MANUAL 2100-059

AIR SOURCE HEAT PUMP
OPERATION AND COMPONENTS

REFRIGERATION, HEATING AND AIR CONDITIONING

BARD MANUFACTURING CO. • BRYAN, OHIO 43506

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INTRODUCTION

Design and maintenance of heat pumps has become very important in the heating and air conditioning industry. The shortage and rising costs of natural gas, oil and electricity is causing an upsurge in heat pump installations.

WHAT IS A HEAT PUMP?

A heat pump is an electrically operated mechanical device that utilizes existing heat in outdoor air to heat home and building interiors. On warmer days, the heating cycle is automatically reversed to absorb indoor heat and disperse it outdoors for indoor cooling.

The term "Heat Pump" denotes a year-round air conditioning system that utilizes the refrigeration process to remove heat from the conditioned space when cooling and dehumidification are desired, and to add heat to the conditioned area when heating service is required. The basic refrigeration process is identical to that of the conventional air conditioner system, but the heat pump design is equally concerned with the cooling effect produced at the evaporator and the heating effect produced at the condenser.

Application considerations of unitary heat pumps are:

1. The unitary heat pump fulfills a dual function, heating or cooling; therefore, only a single piece of equipment is required for year-round comfort.
2. Space savings usually result from item 1.
3. A single source of power supplies both heating and cooling requirements.
4. Installation savings normally result from items 1 and 3.
5. Heat output in Btu is approximately two to three times that of the purchased energy input in Btu, effectively reducing the operating cost of the unit.
6. No vents or chimneys are required, thus reducing building costs.
7. No potential fire hazard from open flames.
8. Accurate determinations of winter heat loss and summer heat gain are essential for proper sizing.
9. Moderate supply air temperatures in the heating cycle require close adherence to sound air distribution principles.
10. Preventive maintenance program is essential, as with any heating and cooling equipment.

HOW A HEAT PUMP OPERATES

From the refrigeration standpoint, a heat pump is similar to a conventional air conditioning system. Changeover between cooling and heating cycles is accomplished by actuating a four-way reversing valve in the refrigerant lines, so as to interchange the positions of the heat exchangers constituting the evaporator and the condenser, respectively, in the refrigerant flow circuit.

There is some heat in the air all the way to absolute zero, which is 459.69°F below zero. This is why a heat pump can be operated at 30°, 20°, or even 0°F and still be a practical heating system.

The systems to be discussed are air-to-air heat pumps, which are the most widely used and most versatile types. Other types of heat pumps on the market are the water-to-air and water-to-water heat pumps. The refrigerant cycle employed by these units is similar to the air-to-air heat pump.

Electrical energy is the power source for both the air conditioner and the heat pump system. Any electrical input to the equipment must be dissipated either in terms of work or heat. Some of the energy is dissipated as work going into the driving of the evaporator blower or condenser fan, but the majority of the energy is utilized by the compressor for the compression cycle and is discharged as heat into the refrigerant gas leaving the compressor.

This heat must then be rejected to the outdoor "heat sink" air space along with all the heat removed from the indoor "heat source" air space by the evaporator. For example, a typical 3 ton, 36,000 Btu air conditioner will remove 36,000 Btu/h (at standard rating conditions) from the "heat source" air space, and must reject that amount, plus all electrical energy input to the unit in terms of heat, through the condenser coil to the "heat sink" air space, for a total of approximately 54,500 Btu/h of heat rejection.

The same unit, on heating cycle, will deliver 40,000 Btu/h (at rating conditions) of usable heat to the indoor (now the "heat sink") air space. Of this 40,000 Btu, roughly 22,900 Btu (or 57%) comes from the outdoor "heat source" air space, and the remaining 17,100 Btu is the electrical energy input to the unit being rejected as heat.

In simple terms, the electrical input to the unit becomes waste heat on cooling cycle, while on heating cycle it becomes usable heat.

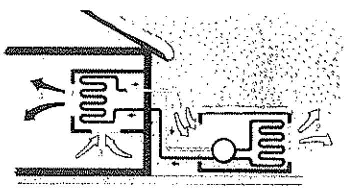
The following examples help explain the increasing popularity of the heat pump:

Cooling cycle.....	32.4¢/hour for 36,000 Btu of heat removal from conditioned space.
Heating cycle.....	30.0¢/hour for 40,000 Btu of heat addition to conditioned space.
Electric strip heating only	70.4¢/hour for 40,000 Btu of heat addition to conditioned space.

NOTE: The above costs for one hour of continuous operation were based on 6¢ per kWh. While actual rates vary from area to area, the comparison or ratio of the above costs per hour would remain the same.

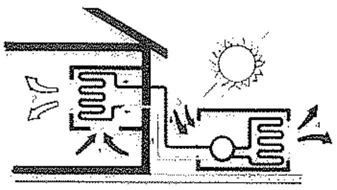
Cooling cycle was shown to further demonstrate how the electrical input is a burden factor on cooling cycle and a usable addition on heating cycle.

The above discussion was based on a typical unit at the ARI standard rating conditions. A review of the "Heating-Cooling Application Curves" for each unit model will show the heating and cooling capacities and power requirements for operating conditions other than standard rating conditions.



Heating Cycle for Winter Operation During cold weather, a Bard Heat Pump extracts heat from cold outside air and pumps this heat into the home.

1. Coil extracts heat from outdoor air.
2. Supercooled air is exhausted.
3. Indoor air picks up heat from coil.
4. Heated air is circulated to living spaces.

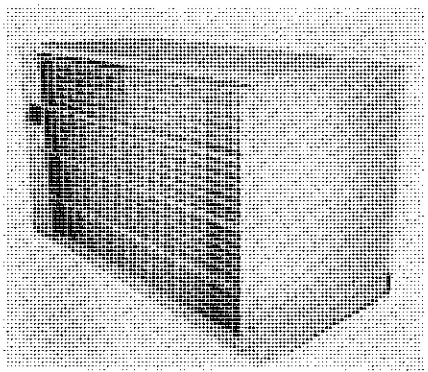


Cooling Cycle for Summer Operation During hot weather, a Bard Heat Pump reverses the winter process to remove heat from living spaces for cooler indoor comfort.

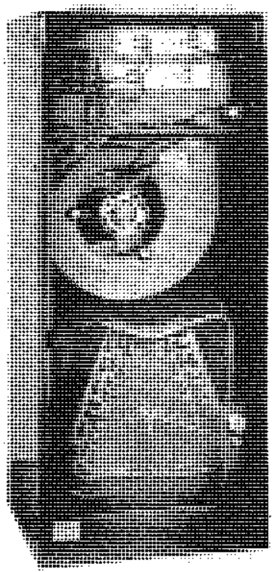
1. Coil extracts heat from indoor air.
2. Cooled air is returned to living spaces.
3. Outdoor air picks up heat from coil.
4. Superheated is exhausted to atmosphere.

HEAT PUMP COMPONENTS

The cooling cycle for a heat pump and an air conditioner is the same. Many component parts are the same. There is a compressor, evaporator, condenser, and refrigerant lines. There is an air mover with both the evaporator and condenser. Since each performs both functions on a heat pump, the evaporator and condenser are referred to as indoor and outdoor coils. With the addition of several components a heat pump can be designed.



HEAT PUMP OUTDOOR UNIT



INDOOR UNIT

GENERAL CONSTRUCTION FEATURES OF BARD UNITS

OUTDOOR UNITS - A/C and H/P

1. 20 gauge galvannealed steel for all external casing parts.
2. Item 1 parts, after being cleaned, degreased and treated, are electrostatically painted with a polyester enamel rated at 1000 hour salt spray test.
3. All painted parts are baked at 425°F in a special gas fired baking oven.
4. Some of the internal parts are 20 gauge galvanized steel, unpainted.
5. Sheet metal screws are zinc plated with a Golden Chromate finish for added durability.
6. Expanded metal grilles are zinc plated with Golden Chromate finish, then electrostatically painted with polyester enamel and baked.
7. Wire type grilles are coated with a minimum of 10 mil thickness of vinyl colored to match the unit.
8. Condensate water pans (under indoor coils on single package units) are 18 gauge steel with welded corners, spray coated with undercoating material for corrosion protection and insulating value, and then painted. All drain pans are equipped with 3/4" pipe coupling for drain connection. Exceptions to the 3/4" drain coupling are the "wall-hung" models which use a plastic drain hose extending out the bottom of the unit.
9. All heat pumps are of the "blow-thru" design.
10. All heat pump bases are "cut-out" under the outdoor coil to allow the defrost condensate to drain cleanly out of the unit.
11. Cabinet insulation consists of the following (or combinations of):

    a. 1/2" thick, 1-1/2# density, Neoprene faced
    b. 1" thick, 1# density, Neoprene faced
    c. 1/2" thick, .6# density, foil faced
    d. 1" thick, .6# density, foil faced

    Also used for acoustic value only on some models is a 1", 1# density unfaced insulation.

INDOOR UNITS - A/C and H/P

1. External casing either 22 gauge or 20 gauge steel, depending on model and unit size.
2. Item 1 parts, after being cleaned, degreased and treated, are electrostatically painted with enamel paint.
3. All painted parts are baked at 425°F in a special baking oven.
4. Internal parts are either unpainted 20 gauge galvanneal or galvanized steel or painted 20 gauge steel.
5. Condensate water pans are 18 gauge steel with welded corners, spray coated with undercoating material for corrosion protection and insulating value, and then painted. All drain pans are equipped with 3/4" pipe coupling for drain connection.
6. Cabinet insulation consists of the following (or combinations of):

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    c. 1/2" thick, .6# density, foil faced
    d. 1" thick, .6# density, foil faced

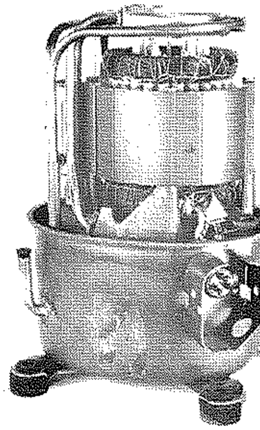
AIR CONDITIONER AND HEAT PUMP COMPONENT PARTS

COMPRESSORS

All compressors used are specifically designed for the application. Some air conditioner models use compressors that are designed for air conditioner service only, and all heat pumps use compressors that are designed for the more rugged operating conditions experienced by a heat pump.

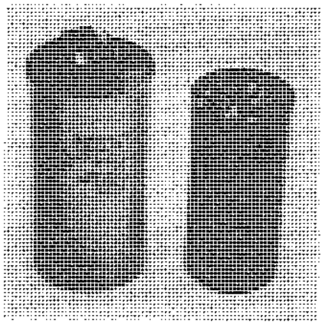
Depending on compressor size, the same compressor as used in a given heat pump size may also be used in the comparably rated air conditioner unit. This is because there are no compressors available for that Btu size that are designed for air conditioning only.

Sources are Tecumseh, Copeland and Bristol.

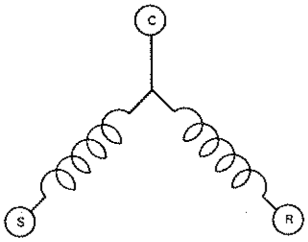


The compressor motor has two sets of windings--a start winding and a run winding. There are three terminals on the compressor. One is marked "C" for the connection that is common to both motor windings. "S" is for the start winding connection, and "R" for the run winding connection. One hot line of the contactor is attached to the common terminal of the motor. The other hot line goes to the run terminal.

A run capacitor is connected between the start and run terminals. Its purpose is to shift electrical phase between the start and run windings so the motor will start. It also increases the power factor when the motor is running.

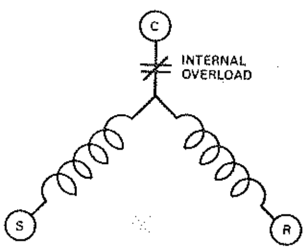


START AND RUN CAPACITORS



COMPRESSOR TERMINALS

Most compressors have a built-in protective device called an internal overload. This device is imbedded in the motor windings at the hottest point, sensing both current and temperature. This overload contains a bi-metal which opens the circuit if the temperature or current becomes excessive. It is inside the compressor shell and wired in series with the common terminal and both the start and run windings. When an internal overload opens, it takes the compressor off the line by breaking the main winding circuit.



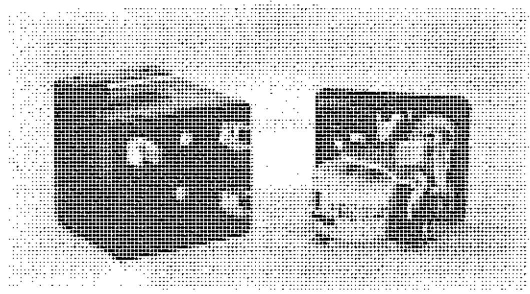
COMPRESSOR OVERLOAD TERMINALS

START CAPACITOR AND POTENTIAL RELAY

If the unit is to be operated with an expansion valve coil, it will need to start against a higher pressure. The run capacitor may not be able to provide enough energy to overcome this additional load. To provide more starting energy, a start capacitor is added in parallel with the run capacitor. A run capacitor is designed to remain in the circuit at all times when the compressor is energized. The start capacitor only stays in the circuit a short period of time; just until the motor gets up to running speed.

A potential relay is used to disconnect the start capacitor from the circuit. This relay contains one normally closed set of contacts and a magnetic coil. The contacts are connected in series with the start capacitor. The coil is connected in parallel circuit between the start and common terminals of the compressor. When the compressor starts and begins to turn, a voltage is generated in the start winding. This voltage, known as back electromotive force, builds up until it reaches the rated voltage of the potential relay coil. The coil is then energized, opening the contacts and holding the start capacitor out of the circuit. The contacts remain open as long as the compressor is running. When the compressor stops, the coil is de-energized and the contacts close.

There is a small resistor connecting the terminals of the start capacitor. This allows the voltage build up to bleed off when the capacitor is de-energized.

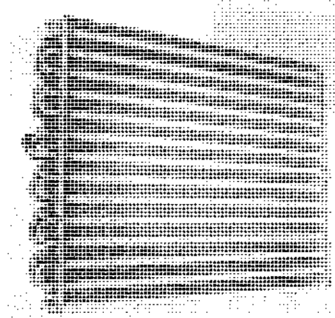


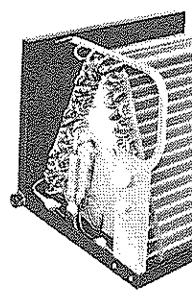
POTENTIAL RELAY

HEAT TRANSFER COILS - CONDENSER AND EVAPORATOR

All heat transfer coils are made especially for Bard units and are designed for the individual application.

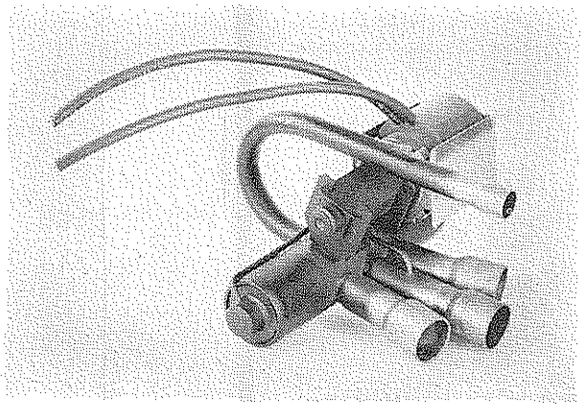
Heat pump coils require special design circuitry because both the indoor and outdoor coil must function equally well as an evaporator and as a condenser coil. This design involves the tube O.D. size and spacing, the number of rows of tubes, the fin design and spacing per inch, and both the air pressure drop and refrigerant pressure drop through the coil.





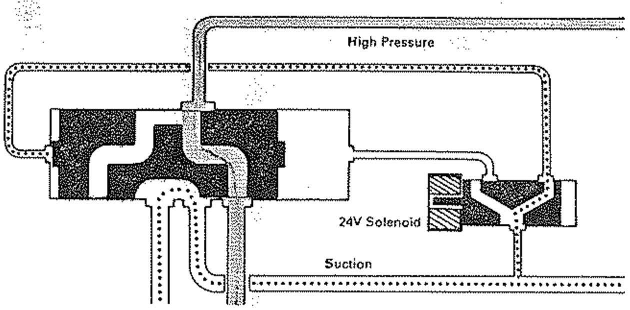
REVERSING VALVE

Used to change the operating cycle of the refrigerant system from one mode to the other, the reversing valve consists of a pilot valve and a main valve. The pilot valve is controlled by a solenoid coil assembly that, when energized, changes position and allows the operating pressures of the refrigerant system (as developed by the compressor) to actually drive (push) the main valve assembly to the opposite end of the main valve chamber. When this occurs, the path of the discharge refrigerant gas entering the valve body is diverted from the outdoor coil to the indoor coil, and simultaneously the return path to the compressor shifts from the indoor coil to the outdoor coil.

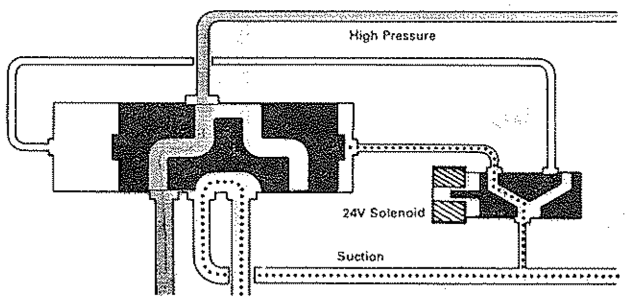


REVERSING VALVE

There are both teflon and nylon seats or gaskets in the valve body and therefore the valve must be cooled with a water bath or wet rags during the brazing operations. The reversing valves are manufactured by Ranco. The same solenoid coil is used on all reversing valves.



Piston In The Cooling Position



Piston In The Heating Position

METERING REFRIGERANTS

Refrigerant metering in a heat pump can be accomplished in several ways. Bard uses a capillary tube system. With this system, one capillary tube is located near the outdoor coil. The other capillary tube is located near the indoor coil. On the cooling cycle, the capillary tube near the indoor coil is used to meter the refrigerant. The capillary tube near the outdoor coil is by-passed. On the heating cycle, the capillary tube near the outdoor coil meters refrigerant while the other is bypassed.

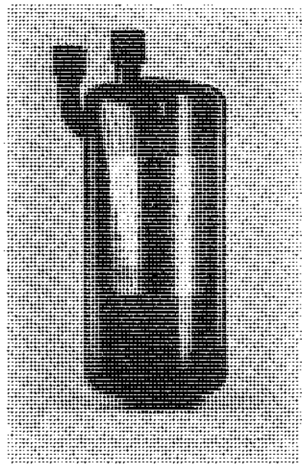
CAPILLARY TUBING

The precise metering of the liquid refrigerant into the evaporator coil is controlled by capillary tubing. The capillary tubing used on all and conditioning and heat pump units is a hard drawn precision I.D. copper tubing of varying lengths. The I.D., length of tubes, and number of tubes required depends upon the application involved. The tubes are formed on a bending fixture to fit the various unit constructions.

ACCUMULATORS

A properly designed suction accumulator, installed between the reversing valve and the compressor suction return connection, can help eliminate the potentially damaging conditions of liquid refrigerant being returned directly into the compressor housing.

Compressors are not designed to pump liquids, operate as hydraulic rams or function without lubrication. Bard heat pumps employ the newly designed Tecumseh accumulator, which is the most advanced and efficient accumulator yet to be developed. There are several sizes used, and they are sized based upon total system charge.

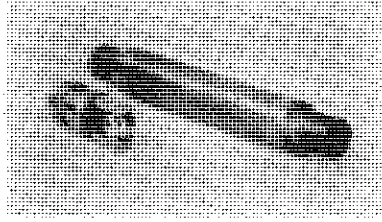


ACCUMULATOR

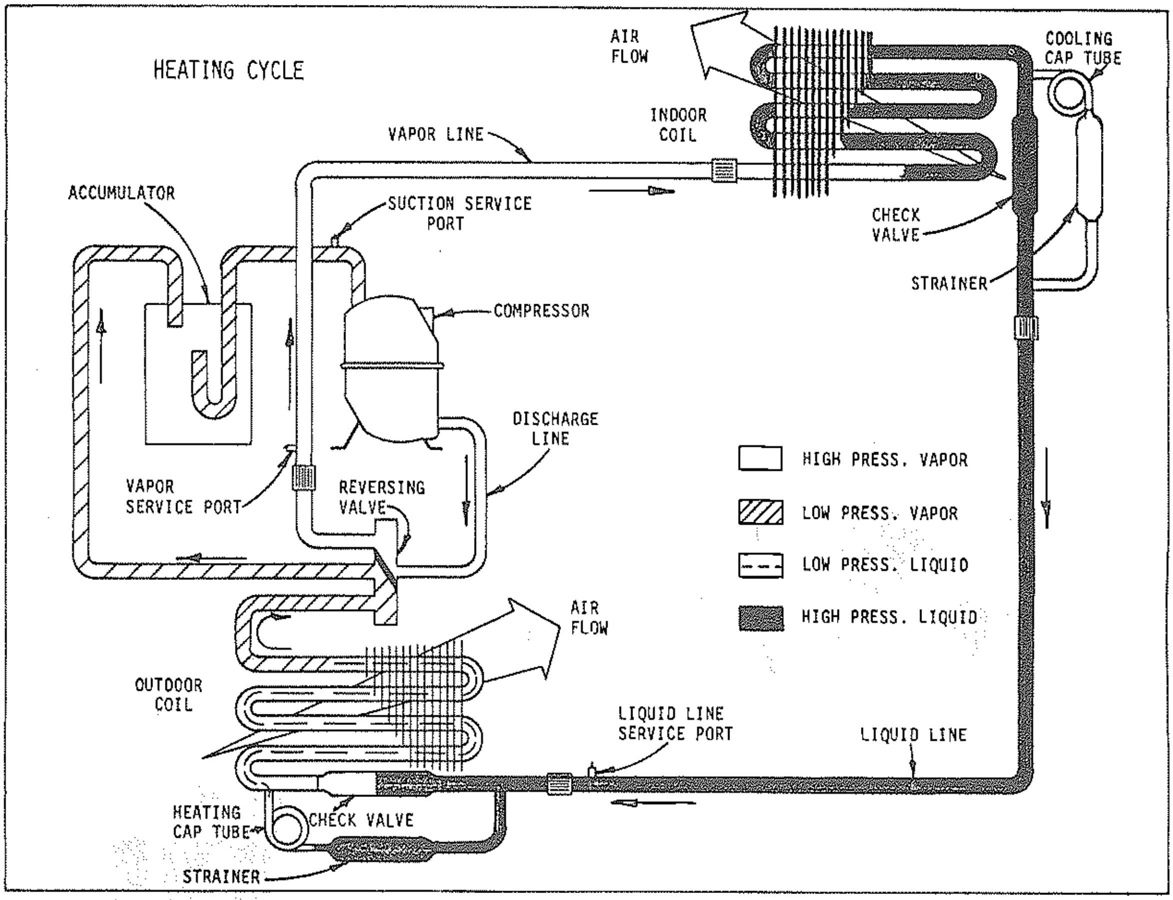
CHECK VALVES

Check valves are required on heat pump systems to control and regulate the flow of liquid refrigerant to the correct refrigerant metering device. All split systems and most self-contained units utilize two check valves, with some self-contained units using a single check valve.

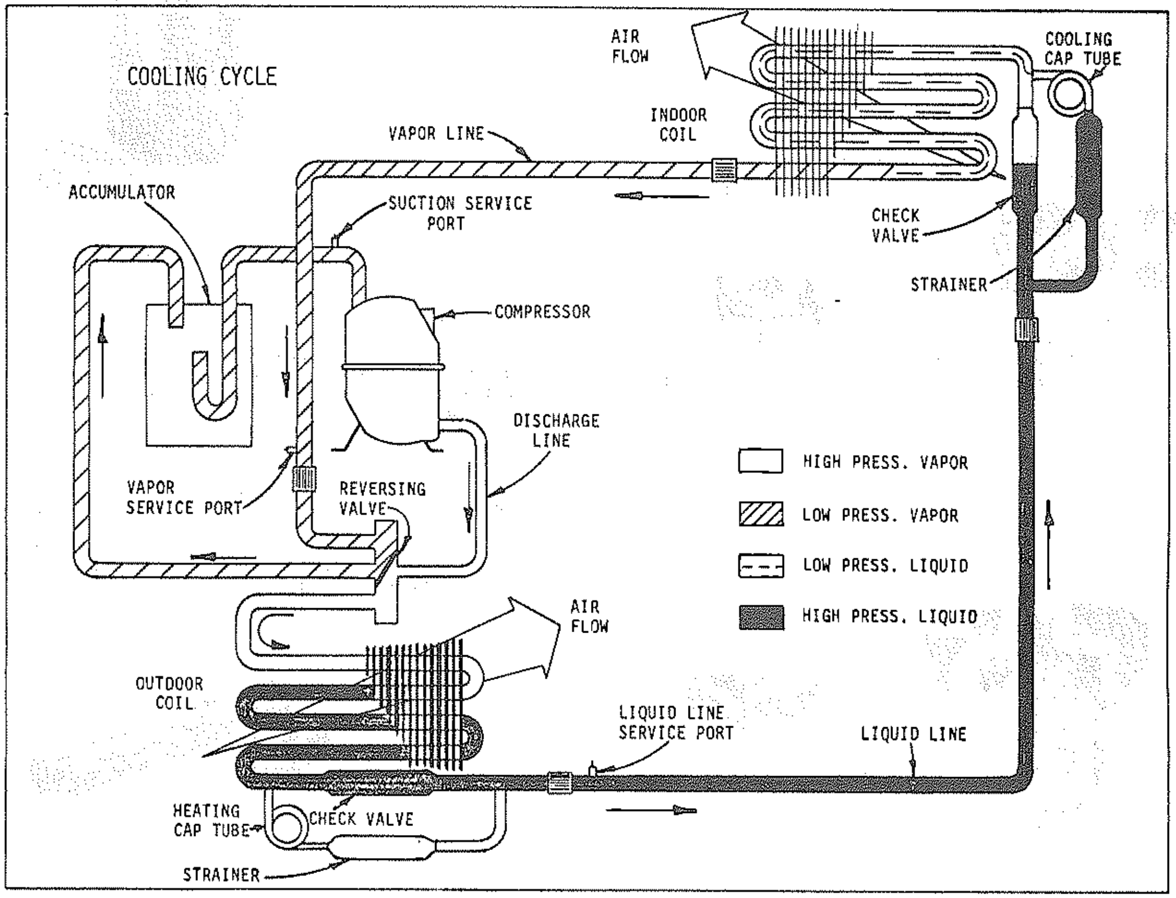
The check valve consists of a stainless steel ball retained in a brass insert section, which includes the ball seat and ball travel path. The brass insert section is enclosed in a 5/8 inch O.D. copper tube approximately 4 inches long and spun down on each end to accept a 3/8 inch O.D. tube. It is not necessary to keep this design of check valve cooled during brazing operations.



CHECK VALVE

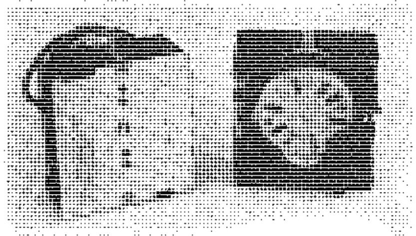


TYPICAL HEAT PUMP SYSTEM



DEFROST TIMERS

When the heat pump is operating in the heating cycle, the outdoor coil collects ice in cold climate conditions. This icing occurs because of temperature differences between the outdoor coil and outdoor air. Moisture contained in the outdoor air condenses on the coil and freezes. This buildup of ice will eventually restrict air from passing through the coil.



The most practical way to remove ice buildup is to heat the coil. If the heat pump is turned to the cooling cycle, even though the thermostat calls for heating, heat will be drawn from indoors and discharged through the outdoor coil. This heat will melt any ice buildup. During the time when ice is being melted from the coil (called a defrost cycle), the blower in the outdoor unit is turned off. If the blower were permitted to run, cold air would be pushed over the coil preventing or delaying defrost.

Incorporated as part of the "Time-Temperature" defrost system used on all Bard heat pumps, the timer is a 240v motor driven switching arrangement that provides a 30 minute or 60 minute delay of the actual defrost cycle after it has been determined that conditions are right for frost to begin to form. This delay period of 30 or 60 minutes allows the heat pump to provide heating capability for this extended period until the system efficiency begins to fall off.

A unique feature of the Mallory timer currently in use is that the service technician can manually advance the timer to the contact point and put the system into a defrost cycle. The above statement is correct as long as the defrost thermostat is closed, which will normally occur any time the heat pump is running and the outdoor temperature is below 40°F. At outdoor temperatures below 30°F the defrost thermostat will automatically be closed.

If some abnormal or temporary condition such as a high wind causes the heat pump to have a prolonged defrost cycle, contacts 3-5 of the defrost timer will open after 7 minutes and restore the system to heating operations automatically.

There is a manual advance knob located on the top of the timer, with access through a punched hole in sheet metal barrier just above timer. This can be used to advance timer to contact closure point if it is desired to check out defrost cycle operation, without waiting for time to elapse.

DRIER

Moisture in the form of water is the worst enemy of any refrigerant system. A means of dehydrating water is accomplished automatically by a drier. The drier uses a drying agent and a molecular sieve to extract damaging moisture and acid.

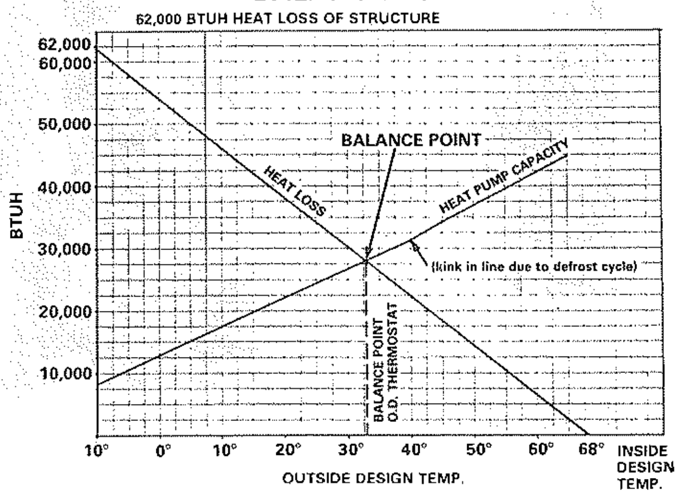
REFRIGERANT STRAINERS

Refrigerant strainers are used to distribute the liquid refrigerant equally to however many capillary tubes are used in a given unit design. This ranges from one to six capillary tubes. There is also a fine mesh Monel screen ahead of the capillary tube inlet point to trap any possible contaminants.

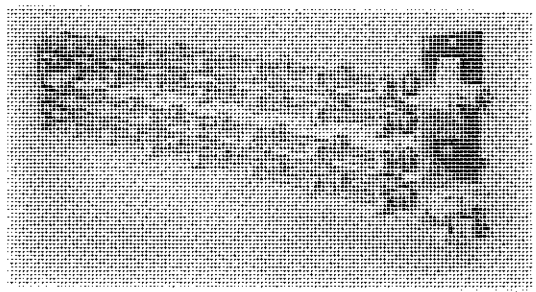
AUXILIARY HEAT FOR HEAT PUMPS

Auxiliary heat is an important part of a heat pump system. As outdoor temperatures drop, a point will be reached when the heat pump will no longer adequately hold proper temperatures within the home. Auxiliary heat is used during these times of heavier heat demands, and can be accomplished by electricity or fossil fuels.

BALANCE POINT



NOTE: The balance point of a system is that point where the heat loss of the structure equals the heating capacity of the heat pump. On mild days, the heat pump handles all heating needs until the outdoor temperature falls below the balance point of the structure. When the balance point is reached, a two-stage thermostat activates the auxiliary heat source.



ELECTRIC HEATERS

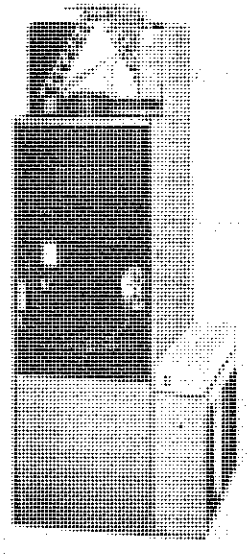
Open coil resistance heating elements are available for most air conditioning and heat pump models to provide additional heating capability. These heating elements consist of a special "Nickel Chromium" wire wound into a coil form and mounted by insulators on to a supporting frame arrangement.

They are available in different nominal Kw ratings and voltages and have the ability to concentrate a high amount of heating capability in a very small space.

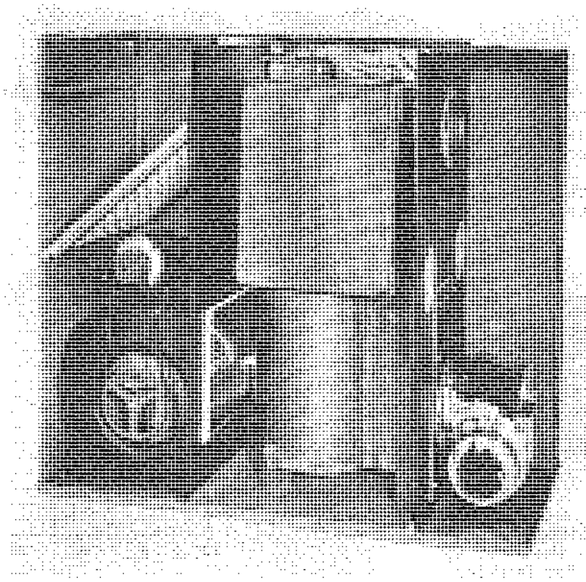
Resistance heating elements operate at 100% efficiency—electrical power in, heat out. It should be noted that the Kw of any given heater is at the rated voltage of that heater, and that the Kw output, and thus the Btu output, varies with the applied voltage. For example, a heater rated at 240v that is connected to a 208v power source will deliver only 75% of the nominal rated Kw, but still will be 100% efficient.

ELECTRIC FURNACE APPLICATION—INSTALLATION

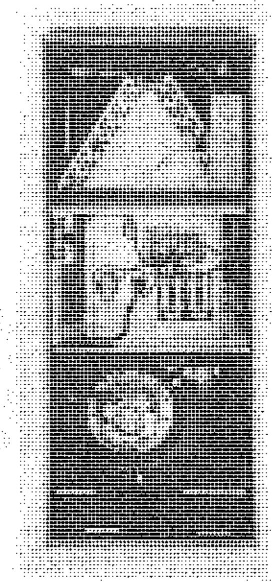
The heat pump A-coil must be installed on the return air side of any electric furnace application. This is mandatory so that the heat output from the electric strip heaters, energized at the lower outdoor temperatures, does not drive into the heat pump coil and cause the refrigerant condensing pressure and temperature to raise to points well beyond the design limitations of a heat pump system, and cause the compressor to be de-energized by the manual reset high pressure switch.



GAS



OIL



ELECTRIC

AUXILIARY FOSSIL FUEL HEATING

General Operation - Heat Pump/Fossil Fuel Furnace - This type of system is a one-stage heating system, even though a two-stage heat wall thermostat is used. The thermostats specified for use are special stats for heat pumps with extra switches, signal lights, and special circuitry for heat pumps, and by design are two-stage heating stats. Since the extra features are also required for the special heat pump/fossil fuel systems, the same stats are used, but the 2nd stage circuit is not used. This is further explained in the next paragraph.

While it would be possible to electrically connect the furnace to the 2nd stage of the stat, the heat pump coil is located downstream from the furnace heat exchanger, and continuous simultaneous operation of the furnace and heat pump will result in excessive high discharge pressures and temperatures at the compressor and resultant overload tripping problems.

A changeover thermostat, properly set to control at or just above the balance point, will allow the most economical operation of the system. The changeover thermostat switches off the heat pump and on the fossil fueled furnace, based on the outdoor temperature. There is a 5°F differential in the changeover thermostat, so when the heat pump is de-energized and the furnace is activated, the outdoor temperature must rise 5°F above the set-point of the thermostat to stop the furnace and start the heat pump again.

The emergency heat switch allows for manual cut-off of the heat pump and operation of the furnace at any outdoor temperature.

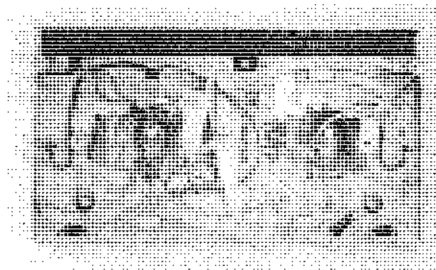
NOTE ON INDOOR BLOWER OPERATION: Because of the design of the heat pump wall thermostats, and the fact that a cooling blower relay must be installed in parallel with the fan side of the combination fan/limit control on the gas or oil furnace, the furnace blower will start as soon as the wall stat calls for heat. This is required for the heat pump and will also occur during the time when the heat pump is off and the furnace is operating. This is contrary to normal blower operation on a gas or oil furnace and is sometimes misunderstood, but an inherent part of the system operation. While in the gas or oil furnace mode of operation, there will still be a run-on in blower operation until the bonnet temperature cools down to the blower off setting of the fan/limit switch.

THERMOSTAT

Two types of thermostats are normally used to operate the heat pump. One thermostat is two-bulb with manual changeover from heating to cooling. The other type is three-bulb thermostat with automatic changeover.

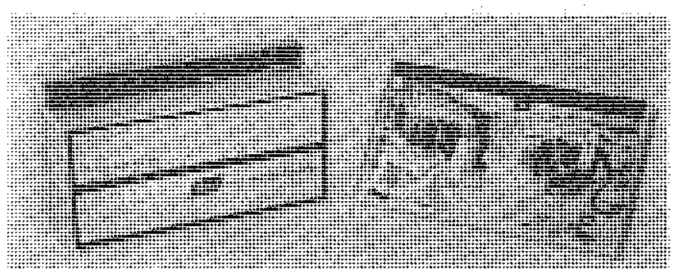
On the thermostat with manual changeover, the reversing valve is energized when the system switch is moved to the heating position. One bulb starts the compressor for either heating or cooling depending on the position of the reversing valve. The second bulb operates auxiliary heat.

Another method of control is the two-bulb heating and cooling thermostat combined with an outdoor thermostat. The outdoor thermostat brings on auxiliary heat when the outdoor temperature drops to the balance point of the unit and the two-bulb thermostat is calling for second stage heat.



TWO-BULB THERMOSTAT

With the three-bulb thermostat the first-stage heating bulb energizes the reversing valve and compressor. The cooling bulb operates the compressor. The first-stage heating bulb operates the compressor. The second-stage heating bulb energizes the auxiliary heat if the indoor temperature drops 2°F below the thermostat setting.

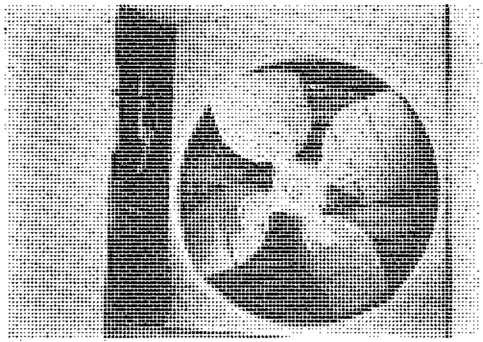


THREE-BULB THERMOSTAT

MOTORS

All direct drive motors for both blower wheel and fan blade applications are specially designed in the Bard engineering laboratory, in conjunction with the design engineering groups of the motor manufacturer. Rigidly tested and evaluated by using both thermocouples and a Wheatstone bridge for resistance measurements, they are designed for the lowest practical winding temperature and low power consumption to deliver optimum efficiency.

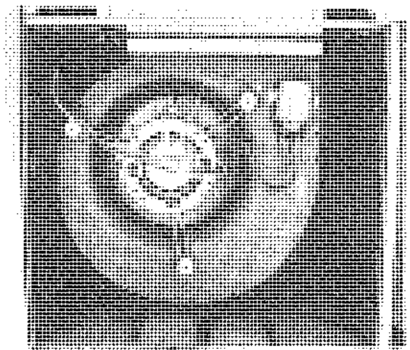
Permanent Split Capacitor (PSC) motors are used on all blower applications, as well as on fan applications. All of the Bard systems use PSC condenser motors.



OUTDOOR FAN

INDOOR BLOWER

The indoor blower motor circuit is independent of the outdoor unit circuit. It may have a separate disconnect and fusing. The motor could be either 120 volts or 220 volts depending on the type of indoor unit being used with the heat pump. The motor is controlled by a fan relay which is actuated from the thermostat whenever the compressor is operating. Normally, there is at least one other heat-actuated switch wired in parallel with the fan relay.



INDOOR BLOWER

OTHER CONTROLS

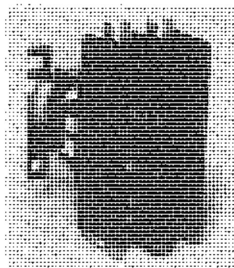
Other component controls include capacitors for motor and compressor circuits, various types of switching relays used for blower motor control and other functions, defrost relay, numerous compressor contactors of different pole configurations and FLA ratings, electric heat contactors, limit controls and thermal cut-offs for electric heaters, high pressure switches and numerous other controls.

All of the above are designed and used for specific applications, while at the same time striving for versatility in using as many common parts in all models as possible without sacrificing system design and compromising product reliability.

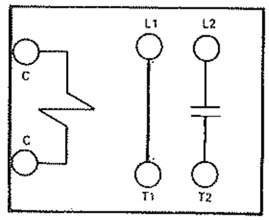
INDOOR BLOWER CONTROL RELAYS

COMPRESSOR CONTACTOR

Power from the disconnect switch is brought to the compressor contactor by the same size wire as used from the main fuse panel. Some building codes require a ground rod and wire connected to the frame of the outdoor unit for safety. Ampacity and fuse sizes are printed on the equipment nameplate. The compressor contactor has two sets of contacts for single phase power to the compressor. Power is connected to the two line terminals of the contactor. The common and run terminal of the compressor are connected to the load terminals of the compressor contactor. The contactor is actuated by a 24V coil that is controlled by a mercury bulb in the thermostat.



COMPRESSOR CONTACTOR



COMPRESSOR CONTACTOR CIRCUITRY

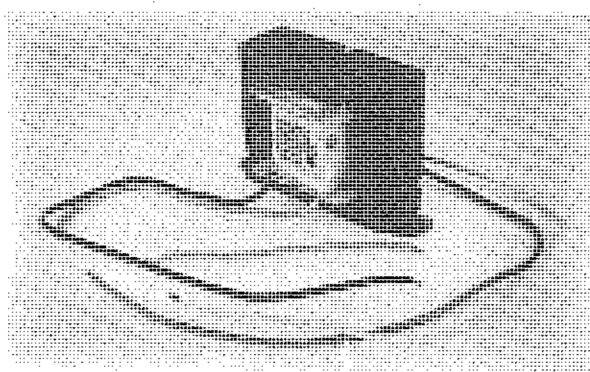
24V TRANSFORMERS

24V transformers designed for cool running temperatures and to perform over an extended operating voltage range are used in all systems. The transformer design assures control circuit operation even beyond the specified operating voltage range of the equipment they are used in.

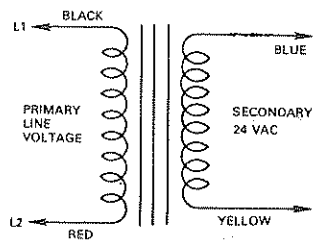
A 40VA transformer is used on all A/C systems that are nominally 3 ton or smaller, 55VA on 3½ and larger A/C and 3 and smaller H/P, and 65VA on 3½,4 and 5 Ton split heat pumps.

The control transformer is a 240V - 24V stepdown transformer located in the indoor unit.

This transformer is wired from the line side of the compressor contactor. When the main disconnect is closed, the transformer will be energized. The secondary circuit may have a fuse in one side of the line for protection against overloads or short circuits.



TRANSFORMER



TRANSFORMER SYMBOL

OUTDOOR FAN AND DEFROST RELAY

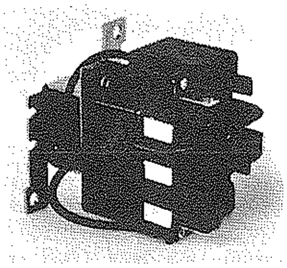
The outdoor fan and defrost relay is one of the more important controls in the heat pump. This relay contains one set of normally closed contacts and two sets of normally open contacts. The relay coil has a 240V rating. When a defrost cycle is initiated, this relay is energized and performs three functions.

1. The normally closed 4-5 contacts are in series with the outdoor fan motor. These open and turn off the outdoor fan. In a defrost cycle, ice buildup is melted from the outdoor coil. This becomes easier when no cold air is being blown through the coil.

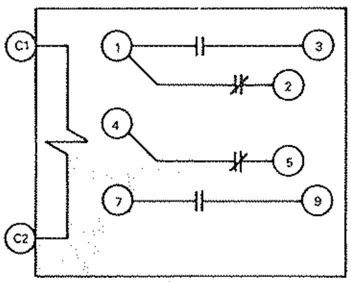
2. One set of normally closed contacts (1-2) opens and breaks the 24V to the reversing valve. The reversing valve is de-energized and switches the unit to the cooling cycle providing hot, vaporized refrigerant gas to the cold outdoor coil.

   The other set of normally open contacts (1-3) closes and provides 24 volts to the auxiliary heat relay. This provides some extra heat to offset the cooling effect from the indoor coil during the defrost cycle.

3. Normally open contacts 7-9 closes and provides interlock circuit holding system into defrost until either the defrost thermostat or timer terminate cycle.



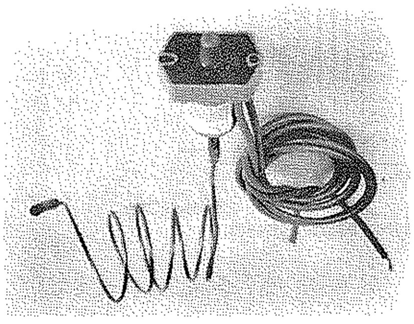
OUTDOOR FAN AND DEFROST RELAY



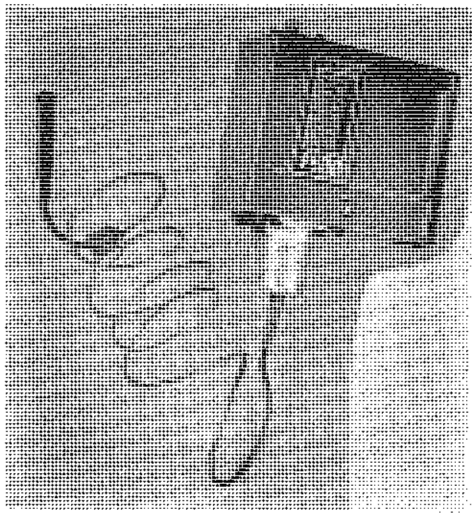
RELAY SCHEMATIC (240V)

PRESSURE CONTROLS

Heat pumps are normally equipped with a high pressure control. The high pressure control is located on the discharge line between the compressor and the reversing valve. This switch has a cutout point of 425 or 475 psig and has a manual reset. This control protects the system against an excessive buildup of pressure in both the heating and cooling cycle. The contacts of this control are in series with the coil of the compressor contactor.



HIGH PRESSURE CONTROL



LOW PRESSURE CONTROL

The low pressure control is located in the suction line. The contacts located within the control are wired in series with the compressor contactor coil and open on a drop in pressure. The primary function of this switch is to protect the unit against a loss of charge. Bard uses it as an option of some equipment. It is also adjustable.

NOTE: This control is often referred to as a "loss of charge switch."

OFF-CYCLE CRANKCASE HEAT

Off-cycle crankcase heat is an essential part of heat pump design criteria. All Bard heat pumps, as well as Bard air conditioning systems, are designed with crankcase heat as an integral part of the factory assembled unit.

Some form of off-cycle crankcase heat is mandatory to drive all liquid refrigerant from the compressor housing before the initial start-up and to assure that there will be no migration of liquid refrigerant into the compressor during the off cycles. Correct design and application of some form of off-cycle heat will help to safeguard the compressor and to improve product reliability.

There are three forms of off-cycle heat presently used on Bard systems. The first and most extensively used type is the capacitor type used on all single phase models. The second type is the immersion and third the wraparound crankcase heater that is used on some three phase models.

The capacitor type off-cycle heat circuit consists of either all or a part of the run capacitance wired in series with the compressor motor start winding, and this circuit is energized at all times that power is applied to the unit. The amount of run capacitance used depends upon the compressor type and overall system design. A unique feature of this type of circuit is that when the unit is in the run cycle, the off-cycle circuit becomes part of the normal run sequence and draws no additional power consumption over and above the normal running power requirements. See Figure 9, page 10.

The capacitor type off-cycle heat takes a little longer for the initial warm-up period, but is superior in the fact that it heats the compressor from the inside out, resulting in less loss to surrounding ambient air. It also assures that all bearing surfaces and other essential lubrication points are warmed.

Refer to "Typical Capacitor Type Off-Cycle Crankcase Heat Circuit" diagram for a general review of how this circuit is developed. Shown are both the off-cycle and running cycle voltage characteristics. These are nominal values and vary with system design.

The immersion type crankcase heaters that are now provided with Tecumseh's model "AG" compressors and Copeland's model "CR" compressors, both 1 phase and 3 phase models, are built into the crankcase and will vary their heating output to maintain oil temperatures in the crankcase.

Even when the outdoor temperature is warm, the crankcase temperature may be cold enough to require heat, and this immersion heater will sense this automatically and develop the necessary heat. The heating elements are replaceable by simply pulling out element and replace with sealing compound.

The wraparound type of crankcase heater for three phase models is mounted externally on the compressor housing, approximately two inches up from the bottom. These heaters are a nominal 54 watt at 240 or 480 volt, and are on continuously as long as power is applied to the unit.

IMPORTANT: Whatever form of off-cycle heat might be designed into the product is of no value unless adequate warm-up time is allowed on start-up. This means that after power is applied to the unit, the compressor should never—for any reason—be allowed to operate, even momentarily. If liquid refrigerant is in the compressor, which is very probable, chances are quite high that damage will result that could cause compressor failure.

The importance of this cannot be over-emphasized and for that reason the following label is applied to all systems, located in the vicinity of the unit rating plate.

IMPORTANT

THESE PROCEDURES MUST BE FOLLOWED AT INITIAL START-UP AND AT ANY TIME POWER HAS BEEN REMOVED FOR 12 HOURS OR LONGER.

TO PREVENT COMPRESSOR DAMAGE WHICH MAY RESULT FROM THE PRESENCE OF LIQUID REFRIGERANT IN THE COMPRESSOR CRANKCASE

1. MAKE CERTAIN THE ROOM THERMOSTAT IS IN THE "OFF" POSITION. (THE COMPRESSOR IS NOT TO OPERATE).
2. APPLY POWER BY CLOSING THE SYSTEM DISCONNECT SWITCH. THIS ENERGIZES THE COMPRESSOR HEATER WHICH EVAPORATES THE LIQUID REFRIGERANT IN THE CRANKCASE.
3. ALLOW 4 HOURS OR 60 MINUTES PER POUND OF REFRIGERANT IN THE SYSTEM AS NOTED ON THE UNIT RATING PLATE, WHICHEVER IS GREATER.
4. AFTER PROPERLY ELAPSED TIME THE THERMOSTAT MAY BE SET TO OPERATE THE COMPRESSOR.
5. EXCEPT AS REQUIRED FOR SAFETY WHILE SERVICING — DO NOT OPEN SYSTEM DISCONNECT SWITCH.

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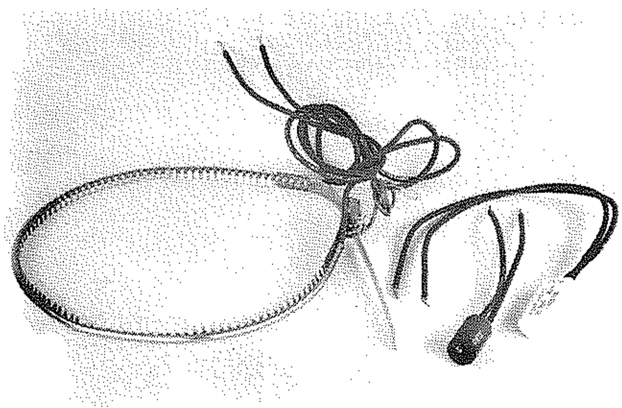
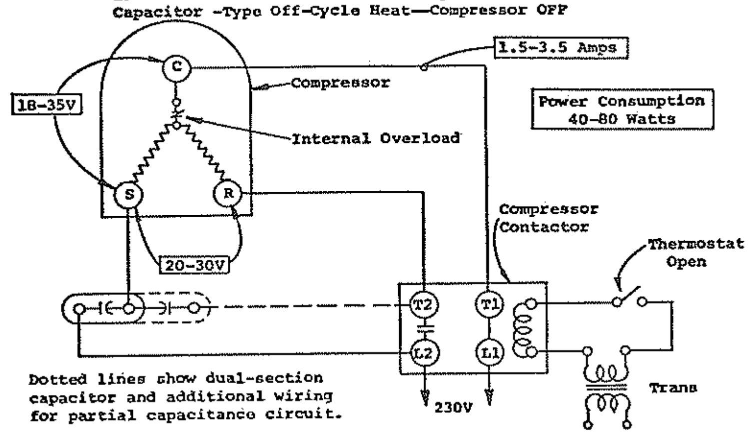


CRANKCASE HEATER

Electrical Characteristics of Compressor With Capacitor -Type Off-Cycle Heat—Compressor OFF



Electrical Characteristics of Compressor With Capacitor - Type Off-Cycle Heat—Compressor ON

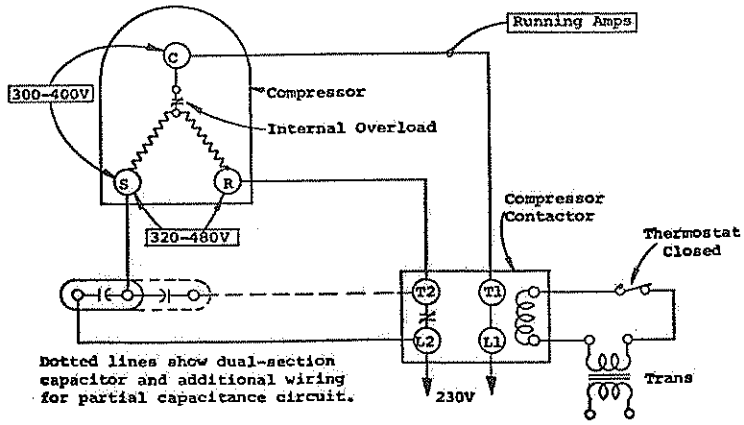


FIGURE 9

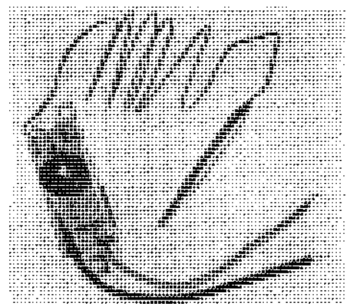
COMPRESSOR CUT-OFF THERMOSTAT AND OUTDOOR THERMOSTATS

Heat pump compressor operation at outdoor temperatures below 0°F are neither desirable nor advantageous in terms of efficiency. Since most equipment at time of manufacture is not designated for any specific destination of the country, and most of the equipment is installed in areas not approaching the lower outdoor temperature range, the compressor cut-offs are not factory installed.

Outdoor thermostats are available to hold off various banks of electric heat until needed as determined by outdoor temperature. Refer to matching indoor section installation manual for more information and required parts.

A separate compartment is located at the top of the control panel section. Holes are prepunched to match with mounting holes of the thermostat brackets.

The sensing capillary can be left coiled at the thermostat and remain in the compartment. Make sure it does not touch any of the electrical terminals. Route the 24V wires through the hole in partition and make necessary connections at 24V terminal board. Refer to 24V wiring diagrams with indoor unit instructions for wiring details.



OUTDOOR THERMOSTAT