G. L. E. KOTHNY.

REFRIGERATING MACHINE.

APPLICATION FILED MAR. 30, 1915.

1,418,002.

Patented May 30, 1922.

2 SHEETS—SHEET 1.

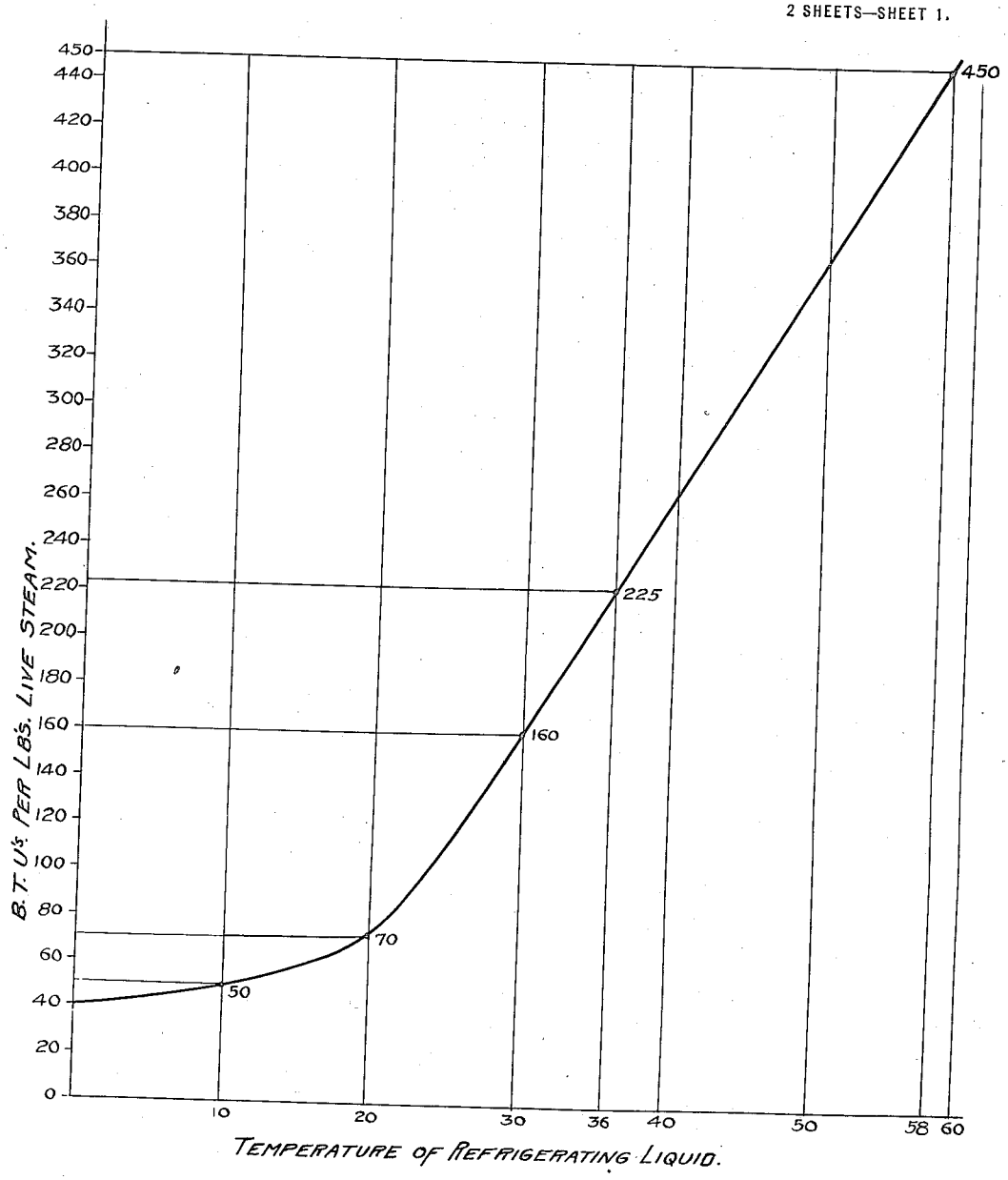


Fig. 1.

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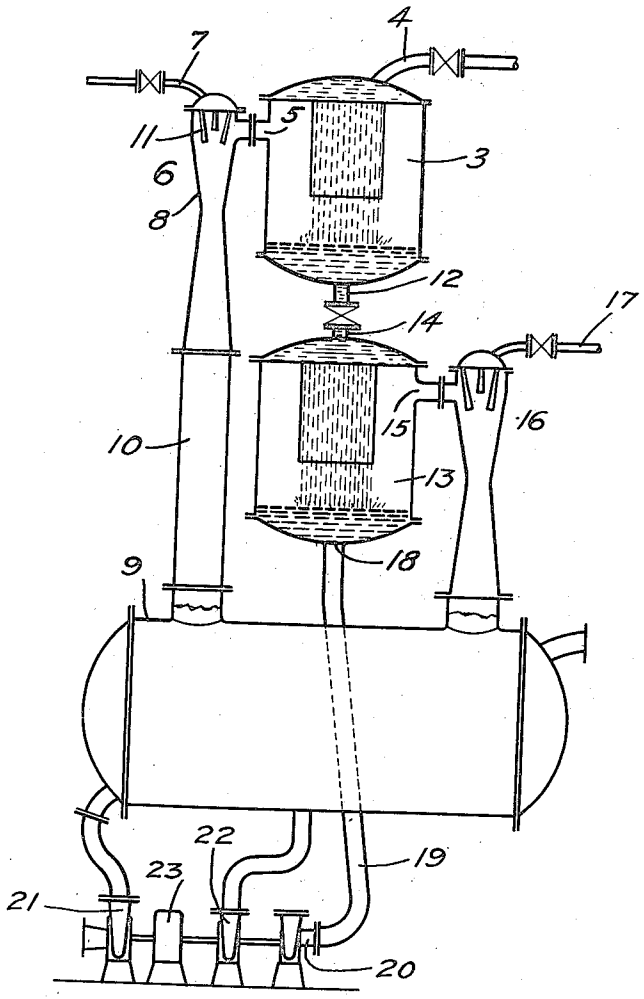


Fig. 2.

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GOTTDANK L. E. KOTHNY, OF PITTSBURGH, PENNSYLVANIA, ASSIGNOR TO WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY, A CORPORATION OF PENNSYLVANIA.

REFRIGERATING MACHINE.

1,418,002. Specification of Letters Patent. Patented May 30, 1922.

Application filed March 30, 1915. Serial No. 17,995.

To all whom it may concern:

Be it known that I, GOTTDANK L. E. KOTHNY, a subject of the Emperor of Austria, and a resident of Pittsburgh, in the county of Allegheny and State of Pennsylvania, have made a new and useful Invention in Refrigerating Machines, of which the following is a specification.

This invention relates to refrigerating machines and has for an object to improve the efficiency of such machines.

This and other objects, which will be made apparent throughout the further description of this invention, are attained by means of apparatus embodying the features herein described and illustrated in the drawings accompanying and forming a part hereof.

In the drawings: Figure 1 is a curve illustrating the number of heat units which may be extracted by one pound of steam for different ranges of temperature of the refrigerating liquid.

Figure 2 is a diagrammatic illustration of refrigerating apparatus embodying my invention.

In refrigeration apparatus in which the reduction of the temperature of the liquid refrigerant is obtained by a partial vaporization of the liquid, it is essential to employ some form of pump for removing the vapors given off from the liquid refrigerant. It is a well settled physical law that the work required to evacuate a given weight of vapor from a region of low absolute pressure to a region of higher pressure varies with the volume per unit weight of the vapor removed, the pressure range being constant. The volume of vapor per unit of weight (known as the specific volume of the vapor) in a closed receptable depends upon the vapor pressure within the receptacle, and, in accord with another well established physical principle, for any temperature of the liquid, there is a definite and corresponding pressure of the vapor in contact with the liquid. These corresponding pressures, temperatures, and specific volumes have been experimentally determined for many substances and for water may be found in any complete steam table.

It follows from the above laws that for a liquid to vaporize in a closed receptacle, it is essential that the circumambient vapor should be at the same or at a lower pressure than that corresponding to the temperature of the liquid. Consequently, should it be desired to reduce the temperature of the liquid to a predetermined low temperature, the circumambient vapor must be maintained at a pressure sufficiently low to cause vaporization, that is, at least as low a pressure as that corresponding to the desired low temperature of the liquid. This means that the specific volume of the vapors removed and hence the expenditure of energy to evacuate the vapors, becomes greater as the pressure of the vapors to be evacuated becomes lower, or in other words, as the temperature to which the liquid is cooled becomes lower.

By way of illustrating the above principle as applied to a refrigeration machine of the continuous cycle vaporization type, the work necessary to remove the vapors at required low temperatures was experimentally determined. A high efficiency vacuum pump was employed for removing the vapors from an enclosed chamber of a refrigeration machine and the results graphically tabulated as indicated in Figure 1, in which the ordinates represent the quantity of heat removed from the vaporizing liquid refrigerant expressed in B. T. U.'s per pound of steam consumed by the pump, and the abscissæ the temperature of liquid refrigerant in degrees Fahrenheit.

Employing the data indicated in the line curve of Figure 1 and assuming that a refrigeration machine is required to cool 1,000 lbs. of water per hour from 80° F. down to 36° F., it must have a capacity of $1000 \times 44 = 44{,}000$ B. T. U.'s per hour and the steam consumption would be

$$\frac{44{,}000}{225} = 196 \text{ lbs. per hour.}$$

Now, if instead of reducing the temperature from 80° F. to 36° F. the reduction is occasioned in two steps, for example, from

80° to 58° and from 58° to 36°, the steam consumption would be as follows:

$$\frac{44,000}{2\times225}+\frac{44,000}{2\times450}=98+49=147 \text{ lbs. per hour.}$$

From this it will be seen a saving of 49 lbs. of steam per hour will be accomplished by reducing the temperature in two steps instead of in a single step. In the example given, the saving in steam is approximately 25% where the reduction is made in two steps, and it will be apparent that if the reduction were made in three approximately equal steps the saving would be approximately 35%.

In the drawing I have illustrated a machine in which the temperature reduction occurs in two steps. As illustrated, the machine consists of an evaporating chamber 3, to which liquid to be cooled, or refrigerating liquid, is delivered through a pipe or passage 4. The chamber 3 is provided with a fluid discharge port 5, with which a fluid exhausting apparatus of any suitable type may communicate. The exhausting apparatus illustrated is a fluid-operated ejector 6, to which steam or any other motive fluid under pressure is delivered through a pipe or passage 7. The ejector includes a convergent divergent tube 8, which communicates with a condenser 9, through a pipe 10, and to which the motive fluid from the pipe 7 is delivered through a series of nozzles 11. The partial evaporation of the liquid contained in or passing through the chamber 3 occasions a reduction in its temperature and the liquid is then delivered through a liquid discharge port 12 to a second evaporating chamber 13 by means of a pipe or passage 14. This chamber 13, like the chamber 3, is provided with a fluid discharge port 15, which communicates with an ejector 16, receiving operating fluid through a pipe or passage 17. This ejector, like the ejector 6, exhausts or discharges into the condenser 9. The liquid passing through the second evaporating chamber is also subjected to partial evaporation and a reduction in temperature results. It is then delivered through a liquid delivery port 18 and communicating piping to the refrigerating chamber or coils. As illustrated, I have shown the port 18 in communication with the pipe 19, which in turn communicates with a circulating pump 20, from which the refrigerating liquid is delivered to the refrigerating coils or chamber, and then back through the pipe or passage 4 to the evaporating chamber 3. As illustrated, the water circulating pump 21 and the air or non-condensable vapor withdrawing pump 22, of the condenser 9, are shown operated by the same motor 23 as the refrigerant circulating pump 20.

While I have illustrated my invention in connection with a surface condenser, it will be apparent that a jet or any type of condenser may be employed and it will also be apparent three or more evaporating chambers may be located in series with relation to the flow of refrigerating liquid and that the ejector or fluid withdrawing apparatus operating in connection with each evaporating chamber may be served by the same condenser.

It will also be apparent that various changes, substitutions, modifications, additions and omissions may be made in the apparatus illustrated without departing from the spirit and scope of my invention as set forth by the appended claims.

What I claim is:

1. In combination in a refrigerating machine, a plurality of evaporating chambers through which refrigerating liquid is successively passed in a continuously moving stream, a fluid ejecting apparatus communicating with each chamber for effecting a partial evaporation of the liquid passing therethrough, and a common condenser into which said fluid ejecting apparatus discharges.

2. In combination in a refrigerating machine, a plurality of evaporating chambers located in series and through which refrigerating liquid passes in a continuously moving stream, a separate fluid exhausting apparatus communicating with each of said chambers for effecting a partial evaporation and a reduction in temperature of the liquid passing therethrough, and a common condenser serving all the fluid exhausting apparatus.

3. In a refrigerating machine in which the temperature reduction is accomplished by subjecting a continuously moving stream of refrigerating liquid to partial evaporation, means for reducing the temperature of said liquid in steps by subjecting the refrigerating liquid to partial evaporation in a number of separate evaporation chambers until the desired temperature is obtained, and separate means operatively independent of each other for maintaining a partial vacuum in each of said chambers.

4. In a refrigerating machine, a plurality of chambers in which the refrigerating liquid is successively subjected to partial evaporation and thereby cooled, means for continuously conducting the liquid from each chamber to each succeeding chamber, a separate steam actuated ejector for maintaining the vacuum in each chamber, and a common condenser into which the ejectors exhaust.

5. The method of cooling liquids which comprises passing continuously the liquid to be cooled serially through separate evaporation chambers, and withdrawing vapors from the several chambers at successively lower pressures, whereby a progressive cooling of

the liquid is obtained with an appreciable economy in the energy required to withdraw the vapors.

6. In a refrigerating machine, a plurality of chambers in which the refrigerating liquid is successively subjected to partial vaporization and thereby cooled, means for continuously conducting the liquid from each chamber to each succeeding chamber and evacuation means for maintaining successively lower pressure in each succeeding chamber.

In testimony whereof, I have hereunto subscribed my name this 25th day of March, 1915.

GOTTDANK L. E. KOTHNY.

Witnesses:
C. W. McGHEE,
E. W. McCALLISTER.