March 3, 1964 G. V. WOODLING 3,123,812

MOISTURE RESPONSIVE DEVICE

Filed April 9, 1958 2 Sheets-Sheet 1

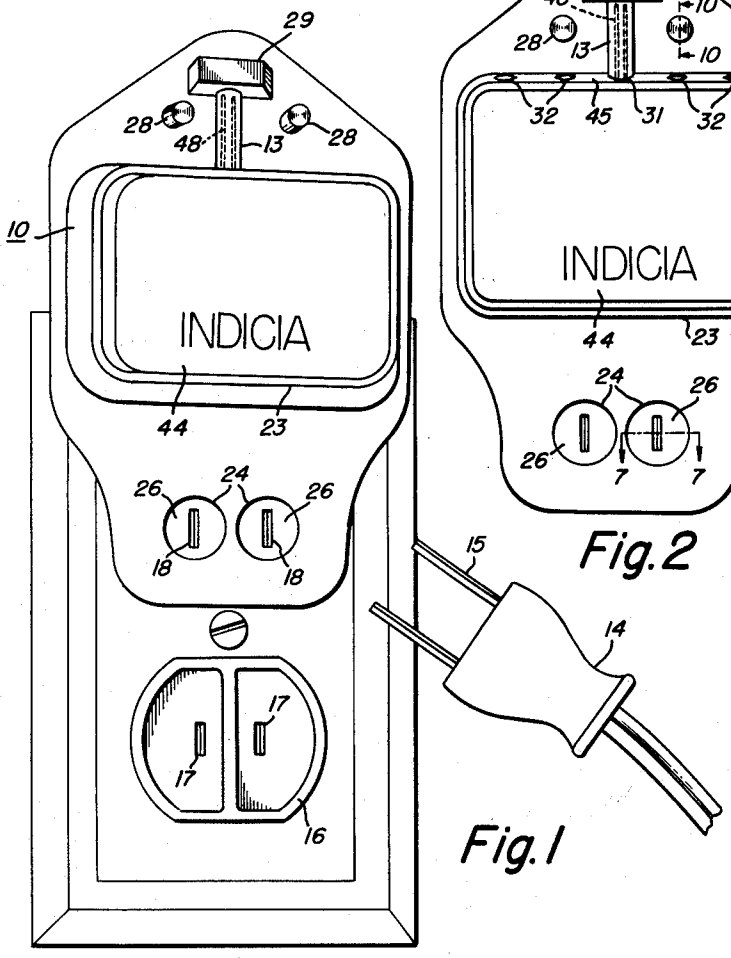


Fig. 1

Fig. 2

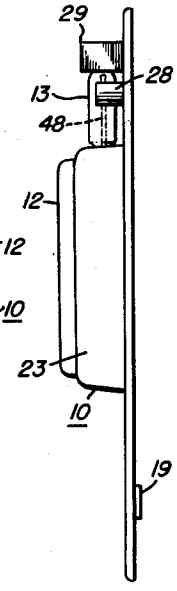


Fig. 3

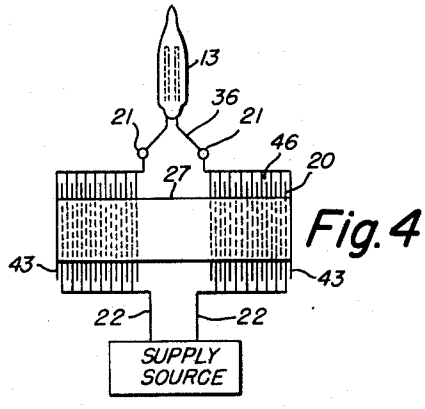


Fig. 4

INVENTOR.
GEORGE V. WOODLING

BY Woodling & Krost

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MOISTURE RESPONSIVE DEVICE

Filed April 9, 1958 2 Sheets-Sheet 2

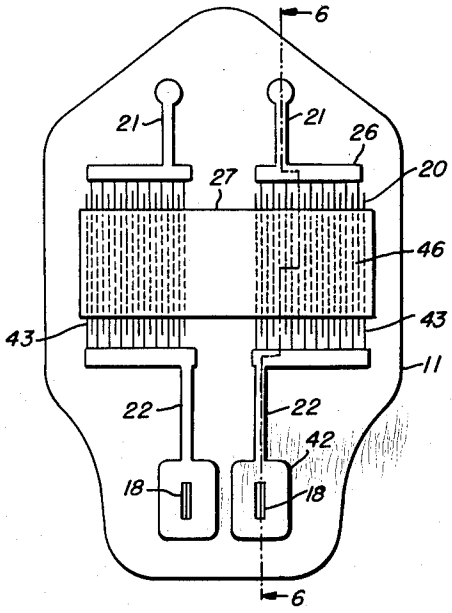


Fig. 5

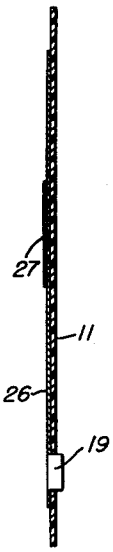


Fig. 6

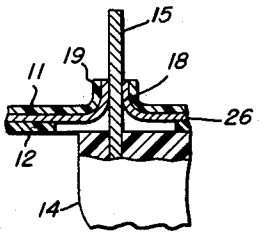


Fig. 7

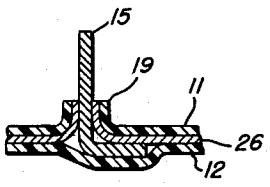


Fig. 12

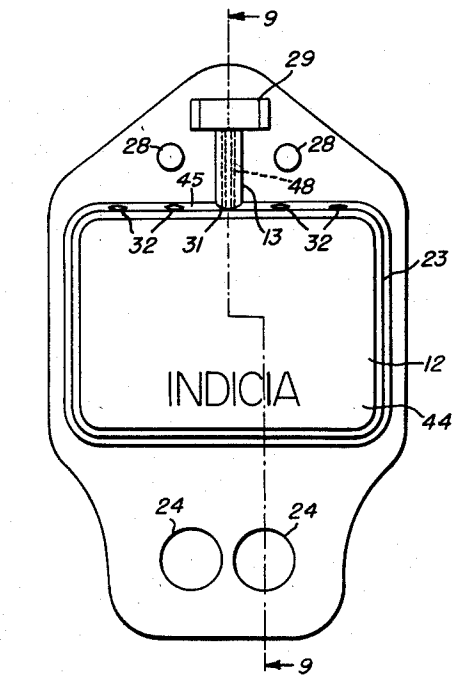


Fig. 8

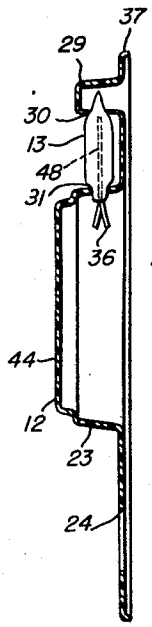


Fig. 9

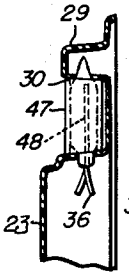


Fig. 13

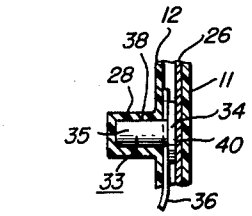


Fig. 10

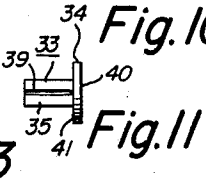


Fig. 11

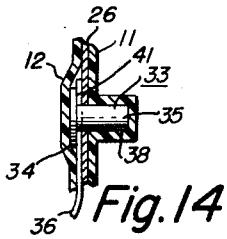


Fig. 14

INVENTOR.
GEORGE V. WOODLING

BY Woodling & Krost

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3,123,812

MOISTURE RESPONSIVE DEVICE

George V. Woodling, 1386 Union Commerce Bldg., Cleveland 14, Ohio

Filed Apr. 9, 1958, Ser. No. 727,490
1 Claim. (Cl. 340—235)

This invention relates to moisture responsive devices and more particularly to moisture responsive devices employing a circuitry which is responsive to moisture.

An object of the invention is to provide a moisture responsive device that will measure moisture and changes of moisture of the surrounding air instantaneously.

Another object of the invention is to provide a moisture responsive device with a printed circuitry that is responsive to moisture.

Another object of the invention is to provide a moisture responsive device with a current responsive member to indicate the amount of moisture in the surrounding air.

Another object of the invention is to provide a moisture responsive device with a surface disposed for indicia.

Another object of the invention is to provide a moisture responsive device with a moisture responsive coating provided on the circuitry to permit current to be conducted to a current responsive member.

Another object of the invention is to provide a moisture responsive device with a circuitry comprising grids with interlacing, spaced lines with non-conducting spaces therebetween on which moisture contacting the spaced area completes the circuit.

A further object of my invention is to provide for an electrical connection between the current responsive member and the printed circuitry embodied on the moisture responsive device.

And still another object of my invention is to provide for an electrical connection between the moisture responsive device and an outside source of voltage.

Another object of my invention is to provide for an electrical connection between the prongs of an appliance plug and a current conducting film used for the printed circuitry embodied in the moisture responsive device.

Another object of my invention is to provide a moisture responsive device that is compact, non-breakable, decorative and colorful.

Another object of my invention is to provide a moisture responsive device that will not cease to function over a period of time.

Another object of my invention is to provide a material embodied in the construction of the moisture responsive device that will permit the moisture responsive coating to migrate into the material so that it cannot be readily removed and therefore lengthen the life of the moisture responsive device indefiniely.

Another object of my invention is to provide a moisture responsive circuitry comprising two portions with a gaseous bulb connected in series between the two portions thereby eliminating the necessity of a current limiting resistor.

Other objects and a fuller understanding of my invention may be had by referring to the following description and claim, taken in conjunction with the accompanying drawing, in which:

FIGURE 1 of the drawings shows the moisture responsive device receiving a source of current from a standard wall socket employed in homes and offices;

FIGURE 2 of the drawings shows a front view of the moisture responsive device;

FIGURE 3 of the drawings shows a side view of the moisture responsive device;

FIGURE 4 of the drawings is a schematic view of the moisture responsive circuit embodied in the moisture responsive device;

FIGURE 5 of the drawings shows a back plate employed in the moisture responsive device with the moisture responsive circuit printed thereon;

FIGURE 6 of the drawings is a section view along the line 6—6 of FIGURE 5 and shows the back plate, the current conducting film and the moisture responsive coating thereon;

FIGURE 7 of the drawings is a section view along the line 7—7 of FIGURE 2 and shows the method of supplying a current to the moisture responsive device;

FIGURE 8 of the drawings shows a top plate employed in the moisture responsive device and the surface which is disposed for indicia;

FIGURE 9 of the drawings is a section view along the line 9—9 of FIGURE 8;

FIGURE 10 of the drawings shows a method of connecting a current responsive device or light bulb to the current conducting film;

FIGURE 11 shows the type of rivet employed as the connection device as shown in FIGURE 10;

FIGURE 12 of the drawings is a modification of FIGURE 7 in which the prongs that engage the wall socket are fastened directly to the moisture responsive device as a fixed part of the device.

FIGURE 13 of the drawings is a modification of FIGURE 9 showing a plastic protective tube around the current responsive device.

FIGURE 14 of the drawings is a modification of FIGURE 10 showing the cavity for holding the rivet in the back plate.

With specific reference to FIGURE 1 of the drawings, the moisture responsive device is designated by the reference character **10**. The moisture responsive device **10** or moisture indicator, as the device may be hereinafter termed, is shown in direct relation with a wall outlet socket **16**. The circuitry is such that the moisture indicator **10** is designed to operate from a source of standard voltage supplied to the home or office. The moisture indicator **10** therefore is constructed to receive a standard plug **14** which engages a standard wall outlet socket **16**. It is understood that any other source of power may be used to supply current to the moisture indicator device **10** by adopting the circuitry as such. The cord plug **14** may connect to any electric appliance used in the home or office which operates from the standard voltage supplied to the outlet plug. Therefore the moisture indicator **10** may be employed into the home or office without detracting from the primary purpose of the wall socket **16**.

Because of the circuitry employed in the moisture indicator **10**, which will be discussed hereinafter, moisture and changes in the moisture of the surrounding air are measured or indicated instantaneously.

The moisture indicator **10** shown in FIGURES 1 through 14 comprises a back plate **11**, and a top plate **12**. The back plate **11** is preferably extruded non-current conducting cellulose butyrate and die cut to the desired shape. The back plate **11** may be of any desired color and is usually opaque to give it decorative beauty. It is understood that many types of plastics, or any other suitable material such as glass, wood, or paper may be used. The plastic material may be either thermoplastic or thermosetting. The top plate **12** is also extruded non-current conducting cellulose butyrate and vacuum formed and die cut to the desired shape. The top plate **12** may be of any desired color and preferably is opaque to give it decorative beauty. It is understood that the top plate **12** may be of the same material as the back plate **11**.

The back plate **11** has printed on one side thereof a current conducting film **26**. The current conducting film **26** is preferably a silver or other metal conducting paint which is printed on one side of the back plate **11** by the

use of silk screening. It is understood that any desirable current conducting film 26 may be used. It is also understood that any other means may be used besides silk screening to print the current conducting film 26.

The circuitry on the back plate 11 as shown in FIGURES 4, 5 and 6 of the drawings comprises two grids 20 that are connected in series with a substantially circular gaseous bulb 13 therebetween. In FIGURE 6, the back plate 11, the conducting film 26 and the moisture responsive coating 27 are shown greatly enlarged. In actual practice, the conducting film 26 and moisture responsive coating 27 are very thin layers and would not be observed in a section view. It is understood that any number of grids may be employed in the circuit and will not detract from the usefulness of the circuit. The two grids 20 comprise evenly spaced interlacing lines 43 with a portion of spaced area 46 of the back plate 11 therebetween. The two grids 20 are supplied with current by means of conductors 22 which are connected to oppositely disposed inward facing tabs 19 which receive a current from an outside source. Extending from the base of the gaseous bulb 13 are two wires 36 which engage the conductive connection portions 21 respectively extending from the grid 20. The gaseous bulb 13 comprises two current conducting electrodes 48 that extend approximately two-thirds the distance of the length of the bulb 13. The bulb 13 is filled with neon gas and the glass containing the gas therein is of a transparent nature so that the electrodes 48 may be observed. When current is supplied to the electrodes 48, the neon gas is ignited and produces an orangish glow. A dim glow first is observed around the electrodes 48 and extends radially away from the electrodes 48 and becomes brighter as the current is increased. It is understood that any other type of bulb may be used which should be of the low wattage type. It is understood that the lines 43 may be of any desired shape and may have any desired spacing therebetween. Since the lines 43 do not touch, a complete circuit is not set up and no current can be conducted through the gaseous bulb 13, in the absence of moisture. The connection of the bulb 13 in series between the two grids 20 eliminate the necessity of a current limiting resistor in order to protect the bulb 13.

With specific reference to FIGURES 5 and 7 of the drawings, I show how a commercial source of power is provided to the moisture indicator 10. In FIGURE 7, the back plate 11, and the conducting film 26 are shown greatly enlarged so that the parts may be more easily observed. As shown in FIGURE 5, connected to the two conducting portions 22 are two rectangular areas 42, respectively, which are printed on the one side of the back plate 11 with the current conducting film 26. Punched into these two rectangular areas 42 by means of a die punch are two rectangular openings 18, respectively. The openings 18 are substantially the same size and shape to receive the prongs 15 of the plug 14. The openings 18 are punched in a direction from the current conducting portion of the back plate 11 to the rear of the back plate 11. This process mentioned hereinabove forms two sets of oppositely disposed, inward facing, substantially V-shaped tabs 19. The oppositely disposed tabs 19 are spaced closer together than the width of the prong 15 of the plug 14. Thus when the prong 15 is inserted into the opening 18, the sides of the prong 15 engage the current conducting film 26 on the tabs 19 and forces the tabs 19 apart. This springing or resilient action of the tabs 19 causes them to lay against the side of the prong 15. Thus even though the prong 15 of the plug 14 is inserted in and pulled out of the opening 18 many times, the tabs 19 never break and always retain their resilient properties and will always engage or lay against the sides of the prong 15 of the plug 14. This always insures a good connection between the prong 15 and the current conducting film 26 which is necessary in the unlimited operation of the moisture indicator 10.

With specific reference to FIGURE 12 of the drawings, I show a modification of the method employed in FIGURE 7 of the drawings and described hereinabove. In the modifications shown in FIGURE 12, the current conducting prong 15 is fastened to the back plate member 11 by means of pressure from the top plate 12. Thus there is no appliance plug 14 needed and this type of current connection can be advantageously used over the other method when there are no appliance plugs handy to the user.

With specific reference to FIGURES 9, 10, 11, 13 and 14 of the drawings, I show a method of connecting the wires 36 of the bulb 13 to the current conducting film 26. It is understood that any other means may be used to connect the wire 36 of the bulb 13 to the current conducting film 26. Mounted in a cavity 28 which is vacuum formed in the top plate 12 is a current conducting rivet 33. It is understood that any current conducting connection device may be used to connect the wire 36 to the current conducting film 26. The rivet 33 as shown in FIGURE 11 comprises a head 34 and a split leg stem 35. The head 34 has a top portion 40 and an underside portion 41. The split leg stem 35 forms an opening 39 therebetween. Inserted into the opening 39 and engaging the underside portion 41 of the head 34 of the rivet 33 is the wire 36 of the bulb 13. The split leg stem 35 of the rivet 33 is then inserted into the cavity opening 38 and held therein by pressure exerted from the walls of the cavity 28. The top portion 40 of the head 34, when the top plate 12 is fastened to the bottom plate 11, engages the current conducting film 26 and is held there by pressure from the top plate 12.

As hereinabove mentioned, the grids 20 have interlacing spaced lines 43 which prevent a complete series circuit. If moisture falls on the lines 43 and the spaces 46 therebetween, the ions; namely, hydrogen and oxygen, would be sufficient to conduct current across the spaces between the lines 43 and complete the series circuit, thus permitting current to flow through the gaseous bulb 13. But the moisture, as it makes contact with the spaces 46 between the lines 43 of the grid 20, "balls-up" into a bead or ball which is caused by a distinctive property of cellulose butyrate and also of the other thermosetting and thermoplastic plastics. Thus, no matter how high the relative humidity in the air surrounding the grid 20 is, current which may be conducted across the spaced area 46 between the lines 43 of the grid 20 is not a dependable measure of the moisture. Therefore, it is desirable to cause the moisture, when it makes contact with this spaced area 46 between the lines 43 to form a smooth layer over the spaced areas 46 and not to "ball-up." Therefore a moisture responsive coating 27 is silk screened over the lines 43 and the spaces 46 therebetween. It is understood that any method may be used to disperse the moisture responsive coating 27 over the grid 20. The moisture responsive coating 27 comprises a material consisting of ion hydrolyte agents and sulphonated fatty agents. The ion hydrolyte agents may be of the anion type of the cation type. The sulphonated fatty agents may be sulphonated fatty alcohols or sulphonated fatty acids. The moisture responsive coating 27 presently employed is a film of powdered detergent. I find that a product sold under the trademark "FAB" is satisfactory as the detergent mentioned herein. The detergent as hereinabove described comprises essentially sodium silicate, sodium sulfate, trisodium phosphate dodecahydrate and sodium salt of an alkyl aryl sulfonate. The active ingredient of the detergent is sodium salt of an alkyl aryl sulfonate. The detergent is originally in a powder form which, when mixed with water, turns to a pasty mass. This pasty mass can thus be silk screened onto the grid 20. When left standing for a time, the water which was mixed into the detergent will evaporate off leaving a hard crusty coating on the grid 20. The moisture responsive coating 27 has the property of "unballing" the balls of moisture which come

in contact with the spaced cellulose butyrate areas **46** between the lines **43**. Thus the ions will now conduct across the spaced areas and permit current to flow through the bulb **13**.

Since the bulb **13** used in the moisture indicator **10** is gaseous, different amounts of current will change the brightness of the bulb **13**. By supplying a greater current, the bulb will shine brighter and vice-versa. The circuitry and the moisture responsive coating **27** are such in the moisture indicator **10** that different amounts of moisture in the surrounding air will determine the brightness of the bulb **13**. In the present moisture indicator device **10**, the circuitry and the moisture responsive coating are in perfect balance with each other so that current will be conducted across the spaced areas **46** at about 40 percent relative humidity of the surrounding air. At 40 percent or "ideal" humidity, the gaseous bulb **13** just barely glows. When the moisture is at 70 percent or near the saturation point, the gaseous bulb **13** glows very brightly and serves as an indication of rain in the near future. When the bulb **13** does not glow, the humidity may be anywhere in the range of zero percent to 35 percent, which is too dry and uncomfortable. It is understood that the bulb **13** may be made to glow at any desired humidity by changing the spacing between the lines **43** and the amount of moisture responsive coating **27** provided on the grid **20**. By spacing the lines **43** farther apart, for example, more moisture would be needed to conduct current across the spaces between the lines **43**. By providing more moisture responsive coating **27** on the grid **20**, for example, less moisture would be needed to conduct current across the spaces **46** between the lines **43**.

Here it is desirable to mention another favorable property of cellulose butyrate and of many other plastics. The molecular structure of the cellulose butyrate is such that the molecules of the detergent are permitted to migrate into the plastic itself, thus if the detergent is washed off or removed by another means, a thin coating of the detergent will still be ingrained in the cellulose butyrate. Thus the longer the detergent is left on the cellulose butyrate, the more will migrate into the cellulose butyrate. Therefore, the moisture responsive device **10** never loses its moisture measuring properties.

With specific reference to FIGURES 8 and 9 of the drawings, I show the top plate **12** which is embodied in the invention. As hereinabove described, the top plate is preferably extruded cellulose butyrate. Cellulose butyrate is used primarily because of its vacuum forming properties and also because it has other desirous properties which are required in the operation of the moisture indicator **10**. Vacuum formed in the top plate is a housing member **29** which is substantially rectangular and has a substantially circular opening **30** in the base thereof. The substantially circular opening **30** is primarily to receive the top of the bulb **13** and to retain it therein. Also vacuum formed in the top plate is a substantially rectangular box member or bulge **23** which has a flat top surface **44** disposed for indicia. On the top edge surface **45** of the bulge **23** is punched a substantially circular opening **31**. The opening **31** is primarily to receive the base of the bulb **13** and to retain it therein. The substantially circular bulb **13** is mounted in the proper position by inserting it into opening **31** of the top edge surface **45** and pushed therethrough until the top of the bulb **13** makes firm contact with the opening **30** of the housing member **29**. The base of the bulb **13** has two substantially flat portions thereon which catch against the sides of the substantially circular opening **31** to prevent the bulb **13** from disengaging the openings **30** and **31**. The lighting portion of the bulb **13** is left uncovered so that when the bulb is lit it can be seen easily from any angle observed.

As shown in FIGURE 13 of the drawings, a substantially circular, hollow, transparent plastic tube **47** may be employed to protect the bulb **13**. The primary purpose of the tube **47** is to absorb shock if the moisture responsive device **10** is dropped so that the glass covering of the bulb **13** will not crack or the bulb **13** itself will not explode as gas bulbs often do.

Punched into the edge surface **45** are substantially circular openings **32** which allow the passage of the surrounding air to migrate into the moisture responsive device **10** enabling the moisture of the surrounding air to make contact with the grid **20**. Also punched in the top plate **12** are two openings **24** which correspond to the openings **18** in the back plate **11**. The openings **24** are substantially circular and permit the prongs **15** of the plug **14** to extend through the top plate **12** and engage the tabs **19** of the back plate **11**. The top plate **12** is fastened to the back plate **11** by flange members **37** which fit around the outside edges of the back plate **11**. The flange members **37** are held in the desired position by adhesive means which bind the two plastic members together.

The moisture responsive device **10** as hereinabove mentioned and as shown in FIGURE 1 of the drawings is commonly used in direct relation with a wall socket **16**. After the device is plugged in the wall socket **16** by the means of the plug **14**, the user may test the moisture responsive device **10** in the following manner. If the bulb **13** does not light after the device is plugged in, the user knows the surrounding air of the room is too dry. The user then may blow his breath through the openings **32** on the edge surface **45** and the moisture from his breath will contact the grid **20** and the bulb **13** will glow. The user then knows the moisture responsive device is in working order. The user by blowing his breath on the grids **20** may also determine how dry the surrounding air is in the room. If the glow of the bulb diminishes at a rapid rate, the relative humidity of the surrounding air is probably around 10 percent to 20 percent, which is very dry and uncomfortable. If the glow of the bulb **13** lingers on for a long time, the user knows the relative humidity of the surrounding air is close to 40 percent or "ideal."

The rectangular box **23** or bulge vacuum formed in the top plate **12** may be vacuum formed in the shape of any desired advertising device and therefore the moisture indicator **10** may be used by any manufacturer to advertise the desired product. The surface **44** disposed for indicia may be of any desired color to identify fully the product advertised.

With specific reference to FIGURE 14 of the drawings, I show a modification of the method of connecting the wires **36** of the bulb **13** to the current conducting film **26**. As hereinabove mentioned, one method is to vacuum form a cavity **28** in the top plate **12** and insert the stem **35** of the rivet **33** in the opening **38** of the cavity **28** and attach the wires **36** to the stem **35** and thus form a good mechanical connection.

Often, before or during assembly of the moisture responsive device **10**, the back plate **11** is bent slightly. Later, the backplate **11** may become upright, putting stress on the above mentioned connection. It is desirable therefore as shown in FIGURE 14, to vacuum form the cavity **28** in the backplate **11** and insert the split leg stem **35** of the rivet **33** into the opening **38** of the cavity **28** in the backplate **11**, thus permitting the wires **36** of the bulb **13** to engage directly the current conducting film **26**. The stem **35** is held in the opening **38** by pressure of the walls of the cavity **28** on the stem **35**. Thus, if stress is put on the connection, the stress will help hold the wires **36** against the current conducting film **26** instead of pulling the wires **36** away from the current conducting film **26** as shown in FIGURE 7.

Either method as described hereinabove and as shown in FIGURES 7 or 14 may be used with equal success, depending on the property of the plastic used at the time of assembly of the moisture indicator **10**.

The circuitry employed in the moisture indicator **10** is such that alternating current or direct current may be supplied without polarizing the circuitry. When the

moisture indicator **10** is supplied with alternating current, the ions will change in polarity as the current reverses direction and thus will always be conducted across the spaced areas **46** between the lines **43** and, of course, there is no tendency for the circuitry to become polarized. When direct current is supplied to the moisture indicator **10**, the ions would tend to become permanently polarized and not conduct current across the spaced areas **46** between the lines **43**. But because of a desirable property of the moisture responsive coating **27**, there is leakage of ions across the spaced areas **46**, thus overcoming any tendency for the circuitry to become polarized. Whether alternating current or direct current is supplied to the circuitry of the moisture indicator **10**, it is still operative.

As mentioned hereinabove, any thermoplastic or thermosetting plastics may be used in the construction of the moisture responsive device **10**.

Some of the thermoplastic plastics that may be embodied in the invention are polyvinyl chloride, polyvinyl acetate, polyvinyl butyral, polystyrene, methyl methacrylate, polyethylene, and cellulose acetate.

Some of the thermosetting plastics that may be embodied in my invention include unsaturated polyester resins. A typical example of such polyester is a product prepared by the reaction of an unsaturated dicarboxylic acid such as maleic, fumaric, itaconic, citraconic or mesaconic acid, maleic anhydride is also widely used, with a dihydric alcohol such as any polymethylene glycol in the series from ethylene glycol to decamethylene glycol, propylene glycol, any butylene glycol, any polyethylene glycol in the series from diethylene glycol to monoethylene glycol, dipropylene glycol, any glycerol monobasic acid monester (in either the alpha or beta position), such as monoformin or monoacetin, any monether or glycerol with a monohydric alcohol, such as monomethylin or monoethylin or any dihydroxy alkane in which the hydroxy radicals are attached to the carbon atoms that are primary or secondary or both, in the series from dihydroxy butane to dihydroxy decane. It is understood that any thermosetting or thermoplastic plastics may be used and the type of plastics mentioned above are only examples.

The moisture responsive device **10** has primarily two functions; to measure the moisture of the surrounding air instantaneously and to promote advertising and selling of any product by the use of a surface disposed for indicia.

Although this invention has been described in its preferred form with a certain degree of particularity, it is understood that the present disclosure of the preferred form has been made only by way of example and that numerous changes in the details of construction and the combination and arrangement of parts may be resorted to without departing from the spirit and the scope of the invention as hereinafter claimed.

What is claimed is:

In a hygrometer indicator device for connection to an alternating current energizing source, a gaseous indicator bulb having at least first and second electrodes, first grid work of conductors comprising first and second spaced interlaced open circuit conductor paths, second grid work of conductors comprising third and fourth spaced interlaced open circuit conductor paths, said first and third conductor paths being energized by said alternating current energizing source, a humidity-sensitive material formed as an adherent film in said grid work of conductors and comprising a granular, solid detergent, said film being porous and readily soluble in water and having an instantaneous current-time response to changes of moisture in atmosphere, and means connecting said first and second electrodes of said gaseous indicator bulb respectively to said second and fourth conductor paths to give an indication of humidity.

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