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REFRIGERATING SYSTEM WITH PURGE MEANS

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Fig. 1.

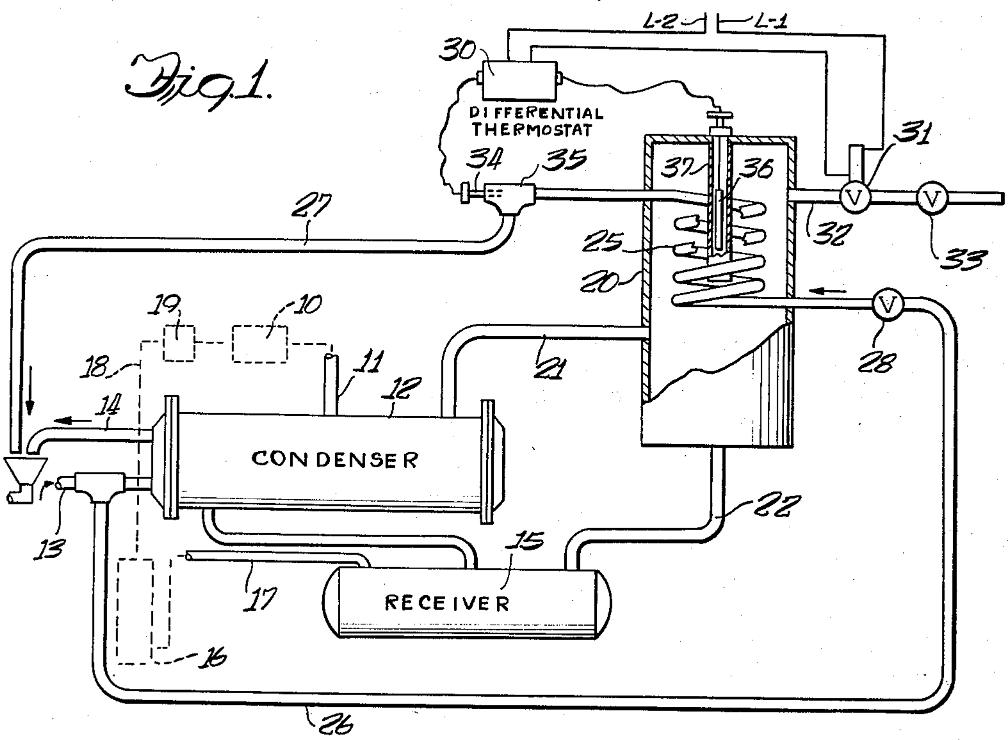
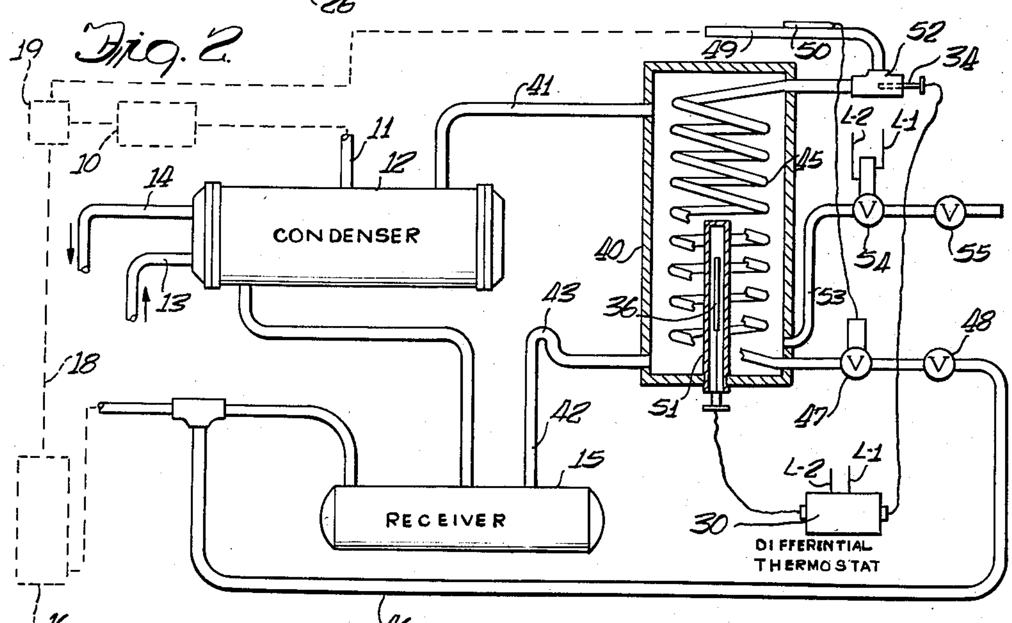


Fig. 2.



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REFRIGERATING SYSTEM WITH PURGE MEANS

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The invention relates to refrigerating systems and more particularly to the purging of such systems of air and other noncondensable gases.

The primary object of the invention is to provide improved means for automatically purging a refrigerating system of noncondensable gases and in a manner such as to enable the system to operate at full capacity with minimum power consumption or, in other words, to operate at peak efficiency at all times.

Another object is to provide a refrigerating system equipped for automatic purging which is extremely simple in construction, which requires little in the way of auxiliary equipment other than a few simple valves and which is dependable and certain in its operation.

It is also an object of the invention to provide a refrigerating system equipped with automatic purging means which, in addition to removing the noncondensable gases from the system, supplements the action of the condenser and which maintains refrigerant losses at a minimum.

Other objects and advantages of the invention will become apparent from the following detailed description of the preferred embodiments illustrated in the accompanying drawings, in which:

Figure 1 is a diagrammatic view of a refrigerating system equipped for automatic purging of noncondensable gases in accordance with the present invention.

Fig. 2 is a diagrammatic view of a refrigerating system equipped with a modified form of purging means.

While a preferred form of the invention and a modification thereof have been shown in the drawings and will be described herein in detail, it is to be understood that this is not intended to limit the invention to the particular forms shown but, on the contrary, the intention is to cover all modifications, adaptations and alternative constructions falling within the spirit and scope of the invention as defined in the appended claims.

Referring to the drawings, I have shown by way of illustration a typical refrigeration system in which a refrigerant gas such as ammonia, Freon or the like, is compressed by a compressor **10**. The compressed gas, which is relatively hot, is discharged through a conduit **11** into a conventional condenser **12**. The condenser shown is of the shell and tube type; the cooling medium, such as cold water, being circulated through the tubes to extract heat from the refrigerant. Such cooling water, in this instance, is supplied to the condenser through an inlet conduit **13** and after circulating through the tubes is discharged therefrom through an outlet conduit **14**.

The cooled and liquefied refrigerant thus produced is drained from the condenser by gravity to a storage tank or receiver **15** from which it is delivered to the expansion or evaporating coils **16** of the system as required by way of a feed conduit **17**. Gas from the expansion coils is returned to the compressor by way of a suction line **18**. A separator **19** is commonly interposed in the suction line ahead of the compressor to remove any liquid refrigerant that has passed through the expansion coils.

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In the operation of any large refrigerating system there is always some leakage of noncondensable gas into the system. This noncondensable gas is usually air and will be so referred to hereinafter. The presence of air in the system reduces efficiency since it necessitates higher condenser pressure with accompanying increases in power cost and cooling water consumption. The capacity of the system is also reduced.

Since it is impractical to prevent leakage of air into the system, the invention aims to eliminate the above objectionable effects by automatically purging or bleeding off the air from the system before it can reach significant concentrations. The means for effecting such purging in its preferred form comprises a vessel or tank **20** connected with the condenser **12** and located above the condenser, preferably at the highest point in the system, so that the air trapped in the condenser can rise along with the gaseous refrigerant and collect in the tank. Since a separate tank is utilized for purging in the exemplary system, the connection with the condenser **12** is provided by a conduit **21** extending from the upper portion of the condenser and opening into the tank **20** at a point intermediate its upper and lower ends. A conduit **22** opening from the bottom of the tank and extending to the receiver **15** provides for draining off the refrigerant condensed or liquefied in the tank.

With the above arrangement the greater part of the air entrapped with the refrigerant gas is diverted to the tank **20**. To condense the refrigerant from the gaseous mixture, the tank is provided with a cooling coil **25** herein shown as located in the upper part of the tank, preferably above the opening for the conduit **21**. Cooling liquid, such as water, from the source supplying the condenser **12** is circulated through the coil **25** to extract the heat from the gas in the tank. To this end a branch **26** of the condenser water inlet **13** is connected with the lower end of the coil. The other end of the coil connects to a drain conduit **27** which carries off the warm water. To control the rate of flow an adjustable metering valve **28** may be interposed in the supply conduit **26**.

As water flows through the coil **25** it absorbs heat from the gaseous mixture in the purging tank **20** and the water discharged through the drain **27** will therefore be at a temperature higher than that of the inlet water. However, the difference between the temperature of the outlet water and the temperature of the gaseous mixture around the coil **25** will depend upon the character of the mixture. Thus, if the gaseous mixture is composed principally of refrigerant gas, such as ammonia, the temperature around the coil **25** will be the condensing temperature of the refrigerant gas for the pressure prevailing in the tank. In operation the refrigerant gas, of course, is condensed continuously and falls to the bottom of the tank or collecting space to pass or return to the receiver **15** by way of the conduit **22**.

Air or other noncondensable gases in the mixture have a lower density than ammonia at the pressures usually prevailing in the system and therefore the air tends to collect at the top of the tank. Over a period of time, the volume of air in the tank increases and, since this is trapped at the top of the tank, a progressively increasing area of the coil **25** is shielded from contact with the refrigerant gas of the tank. As a result, the temperature of the gas immediately surrounding the coil tends to cool down and approach the temperature of the discharge water.

In accordance with the invention advantage is taken of this change in temperature differential to automatically vent the tank 20 and thus purge the accumulated air from the system when a predetermined amount is collected. To this end suitable means, such as a conventional differential thermostat 30, is provided for opening a vent valve when the temperature differential falls below a predetermined value. The particular thermostat shown controls the vent valve through the medium of a switch, which, when closed, completes a circuit by way of conductors L-1, L-2, for energizing and opening a normally closed solenoid valve 31 interposed in a vent conduit 32 opening from the upper end of the tank 20. A manually adjustable metering valve 33 may also be interposed in the vent conduit for regulating the rate of discharge from the tank.

In the particular system illustrated the differential thermostat 30, which may be of any preferred construction, has one temperature sensing element 34 inserted in a T or comparable fitting 35 connected in the water discharge or drain 27. The thermostat also has a second temperature sensing element 36 disposed in proximity to the cooling coil 25. Preferably the element 36 is enclosed in a tubular shield 37 of heat-conducting material extending from the top of the tank 20 down through the cooling coil 25 substantially centrally of the coil.

Consider, by way of example, the operation of the improved purging means when installed in a conventional refrigerating system using ammonia as the refrigerant. Under typical conditions, the system may be operating at 200 p.s.i. total pressure, of which 185 pounds represents ammonia pressure and 15 pounds is due to the air in the system. While such amounts of air are not excessive, it does place an extra load on the compressor and increase power costs by some 6 to 8%.

At 185 p.s.i. the condensing temperature of ammonia is approximately 96° F. The hot gas delivered by the compressor 10 to the condenser is cooled to substantially that temperature by the water flowing through the condenser cooling coil and liquid ammonia at approximately 96° is drained from the condenser to the receiver 15. In a reasonably efficient system the cooling water temperature may be raised a substantial amount as, for example, from 70° F. to 90° F.

Under the assumed operating pressures the density of the air in the system is lower than that of the ammonia and consequently the air will rise in the gaseous mixture in the condenser 12. The air collected in the condenser, mixed with a substantial amount of ammonia gas, then passes by way of the conduit 21 to the purging tank 20 where it is subjected to a cooling action similar to that of the condenser.

Initially, when the system is started with relatively little air entrapped in the refrigerant the gaseous mixture entering the purging tank 20 is largely ammonia. As cooling water flows through the coil 25 the ammonia is condensed to liquid form and falls to the bottom of the tank to be replaced by additional gaseous mixture from the condenser. The water flowing through the coil is adjusted (by setting the valve 28) to provide a desired rate of cooling. For example, using water from the condenser cooling system at 70° F. the flow rate may be set to provide a 10° temperature rise to 80° in the water discharged from the coil. As long as the coil is immersed in a mixture in which ammonia predominates, the temperature adjacent the coil will correspond to the condensing temperature of the ammonia at the prevailing pressure, 96° F. in the exemplary case.

During operation of the system all of the noncondensable gas will gradually collect in the purging tank 20. After a period of operation which may vary from an hour or two to several days, depending on the leakage in the system, the volume of air trapped in the tank 20 which rises to the top of the tank will be sufficient to shield substantially the entire coil 25 from contact with the gaseous mixture containing ammonia. Since the coil is no longer receiving heat from the ammonia gas, the

temperature of the air around the coil will gradually decrease until it approaches the temperature of the water discharged from the coil, in this instance 80° F.

As explained heretofore, the sensing elements 34 and 36 of the differential thermostat 30 are positioned to sense the discharge water temperature and the temperature of the gas or air adjacent the coil 25. When the latter temperature is substantially greater than the former, the switch contacts of the thermostat are open and vent valve 31 is closed. When the temperatures of the sensing elements approach the same value, the thermostatic switch is closed to energize and open the valve 31. This allows the accumulated air to bleed out of the tank through the vent conduit 32 at the rate determined by the setting of the metering valve 33.

As the air bleeds the purging tank, the gaseous mixture entering from the condenser rises around the coil 25 and the ambient temperature again approaches the ammonia-condensing temperature of 96°. This, of course, is sensed by the element 36 and when the desired differential is reestablished with respect to the sensing elements 34 and 36, the thermostatic switch opens to deenergize the valve solenoid and close the valve 31. As there is usually a slight time lag in the functioning of controls such as those described, the ammonia gas vented from the system may be increased somewhat above the amount carried over due to the partial pressure relationship before the valve 31 is reclosed. In any case, the amount of refrigerant gas lost in this manner is extremely small and its cost is made up many times in the saving of power realized through the purging of the air from the system.

In case it is desired to utilize refrigerant gas for cooling the purger rather than condenser water as above described, the purging means is connected in the refrigerating system as shown in Fig. 2. Thus, a purging tank 40 is connected with the condenser 12 by a conduit 41 for admitting the gaseous air and refrigerant mixture to the upper portion of the tank. A return conduit 42 drains condensed refrigerant from the tank to the receiver. Preferably a trap 43 is provided in the return conduit to prevent the passage of air or other gas back to the receiver.

The tank 40 is provided with a cooling coil 45, in this instance extending substantially the full height of the tank. Liquid refrigerant from the receiver is fed to the lower end of the coil by way of a supply conduit 46 and expansion valve 47. A manual stop valve 48 may be interposed in the supply conduit ahead of the expansion valve for convenience of servicing. After its passage through the coil 45, the spent refrigerant in gaseous form is returned to the suction side of the compressor by way of a branch 49 to the suction line 18. The expansion valve 47 may be of any preferred type, that shown being of the thermally regulated type having a temperature sensing element 50 positioned to respond to the temperature of the spent gas in the suction line branch 49.

Because of the low temperature provided by the refrigerant in the purging tank, the air accumulated therein will have a density higher than that of the ammonia-air mixture coming from the condenser. Initially, of course, when the system goes into operation the entire coil will be surrounded by the gaseous mixture at a temperature corresponding to the condensing temperature of the refrigerant gas for the prevailing pressure. As the operation proceeds, more and more air is trapped in the tank below the gaseous mixture and above the liquid refrigerant which, of course, falls to the bottom of the tank and eventually returns to the receiver by way of the return conduit 42. Under such conditions the sensing element 36 of the differential thermostat 30 is positioned within a well 51 located in the bottom of the purging tank. The other sensing element 34 of the thermostat is inserted in the suction branch line as by means of a fitting 52.

Adjacent the lower end of the tank a vent line 53 is provided. This vent line is fitted with a solenoid operated vent valve 54 and a manually adjustable metering valve 55, as in the previously described system. The operating solenoid of the valve 54 is connected with the switch of the differential thermostat as previously explained, so that the solenoid is energized to open the valve when the temperatures of the two sensing elements approach the same value. Under normal operating conditions, as when the cooling coil 45 is substantially completely immersed in the gaseous mixture, the temperature differential will be such that the thermostatic switch remains open and consequently vent valve 54 remains closed.

As accumulated air shields a progressively increasing portion of the cooling coil from contact with refrigerant gas, the temperature around the lower end of the coil approaches that of the discharge end of the coil and eventually the thermostatic switch is closed to open the valve 54. Accumulated air which is heavier than the refrigerant gas is forced out of the purging tank by the pressurized refrigerant gas entering from conduit 41 until the coil is again immersed in the gaseous mixture to restore the desired temperature differential.

It will be apparent from the foregoing that the invention provides simple and inexpensive purging means that is readily incorporated in substantially any commercial type of refrigerating system. This purging means improves the efficiency of the system substantially by keeping it free of air or other noncondensable gases so that power costs are minimized and full operating capacity of the system is maintained. The removal of noncondensable gases eliminates excessive consumption of cooling water and, since it permits operation at low pressures, it reduces wear and tear on the compressor. Moreover, the improved purging means supplements the operation of the condenser and thus adds to the overall capacity of the system.

I claim as my invention:

1. In a refrigerating system, in combination, a compressor, a condenser into which said compressor discharges a gaseous mixture of refrigerant and air under pressure, means for circulating cooling water through said condenser to extract heat from the gaseous mixture and condense the refrigerant to liquid form, any air entrapped in the refrigerant being collected in the upper part of said condenser, a purging tank disposed substantially at the highest point in the system, a conduit connected to deliver the trapped air mixed with refrigerant gas to said tank, a cooling coil in said tank, means for circulating cooling water through said coil to extract sufficient heat from the gaseous mixture therein to liquify the refrigerant gas, a conduit connected to return the liquified refrigerant to the system, the air in said mixture collecting in the upper portion of said tank and acting to shield a progressively increasing area of the coil from direct contact with the mixture containing refrigerant gas whereby the gas around the coil approaches the temperature of the water discharged from the coil, thermostatic means for sensing the temperature of the gas in the vicinity of the coil and the temperature of the water discharged from the coil, a vent for sand tank, valve means normally closing said vent, and means controlled by said thermostatic means for opening said valve when the temperatures sensed by said elements approach the same value.

2. In a refrigerating system, in combination, a purging tank, means for diverting from the system to said tank a mixture of refrigerant gas and any air entrapped in the system, a cooling coil in said tank, means for circulating cooling water through said coil to extract sufficient heat to condense the refrigerant gas from the mixture, said coil normally being exposed throughout its entire length to the gaseous mixture at a temperature corresponding to the condensing temperature of the refrigerant gas at the prevailing pressure, the air in said mixture remaining in said tank and accumulating therein to shield a progressively increasing area of said coil from the warming effect of the condensing refrigerant gas, differential thermostatic means for sensing the temperature in the vicinity of said coil and the temperature of the water circulated in said coil, and normally closed valve means controlled by said thermostatic means operative to vent the accumulated air from said tank when the temperature differential approaches a predetermined value.

3. In a refrigerating system, in combination, a purging tank, conduit means for diverting to said tank a mixture of refrigerant gas and any air entrapped in the system, a cooling coil disposed in said tank and normally fully exposed to the gaseous mixture, means for circulating coolant through said coil to extract sufficient heat from the mixture to liquify the refrigerant gas in the mixture, the noncondensable gas in the mixture remaining in said tank and as it gradually accumulates acting to shield progressively increasing areas of the coil from direct contact with refrigerant gas thereby reducing its heat extracting action, and means responsive to the change in temperature of the coolant discharged from the coil for venting the air from said tank, said means acting to terminate the venting when the coil is again exposed to refrigerant gas.

4. In a refrigerating system, in combination, a purging tank, conduit means for diverting to said tank a mixture of refrigerant gas and any air entrapped in the system, a cooling coil in said tank, a normally closed vent for said tank, means for circulating coolant through said coil, a differential thermostat having one temperature sensing element positioned to sense the temperature of the coolant and another sensing element positioned to sense the temperature of the gas in the vicinity of said coil, and means operative upon a predetermined differential in the temperatures sensed by said elements for venting said tank to the atmosphere.

5. In a refrigerating system, in combination, a chamber disposed at the highest point in the system, means for diverting to said tank all of the noncondensable gas trapped in the system mixed with refrigerant gas, means for circulating a cooling medium through said chamber for condensing the refrigerant to liquid form while retaining the noncondensable gas in gaseous form, means located in said chamber for sensing the temperature of the accumulated gas, means located externally of said chamber for sensing the temperature of the cooling medium leaving the chamber, and means operable jointly by said temperature sensing means when the sensed temperatures approach a common value for venting the noncondensable gas from the tank.

6. In a refrigerating system including a condenser, means providing a space for cooling refrigerant gas and gas that is nonliquefiable, a normally closed vent for said space, means for circulating a cooling medium to cool said space, a differential thermostat having one temperature sensing element positioned to sense the temperature of the gas within said space and another sensing element positioned to sense the temperature of the discharged cooling medium, and means operative upon a predetermined decrease in the differential between the temperature sensed by said elements for opening said vent.

7. In a refrigerating system, in combination, a condenser for extracting the heat from and liquefying compressed refrigerant, means defining a chamber for collecting unliquefiable gas entrapped with the refrigerant gas, means for cooling the entrapped gas, and differential thermostatic means responsive to the temperature of the entrapped gas and the temperature of the medium utilized for cooling the gas after it has been in heat exchange relation with the entrapped gas, and means operable by the thermostatic means when the two temperatures approach a common value for venting said chamber.

8. In a refrigerating system, in combination, means defining a chamber positioned to collect nonliquefiable gas entrapped with the refrigerant gas, means for circulating a cooling medium vertically through said chamber to liquefy the refrigerant gas collected therein, said

circulating means being positioned so that accumulating nonliquefiable gas gradually reduces the area exposed to refrigerant gas, means for sensing the temperature of the gas in the vicinity of said circulating means, means for sensing the temperature of the cooling medium after circulation through said chamber, and means operable by said temperature sensing means jointly for venting said chamber upon accumulation of a predetermined quantity of noncondensible gas.

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