Autolite Ford

ENGINE EMISSION CONTROL SYSTEMS

Foreword . . .

This manual has been prepared primarily for service technicians who attend an Autolite-Ford Field Service Training Clinic covering Engine Emission Control Systems. Accordingly, the information it contains closely follows the clinic format.

The text materials are divided into three general groupings . . . first, an introductory section which explains the need for emission control and provides some necessary background information . . . next, a section dealing with those operating principles which apply to the several types of control systems currently in use in the automotive market . . . and finally, a section which outlines the service procedures which, when they involve an emission control system, are of particular importance. There are also several Appendix items, including a Service Guide, Specifications, Vacuum Diagrams and a Glossary of Terms, which add permanent reference value to this publication.

As clinic training and this manual will emphasize, the capability of an emission control system to effectively reduce the volume of air pollutants released through an automotive breathing and exhaust system depends primarily on the complete combustion of its fuel. Complete combustion, in turn, can only occur when the fuel-air mixture exists in proper proportions and ignition timing is adjusted to exact service specifications. To the service technician, this means that engine tune-ups may be required *more frequently* and must be performed with a *greater degree of skill and accuracy* than ever before. We trust that the information in this manual will be an aid in this respect.

If additional background information is needed, we encourage you to read the last six pages in the book.

. . . They describe . . . AUTO TECH . . .

WHAT IT IS . . . HOW IT WORKS . . . WHAT IT PROVIDES. We encourage you to read about this low-cost correspondence training program which carries a money-back guarantee. (A registration form is included for your convenience.)

NATIONAL SERVICE DEPARTMENT
AUTOLITE-FORD PARTS DIVISION
FORD MOTOR COMPANY

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AUTO TECH

DESCRIPTION .... SEE LAST 6 PAGES
REGISTRATION FORM

Introduction

FIGURE 1. URBAN SCENE OF THE FUTURE?

The air we breathe is composed of approximately 21% oxygen, 78% nitrogen and 1% miscellaneous (inert) gases. Now that the chemical balance of this air supply has been threatened by contaminants in several forms, legislative action at Federal, State, and, in some cases, local levels has been enacted to effect controls aimed at keeping our surrounding atmosphere as pure and clean as possible.

Air pollution can no longer be considered an isolated local problem. It is, in fact, a problem which is worldwide in scope. The growing concentration of population in large metropolitan areas and the increasing use of hydrocarbon fuels are major factors contributing to the gravity of the problem of air pollution. As an example, it has been estimated that the weight of contaminants in the air in the Seven-County Metropolitan Area surrounding Los Angeles amounts to about 1,700,000 tons annually. This level of pollution in the atmosphere . . . which appears to be rising continuously . . . if left unchecked, could result in widespread cases of lung and eye irritation, aggravated respiratory conditions, extensive property damage, and serious crop losses.

A dramatic example of the dangers inherent in air pollution occurred in London, England in December of 1952. The city, at that time, was engulfed in one of its famous "fogs" . . . one which lasted five days. It was not an ordinary fog, however; within that period of five days, 4,000 people died. These deaths were later attributed to one of the most severe penalties of city life . . . SMOG.

Smog is produced by a chemical reaction which occurs in the atmosphere and involves a reaction between unburned hydrocarbons and air in the presence of the oxides of nitrogen and sunlight. The occurrence of smog is not only dependent upon the presence of a large amount of air pollutants, it also depends upon certain natural factors such as terrain, still air, bright sunshine, high temperature, and temperature inversion. Temperature inversion involves a layer of warm air lying above the cooler, ground-level air. The warm air prevents the cooler air from rising into the upper atmosphere. This traps-in the air pollutants and adds to the smog producing conditions.

As suggested in our opening paragraph, the magnitude of the air pollution problem has resulted in increased publicity, public concern, and government legislation aimed at regulating the amount of contaminants allowed to enter the atmosphere. This increased public awareness and concern in conjunction with industry research can prevent the possibility of an urban situation such as that depicted in Figure 1.

SOURCES OF AIR POLLUTION

There are many different sources of air pollution—some more objectionable than others. These pollutants may be in the form of ordinary dust, incomplete fuel combustion in industrial processes, smoke and ash from the burning of trash and leaves, and unburned hydrocarbons from the imperfect combustion of fuel in motor vehicles.

Industrial Processes

By-products from industrial processes can significantly aggravate the air pollution problem (See Figure 2).

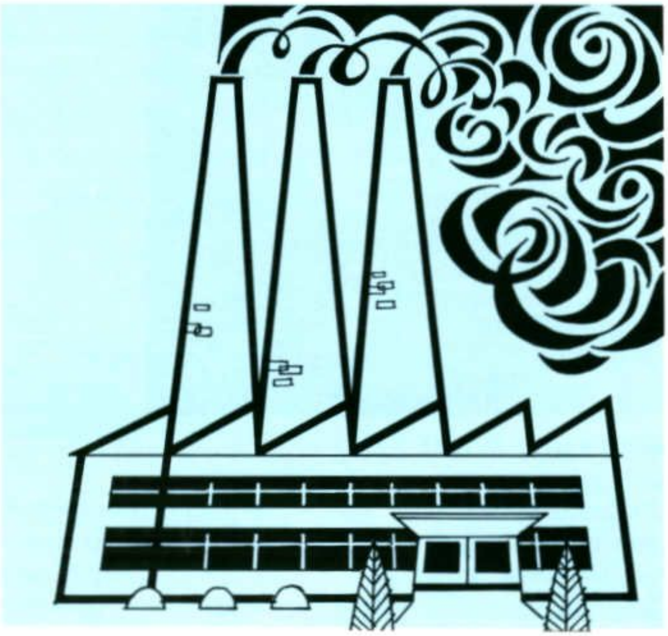


FIGURE 2. GASES FROM INDUSTRIAL PROCESSES

Some industries rely on the combustion of hydrocarbon fuels, such as coal, oil, or kerosene. If the combustion of these fuels is incomplete, a significant proportion of unburned gases containing hydrocarbons may escape to the atmosphere.

Trash Burning

Although seemingly unimportant, the common practice of burning trash or leaves can also contribute to the problem of air pollution. (See Figure 3.)

In the process of combustion, by products including gaseous compounds as well as residual ash, are allowed to enter the atmosphere.

The Automobile

Although industry fuel and household trash burning represent two of the many sources of air pollution, public attention and government regulation are primarily concerned with the automobile as constituting the major source of air pollutants. (See Figure 4.)

FIGURE 3. TRASH BURNING ... A SOURCE OF AIR POLLUTION

The internal combustion engine of the automobile relies on the use of a hydrocarbon fuel . . . gasoline . . . for its operation. It was soon learned that unburned hydrocarbons could escape from four places on the automobile—the fuel tank vent, the carburetor, the engine crankcase vent and the exhaust system. Evaporation losses from the fuel tank and carburetor constitute a small portion of the automobile emission problem. The areas of major concern are the control

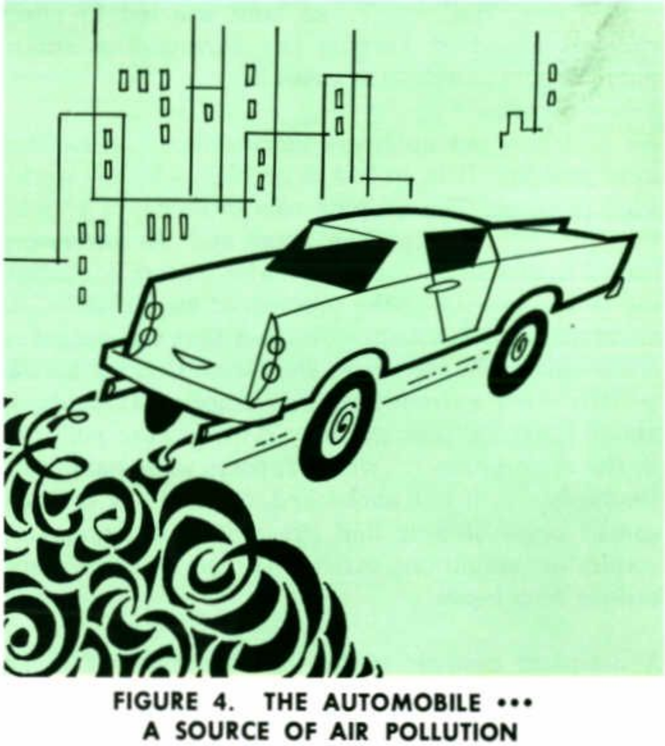


FIGURE 4. THE AUTOMOBILE ... A SOURCE OF AIR POLLUTION

of crankcase vapors and the control of the combustion process during engine idle and deceleration. The automotive industry is currently involved in research aimed at improving the combustion process to reduce the level of unburned hydrocarbons emitted to the atmosphere. Since the industry emphasis is to improve combustion, it is necessary to have a fundamental understanding of the combustion process itself.

ESSENTIALS OF COMBUSTION

"Air pollution", as used in this manual, is any contamination of the air which is harmful to plant life, animals or man. The most harmful and undesirable of the many forms of air pollutants, with which we are directly concerned, are hydrocarbons and the unburned gases resulting from the process of combustion.

Obviously, combustion is a necessary process in our everyday lives. When we smoke a cigarette, strike a match, heat our homes, burn autumn leaves, or operate an automobile, we are employing the principle of combustion.

Combustion is a chemical action, frequently referred to as "oxidation", accompanied by the evolution of light and heat. There are three essentials which must exist before combustion is possible. (See Figure 5). These are:

1. a suitable fuel;
2. an adequate supply of oxygen;
3. a source of heat which will exceed the fuel's kindling point.

The household task of burning leaves each autumn is a typical example of combustion. The three essentials we just mentioned are present . . . the leaves (fuel), the match used to light the leaves (heat), and the surrounding atmosphere which contains the oxygen needed to support combustion (approximately 21% by volume).

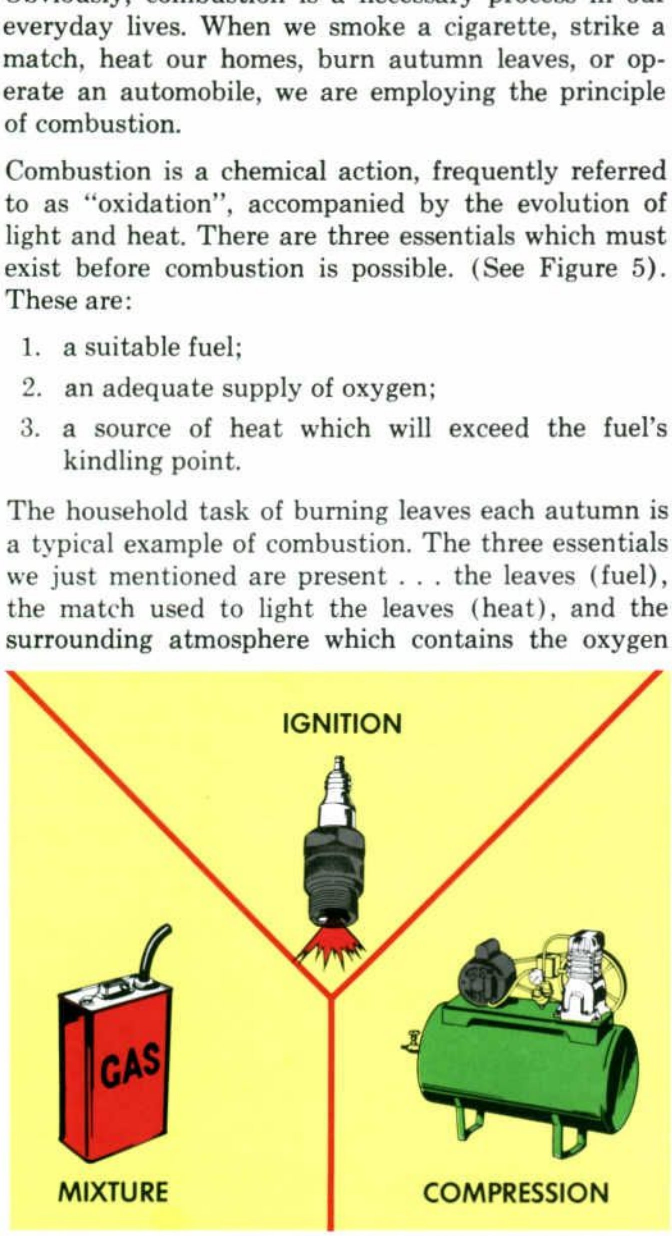


FIGURE 5. ESSENTIALS OF COMBUSTION

During combustion, the fuel and oxygen are chemically converted into new compounds with the aid of the fire (heat). The ashes left on the ground are evidence of part of the conversion which has taken place. The balance of the ingredients, which we no longer see, are expelled and dissipated into the atmosphere as by-products of combustion. These by-products include certain gaseous compounds, as well as certain amounts of residual ash.

THE INTERNAL COMBUSTION ENGINE

In our example of burning leaves, the combustion process was used to accomplish one type of task. The automobile engine, however, is meant to perform another very different function.

The internal combustion used in an automobile engine is designed to convert or transform the *heat energy* released during the process of combustion into *mechanical energy* for the purpose of performing work. In order to accomplish this task, the automobile engine must also be provided with the essentials of combustion. The *fuel*, of course, is the gasoline; which, along with *air* (compressed), is fed into the combustion chamber where the spark plug provides the *heat* above the temperature level produced by compression which is needed to ignite the fuel.

In the four-stroke cycle engine, control over combustion is primarily accomplished by the carburetor, air-fuel distribution system, valve train and ignition systems.

- The *carburetor* exercises control over *fuel* and *air* by regulating the mixture ratio of the two. It also controls the amount of *fuel-air* admitted to the combustion chamber for burning.
- The *intake system* brings the fuel-air mixture from the carburetor through the intake valves into the cylinders. Each intake manifold passage from the carburetor to the cylinder is approximately the same length. Thus, each cylinder receives a similar ratio but unequal amount of the fuel-air mixture. (See Figure 6.)

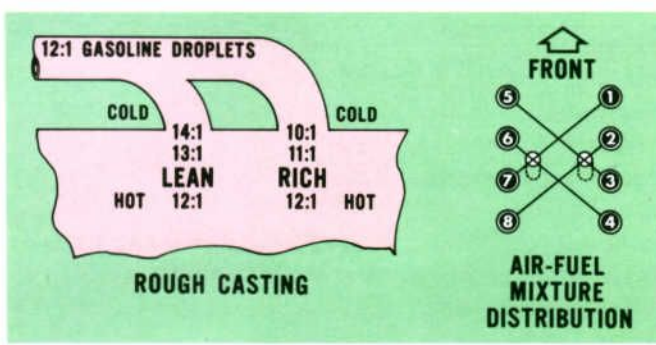


FIGURE 6. INTAKE MANIFOLD FUEL DISTRIBUTION

• The *valve train*, valve size, and duration of valve opening affect the engine's ability to breathe under various load and speed conditions. The camshaft design will determine the amount of valve overlap and the duration of valve opening. Figure 7 illustrates a typical valve train. It is provided so that you may more readily see how the components perform their design function. Most mechanical factors . . . gears, levers, fulcrums, etc. . . . are involved. The camshaft is driven by either a gear or a chain (depending upon engine design) in response to the rotary motion of the crankshaft. A cam-follower (lifter) sits on top of the eccentric (egg-shaped) cam and converts the rotary motion of the revolving cam into linear (straight, up-and-down) motion through the pushrod and rocker arm assembly. The rocker arm then pushes the valve open and the counterforce of the valve spring causes it to close when the cam has passed its high point.

The valves, both intake and exhaust, are designed primarily to open and close the combustion chamber. In order to accomplish this task, most efficiently, they must be *timed* so that most of the air-fuel mixture is either burned or taken out of the combustion chamber. This "taking out" is a part of the process of ventilation and scavenging.

To best understand the principles of emission control, the functions of each component must be taken into consideration. If you understand the function of the component, then it becomes much easier to see *why* emission levels are reduced by changing certain design features. Valve timing is very important to the engine as far as its role is concerned. Let's take a look then, at what valve timing is all about.

Valve Overlap

Figure 8 will give you an indication of how valves are timed. Relate what you know about the up-and-down motion of the piston inside the cylinder; then, add what you know about the four strokes of the four-stroke cycle. For example, the intake and compression strokes account for one-half of the cycle; yet, the crankshaft has made one full revolution (360°). The power and exhaust strokes also account for one full revolution (360°). We now have a total of 720° which the crankshaft must rotate to complete *one* cycle. This is what is being graphically illustrated in the left-hand portion of Figure 8.

In theory, the opening and closing (timing) of the valves in relation to the location of the piston in the cylinder bore would occur ideally in the manner charted on the next page.

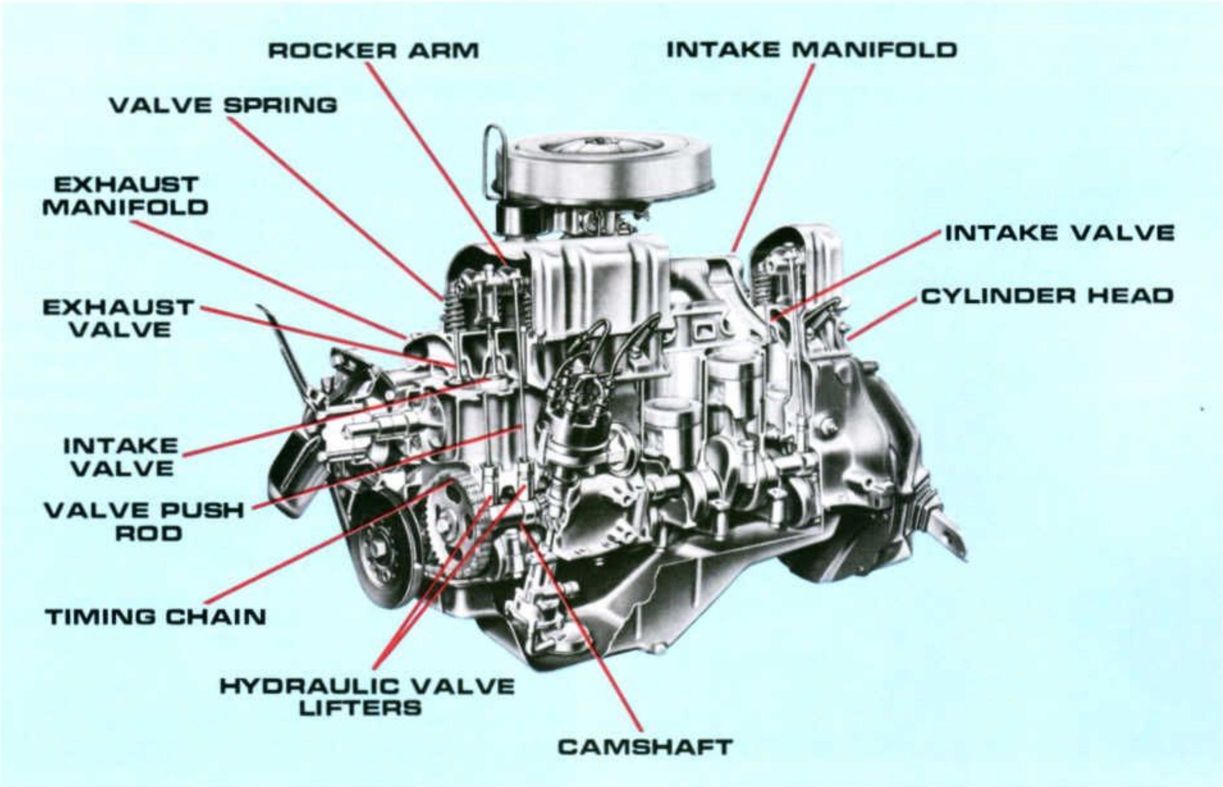


FIGURE 7. VALVE TRAIN

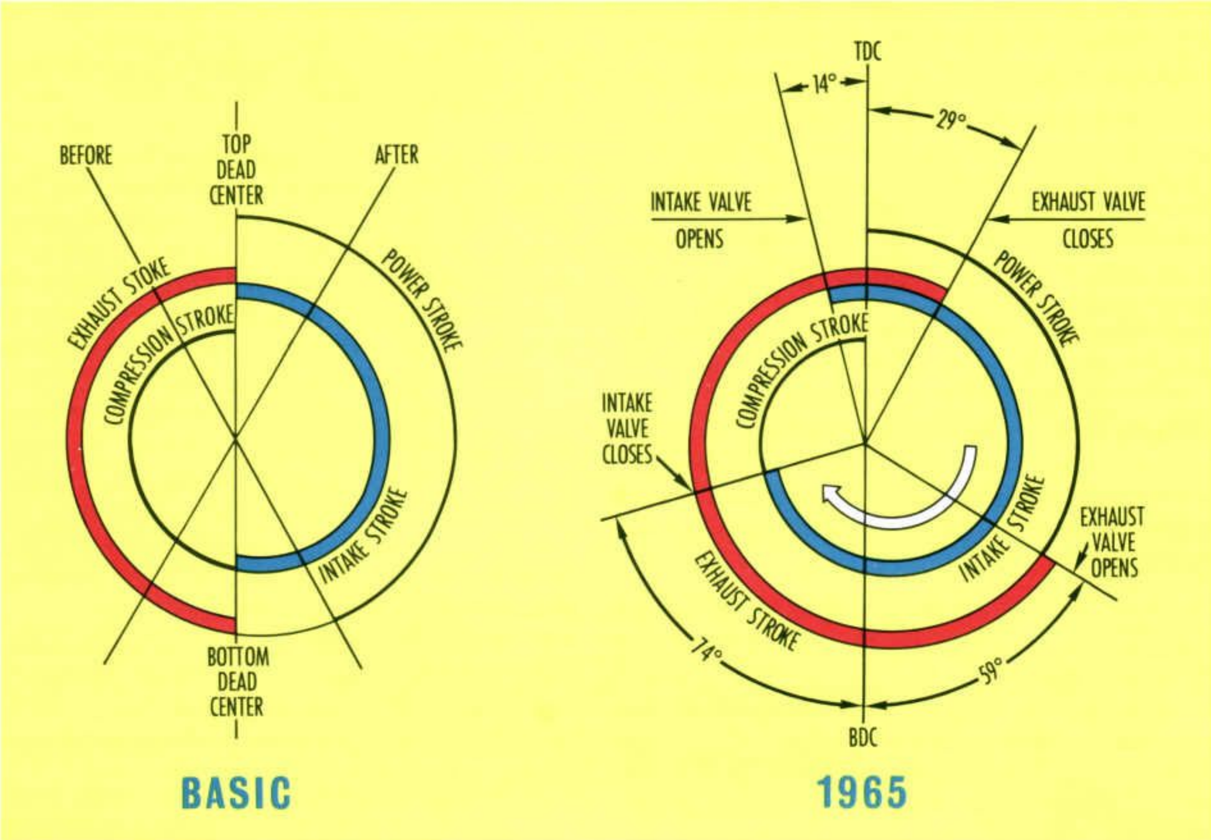


FIGURE 8. VALVE OVERLAP

STROKE			POSITION OF VALVE	
TYPE	BEGINS	ENDS	INTAKE	EXHAUST
INTAKE	TOP DEAD CENTER (TDC)	BOTTOM DEAD CENTER (BDC)	OPEN	CLOSED
COMPRESSION	BDC	TDC	CLOSED	CLOSED
POWER	TDC	BDC	CLOSED	CLOSED
EXHAUST	BDC	TDC	CLOSED	OPEN

This is how a four-stroke cycle engine should operate at slow speeds. Other factors, such as fuel-air mixture characteristics and engine ventilating characteristics enter the picture. Every engine must include provisions for proper ventilation. This is known as "breathing". Just as human beings must breathe to function properly—so must an engine.

We begin to experience difficulty in the engine's breathing ability as soon as we attempt to increase speed. To compensate for the increased speed, the valves are timed so that they overlap. That is, they are opening and closing at times other than exact Top Dead Center or Bottom Dead Center. The right-hand half of Figure 8 shows an actual Ford-built engine, and the areas of valve overlap are shown by the number of degrees before and after T.D.C., as well as before and after B.D.C. Basically, we are concerned with the action of the intake and exhaust valves on the intake and exhaust strokes. They do overlap, however, into the compression and power strokes.

Practically, timing of the valves for a typical 390 C.I.D. engine is as follows . . .

- The intake valve opens 14° BTDC during the intake stroke.
- The intake valve closes 74° ABDC during the compression stroke.
- The exhaust valve opens 59° BBDC during the power stroke.
- The exhaust valve closes 29° ATDC during the exhaust stroke.

The intake valve remains open from 14° Before Top Dead Center during exhaust stroke, a full 180° during the intake stroke, and 74° of the Compression stroke; thus, the intake valve is open for a total of 268° (of a possible 720°). The exhaust valve remains open from 59° BBDC during the power stroke, a full 180° during the exhaust stroke, and 29° of the intake stroke; thus, the exhaust valve is also open for a total of 268° (of a possible 720°). This arrangement of valve timing is designed into the engine for the following reasons . . .

- To allow a fresh fuel-air charge into the cylinder early enough to help push the "burned" gases out of the cylinder.
- To allow more time for the "burned" gases to leave the cylinder.
- The *ignition system* provides the ultimate heat necessary for combustion in the form of an arc across the spark plug electrodes. The ignition system also controls the spark timing to precisely match speed and load conditions under which the four-stroke cycle engine may be operating.

Remembering that all these systems control the combustion ingredients, let's look at the combustion process and see how the by-products and heat (energy) divide in the internal combustion, four-stroke cycle engine.

1. A portion of the pressure developed as the result of ignition is converted by the engine to useful mechanical energy.
2. Some of the high pressure gases escape from the combustion chamber as they are forced between the piston and cylinder walls where they enter the crankcase in the form of unburned hydrocarbons.
3. Some of the heat of ignition is dissipated into the engine's cylinder head and cylinder block casting and the surrounding cooling system.
4. The balance of the by-products, consisting of carbon monoxide and unburned hydrocarbons, are expelled into the atmosphere, through the engine's exhaust system.

Engine Blow-by

In spite of the sophisticated control devices on the modern, four-stroke cycle, internal combustion engine, undesirable by-products from controlled internal combustion remain a problem to human health . . . a problem which, through urbanization, has become national in its scope. Theoretically, the piston and ring assembly form a "gas-tight" seal as it moves along the cylinder walls. However, the extremely high pressure created during the compression and power strokes of the internal combustion process, produces unavoidable leaks commonly known as blow-by.

"Blow-by", then, is the name given to the high pressure gases that escape past the engine piston rings into the crankcase during both the compression and power strokes. The condition becomes more pronounced on high mileage (worn) engines because of the growing imperfection of the sealing characteristics of the rings at the cylinder wall. Blow-by is comprised mostly of unburned fuel-air mixture.

In order to understand the conditions leading to engine blow-by, let's look at the function of each of the engine components related to the "sealing" of the combustion chamber.

Think of the engine as an air pump. On the intake stroke, the piston moves downward and creates a low pressure (VACUUM) area on top of the piston. Air from the atmosphere mixed with fuel from the carburetor then rushes in to fill that space. On the compression stroke, the piston moves upward and squeezes the air-fuel mixture into a smaller space . . . a variable which depends upon the "design" characteristics which determine compression ratio. The valve, cylinder head and top surface of the piston trap the air in the area referred to as the combustion chamber; the piston compression rings provides a less-than-perfect seal at the bottom of the chamber, but a perfect "seal" at this point is not practical. From a cost standpoint, reducing friction by raising surface finish specifications is prohibitive. Decreasing ring clearance at the cylinder wall is also prohibitive . . . in this case . . . functionally. As a result "blow-by," as shown in Figure 9 is a "necessary evil."

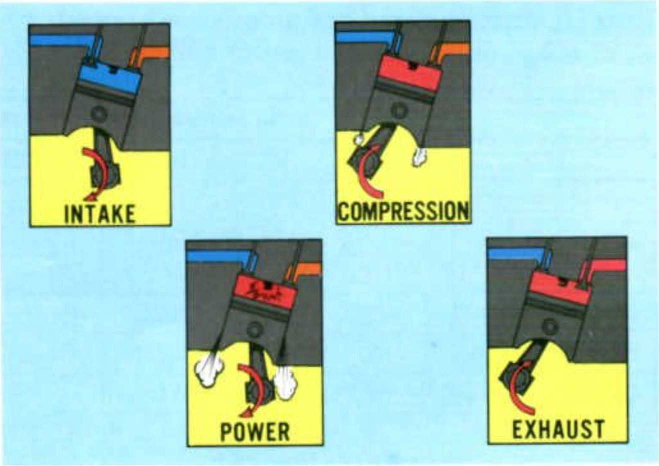


FIGURE 9. BLOW-BY IN THE FOUR-STROKE CYCLE ENGINE

On the power stroke, the expanding gases drive the piston downward, and again, some of the gases are forced by the compression rings to enter the crankcase as unburned "blow-by" gases.

On the exhaust stroke, the exhaust valve is open and the upward movement of the piston forces the "burned" gases out of the combustion chamber into the exhaust manifold.

The gases blown into the crankcase, eventually escape into the atmosphere along with the exhaust gases emitted from the engine's exhaust system.

TYPES OF EMISSION CONTROL SYSTEMS

In both examples of combustion, that of trash burning and that of internal combustion in the automobile engine, the combustion process was controlled to perform a specific task. However, no provisions were made to control the by-products of combustion. They were simply dissipated into the atmosphere.

It is this aspect of combustion, the emitting of unburned hydrocarbons into the atmosphere, that has resulted in public concern and recently in government legislation regulating the level at which man-made air pollutants may be released.

Unburned hydrocarbons from the automobile engine are one of the "offenders" which the law has specified as a pollutant to be controlled. In response, improved burning within the combustion chamber and re-routing of blow-by gases to the combustion chamber through existing ventilation systems is the control measure being adopted by most of the automobile industry.

The Ford Motor Company, as well as other automobile manufacturers, has conducted extensive research, development, test and evaluation programs to determine the most feasible approach to controlling vehicle emissions. The results of these independent programs are apparent in the variety of emission control devices and systems appearing on today's automobiles.

With these observations having been made, the balance of our text materials will be aimed at explaining the operating principles and service procedures which apply to the more representative systems now in use. In this respect, we will cover:

1. Crankcase Emission Controls
   (Positive Crankcase Ventilation)
2. Exhaust Emission Controls
   (Improved Combustion and Air Injection Systems).

Principles of Operation

CRANKCASE EMISSION CONTROL

As we have suggested, the combustion process does take place under "controlled" conditions in the internal combustion engine. Maximum power from this process depends largely upon the high pressures developed in the combustion chamber. These high pressures, however, result in gas leakage between the piston and cylinder wall during the compression and power strokes. If this gas or "blow-by" is allowed to react with the oil in the crankcase or valve covers, it will form thick sludge deposits and contribute to short engine life and poor performance.

To prevent these undesirable side effects, every internal combustion engine must be provided with a means of "breathing" or routing fresh air through the crankcase to remove the accumulated fumes and vapors. Traditionally, engine manufacturers have elected to use the "Road Draft Tube System" to accomplish this task.

ROAD DRAFT TUBE

The road draft tube is designed and located so that a stream of air passing under the moving vehicle will draw the blow-by gases out of the crankcase. The system makes use of the "venturi" princlple; i.e., a low pressure area is created at the lower end of the draft tube as the vehicle moves forward. An opening is provided to allow fresh air to enter; called a crankcase breather opening. In most instances, this breather also serves as the oil filler tube and is protected with an air filtering device in the oil filler tube cap. The locations of the road draft tube and breather opening vary on different makes and models of vehicles.

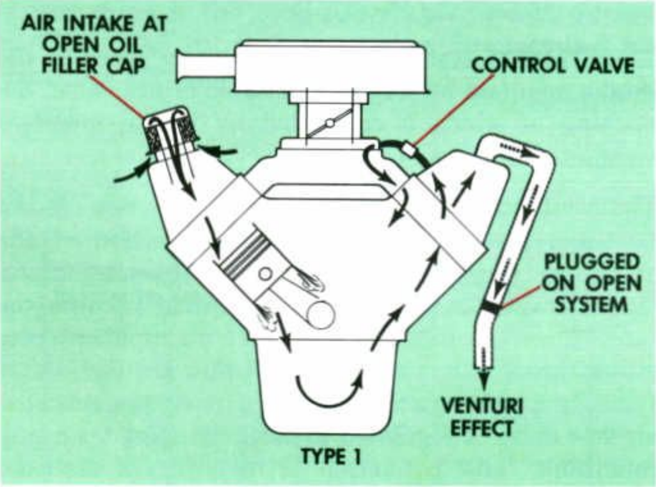


FIGURE 10. TYPE 1 CRANKCASE SYSTEM

One of the major drawbacks to the "road draft tube" system is that vehicle road speeds in excess of 25 m.p.h. are necessary for the ventilating system to operate effectively as a means of purging air pollutants. Accordingly, the draft tube is not an adequate device for minimizing atmospheric pollution with unburned hydrocarbons.

In an effort to solve this problem, automobile manufacturers have developed various positive crankcase ventilating systems which recirculate blow-by gases and ventilating air to the intake manifold for subsequent reburning in the combustion chamber.

CLASSIFICATION OF CRANKCASE EMISSION CONTROL SYSTEMS

Crankcase emission controls were first used on Ford-built engines in 1961. They were installed, at that time, on cars to be registered in the State of California. Nationwide use followed for all vehicles in 1963. Refinements to these earlier systems were incorporated in ensuing production years; and now, variations based on application are used on all Ford vehicles. These variations have been classified according to the following types:

TYPE 1 – Valve Controlled by Intake Manifold Vacuum. (Open).
TYPE 2 – Valve Controlled by Crankcase Vacuum.
TYPE 3 – Tube-to-Air Cleaner Device.
TYPE 4 – Combination Systems. (Closed).

Each of these types of crankcase emission systems has been used by the various car manufacturers at one time or another. The latest requirement is that all engines use the "closed" crankcase ventilation system. According to the above classification, this would be the combination or Type 4 system.

Type 1—Valve Controlled by Intake Manifold Vacuum

The TYPE 1 system conducts blow-by gases to the intake manifold by way of a variable orifice valve, the opening of which is controlled by intake manifold vacuum. (Refer to Figure 10.)

The ventilating air entering the system flows down past the push rods into the lower portion of the crankcase where it mixes with the blow-by gases. Under crankcase pressure and manifold vacuum the fumes are recirculated to the intake manifold entering either through the carburetor or below the carburetor (usually at the spacer plate). In most systems, the air flow must be regulated to meet changing operating conditions. This regulation or metering, is essential when crankcase fumes enter below the carburetor since they will affect the air-fuel mixture ratio. Metering of these fumes is accomplished by the use of a P.C.V. valve.

P.C.V. systems do not rely on vehicle speed, as did the road draft tube system. Instead, they make use of the engine vacuum and crankcase pressure that exist whenever the engine is running. This assures a continuous, positive flow of ventilation through the crankcase at all engine speeds.

P.C.V. VALVE OPERATION

The P.C.V. valve generally used is a spring-loaded regulator-type. (See Figure 11.)

The valve reacts to changes in intake manifold vacuum and serves to regulate the amount of ventilating

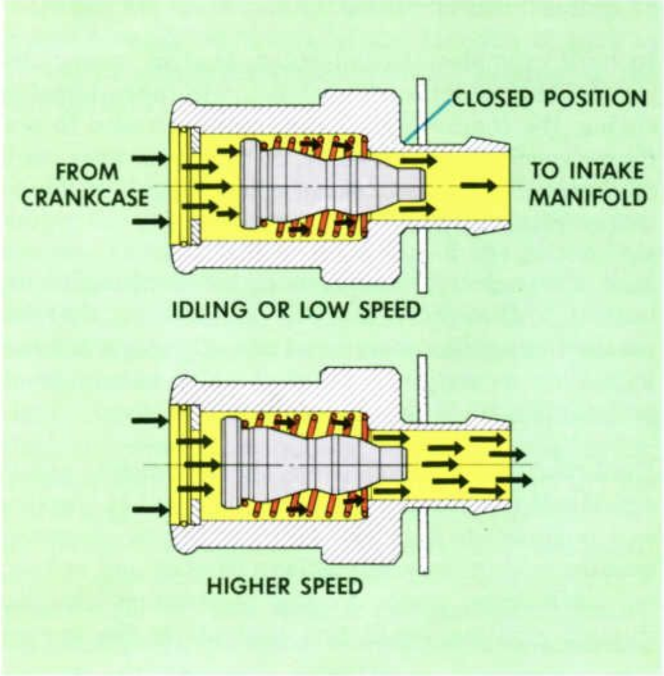


FIGURE 11. P.C.V. VALVE OPERATION

air and blow-by gas allowed to combine with the air-fuel mixture in the intake manifold. During idle, intake manifold vacuum is high. This high vacuum overcomes the force of valve spring pressure and moves the valve to its low-speed operating position. (Refer to Figure 11.) With the valve in this position, there is a minimum of ventilating air and crankcase gas passing between the valve (jiggle) pin and outlet port. As engine speed increases and manifold vacuum decreases, the spring forces the valve to the fully-open position. (Refer to Figure 11.) This increases the flow of ventilating air and blow-by gas to the intake manifold. Another type of valve is used in the PCV system which is controlled by crankcase vacuum. (See Figure 12.)

The flow rate of this valve is dependent upon the amount of blow-by gas generated by the engine. As crankcase vacuum increases, the diaphragm lessens the opening by allowing the modulator to seat, so that the ventilation flow to the intake manifold decreases. When crankcase vacuum decreases or attains positive blow-by pressure, the spring pushes the modulator off its seat. With the valve open, there is an increased flow of blow-by gases and ventilating air to the intake manifold.

A large majority of the crankcase devices installed in American-made cars from 1961 through 1963 were of the Type 1 variety. The system includes a hose between the crankcase and the regulator valve and another hose between the valve and a fitting at the base of the carburetor.

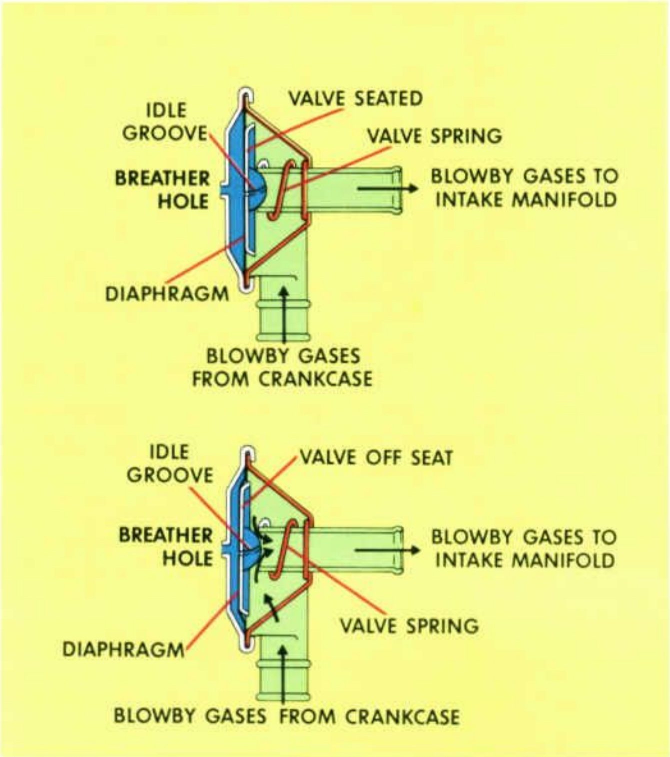


FIGURE 12. VALVE CONTROLLED BY CRANKCASE VACUUM

When the engine is not running, or if it should backfire, the valve remains in the "off" position. Under idle conditions, the manifold vacuum is high and the valve is still closed; a small orifice through the center of the valve handles the flow requirements. As the manifold vacuum approaches 12 to 15 inches of mercury, the valve begins to open; thus, increasing the flow capacity of the valve. The amount of blow-by tends to increase proportionately as manifold vacuum, decreases, until, at high speeds, with low manifold vacuum, the valve, or more specifically, the plunger portion of the valve opens and permits maximum flow. The Type 1 system was factory-installed in 1961 through1963 vehicles; however, it was not approved as a conversion kit for installation on used cars. The overall effectiveness of the Type 1 system in controlling crankcase emissions under various operating conditions is detailed in chart form in Figure 13.

Type 2—Valve Controlled by Crankcase Vacuum

This system conducts emission from the crankcase system through the rocker arm cover to the intake manifold. The valve in the system is controlled by crankcase vacuum. (See Figure 14.)

OPEN SYSTEM

CONDITIONS AFFECTING EMISSION CONTROL	POSITION THROTTLE	AVAILABLE VACUUM	COMPRESSION PRESSURE	AMOUNT OF BLOWBY FROM ENGINE	POSITION OF PCV VALVE	PATH OF BLOWBY	PERCENT (APPROX.) EFFECTIVE IN CONTROLLING CRANKCASE EMISSION
ENGINE OFF (1)	CLOSED	NONE	NONE	NONE	OPEN	NONE	
LOW SPEED (IDLE)	CLOSED	HIGH (2)	LOW (3)	LOW	CLOSED (4)	ALL THROUGH VALVE	100
(5) LOW SPEED (LOAD)	WIDE OPEN	LOW	HIGH	HIGH	FULLY OPEN	HALF THROUGH VALVE	50
						HALF TO ATMOSPHERE	
HIGH SPEED	PARTLY OPEN	MEDIUM	MEDIUM	MEDIUM	PARTLY OPEN	3/4 THROUGH VALVE	75
						1/4 TO ATMOSPHERE	

TYPE 1.

NOTE: 1 IN CASE OF BACKFIRE, DURING CRANKING, THE VACUUM IN THE INTAKE MANIFOLD WILL CAUSE THE PCV VALVE PLUNGER TO MOVE TOWARD THE CRANKCASE; THUS, SEALING THE PASSAGE TO THE CRANKCASE AND PREVENTING A POSSIBLE EXPLOSION.
NOTE: 2 BLOWBY IS AT A MINIMUM WHEN MANIFOLD VACUUM IS HIGH AT IDLE.
NOTE: 3 BLOWBY IS AT A MAXIMUM WHEN COMPRESSION IS HIGH.
NOTE: 4 PCV VALVE IS ON MINIMUM (CLOSED) FLOW POSITION WHEN MANIFOLD VACUUM IS HIGH.
NOTE: 5 FOR LOW SPEED, OPEN THROTTLE POSITION, AS WELL AS VARIOUS THROTTLE PLATE POSITIONS AND LOAD COMBINATIONS. THE MAIN CONCERN OF EMISSION CONTROL IS AT IDLE AND DURING DECELERATION CONDITIONS.

FIGURE 13. OPEN CRANKCASE EMISSION SYSTEM OPERATING CONDITIONS (TYPE 1)

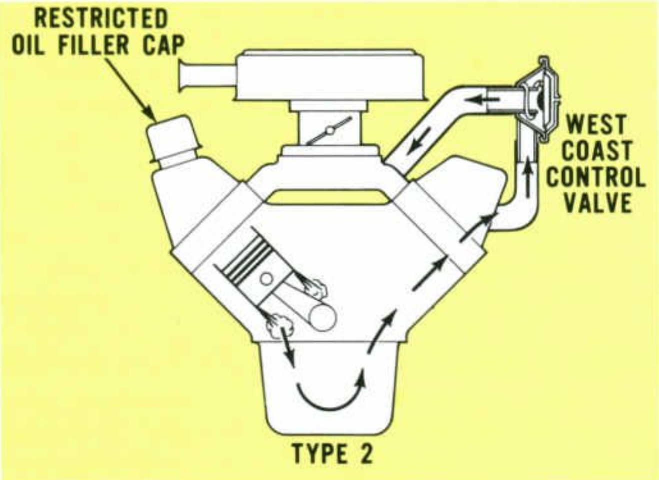


FIGURE 14. CRANKCASE VACUUM CONTROL SYSTEM (TYPE 2)

The crankcase vacuum device was originally produced and continues to be used as a conversion kit for used cars. The system depends greatly on an air tight crankcase. No air leaks from the rocker arm covers, galley pans or road draft tube can be tolerated; inasmuch as this would upset the ability of the valve to control the flow of blow-by gases.

The control valve meters crankcase gases to the intake manifold through a variable orifice valve. The variable orifice is controlled by crankcase vacuum. Ventilating air is admitted to the crankcase through a restricted opening in the breather (oil filler) cap. The valve varies its opening to remove all of the blow-by gases, which are now diluted with a constant amount of ventilating air. The flow rate adjusts to the blow-by rate of the engine and handles the requirements of most vehicles.

Type 3—Tube-to-Air Cleaner Device

This system uses a tube-type conductor between the crankcase and the carburetor air cleaner. (In some installations the air cleaner is connected to the oil filler cap.) Flow is induced into the tube by the pressure drop created as engine air rushes through the air cleaner. (See Figure 15.)

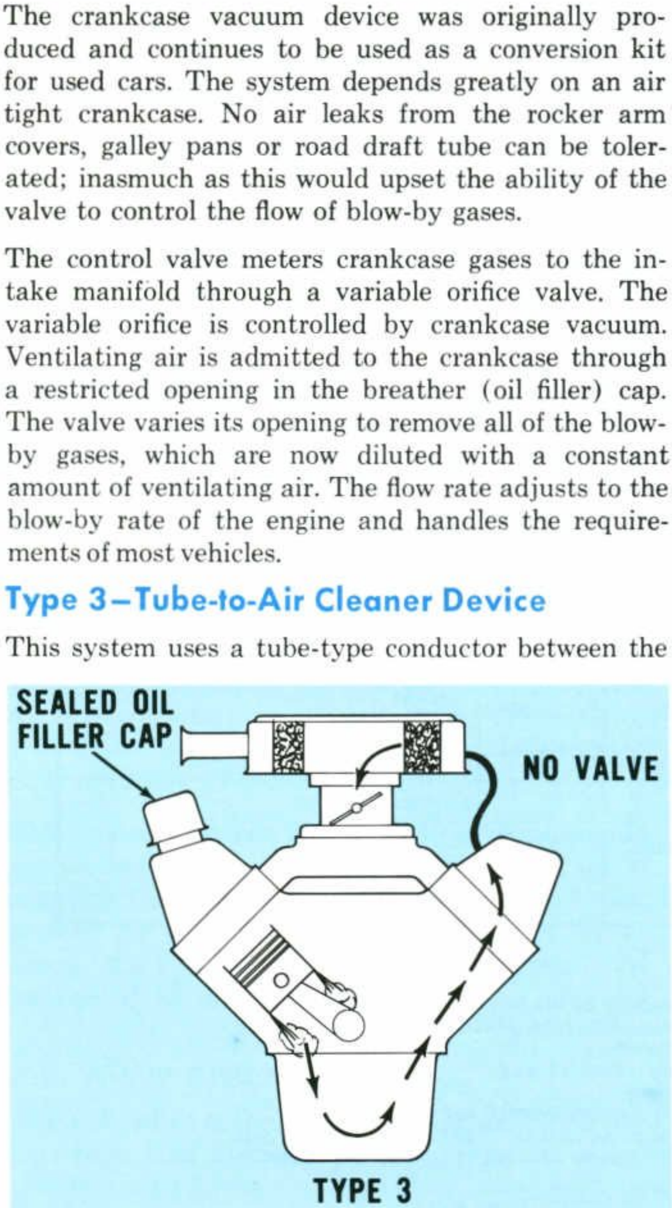


FIGURE 15. CLEAN AIR CRANKCASE SYSTEM (TYPE 3)

Foreign vehicle manufacturers have made use of the Type 3 system merely to provide an escape path for the blow-by gases; no provision is made to introduce ventilating air to the crankcase. Thus, this system is also known as a "sealed" system.

The Type 3 system was abandoned by American manufacturers because it carried over the condensation which develops in the crankcase of a cold engine. The moisture was either deposited on the air filter element or dropped into the carburetor. In cold climates, this could result in carburetor icing.

One of the basic characteristics of this type of system is that it tends to enrich the fuel-air mixture. Since blow-by gases are mostly unburned fuel-air mixtures, the addition of the blow-by flow to the upstream side of the carburetor causes, in effect, a second charge of combustibles to blend with the carbureted mixture as it flows through the carburetor. On newer cars, *carburetor calibrations* compensated for the secondary fuel charge. The opposite effect is encountered when the blow-by gases are added to the downstream side of the carburetor as is the case with Type 1 and Type 2 systems. On these systems, ventilating air induced through the crankcase into the intake manifold tends to create a lean fuel-air mixture.

Type 4—Combination Systems

The combination or closed crankcase system is used on all current Ford-built engines as well as on most other American-made vehicles. (See Figure 16.)

This system is similar in many respects to the open system used earlier. Instead of getting fresh air through the oil filler cap (as with the open system), the closed system obtains fresh air through the carburetor air cleaner. A tube routes the air to the oil filler cap which is sealed from outside air. The fresh air circulates through the crankcase and picks up blow-by gases, as well as condensation vapors and crankcase fumes.

The P.C.V. control valve then meters this mixture of harmful gases into the intake manifold where they combine with the air-fuel mixture and are burned in the combustion chamber. Possible smog-producing hydrocarbons emitted by the exhaust system are thus reduced to an acceptable level. The advantages and effectiveness of the Type 4 system are detailed in chart form in Figure 17.

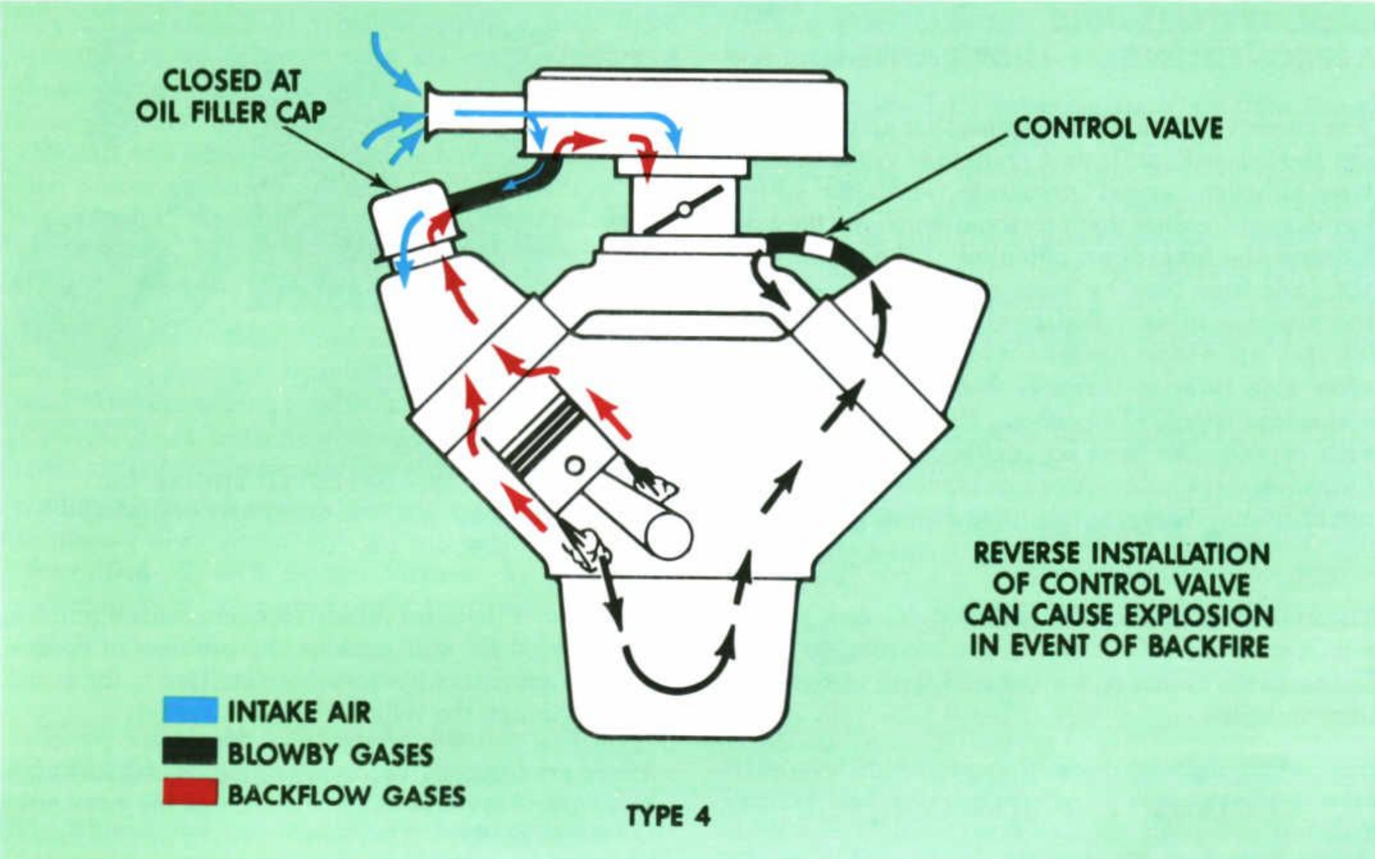


FIGURE 16. CLOSED OR COMBINATION CRANKCASE SYSTEM (TYPE 4)

CLOSED SYSTEM

CONDITIONS AFFECTING EMISSION CONTROL	POSITION THROTTLE	AVAILABLE VACUUM	COMPRESSION PRESSURE	AMOUNT OF BLOWBY FROM ENGINE	POSITION OF PCV VALVE	PATH OF BLOWBY	PERCENT (APPROX.) EFFECTIVE IN CONTROLLING CRANKCASE EMISSION
ENGINE OFF (1)	CLOSED	NONE	NONE	NONE	OPEN	NONE	
LOW SPEED (IDLE)	CLOSED	HIGH (2)	LOW (3)	LOW	CLOSED (4)	ALL THROUGH VALVE	100
(5) LOW SPEED (LOAD)	WIDE OPEN	LOW	HIGH	HIGH	FULLY OPEN	HALF THROUGH VALVE HALF TO AIR CLEANER	100
HIGH SPEED	PARTLY OPEN	MEDIUM	MEDIUM	MEDIUM	PARTLY OPEN	1/4 TO AIR CLEANER 3/4 THROUGH VALVE	100

TYPE 4.

NOTE: 1 IN CASE OF BACKFIRE, DURING CRANKING, THE VACUUM IN THE INTAKE MANIFOLD WILL CAUSE THE PCV VALVE PLUNGER TO MOVE TOWARD THE CRANKCASE; THUS, SEALING THE PASSAGE TO THE CRANKCASE AND PREVENTING A POSSIBLE EXPLOSION.

NOTE: 2 BLOWBY IS AT A MINIMUM WHEN MANIFOLD VACUUM IS HIGH AT IDLE.

NOTE: 3 BLOWBY IS AT A MAXIMUM WHEN COMPRESSION IS HIGH.

NOTE: 4 PCV VALVE IS ON MINIMUM (CLOSED) FLOW POSITION WHEN MANIFOLD VACUUM IS HIGH.

NOTE: 5 FOR LOW SPEED, OPEN THROTTLE POSITION, AS WELL AS VARIOUS THROTTLE PLATE POSITIONS AND LOAD COMBINATIONS. THE MAIN CONCERN OF EMISSION CONTROL IS AT IDLE AND DURING DECELERATION CONDITIONS.

FIGURE 17. ADVANTAGES OF A TYPE 4 SYSTEM

P.C.V. SYSTEMS AND APPROVED ENGINE LUBRICANTS

The current Federal Law requires that all new engines use the "closed" or Type 4 crankcase ventilation system. Although "closed" crankcase ventilation systems significantly reduce hydrocarbon emission, they also increase the breakdown potential of the motor oil. If the acids from blow-by gases remain in the engine in the presence of an imbalanced or low quality motor oil, they are not neutralized; as a result, they usually allow high rates of corrosive wear, varnish build-up, and sludge deposits. To prevent the undesirable result such deposits can have on engine operation and performance, most automotive manufacturers require the use of special detergent oils. (See Figure 18.)

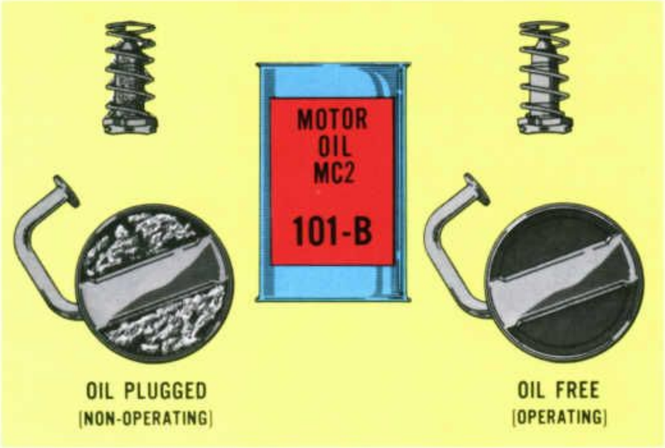


FIGURE 18. APPROVED ENGINE OIL FOR FORD MOTOR COMPANY VEHICLES

The use of manufacturer specified oil and periodic servicing of the P.C.V. system are essential to proper engine performance and a reduced level of hydrocarbon emissions.

EXHAUST EMISSION CONTROL

As we have seen, positive crankcase ventilation constitutes one type of emission control system. The reburning of crankcase vapors resolves approximately one-third of the total vehicle emission control problem. However, there still remains the problem of controlling the amount of hydrocarbons emitted to the atmosphere through the vehicle's exhaust system.

There are basically two types of engine exhaust emission control systems in use throughout the automotive industry. By type, they are:

1. The Air Injection System
2. The IMproved COmbustion System.

VEHICLE MANUFACTURER	AIR INJECTION SYSTEM	IMproved COmbustion TYPE SYSTEM
FORD MOTOR COMPANY	THERMACTOR	IMCO (IMproved COmbustion)
AMERICAN MOTORS CORPORATION	A.G. (AIR GUARD)	ENGINE MOD.
CHRYSLER CORPORATION	NOT USED	C.A.P. (CLEANER AIR PACKAGE) or C.A.S. (CLEANER AIR SYSTEM)
GENERAL MOTORS CORPORATION	A.I.R. (AIR INJECTOR REACTOR)	C.C.S. (CONTROLLED COMBUSTION SYSTEM)

FIGURE 19. ENGINE EXHAUST EMISSION IDENTIFICATION CHART

The characteristics of vehicles equipped with these systems are no different than the characteristics of those not so equipped. Slightly higher engine idle speeds are not of a magnitude that prove objectionable. All American manufacturers have provided emission control devices which, although not identical, are very similar in design and function. The trade name identification for these systems and corresponding manufacturers are listed in Figure 19.

We have selected the Ford IMCO (IMproved COmbustion) system as representative of the improved combustion or engine modification type; and the Ford Thermactor as being typical of the air injection system. Although these systems have certain engine modifications and devices in common, we will attempt to discuss them separately. We will begin with a brief description of each system followed by a detailed explanation of their component parts and operating principles.

AIR INJECTION EXHAUST EMISSION CONTROL SYSTEMS

The Thermactor (air injection) exhaust emission control system continues the combustion of unburned exhaust gases to reduce their hydrocarbon and carbon monoxide content. (See Figure 20.)

This is achieved by injecting fresh air from the air pump into the hot exhaust stream as it leaves the exhaust ports. At this point, the fresh air mixes with the hot exhaust gases and promotes further oxidation (burning) of both the hydrocarbons and carbon monoxide. This induced burning, or oxidation lowers the concentration of hydrocarbons and carbon monoxide, converting some of them into harmless carbon dioxide and water.

The air injection system usually consists of the following major components–

- Belt-drive air supply pump
- Air by-pass valve
- Check valve
- Internal or external air manifolds (combustion pipe)
- Air supply tubes on external air manifolds only.

This system is generally used on high performance engines and vehicles equipped with standard transmissions. Details regarding its operating principles begin on Page 26.

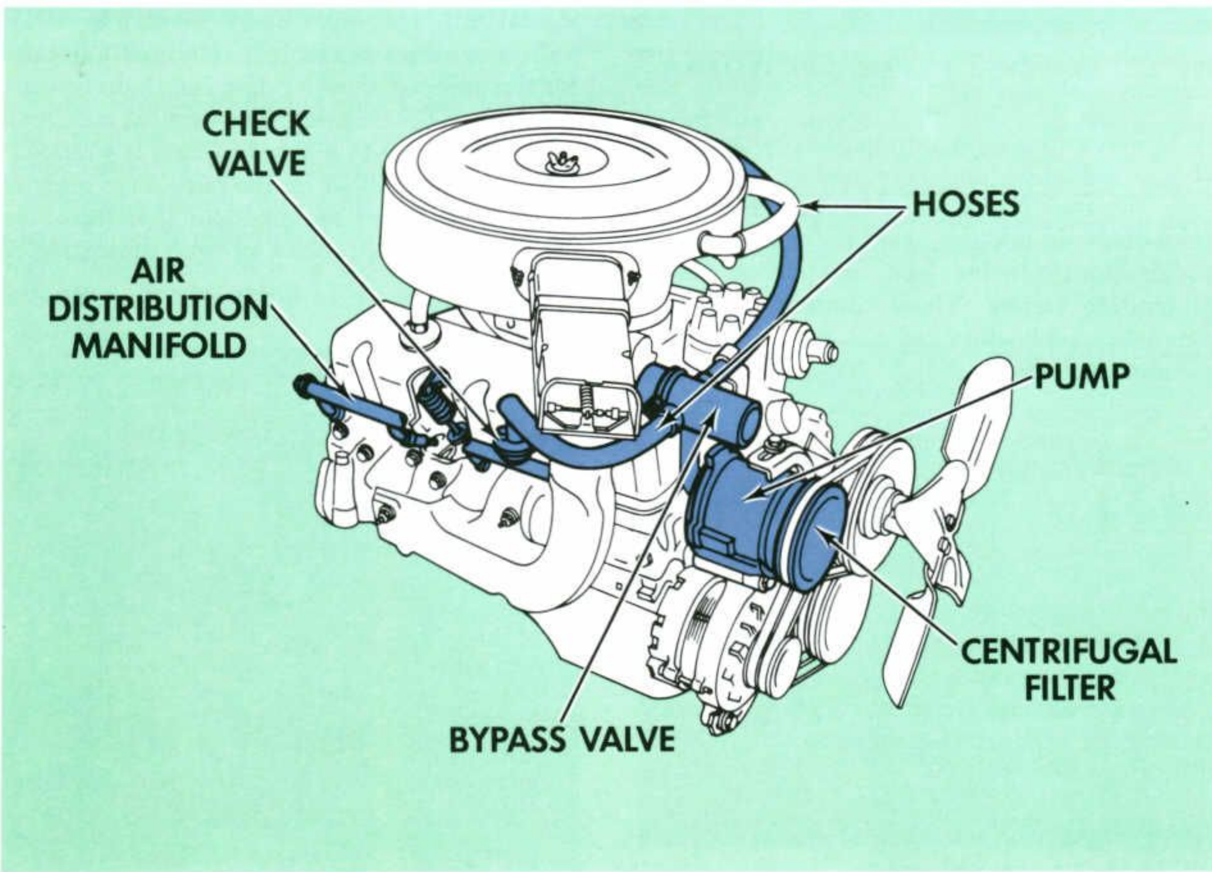


FIGURE 20. THERMACTOR AIR INJECTION EQUIPPED ENGINE

IMPROVED COMBUSTION EXHAUST EMISSION CONTROL SYSTEMS

The IMCO (Improved Combustion) system was originally developed for vehicles equipped with automatic transmissions. (See Figure 21.)

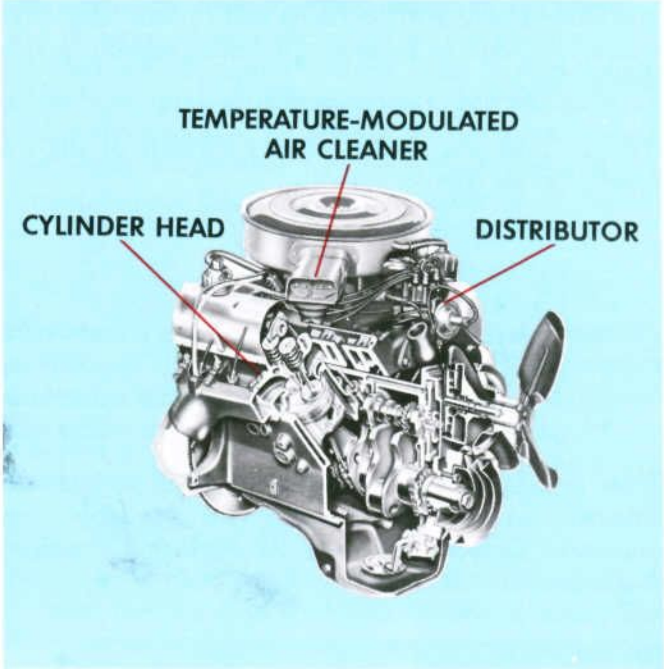


FIGURE 21. IMPROVED COMBUSTION SYSTEM

The IMCO system involves internal engine modifications of the induction and combustion systems to reduce the internal formation of hydrocarbons and carbon monoxide. In addition, carburetor and distributor modifications provide lean carburetion and a retarded ignition timing. These changes promote a more complete combustion of the fuel-air mixture in the combustion chamber.

Essentially, the exhaust gas emissions are reduced in the combustion process rather than by burning the exhaust gases in the exhaust manifolds.

The Improved Combustion system involves modifications to provide improvements in inlet air temperature regulation, carburetion, combustion efficiency and distributor calibration for the purpose of effectively controlling exhaust emissions.

The system depends on a variety of design modifications within the engine, tailored to the requirements of each model engine, transmission and vehicle combination. These modifications affect the following:

- Inlet Air Temperature Regulation
- Carburetor
- Intake Manifold, Cylinder Heads, Combustion Chamber and Exhaust Manifold.
- Camshaft
- Distributor

Inlet Air Temperature Regulation

Many engines equipped with an improved combustion or air injection type emission control system incorporate a device which regulates the temperature of the air entering the carburetor. (See Figure 22.)

This device is a part of the air cleaner and keeps air entering the carburetor at approximately 100°F. when under-hood temperatures are less than 100°F. By keeping the air at 100°F. or above, the carburetor can be calibrated much leaner to reduce hydrocarbon emissions, improve engine warm-up characteristics and minimize carburetor icing.

The temperature of the carburetor intake air is thermostatically controlled and a vacuum over-ride motor built into a duct assembly is attached to the air-cleaner for the purpose of over-riding the thermostatic control during cold acceleration. The exhaust manifold shroud tube is attached to a shroud which is wrapped around the exhaust manifold for the purpose of preheating the inlet air. The duct has an opening at the outer end to permit the entry of cooler air from the engine compartment.

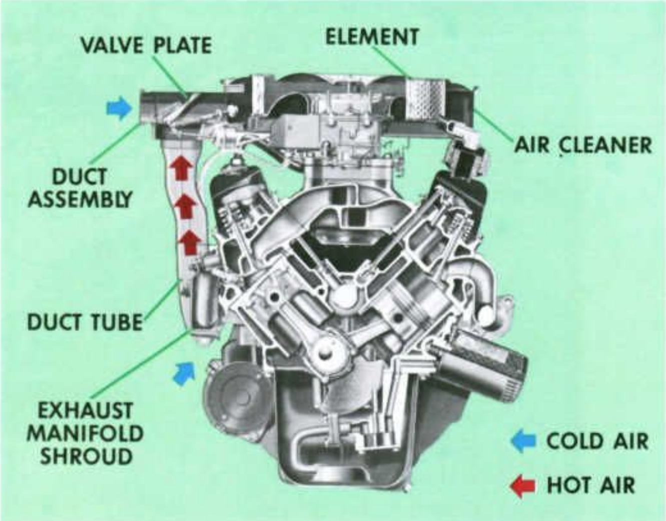


FIGURE 22. TYPICAL AIR INTAKE SYSTEM

The vacuum override motor attached to the duct and connected to the thermostat by the means of an override lever provides the control necessary to balance the air intake during cold acceleration conditions.

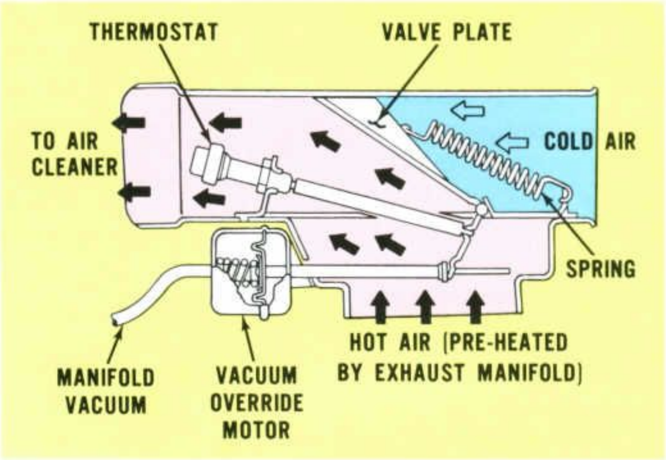


FIGURE 23. DUCT AND VALVE ASSEMBLY IN HEAT-ON POSITION—WARM-UP

During the engine warm-up period when the air is less than 100°F., the thermostat is in the retard position and the valve plate is held in the heat on position (up) by the valve plate spring, thus shutting off the normal, direct ambient air flow from the engine compartment. All air being drawn in at this point passes through the shroud on the exhaust manifold.
(See Figure 23.)

As previously explained, during cold acceleration periods, additional carburetor intake air is provided by the vacuum over-ride motor control. The decrease in intake manifold vacuum during acceleration permits the vacuum motor to over-ride the thermostat control. This opens the system to both engine compartment air and heated air from the exhaust manifold shroud (See Figure 24).

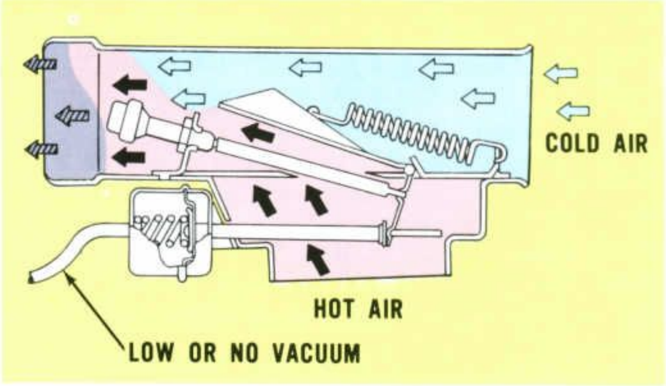


FIGURE 24. DUCT AND VALVE ASSEMBLY IN PARTIAL HEAT-ON POSITION—COLD ACCELERATION

As the temperature of the air passing the thermostat increases, the thermostat starts to expand and forces the valve plate down. This allows cooler air to enter the air cleaner from the engine compartment. When the intake air reaches the operating temperature of approximately 100° Fahrenheit, the valve plate will be held down (heat off position) and the ambient engine compartment air is allowed to enter the air cleaner directly (See Figure 25).

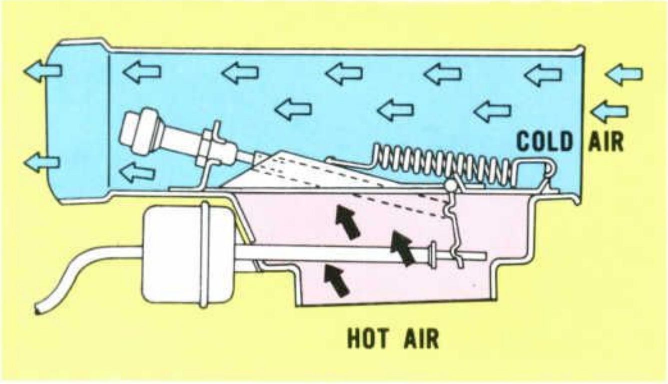


FIGURE 25. DUCT AND VALVE IN HEAT-OFF POSITION—WARM ENGINE

Other Air Temperature Regulation Methods

On some applications, the engine is equipped with a similar duct and valve assembly that operates in the same manner as on other engines, except the vacuum over-ride is not used. A vacuum motor is installed on the perimeter of the air cleaner to take the place of the vacuum over-ride. When the manifold vacuum is low, during heavy engine loading or high speed operation, a spring in the vacuum motor opens the motor valve plate into the air cleaner. This provides the optimum air supply for greater volumetric efficiency during full-power operation. (See Figure 26).

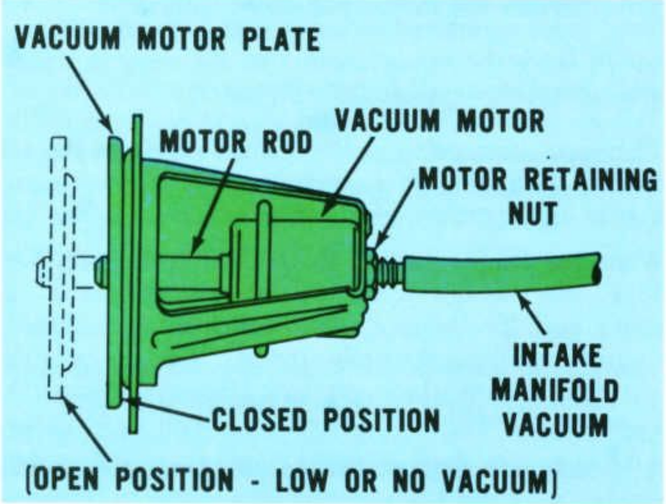


FIGURE 26. AIR VALVE AND VACUUM MOTOR ASSEMBLY

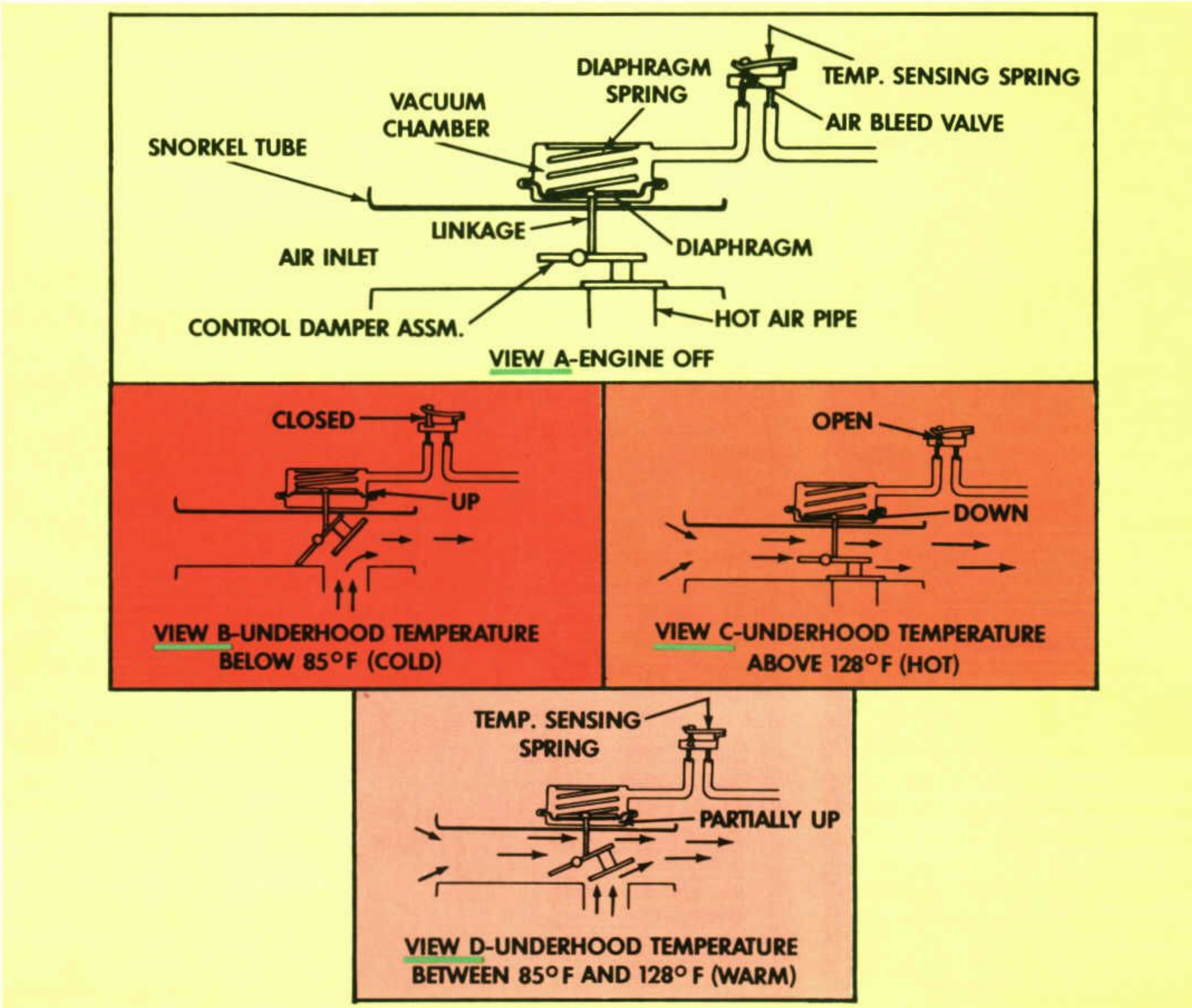


FIGURE 27. TEMPERATURE SENSITIVE AIR-BLEED VALVE

One manufacturer uses a temperature sensitive air bleed valve connected in series with a vacuum chamber to serve the same function as the vacuum motor and thermostat system (See Figure 27).

The vacuum chamber operates the damper in the air cleaner with relation to vacuum at the diaphragm. Figure 27 illustrates four basic engine conditions.

When the temperature at the bimetal spring is below 85°F. the vacuum at the vacuum chamber is 8″ or above and the damper valve closes off the cold air supply and allows the preheated air, from the exhaust manifold to enter the carburetor (Refer to Figure 27, View B).

A bi-metal spring operates the air bleed valve which creates a controlled vacuum leak between vacuum chamber and its source when temperature reaches 85°F. and above. As the temperature increases, the vacuum leak increases proportionally until temperature reaches 128°F. at the bi-metal spring. At this point, the air bleed valve is completely open and vacuum at the diaphragm is approximately 6″ of mercury or less. Now, the spring overcomes the diaphragm in the vacuum chamber and holds the damper in a position that closes off hot air from the exhaust manifold and allows engine compartment air to enter the carburetor (Refer to Figure 27, View C).

When temperatures are between 85°F and 128°F., the damper allows both heated air from the exhaust manifold and engine compartment air to enter the carburetor (Refer to Figure 27, View D).

During cold acceleration periods, the vacuum in the system will drop proportionally, and the damper spring will override the vacuum and push the damper door closed, thus permitting ambient air to pass directly through the snorkel.

Carburetor Design Features

One important aspect of exhaust emission control through improved internal combustion is the use of leaner air-fuel mixtures at idle and low speeds. Compared to the high speed circuit of the carburetor, the idle circuit is inherently rich for the purpose of obtaining stable idle characteristics. These rich idle mixtures, in conjunction with conventional spark timing, could result in incomplete combustion and an excessive emission of unburned hydrocarbons. In order to improve combustion and prevent this possibility, automobile manufacturers have modified and recalibrated all current production carburetors. The objective of these modifications is to prevent overly rich fuel-air mixtures from reaching the engine's combustion chambers during idle and deceleration. This, in conjunction with a retarded spark at slow engine speeds and the various other improved combustion modifications, will result in hydrocarbon and carbon monoxide emissions well below the permissible level.

Briefly, some of the numerous carburetor modifications are . . . internally balanced vent system, reducing operation of external vent to idle conditions only; refined fuel handling system and idle mixture control design to prevent an overly rich adjustment; separate idle air by-pass and transfer slots to provide consistent, smoother idle at leaner mixtures; new carburetor-to-intake manifold characteristics; and air filters designed to match the carburetor.

Regardless of the type of carburetor modification, all current production Ford vehicles are equipped with devices to prevent overly rich air-fuel idle mixture

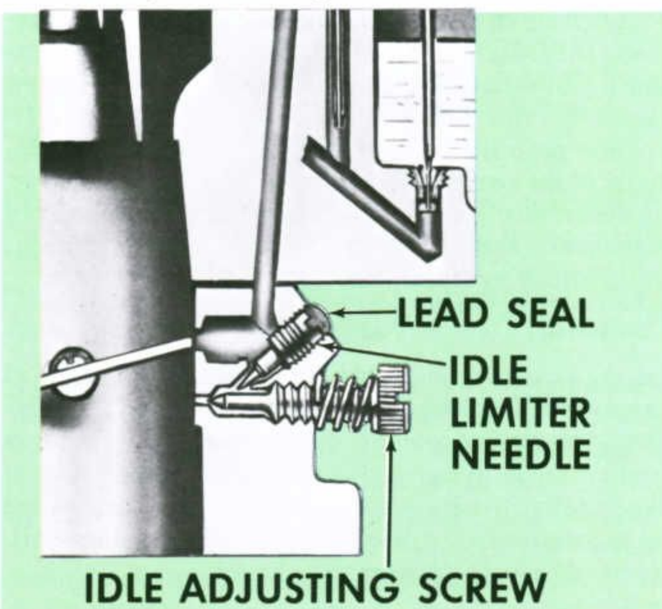


FIGURE 28. INTERNAL IDLE MIXTURE LIMITER

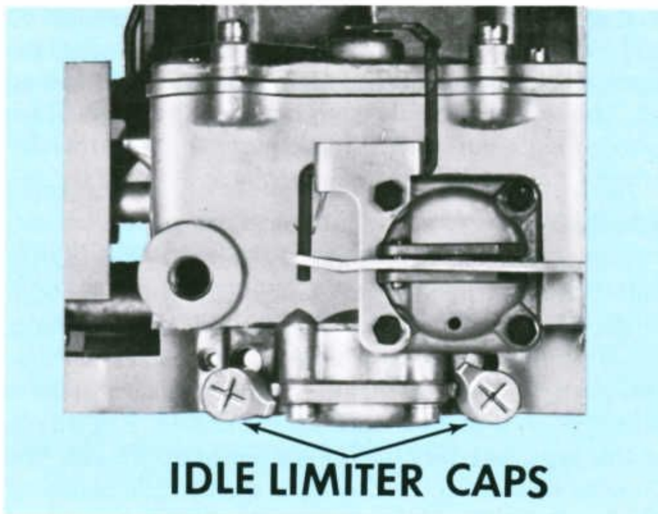


FIGURE 29. EXTERNAL IDLE MIXTURE LIMITER

adjustments. These devices are known as idle limiters. There are two types of idle limiters currently in use . . . internal and external.

INTERNAL IDLE LIMITERS

Figure 28 illustrates an internal needle-type limiting feature, located in the internal idle passage. The limiting device is installed and sealed during manufacture.

An external idle adjustment screw is also located in the idle passage. However, the internal limiter is pre-set during assembly and thus, limits the amount of external adjustment to a pre-determined maximum. Some carburetors do not use a needle-type limiting feature. Instead, they have a fixed restriction in the idle fuel passage.

EXTERNAL IDLE LIMITERS

The external type limiter consists of a plastic cap with a stop tab installed on the head of the idle fuel mixture adjusting screw/s. (See Figure 29.)

The carburetor is pre-adjusted at the factory and idle adjustments can only be made within the range of the idle limiter. The stop tab of the limiter cap is designed to contact the carburetor body upon rotation of the idle adjusting screw. This, in effect, establishes the range of idle adjustment.

IDLE SPEED-UP SOLENOID

On some engines, the leaner idle mixture in conjunction with slightly higher idle speeds, may result in engine "dieseling" when the ignition key is turned off. Unless the carburetor throttle plate is completely closed, it is not possible to prevent dieseling. Thus, these engines are equipped with an electric solenoid attached to the carburetor.

The solenoid is energized with the ignition switch on and serves as the curb idle stop, thus keeping the throttle plate open. When the ignition key is turned off, the solenoid is de-energized and retracts. This allows the carburetor's throttle plate to close, thereby preventing dieseling.

DASHPOT

The term dashpot is an industry name for any device that controls the rate at which the throttle valve closes. This device can be either an internal hydraulic system built into the carburetor, or an external diaphragm type system that is spring and atmospheric pressure controlled or vacuum controlled. Regardless of the type, the function of the dashpot remains the same to slow down the closing of the throttle plates on deceleration. The dashpot was developed to control carburetion on deceleration as an aid to the smooth operation of automatic transmissions. It still performs this function. However, the dashpot is also an important factor in controlling exhaust emissions on deceleration. By holding the throttle open for a longer period of time more air can enter the manifold and help prevent fuel from collecting on the inner surface of the manifold. Thus we could say that the dashpot helps to prevent "manifold flashing." Also the additional air will lean out the mixture and provide a more completely combustible mixture.

Intake Manifold and Cylinder Head Design Features

In some instances, the Ford improved combustion system involves design changes to the cylinder heads and the engine's exhaust and intake manifolds. The cross sectional view of the intake manifold in Figure 30 illustrates how the intake manifold is preheated by the cross flow of exhaust gases, for the purpose of improving performance characteristics.

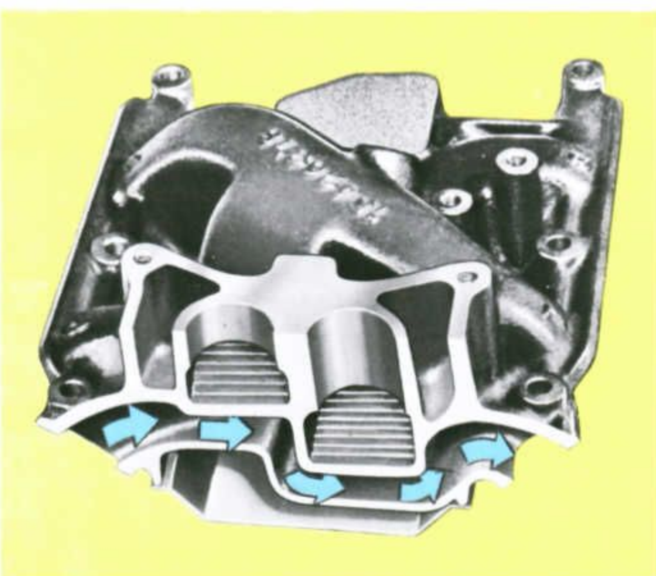


FIGURE 30. INTAKE MANIFOLD

The exhaust gases flowing through the crossover passage provide the initial heat necessary to assist in vaporizing the incoming fuel mixture. This improved vaporization results in more efficient combustion. In addition to this feature, the intake manifold ports are smooth for the purpose of decreasing friction. This also results in less condensation during warm-up periods. Figure 31 illustrates the importance of the intake manifold flow design, which makes the distance from the carburetor to the combustion chambers nearly equal, thereby improving the intake flow characteristics of the fuel-air mixture.

FIGURE 31. INTAKE MANIFOLD AIR-FUEL DISTRIBUTION PATTERN

The manifold flow design also improves the handling of atomized fuel during warm-up periods when vaporization effect is poor due to lack of heat. Vaporization effects are speeded up during the warm-up period as a result of the new exhaust cross-flow design. The total design changes result in improved air-fuel mixture distribution to the cylinders.

Figure 32 is an illustration of changes in valve arrangement necessitated by the intake manifold design. Exhaust valves have also been enlarged to reduce exhaust backflow, and the combustion chamber surface-to-volume ratio has been changed by the rounded contours of the combustion chamber. The combined effect of design changes are aimed towards improvement of combustion and ultimately result in reduced emission of unburned hydrocarbons.

Camshaft Design Features

In the case of some engines, changes in idle air-fuel mixtures and ignition timing may be relatively ineffective in improving combustion if corresponding changes are not made in camshaft design and engine "breathing" characteristics. Many factors must be considered and compromises made when designing a camshaft. Some of these factors are . . .

- The speed at which the engine operates the majority of the time (cruising speed).

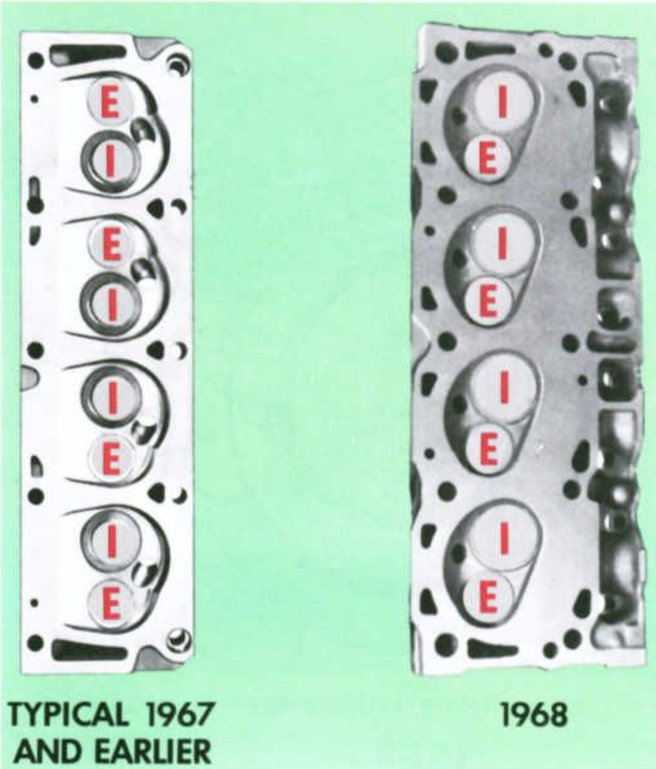


FIGURE 32. CYLINDER HEAD CHANGES

- Whether emphasis must be on power or economy or both.
- The effect of the design on improved combustion during all engine operating ranges.

Current modifications of the camshaft and valve train components on some engines are aimed at improving combustion during conditions of engine idle and deceleration. These modifications, in conjunction with a retarded spark, are intended to improve engine "breathing" characteristics and result in more efficient combustion of the leaner air-fuel mixture during periods of low-speed engine operation.

The effectiveness of these modifications, however, depends upon a very close relationship between valve timing and ignition spark timing, since tolerances have been further reduced. Figure 33 will aid in your understanding of these relationships.

This illustration shows the effect of valve adjustment as it relates to valve timing and ignition spark timing. Note the extensive effect four degrees of camshaft rotation has on related components in the valve train. It results in eight degrees of crankshaft rotation and a .020" movement of the valve. Although valve adjustment does not directly affect spark timing, the indirect affect may adversely upset the delicate relationship between engine breathing and spark timing.

If this relationship is disturbed, it could result in inefficient combustion of the air-fuel mixture in the cylinders and large amounts of unburned hydrocarbons emitted into the atmosphere.

The engine "breathes" through the valves, which, as we have seen, are operated by the camshaft and carefully timed to match piston strokes and spark timing. In order to understand the meaning of engine breathing characteristics, let's consider the theory of valve opening and closing at exact BDC and TDC as previously described in the introduction of this manual. A brief review of the introduction section of this manual may be helpful at this point.

We will hypothetically increase engine speed and observe the results. Almost immediately we begin to experience difficulty in the engine's breathing ability and operating performance. The reason for this difficulty is simply that the fuel-air mixture and the exhaust gases possess the characteristic of being "compressible and stretchable", and when attempts are made to move them quickly, such as would be the case when engine speed is increased, the exhaust gases tend to compress on the exhaust stroke, rather than move out of the cylinder quickly and the fuel-air mixture tends to stretch on the intake stroke rather than move into the cylinder quickly.

In addition, once the air-fuel mixture and exhaust gases are set in motion, they tend to refuse to be stopped. The overall result is poor engine breathing, inefficient combustion, and no power.

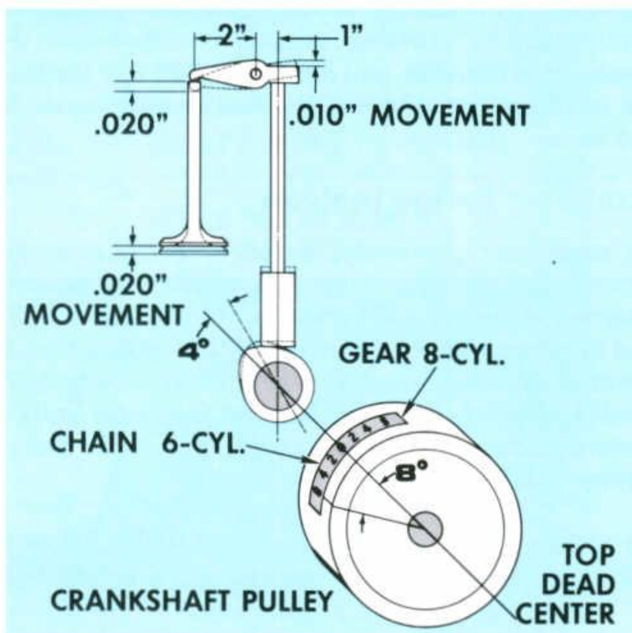


FIGURE 33. CRITICAL TIMING FACTORS

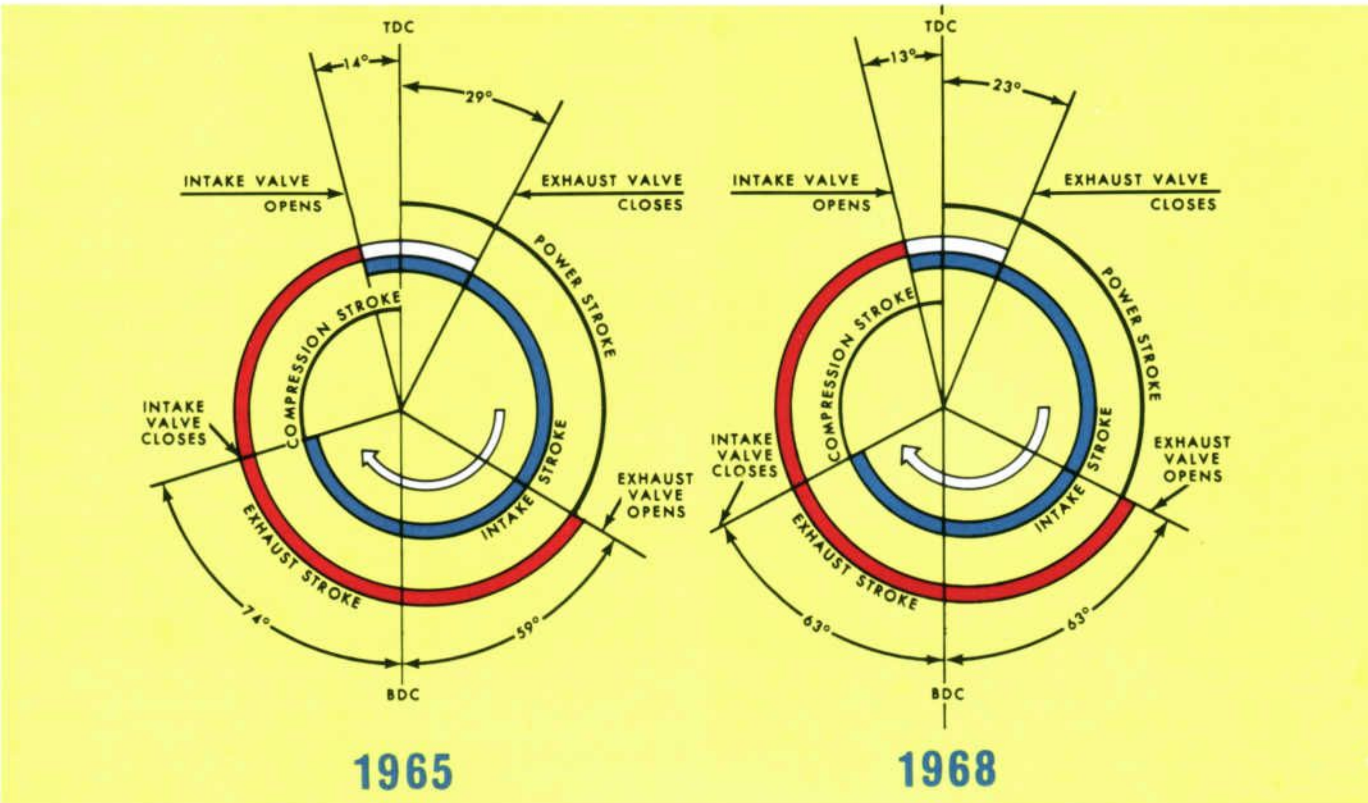


FIGURE 34. VALVE OVERLAP

To compensate for these undesirable "breathing" characteristics, valve opening and closing duration is extended beyond BDC and TDC. Figure 34 illustrates valve openings and overlaps on a typical 1965 and 1968 engine.

In comparing the two diagrams you will note that both exhaust and intake valve opening duration have been shortened in 1968 by changing the lobe design on the camshaft. This change in camshaft design improves combustion by reducing exhaust backflow into the combustion chamber, and prevents dilution of the fuel-air mixture, thus allowing the fuel-air mixture to be set leaner.

Distributor Design Features

As mentioned previously, improved combustion exhaust emission control systems require a specially retarded spark for more complete combustion at idle and low engine speeds, combined with the usual spark advance at normal engine speeds. To provide this extended range of spark control, IMCO engine ignition systems incorporate changes to the distributor timing advance and retard mechanisms.

In order to see how these distributor timing improvements relate to improved combustion, it is necessary to understand the basic principle of distributor point dwell as well as the operating principles of the various distributor advance mechanisms.

DISTRIBUTOR POINT DWELL

Distributor point dwell is proportionate to point gap. Point gap is specified and measured in fractions of inches. However, dwell is measured in degrees because it represents the angle of distributor cam rotation through which the points are closed. (See Figure 35.)

Accurate dwell adjustments are important to ignition coil saturation, output and timing control. Incorrect dwell adjustments may result in inefficient combustion and large amounts of unburned gases.

For example, a dwell adjustment which reduces the period of time the points are closed, may affect ignition coil saturation and output at higher speeds. This, in turn, could result in engine miss and a high level of hydrocarbon emissions.

Dwell adjustments will also affect spark timing and, for this reason, dwell adjustments must always be followed by spark timing adjustment.

For example, one (1) degree of dwell change will result in a corresponding degree of spark timing change. Referring to Figure 35, we see configurations of cam angles as they are related to the point opening. An increase in point gap adjustment will reduce the dwell angle.

To illustrate how point gap or dwell adjustments affect spark timing, let's assume that an increase in point gap has reduced the point dwell 4 degrees. Re-

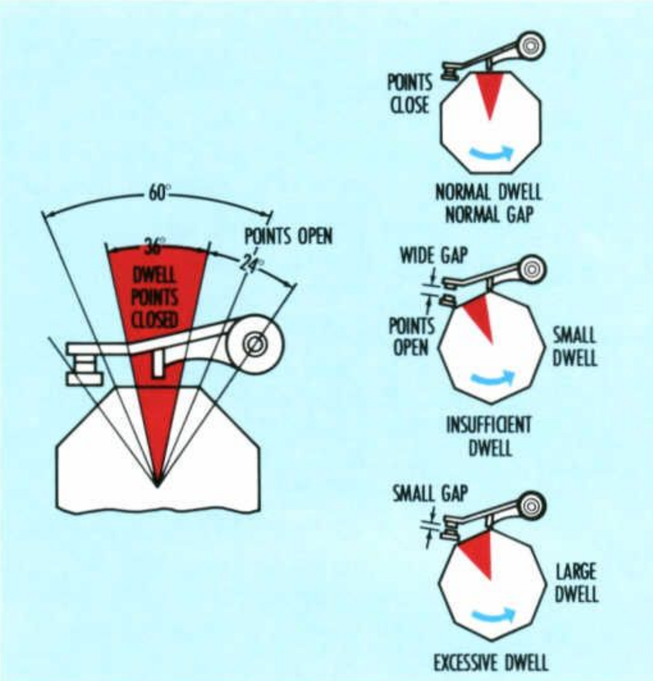


FIGURE 35. DISTRIBUTOR POINT DWELL

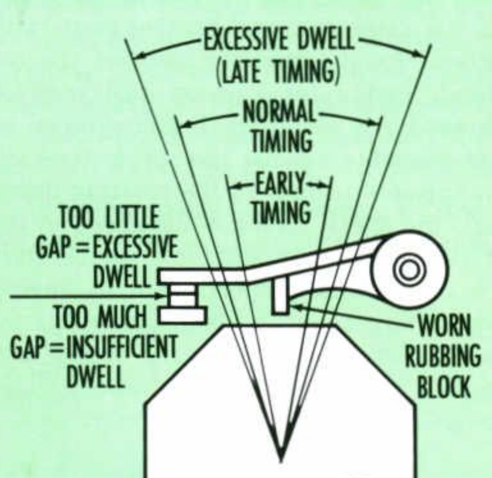
late the angular configurations shown in Figure 35 to this change and observe that the reduction in the dwell angle affects the opening as well as the closing of the points an equal number of degrees. Spark timing, however, is only affected by the point opening.

Thus decreasing the dwell angle will affect the point opening by advancing the time of opening by 2 degrees. Since the crankshaft is moving at twice the speed of the distributor, the total effect resulting from decreasing the dwell angle 4 degrees, is a corresponding advanced spark timing of 4 degrees.

DWELL AND COMBUSTION EFFICIENCY

As indicated in Figure 35-A below, *NORMAL* dwell is equal to *NORMAL* timing. In other words, whenever the dwell is set to the exact specifications of the designing engineer, one need not be concerned if the spark is late or early. Either instance (late or early), will result in inefficient combustion.

You will notice that the small gap results in a longer dwell—thus, causing the timing to be late. Conversely, the large gap results in a shorter dwell period—thus, early timing. This is because of the mechanical design of the distributor, as well as the contact point rubbing block-to-cam relationship. The wider the point gap becomes, the closer the rubbing block; the rotating cam, therefore, will turn very little before the points begin to open. Remember, the *instant* they separate is when the spark occurs and the fuel-air mixture in the combustion chamber begins to burn.



POINT GAP	DWELL PERIOD	EFFECT ON TIMING	EFFECT ON COMBUSTION
ON SPECIFICATION	NORMAL	—	—
SMALL	LONGER	LATE	INEFFICIENT
WIDE	SHORTER	EARLY	INEFFICIENT
NOTE: SPARK PLUG FIRES THE INSTANT THE POINTS COME OPEN.			

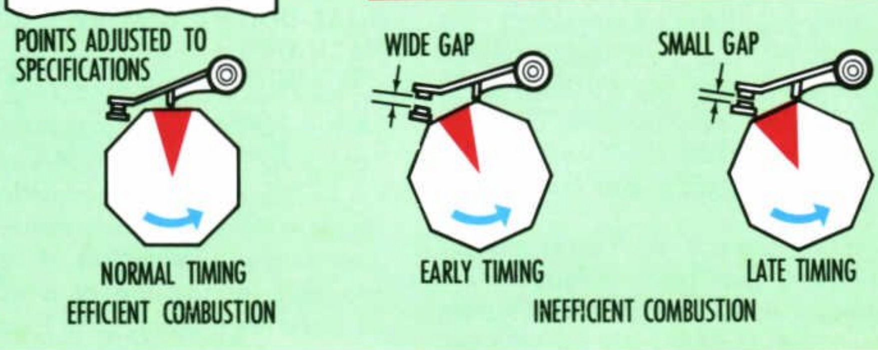


FIGURE 35A. EFFECTS OF DWELL ON COMBUSTION EFFICIENCY

CENTRIFUGAL AND VACUUM ADVANCE MECHANISMS

The mechanical centrifugal advance mechanism of the distributor is responsible for automatically advancing the spark timing in relation to engine speed for the purpose of obtaining maximum power from the engine. Another feature included on most distributors is the vacuum advance diaphragm assembly. The vacuum advance diaphragm is responsible for adjusting spark timing in relation to engine load.

A typical centrifugal advance mechanism is illustrated in Figure 36.

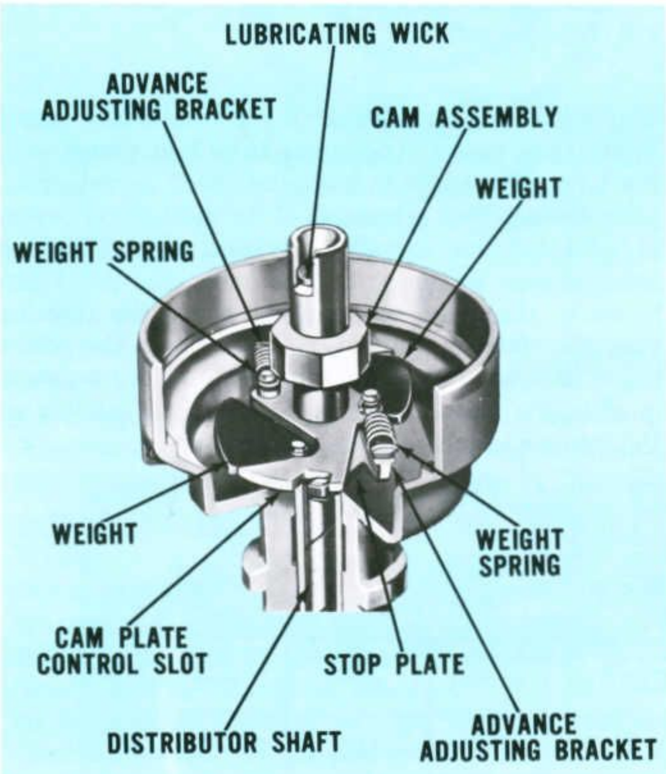


FIGURE 36. CENTRIFUGAL ADVANCE MECHANISM

Two flyweights are attached to the driven distributor cam in a manner which allows them to advance the cam assembly against spring tension, ahead of the driving distributor shaft, as the flyweights move outward under the influence of centrifugal force. Thus, spark timing advance is controlled by centrifugal force which is carefully balanced against spring tension to match the desired spark advance curve. Spark advance characteristics can be altered by changing spring tension.

Figure 37 illustrates a typical vacuum advance mechanism.

The distributor points are mounted on a concentrically movable breaker plate. Movement of the breaker plate assembly is controlled by the vacuum diaphragm. Carburetor vacuum influences the movement of the vacuum diaphragm against spring tension. The spring resting against the vacuum diaphragm tends to hold the diaphragm and breaker plate in the retarded position. As the throttle plate of the carburetor is opened, carburetor vacuum will increase and the vacuum force will move the diaphragm and breaker plate assembly against the spring tension in a direction opposite to that of the rotating distributor cam. Thus, the spark timing is advanced in proportion to the carburetor vacuum force. Since the carburetor vacuum force is proportionate to engine load, the purpose for vacuum advance control is to gain additional control over the spark timing by making it sensitive to engine load conditions. This improves combustion efficiency and economy.

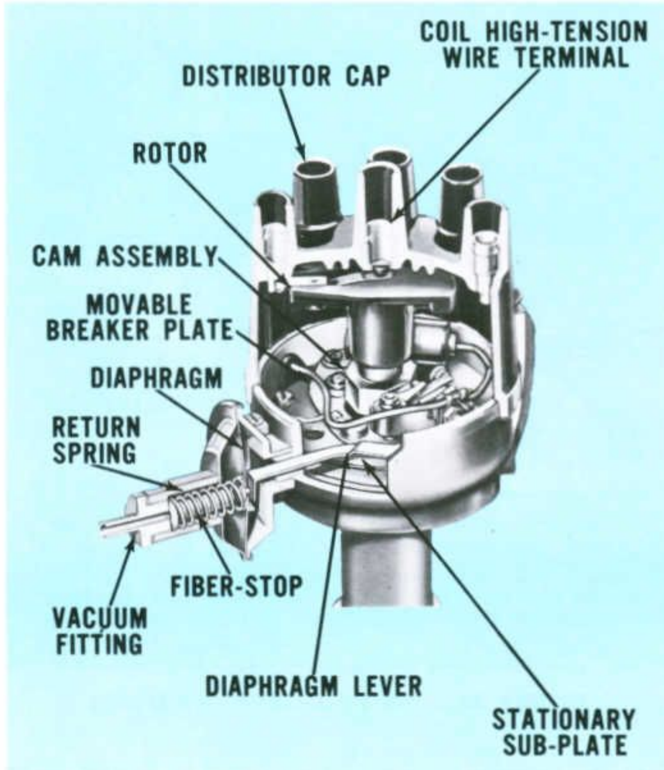


FIGURE 37. VACUUM ADVANCE MECHANISM

DUAL-DIAPHRAGM VACUUM ADVANCE MECHANISM

As we have seen, most distributors are equipped with both centrifugal and vacuum advance units to provide correct ignition timing for maximum engine performance. The improved combustion engine, however, requires additional timing control at low engine speeds and during deceleration. This additional control is provided by the use of a dual-diaphragm vacuum advance mechanism. (See Figure 38.)

On dual-diaphragm vacuum advance distributors, the centrifugal advance unit is similar to earlier model single-diaphragm vacuum advance distributors. However, the dual-diaphragm unit provides additional spark retard during idle to improve the combustion process.

Retarded spark timing at idle provides additional oxygen (air) to support and prolong combustion.

To understand this, consider an engine idling at specified speed with spark timing adjusted to occur at top dead center. Assume that we retard the spark timing 6° on this engine. This would cause the engine speed to decrease, and the engine might even stall. However, we now compensate for this decrease in idle speed by opening the throttle plate at the carburetor's curb idle screw. Normally, the throttle plate in the carburetor is almost closed during idle and as a result, very small volumes of air are admitted to the combustion chamber. This lack of air during idle tends to snuff out combustion of the fuel mixture.

However, opening the throttle plate, to compensate for the retarded timing, allows more air to enter the combustion chamber. This prolongs the combustion process and results in fewer unburned hydrocarbons.

The dual-diaphragm unit, illustrated in Figure 38, consists of two independently operating diaphragms. The advance (primary) diaphragm utilizes carburetor vacuum; while the retard (secondary) diaphragm is actuated by intake manifold vacuum. The advance (primary) diaphragm controls spark advance in the same manner as the single vacuum advance diaphragm previously discussed in this manual. The retard diaphragm works in the opposite direction to retard the spark at low engine speeds and during deceleration.

Calibrated coil springs bear on the vacuum sides of both diaphragms to supply resistance to the actuating

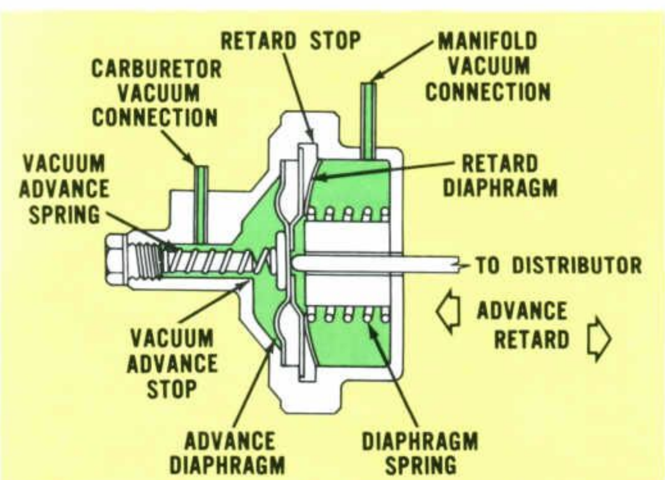


FIGURE 38. DUAL-DIAPHRAGM VACUUM ADVANCE MECHANISM

force of the vacuum. Only the outer diaphragm is linked to the distributor breaker plate. The link passes through the center of the inner diaphragm without contacting it. The inner diaphragm serves to position a return stop for the outer diaphragm to govern the amount of spark retard when spark advance vacuum is reduced.

The dual-diaphragm assembly is designed to provide the distributor with two distinct spark retard stops—a normal retard of 6° before top dead center, and an additional twelve degrees of retard to 6° after top dead center. The normal retard gives the desired spark timing for starting, while the additional retard position provides a setting that's best for more complete combustion and minimum contaminant emission after starting.

The vacuum sides of the two diaphragms are at either extreme of the diaphragm housing, so they provide opposing operating forces. Carburetor vacuum from a port above the throttle plate is supplied to the outer diaphragm, called the advance diaphragm. Vacuum from the intake manifold or below the carburetor throttle plate is supplied to the inner diaphragm—the retard diaphragm.

When the engine is being cranked by the starter, neither carburetor vacuum nor intake manifold vacuum is strong enough to actuate the diaphragms. Consequently, both remain at rest and the diaphragm link holds the breaker plate in the normal retard position until the engine starts.

As the engine starts and begins to run at idle or fast idle rpm, the vacuum from the carburetor is weak because of the closed or nearly closed throttle plates. For the same reason, intake manifold vacuum is strong. The resulting high vacuum against the retard diaphragm moves the diaphragm assembly toward the distributor housing against the resistance of the retard spring until the rim of the diaphragm plate contacts the edge of the retard stop groove around the interior of the diaphragm housing. Carburetor vacuum isn't strong enough to overcome the tension of the vacuum advance spring at the other end of the housing. Consequently, this spring expands to move the advance diaphragm until the small plate at its center is stopped by the retard diaphragm plate. In this position, the diaphragm link turns the breaker plate in the direction of distributor cam rotation to retard the ignition timing another twelve degrees.

As the carburetor throttle plates are opened to increase engine speed and power output, carburetor vacuum gets stronger. This increased vacuum causes the advance diaphragm to move away from the retard diaphragm, against the tension of the advance spring.

As it moves, the advance diaphragm pulls the link and the breaker plate with it, advancing the spark smoothly. At speeds above 1400 to 1600 rpm, the advance diaphragm functions like the single diaphragm of previous Autolite distributors to provide normal ignition timing.

DISTRIBUTOR VACUUM CONTROL (TEMPERATURE SENSING) VALVE

As we have seen, improved combustion depends on a number of engine modifications including lean mixtures and retarded spark timing during engine idle. However (retarded spark timing), during periods of prolonged idle may cause the engine to overheat because the additional heat released by prolonging the combustion process is dissipated through the engine block assembly and picked up by the coolant of the engine's cooling system.

The distributor vacuum control valve illustrated in Figure 39 was developed for the purpose of preventing overheating should the condition occur during prolonged engine idle.

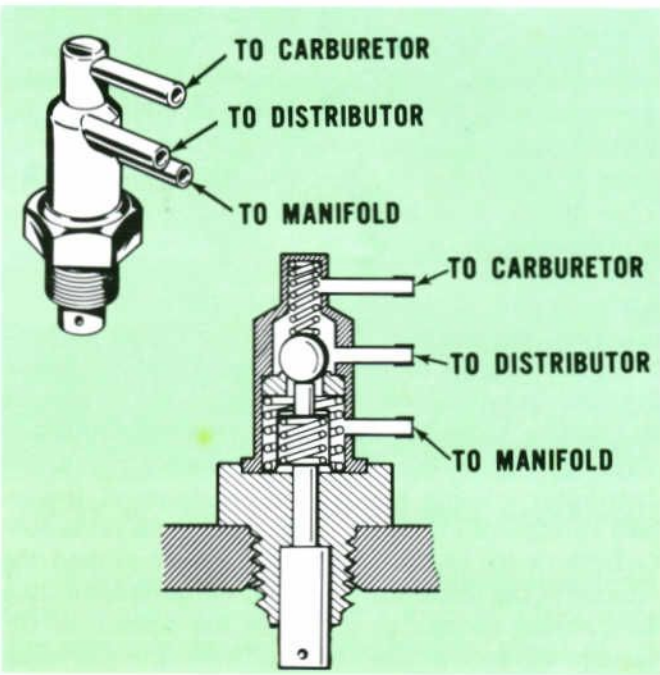


FIGURE 39. DISTRIBUTOR VACUUM CONTROL VALVE

It is a thermostatically operated heat-sensitive control valve, installed in the waterpump outlet housing, for the purpose of sensing the temperature of the engine coolant. The thermostatic portion of the control valve operates a check ball and causes it to be seated in either a "down" or "up" position.

The vacuum control valve has three vacuum connections. The one located in the center of the valve connects to the distributor's vacuum advance diaphragm. The top and bottom vacuum control line connect to the carburetor and manifold vacuum sources respectively.

The position of the check ball (down or up), determines whether carburetor or manifold vacuum is operating the advance diaphragm.

Figure 40 illustrates the normal operating condition of the vacuum control valve when the coolant temperature is normal.

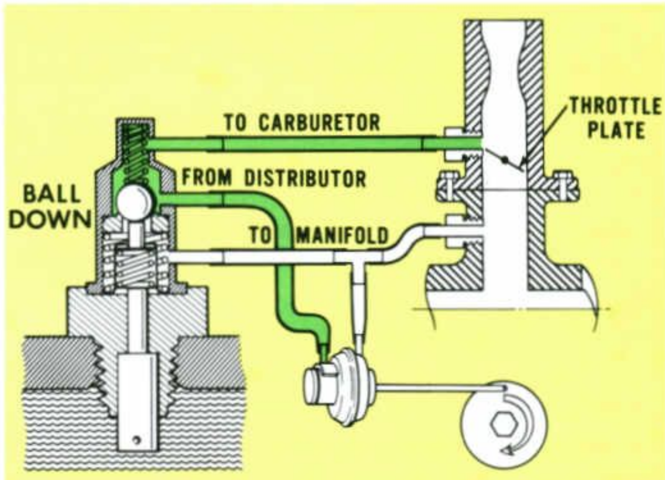


FIGURE 40. VACUUM CONTROL VALVE (NORMAL POSITION)

The check ball is in the down position and normal carburetor vacuum passes through the valve to the distributor.

When the engine coolant temperature exceeds a predetermined level and approaches overheating such as may occur during prolonged periods of idle, the vacuum control valve's check ball is thermostatically moved into its upper position. (See Figure 41.)

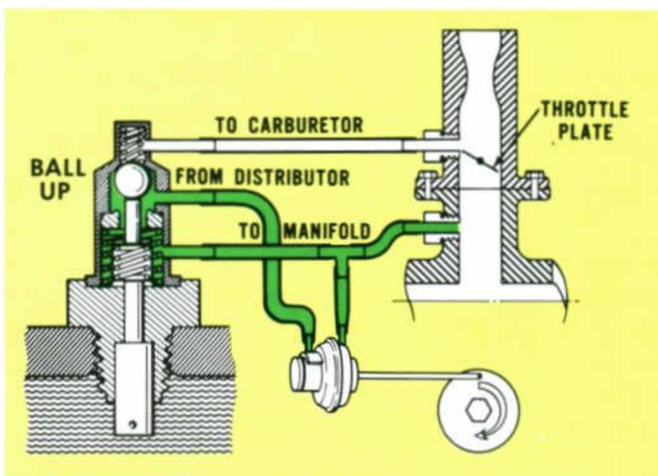


FIGURE 41. VACUUM CONTROL VALVE (ENGINE OVERHEATING)

When the check ball is in the upper position, carburetor vacuum is shut off and manifold vacuum is routed to the distributor's advance diaphragm, causing spark timing to advance. The resulting increase in engine speed when spark timing is advanced, increases the efficiency of the engine's cooling system and thus restores the engine to normal operating temperature.

On some Thermactor equipped engines, the distributor vacuum control valve is installed in the intake manifold vacuum line and routes the vacuum supply through the two uppermost connections to the retard diaphragm of the dual-diaphragm distributor. Should engine overheating occur on this type of installation, the temperature-sensitive valve switches from intake manifold vacuum supply and connects the retard diaphragm to the ambient air pressure in the engine compartment, through a filter. This effectively prevents the diaphragm from retarding the spark timing while the engine is overheated, and the result of less retard is inversely proportionate to additional advance.

DISTRIBUTOR VACUUM ADVANCE CONTROL (DECELERATION) VALVE

On some engines, equipped with the Thermactor air injection system, advanced spark timing is required during periods of deceleration for the purpose of preventing popping or backfire in the engine's exhaust system. The distributor vacuum advance control valve, pictured in Figure 42 (deceleration valve) is added to the advance diaphragm vacuum supply line for the specific purpose of advancing spark timing during engine deceleration.

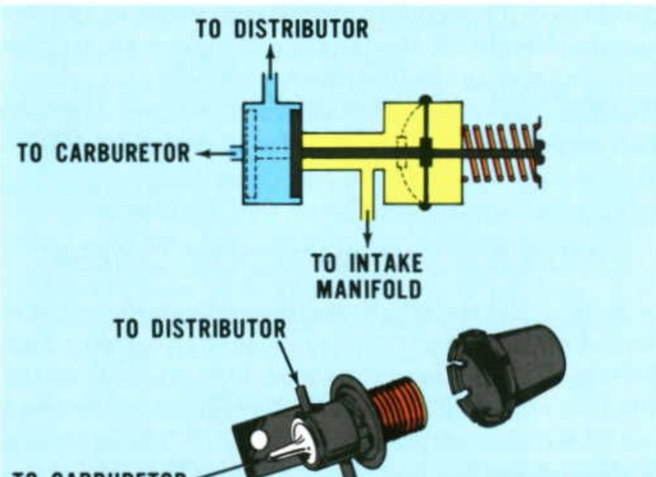


FIGURE 42. DISTRIBUTOR VACUUM ADVANCE CONTROL VALVE

Under normal engine operating conditions, the deceleration valve routes carburetor vacuum to the distributor's advance diaphragm, through the two uppermost vacuum fittings. The third vacuum fitting is connected to the engine's intake manifold, thus exposing the deceleration valve diaphragm to intake manifold vacuum. Adjustable spring tension forces the diaphragm, and the valve connected to it, against normal intake manifold vacuum to retain the position shown in solid outline.

The connections and operation of the deceleration valve are illustrated in Figure 43.

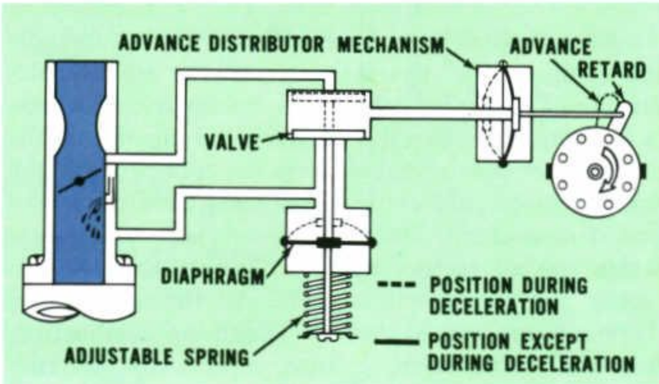


FIGURE 43. DISTRIBUTOR VACUUM ADVANCE CONTROL VALVE (OPERATION)

During periods of deceleration, manifold vacuum rises and the diaphragm, under the influence of the higher vacuum force, moves against the spring tension. The result is pictured by the dotted outline in Figure 43. The valve positions so that carburetor vacuum is shut off and intake manifold vacuum is allowed to act directly on the distributor's vacuum advance diaphragm, causing it to advance the spark timing. The deceleration valve reverts the distributor operation to normal when high intake manifold vacuum ceases to exist.

Our discussion of timing characteristics so far, has carried us into the area of spark timing "retard" as well as spark timing "advance". To avoid a misunderstanding of this seemingly contradictory information and to explain the reasoning behind spark timing as it relates to improved combustion, let's expand our discussion of controlled combustion. Consider the three basic required ingredients for combustion: fuel, heat and air (oxygen). Now let's add another factor . . . "time". How much time is needed to *complete* combustion? We will find that this depends on the amount of fuel to be burned and the velocity of the piston. In terms of the engine's combustion chamber the "time zone" begins with the introduction of the high voltage arc across the spark plug electrodes, and ends when the exhaust valve opens.

It now becomes obvious that the period of time "available" for the combustion is related to engine speed. On the basis of this information, we know that more time is available during engine idle because of the low engine rpm than during deceleration periods when engine overrun occurs. Thus, spark timing can be delayed (retarded) during periods of engine idle and still not interfere with the "time required" to complete combustion, due to the relatively slow piston velocity. However timing must be advanced during deceleration periods when piston velocity is high, for the purpose of gaining additional time, needed to complete combustion before the exhaust valve opens.

We have previously made mention of the "stretchable and compressible" characteristics of the air-fuel mixture. In effect we are referring to volumetric efficiency. It is defined as the ratio between the amount of air-fuel mixture that actually enters the cylinders and the amount that could enter under ideal conditions. Engine temperature, load and speed and mechanical design are all factors in determining just how efficiently the engine will operate. All timing controls, therefore, are aimed toward improved combustion. Improved combustion, in turn, means less contaminants entering the atmosphere. These are the factors to consider when thinking of complete combustion in the engine cylinders under all operating conditions.

IGNITION TIMING

With the introduction of the dual-diaphragm, dual-advance distributor on improved combustion engines, it must be emphasized that spark timing characteristics during starting and at engine speeds above approximately 1400 to 1600 rpm, remain similar to those of the familiar dual-advance distributor. The changes in the dual-diaphragm, dual-advance distributor affect idle and low speed timing characteristics only. The initial spark timing adjustment procedures and specifications, however, have been changed.

Figure 44 illustrates some of the spark timing effects of the dual-diaphragm distributor, as they would appear on the crankshaft pulley under a strobe light.

In View 1, the timing effect shown is that of the engine running at specified idle speed with both vacuum hoses disconnected from the dual diaphragm and plugged. Disconnecting the vacuum hoses is the procedure usually specified for initial spark timing adjustment. (Ignition timing adjustment procedures will be covered in the Service Procedures Section.)

View 2 illustrates the change in spark timing which occurs when the vacuum hoses are reconnected to the

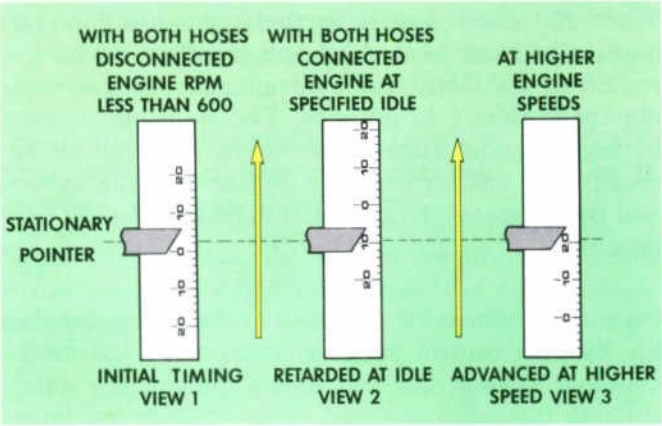


FIGURE 44. EFFECTS OF DUAL DIAPHRAGM ON TIMING

dual-diaphragm during engine idle. The timing mark shown indicates full spark retard, which results from reconnecting the intake manifold vacuum to the retard diaphragm.

Spark timing advance characteristics at high engine speeds, as illustrated in View 3, remain similar to the familiar dual-advance distributor. (For exact spark timing specifications, refer to Appendix II.)

As we have seen, the improved combustion ignition system is designed to provide an extended range of spark timing control. This additional timing control helps to reduce the amount of exhaust gas contaminants emitted to the atmosphere. To effectively control timing, however, the IMCO system depends upon a number of vacuum-sensitive devices. These devices, in turn, may be connected to various vacuum sources. Figure 45 is intended to illustrate a representative distributor vacuum system schematic.

In Figure 45, the distributor vacuum control valve, the distributor vacuum advance control valve and the dual-diaphragm, dual-advance distributor are used in conjunction with the Thermactor air injection system. (For information on additional vacuum schematics and their respective application, refer to Appendix III.)

THERMACTOR (AIR INJECTION SYSTEM)

In spite of the seemingly endless and varying application of emission control components on current production vehicles, there is no misunderstandings on the intended objective . . . to keep the atmosphere as clean and breathable as practically possible. The approach to the problem has been fairly uniform throughout the automobile industry and as we have seen, the trend seems to favor the improvement of combustion internally in the cylinder combustion chambers. However,

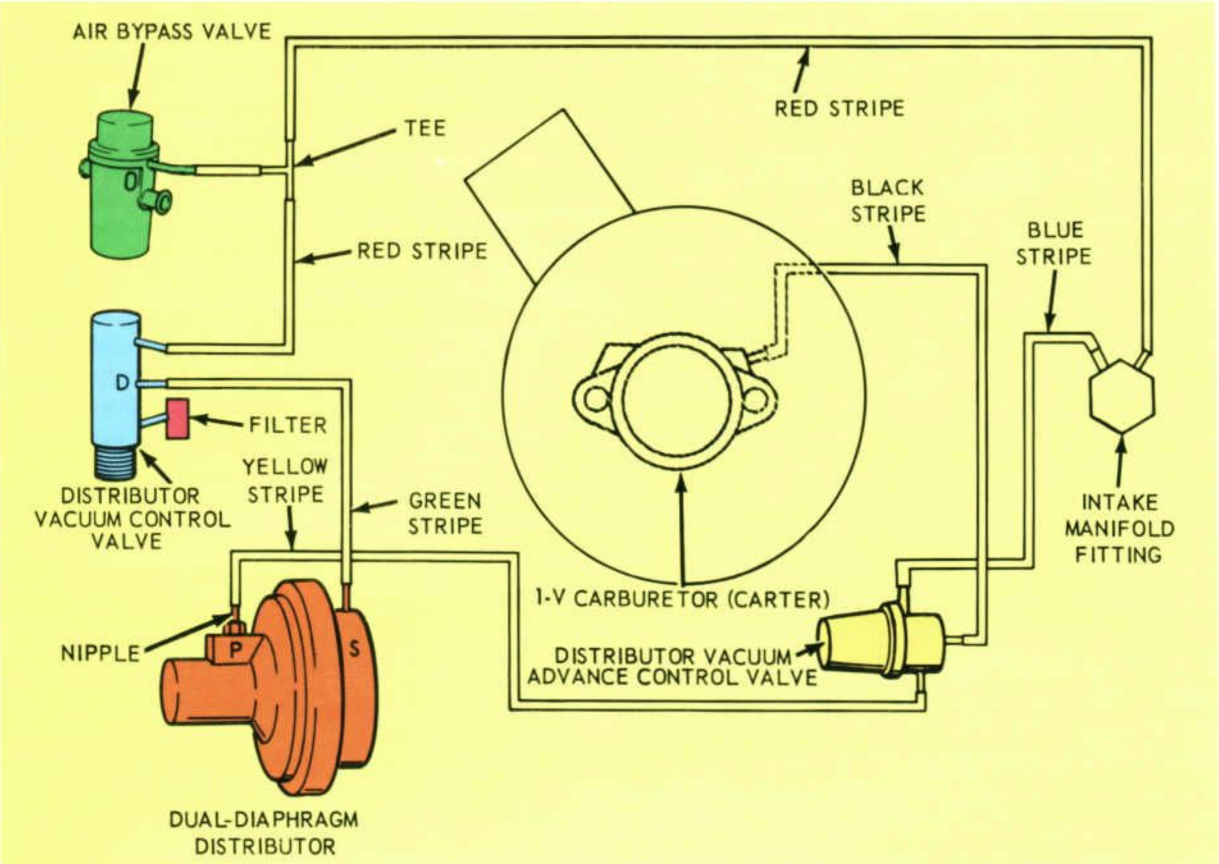


FIGURE 45. DISTRIBUTOR VACUUM SYSTEM SCHEMATIC

in some instances, improvement of internal combustion involves performance characteristics which are incompatible with certain engine and transmission combinations. Examples of such instances are found in vehicles equipped with high performance engines and engines combined with standard transmissions.

A brief review of the required essentials for combustion, as outlined previously under the heading "Essentials of Combustion", will be helpful in understanding the underlying operating principles of the thermactor air injector system.

Remember that the three required essentials of combustion are:

1. Fuel (gasoline . . . or, in the case of the air injection system, the remaining portion of the unburned hydrocarbons in the exhaust gases).
2. Heat (electrical spark . . . or, in the case of the air injection system, the heat of the exhaust gases as they leave the combustion chamber).
3. Oxygen (contained in the air supplied to the combustion chambers through the carburetor . . . or, in the case of the air injection system, supplied by the thermactor air pump to the exhaust ports).

Thus, we see that the essential requirements for combustion are present in the air injection system. The *fuel*, or unburned hydrocarbons in the exhaust gases, and the *heat* of these gases as they leave the combustion chamber, satisfy two of the essential requirements. *Oxygen*, the third requirement, is contained in the air supplied by the air pump and when injected into the engine exhaust ports, will induce combustion of the exhaust gases. This continued combustion of the exhaust gases outside of the combustion chamber results in a reduced level of unburned hydrocarbons emitted into the atmosphere through the vehicle's exhaust system.

To keep the exhaust emission level within the specfied limits and maintain proper vehicle performance characteristics, the combustion process on these vehicles is extended into the engine's exhaust system by the injection of fresh air into the engine's exhaust ports. This sustains and supports the combustion process beyond the combustion chambers, for the purpose of reducing the hydrocarbon and carbon monoxide content of the exhaust gases.

The Ford thermactor air injection system illustrated in Figure 46 is typical of the industry's approach to extend combustion beyond the engine's combustion chambers.

An air injection system, as represented by the thermactor, generally consists of an air supply pump assembly, an air by-pass valve, a check valve/s and an air distributing manifold/s.

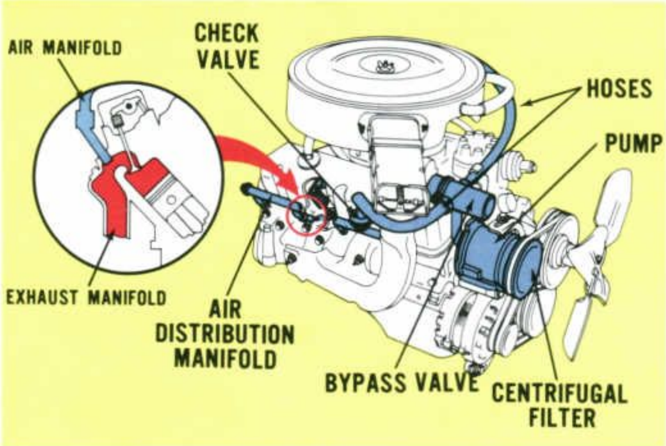


FIGURE 46.—THERMACTOR (TYPICAL AIR INJECTION SYSTEM)

Air Supply Pump

The belt-driven air supply pump pictured in Figure 47 features three serviceable components . . . a centrifugal air filtering fan, a pressure relief valve and a pressure setting plug. (See Figure 47.) The remainder of the vane-type air pump is serviced as an assembly, with lifetime pre-packed bearings and all pump clearances established during assembly.

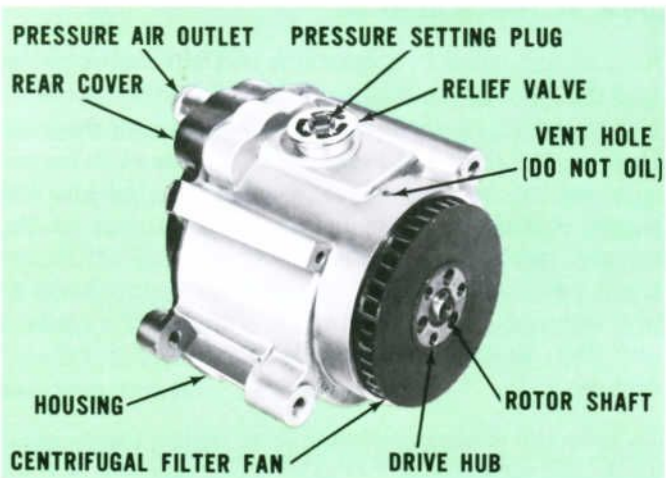


FIGURE 47. AIR PUMP

An impeller type centrifugal air filter fan, mounted on the rotor shaft of the air pump assembly, derives its name from the fact that dust particles in the intake air are prevented from entering the pump assembly by the application of centrifugal force. The dust particles, which are relatively heavier than air, are centrifugally forced in a direction opposite to the flow of the inlet air. Air, being lighter than the foreign particles suspended in it, is drawn into the pump by the impeller-type fan assembly. The centrifugal filter fan eliminates the need for the separate pump air cleaner and hose connections found on some air injection systems. A pressure relief valve is mounted in the pump to prevent the pump pressure from exceeding a predetermined value. The pressure setting of the relief valve is controlled by a replaceable plastic plug. Thus, pressure settings can be varied by changing the plastic plug.

(Detailed service procedures on the air pump may be found under the service procedures section.)

Air By-Pass Valve

The air supply from the air pump assembly then flows through the air by-pass valve before it is injected through a check valve/s into the air manifold/s and the exhaust ports of the engine. The illustration in Figure 48 depicts a cross sectional view of the by-pass valve for the purpose of describing its operation and control of air delivery to the air manifold/s.

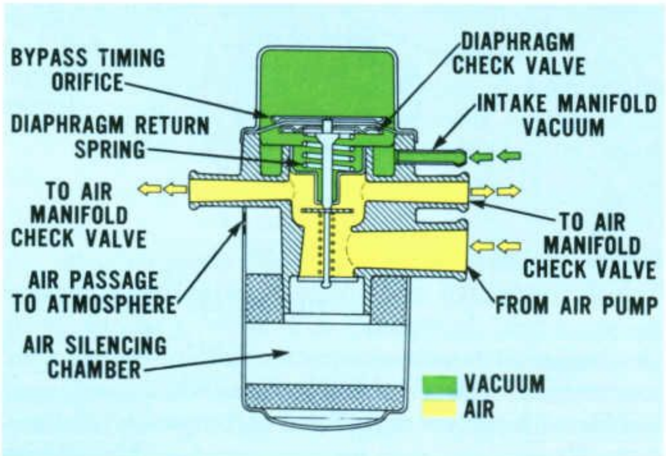


FIGURE 48. AIR BY-PASS VALVE (NORMAL POSITION)

Two valve plates mounted on a common shaft attached to a diaphragm, in conjunction with a diaphragm return spring, form a check valve which controls the air flow through the by-pass valve assembly. Intake manifold vacuum to the by-pass valve is supplied through a vacuum fitting connected to the lower side of the diaphragm vacuum chamber. The vacuum chamber houses a calibrated diaphragm return spring and is sealed off from the lower portion of the by-pass valve assembly. However, a by-pass orifice hole through the diaphragm check valve assembly is designed to allow intake manifold vacuum to distribute equally on both sides of the diaphragm. Thus, during normal engine operation when the intake manifold vacuum has equalized on both sides of the diaphragm, the force acting to position the diaphragm check valve is the diaphragm return spring. The spring forces the valve up to the normal position and air from the air pump is allowed to flow to the exhaust manifold/s. (Refer to Figure 48.) However, during periods of engine deceleration, fuel mixtures tend to richen and an excess amount of unburned hydrocarbons may flow into the exhaust manifold. If air were also allowed to flow through the by-pass valve to the exhaust manifold, during these periods of deceleration, the excess oxygen would cause, "backfire" or extremely rapid combustion of the unburned gases in the exhaust manifold/s.

To prevent the occurrence of "backfire", the by-pass valve is designed to divert the air from the air pump to the atmosphere. In effect, this diverting action assists in resolving the backfire problem by removing one of the combustion ingredients . . . oxygen.

The sudden rise in intake manifold vacuum during deceleration periods creates a vacuum condition under the diaphragm of the valve assembly strong enough to pull the valve downward against the return spring tension. This downward movement of the valve causes the air from the air pump to be momentarily by-passed or diverted to the atmosphere through the by-pass valve silencing chamber. (Refer to Figure 49.) Air diversion is only momentary, however, because the orifice hole in the diaphragm assembly soon equalizes vacuum pressure on both sides of the diaphragm, and the diaphragm return spring brings the by-pass valve back into the normal operating position in a matter of a few seconds. (Refer to Figure 48.)

The illustration of by-pass valve operation in Figure 49 will help to explain how control of combustion, for the purpose of preventing backfire, is accomplished.

Thus, the by-pass valve, in effect, turns the air supply off suddenly to prevent backfire and turns it back on gradually for the purpose of starting combustion in the exhaust manifold. The by-pass valve and deceleration valve, which was discussed earlier in this manual, are the devices currently in use to prevent exhaust manifold backfire on air injection equipped engines. On early Ford-built Thermactor systems, an "air gulp" valve was used in place of the current production by-pass valve. Diaphragm operation of the gulp valve is similar to the operating characteristics of the by-pass valve diaphragm. However, the gulp valve injects air directly into the intake manifold during deceleration, for the purpose of leaning out the fuel-air mixture thereby preventing backfire.

Check Valve and Air Injection Manifold

Figure 50 illustrates the check valve and the air injection manifold.

The check valve allows air to flow from the air pump assembly to the air manifold; however, it is designed to prevent the possibility of a reverse flow of exhaust gases from entering the pump assembly and thus, protects the pump assembly should failures in the form of low or non-existent air pressure occur. If an air pump failure occurs or if air pump pressure drops, the spring tension of the check valve spring will force the valve plug to seat, thereby preventing any back-flow of exhaust gases to the air pump. The air manifold is designed to distribute air from the air pump to all of the engine's exhaust ports.

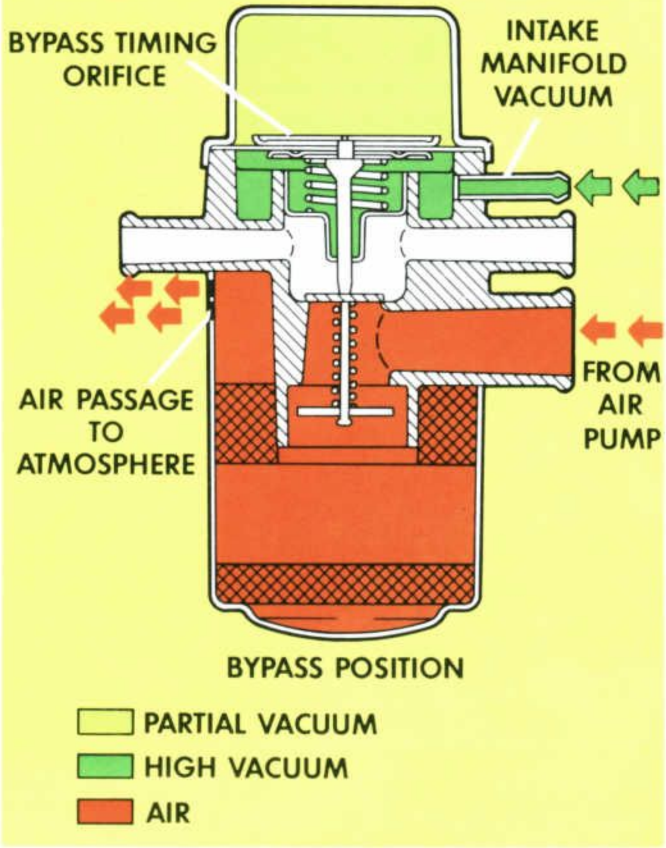


FIGURE 49. AIR BY-PASS VALVE (BY-PASS POSITION)

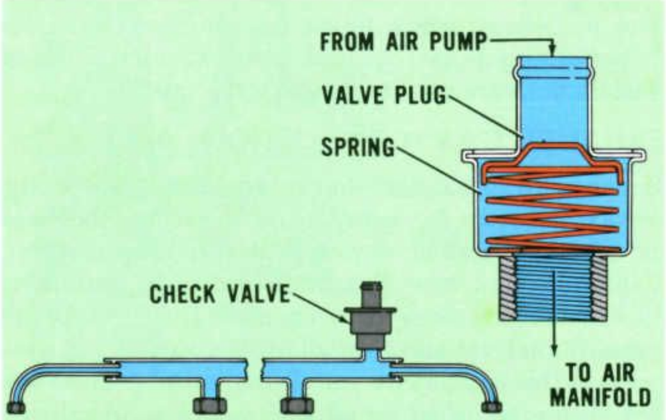


FIGURE 50. CHECK VALVE AND AIR INJECTION MANIFOLD

Service Procedures

Again, basic engine condition has a bearing on the efficiency of the emission control systems. Problems in the cooling system, exhaust system, and even defective engine gaskets, have a definite affect on the overall concept of emission control problems. Accordingly, these areas should be checked and any malfunctions should be corrected before work is performed on emission system components. (See Figure 51.)

FIGURE 51. ENGINE CONDITION AFFECTS EMISSION

Thus, the first step toward repair of a defective emission control system is to verify what problem exists; then, isolate the problem to a certain area. The vacuum gauge and/or compression gauge will help to isolate the problem in this respect.

Poor compression suggests sticking or leaking valves, piston ring wear, piston damage, excessive carbon build-up, or cylinder head gasket leaks. Vacuum conditions which are abnormal suggest faulty ignition system components, improper carburetor adjustments, improper valve timing, worn or damaged valves, leaks at the cylinder head, manifolds, carburetor, or vacuum lines, and excessive exhaust back pressure. (The service procedures which follow assume that the engine is performing properly. Ford Motor Company vehicle installations are used as industry typicals.)

EXHAUST GAS (COMBUSTION) ANALYZER

Exhaust gas analyzers have been available to the service industry for many years; however, their use as a service testing device has been limited. First, California, and now Federal Regulations pertaining to exhaust emissions have changed the need for an exhaust analyzer and soon all service outlets will have to have this equipment. An air-fuel ratio specification has been established for all 1968 vehicles. An exhaust gas analyzer must be used on all tune-ups to assure that the vehicle meets this specification. The following step-by-step procedures involve the use of a Rotunda Model ARE27-76 Exhaust Analyzer.

Step 1. Connect an A.C. powered exhaust analyzer (Rotunda Model ARE27-56U or 27-76 or equivalent) following manufacturer's instructions. Confirm instrument calibration. (Rotunda Analyzers must have "Certified Calibration" marked on the face of the Tester.) (See Figure 52.)

Step 2. On a thermactor-equipped vehicle, disconnect the thermactor pump air supply hose at the air pump or the check valve/s. Do not adjust for the drop in engine idle speed, which occurs when the air supply hose is disconnected. Note the amount of rpm drop for use in Step 4.

Step 3. Observe the reading obtained on the exhaust gas analyzer. *It must be taken with the air cleaner installed.* Refer to the specified minimum air-fuel ratio.

Step 4. Turn the idle mixture adjusting screw(s) as required within the range of the idle limiter until the specified air-fuel ratio is obtained. (On 2-V and 4-V carburetors, turn the screws an equal amount.)

Correct for any changes in engine idle speed immediately as the idle mixture screw(s) are turned. (Refer to the drop in idle rpm obtained when the thermactor air pump hose(s) were disconnected in Step 2, then correct the idle speed to the rpm noted.) *Allow at least 10 seconds following each idle mixture screw adjustment for the analyzer reading to properly respond and stabilize.*

Verify the analyzer reading – Thermal conductivity exhaust gas analyzers will give an erroneously rich reading if the air-fuel mixture is *extremely* lean. To check for this condition, partially hand choke the carburetor, or rapidly open-and-close the throttle three or four times to enrich the air-fuel mixture.

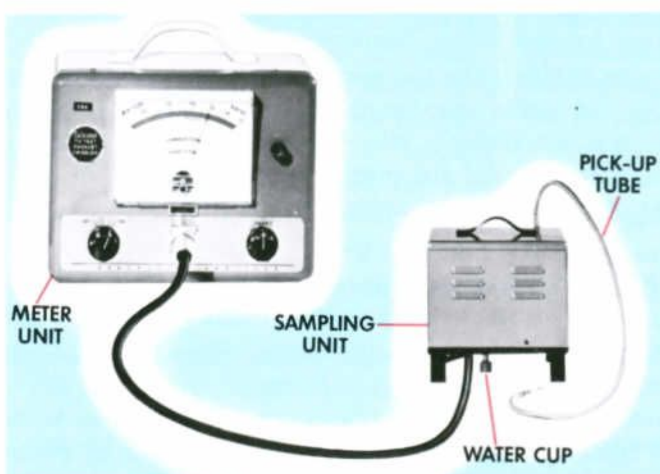


FIGURE 52. ROTUNDA EXHAUST GAS ANALYZER

Vehicles with an automatic transmission must be in Neutral while this is being done.

Step 5. If the air-fuel ratio is to specifications, and the various engine systems are functioning correctly, no further adjustment should be made.

If the air-fuel ratio is not to specifications, as shown by the analyzer reading, it may be corrected by altering the controlling limits of the carburetor idle fuel system.

Step 6. Install air hose removed in Step 2.

CARBURETOR ADJUSTMENTS

Routine Adjustments

Idle mixture adjustments must be made with the engine at operating temperatures and after all other adjustments have been made. If an exhaust analyzer is not available, a vacuum gauge and/or a tachometer can be used to adjust idle mixture within the limits of the idle limiter device used on any given carburetor. Idle adjustment within the limiters is subject to the same precautions as in previous years. (Choke open, hot idle compensator valve closed, headlights on, automatic transmission in drive, air cleaner installed, etc.). If a satisfactory idle adjustment cannot be made within these limits, an analyzer must be used and the limiting device re-adjusted to obtain the proper air-fuel ratio.

Modifying Carburetor Idle Conditions

WITH LIMITING CAPS

Remove the plastic limiter caps (Figure 53) by cutting them with side-cutter pliers and a knife. After the cut is made, carefully pry the limiter apart. *On some carburetors, it may be necessary to remove the carburetor to remove the limiters.* After the limiters are removed, set the carburetor to the correct air-fuel ratio, using the exhaust gas analyzer. When the air-fuel ratio is within specifications, install a colored plastic service limiter cap. When installing the limiter cap, use care not to turn the idle mixture screw with the cap. Position the cap so that it is in the maximum counterclockwise position with the tab of the limiter against the stop on the carburetor. The idle mixture adjusting screw will then be at the maximum allowable outward, or rich, setting.

To install the service limiter cap, use a straight, forward pushing force with thumb pressure or a ⅜-inch socket wrench extension. Recheck the air-fuel ratio with the air cleaner installed, using the exhaust gas analyzer to make sure the limiter caps are properly installed.

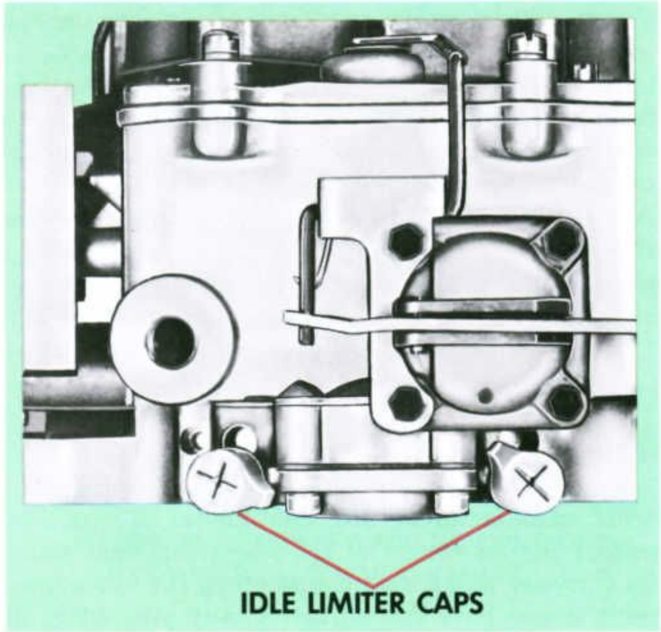


FIGURE 53. IDLE LIMITING CAPS (AUTOLITE 2-V SHOWN)

With Idle Limiting Needles (Carter)

Remove the lead seal covering the idle limiting needle in the throttle body by carefully picking it out with a sharp-pointed tool. If necessary, drill out the center of the lead seal with a ⅛-inch diameter drill in a pin vise. With the idle adjusting needle at the maximum rich setting, slowly back out the idle limiter, $^1/_{16}$ turn at a time, until the specified air-fuel reading is obtained on the exhaust gas analyzer. After obtaining the specified air-fuel reading, install a new lead seal

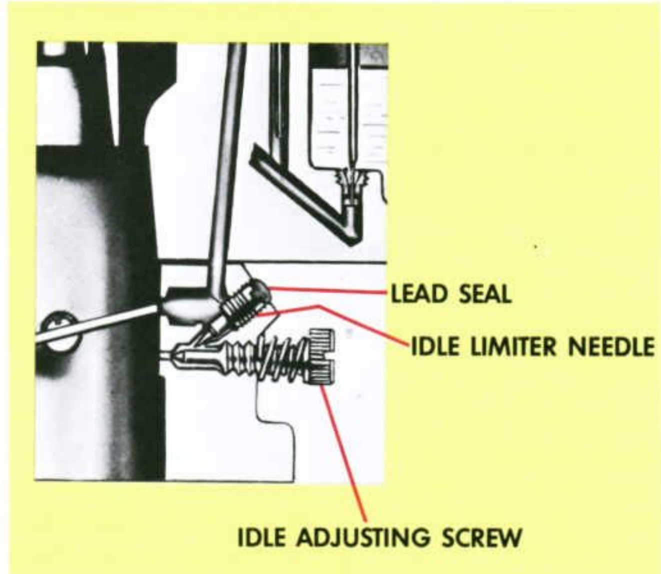


FIGURE 54. IDLE LIMITER, SEAL AND ADJUSTING SCREW (CARTER 1-V SHOWN)

over the idle limiter. Drive the lead seal into the hole with a small punch until the lead just contacts the head of the screw. After the idle limiter has been reset and the air-fuel ratio and idle condition are satisfactory, stamp or scribe the letter "R" on the carburetor identification tag just above the name Autolite to indicate the carburetor has been reworked. (See Figure 54.)

NOTE: Idle limiter modification should not be attempted without an exhaust analyzer and only after all other engine systems have been eliminated as the source of the problem.

WITH OTHER IDLE LIMITERS

Some manufacturers use idle limiter screws that restrict the movement of the idle adjustment screw. On Chrysler Ball & Ball Carburetors, the idle adjustment screws have limited travel. Any attempt to remove the screw will result in damage to the screw and the carburetor will have to be replaced. Rochester Carburetors (General Motors) uses an idle restriction in the idle passage. With this system, the idle adjusting needle can be turned any number of turns but the result is limited by the restricted passage. Due to the fact that the industry is constantly striving to improve emission control, there will undoubtedly be other forms of carburetor limiting devices on future vehicles.

IGNITION (TIMING AND CONTROL VALVE TESTING)

Timing

The importance of correct ignition timing cannot be over-emphasized. Igniting the fuel at exactly the right time, under all load and speed conditions, has always been a determining factor in the performance and economy of the automobile engine. Now, with the introduction of the emission control systems, timing, both advance and retard, has become even more important. As a result of this emphasis on timing, equipment manufacturers have developed a timing light with a meter in conjunction with the light. (Figure 55). This meter measures the advance or retard in degrees, thus enabling the service technician to test the total timing mechanism with the distributor installed on the engine.

Due to the more sophisticated timing requirements, there have to be additional control valves to control vacuum to the distributor under all speed and load conditions. The operating principles of these valves have been discussed on previous pages but, of course, we must be able to service them in the event of a malfunction. Most vehicle manufacturers use either one or both of these valves.

FIGURE 55. ADVANCE METER TYPE TIMING LIGHT

Service procedures for these valves are outlined, step by step, as follows:

Distributor Vacuum Control Valve Test

NOTE: The distributor vacuum control valve is also referred to as a temperature sensing valve.

Make certain that all vacuum hoses are properly routed and installed.

Attach a tachometer to the engine.

Bring the engine up to operating temperature and be certain that the choke plate is in the vertical position. *The engine must not be overheated.*

Note the engine idle rpm with the transmission in Neutral and the carburetor throttle in the curb idle position.

Disconnect the vacuum hose from the intake manifold at the temperature-sensing valve and plug or clamp the hose.

Note the engine idle rpm with the hose disconnected. If there is no change in idle speed, the valve is acceptable up to this point. If there is a drop in idle speed of 100 rpm or more, the valve should be replaced.

Verify that the all-season cooling mixture is up to specifications, and that the correct radiator cap is installed.

Cover the radiator sufficiently to induce a high-temperature condition.

Continue to operate the engine until the red (high-temperature) light comes on indicating an above normal temperature.

If the engine idle speed has by this time increased 100 rpm or more, the temperature-sensing valve is satisfactory. If not, it should be replaced.

Do not permit engine to operate in an overheated condition any longer than is necessary to determine that the valve is good or bad.

ALTERNATE TEST WITH VACUUM GAUGE

Using above procedure, substitute vacuum gauge for tachometer. (Figure 56). Note vacuum gauge reading with gauge connected to distributor outlet on temperature-sensing valve.

With engine temperature normal, guage should read near zero inches of vacuum (venturi vacuum) with other hoses connected.

With engine overheated, gauge should reach sixteen (16) inches of vacuum or above (manifold vacuum).

If these gauge readings are not obtained and the source of vacuum is satisfactory, the valve should be replaced.

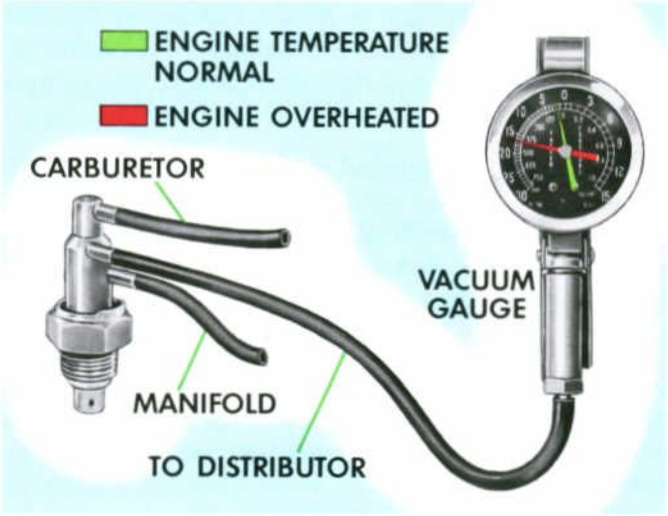


FIGURE 56. TESTING VACUUM CONTROL VALVE WITH VACUUM GAUGE

Distributor Vacuum Advance Control Valve Test

The next valve that we will consider is the Distributor Vacuum Advance Control Valve. (See Figure 57.) This valve controls timing on deceleration. Ford Motor Company uses this valve on relatively few vehicles but Chrysler and General Motors make widespread use of the "deceleration" valve. The following step-by-step procedure for testing this valve is for Ford vehicles. Consult the vehicle repair manual for the particular vehicle you are working on for the proper procedure and specifications.

Connect a tachometer to the engine, and operate the engine until normal operating temperature is reached.

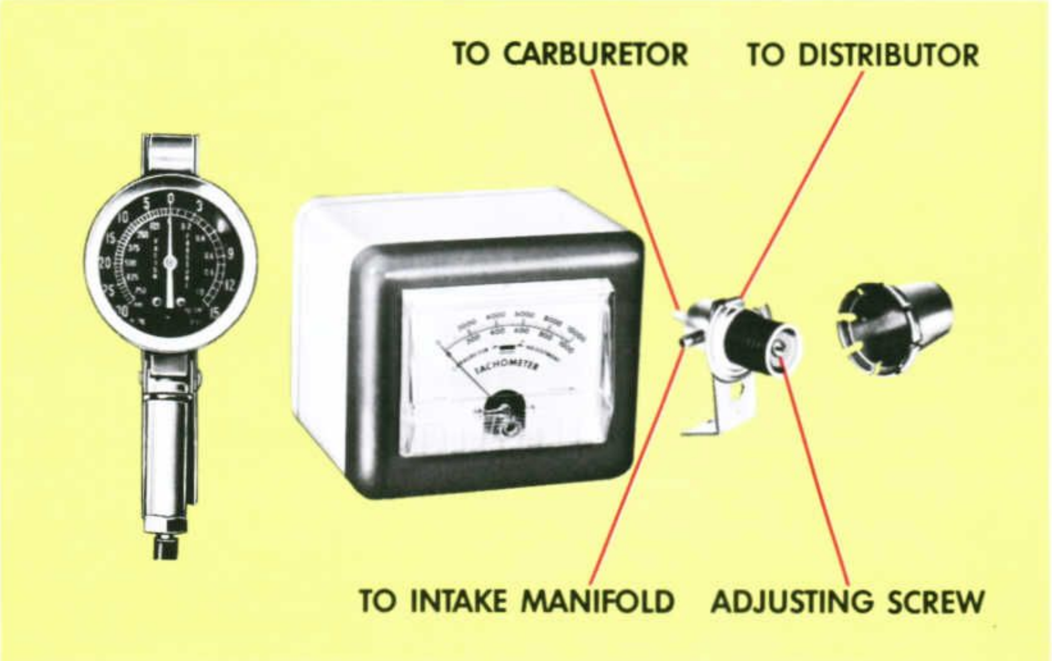


FIGURE 57. VACUUM ADVANCE CONTROL VALVE. (DECELERATION VALVE).

Connect a vacuum gauge to the distributor vacuum line. Be sure the tee has approximately the same inside diameter as the distributor vacuum line to prevent false readings.

If the engine is equipped with a dashpot, tape the plunger in depressed position so that it does not contact the throttle lever at idle speed. Use a clamp to close the vacuum line that connects the deceleration valve to the intake manifold.

Remove the distributor vacuum hose at the distributor and clamp the hose closed. With engine operating at specified idle rpm (transmission in neutral and parking brake on), set the ignition timing to specifications.

If necessary, adjust the carburetor to the specified engine speed and air-fuel ratio. The distributor vacuum must be below six inches of mercury at idle speed.

Remove the clamps from the vacuum tubes and reconnect the vacuum line to the distributor. Remove the distributor vacuum advance control valve cover. Increase engine speed to 2,000 rpm in neutral and hold the speed approximately five seconds. Release the throttle and note the distributor vacuum reading. When the throttle is released, the distributor vacuum should increase to more than 16 inches of mercury and remain there for a minimum of one second. The distributor vacuum should fall below six inches of mercury within three seconds after the throttle is released.

It is normal during this period for a buzzing sound to be heard. If it takes less than one second or more than three seconds for the distributor vacuum to fall below six inches of mercury, adjust the valve. Turning the spring end adjusting screw counterclockwise will increase the time the distributor vacuum remains above six inches of mercury after the throttle is closed. One turn of the adjusting screw, Figure 57, will change the valve setting approximately one-half inch of mercury. If the valve cannot be adjusted to specifications, replace the valve.

Replace the valve cover. Remove the tape from the dashpot plunger, and re-check the performance of the deceleration valve. If the distributor vacuum does not fall below six inches of mercury within four seconds after the throttle is closed, adjust the dashpot to specifications or replace it.

To check the distributor vacuum advance control valve for a possible diaphragm leak, connect a vacuum gauge into the vacuum hose connecting the valve to the intake manifold vacuum connection. Use a tee fitting with the same diameter as the inside diameter of the vacuum hose (¼-inch I.D.). Clamp the vacuum hose connecting the valve to the distributor. Clamp the hose connection between the valve and carburetor.

Start the engine and operate it at normal idle speed. Note the vacuum reading. Place a clamp on the vacuum hose connecting the valve to the intake manifold (between the valve and the vacuum gauge tee). Note the vacuum reading. If the second reading indicates a higher vacuum than the first, replace the deceleration valve.

P.C.V. VALVE SYSTEM TEST

Periodic maintenance of the Positive Crankcase Ventilation system is an important factor in the control of air pollution. It is important to test not only the P.C.V. valve, but also the other component parts of this system. Hoses and oil filler caps, along with the oil dipstick and seal and the vents in the valve covers, are all important factors in the proper performance of this system. There are many P.C.V. valve system testers on the market, but we will describe the step-by-step testing procedures using the Autolite EV44 tester only. (See Figure 58.)

FIGURE 58. P.C.V. VALVE TESTER (AUTOLITE EV44)

Make sure that all vents on valve covers etc. are sealed.

Be sure hoses to air cleaner are closed off and sealed.

Place tester over oil fill hole or tube with engine idling.

Note position of yellow ball—Green (good) indicates that P.C.V. valve system is O.K. Red (repair) indicates that the system needs to be serviced. (Clean hoses, *install new P.C.V. valve* and retest.)

AIR INJECTION SYSTEM TEST

The air injection system has three component parts that need to be tested. The air supply pump, check valve, and air bypass valve can all be tested with a pressure gauge and an adapter that can be made in any shop. Even though the air injection system components may differ slightly between car makes and models, the main function and test procedure is approximately the same. The test procedures and instructions for fabricating the test adapter are for Ford-built vehicles. We suggest that you consult the appropriate vehicle repair manual for specific tests on other makes. (See Figure 59.)

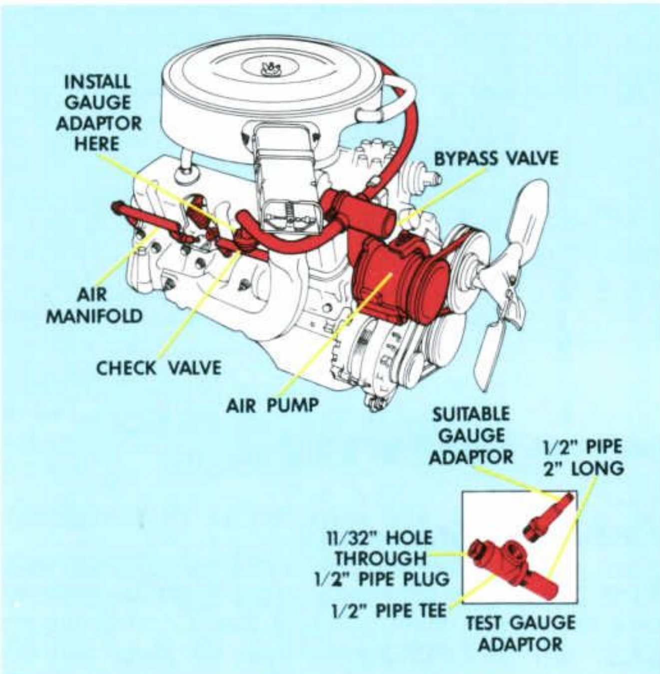


FIGURE 59. THERMACTOR SYSTEM (INCLUDING TEST ADAPTER)

FABRICATE A TEST GAUGE ADAPTER FOR A STANDARD FUEL PUMP TESTER OR SUITABLE PRESSURE GAUGE

Obtain a ½-inch pipe tee, a 2-inch long piece of ½-inch galvanized pipe threaded on one end only, a ½-inch pipe plug, and a ½-inch reducer bushing or suitable gauge adapter.

Apply sealer on the 2-inch long piece of ½-inch pipe and install it on one end of the pipe tee. Apply sealer on the O.D. threads of the ½-inch pipe plug and install it in the opposite end of the tee. Apply sealer on the O.D. threads of the ½-inch reducer bushing or adapter for the pressure gauge and install it in the side opening of the tee.

Using a 11/32 (0.3437) diameter drill, drill a hole through the center of the pipe plug. Clean out the chips produced by drilling.

The gauge must be accurate and readable in ¼ PSI increments.

The tool is ready now for use.

Air Supply Pump Test Procedure

Operate the engine until it reaches normal operating temperatures. Inspect all hoses and hose connections for leaks and correct, as necessary, before checking the air pump.

Check the air pump belt tension and adjust the belt to specifications. Disconnect the air supply hose(s) at the air manifold check valve(s). If there are two check valves, close off one hose by inserting a suitable plug in the end of the hose. Use a hose clamp and secure the plug so that it will not blow out.

Insert the open pipe end of the test gauge adapter in the other air supply hose. Clamp the hose securely to the adapter to prevent it from blowing out. Position the adapter and test gauge so that the air blast emitted through the drilled pipe plug will be harmlessly dissipated.

Install a tachometer on the engine. Start the engine and slowly increase the engine speed to 1500 rpm. Observe the pressure produced at the test gauge. The air pressure should be one PSI or more.

NOTE: If the air pump pressure still doesn't meet the minimum requirements, install a new air pump and repeat the pump test. Replace the air pump as determined by the results of this test.

Check Valve Test Procedure

This test can be performed at the same time as the "Air Supply Pump Test".

Operate the engine until it reaches normal operating temperature. Inspect all hoses and hose connections for obvious leaks and correct, as necessary, before checking the check valve operation.

Disconnect the air supply hose(s) at the check valve(s).

Visually inspect the position of the valve plate inside the valve body. It should be lightly positioned against the valve seat – away from the air manifold.

Insert a probe into the hose connection on the check valve and depress the valve plate. It should freely return to the original position, against the valve seat, when released.

If equipped with two check valve assemblies, check both valves for free operation.

Leave the hose(s) disconnected and start the engine. Slowly increase the engine speed to 1500 rpm and watch for exhaust gas leakage at the check valve(s). There should not be any exhaust leakage. The valve may flutter or vibrate at idle speeds, but this is normal due to the exhaust pulsations in the manifold.

If the check valve(s) does not meet the recommended conditions, replace it.

Air Bypass Valve Functional Test

- Remove the air bypass valve-to-air manifold check valve hose at the bypass valve hose connection.

- With the transmission in neutral and the parking brake on, start the engine and operate it at normal engine idle speed. Verify that air is flowing from the air bypass valve hose connection. Air pressure should be noted as this is the normal delivery flow to the air manifold(s).

Momentarily (approximately five seconds) pinch off the vacuum hose to the bypass valve to duplicate the air bypass cycle.

Release the pinched vacuum hose. Air flow through the air bypass valve should diminish or stop for a short period of time. The length of time required to resume normal flow cannot be specified since the time interval is dependent on engine vacuum and length of time the vacuum line is pinched off.

Evaluate the bypass valve for diaphragm leakage by performing the following check:

Remove the vacuum supply hose to the air bypass valve at the bypass valve connection.

Insert a "tee" connection in the vacuum supply hose.

Connect a vacuum gauge to one of the remaining hose connections on the "tee"; insert a short length of hose (about 3 inches) on the remaining connection.

Insert a suitable plug in the open end of the short length of hose.

Start engine and note the vacuum gauge reading.

Remove the plug from the short length of hose to the air bypass valve vacuum connection.

NOTE: If the indicated vacuum reading does not correspond with the previous reading after 60 seconds, replace the air bypass valve.

The preceding test procedures tell us if the air injection system is functioning properly. If a problem still exists after these tests prove that the air injection system is O.K. the problem lies in the area of tune up.

Tune-up procedures should include the checking and adjusting of the following to manufacturer's specifications:

- Ignition timing (approximate figures will not be sufficient).
- Plugs, plug wires, cap and rotor.
- Carburetor float level.
- Carburetor main metering jets.
- Choke operation (staying closed too long or partially closed when hot).

Poor engine performance and idle can result from a vacuum leak at any of the numerous lines or gaskets in the intake system. A vacuum leak can be erroneously diagnosed as a malfunction of most any other system. It has been said that vacuum leaks are to a tune-up technician as rust is to a body man. Be sure to eliminate any vacuum leak from the system before tests or adjustments are made.

Air Supply Pump Service

Even though the air supply pump must be replaced as a unit if any malfunction is found during the air pump test procedure, some external parts may be replaced as a periodic maintenance item or as needed. The parts that are servicable are the centrifugal filter fan, air pump relief valve, and relief valve pressure-setting plug. (See Figure 60.)

RELIEF VALVE REPLACEMENT

NOTE: Do not disassemble the air pump to replace the relief valve, but remove the pump from the engine.

Position tool T66L-9A486-D* on the air pump and remove the relief valve with the aid of a slide hammer (T59L-100-B).*

To replace, position the relief valve on the pump housing and hold T66L-9A486-D on the relief valve. Use a hammer to *tap the tool lightly* until the relief valve is seated.

*Ford Motor Company Tool Number.

RELIEF VALVE PRESSURE-SETTING PLUG REPLACEMENT

- Compress the locking tabs inward (together) and remove the plastic pressure setting plug.
- Before installing the new plug, be sure that the plug is the correct color. *(The correct plug for all 1968 Ford engines should be color-coded blue.)*
- Insert the plug in the relief valve hole and push the plug in until it snaps into place. (Refer to Figure 60.)

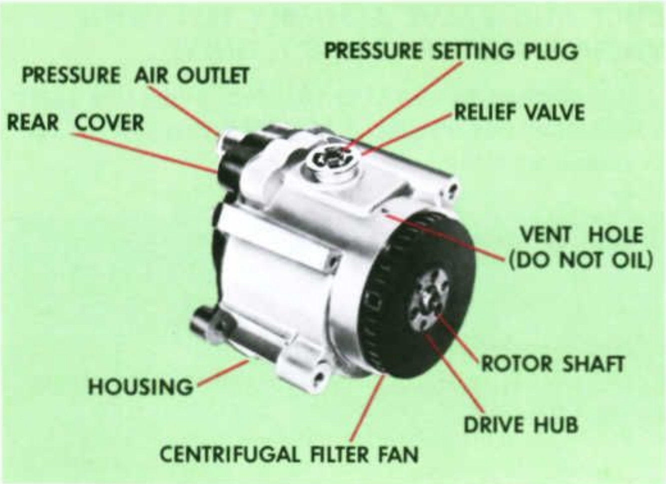


FIGURE 60. AIR SUPPLY PUMP (THERMACTOR SHOWN)

CENTRIFUGAL FILTER FAN REPLACEMENT

Use the following procedures to replace the air pump Centrifugal Filter Fan.

Loosen the air pump adjusting arm bolt and mounting bracket bolt to relieve drive belt tension.

Remove the drive pulley attaching bolts and pull the drive pulley off the air pump shaft.

Pry the outer disc loose and then pull off the centrifugal filter fan with slip joint pliers. (See Figure 61.) Care should be taken to prevent fragments from entering the air intake hole if the fan breaks during removal.

Do not attempt to remove the metal drive hub.

Install the new filter fan by drawing it into position, using the pulley and bolts as an installer. Draw the fan evenly by alternately tightening the bolts, making certain that the outer edge of the fan slips into the housing.

A slight amount of interference with the housing bore is normal. After a new fan is installed, it may squeal upon initial operation until its outer diameter sealing lip has worn in. This may require 20-30 miles of operation.

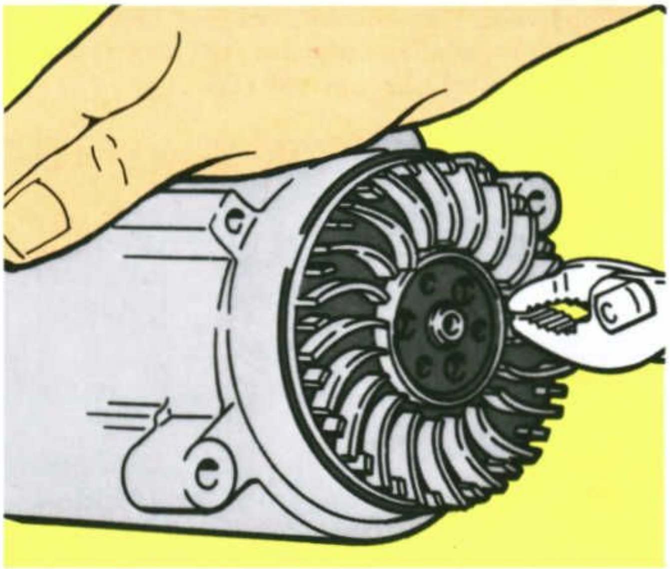


FIGURE 61. CENTRIFUGAL FILTER FAN REMOVAL

Air Intake System Service

The service of this system is not directly connected to the emission system and will not affect the vehicle's exhaust emission. However, the air intake system became necessary as a result of the leaner mixtures used to control hydrocarbon and carbon monoxide emissions and therefore, any malfunction will affect driveability. The service procedures will vary slightly according to vehicle make and model.

Only the Ford vehicle procedures will be outlined in detail. For other makes and models refer to the appropriate service manual.

DUCT AND VALVE ASSEMBLY TEST (WITHOUT OVERRIDE)

- With the duct assembly installed on the vehicle, cold engine, and ambient temperature in the engine compartment less than 100°F., the valve plate should be in the "heat-on" position. (Valve plate up.)
- If the plate is not in the "heat-on" position, check for interference of plate and duct which would cause the plate to hang up. If interference is present, correct by realigning the plate.
- Remove the duct and valve assembly from the vehicle, and immerse it in water so that the thermostat capsule is covered with water.
- Heat the water to 100°F., allow five minutes to stabilize the temperature; the valve should be in the "heat-on" position.
- Increase the water temperature to 135°F. and stabilize the temperature. The valve should now be in the "heat-off" position. (Valve plate down.)

- If the valve does not react to heat properly, and there is no interference noted, the duct and valve assembly should be replaced. (See Figure 62.)

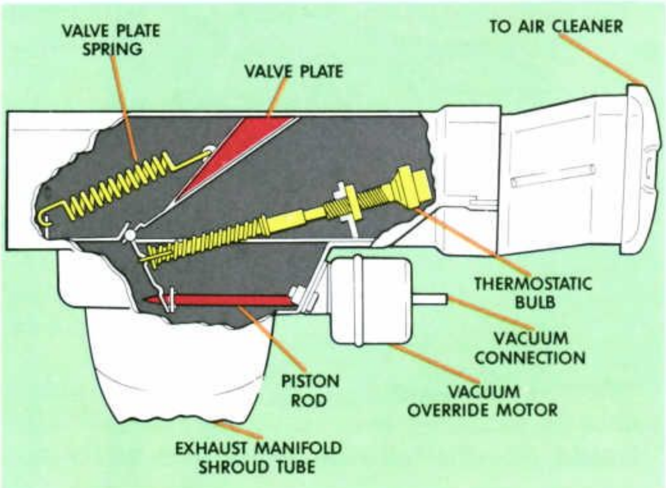


FIGURE 62. AIR INTAKE SYSTEM (68 FORD)

DUCT AND VALVE ASSEMBLY TEST (WITH OVERRIDE)

- With the duct assembly installed on the vehicle, cold engine, and ambient temperature in the engine compartment less than 100°F., the valve plate should be in approximately *one-half heat-on position.*
- If the plate is not in the above position, check for possible interference of plate, duct, and/or vacuum motor which would cause the plate to hang-up in its given travel. Correct by realigning the plate or vacuum motor as required.
- Start the engine, and observe the valve plate position while the engine is still cold. The correct position for the plate is in the full *heat-on* position. Align the plate or vacuum motor if interference is noted.
- If the valve plate remains in the *one-half heat-on* position remove the vacuum hose at the override vacuum motor and check for vacuum at the hose (minimum of 15 inches of Hg at idle).
- If the vacuum is less than 15 inches Hg., check for vacuum leaks in the hose and hose connection.
- When the vacuum meets specifications, reconnect the hose to the override motor and again with the underhood temperature less than 100°F., observe the valve plate position.
- If the plate still remains only in the *one-half heat-on position* and there is no interference between the valve plate, duct, or vacuum motor rod, the vacuum motor should then be removed and connected to another vacuum source.
- If the motor rod moves a minimum of ½ inch, the motor is functional and should be reassembled into the duct assembly. Checks for interference and misalignment and action of the thermostat bulb should be made. If the motor rod does not move a minimum of ½ inch, the vacuum motor is not functional and should be replaced.

DUCT AND VALVE ASSEMBLY TEST (WITH VACUUM MOTOR—390 G.T. ONLY)

- In addition to checking the duct and valve assembly, the vacuum motor should be checked for functional operation. (See Figure 63.)

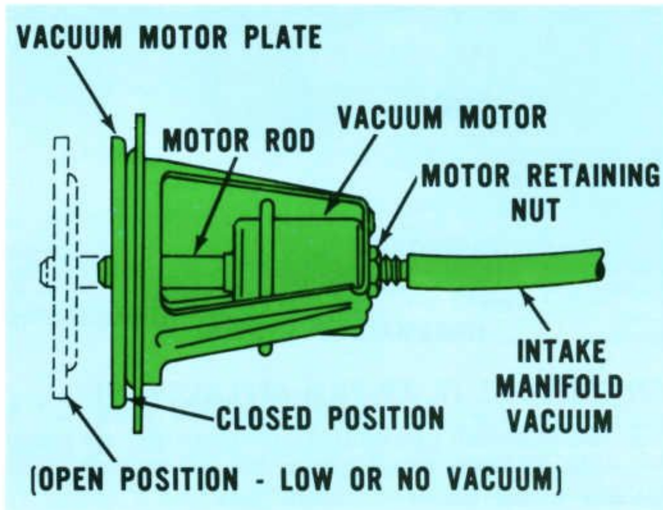


FIGURE 63. AIR VALVE AND VACUUM MOTOR ASSEMBLY

- Start the engine, and observe the vacuum motor plate. It should be fully closed.
- Disconnect the vacuum hose at the vacuum motor. The plate should be in the full-open position.
- If the positions as described, are not obtained, check for interference and alignment of the plate and motor rod, and check for vacuum from hose at the vacuum motor (minimum of 15 inches Hg). If vacuum is not available, check the hose and connection for leaks.
- If the vacuum motor plate still remains in one position, remove the vacuum motor from the air cleaner, connect it to another vacuum source to confirm that the vacuum motor is not operating. If the motor rod does not move when vacuum is applied, the vacuum motor is not functional and should be replaced.

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PERFORMANCE CHARACTERISTICS TO BE CHECKED AND/OR TESTED	PRE-TEST TROUBLE SYMPTOMS	TYPE OF TEST TO BE CONDUCTED	TEST RESULTS	SERVICE OPERATIONS INVOLVED (AS REQUIRED)
COMPRESSION	Rough idle, hard starting, hesitation or stumble, engine misses, poor economy and/or backfiring.	Check Compression with Compression Gauge	NORMAL Compression Gauge reading between cylinders even and within manufacturer's specifications.	NONE
			LOW Low and even in all cylinders.	Valve timing, piston rings.
			Low and even in two adjacent cylinders.	Cylinder head or head gasket.
			Difference between any two cylinders more than manufacturer's specifications.	Cylinder head or head gasket, piston or piston rings, valves.
			Reading above manufacturer's specifications for one or more cylinders.	Incorrect head, excessive carbon deposit in engine cylinders.
VACUUM	Rough idle, hard starting, hesitation or stumble, engine miss, engines crank but won't start, engine starts – then stalls. Loss of power.	Check manifold vacuum with vacuum gauge.	15" or above for 6-cyl. 17" or above on 8-cyl.	NONE
			LOW AND STEADY	Late ignition timing, valve timing. Low compression.
			VERY LOW	Intake manifold, carburetor, carburetor spacer or gaskets. Cylinder head or head gaskets.
			Needle fluctuates steadily as speed increases.	Leaking valve or valves, cylinder head or head gasket, manifold or manifold gasket, ignition system, weak valve spring.
			Gradual drop in reading at engine idle.	Excessive back pressure in exhaust system.
			Intermittent fluctuation.	Ignition system, sticking valve.
			Low fluctuation or drifting of needle.	Improper idle mixture, carburetor spacer or gaskets, intake manifold or gaskets, crankcase ventilation system restricted.

PERFORMANCE CHARACTERISTICS TO BE CHECKED AND/OR TESTED	PRE-TEST TROUBLE SYMPTOMS	TYPE OF TEST TO BE CONDUCTED	TEST RESULTS	SERVICE OPERATIONS INVOLVED (AS REQUIRED)
COOLING SYSTEM TEMPERATURE CONTROL	Loss of coolant, hard to start when hot, steam coming from radiator cap and over-flow, temperature gauge registers high.	Check engine temperature with thermometer.	Normal condition indicates number of degrees registered on thermometer plus 3° for every pound of pressure in cooling system. Result should be same as temperature of thermostat being used.	NONE
			Temperature higher than manufacturer's specifications for thermostat.	Radiator, hoses, heater core, engine block, cylinder head, thermostat, coolant, fan belt, water pump.
		Check system for leaks under pressure with pressure gauge.	Pressure falls below manufacturer's specifications, coolant leaking under pressure.	Radiator, hoses, heater core, engine block, cylinder head, gaskets, water pump.
		Check radiator cap under pressure with pressure gauge.	Over or under manufacturer's specifications.	Replace radiator cap.
		Test temperature with thermometer and add 3° to reading for every pound of pressure the cooling system is designed to operate at.	Temperature falls below manufacturer's specifications.	Thermostat, coolant level.
EXHAUST	Exhaust fumes in automobile, excessive noise.	Check exhaust system for leaks visually.	Leak in exhaust system.	Repair leak in exhaust system.
			▪ Tail or exhaust pipes.	▪ Repair or replace exhaust pipes.
			▪ Muffler or resonator.	▪ Repair or replace muffler or resonator.
			▪ Exhaust manifold.	▪ Repair exhaust manifold or replace manifold and/or gaskets.
			▪ Manifold control valve.	▪ Replace manifold control valve.

PERFORMANCE CHARACTERISTICS TO BE CHECKED AND/OR TESTED	PRE-TEST TROUBLE SYMPTOMS	TYPE OF TEST TO BE CONDUCTED	TEST RESULTS	SERVICE OPERATIONS INVOLVED (AS REQUIRED)
EXHAUST (Cont.)	Poor economy, rough idle, hesitation, burned valves.	Check vacuum using vacuum gauge.	Gradual drop in reading at idle indicates restriction.	Replace or clean defective part. Exhaust or tail pipes Muffler or resonator Exhaust manifold Manifold control valve.
BATTERY	Hard starting, won't start.	Check state of charge with hydrometer.	Below correct reading (battery discharged).	Defective Battery
				Defective Starting System Starter Cables
				Defective Charging System Alternator or generator Regulator Wiring
		Check battery with load tester.	Battery voltage won't stay above manufacturer's specifications for recommended period of time under load.	Battery state of charge too low to test. Charge and re-test.
				Battery defective.
	Battery gasing or uses excessive amount of water.	Check charging (voltage-amperage) with volt amp tester.	Output or voltage high.	Adjust or replace regulator. Eliminate circuit resistance.
IGNITION BY-PASS (SOLENOID TYPE)	Won't start, hard starting "false" starts.	Check voltage at battery side of coil when cranking engine.	Voltage below 9V. when cranking.	Defective solenoid
				Excessive voltage drop
				Open circuit
				Poor connection or wiring.
IGNITION BY-PASS (IGNITION SWITCH TYPE)	Won't start, hard starting "false" starts.	Check voltage at battery side of coil when cranking engine.	Voltage drop more than manufacturer's specifications.	Replace ignition switch.
				Repair wiring.
				Repair bad connection.

PERFORMANCE CHARACTERISTICS TO BE CHECKED AND/OR TESTED	PRE-TEST TROUBLE SYMPTOMS	TYPE OF TEST TO BE CONDUCTED	TEST RESULTS	SERVICE OPERATIONS INVOLVED (AS REQUIRED)
IGNITION SWITCH	Won't start, engine miss, "false" starts, hesitation.	Check voltage drop with voltmeter, thru ignition switch with key on and points closed.	Voltage drop higher than manufacturer's specifications.	Replace ignition switch.
				Replace ignition resistor or resistor wire.
				Repair bad connection or wiring.
PRIMARY RESISTANCE	Hard starting, won't run, engine miss, poor economy, loss of power.	Check voltage drop thru primary circuit with voltmeter.	Voltage drop higher than manufacturer's specifications.	Repair excessive voltage drop. Bad connection in primary wiring.
				Replace points and condenser.
				Replace primary lead.
				Replace coil.
				Replace ignition resistor or resistor wire.
SECONDARY RESISTANCE	Poor economy, hard starting, won't start, back-firing, engine missing, loss of power.	Check ignition with scope.	High required voltage, short spark line on one or more cylinders.	Repair or replace: Spark plugs Ignition wiring (secondary) Distributor cap
			High required voltage, short spark line on all cylinders.	Coil Coil wire Distributor cap Rotor Secondary wiring Spark plugs
		Check ignition wires with ohmmeter.	Over 7,000 ohms per ft. resistance.	Replace ignition wires, as needed.
IGNITION INITIAL TIMING	Poor economy, hard starting, back fire, engine miss, detonation, loss of power.	Check ignition timing with timing light and check dwell with dwell meter.	Timing not set at manufacturer's specifications.	Check and adjust point dwell to manufacturer's specification before adjusting ignition timing. Adjust timing by turning distributor.

PERFORMANCE CHARACTERISTICS TO BE CHECKED AND/OR TESTED	PRE-TEST TROUBLE SYMPTOMS	TYPE OF TEST TO BE CONDUCTED	TEST RESULTS	SERVICE OPERATIONS INVOLVED (AS REQUIRED)
ADVANCE CHARACTERISTICS				
CENTRIFUGAL	Poor economy, hesitation, loss of power.	Check timing advance with vacuum advance hoses disconnected at specified RPM, with timing advance tester.	Timing not advanced to manufacturer's specifications.	Adjust or repair: Centrifugal weights Centrifugal weight springs.
				Check distributor application.
VACUUM	Poor economy, hesitation, back fire, rough idle, loss of power.	Check timing advance at specified RPM using timing advance tester.	Timing not advanced according to specifications.	Adjust or replace vacuum advance unit.
				Check source of vacuum.
		Check vacuum at distributor with vacuum gauge.	Vacuum to distributor not equal to manufacturer's specifications.	Check carburetor vacuum, spark valve (6-cyl. FORD), vacuum leak between distributor and carburetor.
RETARD DIAPHRAGM	Excessive emission at idle.	Check timing at idle with all vacuum hoses connected.	Timing is retarded the correct number of degrees, according to manufacturer's specifications.	NONE
			Timing does not retard correct number of degrees.	Repair or replace the following: Vacuum leak between manifold and diaphragm Distributor vacuum control valve (temperature sensing valve) Vacuum hoses (improperly connected) Distributor (mechanical defect) Dual diaphragm

PERFORMANCE CHARACTERISTICS TO BE CHECKED AND/OR TESTED	PRE-TEST TROUBLE SYMPTOMS	TYPE OF TEST TO BE CONDUCTED	TEST RESULTS	SERVICE OPERATIONS INVOLVED (AS REQUIRED)
ADVANCE CHARACTERISTICS (cont.)		Remove hose from manifold side of vacuum control temperature sensing valve and measure vacuum present at hose.	Manifold vacuum below manufacturer's specifications.	Repair or replace one or both of the following – Vacuum source; Vacuum leak between valve and source of vacuum.
DISTRIBUTOR VACUUM CONTROL (TEMPERATURE SENSING) VALVE	Rough idle, engine overheats, engine dies after prolonged idle conditions, engine idles fast.	With hose reconnected to manifold side of vacuum control temperature sensing valve, remove hose at distributor side of valve and connect a vacuum gauge to the valve. Accelerate engine and read vacuum.	Vacuum doesn't register when engine speed is increased.	Repair vacuum leak between valve and carburetor distributor port.
				Replace vacuum control temperature sensing valve.
		With vacuum gauge connected to distributor side of vacuum control temperature sensing valve, bring engine temperature up above manufacturer's specifications by disconnecting the fan belt or blocking ventilation to radiator with a piece of cardboard. Use thermometer to determine when temperature is above specifications.	Vacuum at distributor side of valve below manifold vacuum when temperature of valve is above manufacturer's specifications.	Replace vacuum control temperature sensing valve.
VACUUM ADVANCE CONTROL (DECELERATION) VALVE	Popping in exhaust under deceleration conditions.	Check vacuum at distributor under deceleration conditions. Insert tee in vacuum line at distributor, connect vacuum gauge.	Vacuum equals or exceeds manufacturer's specifications under deceleration conditions for correct amount of time.	NONE
			Vacuum is below manufacturer's specifications under deceleration conditions.	Vacuum leak from distributor to deceleration valve.
				Low vacuum at manifold side of deceleration valve.
				Vacuum source too low.
				Vacuum leak from source to deceleration valve.
				Deceleration valve.

PERFORMANCE CHARACTERISTICS TO BE CHECKED AND/OR TESTED	PRE-TEST TROUBLE SYMPTOMS	TYPE OF TEST TO BE CONDUCTED	TEST RESULTS	SERVICE OPERATIONS INVOLVED (AS REQUIRED)
EXHAUST EMISSION	Excessive emissions in exhaust.	Check belt tension with gauge.	Results of test not within manufacturer's specifications.	Tighten or replace belt.
AIR PUMP		Remove outlet hoses from pump, accelerate engine to 1500 RPM. Check for air flow from pump.	Air flow doesn't increase with engine speed.	Replace pressure relief valve.
				Replace air pump.
BY-PASS VALVE	Engine backfires on deceleration.	Check all hoses and connections for leaks.	Hoses cracked and leaking, connections are bad.	Replace hoses or repair connections.
		Disconnect vacuum hose at by-pass valve and connect vacuum gauge to hose. Observe reading at idle.	Below normal vacuum.	Repair source of vacuum to by-pass valve.
		Reconnect hoses and stabilize engine speed to idle. Check air flow from valve.	Air escapes from muffler on by-pass valve.	Replace by-pass valve.
		Accelerate engine by quickly opening and closing throttle valve. Check air flow at muffler on by-pass valve.	No momentary blast of air escaping through muffler on by-pass valve for at least one second.	Replace by-pass valve.
CHECK VALVE	Exhaust gases in air pump.	Disconnect hose from by-pass at check valve with engine running, check for exhaust fumes escaping from valve.	Exhaust fumes escaping from check valve.	Replace check valve.
		With hose disconnected and observing valve, position screwdriver in check valve and force valve off from seat several times. Check for valve seating properly when returning to seat.	Exhaust gases continue to flow from valve after check has returned to seat.	Replace check valve.

APPENDIX II

1968 FORD MOTOR COMPANY VEHICLES

CARBURETOR APPLICATIONS

PASSENGER CAR

VEHICLE	ENGINES	CARBURETOR TYPE	CARBURETOR PART NUMBER (9510)*		
			THERMACTOR		IMCO
			Automatic Transmission	Manual-Shift Transmission	Automatic Transmission
Falcon	170 Six	Carter YF 1-V		C8DF-A	C8DF-B
Falcon, Fairlane, Montego, Mustang, Cougar	200 Six	Autolite 1100 1-V		C8OF-A	C8OF-B
Ford, Taxi	240 Six	Carter YF 1-V		C8AF-V	
		Autolite 1101 1-V			C8AF-E
Fairlane, Falcon, Mustang	289 V-8	Autolite 2100 2-V		C8AF-AK	C8ZF-G
Mustang	289 V-8 High Performance	Autolite 4100 4-V	C8ZF-K	C8ZF-J	
Fairlane, Montego, Cougar	302 V-8	Autolite 2100 2-V			C8ZF-G
Ford, Fairlane, Montego, Cougar		Autolite 2100 2-V		C8AF-AK	
Ford		Autolite 2100 2-V			C8AF-L
Falcon, Montego, Mustang, Cougar		Autolite 4300 4-V		C8ZF-C	C8ZF-D
Ford, Mercury, Fairlane, Montego, Cougar	390 V-8	Autolite 2100 2-V		C8AF-M	
Fairlane, Montego, Cougar		Autolite 2100 2-V			C8OF-U
Ford, Mercury		Autolite 2100 2-V			C8AF-AN
Mercury	390 V-8 Premium Fuel	Autolite 2100 2-V			C8AF-N
Cougar		Autolite 2100 2-V			C8OF-K
Fairlane, Montego, Cougar, Mustang	390 V-8 GT	Holley 4150C 4-V	C8OF-D	C8OF-C	
Ford, Mercury	390 V-8	Autolite 4300 4-V		C8AF-A	
Ford, Mercury, T-Bird		Autolite 4300 4-V			C8AF-B
Fairlane, Montego, Cougar, Mustang	427 V-8	Holley 4150C 4-V	C8AF-AD		
Ford, Mercury	428 V-8	Autolite 4300 4-V		C8AF-A	C8AF-B
Ford, Mercury Police		Autolite 4100 4-V	C8AF-AE		
T-Bird	429 V-8	Autolite 4300 4-V			C8SF-E
Lincoln	462 V-8	Carter AFB 4-V			C8VF-E

LIGHT TRUCKS (Under 6000 Lbs. G.V.W.)

VEHICLE	ENGINES	CARBURETOR TYPE	CARBURETOR PART NUMBER (9510)*		
			THERMACTOR		IMCO
			Automatic Transmission	Manual-Shift Transmission	Automatic Transmission
Bronco, Econoline	170 Six	Carter YF 1-V		C8TF-A	
Econoline, F-100	240 Six	Carter YF 1-V		C8UF-G	
		Autolite 1101 1-V			C8TF-C
Bronco, Econoline	289 V-8	Autolite 2100 2-V		C8TF-AA	
F-100	300 Six	Autolite 1101 1-V		C8TF-E	C8TF-F
F-100 4 x 4		Autolite 1101 1-V		C8TF-G	
F-100	360 V-8	Autolite 2100 2-V		C8TF-AB	C8TF-AE
F-100	390 V-8	Autolite 2100 2-V		C8TF-AD	C8TF-AE

*The basic part number of all the carburetors is 9510. The part number prefix and suffix appears on the identification tag mounted on the carburetor.

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

AUTOLITE MODEL CARBURETOR	PART NUMBER	MAIN METERING JET				POWER VALVE COLOR		CHOKE SPRING IDENT.
		NORMAL		ALTITUDE				
		Pri	Sec	Pri	Sec	Normal	Altitude	
1100	C8OF-A	60F	—	58F	—	①	—	TS
	C8OF-B	60F	—	62F	—	①	—	TP
1101	C8AF-E	70F	—	68F	—	①	—	AR
	C8TF-C	67F	—	65F	—	①	—	—
	C8TF-E	69F	—	67F	—	①	—	—
	C8TF-F	68F	—	66F	—	①	—	—
	C8TF-G	68F	—	66F	—	①	—	—
2100	C8AF-L	48F	—	46F	—	Black	—	TT
	C8AF-M	56F	—	54F	—	Plain	—	TN
	C8AF-N	55F	—	53F	—	Plain	—	TW
	C8AF-AK	48F	—	46F	—	Green	—	TO
	C8AF-AN	55F	—	53F	—	Plain	—	TW
	C8OF-K	55F	—	53F	—	Plain	—	TW
	C8OF-U	49F	—	47F	—	Green	—	—
	C8TF-AA	44F	—	42F	—	Plain	—	—
	C8TF-AB	56F	—	54F	—	Plain	—	—
	C8TF-AD	56F	—	54F	—	Plain	—	—
	C8TF-AE	55F	—	53F	—	Plain	—	—
	C8ZF-G	48F	—	46F	—	Black	—	TT
4100	C8AF-AE	51F	71F	49F	69F	Plain	Green	TU
	C8ZF-J	51F	69F	49F	67F	Plain	—	—
	C8ZF-K	50F	70F	48F	68F	Plain	—	—
4300	C8AF-A	48F	—	46F	—	—	—	EY
	C8AF-B	46F	—	44F	—	—	—	EN
	C8SF-E	64F	—	62F	—	—	—	DY
	C8ZF-C	49F	—	47F	—	—	—	EY
	C8ZF-D	48F	—	46F	—	—	—	EX
CARTER MODEL								
YF	C8AF-V	0.104	—	—	—	—	—	T
	C8DF-B	0.095	—	—	—	—	—	AS
	C8DF-A	0.095	—	—	—	—	—	AS
	C8TF-A	0.095	—	—	—	—	—	—
	C8UF-G	0.104	—	—	—	—	—	—
AFB	C8VF-E	0.0945	0.081	—	—	—	—	RK
HOLLEY MODEL								
4150C	C8AF-AD	66	72	64	70	85	—	—
	C8OF-C	66	71	64	69	85	—	GT1
	C8OF-D	65	71	63	69	85	—	GTA

① Gradient Type.

*All Carburetors are numbered 9510; only number prefix and suffix listed in column.

1968 FORD MOTOR COMPANY VEHICLES

(MAINTENANCE RELATED TO EXHAUST EMISSION CONTROL SYSTEMS)

6 MONTH OR 6000 MILE RECOMMENDED SERVICE INTERVAL

Change engine oil and filter.
Clean crankcase oil filler breather cap(s).
Test crankcase ventilation system. Clean system & replace PCV Regulator valve if necessary.
Check exhaust control valve for free operation (if so equipped).
Check tension of drive belts and adjust—if required.

12 MONTH OR 12,000 MILE RECOMMENDED SERVICE INTERVAL

Replace fuel system filter.
Replace air cleaner filter.
Clean crankcase, ventilation system hoses, tubes, fittings, carburetor spacer and replace as necessary. Replace PCV regulator valve.
Check and adjust distributor points—replace as required.
Check and adjust carburetor idle speed, fuel mixture.
Clean external choke linkage.
Check and adjust ignition timing—initial timing mechanical and vacuum advance and vacuum retard (if so equipped).
Inspect ignition wiring (secondary) for proper installation and condition.
Inspect, clean, adjust and test spark plugs—replace as required.
Inspect fuel lines and filter for leaks.
Torque intake manifold bolts to specifications (8-cyl. only).
Inspect cooling system hoses for deterioration, leaks and loose hose clamps. Repair and replace as required.
Adjust mechanical valve lash where applicable.
Inspect Thermactor exhaust emission system hoses and replace if required.

24 MONTH RECOMMENDED SERVICE INTERVAL

Replace engine coolant.

NOTE: Recommended service interval is for normal driving. When vehicle is driven under severe conditions, all service should be more frequent.

APPLICATION	ENGINE AND CARBURETOR (3)								IGNITION SYSTEM (4)						
PASSENGER CARS	CURB IDLE RPM (1) EXHAUST EMISSION			FAST (COLD) IDLE PRM EXHAUST EMISSION			IDLE AIR-FUEL RATIO		INITIAL IGN. TIMING EXHAUST EMISSION			DWELL ANGLE AT IDLE SPEED		DISTRIBUTOR POINT GAP	
	Imco	Thermactor		Imco	Thermactor				Imco	Thermactor					
	Auto. Trans.	Auto. Trans.	Std. Trans.	Auto. Trans.	Auto. Trans.	Std. Trans.	Imco	Therm-actor	Auto. Trans.	Auto. Trans.	Std. Trans.	Imco	Therm-actor	Imco	Therm-actor
170 Six (1-V)	550		700				14.2	14.0	6° BTC		6° BTC	35°-40°	35°-40°	0.027	0.027
200 Six (1-V)	550 (2)		700	1500		1400	14.2	14.0	6° BTC		6° BTC	35°-40°	35°-40°	0.027	0.027
240 Six (1-V)	500		600	1600			14.2	13.8	6° BTC		6° BTC	35°-40°	35°-40°	0.027	0.027
289 V-8 (2-V)	550		625	1400		1200	13.8	14.2	6° BTC		6° BTC	24°-29°	24°-29°	0.021	0.021
289 V-8 (4-V) H.P.		650	750		1400	1400		14.2		6° BTC	6° BTC		30°-33°		0.020
302 V-8 (2-V)	550 (2)		625	1400		1200	13.8	14.2	6° BTC		6° BTC	24°-29°	24°-29°	0.021	0.021
302 V-8 (4-V)	550		625	1400		1250	14.4	14.2	6° BTC		6° BTC	26°-31°	24°-29°	0.017	0.021
390 V-8 (2-V)	550		625	1500		1300	14.7	13.8	6° BTC		6° BTC	26°-31°	24°-29°	0.017	0.021
390 V-8 (2-V) Prem. Fuel	550			1500			14.7		6° BTC			24°-29°		0.021	
390 V-8 (4-V)	550		625	1400		1300	14.4	13.2	6° BTC		6° BTC	26°-31°	24°-29°	0.017	0.021
390 V-8 (4-V) G.T.		550	700		2100	1900		13.2		6° BTC	6° BTC		26°-31°		0.016
427 V-8 (4-V)		600			2100			13.2		6° BTC			26°-31°		0.017
428 V-8 (4-V)	550		625	1400		1300	14.4	13.2	6° BTC		6° BTC	26°-31°	24°-29°	0.017	0.021
428 V-8 (4-V) Police		600			1350			13.2		6° BTC			26°-31°		0.017
429 V-8 (4-V)	550			1500			14.4		6° BTC			26°-31°		0.017	
462 V-8 (4-V)	550			1600			14.4		10° BTC			26°-31°		0.017	
Bronco, Econoline & Light Trucks															
170 Six (1-V)			700					14.0			6° BTC		35°-40°		0.027
240 Six (1-V)	500		600	2700			14.2	13.8	6° BTC		6° BTC	35°-40°	35°-40°	0.027	0.027
289 V-8 (2-V)			625			1200	13.8	14.2			6° BTC		24°-29°		0.021
300 Six (1-V)	500		600	2700		2700	14.2	13.8	6° BTC		6° BTC	35°-40°	35°-40°	0.027	0.027
360 V-8 (2-V)	550		625	1400		1200	14.7	13.8	6° BTC		6° BTC	24°-29°	24°-29°	0.021	0.021
390 V-8 (2-V)	550		625	1400		1200	14.7	13.8	6° BTC		6° BTC	24°-29°	24°-29°	0.021	0.021

TORQUE LIMITS—FT-LBS

Distributor Vacuum Control Valve (Temperature Sensing)	15-18
Thermactor Air Manifold to Cylinder Head	14-16
Thermactor Check Valve to Air Manifold or Supply Tube	16-19
Thermactor Air Pump Adjusting Arm Bolt	15-20
Thermactor Air Pump Drive Pulley to Pump Hub	7-11
Thermactor Air Pump Mounting Bolts	23-28

NOTES

(1) Adjust With Headlights On, Automatic Transmission in Drive, And A/C in Max. Cooling Position.

(2) Adjust With A/C Off.

(3) Belt Tension (All) (Ft.-Lbs.):
New—140 Used—110

(4) Spark Plug Gap (All) (Inch)—0.032-0.036

ENGINE	ANTI-STALL DASHPOT CLEARANCE		AUTOMATIC CHOKE SETTING		CHOKE PLATE CLEARANCE		ACCELERATOR PUMP SETTING ⑥				FUEL BOWL VENT VALVE CLEAR-ANCE
							Pump Link		Throttle Lever		
	Imco	Therm-actor	Imco	Therm-actor	Imco	Therm-actor	Imco	Therm-actor	Imco	Therm-actor	
170 Six (1-V)	0.100	0.100	1-Lean	Index	0.280	0.280	No Adj.	No Adj.	No Adj.	No Adj.	—
200 Six (1-V)	2 ①	2 ①	1-Lean	2-Lean	0.234	0.234	Hi ②	Hi ②	0.190 ③	0.190 ③	—
240 Six (1-V)	0.080	0.100	3-Lean	Index	0.234	0.280	Hi ②	No Adj.	0.190 ③	No Adj.	—
289 V-8 (2-V)	0.125	0.125	1-Lean	Index	0.060	0.060	Inboard	Inboard	#2 Hole	#2 Hole	0.070
289 V-8 (4-V) H.P.		0.062		—		—		Inboard		#2 Hole	7/64
302 V-8 (2-V)	0.125	0.125	1-Lean	Index	0.060	0.060	Inboard	Inboard	#2 Hole	#2 Hole	0.070
302 V-8 (4-V)	0.093	0.062	Index	Index	0.300	0.300	#1 Hole	#2 Hole	—	—	0.070
390 V-8 (2-V)	0.125	0.125	Index	Index	0.060	0.060	Inboard	Inboard	#3 Hole	#3 Hole	0.070
390 V-8 (2-V) Prem. Fuel	0.125		Index		0.060		Inboard		#3 Hole		0.070
390 V-8 (4-V)	0.093	0.093	2-Rich	1-Rich	0.300	0.300	#3 Hole	#3 Hole	—	—	0.070
390 V-8 (4-V) G.T.		0.100		3-Rich		0.300				#1④#2⑤	0.070
427 V-8 (4-V)		0.100		—		0.300		—			0.070
428 V-8 (4-V)	0.093	0.093	2-Rich	1-Rich	0.300	0.300	#3 Hole	#3 Hole	—	—	0.070
428 V-8 (4-V) Police		0.109		2-Rich		0.060		Inboard		#3 Hole	7/64
429 V-8 (4-V)	0.093		1-Rich		0.300		#2 Hole				0.070
462 V-8 (4-V)	0.171		Index		0.096		Top				—
Bronco, Econoline & Light Truck Engines											
170 Six (1-V)	—	0.100	—	—	—	0.280	—	No Adj.	—	No Adj.	—
240 Six (1-V)	0.100	0.100	—	—	—	0.280	Hi ②	No Adj.	0.220 ③	No Adj.	—
289 V-8 (2-V)	0.125	0.125	—	—	0.250	0.250	Inboard	Inboard	#2 Hole	#2 Hole	0.070
300 Six (1-V)	0.100	0.100	—	—	—	—	Hi ②	Hi ②	0.220 ③	0.220	—
360 V-8 (2-V)	0.125	0.125	—	—	0.150	—	Inboard	Inboard	#3 Hole	#3 Hole	0.070
390 V-8 (2-V)	0.125	0.125	—	—	0.150	—	Inboard	Inboard	#3 Hole	#3 Hole	0.070

① Turns in after contact.

② Install 3/32-inch diameter roll pin in Hi position for adjustment purposes.

③ Clearance adjustment between roll pin and pump cover after note ② is performed. Remove the roll pin.

④ Manual-shift transmission.

⑤ Automatic transmission.

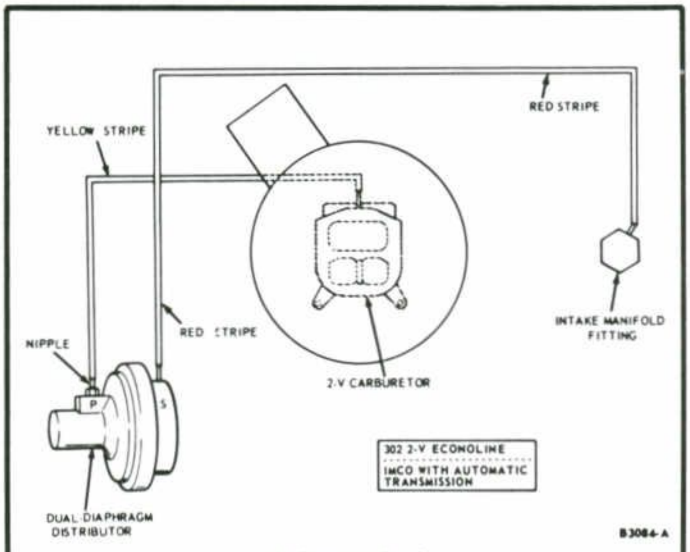
⑥ Accelerator pump stem height on Autolite Model 4300 (4-V)—302, 390 & 428 V-8—7/16 inch—429 V-8—5/16 inch.

The specifications found in this manual were in effect at the time the publication was approved for printing. The Autolite-Ford Parts Division of Ford Motor Company reserves the right to alter its product line at any time, or change specifications or design without notice and without incurring obligation.

APPENDIX III
DISTRIBUTOR VACUUM SYSTEM SCHEMATICS
INDEX

SCHEMATIC Description	SCHEMATIC Number	Page
IMCO WITH AUTOMATIC TRANSMISSION		
302 2-V Econoline	1	
IMCO WITH AUTOMATIC TRANSMISSION—A/C AND NON-A/C		
302 4-V Cougar, Falcon, Montego, Mustang	2	57
360 2-V F-100 Truck	3	
390 2-V F-100 Truck	3	
390 2-V Fairlane, Ford, Mercury, Montego	4	
390 4-V Ford, Mercury, Thunderbird	4	
428 4-V Ford, Mercury	4	
429 4-V Thunderbird	5	
462 4-V Lincoln	6	
IMCO WITH AUTOMATIC TRANSMISSION AND A/C		
289 2-V Falcon, Mustang	7	
302 2-V Cougar, Fairlane, Montego	7	
302 2-V Ford (including Police and Taxi)	8	
390 2-V Mercury (Premium Fuel)	9	
390 2-V Cougar (Premium Fuel)	10	58
IMCO WITH AUTOMATIC TRANSMISSION—NON-A/C		
170 1-V Cougar, Fairlane, Falcon, Montego, Mustang	11	
200 1-V Cougar, Fairlane, Falcon, Montego, Mustang	11	
289 2-V Falcon, Mustang	12	
302 2-V Cougar, Fairlane, Montego	12	
302 2-V Ford (including Police and Taxi)	13	
390 2-V Mercury (Premium Fuel)	14	
THERMACTOR WITH MANUAL-SHIFT TRANSMISSION		59
170 1-V Falcon	15	
170 1-V Bronco, Econoline	16	
200 1-V Cougar, Fairlane, Falcon, Montego, Mustang	17	
240 1-V Ford, Econoline, F-100 Truck	18	
289 2-V Bronco	19	60
302 2-V Econoline	19	

SCHEMATIC Description	SCHEMATIC Number	Page
300 1-V F-100 Truck	20	
390 2-V Fairlane, Ford, Mercury, Montego	21	
390 4-V Ford	21	
428 4-V Ford, Mercury (except Police)	21	
THERMACTOR WITH MANUAL-SHIFT TRANSMISSION AND GOVERNOR		
360 2-V F-100 Truck	22	
390 2-V F-100 Truck	22	60
THERMACTOR WITH MANUAL-SHIFT TRANSMISSION, WITHOUT GOVERNOR		
360 2-V F-100 Truck	23	
390 2-V F-100 Truck	23	
THERMACTOR WITH MANUAL-SHIFT TRANSMISSION—A/C AND NON-A/C		
289 2-V Falcon, Mustang	24	
302 2-V Cougar, Fairlane, Montego	24	
302 4-V Cougar, Falcon, Montego, Mustang	24	
390 GT and 4-V Cougar, Fairlane, Montego, Mustang	25	
THERMACTOR WITH MANUAL-SHIFT TRANSMISSION AND A/C		
302 2-V Ford (including Police and Taxi)	26	
THERMACTOR WITH MANUAL-SHIFT TRANSMISSION—NON-A/C		
302 2-V Ford (including Police and Taxi)	27	
THERMACTOR WITH AUTOMATIC TRANSMISSION—A/C AND NON-A/C		61
428 4-V Ford, Mercury Police Interceptor	28	
THERMACTOR WITH AUTOMATIC TRANSMISSION—NON-A/C		
390 GT 4-V Cougar, Fairlane, Montego, Mustang	29	
427 4-V Cougar, Ford, Montego, Mustang	30	



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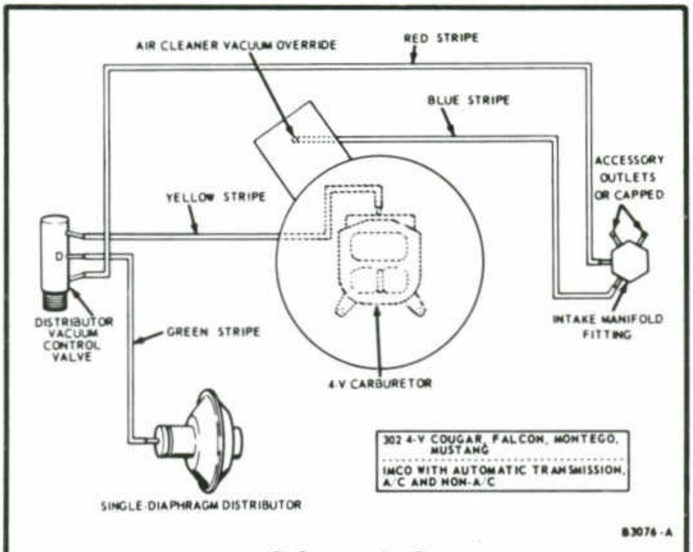

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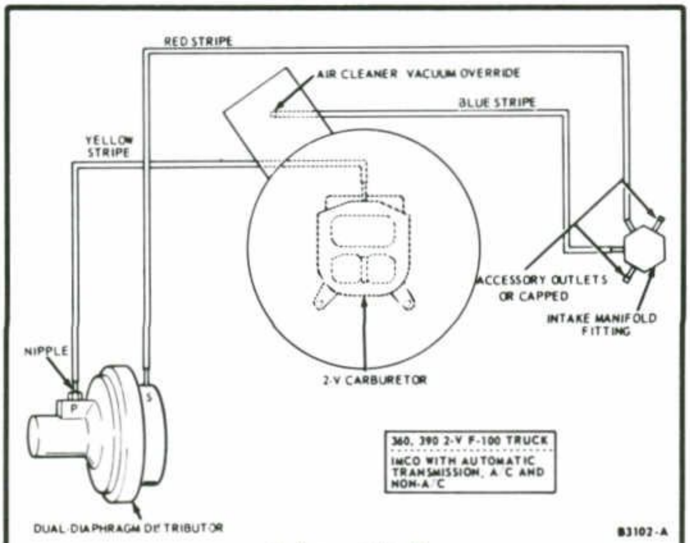

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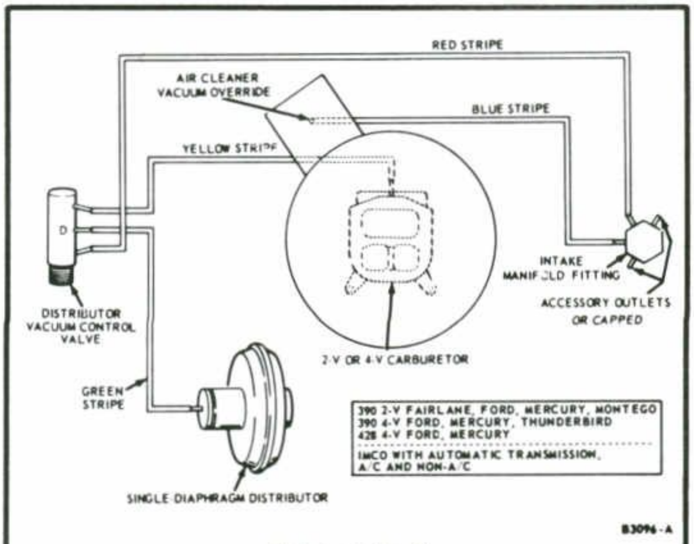

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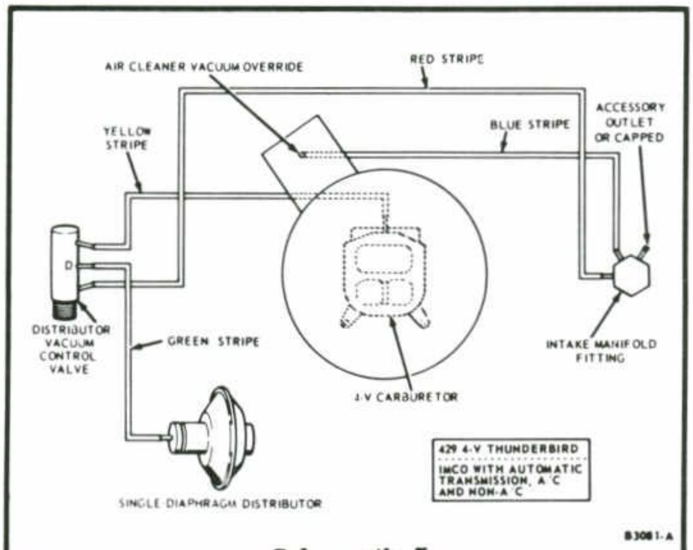

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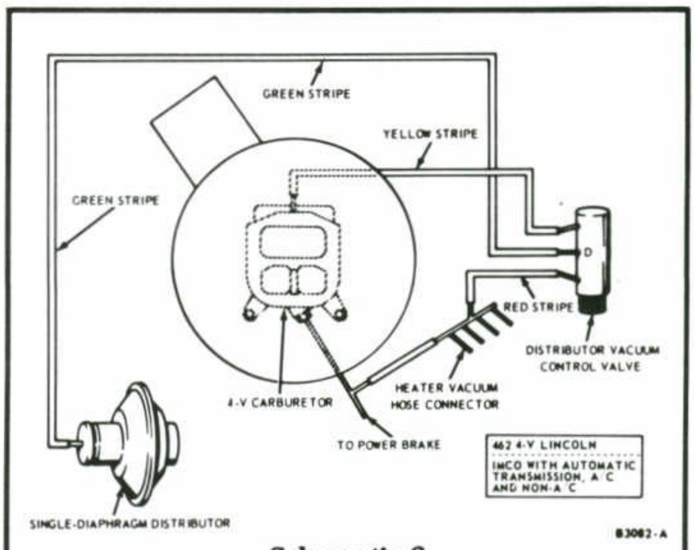

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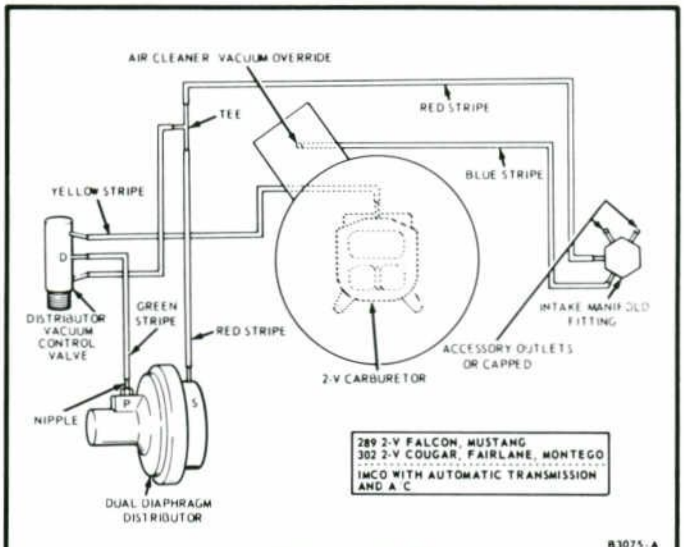

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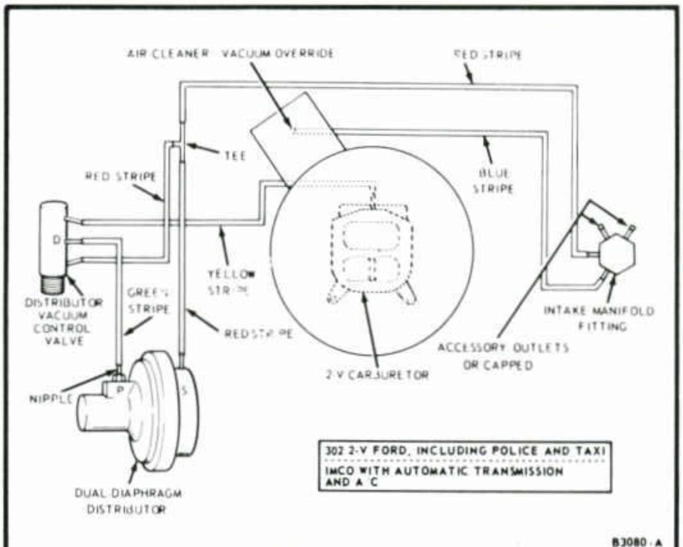

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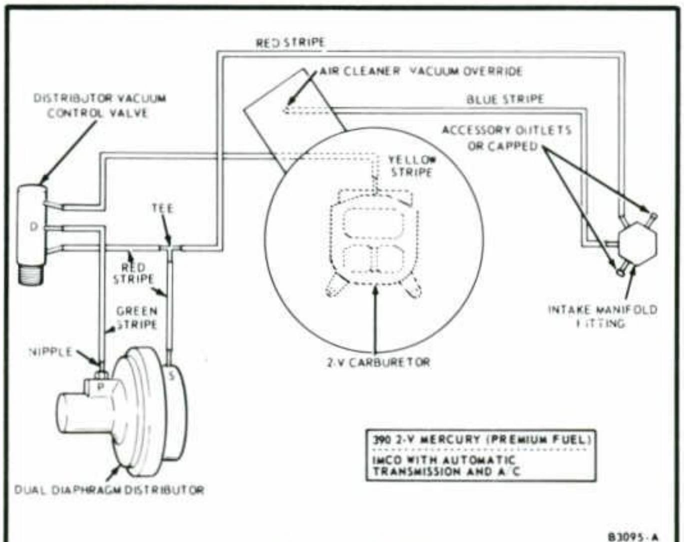

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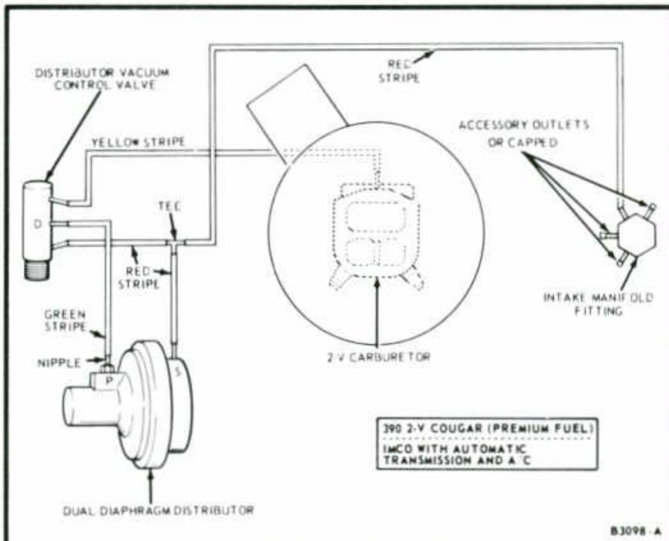

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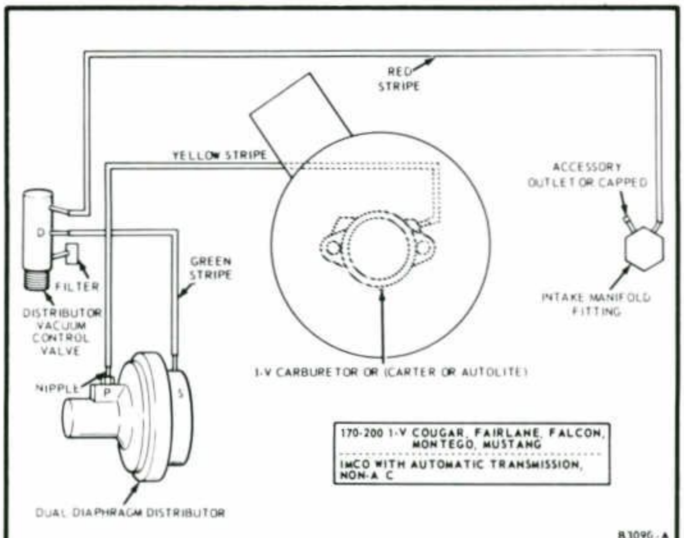

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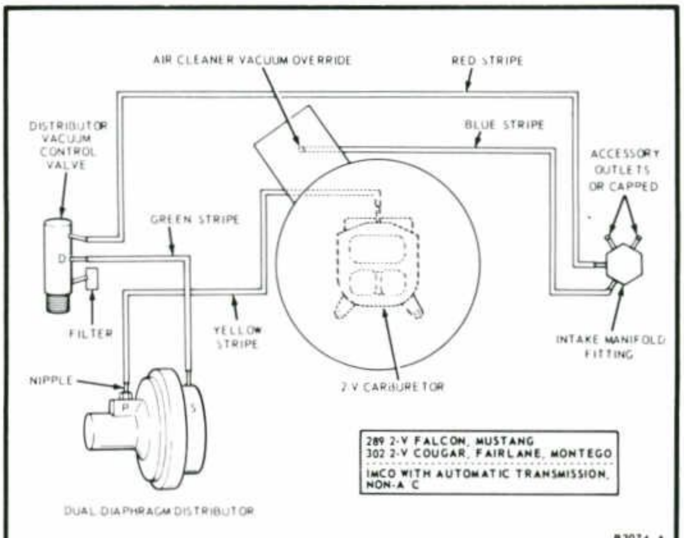

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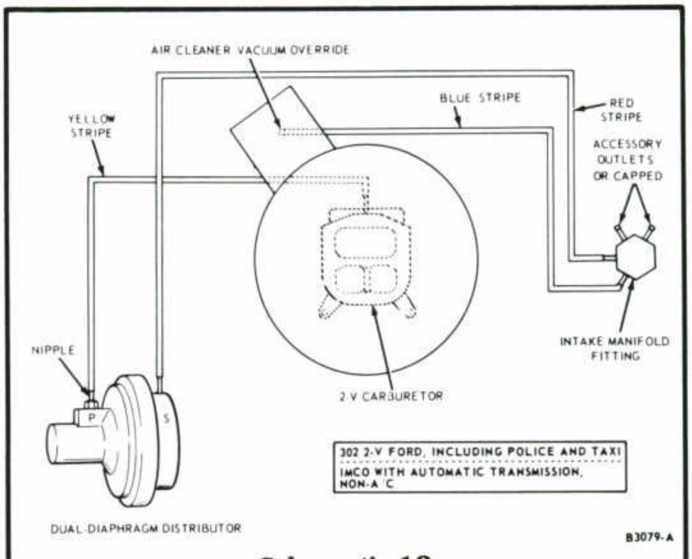

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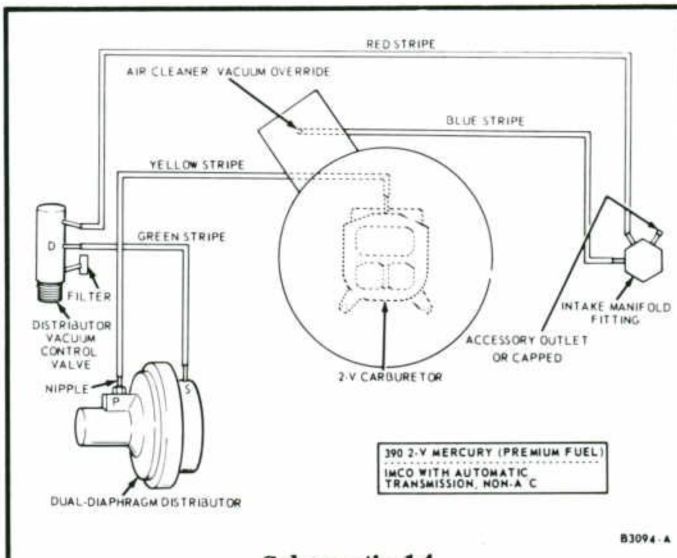

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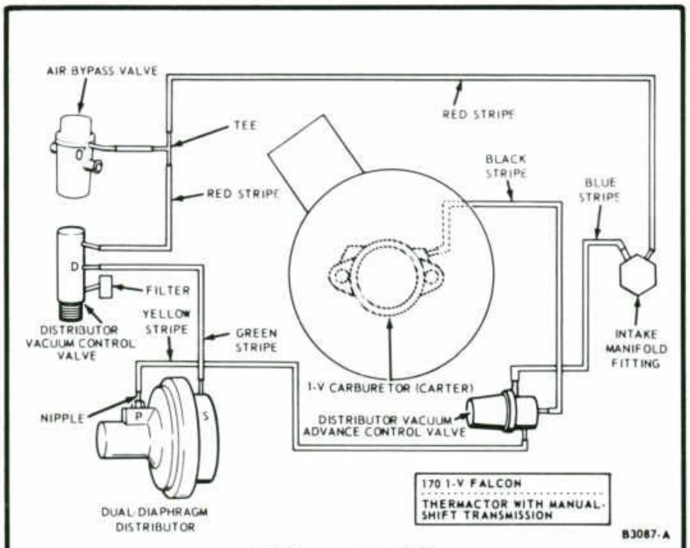

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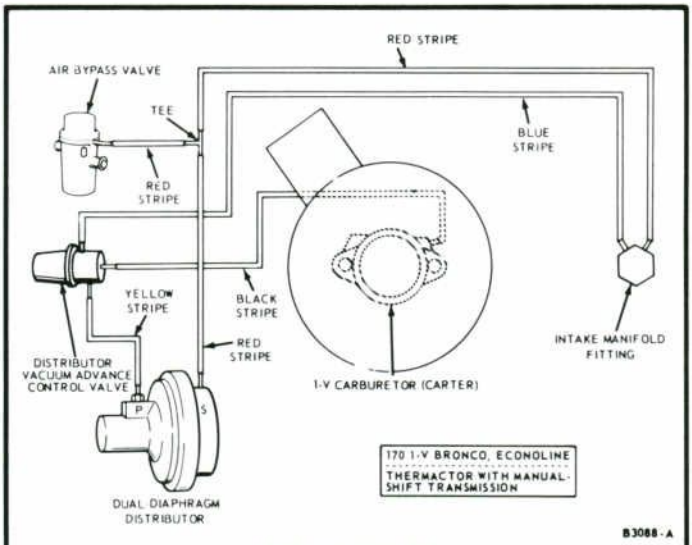

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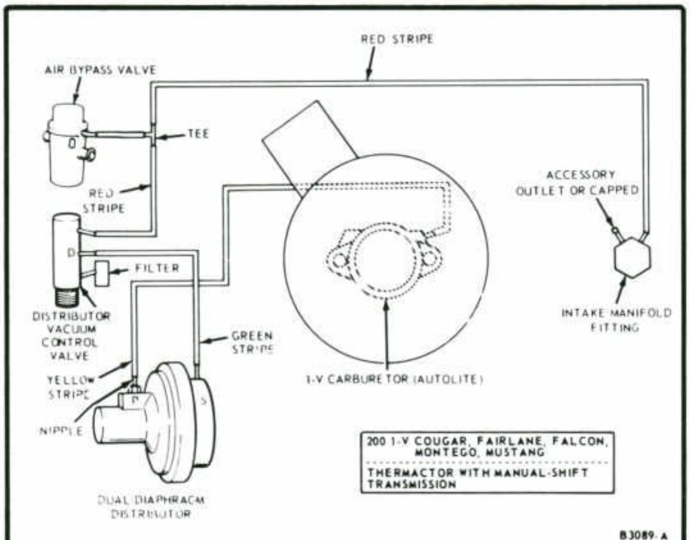

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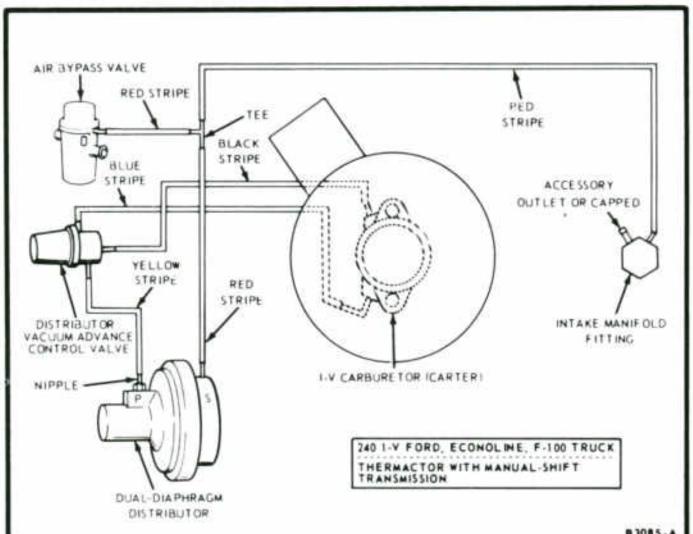

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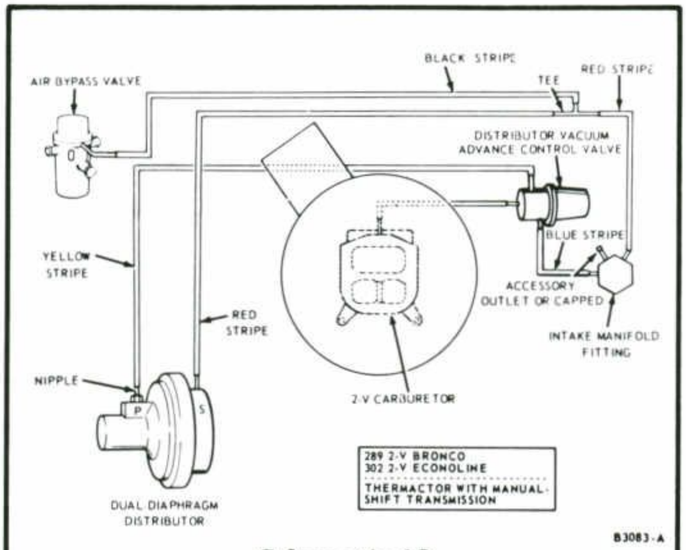

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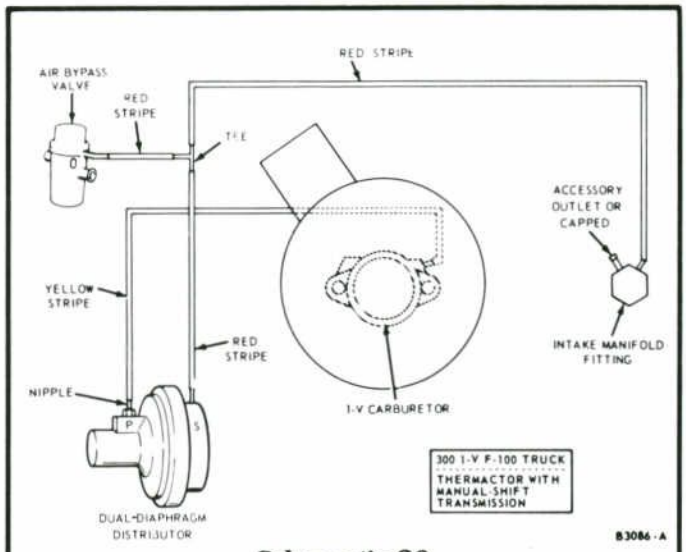

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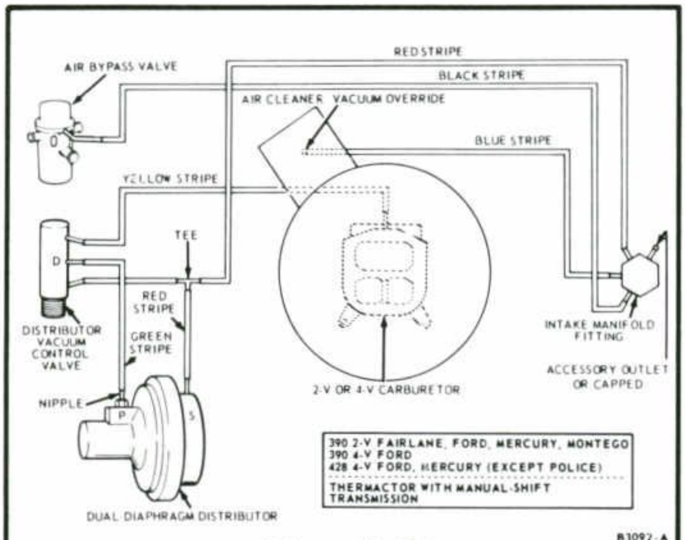

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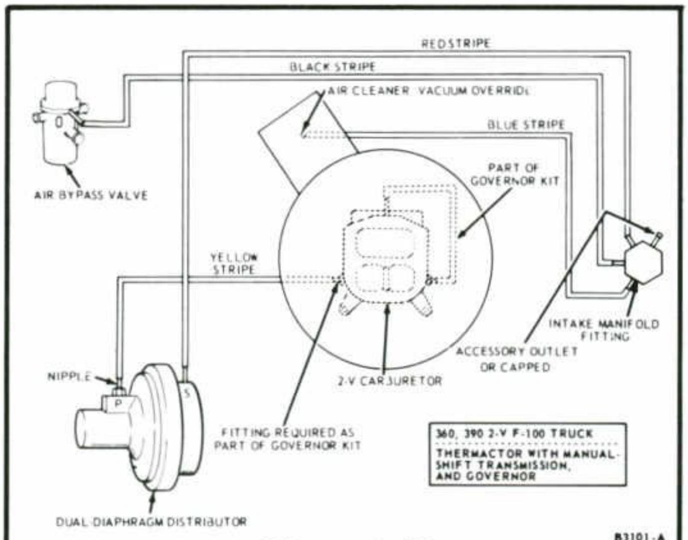

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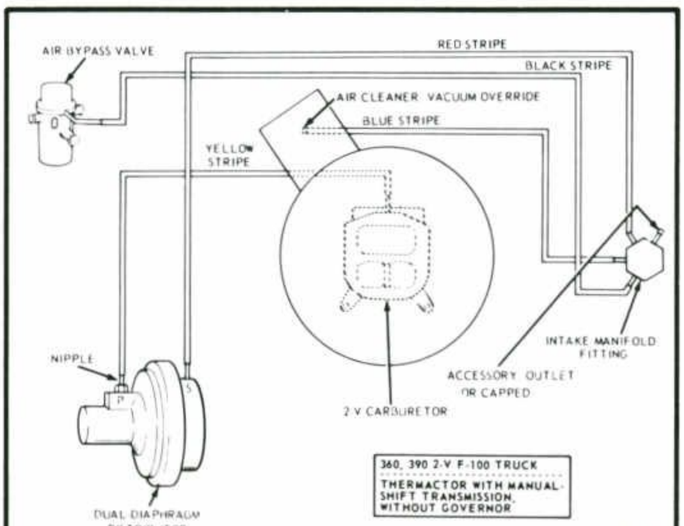

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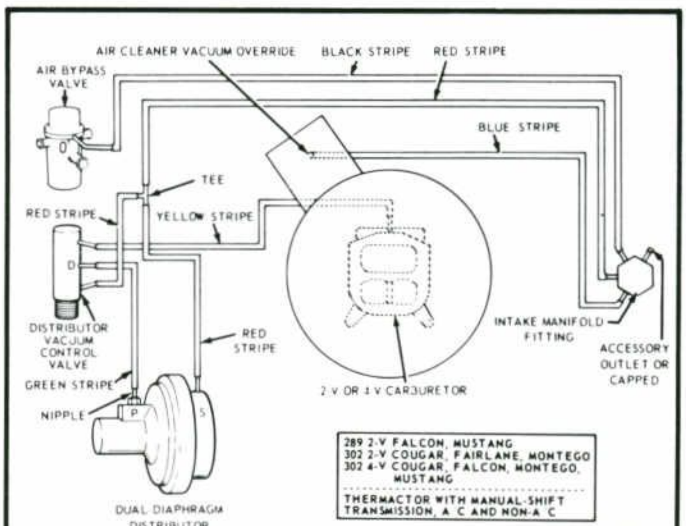

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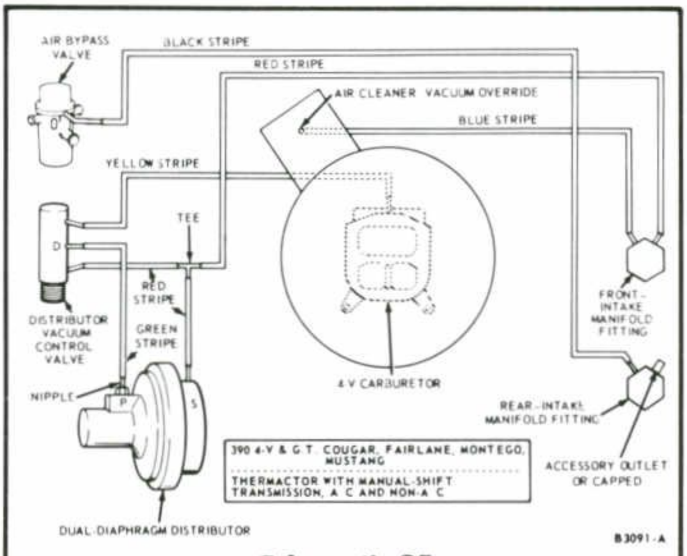

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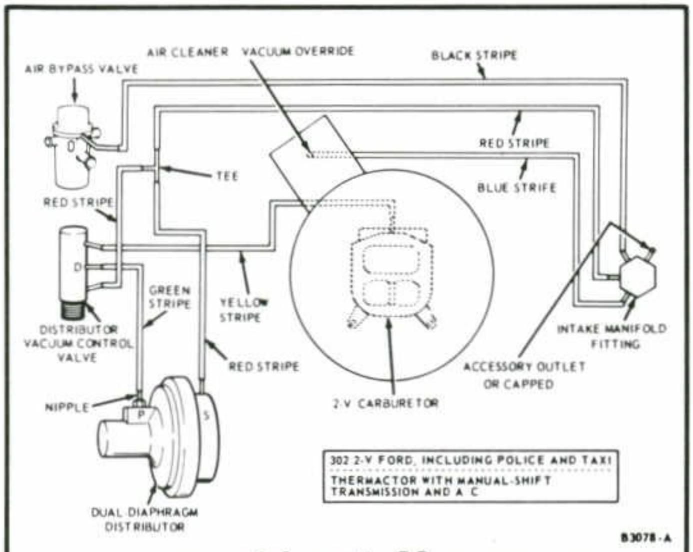

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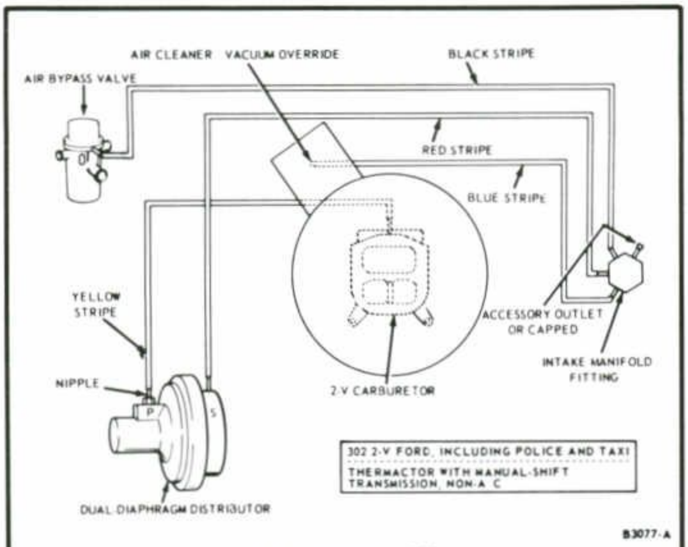

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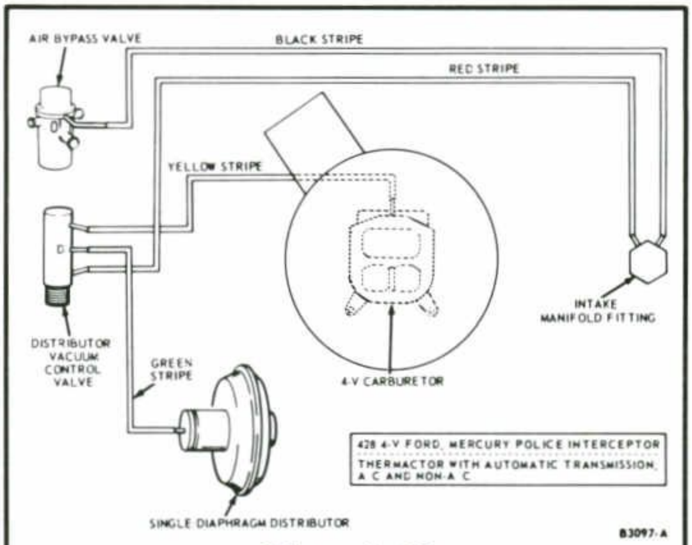

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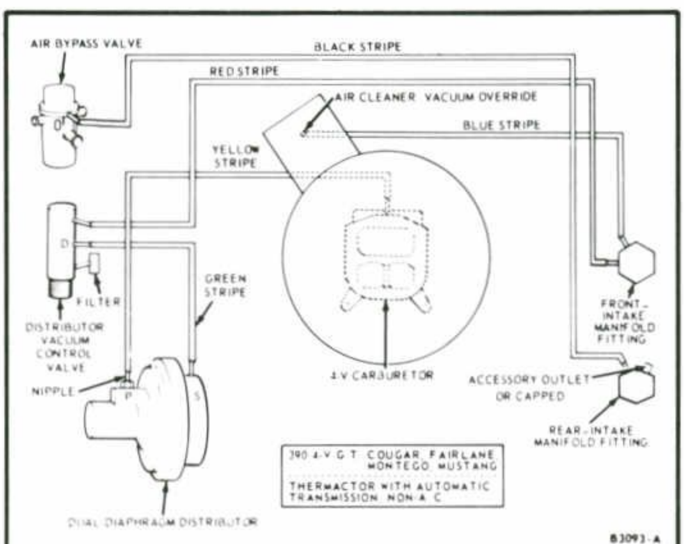

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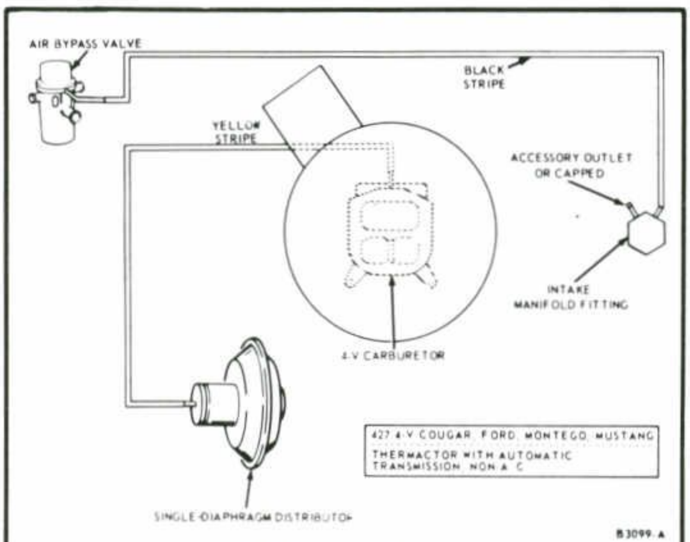

Schematic 30

APPENDIX IV

Glossary of Terms

The following definitions are offered for your convenience and as aids to understanding the specialized terminology of emission control systems. You will notice that some of the terms are applicable to all manufacturer's products while others are trademarks of a particular car maker.

A/C – Air conditioning.

A.I.R. – An air injection type exhaust emission system. (Air Injection Reactor.) A product identification name of General Motors Corporation.

Advance – To move forward, such as ignition timing.

Air Cleaner – A device mounted on the carburetor, through which air must pass on its way into the carburetor air horn. It filters out dirt and dust particles and also silences the intake noise.

Air Guard – An Air Injection type exhaust emission system. A product identification name of American Motors Corporation.

Air Injection – A system, whereby pressurized air is transmitted to each exhaust port of the engine. Here, the fresh charge of air mixes with hot exhaust gases and promotes more complete burning of hydrocarbons and carbon monoxide.

Air Pump – An engine belt-driven air pump, incorporating a rotor and three vanes. The vanes rotate freely about an off-center pivot pin, and follow the circular shaped pump bore. A basic component of all air injection type exhaust emission systems.

Backfire Suppressor Valve – A device used in conjunction with the early design "Thermactor" exhaust emission system. Its primary function is to lean-out the excessively rich fuel mixture which follows closing of the throttle after acceleration. Allows additional air into the induction system whenever intake manifold vacuum increases.

Belt Tension – Usually associated with the looseness or tightness of a drive belt. A loose belt may cause improper air pump operation; a tight belt places a severe strain on support bearings. Specified tension should be checked and adjusted according to manufacturer's specifications.

Blowby – The name given to the high pressure gases that escape past the engine piston rings into the crankcase during both compression and power strokes. More pronounced on high mileage engines because of imperfect seal of piston rings to cylinder wall. Comprised mostly of unburned fuel-air mixture.

Bypass Valve – A valve to control the air supply from the air pump. Normally closed, but opens on engine deceleration to divert air from cylinder head ports to the atmosphere.

Cam – A device that controls or alters motion. For example, the ignition distributor breaker cam which in rotating, causes contact points to open and close.

Carbon Monoxide – A colorless, odorless, poisonous gas; a by-product of incomplete combustion of carbon.

Carburetor – A device to meter and mix air and fuel in the correct proportion, according to the demands of the engine.

C.A.P. (Clean Air Package) – An engine modification type exhaust emission system which relies on precision carburetion, breathing and ignition to burn fuel more efficiently. (Cleaner Air Package.) A product identification name adopted by Chrysler Corporation.

C.C.S. (Controlled Combustion System) – An engine modification type exhaust emission system. Similar to C.A.P. offered by Chrysler Corporation. A product identification name adopted by General Motors Corp.

C.I.D. (Cubic Inch Displacement) – Air displacement by pistons from BDC to TDC. A method for classifying engine sizes.

Centrifugal – A force exerted from the center, outward.

Centrifugal Advance Mechanism – A device that advances ignition timing with relation to engine speed.

Centrifugal Filter Fan – A filter fan mounted on the air pump drive shaft used to clean the air entering the air pump.

Check Valve–A one-way valve to prevent exhaust gas backflow into the air pump and air bypass valve in event of pump failure.

Choke Plate – In carburetor, a valve that chokes off air flow through carburetor air horn, producing a partial vacuum in the carburetor for greater fuel delivery and a richer mixture.

Closed System – Related to a crankcase emission system which obtains fresh air through the carburetor air cleaner and routes it through a tube to the oil filler cap.

Combustion – The process of burning and requires three basic ingredients; fuel, oxygen, ignition (spark).

Cycle – A series of events that occur over and over in a given sequence. In an internal combustion engine, the four strokes (intake, compression, power, exhaust) of a four-stroke cycle.

Dashpot – A device whose function is to slow down the closing action of the carburetor throttle plates. It may be either of external or internal design and may be either mechanically or hydraulically operated; aids in reduction of rich mixtures in the intake manifold on deceleration.

Deceleration Valve (Distributor Vacuum Advance Control Valve) – A device used in conjunction with the dual diaphragm vacuum advance unit to advance timing under deceleration conditions.

Diaphragm – A flexible membrane, usually made of fabric and rubber in automotive components, clamped at edges and usually spring loaded; used in various pumps and controls.

Distributor – The part of the ignition system which closes and opens the circuit to the ignition coil, with correct timing and distributes to the proper spark plugs the resulting high voltage surges from the ignition coil.

Distributor Plate (stationary) – The plate in distributor that is fastened to housing and does not move.

Distributor (sub-plate) – The plate in distributor that pivots on the stationary plate with movement of the vacuum advance. The points and condenser are usually fastened to this plate.

Distributor Vacuum Advance Control Valve – (Refer to deceleration valve.)

Diverter Valve – (Refer to by-pass valve.) This provides same function as by-pass valve. A product name of General Motors.

Dual-Diaphragm – A vacuum advance mechanism that attaches to the engine distributor to control spark timing. One diaphragm provides normal ignition timing advance for starting and acceleration; the other diaphragm retards the spark during idle and part throttle operation. Some engine/transmission applications utilize a special valve to advance timing during deceleration to further reduce emissions.

Duct – A tube or channel used in conveying air or liquid from one point to another. In emission systems, a device used in conjunction with temperature regulation of the carburetor intake air–in conjunction with a thermostatic valve and vacuum motor.

Duct and Valve Assembly – An assembly incorporated in air cleaner to regulate the temperature of carburetor intake air.

Emission – The act of emitting or releasing from an engine products of incomplete combustion – principally hydro-carbon and carbon monoxide.

Engine-Mod – An improved combustion type exhaust emission system. Similar to exhaust emission systems used on G.M., Chrysler and Ford vehicles. A product identification name of American Motors Corporation.

Exhaust Gas Analyzer – An instrument for determining air-fuel ratio of the carburetor. These instruments usually incorporate a "wheatstone bridge" to analyze the thermal conductivity of the mixture. A means of determining the efficiency with which the engine is then burning fuel.

Exhaust Manifold – The part of the engine that provides a series of passages through which burned gases from the engine cylinders flows.

Fast Idle Cam – The mechanism of the carburetor that holds the throtle valve slightly open when the engine is cold so that the engine will idle at a higher RPM when cold.

GVW – Gross vehicle weight or curb weight, plus rated load. (Emission control systems not required currently on engine applications for vehicles that exceed 6,000 lbs. G.V.W.)

Grommet – A device, usually of hard rubber composition, to encircle or support a component. In emission systems, located in the valve cover assembly to support and help seal the crankcase emission control (regulator/P.C.V.) valve.

Gulp – A sudden swallow or intake of air. Principle used in early designed "Thermactor" exhaust emission system as a backfire-suppressor valve.

Hot Idle – A thermostatically controlled carburetor valve that opens whenever inlet air temperatures are high. Additional air is allowed to discharge below the throttle plates at engine idle. This feature improves idle stability and does not allow the rich fuel mixture normally associated with increased fuel vaporization of a hot engine.

Hydrocarbon – Any compound composed of carbon and hydrogen, such as petroleum products. Excessive amounts in the atmosphere are considered undesirable contaminents and a major contributor to air pollution.

Idle Mixture Adjusting Screw – The adjusting screw that can be turned in or out to lean or enrich the idle mixture.

Idle Limiter – A device to control maximum idle fuel richness of the carburetor. Also aids in preventing unauthorized persons from making overly rich idle adjustments. The limiters are of two distinct types: The external plastic limiter caps installed on the head of idle mixture adjustment screws or the internal needle-type located in the idle channel.

Idle Port – The opening into throttle body through which the idle circuit in the carburetor discharges.

Idle Vent – An opening from an enclosed chamber through which air can pass under idle conditions.

IMCO–An Improved Combustion type engine exhaust emission system. Similar to engine exhaust emission systems used on G.M., Chrysler and American Motors vehicles. (IMproved COmbustion). A product identification name of Ford Motor Company.

Intake Manifold–The part of the engine that provides a series of passages from the carburetor to the engine cylinder through which the air fuel mixture flows.

Lobe – A projection of a rounded form. The highest spot of a cam.

MVPC – Motor Vehicle Pollution Control; name of official governing Board in California which administers provisions of legislation applicable to vehicle emission systems.

Malfunction – The act of performing improperly or incorrectly. The ultimate aim of diagnosis is specifically directed toward the isolation and correction of any given problem or undesirable condition.

Manifold – A tube or pipe for conveying liquids or gases. On injector emission control-equipped engines, an air manifold is utilized in addition to the engine intake and exhaust manifolds.

Manifold Control Valve – A thermostatically operated valve in the exhaust manifold for varying heat to intake manifold with engine temperature.

Modification – An alteration. To change from original, such as engine modifications – design change, component change, etc. . . .

Nozzle – A restricted orifice or hole. The final outlet for air entering the exhaust manifold on injector emission systems.

O.E.M. – Original Equipment Manufacturer.

Oil Separator – A device for separating oil from air or oil from another liquid. Used on some applications of engine crankcase emission controls.

Open System – Descriptive term for crankcase emission control system which draws air through the oil filler opening.

P.C.V.– (Regulator crankcase emission control valve.) A valve which controls crankcase vapors that are discharged into the engine intake system and pass through the engine cylinders rather than being discharged into the air.

Polyurethane – A synthetic substance used in filtration materials, normally associated with filtering of carburetor inlet air.

Pollution – To soil, stain or corrupt by contact. To render unfit for a specified use. (Contaminate level presently specified as less than 275 parts per million of hydrocarbon and less than 1.5% carbon monoxide (by volume). Further reduction is planned in vehicle emission levels by federal legislation.

Ratio – The expression of the proportional mixture of two substances, usually expressed as a numerical relationship, such as 2:1, 10:1, etc. . . . in emission systems, concern is with air-fuel mixtures.

Relief Valve – A pressure limiting valve located in the exhaust chamber of the air supply pump. Its function is to relieve part of the exhaust air flow if the pressure exceeds a pre-determined value.

Retard – Usually associated with spark timing mechanisms of the engine. Opposite of spark advance. To delay the introduction of the spark into the combustion chamber.

Road Draft Tube–The traditional method of scavenging the engine crankcase of fumes and pressure. A means by which the engine crankcase was ventilated. Prior to the introduction of crankcase emission control systems a tube, vented at the crankcase and suspended a few inches from the ground. Depends on "venturi action" to create a partial vacuum as the vehicle moves. Very ineffective below 20 m.p.h.

Schematic – A pictorial representation, most often in the form of a line drawing. A systematic positioning of components in a system and their relationship to each other or to the total function.

Smog – A derivative of two words – smoke and fog; caused by a chemical reaction between hydrocarbons and air in the presence of oxides of nitrogen and sunlight.

Solvent – A petroleum product of low volatility used in the cleaning of engine or component parts.

Test Gauge Adapter – An adapter used in conjunction with a fuel pump tester to check the air supply pump.

Thermactor–An air injection type of exhaust emission control system. Similar to exhaust emission control systems used by G.M., and American Motors vehicles. A product identification name of Ford Motor Company. Currently used with engines coupled with standard transmissions or high performance engines.

Thermostat – A valve which depends on heat to control temperature by opening or closing a damper. In emission systems, to control hot or cold carburetor inlet air.

Vacuum – A term used to describe a pressure that is less than atmospheric pressure; hence, a partial vacuum. A perfect vacuum has not yet been created, as this would necessitate a complete lack of pressure. Used for control purposes throughout the automotive industry.

Vacuum Advance – Advances ignition timing with relation to engine load conditions. This is achieved by using engine vacuum.

Vacuum Control Temperature Sensing Valve – A valve that connects manifold vacuum to the distributor advance mechanism under hot idle conditions.

Vane – Any flat, extended surface attached to an axis and moved by or in air or liquids. Part of the integral revolving portion of an air supply pump.

Ventilation – The process by which fresh air is caused to circulate, so as to replace impure air. Principle utilized in crankcase emission systems.

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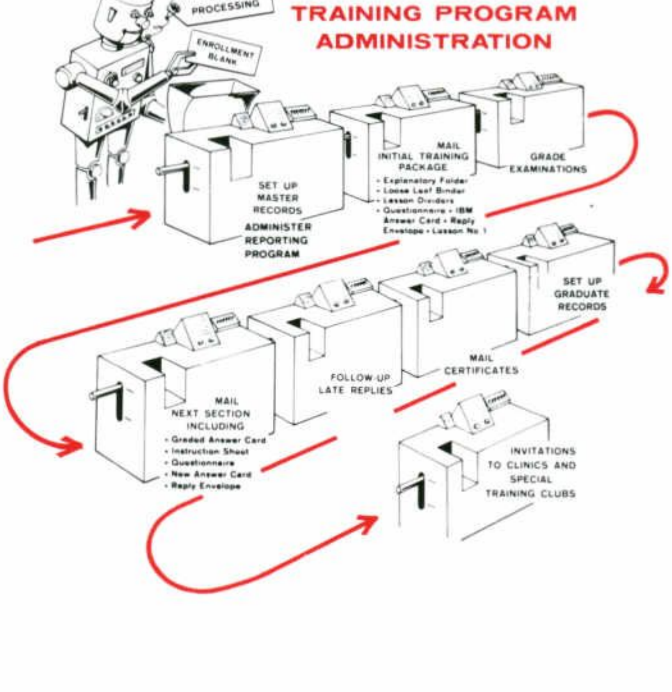

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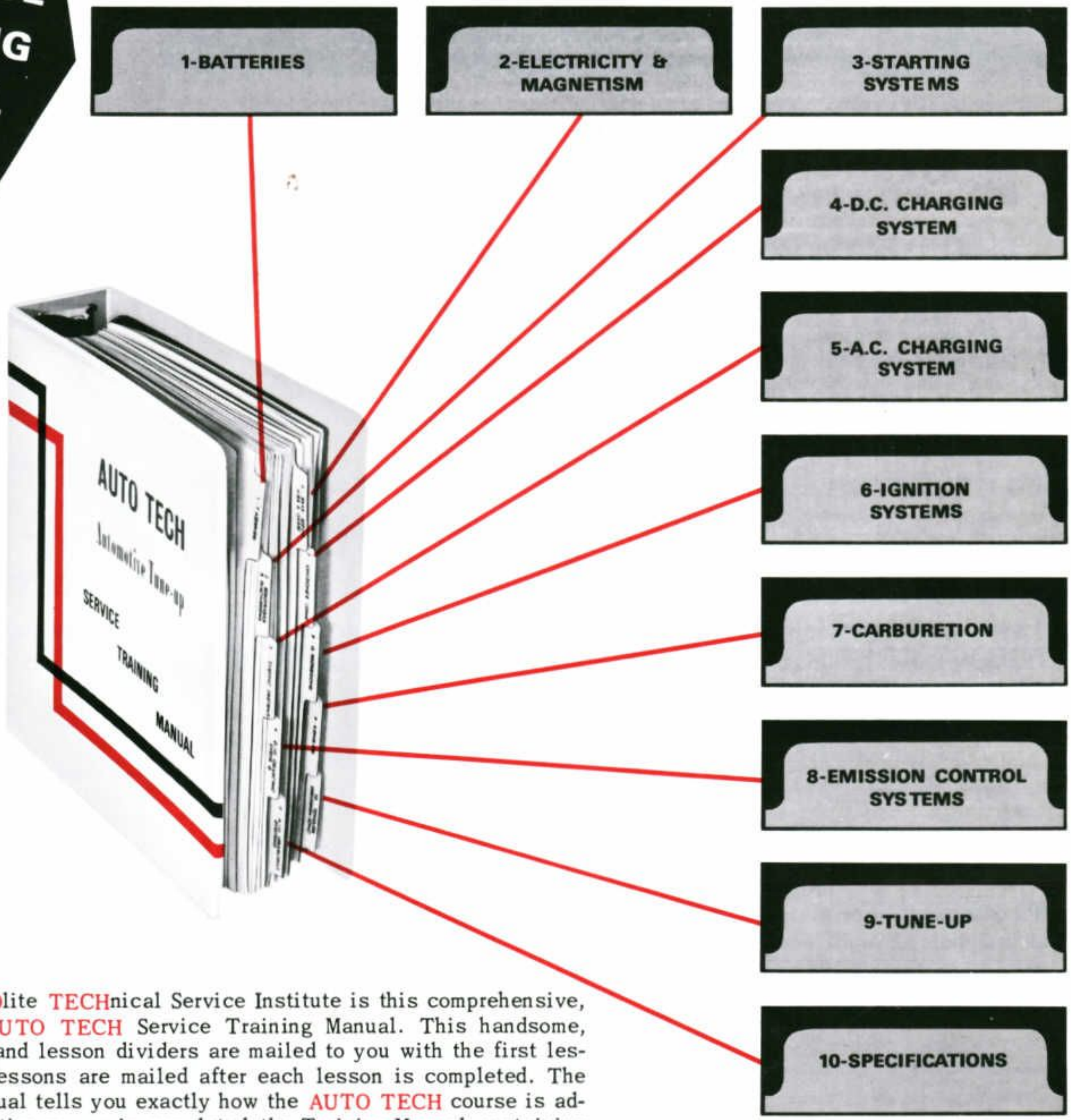

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- A Self-addressed Reply Envelope
- An Answer Reference Sheet

Because lesson materials require periodic up-dating, Autolite—Ford Parts Division reserves the right to alter the content of the AUTO TECH Service Training Manual at any time without notice or obligation.

Don't Delay... Register today in AUTO TECH

There's no need for you to delay . . no waiting for the next "semester" to begin . . all you have to do to get started in this unique Service Training Program is to complete the ENCLOSED Registration Form and send it to Autolite Technical Service Institute. The address is 10800 Puritan Avenue, Detroit, Michigan – 48238. MAIL IT TODAY !

REMEMBER...

YOU MUST BE SATISFIED!

If you are not completely satisfied with the AUTO TECH service training course, the Autolite Technical Service Institute will refund you the entire cost of $20.00 . . . and you may retain all of the materials received!

GRADUATION CERTIFICATE OF COMPLETION – When you complete the course, you'll receive this impressive-looking personalized certificate of completion. You'll want to display it to let your customers know that their car is being serviced by a fully-trained mechanic!

ALL THIS FOR ONLY $20

A fraction of the actual value-
AUTOLITE pays the major cost.

AUTOLITE TECHNICAL SERVICE INSTITUTE

REGISTRATION FORM

Please enroll me in the Autolite Technical Service Institute. I am enclosing a check/money order for $20.00 and I understand that this entitles me to receive all instructions, reference material, questionnaires, answer cards, etc., required to complete the first lesson of this training program – and that the forwarding of each subsequent lesson by Auto Tech is dependent upon receipt of my answer cards reflecting completion of the preceding lesson.

I further understand that if I am not completely satisfied with the lessons provided in the Auto Tech service training program, the Autolite Technical Service Institute will refund to me the entire cost of $20.00 ... and that I may retain all of the materials received.

PLEASE PRINT OR TYPE

ENROLLEE

Name ______________________________

Home Address ______________________________

City ______________ State ______________ Zip Code ______________

Social Security Number ______________ Job Description ______________

Enrollee's Signature ______________________________

TEAR HERE

EMPLOYED BY

Company Name ______________________________

Address ______________________________

City ______________ State ______________ Zip Code ______________

Type of Business ______________________________

Employer's Signature (optional) ______________________________

NOTE: All materials will be sent to home addresses unless otherwise indicated below.

Address ______________________________

City ______________ State ______________ Zip Code ______________

> **Important:** Be sure to enclose check with this form in the amount of $20 payable to Autolite Technical Service Institute. (Michigan Enrollees must add 4% sales tax)

Fill in form and mail with enrollment fee to:

AUTOLITE TECHNICAL SERVICE INSTITUTE HEADQUARTERS

10800 Puritan, Detroit, Michigan 48238

NATIONAL SERVICE DEPARTMENT

AUTOLITE-FORD PARTS DIVISION

Ford Motor Company