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MEANS FOR MAINTAINING LIQUID LEVEL IN HEAT-EXCHANGE APPARATUS

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2,581,466

FIG. 1

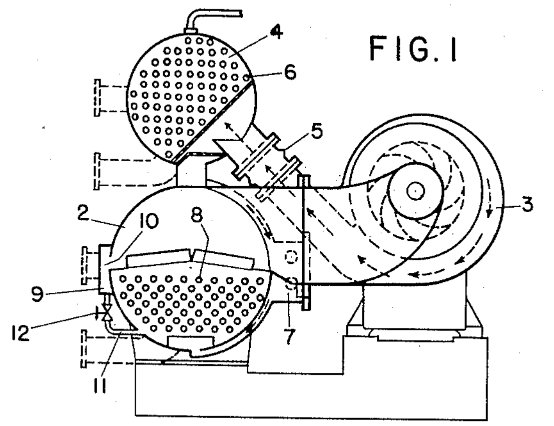



FIG. 2

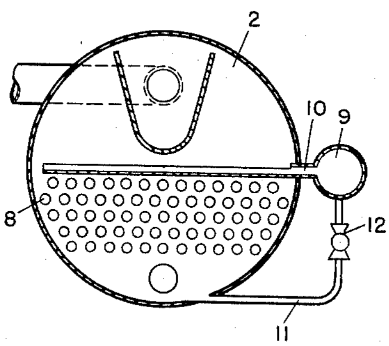



FIG. 3

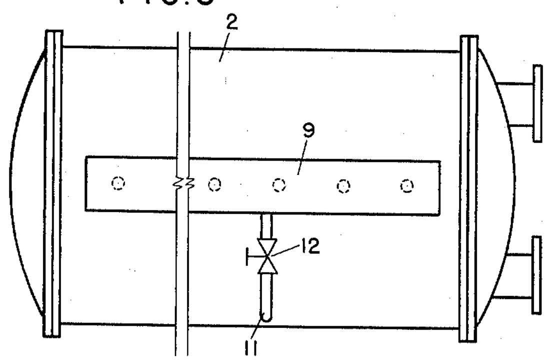



FIG. 4

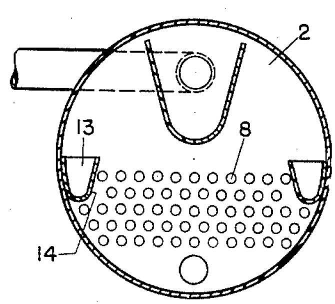
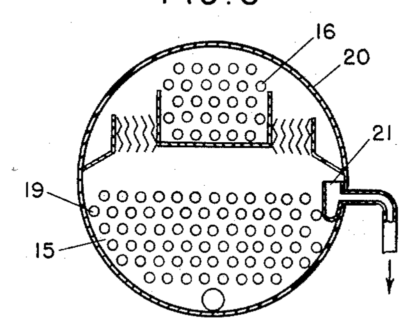



FIG. 5




INVENTOR.

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## MEANS FOR MAINTAINING LIQUID LEVEL IN HEAT-EXCHANGE APPARATUS

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1 Claim. (Cl. 62—115)

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This invention relates to heat exchange apparatus and more particularly to automatic means for preventing the liquid level in the evaporator or cooler of, for example, a centrifugal refrigeration machine, from rising above a predetermined point under overload conditions.

In centrifugal refrigeration systems, for example, a balanced charge of refrigerant is normally maintained in the evaporator. In use, however, as the load imposed upon the system increases, the amount of refrigerant gas trapped in the liquid in the evaporator increases. The increase in the amount of gaseous refrigerant present in the evaporator decreases the density of the liquid refrigerant. The decrease in density of the liquid refrigerant results in a greater volume of refrigerant and an increase in foam in the space above the tubes of the evaporator. Generally, eliminators are provided to break up the foam and to prevent liquid carry-over to the compressor. The use of eliminators increases the cost of the system and in addition increases the amount of space required. Without eliminators, however, the amount of space required to perform the same function is so great as to be impracticable under normal conditions of use.

The chief object of the present invention is to provide heat exchange apparatus in which carry-over at high loads is prevented and increased capacity is obtained at low loads.

An object of the present invention is to provide a refrigeration system including means for effectively preventing the liquid level in the cooler from rising above a predetermined point under overload conditions.

A further object of the invention is to provide a refrigeration system including means for automatically regulating the liquid level maintained in the evaporator under all conditions of use.

A still further object is to provide a refrigeration system including a collecting chamber attached to the evaporator of the system, the collecting chamber being effective for withdrawing a portion of the liquid refrigerant from the evaporator upon an increase in load to prevent a corresponding increase in the effective liquid level maintained in the evaporator, and means for returning the withdrawn refrigerant to the cooler when such conditions have ceased. Other objects of my invention will be readily perceived from the following description.

This invention relates to a refrigeration system including a compressor, a condenser, and an evaporator or cooler. As is well known, an economizer may be provided to reduce the cost of operation of the system. Liquid refrigerant is collected in the evaporator and is placed in heat exchange relation with a medium to be cooled. Such medium passes through a coil disposed in the evaporator. The system is designed to operate upon a balanced refrigerant charge so that a predetermined quantity of liquid refrigerant is present in the evaporator under normal load conditions. As load imposed upon the system increases, the density of the liquid decreases due to trapping of gaseous refrigerant in the form of bubbles. Trapping of gaseous refrigerant within the pool of liquid refrigerant maintained in the evaporator causes an increase in the effective level of the liquid refrigerant; such increase or rise in effective level of the liquid refrigerant results in a considerable increase in the amount of foam present above the tubes of the evaporator and permits carry-over to some extent of liquid refrigerant to the compressor. In order to stabilize the level of refrigerant within the evaporator at a maximum point under overload conditions, a collecting chamber is provided disposed with its opening slightly above the top level of the coil and with its bottom at approximately the shut-down level of the liquid. Such chamber may be located within or without the evaporator. As the load imposed upon the system increases, the level of foam within the evaporator increases until it is slightly above the opening leading to the collecting chamber. The foam then spills over into the collecting chamber; the collecting chamber eventually fills with liquid, thereby removing a portion of the refrigerant charge from active circulation in the system and stabilizing the level of refrigerant in the evaporator at a predetermined point. Preferably, means are provided to return a portion or all of the liquid collected in the collecting chamber to the evaporator when the load imposed upon the system decreases.

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The attached drawing illustrates a preferred embodiment of my invention, in which

Figure 1 is a diagrammatic view of a centrifugal refrigeration system embodying the present invention;

Figure 2 is a sectional view through the evaporator of the system shown in Figure 1 illustrating the collecting chamber;

Figure 3 is a view in elevation of the evaporator of the system shown in Figure 1;

Figure 4 is a sectional view of a modified form of evaporator illustrating the collecting chamber disposed within the evaporator; and

Figure 5 is a sectional view illustrating the present invention embodied in an absorption refrigeration system.

Referring to the drawing, the present invention is illustrated embodied in a centrifugal refrigeration system of the type disclosed in Jones Patent No. 2,314,402, granted March 23, 1943. The system comprises an evaporator or cooler **2** connected to a centrifugal compressor **3** which in turn is connected to a condenser **4** by line **5**. A plurality of tubes or coils **6** are disposed in condenser **4**. Cooling water is passed through the tubes **6** in heat exchange relation with compressed gaseous refrigerant forwarded to condenser **4** by compressor **3** to liquefy the same. Liquid refrigerant from condenser **4** flows into an economizer **7**. Refrigerant from economizer **7** passes into cooler **2** and serves as make-up refrigerant for the refrigerant being evaporated therein. Tubes or coils **8** are disposed in cooler **2**. A medium to be cooled is passed through the tubes **8** in heat exchange relation with refrigerant in cooler **2**; gaseous refrigerant formed in cooler **2** passes to compressor **3**, is compressed and again forwarded to condenser **4**.

To maintain a desired liquid level in cooler **2** even under conditions of overload of the system, a collecting chamber **9** is provided extending longitudinally of cooler **2**. Preferably, chamber **9** is disposed without the shell of cooler **2**. Suitable trough-like members **10** connected to chamber **9** extend above tubes **8** to permit foam within cooler **2** to spill therein and to flow into collecting chamber **9**. The members **10** are disposed in such position within the cooler **2** as to maintain a maximum liquid level within the cooler under overload conditions. A line **11** connects chamber **9** with the bottom of cooler **2** to permit refrigerant condensed therein to be returned to the evaporator or cooler **2** as hereinafter described. A restriction **12** is disposed in line **12** in order to regulate the quantity of refrigerant returning to the cooler. Preferably, restriction **12** is so designed as to limit returned refrigerant to such quantity as to balance the rate of collection, i. e., permitting an equivalent amount of liquid refrigerant to return to the cooler to balance the amount of foam which spills over into the collecting chamber.

In operation, conditioning medium flowing through the tubes **6** of cooler **2** is warmer than the liquid refrigerant in the cooler. Consequently, heat is transferred from the conditioning medium to the liquid refrigerant. This heat evaporates or boils off the refrigerant at a temperature corresponding to the pressure in the cooler. The refrigerant evaporated is drawn into the suction of compressor **3**; the suction gas (gaseous refrigerant) is partially compressed by the first stage impeller of compressor **3** and then enters the second stage impeller of the compressor. Compression of the gaseous refrigerant is completed by the following compressor stages and the compressed gas is discharged into condenser **4**. Refrigerant discharged by compressor **3** into condenser **4** condenses on the exterior of the condenser tubes **6** at a temperature corresponding to condenser pressure. This temperature is higher than that of the water in tubes **6** so that the heat of condensation is transferred to the condenser water. Liquefied refrigerant drains from condenser **4** into economizer **7** and is supplied from economizer **7** to cooler **2** as previously described.

Assume an increase in load imposed upon the centrifugal system; such increase in load reduces the density of the liquid refrigerant within cooler **2** since gaseous refrigerant is trapped in the liquid in the form of bubbles. Trapping of gaseous refrigerant increases the volume of refrigerant within cooler **2** which results in a considerable increase in the amount of foam present above tubes **8** of cooler **2**. In order to prevent an increase in liquid refrigerant within cooler **2** beyond a desired point, collecting chamber **9** is provided. Under overload conditions, for example, the level of foam within cooler **2** increases until it is slightly above members **10** connected to the collecting chamber **9**. The foam then spills over into members **10** and flows into the collecting chamber **9**, thus maintaining a predetermined liquid level within cooler **2**. The collecting chamber **9** eventually fills with liquid refrigerant thereby removing a portion of the refrigerant charge from active circulation in the system and stabilizing the level of the refrigerant in the evaporator at a predetermined point. As the load imposed upon the system decreases, liquid refrigerant in chamber **9** is returned to cooler **2** through line **11**. Restriction **12** in line **11** serves to regulate the quantity of refrigerant returned to cooler **2**.

In the system described above, collecting chamber **9** is disposed without the shell of cooler **2**. In Figure 4, I have illustrated a modified form of my invention in which collecting chambers **13** are provided, such chambers **13** being disposed within the shell of cooler **2** between the bank of coils **8** and the interior wall of the shell. Such chambers **13** serve the same function as chamber **9** in that upon an increase in load imposed upon the system with a resulting decrease in density of refrigerant within cooler **2**, excess foam spills over into chambers **13** thus maintaining the liquid level within the cooler at a predetermined point. Such refrigerant may be returned to the cooler through restrictions **14** therein as the load imposed upon the system decreases.

Figure 5 illustrates the present invention applied to an absorption refrigeration system. An absorption refrigeration system may include a generator **15**, condenser **16**, absorber (not shown), and evaporator (not shown), connected by suitable lines permitting flow of strong and weak solutions between such elements of the system. A coil **19** is disposed in generator **15** and a suitable heating medium is passed therethrough in heat exchange relation with solution in the generator. Such a system is shown diagrammatically in Figure 5. Condenser **16** and generator **15** are disposed in shell **20**. A collecting chamber **21** is disposed adjacent generator **15** in shell **19**; collecting chamber **21** is adapted to maintain the level of solution in the generator at a predetermined point. When ebullition of solution in the generator occurs, the density of the solution therein is decreased and the level of solution in the generator rises, excess solution spilling over into the chamber **21**. Solution from chamber **20** is not returned directly to the generator but is forwarded to the strong solution line connecting the generator and the absorber for supply to the absorber of the system.

The present invention provides a simple and effective means for regulating the liquid level within the cooler, generator or evaporator of a refrigeration system under high and overload conditions. The invention may be applied to centrifugal, reciprocating and absorption refrigeration systems. The invention permits complete submergence at low load as well as preventing carry-over at high loads without substantial increase in the cost of the system. The means so provided permits a reduction in the size of equipment required for a specific load and reduces the initial cost of the equipment by eliminating the various elements of the system heretofore required to prevent liquid carry-over from the cooler to the compressor.

While I have described a preferred embodiment of the invention it will be understood the invention is not limited thereto, since it may be otherwise embodied within the scope of the following claim.

I claim:

In a centrifugal refrigeration system, the combination of a compressor, a condenser and a cooler connected in a closed circuit, a coil in the cooler through which a medium to be cooled passes, a pool of liquid refrigerant in the cooler surrounding at least a portion of the coil, ebullition of the liquid occurring during operation of the system thereby increasing the liquid level in the cooler, a chamber without the cooler extending longitudinally of the cooler and connected thereto to receive excess refrigerant only when the liquid level in the cooler reaches a predetermined maximum under overload conditions, a line connecting the chamber and the cooler to return refrigerant from the chamber to the cooler, and a valve in said line to regulate return of refrigerant from the chamber to the cooler.

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