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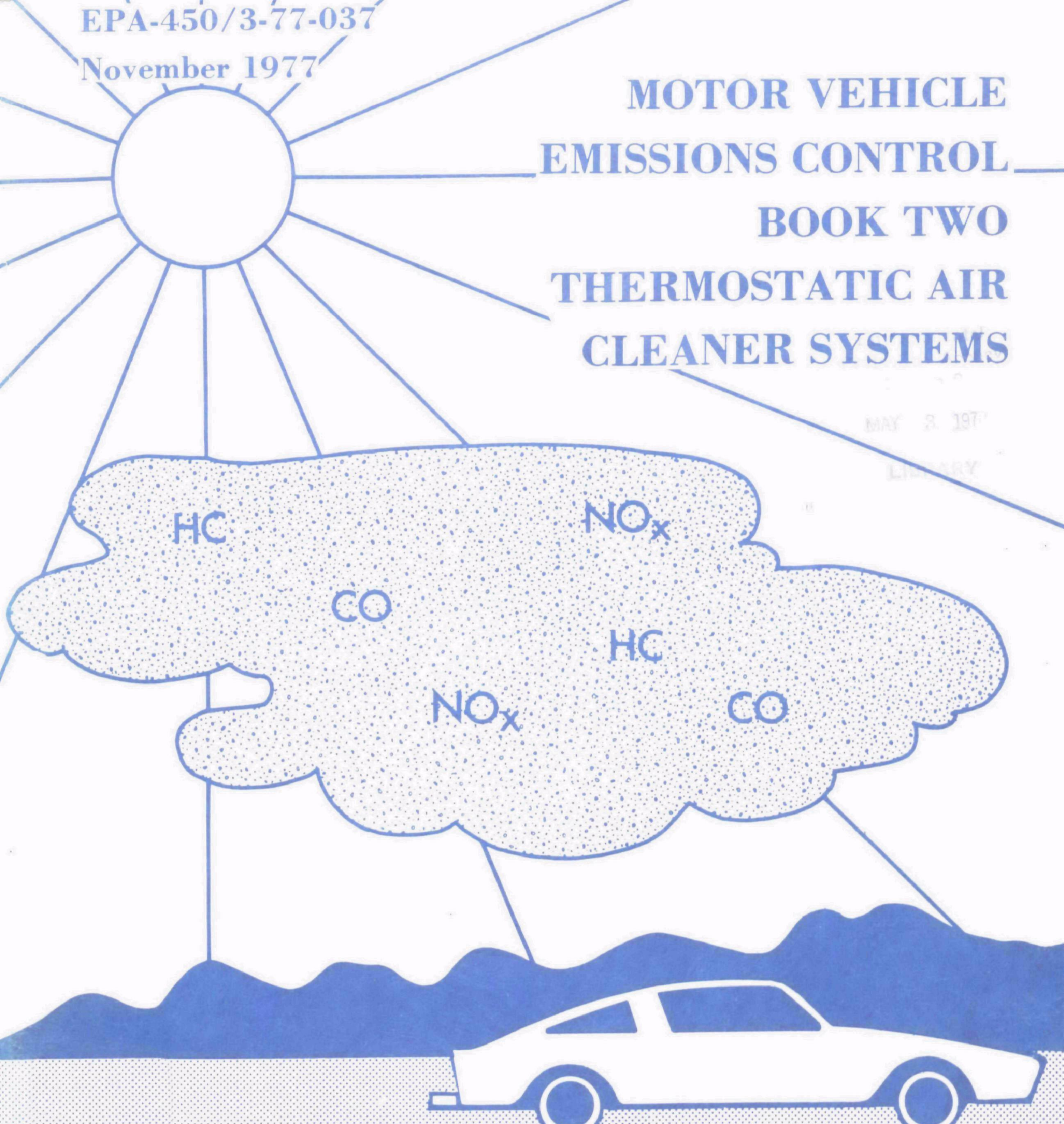
MOTOR VEHICLE EMISSIONS CONTROL
BOOK TWO
THERMOSTATIC AIR CLEANER SYSTEMS



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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BOOK TWO
THERMOSTATIC AIR CLEANER SYSTEMS

by

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MOTOR VEHICLE EMISSIONS CONTROL

-- SERIES OF SEVEN BOOKS --

MOTOR VEHICLE EMISSIONS STAFF, COLORADO STATE UNIVERSITY

BOOK ONE - POSITIVE CRANKCASE VENTILATION SYSTEMS

BOOK TWO - THERMOSTATIC AIR CLEANER SYSTEMS

BOOK THREE - AIR INJECTION REACTION SYSTEMS

BOOK FOUR - FUEL EVAPORATION CONTROL SYSTEMS

BOOK FIVE - EXHAUST GAS RECIRCULATION SYSTEMS

BOOK SIX - SPARK CONTROL SYSTEMS

BOOK SEVEN - CATALYTIC CONVERTER SYSTEMS

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 combusion 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 next emissions control system we will examine is the Thermostatic Air Cleaner system, abbreviated TAC. The TAC system helps in controlling auto emissions and also increases vehicle performance and driveability.

Certain engineering changes on late model engines were necessary to obtain the most "complete combustion" with the least amount of air pollution. The TAC system is one of these engineering changes. By varying the necessities of combustion (air, fuel, spark timing, etc.) we may obtain a higher combustion efficiency and lower emissions. As you know, two of the most common emissions are hydrocarbons (HC) and carbon monoxide (CO). These pollutants are produced because of "incomplete combustion." Incomplete combustion occurs when all of the air/fuel mixture entering the engine is not used in the combustion process. When the combustion process is not complete, some of the unused air/fuel mixture is exhausted to the atmosphere. These left-over products of combustion are hydrocarbon and carbon monoxide emissions. One method used to help limit the amount of HC and CO in the automobile's exhaust is to provide a leaner air/fuel mixture to the engine. This means less fuel is mixed with the air entering the carburetor. This increases the efficiency of the combustion process and leaves fewer left-over HC and CO pollutants to go into the exhaust. There is a problem, however. This leaner air/fuel mixture burns well when the engine has been warmed up and is running at a relatively high temperature. The problem occurs when using a lean mixture in a cold engine.

Before the engine is warmed up to normal operating temperature we usually "choke" the carburetor. This provides a very "rich" air/fuel mixture to the engine. A mixture rich in fuel is necessary to obtain satisfactory performance with a cold engine. When gasoline leaves the carburetor it must atomize to be easily mixed with the air. Atomization is the process of breaking down the fuel into small particles to form a vapor to mix with the air entering the carburetor. The air and fuel must be thoroughly mixed for a more complete combustion to occur.

This is easily accomplished when the engine has been warmed up. When the engine is warm, the air entering the carburetor is at a temperature high enough to rapidly atomize the fuel. When the engine is cold however, the carburetor is cold and the air entering the carburetor is also cold. This causes problems in the fuel atomization process. The atomization of fuel can be compared to the evaporation or vaporization of water on a hot day in summer compared to a cold day in winter. When the air temperature is high, atomization occurs much easier. Fuel atomizes much easier with warm air than with cold air. When the fuel is not atomized completely the engine operates rough because the air/fuel mixture will not burn smoothly. Under certain cold conditions, when the air entering the carburetor is insufficient to warm the fuel, a freezing of the air/fuel mixture may occur. This is called "carburetor icing."

What is now used to eliminate this cold engine problem is the Thermostatic Air Cleaner (TAC). The TAC system was first introduced on some 1966 automobiles. This thermostatic (heat-activated) air cleaner provides heated air to the carburetor during warm-up operations. Air is heated by the exhaust manifold before entering the carburetor.

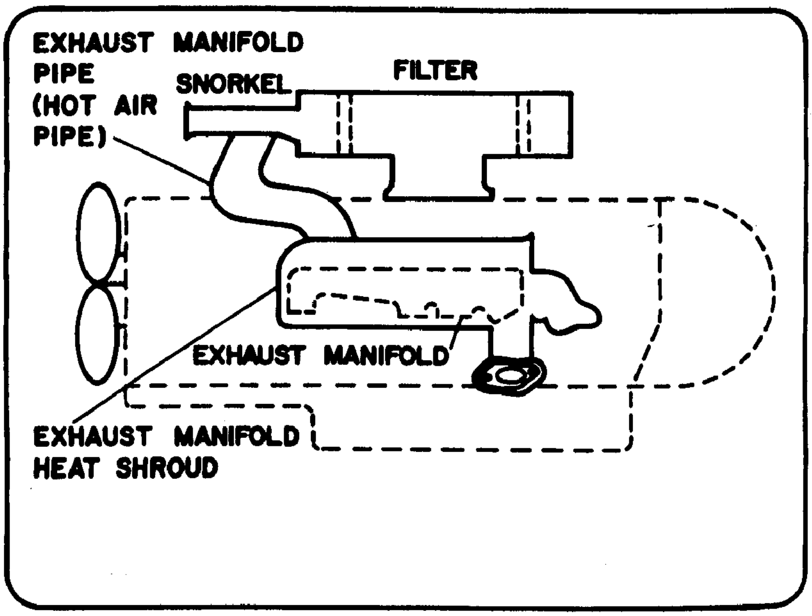

FIGURE 2-1

Heated air entering the carburetor allows better fuel atomization, smoother cold engine performance and helps reduce carburetor icing. The thermostatic air cleaner provides heated air only during the engine warm-up period. The air temperature is regulated as needed during this time. After the engine has been warmed-up and no longer needs heated air, normal engine compartment air is provided as with conventional air cleaner systems. The thermostatic air cleaner permits smooth engine operation while using a lean air/fuel mixture at all times.

During warm-up periods heated air is provided. During normal operating conditions engine compartment air is supplied. The TAC system eliminates much of the hydrocarbon and carbon monoxide emissions usually formed during cold engine warm-up.

---

1. TAC means ____________ ______ __________.

---

2. The TAC system helps control auto emissions. It also increases vehicle performance and ____________.

---

3. Two of the most common emissions are hydrocarbons and carbon monoxides. These pollutants are produced because of ____________ ____________.

---

4. One method used to help limit the amount of HC and CO in auto emissions is to provide a ________ air/fuel mixture to the engine.

---

5. ____________________ is the process of breaking down the fuel into small particles to form a vapor to unite with the air entering the carburetor.

---

6. Fuel atomizes much easier with _______ air than with cold air.

---

7. The thermostatic air cleaner provides ___________ _____ to the carburetor during engine warm-up operations.

---

8. The TAC system provides heated air only during the engine _______-____ periods.

---

9. The TAC system eliminates much of the HC and ____ emissions usually formed during cold engine warm-up.

SYSTEM/COMPONENT PURPOSE

The introduction explained how heated air, provided during warm-up operation would benefit engine performance. The purpose of the Thermostatic Air Cleaner is to provide heated air. The TAC system provides this heated air and regulates the temperature at which it enters the carburetor. Therefore, the TAC system improves cold engine performance and reduces emissions by warming the air used for the combustion process.

There are two widely used types of thermally activated systems. One is called a thermostatic type, the other an air valve type. You will see that although the component parts of the two differ somewhat, the purpose of both is to control intake air temperature.

THERMOSTATIC TYPE AIR CLEANER

The main component acting on intake air entering the carburetor is the air cleaner. The air cleaner is composed of two main parts: the main body, containing the filter and air inlet tube or snorkel. With both types of TAC systems we have an opening in the bottom of the snorkel to which is attached an exhaust manifold pipe or hot air pipe. This pipe connects the opening in the snorkel to an exhaust manifold heat shroud.

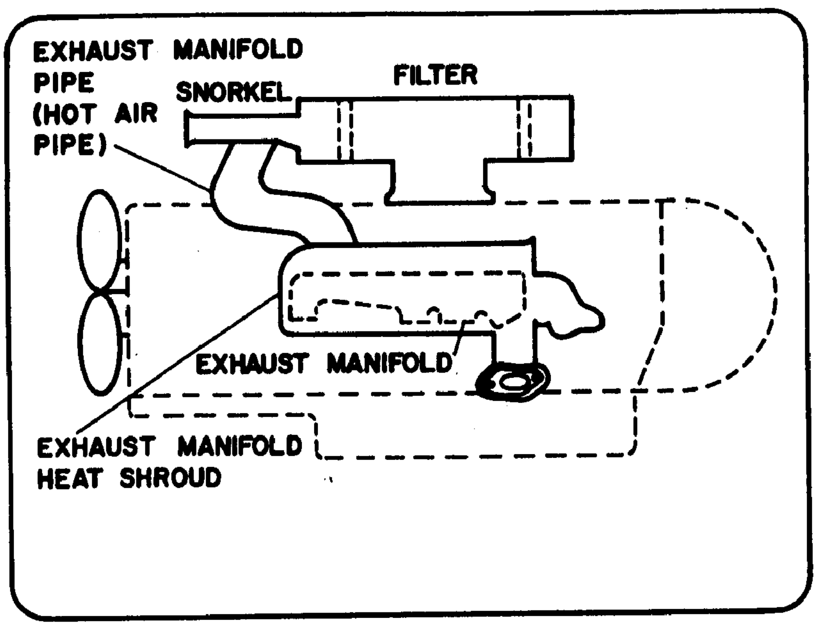

FIGURE 2-2

These two components form a heat path to the air intake system. Heat is picked up by air passing through the shroud. The heated air is drawn up through the hot air pipe to the snorkel.

---

10. There are two widely used types of thermostatic air cleaner systems. One is called a ____________________ type. The other is called an air valve type.

---

11. Both types of TAC systems have an opening in the bottom of the snorkel to which is attached a ______ ______ pipe.

AIR VALVE DOOR

The next component we will look at is the air valve or air valve door. The air valve door is located inside the snorkel and above the hot air

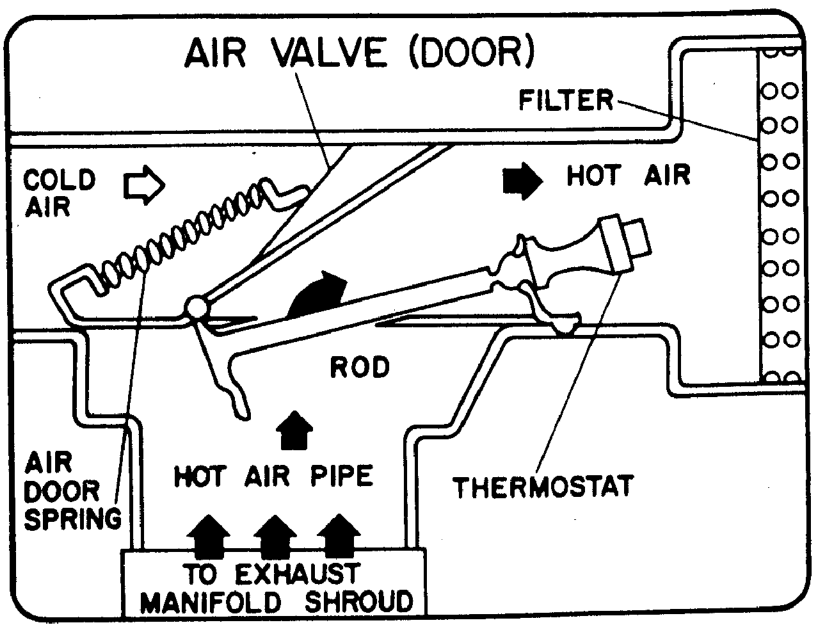

FIGURE 2-3

pipe. The valve is hinged on one side acting as a door to the hot air coming from the exhaust manifold heat shroud. The air valve door is connected to an air door spring. This spring holds the air door up, blocking cold engine compartment air from entering the snorkel. This allows hot air to enter from the hot air pipe.

To regulate the temperature of air entering the carburetor the TAC system mixes relatively cold engine compartment air with heated air. The door should be open to the hot air pipe allowing heated air to enter during engine warm-up periods. During warm-up it should prevent cold engine compartment air from entering. When the engine has been warmed up and is operating at normal temperature, the door should cover the hot air pipe and allow only cooler engine compartment air to enter.

THERMOSTAT

The door operation is controlled by a thermostat connected to the air door near its hinge or pivot point. The thermostat is a heat sensing device that operates the air valve door as determined by the temperature of the intake air.

VACUUM OVERRIDE MOTOR

Figure 2-3 shows the basic components used in thermostatic type air cleaners. One additional device however is sometimes used on this type system. A Vacuum Override Motor seen in figure 2-4 may be attached to

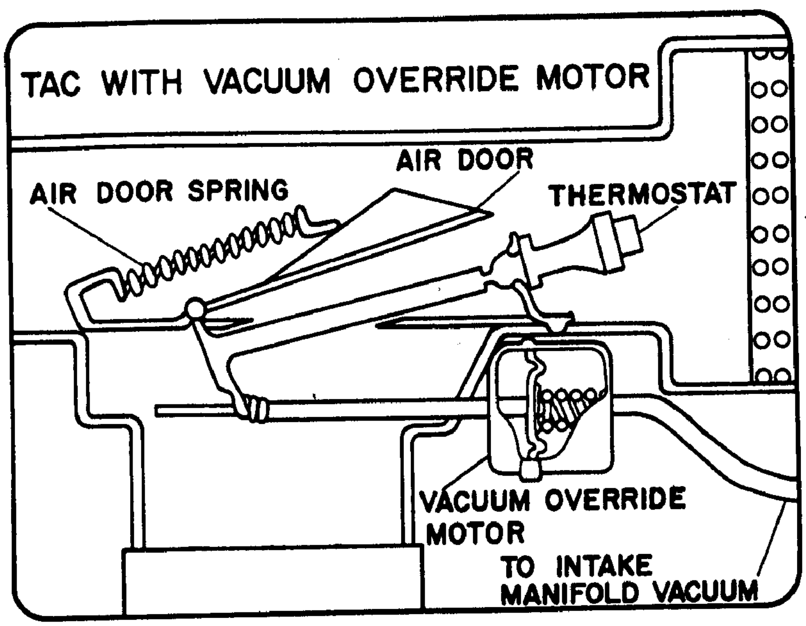

FIGURE 2-4

the snorkel and connected to the thermostat and air door by an override lever. The motor uses intake manifold vacuum. The override motor is used only during cold engine acceleration. We have seen that when the engine is cold the air valve door is closed to engine compartment air and is passing air from the hot air pipe. During cold engine acceleration however, more air is needed by the engine than can be supplied through the hot air pipe. The purpose of the vacuum override motor is to override the thermostatic control of the air valve door. This provides air from both the engine compartment and the hot air pipe in a sufficient amount to sustain cold engine acceleration.

---

12. Located inside the snorkel and above the hot air pipe opening is an ______ __________ door.

---

13. To control the temperature of air entering the carburetor, the TAC system mixes heated air and ____________ ______________________ air before it enters the air cleaner.

---

14. Sometimes a ____________ ________________ motor is attached to the snorkel and air door on the thermostatic type system.

---

15. The vacuum override motor is operated by _______________ ________________ vacuum.

---

16. The vacuum override motor's purpose is to override the control of the air valve door during cold engine _______________________.

AIR VALVE TYPE AIR CLEANER

Next we will look at the Air Valve Type air cleaner. As mentioned before, the purpose of both the Thermostatic Type and Air Valve Type air cleaner is the same -- to heat air entering the carburetor and insure a warm air/fuel mixture during cold engine operation. By heating the air we eliminate many of the HC and CO emissions which occur during engine warm-up and cold engine operation.

When describing components of the Air Valve Type air cleaner you will see many are similar to the Thermostatic Type. The differences occur in the method of regulation.

As with the Thermostatic Type system, we have an air cleaner consisting of a filter and a snorkel as seen in figure 2-5. The snorkel has an

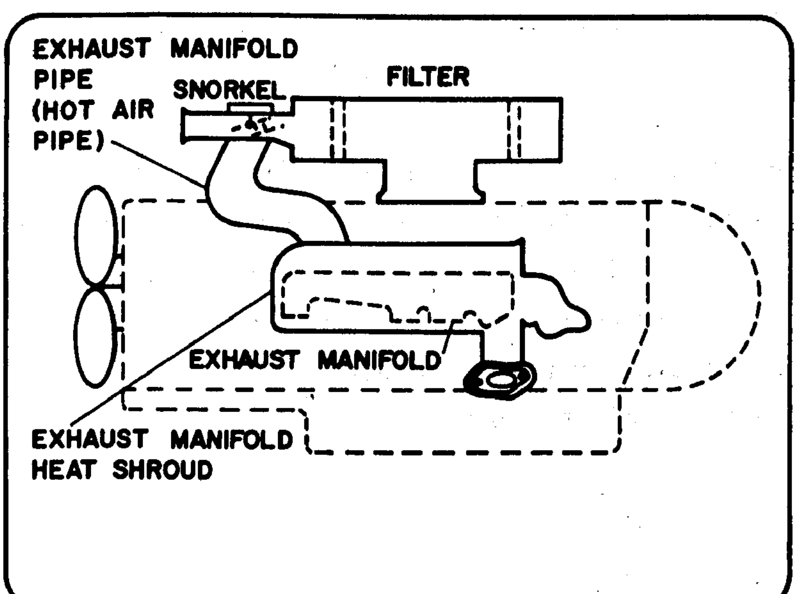

FIGURE 2-5

opening through which heated air enters. The heat collector is again the exhaust manifold heat shroud, connected to the snorkel opening by a hot air pipe.

AIR VALVE DOOR

As with the Thermostatic Type system, the heat path opening is regulated by an air valve door. It is the air door that regulates the amount of cold engine compartment air and warm, exhaust-heated air entering the system. In the Air Valve Type system, the air door is operated by a vacuum motor. As seen in figure 2-6, a vacuum hose runs from the intake manifold to a vacuum motor positioned on top of the snorkel. The vacuum motor has a linkage connecting it to the air door.

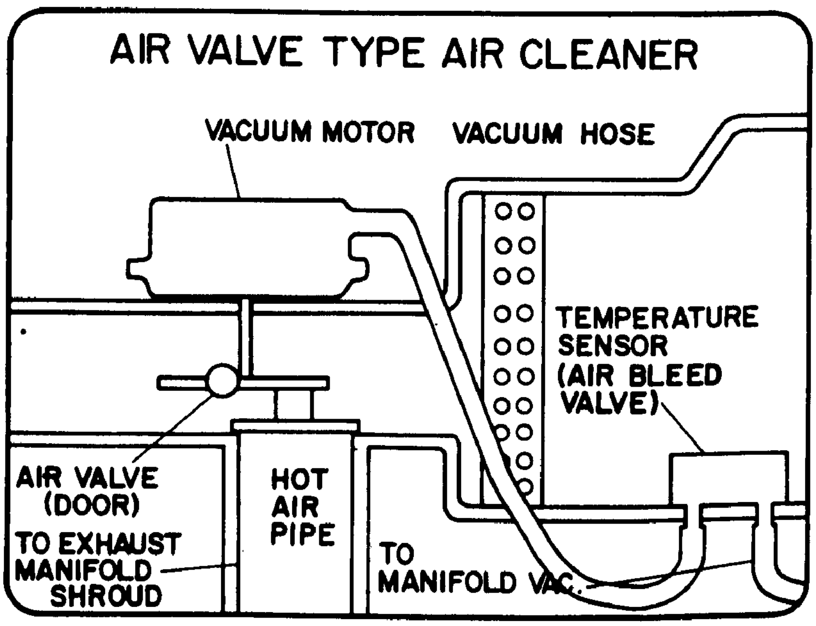

FIGURE 2-6

As vacuum reaches the vacuum motor the air door is lifted up limiting engine compartment air and allowing heated air to enter the system. The amount of intake manifold vacuum reaching the vacuum motor determines the position of the air door. This vacuum is carried by a vacuum hose routed through the air cleaner body. Located on the vacuum hose in the air cleaner body is an air bleed valve.

AIR BLEED VALVE-TEMPERATURE SENSOR

The air bleed valve controls the amount of vacuum in the vacuum hose. When the air bleed valve opens, the vacuum in the hose is released. When and how much the air bleed valve opens is determined by a temperature sensor on the air bleed valve. This means both the amount of vacuum reaching the vacuum motor and the temperature of air entering the system is controlled by a temperature sensing device.

Now that you are familiar with the purpose of the components in the TAC system it is time to learn how they function.

---

17. With the air valve type TAC system the amount of intake manifold vacuum received by the vacuum motor determines the position of the _____ ________.

---

18. An ______ __________ __________ is located in the vacuum hose in the air cleaner body.

---

19. When and how much the air bleed valve opens is determined by the ______________________ ____________.

SYSTEM/COMPONENT FUNCTION

The purpose of the TAC system is to provide heated air to the carburetor. The function of the system is to control the temperature of the intake air. This is done by regulating the position of the air valve door. By changing the position of this door the TAC system controls the amount of heated air entering the system and thereby controls the temperature of air entering the carburetor.

THERMOSTATIC TYPE AIR CLEANER

We will now examine how the Thermostatic Type system functions. As you recall, the air door is connected to a spring and a thermostat. In the cold start position the spring holds the air door up. This allows only heated air to enter the system. Remember, the heated air has been warmed by passing through the exhaust manifold heat shroud. This air door position is called the "Hot Air Mode."

---

20. The TAC system functions to ______________ the temperature of the air entering the carburetor.

HOT AIR MODE

When the TAC system is in the hot air mode, air from the engine compartment is blocked from entering the system. Only heated air will be allowed to enter the carburetor. The door is in the "Hot Air Mode" when air entering the system is below approximately 100°F. The system would be in this position when a cold engine has just been started. It would also be in this position if the engine was off and cold.

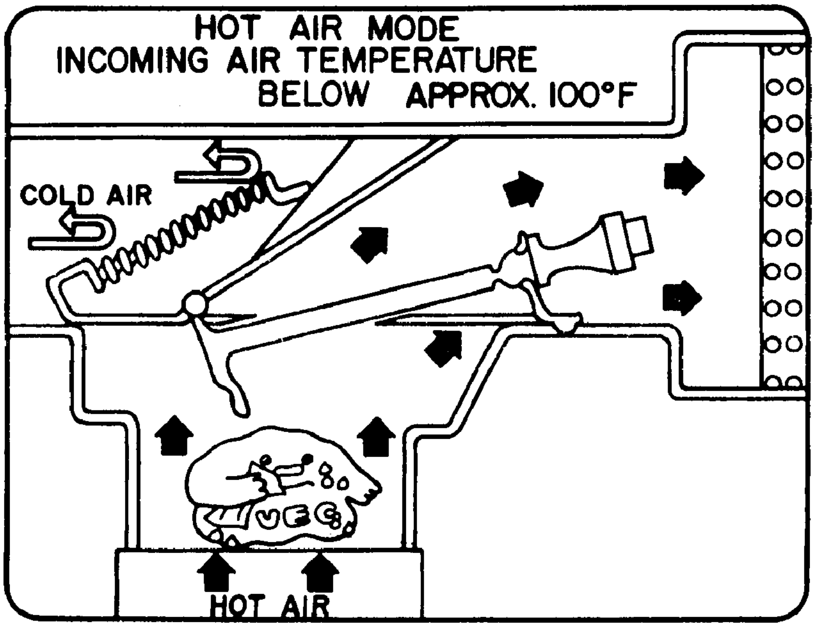

FIGURE 2-7

REGULATING MODE

As the temperature of the air entering from the hot air pipe reaches approximately 100°F the thermostat becomes activated. Remember a thermostat is just a temperature sensing device. The thermostat is connected to the air door by a rod. As the temperature rises above 100°F, the

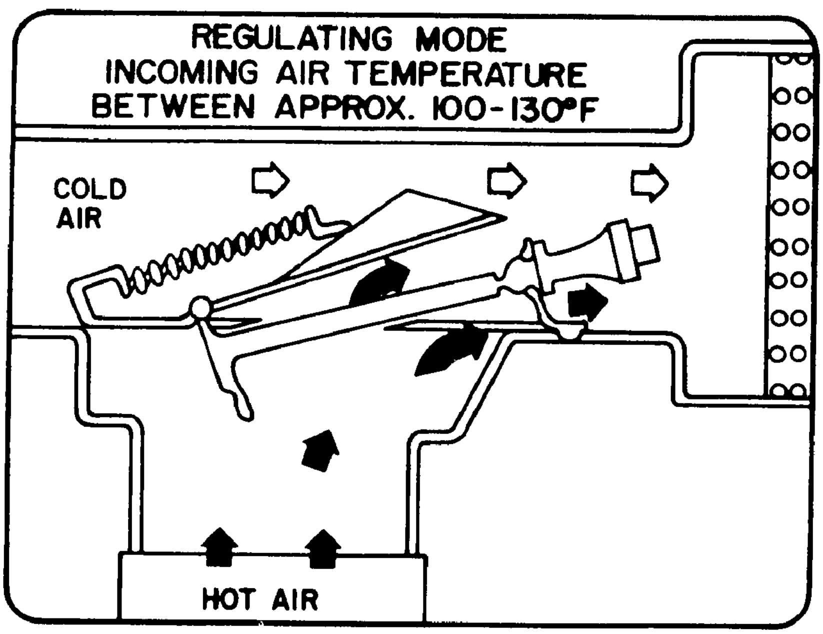

FIGURE 2-8

thermostat begins to extend; this pushes the rod and moves the door away from the "Hot Air Mode" into the "Regulating Mode." In this mode both heated air and cooler engine compartment air enter the system. The amount of heated and cool air is regulated by the thermostat which controls the position of the door. The system is in the "Regulating Mode" when the temperature is between approximately 100°F and 130°F. This temperature range will occur after the engine has been started and is approaching operating temperature.

COLD AIR MODE

When the temperature of the air passing the thermostat on its way to the carburetor has reached approximately 130°F the air door will be completely closed to heated air. This position is called the "Cold Air Mode."

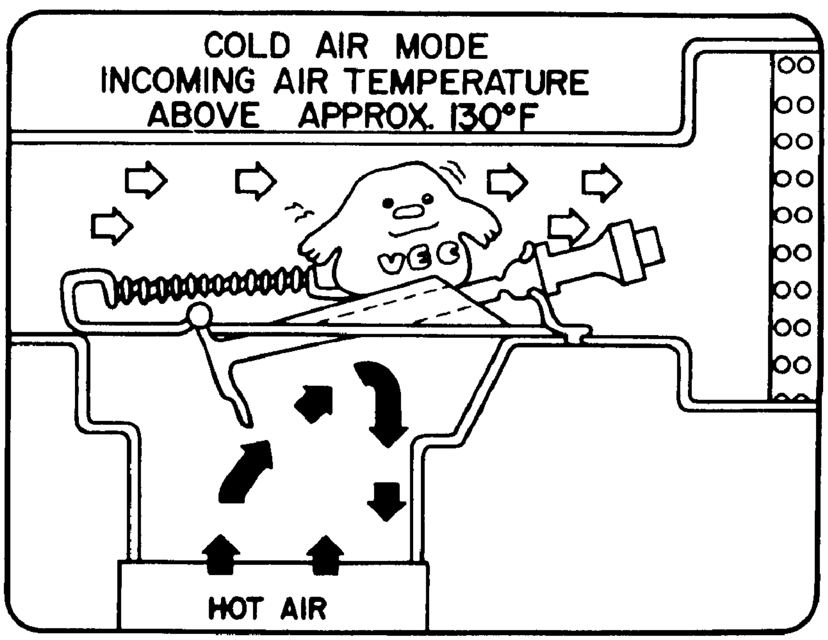

FIGURE 2-9

The system will be in this position when the engine has warmed up. All air entering the carburetor will now be coming from the engine compartment.

---

21. The air door will be in the "______ ______ ________" when air entering the system is below approximately 100°F.

---

22. As the temperature rises above 100°F, the air door will move away from the "Hot Air Mode" into the ____________________ ________.

---

23. When the temperature of the air has reached approximately 130°F, the door will be completely closed to heated air. This position is called the "______ ______ ________."

---

24. In the Regulating Mode both heated air from the heat shroud and cooler ____________ ______________________ air enters the system.

---

25. In the "________ ______ ________" only cooler engine compartment air can enter the system.

VACUUM OVERRIDE MOTOR

We have discussed the way all thermostatic type air cleaners work. However, some systems include an additional vacuum override motor. You will recall that the vacuum override motor was used to provide additional air during cold acceleration. During engine warm-up when the air door is in the "hot air mode" or beginning stages of the "regulating mode," only a limited supply of air is entering the system. This is obvious since the air door is blocking much of the engine compartment air from entering the system. Also the engine compartment is the main source of air for the carburetor. During cold acceleration more air is needed to sustain the engine than can be supplied from the hot air pipe. Therefore, we use a vacuum override motor to override the thermostatic control of the air door and allow more engine compartment air to enter. Figure 2-10 shows a cut-away view of the vacuum override motor. The override motor is connected

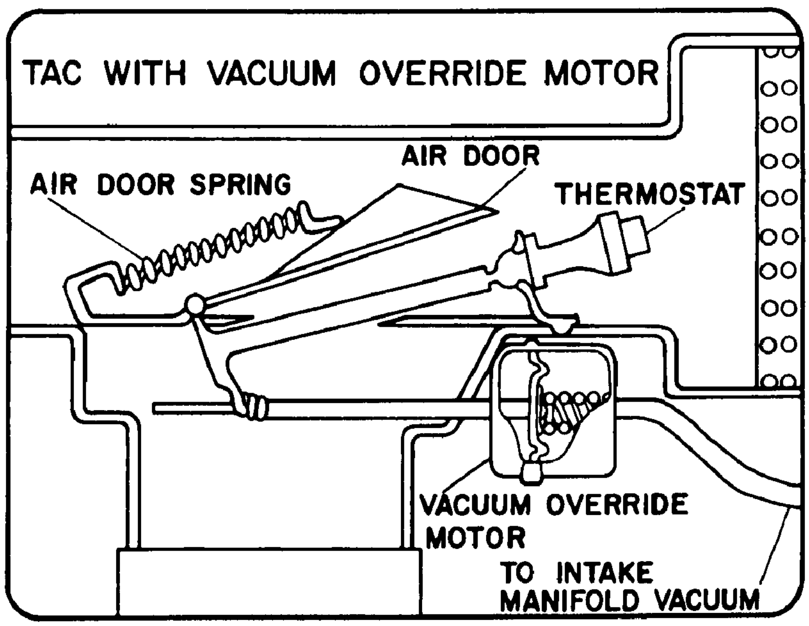

FIGURE 2-10

to the air door on one end and to an intake manifold vacuum hose on the other. The motor is made up of a spring and a diaphragm. As you can see in Figure 2-11, when the engine is at idle, there is high intake manifold vacuum. This vaucum will pull the motor diaphragm back and allow the air door to be pulled up by the air door spring. As the temperature increases the thermostat will begin to close the door as usual. However, if acceleration is needed before the thermostat has opened the system to engine compartment air, there would not be enough air to supply the engine. With the vacuum override motor, when the throttle is opened, the intake manifold loses much of its vacuum. This allows the spring in the motor to push the diaphragm and rod forward. Pushing the rod forward overcomes spring

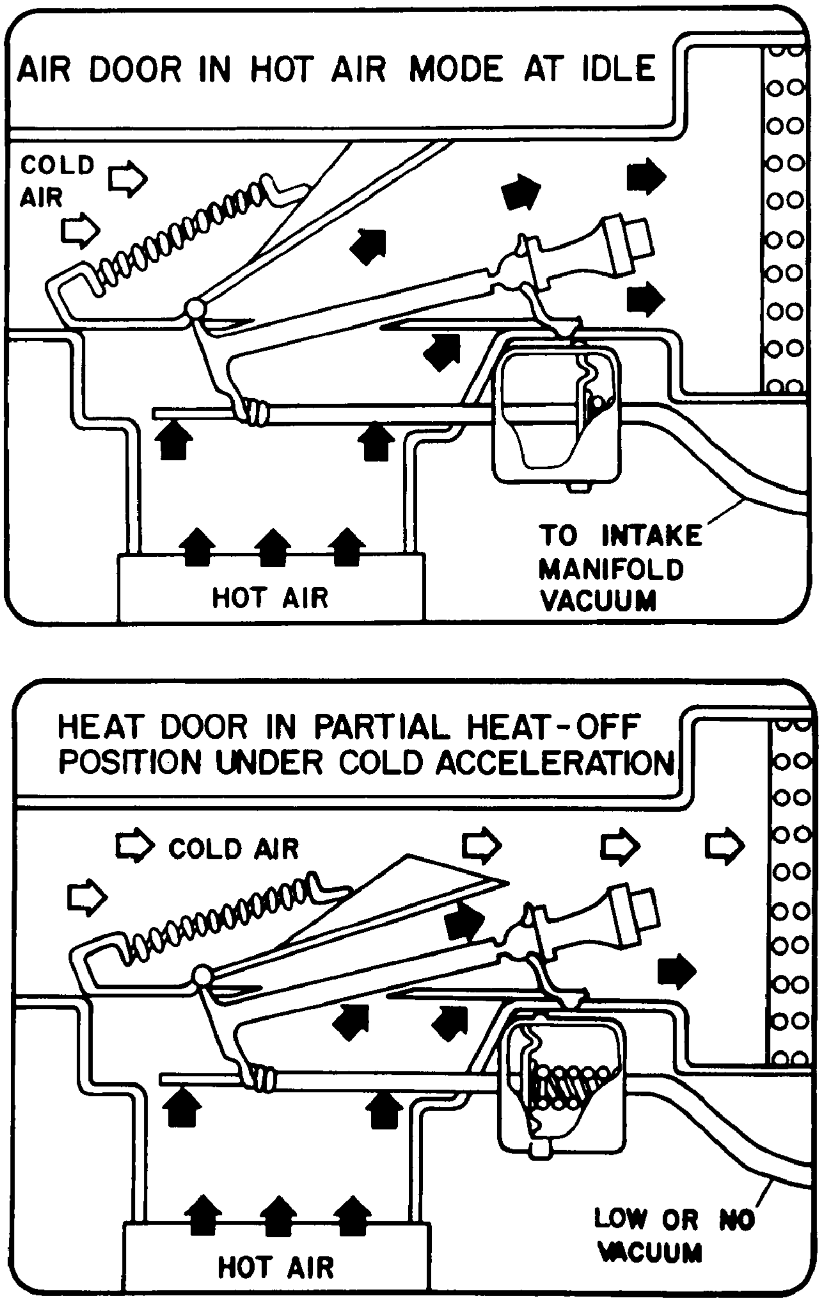

FIGURE 2-11

tension on the door and allows engine compartment air to enter. This will happen regardless of the position of the thermostat.

The action of the vacuum override motor essentially forces the system into a "regulating mode" regardless of the temperature of the entering air. One more thing to remember about a thermostatic system with a vacuum override motor is that when the engine is off the hot air door will be down, in a "cold air mode." In systems without the vacuum override motor the air door would be in the "hot air mode" because of the spring connected to the door. In a system with the vacuum override motor, the spring connected to the door would also try to hold the door up, but with the engine off there would be no intake manifold vacuum. With no vacuum, the motor's spring would force the door down just as in cold acceleration.

---

26. The override motor is connected by a linkage to the air door on one end. It also has an ____________ ________________ vacuum hose connection on the other end.

---

27. The vacuum override motor essentially forces the system into a "____________________ ________" regardless of the temperature of the entering air.

AIR VALVE TYPE AIR CLEANER

The purpose of the Air Valve Type air cleaner as mentioned before is to provide heated air to the carburetor during warm-up operations. The Air Valve Type system functions somewhat differently than the Thermostatic Type, but the purpose is the same.

This system regulates the position of the air door according to intake manifold vacuum. The air door is linked mechanically to a vacuum motor mounted on top of the snorkel above the hot air pipe. The motor consists of a spring and a diaphragm assembly much like a vacuum override motor. A vacuum hose connects the vacuum motor to the intake manifold. This hose runs through the air cleaner. Located on the hose inside the air cleaner is a temperature sensor. This temperature sensor is the device that controls the vacuum signal. Vacuum for the motor is supplied by the intake manifold. The temperature sensor controls the vacuum

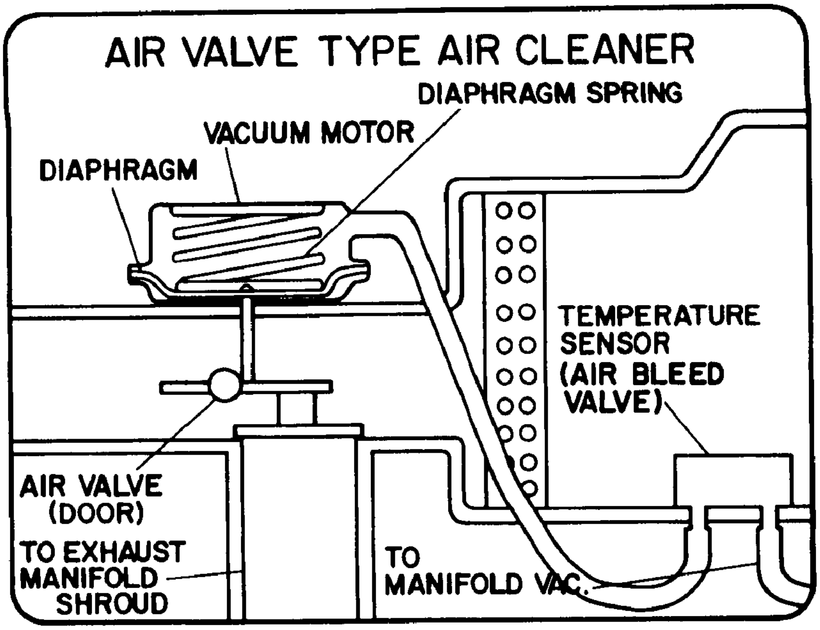

FIGURE 2-12

signal to the vacuum motor by using an air bleed valve and a temperature sensing spring or thermostat.

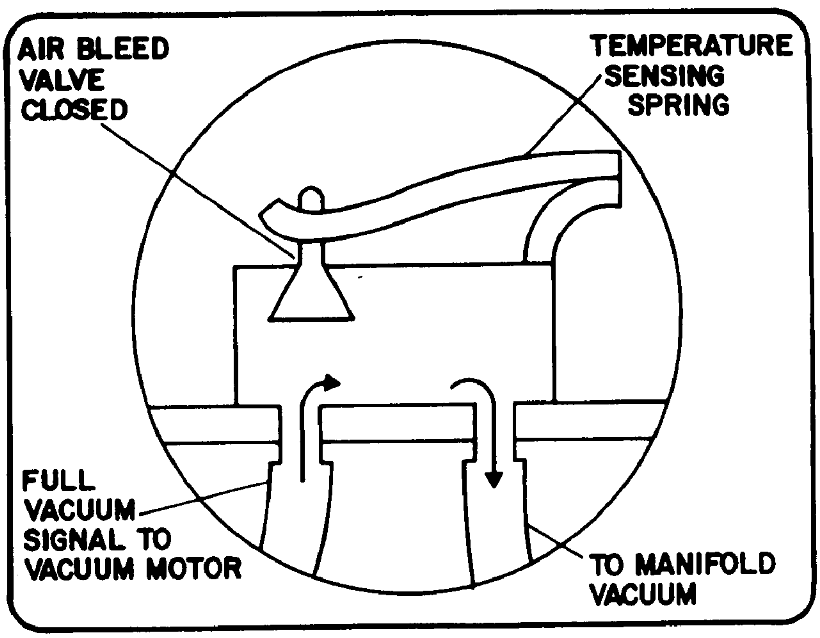

FIGURE 2-13

HOT AIR MODE

When a cold engine is started and the temperature of the air passing the temperature sensing spring is below approximately 85°F, full vacuum is allowed to the vacuum motor. Full vacuum is allowed below approximately 85°F and the temperature sensing spring keeps the air bleed valve closed. As you can see in figure 2-13, this allows a full vacuum signal to reach the vacuum motor. When the temperature sensor allows a full vacuum signal to reach the vacuum motor, such as when the temperature is below approximately 85°F, the system is in the "Hot Air Delivery Mode." This is shown in figure 2-14.

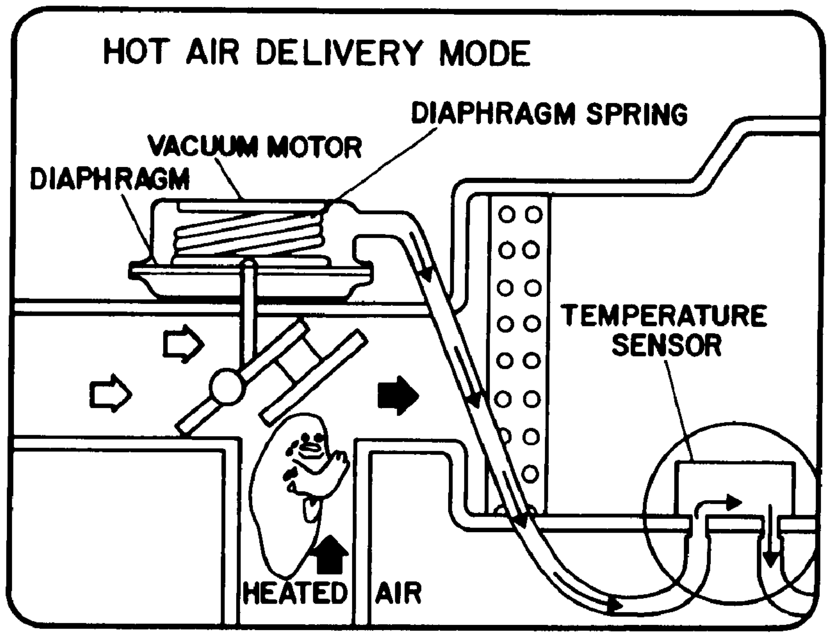

FIGURE 2-14

In the "Hot Air Delivery Mode" the vacuum draws the motor diaphragm up, overcoming the diaphragm spring tension. Because the air door is linked to the diaphragm spring, as the spring is pulled up by vacuum the air door is also pulled up. This opens the system to heated air from the hot air pipe. In the Hot Air Delivery Mode cooler engine compartment air is prevented from entering the system.

REGULATING MODE

When the temperature of the air passing the temperature sensing spring in the air cleaner rises above approximately 85°F the air bleed valve begins to open. The sensor has reacted to the increase in temperature. As it

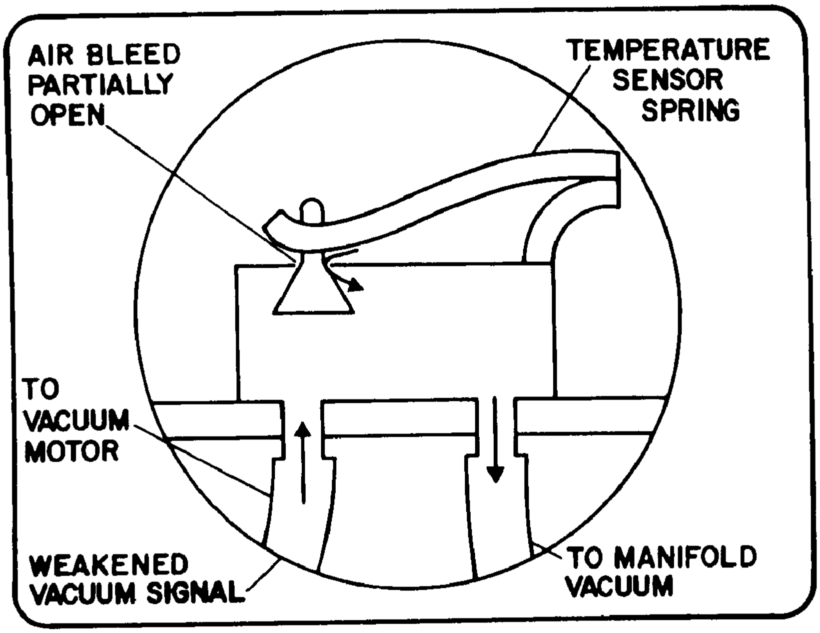

FIGURE 2-15

senses these warmer temperatures it forces the air bleed valve to allow atmospheric pressure to bleed into the vacuum line. This reduces the vacuum signal to the vacuum motor. The weakened vacuum signal can no longer hold the diaphragm spring and the spring tension starts to close the air door. It has now moved to the "Regulating Mode."

In the Regulating Mode both heated air from the exhaust manifold and cooler engine compartment air enter the system. The air door begins to move down at a temperature of approximately 85°F. It is fully closed when the temperature of air passing the temperature sensing spring is approximately 130°F.

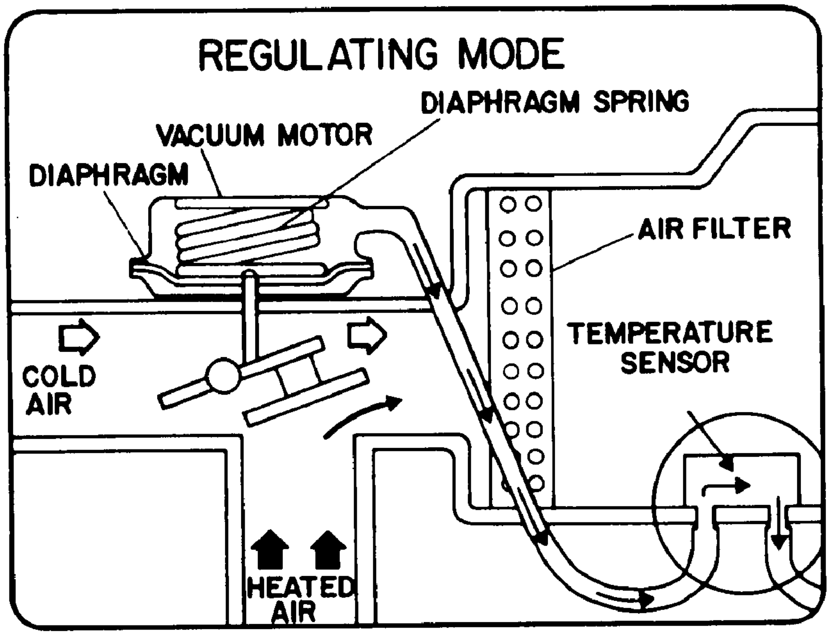

FIGURE 2-16

COLD AIR MODE

When the temperature of air passing the temperature sensing spring reaches approximately 130°F or above, the air bleed valve has opened completely. The air bleed valve now allows atmospheric pressure into the hose at such a rate that it eliminates the vacuum reaching the vacuum motor.

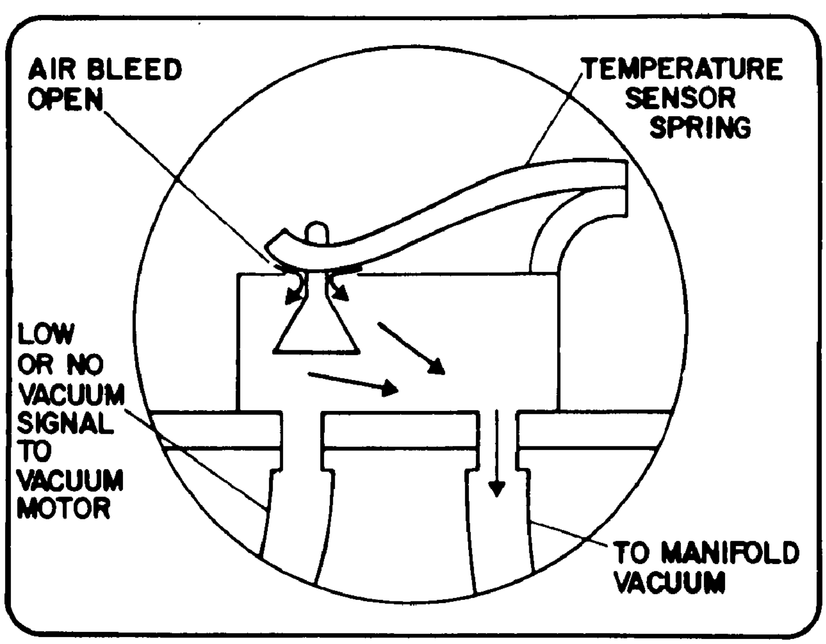

FIGURE 2-17

The vacuum signal can no longer overcome the diaphragm spring tension on the vacuum motor. The air door is forced closed to heated air. The system is now in the "Cold Air Mode."

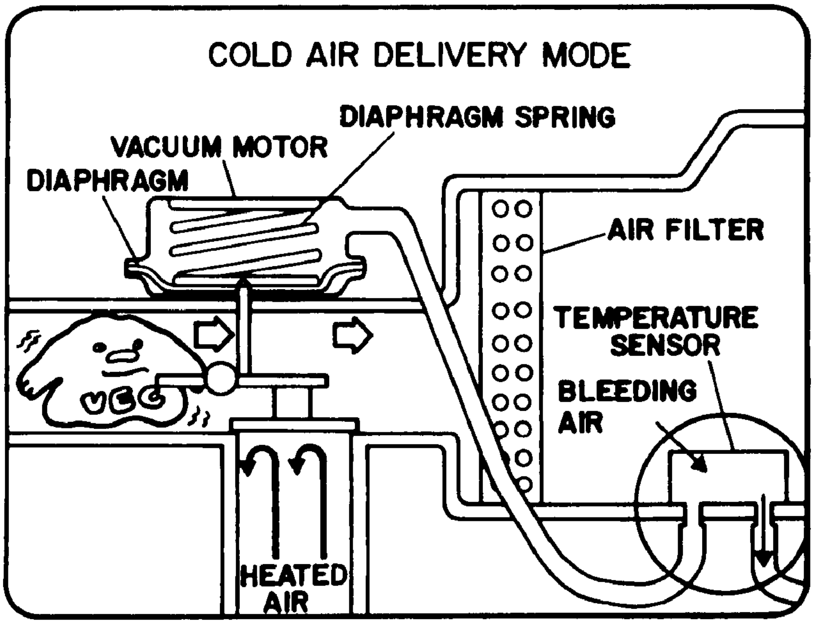

FIGURE 2-18

In the Cold Air Mode only cooler engine compartment air can enter the system. This operating mode is used whenever the vacuum can no longer overcome the diaphragm spring tension. This occurs when either the temperature sensing spring has opened the air bleed valve to atmospheric pressure (temperature above approximately 130°F) or when intake manifold vacuum is too low to overcome the spring tension.

---

28. When the intake air passing the temperature sensor in the air cleaner rises above approximately 85°F, the air bleed valve begins to ________.

---

29. When the engine has reached normal operating temperature the air bleed valve will be fully ________.

30. The air door is held in the hot air mode by ____________.

COLD ACCELERATION

You will recall that under certain cold acceleration conditions more air is needed by the engine than can be supplied through the hot air pipe. In the Thermostatic Type air cleaner a vacuum override motor was used to supply more air. The Air Valve Type air cleaner does not need such a device. During acceleration the carburetor throttle plates open. This reduces manifold vacuum. With low manifold vacuum, the vacuum signal to the vacuum motor is too weak to overcome the spring tension holding the door closed to engine compartment air. Thus the volume of air required for acceleration is provided regardless of the air temperature passing the sensor.

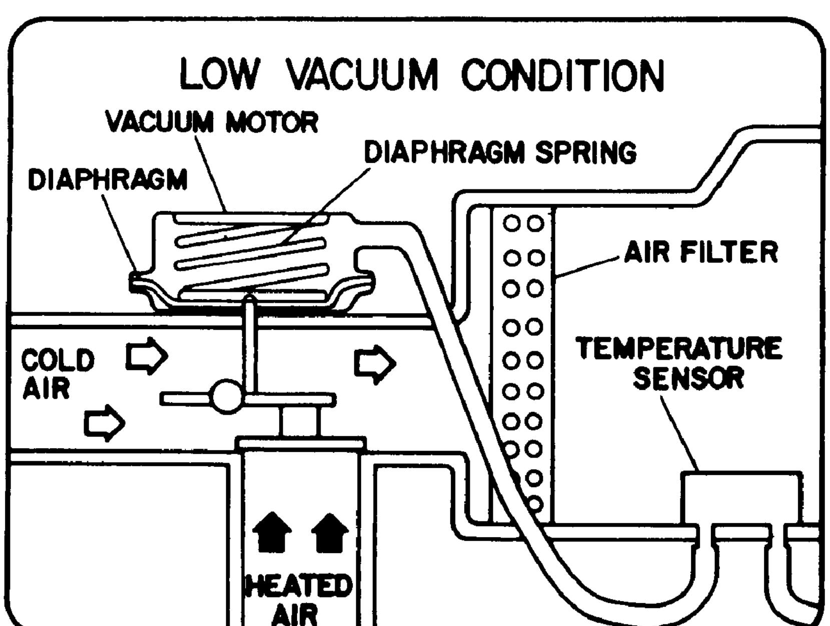

FIGURE 2-19

With the engine off or during low vacuum conditions the air door blocks the hot air pipe.

Now that you are familiar with the function of the TAC system, it is time to learn about the inspection and testing procedures used for this system.

---

31. The Air Valve Type air cleaner does not need a ___________ _________________ motor to supply more air during cold acceleration.

---

32. The Air Valve Type air cleaner will move to the ________ air mode during cold wide-open throttle acceleration.

SYSTEM INSPECTION

A visual inspection of the TAC system should take place periodically and previous to any testing. The visual inspection requires no tools or instruments and takes only a few minutes. Many problems can easily be avoided by following this simple procedure.

1. Check that the air cleaner is in place and has not been modified.

   The snorkel opening should not be blocked preventing air from freely entering the system. Modifications to the air cleaner, such as an upside down lid, shortened snorkel or holes drilled into the air cleaner body will not allow the TAC system to operate correctly.

2. Check that the air cleaner filter element is in place and clean.

   A dirty filter element will decrease air flow to the carburetor and possibly starve the engine of air.

3. Check the exhaust manifold heat shroud and hot air pipe leading to the snorkel. They should be installed properly and securely fastened.

   These two components provide the path for heated air used in the system. Connections must be secure to prevent loss of heat. Passages must be open to allow proper flow of air.

4. Check the vacuum hose routing through the system.

   Hose routings must be correct for the system to operate. The routing must be followed from the vacuum motor into the air cleaner and to the temperature sensor. This is accomplished by simply removing the air cleaner wing nut and lifting off the top. From the temperature sensor the hose should connect to the intake manifold where the vacuum signal is produced. On systems equipped with a vacuum override motor, the vacuum hose from the motor should be followed to the intake manifold connection.

5. Check the vacuum hoses for cracks and deterioration.

   Cracks and deterioration on vacuum hoses allow atmospheric pressure to leak into the lines. This severely limits the vacuum signal and prohibits proper system response.

6. Check that all hose connections are tight and secure.

   A loose connection anywhere in the system will weaken or prevent the vacuum signal from passing any further along the routing.

---

33. When inspecting the TAC system, insure that the air cleaner is properly in place and has not been ________________.

---

34. The ______________ opening should not be blocked preventing air from freely entering the system.

---

35. All hose connections should be ____________.

SYSTEM TESTING

The system should be tested periodically and whenever it is suspected of working improperly. We have discussed the Thermostatic Type air cleaner with and without the vacuum override motor. We have also examined the Air Valve Type air cleaner. The testing procedures for each type will now be presented.

THERMOSTATIC TYPE AIR CLEANER TEST

The Thermostatic Type air cleaner is relatively easy to test. First inspect the air door linkage and spring for freedom of movement. If the linkage and spring are functioning properly, remove the air cleaner assembly from the carburetor. Lift off the air cleaner top and remove the air cleaner assembly from carburetor. Place the snorkel, containing the thermostat in a pan of water with a temperature below 85°F or place a cold rag on the thermostat. Allow a few minutes for the assembly to reach this

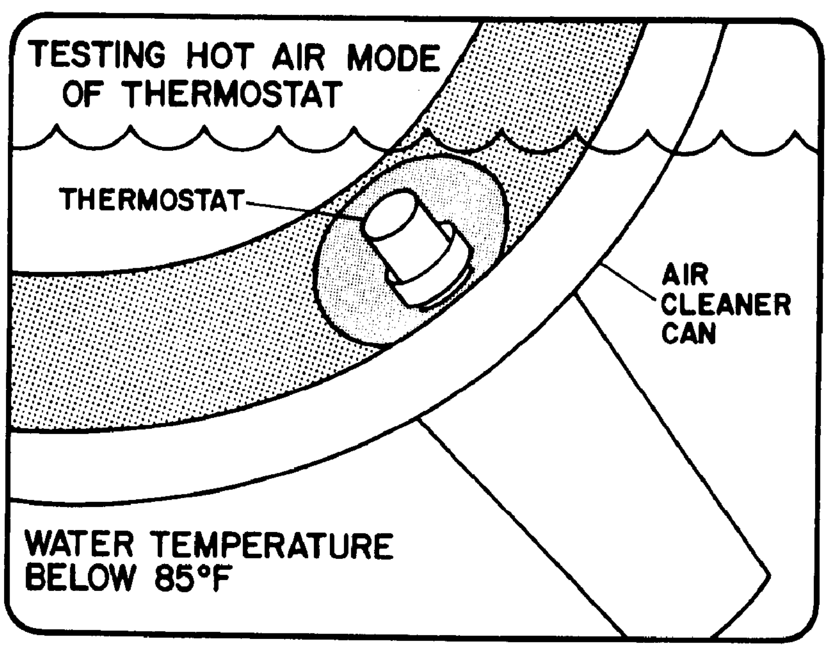

FIGURE 2-20

cooler temperature. The thermostat should position the air valve door in the heat on or hot air delivery mode.

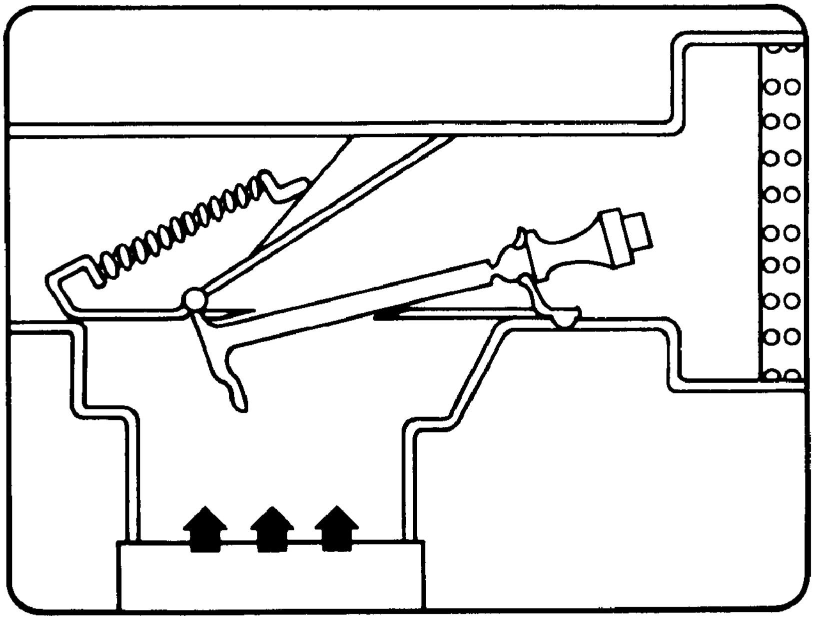

FIGURE 2-21

Now, using a thermometer and heat source, heat the water (or hot rag) to approximately 130°F. At this temperature the thermostat should be fully extended. This would position the air door in the cold air delivery mode, allowing only cooler engine compartment air to enter the carburetor. Should this cold air delivery mode not occur, the thermostat should be replaced.

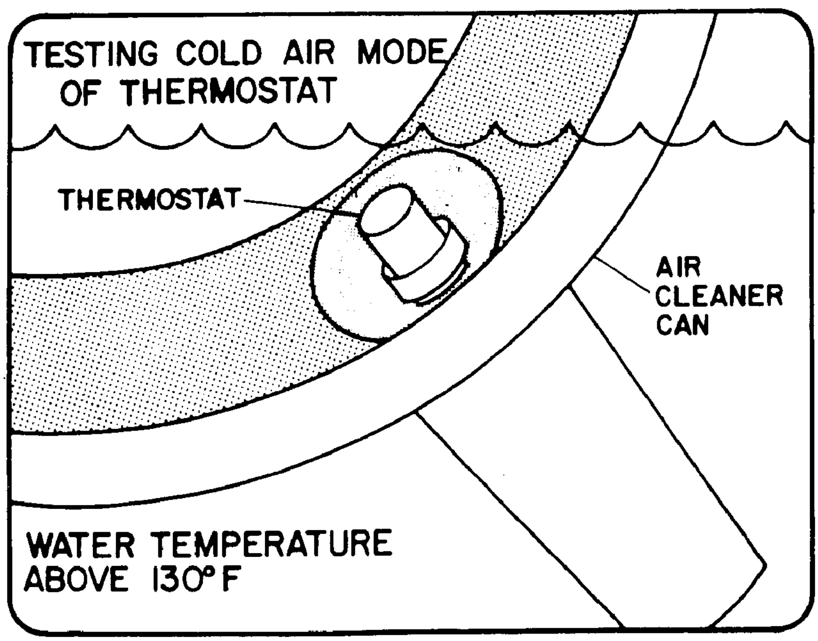

FIGURE 3-22

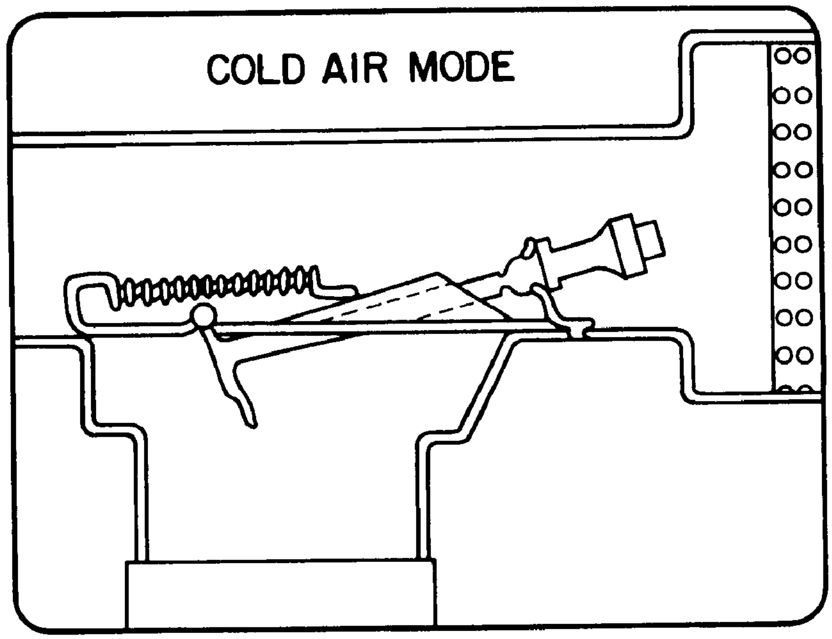

FIGURE 2-23

VACUUM OVERRIDE MOTOR TEST

If the system has a vacuum override motor, this component must also be tested. With the engine off and the air cleaner assembly installed, cool the thermostat to below 85°F. The air valve door should be in the regulating mode position. If the air door is not in this position, check for possible interference with the door opening or vacuum motor which would not allow the door to move. Correct by realigning the air door or vacuum motor as required. Next, with the temperature still below 85°F, start the engine to introduce intake manifold vacuum to the override motor. With temperature below 85°F the air valve door should be in the full hot air delivery mode. Align the door or vacuum motor if interference is noted. If the air valve door remains in the regulating mode position, remove the vacuum hose at the override motor. Using a vacuum gauge check for full manifold vacuum at the hose. If vacuum is weak, check for vacuum leaks. If the vacuum signal is correct and the air valve door still will not move, disconnect the vacuum motor and observe the action of the thermostat on the air valve door. Using the testing procedure for the air cleaner with the thermostat alone, determine if the air valve door moves with temperature changes. If the thermostat operates the air door properly without the vacuum motor, the problem is not in the thermostat or linkage but with the vacuum motor itself.

AIR VALVE TYPE AIR CLEANER TEST

We will now discuss the relatively easy testing procedures for the Air Valve Type air cleaner. First a thermometer is taped in the air cleaner next to the temperature sensor. Install a tee in the vacuum line between vacuum motor and temperature sensor. Connect a vacuum gauge to the tee.

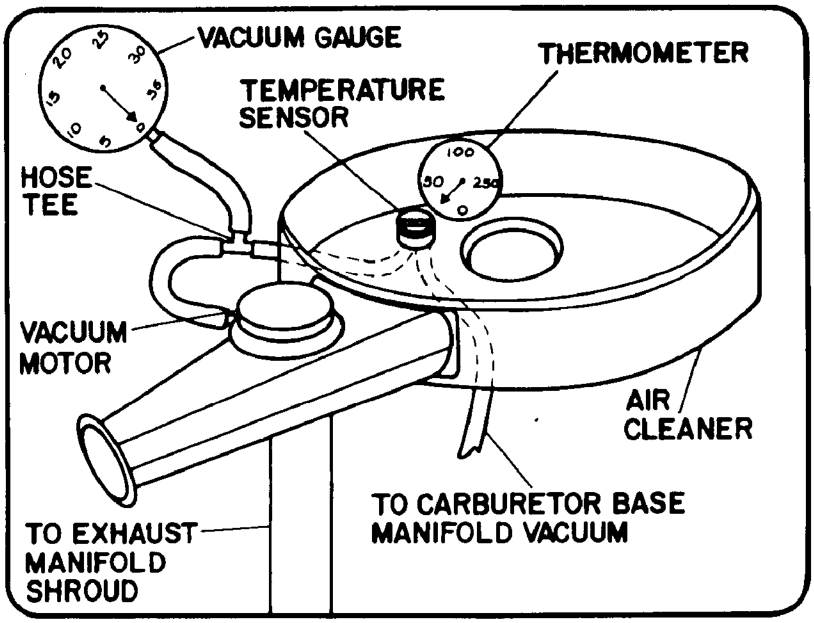

FIGURE 2-24

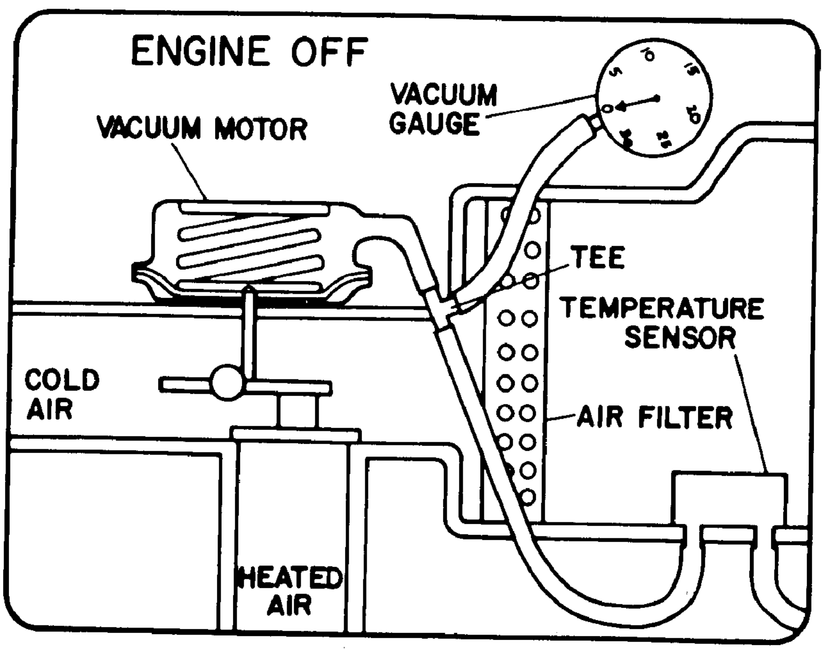

FIGURE 2-25

With the engine off the air valve door should be closed to hot air, allowing cold air to enter carburetor. This will occur at any temperature if the engine is off. Look into the snorkel to make sure.

Either allow engine compartment to cool down or apply a cold wet rag or ice to bring temperature down to 85°F or less. Start engine and allow it to idle. The air valve door should be closed to engine compartment air. The vacuum gauge should register full manifold vacuum.

A hand vacuum pump can also be used without starting the engine. If the valve door is not closed with full vacuum at idle, shut off the engine and check for the following:

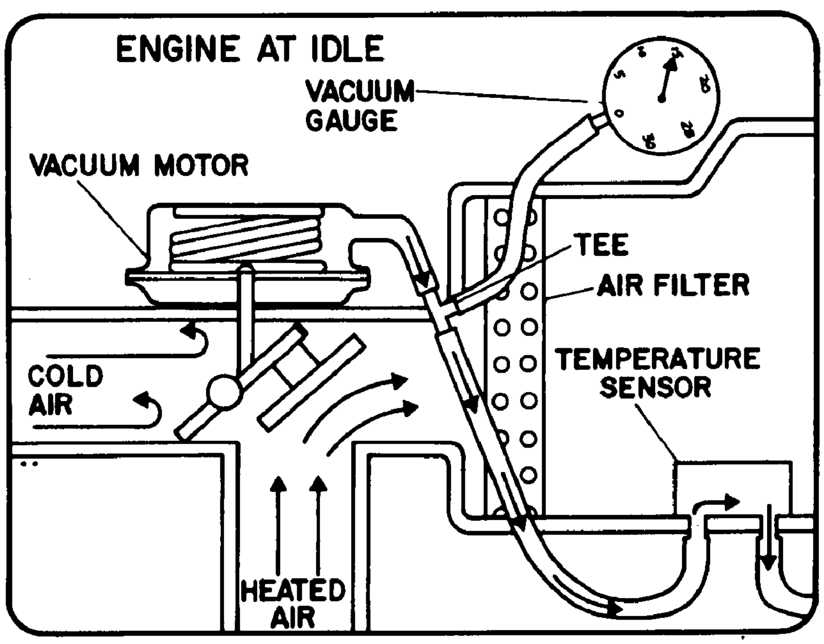

FIGURE 2-26

1. Binding air valve door. This is a common problem. Align for free movement as necessary.
2. Disconnected linkage.
3. Vacuum leaks in the system (if full vacuum is not indicated on vacuum gauge).
4. Defective vacuum motor.

Next with the engine at idle (or vacuum created by hand pump) allow temperature to rise above 85°F. As the temperature rises the air door should begin to open to cooler engine compartment air.

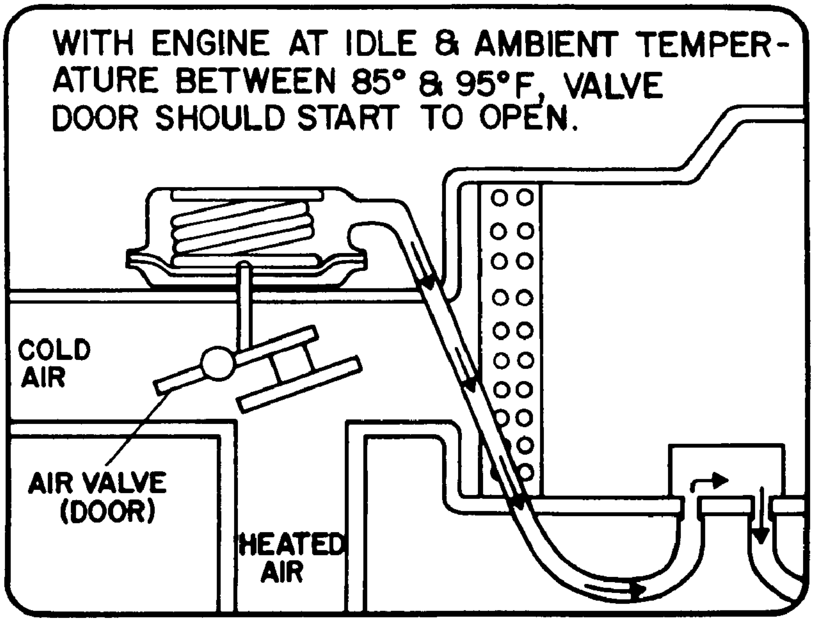

FIGURE 2-27

Without a change in vacuum reading, the air door should be completely opened to cold air at a temperature of approximately 130°F. If vacuum reading drops to 5"-9" mercury (Hg) the temperature will be between 105°F and 130°F when the door is completely opened.

When the air valve door in the snorkel begins to move toward the cold air delivery mode, remove the cover on the air cleaner and check the thermometer next to the sensor for specified temperature. Also check vacuum reading. Vacuum reading should be 5"-9" of mercury (Hg) when the air door is completely open to cold air. A hand vacuum pump with attached gauge can also be used to conduct the vacuum test.

If the temperature is within specifications and the air valve door opens to cold air, the system is operating correctly.

If the temperature is out of specifications, but vacuum is correct, "replace the temperature sensor."

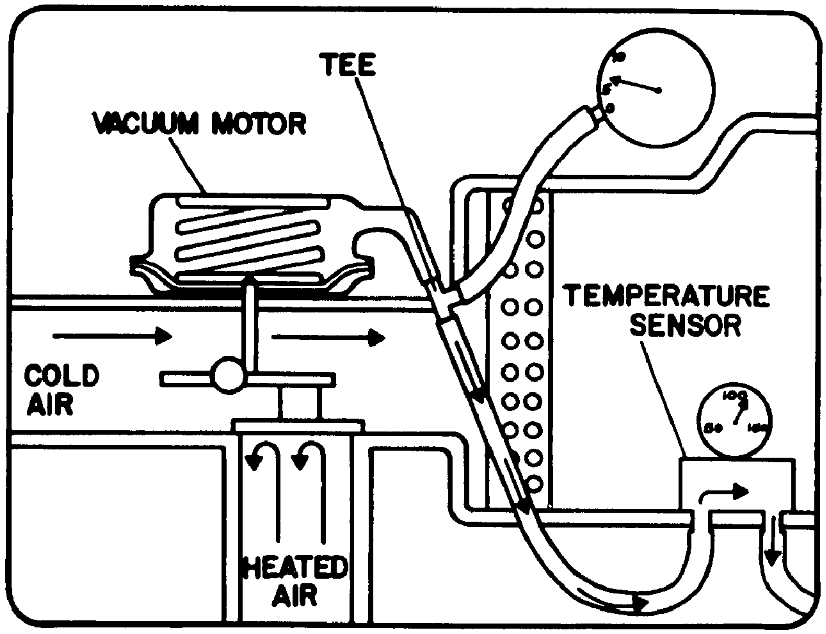

FIGURE 2-28

If both the temperature and vacuum are within specifications and the air valve door remains closed to cooler engine compartment air, "replace the vacuum motor." Remember: the temperature sensor is preset at the factory, do not adjust.

Some manufacturers use an additional air intake that is available as an option on certain models. The thermostatic controlled air cleaner is basically the same as the air valve type discussed previously except it has two snorkels.

One snorkel contains a vacuum motor with a temperature sensor and works the same as we have discussed. The additional snorkel contains a vacuum motor but does not have a temperature sensor. The air valve door is controlled only by intake manifold vacuum and is closed to cold air under all conditions except heavy acceleration. Testing procedure is the same as for the single snorkel air cleaner.

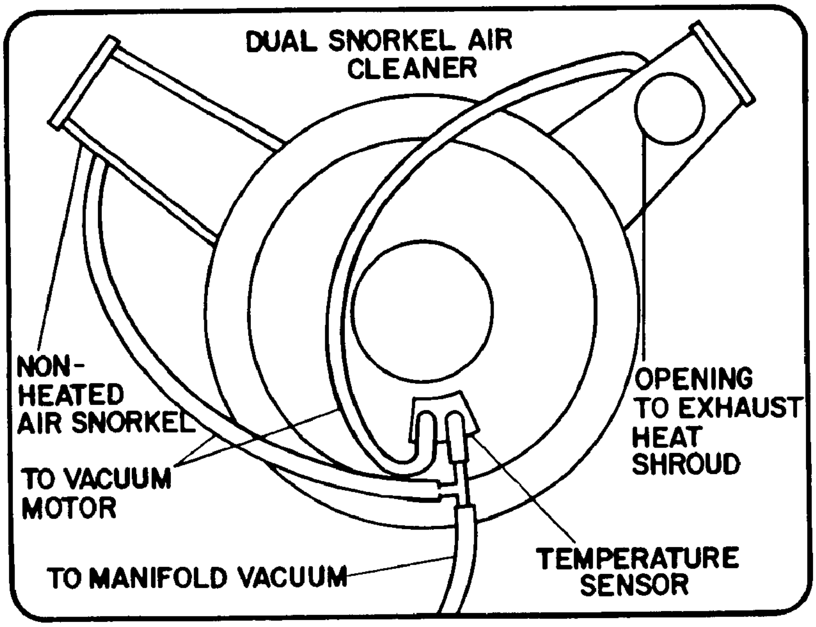

FIGURE 2-29

The processes and procedures above are basic to temperature controlled air cleaners. For exact procedures and specifications on specific makes and models you should refer to the manufacturer's technical and/or service manual.

By following the inspection and servicing procedures for the TAC system, the intake air for the carburetor will be approximately 100°F or higher. This temperature enhances a more complete combustion, better cold engine driveability and a significant reduction of HC and CO emissions.

---

36. First inspect the air __________ ________ linkage and spring for freedom of movement.

---

37. Place the snorkel, containing the ____________________ in a pan of water with a temperature below 85°F.

---

38. Using a thermometer and heat source, heat the water (or hot rags) to approximately 130°F. At this temperature, the thermostat should be __________ ________________.

---

39. During the vacuum override motor test, and if the thermostat operates the air door properly without the vacuum motor, the problem is not the thermostat or linkage but with the ____________ __________ itself.

SYSTEM SUMMARY

PURPOSE

The TAC system is designed to provide heated air to the carburetor during cold-engine conditions. By providing heated air during engine warm-up conditions, a leaner air/fuel mixture can be used thereby reducing hydrocarbon emissions. The system also assists in cold-engine driveabiltiy and the elimination of carburetor icing.

MAIN COMPONENTS

Exhaust Manifold Heat Shroud - A metal shroud around the exhaust manifold that directs air flow over the exhaust manifold to preheat it.

Hot Air Pipe - Directs air from the exhaust manifold heat shroud to the snorkel of the air cleaner.

Air Door Assembly - Regulates when and how much heated air enters the air cleaner.

Vacuum Diaphragm Unit - Controls the air door assembly. Actuated by spring pressure and intake manifold vacuum.

Temperature Sensor - Senses incoming air temperature by means of a temperature sensing spring. The position of the spring operates a small valve that determines if vacuum is applied to vacuum diaphragm or if it is vented.

SYSTEM FUNCTION

When the temperature sensor detects cold engine conditions, it allows intake manifold vacuum to reach the vacuum diaphragm unit. When the vacuum diaphragm receives a vacuum signal, it opens the air door assembly to allow exhaust manifold heated air to enter system. As temperature of incoming air reaches approximately 100°F, the temperature sensor bleeds off vacuum to the diaphragm unit closing the system to heated air allowing only cooler engine compartment air to enter.

ANSWERS

1. Thermostatic Air Cleaner
2. driveabiltiy
3. incomplete combustion
4. leaner
5. atomization
6. warm
7. heated air
8. warm-up
9. CO
10. Thermostatic
11. hot air
12. air valve
13. engine compartment
14. vacuum override
15. intake manifold
16. acceleration
17. air door
18. air bleed valve
19. temperature sensor
20. control or adjust
21. hot air mode
22. regulating mode
23. cold air mode
24. engine compartment
25. cold air mode
26. intake manifold
27. regulating mode
28. open
29. open
30. vacuum
31. vacuum override
32. cold
33. modified
34. snorkel
35. secure
36. valve door
37. thermostat
38. fully extended
39. vacuum motor

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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 Thermostatic Air Cleaner 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, Thermostatic Air Cleaner, Photochemical, Hydrocarbons, Intake Manifold, System Inspection, Carbon Monoxide, Oxides of Nitrogen, Ignition Timing, Carburetion, Atomization, Acceleration, Temperature Sensor, Snorkel, Thermostat		

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