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METHOD OF PRODUCING A HUMIDITY SENSOR BY
SHADOW CASTING AND RESULTANT PRODUCT
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FIG. 2

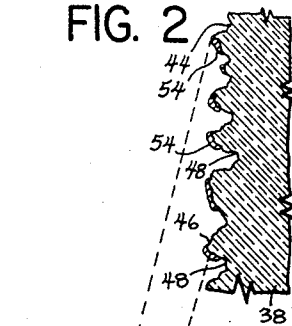


FIG. 1

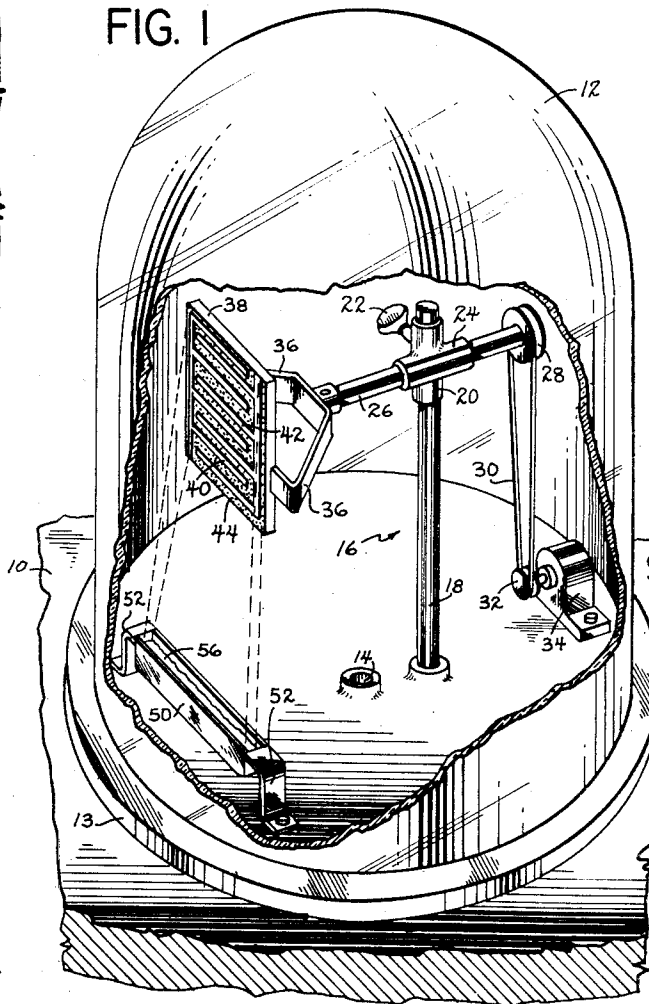
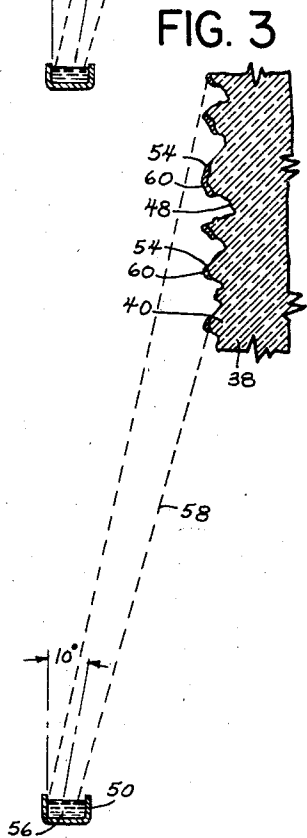


FIG. 3



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**METHOD OF PRODUCING A HUMIDITY SENSOR
BY SHADOW CASTING AND RESULTANT
PRODUCT**

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7 Claims. (Cl. 201—63)

This invention relates generally to humidity sensing devices, and pertains more particularly to a method of enhancing the conductivity characteristics of a humidity sensor of the adsorbing type.

As an aid to understanding better the type of humidity sensor with which the present invention is concerned, it may be explained that the term "adsorbing" is herein defined, in contradistinction to "absorbing," as encompassing or involving a characteristic in which there is a preferential attraction for water vapor molecules and while said molecules are in contact with the adsorber there is no chemical change or irreversible action. Absorption, on the other hand, occurs when water vapor molecules are actually combined through chemical reaction with the absorber, incorporated into the molecular structure of the absorber (for instance, water of crystallization), or there is a release of ions by virtue of a binding action such that the conduction of electric current by the ions may result in physical changes. Typical of such reactions are the swelling of cellulose and the ion-exchange resins.

Where adsorbing materials such as quartz, fused quartz and high silica glass are employed in the construction of humidity sensing elements, it frequently happens that the resistance range is too high for practical purposes. Accordingly, one object of the invention is to provide a humidity sensor and a method of making such sensor that will lower the resistance range of humidity sensors functioning on the aforementioned "adsorbing" principle to such an extent that the humidity element is more useful. One nicety of the invention resides in the fact that the exposed surface area of a humidity sensing element manufactured in accordance with the teachings of the instant invention is decreased without decreasing the probability of adsorption. More specifically, the invention contemplates the steps of first roughening the surface to be used, such as by grinding or etching, and then shadow casting discrete metallic areas onto portions of the minute peaks or hills, leaving the crevices or valleys uncoated. Since it is in the crevices that most of the moisture will accumulate, it will be recognized that by use of shadow casting techniques the metal is applied to regions of relatively poor adsorption, these regions contributing comparatively little to the functioning of the sensor. Stated somewhat differently, the applied small areas of metal serve to bridge at least partially the regions where a lower conductivity is experienced by virtue of a lesser thickness of moisture film being present, that is where the "high spots" exist.

Another object of the invention is to provide a method lending itself readily to the controlling of the resistance range during fabrication so that it will fall within desired limits.

Other objects will be in part obvious, and in part pointed out more in detail hereinafter.

The invention accordingly consists in the features of construction, combination of elements and arrangement of parts which will be exemplified in the construction

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hereafter set forth and the scope of the application which will be indicated in the appended claims.

In the drawing:

Figure 1 is a perspective view, partly broken away, showing a suitable apparatus for carrying out the improved method or process embodying my invention;

Fig. 2 is an enlarged sectional view showing the relative disposition of the adsorber plate and the evaporating boat, the view being before rotation of the adsorber plate, and

Fig. 3 is a view similar to Fig. 2, but showing the adsorber plate after it has been rotated through 180°.

Referring in detail to the drawing, certain apparatus appurtenant to the method by which the invention may be practiced is illustrated in Fig. 1. Such suitable apparatus suggestively includes a supporting base 10 upon which is mounted a housing 12. The housing 12 may be in the form of a bell-jar or the like having a closed dome-shaped or semispherical top and a bottom open end having an annular flange 13 which is adapted to rest upon the top face of the supporting base 10 in a gas tight manner. For the purpose of evacuating air from the housing 12, there is provided a nipple or opening 14 to which an exhaust pump (not shown) is attached.

Within the housing 12 is a stand 16 comprising an upright 18 upon which is mounted a vertically slidable collar 20, there being a set screw 22 by which the collar can be retained at a preferentially adjusted elevation. Integral with the collar 20 so as to be movable therewith is a sleeve bearing 24 having a rotatable shaft 26 journaled therein. To one end of the shaft 26 is affixed a pulley 28 and trained over this pulley is a belt or cord 30 which is driven by another pulley 32 on the shaft of a small electric motor 34. Suitable electrical connections for the motor extend through the base 10 but these are not herein pictured.

At the end of the shaft 26 opposite from the pulley 28 is a clamping device composed of a strip of spring metal forming a pair of gripping fingers 36. These gripping fingers 36 may be manually spread apart sufficiently for the accommodation therebetween of a plate 38, such as glass, having previously applied interleaved grids 40 and 42 on one face thereof. These grids may be formed by a metal evaporation process somewhat analogous to the one utilized in the realization of the instant invention, employing noble metal such as gold or platinum and a mask through which the evaporated metal passes.

However, prior to the application of the grids 40 and 42 the face 44 is roughened, either by etching or fine grinding. The etching procedure may be performed by exposing the face 44 to fluoboric acid fumes and the grinding may be accomplished by using #500 or finer grit, the operation being conducted in a random fashion.

With respect to the facial configuration produced by the above-described roughening action, whether by etching or grinding (including sand blasting), attention is directed to Fig. 2 where a greatly magnified cross-section of the glass plate 38 is presented. From this figure it can be perceived that the contour of the surface is highly irregular, being formed of numerous peaks 46 and valleys or crevices 48. Because of this uneven surface outline, it will be observed that the actual distance between grids along the irregular profile of the face 44 is much greater than any straight line distance would be. Also, the moisture layer that will form on the face 44 will tend to form "pools" in the valleys 48, leaving a thinner layer of moisture on the various intervening peaks 46.

It is with the peaks 46 and their lower electrical conductivity that we are currently concerned, and it is within the purview of the invention to coat these peaks, or portions thereof, with metal so as to lower the over-all resistance between grids. To this end, a boat or crucible

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50 is suspended between two vertical posts 52, suitable electrical connections (not visible) passing upwardly through these posts so as to heat the boat 50 resistively. Other modes of heating, of course, may be employed.

At any rate it is to be noted that the boat 50 is located slightly forward of the plate 38 and a considerable distance therebelow. As best seen in Fig. 2 the boat forms an acute angle of about 10° with respect to the plate 38. Consequently, many of the peaks 46 provide a shielding action for the valleys 48 on the far side of the peaks.

In order to cause formation of discrete metallic areas, which we will collectively represent by the numeral 54 in Fig. 2, a noble metal 56 such as gold or platinum is placed in wire or powder form in the boat 50. When the boat is heated this metal 56 will become molten and emit minute particles of molecular size which will emanate in straight lines in different directions within the housing 12. Those straight paths with which we are interested are those heading toward the glass plate 38. Accordingly, these particular paths have been designated in phantom outline and bear the reference numeral 58. It is these dotted lines that produce the previously alluded to angle of 10° which of course can be varied as particular circumstances dictate.

In Fig. 2 we will assume that no rotation of the shaft 26 has taken place and that the plate 38 is therefore in its initial position. Hence, the areas or islands 54 are all on the underside of the peaks 46. However, the invention includes the idea of controlling the amount of metal to be deposited onto the peaks, and with this in mind structure 16 has been set forth in Fig. 1, as already described, for turning the plate 38 in a spit-like manner. In Fig. 3 it will be observed that the plate 38 has been turned through 180° and that the earlier formed areas 54 are now uppermost. Newer formed areas 60 are now produced, since the sides of the peaks 46 which were previously shielded are now exposed to the coating action and receive evaporated metal.

By governing the degree of angular turning of the plate 38 by the simple expedient of stopping the motor 34 after it has rotated through a desired angle, the overall area receiving metal is controlled. Owing to the acute angle (10° in the exemplified situation) the valleys 48 do not receive metal and these valley regions therefore do not have their conductivity increased as do the peaks.

After fabrication and when the humidity sensor is subjected to a humid atmosphere, electrical energization of the grids 40, 42 will permit a humidity measurement to be made. By virtue of the presence of the metallic areas 54, coupled with those areas 60 derived from whatever rotation has been made, the resistance characteristics are modified so that the over-all resistance range for different humidity states will be lowered from what would otherwise occur. As hereinbefore stated, the proposed surface alteration results in a more optimum operating procedure than if no treatment is undertaken. It might be mentioned that in manufacturing humidity sensing elements in accordance with the invention, it will be left up to the designer to decide as to whether the grids 40, 42 are to be applied before or after the shadow casting step.

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As many changes could be made in the above construction and many apparently widely different embodiments of this invention could be made without departing from the scope thereof, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

It is also to be understood that the language used in the following claims is intended to cover all of the generic and specific features of the invention herein described and all statements of the scope of the invention which, as a matter of language, might be said to fall therebetween.

What is claimed:

1. A humidity sensor comprising an inert base having a roughened surface of high electrical resistivity composed of peaks and valleys, relatively small metal areas on the top portions only of the peaks but not the valleys, and interleaved metallic grids spaced from each other on said surface.
2. A humidity sensor comprising an adsorbing element having a roughened surface of high electrical resistivity thereon composed of a multiplicity of peaks and valleys, discrete metallic areas on the top portions only of said peaks, and interleaved metallic grids spaced somewhat from each other on said surface.
3. A humidity sensor in accordance with claim 2 in which said metallic areas all face in a single direction.
4. A humidity sensor in accordance with claim 2 in which the metallic areas face in the same general direction within an acute angle subtended by a preferred arc.
5. A method of making a humidity sensor comprising the step of subjecting an adsorbing element having a roughened surface of high electrical resistivity composed of peaks and valleys to evaporated metal, the plane of the roughened surface being disposed at an acute angle to the direction of impingement of said metal so as to coat the top portions only of said peaks but not the valleys.
6. A method in accordance with claim 5 in which said acute angle is approximately 10°.
7. A method of making a humidity sensor comprising the steps of disposing an adsorbing element having a roughened surface of high electrical resistivity composed of peaks and valleys to a source of evaporated metal, the plane of the roughened surface being at an acute angle relative to the direction of impingement of said metal so as to expose the top portions only of said peaks to said source, and rotating said element while at said preferred angle to coat thereby various top portions of said peaks with evaporated metal.

References Cited in the file of this patent

UNITED STATES PATENTS

1,749,826	Lubach	Mar. 11, 1930
2,075,377	Varian	Mar. 30, 1937
2,351,536	Osterberg	June 13, 1944
2,539,149	Miller	Jan. 23, 1951
2,609,688	Larach	Sept. 9, 1952
2,613,302	Gurewitsch	Oct. 7, 1952
2,707,880	Wannamaker	May 10, 1955