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DUAL TEMPERATURE REFRIGERATION

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Fig. 1.

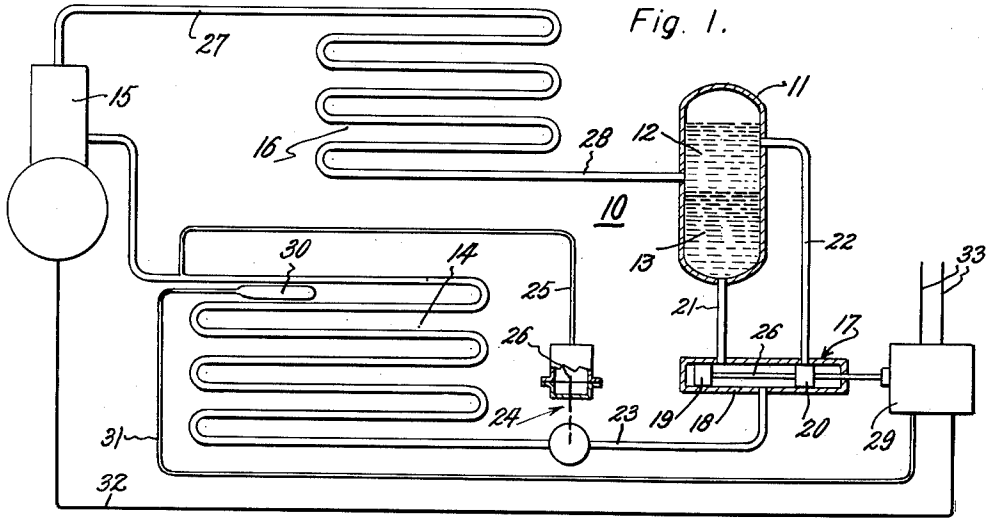
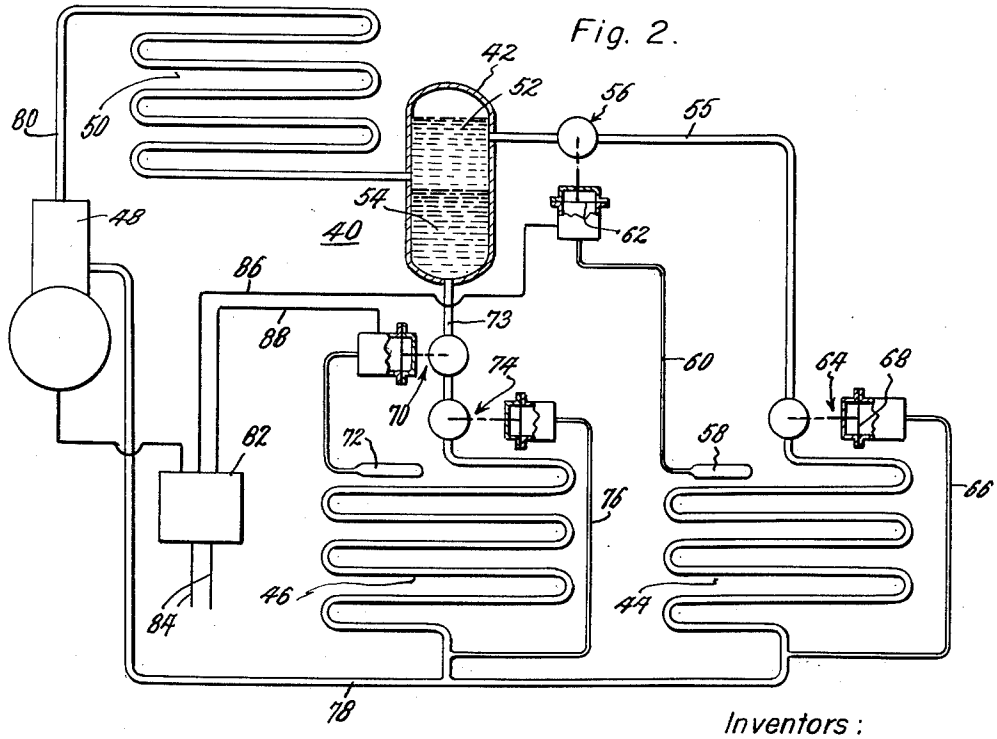


Fig. 2.



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DUAL TEMPERATURE REFRIGERATION

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3 Claims. (Cl. 62—114)

This invention relates to refrigeration systems and more particularly to a method and apparatus to obtain dual temperature levels or variable capacity refrigeration in such systems. This application is a conintuation-in-part of our copending application, Serial No. 440,028, now abandoned, filed June 29, 1954 and assigned to the same assignee as the present invention.

Refrigeration systems which are capable of providing dual temperature levels and/or variable capacity refrigeration, are desirable not only in commercial applications but also in the domestic field of household refrigerators, freezers, and the so-called reverse refrigeration system or heat-pump. A particular desirable feature in refrigeration systems in general is the employment of the compressor at its full rated horsepower for optimum results. Also, when a heat pump is employed, it is a desirable feature to maintain a constant specific volume of the compressor suction vapor in spite of comparatively wide variations in evaporator temperatures. The ordinary refrigeration system employs but a single refrigerant and will not provide the operating conditions as heretofore mentioned.

A proposed method of overcoming operating difficulties and low efficiencies of a single refrigerant system is a refrigeration system which employs a plurality of specific refrigerants, these refrigerants being employed in a selective manner, each providing a different level of refrigerant or coacting to provide intermediate levels of refrigeration. The many and various problems associated with a refrigeration system employing a plurality of refrigerants have rendered these systems rather bulky, unwieldy, and uneconomical for general applications. The most important problem relates to the separability of the refrigerants when the refrigerating machine is in general use. Separability being the key item, considerable attention has been given to separation in the form of mechanical devices such as particular valve arrangements, distilling apparatus, etc. or various adsorbers such as silica gel, salt solutions and the like. The general uncertainty and inefficiency of these means have prevented full scale development of plural refrigerant machines. Therefore, a refrigerant system which includes a plurality of different refrigerants capable of separability without the need of additional or complicated devices would provide a new and novel form of refrigerating machine overcoming the problems as heretofore mentioned. In this respect it has been discovered that a pair of, or a plurality of refrigerants which are insoluble one in the other, when employed with comparative systems provides satisfactory results.

Accordingly, it is an object of this invention to provide particular plural refrigerants having insolubility characteristics, one with the other.

It is another object of this invention to provide a refrigeration system employing a plurality of insoluble refrigerants.

It is a further object of this invention to provide a dual temperature or variable capacitor refrigeration system which selectively circulates a particular refrigerant in response to a load upon the system.

It is another object of this invention to provide a refrigeration system in which different temperature levels are maintained in separate evaporators.

It is still another object of this invention to provide a

novel method of refrigeration in which a pair of insoluble refrigerants are effectively separated and selectively circulated in a system.

In carrying out our invention in one form, a pair of refrigerants substantially insoluble, one with the other, are selectively circulated in a refrigeration system to provide a variable capacity refrigeration system wherein the mutual insolubility of the refrigerants is the means providing separability and dual temperature levels.

These and other objects feature the advantages of the invention and will be better understood from the following description taken in connection with the accompanying drawings in which:

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

FIG. 2 is a schematic view of a second form of a refrigeration system which embodies our invention.

The principle of this invention resides in the employing of two refrigerants which co-exist in a liquid receiver and which exhibit the characteristics of partial or preferably substantially complete insolubility in the liquid phase at the temperatures commonly available in the liquid storage containers of refrigerating machines. Variation from substantially complete insolubility is governed by the requirement that the refrigerants must form two separate layers or phases due to insolubility and immiscibility under the operable conditions of the refrigeration system. A further characteristic is that the desirable vapor pressure for each liquid phase be in the range of vapor pressures common to refrigerants, but the two refrigerants must be sufficiently different in vapor pressure that the desirable different temperatures are obtained when the liquid phases evaporate at the same pressure. It is of primary importance that the refrigerants be mutually insoluble in order for efficient separation to take place. The term "mutually insoluble" as employed in this invention must be distinguished from those relative terms such as intermingling, adapted to float upon, and different densities. Refrigerants of different densities may be soluble, one with the other, to a substantial degree such that separation by mere differences in densities would not likely occur or require an inordinately long period of time, so that such a system would be unworkable. Refrigerants which are basically insoluble, one with the other, form the basis of the invention. Progressing from the basic insolubility, the added characteristics of different densities and different volatilities etc. render the machine more efficient, but only when the refrigerants are basically insoluble of a high degree originally.

It has been discovered that certain refrigerants meet the insolubility requirements and perform well in refrigerating systems hereinafter described. Such refrigerants, by way of example, include:

"Freon 12" (CCl_2F_2) and ammonia (NH_3)
"Freon 114" ($C_2F_4Cl_2$) and ammonia (NH_3)
Perfluorocyclobutane (C_4F_8) and ammonia (NH_3)
"Freon 115" (C_2F_5Cl) and ammonia (NH_3)
Perfluoropropane (C_3F_8) and ammonia (NH_3)
Perfluorocyclobutane (C_4F_8) and sulfur dioxide (SO_2)
Perfluorocyclobutane (C_4F_8) and methyl bromide (CH_3Br)
Perfluorocyclobutane (C_4F_8) and methylene chloride (CH_2Cl_2)
Perfluoropropane (C_3F_8) and ethyl chloride (C_2H_5Cl)
Perfluoropropane (C_3F_8) and methylene chloride (CH_2Cl_2)

These refrigerants have been found to be mutually insoluble, one with the other, and to further provide different densities and different volatilities.

The insolubility characteristics of the following refrigerants are given by way of example and not as limita-

tions for insoluble refrigerants which may be employed in plural refrigeration systems:

Example 1.—"Freon 115" and (NH_3)

A vessel of approximately 75 milliliters in volume was evacuated at to about 0 p.s.i. at a temperature of near 30° C. Approximately 25 milliliters of "Freon 115" together with 25 milliliters of ammonia (NH_3) were condensed in the vessel. The final pressure was about 312 p.s.i.g. Condensation was observed to be separate with two liquid phases forming as further condensation occurred.

Example 2.—(CH_3Cl) (C_3F_8) (CH_3Br)

In the vessel of Example 1 and under the same conditions, approximately 25 milliliters of CH_3Cl, 25 milliliters C_3F_8, and about 5 milliliters CH_3Br were condensed in the vessel to a final pressure of about 135 p.s.i.g. Separation of CH_3Cl_2 and C_3F_8 was observed to occur upon condensation forming two liquid phases.

Exemplary refrigeration systems employing the aforementioned refrigerants to the best advantage are illustrated in FIGS. 1 and 2. Referring now to FIG. 1, there is disclosed a refrigeration system generally indicated by the numeral **10** having application to general refrigeration systems and more particularly to the heat pump type of refrigeration system. The compressor of this system may operate at full rated horsepower by the selection of a refrigerant to maintain approximately constant specific volume in the compressor suction vapor in spite of comparatively wide variations in evaporator pressures. Seasonal changes in the demand upon the heat pump when used for domestic purposes makes this dual refrigerant invention particularly pertinent to this application. The primary components of the refrigeration system are shown as the receiver or reservoir **11** for a pair of refrigerants **12** and **13**, evaporator **14**, compressor **15**, and condenser **16**. Receiver **11** contains a plurality of refrigerants, for example, two, **12** and **13**, which, in a preferred form of this invention, have different densities and volatility characteristics together with mutual insolubility as previously described, and taken from the above group of refrigerants or other refrigerants meeting the same requirements. The refrigerants are selectively circulated through the system by means of a valve assembly **17**. Valve assembly **17** may be any generally well known three-way valve common to the art and in this exemplary application includes a piston cylinder type valve having a cylinder **18** in which a pair of pistons **19** and **20** interconnected by means of a shaft **26**, are adapted for reciprocatory movement. Valve **17** may be a pair of one way on-off valves to provide a different refrigerant at different times or alternately by the piston arrangement provide the same result. In the illustrated form of this invention, the pistons of valve **17** are arranged such that at intermediate levels of refrigeration a mixture of refrigerants may be circulated through the system. Valve **17** is connected to receiver **11** by means of a pair of conduits **21** and **22**, each conduit being, in turn, connected to the receiver in such a manner that the connecting tubes **21** and **22** will withdraw one or the other of the refrigerants **12** and **13** in the receiver since the refrigerants therein are in separate phases or layers. Operation of valve **17** therefore provides a flow of refrigerants through a conduit **23** into the evaporator **14**. The refrigerant flowing through the conduit **23** is expanded into the evaporator **14** by means of an expansion valve **24** located in the conduit **23** before the evaporator **14**. While many well-known expansion devices may serve equally well in this invention, in the exemplary application as illustrated, valve **24** is a common pressure operated needle type expansion valve. This type of valve maintains a constant pressure in evaporator **14** by being connected to the low pressure side of the evaporator **14** through a further pressure conduit **25**. Pressure in conduit **25** acts upon a diaphragm assembly **26** in valve **24** to vary a needle setting on its seat to in turn control the expansion of refrigerant through the evaporator and to maintain the pressure in the evaporator constant. After the refrigerant has expanded in the evaporator **14**, it is compressed by compressor **15** to flow through conduit **27** into the condenser **16**. In condenser **16**, it is important to note that by means of the particular refrigerants employed in this invention, that is, by refrigerants which are mutually insoluble, condensation takes place separately, i.e., that separation of refrigerants begins in the condenser and the refrigerants return to receiver **11** through conduit **28**. If at this point, refrigerants are employed having merely different densities or merely different boiling points or those that are soluble, separation will not occur within the period of time that normal refrigeration may again call for a specific refrigerant, and accordingly, where circumstances require one particular refrigerant to be circulated, a mixture of refrigerants may flow through the system and the system will not attain the desired temperature. Such a set of circumstances will aggrevate the conditions such that separation will then possibly never occur while the refrigerator is in operation. Conduit **28** is connected to the receiver at the approximate mid point of the refrigerant layers such that each returning refrigerant need move only a minimum distance to its layer.

Valve **17** is actuated by means of a load sensing device **29** which is employed to receive a signal with respect to the load on the system and to transmit the signal to the system by means of valve **17** operation. The signal is provided by a thermal bulb or sensing element **30** which is usually fluid filled and connected by a capillary tube **31** to load sensing device **29**. It is to be understood that various sensing elements may be employed to transmit pressure variations, dependent on the temperature of the space cooled by the evaporator, by means of electrical signals. The device **29** is of the integrated control variety, well known in the art and similar to the domestic refrigerator control where the operator may control the level of refrigeration or the on off operation of the compressor and the system as indicated by electrical lead **32** connecting the compressor **15** to the device **29**. The inner mechanism of device **29** is also common in the art as containing the required mechanical or electrical devices for the switches, their actuation, or varying means. In the application as illustrated in FIG. 1, device **29** is shown connected to a source of power, not illustrated, by means of electrical leads **33**. Accordingly, valve **17** may be operated by an electric motor, solenoid, or other means.

An exemplary operation of the refrigeration system illustrated in FIG. 1, is as follows: In the receiver **11**, two of the refrigerants mentioned in this invention **12** and **13** or refrigerants having similar characteristics reside in two separate levels. With the pistons **19** and **20** of valve **17** in their indicated position, a first refrigerant **13** flows through valve **17**, through expansion valve **24** to the evaporator **19** for a particular capacity refrigeration or for one level of refrigeration. Thereafter the refrigerant vapor is compressed by compressor **15** condensed in condenser **16** where initial separations occurs and returns to receiver **11** for final stages of separation. When a further level of refrigeration is called for or a change of capacity is required, pistons **19** and **20** are moved to the right so that the piston **19** covers its respective inlet or conduit **21** and piston **20** uncovers its respective inlet or conduit **22** so that a different refrigerant **12** now flows through the three-way valve **17** through evaporator **14** to be compressed by compressor **15**, condensed by the condenser **16** for the initial stages of separation and then returns to receiver **11** for the final stages of separation. It is accordingly understood that by means of this system, together with the particularly described refrigerants, that separation continues to take place with repeated operations without further atten-

tion, and that the system may operate continuously without fouling.

In FIG. 2, a modified form of refrigeration system, which may be embodied in domestic refrigerators to prowide different tempertaures in the freezer and food storage compartments, and which is indicated generally at 40 comprises a receiver 42, a first evaporator 44, a second evaporator 46, a compressor 48, and condenser 50. Within receiver 42, a pair of refrigerants 52 and 54 having characteristics as described for the refrigerants in system of FIG. 1 reside in two different levels. From the level of refrigerant 52, a conduit 55 leads to the evaporator 44. In the conduit 55, there is positioned a valve 56 which may be operated by means well known in the art. In this exemplary application valve 56 is temperature controlled through a temperature sensor 58 which transmtis a temperature signal by an electrical or pressure line 60 to the valve operating mechanism. As an example, or a pressure signal temperature sensor, valve 56 includes a diaphram 62 on one side of which the pressure from the differences in temperature acting on fluid filled bulb 58 acts to open or close valve 56 so that refrigerant 52 may flow into the evaporator 44. In order to maintain a constant pressure in the evaporator, a further conventional expansion valve 64 is positioned in the conduit 54 just prior to evaporator 44. Valve 64 is similar in its components and operating characteristics to valve 24 of FIG. 1. A pressure line 66 leads from the low pressure side of evaporator 44 to the valve operating mechanism 68 of valve 64 and the variation of pressure serves to position a needle on its seat to maintain a proper pressure in the evaporator. From the second level of refrigerant 54 in the receiver, a valve 70 together with a temperature sensor 72, each similar to valve 56 and temperature sensor 58 is positioned in a conduit 73 leading from the refrigerant level 54 to the evaporator 46. A further valve 74 and conduit 76 are similar to valve 64 and conduit 66 for maintaining constant pressure in the evaporator 46. The conduit 78 serves to connect each of the evaporators 44 and 46 to compressor 48 such that the refrigerants may be compressed by the compressor to flow through conduit 80 to the condenser 50 for condensation and initial separation and return to the reservoir 42 for final separation. It may be seen that the invention as illustrated in FIG. 2 will permit the temperature level in each evaporator to be constant and determined solely by the properties of the refrigerant in the particular layer which is admitted to that evaporator. The constancy of the temperature in the evaporator will be assured at a given suction pressure, and the control required to obtain this situation is simple. This invention permits the use of different temperature levels alternatively in the same evaporators through the choice of one or two layers available by the setting of valves. Accordingly, in any given situation where a temperature level, for example, in evaporator 44 rises above a predetermined limit, the valve 56 is operated to permit a refrigerant to flow through the evaporator 44 to reduce the temperature. By the same token if the temperature in evaporator 46 rises above expressed limits, valve 70 is operated and a second refrigerant flows to the evaporator to maintain a given temperature therein. A centralized or integrated control well known in the art of domestic refrigeration, is shown as numeral 82 and is the control means by which an operator changes the various settings required in refrigeration systems including on and off operation. Control 82 is connected to a source of power, not shown, by means of electrical leads 84 and control 82 is further connected to valves 56 and 70 by means of leads 86 and 88 such that the operator may control temperature settings and valve response.

As will be apparent to those skilled in the art, the objects of our invention are attained by the use of a pair of mutually insoluble refrigerants preferably with different volatility and density characteristics, and which are circulated through a refrigeration system to provide dual temperature level and/or variable capacity refrigeration. It is required only that the refrigerants be insoluble and therefore separable at some time before entering the evaporator.

It is to be noted that a wide range of proportion of the various refrigerants may be employed so long as the proportion is within the range of insolubility. A very small proportion of one of the refrigerants may tend to permit it to become soluble, contribute to the inefficiency of the system or require an exceptionally large receiver.

While solubility is influenced in a varying manner with respect to different refrigerants and proportions a 50 to 75 percent mixture has been found to give satisfactory results. Although it is contemplated that various mixtures may be provided for predetermined circumstances.

While other modifications of this invention and variations thereof 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 we claim as new and desire to secure by Letters Patent of the United States is:

1. In a refrigeration system including a compressor, a condenser and an evaporator connected in fluid flow relationship, a pair of substantially mutually insoluble refrigerants with different density and volatility characteristics in said system, said pair of refrigerants being taken from the group consisting of:

"Freon 12" (CCl_2F_2) and ammonia (NH_3)
"Freon 114" ($C_2F_4Cl_2$) and ammonia (NH_3)
perfluorocyclobutane (C_4F_8) and ammonia (NH_3)
"Freon 115" (C_2F_5Cl) and ammonia (NH_3)
perfluoropropane (C_3F_8) and ammonia (NH_3)
perfluorocyclobutane (C_4F_8) and sulfur dioxide (SO_2)
perfluorocyclobutane (C_4F_8) and methyl bromide (CH_3Br)
perfluorocyclobutane (C_4F_8) and methylene chloride (CH_2Cl_2)
perfluoropropane (C_3F_8) and ethyl chloride (C_2H_5Cl)
perfluoropropane (C_3F_8) and methylene chloride (CH_2Cl_2),

and means to circulate said refrigerants through said evaporator.

2. In a refrigeration system the combination comprising a compressor, condenser, and liquid receiver connected in fluid flow relationship, a pair of mutually insoluble refrigerants having different densities and volatility characteristics in said receiver, said refrigerants being taken from the group consisting of:

"Freon 12" (CCl_2F_2) and ammonia (NH_3)
"Freon 114" ($C_2F_4Cl_2$) and ammonia (NH_3)
perfluorocyclobutane (C_4F_8) and ammonia (NH_3)
"Freon 115" (C_2F_5Cl) and ammonia (NH_3)
perfluoropropane (C_3F_8) and ammonia (NH_3)
perfluorocyclobutane (C_4F_8) and sulfur dioxide (SO_2)
perfluorocyclobutane (C_4F_8) and methyl bromide (CH_3Br)
perfluorocyclobutane (C_4F_8) and methylene chloride (CH_2Cl_2)
perfluoropropane (C_3F_8) and ethyl chloride (C_2H_5Cl)
perfluoropropane (C_3F_8) and methylene chloride (CH_2Cl_2),

said refrigerants residing in two layers in said receiver, a first evaporator connected in fluid flow relationship in said system and to one of said layers, a second evaporator connected in fluid flow relationship in said system and to the other of said layers, and means to circulate said refrigerants through their respective evaporators.

3. In a variable capacitor refrigeration system wherein the capacity is varied by regulating the proportions of a mixture of a plurality of refrigerants which are caused

to be circulated through the system, a method of operating such a system comprising utilizing at least a pair of refrigerants which are substantially completely insoluble in the liquid phase at a predetermined temperature in the condenser and in a storage part of said system, said refrigerants capable of forming two separate phases due to insolubility characteristics under the operable conditions of the system, said two refrigerants having different vapor pressures so that different temperatures are obtained when the liquid phase evaporates at the same pressure with each of said refrigerants operating as a refrigerant medium, circulating a mixture of said refrigerants through the said system the proportion of which is dependent upon system refrigerant load, condensing said refrigerants at a temperature where the said refrigerants are insoluble with respect to each other, utilizing

insolubility characteristics of said refrigerants during condensation thereof from the vapor stage for separation, and storing the refrigerants in a receiver.

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