Nov. 30, 1965 H. MÜLLER ETAL 3,220,198

THERMOELECTRIC REFRIGERATING APPLIANCES

Filed Jan. 16, 1962 3 Sheets-Sheet 1

Fig. 1

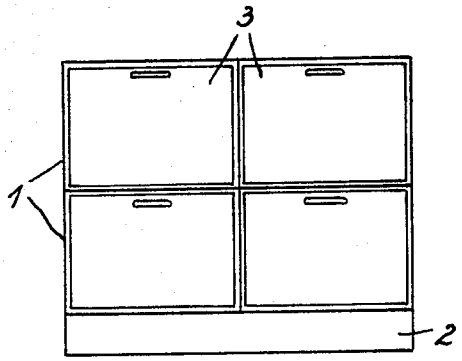


Fig. 2

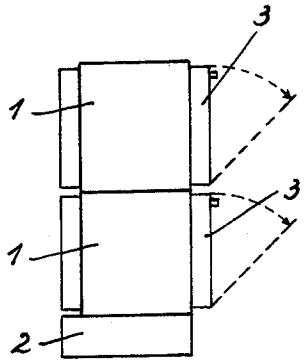


Fig. 5

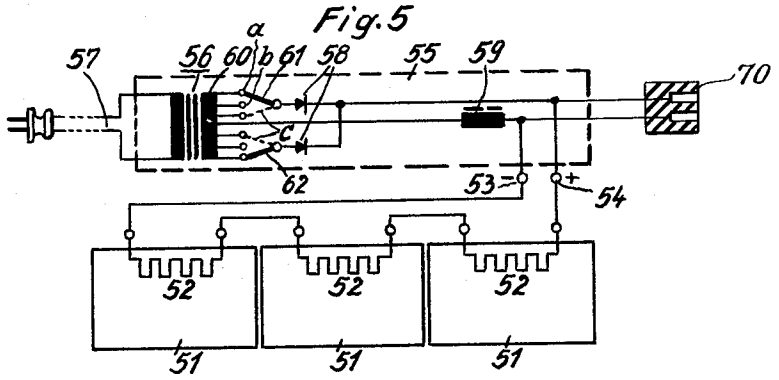
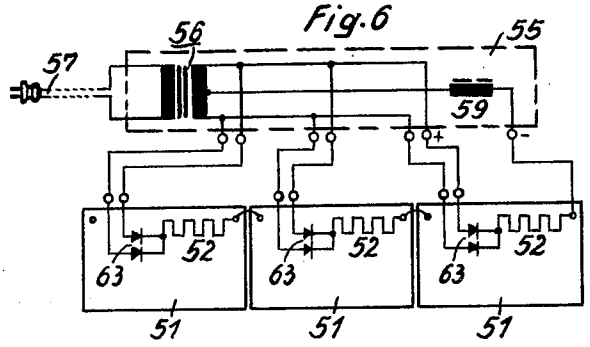


Fig. 6



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THERMOELECTRIC REFRIGERATING APPLIANCES

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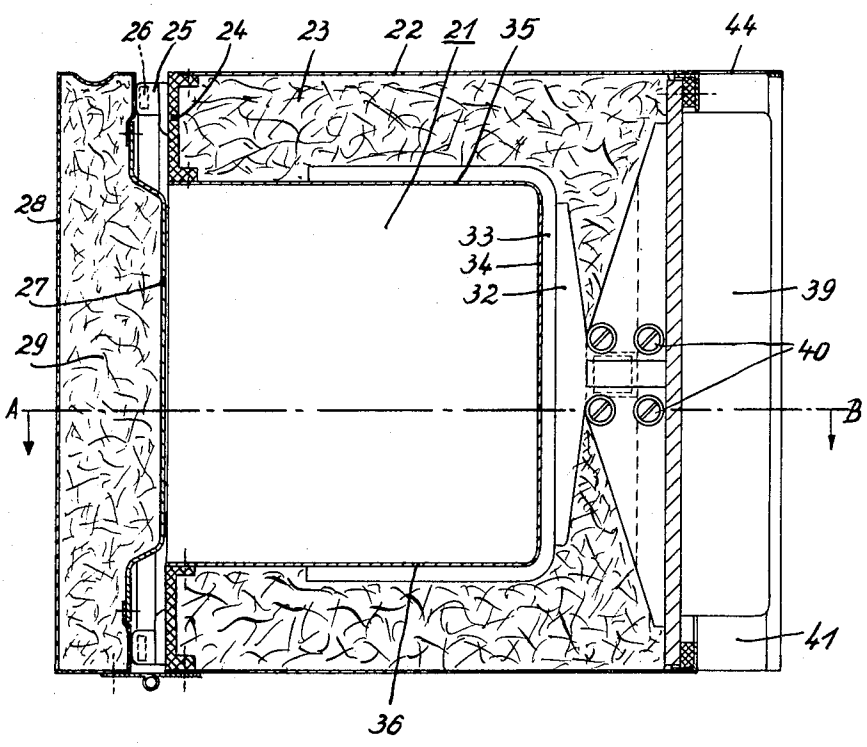
Fig. 3



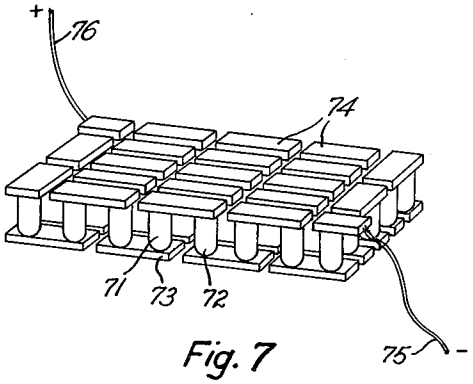


Fig. 7

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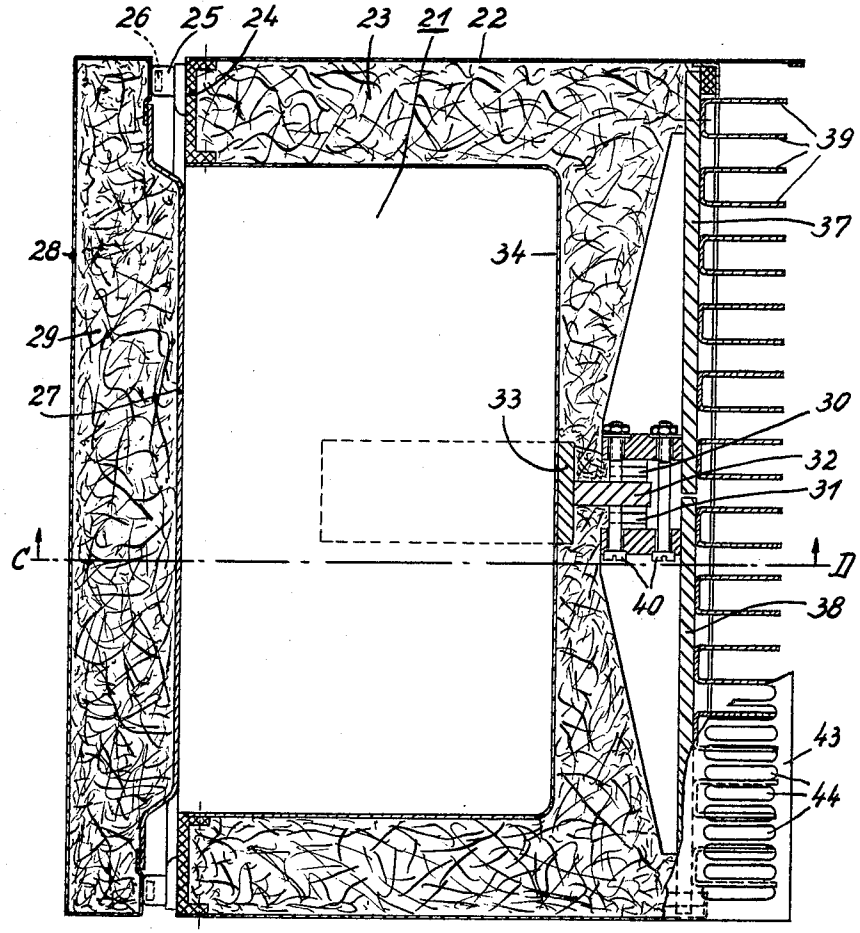
Fig. 4
A-B



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3,220,198

THERMOELECTRIC REFRIGERATING APPLIANCES

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Claims priority, application Germany, Jan. 19, 1961, S 72,113
1 Claim. (Cl. 62—3)

Our invention relates to thermoelectric refrigerating appliances and in particular, while not exclusively, to household refrigerators generally of the cabinet type operating with batteries or blocks of Peltier couples as the cold-producing components.

In refrigerating appliances, particularly those for use in kitchens, it is often desirable to subdivide the cooling space in the refrigerator cabinet into a number of compartments of respectively different operating temperatures. For example, it is usually necessary to provide for a normal cooling compartment in which a temperature of about plus 5° C. is maintained. It is further desirable to provide a freezing compartment, such as for the production of ice cubes or preserving frozen-food packages, in which the temperature is to be kept below the freezing point. It is also of advantage to provide another cabinet for a temperature slightly above normal cooling for the purpose of storing or crisping vegetables or preserving butter, for example. In the conventional refrigerators equipped with compression-type refrigerating machines or absorption-type refrigerating systems, the requirement for such compartments of respectively different operating temperatures is met with the aid of a single evaporator by inserting heat insulating partitions or similar means into the cabinet space. It is also known to provide compression-type machines with two evaporators which are supplied with refrigerant from one and the same compressor but are mounted in mutually heat-insulated compartments of the refrigerator cabinet and are so controlled as to maintain different temperatures in the respective compartments. If only one evaporator is used for the above-mentioned purpose, then the necessity for differently adjusting and regulating the temperatures in mutually insulated compartments of the cabinet is difficult and troublesome. Thus it is not reliably feasible to solve the problem in a satisfactory manner and without an excessive maintenance requirement for prolonged periods of refrigerating operation. If more than one evaporator are used, the amount of equipment in the refrigerating system, including the interconnecting refrigerant lines, becomes excessive and unduly increases the cost as well as the space requirements.

Our invention has for its general object to solve the above-described problem in a much simpler and more advantageous manner than heretofore attainable.

Another object of the invention is to afford, without detrimentally affecting the simplicity of design and economy of operation, a subdivision of refrigerating appliances into individual modular units that can be put together or employed in electric connection with one another in any combination that may be desirable at the particular place of installation or employment of the appliance.

Another object of the invention, akin to the one just mentioned, is to readily afford a subsequent enlargement of an existing refrigerating appliance by any desired addition of individual compartments or modular units, all operating from the same electric current supply and permitting in a particularly simple and reliable manner an adjustment to desired temperatures in the subsequently added appliance units.

Still another object related to those mentioned is to afford a better temperature adaptation of individual compartment spaces in the refrigerating appliance to the particular food or type of food to be stored therein and to also provide for a definite aromatic separation of the foods stored in the different compartments of the appliance, to an extent not secured by refrigerating appliances of the type heretofore known.

According to the invention, the refrigerating or cooling appliance is composed of two or more units of which each is equipped with one or more blocks of Peltier couples and which form respectively separate and separately accessible compartment spaces and are adapted to be individually heat-insulated and installable separately from the other units of the appliance. The plurality of thermoelectrically cooled cabinet units, however, are electrically interconnected and provided with one and the same current-supply unit which contains the terminals for attaching the entire refrigerating appliance to the power supply, such as a utility line, and, as a rule, also comprises the rectifying means for converting the line voltage, being normally an alternating voltage, for example of 110 volts and 60 c.p.s., into the low direct voltage needed or preferably for the operation of the Peltier blocks.

Such provision of thermoelectric cooling devices in the component compartment units of the refrigerating appliance, these devices being all connected to a common line-connection unit, makes it possible to subdivide the refrigerating appliance in any desired manner, corresponding to the particular requirements, and to separately adjust or regulate the temperature in each individual component unit to the preferred value. Such possibility is not offered in a comparably simple manner by the conventional refrigerators of the compression or absorption type because they would require employing a corresponding plurality of individual evaporators with appertaining refrigerant lines. By virtue of the fact that according to the invention several and individually insulated cooling units are employed, a refrigerating cabinet, for example a wall-mounted cabinet, can readily be subdivided for example into individual cabinet or compartment units, for example 5 to 10 liter boxes, or boxes having a volume of as little as 1 gallon up to several gallons, each box being individually cooled by its own Peltier block or group of blocks. Such small boxes can be universely employed in form of a modular or building-block system so that any desired number of these boxes can be put together to form a refrigerating furniture whose shape and size can be chosen by the user himself. The invention, for example affords covering a kitchen wall or part thereof with individual cooling units in form of cupboards, or the units may be used to fill wall recesses or mounting niches and the like.

The individual cooling units, separately insulated and separately installable although provided with a common current-supply unit, can be readily adapted to the specific use or purpose as far as size of the individual compart-

ment and internal equipment are concerned. Thus for example, separately insulated cooling units can be provided for the normal-temperature compartment, for a butter compartment, a bottle or beverage compartment or the like, and each of these compartments can be adapted and equipped to a particular intended use.

The foregoing and other objects, advantages and features of the invention, said features being set forth with particularity in the claims annexed hereto, will be apparent from, and will be further described in, the following with reference to the embodiments of appliances according to the invention illustrated by way of example on the accompanying drawings in which:

FIG. 1 is a front view and FIG. 2 a lateral view of a refrigerator;

FIG. 3 shows schematically a cross section through one of the cooling units that form part of the refrigerator according to FIGS. 1 and 2, the section being taken along the line C–D in FIG. 4; FIG. 4 is a section taken at a right angle to that of FIG. 3 and extending along the line A–B in FIG. 3;

FIG. 5 is an electric circuit diagram of a refrigerator according to the invention.

FIG. 6 is a modified circuit diagram of such a refrigerator; and FIG. 7 illustrates in perspective the details of one of the Peltier blocks used in apparatus according to FIGS. 1 to 6.

The refrigerator shown in FIGS. 1 and 2 is essentially a piece of furniture which comprises four modular cabinet units **1** placed upon a common mounting base **2** and each provided with a door or lid **3** hinged along the lower horizontal edge of the compartment unit so that it can be turned downward as indicated by a broken-line arrow in FIG. 2. The interior of each compartment unit **1** thus forms a cooling space separate from the spaces of the other units and accessible separately therefrom. The mounting base **2** is hollow and contain the line-connector components common to the Peltier devices with which the respective compartments units **1** are individually equipped.

As apparent from FIGS. 3 and 4 for one of the individually insulated cooling units, each unit is essentially a box structure with an inner cell space **21** for receiving the products to be cooled, an external shell **22** which like the inner shell may consist of sheet metal, and a heat-insulating substance **23** such as glass wool which fills the interspace between the inner and outer shells. At the side facing the door, the cell is connected with the outer shell **22** by a sealing frame structure **24** of solid material having poor heat conductance which carries a rubber basket **25** and a magnet **26**. The magnet serves to keep the door closed. The door comprises an inner sheet-metal portion **27**, an outer shell **28** of sheet metal and an intermediate insulation **29**.

A Peltier battery serves for cooling the cell space **21** of the box structure. The Peltier battery comprises two Peltier blocks **30** and **31**, each composed of a multiplicity of individual thermocouples whose hot junctions are all located on one side of the block and whose cold junctions are all located on the other side of the block. The design and the particular details of the Peltier blocks are not essential to the present invention. They may correspond, for example, to the Peltier blocks described in the copending application of Heinz Müller Serial No. 164,079 filed January 3, 1962, and the patent of Wolfram Blumentritt, No. 3,111,813, both assigned to the assignee of this application. With respect to suitable materials for the Peltier couples and the design of the Peltier blocks reference may also be had to U.S. Patent 2,978,570 and to the copending application Serial No. 150,701 of W. Hänlein for Thermoelectric Battery and Method of Its Production, filed November 7, 1961. The two Peltier blocks **30** and **31** have their cold-junction sides facing each other and in heat conducting face-to-face relation with a heat conducting body **32** of aluminum which forms part of a cooling bracket **33**. The design and performance of the two Peltier blocks in relation to the intermediate heat conducting body **32** are in accordance with the cooling apparatus illustrated and described in the above-mentioned patent of Wolfram Blumentritt, No. 3,111,813, and corresponds to FIG. 3 of that application. The cooling bracket **33** straddles the cell **21**, being in good heat conducting contact with the rear wall **34** and the two side walls **35** and **36** of the cell. The two hot-junction sides of the respective Peltier blocks **30** and **31**, facing away from each other, are connected with respective heat exchangers **37** and **38** of which each is provided with cooling fins **39**. The heat exchangers **37** and **38** are joined with each other by means of screw bolts **40** which clamp them against the Peltier blocks and against the intermediate heat conducting body **32**, thus pre-stressing the assembly and maintaining a reliable heat conducting contact between the mutually adjacent parts. The heat conducting body **32**, however, is provided with a thin insulating coating so as to be electrically insulated from the two Peltier blocks without appreciably reducing the heat transfer from the blocks to the body **32**. A similar thin insulating coating may be provided between the heat exchangers **37**, **38** and the Peltier blocks to prevent electric short circuits while permitting the desired heat transfer. The Peltier blocks **30** and **31** and the parts of the heat exchangers **37** and **38** clamped together therewith by means of the bolts **40** are built into a recess in the rearward insulation of the compartment structure. The cooling fins **39** of the heat exchangers are arranged in a venting shaft at the rear of the box structure. The upper cover **43** of the box structure extends rearwardly over the venting shaft **41** where it is provided with openings **44** for the passage of the cooling air ascending through the venting shaft and thereby cooling the fins **39**.

In the circuit diagrams of FIGS. 5 and 6 only three of the individual cooling compartments are illustrated and denoted by **51**, it being understood that any number of such compartments can be analogously connected with the same current-supply unit. Furthermore, in FIGS. 5 and 6 the Peltier assembly of each compartment unit **51** is schematically shown only and is denoted by **52**.

According to FIG. 5, several compartment units **51** as described above with reference to FIGS. 1 to 4, each containing its own Peltier battery **52**, are connected to a common line-connector unit **55** which, as explained above, is accommodated in the mounting base **2** of the cabinet structure exemplified in FIGS. 1 and 2. The Peltier batteries **52** in FIG. 5 are all connected in series with each other across the output terminals **53** and **54** of the line-connector unit **55**. The unit **55** comprises a transformer **56** whose primary winding is connected to a cord **57** and plug for attachment to an outlet of a utility line. The secondary winding of the transformer **60** comprises rectifiers **58** and filter means here represented by a reactor coil **59**.

Connected between the secondary winding **60** and the rectifiers **58** are the contacts **61**, **62** of a selector switch. In the illustrated switch position *a*, the selector switch is set for energizing the three illustrated cooling-box units **51**. If only two such box units are employed, the switches **61**, **62** are to be placed into the mid-position *b*. If only one box **51** is to be energized from the unit, the switches **61**, **62** are to be set to the broken-line position *c*. It will be understood that any number of tap positions may be provided for the transformer secondary **60** in order to make the power-supply unit **55** adaptable to a greater number of units so that one and the same power supply unit can be used regardless of the number of box units initially connected thereto or subsequently added to the refrigerating equipment of a home, for example.

The circuit diagram according to FIG. 6 is substantially similar to that of FIG. 5 as is apparent from the use of the same reference numerals for respectively cor-

responding circuit components. According to FIG. 6, however, rectifiers **63** are built into each box unit. The Peltier assembly **52** together with the rectifiers **63** of each unit is connected in parallel relation to the corresponding components of each other unit to the same secondary voltage of the transformer and of the filtering means **59** which all box units have in common. One pole of the Peltier assembly may be connected to the housing for forming a ground potential, so that when a multiplicity of boxes are employed, single-pole connections are sufficient if the housings of all boxes are connected with one another.

The line-connector units **55** as shown in FIGS. 5 and 6 can be so dimensioned electrically that they are suitable for energizing any devices that may be employed in a household and are to be operated with direct current. A power outlet **70** is provided on unit **55** for this purpose. Such household devices may be those that operate with Peltier blocks, for example selectively operable cooling and hot plates, cold or hot water storage containers, or other direct-current devices of any type.

By virtue of the fact that according to the invention a refrigerating appliance of the size heretofore customary is subdivided into individual small or miniature boxes or cabinets, the resulting universal possibility of subsequent enlargement greatly reduces the cost of initial investment to the customer or user because he can start for example with only one or two normal cooling-compartment units, leaving it to the future, to subsequently enlarge the refrigerating furniture by addition of bottle compartments, butter compartments or the like. A particular advantage of a refrigerating appliance according to the invention resides in the fact that the different products are aromatically separated to a greater extent than in refrigerator cabinets of the conventional type in which a single cooling chamber is subdivided by partitions into individual compartments. Furthermore, the stored objects in an appliance according to the invention, are accurately kept at the desired or most favorable temperature in a particularly simple manner and are accessible, independently of the products stored in other compartments, through the door or lid with which each individual box is equipped.

The miniature boxes of which a refrigerating appliance according to the invention is composed can be given respectively different dimensions depending upon their particular purpose. However they are preferably so designed that all Peltier assemblies in the individual cooling units constitute single, or, if desired, multiple structural units which are all of the same design, for example are all rated for 1 volt and 12 amperes. If preferred, all individual box units can then be equipped with a single thermoelectrical unit of the Peltier assembly having the rating adopted and kept uniform for all units. However, the system of unit boxes may also be so designed that some of the boxes are equipped with a plurality of Peltier base units, for example rated for 2 volts and 12 amps. In conjunction with mixed units of the latter type, it is preferable to make the electric-line connection unit of the system selectively switchable in order to permit the connection and operation of several series connected Peltier assemblies, each appertaining to one of the respective boxes. According to another embodiment of such a system, the Peltier unit in all boxes has the same rating and rectifiers are mounted together with the Peltier assemblies so that a plurality of such boxes, all requiring the same operating voltage, are connected in parallel relation to a transformer with a common filter or smoothing device.

As exemplified by the embodiments above described, it is essential to the invention that a single current-supply unit for connection to the power supply line is common to a plurality of direct-current consuming thermoelectric cooling units to be operated selectively or simultaneously. It is particularly advantageous to give such a line-connection unit a rating such that it can be universally employed wherever direct current is needed or desirable for use with household appliances. Consequently, the dimensioning and connecting possibilities of the line-connection unit are preferably chosen so that not only a plurality of cooling boxes equipped with Peltier blocks are connected thereto, but that also other household appliances operating with Peltier cooling devices can be selectively energized from the same power-supply unit, for example bottle cooling devices, cooling or heating plates, cold or hot water storage containers or the like. The same power supply unit, preferably equipped with an outlet to make direct current available for other purposes, can then also be used for the operation of other direct-current consuming devices as may be employed in the household although they are not equipped with Peltier cooling devices.

An example of a single Peltier block as incorporated in FIGS. 1 to 6 is shown in FIG. 7. The Peltier block is composed of thermocouples. Each individual couple is formed of two thermoelectrically different legs **71** and **72** consisting, for example, of semiconductor material having p-type conductance in one leg and n-type conductance in the other leg. The two legs **71** and **72** of each couple are electrically and thermally connected with each other by a bridge plate **74** of good conducting metal such as copper. Each of the two legs is further connected at the opposite end with the leg of an adjacent thermocouple by a similar bridge plate **73** of good conducting material. In the illustrated embodiment, a large number of such couples are electrically connected in series with each other and the terminal plates of the entire series are provided with electric leads **75** and **76** respectively for passing an electric current through the entire series of thermocouples in order to then produce hot junctions at the plates **74** and cold junctions at the plates **73**. The hot-junction plates **74** have their top surface located in a single plane, and the cold-junction plates **73** have their bottom surface located in a single plane parallel to that of the hot-junction plates. The p-type material for the thermocouples may consist of example of a solid solution of bismuth telluride and antimony telluride. The n-type material for the thermocouple may consist of a solid solution of bismuth telluride and bismuth selenide. The front faces of the couple legs **71** and **72** are made solderable, for example with the aid of ultrasonics, by electroplating with iron copper or nickel, or by vaporizing iron copper or nickel or other solderable metal onto these faces. The coatings then produced are then soldered together with the above-mentioned plates **73** and **74**. It will be understood, however, that the particular thermoelectric materials used for the thermocouples are not essential to the invention proper and that various other known substances are available for this purpose. Furthemore, the Peltier blocks may be given an arrangement and design different from the one described above with reference to FIG. 7.

Upon a study of this disclosure, it will be obvious to those skilled in the art that the invention permits of various modifications with respect to individual components and arrangement of the block units and the power-supply unit, and hence can be given embodiments other than particularly illustrated and described herein, without departing from the essential features of the invention and within the scope of the claim annexed hereto.

We claim:

A cooling appliance, comprising a plurality of mutually separable and thermally insulated cooling units having respective chambers for operation at different temperatures and being individually mountable in a multitude of relative positions, common mounting means for holding said cooling units in one of a number of modular formations forming a single unitary piece of furniture,

said units having individual independently accessible opening means, separate Peltier-couple assembly means connected to each of said units for cooling the respective chambers, and a line-connection power supply in said mounting means common to said cooling units ad electrically connected to all of said Peltier-couple assembly means, said individual Peltier-couple assembly means in the cooling units each having rectifier means, connector means for connecting each Peltier-couple assembly means parallel to the components of the other assembly means, said power-supply having a transformer and a filter to which all of said assembly means are electrically connected.

References Cited by the Examiner

UNITED STATES PATENTS

1,377,824	5/1921	Forbes	62—441
1,726,631	9/1929	Shipman	62—265
2,518,344	8/1950	Luneke	62—326
2,872,788	2/1959	Lindenblad	62—3
2,922,284	1/1960	Danielson	62—3
2,932,953	4/1960	Becket	62—3
2,970,450	2/1961	Roeder	62—3
2,986,009	5/1961	Gaysowski	62—3

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