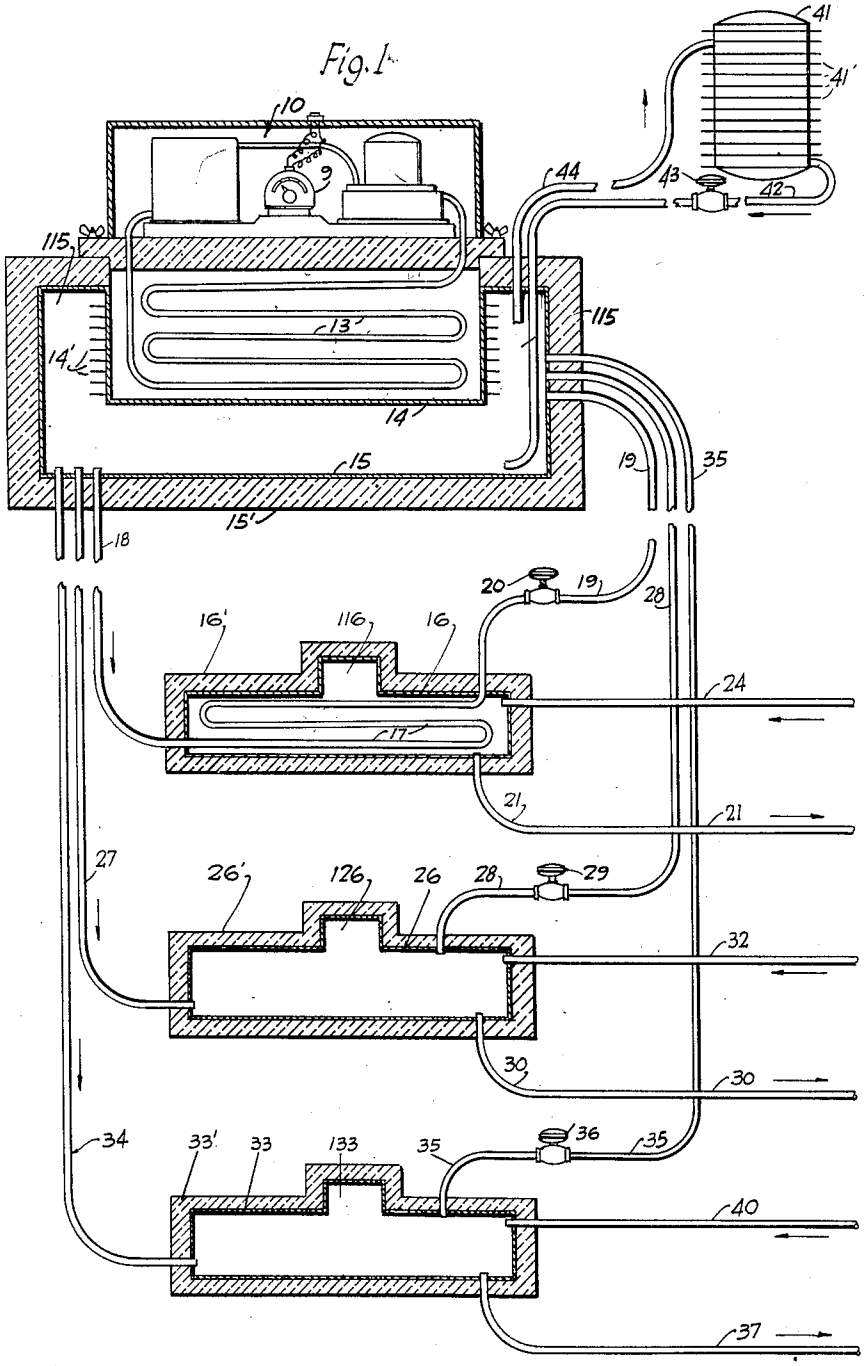
June 20, 1950 F. E. HAZARD 2,512,545

STRUCTURE FOR AND METHOD OF TRANSFER, EXCHANGE, CONTROL REGULATION, AND STORAGE OF HEAT AND COLD

Filed June 11, 1948 10 Sheets-Sheet 1

Fig. 1.



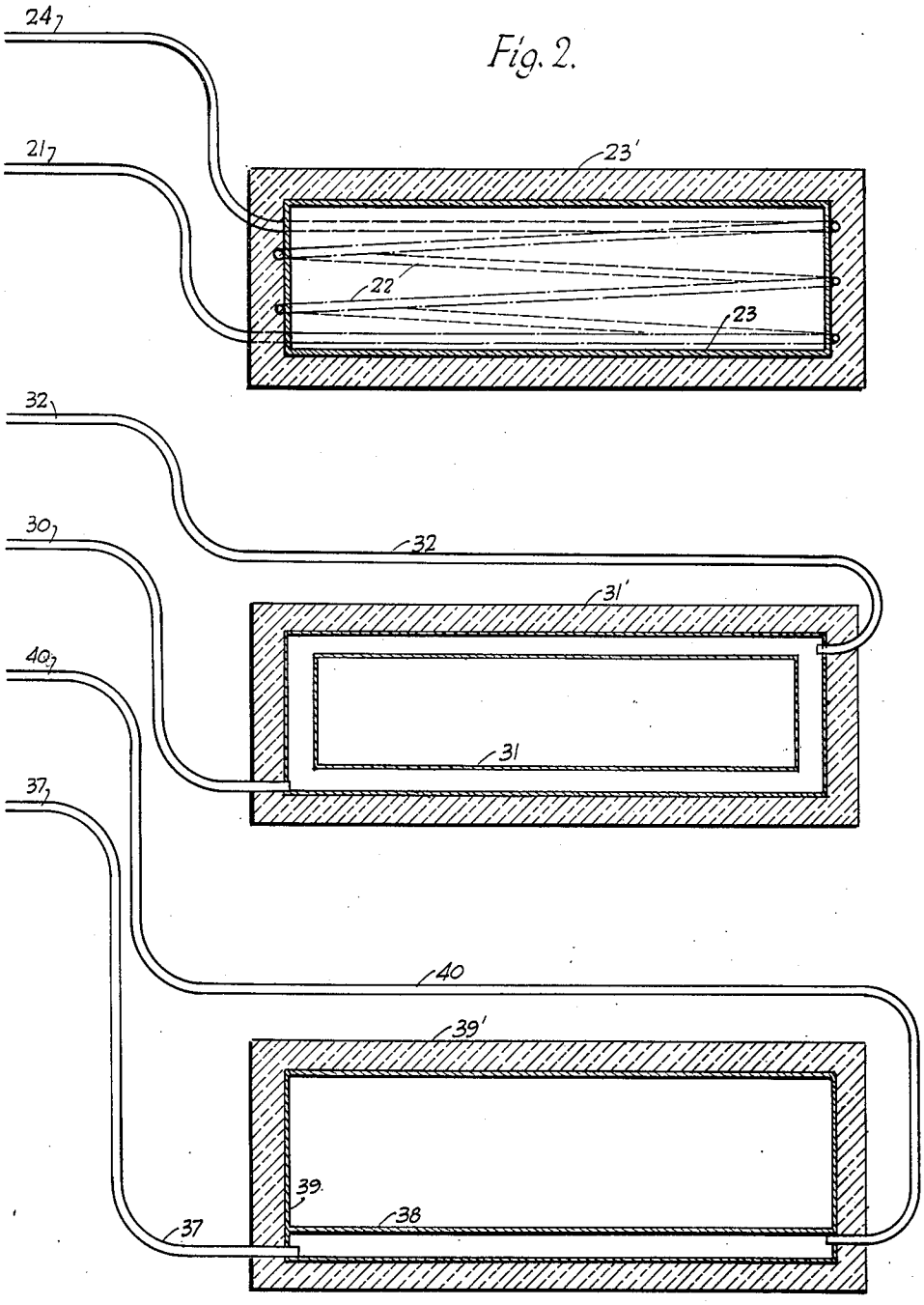
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STRUCTURE FOR AND METHOD OF TRANSFER, EXCHANGE, CONTROL REGULATION, AND STORAGE OF HEAT AND COLD

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Fig. 2.



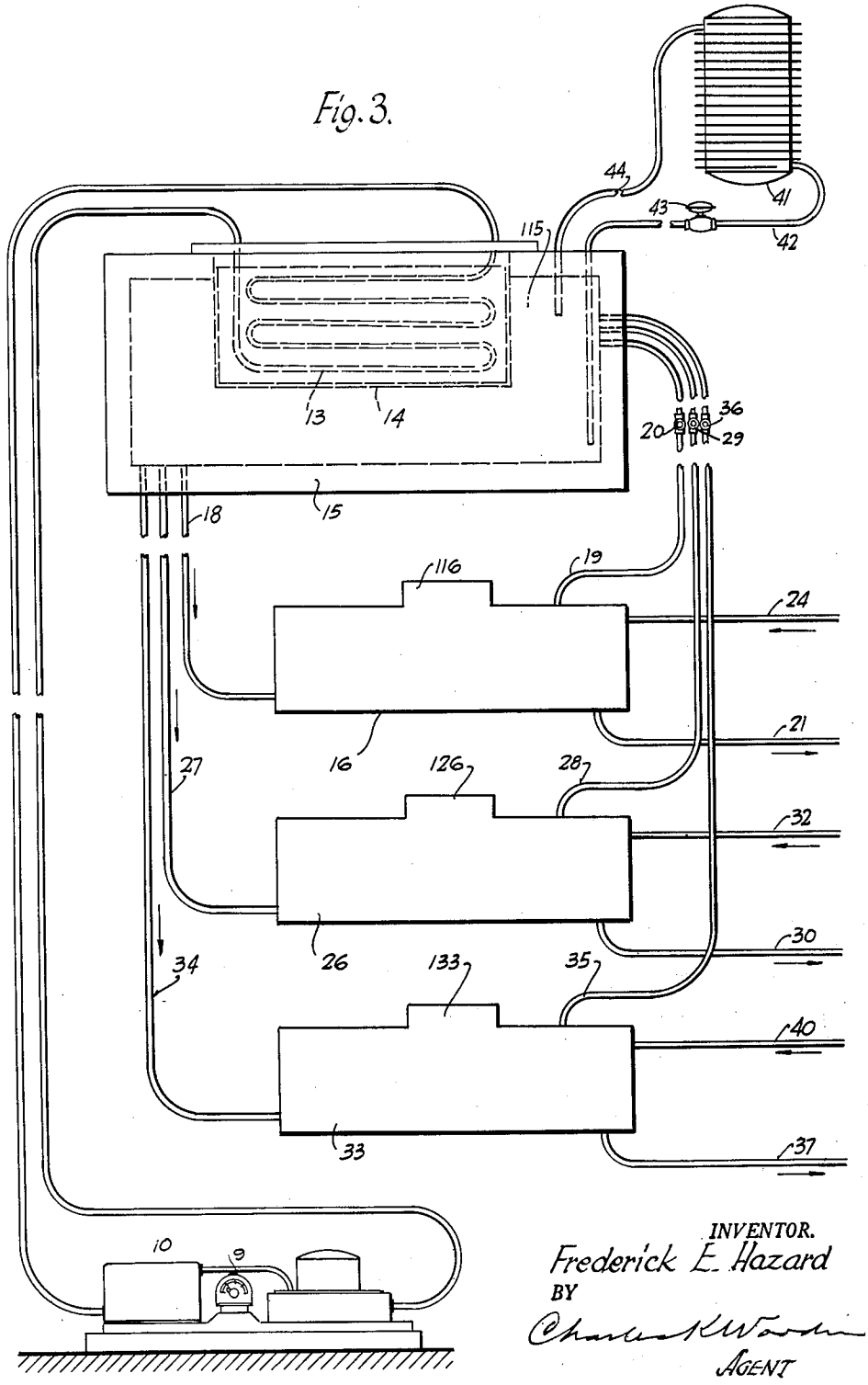
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STRUCTURE FOR AND METHOD OF TRANSFER, EXCHANGE, CONTROL REGULATION, AND STORAGE OF HEAT AND COLD

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Fig. 3.



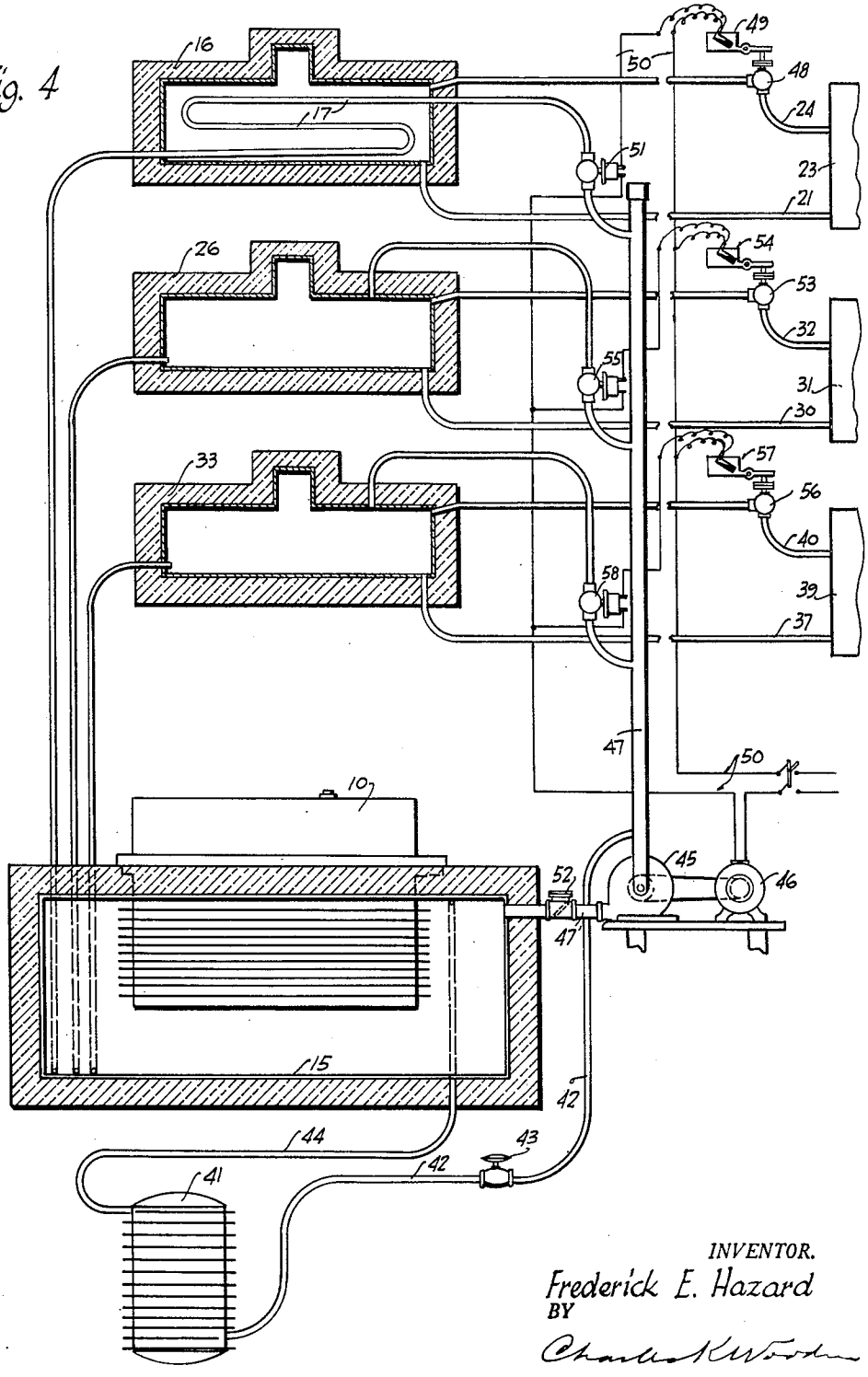
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STRUCTURE FOR AND METHOD OF TRANSFER, EXCHANGE, CONTROL REGULATION, AND STORAGE OF HEAT AND COLD

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Fig. 4



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STRUCTURE FOR AND METHOD OF TRANSFER, EXCHANGE, CONTROL REGULATION, AND STORAGE OF HEAT AND COLD

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Fig. 5.

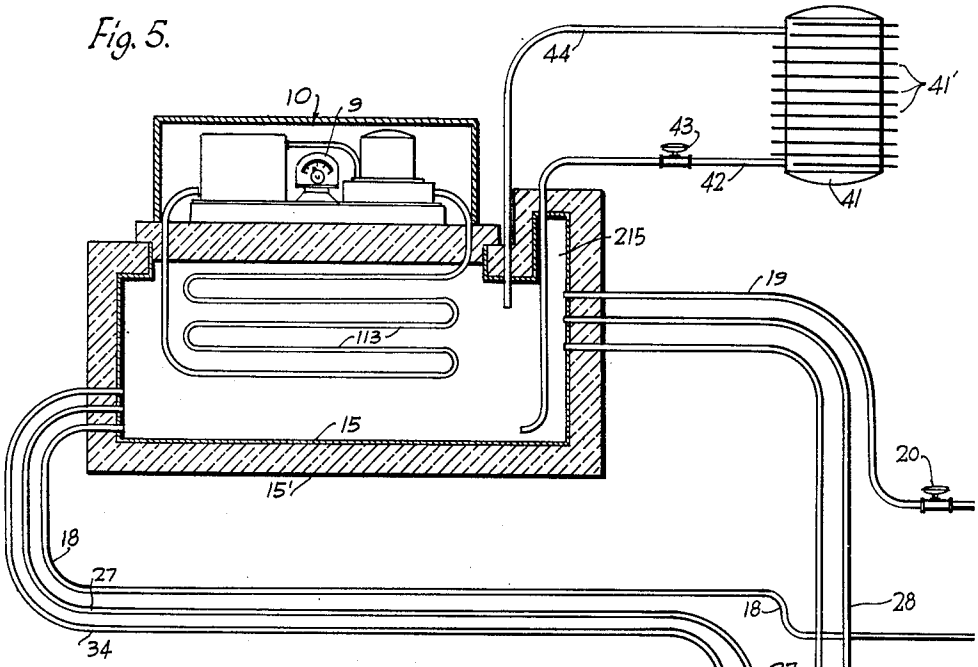
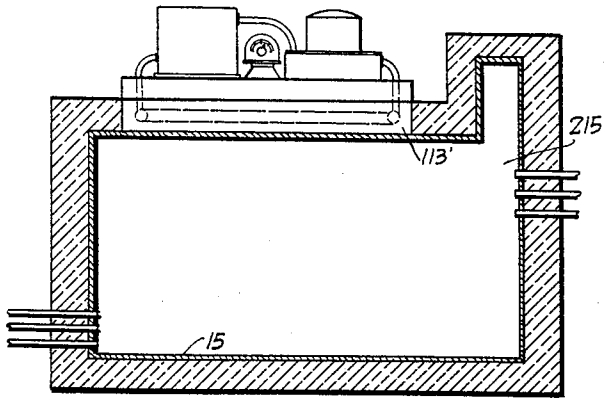


Fig. 6.



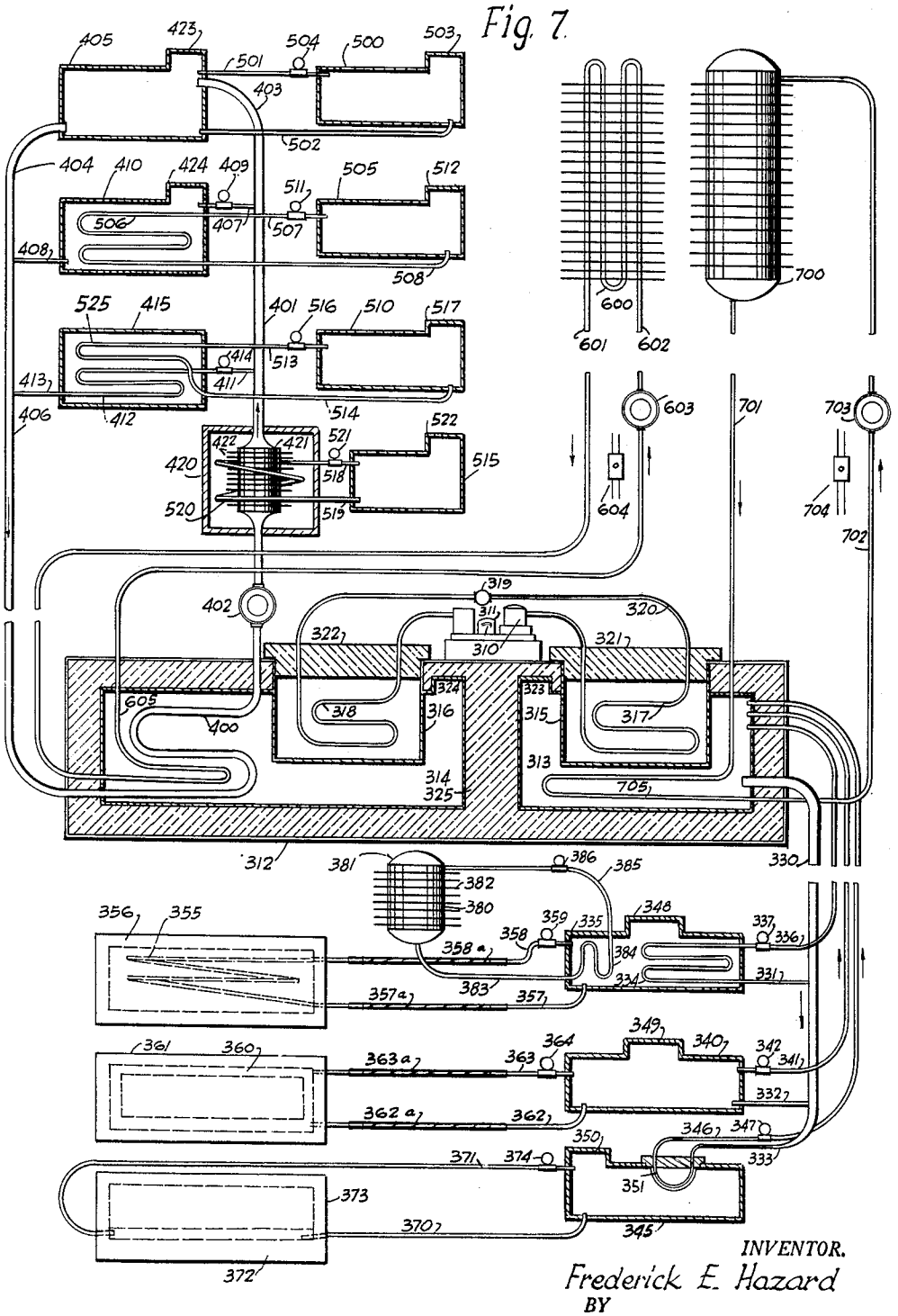
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STRUCTURE FOR AND METHOD OF TRANSFER, EXCHANGE, CONTROL REGULATION, AND STORAGE OF HEAT AND COLD

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Fig. 7.



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STRUCTURE FOR AND METHOD OF TRANSFER, EXCHANGE, CONTROL REGULATION, AND STORAGE OF HEAT AND COLD

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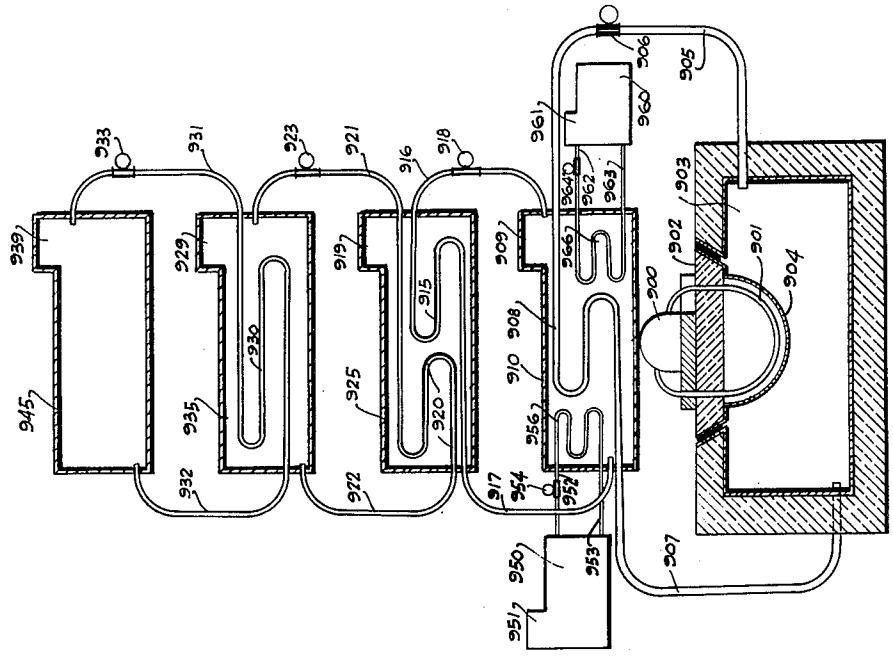


Fig. 9.

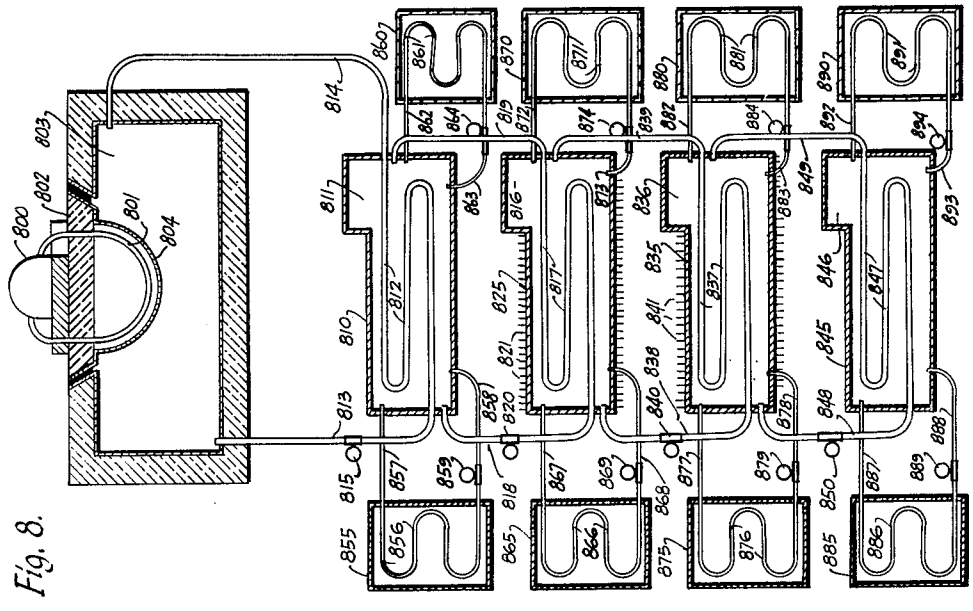


Fig. 8.

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STRUCTURE FOR AND METHOD OF TRANSFER, EXCHANGE, CONTROL REGULATION, AND STORAGE OF HEAT AND COLD

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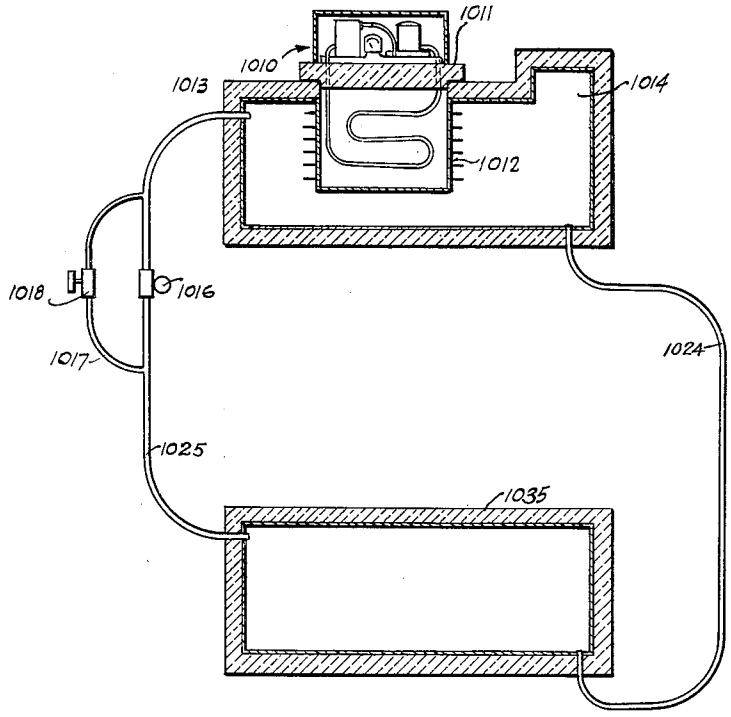


Fig. 10

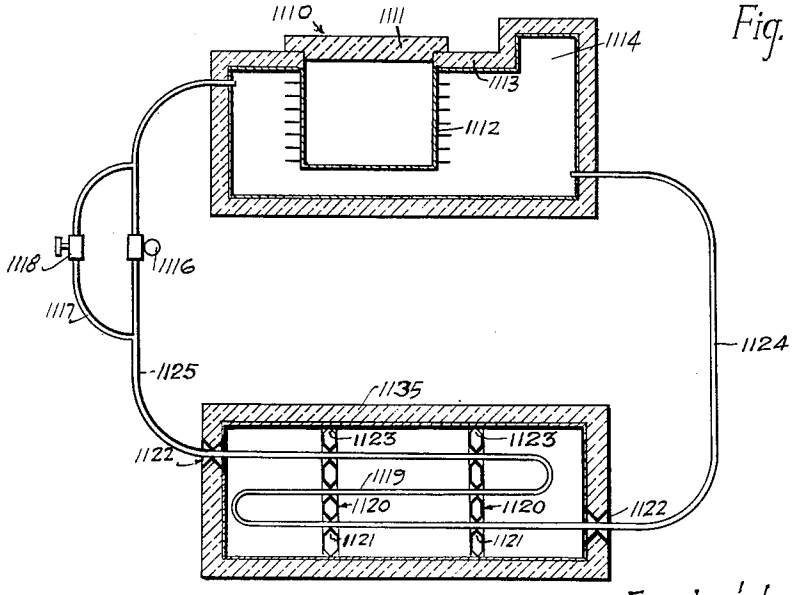


Fig. 11

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STRUCTURE FOR AND METHOD OF TRANSFER, EXCHANGE, CONTROL REGULATION, AND STORAGE OF HEAT AND COLD

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Fig. 12

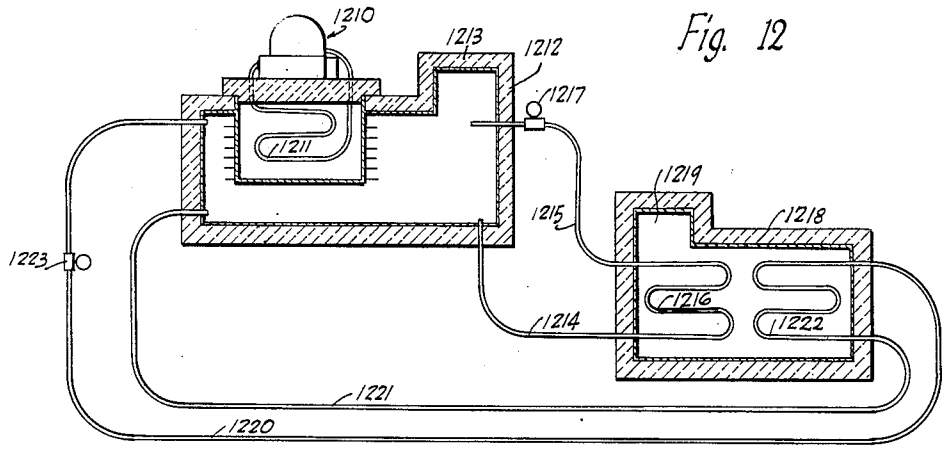
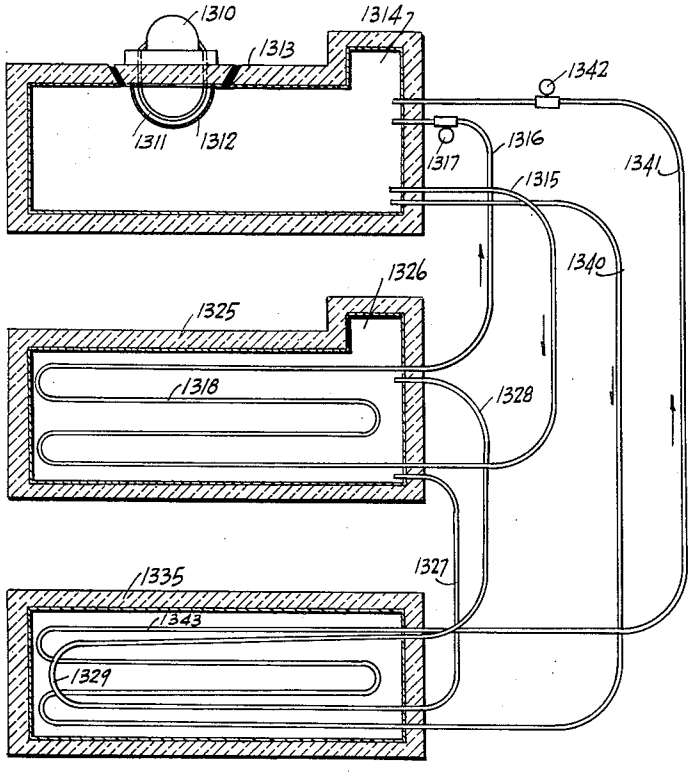


Fig. 13



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STRUCTURE FOR AND METHOD OF TRANSFER, EXCHANGE, CONTROL REGULATION, AND STORAGE OF HEAT AND COLD

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Fig. 15.

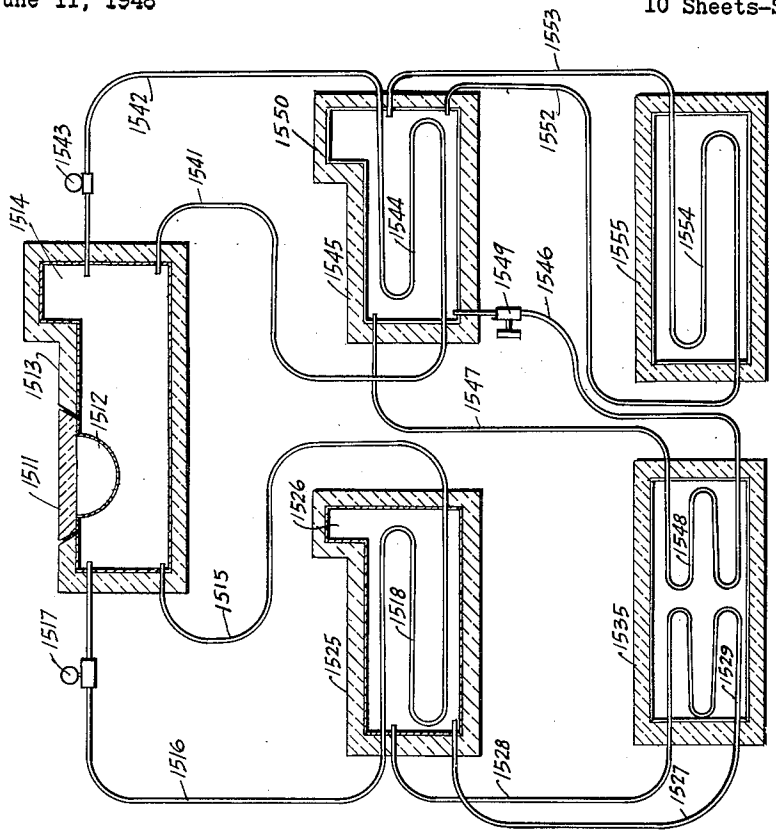
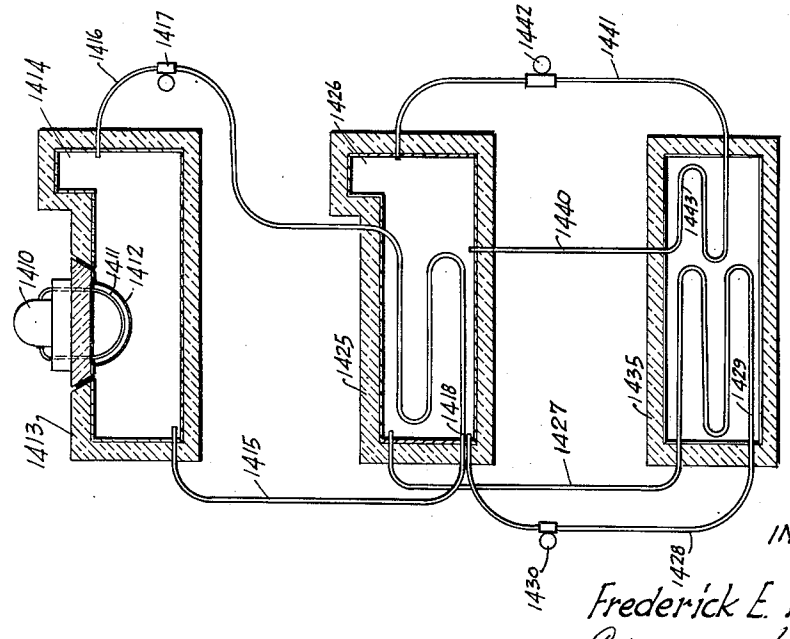


Fig. 14



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Patented June 20, 1950 2,512,545

UNITED STATES PATENT OFFICE

2,512,545

STRUCTURE FOR AND METHOD OF TRANSFER, EXCHANGE, CONTROL REGULATION, AND STORAGE OF HEAT AND COLD

Frederick E. Hazard, Buffalo, N. Y.

Application June 11, 1948, Serial No. 32,318

22 Claims. (Cl. 62—125)

1

This invention pertains to apparatus and methods for the transfer, exchange, control, regulation and storage of cold and heat in refrigerating apparatus, heating apparatus, and combined refrigerating and heating apparatus.

This application is a continuation-in-part of my co-pending application for patent Serial No. 579,185, entitled "Refrigerating Apparatus," filed February 22, 1945, and incorporates the full subject matter of the application mentioned as well as certain improvements in fundamental structure and methods of use thereof discovered by me during the pendency of such application.

One object of the invention is to provide a heat transfer and exchange system which will enable the temperatures of ultimate heat absorbing or dissipating apparatus to be maintained and controlled within limited ranges irrespective of the temperature at which other portions of the system are maintained.

Another object of the invention is the provision of structure and methods whereby desired thermal conditions may be developed in the several volumes of heat transfer and exchange fluid contained in a plurality of reservoirs arranged in heat transfer and exchange relation to one another, at least one of the reservoirs being a master reservoir and having as its chief purpose that of storing in the fluid therein a reserve of heat or cold, and all the other reservoirs being subsidiary in some degree to the master reservoir and each to some degree functioning for storage of heat or cold, and certain of the other reservoirs being subsidiary one to another so that there can exist between the fluids in immediately interrelated reservoirs a temperature differential arranged in readily controllable stages or steps.

Another object of the invention is the provision of means and methods whereby the heat units absorbed by a primary thermal conditioning means in providing refrigeration may be removed from such means and put to productive use to provide heat, or the primary thermal conditioning means, in producing heat, can be applied to create a condition of cold for purposes of refrigeration.

Still another object is to provide a refrigerating or heating system having a large thermal reserve or storage capacity for heat or cold forming a thermal flywheel which may be called upon for heat absorption or dissipation, thereby assuring a uniform level of performance in ultimate heat transfer and exchange units, during the periods of demands on the system for heat and/or refrigeration in excess of the relatively immediate production ability of the source of heat or refrigeration.

2

Another object is to provide structure for heating or refrigerating, or both, wherein the means for producing either heat or cold in an appropriate master secondary reservoir, or the means for transmitting heat or cold from one reservoir to another reservoir or from a reservoir to an ultimate heat transfer and exchange unit, may be readily installed or removed without interfering with the ability of the other portions of the system to function in a normal manner.

Still another object of the invention is to provide a structure, portions of which are flexibly integrated with the structure anteceding it in the system thereby making possible the use, particularly as ultimate heat transfer and exchange units, of movable members which may be swung or otherwise moved without disturbing their ability to be directly refrigerated or heated by the fixed portion of the system.

Yet another object is to provide structure for refrigeration or heating, utilizing as a source of heat and/or cold the condensers and evaporators, respectively, of one or more complete compressor-condenser-evaporator units functioning as a heat pump or heat pumps, the stored or reserve heat absorption or heat dissipation capacity of the structure, mentioned hereinbefore, eliminating the necessity for frequent wear-inducing and excessive power-consuming cycling of the compressor-condenser-evaporator unit, the reserve or storage capacity also readily permitting the motor operation to be largely limited to those periods wherein off-peak low cost electric rates are in effect.

Yet another object is to provide, for use in conjunction with the main heating or refrigeration system or combined refrigerating-heating system, a supplemental system of heat pickup or dissipation of a type exposed to conditions such as those extant in the ground, in water or in the air, whether in naturally occurring or produced condition, the supplemental system being such as to be capable of serving to balance an integrated heating-refrigerating system; or to pick up or dissipate heat units and thus relieve the primary source of heat or cold from operation, otherwise required; or which may serve as a primary source of heat or cold.

Another object is to provide means whereby heat units, once produced and present in a carrier such as air, water or the like may be picked up and re-used, when the carrier for any reason

is to be disposed of, for heating a new volume of the carrier or for other heat unit utilization.

Another object is the provision, in apparatus including a common means for producing both heat and cold such as, for instance, an integrated compressor-condenser-evaporator unit used as a heat pump, and in which apparatus both the heat and cold sides are productively utilized, of a means for balancing the heat and/or cold utilizing sides with one another, irrespective of demands on the system for heat or cold, which might, without such balancing means, throw the whole system into an inefficient operating phase.

A still further object is to provide means whereby a primary source of heat and/or cold may be positioned remote from the location at which the heat or cold is to be utilized, a thermally conditioned fluid being circulated through appropriate conduits, the conduits being capable of being interconnected as desired into heat transfer and exchange relation with subsidiary secondary reservoirs and ultimate heat transfer and exchange units served by such subsidiary secondary reservoirs, so that various temperatures may be produced in various portions of an installation at will, irrespective of where these portions may be located with respect to one another or with respect to other portions of the system.

Another object is to provide means and methods by which the temperature of a space or object to be cooled or heated is regulated by controlling the volume of heat transfer and exchange fluid brought into heat transfer and exchange relation with the space or object with which heat units are to be exchanged.

Another object of the invention is the provision of structure whereby the temperature of the fluid in an ultimate heat transfer and exchange unit may be changed from one range to another at will, thereby making it possible for a space to be heated to variant temperatures or for a refrigerated space to be utilized at temperature ranges controllable, for instance, from those sufficiently low to maintain frozen foods to those sufficiently high to prevent food dehydration or freezing.

Another object of the invention is to provide structure whereby the temperature of an ultimate heat transfer and exchange unit, one or more stages removed from a master secondary reservoir, may be normally controlled for the major portion of its use period within a predetermined temperature range and wherein means are provided for temporarily substantially increasing the heat transfer and exchange ability of the utlimate heat transfer and exchange unit at will for limited periods by flowing heat transfer and exchange fluid through such unit at a temperature considerably differing from that at which the heat transfer and exchange fluid is normally flowed therethrough.

Still another object of the invention, particularly in its refrigeration-use phase, is the provision of structure wherein a coil type heat exchanger may be positioned within a fluid-flooded heat transfer and exchange unit, the heat exchanger being supported in the named unit in heat-insulated relation to the walls of the unit so that the heat transfer and exchange fluid forms the sole heat-unit conductive element.

Another object is the provision of refrigeration apparatus in which the temperature of the refrigerating medium is maintained at a relatively constant temperature as contrasted to the variant temperature ranges characteristic of the refrigerating medium in a conventional direct expansion system.

An additional object is to provide apparatus for and methods of refrigeration in which a relatively high temperature refrigerant is placed in direct heat transfer and exchange relation to the space or object to be refrigerated, the surface of the heat transfer and exchange unit serving the space or object and/or the refrigerant itself being maintained at a temperature above the freezing point of water, thus reducing dehydration of foodstuffs to a negligible minimum, reducing moisture condensation and the freezing of moisture on the heat transfer and exchange unit or parts adjacent thereto, also eliminating the freezing of objects to the walls or shelves, making defrosting unnecessary, and achieving these results while maintaining the heat extraction ability of a low temperature refrigerant.

Other and further objects and advantages of the device and methods of the invention will become apparent from the detailed description which follows and from the drawings in which:

Fig. 1 is a diagrammatic showing, principally in section, of structure used in the invention wherein the high side of a primary thermal conditioning means comprising a complete compressor-condenser unit consisting of motor, compressor, condenser, receiver and expansion valve (the latter two not shown) is the principal source of cold and an exposed heat unit dissipating tank is an auxiliary source of cold, the structure also including a primary tank filled with heat transfer and exchange fluid in which the low side or evporator portion of the primary thermal conditioning means is immersed, and this showing also including portions of a secondary system comprising a master secondary reservoir, and certain subsidiary secondary reservoirs, which are shown typically interconnected in accordance with certain of the methods herein disclosed:

Fig. 2 is a diagrammatic showing, chiefly in section, of further subdivisions forming branch systems for the subsidiary secondary system and comprising individual ultimate heat transfer and exchange units associated with or comprising refrigerating compartments;

Fig. 3 is a diagrammatic showing following closely that of Fig. 1 but differing therefrom in indicating the installation of the high side or complete compressor-condenser unit remote from the secondary system;

Fig. 4 is a diagrammatic showing of structure permitting installation of the high side compressor-condenser unit, the low side evaporator, the primary tank and master secondary reservoir remote from the other portions of the system, pump means being provided for inducing the flow of the heat transfer and exchange fluid partly in lieu of the thermo-siphonic fluid flow generally characteristic of the showings of those figures preceding this one;

Fig. 5 is a diagrammatic showing of a modified and simplified form of the invention following the principles generally shown in Fig. 1, the primary tank being eliminated;

Fig. 6 is a fragmentary showing of a modified form of structure whereby the primary unit low side or evaporator is in direct heat transfer and exchange relation with the fluid in the master secondary reservoir;

Fig. 7 is a diagrammatic showing of the structure of Fig. 1, modified in minor degree, wherein

such structure is shown as being used for heating as well as for refrigeration;

Fig. 8 is a diagrammatic showing of a refrigeration-type system, utilizing the principles of the invention, wherein multiple reservoirs are shown arranged in series in sequentially succeeding subsidiary relation to one another;

Fig. 9 is a diagrammatic showing of the structure and methods of the invention wherein a plurality of reservoirs are arranged in series in a typical heating installation;

Figs. 10, 11 and 12 show modifications of the basic structure wherein means are provided for maintaining a relatively constant temperature for the majority portion of its use period in an ultimate heat transfer and exchange unit one stage removed from the master secondary reservoir and wherein during temporary periods the heat transfer and exchange capacity of the heat transfer and exchange unit may be substantially enhanced; and

Figs. 13, 14 and 15 show structure whereby an ultimate heat transfer and exchange unit two stages removed from the master secondary reservoir may, for temporary periods, be caused to have greater heat transfer and exchange capacity than generally characteristic of the usual operation of such ultimate heat transfer and exchange unit.

Broadly viewed, the structure comprises a generally closed system wherein a primary source of differential from ambient temperature, which may be of any type, provides a desired thermal range in a volume of heat transfer and exchange fluid contained in a master secondary reservoir or tank. The mastsr-reservoir-contained fluid is flowed into heat transfer and exchange relation with the heat transfer and exchange fluid contained in other reservoir units comprising a subsidiary secondary system. The subsidiary secondary system is divided into branch subsidiary systems usually comprising reservoirs or heat exchangers containing heat transfer and exchange fluid, the branch system being connected in heat transfer and exchange relation with the portions of the system to which they are subsidiary; and these branch subsidiary systems may themselves be branched, if desired, into further similar subsidiaries, or they may be attached to or become the ultimate heat transfer and exchange units for cooling or heating spaces or objects. Each of the units comprising the subsidiary systems or branches functions independently, being related to the system or unit anteceding it only to the extent of reliance on the latter as its source of heat or cold.

The heat transfer and exchange fluid is of an uncompressed type, relatively unpressurized except as it may be solely by that condition it assumes within the thermal range at which it operates for heat transfer and exchange purposes, and should preferably have high thermo-siphonic flow characteristics.

To induce thermo-siphonic flow of heat transfer and exchange fluid from each tank or reservoir to any or all tanks or reservoirs subsidiary thereto, the subsidiary reservoirs are preferably elevated or lowered, dependent on whether used for heating or refrigerating, with respect to the reservoir or tank to which each is subsidiary. Certain portions of each subsidiary system operate at a temperature differential from a preceding portion of the system, to induce thermo-siphonic flow between them. Certain of the conduit means which permit flow of heat transfer and exchange fluid from each reservoir to a reservoir subsidiary thereto have temperature control means associated with them permitting flow of heat transfer and exchange fluid therethrough only during those periods wherein the temperature of the heat transfer and exchange fluid in the more subsidiary reservoir is at an undesirable imbalance to the temperature of the heat transfer and exchange fluid in the reservoir antecedent thereto. If desired, pump means may be utilized to supplement the thermo-siphonic flow principle generally utilized throughout the systems of the invention.

Referring now to the drawings, in Fig. 1 is shown a conventional integrated compressor-condenser or high side unit **10** having a low side comprising an evaporator **13** operatively connected thereto, the integrated high and low side unit being hereinafter occasionally referred to as a primary thermal conditioning means. This apparatus is mounted on the insulated base shown, the evaporator thereof being positioned in heat transfer and exchange relation with a master secondary tank or reservoir **15**. Reservoir **15** contains a suitable heat transfer and exchange fluid, and is preferably fully blanketed by insulation **15'**.

The primary thermal conditioning means is regulated to operate within a predetermined temperature range by a control means **9** which typically may be a pressure valve or a thermostat.

The insulated base is removably mounted to cover a primary tank **14** formed integral with master secondary reservoir **15**, and tank **14** extends into reservoir **15** a distance, as shown. Tank **14**, like reservoir **15**, has a suitable heat transfer and exchange fluid therein and may be equipped with heat absorption fins **14'** to accelerate heat exchange. The primary thermal conditioning means evaporator **13**, shown in this instance as being of conventional coil type, is supported from the base shown, and is immersed in the heat transfer and exchange fluid in tank **14**. A header or expansion space **115** is provided on reservoir **15** to permit the heat transfer and exchange fluid in such reservoir to expand or contract in accordance with its requirements.

Positioned at a point somewhat lower than the master secondary reservoir **15**, is a subsidiary secondary reservoir **16**, fully encompassed by insulation **16'**, this reservoir also having heat transfer and exchange fluid therein. A header **116**, integral with the reservoir **16**, is provided to accommodate expansion and contraction of the reservoir-held fluid. A heat exchanger **17**, typically in the form of a coil, is positioned in subsidiary secondary reservoir **16**, this heat exchanger being in communication with reservoir **15** by means of a conduit **18**, which extends from the bottom of reservoir **15**, and another conduit **19**, which extends to the top of such reservoir. Conduit **19** has in its length a temperature control means **20** typically comprising a thermostatic valve. It will be obvious that the heat transfer and exchange fluid in reservoir **15** may flow thermo-siphonically through heat exchanger **17** except to the extent that the flow of the fluid is cut off by temperature control means **20**.

A conduit **21** in communication with subsidiary secondary reservoir **16** leads outwardly therefrom adjacent its bottom and another conduit **24** leads from a point adjacent the top thereof. By referring to Fig. 2, it will be seen that conduits **21**, **24**, respectively, communicate with a heat exchanger **22**, typically in the form of a

coil, which is positioned within the walls of an ultimate heat transfer and exchange unit which latter typically may be of a refrigerator compartment 23. Compartment 23 is preferably encompassed by insulation 23', as shown.

Referring again to Fig. 1, it will be seen that another subsidiary secondary reservoir 26, enclosed within insulation 26' and having an integral header 126, is positioned below master secondary reservoir 15. Subsidiary secondary reservoir 26 contains heat transfer and exchange fluid and communicates with master secondary reservoir 15 by a conduit 27 and another conduit 28, there being a temperature control means 29, typically comprising a thermostatic valve, interposed in the line of conduit 28. Reservoir 26 is provided with conduits 30 and 32 and by again referring to Fig. 2, it will be seen that conduit 30 communicates with the bottom of a hollow walled portion of compartment 31 and conduit 32 communicates with the top of the hollow wall portion. Compartment 31 may be considered an ultimate heat transfer and exchange unit and typically may be another type of refrigerator compartment. The latter is shown as being encompased by insulation 31'.

Referring again to Fig. 1, it will be seen that another subsidiary secondary reservoir 33, encompassed by insulation 33' and having an integral header 133, is positioned below master secondary reservoir 15. Reservoir 33, like reservoirs 16 and 26, contains heat transfer and exchange fluid and communicates with master secondary reservoir 15 by means of a conduit 34 leading from the bottom and another conduit 35 leading to the top of the last-mentioned reservoir. A temperature control means 36 is provided in the line of conduit 35. A conduit 37 leads from the bottom of reservoir 33 into communication with a hollow bottom portion 38 forming a base of a compartment 39, and another conduit 40 communicates between the top of the hollow bottom portion 38 and the top of the subsidiary secondary reservoir 33 as shown. Compartment 39 may be considered to be an ultimate heat transfer and exchange unit and may typically be still another type of refrigerator compartment. Compartment 39 is preferably encompassed by suitable insulation 39'.

In the drawings referred to up to this point and in the foregoing description, three different types of refrigerator structure have been shown and described which constitute ultimate heat transfer and exchange units. These ultimate units are disclosed as being served from three individual subsidiary secondary reservoirs, the latter in this instance being shown as comprising two types. It will be obvious that there is no limit to the interrelated combinations of secondary reservoirs and ultimate heat transfer and exchange units that may be made. It is pointed out, however, that the subsidiary secondary reservoirs and ultimate heat transfer and exchange units, however formed or integrated, are each independently functioning, although interrelated heat transfer and exchange systems. The arrangement of the three subsidiary secondary reservoirs and the three refrigerated structures shown and described are merely examples of a few of the numerous ways in which the systems utilizing the methods of the invention may be interrelated.

Now referring to the upper right hand side of Fig. 1, it will be seen that there is provided an auxiliary heat transfer and exchange system including a tank 41 exposed to naturally occurring conditions and having on its exterior heat dissipating fins 41'. Tank 41 contains heat transfer and exchange fluid and in this instance is positioned above the master secondary tank 15. Extending from the bottom of the tank 41 is a heat transfer and exchange fluid conduit 42, the flow of fluid therethrough being controlled by temperature control means 43 typically in the form of a thermostatic valve. Conduit 42 extends into master secondary reservoir 15 and communicates with the latter adjacent its bottom. Another conduit 44 extends from the top of reservoir 15 to the top of the tank 41, being in open communication with each. Tank 41 has an appropriate header, as shown.

Referring now to Fig. 3, there is therein shown a construction similar to that shown in Fig. 1, except that the complete primary thermal conditioning means high side unit is shown as it would appear when positioned at a lower level than the master secondary reservoir 15, as if such high side unit were located, for example, in a basement.

It will be obvious that, for refrigeration purposes, the complete subsidiary secondary systems should preferably be arranged below the master secondary reservoir, in order to most readily permit thermo-siphonic flow of the heat transfer and exchange fluid between each reservoir and the one to which it is subsidiary. The heat transfer and exchange fluid in colder condition will flow through the lowermost of the conduits interconnecting it in heat transfer and exchange relation with the reservoir subsidiary thereto, and, having served its heat-absorbing function, will obviously tend to rise and be returned from each subsidiary reservoir to the reservoir antecedent thereto through the uppermost of the conduit means shown, for re-cooling.

When the heat transfer and exchange fluid is of optimum characteristics, the necessity for substantial difference in levels between each reservoir and its antecedent reservoir is considerably reduced, yet some difference in the elevation between the several subsidiary systems should preferably be provided where thermo-siphonic action alone is relied upon for flow of the heat transfer and exchange fluid.

There are, however, some conditions which make desirable the installation of the master secondary reservoir 15 and the auxiliary cold source heat-dissipating tank 41 below the levels of the ultimate heat transfer and exchange units. This problem may be solved, among other similar methods, by the arrangement which is described immediately hereinbelow.

Referring now to Fig. 4, the general arrangement of the over-all structure and the conduits leading to and from the subsidiary secondary reservoirs 16, 26 and 33 and the ultimate heat transfer and exchange units 23, 31 and 39 will be seen to be generally the same as have been previously described. That is to say that as far as possible, the units comprising the subsidiary system and the branch system or systems subsidiary thereto are arranged at respective elevations sufficient to permit thermo-siphonic flow of the heat transfer and exchange fluid.

However, with the master secondary reservoir 15 at the low level shown for it, it is obviously impossible to get flow of heat transfer and exchange fluid from such reservoir to the subsidiary secondary tanks or reservoirs by thermo-siphonic action alone, and therefore the fluid must be cir-

culated by pump means. To achieve this object, in this modification, a pump 45 is utilized, such pump being mounted in the line of a main conduit comprising conduit portions 47, 47'. Pump 45 is driven by an electric motor 46 or other driving means.

As shown at the upper right hand side of Fig. 4, the conduit 24 from ultimate heat transfer and exchange unit 23 in this instance has in its length a temperature control means 48, typically in the form of a thermostatic valve, which precludes the flow of heat transfer and exchange fluid between such unit and subsidiary secondary reservoir 16 except at periods when the temperature differential between such structures is in undesirable imbalance. When the temperature rises above desired levels in conduit 24 the thermostatic valve 48 opens and in so doing closes a switch 49 suitably connected into an electric circuit 50 which controls operation of pump-driving motor 46. Simultaneously, electrically actuated valve 51, which is also in circuit 50 and energized by closure of such circuit, is opened. The operation of the pump 45 thereupon circulates the heat transfer and exchange fluid from master secondary reservoir 15 through heat exchanger 17, thereby lowering the temperature of the heat transfer and exchange fluid in subsidiary secondary tank or reservoir 16. Heat transfer and exchange fluid will then flow thermo-siphonically from reservoir 16 through heat exchanger 22 (Fig. 2) in ultimate heat transfer and exchange unit 23 until the desired temperature is reached in such unit, whereupon thermostatic valve 48 will close, in so doing breaking the motor operating circuit maintained by switch 49, thus inactivating the motor and pump and also causing electrically actuated valve 51 to close. A check valve 52 may be inserted in the main conduit portion 47' to assure that pump 45 will at all times be fully primed.

The combined pumped and thermo-siphonic flow of the heat transfer and exchange fluid is regulated for subsidiary secondary reservoir 26 and its associated subsidiary branch or ultimate heat transfer and exchange unit 31 by the coacting series of elements comprising thermostatic valve 53, switch 54 and electrically actuated valve 55; and for subsidiary secondary reservoir 33 and its associated subsidiary branch or ultimate heat transfer and exchange unit 39 by the coacting series of elements comprising thermostatic valve 56, switch 57 and electrically actuated valve 58, all of which function independently or in unison, as described above, with respect to those similar elements associated with subsidiary secondary reservoir 16 and its branch which terminates in ultimate heat transfer and exchange unit 23.

With the auxiliary system tank 41 located at a level lower than the reservoir 15, positioned, for example, in a spring or well, it is also necessary to pump-circulate the heat transfer and exchange fluid in the auxiliary system of which such tank is part. To do this, a conduit 42 is provided which communicates between main conduit 47 and the bottom of tank 41, the flow through the conduit being controlled by a temperature control means 43 typically comprising a thermostatic valve. Another conduit 44 communicates between the upper portion of tank 41 and reservoir 15 adjacent the top of the latter. It will be clear that during operation of pump 45 heat transfer and exchange fluid will be circulated through tank 41, thereby dissipating heat units through the latter.

It will be obvious that there is provided by the apparatus described immediately hereinabove structure whereby the thermo-siphonic flow of heat transfer and exchange fluid may be maintained within certain portions of the secondary system due to their relative positioning and that the flow of such fluid to certain other portions of the secondary system may be augmented by pump means. It will be further obvious that any single subsidiary secondary reservoir or any system comprising any combination of such reservoirs and associated still further subsidiary system may function under pump-induced flow generally in the same manner as described above.

Now referring to Fig. 5, there is therein shown another optional form of the invention wherein the subsidiary secondary reservoirs are eliminated and the heat transfer and exchange fluid from the master secondary tank or reservoir 15 is circulated directly to the ultimate heat transfer and exchange units such as the coils or hollow wall portions of the refrigerating compartments illustrated in Fig. 2. The modified structure shown as comprising this system achieves a few of the accomplishments of the over-all system wherein subsidiary secondary reservoirs are interposed between the master secondary reservoir and the ultimate heat transfer and exchange units, but in some instances and applications this form is adequate. In installations of this kind it has been found best to provide sufficient heat transfer and exchange fluid capacity in master secondary reservoir 15 so that it will contain about twice the amount of heat transfer and exchange fluid as the heat transfer and exchange systems subsidiary thereto.

It will be noted that in this instance there is provided at one side of the master secondary reservoir 15 a header 215 above the level of the base of the primary thermal conditioning means to serve the same function as header 115 shown in Fig. 1 and that the evaporator 113 is directly immersed in the heat transfer and exchange fluid in master reservoir 15.

Now referring to Fig. 6, there is therein shown still another form of the invention. In this modification the primary thermal conditioning means is mounted on a hollow channelled base 113' formed within which is the evaporator. This base is securely clamped in planar heat exchange relationship with master secondary reservoir 15. In this instance reservoir 15 is provided with a top of heat conductive metal which readily permits heat exchange by conduction between the heat transfer and exchange fluid in master reservoir 15 and the evaporator. As in the case of the showing of Fig. 1, a header 215 is provided to permit expansion and contraction of the heat transfer and exchange fluid and to assure continuous contact of such fluid with the top of the reservoir 15. It will be appreciated that the hollow base 113' can be arranged to contact any desired portion of the surface area of reservoir 15.

Up to this point the structures and independent but correlated heat transfer and exchange systems comprising the invention have been shown and described as being applied wholly to refrigeration. For refrigeration purposes, where thermo-siphonic flow of the heat transfer and exchange fluid is entirely relied upon for circulation of such fluid, it is obvious that the entire secondary system including its subsidiary and branch reservoirs or tanks should be positioned below the tank in which the evaporator of the primary thermal conditioning means is located

where, as in Fig. 1, such a tank is provided, or, at any rate below the cold producing evaporator and the master secondary reservoir, however these elements may be correlated. It is also obvious that to induce thermo-siphonic flow between the master secondary reservoir, the subsidiary secondary reservoirs and those other reservoirs or similar elements which form the more remote or the ultimate heat transfer and exchange means or units (for example, the compartments 23, 31, or 38 and associated structure of Fig. 1) these intermediate and ultimate heat transfer and exchange structures should be positioned in "stepped" fashion below that reservoir to which each is subsidiary.

It is also obvious that where the respective reservoirs cannot be positioned in the respectively "stepped" positions most desirable for fully thermo-siphonic flow of the heat transfer and exchange medium, pump flow can readily be wholly or partially substituted for thermo-siphonic flow between any desired portions of the system.

Further, up to this point only the evaporator side of the thermal conditioning means has been shown and described as being productively utilized, the heat from the condenser being dissipated.

Thus, were the system reversed, i. e. with the condenser positioned in heat transfer and exchange relation to a volume of heat transfer and exchange fluid in a master heat secondary reservoir, and were its immediately subsidiary reservoirs and those subsidiary to the latter positioned to be at correspondingly higher positions with respect to one another, structures and methods similar to those hereinbefore described would as well function for heating purposes as for refrigeration use. Obviously, pump induced flow as well as thermo-siphonic flow of the heat transfer and exchange fluid can be used in any portion of the system, generally in the same manner as has been described with respect to the refrigeration use of the structures and methods of the invention.

The same thermal flywheel effect, and other corresponding advantages including control, regulation, transfer and exchange of heat units can be had in a heating system as are had in a refrigerating system and, of highest importance, dual use may be had of the heat unit collecting and dissipating characteristics of a conventional thermal conditioning means having both an evaporator and a condenser.

Typical of dual use of refrigeration and heating, in a restaurant, the ice cream, meats, milk products and similar perishables require refrigeration and the steam tables, roll warmers, coffee makers and other like units require heat. In present restaurant practice primary thermal conditioning means utilized for refrigeration results in a nearly total loss of readily usable heat, while coal, gas, and electricity are consumed to produce heat for other fixtures requiring it, and these fixtures, having opposite uses, are often in close juxtaposition. Thus, by the use of apparatus similar to that about to be described, the heat from cooking devices and from the restaurant itself as well as the heat extracted by use of refrigerating apparatus may be re-captured and reused not only for heating the necessary units but also for heating the restaurant itself in cold weather.

Referring now to Fig. 7, the over-all refrigeration system including the refrigeration master secondary reservoir, the subsidiary secondary systems and still further subsidiary systems shown at the lower right hand side of the drawing are very much like the showings of similar structure in Figs. 1 and 2.

In Fig. 7, reference numeral 310 indicates a primary thermal conditioning means which in this instance comprises a motor, compressor, condenser, receiver (not shown), expansion valve and evaporator, and having a temperature control means 311. Primary thermal conditioning means 310 is shown as being mounted medially of a tank structure generally indicated 312 having at its one side a refrigeration master secondary reservoir 313 and at its other side a heat master secondary reservoir 314. Extending downwardly into master secondary reservoirs 313, 314 are primary tanks 315 and 316.

Primary tanks 315 and 316 and master secondary reservoirs 313 and 314 all contain a suitable heat transfer and exchange fluid. The primary thermal conditioning means evaporator 317 is immersed in the fluid in tank 315 and its condenser 318 is immersed in the fluid in tank 316. An expansion valve 319 is interposed in the conduit 320 which interconnects the evaporator and the condenser.

The entire unit comprising the primary thermal conditioning means, including its condenser and evaporator, is unitarily removable from the main tanks in which the evaporator and condenser are positioned, without disturbing the secondary systems, by removing the normally bolted down covers 321 and 322.

Master secondary reservoirs 313, 314 may, if desired, be provided with header spaces 323 and 324 to permit expansion and contraction of the fluids in such reservoirs. It will be obvious that the fluids in each primary tank and the master secondary reservoir with which each tank is associated are in such heat exchange relation that their respective temperatures are normally maintainable within a limited common temperature range.

Since the tank structure 312 comprises refrigeration and heat master secondary reservoirs 313, 314, respectively, an insulating partition 325 is interposed between such reservoirs to prevent heat exchange therebetween. Leading outwardly from the refrigeration master secondary reservoir 313 is a master conduit 330 which forms a common heat transfer and exchange fluid supply means for certain of the hereinafter described subsidiary secondary reservoirs which form a part of the subsidiary secondary system. Branched from master conduit 330 are other conduits 331, 332 and 333 leading into communication or association with the below-described subsidiary secondary reservoirs, as shown.

Conduit 331 communicates with a heat exchanger 334 which is contained within subsidiary secondary reservoir 335, a conduit 336 leading from the top of such heat exchanger and communicating with reservoir 313 adjacent its top. Reservoir 335 also contains a suitable heat transfer and exchange fluid. A temperature control means 337 comprising, typically, a thermostatic valve, is shown as interposed in the line of conduit 336 to regulate the flow of heat transfer and exchange fluid therethrough, limiting the flow of such fluid between heat exchanger 334 and reservoir 313 to times when the heat transfer and exchange fluid in reservoir 335 rises to a temperature undesirable therefor.

Conduit 332 communicates with another subsidiary secondary reservoir 340 adjacent the bot-

tom of the latter, and a conduit 341 communicates between the top of such reservoir and the top of master secondary reservoir 313. A temperature control means 342, typically in the form of a thermostatic valve, limits the flow of heat transfer and exchange fluid between subsidiary secondary reservoir 340 and master reservoir 313 to periods of time when the respective volumes of such fluids are in undesirable thermal imbalance.

Conduit 333 communicates between main conduit 330 and one side of a removable heat exchanger 351, later hereinafter described, which is associated in heat transfer and exchange relation with the fluid in subsidiary secondary reservoir 345, being positioned on the latter. A conduit 346 communicates between the heat exchanger and master secondary reservoir 313 at a point adjacent the top of the latter. A temperature control means 347, typically in the form of a thermostatic valve, is interposed in the line of conduit 346 to limit the flow of heat transfer and exchange fluid between heat exchanger 351 and master reservoir 313 to periods when certain differentials exist between the respective volumes of heat transfer and exchange fluid in the named heat exchanger and master reservoir.

The removable feature of the heat exchanger mentioned immediately hereinabove, in addition to such obvious advantages as accessibility and ease of repair and inspection also makes for flexibility in the system of the invention in that the evaporator of a primary thermal conditioning means may, if desired, be substituted for the heat exchanger thereby making of the reservoir 345 a master secondary reservoir. Obviously where similar structure is provided any subsidiary secondary reservoir, wherever located in the systems, may be converted to a master secondary reservoir or changed to be served by another unit antecedent thereto, or changed from one system to another, thereby permitting expansion or contraction of a system, after installation, as conditions may require.

Each above-mentioned subsidiary secondary reservoir is preferably provided with a header, reference numerals 348, 349 and 350 indicating, respectively, the headers on reservoirs 335, 340 and 345. As has been previously mentioned, these headers substantially accelerate thermo-siphonic flow of the heat transfer and exchange fluid.

The ultimate heat transfer and exchange unit served by subidiary secondary reservoir 335 comprises a heat exchanger 355 shown in the form of a coil positioned within the walls of a compartment 356, which might typically be a movable member such as a refrigerated drawer in a bottle cooler or the like. A heat transfer and exchange fluid conduit 357 communicates between the lower end of heat exchanger 355 and the lower portion of subsidiary secondary reservoir 335 and another conduit 358 communicates between the upper end of such heat exchanger and the upper portion of such reservoir. A temperature control means 359, usually in the form of a thermostatic valve, is interposed in the line of conduit 358 to permit or preclude flow or heat transfer and exchange fluid between the ultimate heat transfer and exchange unit 355 and subsidiary secondary reservoir 335 when the fluid in such unit is at an undesirable or a desirable temperature, respectively.

To permit compartment 356 to move or swing, conduits 357, 358 are provided with flexible tube portions 357*a* and 358*a*, respectively, as shown.

The ultimate heat transfer and exchange unit served by subsidiary secondary reservoir 340 comprises a hollow wall portion 360 of a compartment 361 which, in a restaurant installation, might typically be a swinging-shelf-type frozen food compartment.

A heat transfer and exchange fluid conduit 362 communicates between the lower part of hollow wall portion 360 and the lower part of subsidiary secondary reservoir 340, and another conduit 363 communicates between the top of the hollow wall portion and a position in reservoir 340 elevated above that point with which conduit 360 communicates with the latter. A temperature control means 364 permits or precludes flow of heat transfer and exchange fluid within selected ranges between the above-named subsidiary secondary reservoir and the hollow wall portion 360 and its associated compartment 361.

To permit compartment 361 to be moved or swung with respect to reservoir 340 which serves it, conduits 362, 363 have in their length flexible tube portions indicated, respectively, by reference numerals 362*a* and 363*a*.

Referring now to the showing at the extreme bottom right hand portion of Fig. 7, it will be seen that conduits 370, 371 communicate with subsidiary secondary reservoir 345 at, respectively, lower and higher levels of the latter and terminate, respectively, at lower and higher levels in communication with a hollow bottom portion 372 forming an ultimate heat transfer and exchange unit integral with a compartment 373. Compartment 373 in a restaurant application might typically be a bottle cooler in which the bottoms of the bottles repose in heat-conductive contact with the upper surfaces of hollow bottom portion 372. A temperature control means 374, typically in the form of a thermostatic valve, is interposed in the line of one of the aforementioned conduits, in this case conduit 371, to shut off the flow of heat transfer and exchange fluid between portion 372 and subsidiary secondary reservoir 345 when the temperature of the heat transfer and exchange fluid in the hollow bottom portion is in desired temperature relation to that fluid in the subsidiary secondary reservoir 345.

It will be obvious from the foregoing that subsidiary secondary reservoirs 335, 340 and 345 and their associated conduits and controls comprise individual systems, subsidiary to master secondary reservoir 313, in which the heat transfer and exchange fluid in any one or all of the former of which may be maintained, if desired, at a temperature differential to that of the similar or same fluid in the master secondary reservoir; and it will be further obvious that the heat transfer and exchange fluid-containing portions of compartments 356, 361 and 373, together with their several integrated individual conduits and controls together with the compartments or the like with which the fluid-containing portions are associated constitute branch systems served by the subsidiary secondary reservoir systems forming, in this instance, ultimate heat transfer and exchange units, the temperatures in the heat transfer and exchange fluid contained in which may be maintained at a differential to the same or similar fluid in the subsidiary secondary system by which each branch is served.

Still referring to the lower right hand portion of Fig. 7, shown diagrammatically below master secondary reservoir 313 is a tank 380 having a header portion 381. Tank 380 is exposed to natural conditions, as, for instance, those occurring in a spring or well, to function as a heat-

dissipating or cold accumulating means to supplement the function of the cold producing means otherwise shown.

Tank **380** and its below-described associated conduit system contains a quantity of heat transfer and exchange fluid and is preferably provided with fins **382**. A heat transfer and exchange fluid conduit **383** communicates between the bottom of tank **380** and the bottom of a heat exchanger **384**, shown in this instance as being of the coil type, and another conduit **385** communicates between the upper levels of the heat exchanger and a point adjacent the top of the tank. Heat exchanger **384** in this instance is shown as being positioned in subsidiary secondary reservoir **335** and in heat transfer and exchange relation to the fluid in the latter. A temperature control means **386**, usually in the form of a thermostatic valve, is interposed in the line of one of the conduits communicating between tank **380** and subsidiary secondary reservoir **335**, in this instance shown as being in the line of conduit **385**, this valve being so set as to preclude flow of heat transfer and exchange fluid within the closed system comprising tank **380**, conduits **383**, **385** and heat exchanger **384** during periods of time when the fluid in tank **380** is warmer than the similar fluid in reservoir **335**.

Referring now to the upper left hand portion of Fig. 7, wherein are shown typical systems and arrangements for utilizing the inventive concepts herein disclosed in heating apparatus, it will be seen that a heat exchanger **400** is immersed in the heat transfer and exchange fluid in master heat secondary reservoir **314**. Heat exchanger **400** is shown diagrammatically as being of the coil type but obviously may be of any other form as, for instance, the plate type.

The upper portion of heat exchanger **400** communicates with a master conduit **401** in the line of which is a motor driven pump **402**, the motor of which is not shown. Master conduit **401** communicates by means of a conduit **403** with the upper portion of a subsidiary secondary reservoir **405** and a conduit **404** communicates between the bottom portion of subsidiary secondary reservoir **405** and another heat transfer and exchange fluid master conduit **406**. Master conduit **406** communicates with the lower portion of heat exchanger **400**, as shown.

Typically, another type of subsidiary secondary reservoir **410** may be in communication by means of a heat transfer and exchange fluid conduit **407** with master conduit **401** adjacent the top of the former, and another conduit **408** communicates between lower portions of such reservoir and master conduit **406**. A temperature control means **409**, generally in the form of a thermostatic valve, is shown as being in the line of conduit **407** to shut off flow of fluid from master conduit **401** into reservoir **410** when the temperature of that volume of the same fluid in subsidiary secondary reservoir **410** is at the temperature desired.

Reference numeral **415** indicates a type of subsidiary secondary reservoir which contains a wholly enclosed volume of heat transfer and exchange fluid. This enclosed volume of fluid is brought to desired temperature by means of a heat exchange **412** having a conduit **411** communicating between its upper portion and master conduit **401** and having another conduit **413** communicating between its lower portion and fluid master conduit **406**. A temperature control means **414**, for instance, a thermostatic valve, is shown as being interposed in the line of conduit **411** to limit flow of heat transfer and exchange fluid through heat exchanger **412** to times when the temperature of the inert fluid in reservoir **415** is lower than required.

Still another form of subsidiary secondary reservoir having great utility in the heat-use application of the invention is shown below the above-described reservoir **415**. In this instance, the subsidiary secondary reservoir is indicated by reference numeral **420** and contains an enclosed volume of heat transfer and exchange fluid. The enclosed fluid is heated by a heat exchanger in the form of an enlargement **421** of master conduit **401**, the enlargement having thereon heat-dissipating fins **422**.

Referring again to pump **402**, this unit should be of a type which freely permits passage therethrough of the fluid in master conduit **401** by thermo-siphonic action when the pump is not being driven; and under driven conditions it should flow the heat transfer and exchange fluid with desired rapidity at all times through master conduit **401**, its enlargement **421**, the subsidiary secondary reservoir **405**, master conduit **406** and heat exchanger **400**; and under open conditions of temperature control means **409** and **414** it will also flow the conduit-borne fluid through subsidiary secondary reservoir **410** and through heat exchanger **412**.

To accommodate expansion of the heat transfer and exchange fluid passing therethrough, both subsidiary secondary reservoirs **405** and **410** are provided with expansion heads **423**, **424**, respectively.

It will be obvious that reservoirs **405**, **410**, **415** and **420** comprise subsidiary systems in which, as in the case of reservoir **405**, the heat transfer and exchange fluid contained in the associated conduit system master conduits **401**, **406**, may have free, unrestricted thermo-siphonic and/or pump-induced flow therethrough; in the case of reservoir **410** the flow of fluid is open to the interior of such reservoir but restricted by temperature control means to periods wherein the temperature of the separate volume of the same fluid in the reservoir is at an undesirable thermal imbalance to that portion of the secondary system antecedent thereto; in the case of reservoir **415** the flow of fluid between master conduits **401**, **406**, respectively, is restricted to the confines of a heat exchanger and is further limited to flow in the heat exchanger, by temperature control means, to periods of time when the non-flowing fluid in the subsidiary secondary reservoir is undesirably colder than the fluid in the master conduit system; and in the case of reservoir **420** the heat exchange relation between master conduit enlargement **421** and the inert fluid in the immediately aforementioned reservoir permits unrestricted flow of the fluid through the conduit while bringing the fluid in the reservoir to a temperature range approximating that of the fluid in the conduit.

Served by the subsidiary secondary reservoirs described hereinabove are branch systems, shown in this instance as ultimate heat transfer and exchange units in the form of heat-dissipating radiators or the like. Since these ultimate units rely predominantly upon heat reception by convection involving thermo-siphonic flow of the heat transfer and exchange fluid therein, these ultimate heat dissipation units are preferably elevated with respect to the sub-

sidiary secondary reservoirs by which they are served.

In the case of the ultimate heat transfer and exchange unit served by subsidiary secondary reservoir **405** it will be seen that a conduit **501** communicates between the upper levels of reservoir **405** and reservoir **500** and another conduit **502** communicates between the respective lower levels of such reservoirs. Reservoir **500** has on it a header **503**. A temperature control means **504**, typically a thermostatic valve, is shown as being interposed in the line of conduit **501** to limit flow of fluid between such reservoirs to periods of time when the temperature of the volume of fluid in reservoir **500** is undesirably colder than the volume of the same fluid in reservoir **405**.

Subsidiary secondary reservoir **410** is in heat transfer and exchange relation with the ultimate heat transfer and exchange unit **505** served thereby by means of the heat exchanger **506** which is immersed in the fluid in subsidiary secondary reservoir **410**. A conduit **507** communicates between the upper portion of heat exchanger **506** and the reservoir mentioned at a point adjacent the upper level of the fluid in the reservoir, and another conduit **508** communicates between the lower portion of heat exchanger **506** and the lower part of reservoir **505**. A temperature control means **511** may be utilized, being interposed in the line of conduit **507** to permit free flow of heat transfer and exchange fluid in the closed system comprising reservoir **505**, conduits **507**, **508** and heat exchanger **506** when the temperature of the fluid in such reservoir is undesirably low in relation to that of the fluid in reservoir **410**. Reservoir **505** has on it a header **512** to permit expansion of the fluid contained in the former.

The branch system served by closed subsidiary secondary reservoir **415** is identical to that shown and described with respect to the system associated with subsidiary secondary reservoir **410**. This branch or further subsidiary system includes reservoir **510**, forming an ultimate heat transfer and exchange unit, the conduits **513**, **514**, forming, respectively, upper and lower intercommunicating means between reservoir **510** and a heat exchanger **525**. A temperature control means **516** may be in the line of conduit **513**, typically a thermostatic valve, which would shut off flow of heat transfer and exchange fluid between the heat exchanger and the reservoir operatively intercommunicating therewith, when the temperature of the fluid in the latter reaches a desired temperature. Like the other above-described reservoirs, forming the ultimate heat transfer and exchange units (**500** and **505**) reservoir **510** has on it a header **517** to permit expansion of the fluid in the reservoir.

The ultimate heat transfer and exchange unit served by subsidiary secondary reservoir **420** comprises the reservoir **515** having a header **522** thereon, a heat exchanger **520** and conduits **518**, **519** connecting, respectively, the upper and lower portions of the heat exchanger with the upper and lower portions of reservoir **515**. A temperature control means **521**, again usually a thermostatic valve, permits the flow of heat transfer and exchange fluid between the heat exchanger and the reservoir by which it is served when the temperature of the fluid in the terminal reservoir is below a desired level and precludes flow when the fluid is at a desired level.

The over-all heating and refrigerating system shown in Fig. 7 should have means associated with it for balancing the heating and refrigerating load. Obviously, conditions could be encountered wherein an unusual demand on either side might develop on the opposite side an excess of the desirable amount of the converse condition of heat or cold.

Illustratively, suppose an unusual and continuous demand for heat were made upon ultimate heat transfer and exchange units **500**, **505**, **510** and **515**. This would tend to rapidly cool the fluid in these units and the temperature control means **504**, **511**, **516** and **521** would thereupon permit flow of heat transfer and exchange fluid through the units. This would rapidly withdraw heat units from the volumes of the same fluid or the separate fluids in the subsidiary secondary reservoirs, the temperature control means associated with any subsidiary would open, and pump **402** would be called upon to circulate the fluid through the master conduits and associated units, as well as through the heat exchanger **400**. Ultimately the temperature of the fluid in master heat secondary reservoir **314** would be reduced to the point that the primary unit motor and compressor **310** would be brought into operation.

Assuming a normal or less-than-usual demand for refrigeration, the operation of the primary unit might create in the fluid in master cold secondary reservoir **313** an undesirable temperature condition.

As previously mentioned, the converse situation could also happen. An excessive continuous demand for refrigeration might ultimately cause the build-up of an undesirable heated condition of the fluid in master heat secondary reservoir **314**.

It will be obvious that under conditions wherein a large amount of heat were required by the heating side and where the temperature of the heat transfer and exchange fluid in the cold side master secondary reservoir were at an extremely low level, the primary thermal conditioning means evaporator, in the absence of balancing means, would have but few heat units upon which to draw, and, in consequence, would be put into operation under conditions wherein its efficiency would be low.

Conversely, if the heat side were at desired levels and an extreme demand for refrigeration developed, the primary thermal conditioning means condenser would have difficulty in disposing of the heat units accumulated by the evaporator, and, in the absence of balancing means, the primary unit would first be forced into an inefficient operating phase which, if continued, would cause the motor of the unit to become overheated and perhaps to burn out.

To take care of this situation, should it develop, there is provided the heat dissipating and procuring means described hereinafter.

To dissipate undesirable accumulation of heat units from master heat secondary reservoir **314** conduit means **601**, **602** are provided in communication between a heat exchanger **605** positioned in master heat secondary reservoir **314** and a heat dissipator **600**. A motor-driven pump **603**, the motor of which is not shown, is in the line of one of the conduits and temperature-controlled switch means **604**, in the electric circuit into which the motor is connected, puts the motor and pump **603** in operation only at such times as the temperature of the heat transfer and exchange fluid in reservoir **314** is at an undesirably high level.

To absorb a desired amount of heat to counter-

act the effect of production-above-usage of refrigeration, a heat absorber **700** is provided. Heat absorber **700** is in communication by means of conduits **701**, **702**, with a heat exchanger **705** positioned within master cold secondary reservoir **313**. A motor-driven pump **703**, the motor of which is not shown, is in the line of one of such conduits and temperature controlled switch means **704**, in the electric circuit into which the motor is connected, puts the motor and its interengaged pump **703** in operation. The temperature-controlled switch is set to operate only when the temperature of the heat transfer and exchange fluid in reservoir **314** is at an undesirably low level.

Throughout the description to this point, reference has many times been made to the heat transfer and exchange fluid. Several types of fluid, either liquid or gas, or both, may be used individually or in separated combination in the system comprising the invention. The type and kind of heat transfer and exchange fluid is dependent on what is to be expected of it under its particular conditions of use, i. e., the temperature range within which the system containing it is to operate and the characteristics of the fluid as to conductivity, specific heat, density, viscosity, fusion points, etc., within the required temperature ranges. Illustratively, it will be obvious that the heat transfer and exchange fluid in the primary cold and heat tanks **14** (Fig. 1) or **315**, **316** (Fig. 7) serve only for heat unit exchange purposes. Thus, for refrigeration purposes, a fluid having a relatively high fusion or freezing point, water, for instance, would normally not be feasible for use in tank **14** and the secondary systems associated therewith because of the tendency of water to freeze. However, on the heating side, if the system were one operating at less than the boiling point of water, the latter might be readily usable throughout the heat system as the heat transfer and exchange fluid. If temperatures above the boiling point of water were developed, a fluid having a higher boiling point than water might be used in tank **316**, or in master secondary reservoir **314**, and water might be used in the subsidiary secondary system therebeyond; or, as in the case of that form of the structures shown in Fig. 7 as third from the top at the upper left, wherein reservoir **510** is the ultimate heat transfer and exchange unit and subsidiary secondary reservoir **415** is the portion of the system immediately antecedent to the named ultimate heat transfer and exchange unit, water might well be the heat transfer and exchange fluid in reservoir **510**, and its associated conduits leading to and from heat exchanger **525** and a light oil or a glycerine base fluid might be used as the heat transfer and exchange fluid in subsidiary secondary reservoir **415**.

It will thus be apparent that a great variety of heat transfer and exchange fluids may be used. Typical forms of fluids found useful under variant conditions are methyl chloride, water, alcohol, brine solutions, oils, and the like.

It will be obvious that to some degree the structures of the several interrelated but independent heat transfer and exchange systems may be varied in accordance with the type of heat transfer and exchange fluid or fluids used. For instance, whether the subsidiary secondary reservoirs or those heat transfer and exchange units therebeyond are or are not hermetically sealed will depend a good deal on the type of the heat transfer and exchange fluid used.

One heat transfer and exchange fluid which has been found highly satisfactory for use in the secondary and ultimate heat transfer and exchange units, when used for refrigeration purposes, has been used extensively in refrigerated trucks and the like and is sold under the trade name "Thermerant." The exact chemical composition of this heat transfer and exchange fluid is not known.

When using heat transfer and exchange fluid of the type immediately hereinabove indicated for refrigeration purposes, the several fluid-containing tanks and reservoirs and their associated conduits are completely filled with the fluid, the temperature of such fluid being raised to about 70° F. The reservoirs are then hermetically sealed. This particular heat transfer and exchange fluid contracts when the temperature is reduced below 70° F., thus when the temperature is lowered, as will be done at "in-use" refrigeration temperature ranges, the fluid contracts and headers **115**, **116**, **126** and **133** (Fig. 1) or the similar elements **323**, **348**, **349** and **350** (Fig. 7) will be under partial vacuum and this vacuous condition accelerates thermo-siphonic flow of the fluid within the system.

In the drawings and description the structures have all been directed to a system including a compressor-condenser-evaporator unit. It will be obvious that the primary unit of the type described is merely a convenient means of supplying heat or, conversely, its condition of absence, cold, and that other primary thermal conditioning means may be substituted therefor.

From a refrigeration standpoint, in larger installations, due to the necessity for high reserve heat unit absorbing capacity in the master secondary reservoir, usually greater refrigerating ability is required in the portions of the entire systems therebeyond than can be had from water-ice because of its relatively high melting temperature. However, for certain installations, water-ice or water-ice and an accelerator such as salt may be used as the cold source. Solid carbon dioxide is a convenient primary thermal conditioning substance which is now readily available and this product has been found satisfactory for many types of refrigeration applications utilizing the structures of this invention.

When water-ice or Dry Ice is used as a primary thermal conditioning means, tank **14** (or **315**) may be utilized as a dry non-fluid containing tank or receptacle.

From a heating standpoint, the primary thermal conditioning means, in addition to those heat-producing means shown in Fig. 7, typically may be a gas or other type fire or flame, an electrical heating unit, or any other source of heat.

Wherever temperatures are mentioned herein in terms of degrees, they are to be interpreted in terms of the Fahrenheit scale.

Hypothetically illustrative of use of the refrigeration structure shown in Fig. 1, let it be assumed that the temperature control means **9** were set to maintain the heat transfer and exchange fluid in tank **14** within a temperature range of, say, −20° to −30° F. The heat transfer and exchange fluid in master secondary reservoir **15** will be found, under usual conditions, to be maintained approximately within the range indicated hereinabove. In the absence of temperature control means such as that indicated by reference numeral **20**, it will be obvious that the temperature of the heat transfer and exchange fluid in subsidiary secondary reservoir **16** would

soon be brought to close proximity to that in master secondary reservoir **15** due to flow of the fluid in reservoir **15** through heat exchanger **17**.

Assuming now that the desired temperature range to be maintained in compartment **23** were, say 34° to 38°, it might be established that temperature control means **20** should be so set for operation as to regulate flow of heat transfer and exchange fluid through heat exchanger **17** within a temperature range, as to the fluid in subsidiary secondary reservoir **16**, of, say, 32° to 34° F.

Referring now to Figs. 1 and 2 and further illustratively, assuming that compartment **31** were to be used for the storage of frozen foods and it were desired to maintain in this compartment temperatures within the range, say, of from −5° to −15° F., in this case, it might be determined that temperature control means **29** should be set to regulate flow of heat transfer and exchange fluid between master secondary reservoir **15** and subsidiary secondary reservoir **26** to a range wherein the temperature of the fluid in the latter were maintained at, say, −15° to −20°.

Further illustratively, assuming that compartment **39** were to be maintained at an average temperature of about 32° as might be desirable for storage therein of bottled beverages, it might be found that temperature control means **36** should be set to permit flow of heat transfer and exchange fluid between subsidiary secondary reservoir **33** and master secondary reservoir **15** so as to maintain the fluid in subsidiary secondary reservoir **33** within the temperature range of, say, 27° to 31°.

As a practical example of the use of the structure of Fig. 1, a small hotel might typically have a single high side unit and associated structure including a master secondary reservoir installed in a first floor hallway. A beer cooler located at the bar and forming an ultimate heat transfer and exchange unit might typically be served by a subsidiary secondary reservoir located at any convenient place, the beer cooler being maintained at, say, at 36° to 38° F. temperature; another compartment forming an ultimate heat transfer and exchange unit and located in the service pantry, served by a conveniently located subsidiary secondary reservoir, might be an ice cream compartment maintained at, for instance, 0° to −5° F.; still another compartment having an ultimate heat transfer and exchange unit associated with it might be for general food storage, and located in the kitchen, and this compartment might typically be maintained within a range of from 34° to 38° F. Were it ever necessary or desirable to change the use of any ultimate heat transfer and exchange unit, all that would be required would be to change the temperature control means to another range. By simply adjusting the controls, for instance, the general food compartment could be used for frozen food storage.

Thus from a single source of refrigeration there are provided multiple temperature outlets, and, of course, these advantages may correspondingly be had by the use by similar structure in two or more compartments in a unitary household or commercial refrigerator.

Where, in the above indicated installation, it might be advantageous to do so, the entire high side unit may be located remote from the remainder of the structure as shown in Fig. 3; or the high and low side unit including the master secondary reservoir may be positioned remotely

from the other portions of the system as shown in Fig. 4.

Referring again to Fig. 7, generally the same situations as hereinbefore set out would obtain with respect to the structures shown at the lower right hand portion of such figure as has been described with respect to the similar showings of Fig. 1.

Referring again to the heat dissipating structures at the upper left hand side of Fig. 7, it will be obvious that the temperature of the heat transfer and exchange fluid in subsidiary secondary reservoir **405**, being in open communication with master conduits **401**, **406** will be maintained by thermosiphonic and pump flow, generally at the temperature of the fluid in heat exchanger **400**.

Similarly, the inert heat transfer and exchange fluid in subsidiary secondary reservoir **420** will normally approximate the temperature of the heat transfer and exchange fluid in master conduit **401**, since the enlargement **421** thereof will effectively act as a heat exchanger.

Thus, with respect to the volumes of heat transfer and exchange fluids in both ultimate heat transfer and exchange units or reservoirs **500** or **515**, the sole means of regulating the temperatures thereof comprises temperature control means **504** and **521**, respectively.

Illustratively, were ultimate heat transfer and exchange unit **500** positioned in a room in which an air temperature of 72° were desired, it might typically be found that an average temperature of the heat transfer and exchange fluid in the unit **500** should preferably be 100°, in which case temperature control means **504** might be set to permit flow of heat transfer and exchange fluid between unit **500** and subsidiary secondary reservoir **405** up to a maximum of 105° at which maximum temperature the control means would shut off flow of fluid through conduit **501**.

Similarly with respect to reservoir or ultimate heat transfer and exchange unit **515**, it might be found, for instance, that were this unit located in a position whereby to achieve the desired atmospheric condition temperature control means **521** might be set to preclude flow of heat transfer and exchange fluid through conduit **518** at a maximum temperature of 120°.

Referring now to subsidiary secondary reservoir **410** and the branch system subsidiary thereto comprising ultimate heat transfer and exchange unit or reservoir **505** and its associated heat exchanger **506** and conduits **507**, **508**, temperature control means **409** might be set, for example, to permit flow of heat transfer and exchange fluid from master conduit **401** through conduit **407** until a temperature of 120° were reached by the heat transfer and exchange fluid in subsidiary secondary reservoir **410**. Were ultimate heat transfer and exchange unit **505** located in a place where to maintain a desired air temperature condition of say, 72°, it were required that the fluid in such ultimate unit be maintained at, say, 100°, temperature control means **511** might be set to shut off flow of heat transfer and exchange fluid through such reservoir and associated conduits when a temperature of 115° were reached by the fluid.

With respect to the secondary system comprising subsidiary secondary reservoir **415**, heat exchanger **412** and the branch system subsidiary thereto comprising ultimate heat transfer and exchange unit or reservoir **510** including its associated heat exchanger **525** and the conduits **513**

and 514, assuming it were desirable to maintain in the inert heat transfer and exchange fluid in subsidiary secondary reservoir 815 an average temperature of, say, 120° it might be desirable to so set temperature control means 414 as to preclude flow of heat transfer and exchange fluid from master conduit 401 and through heat exchanger 412 at temperatures higher than, perhaps, 125° F., and were reservoir or ultimate heat transfer and exchange unit 510 so located that to maintain the desired atmospheric condition an average temperature of, say, 110° were required in the fluid in unit 510, then temperature control means 516 might typically be set to permit flow of fluid at temperatures up to, say, 115° F.

Referring now to Fig. 8, reference numeral 800 indicates the motor and compressor of a primary thermal conditioning means, the evaporator 801 of which is of semi-cylindrical configuration in end view, the entire unit, comprising motor, compressor, evaporator and other requisite parts being mounted on an insulated base 802 attached to the upper surfaces of a master cold secondary reservoir generally indicated by numeral 803. Base 802 and the entire unit comprising the thermal conditioning means is removable from the secondary reservoir 803 for replacement or repair. The evaporator 801 is immersed in a volume of heat transfer and exchange fluid contained in a primary tank 804. Primary tank 804 extends a distance into master secondary reservoir 803, being in heat transfer and exchange relation with a volume of heat transfer and exchange fluid in such reservoir.

Shown as being positioned at a lower level with respect to master cold secondary reservoir 803 is a subsidiary secondary reservoir 810 having a header 811 formed integral therewith. Reservoir 810 contains a volume of heat transfer and exchange fluid immersed in which is a heat exchanger 812. Leading into heat exchanger is a conduit 813 and another conduit 814 which communicate, respectively, between the lower portion of reservoir 803 and heat exchanger 812, and the upper portion of reservoir 803 and heat exchanger 812, so that the heat transfer and exchange fluid may flow between the last named reservoir and the heat exchanger. A temperature control means 815 is shown as being interposed in the line of conduit 813 to allow flow of fluid through such conduit when the volume of heat transfer and exchange fluid in subsidiary secondary reservoir 810 is at a higher temperature than is desired for it.

Shown as being positioned below and served by subsidiary secondary reservoir 810 is another subsidiary secondary reservoir 825 which has a header 816 formed integral with it. Reservoir 825 contains a volume of heat transfer and exchange fluid immersed in which is a heat exchanger 817 having a conduit 818 communicating between its lower end and the bottom of subsidiary secondary reservoir 810 and another conduit 819 communicating between its upper end and the upper part of the last named reservoir to allow for flow of the fluid in subsidiary secondary reservoir 810 through heat exchanger 817. A temperature control means 820 is set to limit flow of fluid through conduit 818 to periods wherein the temperature of the fluid in reservoir 825 is higher than it should be for its purposes. So that it may operate as a heat absorbing refrigeration means in the nature of an ultimate heat transfer and exchange unit, reservoir 825 may be provided with outwardly directed fins 821, as shown.

Positioned below subsidiary secondary reservoir 825 is still another subsidiary secondary reservoir 835 which also contains a volume of heat transfer and exchange fluid, immersed in which is a heat exchanger 837. A header 836 is provided on reservoir 835, as shown. Heat exchanger 837 is in communication by means of conduits 838, 839, with the lower portion and the upper portion of subsidiary secondary reservoir 825 so that the fluid in the latter may flow through heat exchanger 837. There is interposed in conduit 838 a temperature control means 840, which permits flow of fluid between the reservoir and its dependent heat exchanger when the temperature of the heat transfer and exchange fluid in subsidiary secondary reservoir 835 is higher than is to be desired for it. As in the case of reservoir 825, reservoir 835 has heat absorption fins 841 about its periphery to permit use of this reservoir as an ultimate heat transfer and exchange unit.

Shown as below and served by subsidiary secondary reservoir 835 is still another subsidiary secondary reservoir, indicated by reference numeral 845. Reservoir 845 has a header 846 formed integral with it and it also contains a volume of heat transfer and exchange fluid in which is immersed a heat exchanger 847. Heat exchanger 847 is in communication by means of conduits 848 and 849 with subsidiary secondary reservoir 835 which antecedes it so that the fluid in the latter may flow between the elements mentioned, except at times when temperature control means 850, shown as being interposed in the line of conduit 848 would shut off flow of fluid, as it would be set to do, when the temperature of the heat transfer and exchange fluid in reservoir 845 was within the temperature range desired for it.

Shown at the left and right of subsidiary secondary reservoirs 810, 825, 835 and 845 are other branch systems in which reference numerals 855, 860, 865, 870, 875, 880, 885 and 890 may represent fluid-containing ultimate heat transfer and exchange units; or alternatively, they may be taken to represent spaces or objects to be refrigerated. In the last-mentioned situation the heat exchangers 856, 861, 866, 871, 876, 881, 886 and 891 would be the ultimate heat transfer and exchange units.

The heat transfer and exchange fluid in subsidiary secondary reservoir 810 serves to cool heat exchangers 856 and 861, conduits 858, 863, leading from the bottom of such reservoir into communication with the lower ends of the respective heat exchangers, and conduits 857 and 862 being in communication between such reservoir and the upper ends of the respective heat exchangers. Temperature control means 859 and 864 are provided in the line of certain of the conduits to open for flow of fluid therethrough only when the temperature of the fluid in the heat exchanger served by each respective conduit is higher than desired.

The heat transfer and exchange fluid in reservoir 825 serves to controlledly cool heat exchangers 866 and 871, reservoir 825 being in communication with such respective heat exchangers through conduits 868 and 873 and conduits 867 and 872. The flow of fluid through conduits 868 and 873 is regulated by temperature control means 869, 874, respectively, to times when the fluids in respective heat exchangers 866

and 871 are at a higher temperature than desired.

The heat transfer and exchange fluid in subsidiary secondary reservoir 835 serves to cool heat exchangers 876 and 881. Each immediately aforementioned heat exchanger is in communication with subsidiary secondary reservoir 835 through conduit means 877, 878, and 882, 883, respectively. Temperature control means 879 shuts off flow of heat transfer and exchange fluid to heat exchanger 876 and temperature control means 884 shuts off flow of heat transfer and exchange fluid to heat exchanger 881, when the temperature of the fluid in the heat exchanger with which each temperature control means is associated is at the desired temperature.

The heat transfer and exchange fluid in subsidiary secondary reservoir 845 is used to cool heat exchangers 886 and 891. In the case of the first mentioned heat exchanger it will be seen that conduit 888 communicates between the respective lower portions of the heat exchanger and the aforementioned reservoir and that conduit 887 communicates between the respective upper portions of the heat exchanger and reservoir. Temperature control means 889 shuts off flow of fluid through conduit 888 when the temperature of the fluid in heat exchanger 886 is at a desired level. In the case of heat exchanger 891 it will be seen that conduit 893 communicates between the respective lower portions of reservoir 845 and the aforementioned heat exchanger, and another conduit 892 communicates between the respective upper portions of the reservoir and the heat exchanger. Temperature control means 894 opens to permit flow of heat transfer and exchange fluid through the heat exchanger when the temperature of the fluid in the latter is higher than desired.

From the above description of Fig. 8 and from the drawing, it will be obvious that the master secondary reservoir and the subsidiary secondary reservoirs may be interrelated in a series, between adjacent ones of which a stepped temperature differential may be produced and maintained; and it will further be obvious that any of the subsidiary secondary reservoirs may be utilized for refrigeration purposes, or, in other words, as an ultimate heat transfer and exchange unit. It will be further obvious that each subsidiary secondary reservoir beyond that first one indicated by reference numeral 810 is, in effect a branch of the one anteceding it and that each ultimate heat transfer and exchange unit is a branch of the subsidiary secondary system which serves it.

The utility of a means for producing multiple stage refrigeration of the type shown is best illustrated by saying that, particularly as respects food for human consumption, research of recent years has developed data indicative of temperature ranges most desirable for preventing deterioration of almost any food product and that the temperatures for each group vary widely, ranging all the way from the problems inherent in the freezing of frozen foods and the protection of such foods from deterioration to the maintenance of relatively high but uniform temperatures, approaching comfortable room temperature. at which products such as flour, citrus fruits, etc., may be kept to prevent insect infestation and spore development. An installation along the lines of the construction of Fig. 8 would have great utility in a cold storage warehouse.

Referring now to Fig. 9, reference numeral 900 indicates a primary thermal conditioning means comprising a motor, compressor, evaporator, receiver and expansion valve having a condenser 901 integrated therewith. The entire primary thermal conditioning means and associated condenser is mounted on an insulated base 902 forming a removable cover for a main primary tank 904 which extends downwardly a distance into a master heat secondary reservoir 903. Tank 904 and master heat secondary reservoir 903 each contain a volume of heat transfer and exchange fluid. Master secondary reservoir 903 has a conduit 905 leading outwardly therefrom adjacent its top and communicating with the upper end of a heat exchanger 908 immersed in the heat transfer and exchange fluid contained within a subsidiary secondary reservoir 910. Another conduit 907 communicates between the lower end of heat exchanger 908 and master secondary reservoir 903. A temperature control means 906 is in the line of conduit 905 and so arranged as to permit flow of fluid between master secondary reservoir 903 and heat exchanger 908 only when the temperature of the heat transfer and exchange fluid in subsidiary secondary reservoir 910 is at an undesirable temperature. Reservoir 910 has a header 909 thereon to allow for expansion of the fluid therein.

Branched from subsidiary secondary reservoir 910 is another subsidiary secondary reservoir 925 which contains a volume of inert heat transfer and exchange fluid which is served in heat exchange relation by a heat exchanger 915 immersed in such fluid, the heat exchanger having conduits 916, 917, which communicate with subsidiary secondary reservoir 910, there being a temperature control means 918 in the line of conduit 916 to preclude flow of heat transfer and exchange fluid therethrough when the temperature of the heat transfer and exchange fluid in reservoir 925 is within the range desired for it. Subsidiary secondary reservoir 925 has on it an expansion header 919.

Another heat exchanger 920 is immersed in the heat transfer and exchange fluid in reservoir 925 which communicates by means of conduits 921, 922, with another subsidiary secondary reservoir 935 which has heat transfer and exchange fluid therein, a temperature control means 923 serving to permit flow of the fluid between reservoir 935 and heat exchanger 920 when the temperature of the fluid in the former is below a desired level. Like the other above-mentioned subsidiary secondary reservoirs antecedent thereto, subsidiary secondary reservoir 935 has a header 929 on its top.

Branched from subsidiary secondary reservoir 935 is a still further branch system comprising subsidiary secondary reservoir 945 which contains heat transfer and exchange fluid, there being a header 939 thereon.' A heat exchanger 930 which is immersed in the heat transfer and exchange fluid in subsidiary secondary reservoir 935 serves to pick up heat units for subsidiary reservoir 945 by means of conduit 931 and conduit 932 in the line of the former of which is a temperature control means or device 933 which precludes or permits flow of heat transfer and exchange fluid between subsidiary secondary reservoir 945 and heat exchanger 930 dependent upon whether the heat transfer and exchange fluid is subsidiary secondary reservoir 945 is or is not at a desired temperature.

At the left and right of subsidiary secondary reservoir 910 are branches constituting ultimate

heat transfer and exchange units shown as being of the reservoir-type such as might be used for space heating radiators. That system comprising the branch at the left of subsidiary secondary reservoir 910 consists of a reservoir 950 in which is a volume of heat transfer and exchange fluid. Reservoir 950 has a header 951. The fluid in reservoir 950 is served in heat exchange relation by a heat exchanger 956, immersed in the heat transfer and exchange fluid in subsidiary secondary reservoir 910, and conduits 952, 953, communicate between the named reservoir and heat exchanger at respective high and low levels, as shown. A temperature control means 954 is positioned in the line of conduit 952 to shut off flow of fluid therein when reservoir 950 is at the temperature desired.

The ultimate heat transfer and exchange unit shown at the right of subsidiary secondary reservoir 910 comprises a reservoir 960 having a header 961. The heat transfer and exchange fluid in reservoir 960 may flow to and from a heat exchanger 966 immersed in the heat transfer and exchange fluid in subsidiary secondary reservoir 910 through conduits 962, 963, the flow therethrough being controlled by a temperature control means 964 positioned in the line of conduit 962 to limit flow between the named reservoir and heat exchanger to periods wherein the temperature of reservoir 960 is undesirably low.

From the drawings and above description of Fig. 9 it will be obvious that in the case of the heat use of the structure of the invention the subsidiary secondary reservoirs may be branched in a series or in "stepped" fashion to permit a large number of temperature ranges to be developed and to permit use of any portion of the branch systems as an ultimate heat transfer and exchange unit.

So far as is known, no means other than the structures disclosed herein have been capable of the effective production and maintenance of relatively innumerable multiple series of temperature ranges in ultimate heat transfer and exchange units from a single source of heat or cold.

In Fig. 10, reference numeral 1010 indicates generally a primary thermal conditioning means wherein a cover 1011 is closely fitted on a primary tank 1012 which extends a distance into a master secondary reservoir 1013, the latter containing a volume of suitable heat transfer and exchange fluid. The level of the heat transfer and exchange fluid in master secondary reservoir 1013 is maintained so that tank 1012 is in constant heat exchange relation therewith. Master secondary reservoir 1013 has on it a header 1014 to accelerate flow of heat transfer and exchange fluid between master secondary reservoir 1013 and a subsidiary secondary reservoir 1035 which may, if desired, serve as an ultimate heat transfer and exchange unit. Conduits 1024 and 1025 are in communication between master secondary reservoir 1013 and subsidiary secondary reservoir 1035, and a temperature control means 1016 is interposed in the line of one of the conduits to continuously regulate flow of fluid between the master secondary reservoir and the subsidiary secondary reservoir.

In order to permit the flow of heat transfer and exchange fluid from master secondary reservoir 1013 to subsidiary secondary reservoir 1035 uninterruptedly for certain periods, when desired, a bypass conduit 1017 having in its line a control valve 1018 communicates with conduit 1025 from one side thereof to the other, bypassing continuous temperature control means 1016.

Under conditions wherein, for instance, an extremely low temperature is maintained in master secondary reservoir 1013 and wherein temperature control means 1016 is set to maintain the temperature of the heat transfer and exchange fluid within a range, say, of from 32° to 34°, thereby maintaining in subsidiary secondary reservoir 1035 a temperature condition approximating the named range, it would be possible by opening valve means 1018 to temporarily flow the extremely cold refrigerant through the subsidiary secondary reservoir thereby temporarily increasing its heat unit absorption ability and, if desired, ultimately bringing the subsidiary secondary reservoir to a temperature condition closely approximating that of the fluid in the master secondary reservoir.

In Fig. 11, reference numeral 1110 indicates generally a primary thermal conditioning means which brings to a desired temperature the heat transfer and exchange fluid in master secondary reservoir 1113, the latter having a header 1114 formed thereon. Reference numeral 1111 indicates a cover for a tank 1112 which tank extends a distance into the heat transfer and exchange fluid in master secondary reservoir 1113 in which tank, a charge of Dry Ice may typically be put. Master secondary reservoir 1113 is in heat transfer and exchange relation with a subsidiary secondary reservoir 1135 which may, if desired, serve as an ultimate heat transfer and exchange unit and which contains a quantity of inert heat transfer and exchange fluid.

The means for maintaining master secondary reservoir 1113 in heat transfer and exchange relation with subsidiary secondary reservoir 1135 comprises the conduits 1124, 1125 which communicate with a coil type heat exchanger 1119 immersed in the inert fluid in the subsidiary secondary reservoir. A continuously operable temperature control means 1116 is interposed in the line of one of the aforementioned conduits to operate to preclude flow of heat transfer and exchange fluid between the master secondary reservoir and heat exchanger 1119 only when the temperature of the heat transfer and exchange fluid in the subsidiary secondary reservoir 1135 is at a desired thermal differential to the temperature normally maintained in the master secondary reservoir.

To permit flow of the heat transfer and exchange fluid between master secondary reservoir 1113 and heat exchanger 1119 at temperatures other than the range wherein the continuously operable temperature control means 1116 would permit flow, a conduit 1117 having in its line the control valve means 1118 circuitously bypasses temperature control means 1116. When valve means 1118 is opened, free flow of heat transfer and exchange fluid may be had between the master secondary reservoir and the heat exchanger.

As previously mentioned, heat exchanger 1119 is of the coil type and to support the coil comprising such heat exchanger wthin subsidiary secondary reservoir 1135 brace means 1120, 1120 are provided through which the coil may run. These brace means are formed of a relatively non-heat-conductive material and are tapered adjacent their areas of contact with the coil forming heat exchanger 1119 as at 1121 and along their lateral peripheries as at 1123 to support the heat exchanger 1119 without permitting other than a minor portion of each brace to come into contact with the coils or the inner walls of subsidiary sec-

ondary reservoir 1135. At the points of entry of conduits 1114 and 1115 into the subsidiary secondary reservoir insulating plugs 1122, 1122 are provided which encompass the conduits.

The purpose of insulating conduits 1124, 1125 and of supporting heat exchanger 1119 in the insulating braces is to insure that the heat transfer and exchange fluid in subsidiary secondary reservoir 1135 shall be the sole means of uniformly maintaining the temperature of the surface of subsidiary secondary reservoir 1135.

Thus, where a constant flow of heat units is had into the fluid contained within subsidiary secondary reservoir 1135 such as to maintain the temperature on the surfaces of such reservoir and in the heat transfer and exchange fluid contained therein above that of the freezing point of water, and wholly irrespective of the temperature extant in heat exchanger 1119, condensation of moisture on the surfaces of the reservoir will be reduced to a negligible minimum, there will be only minor dehydration of foods within a cabinet in which such a unit is placed, such condensation as takes place will not freeze and no defrosting need be done, and articles to be refrigerated will not freeze to the refrigeration unit, nor need such a unit be defrosted.

Referring to Fig. 12, reference numeral 1210 indicates a primary thermal conditioning means, in this instance a typical high side refrigeration unit having an evaporator 1211 integrated therewith. Evaporator 1211 is immersed in a quantity of heat transfer and exchange fluid contained within a master secondary reservoir 1212 having a header 1213 formed thereon. Master secondary reservoir 1212 is in heat transfer and exchange relation with a subsidiary secondary reservoir 1218 by means of conduits 1214, 1215 which flow the heat transfer and exchange fluid contained within master secondary reservoir 1212 through a heat exchanger 1216 associated in heat transfer and exchange relation with a quantity of heat transfer and exchange fluid contained in subsidiary secondary reservoir 1218. A temperature control means 1217 is interposed in one of the aforementioned conduits to limit the flow of heat transfer and exchange fluid between master secondary reservoir 1212 and heat exchanger 1216 to periods of time when the fluid in subsidiary secondary reservoir 1218 is undesirably high.

Another pair of conduits 1220, 1221 are in communication between master secondary reservoir 1212 and another heat exchanger 1222 immersed in the heat transfer and exchange fluid in the subsidiary secondary reservoir 1218 and a control valve 1223 is in the line of one of the conduits, as shown.

Assuming, for instance, that the temperature of the heat transfer and exchange fluid in master secondary reservoir 1212 were, say, maintained at 0° to −5° and that temperature control means 1217 were set to limit flow of heat transfer and exchange fluid between master secondary reservoir 1212 and heat exchanger 1216 to maintain in the subsidiary secondary reservoir a temperature within a range of, say, 32° to 34°, it will be obvious that the heat transfer and exchange fluid in subsidiary secondary reservoir 1218 would normally be maintained at a temperature close to the 32° to 34° range indicated.

However, in instances where an extreme demand were made upon subsidiary secondary reservoir 1218 for heat unit absorption it would be possible to directly flow the extremely cold heat transfer and exchange fluid contained within master secondary reservoir 1212 through heat exchanger 1222 by opening valve 1223. Thus, for an actually timed or otherwise limited period, it would be possible for subsidiary secondary reservoir 1218 to have an extremely high heat unit absorption capacity and were it desired to do so, the temperature of the fluid in the subsidiary secondary reservoir could, by the structure shown, be reduced to a temperature closely corresponding to that of the heat transfer and exchange fluid in master secondary reservoir 1212.

Referring now to Fig. 13, reference numeral 1310 indicates a primary thermal conditioning means, shown in this instance as a conventional motor driven compressor-condenser unit having an evaporator 1311 operatively associated therewith. Evaporator 1311 is immersed in a quantity of heat transfer and exchange fluid contained within a primary tank 1312 which, as shown, is formed integral with and extends into master secondary reservoir 1313. Master secondary reservoir 1313 contains a quantity of heat transfer and exchange fluid and is provided with header 1314 to permit expansion and contraction of such fluid.

Master secondary reservoir 1313 is in heat transfer and exchange relation with a subsidiary secondary reservoir 1325 which contains a quantity of suitable heat transfer and exchange fluid and has formed thereon a header 1326. Master secondary reservoir 1313 is maintained in heat transfer and exchange relationship with subsidiary secondary reservoir 1325 by means of conduits 1315, 1316 which communicate with a heat exchanger 1318 immersed in the fluid of subsidiary secondary reservoir 1325, a temperature control means 1317 being interposed in the line of one of such conduits to limit flow of fluid between the master secondary reservoir and heat exchanger 1318 to periods of time when the heat transfer and exchange fluid in subsidiary secondary reservoir 1325 is in undesirable thermal imbalance to that of the fluid in master secondary reservoir 1313. Subsidiary secondary reservoir 1325 is in heat transfer and exchange relation with an ultimate heat transfer and exchange unit 1335 by means of interconnecting conduits 1327, 1328 which are in open communication with a heat exchanger 1329 immersed in the inert fluid contained in or the material of ultimate heat transfer and exchanger unit 1335.

As shown, master secondary reservoir 1313 may also be brought into heat transfer and exchange relation with ultimate heat transfer and exchange unit 1335 by means of conduits 1340, 1341 which communicate with a heat exchanger 1343 which is immersed in the fluid contained in or which may be formed within the material of the ultimate heat transfer and exchange unit. A valve means 1342 is interposed in the line of one of the last-mentioned conduits, this valve being openable at will to permit flow of heat transfer and exchange fluid directly from master secondary reservoir 1313 to ultimate heat transfer and exchange unit 1335.

During periods of normal operation the heat transfer and exchange fluid in master secondary reservoir 1313 might, for instance, be maintained within a temperature range of −35° to −40°. Temperature control means 1317 might be set to limit flow of heat transfer and exchange fluid between the master secondary reservoir and subsidiary secondary reservoir 1325 so as to maintain the heat transfer and exchange fluid in such

subsidiary secondary reservoir within a temperature range of, say, 32° to 34°. Subsidiary secondary reservoir 1325, being in open communication with heat exchanger 1329, would tend to maintain ultimate heat transfer and exchange unit 1335 at a temperature closely approximating that extant in the subsidiary secondary reservoir.

Were it desired to permit ultimate heat transfer and exchange unit 1335 to be substantially reduced in temperature for any reason to a temperature lower than that which would normally be maintained therein by its heat transfer and exchange relation with subsidiary secondary reservoir 1325, valve means 1342 might be opened for a period of time, permitting heat transfer and exchange fluid from master secondary reservoir 1313 to be flowed through heat exchanger 1343, thus bringing the extremely low temperature fluid into such ultimate heat transfer and exchange unit and correspondingly substantially increasing its heat absorption ability or markedly cooling such ultimate heat transfer and exchange unit to a desired temperature.

Referring to Fig. 14, reference numeral 1410 indicates a primary thermal conditioning means having an evaporator 1411 immersed in the heat transfer and exchange fluid contained within a tank 1412 formed integral with and extending into a master secondary reservoir 1413. Master secondary reservoir 1413 has a header 1414 formed thereon and this master secondary reservoir contains a quantity of suitable heat transfer and exchange fluid which is flowed by suitable conduits 1415, 1416 through a heat exchanger 1418, the latter being immersed in the heat transfer and exchange fluid contained within a subsidiary secondary reservoir 1425. A temperature control means 1417 interposed in the line of one of the aforementioned conduits is adapted to limit the flow of heat transfer and exchange fluid from master secondary reservoir 1413 through heat exchanger 1418 to periods of time when the heat transfer and exchange fluid in subsidiary secondary reservoir 1425 is at a higher temperature than desired.

Subsidiary secondary reservoir 1425 has a header 1426 formed thereon, and the heat transfer and exchange fluid contained in this reservoir is permitted to flow by appropriate conduit means 1427, 1428 through a heat exchanger 1429 in heat transfer and exchange relation with ultimate heat transfer and exchange unit 1435. A temperature control means 1430 may be interposed in the line of one of the conduits communicating between subsidiary secondary reservoir 1425 and heat exchanger 1429 to permit or preclude flow of fluid through this system at predetermined temperature ranges.

The heat transfer and exchange fluid in subsidiary secondary reservoir 1425 may also be flowed through that system comprising conduits 1440, 1441 and heat exchanger 1443 when control valve 1442 is opened.

Ultimate heat transfer and exchange unit 1435 may be, typically, a plate or shelf in which the heat exchangers are located or it may be a tank or reservoir having therein an inert heat transfer and exchange fluid.

Illustrative of how the system of Fig. 14 is operable, let it be assumed that the temperature of the heat transfer and exchange fluid in the master secondary reservoir 1413 were maintained at, say, −10° to −15°. Temperature control means 1417 might be set, for instance, to permit flow of heat transfer and exchange fluid between master secondary reservoir 1413 and heat exchanger 1418 during periods of time when the heat transfer and exchange fluid in the subsidiary secondary reservoir 1425 is above a temperature, say, 0°, and preclude flow of heat transfer and exchange fluid at, say, −5°. Temperature control means 1430 serving ultimate heat transfer and exchange unit 1435, during periods of normal operation, might be set, for instance, to so limit flow of heat transfer and exchange fluid between subsidiary secondary reservoir 1425 and heat exchanger 1429 as to maintain the heat transfer and exchange fluid in ultimate heat transfer and exchange unit within a range of, say, 32° to 34°. Should ultimate heat transfer and exchange unit 1435 be called upon to absorb a tremendous shock load of heat units, it would be possible, by opening valve 1442, to permit the 0° to −5° heat transfer and exchange fluid normally contained within subsidiary secondary reservoir 1425 to flow through heat exchanger 1443 for a period of time sufficient to adequately and very rapidly absorb the shock or, if valve 1442 were permitted to remain open for a considerable period of time, the temperature of ultimate heat transfer and exchange unit 1435 could, if desired, be brought down to a temperature condition closely approximating that mainained in subsidiary secondary reservoir 1425.

Referring to Fig. 15, reference numeral 1512 indicates a main tank adapted to receive a charge of Dry Ice, which in this instance is the primary thermal conditioning means. Tank 1512 is provided with an appropriate cover 1511 and this tank is integral with a master secondary reservoir 1513 and extends therein a distance to be in proper heat transfer and exchange relation with the heat transfer and exchange fluid contained within master secondary reservoir 1513. Reference numeral 1514 indicates an appropriate header adapted to permit expansion and contraction of the fluid contained within the master secondary reservoir 1513. The heat transfer and exchange fluid contained within master secondary reservoir 1513 may flow through appropriate conduits 1515, 1516 and through a heat exchanger 1518 immersed within the heat transfer and exchange fluid contained by a subsidiary secondary reservoir 1525 which has a header 1526 formed thereon. A temperature control means 1517 is interposed in the line of one of the aforementioned conduits to regulate flow of heat transfer and exchange fluid between master secondary reservoir 1513 and heat exchanger 1518 so as to bring the temperature of the heat transfer and exchange fluid in subsidiary secondary reservoir 1525 to a desired thermal relation to that of the fluid in the master secondary reservoir.

The heat transfer and exchange fluid in subsidiary secondary reservoir 1525 may flow in heat transfer and exchange relation by means of conduits 1527, 1528 through a heat exchanger 1529 contained within an ultimate heat transfer and exchange unit 1535.

Not only does the heat transfer and exchange fluid from master secondary reservoir 1513 flow in heat transfer and exchange relation with subsidiary secondary reservoir 1525, but it also flows in heat transfer and exchange relation by means of conduits 1541, 1542 into another subsidiary secondary reservoir 1545 which contains a suitable heat transfer and exchange fluid and immersed in which fluid is heat exchanger 1544 with which conduits 1541, 1542 communicate.

A temperature control means 1543 is interposed

in the line of one of the aforementioned conduits to regulate the flow of heat transfer and exchange fluid between master secondary reservoir 1513 and heat exchanger 1544. Subsidiary secondary reservoir 1545 is provided with a header 1550, as shown.

Subsidiary secondary reservoir 1545 primarily serves to cool an ultimate heat transfer and exchange unit 1555, there being conduits 1552, 1553 communicating with a heat exchanger 1554 positioned in ultimate heat transfer and exchange unit 1555. In addition to serving ultimate heat transfer and exchange unit 1555, subsidiary reservoir 1545 may also, at predetermined times, serve ultimate heat transfer and exchange unit 1535, there being conduits 1546, 1547 communicating between subsidiary secondary reservoir 1545 to convey the fluid contained therein through a heat exchanger 1548 associated with ultimate heat transfer and exchange unit 1535.

The valve means 1549 is interposed in the line of conduit 1546 to control and regulate the flow of heat transfer and exchange fluid between subsidiary secondary reservoir 1545 and heat exchanger 1548.

Assuming that the temperature in master secondary reservoir 1513 were to be maintained at, say, −20° to −25°, it would nevertheless be possible, by regulating temperature control means 1517 to limit flow of heat transfer and exchange fluid within a range appropriate to maintain the temperature in subsidiary secondary reservoir 1525 at a range, say, of from 32° to 34°. It will be noted that no temperature control means is interposed in either conduit 1527 or 1528 which serve ultimate heat transfer and exchange unit 1535 by means of heat exchanger 1529, thus, the normal temperature of ultimate heat transfer and exchange unit 1525 would usually closely approximate that of the fluid in subsidiary secondary reservoir 1525.

Assuming that it were desired to maintain in subsidiary secondary reservoir 1545 a temperature of, say, 0° to −5°, temperature control means 1543 could be set to limit flow of heat transfer and exchange fluid between master secondary reservoir 1513 and heat exchanger 1544 to appropriately maintain the desired temperature. Since there is no temperature control means interposed in either of lines 1552 or 1553, the temperature of ultimate heat transfer and exchange unit 1555 would normally be maintained at a temperature closely approximating that of the fluid in subsidiary secondary reservoir 1545.

Thus, were ultimate heat transfer and exchange unit 1535 suddenly called upon to absorb within a relatively short period of time a large volume of heat units, it would be possible, by opening valve means 1549, to flow heat transfer and exchange fluid from subsidiary secondary reservoir 1545 directly through heat exchanger 1548 by means of conduits 1546 and 1547.

This would greatly increase the heat absorption capacity of ultimate heat transfer and exchange unit 1535, and were it desirable to do so, by continuing to permit valve means 1549 to remain open, the temperature of ultimate heat transfer and exchange unit 1535 could soon be brought to that approximating the temperature of ultimate heat transfer and exchange unit 1555.

It will be clear from Figs. 10 through 15 and the description directed thereto that the structure and methods of the invention are well adapted to absorb extreme requirements for heat transfer and exchange imposed upon any ultimate heat transfer and exchange unit, however remote it may be from the master secondary reservoir which serves it, or without regard to the exact manner in which the subsidiary systems are interrelated.

While Figs. 10 through 15 have been entirely directed to the refrigeration-use aspects of the invention it is to be understood that the same general principles of construction and operation are equally adapted for use for the dissipation and use of heat.

Structures such as those shown in and described with respect to Figs. 10 through 15 have wide application in industry, particularly in the chemical and food fields.

It will be obvious that conditions of heat or of cold are converse situations. In its heated condition a fluid contains an appreciable quantity of energy in the form of heat units and the cold condition of the fluid merely is a condition of paucity of heat units. Any fluid, down to the condition of absolute zero, contains some heat units and heat unit flow is always in the direction of the cooler of any two fluids or objects. Transfer of heat units takes place by convection in a volume of fluid wherein the presence of the heat units in the carrier changes the carrier's specific gravity in certain of its portions, thereby making the more heated portions less responsive to gravity, the cooler portions being more responsive to gravity and thereby flowing to a lower level. Exchange of heat units takes place by conduction under conditions wherein certain molecules of a substance are at a temperature differential to other molecules, either of the same substance or another substance, with which the first substance is in contact.

The structures of this invention make use of these well known principles by providing at one terminus of the structure ultimate heat transfer and exchange units adapted to create a condition of heat or cold in a space or object at a desirable end-use range and at the opposite terminus having a fluid-containing master secondary reservoir having means associated with it for bringing the temperature of the fluid therein to a range substantially differing from the usable range temperature of the ultimate heat transfer and exchange units. This master secondary reservoir contains such a volume of heat transfer and exchange fluid and the fluid therein is brought to such a temperature differential to that of the fluid in the ultimate heat transfer and exchange units that a large "thermal flywheel" or reserve storage of heat or cold is built up. Interposed between the ultimate heat transfer and exchange units and the master secondary reservoir are temperature control and regulation means which may take the form of fluid-containing subsidiary secondary reservoirs which may be maintained either at the same temperature as that of the volume of heat transfer and exchange fluid in the master secondary reservoir or at a temperature differential thereto. The volumes of fluid in the master secondary reservoir, the subsidiary secondary reservoir or reservoirs and the ultimate heat transfer and exchange units are each in heat transfer and exchange relation to the fluid in each portion of the system subsidiary thereto. The provision of a volume of fluid in the subsidiary secondary reservoir or reservoirs provides an additional "thermal flywheel" or reserve storage of heat or cold upon which the ultimate heat transfer and exchange units may rely.

Obviously, this arrangement and correlation of systems makes possible the use of the structure of the invention for the purposes enumerated above and many other uses and advantages wholly incapable of accomplishment by other means.

It should be adequately apparent that the structure shown and described will achieve all those objects and advantages set forth with respect to it, and still others readily apparent to those skilled in this art, and while the drawings and description are highly specific, I do not wish this exactness of disclosure to be taken in other than an illustrative sense, desiring to be limited only as I may be by the scope of the appended claims.

I claim:

1. In heat transfer and exchange apparatus, a secondary system comprising an ultimate heat transfer and exchange unit, a subsidiary secondary reservoir and a master secondary reservoir, conduit means interrelating each to the other in antecedent and superior relation in the order named, said ultimate heat transfer and exchange unit, said subsidiary secondary reservoir and said master secondary reservoir each having a volume of suitable heat transfer and exchange fluid therein and at least two of said volumes being separated one from another, said master secondary reservoir being in heat transfer and exchange relation with said subsidiary secondary reservoir and the latter being in heat transfer and exchange relation with said ultimate heat transfer and exchange unit solely by thermo-siphonic flow of the heat transfer and exchange fluid contained by each through said conduit means, the latter having appropriate inlets and outlets at elevations so differing as to induce thermo-siphonic flow of said heat transfer and exchange fluid, means for controlling and regulating the temperatures in selected portions of said system and means for creating a temperature condition in said secondary system differing from ambient temperature.

2. Heat transfer and exchange apparatus as specified in claim 1 including structure whereby said last-named means may be removed from said secondary system without relatively immediately disturbing its operation.

3. In heat transfer and exchange apparatus, a secondary system containing heat transfer and exchange fluid in each of its portions, the fluid in at least two of its portions being mechanically separated from one another, and its portions including an ultimate heat transfer and exchange unit, a subsidiary secondary reservoir and a master secondary reservoir, conduit means interrelating each to the other in antecedent and superior relation in the order named, said master secondary reservoir being in heat transfer and exchange relation with said subsidiary secondary reservoir and the latter being in heat transfer and exchange relation with said ultimate heat transfer and exchange unit by both thermo-siphonic and pump-induced flow of the heat transfer and exchange fluid through said conduit means, the latter having appropriate inlets and outlets at elevations so differing as to induce thermo-siphonic flow of said heat transfer and exchange fluid, means for producing in said secondary system a temperature condition differing from ambient temperature and means for inducing and maintaining temperature differentials between selected portions of said secondary system.

4. Heat transfer and exchange apparatus as specified in claim 3 including structure whereby said means for producing the temperature condition in said secondary system different from ambient temperature may be removed from said system without relatively immediately disturbing its operation.

5. In heat transfer and exchange apparatus, means for producing a differential from ambient temperature, a secondary system including a master secondary reservoir having a suitable heat transfer and exchange fluid therein and associated in heat transfer and exchange relation with said means, subsidiary secondary reservoirs having a suitable heat transfer and exchange fluid therein and in heat transfer and exchange relation with the fluid in said master secondary reservoir, ultimate heat transfer and exchange units having a suitable heat transfer and exchange fluid therein and in heat transfer and exchange relation with said subsidiary secondary reservoirs, means for inducing and maintaining temperature differentials between selected portions of said secondary system, and an auxiliary heat transfer and exchange system having a suitable heat transfer and exchange fluid therein and attached to said secondary system to supplement the function of the latter, said auxiliary system being exposed in major part to thermal conditions found in nature.

6. The method of establishing and maintaining in a secondary heat transfer and exchange system a desired approximately uniform temperature in the second of two physically separated heat transfer and exchange fluids contained in said secondary system comprising the steps of providing a primary thermal conditioning means and a secondary system subsidiary thereto and bringing the first heat transfer and exchange fluid to a desired thermal condition, flowing said first fluid into heat transfer and exchange relation with a second fluid, and regulating heat transfer and exchange between said fluids by accelerating or retarding the transfer and exchange of heat units between them, said last named fluid being thereby brought to and maintained at a desired thermal condition for use.

7. The method of establishing and maintaining a desired thermal condition in the third of three interrelated heat transfer and exchange fluids at least two of which are physically separated from one another comprising the steps called for in claim 6 plus as additional steps those of flowing said second heat transfer and exchange fluid into heat transfer and exchange relation with a third heat transfer and exchange fluid, thereby bringing said last-named fluid to a desired thermal condition for use.

8. The method of establishing and maintaining a desired approximately uniform temperature in the second of two interrelated but physically separated heat transfer and exchange fluids contained within a secondary heat transfer and exchange system comprising the steps of providing a primary thermal conditioning means and a secondary system subsidiary thereto and bringing the first fluid to a desired thermal condition, flowing said fluid into heat transfer and exchange relation with a second fluid, intermittently flowing said second fluid in heat transfer and exchange relation with said first fluid during limited periods when said fluids are in undesirable thermal imbalance with one another, said last-named fluid being thereby brought to desired thermal condition for use.

9. The method of establishing and maintaining a desired thermal condition in the third of

three interrelated heat transfer and exchange fluids at least two of which are physically separated comprising the steps called for in claim 8 plus as additional steps those of flowing said second heat transfer and exchange fluid into heat transfer and exchange relation with said third heat transfer and exchange fluid, thereby bringing said last-named fluid to a desired thermal condition for use.

10. The method of establishing and maintaining a secondary heat transfer and exchange system a desired approximately uniform temperature in the second of two interrelated physically separate heat transfer and exchange fluids comprising the steps of providing a primary thermal conditioning means and a secondary system subsidiary thereto and bringing the first fluid to a desired thermal condition, flowing said first fluid in heat transfer and exchange relation with a second fluid continuously until the second fluid is brought to a thermal condition at a desired relationship to the thermal condition of the first fluid, then intermittently flowing said first fluid in heat transfer and exchange relation to the second fluid during limited periods when said fluids are in undesirable thermal imbalance with one another, the second fluid being thereby brought to and maintained at desired thermal condition for use.

11. The method of establishing and maintaining in a secondary heat transfer and exchange system a desired approximately uniform temperature in the second of two interrelated physically separate heat transfer and exchange fluids comprising the steps of providing a primary thermal conditioning means and a secondary system subsidiary thereto and bringing the first heat transfer and exchange fluid to a desired thermal condition, flowing said fluid into heat transfer and exchange relation with a second fluid, and regulating by permitting or precluding the transfer and exchange of heat units between said fluids, said last named fluid being thereby brought to and maintained at a desired thermal condition for use.

12. The method of establishing and maintaining desired approximately uniform temperatures in a series of physically separated volumes of heat transfer and exchange fluid comprising more than two of such volumes which comprises the steps of dividing a predetermined quantity of heat transfer and exchange fluid into the desired number of volumes, physically separating them in predetermined volumetric relation to one another bringing one volume to a desired temperature, passing at least a portion of one volume into heat exchange relation with another volume of the series while regulating the transfer and exchange of heat units between them.

13. The method of establishing and maintaining a desired substantially uniform temperature in an ultimate heat transfer and exchange unit comprising the steps of providing a plurality of sequentially successive volumes of heat transfer and exchange fluid, physically separating said volumes from one another in increasingly subsidiary relation bringing the first volume of said fluid to a desired thermal condition, bringing said first volume into heat transfer and exchange relation with its sequentially succeeding volume, and bringing each sequentially succeeding volume into heat transfer and exchange relation with the next sequentially succeeding volume, and controlling the transfer and exchange of heat units between each volume and the volume sequentially succeeding it.

14. The method of establishing and maintaining a desired substantially uniform temperature in an ultimate heat transfer and exchange unit comprising the steps of providing a plurality of increasingly subsidiary volumes of heat transfer and exchange fluid, separating said volumes physically from one another, bringing the first volume of said fluid to a desired thermal condition, bringing said first volume into heat transfer and exchange relation with a subsidiary volume, bringing said subsidiary volume into heat transfer and exchange relation with a still further subsidiary volume and continuing the steps enumerated between each volume and the volume subsidiary thereto and antecedent to said ultimate heat transfer and exchange unit while controlling the rate of heat transfer and exchange between selected ones of said volumes.

15. In a heat transfer and exchange system, master reservoir means having a volume of heat transfer and exchange fluid therein, means for bringing said fluid in said master reservoir means to and maintaining it within a desired temperature range, subsidiary reservoir means having a volume of heat transfer and exchange fluid therein, means interconnecting said master reservoir means and said subsidiary reservoir means in heat transfer and exchange relation, other reservoir means subsidiary to said subsidiary reservoir means and having a volume of heat transfer and exchange fluid therein, and means interconnecting said subsidiary reservoir means and said other reservoir means in heat transfer and exchange relation, the volumes of heat transfer and exchange fluid in each reservoir being physically separated from that in each other reservoir.

16. In a heat transfer and exchange system as set forth in claim 15, means for limiting the heat transfer and exchange relation between the volume of fluid in said master reservoir means and the volume of fluid in said subsidiary reservoir means to periods when the respective temperatures of said volumes are in undesirable imbalance.

17. In a heat transfer and exchange system as set forth in claim 15, means for limiting the heat transfer and exchange relation between the volume of fluid in said subsidiary reservoir means and the volume of fluid in said other subsidiary reservoir means to periods when the respective temperatures of said volumes are in undesirable imbalance.

18. In a heat transfer and exchange system as set forth in claim 15, means for limiting the heat transfer and exchange relation between the volume of fluid in said master reservoir means and the volume of fluid in said subsidiary reservoir means, and between the volume of fluid in said subsidiary reservoir means and the volume of fluid in said other subsidiary reservoir means to periods when the respective temperatures of said volumes are in undesirable thermal imbalance.

19. In a secondary heat transfer and exchange system, master reservoir means, a heat transfer and exchange system subsidiary to said master reservoir means comprising at least one separately operable but related subsidiary system and at least one separately operable branch system related and subsidiary to said subsidiary system, said master reservoir means, said subsidiary system and said branch system all having certain

physically separated volumes of heat transfer and exchange fluid therein, the fluid in said master reservoir means, said subsidiary system and said branch system being in heat transfer and exchange relation with the fluid in the system subsidiary thereto, and means between said reservoir means and selected portions of said subsidiary system and between selected portions of said subsidiary system and said branch system for regulating the extent to which heat transfer and exchange may take place between the heat transfer and exchange fluid in any one of them and the heat transfer and exchange fluid in that portion of the secondary system related and subsidiary thereto.

20. In heat transfer and exchange apparatus, means for producing a differential from ambient temperature, a master reservoir having a heat transfer and exchange fluid therein, said means producing a desired thermal range in the heat transfer and exchange fluid in said master reservoir, a subsidiary system having heat transfer and exchange fluid therein in heat transfer and exchange relation to said master reservoir and operative in selected ones of its portions at a thermal differential from that obtaining in said master reservoir, conduit means interconnecting said master reservoir and said subsidiary system, temperature control means for limiting the flow of heat transfer and exchange fluid between said master reservoir and selected portions of said subsidiary system to periods wherein the temperature of the heat transfer and exchange fluid in said subsidiary system is at an undesirable differential to the temperature of the heat transfer and exchange fluid in said master reservoir, a branch system having heat transfer and exchange fluid therein, said branch system being subsidiary to said subsidiary system and in heat transfer and exchange relation thereto, and conduit means interconnecting said branch system and said subsidiary system, the heat transfer and exchange fluid contents of said master reservoir, said subsidiary system and said branch system being in physically separated condition.

21. In heat transfer and exchange apparatus, means for producing a differential from ambient temperature, a master reservoir having a heat transfer and exchange fluid therein, said means producing a desired thermal range in the heat transfer and exchange fluid in said master reservoir, a subsidiary system having heat transfer and exchange fluid therein in heat transfer and exchange relation to said master reservoir and operative in selected ones of its subsidiary portions at a thermal differential from that obtaining in said master reservoir, conduit means inter-connecting said master reservoir and said subsidiary system, temperature control means for limiting the flow of heat transfer and exchange fluid between said reservoir and selected portions of said subsidiary system to periods wherein the temperature of the heat transfer and exchange fluid in said subsidiary system is at an undesirable differential to the temperature of the heat transfer and exchange fluid in said master reservoir, a branch system having heat transfer and exchange fluid therein, said branch system being subsidiary to said subsidiary system and in heat transfer and exchange relation thereto, conduit means inter-connecting said branch system and said subsidiary system, and temperature control means for limiting the flow of heat transfer and exchange fluid between said subsidiary system and selected portions of said branch system to periods wherein the temperature of the heat transfer and exchange fluid in said branch system is at an undesirable differential to the temperature of the heat transfer and exchange fluid in said subsidiary system, the heat transfer and exchange fluid in said systems subsidiary to said master reservoir being physically separated from one another.

22. In heat transfer and exchange apparatus used for the production and maintenance of usable conditions of cold and heat, a primary thermal conditioning means including an evaporator and a condenser, a master secondary reservoir having heat transfer and exchange fluid therein associated in heat transfer and exchange relation with said evaporator, another master secondary reservoir having heat transfer and exchange fluid therein in heat transfer and exchange relation with said condenser, a subsidiary system in heat transfer and exchange relation with said first-named reservoir for refrigeration, a subsidiary system in heat transfer and exchange relation with said last-named reservoir for heating, and means for automatically balancing the heat unit content of the respective fluids in said reservoirs so that said fluids will have requisite heat unit accumulation or dissipation characteristics at all times and irrespective of demands made upon them by the subsidiary systems.

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