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REFRIGERATING APPARATUS

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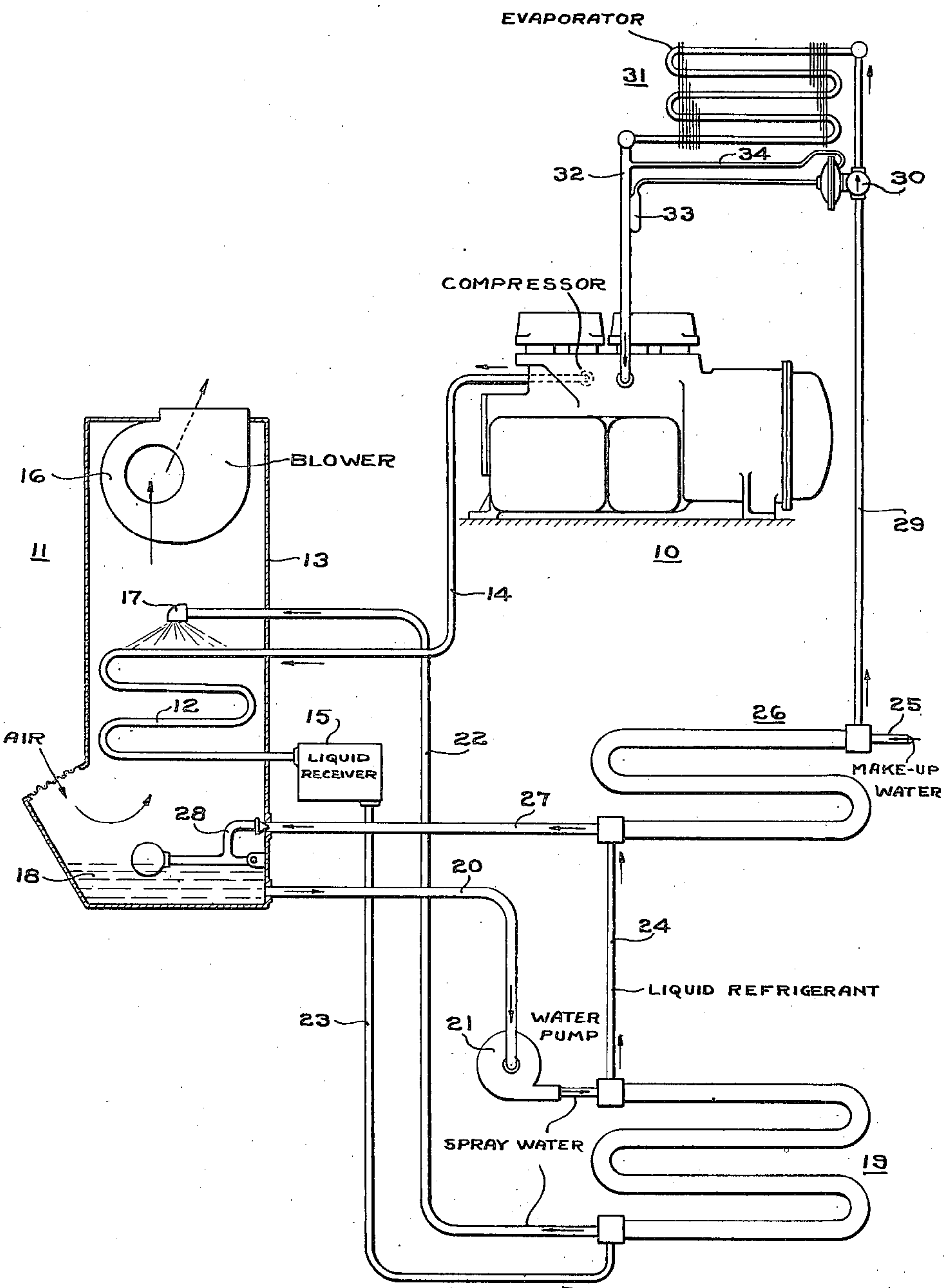

WITNESSES:
R. J. Eisinger
E. H. Lutz

INVENTOR
MILTON KALISCHER.
BY W. A. Steiger
ATTORNEY

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REFRIGERATING APPARATUS

Milton Kalischer, Springfield, Mass., assignor to Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., a corporation of Pennsylvania

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4 Claims. (Cl. 62—115)

My invention relates to refrigerating apparatus, more particularly to a refrigerating system having an evaporative condenser, and it has for an object to provide improved operation of the refrigerating system.

A more particular object is to provide sub-cooling of the condensed refrigerant, that is, cooling of the refrigerant to a temperature below that at which it is condensed.

An evaporative condenser is commonly used in a refrigerating system when it is desired to reduce the quantity of cooling water required. In such type of condenser, the major portion of cooling is effected by the evaporation of water, water being sprayed or otherwise delivered to the surfaces of the condenser and a stream of air passed thereover in which the water is evaporated.

In accordance with my invention, I provide a heat exchanger through which the unevaporated spray water being returned to the spray nozzles is conveyed in heat exchange relation with liquid refrigerant flowing from the liquid receiver to the expansion valve. The liquid refrigerant is thus further cooled to a temperature below that at which it is condensed.

These and other objects are effected by my invention as will be apparent from the following description and claims taken in connection with the accompanying drawing, forming a part of this invention, in which:

The single figure is a diagrammatic view of a refrigerating system embodying my invention.

Referring to the drawing in detail, I show a compressor **10** of the hermetically sealed multi-cylinder type, although it may be of any suitable type known in the art. The evaporative condenser shown at **11** includes a condenser coil **12** mounted in a casing **13**.

A conduit **14** conveys the compressed refrigerant from the compressor to the inlet end of the condenser coil. A liquid receiver **15** is connected to the outlet end of the condenser coil. A blower **16** effects flow of a stream of air through the casing and over the condenser coil, as indicated by the arrows. The air cooled surfaces of the condenser coil are wetted in any suitable manner, as by means of spray nozzles **17**, which direct a spray of water through the air stream and onto the air cooled surfaces. The bottom of the casing **13** serves as a sump **18** for collecting unevaporated spray water draining from the coil.

In accordance with the present invention, I provide a heat exchanger **19** for sub-cooling the liquid refrigerant by means of the unevaporated spray water. The heat exchanger shown on the drawing is of the double tube type, the water flowing through the inner passage formed by the inner tube, and the liquid refrigerant flowing through the outer passage between the inner and outer tubes. The inlet end of the inner passage is connected to the bottom of the sump **18** by a conduit **20** and a pump **21**, while the outlet end is connected to the spray nozzles **17** by a conduit **22**. The inlet end of the outer passage is connected to the bottom of the liquid receiver by a conduit **23** and its outlet end is connected to a conduit **24**. It will be noted that the connections are such as to provide counterflow of the two fluids through the heat exchanger.

Make-up water, to replace water evaporated by or carried away in suspension by the air stream passing through the casing **13**, is supplied from any suitable source, through a conduit **25**. When such water is of substantially lower temperature than the prevailing wet bulb temperature of the air, it may be desirable to use such make-up water for further sub-cooling the liquid refrigerant in a second heat exchanger **26**, also of the double tube type. The inlet end of the inner passage is connected to the supply conduit **25**, and a conduit **27** conveys the make-up water to the sump **18**. A float valve **28** controls the admission of make-up water in response to the water level in the sump, operating to maintain said level constant. The inlet end of the outer passage is connected to the liquid refrigerant conduit **24** and its outlet end is connected to a conduit **29** providing counterflow of the fluids through the heat exchanger. The conduit **29** conveys the liquid refrigerant to an expansion valve **30** and then to an evaporator **31**. The latter is connected at its outlet end to the inlet of the compressor through a suction conduit **32**.

While an expansion valve of any suitable type may be used, the one shown is a thermostatic expansion valve. It is responsive to the temperature and the pressure of the vaporized refrigerant leaving the evaporator, being provided with a thermostatic bulb **33** contacting the suction conduit **32** and a pressure connection **34** with said conduit. Such a valve controls the admission of refrigerant to the evaporator to maintain a constant superheat of the vaporized refrigerant leaving the same, as is well known in the art.

Operation

The refrigerating system operates in the usual manner of such apparatus, the vaporized refrigerant from the evaporator being compressed by the compressor and delivered to the condenser coil **12**, in which it is condensed. The condensed refrigerant is collected in the liquid receiver **15**, the refrigerant system being charged with such quantity of refrigerant that a liquid level intermediate the top and bottom of the liquid receiver is always maintained therein. There is, therefore, a solid stream of liquid refrigerant entering the conduit **23**. From the latter, the liquid refrigerant passes through the outer passage of the heat exchanger 19, the conduit 24, the outer passage of the heat exchanger 26, and the conduit 29 to the expansion valve 30, by which it is expanded and admitted to the evaporator 31. In the latter, it is vaporized by the absorption of heat from the air or other fluid passing over the evaporator. The vaporized refrigerant returns to the compressor for recirculation.

In the evaporative condenser 11, the nozzles 17 direct a spray of water onto the outer surfaces of the condenser coil 12. The heat absorbed from the refrigerant being condensed is dissipated by the evaporation of water in the air stream passing over the wetted surfaces. Most of the heat is dissipated, therefore, as latent heat of vaporization of water rather than as sensible heat of the air.

Considerably more water is sprayed onto the condenser coil surfaces than can be immediately evaporated, so that the surplus drops to and is collected by the sump 18. Such water is at the wet bulb temperature of the air, having been cooled by direct contact therewith. The cooled water in the sump 18 flows through the conduit 20 to the pump 21, by which it is pumped through the inner passage of the heat exchanger 19 and the conduit 22 to the spray nozzles 17. In passing through the passage in the heat exchanger, it flows in heat exchange relation with the liquid refrigerant flowing through the outer passage and thereby serves to cool the liquid refrigerant to a materially lower temperature than that at which it is condensed. The water sprayed from the nozzles 17 is, therefore, at a higher temperature than the wet bulb temperature of the air, since it has absorbed heat from the liquid refrigerant, but it is quickly cooled by direct contact with the air stream, so that it may again serve to assist in the condensing of the compressed refrigerant by partial evaporation.

Cold make-up water flows from the conduit 25, through the inner passage of the heat exchanger 26, the conduit 27 and the float valve 28 to the sump 18, where it mixes with the unevaporated spray water. In the heat exchanger 26, it further sub-cools the liquid refrigerant flowing through the outer passage thereof.

The advantages of my invention are twofold. First, the efficiency of the refrigerating system is improved, since the amount of heat extracted from the liquid refrigerant is increased, thereby increasing its heat absorbing capacity in the evaporator. Secondly, when the evaporator is disposed at a substantially higher elevation than the liquid receiver 15, as shown on the drawing, the pressure in the liquid line adjacent the expansion valve is lower than the pressure in the liquid receiver, due to the gravity head on the liquid. Such reduction in pressure, if the liquid refrigerant is not sub-cooled, results in the formation of vapor bubbles, which interfere with the proper operation of the expansion valve. By my invention, the liquid refrigerant is sufficiently cooled so that the formation of vapor bubbles is avoided, the refrigerant being cooled to a temperature below the lower saturation temperature corresponding to the reduced pressure.

While I have shown my invention in but one form, it will be obvious to those skilled in the art that it is not so limited, but is susceptible of various changes and modifications without departing from the spirit thereof, and I desire, therefore, that only such limitations shall be placed thereupon as are imposed by the prior art or as are specifically set forth in the appended claims.

What I claim is:

1. In refrigerating apparatus, the combination of a compressor, a condenser, a liquid receiver, an expansion device, an evaporator, means for conveying a stream of air over the condenser, means for delivering water to the air cooled surfaces of the condenser and wetting said surfaces sufficiently so that most of the heat from the condenser is dissipated as latent heat of vaporization of water, a heat exchanger having first and second passages for flow of liquid refrigerant and water in heat exchange relation, means for connecting said first passage between the liquid receiver and the expansion device for flow of liquid refrigerant therethrough, and means for conveying water to said delivery means through said second passage in a definite stream at substantial velocity for cooling the liquid refrigerant flowing through said first passage.

2. In refrigerating apparatus, the combination of a compressor, a condenser, a liquid receiver, an expansion device, an evaporator, means for conveying a stream of air over the condenser, means for delivering water to the air cooled surfaces of the condenser, a sump under the condenser for collecting unevaporated water, a heat exchanger having first and second passages for flow of liquid refrigerant and unevaporated water in heat exchange relation, means for connecting said first passage between the liquid receiver and the expansion device for flow of liquid refrigerant therethrough, and means including a pump for conveying unevaporated water from said sump to said delivery means through said second passage in a definite stream at substantial velocity for cooling the liquid refrigerant flowing through said first passage.

3. In refrigerating apparatus, the combination of a compressor, a condenser, an expansion device, and an evaporator all connected in a closed circuit to form a refrigerating system, means for conveying a stream of air over the condenser, means for delivering water to the air cooled surfaces of the condenser, a sump under the condenser for collecting unevaporated water, and means including a pump for effecting flow in a definite stream at substantial velocity of unevaporated water, which has been collected in said sump, from said sump and in heat exchange relation with liquid refrigerant flowing from said condenser to said expansion device and then conveying the same to said water delivery means.

4. In refrigerating apparatus, the combination of a compressor, a condenser, a liquid receiver, an expansion device, and an evaporator all connected in a closed circuit to form a refrigerating system, means for conveying a stream of air over the condenser, means for delivering water to the air cooled surfaces of the condenser, a sump under the condenser for collecting unevaporated water, and means including a pump for effecting flow in a definite stream at substantial velocity of unevaporated water, which has been collected in said sump, from said sump and in heat exchange relation with liquid refrigerant flowing from said liquid receiver to said expansion device and then conveying the same to said water delivery means.

MILTON KALISCHER.