

March 1, 1927.

G. HILGER

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AUTOMATIC REFRIGERATION SYSTEM

Original Filed Aug. 20, 1923

2 Sheets-Sheet 1.

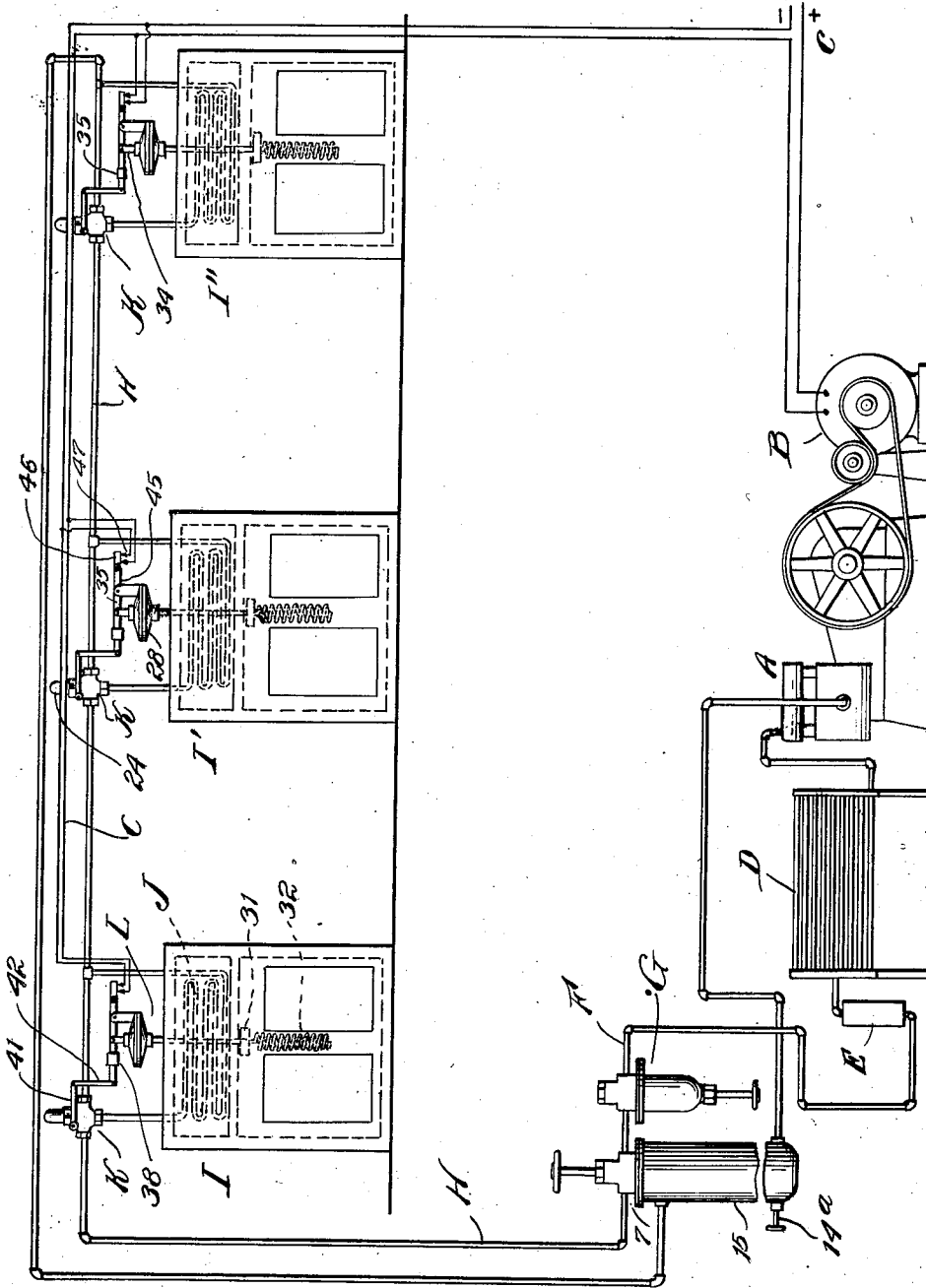


FIG. 1

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FIG. 3

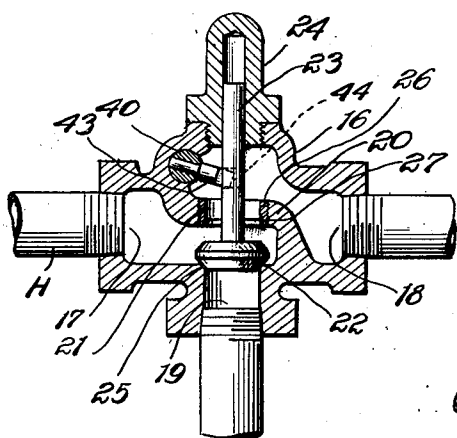


FIG. 2

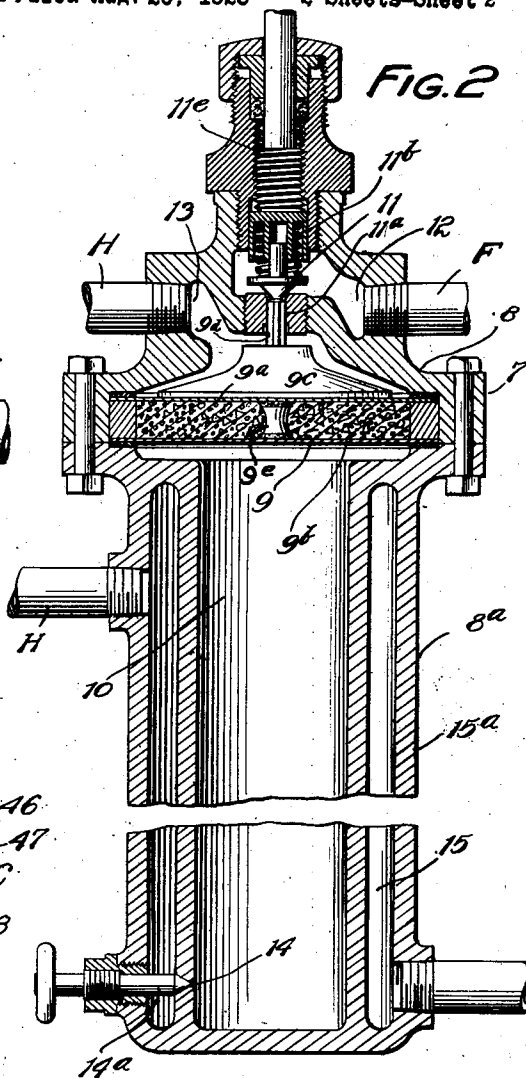
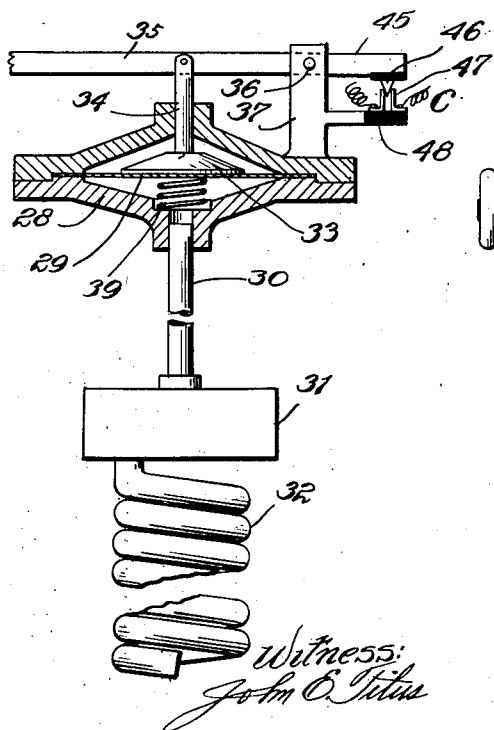


FIG. 4



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UNITED STATES PATENT OFFICE.

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AUTOMATIC REFRIGERATION SYSTEM.

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The invention pertains to refrigeration systems of the compression type, and has for its general aim the production of an improved system to the end that a substantial saving may be effected through the increased efficiency of the apparatus.

Refrigeration systems are commonly operated with a substantial loss in efficiency due to the fact that it is impracticable with the systems as at present constructed, to control the flow of the ammonia refrigerant or other refrigerant to meet the varying requirements of a series of chambers being refrigerated. Thus, if the expansion valve is set so that pressure of the refrigerant is made high enough to effect a rapid freezing of all of the coils, the temperature of the refrigerant is correspondingly increased, thus lowering its cooling effect, and further, there is danger that when the coils have become frozen an objectionable freezing back to the compressor will result. On the other hand, when the valve is set to supply the refrigerant at a low pressure, the freezing of the several coils occurs so slowly that some of them remain practically inoperative for a substantial portion of the period of operation.

The primary object of my invention is to provide for the automatic control of the flow of the refrigerant through the cooling coils, operating to supply the refrigerant initially at a pressure such as to effect a freezing of all of the coils as rapidly as possible, and then at a reduced pressure, thus insuring the operation of the system as a whole during substantially the entire operating period and under conditions closely approaching the ideal for maximum efficiency.

More specifically stated, the invention has for its principal object the provision of automatically operable valve means arranged to be governed by temperature variations in the system, whereby to regulate the flow of the refrigerant in accordance with the varying requirements.

A further object is to provide in a refrigeration system means controlled by the temperature in a storage room, which is adapted to restrict and entirely cut off the flow of refrigerant to such room when the temperature falls to a predetermined degree.

Another object is to provide a means of the character last above mentioned including

a three-way valve which remains at all times in a balanced condition whereby to facilitate its automatic operation.

Still another object is to effect a further saving in power by the provision of a means for automatically interrupting the operation of the electric motor employed for operating the compressor when the storage room or rooms have been sufficiently cooled.

In the accompanying drawings, Fig. 1 is a diagrammatic illustration of a refrigeration system embodying my invention. Fig. 2 is a fragmentary vertical sectional view through my improved automatic control valve. Fig. 3 is a vertical sectional view through the three-way valve. Fig. 4 is a view partially in elevation illustrating the means for automatically operating the three-way valve and a switch for controlling the motor line circuit.

Referring now to Fig. 1, the system comprises a compressor A actuated by an electric motor B receiving current through a line C. The compressor A discharges into a condenser D, which in turn discharges into a liquid receiver E. From the receiver the liquid flows by way of a pipe F to the expansion valve indicated at G; and from the latter the ammonia discharges under the control of an automatic valve 7 into the main pipe line H. I, I' and I'' indicate three storage rooms each having a cooling element or coil J communicating at its opposite ends with the pipe line H which finally returns the expanded gas to the compressor A for recompression.

The compressor A, actuating motor B, condensers D, liquid receiver E and expansion valve G, may be of any suitable or preferred construction.

The controlling valve 7 (Fig. 2) comprises a sectional casing, including an upper section 8 and lower section 8'. Between said sections, a diaphragm 9 is interposed so as to be secured in position. Said diaphragm forms with the lower section of the casing a closed chamber 10, and operatively associated with the diaphragm in the upper section of the casing is a valve 11, arranged to control the flow of refrigerant, entering an inlet port 12 into which the pipe F discharges, through a central port 11', to an outlet port 13 leading to the pipe line H.

In the present instance, the diaphragm 9

is responsive to variations in the temperature of the refrigerant returned by the pipe line, through the medium of a thermostatic element comprising the chamber 10 and an expansion element such as ammonia gas therein; but it will be apparent that any other suitable means responsive to temperature changes may be employed for actuating the valve 11.

- 10 The diaphragm 9 is in accordance with the present arrangement, preferably formed of two thin flexible discs 9^a spaced apart and having interposed therebetween suitable insulating material 9^b. A spacing member 9^c may also be employed to insure that the discs shall be maintained in properly spaced relation. This construction of the diaphragm it will be seen is such as to reinforce it, each of the discs serving to transmit the pressure uniformly throughout its area, to the other disc through the insulating material and said spacer member.

- The connection between the diaphragm and the valve member 11 consists of a bearing member 9^c acting through a stem 9^d upon the valve member 11, said stem passing through the central port 11^a. A coiled expansion spring 11^b tends to move the valve member 11 toward its seat upon the upper end of the port 11^a, and the tension of said spring is arranged to be varied at will by means of a suitable adjusting screw 11^e mounted in the upper section of the casing.

- The chamber 10 is arranged to communicate by way of a port 14 controlled by a manually operated valve 14^a, with an annular chamber 15 formed by a jacket 15^a. Said chamber 15 is interposed in the return side of the pipe line H leading to the compressor, and it will be seen that the chamber is arranged to be charged with ammonia gas discharged from the pipe line into the chamber 15. Preferably this is accomplished when all of the coils of the system have become frozen and a freezing back to the compressor initially occurs so that the gas with which the chamber 10 is charged is in a partially saturated condition. It will be noted also that the pressure of the charge in the chamber 10 will be line pressure, so as to balance the pressure upon the upper side of the diaphragm as it passes from the intermediate valve controlled port 11^a to the outlet 13 and into the pipe line. The spring 11^b is adjusted so as to equalize any excess in the pressure of the gas in the chamber 10 due to radiation.

- Each of the cooling or storage rooms I, I' and I'' into which the refrigerant is discharged from the pipe line H is herein shown as being similarly equipped with a cooling coil J, one end of which communicates with the pipe line H through a three-way valve K, and the other end of which discharges into the pipe line. The valves K

are specially constructed for automatic operation by a temperature-controlled device indicated generally at L.

Referring first to Fig. 3, each of the valves K comprises a casing having opposed inlet and outlet ports 17 and 18 communicating with the main pipe line, and a second outlet port 19 communicating with the inlet side of the cooling coil J. Between the inlet and outlet ports 17 and 18 there is provided a partition 20 after the fashion of the ordinary globe valve, having a port or passage 21 therein axially aligned with the outlet port 19. Between the ports 19 and 21 I arrange a valve member 22 having a stem 23 passing through the port 21 and guided at its upper end in a cap 24. At the mouth of the port 19 a seat 25 is provided for the valve when in its lowermost position, and a bushing 26 screw-threaded into the opening forming the port 21 provides at its lower end a seat 27 for the valve member when in its uppermost position.

The device L for automatically operating the valve K comprises (Fig. 4) a casing 28 having a diaphragm 29 therein which is arranged to be subjected to pressure upon its underside received into the casing through a pipe 30 communicating at its lower end with a pressure chamber 31 and a coil 32 communicating therewith. Said coil is closed at its lower end so as to be adapted to contain a liquid, such as liquid ammonia, vaporizing readily under variations in the temperature of the cooling room, the coil and its chamber 31 being arranged, as shown in Fig. 1, at a convenient place in the cooling or storage room. Upon the upper side of the diaphragm 29 rests a member 33 having a stem 34 sliding through the casing, and pivoted at the upper end of the stem is a lever 35 fulcrumed at 36 upon an upstanding arm 37 supported by the casing. The lever 35 preferably carries an adjustable weight 38 (Fig. 1) whereby the effect of the pressure upon the diaphragm as transmitted to the lever 35 may be varied at will. Preferably a coiled expansion spring 39 is interposed between the diaphragm at the lower wall of the casing 28 to balance the weight of the stem 34 and associated parts.

The valve member 22 of the valve K is adapted for connection with the lever 35 for operation thereby, in the present instance by a rock-shaft 40 (Fig. 3) having rigid therewith a lever arm 41 (Fig. 1) which latter is connected by a link 42 with the free end of the lever 35. The shaft 40 is suitably journaled in one wall of the valve casing, and the lever arm 41 is secured thereto upon the outer side of the casing. Within the casing said shaft has rigid therewith a finger 43 operating in a slot 44 in the valve stem 23. By this means, it will be apparent, when the temperature in the storage or

cooling room rises or falls, the pressure upon the diaphragm 29 in the device L correspondingly varies so that the lever 35 operates to actuate the valve 22, the arrangement being such that when the room has become sufficiently cool, the flow of the refrigerant to the cooling room is cut off by the engagement of the valve with the seat 25 of the lower outlet port 19; and similarly, when the temperature in the cooling room rises the valve is operated toward its seat 27 so as to direct the flow of the refrigerant through the coil J and thence into the pipe line.

It is to be noted that the construction of the valve K and its arrangement in the system are such that the valve member 22 is at all times subjected to pressure upon both sides, so that it is maintained substantially in a condition of balance. Thus, when the valve member is in the position shown in Fig. 3, both sides are subjected to line pressure, since the discharge end of coil J is in constant communication with the pipe line; and when the valve member is in its uppermost position, both sides thereof are subject to line pressure, since the outlet port 18 of the valve is in constant communication with the line. The importance of this balanced condition in the present system will be apparent from the fact that the valve is thereby rendered capable of automatic operation directly by the thermostatic device L.

The means for controlling the operation of the electric motor B which actuates the compressor is herein associated with and operated by the device L of the several cooling rooms. Thus, the lever 35 of each of said devices (Fig. 4), may be extended somewhat beyond its fulcrum to provide a swinging arm 45 for the movable contact 46 of a switch having stationary contacts 47 connected with opposite sides of the line C. Said stationary contacts 47 may be conveniently supported by a member 48 carried by the upstanding arm 37 on the casing 28. It will be apparent that the arrangement is such that when the temperature in one of the cooling rooms falls to a predetermined point so as to cause the lever arm 35 to descend, the movable contact 46 is carried out of engagement with the stationary contacts 47 so as to open the switch. The motor circuit, however, remains closed until the switches 46, 47 of all the cooling rooms are broken, and conversely, when the temperature in one of the rooms rises, the switch is closed to re-start the motor and restore the system to operation.

Summarizing the operation of my improved system: The expansion valve G is set so as to supply refrigerant to the pipe line at a pressure determined by the number of storage chambers to be cooled. Obviously it

is desirable that all of the coils be frozen as quickly as possible so that the initial pressure is preferably relatively high. Until all of the coils are thus frozen, the refrigerant returning to the compressor through the return side of the pipe line H, is heated, so that in passing through the chamber 15 surrounding the lower section 8^a of the controlling valve casing, the pressure of the gas in the chamber 10 is such as to hold the valve member 11 open, allowing free passage of the refrigerant into the pipe line. When, however, all of the coils become frozen, the lowered temperature of the returning refrigerant is imparted to the gas in the chamber 10 and the decreased pressure causes the valve 11 to close partially, thus automatically reducing the pressure of the refrigerant discharged into the line in accordance with the changed requirements. It will be observed that the returning refrigerant in passing through the chamber 15 surrounds the chamber 10 so that the gas in the latter is subjected to the temperature of the refrigerant only and is uninfluenced by the room temperature. Also the gas is not influenced by the temperature of the refrigerant in the upper portion of the casing due to the presence of the insulation in the diaphragm 9. This is of vital importance for the reason that the valve in order to be operative must be set to operate under a fixed temperature difference between the temperature and pressure of the refrigerant passing to the coils and the temperature of the refrigerant returning from the coils, and if subjected to variable disturbing influences such as the temperature of the chamber being cooled or the temperature of the refrigerant passing to the coils, the valve will obviously fail to operate as intended.

Should one of the storage rooms become sufficiently cooled, the pressure required to supply the remaining rooms falls still further. The result is that the temperature of the refrigerant returning to the compressor is lowered, and the effect of such lowered temperature on the gas in the chamber 10 of the controlling valve is such as to cause the valve member 11 to restrict further the flow of refrigerant to the pipe line substantially in accordance with the changed requirement. The result, it will be apparent, is a saving in the power consumed in providing the necessary refrigeration for the several rooms. In the first place all of the coils, because of the initial high pressure of the refrigerant discharged into the pipe line, become frozen in a relatively short time, so that the system rapidly becomes operative in its entirety. In the second place, by reducing the pressure of the refrigerant after such initial operation, the temperature thereof becomes lowered and the system continues in operation at maximum efficiency, effecting a sav-

ing in the power consumption, avoiding injury to the compressor by preventing the return thereto of liquid ammonia caused by an excessive freezing back; and insuring that the gas shall be returned to the compressor in a saturated or partially saturated condition.

When the temperature in one of the cooling rooms falls to a predetermined point, that is to say, when the room has become sufficiently cooled, a decreased pressure upon the diaphragm 29 of the device L, due to such lowering of the temperature in the cooling room, operates the lever 35 and thereby the valve member 22 of the valve K, to effect a restriction of the port 19 discharging into the cooling coil J, ultimately cutting off the flow of refrigerant to such coil entirely. Simultaneously with the closing of the port 19 by the valve member, port 21 is opened to allow the refrigerant to pass through the valve effectively cutting out the coil J. As a result, the temperature of the refrigerant returned to the compressor falls, and in passing through the chamber formed by the jacket 15, causes the pressure in the chamber 10 to decrease and effecting a restriction of the valve opening accordingly.

Finally, when the several rooms are reduced to the desired temperatures, the switches 46, 47 are operated by the devices L to open the motor line circuit C, effecting the stoppage of the motor.

It will thus be observed that I have through the provision of relatively simple control devices rendered it possible to operate a refrigeration system entirely automatically and in such a way as to increase substantially the efficiency of the system as whole, to accomplish a higher compressor efficiency and avoid injury to the compressor. At the same time, the elimination of manual control results in a saving in time and labor, while loss due to the production of temperatures too low or too high, occurring through carelessness on the part of an attendant, is avoided. The use of an expansion or reducing valve in combination

with a control valve is advantageous because a sudden or sharp reduction in pressure such as would be effected by the use of a single valve would result in a wire drawing of the refrigerant which is objectionable because of an attendant cutting action on the valve and its seats producing excessive wear and requiring frequent repairs. With applicant's arrangement the expansion valve operates to reduce the pressure only partially, while the control valve effects a further pressure reduction as determined by the requirements of the system. Consequently neither valve is required to make sharp pressure reductions as is necessary when only one valve is used.

I claim as my invention:

1. A refrigeration system comprising, in combination, a feed line, a condenser and compressor supplying liquid refrigerant to said feed line, a valve for expanding the liquid refrigerant into said line at constant pressure, a succession of refrigerating coils each having its inlet and outlet communicating with said feed line, individual thermostatic valves controlling the flow of refrigerant to each of said coils, a common return line leading from said feed line beyond the outlet of the last coil, and a control valve interposed in said feed line between said expansion valve and the first refrigerating coil, said valve being adapted to regulate the flow of refrigerant to all of said coils solely under the control of the temperature in said return line.

2. In a refrigeration system, the combination with a feed line, a return line, and a plurality of coils adapted to be shunted into said feed line, of a source of compressed refrigerant, a valve for expanding said refrigerant to a constant point, and a valve operable under the control of the temperature in said return line for further expanding the refrigerant supplied to said feed line and regulating the flow thereof to said coils.

In testimony whereof, I have hereunto affixed my signature.

GEORGE HILGER.