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R. N. BOOTH

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CONTROL APPARATUS

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FIG. 1

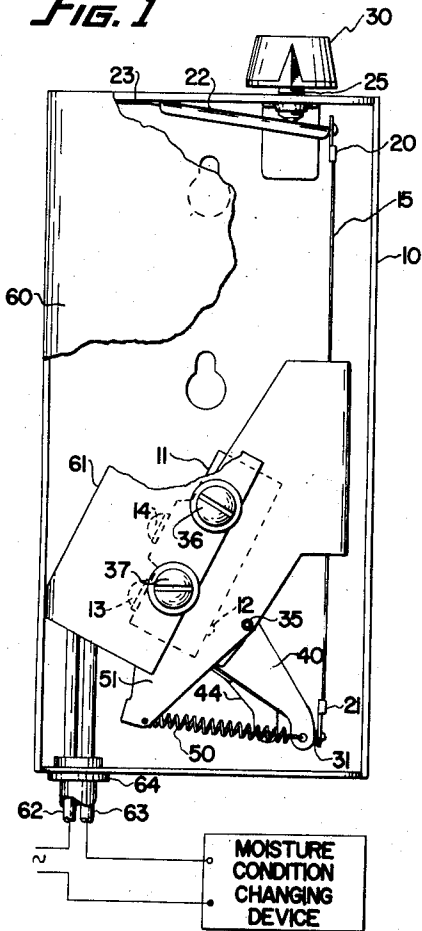


FIG. 2

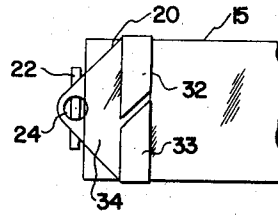


FIG. 3

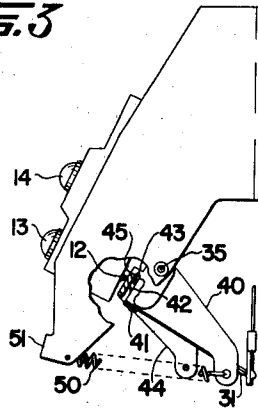


FIG. 5

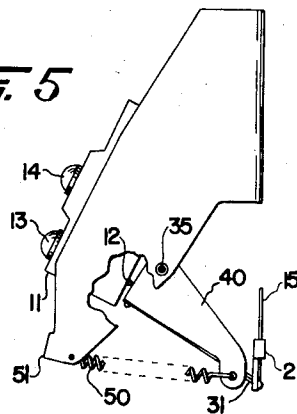
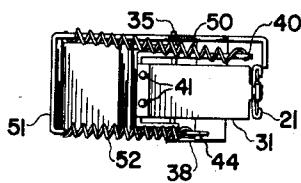


FIG. 4



INVENTOR.
RUSSELL N. BOOTH

BY

Robert S. Craig

ATTORNEY

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2,866,023

CONTROL APPARATUS

Russell N. Booth, Lakeville, Minn., assignor to Minneapolis-Honeywell Regulator Company, Minneapolis, Minn., a corporation of Delaware

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9 Claims. (Cl. 200—61.06)

The present invention is concerned with a moisture responsive control device, in particular one which has a thin ribbon moisture responsive element.

In moisture responsive control devices the use of hair elements and other expensive elements has been quite common in the past, and this increases the cost of the overall control device. With the increase in residential air conditioning and residential dehumidification units there is a need for a relatively accurate and yet inexpensive moisture responsive control device for such application. In the present invention a thin ribbon element is used for obtaining motion upon a change in the moisture content of the surrounding air to operate a control switch. The element is a material chemically known as a condensation product of a dibasic acid with a difunctional primary amine. This material has many desirable characteristics for use in a moisture responsive element. It has negligible hysteresis when operating under a constant tension, it has practically a linear change in length through the humidity range for most applications, and it provides a large movement for small changes in the amount of water absorbed. In order to obtain successful operation of a device using the above material for the sensing element it is necessary to maintain a relatively uniform tension, less than some predetermined value, on the element. The present invention has a novel linkage to maintain a constant tension on the sensing element.

It is therefore an object of the present invention to provide an improved moisture responsive control device.

Another object of the present invention is to provide in an improved control device a means of maintaining a constant tension on a sensing element.

And still another object of the present invention is to provide an improved control device with a thin ribbon sensing element.

These and other objects will become apparent upon the study of the following specification and claims of which:

Figure 1 is a front view of the control device with a portion of the cover cut away.

Figure 2 is a showing of one end of the sensing element with a clamp for holding the element.

Figure 3 is a front view of the control device showing the switch and the operating linkage connected to the sensing element.

Figure 4 is a view of a modified embodiment looking upward at the bottom of the linkage of a control device similar to that shown in Figure 1.

Figure 5 is a front view of a third embodiment of the control device showing only one lever which has a biasing spring for holding it against the switch.

Referring to Figure 1, a control apparatus is shown having a base or frame 10 having a snap switch 11 mounted thereon. The switch is a conventional type having an operating plunger 12. Upon moving plunger 12 inward the switch is operated to close the circuits between terminals 13 and 14. A sensing element 15 is

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a thin ribbon of moisture responsive material which expands upon an increase in the moisture content in the air surrounding. The element is connected at its extremities to clamps 20 and 21. Element 15 is chemically known as a condensation product of a dibasic acid with a difunctional primary amine made in thin ribbon form. The specific material used is a condensation product of 1,6-hexanediamine and adipic acid more commonly known as Nylon. The upper extremity of element 15 is attached to a manual adjustment having a lever 22 which is attached at one end 23 to the frame. The other end of lever 22 is attached to clamp 20 by the insertion of a projection on the lever into a hole of the clamp. This is shown in greater detail in Figure 2 in which hole 24 in clamp 20 is shown having the projection therein. Lever 22 is forced downward against its own spring resilience by a screw 25 which is attached to a control point adjusting knob 30. Upon adjustment of the knob the normally fixed position of the upper extremity of element 15 is changed.

The lower extremity of element 15, which is also attached to a clamp 21, is connected to one extremity of an ambient temperature compensation bimetal 31 by means of a projection thereon being received into a hole of clamp 21. The clamps are held rigid on the associated projections by a cement, not shown. Clamps 20 and 21 are substantially the same; thus the description of clamp 20 as shown in Figure 2 describes both clamps. Referring to Figure 2, the clamp has a pair of ears 32 and 33 opposite one another on the outer sides of the clamp. One side 34 of the clamp, which also includes the ears 32 and 33, is coated with a rubber-like material before assembly. Upon placing element 15 in the clamp and bending ears 32 and 33 downward to pinch the element between the main portion of the clamp and the ears, as shown in Figure 2, no part of the clamp including the ears will come in contact with the element. Such a coating not only aids the clamp in holding the smooth thin element 15 but also provides a protective coating should the ears 32 and 33 be pinched too hard against the element.

Referring to Figure 1, a bracket 51 is mounted on switch 11 by a pair of screws 36 and 37 received by frame 10 to hold the bracket and switch. The bracket has a downwardly extending portion 38, shown in Figure 4. A shaft 35 is mounted between the main part of the bracket and portion 38. Pivotaly mounted on shaft 35 is a lever 40. Attached as a part of lever 40 is bimetal 31, the lever and bimetal pivoting as an integral part of shaft 35. A portion 42 of lever 40 has a projection 43 thereon engaging a portion 45 of a second lever 44 also pivoted on shaft 35. Portion 45 is interposed between projection 43 and operating button 12 of the switch. Lever 44 has no function in the embodiment shown in Figures 1 and 3 other than to transmit movement from lever 40 to the plunger 12.

A spring 50 is attached to the outer extremity of lever 40 and bracket 51. The spring applies a clockwise force to lever 40 at approximately a 50 degree angle. Element 15 is attached to the outer extremity of bimetal 31 to apply a counterclockwise force to lever 40 at approximately 40 degrees. The aforementioned linkage is designed so that upon element 15 shortening to pivot lever 40 counterclockwise thereby lengthening its effective lever arm, the effective lever arm upon which spring 50 acts is shortened. The spring force increases as it is stretched, but by the present design of the linkage, it is possible to maintain a relatively constant tension on element 15. The effect of the angular relation between spring 50, lever 40, and element 15 is to provide a spring of substantially zero rate to bias the element. Neglecting the force needed to operate the switch 11, or assuming

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some other control device having zero loading, the tension maintained on the element is substantially constant throughout its range of movement.

Assuming for explanation purposes, switch 11 has an operating force requirement of 230 grams and a release force of 200 grams. It is obvious that as lever 40 moves clockwise, upon the expansion of element 15, to engage plunger 12 through lever 44, a portion of the force of spring 50 is used to depress plunger 12. Thus as plunger 12 is loaded the tension on element 15 is decreased. The element tension will remain at the lower values until lever 40 removes the load from plunger 12.

This loss of loading on element 15 is only the result of the needed load to operate switch 11 and with a control device requiring little or no load such as a potentiometer the force of spring 50 would always be available to keep a constant tension on element 15. Throughout the operating range of the element, where no loading is required on control device 11, the linkage provides a zero rate spring bias on the element.

A second embodiment is identical to that described above except, as shown in Figure 4, lever 40 is biased in a clockwise direction as seen in Figure 1, by spring 50 attached between the outer extremity of lever 40 and bracket 51, and a constant bias is placed on plunger 12 of the switch by spring 52 acting on lever 44. The additional force applied through lever 40 when the element 15 expands or contracts is used to operate the switch. Assuming the same operating and release force requirements of 230 and 200 grams, respectively for switch 11, the bias on plunger 12 provided by lever 44 might be adjusted to less than 200 grams. The force needed to operate the switch as supplied by element 15 through lever 40 is then 30 grams. The lever arm ratio between pivot 35 and plunger 12 and pivot 35 and element 15 is approximately 1 to 2½ when lever 40 is near the operating position of switch 11. It is seen that the variation in the tension on the element throughout the range of the switch is reduced to approximately 12 grams. Therefore even with a control device requiring a relatively large force for operation it is possible to maintain the variation in element tension through its operating range rather low.

In Figure 5 another embodiment is shown. This embodiment is similar to that shown in Figure 1, except that lever 44 is omitted and acts directly on plunger 12. The force to operate the switch 11 by pushing plunger 12 inward is obtained through spring 50 as it pivots lever 40 clockwise about pivot 35 when element 15 expands upon taking on moisture. The bimetal 31 is also shown as part of the assembly of lever 40.

In Figure 1, as mentioned heretofore, lever 44 is not being used, thus the operation of the embodiments of Figures 1 and 5 are similar. When a switch is used which requires a low or zero release force these embodiments are used as element 15 upon shortening and acting through lever 40 can remove all the load on plunger 12 as produced by spring 50. The embodiment in Figure 1 is substantially as the invention is presently produced and it can be easily modified to provide a constant switch load by placing spring 52 on lever 44.

In all three embodiments of the present invention shown in Figures 1, 4, and 5, the maximum tension on the element can be preselected by spring 50. This is important as the tensile strength of elements such as 15 is low. Should knob 30 be turned from a low to high setting the upper end of element 15 would be raised; however the tension on element 15 will not exceed the predetermined maximum value as lever 40 would only lift away from plunger 12.

The device has a cover 60 as shown in Figure 1 which fits frame 10. In order to prevent the cover from touching terminals 13 and 14 a paper insulator 61 is placed over these terminals and held on switch 11 by screws 36 and 37. The terminals 13 and 14 are connected through conductors 62 and 63 to a moisture con-

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dition changing device which might be humidification or dehumidification apparatus to add moisture or take out moisture from the air surrounding the control device shown. Conductors 62 and 63 are electrically insulated from base 10 by an insulated bushing 64.

Operation

For explanation purposes let us assume that the device as shown in Figure 1 is attached to a dehumidification moisture condition changing device so that upon an increase in the moisture content of the air surrounding element 15 will expand to cause button 12 to move inward and complete the circuit between terminals 13 and 14. This will energize the dehumidification apparatus and begin to remove the water from the air.

Neglecting the force required on plunger 12 to operate switch 11, the tension on element 15 provided by the spring 50 remains substantially constant throughout the range of change in length of the element. This effective zero rate spring bias on the element is quite important as thin ribbon elements of the type used have little hysteresis when the tension on the element is constant. As the element expands and the lever 40 engages plunger 12 a portion of the force developed by spring 50 is then applied to the plunger and depending upon the needed force to operate the switch the tension on the element is decreased. With this novel zero rate spring mechanism it is seen that at no time will the tension on the element exceed some predetermined maximum value. This would even be the case upon re-adjustment of control point adjusting knob 30 to a higher humidity level as lever 40 would only move counterclockwise away from the plunger and the tension on the element would remain the same.

A constant loading on plunger 12 might be provided through lever 44 by a spring 52 as shown in Figure 4. This constant loading could be selected to be slightly below the release force necessary for the particular switch used. With the constant loading on the switch plunger the force to be supplied by lever 40 need only be the difference in force between the release and operating forces of the switch, in the assumed values for a particular switch, this is 30 grams. As the lever moves back and forth to operate the switch the tension on element 15 varies approximately 12 grams which would be quite low.

The embodiments shown in Figures 1, 4, and 5 operate substantially the same except where the constant loading is desired the aforementioned spring 52 can be placed on lever 44 as shown in the embodiment of Figure 4.

As the temperature has some effect on the element 15 the bimetal 31 acts to compensate for this temperature effect so that should the element expand on a temperature change the extremity of bimetal 31 connected to clamp 21 would move downward to take up the increase in element length due to temperature change. The bimetal could be designed to over or under compensate and thus satisfy humidity-temperature comfort conditions.

While the invention has been described with a control device 11 requiring loading through a plunger 12 for its operation it is obvious that the present invention when used with a control device requiring no loading the effective zero rate spring linkage would maintain a constant tension on the sensing element 14 throughout the complete operation of the control device, therefore the present invention should be only limited by the scope of the appended claims, in which I claim:

1. In a moisture responsive device, a frame, a lever pivotally mounted on said frame, control means, said lever means being adapted to operate said control means when pivoted in a first direction, a spring connected to said frame and said lever, the force applied by the spring to said lever being at substantially a 50 degree angle and biasing said lever in said first direction, and a thin ribbon moisture responsive element changing in length upon

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a change in the moisture level therearound, said element being made of a condensation product of a dibasic acid with a difunctional primary amine, means connecting said element between said base and said lever, the force applied by said element to said lever being at substantially a 40 degree angle, said first mentioned and said last mentioned forces being substantially normal to each other so that upon a change in the length of said element to rotate said lever the force applied to said element remains constant.

2. In an atmospheric moisture sensing device, a frame, a control element carried by said frame, a lever pivoted in said frame and adapted to actuate said control element, a stretchable humidity responsive element acting between said frame and said lever on a line making an acute angle with said lever and so disposed that the angle increases to increase the effective length of said lever as said element contracts, and a spring acting between said frame and said lever on a line making an acute angle with said lever and so disposed that said last mentioned angle decreases as said element contracts.

3. In an atmospheric moisture sensing device, a frame, a control element carried by said frame, a lever pivoted in said frame and adapted to actuate said control element, a stretchable humidity responsive element acting between said frame and said lever, and a spring acting between said frame and said lever on a line making an acute angle with said lever and so disposed that said last mentioned angle decreases as said element contracts to maintain a constant load on said element.

4. In an atmospheric moisture sensing device, a frame, a control element carried by said frame, said control element requiring a force of a predetermined value to operate said element and a predetermined lesser force to release said element from its operated position, a first lever pivoted on said frame and adapted to place a force on said control element less than said release force, a second lever pivoted on said frame and adapted to actuate said control element by applying an additional force so that said force of said first lever and said second lever exceeds said operating force, a humidity responsive element acting between said frame and said second lever, and a spring acting between said frame and said second lever on a line making an acute angle with said second lever and so disposed that said angle decreases as said element contracts upon a change in atmospheric moisture.

5. In a moisture control device, a base member, a sensing element having an overall length which varies with moisture content in the surrounding space, an adjustable mounting member to which one extremity of said sensing element is connected, a lever pivoted about a shaft on said base, a switch having an operating plunger, a portion of said lever engaging said plunger, an outer extremity of said lever having a second extremity of said sensing element connected thereto, a spring, means connecting said spring between said outer extremity of said lever and said base so that said spring applies a force to said lever at an angle to the force of said sensing element thereby upon said sensing element lengthening upon a change in the moisture level said lever pivots to operate said switch.

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6. In a humidity control device, a base member, a thin ribbon sensing element attached at one extremity to said base member, said element changing in length as the moisture content of the air therearound changes, a shaft mounted to said base member, a first member pivotally mounted on said shaft, a snap switch having an operating plunger, said switch being mounted on said base member, said first member having a portion engaging said plunger, first resilient means attached between said member and said base member for applying a biasing force to said first member and against said plunger, a second member pivotally mounted on said shaft, said member having a portion engaging said first member, means connecting the other extremity of said element to said second member, second resilient means connected between said second member and said base member for applying a tension force on said element, said second resilient means being connected so that as said second member pivots the tension force on said element will remain constant.

7. In a moisture responsive device, a thin ribbon sensing element, a base member, switch means, a member pivotally mounted on said base member and adapted to operate said switch means upon a predetermined movement of said member, connection means for connecting one extremity of said element to said member and the other extremity to said base member, said connection means comprising a clamp coated with a soft material so that upon clamping said element said clamp does not come in direct contact with said element.

8. In a moisture responsive device, a sensing element made of a relative thin ribbon of material, switch means having an operating member, a base member, connecting means connecting said sensing element between said operating member and said base member, said connecting means comprising a clamp having one surface covered with a protective coating so that when said clamp is placed on said sensing element said coating will protect said element and provide a better hold on said element.

9. In an atmospheric moisture sensing device, a frame, a control element carried by said frame, a lever pivoted in said frame and adapted to actuate said control element, said lever having a portion made of temperature responsive bimetal, a humidity responsive element acting between said frame and said bimetal, and a spring acting between said frame and said lever on a line making an acute angle with said lever and so disposed that said last mentioned angle decreases as said element changes in length with a change in atmospheric moisture.

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