Feb. 27, 1951 R. T. SQUIER 2,543,384

HYGROSCOPIC CONTROL DEVICE

Filed March 29, 1948 2 Sheets-Sheet 1

Fig. 1.

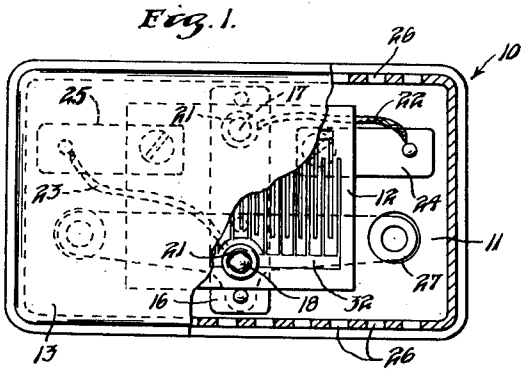

Fig. 2.

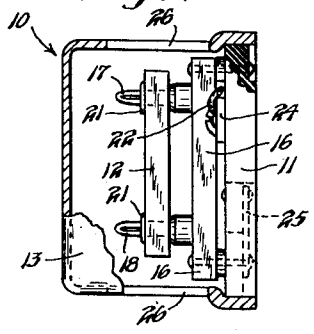

Fig. 3.

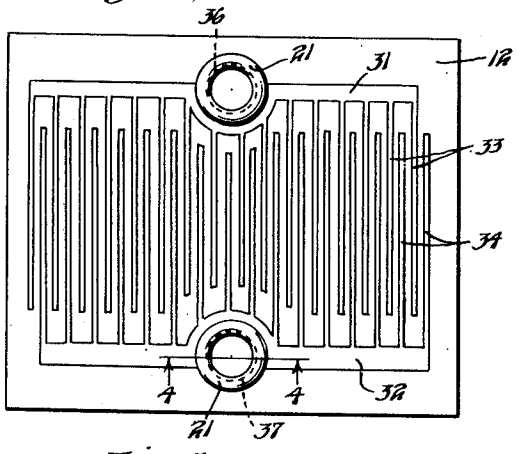

Fig. 4.

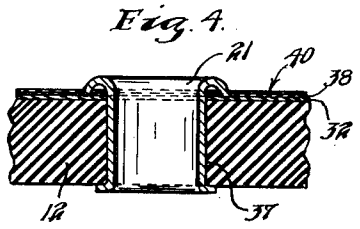

Fig. 5.

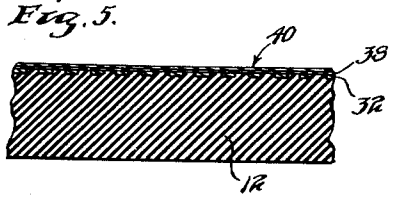

Fig. 6.

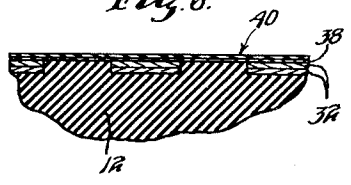

Fig. 7.

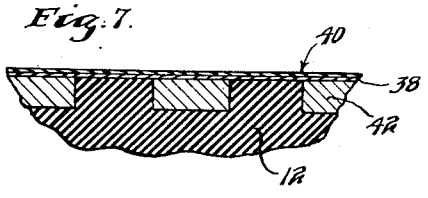

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Fig. 8.

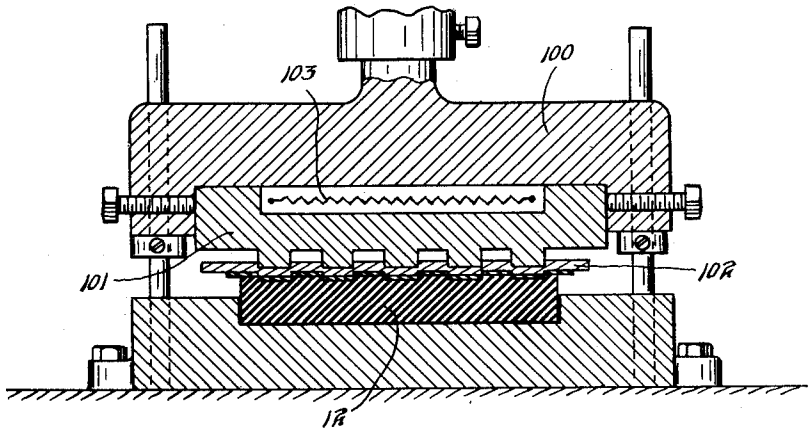
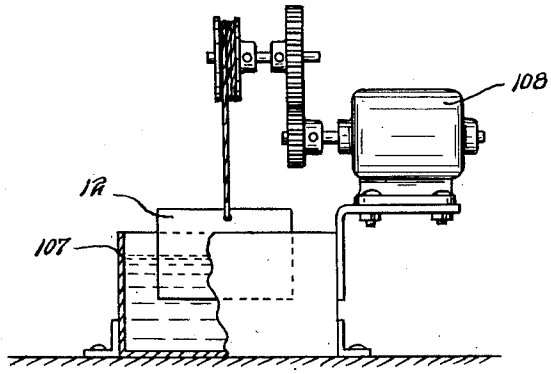


Fig. 9.



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UNITED STATES PATENT OFFICE

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HYGROSCOPIC CONTROL DEVICE

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Application March 29, 1948, Serial No. 17,622

8 Claims. (Cl. 201—63)

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The present invention relates to hygroscopic control devices and more particularly to improvements in humidity responsive elements or units of the resistance type.

Humidity regulators and indicators of the resistance salt type are old, but the inaccuracies in them due to variations in resistance of the conductive coatings, the expense of calibration, the instability of calibration, and the difficulties in reproduction within given ranges of operation have greatly limited their usage.

It is therefore an object of this invention to provide an improved hygroscopic control unit or element of the resistance type.

It is an object of the present invention to provide a hygroscopic unit in which the conductor elements are so positioned as to permit a uniform conductive and hygroscopic coating therebetween.

It is also an object of this invention to provide a hygroscopic unit with a conductive element or coating of uniform thickness and resistance.

It is still further an object of this invention to provide a hygroscopic unit in which the conductors are embedded or impressed into a moisture impervious base material to facilitate a uniform conductive or hygroscopic coating thereupon.

Another object of this invention is to provide in a humidity sensitive unit substantially flat conductors flush with the surface of the moisture impervious mounting element to facilitate uniformity of coating of the hygroscopic material.

Still another object of this invention is to provide a humidity sensitive unit of the resistance type having a hygroscopic and conductive film and a moisture permeable film enclosing the same to protect the hygroscopic film.

A further object of this invention is to provide a hygroscopic control device of the resistance type which gives a rapid response to changes in humidity or moisture.

It is also an object of this invention to provide a hygroscopic control device of the resistance type which is sensitive to small changes in the condition of humidity.

A still further object of this invention is to provide a hygroscopic control device of the resistance type with improved accuracy, sensitivity and rapidity of response which is easily reproduced by mass production at greatly reduced cost.

It is also an object of this invention to provide a humidity responsive unit of the resistance

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type in which the conductors are formed by stamping or pressing foil of a conductive material into a suitable moisture impervious base unit or by filling grooves in said base with a suitable conductive material.

A further object of this invention is to provide, in a hygroscopic control device, a mounting means such that the elements may be readily installed or replaced, so that a plurality of elements may be mounted in adjacent position, and whereon one or more of the elements may be so mounted that the maximum surface of said elements is exposed to the circulating surrounding air.

It is also an object of this invention to provide an improved method of making such a humidity responsive element of the salt resistance type.

These and other objects, advantages and features of this invention will become apparent upon study of the following specification and drawings wherein:

Figure 1 is an elevation view of the humidity control device and its associated mounting structure, with parts broken away.

Figure 2 is an end elevation view of the device of Figure 1, with parts broken away.

Figure 3 is an enlarged view of the humidity responsive element detached from its mounting structure.

Figure 4 is a sectional view taken along the line 4—4 of Figure 3 and showing the connection between a conductor and a conductive eyelet or mounting sleeve.

Figure 5 is an enlarged cross-sectional view of the portion of the humidity responsive element showing the conductors, the hygroscopic conductive coating and the protective coating covering the same.

Figure 6 is a modification of the preferred embodiment of this invention, still further enlarged, disclosing the use of two layers of conductor material to form the conductors of the humidity responsive element.

Figure 7 is a sectional view of still another embodiment of the humidity responsive element in which grooves are machined into the moisture impervious material of the element and the conductors are formed of a paste comprising colloidal graphite.

Figure 8 shows generally a press.

Figure 9 shows the method of dipping.

The present humidity control device 10 comprises, generally, a mounting or base portion 11, a humidity responsive resistance element 12,

and a cover 13, element 12 being an improvement over the hygroscopic elements disclosed in the Dunmore Patents No. 2,285,421, dated January 9, 1942, and No. 2,295,570, dated September 15, 1942.

The base portion 11 includes an insulating strip 16 having spaced prongs 17—18 attached thereto which extend outwardly from the plane of the base portion and perpendicular to it. Prongs 17—18 have flexible sides so that eyelets or mounting sleeves 21 in the element 12 may be pushed over said prongs, with said flexible sides frictionally engaging said eyelets for securing the element 12 to base 11 and for making electrical connections between the element and said prongs. Lead wires 22—23 connect the prongs 17—18, respectively, to terminals 24—25 mounted on base portion 11. Cover 13 is similar to a thermostat cover in that it has slots 26 in the top and bottom to give free access of the circulating air to the element. It fits over the element 12 and is secured to base 11 in a suitable manner, not shown, to enclose and protect the device. A mounting bracket 27 attached to base 11 permits mounting the device on any suitable surface, such as the wall of a room.

In the preferred embodiment, element 12 includes a relatively thin block or strip of electrically insulating and moisture impervious material, such as polystyrene, having a substantially flat and uniform surface. Element 12 may be of any suitable shape but a rectangular member has been found most convenient. The thickness of element 12 is not critical but should be adequate to provide sufficient strength for manufacturing operations and handling. Conductors 31—32, of electrically conductive thin foil or leaf material, are embedded in the surface of the element in a grid-like pattern including interlaced finger portions 33—34. The eyelets 21 which extend through holes 36—37 in element 12 are crimped over to contact the conductors 31—32 and provide electrical connections between said conductors and prongs 17—18.

The conductors 31—32 are embedded in element 12 to a sufficient depth to provide a substantially flush surface for facilitating the application of a coating 38 of hygroscopic material over the conductors. The uniformity of this coating is highly important because it is essential for accuracy in calibration and fast response that uniform amounts of resistance material be placed between each of the finger-like portions 33—34 of the conductors 31—32, respectively. Any lack of uniformity will vary both the rate of resistance change and the total change in the resistance value of the element 12 in response to humidity changes, thus destroying the accuracy of its controlling effect. The flat surface of the element 12 and the positioning of the conductors therein permit the application of this necessary uniform coating, in a manner which will be later described.

Preferably a protective film or coating 40 is formed over the hygroscopic coating 38 on element 12 to guard against damage to the underlying conductive coating. This protective film or coating 40 obviously must be moisture permeable but should also be insoluble in the solvent to be used for cleaning, such as ether, alcohol, or the like. Various materials are suitable for this purpose but good results have been obtained with a solution said to comprise a vinyl-acetate in ethyl alcohol, obtained from the Minnesota Mining and Manufacturing Company and designated by Specification RD-816. Such a coating has but little retarding effect on the conductive film or coating 38 and permits the element 12 to be cleaned of grease, lint, dust or other accumulations that might eventually interfere with proper operation of said element. This protective coating may be formed by spraying or dipping, with care being taken to keep the thickness of the coating uniform to permit uniformity of passage of moisture therethrough. It has also been found that the protective coatings tried, including that above described, tend to stabilize the elements and improve their aging characteristics.

In the manufacture of these elements, the following procedure has been found suitable to give the improved characteristics and performance recited above. The blank strip or block or polystyrene is machined or cut to provide substantially flat, or otherwise uniform surface, and the block is then accurately sized. The working or upper surface of the block or strip is then slightly roughened by sanding for the purpose of better adhesion of the gold leaf later to be applied. Holes are then drilled in the block or blank through which the mounting eyelets will later be placed. The blanks are then annealed to remove the stresses set up in the material during the machining operations and subsequently cleaned with chromic acid, rinsed with water and allowed to dry.

The next step in the operation is the embedding or embossing of the conductors into the surface of the blank. In the present application it has been found that gold leaf or foil of a commercial grade, approximately .0006 inch in thickness, makes a desirable conductor. Such a foil is obtainable in tape form on a plastic backing or ribbing, the foil having a varnish coating on its other side. The conductors may take any suitable shape or form but it has been found preferable to use a grid-like conductor structure with interspaced finger portions 33—34. This arrangement is best shown in Figure 3 and is used to insure accurate positioning and spacing of the conductors to provide for equal amounts of hygroscopic salt and equal resistance between the conductors. Figure 8 shows generally a press 100 which could be used for the embedding process. A die 101 cut in the form of the grid-like conductors shown and carried in press 100 is used for embedding the conductors 31—32 into the element 12. The die and conductor are exaggerated in Figure 8 for the purpose of clarity. This is done, as shown in Figure 8, by placing the foil tape 102 over the element, varnish side down and backing up, with the die heated, as by heater 103, above the tape and parallel to the surface of the element, the die then being forced downwardly to press the foil into the polystyrene base material to form the desired pattern of conductors. The base material becomes somewhat softened by the heat and the foil conductors are cut from the tape and impressed into the surface of the element 12 to a depth such that their upper surfaces are substantially flush with the surface of element 12, as can be seen in Figure 5 and Figure 8. With a substantially flat or flush surface on the element 12, accurate positioning of the conductors 31—32 is readily obtained. Good results have been obtained in the above operation with approximately 700 pounds per square inch pressure on the die, approximately 230° F. temperature of the die and a dwell time of approximately two seconds. The backing strip is then pealed off, leaving the foil conductors embedded in the element. After sufficient cleaning of the

surface of conductors 31—32 to make good electrical contact, eyelets 21 are then inserted through the holes 36—37 and crimped over their respective conductors, these eyelets being made of silver plated brass. The blanks are then annealed again to relieve the stresses set up therein due to the embedding and crimping operations. Next, the blanks are cleaned with a suitable cleaning material, such as clear naphtha or gasoline, rinsed with alcohol, and then rinsed with water and dried.

The next phase of procedure comprises dipping the element or blank into a hygroscopic salt solution such as described in the previously mentioned Dunmore patents and shown schematically in Figure 9. The solution used comprises lithium chloride, polyvinyl alcohol and water, the proportions being varied depending on the range through which the element is designed to operate. In this dipping process, the block 12 is inserted into the liquid in a container 107 in such a manner that all of the exposed surface of the interspaced finger portions of the conductors is immersed with the exception of a portion of one eyelet by which the block is suspended in the solution. The block is withdrawn at a uniform and timed rate by any suitable means such as a motor 108 to insure uniformity of coating and to obtain a predetermined thickness of deposit. The excess of the solution remaining on the edges of the block is then blotted off and the unit dried. The beforementioned protective coating may then be applied in the same manner as above, or otherwise formed. After the protective coating has been applied and the unit dried, the eyelets are cleaned, if necessary. The elements are then seasoned or aged for two or three months by storing in a controlled atmosphere before they are ready for use.

Since the elements 12 are readily installed by merely slipping the eyelets of the element on the prongs 17—18, they can be made relatively thin and several such units can be connected in parallel by merely slipping them over the pegs or prongs 17—18.

The modification of Figure 6 uses two layers of leaf or foil material to form the conductors of the element. This modification permits an increase in conductor cross section without using thicker foil and this avoids some manufacturing difficulties, in addition to decreasing the internal resistance of element. The method of making this modified element is substantially that described above but includes a repetition of the embossing or embedding of the conductors prior to application of the hygroscopic and protective coatings.

The modification of Figure 7 discloses a similar sensing element which is formed by a slightly different process. In this modification grooves are machined into the surface of the element in the form of the grid-like conductors of the preferred design, or its equivalent, and the grooves are filled with a colloidal graphite paste to form conductors 42. These graphite conductors are made with their exposed surfaces substantially flush with the surface of the element as in the previously described elements, so that hygroscopic coating 38 and the protective coating 40 may be applied as recited above. With the exception of the conductor material and the method of forming the conductor 42, this element is substantially the same as those described above. Obviously, because the graphite material has higher resistance than the gold leaf ordinarily used, conductors 42 have considerably more cross sectional area than the conductors 31—32.

While I have disclosed the preferred form of my invention, and in addition have shown two modifications, it is to be understood that changes may be made in the shape of the element, the conductors, and the materials without departing from the scope of the invention. Hence the scope of the invention should be determined only by the appended claims.

I claim as my invention:

1. A hygroscopic unit comprising, in combination, a base member of water impervious material, a pair of spaced metallic electrical conductors arranged on said member, spaced terminal means connected to each of said conductors, a thin film of hygroscopic material of a sort rendered electrically conductive in the presence of vapor extending between said conductors, and a thin protective coating covering said film, said coating being permeable to water vapor but relatively insoluble in water.

2. A hygroscopic unit comprising in combination, a base member of water impervious material, said member having a plurality of uniformly spaced grooves in its surface, electrical conductive material positioned in said grooves so that the surface of said conductive material is substantially flush with the surface of said base member thus providing a relatively smooth surface on said base member, and a uniform coating of hygroscopic material in electrical conductive relation with said electrical conductive material in said grooves, said coating being of a sort rendered conductive by the presence of moisture.

3. A hygroscopic unit comprising in combination, a base member of water impervious material having a flat surface, said base member having a plurality of grooves in said surface, electrical conductive material positioned in said grooves and arranged so that the surface of the same is substantially flush with the surface of said base member providing a substantially uniform flat surface of said base member, a coating of hygroscopic material extending over said flat surface and positioned in electrical conductive relation with the electrical conductive material in said grooves, and a moisture permeable and water insoluble protective coating covering said hygroscopic conductive coating.

4. A hygroscopic unit comprising in combination, a base element of water impervious material, said element having a plurality of grooves in the form of a grid consisting of a pair of main channels and a plurality of appending minor channels connected thereto and so positioned that the minor channels of one are interspaced with the minor channels of the other, said grooves being filled with an electrical conductive paste material to the surface of said base element to form a pair of electrical conductors substantially flush with the surface of said element, and a thin coating of hygroscopic material in electrical conductive relation with said conductors, said coating being of a sort rendered electrically conductive by the presence of moisture.

5. A hygroscopic unit comprising in combination, a base element of water impervious material, said member having a plurality of grooves in the form of a grid consisting of a pair of main channels and a plurality of appending minor channels connected thereto and so positioned that the minor channels of one are interspaced with the minor channels of the other, said grooves being filled with a plurality of layers of thin metal

to form a pair of electrical conductors substantially flush with the surface of said base member, an electrically conductive microscopically thin hygroscopic coating over at least a portion of said conductors, and a moisture permeable and water insoluble protective coating covering said hygroscopic conductive coating and said conductors.

6. A hygroscopic unit as defined by claim 1 where in the hygroscopic film comprises a mixture of a water soluble salt and a suitable film forming material.

7. A hygroscopic unit as defined by claim 1 wherein the hygroscopic film comprises a mixture of a water soluble salt and a suitable film forming material and wherein the protective coating comprises an organic plastic material different from said film forming material.

8. A hygroscopic unit as defined by claim 1 wherein the protective coating comprises an organic plastic material.

RALPH T. SQUIER.

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Certificate of Correction

Patent No. 2,543,384 February 27, 1951

RALPH T. SQUIER

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows:

Column 6, line 68, for the word "element" read *member*;

and that the said Letters Patent should be read as corrected above, so that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 15th day of May, A. D. 1951.

[SEAL]

THOMAS F. MURPHY,
Assistant Commissioner of Patents.

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