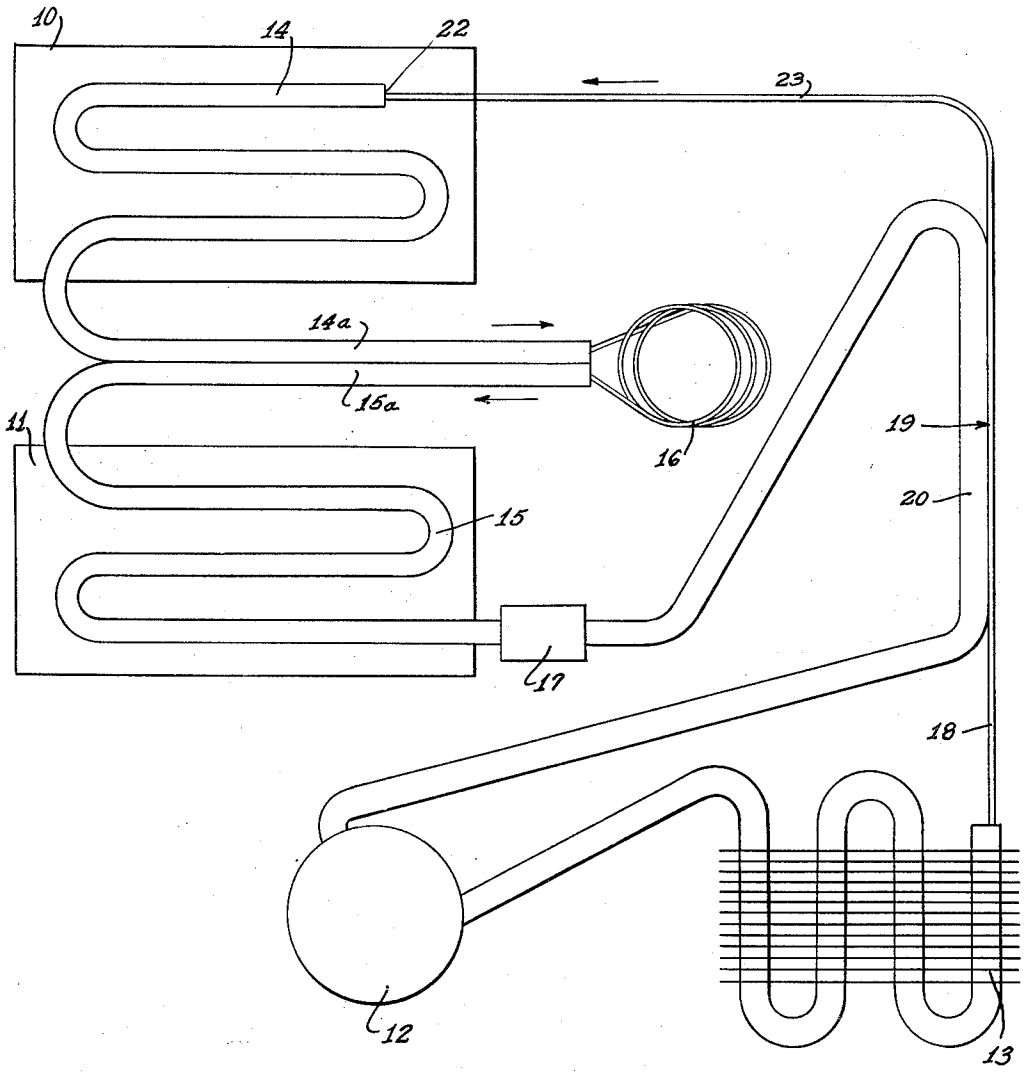
Nov. 18, 1958 H. A. WHITESEL 2,860,494

MULTIPLE TEMPERATURE REFRIGERATION SYSTEM

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Fig. 1



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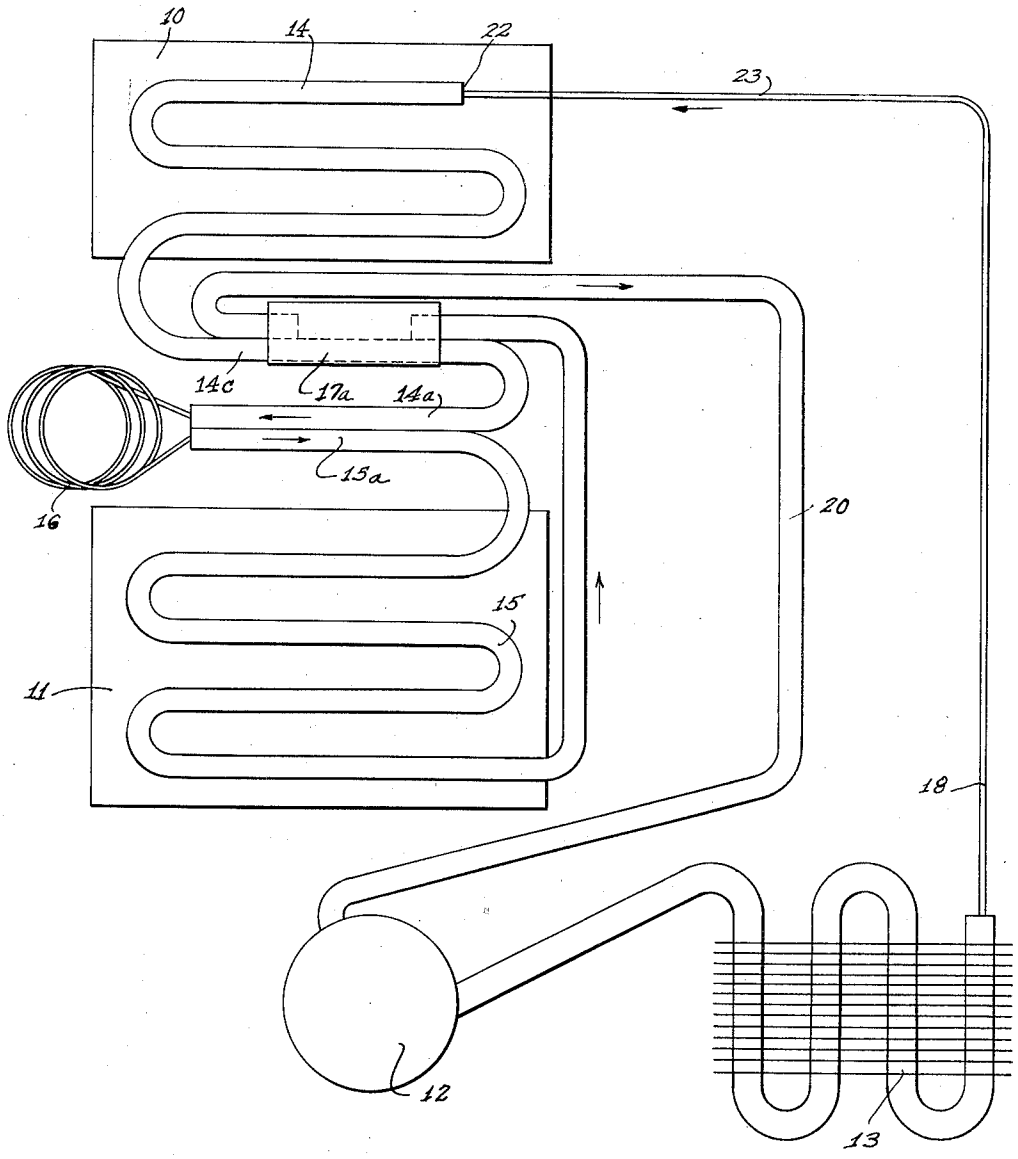
by Kill, Sherman, Morris, Gross & Simpson Attys.

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MULTIPLE TEMPERATURE REFRIGERATION SYSTEM

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Fig. 2



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2,860,494

MULTIPLE TEMPERATURE REFRIGERATION SYSTEM

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7 Claims. (Cl. 62—513)

The present invention relates to refrigeration apparatus and it is, more particularly, concerned with the provision of a refrigerating system capable of producing accurately controlled multiple temperatures in a plurality of separate refrigerating compartments.

As those familiar with the art of refrigeration as applied to domestic appliances such as household freezers, refrigerators, and air conditioning units, are aware there has been an increasing demand for a domestic refrigeration unit having separate food freezer and food refrigerating compartments in a single cabinet. As a result of this demand there have been numerous combined freezer and refrigerator units marketed in recent years. These combined units have utilized various types of refrigeration systems among which are included the method of providing two temperature refrigeration by means of a restrictor valve separating the refrigeration evaporator into two units; the use of a secondary or completely separate refrigeration system; and alternatively the use of hold-over mass in the freezer compartment which is great as compared to the hold-over ability of the refrigerator evaporator section, which latter unit receives by far the more fluctuating use. While all of the above mentioned systems have been or are currently being used in commerce to produce a two-temperature refrigeration system in a single cabinet, none of the systems mentioned have been completely satisfactory.

The most fundamental objection to them has lain in the provision of the necessary accurate control over the respective temperatures in the freezer and refrigerator compartments. In the prior art systems utilizing valves, the control becomes extremely complicated and accordingly quite expensive. For obvious reasons, the use of separate refrigeration systems for the two separate compartments is likewise extremely expensive. The use of hold-over mass variation is likewise expensive and is much less satisfactory.

By the present invention, the excessively costly systems heretofore required in prior art refrigeration systems have been completely eliminated. At the same time, an unusually effective dual, or multiple, temperature system is provided wherein the temperatures are controlled accurately without the use of a single moving part, dual compressors, or any other similar expensive control units.

In accordance with the present invention, a substantially conventional evaporator coil is provided for the refrigerator, or high temperature food storage compartment which is preferably positioned above the food freezer compartment. Likewise, a substantially conventional evaporator coil section is provided in the walls and shelves of the low temperature food freezer compartment. The high temperature refrigerator coil, which also operates at a relatively high pressure, is connected to the low temperature, low pressure coil by means of a capillary tube or other fixed restrictor associated with a heat exchanger designed to provide in combination therewith a predetermined substantially constant pressure differential between the refrigerator and freezer evaporator coil sections. This pressure differential will vary slightly with the rate of refrigerant flow through the entire system, but will be substantially constant for any particular dual temperature unit in a particular geographic location.

It has been found in practice that the use of a capillary tube or other fixed restrictor between the high temperature and low temperature evaporator coil sections will not alone provide complete control. This is due to the fact that a substantial portion of the liquid refrigerant entering the high temperature evaporator coil will evaporate while withdrawing heat from the stored food. As a result, as the refrigerant enters the capillary tube between the high temperature evaporator coil section and the low temperature evaporator coil section it will contain a substantial amount of gas as well as liquid. Tests have shown that the resistance of fixed restrictors, such as for example a capillary tube, to the passage of gas, such as Freon 22, a commercially popular refrigerant, is many times greater than the resistance to the flow of the same amount, by weight, of liquid. Since the heat load varies, gas will be formed in varying quantities and accordingly mixed with a variable amount of liquid refrigerant such that the passage of the combination through the capillary tube varies over a wide range. As a result, the pressure differential between the two sections of the evaporator coil is caused to fluctuate.

Fluctuations would accordingly occur with every change in the load applied to the high temperature evaporator coil since with changes in load a varying percentage of the liquid refrigerant would evaporate in the high temperature section. Thus, if a greatly increased load were to be applied to the high temperature portion, as a result of summer time use, or repeated openings of the cabinet door, a large percentage of gas would be provided in the high temperature evaporator section and accordingly a greater percentage of gas would appear at the capillary tube between the two evaporator sections. This greater percentage of gas would result in an increased resistance to flow through the capillary with a resultant increased pressure differential, with the result that the pressure in the low temperature section of the evaporator would be lower than the planned design pressure with a resultant lower than design temperature. Since such fluctuations in temperature in the food freezer compartment cannot be tolerated, the control of dual temperature food storage units has heretofore required much more complex apparatus than a mere capillary tube.

The present invention overcomes the problem of constant temperature control without the need of complex valves or separate freezer systems by providing means for positively assuring the flow of liquid refrigerant only through the capillary tube between the high and low temperature sections of the evaporator coils. In the preferred form of the invention, this is accomplished by placing the exit of the high temperature section of the evaporator coil in heat transfer relation with a portion of the low temperature section of the evaporator coil. In practice, a long portion of the end of the high temperature section of the evaporator coil is placed in contact with a portion of the low temperature evaporator coil section so that the refrigerant at the opening of the capillary tube is always completely liquid.

By completely liquefying and subcooling the refrigerant immediately prior to, and preferably also during, passage through the connecting capillary tube, a substantially constant control of the pressure differential, and hence the pressure in both sections of the evaporator coil, is provided. Thus, variations in the heat load applied to the high temperature portion of the evaporator coil will not affect the temperature of the low temperature, or food freezer portion of the evaporator coil. Accordingly, the dual temperature food storage unit is provided in which

a substantially constant food freezer temperature is maintainable without complex valves or other controls.

In addition to the system above discussed, and as a further means of improving the efficiency and stability thereof, a modified form of the present invention contemplates an additional cooling of the high temperature evaporator coil immediately prior to its heat transfer contact with the inlet of the low temperature evaporator coil by means of heat transfer contact with the exit end of the low temperature evaporator coil. This is accomplished in a simple manner in accordance with the present invention by providing an accumulator at the exit or exhaust end of the low temperature evaporator for trapping any overflow, unevaporated refrigerant and simultaneously placing that unevaporated refrigerant in heat transfer relation with the exit end of the high temperature evaporator immediately prior to its heat transfer relation with the inlet of the low temperature evaporator coil as above described. The result of this heat transfer at the accumulator is to assure substantially complete evaporation of the refrigerant entering the accumulator and at the same time permit complete liquefaction of the refrigerant immediately prior to its passage through the capillary tube with a smaller amount of contacting surface between the high temperature evaporator and low temperature evaporator coils adjacent the capillary. Accordingly, wasted refrigeration, which might ordinarily result from an excess of unevaporated refrigerant in the accumulator, with resultant splash-over into the compressor suction line, is prevented.

It is, accordingly, an object of the present invention to provide a simple yet highly efficient dual temperature food storage unit.

Another object of the present invention is to provide a simplified control system for a dual temperature food storage unit wherein a capillary tube provides a constant pressure differential between the high and low temperature portions of the evaporator.

Still a further object of the present invention is to provide a dual temperature food storage unit having an automatically constantly controlled temperature in the low temperature or food freezer compartment without the need for complex valves or other devices.

A feature of the present invention resides in the provision of a capillary tube between a pair of evaporator coil sections arranged to assure that refrigerant passing from one evaporator section to the other through the capillary is completely liquid during passage through the capillary.

A further feature of the present invention is the provision of a capillary tube connecting a pair of refrigerator evaporator sections and arranged in combination therewith so that the exit portion of the first evaporator section is in heat transfer contact with the second section thereof.

Yet another object of the present invention is to provide a dual temperature refrigerator and freezer unit wherein a substantially constant pressure and temperature differential is maintained between the refrigerator and freezer unit without the use of complex valves through the use of a pair of heat transfer apparatuses associated with the respective refrigerator and freezer units.

A feature of the invention is the use of a capillary tube between the high and low temperature refrigerator and freezer evaporator coils respectively in combination with a pair of heat transfer means associated with the outlet end of said high temperature evaporator and both the inlet and outlet of said low temperature evaporator whereby flow through the capillary is accurately controlled.

A further object of the present invention is to provide a simplified dual temperature refrigerator and freezer unit having a single compressor and condenser circuit.

Still a further object of the present invention is to provide an inexpensive yet highly efficient dual temperature refrigeration system.

Still other and further objects and features of the present invention will at once become apparent to those skilled in the art from a consideration of the attached drawings wherein a preferred form of the invention is shown by way of illustration only and, wherein:

Figure 1 is a view in diagrammatic form illustrating the relationship of the several components of a first embodiment of the present multi-temperature refrigerating system; and

Figure 2 is a view in diagrammatic form illustrating a modified form of the invention.

As shown in the drawings:

From the description to follow it will be apparent that the multi-temperature system herein contemplated may be used to provide a large number of different temperature compartments. However, a very important use of the invention is in the construction of the presently popular dual-temperature domestic food storage unit. Such units are provided with a first high temperature compartment preferably maintained at approximately 37° F. wherein food is preserved in a non-frozen state, and a second low temperature compartment wherein the food is frozen and wherein the temperature is preferably maintained at or about 0° F. Accordingly, as shown in Figure 1 of the drawings a first refrigerator compartment 10 and a second freezer compartment 11 are provided.

In Figure 1 the refrigeration system for controlling the temperatures of the compartments 10 and 11 comprises a conventional compressor 12, a conventional refrigeration condenser 13, a first evaporator section 14, a second evaporator section 15, a capillary tube 16 connecting the evaporator sections, and a conventional accumulator 17.

As in the usual refrigeration system, the compressor delivers refrigerant under high pressure to the condenser 13 where it is liquefied and maintained at a relatively high pressure. The liquid refrigerant flows through a conventional capillary tube 18 which may, if desired, be in heat transfer contact at 19 with the suction line 20 of the compressor 12. The refrigerant leaving the capillary tube 18 expands in the evaporator section 14 in the conventional manner to provide high temperature food storage refrigeration. To provide the desired temperature range of 37° to 40° F. it has been found that an average temperature of approximately 25° F. should be maintained in the evaporator section 14. When using Freon 22, as above suggested, the pressure in the refrigerator evaporator section 14 is approximately 50 pounds per square inch, at which pressure the liquid refrigerant temperature will be approximately 25° F.

From the evaporator section 14, the refrigerant passes through the capillary 16 to the low temperature or food freezer evaporator section 15. As has been indicated above, it is desired that a substantially constant pressure differential be maintained between the sections 14 and 15 and it has been found that it is impossible to maintain an accurate control of such pressure differential where the capillary 16 is required to pass a mixture of liquid and gaseous refrigerant. In accordance with the present invention control is stabilized by placing the exit portion 14*a* of the evaporator section 14 in heat transfer contact with the inlet portion 15*a* of the low temperature evaporator section 15. As a result of this heat transfer contact between the sections 14*a* and 15*a* of the respective evaporator sections 14 and 15, refrigerant leaving the section 14 is completely liquefied immediately prior to entry into the capillary tube 16. The heat transfer contact between the sections 14*a* and 15*a* is constructed with sufficient capacity to completely liquefy and subcool the refrigerant under the most severe heat load conditions in the compartment 10. Thus, while ordinarily it is expected that refrigerant leaving the evaporator section 14 would comprise approximately 50% gas and 50%

liquid refrigerant, it is possible that in hot weather or other conditions leading to increased heat load on the evaporator section **14** the refrigerant leaving the evaporator **14** might be as much as 80% gas and 20% liquid. Accordingly, the heat transfer sections **14***a* and **15***a* are in contact over a long enough distance to assure complele liquefaction and subcooling of the refrigerant even in the extreme condition of 80% as gas above noted.

In a dual temperature food storage unit having a pressure of approximately 50 pounds per square inch in the evaporator section **14** and a pressure of approximately 15 pounds per square inch in the evaporator section **15**, which latter pressure provides a corresponding liquid refrigerant temperature of approximately —12° F., sufficient to provide an average temperature in the compartment **11** of 0° F., a contact length between the sections **14***a* and **15***a* of 4 feet was found completely satisfactory. It will be understood, however, that the heat transfer length may vary in different installations depending upon tubing sizes and other physical characteristics of the system, such as for example the presence of a heat exchanger **17***a* to be discussed later.

As the liquid refrigerant passing through the capillary **16** enters the evaporator **15**, it gradually assumes its previous mixed state of gas and liquid, with a slightly greater percentage of gas than found in the section **14** as a result of absorbing the heat of the liquid in subcooling the refrigerant prior to its entry into the capillary tube **16**. This change will not, however, affect the operation of the freezer compartment **11** since the temperature therein is affected only by the pressure of the refrigerant which is controlled at this stage in the conventional manner at the compressor **12**. As stated above, it is preferred that the pressure be approximately 15 pounds per square inch in the evaporator section **15** thereby providing a liquid Freon 22 temperature of approximately —12° F. with a corresponding temperature in compartment **11** of substantially 0° F.

While in the diagrammatic showing of the drawings, the capillary tube **16** is not shown in heat transfer contact with the sections **14***a*, **15***a*, it will be understood that the capillary **16** may be wound about the heat transfer sections **14***a* and **15***a* in order to assure liquefaction of the refrigerant throughout a substantial length of the capillary tube.

As a result of the above described construction variation in the heat load applied to either the evaporator section **14** or section **15** will not cause a variation in the pressure differential between the sections **14** and **15**. The capillary tube **16** will at all times be passing the same material, i. e., completely liquid refrigerant, and accordingly the pressures in the sections **14** and **15** will maintain their desired substantially constant relationship.

In the modified form illustrated in Figure 2, additional control is provided for absorbing heat from the refrigerant immediately prior to its passage through the capillary **16**. As there shown, the accumulator **17***a* takes the form of a container through the ends of which the portion **14***c* passes prior to heat transfer association between the evaporator portions **14***a* and **15***a*. The accumulator **17***a* accepts refrigerant from the low temperature evaporator coil **15** and traps the liquid portions thereof, permitting the evaporated portions to pass to the compressor **12** via the compressor suction line **20**.

During the initial operation of the system on its recurring cycle, liquid refrigerant will splash into the accumulator **17***a* and will withdraw heat from the liquid refrigerant passing through the portion **14***c* of the high temperature evaporator coil, thereby evaporating and passing to the compressor **12** in vapor form. As a result of the combined use of the accumulator **17***a* as an accumulator and as a heat transfer unit, therefore, the chance of liquid refrigerant passing to the compressor is substantially minimized and at the same time the liquid refrigerant serves the useful function of assuring complete liquefaction of the refrigerant immediately prior to its entry through the capillary tube **16**. Accordingly, no "waste refrigeration" takes place from failure to liquefy substantially all of the refrigerant prior to its recompression and at the same time the length, and hence capacity of the heat transfer portions **14***a* and **15***a* may be kept at a minimum. It will, of course, be understood that various designs of accumulators may be utilized but the simple well known cylindrical form has proven very satisfactory when pierced at its opposite ends to permit passage of the portion **14***c* of the evaporator coil **14**. This arrangement places the portion **14***c* in direct contact with the pool of liquid refrigerant in the bottom of the accumulator and thereby provides a maximum in heat transfer efficiency.

It will be understood that the apparatus herein disclosed may be utilized in refrigeration systems having a large number of different evaporator sections each connected to the next through a capillary tube arranged to transmit only liquid refrigerant. Under such an arrangement a large number of different temperatures may be achieved and maintained without the need for separate compressors, complex valves, or any other similar mechanism heretofore used in the prior art for providing multi-temperature control. Accordingly, it will be understood that I have provided a novel and greatly improved refrigeration system having extreme simplicity and maximum stability of operation.

Since it will be apparent that variations and modifications may be made in the above disclosed construction without departing from the novel concepts of the present invention it is intended that the invention be limited solely by the scope of the appended claims.

I claim as my invention:

1. In multi-temperature refrigeration means, a first high temperature compartment and a second low temperature compartment, a first high temperature evaporator coil in said first compartment, a second low temperature evaporator coil in said second compartment, pressure reducing means connecting the outlet of said first coil to the inlet of said second coil, the outlet portion of said first high temperature coil being for a substantial portion of its length in advance of said pressure reducing means in heat transfer contact with said second low temperature coil for a substantial portion of the length of the inlet portion thereof effective for liquefying refrigerant gas in said outlet portion of said high temperature coil before the refrigerant enters said pressure reducing means, refrigerant liquefying and supply means having an inlet connected to the outlet of said second coil, and pressure reducing means connecting the outlet of said liquefying and supply means to the inlet of said first coil.

2. In multi-temperature refrigeration means, a first high temperature compartment and a second low temperature compartment, a first high temperature evaporator coil in said first compartment, a second low temperature evaporator coil in said second compartment, fixed pressure reducing means connecting the outlet of said first coil to the inlet of said second coil, the outlet portion of said first high temperature coil being for a substantial portion of its length in advance of said pressure reducing means in heat transfer contact with said second low temperature coil for a substantial portion of the length of the inlet portion thereof effective for liquefying refrigerant gas in said outlet portion of said high temperature coil before the refrigerant enters said pressure reducing means, means for withdrawing refrigerant from said second coil and liquefying it under pressure, and fixed pressure reducing means connecting said withdrawing and liquefying means to the inlet of said first coil for delivery of refrigerant thereto.

3. In multi-temperature refrigeration means, a first high temperature compartment and a second low temperature compartment, a first high temperature evaporator coil in said first compartment, a second low temperature evaporator coil in said second compartment, fixed pressure re-

ducing means connecting the outlet of said first coil to the inlet of said second coil, means providing heat transfer relation between the outlet portion of said high temperature coil and the inlet portion of said low temperature coil effective for substantially completely liquefying refrigerant in the outlet portion of said first coil in advance of said pressure reducing means, means for withdrawing refrigerant from said second coil and liquefying it under pressure, and fixed pressure reducing means connecting said withdrawing and liquefying means to the inlet of said first coil for delivery of refrigerant thereto.

4. In multi-temperature mechanical refrigeration means, a first high temperature compartment and a second low temperature compartment, a first high temperature evaporator coil in said first compartment, a second low temperature coil in said second compartment, pressure reducing means connecting the outlet of said first coil to the inlet of said second coil, the latter coil being disposed for a substantial portion of its extent in heat transfer contact with said first high temperature coil in advance of said pressure reducing means effective for liquefying gaseous refrigerant in said first high temperature coil prior to its entering said pressure reducing means, a compressor and condenser unit having its inlet connected to the outlet of said second coil, and means connecting the outlet of said unit to the inlet of said first coil for delivery of refrigerant thereto, said last named means comprising pressure reducing means connected to the inlet of said first coil.

5. In multi-temperature mechanical refrigeration means, a first high temperature compartment and a second low temperature compartment, a first high temperature evaporator coil in said first compartment, a second low temperature coil in said second compartment, a capillary tube connecting the outlet of said first coil to the inlet of said second coil, the latter being disposed for a substantial extent of its inlet portion in heat transfer contact with the outlet portion of said first high temperature coil effective for liquefying gaseous refrigerant in the outlet portion of said first high temperature coil immediately prior to entry of the refrigerant into said tube, a compressor and condenser unit having its inlet connected to the outlet of said second coil, and means connecting the outlet of said unit to the inlet of said first coil for delivery of refrigerant thereto, said last named means comprising a capillary tube connected to the inlet of said first coil.

6. In multi-temperature mechanical refrigeration means, a first high temperature compartment and a second low temperature compartment, a first high temperature evaporator coil in said first compartment, a second low temperature coil in said second compartment, pressure reducing means connecting the outlet of said first coil to the inlet of said second coil, means providing heat transfer contact between the outlet portion of said first coil and the inlet portion of said second coil for a substantial extent of each thereof effective for substantially completely liquefying refrigerant delivered from said first coil to said reducing means, a compressor and condenser unit having its inlet connected to the outlet of said second coil, and means connecting the outlet of said unit to the inlet of said first coil for delivery of refrigerant thereto, said last named means comprising pressure reducing means connected to the inlet of said first coil.

7. A dual temperature refrigeration system comprising a first high temperature high pressure section and a second low temperature low pressure section, a fixed restrictor connecting the outlet of said first section to the inlet of said second section, the outlet portion of said first section having heat transfer connection for a substantial extent to the inlet portion of said second section effective for liquefying gaseous refrigerant in said first section in advance of said restrictor, an accumulator in advance of said heat transfer connection receiving a part of the outlet portion of said first section and connected to the outlet of said second section, a compressor and condenser unit having its inlet connected to said accumulator, and means connecting the outlet of said unit to the inlet of said first section for delivery of refrigerant thereto, said last named means comprising pressure reducing means connected to the inlet of said first section.

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