Dec. 15, 1936. M. E. FIENE 2,064,651

HUMIDITY RESPONSIVE DEVICE

Filed Dec. 30, 1931

Fig. 1.

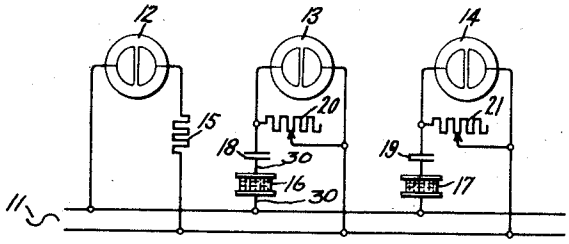
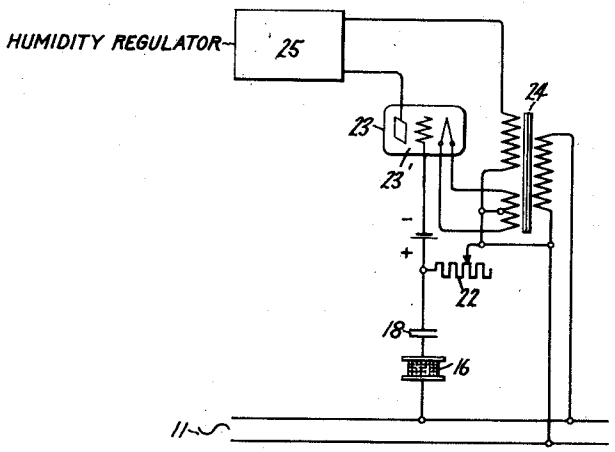



Fig. 2.



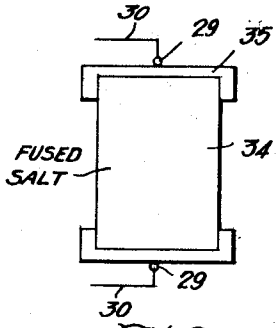




Fig. 6.

Fig. 3.

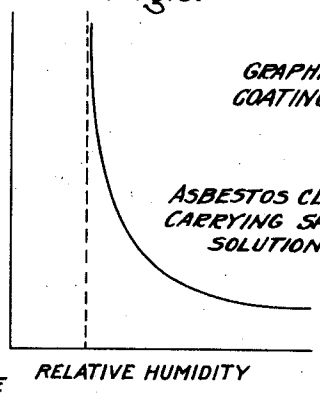
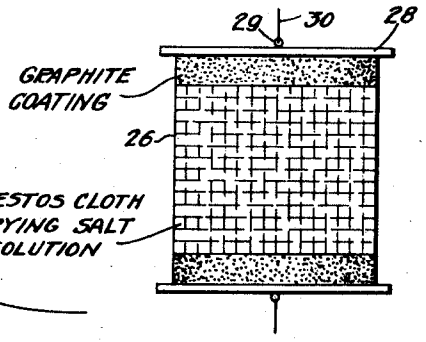



Fig. 4.



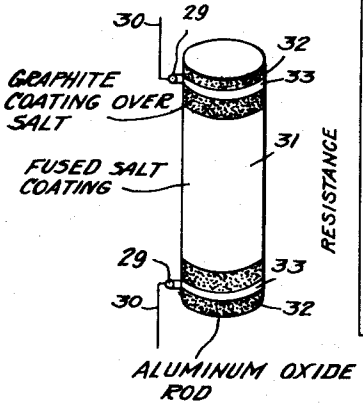




Fig. 5.

Inventor:
Marcus E. Fiene,
by Charles V. Mullan
His Attorney.

Patented Dec. 15, 1936

2,064,651

# UNITED STATES PATENT OFFICE

2,064,651

## HUMIDITY RESPONSIVE DEVICE

Marcus E. Fiene, Ballston Lake, N. Y., assignor to General Electric Company, a corporation of New York

Application December 30, 1931, Serial No. 583,818

7 Claims. (Cl. 177—311)

My invention relates to humidity indicators and regulators, and has for its principal object the provision of a simple, reliable and quickly acting humidity responsive device.

I have found that certain substances, particularly certain salts have the property of being relatively non-conducting when the humidity of the surrounding atmosphere is below a certain critical value and becoming conductive above this value of humidity.

In accordance with my invention a resistor containing such a humidity sensitive material is connected in a circuit supplied by a source of electrical energy, and the variation in the flow of current caused by the change in resistance as the humidity changes is utilized to provide an indication of humidity or to control humidifying or dehumidifying apparatus.

The features of my invention which I believe to be novel and patentable are pointed out in the claims appended hereto. My invention itself however will be best understood by referring to the following description taken in connection with the accompanying drawing in which Fig. 1 represents an arrangement in which variations in humidity are indicated by the lighting up or the extinction of electric lamps; Fig. 2 represents an arrangement for controlling humidity correcting apparatus; Fig. 3 is a curve showing the variation in resistance with relative humidity of humidity sensitive material used in accordance with my invention; Fig. 4 is an enlarged detail view of one of the humidity-responsive variable-resistance elements of Fig. 1; Fig. 5 is a perspective view of a modified form of humidity-responsive variable-resistance unit; and Fig. 6 represents still another embodiment of my humidity-responsive variable-resistance unit.

Referring more in detail to the drawing, in Fig. 1 a source of alternating current 11 is represented as supplying neon tube lamps 12, 13 and 14. Lamp 12 is connected in series with an ordinary resistor 15, but lamps 13 and 14 are connected in series with humidity sensitive resistance elements 16 and 17 respectively. Condensers 18 and 19 are also connected in series with resistance elements 16 and 17 in order to prevent any tendency toward decomposition of elements 16 and 17 caused by the component of direct current resulting from the slight rectifying action of the neon tubes 13 and 14.

Resistance elements 16 and 17 contain substances which become conducting for different critical values of humidity. For example, the element 16 may contain chromium trioxide which becomes conducting at a humidity of approximately 35% and the element 17 may contain a mixture of ammonium chloride and potassium nitrite which becomes conducting at about 70% relative humidity.

The neon tube lamp 12 will be illuminated at all times. When the humidity rises above 35% the element 16 will become sufficiently conducting to permit a value of current to flow in the neon tube lamp 13 which will cause it to be illuminated, and when the humidity rises above 70% the lamp 14 will also be illuminated. Accordingly, for humidities below 35% only lamp 12 will be illuminated, for humidities between approximately 35 and 70%, lamps 12 and 13 will be illuminated, and for humidities above 70% all three lamps will be illuminated.

In order to modify slightly the values of humidity at which the lamps 13 and 14 become illuminated the shunt rheostats 20 and 21 are provided. By decreasing the resistance of the shunt rheostat the amount of current which must flow through the humidity sensitive element in order to illuminate the lamp is increased. Accordingly, a reduction in the shunt resistance of the lamp increases the value of humidity at which an indication is obtained and an increase in the shunt resistance decreases the value of humidity at which an indication is obtained.

In Fig. 3 is represented a characteristic curve of humidity sensitive substances which may be used in accordance with my invention. Below a certain value of humidity the resistance is very great and the conductivity is negligible. When this value of relative humidity is exceeded however, the resistance falls off very rapidly. I have found in the case of resistance elements composed of a salt that the value of relative humidity at which the resistance of the salt begins to fall off rapidly, which is represented by the dotted line, corresponds approximately to the humidity above a concentrated solution of the salt contained in an enclosed vessel. This value is known for a large number of salts and is given at page 67 in Vol. I of the 1926 edition of the International Critical Tables. Although indicating lamps are shown in Fig. 1, it will be understood that my invention is not limited to this exact arrangement but that any other suitable type of current responsive device such as a deflecting instrument or a contact making device may also be employed. Likewise, my device may

be employed to control other apparatus in response to changes in humidity.

In Fig. 2 the humidity sensitive resistance element 16, a condenser 18 and a rheostat 22 are connected in series across a source of alternating current 11. Rheostat 22 forms a portion of the grid circuit of a grid controlled discharge tube 23 which is preferably of the arc discharge type in order to control a greater amount of power. The plate circuit of the discharge tube 23 is energized by the secondary winding of a transformer 24 and supplies a device 25 of any suitable type for modifying the humidity. Device 25 may, for example, be a valve for admitting steam, a motor driven blower for introducing moist air into a room, or any other device which will suggest itself to those skilled in the art. When the relative humidity is below the critical value for the resistance element 16, only negligible current will flow through rheostat 22 and the grid 23' of the discharge tube 23 will remain at a negative bias permitting no current to flow through the plate circuit of the discharge tube. When the critical value of humidity is exceeded, however, the current will flow through rheostat 22 increasing the potential difference across it sufficiently to raise the potential of grid 23' and cause the tube 23 to become conducting thereby effecting an appropriate change in the setting of the humidity modifying apparatus 25. It will be understood that the apparatus may also be arranged to cause a de-humidifying device 25 to be operated until the relative humidity falls below a specified value. Obviously, I may also employ a pair of discharge tubes or other suitable relays arranged to affect humidity modifying apparatus oppositely, in connection with resistance elements which become conducting at different critical values of humidity in order to maintain the humidity between the two critical values.

As in the arrangement shown in Fig. 1, slight adjustments in the value of humidity at which the device operates may be made by adjusting the resistance of the rheostat 22. It will also be understood that where a device is to be made responsive to any one of several different humidities, a number of resistance elements 16 having different critical values may be arranged so that any desired one of them may be connected in the circuit by means of a multi-point selector switch.

The device shown in Fig. 2 may be arranged to operate, for example, at a critical value of 45% relative humidity by using potassium nitrite as the humidity sensitive resistance material. Potassium nitrite has the advantage not only of absorbing moisture rapidly as the humidity increases, but also of giving up moisture quickly when the humidity falls so that a device using this substance responds very rapidly to changes in humidity. In addition to the substances already mentioned, sodium nitrite, sodium dichromate, lithium chloride and potassium acetate, for example, also possess the property of responding quickly to changes in the humidity. But it will be understood that numerous other substances have this property and where rapidity of response is not required, the number of available substances is still further increased.

The resistance element 16 may take any suitable form in which the humidity responsive substance may be caused to form a portion of an electrical circuit. For example, the element may be produced by employing a strip of woven asbestos cloth as an absorbing medium and permitting this strip to absorb a solution of the desired salt. When the salt is used under conditions such that the humidity of the atmosphere may become considerably higher than the humidity at which the salt tends to be deliquescent in nature, it is preferable to limit the concentration of the salt in the solution to approximately a one-fourth saturated solution. This precaution will however not be necessary when the humidity of the atmosphere is ordinarily at a value close to that at which the hygroscopic substance tends to become deliquescent or the substance is definitely nondeliquescent.

In order to eliminate corrosion of the electrodes, graphite electrodes may be used to establish a connection with the salt. One manner of forming graphite electrodes is to paint the ends of the resistance element with "Aquadag" which is a mechanical suspension of graphite in water. In Fig. 4, the features of the variable-resistance units 16 and 17 are shown more in detail. The strip 26 of asbestos cloth is coated at the ends 27 with graphite and metal clamps 28 carrying the terminals 29 are provided for completing the electrical circuit between the conductors 30 through the asbestos cloth 26, which is impregnated with a saline solution as described above.

Another manner of forming the resistance element is to form a film of the desired salt upon a base of impervious materials such as ground glass, aluminum oxide, or other vitreous materials by dipping the base into the molten salt. The resistance element may also be composed of a stick of the desired fused salt.

In the arrangement shown in Fig. 5, there is an aluminum oxide rod 31 coated with fused salt which, in turn, is coated with graphite at the ends 32. There are metal bands 33 encircling the graphite ends 32 and carrying terminals 29 for connection to the conductors 30.

In the arrangement of Fig. 6, a solid block of fused salt 34 is employed having metal caps or clamps 35 carrying terminals 29 for connection to the conductors 30.

In accordance with the provisions of the patent statutes, I have described the principle of operation of my invention, together with the apparatus which I now consider to represent the best embodiment thereof, but I desire to have it understood that the apparatus shown is only illustrative and that the invention may be carried out by other means.

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

1. A humidity indicator including a source of electrical energy, a resistance element supplied thereby, and indicating means responsive to variations in the resistance of said element, said resistance element comprising a base of impervious material and a film of hygroscopic material coated thereon, said material containing a substance of the group consisting of potassium nitrite, sodium nitrite, lithium chloride, potassium acetate, chromium trioxide and sodium dichromate.

2. A humidity indicator including a source of electrical energy, a resistance element connected thereto, and indicating means responsive to variations in resistance of said element, said resistance element comprising a nondeliquescent saline substance in the solid state, said substance being of the group consisting of potassium nitrite, sodium nitrite, lithium chloride, potas-

sium acetate, chromium trioxide, and sodium dichromate.

3. A humidity indicator including a source of electrical energy, a resistance element in circuit therewith, and indicating means responsive to variations in the resistance of said element, said resistance element comprising a substance of the group consisting of potassium nitrite, sodium nitrite, lithium chloride, potassium acetate, chromium trioxide, and sodium dichromate.

4. A humidity indicator including in combination with a source of electrical energy, a resistance element and indicating means in circuit with said source of electrical energy, said resistance element comprising a substance of the group consisting of potassium nitrite, sodium nitrite, lithium chloride, potassium acetate, chromium trioxide, and sodium dichromate.

5. A humidity responsive resistance element comprising a base of impervious material and a film of hygroscopic material fused thereon, said material comprising a substance of the group consisting of potassium nitrite, sodium nitrite, lithium chloride, potassium acetate, chromium trioxide, and sodium dichromate.

6. An element, the resistance of which varies in response to variations in humidity, comprising a saline substance in the solid state, said substance being of the group consisting of potassium nitrite, sodium nitrite, lithium chloride, potassium acetate, chromium trioxide, and sodium dichromate.

7. A humidity responsive element which varies in resistance with variations in humidity, said element comprising a substance of the group consisting of potassium nitrite, sodium nitrite, lithium chloride, potassium acetate, chromium trioxide, and sodium dichromate.

MARCUS E. FIENE.