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REFRIGERATION APPARATUS

Filed July 22, 1963

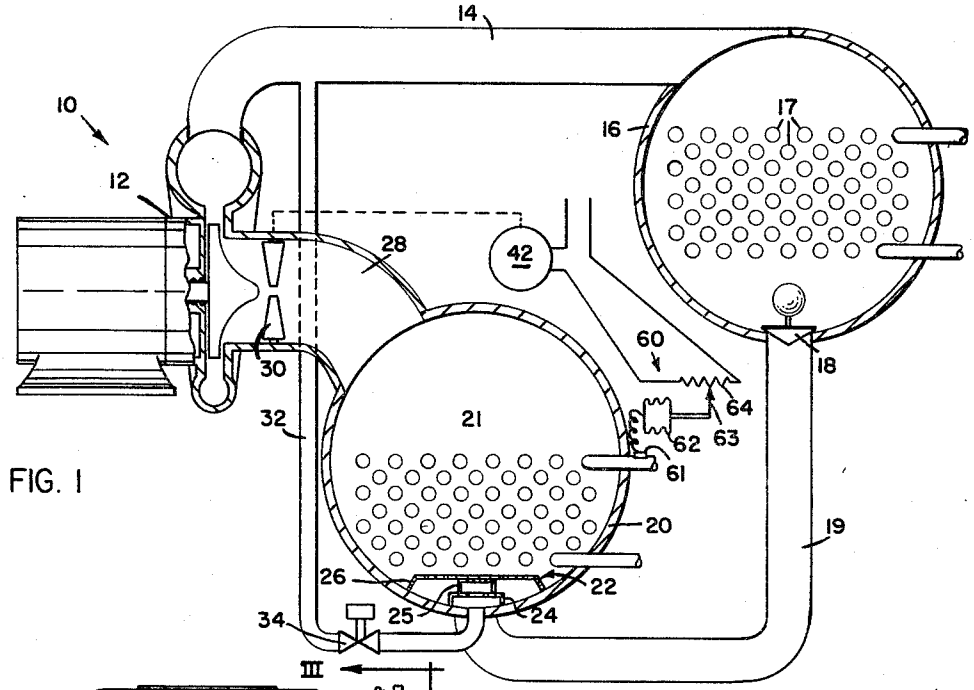

FIG. 1

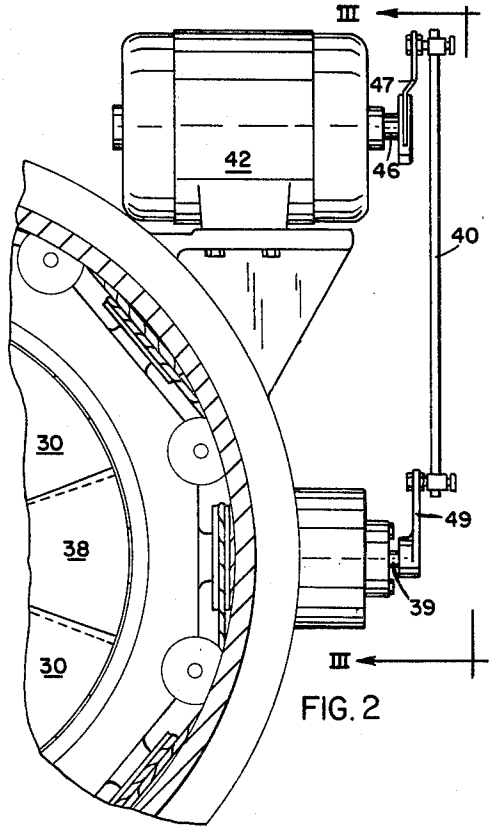

FIG. 2

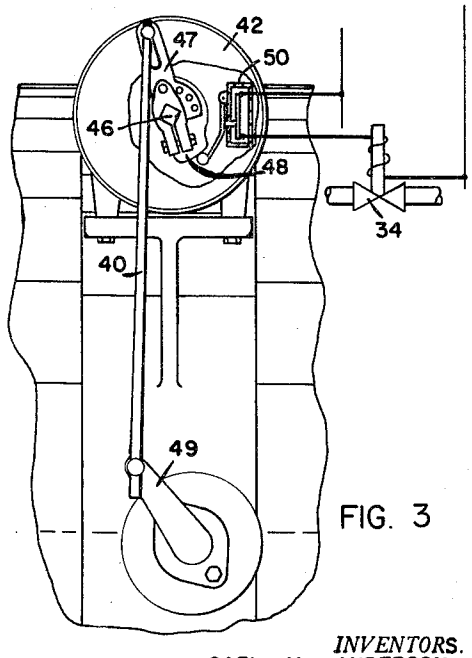

FIG. 3

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REFRIGERATION APPARATUS

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5 Claims. (Cl. 62—117)

This invention relates broadly to refrigeration apparatus. More particularly, this invention relates to refrigeration apparatus having improved refrigerant distribution means associated therewith. Still more particularly, this invention relates to a control for regulating the distribution of refrigerant to the evaporator of a refrigeration machine so that certain operating economies associated with the distribution of refrigerant to the evaporator may be realized.

In the efficient operation of a mechanical refrigeration apparatus it is important that refrigerant be distributed within the cooler or evaporator in such a manner that heat transfer may be obtained throughout the tube bundle incorporated within the cooler or evaporator. In copending United States application Serial No. 281,400, filed in the name of William E. Clark and assigned to the assignee of this application, there is shown an arrangement for distributing liquid refrigerant to the cooler or evaporator of a centrifugal refrigeration machine. The arrangement disclosed in said copending application includes a connection between the high side of the refrigeration machine and the liquid distribution arrangement such that under low load conditions gaseous refrigerant under relatively high pressure may be supplied to the bottom of the evaporator in order to supplement the normally reduced flow of refrigerant encountered at low load conditions.

This invention has for its chief object the provision of an improved control arrangement regulating flow of high pressure gas from the discharge line of the machine to the liquid refrigerant distribution means disposed within the evaporator of the refrigeration machine.

Another object of the invention is the provision of a control of the kind contemplated wherein there is provided means regulating the supply of high pressure gaseous refrigerant to the evaporator wherein the control is responsive to the operation of the capacity control means associated with the centrifugal refrigeration machine. To this end, there is provided in a refrigeration machine of the type described, a guide vane assembly disposed at the inlet to the compressor. Manipulation of the guide vanes varies the amount of gaseous refrigerant supplied to the compressor. Variation of the amount of gas supplied to the compressor directly varies the pumping capacity of the compressor and thus regulates the capacity of the machine.

A still further object of this invention is the provision of an improved control of the kind described wherein the mechanism employed in the centrifugal refrigeration machine for the purpose of adjusting the guide vanes to equate the capacity of the machine to the load imposed thereon, is employed for the purpose of controlling flow in the hot gas line provided to augment flow of refrigerant to the evaporator of the machine.

The objects of the invention are attained with a construction wherein there is provided a refrigeration machine including a compressor, a condenser and an evaporator connected to form a circuit for the flow of refrigerant, refrigerant flow metering means interposed in said circuit between said condenser and said evaporator, capacity control means regulating refrigerant flow from said evaporator to said compressor, liquid refrigerant distribution means for supplying liquid refrigerant from the refrigerant flow metering means to the evaporator, means

for supplying high pressure refrigerant to the liquid refrigerant distribution means to augment delivery of refrigerant to the evaporator, control means regulating operation of the high pressure refrigerant supply means, said last-mentioned control means being responsive to the operation of said capacity control means.

Other objects and features of the invention will be apparent upon a consideration of the ensuing specification and drawings in which:

FIGURE 1 is a schematic diagram of a refrigeration machine incorporating the invention serving as the subject of this application;

FIGURE 2 is a fragmentary view illustrating mechanism for regulating the guide vanes employed for the purpose of controlling capacity of the machine; and

FIGURE 3 is a fragmentary view of the mechanism illustrated in FIGURE 2 taken along lines III—III of FIGURE 2.

Referring more particularly to the drawings for a description of a preferred embodiment of the invention there is shown refrigeration apparatus **10** incorporating a motor compressor unit **12** of the centrifugal type arranged so as to discharge hot gaseous refrigerant into line **14** connecting the compressor with condenser **16**.

In the condenser, the vaporous refrigerant flowing from the compressor is converted to the liquid phase through the action of a cooling coil **17** interposed in said condenser. Liquid refrigerant flows from the condenser **16** through float valve **18** to liquid line **19** connected with the evaporator **20**.

There is shown a liquid distribution system **22** located at the bottom of the evaporator. The particular liquid distribution system illustrated at **22** is defined in detail in the copending application mentioned above. For the purpose of this invention there is shown in the system **22**, a first apertured base plate **24** extending along the base of the evaporator **20**. Superimposed over the plate **22** is a baffle plate **25** having openings limited to the sides thereof for the purpose of distributing liquid flowing from the apertured plate **24** outwardly through the sides thereof. Located above the baffle plate **25** is a distribution plate **26** containing a plurality of apertures in its upper surface. With the construction shown, liquid refrigerant is introduced through the tube bundle from the bottom thereof with a considerable velocity due to the action of the apertures, functioning as nozzles, in the distribution plate **26**.

The liquid refrigerant is converted to vaporous refrigerant as heat transfer between a load represented by coil **27** and the refrigerant in liquid form, occurs. Gaseous refrigerant formed as a result of the heat transfer action described flows through suction line **28** through guide vanes **30** to the inlet of the motor compressor unit **12**, completing the refrigeration circuit.

Under low load condition, the amount of liquid refrigerant introduced into the evaporator is reduced resulting in the upper few rows of tubes in the tube bundle receiving little or no refrigerant. In order that the distribution of refrigerant in the evaporator be such as to insure the entire wetting of the tube bundle therein, there is provided a line **32** connecting the discharge of the compressor with the liquid distribution system **22** disposed in the bottom of the evaporator **20**. Flow in line **32** is under the influence of valve **34**, control of which, is one of the important features of this invention. As pointed out above, the control of the flow in line **32** is under the regulation of valve **34** which, in turn, is governed by the position of the guide vanes, an indication of the loading on the machine.

Referring more particularly to FIGURES 2 and 3, there is illustrated mechanism for controlling the position

of the guide vanes in accordance with the refrigeration demand on the machine. The individual guide vanes as illustrated in FIGURE 2 have portions thereof provided with pulley sections so that operation of a power vane **38** having an actuating shaft **39** extending therefrom will cause movement of the other vanes in unison toward either a closed or open position depending upon the signal transmitted to the actuating mechanism. Referring more particularly to FIGURE 2, there is shown a motor **42** connected to the shaft on the power vane through a linkage **40**. Motor **42** includes a motor shaft **46** having an arm **47** secured thereto. A corresponding arm **49** is attached to the actuating shaft **39** of the power vane and connection between the arms **47** and **49** is accomplished through a link **40**. A capacity control sensor transmits a signal to motor **42** which, in turn, causes rotation of motor **42** in a direction to either open or close the guide vanes depending upon the particular requirement of the machine at the time. The capacity control sensing means does not form a part of this invention. Schematically, a thermal responsive unit **60** includes a bulb **61** on the coil **21** representing the load on the machine. Bellows **62** is connected to the bulb and has attached thereto an arm **63** engaging a variable resistance **64** in circuit with the winding of the motor **42**. Incremental movement of shaft **46** is obtained by varying the current supplied via resistor **64** to the motor windings.

Referring more particularly to FIGURE 3, there is shown a cam member **48** secured to motor shaft **46** and arranged to engage switch **50** arranged in a circuit in series with coil regulating solenoid valve **34**.

Considering the operation of this machine, a variation in the load on the machine is represented by a difference in the temperature of the water entering the tube bundle **21** in evaporator **20**, any variation in the temperature being sensed by the unit **60**. A signal is forwarded to the motor **42** for rotating the guide vanes to a position corresponding to the change in load on the machine. As the temperature of the entering water is reduced the motor is actuated in a manner to move guide vanes **30** to a closed position. At some predetermined loading above zero load, cam member **48** engages switch **50** completing the circuit through the coil regulating operation of valve **34**. Under these circumstances, high pressure hot gaseous refrigerant is free to flow in line **32** for the purpose of augmenting or supplementing delivery of refrigerant to the cooler. The high pressure refrigerant flowing in line **32** provides additional pressure to the liquid refrigerant delivered from liquid line **19** to the liquid distribution system **22** located in the bottom of the evaporator. With this arrangement, it is possible to insure that each of the rows of tubing receives a portion of the refrigerant charge being circulated in the machine.

As the load on the refrigeration machine is increased, as for example, when the temperature of the water entering tube bundle **21** located in evaporator **20** rises, the signal from the sensor **60** causes the motor shaft **46** to rotate in a manner designed to open or increase the opening about which guide vanes **30** are disposed. Movement of motor shaft **46** carries cam **48** away from the switch **50** causing it to open deenergizing the coil regulating the solenoid valve **34**.

In determining the design of the cam member **48** located on motor shaft **42**, the load condition on the machine at which incomplete wetting of the upper rows of tubes is encountered, is computed. The liquid refrigerant flow at this load condition is insufficient to accomplish

complete wetting of the tubes with the distribution plates described. It is at this point that cam member **48** should actuate the switch **50** controlling opening of solenoid valve **34** permitting introduction of additional refrigerant to the liquid distribution system to improve heat transfer of the tube bundle.

While we have described a preferred embodiment of our invention it will be understood that it is not limited thereto but may be embodied within the scope of the following claims.

We claim:

1. Refrigerant apparatus comprising a compressor, a condenser, and an evaporator connected to form a circuit for the flow of refrigerant, refrigerant flow control means for delivering liquid refrigerant to the evaporator interposed in said circuit between said condenser and said evaporator, capacity control means regulating refrigerant flow from said evaporator to said compressor in accordance with the refrigeration demand on said apparatus, said flow varying from a relatively high volume substantially unimpeded flow at high demand to low volume substantially restricted flow at low demand, means for supplying high pressure refrigerant to the evaporator to augment delivery of refrigerant thereto by elevating the level of liquid refrigerant in said evaporator, and control means regulating operation of the high pressure refrigerant supply means, said last-mentioned means being responsive to the action of the capacity control means at a predetermined apparatus demand above the low demand limit.

2. A refrigeration machine as described in claim **1** wherein said capacity control means are guide vanes interposed at the inlet to the compressor.

3. A refrigeration machine as described in claim **2** wherein said guide vanes are regulated by a motor driven linkage.

4. A refrigeration machine as described in claim **3** wherein said motor driven linkage includes a cam actuator carried by said motor drive shaft.

5. In the operation of a refrigeration machine including capacity control means for continuously regulating flow of refrigerant gas to the compressor, said flow varying from a relatively high volume substantially unimpeded flow at high demand to a low volume substantially restricted flow at low demand, and actuating means for regulating said capacity control means, the method of distributing refrigerant to the evaporator of said machine which comprises the steps of supplying liquid refrigerant formed in the condenser to the evaporator; transmitting high pressure refrigerant flowing from the compressor to the condenser to the evaporator to supplement liquid refrigerant flow under predetermined machine operating conditions; regulating transmittal of the high pressure refrigerant in response to operation of the capacity control actuating means at a predetermined loading above the low load limit.

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ROBERT A. O'LEARY, *Primary Examiner.*

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,210,955 October 12, 1965

Carl M. Anderson et al.

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 4, line 12, for "Refrigerant" read -- Refrigeration --.

Signed and sealed this 11th day of October 1966.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents