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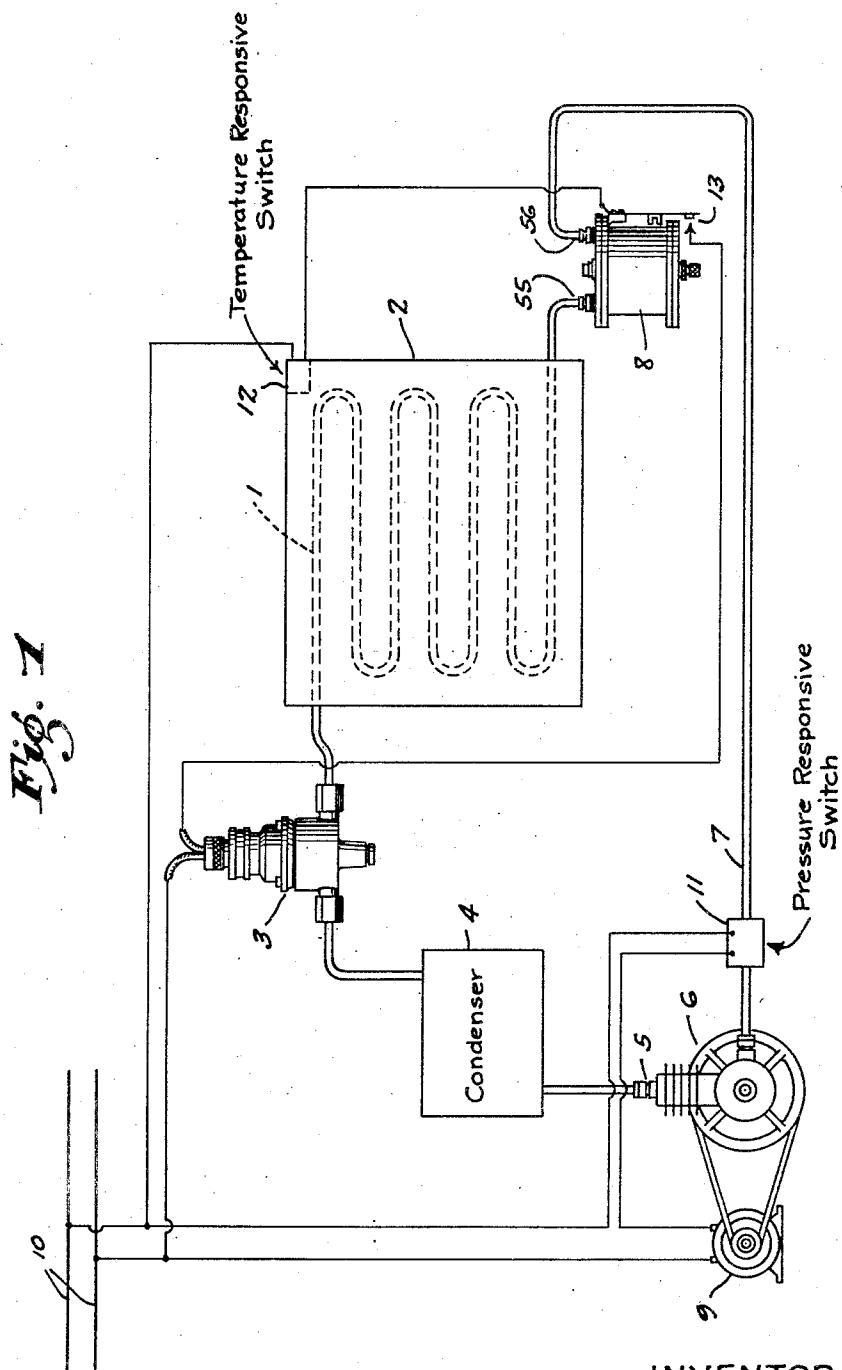
W. A. RAY

2,355,894

REFRIGERATING SYSTEM

Filed Sept. 4, 1942

3 Sheets-Sheet 1



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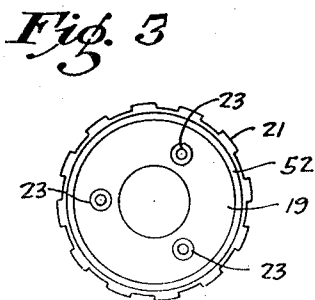
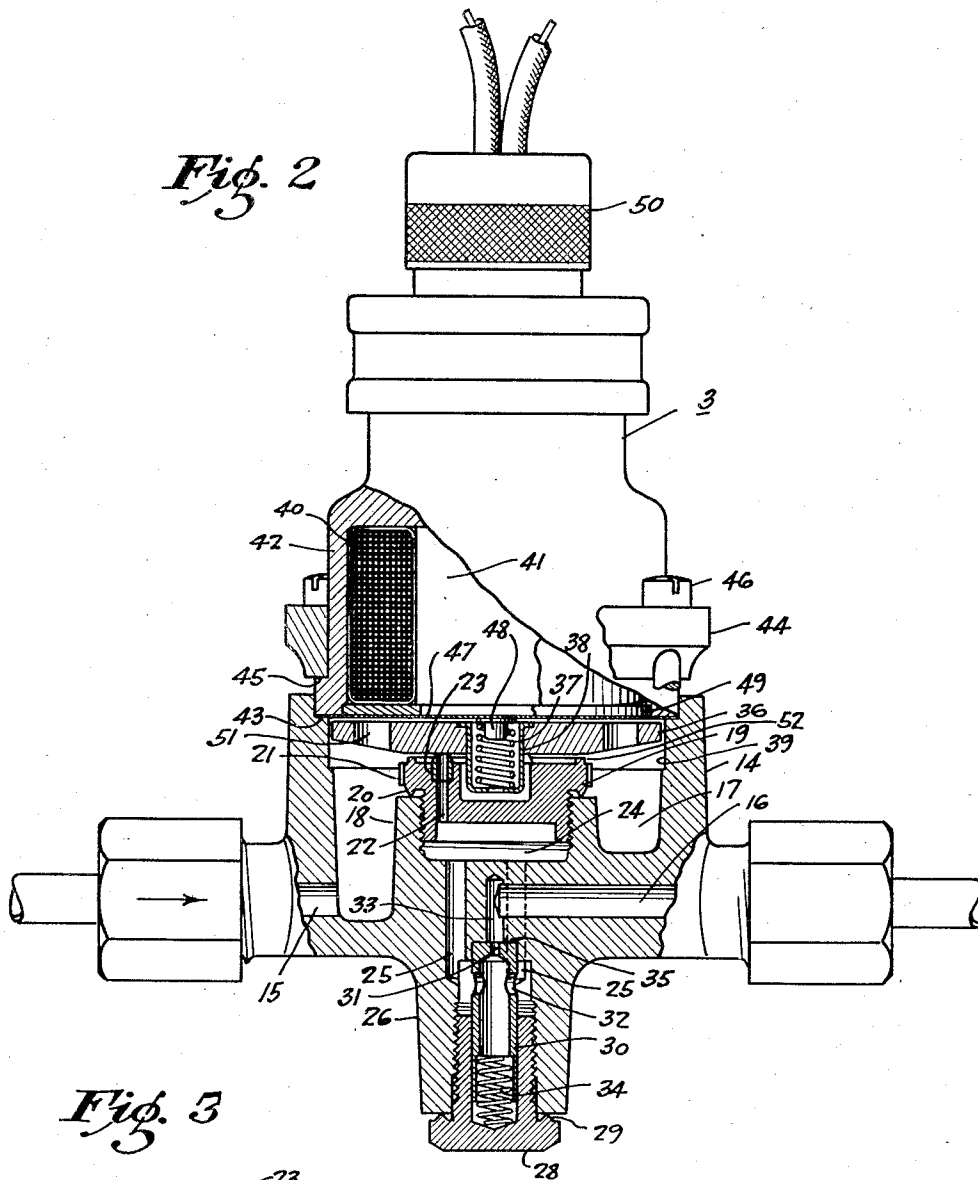
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3 Sheets-Sheet 2



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3 Sheets-Sheet 3

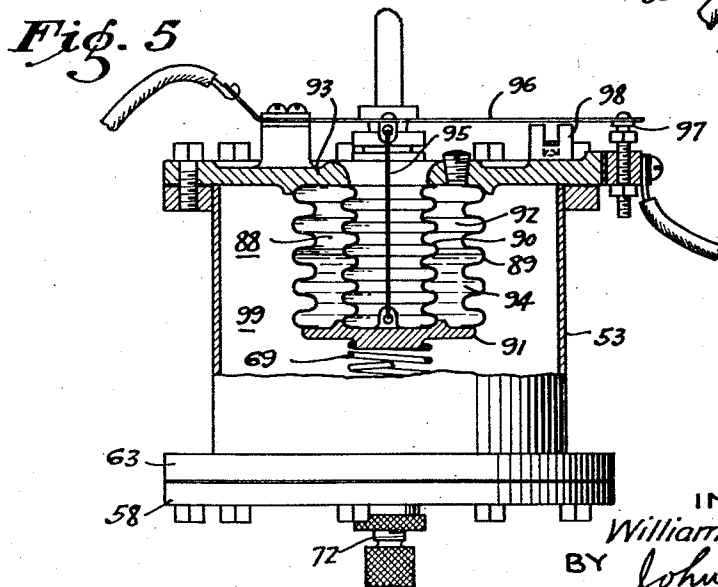
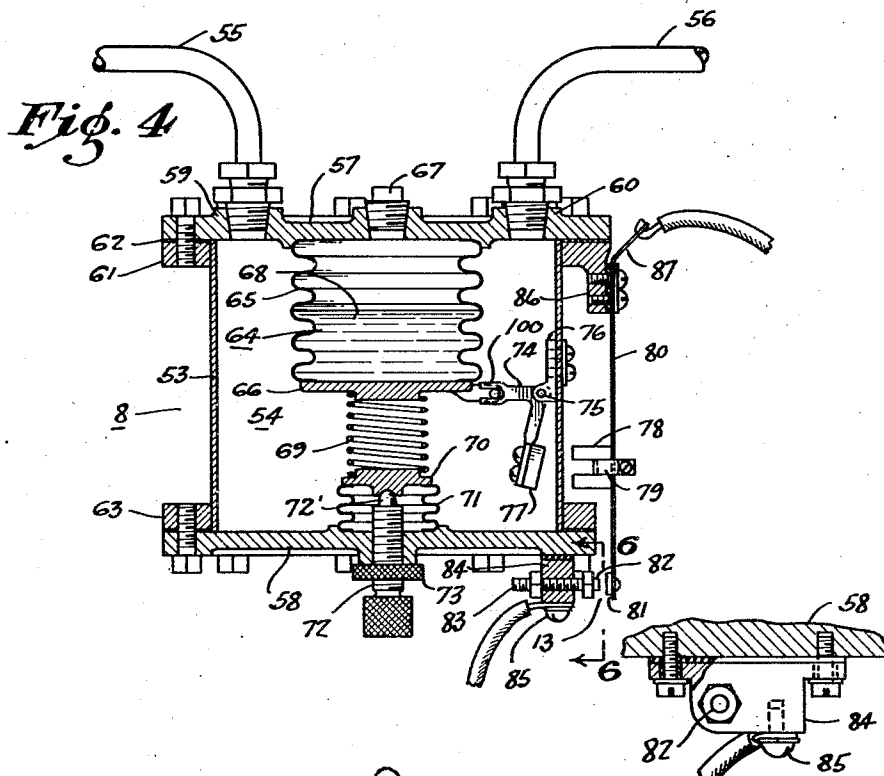


Fig. 6

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UNITED STATES PATENT OFFICE

2,355,894

REFRIGERATING SYSTEM

William A. Ray, Glendale, Calif.

Application September 4, 1942, Serial No. 457,302

3 Claims. (Cl. 62—8)

This invention relates to a mechanical refrigerating system.

Such systems almost invariably rely upon the absorption of heat attendant upon a change of state of a refrigerant from liquid to gaseous. The vaporization of the liquid refrigerant is accomplished by conducting it to a space where the pressure is low. This low pressure reduces the boiling point temperature of the refrigerant below that to which the refrigerant is subjected. Accordingly the liquid quickly vaporizes, and heat is absorbed in the process.

The evaporation space where the change of state occurs is usually an expansion coil formed of tubing. After evaporation, the vapor or gas is conducted to the inlet of a compressor, where the gas is placed under high pressure; then the gas is conducted to a condenser, where the gas is cooled below its condensing point and reverts to a liquid. From the condenser the liquid refrigerant is then conducted at intermittent periods as required, to the expansion space.

One of the factors determining the degree of refrigeration is the rate at which the liquid refrigerant is passed to the evaporator. In many systems the control of the passage of the refrigerant to the evaporator is performed by an expansion valve, operated automatically in accordance with pressure differentials on opposite sides of the valve. Such a valve is operative at frequent intervals, to permit small successive charges of refrigerant to pass to the evaporator. The automatic control of the valve is made responsive to predetermined conditions, such as temperature of the space being cooled, the pressure or temperature of the refrigerant in a specified part of the cycle of refrigeration, or combinations thereof. With a usual form of expansion valve, such automatic controls are quite complex, and therefore apt to be unreliable in extended service.

It is one of the objects of this invention to provide a simplified control apparatus for a refrigerator system.

This object is accomplished, in the present instance, by providing a simple electric control circuit for the valve that controls the passage of the refrigerant to the vaporizer. Thus it is another object of this invention to make it possible to utilize an electrically operated valve instead of the usual expansion valve, for controlling the passage of refrigerant to the vaporizer.

By providing such a valve, it is a relatively simple matter to arrange a series control circuit therefor that is energized only when all of the

control factors are active. Accordingly it is another object of this invention to make it possible to control an electrically operated valve in response to the simultaneous occurrence of controlling factors, such as temperatures and pressures.

In the present instance, one of the controlling factors is the degree of superheat of the vaporized refrigerant adjacent the outlet of the vaporizer; that is, the difference between the boiling point temperature of the liquid refrigerant and the actual temperature of the gas. Another controlling factor is the temperature of the space being cooled.

A refrigerating system, as heretofore explained, requires frequent operation of the valve that admits refrigerant to the vaporizer. It is another object of this invention to make it possible, in a refrigerating system of this character, to provide a valve that can operate millions of times in succession during its useful life.

When an expansion valve is used, the opening of the valve port may be quite gradual, thereby causing wire drawing, which has a destructive effect upon the valve seats. It is another object of this invention to prevent such wire drawing, especially by ensuring that the valve will quickly open and close, without the possibility that the valve will remain in only a partially opened condition. This snap action is most conveniently provided by an electromagnetically operated valve, which is arranged to move the closure member from closed to open position as soon as the valve is energized. Instead of a soft or slow seating, the valve closure is seated with a gentle blow, with correspondingly better seating action.

It is a simple matter with such a valve, to provide a relatively short stroke for the closure. This limits the velocity and inertia effects of the closure movement, and accordingly destructive valve seating velocities are avoided. The life of the valve is thus further increased.

In such an electromagnetically operated valve, the lift of the closure can be so arranged that it is constant, providing a constant valve opening area sufficient to eliminate all danger of wire-drawing. In order nevertheless to make it possible to predetermine the rate at which the refrigerant is to pass to the vaporizer, a throttling orifice can be used; and the size of this orifice can be selected to suit the requirements of the system.

It is still another object of the invention therefore, to provide a valve operating only between a fully open and a fully closed position, with its

attendant advantages, and yet to make it possible to select the rate of supply of refrigerant to the vaporizer.

In the usual type of expansion valve that has been incorporated in refrigerating systems, the pressures that are effective on opposite sides of the valve closure necessitate a comparatively large and cumbersome structure. By using an electromagnetically operated valve, in which fluid pressures on the valve closure have no direct regulating or controlling function, the size of the valve can be drastically reduced.

This invention possesses many other advantages, and has other objects which may be made more easily apparent from a consideration of several embodiments of the invention. For this purpose there are shown a few forms in the drawings accompanying and forming part of the present specification. These forms will now be described in detail, illustrating the general principles of the invention; but it is to be understood that this detailed description is not to be taken in a limiting sense, since the scope of the invention is best defined by the appended claims.

In the drawings:

Figure 1 is a diagrammatic illustration of a system incorporating the invention;

Fig. 2 is an enlarged elevation, partly in vertical section, of an electromagnetically operated valve utilized in connection with the system;

Fig. 3 is a plan view of the valve seat member utilized in connection with the valve illustrated in Fig. 2;

Fig. 4 is a longitudinal sectional view of a control device utilized in connection with the system;

Fig. 5 is a sectional view, similar to Fig. 4, of a modified form of the device; and

Fig. 6 is a fragmentary sectional view taken along plane 6-6 of Fig. 4.

The system as illustrated in Fig. 1 includes an evaporator or vaporizer 1, which may be in the form of convoluted tubing. This evaporator 1 may be disposed in a space to be cooled, such as that formed by the container 2. Liquid refrigerant is passed intermittently into the evaporator 1 as by the aid of an electrically operated valve 3. This valve 3 has its inlet side connected to a condenser 4. This condenser 4 in turn is connected with the outlet 5 of a compressor 6. The inlet of the compressor is connected through a conduit 7 to the outlet 55 of a control device 8. The inlet 55 of the control device 8 is connected to the outlet of vaporizer 1.

The cycle of refrigeration consists of the admission of liquid refrigerant through valve 3 into the vaporizer 1, where the pressure is sufficiently low to cause the refrigerant to vaporize. Any suitable type of refrigerant may be used; for example, Freon. The gaseous refrigerant, after it has absorbed heat, passes through the outlet of vaporizer 1 through the control device 8, and is compressed by the compressor 6. The compressed refrigerant is then cooled by the aid of the condenser 4 so as to be reconverted into a liquid state. The recycling of a refrigerant through a closed system of this character is common. The novelty in the system resides in the manner in which the recycling is controlled.

The compressor 6 is shown in this instance as operated by an electric motor 9. This electric motor is arranged to be supplied with electrical energy from the mains 10. If desired, an automatic pressure responsive switch 11 may be introduced in the motor circuit, whereby the com-

pressor 6 is operated only upon occurrence of sufficient pressure on the inlet side of the compressor 6.

The valve 3 is arranged to be electromagnetically operated. The circuit for operating the valve 3 is automatically controlled in response to one or more factors. Thus the control circuit can be in the form of a series circuit which includes a temperature responsive switch 12. This switch is so arranged that it responds to close the switch when the temperature of the space within the container 2 reaches a limiting high value. The control of the valve 3 is furthermore effected through the control device 8 which controls the switch contacts 13. These contacts 13 are in series with the temperature responsive switch 12. The switch 13 and switch 12 in series complete the circuit for the electromagnetically operated valve 3. The control device 8 is preferably one which causes closing of the switch 13 upon the occurrence of a definite condition of the refrigerant in the vaporizer 1. For example the control may be made to respond to a definite excess in temperature of the refrigerant above that which corresponds to a saturated vapor at the pressure existing in the vaporizer 1. This excess temperature is usually designated as the degree of superheat.

Upon completion of the series circuit through both switch devices 12 and 13, the valve 3 is caused immediately to open fully, thus obviating wire-drawing. This valve stays open until either the temperature of the space in container 2 is reduced, or the superheat of the gaseous refrigerant at the outlet side of the vaporizer 1 is reduced below a definite value. For example, the superheat control member 8 may be so arranged that when the superheat reaches a value of 10° Fahrenheit, the contacts 13 close. Just as soon as enough liquid refrigerant is received in vaporizer 1 to reduce the superheat, the switch 13 opens and valve 3 closes. Closing of the valve occurs immediately. Switch 13 remains open until the refrigerant in the vaporizer reaches 10° of superheat. However, the valve 3 will remain closed unless the temperature switch 12 is also closed.

By controlling the valve 3 so that it is necessary for both the temperature to reach a definite high limit and the superheat to reach a definite high limit, the refrigerating system can be operated in an economical fashion. Although this operation involves fairly rapid successive operations of the valve 3, the structure of this valve is such that this valve can operate successfully for extremely long periods of time without requiring attention.

The valve 3 that controls the passage of liquid refrigerant to the vaporizer 1 is shown to best advantage in Figs. 2 and 3. It is similar in design to a valve described and claimed in application Serial No. 418,707, filed November 12, 1941, in the name of William A. Ray for "Fluid control valve."

The valve structure is shown as having a valve body 14 provided with an inlet passage 15 and an outlet passage 16. The inlet passage communicates with an annular space 17 formed between the outer wall of the body 14 and an inner boss 18. This inner boss 18 is shown as internally threaded to accommodate the external threaded portion of a valve seat member 19. This valve seat member 19 is tightly threaded into the boss 18 and is provided with a sealing flange 20 disposed underneath its main flange

21. This main flange 21, as shown most clearly in Fig. 3, may be interrupted in order to provide a firm grip for a tool to turn the seat member 19 securely into place.

The seat member 19 in this instance is shown as provided with a plurality of ports 22. Each of these ports 22 is supplemented by a tubular insert 23 defining a sharp edge forming the valve seat proper.

When the valve is opened, the liquid refrigerant flows into the space 17 and then downwardly through the inserts 23 into the space 24 within the boss 18. The passageways for the liquid from the space 24 to the outlet 16 include a number of ports 25, all communicating with the space 24. The lower ends of these ports communicate with the interior of a hollow boss 26. This hollow boss is internally threaded for the accommodation of a cap member 28. This cap member 28 is provided at its upper edge with a sealing flange 29, serving when the cap 28 is screwed into place, to seal the opening in the boss 26.

The cap 28 is arranged to accommodate a sleeve 30 that is provided with a restricted axial opening 31. The liquid refrigerant, in its passage to outlet 16, passes through this restricted opening 31. By appropriate choice of the size of the opening 31, the rate of flow of the liquid refrigerant to the outlet 16 may be controlled.

In order to effect these results, the ports 24 communicate with the radial openings 32 in the sleeve 30. Thence the refrigerant can be flow upwardly through the opening 31 and a port 33, into the outlet 16.

The sleeve 30 is purposely made removable so that it may be removed and another sleeve substituted with an appropriate size of aperture 31. The sleeve 30 is held detachably in place by the aid of the compression spring 34, urging the sleeve 30 upwardly into a counterbore seat 35 disposed around the lower end of the port 33.

The passage of liquid refrigerant is interrupted when a closure member 36 is seated upon the seats 23. This closure member 36 is of disk-like form. It is seated by its own weight, as well as by the force of a compression spring 37. This compression spring is shown as accommodated in a cage 38 supported centrally of the disk 36, and extending below it.

The disk 36 has a diameter slightly less than the diameter of the bore 39 in the upper part of body 14. In this way, transverse movement of the disk 36 is limited.

The disk 36 is made of magnetic material so that it may be lifted from seats 23 by electromagnetic action, as by energization of an electromagnet. For this purpose use is made of an electromagnet including a coil 40. This coil is supported within a casing 42 that is a part of the magnetic circuit and thus forms an "iron-clad" type of magnet. An annular space for accommodating coil 40 is provided between the core or pole piece 41 and the casing 42. The lower edge of casing 42 is arranged to be seated upon a shoulder 43 disposed at the upper end of the body 14. It may be held in fluid tight relation with respect to the body 14 as by the aid of a ring 44 seated on top of the shoulder 45 formed on the bottom of the casing 42. The ring 44 may be urged into sealing position by the aid of a plurality of bolts 46.

It is desirable to isolate the electromagnetic coil 40 from the liquid refrigerant. For this purpose a thin sealing diaphragm 47 is interposed between the lower end of the casing 42 and the

shoulder 43. A spring guide 48 for the compression spring 37 is shown as bearing against the lower surface of the diaphragm 47. Furthermore, the coil 40 may be held in place by the aid of the insulation ring 49 disposed over the coil and between the outer wall of casing 42 and the core 41.

Any conventional type of electric coupling means 50 may be utilized for carrying the terminals of the coil 40 externally of the iron-clad electromagnet. When the coil 40 is energized, the disk 36 is attracted, because it forms a part of the magnetic circuit between the exterior wall of the casing 42 and the core 41. Apertures 51 may be provided through the disk 36 to ensure against any material dash pot action.

In order to ensure that a very large number of valve operations may be secured without wearing down the valve seat, provisions are made, as explained in the application hereinabove referred to, for limiting the tilt of the disk 49. In the present instance this tilt limiter is in the form of a raised flange 52 formed integrally with the seat member 19 and shown as concentric therewith. The upper surface of this flange 52 is disposed only slightly below the lower surface of the disk 36; of the order of one or two thousandths of an inch. This clearance is shown exaggerated for the sake of clarity. Since this clearance is very small, the degree of tilt upon the valve seat is limited to a very small angle, before the limiting surface of flange 52 is contacted and the disk 36 completely lifted from the seat.

The lift of the valve closure 36 is quite small. Accordingly only a gentle blow occurs upon the seats 23 when the valve closure drops. Furthermore, the closure can assume only two operating positions corresponding to fully open or fully closed positions. The throttling aperture 31 actually determines the rate at which refrigerant can pass to vaporizer 1.

As before stated, the energization of the coil 40 for operating the valve 3 is made dependent upon simultaneous occurrence of two factors. One of these factors is the closing of the temperature responsive switch 12. The other is the closing of the switch 13 in response to a superheated condition of the gaseous refrigerant in vaporizer 1. The mechanism 8 whereby superheat control of the contacts 13 may be secured is illustrated in Figs. 4 and 6.

A thin exterior wall 53 of non-magnetic material serves to define a space 54 in communication with the outlet of the vaporizer 1. The space 54 is further in communication with the inlet of compressor 6 by the aid of the conduit 56.

The space 54 is otherwise made fluid tight as by the aid of the upper and lower heads 57 and 58. The upper head 57 is shown as provided with the threaded bosses 59 and 60 into which the conduits 55 and 56 may be fastened. The head 57 is held in fluid tight relation with the flange 61 permanently secured to the top of the wall 53. Between the flange 61 and head 57 may be disposed a gasket 62.

Similarly, the lower head 58 is held in sealed relationship to the lower end of the wall 53 by the aid of a flange 63 permanently attached to the lower end of wall 53.

The temperature of the refrigerant in the space 54 is caused to affect a feeler bulb or pressure cell 64 that is located in space 54. In turn, appropriate variation in the volume of the cell 64 will cause operation of switch 13.

Pressure cell 64 is shown as formed by the

aid of a corrugated flexible wall 65. The upper end of the wall 65 is permanently attached and sealed to the lower side of the head 57. Its lower end is sealed by the end flange 66. A threaded aperture in the head 57 is sealed by plug 67 and forms a convenient means for gaining access to the interior of the cell 64. Located within this pressure cell 64 is a body of vaporizable liquid 68. This vaporizable liquid may be of the same kind as the liquid refrigerant used in the system, such as Freon or the like.

The pressure cell 64 is made to respond to variations in temperature of the refrigerant in space 54. For this purpose the wall 65 is purposely made thin and of good heat conducting material.

As the temperature of the refrigerant increases, the pressure within the cell 64 increases correspondingly, and its volume increase. The end flange 66 is therefore urged downwardly. It is this motion of the end flange 66 that controls the operation of the contacts 13.

In order to adjust the degree of superheat before the control effect takes place, the downward movement of the end flange 66 is opposed by an adjustable spring force. This is effected for example by the aid of the compression spring 69. The upper end of this compression spring abuts the lower side of the end flange 66. Its lower end rests upon an adjustable abutment 70. This adjustable abutment is carried on top of a corrugated wall 71. The lower end of this flexible wall 71 is in sealed relation with the inner surface of the head 53. The position of the abutment 70 is controlled by a manually adjustable set screw 72. This set screw is threaded through the head 53. A check nut 73 may be provided for the set screw 72. The upper end 72 of the set screw is provided with a rounded surface to be accommodated in a corresponding seat in the adjustable abutment 70.

The flexible wall 71 ensures against leakage of any refrigerant past the screw 72.

When the refrigerant in space 54 attains a sufficient temperature, as may be determined by the setting of screw 72, the pressure cell 64 expands sufficiently to operate a bell crank lever 74, as by a slot and pin connection 100. This bell crank lever is pivoted on a stationary pivot 75 formed on a bracket 76 fastened on the inside of wall 53. The lower arm of bell crank lever 74 carries an armature 77 made from magnetic material. This magnetic armature, when it approaches the wall 53, passes into the influence of a permanent magnet 78 that is located exterior of the wall 53. This permanent magnet 78 is movably mounted, as by a strip 79 to a flexible spring arm 80. The spring arm 80 is flexed toward wall 53, by the attraction between the armature 77 and the permanent magnet 78. By this magnetic means therefore, the operation of the cell 64 inside of the space 54 may be caused to affect the external arm 80.

This spring arm 80 carries at its lower end one of the contacts 81 of the set of contacts 13. The other contact 82, as shown most clearly in Fig. 6, is mounted on the end of a screw 83. This screw 83 is fastened into a conducting support 84 attached to the lower side of the head 53. Connection is made to the contact point 82 as by the binding post 85.

The upper end of arm 80 is shown as anchored to the projection 86 formed integrally with the flange 61. It is insulated, however, from the projection 86 and is provided with an upwardly ex-

tending portion 87. This portion 87 serves as a terminal for the spring arm 80, and the contact 81.

In the form of the control device just described, the control of the contacts 13 is effected by magnetic forces. This is necessary in order to transmit the control effect of the enclosed pressure cell 64 from inside of the casing wall 53 to the outside thereof. The magnetic effect is advantageous also for the additional reason that upon withdrawal of the armature 77, from the influence of magnet 78, the spring 80 quickly snaps to open position.

The forces acting on the end wall 66 include the pressure of the saturated vapor in cell 64, and the opposing pressure of spring 69. There is a further opposing pressure due to the vapor pressure of the refrigerant in space 54, assisting the action of spring 69. The vapor in cell 64 being saturated at all times, exerts a pressure the value of which can be determined from the curve connecting temperature as abscissae, and vapor pressure as ordinates, and usually referred to as the vapor pressure curve. But in the space 54, if the refrigerant gas therein is unsaturated, the pressure corresponding to the temperature is less than in cell 64. The spring 69 can however readily be adjusted to provide a force that keeps lever 74 in the inactive position of Fig. 4 until a definite temperature is reached. Such a setting of the spring 69 is entirely acceptable to cause the device 8 to operate at a definite degree of superheat if conditions are such that the pressure in the outlet of vaporizer 1 keeps fairly constant. If the pressure varies substantially, a new adjustment of spring 69 may be necessary to provide the controlling function at the desired point of superheat.

In the form of the device illustrated in Fig. 5, adjustment of the spring need be made only when it is desired to adjust the degree of superheat when the control should be effective; and also the need of magnetic forces to operate the control switch is obviated.

The pressure cell 88 in this case is formed of an outer flexible wall 89 and an inner flexible wall 90. These flexible walls are both joined to the end flange 61, corresponding to the end flange 66 of the form illustrated in Fig. 4. The cell 88 thus has an annular space 92 defined by the walls 89 and 90. The upper ends of these walls 89 and 90 are shown as sealed to the upper head 93. The vaporizable liquid 94 as before may be Freon or the like.

The central portion of the upper side of the end flange 61 is exposed to atmosphere. Its movement in response to the expansion of the cell 88 can be transmitted as by a link 95 to the spring contact arm 96. In the position illustrated in Fig. 5, contacts 87 are completed.

If desired, a permanent magnet 98 may be supported on the top of the head 93 to cooperate with arm 96 and to provide a snap action therefor.

The internal surface of the inner wall 90 is open to the atmosphere, as well as a portion of the top surface of the end flange 61.

The ratio of the area of the end flange 61 exposed to the pressure in space 99, to the area of the flange exposed to the pressure in cell 88 can be predetermined to provide an advantageous effect. If this ratio is correctly chosen, then the degree of superheat at which the control is effective is substantially entirely dependent only upon the adjustment of spring 69.

Variations in pressure of the refrigerant in space 99 are automatically compensated for. Switch 97 closes when the pressure in cell 88 reaches a value corresponding to the desired superheat.

In operation, the valve 3 may open and close quite often. A complete cycle, consisting of the admission of refrigerant through valve 3 to the vaporizer 1, the consequent lowering of the degree of superheat, the closing of the valve 3 and subsequent rise of the degree of superheat may occur as often as ten times per minute.

In the event the dissipation of heat from the space in container 2 is very slow, then these cycles are discontinued until thermostat switch 12 closes.

What is claimed is:

1. In a device of the character described, a refrigerant container; a sealed pressure cell having a flexible wall exposed to the temperature within the container, and having as well an end wall adapted to be moved in accordance with the cell temperature, and exposed to the fluid pressure in the container, said cell also having a flexible wall defining the cell space and limiting that area of the said end wall which is exposed to the pressure within the cell to less than the area of said end wall that is exposed within the container; supplemental means for impressing a

force upon said end wall; and control means affected by the position of said end wall.

2. In a device of the character described, a refrigerant container; a sealed pressure cell having a flexible wall exposed to the temperature within the container, and having as well an end wall adapted to be moved in accordance with the cell temperature, and exposed to the fluid pressure in the container, said cell also having a flexible wall defining the cell space and limiting that area of the said end wall which is exposed to the pressure within the cell to less than the area of said end wall that is exposed within the container; supplemental means for impressing a force upon said end wall; and control means attached to said end wall.

3. In a refrigerator system for cooling a space, utilizing the vaporization of a liquid refrigerant in a vaporizer, the combination therewith of an electromagnetically operated valve for admitting refrigerant into the vaporizer, said valve having a closure member operating only between fully open and fully closed positions, and controlling a valve port, a circuit controlling the operation of said valve, and means separate from said port, defining a throttling orifice in the outlet side of the valve.

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