United States Patent [19]

Kramer

[11] **3,791,161**

[45] **Feb. 12, 1974**

[54] **PRESSURE SWITCH FOR REFRIGERATION SYSTEM**

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[52] **U.S. Cl.** **62/226**, 62/215, 62/228

[51] **Int. Cl.** **F25b 1/00**

[58] **Field of Search** 62/226, 215, 228

[56] **References Cited**

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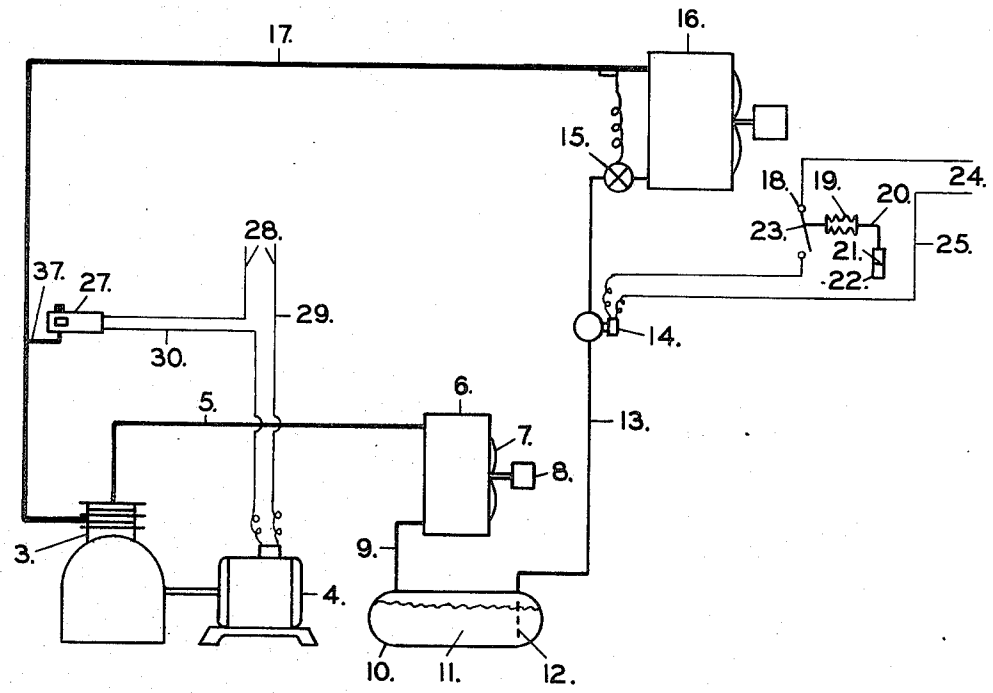
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Primary Examiner—William J. Wye
Attorney, Agent, or Firm—Daniel E. Kramer

[57] **ABSTRACT**

A pressure switch for sensing and responding to pressure on the low side of refrigeration systems where the conduit, which connects the refrigeration system low side to the pressure switch bellows, is restricted for the purpose of minimizing transmission of pressure pulsations from the low side to the bellows. The conduit has a substantial enlargement positioned to act to prevent the entry of oil into the restricted portion of the conduit.

6 Claims, 6 Drawing Figures



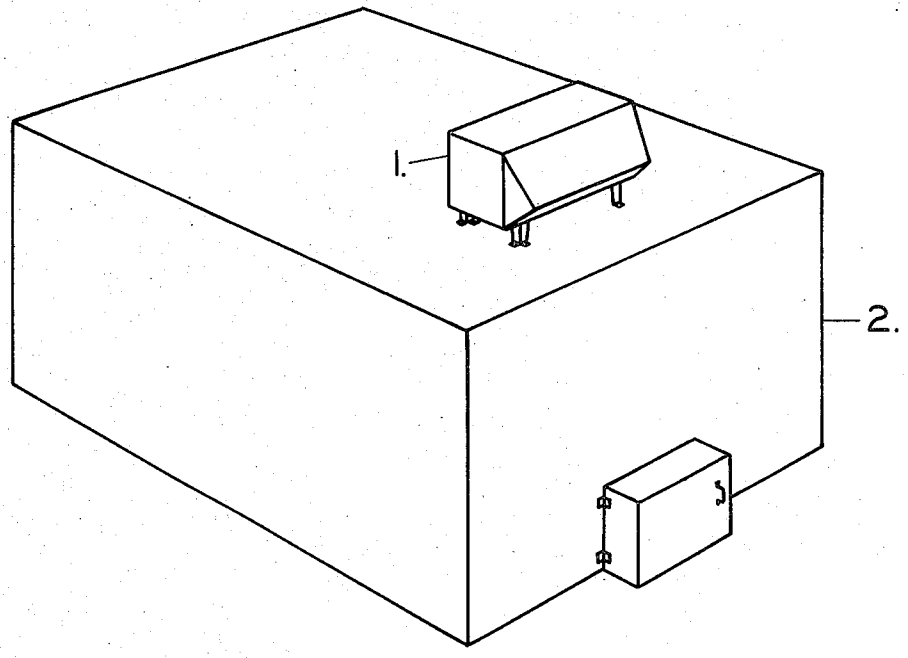

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FIG. 1.

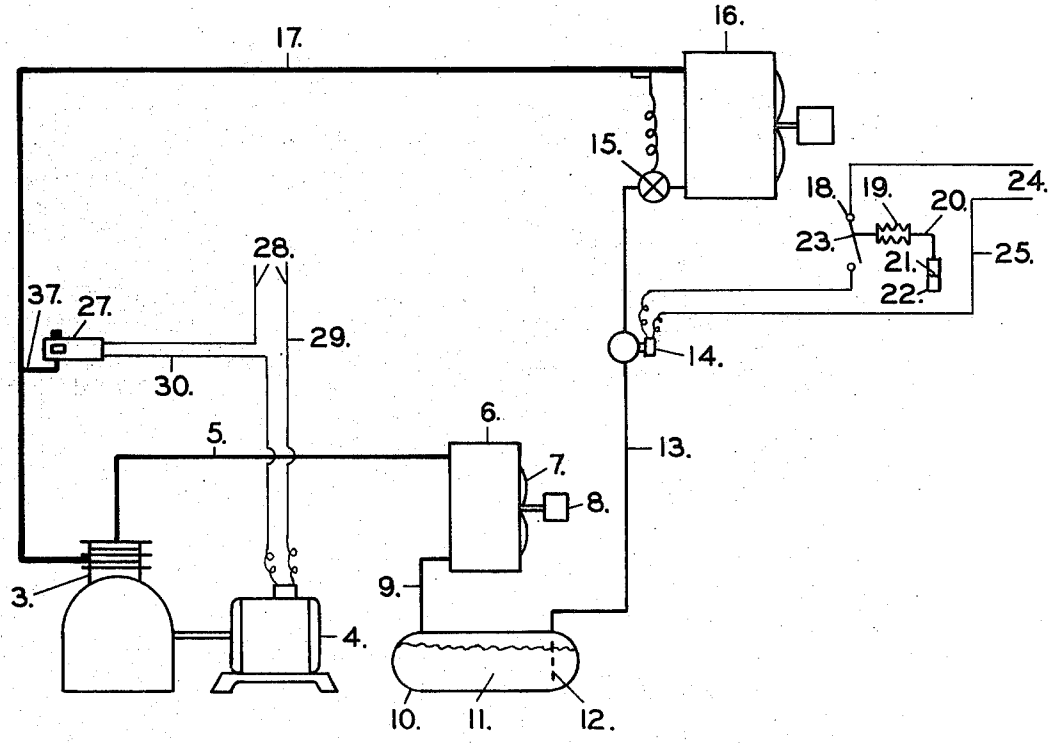

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FIG. 2.

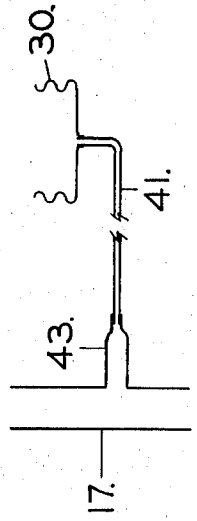


FIG. 4.

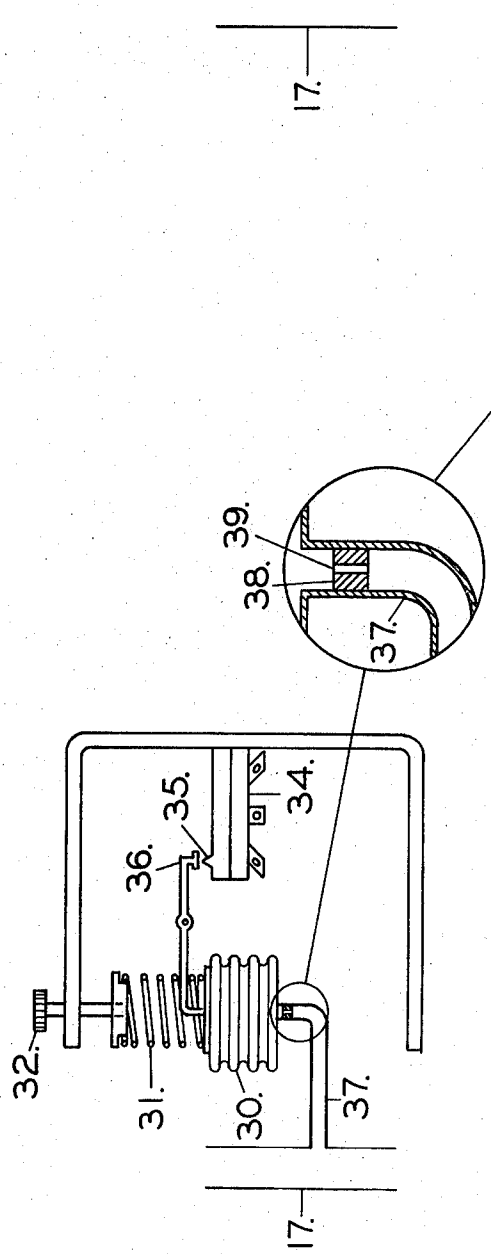


FIG. 3.

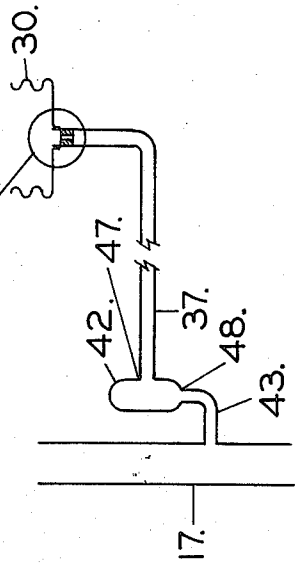


FIG. 6.

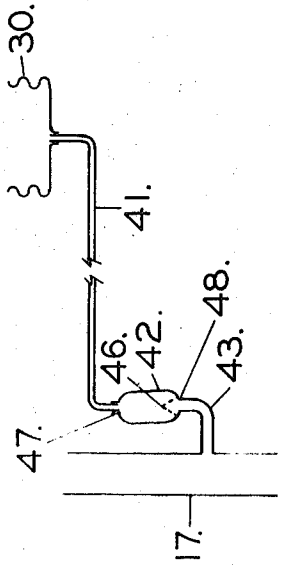


FIG. 5.

PRESSURE SWITCH FOR REFRIGERATION SYSTEM

BACKGROUND

1. Field:

This invention relates to the field of refrigeration which employs a gas compressor to withdraw refrigerant vapor from an evaporator and compress it to a higher pressure level at which a condenser, which employs air or water or a combination of both to remove the latent heat from the refrigerant vapor, condenses the vapor to a liquid. The liquid refrigerant is then conveyed by a conduit to the evaporator where its evaporation creates the desired cooling effect.

The refrigeration compressor is generally driven by an electric motor and the motor is stopped and started by a switch. The switch can be temperature controlled, manual, or pressure controlled, or the switch may be actuated by other means. This invention relates to the use of a switch actuated by the pressure at the suction side of the compressor (also called the "low side") for starting and stopping the compressor.

2. Prior Art:

Pressure switches have been used for many years to control the operation of refrigeration compressors. Typically, a switch is constructed with a pressure sensing bellows for connection to the low side. The expansion and contraction of the bellows acts on a switch to open and close an electric circuit. The pressures at which the bellows activates the switch are preset by adjustment screws which apply more or less force to springs which oppose the action of the bellows. Early in the history of the refrigeration application of pressure switches, it was discovered that rapid, small pressure fluctuations in the low side caused by the pulsating action of the compressor pistons in their cylinders caused sufficiently rapid motion of the bellows to cause its early failure from metal fatigue. In order to extend the life of the bellows, manufacturers provided a restriction or constriction of the conduit joining the lowside to the pressure sensing bellows. One type of construction lumps the restriction in the form of a brass plug with a minute hole, typically 0.005 inches diameter, inserted at the pressure inlet to the bellows chamber. This plug type of restriction is used where it is desired to employ a relatively unrestricted conduit, typically 0.25 inch OD, 0.19 ID to connect the bellows to the lowside. A second type of construction distributes the restriction over the length of the conduit joining the low side and bellows by forming the conduit of soft copper tubing whose inside diameter is typically 0.035 inches, ranging in length from 3 to 15 feet with 6 feet being a norm. For many years, no defect in performance attributable to either of these methods of pulsation reduction was found.

Even after the pressure switches began to be applied for the control of refrigeration compressors in condensing units mounted outdoors, exposed to all summer and winter ambients, no blame was attached to the low pressure switch performance even though other types of controls, such as the oil safety switch frequently malfunctioned, especially in cold weather. The oil safety switch senses the pressure of the oil delivered by the lubricant pump and serves to shut off the compressor and lock it in an off condition if the compressor attempts operation with lubricant pressure lower then the minimum allowed.

Eventually it was found that a large part of the trouble which was being experienced with outdoor compressor systems was attributable to the failure of the low pressure switch to reliably start and stop the compressor at its preset pressures.

Some of the problems which can occur when the low pressure switch does not shut off the compressor at the preset pressure are: (a) oil foaming in the compressor crank case leading to slugging, which is the introduction of liquid into the compressor cylinders, frequently leading to compressor damage; (b) oil pump out which is the condition where the compressor runs and pumps oil out of its oil sump into the discharge stream without the entry of replenishing oil from the suction line; (c) excess wearing of the wrist pin journals caused by the compressor attempting to pump the low side to such a low pressure that pumping essentially ceases. These high compression ratios lead to an unlubricated condition of the wrist pin journal, resulting in early mechanical failure of the compressor.

Deliberate analysis by the inventor of this problem and examination of pressure switches exhibiting this problem disclosed no fault in the pressure switch mechanism. Further analysis disclosed that the erratic functioning of the pressure switch was related to unsatisfactory communication of pressure from the system low side to the pressure switch bellows. Since detailed examination of the restrictors and capillary tubes used on the erratic pressure switches disclosed them to be fully free and open and not abnormally restricted, the inventor decided that the presence of oil or other liquid in the restricted portion of the tube had acted as a plug which served to prevent pressure communication between the system low side and the pressure switch bellows; particularly under conditions of low ambient when the restricted portion was very cold and the oil contained therein very viscous.

This invention sets forth means and method for preventing the entry of oil into the restricted portion of the conduit connecting the system low side and the pressure switch bellows.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows an overall view of a condensing unit **1**, which may include compressor, condenser and pressure switch, installed outdoors on top of a freezer box **2**.

FIG. 2 shows, in elevation, a schematic piping diagram of a refrigeration system of one type including compressor, condenser, receiver, expansion device, evaporator, liquid solenoid, thermostat, and low side pressure switch.

FIG. 3 is an enlargement and partial cross section of a section of FIG. 2 showing in more detail a conduit interconnecting the low side of the system and the bellows of the pressure switch which includes a restricted portion.

FIG. 4 is the same as FIG. 3 except the type of restriction in the conduit is a capillary as distinct from a plug orifice.

FIGS. 5 and 6 are embodiments of the invention which utilize an enlarged portion as a separator to minimize the entry of oil into the restricted portion of the conduit.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

FIG. 2 shows a schematic piping diagram of a refrigeration system of the class described, using a compressor 3, driven by an electric motor 4, which could be located either within the refrigeration system (hermetic type), or without the refrigeration system (open type), as shown. The compressor discharges vapor through the discharge conduit 5 to the condenser 6, which is usually of the finned tube type, over which air is blown by fan 7, driven by motor 8, to abstract the latent heat of the refrigerant vapor, converting it into a liquid. The refrigerant liquid flows via conduit 9 to the receiver 10 wherein it resides until required. The refrigerant liquid 11 leaves the receiver via dip tube 12 and flows by conduit 13 through a liquid solenoid valve 14 to the expansion device 15, which is generally of the thermostatic type. This device controls the flow of liquid refrigerant to the evaporator 16 so that as much as can be utilized by the evaporator is fed, but no more.

The evaporator 16 evaporates the liquid refrigerant to a vapor and in so doing cools the medium with which it is in contact. This medium may be air circulated by gravity or by motor driven fans, as shown, or liquid glycol or water, or product directly. The vapor resulting from the evaporation of the liquid refrigerant is drawn to the compressor for recompression via suction conduit 17. The liquid solenoid 14 controls the operation of the system by allowing liquid refrigerant to flow from the receiver 10 to the expansion device 15 and evaporator 16, or preventing this flow. The action of the liquid solenoid 14, is generally guided or dictated by a thermostat 18 which comprises switch 23 actuated by temperature sensing elements bulb 22 containing volatile fluid, conduit 20 and bellows 19, which is mechanically connected to switch 23. The liquid solenoid 14 is generally located near the expansion device 15 and evaporator 16. The low pressure switch 27, which controls the action of the compressor motor 4, is generally installed near the compressor. When the thermostat 18 causes the liquid solenoid to open, (known as "calling for cooling") refrigerant flow from the liquid receiver 10 to the expansion device 15 and evaporator 16 occurs. Evaporation of the liquid refrigerant in the evaporator serves to raise the pressure in the low side to or above the preset pressure at which the low pressure switch 27 is set to act. At that pressure, known as the cutin pressure, the pressure switch 27 closes its contacts and causes the compressor 3 to run. When sufficient cooling effect has been generated by continued operation of the compressor 3, the thermostat 18 senses this condition and causes the liquid solenoid 14 to close. The compressor 3 continues operation until all the liquid refrigerant in the low side, which is the volume between the expansion valve 15 and the compressor 3 has been evaporated, at which time the pressure in the low side drops to that value at which the pressure switch 27 has been preset to interrupt power to the compressor and cause it to stop. This pressure is known as the cutout pressure. It should be clear from examination of the characteristics of this system that continued operation of the compressor 3 after the liquid solenoid 14 closes, could cause the low side pressure to drop to excessively low values, leading to lubrication problems and compressor failures or at least nuisance trip out of safety devices provided.

FIG. 3 shows a simplified detail of a pressure switch where the switch 34 has activator button 35 which is reversibly moved by arm 36, which in turn responds to motion of bellows 30. The bellows 30 inflates or deflates through conduit 37 connected to the bellows 30 by a fitting 40 which contains a bushing 38 through which a minute hole 39 is formed. In order for the bellows of the pressure switch to actuate and respond adjustably to changes in low side pressure, the action of the bellows 30 is opposed by a spring 31 called a range spring. The greater the degree of compression imposed on the range spring by the range screw 32, the greater the pressure required inside the bellows 30 to overcome the force of the spring 31 before motion can be achieved to actuate the switch 34. In order for the pressure to rise inside the pressure switch bellows 30 actual flow of refrigerant vapor from the suction line 17 to the bellows 30 must occur via conduit 37 and restrictor plug 38 with its orifice 39. If flow were cut off entirely or if very viscous fluid were trapped in the restricted conduit, a sufficiently long time might elapse between the refrigeration low side 17 reaching the desired pressure and the corresponding pressure change inside bellows 30 needed to cause activity of the pressure switch, that system damage might occur.

FIG. 4 shows the restrictor in the form of a long conduit of uniform but small (typically 0.035 inches) inside diameter 41 joining the low side 17 with the bellows 30.

FIG. 5 shows the principle of this invention where a separating chamber, possibly small in diameter compared with the suction conduit 17, for instance ¼ inch or larger inside diameter, is so positioned that vapor and oil from suction conduit 17 entering chamber 42 through its inlet conduit 43 which may be in the bottom of chamber 42 as shown or alternately in its side or top, are separated and only vapor enters the restricted conduit 41. From inlet 48 to outlet 47 a screen 46 for reventing vapor entrainment of oil droplets may be installed in the chamber 42 between inlet 48 and outlet 47.

FIG. 6 shows suction conduit 17 connected to separating chamber 42 by inlet conduit 43. Non-restricting conduit 37 (typically .19 inches ID) connects the chamber outlet 47 with the inlet of the bellows 30, where plug 38 with its fine orifice 39 is located.

Oil circulates in refrigeration system in most cases because relatively little harm arises from allowing its circulation and relatively great cost would have to be extended to prevent its circulation. Since compressors rotate at high speeds, excellent lubrication of their bearing surfaces is required and the pumping by lubricant pumps of large amounts of oil through their bearing surfaces and against the cylinder walls is mandatory. Some of this oil inevitably becomes entrained in the refrigerant vapor stream and is carried through the cylinders into the discharge line where it traverses the condenser, the receiver, and eventually reaches the evaporator dissolved in the liquid refrigerant where it separates from the liquid refrigerant by virtue of remaining a liquid where the liquid refrigerant evaporates to vapor. The oil is returned to the compressor for reuse as a lubricant and for partial recirculation via the gas velocity in the suction line.

Discharge line oil separators can be installed but their cost is great and they still allow the flow of enough oil to cause the problem which this invention corrects.

So long as the refrigeration system and the low pressure switch is exposed to an environment which is sufficiently warm that the viscosity of oil caught in the restricted conduit joining the system low side and the pressure switch bellows remains low enough that flow occurs rapidly, no trouble is experienced and the pressure switch responds sufficiently rapidly for normal system operation. However, under winter conditions when the lower pressure switch as well as all the other components and particularly the capillary of tube joining the low pressure switch bellows with the system low side becomes chilled to ±20F or lower, the oil congeals and its viscosity becomes sufficiently great that adequate pressure communication between the low side and the switch bellows is interrupted.

The installation of the enlarged separating chamber **42,** between the system low side and the restriction leading to the pressure switch bellows eliminates this source of winter problems completely.

I claim:

1. In a refrigeration system of the compression type having a high pressure side and a low pressure side including a conduit connected compressor, condenser, expansion device and evaporator and a pressure switch having a pressure sensing element including fixed restricted means for pressure communication to the element the improvement comprising a chamber having first and second ports where the first port is unrestrictedly connected to the low pressure side and the second port is connected to the means whereby oil circulated by the compressor through the system is allowed to enter the chamber and is prevented from entering the means.

2. An improvement as in claim **1** where the chamber has a screen interposed between the first and the second ports.

3. In a pressure switch having fixed restricted means for connection to the low pressure side of a compression type refrigeration system having both high and low pressure sides, the improvement comprising a chamber having first and second ports where the first port is unrestrictedly connected to the low side and the second port is connected to the means.

4. An improvement as in claim **3** where the chamber has a screen interposed between the first and second ports.

5. An improvement in pressure switches as in claim **3** where the means includes a capillary tube.

6. An improvement in pressure switches as in claim **3** where the means includes an orifice.

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