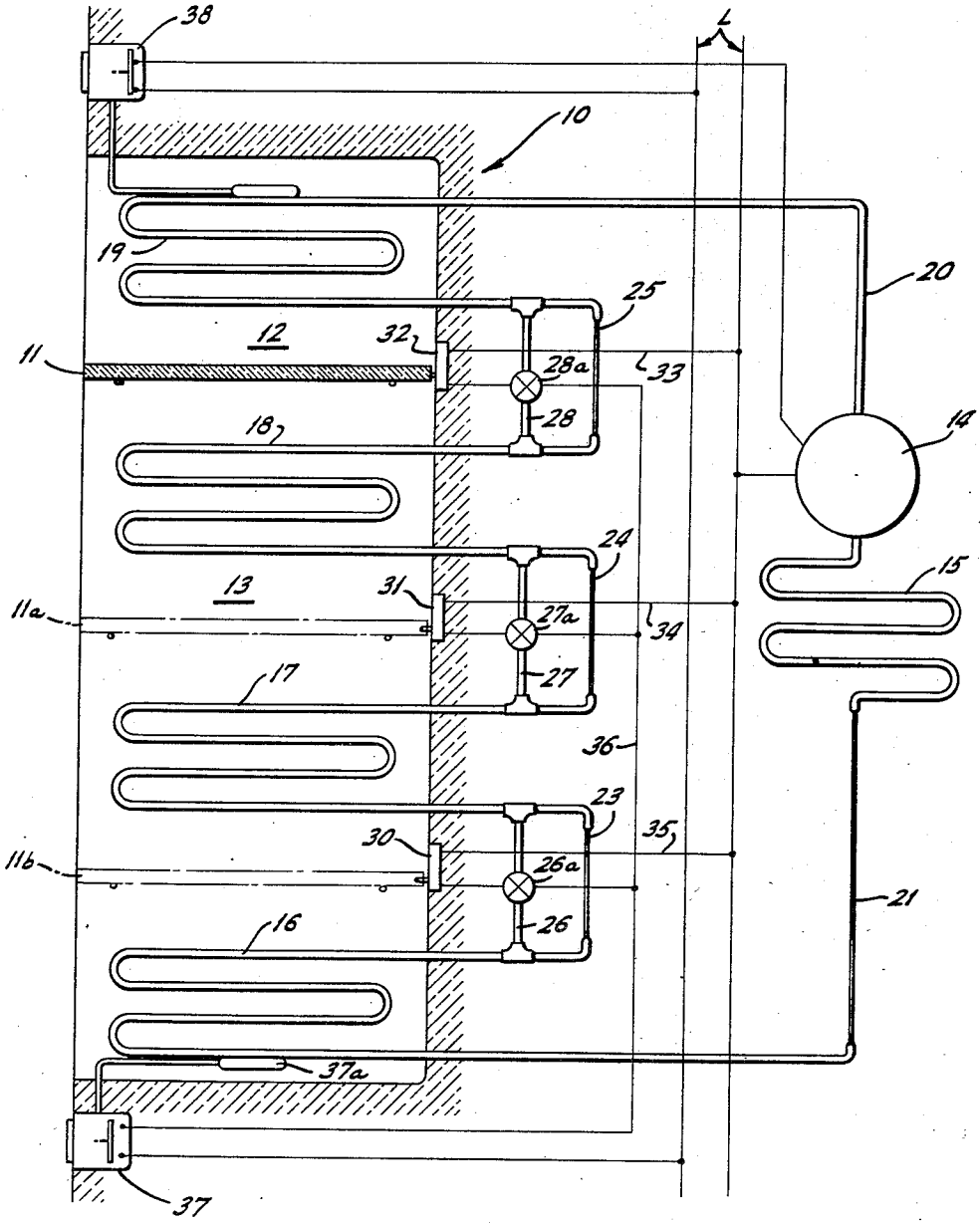
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PLURAL COMPARTMENT REFRIGERATION APPARATUS

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PLURAL COMPARTMENT REFRIGERATION APPARATUS

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This invention relates to refrigeration apparatus, being particularly concerned with plural compartment refrigerators of the type in which it is possible to maintain the several compartments under different temperature conditions. More specifically the invention has to do with refrigerators of the above-mentioned kind, in which provision is made for varying the relative sizes of the compartments as, for example, by varying the ratio of freezer volume to total storage volume. In the co-pending application of Harold W. Schaefer, bearing Serial No. 338,673, filed February 25, 1953, there is described and claimed novel and advantageous apparatus of the foregoing type, and it is with improvements in that apparatus that my invention is especially concerned.

The apparatus of the said Schaefer invention is featured by the fact that all that is required to effect the evaporator temperature adjustments necessitated by variation of the relative sizes of the compartments provided within the cabinet, is to reposition within the cabinet the partitioning means which is employed to divide the cabinet space into the sub-compartments desired. In this apparatus it is also possible to operate the entire space within the cabinet at either a relatively low temperature, for example at a sub-freezing temperature, or at a relatively high temperature, for example a temperature adapted for the storage of fresh foods.

To achieve these general objectives there is provided, in the apparatus of said co-pending disclosure, partitioning means movable to adjust the relative volumes of the two compartments which lie to either side of said means, together with a refrigerating system which includes a plurality of evaporator portions disposed along the length of the cabinet, the equipment further including means—responsive to location of the partitioning means within the cabinet—to determine the temperatures which are to be maintained at the several evaporator portions and therefore within the two compartments. The said portions are connected in series with suitable refrigerant circulating means and, selectively, auxiliary restricting devices may be interposed between said evaporator portions to provide adjustable control of the temperatures at the several portions in accordance with the selected volumetric ratio of the two compartments.

Equipment of this kind is advantageous, but it is less than completely satisfactory in that it does not include provision for independently controlling the temperatures of both compartments. The entire evaporator system is controlled from a single temperature-sensitive switching device the bulb of which is responsive to the temperature within only one of the two sub-compartments.

With the foregoing in mind, it is the primary object of this invention to improve the above-described system by providing for independent control of the temperatures of the two compartments, and particularly of the warmer compartment which underlies the partitioning means.

To this general end I utilize switching means responsive to the temperature of a lower one of the evaporator portions which are disposed along the length of the cabinet, that is, responsive to an evaporator portion which is included in the warmer compartment regardless of the position of the partition within the cabinet. This switching means is effective to provide independent control of that auxiliary restrictor which has been selected for actuation by positioning of the partitioning means within the cabinet.

The manner in which the advantages of my improved apparatus may best be achieved will be understood from

a consideration of the following detailed description taken together with the accompanying drawing, the single figure of which is a somewhat diagrammatic representation of a preferred embodiment of this invention.

Making detailed reference to the drawing, and with initial emphasis upon the constructional features which the apparatus of my invention has in common with that of the above-mentioned Schaefer invention, it will be seen that there is included an insulated enclosure designated, generally, by the reference numeral **10**, this enclosure comprising for example the cabinet of a refrigerator of the household or domestic type. Partitioning means shown at **11** extends horizontally through the compartment, this partitioning means preferably being of material of low thermal conductivity and being selectively disposable at various other locations within the compartment, as is represented by the broken-line indications appearing at **11***a* and **11***b*. Any suitable means may be employed to support the partition within the cabinet, for example simple pins of the type shown may be utilized for this purpose, and it will be observed that the partition may be disposed at any one of the illustrated elevations, or it may be removed entirely from the cabinet. The partition divides the space within the enclosure or cabinet **10** into upper and lower compartments and, with the partition in the position shown in full lines, a relatively small compartment **12** lies thereabove, whereas a larger compartment, shown at **13**, comprises that portion of the total cabinet volume which lies below the partition **11**. As will be understood from the drawing, disposition of the partition in either of the positions shown at **11***a* or **11***b* results in varying the volumetric relation relation between the two compartments **12** and **13**. If the partition **11** be completely removed from the cabinet the entire refrigerator is conditioned for automatic maintenance of either the higher or the lower temperature mentioned, depending upon the adjustment of a "cold" control to which further reference will be made hereinafter.

To provide for automatic maintenance of the compartments **12** and **13** at the desired preselected temperatures, a refrigeration system is used which comprises a circulating device, for example a motor-compressor **14**, a condenser **15**, and a plurality of evaporator portions **16**, **17**, **18**, and **19** arranged in heat exchange relation with spaced sections of the cabinet structure, either interiorly or exteriorly of the cabinet inner liner. All of the aforesaid elements are connected in series flow circuit through the agency of refrigerant flow conduits including a suction line **20** and a continuously open restricted connection of the capillary tube type, shown at **21**.

Control of the evaporator sections **16** to **19**, and consequent maintenance of desired temperatures within the compartments **12** and **13**, is accomplished in the simplest possible manner. Specifically such temperature control is accomplished in response to the very positioning of partition **11** which determines the relative sizes of the two compartments. To this general end auxiliary restricting devices **23** to **25** are provided, as are by-pass conduits **26** to **28**. Flow through each of the latter is under control of valve devices shown at **26***a*, **27***a* and **28***a*. The several valve devices are controlled by switches illustrated at **30** to **32**, each switch including a plunger disposed for cooperation with the partition **11** at one of its illustrated locations. Following suitable actuation of its associated switch, any of the valve devices may be placed across the line "L" through one of the conductors **33** to **35**, and through the common conductor **36**, which latter completes the circuit across the line through the contacts of an adjustable control **37**. This control is of the known Sylphon bellows type, and more detailed reference to its functions will be made in what follows. Similarly, and in accordance with known practice, the compressor **14** is energized through a second switch device or "cold" control **38**, responsive to temperatures prevailing at the upper evaporator section **19**.

As thus far described, and with the exception of the inclusion within the circuit of the switching device **37** which may be placed across the line in series with any one of the shelf-actuated switches **30** to **32**, the apparatus

coincides with that described and claimed in the said Schaefer disclosure. In a system of this kind any one of the valves 26*a*, 27*a* or 28*a* (which are of the normally open type) may be closed by depression of the plunger of its associated switch, which latter action takes place in response to placement of the partition at the level of said associated switch. Under the illustrated condition, that is with the partition 11 disposed at its uppermost location, the plunger of switch device 32 is depressed by the partition and valve 28*a* is therefore closed by being placed across the line "L" through the contacts of switch 37. Valves 26*a* and 27*a* remain open under this condition and, as will be understood, the evaporator sections 16, 17 and 18 (disposed below partition 11 and restrictor 25) are all maintained at substantially the same temperature. By virtue of closure of valve 28*a*, and consequent inclusion of auxiliary restrictor 25 in the circuit, the three evaporator sections disposed below the partition are maintained at a temperature and pressure higher than that prevailing at the upper evaporator section 19. If it is desired to increase the low temperature storage volume the partition is disposed at either of the elevations indicated at 11*a* or 11*b*, with the result that another of the auxiliary restrictors 23 to 25 is included in the circuit, the remaining auxiliary restrictors being substantially by-passed. It will be understood without further description that mere placement of the partition at any of the illustrated locations is sufficient to cause that portion of the cabinet which lies above the partition to function at a relatively low predetermined temperature, and that portion of the cabinet volume which lies below said partition to function at a higher temperature. If it is desired to utilize the entire cabinet at either the higher or the lower temperature, the partition is removed from the cabinet and, as a consequence, each of the valves 26*a* to 28*a* remains open and the auxiliary restrictors are substantially by-passed. Under such conditions all sections of the evaporator operate at substantially the same pressure and temperature and all parts of the cabinet are therefore maintained at the same temperature, the value of which is determined by the setting of the upper switch device 38 which controls the compressor.

Turning now to a consideration of the operation of the lower switch device 37 and its associated circuitry it will be observed that, in particular accordance with the improvements which are characteristic of my invention, it is possible to control the temperature of compartment 13, that is the temperature of the space below the partition 11, independently of the upper compartment. This control is exercised by causing cyclic operation of the particular solenoid valve which has been activated by placement of the partition. The apparatus operates in such a way (considering for example the solenoid valve 28*a* which is energized by placement of the partition 11 at the illustrated location) that said valve 28*a* is opened and closed in accordance with the temperature conditions prevailing within the lower compartment 13, as sensed by the bulb 37*a* which actuates switch 37.

In accordance with my invention each of the individual auxiliary restrictors 23 to 25 has a resistance to flow which is sufficient to insure that, in the closed position of the associated solenoid valve, the pressure drop through said auxiliary restrictor will be sufficient to result in maintenance of a coil temperature, at all coil portions below the restrictor concerned, somewhat higher than the storage temperature which is actually desired. If this condition is met it is possible for the switch device 37 to cause cyclic operation of the solenoid valve in accordance with the refrigeration demands of the compartment 13, and thereby to maintain the temperature of that compartment within predetermined limits.

As will be understood from the foregoing description, closure of any selected valve interposes restriction between the evaporator portions which lie above and below the partition. The addition of this restriction results in maintenance of the upper evaporator portions at a considerably lower pressure and temperature than prevails at the sections which serve to cool the lower part of the cabinet. Since the restricting effect of the capillary tube 25 is sufficient to cause the lower evaporator sections (16 to 18, for example) to be maintained at a temperature somewhat higher than is actually desired, the contacts of switch 37 act to "modulate" the temperature within the lower compartment by causing intermittent operation of the selected valve in accordance with the temperature of the lower evaporator section 16. The switch device 37 is, of course, adjustable to provide for variation of the temperature range within the lower compartment.

Each of the switching devices 37 and 38 is of known type, including contacts which are closed in response to a predetermined rise in the evaporator temperature, the contacts being reopened upon lowering of the evaporator temperature to a predetermined value. Since the partition 11 has conditioned the selected valve for operation in the closed position, it will be understood without further description that opening and closing of the contacts of switch device 37 serves to maintain the lower compartment 13 within a desired, predetermined temperature range.

From the foregoing description it will be understood that by the present invention there is provided novel and improved refrigeration apparatus which make it possible not only to adjust the refrigerating system in accordance with the volumetric relation of two compartments which comprise the cabinet space, but also to provide independent control of the temperature prevailing within the individual compartments. The apparatus of the invention is featured by the ease with which adjustments may be made, the necessary temperature relations being established automatically in response to selection of any desired volumetric ratio.

I claim:

1. In refrigeration apparatus, a cabinet, partitioning means effective to sub-divide the space within the cabinet into a pair of compartments, means for supporting said partitioning means at various selected locations within the cabinet to provide for adjustment of the volumetric ratio of said compartments, cooling means arranged in heat exchange relation with said cabinet, and including a portion disposed to one side of said partitioning means and a portion disposed to the other side thereof, control apparatus disposed for cooperation with said partitioning means and responsive to placement of said partitioning means at a selected location to control the operation of said cooling means, and a switching device including thermo-sensitive actuating means disposed in heat exchange relation wth one of said portions of said cooling means, said switching device being responsive to temperature conditions in the vicinity of said one portion to modify the operation of said control apparatus.

2. In refrigeration apparatus, a cabinet, partitioning means effective to sub-divide the space within the cabinet into a pair of compartments, means for supporting said partitioning means at various selected locations within the cabinet to provide for adjustment of the volumetric ratio of said compartments, cooling means including a plurality of evaporator sections arranged in heat exchange relation with spaced portions of said cabinet, a plurality of control elements individually operable to modify the pressure existing within at least certain of said evaporator sections, said elements being selectively actuatable by said partitioning means in response to placement of said partitioning means at a selected location within the cabinet, and means responsive to the temperature of at least one of said evaporator sections to cause cyclic operation of the selected control element.

3. In refrigeration apparatus, a cabinet, partitioning means selectively disposable at various locations within the cabinet to divide the space therein into a pair of sub-compartments which may be adjusted as to volumetric ratio, cooling means including a plurality of series-connected evaporator sections disposed in heat exchange relation with said sub-compartments, a plurality of pressure reducing devices, means for selectively including said pressure reducing devices in the refrigerant flow circuit between at least certain of said evaporator sections and in accordance with the volumetric ratio between said sub-compartments, and means for maintaining the temperature of one of said sub-compartments within predetermined limits, said last means including apparatus responsive to temperatures at said one sub-compartment to cause discontinuous inclusion of the selected pressure reducing device in the refrigerant flow circuit.

4. In refrigeration apparatus, a cabinet, partitioning means selectively disposable at various locations within the cabinet to divide the space therein into a pair of sub-compartments which may be adjusted as to volumetric ratio, cabinet cooling means comprising elements in-

cluding refrigerant circulating apparatus, a restrictor, and a plurality of evaporator portions, all of said elements being connected in series flow circuit, a plurality of auxiliary restricting devices each of which is disposed in the circuit between a pair of adjacent evaporator portions, means for by-passing said restricting devices selectively, in accordance with the disposition of said partitioning means within said cabinet, and means for controlling the temperature within one of said sub-compartments, said last means being responsive to temperature conditions at said one sub-compartment to control the action of said by-passing means.

5. In refrigeration apparatus, a cabinet, partitioning means selectively disposable at various locations within the cabinet to divide the space therein into a pair of sub-compartments which may be adjusted as to volumetric ratio, cabinet cooling means comprising elements including refrigerant circulating apparatus, a restrictor, and a plurality of evaporator portions each arranged in heat exchange relation with a corresponding part of the length of said cabinet, all of the aforesaid elements being connected in series flow circuit, a plurality of auxiliary restricting devices each of which is disposed in the circuit between a pair of adjacent evaporator portions, means for by-passing all of said auxiliary restricting devices with the exception of a selected auxiliary restricting device, the construction and arrangement being such that said auxiliary restricting devices are, selectively, actively included in the circuit in accordance with the position of said partitioning means within the cabinet, and means for controlling the temperature within one of said subcompartments, said last means being responsive to temperature conditions at said one sub-compartment to effect discontinuous by-passing of said selected auxiliary restricting device.

6. Apparatus in accordance with claim 5, and further characterized in that each auxiliary restricting device has restriction sufficient to produce within those evaporator portions which are disposed—in the series circuit—ahead of any selected auxiliary restricting device, a temperature in excess of a predetermined desired temperature, the mentioned discontinuous by-passing of the selected auxiliary restricting device serving to maintain said one sub-compartment within a desired temperature range.

7. In refrigeration apparatus, a cabinet, means dividing the space within the cabinet into a pair of sub-compartments which may be adjusted as to volumetric ratio, means including refrigerant tubing portions of which are disposed in heat exchange relation with at least a major part of the length of said cabinet, a plurality of restricting devices each adapted for inclusion in series flow circuit with said evaporator tubing at predetermined spaced locations intermediate the ends of said tubing, means including a plurality of valve elements adapted for selective actuation in accordance with the volumetric ratio of said sub-compartments, actuation of any selected valve element serving to effect inclusion of a corresponding one of said restricting devices in the refrigerant flow circuit, and means for controlling the temperature of one of said sub-compartments, said last means being responsive to temperature conditions at said one sub-compartment to modify the operation of the selected valve element and thereby to cause discontinuous inclusion of said corresponding restricting device in the circuit.

8. In refrigeration apparatus, a cabinet, means providing for division of the space within the cabinet into a pair of sub-compartments which may be adjusted as to volumetric ratio, cabinet cooling means comprising elements including refrigerant circulating apparatus, a restrictor and a plurality of evaporator portions, all of said elements being connected in series flow circuit, a plurality of auxiliary restricting devices each of which is disposed within the circuit between a pair of adjacent evaporator portions, means providing for selective by-passing of said restricting devices, whereby to modify the cooling effect of said evaporator portions in accordance with the volumetric ratio of said sub-compartments, and means for controlling the temperature within one of said sub-compartments, said last means including a thermo-sensitive element effective to control the action of said by-passing means.

9. In refrigeration apparatus, a cabinet having partitioning means selectively disposable at various locations therein, means including refrigerant tubing portions of which are disposed in heat exchange relation with at least a major part of the length of said cabinet, a plurality of restricting devices each adapted for inclusion in series flow circuit with said evaporator tubing at predetermined spaced locations intermediate the ends of said tubing, means normally operable to by-pass said restricting devices, means including a plurality of control elements disposed for selective actuation by said partitioning means in accordance with the position of said partitioning means within the cabinet, actuation of any selected control element serving to control said by-passing means in such manner as to effect inclusion of a corresponding one of said restricting devices in the refrigerant flow circuit, and means for controlling the temperature of that portion of the cabinet which lies to one side of said partitioning means, said last means being responsive to temperatures prevailing at the said cabinet portion to modify the operation of the selected control element and thereby to cause discontinuous inclusion of said corresponding restricting device in the circuit.

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