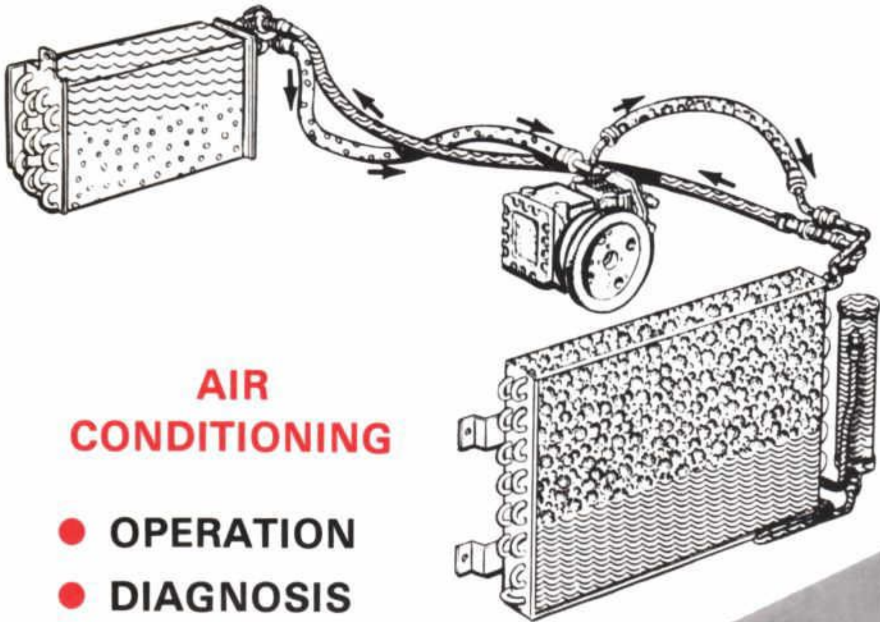
SHOP TIPS FROM Autolite Ford

VOL. 5, NO. 9 MAY, 1967



AIR CONDITIONING

- OPERATION
- DIAGNOSIS
- TESTING

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"PICK THE EMMY AWARD WINNERS" CONTEST

See pages 8 & 9 for full details and entry form

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

GRAND NATIONAL PRIZE!

AIR CONDITIONING...

IN THIS ISSUE

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

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Autolite Ford

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VOL. 67 PSM 105 LITHO IN U.S.A.

INTRODUCTION

Do you remember when air conditioned cars were something of a rarity, even in warm climates? If so, perhaps you will be surprised to learn that nationally about 30% of today's new car buyers order *factory installed* air conditioning. In the warmer southern states this percentage runs as high as 90% in some areas. Combined with the increased popularity of the many "hang on" units for new and used cars, this rapidly rising percentage of cars with air conditioning dictates that . . . *all* air conditioning service no longer should be confined strictly to the specialty shop. *Every* automotive technician should be able to at least diagnose and test a unit for proper operation. If a problem exists, usually a relatively simple service operation to the air distribution or electrical systems will correct the malfunction. If testing indicates the refrigeration system must be opened, you of course, need special tools and knowledge of special service procedures to do a good job. This type of service should be performed only by a thoroughly experienced technician, such as at a Ford or Lincoln-Mercury Dealership. However, much air conditioning service does not involve opening the refrigeration system.

You can save your customers' time and trouble during the hot months ahead, by learning about air conditioning service *now*. This article will acquaint you with some basic fundamentals to help you explain air conditioning service to your customers, plus how to diagnose and test air conditioners . . . whether they are simple hang on units, or the more sophisticated "integral with the heater" units.

NOTE: Comprehensive Air Conditioning Service Training Courses Nos. 19001.1 and 19002.1 in Handbook form can be ordered through your Ford or Lincoln-Mercury Dealer. They include complete information on the diagnosis, adjustment and repair of the refrigeration system.

AIR CONDITIONING PRINCIPLES

WHAT IS COLD AIR?

To cool the air, we remove the "heat" from it. Heat is a form of energy which we measure with a thermometer. The term "cold" describes the *amount* of heat; specifically a low temperature. In other words, "cold" is not something you can produce. Cold is simply the absence of heat, just as darkness is the absence of light. And just as turning the lights off darkens a room, so removing the heat from the air cools it.

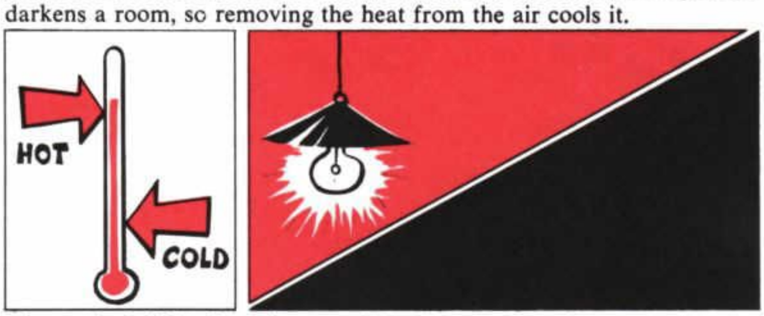


Figure 1—Cold is the Absence of Heat, Just as Darkness is the Absence of Light

HEAT AND STATES OF MATTER

All substances exist as one of the three natural states of matter (solid, liquid or gas). The specific form depends on the amount of heat contained by the substance. A familiar example is water (Fig. 2). If the water is very cold, it is frozen as ice—a solid. Between 32°F and 212°F, water is a liquid. Above 212 degrees, water exists in the form of a vapor, or gas.

Figure 2—States of Matter

When water changes from one form to another (for instance from solid to liquid) it absorbs great quantities of heat. This, of course, was the principle of the old-fashioned ice box, in which a block of ice cooled the food until heat melted the ice. The heat required to change the state of a substance (in this case ice to water) is called *latent*, or hidden heat. You can't measure it directly with a thermometer or feel it, but it is the basis of all refrigeration.

LATENT HEAT

To further illustrate latent heat, observe what happens when we put a thermometer into a beaker of water, and begin to add heat. If the beaker is at sea level where the normal atmospheric pressure is 14.7 psi, the temperature of the (liquid) water will slowly rise to 212° Fahrenheit. At 212 degrees the water will begin to boil or vaporize—BUT THE TEMPERATURE WILL REMAIN AT 212 DEGREES, EVEN THOUGH WE CONTINUE TO ADD MORE HEAT (Fig. 3). The temperature remains constant because the *additional* or latent heat changes the water from a liquid to a vapor, rather than increasing the temperature still further.

Figure 3—Latent Heat

TEMPERATURE-PRESSURE RELATIONSHIPS

Latent heat was illustrated in Figure 3 by showing what happens if we boil water in an open container, where the vapor can escape. If we cover, or plug, the container (Fig. 4) so the vapor can not escape, we discover a fact which is the key to understanding air conditioning. As more and more vapor is released with no room to expand, PRESSURE AND TEMPERATURE INCREASE. The same thermometer that registered a constant 212 degrees when we boiled water in an open container at normal atmospheric pressure will rise 2½ to 3 degrees for each psi pressure rise. In other words, we raise the boiling point by increasing the pressure.

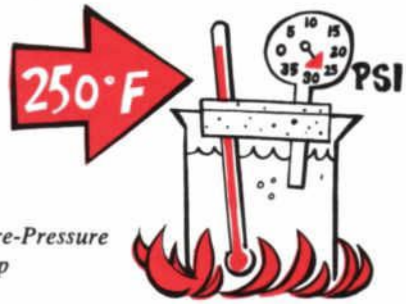


Figure 4—Temperature-Pressure Relationship

This, of course, is the principle behind the pressurized cooling system. By using a pressurized radiator cap, the water can be heated far above 212°F. without boiling away. And as everyone knows who has ever mistakenly removed a radiator cap from a pressurized system—doing so causes the water to instantly boil and turn to steam.

A similar thing happens in the air conditioning system, only under controlled conditions. A liquid refrigerant under high pressure is carefully metered into an area of low pressure . . . causing the refrigerant to boil within a cooling unit called an evaporator, thus changing its state from liquid to gas and absorbing great quantities of heat.

REFRIGERANT SELECTION

Each substance has *two* points on the thermometer where it can absorb heat. Water, for example, absorbs heat at 32°F. when it changes from ice (a solid) to liquid; and again at 212°F. when water boils and changes from a liquid to a vapor. A solid refrigerant is not practical because of recycling problems. So, the first requirement of the refrigerant is that it be a liquid. The second important point to be considered is that the refrigerant can only absorb heat quickly if its boiling point is *lower* than the surrounding air. Since we wish to lower the temperature of the passenger compartment of the car to the human comfort zone of approximately 70-80 degrees, the boiling point must be below this range. As shown in Figure 5, water (with a boiling point of 212 degrees) and alcohol (with a boiling point of 160 degrees) would not be practical, However, Refrigerant-12 (Freon) with a boiling point of −21.7° Fahrenheit (at atmospheric pressure) more than meets this requirement.

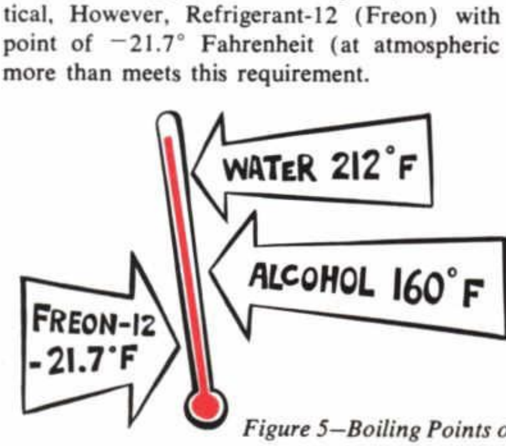


Figure 5—Boiling Points of Liquids

AIR CONDITIONING...

REFRIGERATION CYCLE

Some types of early automotive air conditioners used dry ice to cool the car. Dry ice had one serious disadvantage, however, like the block of ice in the ice box—when the ice melted it had to be replaced, or the cooling stopped. Therefore, it can be seen that the success of the modern automotive air conditioner is due to its ability to recycle the refrigerant. To do this, the refrigerant must lose the heat absorbed when it changes from a liquid to a gas, and the gas must be converted back to the liquid state. This is accomplished in a two-step process as schematically illustrated in Figure 6.

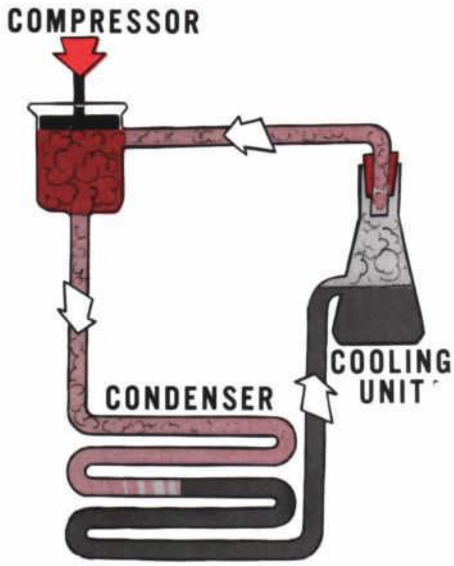


Figure 6—Refrigeration Cycle

The first step is to route the gaseous refrigerant from the cooling unit (evaporator) through a compressor. The compressor squeezes the gas into a smaller space, thus raising temperature. The greater the pressure, the higher the vapor temperature. The hot, high-pressure gas then passes through a condenser. Following a basic law of nature that heat flows from a hot area to a cool area, heat from the hot, compressed gas flows to the cooler air surrounding the condenser. As the hot, gaseous refrigerant continues to lose heat to the surrounding cooler air, it slowly changes back to a liquid. This is the reverse of the process that takes place in the cooling unit (evaporator). With this brief look at the basics of air conditioning, let's examine the components required to cool a car.

AIR CONDITIONING COMPONENTS

REFRIGERATION SYSTEM

The refrigeration system (Fig. 7) is made up of five basic components: a compressor, a condenser, a receiver, an expansion valve, an evaporator and blower assembly, plus hoses and fittings.

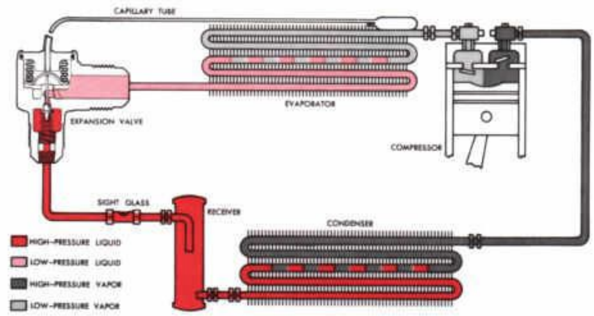


Figure 7—Refrigeration System Components

EVAPORATOR

The evaporator is usually located within the passenger compartment, either as a separate unit, or as an integral part of the heating and air conditioning system. On some trucks it's located outside on the cab roof. It acts as a heat exchanger to transfer heat from the air in the passenger compartment to the vaporizing refrigerant. Several coils of copper tubing pass through many, closely spaced aluminum fins (Fig. 8). When liquid refrigerant is metered into the evaporator under low pressure (about 1/9 the high pressure) the refrigerant boils and absorbs great quantities of heat from the copper tubing and aluminum fins. An airstream, produced by a squirrel-cage blower, is directed over the fins and tubes. This air is warmer than the evaporator and gives up its heat to the fins, tubes, and

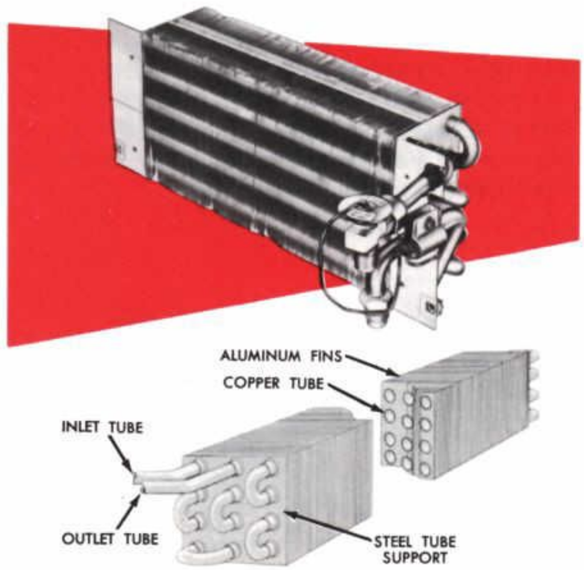


Figure 8—Typical Evaporator

finally to the refrigerant. The air on its way to the passenger compartment is cooled, and water vapor condensed out of the air. A water-collecting pan with a drain hole and drain tube in the housing under the evaporator gets rid of the condensed moisture.

An important point to remember in connection with condensation is that the temperature of the evaporator must be kept above 32°F., or ice will form in the evaporator and block the flow of air. For this reason, Refrigerant-12 which boils at −21.7°F. under normal atmospheric pressure, is kept under sufficient pressure to raise its boiling point above 32°F. A thermostatic control switch regulates evaporator temperature, by controlling compressor operation and pressure.

COMPRESSOR

Ford-built vehicles use a two-cylinder reciprocating compressor (Fig. 9). It is mounted at the front side of the engine and is belt driven. The compressor pulley is integral with a magnetic clutch (Fig. 10) which connects and disconnects the compressor from the engine. With the air conditioning system "off", the magnetic clutch is disengaged from the compressor and the compressor pulley freewheels on its shaft. Turning the A/C system "on" engages the compressor. On the downward stroke of the piston it creates a vacuum in the cylinder (Fig. 11). This vacuum causes the refrigerant to be drawn through the intake valve of the compressor, and creates the low-pressure condition in the evaporator. For this reason, the intake valve is often referred to as the "suction valve." This side of the compressor is also called the "low-pressure side." On the upward stroke, the piston compresses the vapor thereby increasing its temperature and pressure. The vapor is forced past the outlet valve (Fig. 11). This valve is sometimes called the "discharge valve" and this side of the compressor is referred to as the "high-pressure side." The compressor is lubricated by vaporized oil which moves along with the refrigerant. The hot, pressurized vapor flows from the compressor to the condenser.

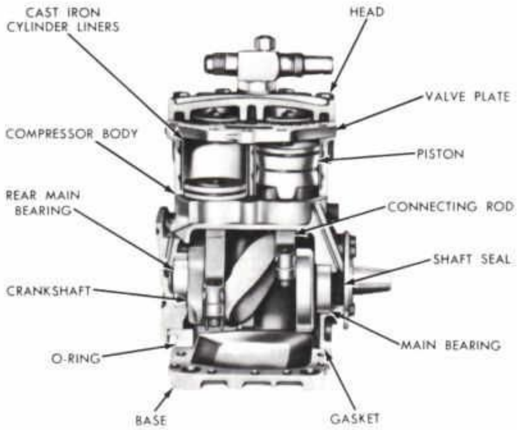


Figure 9—Typical Compressor

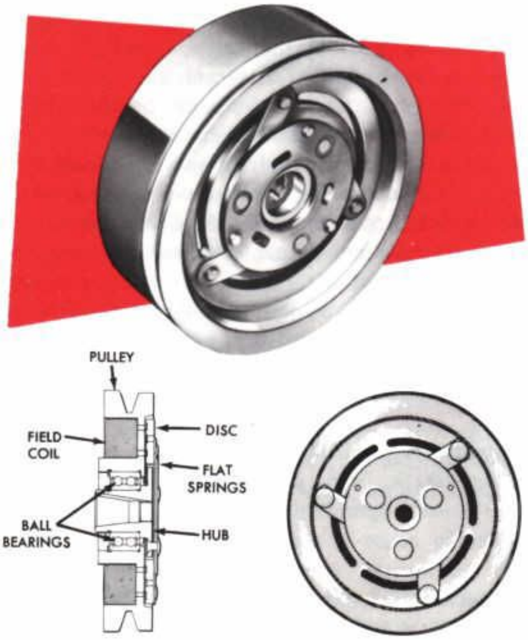


Figure 10—Typical Magnetic Clutch

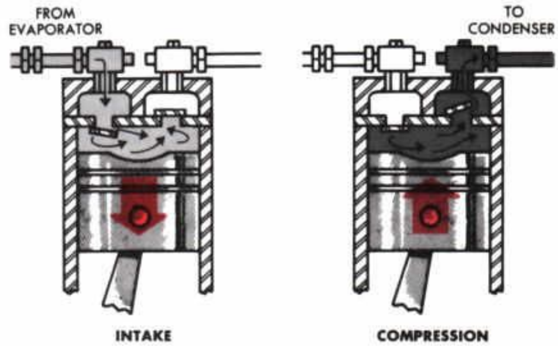
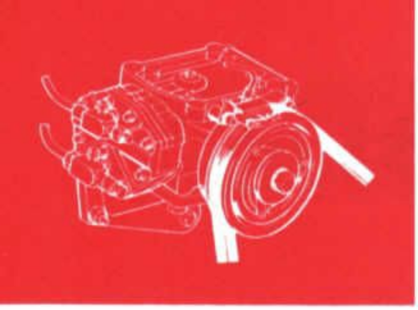


Figure 11—Compressor Action

CONDENSER

The condenser acts as a heat exchanger—much like the evaporator, so its construction (Fig. 12) is much the same.

Figure 12—Typical Condenser



AIR CONDITIONING...

However, its function is reverse to that of the evaporator. It removes the heat that was absorbed in the evaporator so that the refrigerant condenses back to a liquid. The condenser is usually mounted in front of the radiator to take advantage of the high speed air flow. This tends to reduce air flow through the radiator. Therefore, a higher capacity radiator and cooling fan usually are part of the air conditioning package.

The air around the condenser is much cooler than the hot, pressurized refrigerant vapor. The vapor enters at the top of the condenser, and cools as it goes through the coils. As it gives up heat to the surrounding air, the vapor condenses back to a liquid. The liquid refrigerant then flows into the receiver-dehydrator.

RECEIVER-DEHYDRATOR

The receiver-dehydrator (Fig. 13) stores the liquid refrigerant and removes moisture which could cause freezing within the system. The amount of refrigerant stored is greater than that needed for normal operation. Thus, small refrigerant losses will not affect operation of the air conditioner.

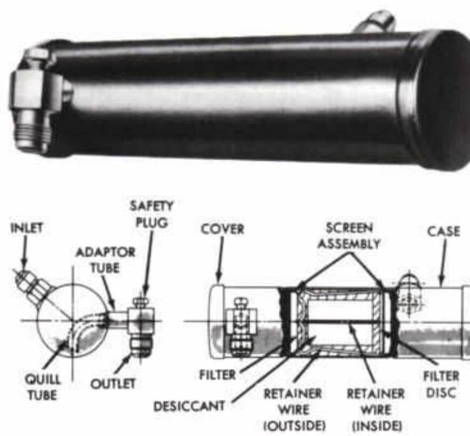


Figure 13–Receiver-Dehydrator

The dehydrator or dryer portion consists of two screens, filter discs and a drying agent. In most systems the dryer material is calcium sulphate.

A fusible plug incorporated in all receiver assemblies, discharges the system if the temperature goes above a safe limit. The fusible plug will open the system at a temperature of 232 degrees.

SIGHT GLASS

A sight glass, which permits inspection of the refrigerant, is installed in the high-pressure line between the receiver and the expansion valve, or in the expansion valve itself. Bubbles, or foaming, in the sight glass indicates that the refrigerant is low. Some bubbling is normal when the system is first started, but a solid stream of refrigerant should show in the glass after a minute or so.

EXPANSION VALVE

The expansion valve meters liquid refrigerant under high-pressure into the low-pressure area of the evaporator.

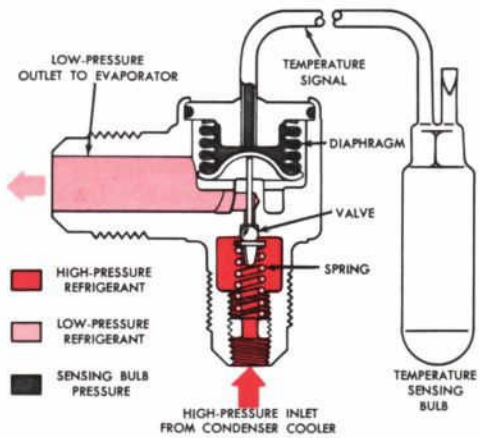


Figure 14–Expansion Valve and Temperature Sensing Bulb

For maximum cooling, the flow of liquid refrigerant must be precisely controlled so that *all* the liquid boils and turns to vapor, to achieve vaporization throughout the total evaporator. Excessive refrigerant must not enter, and remain in the evaporator, as a liquid. The expansion valve senses how much refrigerant is metered by means of a signal from a *temperature sensing bulb* (Fig. 14). The temperature sensing bulb is located next to the evaporator (Fig. 7) and is filled with Refrigerant-12, or carbon dioxide gas. As the temperature around the sensing tube increases, the pressure on the gas within the tube increases. This pushes against the diaphragm (Fig. 14) and opposes the forces tending to hold the valve closed (high-pressure refrigerant, low-pressure refrigerant, and spring pressure). When these pressures are overcome by the temperature sensing tube pressure, the diaphragm moves down and opens the valve to meter refrigerant. This cools the evaporator, which cools the temperature sensing tube. This results in less pressure within the tube and on the diaphragm, so the diaphragm moves up and closes the ball check valve. In actual practice, the valve is never completely closed when the air conditioner is operating because the cycle is repeated over and over again in sort of a "jiggle-pin" fashion.

DIAGNOSIS

Air conditioning malfunctions most often result in (1) insufficient, erratic, or no cooling; (2) lack of cooling control; (3) noisy operation; (4) improper air distribution. The specific cause is usually found in the refrigeration system, compressor and magnetic clutch system, or the door operation of the air distribution system. Before inspecting for the specific cause, however, *every* technician should be aware of and practice the following safety precautions.

Operation, Diagnosis and Testing

SAFETY PRECAUTIONS

Refrigerant-12 is used in all Ford air conditioning systems because it is *nearly* an ideal refrigerant. It operates at low pressure and condenses easily in the temperature ranges encountered in automotive condensers, and is:

- odorless
- colorless
- tasteless
- non-corrosive
- non-toxic
- non-flammable

This makes it a relatively safe refrigerant. However, it is used under pressure, and its low boiling point (−21.7°F.) combined with chemical change when in contact with a flame require certain handling precautions for personal safety.

Don't Spill or Touch Liquid

Liquid Refrigerant-12 vaporizes so quickly and at such a low temperature, that even a drop on your skin will cause severe frostbite. Therefore, take every precaution not to get any liquid on your skin. Open fittings very slowly to release pressure carefully. Operate all testing and service valves according to instructions. When charging the system, let the refrigerant enter as a vapor; don't pour it in. If skin is exposed, treat skin areas for frostbite.

Wear Safety Goggles

Always wear safety goggles when servicing the air conditioning system. Liquid refrigerant in your eyes due to an accidental break or disconnect in the lines could blind you. If liquid refrigerant should get in your eyes, rinse them immediately with mineral oil to absorb the refrigerant. Follow by flooding with a weak solution of boric acid and consult a physician immediately.

Avoid Heat

Pressure in a refrigerant container or in the system will rise with heat. The refrigerant should never be heated unnecessarily. Store containers upright, out of the sun, and away from heat outlets. Always discharge the refrigerant from the system if the car is going into a paint oven; or if welding or steam cleaning are to be done near the system. Also watch the temperature and pressures when testing the system. Direct a fan on the condenser through the radiator grille to avoid overheating.

It is common practice to put a refrigerant bottle in a pan of warm water to raise the pressure and thus speed charging of the system. But NEVER, EVER, use a blow torch to make it happen faster. This could cause an extremely fast pressure rise, and an explosion.

Ventilation

Adequate ventilation is essential for several reasons. Though Refrigerant-12 is non-toxic, it doesn't contain the oxygen we need to breathe . . . and therefore, too much of it in a confined space could be suffocating. Also, too much refrigerant vapor in the air will interfere with leak testing . . . the system will appear to be leaking everywhere. Therefore, always discharge the refrigeration system into an exhaust outlet or through an open window or door.

Avoid Flame

At all normal temperatures, Refrigerant-12 is non-toxic. However, in contact with an open flame, Refrigerant-12 forms phosgene gas, a well-known fumigator. It is highly toxic to humans and animals. Never discharge a system near an open flame. When a flame torch is used to detect leaks, don't breathe the fumes.

TESTS

Operating Conditions

All operational tests of the system should be made with the engine operating at 1500 rpm. Cooling controls should be set in the *maximum* cooling or recirculating position. The blower should be set at its highest speed. The system should be allowed to stabilize for 10 to 15 minutes.

Air Temperature of the discharge air should be checked by holding any good thermometer in the cooling outlets. This will give you a fast, accurate indication of how efficiently the refrigeration system is operating. The discharge air temperature should be 68 degrees Fahrenheit, or less, in a 100 degree atmosphere . . . and should decrease to 58 degrees, or less, when the surrounding air is 80 degrees. If you're making the test indoors, consider the temperature in the shop as your basis; not the outdoor temperature.

Humidity has an adverse effect on air conditioner efficiency. That's because part of the cooling capacity is used to dehumidify, or wring moisture out of the air. In extremely humid weather, the discharge air temperature will not be as low as when the air is dry.

Air Volume should be checked by holding your hand in front of the register outlets, with the blower control set to its highest position. Compare the air volume with a known good unit. If the volume is low, a leak probably exists around one of the air distribution doors.

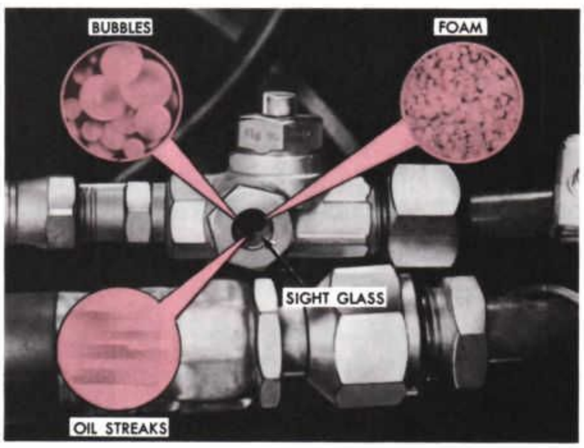


Figure 15—Sight Glass

WIN WITH THE WINNERS!!!

Enter Autolite's Big $25,000 "PICK THE EMMY AWARD WINNERS" CONTEST!

Got a "yen" to own a 1967 Thunderbird? Or watch next year's Emmy Show on a color TV set? Then get started . . . get in on the fun!!!

HOW TO ENTER

First, just pick the "Emmy Award Winners" from the nominees listed on the entry card (There are nominees for each of five categories). Then fill in your estimate of the number of households that will watch the show. (According to the National Nielsen TV Rating, between 16,000,000 and 17,000,000 households tuned in to last year's Emmy telecast.) Mail the self-addressed official entry form, and that's it! Do it now . . . Your entry must be received at Contest Headquarters by Saturday, June 3rd—12:00 noon.

Then watch the show on Sunday, June 4th and see how you did. This high-interest show is co-sponsored by Autolite as another big gun in the biggest advertising program ever to hit the automobile parts business.

The contest is limited to people who sell and/or install automobile parts. You'll be competing only with folks like yourself. YOU CAN WIN!

626 Valuable Prizes!

GRAND NATIONAL PRIZE!

Some lucky winner—it might as well be you—will soon be the owner of a 1967 Thunderbird Four-Door Landau!

100

Polaroid "Swinger" Cameras (Model 20)

25

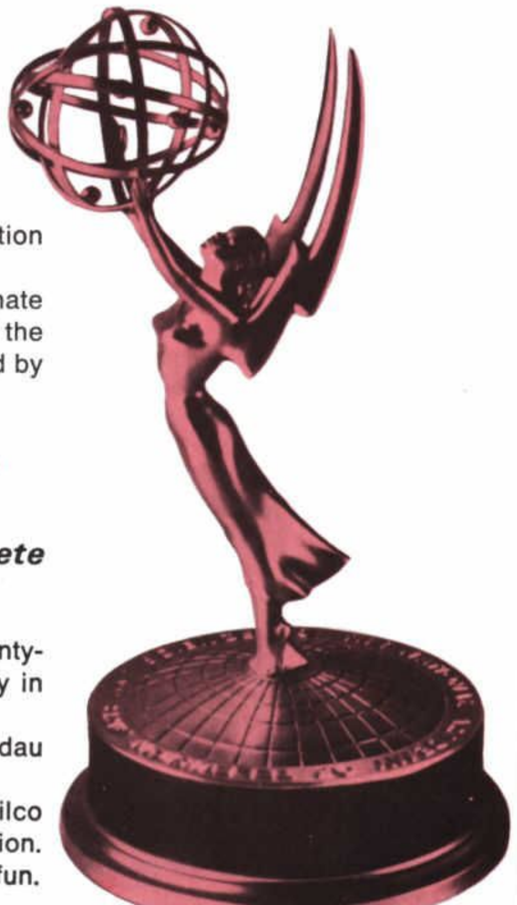
Philco Color Television Sets (Model 5300WA) — one will be awarded in *each* of the 25 Autolite Sales Districts.

500

Philco Transistor Radios (Model T-600)

Autolite sponsors
"THE EMMY AWARDS SHOW!"

SUNDAY–JUNE 4th–ABC-TV



BE A WINNER IN AUTOLITE'S $25,000 CONTEST!

The "Pick the Emmy Award Winners" Contest will be judged on your selection of winners.

In the event of ties, winners will be decided on the basis of your estimate of total households who will watch the Emmy Award show on ABC-TV the evening of Sunday, June 4, 1967. (The correct number will be determined by the A. C. Nielsen rating of the show.)

THE ODDS ARE IN YOUR FAVOR!

You've got a terrific chance to win because you compete only with people in your area for this top award.

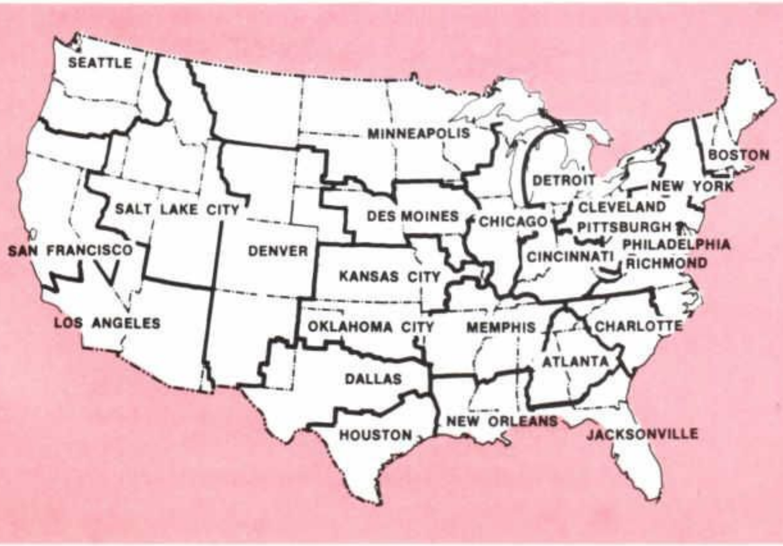
There's a separate contest in each of Autolite's 25 Sales Districts. Twenty-five Philco Color TV Sets will be given—one to the most accurate entry in each district.

The Grand National Award of a 1967 Thunderbird Four-Door Landau will go to the most accurate entry *nationwide*.

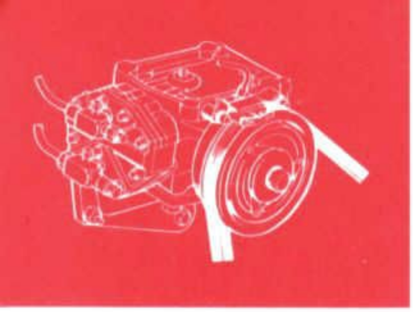
And that's not all! Six hundred Polaroid "Swinger" Cameras and Philco Transistor Radios can be won by entrants regardless of geographic location.

Match your judgment against the experts who pick the winners. It's fun. It's easy. There's nothing to buy . . . nothing to sell. Pick your favorites . . . make your "guess-timate" of households that will watch the show. Get your entry in the mail!

NOTE: If your wife is the TV expert at your house, get her in the act! Win with the winners!



WINNERS IN ALL 25 AUTOLITE SALES DISTRICTS!



AIR CONDITIONING...

SIGHT GLASS CHECK

If the discharge air temperature leads you to believe the refrigeration system could be operating more efficiently, check the sight glass. Continuous bubbles or foam (Fig. 15) in the sight glass indicate the system has lost part of its charge; that is, that some of the refrigerant has leaked out. Some bubbling is normal when the air conditioning is turned on. However, if the system has a full charge, there should be a solid stream of clear refrigerant, with perhaps an occasional bubble at very high temperature.

Cycle the Clutch. Since the refrigerant is clear, a completely discharged system could look just like a fully charged system. To make certain you aren't mistaking an empty sight glass for a solid stream of refrigerant, cycle the compressor clutch once or twice. To cycle the clutch, turn the cooling control knob off. If there is refrigerant in the system, you'll see bubbles during the off-cycle. The bubbles should disappear and the sight glass become clear again during the on-cycle.

Look for Compressor Oil. Another trouble indication is oil in the sight glass (Fig. 15). It may appear in streaks, or as a constant flow. Either way it indicates part of the charge has been lost.

Don't Partial Charge. Simply recharging the system to get a good sight glass reading is not recommended for two reasons: First, a lost charge means a leak exists. If not repaired, the system will malfunction again. Second, a partially charged system can be easily overcharged. Overcharging can cause extensive damage. So, in *any* instance where the system is undercharged, overcharged, or has air in it; perform a leak test, discharge the system, and recharge to the specified refrigerant weight.

"Slugging" Noises. Sometimes a "slugging" noise, which sounds like engine pre-ignition, may be heard in the refrigeration system. It's caused by a faulty operation of the expansion valve. If you hear the noise, check the contact between the expansion valve's sensing bulb and the evaporator tube (Fig. 16). The surface must be clean and corrosion-free, and the bulb must be clamped tightly in the tube. If the bulb is properly clamped and the "slugging" doesn't stop, the expansion valve should probably be replaced.

Some slugging can occur in a normally operating system. If the noise is not extreme, it will not harm the system.

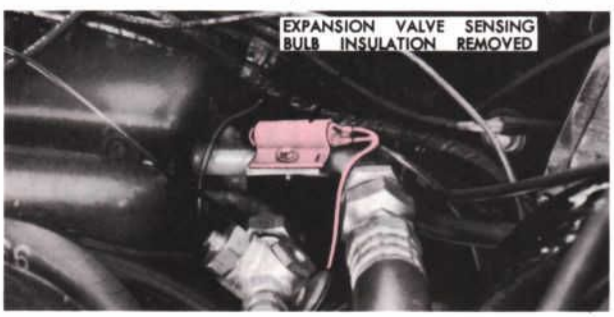


Figure 16—Checking Expansion Valve Bulb Contact

CONDENSER CHECKS

Anything that restricts air flow through the condenser can reduce the efficiency of the refrigeration system. The air flow should be unobstructed by dust, leaves, paper, dried mud, and bug screens to avoid high pressures and provide maximum heat transfer. If necessary, clean with a stiff-brush and compressed air.

REFRIGERANT LINES AND SERVICE VALVE CHECKS

Refrigerant Lines should be visually checked for clamps and brackets which keep the lines separated to reduce the possibility of damage due to vibration, or heat from manifolds. Typical refrigerant lines (Fig. 17) are routed to avoid sharp kinks. Kinked lines reduce refrigerating capacity and should be replaced.

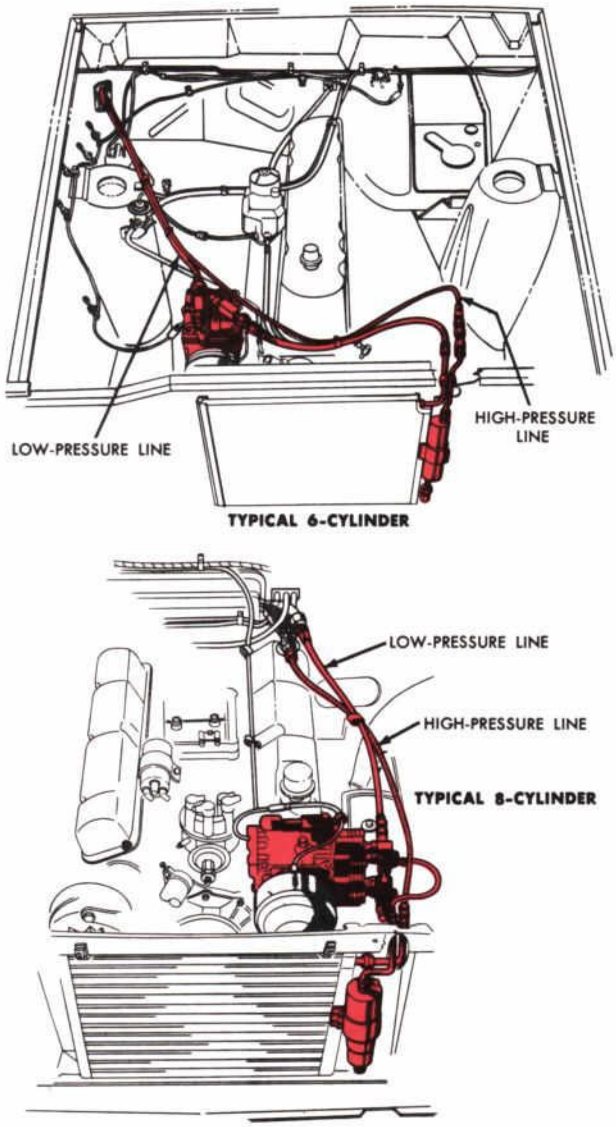


Figure 17—Typical Refrigerant Line Routing

Operation, Diagnosis and Testing

Service Valves are installed in the compressor head to make connections to the condenser and evaporator, and provide a place to charge the system with refrigerant and to connect pressure gauges. When the system is operating, the service valves should be *back-seated* (Fig. 18). When back-seated, the valves are screwed out to open the condenser or evaporator port to the compressor and to block the gauge port. Conversely, when the system is being serviced the valves are front-seated by screwing them inward to close the condenser or evaporator port to the compressor and to open the gauge port.

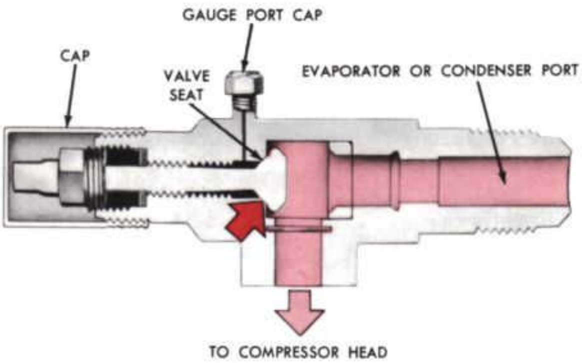


Figure 18—Back-Seated Service Valve

Check that the stems are screwed out (counterclockwise) until the valves are firmly seated for normal system operation.

COMPRESSOR CHECKS

Normally, the compressor operates quietly and efficiently. If noise or vibration are encountered, check for a loose compressor clutch bolt, or an improperly installed clutch field, if so equipped. Check for this condition with the engine stopped. If the clutch field is rubbing against the clutch, make certain the proper field mounting screws are used to correctly locate the field on the compressor. Tighten the clutch field screws securely. If the clutch is loose, remove it and inspect the taper and keyway.

Faulty brushes and/or slip rings can affect clutch operation, and should be checked as a cause of insufficient cooling.

Noisy operation with the clutch engaged may be caused by loose compressor mounting bolts, support bracket bolts, or clutch mounting bolts. Check to see they are all tight. Also check the adjustment and alignment of the drive belt; and clutch runout.

Drive Belts that are loose or slip, cause compressors to run at less than full speed. This is usually the problem when there is *some* cooling, but not the amount specified. Air conditioning drive belts should be tensioned with a gauge to 140 pounds when new. A used belt should be tensioned to 110 pounds. A drive belt is considered "used" after it has run for 10 minutes.

The drive belt also should be checked for alignment. It should come off the pulley grooves perfectly straight. There should be no sideways binds in the belt as it approaches or leaves the pulleys.

Clutch Runout can also cause noisy operation. Diagnose by mounting a dial indicator, and turning the clutch by hand with the ignition off. If total indicated runout is more than $\frac{1}{32}$ inch, the clutch should be replaced.

ELECTRICAL TESTS

Malfunctions in the electrical circuit (Fig. 19) can cause the compressor or blower to be inoperative. The result is insufficient or no cooling. When the compressor doesn't appear to be cycling, the magnetic clutch may not be holding because of excessive resistance. To test the circuit, set the controls for maximum (recirculating) cooling . . . with the blower on high . . . and turn the ignition switch to the "accessory" position.

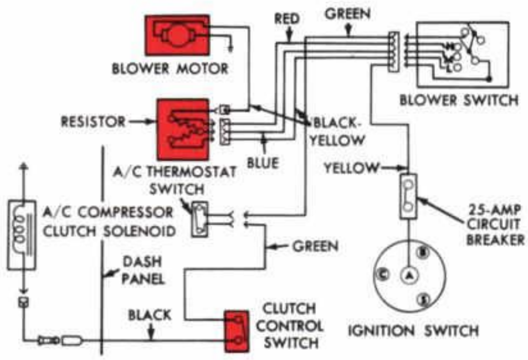


Figure 19—Typical Compressor Clutch and Blower Circuit

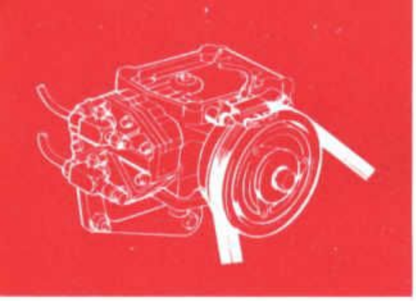
Clutch Operational Test

If the clutch is operating, you should hear a sharp click each time you turn the ignition on or off. If you don't hear the click, on a brush and holder equipped clutch assembly, examine the clutch slip ring and brushes for good contact. If there is grease, dirt, or oily film on these parts, clean them and repeat the test. If the clutch still doesn't operate, make a current draw test.

Clutch Current Draw Test

Test the clutch current draw as follows:

1. Disconnect the clutch lead wire at the bullet connector near the clutch.
2. Set the ammeter to the appropriate scale for the specified current draw (2 amperes for '67 models).
3. Connect an ammeter in series with the clutch lead and the battery positive terminal. Again you should hear a sharp click as the circuit is completed. If you don't hear it, the field should be replaced on cars so equipped.



On a clutch with a slip ring and brush, disconnect the ammeter from the brush lead wire. Bypass the brush and holder, and connect the ammeter lead to the clutch slip ring. If the clutch clicks, replace the brush and holder. If the clutch does not click, replace the clutch.

4. Connect the ammeter once again in series with the clutch lead and the battery positive terminal. Read the current draw. It should be 2 amperes (max.) for all 1967 models.

If the current draw is to specifications and the clutch engages in this test . . . but not with the ignition switch . . . the compressor clutch circuit must be tested.

Compressor Clutch Circuit Test

This test is performed with a 12-volt test light. Set the air conditioning controls as for the clutch operational test, with the ignition switch at the "accessory" position. Begin at the clutch solenoid and proceed back through the circuit until the test lamp lights. At this point, discontinue testing, correct the malfunction, and repeat the clutch operational test.

The procedure:

1. With one end of the test light connected to a good ground, touch the probe to the lead between the clutch control switch and the clutch solenoid (Fig. 20). If the light doesn't burn, move the probe to the switch connection. If it burns now, the lead wire requires repair or replacement.

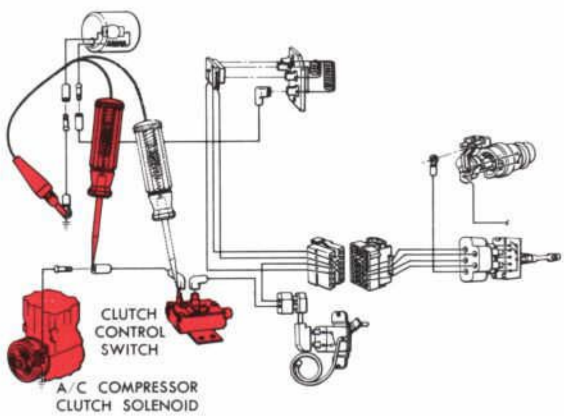


Figure 20—Testing Clutch Lead Continuity

2. If the light doesn't burn in step 1, move the probe to the opposite connection on the switch. Now if it burns, the switch must be misadjusted or damaged. Repair or replace.

3. If the light still doesn't burn, move the test probe to the connection between the thermostatic switch and the clutch switch (Fig. 21). A glowing light here tells you the lead between the switches is open or damaged. Repair or replace. If the light still doesn't glow, test for power to the thermostatic switch.

4. To test the thermostatic switch, move the probe to the input terminal (Fig. 22). If the light glows now, but didn't before, the thermostatic switch isn't functioning and should be inspected and tested.

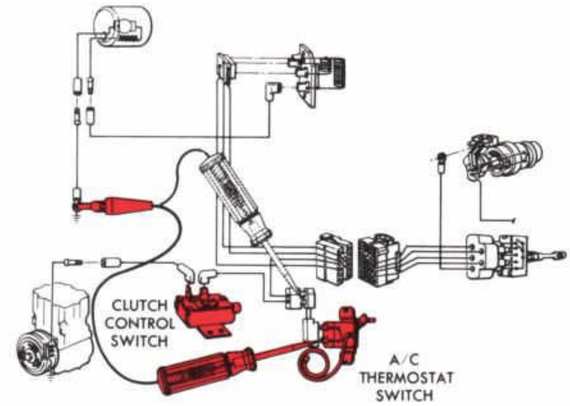


Figure 21—Testing Thermostatic Switch to Clutch Control

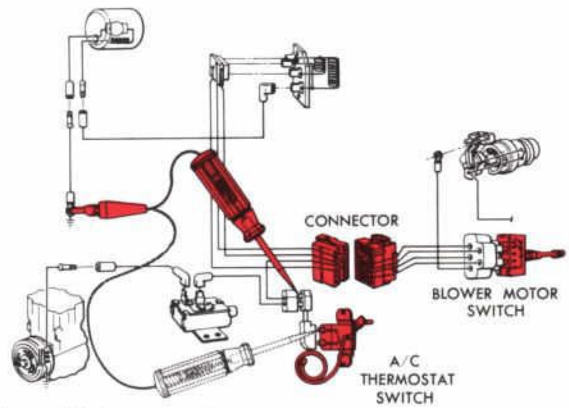


Figure 22—Testing Thermostatic Switch

5. The next test point is the blower switch output terminal which connects to the thermostatic switch (Fig. 23). If the light glows at this point, replace or repair the green lead or its connection.

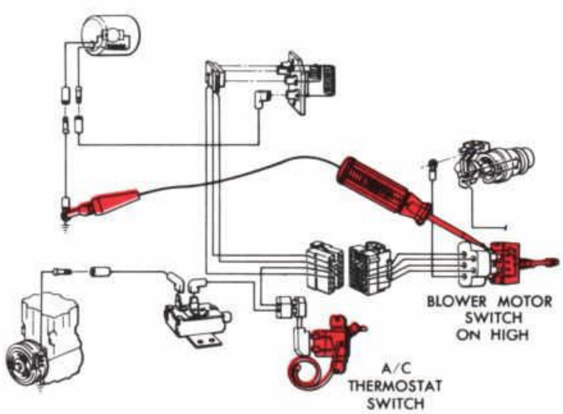


Figure 23—Testing Blower Switch to Thermostatic Switch Lead

6. Next move the probe to the opposite (ignition switch side) terminal of the blower switch. A glowing light here indicates the blower switch isn't working properly. Repair or replace.
7. The final test of the clutch circuit is to move the probe to the circuit breaker terminal (Fig. 24). The circuit breaker is usually mounted on the accessory terminal of the ignition switch. Test for power through the breaker and through the switch. If either isn't passing current, replace as required.

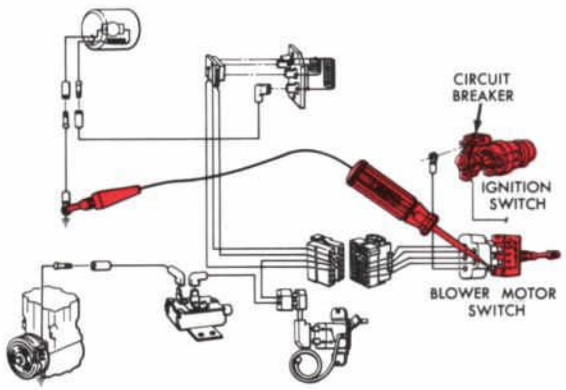


Figure 24—Testing Blower Switch

BLOWER MOTOR CIRCUIT TESTS

As indicated in Figure 19, voltage to operate the blower motor is supplied to the blower switch from the ignition switch. The blower switch passes this voltage on full-strength to the blower resistor. The resistor determines the actual current draw in this part of the circuit, depending on which of its terminals receives the supply voltage. If the air volume is low or there is no air, or the motor doesn't operate properly at all three speeds, check the voltage supply and current draw in these three branches of the circuit.

Blower Supply Voltage Test

To test the continuity of voltage to the blower motor (Fig. 25), again use a test light with one probe grounded.

1. Start at the blower switch and place the probe on each of the L, M, and H terminals . . . with the switch set in the corresponding positions. If the light glows at each point, the switch is passing current. If not, the switch is faulty and should be replaced.
2. Move the probe to the three terminals on the resistor . . . again with the switch set to the corresponding positions. A glowing light indicates continuity through the leads.

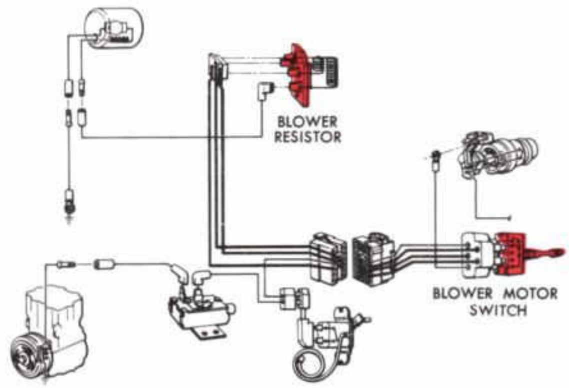


Figure 25—Testing Blower Supply Voltage

3. Proceed to the resistor terminal that leads to the motor, to test resistor continuity in all three blower positions. If the resistor doesn't pass current to the light, replace the resistor.
4. If the trouble still isn't located, continue to test the lead to the blower motor, the motor itself and the motor ground connection. Remember in all these tests, the faulty part is always somewhere between the points where the light burns and doesn't burn.

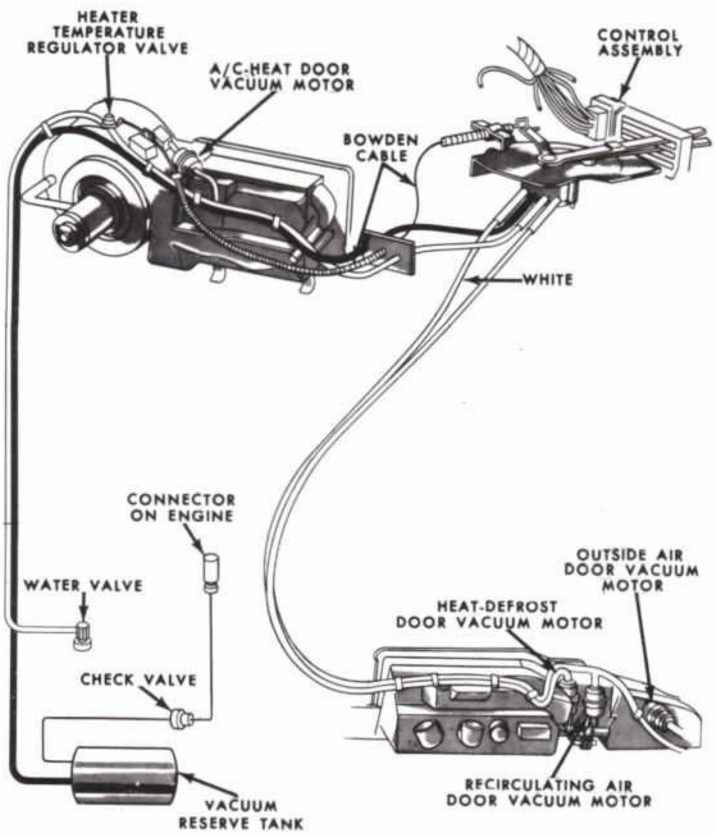


Figure 26—Ford and Mercury A/C-Heater Vacuum Schematic

AIR CONDITIONING...
Operation, Diagnosis and Testing

Diagnosis of Vacuum Controlled Systems—Figure 26 on page 11 schematically illustrates the integral Air Conditioning-Heater system used on Ford and Mercury cars. The vacuum operated air distribution doors are typical for other systems. The following charts indicate the correct position of these doors with respect to Control Lever positions. With this information the technician can make a quick diagnosis of vacuum application and air distribution. Failure to maintain 14-inches of mercury indicates a vacuum leak.

A/C-HEATER CONTROL—THUNDERBIRD

THUNDERBIRD A/C—HEATER CONTROL SYSTEM a	TEMP. CONTROL (LOWER) LEVER (BOWDEN CABLE CONTROLLED)	FUNCTIONAL CONTROL (UPPER) LEVER POSITION (VACUUM CONTROLLED)					
		A/C		OFF	HEAT	PARTIAL DEFROST	FULL DEFROST
		MAX.	FRESH				
Fresh Air Recirc. Door—Brown		Open (Recirc. Pos.) VAC.	Closed (Fresh Air Pos.) NV.	Open (Recirc. Pos.) VAC.	Closed (Fresh Air Pos.) NV.		
Register Air Door — TAN		Open VAC.			Closed NV.		
Heater Core Restrictor (Shutter) — TAN		Closed VAC.			Open NV.		
Heat-Defrost Door: Partial Def.—Red; Full Def.—Yellow & Red		Heat Positon NV.				Part. Def. VAC.	Full Def. VAC.
Water Valve—Blue	Warm / Mod.	Open NV.		Closed	Open NV.		
	Cool	VAC.					
Water Valve Vacuum Switch—Supply—White To Water Valve—Gray	Warm / Mod.	Open NV.		NV. See Note*	Open NV.		
	Cool	Closed Vacuum					
Temperature Blend Door (Bowden Cable Controlled)	Warm	All Cold Air Passes Thru Heater Core			Outside Air Passes Thru Heater Core		
	Mod.	Cold Air Passes Thru and Around Heater Core Then Mixed			Outside Air Passes Thru and Around Heater Core Then Mixed		
	Cool	All Cold Air Bypasses Heater Core			Outside Air Bypasses Heater Core		
Blower Switch		Manually On L-M-H		Man. Off	Manually On L-M-H Off—Ram Air		
A/C Clutch Switch (In Series with Blower Switch)		Automatically Off—On by Thermostat Switch		Manually Off by Blower Selector Lever			

*In OFF position water valve is closed by selector lever and overrides temp. lever. a Colors indicate vacuum hose color code.
L—Low M—Medium H—High VAC.—Vacuum NV.—No Vacuum MOD.—Modulated PART.—Partial DEF.—Defrost

A/C-HEATER CONTROL—FORD AND MERCURY

FORD/MERCURY A/C—HEATER CONTROL SYSTEM a	TEMP. CONTROL (LOWER) LEVER (BOWDEN CABLE CONTROLLED)	FUNCTIONAL CONTROL (UPPER) LEVER				
		A/C		OFF	HEAT	
		MAX.	FRESH		HEAT	DEFROST
AIR DOORS: Outside Recirc.—White		Closed NV.	Open VAC.	Closed NV.	Open VAC.	
AIR DOORS: Recirc.—White		Open NV.	Closed VAC.	Open NV.	Closed VAC.	
AIR DOORS: A/C Heat—Blue		A/C Position NV.		Heat Position VAC.		
AIR DOORS: Heat-Defrost—Red		Heat Position NV.				Defrost Position VAC.
Temperature Regulator Valve (1/8 Blue) (3/16 Brown) Cable Controlled	Low	No Vacuum Available To The Valve		Closed By Cable NV. Thru Valve		
	Mod.			Partially Opened By Cable Metering Vacuum		
	High			Fully Opened By Cable Full Vac. Thru Valve		
Water Valve—Brown	Low	Closed NV.		Closed NV.		
	Mod.			Partially Open-Metered Vac.		
	High			Full Open-Full Vac.		
Clutch Switch		On		Off		
Blower Switch		Manually On—L-M-H		Man. Off	Man. On—L-M-H Off—Ram	Manually On—L-M-H
A/C Switch	Low	On Max.		Off		
	Mod.	On Mod.				
	High	On Min.				

a Colors indicate vacuum hose color code. L—Low M—Medium H—High Min.—Minimum Mod.—Modulated
Max.—Maximum Man.—Manually Vac.—Vacuum NV.—No Vacuum Pos.—Position

A/C-HEATER CONTROL—MUSTANG AND MERCURY COUGAR

MUSTANG AND MERCURY COUGAR A/C—HEATER CONTROL SYSTEM a		TEMPERATURE CONTROL LEVER (BOWDEN CABLE CONTROLLED)	FUNCTIONAL CONTROL LEVER POSITION				
			A/C		OFF	HEAT	
			MAX.	FRESH		HEAT	DEFROST
AIR DOORS	Outside Recirc.—White		Open to Recirc. VAC.	Open to Outside NV.	Open to Recirc. VAC.	Open to Outside NV.	
AIR DOORS	A/C Heat—Blue		A/C Position V.		Heat Position NV.		A/C Position VAC.
AIR DOORS	A/C Defrost—Red		A/C Position NV.			Defrost Position VAC.	
AIR DOORS	Reheat—Green		Blend Position (Closed) NV.			Heat Position (Open) VAC.	
Clutch Switch			On—(by A/C-Defrost Door Arm)			Off—(by A/C-Defrost Door Arm)	
Blower Switch			Manually On—L-M-H	On—L-M-H† Off—Ram Air	Off On*	On—L-M-H Off—Ram Air	
Water Valve Vacuum Switch Purple		Cool	Open (by Temp. Blend Door Arm)				
		Mod.	Sealed (by Temp. Blend Door Arm)				
		Warm					
Water Valve—Purple		Cool	Closed VAC.				
		Mod.	Open NV.				
		Warm					
Temperature Blend Door		Cool	All Cold Air Bypasses Heater Core			Outside Air Bypasses Heater Core	
		Mod.	Cold Air Passes Thru and Around Heater Core Then Mixed			Outside Air Passes Thru and Around Heater Core Then Mixed	
		Warm	All Cold Air Passes Thru Heater Core			Outside Air Passes Thru Heater Core	

L—Low M—Medium H—High VAC.—Vacuum NV.—No Vacuum MOD.—Modulated

*Recirculated Air—Not Recommended. Please note that under the conditions specified in the chart in the OFF position and the blower switch is turned on, it is possible to receive cooled air out of the heater duct, depending upon the position of the temperature blend door.

†Under the conditions specified under the A/C FRESH position and with the blower switch turned off, it is possible to receive outside ram air through the A/C registers. This will be ambient air if the temperature blend door is in the COOL position or partially or fully heated air if the temperature blend door is in the MOD or WARM position.

a Colors indicate vacuum hose color code.

A/C-HEATER CONTROL—FAIRLANE, FALCON AND MERCURY INTERMEDIATE

FAIRLANE, FALCON AND MERCURY INTERMEDIATE A/C-HEATER CONTROL SYSTEM a		TEMPERATURE CONTROL LEVER (BOWDEN CABLE CONTROLLED)	FUNCTIONAL CONTROL LEVER POSITION				
			A/C		OFF	HEAT	
			MAX.	FRESH		HEAT	DEFROST
AIR DOORS	Outside Recirc.—White		Recirc.-Pos. VAC.	Open to Outside NV.	Recirc.-Pos. VAC.	Open to Outside NV.	
AIR DOORS	A/C-Heat—Blue		A/C Position VAC.			Heat Position NV.	
AIR DOORS	Heat-Def—Red		Heat Position NV.				Def. Pos. VAC.
Clutch Switch			ON—(by A/C-Heat Door Arm)		OFF—(by A/C-Heat Door Arm)		
Blower Switch			Manually On L-M-H Off—No Air Flow	On L-M-H Off—Ram Air†	Off‡ On-Recirc. Air Out Heat Duct	Manually on L-M-H Off—Ram Air	
Water Valve Vac. Switch Blue		Cool	Open (By Temp.—Blend Door Arm)				
		Mod.	Sealed (At Rest—Sprung Position)				
		Warm					
Water Valve Blue		Cool	Closed VAC.				
		Mod.	Open—NV.				
		Warm					
Water Valve Yellow*			Closed—VAC.			Open—NV.	
Temperature Blend Door		Cool	All Cold Air Bypasses Heater Core			Outside Air Bypasses Heater Core	
		Mod.	Cold Air Passes Thru and Around Heater Core Then Mixed			Outside Air Passes Thru and Around Heater Core Then Mixed	
		Warm	All Cold Air Passes Thru Heater Core			Outside Air Passes Thru Heater Core	

L—Low M—Medium H—High VAC.—Vacuum NV.—No Vacuum MOD.—Modulated

†Under the conditions specified under the A/C FRESH position and with the blower switch turned off, it is possible to receive outside ram air through the A/C registers. This will be ambient air if the temperature blend door is in the COOL position or partially heated air if the temperature blend door is in the MOD or WARM position.

*The water valve vacuum motor color coded yellow has vacuum applied and removed under the same conditions as the A/C-heat door vacuum motor. Both motors receive vacuum from the same supply line from the control head.

‡Recirculated Air—Not Recommended. Please note that under the conditions specified in the chart in the OFF position and the blower switch on, it is possible to receive recirculated air; either at inside temperature or reheated temperature, out of the heat ducts.

a Colors Indicate Vacuum Hose Color Coding

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