

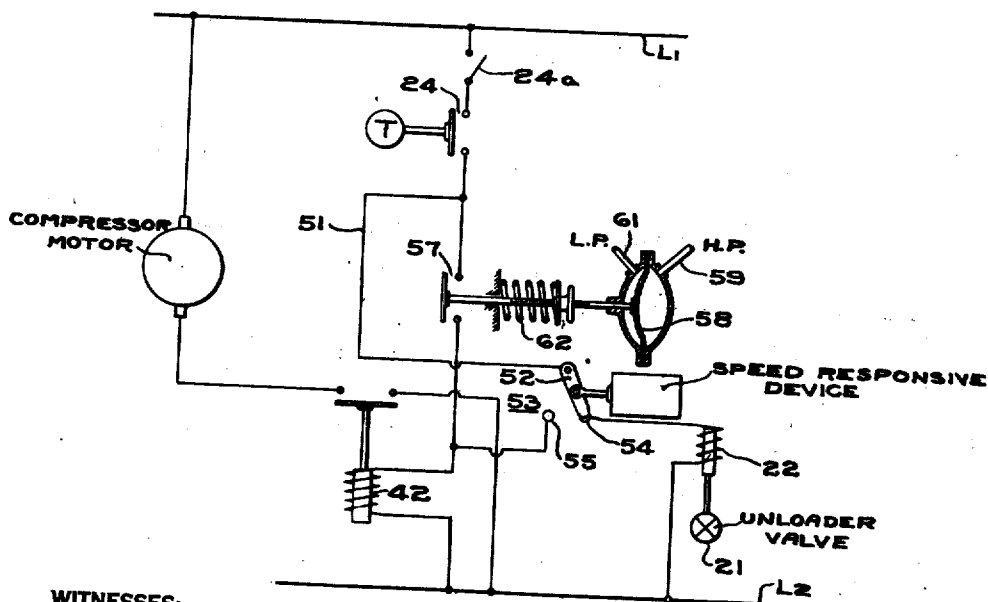
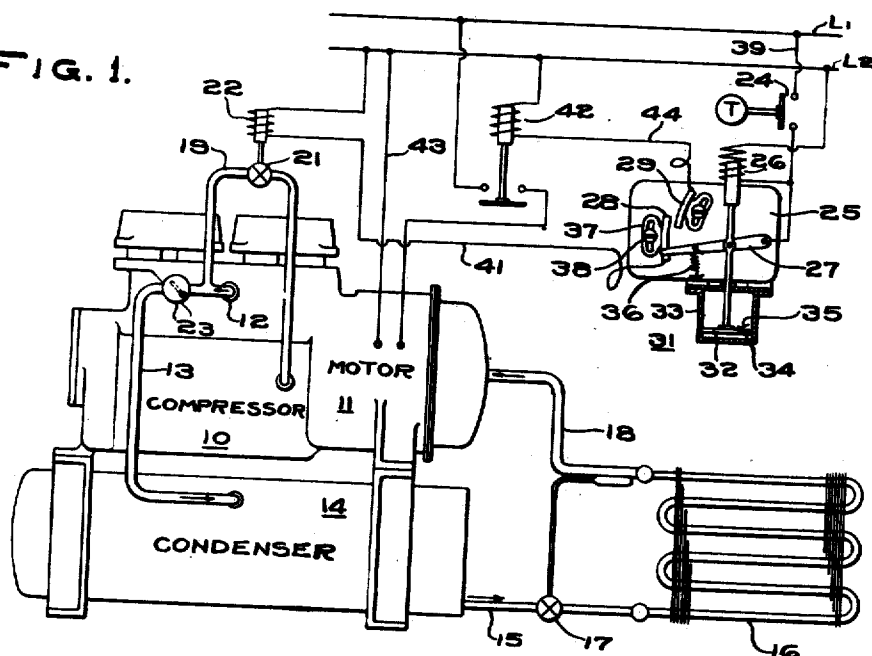
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REFRIGERATING APPARATUS

2,254,593

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FIG. 1.



WITNESSES:

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FIG. 2.

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REFRIGERATING APPARATUS

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3 Claims. (Cl. 230—22)

Our invention relates to refrigerating apparatus, more particularly to mechanism for unloading the compressor of such apparatus during the starting period thereof in order to reduce the starting current of the motor driving the compressor.

One way of unloading a compressor is to provide an unloader valve which permits flow of refrigerant from the high pressure side to the low pressure side of the system for equalizing the pressures therein. The valve is closed only during operation of the compressor, so that the pressures are equalized while the compressor is shut down. This method of unloading has a disadvantage in certain cases where the compressor crank case containing a supply of lubricating oil is connected to the low pressure side and a refrigerant miscible in oil, such as dichlorodifluoromethane, is used. The pressure in the crank case is raised by the pressure equalization to such an extent that the oil absorbs an excessive quantity of refrigerant while the compressor is shut down. Upon starting, slugs of oil may be carried into the cylinders, due to the foaming of the oil caused by vaporization of the refrigerant absorbed therein.

Another method of unloading is to equalize the pressures at the moment of starting the compressor. Since the starting current rises rapidly, this method involves the problem of effecting the pressure equalizing flow almost instantaneously, which is difficult with refrigerating apparatus of the larger sizes.

It is an object of our invention to provide improved unloader mechanism for a compressor.

A more particular object is to provide unloader mechanism which permits the pressure difference between the two sides of the system to be maintained while the compressor is shut down, and which effects substantially complete unloading before the compressor starts, so that the starting current is effectively limited.

In accordance with our invention, we provide a mechanism including an unloader valve for effecting pressure equalizing flow, which valve is normally closed so that the desired pressure difference is maintained while the compressor is shut down. The unloader valve is opened only when the master or automatic control calls for operation of the compressor. Starting of the compressor is delayed for a short time in order to permit the pressure-equalizing flow to be substantially completed, so that the compressor is unloaded before it starts and the starting current is effectively limited.

The starting of the compressor and the closing of the unloader valve may be effected in timed relation to the action of the master or automatic control, the closing of the unloader valve being delayed sufficiently to permit the compressor to come up to speed. Alternatively, the compressor may be started in response to pressure difference in the high and low pressure sides of the refrigerating system, and the unloader closed in response to speed of the compressor.

The above recited 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 diagrammatic view of one embodiment of our invention in which the starting of the compressor and closing of the unloader valve are effected in timed relation to the closing of a thermostatic switch; and

Fig. 2 is a wiring diagram of a modified form of control mechanism in which the compressor is started in response to the difference between the pressures in the high and low pressure sides of the compressor.

Referring to Fig. 1 in detail, the refrigerating system includes a compressor 10 driven by a motor 11. The compressor and motor are enclosed in a common casing, thereby forming a hermetically sealed motor compressor unit. The outlet of the compressor, shown at 12, is connected through a discharge conduit to a condenser 13, of any suitable type. The refrigerant condensed in the condenser 13 is conveyed through a conduit 14 to an evaporator 15, the flow thereof being controlled by a thermostatic expansion valve 17, as is well known in the art. The refrigerant is vaporized in the evaporator and conveyed through a suction conduit 18 to the casing of the motor compressor unit, being preferably admitted to the end thereof containing the motor, so as to pass in contact with the motor parts for cooling same before being admitted to cylinders of the compressor.

The compressor 10 is of the reciprocating type and has a crank case containing a body of oil for lubricating the motor compressor unit. The crank case is connected to the low pressure side of the system.

A conduit 19 is connected to the discharge conduit 13 adjacent the outlet 12 and to the low pressure side of the system at any suitable point, such as the crank case. An unloader valve 21 is connected in the conduit 19 for controlling flow of fluid therethrough. The valve 21 is oper-

ated in any suitable manner as by a solenoid 22, which opens the valve when energized and closes same when deenergized. A check valve 23 may be interposed in the discharge conduit 19 beyond the connection with the conduit 18 to prevent back-flow of compressed refrigerant from the condenser when the valve 21 is opened.

The control mechanism for the motor compressor unit includes a master control device, preferably automatic, which may be of any suitable conventional form. For example, it may comprise a thermostatic switch 24 responsive to the temperature of an enclosed space which is cooled by the evaporator 16. The thermostatic switch 24 is adapted to close its contacts when the temperature exceeds a predetermined value and to open its contacts when the temperature decreases substantially below said predetermined value.

The control system further includes an instant reset, time-delay relay mechanism 25 including solenoid 26, a contactor arm 27 adapted to engage arcuate contacts 28 and 29, and a dash-pot 31 connected to the solenoid 26. The dash-pot 31 includes a piston 32 operating in a cylinder 33. The piston is formed with an opening 34 adapted to be closed by a check valve 35, so that the piston retards only upward movement of relay but permits instantaneous downward movement under force of a spring 36 when solenoid 26 is deenergized.

The arcuate contact 28 is disposed to be engaged by the contact arm 27 from the lower end of its travel throughout most but not all of the upward movement. The arcuate contact 29 is disposed to be engaged by the contact arm 27 shortly before the latter disengages the contact 28 and to remain in engagement with said arm at the upper end of its travel. The contacts 28 and 29 are adjustable with respect to the arm 27, for example, each contact may be provided with a slotted member 37 engaged by a binding screw 38.

Electric energy for the control system is supplied from line conductors L₁ and L₂. The several control circuits extend in common from line conductor L₁ through conductor 39 and the thermostatic switch 24 so that they are deenergized when the switch 24 is opened. Thence, one circuit extends through the solenoid 26 to the line conductor L₂ so that the solenoid is energized as long as the thermostatic switch is closed. A circuit for the solenoid 22 extends from the thermostatic switch 24 through the contact arm 27, the contact segment 28 and a conductor 41 to the solenoid 22, and thence to the line conductor L₂. A relay 42 is preferably provided for controlling the supply line 43 to the compressor motor 11. The relay 42 is controlled by a circuit extending from the thermostatic switch 24 through the arm 27, the contact segment 29, a conductor 44 and the relay 42 to the line conductor L₂.

OPERATION

When the temperature controlling the operation of the apparatus is below the predetermined value, the thermostatic switch 24 is opened, so that all of the circuits are open as shown on the drawing. Assuming said temperature to increase above said determined value, the thermostatic switch 24 is closed. The circuit through the solenoid 26 is completed thereby energizing the same. The contact arm 27 being in engagement with the contact segment 28, as shown in the drawing, the solenoid 22 is energized to open the

unloader valve 21. Accordingly, compressed refrigerant at the outlet of the compressor is released to the low pressure side thereof, thereby equalizing the pressure in the inlet and outlet sides of the compressor. The compressor is thus unloaded, thereby reducing the starting current of the motor 11. When the check valve 21 is employed, which is optional, only a relatively small volume of compressed gas is released, the compressed gas in the condenser being held back from the pressure equalizing conduit 19 by the check valve.

The contact arm 27 moves upwardly under force of the solenoid 26, the movement thereof being retarded by the dash-pot 31. At the end of a predetermined period of time, sufficient for unloading, the arm engages the contact 29, thereby completing the circuit controlling the compressor motor. The compressor is thereby started. The arm now engages both the contacts 28 and 29 so that the unloader valve remains open during the starting period. The arm continues its upward movement and at the end of a further predetermined period of time, sufficient for the motor compressor unit to attain substantially the normal running speed, it disengages the contact 28, thereby opening the circuit through the solenoid 22 and closing the unloader valve 22. The compressor is thereby loaded and normal operation of the refrigerating system begins.

When the controlling temperature is reduced substantially below the predetermined value, the thermostatic switch 24 opens, thereby opening the circuit through the relay 42 to terminate operation of the compressor. At the same time, the solenoid 26 is deenergized, so that the arm 27 is moved to the lower end of its travel. This movement is effected rapidly or substantially instantaneously, since the check valve 35 permits the fluid below the piston to escape through the opening 34. The purpose of instantly resetting the time delay mechanism is to insure that, in the event of opening of the switch 24 for a short period, the compressor is again unloaded during the starting period. When the arm 27 is moved to the lower end of its travel, it again engages the contact 28 but the circuit through the solenoid 22 is opened by the thermostatic switch 24 so that the unloader valve remains closed. The circuit is conditioned, however, to be energized when the thermostatic switch 24 recloses.

Figure 2

In Fig. 2, I show a modified form of control mechanism including a thermostatic switch 24 similar to that shown in Fig. 1. A manual switch 24a, in series with the switch 24, is preferably provided. A conductor 51 extends from the switch 24 to the contact arm 52 of a switch 53. The arm 52 is adapted to engage either a contact 54, from which a circuit extends through the solenoid 22, or a contact 55, from which a circuit extends through the coil of the relay 42.

The contact arm 52 is actuated by a suitable mechanism, indicated diagrammatically at 56, which is responsive to the speed of the motor compressor unit, for example, a centrifugal fly-ball governor or a pressure responsive element which may be responsive to the pressure developed by the oil pump of the compressor. The contact arm 52 engages the contact 54 when the speed is below a predetermined value, and it engages the contact 55 when the speed is above the predetermined value. The predetermined speed is preferably slightly below the normal running

speed; for example, if the motor compressor unit operates at 1170 R. P. M., then the switch may be operated at 1050 R. P. M. A suitable form of snap-acting mechanism (not shown as it is well understood in the art) is preferably provided to move the contact arm 52 rapidly from one contact to the other.

In this embodiment, the compressor is started when the pressures in the inlet and outlet sides of the compressor have been substantially equalized. The circuit for initially energizing the relay 42 extends through the switch 24 and then through a switch 57 actuated by a pressure responsive diaphragm 58. The latter is subjected, in switch opening direction, to the pressure at the outlet of the compressor, which pressure is conveyed through a tube 59. It is biased in switch closing direction by the pressure in the inlet side of the compressor conveyed through a tube 61. The switch 57 is biased in closing direction by a spring 62, which is preferably adjustable in order to vary the pressure difference at which the switch opens and closes. As will be noted from the drawing, the switch 57 is in parallel with the contact 55 of the switch 53.

Figure 2—Operation

Assume that the compressor is shut down and that the pressure at the outlet remains higher than the pressure in the inlet side because of previous operation of the compressor. The switch 57, therefore, is open and the contact arm 52 engages the contact 54. When the thermostatic switch 24 closes, the circuit through the solenoid 52 is closed, so that the unloader valve is opened to provide pressure equalizing flow for unloading the compressor. The circuit for the compressor relay 42 remains open because the switch 57 is open and the contact 55 is disengaged.

As soon as the pressures in the inlet and outlet sides of the compressor have been substantially equalized by the flow through the unloader valve, the spring 62 closes the switch 57 to close the circuit for the relay 42. The latter closes the circuit supplying current to the compressor motor to start operation thereof. The unloader valve remains open for the time being in order that the compressor may be brought up to speed, thereby reducing the starting current of the motor. As the motor compressor unit approaches the normal operating speed, the arm 52 is moved from the contact 54 to the contact 55. The unloader valve is closed so that the compressor becomes effective to compress refrigerant. The compressor immediately begins to build up a pressure difference so that, within a short time, the diaphragm 58 opens the switch 57. The circuit for the relay 42 remains closed, however, for the reason that the contact arm 52 is moved into engagement with the contact 55 at the same time that the unloader circuit was opened. The refrigerating apparatus now remains in normal operation as long as the thermostatic switch 24 is closed.

When the switch 24 opens, the circuit through the coil of the relay 42 is deenergized to terminate operation of the motor compressor unit. As the speed of the motor compressor unit drops below 1050 R. P. M., the contact arm 52 engages the contact 54, but the solenoid 22 remains deenergized because of the opening of the switch 24. The circuit is conditioned, however, to be reclosed immediately upon reclosing of the switch 24, in which case the compressor is again un-

loaded while starting is delayed, as described above.

In the event that the circuit through the coil of the relay 42 is opened, for any reason, for a period of time so short that the speed of the compressor does not drop down to 1050 R. P. M., then the relay 42 is immediately reenergized, since the contact arm 52 remains in engagement with the contact 55. In such event, it is not necessary to unload as the motor compressor is operating at sufficient speed. However, when the speed once drops below 1050 R. P. M., then the compressor must be unloaded before it can be restarted.

If the motor compressor unit is shut down for a greater length of time, the pressures in the high and low side of the compressor may be substantially equalized by slight leakage through the compressor valves or other part of the refrigerating system. In such case, the switch 57 is closed and the compressor starts immediately upon the closing of the switch 24. The unloader valve 21 remains open, however, to avoid placing load on compressor until it has come up to the predetermined speed, for example, 1050 R. P. M.

From the above description, it will be seen that we have provided refrigerating apparatus wherein the unloader valve is closed while the motor compressor unit is shut down, so that absorption of refrigerant in the crank case coil is avoided or minimized, and wherein starting of the motor compressor unit is delayed, when the master or automatic control calls for operation, to provide time for the pressure equalizing flow to be effected for unloading the compressor.

While we have shown our invention in two forms, it will be obvious to those skilled in the art that it is not so limited, but is susceptible of various other changes and modifications without departing from the spirit thereof, and we 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 we claim is:

1. In a mechanical compression refrigerating system, the combination of a compressor having a crank case containing a body of lubricating oil connected in the low pressure side of the system, a normally closed pressure-equalizing valve connected between the inlet and the outlet sides of the compressor, an electrically actuated device for operating said valve and arranged to open said valve when energized and to close said valve when deenergized, an automatic control switch which closes in response to an operating condition indicating demand for operation of the compressor, a time delay device set into operation by closing of said automatic control switch and having a first set of contacts which are closed for a predetermined period of time after closing of the automatic control switch and then opened and a second set of contacts which are open for a predetermined period of time after closing of the automatic control switch and then closed, an electrical circuit for the operating mechanism of said valve extending through said automatic control switch and said first set of contacts in series, and an electrical circuit for controlling operation of the compressor extending through said automatic control switch and said second set of contacts in series, whereby said unloader valve is opened only for a predetermined period

following closing of said automatic control switch and starting of the compressor is delayed to provide time for unloading.

2. A refrigerating system having a low-pressure side and a high-pressure side and including a motor compressor unit for translating refrigerant vapor from the low-pressure side to the high-pressure side, a normally closed, pressure-equalizing valve connected between the low-pressure side and the high-pressure side of the system, an electrically energized valve-operating device directly connected to said valve, master control means for controlling the operation of the motor compressor unit, and means operable automatically in response to action of the master con- 15

5 trol means calling for operation of the motor compressor unit to control said valve-operating device to open said valve substantially instantaneously while delaying starting of the motor compressor unit for a period of time after said valve is opened to provide pressure-equalizing flow and then to start the motor compressor unit.

3. A refrigerating system as set forth in claim 2, wherein the automatically-operable means controls said valve-opening device to close said valve at the end of a predetermined period of time after the motor-compressor unit is started.

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