

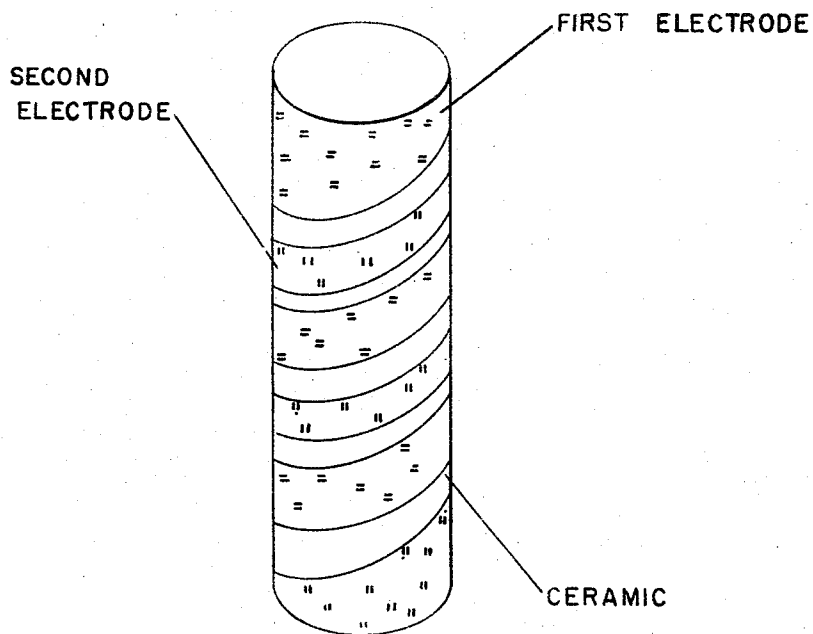
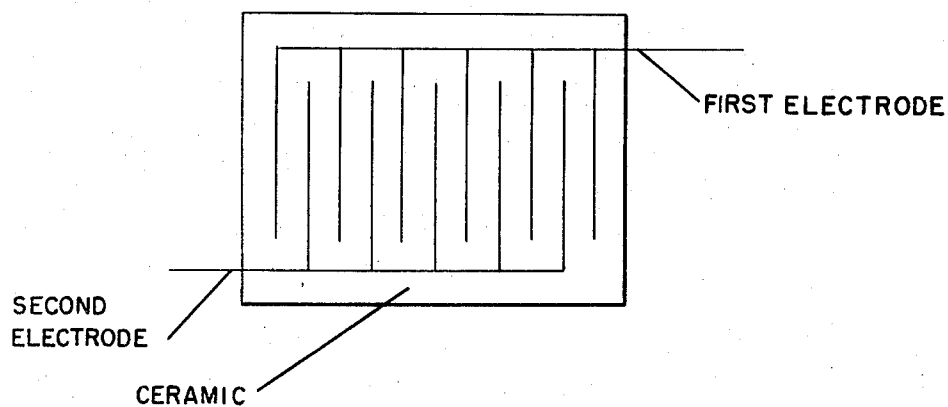
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2,862,090

APPARATUS FOR DETERMINING MOISTURE

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1

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APPARATUS FOR DETERMINING MOISTURE

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6 Claims. (Cl. 201—63)

This invention relates to an apparatus for determining humidity, moisture content and similar water vapor-gas relationships by a simple electrical measurement. More particularly it relates to a novel moisture responsive sensing element suitable for use in an apparatus of the type described.

Numerous devices are presently known for determining the moisture content of the atmosphere or of other gases or vapors, some of which are described in an article by F. Lichtgarn appearing in "Instruments," volume 20, pages 336, 337 and 338, published April 1947 by the Instruments Publishing Company, Inc. (U. S. A.).

This article describes the development of sensitive elements for humidity measuring devices based on porous ceramic compositions such as those described in United States Patent 2,358,406, issued September 19, 1944. Unlike many of the devices described in the literature, these devices depend upon a change in resistance produced by absorption of water vapor by the surface of the element itself rather than by a change in resistance produced by absorption of water vapor by an active material distributed as a coating or winding on the surface of a carrier element.

The present invention contemplates the provision of a moisture-sensing element made of specific constituents and which responds in an improved manner to water vapor changes in the environment in which it is disposed, in a repeatable and reversible manner. The moisture-sensing element is simple and inexpensive to produce and to operate and can be provided in any desired size or shape. It is further characterized by a combination of optimum properties hitherto unobtainable by any of the prior art devices known to me.

One object of the invention is the provision of a simple and inexpensive moisture-sensing element whose electrical conductance varies reversibly with the amount of moisture in the medium surrounding the element.

Another object of this invention is the provision of a moisture-sensing element which can be produced simply and inexpensively so as to have reproducible properties.

These and other objects and advantages of the invention will become apparent from the following description which is illustrative of but one mode of carrying out the invention and is not limitative thereof.

Two preferred embodiments of the invention are illustrated in the accompanying drawings in which:

Figure 1 is a plan view of one form of humidity detecting device according to the invention; and

Figure 2 is a perspective view of another form of humidity detecting device according to the invention.

The device shown schematically in Figure 1 consists of a fired ceramic plate to one surface of which electrodes have been applied as described in the example below.

In Figure 2, the device is in the form of a cylinder, on the surface of which there are disposed two electrodes, encircling the cylinder.

I have discovered that titanates possess a number of

2

advantages as humidity sensing elements. Of these, the titanate formed by cerium appears to possess the most useful combination of properties. To prepare sensing elements, a blend is formed of powdered materials composed of a suitable compound of cerium and a suitable compound of titanium in proportions which will produce the desired product. The blend is then passed through a micropulverizer and after it has been reduced to an impalpable powder it is charged into crucibles in which it is calcined. The calcined product is then comminuted in a jaw crusher after which it is ball milled for a time sufficient to reduce the particles to the desired fineness. The finely powdered material is then dried at about 100° C. after which it is shaped into any suitable configuration. The green elements are then fired at a high temperature to convert them into fired ceramic pieces. Following the firing operation, electrodes are attached to the element by any suitable technique, thereby producing the finished element, ready for testing and incorporation into any desired electronic equipment wherein it serves as a sensing element responsive to variations in the moisture content of the medium surrounding it.

The titanates produced in accordance with this invention should be as pure as possible, and hence should be prepared, preferably, from pure starting materials.

The titanium dioxide should be of high purity and may be provided by either artificially or naturally occurring sources. It is preferred to use pigment grade titanium dioxide as the starting material so that the titanate produced will require no further purification to place it in useful condition for incorporation in a sensing element.

The cerium compound which is combined with the titanium dioxide to form a titanate need only be as pure as that which is commercially available. A convenient compound for the purpose is a commercially available cerium hydrate, in powder form, as $\text{CeO}_2 \cdot 2\text{H}_2\text{O}$. Other cerium compounds which may be ignited to the oxide may also be used, but for reasons of economy, the hydrated oxide is preferred.

Powdered cerium hydrate and titanium dioxide are intimately mixed together to form the initial blend from which the sensing element is to be formed. For each three mols of titanium dioxide present in the initial mixture, there must be about two mols of cerium oxide in order to form the desired titanate. I have found however that about 1.5–2.5 mols of cerium oxide will, when blended with 3 mols of titanium dioxide, produce a ceramic material with the desired properties. I have found that the ratio of 3 mols: 2 mols produces a composition with an optimum combination of properties.

The following example will serve to more fully illustrate this invention.

Example

Eleven and one-half (11.5) parts by weight of cerium hydrate ($\text{CeO}_2 \cdot 2\text{H}_2\text{O}$) and six and one-half (6.5) parts by weight of pigment grade titanium dioxide (TiO_2), both in powder form, were blended in a twin-shell blender. The blended materials were then micropulverized to a product substantially all of which was finer than 325 mesh (Tyler standard). The micropulverized product was placed in crucibles and calcined in an electric furnace for one hour at about 2100° F. The resulting calcine was crushed in a jaw crusher and then ball milled for several hours. Prior to forming the finely divided material into green elements of the desired shape, it was dried in an oven at 100° C. The dried powder was then formed into sensing elements about 1 inch long, ¼ inch wide and .040 inch thick in a pelleting press capable of forming between 500 and 3000 elements per hour. The green elements were loaded on trays and fired in an electric furnace for one hour at 2200° F. Electrodes were then formed on the

fired elements by a silk-screen process and were permanently joined to the elements by firing in place in an electric furnace to produce the devices shown by way of example in Figures 1 and 2.

Humidity-sensing elements produced as above described were then evaluated by comparing the sensitivity and response speed with that of other devices presently commercially available. In addition, curves were plotted for moisture content (as relative humidity of air) vs. resistance. It was found that elements of the size and shape described had a very rapid rate of response to changes in moisture content, and that when incorporated in suitable circuits, could be made to accurately indicate even drastic changes in the moisture content of the surrounding atmosphere in between 15 and 30 seconds and that the elements were able to follow gradual changes in the moisture content of the atmosphere about them even more rapidly.

The resistance values of elements constructed as above described were found to bear a straight line relationship to the relative humidity when plotted on semilogarithmic graph paper.

Having now described my invention in detail in accordance with the patent statutes, what I desire to secure by Letters Patent is set forth in the following claims:

I claim:

1. A humidity-sensitive member comprising a porous ceramic body portion formed of cerium titanate.
2. A humidity-sensitive member comprising a core of cerium titanate and a pair of spaced electrodes in intimate contact therewith.

3. A hygrometric resistance element comprising two conductors connected electrically to one another through a core of titanate material whose resistance varies with the moisture content of the atmosphere surrounding said material, said material comprising the product of firing a mixture of (1) a cerium compound selected from the compounds of cerium which yield cerium oxide when ignited and (2) titanium dioxide.

4. The device of claim 3 in which the titanate material is $\text{Ce}_2(\text{TiO}_3)_3$.

5. The device of claim 3 in which the titanate core is composed of two mols of the cerium oxide yielding compound for each three mols of titanium dioxide.

6. The device of claim 3 in which the titanate core consists essentially of between 1.5 and 2.5 mols of cerium oxide for each 3 mols of titanium dioxide.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 2,862,090

Edward F. Mayer

November 25, 1958

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 1, lines 33 and 35, for "absorption", each occurrence, read
-- adsorption --.

Signed and sealed this 24th day of March 1959.

(SEAL)
Attest:

KARL H. AXLINE
Attesting Officer

ROBERT C. WATSON
Commissioner of Patents

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