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Bennewitz

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[54] **MOISTURE SENSING ELEMENT AND METHOD OF MAKING SAME**

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[52] **U.S. Cl.** **338/34,** 29/610, 73/335, 338/35

[51] **Int. Cl.** **H01c 13/00**

[58] **Field of Search** 338/34, 35; 200/61.06; 29/610; 252/518; 73/73, 336.5, 335; 340/235

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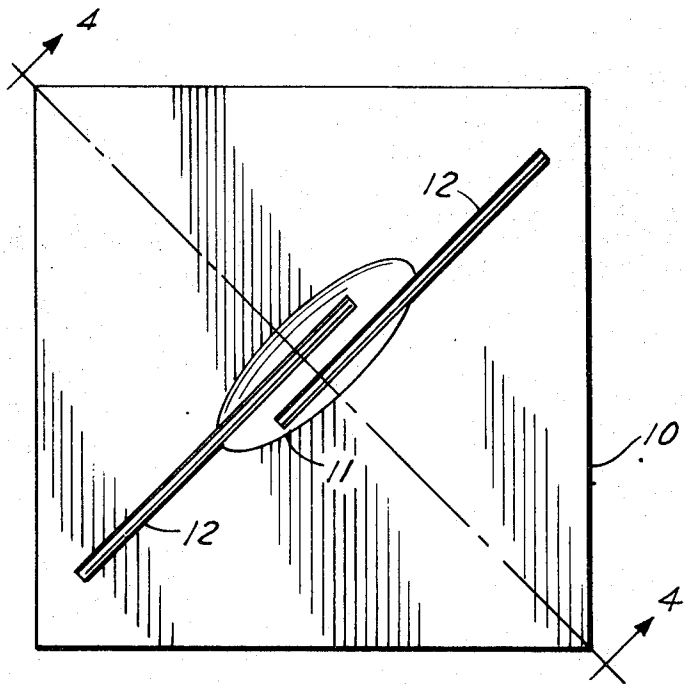
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[57] **ABSTRACT**

A moisture sensing element includes a pair of electrodes held spaced apart by a crystal lattice. The crystal lattice has interstitial spaces formed therein and is electrically neutral so that molecules of atmosphere having water ions therein randomly drift in and out of the crystal interstices. The resistance of the sensing element varies as a function of the per cent of water vapor present in the interstices of the crystal lattice. The sensing element may be formed by embedding platinum-iridium wires in a Cr_2O_3 - V_2O_5 mixture and baking the mixture in the presence of Al_2O_3 doping chips.

18 Claims, 10 Drawing Figures



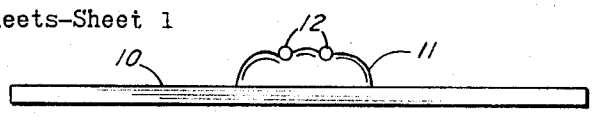


FIG. 4

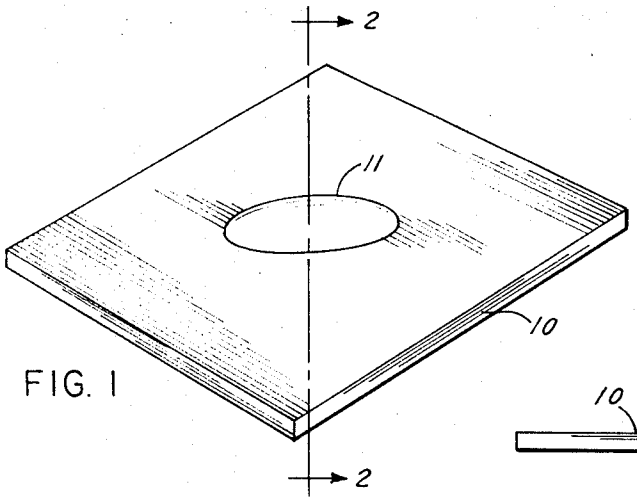


FIG. 1

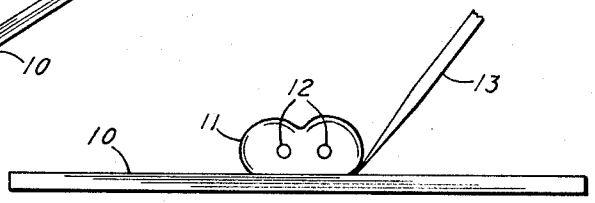


FIG. 5a

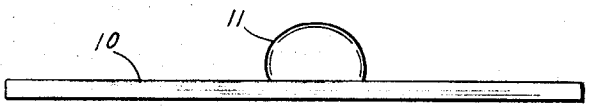


FIG. 2

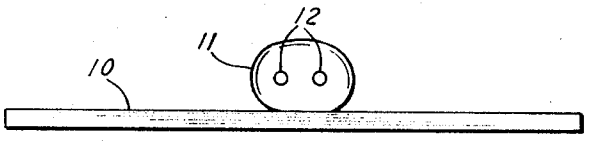


FIG. 5b

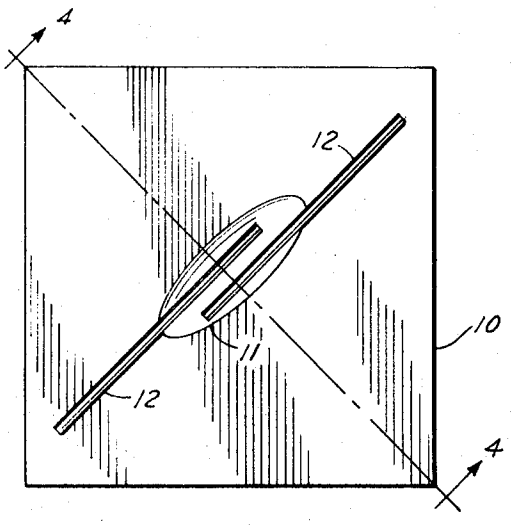


FIG. 3

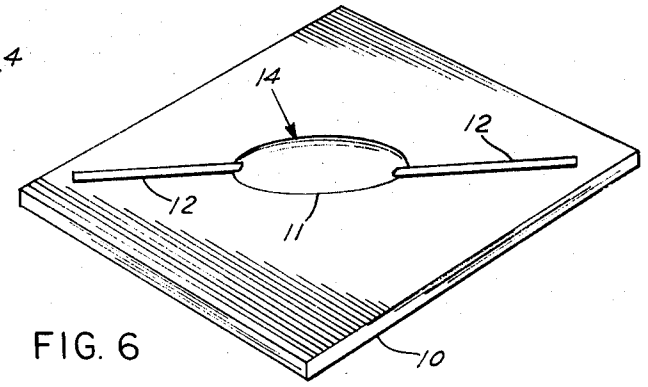


FIG. 6

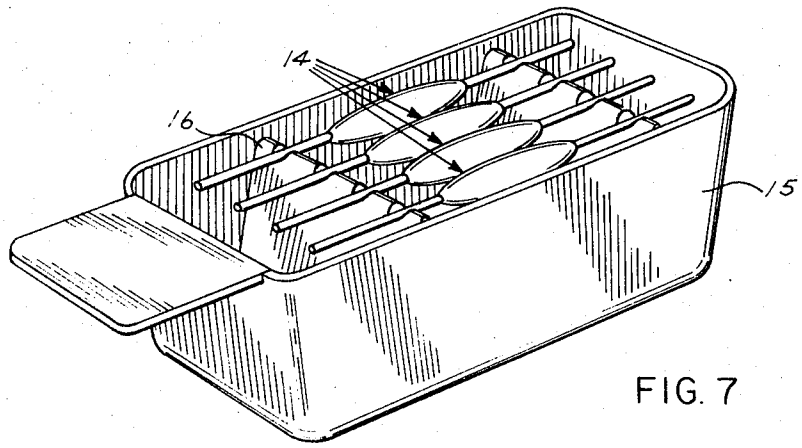


FIG. 7

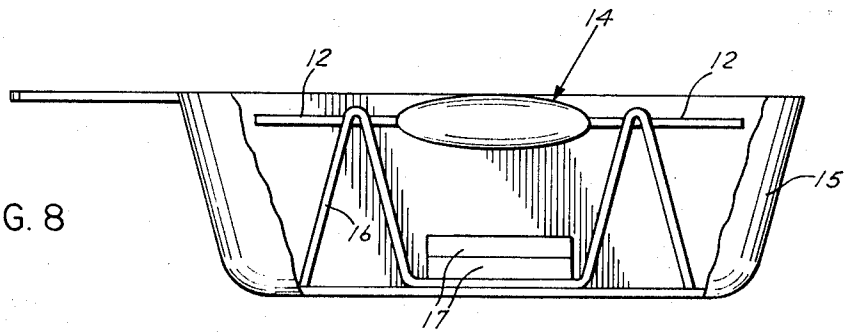


FIG. 8

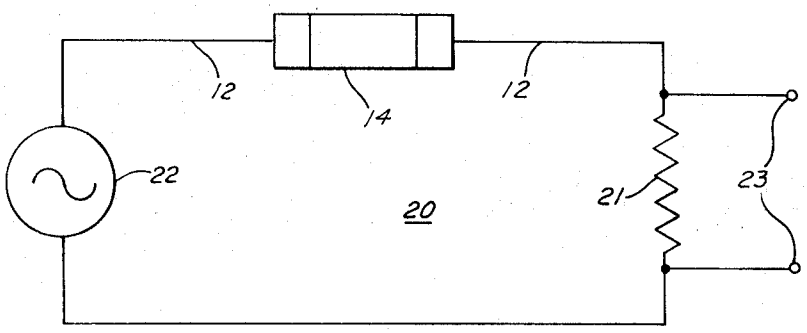


FIG. 9

MOISTURE SENSING ELEMENT AND METHOD OF MAKING SAME

The present invention relates to sensing elements and more particularly to moisture or humidity sensing elements and apparatus.

Prior art humidity sensors have generally functioned by either the absorption or adsorption of moisture operating on the theory that moisture must be attracted to make a measurement. As a consequence, these sensors have been relatively slow acting, exhibiting a hysteresis or delayed response due to the time interval required for the absorbed or adsorbed moisture level of the sensor to reach equilibrium with the atmosphere being monitored. Additionally, these prior art sensors have generally been extremely temperature sensitive; had limited operating ranges, i.e., were not capable of measuring relative humidity over the full range of 0 to 100 percent; and were relatively large and bulky.

Oftentimes such humidity sensors are employed to monitor relative humidity in enclosed areas or closed containers. A significant disadvantage inherent with utilizing one of the prior art sensors which is hygroscopic, i.e., moisture absorbing, to monitor an enclosed area is that the abosrption of the moisture from the atmosphere therein causes the moisture level adjacent the sensor to change. As a result, the resultant measurement by the sensor does not reflect the true moisture level within the enclosed region.

Another significant drawback with these prior art sensors is that they frequently sense humidity through changes in their surface resistance caused by the absorption or adsorption of moisture. As a consequence, contamination of the surfaces of such sensors, such as by dust or gaseous elements, cause the response characteristics of these sensors to be altered whereupon inaccurate measurements result.

Further drawbacks with the prior art sensors or sensing elements are that complex A.C. bridge circuitry oftentimes had to be employed with them in order to obtain accurate readings and once they were driven into saturation they frequently lost their original calibration.

It is, accordingly, an object of the present invention to provide an improved moisture sensing element and method for making same which obviates the aforementioned disadvantages of prior art sensing elements.

It is further an object of the present invention to provide an improved moisture sensing element characterized by being of a relatively small size, operable to measure substantially the entire range of relative humidity from 0 to 100 percent, extremely accurate, highly sensitive and substantially unaffected by temperature variations and which has a relatively fast response time and does not lose its calibration or become permanently damaged when saturated.

It is also an object of the present invention to provide an improved moisture sensing element which does not remove moisture from the atmosphere being monitored but which rather measures relative humidity without affecting the environment being monitored.

It is additionally an object of the present invention to provide an improved humidity sensing apparatus which has an extremely fast response time and is capable of accurately monitoring the moisture content of an environment without affecting or altering the environment's moisture level.

In accomplishing these and other objects, there is provided an improved humidity sensing element which includes a pair of electrodes spaced apart by a crystal lattice or array. The crystal lattice is formed of material which is electrically neutral to water molecules or dipoles so as to neither attract nor repulse water ions and has interstitial spaces formed therein between the electrodes. The interstitial spaces in the crystal lattice are formed to permit molecules of the atmosphere being monitored to randomly drift in and out of the crystal interstices due to vapor pressure.

The sensing element functions to measure relative humidity by changes in its volumetric resistance which changes occur as a function of the percent of water vapor present in the molecules of atmosphere within the interstices of the crystal lattice. It has been found that the major changes in the resistance of the crystal lattice occur at the interstitial spaces bounded by the electrodes and not along its surfaces. A humidity sensing apparatus may be formed by exciting one of the sensing elements with an A.C. voltage source and using a simple series resistance readout arrangement.

The crystal lattice of the sensing element is preferably made by mixing and processing chrome sesquioxide, Cr_2O_3, and vanadium pentoxide, V_2O_5, by the method hereinafter described. The electrodes are preferably made from platinum-iridium wire.

Additional objects of the present invention reside in the specific construction of the moisture sensing element and the method for forming it which are hereinafter particularly described in the specification and shown in the several drawings.

FIG. 1 is a perspective view of a cover plate having thereon a shaped quantity of the mixture used for forming the body of a sensing element according to the present invention.

FIG. 2 is a sectional view taken along the line 2—2 of FIG. 1.

FIG. 3 illustrates a pair of leads pressed in a spaced apart parallel relationship into the mixture on the cover plate of FIG. 1.

FIG. 4 is a sectional view taken along the line 4—4 of FIG. 3.

FIGS. 5*a* and 5*b* are sectional views as in FIG. 4 which illustrate the step of shaping the mixture over the spaced apart leads.

FIG. 6 is a perspective view of the cover plate of FIG. 1 illustrating the mixture shaped over the leads, as shown in FIG. 5*b*, to form a sensing element according to the present invention.

FIG. 7 is a perspective view of several sensing elements of the type shown in FIG. 6 positioned spaced apart in a firing boat ready for placement in a furnace.

FIG. 8 is a side cutaway view of the firing boat of FIG. 7.

FIG. 9 is a circuit diagram of a humidity sensing apparatus utilizing a sensing element according to the present invention.

An exemplary moisture sensing element which includes a pair of electrodes held spaced apart by an electrically neutral crystal lattice having interstitial spaces formed therein may be made by the following method. Sufficient quantities of the chemical compounds chrome sesquioxide (chromic oxide) Cr_2O_3 and vandium pentoxide V_2O_5 are first separately ground to fine powders, for example, in a pestle. The chemical com-

pounds used may be reagent grade chemicals although chemical compounds of higher purity are preferred.

Predetermined quantities of the ground compounds Cr_2O_3 and V_2O_5 are combined in a one to one ratio by weight, weighing each compound to an accuracy of approximately about 0.001 gram. The final mixture of Cr_2O_3 and V_2O_5 is preferably formed by the steps of: initially mixing the Cr_2O_3 and V_2O_5 powders; grinding and further mixing this initial mixture in a pestle; and then further mixing the compounds under a microscope with a suitable vehicle to form a thick paste which may be pulled apart or separated by drawing a spatula across it. The vehicle used in mixing the Cr_2O_3 and V_2O_5 into the paste may be beta terpinol in combination with a suitable organic type of binder, such as an organic acetate.

The homogeneous paste formed by the mixture of Cr_2O_5 and V_2O_5 is allowed to combine chemically by aging it for a predetermined period of time. This step is accomplished preferably by storing the paste material in a sealed container for at least about two weeks.

After the mixture of Cr_2O_3 and V_2O_5 has been allowed to set or age for the two week period, a predetermined quantity of the mixture is placed on a clean microscope cover slip or plate **10.** The mixture is then shaped, preferably by use of a pointed instrument such as a knife blade, under a stero-optic microscope to form an elongated sensor body portion **11** of the shape shown in FIGS. **1** and **2.** The body portion **11** shown in FIGS. **1** and **2** has preferably a length of about 100 mils, i.e., 0.1 inch; a diameter of about 10 mils at its center; and is symmetrically shaped to points at each end. A micrometer eyepiece may be used with the microscope to accomplish the shaping above-described.

A pair of electrical leads **12** which form electrodes are pressed into the sensor body portion **11** as shown in FIGS. **3** and **4.** The leads **12** are straight wires and are layed longitudinally on the sensor body **11** side by side each other in a mutually parallel spaced apart relationship. The leads **12** are preferably placed by use of tweezers and a knife blade and are laid end to end so that each lead **12** extends from an opposite end of the sensor body **11.** The leads **12** are pressed into position to have a predetermined measured separation of approximately 5 mils and are symmetrically laid in the sensor body **12** to overlap longitudinally side by side for a distance of about 75 mils.

It is noted that 4 mil wire made of platinium and 10 percent iridium has been found suitable for use as the electrodes **12.** The platinium-iridium wire has been found compatible with the Cr_2O_3 - V_2O_5 mixture from a chemical and temperature standpoint. The platinium-iridium wire should be annealed prior to being pressed into a sensor body **11.** One suitable manner for annealing the platinium-iridium wire is by subjecting it to a nitrogen or hydrogen mixture at a temperature of 600° C for 15 minutes. The annealed platinium-iridium wire is cut into measured lengths of approximately 0.25 to 0.40 inches to form the electrodes or leads **12** and then stored in a clean culture dish until needed.

The Cr_2O_3 - V_2O_5 mixture of the sensor body **11** is next folded up and around the electrodes **12** by use of a knife blade **13** or other suitable instrument, as shown in FIG. **5***a*, thereby to embed the electrodes **12** in the mixture. The sensor body **11** is shaped until a rounded symmetrical cross-section, as shown in FIG. **5***b*, is achieved. It is noted that during this shaping step, the cover slip **10** may be placed in a culture dish to allow the body **11** to set and dry, and that periodically the cover slip **10** is removed from the dish to reshape the sensor body **11.** In particular the portion of the sensor body **11** resting upon the plate **10** is reshaped until it is sufficiently rounded so that the sensor body **11** may be easily lifted from the cover slip **10** by the knife blade **13.** At this time the sensor body **11** with the electrodes **12** held therein in the spaced apart positioning above-described is lifted from the cover slip **11** and turned over thereon. It is noted that the outer surface of the material of the sensor body **11** glazes as it dries and that as it glazes the material becomes easier to work.

A sensing element **14** including a pair of electrodes **12** and a symmetrically rounded elongated body **11** shaped in the manner above-described is shown on the cover plate **10** in FIG. **6.** This element **14** when finally shaped, as shown in FIGS. **5***b* and **6**, is dried preferably by being turned over on the cover plate **10** and air dried for a period of at least about 12 hours.

Following the drying of one or more sensing elements **14**, they are placed side by side in an upwardly opening firing boat **15** upon a notched mandrel **16** or other suitable support structure. The firing boat **15** and mandrel **16** are each preferably made of platinum. The mandrel **16** is appropriately constructed for holding a plurality of sensing elements **14** by their electrodes **12** spaced apart above the bottom of the boat **15**, as shown in FIGS. **7** and **8.** Doping chips **17** are positioned in the bottom of the boat **15** on the central U-shaped portion of the mandrel **16** just below the body portions **11** of the suspended sensing elements **14.** The doping chips **17** are preferably stacked on the bottom of the firing boat **15**, as shown in FIG. **8**, and are ⅛ inch square, 30 mil thick aluminum oxide, Al_2O_3, chips. Four of such chips are preferably placed in the firing boat **15.**

The firing boat **15** with the sensing elements **14** and the doping chips **17** stacked therein is placed in a furnace. The furnace should be preferably equipped with a ceramic diffusion tube, be capable of generating a temperature of at least about 1,700° C, and be capable of holding a prescribed peak baking temperature within about 2° C. The firing boat **15** is placed in the center of the diffusion tube so that it is positioned in the most uniformly heated region of the furnace. It is noted that the diffusion tube should be clean at the time of placing the boat **15** therein and that the furnace should be arranged with an appropriate gas circulation and control system so that the sensing elements **14** in the boat **15** are not exposed to a carbonaceous atmosphere during their processing therein.

With the firing boat **15** placed in the diffusion tube as above-described, the furnace is sealed in a cold or ambient condition. Nitrogen gas is then injected into the furnace to build the internal pressure to about 5 pounds per square inch and heat is applied to increase the internal temperature of the furnace at the rate of about 10° C per minute for 40 minutes. At the end of the 40 minute period, the nitrogen supply is stopped and the furnace is exhausted.

Uncontaminated dry air is now pumped or flowed at the rate of about 200 cm^3 per minute into the furnace. This pure dry air has a moisture content of approximately 200 parts per million. The rate of temperature increase of 10° C per minute is still continued until a furnace temperature of 860° C is reached.

When a furnace temperature of about 860° C is reached, the rate of temperature increase is increased to about 20° C per minute. The furnace temperature is increased at this rate until a desired peak baking temperature is reached and the furnace is then held at this peak temperature for a predetermined period of time.

It has been found that the level of volumetric resistance of the processed sensing elements **14** is dependent upon both the peak temperature at which the elements **14** are baked and the length of time the elements **14** are baked at this peak temperature. It further has been found that increases in both the baking temperature and the processing times cause the crystals formed in the sensor body **11** between the electrodes **12** to increase in size and also causes the V_2O_5 to vaporize more slowly from the interstices of the formed crystals. It has also been found that it is this combination of events, i.e., relatively large crystal growth and slow vaporization of the V_2O_5, which repeatedly produces sensing elements having uniform electrode spacings and similar response characteristics.

Testing has revealed and indicated that workable moisture sensing elements may be produced by using a peak furnace temperature within the range of 1,100° C up to the melting point of the crystal lattice being formed in the sensing elements. The melting point of this crystalline material is above 1,600° C. The preferred peak baking temperature, however, is 1,350° C or above since sensing elements formed by being baked at a peak temperature below 1,350° C have had very low resistances, i.e., under 10,000 ohms.

Testing further has indicated that the time which the sensing elements **14** are baked at the peak furnace temperature may range from 1½ to 2 hours at the lower peak temperatures to as little as 10 to 15 minutes at a peak temperature of 1,550° C or above. Suitable moisture sensing elements have been repeatedly produced, for example, by baking the elements **14** for 30 minutes at a peak temperature of 1,550° C maintained to an accuracy of plus or minus 2° C.

Immediately following the baking of the sensing elements at the peak temperature for the predetermined period of time, the supply of heat or power to the furnace is stopped and the furnace is cooled as rapidly as possible to the temperature of about 860° C. When this furnace temperature is reached, the firing boat **15** is removed therefrom and cooled to ambient temperature as quickly as possible by quenching.

The sensing elements **14** are now electrically active and may be removed from the mandrel **16** and mounted in a suitable housing for use or may be placed in suitable holders for tests and calibration. The sensing elements **14** produced by the above-described process are characterized by having a pair of parallel spaced apart electrodes **12** which extend alongside each other a predetermined lengthwise distance, i.e., 75 mils and are held apart by a crystal array or lattice which has interstitial spaces formed therein.

The crystal lattice is formed in the sensor body **11** during the above-described baking process. It is believed that during this baking process that the V_2O_5 acts as a transport medium, oxidizing and thereby catalyzing a phase change in the Cr_2O_3. Thereby, the melting point of the Cr_2O_3 is lowered and the desired crystal lattice having interstitial spaces therein is formed.

During this crystal forming process, the Cr_2O_3 - V_2O_5 mixture looses approximately 40–50 percent of its weight, the sensing element shrinks and a crystal lattice with interstitial spaces therein is formed between the electrodes **12.** This crystal lattice between the electrodes **12** may be repeatedly formed by the above-described process so that precise and repeated inter-electrode spacings result. It has been found that with an initial 5 mil inter-electrode spacing the electrodes **12** are uniformly pulled together as the sensor body **11** shrinks during the above-described baking process to a final inter-electrode spacing equal to one block or mono-layer of the crystals in the crystal lattice. It is noted that an initial 5 mil electrode spacing is preferred since an initial spacing of the electrodes closer or farther apart has been found to result in either too much or too little electrical conduction in the final sensing element.

During the earlier described baking process, the mandrel **16** and the sensing elements **14** were quenched when they reached the temperature of 860° C to cool them to ambient temperature. The quenching step has been found necessary in order to insure formation of a crystal lattice of uniform width between the electrodes **12.** Quenching at the temperature of 860° C has been found suitable since this temperature is above the melting point of the V_2O_5, the melting point of V_2O_5 being 690° C. Permitting the sensing elements **14** to gradually cool below 690° C has been found to cause a significant drop in the volumetric resistance of the sensing elements **14** while quenching the sensing elements **14** at a temperature above 860° C has been found to increase the sensing elements' resistances.

In the above-described baking process, the Al_2O_3 doping chips function to slightly dope the crystals being formed and also to absorb in a controlled manner a portion of oxidant V_2O_5. The concentration of the Al_2O_3 is believed to control the final resistive response characteristics of the sensing elements through the chips' doping and absorbing characteristics. The final spectrum analysis of the crystalline body portion **11** of a finished sensing element **14** made by the above process indicated that the sensing element body contained approximately 80 percent chromium by weight, 20 percent vanadium by weight, and 5 parts per million aluminum.

In operation, a sensing element **14** operates to measure relative humidity by changes in its volumetric resistance as a function of the percent of water vapor present in the atmosphere instantly within the interstitial spaces of the crystal lattice bounded by the electrodes **12.** The crystal lattice formed from the Cr_2O_3-V_2O_5 mixture is an electrically neutral semiconducting solid state type body having a fermi level at or near neutral so that water ions in the atmosphere are not attracted into nor repelled from the crystal interstices. Thereby, molecules of the atmosphere randomly drift in and out of the crystal lattice with changes in pressure and the moisture level within the crystal interstices accurately reflects the true relative humidity of the atmosphere being monitored. Thus, a true bulk or volumetric moisture sensing element **14** is provided which does not change the moisture level of the atmosphere being monitored since it neither adsorbs nor absorbs moisture from the atmosphere.

The exemplary moisture sensing element **14** also has the characteristics of being operable to measure the full range of relative humidity from 0 to 100 percent with an accuracy of plus or minus 2 percent; being ex-

tremely small with a length less than 100 mils and a final width on the order of 6 to 8 mils; being operable over a broad temperature range, such as from −100° C to 70° C; and not being damaged nor permanently losing its calibration by saturation. Further, since the crystal lattice between the electrodes **12** permits molecules of the atmosphere freely to move in and out of the crystal interstices, the atmosphere in the crystal interstices at all times remains substantially in equilibrium with the atmosphere being monitored. As a result, changes in the relative humidity of the atmosphere are measured almost immediately by the sensing element **14**, the response or rise time of the moisture sensing element **14** being on the order of 150 milliseconds.

The sensing element **14** may be operated by relatively simple circuitry, as shown in FIG. **9**. A humidity sensing apparatus **20** is there shown in which a moisture sensing element **14** is connected through its leads or electrodes **12** in series with a fixed value resistor **21**. The series-connected sensing element **14** and resistor **21** are connected across the output terminals on an A.C. voltage source **22**. The A.C. voltage source **22** may be, for example, a low current, low power, solid-state oscillator which operates at a frequency of 1,000 hertz. The output level of the voltage source **20** is preferably set at 5 volts RMS. The resistor **21** employed preferably has a resistance of 500 kilo-ohms.

In operation, the humidity sensing apparatus **20** measures relative humidity through changes in the volumetric resistance of the sensing element **14**. The sensing element **14** used may have a true linear resistive-vapor pressure characteristic or may have been deliberately doped during manufacture, as before described, to have a logarithmic relation thereto. Changes in the volumetric resistance of the sensing element **14** appear as A.C. output voltages across the resistor **21**. A pair of output terminals **23** are connected to the terminals of the resistor **21** to transmit these output voltages to readout devices. A standard lab-type differential A.C. voltmeter, for example, may be connected to output terminals **23** for measuring these output signals which represent relative humidity or other conventional readout devices and circuitry may be employed. It is noted that the typical range of output voltages generated by the sensing apparatus **20** when using a 5 volt A.C. source **22** will be from 0.1 volt for a relative humidity of zero to 1 volts for a 100 percent relative humidity.

It is noted that the exemplary humidity sensing elements **14** may also be made by vacuum sputtering techniques. Also a linear temperature compensator may be formed by coating one of the sensing elements **14** with glass frit and baking it at approximately 650° C for 4 minutes.

Thus, there has been provided an improved sensing element which is characterized by being solid state, relatively small, capable of accurately measuring relative humidity from 0 to 100 percent over a broad temperature range, fast responding, not permanently damaged by saturation and which is capable of measuring relative humidity without affecting the environment being monitored.

Although I have herein shown and described my invention in what I have conceived to be the most practical and preferred embodiment, it is recognized that departures may be made therefrom within the scope of my invention.

What is claimed is:

1. A moisture sensing element comprising a pair of electrodes held spaced apart by a crystal lattice, said crystal lattice being made of a substantially electrically neutral material and having interstitial spaces formed therein between said electrodes, said interstitial spaces being formed in said crystal lattice so that the molecules of atmosphere being monitored may randomly drift in and out said crystal interstices whereby the volumetric resistance of said sensing element between said electrodes varies as a function of the percent of water vapor present in the molecules of atmosphere within said crystal interstices.

2. The invention defined in claim **1**, wherein said electrodes are positioned a predetermined distance apart alongside each other in a substantially mutually parallel relationship to extend away from each other.

3. A method of making a moisture sensing element, comprising the steps of:

mixing the compounds Cr_2O_3 and V_2O_5 into a substantially homogenous mixture;

embedding a pair of straight electrodes in a predetermined shaped quantity of said Cr_2O_3 - V_2O_5 mixture to form a sensing element, said electrodes being positioned in said mixture a predetermined distance apart alongside each other to extend away from each other in a substantially mutually parallel relationship;

baking said sensing element to form between said electrodes a crystal lattice having interstitial spaces therein; and

cooling said sensing element to ambient temperature.

4. The method defined in claim **3**, wherein said compounds Cr_2O_3 and V_2O_5 are mixed in a ratio of approximately one to one by weight.

5. The method defined in claim **3**, wherein said sensing element is baked at a temperature within the range of 1,100° C up to the melting point of the crystal lattice being formed therein for a period of time in the range of 10 minutes to 2 hours.

6. The method defined in claim **3**, wherein said sensing element is cooled to ambient temperature by first lowering its temperature to approximately 860° C and then quenching it.

7. The method defined in claim **3**, wherein said electrodes are measured lengths of platinium-iridium wire.

8. The method defined in claim **3**, wherein said sensing elements are baked in the presence of Al_2O_3 doping chips.

9. The method defined in claim **7** wherein the electrodes are spaced apart approximately 5 mils.

10. A method of making a moisture sensing element, comprising the steps of:

mixing the compounds Cr_2O_3 and V_2O_5 in approximately a 1 to 1 ratio by weight into a substantially homogeneous mixture;

aging said Cr_2O_3-V_2O_5 mixture for at least two weeks;

embedding a pair of platinium-iridium wires in a predetermined shaped quantity of said mixture to form a sensing element, said wires being positioned in said mixture a predetermined distance apart alongside each other to extend away from each other in a substantially mutually parallel relationship;

air drying the sensing element for at least 12 hours;

baking said sensing element to form between said wires a crystal lattice having interstitial spaces therein, said sensing element being baked at a temperature within the range of 1,100° C up to the

melting point of the crystal lattice being formed therein for a period of time in the range of 10 minutes to 2 hours; and

cooling said sensing element to ambient temperature by first lowering its temperature to approximately 860° C and then quenching it.

11. The method defined in claim **10**, wherein:

said platinium-iridium wires are measured lengths of annealed platinium-10 percent iridium 4 mil wire, are embedded in said mixture approximately 5 mils apart and are positioned to have a side by side length alongside each other of approximately 75 mils; and

said sensing element is baked in the presence of Al_2O_3 doping chips for 30 minutes at a temperature of 1,550° C.

12. The method defined in claim **11**, wherein:

the compounds Cr_2O_3 and V_2O_5 are ground into powders and are mixed by grinding;

said sensing element is baked in a furnace, said sensing element being placed in said furnace when said furnace is at ambient temperature and the temperature of said furnace being increased to 1,550° C by injecting nitrogen gas under pressure into said furnace and supplying heat to increase the temperature of said furnace at the rate of 10° C per minute for forty minutes, exhausting said nitrogen gas, pumping dry air into said furnace and supplying heat to continue increasing the temperature of said furnace at the rate of 10° C per minute until the temperature of 860° C is reached, and then supplying heat to increase the temperature of said furnace at the rate of 20° C per minute until the baking temperature of 1,550° C is reached; and

said sensing elements are cooled after baking to approximately 860° C by stopping the supply of heat to said furnace and cooling said furnace.

13. A moisture sensing element comprising a pair of electrodes held spaced apart by a crystal lattice formed by baking a mixture of V_2O_5 and Cr_2O_3, said crystal lattice being made of a substantially electrically neutral material and having interstitial spaces formed therein between said electrodes, said interstitial spaces being formed in said crystal lattice so that the molecules of atmosphere being monitored may randomly drift in and out of said crystal interstices whereby the volumetric resistance of said sensing element between said electrodes varies as a function of the percent of water vapor present in the molecules of atmosphere within said crystal interstices.

14. The invention defined in claim **13**, wherein said mixture of V_2O_5 and Cr_2O_3 is baked in the presence of Al_2O_3 doping chips.

15. The invention defined in claim **13**, wherein said electrodes are platinium-iridium wires.

16. A moisture sensing element comprising a pair of electrodes held spaced apart by a crystal lattice formed by baking a mixture of V_2O_5 and Cr_2O_3 in the presence of Al_2O_3 doping chips, said electrodes being annealed platinum - 10 percent iridium 4 mil wires which are positioned a predetermined distance apart alongside each other in a substantially mutually parallel realtionship to extend away from each other and have a side by side length alongside each other of approximately 75 mils, said electrodes being held spaced apart by approximately one layer of the crystals forming said crystal lattice, said crystal lattice being made of a substantially electrically neutral material and having interstitial spaces formed therein between said electrodes, said interstitial spaces being formed in said crystal lattice so that the molecules of atmosphere being monitored may randomly drift in and out said crystal interstices whereby the volumetric resistance of said sensing element between said electrodes varies as a function of the percent of water vapor present in the molecules of atmosphere within said crystal interstices.

17. The invention defined in claim **16** including a coating of glass frit formed around the body portion of said sensing element.

18. A moisture sensing element comprising a pair of electrodes held spaced apart by a crystal lattice, said crystal lattice having interstitial spaces formed therein between said electrodes and being made of a substantially electrically neutral semi-conducting solid state type material having a Fermi level approximately neutral so that water ions in the atmosphere are not attracted into nor repelled from said crystal interstices, said interstitial spaces being formed in said crystal lattice so that the molecules of atmosphere being monitored may randomly drift in and out said crystal interstices whereby the volumetric resistance of said sensing element between said electrodes varies as a function of the percent of water vapor present in the molecules of atmosphere within said crystal interstices.

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