Aug. 23, 1949. W. E. DODSON 2,479,733

LOW-TEMPERATURE REFRIGERATING SYSTEM AND CONTROL THEREFOR

Filed Aug. 5, 1947

Fig. 1.

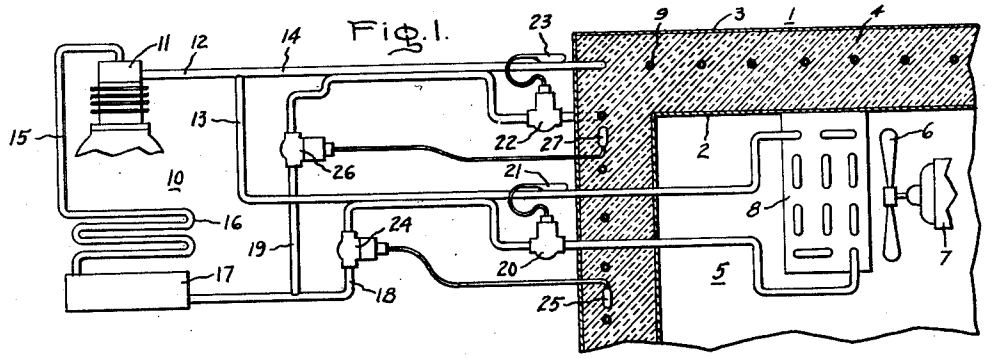



Fig. 2.

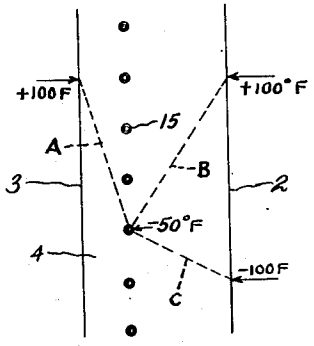
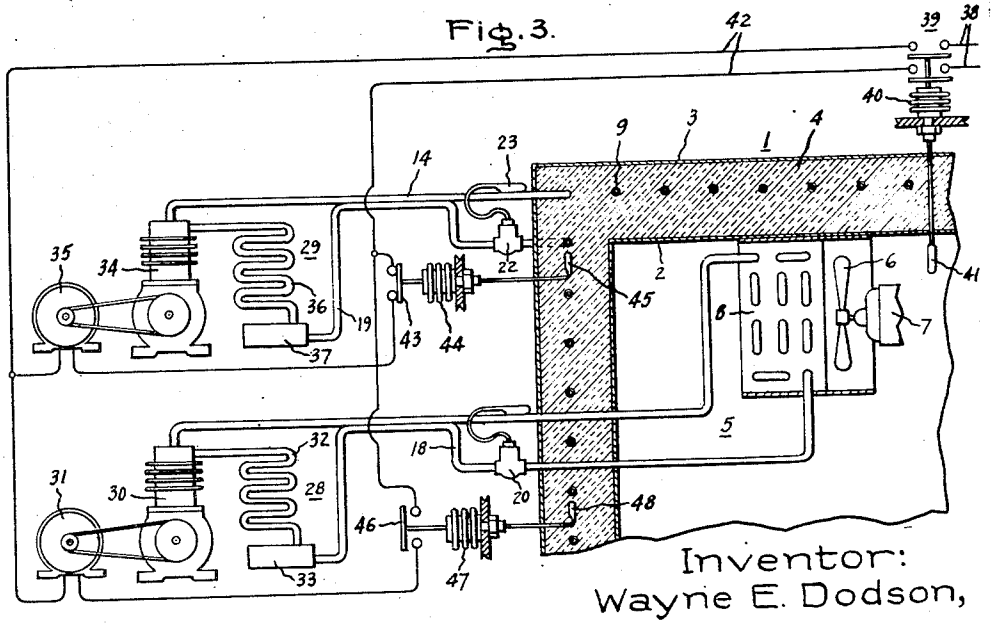



Fig. 3.




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2,479,733

## LOW-TEMPERATURE REFRIGERATING SYSTEM AND CONTROL THEREFOR

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Application August 5, 1947, Serial No. 766,387

6 Claims. (Cl. 62—4)

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My invention relates to refrigerating systems for operation at low temperatures and particularly to control arrangements for such systems for cooling air in cold storage compartments, test rooms, and the like.

The coefficient of performance of mechanical refrigerating machines of the compression type decreases rapidly as the temperature at which the evaporator is operated is lowered. When evaporator temperatures below zero degrees Fahrenheit are employed, the capacity of the refrigerating machine is materially reduced over its capacity at higher temperatures, such as those employed in the temporary preservation of foods. It is desirable to operate a refrigerating machine at the highest possible coefficient of performance and accordingly it is an object of my invention to provide a refrigerating system for operation at low temperatures, including an improved arrangement and control for the system to obtain an increased overall coefficient of performance.

It is another object of my invention to provide a low temperature refrigerating system wherein the major portion of the heat load may be removed at relatively high coefficients of performance and wherein a minimum amount of heat is removed at lower coefficients of performance throughout both the transient and steady state conditions of operation.

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 in which Fig. 1 represents diagrammatically a low temperature refrigerating system embodying my invention; Fig. 2 is a graph representing a characteristic of operation of the system; and Fig. 3 is a diagrammatic view of another embodiment of my invention.

Referring now to the drawing, the refrigerating system illustrated in Fig. 1 comprises a cabinet or storage room 1 having inner and outer retaining walls 2 and 3, respectively, which are spaced apart to accommodate a body of thermal insulation 4 therebetween. Only one corner of the cabinet has been shown, as an illustration of the arrangement of the entire cabinet structure is not necessary to an understanding of the invention. Within the cabinet there is provided a compartment 5 which is cooled by circulation of air produced by a fan 6 driven by a motor 7

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so that the air is directed over an evaporator 8. Fan 6 and motor 7 are optional, as gravity circulation may be used if desired. In order to remove a major portion of the heat load due to leakage from the outside air before the heat is conducted to the compartment 5, a second evaporator 9 is arranged within the thermal insulation 4. The evaporator 9 comprises a plurality of turns or runs of refrigerant conduit extending over a major portion of the area of the wall and arranged in planes spaced from and substantially parallel to the inner and outer walls 2 and 3. A condensing unit 10 is provided in order to supply liquid refrigerant for operation of the evaporators 8 and 9. The condensing unit includes a compressor 11 having an intake connection 12 for withdrawing vaporized refrigerant from the evaporators 8 and 9 through branch suction conduits 13 and 14 respectively. The refrigerant withdrawn from the evaporators is compressed and then discharged from the compressor through a connection 15 and flows to a condenser 16 where it is cooled and liquefied, the liquid refrigerant being collected in a receiver 17. From the receiver 17 the liquid flows through branch liquid lines 18 and 19 to the evaporators 8 and 9, respectively. During the operation of the evaporator 8, the flow of liquid refrigerant is controlled by a suitable fluid flow control device such as a thermostatic expansion valve 20 arranged in the liquid line and having a temperature feeler element 21 in heat exchange relation with the suction line 13. In a similar manner the evaporator 9 is controlled by a thermostatic expansion valve 22 having a temperature feeler element 23.

During the operation of the refrigerating machine the evaporator 8 operates at a low temperature, for example, a temperature well below zero degrees Fahrenheit, and consequently the heat absorbed by this evaporator is absorbed at a relatively low coefficient of performance. In other words, a greater amount of work is required to remove a given amount of heat at this low temperature. The evaporator 9, which removes heat from the insulation, is operated at a substantially higher temperature and consequently the heat is removed at a higher coefficient of performance.

The supply of liquid refrigerant through the branch conduit 18 of the evaporator 8 is also controlled by a temperature responsive valve 24 having a feeler element 25 arranged within the cabinet wall substantially in the plane of the evaporator 9. The valve 24 is normally closed

and is opened only when a predetermined low temperature exists at the control bulb 25. The supply of liquid refrigerant to the valve 22, and hence to the evaporator 9, is controlled by a temperature responsive valve 26 having a temperature feeler element 27 arranged in the plane of the evaporator 9 in a manner similar to the feeler element 25. The valve 26 is normally open and is closed automatically when a predetermined low temperature is attained adjacent the evaporator 9. The arrangement of these control valves 24 and 26 is such that the system operates to remove a minimum amount of heat at the lower coefficient of performance. When the condensing unit 10 is placed in operation in the usual manner, for example, by a demand for cooling as determined by a control (not shown) responsive to the temperature of the air in the cabinet 5, the valve 24 is in its closed position and the valve 26 open. Consequently only the evaporator 9 is operated. The evaporator 9 continues to operate until the temperature within the wall has been decreased to a predetermined value at which the valve 24 automatically opens to start the operation of the evaporator 8. It will thus be apparent that the evaporator 8 is not required to remove heat during the pull-down conditions when the system is first placed in operation. Thus the large amount of heat necessary to bring the wall temperatures down to a predetermined value is removed at the higher coefficient of performance at which the evaporator 9 operates. The valve 26 is arranged to close automatically in the event the temperature along the plane of the evaporator 9 reaches a predetermined low value. Thus under low temperature ambient air conditions the system might operate so that substantially all the heat is removed through the evaporator 8 and short cycling due to operation of the evaporator 9 would be avoided.

The characteristics of operation of the system of Fig. 1 during pull-down are indicated generally in Fig. 2, which is a graph representing the temperature gradients prevailing in the wall 4, assuming that the outside air and the cabinet air are both at 100 degrees Fahrenheit when the pull-down operation is started. The initial operation of the evaporator 9 lowers the temperature in the plane of the evaporator to a desired value, say 50 degrees below zero Fahrenheit, the gradients to the outside and inside walls being represented by A and B respectively, in Fig. 2. After the temperature has been reduced in this manner, the evaporator 8 is brought into operation and removes the heat within the walls below the gradient B until the temperature within the cabinet reaches a value of, say, 100 degrees below zero Fahrenheit, the gradient then being as represented by the line C in Fig. 2.

For some systems it is desirable to provide different pressure conditions in the two evaporators employed in accordance with this invention, and the system illustrated in Fig. 3 is of the two-pressure type described and claimed in my copending application Serial No. 766,386, filed concurrently herewith and assigned to the same assignee as the present invention.

In Fig. 3 the cabinet and evaporator construction is the same as that of Fig. 1 and corresponding parts have been designated by the same numerals. In the system of Fig. 3, the evaporator 8 is operated at a predetermined low pressure corresponding to the required low temperature and is connected to a low pressure condensing unit



28. The evaporator 9 is connected to a higher pressure condensing unit 29 for operation at a pressure corresponding to the higher temperature of this evaporator. The condensing unit 29 includes a compressor 30 driven by an electric motor 31 and arranged to receive vaporized refrigerant from the suction line 13 and to deliver the refrigerant to a condenser 32, the liquid refrigerant being collected in a receiver 33 from which it flows to the liquid line 18. In a similar manner the condensing unit 28 comprises a compressor 34 driven by a motor 35, a condenser 36 and a liquid receiver 37, vaporized refrigerant being delivered to the compressor 34 from the suction line 14 and liquid refrigerant being supplied to the valve 22 from the receiver 37 through the liquid line 19. The motors 31 and 35 are connected to receive power from supply lines 38 upon operation of a switch 39. The switch 39 is actuated by a bellows 40 in accordance with the temperature within the compartment 5 as determined by a temperature responsive element 41. When the air in the compartment 5 is above a predetermined value, say a value well below zero degrees Fahrenheit, the bellows 40 expands and connects the supply lines 38 to motor supply leads 42. This starts the motor 35, which is connected to the leads 42, through a normally closed switch 43. The switch 43 is actuated by a bellows 44 having a temperature feeler element 45 arranged within the insulation 4 adjacent the evaporator 9, preferably in the plane of the evaporator. The control including the bellows 44 and the element 45 operates to open the switch 43 and stop the operation of the condensing unit 29 whenever the temperature at the element 45 falls below a predetermined value.

The motor 31 is arranged to be connected to the supply leads 42 through a normally open switch 46, the switch 46 being provided with an actuating bellows 47 having a temperature feeler element 48 arranged adjacent the evaporator 9, preferably in the plane of the evaporator. The control of the switch 46 is arranged to close the switch whenever the temperature near the evaporator 9 at the control element 48 reaches a predetermined low value, and at this temperature the condensing unit 28 is placed in operation to supply refrigerant to the evaporator 8 and cool the air in the compartment 5. It will thus be apparent that the control switches 43 and 46 are arranged to actuate the condensing units 29 and 28 respectively to effect the same type of control as that accomplished by operation of the valves 24 and 26 in the system of Fig. 1. This control arrangement is such that the condensing unit 28, which operates at the low temperature of the evaporator 8 and consequently at the lower coefficient of performance, is placed in operation only after the heat load due to leakage through and heat stored within the insulation 4 has been reduced to a sufficiently low value to minimize the leakage and stored heat load carried by the evaporator 8. The condensing units 28 and 29 may be provided with the usual back pressure controls (not shown) to maintain the respective predetermined pressures in the evaporators 8 and 9. Furthermore, it will be understood that other devices may be employed to control the flow of the refrigerant; for example valves such as the valves 24 and 26 of Fig. 1 might be employed instead of the motor circuit switches.

From the foregoing it will readily be apparent that I have provided a simple and effective arrangement for insuring operation of a refrigerat-

ing machine at a maximum overall coefficient of performance, the arrangement being simple and easy to maintain in operation.

Although I have illustrated my invention as applied to a particular type of cooling system, other applications will be apparent to those skilled in the art. For example, although the systems illustrated employ evaporators directly for cooling the walls and interior of the storage compartment, it is obvious that the evaporators may be employed to cool brine or other suitable secondary refrigerant which is then circulated through cooling units arranged in the walls and in the storage compartment. I do not, therefore, desire my invention to be limited to the specific arrangements illustrated and described, and I intend by the appended claims to cover all modifications which fall 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. In a low temperature refrigerating system, means including a thermally insulated wall for providing a compartment to be cooled, a first cooling element arranged to abstract heat from the medium within said compartment, a second cooling element arranged within said wall, means including a refrigerant condensing apparatus for supplying cooling fluid to said elements, means responsive to the temperature within said wall adjacent said second element for admitting cooling fluid to said second element to maintain a predetermined temperature in said wall in the vicinity of said second element, and means dependent upon the reduction of the temperature in the vicinity of said second element substantially to said predetermined temperature for admitting cooling fluid to said first element whereby said first element is required to abstract heat from the medium within said compartment only after the temperature within said wall has been reduced substantially to said predetermined value.

2. In a low temperature refrigerating system, means including a thermally insulated wall for providing a compartment to be cooled, a first cooling element arranged within said compartment to cool the air therein, a second cooling element comprising a plurality of runs of conduit distributed throughout a major area of said wall and arranged substantially in a plane parallel to the surfaces of said wall, means including a refrigerant condensing apparatus for supplying cooling fluid to said elements, means responsive to the temperature within said wall adjacent said plane for admitting cooling fluid to said second element to maintain a predetermined temperature in said wall along said plane, and means dependent upon the reduction of the temperature in said plane substantially to said predetermined temperature for admitting cooling fluid to said first element whereby operation of said first element is effected only after substantially said predetermined temperature has been attained in said wall.

3. In a low temperature refrigerating system, means including a thermally insulated wall for providing a compartment to be cooled, means including a first cooling element arranged within said compartment for maintaining a predetermined low temperature therein, means including a second cooling element arranged within said wall for maintaining a predetermined higher temperature within the insulation in said wall, and means responsive to the temperature within said wall adjacent said second element for rendering said first cooling element effective to operate only after the temperature in said wall has been decreased to a predetermined value.



4. In a low temperature refrigerating system, means including a thermally insulated wall for providing a compartment to be cooled, a first cooling element arranged within said compartment, a second cooling element arranged within the insulation in said wall, a source of refrigerant, means for connecting said second cooling element to said source and for controlling the flow of refrigerant to said second element to maintain a predetermined temperature within said insulation, means for connecting said first element to said source, and means responsive to the temperature within said wall adjacent said second element and controlling the flow of refrigerant to said first element for admitting refrigerant to said first element only after the temperature of said wall has been decreased to a predetermined value.

5. In a low temperature refrigerating system, means including a thermally insulated wall for providing a compartment to be cooled, a first evaporator arranged within said compartment for cooling the air therein, a second evaporator comprising a plurality of refrigerant runs distributed over the major portion of said wall in a plane substantially parallel to the surfaces of said wall, means for supplying liquid refrigerant to said first evaporator to maintain a predetermined low temperature in said compartment, means for supplying liquid refrigerant to said second evaporator to maintain a predetermined higher temperature along said plane within said wall, and means dependent upon the temperature within said wall adjacent said second evaporator for connecting said first evaporator to receive refrigerant only after the temperature in said wall has been decreased to a predetermined value.

6. In a low temperature refrigerating system, means including a thermally insulated wall for providing a compartment to be cooled, a first cooling element arranged within said compartment, a second cooling element arranged within the insulation in said wall, means including first and second refrigerant condensing units for supplying cooling fluid respectively to said first and second elements, means responsive to the temperature in said wall near said second element for actuating said second condensing unit to lower the temperature within said wall to a predetermined value, and means responsive to the temperature in said wall near said second element for actuating said first condensing unit only after the temperature in said wall has been decreased to a predetermined value.

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No references cited.