July 5, 1966 W. T. OSBORNE 3,258,933

REFRIGERATION

Filed Oct. 8, 1964

FIG. 1

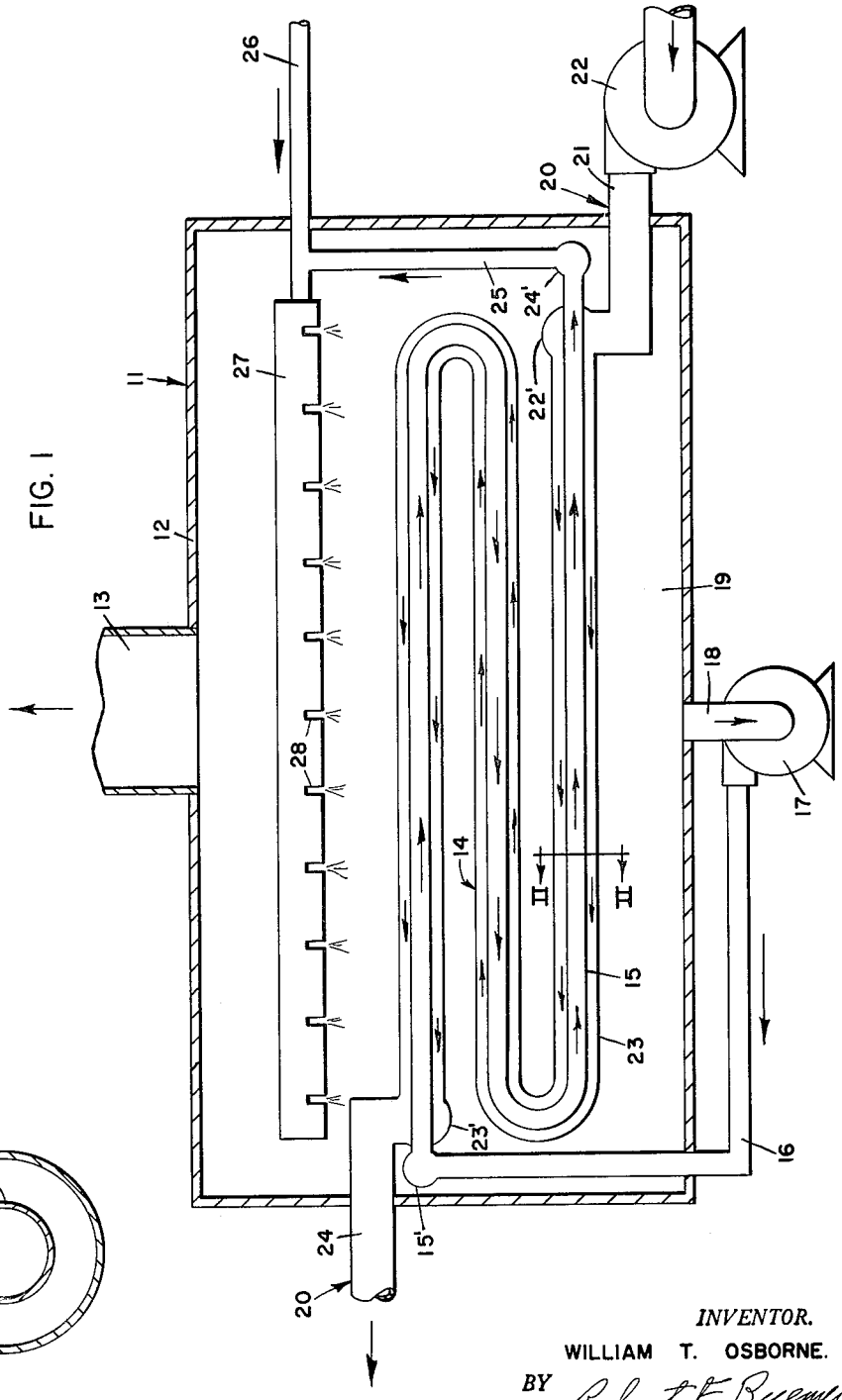

FIG. 2

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United States Patent Office 3,258,933 Patented July 5, 1966

3,258,933

REFRIGERATION

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Filed Oct. 8, 1964, Ser. No. 402,427
9 Claims. (Cl. 62—98)

This invention relates to refrigeration and, more particularly, to a direct contact cooler and to a method of cooling chilled water to be circulated to a load to be cooled.

In general, the principle of direct contact cooling of chilled water with a suitable refrigerant has many advantages. Among these advantages are a reduction in manufacturing cost of the refrigeration machine and particularly the required evaporator or cooler, a smaller required refrigerant charge and higher cooling efficiency. A major disadvantage of a direct contact cooler is that the chilled water which is cooled by direct contact with the refrigerant can be expected to carry some refrigerant along with it through a chilled water line to a load, such as a heat exchanger in a room to be cooled. Such carryover of refrigerant may cause flashing or gas blanketing of the heat exchanger and an accompanying reduction of efficiency in the heat exchanger.

The invention is, in brief, directed to a refrigeration system and method of providing refrigeration wherein a refrigerant is immiscible with and has a lower boiling point than water and a cooler has a sump for primary chilled water. The cooler is hermetic and has provision for connection with a suction line for withdrawing refrigerant vapor. A tube bundle assembly includes a plurality of inner tubes for the circulation of the primary chilled water from the sump with an outer tube about each inner tube for the circulation of secondary chilled water to a load to be cooled. Means is provided for mixing liquid refrigerant and the primary chilled water leaving the tube bundle assembly and spraying the mixed fluids on the tube bundle assembly to cool the secondary chilled water by cooling the sprayed primary chilled water by direct contact with the vaporizing refrigerant, thereby cooling the tube bundle assembly as the primary chilled water passes over the outer tube and into the sump for recirculation through the inner tubes. Thus, the secondary chilled water passing to the load is effectively refrigerant free.

It is a primary object of this invention to provide a new and improved system and method for providing refrigeration.

Another object is to provide refrigerant free chilled water in a direct contact cooler. A related object is provision of relatively high efficiency in such a cooler. Another related object is provision of such a cooler requiring but a small refrigerant charge.

These and other objects of the invention will be apparent from the following description and the accompanying drawing in which:

FIGURE 1 is a schematic, vertical longitudinal sectional view of a cooler embodying a preferred embodiment of the invention; and

FIGURE 2 is an enlarged sectional view of a tube assembly in a chilled water tube bundle of the cooler, and is taken generally along the line II—II in FIGURE 1.

The invention will be described with reference to preferred chilled mediums which are water, and a preferred refrigerant, which is octafluorocyclobutane, commonly referred to as C318 and having a chemical formula C_4F_8. These fluids are particularly preferred because of their relative immiscibility and because they are inherently highly stable and do not tend to decompose or chemically

react with each other or other materials in the system, or cause or promote corrosion or undesirable by-products. Also, this refrigerant has a lower boiling point than water. However, other chilled mediums and refrigerants having these desired chemical and physical properties may be utilized within the scope of this invention.

As illustrated in FIGURE 1 of the drawing, a cooler **11** has a closed outer shell **12** communicating with a suction line **13** to a suitable refrigerant compressor (not shown) for withdrawing vaporized refrigerant from the cooler. A chilled water tube bundle includes a plurality of side-by-side tube bundle assemblies **14** (see also FIGURE 2). Each assembly includes an inner tube **15** connected with an inlet header **15'** for the circulation of primary chilled water received through a supply line **16** from a recirculating water pump **17** having its inlet **18** communicating with a primary chilled water sump **19** in a lower portion of the cooler shell **12**. A chilled water line **20** includes an inlet line **21** with a chilled water pump **22** for circulating secondary chilled water from a load to be cooled and through a header **22'** connecting outer tubes **23**, one about each inner tube **15**. The outer tubes **23** discharge the secondary chilled water through an outlet header **23'** to an outlet line **24** of the chilled water line. As illustrated in the drawing, the outer tubes **23** each envelop a respective one of the inner tubes **15**.

Primary chilled water leaving the inner tubes **15** passes through an outlet header **24'** and into a line **25** to a refrigerant liquid inlet line **26** from a suitable flow metering device (not shown) for passing liquid refrigerant from a high side of the system. The water and liquid refrigerant are mixed and pass into a spray header **27** having suitable spray means such as slots **28** for spraying the mixture across the tube bundle assembly **14**. Thus, the primary chilled water is cooled by direct contact with the liquid refrigerant which vaporizes upon being sprayed into the low pressure cooler shell **12**. The resultant cooled primary chilled water and any droplets of liquid refrigerant which have not vaporized during cooling of the primary chilled water, fall onto the plurality of outer tubes **23** and vaporize as they cool the secondary chilled water passing therethrough. The primary chilled water and residual, unvaporized refrigerant passing across the outer tube bundle **23** collect in the sump **19** for recirculation by the water pump **17** through the inner tube bundle **15** to provide additional cooling of the secondary chilled water by sensible cooling. As illustrated in the drawing, the primary and secondary chilled waters are circulated in opposite directions through their respective tube bundles to obtain an efficient counterflow type sensible heat exchange.

Thus, the secondary chilled water passing through the chilled water line **20** to the load to be cooled is effectively refrigerant free since it is in a circuit entirely separate from the primary chilled water and the refrigerant.

While a preferred embodiment of the invention has been described and illustrated, it will be understood that the invention is not limited thereto since it may be otherwise embodied within the scope of the following claims.

I claim:

1. In a refrigeration system utilizing a refrigerant fluid immiscible with and having a lower boiling point than water, a cooler comprising a cooler shell, means for the withdrawal of refrigerant vapor from said shell, means including a tube bundle assembly having an inner tube for the circulation of primary chilled water and an outer tube about said inner tube for the circulation of secondary chilled water to be cooled by the primary chilled water in said inner tube and passed to a load to be cooled, means for mixing liquid refrigerant fluid and the primary chilled water leaving said inner tube, means for cooling the sec-

ondary chilled water in said outer tube and including means for spraying the mixed fluids on said tube bundle assembly, thereby cooling the primary chilled water by direct contact with the vaporizing refrigerant fluid and vaporizing droplets of liquid refrigerant from said spray as they engage and cool said outer tube bundle, and means for circulating the cooled primary chilled water through said inner tube, whereby the secondary chilled water passing to said load is effectively refrigerant free.

2. In a refrigeration system utilizing a refrigerant fluid immiscible with and having a lower boiling point than water, a cooler comprising means for the circulation in a closed circuit of secondary chilled water to be passed to a load to be cooled, and means for cooling the secondary chilled water by mixing liquid refrigerant fluid and primary chilled water and spraying the mixed fluids into heat exchange relationship with said secondary chilled water while maintaining said secondary chilled water separate from said mixture.

3. In a refrigeration system utilizing a refrigrant fluid immiscible with and having a lower boiling point than water, a cooler comprising means for the circulation in separate circuits and in heat exchange relationship of primary chilled water and secondary chilled water to be passed to a load to be cooled, and means for cooling the secondary chilled water by mixing liquid refrigerant fluid and said primary chilled water and spraying the mixed fluids into heat exchange relationship with said secondary chilled water while maintaining said secondary chilled water separate from said mixture.

4. In a refrigeration system, a cooler comprising means including a tube bundle assembly having a first tube for the circulation of primary chilled water, and a second tube for the circulation of secondary chilled water to be passed to a load to be cooled, said second tube being in heat exchange relationship with said first tube to cool said secondary chilled water, and means for cooling said primary chilled water by direct contact with the refrigerant, whereby the secondary chilled water passing to said load is effectively refrigerant free.

5. In a refrigeration system, a cooler comprising means including a first tube for the circulation of secondary chilled water to be passed to a load to be cooled, means for cooling said secondary chilled water and including a second tube for passing primary chilled water in heat exchange relationship with said first tube, means for cooling said primary chilled water by direct contact with refrigerant to vaporize the refrigerant, and means for passing refrigerant not vaporized by said direct contact with said primary chilled water through said second tube.

6. In a refrigeration system utilizing a refrigerant fluid immiscible with and having a lower boiling point than water, a cooler comprising a cooler shell having a lower portion with a sump for primary chilled water, means for the withdrawal of refrigerant vapor from said shell, means including a tube bundle assembly above and in communication with said sump and having an inner tube in circuit with said sump for the circulation of said primary chilled water from said sump and an outer tube about said inner tube for the circulation of secondary chilled water to be cooled by the primary chilled water in said inner tube and passed to a load to be cooled, means for circulating the primary chilled water in said sump through said inner tube, means for passing the primary and secondary chilled waters through their respective tubes in opposite directions, means for mixing liquid refrigerant fluid and said primary chilled water leaving said first tube, and means for cooling the secondary chilled water in said outer tube and including means for spraying the mixed fluids on said tube bundle assembly, thereby cooling the primary chilled water by direct contact with the vaporizing refrigerant fluid and cooling the outer tube bundle as the cooled primary chilled water passes over the outer tube and into said sump for recirculation through the inner tube, whereby the secondary chilled water passing to said load is effectively refrigerant free.

7. In a refrigeration system utilizing a refrigerant fluid immiscible with and having a lower boiling point than water, a method of providing refrigeration comprising, circulating secondary chilled water to a load to be cooled, mixing liquid refrigerant and primary chilled water, spraying the mixture to cool the primary chilled water by direct contact with the sprayed refrigerant which vaporizes upon cooling the water, and cooling the secondary chilled water by passing the spray into unmixed heat exchange relationship with said secondary chilled water.

8. In a refrigeration system having a cooler with a tube bundle assembly including an outer tube about an inner tube and utilizing a refrigerant fluid immiscible with and having a lower boiling point than water, a method of providing refrigeration comprising, providing a reduced pressure in the cooler to withdraw vapor, circulating secondary chilled water through the outer tube for passage to a load to be cooled, mixing liquid refrigerant and primary chilled water, spraying the mixture to cool the primary chilled water by direct contact with the sprayed refrigerant which vaporizes upon cooling the water, and cooling the secondary chilled water by passing the spray onto the outer tube, and further cooling the secondary chilled water by circulating the cooled primary chilled water through the inner tube.

9. In a refrigeration system having a cooler with a tube bundle assembly including an outer tube about an inner tube and utilizing a refrigerant fluid immiscible with and having a lower boiling point than water, a method of providing refrigeration comprising, providing a reduced pressure in the cooler to withdraw vapor, circulating secondary chilled water through the outer tube for passage to a load to be cooled, mixing liquid refrigerant and primary chilled water, spraying the mixture to cool the primary chilled water by direct contact with the sprayed refrigerant which vaporizes upon cooling the water, and cooling the secondary chilled water by passing the spray onto the outer tube, collecting the cooled primary chilled water, and further cooling the secondary chilled water by circulating the collected primary chilled water through the inner tube in a direction opposite that of the secondary chilled water, whereby the secondary chilled water passing to said load is effectively refrigerant free.

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