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HEAT PUMP

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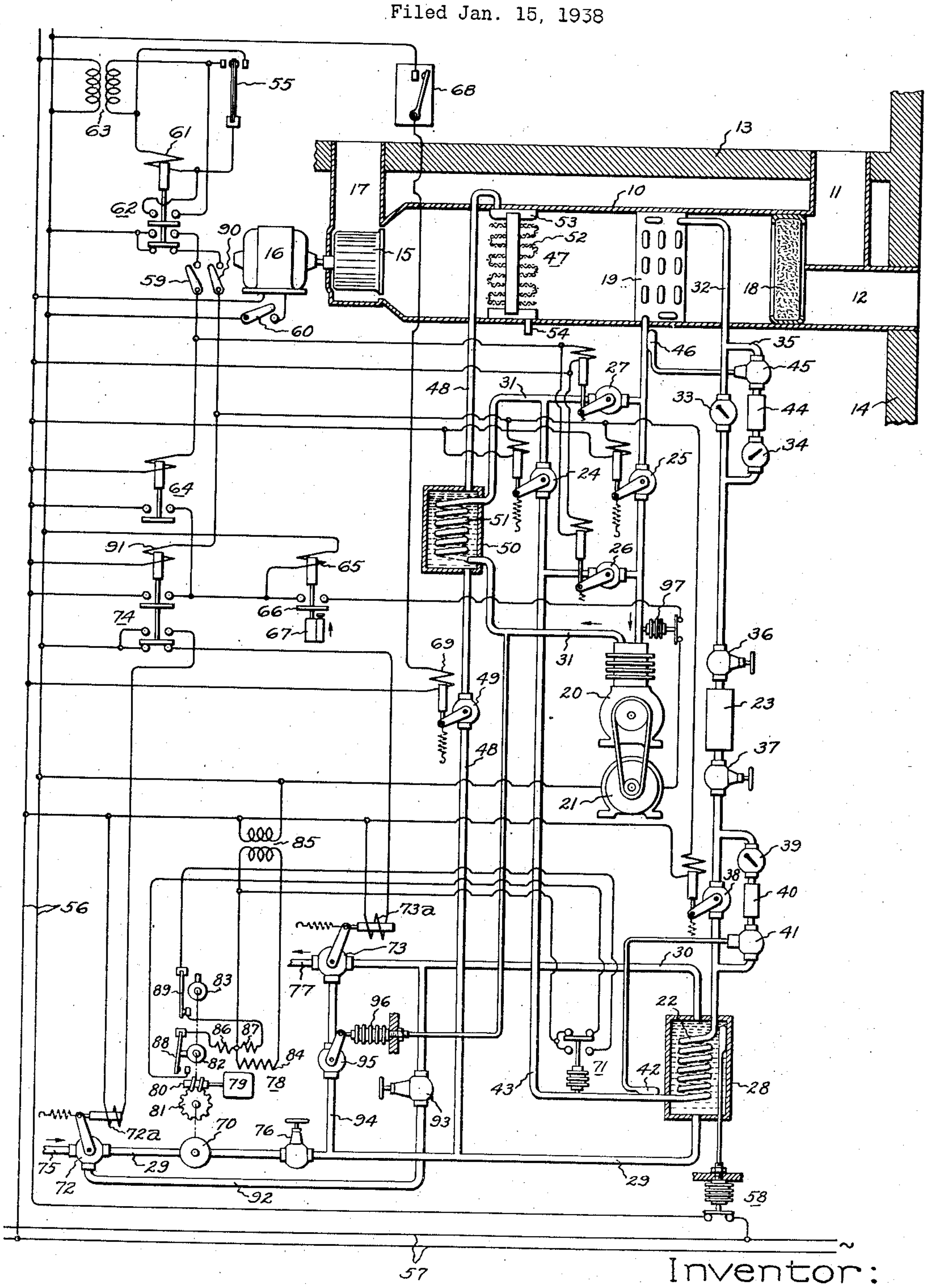

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HEAT PUMP

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My invention relates to systems for conditioning the air within rooms or enclosures, and particularly to such systems which utilize reversible refrigerating machines to supply both heating and cooling medium.

Reversed cycle refrigerating machines or heat pumps, are frequently employed to supply the heating units of air conditioning systems. Heat pumps require a suitable source of heat such as well water, water from city mains, or outdoor air. In such systems, particularly those using city water, it is desirable to utilize the water as economically as possible since it is necessary to circulate considerable quantities of water whenever the refrigerating machine is in operation. Accordingly, it is an object of my invention to provide an air heating system utilizing a reversed cycle refrigerating machine and having an improved arrangement for controlling the supply of fluid constituting the heat source.

Another object of my invention is to provide an air conditioning system utilizing a refrigerating machine for pumping heat between a fluid medium and the air within an enclosure to be conditioned to thereby either heat or cool the air within the enclosure, which system includes an improved arrangement for controlling the supply of fluid medium.

Further objects and advantages of my invention will become apparent as the following description proceeds, and the features of novelty which characterize my invention will be pointed out with particularity in the claims annexed to and forming a part of this specification.

For a better understanding of my invention, reference may be had to the accompanying drawing, the single figure of which shows diagrammatically an air conditioning system embodying my invention.

Referring now to the drawing, I have shown an air conditioning system including a duct 10 connected to receive air from an enclosure to be conditioned through an inlet 11 and fresh air from outside the enclosure through an inlet 12, the wall of the enclosure being indicated at 13 and the outside wall of the building at 14. A fan 15 driven by a motor 16 is provided to circulate air through the duct 10, and into the enclosure or room to be conditioned through an outlet 17. Dust and particles of foreign matter are removed by a filter 18 arranged at the entrance of the duct 10. In order to control the temperature of the air passing through the duct 10, I provide a heat exchange element 19 arranged within the duct and comprising a coil connected in the refrigerant circuit of a reversible refrigerating machine. The refrigerating machine includes a compressor 20 driven by a motor 21, a heat exchanger or coil 22 which may serve either as a condenser or evaporator depending upon the direction of flow of refrigerant in the circuit, and a liquid receiver 23. The heat exchanger 19 is connected as the second heat exchange element in the refrigerating circuit, and may be employed either as a condenser or an evaporator depending upon the direction of flow of refrigerant in the circuit. A plurality of normally closed spring biased solenoid valves 24, 25, 26 and 27 are provided in order to control the direction of flow of refrigerant in the refrigerating circuit. These valves are arranged to operate in series, the valves 24 and 25 being opened and the valves 26 and 27 being closed when it is desired to cool the air passing through the duct 10, and the valves 26 and 27 being opened and the valves 24 and 25 being closed when it is desired to heat the air passing through the duct 10. A supply of fluid medium, such as well water or water from the city mains, is circulated over the heat exchanger 22 through a suitable casing 28, in order to supply heat thereto when the refrigerating machine is used to heat the air in the duct 10, and to absorb heat from the heat exchanger when the refrigerating machine is used to cool the air in the duct 10. Water is supplied to the casing 28 through pipes 29 and 30, the direction and rate of flow of the water being controlled in a manner to be hereinafter described.

When the refrigerating machine is employed to heat the air passing through the duct 10, the compressed refrigerant is discharged from the condenser through a conduit 31. The valves 26 and 27 being opened and the valves 24 and 25 closed, the hot compressed refrigerant flows through the coils of the heat exchanger 19 and heats the air in the duct. The refrigerant is thereby cooled and liquefied and flows out through a connection 32 and a check valve 33 to the liquid receiver 23. A check valve 34 is provided to prevent flow of the refrigerant through a conduit 35 by-passing the valve 33. Manual shut-off valves 36 and 37 on either side of the receiver 23 are maintained open whenever the refrigerating machine is in use. A normally closed solenoid operated valve 38 below the receiver 23 remains closed during the heating operation and the liquid refrigerant flows through a check valve 39 in a by-pass around the valve 38 and through a scale trap 40 to a thermostatic expansion valve 41. The thermostatic expansion valve is provided with a thermostatic element 42 adjacent the outlet of the coil 22 on the side opposite the valve 41. The valve 41, therefore, controls the flow of liquid refrigerant to the heat exchanger 22 which acts as an evaporator. Refrigerant within the coil 22 is vaporized by the absorption of heat from the water circulating through the casing 28 and the vaporized refrigerant returns through a conduit 43 and the open valve 26 to the intake of the compressor.

When the refrigerating machine is operated to cool the air passing through the duct 10, the valves 24 and 25 are opened, and the hot compressed refrigerant flows through the conduit 31 and valve 24 to the coil 22 through conduit 43. The refrigerant is cooled and condensed in the coil 22 and flows through the now open valve 38 to the liquid receiver 23, the check valve 39 preventing the flow of refrigerant through the scale trap 40. The liquid refrigerant flows from receiver 23 through check valve 34 and a scale trap 44 to a thermostatic expansion valve 45 which controls the flow of refrigerant to the coil 19, the valve 45 being provided with a thermostatic element 46 adjacent the outlet side of the coil 19. The check valve 33 prevents the liquid refrigerant by-passing the scale trap 44 and the thermostatic expansion valve 45. The liquid refrigerant in the coil 19 absorbs heat from the air passing through the duct 10 and cools the air, the refrigerant being thereby vaporized. The vaporized refrigerant returns to the compressor 20 through open valve 25.

In order to humidify the air passing through the duct 10 when it is being heated, I provide a humidifier 47. Water is admitted to the humidifier 47 through a pipe 48 under control of a solenoid valve 49. In order to heat the water supplied to the humidifier 47 I provide a suitable enclosure such as a casing 50 around a coil 51 formed in the discharge conduit 31 of the compressor. The water flowing through the pipe 48 is therefore heated by the hot compressed gases flowing through the conduit 31. Water which flows to the humidifier 47 is distributed over a screen 52 from a pan 53, any excess water which has not been absorbed in the air being removed from the duct 10 through a drain 54.

In order to control the operation of the refrigerating machine, I provide a thermostat 55, which may be utilized to maintain the desired temperature within the enclosure during both the heating and cooling operations. Power for driving the motors 16 and 21 and for energizing the control circuits of the system is supplied through lines 56 which are connected to supply lines 57, a normally closed switch 58 being provided in one side of the lines 56 to deenergize the power and control circuits whenever the temperature of the water circulating over the exchanger 22 is reduced sufficiently to endanger freezing thereof within the casing 28.

When it is desired to heat the air passing through the duct 10, the control and power circuits are prepared by closing manual switches 59 and 60, the switch 59 preparing the thermostatic control and the switch 60 starting the motor 16 to drive the fan 15. When there is a demand for heat, the thermostat 55 engages its left-hand contact to connect a coil 61 of a relay 62 across the secondary of a transformer 63, the primary of which is connected across the lines 56. The relay 62 is thereby picked up, the upper arm closing a holding circuit for the coil 61, and the lower arm connecting the coils of solenoid valves 26 and 27 across lines 56 to open the valves, and also energize and pick-up a switch 64 which energizes a coil 65 of a time delay switch 66. The time delay switch closes after a predetermined interval determined by a dashpot or other suitable time delay mechanism 67 and, on closing, starts the motor 21 to drive the refrigerating machine. The time delay mechanism is provided so that the solenoid valves 26 and 27 will be opened before the compressor 20 is started. The refrigerating machine, therefore, operates to supply hot compressed refrigerant to the coil 19 to heat the air passing through the duct 10 in the manner described above. When the thermostat 55 is satisfied due to the heating of the air of the enclosure to a predetermined temperature, it engages its right-hand contact and short circuits the coil 61 thereby causing the relay 62 to drop out and deenergize the control and motor circuits thereby stopping the supply of hot refrigerant to the coil 19. During the heating of the air in the enclosure, should there be a demand for an increase in humidity, a humidostat 68 will close its contact to connect a coil 69 across the lines 56. Coil 69 opens the valve 49 to supply water to the humidifier 47, the water being heated by the coil 51 during its passage through the casing 50. When the humidostat 68 is satisfied, it opens to break the circuit of the coil 69 and stop the supply of water to the humidifier.

The heat supplied to the air passing through the duct 10 is pumped by the refrigerating machine from the water passing through the casing 28, the rate of flow of water being controlled by a valve 70 in response to the pressure within the return or suction line 43 of the compressor, a pressure responsive switch 71 being employed for this purpose. The direction of the flow of water through the casing 28 is controlled by three-way solenoid valves 72 and 73, and the position of these valves is determined by the lower arm of a switch 74. The valves 72 and 73 are provided with actuating coils 72*a* and 73*a* respectively. The direction of flow of water through the casing 28 is maintained in counterflow to the direction of refrigerant flowing through the coil 22, so that there is a maximum efficiency of heat exchange between the water and refrigerant during both the heating and cooling operations. The valves 72 and 73 reverse the water circuit when the refrigerant circuit is reversed. When the switch 74 is in its drop out position, which is its position during the heating operation, the coil 73*a* of the solenoid of the valve 73 is connected across the lines 56 and the coil 72*a* of the valve 72 is not energized. The coils 72*a* and 73*a* cannot be energized simultaneously. During the heating operation with the coil 73*a* energized, water flows from a supply pipe 75 through the valve 72 to the pipe 29, the valve 70 being connected in the pipe 29 to control the flow of water therethrough. A manual valve 76 is provided to shut off the flow of water through the pipe 29 if desired. Water flows from the pipe 29 through the casing 28 to the pipe 30 and thence through the valve 73 to a return pipe 77. The pressure control switch 71 cooperating with a control mechanism 78 of the valve 70 maintains a predetermined pressure within the evaporator coil 22. The control mechanism 78 includes a reversible induction motor 79 of the shaded pole type. The motor drives the valve through a worm and pinion 80 and 81 respectively. Cams 82 and 83 are provided to operate limit switches to determine the limiting position of the valve 70 at either end of its movement. The motor 79 is provided with a main or driving winding 84 connected across the secondary of a transformer 85. Shaded pole windings 86 and 87 are provided to determine the direction of rotation of the motor. As long as both the windings 86 and 87 are open circuited, the motor remains stationary. As soon as one of the windings 86 or 87 is short-circuited, torque is developed and the motor rotates the valve until the short circuit is opened by the pressure switch or until one of the cams 82 and 83 operates its corresponding one of limit switches 88 and 89 respectively. The pressure responsive switch 71 operates to short-circuit the windings 86 and 87 depending upon the pressure within the conduit 43. When the pressure increases to a predetermined value, the switch 71 closes its upper set of contact and short-circuits coil 86 causing the valve 70 to rotate in a direction to decrease the flow of water through the casing 28. When the pressure within the conduit 43 decreases to a predetermined low value, the switch 71 closes its lower set of contacts to short the coil 87 and cause the valve 70 to rotate in a direction to increase the flow of water through the casing 28. It is, therefore, evident that by selecting the desired range of limits for the operation of the switch 71, the pressure within the evaporator 22 may be maintained within any desired range and thus limit the load on the compressor. The required supply of heat to the evaporator 22 is thereby maintained with a minimum flow of water through the casing 28 for whenever there is more water flowing through the casing than required, the supply is limited by operation of the valve 70. More efficient operation of the refrigerating machine is obtained because the temperature of the evaporator is not permitted to become too low, and more economical operation is obtained by not permitting the temperature of the evaporator to become too high. Should the water in the casing 28 for any reason, such as the failure of the valve 70, be reduced to a predetermined minimum, the thermostatic switch 58 will open to deenergize the motor and control circuits and stop the operation of the system.

When it is desired to cool the air within the enclosure, a manual switch 90 is closed, switch 59 being open, and the switch 60 is closed in order to drive the motor 16. The closing of the switch 90 prepares the motor and control circuits for the cooling operation. During the cooling operation, the relay 62 falls to its drop out position when there is a demand for cooling, since the thermostat 55 engages its right-hand contact whenever the room temperature reaches a predetermined high value and short-circuits the coil 61. On a demand for cooling, when the relay 62 is in its drop out position, the coils of solenoid valves 24 and 25 are connected across the lines 56 through the switch 90 and the bottom arm of the relay 62, and the valves 24 and 25 are thereby opened. Valves 26 and 27 cannot be energized since the switch 59 is open. An operating coil 91 of switch 74 is also energized and the switch 74 is picked up. The upper arm of the switch 74 closes a circuit of the coil 65 and the time delay switch 66 closes after an interval to start the motor 21 and operate the refrigerating machine to supply liquid refrigerant to the heat exchange element 19. The lower arm of the switch 74 in its pick-up position energizes the coil 72a and opens the circuit of the coil 73a, thereby reversing the positions of the valves 72 and 73. Water from the supply pipe 75 flows through the valve 72 and through a pipe 92 to the pipe 30. A manual valve 93 is provided in the pipe 92 to close the pipe and prevent the flow of water therethrough when desired. The valve 73 is in position to prevent the flow of water therethrough from the pipe 30 and the water flows from the pipe 30 to the casing 28 and thence through the pipe 29 and a pipe 94 to the outlet 77 through the valve 73. In order to control the flow of water through the pipe 94, I provide a valve 95 operated by a pressure element 96 which is in communication with the discharge pipe 31 of the compressor 20. The valve 95 is, therefore, controlled in response to the head pressure of the compressor, the flow of water through the casing 28 being increased on a rise in head pressure and vice versa. It will be noted that the water flowing through the casing 28 flows in the opposite direction from that of the refrigerant flowing through the coil 22. While the refrigerating machine is operating to cool the air passing through the duct 10, compressed refrigerant is discharged through the conduit 43 and the pressure element 71 is thereby maintained at a relatively high pressure. The upper contacts will then be closed and the motor 79 will operate until the cam 82 opens the circuit of the coil 86 thereby preventing further rotation of the motor and holding it in its limiting position pending a subsequent reduction of the pressure in the element 71. The motor 79 is, therefore, not operated during the cooling operation.

During the operation of the refrigerating machine, should the back pressure at any time be reduced to a predetermined minimum, a pressure responsive switch 97 will operate to open its contacts and stop further operation of the motor 21 until the pressure has again increased to normal. This is the type of back pressure control commonly employed in refrigerating machines to prevent excessive low pressures and temperatures.

From the foregoing, it is evident that I have provided an air conditioning system utilizing a refrigerating machine as a heat pump to either heat or cool the air within an enclosure and that the system is so arranged as to provide the most efficient use of the cooling medium which is utilized to cool the condenser during the cooling operation or to supply heat to the refrigerating machine during the heating operation.

While I have described a particular embodiment of my invention in connection with an air conditioning system, other modifications will be apparent to those skilled in the art. I do not, therefore, desire my invention to be limited to the particular construction shown and described and I intend in the appended claims to cover all modifications within the spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A fluid heating system including a reversed cycle refrigerating machine having a compressor and an evaporator and a condenser, said compressor being arranged to withdraw vaporized refrigerant from said evaporator, means for circulating a fluid over said condenser to heat said fluid, means for circulating a fluid over said evaporator to supply heat to said system, and means dependent upon the pressure of the vapor-

ized refrigerant withdrawn from said evaporator for controlling the rate of flow of said heat supplying fluid over said evaporator to limit the load on said compressor.

2. A system for heating the air within an enclosure including a duct, a reversed cycle refrigerating machine having a compressor and an evaporator and a condenser, said compressor being arranged to supply compressed refrigerant to said condenser and to withdraw vaporized refrigerant from said evaporator, means for circulating air through said duct and into said enclosure, means including said condenser for heating the air circulated through said duct, means for circulating a fluid over said evaporator to supply heat to said system, and means dependent upon the pressure of vaporized refrigerant withdrawn from said evaporator for controlling the rate of flow of said fluid over said evaporator to limit the load on said compressor.

3. A system for conditioning the air within an enclosure including a duct, a reversed cycle refrigerating machine having a compressor and an evaporator and a condenser, said compressor being arranged to supply compressed refrigerant to said condenser and to withdraw vaporized refrigerant from said evaporator, means for circulating air through said duct and into said enclosure, means including said condenser for heating the air circulated through said duct, means for circulating a fluid over said evaporator to supply heat to said system, means dependent upon the pressure of vaporized refrigerant withdrawn from said evaporator for controlling the rate of flow of said fluid over said evaporator to limit the load on said compressor, means for reversing the operation of said refrigerating machine to supply liquid refrigerant to said condenser to cool the air circulating through said duct and to supply heat to the fluid circulated over said evaporator, and means dependent upon the pressure of refrigerant discharged by said compressor for controlling the flow of said fluid over said evaporator to limit the load on said compressor when the operation of said refrigerating machine is reversed.

4. A system for conditioning the air within an enclosure including a duct, a reversed cycle refrigerating machine having a compressor and an evaporator and a condenser, said compressor being arranged to supply compressed refrigerant to said condenser and to withdraw vaporized refrigerant from said evaporator, means for circulating air through said duct and into said enclosure, means including said condenser for heating the air circulated through said duct, means for circulating a fluid over said evaporator to supply heat to said system, means dependent upon the pressure of vaporized refrigerant withdrawn from said evaporator for controlling the rate of flow of said fluid over said evaporator to limit the load on said compressor, means for reversing the operation of said refrigerating machine to supply liquid refrigerant to said condenser to cool the air circulating through said duct and to supply heat to the fluid circulated over said evaporator, means for reversing the direction of flow of fluid over said evaporator, and means dependent upon the pressure of refrigerant discharged by said compressor for controlling the rate of flow of said fluid in said reversed direction.

5. A system for heating the air within an enclosure including a duct, a reversed cycle refrigerating machine having a compressor and an evaporator and a condenser, said compressor being arranged to supply compressed refrigerant to said condenser and to withdraw vaporized refrigerant from said evaporator, means for circulating air through said duct and into said enclosure, means including said condenser for heating the air circulated through said duct, means dependent upon the temperature of the air within said enclosure for controlling the operation of said refrigerating machine, means for circulating a fluid over said evaporator to supply heat to said system, and means dependent upon the pressure of vaporized refrigerant withdrawn from said evaporator for controlling the rate of flow of said fluid over said evaporator to limit the load on said compressor.

6. A system for heating the air within an enclosure including a duct, a reversed cycle refrigerating machine having a compressor and an evaporator and a condenser, said compressor being arranged to supply compressed refrigerant to said condenser and to withdraw vaporized refrigerant from said evaporator, means for circulating air through said duct and into said enclosure, means including said condenser for heating the air circulated through said duct, means arranged within said duct for supplying moisture to the air circulating therethrough for increasing the relative humidity of the air within said enclosure, means for supplying water for said humidifying means, means utilizing a portion of the heat of compression of the refrigerant discharged from said compressor for heating the water supplied to said humidifying means, means dependent upon the relative humidity of the air within said enclosure for controlling the flow of water to said humidifying means, means for circulating a fluid over said evaporator to supply heat to said system, and means dependent upon the pressure of vaporized refrigerant withdrawn from said evaporator for controlling the rate of flow of said fluid over said evaporator to limit the load on said compressor.

7. A system for heating the air within an enclosure including a duct, a reversed cycle refrigerating machine having a compressor and an evaporator and a condenser, said compressor being arranged to supply compressed refrigerant to said condenser and to withdraw vaporized refrigerant from said evaporator, means for circulating air through said duct and into said enclosure, means including said condenser for heating the air circulated through said duct, means for circulating a fluid over said evaporator to supply heat to said system, means dependent upon the pressure of vaporized refrigerant withdrawn from said evaporator for controlling the rate of flow of said fluid over said evaporator to limit the load on said compressor, said flow controlling means being arranged to vary the rate of flow of fluid over said evaporator substantially in proportion to the change of pressure of said vaporized refrigerant.

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