March 10, 1942. R. H. TULL 2,275,829

REFRIGERATING APPARATUS

Filed May 4, 1939

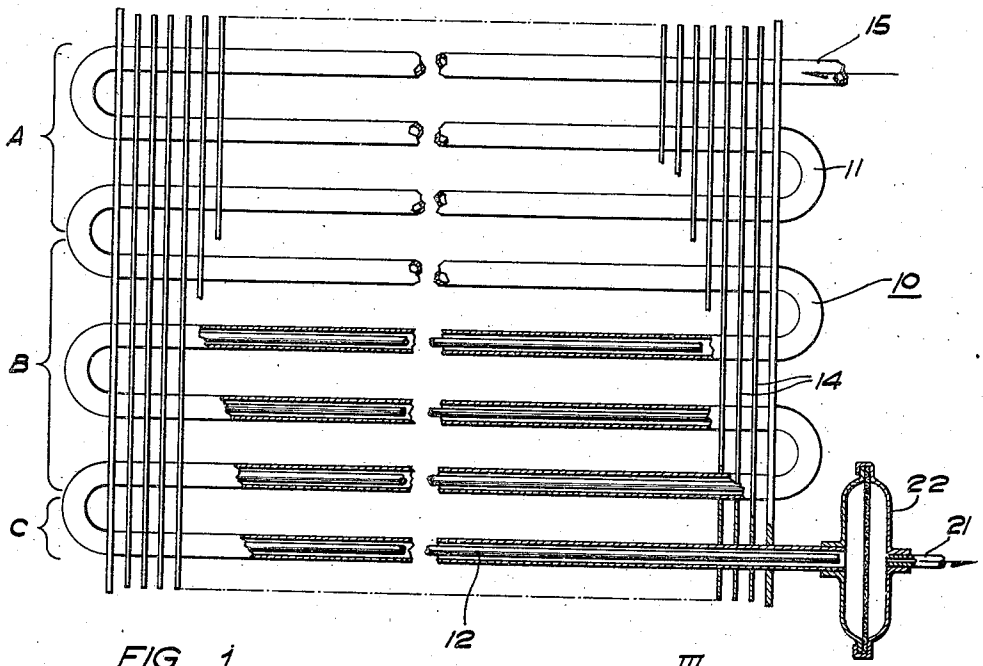


FIG. 1.

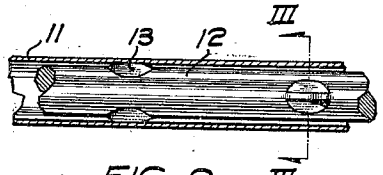


FIG. 2.

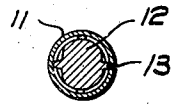


FIG. 3.

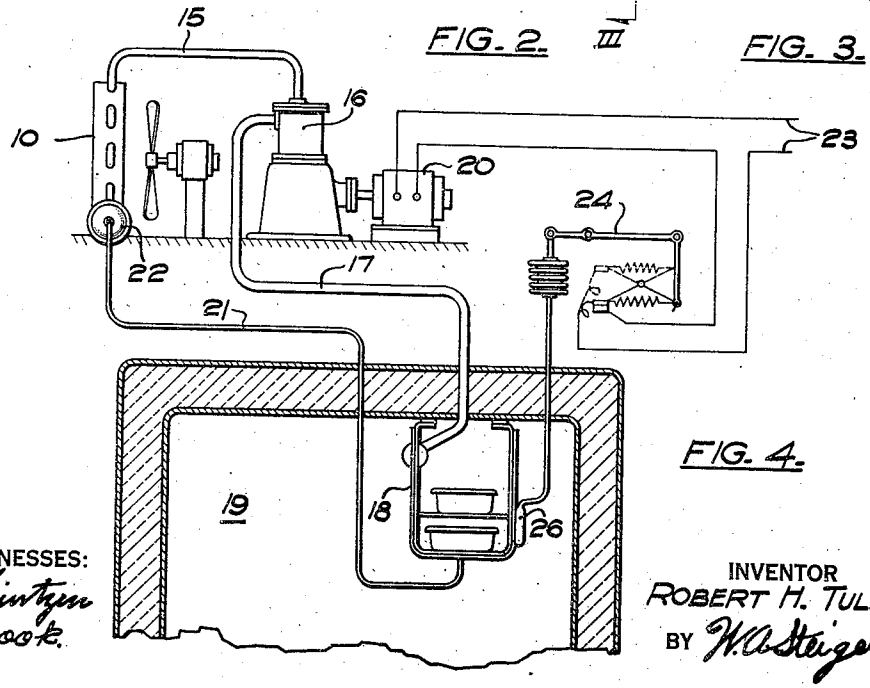


FIG. 4.

WITNESSES:

E. W. Steintzen

A. J. Cook

INVENTOR

ROBERT H. TULL

BY W. A. Steiger

ATTORNEY

Patented Mar. 10, 1942

2,275,829

UNITED STATES PATENT OFFICE

2,275,829

REFRIGERATING APPARATUS

Robert H. Tull, Springfield, Mass., assignor to Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., a corporation of Pennsylvania

Application May 4, 1939, Serial No. 271,636

7 Claims. (Cl. 62—115)

This invention relates to mechanical refrigerating apparatus and more especially to means for increasing the efficiency of refrigerating apparatus employing a constantly open flow impeding device.

In mechanical refrigerating apparatus of the compressor-condenser-evaporator type employing a constantly open flow-impeding device between the condenser and the evaporator, such as used, for example, in domestic refrigerating apparatus, a flooding of the condenser with liquid refrigerant may occur at abnormally low room temperatures. At such temperatures an abnormally large amount of refrigerant is condensed in the condenser and accumulates in the lower passages thereof. If the evaporator of such a system is of relatively small refrigerant-carrying capacity, such as is usually the case when the more expensive refrigerants are used, the accumulation of the refrigerant in the condenser robs the evaporator of its normal content of refrigerant and starves the evaporator. This produces an uneconomical operation of the apparatus because the liquid level in the evaporator is then too low. If the room is very cold, the evaporator may be starved completely of liquid refrigerant, in which case the suction of the compressor produces a vaporization of the liquid refrigerant at or within the restricting device thereby cooling the restrictor rather than the evaporator.

One object of the invention, therefore, is to control the quantity of liquid refrigerant in the evaporator of a mechanical refrigerating system employing a constantly open flow impeding device between the condenser and the evaporator.

Another object is to provide a condenser for refrigerant vapor which condenser has a high heat-dissipating value and a low volumetric capacity.

A further object is to effect a relatively large change in the vapor condensing area of a refrigerant condenser when a relatively small change in the volume of liquid refrigerant in the condenser occurs.

These and other objects are effected by my invention as will be apparent from the following description and claims taken in connection with the accompanying drawing forming a part of this application, in which:

Fig. 1 is a side elevation of a condenser with portions of the tube broken away;

Fig. 2 is an enlarged section of a portion of the condenser tube showing the restricting rod;

Fig. 3 is a section taken along the line III—III of Fig. 2; and,

Fig. 4 is a diagrammatic view of a refrigerator embodying the condenser of this invention.

Referring now to the drawing for a detailed description of the invention, the reference numeral 10 represents a condenser and comprises a tube 11 containing a rod 12 of slightly less diameter than the inside diameter of the tube. The rod 12 may be formed with pinched-out protrusions 13 on its surface to hold the rod 12 centrally in the tube 11. The condenser is formed by inserting the rod 12 in the tube 11, bending the tube 11, together with the rod 12, into a sinusoidal configuration, and securing cooling fins 14 to the outer surface of the tube. The rod 12, as shown, occupies the lower portion of the tube 11 and is gradually tapered at its upper half. The rod 12, however, may be of any length and may be tapered in any manner suited to the operation of the apparatus. The purpose of the rod 12 is to decrease the volumetric capacity of the tube 11, especially at its lower end without decreasing its external diameter upon which depends its heat dissipating effect.

The condenser 10 is of particular application in a refrigerating apparatus of the compressor-condenser, evaporator type employing a constantly open impeding device between the condenser and the evaporator. One embodiment of such an apparatus is shown in Fig. 4, and comprises the condenser 10 receiving hot compressed refrigerant vapor at its upper end through a tube 15 from a compressor 16, which compressor withdraws vaporized refrigerant through a suction tube 17 from an evaporator 18 in an insulated chamber 19. The evaporator is supplied with liquid refrigerant from the lower portion of the condenser 10 through a capillary impedance tube 21. A screening device 22 is located at the entrance end of the capillary tube adjacent the condenser 10. The compressor 16 is driven by an electric motor 20 which receives power through the electrical conduits 23. It will be apparent that the insulated chamber 19 is refrigerated by the vaporization of liquid refrigerant in the evaporator 18.

The refrigerating apparatus is controlled by a temperature sensitive device 24 actuated by a bulb 26 containing an expansible fluid, which bulb 26 is in contact with a side wall of the evaporator 18. This device 24 controls the temperature of the evaporator 18 between predetermined limits. The volumetric capacity of the condenser 19 is preferably smaller than the volumetric capacity of the space normally occupied by the liquid refrigerant in the evaporator 18.

The action of the condenser 10 on the refrigerant during normal operation can be divided into three distinct steps. These steps take place in the respective zones A, B, and C, as indicated in Fig. 1. Zone A comprises the upper portion of the condenser adjacent the inlet end thereof in which portion the sensible heat of the superheated refrigerant is removed.

Zone B comprises the lower central portion of

the condenser adjacent zone A in which the latent heat of vaporization of the refrigerant vapor is removed and the refrigerant vapor thereby reduced to a liquid. The upper portion of zone B will contain wet refrigerant vapor and very little liquid refrigerant, the proportion of liquid to vapor will increase as the refrigerant passes through this zone and the refrigerant will be entirely liquefied when it reaches the bottom of the zone.

Zone C is the portion of the condenser containing liquid refrigerant which is being subcooled below its vaporizing temperature.

If this apparatus is operated in an abnormally cold room, the areas of zone A and zone B will decrease because the sensible and latent heat is more actively removed than formerly. Zone C containing liquid refrigerant, therefore, will increase in size to occupy the remainder of the condenser 10. The rate at which the refrigerant is forced through the capillary tube 21 into the condenser 18 will also decrease because of the decreased pressure of the refrigerant vapor in zones A and B. This decreased pressure is caused by the decreased temperature of the condenser 10. This decreased flow of refrigerant into the evaporator 18 will also aid in increasing the zone C of the condenser. Because of the insertion of the tapered rod 12 in the lower portion of the condenser, the volume of refrigerant in this portion will be relatively small and comparatively little liquid refrigerant will be taken from the evaporator 18 so that the liquid refrigerant in the evaporator 18 is more nearly at its normal level.

It will be observed that the rod 12 in the lower portion of the condenser 10 does not decrease the cooling capacity of the condenser. Neither does it substantially impede the flow of liquid refrigerant therethrough because the linear velocity of the liquid refrigerant through the tube 11 is very much less than the linear velocity of refrigerant vapor because of the greater density of the liquid.

A very beneficial effect also occurs if the refrigerating apparatus is operated in an abnormally warm room. In this case, zones A and B will increase in width and zone C will decrease and may disappear entirely. The liquid refrigerant normally in zone C is forced into the evaporator 10, but since the volume of liquid in zone C is small because of the presence of the thick end of the rod 12 in this portion of the tube 11, the level of the refrigerant liquid in the evaporator 10 will rise but little. At the same time a portion of cooling surface which is disproportionately large as compared to the quantity of refrigerant liquid displaced in zone C is added to zones A and B which added cooling surface aids in condensing the refrigerant vapor in the tube 11.

From the above it will be apparent that this invention provides a more efficient refrigerating apparatus of the constantly open restrictor type and a means for maintaining the liquid level of the refrigerant in an evaporator more nearly constant.

While I have shown my invention in but one form, it will be obvious to those skilled in the art that it is not so limited, but is susceptible of various changes and modifications without departing from the spirit thereof, and I desire, therefore, that only such limitations shall be placed thereupon as are specifically set forth in the appended claims.

What I claim is:

1. In a closed mechanical refrigerating system, the combination of a cooling unit adapted to evaporate liquid refrigerant, a compressor for withdrawing refrigerant vapor from said cooling unit and compressing said vapor, a condenser for cooling and liquefying said compressed vapor, a conduit including a fixed flow-impeding orifice for conducting the liquid refrigerant from the condenser to the cooling unit, said condenser comprising a refrigerant-carrying tube structure having an entrance and an exit, a substantial portion of said tube structure adjacent its exit end being of relatively small refrigerant-conducting cross-sectional area, and means for cooling the surface of said tube structure, the system being arranged to locate the refrigerant level in said tube structure adjacent its exit end during normal operation, said condenser being formed to have greater heat-abstracting effectiveness per unit of refrigerant-conducting cross-sectional area of the tube structure at the portion adjacent the exit end than at the portion adjacent the entrance end of the tube structure, whereby a small change in the volume of liquid refrigerant in the portion of the tube structure adjacent the exit end thereof causes a large change in the effectiveness of heat abstraction from the refrigerant vapor in the tube structure, thereby maintaining the level of the refrigerant liquid in the cooling unit more nearly constant.

2. In a closed mechanical refrigerating system, the combination of a cooling unit adapted to evaporate liquid refrigerant, a compressor for withdrawing refrigerant vapor from said cooling unit and compressing said vapor, a condenser for cooling and liquefying said compressed vapor, a conduit including a fixed flow-impeding orifice for conducting the liquid refrigerant from the condenser to the evaporator, said condenser comprising a refrigerant-carrying tube structure having an entrance and an exit, a substantial portion of said tube structure adjacent its exit end being of smaller refrigerant-conducting cross-sectional area than the portion of said tube structure adjacent its entrance end, and means for cooling the surface of said tube structure, the system being arranged to locate the refrigerant level in said tube structure adjacent its exit end during normal operation, said condenser being formed to have greater heat-abstracting effectiveness per unit of refrigerant-conducting cross-sectional area of the tube structure at the portion adjacent the exit end than at the portion adjacent the entrance end of the tube structure, whereby a small change in the volume of liquid refrigerant in the portion of the tube structure adjacent the exit end thereof causes a large change in the effectiveness of heat abstraction from the refrigerant vapor in the tube structure, thereby maintaining the level of the refrigerant liquid in the cooling unit more nearly constant.

3. In a closed mechanical refrigerating system, the combination of a cooling unit adapted to evaporate liquid refrigerant, a compressor for withdrawing refrigerant vapor from said cooling unit and compressing said vapor, a condenser for cooling and liquefying said compressed vapor, a conduit including a fixed flow-impeding orifice for conducting the liquid refrigerant from the condenser to the cooling unit, said condenser comprising a refrigerant-carrying tube of uniform cross-sectional area and having an entrance and an exit, a rod in said tube adjacent

its exit end, and means for cooling the surface of said tube, the system being arranged to locate the refrigerant level in said tube adjacent its exit end during normal operation, said condenser being formed to have greater heat-abstracting effectiveness per unit of refrigerant-conducting cross-sectional area of the tube at the portion containing the rod than at the portion adjacent the entrance end of the tube, whereby a small change in the volume of liquid refrigerant in the portion of the tube adjacent the exit end thereof causes a large change in the effectiveness of heat abstraction from the refrigerant vapor in the tube, thereby maintaining the level of the liquid refrigerant in the cooling unit more nearly constant.

4. In a closed mechanical refrigerating system, the combination of a cooling unit adapted to evaporate liquid refrigerant, a compressor for withdrawing refrigerant vapor from said cooling unit and compressing said vapor, a condenser for cooling and liquefying said compressed vapor, a conduit including a fixed flow-impeding orifice for conducting the liquid refrigerant from the condenser to the cooling unit, said condenser comprising a refrigerant-carrying tube of substantially uniform cross-sectional area having an entrance and an exit, a tapered rod in said tube, the large end of said rod being adjacent the exit end of the tube, and means for cooling the surface of said tube, the system being arranged to locate the refrigerant level in said tube adjacent its exit end during normal operation, said condenser being formed to have greater heat-abstracting effectiveness per unit of refrigerant-conducting cross-sectional area of the tube at the portion adjacent the exit end than at the portion adjacent the entrance end of the tube, whereby a small change in the volume of liquid refrigerant in the portion of the tube adjacent the exit end thereof causes a large change in the effectiveness of heat abstraction from the refrigerant vapor in the tube, thereby maintaining the level of the refrigerant liquid in the cooling unit more nearly constant.

5. In a closed mechanical refrigerating system, the combination of a cooling unit adapted to evaporate liquid refrigerant, a compressor for withdrawing refrigerant vapor from said cooling unit and compressing said vapor, a condenser for cooling and liquefying said compressed vapor, a conduit including a fixed flow-impeding orifice for conducting the liquid refrigerant from the condenser to the cooling unit, said condenser comprising a refrigerant-carrying tube of uniform cross-sectional area and having an entrance and an exit, a rod in only a portion of said tube adjacent its exit end, and means for cooling the surface of said tube, the volume in said tube available to the refrigerant being less than the volume of refrigerant liquid normally in the cooling unit, the system being arranged to locate the refrigerant level in said tube adjacent its exit end during normal operation, said condenser being formed to have greater heat-abstracting effectiveness per unit of refrigerant-conducting cross-sectional area at the portion of the tube containing the rod than at the portion of the tube adjacent the entrance end, whereby a small change in the volume of liquid refrigerant in the portion of the tube adjacent the exit end thereof causes a large change in the effectiveness of heat abstraction from the refrigerant vapor in the tube, thereby maintaining the level of the refrigerant liquid in the cooling unit more nearly constant.

6. In a closed mechanical refrigerating system, the combination of a cooling unit adapted to evaporate liquid refrigerant, a compressor for withdrawing refrigerant vapor from said cooling unit and compressing said vapor, a condenser for cooling and liquefying said compressed vapor, a conduit including a fixed flow-impeding orifice for conducting the liquid refrigerant from the condenser to the cooling unit, said condenser comprising a refrigerant-carrying tube of substantially uniform cross-sectional area and having an entrance and an exit, a tapered rod in the tube, the large end of said rod being located near the exit end of the tube, the volumetric capacity of said condenser being less than the volume of refrigerant liquid normally in the cooling unit, and means for cooling the surface of said tube, the system being arranged to locate the refrigerant level in said tube adjacent its exit end during normal operation, said condenser being formed to have greater heat-abstracting effectiveness per unit of refrigerant-conducting cross-sectional area of the tube at the portion adjacent the exit end than at the portion adjacent the entrance end of the tube, whereby a small change in the volume of liquid refrigerant in the portion of the tube adjacent the exit end thereof causes a large change in the effectiveness of heat abstraction from the refrigerant vapor in the tube, thereby maintaining the level of the refrigerant liquid in the cooling unit more nearly constant.

7. In a closed mechanical refrigerating system, the combination of a cooling unit adapted to evaporate liquid refrigerant, a compressor for withdrawing refrigerant vapor from said cooling unit and compressing said vapor, a condenser for cooling and liquefying said compressed vapor, a capillary flow-impeding conduit for conducting the liquid refrigerant from the condenser to the cooling unit, said condenser comprising a refrigerant-carrying tube of substantially uniform cross-sectional area, said tube having an entrance and an exit, a tapered rod in said tube, the large end of said rod being located near the exit end of the tube, and means for cooling the surface of said tube, the volumetric capacity of said tube available to the refrigerant therein being less than the volume of refrigerant liquid normally in the cooling unit, the system being arranged to locate the refrigerant level in said tube adjacent its exit end during normal operation, said condenser being formed to have greater heat-abstracting effectiveness per unit of refrigerant-conducting cross-sectional area of the tube at the portion adjacent the exit end than at the portion adjacent the entrance end of the tube structure, whereby a small change in the volume of liquid refrigerant in the portion of the tube adjacent the exit end thereof causes a large change in the effectiveness of heat abstraction from the refrigerant vapor in the tube, thereby maintaining the level of the refrigerant liquid in the cooling unit more nearly constant.

ROBERT H. TULL.