March 22, 1966 J. E. EMBURY 3,241,335

COOLER

Filed June 23, 1964

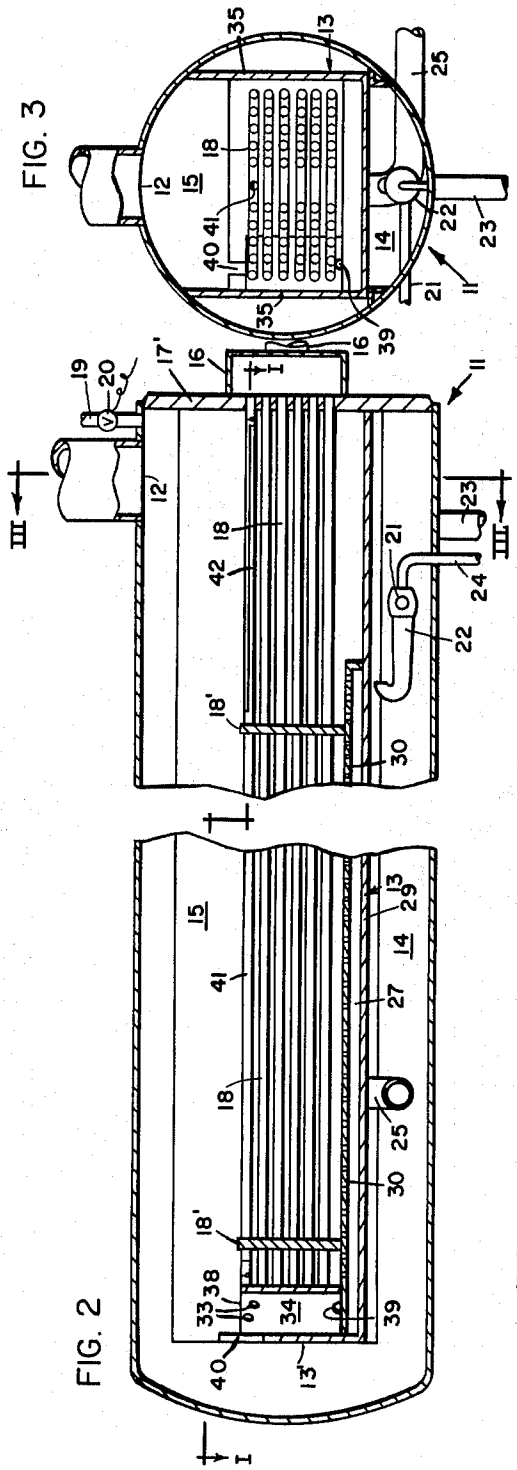


FIG. 3

FIG. 2

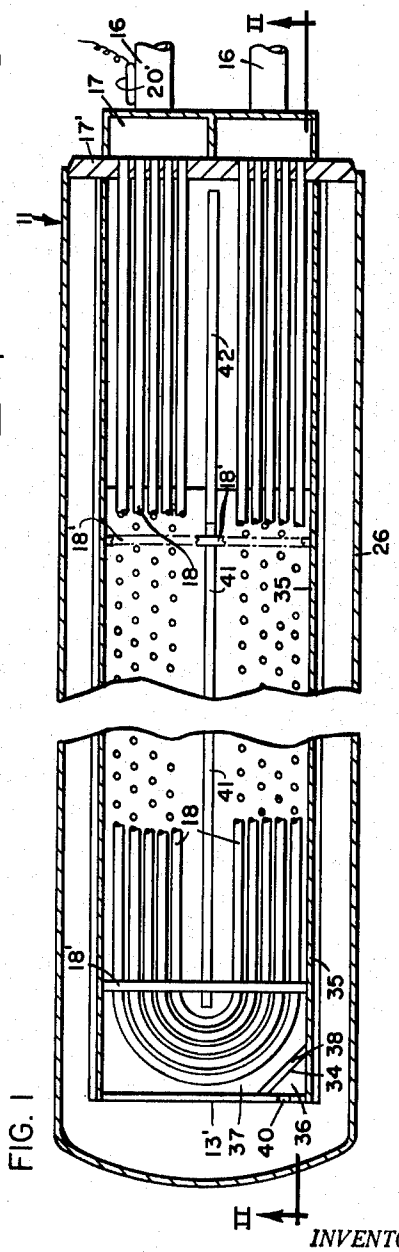


FIG. 1

INVENTOR.
JOSEPH E. EMBURY.
BY Robert F. Ruemeli
ATTORNEY.

United States Patent Office 3,241,335 Patented Mar. 22, 1966

3,241,335

COOLER

Joseph E. Embury, Memphis, N.Y., assignor to Carrier Corporation, Syracuse, N.Y., a corporation of Delaware

Filed June 23, 1964, Ser. No. 377,318
8 Claims. (Cl. 62—475)

This invention relates generally to a cooler in a refrigeration system and, more particularly, to a cooler in a refrigeration system in which refrigerant and power fluid employed to drive the refrigeration equipment are mixed, and are then separated in the cooler.

Various types of refrigeration systems, such as absorption systems and refrigerant compression systems, are well known in the art. The construction, components and relative association of the components as well as the operating characteristics of such systems are also well known. However, each system has certain disadvantages as well as particular advantages, but attempts to provide a system combining the advantages of the accepted systems while avoiding their disadvantages have generally resulted in systems which were impractical.

In a copending United States patent application of Louis H. Leonard for a "Heating and Cooling System," filed June 23, 1964, as Serial No. 377,258, a refrigeration system is disclosed wherein refrigerant fluid and power fluid are immiscible with each other and are mixed to control operation of the system, and are then separated and returned for reuse in the system. Prior expedients for handling and separating such mixed fluids were found to be inadequate, particularly in providing a compact and reliable refrigeration system.

It is a primary object of this invention to provide a new and improved cooler in a refrigeration system. A related object is provision of such a cooler in which fluids are separated. Another related object is provision of such a cooler having improved fluid handling features.

A more specific object is to provide a refrigeration system cooler having provision for separating water and refrigerant heavier than water and having a lower boiling temperature than water, the cooler having a shell and pan in the shell, a chilled water tube bundle in the pan for circulating chilled water to cool a load, the bundle being flooded with liquid refrigerant which boils and vaporizes from the pan and passes through an outlet in the shell and to a suction line, the pan being positioned so that water collects on liquid refrigerant in the pan and passes toward a first portion of the pan having provision for separating the water and refrigerant and toward a second portion of the pan proximate the outlet and spaced from the first portion, with provision for the passage of water through a tube from the second portion to the first portion.

These and other objects of the invention will be apparent from the following description and the accompanying drawings, in which:

FIGURE 1 is a broken, sectional top view of the cooler taken generally along the line I—I in FIGURE 2, with an upper portion of the cooler shell removed for clearer illustration;

FIGURE 2 is a broken sectional side view of the cooler taken generally along the line II—II in FIGURE 1, with the cooler shell and a portion of a tube bundle broken away for clearer illustration; and

FIGURE 3 is a vertical sectional view taken generally along the line III—III in FIGURE 2.

The heating and cooling system described in the aforementioned Leonard patent application may provide cooling, heating, or simultaneous heating and cooling. The

system is preferably hermetic to prevent the escape of fluids in the system and the entry of ambient air into the system. The system may be considered as having a power side including a circuit for the circulation of a power fluid, a refrigerant side including a circuit for the flow of a refrigerant fluid under the influence of drive means driven by the power fluid, with the operation of the system regulated by a control system.

A preferred power fluid is water, and a preferred referred refrigerant is octafluorocyclobutane, commonly referred to as C318 and having a chemical formula C_4F_8. These fluids are particularly preferred because of their relative immiscibility and because they are inherently highly stable and do not tend to decompose or chemically react with each other or other materials in the system, or cause or promote corrosion or undesirable by-products. Also, this refrigerant is heavier than water and is a relatively noncondensible vapor at the temperatures and pressures at which the power fluid (water) condenses, as well as at the usual ambient atmospheric conditions of temperature and pressure. However, other power fluids and refrigerants having these desired chemical and physical properties may be utilized within the scope of this invention.

In the system, a steam generator supplies steam to a turbocompressor from which the steam is discharged to a steam condenser and is returned from the steam condenser to the steam generator by a steam condensate pump, for recirculation through the power side of the system. The turbocompressor has means for retarding leakage of steam and refrigerant from the turbine and the compressor, and has water lubricated bearings. Steam condensate is pumped to the turbocompressor for lubricating the bearings. Leakage from the turbine and compressor, and water from the bearings, passes through a drain line to the steam condenser. On the refrigerant side of the system, the compressor passes compressed refrigerant vapor to a refrigerant condenser from which the condensed refrigerent passes through a suitable refigerant flow restricting means and into an evaporator or cooler **11**, as shown in the drawing, from which refrigerant vapor is withdrawn by the refrigerant compressor through a refrigerant outlet **12** and a suction line, thus completing the refrigerant circuit of the system.

The cooler is generally of a type disclosed in a copending United States patent application of William T. Osborne for a "Cooler," filed June 23, 1964, as Serial No. 377, 317.

Herein the cooler includes a pan **13**, for holding liquid refrigerant and extends lengthwise through an enclosing shell. The pan is in sealed engagement with the shell except at a free, left end wall **13'** of the pan so as to divide the shell into a water sump **14** below the pan and a refrigerant chamber **15** above the pan. A chilled water line **16** has leaving and returning branches which open into a header **17** at an end of the shell (FIGURES 1 and 2) for communication with a U-tube chilled water bundle **18** in the pan **13**. The bundle of U-tubes are mounted at their free ends in the header **17** and loosely seated in support plates, as **18'**, in the pan **13**, so that refrigerant may flow across the plates while covering the tubes with boiling refrigerant during cooling operation. Chiled water is cooled in the bundle **18**, as the refrigerant boils, and is circulated through the line **16** by means of a chilled water pump (not shown) to an area having a cooling requirement.

As is more fully described in a copending United States patent aplication of Louis H. Leonard for a "Heating and Cooling System," Serial No. 377,319, filed June 23, 1964, the control system regulates the capacity of the refrigeration system by controlled blanketing of

a condensing portion of the steam condenser with a non-condensible vapor, herein refrigerant vapor, introduced into the steam condenser through a refrigerant line 19 (FIGURE 2) from the cooler 11. The quantity of non-condensible vapor effectively blanketing the condensing portion is regulated by a modulating refrigerant flow regulating valve 20 actuated responsive to chilled water temperature by means of a temperature sensor 20' on the chilled water line 16. For example, as the cooling load drops, more refrigerant is introduced into the steam condenser, thus reducing the steam condensing rate to increase the steam condenser pressure and therefore the turbine discharge pressure to reduce the turbocompressor output. A purge system passes refrigerant and water vapor at a constant rate from the steam condenser to the cooler sump 14 and includes a purge line 21 from the steam condenser to the throat of a jet pump 22 in the sump. The jet pump is powered by impeller water recirculated through the jet pump and the sump by a water supply pump (not shown) connected with a cooler water outlet line 23 and a cooler water inlet line 24 to the jet pump. The purge line 21 opens into the steam condenser at a level to return the steam condensate to the cooler sump 14 should the condensate level in the condenser rise too high. The water supply pump provides make-up water from the sump 14 to the power side of the system, as needed.

A refrigerant inlet 25 opens through a cooler shell 26 and into a receiving chamber 27 in the pan 13. The chamber is between a bottom wall 29 of the pan and a perforated plate 30 extending from the left end of the pan on both sides of each support plate 18 and terminating short of the right end of the pan, for distributing the incoming refrigerant at a relatively high velocity to agitate the liquid refrigerant in a turbulent area of the pan, as is more fully described in a copending patent application of William E. Clark for "Refrigeration Apparatus," United States Serial No. 281,400, filed May 20, 1963, and in the aforementioned Osborne application. Herein, the area of perforations in the plate 30 is horizontally spaced from the refrigerant vapor outlet 12 at the right end of the cooler shell 26, to provide a relatively quiet area of liquid below the outlet, so that any droplets of liquid refrigerant from the turbulent area resulting from injecting the refrigerant through the perforations in the plate 30, is away from the outlet 12 and is therefore effectively prevented from entering the outlet.

During cooling operation of the system, hot vapors introduced into the sump 14 through the purge line 21 from the steam condenser maintain the water in the sump 14 preferably at least 10° F. above the temperature in the refrigerant chamber 15 so that refrigerant in the sump boils and forms a vapor. To reduce the sump temperature, the jet pump 22 may discharge against the relatively cool bottom wall 29 of pan 13. Refrigerant vapor in the sump, and any water vapor carried with the refrigerant vapor, passes upwardly about the free left end wall 13' of the refrigerant pan 13 and passes over the refrigerant pan so that the water vapor may condense and settle onto the liquid refrigerant in the pan, as the refrigerant vapor is withdrawn through the outlet 12. Also, some water may enter with liquid refrigerant from the refrigerant condenser and through possible leaks in the chilled water bundle 18 or header 17, and collects atop the liquid.

Water in the refrigerant chamber 15 collects on top of the liquid refrigerant in the pan 13 and in part passes to the left free end of the pan from which it flows through a suitable weir or upper ports 33 in a generally vertical, diagonal partition 34 between the left end wall 13' and a side wall 35 of the pan, and passes into a compartment 36 separate from a main portion 37 of the pan which contains the chilled water bundle 18. The ports 33 are at slightly different elevations such that water, and some refrigerant, in the pan main portion 37 will flow therethrough and across the upper edge 38 of the partition 34 and into the compartment 36. A port 39 at the lower end of the partition 34 permits passage of refrigerant from the compartment 36 to the main portion 37 of the pan to provide slight circulation in the compartment. The chilled water tube bundle 18 is outside the compartment 36 and is spaced inwardly from the portion of the left end wall 13' at the compartment, to form a relatively quiet area of liquid refrigerant upon which water in the pan collects in a quiet pool. The portion of the plate 30 which forms a bottom of the compartment 36 is devoid of perforations. A port or weir 40 in the pan end wall 13' opens into the compartment 36 at an elevation for passing water from the compartment into the sump. The density of the refrigerant in the compartment 36 is greater than in the boiling body of refrigerant adjacent the chilled water bundle 18 in the pan main portion 37 so that the refrigerant liquid level is lower in the compartment, and therefore the weir 40 may be slightly lower than the partition upper ports 33. Thus, means is provided for separating water and refrigerant and returning the separated fluids for reuse in the system.

Since water is atop the boiling refrigerant in the pan, it is drawn toward and collects at the relatively quiet portion of liquid below the outlet 12. The level of the refrigerant in the pan 13 below the outlet 12 is higher than the level of the refrigerant in the area of the pan 13 at the left end wall 13. This level difference is caused by the lower pressure existing in the area immediately below the outlet 12 which is caused by the suction of the compressor attached to the outlet 12 and the pressure drop between the left end of the cooler at the end wall 13' and the right end of the cooler at the outlet 12. In order to prevent an excessive collection of water at the right end of the cooler below the outlet 12, a generally level tube 41 is mounted in the bundle supports 18' in the pan and is generally at the elevation of the top of the chilled water bundle 18. The tube 41 has opposite open ends so that water on the liquid refrigerant below the outlet 12 may pass through the tube and be discharged at a slightly lower level adjacent the compartment 36 for return to the sump 14. The right end of the tube 41 in the relatively quiet area is formed as an open top trough 42, by removal of the upper portion of the tube, to facilitate the flow of water into the tube.

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

I claim:

1. For use in a refrigeration system, the combination comprising a cooler having provision for separating water and refrigerant heavier than and having a lower boiling temperature than water, said cooler having a cooler shell, a chilled water tube bundle in said shell adapted to be connected for the circulation of chilled water to cool a load, first means adapted to flood said bundle with liquid refrigerant which boils and vaporizes during normal cooling operation of the system, means including a refrigerant vapor outlet opening into said shell and adapted to withdraw the refrigerant vapor from the shell and cause water to collect on the liquid refrigerant at a limited portion of said liquid refrigerant proximate said outlet, means spaced from said portion for the passage of the water from said liquid refrigerant, and means for the passage of the water from said portion to the last said means, whereby the water and refrigerant are separated.

2. For use in a refrigeration system, the combination comprising a cooler having provision for separating water and refrigerant heavier than and having a lower boiling temperature than water, said cooler having a cooler shell, a pan positioned in said shell for holding liquid refrigerant

and for the collection of water on the liquid refrigerant during cooling operation of the system, a chilled water tube bundle in said pan adapted to be immersed in the liquid refrigerant in said pan and to be connected for the circulation of chilled water to cool a load, means including a refrigerant vapor outlet opening into said shell for withdrawing the refrigerant vapor from the shell and cause water to collect on the liquid refrigerant at a portion of the liquid refrigerant proximate said outlet, means horizontally spaced in said pan from said refrigerant vapor outlet to pass relatively turbulent liquid refrigerant to said bundle and to provide a relatively quiet portion of liquid below said refrigerant vapor outlet for effectively preventing refrigerant droplets from said turbulent area from being carried into said outlet, whereby during cooling operation of the system the flow toward said outlet draws water on the liquid refrigerant toward said portion, means spaced across said turbulent area from said first portion for the passage of the water out of said pan, and means for the passage of water from said portion to the last said means, whereby the water and refrigerant are separated.

3. For use in a refrigeration system, the combination comprising a cooler having provision for separating water and refrigerant heavier than and having a lower boiling temperature than water, said cooler having a cooler shell, a generally horizontal pan positioned in said shell for holding liquid refrigerant and for the collection of water on the liquid refrigerant during cooling operation of the system, a chilled water tube bundle in said pan adapted to be immersed in the liquid refrigerant in said pan and to be connected for the circulation of chilled water to cool a load, said bundle being spaced horizontally from a wall of said pan to define a first quiet portion of liquid, means including a refrigerant vapor outlet opening into an upper part of said shell horizontally spaced from said first portion for withdrawing the refrigerant vapor from the shell and causing water to collect on the liquid refrigerant at a second portion of the liquid refrigerant proximate said outlet, means including a generally horizontal plate in said pan, said plate having a perforated area between the first and second portions for passing liquid refrigerant to said bundle in a relatively turbulent area at said perforated area, whereby refrigerant droplets from said turbulent area are effectively prevented from being carried into said outlet and water which collects on the liquid refrigerant in said pan passes to said first and second portions, conduit means for passing said water from said second portion to said first portion, and means for the passage of water from said first portion out of said pan, thereby separating the refrigerant and the water.

4. The combination of claim 3 in which said conduit means comprises a tube having opposite open ends and extending from said second portion to said first portion, for passing the water.

5. The combination of claim 4 in which said tube is generally at the elevation of the top of said bundle.

6. The combination of claim 5 in which said tube has an open top portion at said second portion to define a trough for collecting the water.

7. For use in a refrigeration system, the combination comprising a cooler having provision for separating water and refrigerant heavier than and having a lower boiling temperature than water, said cooler having, a cooler shell,

a generally horizontal pan positioned in said shell for holding liquid refrigerant and for the collection of water on the liquid refrigerant during cooling operation of the system, said pan being above a bottom portion of said shell and extending in substantially sealed relationship with said shell to an end of the pan to define a water sump in a lower portion of said shell and a refrigerant chamber in an upper portion of said shell, means at said end of said pan for the passage of vapor from said sump into said refrigerant chamber, means for the passage of water and refrigerant into said sump, means for the passage of water out of said sump, a chilled water tube bundle in said pan adpated to be immersed in the liquid refrigerant in said pan and to be connected for the circulation of chilled water to cool a load, said bundle being spaced horizontally from said pan end to define a first quiet portion of liquid, means including a refrigerant vapor outlet opening into an upper part of said refrigerant chamber above said pan and remote from said pan end for withdrawing the refrigerant vapor from the shell and causing water to collect on the liquid refrigerant at a second portion of the liquid refrigerant proximate said outlet, means including a generally horizontal plate in said pan above the bottom of said pan to define a receiving chamber for refrigerant, said plate having a perforated area positioned for distributing liquid refrigerant to said bundle and providing a relatively turbulent portion of the liquid refrigerant between the first and second portions so that said second portion has relatively quiet liquid below said refrigerant vapor outlet and is spaced across said turbulent area from said first quiet portion during cooling operation of the system, thereby effectively preventing refrigerant droplets from said turbulent area from entering said outlet, a refrigerant inlet opening into said receiving chamber for the passage of refrigerant through said perforations, whereby water in said refrigerant chamber collecting on liquid refrigerant in said pan passes to the first and second relatively quiet portions and water vapor carried with the refrigerant vapor from said sump into said refrigerant chamber at said pan end may condense as it passes over the pan toward the refrigerant outlet so that passage of the water vapor into said refrigerant outlet is retarded, means including a tube having opposite open ends and extending from said second portion to said first portion for passing water from said second portion to said first portion, and means for the passage of water from said first area to said sump, thereby separating the refrigerant and the water.

8. The combination of claim 7 in which said pan end is spaced from said shell for said passage of vapor from said sump to said refrigerant chamber, said tube is generally at the elevation of the top of said bundle, the open end of said tube at said second portion is a trough extended in said second portion.

References Cited by the Examiner

UNITED STATES PATENTS

1,874,204	8/1932	Nesbitt	62—471 XR
2,964,926	12/1960	Ware	62—471
3,145,544	8/1964	Weller	62—85 XR

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

W. E. WAYNER, *Assistant Examiner.*