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REFRIGERATION APPARATUS

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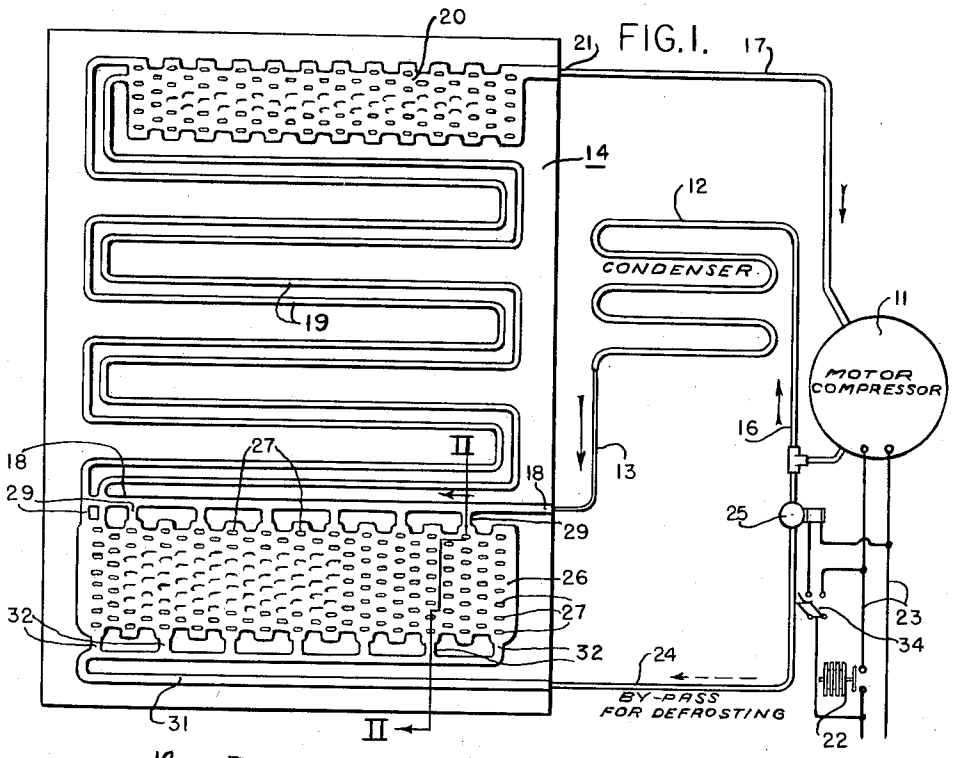


FIG. 1.

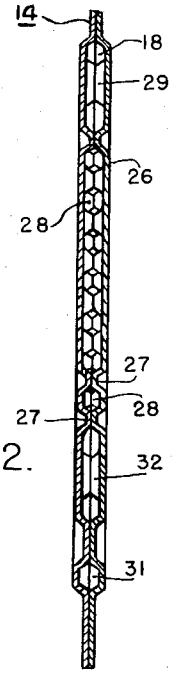


FIG. 2.

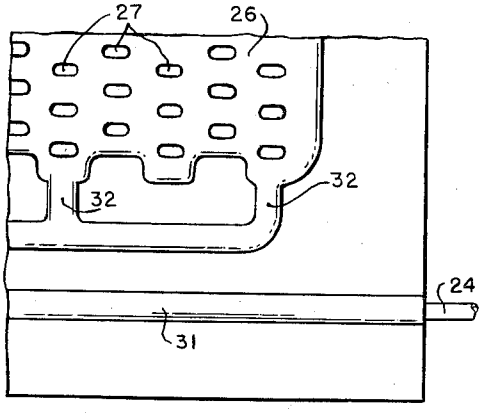


FIG. 3.

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REFRIGERATION APPARATUS

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This invention relates to refrigeration apparatus and more particularly to a defrostable refrigerating circuit having novel and unique components.

Periodic removal of frost from the evaporator, or cooling unit, or a refrigerating system is necessary to permit efficient heat transfer between the media to be refrigerated and the evaporator. In some prior compressor-condenser-evaporator type mechanical refrigerating systems, the temperature of the evaporator is raised to remove frost by introducing into the evaporator warm gaseous refrigerant directly from the compressor by means of a conduit bypassing the condenser and the flow impeding device normally interposed in the refrigerating circuit between the condenser and the evaporator. In this type of defrostable refrigerating circuit, commonly called a "hot gas" or "bypass" system, the warm refrigerant gas entering the evaporator condenses therein, giving up its latent heat of vaporization and whatever sensible heat may be therein and raising the temperature of the evaporator above 35 degrees F. Modern bypass defrost systems of this type are also generally equipped with some type of sump, or accumulator vessel, capable of storing a quantity of liquid refrigerant during the periods of refrigeration operation, and which sump is capable of dumping its contents into the evaporator to overcharge the evaporator and cause liquid refrigerant to be forced out of the evaporator and into the suction line communicating with the compressor. The effect of this overcharging of the evaporator is to speed the defrosting operation by preventing the re-evaporation of refrigerant within the evaporator and causing re-evaporation to take place elsewhere in the refrigerating circuit. It can be readily appreciated that, if refrigerant were permitted to re-evaporate in the evaporator, a quantity of heat equal to the latent heat of vaporization of the refrigerant would be absorbed from the evaporator. This quantity of heat would be equal to the quantity of heat previously added to the evaporator by the condensation of refrigerant therein and, consequently, only the sensible heat available from the refrigerant could be utilized in raising the temperature of the evaporator to effect defrosting. The result would be a prolonged defrosting period.

This invention is particularly concerned with the construction and arrangement of the sump, or accumulator, portion of the defrostable refrigerating system and it is an important object of this invention to provide an accumulator capable of selectively collecting or dumping liquid refrigerant without the necessity for complicated dumping valves or systems.

In achieving this objective, this invention utilizes, in combination with a bypass type refrigerating system, an accumulator constructed in such a manner as to possess a plurality of vertically extending restricted passages disposed throughout its entire horizontal cross-sectional area. This accumulator is connected into the refrigerating system in such a manner that the upper ends of the accumulator passages communicate with the inlet of the evaporator and receive a portion of the liquid refrigerant

conveyed to the evaporator during refrigeration operation of the system. The bypass conduit that is adapted to convey warm gaseous refrigerant to the evaporator during defrosting is arranged to discharge this gas into the lower ends of the accumulator passages. The comparatively small flow area of the accumulator passages causes liquid refrigerant trapped in the accumulator to be entrained in the warm gaseous refrigerant flowing upwardly through the accumulator, whereby the liquid refrigerant is carried out of the accumulator and into the evaporator.

The accumulator construction envisioned by this invention is particularly appropriate for utilization in, and in connection with, evaporators formed of two metal sheets that are roll bonded, or forge welded, in all but preselected surface areas thereof which are spaced apart to form refrigerant flow passages. The accumulator of this invention can be formed directly into the roll bonded evaporator; the shape of the accumulator being that of a vertically arranged vessel of narrow thickness as compared to its height and width. The restricting flow passages are provided in the roll bonded accumulator by closely spaced welded areas where the two sheets forming the accumulator are joined together. The storage areas or passages of the accumulator lie between these spaced welded areas of the accumulator wall in the form of interconnected interstices which are of such small size as to cause liquid refrigerant therein to be carried along with the warm gaseous refrigerant introduced into the lowermost portion of the accumulator.

Other objects, features and advantages of this invention will become apparent from the following detailed description thereof in which reference is made to the accompanying drawing, wherein:

Fig. 1 is a diagrammatic illustration of a defrostable refrigerating circuit embodying this invention;

Fig. 2 is an enlarged cross-sectional view through the accumulator employed in this invention, which view is taken as indicated by the line II—II of Fig. 1; and

Fig. 3 is an enlarged fragmentary view of the lower right-hand corner of the accumulator shown in Fig. 1.

Referring in particular to Fig. 1, the invention is shown applied to a defrostable refrigerating circuit of the compressor-condenser-expander type. The principal components of the circuit are connected in series flow relationship and comprise a motor-compressor unit **11**, a condenser **12**, a flow impeding device **13**, which may, for example, take the form of a capillary, or small bore, tube, and an evaporator, indicated generally by the reference numeral **14**. In operating to extract heat from the evaporator **14** and the media surrounding the evaporator, refrigerant from the compressor **11** is delivered by a warm gas conduit **16** to the condenser **12** wherein heat is removed from the refrigerant to convert the refrigerant to a liquid state. This liquid refrigerant is delivered to the evaporator **14** by the flow impeding device **13**, and the low pressure maintained in the evaporator **14** by the motor compressor **11** causes evaporation of refrigerant in the evaporator **11** with the vaporous refrigerant being thereafter returned to the motor compressor unit by a suction conduit **17**.

The evaporator **14** chosen for purposes of illustration is of the so-called roll-bonded or forge-welded variety. The roll bonding, or forge welding, process comprises, generally: Subjecting two superimposed metal plates, having a pattern of stop weld metal therebetween, to heat and pressure to cause the plates to become welded together in areas where the stop weld metal is not present. After the plates have been forged together, the internal passages formed by the stop weld material are dilated by subjecting the passages to internal fluid pressure. By this method, refrigerating system components having complicated flow passages can be readily and easily fabri-

cated. All of the flow passages in the evaporator **14**, namely an inlet passage **18**, an intermediate passage system consisting of two parallel passages **19**, and a suction accumulator **20**, the outlet of which is joined to the suction conduit **17** at the evaporator outlet **21**, are formed in the evaporator by the roll bonding process. The evaporator **14** is illustrated as having a vertical, plate-like configuration although it is to be understood that it may take other forms and shapes if desired.

The temperature of the evaporator **14** is maintained at a predetermined value by a temperature responsive switch **22** controlling the supply of electrical current to the motor compressor unit **11** through electrical leads **23**. The temperature responsive switch **22** normally includes a temperature sensitive bulb located on or near the evaporator **14**, but this bulb has been omitted from the drawing to simplify the illustration. Controls of this type are well known and well understood in the refrigeration art, and no further description thereof is deemed necessary here.

The operation of the refrigerating system shown in Fig. 1 can be modified to cause addition of heat to the evaporator **14** to raise the temperature of the evaporator to melt ice and frost which collects thereon. The modifying means includes a bypass conduit **24** adapted to convey warm gaseous refrigerant from the motor compressor unit **11** to the evaporator **14**. The flow of refrigerant through the bypass conduit **24** is controlled by a solenoid-actuated valve **25** which, when energized, opens to permit flow of refrigerant through the conduit **24** and, when deenergized, closes to prevent flow through the conduit **24**.

The flow circuit modifying means also includes a sump, or accumulator, **26** disposed in the refrigerant circuit between the bypass conduit **24** and the inlet passage **18** of the evaporator **14**. The accumulator **26** serves to trap and store refrigerant liquid during refrigerating operation of the circuit and to dump, or discharge, its liquid contents into the evaporator **14** during defrosting operation of the circuit.

The accumulator **26**, the construction of which is shown in greater detail in Figs. 2 and 3, can, as shown in Fig. 1, be made integral with the evaporator **14** so that the same method of manufacture can be employed for the simultaneous formation of both components. The accumulator **26** is a vessel that has a narrow width as compared to its vertical height and horizontal length (compare Figs. 1 and 2). Spaced areas of the sheets, or plates, forming the side walls of the accumulator **26** are welded together, as indicated at **27**. When viewed exteriorly, these spaced welded areas appear as indentations in the surface of the accumulator side wall (see Figs. 1 and 3). Only a part of the total number of welded areas in the accumulator are illustrated in Fig. 1. The location of the omitted welded areas is, however, indicated in this figure of the drawing by short curved lines positioned in the locations where the welded areas should appear. This has been done to simplify the illustration.

These spaced welded areas of the side walls of the accumulator **26** divide the interior of the accumulator into numerous interconnected interstices **28** which form, in effect, a plurality of vertically disposed restricted flow passages throughout the horizontal extent of the accumulator **26**. These flow passages are of such size, i.e. small size, as to cause the entrainment of liquid refrigerant in gaseous refrigerant circulated through the accumulator **26**, with the result that the accumulator **26** is capable of being emptied of its liquid contents by passing gaseous refrigerant therethrough from the bottom to the top thereof.

The accumulator **26** is connected into the inlet passage **18** of the evaporator **14** by means of several parallel liquid inlet passages **29** that communicate with the uppermost region of the accumulator. These flow passages **29** permit a part of the liquid refrigerant passing through the evaporator inlet passage **18** during refrigerating operation of the circuit to flow into and fill the accumulator **26**. The liquid refrigerant stored in the accumulator **26** and, in effect, removed from the body of refrigerant that is circulated through the system, is held available for use during a defrosting operation of the circuit.

During a refrigerating operation some refrigerant will normally vaporize within the accumulator **26** and flow therefrom into the evaporator passage **19**. The refrigerant thus leaving the accumulator **26** is continually replaced by liquid refrigerant from the evaporator inlet passage **18**.

The accumulator **26** is connected to the bypass conduit **24** by means of an inlet passage **31** that terminates in a plurality of parallel flow passages **32** communicating with the lowermost region of the accumulator **26**. The passages **32** are disposed along the bottom of the accumulator **26** in a manner to equally distribute the warm defrost gas throughout the entire horizontal area, or extent, of the accumulator **26**.

Initiation of a defrosting operation of the refrigerant circuit shown in Fig. 1, i.e. rendering effective the circuit modifying means, is effected by closing a double pole, single throw switch **34** controlling energization of the solenoid valve **25** in the refrigerant bypass conduit **24**. The switch **34** is also capable of establishing an electrical shunt circuit around the thermostatic switch **22** to insure energization of the motor compressor **11** during defrosting and regardless of the condition of the switch **22**. Energization of the solenoid valve **25**, which causes the valve **25** to open, permits warm refrigerant gas discharged by the motor compressor **11** to enter the bypass conduit **24** for passage to the evaporator **14** without going through the condenser **12** and the flow impeding device **13**. Since the flow passages in the condenser **12** and the flow impeding device **13** remain open, a small quantity of refrigerant will continue to flow into the evaporator **14** through these components. However, the restriction to refrigerant flow offered by the flow impeding device **13** causes the major portion of the refrigerant leaving the motor-compressor **11** to pass through the bypass conduit **24** as a warm gas. This warm refrigerant gas flows into the accumulator inlet passages **31** and **32** and is forced upwardly through the restricted flow passages in the accumulator **26**. In passing through the accumulator, the warm gas entrains, or picks up, the liquid refrigerant stored in the accumulator and carries this liquid refrigerant out of the accumulator and into the several passages of the evaporator **14**. The heat from the warm gas entering the accumulator **26** may vaporize a part of the liquid refrigerant stored in the accumulator, which refrigerant then flows from the accumulator into the evaporator **14** wherein it condenses along with the main body of warm gas, giving up its heat of vaporization to raise the temperature of the evaporator **14** and defrost the evaporator.

The quantity of refrigerant conveyed into the evaporator **14** during defrosting as a result of emptying the accumulator **26** floods the evaporator **14**, with the result that liquid refrigerant is forced from the evaporator outlet **21** into the suction conduit **17** and is conveyed into the housing or casing of the motor compressor **11**, which is normally made oversize to receive this liquid refrigerant. The liquid refrigerant conveyed to the motor compressor housing is evaporated therein by heat supplied from the thermal mass of the motor and compressor, by heat derived from the air surrounding the compressor housing, and by heat generated by the electrical losses which inevitably occur in the compressor drive motor.

The vaporization of refrigerant in the motor compressor housing makes available warm gas which is thereafter circulated by the motor compressor **11** through the bypass conduit **24**, the accumulator **26**, and the evaporator **14**. The evaporation of refrigerant in the motor compressor housing also raises the suction pressure im-

posed on the evaporator **14** by the motor compressor **11** and prevents the re-evaporation of refrigerant in the evaporator. This phenomenon is the result of the following factors: The ice and frost being melted from the evaporator **14** maintains the temperature of refrigerant circulating through the evaporator at slightly above 32° F. The evaporation of refrigerant in the motor compressor **11** raises the suction pressure to the point at which the 32° F. refrigerant will not vaporize. Consequently, refrigerant flows from the evaporator in a liquid state. Thus, the speed of defrosting by the condensation of refrigerant in the evaporator is not slowed by re-evaporation of refrigerant in the evaporator **14**; the re-evaporation is transferred to the housing of the motor compressor **11** because of the additional refrigerant added to the circuit from the accumulator **26**.

From the foregoing it will be apparent that this invention provides an accumulator arrangement that can be economically provided in a defrostable bypass refrigerating system. The accumulator **26**, because of its unusually simple construction, can be fabricated integrally with the evaporator portion of the refrigerating system. Because it does not require the addition of fabricated valves or tanks with complicated valving arrangements, this invention offers considerable cost-saving possibilities in the manufacture of defrostable refrigerating systems.

While certain advantages attend integral fabrication of the accumulator **26** and the evaporator **14**, it is to be understood that the accumulator can, if desired, be formed as a separate component of the refrigerating system and joined to the other components of the system by suitable pipes or conduits providing flow passages similar in function to those described above. Moreover, the underlying principles of this invention can be utilized in accumulators formed by a method or process other than the roll bonding, or forge welding, method of fabrication described above. Other arrangements will undoubtedly occur to those skilled in the art whereby the accumulator can be made to comprise a plurality of small area flow passages which are capable of storing liquid refrigerant and which are further capable of being emptied of their liquid contents by passing warm refrigerant gas therethrough to entrain and carry away such liquid.

While the invention has been shown in but one form, it will be obvious to those skilled in art that it is not so limited, but is susceptible of various changes and modifications without departing from the spirit thereof.

What is claimed is:

1. The combination with a refrigerating circuit comprising a compressor, a condenser, a flow impeding device and an evaporator having an inlet and an outlet, of an accumulator in said circuit at the inlet of said evaporator, said accumulator being adapted to collect a part of the liquid refrigerant conveyed to said evaporator, and means for bypassing the flow impeding device of said circuit and for conveying warm refrigerant gas to said evaporator to effect defrosting of the evaporator, said bypassing means including a conduit communicating with the lowermost portion of said accumulator for discharging warm refrigerant gas into the said portion of the accumulator, said accumulator being characterized by having its horizontal cross-sectional area divided into a plurality of upwardly extending, restricted flow passages which promote the entrainment of liquid refrigerant in the warm gas discharged into the accumulator, whereby the liquid refrigerant collected in said accumulator is carried from the accumulator and into the evaporator when said bypassing means is rendered effective.

2. A defrostable refrigerating circuit comprising an evaporator having an inlet and an outlet, a flow impeding device connected to the inlet of said evaporator, a compressor and a condenser for supplying liquid refrigerant to said evaporator through said flow impeding device, an accumulator, passage means connecting an upper portion of said accumulator to said evaporator, whereby said accumulator collects a part of the liquid refrigerant conveyed to said evaporator, and means for modifying the operation of said circuit to effect defrosting of said evaporator, said modifying means comprising conduit means communicating with a lower portion of said accumulator for conveying warm gaseous refrigerant to said accumulator, said accumulator being characterized by having its horizontal cross-sectional area divided into a plurality of upwardly extending restricted flow passages, said accumulator passages causing entrainment of liquid refrigerant in the gaseous refrigerant passing upwardly through said accumulator, whereby the liquid refrigerant collected in said accumulator is carried from the accumulator and into the evaporator when said modifying means is rendered effective.

3. A defrostable refrigerating circuit comprising an evaporator having an inlet and an outlet, a flow impeding device connected to the inlet of said evaporator, a compressor and a condenser for supplying liquid refrigerant to said evaporator through said flow impeding device, means defining a plurality of upright storage passages at the inlet of said evaporator, means providing communication between an upper portion of each of said storage passages and the inlet of said evaporator, whereby a portion of the liquid refrigerant entering said evaporator from said flow-impeding device is trapped in said storage passages, and means for modifying the operation of said circuit to effect defrosting of said evaporator, said modifying means comprising conduit means communicating with a lower portion of each of said storage passages for conveying warm gaseous refrigerant to said storage passages, said storage passages being characterized by having restricted flow areas to cause entrainment of liquid refrigerant in the gaseous refrigerant conveyed into said storage passages by said conduit means, whereby the liquid refrigerant trapped in said storage passages is carried from the storage passages and into the evaporator when said modifying means is rendered effective.

4. A defrostable refrigerating circuit comprising an evaporator having an inlet and an outlet, a flow impeding device connected to the inlet of said evaporator, a compressor and a condenser for supplying liquid refrigerant to said evaporator through said flow impeding device, an accumulator, said accumulator being formed by a pair of generally vertically disposed metal sheets arranged in face to face relationship and having spaced apart areas defining said accumulator, said sheets being joined together at a plurality of spaced points throughout the area of the sheets defining the accumulator whereby the accumulator is comprised of a plurality of interconnected interstices, passage means connecting an upper portion of said accumulator to the inlet of said evaporator, whereby said accumulator collects a part of the liquid refrigerant conveyed to said evaporator, and means for modifying the operation of said circuit to effect defrosting of said evaporator, said modifying means comprising conduit means communicating with said accumulator at a plurality of locations along the lower edge of the accumulator for conveying warm gaseous refrigerant to said accumulator throughout the horizontal extent thereof, the construction and arrangement being such that the interstices of said accumulator cause entrainment of liquid refrigerant in gaseous refrigerant passing upwardly through said accumulator, whereby the liquid refrigerant collected in said accumulator is carried from the accumulator and into the evaporator when said modifying means is rendered effective.

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