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REFRIGERATION CONTROL APPARATUS

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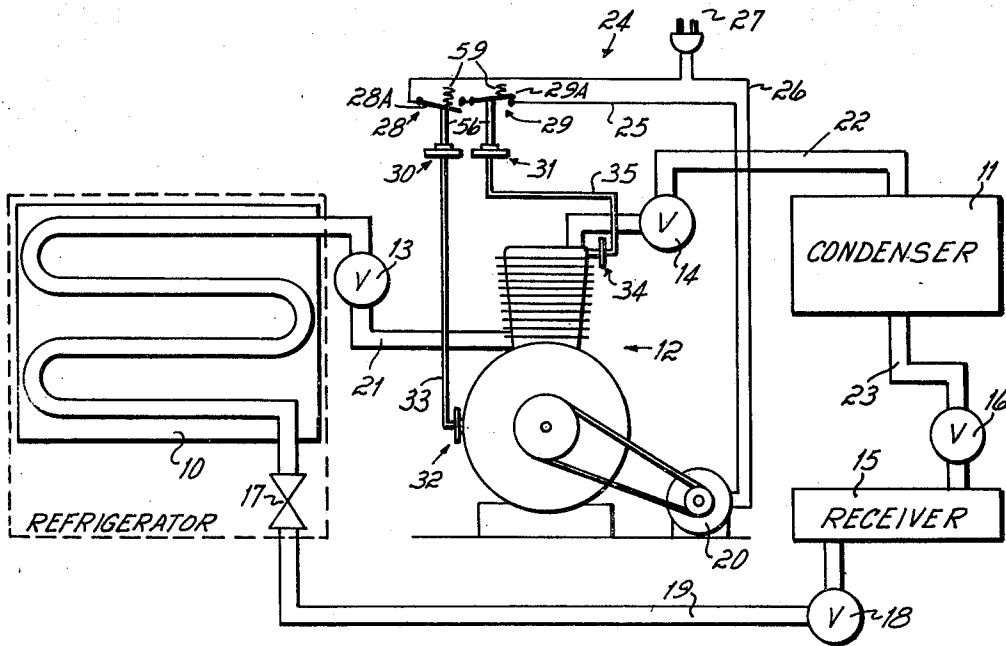


Fig. 1

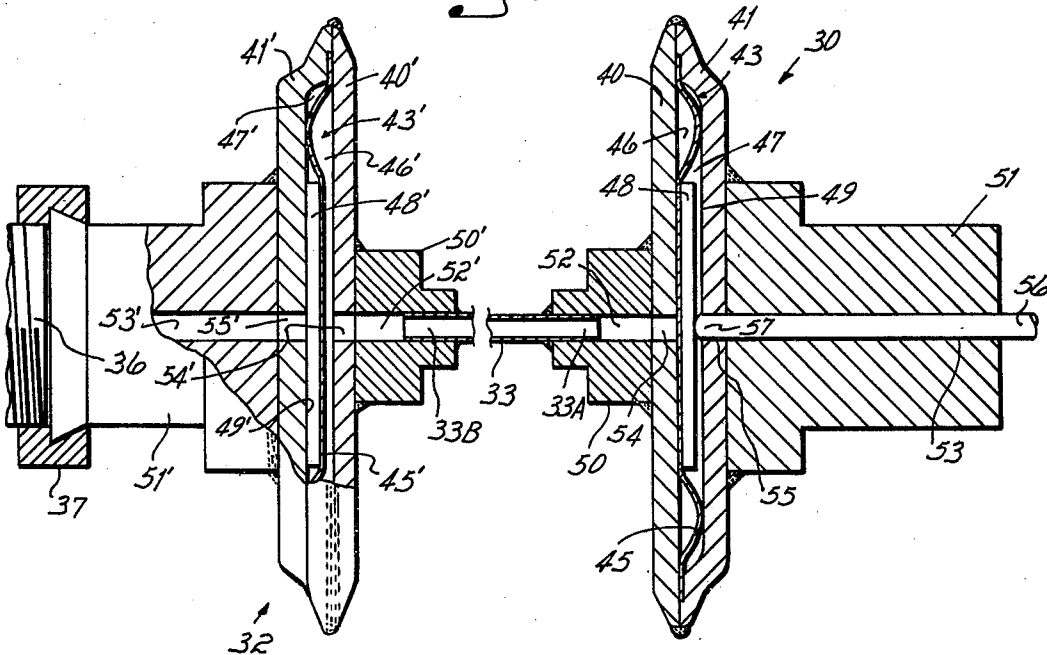


Fig. 2

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REFRIGERATION CONTROL APPARATUS

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Continuation-in-part of application Ser. No. 680,379,
Nov. 3, 1967. This application Jan. 22, 1969, Ser.
No. 814,486

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U.S. Cl. 62—209

8 Claims

ABSTRACT OF THE DISCLOSURE

A refrigeration system including a pressure actuated switch for controlling the refrigeration compressor. The switch is actuated by changes of pressure in the refrigerant of the system but is isolated from the refrigerant by a fluid filled capillary tube having pressure actuators at its opposite ends, one of which senses changes of refrigerant pressure and the other of which senses changes in condition of the first pressure actuator and effects changes in the condition of the control switch.

This application is a continuation-in-part application of co-pending application Ser. No. 680,379, filed Nov. 3, 1967, and now abandoned.

Background of the invention

The majority of all commercial refrigeration or air conditioning systems operate upon the principal of compressing a refrigerant in a compressor, passing the compressed refrigerant through a condenser to remove heat from the compressed refrigerant and then passing the cooled and compressed refrigerant through an expansion valve and evaporator back to the compressor. In passing through the evaporator, the refrigerant picks up heat from the surrounding atmosphere so as to cool that atmosphere. Refrigerant flow is generally controlled by controlling operation of the compressor; in other words, by turning the compressor on and off depending upon the temperature of the area to be cooled.

To control actuation of the compressor, most larger refrigeration systems utilize a pressure actuated switch. The bellows or actuator of this switch is connected directly to the refrigerant line by a small capillary tube so that changes in pressure (and temperature which is directly proportional to pressure) result in actuation of the switch and consequently the compressor.

It has been my experience that one of the very severe shortcomings or weaknesses of a refrigeration system of the type described hereinabove is the frequency of failure of the system because of a failure of the capillary tube. Generally, this tube is made from $\frac{1}{16}$ inch copper tubing connected at one end to the compressor and at the other end to the pressure switch control unit. Frequently, this tube breaks, either as a consequence of mechanical fatigue or as a consequence of a serviceman or other personnel accidentally bumping it. Breakage of this tube involves not only replacement of the tube but much more seriously, replacement of the complete charge of refrigerant plus in some instances, loss of refrigerated food products. In many larger installations, replacement of the refrigerant alone involves an expenditure of hundreds or even thousands of dollars.

It has, therefore, been an objective of this invention to provide an improved refrigeration system which is not subject to the shortcomings of conventional systems as outlined hereinabove. Specifically, it has been an objective of this invention to provide a refrigeration system which avoids the severe consequences of failure of the capillary tube of the control system.

Generally, in my improved refrigeration system, the control unit and specifically the pressure switch of the con-

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trol unit is physically isolated from the flow control path of the refrigerant so that failure of the control unit or of the interconnection between the refrigerant and the pressure switch has not effect upon and does not result in the loss of the refrigerant. This isolation is provided by pressure actuated diaphragm motors or bellows located at opposite ends of a non-compressible capillary tube and interconnected by a pressure transmitting fluid enclosed within the tube.

The primary advantage of the system is that it avoids escapement of the refrigerant into the atmosphere upon failure of the capillary tube. Since, in my experience, 90% or more of all system failures which result in the loss of the refrigerant occur at this point in the system, this invention avoids the severe consequences of most system failures.

These and other objectives and advantages of this invention will be more readily apparent from the following detailed description of the drawings in which:

FIGURE 1 is a diagrammatic illustration of a typical refrigerant or air conditioning system incorporating the novel control unit of this invention, and

FIGURE 2 is a side elevation view, partially broken away, of the pressure transmitting section of the control unit including the two pressure actuated diaphragm motors or bellows and the interconnecting fluid filled capillary tube.

Generally, the invention of this application is illustrated as applied to a conventional vapor compression cycle refrigeration or air conditioning system. It should be appreciated, however, that the inventive control unit of this system is equally applicable to other types of refrigeration systems. Therefore, the term "refrigeration" is used generically throughout this application to designate any type of cooling, refrigerating, or air conditioning system.

The vapor compression cycle refrigeration system illustrated in FIGURE 1 is a typical commercially available refrigeration system except for the novel control portion of the system. Basically, it comprises an evaporator 10, a compressor 12, a condenser 11, a receiver 15, and an expansion valve 17. Liquid refrigerant boils at a low temperature in the evaporator 10 to produce cooling. From the evaporator, the gaseous refrigerant is supplied through a conduit 21 via an inlet valve 13 to the compressor 12 which raises the temperature and pressure of the refrigerant. The gaseous pressurized refrigerant is then fed through a conduit 22 and an outlet valve 14 to the condenser 11 in which heat is withdrawn from the refrigerant. From the condenser, the refrigerant passes as a liquid through a conduit 23 and valve 16 to the receiver 15 where it is stored. From the receiver, the liquid refrigerant passes through an outlet or king valve 18 and conduit 19 through the expansion valve 17 back to the evaporator. In passing through the expansion valve 17, the liquid refrigerant expands and changes from the high pressure level in the condenser to the low pressure level in the evaporator 10. This flow cycle continues so long as a motor 20 continues to drive the compressor 12.

The control unit 24 which supplies power to the motor and thus controls its operation includes a pair of lead wires 25, 26 which interconnect the motor to an electrical power source 27 through a pair of series connected switches 28, 29. One of these switches 28 is spring biased to a normally open condition and the other 29 is spring biased to a normally closed position. Both switches 28, 29 are pressure actuated by diaphragm piston actuators or motors 30, 31. One switch 28 serves as a control switch to cycle the compressor while the other 29 serves as a high pressure safety switch to shut off the compressor in the event that pressure in the system exceeds a predetermined safe value, as is explained more fully hereinafter.

The control unit 24 has only been illustrated diagrammatically since, except for the interconnection or interface between the electrical portion of the unit and the refrigerant flow path, it is a conventional "off the shelf" item of hardware which may be purchased from any of several sources. One such suitable control unit is manufactured by the Milford Division of the Robertshaw Controls Company and is designated as their Model No. PT 22-7401.

The pressure actuator 30 of switch 28 is connected to another diaphragm motor 32 via a capillary tube 33, and similarly the diaphragm motor 31 is interconnected to a diaphragm motor 34 via a capillary tube 35. Both diaphragm motors or actuators 32, 34 are connected directly to the compressor 12 by a pair of conventional fittings 36, 37 (FIGURE 2); the actuator 32 being connected to the low pressure side of the compressor and the actuator 34 being connected to the high pressure side. Thus, the diaphragm motor 32 is operable to sense or respond to changes of pressure on the low pressure side of the compressor and the refrigerant system and the diaphragm motor 34 senses or responds to changes of pressure on the high pressure side of the compressor and the refrigerant network.

The pressure actuators 30, 32 and transmitting capillary tube 33 are identical to the actuators 31, 34 and transmitting capillary tube 35 so that only one pair of actuators and interconnecting tube 33 have been illustrated in detail. It should be appreciated, however, that an identical pair of actuators and transmitters are located on the high pressure side of the compressor.

The diaphragm motor or pressure actuator 30 comprises a pair of discs 40, 41 brazed together at their peripheral edge so as to define a sealed central cavity 43 therebetween. A circular diaphragm spring 45 is sandwiched between and sealingly separates the two chambers 46, 47 on opposite sides of the spring 45. This spring 45 is operative to bias a piston 48 of the motor against the inner surface 49 of the plate 41. Sleeves 50, 51 are brazed or welded to opposite sides of the discs 40, 41 and are provided with axial apertures 52, 53 co-axial with central apertures 54, 55 in the discs 40, 41 respectively. The aperture 52 in the sleeve 50 sealingly receives and is welded or brazed to one end 33A of the copper capillary tube 33. The opposite end 33B of the tube is mounted within and welded to an identical sleeve 50' of the pressure actuator 32. Sleeve 51 slidingly supports a piston rod 56, one end 57 of which bears against the disc 48 and the opposite end of which contacts the blade 28A of switch 28. A heavy spring 59 biases the switch 28 to a normally opened position against the bias of the diaphragm spring 45. Generally, an adjustment screw (not shown) is provided to adjust the compression of the spring 59 and thus the pressure required to close the switch 28.

The pressure actuator 32 is identical to the actuator 30 except that it does not include the piston rod 56. Accordingly, the components of the actuator 32 which are identical to corresponding components of the actuator 30 have been given identical numerical designations followed by a prime mark.

The inexpandable copper capillary tube 33 together with the chamber 46 of actuator 30 and chamber 46' of actuator 32 sealingly enclose a pressure transmitting fluid, such as a conventional refrigeration oil. One such suitable oil is identified as Suniso 3G refrigerant oil manufactured by the Sun Oil Company. This is an incompressible oil which is compatible with the refrigerant of a refrigeration system and has a viscosity rating of SAE 150. Other refrigerant oils having viscosity ratings as low as SAE 75 would also be suitable and in some applications might even be preferable. Thus, changes in pressure at the fittings 36 of the compressor are operative to move the diaphragm 45' and piston 48' of the actuator 32 so as to effect fluid flow of the refrigerant oil in the capillary tube 33.

Assuming that there is a refrigerant pressure increase in the evaporator and on the low pressure side of the refrigerant system (and consequently a temperature increase) the pressure in the chamber 47' of the pressure actuator 32 is increased upon a pressure increase in the chamber 47' of actuator 32, the piston 48' and diaphragm 45' are moved to the right forcing fluid from the chamber 46' into the capillary tube 33. This fluid flow through the tube 33 results in rightward movement of the piston 48 and piston rod 56 of the actuator 30 so as to effect closing of the switch 28. When the switch 28 is closed, it results in completion of an electrical circuit to the compressor motor 20 from the power source 27 through the series connected switches 28, 29.

Switch 28 is the control switch which cycles the compressor by turning it on when the temperature (and pressure) of the refrigerant in the evaporator and the compressor exceeds a preset value and turning it off when the temperature reaches the desired value. The other switch 29 is a high pressure safety switch operative to open the motor circuit in the event that the pressure at the head of the compressor or on the high pressure side of the refrigerant system exceeds a preset safe value. This might occur in the event of failure of the condenser or of any component in the system. In this event, the actuator 34 senses the unsafe high pressure condition and transmits the high pressure increase through the fluid in the capillary tube 35 to the pressure actuator 31 to open the switch 29. Thus, the compressor is stopped until the pressure is relieved and the condition corrected.

Because the refrigerant system and the conduits 19, 21, 22, 23 through which the refrigerant is transmitted are physically isolated from the capillary tubes 33, 35 by the sealed pressure actuators 32, 34, failure of the small capillary tubes does not result in the loss of the refrigerant to the atmosphere. The copper tubes 33, 35 are only $\frac{1}{16}$ inch in inside diameter while the refrigerant conduits are at least $\frac{1}{2}$ inch in inside diameter and may go to several inches in diameter. Thus, when tube or conduit failure occurs, it generally is the capillary tube which fails and which, prior to this invention, resulted in the loss of all the refrigerant in the system.

I prefer that the entrapped pressure transmitting fluid in the capillary tubes 33, 35 be a conventional refrigerant oil such as Sunisco G3. The requirements of the fluid are that it be stable and non-responsive to temperature or other external environmental conditions and compatible with the refrigerant and the refrigeration system so that the oil will have no detrimental effect upon the system or the equipment if it leaks into the refrigerant conduits 19, 21, 22 and 23. It must also be operable to transmit pressure changes through the tube at pressures which range from plus 450 pounds per square inch to 27 inches of mercury vacuum at temperatures which range from plus 160° Fahrenheit to minus 100° Fahrenheit. These are the operating pressure and temperature ranges of conventional refrigeration systems.

While I have only described a single preferred modification of my invention, those persons skilled in the refrigeration arts will readily appreciate numerous changes and modifications which may be made without departing from the spirit of my invention. Therefore, I do not intend to be limited except by the scope of the appended claims.

Having described my invention, I claim:

1. In combination with a refrigeration cooling system of the type which comprises a motor driven compressor for increasing the pressure of a refrigerant material in said system, a condenser for removing heat to cool said pressurized refrigerant material after it exits from said compressor, an expansion valve, and an evaporator through which said cooled pressurized refrigerant passes to extract heat from the area surrounding said evaporator before being returned to the inlet side of said compressor,

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a control unit for controlling the operation of said compressor, said control unit comprising:

a pressure responsive switch operable to control operation of said compressor, and

an inexpandible fluid capillary tube interconnecting the flow path of said refrigerant and said pressure responsive switch, the improvement which comprises a pair of pressure responsive actuators located at opposite ends of said capillary tube and a pressure transmitting refrigerant oil fluid medium compatible with the refrigerant in the system and sealingly entrapped within said capillary tube between said pressure actuators, said entrapped refrigerant oil being operable to transmit a pressure change in the refrigerant of said cooling system to said pressure responsive switch while maintaining said refrigerant physically separated from said capillary tube so that a break in said tube does not result in the loss of said refrigerant to atmosphere, said refrigerant oil being operable to transmit pressure changes at temperatures which range from plus 160° Fahrenheit to minus 100° Fahrenheit.

2. The control unit of claim 1 wherein said refrigerant oil is operable to transmit pressure changes which range seven inches of vacuum.

3. The combination of claim 1 wherein said capillary tube interconnects said pressure switch to the low pressure side of the refrigerant flow path between the evaporator and the high pressure side of the compressor.

4. The combination of claim 1 wherein said capillary tube interconnects the pressure switch to the high pressure side of the refrigerant flow path between the low pressure side of the compressor and the condenser.

5. The combination of claim 1 wherein said pressure responsive fluid actuators comprise a pair of diaphragm type piston motors.

6. For use in combination with a refrigeration cooling system of the type which comprises a motor driven compressor for increasing the pressure of a refrigerant material in said system, a condenser for removing heat to cool said pressurized refrigerant material after it exits from said compressor, an expansion valve, and an evaporator through which said cooled pressurized refriger-

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ant passes to extract heat from the area surrounding said evaporator before being returned to the inlet side of said compressor, a control unit for controlling the operation of said compressor, said control unit comprising:

a pressure responsive switch operable to control operation of said compressor, and

an inexpandible fluid capillary tube interconnecting the flow path of said refrigerant and said pressure responsive switch, the improvement which comprises a pair of pressure responsive actuators located at opposite ends of said capillary tube and a pressure transmitting refrigerant oil compatible with the refrigerant in the system and sealingly entrapped within said tube between said pressure actuators, said entrapped refrigerant oil being operable to transmit a pressure change in the refrigerant of said cooling system to said pressure responsive switch while maintaining said refrigerant physically separated from said capillary tube and said pressure switch so that a break in said tube does not result in the loss of said refrigerant to atmosphere, said refrigerant oil being operable to transmit pressure changes at temperatures which range from plus 160° Fahrenheit to minus 100° Fahrenheit.

7. The control unit of claim 6 wherein said refrigerant oil is operable to transmit pressure changes which range from plus 450 pounds per square inch to minus twenty-seven inches of vacuum.

8. The control system of claim 6 wherein said pair of pressure responsive actuators comprises a pair of diaphragm type piston motors.

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MEYER PERLIN, Primary Examiner

U.S. Cl. X.R.

62—226, 228; 200—83

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,498,075 Dated March 3, 1970

Inventor(s) William A. Zumbiel

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 4, delete the word "not" and substitute the word --no--.

Column 3, line 69, delete the word "regrigerant" and substitute the word --refrigerant--.

Column 5, lines 25 and 26 should be reversed.

SIGNED AND
SEALED
JUL 14 1970

(SEAL)

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