Dec. 27, 1966 W. J. SMITH 3,295,088

ELECTRICAL HUMIDITY SENSING ELEMENT

Filed Oct. 14, 1964

Fig. 1.

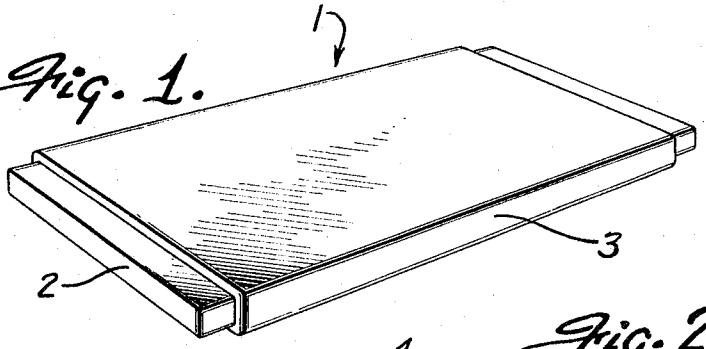
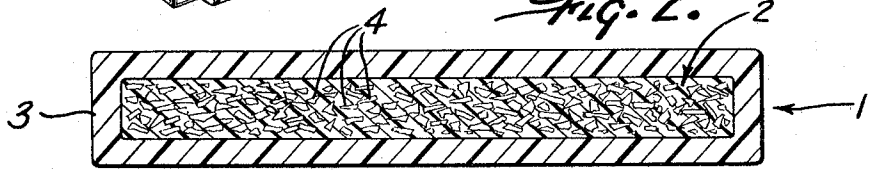


Fig. 2.



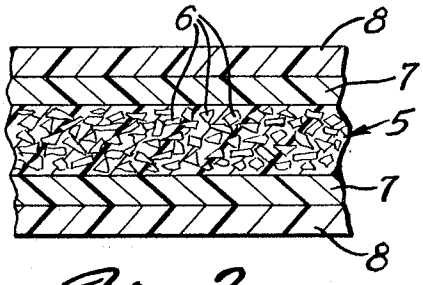


Fig. 3.

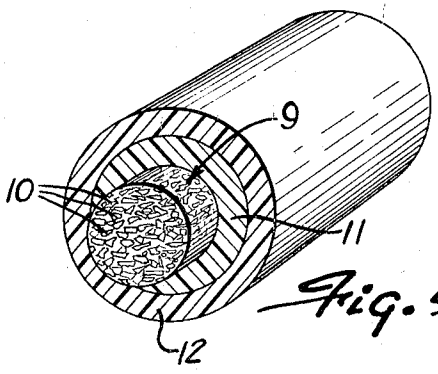


Fig. 4.

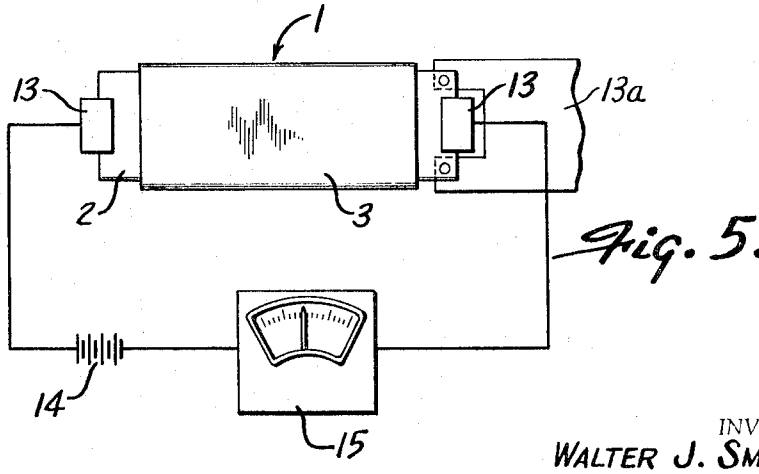


Fig. 5.

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3,295,088

Patented Dec. 27, 1966

3,295,088

ELECTRICAL HUMIDITY SENSING ELEMENT

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Filed Oct. 14, 1964, Ser. No. 403,778

14 Claims. (Cl. 338—35)

This invention relates to an improved varying dimension, electrical humidity sensing element for use in humidity control and/or humidity indication systems and to a method of fabricating the element.

In the past, electrical humidity sensing elements have been of two general types. In one type the element consists of a support surface covered with a film of humectant material containing an ionizable substance. The film forms an electrical connection between two electrodes. Water content of the film is in equilibrium with the moisture content of the surrounding air. The degree of ionization in the film, and consequently the electrical resistance of the sensor, is then a measure of the ambient relative humidity. In the second type of element, electrically conductive particles, such as carbon, are dispersed within a moisture sensitive material which is sensitive to changes in the moisture content of the atmosphere and responds in the form of dimensional changes to variations in humidity. As the moisture sensitive material changes in dimension in accordance with changes in moisture content of the atmosphere, the resistance path through the conductive particles is altered to change the current flow through the element. The resistance in the sensor indicates the relative humidity directly. This is shown on an electrical instrument, or the change in resistance can actuate a humidity control device.

The electrical humidity sensing elements used in the past have had serious disadvantages. For example, in the lithium chloride type, droplets of free water may contact or collect on the surface of the element and wash away the lithium chloride containing film with the result that the conductivity of the element would be destroyed or erroneously changed. In the carbon film type of element, contamination by foreign matter is a serious problem, for the contaminating material will introduce ions and alter the electrical characteristics of the element, and the element will become worthless.

An object of the present invention is to provide an improved, electrical, varying-dimension, humidity sensing element which does not have the inherent disadvantages of the prior art devices. According to the invention, the humidity sensing element comprises an elastic, moisture-insensitive, creep-resistant base portion or core with an outer moisture-sensitive surface which is bonded to the core throughout its length. The core contains interconnected particles of an electrically conductive material, such as carbon, which are embedded within the core. On an increase in moisture in the atmosphere, the moisture sensitive surface absorbs moisture and expands. The expansion of the moisture sensitive surface puts the core under stress or tension which serves to elongate the chains of particles within the core to increase the electrical resistance of the element. On a decrease in humidity conditions, the moisture sensitive surface layer will shrink and the elastic core acts as a spring to return the moisture sensitive layer to its original dimension for the original relative humidity. This release of the tension on the core serves to compress the particle chains in the core and thereby decrease the resistance to current flow through the core.

The moisture sensitive surface and the elastic core, containing the electrically conductive material, cooperate to provide a humidity sensing element having a rapid response to humidity conditions and a reliability that is not affected by extremes of humidity or temperatures.

As the electrically conductive material is embedded within the moisture-insensitive core, which in turn is covered or surrounded with the moisture sensitive layer, the problem of contamination of the electrically conductive layer is minimized, thereby insuring more accurate and reliable readings.

As the element is a synthetic product, it can be fabricated under controlled conditions and therefore requires less calibration from element to element. Since only the thin outer surface layer is moisture responsive, atmospheric moisture can readily enter, leave and diffuse throughout the moisture sensitive material, thus contributing to rapid response in the element. Moreover, since only a portion of the over-all element consists of the moisture sensitive material, a smaller quantity of water is needed to actuate the element, thus further contributing to the speed of response.

Other objects and advantages will appear in the course of the following description.

The drawing furnished herewith illustrates the best mode presently contemplated for carrying out the invention.

In the drawing:

FIG. 1 is a perspective view of the electrical humidity sensing element of the invention;

FIG. 2 is a transverse section of the element;

FIG. 3 is a fragmentary section of a modified form of the element having a hydrolyzed outer moisture sensitive layer;

FIG. 4 is a perspective view of a further modified form of the element having an annular hydrolyzed moisture sensitive outer layer;

FIG. 5 is a schematic representation showing the element in an electrical humidity indicating system.

FIGS. 1 and 2 illustrate an electrical humidity sensing element 1 comprising an inner core 2 and outer surfaces 3 which are integral with the core.

The core 2 is formed of a material which is relatively insensitive to moisture and capable of withstanding the mechanical load with insignificant creep. As shown in the drawing, a plurality of uniformly distributed particles of an electrically conductive material 4 are dispersed within the core. The particles 4 are generally interconnected in the form of chains and provide a path for the flow of current through the core 2.

Core 2 need not be completely insensitive to moisture, but should have a dimensional increase of less than 2%, and preferably less than 1%, with a change from 0% to 100% relative humidity. Since the moisture sensitivity of the core does not contribute to performance, the primary function of the core is the complete restoration from expansion or contraction experienced under changing humidity conditions and induced by the outer surfaces 3. In other words, the core material should be resistant to creep or permanent deformations and should recover substantially completely from elongation up to 5%.

The core can be formed of organic or inorganic materials. Organic polymers having a minimum number of polar groups, such as hydroxyl, carboxyl, amino and imino can be used as a core material. Organic polymers which can be utilized as the core are cellulose esters in which the esterifying acids contain up to 8 carbon atoms, and preferably up to 6 carbon atoms. Specific examples of cellulose esters are cellulose triacetate, cellulose acetate-butyrate, cellulose acetate-propionate, cellulose acetate-valerate, cellulose butyrate, cellulose succinate, cellulose phthalate, and the like. It is preferred that the cellulose be substantially 100% esterified so that a minimum number of hydroxyl groups remain in the molecule. Thus, cellulose triacetate is preferred over cellulose monoacetate or cellulose diacetate.

Other organic materials which can be used as the core are polycarbonate films; copolymers of vinylene carbonate and vinyl acetate having approximately 30 mol percent vinylene carbonate; polyacetal films, such as Delrin (E. I. du Pont de Nemours & Co.); oriented polyester film such as Mylar (E. I. du Pont de Nemours & Co.); and Kodar (Eastman Kodak Company); oriented polyolefin films, such as polyethylene or polypropylene and the like.

In some cases, inorganic polymers, where the chain structure is based on sulphur, phosphorus or boron, can be used.

The particles 4 can be formed of any electrical conductive material such as carbon, aluminum dust, zinc dust, or the like. The particles should be interconnected in electrical conductive relation within the core 2 to provide a path for current flow through the core. Thus, the most effective carbon to be used is the chain-forming or electrical conductive type in which the carbon particles gather together in small chains to provide continuous conductive paths through the core.

The particles 4 generally comprise from 5 to 50% by weight of the core. The particular weight relation of the particles 4 to the core material 2 depends upon the type and quality of the electrically conductive particles, the effectiveness of the dispersion, the resistance desired in the element and the size and shape of the core material and surfaces 3.

The size of the particles 4 is not particularly critical but generally the individual particles 4 will have a particle size less than 10 microns and, preferably, smaller than 1 micron.

The surface layers 3 should be formed of a material which has a high sensitivity to moisture and responds in the form of dimensional changes to moisture changes. Generally, the outer surfaces 3 should have a moisture sensitivity such that the material will show a dimensional increase of at least 3%, and preferably 4% to 7% with a change from 0% to 100% relative humidity. These sensitivity values are based on the outer surface material disassociated from the core and are expressed as linear changes. The surface material should absorb at least 10% of its own weight upon immersion in water in accordance with ASTM D–570 test procedure.

Generally speaking, the outer surfaces 3 are formed of materials characterized by having molecular chains with long, bulky repeat units, inhibited rotation of the chain segments and polar groups, such as hydroxyl, carboxyl, amino and imino. These characteristics result in repeatable dimensional changes, high diffusional transport rates for water and dependence of linear dimension on relative humidity independent of temperature.

Specific examples of moisture-sensitive materials which can be used as the outer surface layers 3, are cellulose; hydroxyethyl cellulose; carboxymethyl cellulose; cellulose derivatives, such as cellulose ethers; gelatin; polyvinyl alcohol; polyacrylamide; polyacrylic acid; keratin; collagen; starch and starch derivatives; regenerated proteins, such as casein and zein; synthetic materials, such as polyvinyl pyrrolidone and modified nylon; and the like.

The thickness of the core 2 has a definite relation to the thickness of the outer surfaces 3. If the core is too thick with respect to the outer layers 3, the layers 3 cannot provide the necessary dimensional change under changes in atmospheric moisture. Conversely, if the core is too thin with respect to the thickness of the outer layers 3, the core will not provide the necessary strength and resiliency to restore the layers to their original dimension and prevent permanent deformation of the outer surfaces. The thickness of each of the outer surfaces 3 should be less than 0.5 mil, and generally be between 5 to 50% of the thickness of the core 2, with about 10 to 20% being preferred. However, this relationship is variable. For example, if the moisture sensitivity of the outer surface 3 is high, and the core 2 is formed of a material having a low modulus, then the core can be relatively thick. The optimum thickness ratio for a given surface material 3 and core material 2 is generally arrived at experimentally.

It is preferred that the core 2 and outer surfaces 3 be coextensive in length and width. However, in some instances either the core or the outer layers may project beyond the other element, and the function of the elements will not be altered. Any mechanical clamping of the element in use must, however, be directly tied in with the core and not solely attached to the surface layers 3. Electrical connections to the element must be made to the core 2.

While FIG. 1 illustrates the layers 3 being on both surfaces of core 2, it is contemplated that the layer 3 may only be on one surface of the core. In this case, the element would tend to bow or curve under changes in the humidity conditions rather than remain flat as it does when both surfaces are adsorptive.

The core 2 and surface layers 3 are bonded together throughout their length, and various methods may be employed to provide the bond between the members. For example, the surface layer 3 can be applied by coating the core with a solvent solution of the moisture-sensitive material, and subsequently evaporating the solvent. As a second method, the moisture-sensitive layers can be bonded to the core by use of auxiliary adhesives.

It is preferred that the layers 3 and the core 2 have coefficients of thermal expansion which are similar, because differences in the coefficients of thermal expansion between the core 2 and the layers 3 will introduce interfacial stresses. The coefficients of thermal expansion of the components should also be relatively low to reduce the effect of temperature on the element's performance.

The moisture-sensitive outer surface layers 3 will absorb moisture on increase in humidity and tend to swell or expand. This expansion is resisted by the core 2, putting the core under tension which results in a stretching or cleavage of the chains of the electrically conductive particles 4 causing an increase in the resistance to current flow through the element 1. On a decrease in moisture conditions, the outer layers 3 will shrink releasing the tension on the core and putting the core in compression, with the result that the chains of the electrically conductive particles 4 will be compressed to thereby decrease the resistance of the element 1. Without the spring effect of the core material 2, the outer surface layers 3 would not regain their original dimension on contraction with decreasing moisture conditions. The creep-resistant inner core 2 provides a stability which cannot be achieved in the moisture-sensitive layer itself.

FIG. 3 shows a modified form of the invention in which the humidity sensing element comprises a central core 5, similar to core 2 of the first embodiment, and containing a series of electrically conductive particles 6, similar to particles 4 of the first embodiment. In this embodiment, a layer 7 of a material which is relatively insensitive to moisture is applied to the opposite surfaces of the core 5. The material of the layer 7 is similar to that of core 5, except the layer 7 does not contain electrically conductive particles.

As previously mentioned, the layer 7 can be applied to core 5 by a solvent solution method or by use of auxiliary adhesives.

In the embodiment shown in FIG. 3, the layers 7 of the moisture-insensitive material are chemically treated to provide moisture-sensitive outer surfaces 8.

It has been found that a cellulose ester layer 7 having its outer surface hydrolized to regenerated cellulose, provides an excellent humidity sensing element. The cellulose ester core can be subjected to the influence of either an alkaline or an acid medium to hydrolyze substantially all of the acid radicals on the surface layer to thereby obtain a regenerated cellulose film which provides a maximum moisture sensitivity. The hydrolyzation can be accomplished by dipping the cellulose ester core into the alkali or acid bath and maintaining it in the bath for a

period of time sufficient to hydrolyze the acid groups on the surface of the outer layer. Alkaline materials which can be employed for the hydrolyzation are aqueous or alcoholic solutions of alkali metal bases, such as sodium hydroxide, potassium hydroxide or lithium hydroxide. Alternately alcoholic solutions of strong organic bases such as tetramethyl guanidine, trimethylamine, and benzyltrimethyl ammonium hydroxide can be used for the hydrolyzation.

Hot alkaline solutions are preferred to increase the reaction rate, and generally a boiling solution is used. The time of contact or immersion in the alkaline solution depends, of course, on the materials used, the temperature and strength of the solution. For example, a two-hour hydrolysis period using a 5% sodium hydroxide solution was required to hydrolyze a mixed cellulose ester core to produce a satisfactory element. By increasing the strength of the solution to 50%, an almost immediate hydrolyzation occurred. Effective reaction conditions were found to be obtained by immersing the core material in a boiling 40% sodium hydroxide solution for four minutes.

After treatment with the alkaline solution, it is preferred to neutralize the element in a dilute acid solution. Any conventional mineral acid, such as hydrochloric acid or sulphuric acid can be used. The neutralization removes all of the alkali metal ions which tend to increase the sensitivity of the composite element, but lower the response rate, increase the hysteresis and decrease the reproducibility of the element.

After the neutralization, the element is preferably rinsed in water to leach out the resulting salt.

Solutions of mineral acids, such as hydrochloric acid and sulphuric acid, can also be used to hydrolyze the cellulose ester. However, the use of alkaline material provides a faster hydrolyzation and is preferred. If the hydrolyzation is performed by use of an acidic material, the hydrolyzed product is dipped in an alkaline solution to neutralize the acid and subsequently subjected to the water rinse.

When using a cellulose ester as the layer **7**, it is also preferred to use a cellulose ester for the core material **5** in order to provide more uniform characteristics for the element.

The hydrolization treatment can also be employed to provide a moisture-sensitive outer surface on a layer **7** consisting of a copolymer of vinylene carbonate and vinyl acetate. The unhydrolyzed copolymer is a tough, dimensionally stable film with little sensitivity to moisture and can be used as the core **5** and as the layer **7**. By hydrolyzing the outer surface of the copolymer layer **7** with an alkaline material, as described above, an outer surface layer **8** is produced which is sensitive to moisture and responds to changes in relative humidity.

FIG. 4 illustrates a second modified form of the invention in which the humidity sensing element comprises a central core **9** containing uniformly distributed particles **10** of an electrically conductive material. The core **9** is similar to core **2** of the first embodiment but is in the form of a filament, and the particles **10** are similar to particles **4**. An annular layer **11** of a moisture-insensitive material, similar to the material of core **9**, is chemically treated or hydrolyzed, as previously described, to provide a moisture-sensitive outer surface **12**. The ends of the conductive core **9** project beyond the sheath layers **11** and **12** so that electrical contact can be made directly with the electrically conducting core.

The humidity sensing element shown in FIG. 4 operates in a manner similar to that shown in FIG. 3. Variations in moisture conditions cause expansion and shrinkage of the outer moisture-sensitive surface **12**. The inner layer **11**, as well as the core **9**, serve as a spring to return the element to its original dimension. As previously described, expansion and contraction of the moisture-sensitive layer **12** puts the core **9** in tension and compression, respectively, which tends to elongate or contract the core to correspondingly vary the resistance of the element.

FIG. 5 is a schematic representation of the use of the element **1** in a humidity indicating system. As shown in FIG. 5, electrodes or clamps **13** are attached to the ends of the element and the ends of the core **2** are free of the outer surface layer **3** so that the electrodes **13** can be directly attached to the core. One of the clamps **13** is rigidly secured to a fixed, insulated support **13***a*. The electrodes **13** are connected in an electrical circuit in series with a source of electric power **14** and an electrical instrument **15** which provides a means for measuring the electric current in the circuit. The instrument **15** may be an ammeter, as shown in FIG. 5, or an ohmmeter, potentiometer, or any other conventional device properly arranged for measuring either resistance of the element or the amount of current which passes in the circuit. As previously described, an increase in moisture conditions in the atmosphere causes the moisture-sensitive layers **3** to expand, which puts the core material **2** under tension. Tension in the core material re-arranges the chains of the electrically conductive particles **4** to change the resistance in the element and provide a reading on the instrument **15**. With a decrease in moisture conditions in the atmosphere, the moisture-sensitive layers **3** will shrink and will be returned to their original dimension by the core material **2**. This, in turn, will again re-arrange the chains of electrically conductive particles **4** to lower the resistance of the element and change the current in the circuit.

The moisture sensitive outer surface layers and the dimensionally stable core containing the electrically conductive material cooperate to provide a humidity sensing element having a rapid response. As the electrically conductive material is embedded and sealed within the moisture-insensitive core the problem of electrolytes or other foreign material contaminating the electrically conductive material is minimized, thereby insuring more accurate and reliable readings.

As the element is synthetically produced under controlled conditions, the thickness and structure are more uniform with the result that less element-to-element calibration is required.

The following example illustrates the method of preparing the electrical humidity sensing element:

EXAMPLE

A glass slide was initially cleaned by rubbing a few milliliters of 5% Hooker fluorolube T80 in methyl ethyl ketone on the slide and the slide was air dried. On this treated slide was cast a 6-mil thick wet film of a 5% solution of cellulose acetate-butyrate in methyl ethyl ketone. The cast film was then air dried. Next, a 5.7-mil thick wet film of 1% conducting carbon and 9% cellulose acetate-butyrate by weight in methyl ethyl ketone was cast onto the first film and air dried. Ends of each of this second film strip containing the carbon were masked for making electrical contact. Finally, a 5.1-mil thick wet film of the 5% solution of cellulose acetate-butyrate in methyl ethyl ketone was cast on the second film and air dried. The entire assembly was then baked at 56° C. in an oven for 15 minutes. The desired outline for the hygrometer element was then cut out with a razor blade and run under cool tap water while the film assembly was still warm. The film readily separated itself from the glass plate.

This film assembly was boiled in fresh 25% sodium hydroxide solution for 15 minutes to hydrolyze the outer surface of the acetate-butyrate film. After removal from the solution, it was washed for 5 minutes in running tap water and then soaked overnight in distilled water. The entire assembly was then air dried and the sample was cut to size and clamped between two electrodes. The over-all film thus prepared was about 1-mil thick and measured 0.5" long by 0.5" wide between the electrodes.

The resistance of this film under various conditions of relative humidity was then measured in a split-stream humidity chamber with an RCA Volt Ohmyst and the response rate was measured to be approximately 90% in 4 to 5 minutes.

Various modes of carrying out the invention are contemplated as being within the scope of the following claims particularly pointing out and distinctly claiming the subject matter which is regarded as the invention.

I claim:

1. An electrical variable dimension humidity sensing element, comprising a first section having a high sensitivity to moisture and characterized by the ability to respond in the form of dimensional changes to relative humidity, a second section substantially coextensive and bonded to a substantial surface portion of the first section and being relatively insensitive to moisture as compared to the first section and characterized by the ability to resist creep and permanent deformation when subjected to dimensional change caused by dimensional changes in the first section through variations of relative humidity, and a series of interconnected electrically conductive particles embedded and dispersed within a substantial portion of said second section and disposed in sufficient contact to effect a measurement of variable resistance.

2. An electrical, synthetic, laminated humidity sensing element, comprising a first section formed of a material having a high moisture sensitivity such that the material will show a dimensional increase of more than 3% of its initial dimension with a change of relative humidity from 0% to 100%, a second section integral and coextensive with a substantial surface portion of the first section and formed of a material having a low moisture sensitivity such that the material will show a dimensional increase of less than 2% of its initial dimension with a change of relative humidity from 0% to 100% and said last named material being resistant to creep and capable of recovering substantially completely from dimensional increases up to 5% of its initial dimension, and a series of interconnected electrically conductive particles embedded within the second section and extending throughout a substantial portion of the length of said second section and disposed in sufficient contact within said second section to effect a measurement of variable resistance.

3. An electrical, synthetic laminated humidity sensing element, comprising a first section formed of a material having a high moisture sensitivity such that the material will show a dimensional increase of more than 3% of its initial dimension with a change of relative humidity from 0% to 100%, a second section integral and coextensive with a substantial surface portion of the first section and formed of a material having a low moisture sensitivity such that the material will show a dimensional increase of less than 2% of its initial dimension with a change of relative humidity from 0% to 100% and said last named material being resistant to creep and capable of recovering substantially completely from dimensional increases up to 5% of its initial dimension, and a series of interconnected electrically conductive particles embedded and distributed throughout a substantial portion of said second section in the form of elongated chains, said chains being elongated and compressed when said second section is subjected to dimensional change to thereby vary the resistance to current flow through said chains.

4. An electrical, synthetic, laminated humidity sensing element, comprising a core formed of a material having a low moisture sensitivity such that the material will show a dimensional increase of less than 2% of its initial dimension with a change of relative humidity from 0% to 100% and said last named material being resistant to creep and capable of recovering substantially completely from dimensional increases up to 5% of its initial dimension, a plurality of interconnected electrically conductive particles embedded within said core and extending substantially the length of said core, said particles characterized by the ability to change their electrical conductivity in accordance with a change in dimension of said core, and an annular sheath surrounding a substantial portion of the length of the core and bonded thereto, said sheath being formed of a material having a high moisture sensitivity such that the material will show a dimensional increase of more than 3% of its initial dimension with a change of relative humidity from 0% to 100%.

5. The structure of claim 3 in which the particles are formed of carbon.

6. The structure of claim 2, and including means attached to spaced portions on said electrical conductive material for connecting said material in an electrical circuit.

7. A synthetic laminated electrical humidity sensing element, comprising a core formed of a material relatively insensitive to moisture changes and being resistant to creep and capable of recovering substantially completely from dimensional increase up to 5% of its initial dimension, a plurality of interconnected electrical conductive particles embedded and dispersed within a substantial portion of the length of said core and bonded to said core and characterized by the ability to conduct an electrical current, and an outer layer bonded in coextensive relation with said core throughout a substantial surface portion of the core to provide a laminated structure, said outer layers formed of a material having a high moisture sensitivity such that the material will show a dimensional increase of more than 3% of its initial dimension with changes of relative humidity from 0% to 100%, said core and outer layers having substantially similar coefficients of thermal expansion.

8. A synthetic laminated humidity sensing element, comprising a core of a substantially 100% esterified cellulose ester in which the esterifying acids contain up to 8 carbon atoms, a plurality of finely divided particles of an electrical conductive material distributed throughout said core and being arranged in electrically conductive chains extending throughout a dimension of said core, and an outer layer of regenerated cellulose bonded in substantial coextensive relationship to the core throughout a substantial surface portion of said core, said cellulose being highly sensitive to moisture conditions and increasing in dimension with increases in relative humidity and said core tending to resist the increase in dimension of said cellulose outer layer and prevent permanent deformation of said cellulose outer layer, changes in dimension of said core tending to elongate and contract the chains of electrically conductive particles to thereby vary the resistance of said chains to current flow.

9. A synthetic laminated electrical humidity sensing element, comprising a thin sheet-like strip of a cellulose ester in which the esterifying acids contain up to 8 carbon atoms and said esters are substantially free of hydroxyl groups, and an outer layer of cellulose bonded to opposite faces of the strip and extending throughout a substantial portion of said faces, said cellulose being highly sensitive to moisture conditions and increasing in dimension with increases in relative humidity, said cellulose ester strip tending to resist the increase in dimension of the cellulose outer layers and preventing permanent deformation of said cellulose outer layers, and a series of interconnected particles of an electrically conductive material dispersed and embedded within a substantial portion of the length of the strip and bonded to said cellulose ester, said particles disposed in sufficient contact to effect a measurement of variable resistance with changes in relative humidity.

10. The structure of claim 7 and including means for securing one end of said core to a fixed support, and means for connecting said electrical conductive material in an electric circuit.

11. A synthetic laminated electrical humidity sensing element, comprising a core formed of a material rela-

tively insensitive to moisture changes and being resistant to creep and capable of recovering substantially completely from dimensional increases up to 5% of its initial dimension, a plurality of finely divided particles of electrically conductive carbon distributed throughout the core in electrically conductive relation, an outer layer bonded in coextensive relationship with the core throughout a substantial surface portion of said core to provide a laminated structure, said outer layer formed of a material having a high moisture sensitivity such that the material will show a dimensional increase of more than 3% of its initial dimension with changes of relative humidity from 0 to 100%, means for connecting one end of said core to a fixed support, and means for connecting said chains of electrically conductive particles in an electrical circuit.

12. A method of fabricating a synthetic laminated electrical humidity sensing element, comprising the steps of embedding a plurality of electrically conductive particles in electrical conductive relation within a substantial portion of the length of a substance characterized by being relatively insensitive to moisture and being resistant to creep, and forming a coating of a material having a high sensitivity to moisture and characterized by the ability to respond in the form of dimensional changes to changes in relative humidity on a substantial surface portion of said substance.

13. A method of fabricating a synthetic laminated electrical humidity sensing element, comprising the steps of dispersing particles of an electrically conductive material so as to form conducting chains and paths in a core of a material relatively insensitive to moisture changes and resistant to creep, said material capable of recovering substantially completely from dimensional increases up to 5% of its initial dimension, and applying a coating of a material having a high moisture sensitivity to a substantial surface portion of said core, said material showing a dimensional increase of more than 3% of its initial dimension with changes of relative humidity from 0 to 100%.

14. A method of forming a synthetic electrical humidity sensing element, comprising the steps of embedding particles of carbon within a core with the particles being in interconnecting relation to form a plurality of chains extending through the core, said core having a low sensitivity to moisture such that the material will show a dimensional increase of less than 2% of its initial dimension with a change in relative humidity from 0 to 100% and said core material being resistant to creep and capable of recovering substantially completely from dimensional increase up to 5% of its initial dimension, and applying a thin outer layer of a substantial moisture sensitive material to a surface portion of said core, said outer layer being integral with the core and being characterized by having a high sensitivity to moisture such that it will show a dimensional increase of more than 3% of its initial dimension with a change of relative humidity from 0 to 100%.

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