

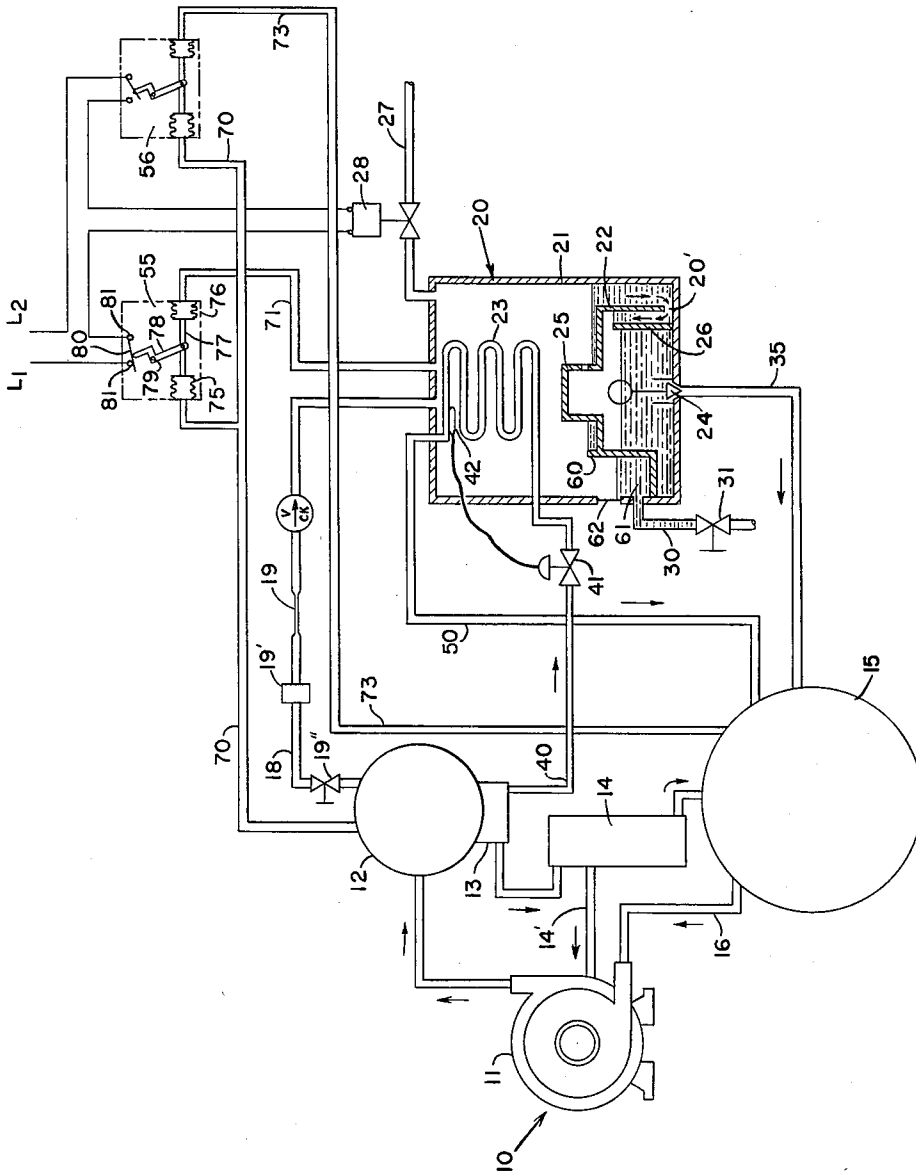
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PURGE RECOVERY ARRANGEMENT FOR REFRIGERATION SYSTEMS

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**PURGE RECOVERY ARRANGEMENT FOR REFRIGERATION SYSTEMS**

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This invention relates to purge-recovery arrangement for refrigeration systems, more particularly, to an arrangement for purging non-condensable gases from a centrifugal refrigeration system and recovering from these purged non-condensable gases any refrigeration admixed therewith.

In refrigeration systems such as centrifugal and absorption refrigeration systems with time, air, water vapor and other foreign matter gradually leak into or are formed in the system. This, as is to be expected, results in a malfunctioning of the system since non-condensable gases, for example, interfere with the heat exchange relation between the refrigerant and condensing or cooled mediums. Water in such a refrigeration system causes corrosion and also interferes with heat exchange between the refrigerant and condensing or cooled mediums.

A variety of systems have been evolved, designed to purge this foreign matter from a refrigeration system and to facilitate recovery of any refrigerant removed with said foreign matter. For example, some devices have employed an auxiliary compression refrigeration system for initiating flow of the non-condensable gases from the primary refrigeration system and for chilling and condensing these non-condensable gases. The increased cost of manufacture and subsequent maintenance arising from the provision of an auxiliary purge refrigeration system is obvious. Other systems, for example, have employed steam and water ejectors which do not permit recovery of the refrigerant.

The present invention provides an arrangement which permits purging of a refrigeration system to remove non-condensable gases and foreign matter from the refrigeration system, and thereafter to separate any purged refrigerant from the foreign matter and permit return of the refrigerant to the refrigeration system thus assuring that loss of refrigerant due to the necessary purging operation is a minimum.

It is accordingly a primary object of this invention to provide an improved purge system for refrigeration systems permitting removal of non-condensable gases from the refrigeration system, and return to the system of any refrigerant admixed with said non-condensable gases thus obviating the loss of refrigerant from the refrigeration system.

Another object of this invention is to provide a purge-recovery system of a simple nature, having a minimum number of components.

These, and other objects of the invention, which will become apparent in the following description and claims, are achieved by provision of a novel purge-recovery arrangement including a separation chamber within which a mixture of refrigerant, water and non-condensable gases may be separated. The mixture is admitted to the separation chamber from the condenser of the refrigeration system, for example, a centrifugal refrigeration system, the chamber pressure and temperature being maintained during operation lower than pressure and temperature in the condenser. A cooling coil is placed within the chamber, liquid refrigerant from the condenser passing through the coil and being evaporated therein by its heat exchange relation with the gases and vapors passing over the exterior of the coil. Passage of the gases

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over the coil condenses any refrigerant and water vapor present therein, the liquid collecting in a sump below the coil. Since the refrigerant is not miscible with and is heavier than water, the liquids separate. The refrigerant is then returned to the refrigeration system; the water can then be eliminated; and the non-condensable gases are passed off to the atmosphere. A novel valving arrangement is provided controlling the elimination of non-condensable gases from the chamber in response to variation in pressure differentials between the condenser, separation chamber and evaporator.

A primary feature of the invention relates to the provision of a purge-recovery arrangement for a refrigeration system which permits automatic flow of non-condensable gases carrying entrained refrigerant and water vapors from the condenser of the refrigeration system to be purged, to a separation chamber where the non-condensable gases are cooled to condense refrigerant and water vapors intermingled therewith and then the non-condensable gases are passed off to the atmosphere while the condensed water is passed off to a water line, and the liquid refrigerant is separated from the water and returned to the refrigeration system.

Another feature of the invention resides in the fact that the separation chamber is provided with cooling by employing the refrigerant from the condenser to the refrigeration system, permitting said refrigerant to pass through an expansion means to the separation chamber.

The specific construction details of a preferred embodiment of the invention and their modes of functioning will be made most manifest and particularly pointed out in conjunction with the accompanying drawing, wherein:

The figure represents a schematic view of the novel purge-recovery system shown as applied to a centrifugal refrigeration system.

Referring now more particularly to the drawings, a centrifugal refrigeration system 10 including the purge-recovery arrangement of the present invention is shown. Refrigeration system 10 comprises a compressor 11, a condenser 12 having condenser sump 13 leading to an economizer 14 which supplies liquid refrigerant to evaporator or cooler 15; liquid refrigerant is flash-cooled in the economizer, the flashed vapor being forwarded to the second stage of compression of compressor 11 through line 14', as shown in Jones Patent Number 2,277,647, granted March 24, 1942. In cooler 15, liquid refrigerant is placed in heat exchange relation with a medium to be cooled, refrigerant vapor so formed being forward through line 16 to the first stage of compression of compressor 11.

From the upper part of condenser 12, a purge line 18, having a restricting orifice 19, strainer 19' and line valve 19'', is extended to separation chamber 20.

Separation chamber 20 is formed by a shell or casing 21. A condensing coil 23 is placed, preferably, in the upper part of the casing adjacent the purge line inlet so that gases entering the casing are passed over the coil in heat exchange relation with refrigerant passing through the coil thereby condensing any refrigerant or water vapor carried by the non-condensable gases to separate the refrigerant and water from the non-condensable gases.

A separation deck 22 is placed below coil 23 and receives the liquid condensed by the coil. A refrigerant generally employed in centrifugal refrigeration systems is dichlorodifluoromethane which is not miscible with water and is heavier than water. Thus in the separation deck, the liquid refrigerant separates from the water and passes through passageway 20' to the sump in the bottom of casing 21. A weir 26 regulates the volume of liquid refrigerant passing to the sump and prevents passage of water due to difference in density and immiscibility of the water. A float valve 24 placed in the sump regulates pas-

sage of liquid refrigerant from the sump through line 35 to the cooler 15. An equalizer tube 25 is formed in deck 22 and is provided with one or more openings in order that pressure in the upper and lower portions of the casing are equalized during operation.

Water collects in deck 22 as it separates from the liquid refrigerant and eventually overflows weir 60 of deck 22 to sump 61. A sight glass 62 is placed adjacent sump 61 so that an operator may check the volume of water collected in sump 61. Water line 30 controlled by valve 31 is connected to sump 61. As water collects in sump 61, valve 31 is operated by the operator permitting water to drain from the sump to waste.

Atmospheric line 27 leads from the separation chamber casing 21 and is provided with a normally closed solenoid relief valve 28 for the relief of non-condensable gases which collect in chamber 20. Control of valve 28 will be explained hereafter.

Liquid refrigerant supply line 40 is connected from the sump 13 of condenser 12 to the cooling coil 23 within separation chamber casing 21. Suitable expansion means such as temperature controlled expansion valve 41 or back pressure valve (not shown) is provided in the liquid refrigerant supply line 40 to control supply of refrigerant to coil 23. It will be understood expansion means 41 operates to maintain a desired coil temperature to prevent collection of frost or ice thereon or in the separation chamber. A temperature responsive control 42 (here shown in the form of a bulb and capillary tube) is connected to valve 41 to regulate the action thereof. If desired, as shown, the bulb may be placed on the refrigerant leaving line 50 of coil 23 which in effect constitutes the suction line. The refrigerant after passage through coil 23 is forwarded to the cooler 15 through line 50.

Solenoid valve 28 is controlled by means of two differential pressure switches 55, 56 placed in series in an electrical circuit including valve 28. Switch 55 is connected to the condenser 12 by line 70 and to chamber 20 by line 71 so that it responds to the difference in pressure therein. Switch 56 is connected to the condenser 12 by line 70 and to suction line 50 or cooler 15 by line 73 so that it responds to the difference in pressure between cooler pressure and condenser pressure. Both switches 55, 56 are affected by such pressure differentials to control opening and closing of valve 28. Preferably, the switches are in series with each other and the main starter holding coil of the refrigeration system so that the switches are energized upon start-up of the refrigeration system. For example, switch 55 may be set to close at 8 pounds per square inch pressure differential and to open at 16 pounds per square inch pressure differential while switch 56 may be set to close at twenty-four pounds per square inch pressure differential and to open at sixteen pounds per square inch pressure differential.

The switches are shown diagrammatically. Both switches are the same except that switch 55 is normally closed and switch 56 is normally open. Each includes a first bellows 75, and a second bellows 76 connected by a rod 77. A lever 78 is attached to rod 77 and is pivoted at point 79. Thus as the pressure differential reflected by bellows 75, 76 moves rod 77 lever 78 pivots about point 79 to move switch arm 80 toward or from contacts 81 breaking or closing the circuit. The differential pressure switches employed may be manufacture by Penn Controls, Inc., of Goshen, Indiana, the normally closed switch being sold commercially as type HK06BA102 and the normally open switch being sold commercially as type HK06BA104.

#### Operation

The novel purge-recovery system above disclosed is employed preferably in connection with the condenser of a centrifugal refrigeration system in which during operation condensing pressure is generally above atmospheric pressure. The primary function of the purge-recovery system is to remove non-condensable gases and water

from the refrigeration machine and to recover most of the refrigerant entrained or mixed with the non-condensable gases and water vapor which is purged from the condenser. The non-condensable gases tend to accumulate at the top of the condenser and when removed from the condenser through purge line 18 carry refrigerant and water vapor therewith if water vapor is present in the condenser. When the system is placed in operation, the compressor quickly pulls-down so that a substantial pressure difference exists between the condenser 12 and chamber 20. The greater pressure in condenser 12 forces the non-condensable gases and mixed refrigerant and water vapors through the line 18, orifice 19, and strainer 19', valve 19" being open, and over cooling coil 23, thus condensing vapors by the heat exchange relation with the refrigerant in the coil, refrigerant in the coil evaporating and passing through line 50 to cooler 15. Valve 41 regulates the supply of refrigerant to coil 23.

The non-condensable gases collect in the top of the separation chamber and may be released to the atmosphere through atmospheric line 27. The condensed vapors, liquid refrigerant and water are collected below condensing coil 23 in separation deck 22. In the separation deck 22 the liquid refrigerant separates from the water, the heavier refrigerant settling to the bottom and passing over weir 26 beneath the separation deck to the refrigerant sump in the bottom of chamber 20. It will be observed that float valve 24 will open when it is buoyed up to a sufficient height by a depth of refrigerant sufficient to permit opening the discharge refrigeration line 35, without backup of refrigerant from the evaporator.

The lighter water normally accumulates at the top of the separation deck, overflows weir 60, collects in the water sump and is discharged through water line 30 by means of manual valve 31.

In operation, the novel purge recovery unit is provided with controls so as to permit automatic purging of the refrigeration system. Condenser-separation chamber differential pressure switch 55, and condenser evaporator switch 56 are both energized at start-up of the refrigeration system 10, since switches 55 and 56 preferably are in series with the main starter holding coil. When the pressures are substantially equal in the condenser 12, separation chamber 20, and evaporator 15, as at start-up, switch 55 is closed, and switch 56 is open. So long as either of switches 55 or 56 is open, atmospheric valve 28 remains closed. When the condenser pressure builds up under normal refrigeration system operation switch 56 closes, thus completing the circuit to the solenoid of valve 28 opening the same, and permitting discharge of non-condensable gases through atmospheric line 27 from separation chamber 20 to the atmosphere.

The resultant decrease in pressure in separation chamber 20 results in a pressure differential between the separation chamber and the condenser producing purging of the non-condensables from the condenser. Switch 55 responds to this pressure differential deenergizing the solenoid of valve 28 thus closing relief valve 28, permitting an increase in separation chamber pressure. This cycle is repeated during operation of the refrigeration system.

The present invention provides a novel purge-recovery system for use in removing non-condensable gases from refrigeration systems, and returning to the refrigeration system refrigerant admixed with the purged non-condensable gases. The arrangement functions by means of pressure differentials in the condenser of the refrigeration system and the separator of the purge system to accomplish automatic purging, without necessitating the use of conventionally employed auxiliary refrigeration apparatus such as compressors, air cooled condensers and the like.

The above disclosure has been given by way of illustration and elucidation, and not by way of limitation, and it is desired to protect all embodiments of the herein dis-

closed inventive concept within the scope of the appended claims.

We claim:

1. In combination with a refrigeration system, a purging arrangement to purge non-condensable gases from the system and to recover refrigerant mixed with the non-condensable gases, said arrangement comprising a casing forming a chamber, a line connecting the chamber with the condenser to permit flow of non-condensable gases and entrained vapor to the chamber from the condenser, a heat exchanger placed in the path of flow of the gases, a second line connecting the heat exchanger with the condenser to supply liquid refrigerant to the heat exchanger from the condenser, means in said second line regulating supply of refrigerant to the heat exchanger, non-condensable gases carrying entrained vapor flowing over the heat exchanger in heat exchange relation with refrigerant therein to condense vapor carried thereby thus separating the same from the non-condensable gases, a third line connecting the outlet of the heat exchanger to the evaporator of the refrigeration system to forward refrigerant from the heat exchanger to the evaporator, means to return condensate directly to the evaporator, and means governing release of non-condensable gases from the chamber, said governing means including a line connecting the chamber with ambient atmosphere, a valve in said line governing passage of non-condensable gases to the line and a control for said valve including a member responsive to predetermined variation in the difference in pressure between condenser pressure and chamber pressure to actuate the valve and said control further including a second member responsive to predetermined variation in the difference in pressure between the condenser pressure and the evaporator pressure to actuate the valve.

2. A purging arrangement according to claim 1 in which the valve in said line is a solenoid valve, the first member is a first pressure differential switch and the second member is a pressure differential switch, the first and second members being placed in an electrical circuit with said valve, the first switch responding to predetermined variation in the difference in pressure between condenser pressure and chamber pressure, the second switch responding to a predetermined variation in the difference in pressure between condenser pressure and evaporator pressure whereby, upon startup, the first switch is closed and the second switch is open, the second switch closing upon a predetermined variation in the difference in pressure between condenser pressure and evaporator pressure being attained to energize the valve to permit non-condensable gases to flow from the chamber, the first switch remaining closed until a predetermined variation in pressure difference between condenser pressure and chamber pressure is attained, then opening to de-energize the valve and remaining open until a further predetermined variation in pressure difference between condenser pressure and chamber pressure is attained, then again closing to energize the valve to permit non-condensable gases to flow from the chamber, actuation of the first switch repeating cyclically throughout operation of the system.

3. In combination with a refrigeration system, a purging arrangement to purge non-condensable gases from the system and to recover refrigerant mixed with the non-condensable gases, said arrangement comprising a casing forming a chamber, a line connecting the chamber with the condenser to permit flow of non-condensable gases and entrained water and refrigerant vapors to the chamber from the condenser, a heat exchanger placed in the path of flow of the gases, a second line connecting the heat exchanger with the condenser to supply liquid refrigerant to the heat exchanger from the condenser, means in said line regulating supply of refrigerant to the heat exchanger, non-condensable gases carrying entrained vapor flowing over the heat exchanger in heat exchange

relation with refrigerant therein to condense refrigerant and water vapors carried thereby, thus separating the same from the non-condensable gases, means in the casing for separating liquid refrigerant from water, means to remove the water from the casing, a third line connecting the outlet of the heat exchanger to the evaporator to forward refrigerant from the heat exchanger to the evaporator, means to return liquid refrigerant from the casing to the evaporator and means governing release of non-condensable gases from the chamber, said governing means including a line connecting the chamber with ambient atmosphere, a valve in said line governing passage of non-condensable gases through the line and a control for said valve, said control including a member responsive to predetermined variation in the pressure between condenser pressure and chamber pressure to actuate the valve, said control means further including a second member responsive to predetermined variation in the difference in pressure between condenser pressure and evaporator pressure to actuate the valve.

4. In combination with a refrigeration system, a purging arrangement to purge non-condensable gases from the system and to recover refrigerant mixed with the non-condensable gases, said arrangement comprising a casing forming a chamber, a line connecting the chamber with the condenser to permit flow of non-condensable gases and entrained water and refrigerant vapors to the chamber from the condenser, a heat exchanger placed in the path of flow of the gases, a second line connecting the heat exchanger with the condenser to supply liquid refrigerant to the heat exchanger from the condenser, means in said line regulating supply of refrigerant to the heat exchanger, non-condensable gases carrying entrained vapor flowing over the heat exchanger in heat exchange relation with refrigerant therein to condense refrigerant and water vapors carried thereby, thus separating the same from the non-condensable gases, means in the casing for separating liquid refrigerant from water, means to remove the water from the casing, a third line connecting the outlet of the heat exchanger to the evaporator to forward refrigerant from the heat exchanger to the evaporator, means to return liquid refrigerant from the casing to the evaporator and means governing release of non-condensable gases from the chamber, said governing means comprising a line connecting the chamber with ambient atmosphere, a solenoid valve in said line governing passage of non-condensable gases through the line and control means for said valve including a first pressure differential switch and a second pressure differential switch placed in an electrical circuit with said valve, the first switch responding to a predetermined variation in pressure difference between condenser pressure and chamber pressure, the second switch responding to a predetermined variation in difference in pressure between condenser pressure and evaporator pressure, whereby, upon startup, the first switch is closed and the second switch is opened, the second switch closing upon a predetermined difference in pressure between condenser pressure and evaporator pressure being attained to energize the valve to permit non-condensable gases to flow from the chamber, the first switch remaining closed until a predetermined variation in difference in pressure between condenser pressure and chamber pressure is attained and then opening to de-energize the valve and remaining open until a further predetermined variation in difference in pressure between condenser pressure and chamber pressure is attained, then closing to energize the valve to permit non-condensable gases to flow from the chamber, actuation of the first switch repeating cyclically throughout operation of the system.

5. A method of purging a refrigeration system to remove non-condensable gases and water from the system and to recover refrigerant mixed with the non-condensable gases and water in which the steps consist in collecting the non-condensable gases in a first portion

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of the system, removing the non-condensable gases carrying entrained refrigerant vapor and water vapor to a second portion of the system, placing liquid refrigerant from the first portion of the system in heat exchange relation with the non-condensable gases and vapors in the second portion of the system to condense the vapors, separating refrigerant condensate from water in the second portion of the system, supplying the refrigerant condensate to a third portion of the system to compensate for a heat load imposed on the system, removing water from the second portion of the system, and in response to predetermined variation in difference in pressure between pressure in the first portion and pressure in the second portion, purging non-condensable gases from the second portion of the system, and purging at start-up of the system, non-condensable gases from the second portion of the system in response to predetermined variation in difference in pressure between pressure in the first portion of the system and pressure in the third portion of the system.

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6. A method of purging a refrigeration system in which the steps consist in collecting non-condensable gases in a portion of the system, and, in response to predetermined variation in difference in pressure between pressure in the condenser of the refrigeration system and pressure in the collecting portion of the system and a predetermined variation in pressure difference between pressure in the condenser and pressure in the evaporator of the refrigeration system, purging the non-condensable gases from the system.

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UNITED STATES PATENT OFFICE  
CERTIFICATE OF CORRECTION

Patent No. 2,986,894

June 6, 1961

James W. Endress 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 2, line 26, for "to the" read -- of the --;  
column 3, line 39, for "pressure" read -- pressures --;  
line 63, for "manufacture" read -- manufactured --; column 4,  
line 51, strike out "the"; column 5, line 26, for "ambiet"  
read -- ambient --; column 7, line 12, for "predetremined"  
read -- predetermined --.

Signed and sealed this 5th day of December 1961.

(SEAL)

Attest:

ERNEST W. SWIDER

Attesting Officer

DAVID L. LADD

Commissioner of Patents

USCOMM-DC