

June 22, 1943.

A. E. BEALS

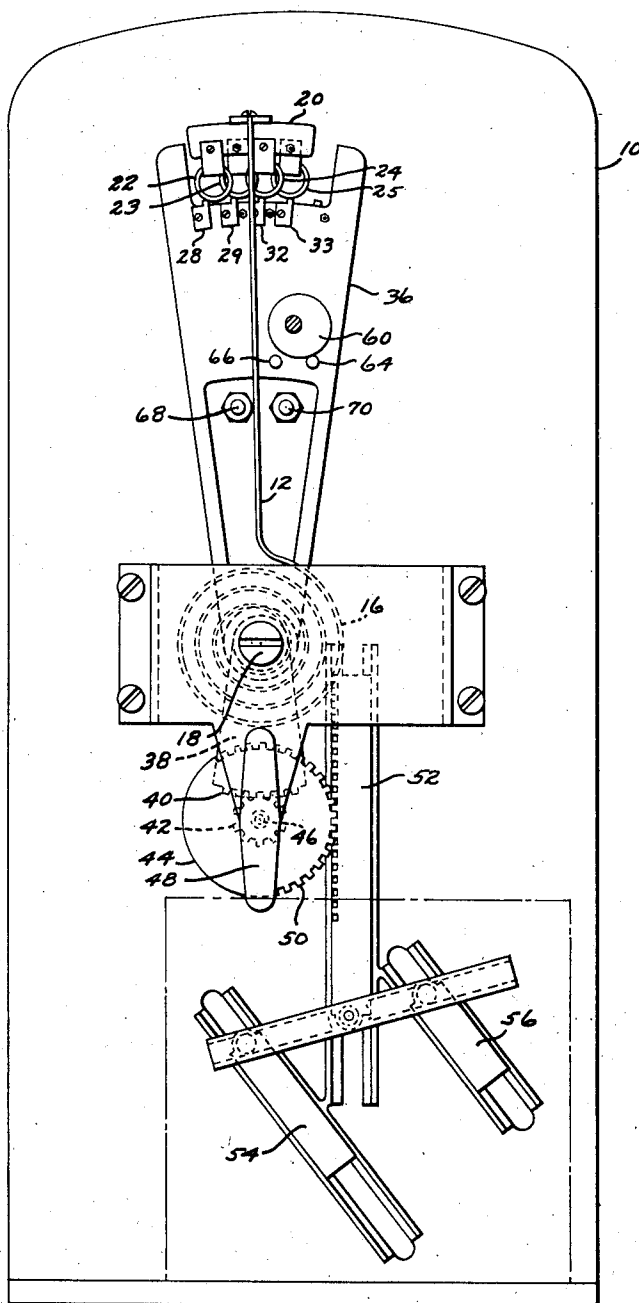
2,322,339

REFRIGERATING APPARATUS

Filed Feb. 26, 1938

7 Sheets-Sheet 1

Fig. 1



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7 Sheets-Sheet 2

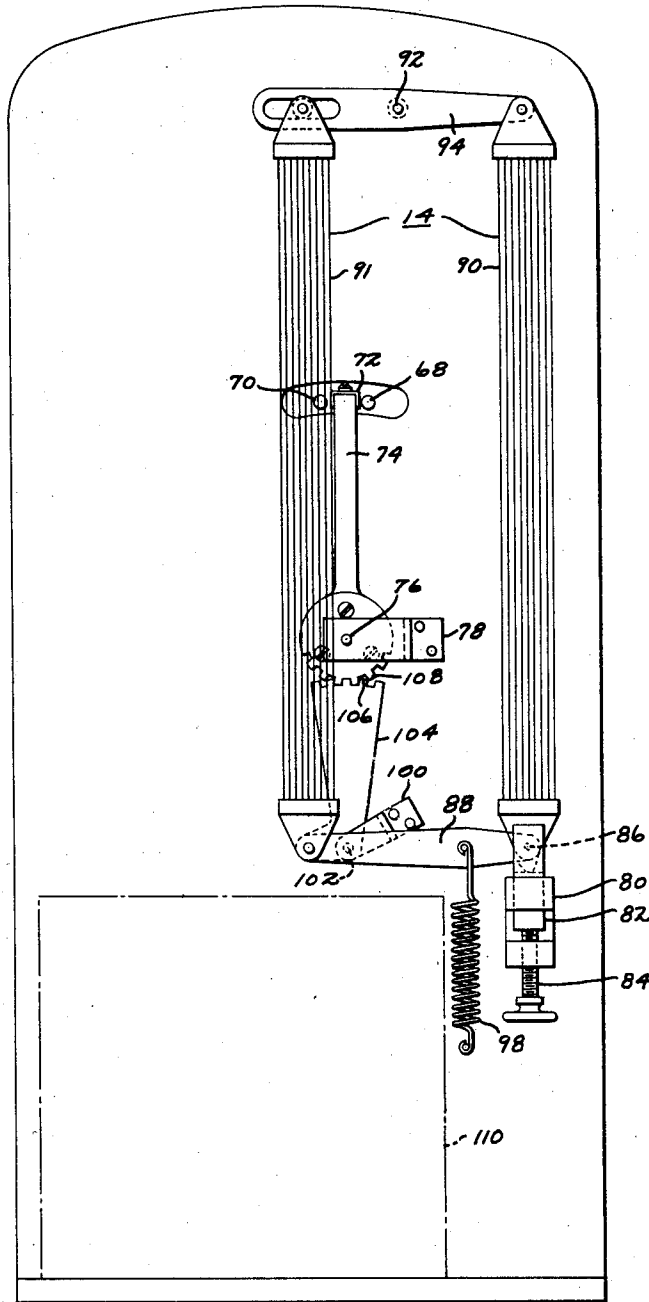


Fig. 2

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7 Sheets-Sheet 3

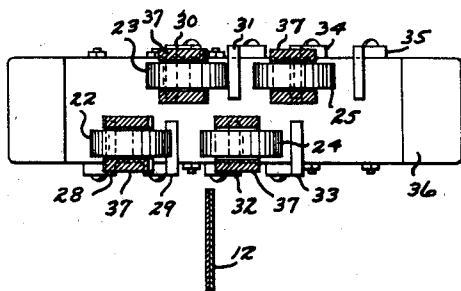


Fig. 5

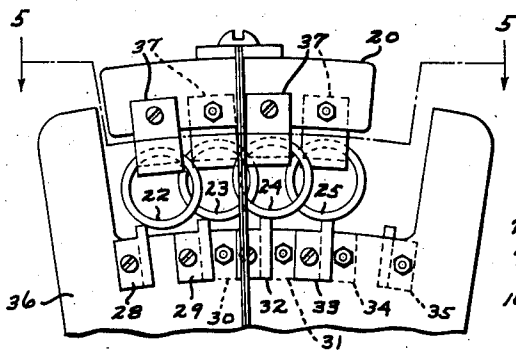


Fig. 4

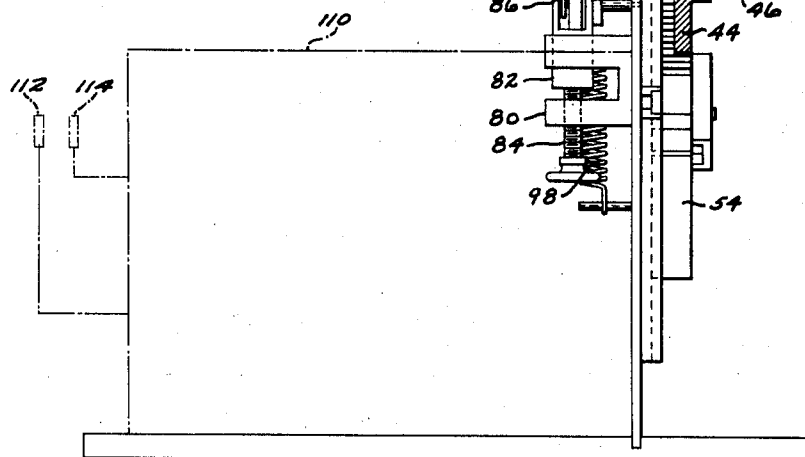


Fig. 3

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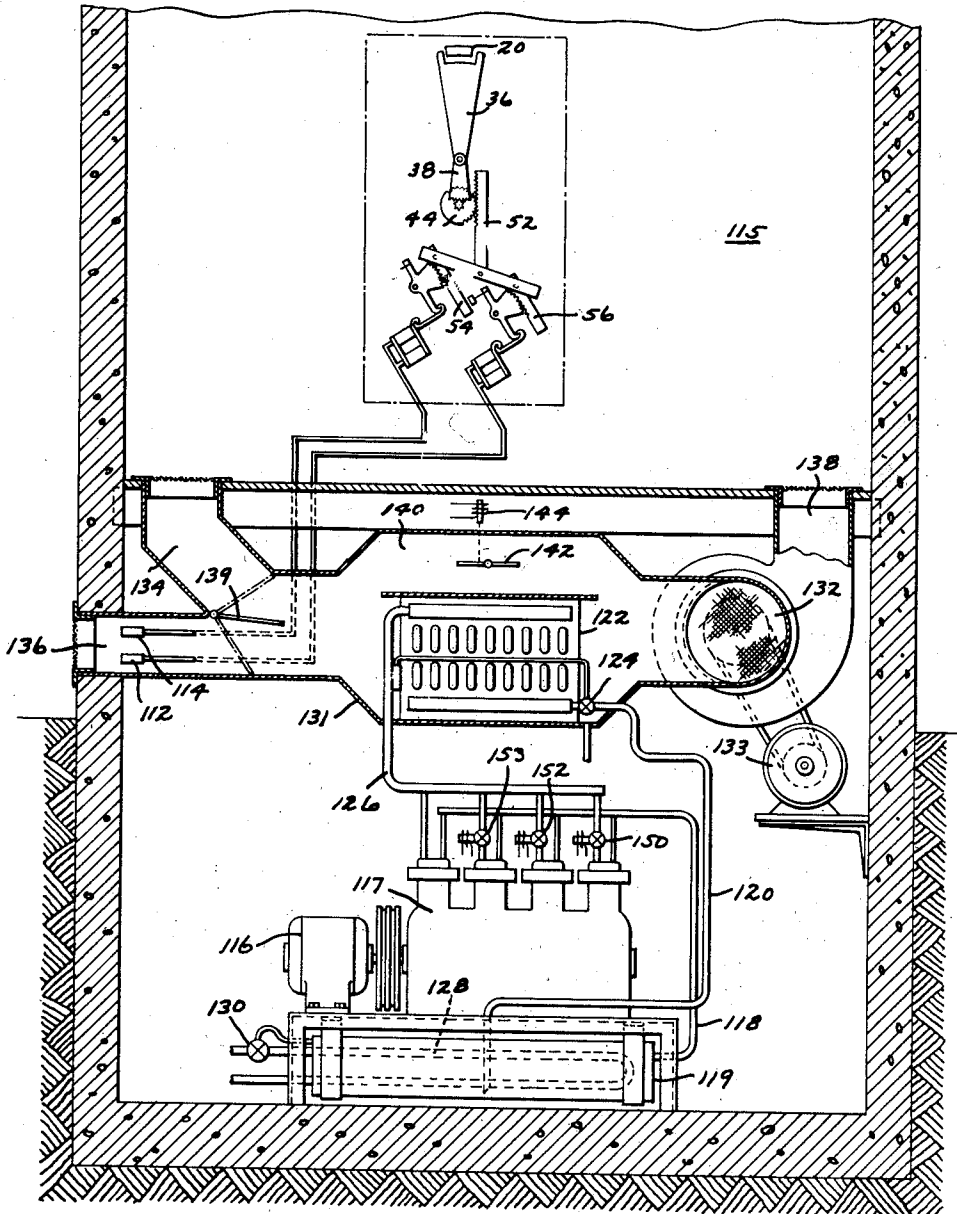


Fig. 6

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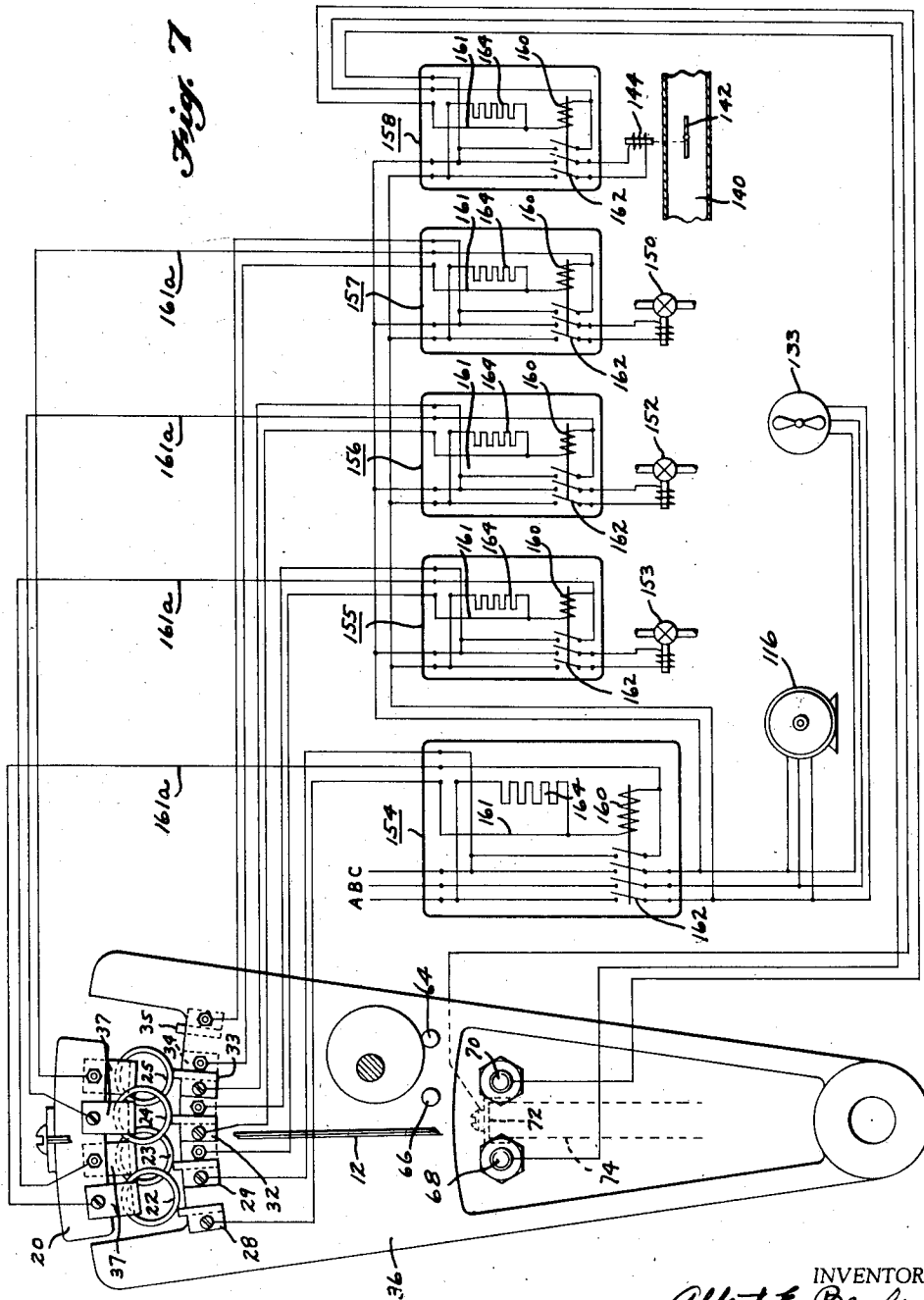
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7 Sheets-Sheet 5



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REFRIGERATING APPARATUS

Filed Feb. 26, 1938

7 Sheets-Sheet 6

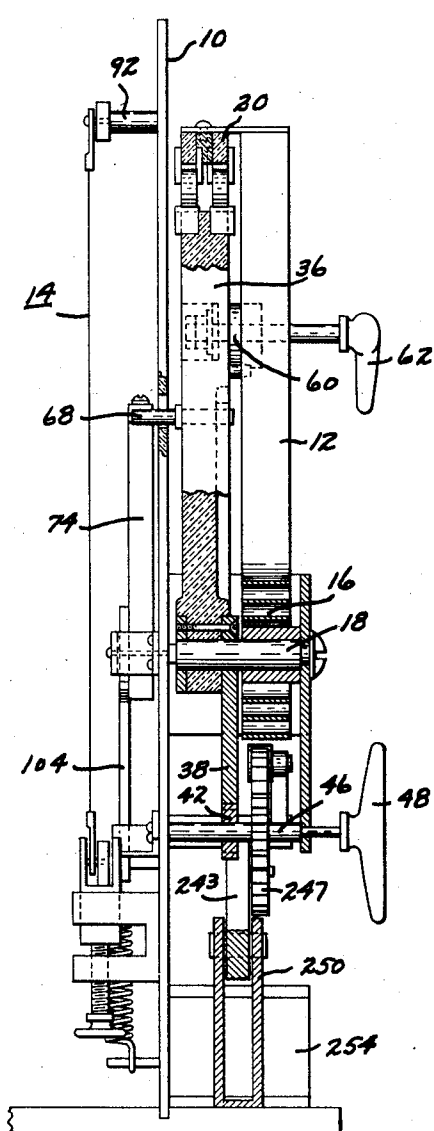


Fig. 10

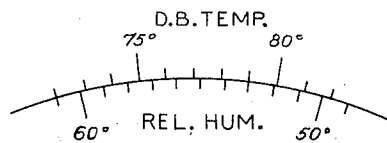


Fig. 8

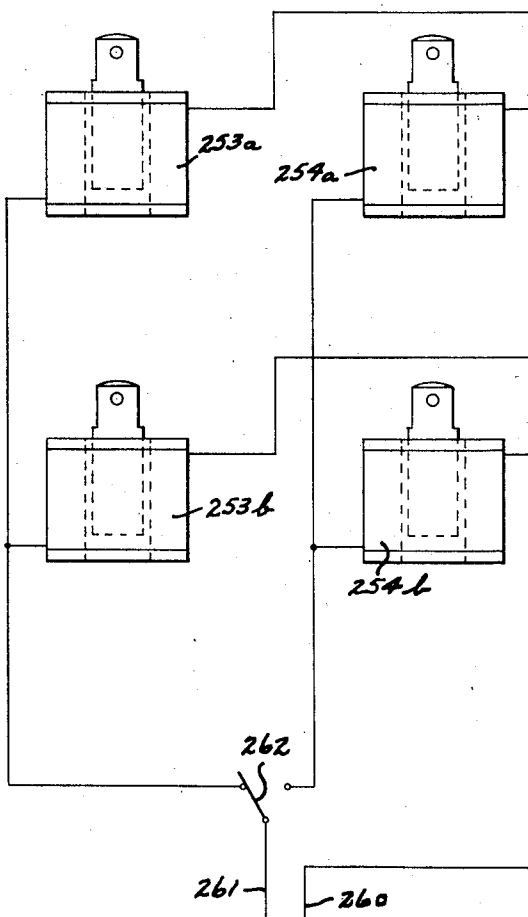


Fig. 11

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2,322,339

REFRIGERATING APPARATUS

Filed Feb. 26, 1938

7 Sheets-Sheet 7

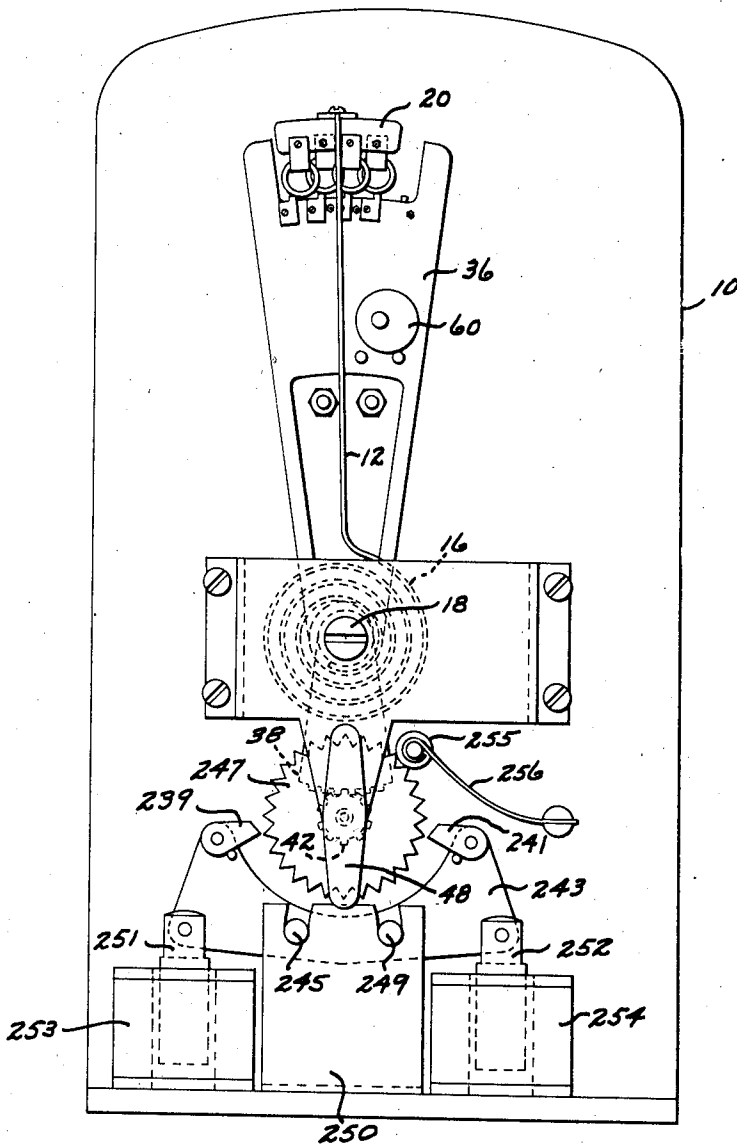


Fig. 9

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UNITED STATES PATENT OFFICE

2,322,339

REFRIGERATING APPARATUS

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Application February 26, 1938, Serial No. 192,849

8 Claims. (Cl. 62—6)

This invention relates to an apparatus for controlling the operation of air conditioning equipment.

The term "air conditioning equipment," as here used, is to be interpreted as a broad and most inclusive term. It is not to be confused with the general understanding of the term "air conditioning apparatus."

Air conditioning equipment, designed for cooling and dehumidifying, or humidifying as occasion demands, is purely refrigerating equipment in its entirety. The "air conditioning apparatus," generally considered to be preeminent, is merely a small part of the total equipment.

Considered as a unit, air conditioning equipment consists of, primarily, a vapor compressor with its motive power; second, a heat absorbing unit into which the heat extracted from the air to be cooled is transferred, either directly or indirectly; and third, a condensing unit to which the absorbed heat is delivered by the compressor and from which it is extracted and carried away from the system.

The popular conception of the "air conditioning apparatus" merely consists of an enlargement in the duct system through which the air to be cooled is circulated. In this enlarged portion of the duct system is placed either the heat absorbing unit itself, for direct absorption of heat, or water, in the form of spray which has been cooled by the heat absorbing unit, for indirect transfer of heat.

An object of this invention is to provide a control by means of which the relative humidities of an enclosure to be conditioned have definite and predetermined relations to the temperatures therein, said temperatures varying from time to time as may be required.

Another object is to provide a control whereby the capacity of the vapor compressor for carrying heat from the heat absorbing unit to the condensing unit may be automatically varied in accordance with varying requirements of the refrigerating load in the enclosure.

Still another object is to provide a control whereby the temperature and corresponding relative humidity within an enclosure may be changed to another temperature and relative humidity by either manual manipulation or automatically, through remote control means from some distant station, the changed relative humidity bearing a predetermined relation to the changed temperature.

Another is to provide means whereby a multiplicity of conditioning units, individually

equipped with this control, may be regulated synchronously from a remote station so that the enclosures served by the several units may each be maintained at the same variable temperatures and relative humidities.

And another object is to provide a thermostat and a hygrostat having registering members which are free to move through desired ranges of temperatures and relative humidities, the range of relative humidities bearing a definite and predetermined relation to the range of temperatures.

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 an elevational view showing the front side of my novel control instrument;

Fig. 2 is a rear elevational view of my control instrument;

Fig. 3 is a side elevational view of my control instrument with parts broken away so as to more clearly show certain details of construction;

Fig. 4 is a fragmentary, elevational view showing the arrangement of the contacts;

Fig. 5 is a sectional view taken on line 5—5 of Fig. 4;

Fig. 6 is a diagrammatic view illustrating the manner in which my novel control apparatus may be employed in connection with air conditioning apparatus; and

Fig. 7 is a circuit diagram illustrating the operation of the control system.

For obtaining a desired degree of comfort for people assembled in rooms, auditoriums, schools, or the like, it has been found necessary, especially during the summer months, to not only regulate the dry-bulb temperatures of the air in such enclosures within certain limits but also to regulate the relative humidities in definite relations to the temperatures.

Fig. 8 shows the preferred scope of travel for the registering members of the thermostat and the hygrostat and also a preferred relationship between the temperature and the relative humidity scales;

Fig. 9 is a view corresponding to Fig. 1 showing a modified arrangement;

Fig. 10 is a side, elevational view of the modified arrangement with parts broken away so as to more clearly show certain details of construction; and

Fig. 11 is a diagrammatic showing of the circuit for energizing the solenoids.

The control instrument, as illustrated in the drawings, consists of a supporting plate 10 which carries a temperature responsive member 12 on its one face and a humidity responsive element 14 on its other face. The temperature responsive instrument comprises a spiral bimetallic member 15, one end of which is secured to the mounting stud 18 carried by the base 10. On the outer end of the temperature responsive element 16 is carried a block of insulation 20 which in turn carries a plurality of contact members 22, 23, 24, and 25. These contact members cooperate with a plurality of contact members 28, 29, 30, 31, 32, 33, 34, and 35 carried by an insulating support 36 which is pivotally mounted on the supporting stud 18. The contact support 36 has a depending member 38 secured thereto which is provided with gear teeth 40 which mesh with gear teeth on pinion 42 of the member 44 carried by the member 46. The member 44 is also provided with a set of gear teeth 50 which mesh with the teeth on the rack 52.

This rack 52 may be made responsive to outside effective temperatures so as to cause the instrument to be adjusted to maintain higher indoor effective temperatures at higher outdoor effective temperatures. The effective temperature instrument responsive to outdoor conditions which is used for operating the rack 52 is similar to that shown in my Patent No. 1,986,316; the rack or slide 52 corresponding to the slide 14 of the patent; the slide 54 corresponding to the slide 12 of the patent; and the slide 56, likewise, corresponding to the slide 13 of the patent. The means for operating the slides 54 and 56 is the same as the means used in operating the slides 12 and 13 of the device shown in my patent. For a complete description of the outside effective temperature responsive means reference may be had to my above mentioned patent. While I have disclosed an outside effective temperature responsive means similar to the outside effective temperature responsive means disclosed in the above mentioned patent, it is obvious that other types of outside effective temperature responsive means may be substituted for the particular means shown.

The arrangement is such that a change in the outside effective temperature will shift the stationary contacts carried by member 36 to such an extent that the conditioning equipment will maintain the inside effective temperature in predetermined relation to the effective temperature outside.

A cam member 60 is pivotally mounted on the insulating support 36 and is provided with an operating handle 62. The purpose of the cam 60 is to make it possible for one to manually move the outer end of the temperature responsive member 12 to the extreme left, thereby shutting down the air conditioning equipment in a manner to be explained hereinafter. A plurality of stop pins 64 and 66 limit the movement of the cam 60. When the cam 60 is in the position shown in Fig. 1, the contact carrying block 20 is permitted to move to the extreme right; whereas, when the cam 60 is rotated so as to engage with the stop 66, the contact block 20 is held in the extreme left position.

Also carried by the member 36 are a pair of contacts 68 and 70 which cooperate with a contact 72 carried by the arm 74. The arm 74 is pivotally mounted on the reverse side of the supporting plate 10 by means of a pivot 76. The

arm 74 is adapted to be actuated in response to changes in humidity within the room. A U-shaped block 80 is carried by the base plate 10, in one arm of which there is slidably supported a member 82 which may be adjusted vertically by means of an adjusting screw 84 carried by the other arm of the U. The slide member 82 is slotted as shown and serves to freely support one end of the lever 88. The slot in the slide member 82 serves to restrict the lateral motion of the lever 88 but said lever is free to move vertically away from the supporting surface at the bottom of the slot.

The pivot pin 86 connects this end of the lever 88 with the end of the section 90 of the humidity responsive material.

The end of the lever 88 being freely supported in the slotted member 82 and free to move vertically assures that a strain cannot be induced in the sections 90-91 greater than that normally exerted by the tension in the spring 98.

As best shown in Fig. 2, the humidity responsive material is in two sections 90 and 91 each of which is made up of a plurality of separate strands of material which, for example, may be human hairs. The effect which changes in humidity has on material of this kind is well known and need not be described. Adjacent the upper end of the base plate 10 there is provided a pivot member 92 which pivotally supports a lever 94. This lever serves to support the two sections of the hygroscopic material as shown in Fig. 2. A spring member 96 is provided for tensioning the hygroscopic element.

A bell crank 104 is pivotally mounted on a pin 102 which is carried by the base 10. One arm of the bell crank is actuated in one direction by the contraction of the humidity responsive material 90-91. When the outer end of the lever 88 is in contact support with the member 82, the tension in the spring 98, acting through the lever 88, moves the bell crank 104 in the opposite direction upon an expansive movement of the humidity responsive material 90-91. The other arm of the bell crank is provided with a gear sector 106 which meshes with the gear sector 108 carried by the contact supporting arm 74. From this arrangement, it will be seen that a change in humidity will cause the contact arm 74 to move either to the right or to the left depending on the humidity change. As shown in Fig. 2, very slight movement of the contact 72 is necessary to close the circuit. In this way the relative humidity in the room may be very closely controlled.

The outside effective temperature responsive mechanism may also be supported from the rear side of the supporting plate 10. The outside effective temperature mechanism has been designated by the reference numeral 110; and the wet and dry bulbs, which are adapted to be placed outside of the enclosure, have been designated by the reference numerals 112 and 114 respectively. The wet and dry bulbs 112 and 114 correspond to the bulbs 92 and 93 respectively of my aforementioned patent.

In Fig. 6 I have shown diagrammatically a room 115 in which is placed one of my control instruments. The apparatus for conditioning the air for the room includes a four-cylinder compressor 117 which is driven by a motor 116. The compressor 117 is adapted to compress refrigerant and discharge the compressed refrigerant through the pipe 118 into the condenser 119 from whence the liquid refrigerant may flow through

the line 120 into the evaporator 122. The usual form of restrictor valve 124 is provided for controlling the flow of refrigerant through the evaporator. The evaporated refrigerant returns to the compressor through the return line 126. The condenser is a water cooled condenser which is provided with the usual form of water coil 128. The amount of water flowing through the coil 128 is determined by the valve 130.

The evaporator 122 is mounted within the chamber 131 which chamber is connected at the one end by a suitable conduit 134 with the enclosure 115 and by another conduit 136 with the outside atmosphere. A fan 132 driven by motor 133 circulates air through the chamber and discharges the conditioned air through the conduit 138 into the enclosure 115. A damper 139 is provided for controlling the flow of air through the conduits 134 and 136. This damper may be manually controlled and, coincidentally therewith, it may be automatically controlled to entirely close the conduit 134 from the enclosure 115 whenever the outside wet-bulb temperature drops below the desired wet-bulb temperature within the enclosure.

In order to control the humidity conditions within the room, a by-pass 140 has been provided through which at least a portion of the air being circulated may pass thereby avoiding the evaporator 122. The by-pass 140 is provided with a control damper 142 operated by a solenoid 144 which is under the control of the humidostat hereinbefore described. The thermostat controls the operation of the compressor in a manner to be described hereinafter. The compressor is a four-cylinder unit which is provided with solenoid valves 150, 152, and 153 in the suction lines leading to three of the cylinders. Closing all the solenoid valves has the effect of unloading the three cylinders of the compressor. While I have shown this arrangement for unloading the compressor, it is to be understood that any of the usual unloading expedients may be used, such as opening a by-pass, opening the discharge valves, etc.

Referring now to Fig. 7 in which I have shown the circuit arrangement used, it will be observed that there are five remote control switches 154, 155, 156, 157, and 158, the first of which controls the compressor and fan motors, three of which control the unloading valves and the last of which controls the by-pass damper 142. The remote control switch 154 is connected directly into the main supply lines and controls the operation of the compressor motor 116 and the blower motor 132.

The control switches 154 through 158 are the standard form of remote control switches which are commonly used and which operate as follows: The solenoid 160, when energized, automatically closes the multiple switch 162 and holds this switch closed so long as the solenoid is energized. In order to open the multiple circuit switch 162, a short circuit is placed around the solenoid 160 thereby deenergizing the solenoid. Referring now to the switch 154 which is similar to the switches 155 through 158, except that it is a three-wire switch whereas the others are two-wire switches; it will be seen that, when the movable contact 22 engages the stationary contact 29, a circuit is completed from the line C through the contacts 29—22, through the solenoid 160 and the resistance 164 to the main line A. This energizes the solenoid 160 thereby closing the multiple switch 162. Closing of the switch

162 closes a stick circuit from the main line C through the solenoid 160, through the resistance 164 to the main line A, with the result that the contact 22 may leave the contact 29 without deenergizing the solenoid.

In order to open the main remote control switch 154, a short circuit is placed across the solenoid 160. This takes place when the contact 22 engages the contact 23. When the contact 22 is in engagement with the contact 23, no current flows through the solenoid 160 since all of the current will flow through the shunt circuit which includes conductor 161, contacts 22—23, and the conductor 161a.

It will be further noted that each of the contact rings 22 through 25 controls a separate one of the remote control switches hereinabove described. The contact ring 22, for example, closes the circuit through the remote control switch 154 when it engages with the stationary contact 29 and opens the circuit through the same remote control switch when it engages the contact 28. In a similar manner, contact 23 cooperates with stationary contacts 30 and 31 to open and close the circuit through the control switch 155; contact 24 cooperates with the stationary contacts 32 and 33 to open and close the circuit through the remote control switch 156; and, contact 25 cooperates with the contacts 34 and 35 to open and close the circuit through the remote control switch 157.

As the contact carrying member 20 moves from the extreme left to the right, the circuits through the remote control switches 154 through 157 are consecutively closed; and, as the contact carrier 20 moves from the extreme right to the left, the circuits are opened through these control switches in the reverse order. Obviously, the contact carrying member will not always move from one extreme to the other but may move any portion of the distance.

The remote control switch 158 is under control of the humidity responsive mechanism; and, referring again to Fig. 7, it will be noted that, when the humidity is high the movable contact 72 will engage the stationary contact 62, closing a circuit through the solenoid 160 of the remote control switch 158 with the result that the solenoid 144 will close the butterfly damper 152. Upon the humidity being lowered the desired amount the contact 72 will swing into engagement with the contact 70 with the result that the damper 142 will be opened.

Considering now that the temperature within the room is increasing and that the contact carrying member 20 moves from the extreme left to the right, the following will take place: The movable contact 22 will, first, engage the contact 29 with the result that the compressor mechanism will start up as just explained. Only the first cylinder will do any pumping, however, as the solenoid valves 153, 152, and 150 are all closed. Further movement of the contact carrying member 20 will cause the contact member 23 to engage the contact 31 with the result that the circuit through the remote control switch 155 will be closed thereby opening the solenoid operated valve 153. Further movement of the contact carrying member 20 will cause the contact 24 to engage the contact 33 with the result that the solenoid valve 152 placed in the suction line of the third cylinder of the compressor will be opened. Further movement of the contact carrying member 20 will cause the contact 25 to engage the stationary contact 35 whereby the solenoid valve 150 in the suc-

tion line of the fourth cylinder of the compressor will be opened.

Upon the decrease in the temperature within the room the movable contact carrying member 20 will move from the right to the left. In so moving, the contact 25 will first engage the contact 34 with the result that the solenoid valve 159 will be closed. A further decrease in the temperature will cause the contact member 24 to engage the stationary contact 32. This, in turn, deenergizes the solenoid of the remote control switch 156 with the result that the solenoid valve 152 is again closed. Further decrease in the temperature within the room will cause the contact 23 to engage the stationary contact 30 which, in a similar manner, will cause the solenoid valve 153 to close. Still further decrease in the temperature within the room will cause the contact 22 to engage the stationary contact 28 with the result that the main remote control switch 154 will be opened, thereby completely closing down the air conditioning system. By virtue of such an arrangement, it is possible to vary the loading of the compressor in accordance with refrigeration requirements; and to control the amount of air passing over the evaporator, and thereby control the humidity within the room. It will be noted that when the circuit is broken through the main remote control switch 154, the current supply for the humidity control circuit is cut off.

Special attention is called to the novel manner in which the movable contacts 22 through 25 are supported. As best shown in Figs. 4 and 5, the movable block 20 carries a plurality of U-shaped contact supporting members 37 which loosely support the movable contacts in the manner shown. The movable contacts are in the form of rings which are loosely supported on the U-shaped contact supports 37. This arrangement provides for a two-point support, thereby assuring proper alignment of the contacts as they move away from the vertical center line, and preventing the contacts from swinging out of position, as they otherwise might do if they were suspended from a pin support. This arrangement also provides for a minimum amount of resistance to movement, with the result as the temperature increases or decreases, the movable contact rings 22 through 25 may pass over the stationary contacts without offering any appreciable resistance to movement.

In Figs. 9, 10, and 11, I have shown a second modification with which a different type of outside effective temperature integrator may be used. The instrument shown in this second modification has the same contact arrangement and is intended to be used in systems of the type shown in Figs. 6 and 7. As will be pointed out hereinafter, the arrangement shown in the second modification is especially well adapted for installations where it is desirable to permit either raising or lowering the inside conditions to suit individual preferences and in which it is desirable to synchronously regulate a number of inside controls from one master integrator located at a point remote from the individual controls.

In this second modification the member 46 carries a ratchet wheel 247 operable in reverse directions through engagement by the pawls 239—241. The pawls 239—241 are pivotally mounted upon a lever member 243, alternatively pivotal about the pins 245—249. A channel shaped member 250 supports the pins 245—249 in slotted bearings without restriction in an upward direction. At the ends of the lever 243

are pivotally hung solenoid cores 251—252 in operable relation with their respective electromagnetic coils 253—254. A roller stop member 255 is pressed upon the teeth of the ratchet 247 by means of a spring 256. Through the action of the roller 255 the motion of the ratchet is restricted to equal increments of movement and is held in positive positions.

In operation, if an electric current is passed through the solenoid coil 253, the electro-magnetic force tends to pull the core 251 into the magnetic center position, thus moving the lever 243 about the pin 245 and engaging the pawl 241 with the ratchet wheel 247. In this manner the contact support 36 is moved clockwise and the control is reset to maintain a higher temperature and a lower relative humidity within the enclosure. When the current is cut off, the solenoid coil 253 is deenergized and the lever 243 drops into the neutral position. Conversely, if the solenoid coil 254 is energized, the contact support 36 is moved counterclockwise and the control is reset to maintain a lower temperature and higher relative humidity within the enclosure.

It is to be noted that when neither of the solenoid coils 253—254 is energized, the pawls 239—241 are entirely out of contact with the ratchet wheel 247 and the instrument is free to be manually reset through the knob 48. The current for energizing the solenoids 253—254 may be turned on from remote switches, manually operated; from switches, automatically operated and remotely located; or the current may be controlled by means of the effective temperature slide of the control instrument disclosed in my former Patent No. 1,986,316.

If used in connection with the device disclosed in the above patent, the inside effective temperatures may then be regulated by this control in predetermined relations to the outside effective temperatures. Also a plurality of air conditioning units, individually equipped with the device herein disclosed, may be controlled synchronously from one outside effective temperature slide, located at any convenient place.

In Fig. 11 I have shown an arrangement for synchronously operating the solenoids of a plurality of separate control instruments which may be located at widely separated points. Reference numerals 260 and 261 represent the source of electric power. The solenoids for one control instrument are represented by 253a and 254a, while 253b and 254b are similar solenoids for another control instrument which it might be desirable to regulate simultaneously with the first from a remote control. A double throw switch, 262, arranged to be either manually or automatically operated and which is normally open, represents the means by which either one of the pair of solenoids on all of the control instruments connected in the circuit may be energized. When it is desired to regulate one, or any number, of controls in accordance with the outside effective temperature, the switch E would be operated automatically from an outside effective slide such as 52 shown in Fig. 1. In this manner, an office building with a number of individual units can be modified by outside conditions from one integrating instrument. At the same time, any one or more of the separate controls may be set either forward or back, according to the individual preference of the occupants, by means of the control knob 48.

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. An instrument for controlling the operation of air conditioning equipment comprising, in combination, a thermostatic element responsive to variations in the temperature of air in an enclosure; a hygrostatic element responsive to variations of relative humidity of air in said enclosure, an adjustable element, common to both the thermostatic and hygrostatic elements and coacting synchronously with each; a ratchet, adapted to move in reverse directions and operatively connected with said adjustable element; two contra-positioned pawls, adapted to engage the teeth of said ratchet; a reversibly acting lever, adapted to be fulcrumed at either of two points and pivotally supporting said pawls; two electromagnets, oppositely connected with said lever and adapted to move same in reverse directions; and electric conducting means for alternatively energizing the solenoid coil of either electromagnet.

2. In combination with an enclosure to be air conditioned; air conditioning equipment comprising a compressing unit, a condensing unit and an evaporating unit in refrigerant flow relationship; a controlling unit comprising, in combination, hygrostatic means responsive to variations of relative humidity for varying the amount of air passing over the evaporating unit; thermostatic means responsive to variations of temperature for progressively varying the capacity of said compressing unit; and an adjustable element, common to both the thermostatic and the hygrostatic elements and coacting synchronously with each.

3. Apparatus for synchronously controlling a multiplicity of air conditioning units which comprises a control instrument for each conditioning unit, each of said control instruments comprising a thermostatic element responsive to variations in temperature of air within its respective enclosure, a hygrostatic element responsive to variations of relative humidity within its respective enclosure, an adjustable element coacting with the temperature and relative humidity responsive elements to determine the responding positions of said thermostatic and hygrostatic elements, and electromagnetic means for varying the position of said adjustable element of each instrument, and electrical means for synchronously energizing a multiplicity of said electromagnets from a remote control station.

4. In combination with a multiplicity of units for varying the temperature and the humidity of air, first means for individually controlling said units so as to control the variation in the temperature produced by said units, second means for controlling the variation in the humidity produced by said units, means operated by said first means rendering said second means inoperative and means common to said first and second means for adjusting the operation of said first and second means.

5. In combination with an enclosure to be air conditioned; air conditioning equipment comprising a compressing unit, a condensing unit and an evaporating unit in refrigerant flow relationship; a controlling unit comprising in combination, hygrostatic means responsive to variations of rela-

tive humidity for varying the amount of air passing over the evaporating unit; thermostatic means responsive to variations of temperature for progressively varying the capacity of said compressing unit; an adjustable element, common to both the thermostatic and the hygrostatic elements and coacting synchronously with each; and means responsive to the temperature outside said enclosure for operating said adjustable element.

6. An instrument for controlling the operation of air conditioning equipment comprising, in combination, a thermostatic element responsive to variations in the temperature of air in an enclosure; a hygrostatic element responsive to variations of relative humidity of air in said enclosure, an adjustable element, common to both the thermostatic and hygrostatic elements and coacting synchronously with each; a ratchet, adapted to move in reverse directions and operatively connected with said adjustable element; two contra-positioned pawls, adapted to engage the teeth of said ratchet; a reversibly acting lever, adapted to be fulcrumed at either of two points and pivotally supporting said pawls; two electromagnets, oppositely connected with said lever and adapted to move same in reverse directions; electric conducting means for alternatively energizing the solenoid coil of either electromagnet; and means responsive to the outside air temperature for controlling the flow of current in said electric conducting means.

7. An instrument for controlling the operation of air conditioning equipment comprising, in combination, a thermostatic element responsive to variations in the temperature of air in an enclosure; a hygrostatic element responsive to variations of relative humidity of air in said enclosure, an adjustable element, common to both the thermostatic and hygrostatic elements and coacting synchronously with each; a ratchet, adapted to move in reverse directions and operatively connected with said adjustable element; two contra-positioned pawls, adapted to engage the teeth of said ratchet; a reversibly acting lever, adapted to be fulcrumed at either of two points and pivotally supporting said pawls; two electromagnets, oppositely connected with said lever and adapted to move same in reverse directions; electric conducting means for alternatively energizing the solenoid coil of either electromagnet; and switch means controlling the flow of current in said electric conducting means, said switch means being operative to energize one of said electromagnets upon movement in one direction and operative to energize the other of said electromagnets upon movement in the opposite direction.

8. In combination with an enclosure to be air conditioned; air conditioning equipment comprising a compressing unit, a condensing unit and an evaporating unit in refrigerant flow relationship; a controlling unit comprising, in combination, hygrostatic means responsive to variations of relative humidity for varying the amount of moisture removed from the air by the evaporating unit; thermostatic means responsive to variations of temperature for progressively varying the capacity of said compressing unit; and an adjustable element, common to both the thermostatic and the hygrostatic elements and coacting synchronously with each.

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