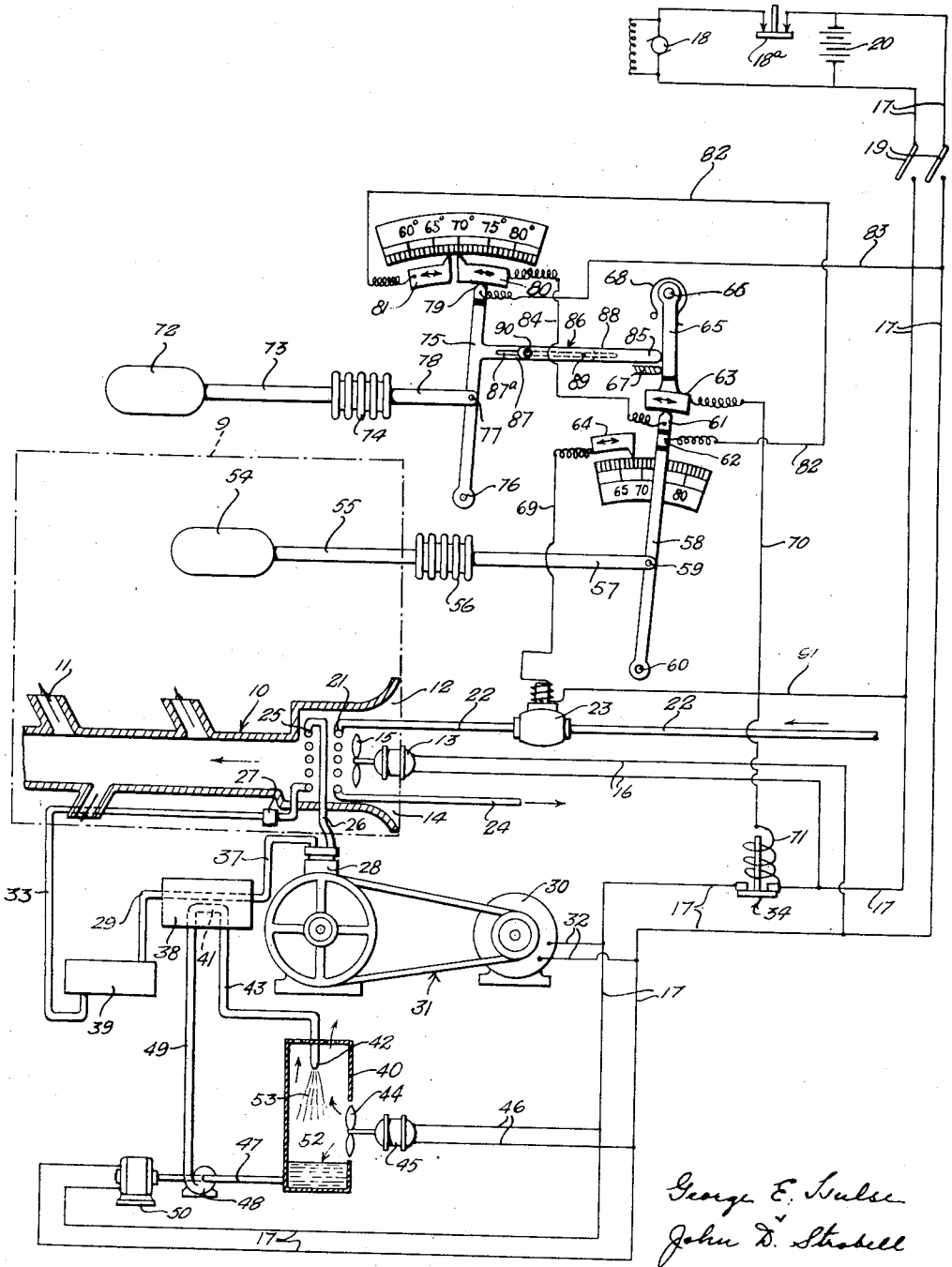
Jan. 22, 1935. G. E. HULSE ET AL 1,988,495

TEMPERATURE CONTROL

Filed Jan. 15, 1931



George E. Hulse
John D. Strobell
INVENTORS

BY

Janney, Blair & Curtis ATTORNEYS

Patented Jan. 22, 1935

1,988,495

UNITED STATES PATENT OFFICE

1,988,495

TEMPERATURE CONTROL

George E. Hulse and John D. Strobell, New Haven, Conn., assignors to The Safety Car Heating & Lighting Company, a corporation of New Jersey

Application January 15, 1931, Serial No. 508,835

31 Claims. (Cl. 236—1)

This invention relates to temperature control.

This invention relates to a method and an apparatus for controlling the temperature of the atmosphere in a space, such as a room, railway car, or the like.

One of the objects of this invention is to provide an atmosphere-conditioning apparatus of simple design, durable construction and reliable action. Another object of this invention is to provide an apparatus and system of the above-mentioned character which will be highly efficient and well adapted to meet the peculiar and widely-varying conditions and requirements met with in practice. Another object of this invention is to provide a system and apparatus of the above-mentioned character which will be of ready and economical construction, characterized by ease of installation, and capable of dependable and long-continued operation. Another object of this invention is to provide a system and apparatus of the above-mentioned character which will regulate and maintain the temperature in the space at a value to render it comfortable at all times in spite of weather, climatic or like changes. Another object of this invention is to provide a system and apparatus of the above nature which will be automatic in action and may be operated by unskilled personnel. Other objects will be in part obvious and in part pointed out hereinafter.

The invention accordingly consists in the features of construction, combinations of elements, arrangements of parts and in the several steps and relation and order of each of the same to one or more of the others, all as will be illustratively described herein, and the scope of the application of which will be indicated in the following claims.

The single figure in the accompanying drawing is a diagrammatic representation showing one of various possible embodiments of the mechanical and electrical features of our invention.

As conducive to a clearer understanding of certain features of our invention, it might at this point be noted that one of various disadvantages inherent in known systems and methods for cooling the interior of a room in hot weather resides in the fact that great discomfort is caused because of the oftentimes too great a difference in temperature between the outside atmosphere, to which the person has become temporarily accustomed, and the temperature inside the cooled room; the higher that the outside temperature is, the greater is the above-mentioned difference in temperature, the greater is the resultant discomfort, and the greater are the difficulties in acclimating one's self to the lower temperature. Though the lower or inside temperature may be one that is well suited to comfort, yet the abrupt change due to entering the cooled space is sufficient to cause chills, and like great discomforts. One of the dominant aims of this invention is to provide a system and method for avoiding such difficulties and disadvantages as have just been mentioned.

Turning now to the illustrative embodiment of this invention shown in the accompanying drawing, a conduit, generally indicated at 10, is so positioned in relation to the space, such as a room, railway car, or the like, the temperature of which is to be controlled, that various outlets 11 therefrom afford the discharge of suitable quantities of air into the space, the latter being diagrammatically indicated at 9. The mouth 12 of conduit 10 is disposed in such a position that it will receive fresh air from a suitable source, such as the outside atmosphere. Adjacent mouth 12 is a motor 13, supported in any suitable manner, and driven from the shaft of motor 13 is a fan 15 of suitable size to force the desired quantity of air through conduit 10, in a direction indicated by arrows, and into the room or space 9. The motor 13 is connected by conductors 16 to the main lines 17, which, through a manually operated switch 19, lead to a suitable source of current. Certain advantages of our invention are more fully realized in connection with the control of temperature in, particularly, passenger vehicles, such as railroad cars, but it is to be understood that we do not limit the scope of this invention thereto. If this apparatus were installed in a railroad car, the source of current connected to main lines 17 preferably takes the form of a generator 18 driven from the car axle and a storage battery 20, an automatic switch 18^a, of any suitable construction, connecting the generator to the battery 20 when its voltage is adequate and effecting disconnection when the generator voltage drops below a certain value; in the latter case, the battery 20 serves to supply energy to lines 17 and associated devices. In so far as the broader aspects of our invention are concerned, line conductors 17 lead to any appropriate source of current.

Positioned in the path of movement of air moved by the fan 15, and conveniently near the mouth 12 of the conduit 10, is a heater, preferably in the form of a coil 21 of pipe adapted to have steam passed therethrough. A pipe 22 leads from the coil 21, through an electrically

actuated valve 23, to a suitable source of steam; in a railway vehicle, the latter may be the train steam-line. Steam exhausted from heating coil 21 passes out through pipe 24. Positioned also in the path of movement of air in conduit 10 and preferably in front of fan 15 is a refrigerating coil 25, supplied with refrigerant from a suitable refrigeration apparatus to be more fully described hereinafter. When the fan 15 is in motion, a continuous blast of air is passed over the coils 21 and 25, into the conduit 10, and thence into the space 9, through the outlets 11. Furthermore, if steam is passing through heater coil 21, the air is heated, thus heating the space 9, and, conversely, if the refrigeration coil 25 is effective, the air passing thereover is cooled, thus to cool the space 9. Thus either a heated medium or a cooled medium is passed into space 9 according to whether the steam coil 21 or the refrigerating coil 25 is in operation.

The refrigeration unit for supplying cooling coil 25 with refrigerant includes a compressor 28 driven by an electric motor 30, through suitable driving connections 31. Motor 30 is connected by conductors 32 to the lines 17. The refrigeration apparatus may be of any suitable type or construction but preferably is of the compression-expansion type. A pipe 37 leads compressed refrigerant to a condenser 38, where it is condensed, whence a pipe 29 conducts the liquefied refrigerant to a receiver or collecting tank 39. A pipe 33 conducts condensed refrigerant from the storage tank 39 to refrigerating coil 25 through the expansion valve 27; and a pipe 26 returns expanded refrigerant from coil 25 to the compressor 28.

Heat may be extracted from the refrigerant in the condenser 38 by any suitable means, and illustratively we have shown condenser 38 as water-cooled, conveniently by means employing the same cooling water over and over. In order to keep cooling water supplied to condenser-cooling coil 41 at a suitable low temperature, we provide a cooling—tower including a tank 40 into which the warmed water from the cooling coil 41 in condenser 38 is lead by pipe 43 and through a spraying device 42 in the upper part of tank 40. A fan 44, driven by motor 45, is disposed at one side of tank 40 to blow sufficient cooling air, in countercurrent relation to the water spray 53 to effect the necessary cooling. Motor 45 is connected by conductors 46 to the main lines 17. A pipe 47 leads from the bottom of tank 40 to a rotary pump 48 of any desired construction, the pump discharging water, by a pipe 49, into the cooling coil 41 in the condenser 38. A motor 50 drives the rotary pump 48 and is connected to the main lines 17.

Tank 40 is preferably of a size sufficient to hold such a quantity of water 52 as to compensate for loss by evaporation over substantial periods of time.

It may be further pointed out that the motor 30 for driving the compressor 28, the motor 45 for actuating the fan 44, and the motor 50 for driving the rotary pump 48 are all connected in parallel to main lines 17 but on the same side of an automatic switch 34. Thus when switch 34 is closed these three motors will be operated simultaneously.

A thermostatic bulb 54, having therein any suitable medium such as a volatile liquid whose vapor pressure changes in response to temperature changes, is positioned inside the space or room 9 whose temperature is to be regulated. Connected to bulb 54 by a pipe or conduit 55 is a pressure-responsive bellows 56, constructed in any suitable manner so that an increase or decrease of pressure due to the medium disposed therein and in the bulb 54 will cause an expansion or contraction of bellows 56 with a consequent transverse motion of the unanchored or right-hand end of bellows 56. Secured to the right-hand end of bellows is an arm 57 pivotally connected at 59 to an arm 58. Arm 58 is pivoted at 60 so that it will swing under the action of bellows 56; at its upper end it carries insulated contacts 61 and 62 for coaction with relatively fixed contacts 63 and 64 respectively, according to the position of arm 58. Thus a transverse motion of rod 57 connected to the thermostatic bellows 56 is effective to move the contact 61 into engagement with the contact 63 or to move the contact 62 into engagement with and over the contact 64.

Contact 63 is movable, however, and is supported by and insulated from a swinging arm 65 pivoted at 66. To one side of arm 65 is a stationary stop 67 limiting the extreme swinging movement of the arm 65 in a clockwise direction. A spring 68 is disposed in such a position as to exert pressure on the arm 65, tending to swing and hold it against the stop 67. Thus the swinging arm 65 and the contact 63 carried thereby are prevented from swinging in a clockwise direction beyond the stop 67 but if a pressure greater than that of the spring 68 is applied to arm 65 on the same side as the stop 67, the arm 65 and the contact 63 are moved in a counterclockwise direction and contact 63 is thus positioned a greater distance toward the right from the contact 64. Contact 64 is of such a length that when the bellows 56 is actuated by a pressure corresponding to any temperature greater than, for example, 68° F. contact 62 on arm 58 is moved out of engagement therewith. Contact 63 in its normal position with arm 65 against the stop 67, is engaged by the contact 61 on arm 58 when bellows 56 is affected by a temperature of, for example, 70° F. or above. The circuits controlled or affected by these various contacts will be more fully described hereinafter.

A thermostatic bulb 72, similar in construction to the above described thermostatic bulb 54, is disposed out-doors or outside of the space 9 whose temperature is to be regulated, and connected thereto by a pipe 73 is a thermostatic bellows 74 like the bellows 56, actuated by changes in pressure therein due to temperature changes affecting bulb 72. An arm 75 pivoted at 76, is pivotally connected as at 77 to an arm 78 attached to the free or unanchored end portion of the bellows 74. Arm 75 carries at its upper end an insulated contact 79 adapted to coact with relatively fixed spaced contacts 80 and 81; as arm 75 is moved by bellows 74, the contact 79 comes into engagement with either the contact 80 or the contact 81 according to the position of the moving end of the bellows. Contact 81 is here positioned so that when the thermostatic bellows 74 is affected by a pressure corresponding to, for example, a temperature of 68° F. or below affecting bulb 72, contact 79 is moved into engagement therewith, and the contact 80 is here positioned so that the contact 79 is moved into engagement with it when the bellows 74 is actuated by a pressure

corresponding, for example, to an outside temperature of 73° F. or greater.

Secured to and movable by arm 75 and related so that its end 85 can engage the swinging arm 65 is an arm member generally indicated at 86. Member 86 is preferably adjustable in length and conveniently consists of two overlapping parts 87 and 88, one of them, part 87, being slotted as at 87a to receive clamping screws 89 and 90. Thus arm members 86 may be made any desired length and the point at which it engages and begins to move arm 65, which carries contact 63, may be predetermined. Hence, the distance between the contacts 63 and 64, dependent upon the action of the member 86, may be predetermined by the length at which this member is set. Likewise, the point or points at which movable contact 61, controlled by the inside thermostatic bulb 54, coacts with contact 63 may be affected.

The automatic switch 34 is, as above noted, positioned in circuit 17—17 so that it controls the actuation of motors 30, 45 and 50. Switch 34 is controlled by a coil 71 which, when energized, closes switch 34 to effect operation of these motors and the parts operated thereby, and which, when de-energized, effects opening of the switch 34 to stop these motors. Coil 71 and the electromagnetic operation of steam-line valve 23 are controlled by the contacts above described.

Contacts 64, 81 and 80 are mounted in any suitable manner to be manually adjustable, in the directions of the arrows shown in the drawing, and preferably each of these contacts is provided with an index or pointer member for coaction with suitable temperature indicia or scales substantially as shown in the drawing. By such means as these, these adjustable contacts may be accurately set at will to cause the apparatus to act to meet the various conditions met with in practice, certain illustrative examples of which may now be considered.

We have hereinabove pointed out certain disadvantages and difficulties met with in achieving the cooling of, for example, the interior of a room, and as illustrative of one of various features of our invention whereby such disadvantages and difficulties are overcome, we may at this point note that we make it possible to avoid discomfitting and undesired differences in temperature by maintaining a relatively fixed but variable difference between the outside temperature and the inside temperature though the former may vary through wide ranges above a certain predeterminable value. For purposes of illustration, let it be assumed that it is desired to maintain, in accordance with certain features of our invention, a difference of 5° F. between the outside temperature and the temperature within the space 9, and that, for the time being, the outside temperature is 75° F., and that, therefore, the temperature desired to be maintained within the space 9 is 70°. Let it also be assumed that the temperature within the space 9 is now 73° and is at no time to be reduced below 68° F.

We first set contact 81 at the 68° position so that movable contact 79 engages or disengages contact 81 when the outside thermostatic bulb 72 is affected by a temperature of 68°; we similarly set contact 64 at the 68° position so that contact 62 engages or disengages contact 64 when the inside thermostatic bulb 54 is affected by a temperature within the space 9 of 68°. Movable contact 80 is set at a 70° position, a few degrees higher than the setting of contact 81, so that contact 79 on arm 75 engages or disengages contact 80 when outside thermostatic bulb 72 is affected by a temperature of 70°.

Arms 75 and 58, under the above assumed conditions, hence occupy positions substantially as shown in the drawing. The adjustment of the length of extension 86 and the consequent position of contact 63 are then so fixed that the arc of travel (toward the left) of contact 61 along contact 63 necessary to disengage contact 61 from contact 63 corresponds to a 5° temperature arc of travel of arm 58 and contact 61. Further, with the above assumed temperature values, it will be noted that cooling of the space 9 is now in order, the temperature having to be brought down to 70° F., 5° lower than the outside temperature of 75° F.

The switch 19 is then closed to make effective the source of current, either generator 18 or battery 20 or both. The closing of the switch 19 conditions the system for continuous automatic operation, and the motor 13, connected by lines 16 to lines 17, is set in operation and actuates the fan 15; it will be noted that motor 13 is connected on the generator side of automatic switch 34. Thus, a continuous current of air flows through the conduit 10 and out through the various outlets 11 into the space 9 to accomplish a thorough and constant movement of air in the space whose temperature is to be regulated. As the temperature in this space, above assumed to be 73° F., is 3° above that preferred, refrigeration or cooling is made to take place in the coils 25 in order to cool the air being passed into space 9. As the outside temperature has been assumed to be 75° F., the contact 79 is in engagement with contact 80 substantially as shown in the drawing. Furthermore, as the temperature inside is 73°, the arm 58 and thus the contact 61 are moved by the thermostatic bellows 56 to a position in which the contact 61 is in engagement with the contact 63.

With the parts in this position, a circuit is established between the source of current and the solenoid 71, this circuit extending from one of lines 17, line 83, contact 79, contact 80, line 84, contact 61, contact 63, line 70, solenoid winding 71, and from the latter, to the other line 17; solenoid 71 being energized, switch 34 closes. Closure of switch 34 starts motor 30, motor 45, and motor 50. The moving parts of the refrigeration unit are thus actuated and refrigeration takes place in the coil 25; the current of air being passed into thermal contact with these coils by the fan 15 becomes cooled thereby. This current of air passes out through the outlets 11 and, circulating in the space 9, cools that space. As the temperature inside space 9 is thus reduced, bellows 56 contracts, moving arm 58 and contact 61 toward the left. When a temperature of 70° in space 9 has been reached, the thermostatic bellows 56 moves the contact 61 out of engagement with contact 63, thus breaking the circuit between the source of current and the solenoid 71. Upon de-energization of the solenoid 71, the switch 34 opens, thus breaking the circuit of, and stopping, the motors 30, 45, and 50. Refrigeration ceases in the coil 25 until such a time as the temperature in the space rises above 70° whence contact 61, under control of bellows 56, is moved into engagement with contact 63 and refrigeration again takes place.

Let it be assumed, however, that the outside

temperature rises to 78°, and, as described above, a fixed difference between the outside and inside temperatures of 5° is to be maintained; hence the inside temperature must now be maintained at 73°. The thermostatic bellows 74, being affected by this increase in temperature under the action of bulb 72, moves arm 75 and contact 79 farther along the contact 80, the two remaining in engagement with each other. However, when this action takes place, the extendable member 86 is similarly moved (to the right) and, being in engagement with the swinging arm 65, thus moves the contact 63 farther to the right throughout a distance corresponding to the increment of increase in outside temperature. The parts in this new position prevent contact 61 from engaging contact 63 until a temperature of about 73° inside of space 9 has been reached. Thus no refrigeration in the coil 25 and consequently no cooling will take place until a temperature of 73° in space 9 is exceeded. If such a temperature is reached, the contact 61 engages the contact 63, thus completing the circuit to the solenoid 71 and the refrigerating parts will function as described above, contact 61 disengaging contact 63 when the temperature of 73° in space 9 is restored.

For further purposes of illustration let it be assumed that it is a very hot day, and the outside temperature is 90° F. In such a case it might be desirable to have a greater difference between the temperature inside the space and the temperature outside the space in order to maintain a comfortable temperature therein. To increase the temperature difference to be maintained, screws 89 and 90 are loosened and member 86 is shortened so that contact 61 engages or disengages contact 63 at a point that is 10 temperature degrees displaced from the particular point at which arm 75 and contact 79 happen to be. Arm 75 assumes a 90° position, being moved toward the right of the position it has as shown in the drawing, and arm 65 with contact 63 likewise assumes a position considerably to the right of that shown in the drawing. Under these conditions, contact 61 will not engage contact 63 until an inside temperature of about 80° is reached; thus the parts function as described above, maintaining a 10° difference between the outside and inside temperatures.

Let it now be assumed that the outside temperature falls below 68° F., and that instead of refrigerating the air supplied to the space 9, it is now necessary to heat it in order to maintain a comfortable temperature therein. When the temperature outside of space 9 is 68°, or below, the thermostatic bellows 74 is actuated to move contact 79 into engagement with contact 81. As arm 75 with extendable member 86 moves to the left, spring 68 causes arm 65 to follow this movement until arm 65 engages stop 67 so that a subsequent movement of arm 58 to the left is effective to move contact 61 out of engagement with contact 63. If the temperature inside the space 9 falls below 68° F., the inside thermostatic bellows 56 moves the contact 62 into engagement with the contact 64. A circuit is now established between the source of current and the winding of the electrically actuated valve 23, this circuit extending from one of the lines 17, line 91, winding of valve 23, line 69, contact 64, contact 62, line 82, contact 81, contact 79, line 83, and to the other of the main lines 17. Valve 23 is thus caused to open and permit steam to pass through the pipe 22 to the series of heater pipes 21 positioned in front of the fan 15. The current of air passing into thermal contact with pipes 21 is heated and is then passed through the conduit 10 and the outlets 11 to circulate in and heat the space 9. This heating action continues until the temperature in the space rises above 68°, when the thermostatic bellows 56 moves the contact 62 out of engagement with contact 64, thus breaking the circuit between the valve 23 and the source of current. The valve 23 closes, stopping the circulation of steam through the series of pipes 21 and heating of the incoming air ceases.

A subsequent decrease in the temperature inside of space 9 effects a movement of arm 58 and contact 62 toward the left to re-establish the circuit of the electro-magnetic means operating the valve 23, whence the heating operation continues until the desired inside temperature is re-established. This cycle or these cycles of heating operations are repeated under the control of the inside thermostatic bulb 54, as long as the temperature outside of the space 9 is at or below 68° F., as determined by the position of adjustable contact 81 with which contact 79, controlled by the outside thermostatic bulb 72, coacts. Should it be desired to prevent lowering of the inside temperature below a temperature other than the above-assumed 68° F., adjustable contacts 64 and 81 are correspondingly reset. Also, it may be desired to prevent heating action inside of the space 9 as long as the temperature outside of the space 9 is at or above a temperature other than the above-assumed 68° F.; in that case, contact 81 is correspondingly reset.

It will thus be seen that there has been provided in this invention a system and apparatus in which the various objects hereinbefore noted, together with many thoroughly practical advantages, are successfully achieved. It will be seen that the apparatus is of thoroughly dependable action and is, moreover, well adapted to meet a great variety of possible practical conditions met with in practice, of which the purely illustrative examples above-described in detail are but a few. The flexibility of control or setting of the system and apparatus is such that not only may the temperature difference desired to be maintained between the outside temperature and the inside temperature be widely varied, but also the limiting temperatures affecting the initiation of heating action or cooling action inside of space 9 may be set throughout wide ranges.

As many possible embodiments may be made in this invention, and as many steps may be made in the embodiments above set forth or in the steps hereinbefore set forth, it is to be understood that all matter hereinbefore described or set forth in the accompanying drawing is to be interpreted as illustrative and not in a limiting sense.

We claim:

1. In apparatus of the character described, in combination, means forming a space whose temperature is to be regulated, a refrigeration unit for said space, a controlling system for said refrigeration unit comprising thermostatic apparatus responsive to the temperature inside said space, thermostatic apparatus responsive to the temperature outside said space, said two apparatuses adapted to place said refrigeration unit in operation when the parts of said two apparatuses are in certain positions, said second-

mentioned thermostatic apparatus adapted to change the position of one of the parts of said first-mentioned apparatus to change the controlling standard of said controlling system.

2. In apparatus of the character described, in combination, means forming a space whose temperature is to be regulated, a refrigeration unit for said space, a heating unit for said space, thermostatic means responsive to the temperature inside said space for selectively controlling the operation of said refrigeration unit and said heating unit, and thermostatic means responsive to the temperature outside said space adapted to coact with said first-mentioned thermostatic means to control the operation of said heating unit and said refrigeration unit, said second-mentioned thermostatic means adapted to modify the action of said first-mentioned thermostatic means whereby said first-mentioned thermostatic means operates for temperature values determined by said second-mentioned thermostatic means.

3. In apparatus of the character described, in combination, means forming a space whose temperature is to be regulated, a refrigeration unit for said space, a heating unit for said space, thermostatic means responsive to the temperature inside said space including a plurality of parts adapted to engage or disengage, and thermostatic means outside said space including a plurality of parts adapted to engage or disengage, said refrigeration unit adapted to operate when the parts of said first-mentioned thermostatic means are in engagement with each other and the parts of said second-mentioned thermostatic means are in engagement with each other, said second-mentioned thermostatic means adapted to move one of said parts of said first-mentioned thermostatic means with respect to the other parts of said first-mentioned thermostatic means to change the engaging position of the parts of said first-mentioned thermostatic means.

4. In apparatus of the character described, in combination, means forming a space whose temperature is to be regulated, a refrigeration unit for said space, an electric motor for driving an element of said refrigeration unit, a source of current, a circuit between said source of current and said motor, a controlling system for said circuit including a switch having two movable contacts, a thermostatic device responsive to the temperature inside said space for controlling the position of one of said movable contacts, a switch including a movable contact and a relatively fixed contact, a thermostatic device for controlling the position of said last-mentioned movable contact with respect to said fixed contact, and means forming an operative connection between said last-mentioned thermostatic device and the other of said movable contacts of said first-mentioned switch whereby the operation of said last-mentioned thermostatic device controls the position of said last-mentioned movable contact with respect to said first-mentioned movable contact.

5. In apparatus of the character described, in combination, means forming a space whose temperature is to be regulated, a refrigeration unit for said space, a switch responsive to the temperature outside said space, and a switch responsive to the temperature inside said space, said first-mentioned switch adapted to modify the action of said second-mentioned switch whereby a predetermined fixed difference in temperature between the inside of said space and the outside of said space is maintained.

6. In apparatus of the character described, in combination, means forming a space whose temperature is to be regulated, a refrigeration unit for said space, said unit including a compressor and electric motor for driving said compressor, a circuit between said electric motor and a source of current, means for breaking and making said circuit, temperature responsive devices inside said space and outside said space coacting with each other to control said last-mentioned means, and means for fixing the range of coaction of said devices to maintain a predetermined difference between the temperatures within said space and outside said space.

7. In apparatus of the character described, in combination, a space whose temperature is to be regulated, a refrigeration unit for said space including a compressor and a condenser, means for passing cooling water through said condenser, means for cooling said water including an electric fan, an electric motor for actuating said compressor, a circuit between a source of current and said motor and said fan, means for making and breaking said circuit, and temperature responsive devices located inside said space and outside said space coacting to control said last-mentioned means to maintain a predetermined fixed difference between the temperatures outside said space and inside said space as the outside temperature varies.

8. In apparatus of the character described, in combination, a space whose temperature is to be regulated, a refrigeration unit for said space including a compressor and a condenser, means for passing cooling water through said condenser, means for cooling said water including an electric fan, an electric motor for actuating said compressor, a circuit including a source of current and said motor and said fan, means for making and breaking said circuit, temperature responsive means for controlling said last-mentioned means to maintain a difference between the temperatures outside said space and inside said space as the outside temperature varies, and means for breaking said circuit when the outside temperature reaches a certain minimum value.

9. In apparatus of the character described, in combination, a space whose temperature is to be regulated, an electric circuit, a refrigeration unit for said space dependent for operation upon the condition of said circuit, a switch in said circuit, electric means for actuating said switch, a switch in the circuit of said electric means, a thermostatic member responsive to the temperature inside said space for actuating said second-mentioned switch when the temperature inside said space is at or above a certain value, a switch in the circuit of said electric means, a thermostatic member responsive to the temperature outside of said space and adapted to actuate said last-mentioned switch when the temperature outside said space reaches a certain value, said second-mentioned value being greater than said first-mentioned value.

10. In apparatus of the character described, in combination, a space whose temperature is to be regulated, a refrigeration unit for said space, electrical means for operating said refrigeration unit, a source of current, a circuit between said source of current and said electrical means, a switch in said circuit, electric means for actuating said switch, a switch having two contacts in

the circuit of said electric means, thermostatic means responsive to the temperature inside said space for moving one of said contacts into engagement with the other of said contacts when the temperature of said space reaches a certain value, a second switch in the circuit of said electric means, and means responsive to the temperature outside said space for closing said last-mentioned switch when the temperature outside said space reaches or exceeds a certain value, said last-mentioned means adapted to change the position of one of said contacts with respect to the other of said contacts so that said second-mentioned switch closes at a different temperature value in said space.

11. In apparatus of the character described, in combination, means forming a space whose temperature is to be regulated, a refrigeration unit for said space, electrical means for driving an element of said refrigeration unit, a source of current, a circuit between said electrical means and said source of current, switching means for controlling said circuit including a movable contact, a thermostat responsive to the temperature inside said space for controlling the range of movement of said contact, a second movable contact, and a thermostatic device responsive to the temperature outside said space for controlling the movement of said last-mentioned contact relative to said first-mentioned contact whereby both of said thermostatic devices coact to maintain a predetermined fixed difference between the temperature inside said space and the temperature outside said space.

12. In apparatus of the character described, in combination, means forming a space whose temperature is to be regulated, a refrigeration unit for said space, electrical means for driving an element of said refrigeration unit, a source of current, a circuit between said electrical means and said source of current, switching means for controlling said circuit including a first contact, a second contact, a thermostatic device responsive to the temperature inside said space for controlling the engagement and disengagement of said second contact with said first contact, a third contact, a fourth contact, and a thermostatic device responsive to the temperature outside said space for controlling the engagement and disengagement of said fourth contact with said third contact, said last-mentioned thermostatic device adapted to control the position of said first contact with respect to said second contact whereby said circuit is closed when said first and second contacts engage and said third and fourth contacts engage.

13. In apparatus of the character described, in combination, means forming a space whose temperature is to be regulated, a refrigeration unit for said space, temperature responsive means inside said space for controlling the operation of said refrigeration unit, temperature responsive means outside said space for controlling the operation of said refrigeration unit, said means coacting to maintain a predetermined difference between the temperatures inside and outside said space, and means related to said last-mentioned temperature responsive means for changing at will the operative range of said first-mentioned temperature responsive means.

14. In apparatus of the character described, in combination, means forming a space whose temperature is to be regulated, an electric circuit, a refrigeration unit for said space dependent for actuation upon the condition of said circuit, a switch for controlling said circuit comprising a relatively fixed contact and a movable contact, means responsive to the temperature in said space adapted to move said movable contact into engagement with said fixed contact when the temperature of said space reaches a certain value, a second switch for controlling said circuit comprising a relatively fixed contact and a relatively movable contact, thermostatic means outside said space for moving said last-mentioned movable contact into engagement with said last-mentioned fixed contact when the temperature outside said space reaches a certain value, and means associated with said last-mentioned movable contact adapted to move said first-mentioned relatively fixed contact in the direction of movement of said first-mentioned movable contact when the temperature outside said space is at or above a certain value.

15. In apparatus of the character described, in combination, means forming a space whose temperature is to be regulated, a refrigeration unit including a cooling coil, a heating coil, means for forcing air past said coils and into said space, and temperature responsive devices inside said space and outside said space for controlling the operation of said refrigeration unit and said heating coil, said temperature responsive devices coacting to maintain a predetermined difference between the temperature inside said space and outside said space when said temperatures are above certain values and for maintaining a fixed temperature in said space when the temperature outside said space is below a certain value.

16. In apparatus of the character described, in combination, means for passing a medium into thermal relation to a space whose temperature is to be regulated, refrigeration means for cooling said medium, heating means for heating said medium, means thermally responsive to the temperature within said space for selectively controlling the action of said heating means and said refrigeration unit, and temperature responsive means outside said space coacting with said last-mentioned means to maintain a fixed difference between the temperatures outside said space and inside said space when said temperatures are above certain limits.

17. In apparatus of the character described, in combination, means for passing a medium into thermal relation to a space whose temperature is to be regulated, refrigeration means for cooling said medium, heating means for heating said medium, means thermally responsive to the temperature within said space for selectively controlling the action of said heating means and said refrigeration unit, and temperature responsive means outside said space coacting with said last-mentioned means to maintain a fixed difference between the temperatures outside said space and inside said space when said temperatures are above certain limits and for causing action of said heating means when the temperature of said space falls below a certain limit.

18. In apparatus of the character described, in combination, means forming a space whose temperature is to be regulated, a refrigeration unit for said space, means for controlling the action of said unit, means responsive to the temperature outside said space and to the temperature inside said space for affecting said controlling means to cause said refrigeration

unit to maintain a predetermined fixed difference between the outside and inside temperatures, heating means for said space, and means effective, when a receding outside temperature causes said temperature responsive means to effect depression of the inside temperature to a certain minimum, to halt the action of said refrigeration unit and initiate action of said heating unit.

19. In apparatus of the character described, in combination, means forming a space whose temperature is to be controlled, means for cooling said space, a switch responsive to temperature outside of said space, a switch responsive to temperature inside of said space and having a contact controlled in its position by said first-mentioned switch, and electrical control means for said cooling means controlled by said switches.

20. In apparatus of the character described, in combination, means forming a space whose temperature is to be controlled, means for cooling said space, a switch responsive to temperature outside of said space, a switch responsive to temperature inside of said space and having a contact controlled in its position by said first-mentioned switch, electrical control means for said cooling means controlled by said switches, and means limiting the position of said contact to prevent actuation of said control means to prevent cooling action by said cooling means when the temperature inside of said space recedes to a certain value.

21. In apparatus of the character described, in combination, means forming a space whose temperature is to be controlled, means for cooling said space, a switch responsive to temperature outside of said space, a switch responsive to temperature inside of said space and having a contact controlled in its position by said first-mentioned switch, electrical control means for said cooling means controlled by said switches, heating means for said space, means limiting the movement of said contact in response to the operation of said first-mentioned switch to prevent cooling by said cooling means when the temperature inside of said space recedes to a certain value, and means for causing heating of said space by said heating means upon further recession in temperature outside of said space.

22. In apparatus of the character described, in combination, means forming a space whose temperature is to be controlled, means for cooling said space, a switch responsive to temperature outside of said space, a switch responsive to temperature inside of said space and having a contact controlled in its position by said first-mentioned switch, electrical control means for said cooling means controlled by said switches, heating means for said space, means limiting the position of said contact to prevent cooling by said cooling means when the temperature inside of said space recedes to a certain value, and means controlled by both of said thermostatic switches in response to recession in temperatures outside and inside of said space for initiating the heating action of said heating means.

23. In apparatus of the character described, in combination, means forming a space whose temperature is to be controlled, means for cooling said space, a member variable in position in accordance with changes in temperature outside of said space, a member variable in position in accordance with changes inside of said space, and control means for said cooling means dependent upon departures from a certain predetermined fixed difference in the positions of said two members.

24. In apparatus of the character described, in combination, means forming a space whose temperature is to be controlled, means for cooling said space, a member variable in position in accordance with changes in temperature outside of said space, a member variable in position in accordance with changes inside of said space, heating means for said space, control means for said cooling means dependent upon departures from a certain difference in the positions of said two members as long as said members occupy positions corresponding to temperatures above certain values, and control means for said heating means adapted to cause the latter to become effective when said two members occupy positions corresponding to temperatures below said certain values.

25. In apparatus of the character described, in combination, means forming a space whose temperature is to be controlled, means for cooling said space, heating means for said space, a switch member responsive to temperature outside of said space and coacting with two contacts to close a circuit upon increase in outside temperature and to close a circuit upon decrease in outside temperature, a switch member responsive to temperature inside of said space and having a movable contact, said last-mentioned switch member and said movable contact being connected in said first above-mentioned circuit, means causing said movable contact to vary in its position in accordance with changes in temperature outside of said space, control means for said cooling means connected in said first above-mentioned circuit, and control means for said heating means connected in said second above-mentioned circuit.

26. In apparatus of the character described, in combination, means forming a space whose temperature is to be controlled, means for cooling said space, a switch member movable in position in accordance with changes in temperature inside of said space, a switch member coacting with said first-mentioned switch member and movable in position in accordance with changes in temperature outside of said space, and means whereby said switch members control the action of said cooling means to maintain a fixed difference between the temperatures inside said space and outside said space.

27. In apparatus of the general character described, in combination, means forming a space whose temperature is to be regulated, a refrigerating unit for cooling said space, thermostatic means responsive to the temperature outside said space, a thermostatic part responsive to the dry bulb temperature inside said space, and means adapted to actuate said refrigerating unit when said thermostatic means and said thermostatic part respond to temperatures whose difference is greater than a certain predetermined fixed value thereby to maintain a fixed difference between the temperature outside said space and the temperature inside said space.

28. In apparatus of the general character described, in combination, means forming a space whose temperature is to be regulated, a refrigerating unit for cooling said space, means responsive to the dry bulb temperature of said space adapted to cause the actuation of said refrigerating unit when the dry bulb temperature thereof exceeds a certain predetermined

value, and means responsive to the temperature outside said space adapted to act on said last-mentioned means to change said temperature value and thus maintain a predetermined fixed difference between the dry bulb temperature inside said space and outside said space.

29. In a temperature regulating system, in combination, means forming an air space whose temperature is to be regulated, means for cooling said space, dry bulb thermostatic means responsive to the temperature of said space for exerting an exclusive control of the effect of said last-mentioned means on said space, and means responsive to the temperature conditions outdoors for changing the standard of operation of said last-mentioned means to cause higher temperature levels to be maintained within said space as said outdoor temperature rises and to cause lower temperature levels to be maintained within said space as said outdoor temperature falls, each temperature level in said space being maintained at a constant during the continuation of any constant temperature level outdoors.

30. In a temperature regulating system, in combination, means forming an air space whose temperature is to be regulated, means for cooling said space, dry bulb thermostatic means responsive to the temperature of said space for exerting an exclusive control over the starting and stopping of said last-mentioned means, and means responsive to the temperature conditions outdoors for changing the standard of operation of said last-mentioned means to cause higher temperature levels to be maintained within said space as said outdoor temperature rises and to cause lower temperature levels to be maintained within said space as said outdoor temperature falls, each temperature level in said space being maintained at a constant during the continuation of any constant temperature level outdoors.

31. In a temperature regulating system, in combination, means forming an air space whose temperature is to be regulated, means for cooling said space, dry bulb thermostatic means responsive to the temperature of said space for exerting an exclusive control of the effect of said last-mentioned means on said space, and means responsive to the temperature conditions outdoors for changing the standard of operation of said last-mentioned means to cause higher temperature levels to be maintained within said space as said outdoor temperature rises and to cause lower temperature levels to be maintained within said space as said outdoor temperature falls, said last-mentioned means only operating when said outdoor temperature rises above a certain predetermined level, each temperature level in said space being maintained at a constant during the continuation of any constant temperature level outdoors.

GEORGE E. HULSE.
JOHN D. STROBELL.