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SURGE PROTECTION FOR COMPRESSORS OF HEAT PUMPS

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This invention relates to heat pumps that are used for cooling or heating indoor air.

A heat pump used for cooling or heating indoor air usually includes a refrigerant compressor that is connected through a refrigerant reversal valve to indoor and outdoor heat exchange coils. When indoor air heating is desired, the reversal valve is adjusted to route discharge gas from the compressor into the indoor coil operating as a condenser, from which refrigerant liquid is supplied through expansion means into the outdoor coil operating as an evaporator. When indoor air cooling is desired, the reversal valve is adjusted to route the discharge gas from the compressor into the outdoor coil operating as a condenser, from which refrigerant liquid is supplied through the expansion means into the indoor coil operating as an evaporator.

When the reversal valve of such a heat pump is adjusted from one position to the other, at the instant of reversal, the compressor suction is applied to the high pressure coil that has been operating as a condenser, and the high pressure refrigerant from the latter discharges through the compressor into the low pressure coil that has been operating as an evaporator. This creates objectionable noise, may damage the compressor valves, and liquid from the high pressure coil passes into the compressor, diluting its lubricant, and causing increased wear of the compressor components.

In a widely used heat pump, a heating control thermostat, when it calls for indoor air heating, starts the compressor, and energizes a solenoid which adjusts the reversal valve to its air heating position. When such thermostat is satisfied, it deenergizes the solenoid of the reversal valve which then adjusts the reversal valve to its indoor air cooling position, and stops the compressor. A cooling control thermostat cycles the compressor during air cooling operation.

When such a heat pump is operating to heat indoor air with its outdoor coil operating as an evaporator, low outdoor temperatures may cause frost to form on the outdoor coil, and to melt such frost, it is the practice to use a pressurestat responsive to air pressure drop across the outdoor coil caused by the frost, to adjust the reversal valve to its air cooling position so as to operate the outdoor coil as a condenser for melting the frost. Then, when the frost has melted, a control responsive to the rise in refrigerant pressure within the outdoor coil, adjusts the reversal valve back to its indoor air heating position.

Thus, in such a heat pump, a reversal valve is adjusted to reverse the flow of refrigerant each time the heating control thermostat cycles, and when defrosting of the outdoor coil is starting and stopped.

This invention prevents the sudden rush of refrigerant from the high pressure coil into the compressor when the flow of refrigerant is reversed, by throttling the flow to the compressor at such times for periods of time sufficient for the pressures to have equalized.

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An object of this invention is to prevent the sudden rush of refrigerant from a high pressure coil through a refrigerant compressor into a low pressure coil when the flow of refrigerant is reversed.

This invention will now be described with reference to the annexed drawings, of which:

FIG. 1 is a diagrammatic view of a heat pump embodying this invention;

FIG. 2 is a simplified electrical circuit of the heat pump;

FIG. 3a is a diagrammatic view of one of the time delay relays used;

FIG. 3b is a diagrammatic view of another one of the time delay relays used;

FIG. 3c is a diagrammatic view of the switching relay used;

FIG. 3d is a diagrammatic view of the defrost relay used;

FIG. 3e is a diagrammatic view of the compressor motor starter relay, and

FIG. 3f is a diagrammatic view of the fan motor starter.

The discharge side of a conventional refrigerant compressor C, driven by an electric motor CM, is connected by discharge gas tube 10 to a conventional reversal valve RV which is connected by tube 11 to outdoor air coil 12, and by tube 13 to indoor air coil 14. The coils 12 and 14 are connected by a capillary tube 16 serving as a two-way expansion means, in which is connected a restrictor valve 17 such as is disclosed in my U.S. Patent No. 2,785,540, and which serves to reduce the refrigerant volume entering the outdoor air coil during air heating operation. The reversal valve RV is connected by suction gas tube 22 to the suction side of the compressor C, through the motor CM as is usual in hermetic compressors. The tube 22 contains a normally open valve TV, shunted by a capillary, throttling tube 30.

The reversal valve RV is connected at its ends through capillary tubes 23 and 24 to a pilot valve 25 which is connected by capillary tube 26 to the discharge tube 10. The pilot valve 25 is adjusted by a solenoid RVSOL to route discharge gas to one side of or the other side of a piston which is not shown, for moving the piston in opposite directions for adjusting the valve RV to indoor air cooling or indoor air heating positions. When the solenoid is energized, it adjusts the valve RV to its air heating position, and when the solenoid is deenergized, it adjusts the valve RV to its air cooling position.

A fan OF driven by an electric motor FM, moves outdoor air over the coil 12. A conventional defrost initiating control D.C. responds to air pressure drop across the coil 12, and has a normally open switch DCS which closes when the formation of frost on the coil 12 reduces the air flow thereover a substantial amount. A conventional defrost limiting control DLC responds to refrigerant pressure within the coil 12, and has a switch DLCS which opens when the pressure within the coil 12 rises when frost has melted therefrom.

The compressor motor CM is connected through switch CMRS of compressor motor starter relay CMR to electric supply lines L1 and L2. The fan motor FM is connected through switch FMRS of fan motor starter relay FMR to the supply lines. The starter relay CMR is connected through switch CTS of cooling control thermostat CT to the supply lines. The starter relay FMR is con-

connected through the switch CTS and normally closed switch DRS1 of defrost relay DR to the supply lines. Switch HTS1 of heating control thermostat HT is connected to the switch CTS where it connects to the starter relays CMR and FMR. The reversal valve solenoid RVSOL and switching relay SR are connected in parallel, and are connected through switch HTS2 of the thermostat HT and normally closed switch DRS2 of the defrost relay DR to the supply lines.

The defrost relay DR is connected through the switch DCS of the defrost control DC, and the switch DLCS to the supply lines. Switch DRS3 of the relay DR is shunted across the switch DCS.

Time delay relay 1TDR has an electromagnetic coil 32 connected through switch SRS1 of the switching relay SR to the supply lines, and has a heater resistor 31 connected through switch 1TDRS2 of the relay 1TDR to the supply lines. The relay 1TDR has a bimetallic switch 1TDRS3 exposed to heat from the resistor 31 when the latter is energized, and which warps closed when heated by the resistor 31. The relay 1TDR has a switch 1TDRS1 which opens and a switch 1TDRS2 which closes when the coil 32 is energized.

Time delay relay 2TDR has an electromagnetic coil 34 connected through switch SRS2 of the relay SR to the supply lines, and has a heater resistor 35 connected through switch 2TDRS2 to the supply lines. The relay 2TDR has a bimetallic switch 2TDRS3 exposed to heat from the resistor 35 when the latter is energized, and which warps closed when heated by the resistor 35. The relay 2TDR has a switch 2TDRS1 which closes and a switch 2TDRS2 which opens when the coil 34 is energized.

The valve TV in the suction tube 22 is closed and opened by a solenoid TVSOL when the latter is deenergized and energized respectively. The solenoid TVSOL is connected in series with normally closed switch 1TDRS1 of the relay 1TDR and the normally closed switch 1TDRS3 of the relay 2TDR to the supply lines L1 and L2. Normally open switch 1TDRS3 of the relay 1TDR is connected in parallel with the switch 1TDRS1. Normally open switch 2TDRS1 of the relay 2TDR is connected in parallel with the switch 2TDRS3.

Air cooling operation

When air cooling is required, the heating control thermostat HT is off, and the reversal valve RV is in its air cooling position. The cooling control thermostat CT closes its switch CTS which energizes the compressor motor starter relay CMR which closes its switch CMRS to start the compressor motor CM. The switch CTS also energizes the fan motor starter relay FMR through the normally closed switch DRS1 of the defrost relay DR. The relay FMR closes its switch FMRS to start the fan motor FM. Discharge gas from the compressor C flows through the tube 10, the reversal valve RV and the tube 11 into the outdoor coil 12 operating as a condenser. Refrigerant liquid from the coil 12 flows through the capillary tube 16 and the restrictor valve 17 into the indoor coil 14 operating as an evaporator. Gas from the coil 14 flows through the tube 13, the reversal valve RV and the suction tube 22 to the suction side of the compressor. The valve TV in the suction tube 22 is open at this time. The thermostat CT cycles the compressor and fan motors.

Air heating operation

When air heating is required, the thermostat CT is, of course, off. The heating control thermostat HT closes its switches HTS1 and HTS2. The closed switch HTS1 energizes the compressor and fan motor starters CMR and FMR respectively, which close their switches CMRS and FMRS respectively, starting the compressor motor CM and the fan motor FM respectively. The closed switch HTS2 energizes the reversal valve solenoid RVSOL and the switching relay SR through the closed switch DRS2 of the defrost relay DR. The solenoid RVSOL

adjusts the reversal valve RV to its air heating position. The switching relay SR closes its switch SRS1 and opens its switch SRS2. The open switch SRS2 deenergizes the coil 34 of the relay 2TDR which opens its switch 2TDRS2 and closes its switch 2TDRS1. The open switch 2TDRS2 deenergizes the heater resistor 35 of the relay 2TDR, which cools so that the switch 2TDRS3 opens. The closed switch SRS1 of the switching relay SR energizes the coil 32 of the time delay relay 1TDR, which opens its switch 1TDRS1 and closes its switch 1TDRS2. The now open switch 1TDRS1 deenergizes the solenoid TVSOL which closes the valve TV in the suction tube 22.

Discharge gas from the compressor flows through the tube 10, the reversal valve RV and the tube 13 into the indoor coil 14 operating as a condenser. Liquid from the coil 14 flows through the capillary tube 16 and the restrictor valve 17 into the outdoor coil 12 operating as an evaporator. Gas from the coil 12 flows through the tube 11, the reversal valve RV, the suction tube 22 and the throttling tube 30 shunted across the valve TV, to the suction side of the compressor C. The throttling tube 30 prevents the sudden rush of high pressure gas from the coil 12 into the compressor at the moment of refrigerant reversal.

The closed switch 1TDRS2 energizes the heater resistor 31 of the relay 1TDR, which heats the switch 1TDRS3 causing it to close after a time interval sufficient for the refrigerant pressures to have rebalanced through the throttling tube 30, which interval may, for example, be from thirty to sixty seconds. The closed switch 1TDRS3 again energizes the solenoid TVSOL which again opens the valve TV, restoring the system to normal operation.

When the thermostat HT is satisfied, and opens its switches HTS1 and HTS2, the open switch HTS1 deenergizes the compressor and fan motors, and the open switch HTS2 deenergizes the reversal valve solenoid RVSOL which adjusts the reversal valve RV to its cooling position, and deenergizes the switching relay SR which opens its switch SRS1 and closes its switch SRS2. The open switch SRS1 deenergizes the coil 32 of the relay 1TDR, which opens its switch 1TDRS2 and closes its switch 1TDRS1. The open switch 1TDRS2 deenergizes the heater resistor 31 of the relay 1TDR, which cools, causing the switch 1TDRS3 to warp open.

The closed switch SRS2 energizes the coil 34 of the relay 2TDR, which opens its switch 2TDRS1 and closes its switch 2TDRS2. The open switch 2TDRS1 deenergizes the solenoid TVSOL which closes the valve TV in the suction tube 22, causing suction gas to flow through the throttling tube 30 for preventing the sudden rush of refrigerant from the coil 14 into the compressor C at the instant of reversal. The closed switch 2TDRS2 energizes the heater resistor 35 of the relay 2TDR. After a period of time sufficient for the pressures within the coils 14 and 12 to have rebalanced, heat from the resistor 35 causes the switch 2TDRS3 to warp closed, energizing the solenoid TVSOL which opens the valve TV, restoring the latter to its normal position.

Defrosting operation

When frost forms on the outdoor coil 12 when it is operating as an evaporator, at which time the thermostat HT would have closed its switches HTS1 and HTS2, the reduced air pressure drop across the coil 12 will cause the switch DCS to close and energize the defrost relay DR through the closed switch DLCS of the defrost limit control DLC. The relay DR opens its switches DRS1 and DRS2, and closes its switch DRS3. The open switch DRS1 deenergizes the fan motor starter FMR which opens its switch FMRS, stopping the fan motor FM. The closed switch DRS3 across the switch DCS, prevents the relay DR from being deenergized when the control DC is no longer effective as a result of the fan OF having stopped. The open switch DRS2 deenergizes the sole-

noid RVSOL which adjusts the reversal valve RV to its air cooling position so that the outdoor coil 12 can operate as a condenser for melting the frost. The open switch DRS2 also deenergizes the switching relay SR which opens its switch SRS1 and closes its switch SRS2. The open switch SRS1 deenergizes the coil 32 of the relay 1TDR, which opens its switch 1TDRS2 and closes its switch 1TDRS1. The open switch 1TDRS2 deenergizes the heater resistor 31 of the relay 1TDR, which cools, causing the switch 1TDRS3 to warp open.

The closed switch SRS2 energizes the coil 34 of the relay 2TDR, which opens its switch 2TDRS1 and closes its switch 2TDRS2. The open switch 2TDRS1 deenergizes the solenoid TVSOL which closes the valve TV in the suction line 22, causing suction gas to flow through the throttling tube 30. The closed switch 2TDRS2 energizes the heater resistor 35 of the relay 2TDR. After a period of time sufficient for the pressures within the coils 14 and 12 to have rebalanced, heat from the resistor causes the switch 2TDRS3 to warp closed, energizing the solenoid TVSOL which opens the valve TV, permitting unrestricted gas flow through the suction tube 22.

After the frost has melted from the coil 12, the resulting rise of refrigerant pressure within the coil 12 will cause the switch DLCS to open. This deenergizes the defrost relay DR, which closes its switches DRS1 and DRS2, and opens its switch DRS3. The closed switch DRS1 energizes the fan motor starter FMR which closes its switch FMRS which restarts the fan motor FM. The closed switch DRS2 energizes the solenoid RVSOL which adjusts the reversal valve back to its air heating position. The closed switch DRS2 also energizes the switching relay SR which closes its switch SRS1 and opens its switch SRS2. The open switch SRS2 deenergizes the coil 34 of the relay 2TDR which opens its switch 2TDRS2 and closes its switch 2TDRS1. The open switch 2TDRS2 deenergizes the heater resistor 34 of the relay 2TDR, after which the switch 2TDRS3 warps open. The closed switch SRS1 energizes the coil 32 of the relay 1TDR, which opens its switch 1TDRS1 and closes its switch 1TDRS2. The now open switch 1TDRS1 deenergizes the solenoid TVSOL which closes the valve TV in the suction line 22. The closed switch 1TDRS2 energizes the heater resistor 31 of the relay 1TDR, which heats the switch 1TDRS3 causing it to close after a time interval sufficient for the refrigerant pressures to have rebalanced through the throttling tube 30. The closed switch 1TDRS3 energizes the solenoid TVSOL which opens the valve TV, permitting free flow of gas through the suction tube 22.

It is seen that this invention provides that each time a reversal valve of a heat pump is adjusted by a thermostat, by a defrost initiating control, and by a defrost terminating control, the sudden rush of refrigerant from the high pressure coil that has been operating as a condenser, into the compressor is prevented by throttling the flow into the compressor until the pressures within the coils that have been operating as condenser and evaporator have had time to rebalance.

What is claimed is:

1. A heat pump comprising an indoor air coil, an outdoor air coil, a refrigerant compressor, a two-way expansion means and reversal valve means connected in a closed refrigeration circuit, said valve means being adjustable to a first position to route refrigerant from said compressor to said outdoor coil for operating said outdoor coil as a condenser, or to a second position to route refrigerant from said compressor to said indoor coil for operating said indoor coil as a condenser, means for adjusting said valve means from one of said positions to the other one of said positions, a normally open valve in said circuit, means forming a throttling passage connected across said normally open valve, time delay means, and means for successively closing and then reopening said normally open valve when said reversal valve means is

adjusted, said last mentioned means when reopening said valve including said time delay means.

2. A heat pump as claimed in claim 1 in which common means is provided for concurrently energizing said means for adjusting said valve means and said means for closing and reopening said normally open valve.

3. A heat pump as claimed in claim 1 in which means including a first solenoid is provided for adjusting said reversal valve means, in which a second solenoid is provided for closing and reopening said normally open valve, in which means is provided for energizing said first solenoid, and in which means including said last mentioned means is provided for energizing said second solenoid, said means for energizing said second solenoid including time delay means for deenergizing said second solenoid.

4. A heat pump as claimed in claim 3 in which said means for energizing said first solenoid includes a heat control thermostat.

5. A heat pump comprising an indoor air coil, an outdoor air coil, a refrigerant compressor, two-way expansion means and reversal valve means connected in a closed refrigeration circuit, said valve means being adjustable to a first position to route refrigerant from said compressor to said outdoor coil for operating said outdoor coil as a condenser, or to a second position to route refrigerant from said compressor to said indoor coil for operating said indoor coil as a condenser, means including a first solenoid for adjusting said valve means to said second position when said solenoid is energized and for adjusting said valve means to said first position when said solenoid is deenergized, a switching relay having a first switch which closes when said relay is energized and having a second switch which opens when said relay is energized, means including a heat control thermostat for energizing said solenoid and relay when said thermostat calls for heat, a normally open valve in said circuit, means forming a throttling passage connected across said normally open valve, a second solenoid for closing said normally open valve when said second solenoid is energized and for opening said normally open valve when said second solenoid is deenergized, means including said first switch, when closed, for energizing said second solenoid, said last mentioned means including time delay means for deenergizing said second solenoid, and means including said second switch, when closed, for energizing said second solenoid, said last mentioned means including time delay means for deenergizing said second solenoid.

6. A heat pump comprising an indoor air coil, an outdoor air coil, a refrigerant compressor, two-way expansion means and reversal valve means connected in a closed refrigeration circuit, said valve means being adjustable to a first position to route refrigerant from said compressor to said outdoor coil for operating said outdoor coil as a condenser, or to a second position to route refrigerant from said compressor to said indoor coil for operating said indoor coil as a condenser, means including a first solenoid for adjusting said valve means to said second position when said solenoid is energized and for adjusting said valve means to said first position when said solenoid is deenergized, a switching relay having a first switch which is closed when said relay is energized and having a second switch which is open when said relay is energized, a defrost relay, means including means responsive to a condition brought about by the formation of frost on said outdoor coil when said outdoor coil is operating as an evaporator with said indoor coil operating as a condenser, for energizing said defrost relay, said defrost relay having a normally closed switch which opens when said defrost relay is energized, means including a heat control thermostat and said switch of said defrost relay for energizing said solenoid and said switching relay when said thermostat calls for heat and when said last mentioned switch is closed, a normally open valve in said circuit, means forming a throttling passage connected

across said open valve, a second solenoid for closing said open valve when said second solenoid is energized and for opening said open valve when said second solenoid is deenergized, means including said first switch, when closed, for energizing said second solenoid, said last mentioned means including time delay means for deenergizing said second solenoid, and means including said second switch, when closed, for energizing said second solenoid, said last mentioned means including time delay means for deenergizing said second solenoid.

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