

July 31, 1962

R. L. DIETERT

3,047,801

MOISTURE PROBE

Filed Sept. 8, 1959

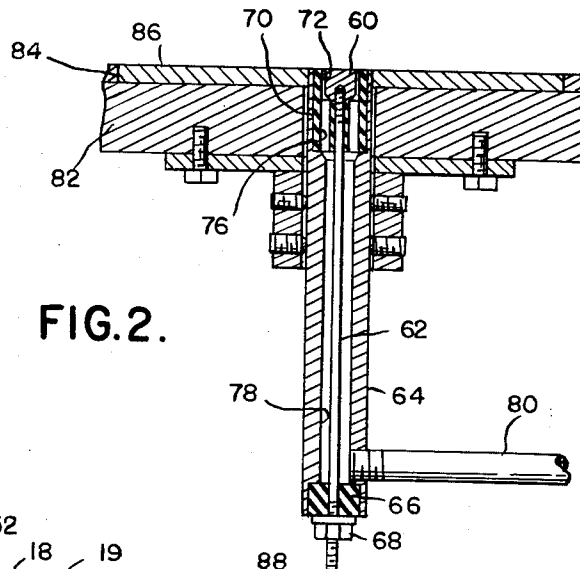


FIG. 2.

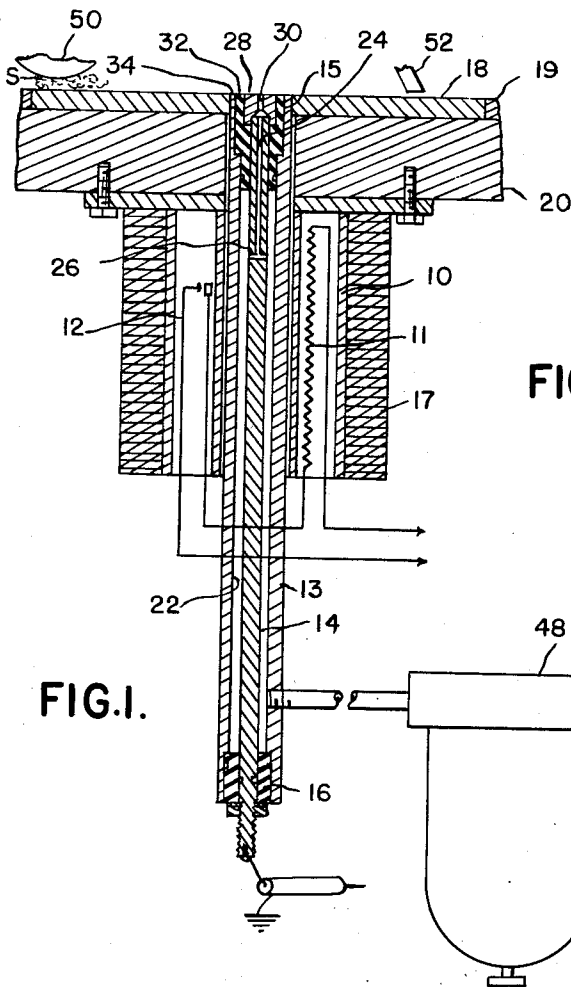


FIG. 1.

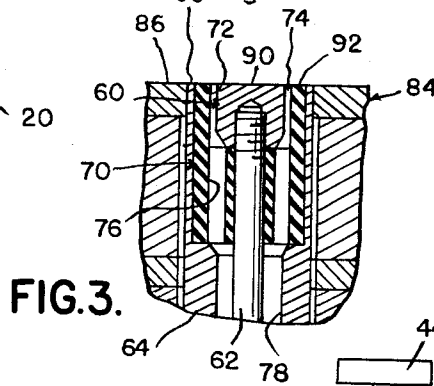


FIG. 3.

INVENTOR.
RANDOLPH L. DIETERT

BY *Whittemore*
Hulbert & Selknap
ATTORNEYS

1

3,047,801

MOISTURE PROBE

Randolph L. Dietert, Detroit, Mich., assignor to Harry W. Dietert Co., Detroit, Mich., a corporation of Michigan

Filed Sept. 8, 1959, Ser. No. 838,615

9 Claims. (Cl. 324-61)

The present invention relates to a probe intended for use in determining the compensated moisture content of a granular or comminuted material such for example as foundry sand.

The term "compensated moisture content" refers to the fact that the measurement takes into account an anticipated or prospective loss of moisture of the material before use.

While the invention is applicable to many fields, it is perhaps best understood by a description of its application to the measurement and/or control of moisture content of foundry sand.

Foundry sand may include different amounts of clay and may include sand of different degrees of fineness, both of which enter materially into evaporation or loss of moisture from a moist quantity of the sand during storage in the open air or transfer from a mill or mixer to a point of use. In addition, the loss of water from moist foundry sand due to evaporation is very materially affected by the temperature of the foundry sand.

In foundries sand is repeatedly used so that in a particular hopper, from which a sand mixture is dumped into a mill, the sand may be at a very substantially elevated temperature due to the fact that it was heated during a previous casting operation after which the sand was recovered for reuse.

In a typical operation foundry sand mixed with binder and including sand of different degrees of coarseness and including different amounts of "fines" is dumped into a mill or mixer and is worked and mixed with water. The mixers may include rollers movable over the sand and operable to compress the sand against the bottom of the mill, working in conjunction with blades or scrapers adapted to loosen the sand and insure complete working of all portions thereof. In other operations rollers may operate at relatively high speed against the cylindrical side wall of the mill. In still other operations the sand may be milled without the addition of water and the required amount of water added during movement of the sand along a conveyor or a combined mixer and conveyor such for example as a screw type conveyor.

In any case, the present invention contemplates the use of a probe for determining an electrical characteristic of the sand dependent upon its physical state. Thus for example, the probe may be connected into a system designed to be controlled by a variable capacitance between electrodes of the probe which are exposed to sand. Alternatively, the system may depend upon variations in electrical resistance between the electrodes of the probe.

In any case, the probe includes a smooth surface adapted to be exposed to the moist sand. In some cases the probe may be positioned in the bottom of a mill so that specimens of sand are alternately compressed by the roller against the probe surface, and between consecutive passes of the rollers the compressed specimen is completely removed by a scraper. Alternatively the smooth surface of the probe may be positioned in a side wall of a mixer. In this case it may be so positioned that rollers operating to compress sand against the side walls may periodically compress specimens against the surface of the probe exposed within the mill, or it may be carried by a member so that it is subjected to continuous relative movement between itself and the moist sand in the mill. Thus for example, the probe may be carried by a rotating mem-

2

ber such as the member which carries the rollers and/or scrapers, or it may be carried by a separate movable support. In some cases the probe may be associated with a mill of the type in which the container itself rotates and in which rollers and/or scrapers and mixing blades are stationary. In such case the probe will be stationary so that rotation of the container will cause the sand to be carried continuously along its smooth probe surface. In the latter cases the probe surface may be substantially parallel to the direction of relative motion between the sand itself or it may be at a substantial angle thereto.

Briefly reviewing the foregoing, it will be seen that in accordance with the present invention the probe is either subjected to a series of sensing operations in which moist specimens are compressed against it and thereafter removed, or alternatively, it is continuously subjected to a flow of the moist material across its sensitive surface.

It has been found that if a substantial flow of air is caused to flow across the probe surface the electrical measurement will be influenced by the same factors which determine loss of moisture of the sand between the mixing operation and its ultimate use.

It is accordingly an object of the present invention to provide a probe designed for use in contact with moist granular material including spaced electrodes, means for inducing a flow of air across the surface of the probe and/or through the granular material instantaneously in contact with the surface of the probe.

More specifically, it is an object of the present invention to provide a probe having a sensitive surface including a central electrode, a second electrode spaced laterally outwardly from the first electrode, and an air passage terminating in a port located in the sensitive surface of the probe.

More specifically, it is an object of the present invention to provide a probe having a pair of spaced electrodes, and means for providing a high velocity flow of air through the space between the electrodes.

It is a further object of the present invention to provide a probe of the type described in the foregoing which includes means for heating the air prior to its discharge through the sensitive face of the probe.

Other objects and features of the invention will become apparent as the description proceeds, especially when taken in conjunction with the accompanying drawing, illustrating preferred embodiments of the invention, wherein:

FIGURE 1 is a longitudinal sectional view of a probe constructed in accordance with the present invention, together with means for conditioning and controlling the flow of air therethrough.

FIGURE 2 is a longitudinal sectional view through a second embodiment of the invention.

FIGURE 3 is an enlargement of the specimen contacting end of the probe.

Referring first to FIGURE 1, the probe includes a highly thermally conductive metal double walled annular case 10 which contains one or more heaters 11 adapted to be controlled by a thermostatic switch indicated diagrammatically at 12. Located within the case 10 is the probe tube 13 and this tube extends outwardly beyond the end of the case 10. The probe tube 13 is also made of highly thermally conductive metal which constitutes one of the electrodes of the probe. A center electrode 14 is provided which acts as a conductor and electrode as well as a tie rod to hold annular insulators 15 and 16 in place. The case 10 is surrounded by an insulating jacket 17 to minimize heat loss from the case 10. Attached to the probe tube 13 at the top is a flange 18 which as shown includes an exposed upper surface coextensive with the upper surface of a wear plate 19 provided to

overlie the bottom wall 20 of a mill in which the probe is mounted.

The center electrode 14 has an outside diameter substantially smaller than the inside diameter of the probe tube 13 and thereby defines a small air passage indicated at 22. Adjacent its upper ends the electrode 14 is provided with a longitudinally extending air passage 24 which communicates with the annular air passage 22 by a cross passage 26. Integral with or secured to the upper end of the center electrode 14 is an electrode element 28 having a passage 30 extending therethrough and in communication with the passage 24. The passage 30 terminates in a port located centrally in the exposed flat smooth surface of the electrode element 28.

It will be observed that between the electrode element 28 and the annular exposed upper end of the tube 13, there is provided a flat smooth annular surface 32 of the insulator 15. Thus, the edge of the electrode element 28 is separated from the exposed surface 34 of the tube by an annular surface of suitable insulating material such for example as Teflon.

Air is supplied to the system from a supply line 40 and its pressure is controlled by a pressure regulator 42 including an adjusting handle 44. The pressure as controlled by the pressure regulator is indicated by a pressure gauge 46. The air system also includes a water trap 48 so as to remove any evaporated water in the air system. The constant pressure regulated dry air is thus discharged into the passage 22 of the probe. The air is brought into the internal part of the probe where it is heated by physical contact with the probe tube 13 which is kept at constant temperature by the heater 11 and thermostat 12. If desired or necessary, baffles may be provided to insure more extended contact between the air and the heated probe tube 13. It will be understood that the granular or comminuted material such as sand is located in contact with the upper surface of the probe and is either being moved across the surface or is periodically compressed against the surface and thereafter removed. In any case, the air which escapes at relatively high velocity tends to "plane" between the interface between the probe as well as the flange 18 and the compressed sample, and thus has a drying effect which is reflected by the reading of resistance or capacitance measured across or between the electrode surfaces 28 and 34.

The operation of the probe will be described in connection with FIGURE 1 on the assumption that the probe is located in the bottom surface of a mill, the surfaces 19, 18, 34, 32, and 28 being smooth continuous coplanar surfaces. A roller, a portion of which is indicated at 50, traverses the probe and compresses a specimen of the moist material S against the upper surface of the probe. The specimen whose compensated moisture content is being measured lies between the center electrode element 28 and the surface 34 of the tubular electrode 13, the latter of which is grounded by connection to adjacent portions of the mill. The maximum reading of the probe occurs at the time the rollers 50 pass directly over the probe. After the roller passes the center of the probe, plows or scrapers 52 remove all or substantially all of the pressed material from the surface of the probe. As soon as the blade or scraper 52 following the roller 50 has passed over the electrode, a new specimen of sand falls downwardly onto the surface of the probe. During the interval before the next passage of a roller hot air escaping through the orifice of the passage 30 will blow through the sand and will perform a certain drying effect thereon. Thus, when the roller next traverses the probe, the specimen of sand which is pressed against the sensitive surface of the probe is one which has been subjected to a predetermined drying effect which may be correlated to the drying effect of the sand during its transfer to and storage at the point of use, up to the time of use. In other words, instead of measuring the actual moisture content of the sand in the mixer, the present probe is de-

signed to perform a predetermined drying action on a small sample which is correlated to the drying action which will subsequently take place on the main body of sand before use. Thus, the measurement is accurately described as a compensated measurement of moisture content.

The drying action of the air jet may be adjusted by controlling its temperature and the pressure or velocity with which it is projected through the passage 30. In addition, the drying effect will be influenced by the nature of the sand, the percentage of clay and/or binder included, and the average grain size of the sand.

Referring now to FIGURES 2 and 3 there is illustrated a specifically different probe for performing compensated measurement of moisture content. In this case the probe comprises a central electrode 60 carried at the upper end of a conducting rod 62 which extends longitudinally of a tubular electrode 64. An insulator 66 is connected between the lower end of the tubular electrode 64 and the rod 62 and is clamped therein by a nut 68. At its upper end the passage through the tubular electrode 64 is enlarged to receive an annular insulator 70. The insulator 70 is provided with an enlarged recess 72 in which the central electrode 60 is received with the side edges of the electrode spaced laterally from the inner surface of the enlargement 72 of the insulator. There is thus provided a continuous annular air passage 74 surrounding the central electrode 60.

The insulator 70 is provided with a plurality of axially extending air passages 76 communicating at the upper end with the continuous annular air passage 74.

The rod 62 has an outside diameter less than the inside diameter of the tubular electrode 64 and there is thus provided an annular air passage 78 which communicates at its upper end with a plurality of air passages 76 extending through the lower portion of the insulator 70. Air is introduced into the passage 78 through a conduit 80 and this air may be of regulated pressure as suggested in FIGURE 2. If desired, its temperature may be regulated externally by means equivalent to the heaters 11 and thermostatic control 12 shown in FIGURE 1.

Again, the electrode shown in FIGURE 2 is assumed to be positioned in a container which receives moist granular material such for example as foundry sand, and the wall 82 may be regarded as the lower wall of a sand mill, the side wall thereof as the side wall of a conveyor or any support which maintains the sensitive surfaces of the probe in continuous or periodic contact with specimens of the moist sand or other granular material.

The probe includes a flange 84 having a smooth surface 86 coplanar or continuous with the smooth exposed surface 88 of the annular electrode, the smooth exposed surface 90 of the central electrode, and the smooth exposed surface 92 of the insulator 70.

In this case it will be assumed that a moist specimen of sand or other granular material overlies the sensitive surfaces of the electrodes. Since the escape of air is through an annular zone completely surrounding the central electrode, it will be apparent that this air will move for the most part radially outwardly across the exposed surface of the insulator 70 and through the portion of the granular material next adjacent to this surface. It will thus exert a drying effect on this granular material which is proportional to its temperature and velocity and the time which the specimen of inert granular material is subjected to the drying current of air. Also of course, the drying effect will be dependent upon the specific characteristics of the sand or other granular material as described above, as well as its porosity.

It is contemplated that a substantial drying effect will be exerted by the air and in practice it is found that the air should be supplied at a pressure of at least one pound per square inch and preferably between two and three pounds per square inch.

A probe constructed in accordance with the disclosure

of FIGURE 2 has been successfully operated having a central electrode, the exposed or sensitive area 90 of which is a circle having $\frac{3}{8}$ inch diameter. The air gap is an annular port having a transverse width of $\frac{1}{16}$ inch. The gap across which the conductor or resistance is measured, or in other words the exposed surface of the insulator 70, is an annular surface having a transverse dimension of $\frac{3}{16}$ inch, including the air gap. Under these circumstances it has been found that the air flow may vary from approximately ten cubic feet per minute with an air supply of two pounds per square inch, to approximately fifteen cubic feet per minute with an air supply at three pounds per square inch. Obviously, the volumetric flow of air will be determined in part by the permeability of the sand as well as whether the probe is being used in continuous uniform contact with moist granular material which has relative sliding motion across the probe, or whether the operation is an intermittent compression of the moist material against the surface of the probe.

The drawing and the foregoing specification constitute a description of the improved moisture probe in such full, clear, concise and exact terms as to enable any person skilled in the art to practice the invention, the scope of which is indicated by the appended claims.

What I claim as my invention is:

1. A probe comprising a central electrode having a smooth specimen contact surface, an annular insulator surrounding said central electrode and having a smooth specimen contact surface forming a smooth continuous extension of the contact surface of said central electrode, an outer annular electrode surrounding and immediately adjacent said annular insulator, said annular electrode having a smooth specimen contact surface forming a smooth continuation of the contact surfaces of said central electrode and said annular insulator, an air passage extending through said insulator and having an air escape port located in the plane of the contact surface thereof.

2. A probe comprising a central electrode having a smooth specimen contact surface, an annular insulator surrounding said central electrode and having a smooth specimen contact surface forming a smooth continuous extension of the contact surface of said central electrode, an outer annular electrode surrounding and immediately adjacent said annular insulator, said annular electrode having a smooth specimen contact surface forming a smooth continuation of the contact surfaces of said central electrode and said annular insulator, an air passage extending through said insulator and having a continuous annular port surrounding said central electrode and located in the plane of the contact surface thereof.

3. A probe for determining the compensated moisture content of moist granular material which comprises a pair of spaced electrodes, an insulator intermediate said electrodes, said electrodes and insulator having a smooth continuous specimen engaging contact surface, an air discharge port located in one of said surfaces for deliver-

ing a continuous flow of drying air to a specimen in contact with said probe.

4. A probe for determining the compensated moisture content of moist granular material which comprises a pair of spaced electrodes, an insulator intermediate said electrodes, said electrodes and insulator having a smooth continuous specimen engaging contact surface, an air discharge port located in the contact surface of one of said electrodes for delivering a continuous flow of drying air to a specimen in contact with said probe.

5. A probe for determining the compensated moisture content of moist granular material which comprises a pair of spaced electrodes, an insulator intermediate said electrodes, said electrodes and insulator having a smooth continuous specimen engaging contact surface, an air discharge port located in the contact surface of said insulator for delivering a continuous flow of drying air to a specimen in contact with said probe.

6. A probe comprising a central electrode having a smooth specimen contact surface, an annular insulator surrounding said central electrode and having a smooth specimen contact surface forming a smooth continuous extension of the contact surface of said central electrode, an outer annular electrode surrounding and immediately adjacent said annular insulator, said annular electrode having a smooth specimen contact surface forming a smooth continuation of the contact surfaces of said central electrode and said annular insulator, an air passage extending through said insulator and having an air escape port located in the specimen contacting surface thereof.

7. A container for a quantity of moist granular material, said container having a smooth continuous wall normally engaged by material in said container, probe structure comprising a pair of spaced electrodes located in said wall and having material engaging surfaces occupying the inner surface of said wall, an insulator between said electrodes having a material engaging surface also occupying the inner surface of said wall, an air supply passage extending through said wall and terminating in a port located in one of said material engaging surfaces.

8. Structure as defined in claim 7 in which one of said electrodes has an annular material engaging surface and the other of said electrodes has its material engaging surface spaced radially inwardly from the inner edge of the annular material engaging surface of said one electrode.

9. Structure as defined in claim 8 in which said port is located inwardly of the annular material engaging surface of said one electrode.

References Cited in the file of this patent

UNITED STATES PATENTS

2,217,626	Strang et al. -----	Oct. 8, 1940
2,228,223	Bays -----	Jan. 7, 1941
2,316,875	Laboulais -----	Apr. 20, 1943
2,852,740	Posey et al. -----	Sept. 16, 1958
2,886,868	Dietert et al. -----	May 19, 1959