SHOP TIPS

Autolite Ford

VOL. 9, NO. 6 FEBRUARY, 1971

Pollution Control ... Part 1

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CONTROLLING

Technical parts and service information published by the Autolite-Ford Parts Division and distributed by Ford and Lincoln-Mercury Dealers to assist servicemen in Service Stations, Independent Garages and Fleets.

IN THIS ISSUE

INTRODUCTION

Air pollution was not considered to be a major issue a short decade ago. People just didn't think about smoke in the air as a threat to environment. And few realized they were actually breathing in contaminants whenever they inhaled. Now they know.

Before production of automobiles reached the level it has today, the average man failed to realize the amount of pollution an automobile engine produced during normal operation. An automobile has now been recognized as one of the significant sources of air pollution—at least in terms of tonnage—and steps have been taken to dramatically reduce the amount of pollutants emitted during normal driving.

The average person does not have the background or mechanical know-how to keep his car's pollution control devices in top working order. And, because control of pollution is necessary if we are to improve the quality of the air we breathe, someone has to take it upon himself to keep abreast of pollution control devices. That someone is you. You have the knowledge and mechanical ability to perform the necessary adjustments to keep pollution control devices in operating order. Help clean the air you breathe.

In order to broaden the coverage of Controlling Pollution and explain various portions in greater detail, the emission control story has been expanded to cover two separate issues.

This month's issue contains information relating to operating principles of the various components used to reduce vehicle emissions.

The following issue will contain information relating to the servicing of emission control devices.

Be sure and file this and future bulletins for ready reference. If you have any suggestions for additional information that you would like to see included in this publication, please write to: Autolite-Ford Parts Division, Merchandising Services Dept., P.O. Box 3000, Livonia, Michigan 48151.

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POLLUTION

THE CAUSES OF POLLUTANTS

There are different kinds of air pollution and many sources of emissions. One of these is a specialized type of air pollution known as "photochemical smog." Automobiles are a major source of the contaminants which ultimately cause this type of air pollution. Substances from ordinary trash burning, gases from industrial processes, and dust from many sources serve to further intensify the severity of general smog conditions and complicate solutions to the problem.

Some of these latter sources contribute to an air pollution problem referred to as particulates. Particulates are very small amounts of liquids or solids composed of a great variety of compounds, some of which include carbon, lead, iron, calcium, sulfates and others. This is the type of air pollution commonly seen in industrial areas and in large cities. Although not a primary source, automobiles do produce some particulate matter which is caused largely by the anti-knock lead additive in gasoline.

Adding to the complexity and aggravation of air pollution is "Mother Nature," who "herself" is a major polluter too. Natural sources are responsible for large amounts of hydrocarbons; such as the terpenes produced by growing trees. Similarly, methane, a natural hydrocarbon produced by decomposition of vegetable matter in substantial quantities, is significant to the content of atmospheric contaminants.

To consider air pollution as having only the factors discussed in this brief summary would be over-simplifying its scope, as there are many intricate aspects and variables we must consider and understand before we can attain full success.

Fortunately, state and federal agencies and the industry researchers are expending great effort to better understand and then develop appropriate air pollution standards and controls.

THE FIGHT AGAINST POLLUTION

Extensive research, development and testing procedures have enabled American automotive manufacturers to achieve substantial reductions in vehicle exhaust emissions. Now, there are effective control systems for all major sources of emissions from automobiles . . . blow-by gases from the crankcase, exhaust gases from the tailpipe, and evaporation from the gas tank and carburetor.

In less than a decade, emission levels of unburned hydrocarbons have been reduced by more than 80 percent, carbon monoxide emissions by almost 70 percent, with controls for oxides of nitrogen to be effective in 1971 for the State of California and nationally in 1973.

To better illustrate this progress, five 1971 cars emit less hydrocarbon than one 1962 model. Similarly, three 1971 cars emit less carbon monoxide than one 1967 model. See Figures 1 and 2.

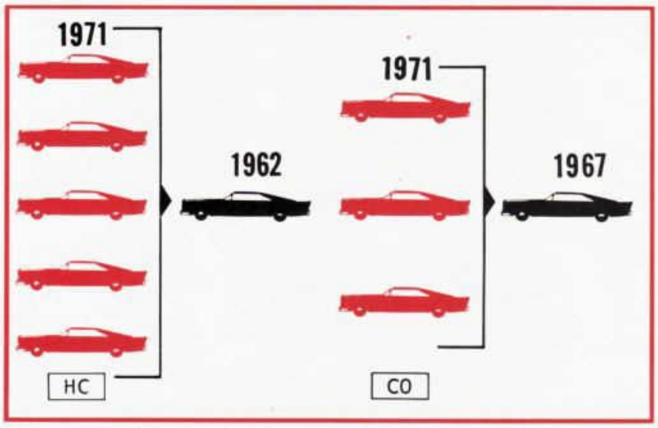

Figure 1—Emission Reduction

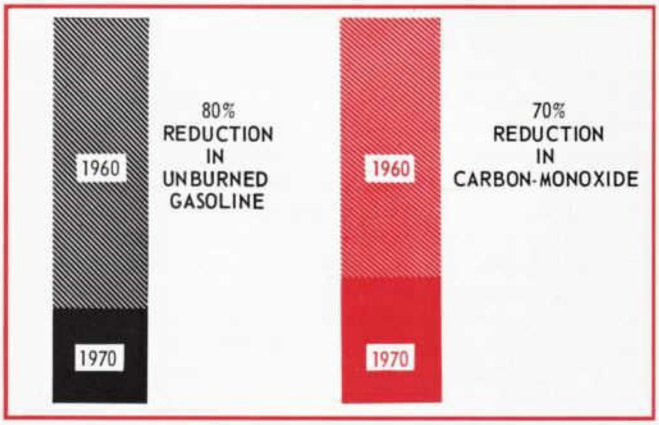

Figure 2—HC & CO Comparisons

THE INTERNAL COMBUSTION ENGINE

The internal combustion engine of the automobile relies on the use of hydrocarbon fuel . . . gasoline . . . for its operation. It was 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. The areas of major concern are control of crankcase vapors and control of combustion process during idle and deceleration.

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.

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 . . . 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 provide 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 3 is a "necessary evil."

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

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

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

EMISSION CONTROL SYSTEM TYPES

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 chambers and re-routing of blow-by vapors to the combustion chamber through existing ventilation systems is the control measure being adopted by most of the automobile industry.

Ford, 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 programs are apparent in the variety of emission control devices and systems appearing on today's automobiles.

With these observations having been made, we will aim 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)

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

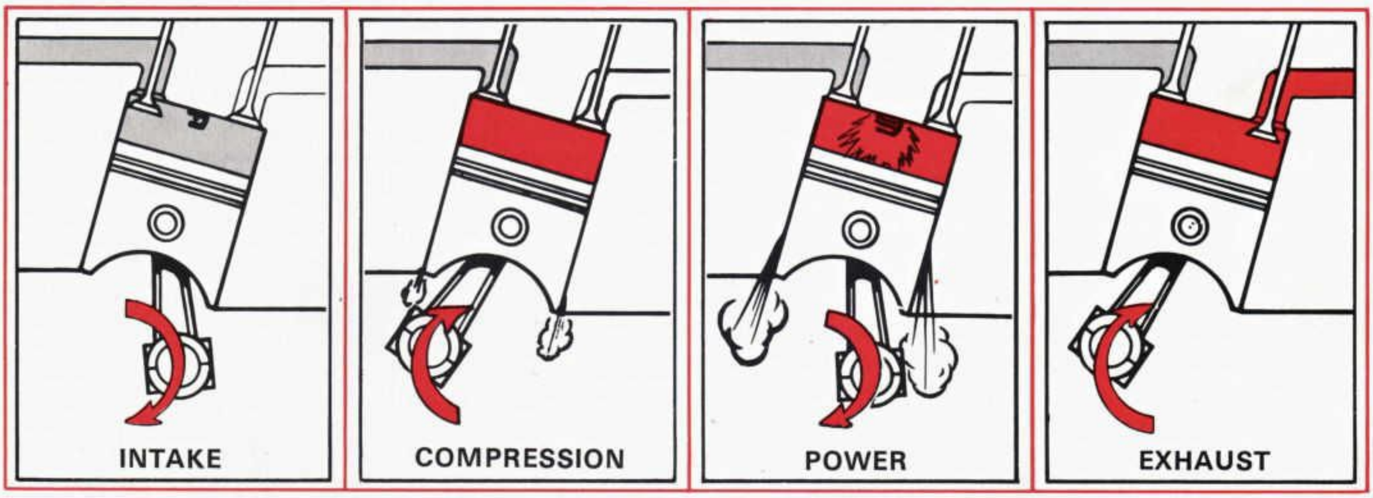

Figure 3—Blow-By in the Four-Stroke-Cycle Engine

chamber. These high pressures, however, result in leakage between the piston and cylinder wall during the compression and power strokes. If this "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 out of the crankcase. The system makes use of the "venturi" principle; 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.

One of the major drawbacks to the "road draft tube" system is that vehicle road speeds in excess of 25 mph are necessary for the ventilating system to operate effectively and crankcase vapors are released directly into the atmosphere. 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 and ventilating air to the intake manifold for subsequent reburning in the combustion chamber. (See Figure 4.)

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.

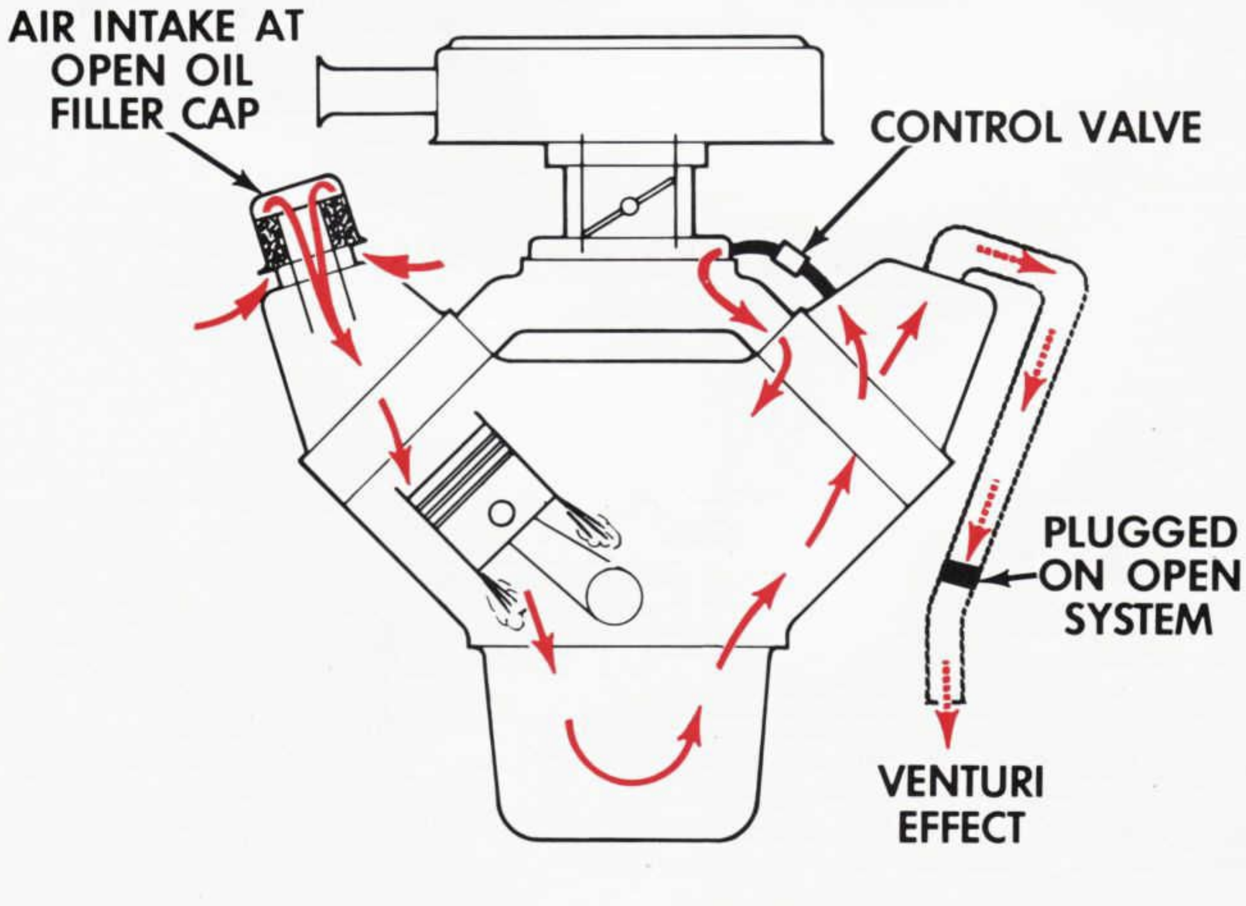

Figure 4—Type 1 Crankcase System

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 the blow-by to the intake manifold by way of a variable orifice valve, the opening of which is controlled by intake manifold vacuum. (Refer to Figure 4).

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. Under crankcase pressure and manifold vacuum the fumes are recirculated to the intake manifold entering either through the carburetor or below the carbureter (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 carbureter since they will affect the air-fuel mixture ratio. Metering of these fumes is accomplished by the use of a PCV valve.

PCV 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.

PCV VALVE OPERATION

The PCV valve generally used is a spring-loaded regulator-type. (See Figure 5.)

The valve reacts to changes in intake manifold vacuum and serves to regulate the amount of ventilating air and blow-by 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 5.) With the valve in this position, there is a minimum of ventilating and crankcase air 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 5.) This increases the flow of ventilating air blow-by to the intake manifold.

Another type of valve is used in the PCV system which is controlled by crankcase vacuum. (See Figure 6.)

The flow rate of this valve is dependent upon the amount of blow-by 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 and ventilating air to the intake manifold.

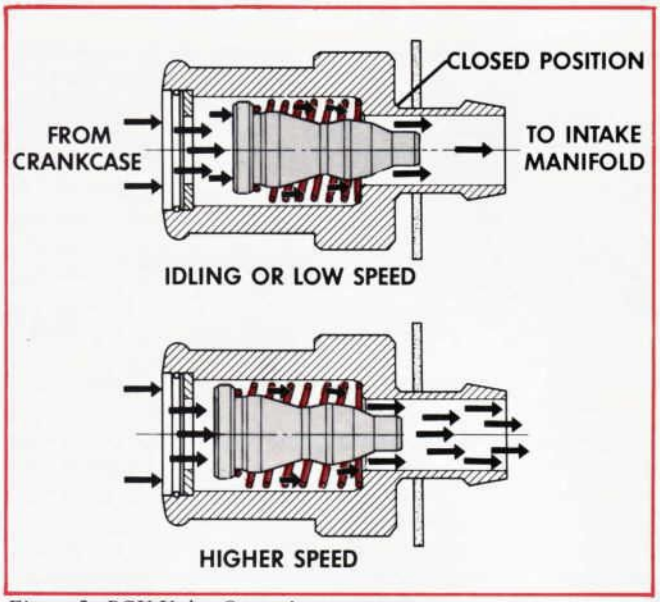

Figure 5–PCV Valve Operation

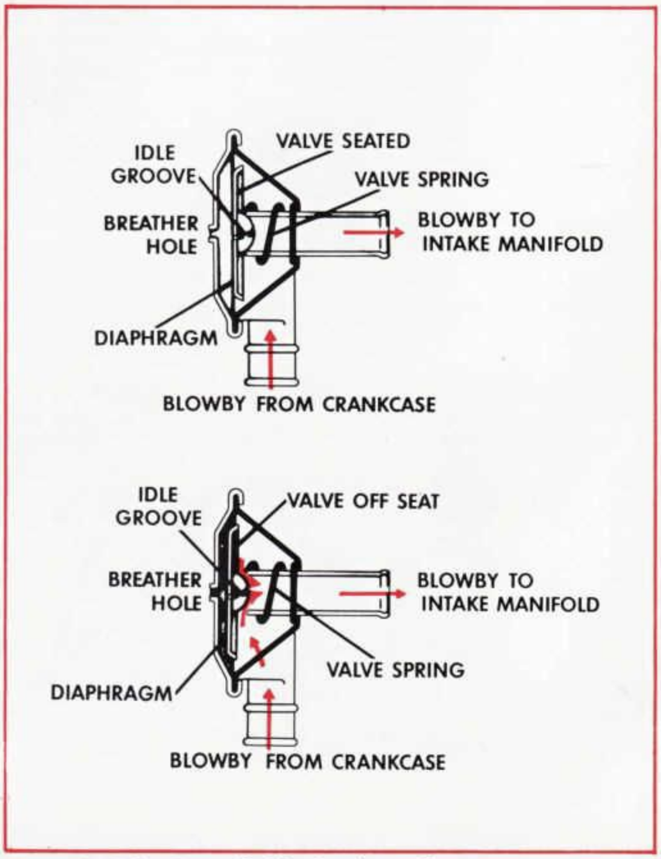

Figure 6–Valve Controlled by Crankcase Vacuum

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.

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 through 1963 vehicles; with individual components instead of conversion kits available for these model year cars. The overall effectiveness of the Type 1 system in controlling crankcase emissions under various operating conditions is detailed in chart form in Figure 7.

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
LOW SPEED (LOAD) (5)	WIDE OPEN	LOW	HIGH	HIGH	FULLY OPEN	HALF THROUGH VALVE HALF TO ATMOSPHERE	50
HIGH SPEED	PARTLY OPEN	MEDIUM	MEDIUM	MEDIUM	PARTLY OPEN	3/4 THROUGH VALVE 1/4 TO ATMOSPHERE	75

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 7—Open Crankcase Emission System Operating Conditions (Type 1)

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 8.)

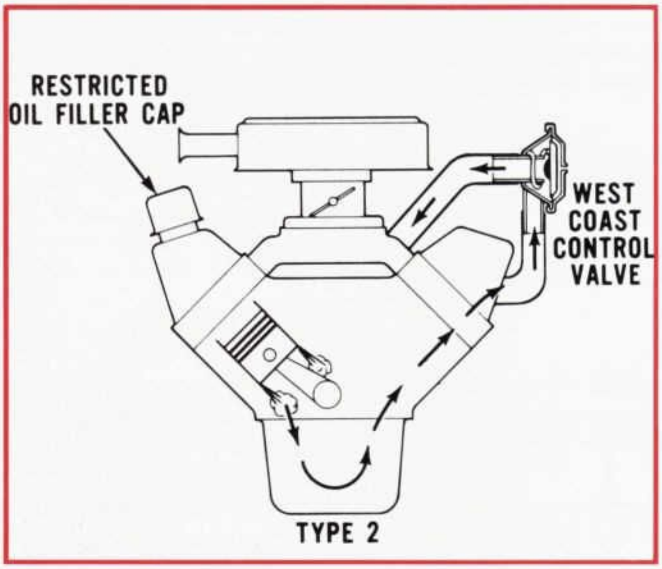

Figure 8—Crankcase Vacuum Control System (Type 2)

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 airtight crankcase. No air leaks from the rocker arm covers, or galley pans can be tolerated (the road draft tube must be removed or plugged when converting a used car); inasmuch as this would upset the ability of the valve to control the flow of blow-by.

The control valve meters crankcase vapors 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 which is now diluted with 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 DEVICES

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 9.)

Foreign vehicle manufacturers have made use of the Type 3 system merely to provide an escape path for the blow-by; 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

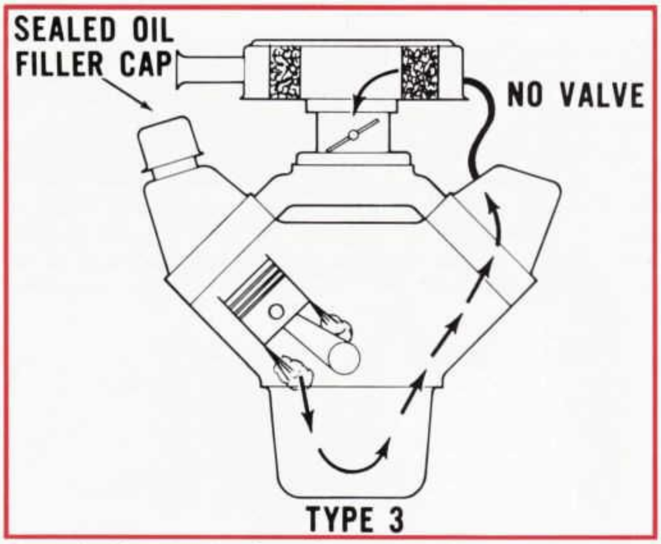

Figure 9—Clean Air Crankcase System (Type 3)

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 is 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 new cars, *carburetor calibrations* compensated for the secondary fuel charge. The opposite effect is encountered when the blow-by is 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 10.)

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, as well as condensation vapors and crankcase fumes.

The PCV control valve then meters this mixture into the intake manifold where it combines with the air-fuel mixture and is burned in the combustion chamber. Possible smog-inducing hydrocarbons emitted by the exhaust system are thus virtually eliminated. The advantages and effectiveness of the Type 4 system are detailed in chart form in Figure 11.

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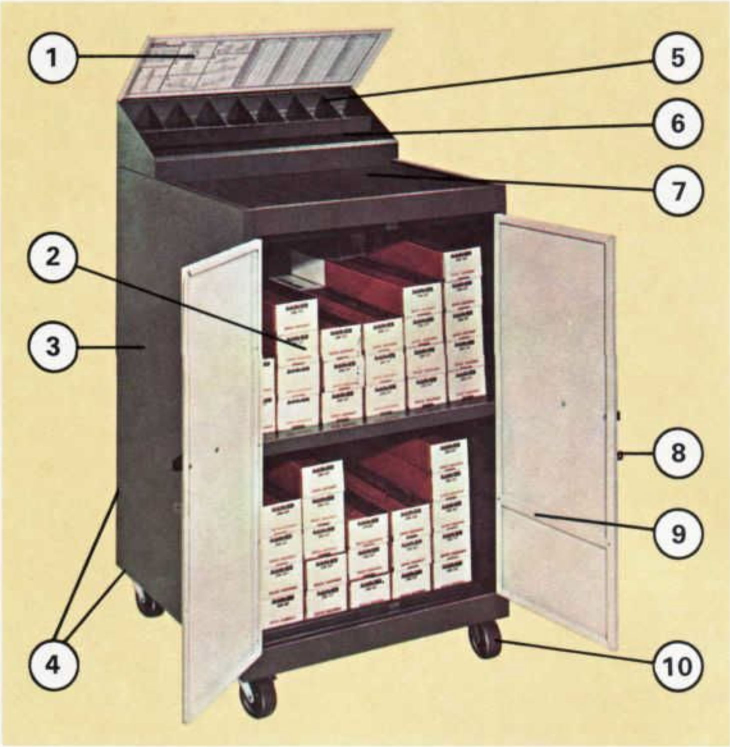

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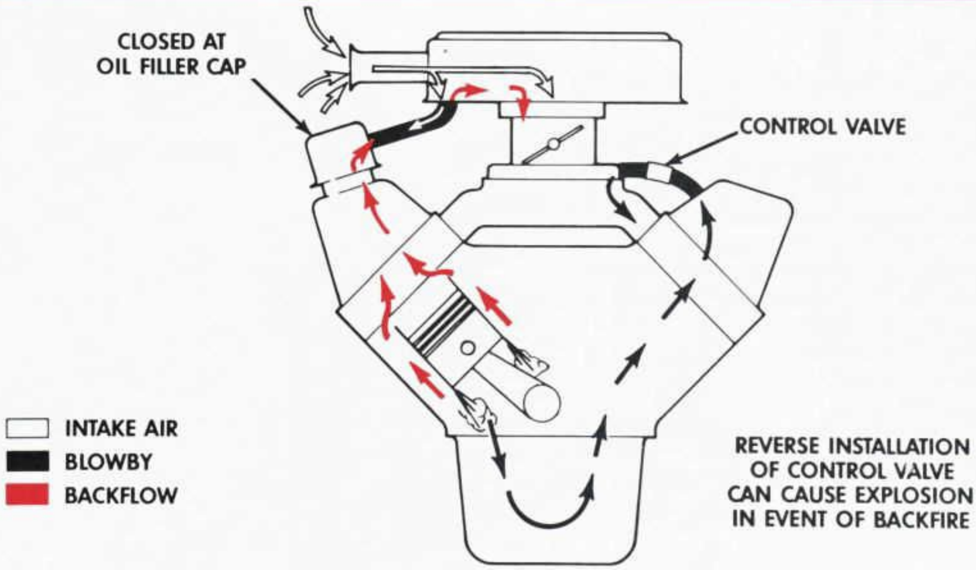

Figure 10—Closed or Combination Crankcase System (Type 4)

CLOSED 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.

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Figure 11—Advantages of a Type 4 System

PCV 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 virtually eliminate hydrocarbon emissions, they also increase the breakdown potential of the motor oil. If the acids from blow-by fumes remain in the engine in the presence of an imbalanced or low quality motor oil, they are not completely neutralized; as a result, they usually allow high rates of corrosive wear, varnish buildup, 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 12.)

The use of manufacturer specified oil or equivalent and periodic servicing of the PCV 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 20% 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. Engine Modification System

Figure 12—Approved Engine Oil for Ford-Built Vehicles

VEHICLE MANUFACTURER	AIR INJECTION SYSTEM	ENGINE MODIFICATION 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 13—Engine Exhaust Emission Identification Chart

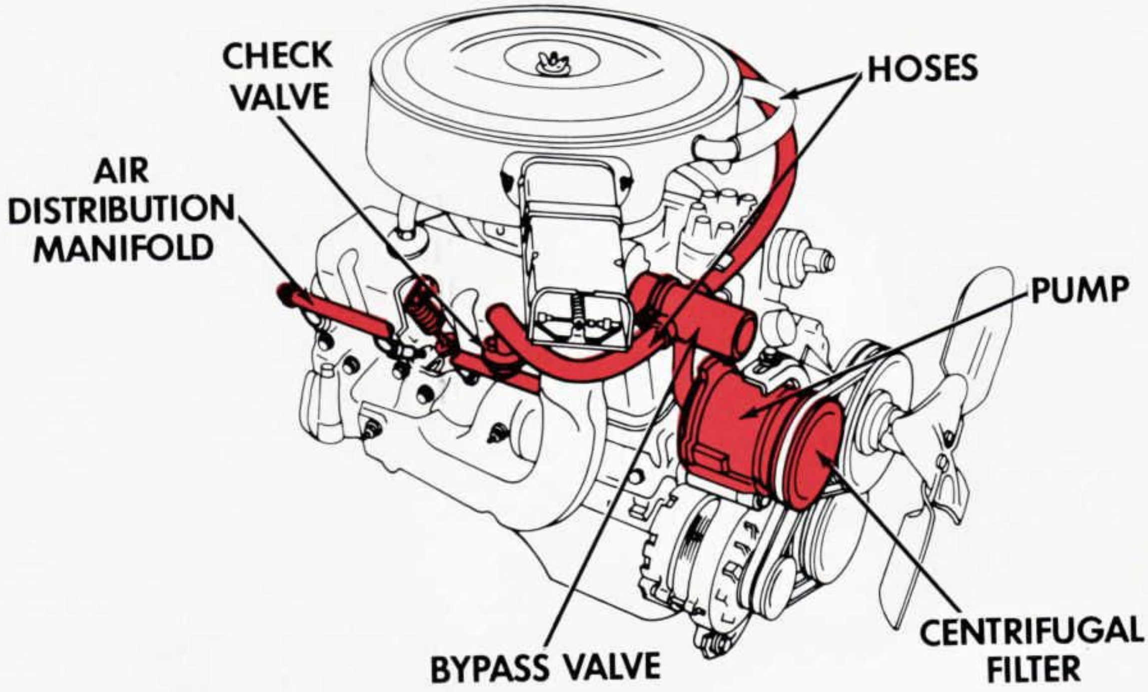

Figure 14—Thermactor Air Injection Equipped Engine

The characteristics of vehicles equipped with these systems are not noticeably different than the characteristics of those not so equipped. Slightly higher engine idle speeds are not of a magnitude that prove objectionable. All motor vehicles sold in the United States are equipped with exhaust control devices. The trade name identification for these exhaust systems and corresponding manufacturers are listed in Fig. 13.

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 prolongs the combustion of unburned exhaust vapors to reduce their hydrocarbon and carbon monoxide content. (See Figure 14.)

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 vapors 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.

IMPROVED COMBUSTION EXHAUST EMISSION CONTROL SYSTEMS ENGINE MODIFICATION

The IMCO (IMproved COmbustion) system was originally developed for vehicles equipped with automatic transmissions. (See Figure 15.)

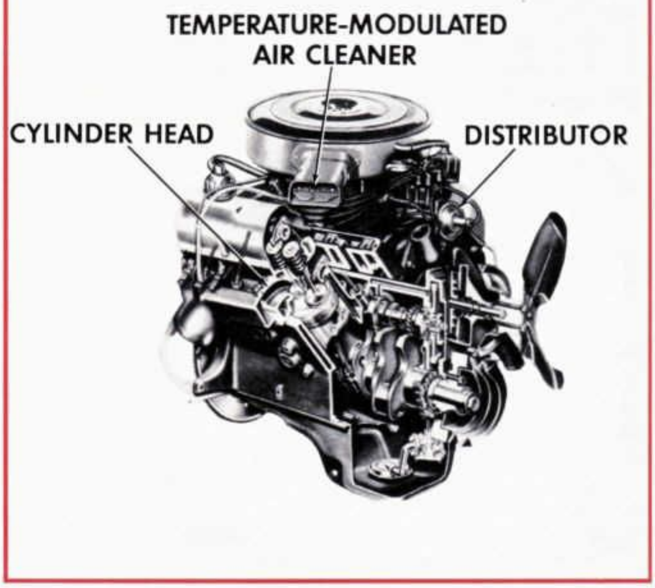

Figure 15–Improved Combustion System

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 emissions are reduced in the combustion process rather than by burning the exhaust unburned fuel 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 16.)

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.

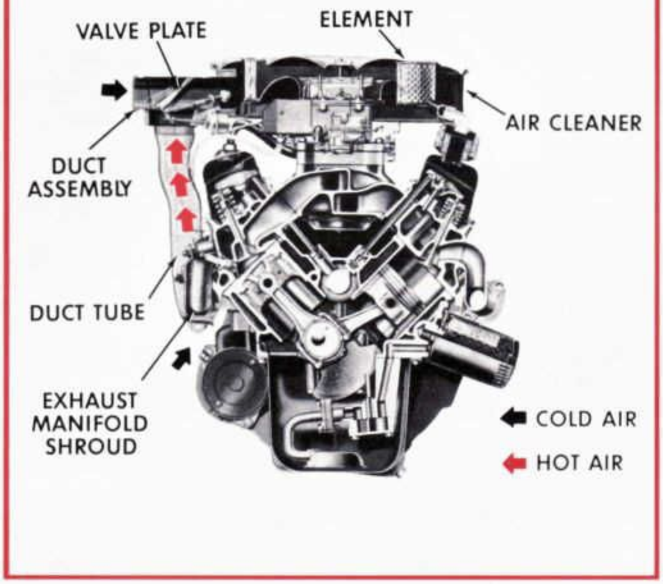

Figure 16–Typical Air Intake System

THERMACTOR (AIR INJECTION SYSTEM)

In spite of the seemingly endless and varying application of emission control components on current production vehicles, there is no misunderstanding on the intended objective . . . to keep the atmosphere as clean as practically possible. Recently the trend has been in the direction of improvement of combustion internally in the cylinder combustion chambers. However, in some instances, improvement of internal combustion involves performance characteristics which are incompatible with certain engine and transmission combina-

tions. Examples of such instances are found in vehicles equipped with high performance engines and engines combined with standard transmissions.

To keep the exhaust emission level within the specified 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 system illustrated in Figure 17 is typical of the air injection approach.

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).

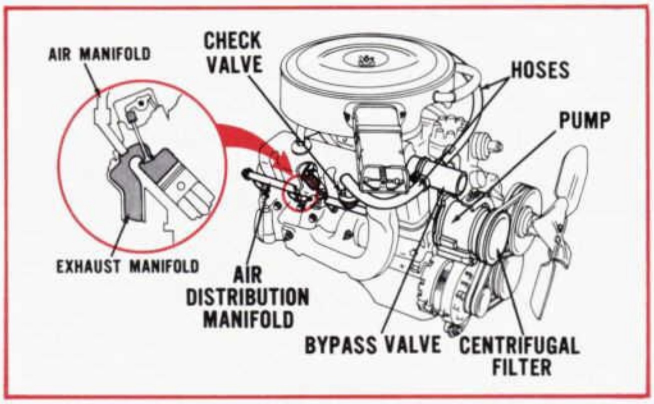

Figure 17—Thermactor (Typical Air Injection System)

AIR SUPPLY PUMP

The belt-driven air supply pump pictured in Figure 18 features three serviceable components . . . a centrifugal air filtering fan, a pressure relief valve and a pressure setting plug. (See Figure 18.) 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.

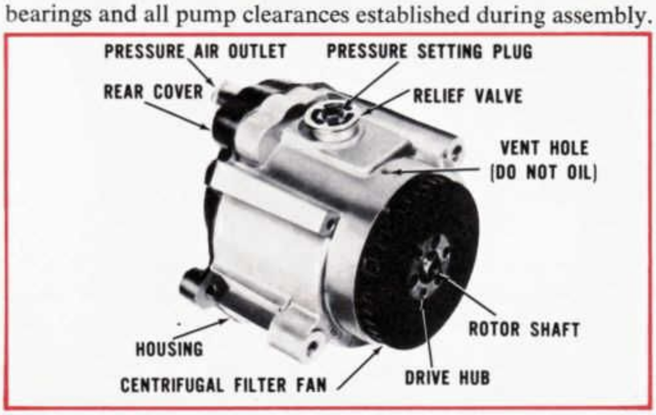

Figure 18—Air Pump

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 19 depicts a cross sectional view of the by-pass valve.

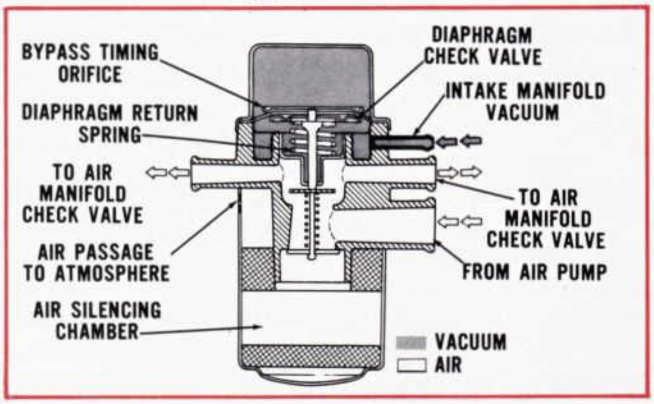

Figure 19—Air By-Pass Valve (Normal Position)

DISTRIBUTOR MODULATOR COMPONENT AND SYSTEM OPERATION

One of the latest engineering advances in the battle against air pollution is the *distributor modulator system,* sometimes referred to as the Dist-O-Vac system. This new system, introduced in some of the 1970 Ford-built passenger cars and light truck lines, functions to assist in a more complete burning of the air-fuel mixture in the engine combustion chambers.

Basically, it accomplishes this goal by controlling the distributor spark advance in a very sophisticated manner. See August 1970 *Shop Tips.*

We have identified the individual components earlier; now, we will detail the operation of each of these sub-components of the entire system.

Speed Sensor . . .

Consists of a rotating magnet and a stationary field winding. The field winding is wound on a nylon bobbin and is insulated from ground. As the magnet rotates, it induces a voltage frequency which is proportional to the speed of the vehicle. A signal given off by the magnet is routed to the Electronic Module and Solenoid Vacuum switch assembly, which contains an electronic counting circuit as well as the vacuum switch assembly.

- The speed sensor unit is serviced as a complete assembly only

Thermal Switch . . .

Overrides the electronic signal from the speed sensor and causes the system to function as the previous distributor vacuum system, any time the outside ambient air temperature (not engine compartment temperatures) is below approximately 58°F; within a range of 58°F to 50°F or lower.

Solenoid Valve . . .

A 3-way control valve which is housed with the printed circuit board assembly in the module. Until the module is triggered by the sensor signal the vacuum distributor connection hose is directed to atmospheric pressure. The carburetor connection (small hose) is closed. When the electronic module is triggered, the solenoid is activated and the solenoid action, in turn, connects the distributor vacuum connection to the carburetor spark port.

- There are six (6) different electronic module packages. A white or black box, and a white, black, or blue lid. The black box cuts-in at 23 mph and the white box at 28 mph. The covers vary in color to identify various wiring lengths and plug configurations

Electronic Control Amplifier . . .

Mounted on a printed circuit board with a 3-way solenoid valve. The entire plastic case is called the "Electronic Control and Solenoid Valve Assembly."

- None of the above units are serviced separately
- The circuit receives an input voltage frequency from the speed sensor and the signal from the thermal switch which determines if the solenoid valve is to be energized or de-energized

EVAPORATIVE EMISSION CONTROL SYSTEM

The vehicle manufacturers are continuing to improve emission control devices to meet Federal regulations for lower emissions.

It has been determined that controlled pollutants (hydrocarbons, carbon monoxide and in California, oxides of nitrogen) reach the atmosphere from the vehicle by way of the:

1. Exhaust
2. Crankcase
3. Carburetor fuel bowl
4. Fuel tank

The majority of the contaminants come from the exhaust system, for which improved combination characteristics have been designed into all engines manufactured since model year 1968. Additionally, the air injection system is utilized on those engine-transmission combustions that are not adaptable to the engine modification approach.

The second largest source of pollutants comes from the crankcase. A closed PCV system is now required to control crankcase pollutants, and accomplishes this task by recycling the unburned hydrocarbons back into the combustion chamber for reburning.

Finally, we now have the evaporative emission system designed to control or limit evaporative losses from the vehicle fuel tank and carburetor fuel bowl. (See Figure 20.)

The purpose of the evaporative emission system is to reduce fuel vaporization into the atmosphere. This is accomplished by funneling fuel tank vapors and carburetor fuel bowl vapors into a carbon canister storage container, or on some applications, back into the engine crankcase for storage, whenever the engine is shut off.

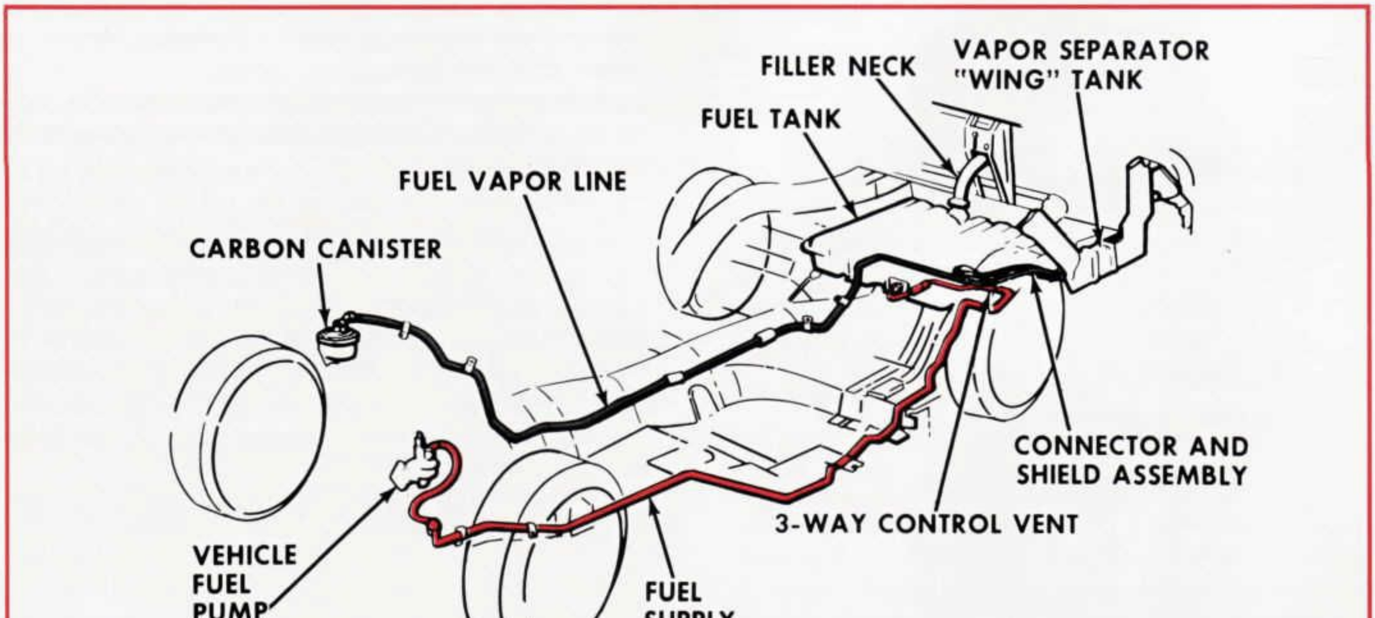

Figure 20—Evaporative Emission Control System

CANISTER vs. CRANKCASE STORAGE AREAS

As you can see in the following illustration, fuel vapors are routed either into a carbon canister or directly into the engine crankcase for storage. (See Figure 21.)

The left side of the illustration shows the path of fuel vapors under engine soak (stopped) conditions. As fuel vapor pressure builds up in the tank (approximately 0.5 psi) it is transported from the vapor separator tank, through the 3-way vent control valve to the carbon canister, to the carburetor air cleaner, to the combustion chamber for burning. Since the carburetor fuel bowl is only vented internally, vapor that collects on top bowl is directed to the canister for storage.

When the engine is started, vapors that have been stored in the carbon canister are extracted or purged by directing fresh, heated air from the carburetor heat stove through the canister. This air then mixes with the fuel vapors, and the mixture is directed through a line connected to the air cleaner where it is drawn into the engine and burned.

On installations where the fuel vapors are stored in the engine crankcase (as shown in Figure 20), the vapors are extracted through the PCV valve and burned in the engine. Additionally, carburetor fuel bowl vapors are directed into the crankcase via the connection on the PCV valve and rocker arm cover.

It is important to remember that the 3-way vent control valve isolates the fuel tank from engine-induced pressures.

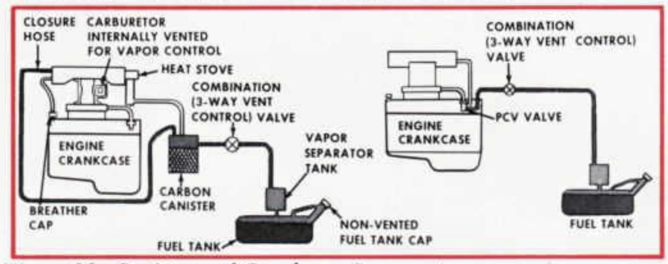

Figure 21—Canister and Crankcase Storage Areas

FUEL TANK FILLER PIPE ASSEMBLIES

When we compare the features of a conventional fuel tank to the one used on evaporative emission systems, we see that the filler pipe on a conventional tank is *not* sealed and the tank is vented through the filler cap. Ventilation is required to prevent pressure or vacuum buildup, which would result in deformation of the tank. (See Figure 22.)

The fuel tank designed for use with the Evaporative Emission System utilizes a sealed filler pipe. A special double seal is used to ensure against vapor loss or leakage into the luggage compartment.

Note the extended filler neck and the vent tube in the filler pipe which projects to the center of the tank, just below the top surface. The vent tube is sealed when the non-vented fill cap is installed.

CAUTION: Installation of a fill cap from a non-emission fuel tank will render the system inoperative . . . because the non-emission fill cap is vented and the system must be sealed to function properly. Conversely, a non-vented fill cap on a conventional tank will result in serious deformation of the tank.

VAPOR SEPARATOR "WING" TANK

Although not all vehicle models make use of the "wing" design, the compact series of cars do. If it is a canister or wing design, the separator tank is always physically situated above the level of the regular fuel tank and is normally found behind the left rear wheel well . . . ahead of the taillight assembly. The tank is secured to the rear back panel and inner roof rail.

CARBON CANISTER

The carbon canister is located within the engine compartment. It is situated on the right-hand firewall on Maverick and Mustang vehicles and on the lower frame rail on various other models. It is secured by a bracket and three bolts.

The unit is a stamped metal canister with an open space provided at the top and bottom.

A center tube is incorporated which extends to the bottom of the canister and has vapor holes along its entire length. The canister is attached externally (by hoses) to the carburetor air cleaner or to the PCV valve (depending on model application).

A somewhat smaller diameter tube extends to the bottom partition of the canister and is externally attached to the vapor hose that connects the three-way control valve.

A tube designed to accept a dust shield protrudes from the cover. The lower end is crimped to the cover itself. Some applications do not make use of the dust shield, but attach an inlet air hose from the carburetor hot-and-cold stove.

A stamped cover is securely attached to the canister by crimping the edges. The area between the top and bottom partitions is filled with a minimum of 500 grams of activated carbon that is tightly packed.

- Activated carbon has the capabilities of storing many times its own weight of fuel vapors, as well as self cleansing or purging which allows it to be re-used over . . . and over.

AIR CLEANER PURGE TUBE CONNECTOR

There are various air cleaners and devices that you will normally encounter while servicing late-model vehicles. As a brief review, the hot-and-cold duct assembly for pre-heating carburetor inlet air may be controlled either by vacuum or by temperature or by a combination of both.

On other models we've seen the following devices:

- Auxiliary air inlet valve and vacuum motor assembly
- Ram air intake
- Choke bleed valve . . . which allows cold air to be blended with hot air from the choke stove when underhood temperatures are below 50°F.

The purge tube connector is used on vehicles with carbon canister fuel evaporative emission systems. On vehicles without the canister, a plug is used.

The purge hose connects to the center of the carbon canister, while the stamped hole in the air cleaner is plugged on non-evaporative emission vehicles.

Remember to always disconnect various hoses and vacuum lines before removing the air cleaner assembly.

End of Part I • In the next issue, Part II will explain servicing emission control devices in detail.

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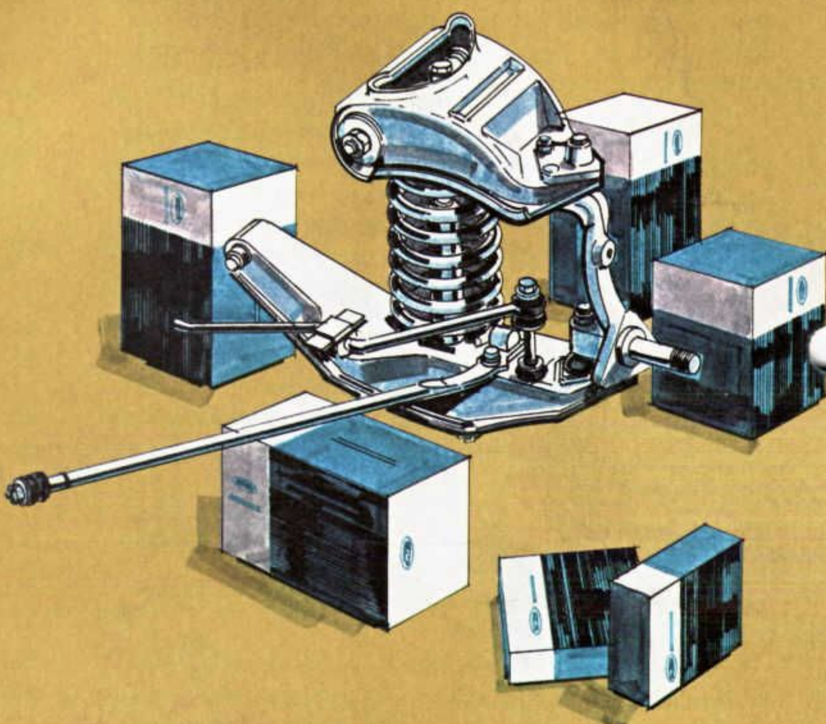

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