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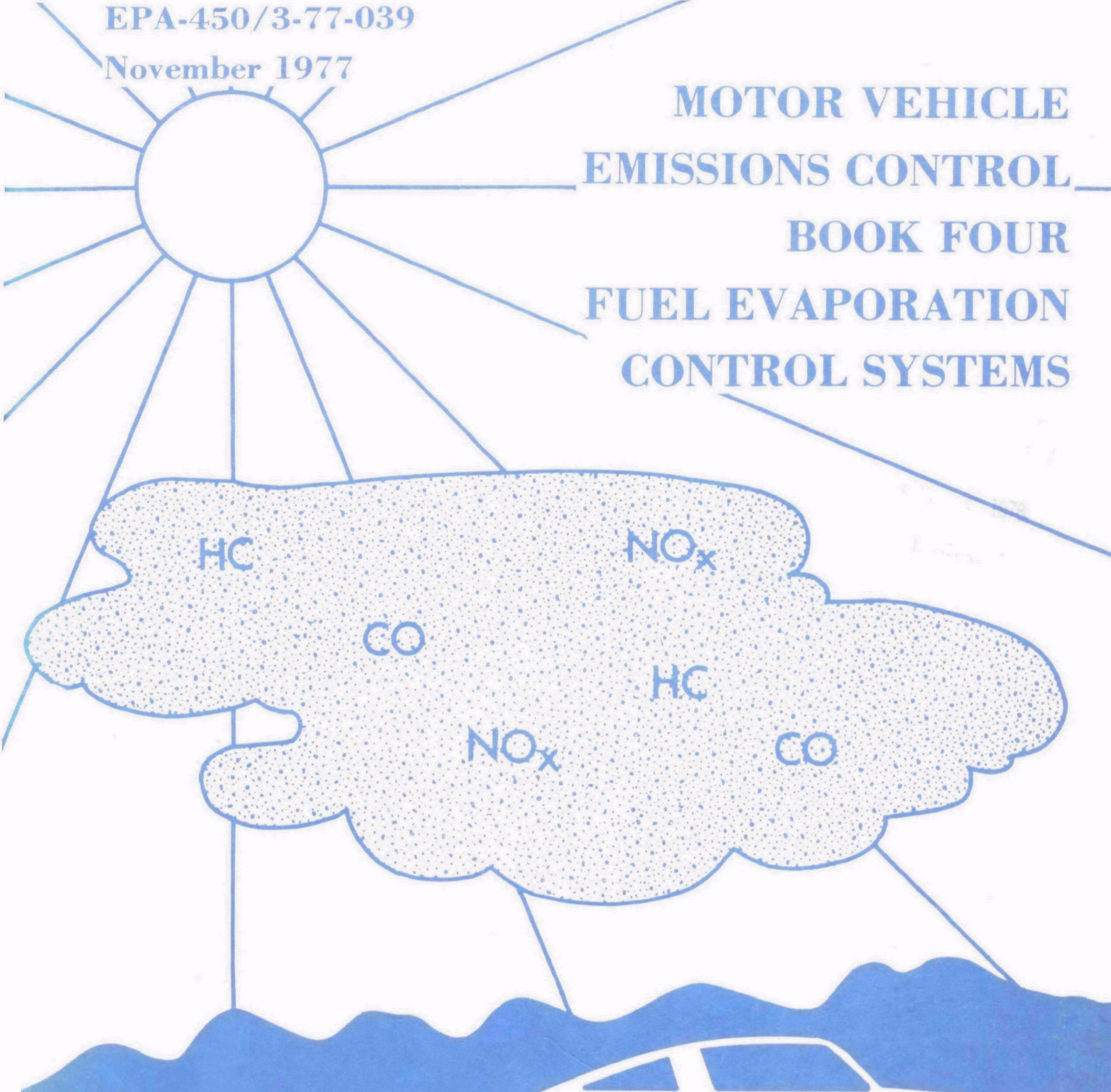
November 1977

MOTOR VEHICLE EMISSIONS CONTROL
BOOK FOUR
FUEL EVAPORATION CONTROL SYSTEMS



U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Air and Waste Management
Office of Air Quality Planning and Standards
Research Triangle Park, North Carolina 27711

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MOTOR VEHICLE EMISSIONS CONTROL
BOOK FOUR
FUEL EVAPORATION CONTROL SYSTEMS

by

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MOTOR VEHICLE EMISSIONS CONTROL

-- SERIES OF SEVEN BOOKS --

MOTOR VEHICLE EMISSIONS STAFF, COLORADO STATE UNIVERSITY

ACKNOWLEDGMENTS

The Motor Vehicle Emissions Control Staff of the Department of Industrial Sciences at Colorado State University would like to acknowledge the efforts extended by the Environmental Protection Agency, Research Triangle Park, and Region VIII Environmental Protection Agency, Manpower Development Division.

A special thanks must be extended to the automotive vehicle equipment and parts manufacturers for their cooperation and assistance in the development of this training material.

INSTRUCTIONS FOR THE USE OF THIS BOOK

This book is one of a series designed specifically to teach the concepts of automobile emissions control systems. Each book is designed to be used as self-instructional material. Therefore, it is important that you follow the step-by-step procedure format so that you may realize the full value of the emissions system which is being presented. The topics are taught in incremental steps and each topic treatment prepares the student for the next topic. Each book is divided into sections which include the introduction, purpose, function, inspection and testing of the emissions system presented.

As you proceed through this series, please begin with book one and read the following books in sequence. This is important because there are several instances where material covered in a given book relies on previously covered material in another book.

To receive the full benefits of the book, please answer the self-evaluation statements related to the material. These statements are separated from the text by solid lines crossing the page. The answers to the statement can be found at the end of the book as identified by the table of contents. You should check for the correct answer after you respond to each statement. If you find that you have made a mistake, go back through the material which relates to the statement or statements.

Fill-in-the-blank statements are utilized for self-evaluation purposes throughout the material. An example statement would appear like this:

The American flag is red, white, and ______.

You would write "blue" in the blank and immediately check your answer at the end of the book.

The material, statements and illustrations should be easy to follow and understand. In several illustrations a small ghost named "VEC" (Vehicle Emissions Control) has been used to make the picture easier to understand.

Upon completion of this series, you should be able to better understand the emissions control systems and devices which are an integral part of automobiles today. Your increased knowledge should help you keep these "emissions controlled" vehicles operating as they were designed to operate. Respectable fuel economy, performance and driveability, as well as cleaner air, can be obtained from the automobile engine that has all of its emissions systems functioning properly.

CONTENTS

INTRODUCTION TO EMISSIONS CONTROL

As we all know emissions systems and devices have been installed on the automobile engine because of the air pollution problem. In order for you to understand these emissions systems and devices you should have a background of the problem. All of the emissions control systems were installed on the engine to reduce just three specific exhaust products. These are known as products of combustion. The three products which the emissions systems are designed to reduce are hydrocarbons, carbon monoxide and oxides of nitrogen.

HYDROCARBONS

Gasoline, like all petroleum products, is made up of hundreds of hydrocarbon compounds. The name "hydrocarbon" has been given to these compounds because they are made up of hydrogen and carbon atoms. This is also the reason hydrocarbons have the abbreviation (HC).

Hydrocarbons are gasoline vapors or raw gasoline itself. One reason hydrocarbon emissions must be controlled is because it is one of the major components of photochemical smog. Photochemical or "Los Angeles" smog forms when hydrocarbons and oxides of nitrogen combine in the presence of sunlight. In order to avoid this smog condition the hydrocarbon emissions from automobiles must be controlled. Hydrocarbons also act as an irritant to our eyes and some are suspected of causing cancer and other health problems.

CARBON MONOXIDE

Another product of combustion that must be controlled is carbon monoxide. Carbon monoxide has the abbreviation (CO). CO is also hazardous to our health when it is mixed with the air we breathe. It can cause headaches, reduce mental alertness and even cause death if enough of it is in the air. Carbon monoxide is also a problem in that it speeds the formation of photochemical smog. For these reasons CO emissions must be controlled.

OXIDES OF NITROGEN

Oxides of nitrogen are the last harmful products of combustion we will discuss. Nitrogen oxides have been given the abbreviation (NO_x). As you already know, oxides of nitrogen and hydrocarbons combine to form photochemical smog. The sunlight which triggers the formation of photochemical smog has another effect on oxides of nitrogen. Some of the oxides of nitrogen are broken down and a gas called ozone is formed. Ozone is a lung and eye irritant and it also deteriorates rubber and affects the growth of vegetation. Since the nitrogen oxides have these effects they must also be controlled.

Now that you are familiar with the emissions which must be controlled let's find out where they originate.

FORMATION OF HYDROCARBONS

Hydrocarbons, you will recall, are fuel vapors or raw fuel. For this reason hydrocarbon emissions will result from any uncontained supply of gasoline. Hydrocarbon emissions also come from the tailpipe. If the automobile engine could achieve "complete combustion," all of the unburned fuel or hydrocarbons would be used up. However, it is impossible for today's automobile engines to achieve "complete combustion." Any time the fuel mixture in the combustion chamber is not completely burned, some hydrocarbons will be emitted from the tailpipe. The two main reasons why hydrocarbons are not completely burned are because of engine misfire and "quench areas." When an engine misfire occurs, none of the raw fuel or hydrocarbons are burned. When this happens they are simply exhausted directly to the atmosphere. Quench areas are places in the combustion chamber where the flame goes out before the fuel is completely burned. Small cavities such as where the head gasket seals the cylinder head to the block is a quench area. Another quench area is located between the top of the piston and the first compression ring. These areas are sources of hydrocarbon emissions.

FORMATION OF CARBON MONOXIDE

Carbon monoxide is partially burned fuel. Carbon monoxide is formed in the combustion chamber whenever there is not enough air to burn all the fuel. This means that whenever a "rich" air/fuel mixture is pulled into the combustion chamber carbon monoxide will be formed. After the flame goes out the carbon monoxide is exhausted through the tailpipe and into the air.

FORMATION OF OXIDES OF NITROGEN

Oxides of nitrogen are also formed in the combustion chamber. These oxides result from the nitrogen which is contained in our air. In some cases combustion temperatures in the automobile engine can exceed 4500°F. At temperatures above approximately 2500°F, nitrogen oxides will start forming. Therefore, if combustion chamber temperatures exceed 2500°F, oxides of nitrogen will be produced and then exhausted to our atmosphere.

Now that you understand how these emissions are formed in the automobile engine, we will see how changes in ignition timing and carburetor adjustment affect the amount of these pollutants.

As you know, changes in timing and carburetion can have a large effect on how an engine performs. These changes in timing and carburetion also can have drastic effects on the amount of pollutants which are present in the automobile's exhaust. The amount of hydrocarbons, carbon monoxide and oxides of nitrogen which are present in the exhaust gases will vary as timing and carburetion adjustments are changed.

IGNITION TIMING

Prior to emissions controlled automobiles, advancing the spark timing was a common practice. Setting the spark timing this way caused the spark plug to fire before the piston reached top dead center. This advanced spark timing allowed the maximum amount of heat energy to be exerted on the piston. As a result the best performance and fuel economy could be obtained. Unfortunately, this also produced high hydrocarbon and nitrogen oxide emissions levels.

In order to reduce emissions levels, ignition spark timing was retarded. By firing the spark plug after the piston reaches top dead center, not as much of the heat energy is converted to work on the piston. The extra heat energy which is not used on the piston now passes through the exhaust valve and into the exhaust manifold. This keeps the exhaust gas temperatures higher. These higher exhaust temperatures allow burning of the air/fuel mixture to continue in the exhaust manifold. This further oxidation or burning in the exhaust manifold helps to reduce HC and CO emissions.

Another advantage of retarded timing from an emissions standpoint is that combustion temperatures are not as high. This is due to the fact that the maximum combustion pressure will be lower. Since the combustion temperatures will be lower and the formation of oxides of nitrogen depends on temperature, a smaller amount of these pollutants will be exhausted to the atmosphere.

There is one more advantage to using retarded spark timing. As you know, when ignition timing is retarded the engine's idle speed will drop. This decrease in idle speed occurs because less heat energy is applied to the combustion chamber and more heat energy is being supplied to continue the burning process in the exhaust manifold. In order to regain an acceptable idle speed, the throttle plates must be opened wider. This wider throttle plate opening allows more air to pass through the carburetor. This increase in air flow will reduce the amount of residual exhaust gases in the cylinder. This in turn will allow a more burnable mixture which can be made leaner. Since the mixture can be leaner there will be more air in the combustion chamber. As you know, the more air that is made available during combustion the lower will be the HC and CO emissions.

CARBURETION

Adjustments made to the carburetor air/fuel ratio can also have a large effect on the amount of pollutants which come from the automobile engine. When idle mixture settings become richer there is less air present for the combustion process. This lack of air results in an increase in hydrocarbon and carbon monoxide emissions.

When the idle mixture screws are turned in, the amount of fuel is reduced and the mixture becomes leaner. This leaner mixture contains more air and therefore more oxygen is available for more complete burning of the fuel. This results in lower HC and CO emissions levels.

As the idle mixture screws are turned in, the idle air/fuel mixture becomes leaner. If this mixture becomes too lean a "lean misfire" will occur. A "lean misfire" will occur because the fuel is so diluted or thinned out by the air that the mixture will not ignite. This leads to a very large increase in hydrocarbon emissions. This happens because the failure of the mixture to ignite results in that amount of raw fuel being emitted to the atmosphere.

The carbon monoxide emissions decrease when a lean misfire condition is present. Carbon monoxide is partially burned fuel. Since no combustion takes place during a lean misfire condition no CO is formed and the total amount of CO produced by the engine will be less.

A lean misfire usually occurs in one or more cylinders. This condition may also move from cylinder to cylinder while the engine is running. This is caused by the uneven distribution of the air/fuel mixture delivered to each cylinder. This condition occurs mainly because of problems with intake manifold design.

Now you should understand how changes in timing and carburetion adjustment can affect emissions levels. With this knowledge you will be able to understand how each emissions control system we will discuss helps to reduce the air pollution caused by the automobile.

SYSTEM INTRODUCTION

The fuel used in most of today's automobile engines is gasoline which is made up of hydrocarbons. Gasoline is mixed with air to be burned in the combustion chamber; therefore, it must be able to vaporize or evaporate easily. Since gasoline is composed of hydrocarbons and evaporates easily, it is a major source of air pollution.

It was found that 20% of all hydrocarbon emissions were caused by fuel evaporation. There are two sources of hydrocarbon emissions caused by evaporation. The two sources of fuel vapors on the automobile are the

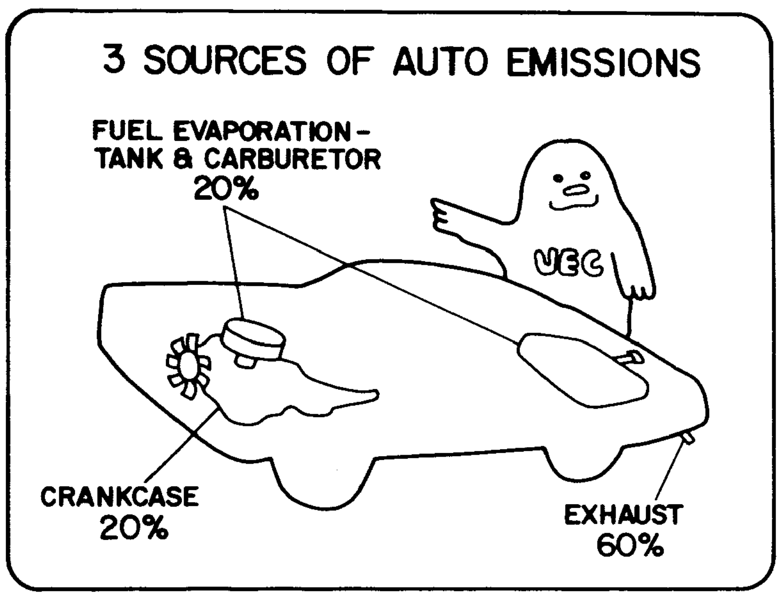

FIGURE 4-1

fuel tank and the carburetor. The evaporation rate will increase as the temperature increases. For this reason most hydrocarbon emissions from the carburetor take place when the engine is shut off. After the engine is turned off, air will no longer be circulating through the engine compartment. The temperature will increase in this area and cause some of the fuel in the carburetor to evaporate. Fuel will also evaporate from the fuel tank as the temperature around it increases.

In 1970 a system was installed on California automobiles to contain this fuel evaporation. This system was called the Fuel Evaporation Control system. It has been used on all US automobiles since 1971. This system was designed to seal the entire fuel system from the atmosphere. This prevents the hydorcarbons from escaping into the atmosphere.

The fuel evaporation control system has several different names. As you can see in figure 4-2, all manufacturers use their own name for this system. However, each one of these systems has the same purpose and operates in the same manner.

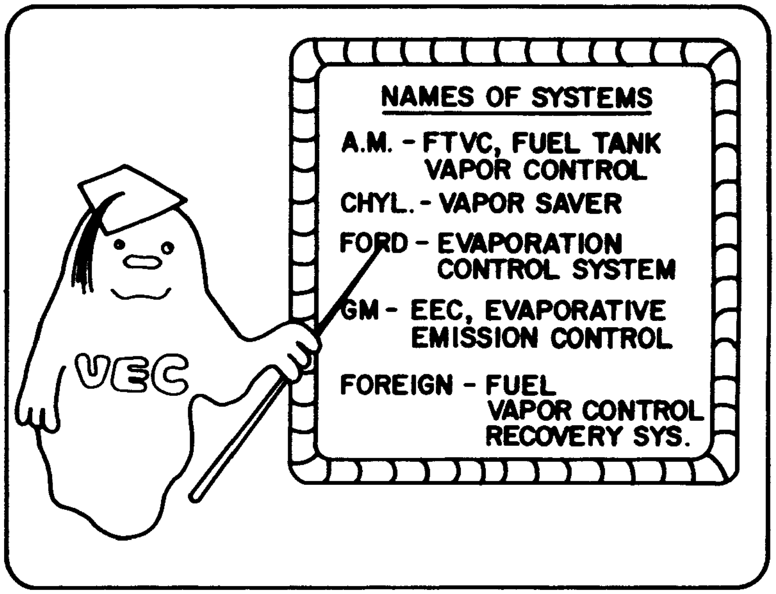

FIGURE 4-2

This system is designed to trap the gasoline vapors in the fuel system. In order to do this the fuel system had to be redesigned. The fuel tank and carburetor were sealed from the atmosphere. This stopped the evaporation of the fuel. This in turn stopped the hydrocarbon emissions. Also a storage system was used to trap the vapors which were given off by fuel in the carburetor and fuel tank. When the engine is first started these vapors in the storage system are drawn into the engine and burned. This empties the storage device to allow a place for any other vapors to accumulate.

This system also prevents wasting gasoline. Since the fuel tank has been redesigned it is now impossible to overfill the gas tank. Fuel can no longer escape to the atmosphere through the gas cap. This prevents loss of fuel when the temperature increases or the vehicle is parked on a hill.

With the use of this system it is possible to control the evaporative loss and the HC emissions from this source. In using this system 20% of all the HC emissions from the automobile are eliminated.

---

1. Before the use of the FEC system ______ of all hydrocarbon emissions were caused by fuel evaporation.

---

2. The evaporation of fuel causes hydrocarbon emissions. The two sources of fuel vapors on the automobile are the ________ ________ and the ____________________.

---

3. As the temperature ________________, the evaporation rate of gasoline will increase.

---

4. Since the evaporation rate of gasoline increases as the temperature increases, most hydrocarbon emissions from the ____________________ take place when the engine is shut off.

---

5. The fuel evaporation control system is designed to seal the entire fuel system from the ____________________.

---

6. The storage system is used to ______________ the vapors which are given off by the fuel in the carburetor and fuel tank.

SYSTEM/COMPONENT PURPOSE

As you will recall from the introduction the fuel evaporation system contains the vapor given off by raw gasoline. This stops the HC emissions which were a problem before this system was used.

The purpose of the fuel evaporation system is to trap these gasoline vapors and return them to the fuel system. Once these vapors are returned to the fuel system they may be burned in the combustion chamber.

The fuel evaporation control system is made of several components. Not all manufacturers use the same components in their system. However, all of the systems do have the same purpose. A typical fuel evaporation system is shown in figure 4-3.

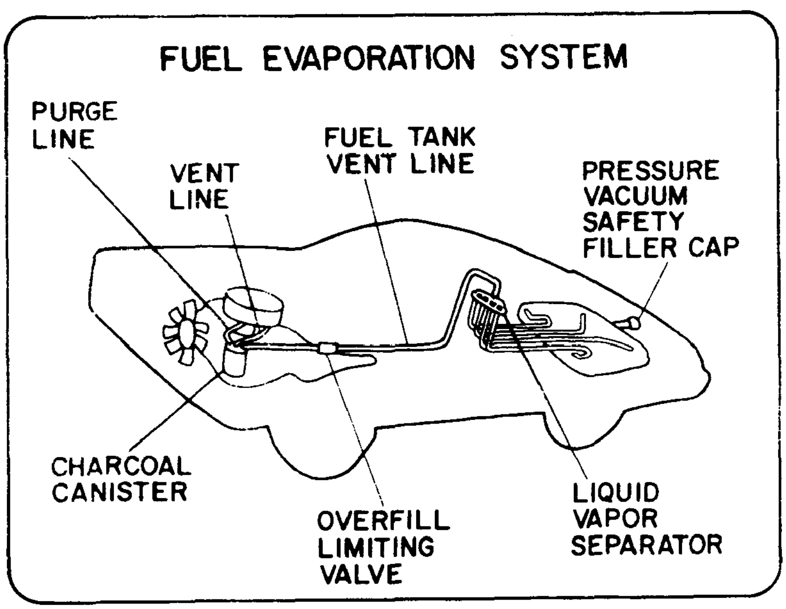

FIGURE 4-3

All manufacturers use similar components in their individual systems. Each fuel evaporation system will have a redesigned fuel tank and gas cap, a liquid vapor separator, a charcoal canister, and an overfill device. The purpose of each one of these components will now be discussed.

Before the fuel system was sealed to prevent hydrocarbon emissions automobiles were equipped with vented gas caps. A typical vented gas cap is shown in figure 4-4. These vented gas caps allowed raw fuel vapors to

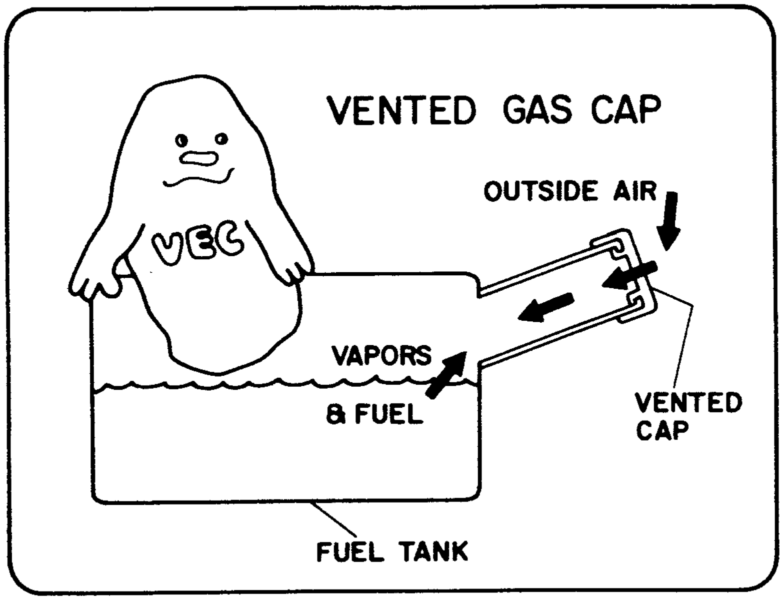

FIGURE 4-4

escape to the atmosphere. Under some conditions these gas caps would even allow liquid gasoline to escape. For these reasons, the gas caps were redesigned when the fuel evaporation system was developed.

SEALED GAS CAP

The new gas caps which are used on the emissions control equipped cars

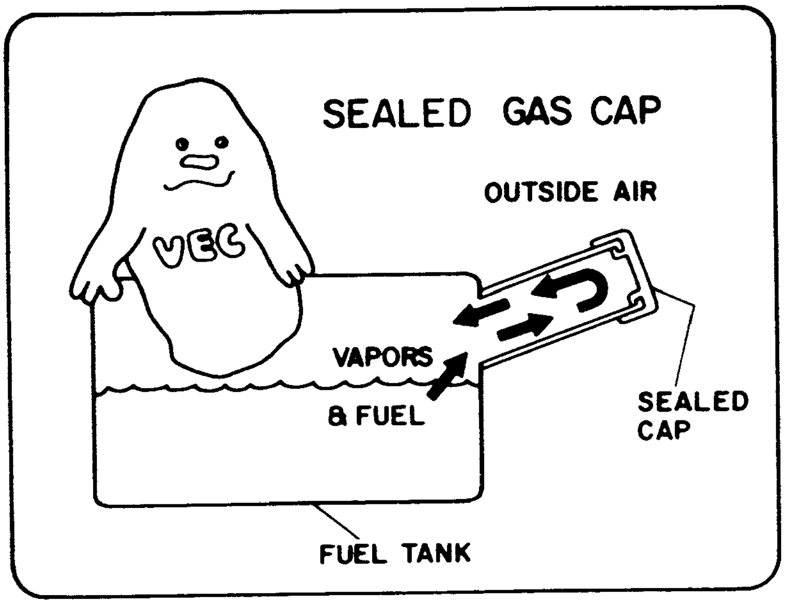

FIGURE 4-5

are not vented. The purpose of these new caps is to prevent any liquid gasoline or vapors escaping from the tank.

This prevents hydrocarbons emissions from the fuel tank under most conditions.

---

7. The main purpose of the fuel evaporation system is to prevent gasoline HC vapors from escaping into the ____________________.

---

8. Automobiles were equipped with ____________ gas caps before the use of the FEC system.

FUEL TANK

In addition to redesigning gas caps, the fuel tank has been modified. The fuel tanks found on today's cars now have some type of expansion space built into them. This additional space is to allow room for the

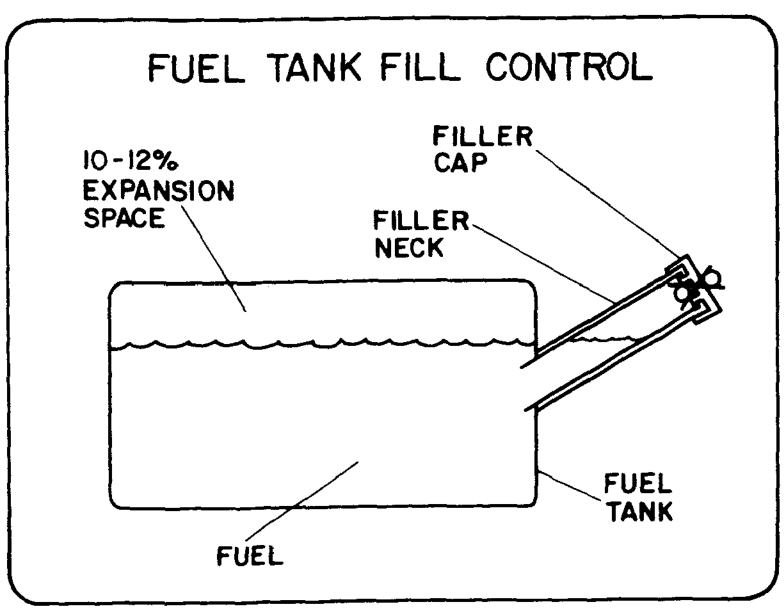

FIGURE 4-6

gasoline as it expands when the temperature increases. The expansion space is usually about 10-12% of the total tank volume. This additional space in the gas tank combined with the redesigned gas cap prevents fuel from escaping from the tank. At this point you know what has been done to contain the raw gasoline but what happens to the vapors?

LIQUID VAPOR SEPARATOR

As you can see in figure 4-7 a device called a liquid vapor separator is connected to the fuel tank by several vent lines. The purpose of this liquid vapor separator, as the name implies, is to separate the raw fuel

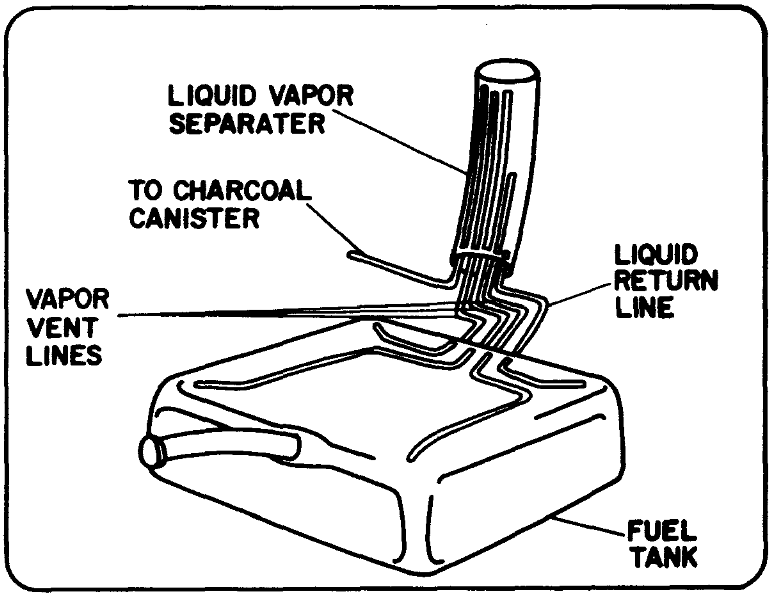

FIGURE 4-7

from the vapors. This is done so the liquid or raw fuel may be returned to the fuel tank and the vapors sent to a storage device.

---

9. The additional space provided in the new fuel tanks is to allow room for the gasoline as it expands when the temperature ________________.

---

10. The expansion space in the new fuel tanks is usually about __________ of the total tank volume.

---

11. The liquid vapor separator is normally located near the fuel tank. Its job is to separate the fuel vapor from the __________ fuel.

CHARCOAL CANISTER

A vapor line from the liquid vapor separator runs forward to the storage device. The liquid vapor separator is normally located near the fuel tank. The vapor storage device is normally located in the engine compartment and is referred to as a charcoal canister. However, 1971 and 1972 Chrysler automobiles used the engine crankcase for storing the gasoline vapors. The purpose of the storage device or charcoal canister is to contain the fuel vapors given off from the fuel tank and the carburetor. The vapors are held in this device until the engine is started. At this time the vapors are drawn out of the charcoal canister and burned in the combustion chamber.

Since the charcoal canister is designed to store vapors, it is important to keep liquid gasoline out of the canister. This is why an overfill device is put in the vapor line somewhere between the liquid-vapor separator and the charcoal canister. This overfill device serves the purpose of stopping any liquid gasoline which might get past the liquid vapor separator and into the vapor line. This saves the charcoal canister from becoming saturated with raw fuel.

The various vacuum and vapor hoses complete the fuel evaporation system. These are connected between the components to operate the system. The positioning and location of these connecting lines will be discussed further in the system function section of this book.

---

12. The vapor storage device which is usually referred to as a ______________ canister, is normally located in the engine compartment.

---

13. Fuel vapors are held in the charcoal canister until the engine is ____________.

---

14. An ______________ device is used in the vapor line between the liquid/vapor separator and the charcoal canister. This device is used since the charcoal canister is designed to store vapors and it is important to keep liquid gasoline out of the canister.

SYSTEM/COMPONENT FUNCTION

In this section we shall talk about the function of each component in the fuel evaporation system. Then we will see how these components work together to make the whole system function.

SEALED GAS CAP

The new fuel tank caps which are used on the emissions control equipped automobiles are not vented. Any new fuel tank cap has two built-in safety relief valves. As you can see in figure 4-8, a safety pressure relief valve and a safety vacuum relief valve are now part of the automobile fuel tank cap. Any time an excessive pressure condition is present

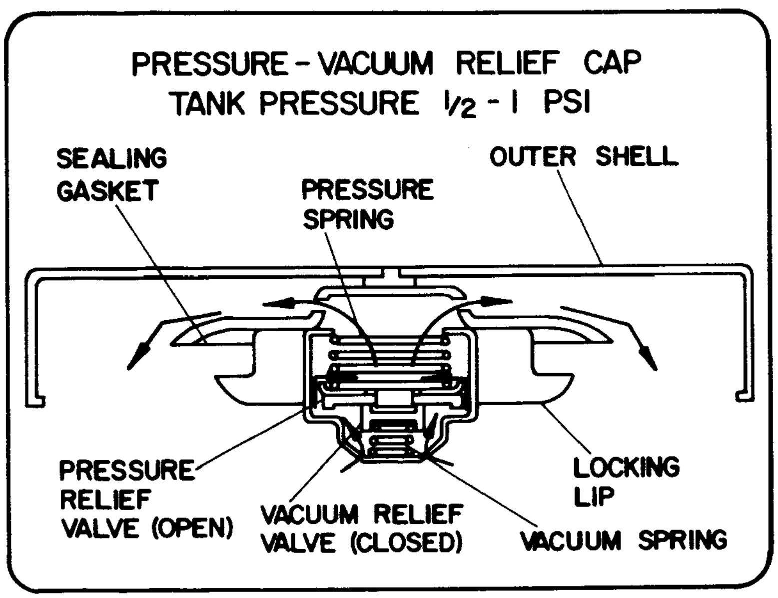

FIGURE 4-8

in the gas tank, the pressure relief valve will open and bleed to the atmosphere. For example, this might happen after the cool gasoline is pumped from the underground storage tank filling the automobile's fuel tank. As the temperature of the fuel rises it will expand and any excess pressure that may build in the tank will be relieved through the cap.

In figure 4-8, you can see the parts of the gas cap. As this pressure builds in the tank, the pressure spring will be compressed. This will move the pressure relief valve off its seat allowing the excess pressure to be vented to the atmosphere. This will occur anytime the pressure in the tank exceeds 1/2 to 1 psi.

The gas cap is also designed to relieve vacuum conditions in the tank. Since the new caps are sealed whenever fuel is drawn from the tank by the fuel pump a vacuum will be created in the tank. As you can see in figure 4-9, when a vacuum is present in the tank the vacuum spring will

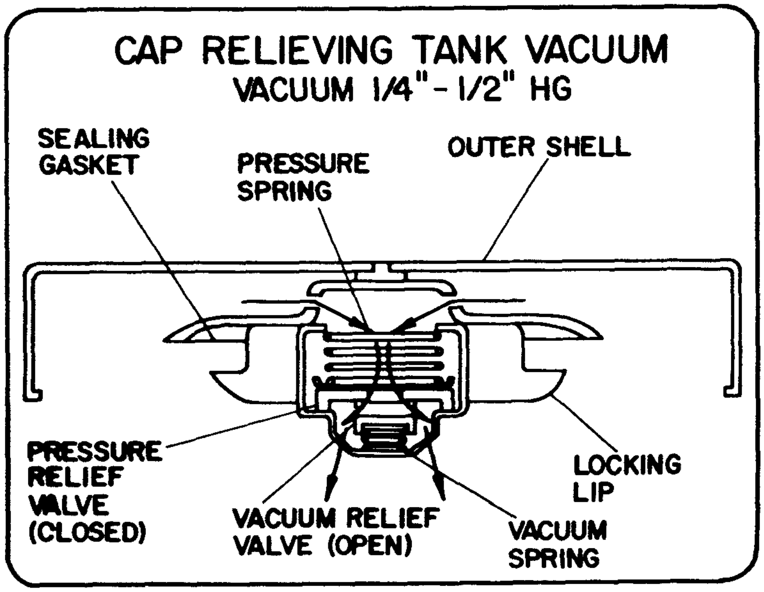

FIGURE 4-9

be compressed and the vacuum relief valve will open. This will allow air into the tank and return the tank to atmospheric pressure. A vacuum of 1/4 to 1/2" Hg is required to open this valve.

---

15. ______ safety relief valve(s) are built into all new fuel tank filler caps.

---

16. Whenever an excessive pressure condition is present in the gas tank, the pressure relief valve will open and bleed to the ________________.

17. The safety pressure relief valve built into the present fuel tank filler cap opens when pressure in the fuel tank exceeds approximately ______________________.

18. The new safety relief cap is also designed to relieve __________ conditions in the tank.

FUEL TANK

Now we shall take a closer look at the redesigned fuel tanks used on the emissions controlled automobile. As you will recall, an expansion space of 10% to 20% is provided in these new tanks. There are several designs used by automobile manufacturers to provide this expansion space.

By far the most popular method of providing an expansion space in the

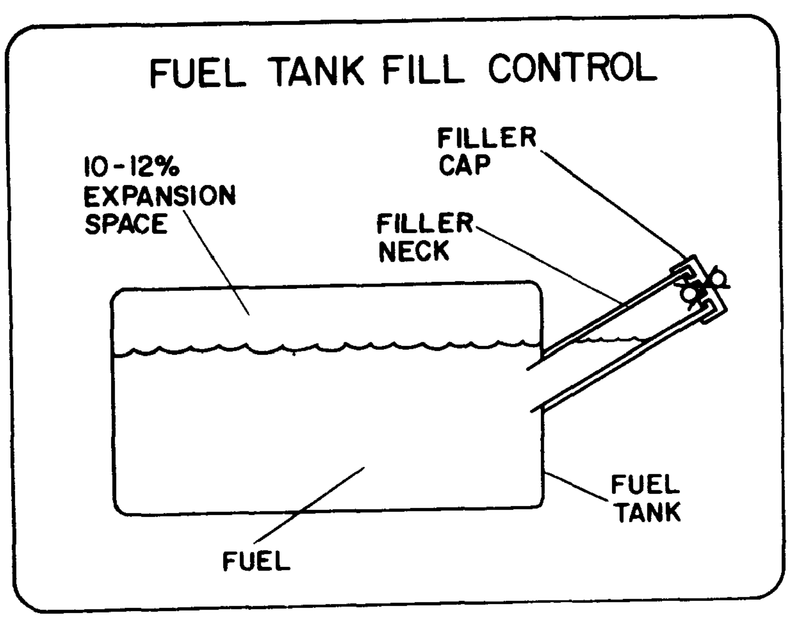

FIGURE 4-10

fuel tank is shown in figure 4-10. The filler neck is located in such a way that an air pocket will be trapped in the top of the tank. This will provide the needed expansion space.

Another means of accomplishing this expansion space is shown in figure 4-11. This tank uses a fill control tube to shut off the gas pump nozzle. The gas pump nozzle will shut off when all but 10-12% of the

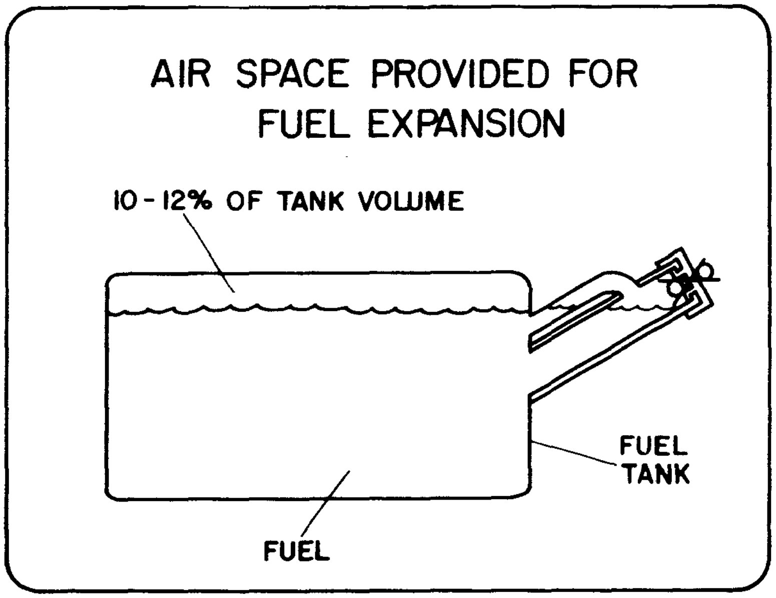

FIGURE 4-11

tank is full. This will provide the necessary expansion space in the tank. The fill control tube is designed to feed gasoline back to the filler neck when the tank is full except for its expansion space. At this time the fuel will rise through the fill control tube until it contacts the gasoline pump nozzle. The fuel when contacting the nozzle will trigger it to its off position. This will prevent any more gasoline from being added to the tank. The 10-12% expansion space will remain in the tank.

Another means of providing the needed expansion space is through the use of an external expansion tank. This is pictured in figure 4-12. This works much like the method just described. A fill control tube will

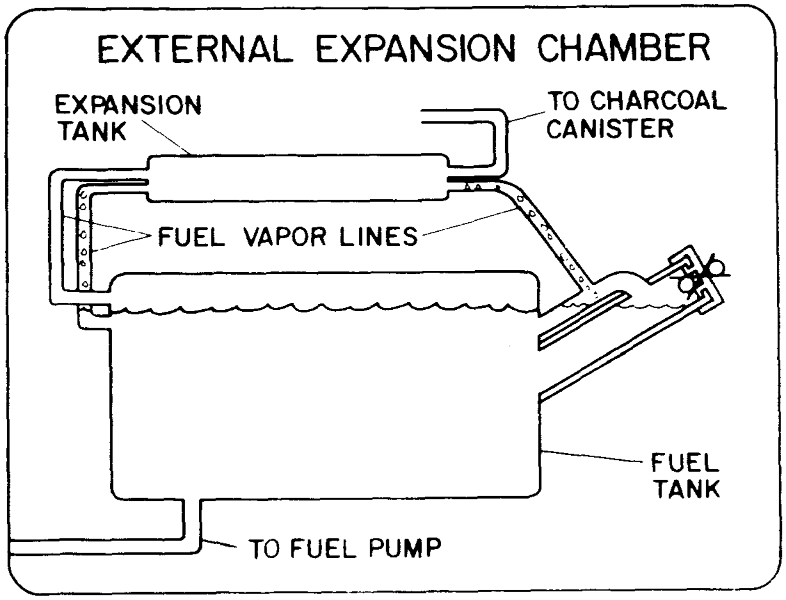

FIGURE 4-12

shut off the gasoline pump nozzle when the main tank is full. The expansion space will be provided in the external tank. This external tank is located near the main fuel tank and looks like a miniature fuel tank.

LIQUID VAPOR SEPARATOR

You will recall from the purpose section of this unit that the vapors are separated from the raw fuel and sent on to the storage device. This process of separating vapors and liquid fuel is done with a liquid vapor separator.

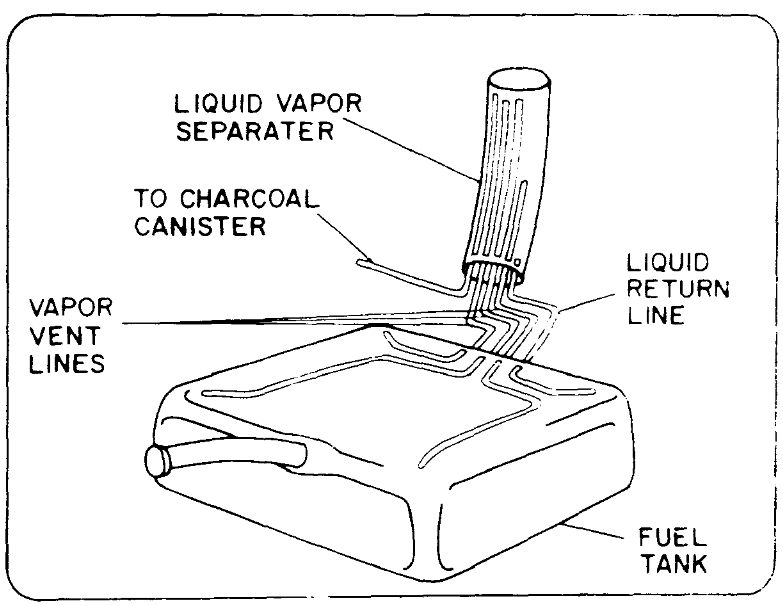

FIGURE 4-13

Figure 4-13 shows the fuel tank, vent lines and liquid vapor separator. Automobiles equipped with the fuel evaporation system will have several vent lines connected to the corners of the fuel tank. These vent lines run from the tank to the liquid vapor separator.

There is also a liquid return line which connects to both the tank and the separator. The remaining line which connects to the liquid vapor separator runs to the storage device or charcoal canister and provides a way to remove the vapor from the tank and separator. A cut-away view of the liquid vapor separator is shown in figure 4-14. Now we will look

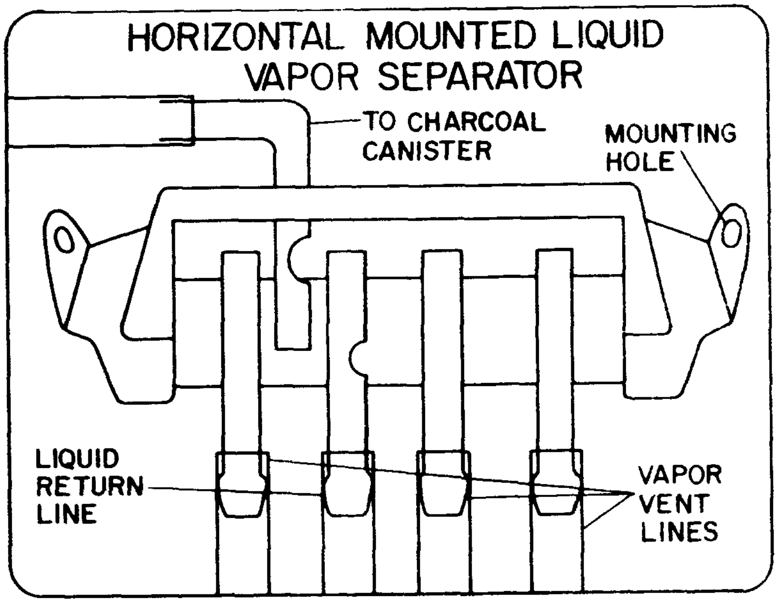

FIGURE 4-14

at how the separator functions. The separator shown in figure 4-14 has three vapor vent lines and a liquid return line. The vapor vent lines provide a means for the vapor to leave the tank. Some amount of liquid gasoline will also enter the separator through these lines. The liquid return is either a shorter line or it will have a hole cut in it near the bottom of the separator. The shorter effective length of the liquid return line will drain the liquid which enters the separator back to the tank. Since the separator is mounted slightly higher than the gas tank the liquid gasoline will naturally flow back to the tank. The vapor which enters the separator is much lighter than the gasoline. For this reason it will stay in the upper portion of the separator. As the vapor comes from the tank it will push any vapors in the separator out through the highest line in the separator. This line connects to the storage device and will usually have a small orifice where it joins the separator. The orifice is to aid in preventing liquid gasoline from entering this line. From this you can see how the separator can return the liquid gasoline to the tank and allow the vapors to move on to the charcoal canister.

---

19. The fuel tanks on most cars are prevented from being filled 100% because of the expansion space of ___-___% designed into the tank, or the design of the filler neck on the fuel tank.

---

20. Most automobiles equipped with the fuel evaporation system will have several vent lines connected to the corners of the ________ ________.

LIQUID CHECK VALVE

A few automobiles do not use a liquid vapor separator in their fuel evaporation system. Instead, a valve is used to allow the vapors to pass from the tank to the charcoal canister. The liquid check valve is shown in figure 4-15. This valve is built into the tank on some models and mounted outside the tank on others. The vent lines from the tank enter the valve at the bottom. The line to the vapor storage device is located at the top of the valve. Figure 4-15 shows the liquid check valve in the open position. In this position, fuel vapors from the

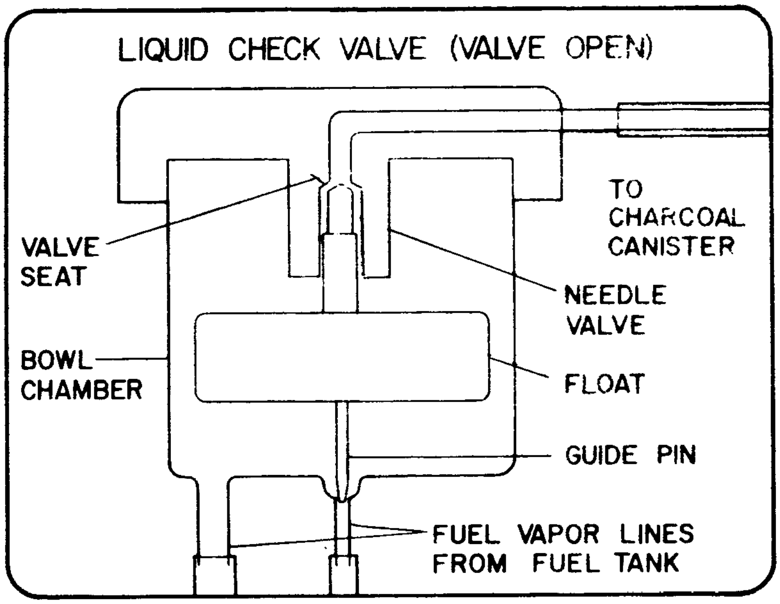

FIGURE 4-15

tank can enter the bowl chamber. These vapors will pass between the needle valve and the valve seat and move on to the charcoal canister. However, if liquid should happen to pass through the tank vent lines, the liquid check valve will close. Figure 4-16 shows the liquid check valve's operation when liquid gasoline enters this device. As you can

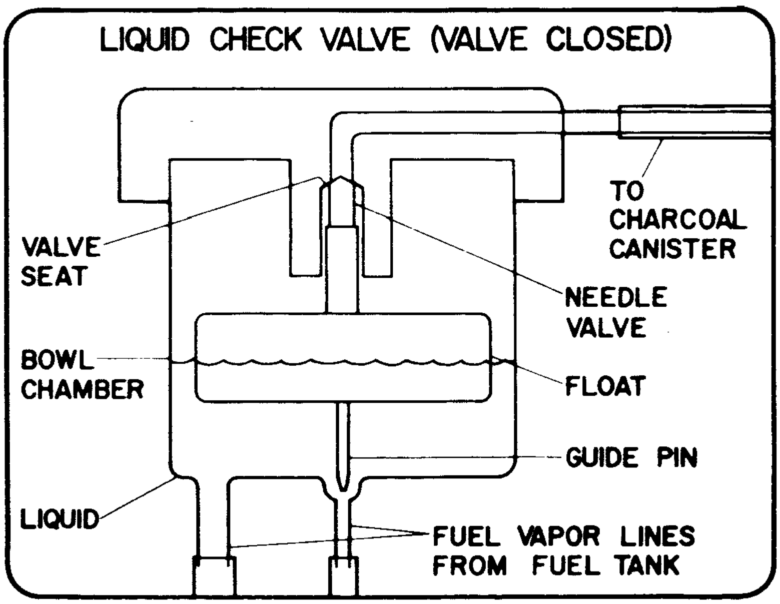

FIGURE 4-16

see, the liquid will enter the bowl chamber through the vent lines. As the gasoline level rises in the bowl chamber, the float will remain above the gasoline. The needle valve is connected to the float. As the float rises the needle valve contacts the valve seat. This will close the line to the charcoal canister. No more fuel will be allowed to enter the valve. As gasoline is used the fuel in the liquid check valve will return to the tank and the valve will again pass vapors to the canister. Now you can see how this liquid check valve acts as a liquid vapor separator and a control to prevent the canister from receiving liquid fuel.

OVERFILL LIMITING VALVE

The overfill limiting valve used on some Chrysler and Ford vehicles works much the same as the liquid check valve. Figure 4-17 shows an overfill

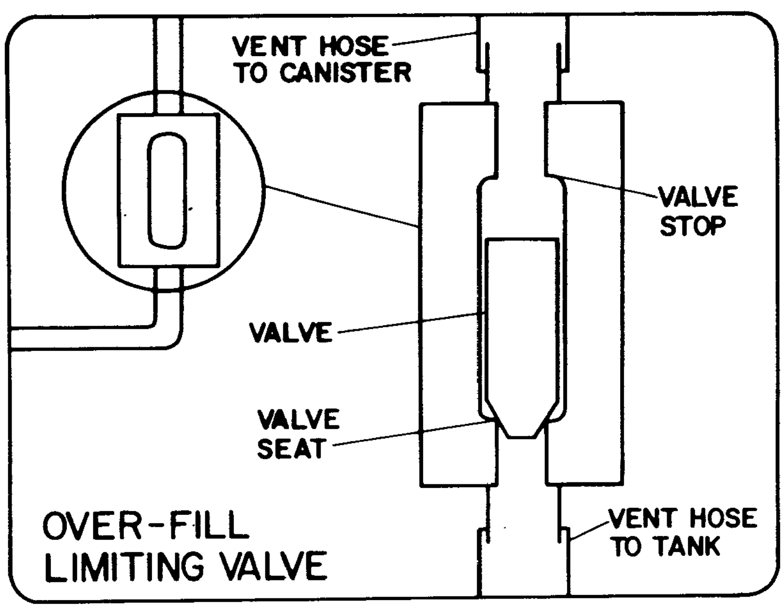

FIGURE 4-17

limiting valve. This valve is usually quite small and is located in the vapor line which leads to the canister. Its function is to prevent any liquid which might pass through the separator from reaching the canister. If liquid reaches this device the valve will float on the fuel until it contacts the valve stop. This will close the line and prevent the fuel from reaching the canister. In normal operation the vapors will pass between the valve and the valve seat. They will then pass on to the cansiter.

THREE-WAY VALVE

Some Ford vehicles did not use a pressure-vacuum fuel tank cap. For this reason a device had to be used to vent any excess pressure or vacuum from the system. A three-way valve is used on these automobiles. This valve is also located between the liquid vapor separator and the charcoal canister. Figure 4-18 shows the three-way valve in its pressure venting condition. This valve will be in this position whenever a vapor pressure

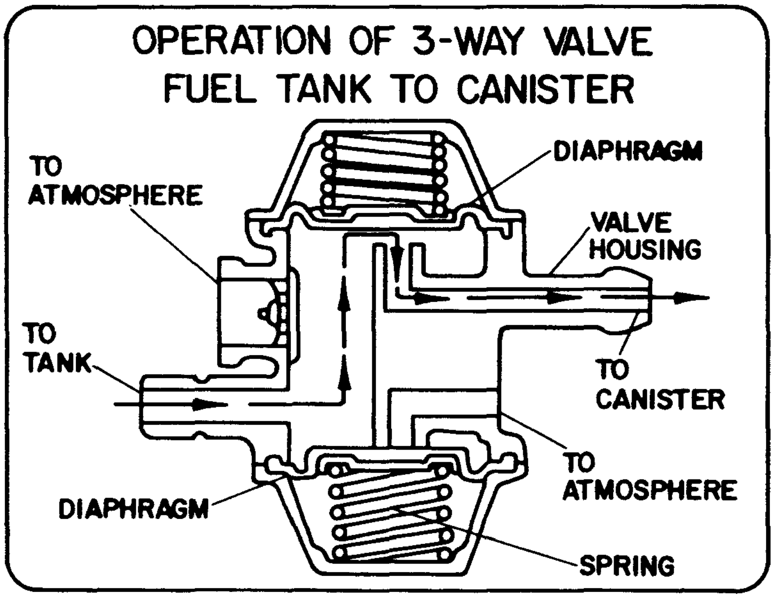

FIGURE 4-18

condition exists in the tank. This pressure acts upon the upper diaphragm and compresses the upper spring. In this position the vapors will move on to the storage canister. When a vacuum condition is present in the fuel tank the upper diaphragm will seat and the atmosphere bleed will open. This condition may be seen in figure 4-19. The atmosphere bleed valve will remain open until the vacuum condition is removed from the tank. The bleed valve will then close. The lower spring and diaphragm are used as a safety pressure relief valve to protect the gas tank. If the vent line to the canister or the canister itself became blocked, it would be necessary to vent the pressure in the system to the atmosphere.

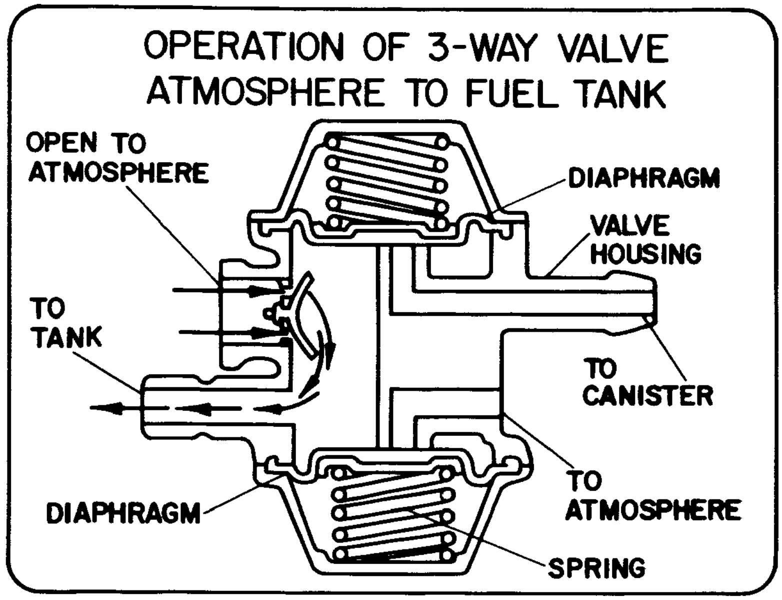

FIGURE 4-19

Figure 4-20 shows the three-way valve in this position. The upper spring and diaphragm will open when a small vapor pressure condition occurs. If a blockage in the vent line is present the vapor pressure will increase.

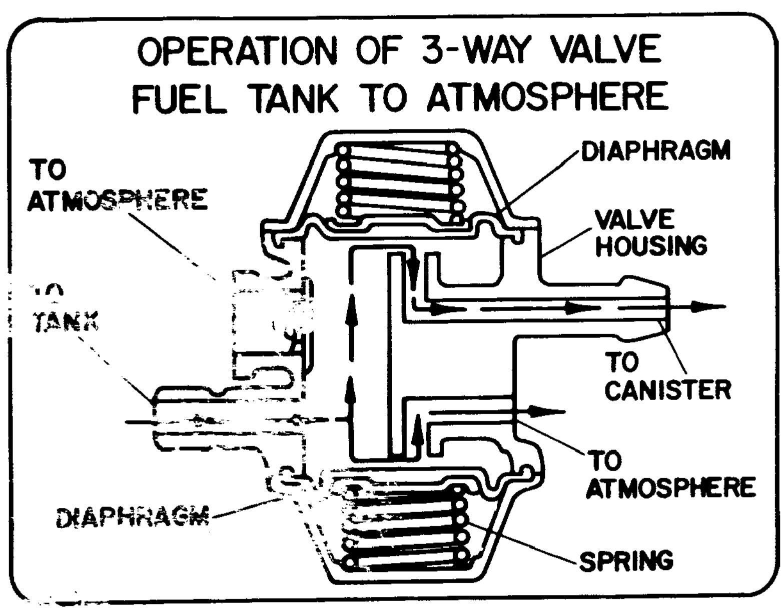

FIGURE 4-20

This higher pressure will push the lower diaphragm and spring off its seat and vent this pressure to the atmosphere. This will prevent the tank from deforming due to the high pressure.

---

21. The purpose of the liquid check valve's bowl and float is to allow vapors to flow through the valve but stop any liquid from entering the vapor line to the ________________.

---

22. A __________________ valve is used on some Ford vehicles which did not use a pressure-vacuum gas tank cap.

---

23. If the vent line to the canister or the canister itself became blocked in a three-way valve system, it would be necessary to vent the pressure in the system to the ____________________.

At this point, you should understand how the liquid gasoline and the gasoline vapors are separated. You have seen how the liquid is returned to the tank and how the vapors are sent to the storage device. We have also looked at several devices which aid in preventing any liquid from reaching the canister. We shall now look at the canister itself and its connecting lines.

CHARCOAL CANISTER

Figure 4-21 shows a cut-away view of a charcoal canister. This storage canister uses activated charcoal granules to store the fuel vapors. The typical canister contains about 1 1/2 pounds of charcoal. This is enough charcoal to store about one cup of fuel in its vapor form. The canister shown in figure 4-21 has two connecting hoses. One line brings the vapors from the tank to the canister. The other line connects to the carburetor, PCV hose or air cleaner. This line is called the purge line.

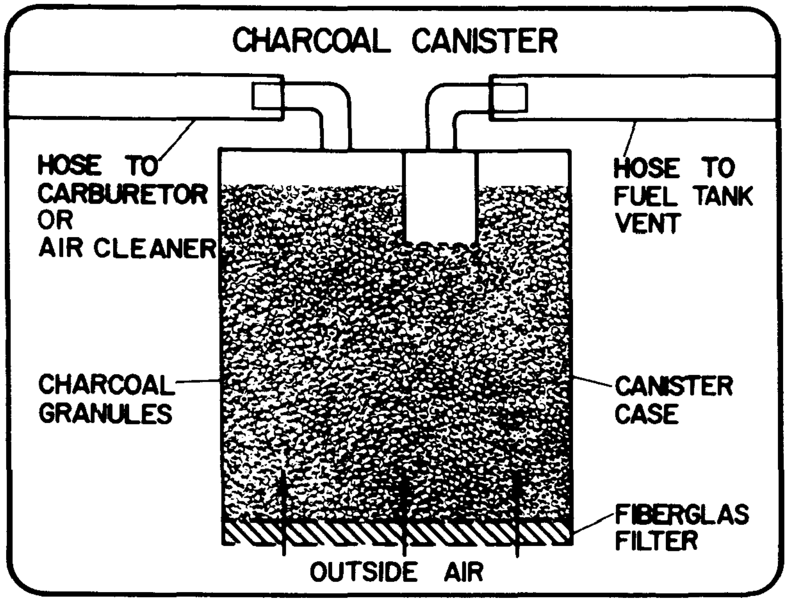

FIGURE 4-21

The bottom of the canister is open to the atmosphere. It also has a fiberglass filter which covers the open bottom of the canister. This filter is simply an air filter used to clean the air which is drawn through the canister.

---

24. Activated ________________ granules are used to store the fuel vapors in the charcoal canister.

---

25. A typical canister contains about 1 1/2 pounds of charcoal. This is enough charcoal to store about ______ cup(s) of fuel in vapor form.

When the engine is started, a vacuum condition will be created in the air cleaner and the carburetor. Figure 4-22 shows what will happen after the engine is started.

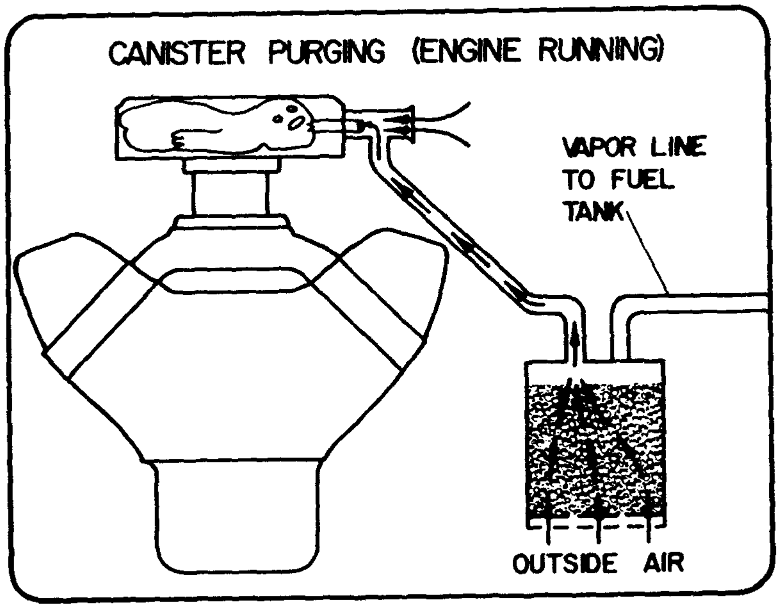

FIGURE 4-22

This vacuum will draw fresh air through the filter in the bottom of the canister. This air will then move through the charcoal granules removing the gasoline vapors. This is called the evacuation or purge cycle. The air and gasoline vapors, after being purged from the canister, are drawn into the intake manifold and burned in the combustion process.

The charocal canister in figure 4-23 is of a slightly different design. This design has an open space above and below the granules.

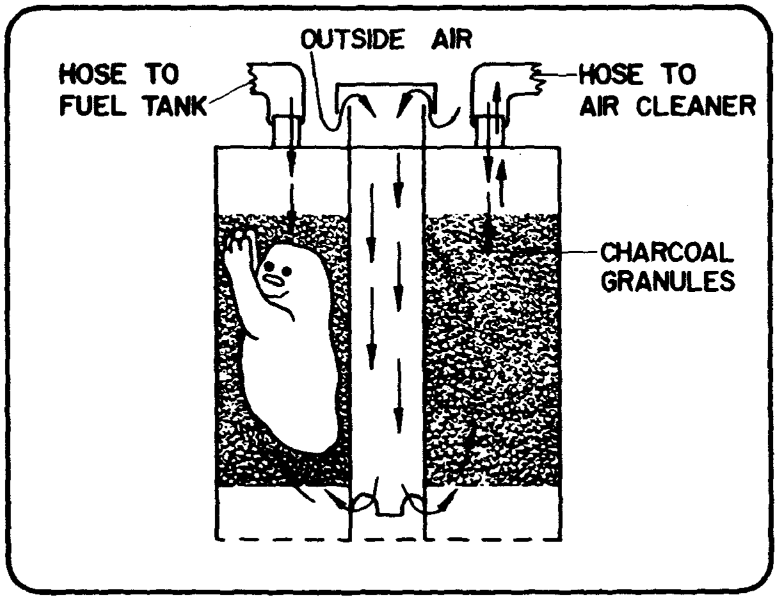

FIGURE 4-23

It also has a tube which extends from the bottom of the canister out through the top. The purge line of this system will connect to the air cleaner or the PCV line. When the car is started a vacuum condition will result in the purge line. This vacuum will draw fresh air down through the center tube. The air will then pass up through the granules removing the gasoline vapors.

The engine crankcase is another area which has been used to store gasoline vapors. This system is shown in figure 4-24. When the engine is started

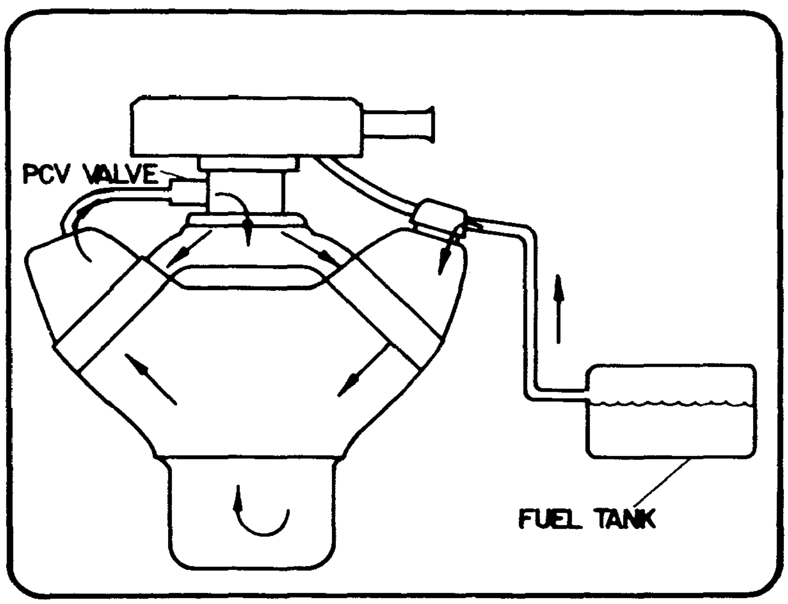

FIGURE 4-24

the stored vapors are drawn into the engine intake system through the PCV valve. This "purges" the stored vapors from the crankcase so it will be ready to store more vapors when the engine is shut off.

ANTI-PERCULATOR VALVE

Before we had emissions controlled automobiles, the carburetors were vented to the atmosphere. This was a source of hydrocarbon emissions. For this reason, the carburetor float bowl is now vented to the charcoal canister. An anti-perculator valve is used to control this venting operation. As can be seen in figure 4-25, the throttle plate is closed.

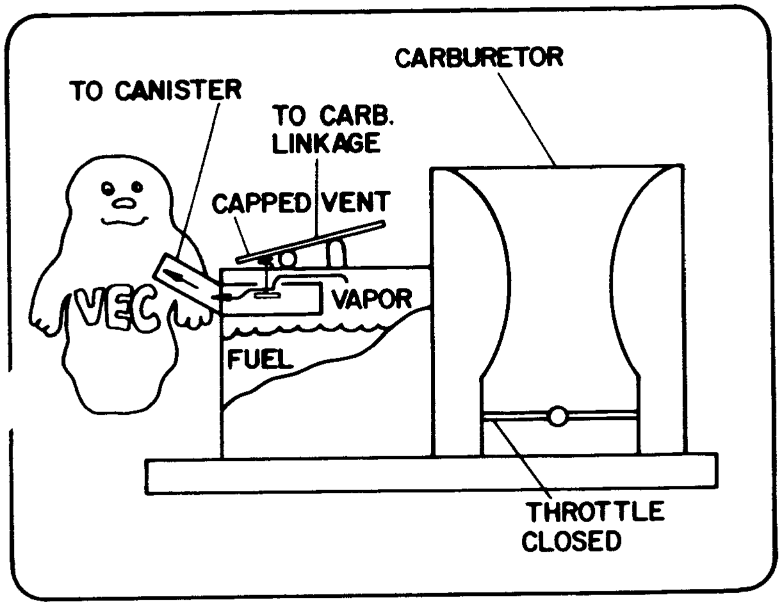

FIGURE 4-25

This will open the anti-perculator valve and vent the vapors into the charcoal canister. When the throttle plate is open, as in figure 4-26, the anti-perculator valve will close and seal the float bowl from the canister. In this way, any excessive vapors which are given off after the engine is shut off will be vented to the charcoal canister.

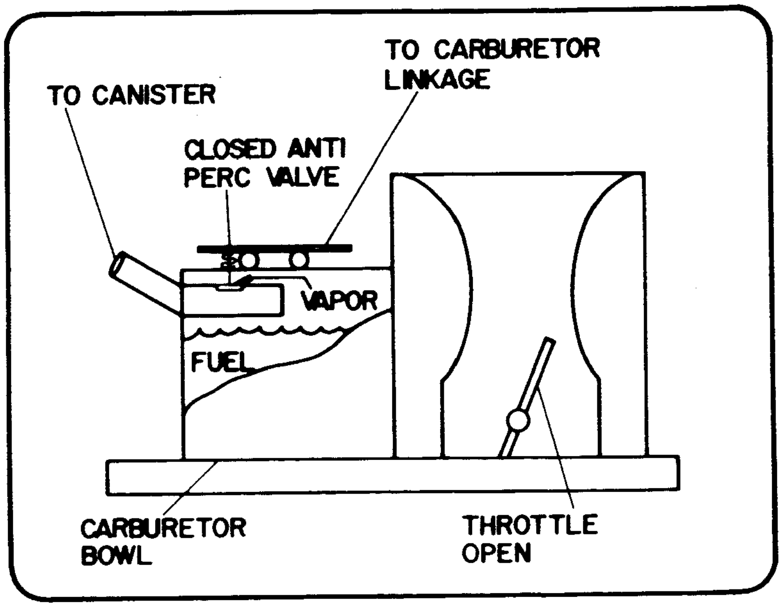

FIGURE 4-26

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26. After the air and gasoline vapors are purged from the canister, they are drawn into the ____________ ________________ and burned in the combustion process.

---

27. In the crankcase storage system when the engine is started, the vapors are drawn into the engine intake system through the ______ valve.

---

28. The anti-perculator valve assures that any excessive vapors which are given off from the carburetor after the engine is shut off will be vented to the ________________ ________________.

Now you should understand the vapor storage devices. It is time to look more closely at the various ways to purge these components of their stored vapors.

VARIABLE PURGE

One method of purging the storage canister is shown in figure 4-27. This

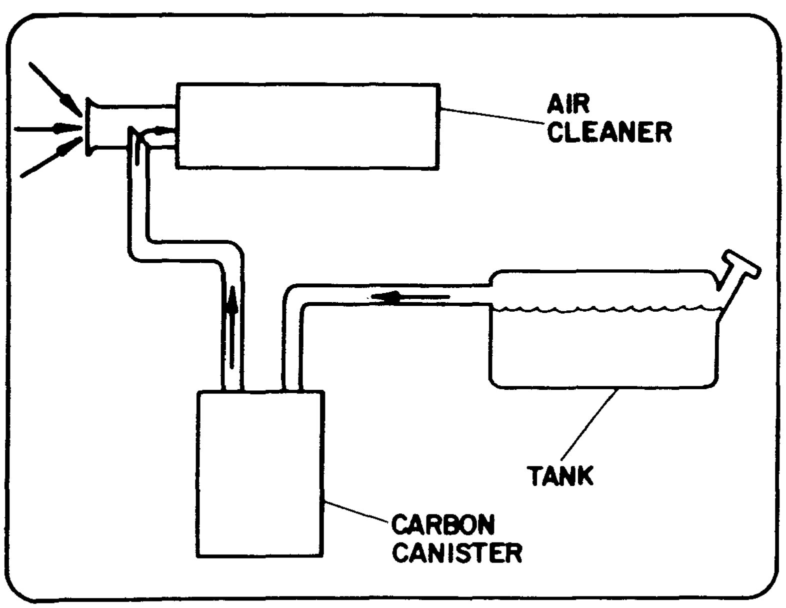

FIGURE 4-27

system has its purge line connected to the air cleaner snorkel. As intake air passes through the snorkel a small vacuum will be created in the purge line. When the speed of the air passing through the snorkel increases the purge vacuum increases. This will cause the purging action to increase. The amount of purging will vary with throttle plate position. For this reason it is called a "Variable Purge."

The purging system shown in figure 4-28 is much the same as the one just discussed. This system of purging, however, uses a second purge line which connects inside the air cleaner. This line, however, is on the carburetor side of the air filter. For this reason, at low air velocity conditions the purging is done through this second line. As the air flow speeds up, the purging is done through the snorkel purge line as in the variable purge system.

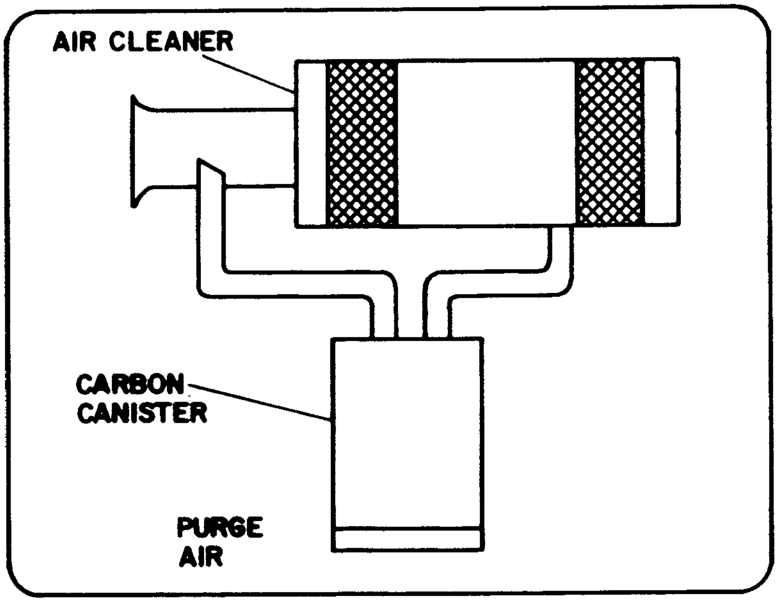

FIGURE 4-28

CONSTANT PURGE

Figure 4-29 shows another type of purging system. As you can see, this system uses a variable purge system. It also shows a "constant" purge line. This purge line is connected to the PCV valve line. There is a

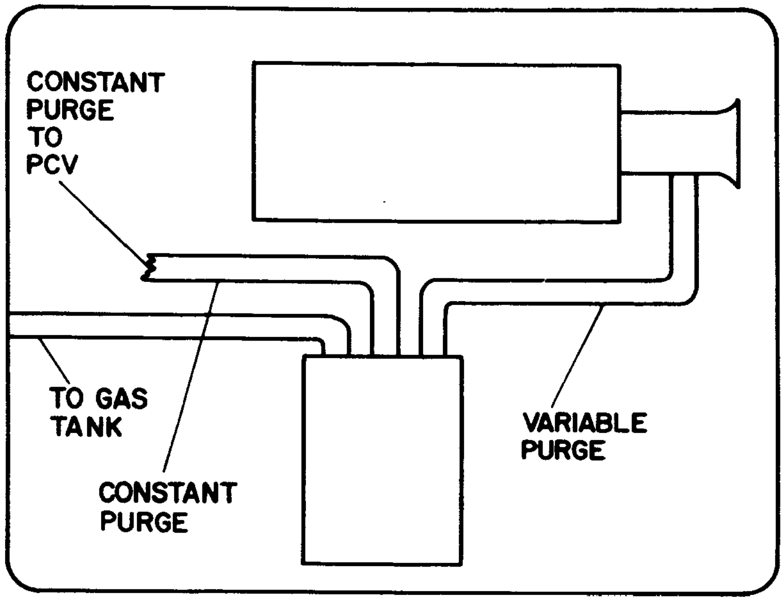

FIGURE 4-29

small orifice located in the canister which limits the amount of air through this line. This purge line will evacuate the cansiter all the time the engine is running. For this reason, it is called a "constant" purge.

CONSTANT AND DEMAND PURGE

The system shown in figure 4-30 is called the "constant and demand"

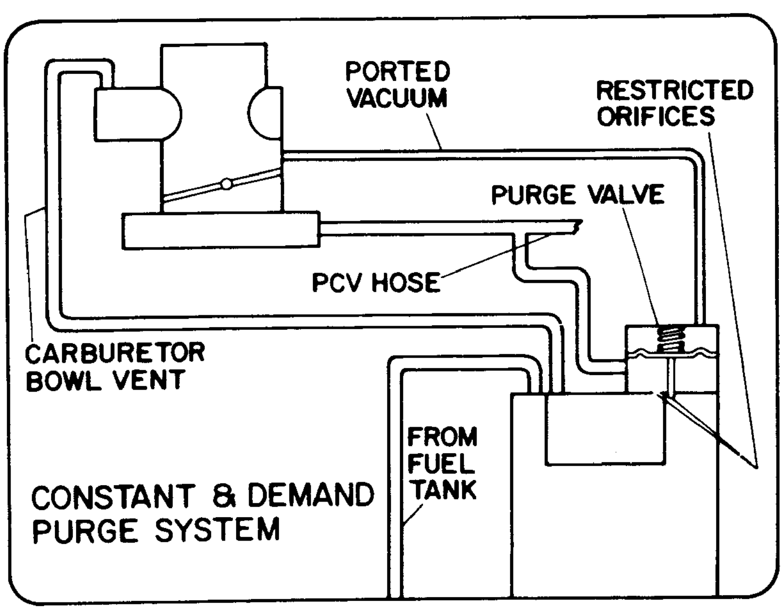

FIGURE 4-30

purge system. This system has a constant purge line connected into the PCV line. This constant purge has a small orifice to control the amount of purging. The charcoal canister also uses a purge valve to control the purging modes. This valve is triggered by a ported vacuum signal. When the throttle plates are opened and the engine begins to gain speed, a vacuum condition will build in the purge valve. This will open an additional area in the canister to the PCV line. When this happens, the amount of purging will increase. This is the "demand" purge. This system allows a small amount of purging at idle, but when the engine speed increases, a greater amount of purging will occur. This "demand" purging is designed to occur during engine conditions which will least affect performance and driveability.

You should now understand the various ways of purging the charcoal canister.

---

29. When the purge rate is controlled by the air flow entering the air cleaner, the system is called the ______________ system.

---

30. The purging system which evacuates the canister whenever the engine is running is known as the ______________ ______ system.

---

31. The purging system which is designed to occur during engine conditions which will least affect performance and driveability is called the __________ purge.

As a review, we will look at the components of the fuel evaporative system again: a fuel tank filler cap which seals the system, a special fuel tank designed to allow space for fuel expansion, and a venting

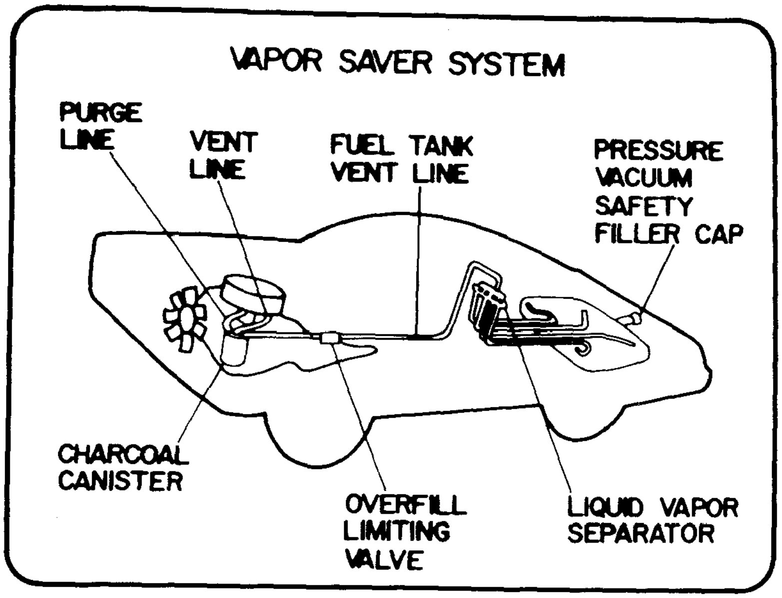

FIGURE 4-31

system to carry vapors from the fuel tank to the charcoal canister and into the engine for burning. With the use of these components, the hydrocarbon emissions caused by fuel evaporation are eliminated.

SYSTEM INSPECTION

An inspection of the fuel evaporative system should be made periodically. This inspection will require no tools or instruments and takes only a few minutes. Many problems may be avoided or corrected by these steps.

1. Check to see that all components are properly installed on the engine and no modifications have been done. Canister, separator and all purge lines should be in place.

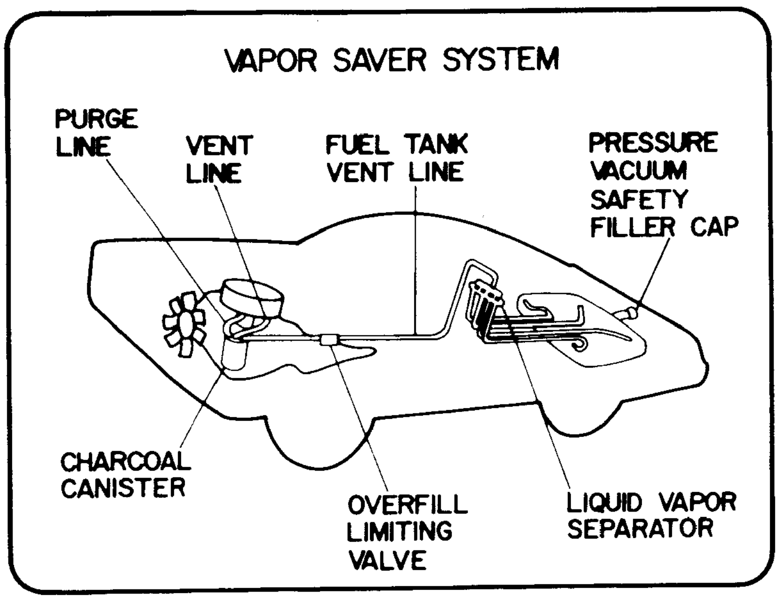

FIGURE 4-32

In order for the fuel evaporative system to function, all components must be installed correctly. If any of these components are missing, the system will operate inefficiently or possibly not at all.

2. Check the gas cap gaskets and relief valves. The gaskets should be inspected for deterioration and any signs that they may be leaking. The relief valves should be checked to see that they operate correctly.

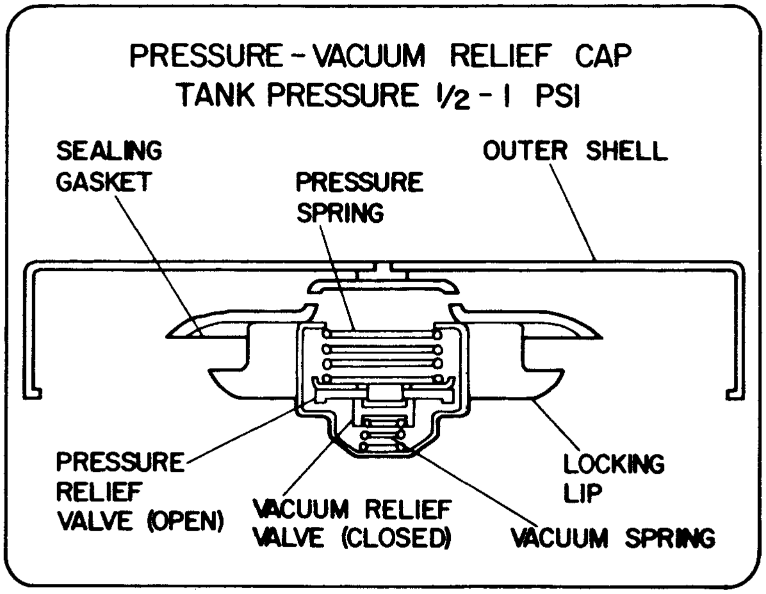

FIGURE 4-33

If either the gaskets or the relief valves are in poor condition, the gas tank will not be sealed from the atmosphere and vapors will escape from the tank.

3. Inspect the liquid check valve, separator, and connecting lines which may be damaged or leaking. If any of these components are not in good condition, leaks may occur. This will allow vapors to escape from the system into the atmosphere.

4. Inspect the filter in the bottom of the canister. If this filter is excessively dirty, replace the filter. Manufacturer's specifications should be checked to see at what intervals this should be done.

   If the filter in the bottom of the canister is dirty, the purging of the canister will be hampered. This will restrict the evacuation of vapors from the canister.

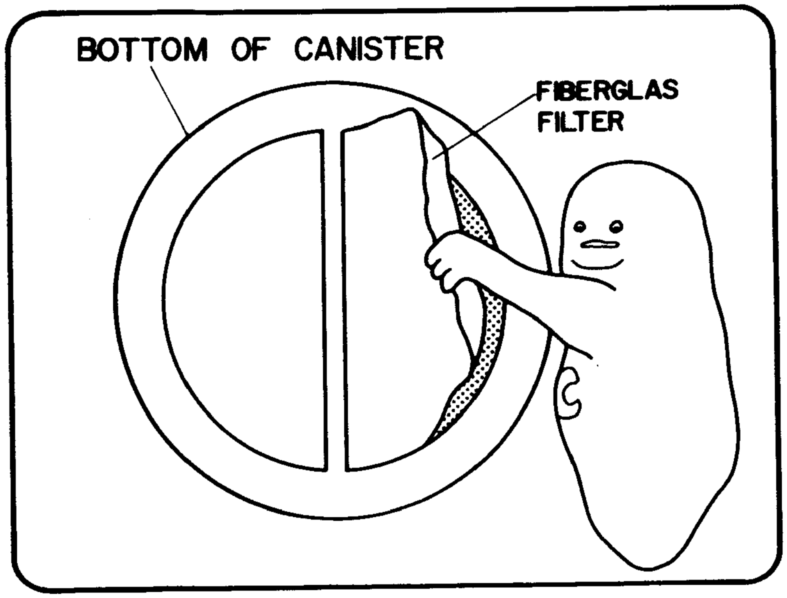

FIGURE 4-34

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32. The gas tank will not be sealed from the atmosphere and vapors will escape from the tank if either the gaskets or the ____________ ____________ are in poor condition.

---

33. The only part.of the fuel evaporation system which required scheduled replacement is the ________________ ____________ used for the charcoal canister.

SYSTEM TESTING

The fuel evaporation control system is usually very troublefree. For this reason no testing procedures have been included in this book. If any problems arise with the fuel evaporation control system, the manufacturer's recommendations for testing and repair should be consulted.

SYSTEM SUMMARY

PURPOSE

The purpose of the evaporative emissions control system is to control the release of hydrocarbons (HC) to the atmosphere that results from raw fuel vapors escaping from the fuel tank and carburetor vents.

MAIN COMPONENTS

Fuel Tank - A sealed unit for storing the fuel that has a built-in air space to allow for fuel expansion due to temperature increases.

Fuel Tank Filler Cap - Seals the fuel tank and acts as a pressure relief valve to protect tank from excessive pressure or vacuum.

Vapor Vent Lines - Allows vapors to escape from the fuel tank and pass to a vapor-liquid separator.

Vapor-Liquid Separator - Prevents passage of liquid fuel to the charcoal canister by means of either a float valve that seals the outlet when liquid fuel enters or by means of vapor lines. Vapor lines are set at different heights to allow liquid fuel to return to the tank and only vapors to escape.

Charcoal Canister - Contains activated charcoal that traps and stores fuel vapors. When the canister is purged with fresh air the fuel vapors are removed and vented to the carburetor.

Purge Line - Allows passage of fuel vapors from the charcoal canister to the carburetor or air cleaner when the engine is running.

SYSTEM FUNCTION

When the fuel tank is full and subjected to an increase in temperature, the fuel expands and is taken up in the built-in air space. Vapors are released; they pass through the vent lines to the vapor-liquid separator which allows the vapors to pass through, but prevents any liquid fuel from passing. The vapors travel to the activated charcoal canister where they are trapped and stored. When the engine is started, the canister is purged via a purge line that runs to the carburetor or air cleaner.

ANSWERS

1. 20%
2. fuel tank, carburetor
3. increases
4. carburetor
5. atmosphere
6. trap or contain
7. atmosphere
8. vented
9. increases
10. 10-12%
11. liquid
12. charcoal
13. started
14. overfill
15. two
16. atmosphere
17. one-half (1/2) psi.
18. vacuum
19. 10-12%
20. fuel tank
21. canister
22. three-way
23. atmosphere
24. charcoal
25. one
26. intake manifold
27. PCV
28. charcoal canister
29. variable purge
30. constant purge
31. demand
32. relief valves
33. filter pad

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(Please read Instructions on the reverse before completing)

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16. ABSTRACT

This book is one of a series designed specifically to teach the concepts of automobile emissions control systems. It is intended to assist the practicing mechanic or the home mechanic to better understand the Fuel Evaporation Control Systems which are an integral part of automobiles today. The mechanic's increased knowledge should help him keep "emissions controlled" vehicles operating as designed. Respectable fuel economy, performance and driveability, as well as cleaner air, can be obtained from the automobile engine that has all of its emissions systems functioning properly.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS		b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Air Pollution	Oxides of Nitrogen		
Photochemical	Carburetor		
Fuel Evaporation	Fuel Tank		
Intake Manifold	Atmosphere		
System Inspection	Vacuum		
Hydrocarbons	Charcoal Canister		
Carbon Monoxide	Variable Purge		
	~~Constant Purge~~		

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