

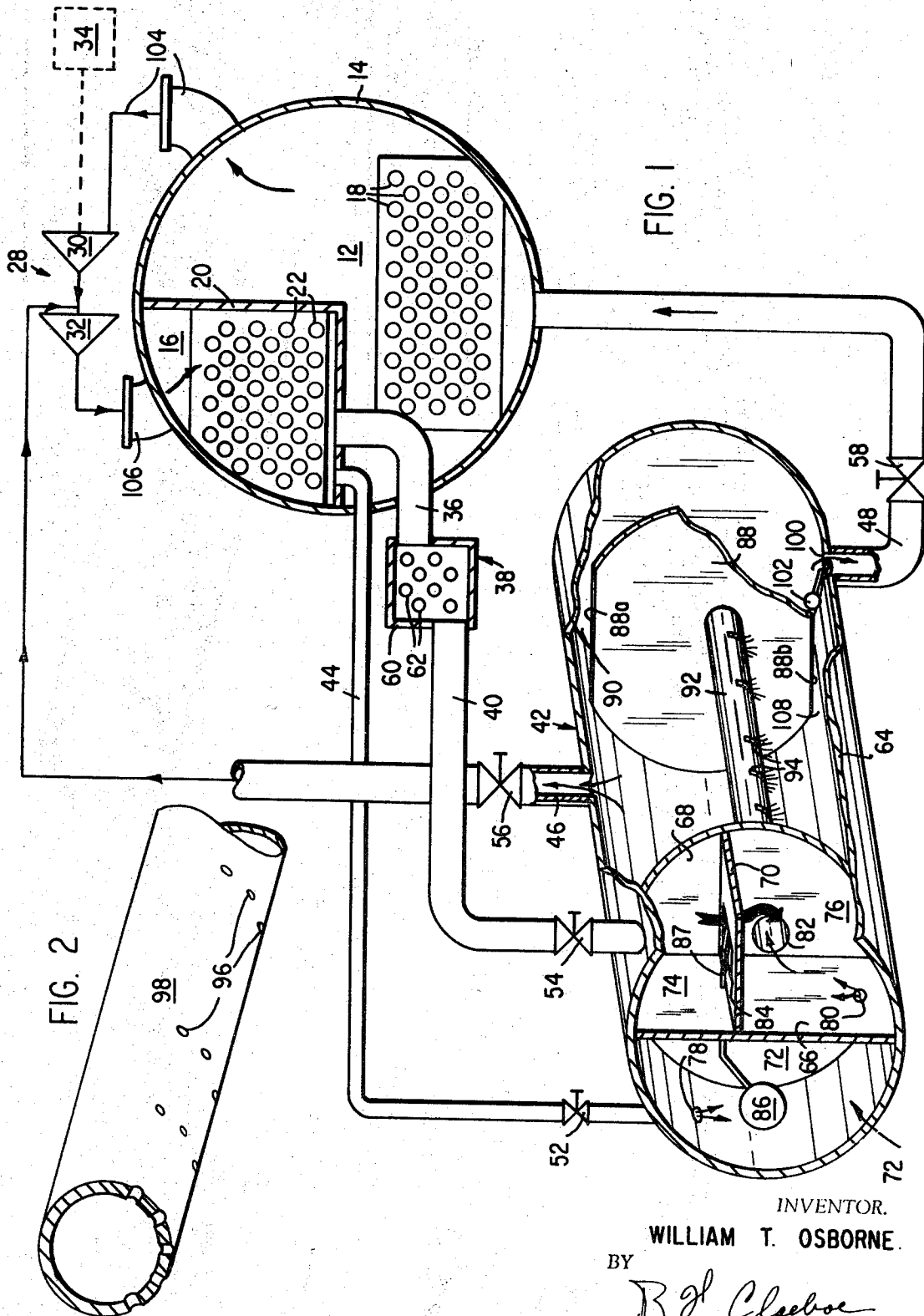
Jan. 12, 1971

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REFRIGERATION SYSTEM

3,553,974

Filed Nov. 29, 1969

2 Sheets-Sheet 1



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3,553,974

REFRIGERATION SYSTEM

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Filed Nov. 29, 1968, Ser. No. 779,831

Int. Cl. F25b 1/00

U.S. Cl. 62-115

5 Claims

ABSTRACT OF THE DISCLOSURE

The present invention is directed to a refrigeration system comprised of a compressor, condenser, evaporator and refrigerant vessel, the vessel interiorly thereof being equipped with perforate distributor means of novel construction functioning in cooperation with a unique valving arrangement to accomplish during the flashing action a more efficient separation of refrigerant liquid and gas, thereby assuring that there will be essentially no flow of liquid to the interstage suction line of the compressor.

BACKGROUND OF THE INVENTION

It is known in the art to which this invention pertains to provide a vessel at a pressure intermediate the condenser and evaporator pressure for extracting refrigerant gas from the refrigerant liquid passing to the evaporator from the condenser. Vessels of this general character have in the past been employed to improve equipment efficiency, and as such have commonly been termed "economizers." Prior refrigerant vessel have had in association therewith various types of distributor means and suitably configured valve devices. However, in most instances effective separation of the liquid and gaseous refrigerant accompanying flashing of the liquid refrigerant has not been accomplished, even though expensive and elaborate eliminator assemblies have been employed.

In economizer constructions presently used, liquid refrigerant from the condenser flows to the economizer chamber or vessel through a float valve responsive to the level of liquid in the condenser. Flow of refrigerant from the economizer to the evaporator is also controlled by a float valve, the valve in this latter instance being responsive to the level of liquid in the economizer. It will be appreciated by those skilled in the art that the economizer chamber communicates with an intermediate stage of the compressor so that the pressure in the economizer is intermediate the evaporator (suction) pressure and the condenser (discharge) pressure. The liquid refrigerant upon entering the economizer chamber flashes in part due to the pressure drop encountered. The flashing action is relatively violent and difficult to control resulting in a tendency for the gaseous component to entrain or induce portions of the remaining subcooled liquid refrigerant as it flows to the intermediate stage of compression. An economizer vessel that would accomplish the flashing phenomena under circumstances wherein carry-over of the kind described above would be avoided has long been desired.

SUMMARY OF THE INVENTION

The present invention is particularly directed to a refrigeration system incorporating therein a refrigerant vessel or economizer taking the form of a multi-chamber tank connected to the condenser and evaporator and therefrom to the first stage of a two stage compressor. Valve means are included in the system to control flow of refrigerant liquid or gas during either full load or part load operation of the machine, as well as during shut down.

The economizer is provided with a first chamber which receives refrigerant liquid from the condenser and controls action of a float valve having a throttle plate extending

into a second chamber communicating with a slotted or perforated header or distributor. Interiorly of the vessel is a baffle member shaped to provide thereabove, in cooperation with the shell interior, a vent space. The baffle member is also cut away along its bottom to provide with a plate member spaced therefrom and with the inner walls of the economizer a region for collection of refrigerant liquid resulting from the flashing action. Liquid received from the condenser through a sub-cooler passes to the second chamber of the economizer and actuation of the float valve by the controlling liquid from the condenser permits refrigerant liquid to flow to the header, wherein it flashes by reason of temperature and pressure differences in the system.

Experience has shown that a slotted or perforate distributor of the configuration herein disclosed effects a much more efficient separation of the liquid from the gas, apparently by reason of better distribution of the mixture throughout the length of the economizer, permitting thereby a smooth and orderly release of the gas from the liquid. By the economizer construction of this invention, the gas bubbles appear to provide a cushioning effect upon the liquid discharged from the header openings and substantially prevents rebounding from the inner walls of the economizer or refrigerant vessel.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates schematically, with portions thereof taken in section, a preferred form of refrigeration system incorporating the novel concepts of this invention;

FIG. 2 is a fragmentary perspective view of an alternate form of distributor means; and

FIGS. 3 and 4 are diagrammatic sectional views illustrative of the liquid and gas separation which takes place in the refrigerant vessel of this invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings and first to FIG. 1 thereof, an exemplary refrigeration system embodying the novel concepts of this invention includes a cooler or evaporator 12 located within a shell 14 which also houses a condenser 16 and a cooler or evaporator tube bundle 18. As is shown, the condenser 16 has a housing 20 mounting therewithin a tube bundle 22.

The refrigeration system of this invention also embodies a compressor 28 which desirably is of the two-stage type and has by reason of the two stages capability of operating over a wide range at substantially reduced power requirements. The first stage is designated as 30 and the second stage 32. The compressor is driven by motor means 34 indicated by phantom lines.

The condenser receives refrigerant gas from the second stage 32 of the compressor 28 and delivers high pressure, high temperature, condensed refrigerant through conduit means 36 communicating with a subcooler generally indicated at 38, which includes a housing 60 surrounding a tube bundle 62. The subcooled liquid passes therefrom through conduit means 40 to an economizer generally referred to by the numeral 42, the structural details of which will shortly be described. Also, communicating with the interior of the condenser 16 is a conduit member 44 which delivers to the economizer what may be referred to as control liquid. Again, the specific function of the control conduit will be noted later.

The economizer is connected to a conduit 46 for delivering the flashed gaseous refrigerant to the second stage 32 of the compressor 28, and also connected to the economizer is conduit means 48 for directing liquid from the economizer to the evaporator 18.

As further appears in FIG. 1 of the drawings, the conduit 44 mounts shut-off valve means 52, while similar valve

means 54, 56 and 58 are connected to the conduits 40, 46 and 48, respectively, for functions shortly to be described.

Referring now more specifically to the refrigerant vessel or economizer 42, there is provided a shell 64 which supports interiorly thereof at one end a substantially upstanding partition member 66 which connects with a generally circular transversely extending divider member 68, each of which intermediate the upper and lower extremities thereof has secured thereto a plate member 70. By this arrangement, in combination with the interior walls of the shell 64, one end of the shell is divided into three compartments, which may be termed a control chamber 72, an entry chamber 74, and a discharge chamber 76.

It is to be seen that the shell 64 is apertured at 78 to receive the control liquid, a bleed opening 80 is formed in the lower end of the partition member 66, and the divider member 68 has a discharge opening 82 placed generally midway of the top and bottom thereof. Located within the control chamber 72 is a float valve 86 having a throttle plate portion 87 which extends into the entry chamber 74 and is effective upon actuation to partially close and completely open a passage 84 in the plate member 70, permitting passage of refrigerant liquid from the entry chamber 74 into the discharge chamber 76. Under normal operating conditions, the entry chamber 74 will be essentially completely filled. This aspect of the invention will be covered in further detail later in connection with a description of the operation of the refrigeration system disclosed.

Axially spaced from the opposite end of the shell 64 is a baffle member 88 preferably originally of generally circular shape from which at diametrically opposed locations a pair of segments have been removed to provide substantially parallel upper and lower surfaces 88a and 88b which define in cooperation with the inner diameter of the shell 64 along the top and bottom portions thereof a vent passage 90 and a liquid collection zone 108. Attached to the divider member 68 at one end and at its opposite end to the baffle member 88 is a cylindrical header or distributor 92 slotted as at 94. However, a distributor of like shape may be provided with circumferentially spaced openings 96 on an arc of approximately 120°, and a header of this configuration is designated in FIG. 2 by the numeral 98. A further description of the operation of these novel headers or distributors will be given later, and particular reference made to FIGS. 3 and 4.

Within the shell 64 of the refrigerant vessel 42 there would normally be a pressure differential between opposite sides of the baffle plate 88, the pressure in the region between the plate member 70 and baffle plate 88 being greater than the pressure in the area defined by the baffle and the adjacent end wall of the shell 64. Accordingly, provision of the vent passage 90 has the important effect of equalizing pressures on opposite sides of the baffle plate 88, thereby assuring a more smooth operation of the entire system.

Removal of a segment of the baffle plate along the lower portion thereof, as at 88b, has the important advantage of providing the liquid collection zone 108. It is important particularly when the machine is operating under part load conditions that an adequate amount of refrigerant liquid be delivered to the evaporator or cooler. To explain more fully, during all conditions of operation of the machine, the refrigerant in the cooler is a mixture of liquid and vapor. Under part load operation the volume of this mixture tends to decrease, due to reduced release of vapor. Under such conditions of part load operation, the low side float valve 102 will operate in a semiclosed position, permitting the excess liquid stored in the refrigerant vessel 42 at full load to reside in the cooler, thereby increasing the liquid in the cooler and improving heat transfer performance.

The operation of the refrigeration system disclosed is as follows, references hereinafter to exemplary tempera-

tures and pressures being related to the refrigerant known to the art as "R-12," which at atmospheric pressure boils at about minus 21.6° F. When the valves 52, 54, 56 and 58 are in open position and a driving force applied to the compressor 28 by the motor 34, condensed liquid refrigerant from the condenser 16 flows through the conduit 36, subcooler 38 and via the conduit 40 into the entry chamber 74. Simultaneously, condensed liquid refrigerant passes through the conduit 44 into the control chamber 72. The liquid refrigerant flowing from the condenser 16 is at a high temperature and pressure, which for R-12 may illustratively be 102° F. and 120 p.s.i.g. The liquid as it moves into the entry chamber 74 is at about 90° F. and 110 p.s.i.g., as an example. The control liquid refrigerant illustratively enters the chamber 72 at about 102° F. and 120 p.s.i.g. The float valve 86 during full load operation of the machine will be in a fully open position, permitting passage of liquid refrigerant through the opening 84 in the plate 70, and liquid will also move through the opening 80 in the partition 66 and opening 82 in the divider 68 into the distributor 92. By way of example, the liquid in the distributor may be at about 67.5° F. and 67 p.s.i.g.

Because of the reduced pressure of the liquid refrigerant in the header 92 or 98, essentially all of the flashing takes place within the header and there is emitted from the slots 94 or holes 96 a froth made up of liquid droplets and entrained gas in generally the manner portrayed in FIGS. 3 and 4. The header 98 with perforations or holes 96 therein is shown as illustrative embodiment of the invention in the same economizer environment of FIG. 1, and good results have been attained when the distributor or header 98 is formed with approximately twelve axially spaced rows of holes with about five holes to each row arranged on an arc of approximately 120°. It is to be noted from FIG. 3 that the rows are not equidistant, and this assures that the gaseous refrigerant which is separated from the liquid-gas mixture will proceed without undue turbulence into the conduit 46 leading to the second stage 32 of the compressor 28.

With further reference to FIGS. 3 and 4, when liquid L within the header 98 flashes there is discharged from the openings 96 a plurality of sprays S of a liquid-gas mixture at a relatively low velocity, generally in the neighborhood of 2 to 4 feet per second. Typically, in the sprays S approximately 85 percent by weight is refrigerant liquid and the remainder the gaseous component of the mixture. Upon emission from the header openings, the liquid-gas mixture in the form of a spray S separates into its two components, and the gas G ascends into the conduit 46 while the liquid droplets D descend to form a pool P on the bottom of the economizer shell 64, earlier designated as a liquid collection zone 108 and the function of which has been described.

By virtue of the internal sizing of the distributor 92 or 98, the extent, number and spacing of the slots 94 or holes 96, and the size of the float valve 86 and throttle plate portion 87 thereof, in combination with appropriate sizing of the opening 84 in the plate member 70, the sprays S issue from the header slots 94 or holes 96 at relatively low velocity, the liquid droplets D are thereby entrained by the gas G until separation takes place and any possibility of rebounding of the droplets against the inner walls of the economizer shell 64 is prevented. There is accordingly accomplished by this invention a smooth and orderly release of the gas from the liquid, assuring that liquid refrigerant will not be passed to the second stage of the compressor 28.

To complete the description of the refrigeration cycle, the liquid in the collection zone 108 passes through opening 100 in the bottom of the shell 64 under control of a float valve 102, shown in FIG. 3 in a raised position when the machine is operating under full load conditions and partially depressed when the machine is at low load. The liquid refrigerant is then directed by the conduit 48 to the evaporator 12 and passes in heat transfer relation

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with coolant circulating in the tube bundle 18, causing the refrigerant to boil vigorously with resultant vaporization. The gaseous refrigerant then passes through conduit 104 to the first stage 30 of the compressor 28. Illustratively, the liquid refrigerant surrounding the tubes 18 in the evaporator 12 is at a temperature of about 35° F. and 32.5 p.s.i.g., again assuming R-12 is being used.

The gas generated within the economizer shell 64 as a result of the flashing which occurs therein is drawn through the conduit 46 to the second stage of the compressor 28 wherein it is mixed with the gas discharged from the first stage 30, and is compressed to a high temperature and pressure and passes through conduit 106 into the condenser 16, completing the refrigeration cycle.

It is to be further emphasized at this point, and with particular reference to FIG. 4, that the header openings 96, which were earlier described as circumferentially spaced and arranged on an arc of about 120°, face downwardly so that the sprays S are directed toward the bottom of the economizer shell 64. The liquid portion of the liquid-gas mixture discharged from the openings thereby falls to the shell bottom to form the pool P. Also, it is important to note that the conduit 46 leading to the compressor 28 is located along the top wall of the shell 64 so that the separated gas ascending in the shell can readily pass into the compressor. Such a structural arrangement assures a more efficient separation of the liquid and gas.

An important advantage of the economizer shown and described is that it permits isolation of the entire charge of the machine in the economizer when machine servicing is required. To accomplish this, the valves 56, 52 and 54 in lines 46, 44 and 40, respectively, are closed when the refrigeration machine is inoperative. By use of a service pump, refrigerant is transferred in liquid form from the cooler to the economizer by pressurizing the cooler with gas from the economizer and permitting the liquid to flow through line 48 and valve 58. After closing the valve 58 to entrap the contents of the economizer, the connections to the service pump are then reversed and the remaining gas in the cooler is passed into the economizer.

Servicing of the economizer may at times be required and it should be noted in this connection that the high side float valve 86 and the low side float valve 102 are located adjacent opposite ends of the economizer shell 64, which considerably facilitates their servicing. Should servicing be required, or work be necessary on any other components of the system, the entire charge of the machine can be isolated in the cooler 12. For this purpose, the valves 52, 54 and 56 are closed while the equipment is inoperative. Liquid remaining in the economizer is transferred through line 48 and valve 58 with a service pump connected to draw refrigerant gas from the cooler and discharge it into the economizer. After closing valve 58, gas remaining in the economizer is then passed to the cooler.

While there has been described a preferred embodiment of the invention, it will be understood that the invention is not limited thereto but may be otherwise embodied within the scope of the following claims.

I claim:

1. In a refrigeration system having a compressor, a condenser, an evaporator, and a refrigerant vessel, the improvement which comprises means interiorly of said vessel dividing the same into a plurality of communicating chambers receiving liquid refrigerant from said condenser, distributor means within said vessel communicating with said chambers and having a plurality of openings therein, and float valve means within the interior of said vessel responsive to the influx of liquid refrigerant into one of said chambers to control the flow of liquid to said distributor means, said distributor means being effective to accomplish essentially complete flashing of the liquid therein into liquid and gaseous components, the liquid-

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gas mixture discharged from said openings being at relatively low velocity to effect substantially complete separation of the liquid and gas.

2. A refrigeration system of the character defined in claim 1, in which within the vessel there is provided in spaced relation from one end of said vessel, a generally upstanding baffle member having portions removed along the top and bottom thereof to first provide with the upper inner walls of said vessel a vent space and to secondly provide with the lower inner walls of said vessel a liquid collection zone, said vent space being effective to equalize pressures on opposite sides of said baffle member and said liquid collection zone being effective to control the liquid level in the evaporator.

3. A method of effecting separation in a refrigeration machine of liquid refrigerant into liquid and gaseous components, which comprises directing into an enclosed perforate flashing chamber a quantity of liquid refrigerant having a boiling point less than sub-ambient temperature, effecting within said chamber substantially complete flash cooling of the liquid to provide a frothy mixture of liquid droplets and gas, discharging from said chamber said frothy mixture to effect a separation thereof into liquid and gaseous components in a smooth and orderly manner, and passing in one direction and in another direction said liquid component and said gaseous component essentially free of admixture.

4. The method of regulating flow of refrigerant within a refrigeration machine including a compressor, a condenser, an evaporator and an economizer vessel disposed between said condenser and evaporator and having an opening in the upper region thereof connected to the compressor, which comprises the steps of:

(a) supplying liquid refrigerant from the condenser to a chamber of the economizer in communication with an intermediate stage of the compressor by:

(i) passing the refrigerant through a first opening into a substantially elongated compartment so as to accomplish flashing of portions of the liquid refrigerant into gaseous refrigerant;

(ii) releasing the refrigerant from the elongated compartment through a plurality of openings disposed in the lower section of the compartment so that the liquid constituent will fall within the chamber and the gaseous constituent will flow upwardly through the connection to the compressor; and

(b) regulating flow of the subcooled liquid refrigerant from the economizer vessel to the evaporator.

5. In a refrigeration system of the character defined in claim 1, in which the openings in said distributor means are arranged along the lower portion of said distributor to discharge the liquid-gas mixture downwardly in said refrigerant vessel whereby the liquid separated drops to the bottom of said vessel, and in which said vessel has a passage along the top wall thereof communicating with said compressor to permit the upward flow thereto of the gas separated from the liquid-gas mixture.

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U.S. Cl. X.R.

62—83, 149, 174, 512