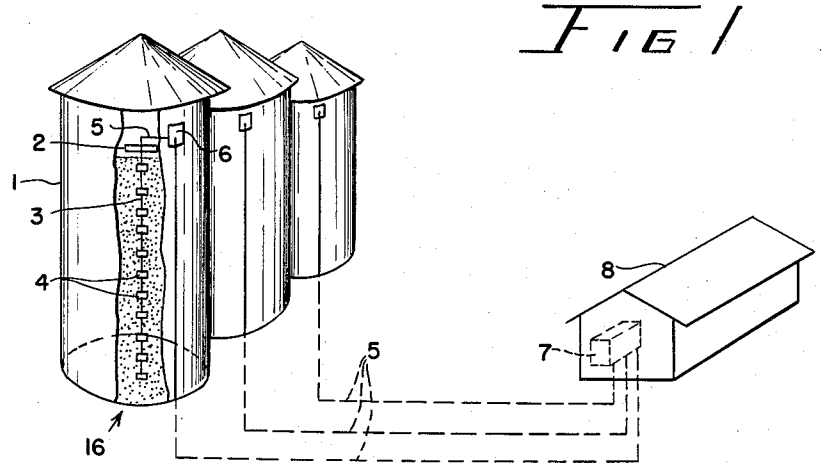
April 24, 1956 R. S. FEIGAL ET AL 2,742,780

MOISTURE INDICATING APPARATUS

Filed Oct. 27, 1950

FIG 1



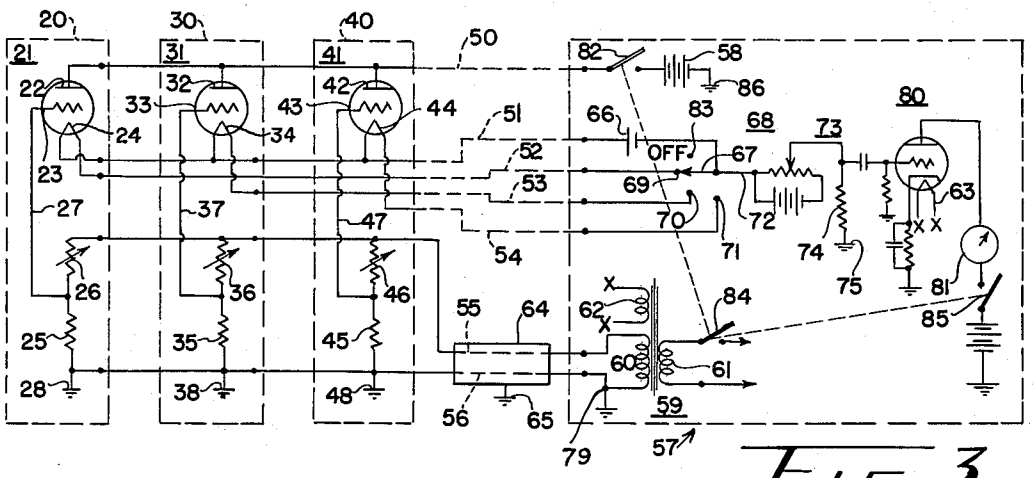
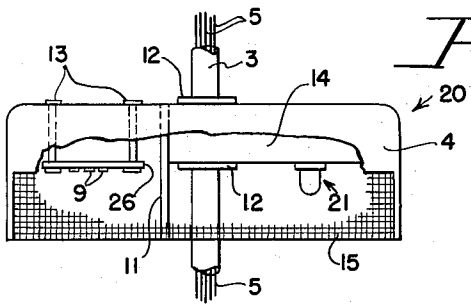


FIG. 3

FIG. 2



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MOISTURE INDICATING APPARATUS

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5 Claims. (Cl. 73—73)

The present invention is concerned with moisture indicating apparatus and particularly with that type of apparatus used where the moisture condition of stored grain is to be measured at a plurality of locations throughout the grain.

It is well known that the relative humidity of the air found in the interstices of a grain mass bears a definite relation to the moisture content of the grain. By experience, it appears that spoilage of the grain may be expected if the relative humidity of the interstitial air is above about 75%. Because of the difficulty of obtaining properly representative samples from a large grain mass, it has been proposed that humidity responsive elements such as described in Dunmore Patent 2,285,421, or preferably, in Squier application Serial No. 17,622, filed March 29, 1948, now Patent No. 2,543,384, be distributed about the mass. This arrangement has not been fully satisfactory before this invention because of the capacitance effects of the long leads necessarily involved, the previous solutions to this capacitance problem not being entirely successful.

It is therefore an object of the present invention to provide an improved moisture indicating apparatus of the type that will give an accurate indication of the moisture condition of a stored substance.

A further object of the present invention is to provide an improved moisture indicating apparatus which will accurately indicate the moisture condition at a plurality of positions throughout a stored substance wherein a high impedance moisture responsive element is electrically coupled to a cable so as to present a low impedance to the cable.

A still further object of the present invention is to provide an improved moisture indicating apparatus that is a permanent installation within a storage bin and will protect the plurality of moisture responsive devices from the abrasive effect of the grain at times such as when the storage bin is being filled.

Still another object of the present invention is to provide an improved moisture indicating apparatus wherein each of the plurality of moisture responsive devices is inoperative at all times except during a short interval necessary to obtain a reading of the moisture condition at the particular moisture responsive device.

A further object of the present invention is to provide an improved moisture indicating apparatus wherein each moisture responsive device includes a high impedance element responsive to moisture and an electron discharge device fixed in a housing which will protect the impedance element from the heat radiated by the electron discharge device during the short time interval the electron discharge device is operative.

These and other more detailed and specific objects will be disclosed in the course of the following specification, reference being had to the accompanying drawings, of which:

Figure 1 shows a typical installation of the invention in a grain storage bin;

Figure 2 shows a cutaway view of one of the plurality of moisture responsive devices, and;

Figure 3 shows the electronic circuit used in the improved moisture indicating apparatus.

Referring to Figure 1, the numeral **1** represents a storage bin of the type used to store grain. Rigidly fixed in this bin is a platform **2** to which is attached a supporting conduit **3** along which the housings **4** of the moisture responsive devices are spaced at appropriate intervals, say five feet, in the substance **16** being stored. The conduit **3** contains a multi-conductor cable **5** which connects the platform **2** to a junction box **6** on the outside of the storage bin wall from which the cable **5** extends to an indicating device located, for instance, in a building **8**. This cable **5** should be a good grade of moisture resistant insulated cable the A. C. supply line in the cable being twisted to minimize induction effects.

An individual moisture responsive device **20** is shown in Figure 2, with numeral **21** representing an electron discharge device. The electron discharge device **21** is separated from the moisture responsive impedance element **26** by a wall **11** which is rigidly fixed to the housing **4** of the device, the element **26** being of the aforementioned Squier or Dunmore type. This figure also shows the conduit **3** and the shoulder **12** which fixes the housing **4** rigidly to the conduit **3**. The impedance element **26** may be attached to the housing **4** in any practical manner and is shown to be held by two bolts **13**. It has been found preferable to prevent dust from affecting the element **26** by mounting the element **26** with the active portion **9** on the under side of the element **26**. This housing **4** also includes a chamber **14** in which is housed the remainder of the electronic circuit which includes the electron discharge device **21** and the impedance element **26**. The housing **4** is covered by a wire cloth screen **15** which will allow the moisture in the stored substance to affect the impedance element **26** but will keep the substance **16** out of contact with the element **26**. This screen **15** will also prevent any flame or spark which may develop in the housing **4** from escaping to the surrounding atmosphere. This is an important consideration in a grain storage bin where an explosive atmosphere is likely to be encountered.

Referring to Figure 3, three identical moisture responsive devices **20**, **30** and **40** of the type indicated in Figures 1 and 2, with the housing **4** of each indicated by dotted lines, are shown connected by conductors **50**, **51**, **52**, **53**, **54**, **55**, and **56** to an indicating device **57** in a housing also indicated by dotted lines. The conductors **51**, **52**, **53**, **54**, **55**, and **56** are shown partially as dotted lines to indicate that they are long conductors such as contained in cable **5**, referring to Figures 1 and 2.

The moisture responsive device **20** includes an electron discharge device in the form of a triode **21** having an anode **22**, a control electrode **23**, and a cathode **24** of the directly heated type. A relatively high impedance element in the form of a resistor **25** is connected in a series circuit with a high impedance moisture responsive element **26** of the resistance type. The junction between the resistor **25** and the moisture responsive element **26** is

connected by conductor 27 to the control electrode of triode 21.

Devices 30 and 40 are identical with device 20 but the corresponding elements are numbered in the 30 and 40 series, respectively, to avoid confusion in the subsequent description.

The anodes 22, 32 and 42 are joined by a common conductor and are connected to a direct current power supply 58 in the indicating device 57 by means of a conductor 50. The power supply 58 is then grounded at 86. The series circuits of the three moisture responsive devices 20, 30 and 40, comprising resistors 25, 35, and 45 connected in a series circuit with resistance elements 26, 36 and 46 respectively, are joined in parallel by common conductors and by means of conductors 55 and 56 are connected to the secondary winding 60 of a transformer 59 located in the indicating device 57. This transformer 59 also contains a primary winding 61 which is connected to an alternating current source of power, not shown, and a second secondary winding 62 which supplies the filament voltage for a filament 63 of an electron discharge device 80. In some instances, it may be necessary to shield one or both of conductors 55 and 56, as indicated by shield 64 which is grounded at 65, to prevent interaction between these conductors and the conductors 50, 51, 52, 53 and 54. However, the latter group of conductors need not be shielded. Conductor 56 may also be grounded at the moisture responsive devices 20, 30 and 40 as shown at 28, 38 and 48, respectively and at the indicating device 57 as shown at 79.

A conductor 51 connects one terminal of each of the cathodes 24, 34 and 44 to a direct current source of power 66 which is also connected to the movable contact arm 67 of a switch 68. The remaining terminal of cathodes 24, 34, and 44 is connected by conductors 52, 53 and 54, respectively, to the fixed contacts 69, 70 and 71 respectively of switch 68. The movable contact arm 67 of switch 68 is connected by conductor 72 to a source of variable bias voltage 73 and then to a relatively low impedance 74 in the form of a resistor which is connected to ground at 75. Resistor 74 is connected in current controlling relation to the electron discharge device 80 and the output of discharge device 80 contains a meter 81 which is calibrated to indicate the moisture condition at one of the moisture responsive devices 20, 30 or 40 as selected by switch 67.

The indicating device 57 is provided with an on-off switch actuator or handle, not shown, which will open a switch 82 in conductor 50, open a switch 84 in the primary winding 61 of the transformer 59, and open the switch 85 located in the output circuit of electron discharge device 80. The movable contact arm 67 of the switch 68 is provided with a dead fixed contact 83 and the switch is returned to this position when no measurement is being made.

Operation of Figure 3

In discussing the operation of the moisture indicating apparatus it will be assumed that an operator wishes to determine the moisture condition of the stored substance and that the on-off switch actuator or handle, not shown, of the indicating device 57 is at the on position so that switches 82, 84 and 85 are closed. The operator then moves the movable contact arm 67 of the switch 68 from the dead contact 83 to the switch contact associated with the moisture responsive device he wishes to operate, for example to contact 69. This energizes the cathode 24 of triode 21 located in the moisture responsive device 20.

The current flow of the triode 21 can be traced from the positive terminal of the direct current power source 58 through switch 82, conductor 50, anode 22, cathode 24, conductor 52, switch contact 69, switch arm 67, conductor 72, bias supply 73, resistor 74, ground 75 to ground 86 and back to the direct current power source 58.

The control voltage circuit for triode 21 can be traced from the upper end of the transformer secondary winding 60, through conductor 55, the humidity responsive element 26, resistor 25, and conductor 56 back to the secondary transformer winding 60. Moreover, this control voltage is determined primarily by the portion of the transformer 59 alternating current voltage present across the high resistance resistor 25. It can be seen from this circuit that as the resistance of the humidity responsive humidity element 26 decreases, as it would for a condition of higher humidity, a greater portion of the transformer 59 voltage would appear across resistor 25. In this manner the humidity responsive element affects the control voltage of triode 21, and the current flow through the triode 21 produces a signal voltage, proportional to the humidity condition at the humidity responsive high resistance element 26 at the low resistance resistor 74 located in the indicating device 57. This signal controls the current flow through electron discharge device 80 and thereby the indication of meter 81 which then gives a visual indication of the moisture condition at this one location within the stored substance. Meter 81 is of the type which will give an indication of the alternating component of current in the plate circuit of discharge device 80. The adjustable bias device 73 is used as a calibration means for meter 81 and is adjusted so the reading on meter 81 corresponds to the measured humidity. Normally this is adjusted upon installation of the system and needs no further attention.

If the operator now wishes to obtain an indication of the moisture condition at the position related to the moisture responsive device 30 it is necessary that he move the movable contact arm 67 of switch 68 to fixed contact 70. The cathode heating circuit of the moisture responsive device 30 is now energized and after the short time necessary for the cathode 34 of triode 32 to heat to an electron emitting condition, the meter 81 will indicate the moisture condition at the position of the moisture responsive device 30. Likewise, moving the switch arm 67 to fixed contact 71 will allow the operator to obtain an indication of the moisture condition at the position of moisture responsive device 40.

From the foregoing description it can be seen that a moisture indicating apparatus has been provided which will indicate the moisture condition at a plurality of positions remote from the indicating device and will do so by electrically coupling a high resistance humidity responsive element to a low resistance through a relatively long electrical connection. This electrical coupling is recognized as a cathode follower circuit, which is well known in the art, which is modified by placing the cathode resistor at a position remotely located from the remainder of the cathode follower circuit, the remainder of the circuit including a plurality of selectively operable portions. Since a cathode follower circuit has the inherent characteristic of a low output impedance and a high input impedance with our invention it is possible to couple a high impedance moisture responsive element to a long electrical cable such that the capacitive characteristics of the cable will not introduce an error into the apparatus. Further we have provided an apparatus which prevents the heat generated by the electronic circuit from introducing errors into the moisture indication.

While we have shown our invention as having three humidity responsive devices it is feasible to so connect a much larger member into the circuit, one installation contemplating sensing from 100 different locations. It is also understood that the indicating device may comprise a variety of devices other than a meter, giving a visual indication. It is therefore to be understood that our invention is to be limited solely by the scope of the appended claims.

We claim:

1. In combination; an electrical power source; switch-

ing means; indicating means; a plurality of moisture responsive means located at a plurality of positions remote from said indicating means, each of said moisture responsive means including a moisture responsive impedance element normally arranged to be responsive to the moisture content of the air surrounding said impedance element, an electron discharge device for each moisture responsive element, each discharge device having an anode, a control electrode and a cathode, and a heat energizing circuit for each of said cathodes; an anode-cathode output circuit for each discharge device; circuit means connecting said anode-cathode circuits of said discharge devices in parallel to said power source; means connecting each of said moisture responsive impedance elements to its respective control electrode; a source of alternating potential, said moisture responsive impedance elements being connected in parallel to said source of alternating potential; means connecting said switching means and said heat energizing circuit in a series circuit, said switching means having switch contacts for rendering any one of said plurality of moisture responsive means operative by energizing its heat energizing circuit and rendering all other of said moisture responsive means inoperative by rendering their associated heat energizing circuits inoperative to thereby prevent the continued heating of the air surrounding the moisture responsive element associated with each of said other moisture responsive means; and means including a low impedance line connecting said cathodes to said indicating means whereby said moisture responsive element is coupled to said remote indicating means.

2. Apparatus for measuring the moisture content of a stored substance comprising: indicating means having a low impedance input; a plurality of moisture responsive means located at a plurality of positions throughout said stored substance; each of said moisture responsive means including an electron discharge device connected to have a low impedance output circuit, a high impedance element responsive to moisture, and a housing, said housing being constructed so as to shield said impedance element from the heat generated by said electron discharge device; said electron discharge device having a cathode, said cathode having resistance whereby said cathode is heated to an electron emitting condition when current is caused to flow through said resistance; means connecting said high impedance element in current controlling condition to said electron discharge device; switching means; a source of direct current potential, said low impedance output circuit comprising the cathode circuit and including means connecting said switching means, said direct current source, and said cathode resistances in a series loop, said switching means having contacts for energizing any one of said cathode resistances thereby rendering the associated responsive means operative only when an indication of the moisture at the associated responsive means is desired to thereby prevent the continued heating of said cathode from affecting the medium surrounding said moisture responsive element, and means connecting the low impedance input of said indicating means to the low impedance output circuit of said discharge devices of said plurality of moisture responsive means.

3. Moisture indicating apparatus comprising: current responsive indicator means; switching means; a source of electric power; a plurality of moisture responsive means located at a plurality of positions remote from said previously named elements, each of said moisture responsive means including an impedance element responsive to moisture and responsive to the moisture content of the medium surrounding said element, an electron discharge device having electrodes including an anode and a cathode, a heating circuit for said cathode, said cathode being heated to an electron emitting condition when current is caused to flow through said heating circuit, and means connecting said moisture responsive impedance element in current controlling relation to said electron discharge device; an anode-cathode output circuit for each discharge device; means connecting the anode-cathode output circuits of said discharge devices to said indicator means in controlling relation thereto; means including said switching means connecting the cathode heating circuits of the electron discharge devices of said plurality of moisture responsive means to said source of electric power, said switching means having a controlling position for each of said heating circuits for selectively energizing any one of said cathode heating circuits from said source of power thereby rendering the associated moisture responsive means operative so that an indication of the moisture at the associated moisture responsive means is obtained, said one circuit being energized only when a moisture indication is desired, thereby preventing the continued heating of the cathode from affecting the medium surrounding said moisture responsive element.

4. Apparatus for measuring the moisture content of a stored substance comprising in combination: a source of relatively constant alternating potential; a resistor; a high impedance resistive element responsive to moisture; circuit means connecting said resistor and said resistance element in circuit with said source of alternating potential, said circuit means including a first junction between said resistor and said source which is connected to a reference potential point; a source of positive potential with respect to the reference potential; an electronic discharge device having an anode, a control electrode and a cathode, and a heating circuit for said cathode, said cathode being heated to an electron emitting condition when current is caused to flow through said heating circuit; means connecting said control electrode to a second junction of said circuit means between said resistor and said resistance element to provide an alternating signal for controlling said discharge device in accordance with the resistance value of said moisture responsive impedance; means connecting said anode to said source of positive potential; a load resistor; switching means; a source of electric power; means including said switching means for connecting said cathode heating circuit to said source of power to provide current flow through said circuit and for connecting one terminal of said load resistor to said cathode of said electronic discharge device, the other terminal of said load resistor being connected to said reference potential point; and indicating means connected to said load resistor and responsive to the current flow through said load resistor.

5. Apparatus for measuring the moisture content of a stored substance comprising; indicating means having a low impedance input; a plurality of moisture responsive means located at a plurality of positions throughout the substance, each of said responsive means including a high impedance element, each responsive means also including an electron discharge device having an anode, a cathode, a control electrode, and heating means for each of said cathodes, a source of direct current potential, switching means, means connecting said direct current source, said switching means and said heating means in a series circuit which comprises a cathode heating circuit, said switching means having contacts for rendering any one of said moisture responsive means operative by energizing its cathode heating circuit and rendering all the other responsive means inoperative by rendering their associated heating circuits inoperative to thereby prevent continued heating of the interstitial air surrounding the moisture responsive element associated with each of the other moisture responsive means, a low impedance output circuit connected to the cathode of each of said discharge devices, each of said high impedance elements being exposed to the interstitial air in the stored substance; an anode-cathode output circuit for each electron discharge device; means connecting the anode-cathode circuits of said discharge devices in parallel and to a source of direct potential; means connecting said high impedance elements in current controlling relation to the respective electron dis-

charge devices, and means connecting the input of said indicating means to the low impedance output circuit.

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