

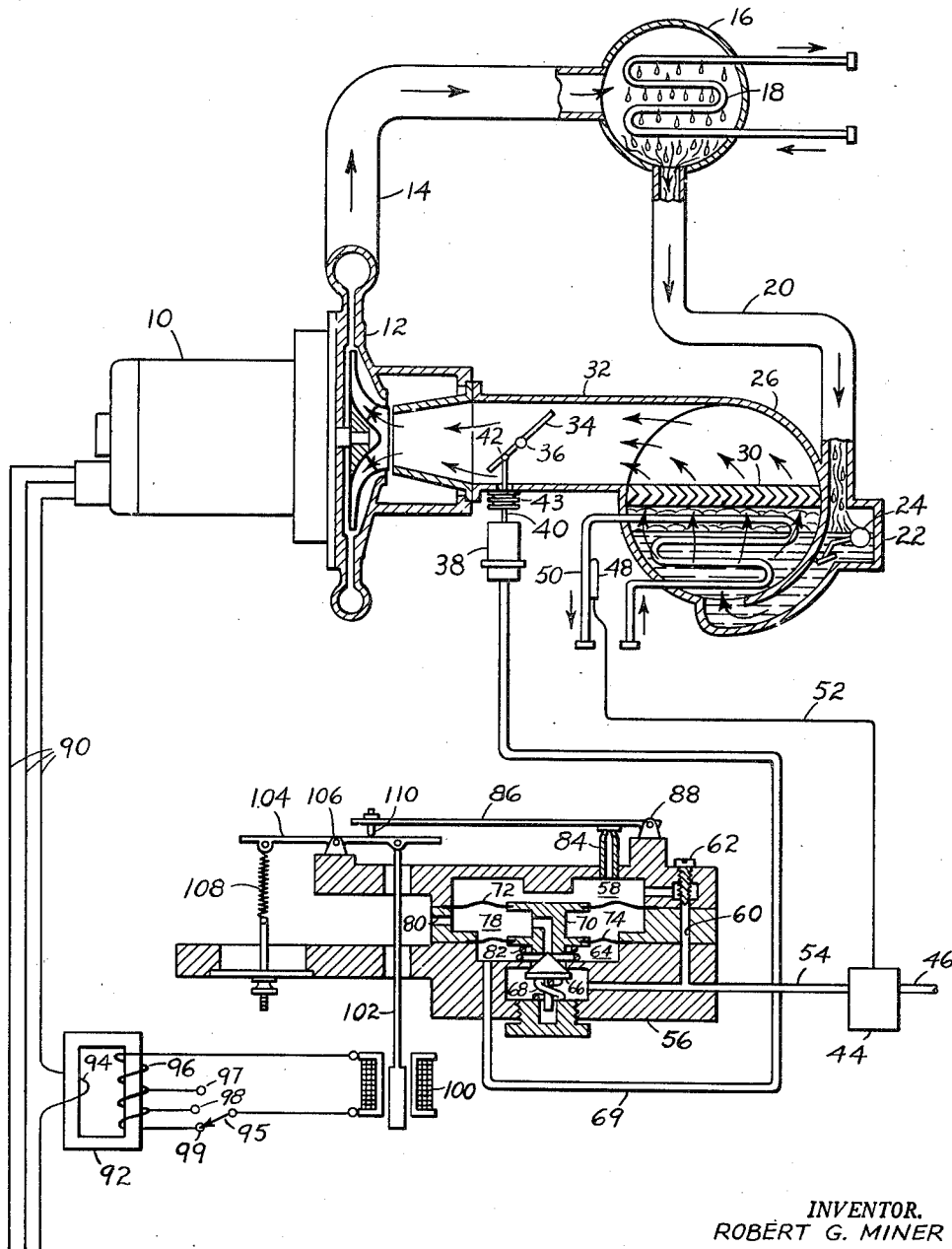
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REFRIGERATION APPARATUS WITH LOAD LIMIT CONTROL

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REFRIGERATION APPARATUS WITH LOAD LIMIT CONTROL

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This invention relates to refrigeration apparatus having control means for operating the apparatus at a capacity which corresponds with the refrigeration load on the apparatus and limiting the capacity of the compressor of the refrigeration apparatus to prevent exceeding a maximum safe current through the driving motor of the compressor.

Refrigeration apparatus is controlled to maintain a desired temperature of refrigerant supplied to the refrigeration load. There are several conditions under which the motor will tend to draw a current of magnitude such that the motor will be damaged. When refrigeration apparatus is started after it has been at rest for a period of time, the suction pressure is substantially equal to the saturation pressure of the refrigerant at the ambient temperature. This pressure is higher than the normal suction pressure with the result that the flow rate through the compressor is considerably increased. A high flow rate through the compressor will put a high load on the motor and the motor will draw a current which will damage the motor.

Low voltage to the motor is another condition which will cause the motor to draw an excessive current. Various other conditions may cause the motor to draw an excessive current.

It is an object of the invention to provide means for measuring the value of the electric current through the driving motor of the compressor and to use this measurement to control the flow of gas to the compressor to prevent exceeding a predetermined maximum motor current.

It is another object of the invention to provide means for setting the load limit device at 100% of full load capacity or some increment of full load capacity such as 60% or 40%. When it is known that the load will be less than full load for a given period, the load limit device may be set at the desired reduced capacity in order to avoid paying the supplier of electrical energy a demand charge on a higher capacity which might be desired only for a few hours during the period.

Other objects and advantages of the invention will become apparent as the specification proceeds to describe the invention with reference to the accompanying drawing in which the apparatus is shown diagrammatically.

An electric motor 10 is connected to and drives a compressor 12. The compressor 12 discharges the refrigerant gas into a pipe 14 which conducts the gas to a condenser 16. The condenser is preferably of the shell and tube type in which cooling water flows through the tubes 18 and the refrigerant is in the shell outside the tubes. Refrigerant liquid condensed in condenser 16 flows by gravity through pipe 20 to a float chamber 22. Float 24 in float chamber 22 opens and closes to control the flow of refrigerant liquid to an evaporator 26 which is preferably of the shell and tube type in which a secondary refrigerant liquid such as water or brine flows through the tubes 28. In removing heat from the secondary refrigerant, the refrigerant in the evaporator 26 boils forming gas which passes through the liquid eliminator 30 and thence into the suction pipe 32 to the compressor 12.

A damper 34 is pivotally mounted at 36 in the suction pipe 32. Damper 34 may be pivoted from a position in which it is in an axial plane of pipe 32 to various angular

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positions to reduce the flow of gas to the compressor 12. It should be understood that means other than the damper shown may be used to vary the flow to the compressor. For instance inlet vanes as shown in the patent to Hagen No. 1,989,413 can be used to vary the flow through the compressor. The rate of flow of gas through the compressor is one of the factors which determines the power required by the compressor and thus the current required by the motor. Therefore the position of the damper 34 determines the current drawn by the motor 10. A pneumatic motor 38 has a rod 40 pivotally connected to the vane 34 at 42. A bellows 43 provides a seal between the rod 40 and the pipe 32. The bellows 43 is flexible to permit movement of the rod 40. The pneumatic motor 38 is of well known construction in which a piston or diaphragm translates pressures into rod positions.

A pneumatic thermostat 44 is connected to receive air under pressure from a source 46. Thermostat 44 has a temperature sensing bulb 48 thermally responsive to the temperature of the fluid in the pipe 50 which conducts the secondary refrigerant to the refrigeration load. If desired the bulb 48 may be immersed in the refrigerant flowing in pipe 50. The bulb 48 is connected to the thermostat 44 by a tube 52.

The pneumatic thermostat 44 is of a well known type which sends out through tube 54 air having a pressure directly proportional to the temperature of the refrigerant in pipe 50. Tube 54 is connected to a load limit relay 56. An upper chamber 58 receives air from thermostat 44 through passageway 60. A needle valve 62 can be adjusted to obtain the desired restricted flow to upper chamber 58. A lower chamber 64 receives air from thermostat 44 and a conical valve 66 controls the flow of air into lower chamber 64. A spring 68 acts to hold conical valve 66 in closed position. Lower chamber 64 is connected to pneumatic motor 38 by tube 69. A spool member 70 is secured at one end to diaphragm 72 and at its other end to diaphragm 74. Diaphragm 72 has approximately twice the area of diaphragm 74. Spool member 70 has a passageway 76 leading to chamber 78 which is open to the atmosphere through hole 80. A spring 82 acts to raise spool member 70 from contact with conical valve 66. A bleed port 84 permits air to escape from upper chamber 58 under certain conditions to be described later. A lever 86 pivoted at 88 opens and closes the bleed port 84 to control the flow of air therethrough.

The motor 10 has three leads 90 connected to a source of electrical energy. A current transformer 92 has its primary winding 94 in one of the leads 90. The secondary winding 96 has three taps 97, 98, and 99 for 40%, 60% and 100% of maximum safe motor current. Taps 97, 98, and 99 may be selectively contacted by switch blade 95. The secondary winding 96 is connected to a solenoid 100 which has a plunger 102 which acts against a lever 104 pivoted at 106. A spring 108 substantially counteracts the weight of plunger 102. Lever 104 acts against lever 86 at 110 to raise the lever 86 to uncover the bleed port 84. The current transformer 92 has a suitable ratio of primary current to secondary current so that the current to solenoid 100 is approximately five amperes.

Having now described the apparatus, its method of operation will now be explained. Assuming first that the load on the refrigeration system is such that the motor current is less than 105% of motor name plate current. The current drawn by the motor is sufficient to open the bleed port 84. The pressure in chamber 58 is therefore substantially the output pressure of pneumatic thermostat 44. Diaphragm 72 has an area substantially twice as great as that of diaphragm 74 and therefore the force

downward on the spool member 70 is sufficient to compress springs 82 and 68 to close passageway 76 and to move conical valve 66 to open position. The pressure in chamber 64 is therefore substantially the output pressure of pneumatic thermostat 44 and this pressure is transmitted through tube 69 to the pneumatic motor 38. It is thus seen that the pneumatic thermostat controls the position of the damper 34 and thus the capacity of the refrigeration apparatus for all loads between a predetermined minimum load and a load which will cause the motor to draw a current equal to 105% of full load current.

When the load increases so that the motor draws a current greater than 105% of full load current, the solenoid 100 moves plunger 102 upwardly and through levers 104 and 86 opens bleed port 84. Opening of bleed port 84 reduces the pressure in chamber 58 to close conical valve 66 and open passageway 76. The pressure in chamber 64 is thus reduced below the output pressure of pneumatic thermostat 44 and pneumatic motor 38 receives this reduced pressure. A reduction in pressure in pneumatic motor 38 moves damper 34 to reduce the flow to the compressor 12. The current transformer 92 and the solenoid 100 by controlling the bleed port 84 prevent the pneumatic thermostat from operating the compressor at a capacity which will cause the motor to draw a current which would damage the motor.

The ratio between the pressure in chamber 58 and in chamber 64 is closely maintained as the pressure is reduced in chamber 58 by the opening of the bleed port 84 increasing amounts. Cone valve 66 admits air to or exhausts air from chamber 64 to always balance the forces on the diaphragms 72 and 74. Thus the reduction in air pressure to the pneumatic motor 38 is proportional to the increase in motor current within the range of the load limit relay which is 105% to 110% of the motor name plate current.

The switch blade 95 may be put in contact with taps 97 or 98 to limit the flow to the compressor so that the current to the motor is limited to 40% or 60% of the motor name plate current. The supplier of electrical energy makes a demand charge based on the maximum current drawn during a given period. Often this maximum current is called for only during a relatively short period. When conditions are such that the load on the refrigeration machine is low most of the time, the blade 95 may be put in contact with tap 98 to limit the apparatus to operation at 60% of name plate current. The demand charge will be based on 60% of name plate current. The refrigeration thus produced might fail to equal the heat load on the apparatus for a short period, but the large mass of refrigerant will prevent the temperature from rising seriously during this short period.

Although I have described specifically the preferred embodiments of my invention, I contemplate that 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. Refrigeration apparatus comprising a condenser, an evaporator, a compressor connected to draw refrigerant from said evaporator and discharge the refrigerant into said condenser, an electric motor for driving said compressor, means for throttling the flow of gas to said compressor, a fluid motor for positioning said throttling means, a fluid thermostat responsive to the temperature of said evaporator, a fluid relay connected to receive fluid from said fluid thermostat and to transmit fluid to said fluid motor and means responsive to the magnitude of the electrical energy drawn by said electric motor for controlling said fluid relay to vary the pressure transmitted from said fluid thermostat to said fluid motor when the electrical energy drawn by said electric motor exceeds a predetermined value.

2. Refrigeration apparatus comprising a condenser, an

evaporator, a compressor connected to draw refrigerant from said evaporator and discharge the refrigerant into said condenser, an electric motor for driving said compressor, adjustable means for throttling the flow of gas to said compressor, a fluid motor for positioning said adjustable throttling means, a fluid thermostat responsive to the temperature of said evaporator, a fluid relay connected to receive fluid from said fluid thermostat and to transmit fluid to said fluid motor, magnetic means for controlling said fluid relay to vary the pressure transmitted from said fluid thermostat to said fluid motor, means for energizing said magnetic means in proportion to the magnitude of electrical energy drawn by said electric motor and means for adjusting said energizing means to vary the energization of said magnetic means.

3. In refrigeration apparatus having a condenser, an evaporator, a compressor connected to draw refrigerant from said evaporator and discharge the refrigerant into said condenser, an electric motor for driving said compressor, and adjustable throttling means for throttling the flow of gas to said compressor; the combination of fluid means for opening said throttling means, a thermostat for controlling the fluid pressure transmitted to said fluid means, said thermostat being responsive to the temperature of said evaporator and means proportionally responsive to the magnitude of electrical energy drawn by the electric motor for proportionally varying the fluid pressure transmitted from said thermostat to said fluid means.

4. A compressor, an electric motor for driving said compressor, means for throttling the flow to said compressor, fluid means for varying the opening of said throttling means and electrically responsive means proportionally responsive to the magnitude of electrical energy drawn by said motor for proportionally limiting the opening of said throttling means, and electrical means for varying the value at which said electrically responsive means limits the opening of said throttling means.

5. In refrigeration apparatus having a compressor, an electric motor for driving the compressor, and means for throttling the flow to the compressor, the combination of fluid means for positioning said throttling means, thermostatic means for controlling said fluid means, and electrically responsive means proportionally responsive to the magnitude of electrical energy drawn by said motor for proportionally limiting the opening of said throttling means and electrically responsive means for varying the value of the magnitude of electrical energy at which the said electrically responsive means limits the opening of said throttling means.

6. In refrigeration apparatus having a condenser, an evaporator, a compressor connected to draw refrigerant from said evaporator and discharge the refrigerant into said condenser, an electric motor for driving said compressor, and adjustable throttling means for throttling the flow of gas to said compressor; the combination of fluid means for opening said throttling means, a thermostat for controlling the fluid pressure transmitted to said fluid means, said thermostat being responsive to the temperature of said evaporator and electric means proportionally responsive to the magnitude of electrical energy drawn by the electric motor for proportionally varying the fluid pressure transmitted from said thermostat to said fluid means, and means for adjusting said electric means to vary the amount that said electric means varies the fluid pressure transmitted from said thermostat to said fluid means.

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