Feb. 24, 1953 C. W. MERRILL 2,629,238

EVAPORATOR AND REFRIGERATION SYSTEM

Filed May 23, 1949 2 SHEETS—SHEET 1

FIG. 1.

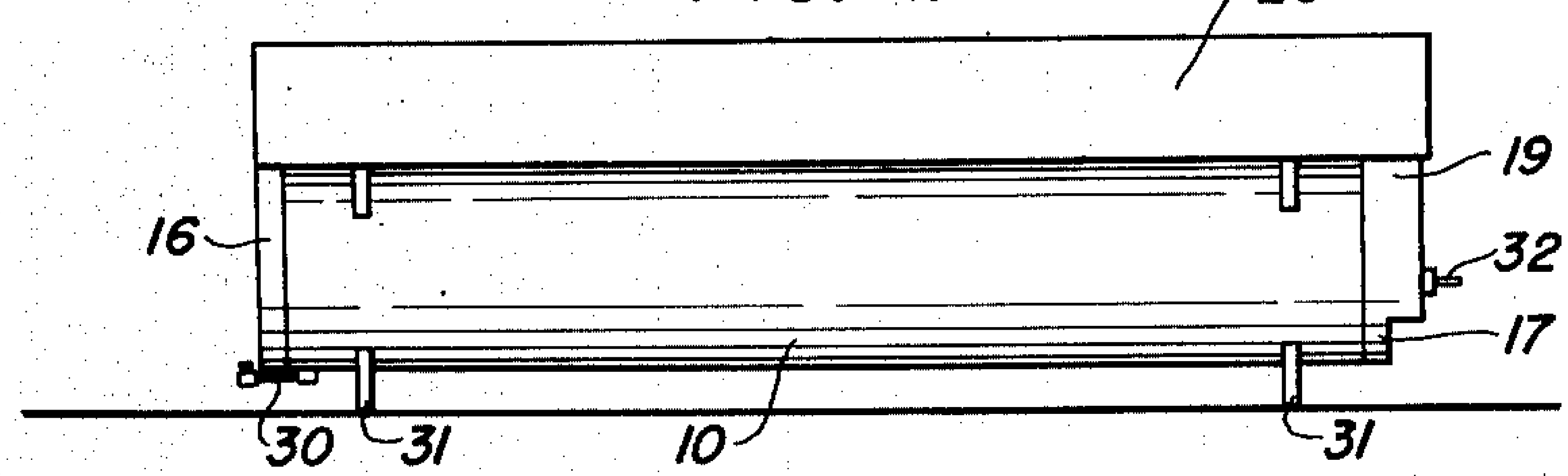
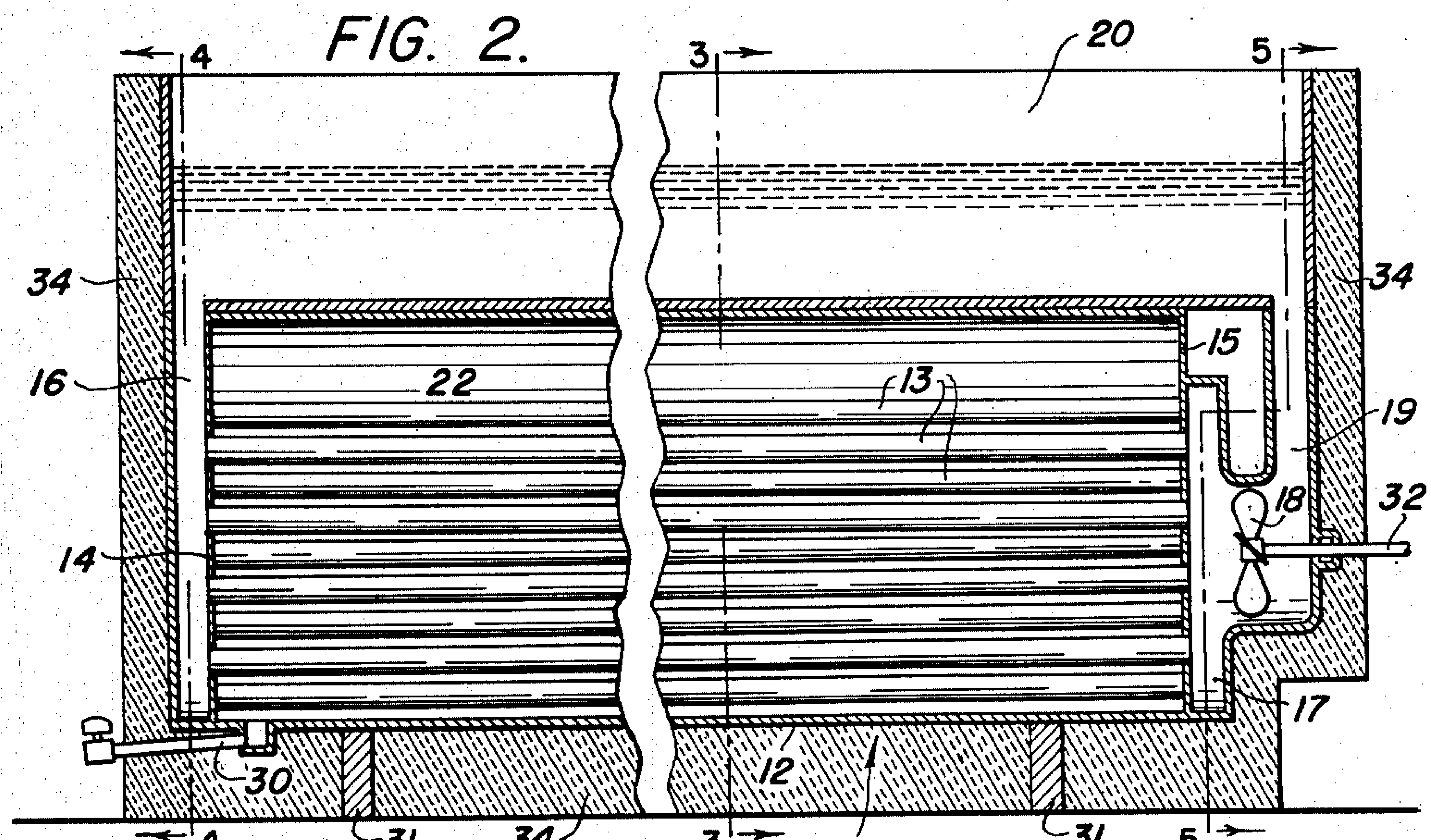


FIG. 2.



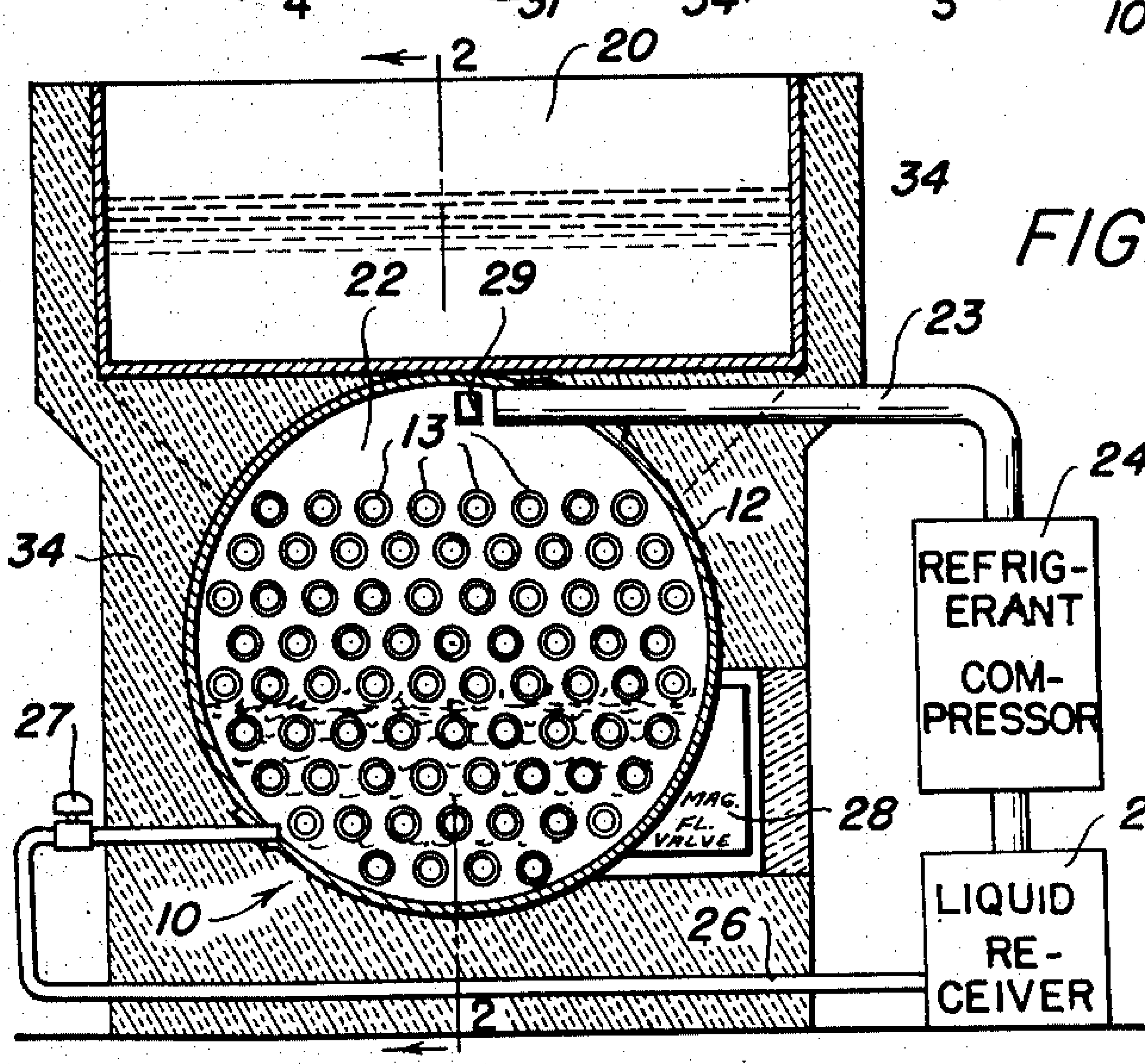


FIG. 3.

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FIG. 4.

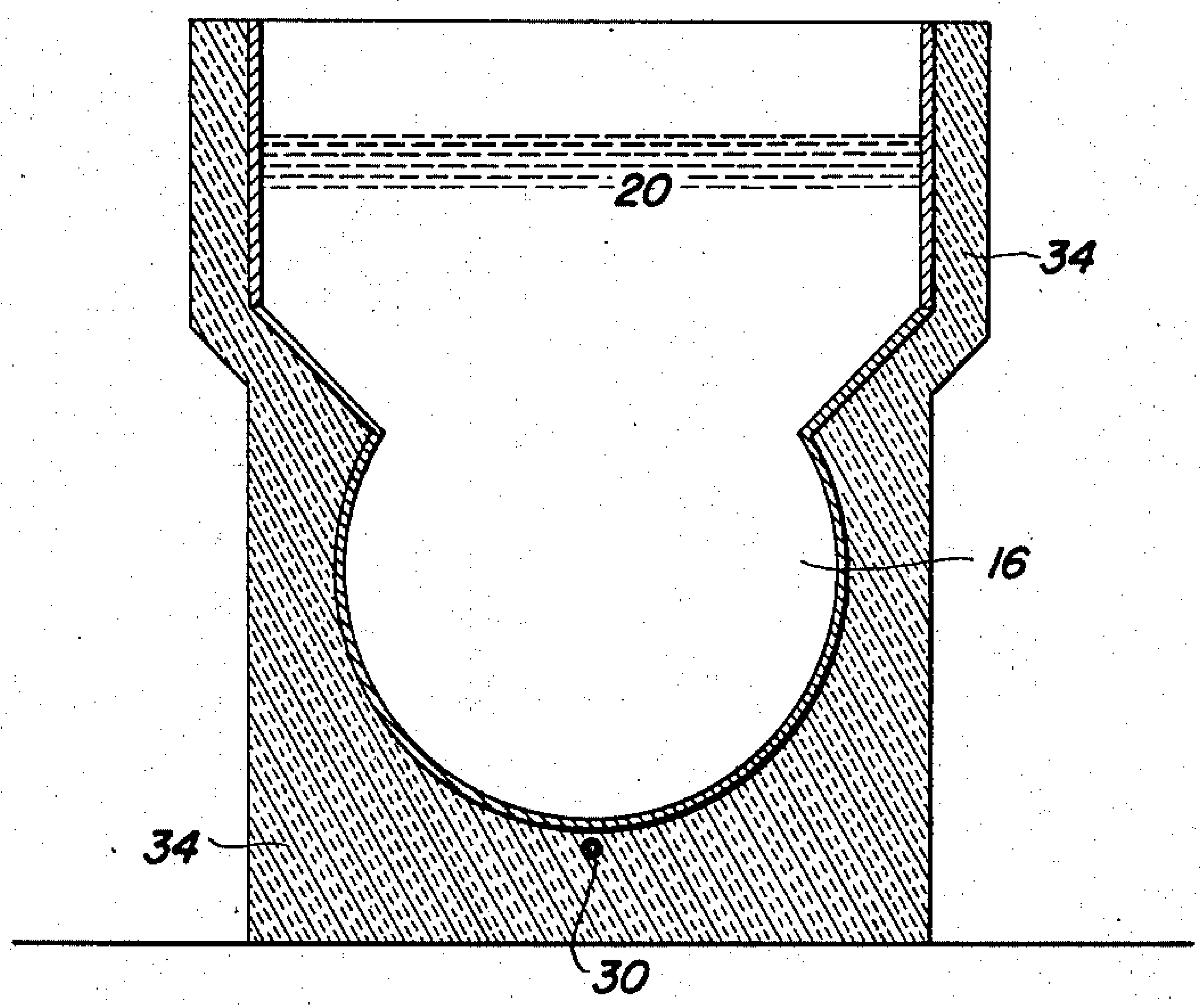
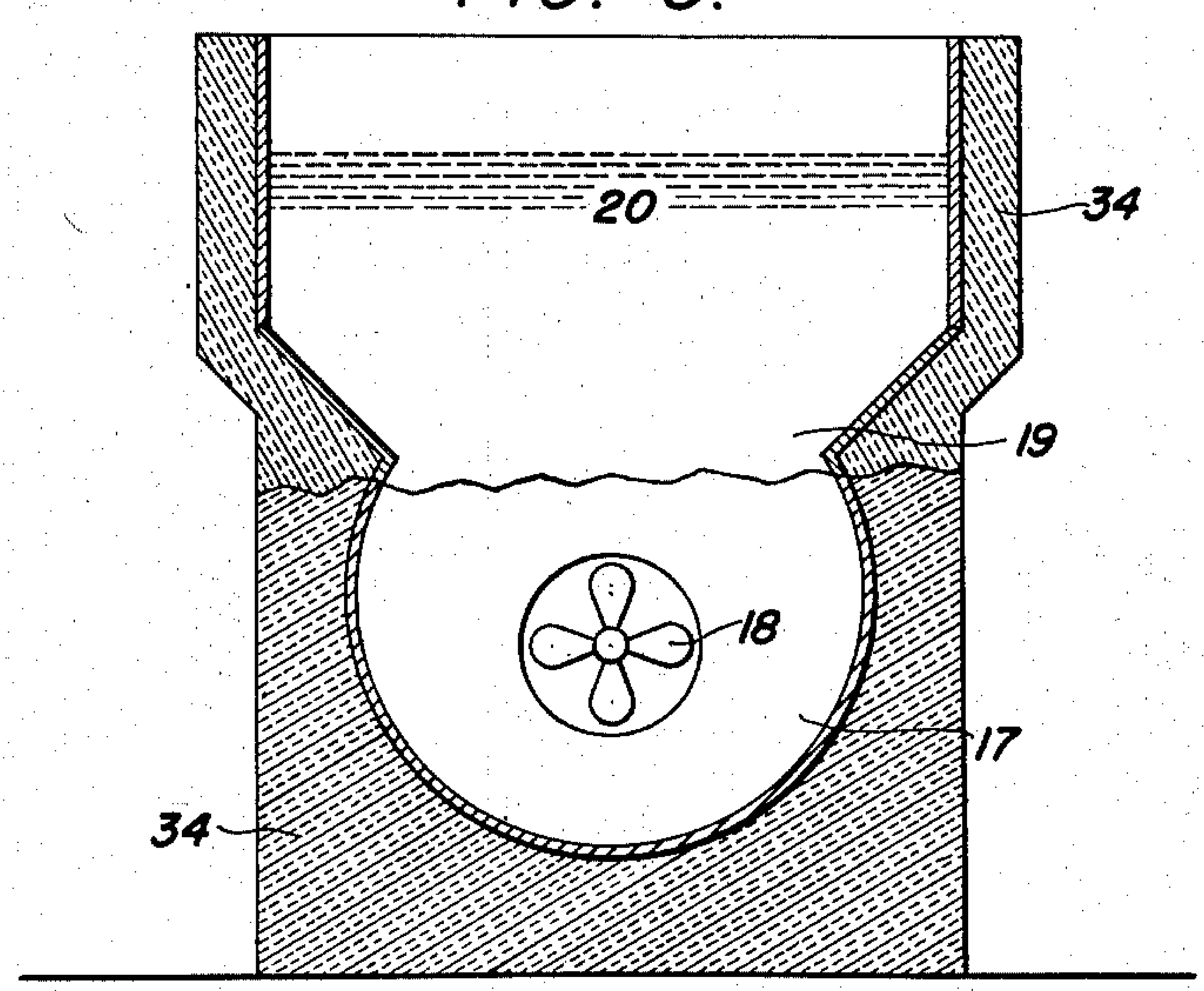


FIG. 5.



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EVAPORATOR AND REFRIGERATION SYSTEM

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4 Claims. (Cl. 62—158)

1

This invention relates to refrigeration systems wherein a fluid refrigerant is mechanically circulated through a closed refrigerating circuit, going through repeated liquid and gaseous phases in the process, if required.

Such systems customarily make use of brine as an intermediate agency for applying the refrigerating action of the refrigerant directly to useful purpose.

It is common practice to so construct the heat-exchange apparatus employed in the system for transfer of heat from the brine to the fluid refrigerant, that a large body of brine is necessary compared to the area of heat-interchange surface separating the fluid refrigerant from the brine. Accordingly, many conventional systems are very slow in reaching required operating temperatures, and their efficiency is far from satisfactory. This is particularly true in instances of brine tank equipment commonly employed to freeze various food items, such as certain commercial ice cream and water-ice products in the nature of lollypops.

In connection with these conventional systems it is usual to employ surge tanks for the gaseous phase of the operating cycle, so there will be no undue occurrence of the condition commonly known as "frost-back" along the line leading from the evaporator or heat exchange equipment, where gasification of the liquid refrigerant occurs, to the compressor. Such frost-back condition is a result of imperfect drying of the fluid refrigerant vapors following the evaporation stage of the process. Droplets of the liquid refrigerant pass into the line leading to the compressor, and these dissipate their usefulness by creating a frost along such line.

A principal object of the present invention is to eliminate the excessively large bodies of semi-stagnant brine employed by conventional systems of the type concerned, and provide for a more nearly equal ratio between the quantity of brine utilized and the extent of operable heat-interchange surface in the evaporator part of the system. An object is to provide for constant positive circulation of substantially the entire body of brine, to the end that freezing temperatures are obtained in a small fraction of the usual time.

An object is to eliminate the need for a conventional surge tank.

An object is to accomplish the above by a simple and compact construction which is comparatively low in cost and economical to operate and maintain.

2

In the refrigeration system of the invention, a brine liquid is mechanically circulated through a closed circuit. This circuit advantageously includes, by way of equipment, principally, an evaporator assembly consisting of a heat exchanger embodying a plurality of elongate tubes. The heat exchanger is provided with an entry compartment or header at one end thereof and an exit compartment at the other end. Both the entry compartment and the exit compartment open into a freezing conduit that desirably surmounts the two compartments.

In one of the compartments, for example, the exit compartment, is a circulation device, such as a screw propeller, located so as to motivate a brine liquid through the tubes of the heat exchanger, from entry compartment to exit compartment, and, thence, through the freezing conduit. A tray or other container for items to be frozen is disposed in preferably coextensive, intimate relationship with the freezing conduit, as, for example, in superimposed position thereon.

In operation, as the brine passes through the tubes of the heat exchanger the refrigerant abstracts heat therefrom. As the cooled liquid flows back along the freezing conduit in the circulation thereof, heat is abstracted from the items to be frozen.

The tubes extend substantially horizontally within a closed housing forming part of the refrigerant circuit. Liquid refrigerant enters at the bottom of the housing, forming a body maintained, by means of suitable controls, at a depth predetermined in accordance with the temperature. Vaporized refrigerant rising in the housing passes in intimate contact with the outer surfaces of the heat exchanger tubes, thereby continuing to abstract heat from the brine and becoming more gaseous in the process.

The upper portion of the housing is free of tubes, forming a drying or accumulator zone wherein practically all remaining droplets of liquid vaporize. The dry, gaseous refrigerant passes from the top of the housing through a line leading to the compressor of the system.

Accordingly, pursuant to the invention there are two constantly active, closed circuits embodying flowing fluid refrigerant and flowing brine liquid, respectively. The brine circuit is so constituted that substantially all the brine liquid is constantly on the move, whereby particularly efficient heat exchange between refrigerated brine, on the one hand, and brine and items to be frozen, on the other, is achieved. In the present system, a far smaller ratio of brine volume to heat-exchange area exists than in former systems. For example, 1:1 for a preferred embodiment of the present invention as compared to 1:10, or even greater, for certain prior systems.

It is preferred that the volume of brine in the freezing conduit portion of the brine circuit be greater than in the remaining portions of the circuit, and that there be a differential between the inside cross-sectional area of the freezing conduit and the sum of the inside cross-sectional areas of the tubes such that the flow velocity in the former is appreciably less, say one-quarter of, the flow velocity in the latter. By providing for a considerable quantity of brine to be constantly passing through the freezing conduit at a reduced velocity, while maintaining sufficient velocity of the brine within the evaporator tubes for effective heat transfer, freezing racks may be submerged in the brine flowing through the freezing conduit without causing undue turbulence or splashing in instances where the top of the conduit is uncovered to afford free access to the brine.

Because of the relatively small quantity of brine liquid utilized in the entire system and of its confinement within the brine circuit, it is possible to provide a very compact assembly within a jacket of insulation.

Further objects and features of the invention will become apparent as the description proceeds with respect to the presently preferred embodiment thereof, illustrated by way of example in the accompanying drawings.

In the drawings:

Fig. 1 represents a side elevation of the evaporator and freezing conduit, without insulation;

Fig. 2, a longitudinal, vertical, center section taken on the line **2—2** in Fig. 3; and

Figs. 3, 4 and 5, cross-sections, taken respectively on the lines **3—3**, **4—4** and **5—5** in Fig. 2.

Referring to the drawing, the numeral **10** denotes a tubular evaporator having the cylindrical shell **12** and a plurality of tubes **13** extending longitudinally through the shell. The evaporator **10** further has the heads **14** and **15** in which the tubes terminate. Such shell, heads and tubes define, in effect, a housing for a fluid refrigerant, such as ammonia. At **16** is an entry compartment or header in communication with the tubes, while at **17** is an exit compartment which is also in communication with the tubes. A screw propeller **18** which draws brine from the exit compartment **17** through an upright conduit **19** discharges this brine into a horizontal freezing tank or conduit **20**. The conduit **20** in turn discharges into the entry compartment or header **16** from which the brine is recirculated indefinitely.

A unique consideration of the invention is that the plurality of tubes in the evaporator is so arranged that drying or accumulator space **22** is provided above the tubes, from which the accumulation of gaseous refrigerant, such as ammonia gas, is returned through a pipe **23** that extends to a compressor **24**. The compressor discharges the compressed refrigerant into a receiver-condenser **25**, from which liquid refrigerant is conducted through a pipe **26**, controlled by valve **27**, back into the lower part of the tubular evaporator **12**. The control valve **27**, by means of which the level of the liquid refrigerant in the evaporator **10** is maintained approximately as indicated in Fig. 3, namely just above

the tubes in the fourth row counting from the bottom, may be manually, electrically, or thermostatically controlled in any usual manner. In case of electrical control, a float device may be located, for example, as indicated diagrammatically in Fig. 3 at **28**, while in case of a thermostatic control, the thermostat may be located as indicated diagrammatically in Fig. 3, in proximity to the entrance to return pipe **23**. An oil drain for the evaporator is located at a suitable point, such as **30**. The entire structure in this instance is supported on legs **31**, which are attached to the cylindrical shell **12**.

In operation, the screw propeller **18** is driven by any suitable means, such as an electric motor, not shown, through a shaft **32** on which the propeller is mounted. The propeller draws brine through the tubes **13** into and through the exit compartment **17**, and forces it through the conduit **19** into and through the freezing conduit **20** and into the entry compartment **16**, from where it passes back to the tubes **13** for recirculation indefinitely. The circulation of the brine through the freezing conduit **20** accomplishes the freezing of any liquids placed in a freezing tray immediately above the conduit **20**.

The evaporator and freezing conduit are insulated in any suitable manner, in this instance, by placing the insulation as indicated at **34**.

In this system the efficiency of cooling approaches that of a direct expansion system. This result is impossible by the usual methods in connection with an open tank.

In the present showing of the system of the invention, approximately one-quarter of the total quantity of brine is contained in the tubular evaporator and its entry and exit compartments. This means that one-quarter of the total quantity of brine is located below the level of the bottom of the freezing conduit, while three-quarters of the volume of brine is contained in the freezing conduit. Accordingly, the velocity of the flow of brine through the tubular evaporator in this instance is approximately three times as fast as its velocity of flow through the freezing conduit.

The present system represents a reversal of the usual practice. This is brought about by the fact that the fluid refrigerant is circulated through the housing of the evaporator in the space which surrounds the tubes externally thereof, while the brine passes through the inside of the tubes.

It is preferable in practice to maintain the liquid refrigerant level in the tubular evaporator at approximately one-third the total height thereof, though this may vary slightly below and up to as much as approximately one-half the total height, dependent upon the desired temperature.

The provision of an unobstructed accumulator space or zone within and along the upper part of the tubular evaporator, above the tubes thereof, is a decided advantage and an important feature of the invention in preventing undue frost-back. Nevertheless, other features of the invention may be utilized independently of the specified feature.

It should be kept in mind that a primary feature of the invention is the construction whereby a minimum of brine is present in the refrigerant-to-brine heat exchanger portion of the system.

The illustrated embodiment of the invention has an open freezing conduit for the brine, so that freezing racks for items to be frozen may be wholly or partially submerged in the flowing brine. However, such conduit may have its top closed. Furthermore, the freezing brine may be employed to useful purpose in other ways, for example, by connecting an auxiliary freezing circuit to such conduit and pumping a portion of the flowing brine therethrough. If such a circuit has sufficient capacity, it may even replace the illustrated freezing conduit in the brine circuit proper.

While this invention is here illustrated and described with respect to a presently preferred form thereof, it should be understood that various changes may be made therein and various other forms may be constructed on the basis of the teachings hereof, by those skilled in the art, without departing from the protective scope of the following claims.

I claim:

1. In a refrigeration system utilizing a fluid refrigerant and having a closed conduit circuit for said refrigerant which circuit includes a compressor and a fluid reserve chamber; an evaporator assembly forming part of the fluid refrigerant circuit, said assembly comprising, in combination, a tubular heat exchanger made up of a horizontally disposed and elongate housing containing a plurality of longitudinally disposed tubes arranged in closely spaced relationship lowerly in the housing so as to leave an open accumulator zone for gaseous refrigerant along and within the upper part of the housing, said heat exchanger being connected in said circuit so that liquid refrigerant enters the housing at the bottom thereof and the gaseous discharge from the housing leaves at the top thereof; means defining a closed channel circuit for brine, said circuit including the said plurality of tubes and a product freezing tank having a brine capacity greater than the combined brine capacities of the other portions of said brine circuit; insulating material substantially isolating said tank from said heat exchanger; circulating means within said brine circuit; and control means for maintaining the fluid refrigerant at a predetermined level within said heat exchanger housing.

2. The combination recited in claim 1, wherein the product freezing tank is superimposed upon the housing of the tubular heat exchanger.

3. The combination recited in claim 1, wherein the housing of the said heat exchanger is cylindrical and is capped at opposite ends by head plates through which the heat-exchange tubes pass; wherein walls define a common entry header for said tubes at one end of said heat exchanger, and walls define a common exit header for said tubes at the other end of said heat exchanger; and wherein the freezing tank opens at one of its ends into the said entry header and at its other end into said exit header.

4. In a refrigeration system utilizing a fluid refrigerant and having a closed conduit circuit which includes a compressor and a fluid reserve chamber; an evaporator assembly forming part of the fluid refrigerant circuit, said assembly comprising, in combination, a tubular heat exchanger made up of a substantially horizontally disposed and elongate housing containing a plurality of longitudinally disposed heat exchange tubes arranged in substantially horizontal tiers, one above another, said heat exchanger being connected in said circuit; a closed channel circuit for brine, said circuit including the said plurality of tubes, an entry header, an exit header, and a freezing tank connecting said headers, said freezing tank having a brine capacity greater than the combined brine capacities of the other portions of said brine circuit; insulating material substantially isolating said tank from said heat exchanger; circulating means within said brine circuit; and control means for maintaining the liquid refrigerant at a predetermined level within said heat exchanger housing.

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