

May 11, 1926.

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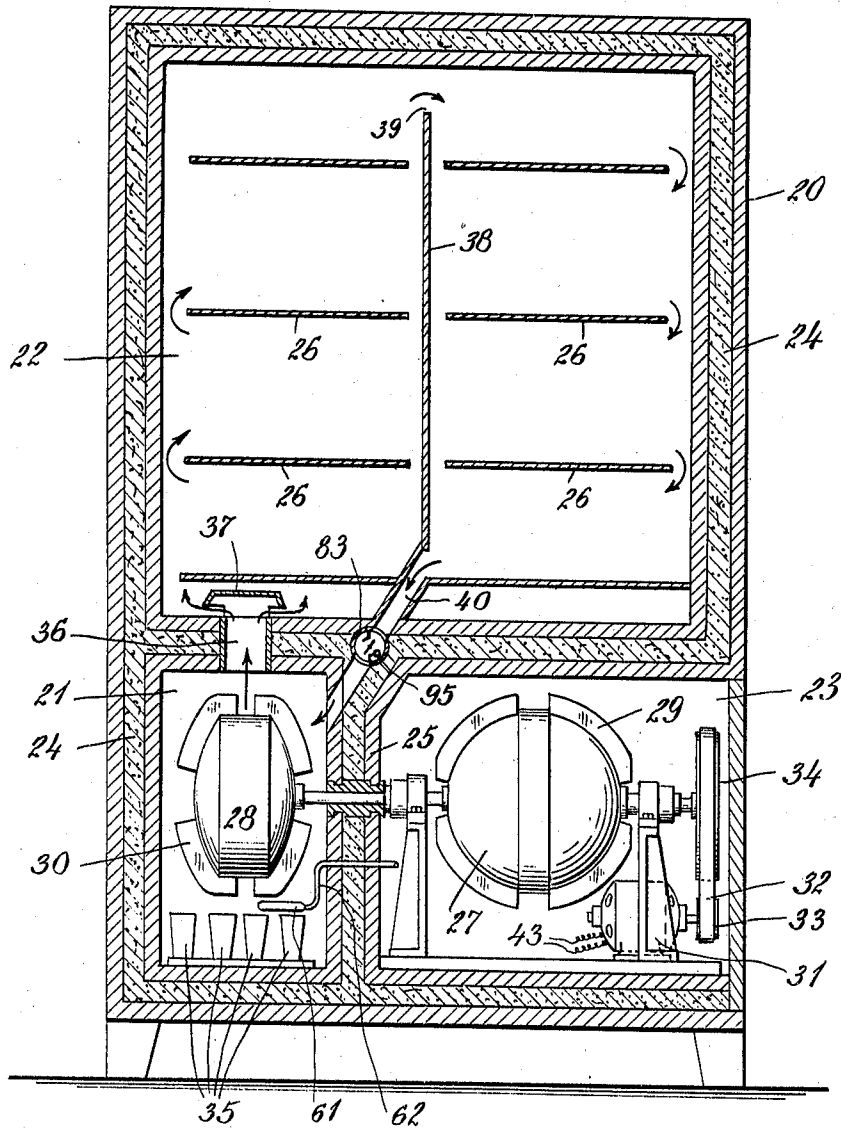
K. D. PERKINS ET AL

CONTROL FOR REFRIGERATING MACHINES

Filed Oct. 11, 1923

4 Sheets-Sheet 1

Fig. 1.



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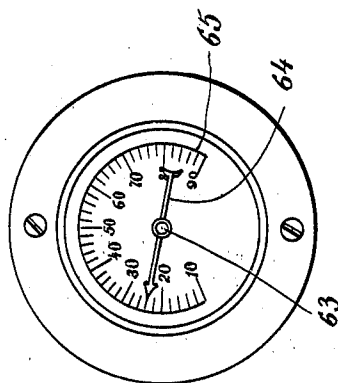
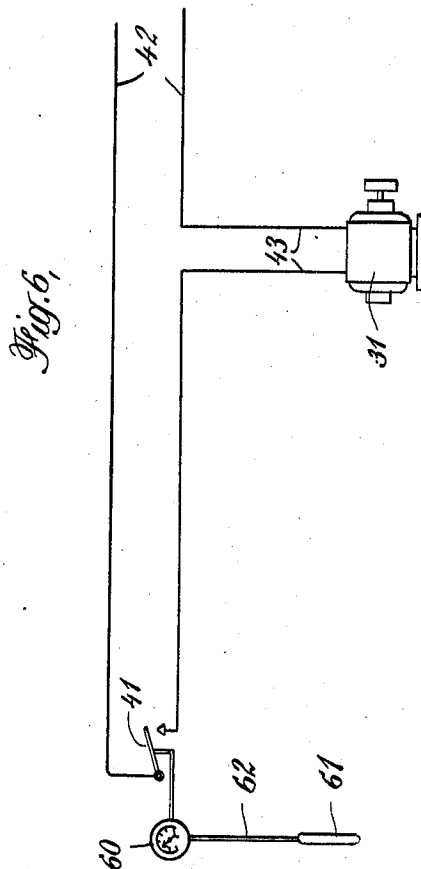
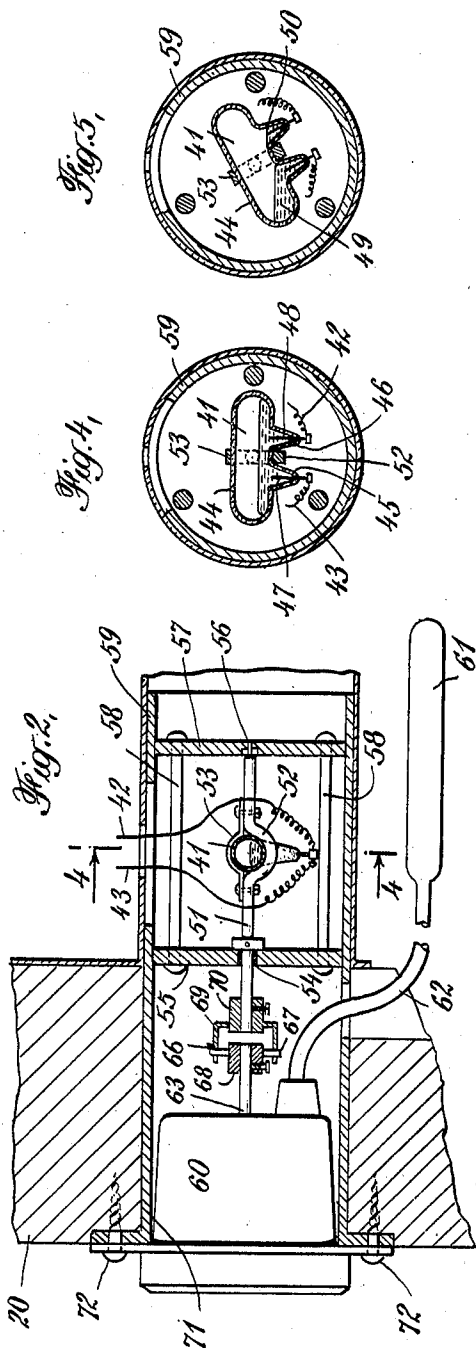
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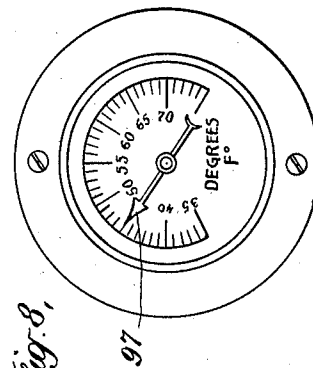
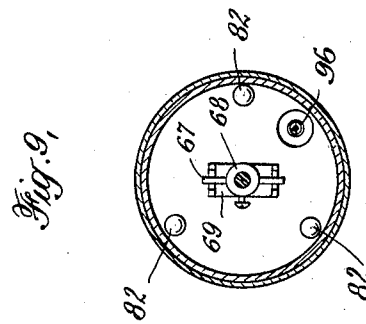
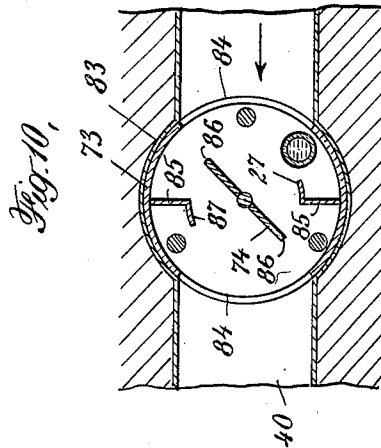
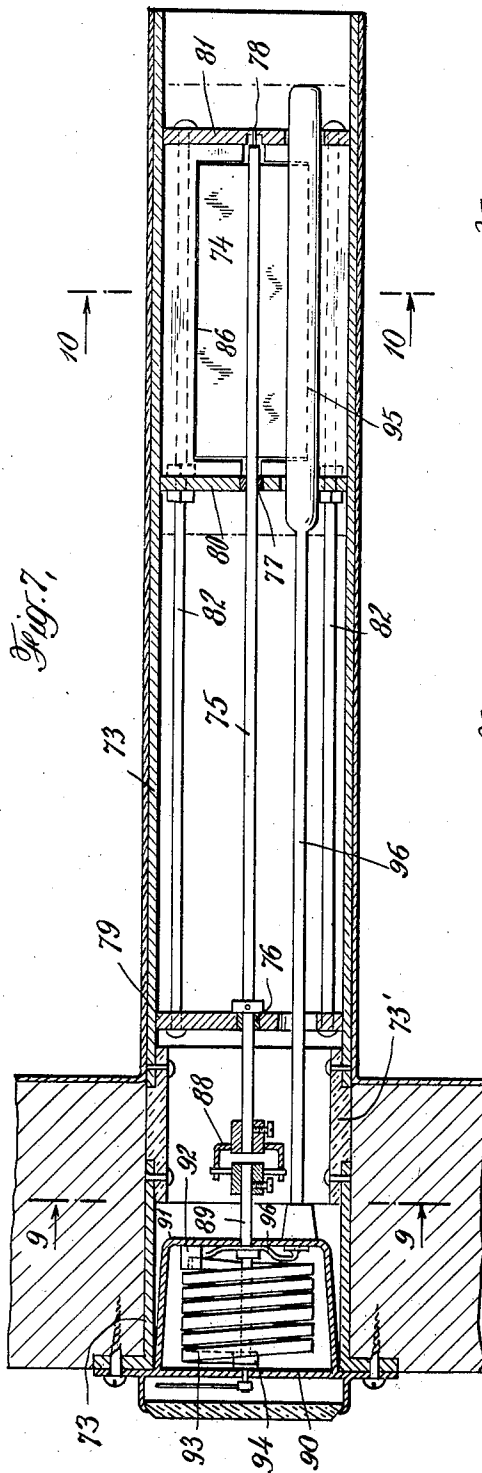
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CONTROL FOR REFRIGERATING MACHINES

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CONTROL FOR REFRIGERATING MACHINES

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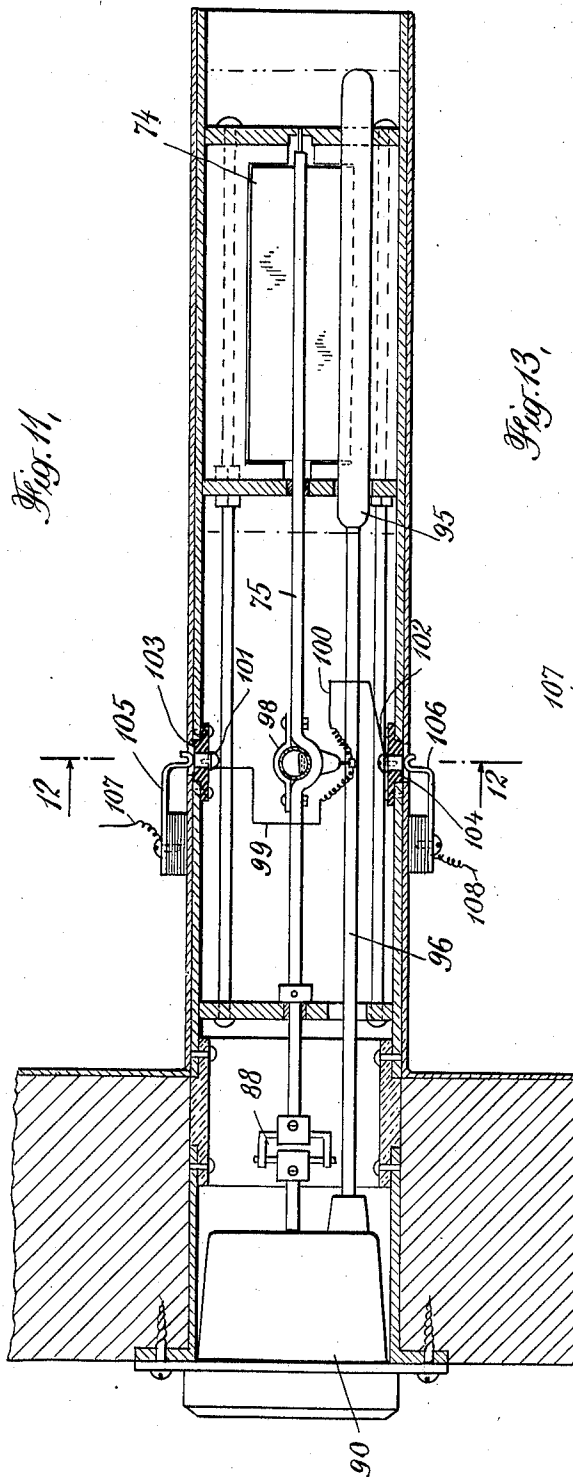


Fig. 13,

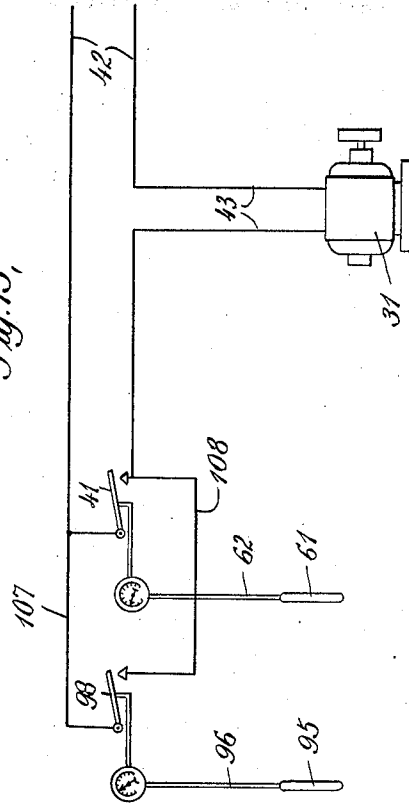
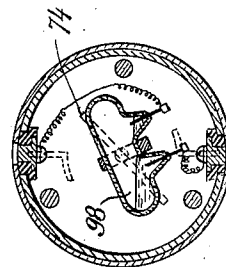


Fig. 12,



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UNITED STATES PATENT OFFICE.

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CONTROL FOR REFRIGERATING MACHINES.

Application filed October 11, 1923. Serial No. 667,800.

The present invention relates to a system of thermostatic control for refrigerating machines, particularly for refrigerating machines for the so-called electric refrigerators intended for domestic use, and the invention has for its object the provision of an improved refrigerator control system and apparatus.

Domestic refrigerators in which the refrigeration is produced mechanically, as used in private residences, restaurants, hotels, etc., are usually provided with a low temperature compartment and a relatively warm storage compartment. The low temperature compartment is utilized whenever it is desired to obtain a relatively low temperature such as in making ice, the temperature of this compartment being ordinarily from 20 to 30° F. The relatively warm compartment is usually considerably larger than the low temperature compartment and is utilized for the storage of perishable articles of food, the temperature of this compartment usually being maintained between 40 and 55° F.

A mechanical refrigerating device or apparatus is provided for extracting the heat from the ice making compartment and the storage compartment. Such a device is ordinarily driven by an electric motor and for the sake of economy this motor is arranged to be operated intermittently. It is therefore necessary to provide an automatically acting control to start and stop the motor at the proper times.

It is important that the ice making compartment be kept below freezing temperature as long as there is any water remaining unfrozen in the freezing flasks placed in this compartment. When the demand for ice is relatively large the low temperature ice making compartment may be kept below freezing temperature, say from 20 to 30° F., for a relatively long period of time, and it is important in such a case, as well as at all times, that the temperature of the storage compartment be not allowed to get too low, say, for example, below 35° to 40° F., as this would damage or freeze the food stored within the compartment.

When the water in the freezing flasks has all been frozen, however, it is no longer necessary to operate the refrigerating device for the purpose of freezing ice, and the apparatus may be shut down. The temperature of the whole refrigerator will now begin to rise and the storage compartment, being larger than the low temperature compartment, may warm up faster than the low temperature compartment. Under these conditions, should the temperature of the storage compartment rise above the maximum desirable temperature therein, the driving motor must again be started so as to cause a circulation of cooling fluid through the storage compartment. It is also of importance to know with accuracy the value of the temperature in the storage and the ice making compartments.

According to our present invention, we provide a refrigerating device operable to reduce the temperature in the low temperature compartment of the refrigerator, and we provide a relatively warm compartment normally in communication with the low temperature compartment, and means operable by temperature changes in the low temperature compartment for controlling the refrigerating device, means being also provided, which are operable by temperature changes in the relatively warm compartment, for controlling the communication with the low temperature compartment. This last named means may also, if desired, be made operable at a predetermined temperature in the low temperature compartment to control the refrigerating device in accordance with the temperature changes in the warm compartment as long as the predetermined temperature in the low temperature compartment exists. We also provide means for indicating the temperatures in either or both of the above mentioned compartments with a relatively high degree of accuracy. Our invention further contemplates an improved form of means for controlling the driving motor of the refrigerating device and for indicating the temperature in the ice making compartment as well as an improved means for controlling the communication between the low temperature compartment and the relatively warm compartment, and for indicating the temperature in the relatively warm compartment. We further mount these means in a unitary housing structure which is particularly suitable for installation in a refrigerator of the domestic type.

In order that these as well as other novel features of the invention may be more fully

understood, reference is made to the accompanying drawings illustrating, by way of example, a mechanical embodiment of the inventive idea. These drawings, however, are intended to assist the description of the invention and not to define the limits thereof. In these drawings:

Fig. 1 is a view in vertical cross section of a refrigerator provided with our improved control system and apparatus;

Fig. 2 is a view partially in longitudinal section and partially in elevation of a combined temperature indicator and thermostatically operated switch for controlling the driving motor;

Fig. 3 is a front view of the device illustrated in Fig. 2 showing the temperature indicator;

Fig. 4 is a view in transverse section taken on line 4—4 of Fig. 2 showing a mercury tube switch in closed position;

Fig. 5 is a view similar to Fig. 4 showing the switch in open position;

Fig. 6 is a schematic diagram showing the electrical connections of the driving motor;

Fig. 7 is a view in longitudinal section of a combined temperature indicating device and thermostatically operated damper for controlling the communication between the low temperature compartment and the relatively warm compartment;

Fig. 8 is a front view of the device illustrated in Fig. 7 showing the temperature indicator;

Fig. 9 is a view in transverse section taken on line 9—9 of Fig. 7 to show the flexible shaft connection;

Fig. 10 is a view in transverse section taken on line 10—10 of Fig. 7 to show the relative arrangement of the operating parts of the damper, and its position in the air duct;

Fig. 11 is a view partially in elevation and partially in longitudinal section of a combined temperature indicator, thermostatically operated switch, and thermostatically operated damper employed in a modified arrangement of the thermostatic control system;

Fig. 12 is a view in longitudinal section taken on line 12—12 of Fig. 11 showing the relative angular position of the mercury tube switch and the damper; and

Fig. 13 is a schematic diagram showing the electrical connections for the refrigerator driving motor in the modified control system.

Referring to Fig. 1 of the accompanying drawings, there is here shown a refrigerator 20 having a low temperature compartment 21, a relatively warm, or storage, compartment 22, and a third compartment 23. The walls of the low temperature compartment 21 and the relatively warm compartment 22 are constructed preferably of suitable

wood filled with heat insulating material 24, the dividing wall 25 between compartments 21 and 23 being also constructed in this manner. The storage compartment 22 is preferably lined with a sanitary material such as porcelain, which also possesses a relatively large thermal capacity. Suitable shelves 26 are provided in this compartment on which to place the articles to be cooled.

In the refrigerator shown in the accompanying drawings the low temperature, or ice making, compartment 21 and the storage compartment 22 are refrigerated by means of a refrigerating machine or device of the Audiffren type, in which the apparatus comprises a pair of rotary communicating vessels 27 and 28, sometimes called a "dumb-bell" from their resemblance thereto. In one of the vessels or bells 27, which is usually known as the compressor bell, the refrigerating fluid is compressed and condensed, and in the other bell 28, which is known as the expansion bell, the fluid is expanded to absorb heat from the medium surrounding it. The refrigerating machine is in this instance constructed in accordance with the disclosure in our co-pending application S. N. 623,333 filed March 7, 1923, the condenser bell 27 being provided with a plurality of heat conducting vanes 29 on its surface, and the surface of the expansion or evaporator bell 28 being also provided with similar heat conducting vanes 30. The refrigerating machine is driven by means of an electric motor 31 through a belt 32 and pulleys 33 and 34, on respectively the motor shaft and the refrigerating machine shaft.

In the example shown the low temperature compartment 21 is sufficiently large to allow the evaporator bell 28 to rotate therein, and to accommodate the freezing flasks 35 in which water may be placed and frozen for making ice. When the refrigerating machine is rotated by means of motor 31 heat is absorbed from the medium in compartment 21, which in this case is air, and when the expanded refrigerating fluid within the evaporator bell 28 is drawn over into bell 27 and compressed by the compressors therein, this heat is conducted from the surface of bell 27 by means of the radiating fins 29 and discharged to the surrounding medium in compartment 23, which in this case is also air. Compartment 23 is provided with suitable openings (not shown) to the atmosphere so as to provide for ample circulation of the air into and out of the compartment.

The shape and positioning of the vanes 29 and 30 is such that the air is discharged from the surface of the bells 27 and 28 respectively in planes transverse to the axis of rotation, and air is drawn toward the surface of the bells 27 and 28 at all other points.

In this way a particularly effective and rapid transfer of heat is obtained to and from these bells.

The rotation of vanes 30 on bell 28 causes a circulation of air to take place through the air duct 36 underneath hood 37 and to the left-hand side of the relatively warm storage compartment 22 which is separated from the right-hand side by a partition 38. An aperture 39 is provided, however, at the upper end of this partition through which the air travels to the right-hand side of compartment 22 and returns to the low temperature compartment 21 by means of air duct 40. By thus placing compartments 21 and 22 in communication with each other the compartment 22 is effectively cooled.

In order to freeze the water in the flasks 35 it is necessary to maintain the temperature of the compartment 21 below about 30° F., and it is desirable to maintain it at an average temperature of about 25° F. in order to provide a thermic head which will result in a relatively rapid rate of freezing. It is thus desirable to start the driving motor 31 when the temperature of compartment 21 rises to about 30° F. and when the temperature of this compartment falls to about 20° F., to stop the operation of the driving motor.

In order to properly store articles of food they should be maintained at a temperature not much lower than 40° F. and not much higher than 55° F., and they should preferably be maintained at or near the lower temperature limit. The temperature may not, however, be lowered much below 40° F. without impairing the flavor or otherwise injuring many articles of food. Hence, it will be seen that the storage compartment 22 should be maintained at a temperature somewhat higher than that of compartment 21 and for this reason compartment 22 is referred to as the relatively warm compartment.

In order to control the operation of the refrigerating machine so as to control the temperatures of compartments 21 and 22 as above described, we have provided the apparatus illustrated in Figs. 2 to 10, inclusive, of the accompanying drawings. We first of all provide a switch 41 (Figs. 2, 6 and 13) for making and breaking the circuit from the power supply lines 42 to the terminals 43 of driving motor 31. Switch 41 is preferably of the mercury tube type and comprises an envelop 44 of glass, quartz, or the like, having in its walls a pair of projections 45 and 46 into the tips of which there are sealed the electrodes 47 and 48 which are provided with suitable terminals to which one of the supply conductors 42 and one of the motor leads 43 are respectively connected, as shown in the diagram of Fig. 6. The interior of the envelop 44 is

exhausted and a small amount of mercury is placed therein, so that when the tube is at or near the horizontal position as shown in Fig. 4, the mercury serves to connect electrodes 47 and 48 and complete the circuit through the tube. When, however, tube 44 is tilted to a position similar to that shown in Fig. 5, the mercury will flow to one end of the tube leaving the isolated pools 49 and 50 each in contact with its corresponding electrode, but the circuit through the tube having been broken. It should be noted that in this form of mercury tube switch the circuit is broken between two pools of mercury so that the arc formed by the rupture merely vaporizes a small amount of mercury and in no way consumes either of the electrodes 47 or 48.

The mercury tube switch 41 is appropriately mounted upon a shaft 51 as by means of the stirrup 52 and clamping member 53 so that the tube is gently but firmly supported with its axis transverse to that of shaft 51, so that by rotating the latter the switch may be opened and closed.

Shaft 51 is preferably mounted for rotation by means of a sleeve bearing 54 in a stationary disc 55 and a pivot bearing 56 in a similar stationary disc 57, these stationary discs being spaced a suitable distance from one another as shown in Fig. 2 and held in this position by the distance rods 58, which also serve to clamp the discs 55 and 57 in position. This switch supporting structure is now placed within a supporting housing 59 which it is desirable to make in the form of a tubular structure of sufficient diameter to allow the switch tube 44 to rotate freely within it.

In the opposite end of the housing 59 we position a temperature-responsive device or thermostat 60, now only briefly referred to, but presently to be described in detail. It is sufficient to say here that this thermostat is provided with a temperature-sensitive bulb 61 which is connected to the thermostat proper by means of a flexible tubing 62 so that the bulb 61 may be positioned at any point where it is desired to measure the temperature. A change in the temperature of bulb 61 effects a rotation of shaft 63 of the thermostat, which projects forwardly of the instrument to carry an indicating pointer 64 (Fig. 3) adapted to move over a scale 65, and which projects rearwardly of the thermostat to actuate shaft 51 through the flexible coupling 66. This coupling comprises a transversely extending pin 67 (Figs. 2 and 9) mounted in the hub 68 on the thermostat shaft 63, and a longitudinally bent forked member 69 carried by hub 70 on the switch shaft 51. By using this flexible coupling it is unnecessary to place shafts 51 and 63 exactly in alignment with one another. The length of the arms of the forked member 69

is such as to allow of a small amount of end play between shafts 51 and 63. The spacing between each pair of arms of the forked member 69 is somewhat greater than the diameter of the pin 67, and by varying this spacing so as to provide a certain amount of lost motion in the operation of shaft 51 by shaft 63, the time of the opening and closing of switch 41 may be adjusted.

The thermostatically operated switch just described is mounted preferably in the front of the refrigerator 20 by providing a recess 71 therein at a suitable position and inserting the tubular housing 59 which carries the mercury tube switch and the thermostat in a single unitary structure which may be easily removed for inspection or repair by merely taking out the screws 72.

The temperature-sensitive bulb 61 is positioned in the low temperature compartment 21 in proximity to the freezing flasks 35 so that the rotation of the shaft 63 is dependent upon the changes of temperature at this point. By appropriately setting the angular position of the mercury tube 44, switch 41 may be made to open when the indicator 64 is at 20° F., and by appropriately designing tube 44, or by varying the spacing between the pairs of arms on the forked member 69 of the flexible coupling, the switch 41 may be made to close at 30° F. With these adjustments made, the thermostatically operated switch 41 is operable by temperature changes in the low temperature compartment 21 to control the operation of the refrigerating machine, this switch closing when the temperature in compartment 21 reaches 30° F. so as to place the refrigerating machine in operation. This operation will continue until the water in the freezing flasks 35 is frozen, after which the temperature in the compartment will drop to around 20° F. at which point switch 41 will open and stop the operation of the refrigerating machine.

In order to properly control the temperature in the relatively warm storage compartment 22 so that it will not fall too low and damage the articles stored therein, we provide the thermostatically operated valve, or damper, illustrated in Figs. 7 to 10, inclusive. This device is housed in a tubular member 73 in a similar manner to the switch 41. Member 73, however, is of metal, and inasmuch as the inner end of this member is subjected to a relatively low temperature while the outer end is at room temperature, a considerable amount of heat will tend to flow toward the cooler portion. In order to intercept this flow of heat the forward end of tubular member 73 is insulated from the inner end by means of an insulating sleeve 73', which is inserted in the housing just back of the thermostat 90 and firmly secured to the front and rear members of the hous-

ing 73 by suitable mechanically strong riveted joints. The damper comprises a vane 74 mounted to rotate on shaft 75 which is carried in sleeve bearings 76 and 77 and a pivot bearing 78. These bearings are mounted in discs 79, 80, and 81, respectively, disc 79 being disposed toward the outer end of the tubular housing 73, and discs 80 and 81 serving to co-act with the ends of vane 74 to close the air passage. These discs are secured together and held firmly in spaced relation by means of the bolts 82. The housing 73 is inserted in an aperture 83 (Figs. 1 and 10) which is let in from the face of the refrigerator for a sufficient depth to reach the air duct 40 and so as to hold the damper 74 in position opposite the openings formed by the intersection of recess 83 with the air duct. Appropriate openings 84 are provided in each side of the housing 73 so as to allow for the passage of air transversely of the housing and past the vane 74. A pair of flanges 85 is provided which extend inwardly from the inner surface of housing 73 to co-act with the longitudinal edges 86 of the vane 74 to close the passageway through the air duct, and the inner edges of these flanges are extended circumferentially as shown at 87 in order to allow a certain amount of freedom of movement of vane 74 without again opening the passageway.

This damper, or vane, 74 is actuated by the rotation of shaft 75, flexible coupling 88 (similar to the one previously described) and shaft 89 of a second temperature-responsive device, or thermostat, 90, which is also similar to thermostat 60. The details of the construction of these thermostats are as follows.

Within the casing 91 there is mounted on a boss 92 firmly attached to the inner end of casing 91, a relatively long hollow Bourdon coil 93. The opposite end 94 of this coil is directly attached to an arm on shaft 89. A temperature-sensitive bulb 95 is connected by means of a flexible capillary tube 96 with the inner end of the Bourdon coil 93, and the bulb, capillary tube, and coil are completely filled with a suitable thermometric fluid. When the temperature to which the bulb 95 is subjected is increased, the thermometric substance expands and the increase in pressure caused thereby causes the outer end 94 of the Bourdon coil to move by a corresponding amount. Because of the extraordinary length of the Bourdon coil the shaft 89 and the indicating pointer 97 mounted thereon are rotated throughout the full scale of the instrument.

The temperature-sensitive bulb 95 may be placed at any point in the relatively warm storage compartment desired, but it is preferably located, as shown in Figs. 7 and 1, within the housing 73 on the storage compartment side of the damper 74. With the

thermostatic damper just described operating in conjunction with the thermostatically operated switch 41, let us suppose that switch 41 is closed, the temperature in compartment 21 being below 30° F. After the refrigerating machine has been operated in this manner for a certain period of time the temperature in the storage compartment 22 will be lowered and the damper 74 will move towards the closed position. The damper is preferably set to close at 40° F. so that when this temperature is reached the circulation of the cold air between compartments 21 and 22 through the ducts 36 and 40 will be cut off. Compartment 22 will now begin to warm up and the damper 74 will slightly open, a condition of equilibrium being finally reached.

When the water in the freezing flasks 35 becomes completely frozen and the temperature of compartment 21 reaches 20° F., the switch 41 shuts down the refrigerating apparatus and both compartments 21 and 22 begin to increase in temperature. The temperature in compartment 22 may become greater than 55° F. before the temperature in compartment 21 reaches 30° F. and the refrigerating apparatus is started again. In order to prevent the temperature in the storage compartment 22 from rising above a predetermined amount, say 50 or 55° F., under these conditions, we have provided the modified refrigerator control which is illustrated in Figs. 11 to 13 of the accompanying drawings.

Referring to these figures, a second mercury tube switch 98 is mounted on shaft 75 of the thermostatic damper 74, there being ordinarily sufficient space between discs 79 and 80 to adequately accommodate this switch. In this manner the thermostat 90 is arranged to control simultaneously damper 74 and switch 98. The terminals of switch 98 are connected in parallel with the terminals of switch 41, as shown in Fig. 13, so that motor 31 may be started by the closing of either switch 41 or 98, but the motor will not stop unless both of these switches are thrown to open position.

In order to make the thermostat, switch 98, and damper self-contained, that is, to provide for the removal of these elements from the refrigerator by the simple withdrawing of their tubular housing from its recess, sliding electrical contacts may be employed to make the connections from the conductors leading from the terminals of switch 98. For this purpose the conductors 99 and 100 lead from the terminals of switch 98 to a pair of contact segments 101 and 102 which are mounted in insulating inserts 103 and 104 mounted in the surface of the housing. Flexible contacts 105 and 106 are suitably mounted in the walls of the recess for the housing so as to make contact with seg-

ments 101 and 102, respectively, when the unit is slid into its recess. Conductors 107 and 108 are respectively connected from the terminals of switch 41 to spring contacts 105 and 106.

By so positioning switch 98 upon shaft 75 that it closes when the damper 74 is, say, from two-thirds to full open, the switch may be made to close at from 50 to 55° F. and the damper will be sufficiently open to allow adequate circulation to take place. A suitable position of the switch 98 with respect to damper 74 is shown in Fig. 12, in which switch 98 is adapted to close when indicator 97 (Fig. 8) is at 50° F. and when damper 74 will be about two-thirds open.

Let us assume that a refrigerator is equipped with the modification of the automatic control just described, and that the temperature of compartment 21 is down to 20° F. so that the refrigerating machine is not running. Under these conditions the temperature of both the compartments 21 and 22 will begin to rise and damper 74 will open, but is powerless to control the temperature of the compartment because no air is being circulated. If the temperature of compartment 22 now rises to 50° F., switch 98 will close, placing the refrigerating apparatus again in operation and causing circulation of cold air through the storage compartment. The lower temperature thus produced will act on the temperature-sensitive bulb 95 to turn switch 98 toward open position, but by suitably designing the contour of the switch envelop or by adjusting the spacing between the pin and forked arm of the flexible coupling 88, switch 98 may be made to remain closed until the temperature in compartment 22 has fallen to an appreciable extent, say, for example, to 45° F. The control of the driving motor 31 is thus placed under switch 98 and bulb 95 which will maintain the temperature of the storage compartment between 45 and 50° F., until the temperature of compartment 21 again rises to 30° F. In other words, switch 98 is operable upon a predetermined reduction in temperature in compartment 21 to control the operation of the refrigerating machine.

The employment of the improved control system of our invention ensures that the refrigerating machine shall be placed in operation whenever either the low temperature or ice making compartment requires additional refrigeration, or when the relatively warm or storage compartment requires refrigeration, and the demands of the two compartments are so coordinated that neither too high a temperature nor too low a temperature may exist in the storage compartment, and at the same time so that the refrigerating apparatus will not be kept running when it is not necessary. In this way the cost of operation of the refrigerator is

reduced to a minimum. By employing a temperature-responsive device of the Bourdon tube type for the actuation of the driving motor controlling switch, providing this device with a pointer and scale, the operation of the switch at the desired predetermined temperatures is assured and an accurate indication of the temperature existing in the compartment is obtained. The direct connection of the thermostatic element with the operating shaft eliminates the necessity of gears or other multiplying mechanism. These same advantages are obtained in the operation of the automatic damper. Furthermore, by employing a mercury tube switch which is actuated by a temperature-sensitive device of the Bourdon tube type, the motor circuit may be controlled directly by the switch without the necessity of using relays for carrying the load current. This is a distinct advantage, inasmuch as such relays are apt to get out of order and increase the maintenance expense of a refrigerator. By providing the tubular housing all of these elements are properly protected from injury and at the same time so mounted that it is an extremely easy matter to remove them for inspection or repair.

We claim:

1. In a refrigerator having a refrigerating chamber, a refrigerating device operable to produce temperature changes therein, and a storage compartment normally in communication with said refrigerating chamber, the combination of, means operable by temperature changes in said chamber for controlling said refrigerating device, and means operable by temperature changes in the storage compartment for controlling the communication with the refrigerating chamber and for controlling said refrigerating device.

2. In a refrigerator having a refrigerating chamber and a storage compartment with a

cooling fluid circulating therebetween, and having a refrigerating device operable to cool the refrigerating chamber, the combination of means operable by temperature changes in the refrigerating chamber for controlling said refrigerating device, and means operable by temperature changes in the storage compartment for controlling the circulation of the cooling fluid and for controlling said refrigerating device.

3. In a refrigerator having a refrigerating chamber, a storage compartment, air ducts for placing said compartments in communication with one another, a refrigerating device operable to produce temperature changes in said refrigerating chamber, and an electric driving motor for said refrigerating device, the combination of a thermostatically operated switch in the circuit of said driving motor operated by temperature changes in said refrigerating chamber, and a thermostat operable by temperature changes in the storage compartment operatively connected to actuate a second switch in the circuit of said driving motor and a damper in one of said air ducts.

4. In a refrigerator, a refrigerating chamber and a storage compartment in communication with one another, a refrigerating device operable to cool the refrigerating chamber and to circulate cooling fluid between said chamber and the storage compartment thereby to cool the latter, and means operable by temperature changes in the storage compartment for controlling the flow of cooling fluid between said compartment and chamber and for controlling said refrigerating device.

In testimony whereof we affix our signatures.

ALFRED D. KARR.
K. D. PERKINS.