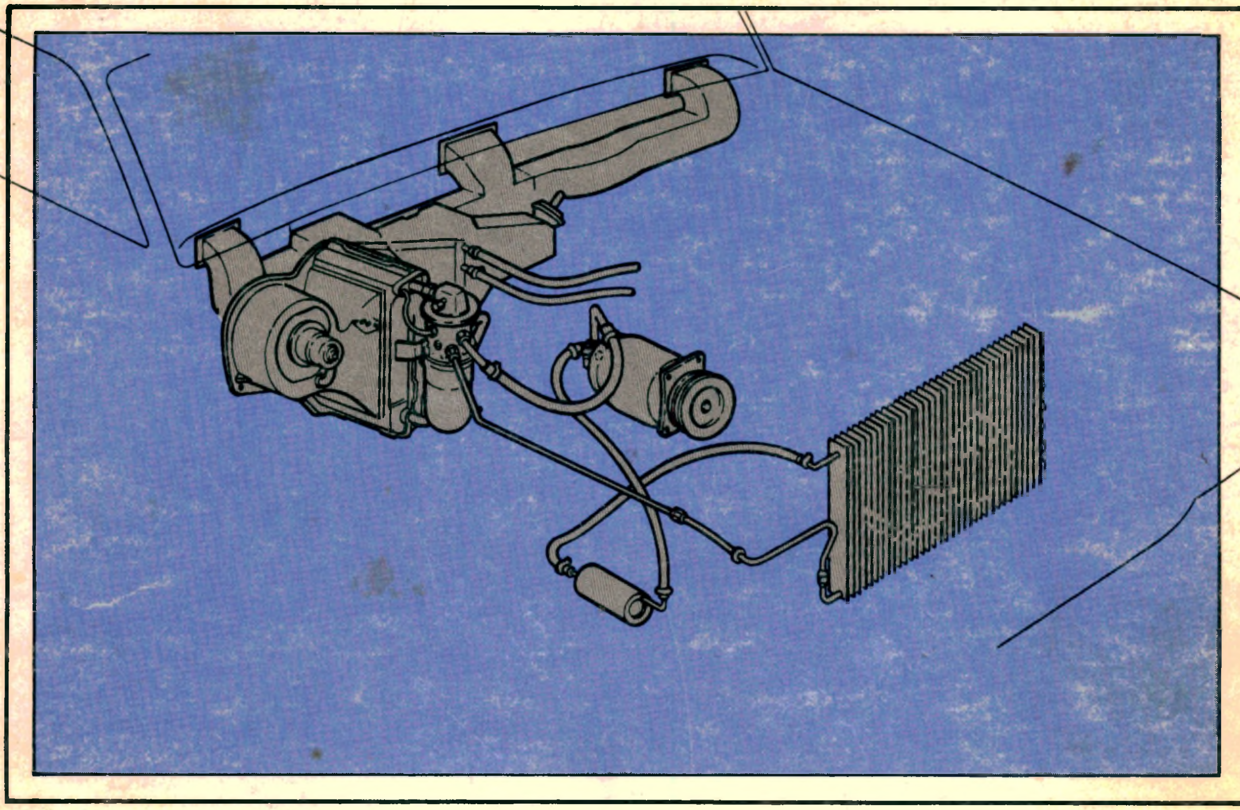
FUNDAMENTALS OF AIR-CONDITIONING



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FUNDAMENTALS OF AIR-CONDITIONING

FOREWORD

This booklet is supplied by GM Product Service Training to GM dealer service personnel upon their completion of the subject course conducted at GM Training Centers.

While this booklet will serve as an excellent review of the extensive program presented in the training center session, it is not intended to substitute for the various service manuals normally used on the job. The range of specifications and variation in procedures between carlines and models requires that the division service publications be referred to, as necessary, when performing these operations.

All information contained in this booklet is based on the latest data available at the time of publication approval. The right is reserved to make product of publication changes, at any time, without notice.

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1. FUNDAMENTALS OF AUTOMOTIVE AIR CONDITIONING

GENERAL INFORMATION

Three basic principles of physics must be grasped to fully understand how air conditioning systems work. You must first understand the nature and behavior of heat. Also, you must understand a few rules governing the behavior of liquids and gases. (Fig. 1-1). And finally, you need to know the purpose, behavior, and characteristics of a substance known as "refrigerant".

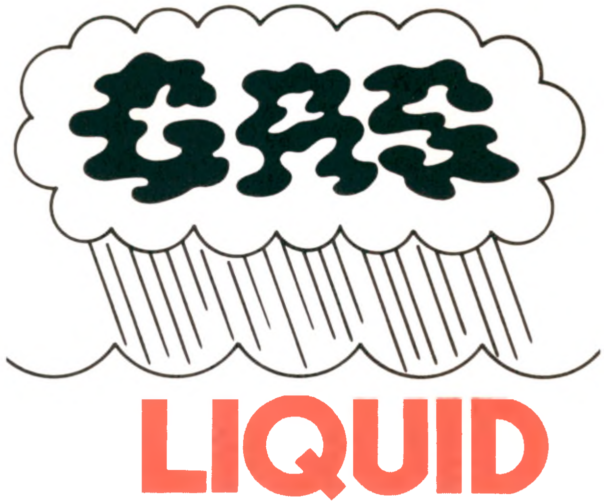

Fig. 1-1 — Liquids and Gases

Heat and Temperature

Within the science of physics, there are laws which describe the behavior of the world around us. One such law deals with the way heat behaves.

But just what is heat? When you think of heat, you might think of a steaming cup of coffee or something with warmth. And that is correct; heat is warmth. But even an iceberg contains heat, too. In fact, anything you can touch contains heat (Fig. 1-2).

Actually, there is no such thing as "cold". The only way we can define it is in a rather negative sort of way. "Cold" is simply the lack of heat, just as darkness is the lack of light.

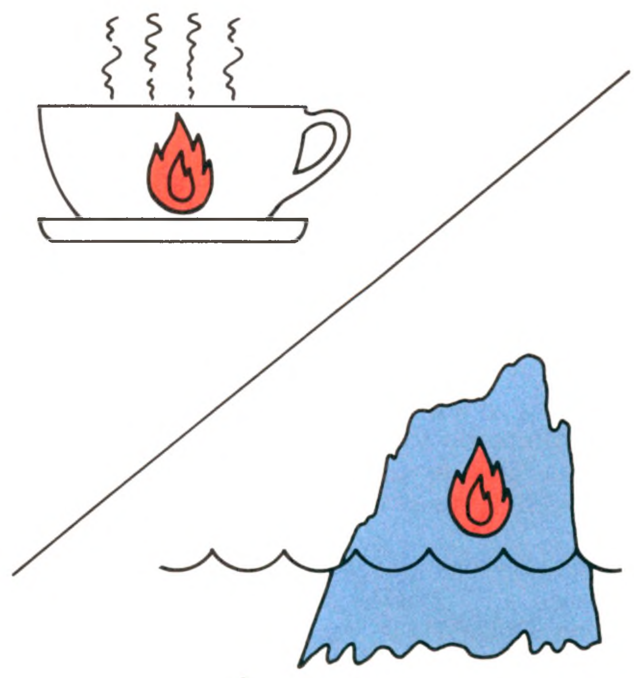

Fig. 1-2 — All Matter Contains Heat

All matter is made up of very small particles called molecules. These molecules are always moving. Heat is the energy of this molecular motion. The only time these molecules do not move is when the substance is at the theoretical temperature of 460 degrees Fahrenheit below zero. In physics this temperature is know as absolute zero (Fig. 1-3).

Since matter does not exist at such an incredibly low temperature, everything you can touch contains at least some heat.

Note the difference between heat and temperature. Heat is the total *quantity* of the energy of the molecules which compose any given object. Temperature measures the *intensity* of the energy of the molecules which compose any given object.

You can compare the difference between heat and temperature to the difference between the amount of gasoline in a car's gas tank and the position of the needle on the fuel gauge. The actual amount of gasoline represents heat. The reading on the gauge represents temperature.

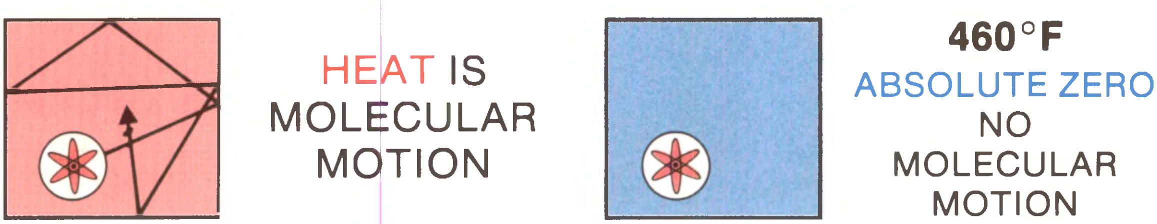

Fig. 1-3 — Heat Is Molecular Motion

Thermometers measure temperature, or the *intensity* of energy in an object. The unit for measuring temperature is *degree*. Thermometers may be scaled in either Celsius or Fahrenheit. In a pot of boiling water a thermometer measuring temperature on the Celsius scale will read 100°. In the same pot of boiling water a thermometer measuring temperature on the Fahrenheit scale will read 212°. The intensity of the heat is the same; it's just being measured on different scales.

The unit for measuring the *quantity* of heat is called a BTU. BTU stands for British Thermal Unit. One BTU is the amount of heat needed to raise the temperature of a pound of water one degree Fahrenheit (Fig. 1-4).

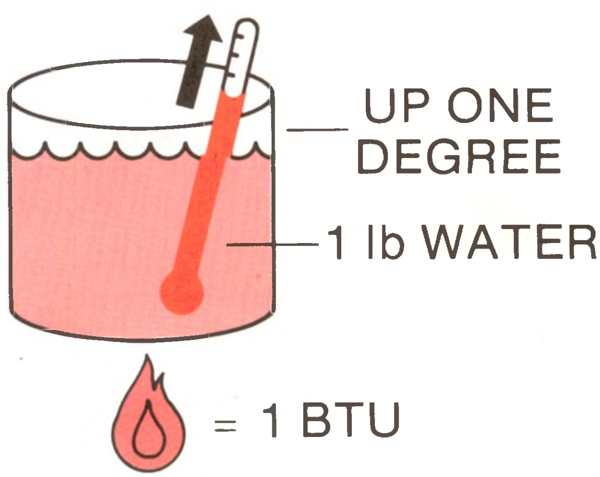

Fig. 1-4 — British Thermal Unit (BTU)

The needle on the gas gauge shows the average quantity of energy in the system. If you have a Volkswagen and a Cadillac in the driveway, both could show half full on their gas gauges. But the Cadillac would obviously have more gallons in its tank. Similarly, two objects could have the same temperature, yet one of these objects could contain much more heat than the other. For example, the hot coals in a barbecue contain less total heat than the water in the kid's swimming pool. This is true even though the temperature of the coals is much higher than the temperature of the water (Fig. 1-5).

Again, you can see that there is no such thing as adding cold when you think of heat this way. To make something cold you can only remove heat.

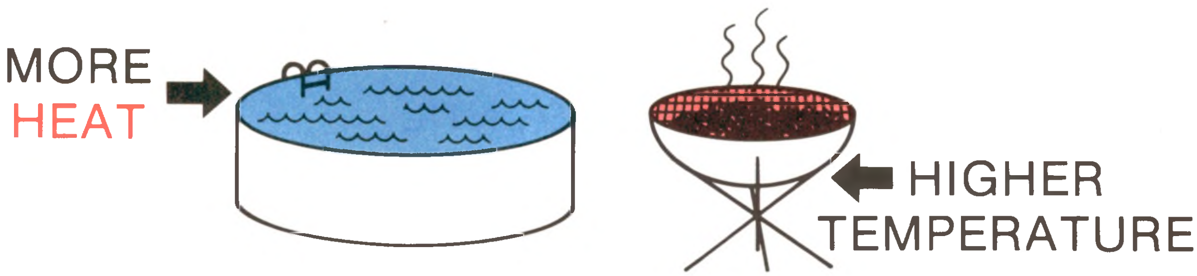

Fig. 1-5 — Heat Versus Temperature

Heat Transfer

One of the laws of physics explains the behavior of heat. This law states that heat always flows from an area of higher temperature to an area of colder temperature. Just as water flows downhill, heat always flows down the temperature scale—from a warm level down to a colder one (Fig. 1-6). When you make a snowball, heat always flows from your warm hand to the colder snow.

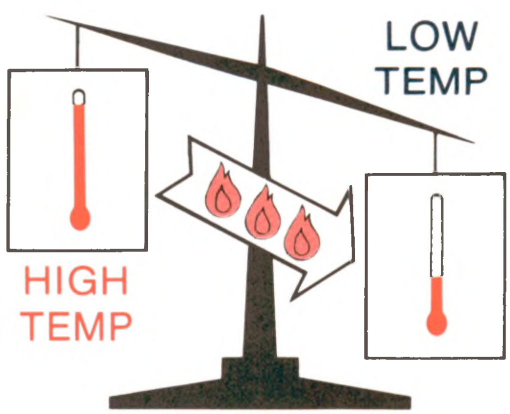

Fig. 1-6 — Heat Transfer

The greater the difference between the high and low temperature, the faster heat flows. Heat continues to flow between the two areas of unequal temperature until both are at the same temperature (Fig. 1-7). In physics this flow of heat is called heat transfer.

One of the best examples of heat transfer in an automobile is in its cooling system. A car's liquid cooling system works because a heat transfer occurs in several areas. The burning fuel generates a lot of heat. Because the cylinder walls are cooler than the temperature of the burning fuel, heat flows, or transfers, into the cylinder walls.

On the other side of the cylinder walls is the engine coolant. Another heat transfer occurs when some of this heat flows from the walls into the coolant. Remember, this happens because the walls are hotter than the coolant. And heat always flows from a warm object to a colder one.

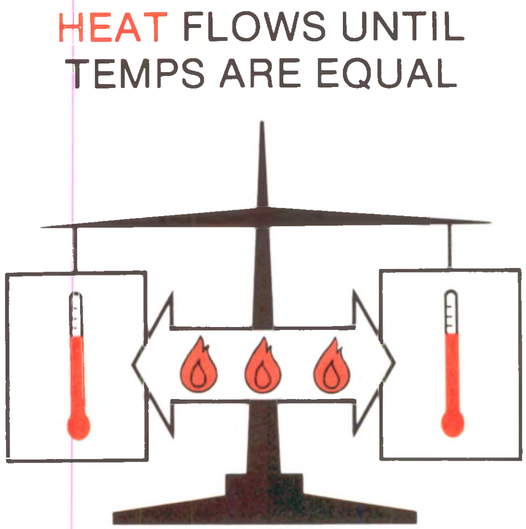

Fig. 1-7 — Equal Temperatures

The water pump circulates the coolant, and the heat absorbed by the coolant is carried away from the cylinder walls. As the coolant reaches the radiator, another transfer occurs. The radiator's metal tubing and fins are another area of lower temperature than the temperature of the heat carried by the coolant. The heat flows from the coolant to the metal surfaces of the radiator.

In one last transfer, heat now flows from the hot metal surfaces of the radiator to the cooler outside air flowing in through the car's grill.

Because of the law of heat transfer, the engine does not overheat. The heat originally created by the burning gasoline flows through a series of transfers to the outside air. In each transfer the law of heat transfer is upheld: heat flows from an area of high temperature to an area of low temperature.

Without heat transfer air conditioning systems could not work. In principle the air conditioning system's job is similar to the job of the engine cooling system. The engine cooling system carries heat away from the cylinder walls. An air conditioning system carries heat away from the air in the passenger compartment. Heat flows from the warm air in the passenger compartment to the cooler evaporator. In the engine cooling system the coolant carries away heat. In an air conditioning system heat is carried away by a substance known as refrigerant (Fig. 1-8).

An engine cooling system releases its heat to the outside air. So does an air conditioning system. Heat flows from the hot condenser to the cooler outside air. An air conditioning system also even makes use of a radiator-style metal tube and fin construction that increases heat transfer to the air.

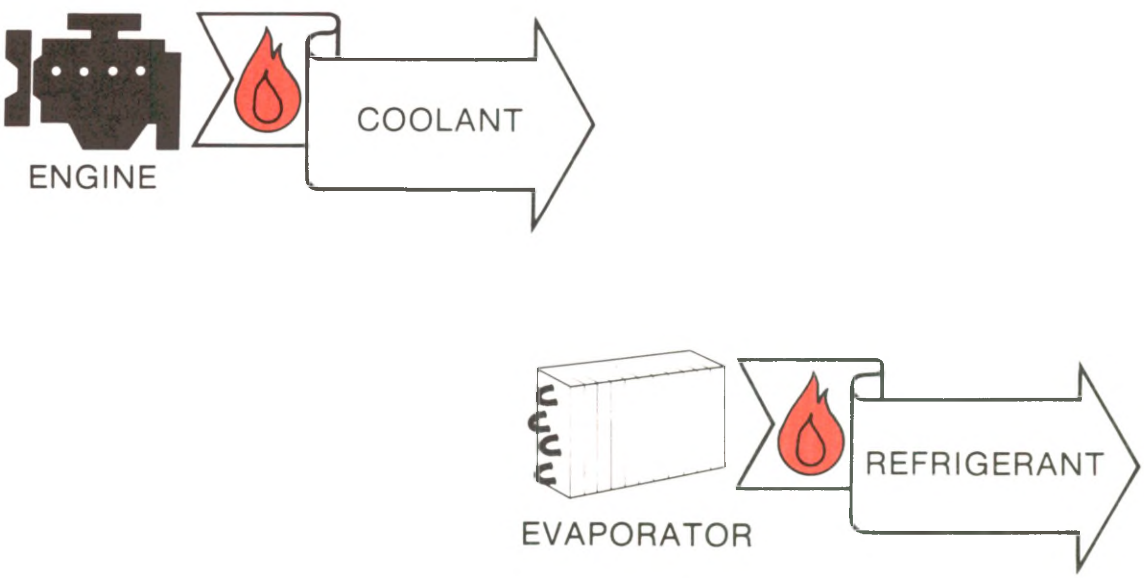

Fig. 1-8 — Mediums of Heat Transfer

However, there are some important differences between the two systems. While an engine cooling system uses coolant, an air conditioning system uses refrigerant. Engine coolant ordinarily remains a liquid while it transfers heat, but refrigerant acts differently. Inside the air conditioning system refrigerant evaporates and condenses over and over again as it transfers heat. Refrigerant, then, is sometimes a liquid and sometimes a vapor and sometimes changing between the two (Fig. 1-9).

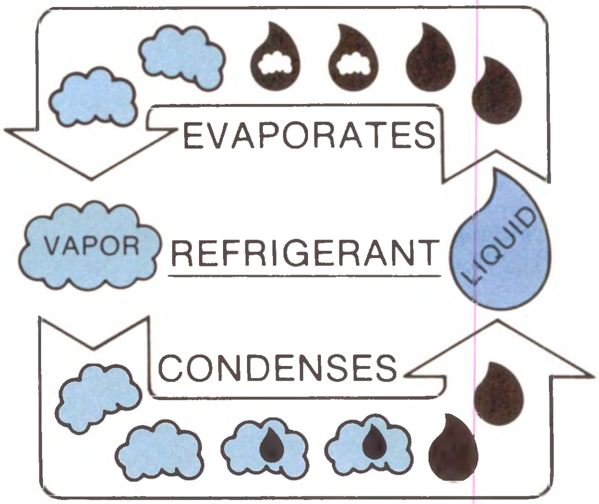

Fig. 1-9 — Refrigerant Changes State

Evaporation

Evaporation, or boiling, occurs when a liquid changes to a vapor. We mentioned earlier that all matter is made up of molecules. We also said that these molecules are always in constant motion. What state the material is in (solid, liquid, or gas), however, varies with the amount of this molecular motion.

A solid object's molecules are held extremely close together. Because they do little more than vibrate in place, a solid has a constant and defined shape. When molecules are this close together the force, or bond, that holds them in place is very strong. This is why the molecules cannot move much (Fig. 1-10).

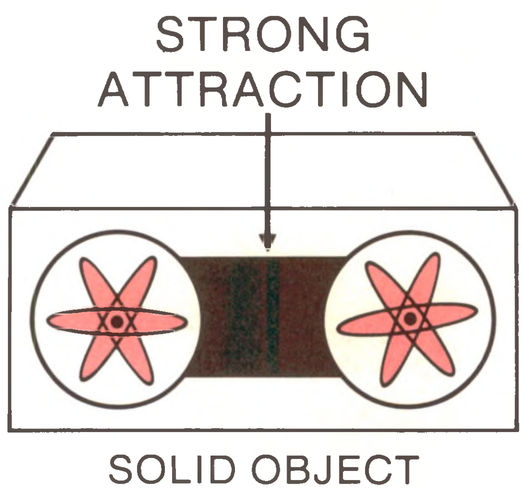

Fig. 1-10 — Molecules in a Solid

In a liquid the force holding the molecules together is not as strong. The molecules are more widely spaced than in a solid, and they move about more freely. This is why a liquid is able to take on the shape of its container (Fig. 1-11).

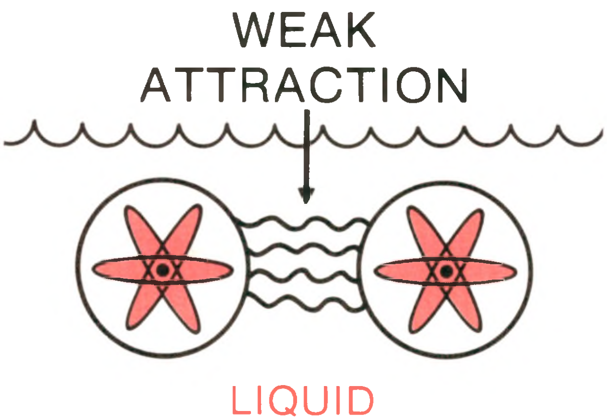

Fig. 1-11 — **Molecules in a Liquid**

Molecules are so widely spaced in a gas or a vapor that there is no force holding them together at all. Being completely free to move, they fill whatever space is available to them.

When heat energy is added to a liquid its molecules move more rapidly. Eventually they break loose from each other and the liquid becomes a vapor. The liquid is said to have undergone a "change of state" (Fig. 1-12).

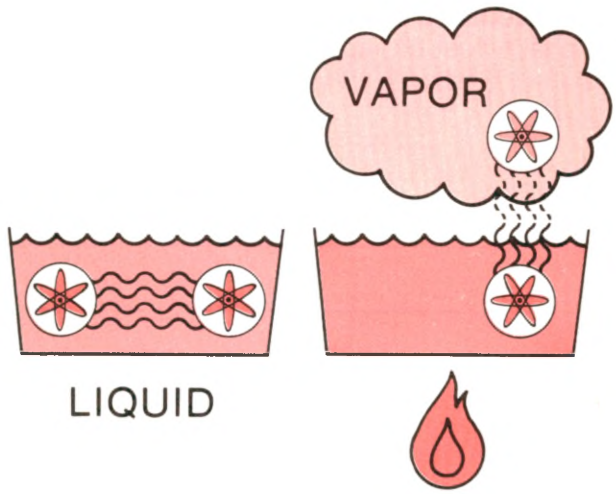

Fig. 1-12 — **Molecules Evaporating**

In physics a change of state is said to occur when a substance's molecular structure is rearranged as it changes between any two of the three physical states: solid, liquid, or vapor. Think of an ice cube tossed onto a hot stove (Fig. 1-13). At first the ice is a solid. As it melts into a liquid, it undergoes a change of state. And as the water evaporates into a vapor, another change of state occurs.

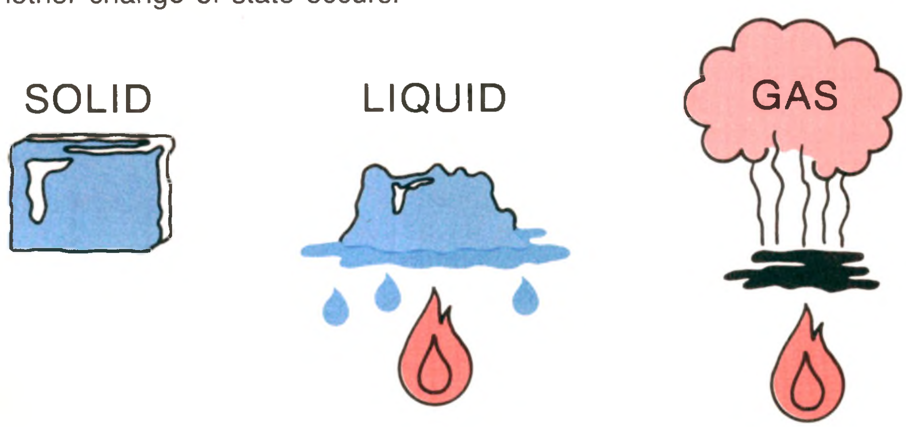

Fig. 1-13 — **Changes in States of Matter**

Heat of Vaporization

Another important law of physics describes the amount of heat needed to change the state of a liquid into a vapor. It's called the Heat of Vaporization law.

To convert a liquid into a vapor a specific amount of heat is needed. This heat frees the molecules from the state of being a liquid by breaking the force holding them together. The amount of heat needed to change one gram of a material from a liquid into a vapor is that material's heat of vaporization (Fig. 1-14).

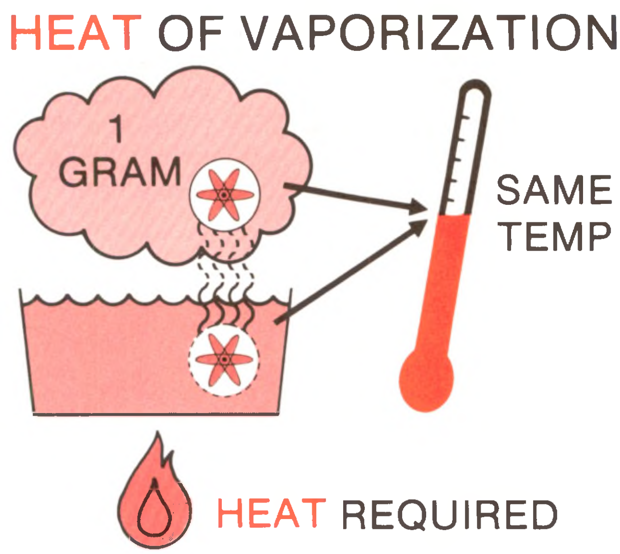

Fig. 1-14 — Heat of Vaporization

To understand this concept better, let's look at how water boils. Boiling, just like evaporation, is the process of converting a liquid into a vapor.

For an example, let's put a pot on the stove and boil an egg. At room temperature some evaporation takes place at the surface of the water. When the stove is turned on, the temperature of the water begins to rise. As it does, the water molecules begin to move faster. At the surface of the water, evaporation increases as more molecules gain the speed needed to break free.

After a while the water reaches 212° Fahrenheit, which is water's boiling point. At this point we have a rolling boil going as bubbles of water vapor rise to the surface. There is enough heat now beneath the surface of the water that molecules don't need to be at the surface to break free.

Now if we were late for work and in a hurry we might think to drop the egg in the boiling water and really turn up the burner. We might think that by turning up the stove and adding more heat the temperature of the water will rise and the egg will cook faster. But actually this is wrong. Once the temperature of the water reaches the boiling point of 212° Fahrenheit it won't go any higher. Any heat that is not needed to keep the water at that temperature is then used to change more liquid to vapor (Fig. 1-15).

Fig. 1-15 — Water at its Boiling Point

Something also to note is that neither the temperature of the water nor the temperature of the vapor will go above 212° Fahrenheit. This may appear to be a peculiarity of the Heat of Vaporization law, yet this is one of the basic principles of refrigeration. While a liquid changes into a vapor, it absorbs abnormally great amounts of heat without getting any hotter. This is what happens in the evaporator of an air conditioning system.

This "heat of vaporization" is also known as latent heat. Latent is a Latin word meaning "hidden" or "concealed". This makes sense because the heat required to make the water change into a vapor stays with the vapor molecules. But the *temperature* of the vapor does not increase as the "latent" heat is absorbed. This is why it's considered hidden heat (Fig. 1-16).

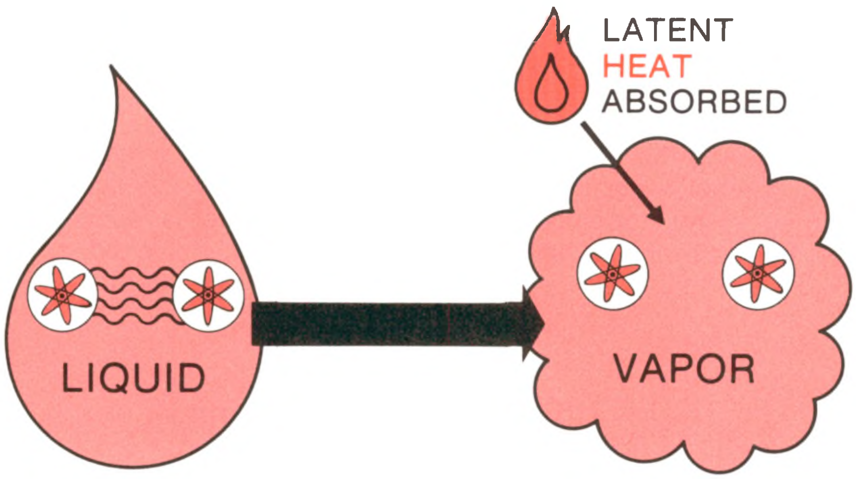

Fig. 1-16 — Latent Heat Absorbed

When a vapor changes back to a liquid, or condenses, the latent heat carried by the molecules is absorbed by the surrounding area. Once again the molecules are held together in a liquid state (Fig. 1-17). This is what happens in the condenser of an air conditioning system.

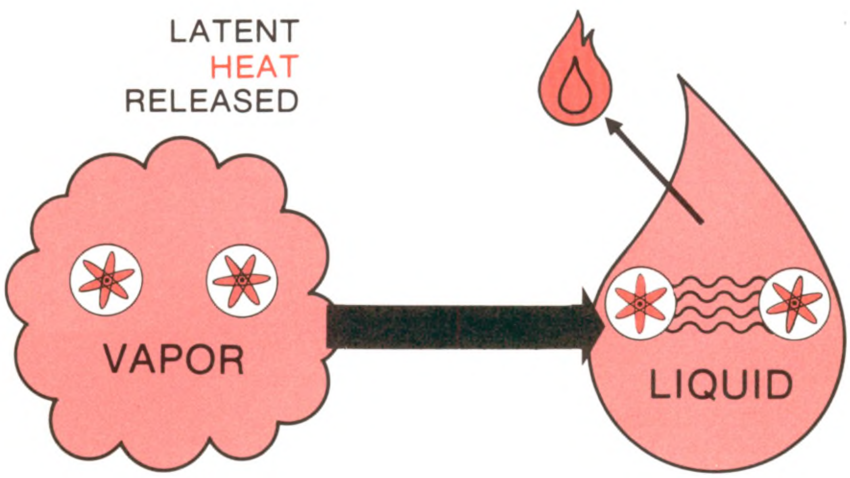

Fig. 1-17 — Latent Heat Released

The Effect of Pressure on Boiling Point

The science of physics also has some laws about the relationship between pressure and a liquid's boiling point. If you raise the pressure above a liquid, you raise its boiling point. In the same manner if you lower the pressure above a liquid, you lower its boiling point.

At the air pressure found at sea level, water boils at 212° Fahrenheit. This pressure is called "one atmosphere". At higher altitudes air pressure is less. Water's boiling point then is lower than 212° Fahrenheit. This is why cooking an egg might take seven minutes in New York versus nine minutes up at Lake Tahoe (Fig. 1-18).

Below sea level, or where air pressure is greater than one atmosphere, water's boiling point is higher than 212° Fahrenheit. A place like Death Valley then would be the place where an egg could be cooked the quickest.

An example of lowering the boiling point of water can be found in nearly any novelty shop. There you can buy a glass globe containing some water. Because some of the air has been taken out of the globe, the pressure above the water is reduced. So when you hold the globe, the water inside boils just from the heat of your hand.

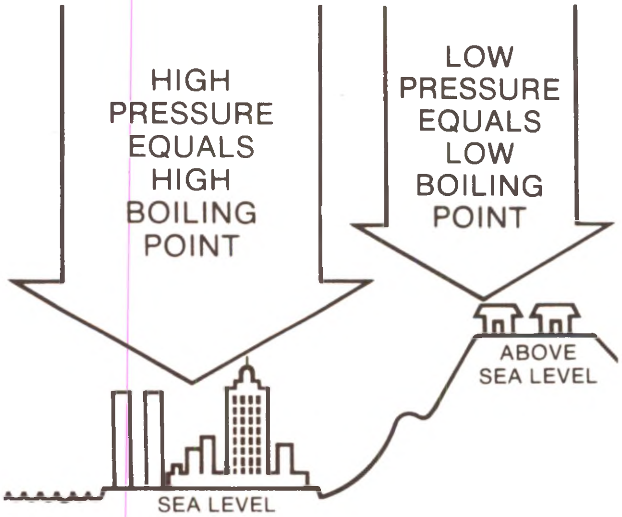

Fig. 1-18 — **Pressure's Effect on Boiling Point**

An example demonstrating the effects of pressure on the boiling point of water can also be readily seen in an automotive radiator. As the coolant warms up pressure builds up inside the sealed system. Because of the pressure in the system, the boiling point of the water rises above 212° Fahrenheit. As long as the system remains sealed and pressure is maintained, the water will not boil even if its temperature is above 212° Fahrenheit (Fig. 1-19).

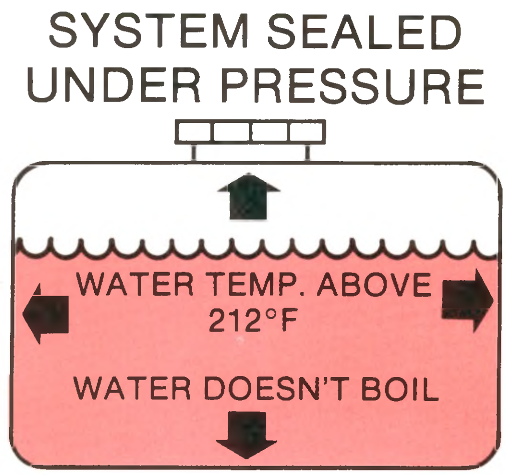

Fig. 1-19 — Pressure Raises Boiling Point

If the hot radiator cap were to fall off, however, pressure in the system would be reduced to ambient air pressure. This would cause the water in the radiator to boil (Fig. 1-20).

The general rule of physics to apply here is that pressure affects all liquids the same way it affects water.

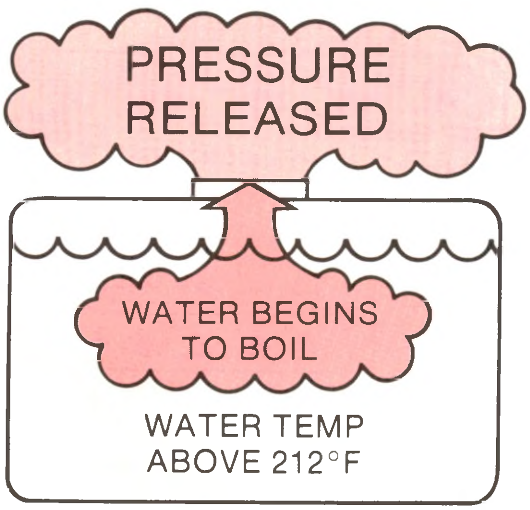

Fig. 1-20 — Pressure Released

Compressing a Gas

In studying refrigeration a final concept of physics to know concerns compressing a gas or vapor. Compressing a vapor concentrates its heat. When a vapor's heat is concentrated this way, the intensity, or the temperature, of the vapor increases. So without adding additional heat, just by compressing or squeezing it, the vapor is made hotter (Fig. 1-21). This is what happens in the compressor.

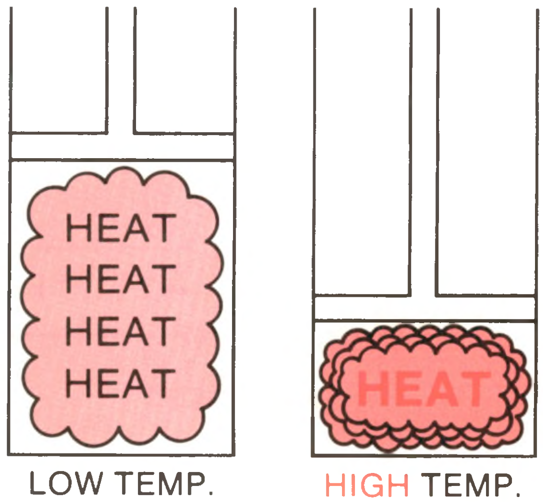

Fig. 1-21 — Concentrating Heat

Basic Refrigerator Operation

We've now covered the scientific ground-rules that apply to refrigeration. Remember these main points: All liquids absorb quantities of heat without getting any warmer when they boil into a vapor. Pressure can then be used to make the vapor condense back into a liquid so that it can be used over again. With just that amount of scientific knowledge, here is how to build a refrigerator.

For our refrigerant we will use the refrigerant especially developed for automotive air conditioning called Refrigerant 12. Refrigerant 12, or more commonly known as R-12, has a boiling temperature of 21.7°F below zero. To picture how cold this is, imagine a flask of R-12 riding on a iceberg in the North Sea. The R-12 would be boiling away from the heat of the iceberg just like a teapot on a stove.

If we were to put flask of R-12 inside a refrigerator cabinet, it would boil and draw heat away from everything surrounding it (Fig. 1-22). As long as any refrigerant remained in the flask, it would keep on soaking up heat. This would continue until the temperature got down to 21.7°F below zero.

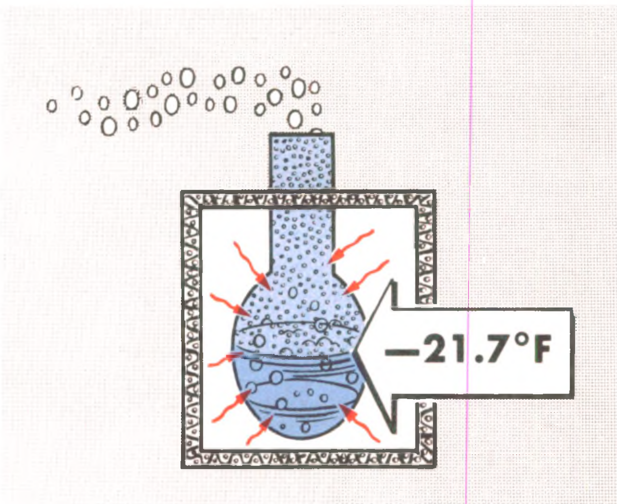

Fig. 1-22 — Simple R-12 Refrigerator

So to build our refrigerator, we can place a flask of refrigerant in a box. We know it will boil at a very cold temperature and will draw heat away from everything inside the box (Fig. 1-23).

We can pipe the rising vapors outside the box and thus provide a way for carrying the heat out. Once we get the heat-laden vapor outside, we can compress it with a pump. With enough pressure, we can concentrate the heat of the "cold" vapor. Once this concentrated heat is raised above room temperature, a heat transfer can occur. An ordinary radiator will help us transfer the heat to the outside air.

By removing the heat and making the refrigerant into a liquid, it becomes the same as it was before. So, we can run another pipe back into the box and return the refrigerant to the flask to be used over again.

This is the way most mechanical refrigerators work today. Now, let's look at an air conditioning unit to see how closely it resembles the refrigerator we just described.

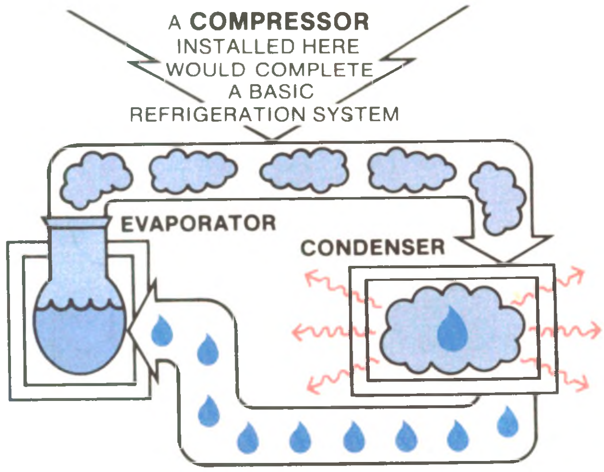

Fig. 1-23 — Basic Refrigeration Circuit

Basic Air Conditioner

When we look at an air conditioning unit, we will always find a set of coils or a finned radiator core through which the air to be cooled passes. This is known as the "evaporator" (Fig. 1-24). It does the same job as the flask of refrigerant we just spoke about. The refrigerant boils in the evaporator. In boiling, of course, the refrigerant absorbs heat and changes into a vapor. By piping this vapor outside the car, heat is carried away.

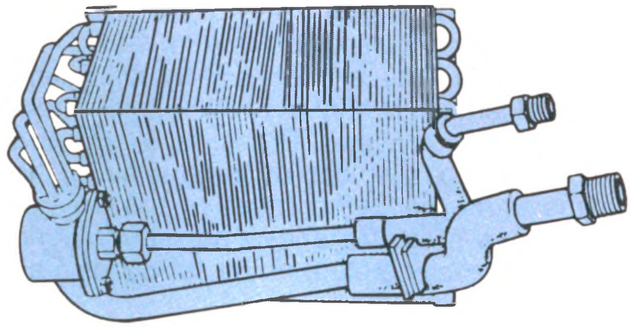

Fig. 1-24 — Evaporator

Once we get vapor out of the evaporator, all we have to do is remove the heat it contains. Since heat is the only thing that expanded the refrigerant from a liquid to a vapor in the first place, removing that same heat will let the vapor condense into a liquid again. Then we can return the liquid refrigerant to the evaporator to be used over again.

At sea level, or an air pressure of one atmosphere, refrigerant boils at 21.7° Fahrenheit below zero. Pressure inside the air conditioning system raises the boiling point of the refrigerant. The ideal temperature for refrigerant to boil inside an air conditioning system is about 30° Fahrenheit. Air conditioning systems are designed to keep their pressure so that refrigerant boils at about this temperature. This creates just the right temperature for taking heat out of the passenger compartment. If it were any colder, the condensation in the evaporator would freeze. If it were any warmer, the cooling would not be efficient.

After the refrigerant has boiled, it flows away as a low pressure, low temperature vapor. Remember that the heat absorbed is not found by an increase in vapor temperature. Instead, it is found in the refrigerant's change of state. The energy needed to make the liquid refrigerant change to a vapor is where the heat has gone.

Even though the refrigerant vapor has absorbed great quantities of heat, its temperature is only about 30° Fahrenheit. Since heat only flows from a warm object to a colder one, a problem arises. The refrigerant vapor must somehow be "cooled" in air temperatures that usually range between 60° and 100° Fahrenheit before it will condense back into a liquid.

With a pump, though, we can squeeze the heat-laden vapor into a smaller space. And, when we compress the vapor, we also concentrate the heat it contains. In this way, we can make the vapor hotter without adding any heat. Then we can cool it in comparatively warm air.

That is the only responsibility of a compressor in an air conditioning system (Fig. 1-25). It is not intended to be a pump just for circulating the refrigerant. Rather, its job is to exert pressure for two reasons. Pressure makes the vapor hot enough to cool off in warm air. At the *same time*, the compressor raises the refrigerant's pressure above the condensing point at the temperature of the surrounding air so it will condense.

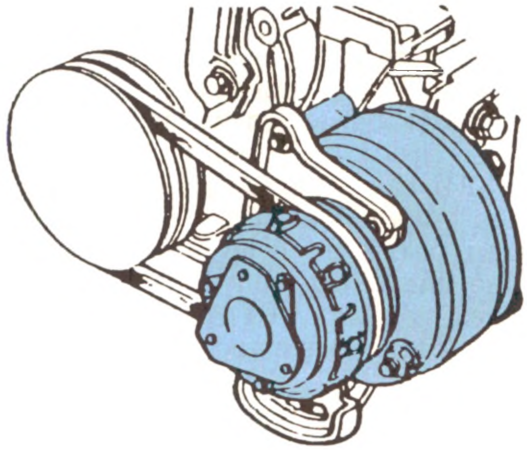

Fig. 1-25 — Compressor

As the refrigerant leaves the compressor, it is still a vapor although it is now quite hot and ready to give up the heat absorbed in the evaporator. One of the easiest ways to help refrigerant vapor discharge its heat is to send it through a radiator-like component known as a condenser (Fig. 1-26).

The condenser is a very simple device with no moving parts. Refrigerant vapor transfers its heat into the surrounding air through the large finned surfaces of the condenser. In giving up its heat, the refrigerant vapor condenses back into a liquid which collects in a pool at the bottom of the condenser.

As we said before, when the refrigerant condenses into a liquid, it again is ready for boiling in the evaporator. So, we can run a pipe from the condenser back to the evaporator.

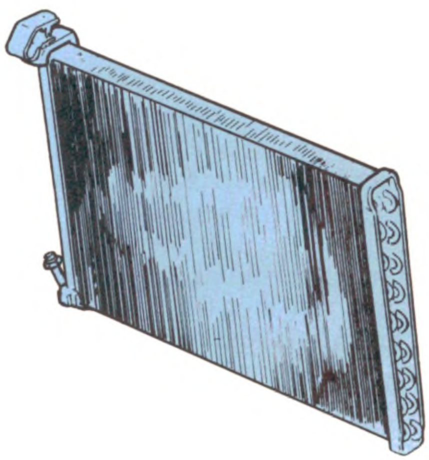

Fig. 1-26 — Condenser

Main Units of the System

These three units then, the evaporator, compressor, and condenser, are the main working parts in any typical air conditioning system. The evaporator is where the refrigerant boils and changes into a vapor while absorbing heat. The compressor puts pressure on the refrigerant so that it can get rid of its heat. And the condenser outside the car body transfers the heat into the surrounding air.

Pressure and Flow

There is one more unit that cooperates with these three. It doesn't do any real work but it does act as sort of a traffic light in controlling the flow of the refrigerant through the system. To get a better idea of what this does, let's first do a little experimenting with an ordinary tire pump.

When we use a tire pump to inflate an automobile tire, we are creating pressure only because we are "pushing" against the air already entrapped inside the tire. If you question this, just try pumping up a tire that has a puncture in it. You could pump all day, and still not be able to build up any pressure. As fast as you would pump the air in, it would leak out through the puncture. About all you would be doing would be circulating nice fresh air through the tire. Unless you have something to push against—to block the flow of air—you can't create pressure.

The same situation holds true in an air conditioning system. The compressor can pump refrigerant vapor through the system, but unless it has something to push against, it cannot build up pressure. All the compressor would be doing would be to circulate the vapor without increasing its pressure.

Yet we can't just block the flow through the system entirely. All we want to do is put pressure on the refrigerant vapor so it will condense at normal temperatures. What's more, this must be done sometime after the vapor leaves the evaporator and before it returns again as a liquid. We can't have high pressure in the evaporator because that would slow down the boiling of the refrigerant and thus penalize the refrigerating effect.

Controlling Pressure and Flow

Pressure and flow can be controlled with a float valve, or with a pressure-regulating valve. They do the same job but in a different way.

Since the float type valve will give us a better idea of pressure and flow control, let's look at it first (Fig. 1-27).

It consists simply of a float that rides on the surface of the liquid refrigerant. As the refrigerant liquid boils and passes off as a vapor, naturally the liquid level drops lower and lower. Correspondingly, the float, because it rides on the surface of the refrigerant, also drops lower and lower as the liquid goes down.

By means of a simple system of mechanical linkage, the downward movement of the float opens a valve to let refrigerant in. The incoming liquid raises the fluid level and, of course, the float rides up along with it. When the surface level of the refrigerant liquid reaches a desired height, the float will have risen far enough to close the valve and stop the flow of refrigerant liquid.

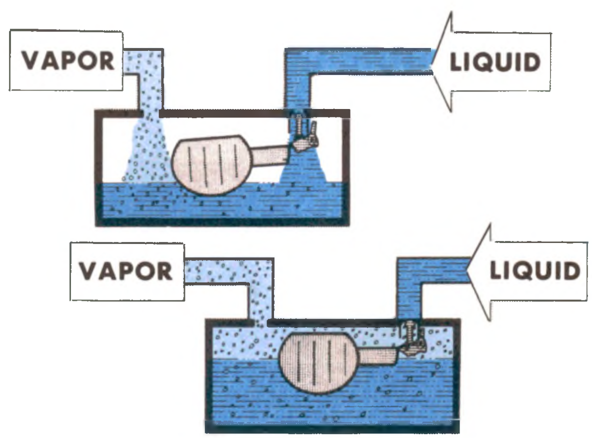

Fig. 1-27 — Float Type Flow Valve

For the sake of simplicity, we have described the float and valve action as being in a sort of definite wide open or tight shut condition. Actually, though, the liquid level falls rather slowly as the refrigerant boils away. Likewise, the float goes down gradually and gradually opens the valve just a crack. New refrigerant liquid barely seeps in through the "cracked" valve. At such a slow rate of flow, it raises the liquid level in the evaporator very slowly.

With that in mind, it is easy to see how it would be possible for a stabilized condition to exist. During a stabilized condition the valve allows in exactly as much liquid refrigerant as is leaving in the form of a vapor. This is a constant, stabilized flow.

Thermostatic Expansion Valve

Some automotive air conditioning systems use a thermostatic expansion valve in place of the float system.

Figure 1-28 shows a cross-section of the valve. It consists primarily of the power element, body, actuating pins, seat, and orifice. At the high pressure liquid inlet is a fine mesh screen which prevents dirt, filings, or other foreign matter from entering the valve orifice.

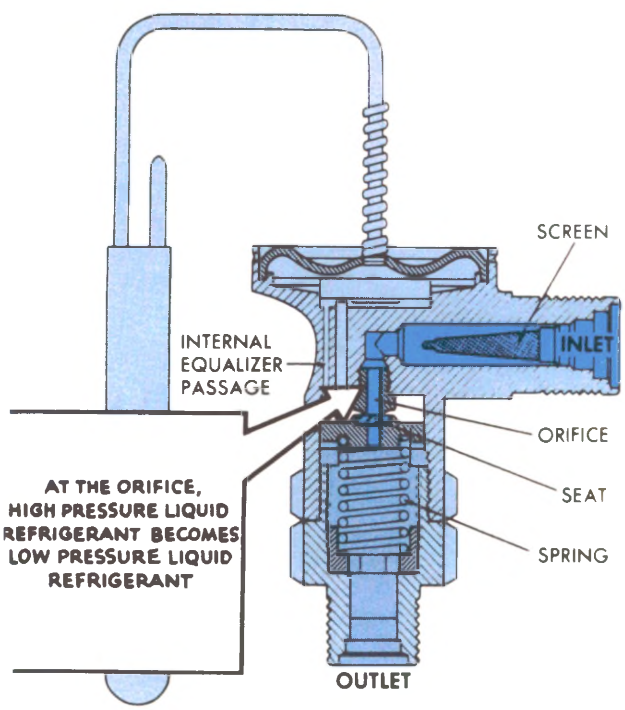

Fig. 1-28 — Thermostatic Expansion Valve

In a system using this valve, the high pressure liquid refrigerant enters the valve through the screen from the receiver-dehydrator. (The receiver-dehydrator acts as a storage tank for the condensed refrigerant as it leaves the condenser.) Liquid refrigerant then passes on to the seat and orifice. Upon passing through the orifice the high pressure liquid becomes low pressure liquid. The low pressure liquid leaves the valve and flows into the evaporator core. There it absorbs heat from the evaporator core and changes to a low pressure vapor. The power element bulb is clamped to the low pressure vapor line just beyond the outlet of the evaporator (Fig. 1-29).

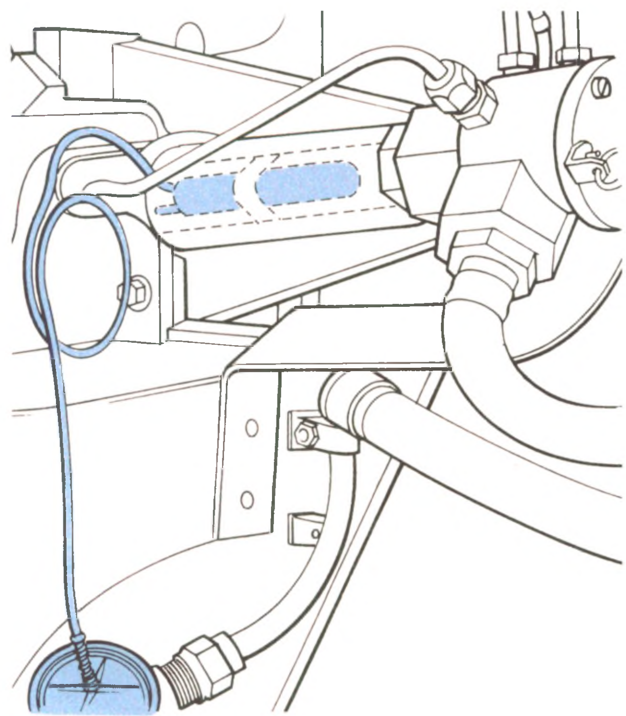

Fig. 1-29 — Expansion Valve Bulb Location

The operation of the valve is quite simple. It is a matter of controlling opposing forces produced by a spring and the refrigerant pressures. For example, pressure in the power element is trying to push the seat away from the orifice, while the adjusting spring is trying to force the seat toward the orifice. These opposing pressures are established in the design of the valve so that during idle periods the adjusting spring tension and the refrigerant pressure in the cooling coil are always greater than the opposing pressure in the power element. Therefore, the valve remains closed. When the compressor is started, it will reduce the pressure and temperature of the refrigerant in the cooling coil to a point where the vapor pressure in the power element becomes the stronger. The seat then moves off the orifice and liquid starts to flow through the valve orifice into the cooling coil.

The purpose of the power element is to help determine the quantity of liquid that is being metered into the cooling coil. As the temperature of the low pressure line changes at the bulb, the pressure of the vapor in the power element changes. This results in a change of the position of the seat. For example, if the cooling coil gets more liquid than is required, the temperature of the low pressure line is reduced. Because this lowers the temperature of the bulb, pressure of the vapor in the power element is reduced. The seat is then allowed to move closer to the orifice. This immediately reduces the amount of liquid leaving the valve. Under normal operation, the power element provides accurate control of the quantity of refrigerant to the cooling coil.

To employ our tire pump analogy once more for clarity, it is the same situation that would exist if you were inflating a tire with a very slow leak. Providing you pumped the air into the tire as fast as it leaked out, you would be able to maintain pressure even though the air would merely be circulating through the tire and leaking out through the puncture.

Orifice Tube

Orifice tubes, or expansion tubes, are used in place of thermostatic expansion valve on many new cars.

Like an expansion valve, the orifice tube and compressor separate the high pressure side from the low pressure side of the system. Also like an expansion valve, the orifice tube meters refrigerant into the evaporator. But the orifice does not adjust its metering rate like an expansion valve does. The orifice is a fixed size and is designed to meter the refrigerant correctly while the system is operating. The pressure difference between both sides of the orifice determines the flow rate through the orifice.

Orifice tubes are often used in cycling clutch systems to make the cycling of the compressor less noticeable. When the clutch is cycled off, the pressure between the evaporator and condenser is relieved quickly. This low pressure reduces the amount of torque needed to start the compressor when the clutch is cycled on.

A filter screen is built into the orifice to catch any debris which might be found in the refrigerant.

High Side and Low Side

The components making up the air conditioning system are connected together with tubing and hoses to form a closed loop for the refrigeration cycle. Refrigerant flows around the closed loop, absorbing heat in the evaporator and releasing it in the condenser.

It is common to say that air conditioning systems have two sides—a high side and a low side. On the high side of the system, refrigerant pressure is high, while on the low side refrigerant pressure is low.

As shown in Figure 1-30, system pressure is high from the compressor outlet to the expansion valve. Pressure is low from the expansion valve to the compressor inlet. During normal operation the hoses on the high side should feel warm or hot. The low side hoses should feel cool.

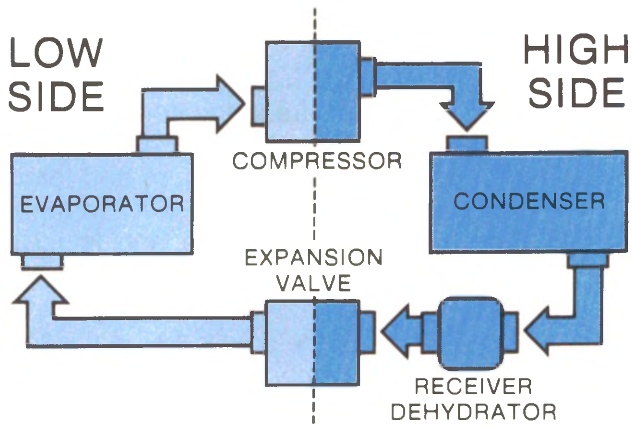

Fig. 1-30 — High and Low Refrigerant Pressures

To Sum Up

So far, we've discussed only what each unit in an air conditioning system does. The evaporator is the unit in which liquid refrigerant soaks up heat from the air. The compressor is a pump for concentrating this heat held by the vapor. The condenser is a radiator for getting rid of the heat. And finally the thermostatic expansion valve is a device for regulating the pressure on the refrigerant. Now, let's find out how the temperature of the cooled air is controlled.

METHODS OF TEMPERATURE CONTROL

Several general methods of temperature control are used in automotive air conditioning systems. One method is to run the compressor intermittently. This method automatically turns it on and off as necessary to maintain proper temperatures. Another method keeps the compressor running continuously, but throttles the flow of refrigerant through the system as required.

Thermostatic Switch Or Pressure Cycling Switch

The compressor can be started and stopped automatically through the use of an electromagnetic clutch and a thermostat affected by variations of temperature. The job is usually done by a gas bulb thermostat (Fig. 31) or a pressure cycling switch.

With the gas bulb type of thermostat, a highly expansive gas is sealed into a metallic bulb. The bulb is exposed to the stream of air leaving the evaporator. A small tube leads from the bulb to a bellows operated switch. As air temperature rises, the gas inside the bulb expands. The expanding gas travels through the tube to the bellows which now also expands. This closes the electrical switch that engages the compressor clutch.

Of course, as soon as the compressor starts running, the temperature begins to go down. As the air being cooled gets colder, the gas in the thermostat bulb begins to reduce the pressure on the switch bellows. This flips "off" the switch and disengages the compressor clutch.

With the pressure cycling switch, the compressor electromagnetic clutch is turned on and off as a function of low side pressure. As the pressure decreases to the lower set point, the compressor clutch is disengaged. This allows evaporator pressure to rise. When evaporator pressure reaches a predetermined amount, the pressure switch closes the clutch circuit and the process begins again.

The pressure cycling switch also acts as a protective device. If ambient temperature is cold enough, the switch will not allow the clutch to engage.

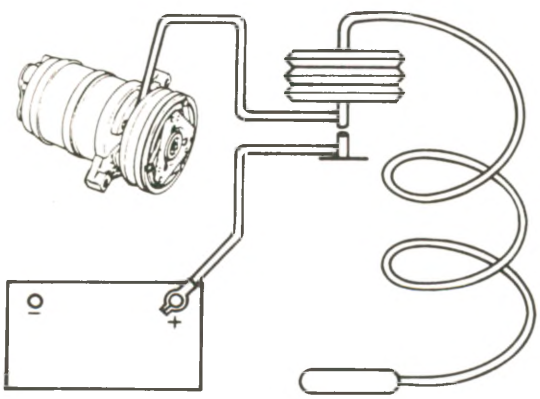

Fig. 1-31 — Thermostatic Switch Schematic

Suction Throttling Valve

Instead of a thermostatically operated clutch to start and stop the refrigeration system compressor, a suction throttling valve (Fig. 1-32) may be used to achieve temperature control.

With this type of control the compressor is in continual operation while the air conditioning system is in use. The valve is located in the evaporator outlet line and is opened and closed by means of its ability to sense the actual evaporator operating pressure. Because of the pressure-temperature relationship of refrigerant, the pressure of the refrigerant vapor actually determines the cooling capacity of the evaporator. Therefore, maintaining the pressure by means of the throttling valve regulates the cool air output of the system.

This action takes place as follows: With the system in operation and calling for cooling, evaporator pressure will open the throttling valve and allow more refrigerant flow. This will then allow evaporator pressure to drop, increasing the cooling capacity. As the pressure approaches the valve setting, the valve will begin to close. As the outlet line closes, refrigerant flow entering into the evaporator inlet line will begin to raise evaporator pressure, lowering the cooling capacity. This will eventually reach a point of balance whereby just the correct amount of refrigerant flow will be permitted through the valve to hold the desired pressure and temperature in the evaporator core.

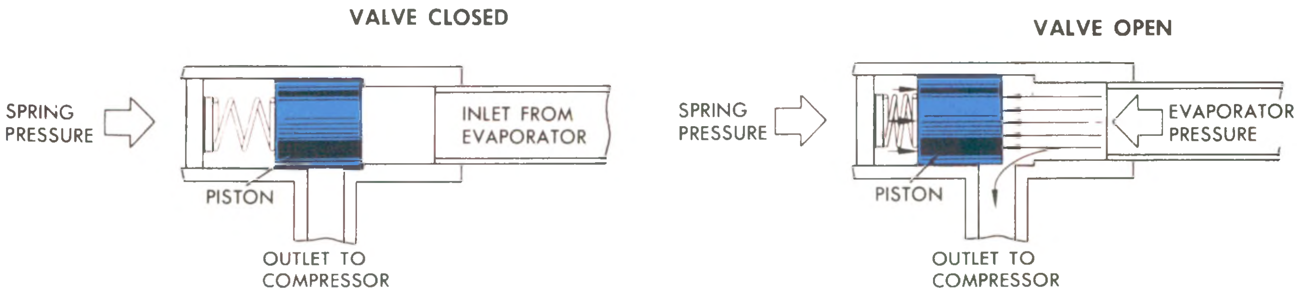

Fig. 1-32 — **Suction Throttling Valve**

Evaporator Pressure Control (POA)

Although the principles of operation differ, the POA valve controls temperature outlet. It does this by opening and closing the evaporator outlet line as necessary to hold evaporator pressure at the required level.

REFRIGERANTS

No matter how scientifically refrigerating machinery is built or how efficiently it runs, it alone cannot remove heat. The only thing that carries heat out of a refrigerator cabinet or an automobile is the substance we call the refrigerant.

Like the coolant in the engine cooling system, refrigerant is the substance in an air conditioning system that absorbs, carries, and then releases heat. To operate properly, the air conditioning system requires the refrigerant to have a number of specific characteristics. Since no single substance found in nature has all these characteristics, a man-made compound was developed.

R-12 has all the qualities needed to be a good refrigerant. R-12 is harmless to common manufacturing materials such as steel, copper, iron, aluminum, rubber, and neoprene. In turn, R-12 itself is also not affected by any of these materials. Another important quality of R-12 is that it is soluble in oil. This is a requirement because R-12 circulates through the system with a special lubricating oil. This oil lubricates the compressor. Also, R-12 is not explosive, flammable, or poisonous.

At sea level, or air pressure of one atmosphere, the temperature at which R-12 boils is 21.7° Fahrenheit below zero. Pressure inside the air conditioning system raises the boiling point of R-12. The ideal temperature for R-12 to boil inside an air conditioning system is about 30° Fahrenheit. This is a few degrees below the freezing point of water. Air conditioning systems are designed to keep their pressure so that R-12 boils at about this temperature. This creates just the right temperature for taking heat out of the passenger compartment.

WARNING: When working with R-12 several safety precautions must be followed. Because R-12 boils at -21.7° Fahrenheit, it is cold enough to cause severe frostbite. Always wear goggles to protect your eyes and gloves to protect your hands. Also, be sure never to expose a can of R-12 to direct heat or sunlight. Even under the pressures normally found in R-12 containers, if heat is added the refrigerant will boil. This could raise the pressure inside the can to a dangerous level. One last caution: **When R-12 is exposed to an open flame or to hot metal, poisonous gas called phosgene is formed.**

Pressure-Temperature Relationships of R-12

A definite pressure and temperature relationship exists in the case of liquid refrigerants and their saturated vapors. Increasing the temperature of a substance causes it to expand. When the substance is confined in a closed container, the increase in temperature will be accompanied by an increase in pressure, even though no mechanical device was used. For every temperature, there will be a corresponding pressure within the container of refrigerant. A table of the temperature-pressure relationship of R-12 is presented in Figure 1-33. Pressures are indicated in gauge pressure, either positive pressure (above atmospheric) in pounds or negative pressure (below atmospheric) in inches of vacuum.

Thus if a gauge is attached to a container of R-12 and the room temperature is 70°, the gauge will register 70 psi pressure; at 100°, the pressure will be 117 psi.

°F	#Pressure	°F	#Pressure
—40	11.0*	50	46.7
—35	8.3*	55	52.0
—30	5.5*	60	57.7
—25	2.3*	65	63.7
—20	0.6	70	70.1
—15	2.4	75	76.9
—10	4.5	80	84.1
— 5	6.8	85	91.7
— 0	9.2	90	99.6
5	11.8	95	108.1
10	14.7	100	116.9
15	17.7	105	126.2
20	21.1	110	136.0
25	24.6	115	146.5
30	28.5	120	157.1
32	30.1	125	167.5
35	32.6	130	179.0
40	37.0	140	204.5
45	41.7	150	232.0

* Inches of Vacuum

Fig. 1-33 — Pressure-Temperature Relationships

AIR CONDITIONING COMFORT

Because air conditioning has always been very closely allied with mechanical refrigeration, most of us are apt to think of it only as a process for cooling room air.

But true air conditioning goes beyond the mere cooling of the air. It controls the humidity, cleanliness, and circulation of the air as well.

Whenever it gets warm and muggy in the summertime, someone is almost sure to say, "It's not the heat; it's the humidity!" But that is only partly right. Actually it is a combination of the two that makes us feel so warm. Temperature alone is not the only thing that makes us uncomfortable.

Humidity is nothing more nor less than the moisture content of the air. To a certain extent, it is tied in with the temperature of the air. Warm air will hold more moisture than will cold air. When air contains all the moisture it can hold, we say it is saturated, and the relative humidity is 100%. If the air contains only half as much water as it could possibly hold at any given temperature, we say that the relative humidity is 50%. If it contains only a fifth of its maximum capacity, we say that the relative humidity is 20%...and so on. This amount of water vapor, or relative humidity, affects the way we perspire on hot days.

Nature has equipped our bodies with a network of sweat glands that carry perspiration to the skin surfaces. Normally, this perspiration evaporates and, in doing so, absorbs heat just like refrigerant absorbs heat when it is vaporized in a freezer. Most of the heat thus absorbed is drawn from our bodies, giving us a sensation of coolness. A drop of alcohol on the back of your hand will demonstrate this principle very convincingly. Because it is highly volatile, alcohol will evaporate very rapidly and absorb quite a bit of heat in doing so. This is what makes the spot on your hand feel unusually cool.

How rapidly evaporation takes place, whether it be alcohol or perspiration, governs our sensation of coolness. So to a certain extent, how cool we feel is independent of the temperature. The rapidity of evaporation is directly affected by the relative humidity, or comparative dampness of the air. When the air is dry, perspiration will evaporate quite readily. But when the air contains a lot of moisture, perspiration will evaporate more slowly. Consequently, less heat is carried away from our body.

Thus, from the standpoint of comfort, complete air conditioning should control the relative humidity of the air as well as its temperature.

By reducing the humidity, we can be just as "cool" in a higher room temperature than otherwise would be comfortable. Laboratory tests have shown that the average person will feel just as cool in a temperature of 79° when the relative humidity is down around 30% as he will in a cooler temperature of 72° with a high relative humidity of 90%.

There are practical limits, though, when it comes to juggling humidity. For human comfort, we can't go much below a relative humidity of 30%. Anything lower than that would cause an unpleasant and unhealthy dryness in the throat and nasal passages.

High summertime temperatures sometimes bring relative humidities around 75% to 80%. Some of the coastal cities have relative humidities averaging as high as 87%. To gain maximum human comfort, an air conditioning system should cool the air down and reduce the humidity to comfortable limits.

Along with the cooling job it does, the evaporator also removes much of the moisture from the air. Everyone is familiar with the sight of thick frost on the freezer of a refrigerator. That frost is simply frozen moisture that has come out of the air.

The evaporator unit in an air conditioning system does the same thing with this one exception. Because its temperature is above the freezing point, the moisture does not collect in the form of ice or frost. Instead, the moisture remains fluid and drips off the evaporator. This action is similar to what occurs on the cool bathroom mirror when a hot shower is turned on (Fig. 1-34). A further advantage of air conditioning is that dust and pollen particles are trapped by the wet surfaces of the evaporator core and then drained off along with the condensed moisture. This provides clean, pure air for breathing, and is of great benefit to those who suffer from asthma or allergies such as hay fever.

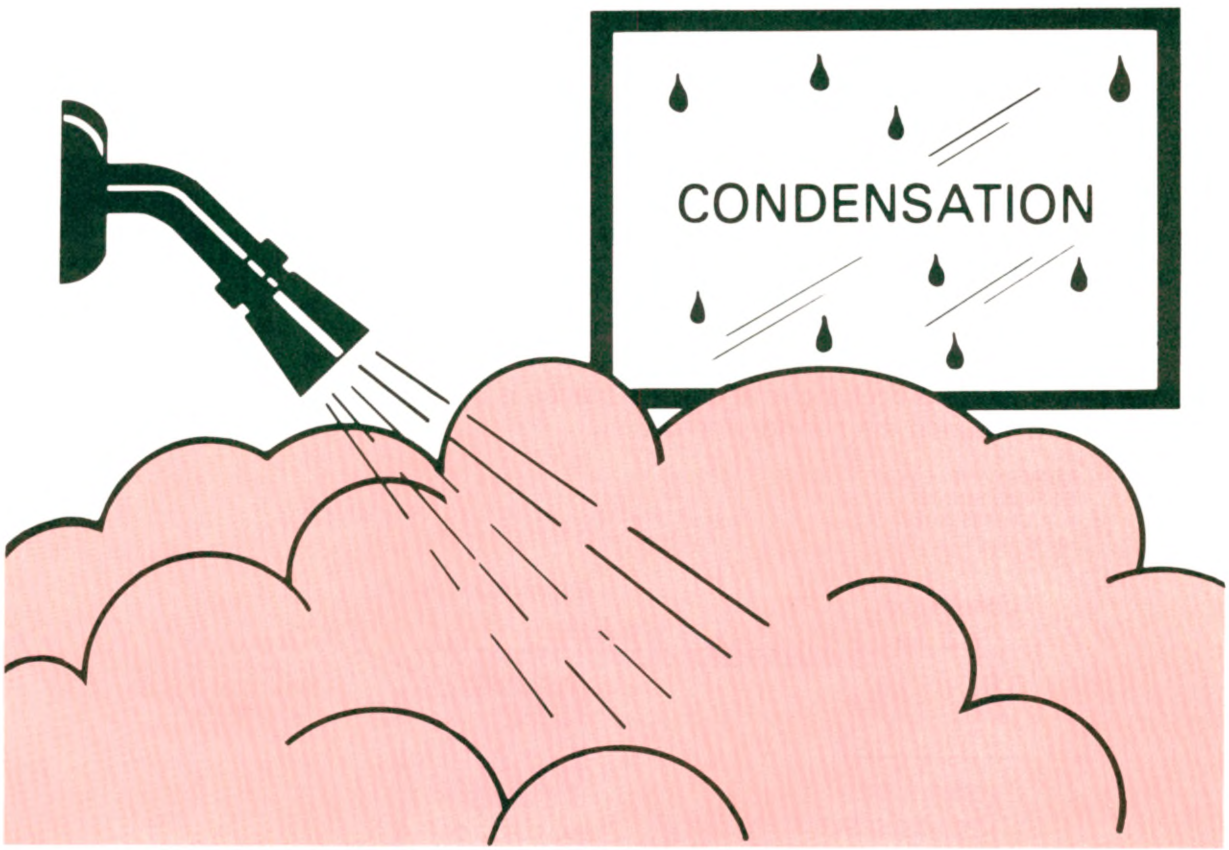

Fig. 1-34 — **Condensation**

Basic Refrigeration Cycle

Let's review the basic refrigeration cycle. Keep this basic cycle in mind because knowledge of the cycle, knowledge of the particular system you are working on, and proper use of the gauges will permit quick, accurate diagnosis of problems as they arise.

Any refrigeration system takes advantage of the principles described above. The air conditioning system illustrated in Figure 1-35 contains five basic parts: a compressor, a condenser, a receiver-dehydrator, an expansion valve, and an evaporator. Assuming R-12 as our refrigerant, let us follow through the refrigeration cycle.

Refrigerant vapor under low pressure is drawn into the compressor where it is compressed to a high pressure. During compression, the refrigerant vapor is squeezed. When sufficient pressure is built up, the hot, high pressure vapor passes into the condenser. There it cools by transferring heat to the air passing over the condenser surfaces.

As the refrigerant vapor cools, it condenses into a liquid at high pressure and accumulates in the receiver-dehydrator. The receiver-dehydrator acts as a storage tank for refrigerant. The high pressure liquid refrigerant passes to the expansion valve at the entrance to the evaporator. At the valve orifice the pressure is lowered and the refrigerant enters the evaporator core as a low pressure liquid. When the refrigerant is exposed to the lower evaporator pressure, it begins to boil and is changed to a vapor state. As the refrigerant passes through the evaporator, it continues to boil by absorbing heat from the air passing over the evaporator surfaces until it is completely vaporized. From the evaporator the cool, low pressure refrigerant gas is drawn back to the compressor and the cycle is repeated.

Thus the air passing over the evaporator surfaces is cooled simply by giving up heat to the refrigerant during the boiling process.

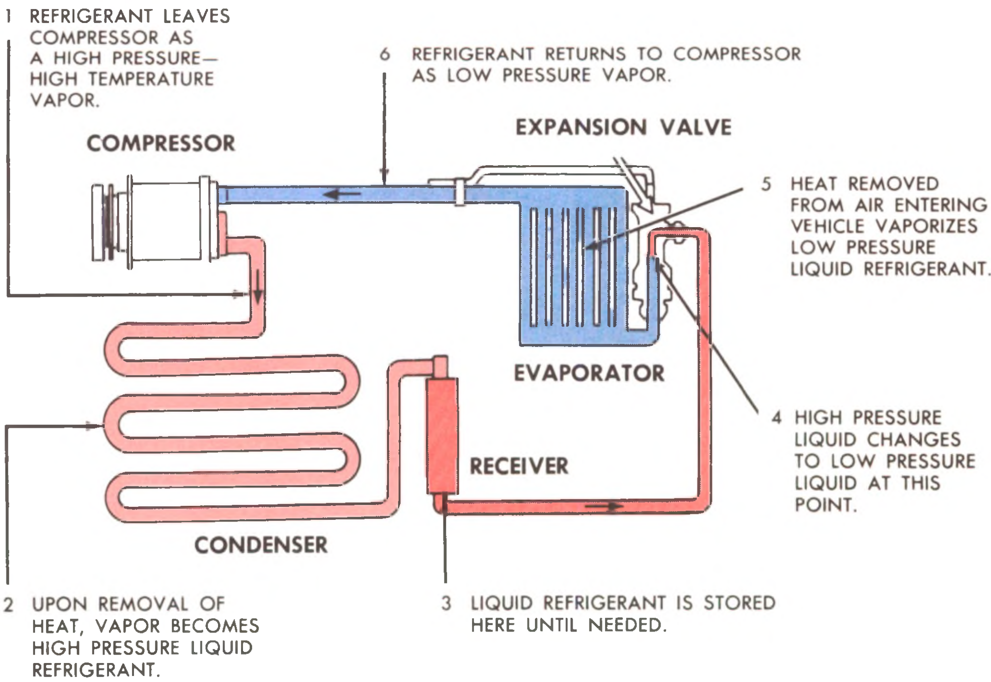

Fig. 1-35 — **Basic Refrigeration System**

CHEMICAL INSTABILITY AND REFRIGERATING SYSTEM FAILURES

A sealed refrigerating system is a complex physical-chemical combination which is designed for stability within certain operating limits. If these limits are exceeded, many physical and chemical reactions occur. Since the results of these reactions within the system cannot be easily removed, they build up into a constantly accelerating vicious circle to eventually fail the system.

CHEMICAL INGREDIENTS OF AN AUTOMOTIVE AIR CONDITIONING SYSTEM

All systems involve metals, refrigerant, and oil. The desiccant, or dehydrating agent, and another chemical ingredient, synthetic rubber, make the air conditioning system even more complex.

All of these ingredients have chemical properties which are entirely different from each of the others. Despite these differences, by careful servicing procedures they can be combined so that they "live together" to provide many years of satisfactory and trouble-free operation.

If, however, only one undesirable element is added or is allowed to enter the system, it can start a chain of chemical reactions which upsets stability and interferes with the operation of the unit.

Metals

In most cases, metals contribute to the decomposition of R-12 and oil in varying amounts. All are attacked by acids.

Each of the metals in common use in a system has been selected for a specific reason: heat conductivity, durability, strength, and chemical composition.

Under favorable conditions, the amount these metals cause Refrigerant 12 and oil to decompose is negligible and allowable. However, if undesirable substances are added and the temperature is increased, the rate of decomposition and the production of harmful acids increase proportionally.

Refrigerant

The chemical properties of refrigerants are very important factors in the stability of a system since the refrigerant penetrates to every nook and cranny of the unit.

Among the many desirable properties of R-12 is its stability under operating conditions. However, if contaminated, it can cause harmful acids to form. These acids will eventually cause the system to fail.

Oil

Oil is the most complex of all the organic chemicals. Its stability in a refrigerating system is dependent upon the source of crude oil and its method of refining. A good refrigerating oil must be free of sludge and gum-forming substances and free of harmful impurities, such as sulphur. It must also be stabilized to resist oxidation and must have a high degree of resistance to carbonization.

The chemical properties of the lubricating oil form another very important consideration in the chemical stability within the system. Like the refrigerant, it travels to every nook and cranny of the unit.

The factory obtains the finest oils which have been refined from the most desirable crudes. It is reprocessed at the factory before it is charged into a system or poured into a container for resale. Its viscosity and flash point are checked and it is forced through many sheets of filtering paper.

Even the containers in which it is poured for resale are processed. As you receive it for field service, it is the cleanest, dryest, and purest oil that is humanly possible to make. Leaving the container uncapped even for a few minutes allows the oil to absorb moisture from the air.

Many system failures have been caused by chemical reactions which were started by servicemen adding contaminated oil.

Desiccant (Drying Agent)

Over the years, the industry has spent hundreds of thousands of dollars in finding and developing chemical substances which are suitable for use in refrigerating systems. An ideal desiccant must have the following characteristics:

1. High capacity.
2. High efficiency.
3. Low tendency to powder.
4. Absorb moisture without reacting chemically with it.
5. Allow refrigerant to flow through it with minimum restriction.
6. Retain moisture at high temperature.

This has been a difficult combination to find. While some desiccants excel in several of the desirable characteristics they are unsatisfactory in others.

Activated silica alumina, used in current air conditioning receiver-dehydrators, is a most satisfactory desiccant. However, its ability to retain moisture is affected by its temperature. As the temperature increases, its ability decreases. This means that moisture which is retained at a lower temperature may be put back into the system at a higher temperature.

THE PRIMARY CAUSES OF SYSTEM FAILURES

Leaks

A shortage of refrigerant causes oil to be trapped in the evaporator. Oil may also be lost with the refrigerant at a point of leakage. Both of these can cause compressor seizure.

Oil circulates in the system with the refrigerant. It leaves the compressor by the action of the pistons and mixes with the refrigerant liquid in the condenser. The oil then enters the evaporator with the liquid and, with the evaporator properly flooded, is returned to the compressor through the low pressure line. Some of the oil returns as globules in the vapor but more importantly, it is swept as a liquid along the walls of the tubing by the velocity of the vapor. If the evaporator is starved, the oil cannot return in sufficient quantities to keep the compressor properly lubricated.

High Temperature and Pressure

As temperature rises, so does pressure. High temperatures cause a contaminated system to break down faster. It will also start the refrigerant in a clean system to begin to break down. Other results from excessive temperatures are brittle hoses and O-ring gaskets. It may also cause decomposed bypass valve diaphragms, broken compressor discharge reeds, and seized compressor bearings.

A fundamental law of nature accounts for the fact that when a substance, such as a refrigerant, is increased in temperature, its pressure is also increased.

Any chemical reactions caused by contaminants already in the system are greatly accelerated as the temperature increases. A 15° rise in temperature doubles the chemical action. Even in a good, clean system, heat alone can start a chain of harmful reactions.

While temperature alone can cause the synthetic rubber parts to become brittle and possibly to decompose, the increased pressure can cause them to rupture or blow.

As the temperature and pressure increase, the stress and strain on the discharge reeds also increase. This can result in broken reeds. This contaminants caused by high temperature and pressure can cause compressor bearings to seize.

High temperature and pressure can be caused by air in the system.

Air In The System

Air results from a discharged system or careless servicing procedures. This reduces system capacity and efficiency and causes oxidation of oil into gum and varnish.

When a leak causes the system to become charged, the resulting vacuum from an ambient temperature decrease within the system will cause air to be drawn in. Air is a non-condensable gas and will build up in the condenser as it would in an air compressor tank. The resultant heat produced will contribute to the conditions discussed previously.

Many systems are contaminated and also reduced in capacity and efficiency by servicemen who either do not know or are careless regarding proper servicing procedures.

Too frequently, systems which have been open to the atmosphere during service operations have not been properly purged or evacuated. Air is also introduced into the system by unpurged gauge and charging lines. Remember that any air in the system is too much air. Air can carry moisture into the system.

Poor Connections

Hose clamp fittings must be properly made. Hose should be installed over the sealing flanges and with the end of the hose at the stop flange. The hose should never extend beyond the stop flange. Locate the clamp and tighten to proper torque. Be especially careful that the sealing flanges are not nicked or scored or else a future leak will result.

When compression fittings are used, over tightening can cause physical damage to the O-ring gasket and will result in leaks. The use of torque and backing wrenches is highly recommended. When making a connection with compression fittings, the gaskets should always be first placed over the tube before inserting it in the connection. Another precaution—inspect the fitting for burrs which can cut the O-ring.

Restrictions

Restrictions may be caused by dirt, foreign matter, or corrosion due to excessive moisture in the system. Restrictions may cause a starved evaporator. A starved evaporator results in the loss of cooling, high temperature at the bypass hose, or a seized compressor. These contaminants can lodge in the various filter screens and block coolant flow. As a result sufficient oil cannot be returned to the compressor and it may sieze.

Dirt

Dirt, which is any foreign material, may come from a number of different sources: cleaner residues, cutting, machining, preserving oils, metal dust or chips, lint or dust, loose rust, soldering or brazing fluxes, paint or loose oxide scale. These can also cause seized bearings, discharge and expansion valve failure, decomposition of refrigerant and oil, or corrosion of metal parts.

Corrosion

Corrosion and its by-products can restrict valve and dehydrator screens, roughen bearing surfaces, or hasten fatiguing of discharge reeds. This can result in high temperature and pressure, decomposition, or leaks. In any event, this means a wrecked compressor or damage to other components.

From this, we can see the vicious circle that can be produced in a refrigerating system to cause its failure. Corrosion can be the indirect cause of leaks, and leaks can be the direct cause of corrosion. We can also see the important role we as servicemen play in maintaining chemical stability.

The major cause of corrosion is moisture.

Moisture

Moisture is the greatest enemy of refrigerating systems. Combined with metal, it produces oxide, iron hydroxide, and aluminum hydroxide. Combined with R-12, it produces carbonic acid, hydrochloric acid, and hydrofluoric acid. Moisture can also cause freeze-up of the expansion valve.

Although high temperature and dirt are responsible for many difficulties in refrigerating systems, in most instances it is the presence of moisture in the system that accelerates these conditions. It can be said, therefore, that moisture is the greatest enemy of all. The acids that it produces, in combination with both the metals and the refrigerant, cause damaging corrosion. While the corrosion may not form as rapidly with R-12 as with some other refrigerants, the eventual formation is as damaging.

If the operating pressure and temperature in the evaporator is reduced to the freezing point, moisture in the refrigerant can collect at the orifice of the expansion valve and freeze. This temporarily restricts the flow of liquid, causing erratic cooling.

As previously mentioned, moisture in excess of the desiccant's capacity can cause corrosion and ice to form.

YOU SHOULD KNOW AND REMEMBER

The inside of the refrigerant system is completely sealed from the outside world. And if that seal remains broken at any point—the system will soon be destroyed.

Complete and positive sealing of the entire system is vitally important. This sealed condition is absolutely necessary to retain the chemicals and keep them in a pure and proper condition.

All parts of the refrigerant system are under pressure at all times, whether operating or idle. Any leakage points are continuously losing refrigerant and oil.

The leakage of refrigerant can be so silent that the complete charge may be lost without warning.

Refrigerant gas is heavier than air and will rapidly drop to the floor as it flows from a point of leakage.

The pressure in the system may momentarily become as high as 400 pounds per square inch. Under such pressure the molecules of refrigerant are forced out through the smallest opening or pore.

The total refrigerant charge circulates through the entire system at least once each minute.

The compressor is continually giving up some lubricating oil to the circulating refrigerant and depends upon oil in the returning refrigerant for continuous replenishment. Any stoppage or major loss of refrigerant will therefore be fatal to the compressor.

The extreme internal dryness of a properly processed system is truly a desert condition. The drying material in the receiver-dehydrator holds tightly onto the tiny droplets of residual moisture.

The attraction of the drying material for moisture is so powerful that if the receiver or container is left open moisture will be drawn in from the outside air.

Just one drop of water added to the refrigerant will start chemical changes that can result in corrosion and eventual breakdown of the chemicals in the system. Hydrochloric acid is the result of R-12 mixing with water.

The smallest amount of air in the refrigerant system may start reactions that can cause malfunctions.

The drying agent in the receiver-dehydrator is activated silica alumina.

The inert gas in the expansion valve-capillary line is carbon dioxide.

NOTES

2. AUTOMOTIVE REFRIGERATION SYSTEM AND COMPONENT OPERATION

BASIC AUTOMOTIVE AIR CONDITIONING SYSTEMS

Generally speaking there are two basic types of automotive air conditioning systems. They can be classified according to the method used in obtaining temperature control. For reference purposes in this manual we will refer to them as the "Cycling Clutch System" and the "Evaporator Pressure Control System".

Each of these typical GM systems has two variations:

- CYCLING CLUTCH SYSTEM
  - —— With thermostatic expansion valve (TXV) and receiver-dehydrator
  - —— With orifice tube and accumulator (CCOT—cycling clutch orifice tube)
- EVAPORATOR PRESSURE CONTROL SYSTEM
  - —— With pilot-operated absolute (POA) valve
  - —— With valves in receiver (VIR)

CYCLING CLUTCH SYSTEMS

In all cycling clutch systems, the compressor is run intermittently through controlling the application and release of its clutch by a thermostatic switch. The thermostatic switch senses the evaporator's outlet air temperature through a capillary tube that is part of the switch assembly. With a high sensing temperature, the thermostatic switch is closed and the compressor clutch is energized. As the evaporator outlet temperature drops to a preset level the thermostatic switch opens the circuit to the compressor clutch. The compressor then ceases to operate until such time as the evaporator temperature rises above the switch setting. From this "on" and"off" operation is derived the term "cycling clutch".

Adjustable and Non-adjustable Thermostatic Switches

Thermostatic switches are used in many systems to control compressor operation. The switches sense evaporator temperature. When evaporator temperature reaches the freezing point, the switches open and voltage to the compressor is cut off. This stops the evaporator from getting cooler. By keeping the evaporator above freezing, condensation on the evaporator fins will not freeze and block air flow. Thermostatic switches can be adjustable or non-adjustable.

Adjustable switches are usually controlled by the driver to regulate the level of cooling in the car. With the switch set to open at its coldest point, for instance, the evaporator will stay near freezing. This setting will provide the most cooling. With the switch set to open at a higher temperature, voltage to the compressor will be cut off before the evaporator gets near the freezing point. Such a setting will provide less cooling.

Non-adjustable switches are set to open at one temperature only. This temperature is usually near the freezing point to keep the evaporator fins from icing. When non-adjustable switches are used in a system, another way of controlling the cooling is used since the switch cannot be adjusted by the driver.

Cycling Clutch System with Thermostatic Expansion Valve

Some factory installations utilize a cycling clutch system that incorporates a thermostatic expansion valve (TXV) and receiver-dehydrator (Fig. 2-1). The evaporator and control components are either in the engine compartment or an integral part of the cowl. In such cases there is a common blower and duct work for both heating and air conditioning purposes.

Also in these installations, the thermostatic switch has no temperature control knob and is usually mounted on the evaporator or its case. Temperature control is accomplished by using fresh or recirculating air and by reheating the cooled air in the heater core. The clutch cycles only to prevent evaporator icing.

A common form of the cycling clutch system is the field-installed (hang-on) unit. With this installation, the evaporator, the thermostatic expansion valve and thermostatic switch are self-contained in an "under dash" assembly. An installation of this type operates solely on passenger compartment recirculated air. Temperature control depends on intermittent operation of the compressor. The thermostatic switch has a control knob to change its setting and allow the compressor clutch to cycle at higher temperatures when less cooling is desired.

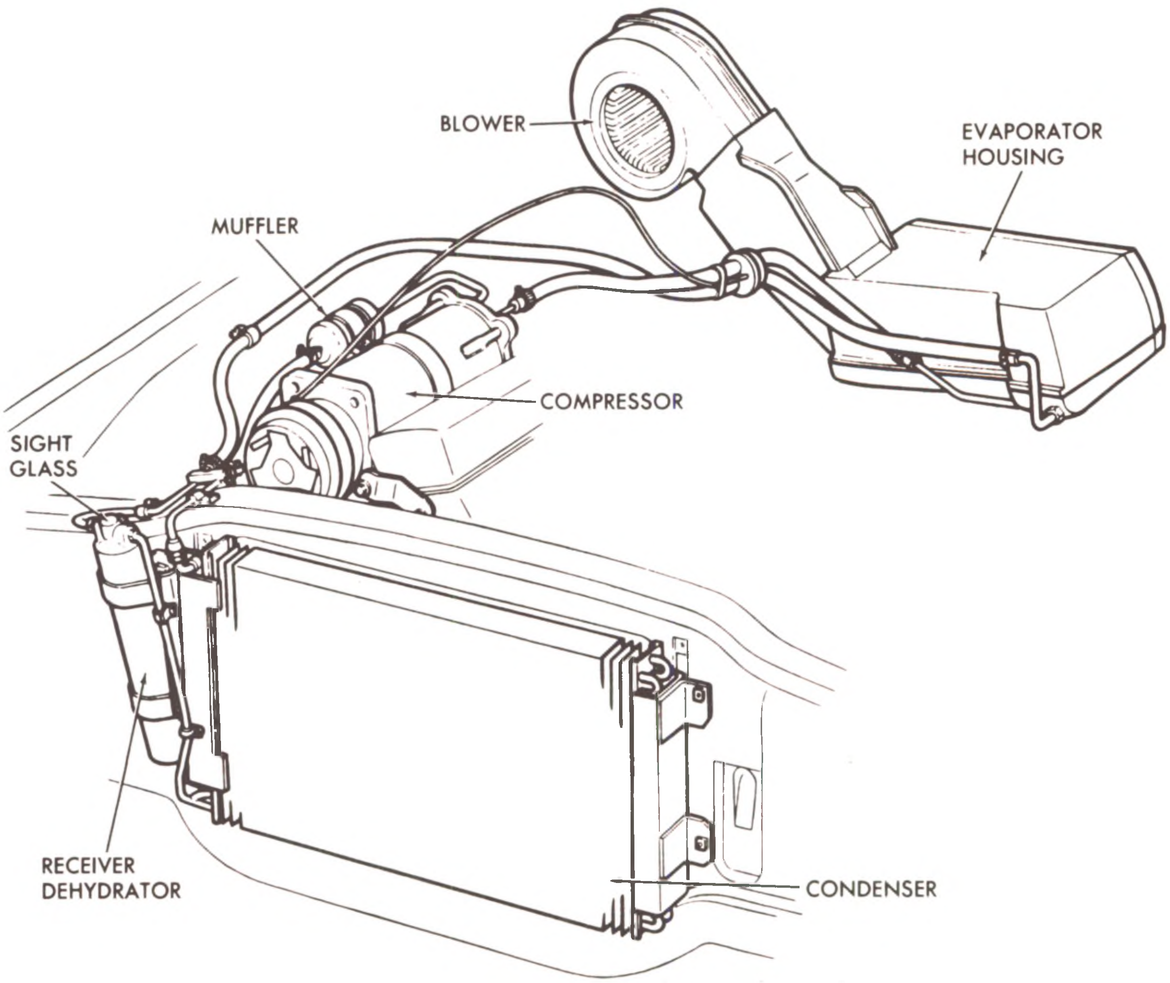

Fig. 2-1 — Typical "Cycling Clutch" System with Thermostatic Expansion Valve

The components of a cycling clutch system with an "in-line" thermostatic expansion valve are shown in Fig. 2-2. Notice the receiver-dehydrator is used with this system. It has two functions: to store refrigerant and to remove small amounts of moisture from the refrigerant.

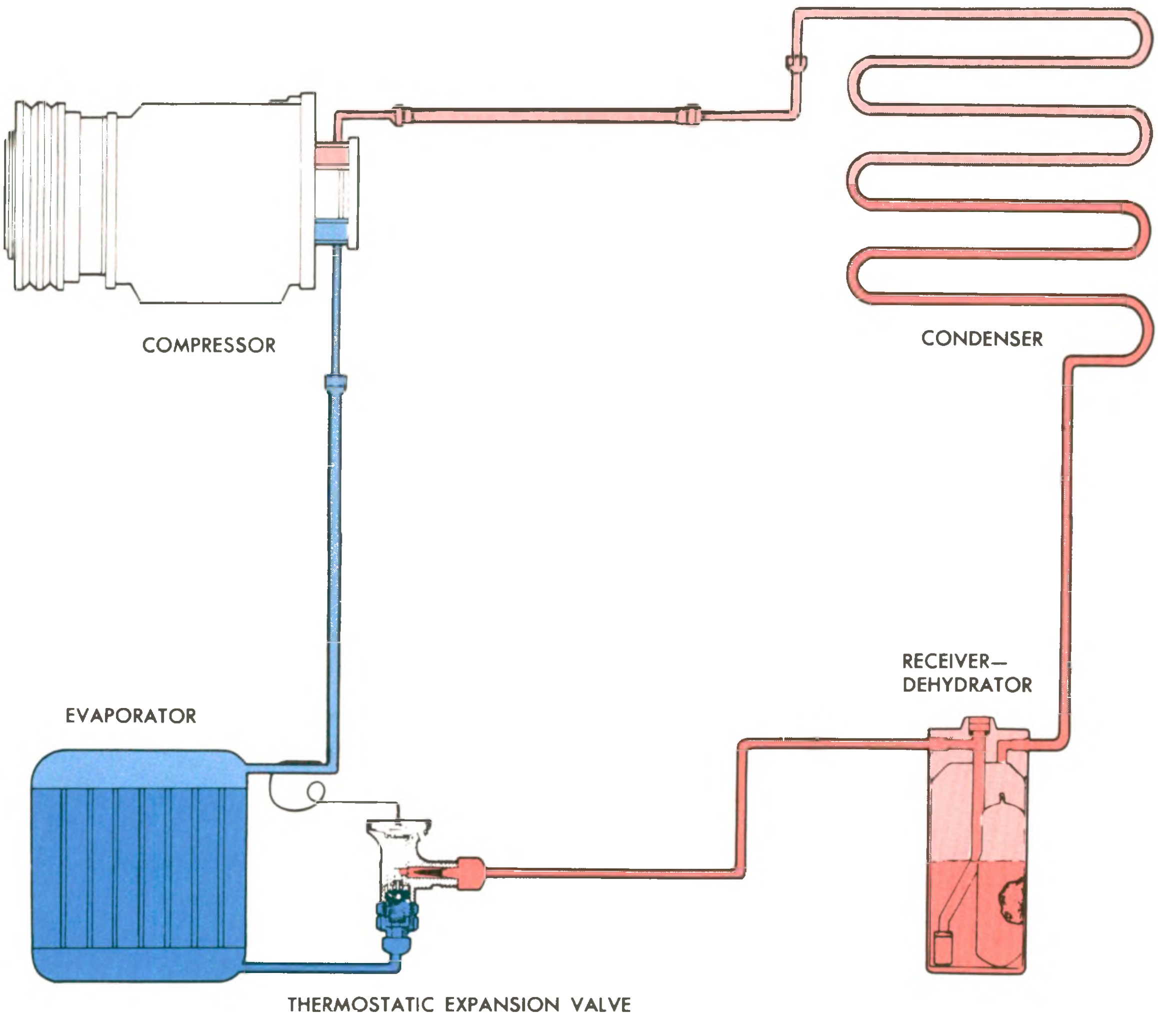

Fig. 2-2 — Basic components of Cycling System Thermostatic Expansion Valve

Cycling Clutch System With Orifice Tube (CCOT)

A typical CCOT system is illustrated in Fig. 2-3. The system is factory-installed and can use a thermostatic clutch-cycling switch mounted on the evaporator case or a pressure cycling switch located on the accumulator.

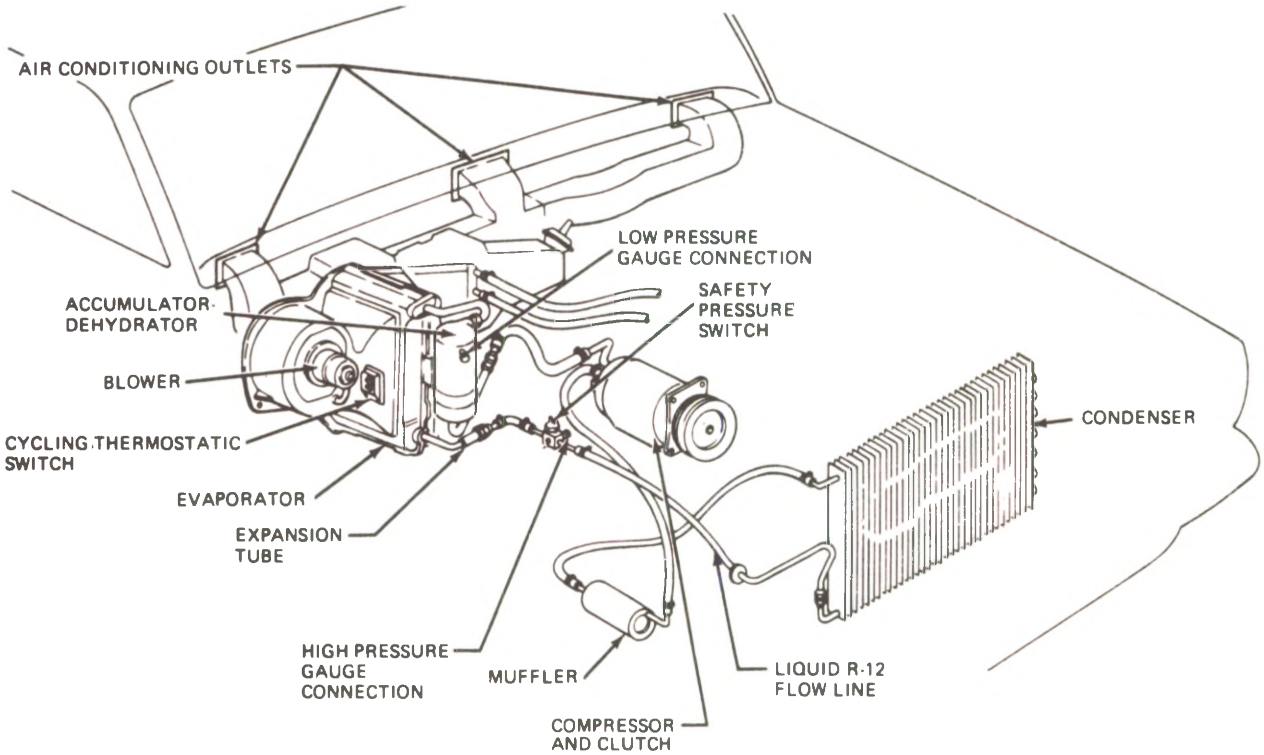

Fig. 2-3 — **Typical Cycling Clutch System with Expansion (Orifice) Tube (CCOT)**

An expansion (orifice) tube is used in place of the TXV (see Fig. 2-4). Also, the system has an accumulator in the evaporator outlet. The accumulator is used primarily to separate vapor from liquid refrigerant before it enters the compressor. It also contains a drying agent or desiccant to remove moisture. The CCOT system has no receiver-dehydrator or sight glass.

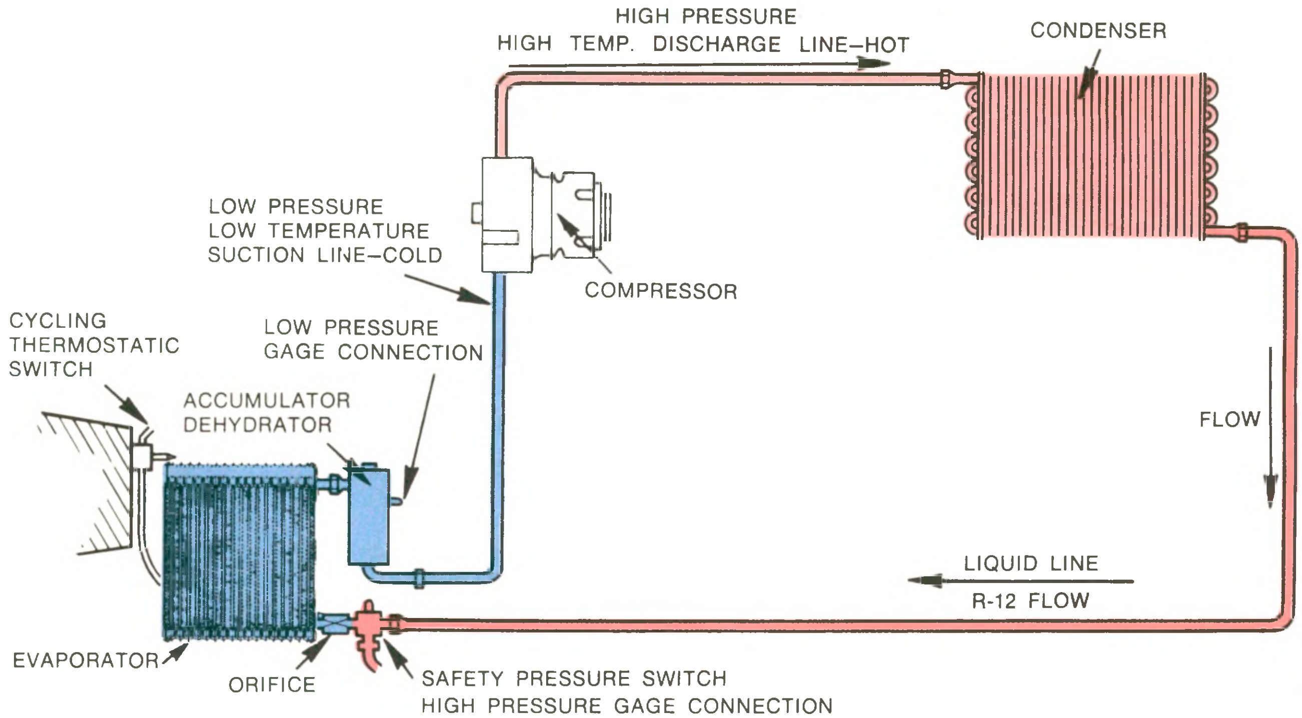

Fig. 2-4 — **Basic Components of Cycling Clutch System with Expansion (Orifice) Tube (CCOT)**

EVAPORATOR PRESSURE CONTROL SYSTEMS

In this type of system the compressor operates continually when dash controls are in the air conditioning position. Evaporator outlet air temperature is automatically controlled by an evaporator pressure control valve such as the STV, POA or EPR. (Refer to "System Component Description and Operation".) This type of valve throttles the flow of refrigerant through the evaporator as required to establish a minimum evaporator pressure and thereby prevent freezing of condensation on the evaporator core. Maximum evaporator pressure is also established by this valve.

POA Valve System

Fig. 2-5 shows a typical General Motors air conditioning system that utilizes a POA valve to control evaporator temperature. In this system both evaporator and heater cores are incorporated in an air distribution duct work that is an integral part of the cowl and dash assembly. Operator controls actuate a series of air doors within the duct work that make it possible to select maximum air conditioning or maximum heated air, as well as any combination of the two that may be desired for passenger comfort.

In diagnosis work it is essential to differentiate between malfunctions that might exist in the refrigeration components and those that might be present in the air distribution section.

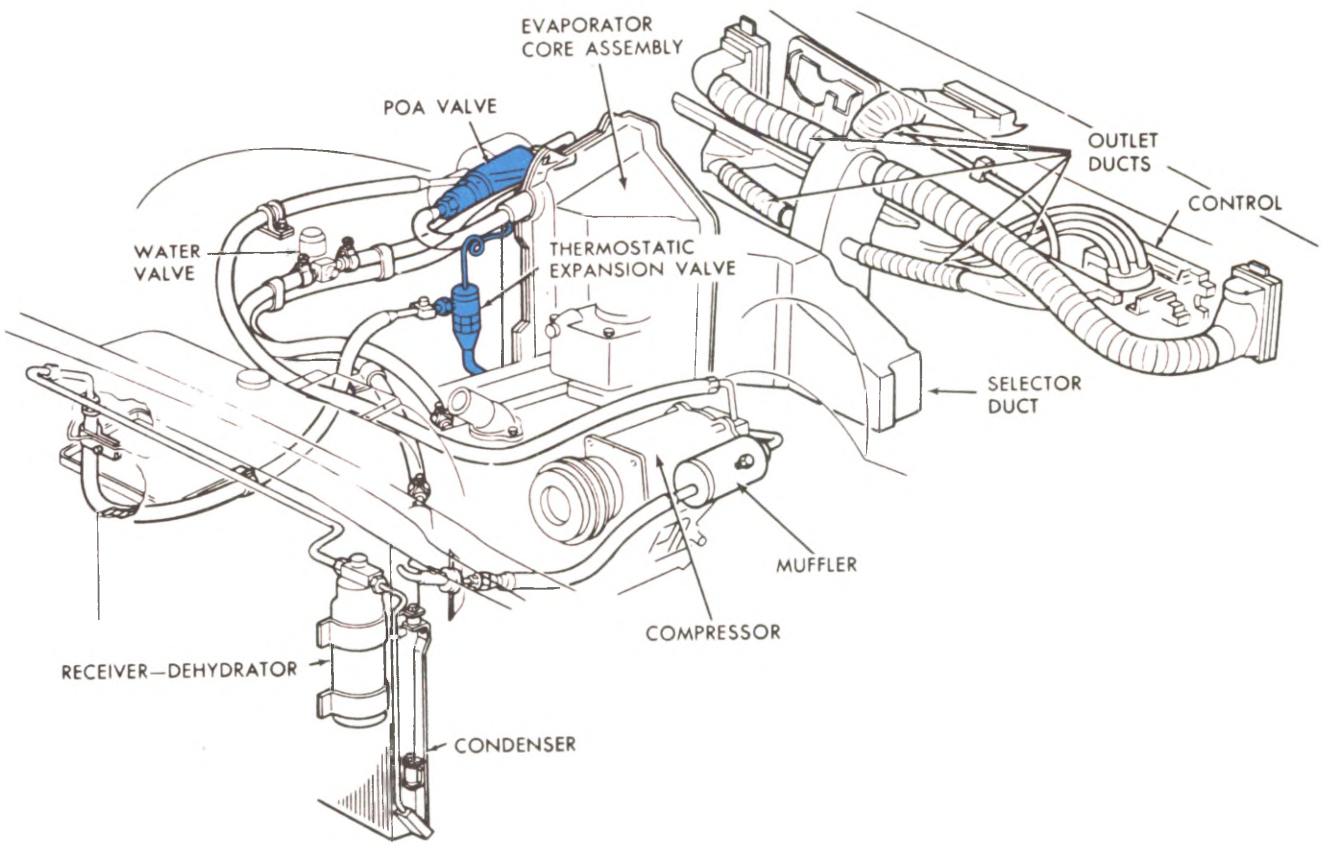

Fig. 2-5 — Typical Evaporator Pressure Control System with POA Valve

Fig. 2-6 shows the basic components for the refrigeration portion of the evaporator control valve system. For comparison purposes with the cycling clutch system (Fig. 2-4), remember that the compressor operates continually and that de-icing control is accomplished by the POA valve. This valve is connected in the refrigerant system between the evaporator outlet and compressor inlet. An equalizer line (pressure sensing) connects from the POA valve to the "in-line" type thermostatic expansion valve. Also, an oil by-pass or "liquid bleed" line connects from the bottom of the evaporator to the POA valve. Its purpose is to insure sufficient oil circulation to the compressor if the POA valve sticks in a closed position. The remaining connector on the POA valve is for the purpose of taking low pressure readings with manifold test gauges.

NOTE: This system uses a receiver-dehydrator, a sight glass, and a thermostatic expansion valve in the high pressure side.

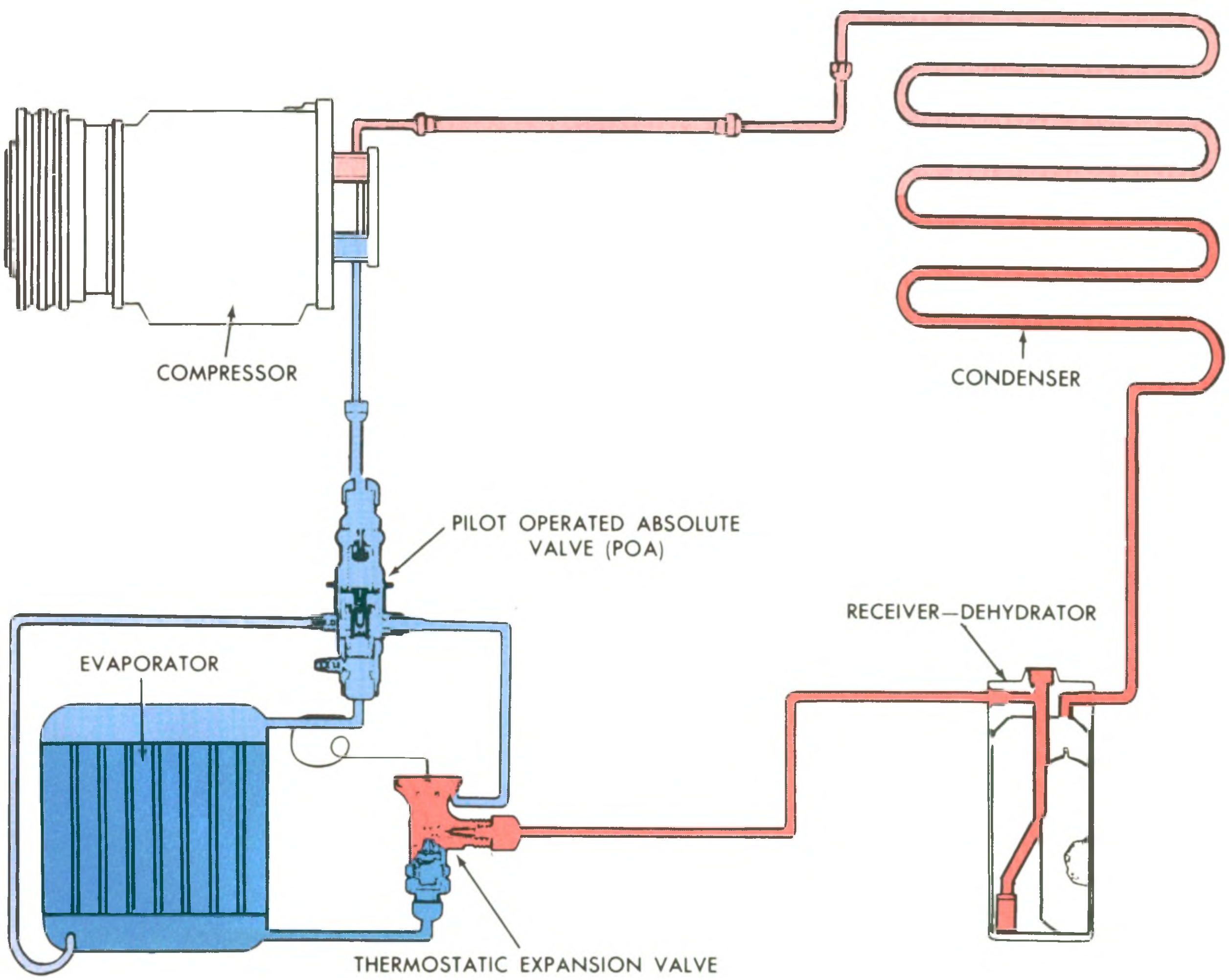

Fig. 2-6 — Basic Components of Evaporator Pressure Control System with POA Valve

VIR (Valves-in-Receiver) System

The valves-in-receiver (VIR) assembly incorporates the POA, TXV and receiver-dehydrator into one assembly (Fig. 2-7). The VIR assembly is mounted close to the evaporator; and is connected to both the evaporator inlet and outlet pipes.

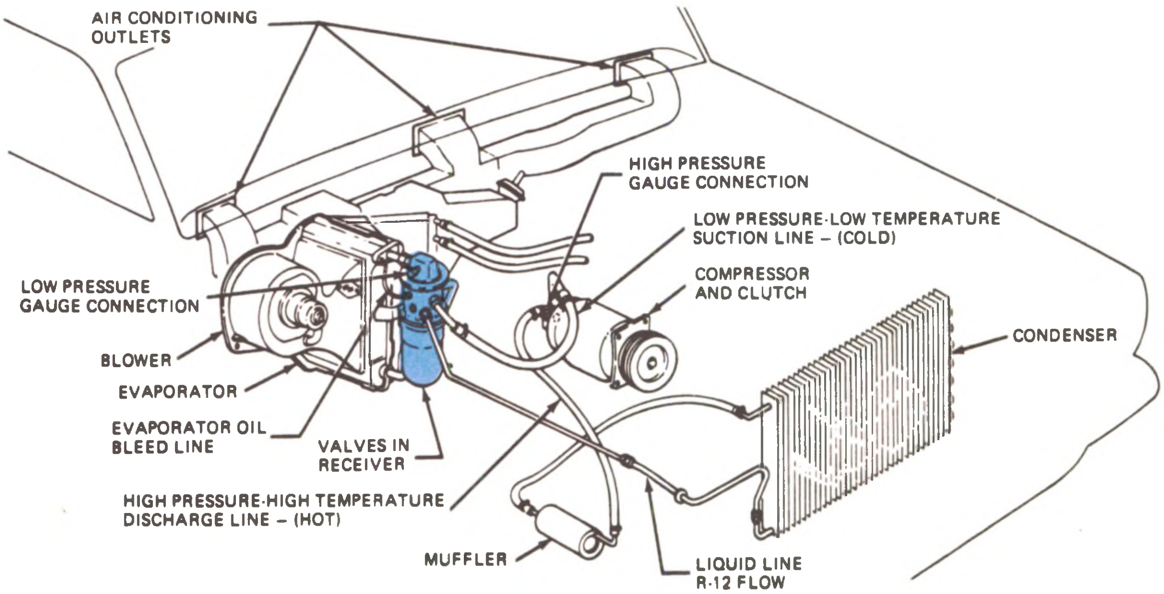

Fig. 2-7 — Typical Evaporator Pressure Control System with VIR Assembly

The basic refrigeration system components for a VIR system are shown in Fig. 2-8.

The thermostatic expansion valve's equalizer function is built into the VIR assemblies. The liquid bleed line (oil bypass line) connects from the bottom of the evaporator to the VIR (outlet).

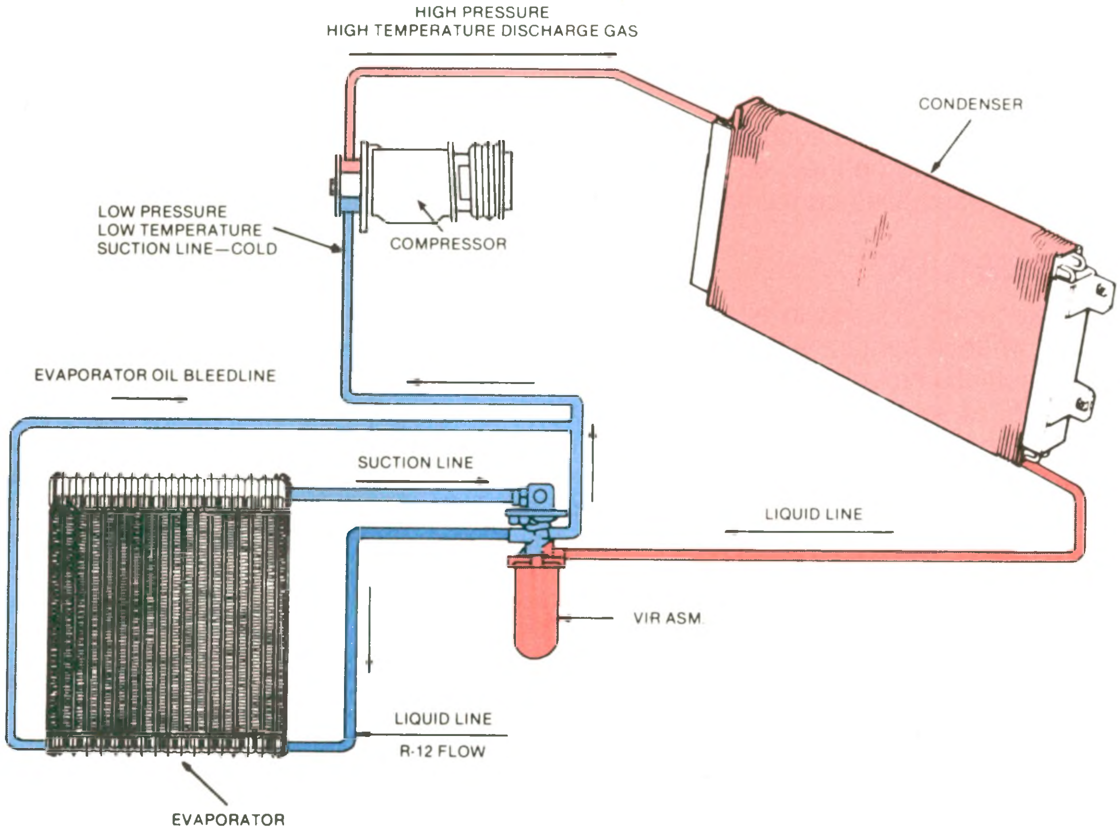

Fig. 2-8 — Basic Components of Evaporator Pressure Control System with VIR Assembly

SYSTEM COMPONENT DESCRIPTION AND OPERATION

All automotive air conditioning systems contain the same basic components:

- Evaporator
- Compressor
- Condenser
- Thermostatic expansion valve (in-line or VIR) or expansion (orifice) tube
- Dryer (in receiver-dehydrator, VIR, or accumulator)

Additional components such as evaporator pressure controls and various switches are utilized depending on the type of system. Following is a description of each basic component or assemblies containing more than one component.

REFRIGERANT

R-12 refrigerant is used in all automotive air conditioning systems. It is nonpoisonous (except when in contact with an open flame), noncorrosive (except when in contact with water), noninflammable and nonexplosive. However, the fact the R-12 has a boiling point of -21.7°F. at sea level, making it necessary to contain it under pressures appreciably above atmospheric, warrants special handling precautions. Also, it is recommended that, in the event of an accidental rapid discharge of a large quantity of R-12, the room be cleared of people until the vapor has dissipated. The quantity of refrigerant vapor might be of sufficient quantity to displace the essential air and oxygen in the room necessary for proper inhalation and breathing.

REFRIGERANT OIL

Automotive air conditioning systems carry a charge of 525 or 300 viscosity oil. R-12 has a definite affinity for oil, a fact which greatly simplifies the lubrication of the entire system. Since the refrigerant and the oil mix completely, even the refrigerant vapor in the system will carry globules of oil. As the liquid or vapor is carried throughout the system it carries enough oil to keep the moving parts of the system lubricated. The compressor is lubricated by the action of its own pump as well as by the oil saturated vapor.

EVAPORATOR

The evaporator (Fig. 1-24) is the device which cools and dehumidifies the air before it enters the passenger compartment of the car. High pressure liquid refrigerant flows through the valve orifice in the expansion valve into the low pressure area of the evaporator. This regulated flow of refrigerant boils immediately. Heat from the core surface is lost to the boiling and vaporizing refrigerant, which is cooler than the core, thereby cooling the core. The air passing over the evaporator loses its heat to the cooler surface of the core, thereby cooling the air. As the process of heat loss from the air to the evaporator core surface is taking place, any moisture (humidity) in the air condenses on the outside of the evaporator core and is drained off as water.

EVAPORATOR PRESSURE CONTROL SYSTEMS

Various automotive air conditioning systems referred to as "Evaporator Pressure Control" systems use valves at the evaporator outlet to prevent evaporator icing. They are variously named:

- Suction Throttling Valve (STV)
- Pilot Operated Absolute (POA) (also being called STV on some late model systems)
- Evaporator Pressure Regulator (EPR) or Evaporator Temperature Regulator (ETR)

In all cases, the valve's function is to maintain a "back-pressure" in the evaporator. Because of the refrigerant temperature-pressure relationship (pages 1-12), the effect is to regulate evaporator temperature. The temperature is controlled to a point that will provide effective air cooling; but will prevent the freezing of moisture that condenses on the evaporator. As noted earlier, the POA valve is incorporated in the VIR assembly in some systems.

Suction Throttling Valve (STV)

The suction throttling valve determines the temperature of the evaporator core by limiting the minimum evaporator pressure. The valve in this manner also protects the core against freeze-up which would result in a partial or complete loss of cooling capacity. While the system is in operation, the evaporator will be held to a minimum pressure of 28 psi and will provide maximum cooling at all times. The evaporator pressure will hold at this level so long as maximum cooling is desired by the occupants of the car.

The STV valve (Fig. 2-9) is located in the evaporator outlet line. It operates on a spring pressure vs. evaporator pressure principle. In operation, the flow of low pressure vapor from the evaporator to the compressor is determined and controlled by the position of the piston in the valve body which is, in turn, determined by the balance of the forces which are applied to the diaphragm. Refrigerant vapor flows through the valve inlet, through three openings in the lower skirt of the piston, and from there through the valve outlet and the suction hose to the compressor. A very small portion of the vapor flow is diverted to the interior of the piston through drilled holes in the piston wall. This pressure, transmitted to the inner side of the diaphragm, permits it to sense the actual pressure in the evaporator. Evaporator vapor pressure thus applied on the inner side of the diaphragm and piston assembly is balanced and opposed by spring load plus atmospheric pressure applied to the outer surface of the diaphragm. An increase of temperature (and thus pressure also) in the evaporator will cause the piston to move against the opposing spring pressure thus opening the valve and allowing an increasing amount of vapor to flow through the valve to the compressor. This in turn lowers the evaporator pressure and allows the piston to close as required. Evaporator pressure is thus controlled to a predetermined setting by the action of the valve in "throttling" or choking off the suction line when evaporator pressure drops below the established setting. With the line thus restricted, the evaporator pressure will rise. As the pressure rises above the valve setting, the valve will be forced open as required to bring the pressure down to the proper level.

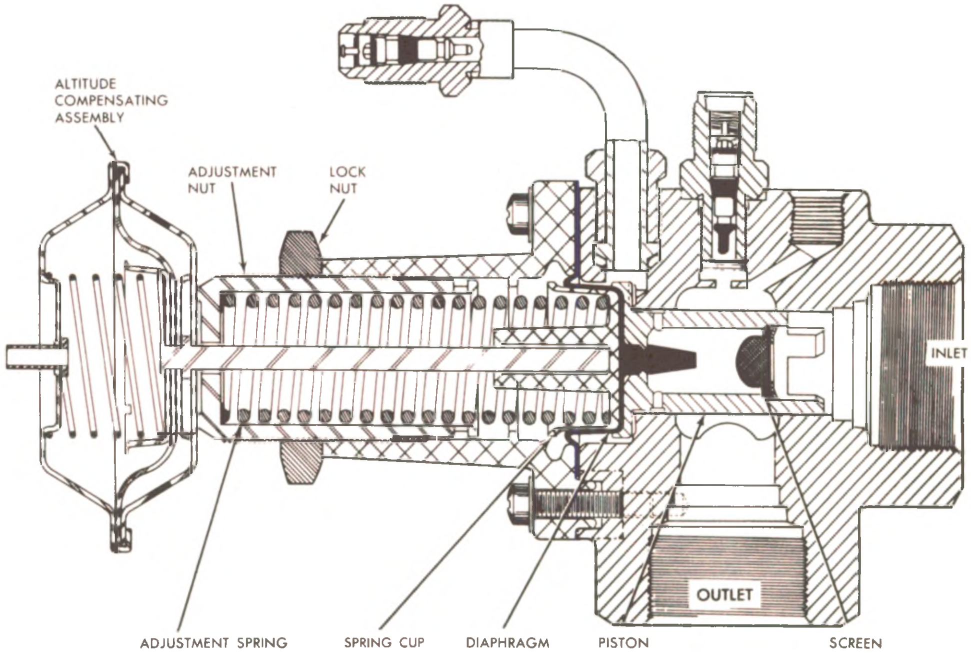

Fig. 2-9 — **Suction Throttling Valve — Sectional View**

The "temperature" lever on the dash control may be moved to mix heated air with the maximum cooled air and thus temper the outlet air to a desired temperature. This action, indicating that maximum cooling is no longer needed, acts through the control cable and linkage to close a vacuum valve through which 4-1/2 inches of vacuum has been applied to the vacuum head on the STV. Loss of this vacuum increases the internal spring pressure exerted upon the STV piston and effectively increases the minimum evaporator pressure approximately 3 pounds to 31 psi. This results in less evaporator cooling capacity.

NOTE: The primary reason for this feature is to guard against evaporator freeze-up when operating at higher elevations. When operating the system at elevations in excess of 4000 feet the TEMP lever should be moved about 1/2 inch.

STV valves have two ports with Schrader valves. One port is capped and utilized to obtain "low" system pressure with a manifold gauge set. The other port connects to the oil bypass line from the bottom of the evaporator. The small threaded opening near the oil bypass fitting connects to the equalizer line of the thermostatic expansion valve.

Pilot Operated Absolute Valve (POA)

The function of the POA valve is to control evaporator pressure. This is accomplished in the same manner as with the previously described STV valve; that is by throttling or restricting the evaporator outlet so that the pressure within the evaporator is maintained at a predetermined point. Although the end result of using this valve in the system is the same as with the STV, there is no similarity in the operation of the two valves.

As its name implies the POA valve contains a pilot valve. This valve has a bronze evacuated bellows. The POA is referenced to the nearly perfect vacuum in this bellows rather than to atmospheric pressure as in the case of the STV. The POA, therefore, requires no external altitude compensating device.

NOTE: Refer to Fig. 2-10 which shows the valve in its closed position.

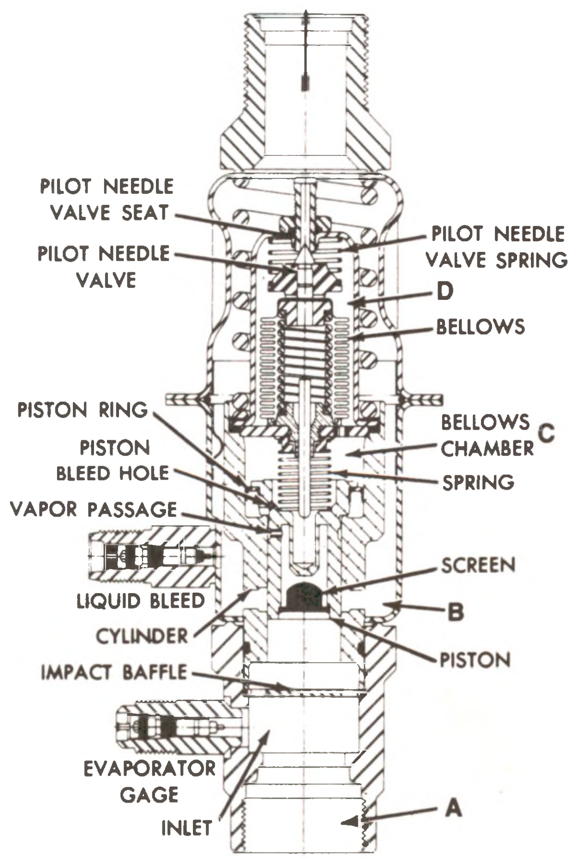

Fig. 2-10 — **Pilot Operated Absolute Valve (POA) — Sectional View**

With the system in operation, evaporator pressure (A) is applied to the inlet fitting of the valve. This pressure passes through the piston screen and drilled holes in the piston to apply itself to the area beneath the piston ring. As the evaporator pressure becomes higher the force of the piston spring will be overcome and the piston will begin to move, gradually opening the main port to refrigerant flow (B). This action is possible because the pressure in the area (C) back of the piston is less than evaporator pressure.

However, as the valve is being forced open, evaporator pressure is slowly flowing through the piston bleed hole into the area (C) above the piston. As the pressure in area "C" approaches evaporator pressure (A) the piston spring will begin to force the piston toward its closed position. When the pressure is equal on both sides of the piston the main port would normally be closed and our valve would be inoperative. Here is where our bellows and pilot valve come into the picture. The area (D) surrounding the pilot bellows and needle valve is connected by a hole to the area (C) above the piston. Therefore, pressures in area "C" and area "D" will be equal. As pressure builds up in area "C", allowing the piston spring to move the piston toward its closed position, it also builds up in area "D" surrounding the evacuated bellows. The higher pressure will begin to collapse the bellows, thus pulling the pilot needle from the needle seat. The pressure in area "D" will be reduced through the resulting orifice to the point where the bellows will expand to close the pilot needle. When the pressure is reduced in area "D" it will also be reduced in area "C", allowing evaporator pressure to overcome the force of the piston spring and move the piston to open the main port. Of course, in operation this cycle operates in such a way that the operations of the various valve components balance out to hold the piston in the proper modulated position to maintain the predetermined control pressure and thus the desired evaporator temperature.

The POA valve is pre-set at the factory and is not repairable. If malfunctioning, it should be replaced as a unit.

Aside from the inlet and outlet, the valve has three external connections. As with the STV valve, the POA valve has two ports with Schrader valves. One connects to the oil bypass line from the evaporator. The other is for connecting a manifold gauge set to the low pressure side of the system. The low pressure gauge connection valve core and the liquid bleed valve core cannot be used interchangeably because they have different spring ratings. The small threaded opening is the connection for the equalizer line of the thermostatic expansion valve.

Valves-In-Receiver (VIR) Assembly

The valves-in-receiver assembly (Figs. 2-11 and 2-12) combines the POA valve, thermostatic expansion valve, desiccant (drying agent), and sight glass into a single assembly. As mentioned earlier, the VIR assembly has port connections (Fig. 2-13) to and from the evaporator, compressor, and from the condenser.

The desiccant is contained in a bag in the receiver shell (Fig. 2-11), and is replaceable. The expansion valve and POA valve capsules also are replaceable as described in Section 4 of this manual.

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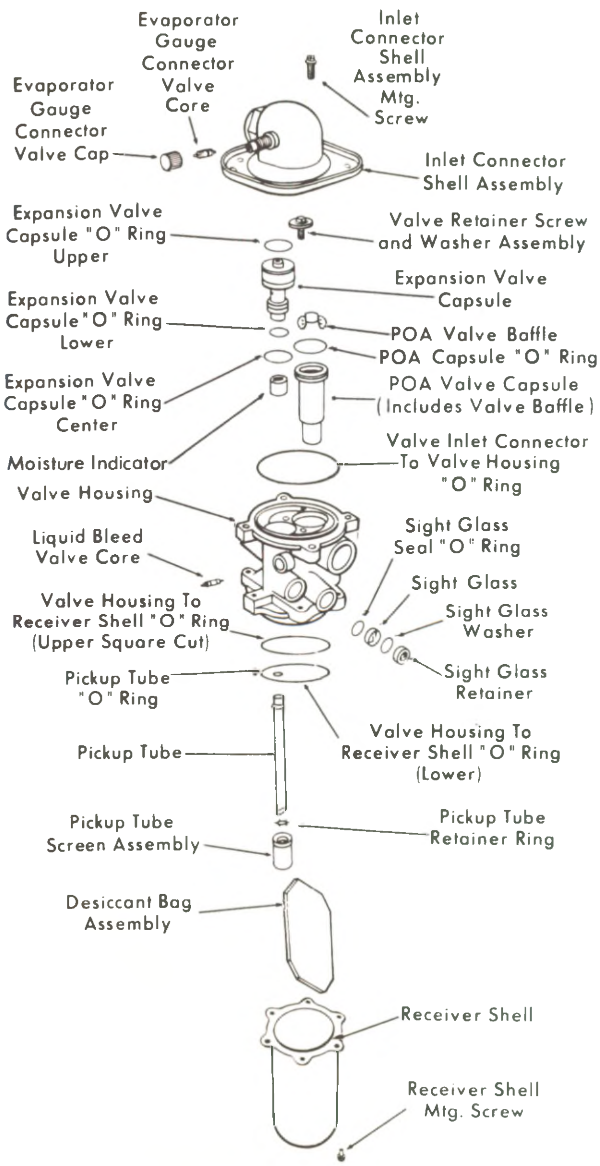


Fig. 2-11 — Components of VIR Assembly

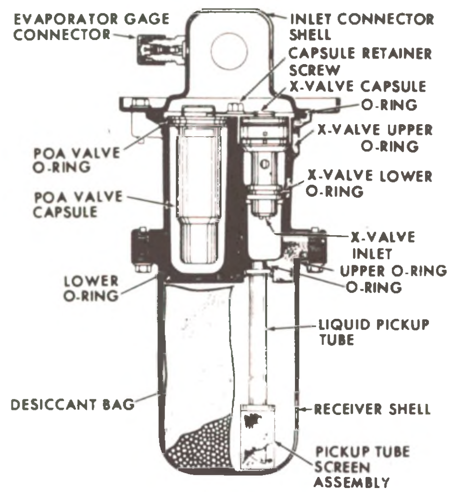


Fig. 2-12 — Sectional View of EEVIR

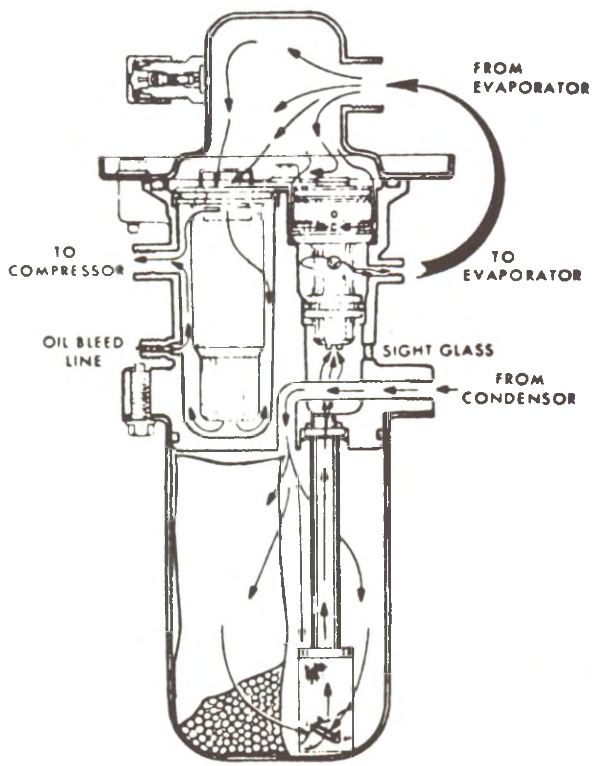


Fig. 2-13 — Refrigerant Flow through EEVIR

VIR and EEVIR Assemblies

There are two basic designs of the VIR with a third variation. The original design (black label) has the equalizer port between POA capsule cavity and the TXV capsule diaphragm of the valve body. The latest design designated EEVIR (red label) does not have an equalizer port between the valve cavities but the top O-ring is left off the TXV to permit evaporator pressure to pass through to the diaphragm area. The EEVIR will replace the VIR as an assembly only. Two specific components which cannot be used interchangeably when making the repair are the valve housing and the expansion valve capsule. Whenever an improper interchange is made, all catalog information for service is nullified.

Moisture Indicator EEVIR

On some EEVIR assemblies, there is a moisture indicator ring installed on the bottom of the expansion valve capsule. This ring is visible through the sight glass and is sensitive to moisture in the system. It changes color from blue (dry) to pink (wet) when moisture is present.

VIR Identification and Parts Interchangeability

For identification purposes, the chart below summarizes the differences between the original VIR and the current EEVIR. Illustrations and procedures in this manual are for the EEVIR.

NOTE: There are two specific components of the EEVIR which must NOT be interchanged with the early design: (1) the valve housing and (2) the expansion valve capsule. Also, on the original VIR, the expansion valve has an O-ring in the upper groove which must NOT be used in the EEVIR. Be sure to consult the parts catalog.

ITEM	VIR (Original)	EEVIR (Current)
Expansion valve O-rings	3 Total — 1 in topmost valve body groove 1 in lower valve groove 1 in valve housing a "Jam Seal Fit"	2 Total — 1 in lower valve body groove 1 in valve housing at "Jam Seal Fit"
Information label color	Black	Red (color dots are indicated on moisture — indicator version).
Expansion valve capsule color	Silver	Gold
Valve housing identification	Equalizer passage between capsule cavities. Colored silver.	Color gold or letter "E" stamped below sight glass.

VIR Refrigerant Flow

In operation, liquid refrigerant from the condenser (Fig. 2-13) flows into the liquid inlet port of the valve housing and to the receiver shell, where it can come in contact with the desiccant. The liquid refrigerant flows directly from the receiver through the filter screen at the bottom of the liquid pickup tube, through the pickup tube to the lower portion of the expansion valve cavity. The expansion valve meters the liquid refrigerant to the evaporator.

Refrigerant vapor from the evaporator returns through the inlet connector shell assembly at the top of the VIR assembly, and the POA valve then regulates the rate of refrigerant flow back to the compressor.

The evaporator gauge fitting (Fig. 2-12) incorporates a valve located in the inlet connector shell assembly at the top of the VIR unit. The oil bleed line fitting is located in the VIR valve housing (Fig. 2-13) and is connected directly into the POA valve cavity outlet.

These two Schrader valves cannot be used interchangeably because they have different spring ratings.

VIR Expansion Valve

The expansion valve (Fig. 2-14) is a pressure and temperature-sensitive, automatic valve used to control the amount of refrigerant entering the evaporator. The valve controls the flow of refrigerant by sensing the temperature and pressure of the refrigerant gas as it passes through the VIR unit on the return to the compressor.

The expansion valve is factory adjusted and cannot be reset or repaired in the field. When it is determined that the valve is malfunctioning, the entire capsule must be replaced.

The equalizer port (Fig. 2-14) assists the operation of the expansion valve under certain conditions. In the VIR the main equalization function is accomplished by an equalization port drilled between the valve cavities. This exposes the diaphragm to compressor suction pressure. On the EEVIR assembly, equalization is accomplished by leaving the top O-ring off the TX body. This permits evaporator pressure to be exerted on the valve diaphragm.

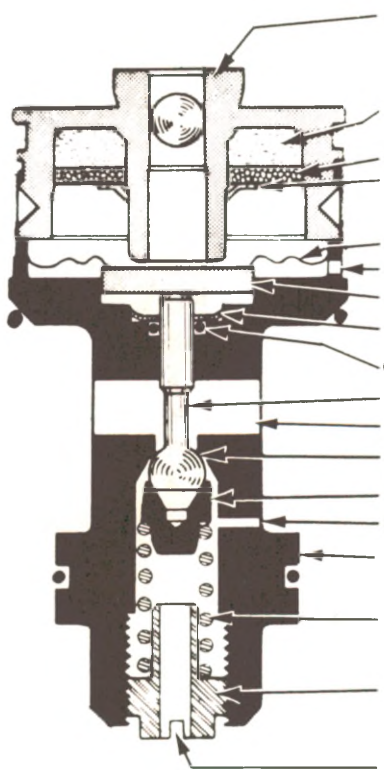


Fig. 2-14 — **Expansion Valve Capsule**

VIR POA Valve

The POA capsule (Fig. 2-15) is located in the VIR unit adjacent to the expansion valve capsule. The function of this valve is to control flow of refrigerant from the evaporator and maintain pressure above 30 PSI or 32°F temperature. The evaporator can be well above 30 PSI, depending on heat load, compressor speed, etc.

The POA valve capsule is factory set and is not adjustable or field repairable. When it is determined that the valve is malfunctioning the complete POA valve capsule must be replaced.

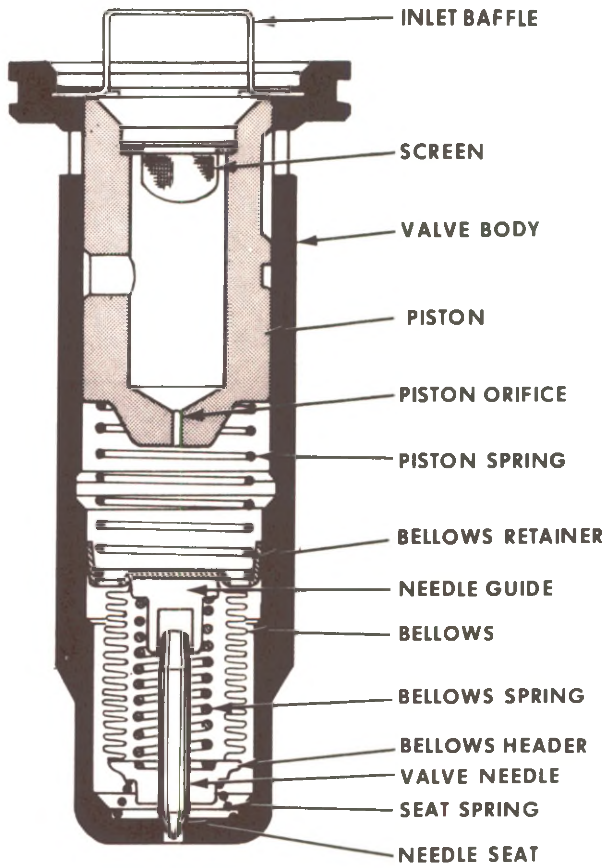


Fig. 2-15 — POA Valve Capsule

Combination Expansion and Suction Throttling Valve

A combination valve (Fig. 2-16) is installed on some Ford systems, combining the TXV and STV in a single assembly. Like the VIR, the combination valve is mounted at the evaporator. However, the system has a separate receiver-dehydrator at the condenser, and no sight glass. Otherwise it functions the same as the VIR. Original designs of the combination valve had an equalizer port between the TXV and STV. Later designs have eliminated this equalizer by notching the valve seat.

A calibrated Schrader valve (liquid bleed valve) is part of the combination valve assembly; as well as a pressure gauge port with a non-calibrated Schrader valve.

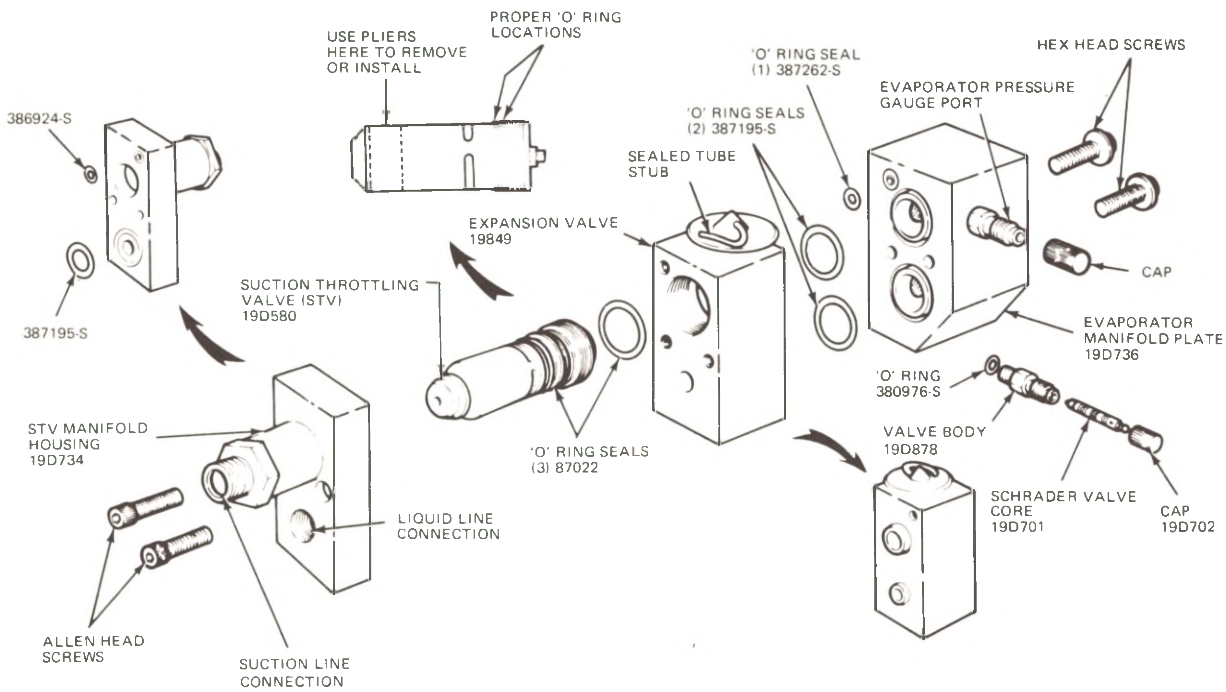


Fig. 2-16 — Combination Valve (TXV & STV) Ford

COMPRESSORS

The compressor is located in the engine compartment. The primary purpose of the unit is to draw the low pressure vapor from the evaporator and compress this vapor into high temperature, high pressure vapor. This action will result in the refrigerant having a higher temperature than surrounding air, and thus enabling the condenser to condense the vapor back to a liquid. The secondary purpose of the compressor is to circulate the refrigerant through the condenser under the different pressures required for proper operation.

The compressor is belt driven by the engine crankshaft through a clutch pulley. Rotation of the compressor shaft operates a pump that supplies oil to the moving parts of the compressor (except the DA6 and R4 compressor). Operation of the pistons draws refrigerant vapor into the suction cavity on the intake strokes. On the compression strokes, the vapor is compressed into the discharge cavity and flows out the connector assembly into the discharge line.

In the "cycling clutch" system, the compressor should start and stop at frequent intervals. However, under high load conditions the compressor may run almost continuously. In the "evaporator pressure control valve system" the compressor operates at all times that the dash controls are in the air conditioning position.

The basic types of compressors in common use are:

1. General Motors
2. Nippondenso
3. Sankyo

General Motors 6-Cylinder Compressor (A6)

The General Motors 6-cylinder compressor (Figs. 2-17 and 2-18) is of basic double action piston type. Three horizontal double acting pistons make up the 6-cylinder compressor. The pistons operate in a 1.5 inch bore and have a 1.25 inch stroke. An axial plate pressed to the shaft drives the pistons. The shaft is driven through a magnetic clutch and pulley (explained later in this section). An oil pump mounted at the rear of the compressor picks up oil from the bottom of the compressor (from sump) and lubricates the bearings and other internal parts of the compressor.

Reed type valves at each end of the compressor open or close to control the flow of incoming and outgoing refrigerant. Two gas-tight passages interconnect chambers of the front and rear heads so that there is one common suction port and one common discharge port.

This compressor is used on many applications other than General Motors built vehicles.

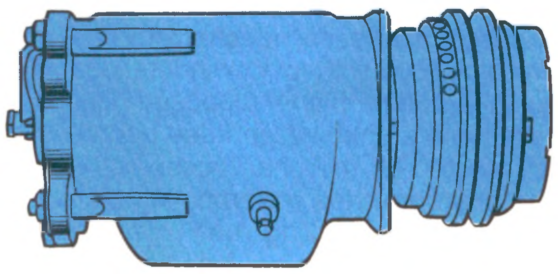


Fig. 2-17 — GM 6 Cylinder Compressor — External

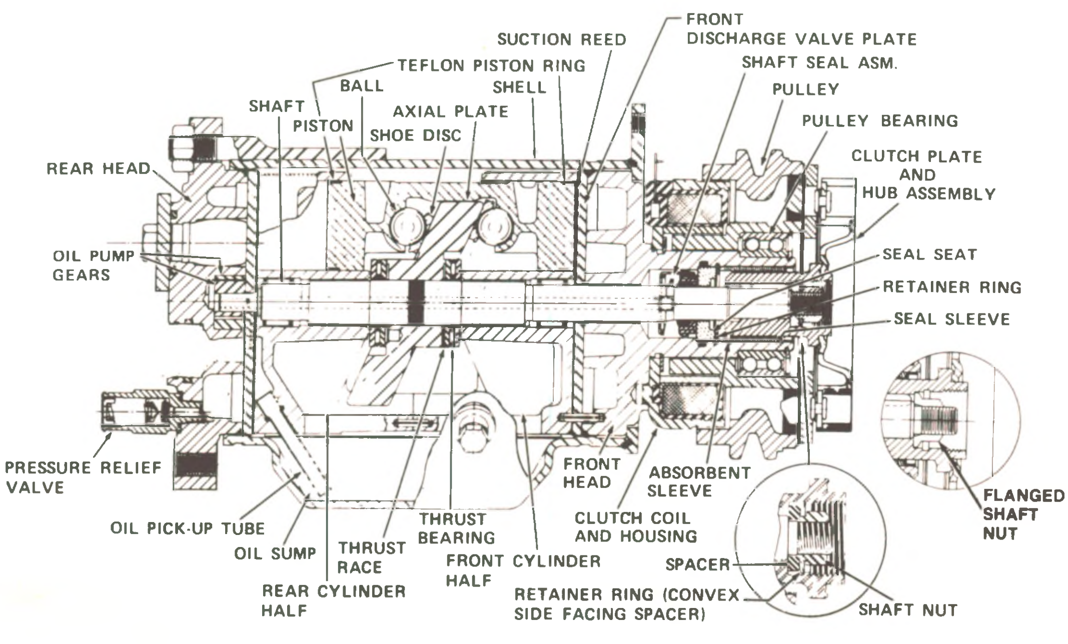


Fig. 2-18 — GM 6 Cylinder Compressor — Internal

General Motors 4-Cylinder Compressor (R-4)

The General Motors 4-cylinder, radial design, compressor is illustrated in Figs. 2-19 and 2-20.

The basic compressor mechanism is a modified scotch yoke with four cylinders located radially in the same plane. Opposed pistons are pressed into a yoke which rides upon a slider block located on the shaft eccentric. Rotation of the shaft provides reciprocating piston motion with no "connecting rods". The mechansim is completely balanced with counterweights. Needle bearings are used for the shaft journals and the shaft eccentric. Pistons and yokes, along with the main cylinder housing and front cover, are made from aluminum to provide light weight. Teflon piston rings are used to provide both a gas compression seal and a piston-to-bore bearing surface. The compressor outer shell is a simple steel band which encloses a large annular discharge muffler space.

Two O-rings provide a seal between the compressor shell and the compressor cylinder. A rubber seal ring seals the front head to the cylinder assembly and the shaft seal assembly provides a front head to shaft seal.

Refrigerant flows into the crankcase from the connector block at the rear, is drawn through the reeds attached to the piston top during the suction stroke, and is discharged outward through the discharge valve plate which is held in place at the top of the cylinder by a snap ring. Discharge gas flows out of the compressor muffler cavity through the connector block at the rear.

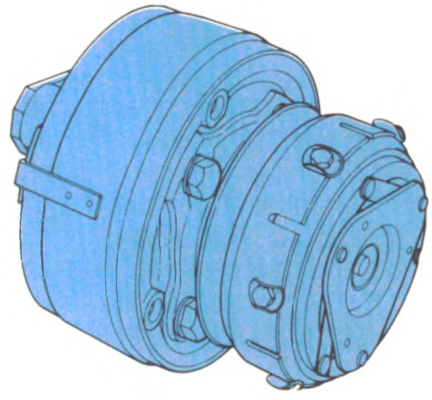


Fig. 2-19 — GM 4 Cylinder Compressor — External

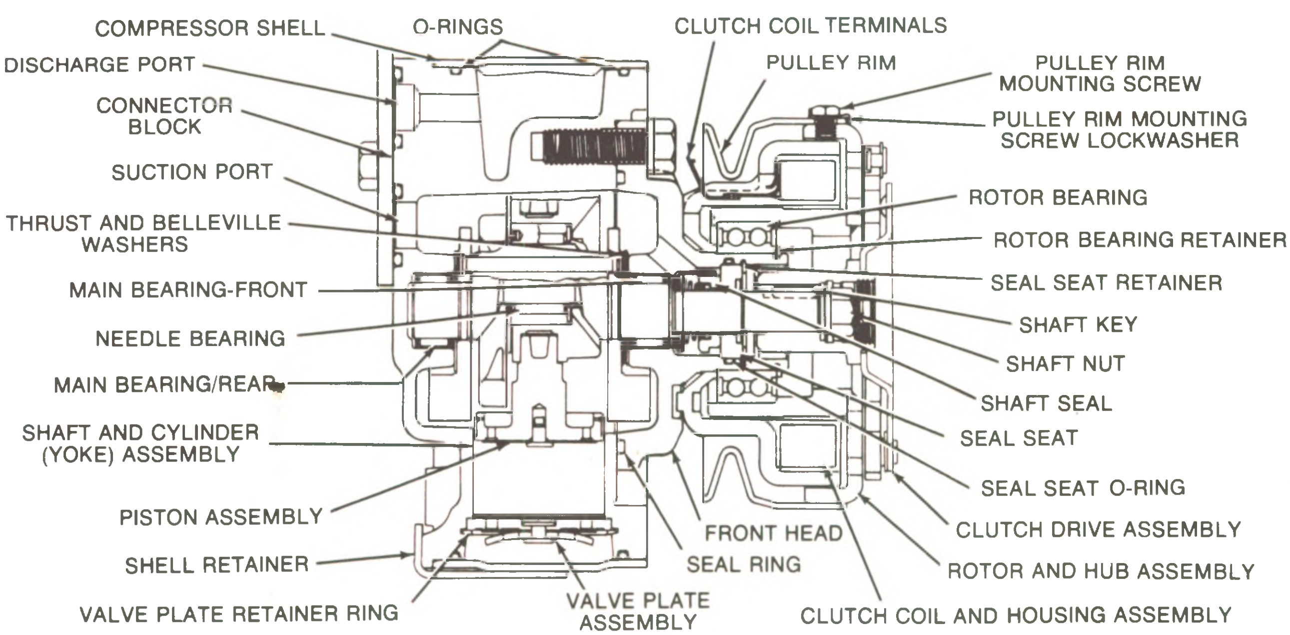


Fig. 2-20 — GM 4 Cylinder Compressor — Internal

General Motors DA 6 Compressor

Rated at ten cubic inches, the General Motors DA-6 compressor (Fig. 2-21) first appeared on selected 1983 GM vehicles. The DA-6 compressor is similar in design and operation of the A-6 axial compressor used for many years. One difference between the two compressors is that the DA-6 is made up almost entirely of aluminum. Making the compressor of aluminum saves weight, which leads to greater fuel economy.

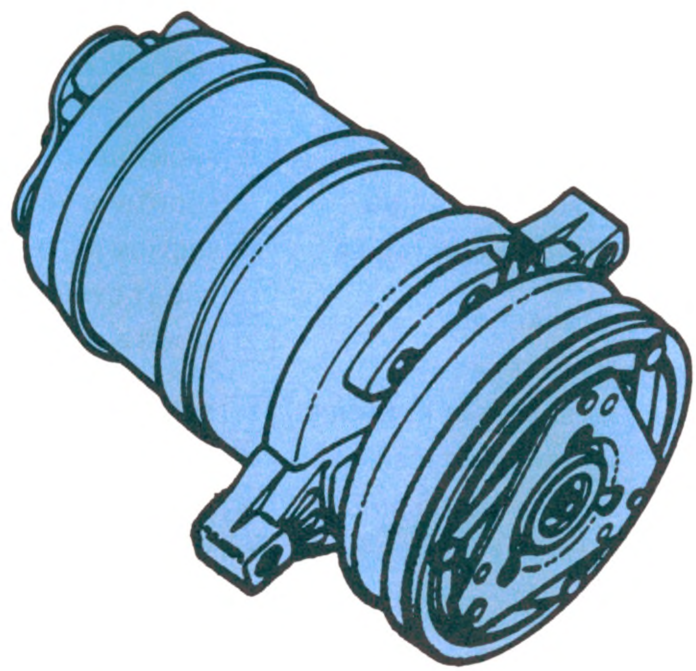


Fig. 2-21 — **DA-6 Compressor, V-Groove Pulley & Standard Mounting**

The DA-6 compressor is a six-cylinder swashplate compressor. Internal passages connect the front and rear compressor heads so that there is one suction and one discharge port (Figure 2-22). Reed valves control refrigerant flow.

An electrical high-pressure switch on the rear of the compressor protects the system from dangerous pressures. If the discharge pressure gets too high, the switch will open and cut off current to the compressor.

Because the compressor is made of aluminum, be careful not to overtighten compressor bolts — the compressor can be damaged.

No parts are interchangeable between the DA-6 and any other GM compressor. Note that the DA-6 is fully metric.

1 SUCTION PORT
2 REAR VALVE PLATE
3 SUCTION REED PLATE
4 PISTON & RING ASSY.
5 PISTON BALL
6 SHOE DISC
7 HEAD GASKET
8 CLUTCH COIL ASSY.
9 PULLEY ROTOR
10 CLUTCH DRIVER
11 PULLEY BEARING
12 BEARING RETAINER RINGS
13 SHAFT NUT
14 SHAFT KEY
15 SEAL SEAT RETAINER
16 SEAL SEAT (CERAMIC)
17 SEAL SEAT O-RING
18 SHAFT SEAL
19 FRONT HEAD
20 FRONT VALVE PLATE
21 SUCTION REED PLATE
22 FRONT CYLINDER
23 SHAFT & AXIAL PLAT ASSY.
24 REAR CYLINDER
25 THRUST BEARING
26 THRUST RACE
27 HEAD GASKET
28 PRESSURE RELIEF VALVE
29 REAR HEAD

*CYLINDER O-RING SEALS

**SHAFT BEARING

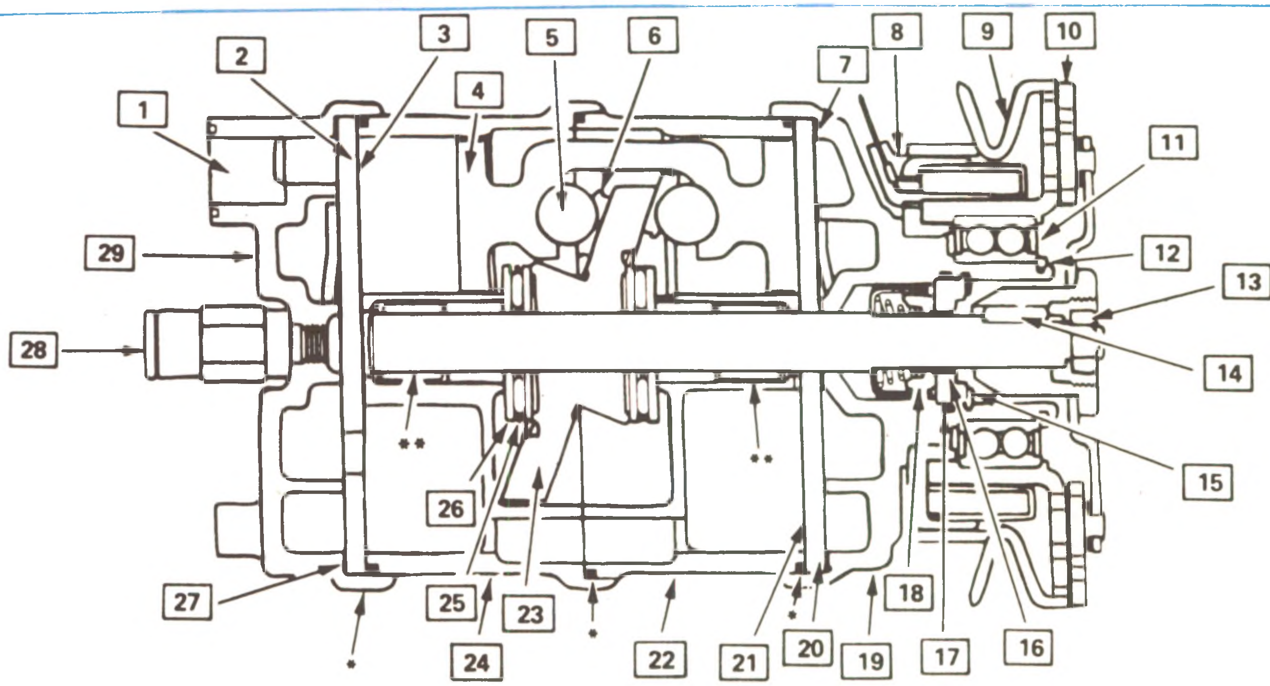


Fig. 2-22 — **DA-6 Compressor — Cross Section**

Sankyo Compressors

Sankyo SD-5 compressors (Figure 2-23) are light-weight, aluminum compressors used in many Japanese vehicles. Like the General Motors A-6 and DA-6 compressors, the Sankyo compressors use a swashplate. Instead of three, double-ended pistons, however, the Sankyo compressors use five single-ended pistons. Because single-ended pistons are used, the need for internal refrigerant passages is eliminated (Figure 2-24). Both the suction and discharge service fittings are at the rear of the compressors.

The SD-505, 507, and 510 compressors use an oil deflector in the compressor to ensure adequate lubrication.

The SD-508 compressor uses a pressure differential lubrication system. The pressure difference between the suction port and compressor block causes the oil to be applied to the internal parts of the compressor.

To prevent damage to the compressor valves, valve stops are designed into the compressor. Valve stops limit the travel of the suction reed valves.

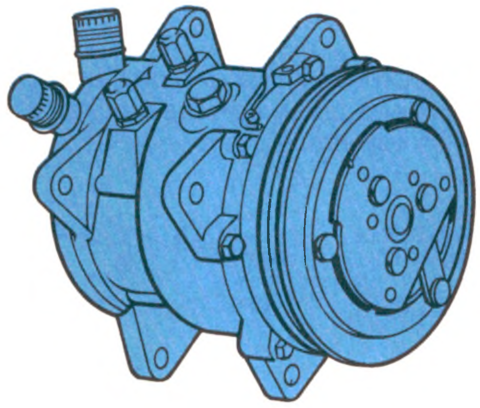


Fig. 2-23 — Sankyo Compressor

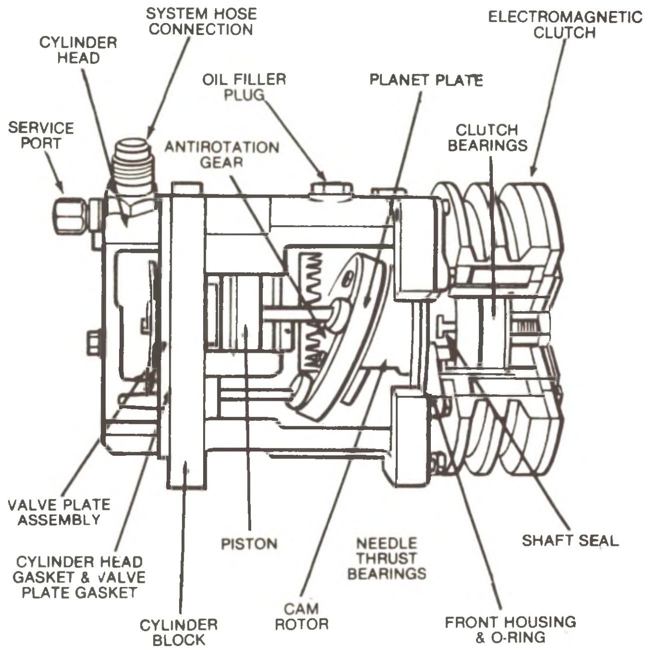


Fig. 2-24 — Sankyo Compressor — Cross Section

Nippondenso Compressor

The Nippondenso compressor is a conventional swashplate compressor with three double-ended pistons (Fig. 2-25). The body of the compressor is made of aluminum to save weight. Nippondenso compressors are used primarily in General Motors vehicles.

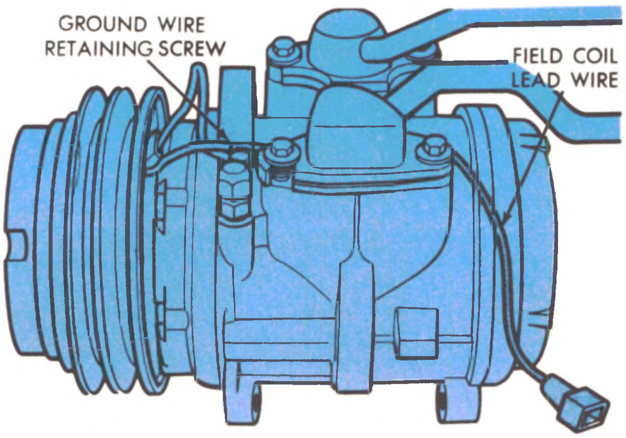


Fig. 2-25 — **Nippondenso Compressor**

CONDENSER

The condenser (Fig. 1-26) consists of a refrigerant coil tube mounted in a series of thin cooling fins to provide a maximum of heat transfer in a minimum amount of space. Mounted directly in front of the car radiator, it receives the full flow of ram air from the movement of the car and from the engine fan.

The purpose of the condenser is to condense or liquify the high pressure hot vapor coming from the compressor. To do so, it must give up its heat (BTUs). The condenser receives very hot, high pressure, refrigerant vapor from the compressor through its discharge hose. The refrigerant vapor enters the inlet at the top of the condenser and, as the hot vapor passes down through the condenser coils, heat (following its natural tendencies) moves from the hot refrigerant into the cooler air as it flows across the condenser coils and fins. This process causes a large quantity of heat to be transferred to the outside air and the refrigerant to change from a high pressure HOT VAPOR to a high pressure WARM LIQUID. This high pressure warm liquid flows from the outlet at the bottom of the condenser through a line to the receiver-dehydrator.

RECEIVER-DEHYDRATOR

The receiver-dehydrator (Fig. 2-26) is a storage tank for the liquid refrigerant from the condenser which flows into the upper portion of the receiver tank containing a bag of desiccant (moisture absorbing material). As the refrigerant flows through an opening in the lower portion of the receiver, it is filtered through a mesh screen attached to a baffle at the bottom of the receiver. The desiccant in this assembly absorbs any moisture that might enter the system during assembly. These features of the assembly prevent obstruction to the valves or damage to the compressor.

A sight glass is often located on the top of the receiver-dehydrator, or in the liquid line through which a solid column of refrigerant flows. The sight glass serves to indicate whether there is enough refrigerant in the system. This provides a means for the serviceman to observe the state of charge within the system.

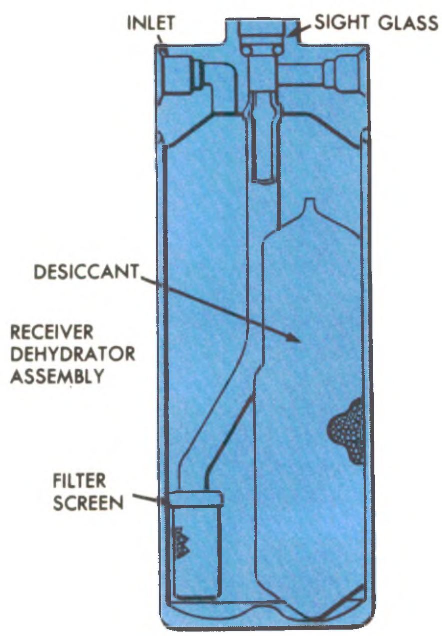


Fig. 2-26 — **Receiver-Dehydrator Assembly**

ACCUMULATOR

The accumulator (Fig. 2-27) is used on GM clutch cycling systems with orifice tube expansion control, and on some Ford systems with suction throttling valves. It is located at the evaporator outlet. Its most important function is not to "accumulate" although this too is important. Its primary function is to separate liquid that gets through the evaporator from vapor; retain the liquid and release the vapor to the compressor.

Thus, in an ideal accumulator with no oil bleed hole, and in a correctly designed system, no liquid can get to the compressor. Too much liquid can "slug" the compressor and damage it.

In an actual accumulator, there is some entrained liquid in the vapor stream to the compressor. The measure of a good accumulator is how well it separates vapor from liquid and how little entrained liquid is released to the compressor. Also, in an actual accumulator, an oil bleed hole is required to prevent trapping of oil in the bottom of the accumulator. This oil bleed hole bleeds some liquid refrigerant as well.

Therefore, flow out of the accumulator to the compressor consists mostly of vapor with the addition of entrained liquid and liquid flow through the oil bleed hole.

A bag of desiccant (dehydrating agent) is located in the base of the GM accumulator as a moisture collecting device.

NOTE: There is no sight glass in the accumulator (CCOT) system.

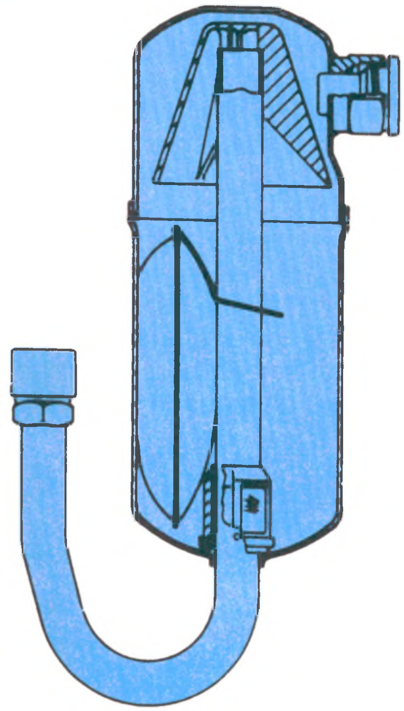


Fig. 2-27 — **Accumulator**

IN-LINE TYPE THERMOSTATIC EXPANSION VALVE

The in-line type thermostatic expansion valve (Fig. 2-28) has the same function as the TXV capsule in the VIR assembly. It regulates the supply of liquid refrigerant to the evaporator at the same rate vaporous refrigerant is removed from the coil. The in-line type valves used in some systems have an external equalizer line. Valves in other systems are internally equalized. The only difference between the two valves is that the former uses an equalizer line connected to the STV or POA valve (or to the evaporator outlet line on clutch-cycling systems) as a means of sensing evaporator outlet pressure. The latter senses evaporator inlet pressure through an internal equalizer passage. Both valves have a capillary tube to sense evaporator outlet temperature.

The valve itself consists of the power element and the body. The body contains the seat and orifice, pressure spring, actuating pins, and a fine mesh screen which prevents dirt or other foreign matter from entering the valve orifice.

To produce refrigeration a dividing point is necessary between the high and low pressure portions of the system. The thermostatic expansion valve, or more specifically the seat and orifice in the valve body, provides this dividing point. During system operation high pressure liquid refrigerant enters the valve from the receiver-dehydrator, passes through the inlet screen and on to the orifice. As the high pressure liquid passes through this orifice, it changes to low pressure liquid.

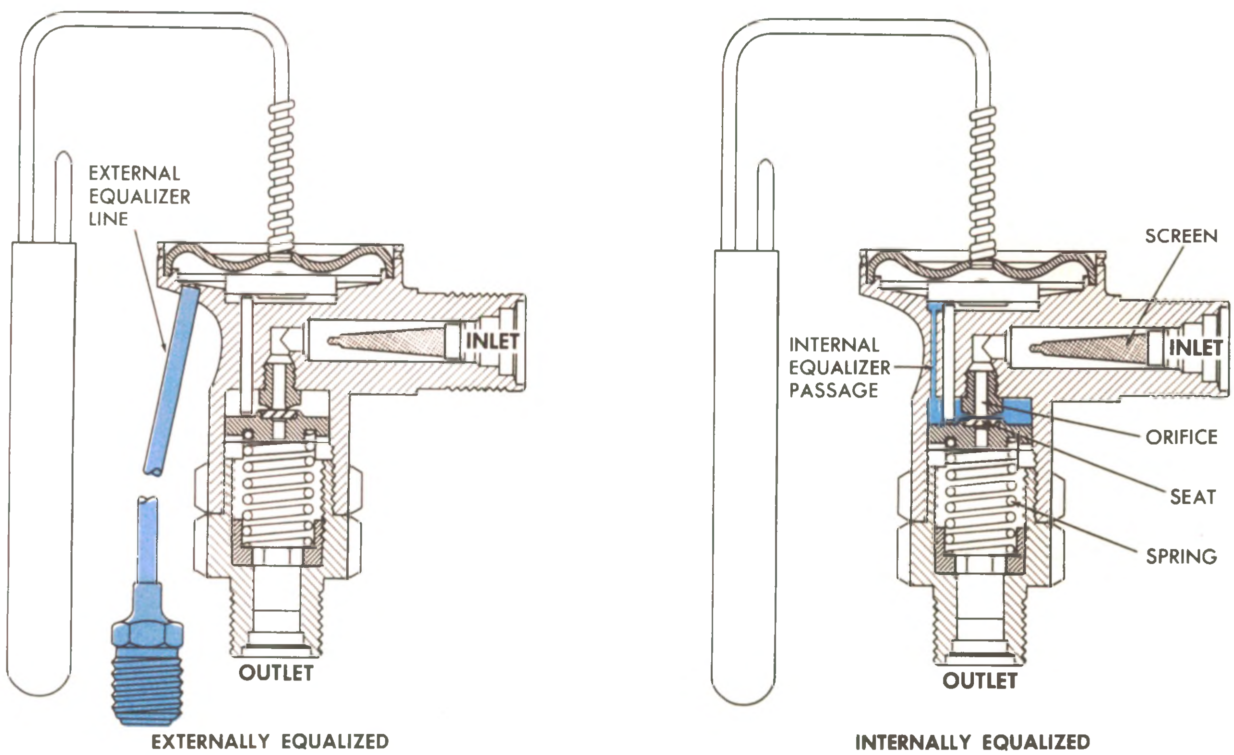


Fig. 2-28 — Thermostatic Expansion Valves — Cross Section View

EXPANSION TUBE (ORIFICE)

The orifice (expansion) tube (Fig. 2-29) is used in place of the thermostatic expansion valve on the cycling clutch orifice tube (CCOT) system. It is located in the enlarged portion of the evaporator inlet line (Figs. 2-3 and 2-4).

Like the expansion valve, the orifice tube is the dividing point between the high and low pressure parts of the system. However, its metering or flow rate control does not depend on comparing evaporator pressure and temperature. It is a fixed orifice. The flow rate is determined by pressure difference across the orifice and by sub-cooling. (Sub-cooling is additional cooling of the refrigerant in the bottom of the condenser after it has changed from vapor to liquid.) The flow rate through the orifice is more sensitive to sub-cooling than to pressure difference.

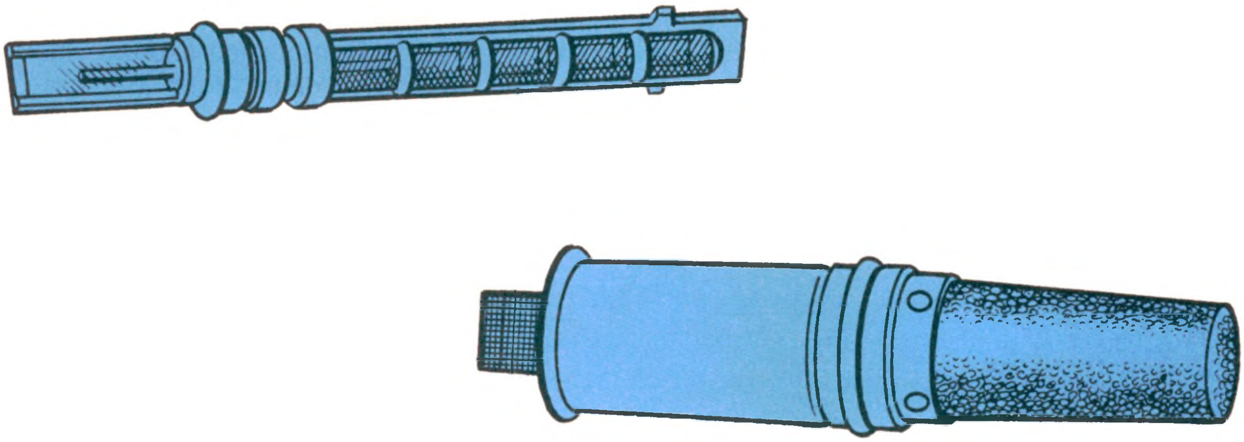


Fig. 2-29 — **Expansion Tube Orifice**

COMPRESSOR CONTROLS

Compressor Clutch and Pulley Assembly

Every compressor is equipped with an electromagnetic clutch as part of the compressor pulley assembly. It is designed to engage the pulley to the compressor shaft when the clutch coil is energized.

The purpose of the clutch is to transmit power from the engine to the compressor and to provide a means of engaging and disengaging the refrigeration system from the engine operation.

The clutch is driven by power from the engine crankshaft which is transmitted through one or more belts to the pulley, which is in operation whenever the engine is running. When the clutch is engaged, power is transmitted from the pulley to the compressor shaft by the clutch drive plate. When the clutch is not engaged, the compressor shaft does not rotate and the pulley freewheels.

The clutch is engaged by a magnetic field and disengaged by springs when the magnetic field is broken. When the controls call for compressor operation, the electrical circuit to the clutch is completed, the magnetic clutch in energized, and the clutch engages the compressor. When the electrical circuit is opened, the clutch disengages the compressor.

The General Motors compressor clutch and pulley assemblies (Figs. 2-30 and 2-31) are made up of several different parts that can be individually replaced as required. The typical clutch and pulley assembly (Fig. 2-32) used with reciprocating compressors is serviced by replacement of either the bearing, or the pulley and clutch assembly.

In a "cycling clutch" air conditioning system the clutch is intermittently energized and de-energized through the use of a thermostatic switch or pressure switch in the electrical control circuit. With the "evaporator pressure control valve system" the clutch is electrically energized whenever the operator controls are in the air conditioning position. In addition to the manually operated controls, however, the clutch electrical control circuit may include protective switches such as the ambient switch, thermal limiter, superheat switch and low pressure cut-off switch.

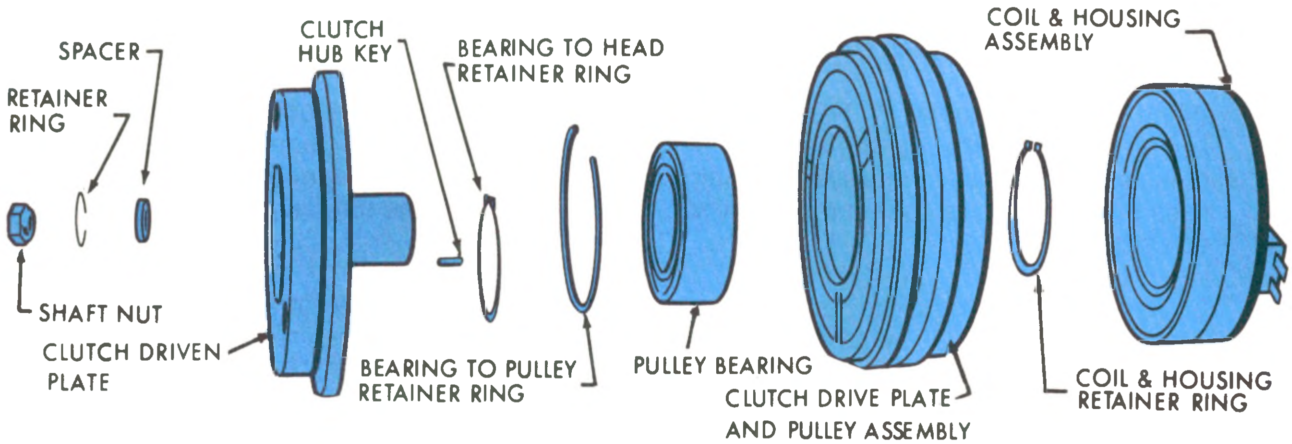


Fig. 2-30 — GM 6 Cylinder Compressor Clutch and Pulley Assembly

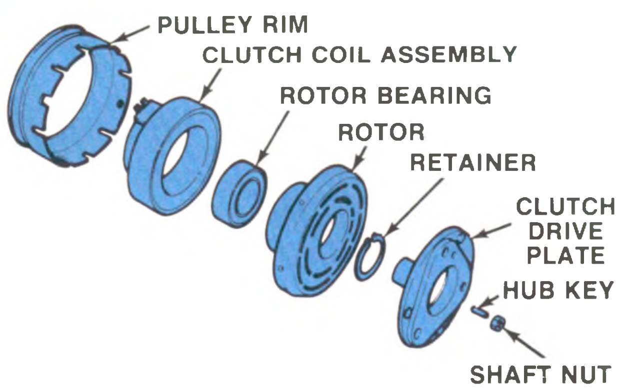


Fig. 2-31 — GM 4 Cylinder Compressor Clutch & Pulley Assembly

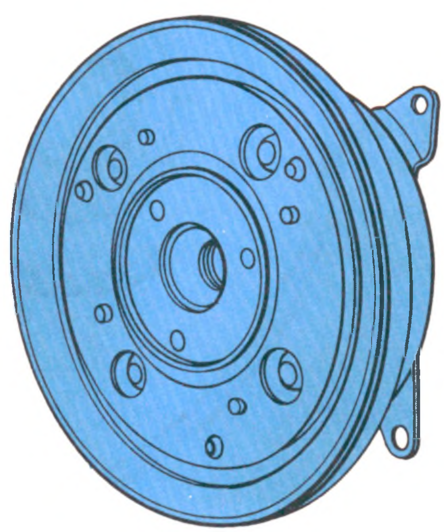


Fig. 2-32 — Typical Clutch used on Reciprocating Compressors

Thermostatic Switch

In cycling-clutch systems, the thermostatic switch (Fig. 2-33) is placed in series with the compressor clutch circuit so that it can turn the clutch on or off. It has two purposes:

1. To de-energize the clutch and stop the compressor if the evaporator is at the freezing point. It acts as a de-icing control.
2. On hang-on units or systems without "re-heat" temperature control, it also controls the air temperature by turning the compressor on and off intermittently. For this purpose it will have a control knob to change the switch setting (Fig. 2-33).

The thermostatic switch incorporates a metallic sensing tube which contains a highly expansive gas. This tube is inserted into the evaporator core between the fins; or is located in the air stream as it leaves the evaporator. The tube leads to a bellows operated switch. As air temperature rises, the gas inside the tube expands, increasing pressure to the bellows and closes the electrical switch. This engages the compressor clutch.

When the temperature of the evaporator approaches the freezing point (or the "low" setting of the switch), the thermostatic switch opens the circuit and disengages the compressor clutch. The compressor remains inoperative until the evaporator temperature rises to the preset temperature; at which time, the switch closes and compressor operation resumes.

Some switches without the temperature control knob have an internal adjusting screw. The screw can be set by service personnel to change the temperature range in which the clutch cycles.

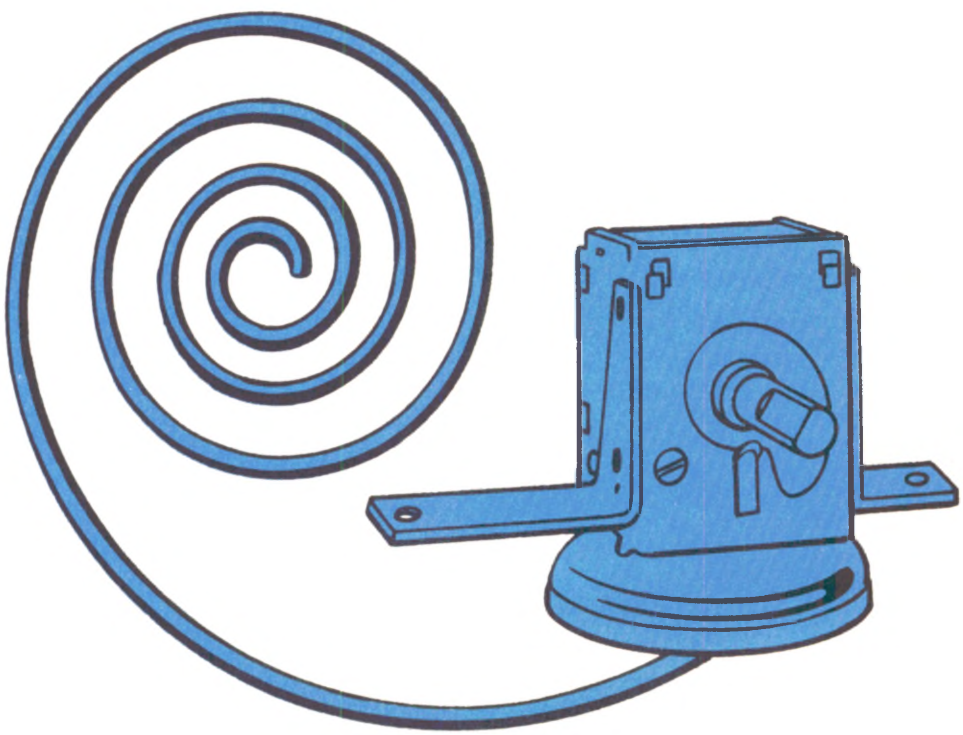


Fig. 2-33 — **Thermostatic Switch**

Pressure Cycling Switch

The pressure cycling switch (Fig. 2-34) is electrically connected in series with the compressor electromagnetic clutch. Like the thermostatic switch, the turning on and off of the pressure cycling switch controls the operation of the compressor. The pressure cycling switch has three interrelated functions:

1. The switch will interrupt compressor operation at a low pressure of approximately 27 PSI to prevent evaporator freeze up. The switch will allow the compressor to run again at approximately 35 PSI of refrigerant pressure.
2. The switch will interrupt compressor operation when the accumulator pressure drops below 27 PSI on a partially charged system. This protects the compressor from damage caused by operating with insufficient lubrication.
3. The switch will not allow the compressor to operate when the system pressure is too low for safe operation of the compressor.

The pressure cycling switch incorporates a spring loaded diaphragm type switch which is referenced to atmospheric pressure.

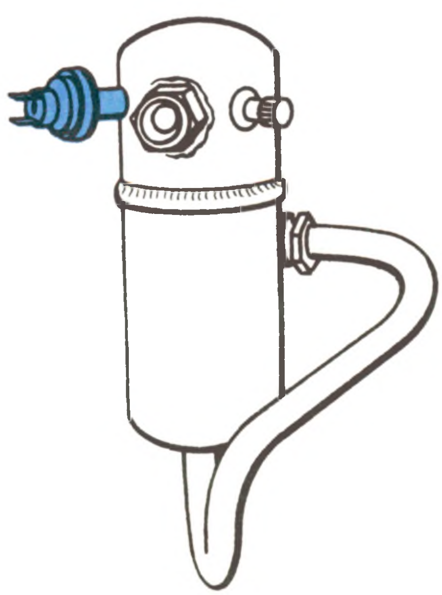


Fig. 2-34 — Pressure Cycling Switch

Manually Operated Controls

A typical GM dash control panel for evaporator pressure control systems is shown in Fig. 2-35. When the top horizontal selection lever is in any of the air conditioning positions, the compressor operates continually and evaporator temperature is controlled by the POA valve or VIR.

The lower horizontal selection lever actuates an "air door" in the air distribution duct work. This door deflects cooled air from the evaporator through the heater core in whatever portions might be desirable for passenger comfort.

The vertical lever on the left side of the control is for blower speed selection.

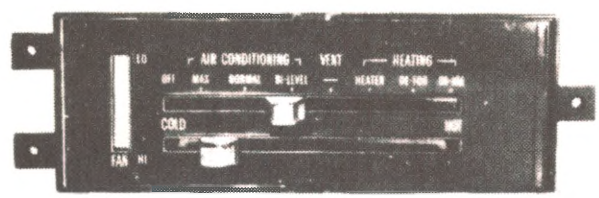


Fig. 2-35 — Manual Control

Ambient Switch

The ambient switch senses outside air temperature and is designed to prevent compressor clutch engagement when air conditioning is not required or when compressor operation might cause internal damage to seals and other parts.

The switch is in series with the compressor clutch electrical circuit and closes at about 37°F. At all lower temperatures, the switch is open thus preventing clutch engagement.

On GM cars, the ambient switch is located in the air inlet duct of the air conditioning systems that are regulated by evaporator pressure controls. Other makes have it installed near the car radiator. It is not required on systems with thermostatic switch.

Thermal Limiter and Superheat Switch

A thermal limiter (fuse) and superheat switch, designed to protect the air conditioning compressor against damage when the refrigerant charge is partially or totally lost, is incorporated in some GM cars. The thermal fuse may be found in various underhood locations and the superheat switch is located in the rear head of the compressor. The fuse and switch are connected in series by an electrical lead.

The thermal limiter on underhood applications should not be moved from its initial location as varing underhood ambients could result in improper operation of the switch.

A wiring diagram of the fuse and switch electrical circuitry is shown in Fig. 2-37. The switch and fuse are shown in Fig. 2-36.

During normal A/C system operation, current flows through the control head switch, ambient switch and thermal fuse to the clutch coil to actuate the compressor clutch. If a partial or total loss of refrigerant occurs in the sytstem, the contacts in the superheat switch close, as the switch senses low system pressure and high suction gas temperature. When the contacts close, current flows to energize a resistor-type heater in the thermal fuse.

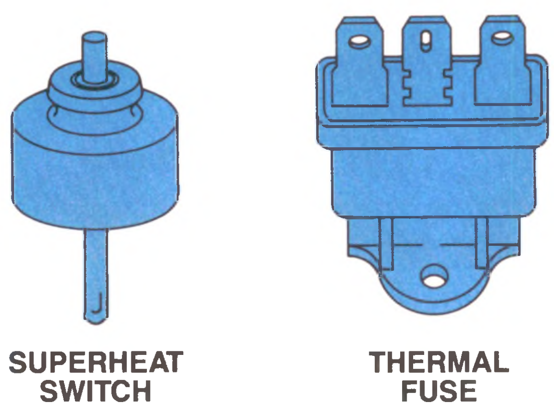


Fig. 2-36 — Superheat Switch and Thermal Limiter

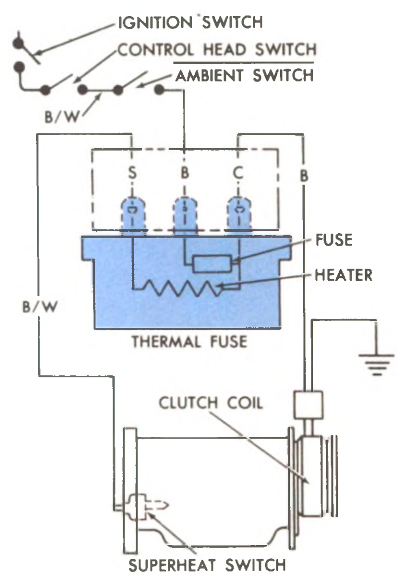


Fig. 2-37 — Fuse and Switch Electrical Circuit

Discharge Pressure Switch (Low-Pressure Cut-Off)

Late model GM systems use a pressure switch in the compressor discharge part of the system to provide compressor protection. This switch is referred to as a discharge pressure switch or low-pressure cut-off switch. It is installed on GM cars in the compressor or in the high pressure line.

NOTE: The low pressure cut-off switch that is located in the rear head of late model GM compressors should not be confused with the superheat switch. The superheat switch was installed in the same location in earlier compressors. The two switches have a similar appearance.

The pressure switch is wired in series with the compressor clutch circuit. It performs the protective functions of the ambient switch. When the switch senses low discharge (high side) pressure, it breaks contact and opens the circuit to the compressor clutch. There are two conditions where this occurs:

1. Cold outside air, because of refrigerant temperature — pressure relationship, causes the pressure to be low. Thus, the compressor will not start up in winter weather.
2. Lost refrigerant causes low pressure. The compressor is shut off to prevent damage from compressor oil loss in case of a major leak.

This switch is serviced by complete replacement only.

AUXILIARY COMPONENTS

Water Control Valve

The water control valve (Fig. 2-38) is located in the heater inlet hose. It consists of a brass tube, piston assembly and vacuum diaphragm assembly.

The valve is generally used in air conditioning systems controlled by an evaporator pressure regulator. Its function is to regulate the flow of coolant to the heater core. Depending on the make and model of car, the valve is either open or closed when vacuum is applied to the diaphragm. On most applications, the water valve is closed when the air conditioning controls are set for maximum cooling.

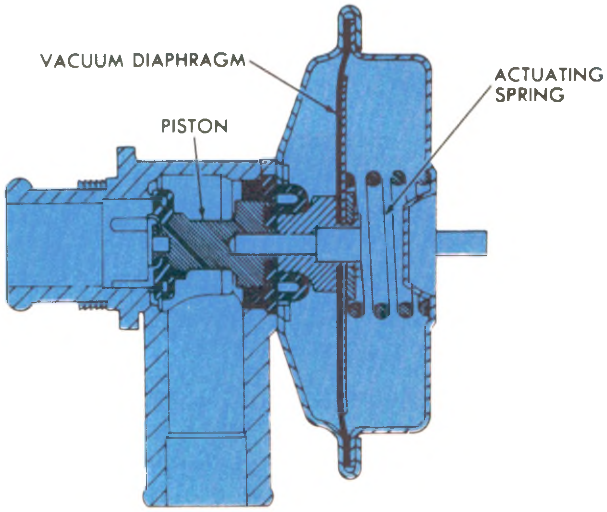


Fig. 2-38 — Water Control Valve

Muffler

Most air conditioning systems now have a muffler (Fig. 2-39) installed in the system. The muffler is located on the discharge side of the compressor. The muffler acts to reduce characteristic pumping noises of the compressor. To further reduce compressor noise transfer through the body to the passenger compartment, a sheet of soft rubber insulation is wrapped around the outside of the muffler on some models.

Mufflers should be installed with inlet connection at the top and outlet connection at the bottom. This will minimize collection of oil in the unit.

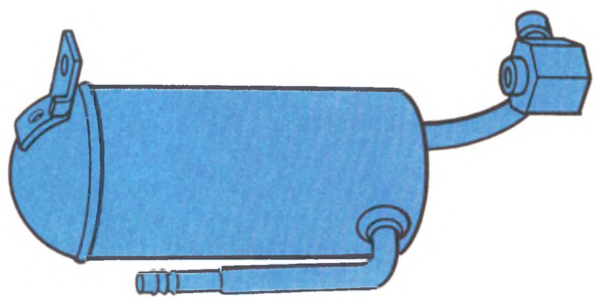


Fig. 2-39 — Muffler

BASIC MAINTENANCE CONSIDERATIONS

Maintaining Systems Stability

The efficient operation of the air conditioning refrigeration system is dependent upon the pressure-temperature relationship of pure refrigerant. As long as the system contains pure refrigerant (plus a certain amount of compressor oil which mixes with the refrigerant) it is considered to be chemically stable.

When foreign materials (Fig. 3-1) such as dirt, air, or moisture are allowed to get into the system they will change the pressure-temperature relationship of the refrigerant. Thus, the system will no longer operate at the proper pressures and temperatures and the efficiency will decrease.

The following general practices should be observed to insure chemical stability in the system:

1. Whenever it becomes necessary to disconnect a refrigerant connection, wipe away any dirt or oil at and near the connection to eliminate the possibility of dirt entering the system. Both sides of the connection should be immediately capped or plugged to prevent the entrance of dirt, foreign material and moisture. It must be remembered that all air contains moisture. Air that enters any part of the system will carry moisture with it and the exposed surfaces will collect the moisture quickly.
2. Keep tools clean and dry. This includes the gauge set and replacement parts.
3. When adding oil, the container and the transfer tube through which the oil will flow should be exceptionally clean and dry due to the fact that refrigerant oil is as moisture free as it is possible to make it. Therefore, it will quickly absorb any moisture with which it comes in contact. For this reason, the oil container should not be opened until ready for use and then it should be capped immediately after use.
4. When it is necessary to open a system, have everything needed ready and handy so that as little time as possible will be required to perform the operation. Do not leave the system open any longer than is necessary.
5. Any time the system has been opened and sealed again, the system must be properly evacuated.

Fig. 3-1 — System Contaminants

Precautions in Handling Refrigerant 12

Refrigerant 12 (R-12) (Fig. 3-2) is transparent and colorless in both the gaseous and liquid state. It has a boiling point of -21.7°F. below zero and, therefore, at all normal temperatures and pressures it will be a vapor. The vapor is heavier than air, and is noninflammable, nonexplosive, nonpoisonous (except when in contact with an open flame). The following precautions in handling R-12 should be observed at all times.

1. Do not carry R-12 containers in passenger compartment of car.
2. Do not subject R-12 containers to high temperatures.
3. Do not weld or steam clean on or near system.
4. Do not discharge vapor into area where flame is exposed.
5. Do not expose eyes to liquid or vapor.

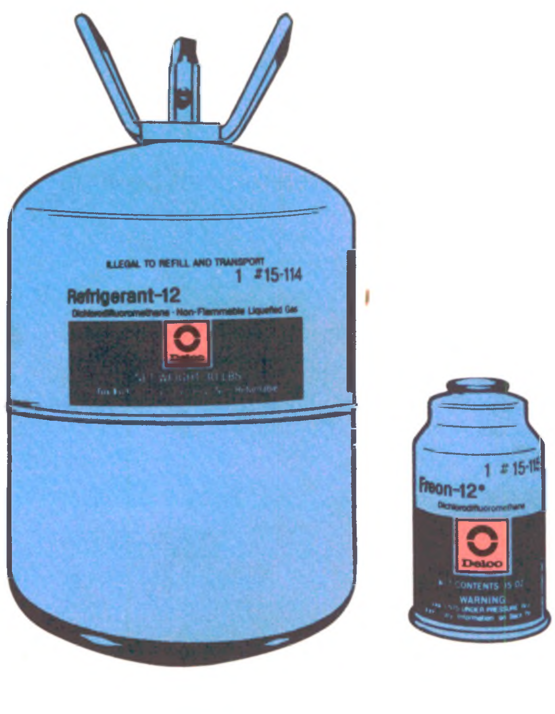


Fig. 3-2 — **Refrigerant-12**

If it is necessary to transport or carry a container of refrigerant in a car, keep it in the luggage compartment. If the container is exposed to the radiant heat of the sun, the resultant increase in pressure may cause the container to burst.

For the same reason, the refrigerant container should never be subjected to excessive temperature when charging a system. The refrigerant container should be heated for charging purposes by placing in 125°F. water. Never heat above 125°F. or use a blowtorch, radiator or stove to heat the container.

Welding or steam cleaning near any of the refrigerant lines or components of the air conditioning system could build up dangerous pressures in the system.

If you ever have the occasion to fill a small container from a large one, never fill the container completely. Space should always be allowed above the liquid for expansion. If the container were completely full and the temperature was increased, tremendous hydraulic force could be developed.

Discharging limited quantities of refrigerant into a room can usually be done safely as the vapor will produce no ill effects. However, this should not be done if the area contains a flame producing device such as a gas heater or running engine. While refrigerant normally is non-poisonous, heavy concentrations of it in contact with a live flame will produce a poisonous gas. This gas will attack all bright metal surfaces.

One of the most important cautions concerns the eyes. Any liquid refrigerant which may accidentally escape is approximately 21.7°F. below zero. If liquid refrigerant should touch the eyes, serious damage could result.

CAUTION: Always wear goggles to protect the eyes when working with refrigerant containers and opening refrigerant connections in the air conditioning system.

IMPORTANT: If refrigerant liquid should strike the eye, call a doctor immediately.

1. DO NOT RUB THE EYES. Splash the affected area with quantities of cold water to gradually get the temperature above the freezing point.
2. The use of an antiseptic oil is helpful in providing a protective film over the eyeball to reduce the possibility of infection.
3. Obtain treatment as soon as possible, from a doctor or eye specialist.

Should liquid refrigerant come in contact with the skin, the injury should be treated in the same manner as if the skin has been frostbitten or frozen.

Periodic System Checks

There are periodic checks and inspections which should be made to insure maximum efficiency of the air conditioning system. They are:

1. Inspect condenser regularly to be sure that the fins are not plugged with leaves or other foreign material.
2. Check evaporator drain tubes regularly for dirt or restrictions.
3. At least once a year, check the system for proper refrigerant charge and the flexible hoses for brittleness, wear or leaks.
4. Every 6000 miles or less check sight glass for low refrigerant indication.
5. Check belt tension regularly.
6. Check blower motor operation at all speeds.
7. Check air door operation in all selector positions.
8. Check air discharge temperature with A/C system operating in maximum A/C.
9. If air temperature is not within specifications make performance test (see Performance Testing).

SYSTEM SERVICE VALVES

System service valves which incorporate a service gauge port for manifold gauge set connections are provided on the low and high sides of some air conditioning systems.

There are two main types used. A stem type service valve is a three position internal double seating valve. It is used on some Tecumseh and York compressors. A Schrader valve, which is a gauge port with a Schrader type valve similar to a regular tire valve, is used on the General Motors and other late model installations. These valves operate as follows:

Stem Type Service Valve

This valve has a valve stem located under a cap opposite the hose connection as shown in Fig. 3-3.

NOTE: Special service wrench should be used on valve stem when operating valve. Other wrenches or improvised tools may damage valve stem.

The valve has three positions as follows:

The "Back Seated Position" is the normal operating position with the valve stem rotated counterclockwise to seat rear valve face and seal off service gauge port.

The "Mid Position" is the test position with valve stem turned clockwise (inward) 1-1/2 to 2 turns to connect service gauge port into the system so that gauge readings may be taken with system operating. (Service gauge hose must be connected with valve completely back seated.)

In the "Front Seated Position" the valve stem has been rotated clockwise to seat front valve face and to isolate compressor from the system.

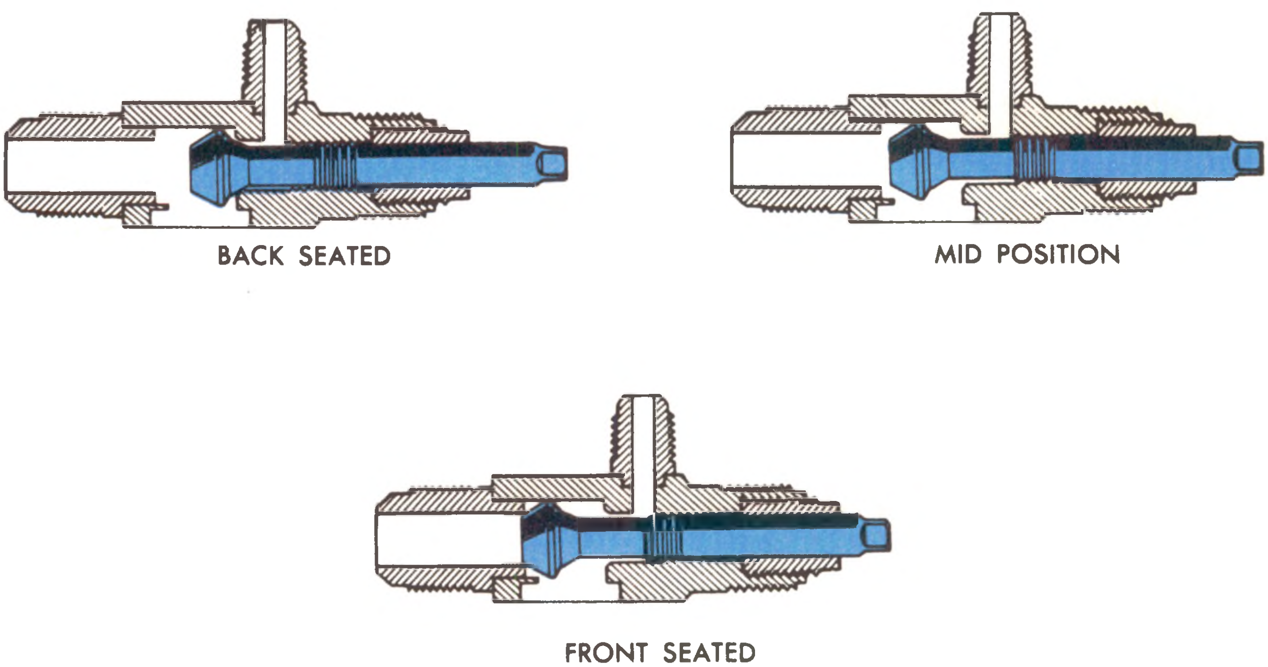


Fig. 3-3 — Stem Type Service Valve Positions

Schrader Type Service Valve

Systems that do not utilize stem type service have Schrader service valves (Fig. 3-4) in both the high and low portions of the system for test purposes.

On GM cars, the Schrader valve locations may be as follows:

- **High pressure valve** — at the compressor outlet fitting; or in the liquid line just ahead of the TXV or CCOT orifice.
- **Low pressure valve** — in the compressor inlet fitting; on the POA valve; on the VIR inlet connector shell; or on the accumulator.

Most test hoses incorporate a valve core depressor that will unseat the valve core when connected. If not, a separate adapter fitting must be installed before connecting the test hose.

NOTE: In late model GM applications, the high and low pressure valve fittings are of different sizes. This minimizes the possibility of making wrong hose connections.

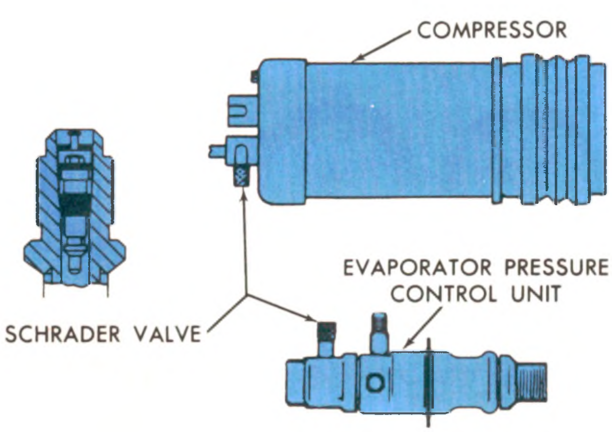


Fig. 3-4 — **Schrader Type Service Valve**

MANIFOLD GAUGE SET

The gauge set shown in Fig. 3-5 is one of the most valuable of the air conditioning tools. It is used when discharging, charging, evacuating; and for diagnosing trouble in the system.

The gauge at the left (Fig. 3-5) is known as the low pressure gauge. The dial is graduated into pounds of pressure from 0 to 120 (with cushion to 250) in 1-pound graduations, and, in the opposite direction, in inches of vacuum from 0 to 30 inches. This is the gauge that should always be used in checking pressure on the low pressure side of the system.

The gauge at the right in Fig. 3-5 is graduated from 0 to 500 pounds pressure in 10-pound graduations. This is the high pressure gauge which is used for checking pressure on the high pressure side of the system.

The center manifold fitting is common to both the low and the high side and is for evacuating or adding refrigerant to the system. When this fitting is not being used, it should be capped.

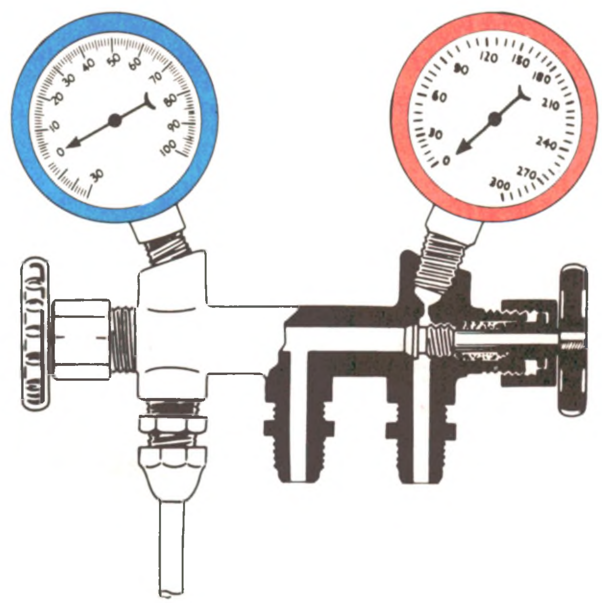


Fig. 3-5 — **Manifold Gauge Set**

A test hose connected to the fitting directly under the low side gauge is used to connect the low side of the test manifold to the low side of the system, and a similar connection is found on the high side.

The gauge manifold is designed to control refrigerant flow. When the manifold test set is connected into the system, pressure is registered on both gauges at all times. During all tests, both the low and high side hand valves are in the closed position (turned inward until the valve is seated).

Refrigerant will flow around the valve stem to the respective gauges and register the system low side pressure on the low side gauge (and the system high side pressure on the high side gauge). The hand valves isolate the low and high side from the central portion of the manifold.

When the gauges are connected to the gauge fittings with the refrigeration system charged, the gauge lines should always be purged. Purging is done by "cracking" each valve on the gauge set to allow the pressure of the refrigerant in the refrigeration system to force the air to escape through the center gauge line. Failure to purge lines may result in air or other contaminants entering the refrigeration system.

CAUTION: DO NOT OPEN HIGH SIDE HAND VALVE WHILE SYSTEM IS IN OPERATION. If the high side hand valve is opened during system operation when a refrigerant can is connected to the center hose, the refrigerant will flow out of the system under HIGH PRESSURE into the can. High side pressure is between 150 and 300 psi and will cause the can to burst.

Opening the low side hand valve with the system operating and a refrigerant can connected to the center hose will allow refrigerant to flow from the container into the system.

The only occasion for opening both hand valves at the same time would be when evacuating the system.

NOTE: Some gauge sets may have an additional COMPOUND GAUGE (Fig. 3-6) (pressure and vacuum) mounted on the manifold to the right of the High Pressure Gauge. This gauge operates independently (no connection to manifold passage) and is used only in checking operation of EPR valve on Chrysler systems.

A third gauge also may be used on Ford systems with STV valves. These systems have low pressure gauge ports both on the valve and in the suction line to the compressor.

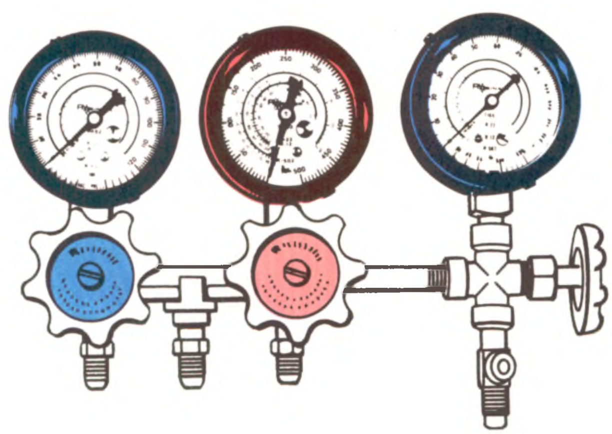


Fig. 3-6 — **Compound Manifold Gauge Set**

Connecting Manifold Gauge Set

CAUTION: Wear safety goggles.

1. With engine stopped, remove the protector caps from system service (test) fittings.
2. Be certain all valves on the manifold gauge set are closed.
3. Leave center hose connection on the manifold capped or connected to a hose attached to a refrigerant storage container.
4. Connect high pressure gauge hose to test fitting on high side of the system.
5. Purge test hoses by opening high pressure manifold valve one turn. Crack open low pressure manifold valve and allow refrigerant vapor to hiss from the low pressure hose for (3) three seconds. Close both valves and then connect low pressure hose to test fitting on low side of system. Also purge the center manifold connection by opening either valve slightly and cracking the manifold cap for three seconds. If the center manifold is connected to a hose to a refrigerant supply purge the supply hose as well.
6. Before accurate pressure tests can be made, the system must be stabilized.

DISCHARGING THE SYSTEM

All refrigerant must be discharged from the system before repair or replacement of any component (except for compressors with Stem Type service valves). This procedure is accomplished through the use of a manifold gauge set (Fig. 3-7) that makes it possible to control the rate of refrigerant discharge; thus minimizing loss of oil from the system.

CAUTION: Wear safety goggles.

Several written procedures and illustrations in this manual relate to the use of a manifold gauge set for discharging, evacuation, charging and testing. They are particularly suggested as the safest and effective procedures for General Motors applications. It will be noted that the high pressure manifold hose is connected to the high pressure system test fitting only for "performance testing" purposes.

Servicing other applications with use of a manifold gauge can be performed in accordance with vehicle manufacturers' or equipment suppliers' recommendations.

To discharge the system:

1. Remove protective cap from the low side test fittings.
2. Make sure gauge valves are closed. Connect low side of manifold gauge set to low side test fitting. The use of a special adaptor may be necessary on some applications.
3. Place open end of center manifold hose in container to collect any oil that may be discharged with refrigerant.
4. Open low side manifold valve until refrigerant starts to flow out without discharging refrigerant oil from the line.
5. Discharge until all pressure is released from the system; then close low side manifold valve.
6. Measure any quantity of oil that might have been discharged from the system so that it can be replaced with an equal amount of new refrigerant oil when recharging.

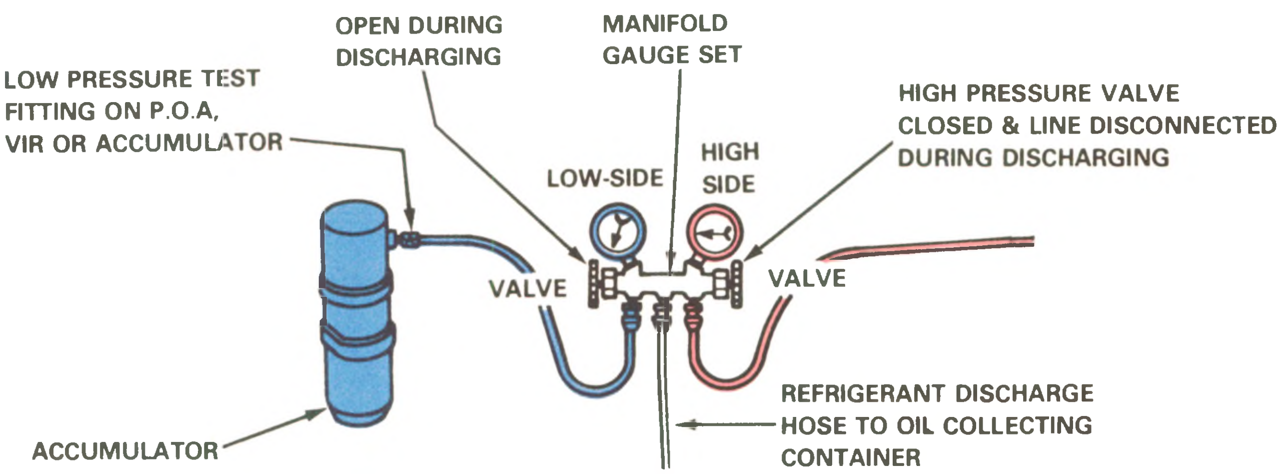


Fig. 3-7 — **Discharging the System**

EVACUATING THE SYSTEM (Fig. 3-8)

NOTE: System must be completely discharged before evacuation. Always wear safety goggles when working with refrigerant containers or servicing air conditioning systems.

NOTE: Pumping refrigerant through vacuum pump can cause early pump failure.

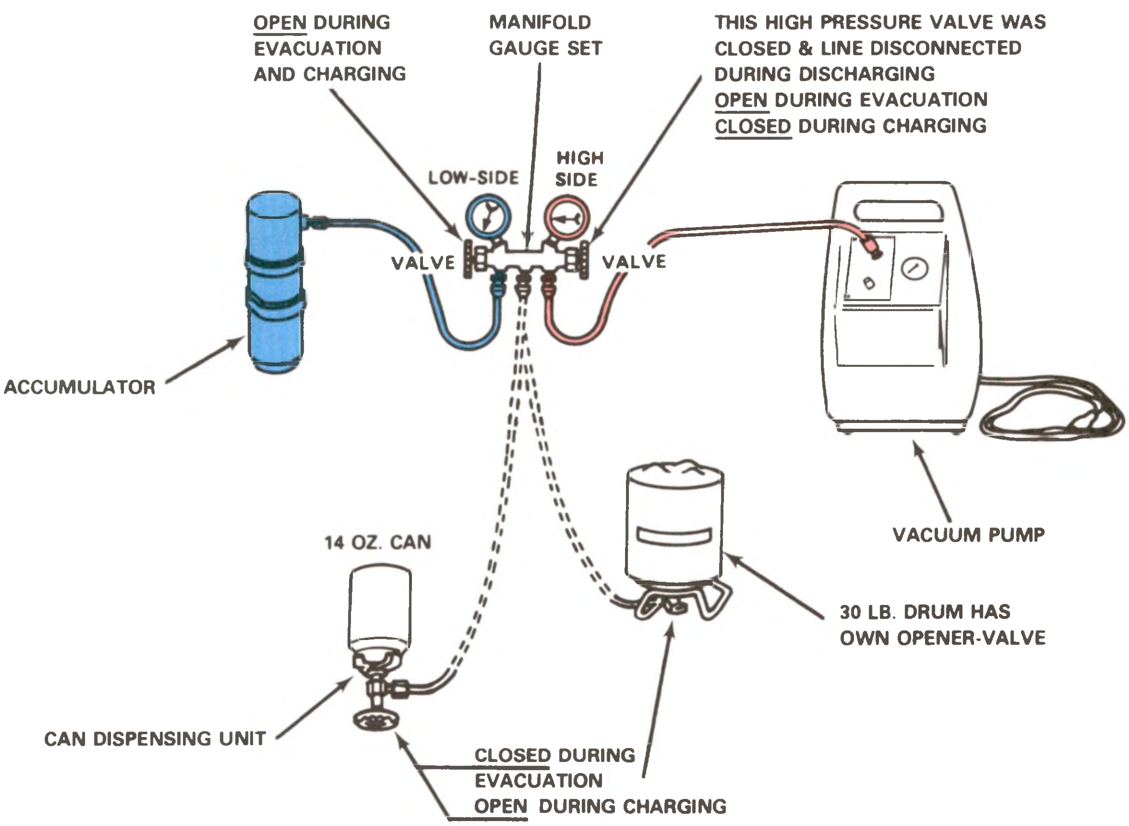


Fig. 3-8 — Evacuating and Charging

After discharging the system the low pressure gauge hose remains connected to the low pressure test fitting and both the high and low pressure manifold gauge valves are closed.

NOTE: Before connecting vacuum pump to system, connect low side gauge to vacuum pump. Run pump a short time. This gives you a reference vacuum to watch for in step 4.

1. Connect high pressure gauge hose to vacuum pump.
2. Connect center manifold gauge hose to refrigerant source with can tapping valve in closed position.
3. With the manifold gauge set and vacuum pump connected as shown in Fig. 3-8, begin evacuation by opening the high and low side gauge valves with the vacuum pump operating.
4. Operate the pump for 15 to 20 minutes after the low side gauge reaches 28"-29" vacuum or more, see Fig. 3-9.

Vacuum Inches of Mercury	Boiling Point
27.32"	110°F
29.18"	70°F
29.76"	30°F
29.90"	−10°F

Fig. 3-9 — **Boiling Point of Water Under a Vacuum**

5. If the system has been exposed to air and/or moisture (left open), it should be partially charged and evacuated again.
6. Check the system for leaks by closing off both high and low side gauge valves and turning off the vacuum pump. There should be no more than 2" vacuum loss in 5 minutes. Excessive loss indicates a leak in the system.
7. If a leak is indicated, check all system connections for proper tightness.
8. Crack open refrigerant container valve. Then open low pressure valve and allow 14 ounces of refrigerant to charge into the system. Close both refrigerant container and low pressure valve and check system for leaks. Correct leaks. Repeat procedure until all leaks are eliminated.
9. Discharge refrigerant from system and re-evacuate.

DO NOT DISCHARGE REFRIGERANT THROUGH VACUUM PUMP.

10. Allow pump to run for 20 minutes at a vacuum of 28+ inches. Close both manifold gauge valves, then stop vacuum pump. The system is now ready for charging.

CHARGING THE SYSTEM (Fig. 3-8)

The system should be charged only after being evacuated as outlined in "EVACUATING THE SYSTEM".

CAUTION: To prevent blowing the thermal limiter while charging the system on late model GM vehicles so equipped, remove the wire from the superheat switch at the rear head of the compressor, if accessible, or connect a jumper wire from "B" to "C" terminal of the thermal limiter. When charging has been completed, replace the wire at the switch or remove the jumper wire at the fuse. This switch should not be confused with a low pressure cut-off switch which on other applications might also be located in the rear compressor head. The latter should not be disconnected while charging the system. On cycling clutch systems, jump the thermostatic switch to keep the compressor from cycling.

Disposable Can Method — GM Applications

After having discharged, repaired (if necessary) and evacuated the refrigerant system, the system may be charged as follows using refrigerant in disposable containers:

CAUTION: Wear safety goggles.

1. Obtain the required quantity of refrigerant.
2. Mount one container on a single can tapping valve.
3. Connect center line of manifold gauge set to fitting on container valve.

NOTE: If line at center gauge fitting has not been purged of air, loosen connection at center fitting on gauge set and "crack" valve at container (for a second or two) to purge air from the line. Retighten line at center of manifold gauge.

4. Start engine. Run with choke open and fast idle speed reduced to normal idle. Set A/C control lever on OFF.
5. With the Refrigerant-12 can inverted, open valve at refrigerant source and low pressure valve on manifold gauge set. Allow one 14 oz. can of liquid R-12 to flow into system through low side service fitting.
6. After 14 oz. can of liquid R-12 has been added to system, immediately engage the compressor, by setting the A/C control lever to NORM and blower speed on HI. Using additional cans of refrigerant complete system charging by drawing in specified amount of R-12 in vapor form (with refrigerant cans in upright position.)

   When changing refrigerant cans always close low side manifold valve. If the center hose is opened in the process of changing the can tapping valve, it should be purged at the manifold before the low side valve is opened again to allow refrigerant into the system.

NOTE: The charging operation can be speeded up by using a large volume fan to pass air over the condenser.

7. Shut off R-12 source valve and run engine for 30 seconds to clear lines and gauges. Then shut off low side manifold gauge valve and disconnect the R-12 source from the center hose. Place the hose in the stored service position on manifold gauge set. The system is now ready for PERFORMANCE TESTING.

Disposable Can Method — Non-GM Applications

Many automotive air conditioning systems utilize a low pressure test fitting at close to the compressor inlet. In general such application requires refrigerant vapor charging. One method of charging these systems is as follows:

1. Obtain required quantity of refrigerant.
2. Mount one refrigerant can as a single can tapping valve.
3. Connect center hose of manifold gauge set to fitting on can tapping valve. Purge center hose.
4. With container in **upright** position open valve at refrigerant source and low pressure valve on manifold gauge set. Leave valve open at refrigerant source until the refrigerant (vapor) has entered the system. Close valve on container.
5. Remove empty container from valve. Install valve on new full container of refrigerant and repeat above steps until the specified quantity of refrigerant has been used to charge the system.

If refrigerant is not up to the desired level, proceed as follows:

1. Start engine and set controls in A/C mode with blower on.
2. Slowly open the R-12 source valve and control vapor pressure to maintain 40 PSI or less on the low side gauge reading. Continue at fast engine idle until the required full charge amount of R-12 is drawn into the system.
3. When charging by the vapor method (refrigerant cans upright) the process can be assisted by placing refrigerant cans in a shallow pan containing lukewarm (125°F) water.

CAUTION: When charging with the use of disposable refrigerant cans, avoid any connection to the high pressure test fitting that could inadvertently lead to high system pressure being diverted into the refrigerant can. One-way safety valves are available for installation in the charging line and are suggested for precautionary use when recommended low side charging procedures are not followed.

Charging Station Method (Fig. 3-10)

The use of a charging station has the following advantages over the disposable can method.

1. Ability to measure the exact amount of refrigerant for the particular operation.
2. Ability to heat the refrigerant to 125°F with internal heater. This speeds up the charging procedure.
3. Minimum of connections to be made before system is discharged, evacuated, charged and performance tested.

When using a charging station to add R-12 to the system, it is recommended that the manufacturer's instructions be followed.

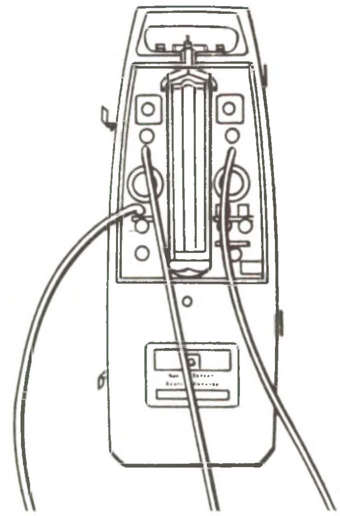


Fig. 3-10 — **Charging Station**

Adding Refrigerant

The following procedure can be used in adding small amounts of refrigerant that may have been lost through normal operation or minor leaks. Before adding refrigerant, check for evidence of oil loss and add oil if necessary.

NOTE: This procedure will apply only if the air inlet temperature is above 70°F. at the condenser. If air inlet temperature at the condenser is below 70°F., bubbles may appear in sight glass even though the proper amount of refrigerant is in the system. Air inlet temperature must be 70°F. or above to make an accurate check.

1. Remove cap from low side test fitting and attach low pressure gauge hose with both control valves in the closed position.
2. Start engine, turn A/C temperature control lever to full cold position, blower in high speed position and selector lever in A/C mode. Operate for ten minutes at 1500-2000 rpm to stabilize system.
3. Observe refrigerant flow through sight glass with system operating for any indication of bubbles. If bubbles are visible in the sight glass a partial shortage of refrigerant is indicated. Add refrigerant as shown in Steps 4, 5, 6 and 7.
4. Attach center hose fitting to refrigerant container valve and leave slightly loose.
5. Open low pressure hand valve and purge hoses until refrigerant appears at loose hose fitting on refrigerant container valve. Tighten hose fitting.
6. Fully open both container and low pressure gauge valves.
7. Add refrigerant until sight glass is clear and then add an additional 14 ounces of refrigerant.
8. When refrigerant has been installed, continue to operate system and test for proper operation as outlined under "Performance Testing".

PERFORMANCE TESTING

Performance testing provides a measure of air conditioning system operating efficiency. A manifold pressure gauge set is used to determine both "high" and "low" pressures in the refrigeration system. At the same time a thermometer is used to determine air discharge temperature into the passenger compartment.

Before making this test, it should be established that the air distribution (air door) portion of factory installed systems is functioning properly. This will insure that all air passing through the evaporator is being routed directly to the air outlet nozzles.

To perform this test proceed as follows:

1. Connect manifold gauge set to respective high and low pressure fittings as shown in Fig. 3-11, with both valves closed. (This is typical of service fitting locations on a GM installation. With other installations these fittings will be found in various locations with the high and low pressure sides of the system.)
2. Keep hood open and close all doors and windows of the car.
3. Adjust air conditioning controls to maximum cooling and high blower position.
4. Idle engine for 10 minutes in neutral or park with brake on. For best results, place a high volume fan in front of radiator grille to insure adequate supply of air flow across the condenser.
5. Increase engine speed to 1500-2000 rpm.
6. Measure temperature at the evaporator air outlet grille or air duct nozzle (35 to 40°F).

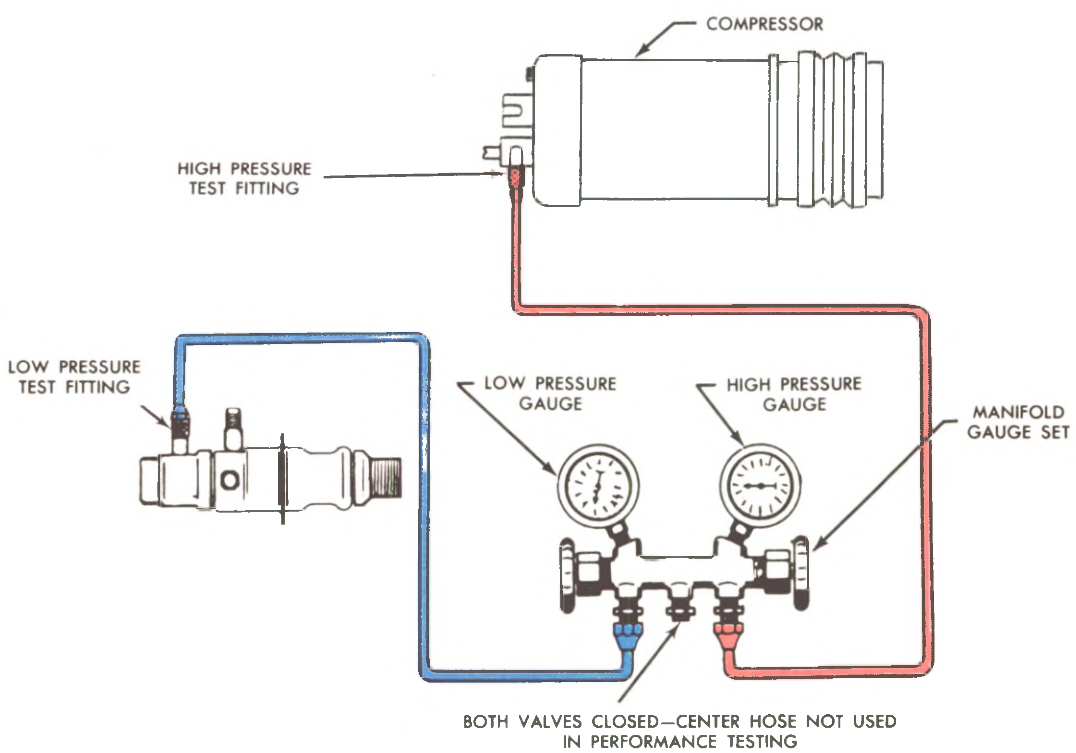


Fig. 3-11 — **Performance Testing**

7. Read "high" and "low" pressure and compare to normal range of operating pressures in Performance Chart (Fig. 3-12).

APPROXIMATE TEST PRESSURE RANGES FOR NORMAL FUNCTIONING SYSTEMS

		AT LOW PRESSURE TEST FITTING (P.S.I.)				
Ambient (Outside Air) Temperature	*At High Pressure Test Fitting (P.S.I.)	S.T.V., P.O.A. or V.I.R. Systems	**Cycling Clutch System with T.X.V. and Rec.-Dehyd.	**Cycling Clutch System with Expansion (Orifice) Tubes and Accumulator (C.C.O.T.)	CCOT System with Pressure Cycling Switch	Chrysler Corp. with Evaporator Pressure Regulator Valve
60°F.	120-170	28-31	7-15	—	—	—
70°F.	150-250	28-31	7-15	24-31	24-31	22-30
80°F.	180-275	28-31	7-15	24-31	24-31	22-37
90°F.	200-310	28-31	7-15	24-32	24-31	25-37
100°F.	230-330	28-35	10-30	24-32	24-36	—
110°F.	270-360	28-38	10-35	24-32	—	—

*Pressures may be slightly higher on very humid days or lower on very dry days.

**Pressure just before clutch disengages (cycles off).

Fig. 3-12 — Performance Chart

Operating pressures will vary with humidity as well as with outside air temperature. Accordingly on more humid days operating pressures will be on the high side of the range indicated in the Performance Chart. On less humid days, the operating pressures will read toward the lower side.

If operating pressures are found to be within the normal range, it can be considered that the refrigeration portion of the air conditioning system is functioning properly. This can be further confirmed with a check of evaporator outlet air temperatures.

Evaporator outlet air temperature will also vary according to outside (ambient) air and humidity conditions. Further variations will be found depending on whether the system is controlled by a cycling clutch compressor or an evaporator pressure control valve. Because of these variations, it is difficult to pin point what evaporator outlet air temperature should be on all applications. In general, however with low (70°) outside air temperatures and humidity of (20%), the evaporator outlet air temperature should be in the 35° to 40° range. On the other extreme of 80° outside air temperatures and 90% humidity condition, the evaporator air outlet temperature may be in the 55° to 60° range.

Since it is impractical to provide a specific performance chart for all the different types of A/C systems, it is desirable to develop an experience factor for determining the correlation that can be anticipated between operating pressures and outlet air temperatures on the various systems.

When a performance test indicates that both operating pressures and temperatures are outside the normal operating range, it is a good indication that some unit in the system is malfunctioning and that further diagnosis is needed (see Diagnosis Section).

SYSTEM STABILIZING PROCEDURE

1. Start engine and adjust idle to 1500 to 2000 rpm.
2. Turn on air conditioner and set for maximum cooling with blower fan on high speed.
3. Close car doors and windows.
4. Operate air conditioner for 5 minutes to stabilize the system.
5. Check system refrigerant charge by noting sight glass indication. (See "Sight Glass Quick Check Procedure" in Diagnosis Section.)
6. Check for normal high and low system pressures. (Refer to Performance Chart, Fig. 3-12, in "Performance Testing" part of this section.) An insufficient charge will be indicated by high side gauge registering lower than normal.

If an insufficient refrigerant charge is indicated by the test gauge reading and/or sight glass indication, the system should be leak tested and charged before accurate tests can be performed to determine if the system is operating normally.

Some refrigerant loss will occur from one season to the next and is accepted as normal. Vibration, hose porosity, and the general construction of components mounted on a moving vehicle make the leak-proof system an exception. Replacing this refrigerant loss between seasons will constitute much of the quick-service required on air conditioning equipment.

LEAK TESTING THE SYSTEM

Whenever a refrigerant leak is suspected in the system or a service operation performed which results in disturbing lines or connections, it is advisable to test for leaks. Common sense should be the governing factor in performing any leak test, since the necessity and extent of any such test will depend upon the nature of the complaint and the type of service performed on the system.

NOTE: The use of a leak detecting dye within the system is not recommended because of the following:

1. Refrigerant leakage can exist without any oil leakage. In this case the dye will not indicate the leak, however a leak detector will.
2. The addition of additives, other than inhibitors, may alter the chemical stability of the refrigerant and cause malfunctions.
3. Dye type leak detectors, which are insoluble, form a curdle which can block the inlet screen of the expansion valve or orifice tube.

There are two types of leak detectors, the propane and the electronic.

Propane Leak Detector

The propane leak detector (Fig. 3-13) is a gas-burning torch designed to locate a leak in any part of the system. Refrigerant gas drawn into the sampling tube attached to the torch causes the torch flame to change color in proportion to the size of the leak. Propane gas fuel cylinders used with the torch are readily available commercially throughout the country.

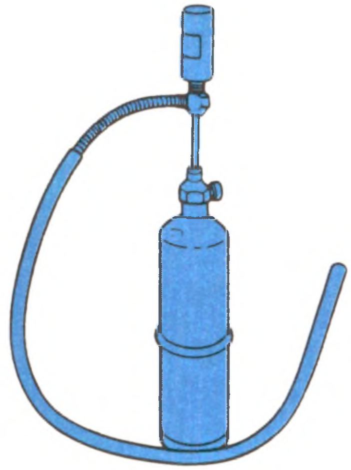


Fig. 3-13 — **Propane Leak Detector**

To Operate Propane Leak Detector:

1. Determine if there is sufficient refrigerant in the system for leak testing.
2. Open control valve until slight hiss of gas is heard, then light gas at opening in chimney.
3. Adjust the flame until the desired volume is obtained. A pale blue flame just touching the reaction plate is best for detecting leaks.

THE REACTION PLATE WILL BE HEATED TO A CHERRY RED.

Correction For Yellow Flame

If the flame is yellow, insufficient air is being aspirated or the reaction plate is dirty. Insufficient air may be caused by:

1. Obstructed or partially collapsed suction tube.
2. Dirt or foreign substance in burner tube.
3. Dirty or partially clogged orifice.

Blowing air through the suction tube and back through the detector will usually clear dirt or foreign matter. If the yellow flame is caused by a dirty reaction plate, allow the flame to burn for several minutes. This will usually burn the plate clean. If an oxide film appears on the reaction plate from continued use, it will reduce the sensitivity of the detector. This may be remedied by removing the plate and scraping the surface gently with a knife.

To Clean Orifice

1. Never attempt to clean orifice by passing anything through the hole.
2. Unscrew burner assembly from burner tube by applying wrench to hexagon part located immediately below search hose connection. Turn to left. This will expose orifice block which is inserted into the end of the tube.
3. Remove orifice block from tube.
4. Reverse orifice block and replace against burner tube; screw burner head onto burner tube (hand tight), then open valve quickly, admitting several short blasts.

5. To reassemble; unscrew burner head, insert orifice block into burner tube, and screw burner head onto burner tube with a wrench to form a gas tight joint.

Checking For Refrigerant Leaks

After the leak detector flame is adjusted, check for refrigerant leaks in an area having minimum amount of air flow in the following manner:

NOTE: Do not breathe the fumes and black smoke that are produced if the leak is a big one. They are poisonous. Any time an open flame is used near a car there is a certain amount of danger. Although the torch flame is small and well protected, it is recommended that a fire extinguisher be close at hand for any emergency that might arise.

Inspect for leaks by slowly moving end of leak detector hose around all connections and points of possible leakage. Refrigerant 12 is heavier than air and will be more apparent at the bottom of the fitting.

The evaporator core can be checked for leaks by removing resistor in evaporator case and inserting the end of leak detector hose into the evaporator case (most models). Others can be checked by removing the blower motor cooler tube and probing with the leak detector hose in the evaporator case.

To check the condenser and receiver-dehydrator, it may be necessary to probe through access holes or through the grille with leak detector hose.

Slight leakage from the compressor shaft seal is normal and the collection of small amounts of refrigerant vapor in this area of the pulley assembly could lead to an erroneous indication that an abnormal shaft seal leak exists.

As a precautionary measure, the shaft seal area can be cleared with compressed air. After a short period the leak test will more effectively indicate any abnormal shaft seal leak.

The color of the flame will turn to a yellow-green when a small leak is detected. Large leaks will be indicated by a change in color to brilliant blue or purple. When the suction hose is moved away from the leak the flame will clear to an almost colorless pale blue again.

NOTE: A refrigerant leak in the high pressure side of the system may be more easily detected if the system is operated for a few minutes, then shut off and checked immediately (before system pressures equalize). A leak on the low pressure side may be more easily detected after the engine has been shut off for several minutes (system pressures equalized); this applies particularly to the compressor seal.

Electronic Leak Detector

Various electronic leak detectors are available and they are generally more sensitive for detecting small leaks. A typical air conditioning system will leak approximately 1/2 ounce Refrigerant per year. Some units are so sensitive that they can detect this normal refrigerant leak. The tester should be set to detect abnormal leaks of greater than 1/2 oz. refrigerant per year.

It is extremely important that manufacturers' instructions for setting the sensitivity adjustment be followed to the letter.

A typical electronic leak detector is shown in Fig. 3-14. It is powered by batteries and uses a combination on-off sensitivity adjustment control knob. Operation is as follows:

1. Turn the control knob on.
2. Place the probe over the calibrated sample. (This sample on most units represents 1/2 fl. oz. refrigerant leak per year.) Lamp will start flashing.
3. Turn the sensitivity knob until a point is found where rotating the knob slightly one way turns the light off and rotating back turns the light on. At this point the tester is ready for use. The light on this unit will flash faster for larger leaks. Be sure to follow recommended procedures in setting the unit up so that time will not be wasted working on non-defective items.

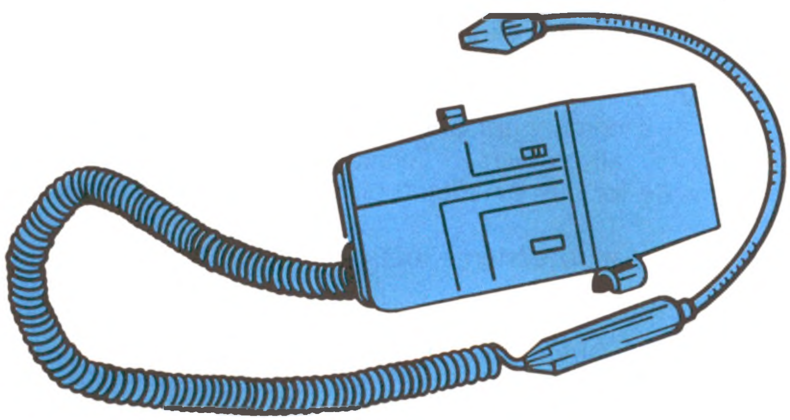


Fig. 3-14 — **Electronic Leak Detector**

COMPRESSOR OIL LEVEL CHECKS

General Motors Compressors

It is not recommended that the oil be checked as a matter of course. Generally, compressor oil level should be checked only where there is evidence of a major loss of system oil such as might be caused by:

1. A broken refrigerant hose.
2. A severe hose fitting leak.
3. A very badly leaking compressor seal.
4. Collision damage to the system components.

Oil Charge Following Excessive Leakage or Unit Replacement

The A-6 General Motors compressor requires 11 fluid ounces of 525 viscosity refrigerant oil in the system. The DA-6 compressor system requires 8 fluid ounces. Likewise the R-4 compressor system requires 6 fluid ounces. It is important that only the specified type and quantity of oil be used in the compressor. If there is a surplus of oil in the system, too much oil will circulate with the refrigerant, causing the cooling capacity of the system to be reduced. Too little oil will result in poor lubrication of the compressor.

When there has been excessive leakage or it is necessary to replace a component of the refrigeration system, certain procedures must be followed to assure that the total oil charge in the system is correct after leak repair or the new part is on the car.

When the compressor is operated, oil gradually leaves the compressor and is circulated through the system with the refrigerant. Eventually a balanced condition is reached in which a certain amount of oil is retained in the compressor and a certain amount is continually circulated. If a component of the system is replaced after the system has been operated, some oil will go with it. To maintain the original total oil charge, it is necessary to compensate for this by adding oil to the new replacement part.

The procedure for adding oil to systems that utilize a receiver-dehydrator or VIR is as follows:

1. Run the system for 5 minutes at 2000 engine rpm with controls set for maximum cooling and high blower speed. (This distributes oil proportionally between system components.)
2. Turn off engine and discharge systems.

3. Follow outline in Fig. 3-15 to determine amount of oil to be added to components or the compressor depending on compressor condition. (Note the difference in amount of oil added depending on which compressor is used.)

Oil Charge Procedures — Compressor Replaced With New or Rebuilt Compressor

Compressor	Amount of oil drained from compressor	Amount of oil to add to new compressor
A-6	More than 4 oz.	Add same amount as drained.
R-4	More than ½ oz.	See note below.
		Drain new compressor.
A-6	Less than 4 oz.	Add 6 oz. to A-6.
R-4	Less than ½ oz.	Add 3 oz. to R-4.
DA-6, Sankyo	Any	Amount drained plus 1 oz.
Nippondenso		New Nippondenso compressors are filled with correct amount of oil.
York	Any	*Dipstick Reading:*
		Horizontal mount 13/16" - 1-3/16"
		Vertical mount 7/8" - 1-1/8"
Tecumseh	Any	Horizontal mount 7/8" - 1-5/8"
		Vertical mount 7/8" - 1-3/8"
Chrysler		
(Round oil sump)	Any	2-1/8" - 3"
(Stepped oil sump)	Any	1-5/8" - 2-1/2"

A-6, R-4 Note: If the amount of oil drained is more than 8 oz., an oil overcharge is likely. Flush the system with R-12. Replace receiver-drier. Install new compressor with full charge of 10½ oz.

Fig. 3-15 — **Oil Charge Procedures**

The procedure for adding oil to components or compressor utilized with the Cycling Clutch Orifice Tube system (CCOT) is as follows:

1. No signs of excessive oil leak.
   a. Compressor — Remove, drain oil, measure, replace same amount plus 1 fluid ounce (see Note).
   b. Evaporator — Add 3 fluid ounces.
   c. Condenser — Add 1 fluid ounce.
   d. Accumulator* — Remove, drain oil, measure, replace same amount plus 1 fluid ounce.
2. Signs of excessive oil leak.
   a. A-6 Compressor Systems

      Remove compressor and accumulator*. Drain and measure total oil from both components.
      If less than 6 fluid ounces, cdd 6 fluid ounces to system.
      If more than 6 fluid ounces, add same amount drained (see Note).
   b. R-4 Compressor Systems

      Remove only the accumulator*, drain and measure quantity of oil. (It is not necessary to remove and drain the compressor. The R-4 compressor only retains a minimum quantity of oil.)
      If less than 3 fluid ounces, add 3 fluid ounces of oil.
      If more than 3 fluid ounces, add same amount drained.

**When installing a new accumulator, add 1 fluid ounce of oil additional to compensate for that retained by the original accumulator desiccant.*

NOTE: For A-6 only — If amount of oil drained from compressor alone is 8 ounces or more, an oil overcharge should be suspected. Flush system with Refrigerant 12, replace accumulator dehydrator, and install compressor with total compressor oil charge, 10 1/2 fluid ounces.

DA-6 Oil Level Check

When a component of a system with the DA-6 compressor is replaced, oil must be added to the system. To add oil, discharge the system and remove the hose at the accumulator outlet. Pour the oil into the hose and reconnect it. DA-6 systems use 8 ounces (240 ml) of refrigerant oil. If there are no signs of excessive oil leakage, add the quantity of oil listed below for the component you have replaced.

Compressor — Drain the oil from the old compressor. Add the amount you drained plus 1 ounce (30 ml).

Evaporator — Add 3 ounces (90 ml).

Condenser — Add 1 ounce (30 ml).

Accumulator — Drain the oil from the condenser. Add the amount you drained plus 2 ounces (60 ml).

If there are signs of excessive oil leakage, remove the compressor and accumulator. Drain the oil from both and measure it. If the amount you drained is less than 8 ounces (240 ml), add 8 ounces of new oil to the system. If the amount you drained is more than 8 ounces, add the same amount of new oil as you drained.

Nippondenso Oil Level Check

Nippondenso compressors are filled with 9 to 10 ounces (270-300 ml) of refrigerant oil. Replacement compressors are filled with the correct amount of oil. Since some of the oil circulates throughout the system, a used compressor will not contain the full 9 or 10 ounces. A replacement compressor may be installed without adjusting the amount of oil in it. If a replacement compressor is installed, however, drain about 4 ounces (120 ml) of oil from it so the system is not overfilled with oil.

To check the oil level in the system, follow these steps:

1. Discharge the system.
2. Remove the suction and discharge hoses from the compressor.
3. Remove the compressor from the car.
4. Turn the compressor upside down and drain the oil.
5. Add 9 to 10 ounces (270-300 ml) of fresh refrigerant oil to the compressor through the suction port.
6. Install the compressor on the car.
7. Install the suction and discharge hoses. Be sure to use new gaskets.
8. Evacuate and charge the system.

Sankyo 505, 507, 508, and 510

1. Determine and record the mounting angle of the compressor.
2. Remove the oil fill plug. Look in the oil fill hole and turn the clutch drive plate until the internal parts of the compressor line up as shown in Figure 3-16. If the compressor is mounted.

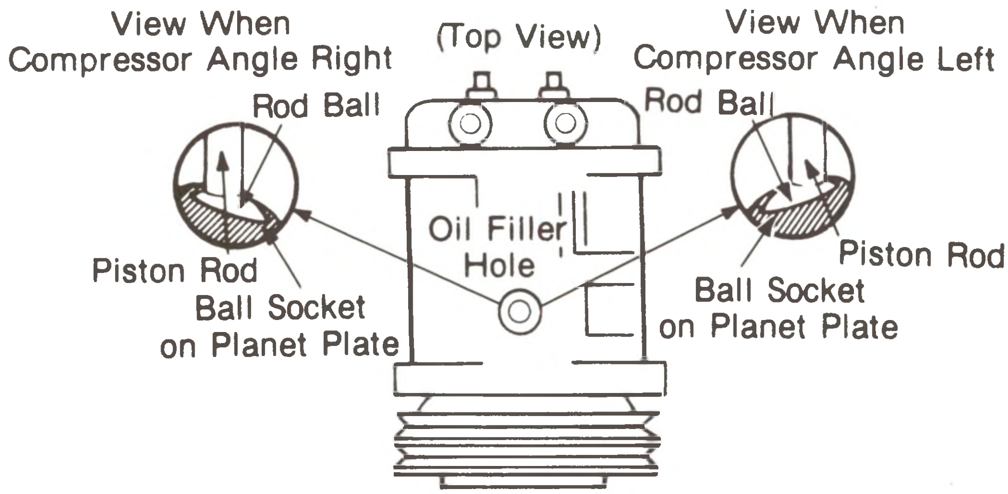


Fig. 3-16 — Sankyo Oil Check Compressor View

3. Insert the dipstick fully. Be sure the dipstick faces the right way. See Figure 3-17.

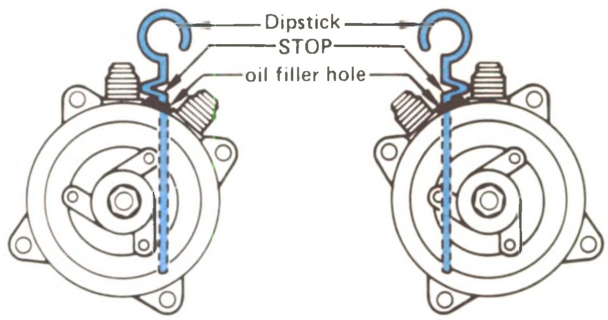


Fig. 3-17 — Sankyo Compressor Dipstick View

4. Remove the dipstick. Count the number of marks that are covered with oil. Check the oil level on the table in Figure 3-18. Adjust the oil level until it is in the acceptable range.

Mounting Angle Degree	Acceptable Oil Level in Increments			
	505	507	508	510
0	4-6	3-5	4-6	2-4
10	6-8	5-7	6-8	4-5
20	8-10	6-8	7-9	5-6
30	10-11	7-9	8-10	6-7
40	11-12	8-10	9-11	7-9
50	12-13	8-10	9-11	9-10
60	12-13	9-11	9-12	10-12
90	15-16	9-11	9-12	12-13

Fig. 3-18 — Sankyo Oil Level Table

REFRIGERANT LINE REPAIRS

All major components of an air conditioning system (compressor, condenser, evaporator, etc.) have inlet and outlet connections that accommodate either "flare" or O-ring fittings. The refrigerant lines that connect between these units are made up of an appropriate length of hose with "flare" or O-ring fittings at each end as required. In either case the hose end of the fitting is constructed with sealing beads to accommodate a hose clamp connection. Typical "flare" and O-ring fittings are shown in Fig. 3-19.

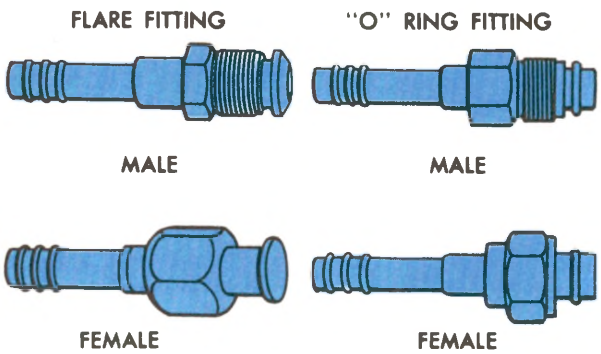


Fig. 3-19 — **Flare & O-ring Fittings**

Repairing Leaks at O-Ring Connections

1. Check the torque on the fitting and, if too loose, tighten to the proper torque. Always use a backing wrench to prevent twisting and damage to the O-ring. Do not overtighten. Again leak test the joint.
2. If the leak is still present, discharge the refrigerant from the system as described under Discharging the System.
3. Inspect and replace fitting if damaged in any way. Discard old O-ring and install new O-ring after coating it with clean refrigerant.
4. Retorque the fitting, using a backing wrench.
5. Evacuate and charge system.

Correct torque specifications are as follows:

METAL TUBE O.D.	THREAD AND FITTING SIZE	STEEL TUBING TORQUE*	ALUM. TUBING TORQUE*
1/4	7/16	13	6
3/8	5/8	33	12
1/2	3/4	33	12
5/8	7/8	33	20
3/4	1-1/16	33	25

*Foot Pounds

Repairing Leaks at Hose Clamp Connections

1. Check the tightness of the clamp itself and tighten if necessary. Recheck for leak.
2. If leak has not been corrected, discharge the system, loosen clamp and remove hose by making an angular cut as shown in Fig. 3-20. This should loosen hose so that it may be worked off the fitting.

CAUTION: Use extreme care not to nick or score the sealing beads when cutting off the hose. Cutting the hose lengthwise may result in this problem.

3. If re-using old hose, make clean square cut just beyond angular cut used for hose removal.
4. Inspect fitting and replace if sealing beads are nicked or scored.
5. Dip end of hose in clean refrigeration oil and carefully reinstall over connector. Never push end of hose beyond the locating bead.
6. Install clamps on hose, hooking the locating arms over the cut end of the hose.
7. Tighten the hose clamps to 35-42 in-lbs torque.
8. Evacuate and charge the system.

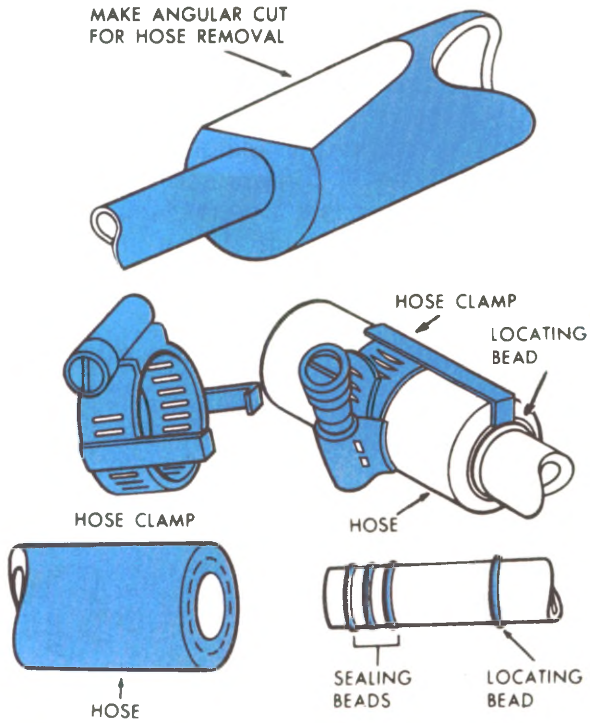


Fig. 3-20 — **Hose Clamp Connections**

Repairing Leaks in Crimped Hose Assemblies

Some factory installations use crimped hose assemblies in which the hose is permanently affixed to the connector fitting. Depending on where leakage might occur, repairs can be made to these assemblies by using a hose clamp type of splicer or hose clamp type of replacement connector fitting. In some cases it might be desirable to utilize a combination of both repairs if there is not a sufficient remaining length of the original hose.

Figs. 3-21 and 3-22 show typical splicer and combination splicer-connector repairs.

A splicer repair should be made only when there is a leak in the mid-section of a hose. If there is a leak at the crimped connection and a sufficient remaining length of hose, a new hose clamp type of connector can be used. When there is not a sufficient length of hose remaining, the combination splicer-connector repair can be made.

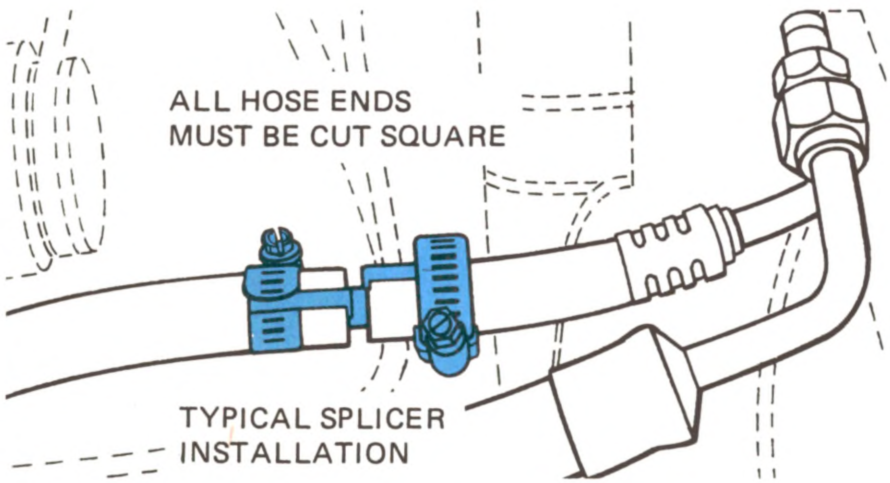


Fig. 3-21 — Typical Splicer Installation

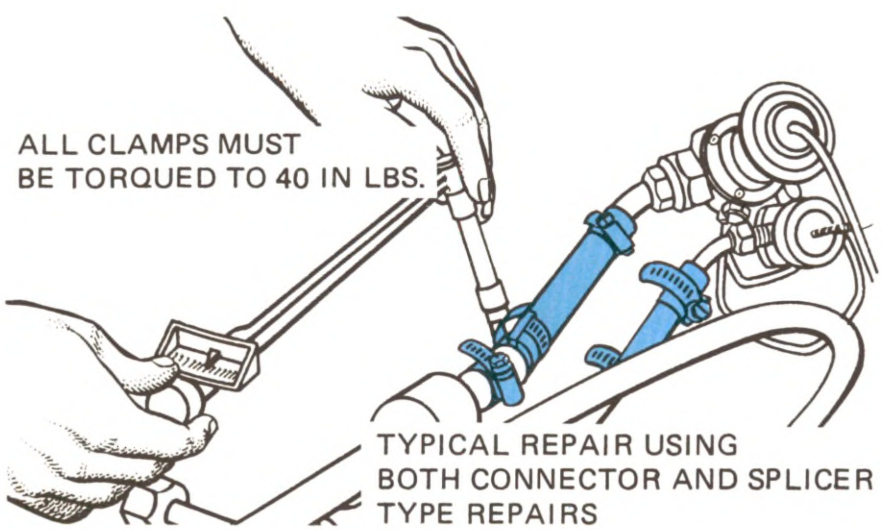


Fig. 3-22 — Combination Splicer Connector Repair

THERMOSTATIC SWITCH ADJUSTMENT

If the thermostatic switch fails in the open position, there will be no electrical circuit to the compressor clutch and the compressor will not operate. If the switch fails in the closed position, the clutch will be engaged and the compressor will run continuously, which may result in the evaporator freezing-up. Erratic operation of the switch will result in wide variations of discharge air temperature. If the power element fails, the switch will remain open and there will be no cooling.

Checking For Proper Operation

1. Install the gauge set and set up the vehicle as described under "Performance Testing the System".
2. Movement of the temperature control should result in a definite change in suction pressure and cycling of the compressor clutch.
   a. If compressor continues to operate regardless of the control adjustment, it indicates that the switch points are fused which will lead to evaporator freeze-up. Replace the switch.
   b. If the compressor does not operate, regardless of the position of the control, a loss of the power element charge is indicated (provided that it has been established and power is supplied to the switch). This, of course, results in no cooling. Replace the switch.
   c. Check the switch adjusting screw for stripped or otherwise damaged threads.

Adjusting Switch

NOTE: The Thermostatic Switch on large model GM cars is not adjustable.

If, after the above checks, the switch seems to be operating properly, adjust for proper setting if necessary, as follows:

1. Vehicle must be set up as described in "Performance Testing the System".
2. The suction side of the system, read on the low pressure gauge, should pull down to the pressure shown in the performance chart (Fig. 3-12) under the ambient temperature at the time the switch is being set.
3. Remove the face plate retaining screws and remove face plate assembly.

NOTE: When removing face plate, note the position of the air sensing capillary so that it can be installed in the same location as when removed.

4. Remove the thermostatic switch retaining screws and remove switch. Remove the non-metal end plate from the switch to gain access to the switch adjustment screw.
5. If the low side pressure was less than the prescribed pressure at the end of each cooling cycle, turn the adjusting screw (Fig. 3-23) a partial turn clockwise.
6. If the pressure was more than the prescribed pressure turn the adjusting screw counterclockwise.
7. Reinstall switch end plate and install switch in face plate. Install face plate on evaporator assembly. Be sure that the air sensing capillary has been replaced properly (as originally installed).
8. Check system performance. If further adjustment is needed, repeat Steps 3 through 7 until the prescribed pressure is reached.

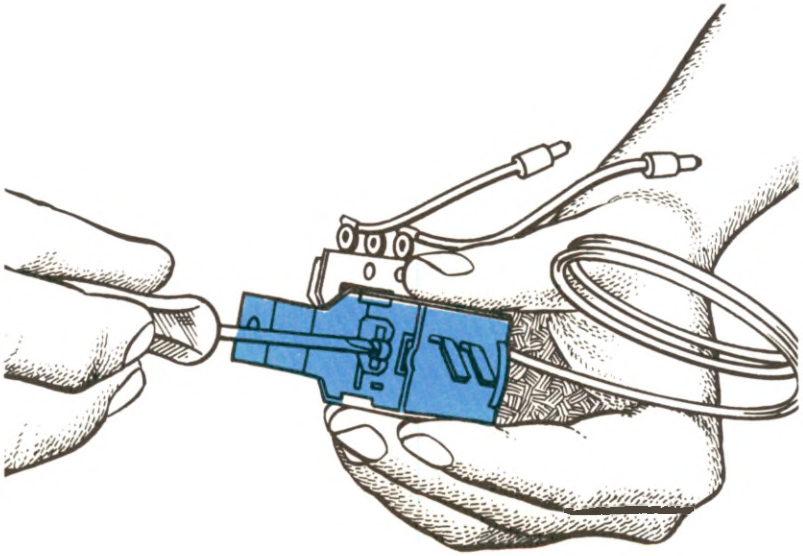


Fig. 3-23 — **Thermostatic Switch Adjustment**

VACUUM OPERATED SUCTION THROTTLING VALVE ADJUSTMENT

The suction throttling valve (Fig. 3-24) is adjusted to regulate evaporator pressure so that it will not fall below 29 to 30 psi. If it controls below 29 psi, the evaporator core will freeze-up and refrigeration capacity will be reduced. If the valve controls higher than this pressure, a loss of cooling will occur which will be noticeable in hot weather. This is because for each pound in pressure higher than 30 psi, the discharge air temperature will be raised one degree. The controlling pressure of the valve can be checked and adjusted as follows:

1. Remove Schrader valve fitting cap at the suction throttling valve.
2. Connect the low pressure gauge hose to the Schrader valve fitting on the suction throttling valve.
3. Purge the gauge and hose by opening the low pressure gauge valve for a few seconds.
4. Start engine and run at fast idle (2000 rpm). Move temperature control lever to the extreme left position. Turn blower speed on "High", and set air conditioning control on"Recirc".

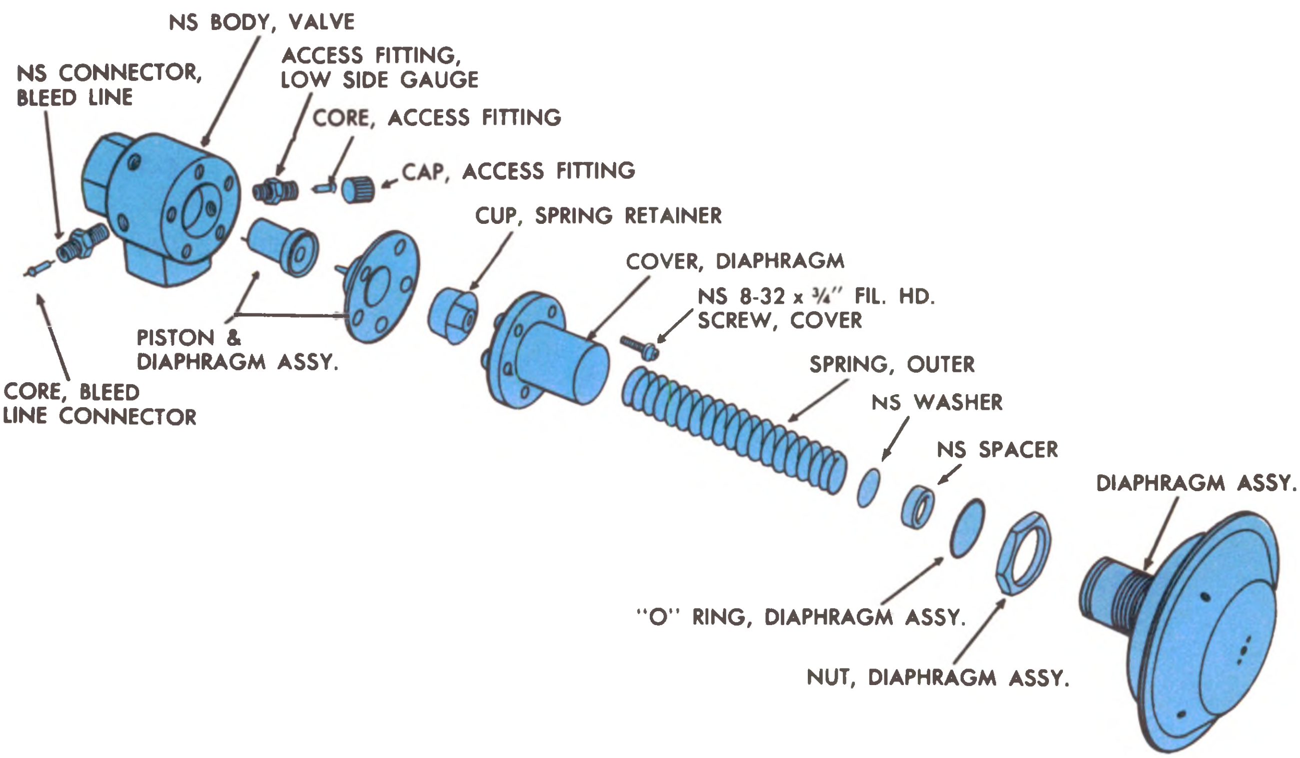


Fig. 3-24 — (Vacuum Operated) Suction Throttling Valve

NOTE: When adjusting the suction throttling valve after the system has been charged, the temperature control lever must be moved back and forth 10 to 15 times to normalize the suction throttling valve diaphragm.

5. Allow system to operate a few minutes, then observe evaporator pressure on gauge. Continue to increase engine rpm until the evaporator pressure no longer changes. If the stabilized evaporator pressure is not 29 to 30 psi, adjust valve as follows:
   a. Disconnect vacuum hose from suction throttling valve diaphragm.
   b. Loosen locknut on diaphragm and rotate diaphragm clockwise to raise evaporator pressure or counterclockwise to lower evaporator pressure.
   c. After pressure has been adjusted to specifications, tighten locknut and install vacuum hose on diaphragm.
6. Shut off engine and remove gauge assembly.
7. Install Schrader valve fitting cap.

NOTES

4. DIAGNOSIS AND TROUBLESHOOTING

GENERAL INFORMATION

Following normal maintenance, service procedures and performance testing as described in Section 2, the majority of air conditioning systems will generally operate with satisfactory air outlet temperatures and within the pressure ranges shown in the Performance Chart Fig. 3-12.

Further diagnosis for unit malfunction is indicated when outlet temperatures and refrigerant system operating pressures are abnormal (after taking into consideration the variation in ambient temperatures and humidity).

Because of many construction and operational variations that exist there is no uniform or standard diagnosis procedure applicable to all air conditioning systems. However, there are three basic prerequisites to total diagnosis:

1. Determining that the system has an adequate, but not excessive refrigerant charge.
2. Establishing whether the refrigerant system is controlled by a cycling clutch compressor or an evaporator pressure control valve.
3. An operational check of the air distribution system (blower motor, switches, vacuum lines and hoses, and air ducts) to insure that it is functioning properly before diagnosing for faulty units in the refrigeration system.

Following is a brief description of the symptoms that each refrigerant system component will evidence if a malfunction occurs.

Evaporator

When the evaporator is defective, the trouble will show up as an inadequate supply of cool air. A partially plugged core due to dirt, a cracked case, or a leaking seal will generally be the cause.

Compressor

Compressor malfunction will appear in one of four ways: noise, seizure, leakage, or low inlet and discharge pressure.

Resonant compressor noises are not cause for alarm; however, irregular noise or rattles are likely to indicate broken parts. To check seizure, de-energize the magnetic clutch and check to see if drive plate can be rotated. If rotation is impossible, compressor is seized. Perform the false compressor seizure check before removing the compressor for repair. Low discharge pressure may be due to a faulty internal seal of the compressor, of a restriction in the compressor.

Low discharge pressure may also be due to an insufficient refrigerant charge or a restriction elsewhere in the system. These possibilities should be checked prior to servicing the compressor. If the compressor is inoperative, but is not seized, check to see if current is being supplied to the magnetic clutch coil terminals.

Condenser

A condenser may malfunction in two ways: it may leak, or it may be restricted. A condenser restriction will result in excessive compressor discharge pressure. If a partial restriction is present, sometimes ice or frost will form immediately after the restriction as the refrigerant expands after passing through the restriction. If air flow through the condenser or radiator is blocked, high discharge pressures will result. During normal condenser operation, the outlet pipe will be slightly cooler than the inlet pipe.

Receiver-Dehydrator

A receiver-dehydrator may fail due to a restriction inside body of unit. A restriction at the inlet to the receiver-dehydrator will cause high head pressures. Outlet tube restrictions will be indicated by low head pressures and little or no cooling. An excessively cold receiver-dehydrator outlet may be indicative of a restriction.

Use of Sight Glass for Diagnosis

At temperatures higher than 70°F., the sight glass may indicate whether the refrigerant charge is sufficient. A shortage of liquid refrigerant is indicated after about five minutes of compressor operation by the appearance of slow-moving bubbles (vapor) or a broken column of refrigerant under the glass. Continuous bubbles may appear in a properly charged system on a cool day. This is a normal situation. If the sight glass is generally clear and performance is satisfactory, occasional bubbles do not indicate refrigerant shortage.

If the sight glass consistently shows foaming or a broken liquid column, it should be observed after partially blocking the air to the condenser. If under this condition the sight glass clears and the performance is other wise satisfactory, the charge shall be considered adequate.

In all instances where the indications of refrigerant shortage continues, additional refrigerant should be added in 1/4 pound increments until the sight glass is clear. An additional charge of 1/2 to 1 pound should be added as a reserve. In no case should the system be overcharged.

The procedure shown in Fig. 4-1 can be used to quickly determine whether or not an air conditioning system has a proper charge of refrigerant. This check can be made in a manner of minutes thus facilitating system diagnosis by pinpointing the problem to the amount of charge in the system or by eliminating this possibility from the overall check-out.

Start engine and place on fast idle. Set controls for maximum cold with blower on high.

(Ambient temperature must be above 70°F)

BUBBLES PRESENT IN SIGHT GLASS.

System low on charge. Check with leak detector. Correct leak, if any, and fill system to proper charge. If foaming still occurs, check for restriction in refrigerant system between condenser and sight glass.

NO BUBBLES. SIGHT GLASS CLEAR.

System is either fully charged or empty. Feel high and low pressure pipes at compressor. High pressure pipe should be warm; low pressure pipe should be cold.

NO APPRECIABLE TEMPERATURE DIFFERENTIAL NOTED AT COMPRESSOR.

System empty or nearly empty. Turn off engine. Induce 1/2# of refrigerant in system. If system will not accept charge, start engine and draw 1/2# in through low pressure side). Check system with leak detector.

TEMPERATURE DIFFERENTIAL NOTED AT COMPRESSOR.

Even though a differential is noted, there exists a possibility of overcharge. An overfilled system will result in poor cooling during low speed operation (as a result of excessive head pressure). An overfill is easily checked by disconnecting the compressor clutch connector while observing the sight glass.

If refrigerant in sight glass remains clear for more than 45 seconds (before foaming and then settling away from sight glass) an overcharge is indicated. Verify with a performance check.

If refrigerant foams and then settles away from sight glass in less than 45 seconds, it can be assumed that there is a proper charge of refrigerant in system. Continue checking out system using performance checks outlined on next page.

Fig. 4-1 — **Sight Glass Quick Check Procedure**

Thermostatic Expansion Valve (TXV)

Expansion valve failures usually will be indicated by low suction and discharge pressures, and insufficient evaporator cooling. The failure is generally due to malfunction of the power element and subsequent closing of the valve. A less common cause of the above symptom is a clogged inlet screen due to contamination, corrosion particles or desiccant beads loose in the system.

CCOT Orifice

A clogged orifice tube will give the same symptoms as a malfunctioning expansion valve.

POA or Suction Throttling Valve

If the POA valve is defective, it may cause evaporator pressure (hence air temperature) to be either too high or too low depending on the type of failure. No adjustment is possible on POA valves. If it is determined that a POA valve has failed it should be replaced.

NOTE: Moisture in the system can cause either the TXV or POA valve to freeze up and malfunction. Before replacing a valve, defrost the system by shutting it down momentarily for warm-up and repeat the performance test.

Refrigerant Line Restrictions

Restrictions in the refrigerant lines will be indicated as follows:

1. Suction Line — A restricted suction line will cause low suction pressure at the compressor, low discharge pressure and little or no cooling.
2. Discharge Line — A restriction in the discharge line generally will cause the pressure relief valve to open.
3. Liquid Line — A liquid line restriction will be evidenced by low discharge and suction pressure, and insufficient cooling.

SYSTEM DIAGNOSIS PROCEDURES

Before making a full performance-diagnosis test, checks should be applied for the following:

1. Proper belt installation and tension.
2. Proper clutch coil terminal connector installation.
3. Proper clutch engagement.
4. Loose fittings on all components and broken, burst or cut hose.
5. Condenser air blockage due to foreign material.
6. Proper air duct hose connections.

After making the above checks, install pressure gauges and thermometers and conduct a diagnosis test according to type of system being worked on.

Diagnosis Procedure for System Equipped with Cycling Clutch Compressor and Thermostatic Expansion Valve

Follow step by step procedures as indicated in Fig. 4-2.

Diagnosis Procedure for System Equipped with POA Valve, VIR or EEVIR

Follow step by step procedure as indicated in Fig. 4-3.

Diagnosis Procedure for System Equipped with Cycling Clutch Compressor Using Pressure Cycling Switch, Expansion Tube (Orifice) and Accumulator

Follow step by step procedure as indicated in Fig. 4-7.

Diagnosis — GM Compressors

Follow step by step procedure as indicated in Fig. 4-5

Diagnosis — GM Compressor Electrical Circuit Equipped with Thermal Limiter and Superheat Switch

Follow step by step procedure as indicated in Fig. 4-6.

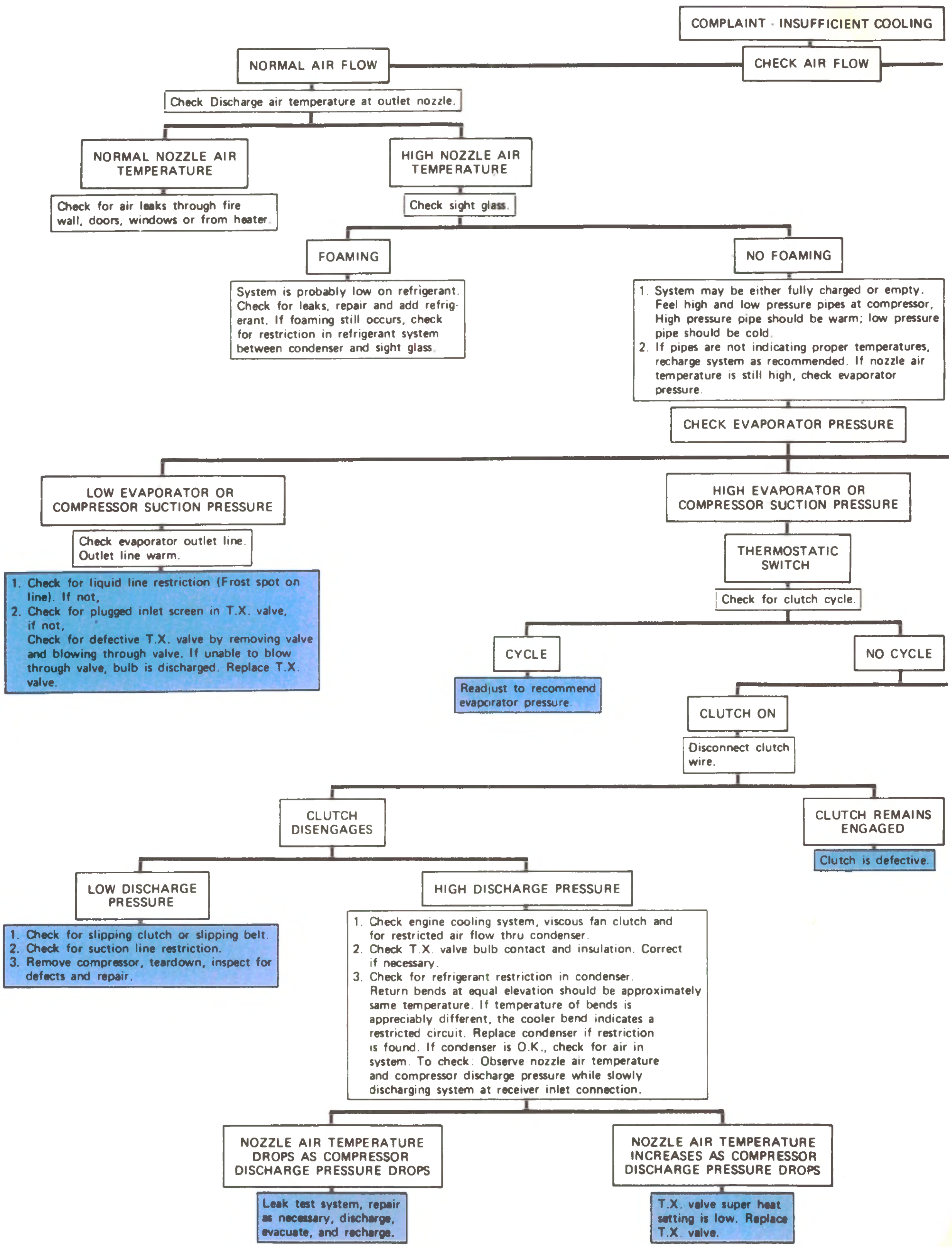


Fig. 4-2 — Diagnosis Procedure for System Equipped with Cycling Clutch Compressor and Thermostatic Expansion Valve

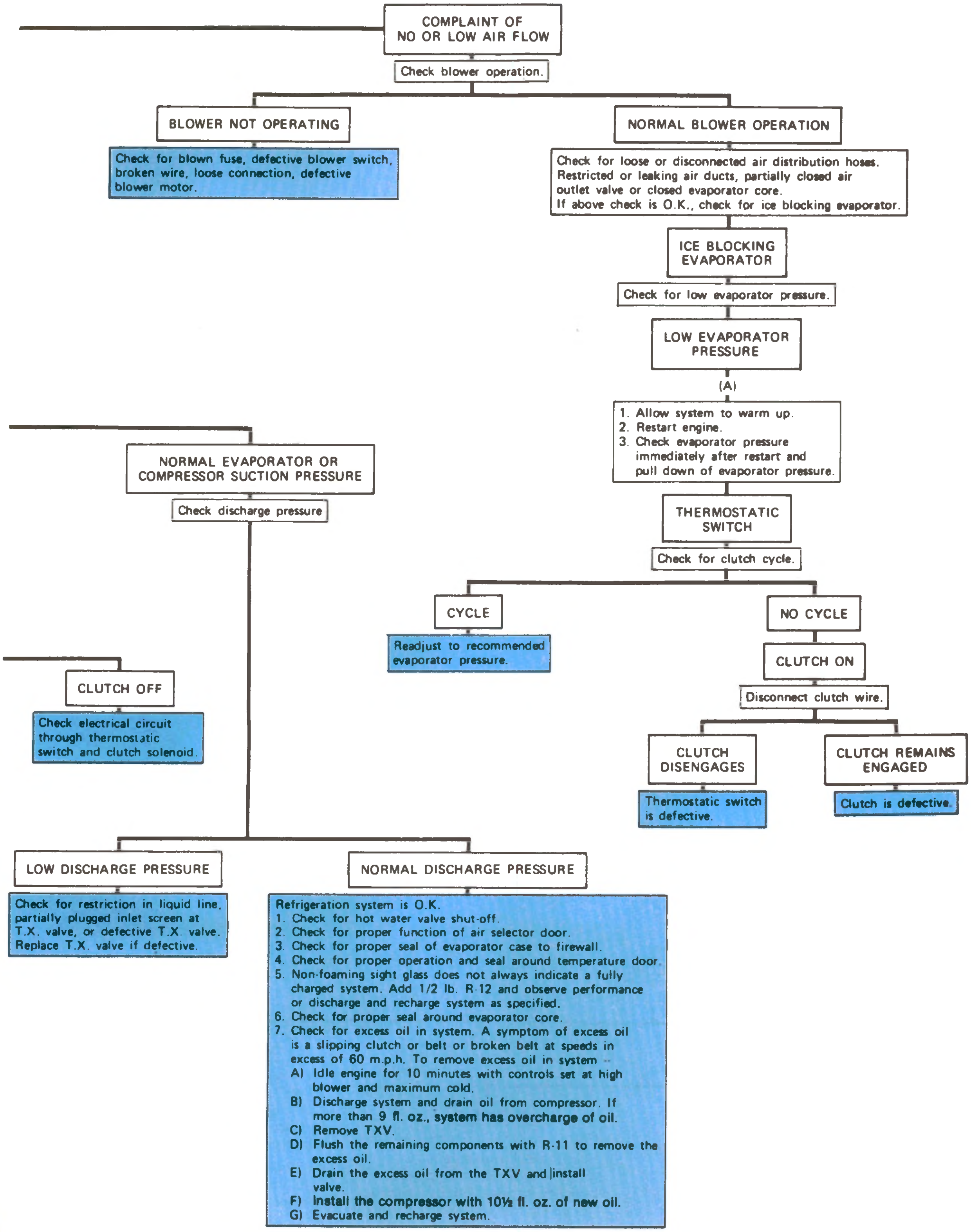


Fig. 4-2 — Diagnosis Procedure for System Equipped with Cycling Clutch Compressor and Thermostatic Expansion Valve

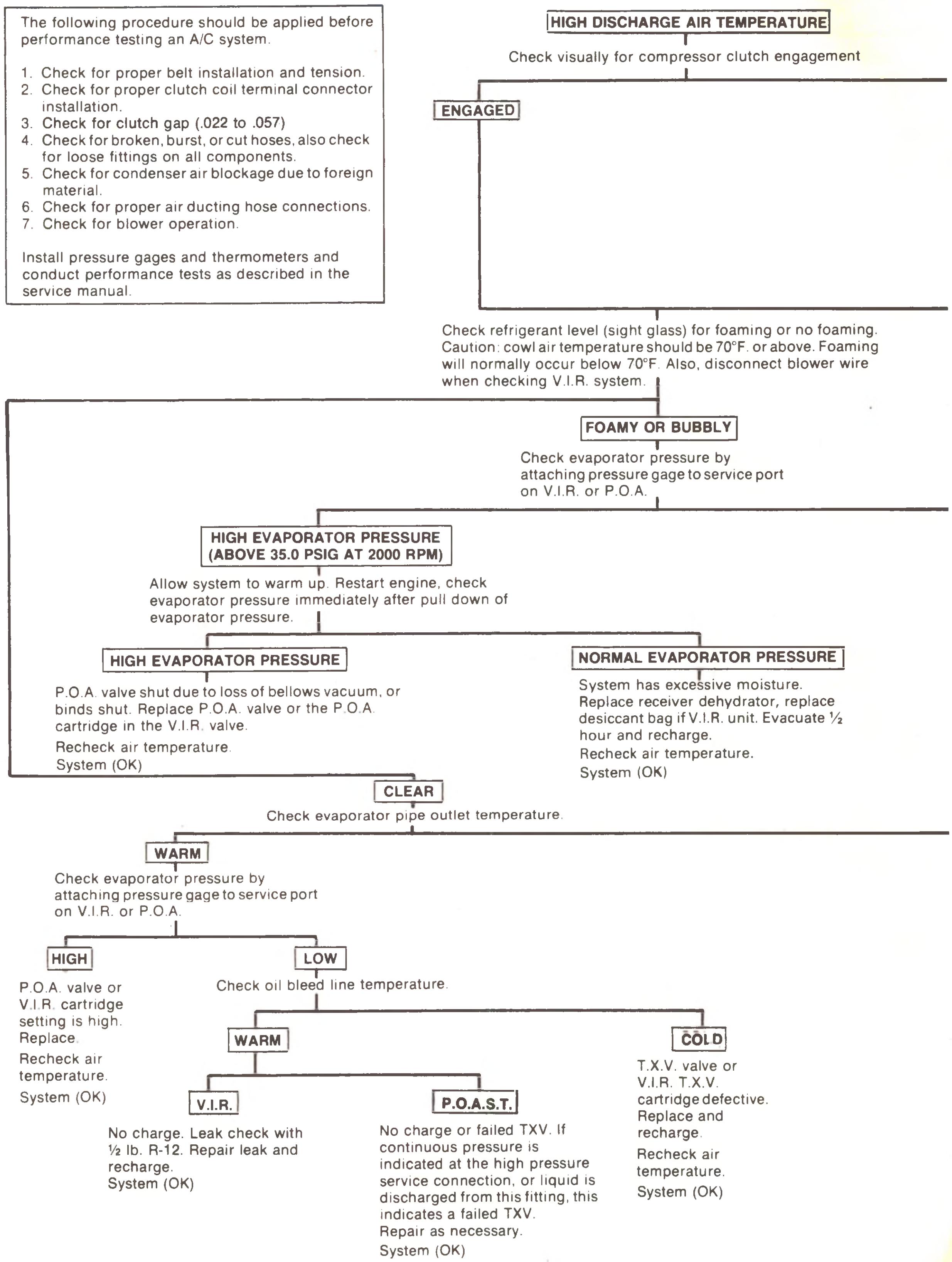


Fig. 4-3 — Diagnosis Procedure for System Equipped with POA Valve, VIR or EEVIR

WARNING: DO NOT CONNECT R-12 CONTAINER TO THE HIGH PRESSURE SIDE OF THE SYSTEM OR ANY SYSTEM OF HIGHER PRESSURE. THIS MAY CAUSE EXCESSIVE PRESSURE AND RESULT IN VIOLENT BURSTING OF THE CONTAINER CAUSING SERIOUS INJURY.

Thermal fuse—on all G.M. passenger vehicles except Vega.

NOT ENGAGED

Disconnect thermal fuse—check for clutch engagement by inserting jumper wire where center terminal (B) and clutch terminal (C) were plugged into connector assembly.

ENGAGED

1. Thermal fuse is blown.
2. Note: leave jumper wire connected and continue checks until problem is identified and corrected. Only after this time, replace with a new thermal fuse.

NOT ENGAGED

Check compressor hot lead wire with a test light or place a jumper wire from the compressor to positive (+) terminal of battery.

NOT ENGAGED

Apply external ground to compressor if clutch is still not engaged, remove clutch and repair per service manual.

System (OK)

ENGAGED

1. Check for blown main fuse.
2. Check for open circuit at control switch, ambient switch.
3. Repair

System (OK)

NORMAL TO LOW EVAPORATOR PRESSURE (BELOW 34.0 PSIG AT 2000 RPM)

Feel liquid line before TXV or V.I.R.

COLD

Restriction in high pressure side of system. A temperature differential will be detected on either side of the restriction. Replace the defective tube or receiver dehydrator. Recheck air temperature.

System (OK)

WARM

V.I.R.

Indicates low charge or plugged screen. Leak check and remove V.I.R. Repair as necessary. Recheck air temperature.

System (OK)

P.O.A.S.T.

Indicates low charge. Leak check and repair as necessary. Evacuate and recharge.

For servicing General Motors vehicles equipped with either the POASTV—TXV control system and/or the V.I.R. control system.

POASTV means—Pilot Operated Absolute Suction Throttling Valve.

TXV means—Thermostatic Expansion Valve.

V.I.R. means—Valves In Receiver. (Both the POASTV and TXV controls are contained in one housing.)

COLD

Check evaporator pressure by attaching pressure gage to service port of V.I.R. or P.O.A.

HIGH EVAPORATOR PRESSURE

Check for dirty condenser. Place large piece of cardboard between condenser and radiator. Blow debris thru condenser, using compressor air. Recheck evaporator pressure.

HIGH EVAPORATOR PRESSURE

Disconnect suction line and check for restriction in line or in P.O.A. screen. If no restriction, replace P.O.A. valve or P.O.A. cartridge because it has a high setting. Clean or replace as necessary.

Recheck air temperature.

System (OK)

NORMAL EVAPORATOR PRESSURE

Recheck air temperature.

System (OK)

NORMAL TO LOW EVAPORATOR PRESSURE

Disconnect blower and check evaporator pressure.

EVAP. PRESS. LOW

P.O.A. valve or P.O.A. cartridge valve stuck open. Replace and recharge.

Recheck air temperature.

System (OK)

NORMAL EVAPORATOR PRESSURE

1. Check for electrical system defects. Check for improper wiring at thermal fuse. Check for defective super heat switch terminal. Check for continuity between switch terminal and housing. If continuity exists, switch is defective. If switch is open, remove and check setting—
   Switch is open below 100°F
   Switch is closed above 150°F
2. Visually check for slipping clutch or belt. If repair is necessary, see chart VIII.

Fig. 4-3 — Diagnosis Procedure for System Equipped with POA Valve, VIR or EEVIR

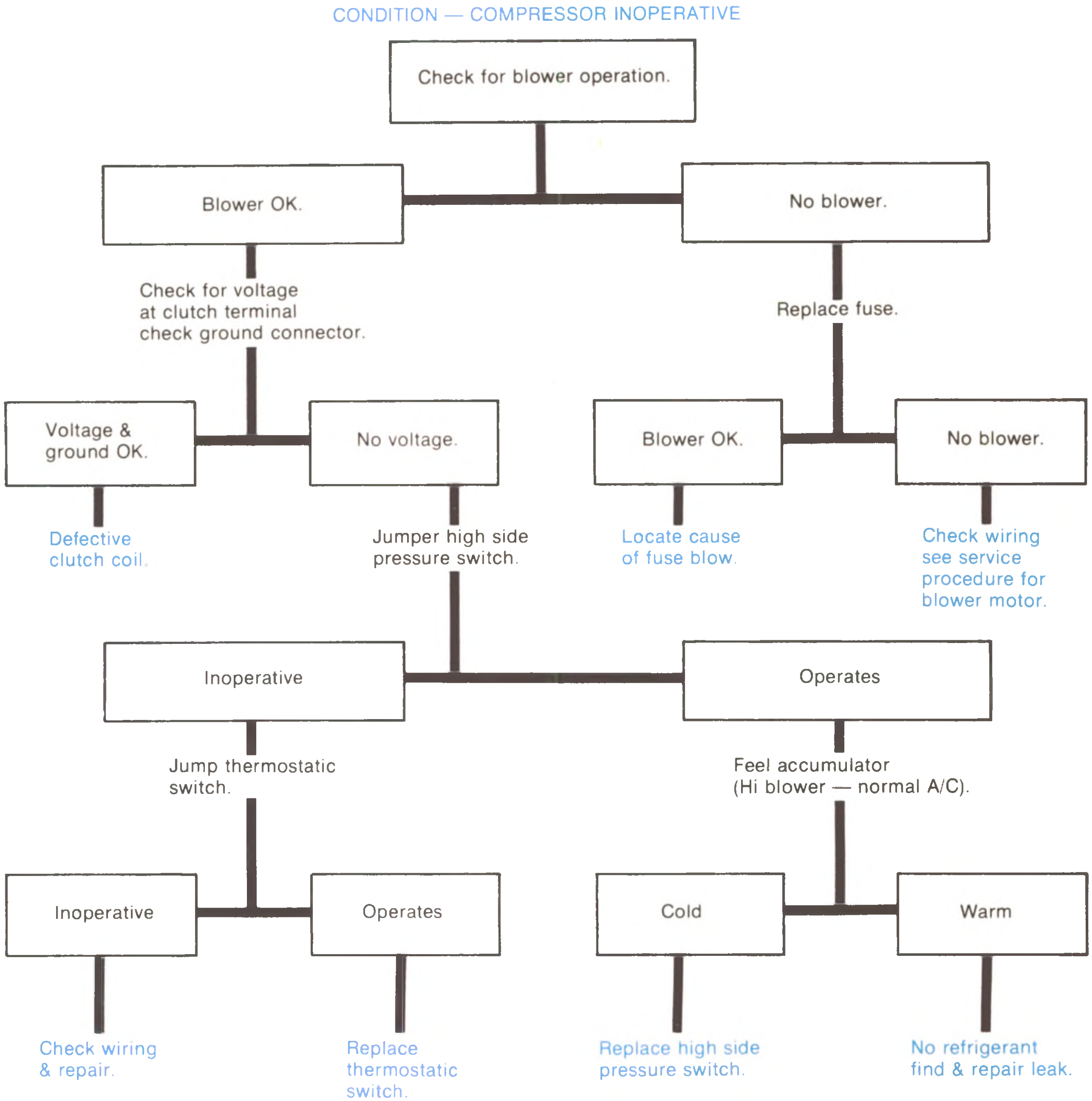


Fig 4-4 — Diagnosis Procedure for System Equipped with Cycling Clutch Compressor, Expansion Tube (Orifice) and Accumulator (CCOT)

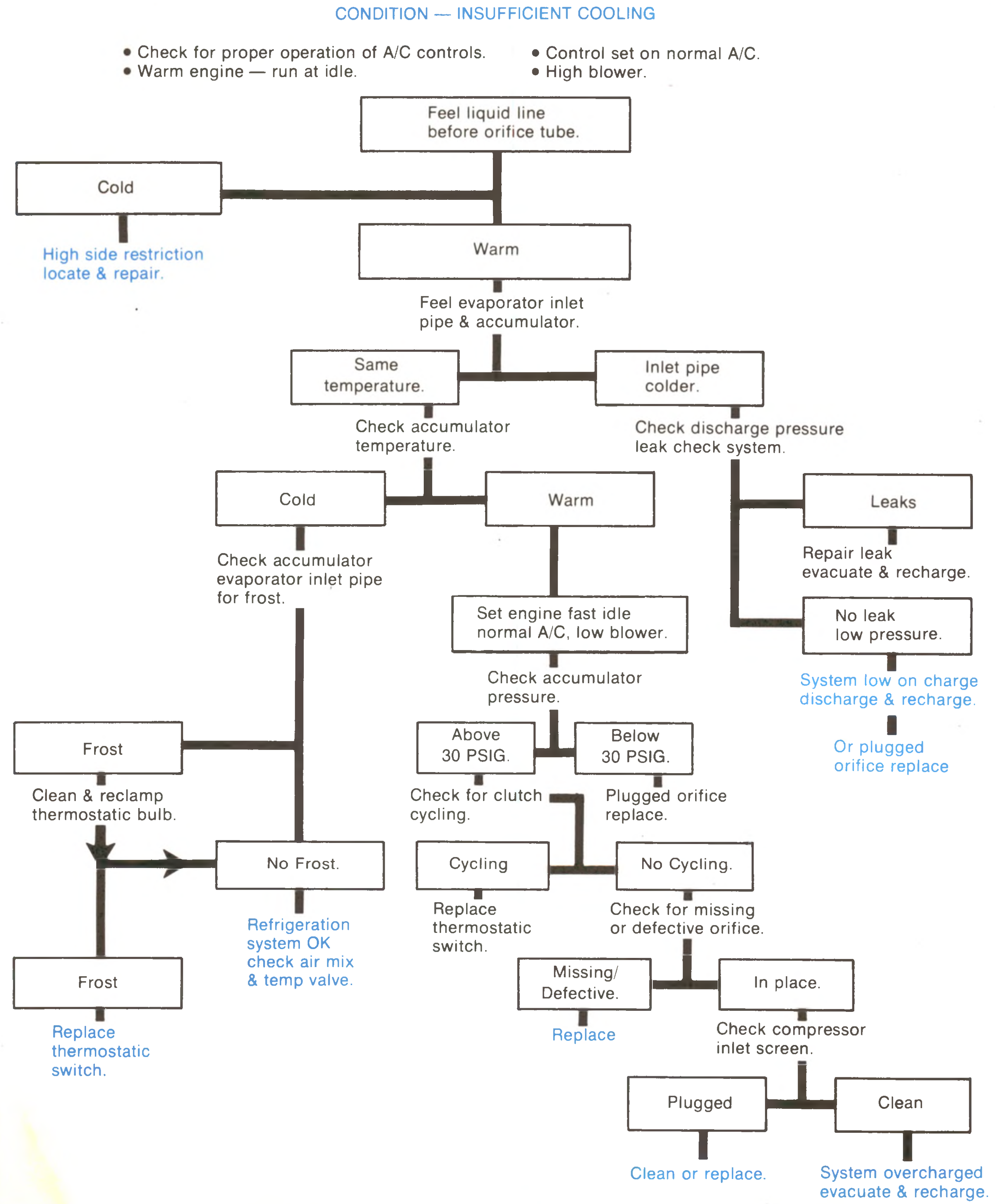


Fig 4-4 — Diagnosis Procedure for System Equipped with Cycling Clutch Compressor, Expansion Tube (Orifice) and Accumulator (CCOT)

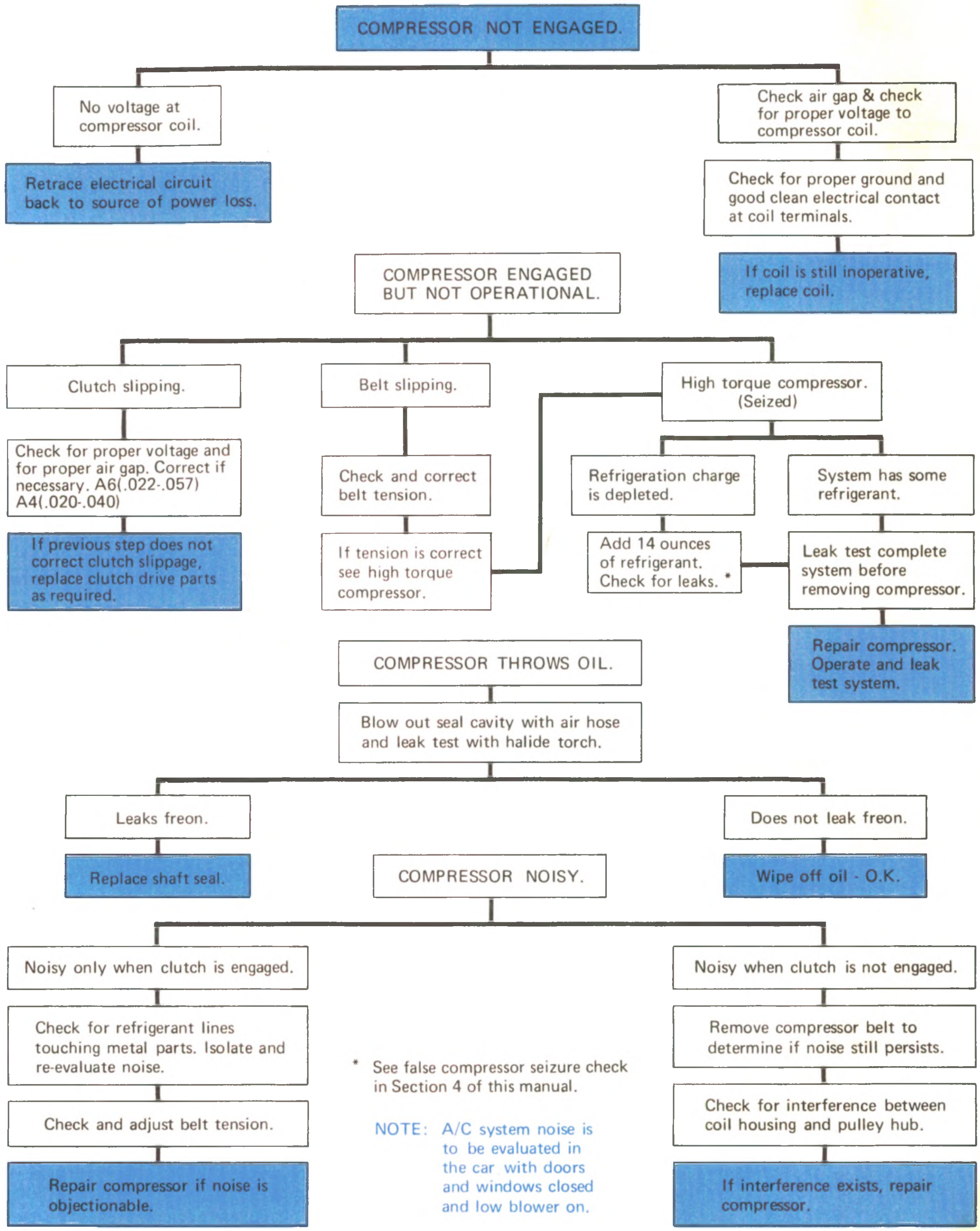


Fig. 4-5 — Diagnosis GM Compressor

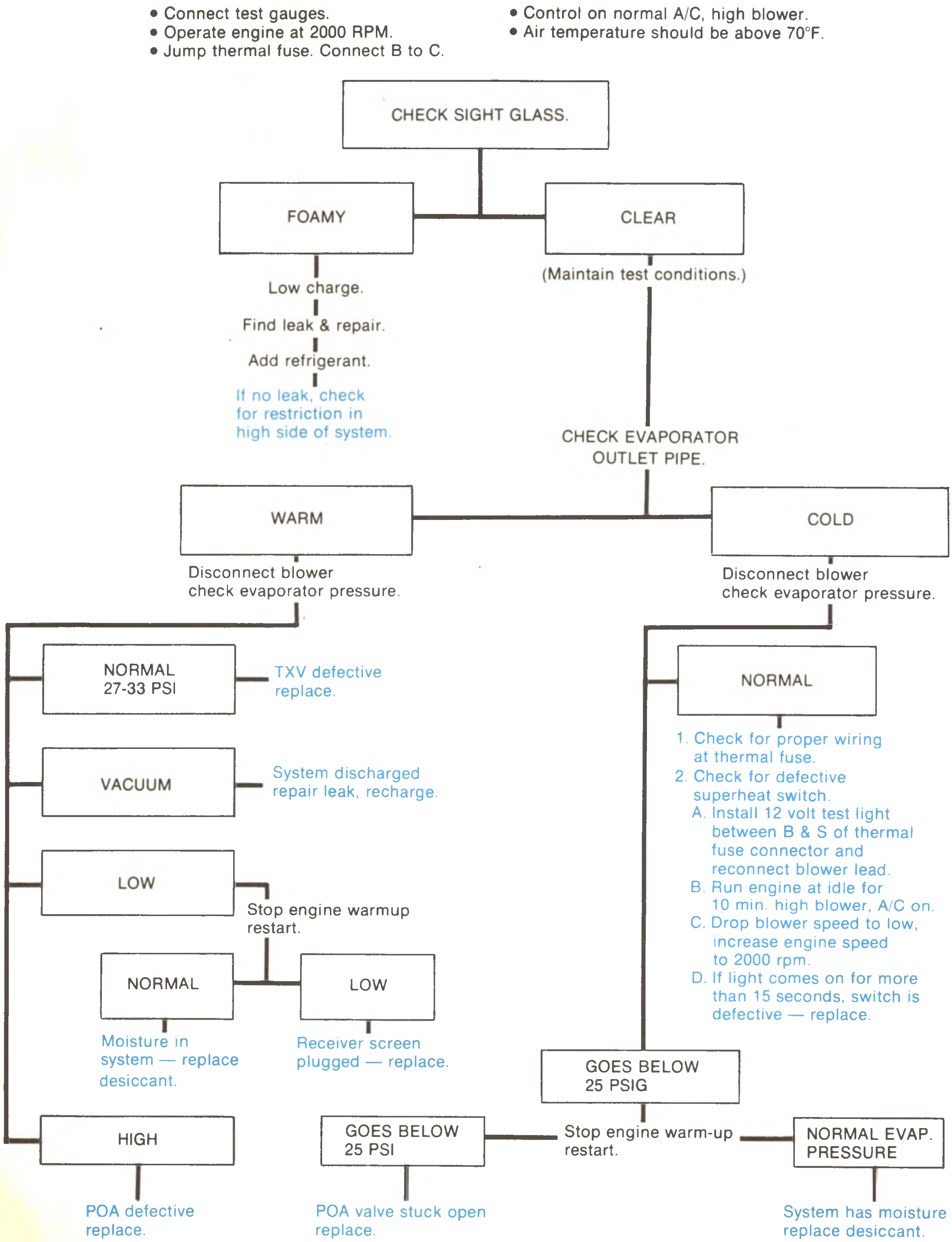
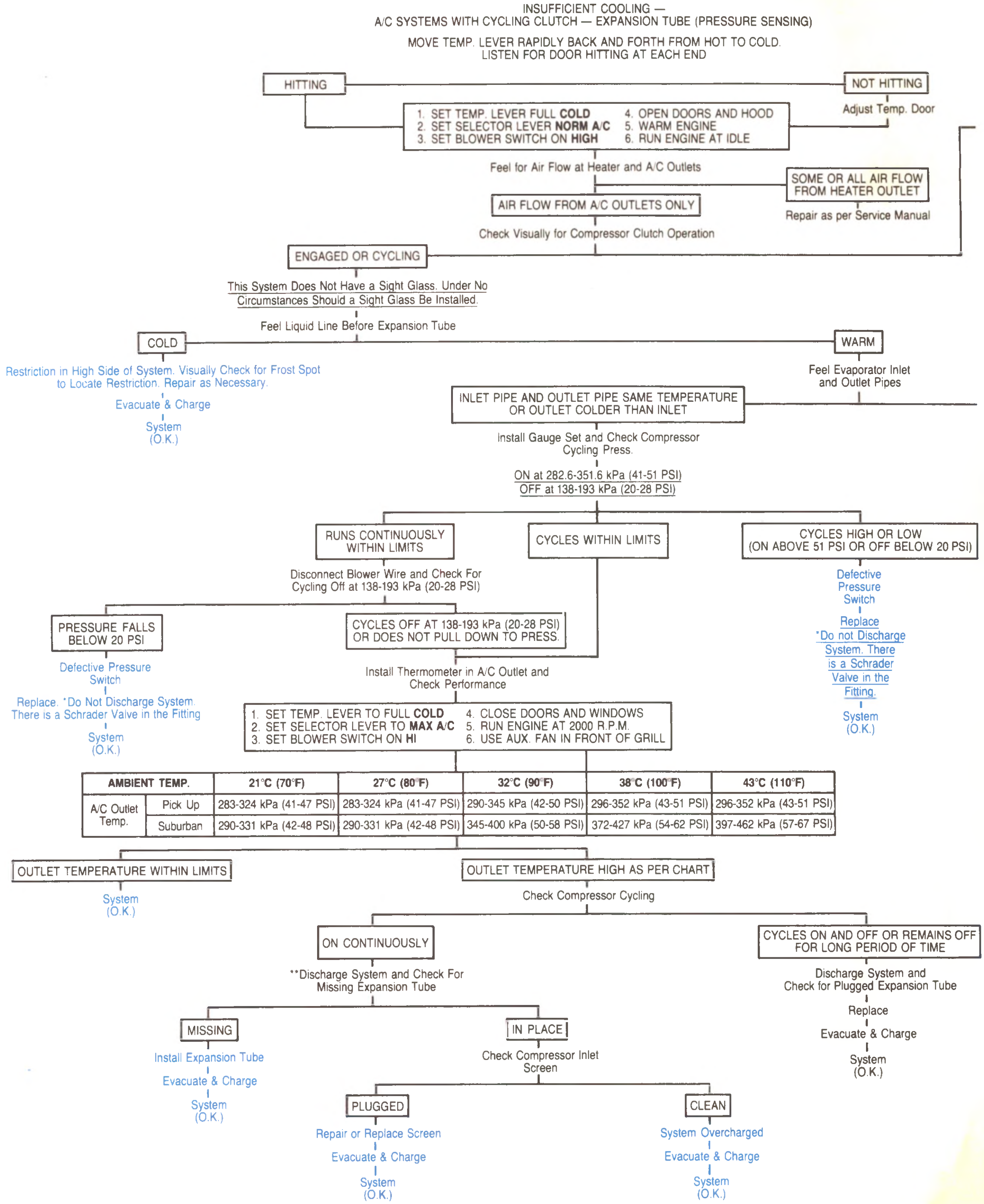


Fig. 4-6 — Diagnosis — GM Compressor Equipped with Thermal Limiter and Super Heat Switch



AMBIENT TEMP.		21°C (70°F)	27°C (80°F)	32°C (90°F)	38°C (100°F)	43°C (110°F)
A/C Outlet Temp.	Pick Up	283-324 kPa (41-47 PSI)	283-324 kPa (41-47 PSI)	290-345 kPa (42-50 PSI)	296-352 kPa (43-51 PSI)	296-352 kPa (43-51 PSI)
	Suburban	290-331 kPa (42-48 PSI)	290-331 kPa (42-48 PSI)	345-400 kPa (50-58 PSI)	372-427 kPa (54-62 PSI)	397-462 kPa (57-67 PSI)

Fig. 4-7 — Diagnosis Procedure for System Equipped with Pressure Cycling Switch, Expansion Tube (CCOT)

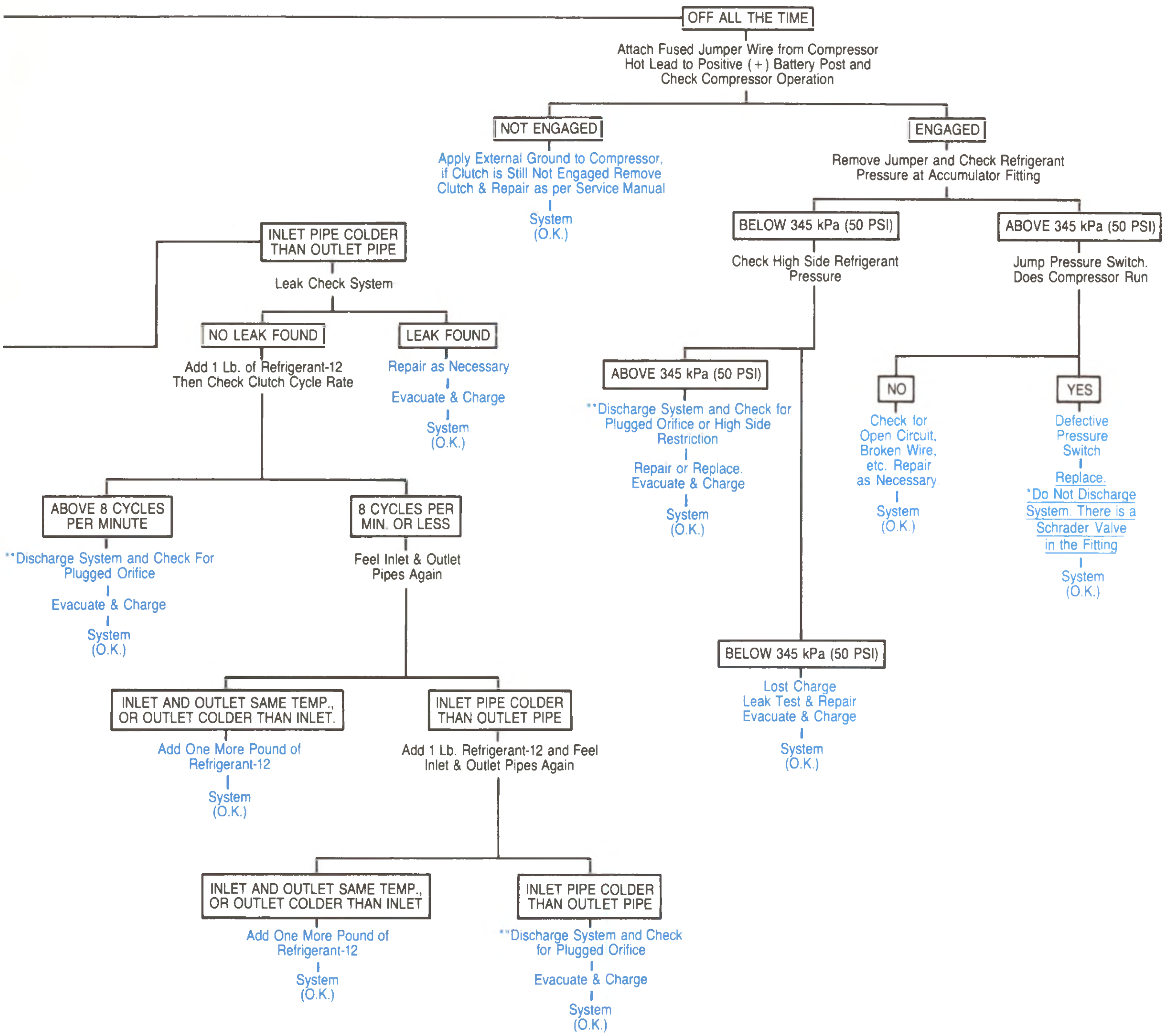
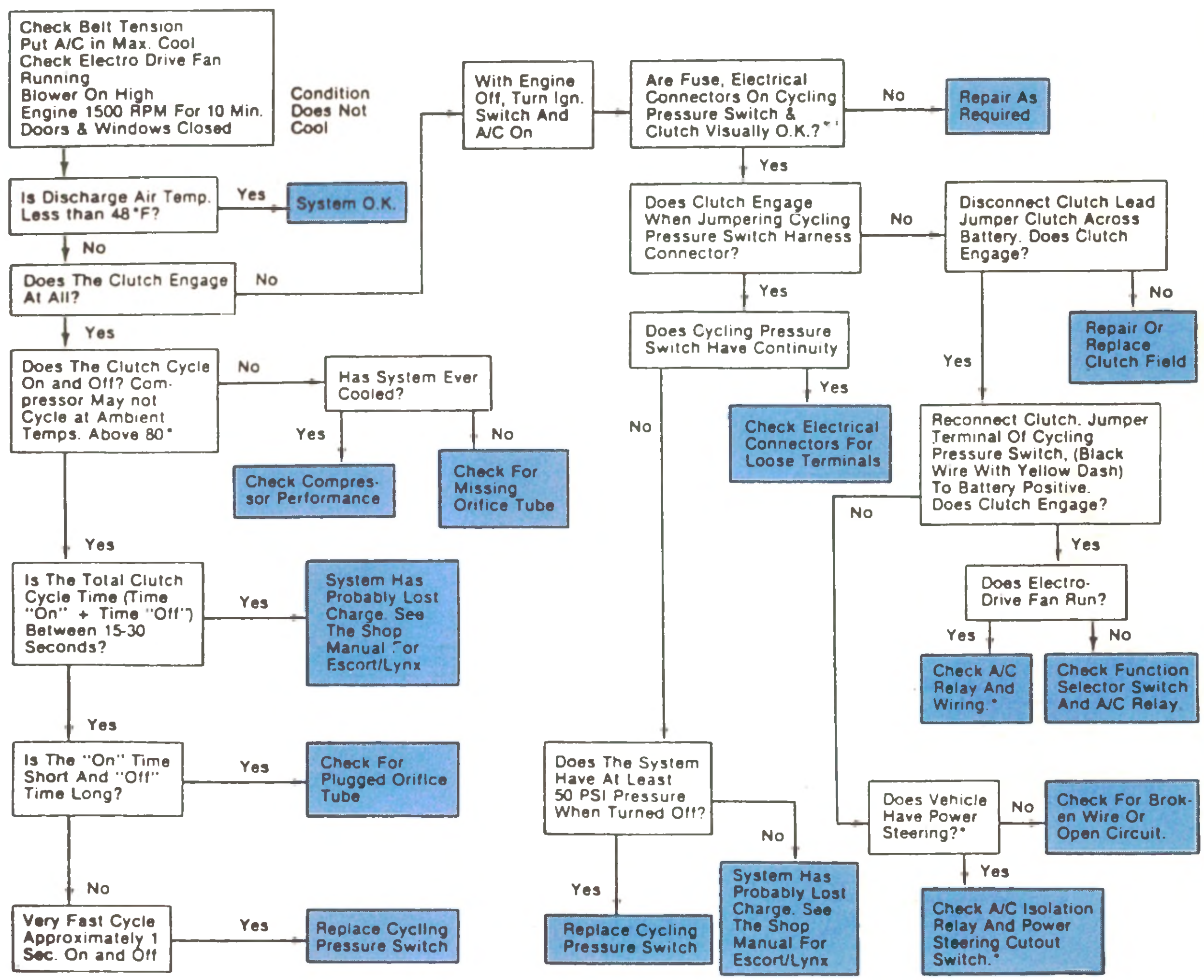


Fig. 4-7 — Diagnosis Procedure for System Equipped with Pressure Cycling Switch, Expansion Tube (CCOT)

FIXED ORIFICE TUBE CYCLING CLUTCH SYSTEMS
For 1981 Passenger Cars



*THESE STEPS APPLY TO ESCORT/LYNX ONLY.

Fig. 4-8 — Diagnosis Procedure for System Equipped with Ford CCOT

5. GLOSSARY — AUTOMOTIVE AIR CONDITIONING TERMS

Air Conditioning — Control of the temperature, humidity, cleanness, and movement of air.

Air Inlet Valve — A movable door in the plenum blower assembly that permits the selection of outside air or inside air for both the heating and air conditioning systems.

Air Outlet Valve — A movable door in the plenum blower assembly that directs air flow either into the heater core or into duct work that leads to the evaporator.

Ambient — Air outside the car.

Ambient Compressor Switch — Energizes the compressor clutch when the outside air temperatures are 32°F. or above; similarly, the switch turns off the compressor when air temperatures drop below 32°F.

Atmosphere — Air.

Atmospheric Pressure — Air pressure at a given altitude (14.69 pounds per square inch at sea level). Atmospheric pressure decreases as altitude increases.

Automatic Control — A thermostat on the instrument panel. The dial can be set at a comfortable level and the device will serve the passenger by controlling the air flow and temperature automatically.

BTU (British Thermal Unit) — The amount of heat necessary to raise one pound of water through one degree Fahrenheit.

By-Pass Control Valve — Same as "Hot Gas By-Pass Valve."

Center Mount Components — Installation of Heating and Air Conditioning which has the evaporator mounted in the center of the firewall on the engine side. The heater is installed directly to the rear, in the passenger compartment.

Change of State — Rearrangement of the molecular structure of matter as it changes between any two of the three physical states (solid, liquid, or vapor).

Charge — A specific amount of refrigerant or refrigerant oil by weight.

Charging — The process of placing a "charge" of refrigerant or refrigerant oil into the system.

Chemical Instability — An undesirable condition caused by the presence of contaminants in a refrigeration system. Refrigerant is a stable chemical by itself but in contact with contaminants may break down into harmful chemicals.

Clutch — A coupling which transfers torque from a driving to a driven member when desired. The compressor clutch delivers torque transmitted from the engine through a drive belt, causing the compressor drive shaft to rotate.

Cold — The absence of heat. An object is considered cold to the touch if it is less than 98.6°F. (body temperature).

Compressor — Component of a refrigeration system that pumps refrigerant and that increases the pressure and temperature of refrigerant vapor.

Condensate — Water taken from air. It forms on the exterior surface of the evaporator.

Condensation — Act of changing a vapor to a liquid.

Condenser — Component of a refrigeration system in which refrigerant vapor is changed to a liquid by the removal of heat.

Conditioned Air — Cool, dry, clean air.

Conduction — Transmission of heat through a solid.

Contaminants — Anything other than refrigerant and refrigerant oil that is in a refrigeration system, such as rust, dirt, moisture, and air.

Convection — The transfer of heat by the circulation of a vapor or liquid.

Under Dash Unit — The trade name used for the "hang-on" or "under-the-dash" type air conditioning system that normally uses only recirculated air. All air outlets are in the evaporator case. Discharge air temperature is controlled by a cycling thermostatic expansion switch or suction throttling valve.

Cooling Coil — Same as "Evaporator."

Customer System — Deluxe air conditioner that uses both outside and inside air. The air distribution ducts and outlets are built into the instrument panel. Air temperature is controlled by a hot gas bypass valve, suction throttling valve or air mixture valve.

Cycle — See "Refrigeration Cycle."

Cycling Clutch System — A term referring to air conditioners in which conditioned air temperature is controlled by the engaging and disengaging of the compressor.

Desiccant — A drying agent used in the refrigeration system to remove moisture. It is located in the receiver-dehydrator.

Diagnosis — The procedure that is followed in locating the cause of malfunction.

Dichlorodifluoromethane — See Refrigerant 12.

Discharge — To bleed some or all refrigerant from a system by opening a valve or connection and permitting the refrigerant to escape slowly.

Discharge Air — Conditioned air as it passes through outlets and enters the passenger compartment.

Discharge Line — Connects the compressor outlet and the condenser inlet. High-pressure refrigerant vapor flows through this line.

Discharge Pressure — Pressure of refrigerant being discharged from the compressor.

Evaporation — Changing from a liquid to a vapor.

Evaporator — Component of an air conditioning system which conditions the air. Refrigerant liquid is changed into a vapor in this component.

Expansion Valve — Same as "Thermostatic Expansion Valve."

Flush — To remove solid particles such as metal chips and dirt. Refrigerant passages are purged (flushed) with Refrigerant 12. Exterior surfaces of system components are flushed with water or an acceptable solvent.

Freeze Protection — Controlling the evaporator temperature so that moisture on its surface will not change to ice and block air flow.

Gauge Set — One or more instruments attached to a manifold (a pipe fitting with several outlets for connecting pipes) and used for measuring pressure.

Head Pressure — Same as "Discharge Pressure."

Heater Core — A water-air heat exchange which provides heat for the passenger compartment.

High-Load Condition — Refers to those times when an air conditioning system must operate continuously at maximum capacity to provide the cool air required, such as at high temperature and high humidity.

High-Pressure Lines — Lines from the compressor outlet to the thermostatic expansion valve inlet that carry high-pressure refrigerant. The two longest high-pressure lines are the "discharge" and "liquid" lines.

Discharge Side — That portion of the refrigeration system under high pressure, extending from the compressor outlet to the thermostatic expansion valve.

Drying Agent — Same as "Desiccant."

Equalizer Line — LIne or connection used specifically for obtaining required operation from certain control valves. Very little if any refrigerant flows through this line.

Evacuate — To create a vacuum within a system.

High-Pressure Vapor Line — Same as "Discharge Line."

High Side — Same as "Discharge Side."

High Side Pressure — Same as "Discharge Pressure."

Humidity — See "Moisture."

Instability — See "Chemical Instability."

Latent Heat — Amount of heat required for a change of state. Latent heat of vaporization is the amount of heat required to change a liquid to a vapor.

Leak Detector — Equipment for locating an opening where the refrigerant may escape. The three common types of detectors are the alcohol torch, gas torch, and electronic detector.

Liquefier — Same as "Condenser."

Liquid Line — Connects the receiver-dehydrator outlet and the thermostatic expansion valve inlet. High-pressure liquid refrigerant flows through this line.

Low-Pressure Line — Same as "Suction Line."

Low-Pressure Vapor Line — Same as "Suction Line."

Low Side — Same as "Suction Side."

Moisture — Humidity, dampness, wetness, or very small drops of water in the air.

Muffler — Device to minimize pumping sounds from the compressor.

Oil Bleed Line — Insures positive oil return to compressor at high compressor speed and under low charge conditions.

Oil Injection Cylinder — A cylinder containing a measured quantity of refrigerant oil added when servicing the air conditioning system.

Operational Test — Same as "Performance Test."

Performance Test — Taking temperature and pressure readings under specified conditions to determine if an air conditioning system is operating satisfactorily.

Plenum Blower Assembly — Air passes through this assembly on its way to the evaporator. It is located on the engine side of the fire wall and contains air ducts, air valves, and a blower that permits selection of air from the outside or inside of the car and direct it either to the evaporator core or to the heater core.

Pressure — Force per unit of area. The pressure that refrigerant exerts within the system is indicated on gauges in pounds per square inch.

Pressure Line — See "Discharge Line." All refrigerant lines are under pressure.

Pressure Sensing Line — Prevents the compressor suction pressure from dropping below a predetermined pressure, by opening the thermostatic expansion valve, allowing liquid refrigerant to flood through the evaporator.

PSIG — Pounds per square inch of gauge pressure.

Purge — To remove moisture and air from a system or a compound by flushing with a dry gas, such as nitrogen or Refrigerant 12.

Radiation — One of the processes by which energy is transferred. Heat energy from the sun's rays, for example, raise the temperature of the passenger compartment.

Receiver-Dehydrator — A container for storing liquid refrigerant from the condenser. A sack of desiccant in this container removes small traces of moisture that may be left in the system after purging and evacuating.

Refrigerant — The chemical compound used in a refrigerant system to produce the desired cooling.

Refrigerant 12 — The refrigerant used in automotive air conditioning systems. It is sold under such trade names as Freon 12, Genetron 12, Isotron 12, Prestone 12, and Ucon 12.

Refrigeration — The removal of heat by mechanical means.

Refrigerant Cycle — Complete course of operation of refrigerant back to a starting point, evidenced by temperature, pressure, and liquid-vapor changes of the refrigerant as it circulates through the system.

Relative Humidity — Actual moisture content of the air in relation to the total moisture that the air can hold at a given temperature. If the air contains 3/4 of the moisture it can hold at its existing temperature, the relative humidity is 75%.

Room Temperature — 68° to 72°F.

Saddlebag — Air chambers or openings in the left and right front corners of the car body between the kickpads and the exterior of the car. On some custom systems the evaporator is located in the right saddlebag.

Schrader Valve — A spring-loaded valve where a connection can be made to the refrigeration system. A gauge set can be used on a Schrader valve only with an adaptor.

Screens — Fine mesh metal screens are located in the receiver-dehydrator, thermostatic expansion valve, and compressor. They prevent solid particles from being circulated through the system and carried to vital moving parts where they might cause damage.

Side Dash Components — Installation of heating and air conditioning which has the evaporator mounted on the curb side of the firewall in the engine compartment. The heater is in back of the evaporator in the passenger compartment.

Sight Glass — A window usually in the top of the receiver-dehydrator used to observe liquid refrigerant flow.

Specifications — Information provided by the manufacturer that describes an air conditioning system, its components, and its proper operation. Service procedures that must be followed in order for the system to operate properly also are called "specifications."

Suction Line — Connects the evaporator outlet and the compressor inlet, low pressure refrigerant vapor flows through this line.

Suction Side — That portion of the refrigerant system under low pressure, extending from the thermostatic expansion valve to the compressor inlet.

Suction Throttling Valve — Prevents evaporator core freeze up and controls temperature of air that flows from the evaporator.

Suction Throttling Valve POA — Prevents evaporator core freeze up, compensates for compressor speed changes and evaporator load — is unaffected by elevation above sea level.

Suction Pressure — Compressor intake pressure as indicated by a gauge set.

Superheated Vapor — Refrigerant vapor at a temperature that is higher than its boiling point for a given pressure.

System — All the components and lines that together make up an automotive air conditioner is a complete system: includes heating and cooling.

TE Valve — Same as "Thermostatic Expansion Valve."

Temperature — Heat intensity measured in degrees Fahrenheit.

Thermostatic Expansion Valve — Component of a refrigerant system that controls the rate of refrigerant flow to the evaporator. It is commonly called the "TE Valve" or "TXV."

Thermostatic Switch — An adjustable component used in a cycling clutch system to engage and disengage the compressor. It prevents water (condensate) from freezing on the evaporator core and controls the temperature of air that flows from the evaporator.

Torque — A turning force such as that required to seal a connection, usually in ft-lbs or in-lbs.

Vacuum Power Unit — Device for operating doors and valves using vacuum as a source power.

Vacuum Pump — A mechanical device to evacuate a system.

Vapor Lines — Lines that carry refrigerant vapor. Also see "Suction Line," "Discharge Line," and "Equalizer Line."

Viscosity — Thickness of a liquid or its resistance to flow. Water has a low viscosity while heavy, sticky oil has a high viscosity.

Volatile Liquid — One that evaporates readily to become a vapor. Refrigerant is volatile at room temperature

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GM

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