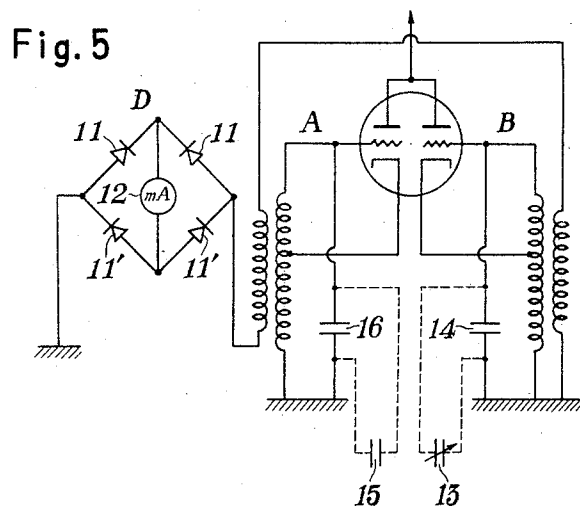
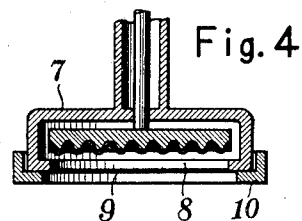
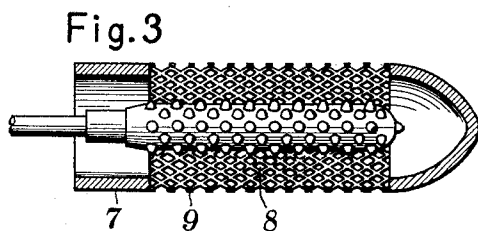
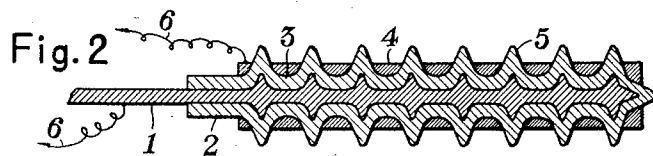
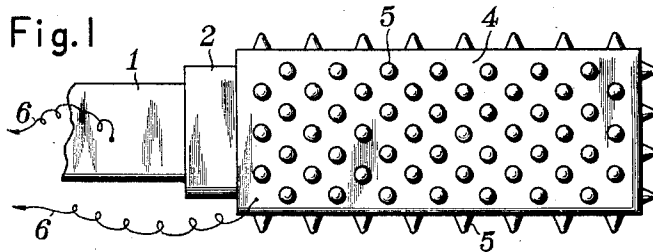


April 28, 1959

AKIRA MIYATA
 DEVICE FOR DETERMINING MOISTURE CONTENT OF
 VARIOUS MATERIALS AND SUBSTANCES
 Filed April 20, 1954

2,884,593



1

2,884,593

DEVICE FOR DETERMINING MOISTURE CONTENT OF VARIOUS MATERIALS AND SUBSTANCES

Akira Miyata, Tokyo, Japan

Application April 20, 1954, Serial No. 424,472

Claims priority, application Japan May 6, 1953

5 Claims. (Cl. 324—61)

When a material does not seem damp in appearance, it is very difficult and troublesome to determine whether it is dry or wet without carrying out scientific and careful measurements. Theoretically, if permissible, the best way for the purpose is to crush the material into minute particles and dry them thoroughly in an oven, and ensuing weighing to deduce the loss due to the moisture content. However, such method is not often practicable, because it necessitates the destroying of the material to be tested. Furthermore, it is very wearisome to wait until the material dries up at a relatively lower temperature without rendering any chemical change and without losing any volatile matter other than moisture. Thus, heretofore the moisture determination has generally been carried out by the electrical measurements, especially with high frequencies, to estimate indirectly the moisture content by reading resistance, capacitance or loss factor of the material that is filled in a definite vessel. But electrical methods are liable at times to cause serious errors due to inhomogeneous distribution and irregular space factor of the material to be put between the electrodes, it being practically impossible to arrange the material uniformly in space at a definite rate, however precisely the measurement itself may be accomplished.

This invention aims to quickly and accurately find out the moisture content indirectly by determining the vapor pressure of the medium adjacent to the material to be tested.

When a material is usually considered to be dried or wetted, it is meant that the material gives up moisture or absorbs it from the surrounding air. Accordingly, at an equilibrium state, the vapor pressure of the surrounding air balances the vapor pressure of the moisture of the material. Thus the vapor pressure of the adjacent medium gives, as a matter of course, the vapor pressure due to the material, or in turn its moisture content. Moreover in this case, despite the probable voids which are apt to happen in most cases, due to irregular distribution of the material, it is correctly estimated when the condition is only satisfied, that an equilibrium is attained; and thenceforce it has merit not without the necessity of destroying the material mechanically or chemically by crushing it into powder or by heating it to high temperature.

The apparatus hitherto usually employed for the measurement of the moisture content of air are hygrometer, psychrometer, dew point indicator or the like. Generally they are so large in size that it is not suitable to define the moisture content at a limited local air space without these instruments. This invention makes use of the moisture-sensitive detector of very small size comparable to that of a hypodermic injection needle. The detector consists of a small piece of dielectric body such as anodized aluminum covered with an electrode permeable to gas displacement. When this detector is inserted into a damp air space, water vapor quickly penetrates into the anodic film, of which thickness is only

2

a few microns and, a quick responsency being justified, apparent value of dielectric constant of the film is remarkably increased to give an abrupt change of capacity. In the present invention a change of capacity is directly read by an ammeter by making use of a special circuit of vacuum tube oscillators.

It will be seen from the aforementioned that, whatever the material may be, so far as it exists in the atmosphere, its moisture content can be estimated merely by bringing the small detector near to it. Into any batch of groups of powdery, granular, lumpy, fibrous or sheet materials, the detector is inserted to ascertain the moisture content of the air space among them, and therefore, in turn, the moisture content of the material which is in equilibrium with it. Rice and other cereals, powdered foodstuffs, chemicals and medicals, raw materials, etc. are tested in this manner.

As the moisture detector, an anodic film of aluminum which remains quite porous to absorb moisture when it is not sealed after electrolysis is utilized. It is ascertained from the new findings that not only its apparent dielectric constant varies so sharply with the moisture content as far as more than thousand times the value in dry state, but also the very thin thickness of the film renders a quick response feasible.

The simplest form of the detector, as mentioned above, consists of a small piece of anodized aluminum, covered with a permeable conducting film which may be produced by any one of the popular techniques such as gold sputtering, silver mirroring or colloidal graphite brushing. It is however preferred to employ the improved types of the detectors as shown in the accompanying drawings, in which:

Figure 1 shows a plan view of a preferred form of the moisture detector constructed according to this invention,

Figure 2 is a longitudinal section thereof,

Figure 3 shows in sectional view a modified form of the moisture detector of the needle type,

Figure 4 shows in sectional view still another modified form of the moisture detector of the disc type, and

Figure 5 illustrates a wiring diagram of an electrical device comprising two electronic oscillating circuits employed in conjunction with the moisture detector.

In Fig. 1, is an aluminum plate, e.g. 3 mm. x 10 mm. x 1 mm., which is beforehand pressed mechanically from both sides to give a fine mesh pattern on the surface. Then it is anodized to give a thin porous film 2 over the indented surface. Thereafter this piece is coated with metallic film 3 which is rubbed off with a plane abrasive, while a conducting film is retained in the recessed part 3 to make one continuous electrode, that is removed in the protruded parts 5 having many exposed points to communicate moisture from the surrounding areas. Thus when lead wires 6 are attached both to the inner aluminum 1 and to the outer metallic film 4, between which is constituted a capacitor, of which capacitance can be measured by a suitable device. Fig. 3 shows a needle form detector, and Fig. 4 shows a unilateral disc detector, each of which is protected mechanically by a small metallic casket 7 having a window 8 provided with a screen of fine wires 9. In the form shown in Fig. 3, a rubber-cushion 10 is provided.

The detector, constructed as hereinbefore mentioned, is devised to make the most of the characteristic behaviors of the anodized aluminum in an efficient manner; a lot of protruded exposed areas of the anodic film make inlets from the surrounding areas, and make contact with the air to receive effectively the influence of humidity and to cause a sensitive change of electrostatic capacity. Moreover this detector is so susceptible that it suffices

only to use quite a spack of anodized film, 1 cm.² in area, 10~30 μ in thickness; thus having the detector of so small a size that it may be well formed in a needle type or a thumbnail type conveniently to be inserted into a small space or to be applied on a small surface.

The type of device for the measurement of a small capacitance, which is regarded most expedient is shown in Fig. 5.

In Fig. 5, setting two electronic oscillating circuits A and B of equal characteristic working on the same electric source, we couple the intermediate circuit D inductively to both of them, put a set of rectifier elements 11 and 11' and a milli-ammeter 12 at one arm in the earth side. In the normal state the circuits A and B oscillate with the same frequency, and there is no exchange of energy between the intermediate circuit D and one of the circuits A and B; and thence no current is found in the intermediate circuit D. However, when either the circuit A or B varies its frequency due to small capacity change in the respective tank circuit, the balance breaks up in the intermediate circuit D to flow an electric current in the milli-ammeter which indicates just the difference of capacity in the both tank circuits, which we intend to know in a direct reading. When the capacitor or the detector 13, of which capacity conforms to the humidity of the surrounding medium, is connected in parallel to the fixed condenser 14 in the circuit B, and is closely brought to the material to be tested, its abrupt change due to the moisture of the material is directly indicated in the reading of ammeter 12, from which the moisture content is easily derived in a previously calibrated measure. There is still another application of the device. When the detector 13 in the circuit B is beforehand inserted into the material of the standard moisture content, and capacitor 15 in the circuit A is adjusted so that the ammeter needle point is set in the middle of the scale, and once more the same detector 13 is put in a similar material of unknown moisture content to be tested, the deviation of the needle point indicates this time the amount of moisture by how far it is more wet or dry than the standard, and instantly tells whether the sample comes up to the permissible range of moisture content or not. These are handy uses of this invention in practical manufacturing, in which temperature effect cancels out to each other, but when a more precise measurement is required the ammeter may well be used as a null detector to compare the sample with various exactly defined known humidities to spot its moisture content.

In this device, required quantity concerning the moisture content being indicated by an ammeter, or thus by an electric quantity which may be easily controlled, the results can either be registered by a recording apparatus or be introduced to an automatic control set to make the moisture content conform to the best desired condition.

What I claim is:

1. A device for indicating the moisture content of grains, powdered chemicals and the like materials com-

prising, a humidity-responsive, substantially rigid, electrically-conductive element for inserting into the material when taking a reading, said element comprising a first metallic electrode having peripheral surface provided with a plurality of spaced indentations and having a thin, moisture pervious anodic film on said surfaces, a second electrode comprising an electrically-conductive metallic film deposited in said indentations thereby to provide, exposed, spaced areas of said film on the surface of said humidity-responsive element, and means connected to said electrodes for indicating humidity variations as a function of capacitance changes between said electrodes.

2. A device for indicating the moisture content of grains, powdered chemicals and the like materials comprising, a humidity-responsive, substantially rigid, electrically conductive element for inserting into the material when taking a reading, said element comprising a first aluminum electrode having peripheral surfaces provided with a plurality of spaced indentations and having a thin, moisture pervious, anodic film on said surfaces, a second electrode comprising an electrically conductive metallic film deposited in said indentations thereby to provide exposed, spaced areas of said anodic film on the surface of said humidity responsive element, and means connected to said electrodes for indicating humidity variations, as a function of capacitance changes between said electrodes.

3. A device according to claim 2, in which said exposed areas of anodic film on said humidity-responsive element comprise protuberances on the surface of said aluminum electrode.

4. A device according to claim 2, in which said exposed areas of anodic film are substantially uniformly spaced on selected surfaces of said aluminum electrode and said areas are of substantially equal dimensions.

5. A device according to claim 2, in which said aluminum electrode comprises a cylindrical member, and in which said humidity-responsive element includes another cylindrical substantially rigid member disposed circumferentially around said aluminum electrode and substantially coaxial therewith, said other cylindrical member having a closed, faired leading end and having perforations disposed on peripheral longitudinally extending surfaces thereof.

References Cited in the file of this patent

UNITED STATES PATENTS

1,708,073	Allem	Apr. 9, 1929
2,177,558	Callan	Oct. 24, 1939
2,237,006	Koller	Apr. 1, 1941
2,304,448	Fletcher	Dec. 8, 1942
2,516,768	Grob et al.	June 25, 1950
2,666,896	Harris	Jan. 19, 1954
2,834,201	Ohlheiser	May 13, 1958

FOREIGN PATENTS

158,105	Germany	Feb. 15, 1905
---------	---------	---------------