

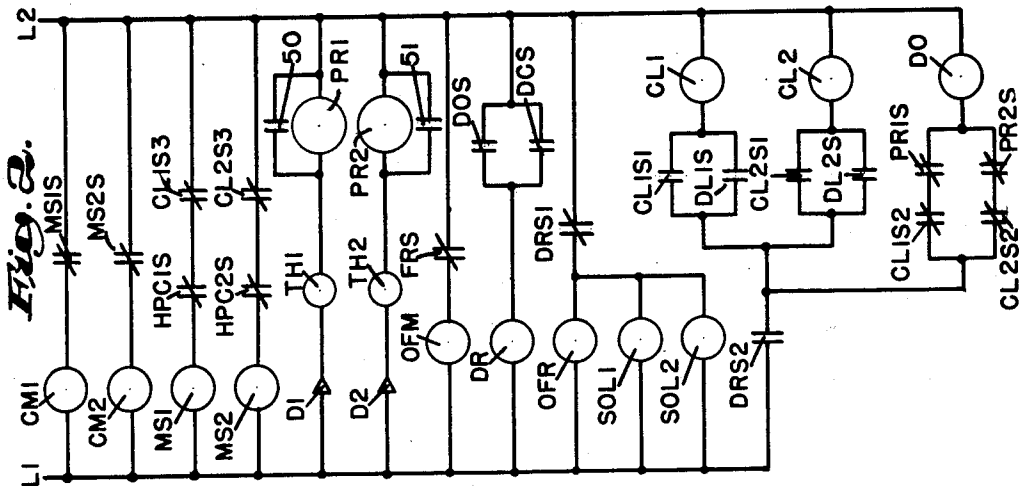
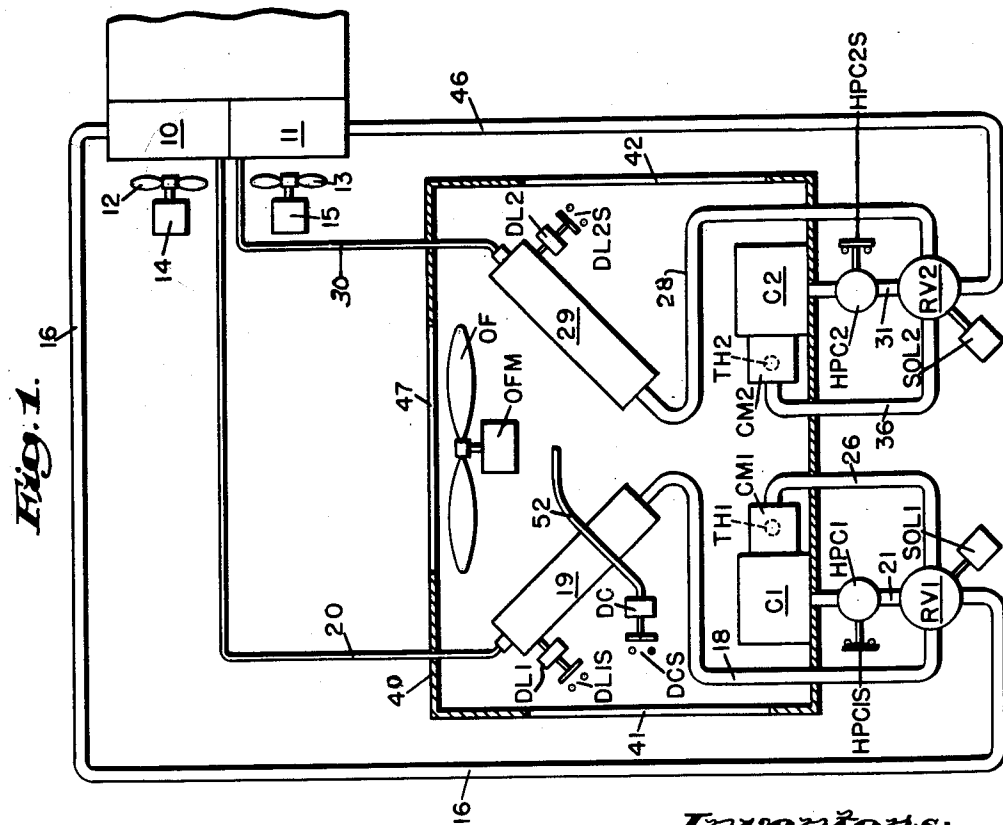
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DEFROST CONTROLS FOR HEAT PUMPS

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DEFROST CONTROLS FOR HEAT PUMPS

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This invention relates to heat pumps, and relates more particularly to controls for defrosting the outdoor coils of multiple system heat pumps having a common fan or fans for moving outdoor air over their outdoor coils.

An air conditioning system using a two system heat pump may be used for cooling indoor air in summer, and for heating indoor air in winter, one system being used for light loads, and both systems being used for heavy loads. The outdoor coils of the two systems may have a common fan or common fans for moving outdoor air over them. During indoor air heating, the indoor coils of the systems act as condenser coils, and their outdoor coils act as evaporator coils. Frost often forms on the outdoor coils when they are operating as evaporator coils at low outdoor temperatures, and for proper operation they should be defrosted. The frost may build up differently on the two outdoor coils, and the usual defrost controls have not proven satisfactory.

An object of this invention is to improve defrosting controls for multiple system heat pumps having common means for moving outdoor air over their outdoor coils.

Another object of this invention is to defrost the outdoor coils of a two system heat pump having common means for moving outdoor air over the outdoor coils, and to prevent the system having the first outdoor coil to finish defrosting from returning to normal operation until the outdoor coil of the other system has finished defrosting.

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

FIG. 1 is a diagrammatic view of a two system heat pump embodying this invention, the relays and electrical wiring used being omitted, and

FIG. 2 is a circuit schematic showing the relays and wiring used, and showing the switches which are open and which are closed when both systems are operating to heat indoor air.

Aligned, abutting, indoor coils 10 and 11 have fans 12 and 13 respectively, driven by electric motors 14 and 15 respectively, for moving indoor air to be conditioned over the coils 10 and 11 and into the space to be served. One end of the coil 10 is connected by tubing 16 to a refrigerant reversal valve RV1 which is connected by tubing 18 to one end of outdoor coil 19, the other end of which is connected by capillary tube 20 serving as a two-way expansion device, to the other end of the coil 10. The valve RV1 is connected by tubing 26 to the interior of electric motor CM1 of refrigerant compressor C1, which interior is connected to the suction side of the compressor C1 as is usual with hermetic compressors. The valve RV1 is connected by tubing 21 containing a high pressure cut-out HPC1, to the discharge side of the compressor C1. The valve RV1 is adjustable by solenoid SOL1 to route refrigerant from the compressor C1 through the tubing 18 to the outdoor coil 19, and from the latter through the capillary tube 20 to the indoor coil 10 when the latter is to act as an evaporator coil, and the outdoor coil 19 is to act as a condenser coil, or to route refrigerant from the compressor C1 through the tubing 16 to the indoor coil 10 and from the latter through the capillary tube 20 to the outdoor coil 19 when the latter is to act as an evaporator coil, and the indoor coil is to act as a condenser coil.

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One end of the indoor coil 11 is connected by tubing 46 to a refrigerant reversal valve RV2 which is connected by tubing 28 to one end of outdoor coil 29, the other end of which is connected by a capillary tube 30 serving as a two-way expansion device, to the other end of the coil 11. The valve RV2 is connected by tubing 31 containing a high pressure cut-out HPC2 to the discharge side of hermetic compressor C2 which is driven by electric motor CM2. The valve RV2 is connected by tubing 36 to the interior of the motor CM2, which interior is connected to the suction side of the compressor C2. The valve RV2 is adjustable by solenoid SOL2 to route refrigerant from the compressor C2 through the tubing 28 to the outdoor coil 29 and from the latter through the capillary tube 30 to the indoor coil 11 when the latter is to act as an evaporator coil and the outdoor coil 29 is to act as a condenser coil, or to route refrigerant from the compressor C2 through the tubing 46 to the indoor coil 11 and from the latter through the capillary tube 30 to the outdoor coil 29 when the latter is to act as an evaporator coil, and the indoor coil 11 is to act as a condenser coil.

The indoor coil 10, the outdoor coil 19, the compressor C1 and their associated components form one system of the heat pump, and the outdoor coil 29, the indoor coil 11, the compressor C2 and their associated components form the second system of the heat pump.

The outdoor coils 19 and 29 and the compressors C1 and C2 are supported within a cabinet having outdoor air inlets 41 and 42 in its ends, and having an air outlet 47 in its top. The coils 19 and 29 are slanted so that they diverge towards the outlet 47, and within the space between the coils below the outlet 47 is a fan OF driven by an electric motor OFM, which draws outdoor air through the inlets 41 and 42, passes this air over the coils 19 and 29, and discharges this air through the outlet 47.

The compressor motor CM1 is connected in series with normally closed switch MS1S of motor starter MS1 to A.C. electric supply lines L1 and L2. The compressor motor CM2 is connected in series with normally closed switch MS2S of motor starter MS2 to the supply lines L1 and L2. The motor starter MS1 is connected in series with normally closed switch HPC1S of the cut-out HPC1, and a normally closed switch CL1S3 of lockout relay CL1 to the supply lines L1 and L2. The motor starter MS2 is connected in series with normally closed switch HPC2S of the cut-out HPC2, and a normally closed switch CL2S3 of lockout relay CL2 to the supply lines.

The compressor motor CM1 has in contact with its windings a thermistor TH1 which is connected in series with a diode D1 and a protective relay PR1 shunted by capacitor 50, to the supply lines. The compressor motor CM2 has in contact with its windings a thermistor TH2 which is connected in series with a diode D2 and a protective relay PR2 shunted by capacitor 51, to the supply lines. The thermistors are of the type having a positive temperature coefficient of resistance. The relays PR1 and PR2 are normally energized, and when the resistances of the thermistors TH1 and TH2 are increased to values corresponding to motor overload, the relays PR1 and PR2 respectively are deenergized.

The outdoor fan motor OFM is connected in series with normally closed switch FRS of fan relay OFR to the supply lines.

The fan relay OFR and the solenoids SOL1 and SOL2 are connected in parallel, and are connected in series with a normally closed switch DRS1 of defrost relay DR to the supply lines.

A defrost control D.C. is connected by tube 52 to the air between the coils 19 and 29, and has a normally open switch DCS which closes when the air pressure between the coils decreases as a result of frost having formed

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on both of the coils. A defrost limit control DL1 is connected to the interior of the coil 19 so as to respond to refrigerant pressure therein, and has a normally open switch DL1S. A similar defrost limit control DL2 is connected to the interior of the coil 29 so as to respond to the refrigerant pressure thereon, and has a normally open switch DL2S. The switches DL1S and DL2S close when the pressures within the coils 19 and 29 respectively, increase to normal pressures of about 220-250 p.s.i. when the frost has been melted from them when they are operating as condenser coils. When the coils 19 and 29 are operating as evaporator coils, the pressures within them are insufficient to close the switches DL1S and DL2S, such pressure being, for example, at -10° F., only 16 p.s.i.

A normally deenergized defrost relay DR has a normally closed switch DRS1 and a normally open switch DRS2. The relay DR is connected in series with the switch DCS to the supply lines L1 and L2. The switch DCS is connected in parallel with normally open switch DOS of normally deenergized defrost operating relay DO.

The relay DO is connected in series with normally closed switch CL1S2 of normally deenergized lockout relay CL1, the normally closed switch PR1S of the normally energized protective relay PR1 and the normally open switch DRS2 of the defrost relay DR to the supply lines. The series connected switches CL1S2 and PR1S are connected in parallel with normally closed, series connected switches CL2S2 of normally deenergized lockout relay CL2 and the normally closed switch PR2S of the protective relay PR2.

The lockout relay CL1 is connected in series with its normally open switch CL1S1, connected in parallel with the normally open switch DL1S, and in series with the normally open switch DRS2 to the supply lines.

The lockout relay CL2 is connected in series with its normally open switch CL2S1, connected in parallel with the normally open switch DL2S, and in series with the normally open switch DRS2 to the supply lines.

Operation

In operation, it is assumed that an associated thermostat which is not shown, has turned both systems of the heat pump on, and that the outdoor coils 19 and 29 are operating as evaporator coils before substantial frost has formed on them. When substantial frost has formed on the coils 19 and 29, the resulting air pressure drop through them will cause the switch DCS to close and to energize the defrost relay DR which will open its switch DRS1 and will close its switch DRS2. The closing of the switch DRS2 energizes the defrost operating relay DO through the normally closed switches CL1S1, PR1S, CL2S2 and PR2S so that the relay DO closes its switch DOS which establishes a holding circuit maintaining the relay DR energized if one of the coils 19 or 29 finishes defrosting before the other. The opening of the switch DRS1 deenergizes the outdoor fan relay OFR and the solenoids SOL1 and SOL2. The relay OFR opens its switch OFRS which stops the fan motor OFM. The solenoids SOL1 and SOL2 adjust the reversal valves RV1 and RV2 respectively, to operate the outdoor coils 19 and 29 respectively, as condenser coils for melting the frost thereon.

Assume that the coil 19 completes its defrosting first so that the pressure within it increases and closes the switch DL1S. The now closed switches DL1S and DRS2 connect the lockout relay CL1 to the supply lines L1 and L2, energizing the relay CL1 which closes its switch CL1S1 which establishes a holding circuit maintaining the relay CL1 energized in case the switch DL1S opens. The relay CL1 opens its switches CL1S2 and CL1S3. The now open switch CL1S2 cannot deenergize the relay DO since the switches CL2S2 and PRS2 are closed at this time and energize the relay DO. The now open switch

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CL1S3 deenergizes the motor starter MS1 which opens its switch MS1S, stopping the compressor motor CM1 and discontinuing the defrosting of the outdoor coil 19. The defrosting of the outdoor coil 29 continues since as described in the foregoing the relay DO is energized through the closed switches CL2S2 and PRS2.

When the outdoor coil 29 is completely defrosted, the pressure within it increases and closes the switch DL2S. The now closed switches DL2S and DRS2 connect the lockout relay CL2 to the supply lines L1 and L2, energizing the relay CL2 which closes its switch CL2S1 which establishes a holding circuit maintaining the relay CL2 energized in case the switch DL2S opens. The relay CL2 opens its switches CL2S2 and CL2S3. The now open switch CL2S3 deenergizes the motor starter MS2 which opens its switch MS2S, stopping the compressor motor CM2, and discontinuing the defrosting of the outdoor coil 29. The now open switch CL2S2 deenergizes the relay DO which opens its switch DOS, deenergizing the defrost relay DR which recloses its switch DRS1 to energize the fan relay OFR and the solenoids SOL1 and SOL2. The fan relay closes its switch OFRS which restarts the outdoors fan motor OFM. The solenoids operate the reversal valves RV1 and RV2 to restore the outdoor coils 19 and 29 to operation as evaporator coils. The now deenergized defrost relay DR also opens its switch DRS2, disconnecting the relays CL1, CL2 and DO from the supply line L1. The two systems of the heat pump are now back in normal indoor air heating operation.

What is claimed, is:

1. An air conditioning system comprising a first refrigerant compressor, a first electric motor for driving said compressor, a first indoor coil, a first outdoor coil, means including a first reversal valve connecting said compressor to said coils, a first solenoid for adjusting said valve to operate said outdoor coil as an evaporator coil or as a condenser coil, a second refrigerant compressor, a second electric motor for driving said second compressor, a second indoor coil, a second outdoor coil, means including a second reversal valve connecting said second compressor to said second indoor and outdoor coils, a second solenoid for adjusting said second valve to operate said second outdoor coil as an evaporator coil or as a condenser coil, a common fan for moving outdoor air over said outdoor coils, a third electric motor for driving said fan, a defrost control responsive to air pressure drop across said outdoor coils, said control having a normally open switch which closes when there is a predetermined air pressure drop across said outdoor coils, a first limit control responsive to refrigerant pressure within said first outdoor coil, said limit control having a normally open switch which closes when there is a predetermined pressure within said first outdoor coil, a second limit control responsive to refrigerant pressure within said second outdoor coil, said second limit control having a normally open switch which closes when there is a predetermined pressure within said second outdoor coil, a normally deenergized defrost relay having a normally open switch and a normally closed switch, electric supply connections, means including said switch of said defrost control for connecting said relay to said connections, means including said normally closed switch of said defrost relay for connecting said solenoids and said third motor to said connections, a normally deenergized operating relay having a normally open switch connected in parallel with said switch of said defrost control, a first lockout relay having a normally open switch and having a pair of normally closed switches, a second lockout relay having a normally open switch and having a pair of normally closed switches, means including said open switch of said defrost relay and said open switch of said first lockout relay in parallel with said switch of said first limit control for connecting said first lockout relay to said connections, means including said open switch of said defrost relay and said open

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switch of said second lockout relay in parallel with said switch of said second limit control for connecting said second lockout relay to said connections, means including said open switch of said defrost relay and one of said closed switches of said first lockout relay connected in parallel with one of said closed switches of said second lockout relay for connecting said operating relay to said connections, means including the other closed switch of said first lockout relay for connecting said first motor to said connections, and means including the other closed switch of said second lockout relay for connecting said second motor to said connections.

2. An air conditioning system comprising a first refrigerant compressor, a first electric motor for driving said compressor, a first indoor coil, a first outdoor coil, means including a first reversal valve connecting said compressor to said coils, a first solenoid for adjusting said valve to operate said outdoor coil as an evaporator coil or as a condenser coil, a second refrigerant compressor, a second electric motor for driving said second compressor, a second indoor coil, a second outdoor coil, means including a second reversal valve connecting said second compressor to said second indoor and outdoor coils, a second solenoid for adjusting said second valve to operate said second outdoor coil as an evaporator coil or as a condenser coil, a common fan for moving outdoor air over said outdoor coils, a third electric motor for driving said fan, a defrost control responsive to air pressure drop across said outdoor coils, said control having a normally open switch which closes when there is a predetermined air pressure drop across said outdoor coils, a first limit control responsive to refrigerant pressure within said first outdoor coil, said limit control having a normally open switch which closes when there is a predetermined pressure within said first outdoor coil, a second limit control responsive to refrigerant pressure within said second outdoor coil, said second limit control having a normally open switch which closes when there is a predetermined pressure within said second outdoor coil, a normally deenergized defrost relay having a normally open switch and a normally closed switch, electric supply connections, means including said switch of said defrost control for connecting said relay to said connections, means including said normally closed switch of said relay for connecting said solenoids and said third motor to said connections, a normally deenergized operating relay having a normally open switch connected in parallel with said switch of said defrost control, a first lockout relay having a normally open switch and having a pair of normally closed switches, a second lockout relay having a normally open switch and having a pair of normally closed switches, means including said open switch of said defrost relay and said open switch of said first lockout relay in parallel with said switch of said first limit control for connecting said first lockout relay to said connections, means including said open switch of said defrost relay and said open switch of said second lockout relay in parallel with said switch of said second limit control for connecting said second lockout relay to said connections, a first protective relay having a normally closed switch, means including a thermistor exposed to the temperature of said first motor for connecting said protective relay to said connections, a second protective relay having a normally closed switch, means including a second thermistor exposed to the temperature of said second motor for connecting said second protective relay to said connections, means including said open switch of said defrost relay and one of said closed switches of said first lockout relay and said switch of said first protective relay in series connecting said operating relay to said connections, means connecting one of said closed switches of said second lockout relay and said switch of said second protective relay in series with each other and in parallel with the series connection of said one closed switch of said first lockout

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relay and said switch of said first protective relay, means including the other closed switch of said first lockout relay for connecting said first motor to said connections, and means including the other closed switch of said second lockout relay connecting said second motor to said connections.

3. An air conditioning system comprising a first refrigerant compressor, a first electric motor for driving said compressor, a first indoor coil, a first outdoor coil, means including a first reversal valve connecting said compressor to said coils, a first solenoid for adjusting said valve to operate said outdoor coil as an evaporator coil or as a condenser coil, a second refrigerant compressor, a second electric motor for driving said second compressor, a second indoor coil, a second outdoor coil, means including a second reversal valve connecting said second compressor and said second coils, a second solenoid for adjusting said second valve to operate said second outdoor coil as an evaporator coil or as a condenser coil, a common fan for moving outdoor air over said outdoor coils, a third electric motor for driving said fan, a defrost control responsive to air pressure drop across said outdoor coils, said control having a normally open switch which closes when there is a predetermined air pressure drop across said outdoor coils, a first limit control responsive to refrigerant pressure within said first outdoor coil, said limit control having a normally open switch which closes when there is a predetermined pressure within said first outdoor coil, a second limit control responsive to refrigerant pressure within said second outdoor coil, said second limit control having a normally open switch which closes when there is a predetermined pressure within said second outdoor coil, a normally deenergized defrost relay having a normally open switch and a normally closed switch, electric supply connections, means including said closed switch of said defrost relay for connecting said solenoids and said third motor to said connections, means including said switch of said defrost control for connecting said relay to said connections, means including a first normally deenergized lockout relay having a normally closed switch connecting said first motor to said connections, means including a second normally deenergized lockout relay having a normally closed switch connecting said second motor to said connections, means including said open switch of said defrost relay and said switch of said first limit control connecting said first lockout relay to said connections, and means including said open switch of said defrost relay and said switch of said second limit control connecting said second lockout relay to said connections.

4. An air conditioning system comprising a first refrigerant compressor, a first electric motor for driving said compressor, a first indoor coil, a first outdoor coil, means including a first reversal valve connecting said compressor to said coils, a first solenoid for adjusting said valve to operate said outdoor coil as an evaporator coil or as a condenser coil, a second refrigerant compressor, a second indoor coil, a second outdoor coil, means including a second reversal valve connecting said second compressor to said second coils, a second solenoid for adjusting said second valve to operate said second outdoor coil as an evaporator coil or as a condenser coil, a common fan for moving outdoor air over said outdoor coils, a third electric motor for driving said fan, a defrost control responsive to air pressure drop across said outdoor coils, said control having a normally open switch which closes when there is a predetermined pressure drop across said outdoor coils, a first limit control responsive to refrigerant pressure within said first outdoor coil, said limit control having a normally open switch which closes when there is a predetermined pressure within said first outdoor coil, a second limit control responsive to refrigerant pressure within said second outdoor coil, said second limit control having a normally open switch which closes when there is a predetermined pressure within said second outdoor coil, a normally deenergized defrost relay having a

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normally open switch and a normally closed switch, electric supply connections, means including said switch of said defrost control connecting said defrost relay to said connections, means including said closed switch of said defrost relay connecting said solenoids and said third motor to said connections, means including a first normally deenergized lockout relay having a normally closed switch connecting said first motor to said connections, means including a normally deenergized lockout relay having a closed switch connecting said second motor to said connections, means including said open switch of said defrost relay and said switch of said first limit control connecting said first lockout relay to said connections, means including said open switch of said defrost

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relay and said switch of said second limit control connecting said second lockout relay to said connections, said first lockout relay having a normally open switch connected across said switch of said first limit control, and said second lockout relay having a normally open switch connected across said switch of said second limit control.

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