Aug. 25, 1942. A. O. GROOMS 2,294,028

REFRIGERATING APPARATUS

Filed July 7, 1938 5 Sheets-Sheet 1

Fig. 1

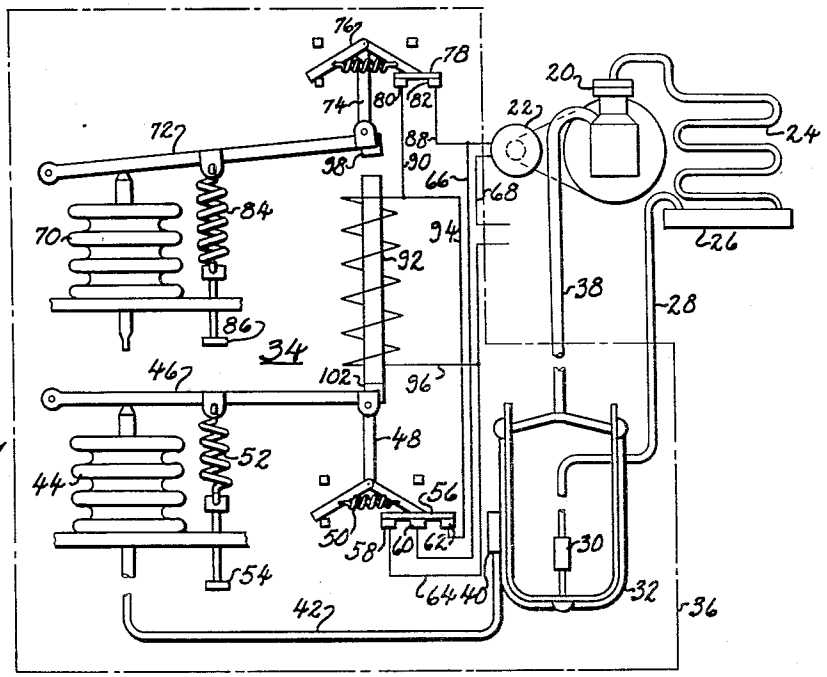
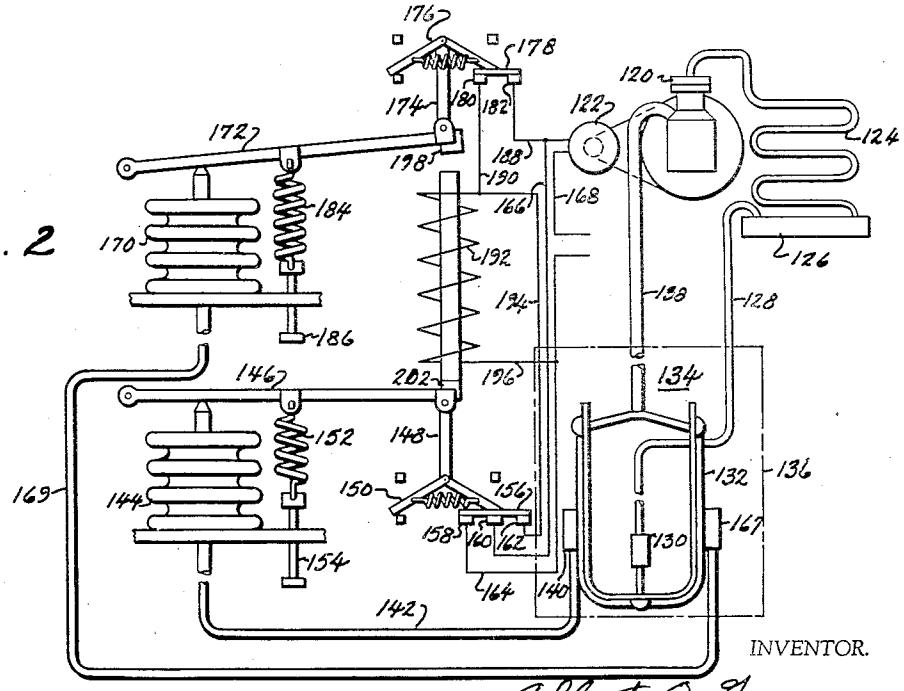


Fig. 2



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REFRIGERATING APPARATUS

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Fig. 3

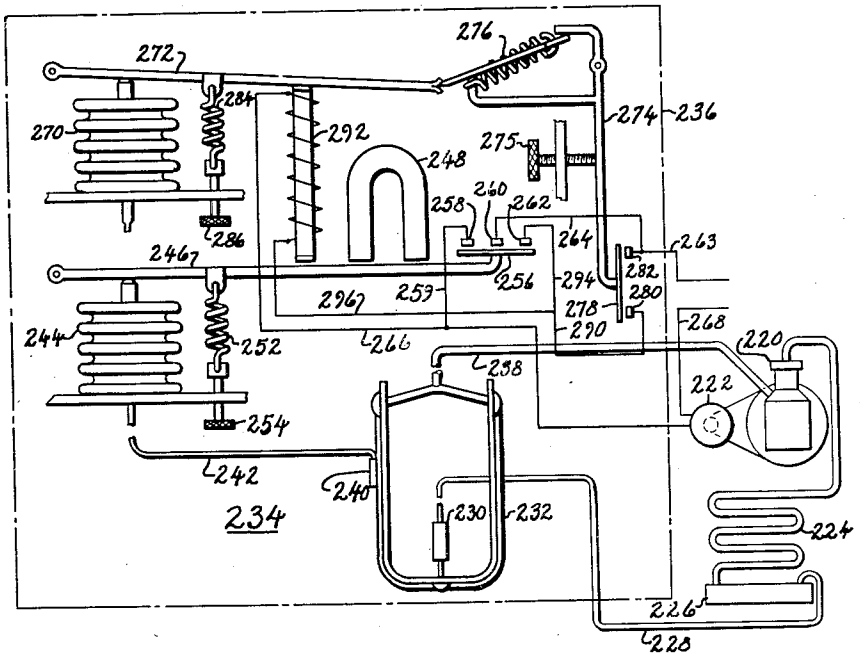
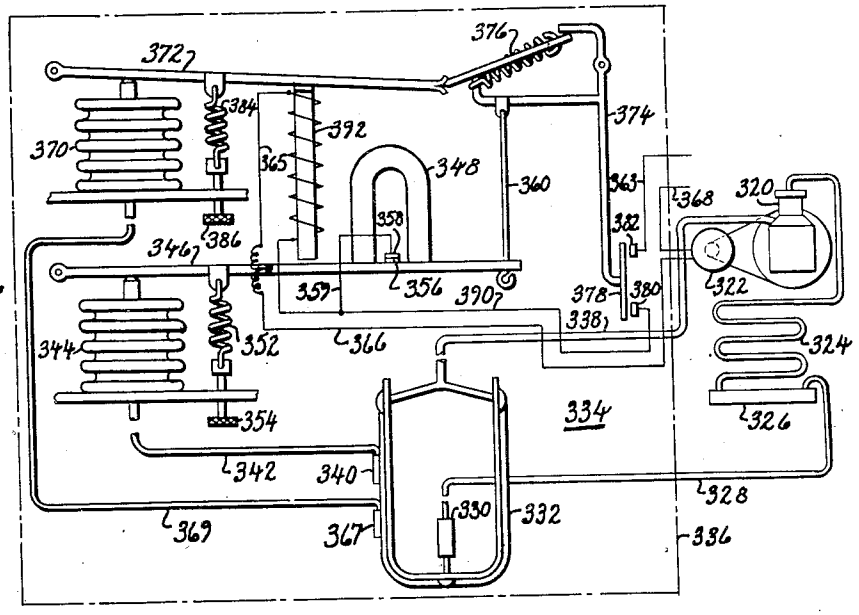


Fig. 4



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REFRIGERATING APPARATUS

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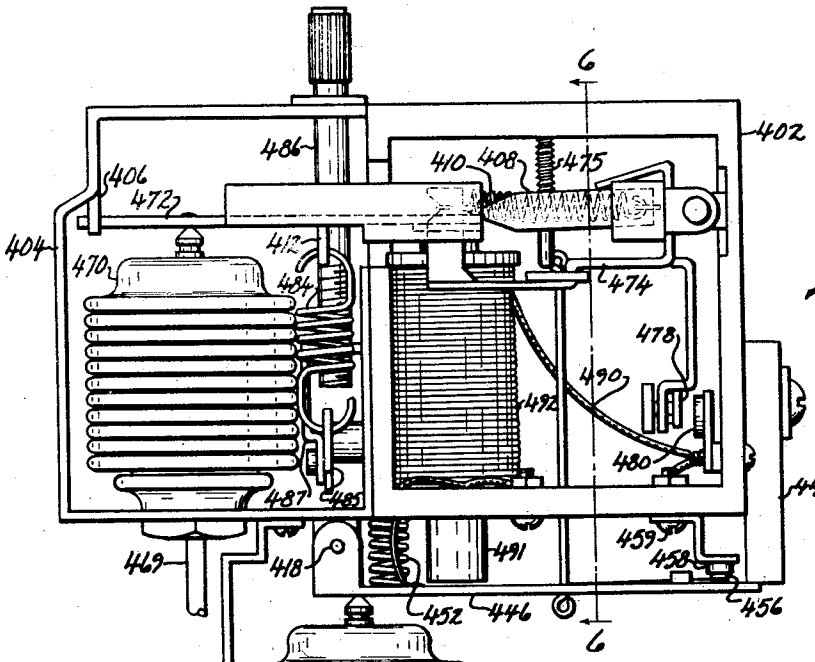


Fig. 5

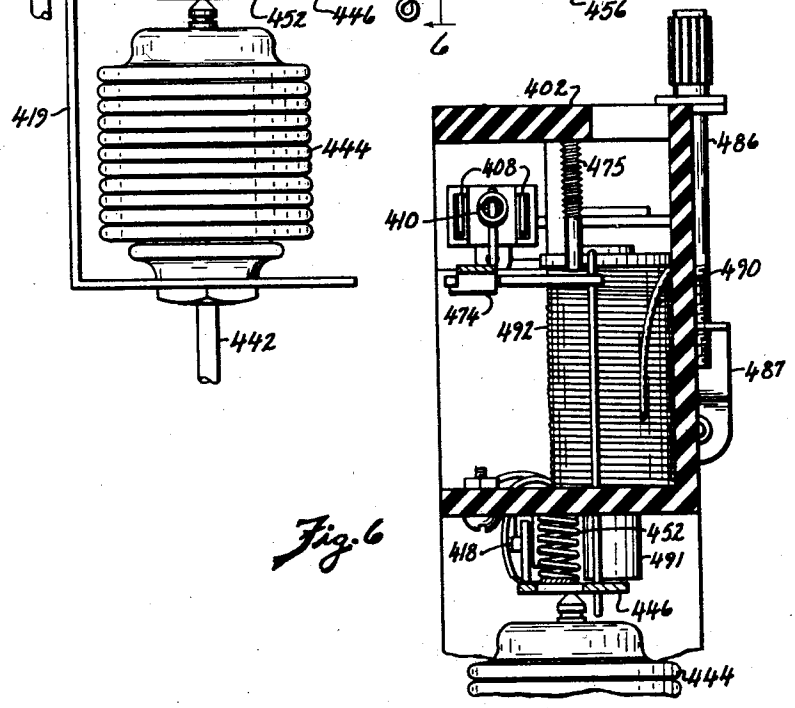


Fig. 6

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REFRIGERATING APPARATUS

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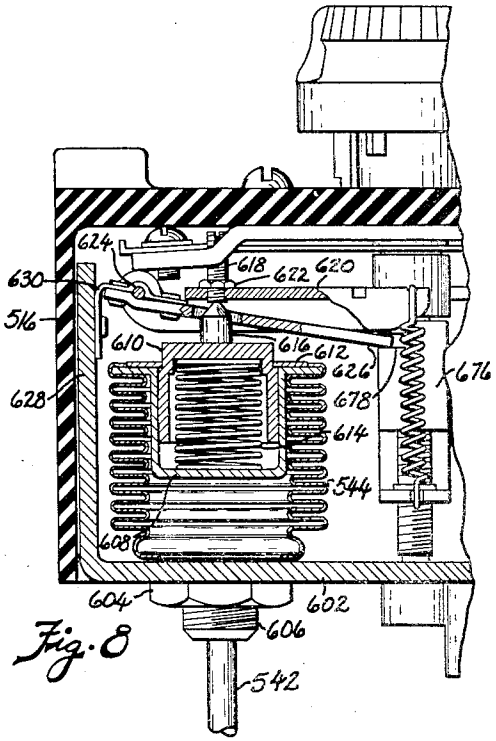


Fig. 8

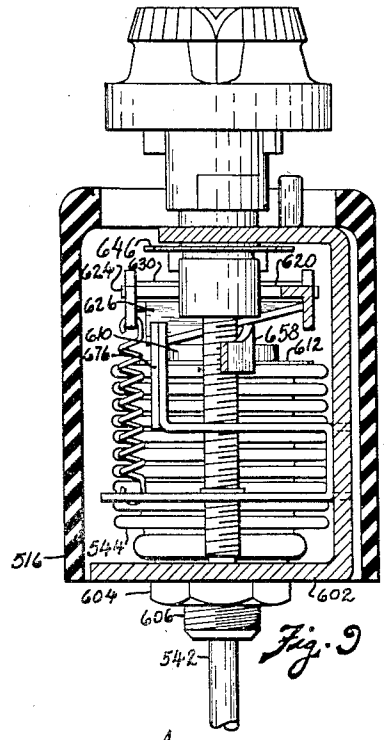


Fig. 9

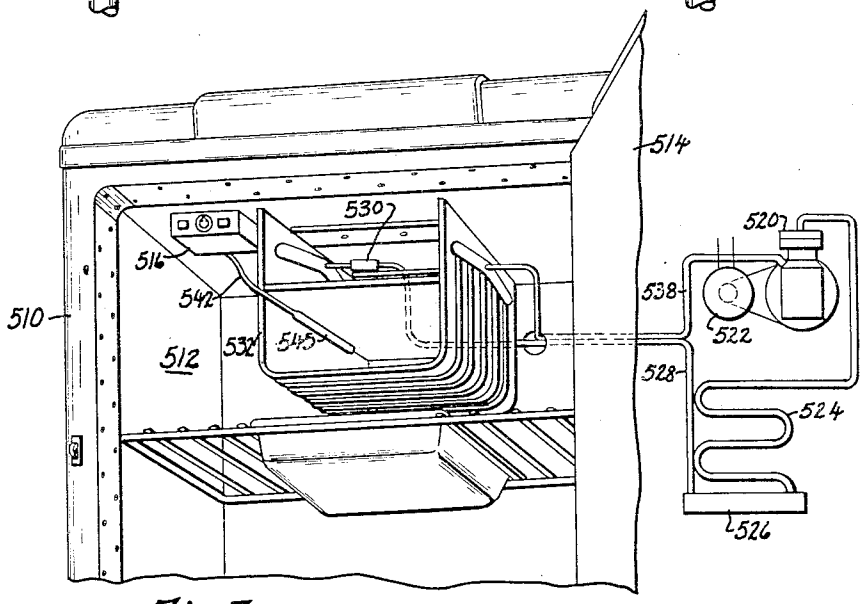


Fig. 7

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REFRIGERATING APPARATUS

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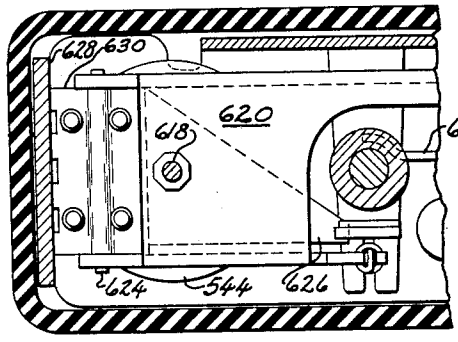


Fig. 10

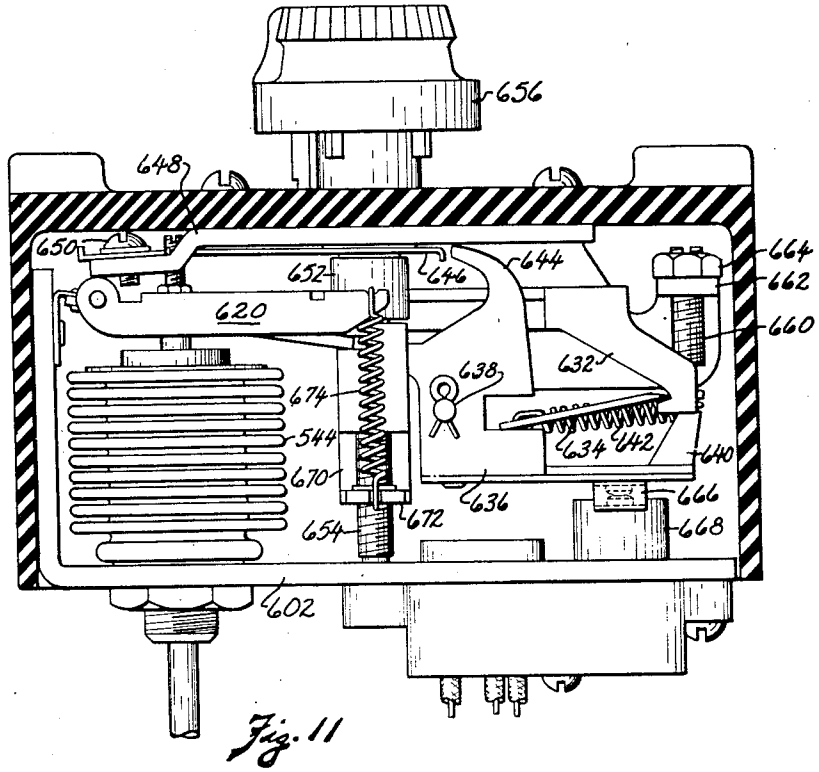


Fig. 11

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UNITED STATES PATENT OFFICE

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REFRIGERATING APPARATUS

Albert O. Grooms, Dayton, Ohio, assignor to General Motors Corporation, Dayton, Ohio, a corporation of Delaware

Application July 7, 1938, Serial No. 217,928

19 Claims. (Cl. 62—4)

This invention relates to refrigerating and tempering apparatus and more particularly to control means for such apparatus.

In household refrigerators it has been customary to control the operation of the refrigerating system according to the temperature of the evaporating means in order that rapid ice freezing can be obtained. Such a system of control permits the box temperature to fluctuate to a certain extent, with changes in environment temperature and also with evaporator temperature. Controls which have been governed by box temperature instead of evaporator temperature have been unsatisfactory because they did not provide sufficiently rapid ice freezing. Various methods for compensating for different room temperature conditions have ordinarily been found to be too complicated and too costly for widespread use.

It is an object of my invention to provide an improved simplified control for a household refrigerator which will regulate both the food compartment temperatures within the refrigerator cabinet and the evaporator temperatures so as to provide better food preserving conditions under all operating conditions and yet retain excellent ice freezing speeds.

It is another object of my invention to provide a control for a household refrigerating system which will maintain the box or food compartment temperature within very close limits and yet will provide rapid ice freezing.

It is still another object of my invention to provide a form of such control in which a very close differential between the opening and closing of the control and starting and stopping of the system can be obtained.

It is a more specific object of my invention to provide control means in which two pressure or temperature operating means are provided wherein one temperature pressure operating means is used to control the opening of the control while the other is used to control the closing of the control in order to provide a more accurate control means.

It is still another object of my invention to provide a snap acting switch means in which an electro-magnetic means is provided for moving the switch in one direction.

It is still a further object of my invention to provide an improved adjusting means for a control means which regulates both food compartment and evaporator temperature.

My improved form of control is also applicable to heating and air conditioning systems. For example, the control may be arranged so as to start the heating system when a predetermined low temperature is reached and to stop the heating system when a predetermined high temperature is reached instead of starting a refrigerating system when a predetermined high temperature is used and stopping the refrigerating system when a predetermined low temperature is reached.

In the simplest form of my invention the control takes the form of a bellows, thermostat bulb and connecting tube which is used to operate either the switch means or the valve for controlling a refrigerating system of the household type, or for controlling an air conditioning system wherein the bulb could be mounted upon some portion of the liquefying apparatus and used as a safety control, or for controlling a steam radiator in which the bulb could be mounted upon the radiator for an anticipating effect, or for controlling a furnace in which the bulb could be mounted in the stack, in a heating duct, or in the boiler while the bellows portion would be mounted in the room. This form of control has an anticipating effect when the bulb is mounted upon a heat exchange unit such as an evaporator or steam radiator, since the evaporator cools more rapidly than the surrounding air while the steam radiator heats up faster than the surrounding air. The bulb which is in heat exchange relation with the heat transfer unit will have an effect upon the bellows portion of the control in such a way that it will compensate for the lag in change of temperature between the heat transfer unit and the surrounding air.

Further objects and advantages of the present invention will be apparent from the following description, reference being had to the accompanying drawings, wherein a preferred form of the present invention is clearly shown.

In the drawings:

Fig. 1 is a diagrammatic illustration of a refrigerating system together with one form of control means for a household refrigerator embodying my invention;

Fig. 2 is a form of control means similar to Fig. 1 but arranged to maintain the evaporating means between extremely close temperature limits;

Fig. 3 is another diagrammatic illustration of a household refrigerating system showing an improved form of control basically similar to that shown in Fig. 1 embodying my invention;

Fig. 4 is another diagrammatic illustration of a refrigerating system showing another form of control applied to a refrigerating system in a

way so as to maintain the evaporating means between very close limits of temperature;

Fig. 5 is a structural embodiment of the control shown in Fig. 4 and shows the control in elevation;

Fig. 6 is a sectional view taken along the line 6—6 of Fig. 5;

Fig. 7 is a fragmentary view of a refrigerator cabinet together with a diagrammatic illustration of a compression refrigerating system showing the application of a simplified form of dual refrigerator control;

Fig. 8 is a sectional view of a portion of the simplified control showing the bellows in section;

Fig. 9 is a sectional view of the simplified control looking at the portion shown in Fig. 8 from the right;

Fig. 10 is a top sectional view of the portion of the control shown in Fig. 8; and

Fig. 11 is a view showing the control mechanism in elevation and the non-metallic portion of the control housing in section.

Brief description

Briefly, in Figs. 1 and 3 I have shown a refrigerating system with a form of control in which a bellows, bulb and connecting tubing are filled with a liquid refrigerant and the bellows is loaded so that the refrigerant will evaporate in the bellows when the food compartment temperature to which it is exposed reaches a predetermined limit. The bulb is mounted upon the evaporator and a second bellows is provided which is charged with vapor of the same refrigerant. The second bellows operates a switch mechanism and the first mentioned bellows also operates a switch mechanism. The first bellows and switch is opened by the reduction in pressure within the bellows which is created by condensation of evaporated refrigerant within the bellows and by the liquid contraction of the liquid refrigerant in the bulb caused by the fall in temperature of the evaporating means. This switch is closed by an electromagnet which has its energization controlled by the second bellows and switch. The second bellows and switch is closed when the temperature and therefore pressure reaches a predetermined limit and is opened when the electromagnet is energized under the control of the first bellows and switch. The control system shown in Figs. 2 and 4 are, in general, like those shown in Figs. 1 and 3 except that each bellows is provided with a bulb on the evaporator and both sets of the bellows and bulbs are provided with vapor charges rather than liquid charges.

In Figs. 7 to 11 a simplified form of the control shown in Figs. 1 and 3 is illustrated. In this form only a single bellows, bulb and connecting tubing is used to accomplish the dual control function. The vapor charged bellows shown in Figs. 1 and 3 is omitted. In this simplified form the bellows, bulb and connecting tubing is provided with a complete or solid fill of liquid refrigerant, and the bellows is placed in a location in the food compartment so that it will be subject to food compartment temperatures while the bulb is placed in heat exchange relation with the evaporating means. A switch mechanism is operated by the bellows and the customary loading spring or range spring is employed for loading the bellows sufficiently to control evaporation of the liquid refrigerant in the bellows. A distance adjustment is provided between the bellows and the switch mechanism which it operates, and the selective temperature regulator operates this distance adjustment as well as the adjustment for the range or loading spring. In this form as well as in the forms shown in Figs. 1 and 3 the sensitivity of the control of evaporator temperature is largely determined by the relation of the volume of the bulb to the volume of the bellows and the connecting tubing.

Detailed description of Fig. 1

Referring now more particularly to Fig. 1 there is shown a refrigerating system including a compressor 20 driven by an electric motor 22 for compressing evaporated refrigerant and forwarding the compressed refrigerant to a condenser 24 where the compressed refrigerant is liquefied and collected in a receiver 26. From the receiver 26 the liquid refrigerant is forwarded through a supply conduit 28 to a restrictor 30 which controls the flow of liquid refrigerant into the evaporating means 32, which preferably has provisions for freezing ice cubes. This evaporating means 32 is located within the food compartment 34 of a domestic electric refrigerator cabinet which is indicated by the dot and dash outline 36. The evaporating means 32 absorbs heat from the air within the food compartment 34 as well as from any water in ice trays, and the refrigerant evaporates under reduced pressure and is returned to the compressor 20 through the return conduit 38.

Heretofore, such a system has been controlled by a simple bellows operated thermostat switch connected in electrical series circuit relation with the electric motor 22 and controlled by mounting a thermostat bulb upon the evaporating means so that the refrigerating system operated when the evaporating means reached a predetermined high temperature and ceased operating when the evaporating means reached a predetermined low temperature. Such a system was excellent for producing rapid ice freezing but did not provide any regulation of the box or food compartment temperature except that provided by the presence of the evaporator within the compartment. Under ordinary conditions such a control was fairly satisfactory but when the room temperature was very low the food compartment temperature would be lower than necessary while when the room temperature was high the food compartment temperature would be undesirably high.

I, therefore, have provided a control which is responsive both to evaporator temperature and to the food compartment temperature. This control includes a thermostat bulb 40 mounted upon and in preponderant heat exchange relation with the evaporator and connected by tubing 42 to a bellows 44 which is mounted in the food compartment so as to be sensitive to the temperature of the food compartment. The bellows 44 operates a bellows follower lever 46 which in turn is connected by link 48 to a snap acting switch mechanism 50. The bellows 44, the bulb 40 and the connecting tubing 42 are preferably completely filled with a refrigerant, such as tetrafluoro-dichloro-ethane, in liquid form which will at atmospheric pressure evaporate at temperatures slightly below the temperature which it is desired to maintain within the food compartment 34.

The expansion of the bellows 44 is opposed by the range or loading spring 52 which is adjusted by the adjusting screw 54 so that sufficient collapsing pressure is exerted upon the bellows 44 to prevent the evaporation of any of the liquid refrigerant in the bellows, bulb and connecting

tubing as long as the temperature of the food compartment is below the maximum desired temperature. This adjustment of the spring **52** should be such that when the temperature of the food compartment **34** reaches the minimum desired temperature the spring **52** will then be sufficiently powerful to condense any evaporated refrigerant in the bellows **44** and this condensation will enable the spring **52** to open the snap acting switch mechanism **50**.

The snap acting switch mechanism **50** includes a contact bar **56** which is adapted to bridge the contacts **58**, **60** and **62**. The contact **58** is connected to the conductor **64** which connects to one of the supply conductors while contact **60** is connected to the conductor **66** which in turn is connected to one of the terminals of the compressor driving motor **22**. Thus when the snap acting switch mechanism **50** is closed, the contact bar **56** will bridge the contacts **58**, **60** and **62**. This will cause the electric energy to flow from the one supply conductor through the conductor **68** to one of the terminals of the motor of compressor driving motor **22**, thence through the driving motor **22** to its other terminal, thence through the conductor **66** to contact **60** and through the contact bar **56** to the contact **58** and thence through the conductor **64** which connects to the other supply conductor.

With such a system, if the food compartment temperature should become sufficiently high, the liquid refrigerant would evaporate within the bellows **44** and cause the snap acting switch means **50** to close and start the operation of the motor compressor unit. This would lower the temperature of the evaporating means and cool the air within the food compartment. This cooling of the air in the food compartment would lower the temperature of the bellows **44** and cause the evaporated refrigerant within the bellows to condense, thereby permitting the spring **52** to operate the snap acting switch means **50** to open position to stop the operation of the compressor driving motor **22**.

If the food compartment temperature were sufficiently low, but there was an ice freezing demand caused by placing warm ice trays within the evaporator **32**, the liquid refrigerant within the thermostat bulb **40** would expand according to the laws of liquid expansion and would extend the bellows **44** to move the snap acting switch means **50** to closed circuit position. This would cause the refrigerating system to operate and cool the evaporating means and when the evaporating means reached a sufficiently low temperature the spring **52** would cause the bellows follower lever **46** to be pulled downwardly because of the contraction of the liquid within the bulb **40** and the snap acting switch mechanism would again be moved to open position. Thus, with such a system the evaporator temperature would be regulated by the liquid expansion within the thermostat bulb **40** while the food compartment temperature would be regulated by the evaporation of the liquid refrigerant in the bellows **44**.

The sensitivity of the snap acting switch **50** to the change in evaporator temperature depends upon the relative size of the thermostat bulb **40**, the bellows **44** and connecting tubing **42** as well as the amount of multiplication provided by the bellows follower lever and the snap action mechanism. The sensitivity of the switch mechanism to the food compartment temperature is regulated by the heat exchange relation of the bellows **44** to the air in the food compartment **34** as well as by the characteristics of the refrigerant and the adjusting spring **52**, and also the characteristics of the bellows **44** and the snap acting mechanism **50**.

I have found that under many conditions it is difficult to obtain a sufficiently close regulation of food compartment temperatures by a simple system such as has been just described. In order to obtain a closer regulation of food compartment temperatures I have provided a second bellows **70** also located in heat exchange relation with the air in the food compartment **34**. This bellows **70** preferably is provided with a vapor charge of the same refrigerant which is provided in the bellows **44**, connecting tubing **42** and the bulb **40**. This bellows **70** operates a bellows follower lever **72** which in turn is connected by a link **74** to a snap acting mechanism **76** which operates a contact bar **78** for bridging the contacts **80** and **82**. The expansion of the second bellows **70** is controlled by a range or loading spring **84** which is adjusted by the adjusting screw **86** so that the bellows **70** will have sufficient vapor pressure to close the switch when the food compartment temperature reaches the desired high temperature limit.

The contact **82** is connected by the conductor **88** to the same terminal of the compressor motor **22** to which the conductor **66** is connected. The contact **80** is connected to the conductor **90** which at its terminus is connected to one end of an electromagnet **92** and is also connected to a conductor which connects to the contact **62** of the snap acting switch **50**. The electromagnet **92** is connected by the conductor **96** to the conductor **64** which connects to one of the supply conductors. With this arrangement the contacts **80** and **82** are connected in parallel electric circuit relation with the contacts **60** and **62** while the electromagnet **92** is connected in series with the contacts **60** and **62** in one circuit, and with the contacts **80** and **82** in another circuit. The contacts **60** and **58** are arranged in series with the compressor drive motor **22** and are in parallel electric circuit relation with the electromagnet **92**.

Thus if the contacts **58** and **60** are bridged by the contact bar **56** the electromagnet **92** is virtually deenergized. Thus in this system the spring **52** may be so adjusted that the switch mechanism **50** will open when the food compartment temperature reaches 40° F. and the spring **84** may be so adjusted that the switch **76** will be closed when the food compartment temperature reaches 41° F. As shown, both switches are closed and the compressor driving motor **22** is energized to operate the refrigerating system which will lower the temperature of the evaporating means and the temperature of the air in the food compartment **34**.

When the temperature within the food compartment **34** reaches about 40° F. the snap acting switch means **50** will be opened thus preventing the flow of any current through the electric circuit except through the contacts **82** and **80** which are bridged by the contact bar **78** so that any current flowing through the motor **22** will also flow through the electromagnet **92**. The electromagnet **92** will then attract the armature **98** which is provided upon the bellows follower **72** to cause the switch **76** to be opened thereby deenergizing the entire system.

It is assumed that each of the snap acting switch mechanisms have a differential which is

considerably greater than the limits 40° and 41° F. which have been assumed as the desired temperature limits for the food compartment 34. For example, if each of these switches had a 10° F. differential the switch mechanism 76 would not open of its own accord until the temperature within the food compartment reached 31° F. while if the switch mechanism 50 had a differential of 10° F. it would not close until the food compartment reached a temperature of 50° F.

Since the refrigerating system has been deenergized by the opening of both the switches 50 and 76 the temperature of the food compartment will begin to rise. When the temperature of the bellows 70 and the temperature of the food compartment 34 reaches 41° F. the switch mechanism 76 will be closed. This will permit the flow of current from the conductor 68 through the compressor motor 22 to the contact 82, the contact bridge 78, the contact 80, the conductor 90 and the electromagnet 92, the conductor 96 to the conductor 64, thereby energizing the electromagnet 92. The energization of the electromagnet 92 will attract the armature 102 which is provided upon the end of the bellows follower 46 and will pull the snap acting switch mechanism 50 to closed position. This will cause the bridging of the contacts 58, 60 and 62 and will permit the current to by-pass the electromagnet 92 by flowing through the conductor 94 to the contact 62 and through contact bar 56 to the contact 58, and thence through the conductor 64 to the power source.

While 40° F. is set as the desired low temperature limit for a food compartment this temperature will be varied by the influence of the thermostat bulb 40 which is mounted upon the evaporator 32. Thus if the temperature of the food compartment 34 approaches 40° F. and a warm ice tray is placed within the evaporator 32 the liquid expansion within the thermostat bulb 40 will prevent the opening of the switch 50 so that the system will continue to operate even though the food compartment temperature has reached 40° F. However, since there is much better heat transfer between the air in the food compartment and the evaporator, the food compartment will not be cooled much below 40° F. even under such conditions.

If the switches are open and warm ice trays are placed within the evaporating means the liquid expansion within the thermostat bulb 40 will expand the bellows 44 and cause the switch 50 to close thereby causing the operation of the refrigerating system even though the food compartment temperature has not reached 41° F.

The control of the refrigerating system, according to evaporator temperature, is governed by the linear relationship of the bellows to the switch means, by the relative volume of the thermostat bulb with respect to the volume of the bellows and the connecting tubing and by the amount of liquid charge. Because the evaporator is used for freezing purposes, it is ordinarily necessary that the refrigerating system be started as well as stopped at temperatures below the freezing point of water. Therefore, the thermostat bulb 40 and the bellows 44 are filled with the liquid control refrigerant to such an extent that the switch means will close when the evaporating means is below freezing, and will open when the evaporating means reaches a temperature considerably below freezing. These temperatures can be controlled by varying the ratio of the volume of the bellows to the volume of the bulb and by varying the amount of liquid charge of the refrigerant at the particular charging temperature employed.

This system may also be used to control different forms of heating systems such as a gas furnace, an oil burner or a stoker. When this system is used for heating purposes the contacts are placed in a reversed position so that the contacts close upon collapsing of the bellows and open upon expansion of the bellows in each instance. The different forms of heating means may be controlled either directly or through a suitable relay circuit.

Detailed description of Fig. 2

The construction of the system shown in Fig. 2 is like that shown in Fig. 1 except that the upper or second bellows is provided with a thermostat bulb thermally connected to the evaporating means and both the bellows are provided with a vapor charge. With this system it is possible to maintain the temperature of the evaporating means between exceptionally close limits such as 0.2° F. For example, the system may be such that the compressor operates when the evaporator temperature reaches 9.2° F. and to cease operation when the temperature reaches 9.0° F.

Like Fig. 1 the system includes a compressor 120 driven by an electric motor 122 for compressing evaporated refrigerant and forwarding the compressed refrigerant to the condenser 124 where the compressed refrigerant is liquefied and collected in the receiver 126. From the receiver, the liquid refrigerant is forwarded through the conduit 128 to an evaporating means 132 under the control of a restrictor 130. The evaporating means 132 is located within a compartment 134 having its wall indicated by the dot and dash outline 136. The evaporating means 132 evaporates the liquid refrigerant under reduced pressure and absorbs heat from the medium to be cooled within the compartment 134. The evaporated refrigerant is returned to the compressor through the return conduit 138.

The evaporating means 132 has thermally connected to it a thermostat bulb 140 connected by tubing 142 to a bellows 144 which operates a bellows follower lever 146 which in turn is connected by link 148 to a snap acting switch mechanism 150. The expansion of the bellows 144 is opposed by a tension coil spring 152 which has its tension regulated by the adjusting screw 154 so that switch mechanism 150 will be opened when the temperature of the evaporating means 132 and the thermostat bulb 140 reaches 9.0° F., when the bulb 140 is provided with a vapor charge of a volatile liquid. A second bellows 170 is operably connected to a bellows follower lever 172. The bellows 170 is connected by tubing 169 to a thermostat bulb 167 mounted in prepondering heat exchange relation with the evaporating means 132. The bulb 167 is preferably charged with a vapor charge of the same refrigerant as is provided in the bulb 140.

A tension type coil spring 184 opposes the expansion of the bellows 170 and has its tension adjusted by the adjusting screw 186 so that the switch contacts 176 which are operated by the lever 172 through the link 174 will be closed when the temperature of the evaporating means 132 and the thermostat bulb 167 reaches 9.2° F. The snap acting switch means 176 operates a contact bar 178 for bridging the contacts 180 and 182. The contact 182 is connected by the

conductor 188 to one of the terminals of the compressor driving motor 122. The other terminal of the compressor driving motor 122 is connected by a conductor 168 to one of the power supply conductors. The contact 180 is connected to conductor 190 which at its terminus is connected to one end of the electromagnet 192. The conductor 190 is also connected to a conductor 194 which is connected to the contact 162 of the snap acting switch mechanism 150. The snap acting switch mechanism 150 operates a contact bar 156 which bridges the contacts 162, 160 and 158. The contact 158 is connected by the conductor 164 to one of the supply conductors while the contact 160 is connected by the conductor 166 to the conductor 188 which connects to one of the terminals of the compressor driving motor 122. The other end of the electromagnet 192 is connected by the conductor 196 to the conductor 164 which connects to one of the supply conductors.

As shown both switches are closed indicating that the compressor is operating and that the temperature of the evaporating means is above 9.0° F. and that the temperature of the evaporating means has previously reached 9.2° F., and in that way has caused the compressor to begin to operate. The current to the compressor driving motor passes through the conductor 163 to the electric motor 122, thence through the conductors 188 and 166 to the contact 160 through the contact bar 156 to the contact 158, thence through the conductor 164 to the other power supply conductor. When the temperature of the evaporating means 132 and the thermostat bulb 140 reaches 9.0° F. the tension spring 152 will open the snap acting switch means 150. This will provide the flow of current through the conductor 188 to the contact 182 through the contact bar 178 to the contact 180, thence through the conductor 190 and through the electromagnet 192, the conductor 196 and the conductor 164 to the other power supply conductor. The flow of current through the electromagnet 192 will attract the armature 198 upon the bellows follower lever 172, thereby causing the opening of the snap acting switch 176 to deenergize the compressor driving motor 122.

The stopping of the compressor driving motor will allow the evaporator 132 to warm up and when the temperature 9.2° F. is reached, the snap acting switch means 176 will close, thus causing the current to flow through the compressor driving motor 122 and electromagnet 192 thereby attracting the armature 202 upon the free end of the bellows follower lever 146 to cause the closing of the snap acting switch mechanism 150. The closing of the switch 150 will provide a shunt around the electromagnet 192 and cause the compressor driving motor to be normally energized. As explained in connection with Fig. 1 this system may be employed for controlling a heating device by rearranging the contacts so that they open upon the expansion of the bellows and close upon contraction of the bellows.

Detailed description of Fig. 3

In this form a somewhat different form of switch mechanism is provided but the function of the control is the same as that shown in Fig. 1. In this figure there is shown a compressor 220 for compressing the refrigerant and forwarding the compressed refrigerant to a condenser 224 where compressed refrigerant is liquefied and collected in a receiver 226. From the receiver 226 the liquid refrigerant is forwarded through a supply conduit 228 to a restrictor 230 which controls the flow of liquid refrigerant into the evaporating means 232 which is located within the compartment 234 containing a medium to be cooled. The compartment is enclosed by a casing indicated by the dot and dash outline 236. The compressor 220 is driven by a driving motor 222.

A thermostat bulb 240 is thermally connected to and in prepondering heat exchange relation with the wall of the evaporating means 232 and is connected by tubing 242 to a bellows 244. The bulb 240, the tubing 242 and the bellows 244 are preferably filled with a solid charge of a volatile refrigerant in liquid form. This refrigerant preferably has an atmospheric boiling point slightly below the temperature at which it is desired to keep the medium to be cooled within the compartment 234. For example, in an ordinary refrigerator it is desirable to use tetrafluorodichloroethane which boils at about 38° F. However, other refrigerants having boiling points close to 38° F. or even somewhat lower than 38° may be used for this type of application. The bellows 244 operates a bellows follower switch lever 246 which is provided with a contact bar 256 at its free end. In order to provide a snap action for controlling the opening movement of the contact bar 256, a permanent magnet 248 is provided which exerts an attraction upon the bellows follower lever 246.

The expansion of the bellows 244 is opposed by the tension coil spring 252 which is provided with an adjusting screw 254, so that its tension may be regulated to cause the opening movement of the contact bar 256 when the temperature of the medium to be cooled in the compartment 234 reaches the desired low temperature limit, such as 40° F. The contact bar 256 is adapted to make engagement with the contacts 258, 260 and 262. The contact 260 is connected to the conductor 264 which in turn connects to a conductor 263 connected to one of the supply conductors. The contact 258 is connected by a conductor 259 to a conductor 266 having one end connected to the electromagnet 292 and the other end connected to the compressor driving motor 222 which in turn is connected by a conductor 268 to the other power supply conductor. The other end of the electromagnet 292 is connected by a conductor 296 to a conductor 290 which is connected to a contact 280 of the second switch mechanism. The contact 262 is also connected by a conductor 294 to the conductor 290.

The conductor 263 is connected to the second contact 282 of the second switch mechanism which has a contact bar 278 bridging the contacts 280 and 282. This contact bar 278 of the second switch mechanism is operated by a bellows 270 containing a vapor charge of the refrigerant with which the bellows 244 is charged. However, if desired a different vapor may be used. The bellows 270 operates a bellows follower lever 272 which in turn operates a double toggle snap acting switch mechanism 276 which operates the contact lever 274. The differential of this switch mechanism is controlled by the adjusting screw 275 which limits the opening movement of the contact lever 274 to control the differential of the double toggle mechanism. The expansion of the bellows 272 is opposed by a tension type coil spring 284 which is adjusted by an adjusting screw 286 to such a tension that the bellows 270 will close the switch mechanism when

the desired upper temperature limit of the medium to be cooled in the compartment 234 has been reached.

For example, the screw 286 may be adjusted so that the contact bar 278 will close the switch contacts at a temperature of 45.2° F. When the contacts 280 and 282 are closed by the contact bar 278, electric energy will flow through the conductor 263 to the contact 282, thence through the contact bar 278 to the contact 280, thence through the conductors 290 and 296 to the electromagnet 292 and after passing through the electromagnet 292 the current will flow through the conductor 266 to one of the terminals of the compressor driving motor and through the compressor driving motor to the other terminal after which the current will flow through the conductor 268 to the other supply conductor.

The current flowing through the electromagnet will cause the electromagnet to attract the bellows follower lever 246 to cause the bridging of the contacts 258, 260 and 262 by the contact bar 256. This will permit the current then to flow through the conductors 263 and 264 to the contact 260, thence through the contact bar 256 to the contact 258, thence through the conductors 259 and 266 to the compressor driving motor 222 and thence through the compressor driving motor 222 and the conductor 268. Thus the electromagnet 292 is deenergized very quickly after the closing of the contacts 280 and 282.

The closing of the contacts will cause the operation of the refrigerating system and thereby reduce the temperature of the medium to be cooled within the compartment 234. When the temperature of the medium to be cooled within the compartment is reduced to the predetermined low temperature limit for which the solid filled switch mechanism is set, such as 45° F., the contact bar 256 will be moved to open position, providing the evaporating means is below a certain temperature, thereby causing the motor current to flow through the electromagnet 292 thereby attracting the lever 272 and causing the double toggle switch mechanism to be moved to open circuit position. This will stop the operation of the refrigerating system.

The solid fill provided in the thermostat bulb 240, tube 242 and the bellows 244 also causes the switch mechanism to be operated according to the temperature of the evaporating means 232. This operation, however, will take place under the laws of liquid expansion of the refrigerant, whereas the control according to the temperature of the medium to be cooled in the compartment 234, will be according to the evaporation of the refrigerant in the bellows 244 and 270.

The loading of the bellows 244 by the spring 252 does not affect the control by liquid expansion, but only affects the control by evaporation in the bellows 244. The control by evaporator temperature through the liquid expansion depends upon a relative volume betwen the bulb 240 and the bellows 244 as well as the linear relationship between the bellows 244, lever 246 and the contacts 258, 260 and 262. By reversing the contacts so that they open with the expansion of all the bellows, this control may be used for controlling different forms of heating systems.

In Fig. 4 there is shown another form of control for a refrigerating system somewhat similar to that shown in Fig. 2. In this form two bellows and two bulbs, each in prepondering heat exchange relation with the evaporator, each with a vapor charge, are employed to obtain a close differential control of evaporator temperature. In this figure a compressor 320 is driven by an electric motor 322 for compressing evaporated refrigerant and forwarding the compressed refrigerant to a condenser 324 where the compressed refrigerant is liquefied and collected in a receiver 326. From the receiver the liquid refrigerant is forwarded through a supply conduit 328 under the control of a restrictor 330 to an evaporator 332 lodged within the compartment 334 enclosed by an insulated wall indicated by the dot and dash lines 336. The refrigerant evaporates within the evaporating means 332 under reduced pressure and absorbs heat from a medium to be cooled within the compartment 334. This evaporated refrigerant is returned to the compressor through the conduit 338.

A thermostat bulb 340 is mounted in prepondering heat exchange relationship with the evaporating means 332 and is connected by tubing 342 to the bellows 344. The second thermostat bulb 367 is connected by tubing 369 to a bellows 370. Each of these bellows, their bulbs and connecting tubing, are filled with a vapor of a volatile refrigerant. The bellows 344 operates a bellows follower lever 346 carrying a movable contact 356 which is adapted to make contact with a stationary contact 358 located between the poles of a permanent magnet 348. The expansion of the bellows 344 is opposed by a tension type coil spring 352 which is adjusted by an adjusting screw 354 to cause the contact 356 to be pulled away from the contact 358 when the evaporator temperature is reduced to a predetermined low temperature such as 9.0° F.

The bellows 370 operates a bellows follower lever 372 which in turn operates a double toggle type of snap acting mechanism 376 which connects to the contact lever 374 carrying the contact bar 378. The expansion of the bellows 370 is opposed by the tension type coil spring 384 which has its tension adjusted by an adjusting screw 386 so as to cause the contact bar 378 to be moved to open position when the evaporator reaches a predetermined high temperature such as 9.2° F. The contact bar 378 is adapted to bridge the stationary contacts 380 and 382. The contact 382 is connected to the supply conductor by a conductor 363 while the contact 380 is connected to the conductor 390 which in turn connects through the conductor 359 to the stationary contact 358 and which also connects to one end of the electromagnet 392, which is capable of attracting the bellows follower levers 346 and 372. The other end of the electromagnet 392 is connected by the conductor 365 to the bellows follower lever 346 and this bellows follower lever 346 is connected by the conductor 366 to one terminal of the electric motor 322 while the other terminal of the electric motor 322 is connected by the conductor 368 to the other supply conductor. The contact 356 is electrically connected to the conductors 365 and 366 through the bellows follower lever 346.

The control mechanism in Fig. 4 is shown in a position which it assumes after it is opened following the lowering of the evaporator temperature to the predetermined low limit. Under such conditions the refrigerating system is idle and when the temperature of the evaporating means rises to the predetermined high limit, such as 9.2° F., the bellows 370 will expand and through the double toggle mechanism will move the contact bar 278 into closed circuit position. This will cause the electric energy to flow through the

conductor 363 to the contact 382 and through the contact bar 378 to the contact 380, thence through the conductors 390 and 359 to the contact 358, thence to contact 356 and through a portion of the lever 346 to the conductor 366 which connects to the electric motor 322, and which is connected to the other supply conductor by the conductor 368.

Prior to the bridging of the contacts 380 and 382 the bellows follower lever 346 is held in its uppermost position by a link 360 which connects the contact lever 374 with the bellows follower 346 for holding the contacts 358 and 356 closed whenever the contact lever 374 is in open circuit position. This link 360 is necessary because the contacts 356 and 358 would not otherwise be closed by the bellows 344 until a temperature considerably above 9.2° F. was reached. Even though the contact lever 374 is moved to closed circuit position, the contacts 356 and 358 remain closed because the temperature of the evaporating means is still above its predetermined low limit. Thus at this time the contacts 356 and 358 are held closed without the support of the link 360.

However, when the predetermined low temperature limit is reached by the evaporating means by the operation of the refrigerating system, the spring 352 will pull the lever 346 downwardly to separate the contacts 356 and 358. This will make it necessary that the electric current flowing through the electric motor 322 pass through and energize electromagnet 392 and thence through the conductor 365 to the conductor 366 in order to attract the bellows follower lever 372 and move the contact lever 374 to open circuit position. By reversing the operation of the contacts this control system may also be used for controlling a heating system.

Detailed description of Figs. 5 and 6

Figs. 5 and 6 show a structural embodiment of the control means shown in Fig. 4. In this form there is shown a box-shaped casing member 402 of a molded insulating material, on the left side of which is fastened a metal frame 404. This metal frame 404 supports a bellows 470 which corresponds to the bellows 370 in Fig. 4 and is provided with tubing 469 which may be connected to a thermostat bulb mounted upon an evaporator. The bellows 470 operates a bellows follower lever 472 which is pivoted to the tongue 406 extending from the metal frame 404. The other end of the bellows follower lever 472 is provided with notches which receive the chisel-shaped ends of the secondary lever 408 which in turn is connected at its opposite end to a tension coil spring 410 having its other end connected to an upwardly extending portion of the contact lever 474. The bellows follower lever 472 has a downwardly extending portion 412 to which is fastened the upper end of a tension coil spring 484 having its lower end connected to a walking beam type lever 485 pivoted at its midpoint and connected at its other end to a threaded member 487 which receives the lower end of the adjusting screw 486.

The contact lever 474 has its opening movement controlled by the adjustable stop screw 475 and at its lower end is provided with a contact bar 478 which is adapted to bridge a set of contacts 480. One of these contacts is connected by the conductor 490 to the electromagnet 492 which is mounted within the insulated box 402 as shown, and is provided with a core 491 capable of attracting at its upper end the bellows follower lever 472 and at its lower end a second bellows follower lever 446. This same contact is also connected through a conductor and screw 459 to a bracket which supports the stationary contact 458 which is adapted to be contacted by a movable contact 456 mounted upon a leaf spring connected through the contact lever 446. A horseshoe-shaped permanent magnet 448 is fastened to the outside of the box 402 so that it will attract the bellows follower lever 446 to provide a form of snap action. The bellows follower lever 446 is provided with upwardly extending ears through which a pivot pin 418 extends and which pivotally connects the lever 446 to the frame 404. The frame 404 has a downwardly extending portion 419 which supports the second bellows 444, which may be connected to tubing 442. The upper end of this bellows is provided with a conical point which is used to operate the lever 446. The expansion of the bellows 444 is opposed by a compression type coil spring 452.

This control may be used with both bellows filled with a vapor charge and each connected to a thermostat bulb, or the bellows may be used without thermostat bulbs and with a vapor charge and, under such conditions, would be responsive to the temperature of the air with which they might be in contact. If desired the bulb 470 may be used with a vapor charge without any bulb connected to it, while the bellows 444 may be connected to a bulb mounted upon an evaporator and provided with a solid charge; that is a solid fill of a volatile liquid refrigerant.

Detailed description of Figs. 7 to 11

In Figs. 7 to 11 there is shown a simplified practical commercial form of a control heretofore described in connection with Figs. 1 to 6 and it particularly resembles that portion of the control shown in Fig. 1 which includes the bellows 44 and a switch mechanism operated thereby, together with its thermostat bulb and connecting tubing filled with a solid liquid charge of a volatile refrigerant. While it is more difficult to obtain a close regulation of food compartment temperatures with this single bellows form of control, in many cases by particular precautions it is possible to so design this form to achieve satisfactory regulation of box temperatures and evaporator temperatures within the household refrigerator.

Fig. 7 shows a household refrigerator including an insulated cabinet 510 containing a food compartment 512 made accessible by a food compartment door 514. Within the food compartment 512 is a sheet metal evaporator 532 provided with a lower shelf and an upper shelf for supporting ice trays which may be provided with water or other substances to be frozen. This evaporating means 532 is supplied with liquid refrigerant by a compressor 520 which compresses evaporated refrigerant withdrawn from the evaporator through the return conduit 538. The compressor is driven by an electric motor 522 and the refrigerant compressed by the compressor is forwarded to a condenser 524 where the compressed refrigerant liquefies and is collected in the receiver 526. The liquid refrigerant in the receiver is supplied to the evaporating means through the supply conduit 528 under the control of the restrictor 530 which controls the flow of liquid refrigerant to the evaporating means 532. The liquid refrigerant evaporates

within the evaporating means 532 under reduced pressure and absorbs heat from the air within the food compartment 512 as well as from any ice trays which rest upon the shelves of the evaporator.

In order to control both the temperature of the air within the food compartment and the evaporator temperature I provide a simplified form of control such as is shown in Figs. 1 and 3, which omits the vapor charged bellows and its switch means and relies wholly upon a single solid liquid charge of volatile refrigerant in the bellows, bulb and connecting tube. This control includes a switch casing 516 mounted upon the bottom face of top wall of the food compartment so that it is in the path of the air which circulates within the food compartment. The natural circulation within the food compartment is normally upwardly along the walls to the top of the cabinet and thence downwardly along the outer walls of the evaporating means to the central portion of the food compartment. The switch casing 516 need not be placed in the specific location shown in Fig. 7 but may be placed anywhere within the food compartment where it will be responsive to the temperature of the air in the food compartment.

The switch casing 516 contains a bellows 544 which is mounted upon the switch frame 602 and fastened thereto by a thin nut 604 which threads onto a threaded fitting 606 extending downwardly from the base of the bellows 544 through an aperture in the frame 602. Extending from the threaded fitting 606 is a small bore capillary tube 542 which at its upper end connects with the interior of the bellows 544 and which at its other end connects to a thermostat bulb 545 which is mounted upon the inside wall of the evaporating means 532 directly underneath the upper ice tray shelf. If is, however, not necessary that this specific location of the bulb be used since any location which reflects the temperature of the evaporating means will prove satisfactory. It is, however, necessary that the bulb 545 be in prepondering heat exchange relationship with the evaporator while the bellows 544 must be in prepondering heat exchange relation with the medium which is cooled by the evaporator.

Inasmuch as the bellows, bulb and tube are filled completely with a liquid refrigerant it is necessary to provide a means for accommodating the liquid expansion of the refrigerant under high temperature conditions, such as are encountered when the refrigerator is being shipped. For example, should the refrigerator be shipped or stored under conditions which would subject it to a temperature of 140° F. some means must be provided to accommodate for the liquid expansion of the refrigerant under such conditions. In order to do this I have provided a well 608 extending into the interior of the bellows and having its upper edges provided with a flange to which the upper end of the bellows is sealed.

This well 608 not only serves to retain the means for accommodating the liquid expansion of the refrigerant under unusual conditions but also serves to reduce the volume of the bellows 544 so that the volume of the bellows may be kept in a desired proportion to the volume of the thermostat bulb 545. The desirable proportions of the volume of the bellows to the volume of the bulb depend upon the characteristics of the refrigerating system and its cabinet. Where the cabinet has a relatively high heat leak the bellows proportionately should be smaller and the thermostat bulb should be proportionately larger. That is, where there is a relatively high difference in temperature between the evaporator temperature and the food compartment temperature, a relatively smaller bellows in proportion to the volume of the bulb should be used. I find that refrigerators which are well insulated and the refrigerating system is well proportioned to the refrigerating load require that the ratio of the volume of the bulb to the volume of the bellows should be between about two to one and one to one. For example, the volume of the bulb to the volume of the bellows might be in proportion of six to five.

The well 608 slidably receives a thimble 610 which has a reduced upper portion providing a flange which normally rests against an angular retainer 612 fastened to and sealed to the top of the bellows. The flange of the thimble 610 is normally held against the angular retainer 612 by a compression type coil spring 614 which may be overcome when the liquid expansion of the refrigerant within the bellows and bulb becomes too great. The upper end of the thimble 610 is provided with a conically pointed projection 616 which engages the recess in the bottom of the adjusting screw 618 which is threaded through the bellows follower lever 620 and locked in place by a thin lock nut 622.

This bellows follower lever 620 is pivoted upon a pin 624 which is not rigidly mounted to the switch frame 602, as has been customary in the past, but which instead is mounted upon a second lever 626 which is pivotally connected to an upwardly extending portion 628 of the switch frame 602 by a spring hinge 630 which is formed of spring bronze and which is riveted to the portion 628 and to the lever 626 so that it serves to retain the pivot pin 624 as is shown in Figs. 8 and 10.

The bellows follower lever 620 extends to the other side of the switch box and is provided with a downwardly extending portion 632 provided with a notch which receives the chisel-shaped ends of a secondary lever 634 having its free end received within the notches provided in the end of the contact carrying lever 636 which is pivoted upon the pin 638 to the rear wall portion of the frame member 602. The contact carrying lever 636 at the portion opposite its pivot is provided with an upwardly extending post 640 which supports one end of the tension type coil spring 642 having its other end connected to the free end of the secondary lever 634. The secondary lever 634 and the tension coil spring 642 together provide a double toggle type snap action mechanism for controlling the opening and closing movement of the contact carrying lever 640.

The contact carrying lever 640 is provided with an arm 644 which contacts the turned down end of a leaf spring 646 which serves as a stop to limit the normal opening movement of the contact carrying lever 640. It should be understood that the amount of movement of the contact carrying lever between open and closed position determines the differential of the double toggle contact mechanism. The leaf spring 646 is fastened at its opposite end to the top portion 648 of the frame member 602 by a screw 650. This leaf spring member 646 is provided with an aperture engaging a groove within a collar 652 which is slidably mounted upon the shank of the adjusting screw 654. This collar 652 is connected to the adjusting knob 656 which through a splined connection is connected to the adjusting

screw 654. The bottom of this collar is provided with a cam which is adapted to engage the arm 658 which also extends from the contact lever 636 for the purpose of forcibly holding the contact lever 636 in open circuit position to stop refrigeration. The collar is turned by the knob 656 for this purpose to the proper position.

The knob may also be pushed inwardly to depress the leaf spring 646 sufficiently so that the arm 644 will ride over the top of the leaf spring 646 and permit a greater opening movement of the contact lever 640. This greater opening movement of the contact lever 640 will be limited by a stop screw 660 which extends downwardly through the ear 662 provided in a portion of the switch frame 602. This screw is adjustable and may be locked in place by the locking screw 664. This wider differential raises the temperature at which the switch mechanism will be closed and the adjusting screw 660 is preferably so set that by this manipulation the evaporator must reach a temperature above freezing before the switch can be closed so that the evaporator will defrost. When the evaporator reaches a sufficiently high temperature the bellows will move the contact lever 636 to closed position and the leaf spring 646 will return to its normal position as shown in Fig. 11 by its own resiliency and the differential will thereby be returned to normal. The temperature of the food compartment which must be reached before it can cause the switch to close is also raised for this defrosting operation.

The contact lever 636 operates a set of switch contacts, the upper of which is mounted upon the spring member 666. This spring member 666 by its resiliency holds the upper contact away from the lower contact whenever the contact lever 636 is moved upwardly or in a counter-clockwise direction about its pivot pin 638. The stationary contact is mounted upon the projection 668 of insulating material which receives electrical conducting members for connecting the switch contacts in series with the compressor driving motor 522. The adjusting screw 654 carries an irregularly shaped strip metal member 670 which is threaded thereon but which is prevented from rotation by tongues which extend into a vertical groove provided in the rear wall of the switch frame 602.

This member 670 has a lower portion 672 to which is connected the lower end of a tension type coil spring 674 having its upper end connected to the bellows follower lever 620 and serves to properly load the bellows 544. The member 670 has an upwardly extending portion 676 provided with a notch 678 which receives the free or lower end of the hinge lever 626 which supports the pivot pin 624. Thus by the turning of the control knob 656, the loading of the bellows 544 is controlled and also the location of the pivot pin 624 is controlled simultaneously in order to vary the linear relationship between the bellows and the switch mechanism, and at the same time vary the loading of the bellows through its loading spring 674 so that the temperature of the evaporating means and the food compartment temperature may be simultaneously raised or lowered by this arrangement. The adjusting screw 618 may be used to provide the linear adjustment between the bellows and the switch mechanism, which is independent of the adjustment of the loading spring 674. The relationship between the changing linear adjustment and the changing loading may be varied by providing different leverage for the pivot pin lever 626 and by providing a different rate spring for the loading spring 674.

The switch casing 516 encloses the switch mechanism except for the bottom which is closed by the bottom portion of the switch frame. I have found that it is not necessary to provide perforations in the switch casing 516 since it appears that sufficient thermal conductivity is ordinarily obtained through the switch frame to provide a sufficient heat transfer between the air in the cabinet and the bellows to cause the vapor pressure within the bellows 544 to correspond to the temperature of the circulating air within the food compartment.

In operation, when the evaporator reaches a predetermined high temperature limit the liquid refrigerant within the bulb 545 will expand sufficiently according to the laws of liquid expansion to expand the bellows 544 sufficiently to move the switch mechanism to closed circuit position. When the evaporator reaches its low temperature limit the liquid within the bellows 544 will contract sufficiently to permit the switch mechanism to be moved to open position under the force provided by the loading spring 674. However, if the evaporator should be at its low temperature limit and the air within the food compartment is still above the desired temperature as determined by tension in its loading spring 674 a small amount of the liquid within the bellows will change into vapor and the vapor pressure within the bellows will be sufficient to prevent the switch from opening until the temperature of the air within the food compartment has become low enough to allow the loading spring 674 to collapse the bellows 544 by condensing substantially all of the vapor in the bellows.

If the evaporator temperature is between its normal temperature limits and the air within the food compartment should become too warm, because of opening the food compartment door, or placing a large amount of warm food into the refrigerator, the refrigerant within the bellows will vaporize and move the switch to closed position and start the operation of the refrigerating system so that refrigeration need not be delayed until the evaporator has reached its high temperature limit. This arrangement also compensates for varying room temperatures since under hot room conditions the vaporization of the refrigerant within the bellows will prevent the stopping of the refrigerating system until the food compartment temperature is below its high temperature limit, and under cold room conditions the cold air within the food compartment will contract the liquid within the bellows sufficiently to prevent excessively cold temperatures within the food compartment.

Under extreme temperatures when the system is not in operation the bellows may expand until the bellows follower lever stops against the switch frame, after which the bellows may further expand because further expansion will be accommodated by the thimble 610 which will be pressed further into the well 608 against the tension of the spring 614 and away from the flange 612. In normal operation, however, the thimble 610 will always remain in the position shown in Fig. 8, with its flange against the angular stop ring 612 so that the linear relationship under normal operation will always remain the same.

In order to stimulate evaporation of the volatile liquid within the bellows to preserve the

pressure-temperature relationship of the volatile liquid, insoluble crystals or sharp metal projections may be provided in the bellows. This prevents any superheated liquid condition which has the effect of elevating the boiling point of the volatile liquid. This superheated liquid condition is more serious when there is considerable pressure upon the liquid in the bellows, as is necessary when the boiling point of the volatile liquid is considerably below the temperature at which it is desired to maintain the medium to be cooled.

While the form of embodiment of the invention as herein disclosed, constitutes a preferred form, it is to be understood that other forms might be adopted, all coming within the scope of the claims which follow.

What is claimed is as follows:

1. Refrigerating apparatus including a means to be cooled, a cooling unit for cooling said means, and a refrigerating supply means for supplying refrigerating fluid to said cooling unit, a control means for controlling the supply of refrigerating fluid to said cooling unit, said control means including an actuating means containing a volatile liquid, said actuating means including a portion in heat exchange relation with said cooling unit, said actuating means being substantially filled with said volatile liquid in its lquid phase, said actuating means having a second portion containing a free liquid surface of said volatile liquid where the volatile liquid can vaporize and where the vapors can collect, said second portion being located in heat exchange relationship with said means to be cooled.

2. Refrigerating apparatus including a means to be cooled, a cooling unit for cooling said means, and a refrigerating supply means for supplying refrigerating fluid to said cooling unit, a control means for controlling the supply of refrigerating fluid to said cooling unit, said control means including an actuating means containing a volatile liquid, said actuating means including a portion in heat exchange relation with said cooling unit, said actuating means being substantially filled with said volatile liquid in its liquid phase, said actuating means having a second portion containing a free liquid surface of said volatile liquid where the volatile liquid can vaporize and where the vapors can collect, said second portion being located in heat exchange relationship with said means to be cooled, and means for loading said actuating means sufficiently to cause said control means to be operated by liquid expansion and contraction when the temperature of the means to be cooled is below a certain limit and by evaporation within the actuating means when said temperature is above a certain limit.

3. Refrigerating apparatus including a compartment containing a medium to be cooled, a cooling unit for cooling said medium, a refrigerating supply means for supplying refrigerating fluid to said cooling unit, a control means for controlling the supply of refrigerating fluid to said cooling unit, said control means including an actuating means having two portions in communication, the first portion being in prepondering heat exchange relation with the cooling unit, the second portion being in prepondering heat exchange relation with the medium to be cooled, said actuating means being substantially filled with a volatile liquid in liquid form, said second portion having a free liquid surface where the liquid can vaporize, means for applying sufficient force to said volatile liquid to cause the vaporized volatile liquid to condense when the medium to be cooled reaches a predetermined low temperature and to evaporate slightly when the medium to be cooled reaches a predetermined high temperature.

4. Refrigerating apparatus including a compartment containing a medium to be cooled, a cooling unit for cooling said medium, a refrigerating supply means for supplying refrigerating fluid to said cooling unit, a control means for controlling the supply of refrigerating fluid to said cooling unit, said control means including an actuating means having two portions in communication, the first portion being in prepondering heat exchange relation with the cooling unit, the second portion being in prepondering heat exchange relation with the medium to be cooled, said actuating means being substantially filled with a volatile liquid in liquid form, said second portion having a free liquid surface where the liquid can vaporize, means for applying sufficient force to said volatile liquid to cause the vaporized volatile liquid to condense when the medium to be cooled reaches a predetermined low temperature and to evaporate slightly when the medium to be cooled reached a predetermined high temperature, said actuating means being also operable by liquid expansion and contraction of the volatile liquid.

5. Tempering apparatus including a medium to be tempered, a heat exchange unit in heat exchange relation with the medium to be tempered, means for supplying heat transfer fluid to said unit, means for controlling the supply of heat transfer fluid, said control means including an actuating means having two portions in communication, one of said portions being in prepondering heat exchange relation with the heat exchange unit, the second portion being in prepondering heat exchange relation with the medium to be tempered, said actuating means being substantially filled with volatile liquid in liquid form, one of said portions having a free liquid surface where the liquid can vaporize, and means for maintaining the pressure within said actuating means at a value sufficient to permit operation of the control means by liquid expansion and by evaporation of the volatile liquid according to predetermined temperatures of the unit and the medium.

6. A control means including a means to be opened and closed, a plurality of separately movable operating means for said means to be opened and closed, said separately movable operating means each having different operating ranges between different predetermined limits, a first of said operating means being provided with means for closing said means to be opened and closed when a predetermined limit of its movement is reached, a second of said operating means being provided with means for opening said means to be opened and closed when a second predetermined limit of its movement has been reached, one of said operating means having its operating range above its predetermined limit and the other having its operating range below its predetermined limit, the portions of the operating ranges of said operating means adjacent said predetermined limits overlapping.

7. A control means including a means to be opened and closed, a plurality of separately movable operating means for said means to be opened and closed, each of said movable operating means having a different predetermined operating range

of movement with relation to a control medium, said operating means including means effective when one of the operating means reaches a predetermined point in its range of movement for opening said means to be opened and closed, said operating means including means effective when another of said operating means reaches a predetermined point in its range of movement for closing said means to be opened and closed, said predetermined points being located in the adjacent portions of said operating ranges of said operating means to provide a close differential, said different ranges overlapping.

8. A control means including a means to be operated into either of two limiting positions, a plurality of movable temperature responsive operating means having different temperature ranges, the low point of the operating means having the higher temperature range being adjacent the high point of the operating means having the lower temperature range, said operating means including means effective when the operating means having the higher temperature range reaches its low point for actuating said means to be operated into one of its limiting positions, said operating means also including means effective when the operating means having the lower temperature range reaches its high point for actuating said means to be operated into the other of its limiting positions, the temperature difference between said high and low points being less than the temperature difference between the opposite ends of each operating range.

9. A control means including a snap acting device biased into either of two extreme positions, temperature responsive means mechanically connected to said snap acting device to mechanically operate said snap acting device, and electromagnetic means for operating said snap acting means from one extreme position to the other.

10. A control means including a snap acting device biased into either of two extreme positions, temperature responsive means mechanically connected to said snap acting device to mechanically operate said snap acting device in one direction, and temperature controlled electromagnetic means for operating said temperature responsive means and said snap acting means in the other direction.

11. A control means including an actuating means having a containing portion substantially filled with a volatile liquid in its liquid phase, said containing portion including a portion containing a free liquid surface where the liquid can evaporate and collect, a means to be actuated operated by the pressure of the volatile liquid in the actuating means, and means for exerting pressure upon the volatile liquid sufficient to cause all the vapor of the volatile liquid to condense when the portion containing the free liquid surface reaches a predetermined low temperature limit but insufficient to prevent some of the volatile liquid from evaporating when the portion containing the free liquid surface reaches a predetermined high temperature limit for operating the means to be actuated.

12. A control means including an actuating means having a container portion, said container portion including flexible wall means, a means to be actuated including a follower member, an adjustable operative connection for operatively connecting the follower member to said flexible wall means and for providing a spacing between the follower member and the flexible wall means, a yielding means for exerting pressure on said flexible wall means, and manually operable means for simultaneously adjusting said yielding means to vary the tension of the yielding means and the adjustable operative connection to vary the spacing between said follower member and said flexible wall means.

13. A control means including an actuating means having a containing portion substantially filled with a volatile liquid in its liquid phase, said containing portion including two connected portions substantially thermally isolated, said two portions being connected by communicating means providing communication between said two portions, said communicating means being provided with means for preventing free circulation between the two portions, a means to be actuated operated by the pressure of the volatile liquid in the actuating means, and means for exerting pressure upon the volatile liquid sufficient to cause all the vapor of the volatile liquid to condense when the portion containing the free liquid surface reaches a predetermined low temperature limit but insufficient to prevent some of the volatile liquid from evaporating when the portion containing the free liquid surface reaches a predetermined high temperature limit for operating the means to be actuated.

14. A control operable in accordance with both the liquid expansion and evaporation of a volatile liquid comprising an actuating means having a containing portion provided with a portion having a free liquid surface where evaporated volatile liquid may collect and condense, said entire containing portion being substantially entirely filled with a volatile liquid in its liquid form, means for exerting pressure upon the volatile liquid sufficient to cause the liquefaction of all the volatile liquid to completely fill the entire containing portion with liquid when the portion containing the free liquid surface goes below a predetermined temperature limit but insufficient to prevent the evaporation of volatile liquid when the portion containing the free liquid surface rises above said predetermined temperature limit.

15. A control operable in accordance with both the liquid expansion and evaporation of a volatile liquid comprising an actuating means having a containing portion provided with a portion having a free liquid surface where evaporated volatile liquid may collect and condense, said entire containing portion being substantially entirely filled with a volatile liquid in its liquid form, means for exerting pressure upon the volatile liquid sufficient to cause the liquefaction of all the volatile liquid to completely fill the entire containing portion with liquid when the portion containing the free liquid surface goes below a predetermined temperature limit but insufficient to prevent the evaporation of volatile liquid when the portion containing the free liquid surface rises above said predetermined temperature limit, and means for adjusting said means for exerting pressure to change said temperature limit.

16. A control including diaphragm means containing a diaphragm chamber, a thermostat bulb means having a chamber therein of greater volume than the diaphragm chamber, tubing connecting said chambers, both of said chambers and tubing being substantially filled with a volatile liquid in liquid form, a snap acting means operated by said diaphragm means, a spring means operating to collapse the diaphragm means with a force sufficient to operate the snap acting means and to condense any vapor in either of

the chambers or tubing whenever the diaphragm means is below a certain temperature to cause the diaphragm means to operate solely by liquid expansion under such conditions, said spring means having a force insufficient to prevent the operation of the snap acting means and the evaporation of the volatile liquid when the temperature of the diaphragm means is above a certain limit.

17. A control including a diaphragm means, a snap acting means operated by the diaphragm means, a spring means for loading the diaphragm means, an adjustable operating connection providing a spacing between the diaphragm means and the snap-acting means, and manually operable means for simultaneously adjusting the tension of said spring means and the adjustable operating connection to adjust the spacing between the diaphragm means and the snap acting means.

18. Refrigerating apparatus including a means to be cooled, a cooling unit for cooling said means, and a refrigerating supply means for supplying refrigerating fluid to said cooling unit, a control means for controlling the supply of refrigerating fluid to said cooling unit, said control means including a diaphragm operating means containing a diaphragm chamber in preponderant heat exchange relationship with said means to be cooled, said control means also including a thermostat bulb containing a chamber in preponderant heat exchange relationship with said cooling unit, tubing connecting said chambers, said diaphragm and bulb chambers and said tubing being substantially filled with a volatile liquid in its liquid form, and means for loading said diaphragm means sufficiently to condense all vapor of said volatile liquid when said diaphragm means is below a certain temperature limit but insufficiently to prevent evaporation when said diaphragm means is above said temperature limit to cause said control to operate according to liquid expansion and contraction under the influence of the cooling unit and according to vapor pressure under the influence of the means to be cooled.

19. A control including a plurality of actuating means, electromagnetic means operating to move one of said actuating means, and switch means controlled by said one and another of the actuating means for controlling the energization of the electromagnetic means.

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