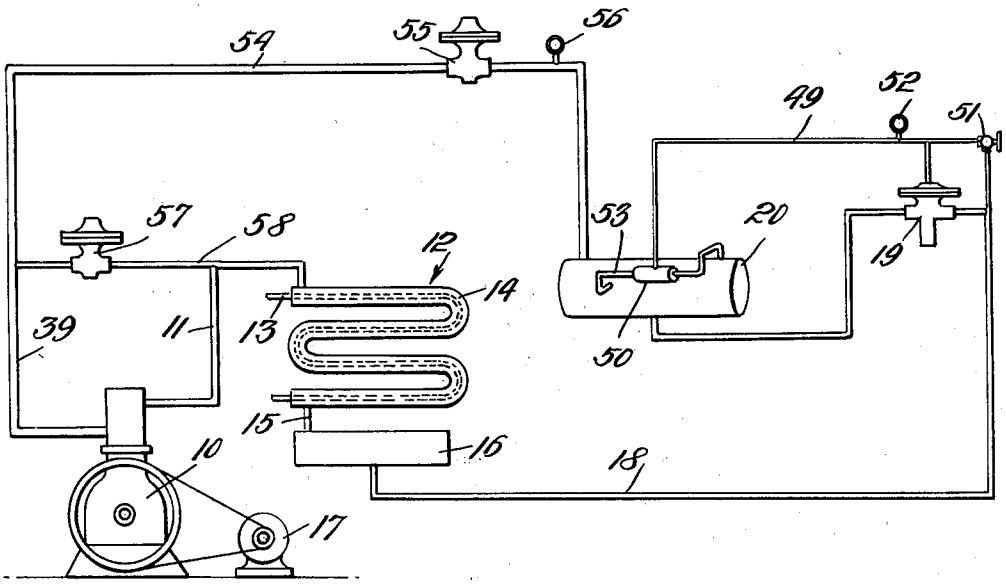
May 17, 1932. H. H. MARSHALL 1,858,517

REFRIGERATING SYSTEM

Filed June 25, 1930

Fig. 1.



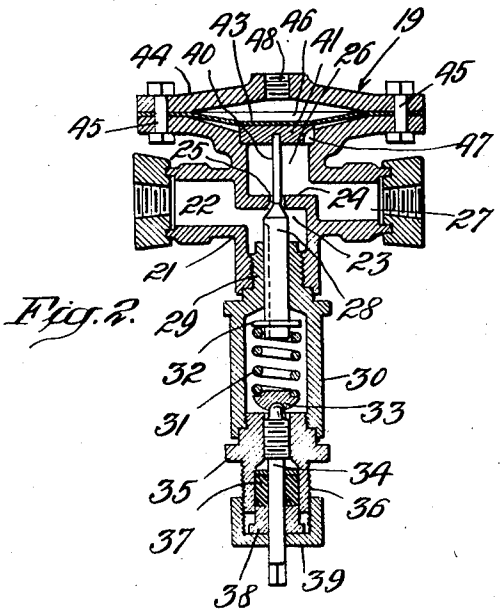


Fig. 2.

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REFRIGERATING SYSTEM

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This invention relates to a control for a liquid cooling system and more particularly to means for automatically preventing the cooling of the cooled liquid below a predetermined temperature.

Heretofore, refrigerating systems operated for the purpose of cooling liquids have had the disadvantage that they are likely to reduce the temperature of the cooled liquid below a desired or predetermined minimum. Such reduction would, in the cooling of water below the freezing point under existing conditions, cause the water to freeze and thus prevent the cooling of the water as desired.

The main object of the present invention is to provide an improved control for liquid cooling systems. A further object is to provide a control for a cooling system which will prevent reduction of temperature of the cooled material below a predetermined point even when the cooling load is substantially eliminated. Another object is to provide a control for a cooling system which will prevent reduction of temperature of the cooled material below a predetermined temperature irrespective of the continued operation of the active parts of the cooling system. To these and other ends the invention resides in the apparatus hereinafter fully described and particularly pointed out in the appended claims.

Apparatus embodying the preferred form of the invention is illustrated in the accompanying drawings in which: Fig. 1 is a diagrammatic view of the complete apparatus; and Fig. 2 is a section of the thermostatic valve.

The improved apparatus, of which the preferred embodiment is illustrated in the drawings, comprises a compressor; a condenser to receive compressed refrigerant from the compressor; a receiver in which liquefied refrigerant is collected; a high pressure liquid line to which refrigerant passes from the receiver; an evaporator; a thermostatic expansion and liquid control valve in the high pressure line; a suction gas line containing an automatic pressure valve controlling the evaporator pressure; and an automatic pressure reducing valve by-passing hot gas from the condenser discharge line to the suction line. The system may be used with any suitable volatile refrigerant, such as ammonia, sulphur dioxide or methyl chloride.

Referring to the drawings, the refrigerant is compressed by the compressor 10 and discharged through a pipe line 11 into a suitable condenser 12. As here illustrated the condenser is of the double tube type, including an inner tube 13 through which cooling water is circulated and an outer tube or jacket 14 which receives the compressed refrigerant from the compressor 10. The compressed refrigerant is liquefied in the condenser and is discharged therefrom through a pipe 15 to a receiver or receiving chamber 16. The compressor 10 may be operated from any suitable source of power, such as an electric motor 17 having a belt and pulley connection with the compressor. From the receiver 16 the liquefied refrigerant is discharged through a pipe line 18, under the control of a thermostatic expansion valve 19, into an evaporator 20.

A form of thermostatic expansion valve suitable for this purpose is illustrated in Fig. 2 and includes a main casing 21 having an inlet 22 through which the refrigerant passes into a chamber 23 at one side of a partition 24 having therein a port 25 to permit the refrigerant to pass into a chamber 26 at the other side of said partition or valve seat. The chamber 26 communicates with an outlet 27 from which the refrigerant passes to the evaporator 20. The port 25 is flared at the end adjacent to the chamber 23 and the passage of refrigerant therethrough is controlled by a reciprocable valve member 28 having a tapered end shaped to cooperate with the flared end of the port 25.

The valve member 28 is mounted for longitudinal sliding movement in a screw-plug 29 threaded into an opening in a corresponding side of the valve casing 21. The screw-plug 29 is integral with a cylindrical casing 30 into which the outer end of the valve member 28 extends. The valve member 28 is normally urged to port closing position by a suitable means such as a spring 31 arranged in said casing 30 and engaging at its inner end a

stop 32 mounted on the valve member 28 and is here shown in the form of an annular flange. Effective support for the outer end of the spring 31 is provided by a spring cap 33 mounted on the inner end of an adjusting screw or spindle 34 of which the inner end is of rounded or ball shape to cooperate with a corresponding depression or recess in the outer face of the spring cap 33.

Adjacent to its inner end the spindle 34 is provided with a screw-thread cooperating with an internal screw-thread in a screw-plug 35 threaded into the outer end of the cylindrical member 30. The screw plug 35 is also provided with an outwardly extending cylindrical member 36 containing suitable packing material 37 which is compressed by means of a packing gland 38 to effect a tight seal around the spindle 34. The inward pressure of the packing gland 38 is effected by means of a cap 39 fitting around the spindle 34 and screwed on the cylindrical member 36 so as to compress the packing 37.

The spring 31 tends to maintain the valve closed, that is, with the end of the valve member 28 in position to close the port 25. To control the opening and closing of the thermostatic expansion valve 19, the valve member 28 is provided with an extension 40 of reduced cross-section, which passes through the port 25 and of which the upper end is seated in a suitable recess in a diaphragm pusher 41 guided in a suitable guide-way in the upper part of the casing 11 and engaging a diaphragm 43 which forms the upper wall of the chamber 26.

The diaphragm 43 is clamped at its outer edge between the upper part of the casing 21 and the lower side of a cover 44 which is forced downwardly toward the upper part of the casing 21 by a plurality of bolts 45. The cover 44 is so shaped as to leave ordinarily a chamber 46 at the upper side of the diaphragm 43. In order that the pressure in the chamber 26 may be transmitted to the lower side of the diaphragm 43, the diaphragm pusher 41 is provided with one or more recesses 47 to permit passage of the refrigerant in the chamber 26 upwardly past the diaphragm pusher 41.

It will be seen that the opening and closing of the expansion valve 19 takes place in accordance with variations of pressure in the chamber 26 and in the chamber 46. In order that the pressure in the chamber 46 may be varied in accordance with changes in condition, the chamber is connected through a suitable outlet 48 with a pipe line 49 connected at one end with a thermal unit or chamber 50. The pipe line 49 and the thermal unit or chamber 50 contain refrigerant under pressure and when the temperature of the thermal unit 50 increases above a fixed limit it acts to open the thermostatic expansion valve 19. To charge the pipe line 49 and thermal unit or chamber 50, the pipe line 49 is connected through a hand valve 51 with the high pressure line 18, so that when it is desired to increase the charge in the line 49 and thermal unit 50, this effect may be obtained by opening the valve 51. When a suitable pressure in the line 49 is reached as indicated by gauge 52, the valve 51 is again closed.

In order to obtain the best results, the liquid level in the evaporator 20 should be maintained at substantially the same liquid level. For this purpose the thermal unit 50 is mounted around a pipe line 53 connected at one end with the interior of the evaporator at a point mid-way the height thereof and at the other end with the upper side of the evaporator. This control depends upon the fact that the temperature of the liquid in the evaporator 20, being lower than the temperature of the air surrounding the thermal unit 50, is utilized to control the expansion valve 19 through the thermal unit 50. It should be understood that the specific features of the thermostatic expansion valve are not parts of the present invention.

The thermal unit 50 is mounted on a horizontal section of the pipe-line 53 and at a height corresponding to the height of liquid level to be retained in the evaporator 20. When liquid refrigerant is in the horizontal portion of the pipe line 53, the thermal unit 50 will be cooled and the refrigerant therein cooled in such a manner as to reduce the pressure in the chamber 46 and permit the diaphragm 43 to rise. The spring 31 will then act to move the valve member 28 upwardly and close the port. In the same manner sinking of the liquid level in the evaporator 20 will tend to cause increase in temperature in the thermal chamber 50 and in the line 49, thereby causing the diaphragm to be compressed and the valve opened.

From the evaporator 20 the evaporated refrigerant is drawn through a pipe line 54, which may be called the suction line, to the compressor 10. The passage of refrigerant through the pipe line 54 may be controlled by any suitable means, such as a diaphragm pressure control valve 55 of known type adjusted by means including a spring (not shown). The adjustment of this valve is such that the valve closes when the evaporator pressure drops to a predetermined point, thereby preventing the production of a refrigerant evaporating pressure (or corresponding temperature) which would freeze the liquid being cooled or cool it below the desired temperature. For convenience, a pressure gauge 56 may be interposed between the evaporator 20 and the valve 55, so as to indicate the evaporator pressure at any time.

The invention also involves the use of an automatic pressure reducing valve 57 in a by-pass line 58 connecting the compressor

discharge line 11 with the suction line 39. The valve 57 may be of the same general nature as the valve 55 and is so adjusted that, when the valve 55 closes or throttles sufficiently to reduce the suction pressure to a predetermined point, valve 57 opens and by-passes hot gas into the compressor suction, thereby reducing the effective capacity of the compressor and preventing the continued action of the compressor on the evaporator. The opening of the valve 57 prevents the compressor from operating on a suction pressure less than atmospheric and drawing air into the system; but the prime purpose of valve 57 is to decrease the capacity of the compressor when the load on the evaporator decreases to a certain point.

In operation at full load, valve 57 is fully closed, valve 55 is open, and valve 19 is alternately open or closed in response to liquid level requirements. In operation on reduced loads, valve 57 opens and closes as valve 55 closes and opens, and valve 19 continues to function as before. The general advantage of this combination of controls is that, when the refrigerating system is so applied that the compressor must of necessity operate continuously, the water or other liquid may be satisfactorily cooled at any rate within the limits of capacity of the system and without any danger whatsoever of the water freezing or of any liquid acted on by the cooler being cooled below an established minimum temperature.

It should be understood that other types of regulators may be used within the scope of the invention. For example, the liquid level control might be effected by entirely different means or the thermostatic control of the valve 19 might be effected in a different manner. In its broad aspects, the present invention covers the feature of reducing the effective capacity of the compressor and is of sufficient breadth to cover apparatus in which the capacity of the compressor is reduced to zero as by stopping the same.

I claim:

1. In a refrigerating system including a compressor, an evaporator, and a suction line leading from the evaporator to the compressor, means for controlling the effective capacity of the compressor, such controlling means including an automatic pressure valve for varying the passage of refrigerant in said suction line to control the evaporator pressure and another valve for admitting gas into said suction line for decreasing the capacity of the compressor.

2. In a refrigerating system, the combination with a compressor, an evaporator, a compressor discharge line through which refrigerant passes to the evaporator and a suction line connecting the evaporator with the compressor, of a by-pass between the discharge line and the suction line and means for opening and closing the by-pass with the decrease of the evaporator pressure below or the increase thereof above a predetermined point, second means being provided for restricting the passage of refrigerant to the suction line responsive to reduction in evaporator pressure.

3. In a compression refrigerating system, the combination with an evaporator, an expansion valve for controlling the supply of refrigerant to the evaporator, and a suction line through which the evaporated refrigerant is discharged from the evaporator, of means for controlling the expansion valve to maintain the liquid level in the evaporator at a predetermined height, means for closing said suction line when the evaporator pressure falls below a predetermined point and means for decreasing the capacity of the compressor upon the closing of said suction line.

4. In a refrigerating system, the combination with a compressor, an evaporator, a compressor discharge line through which refrigerant passes to the evaporator and a suction line from the evaporator to the compressor, of a by-pass between the discharge line and the suction line, an automatic pressure reducing valve in said by-pass adapted to open when the pressure in the suction line falls below a predetermined point so as to reduce the effective capacity of the compressor and a second automatic valve controlling the supply of refrigerant to the suction line, the first valve being arranged to open upon the closing of the second valve.

5. In a refrigerating system, the combination with a compressor, an evaporator, a compressor discharge line through which refrigerant passes to the evaporator and a suction line from the evaporator to the compressor, of a by-pass between the discharge line and the suction line, an automatic pressure reducing valve in said by-pass to open when the pressure in the suction line falls below a predetermined point and thereby reduce the effective capacity of the compressor, and an automatic pressure valve controlling the evaporator pressure, said last valve being in closed position when said first valve is open.

6. In a refrigerating system, the combination with a chamber for receiving liquid refrigerant, a valve for controlling the admission of liquid refrigerant to such receiving chamber, and a line for discharging vaporized refrigerant from the upper part of said chamber, of thermostatic control means for said valve responsive to rise and fall of liquid level at a predetermined level in said chamber, means responsive to changes in vapor pressure in the upper part of said chamber for closing the discharge line when the vapor pressure falls below a predetermined point and other means coordinating

with said first means for varying the capacity of the compressor.

7. In a refrigerating system, the combination of an evaporator, a valve for controlling the admission of liquid refrigerant to the evaporator, thermostatic control means for said valve responsive to rise and fall of liquid at a predetermined level in said evaporator, a compressor withdrawing vaporized refrigerant from said evaporator and means responsive to changes in vapor pressure in the evaporator for reducing the effective capacity of the compressor and maintaining a refrigerant evaporating pressure above a predetermined minimum.

8. In a refrigerating system, the combination of an evaporator, an expansion valve controlling the admission of liquid refrigerant to the evaporator, a thermostatic control for said expansion valve responsive to rise and fall of liquid at a predetermined level in said evaporator, means for controlling the evaporator pressure, a compressor receiving at its suction side vaporized refrigerant from the evaporator and discharging compressed refrigerant at its pressure side, means responsive to fall of suction pressure below a predetermined point for by-passing refrigerant around the compressor and thereby reducing its effective capacity and means for controlling the passage of refrigerant to the compressor to prevent the production of a refrigerant evaporating pressure below a predetermined limit.

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