May 2, 1967 J. L. DUNCAN 3,317,692

AMBIENT TEMPERATURE-MODIFIED TEMPERATURE-ALTERING CONTROL MECHANISM

Filed Oct. 22, 1965

3 Sheets-Sheet 1

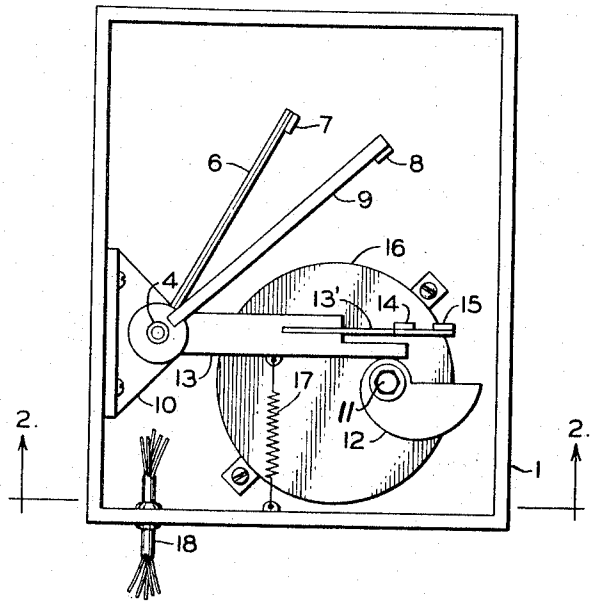


FIG. 1.

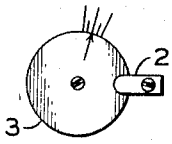


FIG. 3.

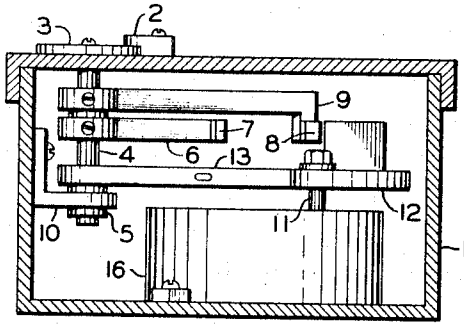


FIG. 2.

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Fig. 4.

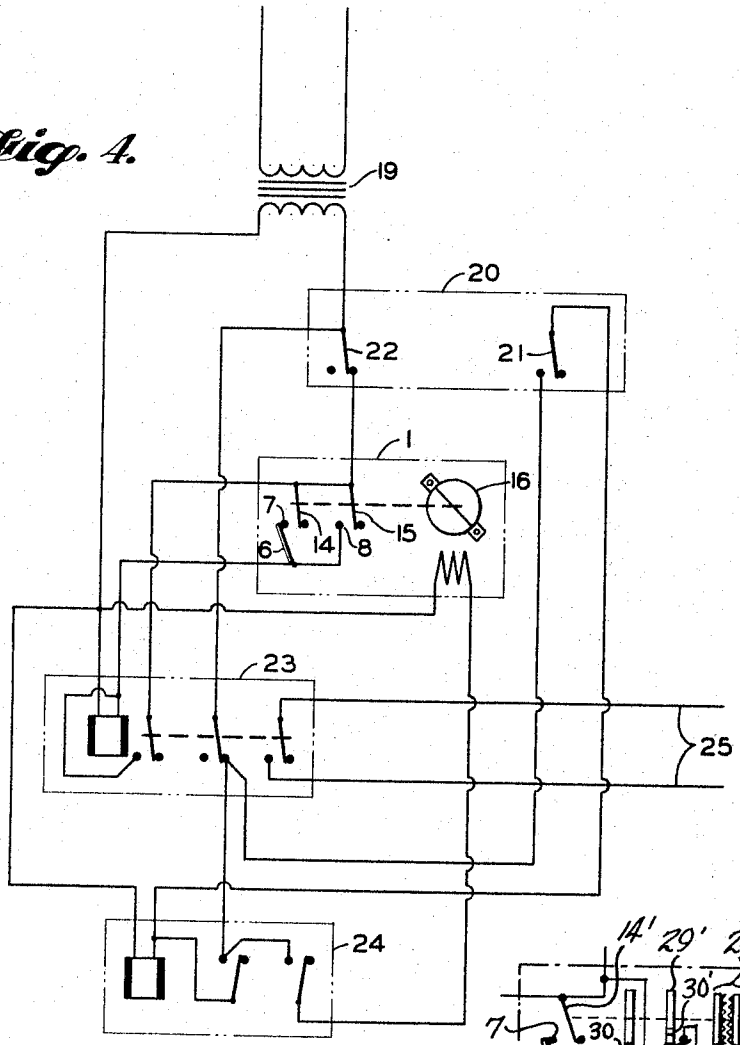
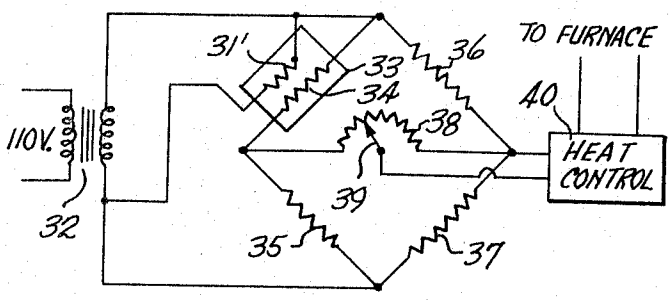


Fig. 8.



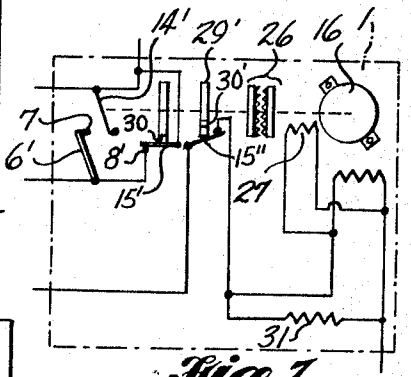


Fig. 7.

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Fig. 5.

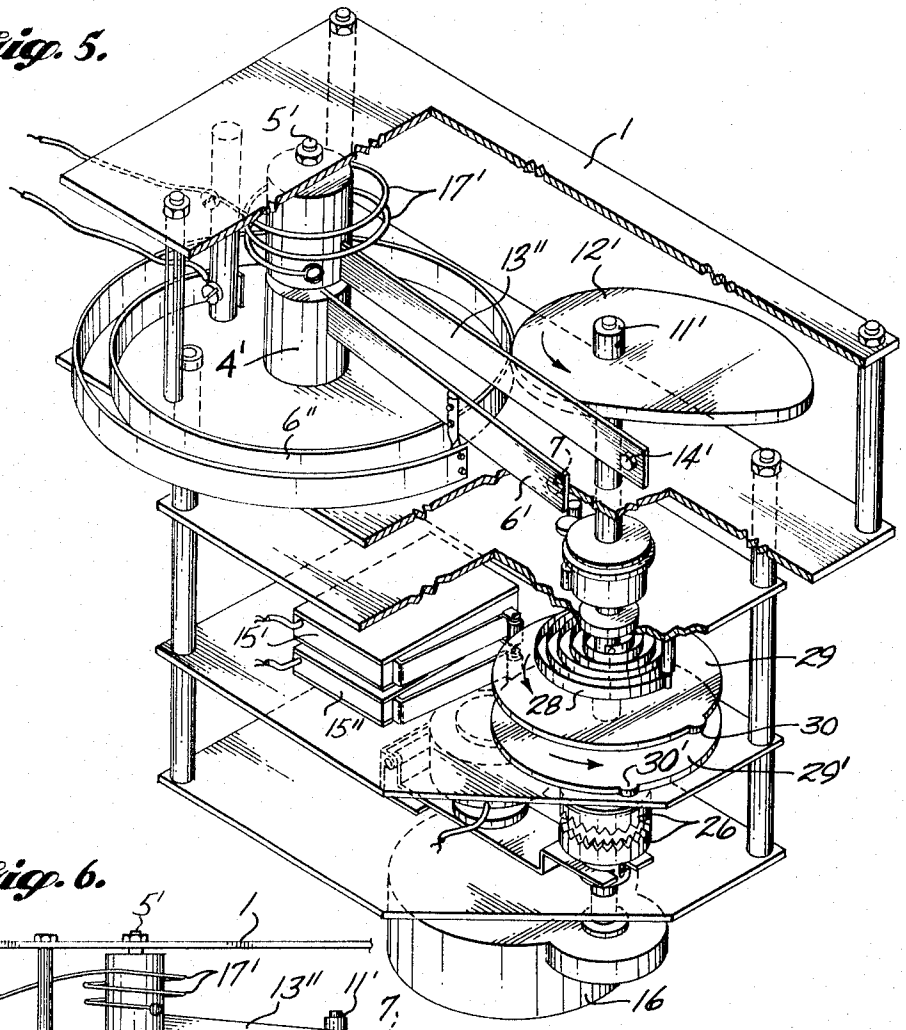
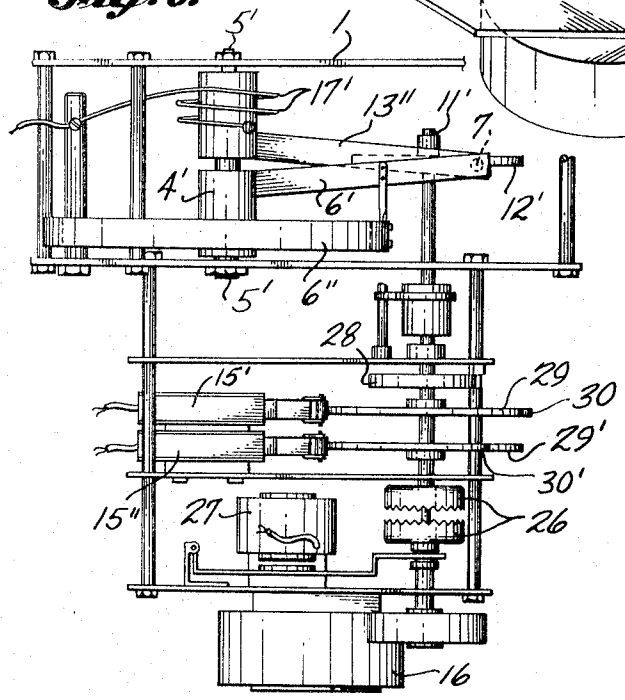


Fig. 6.



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AMBIENT TEMPERATURE-MODIFIED TEMPERATURE-ALTERING CONTROL MECHANISM

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Filed Oct. 22, 1965, Ser. No. 501,074
5 Claims. (Cl. 200—136)

This application is a continuation-in-part of application Ser. No. 358,551, filed Apr. 9, 1964, for Ambient Temperature - Modified Temperature - Altering Control Mechanism, now abandoned.

This invention relates to temperature-altering control mechanism, such as used for controlling a building heating or cooling system, which is modified in its operation by the ambient or outdoor temperature and wind.

During the winter it is customary to initiate the heating operation of a building heating system several hours prior to daytime use of the building, whether it be an office building, a school, a factory, an apartment building or a church. In order for such a building to be substantially at the desired operating temperature when daytime use of the building begins it is necessary for such initial heating to extend over a longer period during cold weather than when the weather is warmer. It is difficult to predict what the morning temperature will be on any particular day, so that it is impossible to set the duration of the initial heating period accurately in advance. Apparatus is provided in modern heating systems for such heating operation of the heating system to be initiated automatically by setting a time clock, so that it is not necessary for a janitor or custodian to be present to start the operation of the heating system. To avoid complaints it has been the practice for such a time clock control mechanism to be set adequately early, but this practice results in the heating of the building extending over an unnecessarily long period in most instances, which is uneconomical.

The same problem arises in connection with the operation of air-conditioning equipment to cool a building during the summer. In order for the building to be comfortably cool at the beginning of its daytime use it is necessary to initiate the operation of the air-conditioning system several hours earlier during hot weather. Again, it has been the practice for the operation of the air-conditioning equipment to be initiated by the time-clock mechanism in order to avoid the necessity of an attendant arriving early, which, in most instances, has resulted in the air-conditioning equipment being operated for a considerably longer period than necessary in the morning, which is uneconomical.

The principal object of the present invention is to modify temperature-altering control mechanism, whether such mechanism is used to control a heating system or an air-conditioning or cooling system, so that its operation for establishing the desired temperature of the building initially in the morning will be altered generally in accordance with ambient or outdoor temperature and wind. Such modifying apparatus will be operated in conjunction with the usual time-clock-operated control mechanism.

Another object is to provide such modified control mechanism which will not interfere with manual selection of the maximum initial temperature-altering period during which heating or air-conditioning apparatus would be in operation.

Specifically it is an object to provide such mechanism which can be utilized to control the operation of a building heating system, a building cooling system, a building air-conditioning system or a heating or cooling building ventilation apparatus.

It is also an object to provide such control mechanism which will serve to modify the usual temperature-responsive temperature-altering control mechanism only during the initial temperature-establishing period of the system, and which will be rendered inoperative and reset to an initial condition when it has exercised its control function of initiating operation of the temperature-altering apparatus at the proper time.

Another object is to provide modifying control mechanism which will regulate the length of the initial temperature-establishing period for the day during which temperature-altering apparatus will operate in accordance with the relationship between ambient weather conditions and the desired building temperature, so that the duration of the initial temperature-altering period will be sufficient, but only sufficient, to bring the building temperature up or down to the desired daytime temperature level by the beginning of the daytime use period. The control should also take into consideration the temperature which is maintained in the building at night, and the effect of wind on the duration of the start-up heating or cooling period.

A further object of the present mechanism is to utilize a construction which can be adapted readily to buildings of different design, having different degrees of insulation and/or different types or capacities of heating, cooling or air-conditioning equipment.

Despite the versatility and effectiveness of the control mechanism of the present invention it is an object for such mechanism to be of simple and economical construction, having few components and being rugged in construction.

In general, the control mechanism of the present invention utilizes a combination of conventional commercially available components in conjunction with any type of time-clock-controlled operation-initiating mechanism. A practical form of the modified control mechanism includes a short-period auxiliary timer, operation of which is initiated at a selected time by time-clock mechanism. This timer drives a timer-controlled arm carrying a contact engageable with a contact on a temperature-sensitive cantilever bimetallic strip, which will be flexed in response to changes in ambient temperature sensed by such strip. Relays in an electric circuit, including the contact members, will activate a circuit of the control mechanism upon engagement of the contacts to initiate operation of the heating, cooling or air-conditioning apparatus to stop the timer mechanism and to reset it preparatory to a further similar controlling operation being effected on the following day. A further contact can be provided for closing the circuit to afford at least a minimum initial operation of the temperature-altering apparatus, even though the contact member of the temperature-responsive element is not engaged.

FIGURE 1 is a plan of control mechanism incorporating the present invention and FIGURE 2 is a section through the mechanism taken on line 2—2 of FIGURE 1.

FIGURE 3 is a detail plan of an adjusting component of the mechanism.

FIGURE 4 is a wiring diagram for the mechanism.

FIGURE 5 is a top perspective of a somewhat modified type of control mechanism, parts being broken away, and FIGURE 6 is a side elevation of such mechanism with parts broken away.

FIGURE 7 is a section of wiring diagram showing a modification of the wiring diagram of FIGURE 4.

FIGURE 8 is a wiring diagram of an alternate type of control mechanism according to the present invention.

As has been mentioned above, the control mechanism of the present invention can be used to control the temperature of a first environment by using either heating, cooling or air-conditioning apparatus, all of which can be designated generally as temperature-altering apparatus.

For purposes of illustration, however, the control mechanism will be described below as being applied to a building heating system. In whatever type of installation it is used the control mechanism can operate simply to energize an electric control circuit. Such control circuit may be operatively connected to fuel supply mechanism for heating apparatus, to damper control mechanism for such heating apparatus, to refrigeration apparatus of a cooling system or to a fan or other component of air-conditioning apparatus. In each case the intended function of the particular control mechanism component with which this invention is concerned will have been accomplished when the control circuit mentioned above has been energized initially.

The modifying component of the control mechanism with which the present invention is particularly concerned is quite compact and can be housed in a small housing **1**, as shown in FIGURES 1 and 2. The only elements of the mechanism shown as being located externally of the housing are the calibrating or adjusting elements **2** and **3** for setting the initial position of the ambient-temperature sensing device of the mechanism. As shown in FIGURE 3, adjustment of the disk **3** can be effected by rotating it relative to suitable index marks, and after the desired adjustment has been effected the disk can be secured in place by tightening the clamp **2** to lock the periphery of the disk. Such disk is secured to the end of a shaft **4** mounted by a bearing **5**.

The ambient temperature-sensing device is preferably in the form of a temperature-sensitive bimetallic strip arm **6** mounted in cantilever fashion on shaft **4**, as shown in FIGURE 2. The temperature-sensitive bimetallic strip should be located in a position such that it will be bent in response to changes in ambient temperature, while being protected from rain, snow and ice by the housing **1**, even if such housing itself were directly exposed to the weather. As seen in FIGURE 1, an increase in temperature would cause the outer end of the bimetallic strip to move counterclockwise, whereas a reduction in temperature would cause the outer end of such strip to move instead in a clockwise direction. Mounted on the outer end of the strip is an electrical contact **7**. An alternate electric contact **8** is mounted on the outer end of a second cantilever arm **9**, the supported end of which is also secured on shaft **4**.

Contact **8** simply serves as a limit contact and it will be positioned on shaft **4** relative to arm **6** in a manner such that the contact **8** will effect energization of the temperature-altering apparatus at least a minimum time before the beginning of the daytime use period of the building. Since both of the arms **6** and **9** are mounted on the same shaft, rotative adjustment of such shaft by turning disk **3** will cause conjoint adjustment of the arms **6** and **9**. The entire shaft and arm assembly is supported on the inner wall of the housing **1** by a suitable bracket **10**.

Shaft **4** also constitutes the support for timer-controlled contacts engageable respectively with the contacts **7** and **8**. On shaft **11** is mounted a cam **12**, the periphery of which is in engagement with the edge of an arm **13** remote from the arms **6** and **9**. The supported end of arm **13** is journaled on shaft **4** so that such shaft constitutes pivot means guiding the arm **13** for swinging about the axis of shaft **4**. A spring leaf **13'** has one end anchored in the outer end of arm **13** and projects outwardly from such arm. On this spring leaf are mounted contacts **14** and **15** located in positions radially of shaft **4** corresponding to the positions of contacts **7** and **8**, respectively, radially of such shaft. Such spring leaf permits some over-travel of arm **13** to enable firm engagement of the contacts.

The timer-controlled arm **13** is swung toward arms **6** and **9** by rotation of shaft **11** effecting swinging of cam **12**. Such shaft is driven by the short-period auxiliary timer **16** in one direction during the period of timer operation and the arm is held in contact with the periphery of cam **12** by the tension spring **17** connected between the timer arm and the housing **1**. The angle through which arm **13** is swung depends on the shape of the periphery of cam **12** and the rate of rotation of shaft **11**. The cam is designed so that arm **13** will be swung through a pre-determined angle for a particular angular movement of shaft **11** and cam **12**. This cam is designed to provide different relationships between swinging of arm **13** and rotation of timer shaft **11** for different specific applications.

The wires **18** in FIGURE 1 simply indicate that connections will be made in suitable fashion from the contacts **7**, **8**, **14** and **15**, and the timer **16** to the remainder of the control mechanism. For this purpose the arms **6** and **9** or contacts **7** and **8** can be connected together electrically, and the contacts **14** and **15** can be connected together electrically, but the arm **13** and the contacts **14** and **15** carried by it must be insulated from the arms **6** and **9** or contacts **7** and **8**. The reason for such electrical isolation will be evident from the wiring diagram of FIGURE 4.

Any suitable power source, such as the constant output voltage transformer **19**, can be provided to power the control mechanism as a whole. As has been mentioned, the present invention simply modifies temperature-altering control mechanism incorporating a time clock **20**, indicated diagrammatically in FIGURE 4, which can be set for the earliest possible desired time at which the heating system or cooling system, as the case may be, might be energized on the coldest or the hottest day. Switch **21** of such time clock will be moved from the open position, shown in FIGURE 4, to the closed position at that time. At the end of the heating or cooling period for the day the time clock will move switch **22** from the closed position, shown in FIGURE 4, to the open position to deenergize the temperature-altering mechanism.

Operation of the time clock **20**, the short-period auxiliary timer **16** and the contacting mechanism described can be coordinated by two conventional relays **23** and **24** to control energization of the temperature-altering control mechanism circuit **25**, which effects energization of the temperature-altering heating apparatus or cooling apparatus.

As the operation-initiating switch **21** is closed by the time clock **20**, the coil of relay **24** will be energized through a normally-closed contact of relay **23**. A circuit-holding armature of relay **24** will maintain this relay energized through the same normally-closed switch of relay **23**, even though time-clock switch **21** should open. At the same time movement of another armature of relay **24** will complete a circuit through the same normally-closed switch of relay **23** to initiate operation of auxiliary timer **16** to rotate shaft **11**. Such rotation of the shaft will continue until cam **12** has swung arm **13** far enough so that either contact **14** on this arm will engage contact **7** on arm **6** or contact **15** on arm **13** will engage contact **8** on arm **9**.

Engagement of contact **14** with contact **7** or contact **15** with contact **8** will complete a circuit to energize the coil of relay **23** if the deenergizing switch **22** of the time clock is in the circuit-closing position shown in FIGURE 4. Energization of such relay will close a normally-open holding switch armature so that such relay coil will remain energized even though contacts **14** and **15** are withdrawn from contacts **7** and **8**, and such relay will remain energized as long as switch **22** is closed. Energization of this relay will, however, open the normally-closed switch in circuit with the holding switch of relay **24**, so that such relay will be deenergized and the timer **16** also will be deenergized and will immediately be reset to its initial position by reverse rotation of the shaft **11** and cam **12**.

The third effect of the energization of relay **23** is that the normally-open switch in the circuit **25** will be moved to closed position and will be held in this position as long as this relay is energized. Consequently the heating

or cooling apparatus will remain energized until relay 23 has been deenergized by opening of switch 22 effected by the time-clock mechanism. Even though switch 22 were to be closed again relay 23 would not be reenergized, but the entire control mechanism would remain deenergized until the time clock 20 closes switch 21 again the next morning, by which action the control sequence described above would be repeated.

It will be evident that the longer auxiliary timer 16 operates after switch 21 is closed by the time-clock mechanism, the greater will be the saving in the operation of the temperature-altering apparatus. Consequently if the control mechanism is being used to control a heating system the bimetallic arm 6 should be arranged so that as the ambient outdoor temperature rises contact 7 will be moved away from the timer, whereas if the temperature should drop contact 7 would be moved toward the timer by bending of the bimetallic arm. Conversely, if the control mechanism were used for controlling air-conditioning apparatus the bimetallic arm 6 should be of such construction that an increase in temperature would cause contact 7 to move toward the timer so that the air-conditioning operation would start earlier, whereas if the temperature should decrease the bimetallic strip would move contact 7 away from the timer to reduce the period during which the air-conditioning apparatus would operate prior to the beginning of the building utilization period of the day. The maximum warmup period which will ever be required, however, will be only a few hours, so the maximum period during which the auxiliary timer needs to operate will be only a short period of a few hours. As has been mentioned previously, rotation of disk 3 will adjust the initial position of the bimetallic bar 6, depending upon the particular characteristics of operation of the control mechanism desired.

In FIGURE 5 temperature-altering control mechanism, generally similar to that shown in FIGURES 1 and 2, is illustrated, but the various components are shown somewhat less diagrammatically. In this instance the hub 4' is loosely mounted on the shaft 5' and carries the arm 6' on which the contact 7 is mounted. Swinging of this arm is governed by the temperature-sensitive bimetallic coil 6''. Cooperating with arm 6' is arm 13'', which is carried by a hub also rotatively mounted on rod 5'. This arm is swung toward arm 6 by the cam 12', carried by shaft 11', being engaged with such arm. Contact of the arm with the periphery of the cam at all times is assured by the helical spring 17' engaged with the hub of the arm.

The cam shaft 11' is rotated by the timer 16 when the clutch members 26 are in engagement. Engagement of such clutch members is effected by the electromagnet coil 27. The timer includes gearing to rotate the shaft very slowly, and when such rotation has caused cam 12' to move arm 13' so that its contact 14' engages the contact 7, a circuit will be completed which will deenergize the coil of the electromagnet 27 to disengage the members of clutch 26. Thereupon the spiral spring 28, which will have been stressed by such rotation of shaft 11', will act to return such shaft to its initial position.

The control circuit utilized for the control mechanism shown in FIGURES 5 and 6 can be very similar to that shown in FIGURE 4, which has been described above. In FIGURE 7 the components of the control mechanism shown in FIGURES 5 and 6 which are directly associated with the timer are shown, it being understood that the rest of the circuit and electrical components can be identical with those of FIGURE 4. Thus, in order to enable the cam 12' to be reset easily, the clutch 26 has been provided to disconnect the timer motor from the cam drive shaft 11'. The coil 27 of the clutch will be energized at the same time that the timer motor is energized, but when the circuit to the timer is broken, either by closing of switch points 7 and 14' or by closing of the switch 8', 15', the timer motor will be deenergized and the coil of the clutch-holding electromagnet will be deenergized so that the clutch will be disengaged to enable the cam to be returned to its starting position by the spring 28, as described above.

If arm 6' should be held in a position by the bimetallic element 6'' so far from arm 13' that contact 14' has not engaged contact 7 before the cam lobe 30 of disk 29 has engaged the arm of switch 15' the switch actuation thus effected will energize relay 23 to deenergize the timer 16 and the coil of the electromagnet 27 to disengage the clutch 26. An additional control switch 15'' can be actuated by the cam lobe 30' on disk 29' to break directly the clutch electromagnet and timer circuits, as shown in FIGURE 7, if the relay 23 should fail to operate.

When the wind is blowing heat will be removed from the control box 1 more rapidly than would be the case if the air were still. The temperature-sensitive bimetallic coil 6'' in the box 1 is affected not only by the atmospheric temperature, but also by heat created by the timer motor 16 and the clutch-actuating electromagnet coil 27. Additional heat may be supplied to the container by a supplemental heater 31, if desired, which is shown in FIGURE 7. This coil is connected in parallel with the timer motor and the electromagnetic coil for clutch 26 so that it will be energized at the same time as the timer and timer clutch. The coil will be selected so that its heating value will provide proper response under various wind conditions.

In FIGURE 8 a different type of control mechanism is illustrated, which will accomplish the same purpose. In this instance, instead of the timer and the associated component being subjected to exterior atmospheric temperature, only a temperature-sensing device is thus exposed. Such temperature-sensing device is shown in FIGURE 8 as the temperature-sensitive resistance 34 mounted in the enclosure 33. Such a temperature-sensitive electrical resistance may be a thermistor in which the resistance decreases as the temperature increases. Such thermistor is connected in a Wheatstone bridge circuit in conjunction with the other resistances 35, 36 and 37 of the bridge circuit. Such bridge circuit is powered by a suitable source of regulated power, for example, as the transformer 32 which is energized by a time clock. Closing of a circuit by the time clock will initiate operation of the control mechanism.

The output connection points of the bridge are connected to opposite ends of a potentiometer winding 38. The arm 39 of such potentiometer is driven by a timer-operated shaft, such as the cam drive shaft 11' of the short-period auxiliary timer 16 shown in FIGURES 4, 5, 6 and 7. One end of the potentiometer winding and the potentiometer arm are connected to a temperature-altering control device 40 which is labeled "heat control" in FIGURE 8 when it controls a furnace, for example. Alternatively, as explained above, such control could be used to operate dampers or air-conditioning equipment for either heating or cooling. The timer for driving arm 39 will be powered by electricity from the same time-clock control source as transformer 32, and power for the timer may be received from such transformer.

The resistance value of the temperature-sensitive electrical resistance 34 being influenced by the atmospheric temperature will determine the flow of current through the potentiometer winding 38. The heat control 40 includes an electrical trigger circuit which will be triggered to effect start-up of the heating system, for example, by closing the circuit between power supply and the temperature-altering apparatus when the level of current flow to the temperature-altering control mechanism circuit has reached a predetermined value. Both the flow of current through winding 38 and the position of the potentiometer arm with reference to the winding will influence the value of the current flowing to the temperature-altering control mechanism circuit. When the combination of current flow and potentiometer arm position combine to produce the triggering current flow, operation of the furnace will be started and operation of the timer will

be stopped and the potentiometer arm **39** will be reset to its initial position by rotation of shaft **11'** ready for the next start-up operation.

Depending upon the heating characteristics of a particular building a special drive for the potentiometer arm **39** may be provided, or a graduated resistance winding may be used as the potentiometer winding **38**. Also, depending upon the particular climatic conditions, an auxiliary heating resistance **31'** can be included in the enclosure for modifying the effect of ambient outdoor temperature on the temperature-sensitive resistance **34**. The supplemental heating effect of such a resistance is desirable in windy climates because, just as wind can increase considerably the heating requirements of a building, so wind will extract heat through the walls of the container **33** by conduction to provide the same effect on the temperature-sensitive resistance **34** as would a lower ambient temperature.

I claim:

1. Control mechanism comprising temperature-altering control means for controlling the operation of temperature altering apparatus in altering the temperature of a first environment, power-supply means, a time clock, short-period auxiliary timer means separate from said time clock, timer-energizing means actuatable by said time clock at a preselected time for initiating operation of said auxiliary timer means, temperature-sensing means responsive to changes in temperature of a second environment, electric circuit-closing means connected to said auxiliary timer means, said temperature-sensing means, said power-supply means and said temperature-altering control means for closing a circuit between said power-supply means and said temperature-altering control means by predetermined coaction of said auxiliary timer means and said temperature-sensing means after a delay period the duration of which is governed by the temperature effect of such second environment on said temperature-sensing means, and timer-deenergizing means connected to said auxiliary timer means and said temperature-sensing means and operable by such predetermined coaction thereof to deenergize said auxiliary timer means preparatory to reenergization thereof by said timer-energizing means under the control of said time clock.

2. The control mechanism defined in claim **1**, in which the temperature-sensing means includes a temperature-sensitive cantilever bimetallic strip, and the electric circuit-closing means includes a first contact carried by said bimetallic strip and a timer-moved member moved by the auxiliary timer means and carrying a second contact engageable with said first contact by movement of said timer-moved member.

3. The control mechanism defined in claim **2**, and a third contact carried by the timer-moved member, and a limit contact engageable by said third contact on predetermined movement of the timer-moved member to deenergize the auxiliary timer means.

4. The control mechanism defined in claim **1**, in which the timer-deenergizing means includes resetting means for actuating the auxiliary timer means to return it to an initial position in which it is conditioned for reenergization by the timer-energizing means.

5. The control mechanism defined in claim **1**, in which the temperature-sensing means includes a temperature-sensitive electrical resistance, the electric circuit-closing means includes a bridge circuit and a potentiometer connected to said temperature-sensitive electrical resistance, and the auxiliary timer means is connected to drive the contact arm of said potentiometer.

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