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REFRIGERATING APPARATUS

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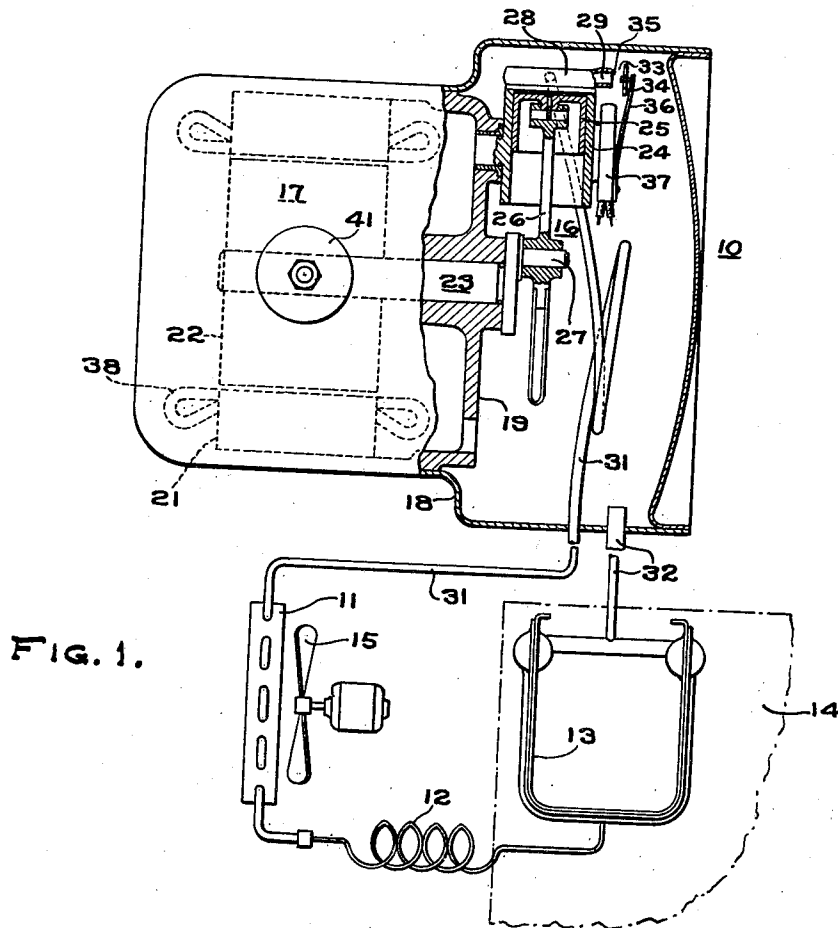


FIG. 1.

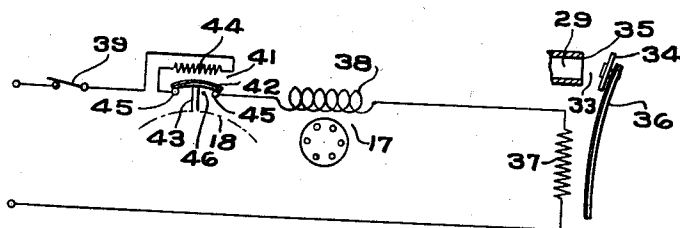


FIG. 2.

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REFRIGERATING APPARATUS

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8 Claims. (Cl. 62—115)

My invention relates to refrigerating apparatus and has for an object to provide improved apparatus of this character.

A further object of the invention is to provide improved means for relieving a refrigerant compressor of a substantial portion of its load during the starting thereof and to load the same thereafter.

A further object of the invention is to progressively load a refrigerant compressor subsequent to the starting thereof.

It is another object of the invention to provide improved refrigerating apparatus of the compression type employing a capillary expansion device, wherein the condensing pressure is prevented from building up rapidly during the acceleration of the compressor.

A still further object of the invention is to provide an improved organization of the elements of a refrigerating system including a motor driven compressor having load relieving means and overload protection means.

These and other objects are effected by my invention as will be apparent from the following description and claims taken in connection with the accompanying drawing, forming a part of this application, in which:

Fig. 1 is a view, partially diagrammatic, of a refrigerating system employing a compressor controlled in accordance with my invention; and,

Fig. 2 is a diagram of the connections of the electrical elements employed in the structure shown in Fig. 1.

Reference will now be had to the drawing wherein I have shown, generally at 10, a motor driven compressor employed for the circulation of refrigerant in a refrigerating system including a condenser 11, an expansion device 12 of fixed flow area, hereinafter referred to as a capillary tube, and an evaporator 13, the latter being disposed for abstracting heat from a chamber 14. As is well understood, the condenser 11 forms a part of the high pressure side of the system and the evaporator 13 a part of the low pressure side thereof, the expansion device or capillary tube 12 functioning to reduce the pressure of the condensed refrigerant in the condenser to the pressure of vaporization in the evaporator 13. Cooling of the compressed refrigerant in the condenser 11 may be effected in any suitable manner such as, for example, by a fan 15.

The motor-compressor unit 10 may be of any suitable type but, preferably, includes a reciprocating type compressor 16, driven by an elec-

tric motor 17, and a casing 18 for hermetically enclosing the same. A frame 19 is secured within the casing 18 and provides a support for the motor and compressor. The motor 17 is of any suitable type and includes a stator 21 supported by the frame 19 and a rotor 22, carried by a shaft 23 that is journaled in the frame 19. The electrical conductors for the motor are not shown in Fig. 1, but extend through the casing 18 in any manner well understood in the art.

The compressor 16 includes a cylinder 24 that is supported by the frame 19 and in which a piston 25 is reciprocated. The piston 25 is actuated, preferably, by a connecting rod 26 and crank pin 27 that is eccentrically carried by the shaft 23. The cylinder 24 includes a head structure 28 enclosing the usual inlet and exhaust valves (not shown) for controlling the flow of refrigerant gas to and from the cylinder 24. A refrigerant gas inlet passage 29 is formed in the head structure 28 and provides a passage for the flow of gas from the interior of the casing 18 to the inlet valve of the compressor. Gas is compressed to a relatively high pressure in the compressor 16 and is discharged to the condenser 11 through a conduit 31, the latter passing through the casing 18, as shown. The refrigerant vaporized in the evaporator 13 is conducted to the interior of the casing 18 by means of a conduit 32.

In the operation of a system of the compressor-condenser-expander type, as shown, having a capillary tube as the expansion element, gas at relatively low pressure is withdrawn from the evaporator 13 and is liquefied in the condenser 11; at relatively high pressure. The liquid is forced through the capillary tube 12 to the evaporator 13 and is vaporized therein for the abstraction of heat. During normal operation, the high pressure gas is liquefied as fast as it is compressed so that the condenser contains but a small amount of liquid. When the operation of the compressor is terminated, both the liquid and gaseous refrigerant in the condenser pass to the evaporator until the pressures in the condenser and evaporator are substantially equalized.

When operation of the compressor is initiated, the pressures at the inlet and outlet thereof are substantially equal. However, the pressure in the condenser rapidly builds up during the first few revolutions of the motor and effects a relatively high load on the motor prior to its attaining full speed. It is an object of my invention to reduce the load on the motor at this time by

preventing the pressure in the condenser from building up too rapidly during the acceleration of the motor and compressor. By attaining this object, I am enabled to employ a smaller and less expensive motor, as its starting duty is reduced, the necessary capacity thereof being determined mainly by its running duty.

In accordance with the invention, I provide a valve 33 for closing the inlet 29 of the compressor 10 16 during inactive periods of the compressor, which valve 33 is progressively opened subsequent to the starting of the compressor. The valve 33 may include a valve member 34 that cooperates with a valve seat 35 formed on the head 15 structure 28. The valve member 34 may be carried and actuated by a thermal responsive member, such as, a bimetallic element 36. The latter is heated by a heating element 37 supported in any suitable manner such as, for example, by the 20 cylinder 24. During inactive periods of the compressor, 16, the bimetallic element 36 is cool and is in a position wherein the valve 33 is closed. When the compressor 16 is started, the heater 37 is energized so that the bimetal element 36 deflects 25 to the position shown in the drawing in which the valve 33 is open. Movement of the bimetal element 36 may be in a snap-acting manner if desired or it may be gradual, as shown, so that the valve 33 is progressively moved to its open 30 position.

The heater 37 is energized simultaneously with the energization of the motor 17 and is, preferably, connected in series with a winding 38 of the motor 17, as shown in Fig. 2. Energization of 35 the winding 38 and heater 37 may be controlled by a suitable master switch 39 which may be manually or thermostatically operated in any manner well understood in the art.

Overload and thermal protection for the motor 40 17 may be provided by a thermal responsive overload device 41 preferably secured to the portion of the casing 18 which supports the motor 17. The device 41 is best shown diagrammatically in Fig. 2 and includes a snap-acting bimetallic 45 disk 42 carried in heat transfer relation with the casing by a stud 43. The disk 42 is disposed also in heat transfer relation with a heater 44 which is energized with the motor 17 and is heated in proportion to the current drawn by the motor 50 17. Preferably, the heater 44 is connected in series with the motor winding 38 as shown. The disk 42 bridges stationary contacts 45 and defines therewith a normally closed switch structure 46.

During normal operation, or when the current 55 in the motor 17 and heater 44 is below a predetermined value, the switch 46 is closed. However, when an abnormal condition causes an increase in motor current to a predetermined value, 60 the heater 44 heats the disk 42 sufficiently to open the switch 46. Accordingly, the heater 44 and motor 17 are deenergized. The disk 42 cools and, when its temperature is reduced to a predetermined value, it effects closure of the switch 65 46 and automatically energizes the motor 17 and heater 44. If the abnormal condition still exists, the switch 46 is again opened. This operation continues until the abnormal condition is corrected. An abnormally high temperature of the 70 motor 17 due to some conditions other than high current also operates the switch 46 as the disk 42 is subjected to the heat of the motor. The disk 42 responds, therefore, to the combined current and thermal conditions of the motor 17. It will be apparent that the switch 46 also con-

trols energization of the heater 37 of the valve mechanism.

Operation

As shown in the drawing, the switches 39 and 5 46 are closed and the valve 33 is open so that the compressor unit 10 is operated. Circulation of refrigerant and cooling of the chamber 14 is effected. When the demand for refrigeration is satisfied, the switch 39 is opened to terminate 10 operation of the motor 17 and compressor 16. Both the liquid and gaseous refrigerant in the condenser continue to flow through the tube 12 to the evaporator until the pressure therebetween is substantially equalized. During inactive period 15 of the compressor 16, the bimetal element 36 cools and closes the valve 33.

Closure of the switch 39 in response to a demand for refrigeration effects energization of the motor 17 and heater 37 simultaneously. As the 20 valve 33 is closed, flow of vapor from the interior of the casing 18 to the inlet chamber 29 is prevented or substantially reduced at this time. Accordingly, downward movement of the piston 25 withdraws vapor from the inlet chamber 29 and depresses the pressure therein. The volume of the chamber 29 is preferably large enough to prevent 25 the compressor from reducing the pressure therein below a predetermined value during closure of the valve 33 and is small enough to prevent high density vapor from filling the cylinder 24 30 during the first few strokes of the piston 25. Accordingly, the density of the vapor in the cylinder 24 at the beginning of the compression stroke is lower than the density of the vapor in the casing 18. The amount of vapor discharged to 35 the condenser is relatively small so that the pressure builds up slowly in the condenser during acceleration of the compressor.

The valve 33 may be constructed to provide a leak for passing a limited amount of refrigerant gas during times when the valve member 34 en- 40 gages the seat 35. In this manner the pressure in the chamber 29 is prevented from being depressed too low. In this connection, it will be apparent that the valve 33 may be inexpensively constructed as it is not necessary to provide a fluid-tight structure as is necessary in a conventional unloader valve. Accordingly, a saving 50 in the manufacturing cost of a refrigerating system is effective by my invention.

The small amount of work expended in depressing the pressure in the inlet chamber is regained on the compression stroke and, as the 55 density of the gas in the condenser is substantially the same as in the casing 18, the work expended in discharging the gas from the cylinder is that necessary to overcome friction in the conduit 31 and the outlet valve of the compressor. Accordingly, during the initial strokes of the piston 25, the load on the motor 17 is relatively 60 low so that a motor having high starting torque or a capacity substantially in excess of the running capacity is not required.

As the motor 17 accelerates, the valve 33 65 is opened by the heater 37 and more gas is admitted to the inlet chamber 29. By proper coordinating of the elements described heretofore, the load on the motor may be progressively increased as its speed increases. This operation may be effected regardless of whether the thermal responsive element 36 gradually opens the valve 33 or does so in a snap-acting manner. In the latter case, a higher vacuum may be effected in the inlet chamber 29 than in the case of the

gradual acting member, but, in both cases, the pressure build-up in the condenser is retarded, which is the primary result sought.

Operation of the compressor unit 10 is terminated by opening the master switch 39 when the demand for refrigeration is satisfied. When the system includes the thermal or overload responsive element 41, it is desirable that the thermal element 36 close the valve 33 before the disk 42 closes its switch 46, subsequent to opening thereof by an overload condition. The reason for this operation is to insure that the compressor is relieved of the starting load when the device 41 starts operation after an abnormal condition. This operation may be effected by predetermining the relative rates of cooling of the elements 42 and 36.

From the foregoing, it will be apparent that I have provided an improved refrigerating system of the compression type wherein the density of the vapor in the compressor cylinder during the first of the compression strokes is controlled, so that the head or condensing pressure progressively increases during acceleration of the motor and compressor. Accordingly, the load is progressively applied to the compressor during starting periods thereof. The capacity of the motor for driving the compressor may, therefore, be determined mainly by its running duty and need not be increased substantially because of high starting loads. The use of an inexpensive valve of the type described in place of a conventional unloader mechanism having a ground valve and seat represents a saving in the cost of manufacture.

While my invention is particularly adaptable to refrigerating systems employing an expansion device of the fixed flow area type, it will be understood that it is not so limited and may be applied to other forms of compression refrigerator systems wherein equalization of the pressures in the high and low sides of the system is not effected during shut down periods.

While I have shown my invention in but one form, it will be obvious to those skilled in the art that it is not so limited, but is susceptible of various changes and modifications without departing from the spirit thereof, and I desire, therefore, that only such limitations shall be placed thereupon as are imposed by the prior art or as are specifically set forth in the appended claims.

What I claim is:

1. In refrigerating apparatus, the combination of a condenser, an evaporator and a compressor for translating refrigerant through the condenser and evaporator, a motor for actuating the compressor, a valve for controlling the flow of refrigerant from the evaporator to the compressor which is normally closed during inactive periods of the compressor, a thermal responsive element for progressively opening the valve when heated, a heater associated with said element, and means for energizing the motor and said heater.

2. In refrigerating apparatus, the combination of a condenser, an evaporator, a compressor for translating refrigerant through the condenser and evaporator, a casing for enclosing the compressor, a motor for driving the compressor, a valve disposed within the casing for controlling communication between the evaporator and the compressor, which valve is normally closed during inactive periods of the compressor, and means for progressively actuating said valve to its open position subsequent to the starting of the

compressor and for retaining said valve in open position during normal operation of the compressor.

3. In refrigerating apparatus, the combination of a condenser, an evaporator, a refrigerant compressor for withdrawing refrigerant vapor from the evaporator and for translating it to the compressor at relatively high pressure, a motor for driving the compressor, a valve for controlling the flow of vapor from the evaporator to the compressor which is normally closed during inactive periods of the compressor, means for controlling the energization of the motor, means for operating said valve and providing for time intervals between the energization of the motor and the opening of the valve and between the deenergization of the motor and the closing of the valve, an overload responsive switch for controlling energization of the motor and movable to its open position in response to a predetermined load on the motor, said switch being closed automatically after a predetermined period of time has elapsed after the opening thereof, which period of time is longer in duration than the period of time required for said valve to close subsequent to the deenergization of the motor.

4. In refrigerating apparatus, the combination of a condenser, an evaporator, a refrigerant compressor for withdrawing vapor from the evaporator and for translating it to the condenser at relatively high pressure, a motor for driving the compressor, a valve for controlling the flow of vapor to the compressor from the evaporator and normally closed during inactive periods of the compressor, electrically operated means for operating said valve and providing for time intervals between its energization and the complete opening of the valve and between its deenergization and the closing of the valve, means for simultaneously controlling energization and deenergization of the motor and the electrically operated means, an overload responsive switch for controlling energization of the motor and the electrically operated means and movable to its open position in response to a predetermined load on the motor, said switch being closed automatically after a predetermined period of time has elapsed after the opening thereof, which period of time is longer in duration than the period of time required for said valve to close after the deenergization of the electrically operated means.

5. In refrigerating apparatus, the combination of an evaporator, a condenser, a compressor for translating refrigerant through the evaporator and condenser, a motor for driving the compressor, a valve for controlling the flow of gas from the evaporator to the compressor and normally closed during inactive periods of the compressor, a bimetallic element for actuating the valve in opening direction when heated, a heater disposed in heat transfer relation with the bimetallic element, and means for simultaneously controlling the energization and deenergization of the motor and heater.

6. The combination as claimed in claim 5 including an overload responsive switch for deenergizing the motor and heater simultaneously in response to a predetermined high load on the motor and for energizing the same automatically after a predetermined period of time has elapsed after the opening of the switch.

7. In a refrigerating system, the combination of a condenser, an evaporator, an expansion device having a passage of fixed flow area con-

trolling the flow of refrigerant from the condenser to the evaporator, a compressor for withdrawing vaporous refrigerant from the evaporator and for translating it to the condenser at relatively high pressure, a motor for driving the compressor, a valve for controlling the passage of vaporous refrigerant from the evaporator to the compressor and normally closed during the inactive periods thereof, electrical means for progressively actuating the valve to its open position and providing a time interval between the energization of the electrical means and the full opening of the valve, and means for energizing said motor and said electrical means.

8. In a refrigerating system, the combination of a condenser, an evaporator, an expansion device having a passage of fixed flow area controlling the flow of refrigerant from the condenser to the evaporator, a compressor for withdrawing vaporous refrigerant from the evaporator and for translating it to the condenser at relatively

high pressure, a motor for driving the compressor, a valve for controlling the passage of vaporous refrigerant from the evaporator to the compressor and normally closed during the inactive periods thereof, electrical means for operating the valve and providing for time intervals between its energization and the full opening of the valve and between its deenergization and the closing of the valve, and a switch movable to its open position for deenergizing the motor and said electrical means in response to a predetermined high load on the motor, said switch being automatically closed for energizing the motor and the electrical means after a predetermined period of time has elapsed subsequent to the opening of the switch, said last-mentioned period of time being longer in duration than said time interval between the deenergization of the electrical means and the closing of the valve.

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