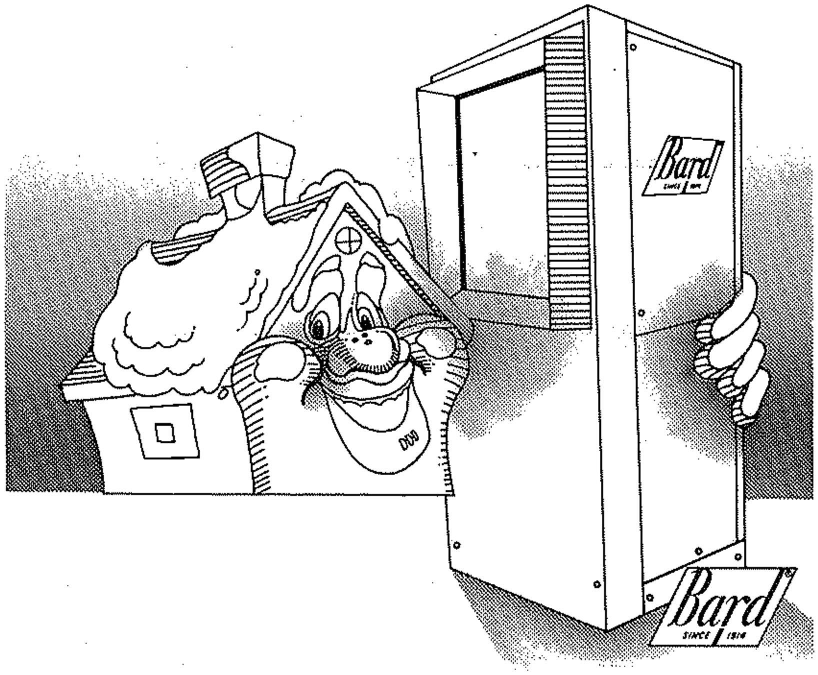
MANUAL 2100-054B

Bard Water Source Heat Pump



OPERATION
AND
TROUBLESHOOTING
WATER-TO-AIR HEAT PUMPS

REFRIGERATION, HEATING AND AIR CONDITIONING

BARD MANUFACTURING CO. • BRYAN, OHIO 43506
Dependable quality equipment. . .since 1914

TROUBLESHOOTING TYPICAL HEAT PUMP SYSTEMS

THE WATER-TO-AIR HEAT PUMP

NOTE: This manual to be used with installation manual for the particular unit being serviced.

THE BASIC PRINCIPLE

In its approach to basic familiarity with heat pump design, application, and installation, the beginning text of this course noted its limitation generally to "Air-To-Air Systems"since they were in the majority and therefore the type the learner would be called upon to design, apply, install or service most frequently.

There is, however, another type of system which, while not generally as popular as the air-to-air heat pump, has recently become more widely used in the more temperate sections of North America. This is the "Water-To-Air System."

The basic principle of operation of this system is that heat is rejected to the water from the air to be conditioned (COOLED) on the cooling cycle and heat is gained from the water by the air to be conditioned (HEATED) on the heating cycle. De-humidification is achieved in the usual manner on the cooling cycle by removal of moisture from the air in the form of condensate. The medium of heat transference is the refrigerant. Basic components used in the system are the compressor and a co-axial heat exchanger. As with the air-to-air system, the transfer from cooling to heating mode and vice versa is accomplished by means of a reversing valve.

The application area for this type system is for heating and cooling residential structures where there is an adequate supply of water and a method of disposal of used water is available.

A typical "Water-To-Air" heat pump, and the one to be used as an example in this lesson, is the Bard High Efficiency Water Source Heat Pumps. This typical unit, the cooling and heating cycles of which are pictured in Figure 13, incorporates the conventional high and low pressure controls.

If the system cuts off on one of the pressure controls due to a known reason or power failure, the controls can be reset by turning the thermostat control switch to "OFF," waiting a few minutes for system pressures to equalize, and then turning the thermostat control switch to either "COOL" or "HEAT" as the occasion warrants. This system can also be reactivated after a stoppage as noted, by turning the main power supply to the system off and then on again after the recommended waiting period for pressure equalization.

GROUND WATER HEAT PUMP ELECTRICAL CONTROLS[1]

Understanding water source heat pump controls is an essential element in the overall understanding of heat pump installations, start-up and troubleshooting. Just as the contractor must become familiar with pump and water system controls to do an effective job, knowledge of how ground water heat pump controls operate helps make the installation a success.

Heat pump controls may be classified in two major groups: electrical and refrigeration. Electrical controls are of initial interest to the installer since they more frequently interface with the balance of the water system and other contractor-installed items. In general, ground water heat pump controls operate in a simple, straightforward manner. This section explains individual control components and how they are put together to form control systems. The contractor, however, must familiarize himself with the specifics relating to his line of ground water heat pumps.

Heat pump electrical systems are grouped into two major categories: line voltage systems and low voltage systems. "Low voltage" is also sometimes referred to as "control voltage." Low voltage is generally used for most of the control functions, especially those that are coupled to devices outside the machine (see Figure 1).

Some of the specific control functions, however, may slide from the line voltage side to the low voltage side or vice versa, depending on the manufacturer.

When low voltage (generally 24 VAC) is used to control heating and air conditioning equipment, the control components can be of a lighter duty and the interconnecting wiring between devices can be made using less expensive materials and wiring methods. There is, however, a strict set of rules that a manufacturer must adhere to when providing a low voltage control system. In order to classify as an NEC (National Electrical Code) Class II control system, the voltage must be 30 volts or less and the power must be limited to 75 VA (volt-amperes). The manufacturer must provide some means to insure that upon an overload or short-circuit, this power level will not be exceeded. This can be accomplished by providing a fuse or a circuit breaker or by use of an "energy-limiting" transformer. If these rules are met by the manufacturer, the contractor then has a Class II electrical system that he may connect in a very fast and economical manner. Note, however, there is a built-in limitation as to the total power allowed in this control system. Only small control loads such as magnetic contactor coils, relay coils, solenoid valve coils, etc., are allowed. As we will see later, these smaller loads are then used to control larger line voltage loads inside the heat pump. Seventy-five VA translates into a maximum current of 3.2 amps at 24 VAC. Thus, the total current that can be used at any time by the control components cannot exceed 3.2 amps. It should be noted that 75 VA is the maximum that can be provided. If a fewer number of control components are normally associated with a manufacturer's piece of equipment, typically, a lesser amount of control power will be made available. Forty VA is another popular power level. In this case, a maximum of 1.6 amps of control power can be used, limited by the size of the control voltage transformer used.

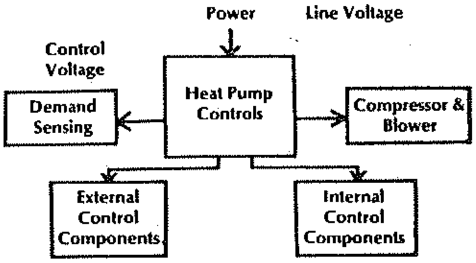


Figure 1. The roll of control voltage and line voltage.

The "demand control" which is, in most cases, the room thermostat, is normally a low voltage device. Modern thermostats are actually rather complex devices. These complexities are required in order to get the thermostat to respond correctly to changes in room conditions. However, the end result of all this is to complete a current path (like closing the switch), telling the heat pump to come on (see Figure 2). In simple terms, it can be thought of as a switch that opens and closes in response to temperature.

Figure 2. One symbol for a thermostat. T.A.S. stands for "Temperature Actuated Switch."

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[1] Fred Jaeger, "Ground Water Heat Pump Electrical Controls," Ground Water Heat Pump Journal, Summer 1981.

The low voltage thermostat signal can be used to control large electrical loads such as compressors and blowers by way of a magnetic contactor. The contactor keeps the low voltage and high voltage circuits completely separate and isolated from each other. They are coupled to one another by way of magnetic or mechanical action. In a simple contactor, the control current travels through a magnetic coil which attracts a movable armature carrying contact points connected to a line voltage circuit. When the armature is "pulled in," this independent set of contacts completes a separate line voltage circuit running to the load. It is in this manner that low power signals are used to control high power loads. Figure 3 is a symbolic representation of a magnetic contactor. Note that the terminals to the coil are separate from the terminals to the contact points.

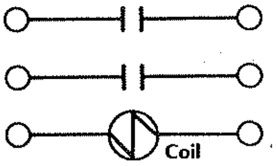

Figure 3. Symbol for a magnetic contactor.

A control relay operates much the same as a contactor, but is used to control other low power loads that are either low voltage or high voltage. Additionally, the switched side of a control relay can have several "poles" or separate circuits that can control different devices. These poles are actuated simultaneously from the same signal to the relay's coil.

Figure 4 depicts a control relay with a coil and two poles, or separate controlled circuits. The contact pairs that are illustrated with diagonal lines through them are "normally closed" contacts and open or break the circuit when the coil is energized.

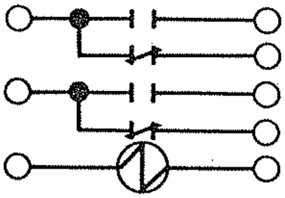

Figure 4. Symbol for a control relay.

Pressure switches are control components that provide a simple switching action, i.e., make or break a control signal in response to refrigerant pressure. A pressure switch is shown symbolically in Figure 5. A ground water heat pump will normally have a high pressure and a low pressure cut-out switch.

Figure 5. Symbol for a pressure switch.

When valves must be opened or closed as part of the heat pump control scheme, low power solenoid coils are used. Just as a low power signal is used to control a large electrical load in a contactor, valves generally encountered in ground water heat pumps use a lower power signal to control the relatively large mechanical force required to actuate the valve. This is done through a "pilot operator." The solenoid coil actuates a small internal valve which then allows the pressure of the fluid ahead of the valve to actually force the valve open. A solenoid capable of providing sufficient force to move the valve stem directly (as in a "direct-acting" valve) would require many times the power. Figures 6 and 7 show two pilot operated valves: a water valve and a refrigerant reversing valve. The reversing valve actually directs two separate flow streams to different locations. Hence, the pilot valve and main valve are configured differently than in a water valve. The same principle applies, however: a small control signal causes a larger force to open or change the position of a valve by taking advantage of the fluid pressure difference in the system.

The low voltage control power required to operate these devices is provided by a small transformer which takes the available line voltage and converts it to low voltage (generally 24 VAC) for use in the control system.

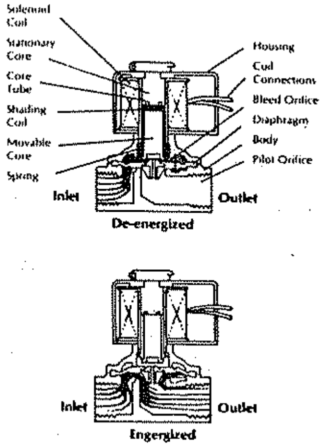

Figure 6. Cut-away view of a pilot-operated solenoid valve.

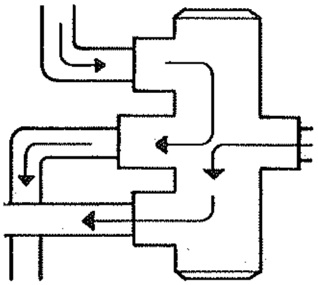

Figure 7. A reversing valve.

Figure 8 is the symbolic representation of a control transformer. Since the control power must be available at all times and the standby power consumed by the transformer is small, it remains energized anytime there is power to the heat pump.

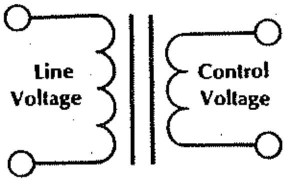

Figure 8. Symbol for a transformer.

What remains is to put all these control components together in such a way that the desired events take place at the right time. This is most easily explained by using a "ladder diagram" which is a control logic representation of a wiring diagram. We have seen how a thermostat, when it closes, creates a "demand" signal that can be used to operate a compressor contactor or control relay. There may be reasons to ignore this signal, interrupt it after the load has started or route it somewhere else. Figure 9 shows a "rung" on a ladder diagram.

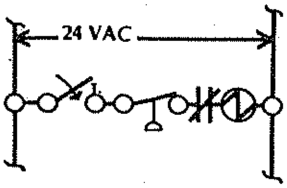

Figure 9. "Rung" on a ladder diagram.

The voltage to be controlled comprises the side members of the ladder. In this example, a temperature-actuated switch, a pressure switch and a normally closed set of contacts of a control relay are placed in series with a contactor coil. All three of the devices ahead of the coil must be closed before the coil will energize. Additionally, if any one of them opens after the coil has been energized, the circuit will be broken and the coil will de-energize. It is in this manner that control signals are properly manipulated inside the heat pump. Note that the intent of the ladder diagram is to show the logical sequence of operation and not to depict the physical relationship between components. The short wire between the temperature switch and pressure switch on the diagram may in fact be many feet long with the components located far from one another.

It is easy to see how several "rungs" may be stacked and interconnected to perform a multitude of functions. No matter how complex the system (and ground water heat pump controls are not very complex), a simple logical procedure can be used to interpret the control sequence. Figure 10 is an example of a complete ladder diagram.

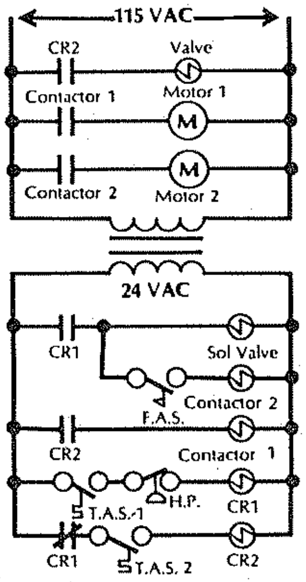

Figure 10. Example of a ladder diagram.

Note that the components below the transformer operate at 24 VAC while the components above operate at line voltage, in this case 115 VAC. A single device, control relay 2 (labeled "CR2" in the diagram) has its coil in one rung of the ladder. One set of its contacts operates on another rung in the low voltage side, while another set of its contacts operates on the line voltage side. When this coil becomes energized, both contactor 1 and the 115 VAC valve will actuate (refer to Figure 10). By continuing this analysis of the unit's ladder diagram, the sequence of operation can be fully understood.

On many applications, components external to the heat pump need to be controlled. These may include water pumps, supplemental electric heaters, valves, etc. The way these external devices are controlled is also indicated on the ladder diagram. Figure 11 illustrates a situation where the heat pump, the supplemental electric heaters and the water pump all receive their main power from separate circuits. This power is controlled, however, by low voltage control signals from the heat pump.

Line voltage controls are sometimes used inside the machine for a few of the control functions. Consequently, the contractor must be aware of which control devices are operating at line voltage and which are operating at low voltage. Again, this information will be contained on the unit's ladder diagram. When installing or troubleshooting a heat pump, it is obvious that a ladder diagram is of extreme value. Voltages may be checked at various points to determine what device is closed or open and where the problem may be. In that ground water heat pumps are all controlled a bit differently, it is more important that the contractor be familiar with the manuals and wiring diagrams associated with his particular equipment.

Understanding heat pump controls and wiring diagrams is important from a safety standpoint as well. A particular coil that operated at 24 VAC in one unit may operate at 230 VAC in another. This could come as quite a shock to the service man who thought he could replace that coil without disconnecting the power. Additional training in this area is available through your distributor, the manufacturer or organizations like the Refrigeration Service Engineers' Society (RSES). The serious contractor or service man will also carry the proper tools and equipment necessary to test or troubleshoot heat pump controls. As a minimum, they include such things as a multimeter (capable of measuring voltage, current and resistance), jumpers, terminals, a crimping tool and spare replacement parts. A good quality multimeter is the control system's equivalent of refrigeration service gauges. You can't go very far into the diagnosis of a control system without one.

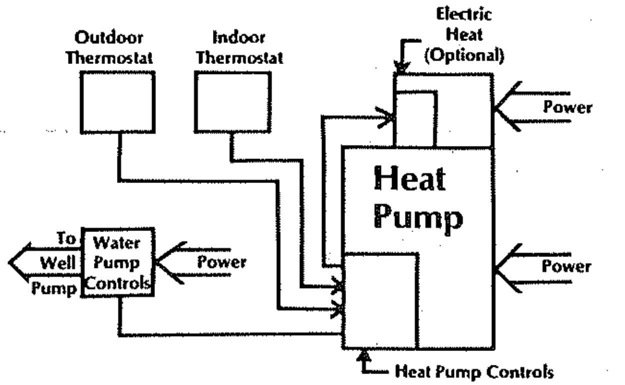

Figure 11. External devices controlled from the heat pump.

As you already know, there is no substitute for experience and training. The principles discussed herein are basic and provide a starting point. A firm understanding of the control system you are working with will reduce the unknowns and risk factors associated with your heat pump installations.

GROUND WATER HEAT PUMP REFRIGERANT CONTROLS[1]

We discussed electrical controls in ground water heat pumps and the importance of the contractor understanding their operation. Installation, proper equipment operation and troubleshooting benefit from this type of understanding. Now we will discuss refrigerant controls in ground water heat pumps. Refrigerant controls are probably of less initial interest to the installing contractor, since they are generally self-contained in the unit, preadjusted and do not require interconnections to other contractor-installed items. However, the contractor should have a sound understanding of the machine he is selling, including the refrigerant controls. Additionally, when it becomes necessary to troubleshoot the unit, or when adjustments are required, an understanding of the refrigerant controls is essential.

By virtue of equipment design, all ground water heat pumps operate a bit differently. Training schools given by the manufacturers or their distributors are generally used to familiarize the contractors with the specific characteristics of their equipment. Also, organizations, such as the Refrigeration Service Engineers' Society (RSES), with chapters nationwide, offer extensive training in heat pumps and other equipment. This section will overview the common refrigerant controls of ground water heat pumps.

Heat pumps operating in either the heating or cooling mode have basically a high pressure side and a low pressure side of the system (see Figure 13). It is this change in pressure that allows the refrigerant to transfer heat by evaporating and condensing at different temperature levels. The component that increases the refrigerant pressure is the compressor. The component that drops the refrigerant pressure is the expansion device. This continual process of raising then lowering the refrigerant pressure while expelling and absorbing heat, respectively, is the key to the refrigeration cycle that heats and cools the structure.

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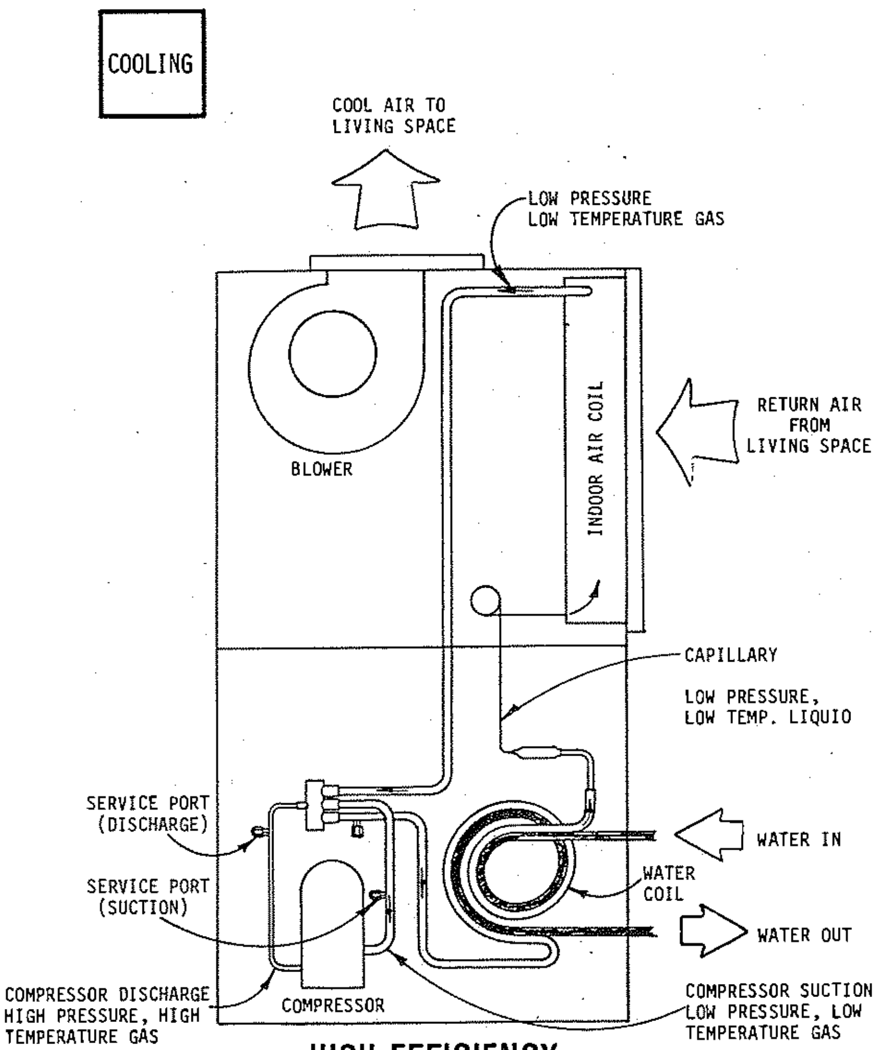
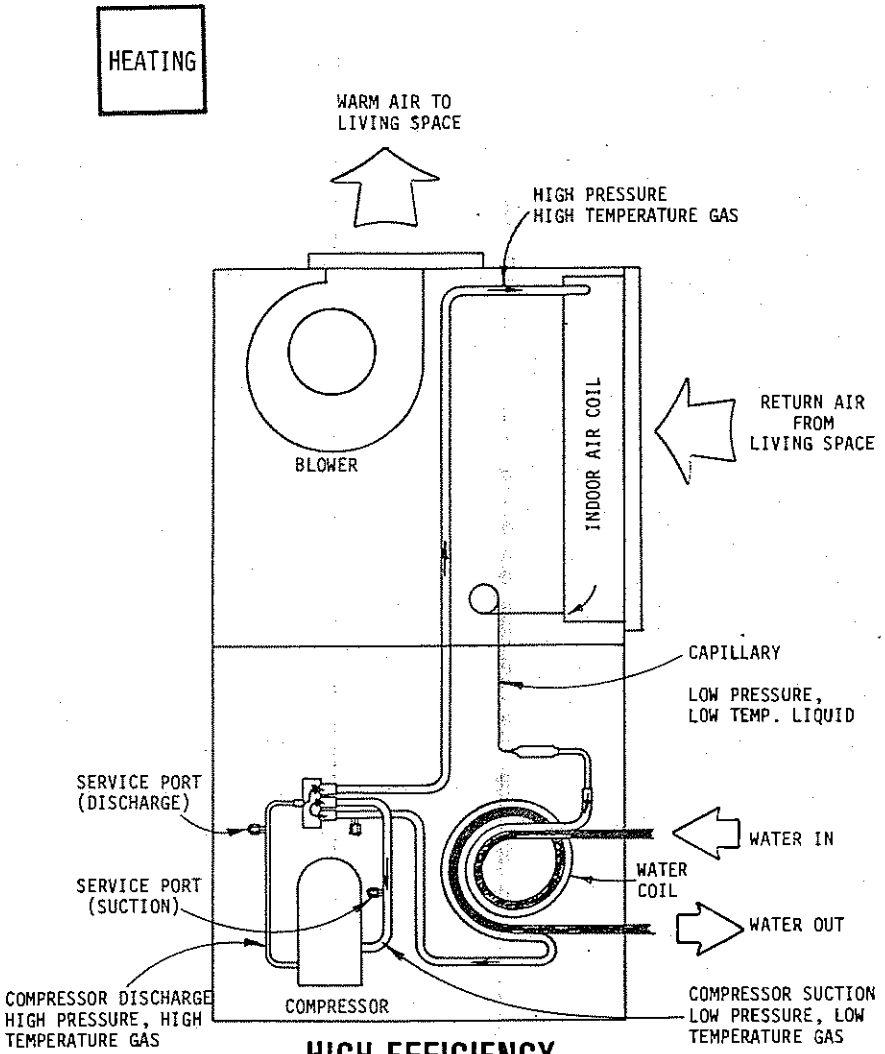
[1] Fred Jaeger, "Ground Water Heat Pump Refrigerant Controls," Ground Water Heat Pump Journal, Fall 1981.



HIGH EFFICIENCY WATER SOURCE PACKAGED HEAT PUMP

FIGURE 12



HIGH EFFICIENCY WATER SOURCE PACKAGED HEAT PUMP

FIGURE 13

The expansion device is clearly one of the important refrigerant controls. Ahead of the device there is high pressure liquid refrigerant. When passing through the expansion device, the pressure of the liquid is drastically reduced, allowing it to boil (evaporate) at a low temperature, extracting heat from the source. The heat source is water when the machine is heating and room air when the machine is cooling. The heat exchanger into which the refrigerant is evaporating becomes part of the "low pressure" side of the system.

There are several types of expansion devices commonly used in ground water heat pumps. The type used depends on the manufacturer of the equipment and the intended application. The capillary tube is one such expansion device. A capillary tube is a length of small-diameter tubing manufactured with its internal diameter held to very close tolerances (see Figure 14). It functions like an orifice (i.e.; a small-diameter opening), but is designed like an "elongated orifice" so that its characteristics can be accurately reproduced. Often, several individual capillary tubes will be bunched together (in parallel) to achieve the required refrigerant flow rate. Since it is a fixed device with no moving parts, it gives reliable operation providing the internal passages are kept completely free of foreign matter. A capillary tube expansion system has a fixed effective orifice size, determined by the length, diameter and number of capillary tubes. Therefore, there is generally one optimum operating point (the design condition) for which this selection has been made. For operating conditions significantly removed from the design conditions, performance of the expansion system will be less than optimal. Many ground water heat pump installations operate under relatively fixed conditions of constant water temperature and return air temperature, where a capillary tube expansion device gives suitable performance. The installer should be aware of off-design conditions, however, such as start-up in a cold building. Here the condensing pressure in the unit would be abnormally low. In such a case, the heat pump may cycle off because there is insufficient pressure drop across the capillary tubes to create the required refrigerant flow rate. Also, a capillary tube system is generally very sensitive to the amount of refrigerant charge in the system. Too much, and the condensing pressure can become abnormally high. A shortage of refrigerant allows vapor to enter the capillary tubes (instead of liquid) causing a loss in capacity.

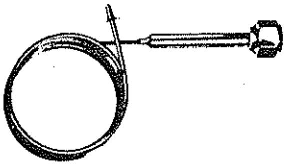


Figure 14. Capillary Tube (coiled up).

Expansion valves are another type of expansion device found in ground water heat pumps. Unlike capillary tubes, the effective opening size changes in response to conditions in the evaporator. The most common type of expansion valve in use today is called a "thermostatic expansion valve," or T.E.V. (see Figure 15). The purpose of this valve is to maintain a constant refrigerant superheat at the evaporator outlet. "Superheat" is the number of degrees of temperature that a gas is heated above its evaporating temperature at a given pressure. The T.E.V. is generally set to give 8 to 12°F of superheat at the evaporator outlet in order to insure that all the refrigerant has evaporated. Changes in the unit's operating conditions can be sensed by a change in superheat at the evaporator. The T.E.V. then opens, or closes slightly, allowing more, or less, refrigerant to pass through maintaining a constant superheat. In general, T.E.V.s can accommodate a wider range of operating conditions (such as varying water temperatures and return air temperatures) than other expansion devices. The effective orifice size automatically changes in response to these changing conditions. For the valve to determine what the superheat actually is, it must measure the temperature and pressure of the refrigerant gas leaving the evaporator. Therefore, you will find a pressure tap and a temperature sensing bulb running from the evaporator outlet to the valve. The temperature sensing bulb is a sealed unit, filled with a fluid that changes its pressure in response to temperature. The valve is purely mechanical in operation. The sensing bulb and evaporator outlet pressures create forces of an internal valve stem that determines the position of the valve pin in relation to its seat. It is in this manner that the optimum refrigerant flow rate is determined in response to the operating conditions imposed on the unit.

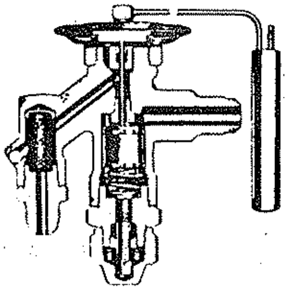


Figure 15. Thermostat Expansion Valve (cut-away view)

Other refrigerant controls typically found in ground water heat pumps include some active and passive components used to direct the flow of refrigerant, contain it, or provide a safety signal to stop the machine if something goes wrong.

Heat pumps that perform both heating and cooling functions contain a reversing valve that directs the flow of high pressure and low pressure gas to and from the proper components (see Figure 16). The high pressure gas exiting the compressor must be routed to the condenser, which is the refrigerant-to-air heat exchanger in the heating mode or the refrigerant-to-water heat exchanger in the cooling mode. Likewise, in order to create a low pressure side in the system, the gas from the heat exchanger which is evaporating the refrigerant must be directed to compressor inlet or "suction." The reversing valve simultaneously directs the flow of the high pressure and low pressure gases to the proper heat exchangers when it receives a signal from the electrical control system. Reversing valves are "pilot operated" valves, utilizing the difference in refrigerant pressures in the system to move the internal valve shuttle. A small, solenoid-operated pilot valve allows high pressure gas to enter one end of the shuttle while venting the opposite end of the shuttle to the suction side of the system. The resulting unbalanced force on the shuttle moves it to its new position. Since the operation of the valve requires high and low pressures to be present, the main shuttle will not move unless the compressor is operating.

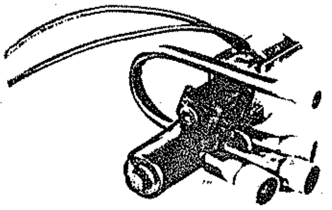


Figure 16. Reversing Valve.

Refrigerant check valves are used in some systems and function in a similar fashion as check valves in a water system; they allow refrigerant to pass in one direction only. A common type consists of a ball and seat, contained in a copper tube (see Figure 17). On reversing-type heat pumps, one would normally find a check valve placed around an expansion valve allowing refrigerant to bypass the valve when the heat exchanger is acting as a condenser rather than an evaporator. When the flow is reversed, requiring the refrigerant to evaporate in the heat exchanger instead of condense, the check valve closes, forcing the refrigerant through the expansion valve.

A "liquid receiver tank" is a passive component found in some systems and is used to store excess refrigerant as the machine operates in different modes, or as the conditions vary in any one mode (such as a change in water temperature). Also, it serves to "drain" the condenser, such that condensed liquid does not take up heat exchanger surface better used for condensing the high pressure gas. The liquid receiver tank is placed on the system between the condenser outlet and the expansion device. In that position it also helps to insure that the expansion device will be supplied with straight liquid, as opposed to a vapor/liquid mixture, which would decrease the heat pump's capacity.

Figure 17. Refrigerant Check Valve

Some heat pumps have a "suction line accumulator" placed just ahead of the compressor inlet. This is also a passive device that intercepts and holds liquid refrigerant that may be in the suction line on its way to the compressor (see Figure 18). Compressors do not think kindly of liquid refrigerant, since they are designed specifically to accept and compress vapor only. The circumstances under which liquid may be in the suction line include start-up, system overcharging, sudden reversal of the unit, or a component failure (like the blower stopping when the unit is cooling). The suction line accumulator is a simple control device that does a very effective job in protecting the compressor against the harmful effects of liquid refrigerant.

It is quite common to find a filter/drier in the refrigerant system. The filter-drier can be either in the liquid line or the suction gas line. Figure 19 shows a liquid line filter/drier. It is very important to keep the refrigerant system free of contaminants for the sake of both proper operation and long unit life. The contaminants that can be introduced into the system, if it is opened for service, are most likely air and moisture. Air can only be removed by proper evacuation techniques after the system is once again sealed up. Ideally, any moisture is also removed during the evacuation process. However, it is rare that evacuation in the field can be as complete or thorough as factory evacuation. The filter/drier contains a desiccant that removes residual moisture that may remain after field evacuation. Since it is a filter as well as a drier, it will also capture and retain minute particles that may be traveling around with the refrigerant. This does not, however, give license to the serviceman to be sloppy and introduce particulates (copper shavings, dirt, etc.) into the system. They may have to travel some distance in the system before reaching the filter, having plenty of opportunity to get stuck along the way.

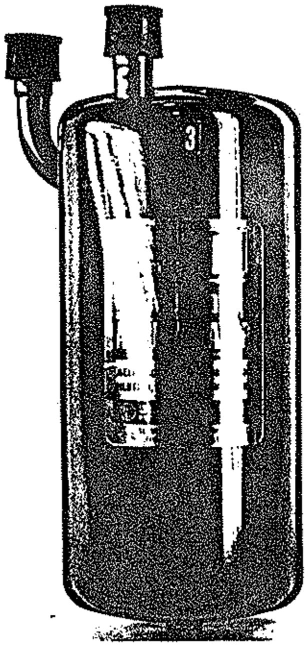


Figure 18. Suction Line Accumulator.

Figure 19. Liquid Line Filter-Drier.

There are a few additional devices that bear discussion which are not refrigerant control devices in the strict sense, but utilize refrigerant pressure or temperature to control other things. Pressure actuated switches are commonly used to stop the compressor when some abnormal condition is detected. When the low pressure switch opens, indicating a decrease in refrigerant pressure on the low pressure (suction) side of the system, it could indicate a loss of the heat source to the evaporator, or a blockage of the expansion device. When the high pressure switch opens, it may indicate a loss of the heat sink to the refrigerant condenser, or a blockage in the liquid line or high pressure gas line. Depending on the design of the equipment, other malfunctions may result in the opening of one of the refrigerant actuated pressure switches.

Refrigerant pressure may also be used to actuate water flow control valves. One such valve is shown in Figure 20. The refrigerant pressure is translated into a force acting on the valve stem by way of a sealed bellows. A water flow control valve operating in the cooling mode would be designed to open further as the refrigerant condensing pressure increases. The increase in condensing pressure indicates the condenser could use more water since the condensing temperature must also be increasing. Conversely, a water valve operating in the heating mode would be designed to close as the suction (evaporator) pressure became too high. This indicates more than sufficient heat is available in the source water and its flow rate should be reduced.

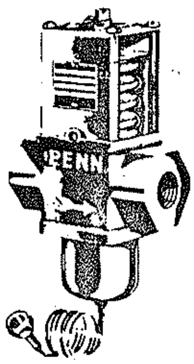


Figure 20. Pressure Actuated Water Flow Valve.

As a final comment, it must be mentioned that refrigeration equipment, including ground water heat pumps, takes some time to respond to adjustments or changes in operating conditions. Often, depending on the degree of adjustment made, it may take 15 to 20 minutes before the result of the adjustment becomes apparent. It is quite possible for a contractor or serviceman to end up "chasing his tail" in making adjustments to heat pump controls too rapidly. Careful, slow adjustments, taken one at a time, is the way to do it.

The above discussion on refrigeration controls is meant to serve only as an introduction. Clearly, participation in training schools offered by the manufacturer or product distributor and the careful study of the service manuals are essential. There is no substitute for training and experience when it comes to insuring success with heat pumps.

FINAL CHECK LIST

Before starting unit after installation or servicing, check the following:

1. Proper voltage to unit.
2. Correct fuse sizes.
3. Tight electrical connections.
4. Water system clean and flushed.
5. Air purged from water system.
6. Adequate water flow and pressure to the unit.
7. Water temperature within range for specific model installed.
8. Condensate line clear and unclogged.
9. Blower wheel free to rotate.
10. Return air filter is installed.
11. Access panels and enclosures are installed and secured.
12. Thermostat on "Off" position.

To start and check balance the unit, see the "Sequence of Operation" and "System Start Up Procedures" in the installation instructions for the particular unit being serviced.

To check the capacity of a water source heat pump for correct refrigerant charge without installing a gauge manifold, do the following:

Heating Cycle

Total Bruh Output = Water Coil Btuh + Motor Btuh

Step 1. Water Coil Btuh = GPM x 500 x ΔT °F drop

or (GPM x 60 min. x 8.33 x ΔT °F drop)

or (Lbs. of H_2O x ΔT °F drop)

BTUH = Capacity of water transfer coil in British Thermal Units per hour.

ΔT = Temperature difference °F, entering to leaving water.

GPM = Flow rate of the water in gallons per minute.

8.33 = Conversion factor to convert gallons of water to pounds of water.

60 = Number of minutes in one hour (omit if flow rate is expressed in gallons per hour)

Step 2. Motor Btuh = Volts x amps x .9 (power factor) x 3.413

Step 3. Water Coil Btuh + Motor Btuh = Total Btuh heating*

Step 4. Air Flow (CFM) = $\dfrac{\text{Total Btuh heating}}{\Delta T \text{ °F rise} \times 1.1}$

*The total Btuh for heat pump should be within 10% of the rated capacity for the unit, at the entering water temperature (see unit specification sheet).

MAINTENANCE PROCEDURES

Proper, regularly scheduled maintenance is important to insure the most efficient operation and longest life for your equipment. The following points are to serve as a general guide. Always consult with your maintenance contractor with regard to the specific requirements of your own installation.

a. Filters - Check the air filters once each month. Wash as required.

b. Bearings - Only sealed bearings are used in the evaporator blower motors. Therefore, bearing oiling is not required.

c. Paint Finish - If paint lifting or peeling occurs, scrape and sand the effected area and touch up with paint obtained from the factory for this purpose.

d. Water System - The pump should be checked whenever filters are cleaned, to assure that it is operating normally. Clogged coils lead to high head pressures and inefficient operation. If coil is limed, acid treatment may be necessary. Condenser coils should be checked yearly for liming or clogging.

e. Refrigerant Pressure - Check at any time unit does not seem to be performing at top efficiency. These should be checked only by a competent service contractor.

f. Contactor Points - Check contactor points twice a year to be sure they are not burned or pitted as a result of low voltage, lightning strikes, or other electrical difficulties.

g. Condensate Drains - Always check to see that condensate is draining properly from the unit, whenever you check the filters.

h. Evaporator Fans - Be alert to any noise that would indicate blower wheel, loose or motors failing.

i. Condensate Drain Pan - Each 6 months, clean and flush evaporator condensate drain pan.

TROUBLESHOOTING

THE ANSWER IS YES

The question is "do these units require service?" The answer, of course is yes, and as with air-to-air systems or conventional air conditioning systems, troubleshooting is best accomplished by following a planned procedure. The recommended approach to isolating a malfunctioning component in a water-to-air heat pump system is illustrated on the ensuing pages of this text. They should be scrutinized closely, for in the field of heat pump service, troubleshooting without a plan of action, is instead, shooting for trouble...from the owner, especially if repeat calls are involved.

CHART 1: THERMOSTAT IN RUN POSITION–UNIT WILL NOT START

NUMBERS IN BOXES REFER TO PARAGRAPHS ON PAGES FOLLOWING THESE CHARTS.

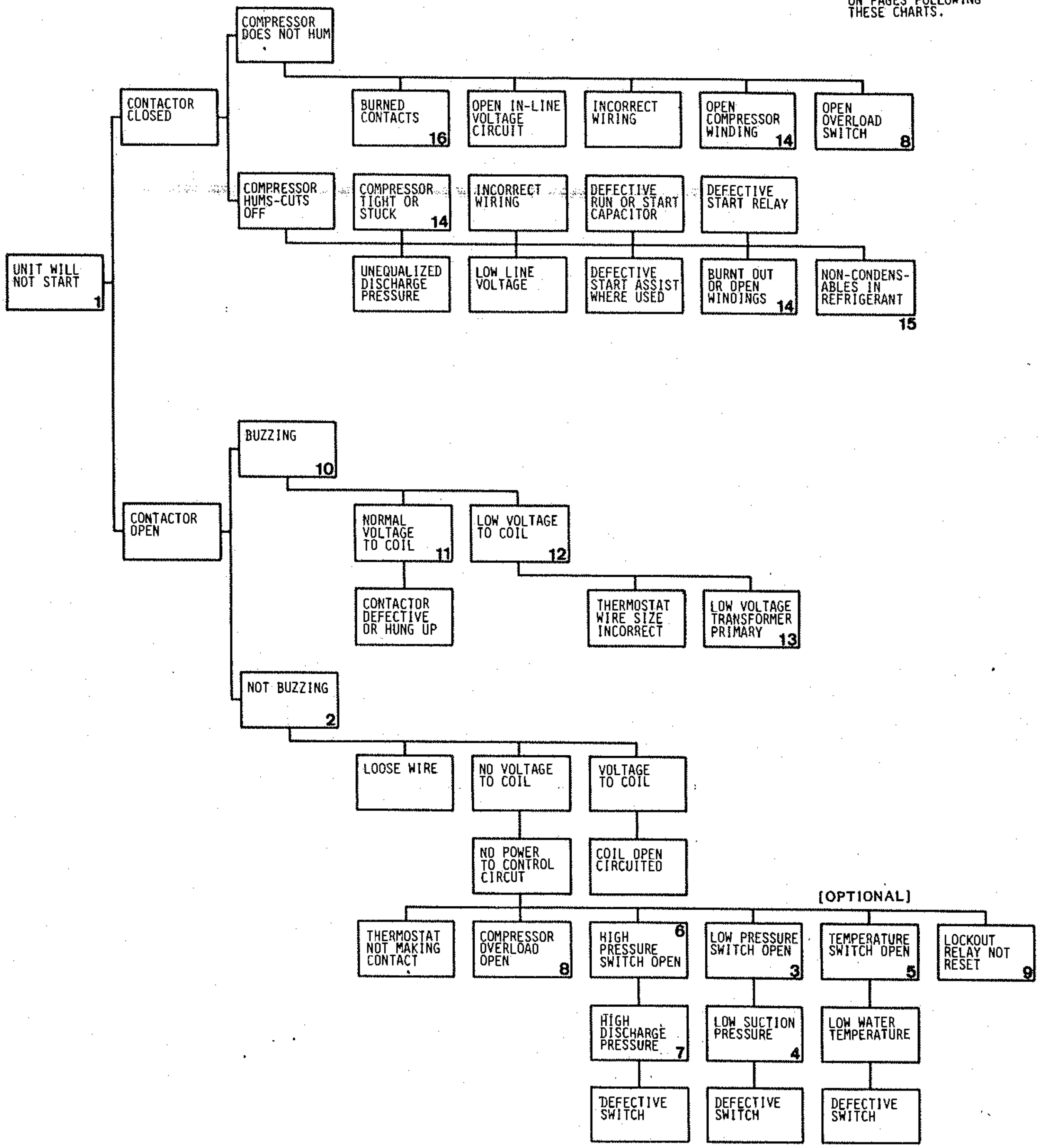


CHART 2: UNIT STARTS THEN CUTS OUT

NUMBERS IN BOXES
REFER TO PARAGRAPHS
ON PAGES FOLLOWING
THESE CHARTS.

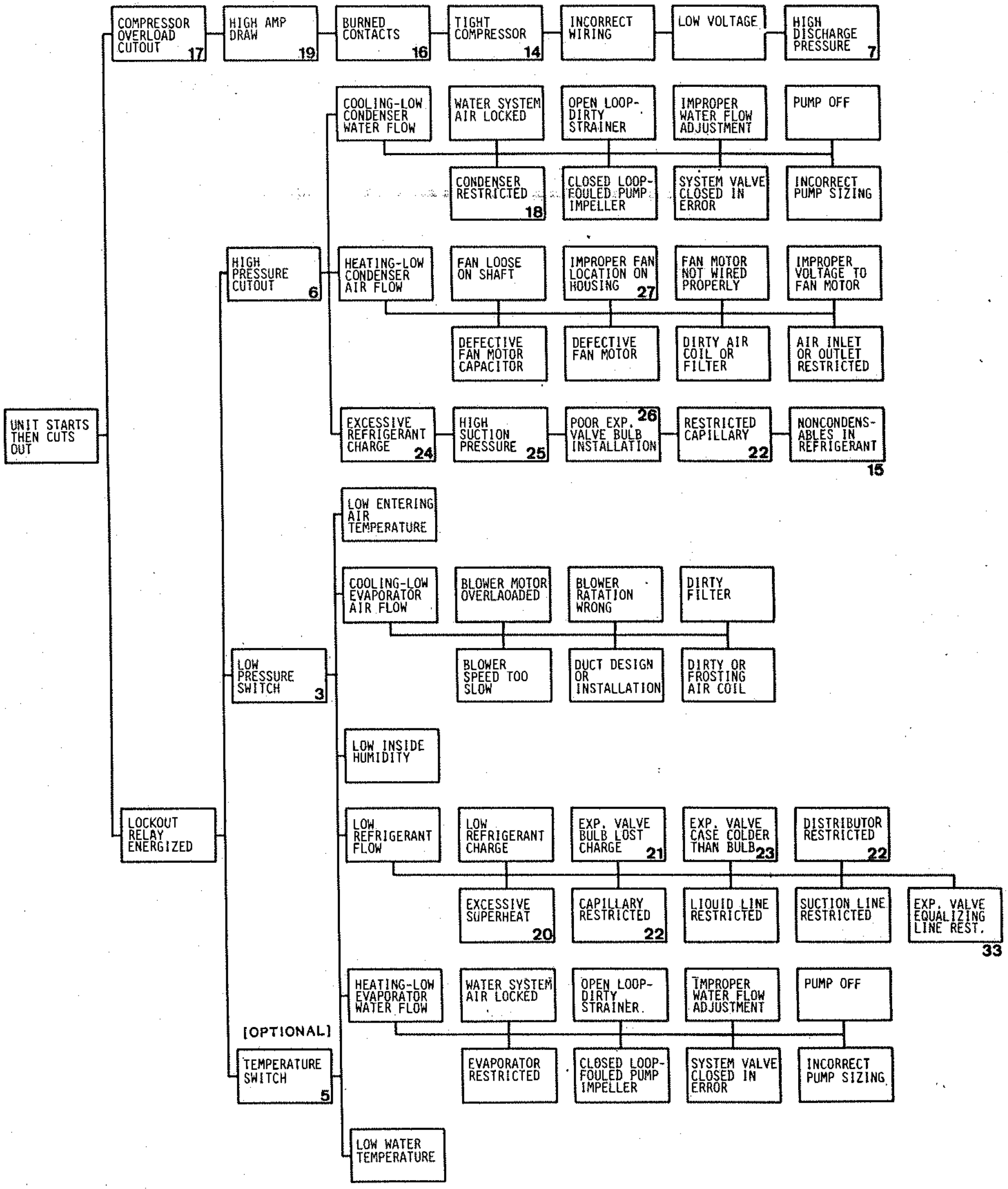


CHART 3: UNIT SHORT CYCLES

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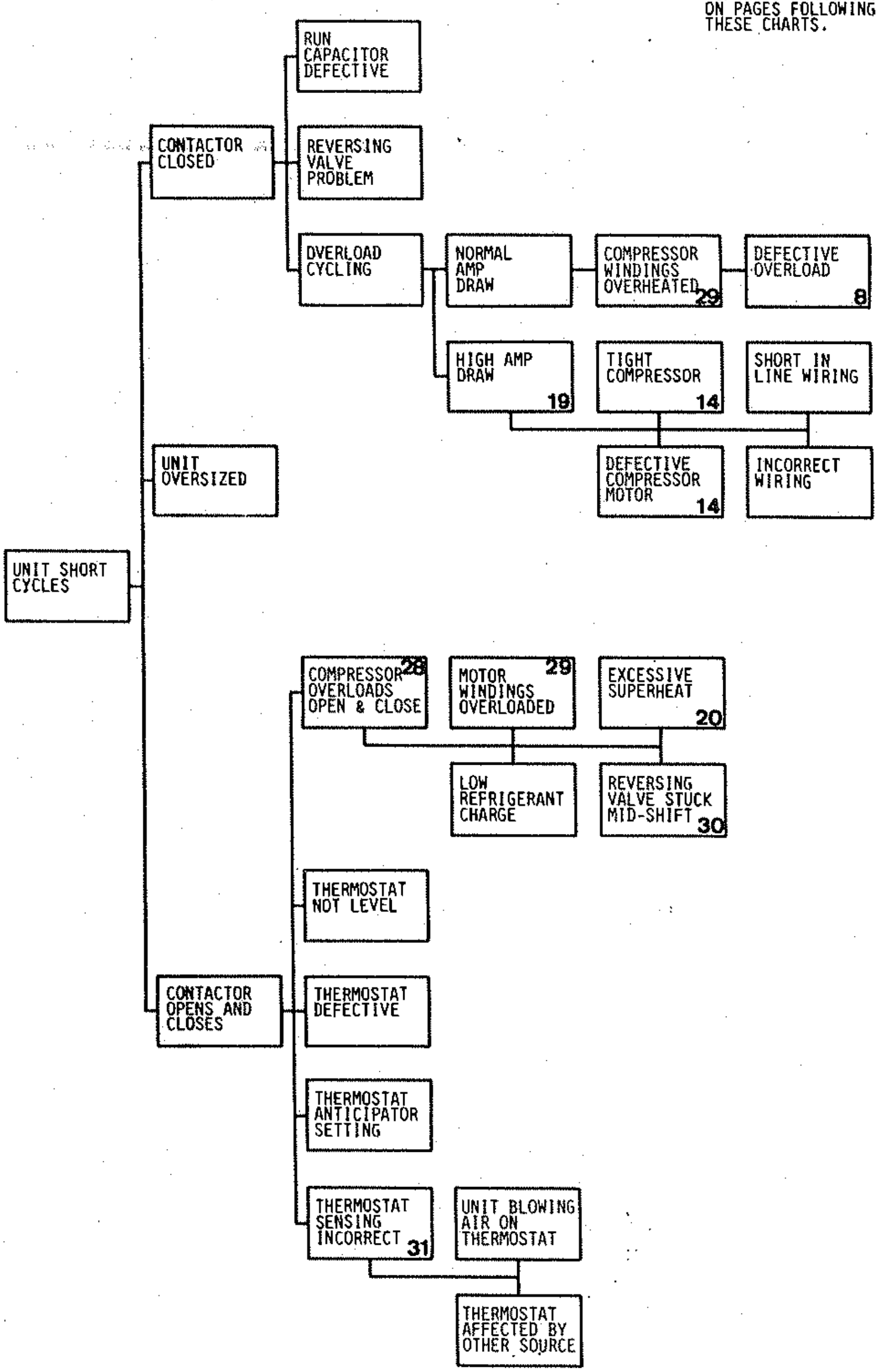

CHART 4: UNIT RUNS-INADEQUATE COOLING

NUMBERS IN BOXES
REFER TO PARAGRAPHS
ON PAGES FOLLOWING
THESE CHARTS.

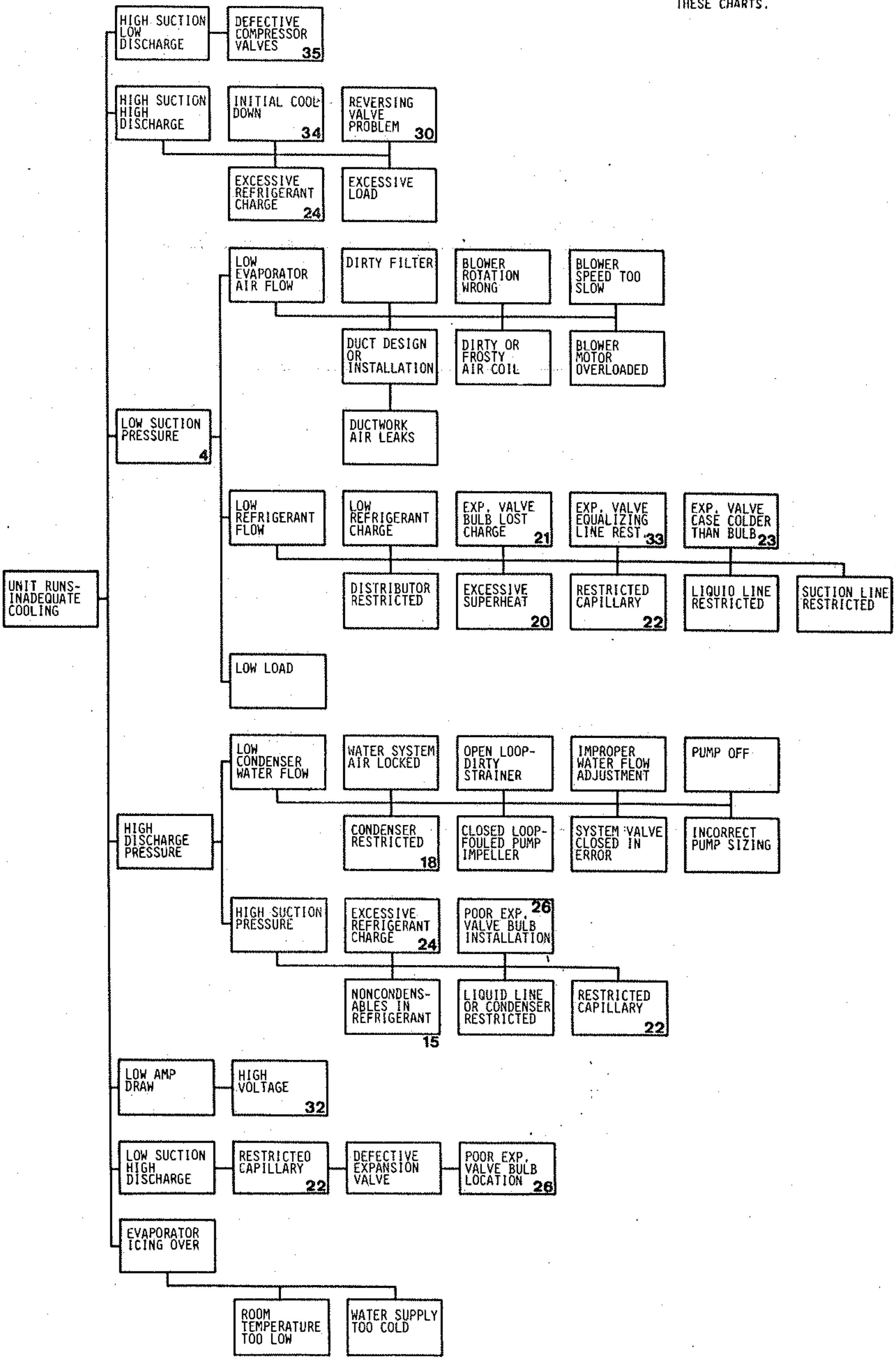

CHART 5: UNIT RUNS-INADEQUATE HEATING

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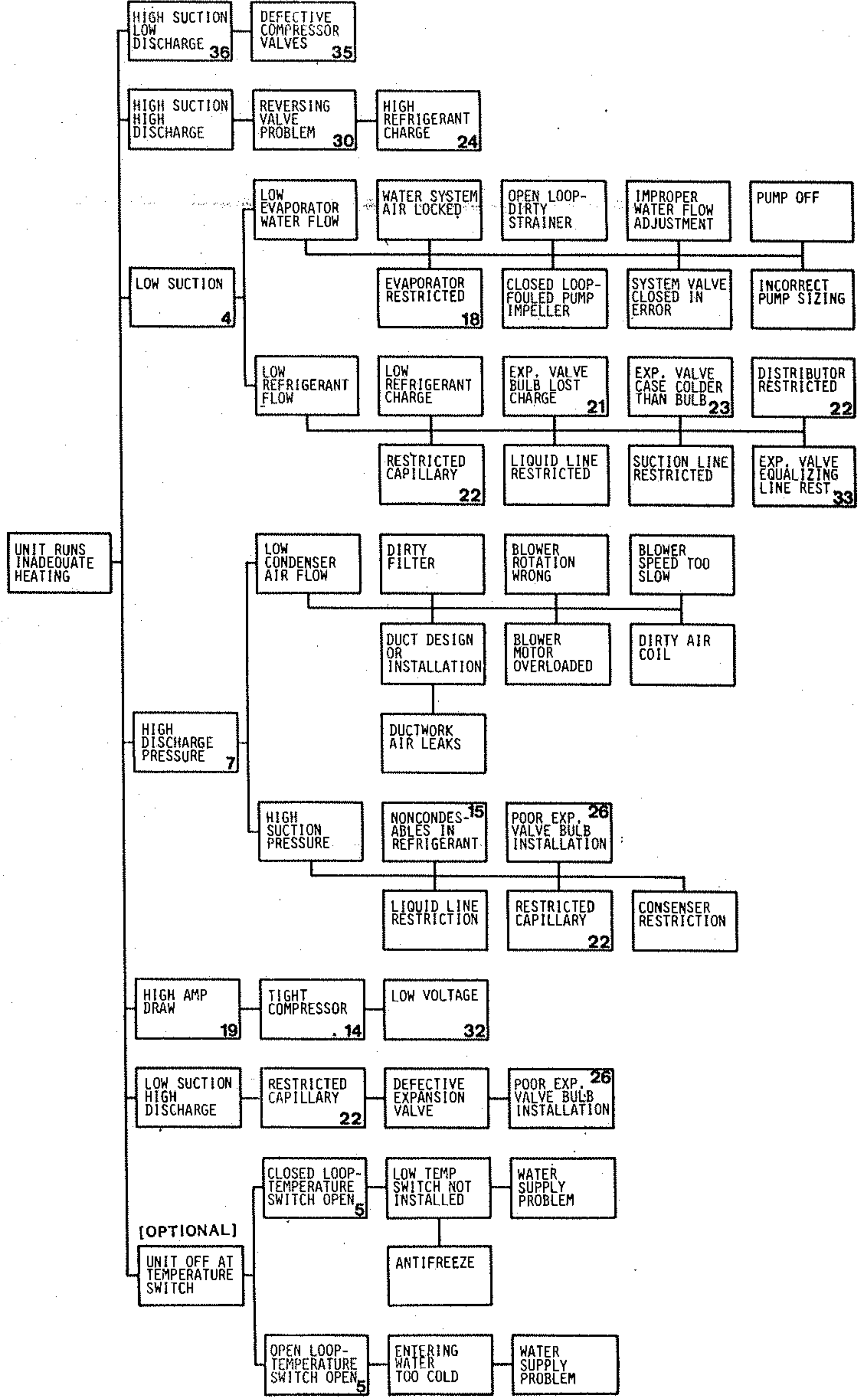


CHART 6: ELECTRIC HEAT OPTION–INADEQUATE HEAT

NUMBERS IN BOXES
REFER TO PARAGRAPHS
ON PAGES FOLLOWING
THESE CHARTS.

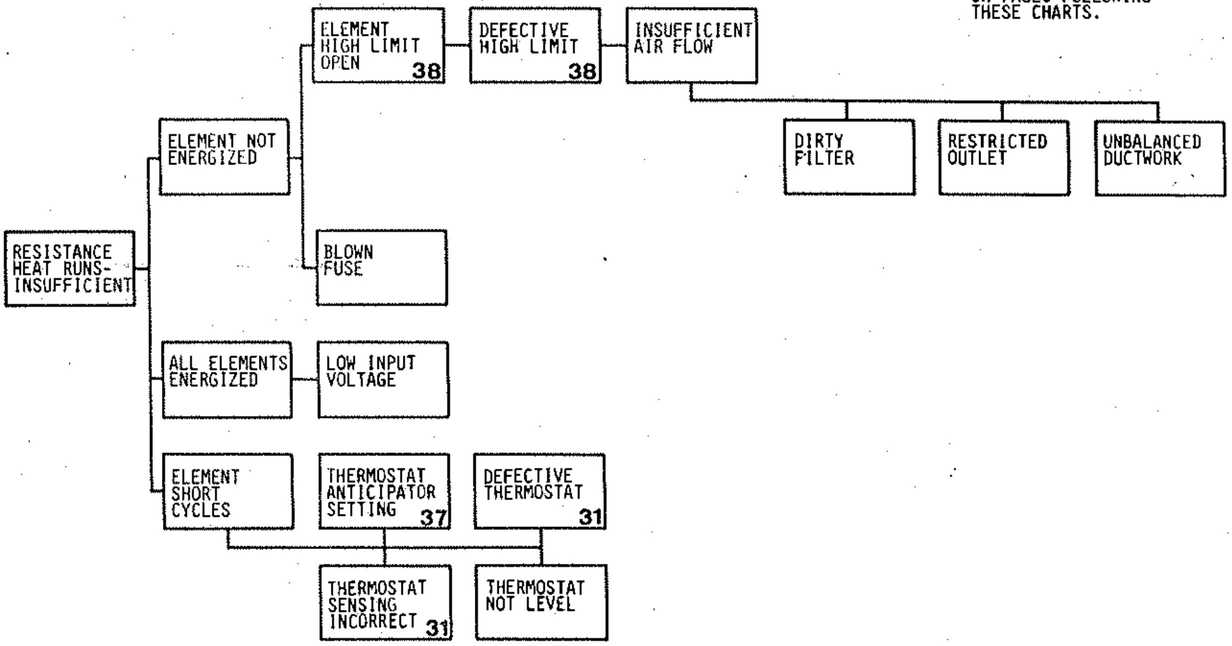
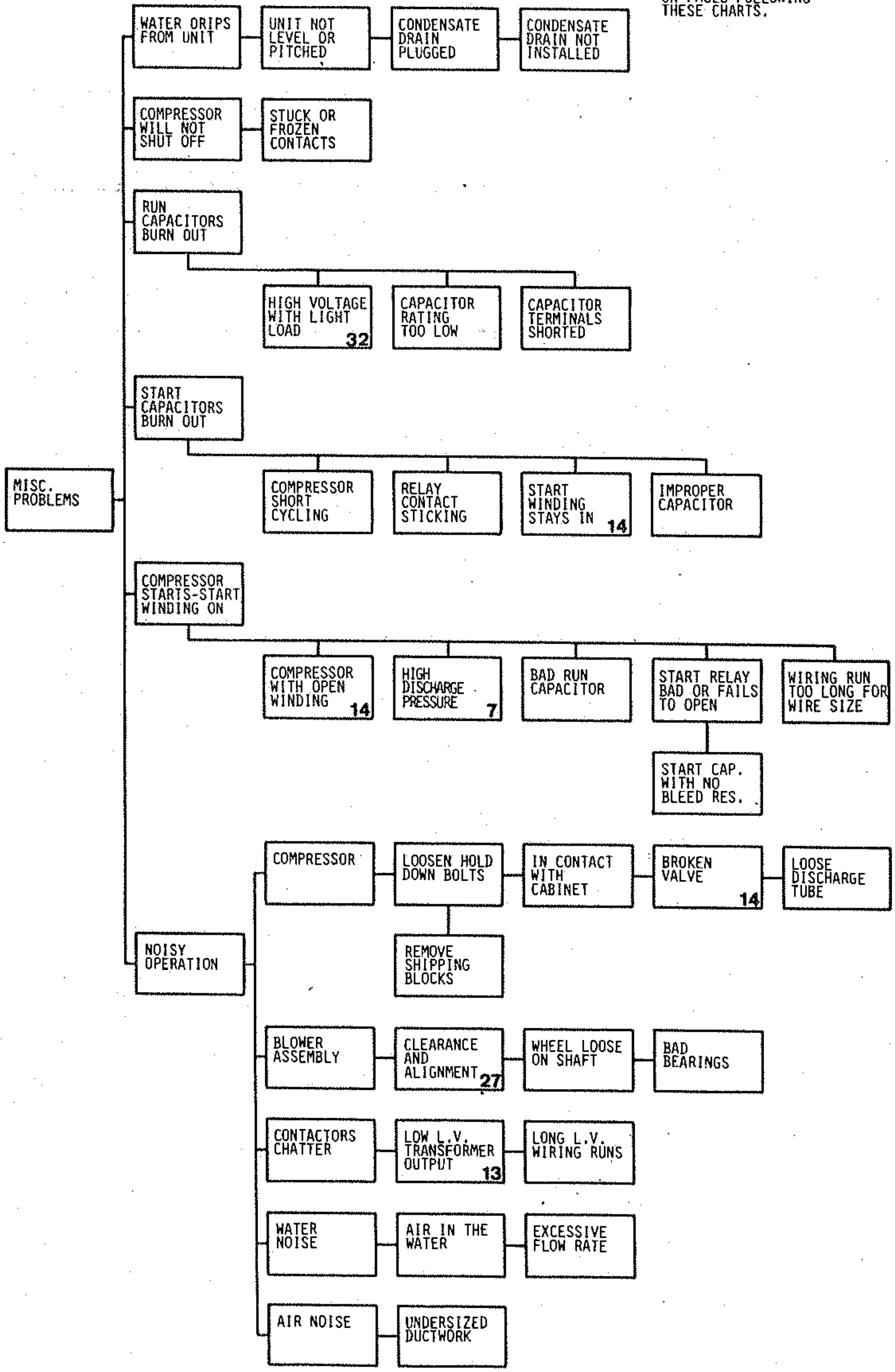


CHART 7: MISCELLANEOUS PROBLEMS

NUMBERS IN BOXES REFER TO PARAGRAPHS ON PAGES FOLLOWING THESE CHARTS.



1. UNIT WILL NOT START

If unit will not start, turn off power and check wiring. Also check for blown/incorrect fuse or tripped/incorrect circuit breaker. Turn power back on. If unit still does not start, check power supply to unit with a voltmeter. If there is power to contactor but unit does not run, see if contactor is closed.

Set thermostat selector switch on "Cool" and lowest temperature setting, unit should run. Set thermostat on "Heat" and highest temperature setting, unit should run. Set fan on "Run", fan should run. If unit does not run all three cases, the thermostat could be wired incorrectly, out of calibration, or faulty. To prove faulty or miswired thermostat, disconnect thermostat wires at the unit and jumper between "R", "Y", "G" and "O" terminals and unit should run. If unit runs, replace defective thermostat. If unit does not run, trace control circuit to find cause.

Also check refrigerant gauges to make sure refrigerant pressure is within high and low pressure limits. If unit still does not run, check contactor.

2. CONTACTOR OPEN--NOT BUZZING

When the contactor is open but not buzzing, it is an indication of voltage to its coil but the coil is open circuited or no voltage to its coil. If unit does not start, check voltage at coil with voltmeter. If there is voltage, the coil is open circuited. Replace the contactor. If no voltage, check power to control circuits.

3. OPEN LOW PRESSURE SWITCH

It is factory set to shut down the unit at approximately 27 psig.

4. LOW SUCTION PRESSURE

If low suction pressure is suspected, switch to heating mode and check the suction pressure. See pressure chart in "START UP" section for pressures to match actual conditions.

5. OPEN TEMPERATURE SWITCH (Optional)

Low Temperature: (Only for closed loop systems with antifreeze). Set to open at 10°F.

6. OPEN HIGH PRESSURE SWITCH

It is factory set to shut down the unit at approximately 355 psig.

7. EXCESSIVE DISCHARGE PRESSURE

If excessive discharge pressure is suspected, switch to heating mode and check the discharge pressure. See pressure chart in "START UP" section for pressures to match actual conditions.

8. OPEN OVERLOAD SWITCH

Sometimes overloads will fail with contacts in the open position, or contacts may be closed but not conducting electrically. If the overload is external, replace. Otherwise, replace the compressor.

9. LOCKOUT RELAY

The refrigerant circuit in the heat pump is protected from excessively low or high pressures by means of the low pressure switch or optional temperature switch and the high pressure switch. Should any one of these switches cut out, the lockout relay will be energized and the heat pump will remain shut down to enable correction of the problem that caused the shutdown. The unit can be restarted by turning the thermostat to "Off" and back on to reset the lockout relay, or by interrupting power to unit.

10. CONTACTOR OR STARTER OPEN--BUZZING

When the contactor is open but buzzing, it is an indication that its coil is energized but the contactor is unable to close. See items 11 and 12 for cause.

11. NORMAL VOLTAGE TO COIL

Check voltage to coil. It should not be lower than 10% below rated voltage as the contactor tries to close. If voltage is normal, the mechanism may be tight or fouled. Remove and inspect mechanism, clean if necessary. If too sluggish, replace contactor.

12. BELOW NORMAL VOLTAGE TO COIL

Check voltage to coil. If it is lower than 10% below rated voltage, it is probably due to low supply voltage, faulty transformer or phase loss.

13. TRANSFORMER PRIMARY

Check 24 volt transformer for burnout or voltage less than 18 volts.

14. COMPRESSOR TIGHT, STUCK, BURNED OUT, OR OPEN WINDING

Refer to "Compressor" in SERVICE INFORMATION section.

15. NONCONDENSIBLES IN REFRIGERANT CIRCUIT

If all other symptoms of high pressure have been checked and pressure remains excessive, there may be noncondensibles in circuit. Release refrigerant slowly to prevent removal of oil. Evacuate and recharge circuit. Refer to refrigerant charges and evacuation procedures in SERVICE INFORMATION section.

16. BURNED CONTACTS

Sometimes contacts will close mechanically but will not conduct electrically. To check for this, disconnect power circuit and measure contact resistance with ohmmeter. The meter should read zero ohms. If meter does not read zero ohms, replace contactor. If ohmmeter is not available, disconnect power circuit, place temporary jumpers from line side of contacts and close power circuit. If unit starts, replace contactor. If unit does not start, the trouble is elsewhere. Burned contacts may also cause high current draw.

17. COMPRESSOR OVERLOAD CUTOUT

If the compressor dome is too hot to touch, the overload will not reset until the compressor cools down. If the compressor is cool and the overload does not reset, there may be a defective or open overload. If the overload is external, replace the overload, otherwise replace the compressor.

NOTE: Some of the newer high efficiency compressors have different characteristics from past models. Some will normally operate with a "hot" dome, cool crankcase, while other brands may be just the opposite. Some of the past methods of "touch analysis" may be misleading with present series units.

18. RESTRICTED HEAT EXCHANGER

Open loop system heat exchangers will sometimes scale and must be flushed (acidized) to restore water flow and performance.

19. HIGH AMPS

Refer to nameplate on unit. Amps should not exceed rating more than 10%. If so, find and correct problem.

20. EXCESSIVE SUPERHEAT

Superheat is the temperature of the refrigerant vapor above the temperature corresponding to the vapor pressure. It should be 10 to 15°F. Excessive superheat is an indication that the evaporator is "starved." That is, not enough liquid refrigerant in the coil. Excessive superheat may be due to undercharge, restriction in refrigerant circuit, low discharge pressure, expansion valve bulb lost charge, too much load on evaporator, or refrigerant flashing ahead of expansion valve or capillary due to pressure drop. See "Expansion Valve" in SERVICE INFORMATION.

21. EXPANSION VALVE BULB LOST CHARGE

If the bulb of the expansion valve loses its charge, there will be no pressure to open the valve, thus causing low suction pressure. To check this, remove expansion valve bulb from suction line and hold it in your hand. If the suction pressure does not increase in a few minutes, and there are no restrictions in the refrigerant circuit, it is an indication that the bulb has lost its charge. Replace bulb element or expansion valve. See "Expansion Valve" in SERVICE INFORMATION.

22. CAPILLARY OR DISTRIBUTOR, RESTRICTED

To check this, check suction pressure, (very low suction pressure is an indication of restriction, or excessive under charge) on cooling cycle temporarily cut off air to air coil and allow unit to operate. If there is a partial restriction or excessive undercharge, frost will occur at that point. If there is no restriction, the evaporator coil will frost uniformly. If there is a total restriction anywhere in the refrigerant circuit from the condenser through the evaporator and back to the compressor, there will be no frost, the suction pressure may go into vacuum, and the discharge pressure will correspond to approximately ambient temperature because there will be no vapor to compress.

23. EXPANSION VALVE DIAPHRAGM CASE COLDER THAN THE BULB

If the diaphragm case becomes colder than the bulb, the charge will leave the bulb and condense in the diaphragm case. Thus, bulb control will be lost. See "Expansion Valve" in SERVICE INFORMATION.

24. EXCESSIVE REFRIGERANT CHARGE

After the unit has been in operation 20 minutes, compare the unit operating pressures to the unit pressure curves in the installation manual. If the curves do not match and no air flow problems have been found, the unit may need to be recharged by weight to ensure the refrigerant charge is correct.

25. HIGH SUCTION PRESSURE

Suction pressure under normal operating conditions should not be higher than approximately 85 psig.

26. POOR EXPANSION VALVE BULB INSTALLATION

The expansion valve bulb should be securely mounted and properly llocated on clean pipe, parallel to pipe with firm metal contact and wrapped with insulation tape to assure proper sensing of suction line temperature. Refer to "Expansion Valve" in SERVICE INFORMATION.

27. IMPROPER LOCATION OF BLOWER WHEEL IN BLOWER HOUSING

Check wheel in operation to see that it is centered between the inlets.

28. COMPRESSOR OVERLOADS OPEN AND CLOSE

The purpose of overloads is to quickly sense excessive compressor current and/or temperature and open the power circuit to prevent burnout of the motor. This condition may be caused by repeated calls to start before pressures equalize, low voltage, tightness of new compressor, excessive current draw or the temperature of the suction gas being too warm to adequately cool the motor. Warm suction gas may be due to an undercharge, too much superheat, restriction in liquid or suction line, or restriction in capillary. When the overload opens, it may take from 5 to 30 minutes for it to cool sufficiently to close.

On units with external overloads check for open circuit, by temporarily jumpering each set of overload terminals. If the unit starts, the overload contacts are open. Wait until compressor cools before again attempting to start it. In the meantime, check for conditions that cause trouble.

29. COMPRESSOR WINDINGS OVERHEATED

When the compressor is drawing normal amps and becomes overheated and cycles by the overload, it is due to the temperature of the suction gas being too high to remove heat from the compressor motor. This in turn is due to undercharge, superheat too high, or restriction in refrigerant circuit.

30. REVERSING VALVE PROBLEMS

See "Reversing Valve" in SERVICE INFORMATION.

31. IMPROPER THERMOSTAT LOCATION OR CALIBRATION

Thermostat should be located where it will sense average temperature and must be mounted level. It should not be located directly exposed to supply air, sun, or external sources of heat.

Thermostats are calibrated prior to shipment. Damage during transit or handling can destroy the calibration. If the thermostat is suspect, replace it. If unit does not function after replacement, the problem is elsewhere.

32. HIGH OR LOW VOLTAGE

Check nameplate on unit for voltage rating. Check voltage at contactor or starter while the unit is operating. This voltage should not vary by more than 10% or minus from nameplate.

3. EXPANSION VALVE EQUALIZER LINE RESTRICTED

Check the equalizer line visually for external damage.

34. INITIAL COOL DOWN

High suction pressure is a characteristic of start up on cooling and initial cool down. Wait until conditioned space is down to approximately 80°F before checking suction pressure.

35. DEFECTIVE COMPRESSOR VALVES

To check this, make sure that the circuit is adequately charged and there are no restrictions in the refrigerant circuit. If in the heating mode, cover the air coil or if in the cooling mode, shut off the water. If the discharge pressure does not increase rapidly, it is an indication of defective valves. If the valves are defective, replace the compressor.

36. INITIAL WARM UP (HEATING)

Low head pressure is a characteristic of start up. Wait until heated space is up to approximately 65°F before checking suction and discharge pressure.

37. THERMOSTAT ANTICIPATOR SETTING

Anticipators for the cooling operation are generally pre-set by the thermostat manufacturer and require no adjustment. Anticipators for the heating operation are of two types; pre-set or adjustable. See "Anticipator Setting" in SERVICE INFORMATION.

38. OPEN OR DEFECTIVE LIMIT, FUSIBLE LINK OR ELEMENT

With a voltmeter, ohmmeter or continuity light, check fusible link, limit switch and element. Be sure to shut off power and disconnect voltage leads if using ohmmeter or continuity light. See "Duct Heater" in SERVICE INFORMATION.

SERVICE INFORMATION

TROUBLESHOOTING--HEAT PUMP

The heat pump is a relatively simple device. It operates exactly as an Air Conditioning unit when it is on the cooling cycle. Therefore, all the charts and data for troubleshooting that apply to air conditioning, also apply to the unit when it is heating, except that the evaporator and condenser reverse function.

When the heat pump is in the heating cycle, it is necessary to redirect the refrigerant flow through the refrigerant circuit external to the compressor. This is accomplished with a reversing valve.

The hot discharge vapor from the compressor is directed to the air coil (evaporator on the cooling cycle) where the heat is removed and the vapor condenses into liquid. It then goes through a capillary tube, or expansion valve, to the water coil (condenser on the cooling cycle) where the liquid is evaporated, and vapor goes to the compressor.

When the reversing valve solenoid is energized, either from heating to cooling or vice versa, it moves the pilot valve, thus putting suction pressure (low pressure) on one side of the piston of the reversing valve and since discharge pressure (high pressure) is on the other side of the piston, the piston slides to the low pressure side and reverses the flow of the refrigerant in the circuit.

In addition to the reversing valve, a heat pump is equipped with an expansion device, either a capillary tube or expansion valve. The capillary tube, or expansion valve, performs the same function on the heating cycle as on the cooling cycle. The refrigerant flows in the opposite direction through the valve or capillary. Some units have a check valve with capillary attached since a longer length of capillary is needed when the unit operates in the heating cycle.

A LOOK AT SERVICE SAFETY

Pressure testing or pressure cleaning refrigeration and air conditioning systems can be dangerous! Extreme caution must be employed in the selection and use of pressurizing equipment.

Hermetic type compressors are low pressure housing compressors. The compressor housing (cans or domes) are not normally subjected to discharge pressure--operating instead at relatively low suction pressures. These compressors are generally installed on equipment when it is impractical to discount or isolate the compressor from the system during pressure testing; therefore, do not exceed 150 psig when pressurizing such a complete system.

GENERAL REFRIGERANT PRECAUTIONS

Refrigerant R-22 is generally considered to be chemically non-toxic and non-inflammable; however, any gas under pressure can be hazardous because of the energy latent in the pressure alone.

When evacuating or purging any system containing R-22, always ventilate the area immediately. R-22 in concentrations and in the presence of open flames such as gas range or gas water heater pilot lights may break down and form small amounts of harmful phosgene gas.

When flushing or purging a contaminated system, care should be taken to protect the eyes and skin from contact with acid-saturated refrigerant or oil mists.

A sudden release of refrigerant liquid sprayed on the skin can cause serious damage to skin tissue. Keep eyes and exposed skin areas away from any potential refrigerant discharge. If such a refrigerant burn occurs--flush immediately with cold water, apply ice packs if severe and see a physician at once.

HEAT PUMP REVERSING VALVES

The four way reversing valve has been developed to conveniently reverse the compressor suction and discharge ports to the evaporator and condenser. Any problem in a heat pump which will affect the normal operating pressures may prevent the reversing valve from shifting correctly; for example (1) leak in the system, (2) compressor not pumping properly, (3) defective electrical system, or (4) mechanical damage to the valve. Each will indicate an apparent malfunction of the valve.

Make the following checks on the system and its components before attempting to diagnose any valve trouble by making the "Touch Test" method of analysis.

A. Make a physical inspection of the valve and solenoid coil for dents, deep scratches and cracks.

B. Check the electrical system. This is readily done by having the electrical system in operation so that the solenoid coil is energized. In this condition, remove the lock nut to free the solenoid coil. Slide it partly off the stem and notice a magnetic force attempting to hold the coil in its normal position.

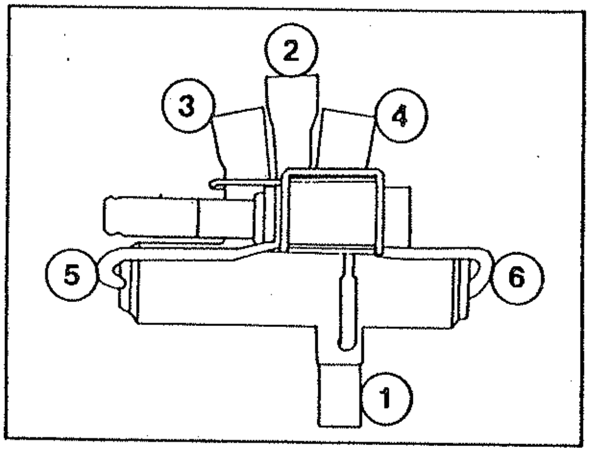
By moving the coil farther off the stem, a clicking noise will indicate the return of the "plunger" to its non-energized position. When returning the coil to its normal position on the stem, another clicking noise indicates that the "plunger" responded to the energized coil.

If these conditions have not been satisfied, other components of the electrical system are to be checked for possible problems.

After all inspections and checks have been made and determined correct, then perform the "Touch Test" on the reversing valve according to chart.

This test is simply performed by feeling the temperature relationships of the six (6) tubes on the valve and compare the temperature differences. Refer to the chart after the comparative temperatures have been determined for the "possible cause" and suggested "corrective action" to be taken.

If it is necessary to replace the valve, follow the procedure for replacement in the valve Installation and Safety Instructions.



INSTALLATION AND SAFETY INSTRUCTIONS

1. Read instructions thoroughly. Failure to comply can result in valve failure or system damage.

2. Use only an alloy whose flow point does not exceed 1145°F. Direct flame away from valve body. CAUTION: Excessive heat applied to the valve may cause the body to warp, thereby distorting the valve slide. Use chill blocks, wet rags or other heat sink material to protect the valve during brazing.

3. The replacement valve MUST be remounted and reconnected in the same position as the original valve. If tubes are changed, they must be the same size as original equipment.

4. Permit removal of the solenoid coil by leaving enough clearance to slide coil over shaft.

TOUCH TEST CHART

NOTES.
*Temperature of Valve Body
**Warmer than Valve Body

VALVE OPERATING CONDITION	DISCHARGE TUBE from Compressor 1	SUCTION TUBE to Compressor 2	Tube to INSIDE COIL 3	Tube to OUTSIDE COIL 4	LEFT Pilot Back Capillary Tube 5	RIGHT Pilot Front Capillary Tube 6	Possible Causes	Corrections
NORMAL OPERATION OF VALVE								
Normal COOLING	Hot	Cool	Cool, as (2)	Hot, as (1)	*TVB	*TVB		
Normal HEATING	Hot	Cool	Hot, as (1)	Cool, as (2)	*TVB	*TVB		
MALFUNCTION OF VALVE								
Valve will not shift from cool to heat	Check electrical circuit and coil						No voltage to coil.	Repair electrical circuit.
							Defective coil.	Replace coil.
	Check refrigeration charge						Low charge.	Repair leak, recharge system.
							Pressure differential too high.	Recheck system.
	Hot	Cool	Cool, as (2)	Hot, as (1)	*TVB	Hot	Pilot valve okay Dirt in one bleeder hole	De-energize solenoid, raise head pressure, re-energize solenoid to break dirt loose. If unsuccessful, remove valve, wash out. Check on air before installing. If no movement, replace valve, add strainer to discharge tube, mount valve horizontally.
							Piston cup leak.	Stop unit. After pressures equalize, restart with solenoid energized. If valve shifts, re-attempt with compressor running. If still no shift, replace valve.
	Hot	Cool	Cool, as (2)	Hot, as (1)	*TVB	*TVB	Clogged pilot tubes.	Raise head pressure, operate solenoid to free. If still no shift, replace valve.
	Hot	Cool	Cool, as (2)	Hot, as (1)	Hot	Hot	Both ports of pilot open. (Back seat port did not close.)	Raise head pressure, operate sole- solenoid to free partially clogged port. If still no shift, replace valve.
	Warm	Cool	Cool, as (2)	Warm, as (1)	*TVB	Warm	Defective Compressor	
Start to shift but does not complete reversal	Hot	Warm	Warm	Hot	*TVB	Hot	Not enough pressure differential at start of stroke or not enough flow to maintain pressure differential.	Check unit for correct operating pressures and charge. Raise head pressure. If no shift, use valve with smaller ports.
							Body damage.	Replace Valve.
	Hot	Warm	Warm	Hot	Hot	Hot	Both ports of Pilot open	Raise head pressure, operate solenoid. If no shift, replace valve
	Hot	Hot	Hot	Hot	*TVB	Hot	Body damage.	Replace valve.
							Valve hung up at mid-stroke. Pumping volume of compressor not sufficient to maintain reversal.	Raise head pressure, operate solenoid. If no shift, use valve with smaller ports.
	Hot	Hot	Hot	Hot	Hot	Hot	Both ports of Pilot open	Raise head pressure, operate solenoid. If no shift, replace valve
Apparent leak in heating	Hot	Cool	Hot, as (1)	Cool, as (2)	*TVB	**WVB	Piston needle on end of slide leaking	Operate valve several times then recheck. If excessive leak, replace valve.
	Hot	Cool	Hot, as (1)	Cool, as (2)	**WVB	**WVB	Pilot needle and piston needle leaking	Operate valve several times then recheck. If excessive leak, replace valve.
Will not shift from heat to cool	Hot	Cool	Hot, as (1)	Cool, as (2)	*TVB	*TVB	Pressure differential too high.	Stop unit. Will reverse during equalization period. Recheck system.
							Clogged Pilot tube.	Raise head pressure, operate solenoid to free dirt. If still no shift, replace valve.
	Hot	Cool	Hot, as (1)	Cool, as (2)	Hot	*TVB	Dirt in bleeder hole.	Raise head pressure, operate solenoid. Remove valve and wash out. Check on air before re-installing, if no movement, replace valve. Add strainer to discharge tube. Mount valve horizontally.
	Hot	Cool	Hot, as (1)	Cool, as (2)	Hot	*TVB	Piston cup leak.	Stop Unit, after pressures equalize, restart with solenoid de-energized. If valve shifts, re-attempt with compressor running. If it still will not reverse while running, replace valve
	Hot	Cool	Hot, as (1)	Cool, as (2)	Hot	Hot	Defective Pilot.	Replace Valve.
	Warm	Cool	Warm, as (1)	Cool, as (2)	Warm	*TVB	Defective compressor.	

VALVE OPERATED SATISFACTORILY PRIOR TO COMPRESSOR MOTOR BURN OUT – caused by dirt and small greasy particles inside the valve. To CORRECT: Remove valve, thoroughly wash it out. Check on air before re-installing, or replace valve. Add strainer and filter-dryer to discharge tube between valve and compressor.
Courtesy RANCO Inc

5. Before energizing valve, be sure source voltage and frequency matches that on coil. Do not energize coil unless coil is securely attached to valve.

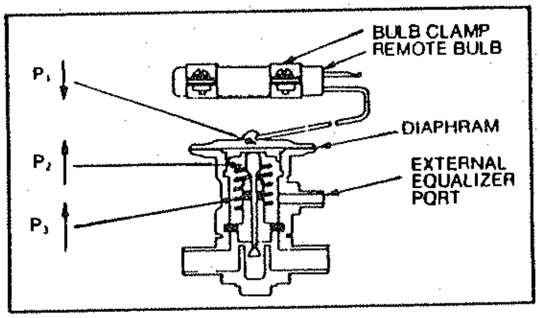
CAUTION:
6. Do not bend or use enclosing tube as lever. A damaged enclosing tube may result in coil burnout, or inoperative valve.

7. Foreign matter in the valve may result in seat leakage, failure to shift, or coil burnout.

THERMAL EXPANSION VALVE

VALVE FUNCTION. The thermal expansion valve is a precision device designed to meter the flow of refrigerant into an evaporator in exact proportion to the rate of evaporation of the refrigerant in the evaporator, thereby preventing the return of liquid refrigerant to the compressor. By being responsive to the temperature of the refrigerant gas leaving the evaporator and the pressure in the evaporator, the thermal expansion valve can control the refrigerant gas leaving the evaporator at a pre-determined superheat.

VALVE OPERATION. Three forces govern the thermal expansion valve's operation. They are: the pressure created by the remote bulb and power assembly (P_1), the evaporator pressure (P_2), and the equivalent pressure of the superheat spring (P_3).



The remote bulb and power assembly is a closed system and in the following discussion it is assumed that the remote bulb and power assembly charge is the same refrigerant as that used in the system.

The proper remote bulb location is the "3 o'clock" position on the horizontal section of the common suction line.

SOLDER TECHNIQUE. It is not necessary to dissemble solder type valve when soldering to the connecting lines. However, the valve body needs to be cooled with wet rags. Any of the commonly used types of solder such as Sil-Fos, Easy-Flow, Phos-Copper or equivalents are satisfactory.

INSTALLATION

1. Before installing the valve, be sure the system is thoroughly clean and dry. A liquid line filter-drier is recommended.

2. Be sure valve is installed so its flow arrow corresponds to flow direction through piping.

3. Install line connections to valve. On valves with solder connections remove the power assembly, cage assembly and gaskets prior to brazing. Use back-up wrench on all wrench flats.

4. When reassembling valve, follow the service instructions.

5. Attach the remote bulb to the suction line as close to the evaporator as possible in a horizontal run and position the bulb at the 3 o'clock poisition. Clean the surface of the suction line where the remote bulb is to be attached then securely fasten the bulb.

6. Connect one end of external equalizer line to the valve. Connect the other end to the suction line slightly downstream from the remote bulb location and positioned so that it cannot siphon oil from the suction line.

7. Check for leaks, sufficient system refrigerant and be sure no flash gas is present.

MEASURING OPERATING SUPERHEAT

1. Measure the temperature of the suction line at the point the bulb is clamped.

2. Obtain the suction pressure that exists in the suction line at the bulb location by either of the following methods:

a. If the valve is externally equalized, a gauge in the external equalizer line will indicate the desired pressure directly and accurately.

or

b. Read the gauge pressure at the suction valve of the compressor. To the pressure add the estimated pressure drop through the suction line between bulb location and compressor suction valve. The sum of the gauge reading and the estimated pressure drop will equal the approximate suction line pressure at the bulb.

3. Convert the pressure obtained in 2a or 2b above to saturated evaporator temperature by using a temperature-pressure chart.

4. Subtract the two temperatures obtained in 1 and 3--the difference is superheat.

A typical example of superheat measurement on a heat pump using Refrigerant-22. The temperature of the suction line at the bulb location is read at 52°F. The suction pressure at the compressor is 66 psig and the estimated suction line pressure drop is 2 psi....66 psig + 2 psig = 68 psig at the bulb, which is equivalent to a 40°F saturation temperature. 40°F subtracted from 52°F = 12°F superheat.

TEMP. F	REFRIGERANT 22 PSIG	TEMP. F	REFRIGERANT 22 PSIG
10	32.8	55	92.6
12	34.7	60	101.8
14	36.7	65	111.2
16	38.7	70	121.4
18	40.9	75	132.2
20	43.0	80	143.8
22	45.3	85	155.7
24	47.6	90	168.4
26	49.9	95	181.8
28	52.4	100	195.9
30	54.9	105	210.8
32	57.5	110	226.4
34	60.1	115	242.7
36	62.8	120	259.9
38	65.6	125	277.9
40	68.5	130	296.8
42	71.5	135	316.6
44	74.5	140	337.2
46	77.6	145	358.9
48	80.8	150	381.5
50	84.0	155	405.1

WATER COILS:

The water to refrigerant heat exchanger used in these units is the tube within a tube type. Water flows through the inner tube, which is Cupro Nickel, and the refrigerant through the outer tube. The O.D. of the inner tube has a continuous set of copper baffles which increases the surface area for heat exchange between the refrigerant and water and swirls the refrigerant around the tube.

BASIC FUNCTION. To extract heat from the refrigerant gas into the water (cooling mode-condenser), or provide a source from which the refrigerant liquid can absorb heat (heating mode evaporator). The rate of heat exchange in either mode is determined by the entering water temperature (EWT) and the flow rate (GPM). A more exact determination for flow rates, at a given EWT, to obtain the desired BTUH output in heating or cooling can be made from the engineering specification sheet for each model. In any case, the temperature differential (delta T) between the entering and leaving water should be between 4.5 to 12.2 F for closed loop and 6.8 to 18.4 for open loop.

FREEZE-UP PROBLEM: OPEN LOOP. In heating mode, inadequate water flow, low entering water temperatures, or a combination of both could cause a freeze-up of the water coil. To avoid this, the water flow rates should be at or above the minimum water flow rates indicated.

If the unit shuts off due to low temperature or low pressure, it can be restarted by resetting the system switch on thermostat (or by interrupting the power supply). If the unit repeats this again, check water flow rates and water temperatures for potential freezing problems.

If partial or a complete freeze-up does occur without water getting into the refrigerant circuit, it can be defrosted by switching the unit into cooling mode and running for a short period. Verify that water flow has been re-established before changing back to heating.

FREEZE-UP PROBLEM: CLOSED LOOP. Refer to the antifreeze and low temperature freezestat in the "INSTALLATION" section. Antifreezed systems can lose flow due to icing caused by improper flow, incorrect antifreeze solution or pump failure.

COIL CLEANING. Where water chemistry may vary or is unknown mineral buildups can occur, coating the inside of the water tube and result in gradual loss of heat exchange. When this happens, unit capacity will decrease as will the temperature differential across the water coil. When a unit is installed, the temperature differential should be recorded and then periodically checked. If, over a period of time, it decreases by more than 2°F at the same flow rate, it indicates some coating has taken place. To correct this situation, the coil must be cleaned as follows:

Isolate water source heat pump from the supply and return by shutting the supply and return valves. If unit is provided with system flushing valves on the unit side of the isolation valves, attach hoses to the flushing valves. If flushing valves are not provided, remove piping from unit and connect system flushing assembly consisting of a bucket with a small portable pump connected to the unit with supply out of a bucket and return back to the bucket. This bucket should be filled with a SCALE REMOVER specifically designed for removing scale from copper or cupro-nickel exchangers. Scale remover is available from a water treatment supplier. Chemicals provided should come with a test kit used to determine when PH has reached neutral to determine when scale is dissolved. Follow the directions coming with the scale remover kit for removal of scale. Once all scale is removed, the unit should be thoroughly flushed with water before placing unit into operation.

AIR COILS

It is important to maintain proper air flow through a clean air coil for efficient heat pump performance. Filters should be changed at three month intervals, or whenever they become clogged or dirty.

Air flow may be restricted by damaged coil fins. Minor damage to fins may be repaired by use of a fin comb available at most refrigeration supply warehouses. It is important to use a fin comb with the correct fins per inch (FPR).

AIR COIL CLEANING. Contaminants in the air composition may eventually coat the fins on the air coil and reduce the heat pump efficiency. Visually inspect the air coil fins periodically for buildup of contaminants.

There are several coil cleaning chemicals available on the market. Be sure to follow the instructions of the chemical manufacturer.

DIRECT DRIVE BLOWER ASSEMBLY

To remove the motor from the blower assembly, loosen the set screw located on the opposite side of the blower wheel as the motor, and disconnect motor mount.

When replacing a motor, be sure blower wheel is centered between blower housing inlet flanges before tightening set screw. This is important to avoid noisy blower operation. Before tightening set screw, be sure it is aligned with and will seat on the flat of the motor shaft.

Refer to wiring diagrams on all units for electrical connections.

CHECKING FOR DEFECTIVE CAPACITORS

Using an analog multimeter, check the capacitors in the following manner:

1. Disconnect current to unit.
2. Set meter on high ohms.
3. Place meter leads on opposite sides of capacitor.
4. Meter should start reading low resistance and gradually build up.
5. Reverse the leads and meter should jump to 0 and gradually build back up.

This indicates a capacitor with good internal division.

THERMOSTAT ANTICIPATOR

Thermostat models having a scale similar to the sketch below MUST be adjusted to each application.

1. Wrap 10 loops of single strand, insulated thermostat wire around the prongs of an amp meter. Set the meter to the 1 to 5 or 1 to 6 amp scale.

2. Connect the uninsulated ends of this wire jumper across terminals "R" and "W" on the subbase. See sketch below. This test must be performed without the thermostat attached to the subbase.

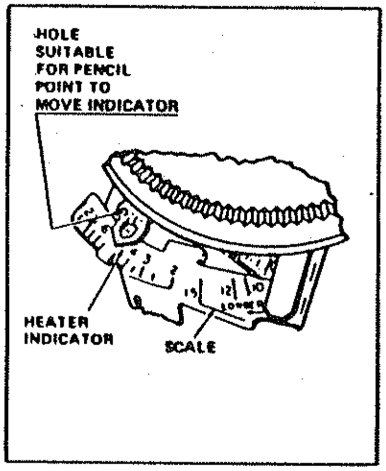
3. Let the heating system operate in this position for about one minute. Read the meter scale. Whatever reading is indicated must be divided by 10 (for 10 loops of wire). This is the setting at which the adjustable heat anticipator should be set.

Formula: $\frac{\text{Meter reading}}{\text{10 loops}}$ = Anticipator Setting

Example: $\frac{\text{02.5 amps}}{10}$ = .25 Amps Setting

4. If a slightly longer cycle is desired, the pointer should be moved to a higher setting. Slightly shorter cycles can be achieved by moving to a lower setting.

5. Remove the jumper wire and reconnect the thermostat. Check the thermostat in the heating mode for proper operation.



HIGH VOLTAGE

NEVER connect a heat pump to a higher voltage than the data plate rating!

Just as the output drops with lower applied voltage, it increases even more rapidly with a higher voltage.

EXAMPLE: Connect 240V to 208V duct heater, 17.25 KW, 3 Ph., 47.9 Amps.

RESULT: Heater output increases to 23 KW drawing 55.3 Amps at 241V.

1. Amp draw is now over the 48 per circuit allowed by UL and NEC.
2. The element output is now at 1/3 more than factory design limit.
3. Contactor and other component capacities may be exceeded.
4. Safe wattage density may now be exceeded and heater short cycles.
5. UL Label and Warranty are VOID!!
6. Product liabilities passes from us! YOU WILL HAVE PROBLEMS!!

DUCT HEATERS

NO HEAT. 1. Check that the controlling thermostat is set to call for heating. If the thermostat has a fan switch, check the ON position. If the fan runs, you have learned there is power to that section and the transformer, fan relay and motor are apparently O.K. Return fan switch to the auto position for checking the heater.

2. The heater should be checked only by qualified service personnel who know how to safely check power and control voltage to the heater. Various components can then be checked with a continuity meter--with ALL HIGH VOLTAGE POWER OFF. Replace parts that have failed but remember the following:

a. An open fusible link or manual reset is usually caused by a stuck contactor that allows heater to "run on" after thermostat is satisfied and the fan goes off.

b. Our U.L. Label is voided and liability passes from us when other than an exact replacement or approved alternate part is used. The same holds true if any safety device is bypassed.

NOT ENOUGH HEAT. 1. Check that the amp draw is reasonably close to that on the heater data plate. You should not be more than 10% short unless the supply voltage is lower than the heater data plate rating or part of the heater is not operational. Replace any non-functioning parts with EXACT PARTS or APPROVED ALTERNATES.

2. A heater that cycles off before the thermostat is satisfied may cause complaints only during the coldest days when maximum performance is required.

3. Thermostat with heat anticipator current draw set too low will "short cycle" a heater off before the set temperature is reached and when maximum running time may be required. Other than exact replacement components may require a change in the heat anticipator setting.

4. If the shortage of heat is in only some areas, you might have a condition that requires seasonal duct correction. A damaged duct would affect a particular area. Restricted airflow usually affects rooms at the end of the duct system first.

5. TIP: Your customer may have turned on the heat after the area had gotten cold and expected it to warm up quickly. Low temperature air blowing on a 98°F hand may seem to indicate the system is not working properly or that there is no heat at all. This is a typical complaint in southern climates or in commercial applications if the heat rise is relatively low.

HEATER CYCLING ON AUTOMATIC LIMIT. 1. A defective or incorrect temperature limit switch is always possible but normally other conditions contribute to a heater cycling problem.

2. Improper airflow caused by obstructions to return air, clogged filters and/or evaporator coils may cause the limit switch to cycle the heater off before the thermostat is satisfied.

3. Improper installation - with insufficient or uneven airflow over the entire heater. Borderline installations may start cycling after coil, filter and blower get dirty.

Heaters are designed not to nuisance cycle provided that sufficient velocity and thickness of inlet air curtain flows between the primary limit and heating element. The U.L. rule for duct heaters to be located 4 feet downstream from an air conditioning unit and 2 feet before or after an elbow will help eliminate nuisance cycling. Some other conditions that contribute to cycling of a heater are listed below:

a. Heater in a large plenum but too close to a small blower prevents even airflow.

b. Baffles bouncing air off heating element onto limit switch can add to problem.

c. Base of heater controls box not flush with the air stream reduces air curtain.

d. Heater connected to higher than rated voltage results in superheated elements.

e. Installing heaters in the top of a horizontal duct is not authorized. Primary limit switch cut-out point is lowered by its location on top.

OPEN SECONDARY PROTECTIVE DEVICE. 1. An open manual reset, fusible link or other secondary thermal device is usually the result of a stuck contactor where the thermostat is satisfied and there is no more fan. The heater "runs on" in this abnormal condition until the secondary device opens.

2. Lack of proper air flow over the heater could cause enough cycling of the limit switch so that a secondary would open after a build up of enough residual heat. This is particularly so when a heater is installed from the top of the duct.

3. Grounded heating element may generate enough heat without fan to open a secondary. Overcurrent fuses or circuit breakers may or may not open depending on the amount of element resistance to ground and the amount of related current it draws.

CONTACTOR CHATTER. 1. Improper wiring.

2. Insufficient transformer capacity. This may occur if chatter happens after a component change. The substitute may draw a more VA overloading the transformer.

3. Vibration or contamination of mercury thermostat.

4. Excessive static pressure on an open face limit control. (Rare)

ELEMENT FAILURE. (Not prevalent if properly designed and not abused.) 1. Excessive overheating with wrong temperature or bypassed primary limit control.

2. Improper installation with enough air directed over the primary limit to keep the heater operating but severely overheating other places not getting enough air.

3. Improper filtering so that elements cannot dissipate heat through dirty covering.

4. Corroded hardware of loose connections causing burned-off wires or elements.

5. Any physical damage, grounding, a nick or an impurity in the element itself.

6. Bad element design with too much KW in a given space and/or not enough element mass to dissipate heat. The hotter an element operates, the quicker it deteriorates.

7. Very light gauges of element wire may be sufficient electrically but they simply flutter in the high velocity air until they ground out and burn through.

COMPRESSOR CHECK

1. Remove wiring from the compressor terminals and check for ground between each terminal and the compressor housing.

2. Check for continuity between the common terminal and run terminal and between the common terminal and the start terminal. (Make sure the compressor is cool to the touch if it has internal overload.)

3. Sample the refrigerant for the characteristic acid odor of a burnout. WARNING: Smell cautiously, the gas could be toxic and highly acid. Occasionally a fault in the motor insulation may result in a motor burn, but in a system with proper design and installation, burnouts rarely occur. Of those that do occur, most are the result of mechanical or lubrication failures, resulting in the burnout as a secondary result. In any case, find and correct the reason for compressor failure.

4. If the above steps check OK, look elsewhere for the trouble. The external electrical components are a good place to start, especially check the run capacitor.

COMPRESSOR REMOVAL

1. Release the system charge, in the liquid state, to a well ventilated location. CAUTION: Avoid getting the refrigerant in the eyes or on the skin.

2. Disconnect compressor from the circuit and temporarily seal the compressor openings. Use rubber gloves to avoid contact with the oil or sludge.

3. Clean the heat pump circuit thoroughly. Flush both the low side evaporator coil and suction line and the high side condenser coil and liquid line with R-22 until clean of all contaminants.

If sludge is evident in the discharge line, the compressor motor burned while running. Sludge and acid has been pumped throughout the system and many changes of a temporary suction filter-drier will be necessary to clean the system. Repiping may be necessary to install temporary suction line filter-drier. The drier, when initially installed in a dirty system, must have a pressure drop not more than 15 PSI. Pressure taps must be supplied immediately before and after the suction filter-drier to permit the pressure drop to be measured.

COMPRESSOR REPLACEMENT/INSTALLATION

Absolute cleanliness is essential in a refrigeration system. In order to insure a reliable, trouble-free unit, there are no compromises.

1. Do not leave dehydrated compressors or filter-driers open to the atmosphere any longer than is absolutely necessary. (One or two minutes maximum suggested.)

2. Install the replacement compressor. NOTE: When soldering refrigerant lines, an inert gas should be passed through the line at low pressure to prevent scaling and oxidation inside the tubing. Dry nitrogen is preferred.

3. Install a generously sized suction line filter-drier immediately upstream of the compressor. Pressure taps must be supplied immediately before and after the suction filter-drier to permit the pressure drop to be measured.

4. Pressure test with dry nitrogen. Repair any leaks with nitrogen in the system.

EVACUATION OF THE SYSTEM

The heat pump is a factory charged unit. However, in cases of service or replacement of major components, it will be necessary to recharge the unit. Prior to recharging the system the following steps are recommended:

1. Pressure test with dry refrigerant. Locate and repair all leaks.

2. Evacuate the system to less than 1000 microns, using a good vacuum pump and an accurate high vacuum gauge. Operate the pump at 1000 microns, or less, for one hour or longer and then allow the system to stand for 30 additional minutes to be sure the vacuum is maintained.

3. An alternate method of removing moisture and noncondensibles from the system is:

   a. Evacuate system to 29 inches for ten minutes per ton of system. Break vacuum with refrigerant to be used for final charging of system and vapor charge to 35-50 lbs. gauge pressure. Leave vapor charge in system for a minimum of five minutes. Reduce pressure to five to zero gauge pressure.

   b. Repeat step (a) two more times.

   c. Evacuate system to 30 inches vacuum for twenty minutes per ton. Charge with the specified kind and quantity of refrigerant (charge into vacuum).

   NOTE: At no time use the compressor to evacuate the system or any part of it.

4. Disconnect charging line at vacuum pump and connect to refrigerant supply. (Dial-A-Charge Cylinder) crack valve and purge charging line at center on manifold. Then close valve.

5. The system is now ready for the correct operating charge of Refrigerant-22.

6. Charge unit with the quantity of Refrigerant-22 as specified in ounces on the data plate. Do not attempt to charge the unit by running the machine and measuring the ampere draw to full load conditions.

There are many variables (airflow, air temperatures) in heat pump system that will affect operating refrigerant pressures and temperatures. Unit shows approximate conditions and is based on airflow at the rated CFM.

For abnormal pressures refer to the Refrigerant Pressure Table for unit being serviced.

CHARGING THE SYSTEM

Charge using one of the following methods: (NEVER ATTEMPT TO MEASURE CHARGE BY PRESSURE)

1. Charging cylinder - charge to the quantity specified on the data plate.

2. Scale - charge by weighing actual ounces being added to the system.

NOTE: Charge into a vacuum.

START-UP AND CHECK-OUT

1. Start the compressor and allow the system pressures and temperatures to stabilize.

2. Check compressor amps.

3. Check the pressure drop across the suction line filter-drier. This will serve two purposes.

   a. Verify that the drier selection is large enough.
   b. Serve as a base point to which subsequent pressure checks can be compared.

   Because the permissible pressure drop across the drier is relatively small, it is suggested that a differential pressure gauge be used for the measurement.

4. Where a severe running burnout has occured, an increased pressure drop will be measured. Change the suction filter-drier whenever the pressure drop approaches or exceeds 15 PSI for temporary operation during cleanup.

Keep changing the suction line filter-drier until the pressure drop stabilizes at 3 PSI or below.

NOTE: It is the serviceman's option as to whether to leave the suction drier in the system or remove it from operation.

5. If the system has suffered multiple burnouts, it is advisable that the oil of the replacement be tested and judged acid free before the system is considered satisfactorily cleaned. An acid kit is available from several manufacturers.

Steps 3, 4 and 5 above provide for cleanup of hermetic systems after burnout through the use of suction line filter-driers. This will prove to be satisfactory in most instances provided the system is monitored and kept clean by repeated drier changes, if such are needed. The failure to follow these minimum cleanup recommendations will result in excessive risk of repeat failure.

QUICK REFERENCE TROUBLE-SHOOTING CHART FOR WATER TO AIR HEAT PUMP

Bard®
SINCE 1914

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DENOTES OCCASIONAL CAUSE ▲

	POSSIBLE CAUSE	POWER SUPPLY																	
		LINE VOLTAGE										CONTROL CIRCUIT							
	PROBLEM CONDITION	POWER FAILURE	BLOWN FUSE OR TRIPPED BREAKER	FAULTY WIRING	LOOSE TERMINALS	LOW VOLTAGE	DEFECTIVE CONTACTS IN CONTACTOR	COMPRESSOR OVERLOAD	POTENTIAL RELAY	RUN CAPACITOR	START CAPACITOR	FAULTY WIRING	LOOSE TERMINALS	CONTROL TRANSFORMER	LOW VOLTAGE	THERMOSTAT	CONTACTOR COIL	PRESSURE CONTROLS (HIGH OR LOW)	INDOOR BLOWER RELAY
HEATING OR COOLING CYCLES	COMPRESSOR WILL NOT RUN NO POWER AT CONTACTOR	●	●	●	●		▲	▲				●	●	●	▲	▲	●	●	
	COMPRESSOR WILL NOT RUN POWER AT CONTACTOR			●	●	●		●	●	●	●								
	COMPRESSOR "HUMS" BUT WILL NOT START			●	●	●	▲		●	●	●								
	COMPRESSOR CYCLES ON OVERLOAD			●	●	●	▲	●	●	●	●								
	THERMOSTAT CHECK LIGHT LITE-LOCKOUT RELAY																	●	
	COMPRESSOR OFF ON HIGH PRESSURE CONTROL																	▲	●
	COMPRESSOR OFF ON LOW PRESSURE CONTROL																		▲
	COMPRESSOR NOISY																		
	HEAD PRESSURE TOO HIGH																		
	HEAD PRESSURE TOO LOW																		
	SUCTION PRESSURE TOO HIGH																		
	SUCTION PRESSURE TOO LOW																		
	I.D. BLOWER WILL NOT START	●	●	●	●							●	●	●	▲	▲			●
	I.D. COIL FROSTING OR ICING																		
	HIGH COMPRESSOR AMPS					●				●									
	EXCESSIVE WATER USAGE																		
COOLING CYCLE	COMPRESSOR RUNS CONTINUOUSLY—NO COOLING																		
	LIQUID REFRIGERANT FLOODING BACK TO COMPRESSOR																		
HEATING CYCLE	COMPRESSOR RUNS CONTINUOUSLY—NO HEATING																		
	REVERSING VALVE DOES NOT SHIFT			●	●														
	LIQUID REFRIGERANT FLOODING BACK TO COMPRESSOR																		
	AUX. HEAT ON I.D. BLOWER OFF			●	●							●	●			▲			●
	EXCESSIVE OPERATING COSTS			▲	▲											▲			
	ICE IN WATER COIL			▲	▲														

	POSSIBLE CAUSE	WATER COIL SECTION												
		COMPRESSOR					REFRIGERANT SYSTEM							
	PROBLEM CONDITION	DISCH. LINE HITTING INSIDE OF SHELL	BEARINGS DEFECTIVE	SEIZED	VALVE DEFECTIVE	MOTOR WINDINGS DEFECTIVE	REFRIGERANT CHARGE LOW	REFRIGERANT OVERCHARGE	HIGH HEAD PRESSURE	LOW HEAD PRESSURE	HIGH SUCTION PRESSURE	LOW SUCTION PRESSURE	NON-CONDENSABLES	UNEQUALIZED PRESSURES
HEATING OR COOLING CYCLES	COMPRESSOR WILL NOT RUN NO POWER AT CONTACTOR													
	COMPRESSOR WILL NOT RUN POWER AT CONTACTOR		▲	●		●								●
	COMPRESSOR "HUMS" BUT WILL NOT START		●	●		●								●
	COMPRESSOR CYCLES ON OVERLOAD		▲		▲	▲	●	●	▲		▲		●	
	THERMOSTAT CHECK LIGHT LITE-LOCKOUT RELAY													
	COMPRESSOR OFF ON HIGH PRESSURE CONTROL							●					●	
	COMPRESSOR OFF ON LOW PRESSURE CONTROL						●			●		●		
	COMPRESSOR NOISY	▲	▲		●									
	HEAD PRESSURE TOO HIGH							●					●	
	HEAD PRESSURE TOO LOW				●		●					●		
	SUCTION PRESSURE TOO HIGH				●			●	●					
	SUCTION PRESSURE TOO LOW						●			▲				
	I.D. BLOWER WILL NOT START													
	I.D. COIL FROSTING OR ICING						●					●		
	HIGH COMPRESSOR AMPS		●	●		▲		●	●		●		●	
	EXCESSIVE WATER USAGE													
COOLING CYCLE	COMPRESSOR RUNS CONTINUOUSLY—NO COOLING				●		●					●		
	LIQUID REFRIGERANT FLOODING BACK TO COMPRESSOR							●	●					
HEATING CYCLE	COMPRESSOR RUNS CONTINUOUSLY—NO HEATING				●		●					●		
	REVERSING VALVE DOES NOT SHIFT						▲			▲				
	LIQUID REFRIGERANT FLOODING BACK TO COMPRESSOR							●	●					
	AUX. HEAT ON I.D. BLOWER OFF													
	EXCESSIVE OPERATING COSTS						●	●						
	ICE IN WATER COIL						●							

	POSSIBLE CAUSE	WATER COIL SECTION												
		WATER REG. VALVE			REV. VALVE		CHECK VALVE		WATER COIL					
	PROBLEM CONDITION	WATER REG. VALVE STUCK CLOSED (HTG)	WATER REG. VALVE STUCK CLOSED (CLG)	WATER REG. VALVE STUCK OPEN (HTG or CLG)	LEAKING	DEFECTIVE VALVE OR COIL	STICKING CLOSED	LEAKING OR DEFECTIVE	PLUGGED OR RESTRICTED CAP TUBE (HTG)	SCALLED OR PLUGGED COIL (HTG)	SCALLED OR PLUGGED COIL (CLG)	WATER VOLUME LOW (HTG)	WATER VOLUME LOW (CLG)	LOW WATER TEMPERATURE (HTG)
HEATING OR COOLING CYCLES	COMPRESSOR WILL NOT RUN NO POWER AT CONTACTOR													
	COMPRESSOR WILL NOT RUN POWER AT CONTACTOR													
	COMPRESSOR "HUMS" BUT WILL NOT START													
	COMPRESSOR CYCLES ON OVERLOAD				▲					▲	▲	▲	▲	
	THERMOSTAT CHECK LIGHT LITE-LOCKOUT RELAY													
	COMPRESSOR OFF ON HIGH PRESSURE CONTROL		●				●		▲		▲		●	
	COMPRESSOR OFF ON LOW PRESSURE CONTROL	●		▲						▲		●		▲
	COMPRESSOR NOISY													
	HEAD PRESSURE TOO HIGH		●			▲	▲		▲		●		●	
	HEAD PRESSURE TOO LOW	▲		▲	▲			▲		●		●		●
	SUCTION PRESSURE TOO HIGH				▲			▲						
	SUCTION PRESSURE TOO LOW	●					▲		▲	●		●		▲
	I.D. BLOWER WILL NOT START													
	I.D. COIL FROSTING OR ICING						▲							
	HIGH COMPRESSOR AMPS						▲		▲		●		●	
	EXCESSIVE WATER USAGE			●						▲	▲			
COOLING CYCLE	COMPRESSOR RUNS CONTINUOUSLY—NO COOLING										▲		▲	
	LIQUID REFRIGERANT FLOODING BACK TO COMPRESSOR													
HEATING CYCLE	COMPRESSOR RUNS CONTINUOUSLY—NO HEATING	●			▲				▲	●		●		▲
	REVERSING VALVE DOES NOT SHIFT					●								
	LIQUID REFRIGERANT FLOODING BACK TO COMPRESSOR	●			▲	▲				●		●		●
	AUX. HEAT ON I.D. BLOWER OFF													
	EXCESSIVE OPERATING COSTS	▲	▲	▲	●	●				▲	▲	▲		
	ICE IN WATER COIL	●				●				▲		●		

	POSSIBLE CAUSE	INDOOR SECTION								AUX.			
		INDOOR BLOWER MOTOR & COIL						CHECK VALVE		HEAT		GEN.	
	PROBLEM CONDITION	PLUGGED OR RESTRICTED CAP TUBE (CLG)	FINS DIRTY OR PLUGGED	MOTOR WINDING DEFECTIVE	AIR VOLUME LOW	AIR FILTERS DIRTY	UNDERSIZED OR RESTRICTED DUCTWORK	STICKING CLOSED	LEAKING OR DEFECTIVE	AUX. HEAT UPSTREAM OF COIL	OUTDOOR THERMOSTAT (SPLIT SYSTEM)		
HEATING OR COOLING CYCLES	COMPRESSOR WILL NOT RUN NO POWER AT CONTACTOR												
	COMPRESSOR WILL NOT RUN POWER AT CONTACTOR												
	COMPRESSOR "HUMS" BUT WILL NOT START												
	COMPRESSOR CYCLES ON OVERLOAD		▲	▲	▲	●	▲						
	THERMOSTAT CHECK LIGHT LITE-LOCKOUT RELAY												
	COMPRESSOR OFF ON HIGH PRESSURE CONTROL	▲	●	●	●	●	●	●		●			
	COMPRESSOR OFF ON LOW PRESSURE CONTROL	●											
	COMPRESSOR NOISY												
	HEAD PRESSURE TOO HIGH	▲	▲	▲	●	●	▲	▲		●			
	HEAD PRESSURE TOO LOW								▲				
	SUCTION PRESSURE TOO HIGH								▲				
	SUCTION PRESSURE TOO LOW	▲	●	▲	●	●	▲	▲					
	I.D. BLOWER WILL NOT START												
	I.D. COIL FROSTING OR ICING	▲	●	●	●	●	▲						
	HIGH COMPRESSOR AMPS	▲	●	●	●	●	▲	▲		▲			
	EXCESSIVE WATER USAGE												
COOLING CYCLE	COMPRESSOR RUNS CONTINUOUSLY—NO COOLING	▲	●	●	●	●	▲						
	LIQUID REFRIGERANT FLOODING BACK TO COMPRESSOR		●	●	●	●	▲		▲				
HEATING CYCLE	COMPRESSOR RUNS CONTINUOUSLY—NO HEATING												
	REVERSING VALVE DOES NOT SHIFT												
	LIQUID REFRIGERANT FLOODING BACK TO COMPRESSOR												
	AUX. HEAT ON I.D. BLOWER OFF			●									
	EXCESSIVE OPERATING COSTS		▲	▲	▲						●		
	ICE IN WATER COIL												