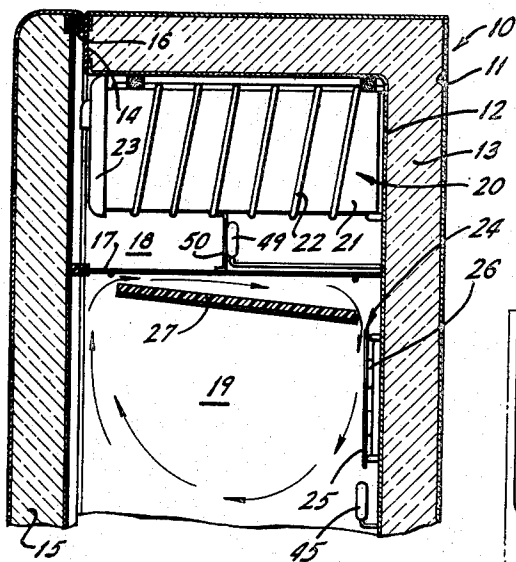


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TWO-TEMPERATURE REFRIGERATION APPARATUS

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TWO-TEMPERATURE REFRIGERATION
APPARATUS

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The present invention relates to refrigeration apparatus of the type including a refrigerator cabinet having a plurality of separate compartments and provided with a refrigerating system adapted to maintain said compartments at different temperatures. More specifically, the herein disclosed and claimed invention has to do with improved means for controlling the operation of refrigerating systems of the above mentioned variety.

To insure proper and adequate refrigeration for various kinds of foods, some of which must be kept in frozen condition and some of which must be cooled without freezing, it is customary to provide the interior of a refrigerator cabinet with two compartments. One compartment, commonly called the "freezing compartment," is maintained within a sub-freezing temperature range (for example -5° to -10° F.) and is adapted for the storage of food to be kept in frozen condition. The other compartment, commonly called the "cooling compartment," is maintained within a considerably higher and non-freezing temperature range (for example $+34^{\circ}$ to $+38^{\circ}$ F.) and is adapted for the storage of food to be cooled without freezing. A convenient refrigerating system which is suitable to maintain the proper and desired temperature range within each compartment, incorporates two evaporators, one arranged in heat exchange relation with the freezing compartment and the other arranged in heat exchange relation with the cooling compartment. These evaporators are connected through appropriate conduits with a compressor and a condenser to constitute a refrigerant circulating system, means being provided in the system to cause said evaporators to operate in such a manner as to bring about the required temperature conditions in the respective compartments.

Because the operation of the compressor is an important factor in establishing and maintaining cabinet temperature conditions, it is desirable that control means be provided to govern the operation (on-and-off cycling) of the motor-compressor unit. Known convenient arrangements for initiating and terminating the on-and-off cycles of the motor-compressor unit comprise thermostatically controlled switch devices interposed in the electrical circuit of said unit and responsive to temperature conditions which exist in the cabinet compartments. In many instances, such known arrangements give rise to constructional difficulties and operational problems in properly interrelating the thermostatically controlled switch devices for the purpose of insuring opera-

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tion of the motor-compressor as long as the cooling compartment demands refrigeration even though the temperature requirements of the freezing compartment be satisfied. An expedient way of accomplishing this purpose has been to incorporate relays in the electrical circuit of the motor-compressor. However, the use of such relays not only is expensive but also complicates the manufacture as well as the operation of the system.

It is an object of the present invention to overcome the above noted difficulties and problems by providing a simplified control arrangement for the above mentioned purpose, said arrangement being characterized in that it does away with the necessity of interrelating control switch devices of electrical relays in the electrical circuit of the motor-compressor.

Another and more specific object of the invention is to provide improved means for controlling the operation of the motor-compressor of refrigerating systems adapted for association with a single cabinet having a freezing zone or compartment and a non-freezing or cooling zone or compartment. This improved means is such that although responsive to the temperature of the freezing zone or compartment, it is influenced by the temperature of the cooling zone or compartment so as to assure operation of the motor-compressor if and when said cooling zone or compartment demands refrigeration.

In achievement of the above mentioned objectives, the invention employs a novel arrangement including a refrigerating system by means of which freezing temperatures are maintained within a zone or compartment arranged interiorly of a refrigerator cabinet and, at the same time, non-freezing temperatures are maintained within another zone or compartment also arranged interiorly of said cabinet, said arrangement further including means responsive to the freezing and non-freezing temperatures and adapted to control the operation of said system as a function of said temperatures jointly. The novel arrangement devised in accordance with this invention has the advantage that although it utilizes a single control to govern the operation of the refrigerating system, it still assures maintenance of the required or desired temperatures within the cooling zone or compartment as well as within the freezing zone or compartment.

The novel features of the invention and the manner in which the above recited and other objectives and advantages are achieved, will clearly appear from the following description of the

embodiment illustrated in the accompanying drawing, in which:

Figure 1 is a sectional view of a portion of a refrigerator incorporating the invention, and

Figure 2 is a diagrammatic view illustrating the construction and operation of a system in accordance with the invention.

With more particular reference to the drawing, it will be seen that the invention as illustrated in Figure 1, is embodied in a domestic refrigerator cabinet 10 which comprises an outer shell 11 and an inner liner 12, said shell and liner being spaced and insulated from each other by means of suitable insulation 13. As is customary, a break strip frame 14 of low thermal conductivity extends about the forward edge of the cabinet and bridges the gap between the outer shell and inner liner. An insulated door 15 of usual construction including sealing gasket means 16, is employed to close the front access opening of the cabinet. The interior of the cabinet is divided by means of a partitioning member 17 into an upper zone 18 and a lower zone 19, said partitioning member serving as a vapor barrier between said zones.

In the form illustrated in the drawing, the upper zone 18 encloses an evaporator 20 which is in the convenient form of a box-like metallic casing 21 having an open front and provided with circuitous conduit means 22 for circulation of refrigerant in heat exchange relation with said casing. A door 23 of suitable known construction is mounted to close the open front of the evaporator 20, which evaporator occupies a major part of said upper zone and is conveniently suspended from and adjacent to the top wall of the inner liner so as to leave a space between the bottom of said evaporator and the upper surface of the partitioning member. The evaporator 20, because of its comparatively large box-like construction, may accommodate ice-trays as well as food to be refrigerated at freezing temperatures.

The lower zone 19 is adapted to form a compartment for the storage of food to be kept at cooling or non-freezing temperatures and, according to usual practice, is supplied with suitable shelves (not shown) for supporting the food. In the illustrated embodiment this lower zone or compartment is effectively cooled by means of an evaporator 24 which advantageously consists of a generally rectangular metallic sheet 25 provided with serpentine conduit means 26 for circulation of refrigerant in heat exchange relation with said sheet. This latter evaporator 24 is conveniently mounted in a vertical position close to the rear wall of the inner liner and in proximity to the underside of the partitioning member 17. As seen in the drawing, the evaporator 24 extends along said rear wall and substantially from one to the other of the confronting side walls of said liner so as to present a comparatively large surface with which the air circulating within the lower compartment may come in contact. Circulation of air within the lower compartment 19 is actively assisted by means of a baffle plate 27 which underlies the partitioning member 17 and which is arranged to permit air from said lower compartment to pass in direct contact with the underside of said partitioning member and with the mentioned surface of said evaporator 24, as is represented by the arrows in Figure 1.

As shown in Figure 2, the upper or freezing evaporator 20 and the lower or cooling evaporator

24 form parts of a refrigerating system which includes a motor-compressor 28, a condenser 29 and means in the form of a solenoid valve device, generally designated at 30, which device is adapted to control the flow of liquid refrigerant to the cooling evaporator. This valve device comprises a solenoid 31, a valve body 32 and a valve member 33, the latter being adapted to open and to close refrigerant passageways 34 and 34a within said valve body. The valve body is provided with an inlet port 35 and a pair of outlet ports 36 and 37; the inlet port 35 being connected with the outlet end of the condenser, one outlet port 36 being connected with a refrigerant feeding conduit 38 leading to the cooling evaporator, and the other outlet port 37 being connected with a refrigerant feeding conduit 39 leading to the freezing evaporator. The two feeding conduits 38 and 39 are each provided with a flow restrictor or capillary tube 40 and 41, respectively, and the outlet end of the cooling evaporator is tapped to the feeding conduit which leads to the freezing evaporator, at a point between said evaporator and the restrictor or capillary tube 41 in the latter conduit, as is indicated at 42, so that refrigerant passing out of the cooling evaporator is admitted, through a portion 41a of said latter conduit, into the freezing evaporator from which gaseous refrigerant flows to the motor-compressor through a suction conduit 43.

As can be seen in Figure 2, the inlet port 35 and the outlet ports 36 and 37 are so arranged with respect to the passageways 34 and 34a that when the valve member 33 is moved into one of its positions (the position shown in full lines) the passageway 34 is open and the passageway 34a is closed so that communication is established between the condenser and the liquid conduit which leads from the outlet port 36 to the cooling evaporator; and when the valve member is moved into the other of its positions (the position shown in broken lines) the passageway 34 is closed and the passageway 34a is open so that communication is established between the condenser and the liquid conduit which leads from the outlet port 37 to the freezing evaporator. Because of the above described arrangement, it will be understood that during normal operation of the illustrated system, the flow of liquid refrigerant to the freezing evaporator is either through the cooling evaporator and conduit portion 41a, or directly through conduit 39 and its said portion 41a, dependent upon the position of the valve member with respect to the passageways 34 and 34a.

As hereinbefore indicated, movement of the valve member is accomplished through the solenoid 31. In the arrangement exemplified in Figure 2, the operation of the solenoid is advantageously controlled in response to temperature conditions within the cooling compartment 19 and, for that purpose, a suitable known bellows type device 44 having a feeler bulb 45 disposed within said cooling compartment, is adapted to actuate a switch element 46 to make or to break the electrical connection to said solenoid. The operation of said bellows type device is such that when the temperature within said compartment 19 exceeds a predetermined high limit (for example +38° F.) the switch element is actuated to energize the solenoid, thereby causing movement of the valve member to open the passageway 34 and to close the passageway 34a, thus allowing refrigerant to flow to the cooling evapo-

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rator 24. However, when the temperature in said compartment drops below a predetermined low limit (for example $+34^{\circ}$ F.) the switch element is actuated to de-energize the solenoid, thereby permitting movement of the valve member to close said passageway 34 and to open said passageway 34a, thus preventing the flow of refrigerant to said cooling evaporator. In this manner, during normal operation of the system, the cooling evaporator produces its maximum refrigerating effect only when its associated compartment 19 demands refrigeration.

To stop the motor-compressor in order to interrupt normal operation of the system when temperature requirements in both compartments are satisfied, and also to start the motor-compressor in order to initiate normal operation of the system when temperature conditions in both or either of the compartments are such that refrigeration is needed, there is provided a control arrangement which functions to open or to close the electrical circuit of said motor-compressor. This control arrangement, as best seen in Figure 2, includes a suitable known bellows type device 47 which is adapted to actuate a switch element 48 to make or to break the electrical connection to the motor-compressor, and which has a feeler bulb 49 so disposed as to be influenced by the temperature conditions of both compartments. This feature of the invention is readily and advantageously obtained by constructing the partitioning member 17 of metallic material having high thermal conductivity, by so arranging said member in the cabinet as to be affected by the temperature within the cooling compartment, and by providing a physical heat-conducting link between the freezing evaporator 20 and the partitioning member 17. This link conveniently takes the form of a metallic strip 50 of high thermal conductivity, which strip is disposed in the hereinbefore mentioned space between the freezing evaporator 20 and the partitioning member 17 and is connected directly to said evaporator and directly to said member. The feeler bulb 49 of said device 47 is mounted on said link or strip in intimate heat exchange relation therewith so that said bulb feels the temperature of said link or strip, which temperature reflects the temperature of the freezing evaporator and the temperature of the partitioning member which, in turn, is affected by the temperature of the air within the cooling compartment 19, as was previously indicated.

The above described switching arrangement including the association of a feeler bulb and a heat conducting link or strip which is affected by the temperature of both the evaporator 20 and the vapor barrier or partitioning member 17, represents the preferred embodiment of the invention. However, it is to be recognized that, within the broader aspect of the invention, other control means capable of responding to the temperature of said evaporator and of said member may be employed. For instance, a device which is suitable for the purpose of the invention and which is generally known in the art, is that conventional type of switch device constructed for actuation in response to a changing temperature differential between two thermo-sensitive pressure elements.

Referring again to Figure 2 which shows the system in the condition existing when both evaporators 29 and 24 demand refrigeration, it will be noted that the switch element 48 engages contacts 48a and closes the main electrical circuit which supplies electric current to the motor-

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compressor 28, and that the switch element 46 engages contacts 46a and closes the secondary electrical circuit which energizes the solenoid 31 to open the passageway 34 and to close the passageway 34a. Under this condition, it will be understood that compressed refrigerant from the motor-compressor 28 liquefies in the condenser 29 and enters the valve body 32 through the inlet port 35. From the valve body, liquid refrigerant passes through the outlet port 36 into the feeding conduit 38 for delivery to the cooling evaporator 24, and, thence to the freezing evaporator through the feeding conduit portion 41a. This mode of operation will continue as long as a refrigeration demand is imposed upon both evaporators.

In the event that the temperature of the air which circulates in the cooling compartment 19, and which is cooled by the evaporator 24, drops below the predetermined lower limit, then the feeler bulb 45 senses the temperature drop and causes the switch element 46 to leave the contacts 46a, thus opening the electrical circuit to the solenoid 31. As a result, said solenoid is de-energized and releases the valve member 33 which then moves to close the passageway 34 and to open the passageway 34a. As was hereinbefore indicated, when this condition occurs, the flow of liquid refrigerant is through said passageway 34a, outlet 37 and conduit 39 into the freezing evaporator 20, thus by-passing the cooling evaporator 24. It will be understood that although the hold-over characteristic of said cooling evaporator has some refrigerating effect, this effect is insufficient to cause further rise in the temperature of said cooling compartment. It will also be understood that although the lowered temperature of the air in the cooling compartment results in cooling the vapor barrier or partitioning member 17 and, to some extent, the heat transfer link or strip 50, the feeler bulb 49 in heat exchange relation with said link or strip is insufficiently affected to cause stoppage of the motor-compressor because said bulb is still primarily influenced by the temperature of the freezing evaporator 20. Of course, when the condition is such that the temperature of the freezing evaporator and the temperature of the air within the cooling compartment drop below their predetermined low limits, then said link or strip becomes cold enough to cause the feeler bulb 45 to react on the bellows device 47 in such a manner that the switch element 48 disengages the contacts 48a thus opening the electrical circuit of the motor-compressor and stopping the latter.

Should the temperature of the air in the cooling compartment 19 rise above a predetermined high limit while the motor-compressor is in operation, then the feeler bulb 45 in said cooling compartment senses the high temperature and the bellows associated with said bulb actuates the switch element 46 to re-engage the contacts 46a and to re-close the solenoid energizing circuit, so that the valve member 33 re-closes the passageway 34a and re-opens the passageway 34, thereby re-establishing the flow of liquid refrigerant to said cooling evaporator to lower the temperature within said cooling compartment. Should the rise of temperature in the cooling compartment occur while the motor-compressor is idle, the bulb 45 will react to cause the switch element 46 to engage contacts 46a, but current will not flow to the solenoid 31 because the main electrical circuit is then open due to the disengagement of the switch 48 from the contacts 48a. However, a continued slight rise in cabinet tem-

perature is soon transmitted by the member 17 to the link or strip 50 which then so affects the feeler bulb associated with the bellows device 47 as to cause closing of said main circuit, energizing of said solenoid and starting of the motor-compressor, thereby setting the system in operation to re-establish the normal flow of liquid refrigerant in the system and, consequently, through the evaporator 24 to effect a lowering of the temperature in the cooling compartment 19. Of course, in this last mentioned eventuality, refrigerant will also be fed to the freezing evaporator 20 with the possibility that the temperature of the latter may be lowered beyond its normal lower limit. However, this condition is not detrimental because the sub-zero temperatures within the compartment in which ice or frozen foods are stored, have no serious adverse result. Moreover, the lowering of the temperature in the freezing evaporator will not interfere with the operation of the motor-compressor for the reason that the heat picked up from the compartment 19 by the member 17 and transmitted to the feeler bulb 49 by the link or strip 50 will be sensed by the bulb, and the latter will be so influenced as to prevent the bellows device 47 from opening the motor-compressor circuit. In this respect, it will be recognized that the extent to which the temperature prevailing within the cooling compartment, below the barrier or partitioning member 17, will influence the operation of temperature-sensitive switch device 47 is a function of the relative mass of the freezing evaporator and said member as well as a function of the heat conducting characteristic of each of these elements, and this influence which the temperature within the lower compartment exerts upon the control device may adequately be determined by constructing said elements from materials having a mass and heat conducting characteristic suitable for the desired purpose.

It will be understood that the fact that the partition 17 is constructed of heat conducting material does not interfere with maintaining different temperatures in the two separate compartments, comprising the non-freezing zone 19 and the area defined by the freezing evaporator 20. As hereinbefore indicated, said partition 17 acts as a vapor barrier and thus isolates the freezing evaporator 20 from the air within the non-freezing compartment or zone 19. As a result, the air within the non-freezing compartment or zone is prevented from circulating in direct heat exchange relation with said freezing evaporator so that the cooling effect of said freezing evaporator upon the lower compartment is minimal, the result being, in such an arrangement, that the temperature of the non-freezing compartment will always be much higher than the temperature of the freezing evaporator.

The lower compartment includes, as is set forth in detail above, a cooling evaporator 24 which is controlled by the valve device 30 in such a way as to cycle between predetermined temperature limits. Operation of the evaporator 24 between predetermined temperature limits, in conjunction with the relatively small amount of heat exchange taking place through the vapor barrier 17, causes the temperature of the lower compartment to vary between rather close limits, for example from about 34° F. to about 38° F., as above stated. To achieve the latter temperature limits within the lower compartment, or other predetermined limits which may be desired, it is of course necessary to take into account the

size of the lower evaporator 24 as compared with the relatively large compartment 19. By properly proportioning this evaporator (the proportions in any specific design being dependent upon the size of the compartment 19, the effectiveness of the insulation, and like factors) and by cycling it within proper predetermined limits, it is possible to maintain the lower compartment 19 within a desired temperature range, for example the range indicated, and no difficulty is encountered in maintaining said lower compartment at a temperature considerably higher than that which prevails above the vapor barrier 17.

From the foregoing description, it will be appreciated that the invention provides an efficient refrigerating system having a simplified yet effective control arrangement by means of which the temperature of each compartment of a plural compartment refrigerator is adequately maintained within proper range for the preservation of the kinds of foodstuff stored in each compartment. It will also be appreciated that the invention, by means of a single control, makes it possible to govern the operation of the compressor so as to provide for operation of the refrigerating system whenever and as long as one or the other of the compartments is in need of refrigeration. It will further be appreciated that the invention is notably advantageous in that it employs a novel combination of simplified instrumentalities cooperating to effect proper control of the refrigerating system in order to achieve the desired refrigerating effects within separate compartments.

35 We claim:

1. Refrigeration apparatus comprising a refrigerator cabinet, a refrigerating system therefor, a first evaporator included in said system and disposed to refrigerate a space within said cabinet, a partition isolating said first evaporator from remaining interior portions of said cabinet, a second evaporator also included in said system and arranged in heat exchange relation with said remaining interior portions to provide a food storage compartment, means for controlling the operation of said second evaporator in response to temperature conditions within said food storage compartment, said partition being disposed in spaced relation with respect to said first evaporator and being constructed of material of relatively high thermal conductivity so as to be affected by the temperature of the air in said food storage compartment, a metallic member spanning the space between said first evaporator and said partition and being disposed in high heat exchange relation with each thereof to provide therebetween a heat conducting link affected by the temperature of said first evaporator and by the temperature of said partition, and means responsive to the temperature of said member to control the operation of said system as a function, jointly, of the temperatures affecting said member.

2. Refrigeration apparatus as set forth in claim 1, in which means is mounted within the food storage compartment to direct air therein into contact with the mentioned partition.

3. Refrigeration apparatus comprising a refrigerator cabinet, a refrigerating system therefor, a first evaporator included in said system and disposed to refrigerate an upper interior portion of said cabinet, a horizontal partition occupying an intermediate interior portion of said cabinet and isolating said first evaporator from a lower interior portion of said cabinet, a second evapo-

rator also included in said system and arranged in heat exchange relation with said lower interior portion to provide a food storage compartment, means for controlling the operation of said second evaporator in response to temperature conditions within said food storage compartment, said partition being spaced away from said first evaporator and being constructed of material of relatively high thermal conductivity so as to be affected by the temperature of the air within said food storage compartment, a metal strip spanning the space between said first evaporator and said partition, said strip being connected to said first evaporator and to said partition to provide therebetween a heat conducting link affected by the temperature of said first evaporator and by the temperature of said partition, and means including a temperature sensitive element mounted in direct heat exchange relation with said strip to control the operation of said system as a function, jointly, of the temperatures affecting said member.

4. Refrigeration apparatus as set forth in claim 3, in which a baffle plate is mounted below and adjacent the underside of the mentioned partition to direct air within the food storage compartment into contact with said partition.

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