

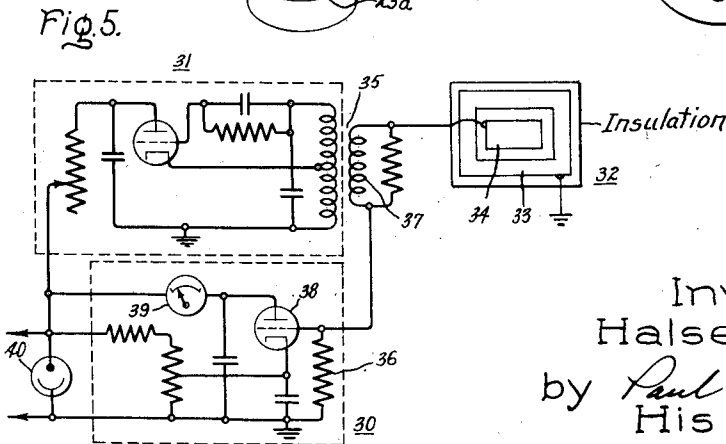
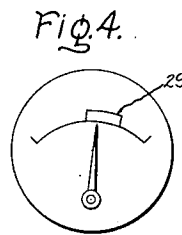
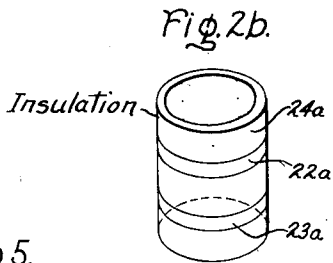
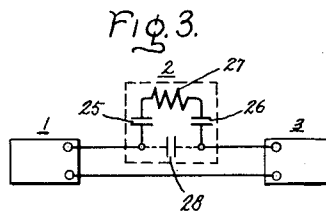
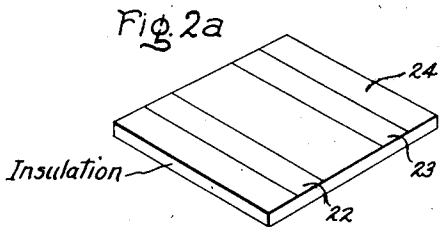
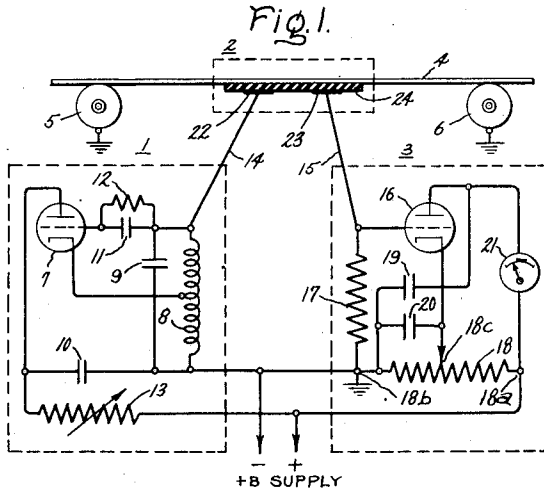
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MOISTURE CONTENT MONITOR

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UNITED STATES PATENT OFFICE

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MOISTURE CONTENT MONITOR

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2 Claims. (Cl. 175—183)

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My invention relates to an electronic instrument which monitors the moisture content of a material by measuring its resistive and capacitive variations.

In the manufacture of certain materials such as paper and cloth it is necessary to keep the moisture content of the materials within predetermined limits, and in the sale of certain materials such for example as twine it is often necessary to know the moisture content of the material. Thus it may be sufficient for an operator to merely know the moisture content of the material, or it may be desirable for the moisture content to be automatically maintained at a given level.

My invention does not employ a bridge circuit or a resonant circuit in the indicator, and consequently its sensitivity does not depend upon the stability of an oscillator. This, of course, increases the sensitivity of the instrument, while reducing its cost.

Very briefly, I accomplish this by means of a conventional radio frequency oscillator which has an adjustable output, a monitoring head over which the material under test passes, and an electric meter which indicates the amount of energy transmitted by the oscillator through the tested material. The amount of energy transferred through the material is proportional to its moisture content, and consequently, any change in this moisture content affects a change in the indication of the electric meter.

Therefore, an object of my invention is a new and improved instrument for measuring the moisture content of a material.

Another object of my invention is an instrument which will continually monitor the moisture content of a material which passes in close proximity thereto.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims. My invention itself, however, both as to its organization and method of operation may best be understood by reference to the following description taken in connection with the figures of the accompanying drawings in which:

Fig. 1 is a schematic electric diagram of my invention.

Fig. 2 shows two common types of monitor heads to be used in conjunction with my invention.

Fig. 3 is an equivalent electric diagram of the circuit of Fig. 1 and it is used to facilitate an understanding of the operation of my invention.

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Fig. 4 is the face of an indicator used in the circuits of Fig. 1 and Fig. 5.

Fig. 5 is a schematic electric diagram of a modification of the circuit shown in Fig. 1.

Referring to Fig. 1, a conventional Hartley type radio frequency oscillator 1 generates a signal which is fed through a monitoring head 2 to an electric indicator 3 preferably of an aperiodic electronic type such as illustrated in the drawings. The term "aperiodic electronic indicator" is employed herein to define an electronic indicator which is substantially unaffected by minor variations in the "period" (frequency) of a radio frequency signal supplied thereto. A material 4 to be tested is passed over the monitoring head, and a pair of rollers 5 and 6 are spaced at such a distance from one another that the resistance of material 4 between either roller and a point half-way between the two, at which monitor head 2 is located, is very high.

Rollers 5 and 6 are not parts of my invention but are integral parts of the machinery used in the manufacture of the material being tested and as such, these rollers will generally be grounded and are, therefore, shown grounded in the drawing.

Oscillator 1 includes a high vacuum triode 7, and an inductor 8 and a capacitor 9 connected in parallel as the resonant tank circuit of the oscillator. A capacitor 10 is the feedback capacitor of the oscillator and a parallel circuit arrangement of a capacitor 11 and a resistor 12 is used to control the d-c bias on the control electrode or grid of triode 7. A variable resistor 13 which is connected from the plate of triode 7 to the positive terminal of the B+ supply is used to adjust the potential on the plate of triode 7 and hence to adjust the output signal of the oscillator.

The radio frequency output of oscillator 1 is taken off across inductor 8 and fed through a lead 14 to the monitoring head 2. The signal is then transmitted through the monitoring head and is directly coupled by lead 15 to the control grid of a triode 16 in the electronic indicator 3. A resistor 17 is connected as a grid leak between the control grid of triode 16 and ground. The plate to cathode voltage of triode 16 is controlled by a three terminal variable resistor 18 connected between the B+ supply, the cathode of triode 16 and ground. A terminal 18a is connected to the positive terminal of the B+ supply, a second terminal 18b is connected to ground, and the sliding contact 18c is connected to the cathode of triode 16. A capacitor 19 provides

a radio frequency bypass for the plate of triode 16 to ground, and a capacitor 20 provides a radio frequency bypass for the cathode of triode 16 to ground. There is an ammeter 21 in the plate circuit of triode 16 which deflects proportionately to the direct current in triode 16.

The monitoring head 2 is of a construction dependent upon the application of the instrument. In Fig. 2 there are shown two of the many configurations of monitor head used for various applications.

Fig. 2a is an underside view of a type of monitor head such as shown in cross section in Fig. 4 suitable for use in the monitoring of a material such as paper or cloth passing over the surface of the monitor head.

Fig. 2b is a cylindrical type of monitor head having an insulating cylinder 24a and spaced circumferential metallic strips 22a and 23a, and suitable for use in the monitoring of small objects such as spools of twine which may be placed within the cylinder 24a.

The monitoring head 2 shown in Fig. 1 consists of a pair of metallic strips 22 and 23 separated from one another and fastened to a flat support 24. This support serves both as the dielectric of a pair of capacitances which appear between strips 22 and 23 and material 4, and also as the member upon which material 4 rests while being monitored.

Preferably, the support 24 has good dielectric properties and is non-hygroscopic in nature, which prevents the moisture in the monitored material from affecting the performance of the instrument. It has been found that for the type head shown in Fig. 2a, and in Fig. 1, a sheet of polystyrene exhibits the previously mentioned characteristics.

The operation of this circuit may best be understood by reference to Fig. 3 in which oscillator 1 feeds a radio frequency signal through monitoring head 2 to electronic indicator 3. In this figure the oscillator is represented by the block 1, the aperiodic indicator is represented by the block 3, and the monitoring head is represented by the block 2 in which is its electrical equivalent circuit. A capacitor 25 and a capacitor 26 represent the capacitance between plate 22 and material 4 in Fig. 1 and the capacitance between plate 23 and the material 4 in Fig. 1 respectively. A resistance 27 is the resistance of material 4 between plate 22 and plate 23 and a capacitor 28 represents the residual capacitance between plates 22 and 23. Oscillator 1, which produces the radio frequency signal, is coupled to the electronic indicator through the monitoring head, or more specifically, through the network consisting of capacitors 25, 26 and 28 and resistor 27.

As the moisture content of the material being monitored increases, the capacitances 25 and 26 increase and resistance 27 decreases. Therefore, the amount of energy reaching indicator 3 from oscillator 1 increases proportionately to the amount of moisture in the material.

Referring once more to Fig. 1, this circuit is an embodiment of my invention to be used in the monitoring of a material which is, at the monitor head, effectively isolated from ground.

I have shown a particular type head which finds application in the monitoring of the moisture content of paper during its process of manufacture. It should be understood, however, that by so doing I do not intend to limit my invention to any one type of monitor head. In

fact, a major advantage of this circuit over the prior art type is that the monitoring head is readily replaceable by a more suitable one when a situation arises which suggests such a change.

The output power of oscillator 1 is controlled by resistor 13. The radio frequency output of oscillator 1 is taken off across inductor 8 and fed to strip 22 of the monitor head. The signal then passes through material 4 to strip 23 and on to indicator 3 where it produces a voltage across resistor 17.

When a change in the moisture content of material 4 occurs, the current through monitor head 2 changes by a corresponding amount. Resistor 17 has a high ohmic resistance such that a small increment of moisture variation in head 2 effects a large increment of voltage variation on the control grid of triode 16. This voltage change on the control grid varies the current in triode 16 and thus causes ammeter 21 to indicate a different value. Hence, a small change in the moisture content of material 4 results in a large change in the deflection of ammeter 21.

The face of ammeter 21 is shown in Fig. 4. There is an arc 29 indicated on the face of the dial over which length the pointer may wander while the moisture content of the monitored material is within specified limits. If, however, the pointer does not indicate a value of deflection within this arc, the operator knows that the amount of moisture in the material is out of limits.

Variable resistor 18 is used to compensate for effects caused by the residual capacitance which appears between strips 22 and 23. This residual capacitance does remain substantially constant for any one configuration of monitoring head. When, however, the head is replaced, it is necessary to compensate for the change in this residual capacitance, and adjustable resistor 18 provides such compensation.

To operate this device as a moisture contents monitor, a piece of material to be monitored which has a moisture content within the desired limits is placed on the monitor head and variable resistor 13 is adjusted until the output of oscillator 2 is such as to cause ammeter 21 to indicate a value within the previously mentioned arc. The limits of this arc are similarly determined.

If the monitor head is to be used for monitoring a different material, the value of the resistor 18 is again adjusted until ammeter 21 reads within the arc.

To facilitate operation of the instrument, a knob is affixed to the adjustable arm of resistor 13 and a scale is so placed that positions of the knob and thence, resistance of resistor 13, may be read directly on the scale. Therefore, with the meter indicating within limits, one position of the knob with respect to the scale corresponds to one value of resistance of resistor 13, and consequently, to one value of moisture content of one material. The positions of the knob may be charted against the material and moisture content which they represent, and thus it becomes unnecessary to calibrate the instrument whenever the material being monitored is changed.

Although I have shown electronic indicator 3 to be an aperiodic voltmeter, any suitable aperiodic radio frequency indicator will suffice. One such device is an amplifier followed by a rectifier stage, the output of which is proportional

to the input. Such a device will, of course, greatly increase the sensitivity of this instrument.

Because an aperiodic indicator is used in my invention, small changes in the operating frequency of oscillator 1 do not affect a change in the indication of ammeter 21. Thus, the use of an expensive stable oscillator is unnecessary and the cost of the instrument is materially reduced.

In many applications, however, the material under test may not be isolated from ground; in which case a modification of the circuit provides more satisfactory operation. This is because the resistance between the monitored material and ground will load down the oscillator by paralleling output inductor 8, and it will likewise effect the indicator by paralleling resistor 17.

Accordingly, in Fig. 5, I have shown an embodiment of my invention whereby a material which is short-circuited to ground may be monitored as to its moisture content.

An electronic indicator 30 of this circuit is substantially the same as the electronic indicator 3 of Fig. 1 and a radio frequency oscillator 31 is also the same as oscillator 1 in Fig. 1. The coupling from the oscillator 31 to a monitoring head 32 and to indicator 30 is different, however. A conductor 33 of monitoring head 32 is grounded and the other conductor 34 is inductively coupled to oscillator 31 through a transformer 35. Conductor 33 is preferably constructed to surround conductor 34, as shown, in order to minimize stray capacitance effects from conductor 34 to ground.

A grid leak resistor 36 in indicator 30 is connected from one terminal of the secondary winding 37 of transformer 35 to ground. The other terminal of winding 37 is connected to conductor 34 of monitor head 32. Thus, resistor 36, winding 37 and monitor head 32 form a series circuit, whereby the change current in this circuit is proportional to the change in impedance of the monitor head.

A change in capacitance and resistance between plates 33 and 34 causes a change in the current in winding 37, resistor 36, and monitor head 32. This change in current produces a change in voltage across resistor 36, and hence, changes the potential on the control grid of a triode 38 in electronic indicator 30. Consequently, the current in triode 38 and in an ammeter 39, which is in the plate circuit of triode 38, changes proportionately.

The indication of meter 39 is thus proportional to the change in impedance of monitor head 32, and as previously described, proportional to the moisture content of a material brought into close proximity with the monitor head. Because plate 33 is grounded, any admittance to ground of a monitored material is short circuited to ground, and therefore, this admittance has no effect on the operation of the instrument.

A voltage regulator tube 40 is used in this circuit to stabilize the plate supply voltage for both radio frequency oscillator 31 and for electronic indicator 30. This constant voltage assures a constant output from oscillator 31 and a constant indication of meter 39 for a constant impedance of monitor head 32. The sensitivity of the instrument is thereby increased because changes in line voltage do not affect its indication.

While I have shown a particular circuit designed to operate in accordance with my invention, it will be understood that this is by way of

illustration of the principles involved and that those skilled in the art may make many modifications in the arrangement and mode of operation. Therefore, I contemplate by the appended claims to cover any such modifications as fall within the true spirit and scope of this invention.

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

1. A device for measuring moisture content of a material comprising in combination an oscillator including a high vacuum electron discharge device having an anode, a cathode and a control electrode, a source of direct voltage, a variable resistor connected between the positive terminal of said potential source and said anode, an inductor and a first capacitor connected in parallel, a second capacitor and a resistance connected in parallel and connected between one terminal of said first capacitor and said control electrode, a third capacitor connected between said anode and the negative terminal of said potential source, said cathode being connected to a tap on said inductor, an electronic indicator comprising an electronic valve having an anode, a cathode and a control electrode, a resistor connected between said control electrode of said valve and ground, a three terminal variable resistor having one terminal connected to the positive terminal of said potential source, another terminal connected to said cathode, and the third terminal connected to ground, an ammeter connected between said anode of said valve and the positive terminal of said potential source, a capacitor connected between said anode of said valve and ground, and a capacitor connected between said cathode and ground; and a monitoring head comprising a sheet of insulating material having non-hygroscopic characteristics, a pair of metallic conductors electrically separated and mounted on said sheet with said monitor head being electrically coupled to said electronic indicator and to said oscillator to cause an ammeter to provide an indication of the moisture content of a sample of material brought into close proximity with said monitoring head.

2. A device for measuring moisture content of a material comprising an oscillator for producing a radio frequency signal, an aperiodic electronic indicator for indicating the magnitude of a radio frequency voltage supplied to its input circuit, and a monitor head having a pair of spaced metallic conductors mounted on one face of a dielectric sheet having substantially non-hygroscopic characteristic, one conductor being connected to said oscillator to receive said signal and the other conductor being connected to the input circuit of said indicator whereby said signal is capacitively coupled to said indicator through a material brought into proximity with an opposite face of said sheet and is responsive to moisture content of the material.

HALSEY W. KLINE.

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