Dec. 24, 1963 T. K. KJELLMAN 3,115,557

HUMIDISTAT ADAPTABLE FOR RESPONSE TO CHANGES IN RELATIVE OR ABSOLUTE HUMIDITY OR FUNCTION AS A THERMOSTAT

Filed Oct. 9, 1959

FIG. 1.

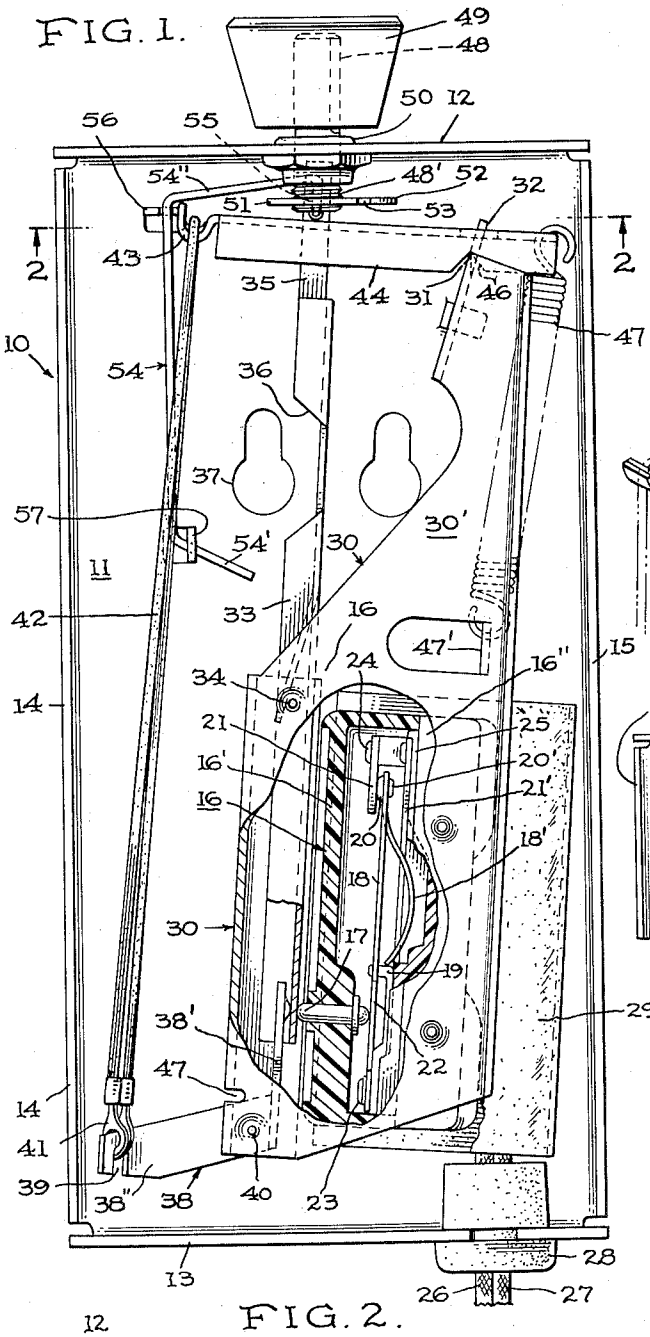
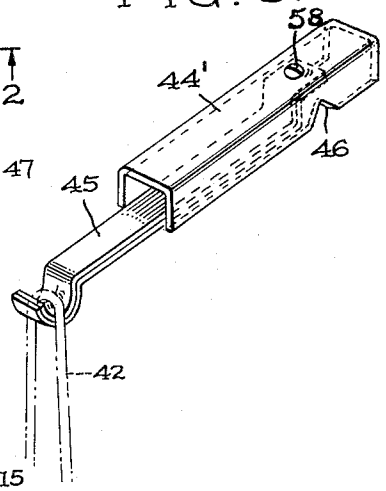


FIG. 3.



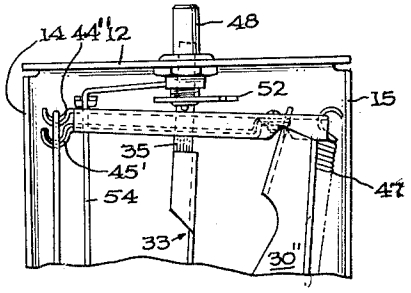


FIG. 4.

FIG. 5.

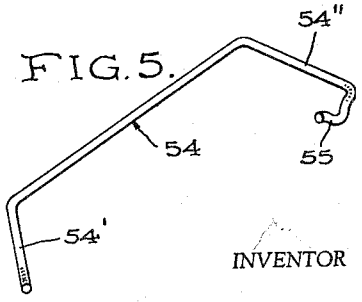
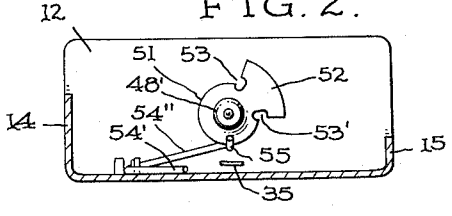


FIG. 2.



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HUMIDISTAT ADAPTABLE FOR RESPONSE TO CHANGES IN RELATIVE OR ABSOLUTE HUMIDITY OR FUNCTION AS A THERMOSTAT

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2 Claims. (Cl. 200—61.06)

The instrument disclosed herein has structural features in common with the humidistat of the Kjellman et al. Patent No. 2,897,304 (common assignee), plus improvements directed primarily to the adjusting and setting mechanism; and it also incorporates means whereby it may be easily and quickly utilized as a control responsive to changes in relative humidity and absolute humidity or function as either a humidistat or a thermostat.

In the humidistat of Patent 2,897,304, when the control or setting knob is turned in a direction to tense the humidity-responsive element (increase relative humidity) to and beyond the maximum calibrated relative humidity setting, it moves a rotatable stop member against a positive "off" stop effective to cut a dehumidifier under control of the humidistat out of its electric power circuit; and when the said knob is turned in the opposite direction to and below the lowest calibrated relative humidity setting, the same stop member comes up against the said stop but in the opposite direction, whereupon the dehumidifier will remain on, subject to manual control. These settings are rendered possible by a manually-operable switch lever which may be utilized to control the humidistat switch independently of the automatic humidity-responsive control; and coacting with this lever is a cam sector (the stop member above noted) formed on a cam which is secured on the setting screw shaft exteriorly of the end wall of the humidistat casing, and when rotated in either direction beyond the calibrated range, causes the segment to abut the outer end of said lever and flex it into switch-operating position. A spring-wire key frictionally engages the screw shaft for the purpose of maintaining the latter in its preset or adjusted position. This external cam has proved to be an annoyance in certain instances in that it impedes installation in cramped spaces, and it also detracts somewhat from the appearance of the instrument; and the spring clip or key does not firmly hold the switch lever in its on or off position. In the herein disclosed humidistat, that "on-off" stop assembly consists of a simple detent cam and coacting spring wire detent member which is not only capable of fulfilling the function of the original assembly but in addition holds the switch lever firmly in either its "on" or "off" position, provides "feel" for the screw shaft and gives an audible "click" when the "on" or "off" position is reached.

An object of the present invention, therefore, is to improve the "on-off" assembly of the humidistat of Patent No. 2,897,304.

Another object is to provide a humidistat which, by simply substituting an easily-removable and replaceable part, is rendered capable of controlling air-conditioning apparatus as a function of relative humidity, absolute humidity or temperature, or a combination of relative humidity and temperature.

The foregoing and other objects and advantages will become apparent in view of the following description taken in conjunction with the drawings, wherein:

FIG. 1 is a view in elevation of a humidity control device or humidistat in accordance with the invention, the cover thereof being removed and part of the switch housing being broken away and shown in section;

FIG. 2 is a reduced sectional view taken substantially on the line 2—2, FIG. 1;

FIG. 3 is a detail view of a modified type of lever assembly for use with the humidity-responsive element of FIG. 1 and whereby the instrument of FIG. 1 may be adapted to control as a function of relative humidity, absolute humidity, temperature, or a combination of relative humidity and temperature;

FIG. 4 is a view of a further modification of said lever assembly by means of which the humidistat of FIG. 1 may be adapted to control in the manner set forth with respect to FIG. 3 without necessitating the substitution of parts; and

FIG. 5 is a detail perspective view of a wire spring detent member forming part of the manual control assembly.

The particular type of humidistat used to illustrate the present invention is adapted to be mounted directly on a dehumidifier, not shown; it utilizes a snap-action switch similar to that of Patent 2,897,304 above noted. Also, in the example shown, the switch is wired for a normally-closed circuit, causing the drive motor for the dehumidifier to run continuously until the humidity of the surrounding air attains a preselected moisture content, whereupon the humidity element (which in the present instance is composed of a hair rope or plurality of strands of human hair) tenses to a point where the switch contacts separate, breaking the motor power circuit. By a rearrangement of the circuitry in a manner obvious to those skilled in the art, the humidistat could be rendered operative to work in the reverse cycle, or it could be adapted to control apparatus effective to both humidify and dehumidify the air.

Referring to FIGS. 1 to 3, inclusive, the working parts of the humidistat are supported by a mounting bracket, generally indicated at 10 (which if a cover is used forms the back half of a case for the humidistat), having a back wall 11, end walls 12 and 13, and side flanges 14 and 15.

The switch proper comprises a relatively small compact unit, generally indicated at 16, the working parts of which are encapsulated in a case of molded composition material made up of two parts 16′ and 16″. The part 16′ contains a plunger-type switch button 17 while the part 16″ contains a snap-action, terminal-bridging leaf spring strip 18, having a bowed and stressed toggle spring tongue 18′, which gives a toggle action to the spring strip 18, said tongue 18′ being cut longitudinally out of the strip 18. The free end of the toggle spring tongue 18′ projects towards the fixed end of the strip 18 and engages a fixed abutment 19. Contacts 20 and 20′ are secured on opposite sides of the free portion of the strip 18 and are adapted to engage coacting terminal contacts 21 and 21′. The spring strip 18 is stamped out with a cross piece 22, which bears against the inner end of the plunger button 17 and urges the latter outwardly against a manually operable "on-off" switch lever 33, to be described. The switch 16 has three external wiring terminals 23, 24 and 25. Terminal 23 connects the fixed end of strip 18 into the circuit, 24 connects the contact 21 into the circuit, and 25 serves to connect contact 21′ into the circuit. When using a normally-closed type circuit as illustrated herein, terminals 23 and 24 only are wired into the supply circuit by leads 26 and 27, brought out through grommet 28 to provide a power cord, and the terminal 25 remains "dead." The bowed spring toggle tongue 18′ tends to snap the contact end of the spring strip 18 past dead center. In the present instance, the strip 18 is biased in a direction opposing depression of the plunger button 17, not only by the spring action of the strip itself but also by the toggle effect of the bowed tongue 18′. Therefore, unless the pressure on said button is sufficient to overcome the toggle thrust of the spring tongue 18′, contacts 20 and 21 will remain closed, as shown in FIG. 1. When the button is de-

pressed, the spring strip 18 and toggle tongue 18' combine to resist contact separation until the pressure builds up to a predetermined value, whereupon the strip 18 snaps the conatct 20' against 21'. However, the spring strip 18 is then still biasing the plunger button to return position although the intermediate portion of said strip has been deflected past the dead-center line of thrust of the tongue 18', which contributes the toggle action to the throw of the switch. When the plunger button 17 is in its "out" position with contacts 20 and 21 in engagement, the spring strip 18 bridges the terminals 23 and 24.

The member indicated at 29 is a piece of insulation fabric to ensure against voltage breakdown between the switch and its adjacent supporting structure.

The entire switch-operating mechanism is assembled to a single one-piece mounting bracket, generally indicated at 30, having a side flange or wall 30', which projects forwardly in a gradually relieved portion and terminates in a knife edge 31, having a tongue 32 projecting therefrom. The manually operable "on-off" switch lever 33 is in the form of an elongated channel-shaped piece of sheet metal having its side flanges pivoted at an intermediate point on a swivel pin 34, the latter at its opposite ends being anchored in the side walls of the bracket 30. At its inner end (lower end as viewed in FIG. 1) the switch lever 33 bears against the exposed end of the plunger button 17, while at its outer end the one side flange of said lever terminates in a projection 35, the purpose of which will be subsequently described. The relieved portions 36 of the side flanges of the lever 33 permit a limited amount of deformation should such become necessary to accurately locate the outer projecting end 35 during assembly and they also provide clearance for anchor screws, not shown, having heads adapted to project through key-shaped hanger slots 37.

An automatically-controlled switch lever is indicated at 38; it is formed with side lugs by means of which it is swiveled on a pin 40 projected through the adjacent side walls or flanges of the bracket 30. The lever 38 is generally in the form of a bell crank, one part 38' of which overlaps the contiguous end of the switch lever 33 and functions to depress switch button 17 when the lever (38) is rocked in a clockwise direction, and the other part of which is in the form of an arm 38'', terminating in a hook 39, in which terminals 41 for the free ends of a humidity element 42 engage, said element in the present instance being of a type which is responsive to changes in relative humidity but non-responsive to changes in temperature over the temperature range to be controlled. A hair rope or cable made up of a multiple of strands of human hair meets this requirement over the required temperature range.

At its opposite end the hair element is hooked over a saddle 43, formed on the outer end of a channel-shaped adjusting lever 44. In FIG. 3, the lever 44 is adapted to receive a bimetal element 45, to provide an absolute humidity control, as will be more fully described hereinafter. The channel-shaped lever 44 may be conveniently fabricated from sheet metal and has its side flanges notched or recessed at 46, by means of which it is fulcrumed on the knife edge 31 of the projection 35, the tongue 32 projecting through an opening formed in the end wall of the channel, holding the lever 44 against sidewise displacement. A spring 47 is connected at one end to a lug 47', punched out of the adjacent wall of the bracket 30, and at its opposite end to the contiguous end of the lever 44. Spring 47 normally biases the lever 44 in a clockwise direction as viewed in FIG. 1, tensioning the hair element 42 to a degree determined by the setting of said lever in a manner to be described. When the tension on the humidity element exceeds a predetermined or selected value, the button 17 will exert sufficient force on the spring strip 18 to snap contacts 20, 21 to open position.

An adjusting and setting screw is indicated at 48; it is

in the form of a short shaft having an inner threaded portion 48' terminating in a pointed end adapted to abut the lever 44. A finger knob 49 is secured on the outer D-shaped end of screw 48; it may be suitably calibrated in increments of relative humidity where the instrument is adapted to control as a function of relative humidity only, as in FIG. 1. Screw shaft 48 is journaled in an internally-threaded bushing 50, having an exterior hexnut portion to facilitate angular location of the knob 49 when calibrating the instrument.

Up to this point the humidistat of FIG. 1 is generally similar to that of the Kjellman et al. Patent 2,897,304 with the exception that the projection 35 on the outer end of manual control lever 33 terminates short of the end wall 12 of the case 10. The features of difference are directed to the "on-off" control cam, here indicated at 51, and the spring means coacting therewith to maintain the setting screw shaft 48 in its "on" and "off" positions and in addition provide the proper "feel" when rotating the screw shaft to a selected setting.

Cam 51 is preferably in the form of a thin metallic washer having a radially-projecting cam sector 52, formed with edge detent notches 53 and 53'. Substantially positive "on-off" stop means is provided in the form of a length of spring wire 54, having its inner end (lower end as viewed in FIG. 1) bent at an angle as at 54' and its outer (or upper) end also bent at an angle as at 54'' and terminating in a detent and friction spring member 55. The wire 54 is removably anchored in its assembled position by lugs 56 and 57, punched out from the metal of the case 10, the lug 56 having an open notch to receive the body of the spring and the lug 57 having an eye in which the end 54' of the spring wire is inserted. The active or detent end 55 of the wire 54 frictionally engages the surface of cam 51 to provide the proper "feel" for set screw 48; and when said cam is rotated to either its "on" or "off" position, the effective edge of the cam segment 52 first engages the projecting end 35 of manual control lever 33 and flexes the said lever to its "on" or "off" setting, following which the said detent spring end 55 engages in either the notch 53 or 53' with an audible "click" and releasably yet firmly holds the screw 48 against reverse rotation. The advantages of this arrangement will be more fully explained in the description of operation.

Operation

The hair strands which make up the humidity element or cable 42 will contract as the moisture content or the relative humidity of the air decreases and will expand when the moisture content increases. However, a characteristic of human hair is that it is substantially unaffected by changes in temperature at least within a tempertaure range well beyond that to be controlled. As heretofore noted, the humidistat as shown in FIGS. 1 and 2 is adapted to control a dehumidifier; it will cause the latter to run and extract moisture from the air in a confined area as long as the relative humidity is above a predetermined or selected value, but when the humidity drops below such value, the machine will stop until the relative humidity or moisture content again increases above the preset value. If sufficient pressure is applied in a clockwise direction to the outer extremity of the manual switch lever 33 beyond its pivotal pin 34 as viewed in FIG. 1, the pressure of the lower or inner end of said lever on the switch button 17 will be overcome by the force of the spring strip 18 and the latter will snap in a direction to move contact 20 against 21 (the position of the parts in FIG. 1), closing the dehumidifier drive circuit, not shown; counterclockwise pressure on the upper end of lever 33 causing the inner end of said lever to depress said button, whereupon the spring strip 18 will snap in a direction to move contact 20 clear of 21 and open the circuit.

Counterclockwise and clockwise pressure is applied on the outer end of lever 33 only when the cam sector 52

of the thin metal cam 51 is rotated manually beyond maximum and minimum calibrated settings. If the bell crank arm 38'' of switch lever 38 is rotated in a clockwise direction a certain distance, as by contraction of the humidity element 42, the said lever will reposition the switch button 17 through the inner or lower end of the manual switch lever 33 in a circuit-breaking direction (press the button 17 inwardly), and if said arm is rotated counterclockwise, the switch button is repositioned in a circuit-closing direction by the spring strip 18. The degree of travel and force required to throw spring strip 18 are constant factors, hence the degree of rotation imparted to bell-crank switch lever 38, permitted by contraction and expansion of the humidity element 42, is the only variable to be determined by adjustment of the lever 44.

The force of the spring 47 pulling on the fulcrum lever 44 is greater than the force required to snap the spring strip 18 of the switch unit 16 to circuit-break position. Hence, once the position of lever 44 is set by adjustment of the screw shaft 48, any contraction of the humidity element 42 will act only on the lever 38.

In the position of the parts as shown in FIG. 1, it will be assumed that the adjustment is such that the humidity element 42 is just slack enough to permit the switch contacts 20 and 21 to remain in engagement, closing the circuit to the dehumidifier drive motor, not shown, so that the machine is running and extracting moisture from the air. Should now the relative humidity decrease below the setting of the humidistat, the hair element 42 will contract and urge the switch lever 38 in a clockwise direction until the spring strip 18 snaps the contacts 20 and 21 to open position, breaking the circuit to the drive motor of the dehumidifier. Should the moisture content of the air increase to a point above the relative humidity setting, the reverse action takes place, i.e. the strands of hair which make up the humidity element or cable 42 will become increasingly slack until the lever 38 relieves its pressure on the switch button 17, whereupon the switch button is urged outwardly by the spring strip 18 until the latter again snaps in the opposite direction and contact 20 engages contact 21, closing the circuit to the said drive motor.

To increase the relative humidity setting of the humidistat, the control knob 49 and consequently the screw shaft 48 is turned in a counterclockwise direction facing the end wall 12 (looking down in FIG. 1), thereby backing off the inner threaded end of said shaft from the channel-shaped lever 44. The force of spring 47 will then be applied by way of the hair element 42 and bell crank lever 38 on the plunger button 17 and reposition the latter inwardly. This assumes, of course, that the hair element is at this time taut; if not, the plunger button will not be affected until the humidity decreases to a point where the slack in the humidity element is taken up.

If the screw shaft 48 is rotated in a counterclockwise direction beyond the maximum relative humidity setting, the one edge of the cam sector 52 (the right-hand edge as viewed in FIG. 2), engages the contiguous edge of the projection 35 on the outer end of the lever 33 and flexes the latter to a point where the switch button 17 causes the spring strip 18 to snap the contacts 20 and 21 to open position. At this moment, the active or detent-spring end 55 of wire 54 snaps with an audible click in the notch 53' and firmly withstands the reverse torque force of the lever 33. This ensures against slippage of the screw shaft from its "off" setting while at the same time the said screw shaft may be reversed by the application of a predetermined amount of turning force. If the hair-strand humidity element remains intact, control of the supply circuit will be automatic or normal when the screw shaft 48 is rotated back within the calibrated range of the humidistat. However, should the hair element be broken, the dehumidifier will be under manual control to the extent that it can be turned off in the manner above noted, and it can also be turned on by rotating the screw shaft 48 in a clockwise direction until the cam segment or sector 52 relieves its pressure on the lever 33, whereupon the latter in turn relieves its pressure on button 17, permitting spring strip 18 to close the contacts 20 and 21.

During normal operation of the humidistat with the humidity element intact, there is usually a minimum and maximum calibrated range of adjustable control. Thus the upper limit of the range may be 80% relative humidity and the lower limit 20%. In certain installations, there may be occasions when it is desired to maintain the air in a space or area at a humidity below 20%. To accommodate such installations, if the screw shaft 48 is rotated in a clockwise direction to a point where the other edge (the left-hand edge as viewed in FIG. 2) of the cam segment 52 engages the opposite edge of the projection 35 on the outer end of the lever 33 and flexes the latter to a predetermined extent (toward the right as viewed in FIG. 2), the contacts 20 and 21 will close and remain closed and the dehumidifier will run continuously until the screw shaft 48 is rotated back within the calibrated range. Here again the active detent end 55 of the spring wire 54 comes into play by engaging in the notch 53 with an audible click and releasably yet firmly holds the screw shaft 48 in its setting against the reverse torque exerted by lever 33. As heretofore noted, the active end 55 of spring wire 54 also functions to give the proper "feel" to rotation of screw shaft 48.

Another advantage of having a manual control as above described is that should the humidistat go out of calibration while in use, an attendant can turn the dehumidifier on and off at will.

Adaptation of the Humidistat to an Absolute Humidity Control, a Temperature Control, or a Combination of Relative Humidity and Temperature

FIG. 3 illustrates how, by simply inserting a bi-metal element 45 in the channel-shaped lever 44', the instrument of FIG. 1 can be converted to an absolute humidity control, a temperature control, or a combination of relative humidity and temperature. The element 45 has its one end removably secured, as by screw 58, to the lever 44 adjacent the fulcrum point of the latter on the knife edge 31, its opposite end being formed with a hook or saddle to receive the hair element 42.

It is known that a hair element remains substantially unaffected by changes in temperature well below and above that to which most domestic and industrial air-conditioned areas are subjected. It will, however, respond to changes in relative humidity over such range. If now the action of the hair element is modified by, or correlated with that of the thermal element 45, the instrument will respond to changes in relative humidity, absolute humidity or a combination of relative humidity and temperature, depending upon the degree of response of the thermal element with respect to the hair element; and if the latter is replaced by a link which is non-responsive to changes in humidity, the instrument will control solely as a function of temperature. To obtain the desired response it may be more convenient in certain instances to substitute different hair ropes or elements, while in other instances it may prove more convenient to substitute different thermal elements, or a combination of both.

An example of a field of use for an absolute humidity response is where an industrial air conditioner is maintaining an area at 80° F. and 50% relative humidity during an eight-hour work day, and overnight the temperature drops to around 68° F. Assuming the absolute humidity remains constant, the relative humidity automatically increases to approximately 75%. By using a dehumidifier with an absolute humidity control, during working hours the air-conditioning system would maintain the desired temperature and relative humidity, while

at other times no dehumidification would take place since the moisture level remains substantially constant. Dehumidification would take place only when a new air mass of higher moisture content moved into the area. If the control responded to changes in relative humidity, frequent and unnecessary dehumidification would occur at times when the building or area was unoccupied.

FIG. 4 shows a further modification in the lever system whereby the instrument of FIG. 1 may be easily changed from a relative humidity to an absolute humidity control, or vice versa, simply by looping the hair element over the hook or saddle of the lever 44'' or that of the temperature-responsive element 45'. In this instance the bi-metal lever element 45' remains connected to the channel-shaped lever 44'' ready for use whenever desired.

What is claimed is:

1. A humidistat comprising a mounting bracket, a rotatable adjusting member having a threaded mounting in a wall of said bracket and terminating in a free abutment end inwardly of said wall, an electric switch unit having a resilient contact member adapted to move to circuit make-and-break positions, said contact member requiring an external force to move it to one of said positions and being spring-biased to the other of said positions, a pushbutton type plunger adapted to actuate said contact member to one of said positions against its biasing force, a first switch lever of generally bell-crank shape having an arm adapted to depress said plunger button and a lever arm projecting free, an adjusting lever movably supported adjacent the inner abutment end of said adjusting member, a spring biasing said adjusting lever toward the abutment end of said adjusting member, the one end of said adjusting lever projecting free in spaced relation to the free arm of said first switch lever, a humidity element consisting of a length of humidity-responsive material connected to the free arm of said first switch lever and the free end of said adjusting lever, a second switch lever fulcrumed at an intermediate point and having its inner extremity adapted to engage and actuate said pushbutton plunger independently of said first switch lever and its outer extremity terminating in the region of said adjusting member inwardly of said wall, a cam secured on the inner extremity of said adjusting member for rotation therewith and having a cam segment adapted to engage the outer end of said second-named lever when said adjusting member is rotated to either one of its extreme positions and actuates said pushbutton plunger independently of said first lever, said cam being provided with detent notches one for each extreme position, and a detent spring member adapted to releasably engage in one of said notches when the cam member is rotated to one of said extreme positions and retain the adjusting member in its set position, said detent member being in the form of a length of spring wire anchored in fixed relation to said cam and having its one extremity projecting free and shaped to frictionally engage the surface of said cam and provide "feel" for the rotatable adjusting member and snap with an audible click in one or the other of said notches when said cam is rotated to either one of its extreme positions.

2. In an instrument for controlling air-conditioning equipment, a mounting bracket, a rotatable adjusting member having a threaded mounting in a wall of said bracket, an electric switch unit having a resilient contact member adapted to move to circuit make-and-break positions, said contact member requiring an external force to move it to one of said positions and being spring-biased to the other of said positions, a pushbutton type plunger adapted to actuate said contact member to one of said positions against its biasing force, a first switch lever of generally bell-crank shape having an arm adapted to depress said plunger button and a lever arm projecting free, an adjusting lever movably supported adjacent the inner abutment end of said adjusting member, a spring biasing said adjusting lever toward the abutment end of said adjustment member, a substantially rigid temperature responsive element connected at its one extremity to said adjusting lever and having its opposite end projecting free in spaced relation to the free arm of said first switch lever, a humidity element in the form of a length of material responsive to changes in relative humidity but substantially non-responsive to changes in temperature over the control temperature range, a second switch lever fulcrumed at an intermediate point and having its inner extremity adapted to engage and actuate said pushbutton plunger independently of said first switch lever and its outer extremity terminating in the region of said adjusting member inwardly of said wall, a cam secured on the inner extremity of said adjusting member for rotation therewith and having a cam segment adapated to engage the outer end of said second-named lever when said adjusting member is rotated to either one of its extreme positions and actuate said pushbutton plunger independently of said first lever, said cam being provided with detent notches, one for each extreme position, and a detent spring member adapted to releasably engage in one of said notches when the cam member is rotated to one of said extreme positions and retain the adjusting member in its set position, said detent member being in the form of a length of spring wire anchored in fixed relation to said cam and having its one extremity projecting free and shaped to frictionally engage the surface of said cam and provide "feel" for the rotatable adjusting member and snap with an audible click in one or the other of said notches when said cam is rotated to either one of its extreme positions.

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