

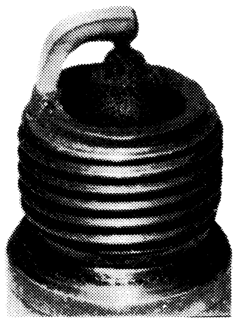
IGNITION WIRES

Without removing wires, inspect for visible damage such as cuts, pinches, cracked or torn boots. Replace as necessary.

IGNITION COIL

Wipe coil tower with a clean cloth dampened with soap and water. Remove any soap film and dry with compressed air. Inspect for cracks, carbon tracking and dirt.

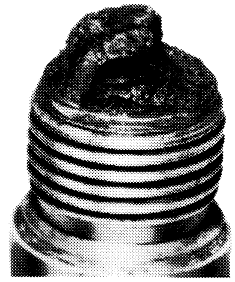
GAP BRIDGED



IDENTIFIED BY DEPOSIT BUILDUP CLOSING GAP BETWEEN ELECTRODES.

CAUSED BY OIL OR CARBON FOULING. REPLACE PLUG, OR, IF DEPOSTIS ARE NOT EXCESSIVE, THE PLUG CAN BE CLEANED.

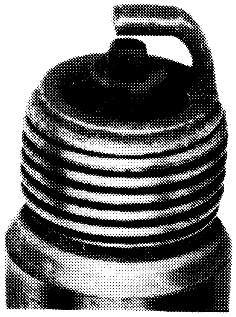
OIL FOULED



IDENTIFIED BY WET BLACK DEPOSITS ON THE INSULATOR SHELL BORE ELECTRODES.

CAUSED BY EXCESSIVE OIL ENTERING COMBUSTION CHAMBER THROUGH WORN RINGS AND PISTONS, EXCESSIVE CLEARANCE BETWEEN VALVE GUIDES AND STEMS, OR WORN OR LOOSE BEARINGS. REPLACE THE PLUG.

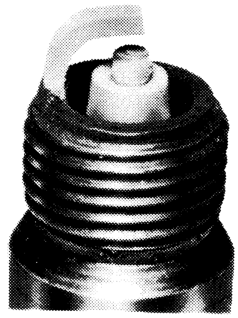
CARBON FOULED



IDENTIFIED BY BLACK, DRY FLUFFY CARBON DEPOSITS ON INSULATOR TIPS, EXPOSED SHELL SURFACES AND ELECTRODES.

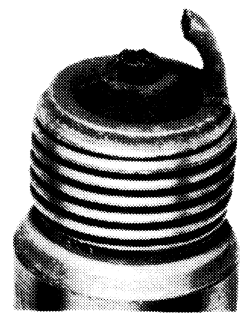
CAUSED BY TOO COLD A PLUG, WEAK IGNITION, DIRTY AIR CLEANER, DEFECTIVE FUEL PUMP, TOO RICH A FUEL MIXTURE, IMPROPERLY OPERATING HEAT RISER OR EXCESSIVE IDLING. CAN BE CLEANED.

NORMAL



IDENTIFIED BY LIGHT TAN OR GRAY DEPOSITS ON THE FIRING TIP

PRE-IGNITION

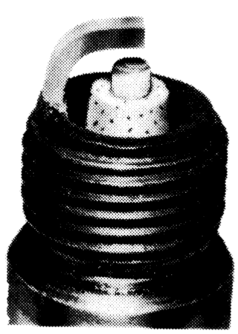


IDENTIFIED BY MELTED ELECTRODES AND POSSIBLY BLISTERED INSULATOR. METALIC DEPOSITS ON INSULATOR INDICATE ENGINE DAMAGE.

CAUSED BY WRONG TYPE OF FUEL, INCORRECT IGNITION TIMING OR ADVANCE, TOO HOT A PLUG, BURNT VALVES OR ENGINE OVERHEATING. REPLACE THE PLUG.

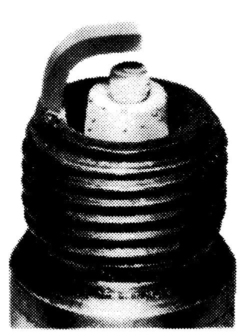
OVERHEATING

IDENTIFIED BY A WHITE OR LIGHT GRAY INSULATOR WITH SMALL BLACK OR GRAY BROWN SPOTS AND WITH BLUISH BURNT APPEARANCE OF ELECTRODES.



CAUSED BY ENGINE OVERHEATING, WRONG TYPE OF FUEL, LOOSE SPARK PLUGS, TOO HOT A PLUG, LOW FUEL PUMP PRESSURE OR INCORRECT IGNITION TIMING. REPLACE THE PLUG.

FUSED SPOT DEPOSIT



IDENTIFIED BY MELTED OR SPOTTY DEPOSITS RESEMBLING BUBBLES OR BLISTERS.

CAUSED BY SUDDEN ACCELERATION. CAN BE CLEANED IF NOT EXCESSIVE, OTHERWISE REPLACE PLUG.

B4054-B

FIG. 11 Spark Plug Inspection

PART 2B — Ignition System — Distributorless

WARNING

- High tension voltage produced by a distributorless ignition system is higher than for a conventional ignition system.
- When carrying out service operations on an engine equipped with distributorless ignition, it is important to be aware of the above point as well as all the usual safety measures to prevent the possibility of electric shocks.

DESCRIPTION

The purpose of an engine's ignition system is to ignite the fuel/air mixture at the correct time and sequence based upon the input it receives.

The Distributorless Ignition System (DIS) used on the VSG 411/413 engines is a state-of-the-art ignition system. The brain of this system is the Universal Electronic Spark Control (UESC) module. This module normally receives four inputs:

- Crankshaft position
- Crankshaft speed
- Engine temperature
- Engine vacuum (load)

From these inputs, the UESC computes spark strategy (spark advance) to obtain optimum engine performance for correct input conditions.

OPERATION

With this system, the electronic control module monitors the engine load, speed, and operating temperature and decides what degree of spark advance is correct for all of the operating conditions. This system maximizes the benefits of the high compression swirl design. Because timing is set for life inherently in the design of the engine, and there are no moving parts in the ignition system itself, no maintenance is required except for periodic spark-plug checks. The system provides for fixed spark advance at start-up, for cold weather starting, fixed advance for service checking, and for "average value" default settings in case of component failure. Particular attention has been given to spark optimization for excellent fuel economy in the warm-up mode, which is coupled with improved warm-up and a new carburetor.

The spark plugs are paired so that one plug fires during the compression stroke and its companion plug fires during the exhaust stroke. The next time that coil is fired, the plug that was on exhaust will be on compression, and the one that was on compression will be on exhaust. The spark in the exhaust cylinder is wasted but little of the coil energy is lost.

The spark strategy is based on sensors and manifold vacuum input to the UESC module, which include the following **inputs:**

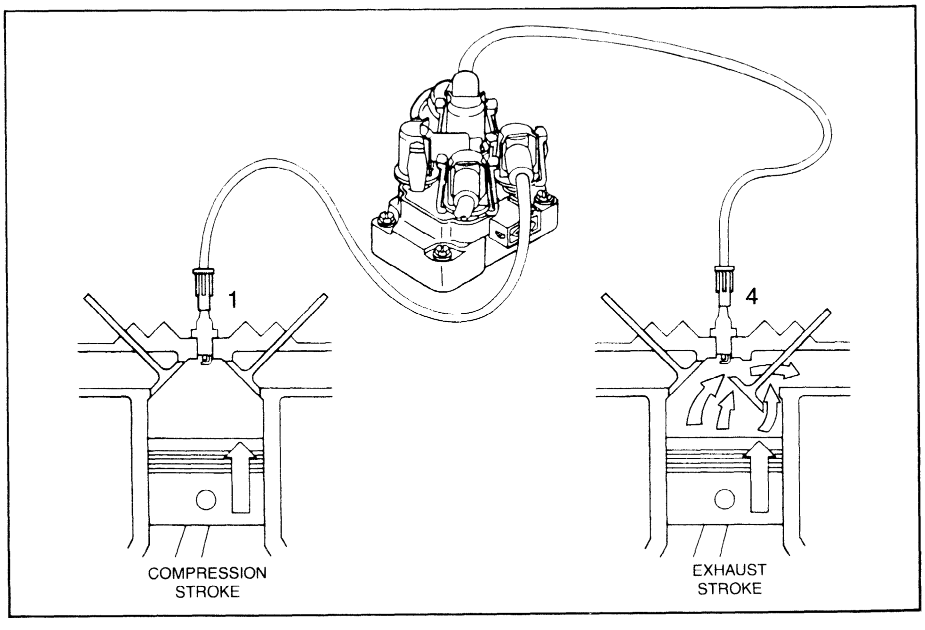


FIG. 1 Spark Plugs Fire in Pairs

1. Engine Speed and C/S Position

The crankshaft position and speed information comes to the UESC from the Variable Reluctance Sensor (VRS). The VRS is triggered by teeth cast into the engine side of the flywheel. The 36-1 teeth, spaced 10° apart, indicate to the UESC the crankshaft speed. The missing tooth indicates crankshaft position.

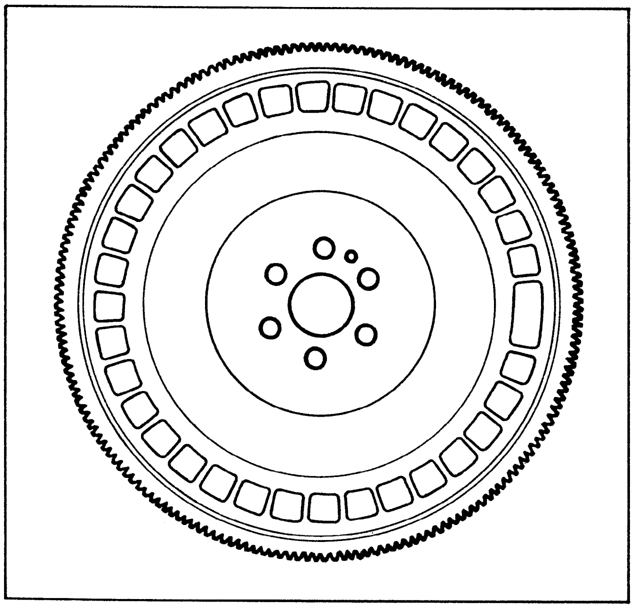


FIG. 2 Toothed Flywheel

2. Engine Load

The engine load information is processed into the UESC's electronics by a pressure transducer located within the UESC. A vacuum line connects the transducer to the engine intake manifold. The engine vacuum is proportional to it's load.

3. Engine Temperature

The Engine Coolant Temperature Sensor (ECTS) sends engine temperature information to the UESC. The ECTS is located in the intake manifold water jacket.

4. Fuel Octane Level Adjustment

Another input to the UESC (which is not usually used in the U.S.) retards the spark.

The UESC module **outputs** are:

IGNITION COIL DRIVER

The UESC switches two ignition coils on and off at the correct times to give the desired spark advance.

SENSOR FAIL-SAFE

If the UESC identifies a failure of any of its inputs, other than the engine speed/position sensor, it will substitute a fixed value for that input until such time that the fault on the input is rectified. A failed sensor is defined as the instantaneous reading of a sensor being made that is either above or below the maximum or minimum reading as defined by the system constants below:

Engine Coolant Temperature	minimum -39°C	(-38°F)
	maximum 112 °C	(232°F)
Manifold Absolute Pressure	minimum 21 KPA	(6.22" Hg)
	maximum 101 KPA	(29.91" Hg)

Ignition timing is adjusted constantly by the UESC module. Many factors, including all the sensors affect the final ignition setting.

CRANKING MODE

Cranking mode is the area of engine operating speed within which the ignition timing is at a static position. The static spark advance is fixed at 10 degrees BTDC up to 250 RPM.

RUN MODE

In this mode the RPM is above 250 and the spark advance is calculated in three main sections which are added together. The UESC sections are: Base Spark Advance (BSA) plus Spark Advance Offset Temperature (SAOT) plus Spark Advance Offset Detonation ECT (SAODE).

The final spark advance is then corrected, for propagation delays and finally the spark advance is limited by the system ranges and the spark slew rate limited.

The Base Spark Advance (BSA) is calculated by the UESC module looking at speed and load inputs.

The Spark Advance Offset Temperature (SAOT) will change ignition timing from the function of Engine Coolant Temperature (ECT). This allows the spark advance to be altered during cold engine conditions to improve starting and operation.

Spark Advance Offset Detonation ECT (SAODE) the ignition timing is offset as a function of Engine Coolant Temperature (ECT). This allows the spark advance to be reduced during hot engine conditions to avoid detonation and allow base spark advance to be calibrated near to the best performance curve.

TRANSIENT MODE

This function is to provide detonation protection when the engine load is increased rapidly by fast opening of the throttle plate. Rapid increases in engine load are determined by large changes in consecutive Manifold Absolute Pressure (MAP) values to the UESC module.

OVERSPEED MODE

If the instantaneous engine speed is greater than the maximum speed threshold, then the spark events are terminated until the instantaneous engine speed falls below 6375 RPM. During this time all other UESC calculations are performed as normal.

SERVICE ADJUSTMENTS AND CHECKS

1. Each 400 hours of engine operation remove the spark plugs and clean & adjust the electrode.
2. Clean and visually check spark plug high tension leads and check for secure fit, replace if necessary.
3. To retard the spark advance if the engine is operated on lower than specified fuel octane it may be necessary to retard the timing. 87 octane or higher fuel does not require any adjustment.
4. To retard the spark advance, cut the wire loop in the harness that connects to pins number 6 and 7. For assistance, or further information, consult Ford Power Products Engineering.

An Grounded	Pin Above Ground	Retarded °
7	6	1-2
6	7	2-4
6&7		6-8

The UESC module must be mounted above the intake manifold vacuum fitting to prevent fuel from entering the UESC module chamber.

The connecting rubber hose must be compatable with gasoline and be as short as possible. It is recommended that a fuel vapor trap be used in line in the connecting hose.

REMOVAL AND INSTALLATION

IGNITION COIL

Removal

1. Disconnect battery ground lead.
2. Disconnect ignition coil multiplug.

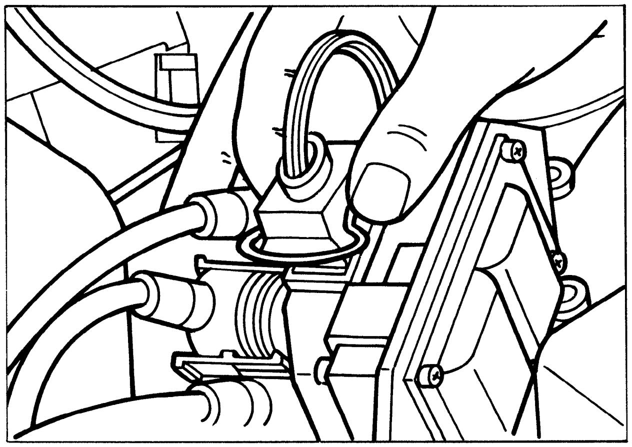


FIG. 3 Removing Ignition Coil Multiplug

3. Compress 2 lugs and disconnect HT leads at coil.

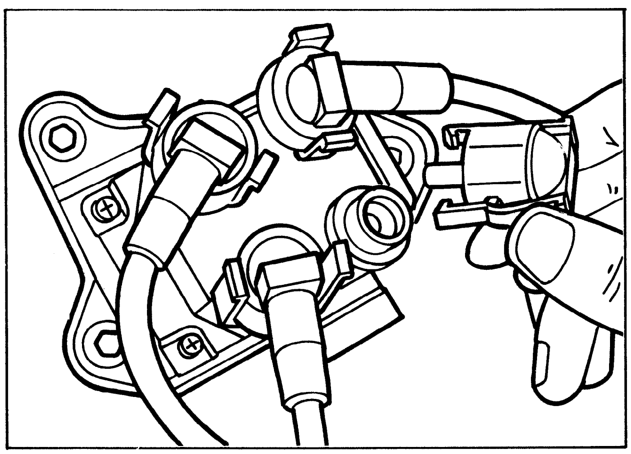


FIG. 4 Disconnecting HT Leads

4. Remove three screws and detach coil assembly.

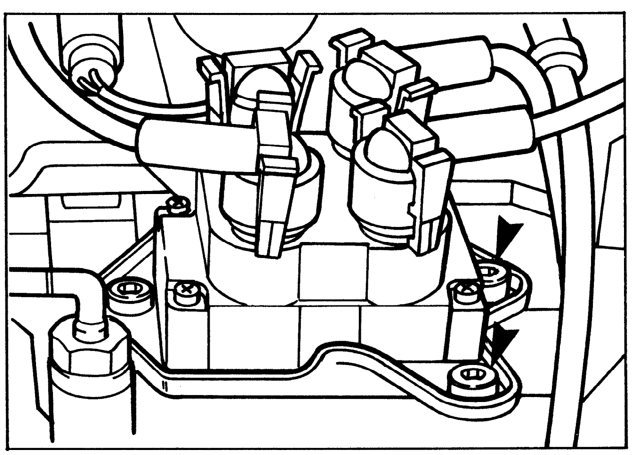


FIG. 5 Ignition Coil Retaining Screws

Installation

1. Position coil assembly, secure with three screws.
2. Connect HT leads at coil, ensuring that locking tabs snap into position.

NOTE: HT connections at coil are marked 1 to 4. It is important that each HT lead is connected in correct sequence.

3. Connect ignition coil multiplug.
4. Connect battery ground lead. Start engine and check coil operation.

ENGINE SPEED SENSOR

Removal

1. Disconnect battery ground cable.
2. Disconnect multiplug from sensor. Remove engine speed sensor, (one screw).

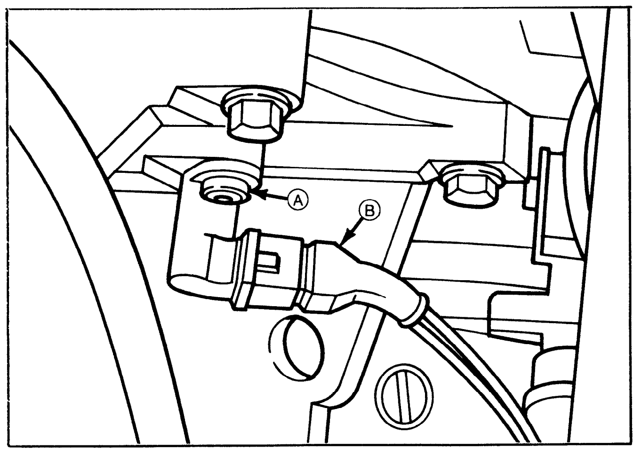


FIG. 6 Engine Speed Sensor
A — Retaining Bolt
B — Multiplug

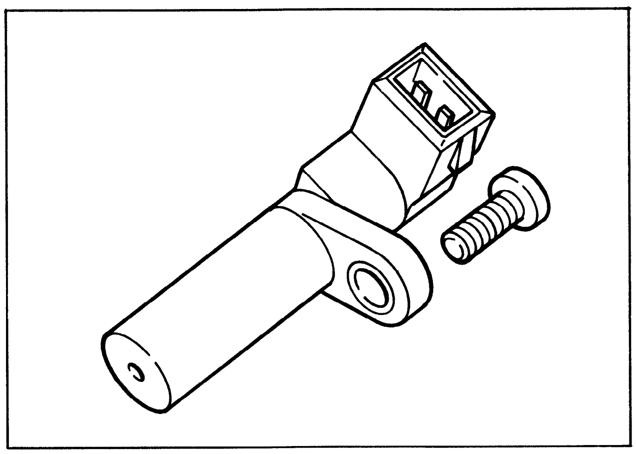


FIG. 7 Engine Speed Sensor (Removed)

Installation

1. Fit engine speed sensor and secure with screw.
2. Refit sensor multiplug.
3. Connect battery ground cable.

ENGINE COOLANT TEMPERATURE SENSOR

Removal

1. Disconnect battery and release cooling system pressure.

WARNING: When releasing system pressure, cover cap with a thick cloth to prevent coolant scalding.

2. Place a clean drain tray below engine under radiator drain plug and remove drain plug. To assist draining remove radiator cap.
3. Remove temperature sensor multiplug, located below the intake manifold. To remove multiplug, pull on multiplug, do not pull on wiring.
4. Unscrew sensor from intake manifold

Installation

1. Install sensor into inlet manifold, do not overtighten sensor. Connect multiplug, ensuring that locking tabs snap into position.
2. Replace radiator drain plug and refill system with correct solution. Remove rubber blanking cap on water outlet. When coolant is evident, refit blanking cap. Fill container to "maximum" mark allowing time for air in system to bubble through. Install radiator cap.
3. Connect battery and start engine. Allow engine to warm to normal operating temperature. Check, and if necessary, add coolant.

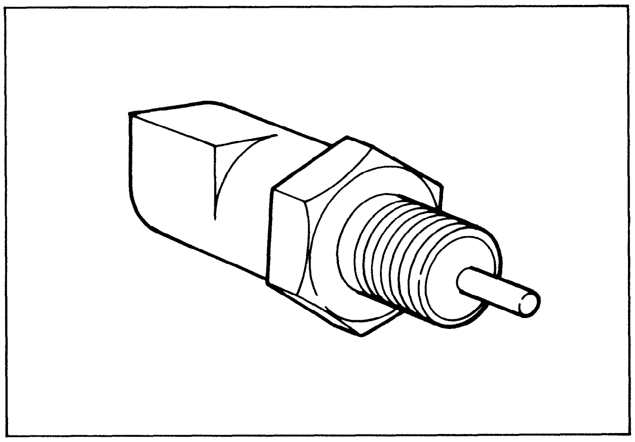


FIG. 8 Temperature Sensor

DIAGNOSING AND TESTING DIS

DIS DIAGNOSIS EQUIPMENT

To accurately diagnose DIS, certain diagnostic equipment and tools are required. In addition, the suggested diagnostic equipment may make the job easier and more convenient.

Prior to diagnosing DIS, obtain the following test equipment or equivalent.

- DIS diagnostic harness PPO111429 or equivalent
- SPARK TESTER, NEON BULB TYPE (CHAMPION CT-436 OR EQUIVALENT)

There is no need to disconnect a plug wire; just place this spark tester on a spark plug wire to determine if spark is being provided to the plug. This is especially useful for those hard to reach plug wires.

- SPARK TESTER, GAP TYPE (SPECIAL SERVICE TOOL D81P-6666-A OR EQUIVALENT)

Connect this gap type spark tester between any spark plug wire and engine ground to instantly determine if spark is being provided to the plug. A spark plug with a broken side electrode is not sufficient to check for spark and may lead to incorrect results.

- VOLT-OHMMETER (ROTUNDA 014-00575 OR EQUIVALENT)

A volt-ohmmeter is essential for gathering system operating data during diagnosis, testing, and engine servicing procedures. This digital volt-ohmmeter (DVOM) can also be used for general purpose electrical troubleshooting on conventional starting and charging systems.

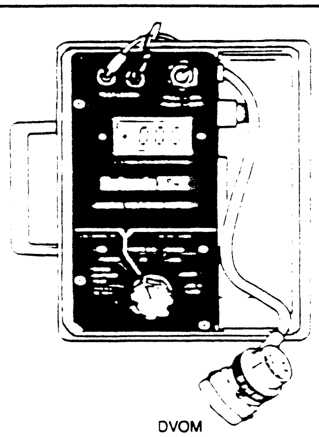


FIG. 10 Volt-Ohmmeter

- 12-14 VOLT TEST LAMP

TIMING LIGHT (ROTUNDA 059-00006 OR EQUIVALENT)

This timing light uses an inductive pickup for convenience and safety on 12 volt systems. This timing light includes a tachometer which reads from zero to 3000 RPM (Figure 11).

DIS DIAGNOSING

Identify the engine harness Ford part number and use the following electrical harness part number sketch that corresponds to the engine harness part number being checked.

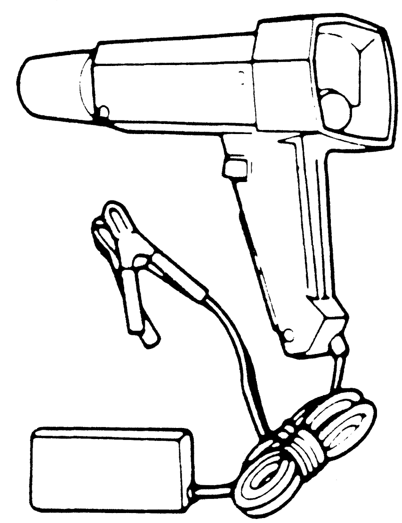


FIG. 11 Timing Light

The first check will test the engine harness, connectors and sensors for both continuity and resistance.

1. Remove the 12 pin UESC harness plug from the UESC module. Pins 1 and 5 are not used, therefore, do not have female connectors in the 12 pin harness connector plug.
2. Check the following circuits with the volt-ohmmeter (with the sensors connected) per the following chart with reference to pages; 2B-06 through 2B-15.

If the DIS Engine Harness checks are not to the chart specifications (page 2B-⚠), complete the following:

- Remove the wire harness connector to the UESC
- Remove each sensor or component from the harness
- Using a high impedance digital volt-ohmmeter (DVOM) check each wire for continuity or resistance (ref. 2B-⚠) for wire numbers & colors for the harness being used.
- If the wire harness has open circuits or resistance higher than specifications repair or replace the harness.
- If the wire harness checks are to specifications — reconnect each sensor and component and complete another DIS Engine Harness check (ref. page 2B-⚠)
- If the same sensor or component circuit does not test to specifications — replace that sensor or coil.
- If the engine will not start and/or run install a new module and make a normal start.

⚠ *Use the electrical sketch that corresponds to harness part number reference pages 2B-06-2B15 and fold-out page.*

DIS ENGINE HARNESS CHECKS (UESC HARNESS CONNECTOR REMOVED ALL SENSORS CONNECTED TO HARNESS)

Test No.	Engine Harness (12A200) Part Number	Harness Connector PIN Nos.	DVOM Set Selection	Reading Ohms/VDC	Codes	Description of Circuit, Wires Checked & Circuit Function
1	E8JL-AC, AD	2 to 3	Ω	200-600		Engine RPM & Crank Position, Wires 264, 265 & V.R. Sensor
2	E9JL-CA	Same as Test 1				
3	E9JL-CB, CC	Same as Test 1				
4	E8JL-AC, AD	4 to 10	Ω	105,000④	①③	Eng. Coolant Temp. Sensor, Wires 354, 354A and 359.
5	E9JL-CA	Same as Test 4				
6	E9JL-CB, CC	4 to 10		95,000④	①②	Eng. Coolant Temp. Sensor, Wires 354 & 359.
7	E8JL-AC, AD	6 to 7	Ω	Continuity 0.00 Resis.		Eng. Spark Adv. Circuit, Wires 6 & 6 No Grounds Equals S/A Set for 87 Oct.
8	E9JL-CA	Same as Test 7				
9	E9JL-CB, CC	Same as Test 7				
10	E8JL-AC*	8 to 9	20 VDC	12 VDC		With the Ignition Switch "ON" — Wires Checked 21A, 16M & 57.
11	E9JL-CA	Same as Test 10				*AD & CC-Ign. Switch "ON", Wires
12	E9JL-CB*	Same as Test 10				Checked 16I, 16C, 16M & 57 — 12 VDC Inidcated
13	E8JL-AC, AD	11 to 12	Ω	0.5-1.0		Wires 850 or 850A, 852 or 852A & Coil Circuit Has Cointinuity.
14	E9JL-CA	Same as Test 13				
15	E9JL-CB, CC	Same as Test 13				
16	E8JL-AC	Coil Sec. 1-4**	Ω	14000 ± .05		**Remove the 4 Spark Plug Wires and Measure the Sec. Resistance.
17	E9JL-CA	Same as Test 16				
18	E9JL-CB	Same as Test 16				
19	E8JL-AC	Coil Sec. 2-3	Same as Test 16			
20	E9JL-CA	Same as Test 16				
21	E9JL-CB	Same as Test 16				

H.T. spark plug wire resistance 9,000 to 16,000 ohms — (maximum 30,000 per wire)

CODES — TEMPERATURE SENSOR CHARACTERISTICS CHART (TSCC)

① Column A converts the sensor only resistance to a temperature reading (page 2B-07)
Column B converts the sensor and harness resistance to a temperature (page 2B-07)

② Use column A when the sensor is connected to the harness (page 2B-07) (Harness does not have 10K resistor)

③ Use column B when the sensor is connected to the harness (page 2B-07) (Harness has 10K resistor)

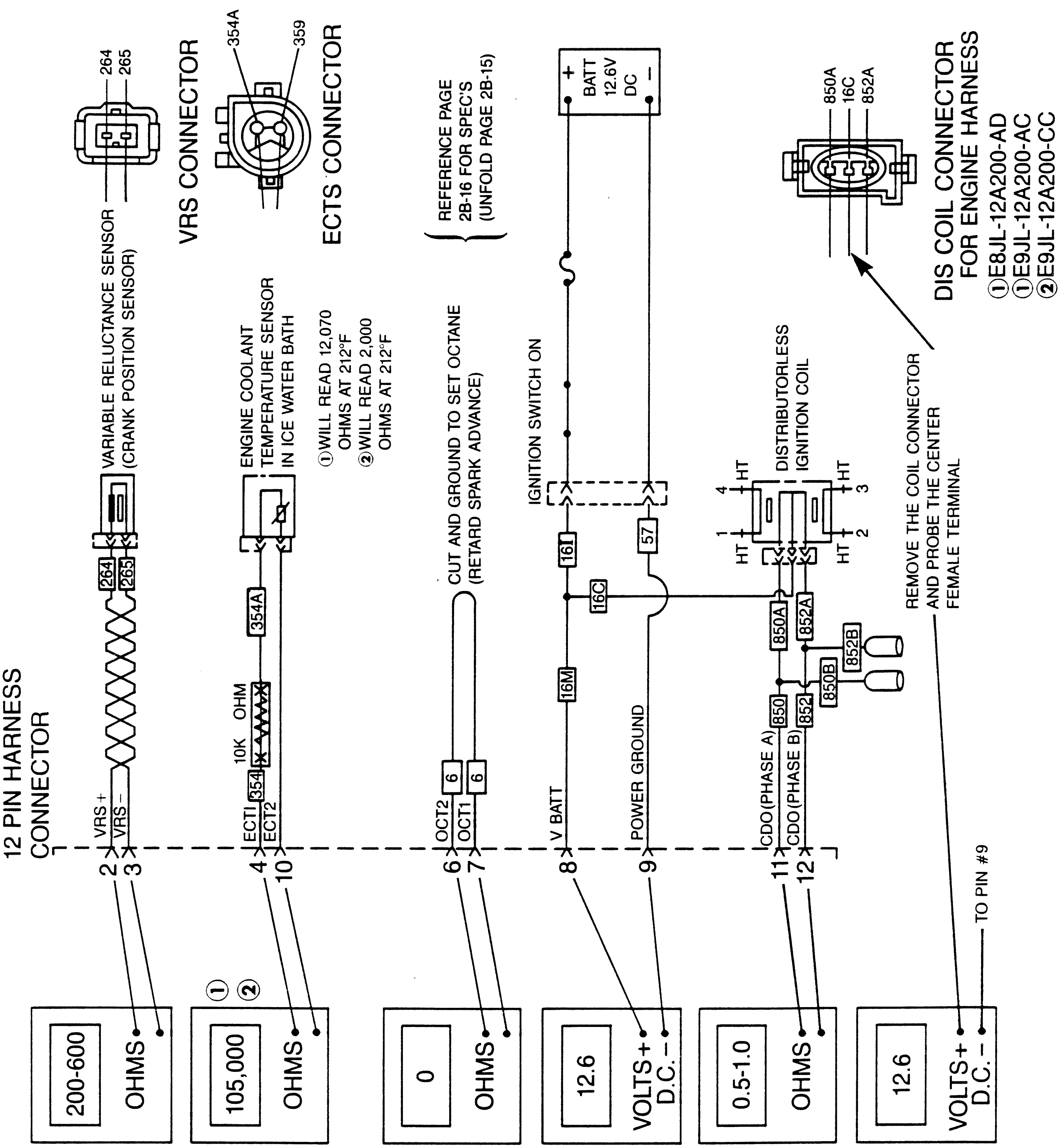
④ E.C.T.S. brass only in 32°F ice water

ENGINE COOLANT SENSOR CHARACTERISTICS

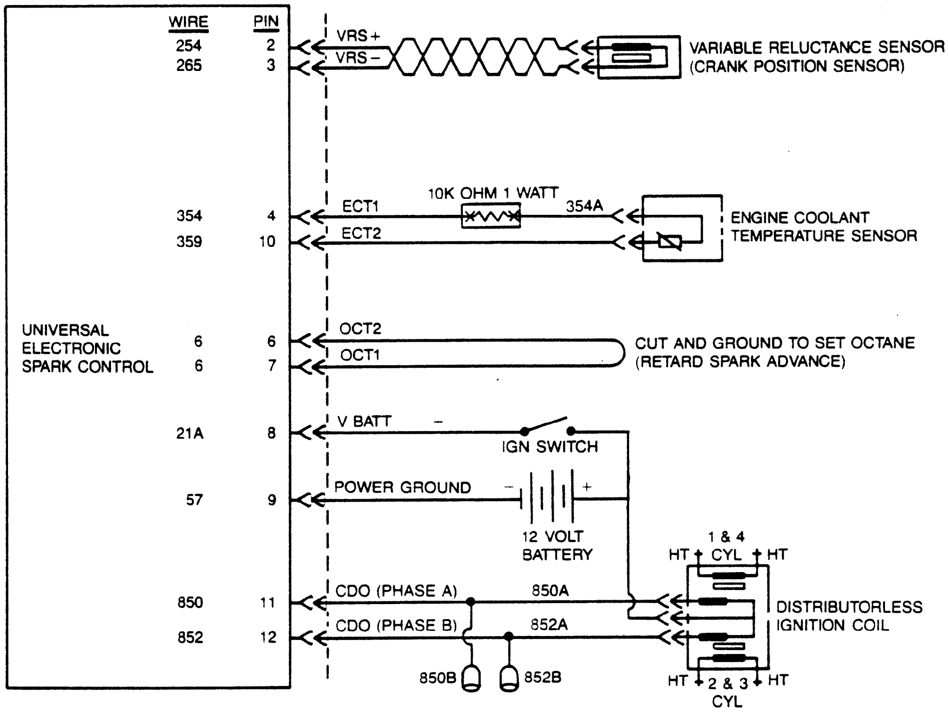
Temperature		Column A Sensor (Ohms) ± .02% ①	Column B Sensor & Harness (Ohms) ± .03% ②
°C	°F		
−30	−22	481,000	491,000
−20	4	271,200	281,200
−10	14	158,000	168,000
0	32	95,000	105,000
10	50	58,750	68,750
20	68	37,300	47,300
30	86	24,270	34,270
40	104	16,150	26,150
50	122	10,970	20,970
60	140	7,600	17,600
70	158	5,360	15,360
80	176	3,840	13,840
90	194	2,800	12,800
100	212	2,070	12,070
110	230	1,550	11,550
120	248	1,180	11,180
130	266	903	10,903
140	284	701	10,701
150	302	550	10,550

① Column A, use to check sensor ohm reading and/or in harnesses without the 10,000 resistor in wire from pin 4 to temperature sensor.

② Column B, use to check temperature sensor when connected to the harness and there is a 10,000 ohm resistor in wire from pin 4 to sensor.

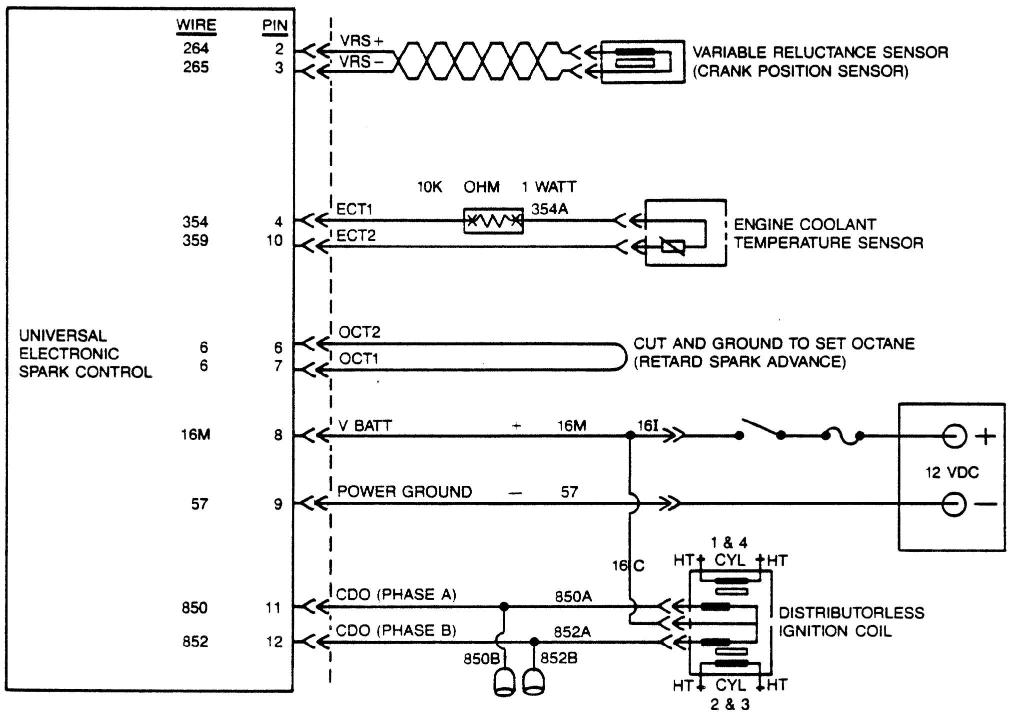


12 PIN HARNESS CONNECTOR
VRS CONNECTOR
264
265
354A
359
ECTS CONNECTOR
VARIABLE RELUCTANCE SENSOR (CRANK POSITION SENSOR)
VRS +
VRS –
ENGINE COOLANT TEMPERATURE SENSOR IN ICE WATER BATH
①WILL READ 12,070 OHMS AT 212°F
②WILL READ 2,000 OHMS AT 212°F
10K OHM
ECT1
ECT2
354
REFERENCE PAGE 2B-16 FOR SPEC'S (UNFOLD PAGE 2B-15)
CUT AND GROUND TO SET OCTANE (RETARD SPARK ADVANCE)
OCT2
OCT1
6
IGNITION SWITCH ON
+ BATT 12.6V DC –
V BATT
16M
16I
16C
POWER GROUND
57
DISTRIBUTORLESS IGNITION COIL
HT
1
2
3
4
CDO(PHASE A)
CDO(PHASE B)
850
852
850A
852A
850B
852B
16C
REMOVE THE COIL CONNECTOR AND PROBE THE CENTER FEMALE TERMINAL
DIS COIL CONNECTOR FOR ENGINE HARNESS
①E8JL-12A200-AD
①E9JL-12A200-AC
②E9JL-12A200-CC
TO PIN #9
200-600 OHMS
① ② 105,000 OHMS
0 OHMS
12.6 VOLTS+ D.C. –
0.5-1.0 OHMS
12.6 VOLTS+ D.C. –



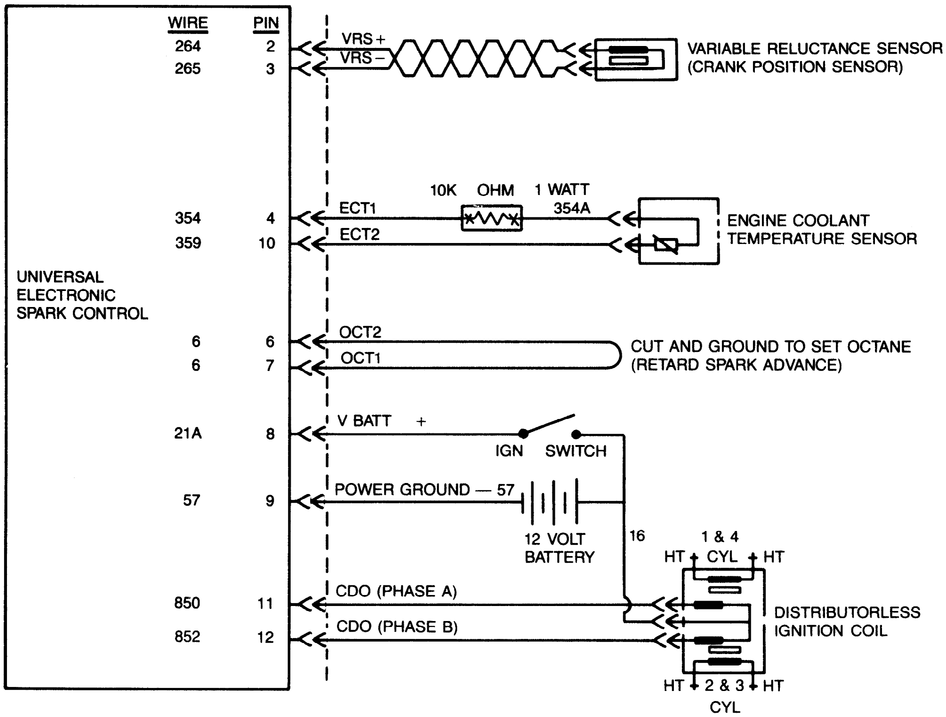
VSG DISTRIBUTORLESS IGNITION SYSTEM (DIS) WIRING DIAGRAM REFERENCE (E8JL-12A200-AC)

UESC PIN	NO	CIRCUIT DESCRIPTION	GA	BASIC COLOR	STRIPE COLOR	SPEC
		BLANK (NO WIRE)				
2	264	UESC TO VRS +	18	WHITE		
3	265	UESC TO VRS −	18	GREEN		
4	354	UESC TO RESISTOR	18	BROWN	WHITE	
5		BLANK (NO WIRE)				
6	6	UESC SPARK RETARD OS2	18	BROWN		
7	6	UESC SPARK RETARD OS1	18	BROWN		
8	21A	UESC TO IGN ON IGN SWITCH (SWITCHED)	18	YELLOW		
9	57	UESC TO BAT GROUND	18	BLACK		
10	359	UESC TO ECTS GROUND	18	GREEN	WHITE	
11	850	UESC TO SPLICE	18	YELLOW	BLACK	
12	852	UESC TO SPLICE	18	YELLOW	WHITE	
—	16	DIS COIL TO BAT POWER (NOT SWITCHED)	18	RED	GREEN	
—	354A	RESISTOR TO ECTS	18	BROWN	WHITE	
—	850A	SPLICE TO DIS COIL 1	18	YELLOW	BLACK	
—	850B	SPLICE TO ELECTRONIC GOVERNOR OR TACHOMETER	18	YELLOW	BLACK	
—	852A	SPLICE TO DIS COIL 2	18	YELLOW	WHITE	
—	852B	SPLICE TO ELECTRONIC GOVERNOR OR TACHOMETER	18	YELLOW	WHITE	



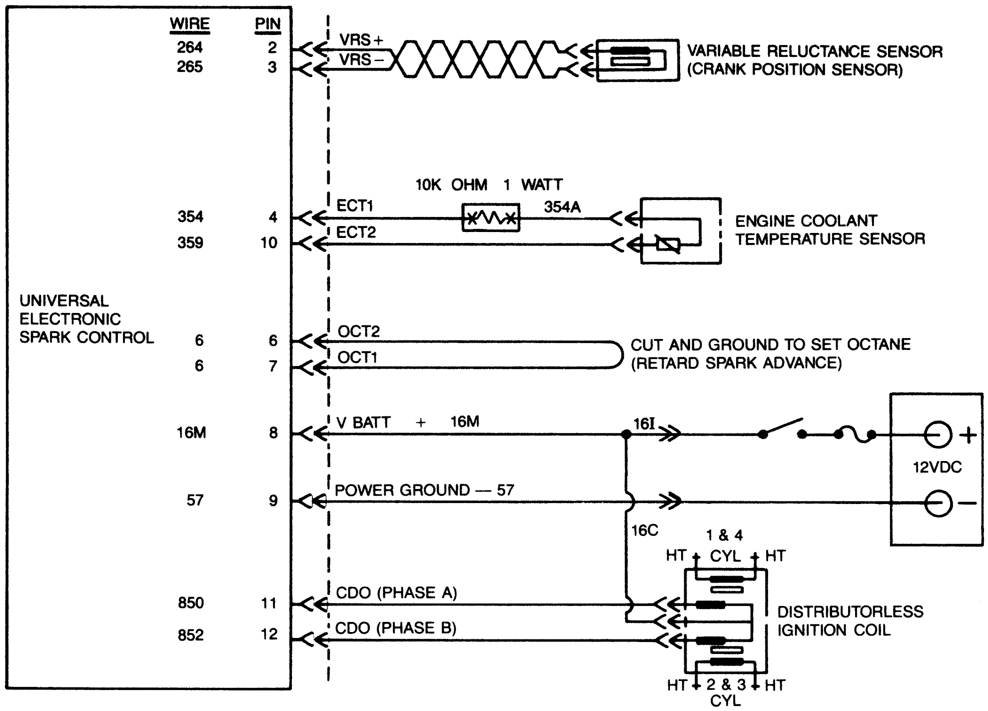
VSG DISTRIBUTORLESS IGNITION SYSTEM (DIS) WIRING DIAGRAM REFERENCE (E8JL-12A200-AD)

UESC PIN	NO	CIRCUIT DESCRIPTION	GA	BASIC COLOR	STRIPE COLOR	SPEC
1		BLANK (NO WIRE)				
2	264	UESC TO VRS +	18	WHITE		
3	265	UESC TO VRS −	18	GREEN		
4	354	UESC TO ECTS	18	BROWN	WHITE	
5		BLANK (NO WIRE)				
6	6	UESC SPARK RETARD OS2	18	BROWN		
7	6	UESC SPARK RETARD OS1	18	BROWN		
8	16M	UESC PIN 8 TO SPLICE	18	RED	GREEN	
9	57	UESC TO BAT GROUND	18	BLACK		
10	359	UESC TO ECTS	18	GREEN	WHITE	
11	850	UESC TO DIS COIL 1 SPLICE	18	YELLOW	BLACK	
12	852	UESC TO DIS COIL 2 SPLICE	18	YELLOW	WHITE	
—	16C	DIS COIL TO SPLICE	18	RED	GREEN	
—	354A	RESISTOR TO ECTS	18	BROWN	WHITE	
—	16I	IGNITION SWITCH TO SPLICE	18	RED	GREEN	
—	852B	SPLICE TO ELECTRONIC GOVERNOR — TACHOMETER	18	YELLOW	WHITE	
—	852A	SPICE TO DIS COIL 2	18	YELLOW	WHITE	
—	850B	SPLICE TO ELECTRONIC GOVERNOR — TACHOMETER	18	YELLOW	BLACK	
—	850A	SPLICE TO DIS COIL 1	18	YELLOW	BLACK	



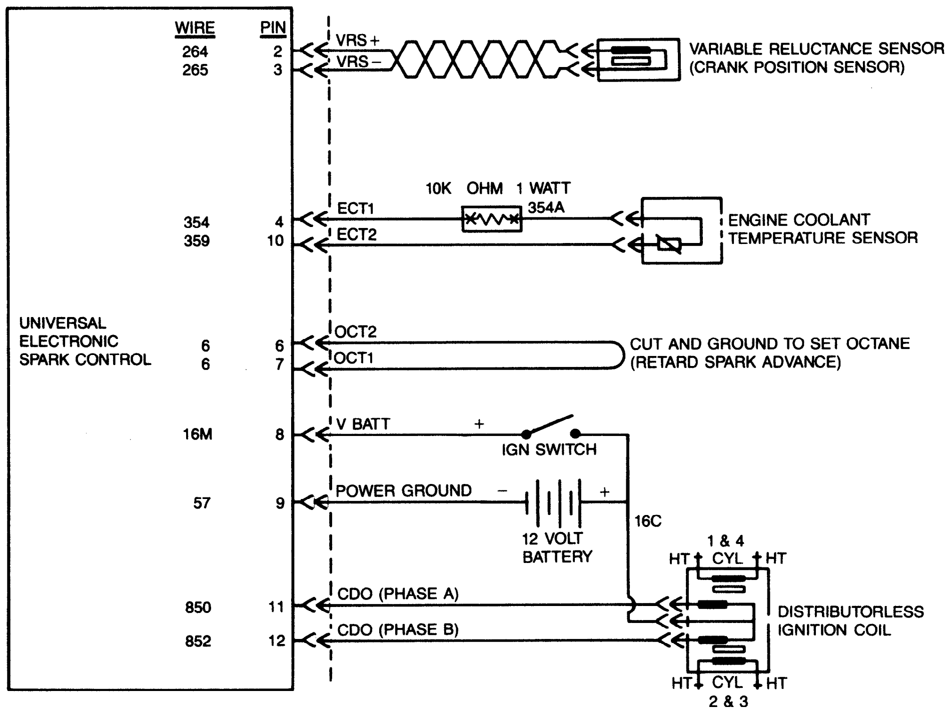
VSG DISTRIBUTORLESS IGNITION SYSTEM (DIS) WIRING DIAGRAM REFERENCE (E9JL-12A200-AB)

UESC PIN	NO	CIRCUIT DESCRIPTION	GA	BASIC COLOR	STRIPE COLOR	SPEC
1		BLANK (NO WIRE)				
2	264	UESC TO VRS +	18	WHITE		
3	265	UESC TO VRS −	18	GREEN		
4	354	UESC TO RESISTOR	18	BROWN	WHITE	
5		BLANK (NO WIRE)				
6	6	UESC SPARK RETARD OS2	18	BROWN		
7	6	UESC SPARK RETARD OS1	18	BROWN		
8	21A	UESC TO IGN ON IGN SWITCH (SWITCHED)	18	YELLOW		
9	57	UESC TO BAT GROUND	18	BLACK		
10	359	UESC TO ECTS GROUND	18	GREEN	WHITE	
11	850	UESC TO DIS COIL 1	18	YELLOW	BLACK	
12	852	UESC TO DIS COIL 2	18	YELLOW	WHITE	
—	16	DIS COIL TO BAT POWER (NOT SWITCHED)	18	RED	GREEN	
—	354A	RESISTOR TO ECTS	18	BROWN	WHITE	



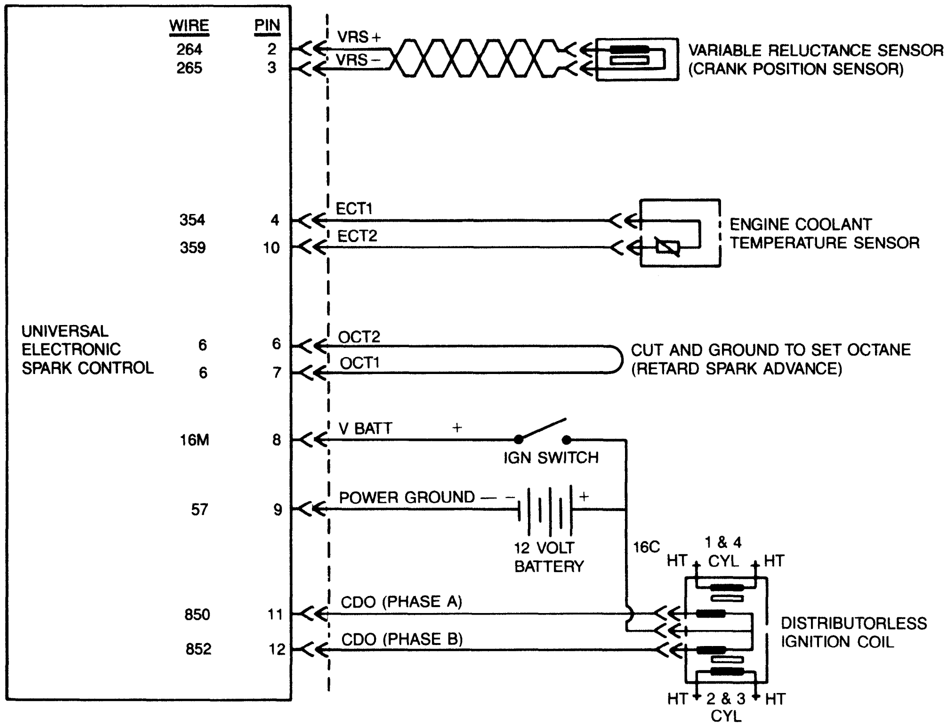
VSG DISTRIBUTORLESS IGNITION SYSTEM (DIS) WIRING DIAGRAM REFERENCE (E9JL-12A200-AC)

UESC PIN	NO	CIRCUIT DESCRIPTION	GA	BASIC COLOR	STRIPE COLOR	SPEC
1		BLANK (NO WIRE)				
2	264	UESC TO VRS +	18	WHITE		
3	265	UESC TO VRS −	18	GREEN		
4	354	UESC TO RESISTOR	18	BROWN	WHITE	
5		BLANK (NO WIRE)				
6	6	UESC SPARK RETARD OS2	18	BROWN		
7	6	UESC SPARK RETARD OS1	18	BROWN		
8	16M	UESC TO IGN ON IGN SWITCH (SWITCHED)	18	RED	GREEN	
9	57	UESC TO BAT GROUND	18	BLACK		
10	359	UESC TO ECTS GROUND	18	GREEN	WHITE	
11	850	UESC TO DIS COIL 1	18	YELLOW	BLACK	
12	852	UESC TO DIS COIL 2	18	YELLOW	WHITE	
—	16C	DIS COIL TO BAT POWER (SWITCHED)	18	RED	GREEN	
—	354A	RESISTOR TO ECTS	18	BROWN	WHITE	
—	16I	IGNITION SWITCH TO SPLICE	18	RED	GREEN	



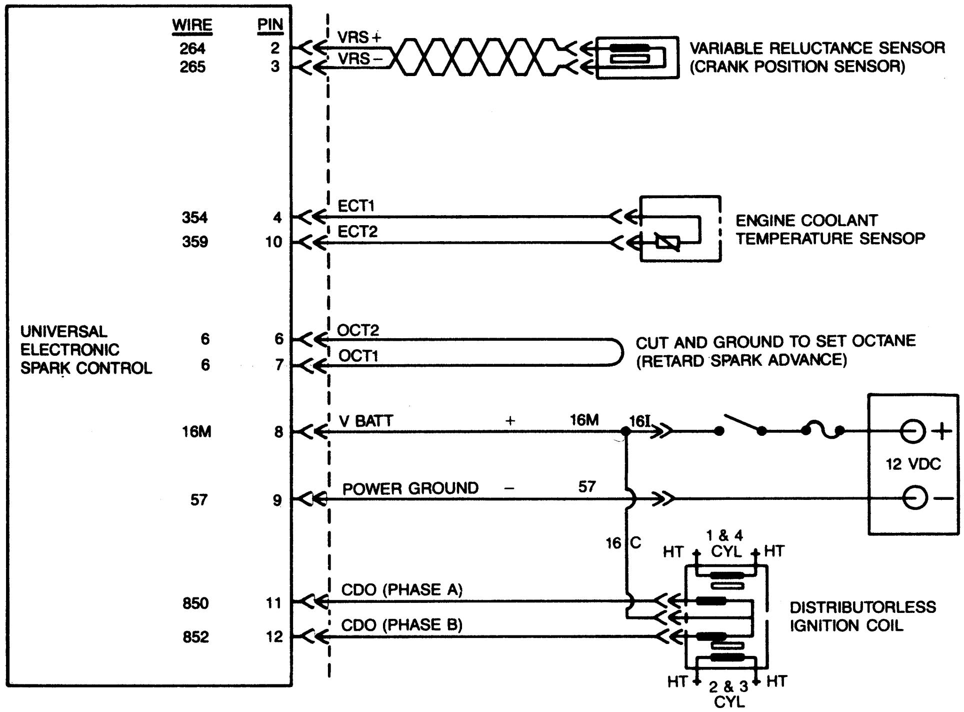
VSG DISTRIBUTORLESS IGNITION SYSTEM (DIS) WIRING DIAGRAM REFERENCE (E9JL-12A200-CA)

UESC PIN	NO	CIRCUIT DESCRIPTION	GA	BASIC COLOR	STRIPE COLOR	SPEC
1		BLANK (NO WIRE)				
2	264	UESC TO VRS +	18	WHITE		
3	265	UESC TO VRS −	18	GREEN		
4	354	UESC TO RESISTOR	18	BROWN	WHITE	
5		BLANK (NO WIRE)				
6	6	UESC SPARK RETARD OS2	18	BROWN		
7	6	UESC SPARK RETARD OS1	18	BROWN		
8	16M	UESC TO IGN ON IGN SWITCH (SWITCHED)	18	YELLOW		
9	57	UESC TO BAT GROUND	18	BLACK		
10	359	UESC TO ECTS GROUND	18	GREEN	WHITE	
11	850	UESC TO DIS COIL 1	18	YELLOW	BLACK	
12	852	UESC TO DIS COIL 2	18	YELLOW	WHITE	
—	16C	DIS COIL TO BAT POWER (NOT SWITCHED)	18	RED	GREEN	
—	354A	RESISTOR TO ECTS	18	BROWN	WHITE	



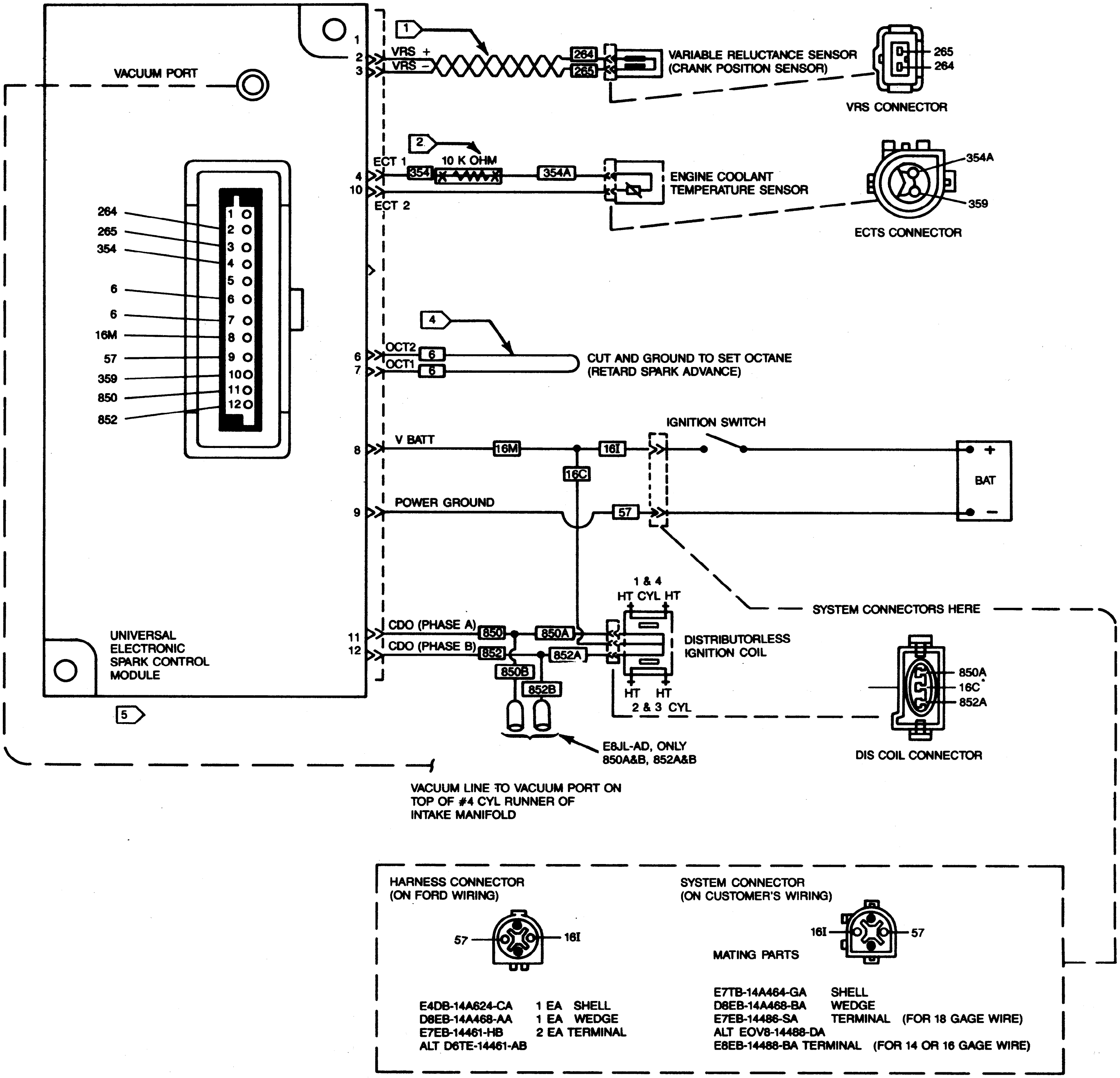
VSG DISTRIBUTORLESS IGNITION SYSTEM (DIS) WIRING DIAGRAM REFERENCE (E9JL-12A200-CB)

UESC PIN	NO	CIRCUIT DESCRIPTION	GA	BASIC COLOR	STRIPE COLOR	SPEC
1		BLANK (NO WIRE)				
2	264	UESC TO VRS +	18	WHITE		
3	265	UESC TO VRS −	18	GREEN		
4	354	UESC TO RESISTOR	18	BROWN	WHITE	
5		BLANK (NO WIRE)				
6	6	UESC SPARK RETARD OS2	18	BROWN		
7	6	UESC SPARK RETARD OS1	18	BROWN		
8	16M	UESC TO IGN ON IGN SWITCH (SWITCHED)	18	YELLOW		
9	57	UESC TO BAT GROUND	18	BLACK		
10	359	UESC TO ECTS GROUND	18	GREEN	WHITE	
11	850	UESC TO DIS COIL 1	18	YELLOW	BLACK	
12	852	UESC TO DIS COIL 2	18	YELLOW	WHITE	
—	16C	DIS COIL TO BAT POWER (NOT SWITCHED)	18	RED	GREEN	



VSG DISTRIBUTORLESS IGNITION SYSTEM (DIS) WIRING DIAGRAM REFERENCE (E9JL-12A200-CC)

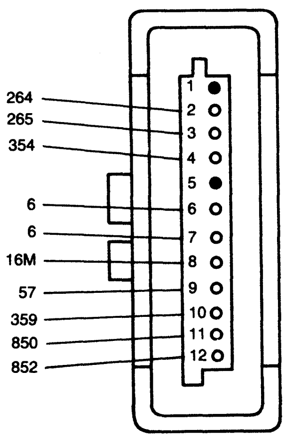
UESC PIN	NO	CIRCUIT DESCRIPTION	GA	BASIC COLOR	STRIPE COLOR	SPEC
1		BLANK (NO WIRE)				
2	264	UESC TO VRS +	18	WHITE		
3	265	UESC TO VRS −	18	GREEN		
4	354	UESC TO RESISTOR	18	BROWN	WHITE	
5		BLANK (NO WIRE)				
6	6	UESC SPARK RETARD OS2	18	BROWN		
7	6	UESC SPARK RETARD OS1	18	BROWN		
8	16M	UESC TO IGN ON IGN SWITCH (SWITCHED)	18	RED	GREEN	
9	57	UESC TO BAT GROUND	18	BLACK		
10	359	UESC TO ECTS GROUND	18	GREEN	WHITE	
11	850	UESC TO DIS COIL 1	18	YELLOW	BLACK	
12	852	UESC TO DIS COIL 2	18	YELLOW	WHITE	
—	16C	DIS COIL TO BAT POWER (SWITCHED)	18	RED	GREEN	
—	16I	IGNITION SWITCH TO SPLICE	18	RED	GREEN	



SYSTEM CONNECTORS USED BY PPO

3 (OTHER SUBMERSIBLE QUALITY CONNECTORS MAY BE USED AT USERS OPTION)

UESC PIN	NO	CIRCUIT DESCRIPTION	GA	BASIC COLOR	STRIPE COLOR	SPEC
1		BLANK (NO WIRE)				
2	264	UESC TO VRS +	18	WHITE		
3	265	UESC TO VRS −	18	GREEN		
4	354	UESC TO ECTS	18	BROWN	WHITE	
5		BLANK (NO WIRE)				
6	6	UESC SPARK RETARD OS2	18	BROWN		
7	6	UESC SPARK RETARD OS1	18	BROWN		
8	16M	UESC PIN 8 TO SPLICE	18	RED	GREEN	
9	57	UESC TO BAT GROUND	18	BLACK		
10	359	UESC TO ECTS GROUND	18	GREEN	WHITE	
11	850	UESC TO DIS COIL 1	18	YELLOW	BLACK	
12	852	UESC TO DIS COIL 2	18	YELLOW	WHITE	
—	16C	DIS COIL TO SPLICE	18	RED	GREEN	
—	354A	RESISTOR TO ECTS	18	BROWN	WHITE	
—	16I	IGN SWITCH TO SPLICE	18	RED	GREEN	
—	852B	SPLICE TO ELECTRONIC GOVERNOR — TACHOMETER	18	YELLOW	WHITE	
—	852A	SPLICE TO DIS COIL 2	18	YELLOW	WHITE	
—	850B	SPLICE TO ELECTRONIC GOVERNOR — TACHOMETER	18	YELLOW	BLACK	
—	850A	SPLICE TO DIS COIL 1	18	YELLOW	BLACK	



12 PIN HARNESS CONNECTOR TO UESC MODULE

Connector Information
For E8JL-12A200-AD
E9JL-12A200-AC
E9JL-12A200-CC

1 The following pair of wires 264 and 265 are to be uniformly twisted at no less than 20 twist/meter

2 Resistor shown is application sensitive and is not used in a few special applications consult Ford PPO applications engineering. (Not used in harness #E9JL-CC) 10/23/89

3 For engine users desiring to fabricate their own wiring assemblies. The four proprietary connectors needed may be obtained from Ford PPO or from the parts manufacturers.

4 Note the wire loop from UESC pin 6 to pin 7. If the engine is operative with low octane fuel it may be necessary to retards the spark. This may be done by cutting open the loop and grounding the wire which goes to pin 6 or 7 or both.

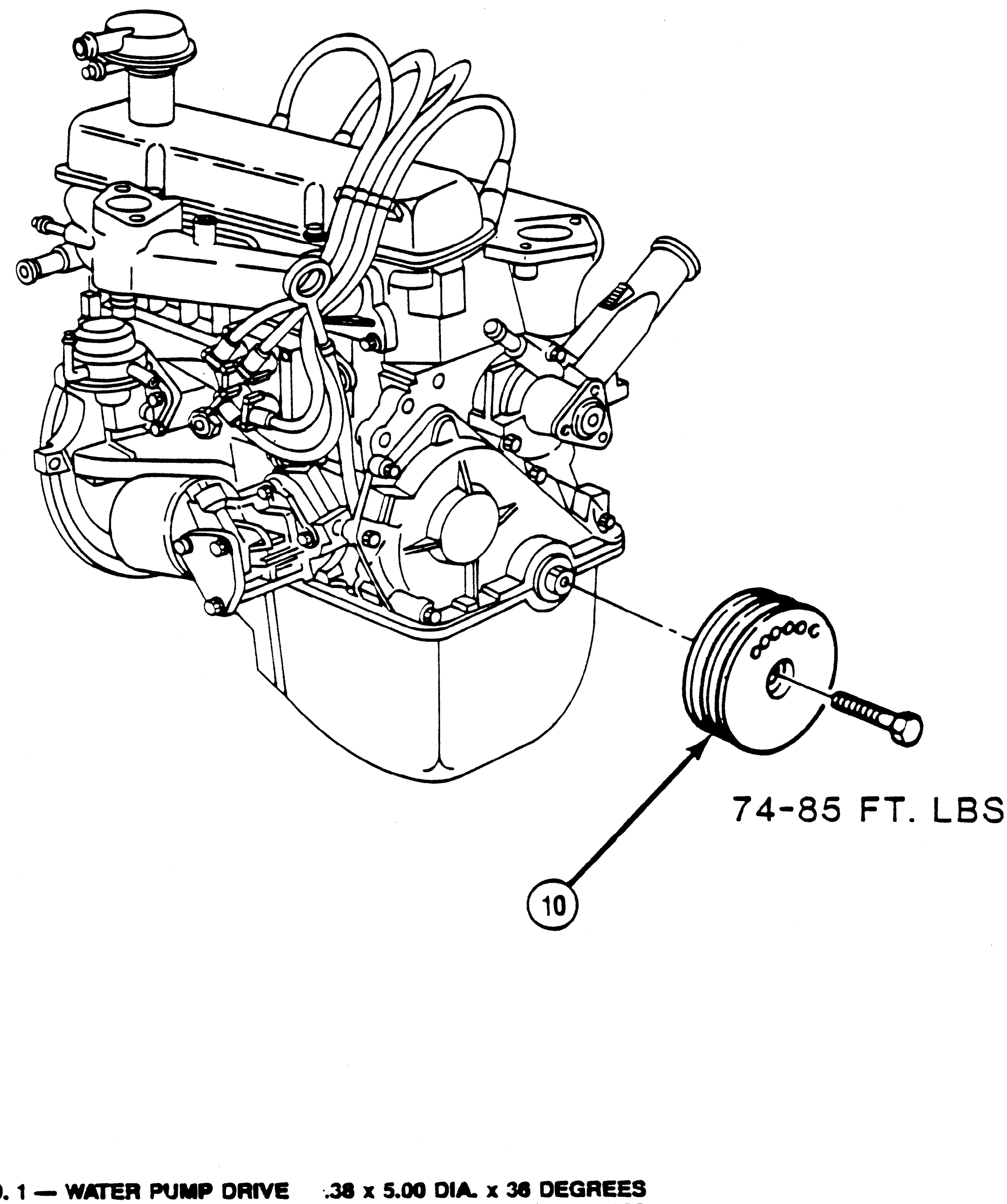
To retard 1-2° ground wire to pin 7
To retard 2-4° ground wire to pin 6
To retard 6-8° ground wire to pin 6 & 7

5 The UESC module must be mounted somewhat above the level of the intake manifold. This is so that fuel or condensed fuel vapor cannot drain (thru the vacuum line) into the module during operation or storage. (Reference service adjustments portion of page 2B-02.)

Male connector symbols: ⊗, →, ☒
Female connector symbols: ○, ←, □

CRANKSHAFT PULLEY – 2 GROOVE

TA-030-002

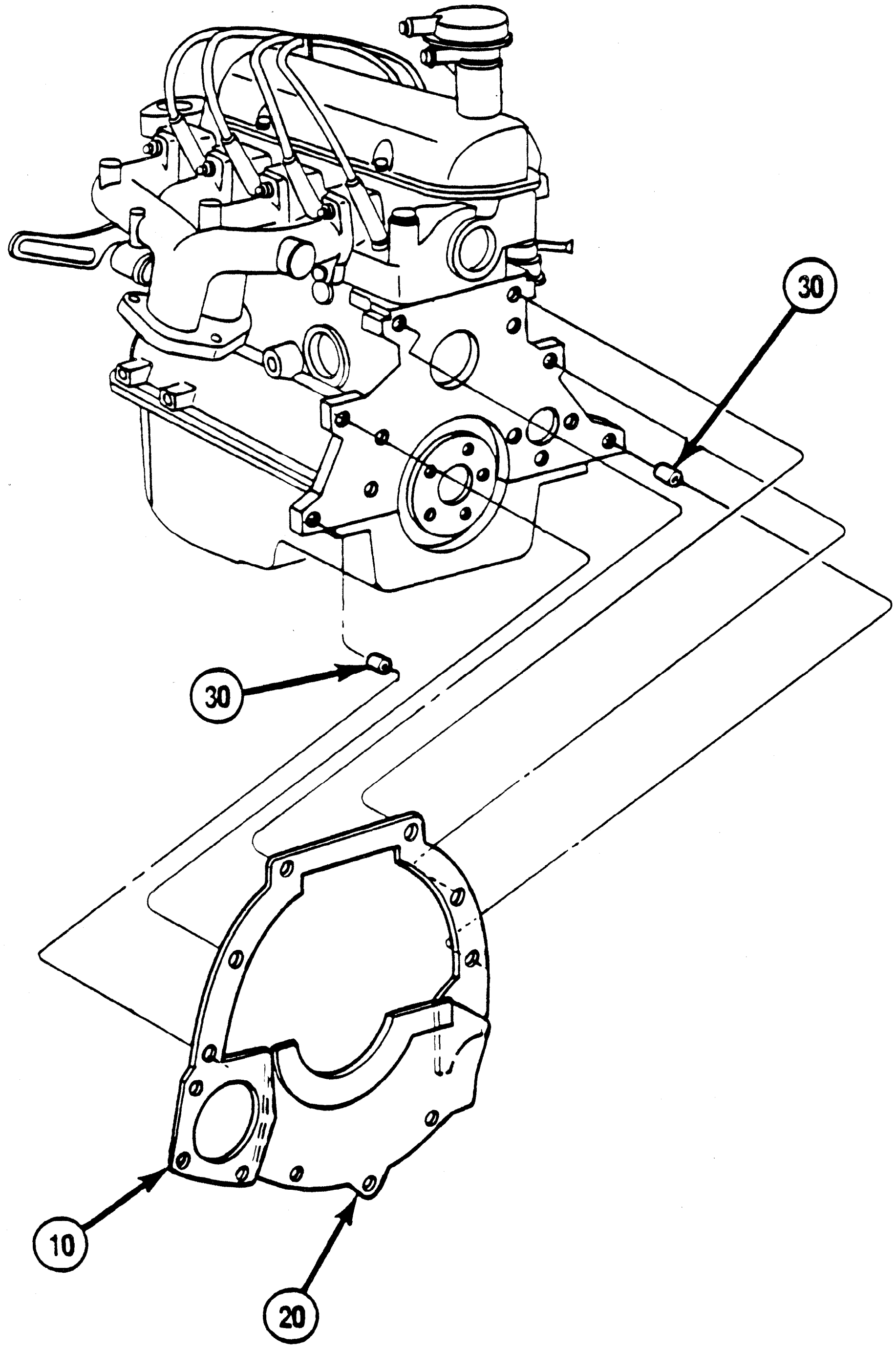


NOTES:
GROOVE NO. 1 — WATER PUMP DRIVE .38 x 5.00 DIA. x 36 DEGREES
GROOVE NO. 2 — GOVERNOR DRIVE .38 x 5.00 DIA. x 36 DEGREES
USE THE SAME CRANKSHAFT PULLEY ATTACHING HARDWARE THAT WAS REMOVED WHEN THE STANDARD CRANKSHAFT PULLEY WAS DELETED FROM THE ENGINE.

(REVISED 11/24/91)

REAR ENGINE PLATES

TA-031-001



NOTES:
MOUNT (20) PLATE-HOUSING LOWER COVER BETWEEN (10) PLATE-REAR ENGINE UPPER AND REAR FACE OF BLOCK ON RIGHT SIDE ONLY.

PART 3 Fuel System

GENERAL DESCRIPTION

The fuel system includes a thermostatically controlled air cleaner with a dry element and a permanently sealed single action fuel pump operated by a lobe on the camshaft and a single barrel variable venturi carburetor with a manual choke. It also has a screen filter located in the fuel inlet.

IDENTIFICATION

The carburetor is identified on the main body near the fuel inlet. The basic part number for all carburetors is 9510. To procure parts, it is necessary to know the part number prefix and suffix (Figure 1).

84BF	—	KJA
PART NO. PREFIX		PART NO. SUFFIX

FIG. 1 Carburetor Identification — Typical

DIAGNOSIS AND TESTING

GENERAL INFORMATION

Water and dirt that accumulate in the fuel tank can cause a restricted fuel line or filter and malfunction of the fuel pump or carburetor. Condensation, which is the greatest source of water entering the fuel tank, is formed by moisture in the air when it strikes the cold interior walls of the fuel tank.

If the accumulation of dirt and water in the filter is excessive, the fuel tank should be removed and flushed, and the line from the fuel pump to the tank should be blown out.

Air leakage in the fuel inlet line can cause low fuel pump pressure and volume.

A restricted fuel tank vent can cause low fuel pump pressure and volume and can result in collapsed inlet hoses or a collapsed fuel tank.

High or low pressure are the two most likely fuel pump troubles that will affect engine performance. Low pressure will cause a lean mixture and fuel starvation at high speeds and excessive pressure will cause high fuel consumption and carburetor flooding.

Dirt accumulation in the fuel and air passages, improper idle adjustments, and improper fuel level are the major sources of carburetor troubles.

AIR CLEANER

DESCRIPTION AND OPERATION

The thermostatically controlled air cleaner has two sources of air supply, the cool air from the front of the engine compartment and hot air from a heat box mounted on the exhaust manifold. The air supply through the air cleaner is controlled by a duct valve mounted on the cleaner spout. The duct valve blends cool air and hot air to achieve the required air intake temperature.

The duct valve is operated by a vacuum diaphragm unit which holds it fully open as long as vacuum is maintained above approximately 100 mm (4.0 in.) of mercury. Under these conditions only hot air from the exhaust manifold is allowed to enter the air cleaner.

As the vacuum applied to the diaphragm unit falls below approximately 100 mm (4.0 in.) of mercury the valve progressively closes allowing cooler air to enter the air cleaner. This action continues until the vacuum is reduced to approximately 50 mm (2.0 in.) of mercury, at which time only cool air from the standard intake enters the air cleaner. The vacuum feed for the diaphragm unit is supplied from the intake manifold via a heat sensor.

The heat sensor unit is located inside the air cleaner and senses the temperature of the air actually entering the carburetor. The unit consists of two vacuum take off points, a bi-metal strip and a ball valve. When the air flow past the sensor is cold the ball valve in the sensor unit will be closed allowing full manifold vacuum to be available at the diaphragm unit.

As the temperature increases above a pre-determined value the ball valve opens allowing air to bleed through the unit into the vacuum line. This reduces the effect of manifold vacuum at the vacuum diaphragm.

The combined effect of the heat sensor, vacuum diaphragm unit, and duct valve is to control the blend of hot and cold air under closed or part throttle conditions thereby maintaining a constant air intake temperature. However, when the ambient temperature is below the sensor operating temperature it will provide colder air at or near full throttle to achieve good performance.

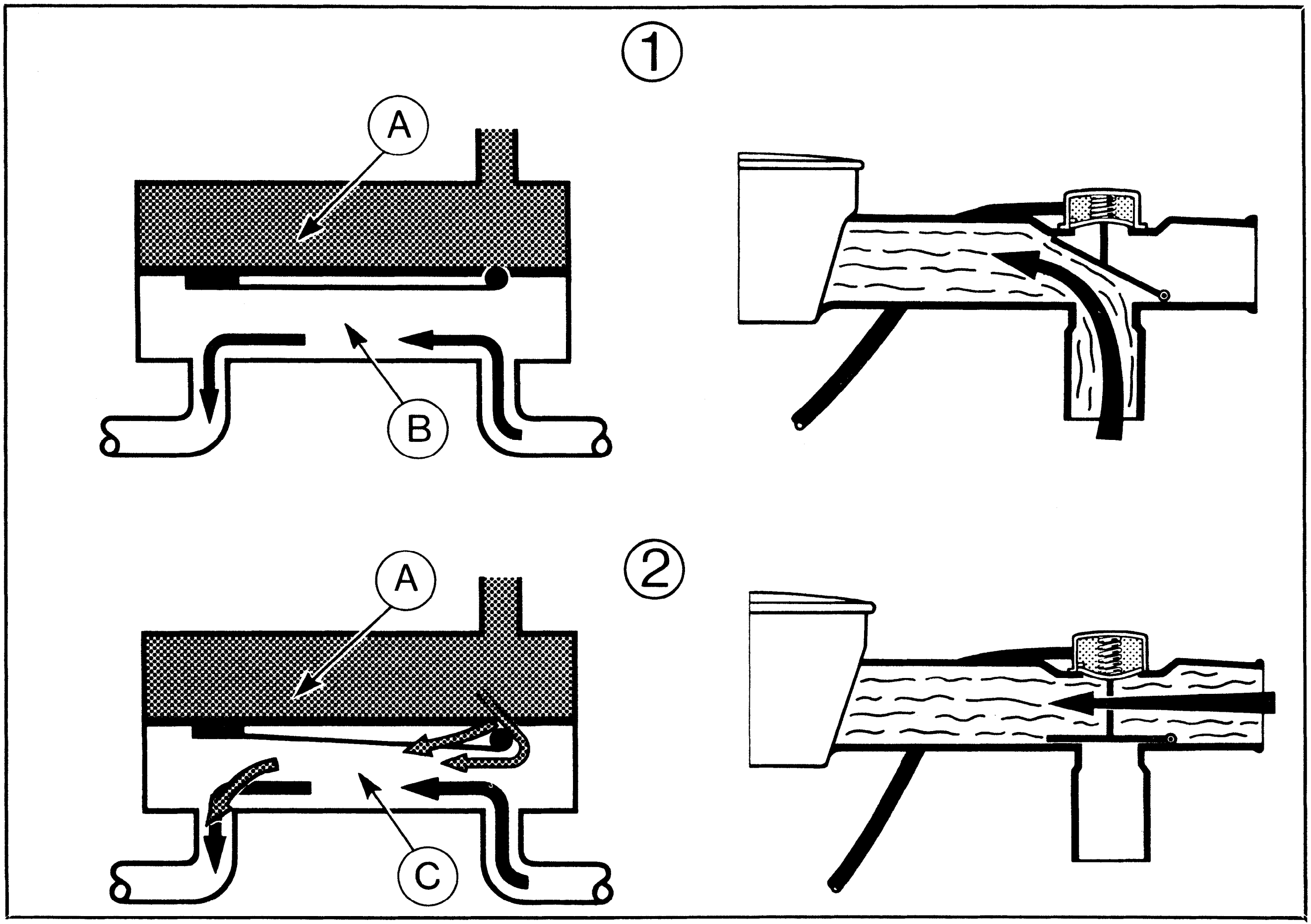


FIG. 2 Heat Sensor and Diaphragm/Duct Valve Operation
1 — Sensor Cold 2 — Sensor Hot
A — Open to Atmosphere
B — Manifold Vacuum
C — Vacuum Reduced by Air Bled Through Ball Valve

REMOVAL AND INSTALLATION

REMOVAL/AIR FILTER ELEMENT REPLACEMENT

1. Remove two screws retaining air cleaner to carburetor.
2. Raise air cleaner and disconnect crankcase ventilation hose from air cleaner and vacuum hose from intake manifold. Remove air cleaner.
3. Remove air cleaner cover. Use caution not to crack cover.
4. Remove element.

Inspection

Visually inspect the element and the air cleaner cover and body for signs of dust or dirt leaking through holes in the filter media or past the end seals. Place a light on the inside (clean side) of the filter and look through the filter at the light. Any hole in the element, even the smallest, is cause for replacement.

Installation

1. Wipe all inside surfaces of the air cleaner body and cover. Install the air filter element.
2. Install air cleaner cover to body.
3. Connect the vacuum hose to intake manifold and crankcase ventilation hose to air cleaner.
4. Position the assembly onto the carburetor and connect heat riser tube from exhaust manifold shroud to air cleaner duct.
5. Install and tighten two retaining screws.

FUEL PUMP
DESCRIPTION

A single action mechanical fuel pump is standard on this engine. It is located on the right side of the engine and is driven by a lobe on the camshaft.

The pump is permanently sealed and serviced by replacing the entire unit (Figure 3).

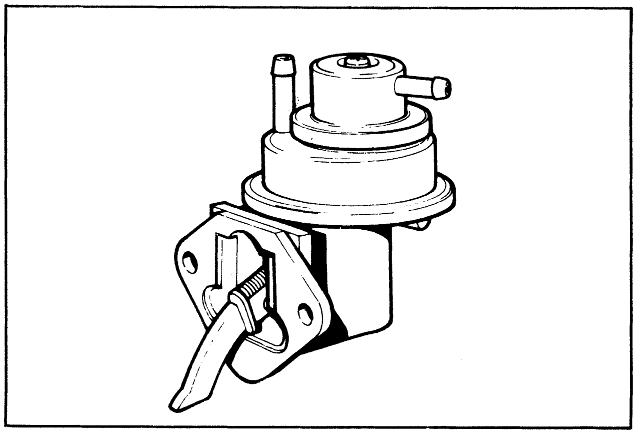


FIG. 3 Permanently Sealed Fuel Pump

DIAGNOSIS AND TESTING

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

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

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

PRESSURE TESTS

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

1. Remove the air cleaner assembly. Disconnect the fuel inlet line or the fuel filter at the carburetor. **Use care to prevent combustion due to fuel spillage.**
2. Connect pressure gauge, restrictor and flexible hose (Figure 4) between the fuel filter and carburetor.

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

3. Position the flexible fuel outlet hose and the restrictor so the fuel can be discharged into graduated container (Figure 4).
4. Before taking a pressure reading operate the engine at the specified idle rpm and vent the system into the container by opening the hose restrictor momentarily.
5. Close the hose restrictor, allow the pressure to stabilize, and note the reading.

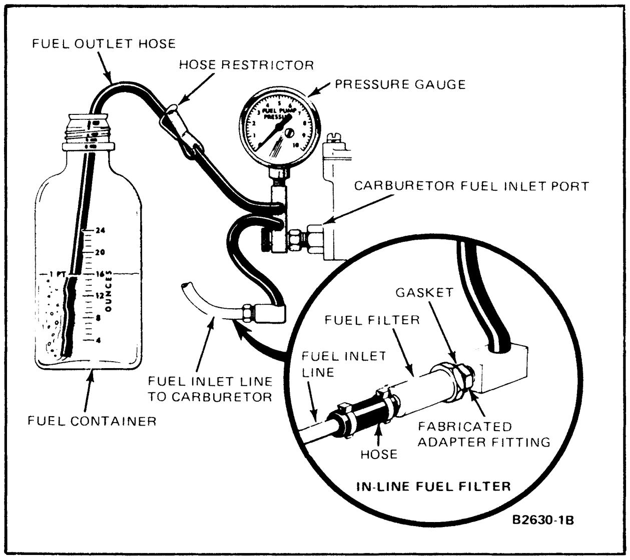


FIG. 4 Typical Fuel Pump Pressure and Capacity Test Equipment

If the pump pressure is not within specifications with temperatures normalized at idle speed and in neutral and the fuel lines and filter are in satisfactory condition, the pump is worn or damaged and should be replaced.

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

CAPACITY (VOLUME) TEST

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

1. Operate the engine at the specified idle rpm.
2. Open the hose restrictor and expel the fuel into the container (Figure 4), while observing the time required to expel one pint. Close the restrictor. One pint or more of fuel should be expelled within the specified time limit (25 sec.).

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

REMOVAL AND INSTALLATION
FUEL PUMP ASSEMBLY
Removal

1. Disconnect the inlet and outlet lines at the fuel pump.
2. Remove the pump attaching screws, then remove the pump and the gasket. Discard the gasket.

Installation

1. Remove all the gasket material from the mounting pad and pump flange. Apply oil-resistant sealer to both sides of a new gasket and to the threads on the attaching bolts.
2. Position the new gasket on the pump flange and hold the pump in position against the mounting pad. Make sure the rocker arm is riding on the camshaft eccentric. (Turn engine over until the fuel pump eccentric is on the low side of the stroke.)
3. Press the pump tight against the pad, install the attaching screws and alternately tighten them to specification.
4. Connect the fuel inlet and outlet lines.
5. Operate the engine and check for leaks.

FACET CARBURETOR

DISASSEMBLY

Disassembly consists of separating the carburetor into two basic groups: air intake and fuel bowl-throttle body and the disassembly of each of these groups. Use exploded illustration as a guide for disassembly and reassembly.

CLEANING AND INSPECTION

Thoroughly clean all metal parts in solvent or Deepalene. Blow out all parts and channels with air pressure. Inspect for damage, excessive wear, burrs or warpage. DO NOT CLEAN NON-METALLIC PARTS in solvent or Deepalene.

ASSEMBLY OF AIR INTAKE

NOTE: The following assembly instructions and the exploded illustration are generalized and include all parts possibly found in the carburetor at this time. Therefore all of the parts shown and mentioned may not be included in the particular assembly being worked on.

1. Drive channel plug (52) into vacuum channel flush with surface.
2. Drive cup plug (4) into end of choke shaft hole opposite choke lever.
3. Insert choke shaft (55) with milled flat toward top.
4. Install choke plate (2) in air intake and start screws (1). Note that edges are beveled to fit against wall when closed. On plates including poppet valve the spring should face the top. Hold choke plate closed with finger and tighten screws.
5. Turn air intake upside down and insert vacuum power piston (6) into cylinder, making sure it will move freely. Hold in place and stake casting with punch at three points to retain piston assembly.
6. Press well filler tube (7) into casting to shoulder. Do not bend or distort.
7. Press idle tube (51) into casting with rolled down orifice into casting until the bottom end is 1.25 inches from the cast surface. Do not bend or distort.

ASSEMBLY OF FUEL BOWL

1. Install the following parts as needed: (not normally removed for service)
   a. Cup plug (18) in shaft hole flush
   b. Fuel channel plug (24) flush
   c. Welch plug (25) over idle port
   d. Idle channel plug (26) flush
   e. Welch plug (32) over spark vacuum port
   f. Spark vacuum tube (33) to approx. 9/16 from casting
   g. Throttle body plug (37) flush
   h. Pump vacuum channel reducer (43) flush
   i. Pump check valve (44) flush using tool C151-53
   j. Well tube (46) making sure that end openings align with notch in casting at top and fuel channel at bottom
2. Slide seal (34) over throttle shaft with lip toward lever and install shaft in body.
3. Back out throttle stop screw (36) and place body on bench with mounting flange up.
4. With milled flat up, install throttle plate (31) with short side toward idle port and start screws (29). Make sure beveled sides of plate are next to throttle body bore. Tap the plate lightly (plate held closed) to center it and tighten screws.
5. While holding throttle closed, screw idle stop screw (36) in until it touches the casting, then screw in an additional 3/4 turn.
6. Install idle needle (28) and spring (27) and screw in to gently touch the seat. Back screw out approximately one turn.
7. Install power jet valve (14) using C161-9 wrench. No gasket required.
8. Install main jet (23) and seat firmly with screwdriver. No gasket required.
9. Install main jet plug (21) and washer (22) and tighten securely. If main jet adjustment or solenoid shutoff are used install in place of plug.
10. Turn body right side up. Insert float axle (13) into holes in float (12). Attach clip (16) to fuel valve (17) and place clip over tab on float.
11. Lower float axle and float into slot provided in body with the float needle sticking into the threaded opening. Be sure that the clip can move freely on the float tab.
12. Install the fuel valve seat (20) and washer (19) making sure that the fuel valve enters the seat properly (the valve will enter the seat more easily if the float is held in the up position) and tighten securely. Recheck clip for freedom of movement after tightening seat.
13. Insert float axle clip (11) in slot to bear against axle ends. Hold axle in place, raise float by applying light finger pressure to the float bracket. **Float pontoons should be level when the valve is seated. If not, bend tab carefully to adjust.**
14. Install o ring (56) on venturi skirt and place venturi (10) into recess provided in body making sure that the nozzle (9) lines up with the notch in the fuel well.
15. Install accelerator pump discharge parts in the following order: Ball (45), Weight (47), Spring (48), Jet assembly (49), Washer (50).
16. Place gasket (8) in position on body. Lower air intake carefully onto bowl and fasten securely and evenly using attaching screws (5).
17. Place accelerator pump diaphragm (38) in place on body with bagged section into cavity. Insert diaphragm protector (39) into end of spring (40) and install spring with protector against diaphragm.
18. Place cover (41) over spring and compress. Insert screws (42) and tighten evenly and securely.

SIDEDRAFT 87-MODEL CARBURETOR

DESCRIPTION

The 87-model Carburetor is of the single barrel horizontal design with twin floats and a single venturi built integral with the throttle body casting. The carburetor is of the "balanced" type in that all air for fuel bowl ventilation, metering well ventilation and idle operation must enter through the air cleaner. Since the metering well surrounds the discharge jet and the main jet (which are both centrally located), operation at extreme angles in any direction is permitted. The fuel supply system consists of the fuel inlet fitting, fuel valve (needle and seat), twin floats and the float chamber. The idle system consists of three idle discharge holes, idle adjusting needle, idle air passage, idle air bleed, idle jet and idle fuel pick-up passage. The high speed system consists of the venturi, main discharge jet, well vent jet, metering well and main jet. The choke system consists of the choke plate, choke shaft, external choke lever, and/or electric choke control. (Reference electric control section for operation.)

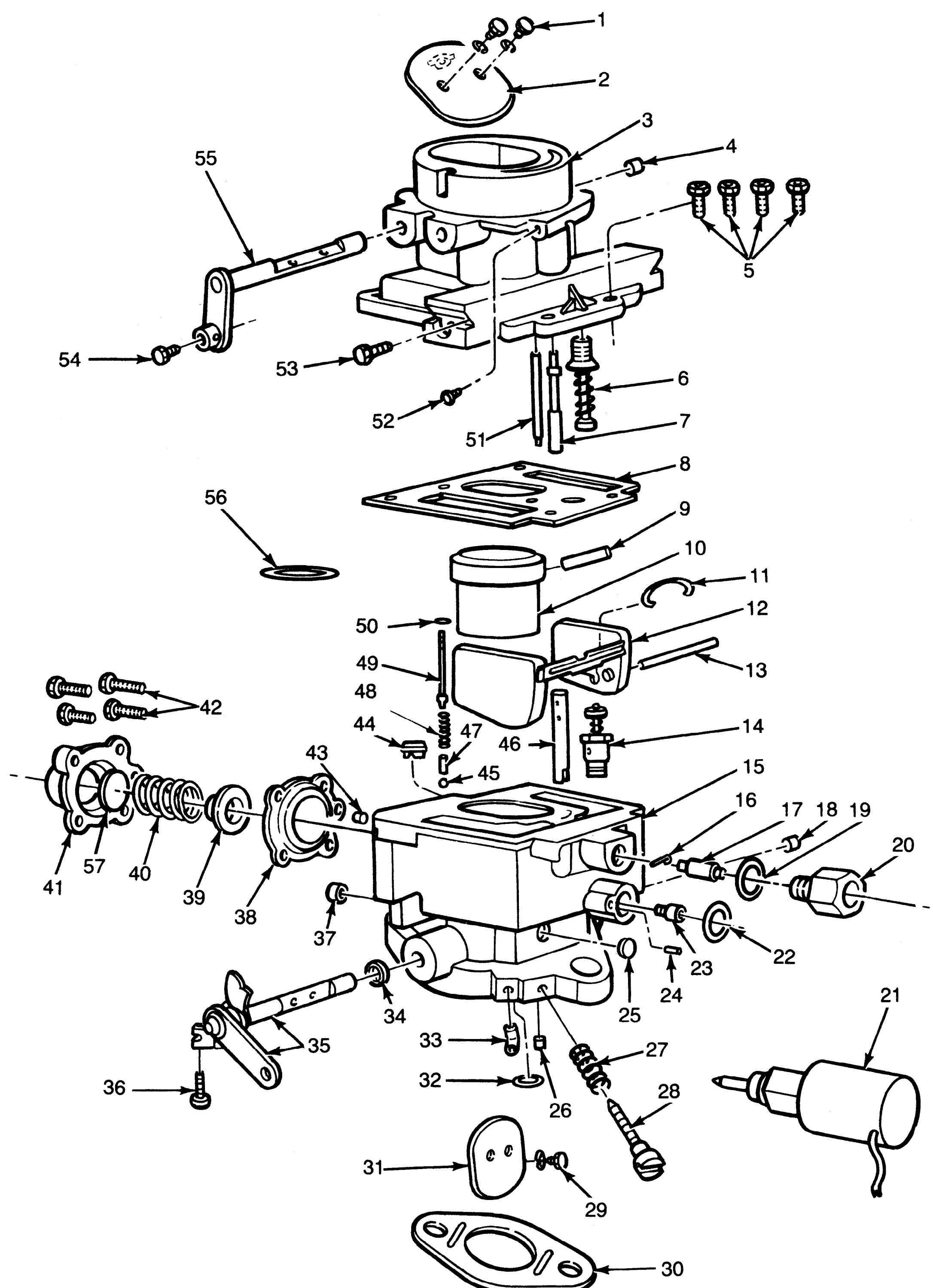


FIG. 4a Facet Carburetor

1. Screw & l'washer-choke plate
2. Plate-choke
3. Body-air intake
4.* Cup plug-shaft hole
5. Screw-intake assembly
6. Piston-vacuum power
7.* Tube-well filler
8. Gasket-intake to body
9.* Tube-discharge
10. Venturi
11. Retainer-float axle
12. Assembly-float
13. Axle-float
14. Valve-power jet
15. Body-throttle
16. Clip-fuel valve
17. Valve-fuel
18.* Cup plug-shaft hole
19. Washer-fuel valve seat
20. Seat-fuel valve
21. Idle shutoff solenoid
22. Washer-main jet plug
23. Jet-main
24.* Plug-fuel channel
25.* Welch plug-idle port
26.* Plug-idle channel
27. Spring-idle adj. screw
28. Screw-idle adjusting
29. Screw & l'washer-thro. plate
30. Gasket-manifold flange
31. Plate-throttle
32.* Welch plug-vacuum spark
33.* Tube-vacuum spark
34. Seal-throttle shaft
35. Lever & shaft-throttle
36. Screw-idle stop
37.* Plug-throttle body
38. Gasket-pump diaphragm
39. Protector-diaphragm
40. Spring-accelerator pump
41. Cover-accelerator pump
42. Screw-pump cover
43.* Reducer-pump vac. channel
44.* Assembly-check valve
45. Ball-pump discharge
46.* Tube-well
47. Weight-pump ball
48. Spring-pump weight
49. Jet assy.-accelerator
50. Washer-accel. jet
51.* Tube-idle jet
52.* Plug-vacuum channel
53. Screw-choke cable
54. Screw-choke swivel
55. Lever & shaft-choke
56. 'O' ring
57. Spacer

*Not normally removed for service

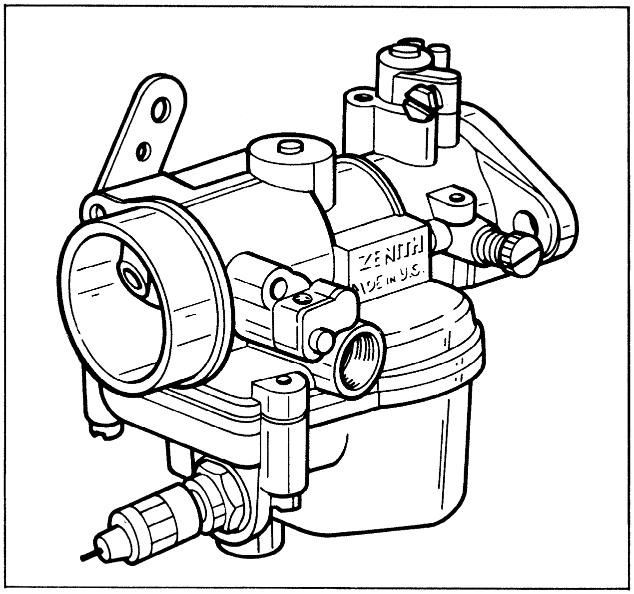


FIG. 4b External View Manual Choke

OPERATION

Fuel Supply System

Fuel under pressure is supplied through the fuel inlet fitting, fuel valve (needle and seat) to the float chamber. The floats in the float chamber automatically regulate the opening through the fuel valve (needle and seat) to maintain the proper level of fuel in the fuel bowl and meet the demands of the engine according to speed and load.

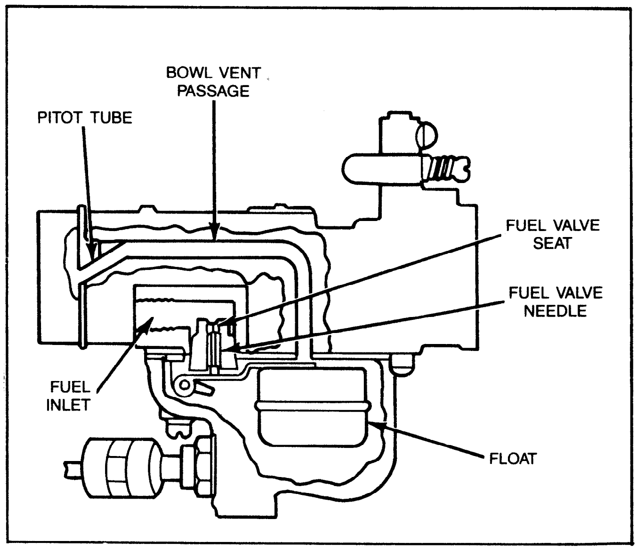


FIG. 4c Fuel Supply System

Idle System

At idle speed the throttle plate is advanced slightly from the fully closed position to expose the upper idle discharge holes to engine manifold vacuum (suction), see Figure 41. This suction is transmitted to the idle jet through a passage connecting the idle discharge holes with the idle jet. Fuel for idle is supplied through the main jet to a well at the base of the discharge jet. Fuel for idle is drawn from this well through the idle fuel pick-up passage and is metered through the idle jet calibration before entering the idle air passage. As the fuel leaves the idle jet, it is mixed with air admitted through the idle air bleed calibration. This fuel-air mixture in the idle passage is discharged into the air stream through the upper two idle discharge holes, one of which is controlled by the idle adjusting needle. Turning the idle adjusting needle IN (clockwise) reduces the amount of fuel-air that reaches the air stream to provide a lean mixture. Turning the idle adjusting needle OUT (counterclockwise) permits more of the fuel-air mixture to reach the air stream to provide a richer mixture.

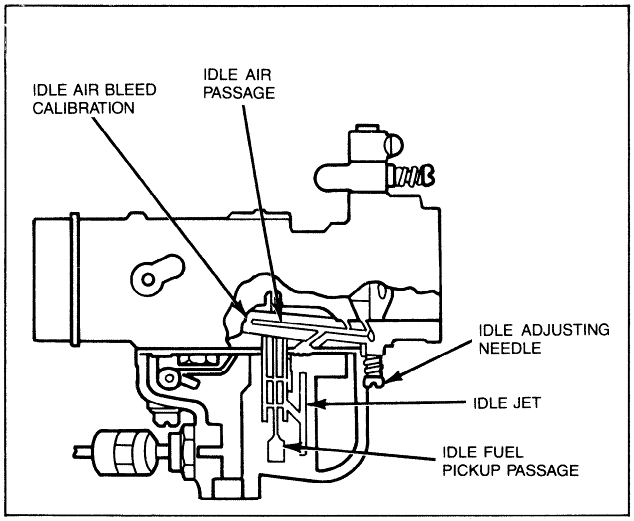


FIG. 4d Idle System

High Speed (Main Metering) System

When the throttle plate is advanced to a point just above the idle range, the suction on the idle system diminishes, but the increased volume of air entering the engine through the venturi creates sufficient vacuum (suction) on the discharge jet to draw a mixture of fuel and air from the metering well. With the float chamber vented to air intake pressure, the pressure in the float chamber causes fuel to flow from the fuel bowl through the main jet into the metering well and discharge jet where it is mixed with air taken in through the well vent jet at a point below the level of fuel in the main discharge jet. The fuel-air mixture from the main discharge jet is discharged into the air stream at the throat of the venturi and mixed with the air passing through the venturi.

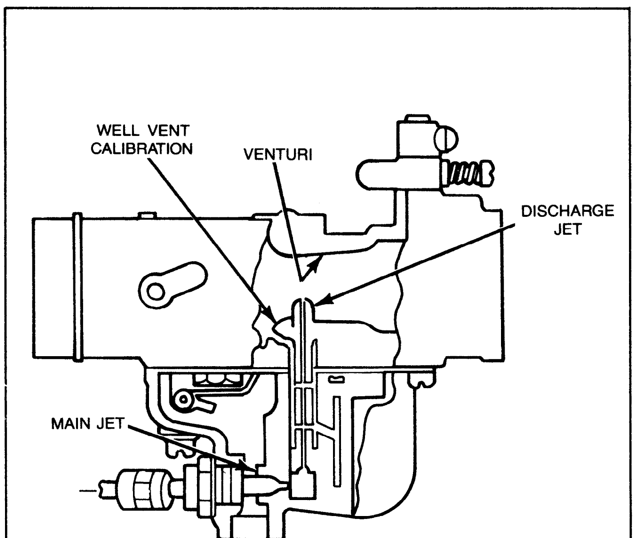


FIG. 4e High Speed System

Choke System

Closing the choke plate when starting a cold engine restricts the entrance of air to the carburetor and creates an increase in suction on the jets. The increase in suction causes more fuel to be drawn into the engine to provide the richer mixture needed for starting a cold engine. As soon as the engine begins to fire, the choke must be partially opened to prevent overchoking or flooding of the engine. As the engine warms up, the choke must be gradually opened to full open position. For electric choke control reference the electric choke control section.

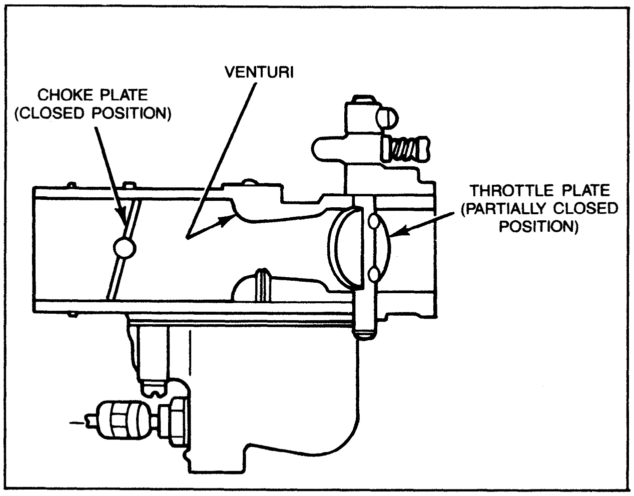


FIG. 4f Choke System

DISASSEMBLY

Removal of Throttle Body Assembly

1. Remove three bowl to body screw and lockwasher assemblies (33) and (32).
2. Raise throttle body slightly and separate bowl to body gasket (24) from fuel bowl.
3. Lift off throttle body assembly being careful not to damage floats.

Disassembly of Throttle Body

1. With throttle body inverted, remove float axle (22) by pressing against end of float axle at slotted end of hinge bracket, using screwdriver.
2. Remove float assembly (23) and fuel valve needle (part of 21).
3. Remove bowl to body gasket (24).
4. Remove main discharge jet (35), using a small screwdriver.
5. Remove fuel valve seat (21) and fiber washer (20) using C161-85 wrench.
6. Remove idle adjusting needle (11) and friction spring (10).
7. Back out throttle stop screw (6) until end of screw is flush with face of throttle stop lever. Close throttle and mark across throttle body and across throttle lever as a guide to correct reassembly of parts.
8. File off threaded end of throttle plate screws until flush with throttle shaft being careful not to damage throttle plate or throttle bore.
9. Remove throttle plate screws (43), throttle plate (42), and throttle shaft and lever assembly (9).

NOTE: If carburetor includes throttle lever (38), it will be necessary to remove nut (36), lockwasher (37) and lever (38) before throttle shaft and lever assembly (9) is removed.

10. To remove throttle shaft seal and retainer from model 87A8 carburetors, screw a 5/16″ fine thread taper tap into seal retainer until firmly seated; then insert long punch or rod through opposite shaft hole and drive punch against end of tap to remove retainer and seal.
11. Close choke and mark across air intake body and choke levers as a guide to correct reassembly of parts.
12. File off threaded end of choke plate screws and remove screws (18) and lockwashers (17).
13. Remove pitot tube setscrew (19), pitot tube (15), and choke plate (16).
14. Rest choke lever on something solid and drive out taper pin (39). Remove lever (40) and then remove choke levers (13) with shaft (14) as an assembly.
15. To remove choke shaft seal and retainer, screw threaded end of C161-185 extractor into retainer until firmly seated; then drive out extractor with retainer and seal from opposite side. Remove seal and retainer from extractor.

Disassembly of Fuel Bowl

1. Remove the idle shut-off solenoid (29).
2. Remove main jet (28) and fiber washer (27), using C161-83 jet wrench.
3. Remove idle jet (25) from machined surface of fuel bowl, using a small screwdriver.
4. Remove fuel bowl drain plug (31) from bottom of casting.

CLEANING

Thoroughly clean all metal parts in Bendix Metalclene or Speedclene and rinse in solvent. Blow out all passages and channels in the castings with compressed air. Reverse the air flow through each passage to insure the removal of all dirt particles. NEVER USE A WIRE OR DRILL TO CLEAN OUT THE JETS.

INSPECTION

Inspect all parts and replace any that are damaged or worn. Always use a Ford Repair Kit. For correct Repair Kit, refer to Ford Parts Catalog. If inspection reveals that the fit of the throttle shaft is quite loose in the throttle body bushings, then it will be necessary to install new throttle shaft bushings. The following procedure should be followed when installing new throttle shaft bushings in the throttle body.

Removal and Replacement of Throttle Shaft Bushings

NOTE: To rebush the throttle body, the following Zenith tools, as well as the new bushings, must be available:

C161-73-1	Counter-bore Reamer
C161-71-1	Shaft Line Reamer
C161-72-1	Bushing Driver

Throttle Shaft Bushings CR9-13 (for 87B5, 87B6 and 87BY6 Models).

Throttle Shaft Bushings C9-72 (for 87A8 Model).

1. Place a suitable center in drill press bed. With one throttle shaft hole on this center, bring spindle down until counterbore reamer contacts opposite shaft hole. Then set stop on drill press to length of bushing.
2. Counter-bore hole to accommodate bushings, using C161-73-1 Counter-bore Reamer.
3. Drive throttle shaft bushing in place, using C161-72-1 Bushing Driver.
4. Ream this bushing, using C161-71-1 Line Reamer.

NOTE: The opposite shaft hole is used as a "pilot" to keep reamer in alignment.

5. Turn throttle body casting over and prepare opposite shaft hole to take bushings. It will be necessary to reset stop on spindle as described above.
6. Counter-bore shaft hole, using C161-73-1 Counter-bore Reamer. Drive second throttle shaft bushing into place, using C161-762-1 Bushing Driver. Line ream this bushing as the final machining operation, using C161-71-1 Line Reamer.

NOTE: When installing new bushings in Model 87A8 carburetors, counter-bore reamer is not used and counter-bore reaming operation is omitted.

RE-ASSEMBLY

Assembly of Fuel Bowl

1. Install main jet (28) and fiber washer (27), using C161-83 jet wrench.
2. Install the idle shut-off solenoid (29) in threaded hole near bottom of fuel bowl.
3. Install idle jet (25) in recessed threaded hole of fuel bowl casting, using small screwdriver.
4. Install fuel bowl drain plug (31) in bottom of casting.

Assembly of Throttle Body

1. To install choke shaft seal and retainer, insert seal in open side of retainer, then place seal and retainer on C161-72-1 bushing driver. Insert small end of driver in choke shaft hole. Start retainer in counter-bore of body and lightly drive retainer into body flush with shaft boss.
2. Install choke shaft and lever assembly (13 and 14) and rotate shaft so that cut section faces out.
3. Slide choke plate into position and align hole in plate with holes in shaft. Then start choke plate screws (18) with lockwashers (17), leaving screws loose.
4. Close choke and center for best closing. Tighten screws securely.
5. On units which include choke lever (40), assemble lever to choke shaft in same position as lever was in originally, using taper pin (39).
6. Install pitot tube (15) in same position as before removal and secure with set screw (19).
7. On 87A8 Models – Install seal in throttle shaft counter-bore with lip side out and then install seal retainer flush with machined surface of throttle shaft boss.
8. Install throttle shaft and lever assembly (9) in throttle body and rotate shaft to open position.
9. Insert throttle plate (42) in milled slot of shaft. Align holes in plate with holes in shaft and start throttle plate screws (43). Make sure throttle plate is in same position as before disassembly.
10. Close throttle several times to center throttle plate. Hold throttle plate closed and tighten screws.
11. On carburetors which include throttle lever (38), assemble lever on shaft in same position lever was in before disassembly and attach to shaft with lockwasher (37) and nut (36).
12. With throttle plate fully closed, turn throttle stop screw (6) in to the point of initial contact with the throttle stop; then turn stop screw IN (clockwise) one-half to three-quarters of a turn as a preliminary idle speed setting.
13. Install idle adjusting needle (11) and spring (10). Turn needle in lightly against its seat and then back needle OUT (counterclockwise) one full turn as a preliminary idle adjustment.
14. Install fuel valve seat (21) and fiber washer (20), using C161-85 wrench.
15. Install main discharge jet (35), using a small screwdriver.
16. Install fuel valve needle (21) in seat and position float assembly in hinge bracket. Insert tapered end of float axle (22) into float bracket at side opposite slot in bracket. Push float axle through slotted end of the bracket until centered in bracket, using handle of screwdriver.
17. To insure correct fuel level in float chamber, check distance "A" from top center of float bodies to machined surface (no gasket), see Figure 7. This dimension should be as follows:

Carburetor Model	Dimension "A"
87 Series with C81-17 Fuel Valve and Seat	31/32"
87 Series with C81-50 Fuel Valve and Seat	23/32"

To increase or decrease distance between top of float bodies and machined surface, use long nose pliers and bend lever close to float body.

NOTE: Do not bend, twist or apply pressure on the float bodies. The float bodies when viewed from the free end of the bodies must be centered and at right angles to the machined surface and must move freely on the float axle.

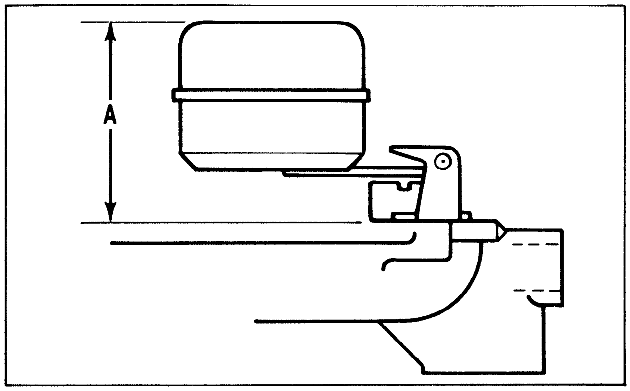


FIG. 4h Float Setting

Assembly of Bowl to Throttle Body

1. Place bowl to body gasket (24) on machined surface of throttle body.
2. Position bowl assembly on throttle body, being careful not to damage floats, and align holes in bowl with holes in gasket and throttle body.
3. Install two long and one short bowl to body screws (32) and (33) with lockwashers (34) and tighten screws evenly and securely.

Adjustments

Final adjustment should be made on the engine with the specified air cleaner in place and the engine at normal operating temperature.

SPECIAL TOOLS REQUIRED

C161-71-1	Shaft Line Reamer
C161-72-1	Bushing Driver
C161-73-1	Counter-bore Reamer
C161-83	Jet Wrench
C161-85	Fuel Valve Wrench
C161-185	Extractor Tool

NOTE: Special tools are available from the Facet dealer in your area.

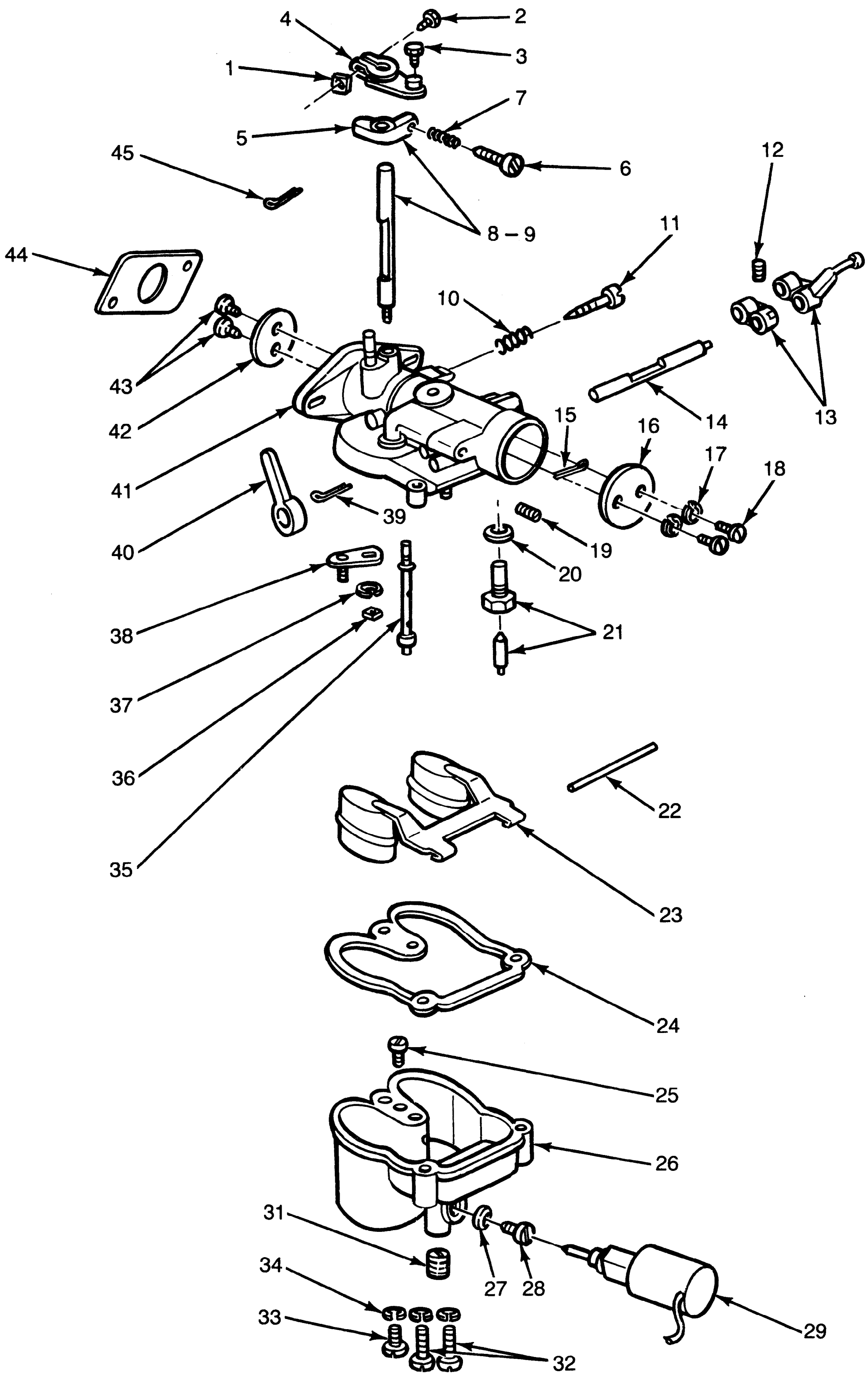


FIG. 4g Sidecraft Model Carburetor

1. Nut
2. Screw
3. Screw
4. Throttle lever
5. Throttle lever
6. Throttle stop screw
7. Spring
8. Throttle lever
9. Throttle shaft/lever
10. Friction spring
11. Idle adjusting needle
12. Set screw
13. Choke levers
14. Choke shaft
15. Pitot tube
16. Choke plate
17. Washers
18. Screws
19. Set screw
20. Fiber washer
21. Fuel valve seat assemble
22. Float axle
23. Float assembly
24. Body gasket
25. Idle jet
26. Fuel bowl
27. Fiber washer
28. Main jet
29. Idle shut-off solenoid
31. Drain plug
32. Lock washer assembly
33. Lock washer assembly
34. Lock washer
35. Main discharge jet
36. Nut
37. Lock washer
38. Throttle lever
39. Taper pin
40. Choke lever
41. Carburetor body
42. Throttle plate
43. Screws
44. Gasket
45. Taper pin

VARIABLE VENTURI CARBURETOR

DESCRIPTION

The variable venturi carburetor adjusts the size of the venturi to match the engine's air demand thereby retaining the high air intake speed required for good fuel atomization. For example, at maximum engine speeds the air valve in the venturi is fully open allowing sufficient air to enter the engine to produce maximum power output. As the engine speed and power reduces, the air required for the engine is also reduced. The air valve closes the venturi which results in a high air speed similar to that achieved at high engine revolutions being available throughout the whole engine speed range.

Figure 5 shows the variable venturi carburetor in the low engine speed condition. Note that the air valve has reduced the size of the venturi resulting in a much higher air speed.

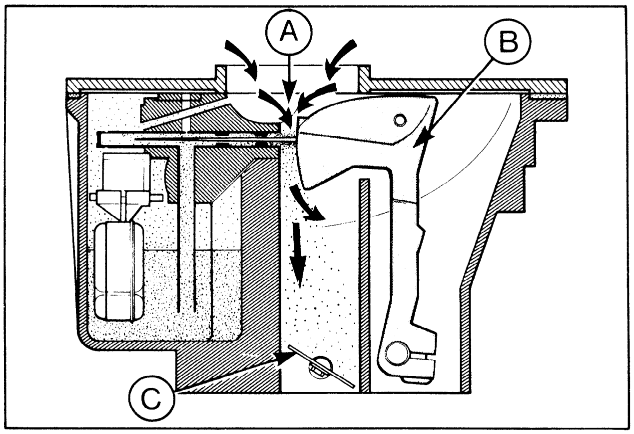


FIG. 5 Variable Venturi Carburetor at Low Engine Speed and Load
A — Air Intake
B — Air Valve (Almost Closed)
C — Throttle Plate

Control of the air supply on both Variable Venturi and Fixed Venturi carburetors is achieved by a throttle butterfly plate mounted in the venturi. It is in the method of controlling the fuel that the types of carburetor differ.

On the fixed venturi unit the main system does not discharge until the throttle plate is open and the increased air flow creates sufficient vacuum to pull fuel through the main nozzle.

It is difficult to achieve a smooth transition from the idle to the main system and at the point where the main jet system comes into operation, fuel atomization is poor with large droplets of fuel being fed into the engine. A good drive condition is achieved during this transition by richening the mixture strength to compensate for the poor fuel atomization.

The variable venturi carburetor does not have this disadvantage because the main jet system, with its associated high velocity, is in operation at all engine speeds and loads.

The reason fuel is drawn in through the main jet system on the VV carburetor at low engine speeds and loads is that the vacuum at the main jet outlet is high, due to the air valve reducing the venturi size and thereby increasing the air velocity.

The amount of fuel passed into the engine is controlled by a tapered metering rod, attached to the venturi valve, which slides through the main jet (Figure 6). As the engine's fuel demand is increased the tapered rod is pulled outwards through the main jet. This enlarges the main jet size and therefore allows more fuel to be fed through the system.

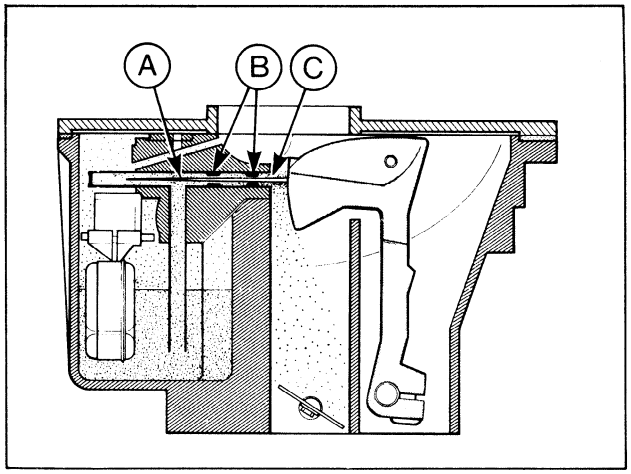


FIG. 6 VV Main Jet System
A — Tapered Metering Rod
B — Main and Secondary Jets
C — Main Fuel Outlet

OPERATION

The operation of the VV carburetor has been sub-divided into nine sub-systems to help simplify and explain its various working conditions.

- Fuel Input
- Venting System
- Air Control
- Main Fuel Control
- Idle System
- Throttle Operation
- Accelerator Pump
- Choke Operation
- Anti-Dieseling Valve

FUEL INPUT SYSTEM

Fuel input is via an inlet filter, located in the inlet tube, a conventional needle valve and a float located in the float chamber (Figure 7).

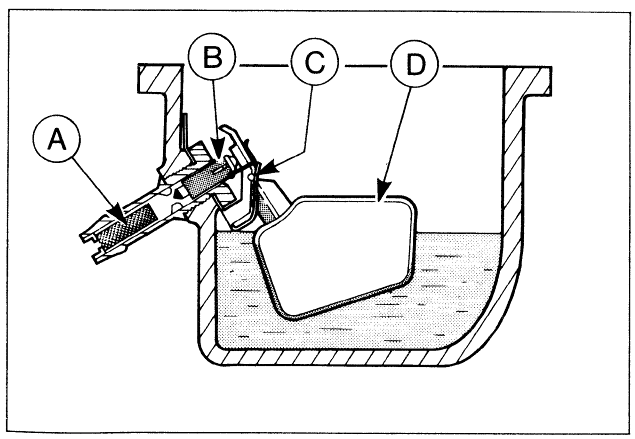


FIG. 7 Fuel Input System
A — Inlet Filter
B — Needle Valve
C — Float Pivot
D — Float

The float level on variable venturi carburetors is not adjustable as small variations in fuel level have no effect on carburetor performance.

The needle valve (Figure 8) has an override system which consists of a light spring, built into the valve, and a plunger. The purpose of the system is to ensure that a steady force is exerted on the needle against the valve seat over a range of float travel. This reduces needle chattering caused by engine and vehicle vibration which would otherwise lead to an unacceptable rise in fuel level.

The leading end of the valve is "Viton" coated. This is a thin rubberized coating applied to ensure that a good seal is achieved between the valve and valve seat.

Needle valve movement is also governed by a clip, attached to the top of the valve, which is hooked around a cut-out in the float arm. This prevents the valve sticking at low float level conditions.

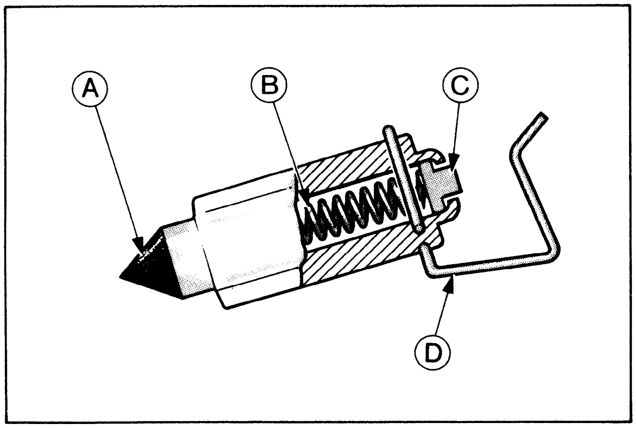


FIG. 8 Needle Valve Assembly
A — Leading End "Viton" Coated
B — Spring
C — Plunger
D — Clip

FLOAT CHAMBER VENT SYSTEM

Figure 9

This carburetor incorporates a closed or internal vent system. This has been achieved by venting the vapor from the float chamber, through a drilling in the main jet body and into the carburetor air inlet.

AIR CONTROL

Air control is achieved by the air valve which varies the size of the venturi to respond to the engine's air demand. The air valve is operated by a diaphragm which is controlled by vacuum, sourced from a point in the venturi between the air valve and throttle butterfly. This depression created in the venturi is known as the control vacuum. The air valve and vacuum diaphragm are directly coupled by levers which means that any movement of the diaphragm is directly transferred to the air valve.

At idle when the engine air requirements are low the air valve is held in its rest position by the diaphragm return spring (Figure 11). This results in a high air speed over the main jet outlet, but because the throttle plate is closed the control vacuum is comparatively low. As the throttle plate is opened the engine's air demand rises and the control vacuum in the venturi increases. This control vacuum is fed to the diaphragm which pulls back, against a spring load, and opens the air valve until a balance between the forces of the control spring and the control vacuum are equal.

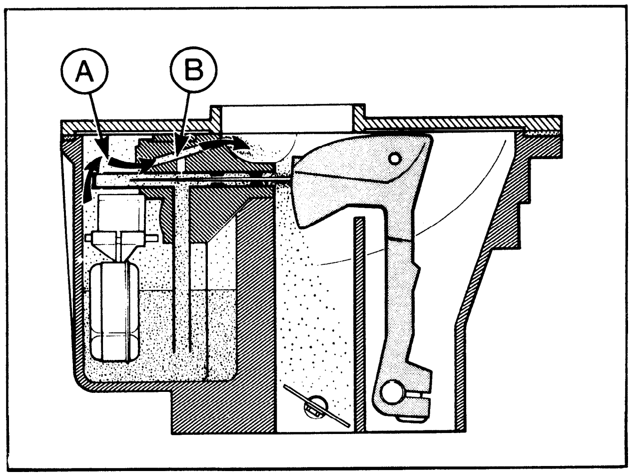


FIG. 9 Float Chamber Vent System
A — Fuel Vapor
B — Vent Gallery

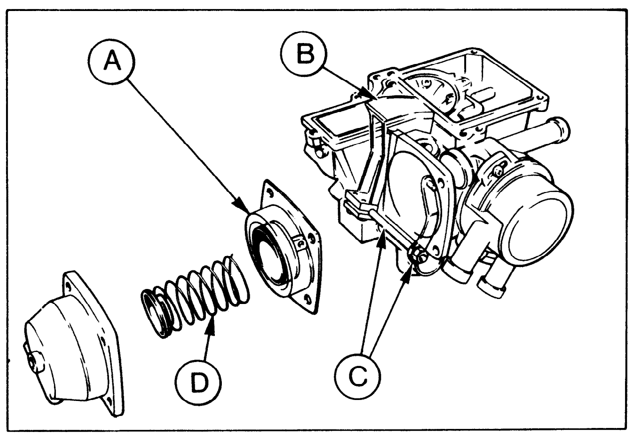


FIG. 10 Air Control System
A — Vacuum Diaphragm
B — Air Valve
C — Operating Linkage
D — Diaphragm Return Spring

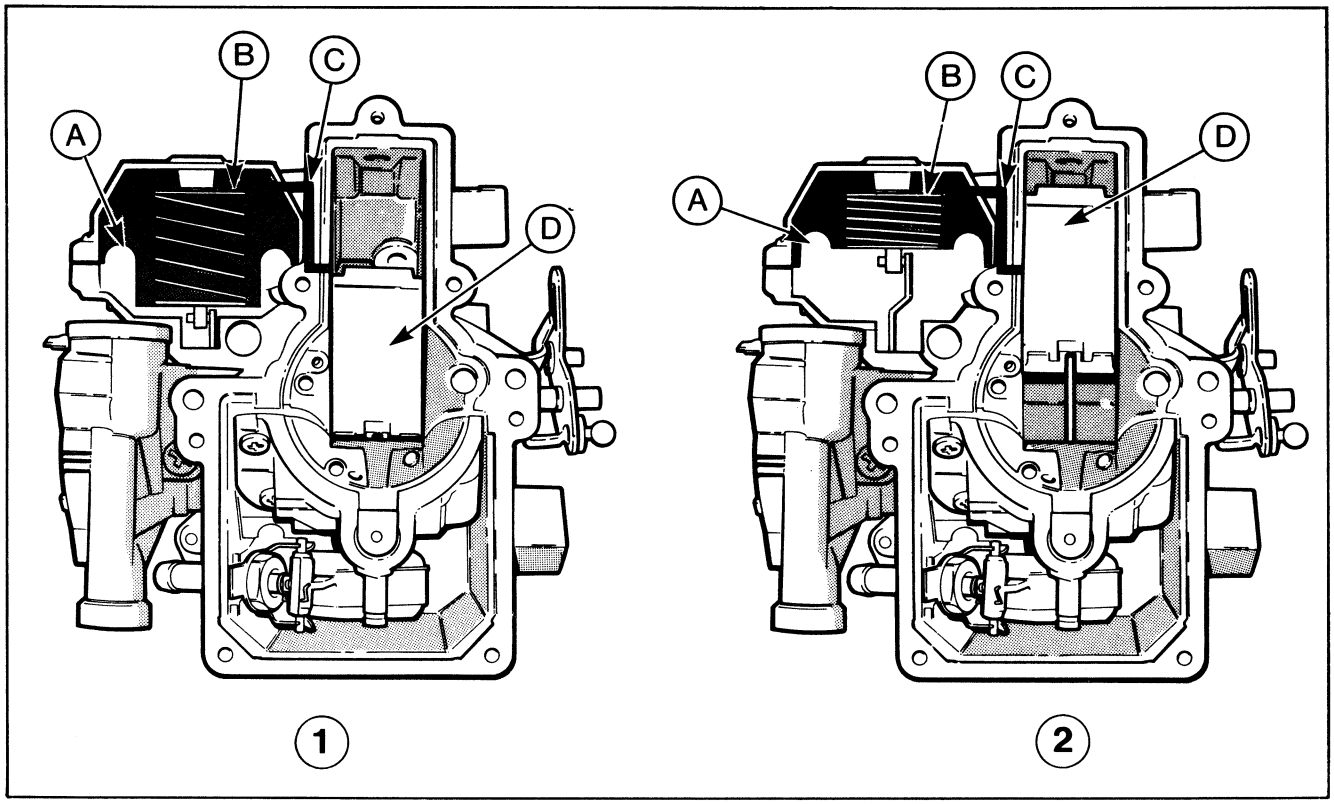


FIG. 11 Two Extreme Conditions of Air/Vacuum Control System, Showing System at Idle (1) and at Full Throttle (2)
A — Vacuum Diaphragm C — Control Valve Source
B — Return Spring D — Air Valve Position

MAIN FUEL CONTROL SYSTEM

The main fuel control system consists of a pick up tube, main and secondary jets and a tapered metering rod. Fuel is drawn from the float chamber, up the pick up tube, metered through both jets and tapered needle and into the engine due to the vacuum created in the venturi between the main jet body and the air valve. Note that the fuel outlet is located opposite the air valve.

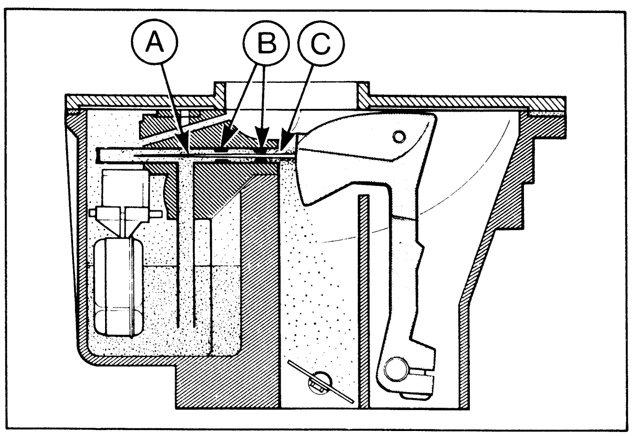


FIG. 12 Main Jet System
A — Tapered Metering Rod
B — Main and Secondary Jets
C — Main Fuel Outlet

Under light loads the metering rod, which is attached to the air valve, almost closes the main jet. As engine load increases the air demand increases with the effect that the air valve opens pulling the rod through both jets allowing additional fuel to be supplied to the engine. The rod's tapered shape controls the amount of fuel supplied to the engine. It is accurately machined and adjusted in production therefore allowing the correct amount of fuel to pass for all engine load conditions. **Therefore the setting of this rod must not be disturbed in service.**

IDLE SYSTEM

Figure 13

On VV carburetors 70% of the idle fuel mixture is supplied through a separate (sonic) idle system, the remaining 30% being drawn from the main system. This proportioning has been found to give optimum idle quality.

With the exception of the air bleed, all the air used by the engine at idle is drawn past the venturi and main jets. It then splits into two streams: one passes the throttle plate and the other passes around the sonic idle system where more fuel is added. The air passing the throttle plate can be varied to provide idle speed adjustment. The small opening of the throttle plate also prevents the butterfly from becoming seized in the bore as the carburetor body contracts during the cooling period after engine switch off.

Fuel supply for the idle system is sourced from the main pick up tube, metered through the idle jet, and mixed with air from an air bleed fitted into the main jet body. The rich air/fuel mixture is then drawn through internal galleries down to the mixture control screw which regulates the amount of fuel to be fed into the engine from the idle system. The fuel mixture is then atomized with air drawn through the by-pass idle channel and fed into the engine through the sonic discharge tube.

The air is accelerated to a high speed and forms shock waves due to the high pressure difference that exists across the discharge tube. The fuel is atomized when the droplets pass through these shock waves and is then fed directly into the intake manifold below the throttle plate.

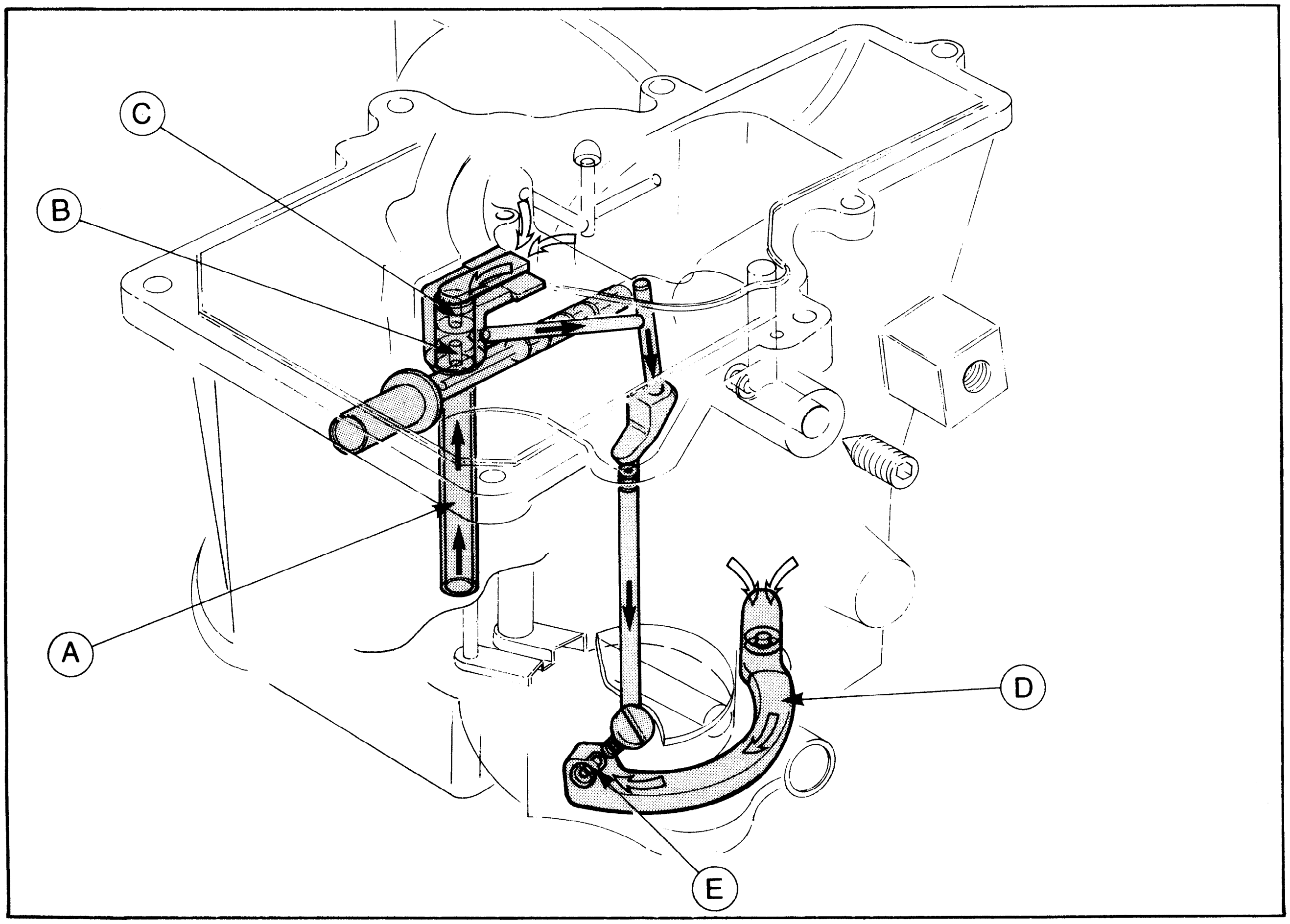


FIG. 13 Idle System
A — Main Pick Up Tube
B — Idle Fuel Jet
C — Idle Air Jet
D — By-Pass Gallery
E — Sonic Discharge Tube

THROTTLE OPERATION

The same basic carburetor is used for all engines. Therefore it can be seen that the throttle bore has to be sufficiently large to pass the air requirements for the larger engines to meet its power needs. However, on the smaller engines maximum air requirements can be achieved with only 75% of throttle. This could make initial opening very sensitive.

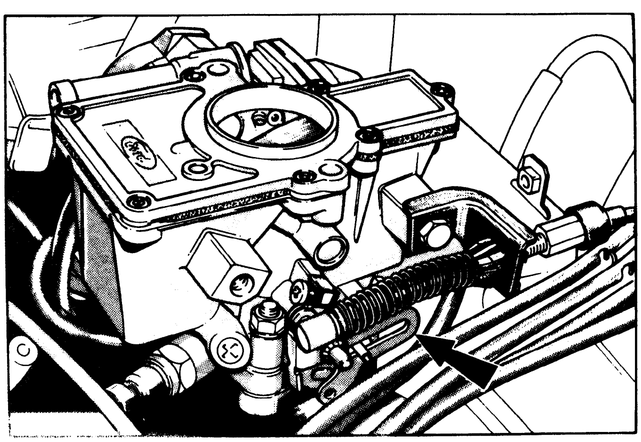


FIG. 14 Progressive Throttle System

To overcome this the throttle linkage has been made progressive with a cam and roller mechanism so that a large initial throttle movement will only give a small throttle plate opening. As the full travel is approached the throttle plate movement is very rapid.

ACCELERATOR PUMP

The accelerator pump is vacuum controlled. The system senses the fall in manifold vacuum and injects fuel directly into the venturi, enriching the mixture and minimizing any hesitation. Under normal operating conditions a vacuum, obtained from beneath the throttle plate, is available at the pump and pulls a diaphragm back against a spring load. This in turn draws fuel, through internal galleries, from the float chamber. In this situation the pump inlet one way valve is open and the outlet one way valve is closed (Figure 15).

The system also includes a back bleed, located in the pump, and a vacuum break air hole, located at the fuel outlet. The function of each is detailed later.

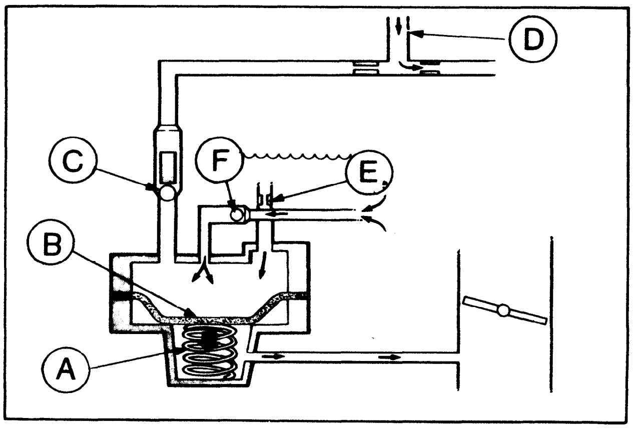


FIG. 15 Accelerator Pump System — Inlet
A — Return Spring (Compressed)
B — Diaphragm
C — One Way Valve
D — Vacuum Break Air Hole
E — Back Bleed
F — One Way Valve

Pump Back Bleed

During prolonged idle the air temperature in the engine compartment will rise considerably. This has the effect of boiling or gassing the fuel contained in the accelerator pump reservoir, resulting in ineffective operation when the pump is next used. This fuel vapor, created in the pump, would seep into the system and therefore richen the idle air/fuel mixture by discharging fuel from the pump jet. The back bleed overcomes this condition by allowing vapor to bleed back into the float chamber, allowing cooler fuel to feed into the pump.

Vacuum Break Air Hole

During normal operation the air speed and therefore the vacuum at the fuel outlet is high. This vacuum during high speed operation would be strong enough to pull fuel through the accelerator pump system. The vacuum break air hole function is to overcome this condition by allowing air to bleed into the pump outlet pipe and lowering the vacuum created at the accelerator pump jet. Note that the bleed hole is located on the outlet side of the pump jet.

When the vehicle is accelerated the vacuum signal beneath the throttle plate drops rapidly which results in the return spring pushing the diaphragm back to its rest position (Figure 16). The

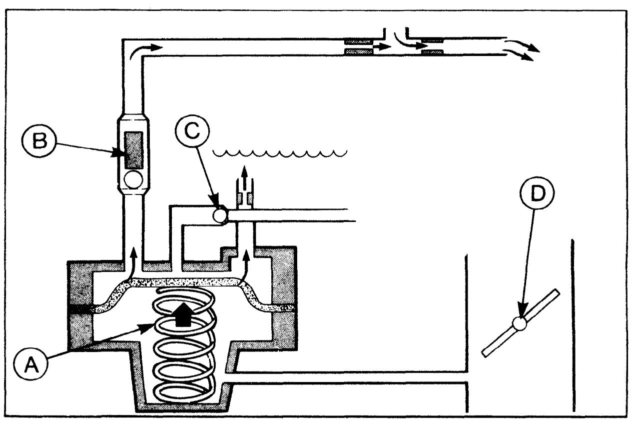


FIG. 16 Accelerator Pump System — Outlet
A — Return Spring (Extended)
B — Outlet One Way Valve (Open)
C — Inlet One Way Valve (Closed)
D — Throttle Plate (Open)

fuel reserve that was initially drawn into the pump is then injected through internal galleries past the outlet one way valve and into the venturi.

MANUAL CHOKE OPERATION

The manual choke unit is activated by the lever housing which is controlled by the cable and switch assembly. The lever housing replaces the bi-metal housing of the automatic choke and contains a spring loaded lever which engages on the choke linkage. Even though it is a manual choke system the pull down piston still activates the choke linkage.

The actual choke system operates like a miniature carburetor utilizing a variable needle jet and a variable air supply.

The choke assembly consists of a tapered needle valve, operating linkage and a vacuum operated pull down piston. The principle of operation for the choke system is split into three parts:

- Choke Fuel Supply and Control
- Choke Air Supply and Control
- Choke Pull Down System

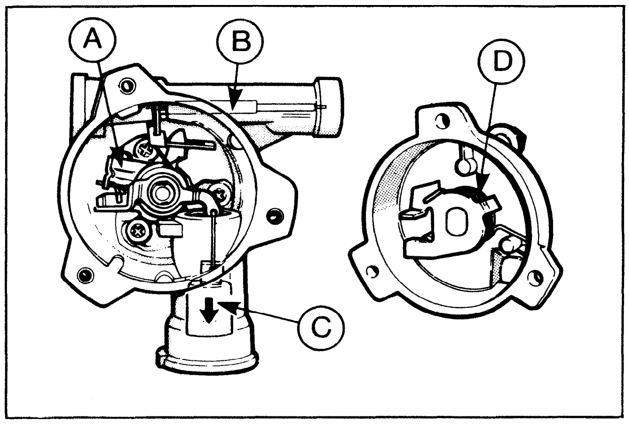


FIG. 17 Manual Choke and Lever Assemblies
A — Choke Linkage
B — Needle Valve
C — Pull Down Piston
D — Spring Loaded Lever

Choke Fuel Supply and Control

Fuel supply to the choke is sourced from the choke pick up tube and partially emulsified by air being bled into the upper section of the supply tube. Fuel is then fed through internal galleries in the main jet body and into the tapered needle valve in the choke housing. As the needle valve is tapered it has the ability to vary the fuel fed through the choke system to match the engine's requirements.

The tapered needle position on a manual choke is controlled by choke cable movement. With the cable fully out the choke jet is fully open allowing maximum fuel delivery. Careful manipulation of the cable will achieve the optimum fuel delivery for each engine load and temperature condition.

Choke Air Supply and Control

Cold engines require extra power to overcome friction, therefore extra air and fuel must be added. The choke air supply is sourced from a point in the venturi above the throttle plate. The air/fuel mixture is fed into the engine beneath the throttle plate, thus forming a throttle by-pass system. The choke air valve is a brass sleeve attached to the central spindle of the choke levers and has a hole drilled through its side wall (Figure 19). When the needle valve is fully out (choke on) the drilled hole lines up with an outlet gallery. The choke fuel is added to the choke air supply before it enters the end of the sleeve and the resulting mixture is supplied to the engine below the throttle plate.

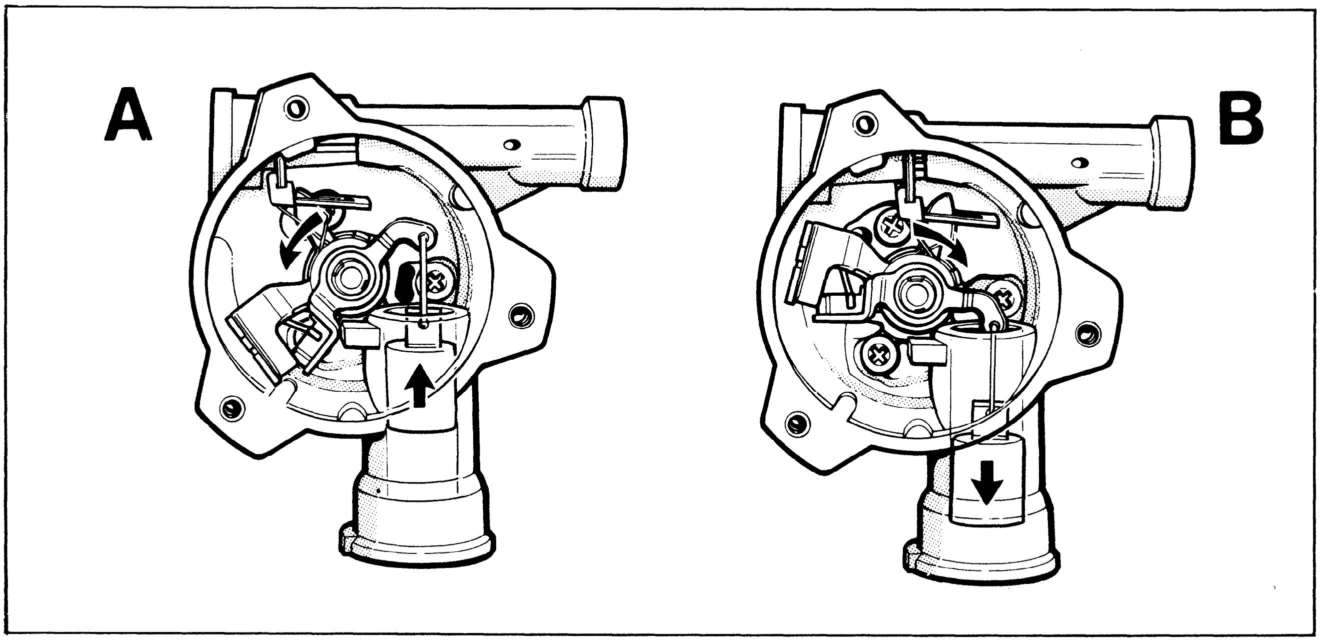


FIG. 18 Two Extreme Conditions of Choke Operation
A — Fully Operational (Choke Operating Lever Fully Counterclockwise)
B — Fully Closed Down (Choke Operating Lever Fully Clockwise)

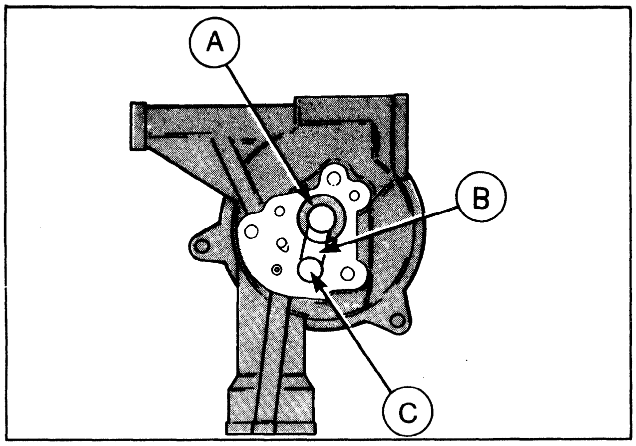


FIG. 19 Air Supply System in Operation
A — Brass Sleeve Attached to Central Shaft and Aligned to Outlet Gallery
B — Outlet Gallery
C — Mixing Chamber and Air Fuel Outlet

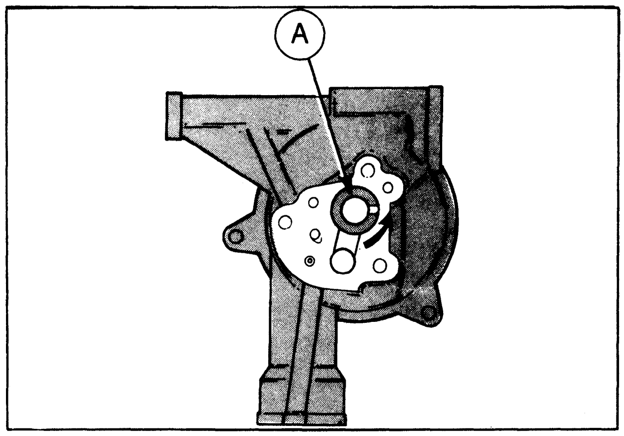


FIG. 20 Air Supply System Closed Down
A — Brass Sleeve Blocking Outlet Gallery

As the choke cable is pushed in, the central shaft is turned with the effect that the control sleeve restricts the mixture flow through the system. When the central shaft is fully counterclockwise (choke off), the air outlet gallery is blocked (Figure 20).

Choke Pull Down System

With a cold engine at a light load or cruise condition it is not necessary to have such a rich mixture as that required during acceleration or heavy load. The choke therefore incorporates a pull down system which pulls the choke off during engine cruise conditions. This system improves emission levels and fuel economy during engine warm up. The system consists of a vacuum piston connected through levers to the central choke spindle. The piston is vacuum operated from a source in the venturi beneath the throttle plate. During acceleration, when the throttle plate is open, the vacuum signal beneath the plate and at the pull down piston is low. Therefore, during acceleration the system has no effect on choke operation. As the cold engine returns to a steady state or idle condition the vacuum signal increases pulling the piston downwards.

With manual choke assemblies, the pull down system will still operate. When the choke lever is fully counterclockwise (full choke) the pull down lever linkage is not held against the choke lever. When the pull down vacuum is high the pull down lever linkage is rotated clockwise until it is pressed against the choke lever. This will reduce the choke fuel supply by moving the needle valve further into its housing. This choke fuel reduction will occur for most positions of the choke lever which is controlled directly by the cable. Therefore the manual choke assembly is both manually and automatically controlled.

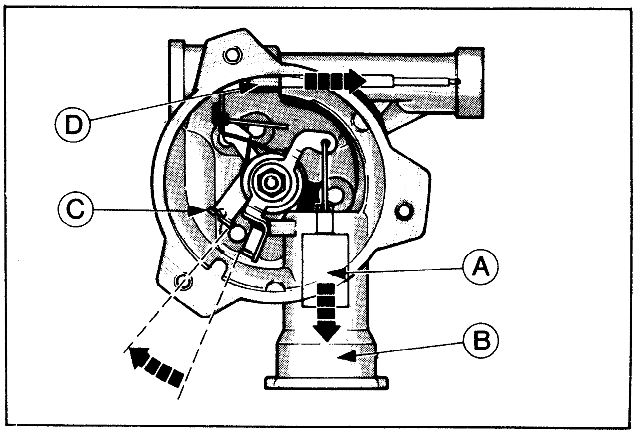


FIG. 21 Manual Choke Pull Down System Operation
A — Pull Down Piston Movement
B — High Vacuum
C — Choke Lever Fully Counterclockwise
D — Needle Valve Closing

ELECTRIC CHOKE CONTROL OPERATION

The electric automatic choke control as adapted to the carburetor is a part of the carburetor assembly. The choke control is attached directly to the choke shaft and controls the opening and closing of the choke plate in accordance with engine operating temperatures. On down-draft and side-draft type carburetors, an external vacuum line is required to provide manifold vacuum which is used to open the choke plate partially, after the initial firing of the engine. The heat for operating the thermostat spiral spring is provided by an electric heating element (6 or 12 volts) in the thermostat chamber. A fast idle cam and rod mechanism connected to the throttle shaft provides fast idle during the warm-up period. A pin located on the stop lever provides a positive means of opening the choke plate should the engine fail to start due to over-choking.

CAUTION: Make sure choke unit voltage matches ignition system voltage. The electrical connection of the choke must be connected to the ignition switch so that current flows ONLY when the ignition switch is turned on.

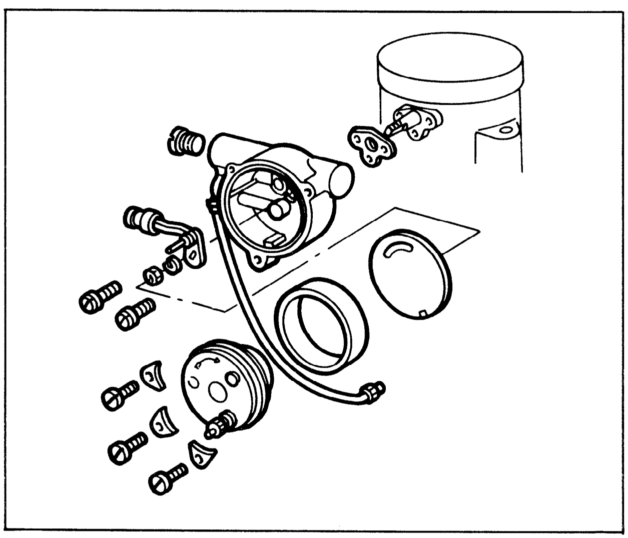


Fig. 21A Electric Choke Control Assembly

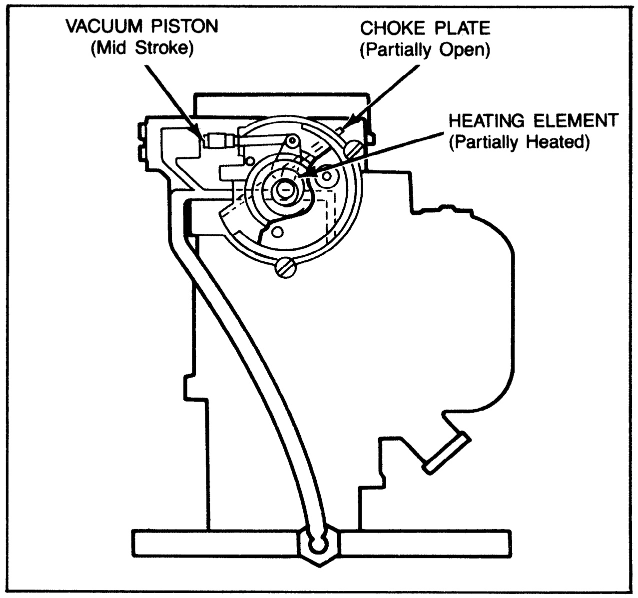


Fig. 21B Choke Partially Open, Engine Warming Up

As the engine starts, manifold vacuum exerts a pull on the vacuum piston (against the tension of the thermostat spiral spring) to open the choke plate and admit sufficient intake for a satisfactory running mixture.

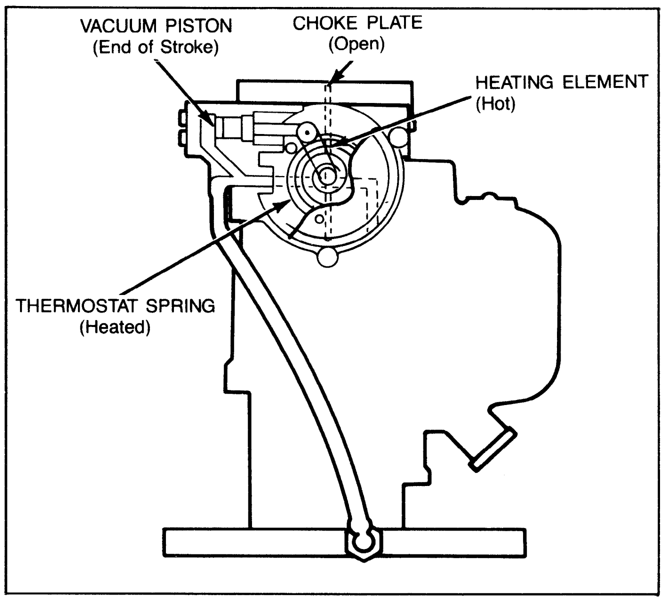


Fig. 21C Choke Open, Engine Warm

The heat applied by the electrical heating element gradually warms the thermostat spiral spring to decrease its tension, permitting the vacuum piston to gradually open the choke plate.

ANTI-DIESELING VALVE

The purpose of the valve is to block the idle system when the ignition is turned **off** preventing engine dieseling.

With the ignition on, a 12 volt supply is fed to the solenoid valve which holds back a plunger against a spring load. This allows air/fuel mixture to flow through the carburetor idle galleries. When the valve power is cut the return spring pushes the plunger into the end of the sonic discharge tube shutting off the mixture flow in the sonic idle system (Figure 22).

The tip of the plunger is "Viton" coated to ensure that a good seal is achieved between the plunger and sonic discharge tube.

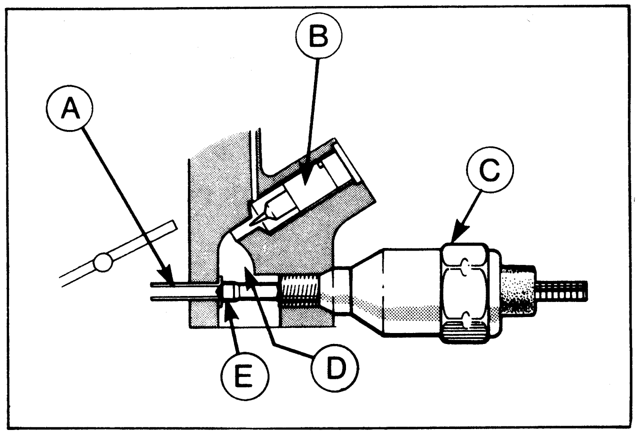


FIG. 22 Anti-Dieseling Valve System
A — Sonic Discharge Tube
B — Mixture Screw
C — Solenoid Valve
D — Bypass Air Channel
E — Tip "Viton" Coated

DIAGNOSTIC CHECKS AND ADJUSTMENTS

The following are useful checks for diagnosing a malfunctioning VV carburetor.

- Check that all accessible nuts or screws are tight and gaskets are correctly positioned.
- Check that the anti-dieseling solenoid is operating. If solenoid is operating an audible click should be heard when the ignition is switched "on" and "off."
- Check throttle linkage for smooth operation by rotating throttle lever by hand to the full throttle position then slowly back to the idle position feeling closely for sticking or binding. Be sure throttle linkage is adjusted to give full throttle.
- Check accelerator pump discharge. With the air cleaner removed and its vacuum supply plugged, warm up engine to normal operating temperature. Open and close throttle three times and, with engine idling, pull open air valve manually observing accelerator pump discharge. Discharge should be a clean shot angled across venturi lasting approximately 2 seconds.
- Check that the manual choke operating linkage is correctly engaged on the choke lever.
- Check manual choke operation ensuring both maximum and minimum travel is achieved.

NOTE: There should be a gap of approximately 1.0 mm (.039 in.) between the lever and the stop in the choke "OFF" position.

- Be sure that the idle speed and fuel mixture are correct.

IDLE FUEL MIXTURE AND IDLE SPEED

The idle fuel mixture and idle speed adjustment screws are the only external adjusting items on this carburetor (Figure 23). To adjust the idle fuel mixture and idle speed, proceed as follows:

1. With air cleaner installed, operate the engine at a fast idle speed until normal operating temperature is reached.
2. Disengage any load on the engine.
3. Be sure the choke linkage is all the way in to the off position.
4. Set the throttle at minimum speed. Be sure the throttle linkage does not control the idle speed. The idle speed adjustment screw must contact the throttle lever.
5. Turn the idle speed adjusting screw either in or out to obtain 800 rpm.
6. Turn the idle mixture adjustment screw inward until the engine speed begins to drop due to a lean mixture. Next turn the screw outward until the engine speed begins to drop due to a too rich mixture. Then turn the screw inward to a point between these two extremes to obtain maximum engine smoothness and rpm.
7. Reset the idle speed to the smoothest point within the range of 750-850 rpm.

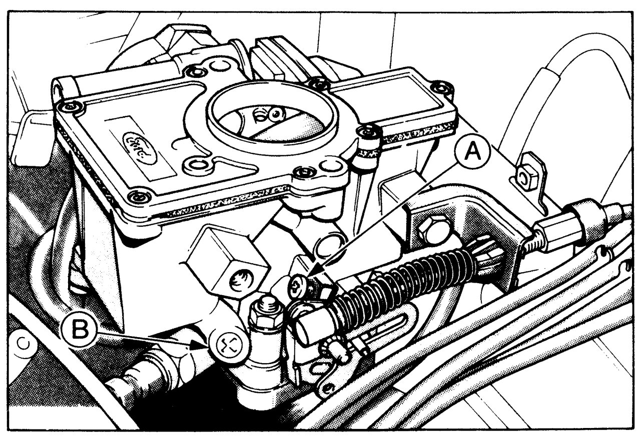


FIG. 23 Idle Adjusting Screws
A — Idle Speed Adjusting Screw
B — Idle Mixture Adjusting Screw

REMOVAL AND INSTALLATION

CARBURETOR

Removal

1. Remove the air cleaner.
2. Disconnect the fuel inlet line, distributor vacuum hose and anti-dieseling solenoid wire (Figure 24).
3. Disconnect the carburetor throttle linkage. Disconnect choke cable.
4. Remove carburetor retaining nuts and lift off carburetor.
5. Remove and discard carburetor gasket.

Installation

1. Install new carburetor gasket and mount carburetor. Secure with retaining nuts.
2. Connect throttle linkage and the choke cable. Check operation of throttle and choke for full travel.
3. Connect fuel line, distributor vacuum line and anti-dieseling solenoid wire.
4. Install air cleaner. Be sure vacuum and crankcase ventilation hoses are connected.
5. Start engine and operate at a fast idle speed until normal operating temperature is reached.
6. Adjust idle fuel mixture and idle speed.

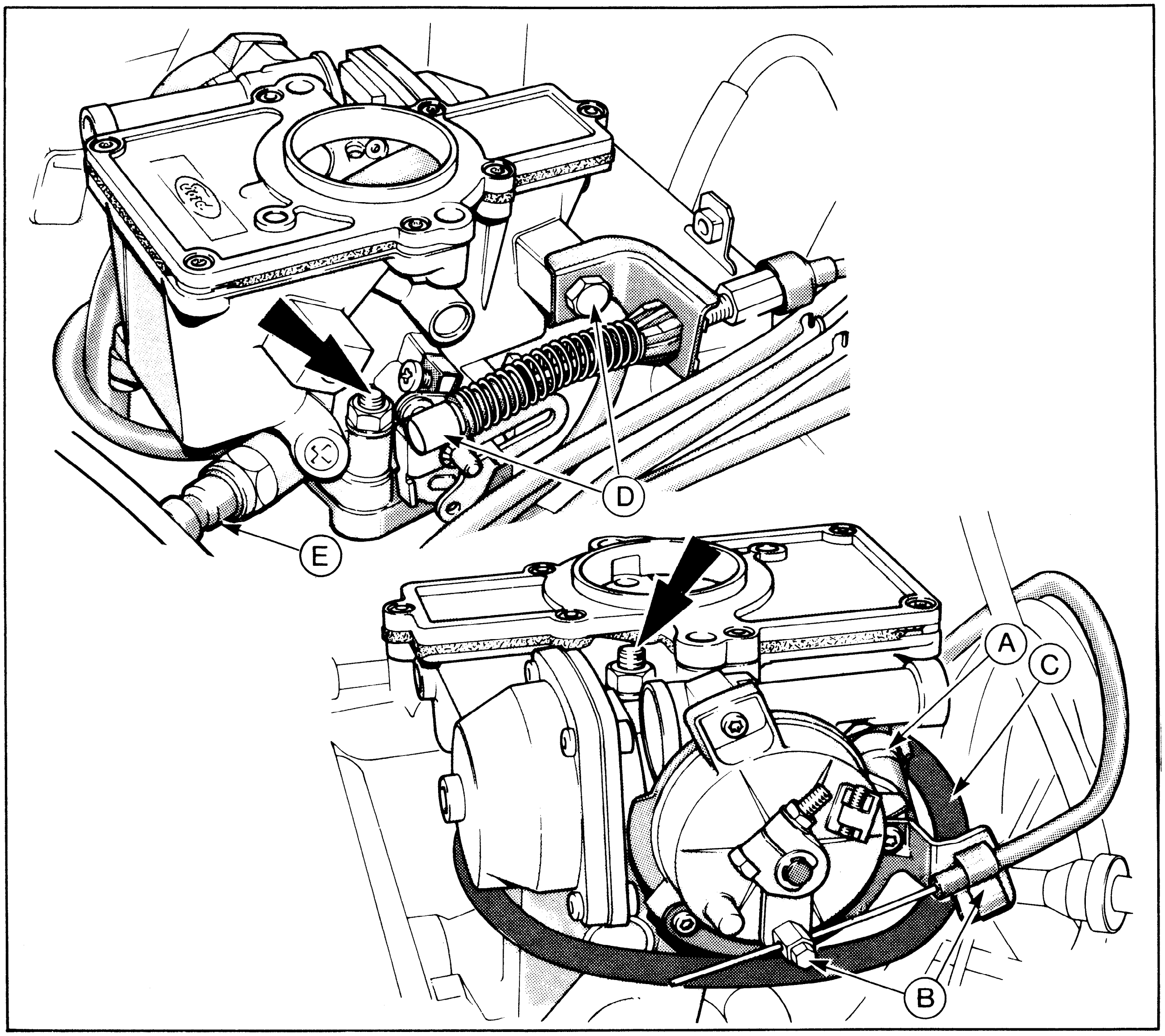


FIG. 24 Items to be Disconnected for Manual Choke Carburetor Removal (Carburetor Retaining Nuts Arrowed)
A — Fuel Supply Hose
B — Choke Cable Connections
C — Vacuum Hose
D — Throttle Linkage
E — Anti-Dieseling Solenoid Wire

ACCELERATOR PUMP — VACUUM DIAPHRAGM

Removal

1. Remove carburetor.
2. Invert carburetor, remove accelerator pump cover screws and detach cover, taking care that return spring is not lost.
3. Remove pump diaphragm (Figure 25).

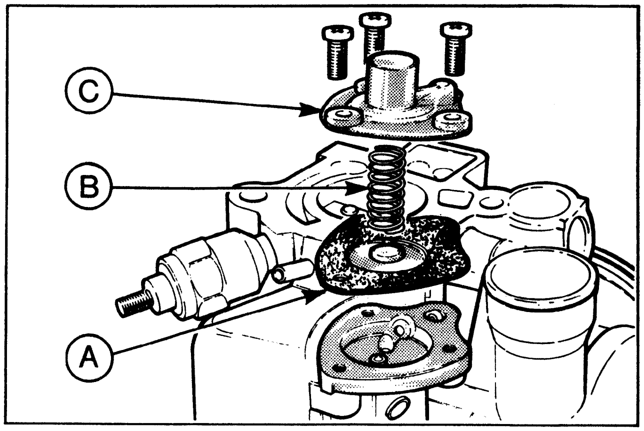


FIG. 25 Accelerator Pump Assembly
A — Diaphragm
B — Return Spring
C — Pump Cover

Installation

1. Check condition of diaphragm; replace if damaged. Clean cover and carburetor mating surfaces.
2. Align pump diaphragm ensuring that gasket side of diaphragm faces cover and that it is aligned to the screw holes in an unkinked state.
3. Install diaphragm spring and pump cover. Be sure spring locates on diaphragm rivet. Tighten cover retaining screws.

NEEDLE VALVE

Removal

1. Remove air cleaner.
2. Remove seven screws and remove carburetor top cover and gasket.
3. Unclip float pivot pin from its mounting and unhook needle valve clip from float cut-out.
4. Lift out needle valve taking care not to let it drop into float chamber.

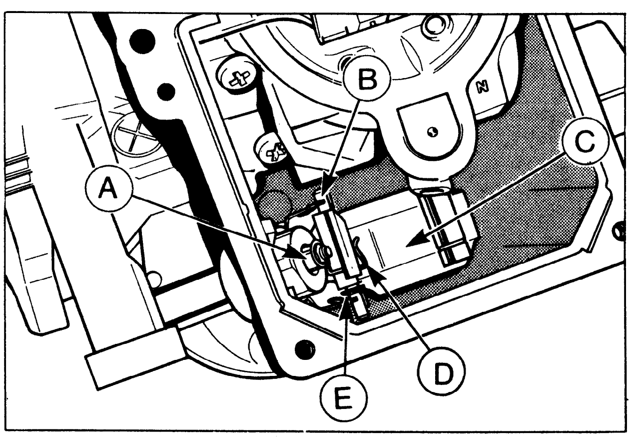


FIG. 26 Needle Valve Installation
A — Needle Valve
B — Float Pivot Pin
C — Float
D — Valve Clip
E — Spacing Washer

Installation

1. Be sure that needle valve clip is engaged in its groove.
2. Position valve clip into float cut-out and install float assembly. Spacing washer must be positioned between float pivot pin bracket and float. Pivot pin locates in detents in float pin bracket.
3. Operate the float several times to check for free movement.
4. Position new cover gasket and install cover. Torque screw to 2 Nm (18 in. lbs.).
5. Install air cleaner.

MANUAL CHOKE ASSEMBLY

NOTE: This operation relates to both the choke and lever assemblies. As both have to be calibrated together, they are only serviced as one assembly, and it is essential that both are replaced together.

Removal

1. Remove air cleaner.
2. Detach manual choke cable from lever assembly (Figure 27).
3. Remove three torx screws and remove lever assembly and cable support braket from choke assembly.
4. Remove three screws and remove choke assembly from carburetor (Figure 28).

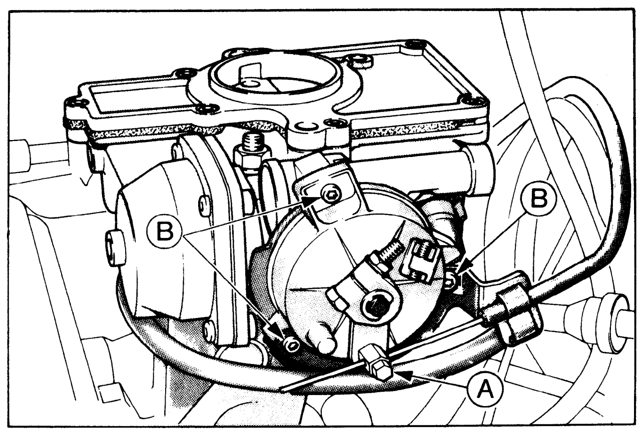


FIG. 27 Choke Cable and Lever Assembly
A — Cable Pinch Bolt
B — Lever Assembly Retaining Screws

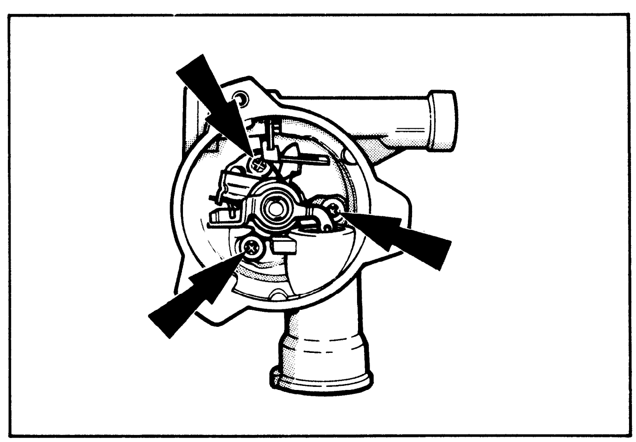


FIG. 28 Choke Assembly Retaining Screws

Installation

1. Use a new gasket position and fasten choke assembly to carburetor.
2. Position new gasket to choke assembly and with choke linkage at mid-travel point install lever housing by engaging spring loaded arm over linkage lever (Figure 29). Secure lever housing and cable support bracket to choke assembly.
3. Install choke cable to lever housing and adjust cable.
4. Install air cleaner.

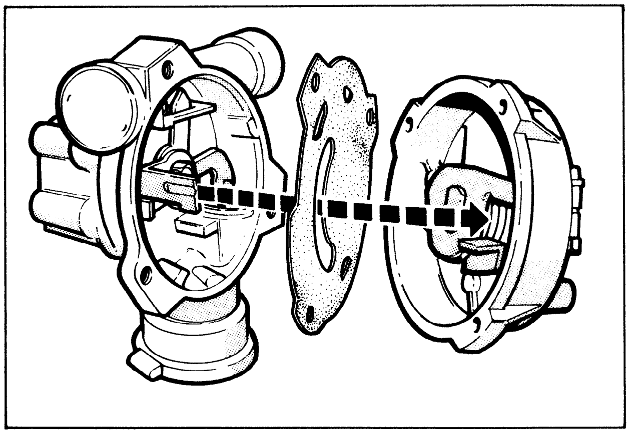


FIG. 29 Refitting Lever Assembly to Choke

CARBURETOR CONTROL DIAPHRAGM

Removal

1. Remove carburetor assembly.
2. Remove four torx screws and remove diaphragm housing return spring and guide (Figure 30).
3. Remove clip and detach control diaphragm from control lever.

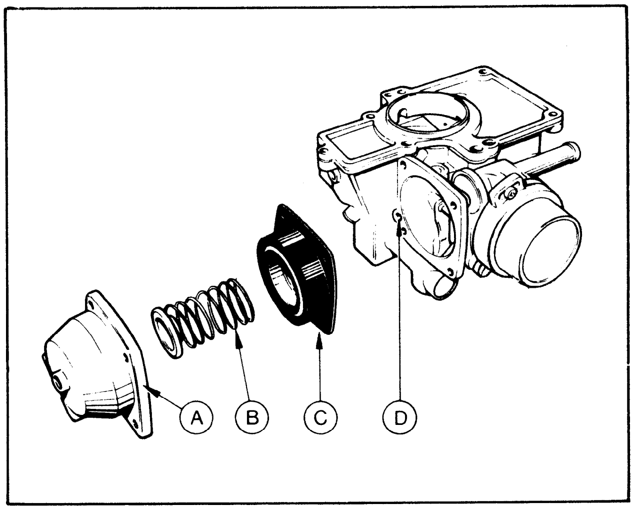


FIG. 30 Control Vacuum Diaphragm Assembly
A — Diaphragm Housing
B — Return Spring and Guide
C — Diaphragm
D — Vacuum Supply Gallery

Installation

1. Connect diaphragm to control lever and install clip.
2. Align diaphragm assembly to carburetor body and position return spring, spring guide and housing.
3. Install retaining screws.

NOTE: The vacuum hole in diaphragm must line up with supply galleries in both carburetor body and housing (Figure 30). When installing assembly, hold air valve fully open until housing is tightened. This will ensure that diaphragm is not trapped.

4. Install carburetor assembly.

PART 4 Charging System

DESCRIPTION AND OPERATION

ALTERNATOR

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

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

The alternator produces power in the form of alternating current. The alternating current is rectified to direct current by six diodes. The alternator regulator automatically adjusts the alternator field current to maintain the alternator output voltage within prescribed limits to correctly charge the battery. The unit has an integral voltage regulator mounted on the rear housing.

DIAGNOSIS AND TESTING

PRELIMINARY INFORMATION

Before performing charging system tests on the engine, note the complaint such as: slow cranking, battery dead or using an excessive amount of water, top of battery wet, ammeter shows charge at all times and/or no charge, alternator warning lamp does not come on and/or never goes out, voltmeter shows above or below open circuit nominal voltage. This information will aid in isolating the part of the system causing the symptom.

Next, visually inspect as follows:

1. Check battery posts and battery cable terminals for clean and tight connections. Remove the battery cables (if corroded), clean and install them securely.
2. Check for clean and tight wiring connections at the alternator, regulator and engine. Inspect for evidence of arcing.
3. Check the alternator belt tension using belt tension gauge T63L-8620-A, Model 210019 or equivalent and tighten to specification (if necessary).

ISOLATING THE PROBLEM

Battery, starting system, and light systems problems can be caused by poor charging system performance. It is also possible to suspect the charging system because of an overload in another area of the electrical system.

To avoid guesswork, it is necessary to isolate the battery, the charging system, and the electrical circuits to correctly identify the area where the difficulty lies. The best method to do this is to check the battery first before any electrical system diagnosis. The battery must be in proper state of charge. The battery must be operating properly before the other areas of the electrical system can perform normally.

BATTERY TESTING

WARNING: Keep batteries out of reach of children. Batteries contain sulfuric acid. Avoid contact with skin, eyes or clothing. Also, shield your eyes when working near the battery to protect against possible splashing of the acid solution. In case of acid contact with skin, eyes, or clothing, flush immediately with water for a minimum of 15 minutes. If acid is swallowed, drink large quantities of milk or water, followed by milk of magnesia, a beaten egg or vegetable oil. Call a physician immediately.

Hydrogen and oxygen gases are produced during normal battery operation. This gas mixture can explode if flames, sparks or lighted tobacco are brought near the battery. When charging or using a battery in an enclosed space, always provide ventilation and shield your eyes.

WARNING: Batteries are heavy, weighing 30 lbs. or more. Lift them with your legs rather than your back to prevent muscle strains, and be careful not to drop them (possible breakage) or to spill the contents (sulfuric acid).

CAUTION: 12-volt starting motors can be damaged beyond repair if connected to a 24-volt power supply (two 12-volt batteries in series, or a 24-volt motor-generator set), even when cranking loads are relatively light. Extensive starting motor damage is more likely if the starter is connected to a 24-volt supply while being subjected to prolonged heavy cranking loads such as attempting to start an engine in subzero temperature.

Tests are made on a battery to determine the state of charge and also its capacity or ability to crank an engine. The ultimate result of these tests is to show that the battery is good, needs recharging, or must be replaced.

Before attempting to test a battery, it is important to give it a thorough examination to determine if it has been damaged. Remove battery cable clamps, negative (−) terminal first. Check for dirty or corroded connections and loose battery posts. Remove hold downs and heat shields and inspect for broken or cracked case or cover. If worn or damaged, loose or broken post, or cracked case or cover, replace battery.

The battery capacity test should be run next to remove any surface charge prior to determining state of charge of a maintenance free battery.

CAPACITY TEST

A high rate discharge tester (Rotunda Battery-Starter Tester 02-0204) or equivalent in conjunction with a voltmeter is used for this test.

1. Turn the control knob on the Battery-Starter Tester to the off position.
2. Turn the voltmeter selector switch to the 20-volt position and test selector switch to "AMP".
3. Connect both positive test leads to the positive (+) battery post and both negative leads to the negative (−) battery post. The voltmeter clips must contact the battery posts and not the high-rate discharge tester clips. Unless this is done, the actual battery terminal voltage will not be indicated.
4. Turn the load control knob in a clockwise direction until the ammeter reaches the applicable discharge rate specified in the discharge rate table.
5. With the ammeter reading the required load for 15 seconds, note the voltmeter reading. Avoid leaving the high discharge load on the battery for periods longer than 15 seconds.

If the voltmeter reading is above the minimum specified in the table with the test equipment for that temperature, the battery has a good output capacity and will readily accept a charge, if required. Check the state of charge.

If the voltage reading obtained during the capacity test is below the minimum specified in the table, check the state of charge.

Battery Discharge Rates

Ampere Hours	Discharge Rate Amperes
45	190
53	200
63	260
68	235
71	235
85	240
90	310

Temperature Correction Chart — All Batteries

Temperature °F	Minimum Acceptable Load Voltage
70 (or above)	9.6
60	9.5
50	9.4
40	9.3
30	9.1
20	8.9
10	8.7
0	8.5

CHARGING SYSTEM TESTS

When performing charging system tests, turn Off all lamps and electrical accessories. Disengage engine load.

NOTE: Battery posts and cable clamps must be clean and tight to ensure accurate meter indications.

BASE VOLTAGE

1. With ignition Off and no electrical load on, connect negative lead of test voltmeter to negative battery cable clamp.
2. Connect positive lead of voltmeter to positive battery cable clamp.
3. Record battery voltage reading shown on voltmeter scale (this is called base voltage).

NO LOAD

1. Connect a tachometer to the engine.
2. Start engine and increase speed to approximately 1500 rpm. With no other electrical load voltmeter pointer should move upward (increase) but not more than 2.0 volts above base voltage (the first recorded battery voltage reading). The reading should be taken when the voltmeter pointer stops rising. It may take a few minutes to reach this point.

   If voltage increases the proper amount, go to Load Test. If voltage increases over 2 volts, perform the Over Voltage Tests. If voltage does not increase, perform Wiring Continuity Test.

LOAD

1. With engine running.
2. Increase engine speed to 2000 rpm. Voltmeter should indicate a minimum of 0.5 volts above base voltage.

If above tests indicate proper voltage readings, charging system is operating normally. Use test lamp and check for battery drain.

OVER VOLTAGE

1. If voltmeter reading indicates more than 2.0 volts above base battery voltage, connect a jumper wire between regulator base and alternator frame. Repeat No Load Test. If over voltage condition disappears, check ground connections on the alternator, and from engine to frame and to battery. Clean and tighten connections securely.
2. If over voltage condition still exists, perform Control Voltage Test.

WIRING CONTINUITY

1. Disconnect the battery ground lead, then disconnect the alternator wiring plug.
2. Inspect the terminals for signs of arcing.
3. Connect the battery ground lead and turn the ignition switch to the "ON" position.
4. Connect a voltmeter between a good ground and each of the wiring plug terminals in turn (Fig. 1). The voltmeter should read approximate battery voltage at all terminals. If voltage readings are correct go to Output Test. A zero reading indicates an open circuit. Repair as required.

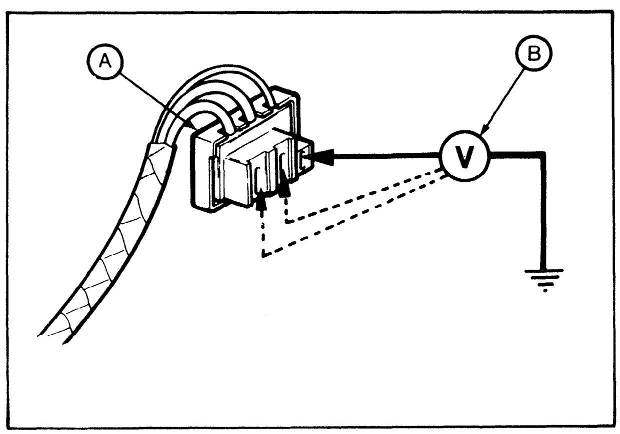


FIG. 1 Wiring Continuity Test
A — Alternator Wiring Plug
B — Voltmeter

CONTROL VOLTAGE

1. Disconnect the battery ground lead, then disconnect the alternator wiring plug.
2. Connect Voltmeter Ammeter and jumper as shown in Figure 2. Use caution to prevent grounding the terminals to the alternator housing.

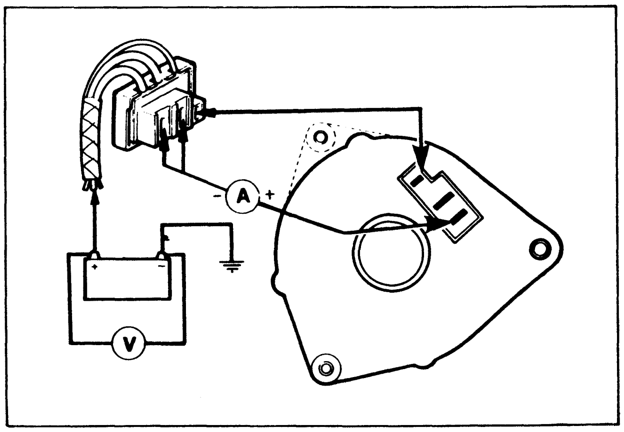


FIG. 2 Control Voltage Test

3. Connect battery ground lead and start engine.
4. Run engine at 3,000 rpm. Note ammeter reading. When this falls to between 3 and 5 amps, check the voltmeter reading. It should be 13.7 to 14.5 volts. If reading is outside specified limits, replace regulator.
5. Turn ignition switch off and disconnect battery ground lead. Disconnect test equipment.
6. Connect alternator wiring plug and battery ground lead.

OUTPUT

1. Connect Voltmeter Ammeter and Rheostat as shown in Figure 3. Use caution to prevent grounding the terminals to the alternator housing.

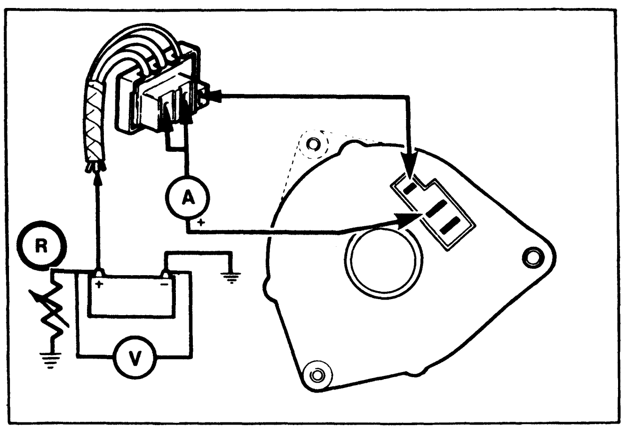


FIG. 3 Output Test

2. Start engine, run it at 3,000 rpm. Vary resistance to increase load current. Rated output should be reached without voltage dropping below 13 volts. If rated output cannot be reached check alternator.

BENCH TESTS

DIODES

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

To test one set of diodes, contact one probe to the diode plate as shown in Figure 4 and contact each of the three diode pin terminals with the other probe. Reverse the probes and repeat the test. All diodes should show a low reading of about 70 ohms in one direction, and an infinite reading (no needle movement) with the probes reversed. Repeat the preceding tests for the other set of diodes.

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

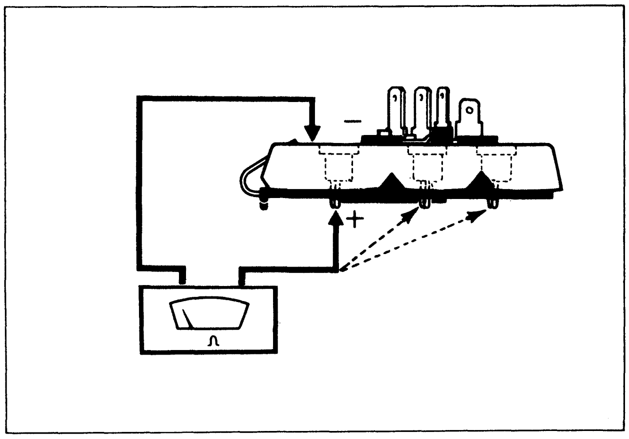


FIG. 4 Diode Test

FIELD DIODES

To test the field diodes contact the negative probe to the brush terminal as shown in Figure 5 and contact each of the three positive diode pin terminals with the positive probe. All diodes should show a low reading of about 70 ohms. Reverse the probes and all diodes should show an infinite reading (no needle movement).

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

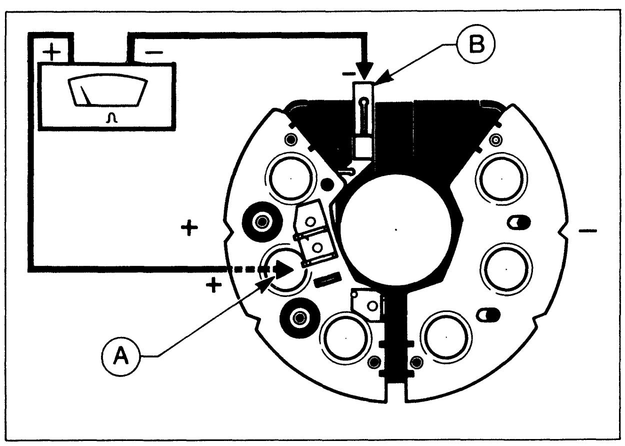


FIG. 5 Field Diode Test
A — Positive Diodes
B — Brush Terminal

STATOR COIL OPEN OR GROUNDED

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

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

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

ROTOR OPEN OR SHORT CIRCUIT

Disassemble the front housing and rotor from the rear housing and stator as outlined under Disassembly. Set the ohmmeter Multiply By knob at 1 and calibrate the meter.

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

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

ADJUSTMENTS

BELT ADJUSTMENTS

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

REMOVAL AND INSTALLATION

REMOVAL

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

INSTALLATION

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

OVERHAUL

DISASSEMBLY

Figures 6 and 7 show a disassembled view of the alternator.

1. Mark both end housings and the stator with a scribe mark for assembly.
2. Remove retaining nut, lockwasher, spacer pulley, spacer, dish washer, fan and fan spacer.
   NOTE: Observe position and direction of spacer and dished washer between pulley and fan (Fig. 6).
3. Remove regulator and brush holder.
4. Remove four through bolts.
5. Separate the front housing and rotor from the stator and rear housing.
6. Press rotor out of front housing.
7. Remove front bearing retainer and bearing.
8. Support rear bearing with a large washer, incorporating a cut out to accommodate the rotor shaft, and press bearing from shaft (Fig. 8).
9. Remove rectifier (diode) assembly retaining screws and lift out stator and rectifier assembly.
10. Unsolder stator to rectifier connections using a pair of pliers as a heat sink to reduce heat spread to diodes (Fig. 9).

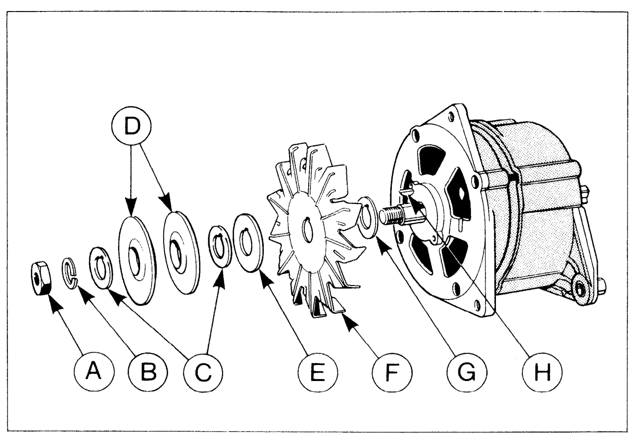


FIG. 6 Fan, Pulley and Associated Components
A — Retaining Nut
B — Lock Washer
C — Spacers
D — Pulley
E — Dished Washer
F — Fan
G — Fan Spacer
H — Key

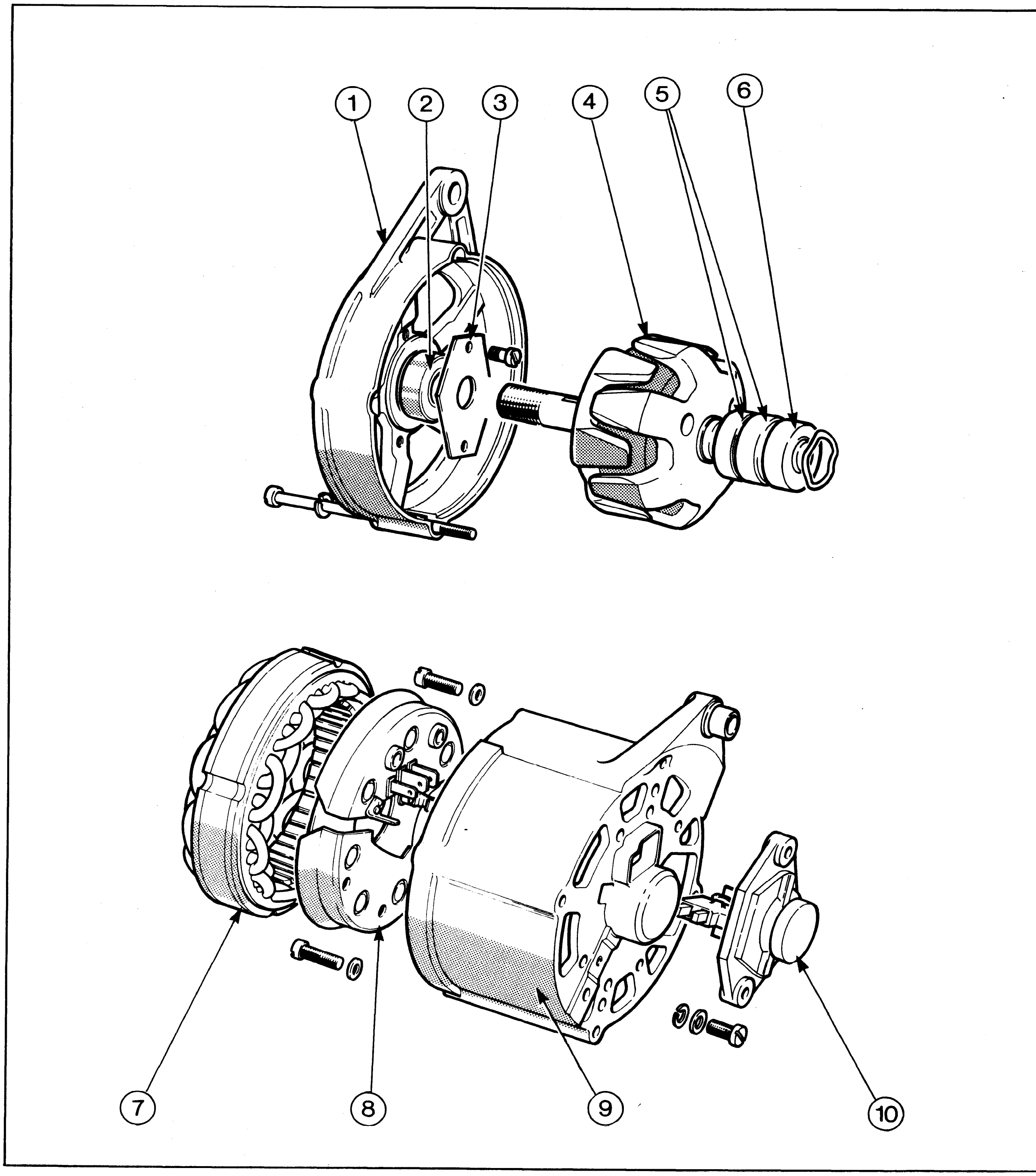


FIG. 7 Disassembled Alternator

1. Front Housing
2. Front Bearing
3. Front Bearing Retainer Plate
4. Rotor
5. Slip Rings
6. Rear Bearing
7. Stator
8. Rectifier Assembly
9. Rear Housing
10. Regulator and Brush Holder

11. Clean and inspect all components. Do not wash the rotor, stator or bearings with solvent. Wipe these parts with a clean cloth.

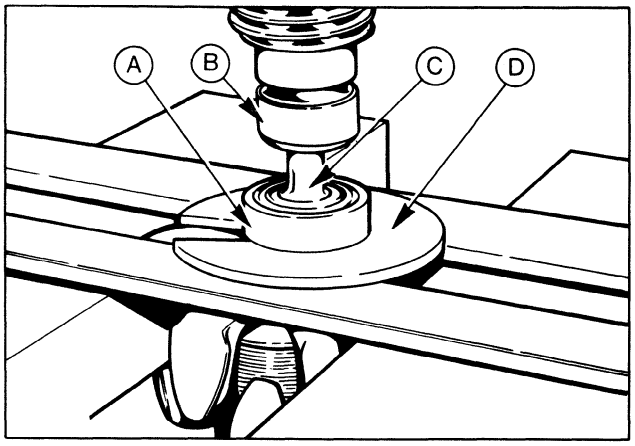


FIG. 8 Rear Bearing Removal
A — Bearing C — Drift
B — Press D — Washer

ASSEMBLY

1. Resolder stator to rectifier (Fig. 9). Use a pair of pliers as a heat sink to reduce heat spread to diodes.
2. Position stator and rectifier assembly in rear housing and install retaining screws.
3. Press rear bearing onto rotor shaft.
4. Install front bearing into front housing. Position retainer plate and install retaining screws.
5. Install rotor to front housing.
6. Position the rear housing and stator assembly over the rotor and align the scribe marks made during disassembly. Seat the machined portion of the stator core into the step in both end housings. Install the housing through bolts.
7. Install the fan spacer, fan, dished washer, spacer, pulley spacer, lockwasher and nut. Tighten nut.
NOTE: Dished washer "E" in Fig. 6 must be fitted correctly, with the outer circumference pressing against the fan. In this way, it acts as a vibration damper and prevents fatigue failures.

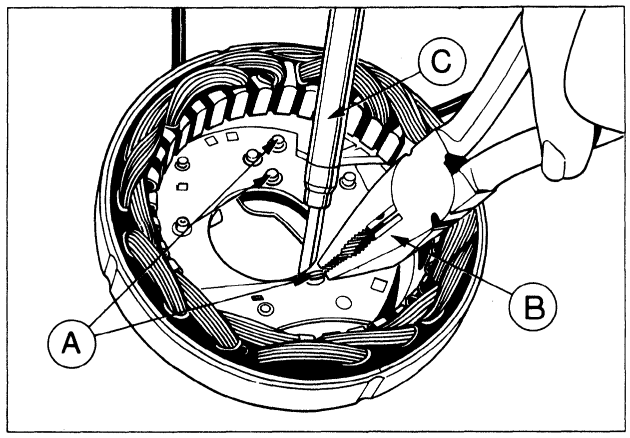


FIG. 9 Soldering Stator to Rectifier Connections
A — Stator Connections
B — Pliers
C — Soldering Iron

PART 5 Starting System

DESCRIPTION AND OPERATION

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

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

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

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

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

After the engine starts, the starter drive is disengaged when the ignition switch is returned from the start to the on or run position. This opens the circuit to the starter solenoid and the solenoid return spring causes the shift lever to disengage the starter drive from the engine flywheel ring gear.

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

TESTING

ROAD SERVICE

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

ON ENGINE TESTING

STARTER CRANKING CIRCUIT TEST

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

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

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

STARTER LOAD TEST

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

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

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

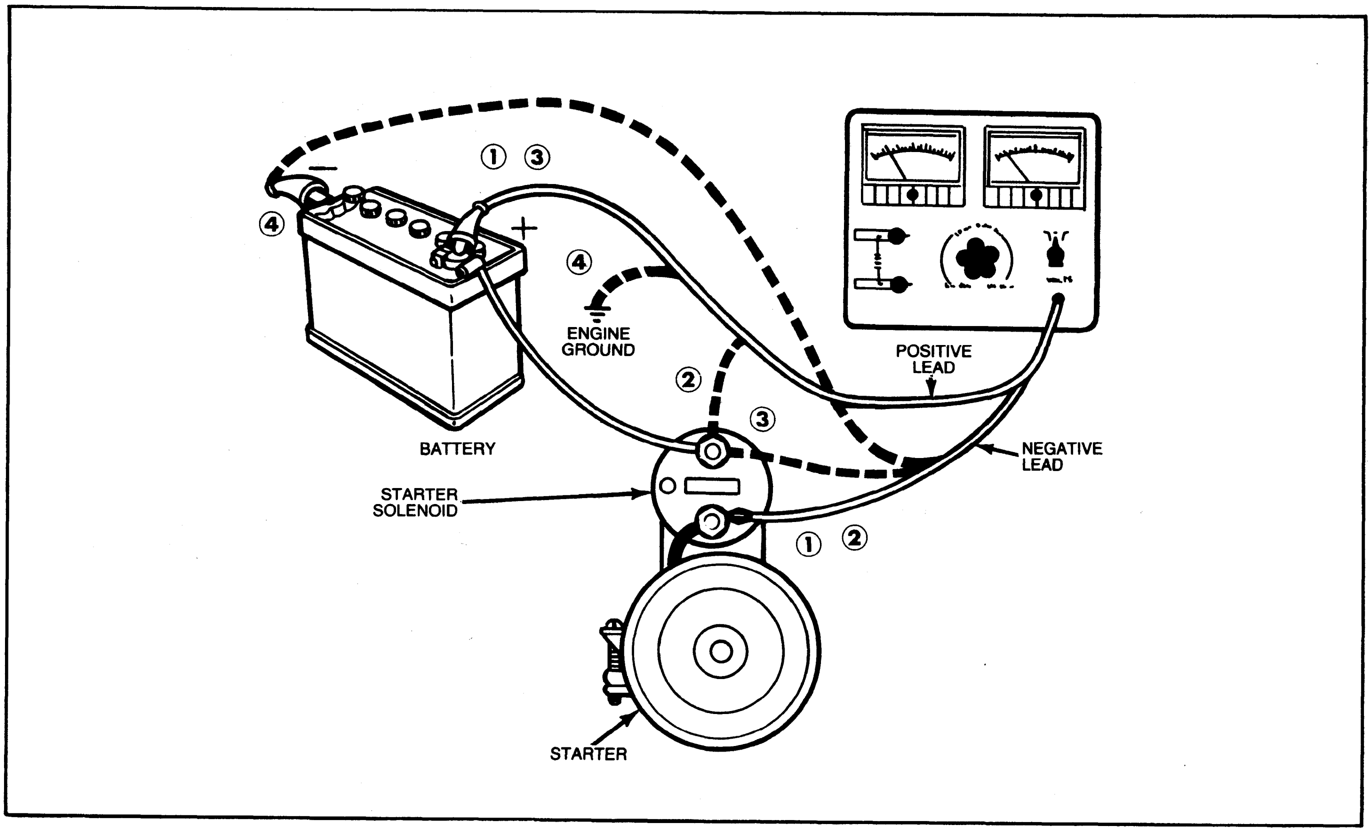


FIG. 1 Starter Cranking Circuit Tests

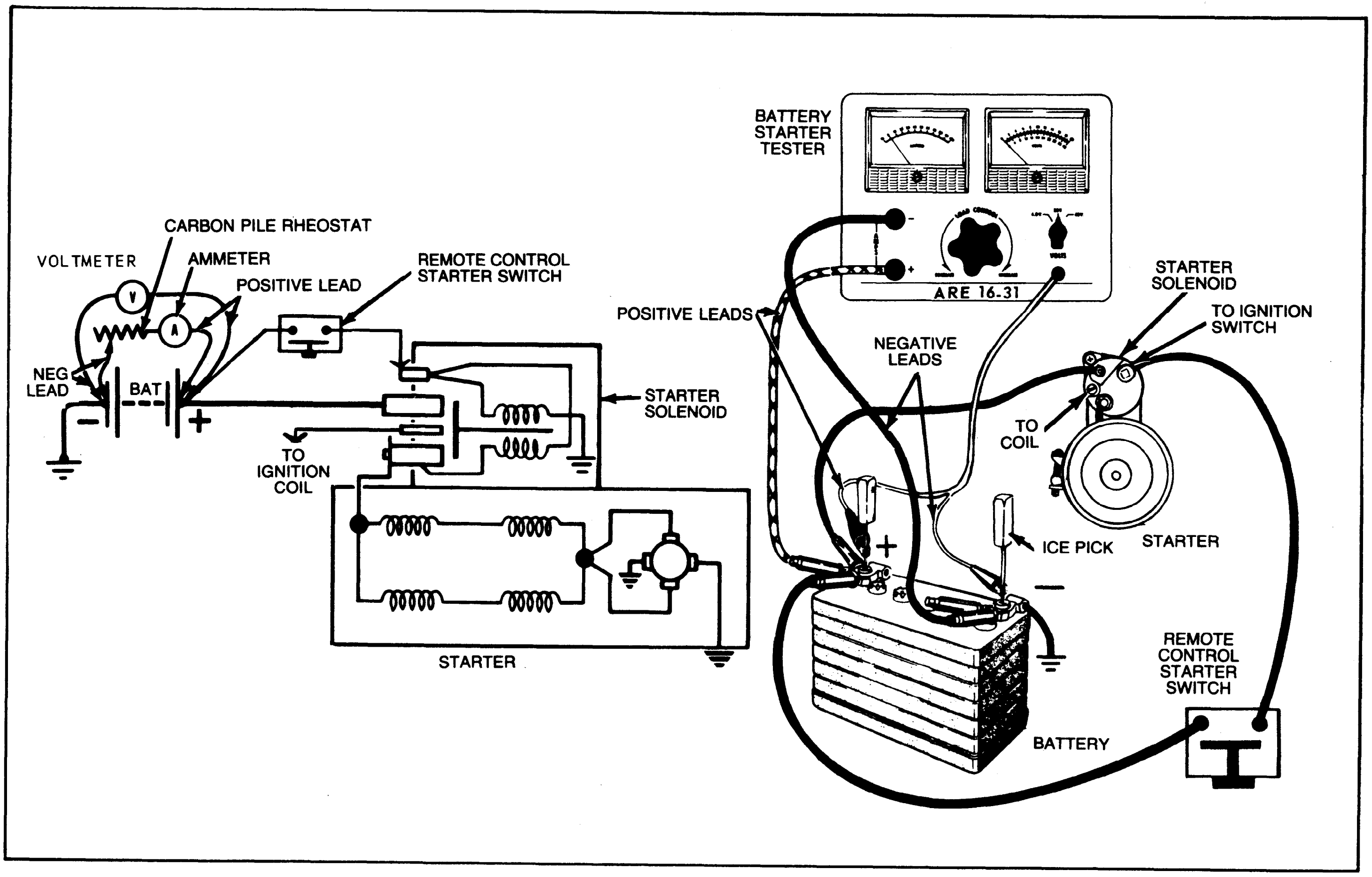


FIG. 2 Starter Load Test

STARTER SOLENOID TEST

If the solenoid does not pull in, in the Starter Load Test, measure the voltage between the starter-mounted solenoid switch terminal and ground with the ignition switch closed. If the voltage is 10 or more volts, a worn or damaged solenoid is indicated. Remove the starter assembly for solenoid replacement.

BENCH TESTS

STARTER NO-LOAD TEST

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

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

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

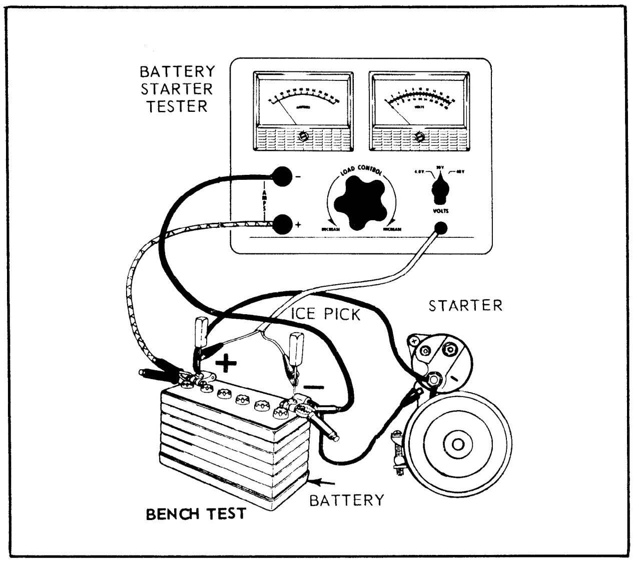


FIG. 3 Starter No-Load Test on Test Bench

ARMATURE OPEN CIRCUIT TEST

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

ARMATURE AND FIELD GROUNDED CIRCUIT TEST

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

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

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

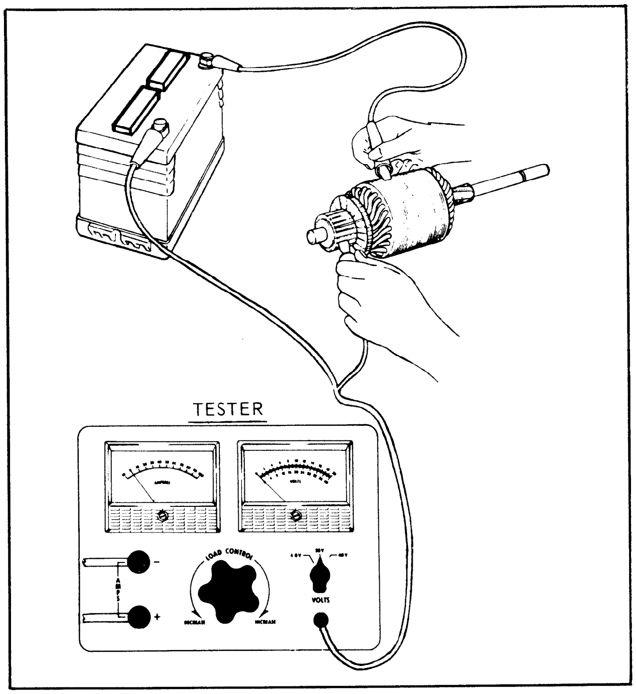


FIG. 4 Armature Grounded Circuit Test

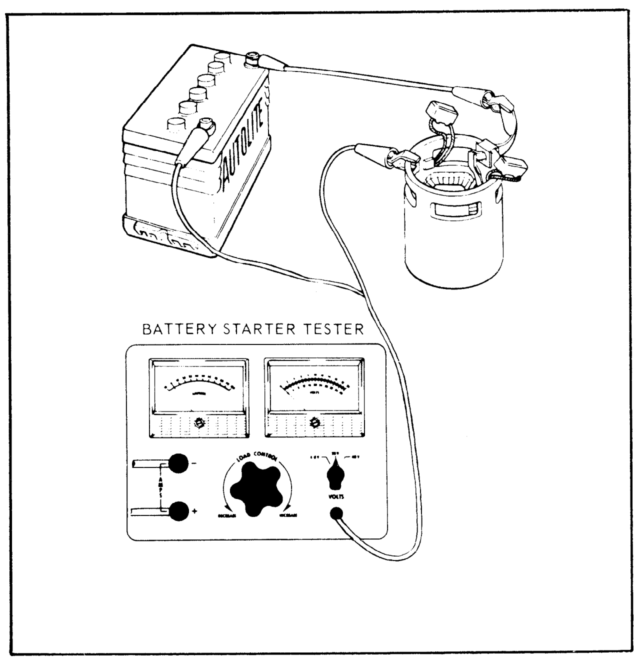


FIG. 5 Field Grounded Circuit Test

REMOVAL AND INSTALLATION

REMOVAL

1. Disconnect the battery ground cable.
2. Disconnect the cable and wires at the terminals on the solenoid.
3. Remove the starter mounting bolts and remove the starter assembly.

INSTALLATION

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

OVERHAUL

DISASSEMBLY

1. Clamp starter motor in vise fitted with protective soft jaws. Remove nut and washer retaining field winding cable to solenoid and remove cable from stud.
2. Remove solenoid by removing three screws.
3. Remove two screws retaining commutator end housing cap, (Fig. 6) remove cap and rubber seal.

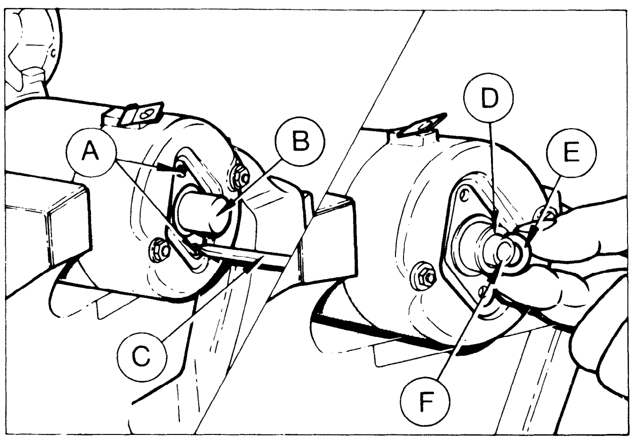


FIG. 6 End Housing Cap and Armature Shims
A — Retaining screw D — Shims
B — Housing Cap E — "C" clip
C — Screwdriver F — Armature shaft

4. Wipe grease from armature shaft, and remove "C" clip and shims from armature end.
5. Remove through bolts or two nuts and washers and lift off commutator end housing.
6. Remove brushes from brush holder assembly by carefully lifting brush retaining/tensioning springs clear and sliding brushes from their holder. Remove brush holder assembly.
7. Separate drive end housing and armature assembly from frame by tapping apart.
8. Remove rubber insert from drive end housing. Remove actuating arm pivot retaining nut and slide pivot pin from housing.
9. Withdraw armature assembly, complete with actuating arm, from drive end housing. Unhook actuating arm from drive pinion flange.
10. To remove drive pinion assembly from armature shaft use a suitably dimensioned tube to separate thrust collar from over "C" clip, (Fig. 7).
    Remove "C" clip from its groove and slide thrust collar and drive pinion assembly off armature shaft.

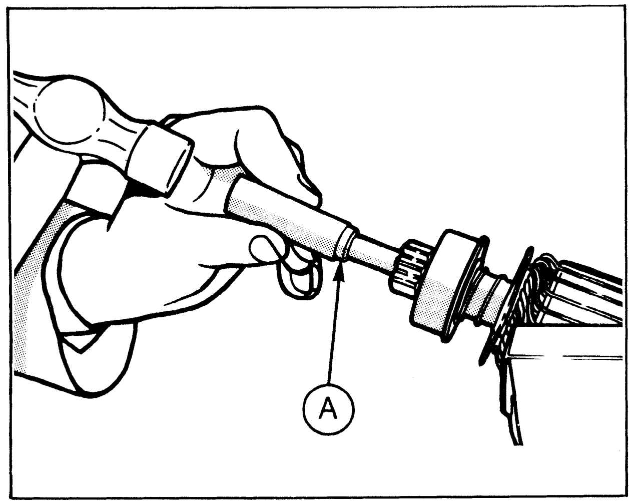


FIG. 7 Using a Suitably Dimensioned Tube
Separate Thrust Collar From "C" Clip Ring.
A — Thrust Collar

CLEANING AND INSPECTION

1. **Do not wash the drive because the solvent will wash out the lubricant, causing the drive to slip.** Use a brush or compressed air to clean the drive, field coils, armature, commutator, armature shaft front end plate, and rear end housing. Wash all other parts in solvent and dry the parts.
2. Inspect the armature windings for broken or burned insulation and unsoldered connections.
3. Check the armature for open circuits and grounds.
4. Inspect the armature shaft and the two bearings for scoring and excessive wear. If the commutator is rough, turn it.
5. Check the brush holders for broken springs and the insulated holder for shorts to ground. Replace the brushes if worn.
6. Check the brush spring tension.
7. Inspect the field coils for burned or broken insulation and continuity. Check the field brush connections and lead insulation. A brush kit is available. All other assemblies are to be replaced rather than repaired.
8. Examine the wear pattern on the starter drive teeth. The pinion teeth must penetrate to a depth greater than 1/2 the ring gear tooth depth (Figure 9, to eliminate premature ring gear and starter drive failure.
9. Replace starter drives and ring gears with milled, pitted or broken teeth or that show evidence of inadequate engagement (Figure 9).

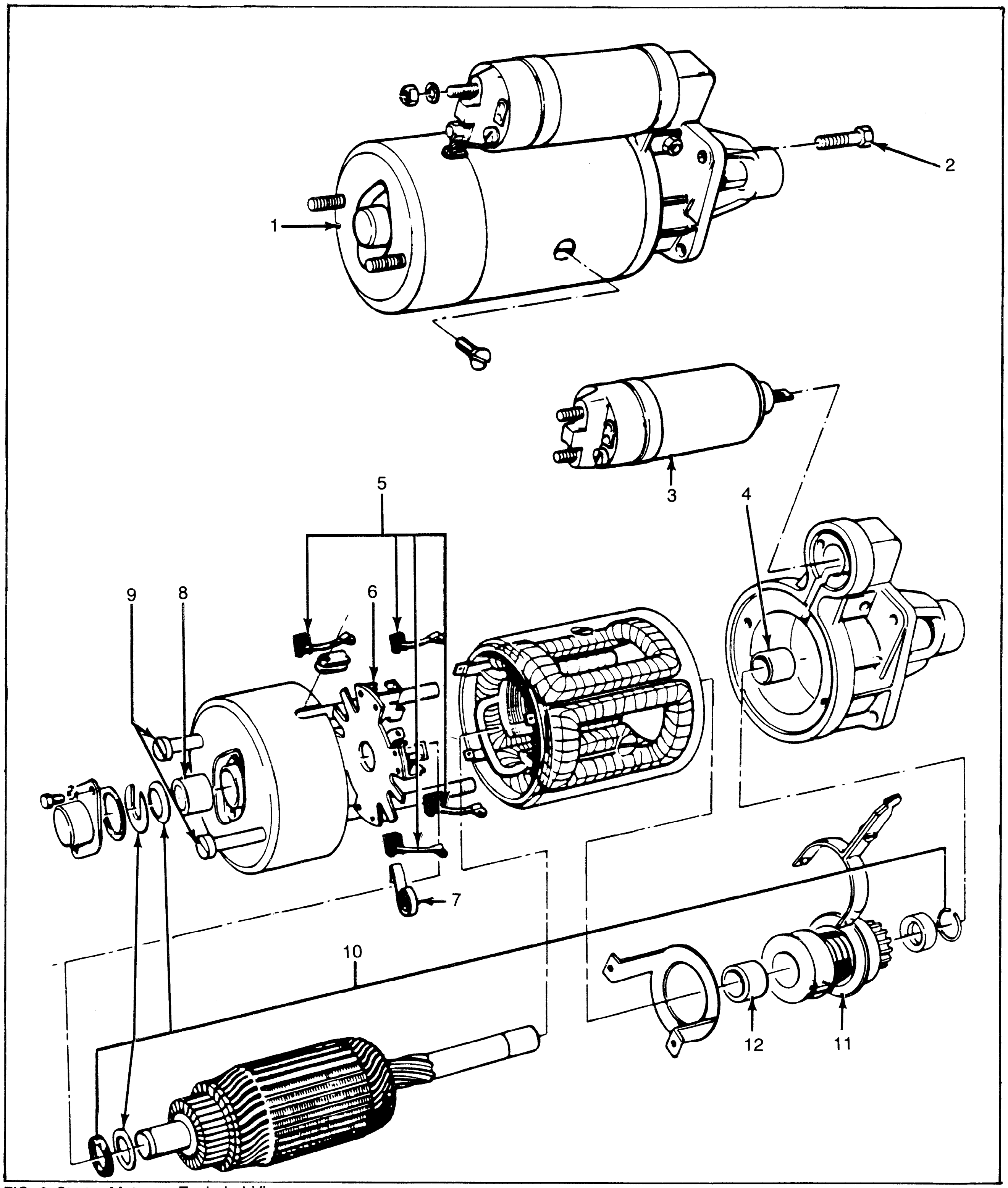


FIG. 8 Starter Motor — Exploded View

1. Starter motor
2. Bolt
3. Solenoid
4. Bushing
5. Brush set
6. Brush holder
7. Brush spring
8. Brush end bushing
9. Through bolt kit
10. Armature installation kit
11. Drive assembly
12. Bushing

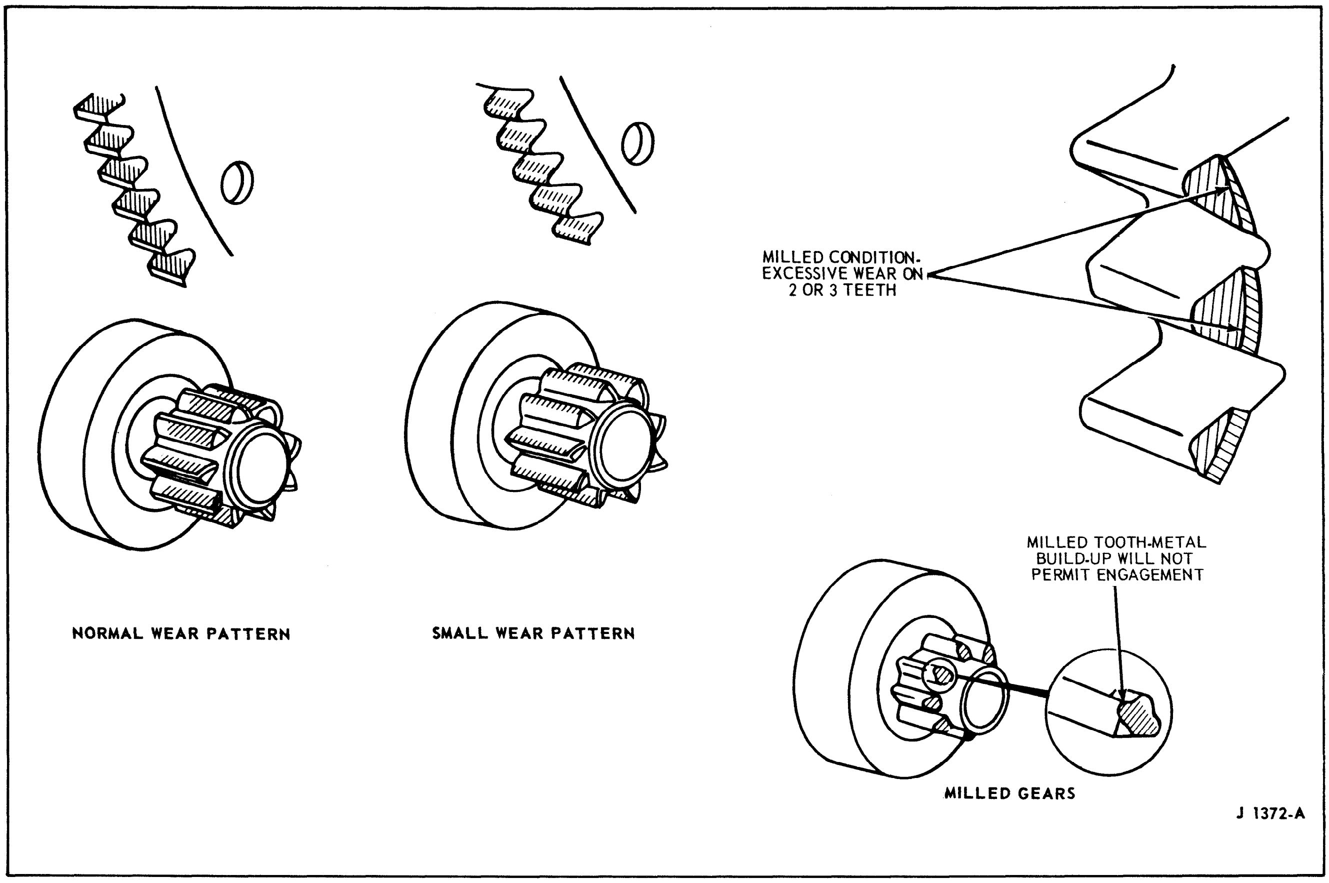


FIG. 9 Pinion and Ring Gear Wear Patterns

ASSEMBLY

1. Slide drive pinion assembly and thrust collar on to armature shaft. Fit “C” clip into its groove in armature shaft and then draw thrust collar over “C” clip.
2. Connect actuating arm on to drive pinion flange. Align armature and actuating arm to drive end housing and couple up components. Install actuating arm pin and secure with retaining nut.
3. Install rubber insert into drive end housing.
4. Guide frame over armature and abut to drive end housing and tap home.
5. Position brush holder over end of armature. Align location “cut-out” in brush holder with “loop” in field windings (Fig. 10). Brush will be positively located when through bolts are installed.
6. Position four brushes in their respective brush holder locations and retain with brush springs.
7. Guide commutator end housing into position, sliding rubber insulator into commutator housing “cut-out”, and locating two through bolts through housing holes. Secure commutator end housing with two nuts and washers or two through bolts as applicable.
8. Slide armature in its bearings, Fig. 11, to obtain maximum possible protrusion of armature shaft at commutator bearing end. Install sufficient shims on armature end play when “C” clip is in place. Fit “C” clip (Fig. 6).
9. Place bearing cap seal in position on commutator housing, smear a small quantity of lithium based grease on end of armature shaft and refit bearing cap, securing with two screws (Fig. 6).

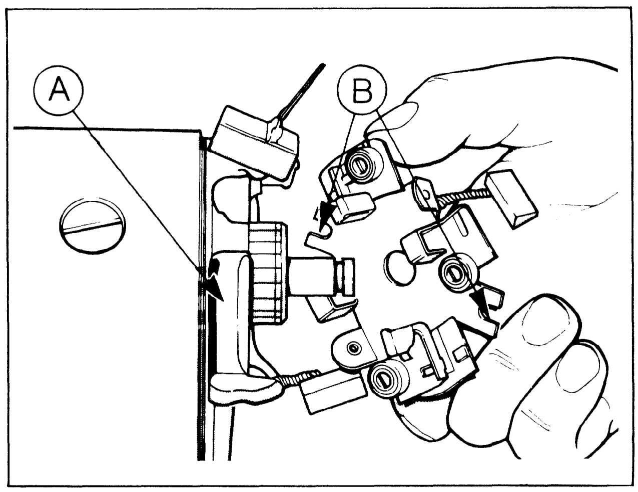


FIG. 10 Position Brush Holder
A — Field Winding Loops
B — Location Cut-Outs

10. Smear lithium based grease onto solenoid armature hook and then locate hook onto actuating arm in drive end housing. Ensure solenoid armature return spring is correctly positioned and then guide solenoid body over armature, Fig. 12. Align body with drive end housing and install retaining screws.
11. Reconnect field winding cable to solenoid and install retaining nut.

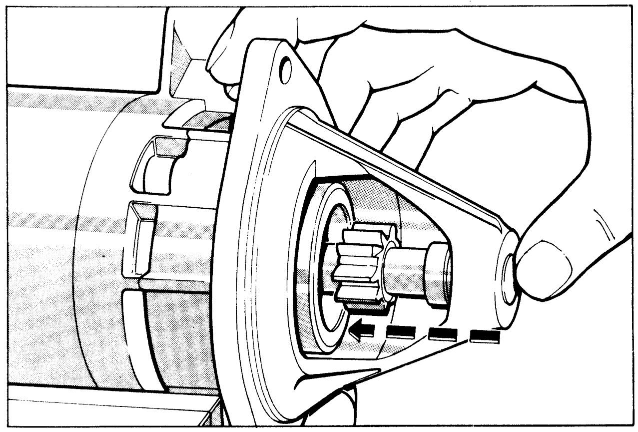


FIG. 11 Slide Armature in its Bearings

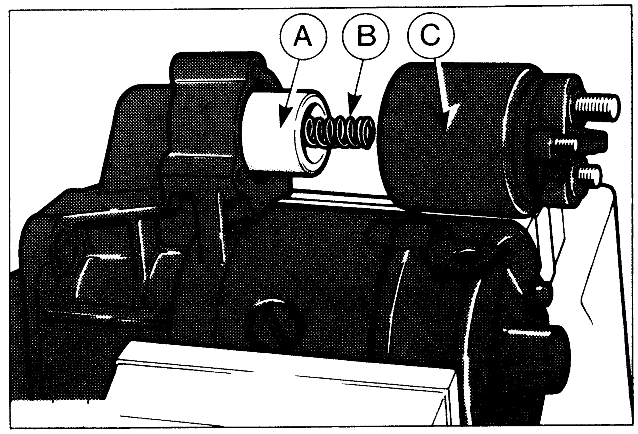


FIG. 12 Solenoid
A — Armature
B — Armature Return Spring
C — Solenoid Body

PART 6 Governor

DESCRIPTION AND OPERATION

The mechanical flyweight type governor is used on this engine. It is mounted on the right front of the engine and is belt driven from the engine accessory pulley.

A direct mechanical linkage from the governor throttle control lever to the carburetor throttle lever limits carburetor action to the governor setting. As the engine speed increases, the rotation of the governor shaft increases. Centrifugal force causes the weights to move outward as the rotation of the governor shaft increases. However, a spring retards or limits the movement of the weights until centrifugal force overcomes the spring tension. At this time the weights are forced outward closing the throttle plates through the linkage to the throttle shaft.

ADJUSTMENTS

PRELIMINARY CHECKS

Three preliminary checks must be made on the mechanical governor before attempting any repair adjustments. These are the governor oil level, drive belt tension and the throttle control rod length. Replace the belt if any damage can be seen e.g., cracks, shipping damage, etc.

OIL LEVEL

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

BELT TENSION

Belt tension should be checked on a cold belt only.

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

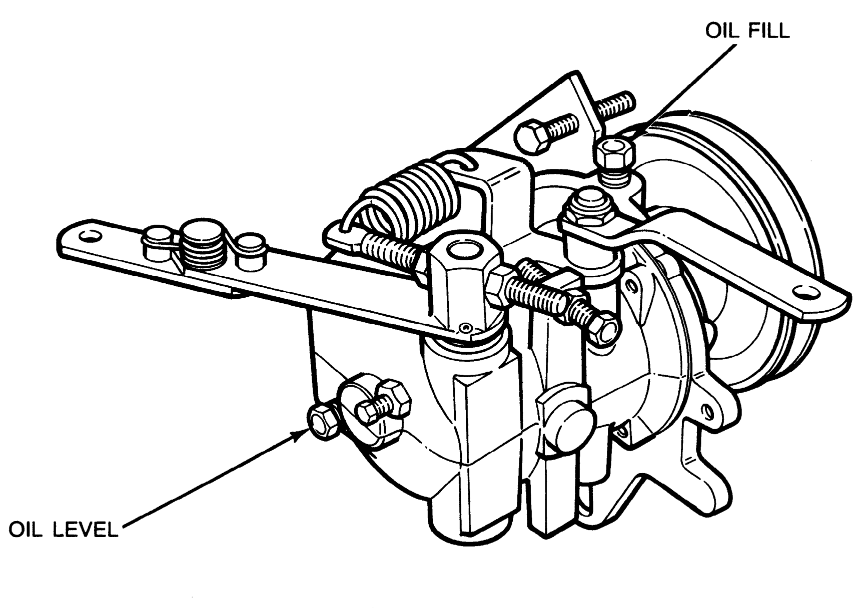


FIG. 1 Mechanical Belt Driven Governor

THROTTLE CONTROL ROD

1. Manually move the governor throttle lever to the maximum open throttle position.
2. Check the gap between the carburetor throttle shaft lever and its maximum open position stop (Figure 2). It should be 3/8 to 7/16 inch wide for variable Venturi carburetors, and 1/32 to 1/16 of an inch for other carburetors.
3. If adjustment is necessary, loosen the control rod ball joint locknuts, remove the rod from the carburetor throttle lever and adjust the length of the rod with the ball joints.
4. Install the throttle control rod on the carburetor throttle lever and recheck the gap. Tighten the locknuts.

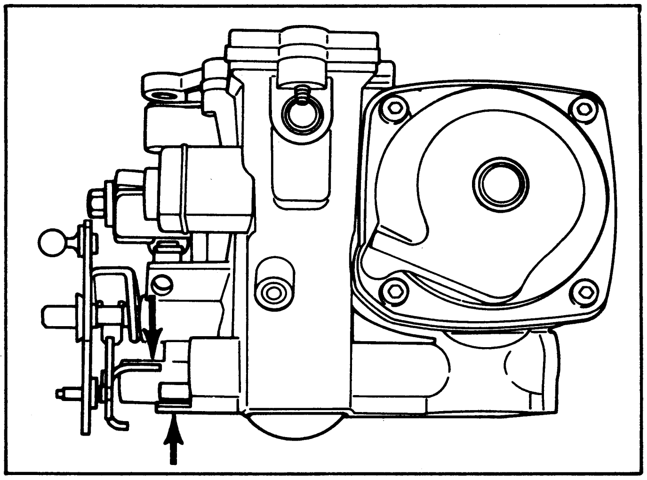


FIG. 2 Throttle Control Rod

RPM ADJUSTMENTS

HIGH SPEED

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

1. Loosen the locknut on the high-speed stop screw.
2. Disengage engine load.
3. Slowly pull the throttle to desired maximum engine speed.
4. Adjust the high-speed stop screw on the governor to attain the desired maximum engine speed. Do not exceed the recommended maximum rpm.
5. Tighten the locknut.

SPREAD OR SENSITIVITY

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

INCREASE SPREAD

1. With the engine running under no-load at maximum governed speed, loosen the locknuts and adjust the screw (Figure 3) to move the spring away from the lever hub. Tighten the lock nuts.
2. Recheck governor operation under full-load and no-load conditions to determine if operation is stabilized and sensitivity is satisfactory.
3. Readjust the governor high-speed stop screw to maintain the correct high-speed under load.

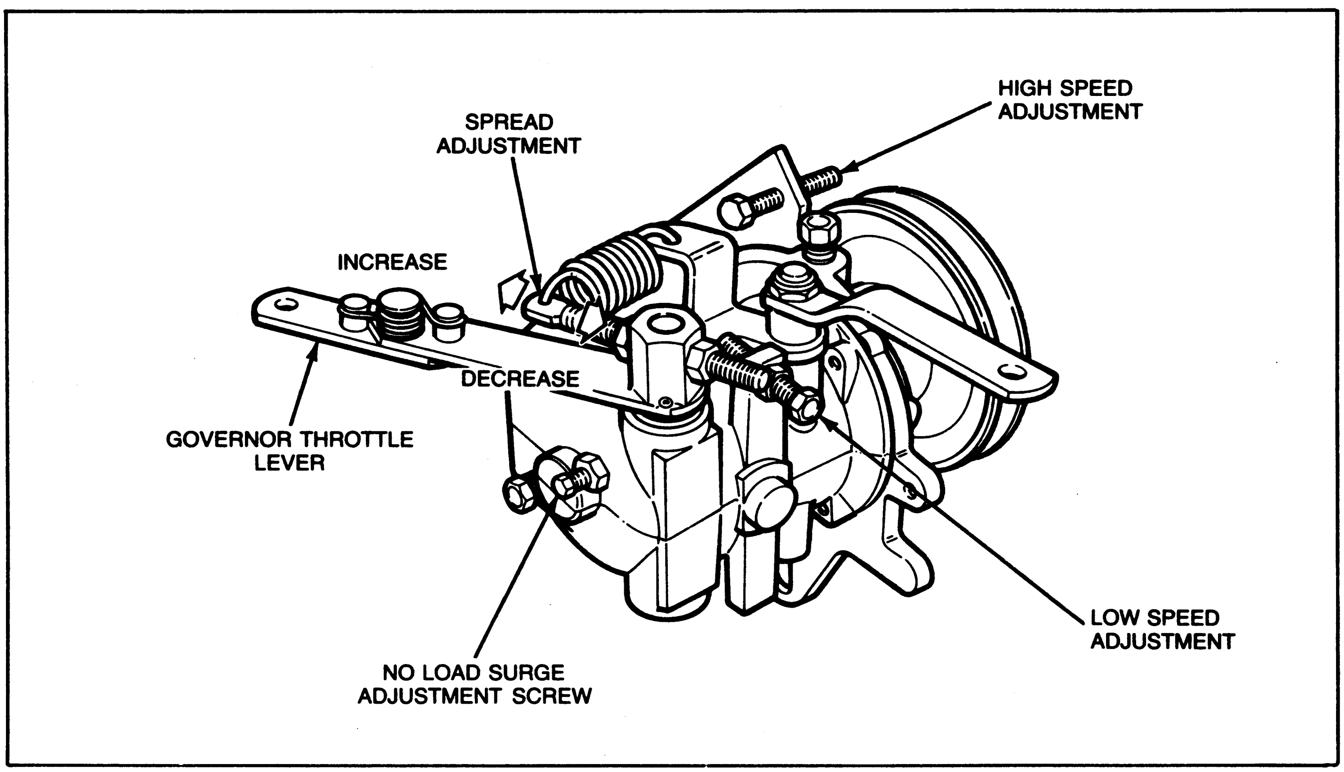


FIG. 3 Governor Adjustments

DECREASE SPREAD

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

LOW SPEED

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

NO-LOAD SURGE

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

1. Make the adjustment with the tachometer installed. Increase the engine speed with the hand throttle or variable speed lever to 75 rpm lower than the maximum no-load desired control rpm.
2. Loosen the no-load surge adjustment screw locknut (Figure 3) and turn the screw inward until the rpm increases to the desired control rpm.
   CAUTION: Do not turn the screw in all the way. It will interfere with proper governor operation and prevent the governor from returning the engine to idle speed.
3. Readjust the governor high-speed stop screw to maintain the correct high-speed under load.

REMOVAL AND INSTALLATION

REMOVAL

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

INSTALLATION

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

PART 7 Cooling System

DESCRIPTION AND OPERATION

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

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

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

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

ADJUSTMENTS

DRIVE BELT

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

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

BELT TENSION

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

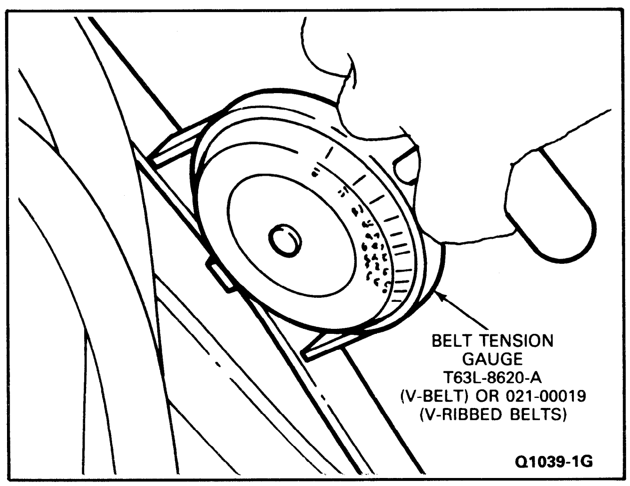


FIG. 1 Belt Tensioning

PART 8 SPECIFICATIONS

	Engine Model Year 1984 to 1988	Engine Model Year 1989-
General Specifications		
VSG-411	4 Cylinder — 1.1 Liter	
VSG-413	4 Cylinder — 1.3 Liter	
Bore and Stroke		
1.1L	73.96 and 64.98 mm	68.68 and 75.48 mm
1.3L	73.96 and 75.48 mm	
Firing Order	1-2-4-3	
Idle Speed	750-850 rpm	700-800 rpm
Rated Engine Speed — Maximum	Full Load 2800 rpm	
	No Load 3050 rpm	
Cylinder Block		
Number of Main Bearings	1.1L-3, 1.3L-5	
Cylinder Bore Diameter		
1.1L	73.94-73.98 mm	68.68-68.710 mm
1.3L	73.94-73.98 mm	73.94-73.97 mm
Out-of-Round		
Maximum	0.038 mm	
Wear Limit	0.127 mm	
Taper		
Maximum	0.0254 mm	
Wear Limit	0.254 mm	
Main Bearing Bore — Standard	60.623-60.636 mm	
	Oversize 61.003-61.016 mm	
Camshaft Bearing Bore	42.888-42.918 mm	
	Oversize 43.396-43.420 mm	
Cylinder Block Liner Bore Diameter		
1.1L	77.086-77.112 mm	71.826-71.852 mm
1.3L	77.086-77.112 mm	
Deck Height (Oil Pan Rail to Head Deck)		
1.1L	183.62 +0.00/−0.13	194.6 ± 0.065 mm
1.3L	205.84 ± 0.065 mm	194.6 ± 0.065 mm
℄ of Crankshaft Above Oil Pan Rail 1.1L & 1.3L	2.578 ± 0.115 mm	
Crankshaft		
Main Bearing Journal Dia. 1.1L		
Standard	56.99-57.00 mm	
Yellow	56.98-56.99 mm	
Main Bearing Journal Dia. 1.3L		
Standard	56.980-57.000 mm	
Yellow	—	
Main Bearing Clearance 1.1L	0.009-0.046 mm	
Main Bearing Clearance 1.3L	0.009-0.056 mm	
Rod Bearing Journal Dia. 1.1L		
Standard	42.99-43.01	
Green	42.74-42.76 mm	
Rod Bearing Journal Dia. 1.3L		
Standard	40.99-41.01 mm	
Green	40.74-40.76 mm	

All specifications are in millimeters.
For Conversion Factors see page 8-05.

PART 8 SPECIFICATIONS (Cont.)

	Engine Model Year 1984 to 1988	Engine Model Year 1989-
Crankshaft (Continued)		
Rod Bearing Clearance 1.1L and 1.3L	0.006-0.060 mm	
End Play 1.1L and 1.3L	0.075-0.285 mm	
Camshaft		
Journal Diameter 1.1 and 1.3L	39.615-39.636 mm	
Bearing I.D. 1.1 and 1.3L	39.662-39.713 mm	
Bearing Clearance (Standard Bearing) 1.1 and 1.3L	0.0254-0.058 mm	0.026-0.067 mm
Wear Limit	0.0762 mm	
Camshaft Thrust Plate Thickness 1.1L and 1.3L	4.457-4.508 mm	
End Play	0.02-0.19 mm	
Cam Lift 1.1L Intake	5.30 mm	5.15 mm
Exhaust	5.30 mm	4.92 mm
Camshaft Lift 1.3L Intake	5.30 mm	5.70 mm
Exhaust	5.30 mm	5.76 mm
Drive 1.1 and 1.3L	Chain	
Connecting Rod		
Piston Pin Bore 1.1L	20.589-20.609 mm	
Rod Bearing Bore 1.1L	46.685-46.705 mm	
Piston Pin Bore 1.3L	17.99-18.01 mm	
Rod Bearing Bore 1.3L	43.99-44.01 mm	
Maximum Twist or Bend	0.10 mm	
End Play 1.1 and 1.3L	0.10-0.25 mm	
Piston		
Diameter 1.1L	73.930-73.955 mm	68.71-68.72 mm
Diameter 1.3L	73.930-73.995 mm	
Piston to Bore Clearance	0.015-0.050 mm	
Piston Pin		
Diameter 1.1L	20.622-20.625 mm	18.026-18.029 mm
Diameter 1.3L	20.622-20.625 mm	18.026-18.029 mm
Length 1.1L	54.6-55.4 mm	58.6-59.4 mm
Length 1.3L	63.0-63.8 mm	63.6-64.4 mm
Interference Fit in Rod at 21°C 1.1 and 1.3L	0.013-0.045 mm	0.013-0.048 mm
Clearance in Piston at 21°C 1.1 and 1.3L	0.005-0.011 mm	0.008-0.014 mm
Piston Rings		
Top Compression Ring Thickness 1.1 and 1.3L	1.578-1.590 mm	1.503-1.505 mm
Bottom Compression Ring Thickness 1.1 and 1.3L	1.978-1.990 mm	1.75 mm (−.010 mm / −.022 mm)
Top Compression Ring Side Clearance 1.1 and 1.3L	.043-.080 mm	.013-.027 mm
Bottom Compression Ring Side Clearance 1.1 and 1.3L	.035-.076 mm	.005-.042 mm
Compression Ring Side Clearance — Wear Limit	0.15 mm	
Oil Ring Thickness 1.1 and 1.3L	3.955-3.980 mm	3.0 mm (−.010 mm / −.022 mm)

All specifications are in millimeters.
For Conversion Factors see page 8-05.

PART 8 SPECIFICATIONS (Cont.)

	Engine Model Year 1984 to 1988		Engine Model Year 1989-	
Piston Rings (Continued)				
Oil Ring Side Clearance 1.1 and 1.3L	.023-.073 mm		0-.032 mm	
Top Compression Ring — Standard Bore — Ring Gap[b]	0.25-0.45 mm			
Bottom Compression Ring — Standard Bore — Ring Gap[b]	0.25-0.45 mm			
Oil Ring — Standard Bore — Ring Gap[b]	0.20-0.40 mm			
Cylinder Head				
Maximum permissible cylinder head distortion 1.1 and 1.3L: Measured over a distance of 26 mm	0.04 mm			
Measured over a distance of 152 mm	0.08 mm			
Measured over the entire length	0.15 mm			
Valve Stem Bore 1.1 and 1.3L	7.907-7.938 mm		7.063-7.094 mm	
Valve Seat Angle	45°			
Valve Seat Insert Exhaust Diameter (Standard Size) 1.1L and 1.3L[c]	31.500 mm (+0.015 and −0 mm)			
1.1 and 1.3L Valve Seat Insert Intake Diameter[c] Standard	Not Available		1.1L: 34.00 mm[e]	1.3L: 36.500 mm[e]
Service Repair Exhaust Insert Only[c] 1.1 and 1.3L	31.900-31.915 mm		Not Available	
Combustion Chamber Volume 1.1	25.55-27.55 cc		27.24-29.24 cc	
Combustion Chamber Volume 1.3	27.00-29.00 cc		31.79-33.79 cc	
Reface cylinder head mating surface: The following minimum combustion chamber depth must be left after skimming — 1.1/1.3	9.67 mm		14.4 mm	
Valve Mechanism				
Lash Intake — Cold	0.22 mm			
Exhaust — Cold	0.59 mm		0.32 mm	
Stem Diameter Intake	7.868-7.886 mm		7.025-7.043 mm	
Exhaust	7.846-7.864 mm		6.999-7.017 mm	
Stem to Guide Clearance Intake	0.021-0.070 mm		0.021-0.690 mm	
Exhaust	0.043-0.092 mm		0.043-0.091 mm	
Length Intake	105.45-106.45 mm		103.70-104.40 mm	
Exhaust	106.04-107.04 mm		104.02-104.72 mm	
Head Diameter Intake 1.1L	32.89-33.15 mm		32.90-33.10 mm	
Exhaust 1.1L	29.01-29.27 mm		28.90-29.10 mm	
Head Diameter Intake 1.3L	38.02-38.28 mm		34.40-34.60 mm	
Exhaust 1.3L	29.01-29.27 mm		28.90-29.10 mm	
Seat Angle 1.1 and 1.3L	44.0°-44.5°			

All specifications are in millimeters.
For Conversion Factors see page 8-05.
[b] *Ring Gap may exceed these specifications by 0.15 mm when measurement is made in the block.*
[c] *Insert must be chilled in liquid nitrogen or dry ice prior to assembly.*
[e] *+0.015 mm*
−0.000 mm

PART 8 SPECIFICATIONS (Cont.)

	Engine Model Year	
	1984 to 1988	**1989-**
Valve Mechanism (Continued)		
Spring Free Length 1.1L, Intake/Exhaust	41.2 mm	41.0 mm
Spring Free Length 1.3L, Intake/Exhaust	42.4 mm	41.0 mm
Spring Assembled Height (Pad to Retainer)	32.08 mm	33.216 mm
Spring Load at Assembled Height	230 newtons	270 newtons
Tappet Diameter	13.081-13.094 mm	
Block Bore	13.110-13.143 mm	
Clearance to Block	0.016-0.062 mm	
Rocker Shaft — Diameter	15.82-15.85 mm	
Rocker Bore	15.875-15.913 mm	
Shaft Clearance in Rocker	0.02-0.09 mm	
Lubrication		
Oil Type — Motorcraft Super Engine Oil, API SG	ESE M2C-153-E	
Oil Capacity With Filter (FL 400)	3.25 Liters (3.5 qts.)	
Without Filter	2.75 Liters (2.9 qts.)	
Oil Pressure — Hot at 2000 rpm (minimum)	1.5 Bars	
Relief Valve Opens	2.41-2.96 Bars	
Oil Pump Outer Rotor to Housing Clearance	0.14-0.26 mm	
Inner to Outer Rotor Gap	0.051-0.127 mm	
End Play — Rotors to Pump Cover	0.025-0.06 mm	
Ignition System		
Firing Order	1-2-4-3	
Distributor Rotation	Counterclockwise	N/A
Initial Timing (with 89 Octane Regular Gasoline) 1.1 and 1.3L	6°BTDC	N/A
DIS[d] (with 87 Octane Unleaded Gasoline) 1.1 and 1.3L	N/A	Fixed
Spark Plugs — AGSF 22C Gap	0.75 mm	1.0 mm
Breaker Type		
Distributor Point Gap	0.40-0.50 mm	N/A
Dwell Angle	48°-52°	N/A
Dwell Variation	Max. 4°	N/A
Coil Primary Resistance (Ohms)	1.20-1.40 (75°F)	N/A
Secondary Resistance (Ohms)	5.000-9.000 (75°F)	N/A
Primary External Resistor (Ohms)	1.50	N/A
Condenser — (Micro Farads)	0.21-0.25	N/A
Solid State Type		
Coil, Ignition Primary Resistance (Ohms)	0.72-0.88	N/A
Secondary Resistance (Ohms)	4500-7000	N/A
Coil, Trigger — Resistance (Ohms)	1000-1200	N/A
Wire, Spark Plug Leads — Resistance	3000 Ohms Max. per Lead	N/A

All specifications are in millimeters.
For Conversion Factors see page 8-05.
[d]Distributorless Ignition System

PART 8 SPECIFICATIONS (Cont.)

	Engine Model Year 1984 to 1988	1989-
Distributorless Type		
Coil Type	N/A	High Output DIS Coil
Coil Output	N/A	37.0 KV Minimum
Primary Resistance (at the Coil Tower)	N/A	0.50-1.00 Ohm
High Tension Leads	N/A	30,000 Ohms Max. per Lead
Belt Tension		
Alternator New	79-101 lbs.	
Used-Reset (Minimum)	56-75 lbs.	
Governor New	75 lbs.	
Used-Reset (Minimum)	50 lbs.	
Fuel System		
1.1 and 1.3L Regular 1984-1985	89 Octane	—
1.1 and 1.3L Unleaded 1986-	—	87 Octane
Pump Delivery Pressure	0.24-0.38 Bar (3.5-5.5 PSI)	
Starter — Current Draw		
Normal Engine Cranking	175 amps	
Maximum Load — at Stall	410 amps	
No Load	35 to 55 amps	

All specifications are in millimeters.

DISTRIBUTOR ADVANCE CHARACTERISTICS

All figures quoted below are spark advance in degrees crankshaft and do not include initial advance setting.

Advance at 2000 rpm (Engine Speed with No Load)	Mechanical	Vacuum	Total
(84/89) 1.1 Liter	3.0° to 9.0°	12.0° to 21.0°	15.0° to 30.0°
(84/89) 1.3 Liter	5.0° to 9.0°	14.0° to 20.0°	19.0° to 29.0°

SPECIAL SERVICE TOOLS

21-007 Installer — Valve Stem Seal — Intake
21-046 Installer — Crankshaft Seal — Front-Timing Cover
21-059A Installer — Rear Crankshaft Seal
21-096 Remover — Crankshaft Oil Seals
T81P-6513-A Valve Spring Compressor
Call Owatonna Tool Company
1-800-533-5338
Ask for Ford Order Desk

CONVERSION FACTORS

Bars x 14.5 = Pounds per Square Inch
Cubic Centimeter x 0.155 = Cubic Inches
Foot/Lbs x 1.3558 = Newton/Meter (Torque)
Inches x 25.4 = Millimeter
Kilogram x 2.2046 = Pounds per Square Inch
Liter x 61.024 = Cubic Inches
Liter x 1.0567 = Quarts
Millimeter x 0.03937 = Inches
Newton x 0.2248 = Pounds (Force)
Newton/Meter x 0.7336 = Ft/Lbs (Torque)

TORQUE SPECIFICATIONS

Item	1984 to 1988		1989-	
	Nm	Ft-Lb	Nm	Ft-Lb
Main Bearing Cap	88 to 102	64-75	88-102	64-75
Connecting Rod Bolts	29 to 36	21-27	①	
Rear Oil Seal Carrier	16 to 20	12-15	16 to 20	12-15
Flywheel	64 to 70	47-52	64 to 70	47-52
Clutch Pressure Plate, 165 mm Dia. 1.1 and 1.3L	9 to 11	6.6-8.1	24 to 35	17.6-25.7
190 mm Dia. 1.1 and 1.3L	16 to 20	11.7-14.7	24 to 35	17.6-25.7
All After 87 M.Y.	24 to 35	17.6-25.7	24 to 35	17.6-25.7
Chain Tensioner	24 to 25	17-18	24 to 25	17-18
Camshaft Thrust Plate	7 to 9	5-7	7 to 9	5-7
Camshaft Sprocket	16 to 20	12-15	16 to 20	12-15
Timing Cover	7 to 10	5-7.5	7 to 10	5-7.5
Water Pump	7 to 10	5-7.5	7 to 10	5-7.5
Crankshaft Pulley 1.1 and 1.3L 84/88 M.Y.	54 to 59	40-44		
Crankshaft Pulley 1.1 and 1.3L 89/M.Y.			100 to 120	73.4-88
Water Pump Pulley	8.5 to 10.6	6.3-7.8	100-120	73.4-88
Starter Motor	35 to 45	26-33	35 to 45	26-33
Fuel Pump	16 to 20	12-15	16 to 20	12-15
Distributor Retaining Bolt	7 to 10	5-7.5	7 to 10	5-7.5
Distributor Clamp Bolt	3 to 4	2-2.5	3 to 4	2-2.5
Oil Pump	16 to 20	12-15	16 to 20	12-15
Oil Pump Cover	8 to 12	6-9	8 to 12	6-9
Oil Pump Pickup Tube Bracket	20 to 25	15-18	20 to 25	15-18
Oil Pan — Step 1 Alphabetical	6 to 8	5-6	6 to 8	5-6
— Step 2 Numerical	8 to 11	6-8	8 to 11	6-8
— Step 3 Alphabetical	8 to 11	6-8	8 to 11	6-8
Retorque after engine has warmed up				
(15 minutes at 1000 rpm)				
Oil Pan Plug	21 to 28	15-20	21 to 28	15-20
Oil Pressure Switch	13 to 15	10-11	13 to 15	10-11
Temperature Sender	4 to 8	3-6	4 to 8	3-6
Rocker Shaft Pedestals	40 to 46	30-34	40 to 46	30-34
Cylinder Head Bolts — Step 1	10 to 15	7.5-11	STEP 1-30	22
— Step 2	40 to 50	30-37	STEP 2-Turn	90° More
— Step 3	80 to 90	60-66	STEP 3-Turn	90° More
— Step 4 (after 10 to 20 mins)	100 to 110	74-81		
Rocker Cover	4 to 5	3-4	4 to 5	3-4
Exhaust Manifold	21 to 25	15-18	21 to 25	15-18
Inlet Manifold	16 to 20	12-15	16 to 20	12-15
Carburetor	17 to 21	12.5-15	17 to 21	12.5-15
Thermostat Housing	17 to 21	12.5-15	17 to 21	12.5-15
Spark Plugs	15 to 20	11-15	15 to 20	11-15

①**Step One** Torque to 4NM, **Step Two** Turn 90° more.