

April 1, 1941.

L. R. KOLLER
ELECTRIC HYGROMETER
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2,237,006.

Fig. 1.

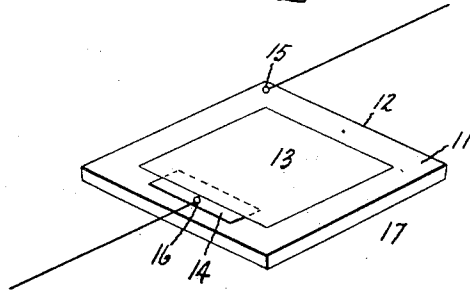


Fig. 2.

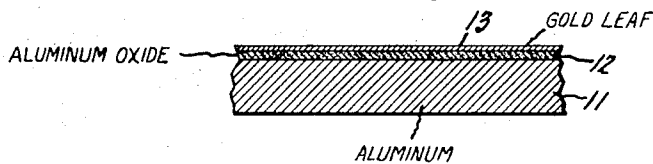


Fig. 3.

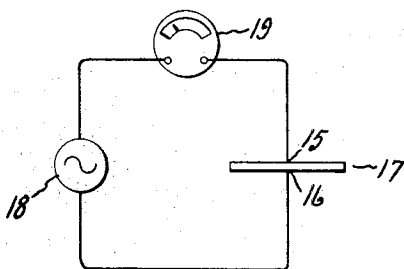
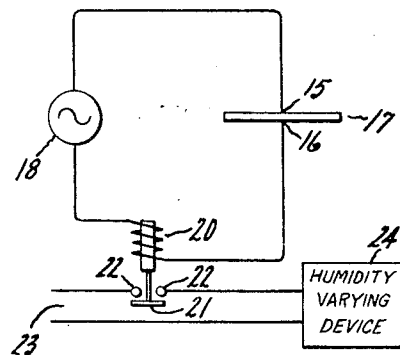


Fig. 4.



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UNITED STATES PATENT OFFICE

2,237,006

ELECTRIC HYGROMETER

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Application April 21, 1938, Serial No. 203,297

5 Claims. (Cl. 201—63)

My invention relates to humidity or moisture indicators and regulators and concerns particularly humidity responsive elements which vary in electrical conductivity with variations in humidity.

It is an object of my invention to provide a humidity responsive element having a high conductivity and which will carry sufficient current to operate contact-making and indicating devices and instruments directly.

It is a further object of my invention to provide a humidity responsive element which responds quickly to variations in humidity and quickly reaches equilibrium after a change in humidity. Other and further objects and advantages will become apparent as the description proceeds.

In carrying out my invention in its preferred form I provide a base of electrically conducting material on the surface of which is coated a very thin film of hygroscopic material such as a metallic oxide, which is covered with a foil of material which can be beaten very thin, such as gold foil. A voltage is applied between the two surfaces of the oxide film by means of terminals connected to the metallic base and to the foil covering, and variations in current are observed to determine variations in humidity.

The invention may be understood more readily from the following detailed description when considered in connection with the accompanying drawing and those features of the invention which are believed to be novel and patentable will be pointed out in the claims appended hereto. In the drawing Figure 1 is a perspective view diagrammatically representing one embodiment of my invention. Figure 2 is a fragmentary enlarged cross sectional view of the arrangement of Figure 1. Figure 3 is a circuit diagram of a humidity indicator utilizing a humidity responsive element of the type illustrated in Figures 1 and 2; and Figure 4 is a circuit diagram of a humidity controller corresponding to the arrangement of Figure 3.

Like reference characters are utilized to designate like parts throughout the drawing.

The humidity responsive element illustrated in Figure 1 comprises a plate 11 of conducting material serving as a base, the surface of which is coated with a suitable hygrometric material such as a metallic oxide 12. Upon the coated surface 12 of the base 11 a cover of very thin conducting material such as metallic foil 13 is laid and electrical connections are provided for the base 11 and the foil cover 13. If desired, the foil 13 may be electrically and mechanically rein-

forced for the electrical connection by providing a sheet 14 of thin electrical conducting material in contact with a portion of the surface of the foil 13. A terminal 15 is shown in electrical contact with the base 11 and a terminal 16 is shown in electrical contact with the foil 13 through the reinforcing sheet 14.

A humidity responsive element such as that shown in Figure 1 is represented by the reference numeral 17 in Figures 3 and 4 and the element 17 is connected to a source of alternating current 18 in series with a current responsive device such as an indicating instrument 19 or contact-making circuit controlling device or a relay 20. In Figure 4 the contact-making device 20 is shown with a movable contact 21 and a pair of stationary contacts 22 included in an electrical circuit 23 which may be an operating circuit for any suitable type of humidity varying device 24 such as, for example, a blower for introducing humidified air into a chamber or a steam valve for controlling the heating of a chamber to dry the atmosphere, or the like.

Although my invention is not limited to the use of particular chemical substances for constructing the humidity responsive element 17, I have found that satisfactory results may be obtained by utilizing as the base 11 a plate of aluminum and forming a film of aluminum oxide 12 thereon electrolytically in a sulphuric acid electrolyte. Although not limited to the specific thickness of film I have found a thickness of approximately $\frac{1}{16}$ of a mil to be satisfactory. I have obtained satisfactory results by using gold leaf as the cover 13 for the aluminum oxide and I believe that gold leaf has the advantage of permitting moisture to pass through it quickly to the aluminum oxide or to the atmosphere. In view of this property of the foil and the extreme thinness with which aluminum oxide can be prepared I find that the humidity responsive element reaches equilibrium very quickly after a change in the humidity of the surrounding atmosphere, so that my humidity responsive element is useful in cases where quick response to variations in humidity is desired.

I have found that the conductivity of the aluminum oxide film 12 varies approximately linearly with the aqueous vapor tension of the surrounding atmosphere for the humidities in the range usually experienced in ordinary rooms.

With a 100-volt alternating current source I have found the relationship between aqueous vapor tension of the atmosphere and current in microamperes for every square centimeter of

surface of oxide film to be approximately as represented in the following table:

Aqueous vapor tension (in mm. of Hg.)	Microamperes per sq. cm. at 100 volts
.0015	20.8
1.03	50
3.97	91.7
8.45	131
13.5	193
17.8	246
20.4	298
23.8	371

It will be obvious that the current-carrying capacity of the device may be varied by varying the surface area of the film.

The electrical supply source 18 may be either alternating current or direct current but where the apparatus is to be in operation for extended periods of time I prefer to utilize an alternating current source since I find that there is no fatigue effect with alternating current.

Although I have obtained satisfactory results by the use of an aluminum base 11 it will be understood that my invention is not limited thereto. For example, I may employ a base of chromium metal with the surface oxidized. Likewise, I have found that satisfactory results are obtained from a steel base on which chromium oxide has been painted to form the hygroscopic film. The hygroscopic film may also be formed by dipping a steel plate into a mixture of chrome oxide, acetone, and a small amount of alkyd resin or varnish such as that sold under the trade name "Glyptal." It will be observed that both aluminum oxide and chromium oxide are refractory oxides.

The foil cover of the arrangement illustrated in Figure 2 consists of a sheet of commercial gold leaf, which has a thickness of approximately 10⁻⁵ centimeters, and is applied to the oxide film 12 by merely laying the foil on the coated base 11, connecting the terminals 15 and 16 to a voltage source and allowing the electrostatic attraction to hold the foil against the coated plate. After a short time, I find that the foil 13 adheres firmly even without the electrostatic attraction. Although I have found such a gold leaf cover satisfactory, my invention is not limited to the use of this precise form of cover. For example, the thickness, the material, or the method of producing may be varied. Gold has the advantage over silver of not tarnishing but silver and various other metals may be used, preferably metals which are not subject to corrosion. Instead of laying metallic leaf upon the oxide film 12, the cover 13 may, for example, be applied by the evaporating process or by cathode sputtering in a manner somewhat similar to these well known processes of producing thin metallic coatings for use as mirror surfaces. In the specification and claims, I use the word "foil" to specify any very thin sheet regardless of the method by which it is produced.

Aluminum oxide has a volume specific resistivity of approximately $\frac{1}{3}$ megohm cm. I am enabled to use such a high resistance hygroscopic material effectively by utilizing a very thin film of large area and passing the current through it transversely. I believe that the aluminum oxide formed in a film as described acts as a spongy

holder for atmospheric water which is hydrolized by the electric field and carries current varying with the humidity.

I have herein shown and particularly described certain embodiments of my invention and certain methods of operation embraced therein for the purpose of explaining its principle and showing its application but it will be obvious to those skilled in the art that many modifications and variations are possible and I aim, therefore, to cover all such modifications and variations as fall within the scope of my invention which is defined in the appended claims.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A humidity responsive element which varies in electrical conductivity with variations in humidity, said element comprising an aluminum base having an electrolytic refractory oxide film thereon and a gold foil lying against and substantially covering the oxide film, with electric terminals connected to the aluminum base and to the gold foil, said film comprising a moisture sensitive oxide of the group consisting of aluminum oxide and chromium oxide, and said gold foil being sufficiently thin to permit atmospheric moisture to reach and affect the oxide film.

2. A humidity responsive element which varies in electrical conductivity with variations in humidity, said element comprising a base of conducting material having a film of aluminum oxide thereon of a thickness less than one mil and a gold foil lying against the oxide film, with electric terminals connected to the base and to the gold foil.

3. A humidity responsive element which varies in electrical conductivity with variations in humidity, said element comprising an aluminum base with an oxidized surface and a thin metallic foil lying against the oxidized surface, with electric terminals connected to the aluminum base and to the metallic foil.

4. A humidity responsive element which varies in electrical conductivity with variations in humidity, said element comprising a base of an electrical conducting material, a film composed of a refractory metallic oxide coated on the surface of the base and a thin metallic foil lying against and substantially covering the oxide film with electric terminals connected to the base and to the foil, said film comprising a moisture sensitive oxide of the group consisting of aluminum oxide and chromium oxide, and said metallic foil being sufficiently thin to permit atmospheric moisture to reach and effect the oxide film.

5. A humidity responsive element which varies in electrical conductivity with variations in humidity, said element comprising a film of hygroscopic material of extreme thinness in comparison with its surface area and continuous sheets of electrical conducting material in contact with the surfaces of said film and substantially covering them, the sheet upon one surface of said film being of sufficient thinness to permit absorption and dissipation of moisture by the hygroscopic material without having openings in the latter sheet.

LEWIS R. KOLLER.

CERTIFICATE OF CORRECTION.

Patent No. 2,237,006.

April 1, 1941.

LEWIS R. KOLLER.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 1, second column, line 36, for the word "golf" read --gold--; page 2, second column, line 55, claim 4, for "effect" read --affect--; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 13th day of May, A. D. 1941.

(Seal)

Henry Van Arsdale,
Acting Commissioner of Patents.

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