United States Patent [19]

Porter

[11] **3,807,192**

[45] **Apr. 30, 1974**

[54] **REFRIGERATION SYSTEM WITH COMBINATION CAPACITY AND COMPRESSOR OVERLOAD CONTROL**

[75] Inventor: **Maxson A. Porter**, Springfield, Mo.

[73] Assignee: **Paul Mueller Company**, Springfield, Mo.

[22] Filed: **Dec. 1, 1971**

[21] Appl. No.: **203,680**

[52] **U.S. Cl.** **62/197**, 62/217

[51] **Int. Cl.** **F25b 5/00**

[58] **Field of Search** 62/197, 217

[56] **References Cited**

UNITED STATES PATENTS

3,631,684 1/1972 Randall 62/197

Primary Examiner—Meyer Perlin

Attorney, Agent, or Firm—Rogers, Ezell & Eilers

[57] **ABSTRACT**

A refrigeration system, and more particularly one having means for controlling against compressor overload and excess system capacity, comprising a compressor means, a condenser means connected at the output of the compressor means for condensing refrigerant discharged from the compressor means. An expansion device is connected between the output of the condenser means and the input of an evaporator means. A vortex amplifier is connected between the output of the evaporator means and the input of the compressor means, the amplifier having a main inlet and an outlet through which the refrigerant passes from the evaporator means to the compressor means, and a control inlet connected to a source of control fluid. Means are provided for varying discharge of the control fluid to the control input of the vortex amplifier in response to variations in compressor load from a prescribed load value, and to variations in system capacity from a prescribed capacity value.

7 Claims, 4 Drawing Figures

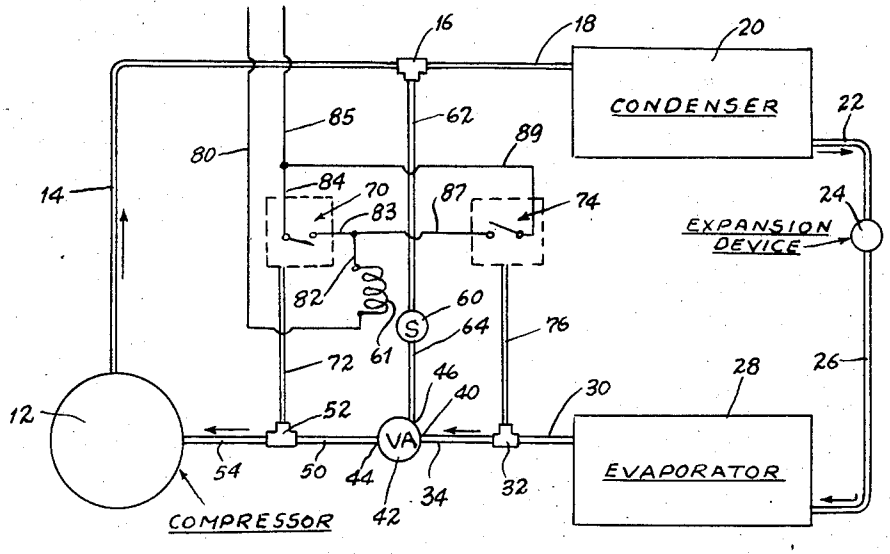


Fig. 1.

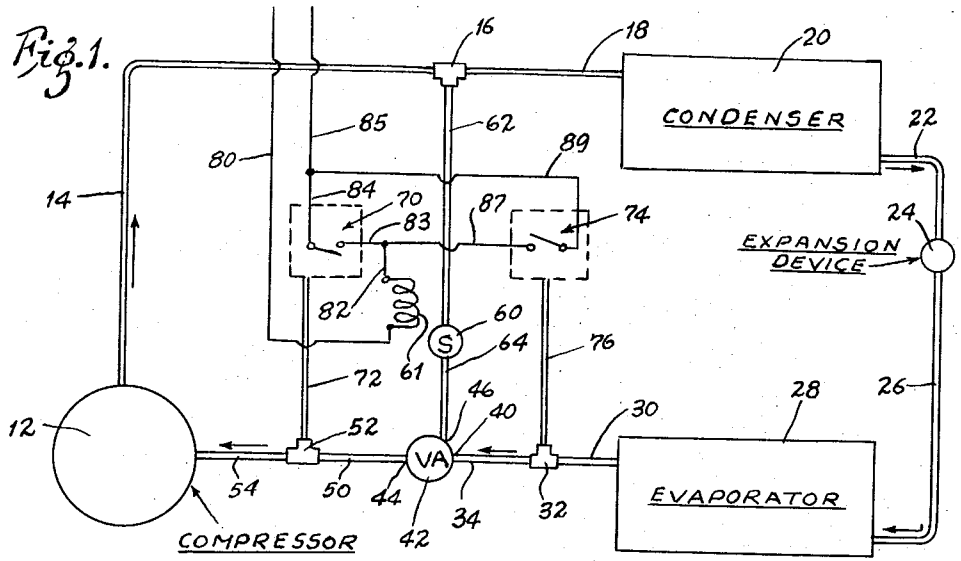


Fig. 3.

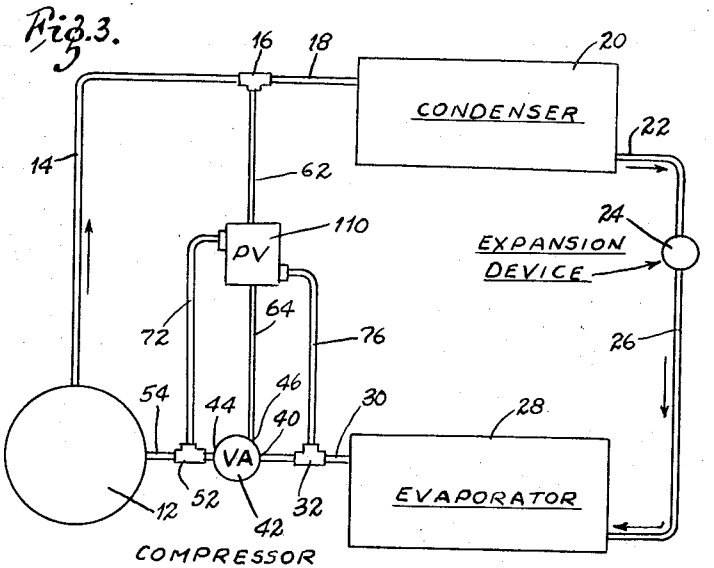


Fig. 2.

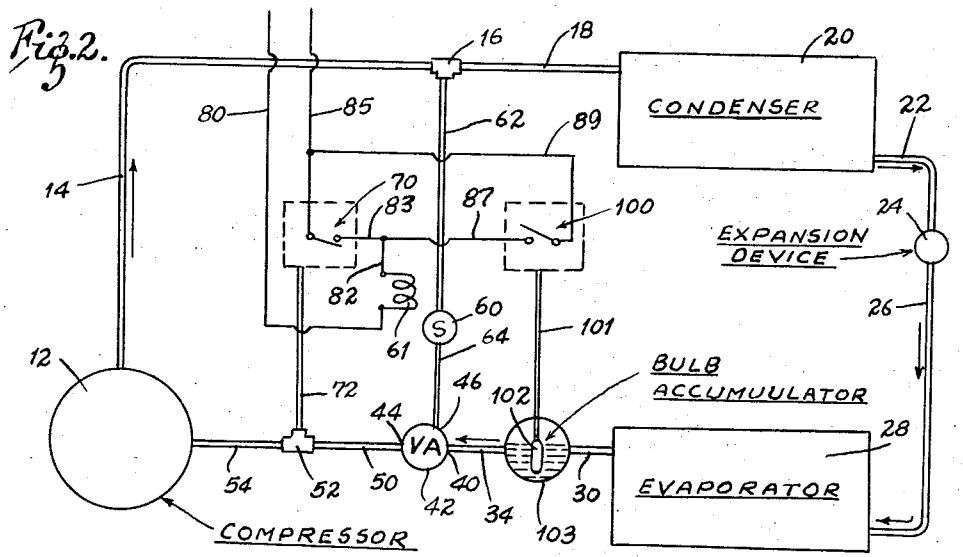
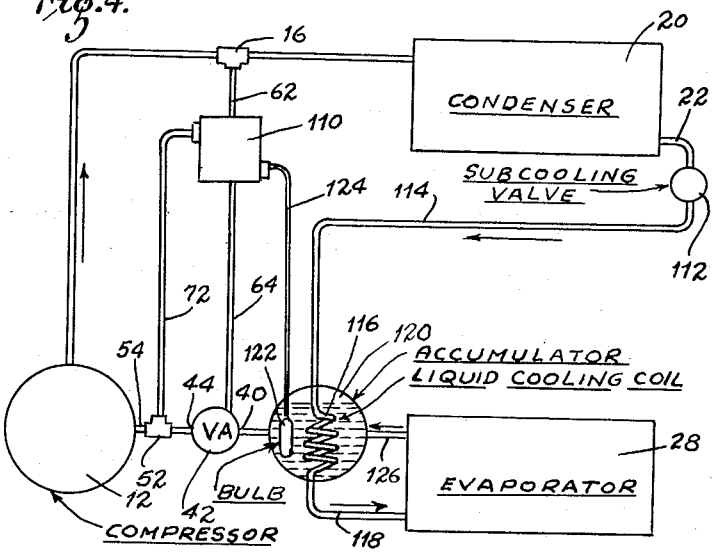


Fig. 4.



REFRIGERATION SYSTEM WITH COMBINATION CAPACITY AND COMPRESSOR OVERLOAD CONTROL

SUMMARY OF THE INVENTION

This invention relates to a refrigeration system, and more particularly to one having means for controlling against compressor overload and excess system capacity.

The control means includes a vortex amplifier which is a fluidic device of the type described and shown in FIG. 3 of U.S. Pat. No. 3,369,374. In that patent such a device is shown as used in a refrigeration system for the single purpose of controlling the capacity of the system. This invention is an improvement over the above-referenced patent in using such a device for the dual purpose of reducing the capacity of the system when full capacity is undesirable and of preventing compressor overload.

Other patents of interest are U.S. Pat. Nos. 3,367,130 and 3,264,837 which describe an expansion valve and refrigeration system responsive to subcooling temperature. With subcooling valves of that type, compressor overload control cannot be built-in as with some conventional expansion devices. This invention, therefore, represents a substantial improvement over those systems using subcooling valves by providing them with such control.

The system of this invention generally includes a compressor means, a condenser means connected at the output of the compressor means for condensing refrigerant discharged from the compressor means. An expansion device is connected between the output of the condenser means and the input of an evaporator means.

The capacity and compressor overload control includes a vortex amplifier connected between the output of the evaporator and the input of the compressor means. The vortex amplifier has a main inlet and an outlet through which refrigerant passes from the evaporator means to the compressor means, and a control inlet connected to a source of control fluid. Means are provided for varying discharge of the control fluid to the control input of the vortex amplifier in response to variations in compressor load when the load exceeds a prescribed load value, and to variations in system capacity when that exceeds a desired, prescribed capacity value.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic diagram of one embodiment of the refrigeration system and control of this invention using a solenoid valve and pressure responsive switches;

FIG. 2 is a schematic diagram of another embodiment of this invention showing the use of a temperature responsive switch in conjunction with a solenoid valve;

FIG. 3 is another embodiment of this invention showing the use of a pilot valve; and

FIG. 4 is a schematic diagram of still another embodiment of this invention as used in a system having a subcooling valve as an expansion means.

DETAILED DESCRIPTIONS OF PREFERRED EMBODIMENTS

In FIG. 1 of the drawing there is shown a refrigeration system of one embodiment of this invention including a compressor means **12**, the output of which is connected by a feed line **14**, T-connection **16**, and feed line **18** to the input of a condenser means **20** for receiving gaseous refrigerant discharged from the compressor means. Condensed refrigerant from the condenser means **20** is fed through a feed line **22** to the input of an expansion device **24** of any suitable type such as a thermostatic expansion valve, capillary tube, subcooling valve, or the like. From the expansion device **24**, expanded refrigerant is fed through a feed line **26** to an evaporator **28**. The refrigerant in the evaporator **28** is vaporized upon absorption of heat from the medium being cooled. Vaporized refrigerant from the output of the evaporator **28** is fed through a feed line **30**, a T-connection **32**, and a feed line **34** to the main input **40** of a vortex amplifier **42**. The vortex amplifier **42** is a fluidic device commonly known in the art and described in the above-referenced U.S. Pat. No. 3,369,374 and includes, in addition to the main input **40**, an output **44**, and a control input **46**. The vortex amplifier **42** is such that the quantity of fluid flow from its main input **40** to its output **44** is a function of the amount of fluid fed to its control input **46**. The refrigerant from the output **44** of the amplifier **42** is fed through a feed line **50**, a T-connection **52**, and a feed line **54** to the input of the compressor means **12**.

The system heretofore described would operate as a conventional refrigeration system for cooling a given medium by contact with the coils of the evaporator **28**.

To provide the control features of this invention a solenoid valve **60** is connected between the T-connection **16** and the control input **46** of the amplifier **42** by feed lines **62** and **64**. A first pressure sensitive switch **70** is connected by a small conduit **72** to the T-connection **52** located between the amplifier **42** and the compressor means **12**. A second pressure sensitive switch **74** is connected by a small conduit **76** to the T-connection **32** located between the evaporator **28** and the amplifier **42**.

One side of the coil **61** is connected by a conductor **80** to one side of a suitable source of electrical power. The other side of the coil **61** is connected by a conductor **82** and a conductor **83** to one contact of the switch **70**, the other contact of which is connected by a conductor **84** and a conductor **85** to the other side of the electrical power source. The other side of the coil **61** is also connected by the conductor **82** and a conductor **87** to one contact of the switch **74**, the other contact of which is connected by a conductor **89** and the conductor **85** to the other side of the electrical power source. Hence, whenever either switch **70** or switch **74** is closed, power is supplied to the coil **61** to open the solenoid valve **60**.

Operation of the First-Described Embodiment

Suppose the capacity of the system is to be controlled when it gets below a prescribed level, and the load on the compressor **12** is to be maintained below a prescribed level. When the evaporator temperature (which is indicative of system capacity) gets below a prescribed level, the pressure at its output (also indica-

tive of system capacity) decreases to below a prescribed value which pressure is sensed by the pressure sensitive switch **74** through the conduit **76.** The pressure sensitive switch **74** is designed to close at the prescribed pressure. With the switch **74** closed, power is supplied to the coil **61** to open the solenoid valve **60** allowing an amount of refrigerant to flow from the output of the compressor **12** through the T-connection **16,** feed line **62,** valve **60,** and feed line **64** to the control input **46** of the amplifier **42.** The flow of refrigerant at the control input **46** reduces the amount of refrigerant flow from the evaporator **28** to the compressor **12** through the amplifier **42** to thereby reduce the capacity of the system and raising the evaporator temperature and output pressure. When its output pressure rises above the prescribed value, the switch **74** opens to close the solenoid valve **60** and again allow full flow of refrigerant from the evaporator **28** to the compressor **12** through the amplifier **42.**

The pressure sensitive switch **70** continually monitors the pressure at the input of the compressor **12** through the T-connection **52** and conduit **72.** When the pressure at the input of the compressor **12** goes above a prescribed level, indicating an overload condition, the switch **70** closes supplying power to the coil **61** to open the solenoid valve **60.** With the valve **60** opened, an amount of refrigerant is fed from the output of the compressor **12** to the control input **46** of the amplifier **42** to restrict the flow of refrigerant from the evaporator **28** to the compressor **12** thereby reducing the pressure at the input of the compressor and preventing its overload. When the pressure at the input of the compressor **12** drops below the prescribed level, the switch **70** opens and the valve **60** closes to cut off the flow of fluid to the control input **46** and allowing full flow of refrigerant from the evaporator to the compressor.

In this manner the system operates between a minimum pressure at the output of the evaporator **28** and a maximum at the input of the compressor **12** to perform the dual function of controlling the capacity of the system and preventing overload of the compressor.

Of course the sizes of the feed lines **62** and **64** and the opening of the valve **60** are suitably chosen to supply an amount of control fluid to the control input **46** of the amplifier **42** as is appropriate for making the necessary capacity and overload corrections. Also it may be necessary to connect the line **62** to the line **22** so as to admit a proportion of liquid refrigerant to cool the gas entering the compressor **12.**

Although pressure sensors and a solenoid-type valve are used in this first-described embodiment, other types of sensors and valves can be used as will become more apparent in the description of the embodiments of FIGS. **2** through **4.**

The embodiment of FIG. **2** is to illustrate the use of temperature responsive switches rather than the pressure responsive switches of the embodiment of FIG. **1.** Hence, the embodiment of FIG. **2** differs from that of FIG. **1** in the use of a temperature responsive switch **100** connected by means of a conduit **101** to a temperature sensing bulb **102** in an accumulator **103** or other suitable location to sense the temperature of evaporating refrigerant. The accumulator **103** replaces the T-connection **32** of FIG. **1** and is of a type commonly known in the art for accumulating liquid refrigerant at the output of the evaporator that might otherwise damage the compressor.

The operation of this embodiment is basically the same as that of the first with the switch **100** being responsive to the temperature of the refrigerant in the accumulator **103** as sensed by the bulb **102,** which temperature is a measure of the system's capacity. When the temperature of the refrigerant in the accumulator **103** goes below the prescribed level, the temperature responsive switch **100** closes to open the solenoid valve **60,** restricting the flow of refrigerant from the accumulator **103** to the compressor **12** and reducing the capacity of the system. When the temperature goes back up to the prescribed value, the switch **100** opens to allow the system to operate at full capacity. The pressure sensitive switch **70** operates as heretofore described to prevent overload of the compressor **12.** Of course, a temperature sensitive switch and appropriate sensor could also be used in place of the pressure sensitive switch **70** and T-connection **52,** when it is desirable to reduce the compressor load because of the temperature of the refrigerant at the input of the compressor **12.**

In FIG. **3** there is shown another embodiment of the invention wherein the solenoid valve **60** and associated electrical circuit, and the pressure sensitive switches **70** and **74** of the first-described embodiment are replaced with a pilot valve **110** of a type commonly known in the art. For example, the pilot valve **110** might consist of a single valve which modulates the flow of the refrigerant from the output of the compressor **12** to the control input **46** of the vortex amplifier **42** in amounts needed to maintain the desired conditions. Such a pilot valve might contain two power elements, one tending to open the pilot valve on pressure rise as sensed at the T-connection **52** between the vortex amplifier **42** and compressor, and the other tending to close the valve on pressure rise sensed at the T-connection **32** between the evaporator **28** and amplifier **42.** The pilot valve **110** might also be temperature sensitive with the T-connections **32** and **52** being replaced with appropriate temperature sensors.

The use of a temperature sensor with the pilot valve **110** is illustrated in the embodiment of FIG. **4.** This system differs somewhat from that of FIG. **3** in that the expansion device **24** is replaced with a subcooling valve **112.** The refrigerant from the output of the subcooling valve **112** is fed through a feed line **114,** a liquid cooling coil **116,** and a feed line **118** to the input of the evaporator **28.** The liquid cooling coil **116** is located in an accumulator **120.** Also located in the accumulator **120** is a temperature sensing bulb **122** connected by a conduit **124** to one side of the pilot valve **110.** Refrigerant from the evaporator **28** is fed through a feed line **126** to the accumulator 12o. The accumulator **120** and bulb **122** perform the same functions and operate in the same manner as the accumulator **103** and bulb **102** of the embodiment of FIG. **2.** The refrigerant is then fed from the accumulator **120** to the vortex amplifier **42** as with the embodiment of FIG. **2.** The subcooling valve **112** and liquid cooling coil **116** perform the expansion function, and are of the type commonly known in the art and described in the above-referenced U.S. Pat. Nos. 3,367,130 and 3,264,837.

The system of FIG. **4** operates with the bulb **122** sensing the temperature of the refrigerant in the accumulator **120** or in the saturated portion of the evaporator

28. When the temperature gets below a prescribed value, one of the power elements in the pilot valve **110** is operated to modulate the valve opening allowing control refrigerant to pass from the output of the compressor **12** or from the outlet of the condenser when needed and so connected, through the valve **110** to the control input **46** of the vortex amplifier **42** restricting the flow of refrigerant from the accumulator **120** to the compressor **12** and reducing the capacity of the system. This continues until the temperature of the refrigerant in the accumulator **120** goes back up to the prescribed value at which time the valve **110** modulates toward the closed position to allow the system to operate at the greatest capacity consistent with the prescribed limits selected. The other power element in the pilot valve **110** operates in the manner heretofore described with respect to the embodiment of FIG. **3** to open the valve **110** in response to pressure sensed at the T-connection **52** in excess of a prescribed value. Opening the valve **110** restricts the flow of refrigerant from the accumulator **120** to the compressor **112**, reducing the pressure at the input of the compressor **112** and preventing its overload. This continues until the pressure of the refrigerant entering the compressor **12** drops below the prescribed upper limit at which time the valve **110** modulates toward the closed position until finally the system is allowed to operate at full capacity.

Hence, there has been described a novel refrigeration system having means performing the dual function of controlling the system capacity and preventing overload of the compressor.

Various changes and modifications may be made in this invention, as will be readily apparent to those skilled in the art. Such changes and modifications are within the scope and teaching of this invention as defined by the claims appended hereto.

What is claimed is:

1. A refrigeration system comprising a compressor means, a condenser means for condensing refrigerant from the output of the compressor means, an evaporator means for evaporating the refrigerant, an expansion device connected between the output of the condenser means and the input of the evaporator means, a vortex amplifier having a control input and a main input and output, means connecting the output of the evaporator means to the main input of the vortex amplifier, means connecting the output of the vortex amplifier to the input of the compressor means, means for supplying a controlled amount of fluid to the control input of the vortex amplifier when the capacity of the system exceeds a prescribed value to restrict the flow of refrigerant from the evaporator means to the compressor means and increase the pressure at the output of the evaporator means to above a selected minimum pressure thereby reducing the capacity of the system, and means for supplying a controlled amount of fluid to the control input of the vortex amplifier when the compressor load exceeds a prescribed value to reduce the pressure at the input of the compressor means to below a selected maximum pressure thereby reducing its load, whereby the system operates between a minimum pressure at the output of the evaporator and a maximum pressure at the input of the compressor to control the capacity of the system and prevent overload of the compressor.

2. The system of claim **1** further comprising a valve means in the flow of control fluid, the valve means being actuatable to allow the control fluid to pass to the control input of the vortex amplifier when the system capacity or compressor load exceeds the prescribed value.

3. The system of claim **2** including means for sensing the capacity of the system between the output of the evaporator means and the vortex amplifier, means for sensing compressor load between the vortex amplifier and the compressor means, the valve means being actuatable in response to the sensing means.

4. The system of claim **3** wherein at least one of the sensing means is temperature responsive.

5. The system of claim **3** wherein at least one of the sensing means is pressure responsive.

6. The system of claim **1** wherein the fluid supplied to the control input of the vortex amplifier is supplied from the refrigerant at the output of the compressor means.

7. The system of claim **1** wherein the expansion device is a subcooling valve, the system further comprising a liquid cooling coil between the subcooling valve and the evaporator means through which the refrigerant from the subcooling valve to the evaporator means must flow, and an accumulator between the output of the evaporator means and the vortex amplifier for accumulating liquid refrigerant from the evaporator means, the liquid cooling coil being immersed in the liquid refrigerant within the accumulator.

* * * * *