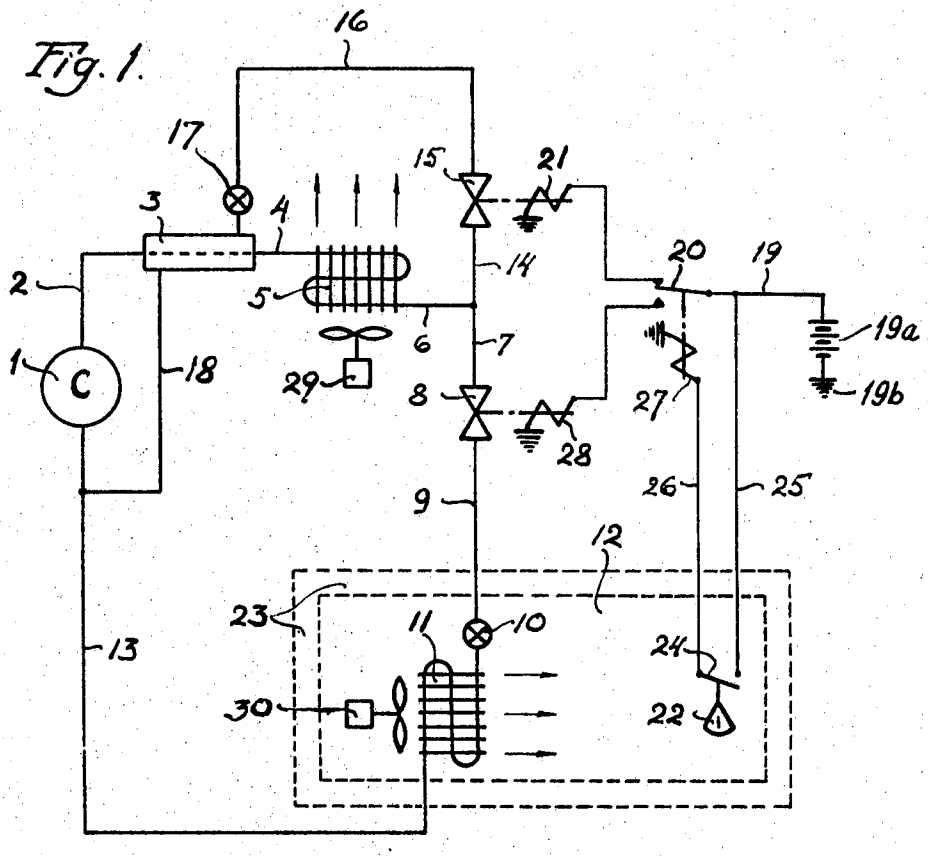
Nov. 11, 1969 O. G. THOREN ETAL 3,477,240

REFRIGERATING METHOD AND SYSTEM FOR MAINTAINING SUBSTANTIALLY CONSTANT TEMPERATURE

Filed March 25, 1968

Fig. 1.



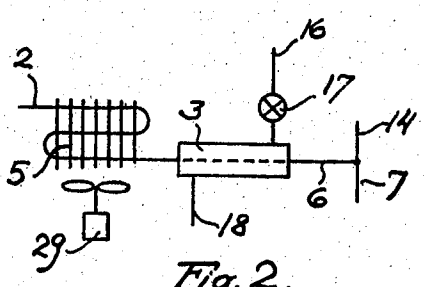


Fig. 2.

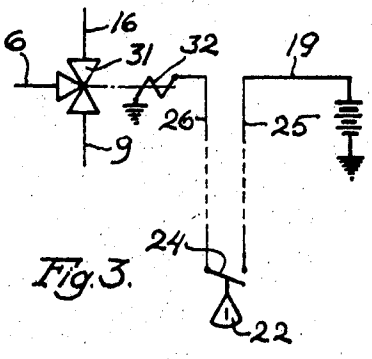


Fig. 3.

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REFRIGERATING METHOD AND SYSTEM FOR MAINTAINING SUBSTANTIALLY CONSTANT TEMPERATURE

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U.S. Cl. 62—115 5 Claims

ABSTRACT OF THE DISCLOSURE

Means are provided for circulating a refrigerating medium from a compressor to the refrigeration evaporator, by way of a condenser and the primary side of an indirect heat exchanger, and back to the compressor at its suction side; and means are also provided for diverting at least some of this medium flowing from the condenser and said primary side and returning it to the suction side of the compressor by way of the secondary side of the heat exchanger, so that the diverted medium by-passes the refrigeration evaporator. The latter is located in the space to be cooled, which also contains a temperature-sensitive member for controlling valve means operable to effect said diversion in response to a predetermined minimum temperature in said space and to discontinue said diversion in response to a predetermined maximum temperature in said space.

This invention relates to refrigeration and more particularly to a novel method and system by which the space to be refrigerated can be maintained at a substantially constant cold temperature while operating the compressor continuously at substantially constant speed.

In conventional refrigerating systems, the refrigerating medium is circulated from the compressor through a condenser to the refrigeration evaporator (expansion coil) in the space to be refrigerated and then back to the compressor at its suction side. By means of a thermostat or other member sensitive to the temperature in this space, the compressor motor is stopped when the temperature drops to a certain minimum value and is restarted when the temperature rises to a certain maximum value. In cases where it is not objectionable to have a substantial spread between the minimum and maximum temperatures (such as several degrees C.), a certain inertia can be tolerated in the temperature-sensitive member, although the temperature will then vary correspondingly. On the other hand, if it is desired to provide a close regulation of the temperature, with only small temperature variations, it is necessary that the temperature-sensitive member have a small inertia and react immediately to marginal temperatures lying very close to each other.

This manner of regulation means that the motor and compressor are started and stopped with great frequency; and the closer the upper and lower temperature margins for starting and stopping are located to each other, the more frequently the compressor must be started and stopped, with obvious disadvantages such as harmful strains and shortened life of the motor and compressor. This is especially the case in refrigerating systems where the temperature margins must be adjustable over a wider range of temperatures. The maximal refrigerating effect of such a system is determined by the lowest permissible temperature margin. Consequently, the system when operating under certain conditions will supply an over-effect of cold, thereby further shortening the periods in which the motor and compressor are running.

With these refrigerating systems in which the compressor is alternately started and stopped, another disadvantage of particular note is that the system is unable to deliver full cold immediately after starting the compressor. This, of course, has a detrimental effect upon the desired temperature regulation.

Another way of regulating refrigerating systems is to provide the compressor with a capacity regulator under control of the temperature-sensitive member, whereby the cooling effect is adjusted to actual requirements without need for shopping the compressor. However, this mode of regulation is so costly that it can be used only for refrigerating systems of large capacity.

A third way of regulating such systems is to provide the compressor with a by-pass between its pressure and suction sides and with a regulating valve in the by-pass. This valve is under control of the temperature-sensitive member and adjusts the flow through the by-pass to regulate the cooling effect in accordance with the actual need in the refrigerated space. Although the compressor is thus operated continuously, this mode has the drawback that the compressor motor, which usually must be cooled by the cold gas from the refrigerating evaporator, cannot be adequately cooled by this gas because it is mixed with relatively high-temperature gas returned through the by-pass, such returned gas having been heated by compression in the compressor. The motor is thus jeopardized by this inadequate cooling.

A fourth way to regulate such systems is to combine the refrigerating evaporator or expansion coil, located in the refrigerated space, with a heat radiator to which the supply of heat is controlled by the temperature-sensitive element, whereby the excess of cold is neutralized by the heat supplied to the heat radiator. While this mode facilitates great accuracy of temperature control by proportional regulation of the heat supply, it has the disadvantage of high operating cost.

The principal object of the present invention is to maintain the refrigerated space at substantially constant temperature while operating the compressor continuously at substantially constant speed, and to provide a method and system for this purpose which are simple, cheap and reliable in operation and which operate automatically once they are adjusted to the selected margins of minimum and maximum temperatures.

According to the invention, the circulating refrigerating medium passes from the compressor to the refrigerating evaporator by way of the aforesaid condenser and also the primary side of an indirect heat exchanger. However, conduit means are provided through which at least part of the refrigerating medium flowing from the condenser and said primary side is adapted to be diverted to the secondary side of the heat exchanger and thence to the suction side of the compressor, while by-passing the refrigerating evaporator. The temperature-sensitive member in the refrigerated space is operatively connected to valve means for effecting said diversion in response to a predetermined minimum temperature in said space, and for discontinuing said diversion in response to a predetermined maximum temperature in said space.

The invention is described more particularly in the following with reference to the accompanying drawing, in which:

FIG. 1 is a schematic view of a preferred form of the new refrigerating system;

FIG. 2 is a similar view showing an alternative to part of the FIG. 1 system and which involves a reversal of the positions of the heat exchanger and the condenser, and

FIG. 3 is a similar view of another alternative to the FIG. 1 system and in which two solenoid valves have been replaced by a single three-way solenoid valve.

As shown in FIG. 1, the refrigerating system comprises a motor-driven compressor 1 from which the compressed refrigerating medium passes through conduit 2 to the primary side of an indirect heat exchanger 3. From this primary side, the refrigerating medium flows through a conduit 4 to a condenser 5, from which the now liquid medium passes through conduits 6 and 7, a solenoid valve 8 and a conduit 9 to a reducing valve 10. From the latter, the refrigerating medium streams into the refrigeration evaporator 11 (which may be a conventional expansion coil) where it is gassified while extracting heat from the environment, that is, the space 12 to be cooled. The refrigerating medium is then sucked from the refrigerating evaporator 11 through conduit 13 to the suction side of compressor 1, whereupon the cycle is repeated.

In FIG. 1, the heat exchanger 3 is located between compressor 1 and condenser 5. As an alternative, however, the positions of the components 3 and 5 may be reversed, as shown in FIG. 2. As there shown, the heat exchanger 3 is located in the conduit 6 in a position downstream from the condenser 5.

According to the invention as illustrated in FIG. 1, a conduit 14 branches from the conduit 6 at its junction with conduit 7, the conduit 14 being connected through solenoid valve 15, conduit 16 and a reducing valve 17 to the secondary side of heat exchanger 3. A conduit 18 leads from this secondary side of the heat exchanger to the suction side of the compressor 1.

It will be apparent, therefore, that a first conduit means are provided for circulating the refrigerating medium from the pressure side of compressor 1 to the refrigeration evaporator 11 by way of condenser 5 and the primary side of heat exchanger 3, and from the evaporator 11 back to the suction side of compressor 1. Also, second conduit means 14, 16 and 18 are provided which lead from the first conduit means at a point upstream from the refrigeration evaporator 11 but downstream from condenser 5 and heat exchanger 3; and the second conduit means are adapted to divert refrigerating medium from the first conduit means at the aforesaid point and circulate the diverted medium through the secondary side of heat exchanger 3 to the suction side of compressor 1 while by-passing the refrigeration evaporator 11.

An electric current-supplying conductor 19 is connected to one side of a current source 19*a*, the other side of which is grounded as shown at 19*b*. Through switch 20, current is supplied from conductor 19 to a grounded solenoid coil 21 to hold the solenoid valve 15 open. A temperature-sensitive member 22 is positioned in the space 12 to be cooled, this space being enclosed by insulating walls 23 indicated by dotted lines. The member 22 is adjustable for different margins of temperature so that when the temperature has reached an adjusted upper value in space 12, the member 22 closes the connection between electrical conductors 25 and 26 by means of a switch 24; and when the temperature has dropped to an adjusted lower value in this space, the member 22 opens switch 24 to break the connection between conductors 25–26. The conductor 25 is connected to the current-supplying conductor 19, and conductor 26 is connected to a grounded relay coil 27. The relay coil 27 is not energized in the illustrated position, because switch 20 of relay 27 is in its upper position to energize the solenoid coil 21 and thereby hold the valve 15 open. However, when the temperature rises to the selected upper value in space 12, the member 22 closes switch 24 to energize the relay coil 27, thereby drawing switch 20 downward to break the connection to solenoid coil 21, with the result that valve 15 closes. This downward movement of relay switch 20 connects conductor 19 to the grounded solenoid coil 28 of solenoid valve 8, thereby opening the latter.

As a result of the above-described action, the refrigerating medium is no longer diverted from the first conduit means through the secondary side of heat exchanger 3 by way of the second conduit means, so as to by-pass the refrigeration evaporator 11. Instead, the refrigerating medium is now circulated through the refrigeration evaporator 11 and back to the compressor 1, thereby by-passing the secondary side of heat exchanger 3.

When the temperature has dropped to its selected lower value in space 12 to cause opening of switch 24, relay coil 27 is de-energized to permit return of switch 20 to its upper position. Consequently, solenoid coil 28 is now de-energized to close valve 8, and at the same time the solenoid coil 21 is re-energized to open valve 15.

It will be understood that this cycling is repeated under control of the temperature-sensitive member 22 to maintain the temperature in space 12 between the selected upper and lower temperature margins.

A motor-driven fan 29 is provided to force cold outdoor air through the condenser 5 and thereby cool it. Another motor-driven fan 30 is located in the space 12 to circulate the air therein and force the air through the refrigeration evaporator 11, so that the temperature is substantially uniform through the space 12.

In the normal operation of the system for refrigerating the space 12, the valve 15 is closed and the valve 8 is open. After a period of time, when the temperature drops to its selected lower limit in space 12, the temperature-sensitive member 22 causes actuation of the valves to close the valve 8 and open the valve 15, as previously described. The refrigerating medium is then passed from conduit 6 through valve 15, conduit 16, valve 17 and the secondary side of heat exchanger 3, where the expanding refrigerating medium extracts heat from the refrigerating medium passing through the primary side of the heat exchanger. Thus, the medium is gassified in the secondary side of the heat exchanger as the temperature of the medium increases, so that it is expedient for the medium to enter the suction side of compressor 1 and again pass through the primary side of the heat exchanger and back to the secondary side. This circulation continues until the temperature-sensitive member 22 again causes actuation of the valves 8 and 15 so that the refrigerating medium circulates in the normal way through the refrigeration evaporator 11.

In this way, a substantially constant temperature is maintained in the space 12 while the compressor 1 operates continuously at constant speed. In effect, the refrigerating medium itself consumes in the heat exchanger 3 its "excess of cold" during the periods when the refrigerating medium does not pass through the refrigerating evaporator 11.

Instead of providing two valves 8 and 15 as shown in FIG. 1, a single three-way valve 31 can be used as shown in FIG. 3. As there shown, the valve 31 is located at the downstream end of conduit 6. In one position of valve 31, it connects conduit 6 with conduit 9 while closing the conduit 16. In the other position of valve 31, it connects conduit 6 with conduit 16 while closing the conduit 9. Regulation of valve 31 is effected substantially in the same way as in FIG. 1; but this regulation is more simple in FIG. 3 in that only a single solenoid coil 32 is needed for actuating the valve 31 from one to the other of its two positions described above.

We claim:

1. In the operation of a refrigerating system wherein the refrigerating medium is circulated from a compressor through a condenser and through an expansion device to a refrigeration evaporator located in a space to be cooled and maintained at substantially constant temperature, and from said evaporator back to the compressor at its suction side, the method which comprises the steps of passing said medium, on its way from the compressor to the refrigerating evaporator, through the primary side of an indirect heat exchanger, diverting at least part of said medium flowing from the condenser and said primary side but before it flows to the expansion device and passing it through the secondary side of the heat exchanger when

said space acquires a predetermined minimum temperature, the diverted medium by-passing the refrigeration evaporator and the expansion device and being expanded in said secondary side, returning the diverted medium from said secondary side to said suction side of the compressor while continuing to by-pass the refrigeration evaporator, and discontinuing said diverting step when said space acquires a predetermined maximum temperature, whereby said space is maintained at a substantially constant cold temperature while continuously operating the compressor at substantially constant speed.

2. In a refrigerating system, the combination of a compressor having suction and pressure sides, an indirect heat exchanger having primary and secondary sides, a condenser, a refrigeration evaporator located in a space to be cooled and maintained at a substantially constant cold temperature, a first expansion device for expanding refrigeration medium into the refrigeration evaporator, a second expansion device for expanding refrigeration medium into said secondary side, first conduit means for circulating a refrigerating medium from said pressure side of the compressor to the first expansion device and to the refrigeration evaporator by way of the condenser and said primary side of the heat exchanger, and from said evaporator to said suction side of the compressor, second conduit means leading from said first means at a point upstream from the first expansion device and the refrigeration evaporator but downstream from the condenser and heat exchanger, said second conduit means being adapted to divert refrigerating medium from the first conduit means at said point and circulate the diverted medium through the second expansion device and into said secondary side of the heat exchanger to said suction side of the compressor while by-passing the first expansion device and the refrigeration evaporator, a temperature-sensitive member in said space, and valve means operatively connected to said member and operable in response to a predetermined minimum temperature in said space to effect said diversion of at least part of said medium from the condenser and said primary side of the heat exchanger,

the valve means being operable to discontinue said diversion in response to a predetermined maximum temperature in said space, whereby the latter is maintained at substantially constant temperature while continuously operating the compressor at substantially constant speed.

3. The combination according to claim 2, in which the condenser is downstream from said primary side of the heat exchanger.

4. The combination according to claim 2, in which said valve means include a first valve located in the first conduit means between said point and the refrigeration evaporator, and a second valve located in the second conduit means between said point and said secondary side of the heat exchanger, said valves being operable by the temperature-sensitive member so that when one valve is entirely open the other valve is entirely closed, and vice versa.

5. The combination according to claim 2, in which said valve means include a first valve located in the first conduit means between said point and the refrigeration evaporator, and a second valve located in the second conduit means between said point and said secondary side of the heat exchanger, said valves being operable by the temperature-sensitive member so that when one valve begins to open the other valve begins to close, and vice versa.

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LLOYD L. KING, Primary Examiner

U.S. Cl. X.R.

62—197

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,477,240 November 11, 1969

Olle G. Thoren et al.

It is certified that error appears in the above identified patent and that said Letters Patent are hereby corrected as shown below:

Column 2, line 11, "shopping" should read -- stopping --.
Column 6, line 30, "2,280,358" should read -- 2,080,358 --.

Signed and sealed this 10th day of November 1970.

(SEAL)
Attest:

Edward M. Fletcher, Jr.
Attesting Officer

WILLIAM E. SCHUYLER, JR.
Commissioner of Patents