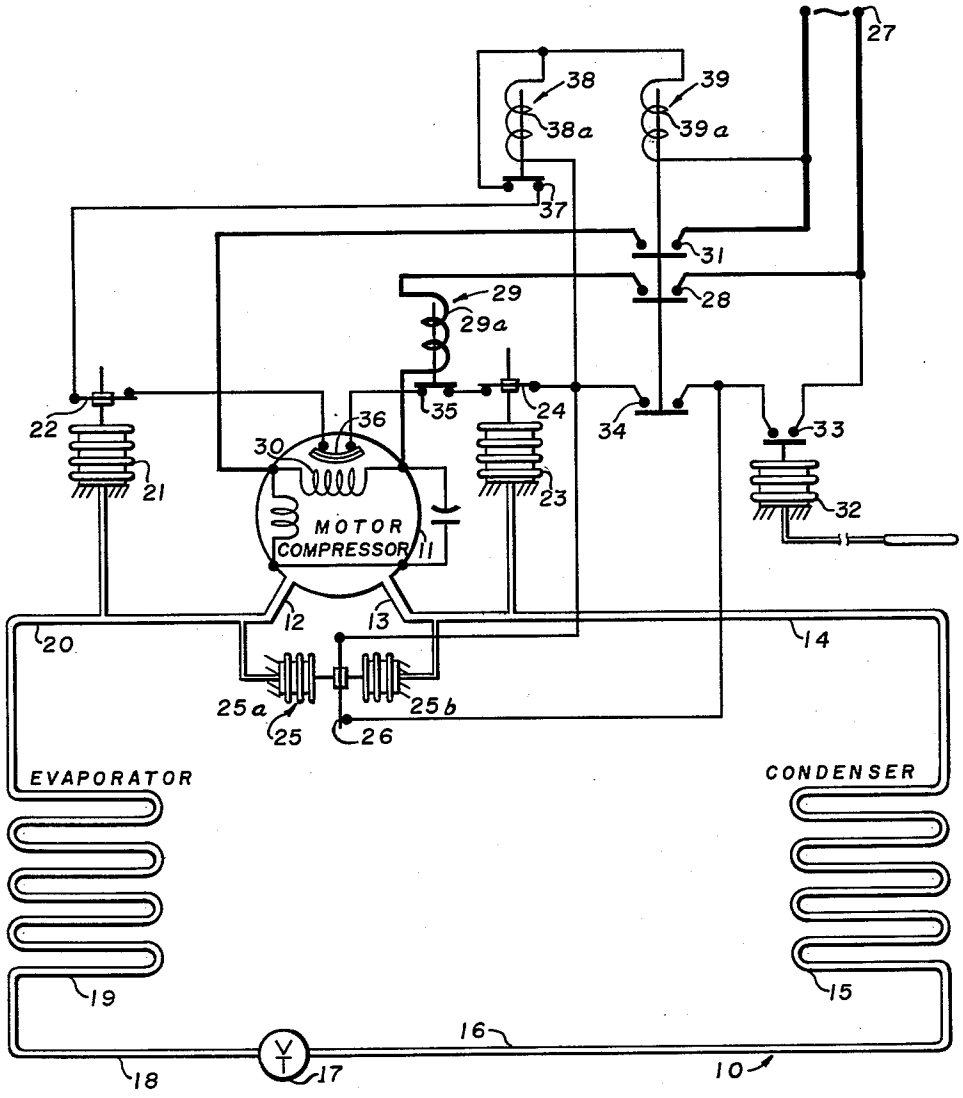
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REFRIGERATION SYSTEM CONTROL

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REFRIGERATION SYSTEM CONTROL

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This invention relates to refrigeration control systems and more particularly to an arrangement for controlling refrigeration compressor motors, especially those having relatively low starting torque.

In a refrigeration system wherein the refrigerant compressor is driven by an electric motor, the torque required by the compressor for starting may exceed the normal starting torque of the motor. This is especially true of induction motors of the capacitor-run and shaded-pole type. Various methods of solving this difficulty have been applied.

One such solution has been to provide the compressor with an unloader mechanism which operates to hold the compressor suction valves in the open position until a sufficient operating speed has been reached, thus reducing the required starting torque.

Another solution that has been practiced widely with capacitor-run motors has been to provide the run capacitor thereof with a parallel starting capacitor which is connected into the circuit momentarily during starting which has the effect of providing the motor with additional starting torque. The invention herein described provides another solution for coping with this difficulty of starting torque in refrigeration systems.

It is an object of this invention, therefore, to provide a refrigeration control system which insures that the required starting torque of refrigerant compressor is below a predetermined level.

It is another object to provide a control system which prevents start-up of the refrigerant compressor until the pressure differential between the compressor suction side and the discharge side has dropped below a predetermined level thereby reducing the required starting torque of the compressor.

A further object of this invention is to provide in a refrigeration control system safety means which prevents recycling of the start-up mechanism after detection of a malfunction in combination with means for preventing start-up until the pressure differential has fallen below a predetermined level.

Other objects and advantages of this invention will become apparent as the description proceeds.

Reference is made to the accompanying drawing in which the single FIGURE diagrammatically illustrates a refrigeration system to which a form of the invention is applied.

Reference numeral 10 designates a refrigeration system wherein a motor-compressor 11 having suction inlet 12 and a discharge outlet 13 supplies compressed refrigerant through conduit 14 to condenser 15. The refrigerant condensate passes through conduit 16 to expansion valve 17 where the refrigerant is expanded and delivered via conduit 18 to evaporator 19, hence back to the compressor through conduit 20. During operation the refrigerant is under high pressure as it passes from compressor 11 through condenser 15 to expansion valve 17. The refrigerant passing from the expansion valve through the evaporator 19 to the compressor 11 is under lower pressure during operation.

Communicating with this conventional refrigerant system are several refrigerant pressure responsive switches. Reference numeral 21 indicates a low pressure responsive switch which opens contacts 22 when the refrigerant pressure in the low pressure side of the system falls below a predetermined level. High pressure responsive switch

23 senses the refrigerant pressure in the high pressure side of the system and opens contacts 24 upon sensing a pressure exceeding a predetermined level. Differential pressure responsive switch 25 senses the pressure in both the high pressure and low pressure sides of the refrigerant cycle preferably at the compressor outlet and inlet and opens circuit interrupting and connecting switch contacts 26 when the pressure differential between the two sides exceeds a predetermined limit. Switch 25 may be composed of a low pressure bellows 25*a* and a high pressure bellows 25*b* provided with fluid pressure transmitting conduits to said low and high pressure sides respectively. A change in the pressure differential effects movement of at least one of the contacts 26 in a manner well known to those skilled in the control art. The operation of these pressure responsive switches will be more fully described as this specification proceeds.

The control system for the aforedescribed refrigerant system comprises a motor power circuit and a control circuit interrelated therewith. The motor power circuit shown in the drawing with relatively heavy lines will first be described.

The motor power circuit includes a power source 27, power circuit interrupting and connecting switch contacts 28, and in series therewith coil 29*a* of overload relay switch 29, motor winding 30, and power circuit interrupting and connecting switch contacts 31. Contacts 28 and 31 are normally open and are actuated by the control circuit yet to be described. The motor in the diagram is shown as a capacitor-run type. However, it will be understood that the herein described invention is also applicable for use with other types of motors. The overload switch 29 is shown as of the electromagnetic type. This switch may, of course, be any current responsive switch.

The control circuit includes a power source, such as 27, and a thermal load responsive switch 32 having contacts 33 in series with said source. In series with contacts 33 are: control circuit interrupting and connecting switch contacts 34; contacts 24 of high pressure malfunction responsive switch 23; contacts 35 of malfunction overload switch 29; motor overheat cut-out malfunction switch 36; contacts 22 of low pressure malfunction responsive switch 21; normally closed circuit interrupting and connecting switch contacts 37 of high impedance lock out relay 38; and motor control actuator relay 39. The coil 38*a* of lock out relay 38 shunts across the series circuit including contacts 37, 22, switch 36, and contacts 35 and 24. Contacts 26 of differential pressure responsive switch 25 shunt contacts 34. Normally open contacts 34 of the control circuit and normally open contacts 28 and 31 of the motor power circuit are closed upon sufficient energization of coil 39*a* of motor control relay 39. The interrelationship of the refrigerant system, motor power circuit and the control circuit will become apparent as the operation of the invention is described.

Operation

Assume the entire system in the dormant condition as shown in the drawing. Relay coils 29*a*, 38*a*, and 39*a* and motor winding 30 are unenergized. The pressures in the high pressure and low pressure sides of the refrigerant system are substantially equal due to normal leakage through compressor 11 or throttling valve 17 or a bypass (not shown). Contacts 22 and 24 are closed since no unusual low pressure or high pressure conditions prevail.

The startup sequence is as follows. Thermal load responsive switch 32 senses load conditions, for instance, at the evaporator inlet receiving the fluid medium to be cooled. It will be noted that contacts 34 of the motor control relay are open and consequently the closure

of contacts 33 of thermal switch 32 will energize the control circuit only if contacts 26 of differential pressure responsive switch 25 are closed, i.e. if the pressure differential between the high and low pressure sides of the refrigerant cycle has dropped below a predetermined level, such as 10 p.s.i. Thus only if the pressure differential is below a predetermined limit is the thermal load responsive switch capable of energizing the control circuit by completing the circuit from the power source 27 through contacts 33, contacts 26 of differential pressure switch 25, contacts 24 and 35, thermal cut-out switch 36, contacts 22 and 37 and motor control relay coil 39*a* and back to power source, thus energizing motor control relay 39 and closing contacts 28, 31, and 34.

Substantially no current passes through high impedance lock out relay coil 38*a* as it is shunted by the low resistance circuit including contacts 24, 35, 36, 22, and 37. Since contacts 28 and 31 are closed, the motor power circuit is energized. Current from the power source 27 passes through contacts 28, overload switch coil 29*a*, motor winding 30 and returns to the power source via contact 31. It will be noted that simultaneously to the energization of the motor power circuit by the closure of contacts 28 and 31, contacts 34 actuated by motor control relay 39 are closed, thus providing a shunt across contacts 26 of differential pressure switch 25. Consequently the buildup of pressure differential in the refrigerant system due to the energization of the motor-compressor will not effect de-energization of the control circuit by pressure differential responsive switch 25 while the motor control relay coil 39*a* is energized. However, should contacts 33 open and reclose as in the normal thermal cycle, it will be noted that motor control relay coil 39*a* will be de-energized, thus opening contacts 28, 31, and 34. Since contacts 34 are then open, the control circuit is placed again in series with differential pressure responsive switch 25. Only when the differential pressure has dropped below the predetermined limit will switch 25 permit the control circuit to be re-energized. Thus it will be seen that the motor-compressor cannot be started initially or upon thermal load responsive cycling unless the differential pressure in the refrigerant circuit is below a predetermined level, thus insuring a minimum compressor starting torque requirement.

The control circuit also includes several safety devices which upon sensing a malfunction lock out the motor control relay 39 and thereby prevent energization of the motor power circuit even if the malfunction is momentary. Should abnormally high or low pressures be sensed by switches 23 or 21, contacts 24 or 22 will be opened. If the motor becomes overloaded or overheated, contacts 35 will be opened by overload switch 39 or motor overheat cut-out contacts 36 will open. The opening of any one of contacts 24, 35, 36, or 22 will shift the control circuit current through lock out relay coil 38*a*, thus opening contacts 37. The lock out relay coil, being of high impedance, permits insufficient current to pass to motor control relay coil 39*a*, thus causing it to drop out and interrupt the motor power circuit. Once contacts 37 of lock out relay 38 are opened, the reclosing of the contacts of any of the malfunction sensing devices will have no effect since contacts 37 in series therewith will remain open. The system remains in this condition until it is manually reset, for example by shutting off the power to permit contacts 37 actuated by relay 38 to close.

Although I have described in detail the preferred embodiment of my invention, I contemplate that many changes may be made without departing from the scope or spirit of my invention, and I desire to be limited only by the claims.

I claim:

1. In a refrigeration system having a closed refrigerant cycle including a refrigerant compressor, a refrigerant condenser, a throttling means and an evaporator connected respectively in series, the refrigerant path from said compressor through said condenser to said throttling means defining a high pressure side of said cycle and the refrigerant path from said throttling means through said evaporator to said compressor defining a low pressure side of said cycle and a motor for driving said compressor, the improvement comprising the combination: a motor power circuit means for delivering power to said motor, said power circuit means including a power circuit interrupting and connecting means for selectively de-energizing and energizing said power circuit means, control circuit means for selectively actuating said power circuit interrupting and connecting means toward the circuit connecting position in response to the thermal load on the refrigerant system, switch means for rendering said control circuit means inoperative in response to a pressure differential between said high pressure and low pressure sides in excess of a predetermined limit, means for rendering said switch means ineffective while the motor power circuit is energized, said control circuit means further including at least one control circuit interrupting and connecting means for interrupting said control circuit upon sensing a malfunction in said refrigeration system, and means responsive to the interrupting action of said control circuit interrupting and connecting means for retaining said control circuit in an at least partially interrupted condition until manually reset.

2. In a refrigeration system having a closed refrigerant cycle including a refrigerant compressor, a refrigerant condenser, a throttling means and an evaporator connected respectively in series, the refrigerant path from said compressor through said condenser to said throttling means defining a high pressure side of said cycle and the refrigerant path from said throttling means through said evaporator to said compressor defining a low pressure side of said cycle and a motor for driving said compressor, the improvement comprising: a motor power circuit for delivering power to said motor; said motor power circuit including a power switch in series with said motor; a control circuit for controlling said power switch; said control circuit including a motor control relay coil for actuating said power switch to the closed circuit position when sufficiently energized; a refrigeration load responsive switch in series with said control relay coil; a pressure differential responsive switch connected in series with said control relay coil and said load responsive switch; a control circuit interrupting and connecting means disposed in parallel with said pressure differential responsive switch and actuated to a closed circuit position by sufficient energization of said motor control relay coil; said pressure differential responsive switch being operatively connected to said high and low pressure sides of the refrigerant cycle for closing only when the pressure differential therebetween is below a predetermined limit; a lock out switch; a malfunction responsive switch in series with said lock out switch; said malfunction responsive switch and lock out switch being connected in series with said motor control relay coil, said control circuit interrupting and connecting means and said pressure differential responsive switch; and a lock out relay coil shunting said malfunction responsive switch and said lock out switch; said lock-out relay coil functioning to open said lock out switch when energized; said lockout relay coil being of sufficiently high impedance to render said motor control relay coil inoperative when at least one of said malfunction responsive and lock out switches is in the open circuit position.

3. In a refrigeration system having a closed refrigerant cycle including a refrigerant compressor, a refrigerant condenser, a throttling means and an evaporator connected respectively in series, the refrigerant path from said compressor through said condenser to said throttling means defining a high pressure side of said cycle and the refrigerant path from said throttling means through said

evaporator to said compressor defining a low pressure side of said cycle and a motor for driving said compressor, the improvement comprising the combination: a motor power circuit means for delivering power to said motor, said power circuit means including a power circuit interrupting and connecting means for selectively de-energizing and energizing said power circuit means, control circuit means for selectively actuating said power circuit interrupting and connecting means toward the circuit connecting position in response to the thermal load on the refrigerant system, switch means for rendering said control circuit means inoperative in response to a pressure differential between said high pressure and low pressure sides in excess of a predetermined limit, means for rendering said switch means ineffective while the motor power circuit is energized, said control circuit means further including at least one control circuit interrupting and connecting means for interrupting said control circuit upon sensing a malfunction in said refrigeration system, a lock-out switch arranged in series with said control circuit interrupting and connecting means; and a lock-out relay coil means shunting said lock-out switch and said control circuit interrupting and connecting means for actuating said lock-out switch to its circuit interrupting position.

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