# PHASE 8
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UNIVERSAL TECHNICAL INSTITUTE

PHASE 8 - AUTOMOTIVE AIR CONDITIONING

LIST OF LAB PROJECTS

INSTRUCTOR____________

STUDENT'S NAME____________

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | TRAINING AIDS: |
| | | | | | | | | R & R SEAL AND CYL. HEAD ON A YORK COMP. |
| | | | | | | | | R & R SEAL AND CYL. HEADS ON A CHRYSLER V-2 COMP. |
| | | | | | | | | R & R SEAL ON A GM SIX-CYL. COMP. |
| | | | | | | | | PURGE, EVACUATE, CHARGE AND PRESSURE TEST TRAINING AID UNIT. |
| | | | | | | | | CHARGE SYSTEM WITH NITROGEN. |
| | | | | | | | | |
| | | | | | | | | ON VEHICLE: |
| | | | | | | | | EVACUATE COMPLETE SYSTEM. |
| | | | | | | | | CHARGE COMPLETE SYSTEM WITH NITROGEN. |
| | | | | | | | | CHARGE COMPLETE SYSTEM WITH R-12. |
| | | | | | | | | PERFORM COMPLETE PRESSURE CHECK. |
| | | | | | | | | PERFORM COMPLETE TEMPERATURE CHECK. |
| | | | | | | | | PERFORM LEAK TEST. |
| | | | | | | | | R & R P.O.A. VALVE. |
| | | | | | | | | R & R EXPANSION VALVE. |
| | | | | | | | | R & R E.P.R. VALVE. |
| | | | | | | | | |

# PROPERTIES OF THERMAL (HEAT) ENERGY

## Heat:

Heat is defined as a form of energy. Since this definition is applied to several other forces, as well as heat, it doesn't really do very much for us in the way of actually defining heat. Despite all we have learned about heat, its behavior, the various effects it has on all kinds of materials, methods of generating it, and the many uses it can be put to -- we still don't know just exactly what it is.

In trying to compose a more explicit definition of heat, we might say, "Heat is that which when added to a substance, will cause its temperature to rise or bring about a change in its physical state". Of course, the reverse is also true, "Heat is that which when removed from a substance will cause its temperature to drop or bring about a change in its physical state".

While these two statements certainly don't give us a pinpoint definition of heat, they do point out two of the major effects of heat. Later on, we shall see just how important these two effects are to the service technician. More important, at the moment, these two statements indicate that "heat" and "temperature" are not terms which actually mean the same thing, even though most of us are accustomed to thinking of "heat" in terms of "temperature".

## Temperature:

Temperature is defined as the intensity of heat at a certain point or in a specified area. In other words, temperatures are used in answering the question, "How hot is this material?", rather than "How much heat is there in this material?"

Since we have been discussing "heat" and "temperature", it might be well, at this point, to answer the question, "What is Cold?". The only possible answer to this question is "There is no such thing as "cold". There is always a certain amount of heat present, and the term "cold" is used to indicate comparatively low temperatures or conditions where an unusually small amount of heat is present.

## Measurement Of Heat Intensity:

Obviously, some basic unit or system must be employed whenever it becomes necessary to measure or express intensities of heat. Throughout the world, there are several such systems in current use, but the two most widely recognized are the Fahrenheit scale and the centigrade scale, both of which are used in this county. Both scales are based on the freezing and normal boiling points of water.

## The Fahrenheit Scale:

On the Fahrenheit scale, water freezes at 32 degrees and boils at 212 degrees, with 180 degrees between the two reference points.

## The Centrigrade Scale:

On the centrigrade scale, water freezes at 0 degrees and boils at 100 degrees, with 100 degrees between the two reference points.

## Expression Of Temperatures:

Since both the Fahrenheit and centigrade scales are widely used in this country, it is necessary to indicate which scale is being used whenever temperatures are expressed. For example, we know that 212 deg. F. is equal to 100 deg. C.

## Quantities Of Heat:

While most of us don't realize it, we are just as greatly concerned with quantities or amounts of heat as we are with intensities of heat. For example, we all like to keep our homes at a comfortable temperature during the winter months, but in order to do this we must have a heating plant that is capable of generating a certain amount of heat in a given period of time.

## Measurement Of Heat:

Since we will be dealing with quantities of heat, as well as intensities, it is necessary that we have a unit of measure to work with. There are actually three units of measure used in expressing quantities of heat: The "small calorie", the "large calorie" and the "British thermal unit".

## The Small Calorie:

The small calorie is defined as the amount of heat required to raise the temperature of one gram of water one degree centrigrade. Since this is a very small amount of heat, the small calorie is not very widely used except in laboratory experimentation.

## The Large Calorie:

The large calorie is defined as the amount of heat required to raise the temperature of 1,000 grams of water one degree centigrade. One large calorie is, of course, equal to 1,000 small calories. In this country, the use of the large calorie, written calorie (L) or calorie, is limited to expressing the amount of potential heat energy contained in foods. For example, we are told that the average slice of white bread contains about 60 calories.

## The British Thermal Unit (B.T.U.):

The British thermal unit is defined as the amount of heat required to raise the temperature of one pound of water one degree Fahrenheit. One B.T.U. is equal to 252 small calories. In this country, the B.T.U. is used whenever it is necessary to express large quantities of heat.

## Freezing And Melting Points:

The freezing point of any given material is defined as the temperature at which it will change from a liquid state into a solid state.

The melting point of any given material is defined as the temperature at which it will change from a solid state into a liquid state.

For any given material, the freezing and melting points are the same. For example, water freezes at 32 deg. F. and ice melts at 32 deg. F.

## Vaporization And Condensation Points:

The vaporization point of any given material is defined as the temperature at which it will change from a liquid state into a gaseous state.

The condensation point of any given material is defined as the temperature at which it will change from a gaseous state into a liquid state.

For any given material, the vaporization and condensation points are the same. For example, water boils (changes from a liquid state into a gaseous state) at 212 deg. F. and steam condenses (changes from a gaseous state into a liquid state) at 212 deg. F.

## Effects Of Pressure On Vaporization Points:

When we state, without qualification, that a certain liquid material will vaporize at a given temperature, it must be assumed that the amount of pressure on the surface of the liquid is a normal atmospheric pressure of 14.7 pounds per square inch.

If the pressure on the surface of a liquid is increased, the vaporization point of the liquid will be raised.

The attached chart shows the vaporization (boiling) points of water at various pressures, both above and below normal atmospheric pressure.

## Latent Heat:

Latent heat is defined as that heat which will cause a change of state in materials which it is either added to or removed from.

Latent heat will not affect the temperature of materials which it is either added to or removed from.

Latent heat is classified according to the change of state which it causes.

## Latent Heat Of Vaporization:

The latent heat of vaporization of any given material is defined as the amount of heat which must be added to one pound of that material in order to change it from a liquid state into a gaseous state. The same amount of heat must be removed from one pound of that material in order to change it from a gaseous state into a liquid state.

## The Effects Of Heat:

Heat, itself, is intangible and cannot be directly detected in any way. However, the effects of heat can be detected through one or more of the five senses. If we seem to feel the presence of heat, it is only because we are aware of its effect on our bodies and not because we feel the heat itself.

We have learned that heat will cause either a temperature change or a physical state change in materials it is added to or removed from. Based on these two effects, we find that there are two kinds of heat -- sensible heat and latent heat.

## Sensible Heat:

Sensible heat is defined as that heat which will cause a temperature change. If sensible heat is added to a substance, the result will be a temperature rise in that substance. If sensible heat is removed from a substance, the result will be a temperature drop in that substance.

It should be obvious, even to the casual observer, that all materials are not effected to the same extent by a specific quantity of heat. Because this is true, it has been necessary to determine the specific heats of all known materials.

## Specific Heat:

The specific heat of any material is defined as the amount of heat required to cause a one degree (F) temperature change in one pound of that material. For example, the specific heat of water is one B.T.U., the specific heat of ice is .504 B.T.U., and the specific heat of steam is .45 B.T.U. If we wished to change the temperature of one pound of water from 69 deg. F. to 70 deg. F., we would have to add one B,T.U. of heat to it. If we wished to change the temperature of one pound of water from 70 deg. F. to 69 deg. F., we would have to remove one B.T.U. of heat from it.

## Specific Heat (Continued):

The direction of temperature change has no effect on the amount of heat that must be transferred.

## Changes Of State:

As we know, all matter exists as either a gas, liquid or solid. These are known as physical states. A change of state takes place when a given material is converted from one physical state into another. Since there are three physical states, it follows that four changes of state can take place -- two in each direction. For example, we can change ice into water or water into ice. We can change water into steam or steam into water.

In both cases, the physical change is completed without causing any temperature change in the material. For example, the latent heat of vaporization of water is 970 B.T.U.'s. If we had a pound of water with a temperature of 212 deg. F. and we added 970 B.T.U.'s of heat to it, we would have a pound of steam with a temperature of 212 deg. F. If we had a pound of steam with a temperature of 212 deg. F. and we removed 970 B.T.U.'s of heat from it, we would have a pound of water with a temperature of 212 deg. F. The figures used in this example are, of course, based on an atmospheric pressure of 14.7 pounds per square inch or 29.92 inches of Mercury.

## Latent Heat Of Fusion:

The latent heat of fusion of any given material is defined as the amount of heat which must be removed from one pound of that material in order to change it from a liquid state into a solid state. The same amount of heat must be added to one pound of that material in order to change it from a solid state into a liquid state. In both cases, the physical change is completed without causing any change in the temperature of the material. For example, the latent heat of fusion of water is 144 B.T.U's. If we had a pound of water with a temperature os 32 deg. F. and we removed 144 B.T.U.'s of heat from it, we would have a pound of ice with a temperature of 32 deg. F. If we had a pound of ice with a temperature of 32 deg. F. and we added 144 B.T.U.'s of heat to it, we would have a pound of water with a temperature of 32 deg. F.

### BOILING TEMPERATURES OF WATER AT CONVERTED PRESSURES

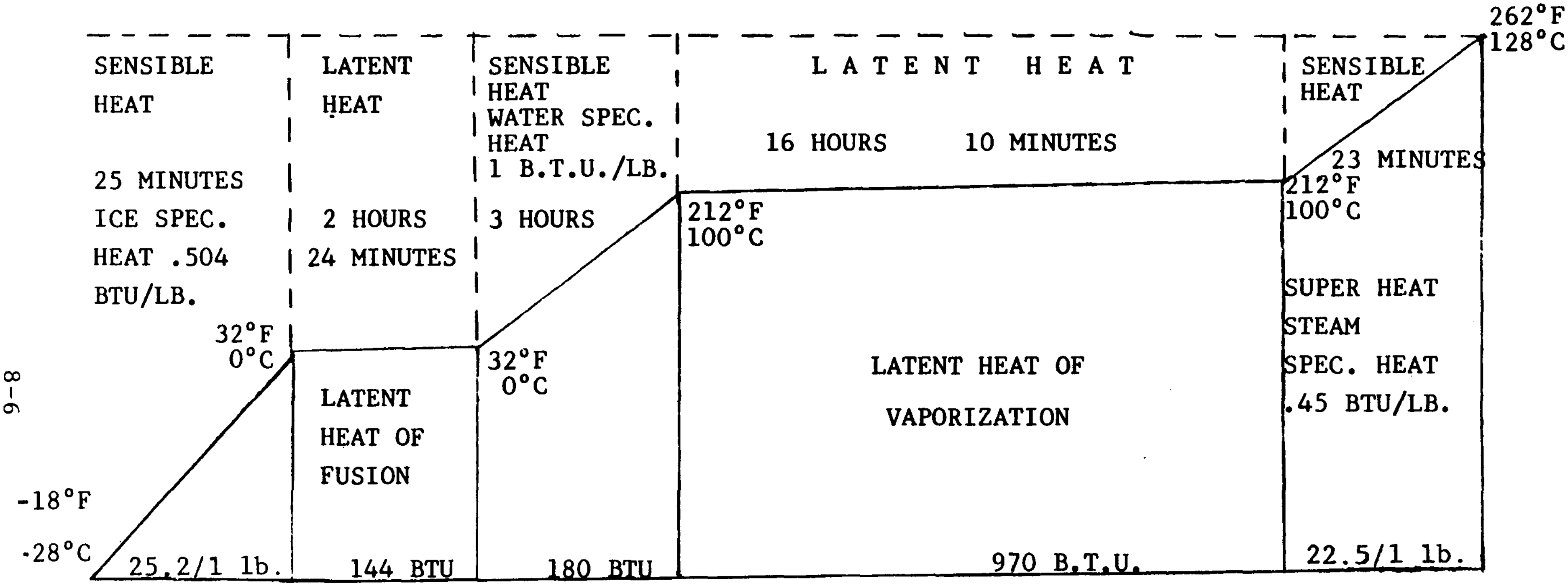
| Temperature in °F. | Inches of Mercury | Pounds Sq. In. (Pressure) | Microns* |
|---|---|---|---|
| 212° | 29.92 | 14.696 | 759,968 |
| 205° | 25.00 | 12.279 | 635,000 |
| 194° | 20.69 | 10.162 | 525,526 |
| 176° | 13.98 | 6.866 | 355,092 |
| 158° | 9.20 | 4.519 | 233,680 |
| 140° | 5.88 | 2.888 | 149,352 |
| 122° | 3.64 | 1.788 | 92,456 |
| 104° | 2.17 | 1.066 | 55,118 |
| 86° | 1.25 | .614 | 35,560 |
| 80° | 1.00 | .491 | 25,400 |
| 76° | .90 | .442 | 22,860 |
| 72° | .80 | .393 | 20,320 |
| 69° | .70 | .344 | 17,780 |
| 64° | .60 | .295 | 15,240 |

| Temperature in °F. | Inches of Mercury | Pounds Sq. In. (Pressure) | Microns* |
|---|---|---|---|
| 59° | .50 | .246 | 12,700 |
| 53° | .40 | .196 | 10,160 |
| 45° | .30 | .147 | 7,620 |
| 32° | .18 | .088 | 4,572 |
| 21° | .10 | .049 | 2,540 |
| 6° | .05 | .0245 | 1,270 |
| −24° | .01 | .0049 | 254 |
| −35° | .005 | .00245 | 127 |
| −60° | .001 | .00049 | 25.4 |
| −70° | .0005 | .00024 | 12.7 |
| −90° | .0001 | .000049 | 2.54 |

*Remaining pressure in system in microns*

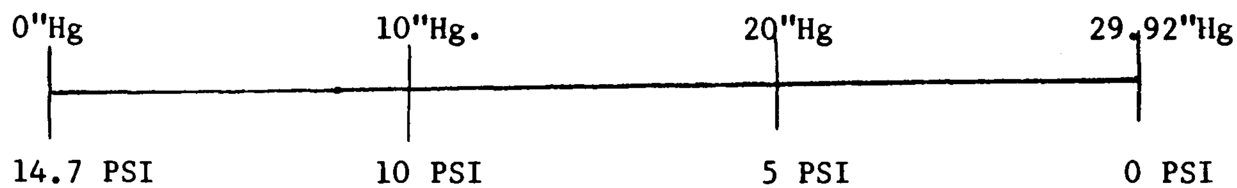
*1.000 inch = 25,400 microns = 2.540 CM = 25.40 MM*
*.100 inch = 2,540 microns = .254 CM = 2.54 MM*
*.039 inch = 1,000 microns = .100 CM = 1.00 MM*

# HEAT CHART




## VACUUM-PRESSURE RELATIONSHIP

VACUUM IN INCHES OF MERCURY (HG)




ATMOSPHERE IN POUNDS PER SQUARE INCH

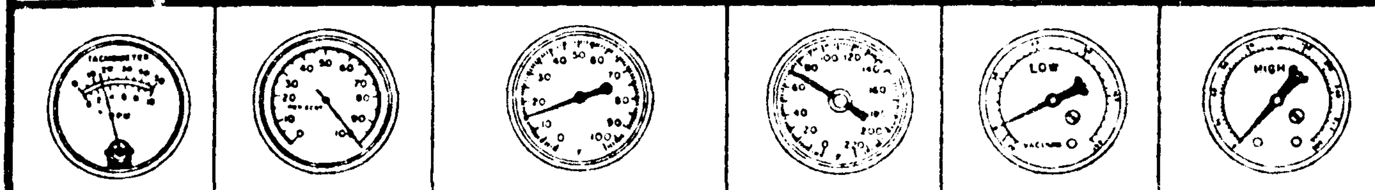
## TEMPERATURE-PRESSURE CHART FOR REFRIGERANT "12"

| TEMP. °F. | PRESS. OF REFRIG. | TEMP. °F. | PRESS. OF REFRIG. | TEMP. °F. | PRESS. OF REFRIG. | TEMP. °F. | PRESS. OF REFRIG. |
|---|---|---|---|---|---|---|---|
| 0 | 9.1 | 43 | 39.7 | 76 | 78.3 | 109 | 135.1 |
| 2 | 10.1 | 44 | 40.7 | 77 | 79.2 | 110 | 136.0 |
| 4 | 11.2 | 45 | 41.7 | 78 | 81.1 | 111 | 138.0 |
| 6 | 12.3 | 46 | 42.6 | 79 | 82.5 | 112 | 140.1 |
| 8 | 13.4 | 47 | 43.6 | 80 | 84.0 | 113 | 142.1 |
| 10 | 14.6 | 48 | 44.6 | 81 | 85.5 | 114 | 144.2 |
| 12 | 15.8 | 49 | 45.6 | 82 | 87.0 | 115 | 146.3 |
| 14 | 17.1 | 50 | 46.6 | 83 | 88.5 | 116 | 148.4 |
| 16 | 18.3 | 51 | 47.8 | 84 | 90.1 | 117 | 151.2 |
| 18 | 19.7 | 52 | 48.7 | 85 | 91.7 | 118 | 152.7 |
| 20 | 21.0 | 53 | 49.8 | 86 | 93.2 | 119 | 154.9 |
| 21 | 21.7 | 54 | 50.9 | 87 | 94.8 | 120 | 157.1 |
| 22 | 22.4 | 55 | 52.0 | 88 | 96.4 | 121 | 159.3 |
| 23 | 23.1 | 56 | 53.1 | 89 | 98.0 | 122 | 161.5 |
| 24 | 23.8 | 57 | 55.4 | 90 | 99.6 | 123 | 163.8 |
| 25 | 24.6 | 58 | 56.6 | 91 | 101.3 | 124 | 166.1 |
| 26 | 25.3 | 59 | 57.1 | 92 | 103.0 | 125 | 168.4 |
| 27 | 26.1 | 60 | 57.7 | 93 | 104.6 | 126 | 170.7 |
| 28 | 26.8 | 61 | 58.9 | 94 | 106.3 | 127 | 173.1 |
| 29 | 27.6 | 62 | 60.0 | 95 | 108.1 | 128 | 175.4 |
| 30 | 28.4 | 63 | 61.3 | 96 | 109.8 | 129 | 177.8 |
| 31 | 29.2 | 64 | 62.5 | 97 | 111.5 | 130 | 180.2 |
| 32 | 30.0 | 65 | 63.7 | 98 | 113.3 | 131 | 182.6 |
| 33 | 30.9 | 66 | 64.9 | 99 | 115.1 | 132 | 185.1 |
| 34 | 31.7 | 67 | 66.2 | 100 | 116.9 | 133 | 187.6 |
| 35 | 32.5 | 68 | 67.5 | 101 | 118.8 | 134 | 190.1 |
| 36 | 33.4 | 69 | 68.8 | 102 | 120.6 | 135 | 192.6 |
| 37 | 34.3 | 70 | 70.1 | 103 | 122.4 | 136 | 195.2 |
| 38 | 35.1 | 71 | 71.4 | 104 | 124.3 | 137 | 197.8 |
| 39 | 36.0 | 72 | 72.8 | 105 | 126.2 | 138 | 200.0 |
| 40 | 36.9 | 73 | 74.2 | 106 | 128.1 | 139 | 202.9 |
| 41 | 37.9 | 74 | 75.5 | 107 | 130.0 | 140 | 205.5 |
| 42 | 38.8 | 75 | 76.9 | 108 | 132.1 | | |

# HOW COLD IS COLD?

## AIR CONDITIONER PERFORMANCE CHART

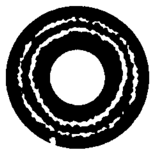
NOTE: THESE ARE APPROXIMATE READINGS.



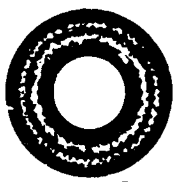
| ENGINE R.P.M. | RELATIVE HUMIDITY | OUTSIDE AIR TEMPERATURE | APPROX. DISCHARGE AIR TEMP. | LOW PRESSURE GAUGE | HIGH PRESSURE GAUGE |
|---|---|---|---|---|---|
| 1500 | 20 – 25 | 70 | 43 | 11 | 177 |
| | | 80 | 48 | 15 | 208 |
| | | 90 | 55 | 20 | 228 |
| | | 100 | 63 | 23 | 255 |
| 1500 | 30 – 35 | 70 | 45 | 12 | 181 |
| | | 80 | 51 | 16 | 214 |
| | | 90 | 59 | 22 | 234 |
| | | 100 | 67 | 26 | 267 |
| 1500 | 40 – 45 | 70 | 47 | 13 | 185 |
| | | 80 | 54 | 18 | 220 |
| | | 90 | 62 | 24 | 243 |
| | | 100 | 72 | 29 | 278 |
| 1500 | 50 – 55 | 70 | 49 | 14 | 189 |
| | | 80 | 57 | 19 | 226 |
| | | 90 | 66 | 26 | 251 |
| | | 100 | 77 | 32 | 289 |
| 1500 | 60 – 65 | 70 | 51 | 15 | 193 |
| | | 80 | 60 | 21 | 233 |
| | | 90 | 70 | 28 | 259 |
| | | 100 | 82 | 35 | 300 |
| 1500 | 70 – 75 | 70 | 53 | 16 | 198 |
| | | 80 | 63 | 22 | 238 |
| | | 90 | 73 | 30 | 267 |
| | | 100 | 88 | 37 | 312 |
| 1500 | 80 – 85 | 70 | 55 | 18 | 202 |
| | | 80 | 65 | 24 | 244 |
| | | 90 | 77 | 32 | 277 |
| | | 100 | 90 | 39 | 316 |
| 1500 | 90 – 95 | 70 | 58 | 19 | 206 |
| | | 80 | 68 | 25 | 250 |
| | | 90 | 81 | 34 | 284 |
| | | 100 | 95 | 41 | 321 |

AIR CONDITIONING
HOSES, FITTINGS
AND O RINGS

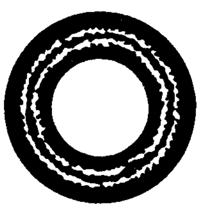
**Double Braid
Freon Hose**



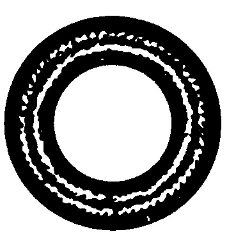
3/8"-6 5/16"-I.D.
3/4"-O.D.



1/2"-8 13/32"-I.D.
29/32"-O.D.

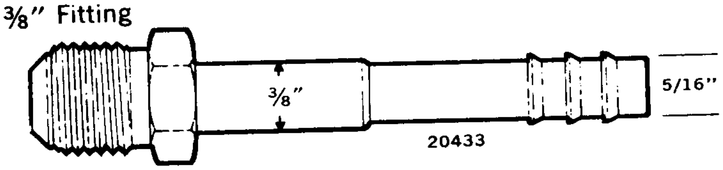


5/8"-10 1/2"-I.D.
1"-O.D.

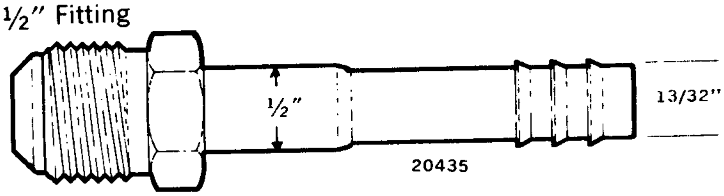


3/4"-12 5/8"-I.D.
1 1/8"-O.D.

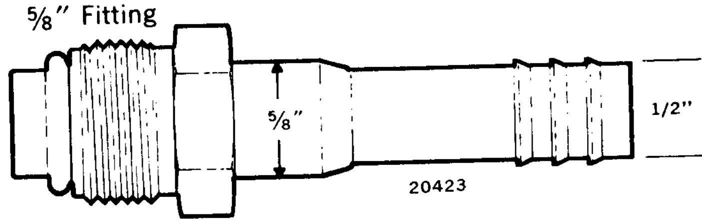
3/8" Fitting



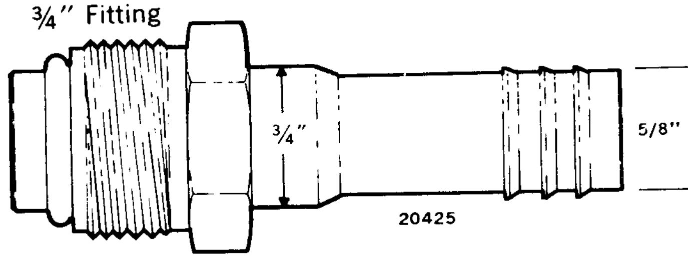

1/2" Fitting




5/8" Fitting




3/4" Fitting




**"O" Rings**

## THE REFRIGERATION CYCLE

The modern automobile air conditioning system has more refrigeration capacity than most typical home units. During operation, it performs four functions: cooling, drying, circulating and cleaning.

To cool the air, an air conditioner has a refrigeration system which consists of five basic parts: the compressor, the condenser, the evaporator, the receiver and a refrigerant flow-control valve of some sort (thermostatic expansion valve or orifice tube).

1. The compressor is a high pressure pump driven by the engine. To pump, it uses reciprocating pistons or rotating vanes. The pumping action causes a vacuum which pulls low-pressure refrigerant vapor from the evaporator. The compressor raises this vapor to a high pressure and sends it to the condenser where the high-temperature, high-pressure vapor loses heat and becomes a liquid.

2. A condenser is a heat exchange unit in the same fashion as the engine's radiator. Vapor enters, loses heat and becomes a liquid. Heat is exchanged from the tubes and fins to the airflow passing over the condenser.

3. The other heat exchange unit of the system is the evaporator. It is located in the passenger compartment and either outside or recirculated air passes over it before being ducted to the occupants.

4. The receiver is a device which stores refrigerant until the evaporator is ready to accept it. The receiver is located in the refrigerant line between the condenser and the evaporator.

5. The refrigerant flow control valve limits the amount of refrigerant that can enter the evaporator. Two common types are the fixed orifice (orifice tube) and the thermostatic expansion valve (T.X.V.).

Connecting these five basic parts are hoses and/or tubes which carry the refrigerant. To see how the system works, we will follow the refrigerant, starting at the compressor.

The compressor draws low-pressure refrigerant vapor from the evaporator. Then the compressor compresses the low-pressure vapor to a high-pressure vapor. During compressions, the vapor is heated to a much higher temperature than the air passing over the condenser. As the hot compressed vapor enters the condenser, it loses much of its heat to the air.

As the refrigerant vapor cools, it condenses into a high-pressure liquid and accumulates in the receiver. The entrance of refrigerant into the evaporator is controlled by a valve or orifice which restricts the refrigerant line. As a result, more refrigerant reaches the restriction than can pass through it.

As some of the refrigerant passes through the restriction, the pressure on the liquid passing through is reduced. The refrigerant enters the evaporator as a low-pressure liquid.

At this low pressure, the liquid absorbs heat, boils and turns into a low-pressure vapor. The air passing over the evaporator loses heat and is reduced in temperature before reaching the passengers. The warm, low-pressure vapor then is drawn into the compressor to repeat the process, which continues as long as the compressor is turning.

A by-product of the cooling generated in the refrigeration cycle is that the air is dryed and cleaned. As the air passes through the evaporator, moisture condenses on the cool tubes and fins. Water-vapor molecules from the warm air are trapped by the cold metal and clump together to form liquid water, which then drips off. Dirt particles in the air get trapped on the wet surface and are carried away with the drops.

Therefore, with the addition of a fan or blower, the air conditioner accomplishes four things: cooling, drying, cleaning and circulation. The dry, cool, circulating air removes heat from the passengers' skin, making them feel comfortable.

## REFRIGERATION SYSTEM CONTROLS

Two basic controls are required for proper system operation. First, a restriction in the line feeding the evaporator and, second, a valve or switch to prevent evaporator icing.

1. Restriction. There must be a restriction to cause a pressure differential. This is placed at the entrance to the evaporator to keep the refrigerant as a high-pressure liquid in the condenser and receiver and as an easy to boil low pressure liquid in the evaporator.

2. Anti-Icing Controls. A second control is needed to prevent the evaporator from becoming so cold that the moisture in the air freezes on the evaporator, blocking the airflow. A temperature or pressure sensitive valve which can reduce the refrigerant flow into the evaporator may be used, or a switch capable of cycling the compressor when evaporator pressure or temperature falls too low.

## THERMOSTATIC EXPANSION VALVE

Many air-conditioning systems use a thermostatic expansion valve (T.X.V.) as the restriction between the condenser and evaporator. The valve includes a temperature sensing bulb, a diaphragm and a spring-loaded ball valve. The bulb is in contact with the evaporator core or inlet line. As the core warms up the bulb, its internal expansion signals the diaphragm to open the T.X.V. and allow more liquid refrigerant to enter the evaporator, cooling it. If the evaporator becomes too cool, the bulb will signal the T.X.V. to shut off the flow of liquid refrigerant. The variable orifice diameter of most T.X.V.'s can vary from fully closed to about .040 inches.

### FIXED ORIFICE TUBE

The fixed orifice or orifice tube, also called the expansion tube, is a small diameter (typically about .072 inches) section in the inlet line to the evaporator. Its size remains constant and is more resistant to plugging with dirt than a T.X.V. Because the orifice size cannot change to reduce liquid refrigerant flow when evaporator temperatures fall to the icing point, this system incorporates some method of cycling the compressor clutch. An air conditioner using an orifice tube is often referred to as a C.C.O.T. system (cycling clutch orifice tube).

### SUCTION-THROTTLING VALVE

In air conditioners that do not cycle the clutch, the compressor runs all the time. The amount of cooling may then be regulated by the operation of a suction throttling valve (S.T.V.).

To prevent evaporator icing, the S.T.V. monitors evaporator outlet pressure. Spring and atmospheric pressure oppose the outlet pressure to maintain 28 P.S.I. At lower pressures the evaporator would likely ice up, and at higher pressures may not give maximum cooling. A vacuum element which compensates for altitude changes receives engine vacuum when the A/C control lever is in the maximum cooling position.

### ELECTRIC PRESSURE SWITCH

This device is similar to the S.T.V. system, but simpler. It also senses evaporator outlet pressure, but maintains it by cycling the compressor clutch. If evaporator outlet pressure stays over 28 P.S.I., the contacts stay closed and the compressor runs. When outlet pressure drops below 28 P.S.I., the contacts open and the clutch disengages.

### THERMOSTATIC CYCLING SWITCH

This control mechanism senses the temperature in the evaporator inlet tube with a capillary bulb and will cycle the compressor to keep the evaporator from icing. In after-market hang-down units this switch also has a control knob so that evaporator temperatures can be controlled over a wide range. At the coldest setting, the switch will still cycle the compressor before evaporator icing occurs.

### RECEIVER-DEHYDRATOR

This component, also called the receiver-dryer, has four main functions:

1. To receive liquid refrigerant from the condenser and hold it in reserve for the evaporator.

2. To filter out any dirt or other foreign particles from the refrigerant.

3. To absorb any small amount of moisture that is circulating through the system. The receiver contains a bag of dessicant, a chemical which soaks up any moisture before it can do harm to the system.

4. To trap any refrigerant which did not liquify in the condenser and hold it until it condenses.

## SIGHT GLASS

Many air conditioning systems have a sight glass either in the condenser outlet line or in the receiver-dryer. This is intended as a diagnostic device and is not intended to read the proper refrigerant charge. Observation of pressures and temperatures give a much more accurate method of determining system condition and proper operation.

## REFRIGERANT

Refrigerant is a very special substance. It is a liquid at low temperature and a vapor at fairly low temperatures. The refrigerant used in automotive air conditioners boils at -22 deg. F. at atmospheric pressure.

The ideal refrigerant must not be toxic or poisonous, flammable or explosive. It must be reasonably inert and not cause damage to any metal, rubber or substance it touches. The refrigerant that has all these desirable qualities is a substance created by chemists. It is called dichlorodiflouromethane and is commonly known as Freon-12, Refrigerant 12, R-12 or simply Freon. It has the chemical formula CCl2F2. However, "Freon" is actually the trademark of the manufacturer, Du Pont.

**CAUTION**: **Although R-12 is safe if handled properly, it is dangerous when handled carelessly or improperly. If you get R-12 on your hand, it will freeze the flesh, be very painful and may cause permanent injury. If you get R-12 in your eye, it can freeze the eye and cause loss of sight. Also, if R-12 comes in contact with a flame, it turns into poisonous phosgene gas.**

## REFRIGERANT OIL

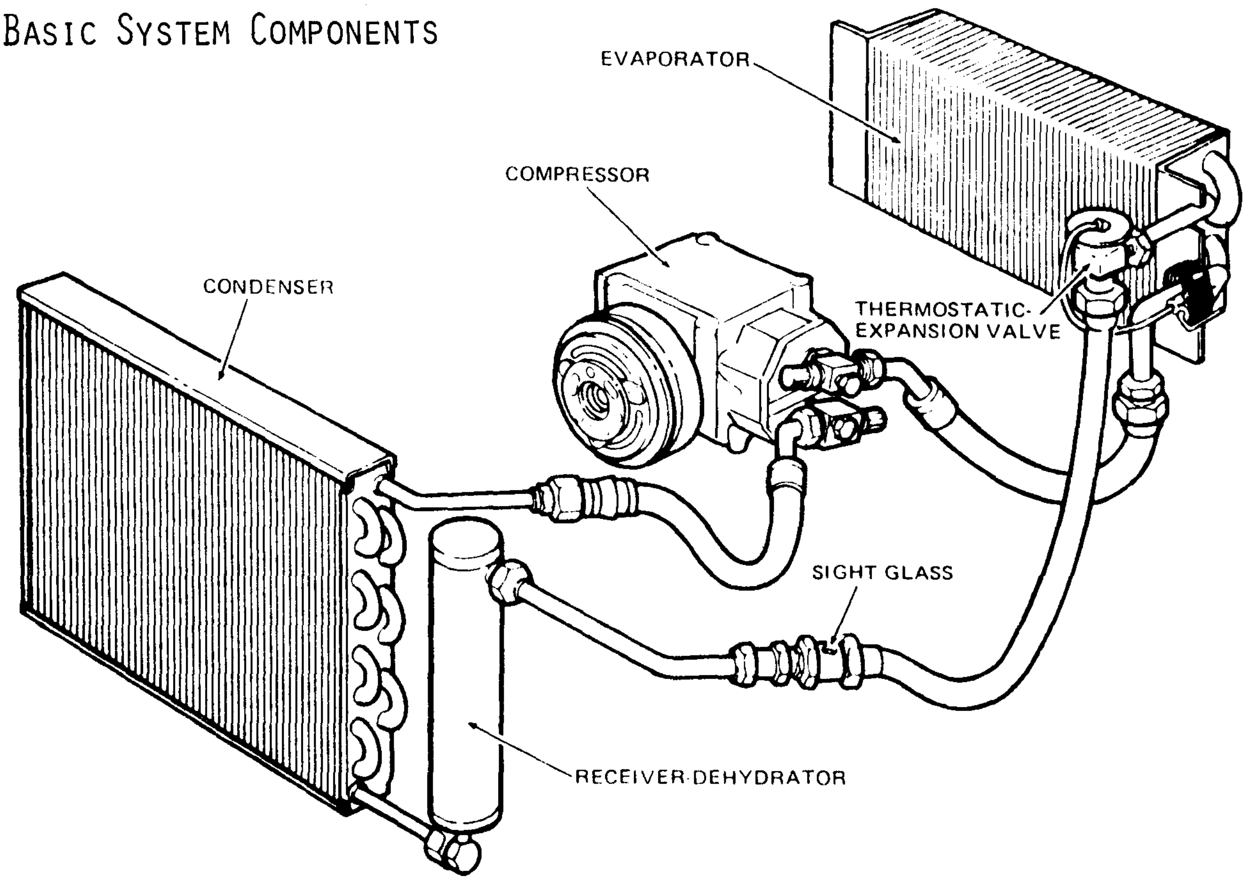
The air-conditioning system needs oil to keep the moving parts and seals lubricated. This is a special highly refined oil which is non-foaming and has impurities such as wax, moisture and sulfur removed. The majority of this oil remains in the sump of the compressor and the amount must be carefully controlled as it is difficult to check or accurately add oil. As this oil tends to attract water, it should be in a tightly sealed container when stored.

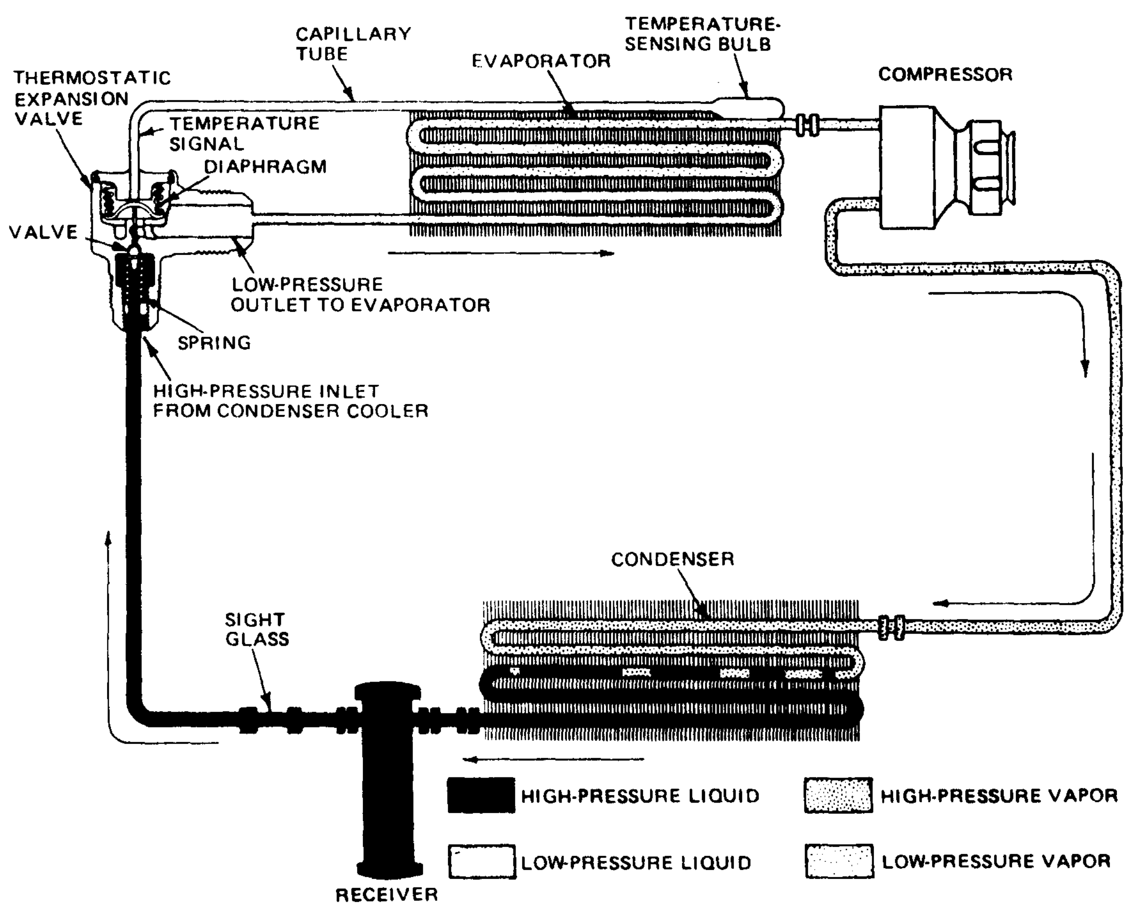
## MOISTURE IN THE REFRIGERATION SYSTEM

Even a trace of moisture can cause trouble in the refrigerant system of an air conditioner. Moisture can combine with the metals in the system, producing oxides. Moisture can also combine with the refrigerant to produce a variety of acids. Oxides and acids can cause the valves and compressor to malfunction and the system to cool poorly. Moisture may also freeze up the valves, and this can cause the system to fail.

The receiver contains a bag of dessicant, which is a moisture-absorbing chemical. Under normal conditions, this chemical absorbs any moisture that gets into the system when it is first assembled. However, if the system is opened improperly for service, then more moisture can enter and cause system failure. The job of the dessicant is to prevent this.

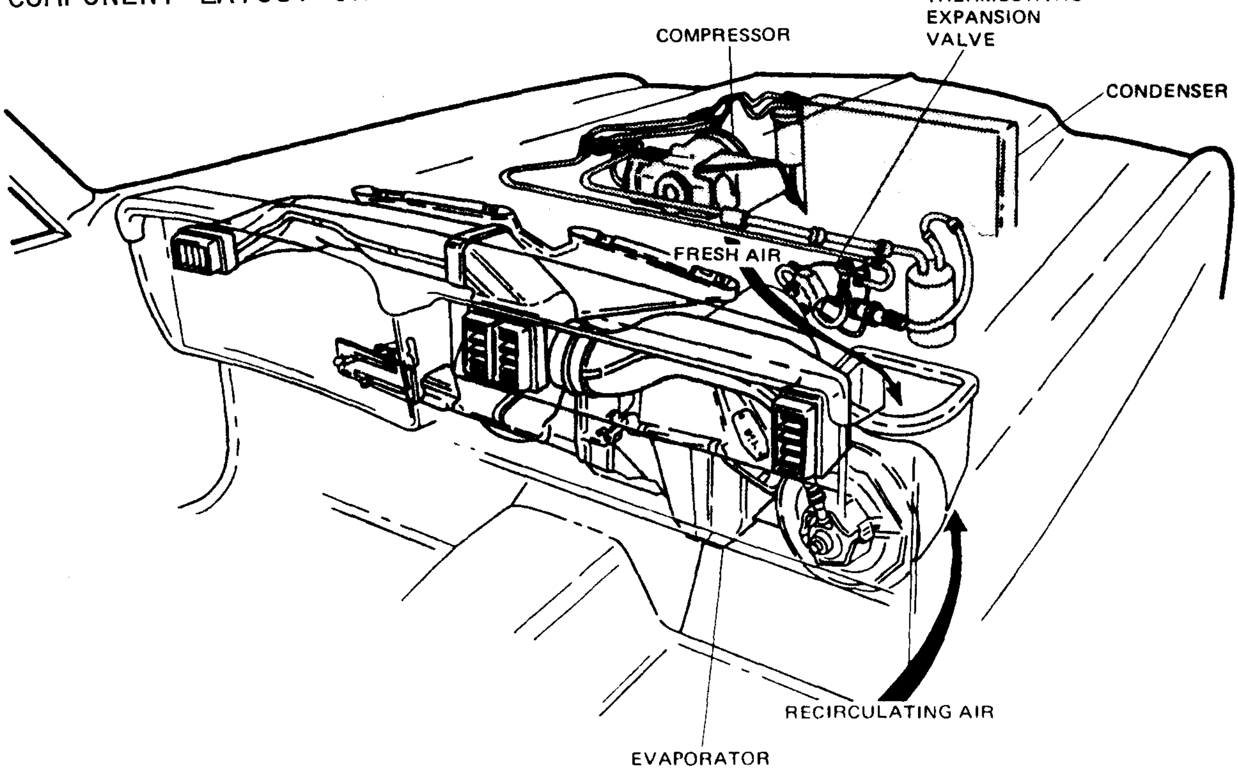
# Basic System Components



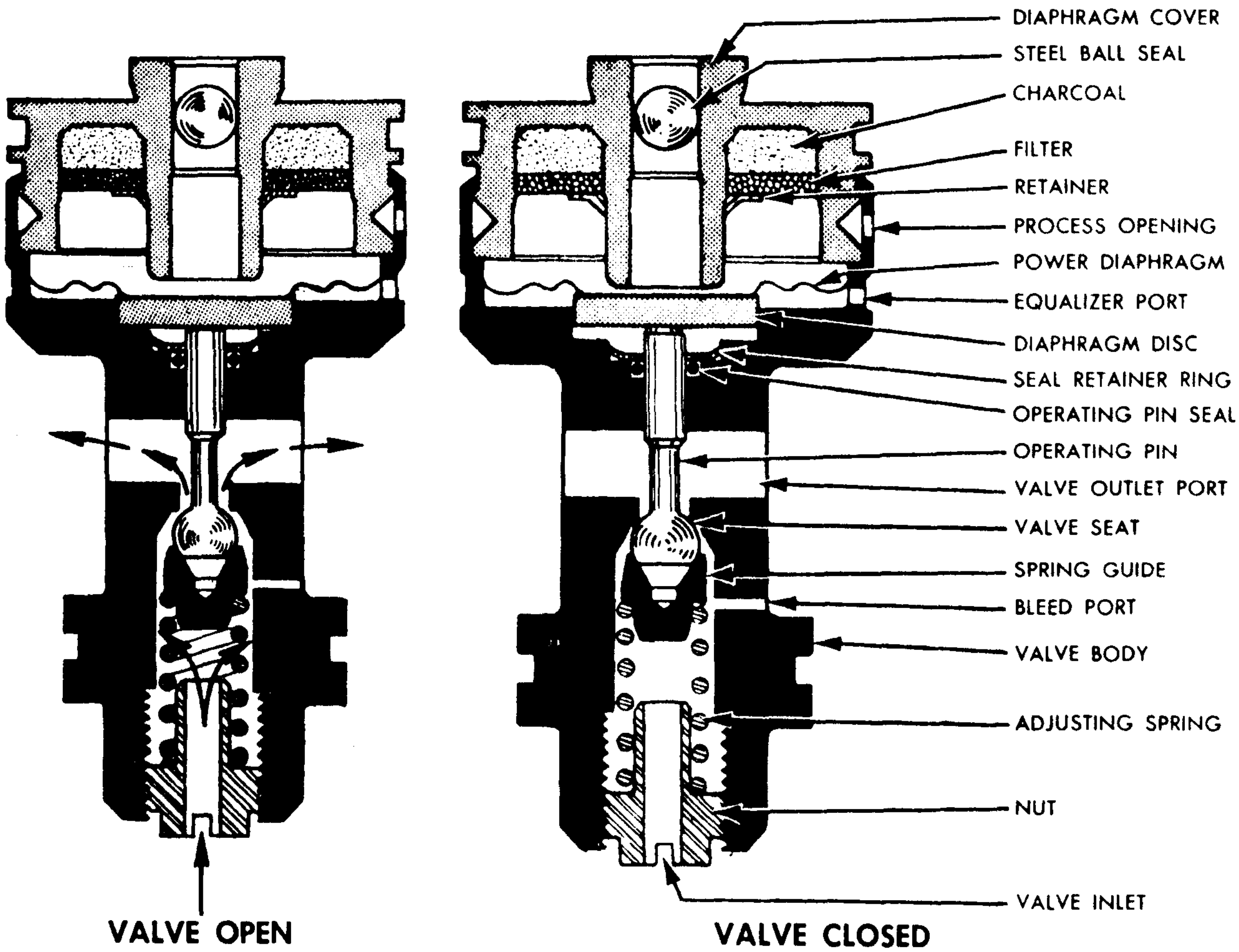




Refrigerant Flow in TXV System

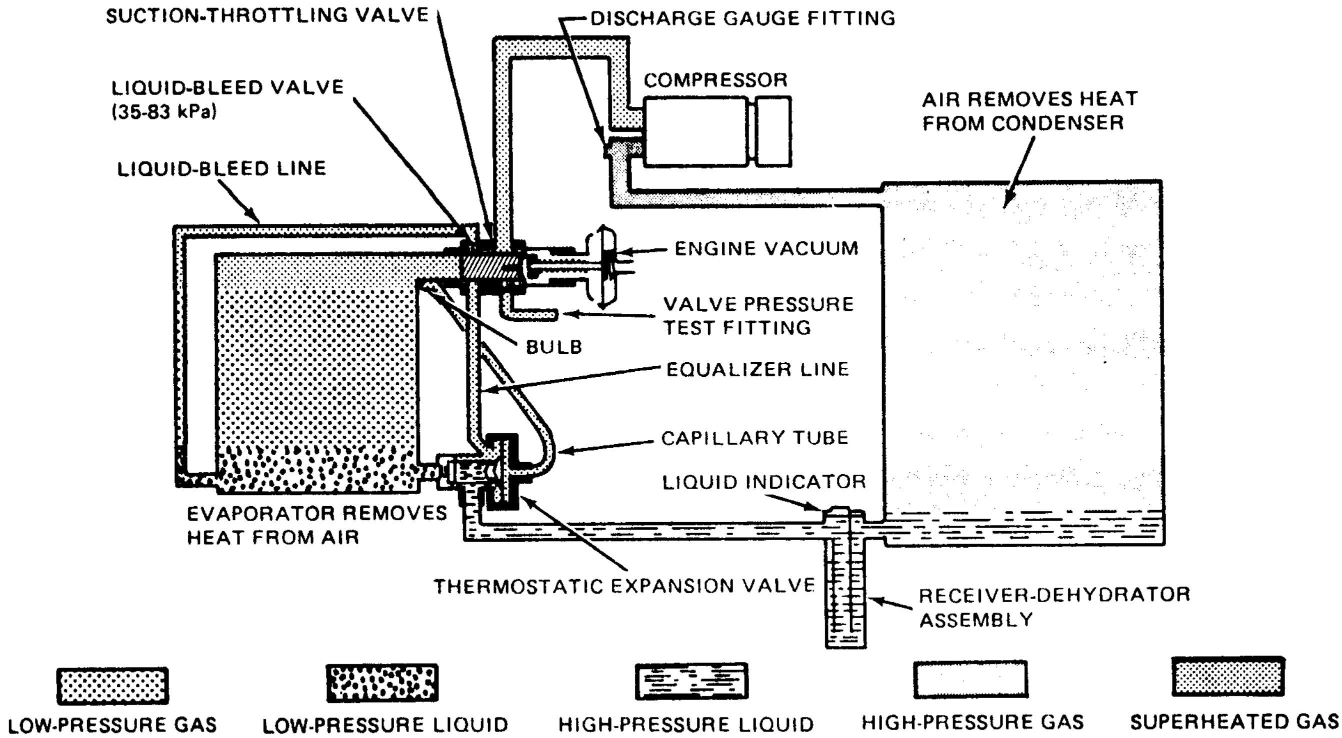
## Component Layout in Car



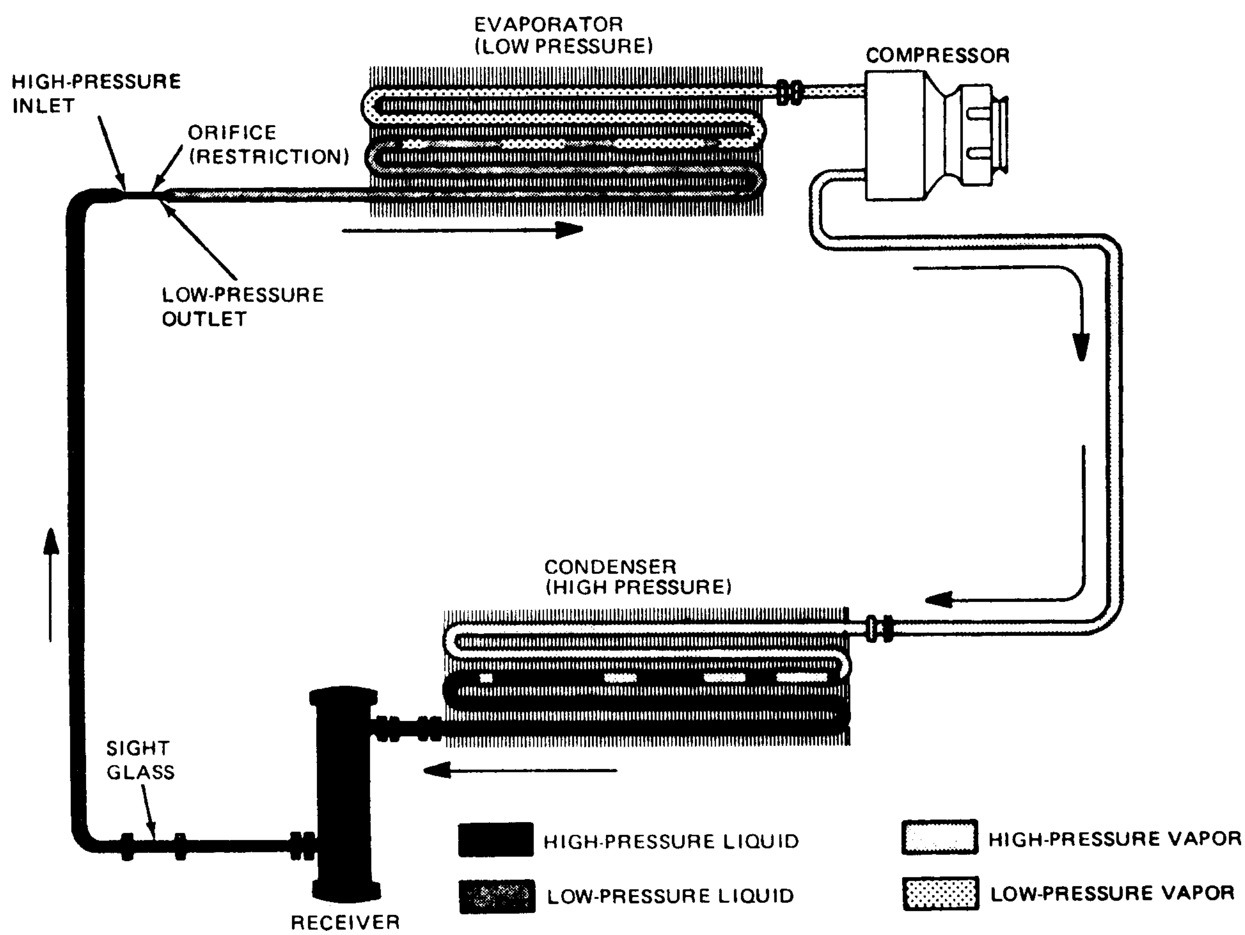

## Thermostatic Expansion Valve (TXV)



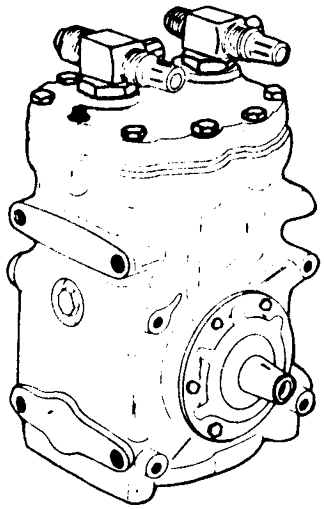
# Suction Throttling Valve System



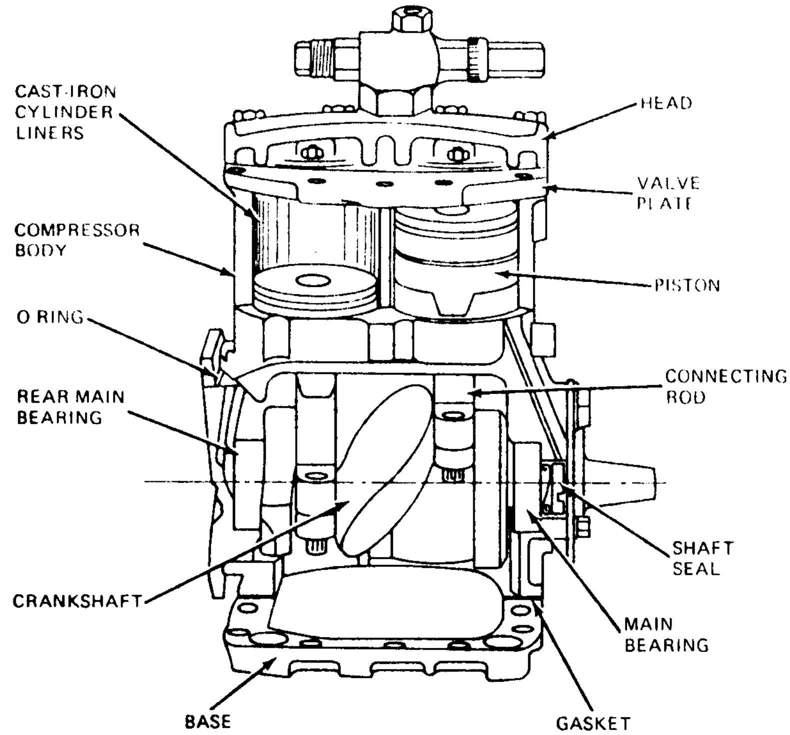

# Fixed Orifice Tube System

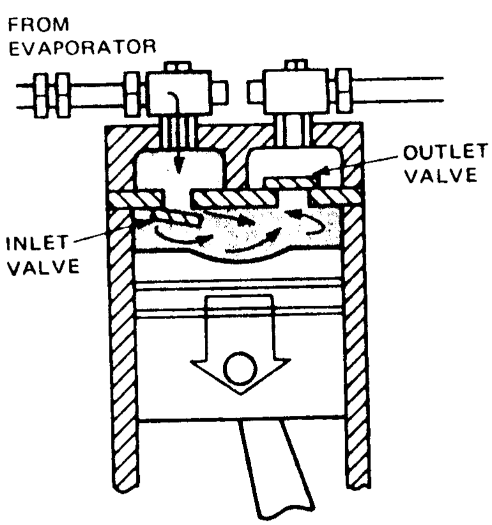


# Parallel Cylinder Compressor Components

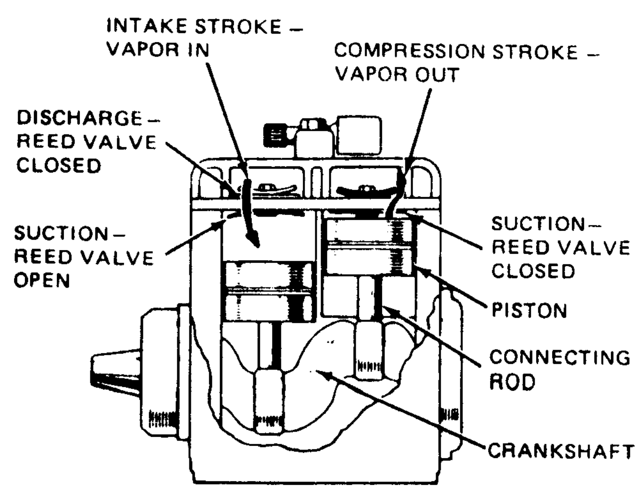


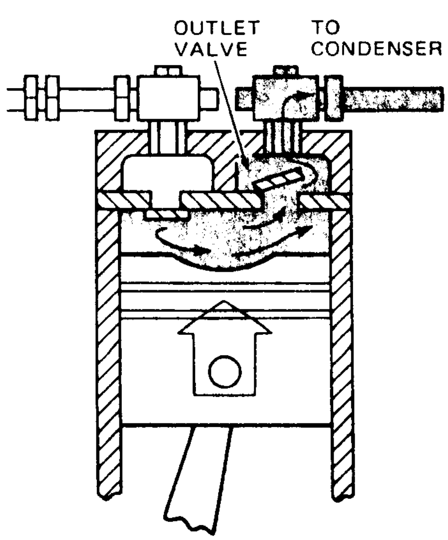
TECUMSEH OR YORK TWO-CYLINDER SQUARE COMPRESSOR



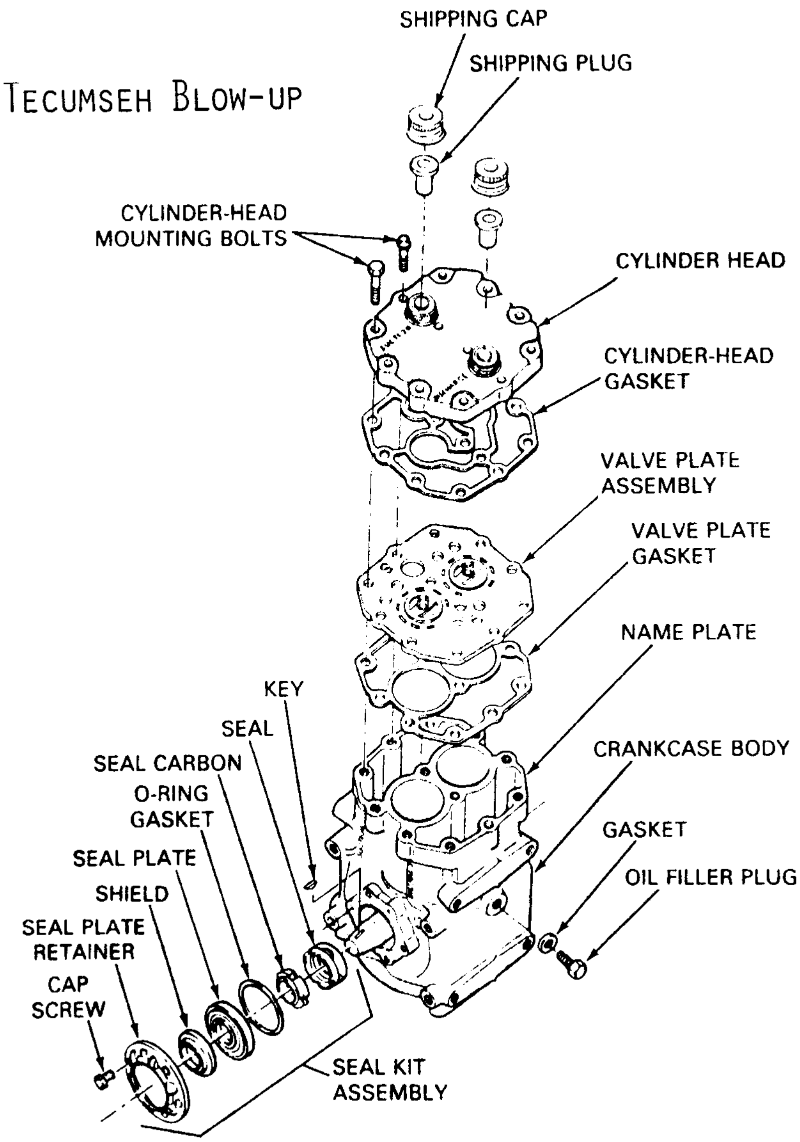

INTAKE

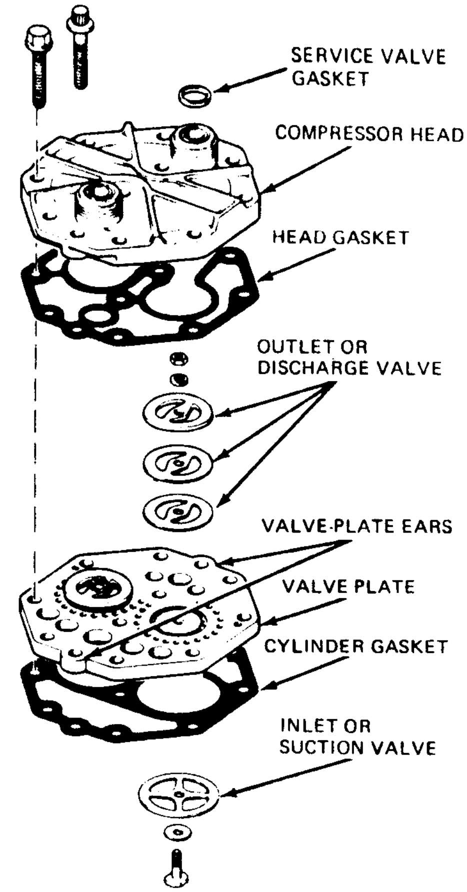


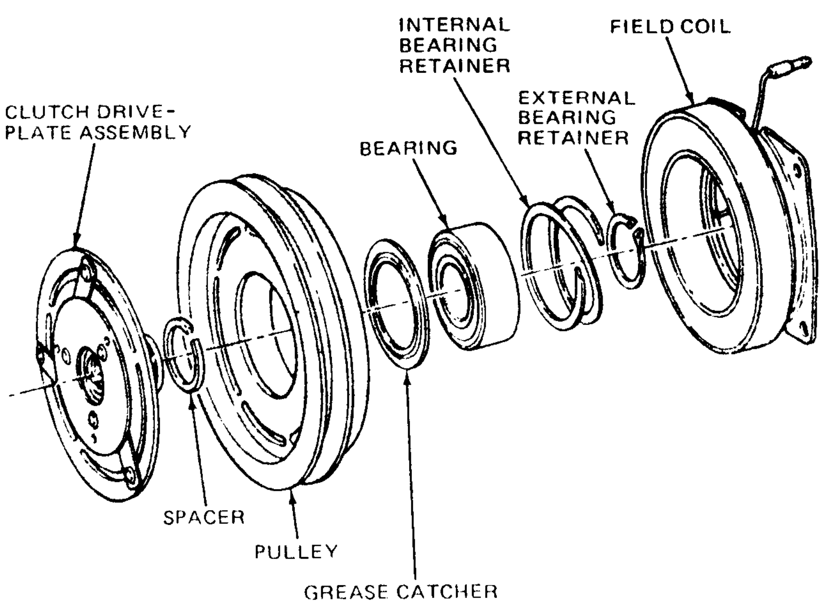




COMPRESSION

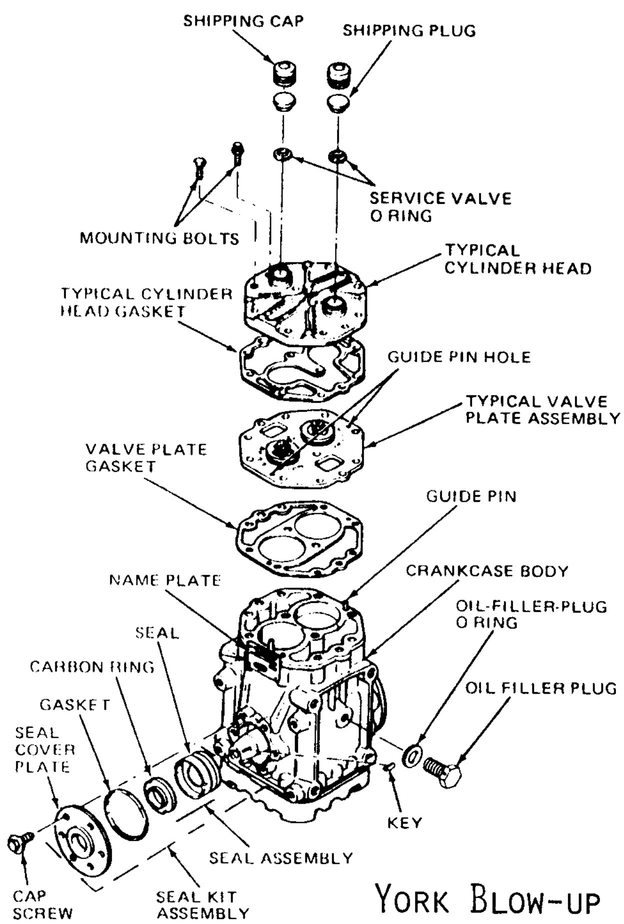
# TECUMSEH BLOW-UP



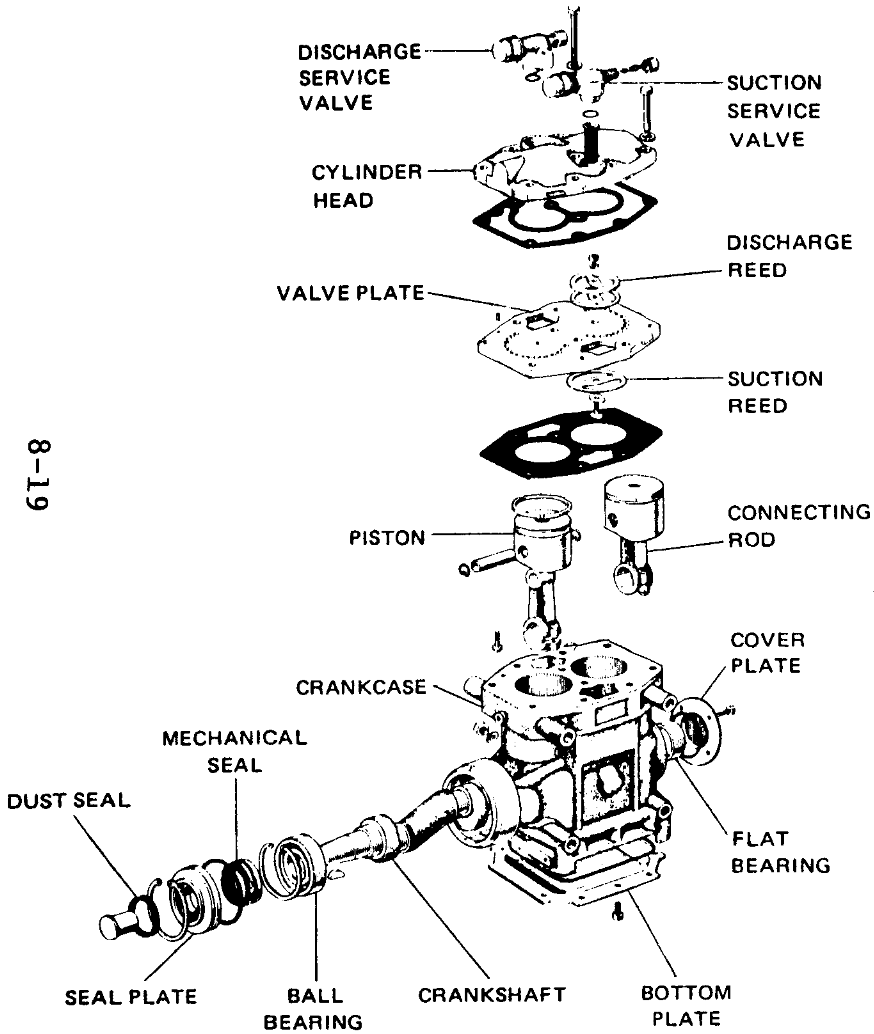




# MAGNETIC CLUTCH COMPONENTS

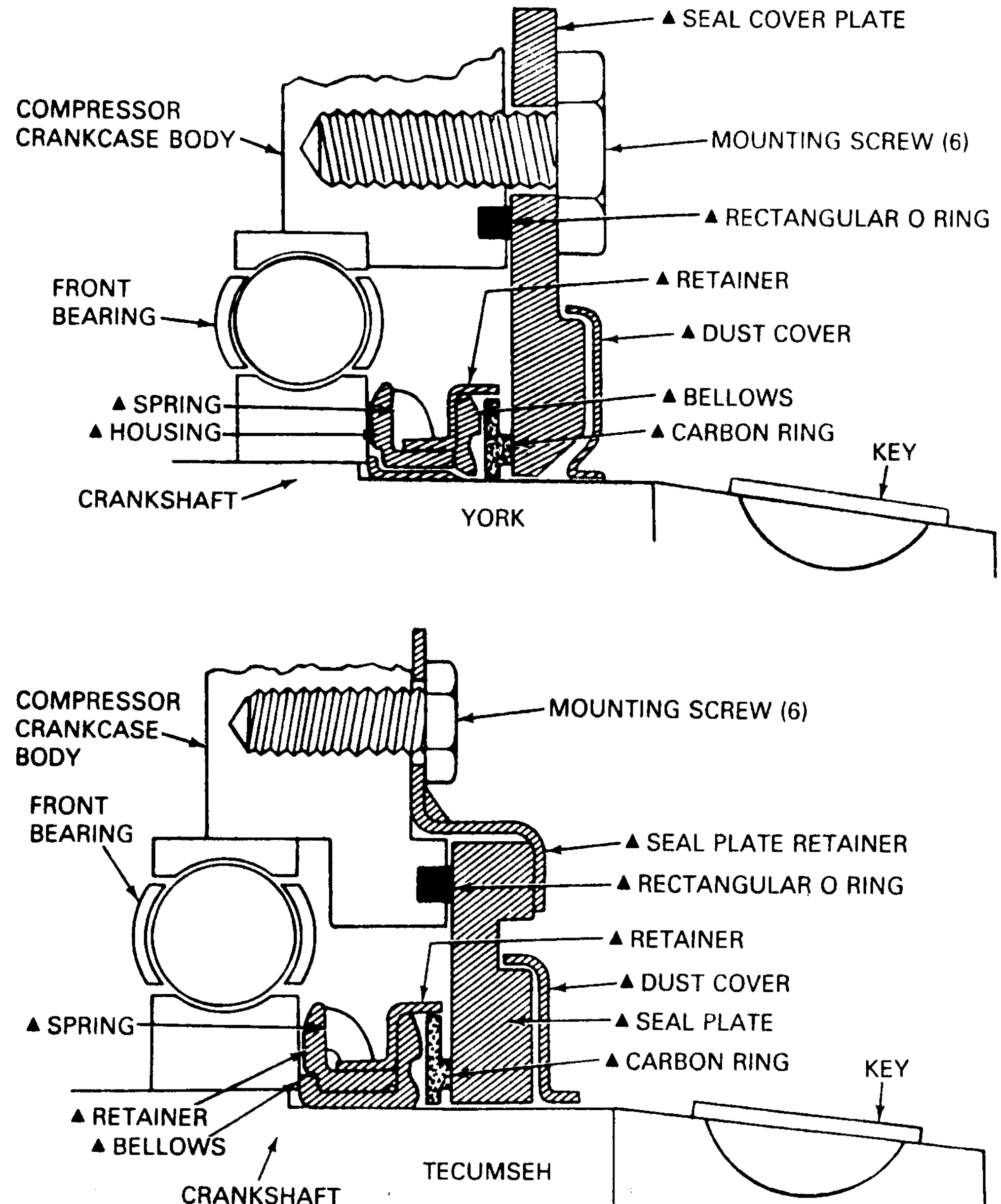



# YORK BLOW-UP



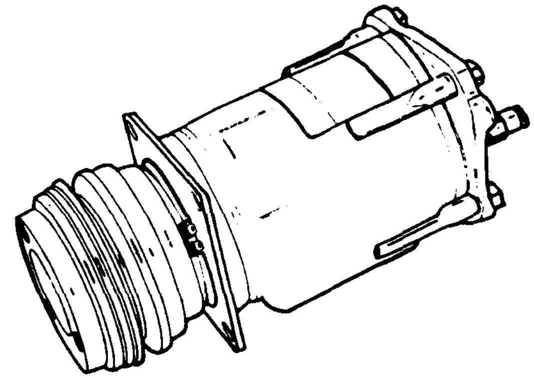

Typical Import Two-Cylinder

## York and Tecumseh Shaft Seals

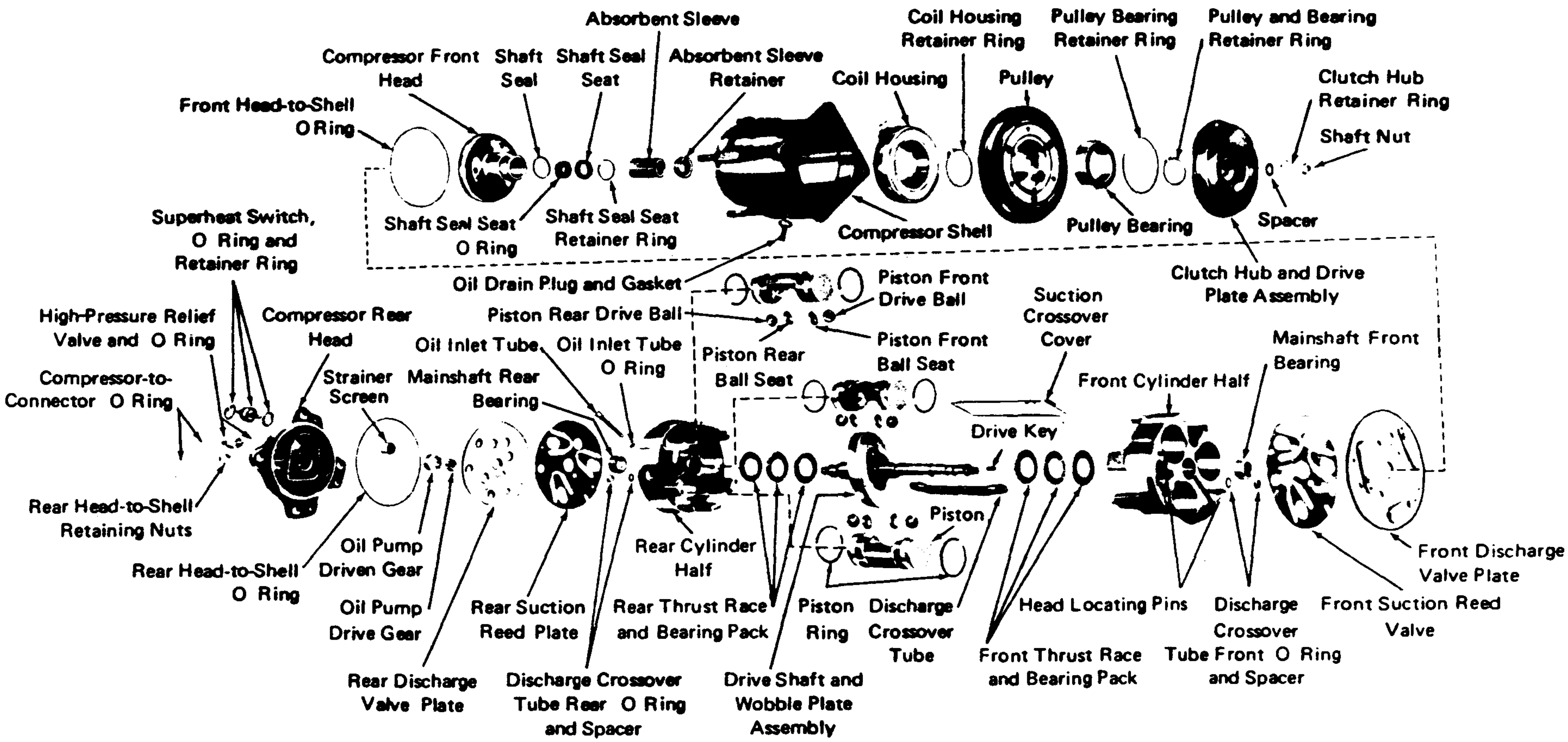


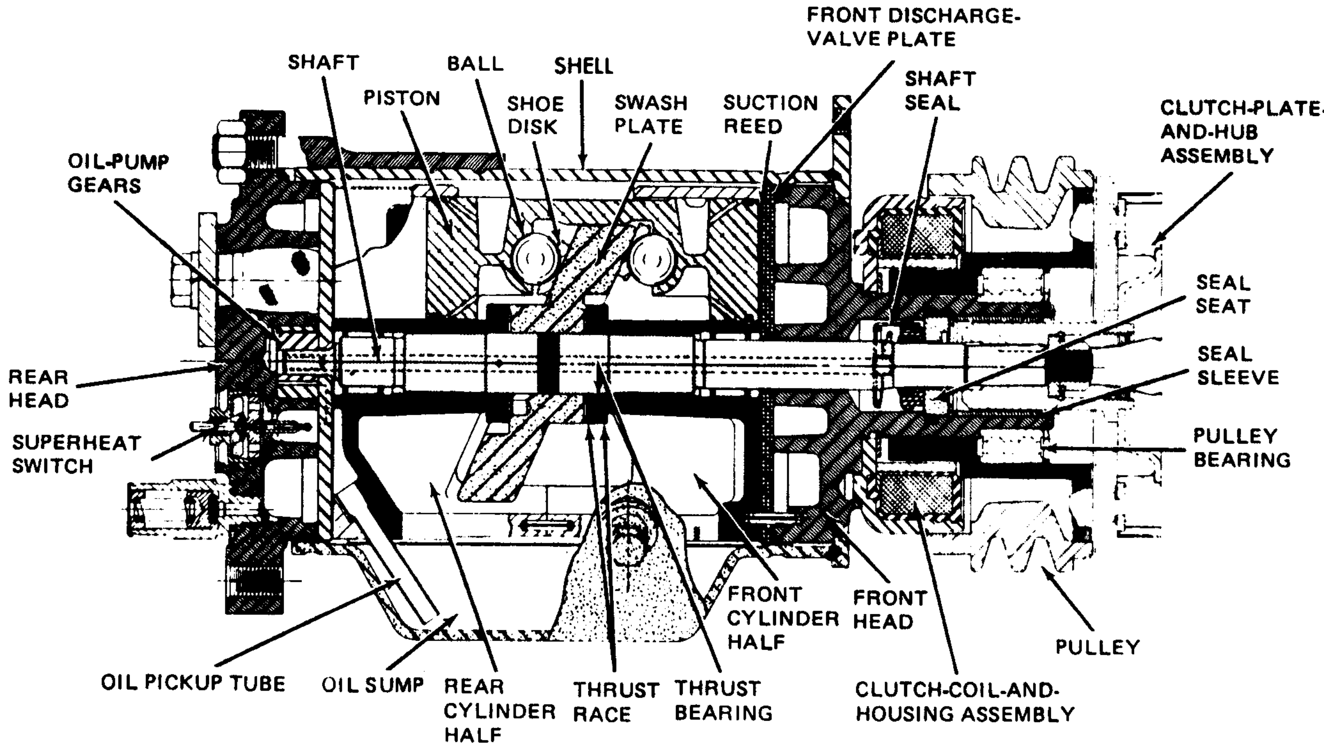

▲ INDICATES SERVICED IN SEAL KIT

# General Motors Six-Cylinder Components



GENERAL MOTORS SIX-CYLINDER
ROUND COMPRESSOR




FRONT DISCHARGE-
VALVE PLATE
SHAFT
BALL
SHELL
PISTON
SHOE
DISK
SWASH
PLATE
SUCTION
REED
SHAFT
SEAL
CLUTCH-PLATE-
AND-HUB
ASSEMBLY
OIL-PUMP
GEARS
SEAL
SEAT
REAR
HEAD
SEAL
SLEEVE
SUPERHEAT
SWITCH
PULLEY
BEARING
FRONT
CYLINDER
HALF
FRONT
HEAD
PULLEY
OIL PICKUP TUBE
OIL SUMP
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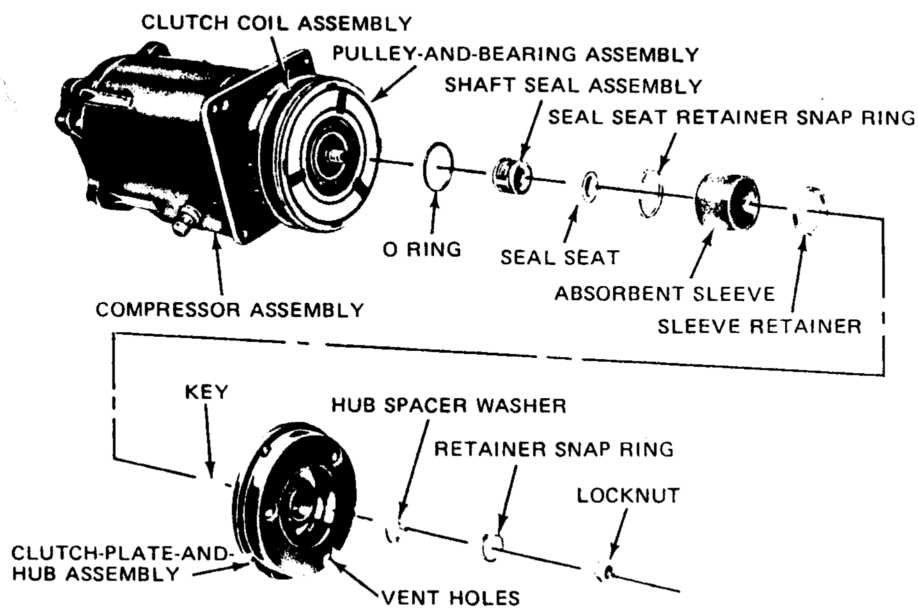
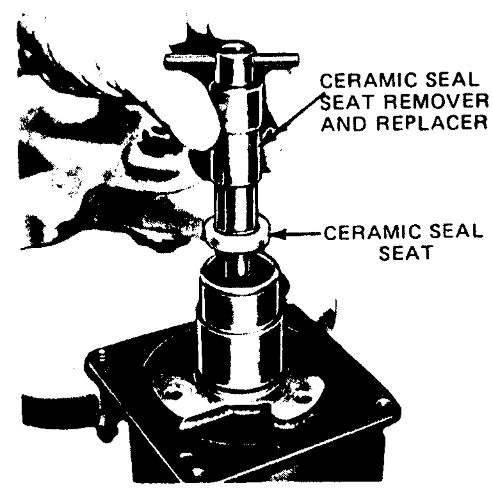
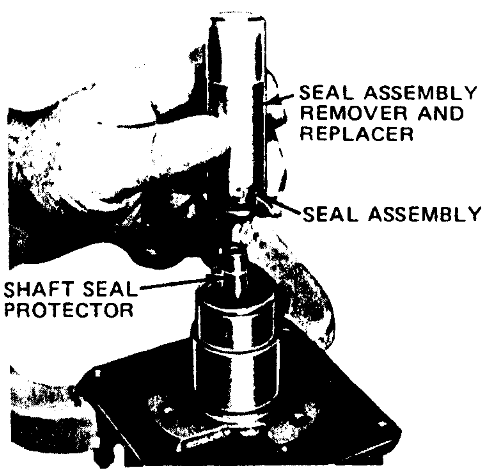
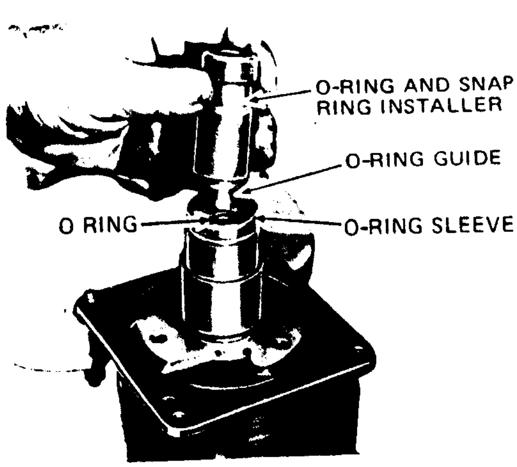
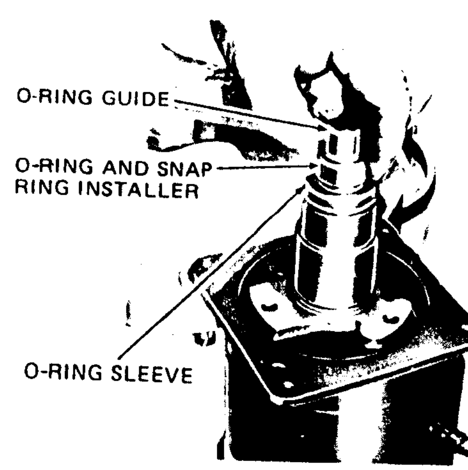
CYLINDER
HALF
THRUST
RACE
THRUST
BEARING
CLUTCH-COIL-AND-
HOUSING ASSEMBLY


CLUTCH COIL ASSEMBLY
PULLEY-AND-BEARING ASSEMBLY
SHAFT SEAL ASSEMBLY
SEAL SEAT RETAINER SNAP RING
O RING
SEAL SEAT
ABSORBENT SLEEVE
SLEEVE RETAINER
COMPRESSOR ASSEMBLY
KEY
HUB SPACER WASHER
RETAINER SNAP RING
LOCKNUT
CLUTCH-PLATE-AND-
HUB ASSEMBLY
VENT HOLES

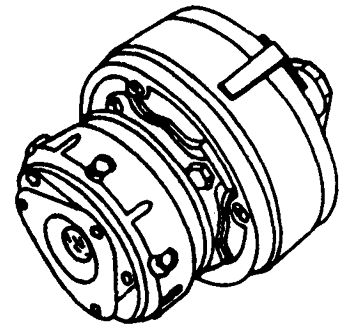

CERAMIC SEAL
SEAT REMOVER
AND REPLACER
CERAMIC SEAL
SEAT


SEAL ASSEMBLY
REMOVER AND
REPLACER
SEAL ASSEMBLY
SHAFT SEAL
PROTECTOR

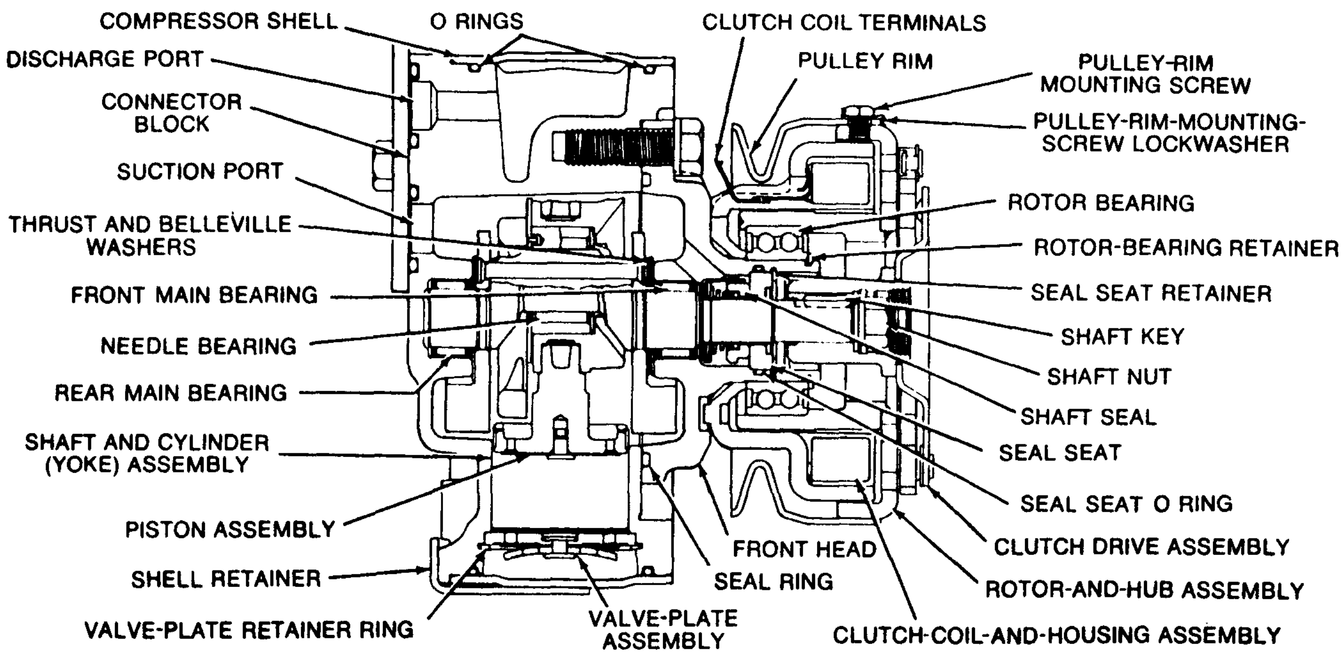

O-RING AND SNAP
RING INSTALLER
O-RING GUIDE
O RING
O-RING SLEEVE

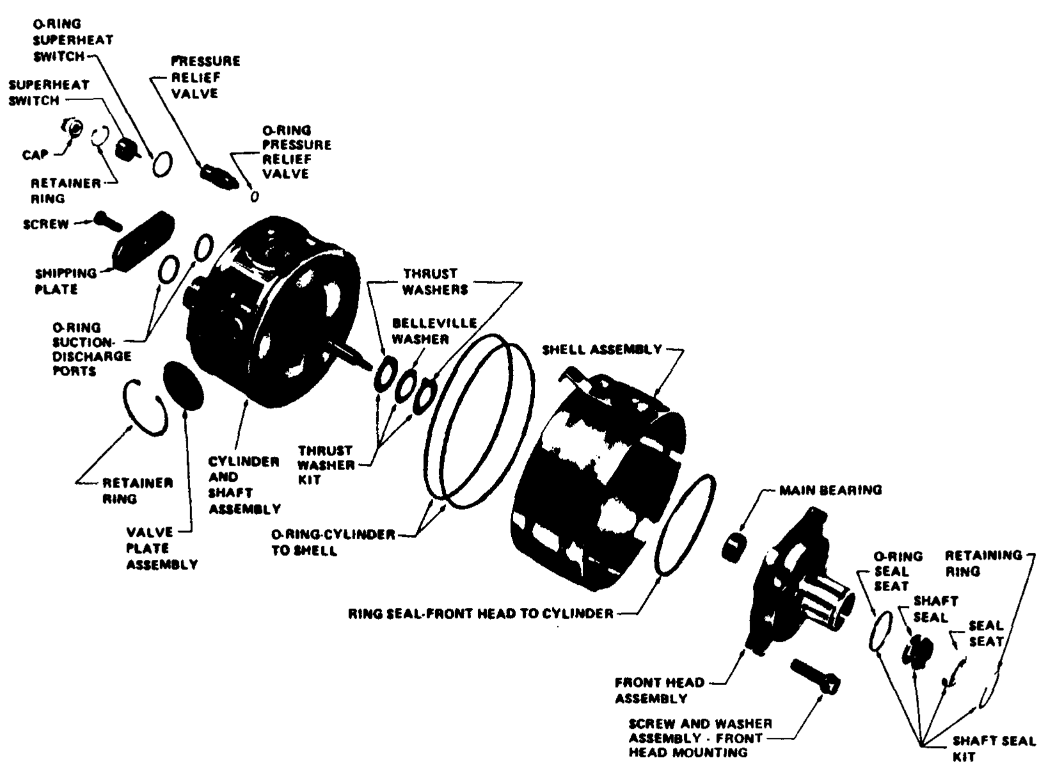

O-RING GUIDE
O-RING AND SNAP
RING INSTALLER
O-RING SLEEVE

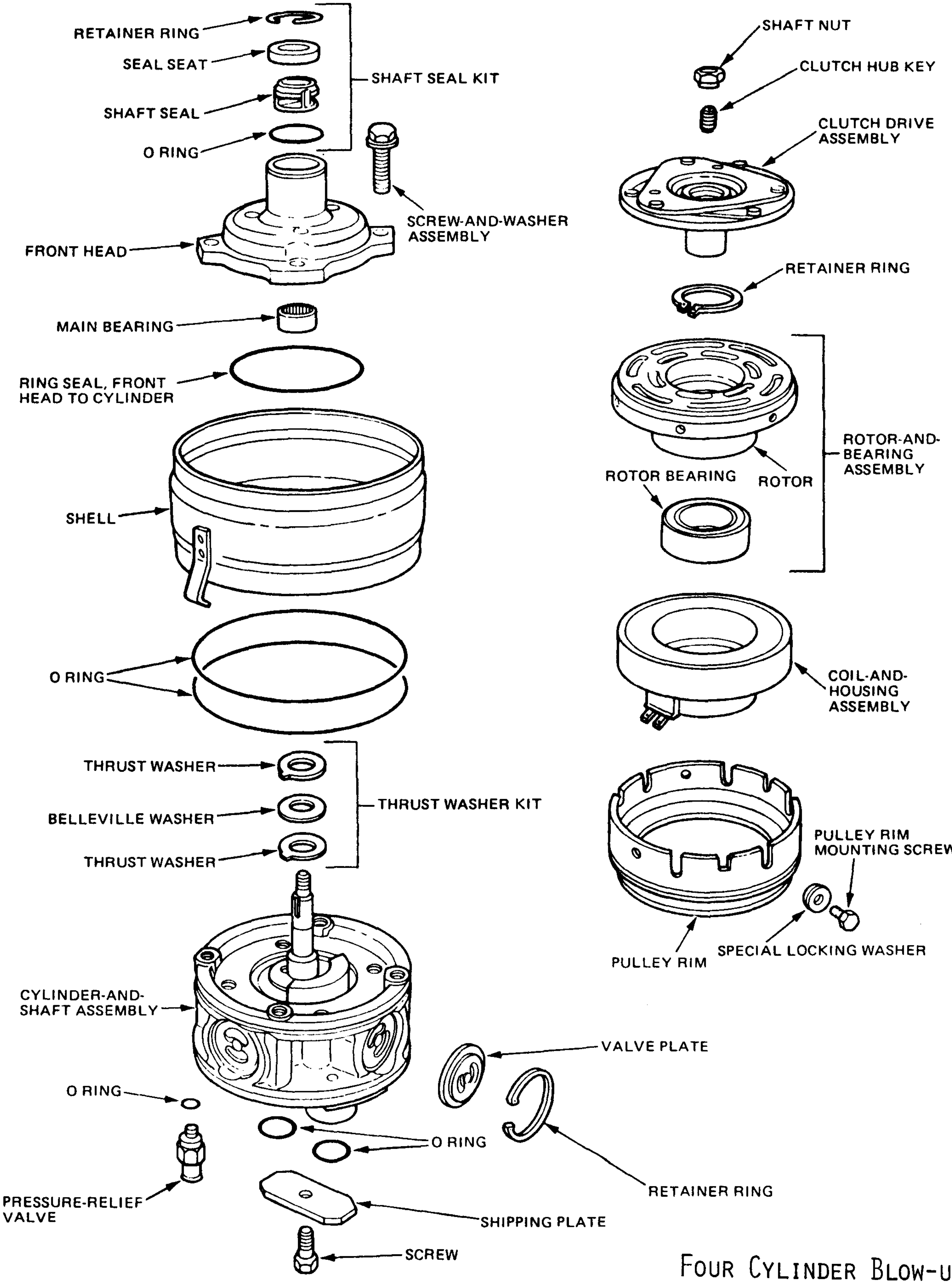
# General Motors Four-Cylinder Components



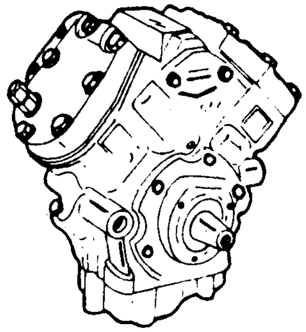
GENERAL MOTORS FOUR-CYLINDER
ROUND COMPRESSOR



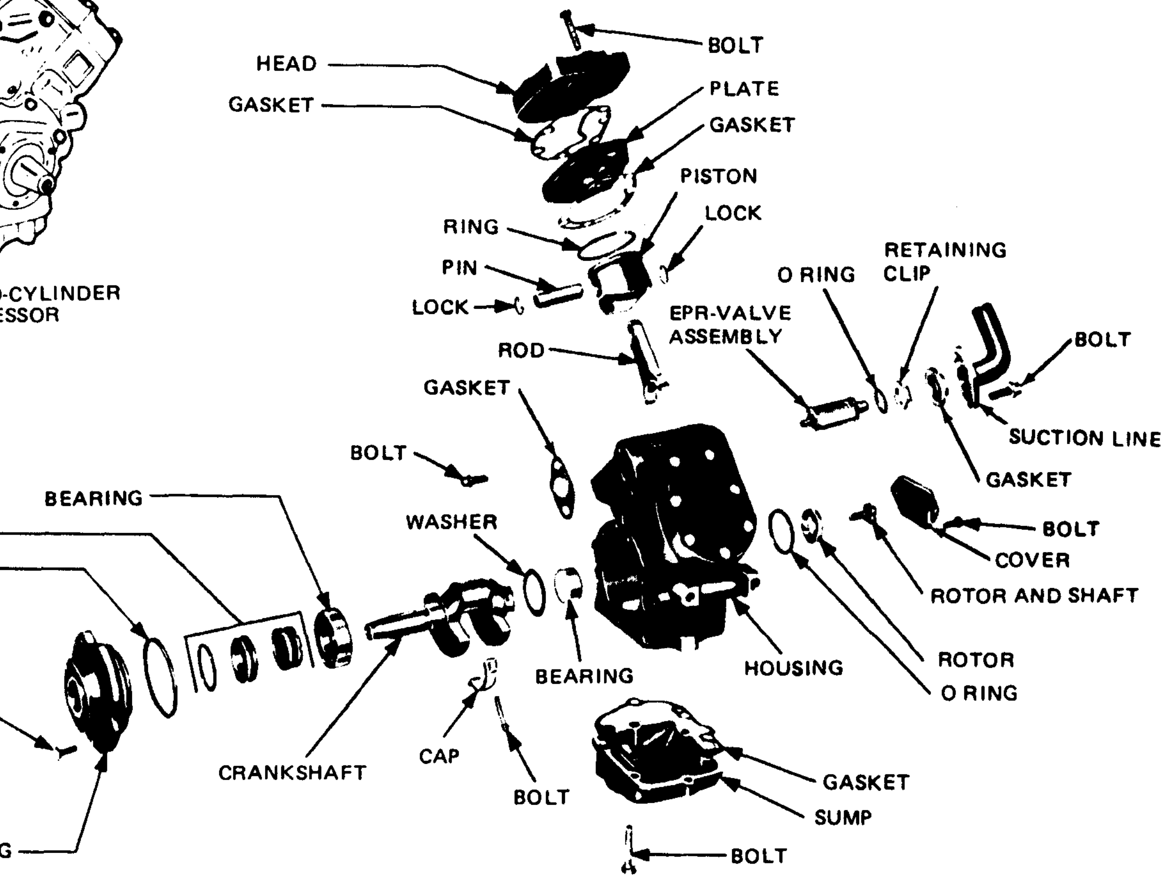


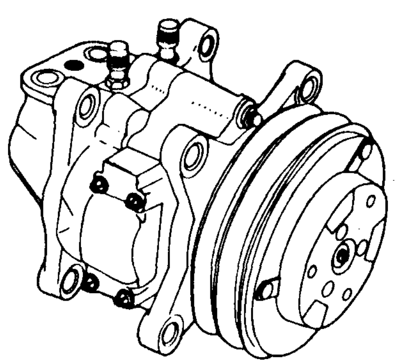

Four Cylinder Blow-up



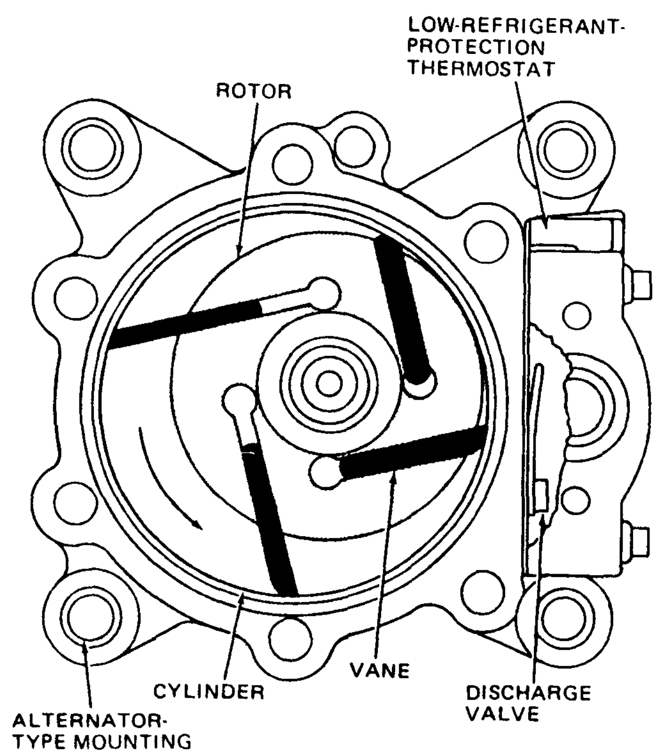
CHRYSLER TWO-CYLINDER
V-TYPE COMPRESSOR

## CHRYSLER V-2 BLOW-UP

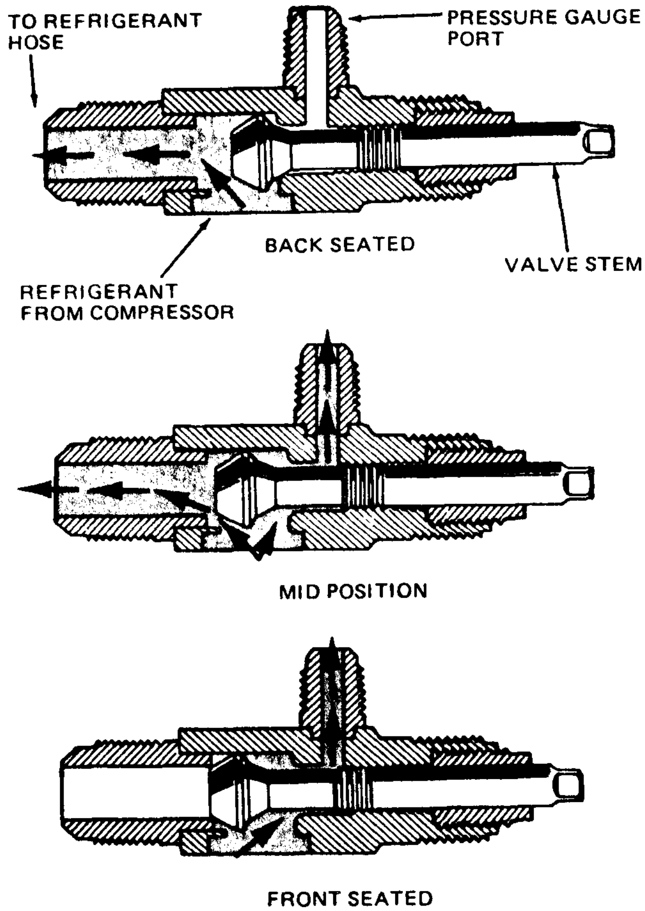


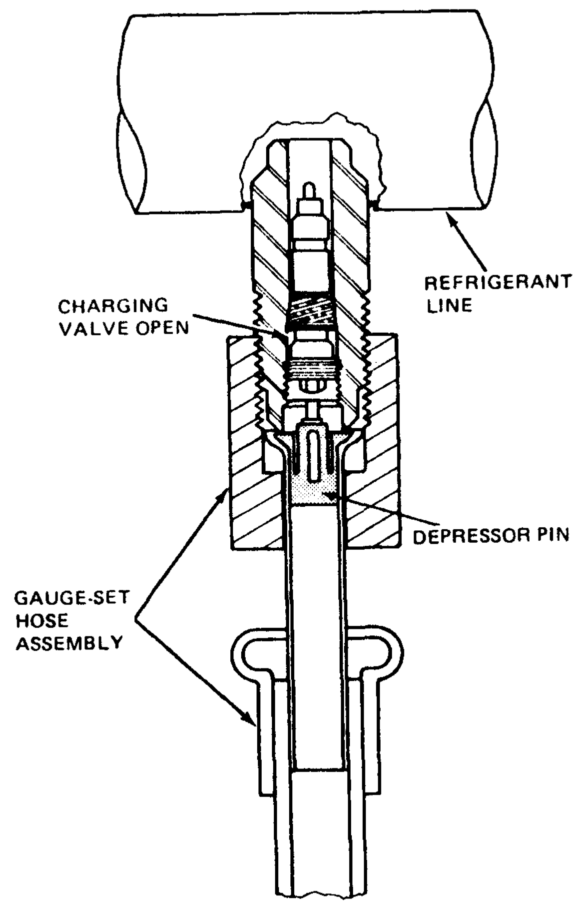



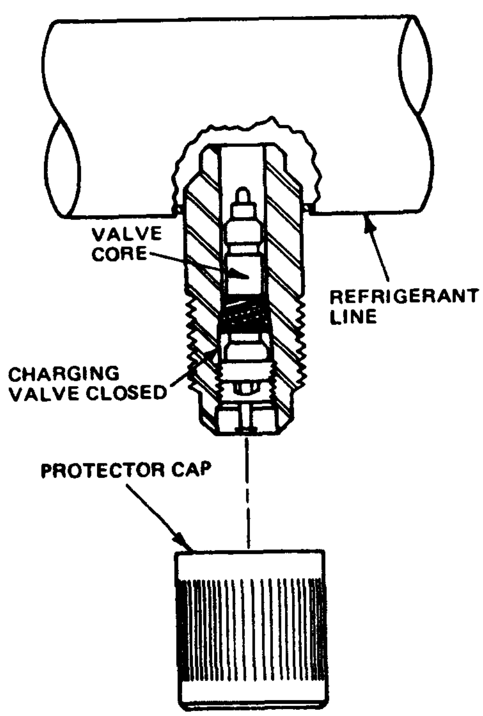
YORK ROTARY VANE
COMPRESSOR

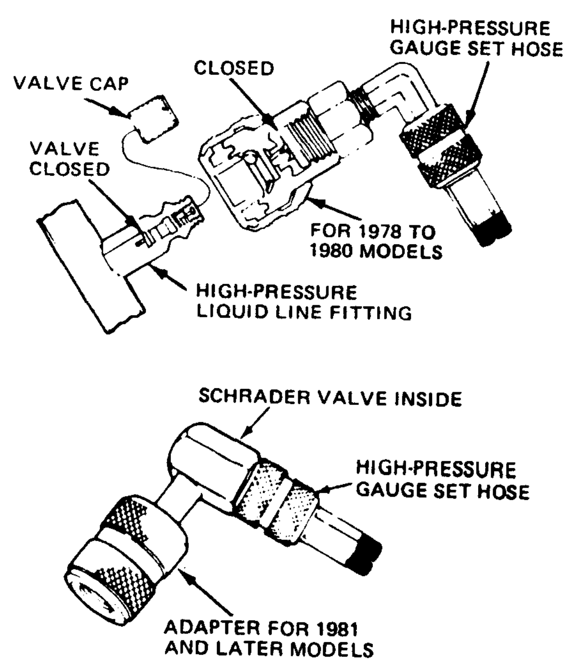


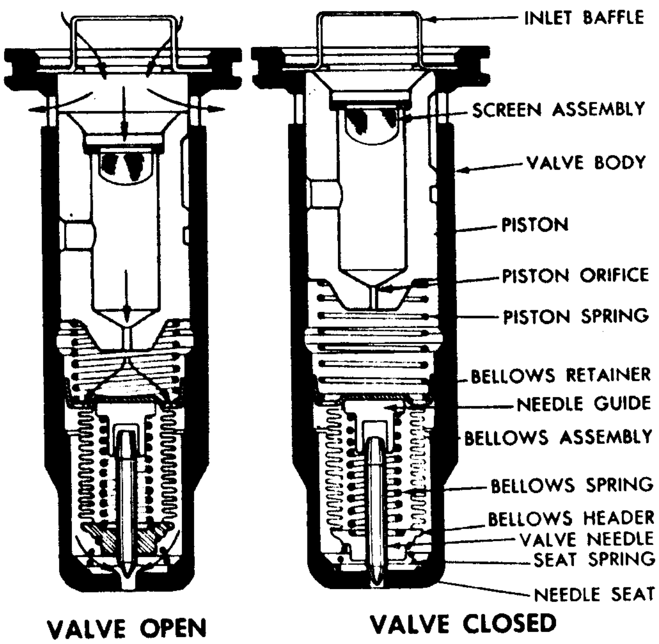
# AIR CONDITIONING VALVES



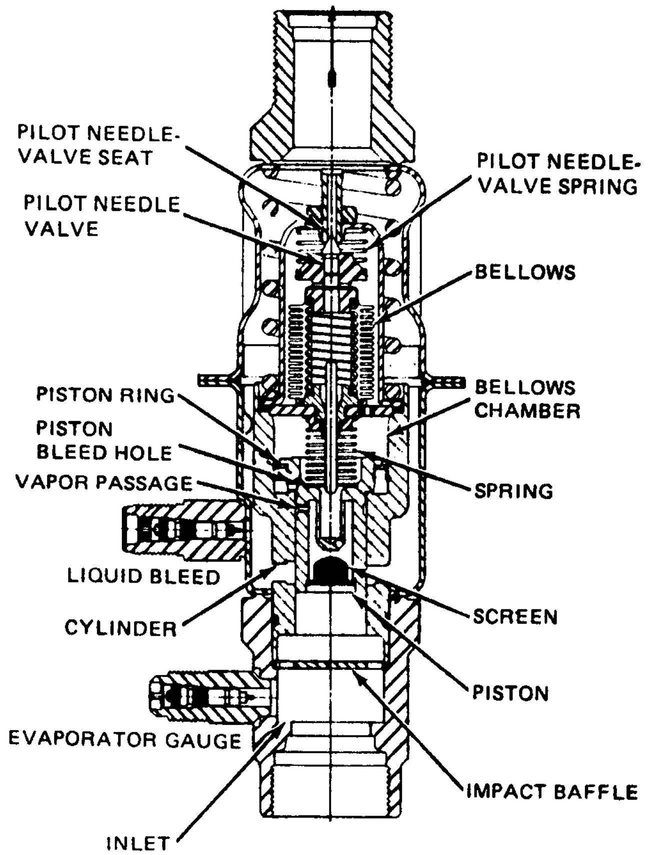



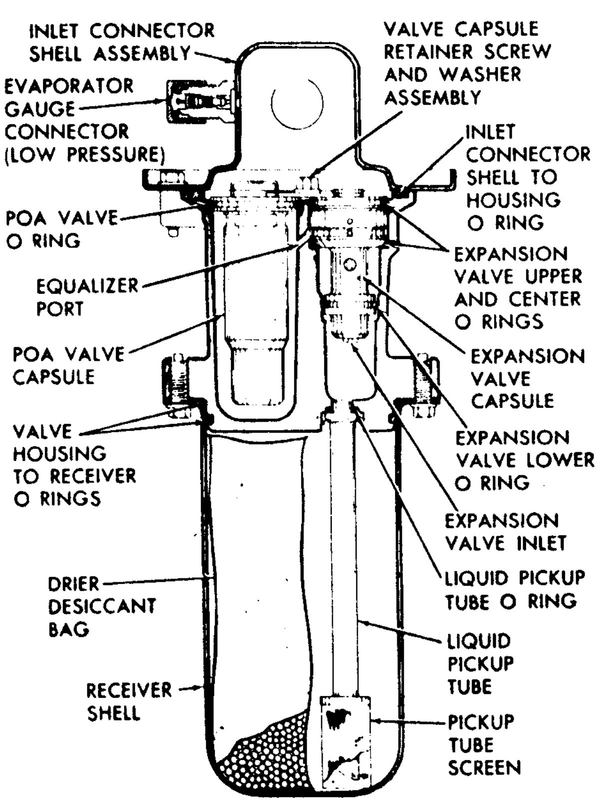


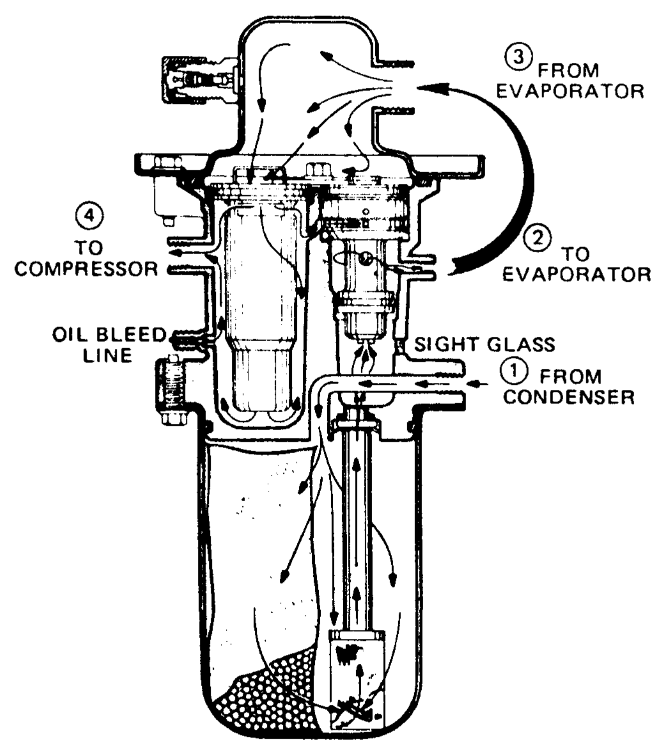

SUCTION THROTTLING VALVE (STV)

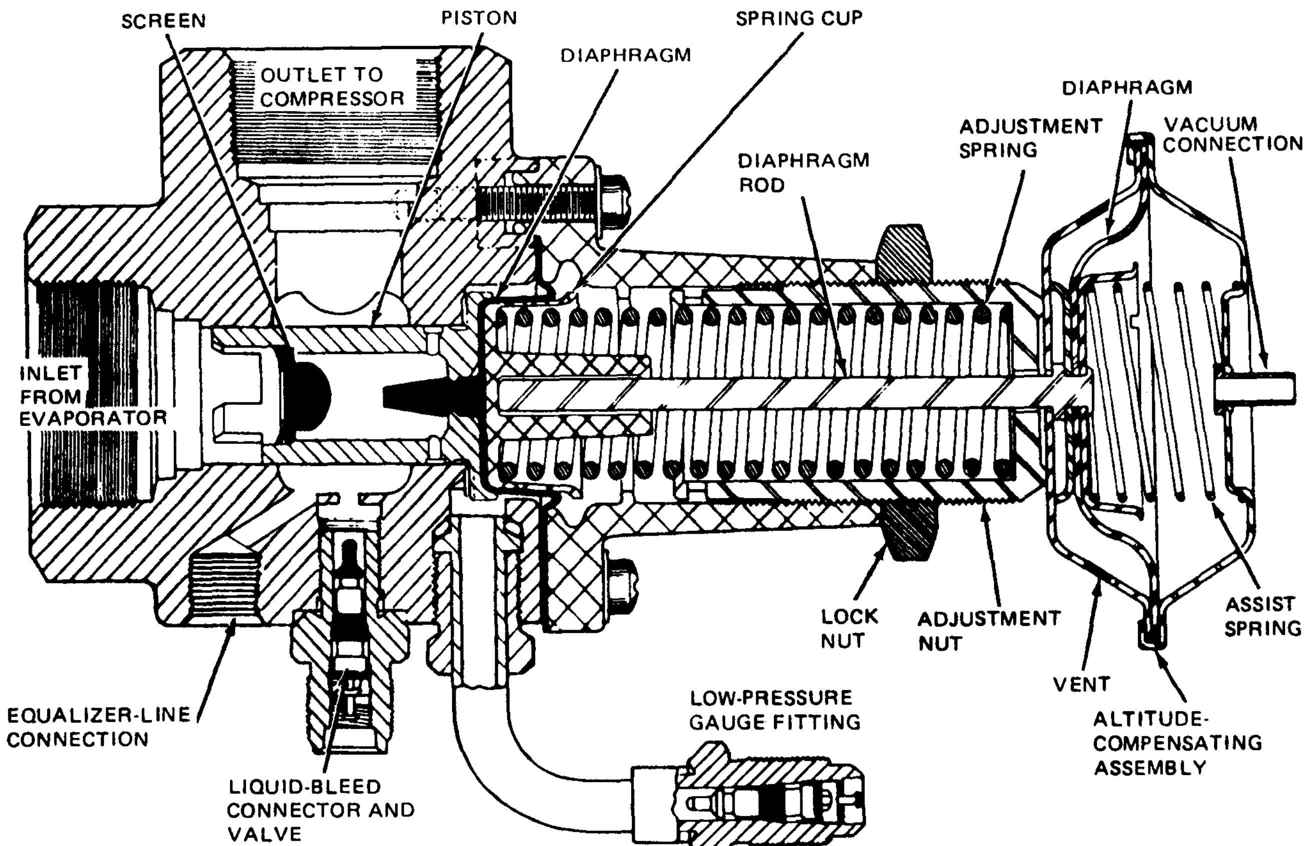



PILOT OPERATED ABSOLUTE (POA) VALVE

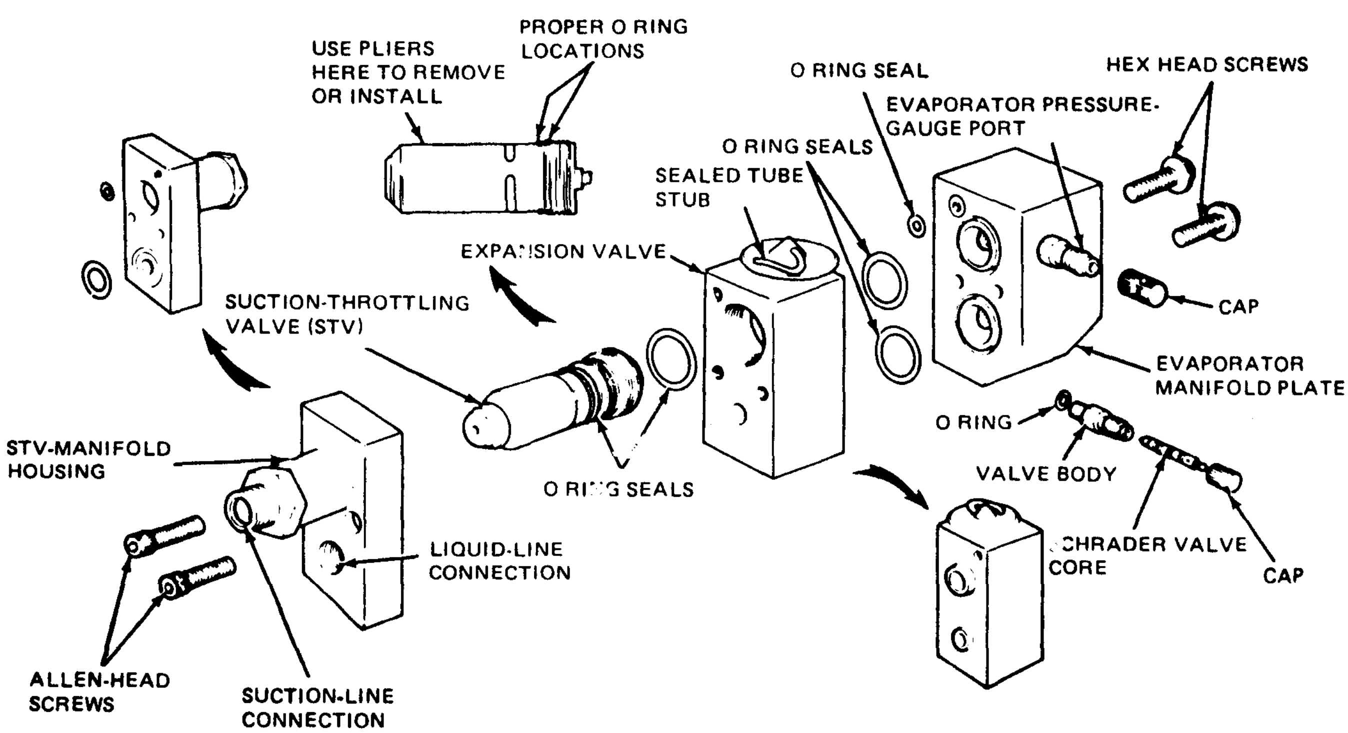
VALVES IN RECEIVER (VIR)



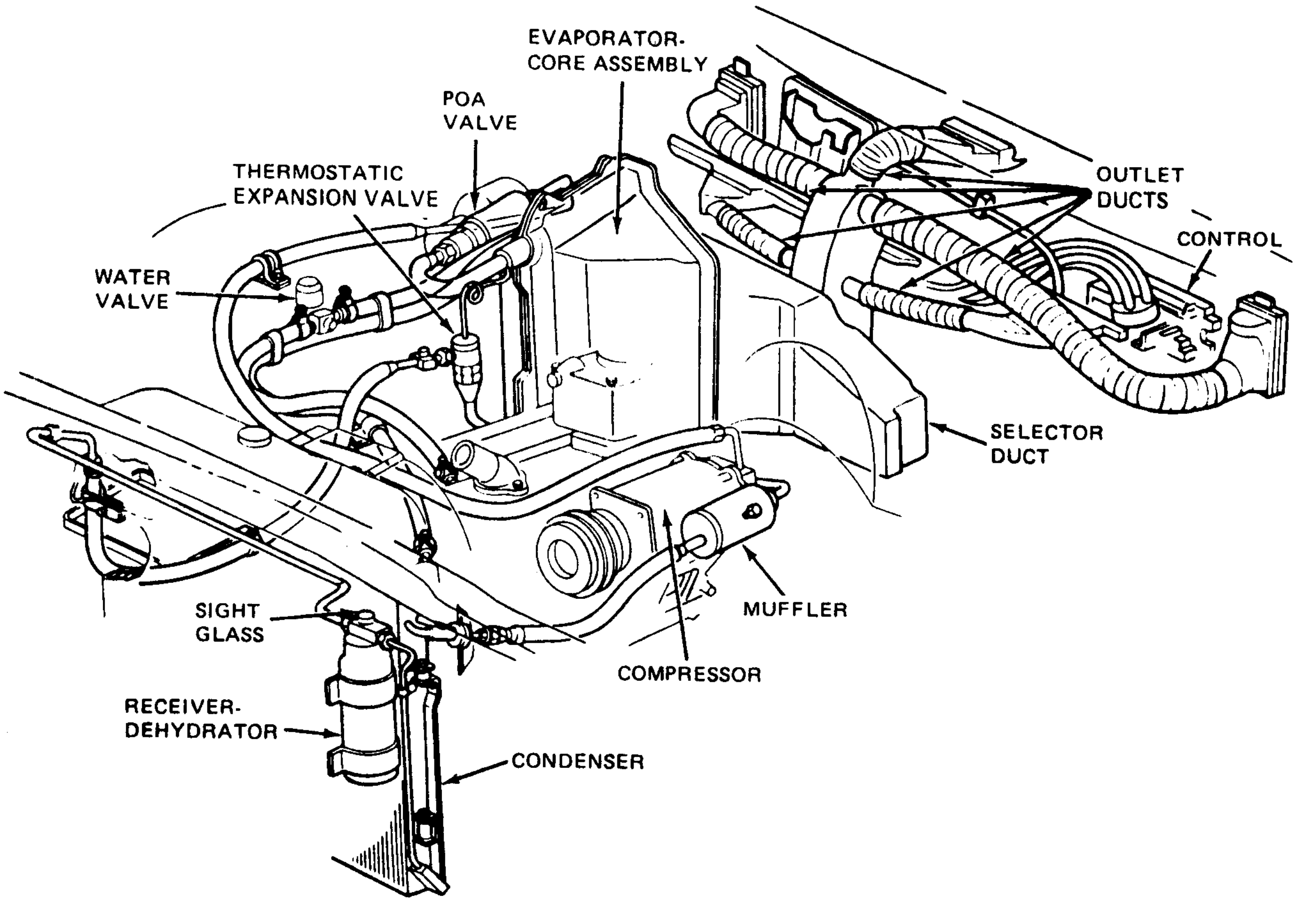



SUCTION THROTTLING VALVE (WITH ALTITUDE COMPENSATION)

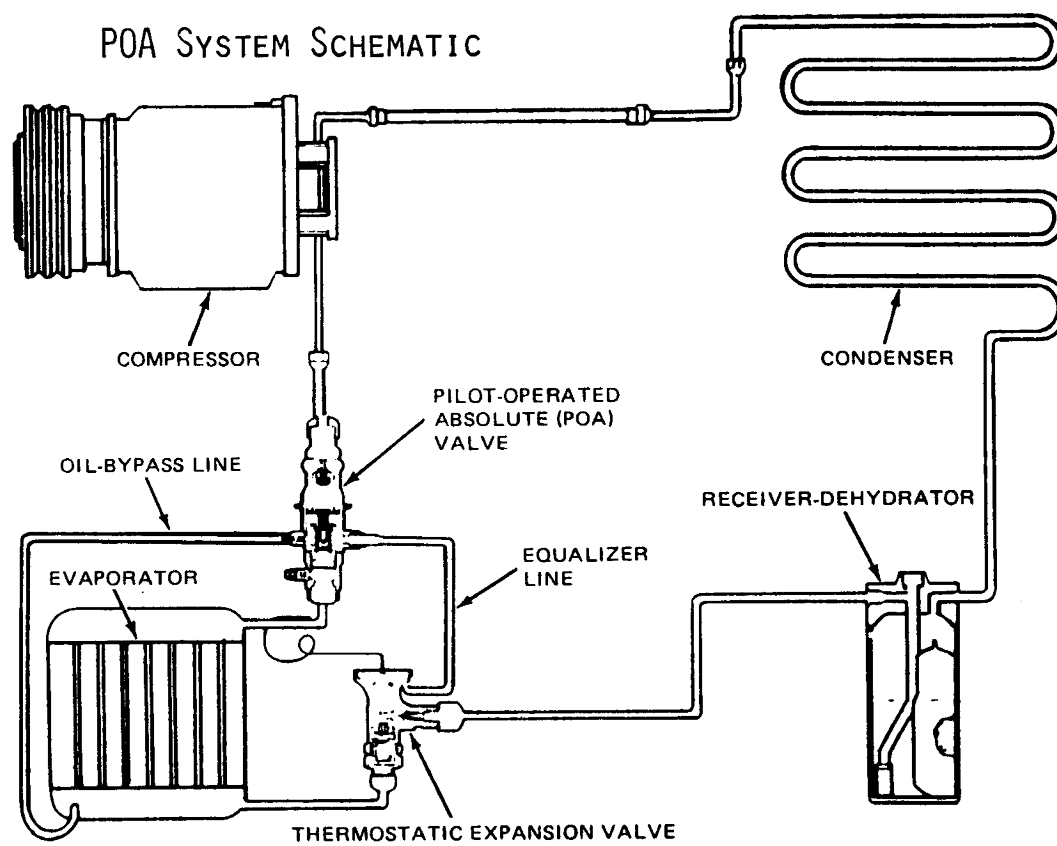



COMBINATION VALVE (TXV AND STV)

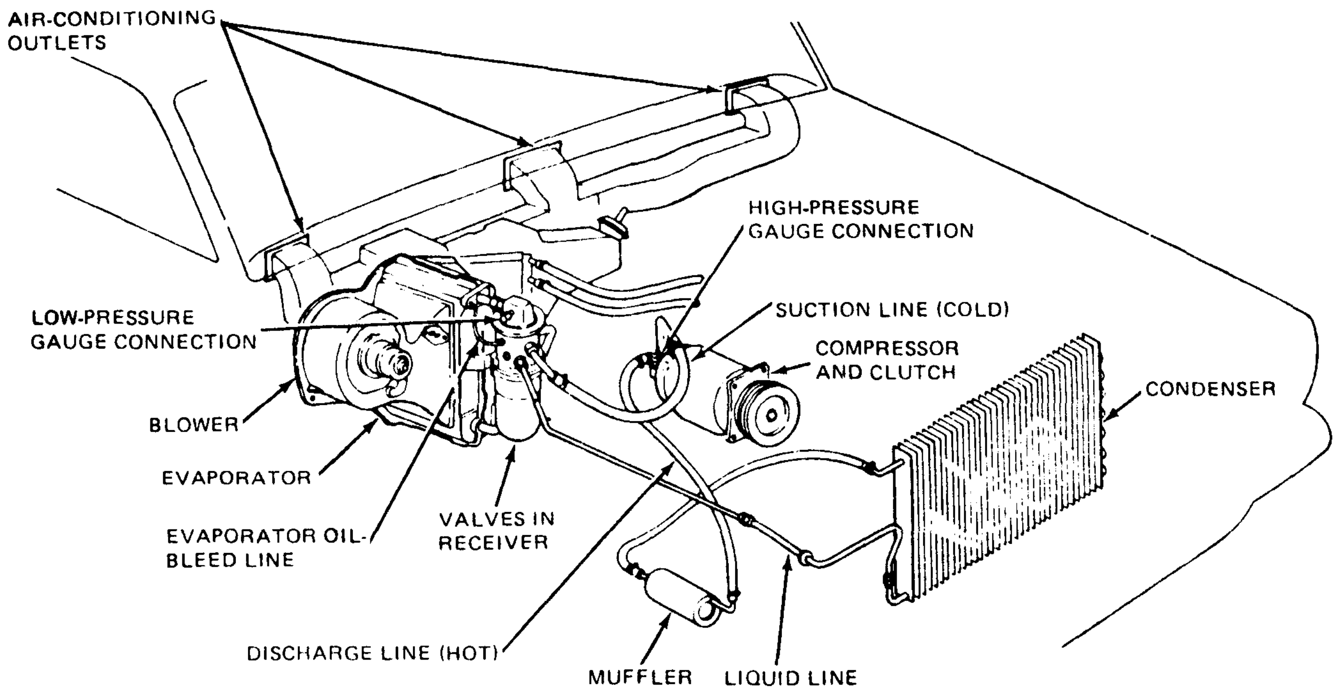
## A/C Layout in Car (POA System)



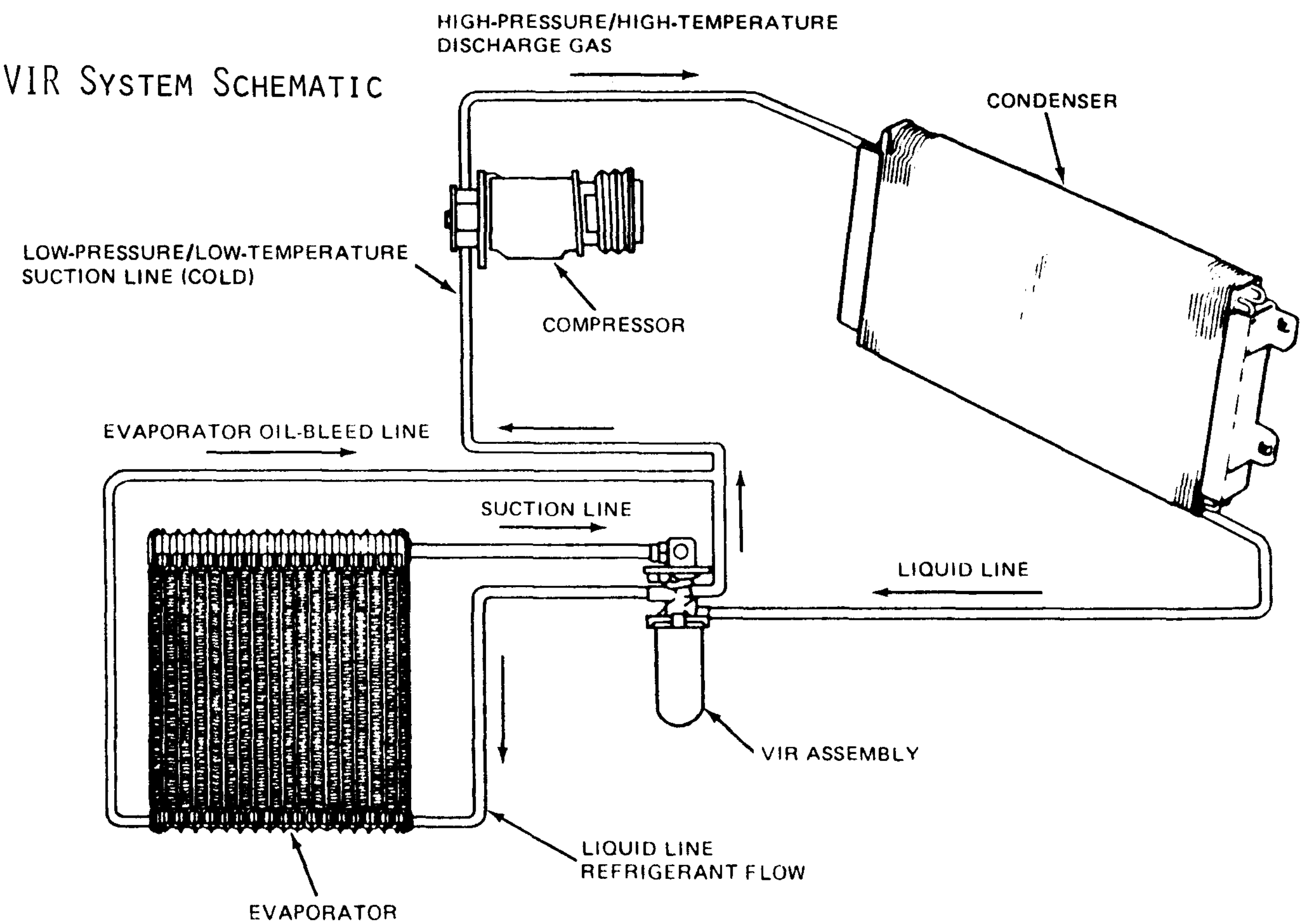

## POA System Schematic



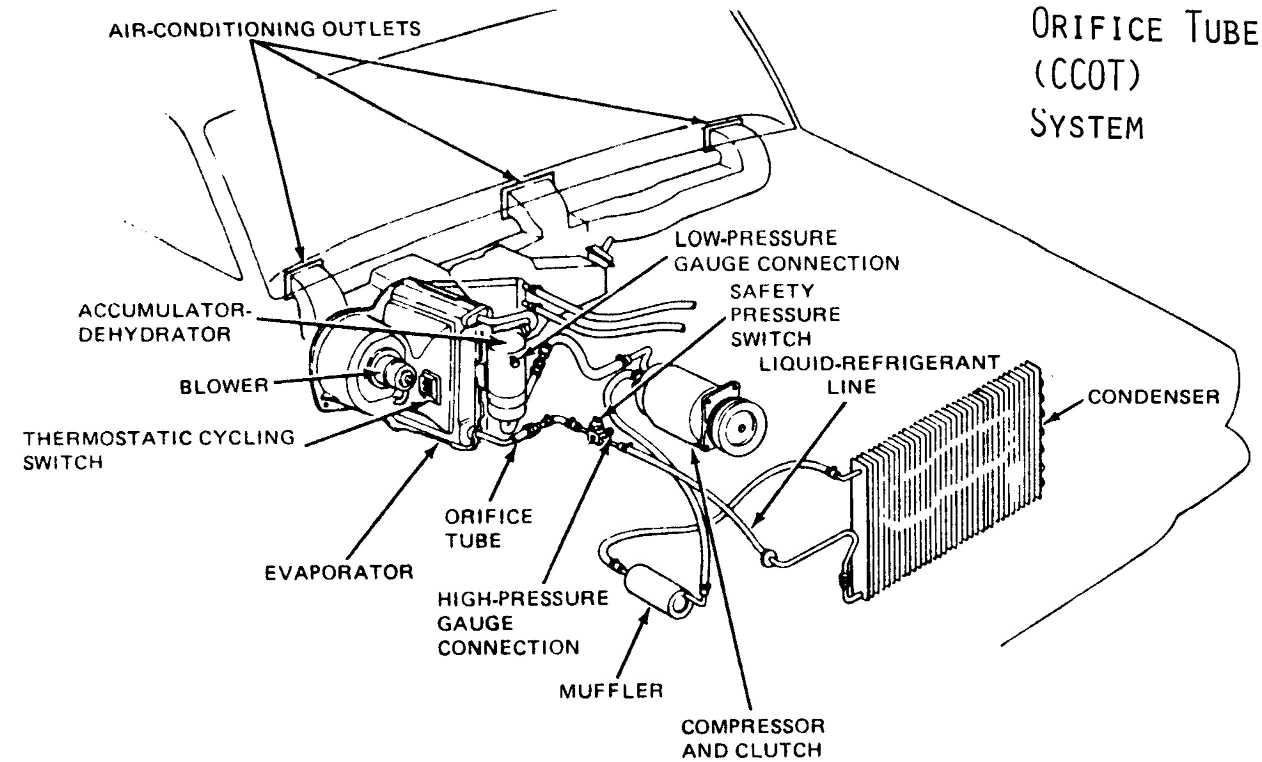
# A/C Layout in Car (VIR System)

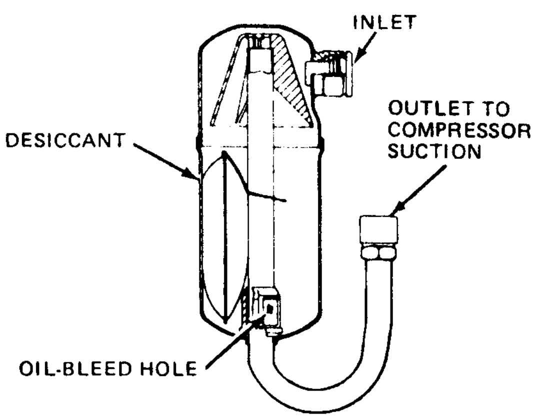



# VIR System Schematic



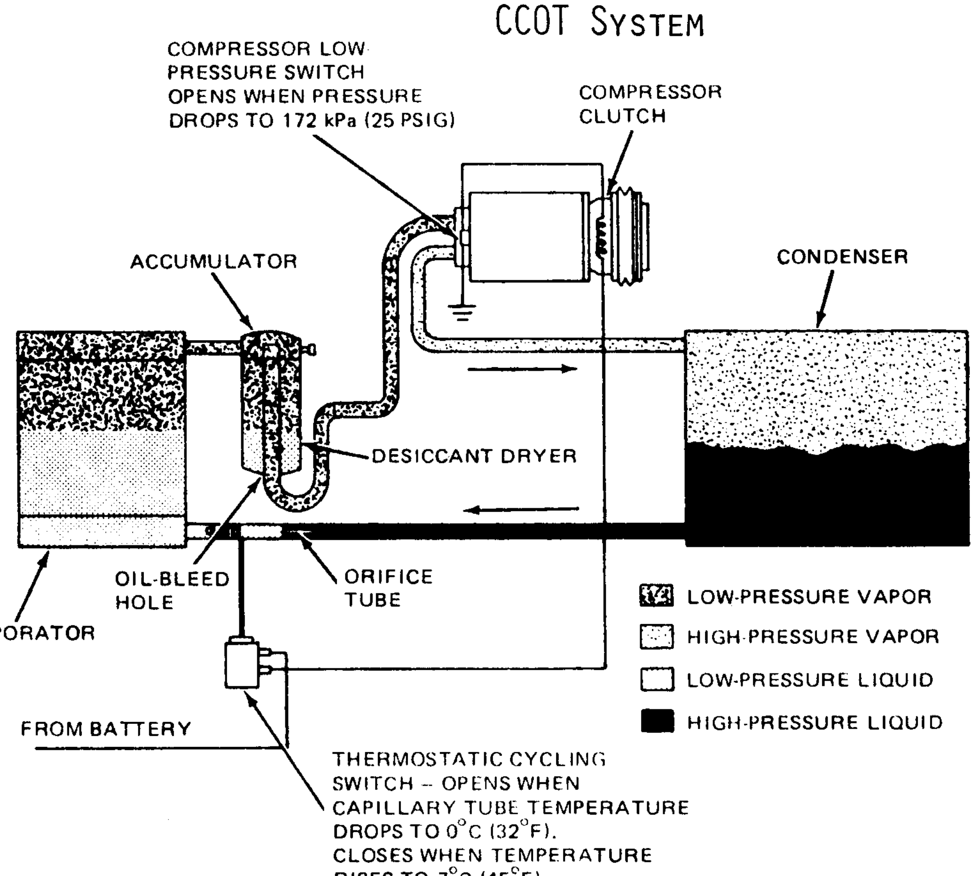
## Cycling Clutch Orifice Tube (CCOT) System




## Accumulator

## Refrigerant Flow Through CCOT System

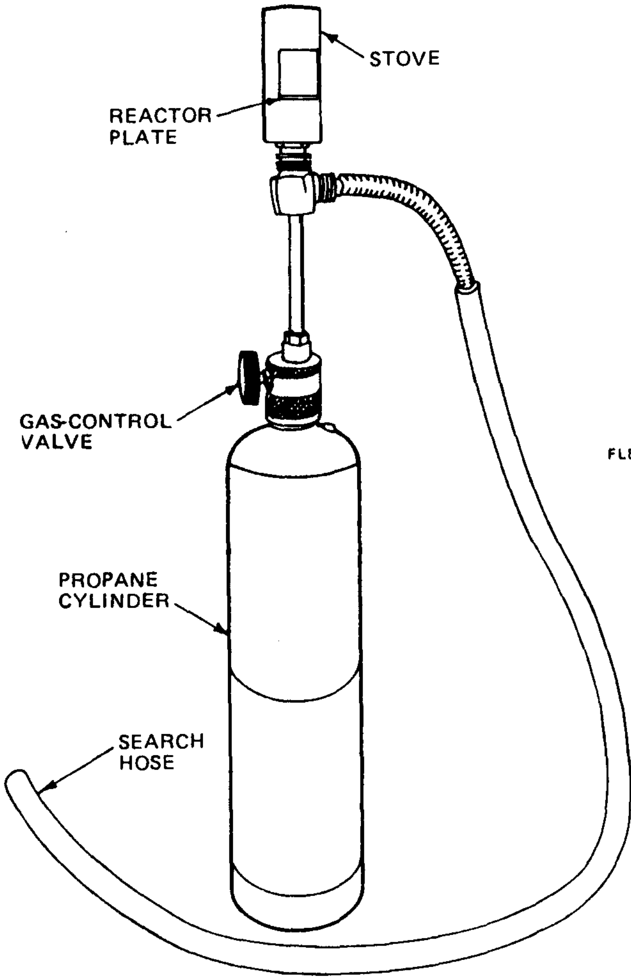


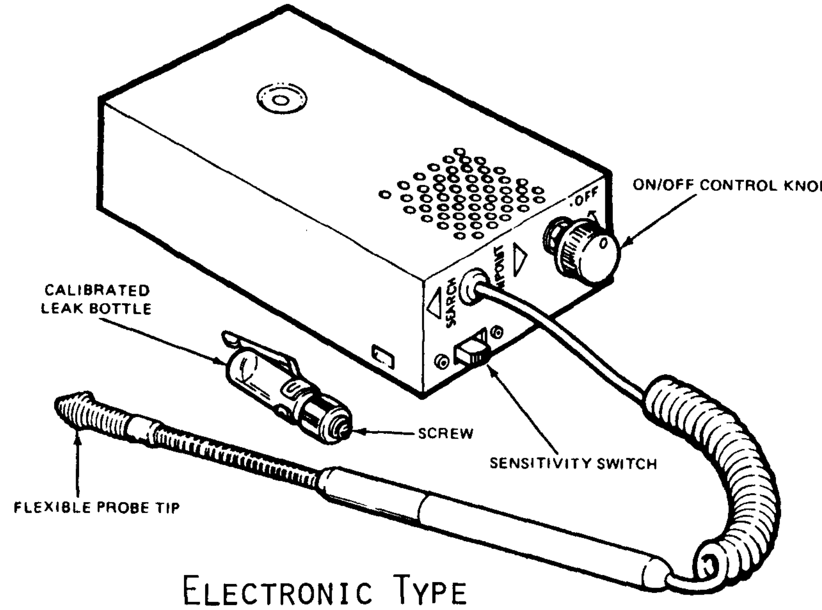
# Air Conditioning Diagnosis Chart

<table>
<tr><td colspan="7">NOTE: Normal system conditional requirements must be maintained to properly evaluate refrigerant system pressures.<br>Refer to chart applicable to system under test.</td></tr>
<tr><th colspan="2">HIGH PRESSURE</th><th rowspan="2">LOW PRESSURE</th><th colspan="3">CLUTCH CYCLE TIME</th><th rowspan="2">COMPONENT — CAUSES</th></tr>
<tr><th>@ LIQUID LINE</th><th>@ COMPRESSOR</th><th>RATE</th><th>ON</th><th>OFF</th></tr>
<tr><td>HIGH</td><td>HIGH</td><td>HIGH</td><td>LOW</td><td>NORMAL TO LOW</td><td>NORMAL</td><td>ENGINE OVERHEATING</td></tr>
<tr><td>HIGH</td><td>HIGH</td><td>NORMAL TO HIGH</td><td rowspan="3">LOW</td><td rowspan="3">LONG</td><td rowspan="3">SHORT</td><td>CONDENSER — Inadequate Airflow</td></tr>
<tr><td>HIGH</td><td>HIGH</td><td>NORMAL</td><td>AIR IN REFRIGERANT<br>REFRIGERANT OVERCHARGE (a)</td></tr>
<tr><td>NORMAL TO HIGH</td><td>NORMAL TO HIGH</td><td>NORMAL TO HIGH</td><td>HUMIDITY VERY HIGH (b)</td></tr>
<tr><td>NORMAL</td><td>NORMAL</td><td>HIGH</td><td>NORMAL TO LOW</td><td>NORMAL</td><td>NORMAL TO LOW</td><td>CLUTCH CYCLING SWITCH — High Setting</td></tr>
<tr><td rowspan="2">NORMAL</td><td rowspan="2">NORMAL</td><td rowspan="2">NORMAL</td><td>HIGH</td><td>SHORT</td><td>NORMAL</td><td>FIXED ORIFICE TUBE — Partially Restricted<br>A/C LIQUID LINE — Partially Restricted</td></tr>
<tr><td>LOW</td><td>LONG</td><td>SHORT</td><td>MOISTURE IN REFRIGERANT SYSTEM<br>EXCESSIVE REFRIGERANT OIL</td></tr>
<tr><td rowspan="7">NORMAL TO LOW</td><td rowspan="7">NORMAL TO LOW</td><td rowspan="7">NORMAL</td><td>NORMAL TO LOW</td><td>LONG</td><td>SHORT</td><td>FIXED ORIFICE TUBE — Restricted</td></tr>
<tr><td>HIGH</td><td>SHORT</td><td>NORMAL TO SHORT</td><td>EVAPORATOR CORE — Partiallv Restricted</td></tr>
<tr><td>LOW</td><td>SHORT</td><td>LONG</td><td>EVAPORATOR — Low Airflow</td></tr>
<tr><td>HIGH</td><td>SHORT</td><td>NORMAL TO SHORT</td><td>A/C SUCTION LINE — Partially Restricted</td></tr>
<tr><td>HIGH</td><td>VERY SHORT</td><td>LONG</td><td>A/C LIQUID LINE — Restricted</td></tr>
<tr><td>HIGH</td><td>SHORT TO VERY SHORT</td><td>SHORT TO VERY SHORT</td><td>LOW REFRIGERANT CHARGE</td></tr>
<tr><td colspan="3">CONTINUOUS RUN</td><td>CLUTCH CYCLING SWITCH — Sticking Closed</td></tr>
<tr><td>LOW</td><td>NORMAL</td><td>NORMAL</td><td>HIGH</td><td>SHORT</td><td>NORMAL</td><td>CONDENSER — Partially Restricted</td></tr>
<tr><td rowspan="4">LOW</td><td rowspan="4">LOW</td><td rowspan="4">HIGH</td><td>NORMAL TO LOW</td><td>LONG</td><td>SHORT</td><td>FIXED ORIFICE TUBE — O-Ring Leaking</td></tr>
<tr><td>RAPID</td><td>VERY SHORT</td><td>VERY SHORT</td><td>CLUTCH CYCLING SWITCH — Low Setting</td></tr>
<tr><td>LOW</td><td>LONG</td><td>SHORT</td><td>COMPRESSOR — Low Performance</td></tr>
<tr><td colspan="3">CONTINUOUS RUN</td><td>A/C SUCTION LINE — Restricted</td></tr>
<tr><td>NORMAL TO LOW</td><td>NORMAL TO LOW</td><td>NORMAL TO LOW</td><td rowspan="2">HIGH</td><td rowspan="2">VERY SHORT</td><td rowspan="2">LONG</td><td>CONDENSER — Restricted</td></tr>
<tr><td>LOW</td><td>LOW</td><td>NORMAL</td><td>EVAPORATOR CORE — Restricted</td></tr>
<tr><td colspan="3">ERRATIC OPERATON OR COMPRESSOR NOT RUNNING</td><td>—</td><td>—</td><td>—</td><td>CLUTCH CYCLING SWITCH — Dirty Contacts or Sticking Open.</td></tr>
<tr><td colspan="7">ADDITIONAL POSSIBLE CAUSE COMPONENTS<br>ASSOCIATED WITH INADEQUATE COMPRESSION OPERATION</td></tr>
<tr><td colspan="7">• COMPRESSOR CLUTCH Slipping • LOOSE DRIVE BELT<br>• CLUTCH COIL With Open, Blown Circuit, Blown Fuse or Loose Mounting<br>• CONTROL ASSEMBLY SWITCH<br>— Dirty Contacts or Sticking Open</td></tr>
<tr><td colspan="7">ADDITIONAL POSSIBLE CAUSE COMPONENTS<br>ASSOCIATED WITH A DAMAGED COMPRESSOR</td></tr>
<tr><td colspan="7">• CLUTCH CYCLING PRESSURE SWITCH — Sticking Closed or Compressor Clutch Seized<br>• SUCTION ACCUMULATOR/DRIER — Refrigerant Oil Bleed Hole Plugged<br>• REFRIGERANT LEAKS</td></tr>
<tr><td colspan="7">(a) Compressor may make noise on initial run. This is a slugging condition caused by excessive liquid refrigerant.<br>(b) Compressor clutch may not cycle during very high humidity condition.</td></tr>
</table>

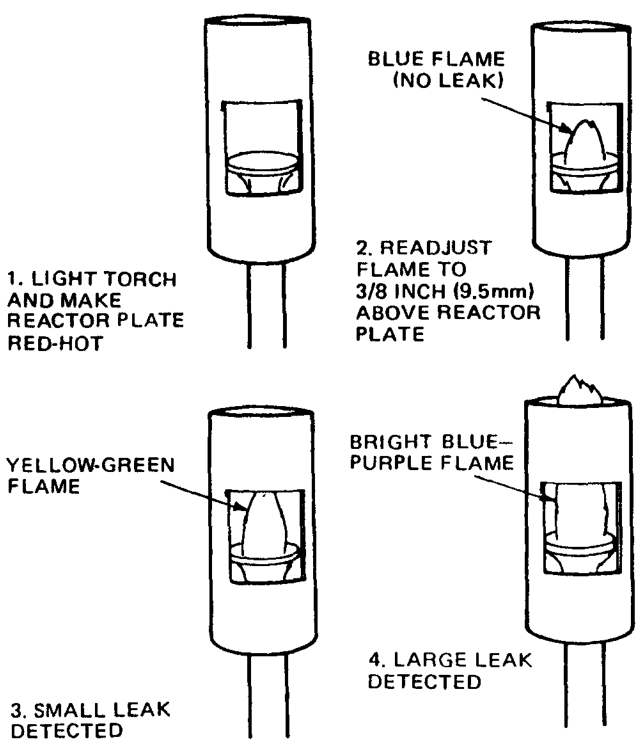
# LEAK DETECTORS

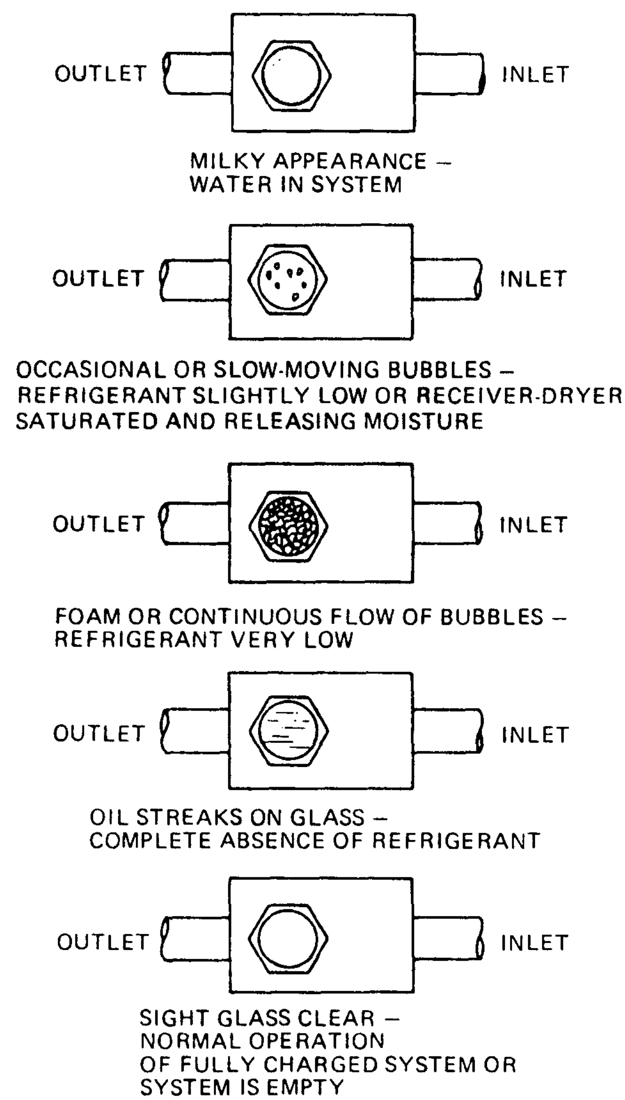
## TORCH TYPE



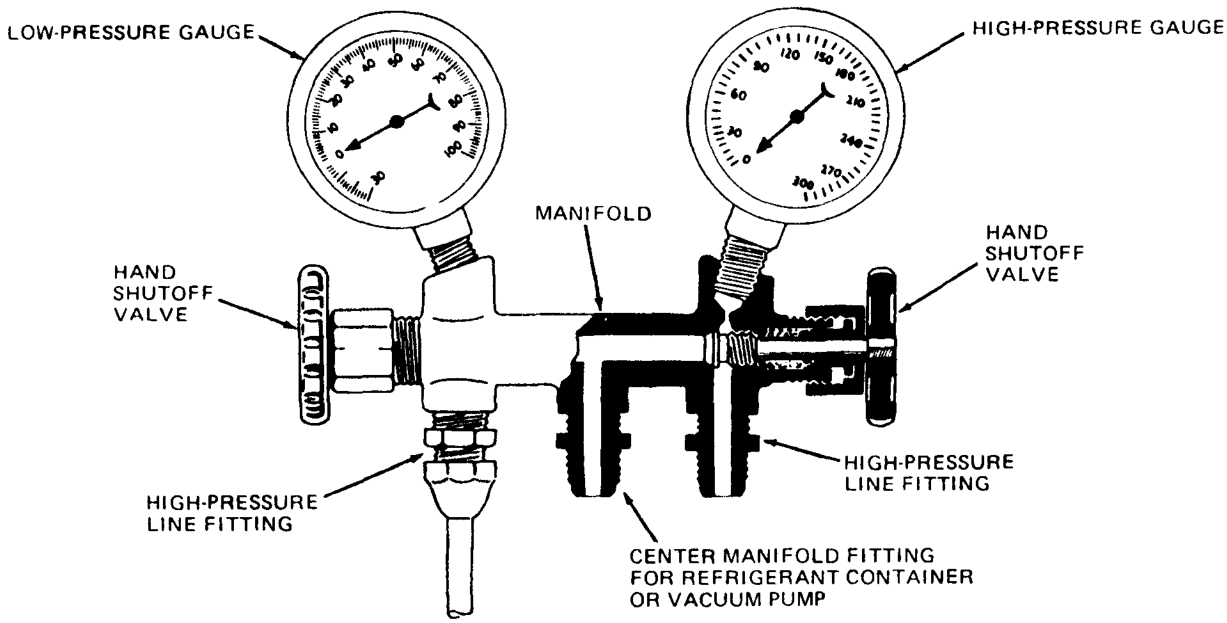

## ELECTRONIC TYPE

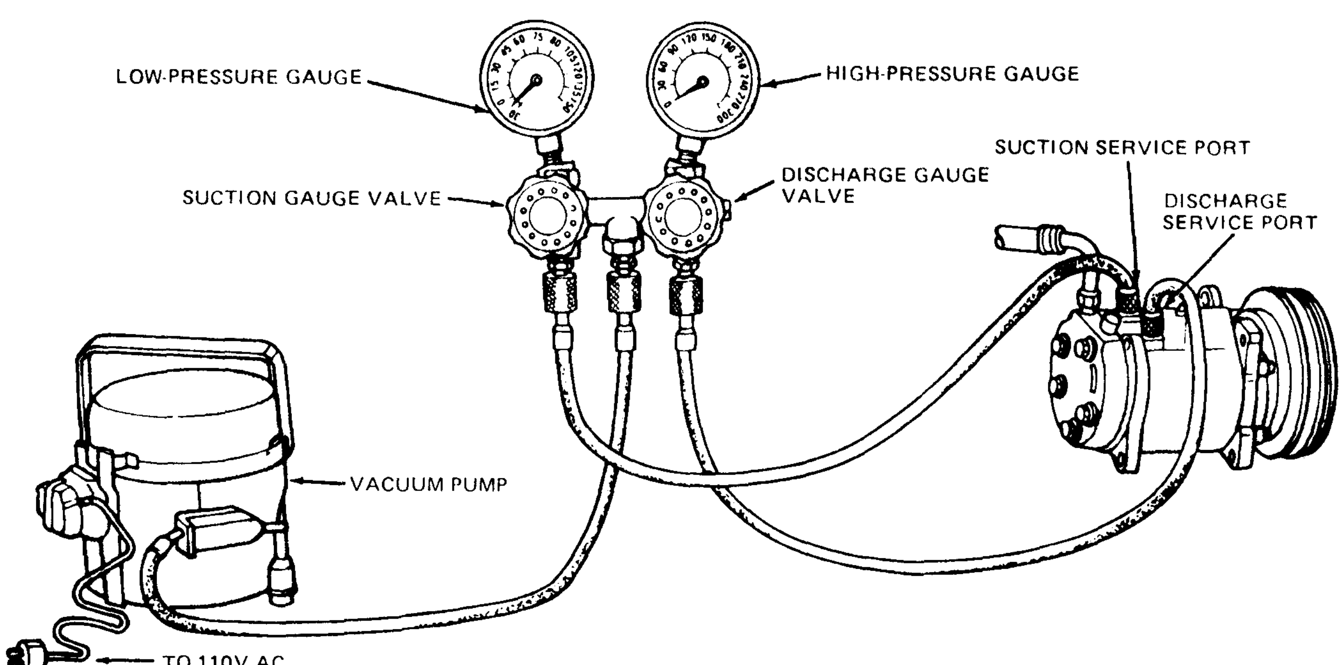



## READING THE SIGHT GLASS

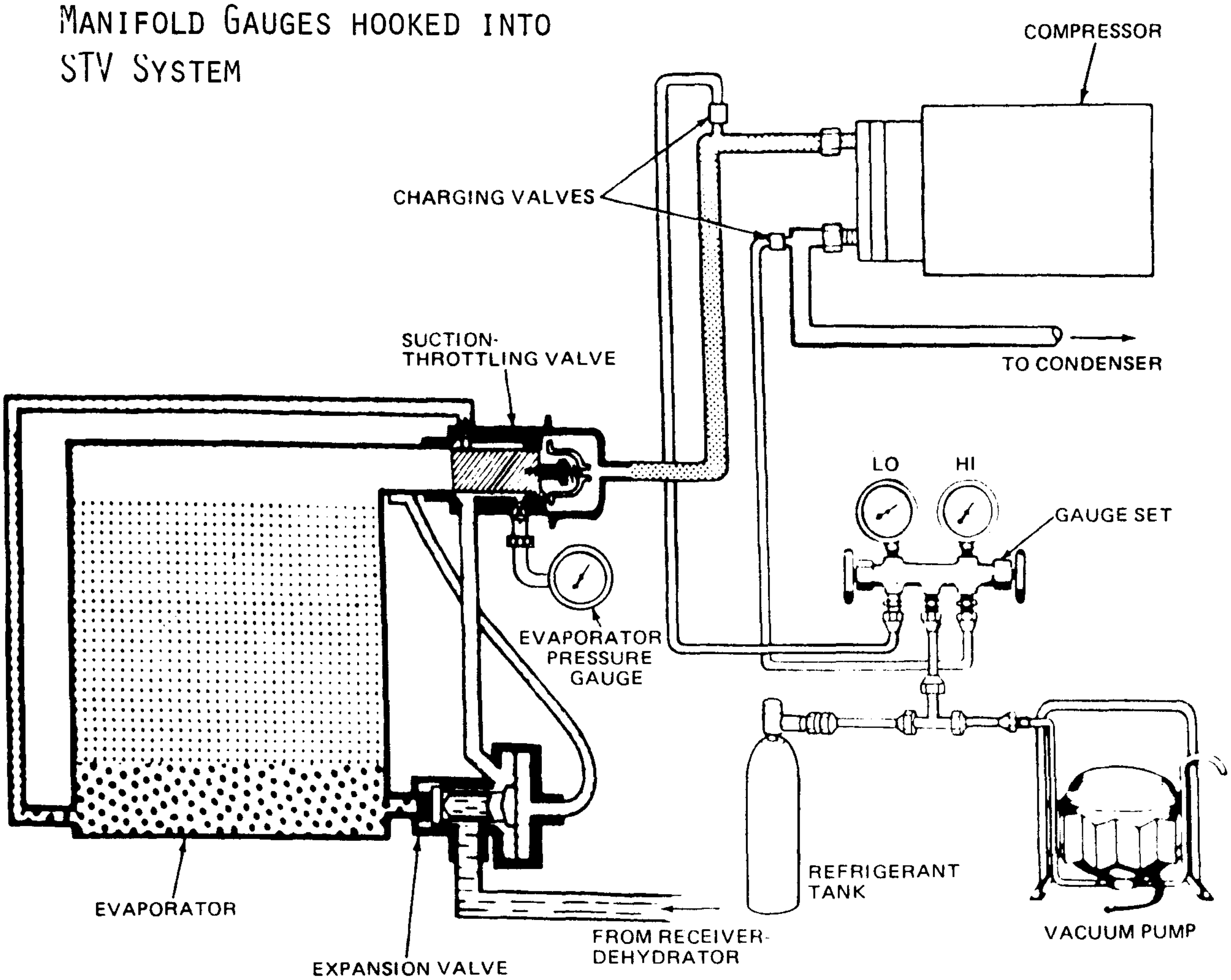
## Manifold Gauge Set

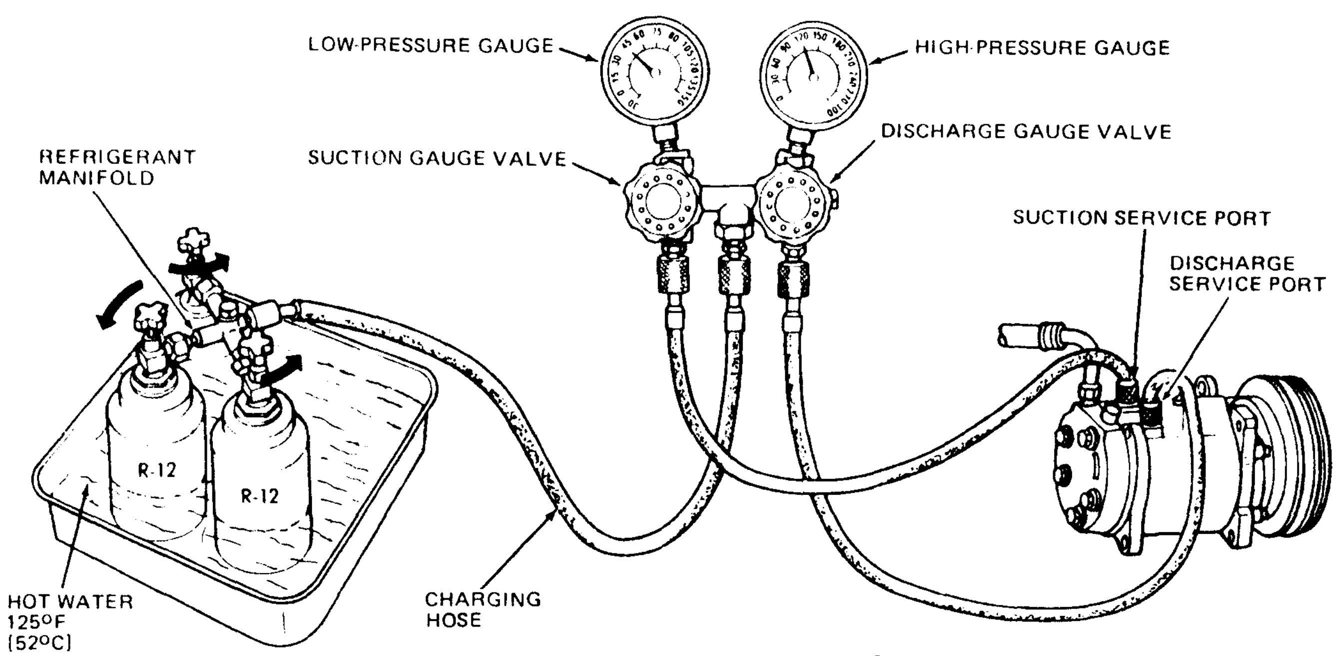


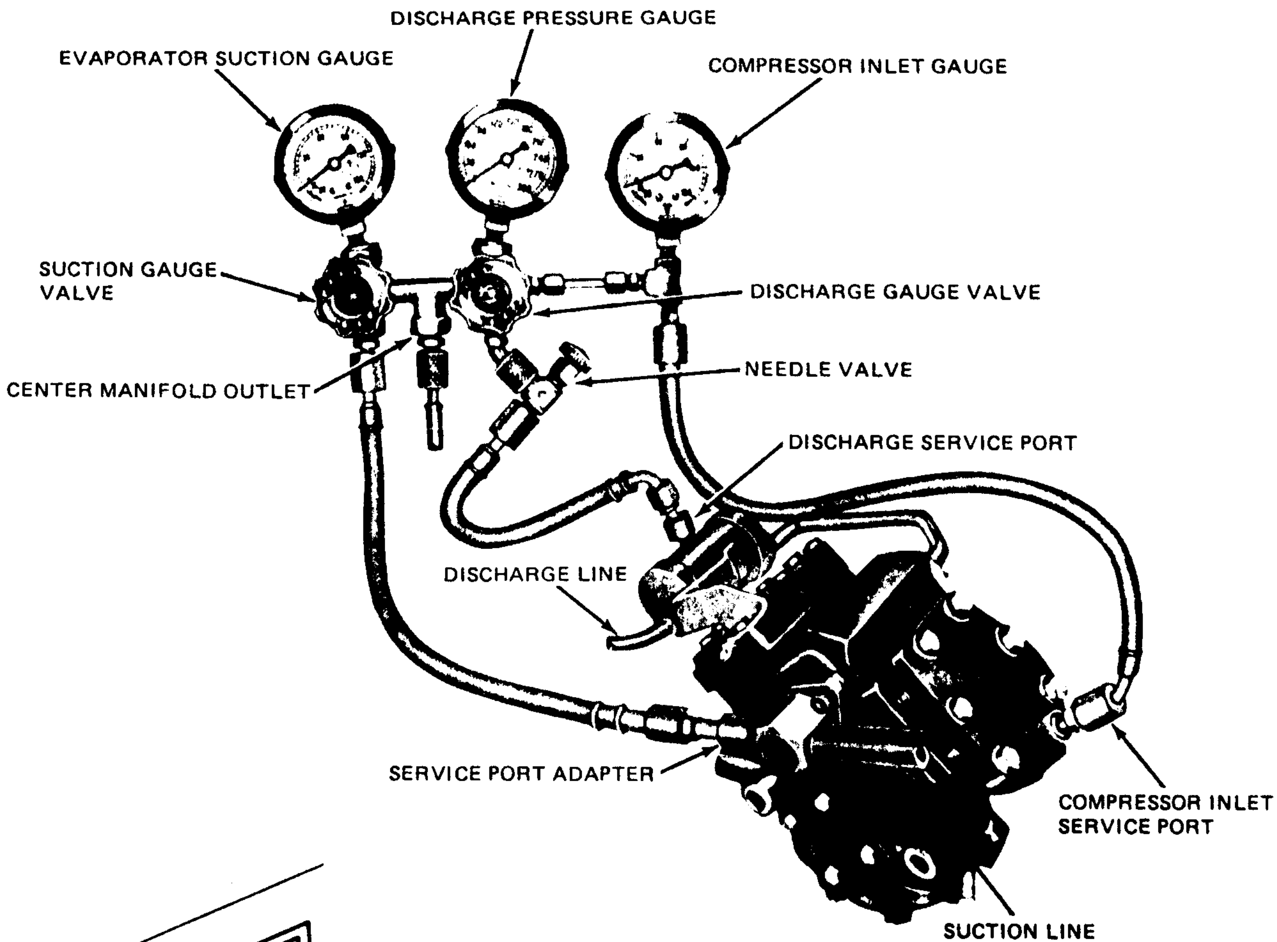

Manifold Gauge Set Hook-up to Evacuate

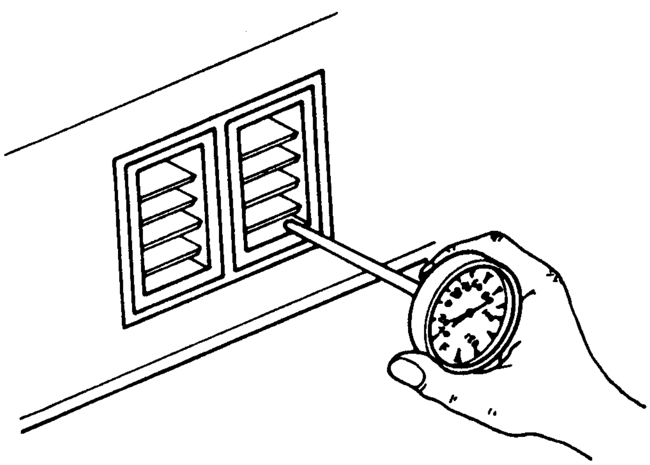
## Manifold Gauges hooked into STV System



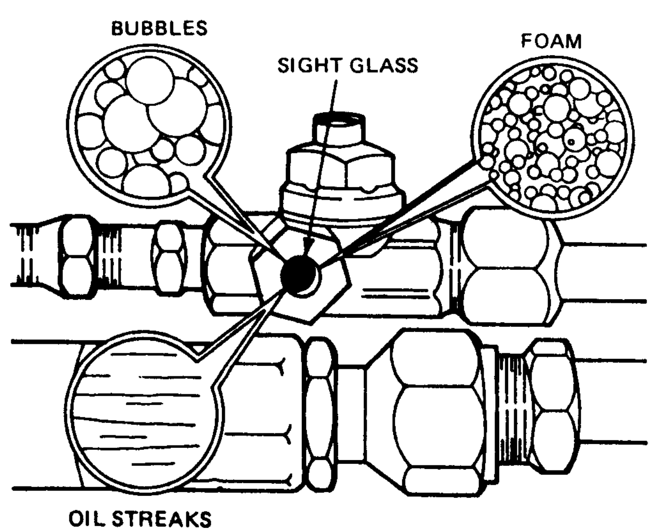

Charging with Manifold Gauges



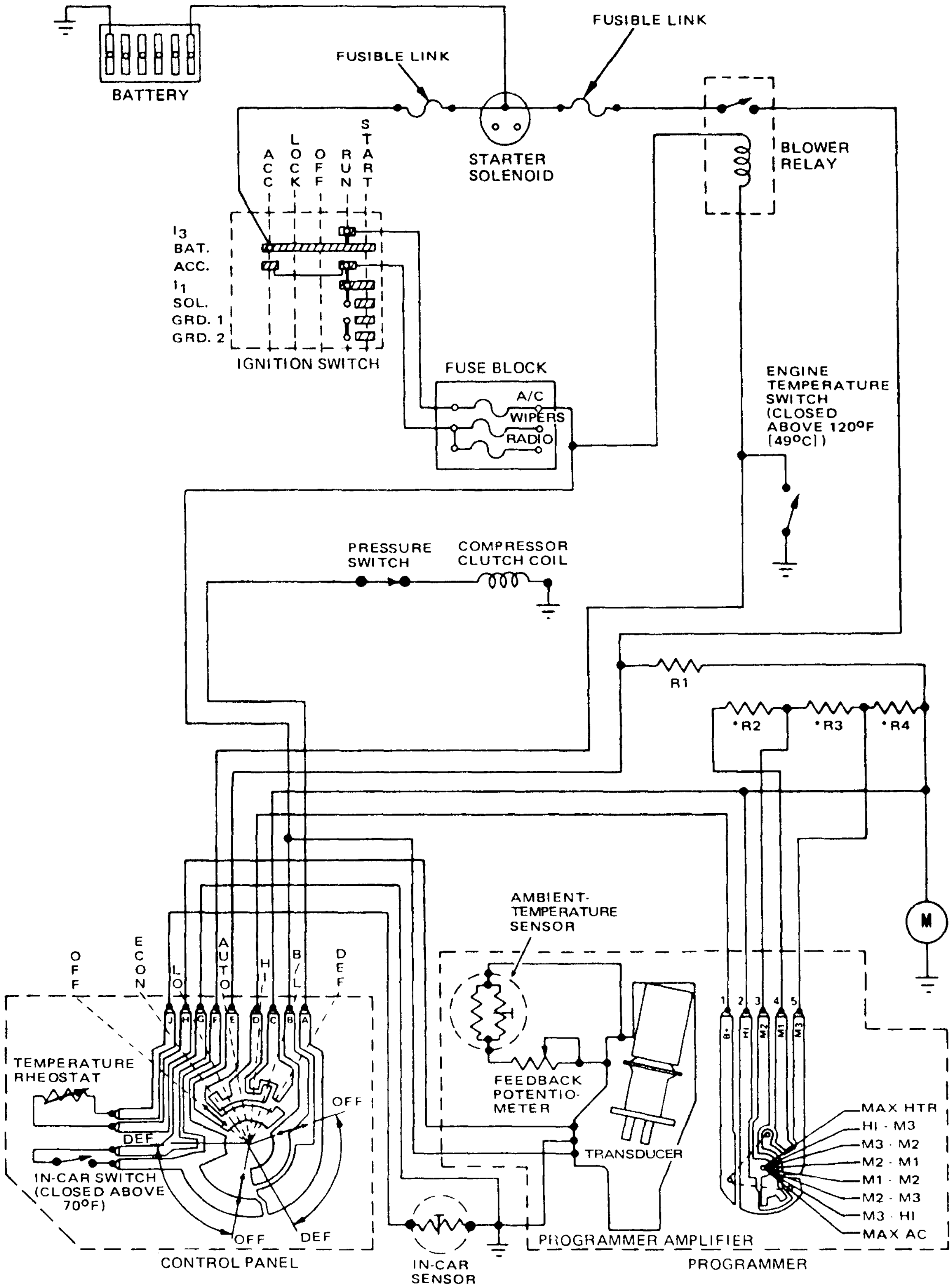



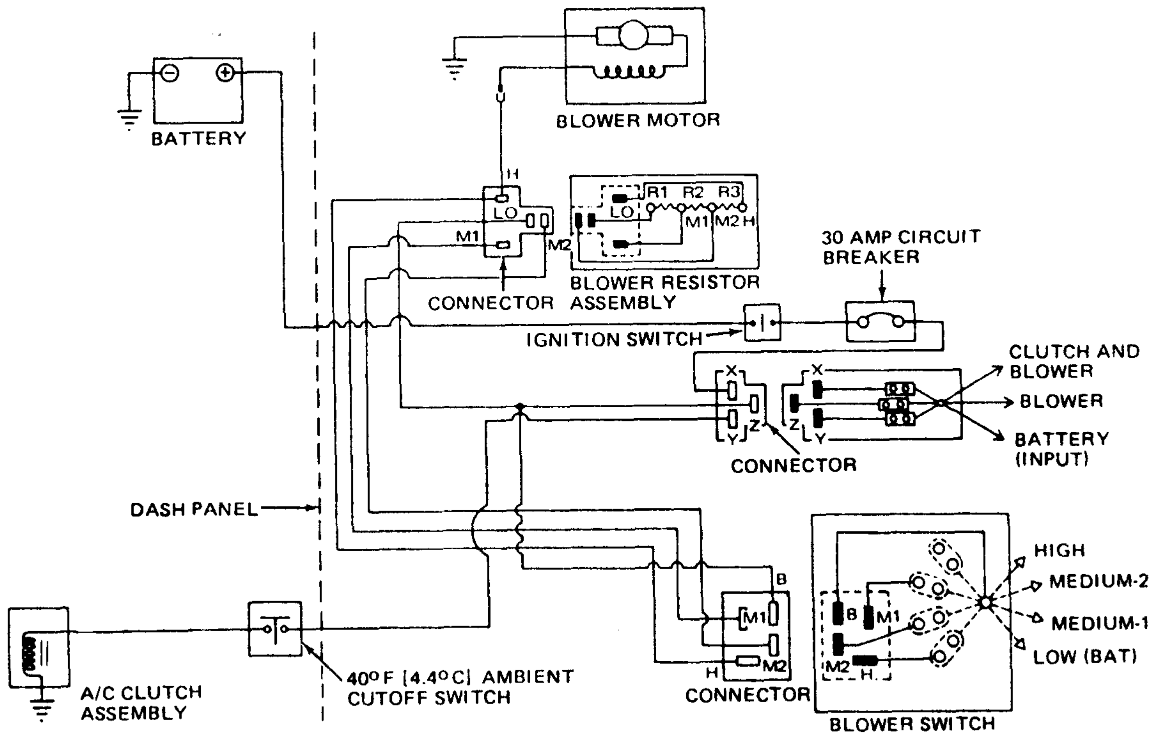
CHECKING DUCT TEMPERATURE

COMMON SIGHT GLASS SYMPTOMS

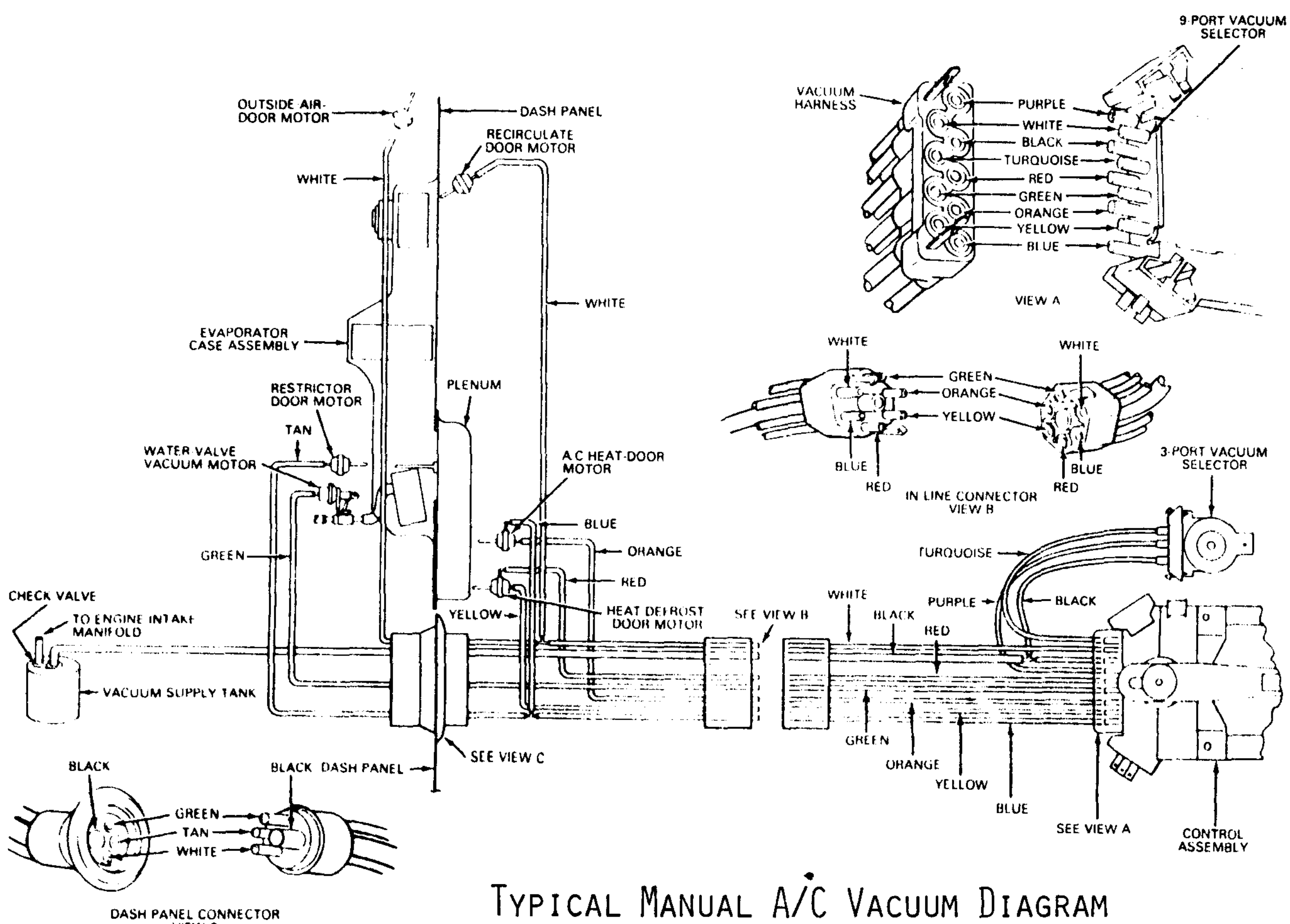


# Wiring Diagram for GM Automatic Temperature Control System (Typical)



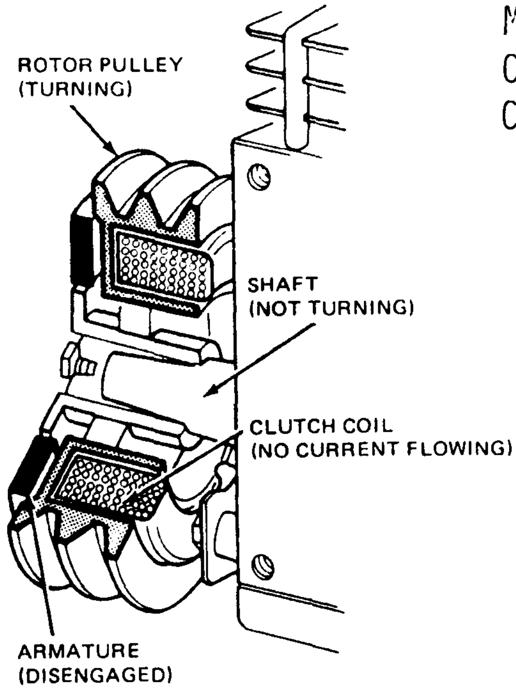


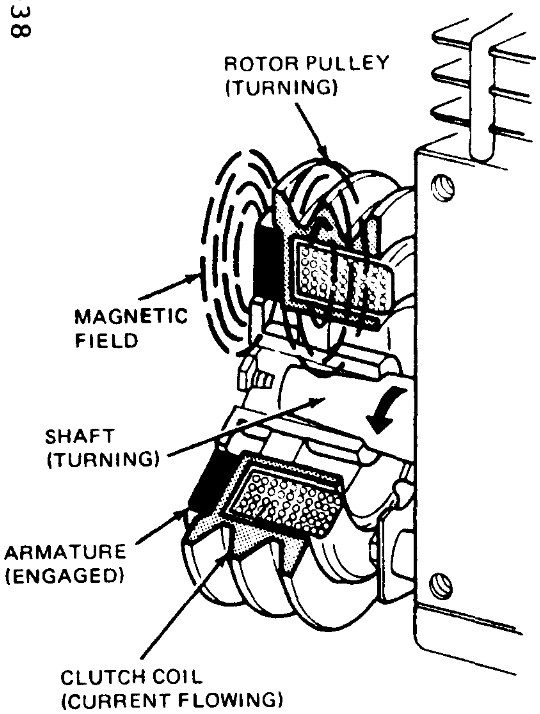

TYPICAL MANUAL A/C WIRING DIAGRAM

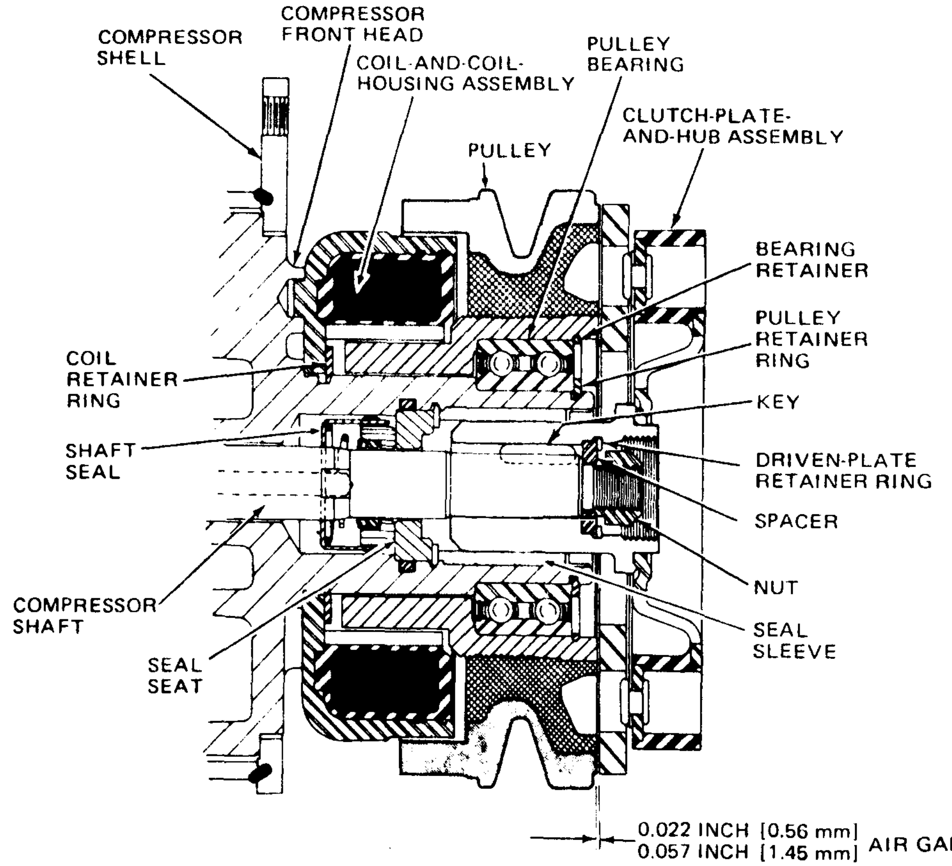


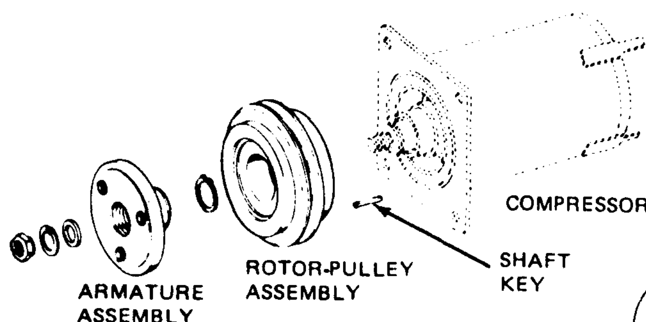

TYPICAL MANUAL A/C VACUUM DIAGRAM

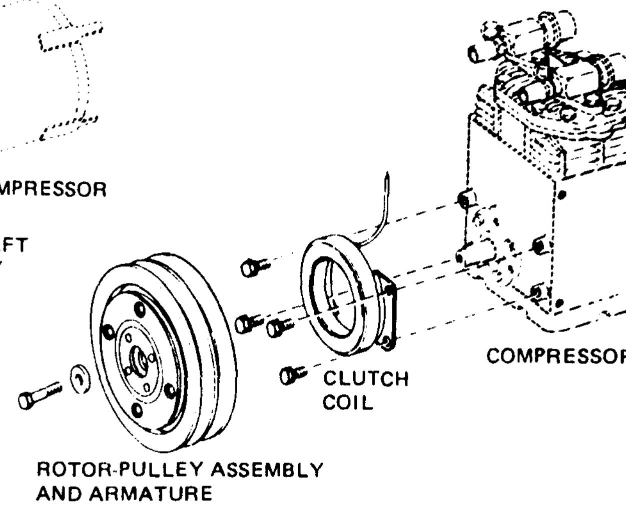
# Magnetic Clutch Components



# NOTES