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VARIABLE TEMPERATURE REFRIGERATION

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Fig. 1.

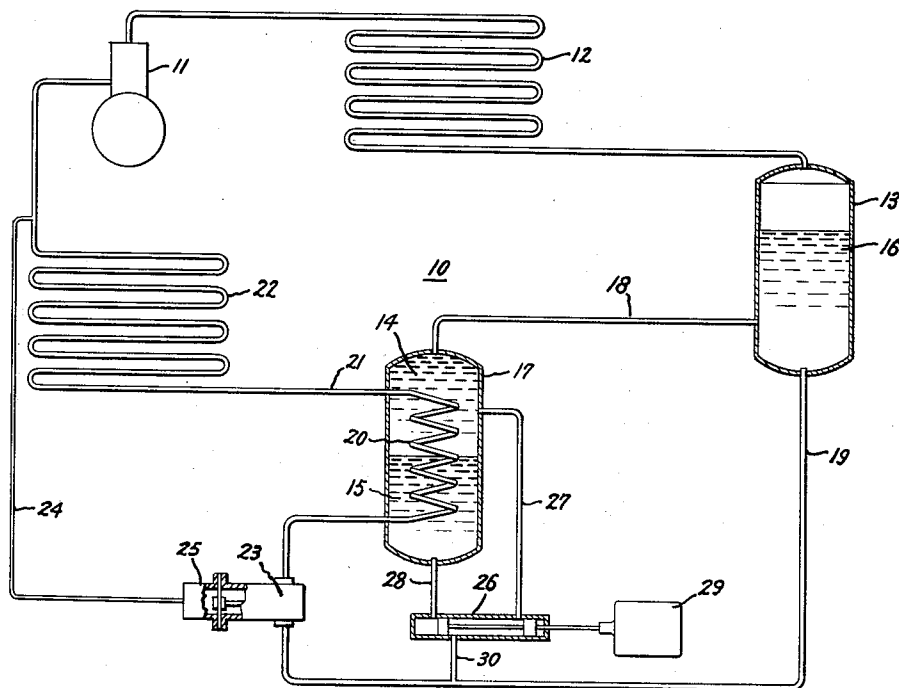
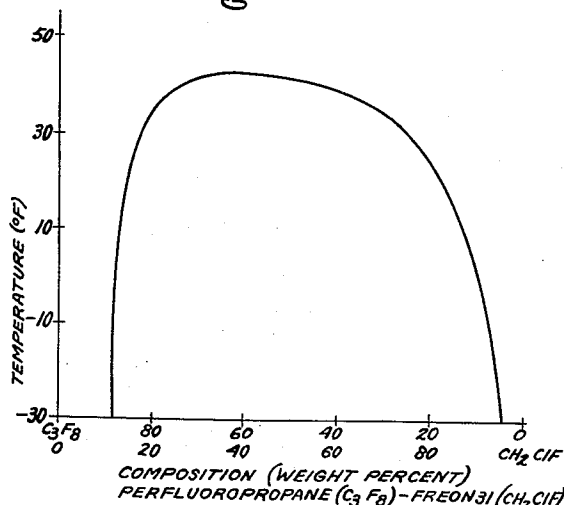


Fig. 2.



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## VARIABLE TEMPERATURE REFRIGERATION

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3 Claims. (Cl. 62—174)

This invention relates to refrigeration systems and specifically to a method and apparatus to secure variable temperature levels in such systems.

A refrigeration system, which is capable of providing variable temperature levels, is desirable in heat pump construction and in commercial and domestic refrigerators. It is desirable that a reverse refrigeration system or heat pump employ a selectively variable refrigerant mixture to match capacity with load over a wide variation in the evaporator temperatures. A single refrigerant system will not match capacity with load unless the load is constant.

Accordingly, it is an object of my invention to provide a new and improved refrigeration system in which a pair of low temperature immiscible refrigerants with different volatility and density characteristics are employed.

It is another object of the invention to provide a refrigeration system which selectively circulates a refrigerant mixture of variable composition in response to the load upon the system.

It is another object of the invention to provide a refrigeration system in which a pair of liquid receivers are employed.

It is a further object of the invention to provide a novel method of refrigeration in which a pair of low temperature immiscible refrigerants are separated and selectively mixed in the refrigeration system to produce variable temperature levels of refrigeration.

In carrying out my invention in one form, a pair of low temperature immiscible refrigerants are selectively mixed and circulated in a refrigeration system to provide variable temperature levels of refrigeration.

These and various other objects, features and advantages of the invention will be better understood from the following description taken in connection with the accompanying drawing in which:

Fig. 1 is a schematic view of one form of a refrigeration system which embodies my invention; and

Fig. 2 is a solubility graph determined at the system pressure of a perfluoropropane ( $C_3F_8$ ) and "Freon 31" ( $CH_2ClF$ ) solution in which composition in weight percentage is plotted against the temperature in degrees Fahrenheit.

In Fig. 1 of the drawing, a refrigeration system, which may be used in heat pump construction or in commercial or domestic refrigerators and which is indicated generally at 10, comprises a compressor 11 which communicates on its high pressure side with a condenser 12. Condenser 12 is connected to a liquid running receiver 13 in which a pair of low temperature immiscible refrigerants 14 and 15 coexist in a mixture 16 to form one liquid phase of desired composition. A liquid storage receiver 17 is filled completely with additional amounts of essentially pure refrigerants 14 and 15 in two separate liquid phases immiscible one with the other. A tube 18 connects receiver 13 to receiver 17 to maintain condenser pressure in receiver 17 and to replenish refrigerants 14 and 15 from refrigerant mixture 16 in receiver 13. The main-

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tenance of receivers 13 and 17 at condenser pressure eliminates a liquid level control therebetween.

Refrigerant mixture 16 is circulated from receiver 13 through a tube 19 to a heat exchange coil 20 which is positioned within receiver 17. A tube 21 connects coil 20 to an evaporator 22 which communicates with the low pressure side of compressor 11. Coil 20 carries mixture 16 expanded to a low temperature to cool immiscible refrigerants 14 and 15 in receiver 17 to approximately the evaporator temperature of the refrigeration system. An expansion valve 23 of a conventional type which is operated by a pressure tube 24 and diaphragm 25 is positioned in tube 19. A temperature-operated or thermostatic valve or sections of capillary tubing may be employed as the expansion device.

A three-way, three-position valve 26 controls a pair of outlets 27 and 28 which communicate with refrigerants 14 and 15 in receiver 17. A load sensing and sequence control device 29 of any conventional construction is provided to selectively operate valve 26 in response to the system load. A tube 30 connects valve 26 to tube 19 between receiver 13 and expansion valve 23. If it is desired, tube 30 may be connected to tube 19 at the low pressure side of valve 23.

Low temperature immiscible refrigerants 14 and 15, which have different volatility and density characteristics are selectively mixed and circulated through the refrigeration system in response to the load thereon. It is important that each of the refrigerants which is selected for circulation in the system has a different density from the other refrigerant and exhibits insolubility in the other refrigerant of the pair at or below customary evaporator temperatures to provide a separation of the refrigerants into two layers in storage receiver 17. The following pairs of refrigerants, which exhibit different volatilities, solubilities and densities and which possess immiscibility at customary evaporator temperatures, are given as examples of suitable refrigerant combinations to be employed in a variable temperature system: perfluoropropane ( $C_3F_8$ ) and methyl chloride ( $CH_3Cl$ ), perfluoropropane ( $C_3F_8$ ) and "Freon 31" ( $CH_2ClF$ ), perfluorobutane ( $C_4F_{10}$ ) and "Freon 21" ( $CHCl_2F$ ), perfluorobutane ( $C_4F_{10}$ ) and methyl chloride ( $CH_3Cl$ ), "Freon 115" ( $C_2F_5Cl$ ) and sulfur dioxide ( $SO_2$ ), perfluoropropane ( $C_3F_8$ ) and methyl bromide ( $CH_3Br$ ), "Freon 115" ( $C_2F_5Cl$ ) and methylene chloride ( $CH_2Cl_2$ ), perfluorobutane ( $C_4F_{10}$ ) and methylene chloride ( $CH_2Cl_2$ ), and perfluorobutane ( $C_4F_{10}$ ) and ethyl chloride ( $C_2H_5Cl$ ).

In the operation of the refrigeration system in Fig. 1, the pair of refrigerants 14 and 15, which form a refrigerant mixture 16 in liquid running receiver 13, are selectively mixed and circulated in the system. Three-way, three-position valve 26 is shown in open position for outlet 27 and tube 30 and in closed position for outlet 28. Compressor 11 pumps refrigerant mixture 16 through condenser 12 to liquid running receiver 13. Refrigerant mixture 16 is then circulated through tube 19, expansion valve 23, coil 20, tube 21, and evaporator 22 to the inlet side of compressor 11. When outlet 27 is opened to tube 30, refrigerant 14 is added to refrigerant mixture 16 which is circulating in the system. An equal volume of refrigerant mixture 16 is simultaneously conveyed from receiver 13 to receiver 17 through tube 18. While complete liquid miscibility may exist at liquid running receiver temperatures, i. e., 65° F. or higher, essentially complete immiscibility exists at temperatures equal to or less than evaporator temperatures. Coil 20 in receiver 17 maintains the temperature therein at evaporator temperature to separate refrigerant mixture 16 into refrigerants 14 and 15 in two immiscible phases.

When the load on the system changes, it activates load sensing and sequence control device 29 to close out-

let 27 and to open outlet 28 whereby refrigerant 15 is added to refrigerant mixture 16 in the same manner as refrigerant 14. The composition of refrigerant mixture 16 is determined by the system load through a load sensing and sequence control device 29 which operates valve 26 to admit additional essentially pure refrigerant 14 or 15 to the system. It should be noted, however, that at relatively high temperatures refrigerants 14 and 15 in the storage receiver 17 may be partly in solution with each other such that, in the preliminary operation of this system, either of the refrigerants from storage receiver 17 that may be added to the system would not be in substantially pure form. As the temperature in the evaporator is reduced, the temperature in the storage receiver is also reduced through the action of the refrigerant expanding through coil 20 in storage receiver 17. Therefore, refrigerants 14 and 15 progressively separate until they are in substantially pure form. Thereafter, capacity modulation may be attained for high or low capacity by circulating either refrigerant 14 or 15 in their substantially pure form through the system. The volume of refrigerant mixture 16 remains constant through the simultaneous addition to and withdrawal from the circulating refrigerant mixture. The refrigeration system circulates either essentially pure refrigerant 14 or 15 or a refrigerant mixture 16 of any desired composition.

In Fig. 2, a solubility graph is shown in which composition in weight percentage of a perfluoropropane ( $C_3F_8$ ) and "Freon 31" ( $CH_2ClF$ ) mixture is plotted against the temperature in degrees Fahrenheit. Such a refrigerant mixture is generally miscible above about 45° F. and immiscible below this temperature. The temperature of storage receiver 17 in Fig. 1 is maintained at or below evaporator temperature to maintain refrigerants 14 and 15 in two immiscible phases. If the temperature of the refrigerants in the receiver 17 is assumed to be 20° F. for purposes of illustration, one immiscible refrigerant phase is composed of about 86% by weight of perfluoropropane ( $C_3F_8$ ) and about 14% by weight of "Freon 31" ( $CH_2ClF$ ). The other refrigerant phase is about 84% "Freon 31" and about 16% perfluoropropane.

As will be apparent to those skilled in the art, the objects of my invention are attained by the use of a pair of immiscible refrigerants with different characteristics which are separated and then selectively mixed and circulated in a refrigeration system to provide variable temperature levels of refrigeration and refrigeration capacities.

While other modifications of this invention and variations of apparatus which may be employed in the scope of the invention have not been described, the invention is intended to include all such as may be embraced within the following claims.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A refrigeration system comprising a compressor, a condenser connected in fluid flow relation to said compressor, a liquid receiver maintained at condenser pressure and connected in fluid flow relation to said condenser, a supply of low temperature immiscible refrigerants in said receiver, an evaporator, a conduit connecting said receiver to said evaporator, means connecting said evaporator to said compressor in fluid flow relation, a storage receiver maintained at condenser pres-

sure, a supply of low temperature immiscible refrigerants in two separate liquid layers within said storage receiver, said storage receiver arranged to receive refrigerant from said liquid receiver, said conduit connecting said liquid receiver to said evaporator being positioned partially within said storage receiver in heat exchange relationship to the refrigerants therein, and means to selectively add one of the refrigerants from the storage receiver to the system.

2. A refrigeration system comprising a compressor, a condenser connected in fluid flow relation to said compressor, a liquid receiver maintained at condenser pressure and connected in fluid flow relation to said condenser, a supply of low temperature immiscible refrigerants in said receiver, an evaporator, a conduit connecting said receiver to said evaporator, means connecting said evaporator to said compressor in fluid flow relation, a storage receiver maintained at condenser pressure, a supply of low temperature immiscible refrigerants in two separate liquid layers within said storage receiver, said storage receiver connected in fluid flow relation to said liquid receiver, said conduit connecting said liquid receiver to said evaporator being positioned partially within said storage receiver in heat exchange relationship to the refrigerants therein, control means connected to each layer of refrigerant in said storage receiver and responsive to the load upon the system to selectively add a refrigerant from the said storage receiver to circulate through the system, and means to expand the circulating refrigerant in the said conduit partially positioned within said storage receiver to reduce the temperature of the refrigerants therein.

3. A refrigeration system comprising a compressor, a condenser connected in fluid flow relation to said compressor, a liquid receiver maintained at condenser pressure and connected in fluid flow relation to said condenser, a supply of low temperature immiscible refrigerants in said receiver, an evaporator, a conduit connecting said receiver to said evaporator, means connecting said evaporator to said compressor in fluid flow relation, a storage receiver maintained at condenser pressure, a supply of low temperature immiscible refrigerants in two separate liquid layers within said storage receiver, said storage receiver connected in fluid flow relation to said liquid receiver, said conduit connecting said liquid receiver to said evaporator having a heat exchange coil portion, said coil being positioned within said storage receiver, means for circulating the refrigerant in the running receiver through said system, means for expanding the refrigerant circulating through said system through the said coil positioned in said storage receiver to vary the solubility of the refrigerants therein, and means to selectively add one of the refrigerants in said storage receiver to the refrigerant circulating in the system.

#### References Cited in the file of this patent

##### UNITED STATES PATENTS

|           |              |               |
|-----------|--------------|---------------|
| 1,735,995 | Davenport    | Nov. 19, 1929 |
| 2,255,585 | Hubacker     | Sept. 9, 1941 |
| 2,277,138 | Newton       | Mar. 24, 1942 |
| 2,483,842 | Philipp      | Oct. 4, 1949  |
| 2,682,756 | Clark et al. | July 6, 1954  |