

PHILCO



SERVICE

AIR CONDITIONER

PHILCO AIR CONDITIONER HANDBOOK

**Air Conditioning Principles
House Wiring Circuits
Electrical System — Model 1204-J**

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INTRODUCTION

This booklet reviews some of the basic air-conditioner principles and discusses the advantages of installing single-room air conditioners rather than a central system for large office buildings. An explanation of simple house wiring circuits is given as an aid in locating troubles in the house. In addition, a complete analysis of the electrical wiring and components of Philco Model 1204-J Air Conditioner is presented, to help the service technician to understand the action of the several components and the operation of the two separate units.

AIR CONDITIONING

The term "air conditioning" to most persons means cooling, filtering, and removing moisture from the air to produce comfortable and healthful living conditions during hot weather. In reality, the term may be applied to conditioning the air during the cold season as well. Whether heat is added to the room or removed from it, the purpose is the same; to produce the best condition for good living. To maintain the best conditions during cold weather the air should be heated and filtered, and moisture should be added; for similar conditions in hot weather, the air should be cooled and filtered, and moisture should be removed. The heated winter air is usually too dry, while the summer air ordinarily contains too much moisture unless some method of removing it is employed.

In addition to the air conditioning factors mentioned above, air movement is always desirable for comfort, especially for warm conditions. When the body is surrounded by still air, a layer of warm, and probably humid, air envelops it. A slight air movement not only carries this enveloping layer of air away from the body but also seems to have a stimulating action on the sensory nerves. The movement of the air should be very gentle; never with enough force to form drafts.

"The average person requires three pounds (approximately three pints) of water per day, and several pounds of food per day, but he must breathe thirty pounds of air each day. He can do without food for several weeks or water for several days, but without air he cannot live 10 minutes."

The air we breathe and live in must have many qualities in order for us to be healthy and comfortable. It should be maintained within certain relatively narrow limits of temperature and humidity, and should be free from harmful quantities of dust, dirt, bacteria, and other foreign matter. Therefore, in order to provide the proper "quality" of air in closed

spaces occupied by human beings, the air supplied by nature must be "conditioned" by mechanical means.

One of the basic functions of a Philco air conditioner is to provide comfortable conditions in a room during hot, humid weather. In order to perform this function, the air conditioner reduces the temperature, lowers the humidity, passes the air through a filter, like that shown in figure 1, and, with the exception of water-cooled models, it brings in outdoor air for ventilation.

In the summer time the primary function of an air conditioner is to cool and dehumidify the air in the room. Since cold is, in reality, the absence of heat, an air conditioner is equipped with a refrigerating machine to extract the heat from the room air and from outside air passing through the unit. Fans operating in conjunction with the refrigerating machine discharge this heat to the outdoors. An air-conditioned room can be compared to the cabinet of a domestic refrigerator. However, a refrigerating unit for an air conditioner must have a great deal more refrigerating capacity than the machine in the average electric refrigerator, for several reasons.

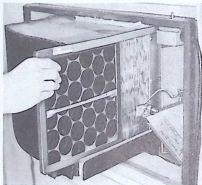
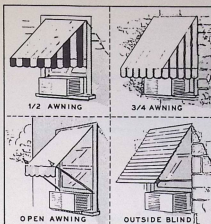


Figure 1. Air Filter

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Figure 2. Awning Types

First of all, a room is many times larger than a refrigerator. Then, the walls, ceiling, and floor of a room are seldom, if ever, insulated as well as the walls of a refrigerator cabinet. The outside wall of a room is frequently heated by direct rays of the sun, resulting in considerable heat transmission into the room. Also, windows in the outside walls of a room are responsible for a very substantial amount of heat transmission into the room, especially if they are sunlit and are not protected by an outside awning, as shown in figure 2. The shade from adjoining buildings or trees helps in decreasing the amount of heat that enters a building. See figure 3. Finally, a substantial amount of heat is dissipated into the room by the occupants, lights, and electrical appliances.

In view of these factors, air conditioners are equipped with refrigerating machines powered by motors ranging from $\frac{1}{8}$ hp to 1 hp, and even larger, as compared to the $\frac{1}{16}$, $\frac{1}{8}$, and $\frac{1}{4}$ -hp motors in domestic refrigerating machines.

The refrigerating system in an air conditioner consists of an evaporator, a motor-driven compressor, which is hermetically sealed in a steel casing, a condenser, a means of controlling the flow of refrigerant and interconnecting piping. The evaporator and condenser each consist of a continuous circuit of finned copper tubing, arranged to form a compact rectangular coil. In the case of the evaporator, the fins provide a large amount of surface to transfer heat from the air in contact with these fins to the refrigerant flowing through the tubing. In condensers, the fins function in the same manner, but, in this case, the heat is being transferred from the refrigerant to the air. A long tube having a relatively small diameter (capillary tube) provides the means for controlling the flow of the refrigerant from the condenser to the evaporator.

The components of the refrigerating system are interconnected by tubing in such order that the refrigerant flows from the evaporator to the compressor, thence to the condenser, and then through the capillary tube and back to the evaporator to complete the circuit.

There are two primary air circuits in an air conditioner, as shown in figure 4. The first is the evaporator air circuit, in which a motor-driven fan or blower causes the room air and ventilation air to flow through the air filter, thence over the fins and tubes of the cold evaporator and into the room through the conditioned air outlet grilles. The other circuit is through the condenser, where a motor-driven fan or blower draws air from outdoors and passes it over the fins and tubes of the hot condenser, from which the hot air is discharged outdoors.

In operation, the heat in the air passing over the evaporator fins is transmitted into the liquid refrigerant inside the tubes. This heat causes the liquid refrigerant to boil and turn to a vapor. This action is similar to that of heat in causing water to boil and to create steam. Remember that heat is absorbed during any vaporizing or boiling process. The com-

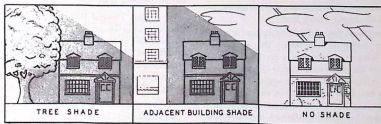


Figure 3. Shading on Buildings

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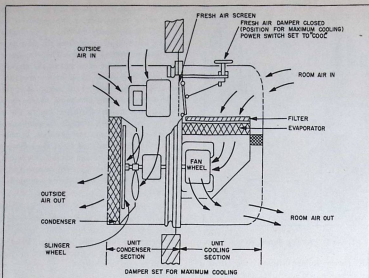


Figure 4. Primary Air Circuits

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pressor draws the heat-containing gas from the evaporator and raises its pressure. This increased pressure increases the temperature of the gas in the compressor to a value higher than the temperature of the surrounding air. The compressor discharges this hot gas through a connecting tube to the condenser. The cooler outdoor air, flowing over the finned tubing in the condenser, cools the compressed gas sufficiently to make the vapor condense back into a liquid, because it is still at practically the same high pressure as the gas leaving the compressor. The liquid refrigerant then flows through the capillary tube and on to the inlet of the evaporator. As the liquid refrigerant passes through the capillary tube, its pressure and temperature progressively drop, with the result that when it reaches the evaporator inlet, the greatly decreased pressure allows the refrigerant to vaporize and thereby absorb heat.

This continuous flow of liquid refrigerant into the evaporator constantly replenishes the refrigerant which is being evaporated into a gas and which is flowing from the evaporator outlet to the compressor. Thus the refrigerant travels in a continuous circuit. It absorbs heat from both the room air and ventilation air passing through the evaporator, and dissipates that heat to the outdoors through the condenser. The complete refrigerant system for a window model air conditioner is shown in figure 5.

Quite obviously, when the motor-compressor unit is stopped, the refrigerant flow ceases and the cooling effect stops. However, when the compressor is not running, the fans in Philco air conditioners can be operating to provide ventilation during periods when cooling is not required. Most models are also arranged to provide room air pump-out. Either of these features is obtainable while operating on cooling or on fan only.

It is a matter of importance to note that when the compressor stops the capillary tube permits the pressure to equalize throughout the system. With this arrangement the compressor starts easily, since it has the same pressure on both sides of the piston.

BRITISH THERMAL UNIT

The British Thermal Unit, usually abbreviated to B.T.U., is an arbitrary quantity of heat, just as the foot and the inch are man-made units. A simple definition of a B.T.U. is that it represents the amount of heat required to raise the temperature of one pound of water by one degree Fahrenheit. For precise engineering calculations, the B.T.U. is more accurately defined.

An expression involving a definite number of B.T.U.'s, such as 4000 B.T.U.'s, means a certain quantity of heat, whereas the expression, 4000 B.T.U.'s per

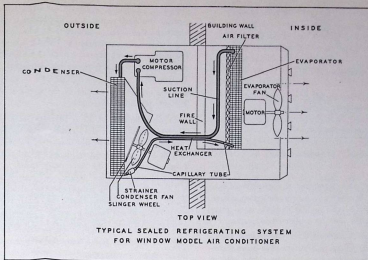


Figure 5. Typical Sealed Refrigeration System for Window Model Air Conditioner

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hour means a **certain** specified rate of heat transmission from one **material** to the other, or from one place to another.

Why are B.T.U.'s, which are a measure of heat, used to express the **cooling** or refrigerating capacity of an air conditioner? **The** only way in which the cooling capacity of a **unit** can be expressed is to state the amount of heat **which** the unit is capable of removing from the air **in** a given length of time. Cold is merely the **absence** of heat.

It is a standard **practice** to use one hour as the time reference, with the **result** that the cooling effect of an air conditioner is **expressed**, for example, as 10,000 B.T.U.'s per hour, or 10,000 B.T.U./hr.

VENTILATION

The occupants **of** a room are continually reducing the oxygen contained in the air, increasing its carbon dioxide content, and, at the same time, increasing the room temperature from body heat. In addition, the humidity of the air is raised by the moisture that is discharged from the skin by perspiration and from the lungs during **respiration**.

As the term is **generally** used, ventilation is the replacement of **room** air by some outside air that is relatively fresh.

THE ATMOSPHERE

Air is a mixture of several gases, consisting chiefly of oxygen, nitrogen, and water vapor. Certain other rare gases are present in the air, in addition to dust, bacteria, smoke, and other impurities. The composition of dry air is shown in figure 6.

The water vapor in air, usually called moisture, is an important, but quite variable constituent, of the atmosphere. The amount of moisture that the outside air contains depends upon the weather conditions.

When a mixture of air and water vapor contains the maximum amount of water vapor, it is said to be saturated. If the temperature of the air drops below that corresponding to the temperature at saturation, some of the water vapor will be condensed.

Air has considerable weight (about .08 lb. per cu. ft.), which accounts for the pressure that it exerts on the surface of the earth (approximately 14.7 lbs. per sq. in.).

TEMPERATURE AND HEAT

If one's hand touches a piece of ice, the sensation of cold is noticed. This is because the hand, being much warmer than the ice, causes heat to travel rapidly to the ice, leaving the hand at a lower tempera-

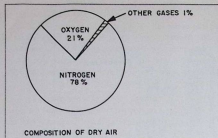


Figure 6. Composition of Dry Air

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ture. If a hot stove is touched, the sensation of heat is observed. In this case the reverse action occurs; that is, the heat travels rapidly from the stove to the hand, leaving the hand at a higher temperature.

Temperature is the sensation which such bodies produce on the senses, or more specifically, on instruments that are used to measure temperature, such as the ordinary Fahrenheit thermometer. The temperature of a substance does not determine directly the quantity of heat that it contains, but merely its intensity. For example, if the pail at A in figure 7 contains 10 lbs of water at 60° F., and the other pail at B contains 2 pounds of water at 150° F., the first pail, although at a lower temperature, has a much greater quantity of heat. If the heat is measured from 32° F. in both cases, the heat in pail A would be equal to 10 x 28 or 280 B.T.U.'s, while the heat in pail B would be equal to only 236 B.T.U.'s (2 x 118). Remember that it requires 1 B.T.U. to raise the temperature of one pound of water by one degree Fahrenheit. Temperature, therefore, tells only the intensity of heat, and not the amount of heat a body contains.

If two bodies have the same temperature, there can be no transfer of heat from one to the other. But if one is at a higher temperature, heat will always pass from the higher to the lower temperature.

Heat, as previously explained, is measured in British Thermal Units, and it may exist either as sensible heat or latent heat.

Sensible heat is the heat that may be added to, or subtracted from, a substance without changing its state. If the temperature of a substance rises, it will contain more sensible heat. If the temperature is lowered, it will contain less sensible heat.

Latent heat is the heat that is added to, or removed from a substance without changing its dry-bulb temperature. The heat required to change a solid to a

liquid, or vice versa, is known as the latent heat of fusion; the heat required to change a liquid to a vapor, or vice versa, is known as the latent heat of vaporization, or condensation. All compression refrigerating systems depend upon the latent heat of vaporization of the refrigerant to produce the refrigeration effect.

SPECIFIC HEAT OF AIR

The specific heat of air is the number of British Thermal Units required to raise the temperature of one pound of dry air by one degree Fahrenheit. The specific heat of air is approximately .24 B.T.U. which is about one-fourth the heat required to raise one pound of water by one degree. Since it requires 1 B.T.U. to increase the temperature of one pound of water by 1° F., it follows that 1 B.T.U. will raise the temperature of one pound of air by about 4° F. under average conditions. One pound of air occupies about $\frac{1}{.08}$ or 12½ cubic feet. Remember that air weighs about .08 lb. per cubic foot.

HUMIDITY

The water vapor that is contained in the air is called humidity. The amount of water vapor that the air can hold depends upon its temperature. As the temperature of the air is increased, its ability to hold moisture is increased. When its temperature is reduced, the air can hold less moisture, and if this reduction reaches the "dew point" temperature, condensation will occur.

RELATIVE HUMIDITY

The ratio of the weight of the water vapor in the air at a given temperature to the weight of the water vapor that the air would contain if it were fully saturated at the same temperature is called the relative humidity. Relative humidity is usually expressed as a percentage; for example, saturated air at 70° F. contains approximately 8 grains of water vapor per cubic

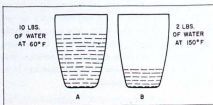


Figure 7. Temperature and Heat

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foot. Now, if another sample of air, also at 70°F., contains only 4 grains per cubic foot, then the relative humidity of the second sample would be $4 \div 8$ or 50 percent.

DEW POINT

The temperature at which air is saturated is called the dew point. It is the temperature of the air at which any reduction in temperature causes some of the water vapor to condense. If the air contains moisture, there is always some temperature at which it will be saturated, and any lowering of the temperature from this point will cause condensation.

DRY-BULB AND WET-BULB THERMOMETERS

Usually the temperature of the air is determined by an ordinary dry-bulb thermometer. A wet-bulb thermometer is used for another purpose, and has its bulb covered with a piece of clean, soft wicking which must be dipped in water before it is used. In order to obtain an accurate reading, it is necessary to place the thermometer bulb in a strong current of air. This may be accomplished by a *sling psychrometer*, which is a wet-bulb thermometer provided with handle which permits it to be whirled rapidly through the air. The wet-bulb thermometer gives a depressed reading; that is, a lower reading than the dry-bulb thermometer, provided that the air is not saturated. The wet-bulb temperature is a direct measure of the amount of heat in the air.

When taking wet-bulb readings, the peripheral speed of the wet bulb should not be less than 15 feet per second. For an 8-inch sling psychrometer, this speed is equivalent to $3\frac{1}{2}$ revolutions per second.

DEHUMIDIFICATION

The process involved in removing moisture from the air in the modern air conditioner is very simple. The process depends upon the fact that the air can

hold more moisture at a higher temperature than it can at a reduced temperature. Dehumidification of the air occurs at some particular place every time it rains. Moisture-laden air is carried by the wind from a warmer to a colder region, and, if the temperature of the air is reduced sufficiently to cause some of its contained vapor to condense, rainfall and a drier atmosphere will result.

The cold evaporator in the air-conditioning system performs this function in exactly the same manner. The air, either from the room or from the outside, passes over the cold evaporator tubes and fins and gives up sufficient heat to reduce its temperature by 15° or 20°F. Since the cooled air cannot hold all the moisture that it could at the higher temperature, some of the vapor is condensed, and the resulting water is disposed of by blowing it against the hot condenser, where it is again vaporized and blown to the outside with the condenser air stream.

COOLING CAPACITY OF AN AIR CONDITIONER

A one-ton refrigeration system, such as that used in Philco Model 106-J (figure 8), is designed to produce the same cooling effect as the melting of 1 ton of ice in 24 hours. When one ton of ice is melted, it will absorb 288,000 British Thermal Units. If this amount of ice is melted in 24 hours, it absorbs heat at the rate of $1/24$ of 288,000, or 12,000 B.T.U.'s per hour. It follows, therefore, that a one-ton refrigeration system will have a cooling capacity of 12,000 B.T.U.'s per hour, which is roughly equivalent to a one-horsepower unit.

In reality, the capacities of single-room air conditioners are somewhat less than indicated above, probably nearer the values given in the table below:

Horsepower	B.T.U./hr. Rating	Approximate Tonnage Rating
$\frac{1}{8}$	3600—4200	$\frac{1}{8}$
$\frac{1}{4}$	5500—6000	$\frac{1}{4}$
$\frac{3}{4}$	8000—9000	$\frac{3}{4}$
1	10,000—11,000	1

It will be noted from the table that the tonnage rating of an air conditioner is approximately the same as the horsepower rating.

To further illustrate cooling capacity, let us assume that we have a $\frac{3}{4}$ -hp air conditioner which is rated at 8640 B.T.U.'s per hour; this would be equivalent to $\frac{1}{144}$ of 8640, or 60 lbs. of ice melted each hour. In other words, to obtain the same cooling effect as that produced by the average $\frac{3}{4}$ -hp air conditioner, it

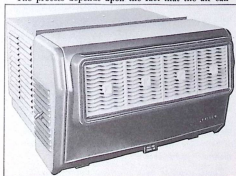


Figure 8. Philco Window Model TP2-2966

would be necessary to completely melt 60 pounds of ice every hour in the room to be cooled. If we had to resort to cooling of this type it would certainly require the services of a very alert ice man, especially if he had to service a number of installations.

NATURAL DRAFTS

All natural drafts (winds) are originally caused by a difference in temperature of two or more bodies of air. In the atmosphere over a sandy desert without vegetation much of the radiant heat received from the sun will be reflected to the air, and the air will become hotter. As its temperature rises, the air expands and becomes lighter. Let us assume that a large grove of trees is located adjacent to the desert area. Here much of the sun's heat will be absorbed, and only a small portion will be reflected to the air, leaving the air over that area much cooler than the adjacent air over the desert. Since the cooler air is heavier, it flows toward the area of lighter air, thus setting up the air motion that is known as wind.

This action may be compared to the weighing balance shown in figure 9. As long as the two weights shown at A are the same, the scale remains in perfect balance and there is no motion. When one side becomes heavier than the other, as at B, the arm is set in motion, the lighter side going upward and the heavier side moving downward.

Such air movements in the atmosphere are well illustrated by what are commonly called *air pockets* that disturb airplanes in flight, especially the lighter planes. Air pockets are usually upward or downward drafts, caused by differences in air temperature.

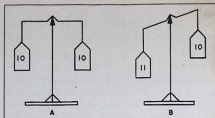
Natural drafts for condenser cooling are used in all Philco refrigerators. The heat from the condenser raises the temperature of the surrounding air, which causes this air to rise and to be replaced by cooler, heavier air from below.

FORCED DRAFTS

All Philco air conditioners and all of the later Philco freezers use a forced draft to cool the condenser in the refrigerating unit.

With this method the air movement depends upon a difference in pressure caused by a motor-driven fan. With natural drafts the difference in pressure is the result of temperature differences.

An example of forced draft is the use of a desk fan to circulate the air within a room. While the fan does not actually cool the air, it does make the air more comfortable by causing more rapid evaporation of moisture from the skin, and in this manner it does produce a definite cooling effect, as far as the occupants are concerned.



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Figure 9. Weighing Balance

Another place where forced drafts may be used to good advantage is in the attic of a house. An attic exhaust fan has proved popular as an inexpensive means of obtaining a cooling effect in the home. While it can in no way be called a substitute for a complete air conditioner, its principle is sound. The maximum temperature during the day usually occurs between noon and about 4 o'clock in the afternoon. During this time a considerable amount of heat is stored up in the entire building. If the air in the attic is not circulated, temperatures as high as 130°F. are common. After sunset the outside temperature begins to drop, with the lowest temperature occurring between midnight and 6 A. M. The heat that is stored in the building is slowly dissipated during the night.

If an attic fan is started about sundown, it will draw in the cooler outside air and circulate it through the house, resulting in a lowered indoor temperature and in air movement that has a cooling effect on human bodies.

Rooms that are to be cooled by an attic fan should have the windows open that are farthest from the fan, and the others should be closed or partly closed.

It is important to install a fan that is capable of handling enough air to do the job properly. It should have enough capacity to give a complete air change every few minutes.

SINGLE-ROOM AIR CONDITIONERS VS. CENTRAL SYSTEMS

There are thousands of older office buildings all over the country where the managements are finding that, in order to compete with new air-conditioned buildings, they must provide this comfort and service for their tenants. This may be accomplished in either of two ways—with a central system, or with single-room air conditioners.

There seems to be a prevalent misunderstanding among many people that it is better in every way to

install a central system rather than a number of room units. Actually, nothing could be further from the truth. Upon investigation, it will be found that the installation of a number of Philco room units is the best from every angle, including cost, method of installation, ease of maintenance, and service rendered.

These facts were all proved to be correct after an exhaustive year's study by the management of the Gulf Building in Pittsburgh, who were considering both approaches to air conditioning to meet the many demands of their tenants. They began with the premise that air conditioning "should function to create comfortable, clean, and healthfully pleasant atmospheric conditions in the rooms where air conditioners are installed" . . . and their conclusions were overwhelmingly in favor of single-room units . . . "We have found that air-cooled window-type units meet all of these requirements."

The cost difference between the two methods is a tremendous one. To put a central system in the Gulf Building would have meant an expenditure of between \$1,500,000 and \$2,000,000 for the necessary alterations and installations, whereas window units, providing better service, costs in the neighborhood of \$300,000. A bid of some \$60,000 for a central system for just one floor was contrasted with the cost of supplying an equal amount of air conditioning with room units of only \$8,500.

To install a central system for the entire 38 floors of the Gulf Building would have meant running a duct system throughout and the tearing down of nearly all plastered ceilings to cover the exposed duct work. In addition, this would have interfered with existing doors and windows, and a large amount of rentable area would have been required to house the equipment. On the other hand, very little loss of space would be experienced with the installation of room units. Another consideration in connection with the Gulf Building was the fact that no cooling tower for salvaging condenser cooling water could be put on the roof. And, their estimates showed that the cooling water for a central system would be very expensive.

As far as maintenance is concerned, the building's own mechanics can install and service the single units, thus saving a great deal on this cost.

In any big building modifications and renovations are continually being made which involve moving and tearing out partitions. It was felt that, with a duct system throughout the building the cost of these alterations would be greatly increased. With the window-type unit, on the other hand, it is a simple matter to move the equipment from one location to

another, or to add to it when the layout requires additional equipment. In addition, tenants or individuals who do not wish air conditioning need not have it, and the building is not put to the expense of providing them with air conditioning when they do not want it.

One of the most outstanding and desirable features of the individual unit is the complete flexibility that it offers to any building. Individual tastes differ in air conditioning, as they do in lighting, heating, and decoration. The individual air-conditioning unit meets the individual tenant's requirements. The central system invokes the phone calls with the complaint, "it is too cold for me," or "it isn't cool enough for me." The tenant with his own individual unit is his own master, and can turn it "on" or "off" as often as he wishes, to suit his own tastes.

Philco single-room units also give far greater all year 'round comfort and service, in that they provide outside fresh, filtered air at any time. This feature is frequently desirable even during the winter months. In addition, Philco individual units do just as good a job as a central system in shutting out noise, smoke, soot, and pollens.

Heretofore, many office buildings, apartments, and other city structures were limited to central systems because of civic ordinances and other restrictions. Now, however, with Philco's new console line . . . built for any window, large, small, or casement, there is no building where such equipment cannot be installed.

THE PHILCO THERMO-COOL AIR CONDITIONER

In order to greatly extend the seasonal utility of room air conditioners, the industry has labored long in devising ways to not only supply cool air in the summer, but to also supply warm air during the cooler seasons.

There is more than one way to accomplish a heating effect in an air conditioner. It can be done with an electric heating coil or by a reversed-cycle method. The heating-coil method, as adopted by some competition, is by far the least effective. This system uses an open Nichrome heating wire rated from 1250 to 1275 watts. The heating unit is located in front of the evaporator coil and directly behind the air outlet grilles at the front of the air conditioner.

In operation, the compressor does not function at the same time as the heater. The ventilating fan merely propels the flow of heated air into the room through the air outlet grilles.

British Thermal Units, as you know, are a measure of heat. To determine the rate at which the electrical heat is generated, it is only necessary to multiply the wattage of the heater by a factor of 3.4. The heater in this type of unit is rated at 1250 to 1275 watts, and, therefore, delivers approximately 4270 B.T.U.'s per hour.

The $\frac{1}{4}$ -horsepower Philco Thermo-Cool Air Conditioner operates on a principle of reversed cycle, and heats without the need of an electric heater. It delivers about 9300 B.T.U.'s per hour, or 2.26 times as much heat as an air conditioner employing an electric heater. In other words, for the same number of watts required to operate the two units, the Philco Thermo-Cool Unit provides the user with more than twice as much heat.

The method by which this reversed-cycle heating is accomplished is very simple. You are probably well aware that when an air conditioner is cooling a room, the heat in the room is absorbed by the evaporator and then dissipated by the condenser into the outside air; this action is illustrated at A in figure 10. Although the air conditioners shown in the illustration are not equipped with a reverse-flow valve, nevertheless, room heating could be accomplished by turning the air conditioner around and mounting it

with the evaporator end outside, as shown at B. Since a properly operating air conditioner blows cool air out of one end and hot air out of the other, the question of whether it produces a heating or cooling effect depends upon which end is used. Reversing the mounting of the air conditioner causes heated air, which normally flows to the outside, to be directed into the room. It would be a very cumbersome method of changing from cooling to heating, or vice versa, if it were necessary to turn the air conditioner end-for-end each time; so, instead of turning the unit, a valve is installed to reverse the flow of refrigerant through the system, to obtain the same results. The condenser then becomes an evaporator, and the evaporator becomes a condenser. Heat, which in cooling was dissipated to the outdoors, is now utilized in the room.

The control which converts the air conditioner from a room cooling unit to a room heating unit actuates a special Philco-developed four-way valve. This valve is so named because it actually has four connections, which are required to reverse the flow of the refrigerant. When this valve is positioned at one end of its travel, the unit will cool the room, and, in the other position it will heat the room. Figures 11 and 12 show the refrigerant circuits for both types of operation.

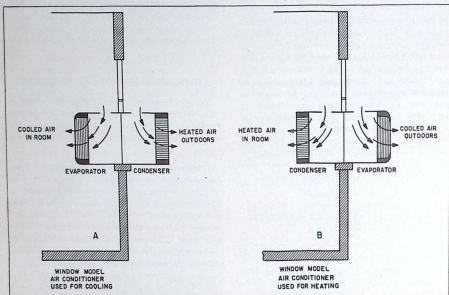
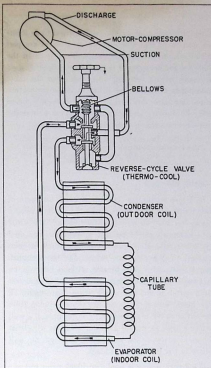


Figure 10. Cooling and Heating with Air Conditioner

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TP3-401

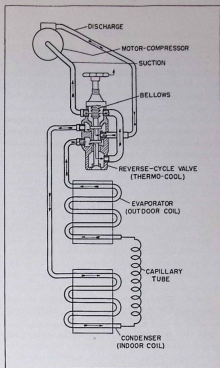
Figure 11. Refrigeration System—Thermo-Cool Valve Set for Cooling

With this feature, users receive pleasant relief from the heat on sultry, muggy days, and warmth when needed during cool, chilly days in the spring and fall. During the winter months, in homes where a heating plant is required, the air conditioner will provide, independently of cooling or heating, a welcome source of filtered fresh air ventilation and pump-out.

The Philco Thermo-Cool Air Conditioner is the perfect answer for the owners of cottages, residences, and motels, especially those located in the milder climates of the South and West. By providing such dwellings with these units, the owner will not only be able to command higher rental rates during the regular season, but he will be assured of an extended season.

ELECTRIC CIRCUITS AND WIRING

In most cases, connecting a room air conditioner to a 115-volt electric circuit means simply inserting the power-cord plug into the proper receptacle. But



TP3-402

Figure 12. Refrigeration System—Thermo-Cool Valve Set for Heating

such a simple procedure is not always possible, for the following reasons:

1. There may not be any electrical outlet near the position where the air conditioner must be installed.
2. The outlet may be available, but, because of other loads connected to the same circuit, the circuit fuse blows when the air conditioner is started.
3. The air conditioner to be connected may be rated for 230 volts; therefore, the ordinary wall receptacles cannot be used.

Every serviceman should have some knowledge of the principles of house wiring. If electrical trouble occurs, such information will assist in locating the defect, either in the house circuits or in the air conditioner.

Because the installation of room air conditioners may present problems that involve electric circuits and wiring, a review of the underlying principles and protective devices is given below.

WIRE DATA

In home wiring, #14 gauge wire is ordinarily used for all circuits, but for the main wires coming into the house, #8 is the minimum size permitted by the Electrical Code, and #6 is usually installed. For appliance cords, #16 or #18 are ordinarily used, but for devices that use as much power as an air conditioner, a power cord having #14 is required. A part of the copper wire table used in the United States follows. This table gives data on the wires that are commonly used in house wiring and appliance cords.

Gauge No.	Diameter of Solid Wire in Inches	Area in Circular Mils*	Feet per Pound	Current-Carrying Capacity in Amperes
18	.0403	1624	203	appliance cord only
16	.0508	2582	127	
14	.0641	4106	80	15
12	.0808	6529	50	20
10	.1019	10381	32	30
8	.1285	16509	20	45
6	.1620	26250	12.5	60

* 1 mil is 1/1000 of an inch. One circular mil is the area of a circle 1 mil in diameter. To obtain the circular mil area of any wire, square the diameter in mils.

Odd wire sizes are used extensively in motor winding and other electrical devices, but are not commonly used in house wiring. Ordinarily, only the even sizes listed above are used for this purpose.

By referring to the table above, it will be seen that any wire which is 6 sizes larger than another has twice the diameter and four times the cross-section area of the smaller wire. For example, a #8 wire is six sizes larger than a #14 wire. Since the cross-section area is a measure of the current-carrying capacity, this means that a #8 wire will carry (with the same safety factor) 4 times as much current as a #14 wire.

Although odd wire sizes are not shown in this table, it is also a fact that 3 sizes larger gives a cross-section area of twice that of the smaller wire. In other words, a #11 wire will carry twice as much current as a #14 wire, because it has twice the cross-section area.

CARRYING CAPACITY OF WIRES

When electricity flows through a wire, it always develops heat. For this reason, the proper size of wire for a given purpose must be selected so that the heat stays within reasonable limits. If the conductor is too small for the amount of current it is carrying, it will not only heat excessively, but there will also be considerable loss in voltage.

For this reason, the National Electrical Code limits the amperage that different kinds of wires are permitted to carry. The amperage values given in the table are for the types of copper wires ordinarily used in house wiring. It will be noticed that the table shows that the amperage is not in direct proportion to the wire size; for instance, #14 wire is allowed to carry 15 amperes, and #8 wire, which has 4 times the cross-section area, is only allowed 45 amperes.

NOTE: The carrying capacity of wires varies with the installation methods and type of insulation that covers the wire. The values given in the table are average values for wires in conduit or cable.

WIRING METHODS

In house wiring for 115-volt circuits, one wire of the circuit is always white, while the other is usually black, but may be of some other color. The white wire is known as the neutral (grounded) wire, and the other side of the circuit (black wire) is commonly known as the "hot" wire. The code requires that a white wire shall be run, without interception by a switch, fuse or other device, from the housemeter main switch to one side of all outlets. See figure 13. The black wire includes all fuses and switches from the outlet to the main switch. For example, if a wall switch is used to control a ceiling light, the wire from the main switch to the wall switch and from the wall switch to the light must be black.

If a 3-wire system is used, two black wires and one white (grounded) wire are used, with 230 volts between the two black wires and 115 volts between either black wire and the neutral (white wire). See figure 14.

NECESSITY OF FUSES

Fuses are the safety valves in an electrical installation. If the pressure in a steam boiler gets too high, the safety valve opens automatically and lets some of the steam out, to relieve the pressure. When the current flowing through a circuit becomes too great, the fuse blows and opens the circuit before the ex-

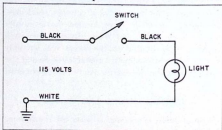


Figure 13. 2-Wire, 115-Volt Circuit

TP3-1721

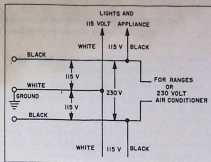


Figure 14. 3-Wire, 115/230 Volt Circuit

cessive current can cause damage to the conductors or connected appliances by overheating.

In any given size of wire, the heat generated by the current flowing through it is proportional to the square of the amperage; that is, doubling the amperage increases the heat by four times; increasing the amperage 3 times increases the heat generated by 9 times, and so on.

If the circuit is not properly fused, short circuits or defective equipment may cause a fire. Certainly, if a short circuit occurs in an unfused circuit, a fire will start if there is anything near the circuit that will burn.

If, however, the circuit is properly fused, when a connected device draws too much current, the fuse will blow and open the circuit.

The fuse used to protect a circuit should not be rated higher in amperage than the current-carrying capacity of the wires in the circuit being protected.

VOLTAGE DROP

As already explained, any current flowing through a wire creates heat, and this generated heat represents wasted electrical power. Doubling the number of amperes in any given circuit increases the wasted power by four times. More amperage forced through a circuit means that there will be more voltage and wattage lost in the line. For instance, a voltmeter reading at the house meter may indicate 115 volts, but the same voltmeter connected across the lead wires at an air-conditioner motor may, in an extreme case, read only 105 volts while the motor is operating. This means that 10 volts were used in causing the current to flow from the house meter through the air conditioner motor. The actual number of watts lost in any circuit depends upon the amount of current flowing (amperage), the length of the wire, and the size of the wire. If, as in this case, 10 volts were lost

in the circuit, and if 10 amperes were flowing, the power lost would be 100 watts, since the power in watts is equal to volts multiplied by amperes.

The obvious cure for excessive voltage loss is to either increase the size of the wire or arrange to have less current flow through it by connecting some of its load to another circuit.

Probably the best thing to do in the case of an air conditioner, especially in the $\frac{3}{4}$ -hp sizes or larger, is to run a separate line directly from the house meter to the place where the air conditioner is to be located.

The number of watts wasted as heat in the wires varies as the square of the amperage flowing. For example, if 5 amperes flow through a 100-foot circuit consisting of two 100-foot lengths of #14 wire, roughly $12\frac{1}{2}$ watts will be wasted as heat in the wires; if the current is doubled to 10 amperes, about 50 watts will be wasted; if the amperage is again doubled to 20 amperes, about 200 watts will be wasted as heat. These values are given to show the need for installing wires of sufficient size to reduce losses to a minimum.

In this connection it should be noted that if 230 volts is available for the air conditioner, only half as much current will be used to obtain the same power, and consequently, the voltage and heating losses will be reduced accordingly.

TIME-LAG FUSES

A number 14 wire can safely carry 15 amperes continuously, and, even in hot weather, will probably not reach over 140°F. , which will neither damage the insulation nor start a fire. If this wire carried 30 amperes continually, it would probably become dangerously hot. However, if it carried 35 or 40 amperes for a few seconds, and thereafter carried only 12 amperes, its temperature would not be affected to an appreciable extent.

The ordinary fuse blows quickly on a heavy overload, but heavy loads of very short duration do no harm to the circuit. The electric motor represents the type of equipment that loads a circuit in this manner; it draws a heavy starting current for a fraction of a second which is equal to 3 or 4 times its normal running current. If an ordinary house fuse is used in an electric motor circuit, and if it is rated low enough to protect the motor properly, it may blow while the motor is starting. This situation causes people to use fuses of greater amperage, which do not protect the wiring and appliances against permanent overload.

There is another type of fuse that will handle overloads of short duration and also protect the motor and circuit. Such fuses are known as time-lag fuses.

They will blow just as quickly as ordinary fuses on small continuous overloads or short circuits, but, if properly rated, will not blow on an overload of short duration, like that which occurs when starting a motor. It is recommended that time-lag fuses be used as protection against overloads in air conditioner motor circuits wherever possible.

CIRCUIT BREAKERS

When a fuse blows, it must be replaced, and a new one is not always handy. Many new installations of electric service replace the main fuses with circuit breakers, and this eliminates the troubles experienced with fuses. A circuit breaker opens the circuit when there is an overload, but has no replaceable parts. The circuit is made operative again by merely moving the switch handle or by resetting a push button. On a short circuit, the circuit breaker opens instantly; on a slight overload, it will carry the current for a long time; the larger the overload, the quicker it will

trip. Most circuit breakers are similar to time-lag fuses in that they will carry momentary overloads without tripping.

ANALYSIS OF ELECTRICAL CIRCUITS IN PHILCO AIR CONDITIONER MODEL 1204-J

The purpose of this section is to analyze the electrical circuits of the Philco water-cooled air conditioner Model 1204-J.

In addition, this section describes the various parts of the electrical system, and explains how each part functions to operate either one or both of the units, to maintain the desired room temperature.

Model 1204-J has two separate water-cooled refrigerating systems, as shown in figure 15. It is equipped with an adjustable Dual-Step thermostat that causes only one of the units to operate if the air conditioning requirements are moderate; if more cooling is required, another set of contacts on the thermostat closes, to start the second unit.

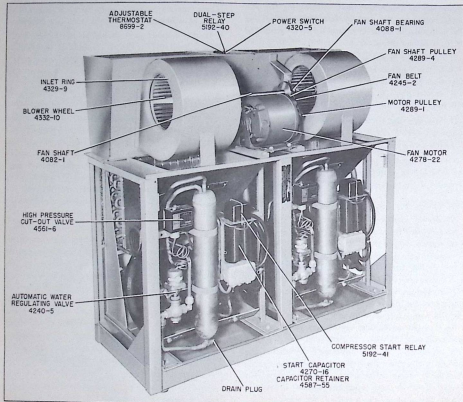
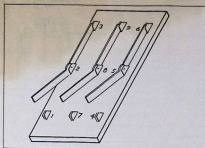


Figure 15. Model 1204-J Twin Unit System

TP9-233



TP3-1774

Figure 16. Three-Pole, Double-Throw Switch in FAN ONLY Position

POWER SWITCHES

Either one or the other of two types of power switches is used in this model:

1. The 3-pole, double-throw, toggle switch has three positions: COOL, OFF, and FAN ONLY. Its action is illustrated in figure 16, where it is shown in the FAN ONLY position. The switch has wire jumpers that connect certain of the switch terminals as shown in figure 17. When the switch is positioned as shown at A, only the fan motor operates. When the other end of the switch blades are pushed into contact with terminals 1, 7, and 4, as at B, this closes the circuits through the fan motor and to both compressor motor control circuits. If the room tem-

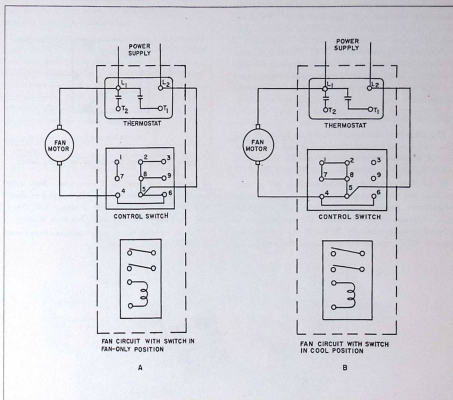


Figure 17. Fan Circuits

TP3-1771

perature is such that both sets of Dual-Step thermostat contacts are closed, both compressor motors will operate.

If only one set of thermostat contacts is closed, only one compressor motor will operate until a temperature rise causes the other set to close, thus starting the second compressor motor.

2. The other control switch that may be installed in Model 1204-J is of the rotary type, and has the same positions (COOL, OFF, and FAN ONLY) as the toggle switch. Figure 18 shows the internal connections for each position of the rotary switch.

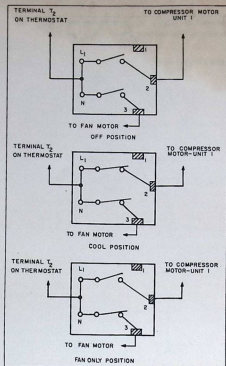
TEMPERATURE SELECTOR

The Temperature Selector, located under the hinged cover at the top-rear of the air conditioner, is the adjusting knob for the Dual-Step thermostat. It determines the temperature range within which the thermostat contacts will open and close. When the selector knob is turned to the extreme clockwise position, the room air entering the air conditioner is maintained at approximately 73°F. Extreme counterclockwise positioning of the switch regulates the temperature to about 85°F. Intermediate temperatures are obtained by intermediate settings of the Temperature Selector.

DUAL-STEP THERMOSTAT

The Dual-Step thermostat, shown in figure 19, contains two sets of contacts (marked A and B in figure 24); A controls the running periods for unit No. 1, and B performs the same function for unit No. 2.

If the Temperature Selector knob is set at mid-position, the thermostat starts No. 1 unit when the temperature reaches approximately 78°F., and this unit continues to operate until the temperature is reduced to approximately 76°F. If the temperature soars to 82°F., the thermostat closes the second set



TP3-1772

Figure 18. Internal Connections for Rotary Switch

of contacts, and unit No. 2 runs, also. Both units operate until the temperature has dropped to about 80°F., at which time unit No. 2 stops. Unit No. 1 runs until approximately 76°F. has been reached.

The air circulation fan motor continues to run even though both units are idle.

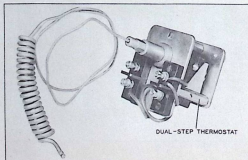


Figure 19. Dual-Step Thermostat

TP0-481

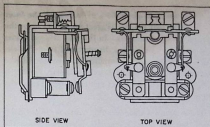


Figure 20. Interlocking Relay

INTERLOCKING RELAY

The interlocking relay, shown in figure 20, is another important component in the electrical system. The function of this relay is to prevent both motors from starting at the same time, since this would cause excessive current in the circuit.

If the power switch had been turned to the OFF position, and if the room temperature were such that both sets of thermostat contacts were closed, placing the power switch in the COOL position would start both motors simultaneously if contact P on Unit No. 1 were not open. After contact P on unit No. 1 closes, it actuates the interlocking relay, and starts the second unit about one second later.

HIGH-PRESSURE CUTOUT

Another important component required in all air conditioners having a water-cooled condenser is the

High-Pressure cutout. If the system's pressure becomes excessive, due to water failure (or any other cause), the cutout contacts open and stop the unit. Each unit has a cutout. In Model 1204-J the cutout relay contacts must be reset manually if they open. Previously, an automatic reset had been employed to do this.

The cutout is operated from pressure bellows connected to the refrigerant system.

AIR-CIRCULATING FAN

The air-circulating fan motor is connected into the circuit as shown in figure 17. This diagram shows that the fan motor will run at all times when the control switch is in either the COOL or the FAN ONLY position, regardless of thermostat contact position.

The fan motor is of the split-phase type, having a centrifugal switch to disconnect the starting winding when the motor approaches full speed. Like any other split-phase motor, it requires both windings to start, but only the running winding to maintain speed.

Figure 21 shows a cutaway view of a typical split-phase motor with a centrifugal switch. Figure 22 shows internal connections for this type of motor.

The sealed compressor motors are also of the split-phase type, but, in addition, employ two capacitors to produce more starting torque.

MOTOR-STARTING RELAY

The motor-starting relay is supplied with sequential motor starting contacts. See figure 23. The motor-

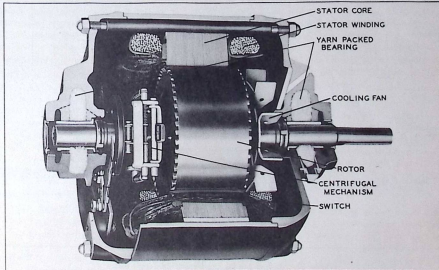


Figure 21. Cutaway View of Split-Phase Motor

TP0-1772

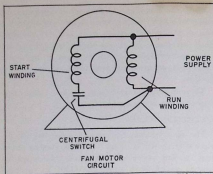


Figure 22. Centrifugal Switch Connections

starting relay contacts are operated by a voltage coil that is in parallel with the motor-starting winding.

When current is applied to the compressor motor, both starting and running windings are energized, but the voltage across the starting winding and relay coil is considerably less than the line voltage, because both are in series with the capacitors. As the motor gains speed, the voltage across the starting winding

increases until, at about 80% of full speed, the force of the relay coil magnet is great enough to open the normally closed contacts. In this way the capacitors and starting winding are disconnected from the circuit. After the starting winding is disconnected, the induced voltage in the starting-winding circuit is sufficient to hold the relay contacts open during the running period.

The sequential motor starting contacts are normally open, but are pushed to a closed position when the relay contacts open. Refer to figure 23. Assume that both thermostat contacts A and B are closed. If it were not for the back contacts on compressor No. 1 starting relay, the motors in both units would start simultaneously when the control switch is closed.

After the power switch is turned to COOL and compressor motor No. 1 approaches full speed, the starting relay contacts open and push contact P closed, thus energizing coil M of the interlocking relay. The magnetic coil M closes the switch S and completes the electrical circuit through compressor motor No. 2. This arrangement provides a small time interval between the starting of the two units. Note that relay contacts are not used in unit No. 2.

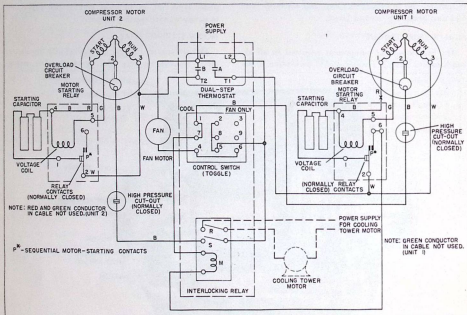


Figure 23. Starting and Running Circuits, with Toggle Switch

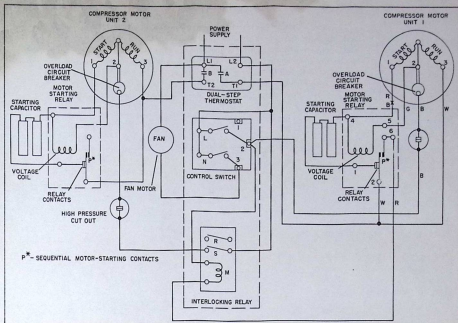


Figure 24. Starting and Running Circuits, with Rotary Switch

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The diagram in figure 23 shows the complete layout for starting and running both units in a model that employs a toggle control switch, and figure 24 shows a similar diagram for a model using a rotary switch.

Figure 25 shows the running circuits only, for both motors. It is presented to help visualize portions of the circuit required to help start the compressor motors (figures 23 and 24) and those necessary to maintain operation. As can be seen, both sets of thermostat contacts are closed, the Control Switch is set to COOL, and interlocking relay switch S is closed. Keep in mind that, although they are not shown, the motor-starting relay contacts would be open, since that part of the circuit is not being used.

INSTALLATION WITH AUXILIARY THERMOSTAT

In some installations, an air duct is incorporated, so that Model 1204-J may be used to cool two separate rooms. In this type of installation, one set of contacts in the Dual-Step thermostat is shorted out, as shown in figure 26, by placing a wire jumper from L₁ to T₂. The wiring is completed by running a lead from L₂

to the auxiliary thermostat and from the thermostat to the terminal of coil M, as shown. The original lead to this terminal is disconnected, and the bare end is taped.

When connected as shown, the two units will operate independently, unit No. 1 being controlled by the Dual-Step thermostat, and unit No. 2 by the auxiliary thermostat in the other room.

COOLING TOWER

It is sometimes profitable to install a cooling tower, so that the condenser water may be cooled and used again. This device requires an electric water-circulating motor which must be connected into the circuit so that it runs when either unit is operating. Since unit No. 1 starts first and stops last, the cooling tower motor is connected so that it starts and stops with that unit as follows:

When the compressor motor in unit No. 1 comes to speed, contact P in the starting relay closes; coil M is energized and switches S and R in the interlocking relay close. Refer to figure 23. When switch R closes, it starts the cooling tower motor which will run as long as unit No. 1 is in operation.

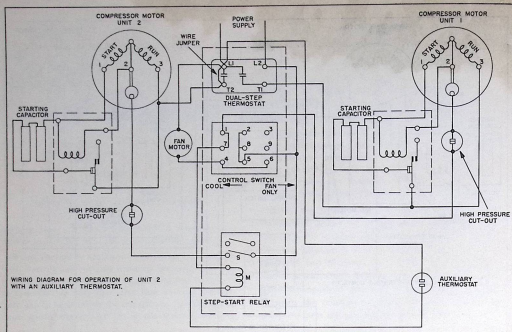


Figure 25. Running Circuits for Both Motors

TP3-1775

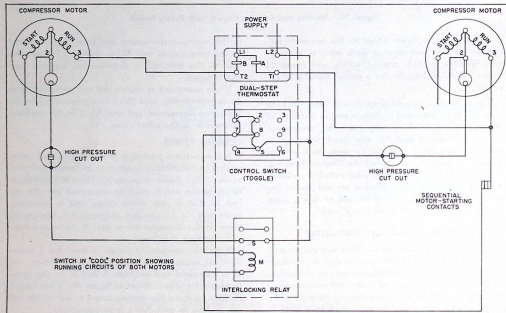


Figure 26. Auxiliary Thermostat Connections

TP3-1776