

[54] **METHOD AND APPARATUS FOR
DETERMINING MOISTURE CONTENT OF
TOBACCO**

[75] Inventor: **James O. Pullman**, Chapel Hill,
N.C.
[73] Assignee: **Liggett & Myers Incorporated**, New
York, N.Y.
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[58] Field of Search **324/65 R, 57 R**

[56] **References Cited**

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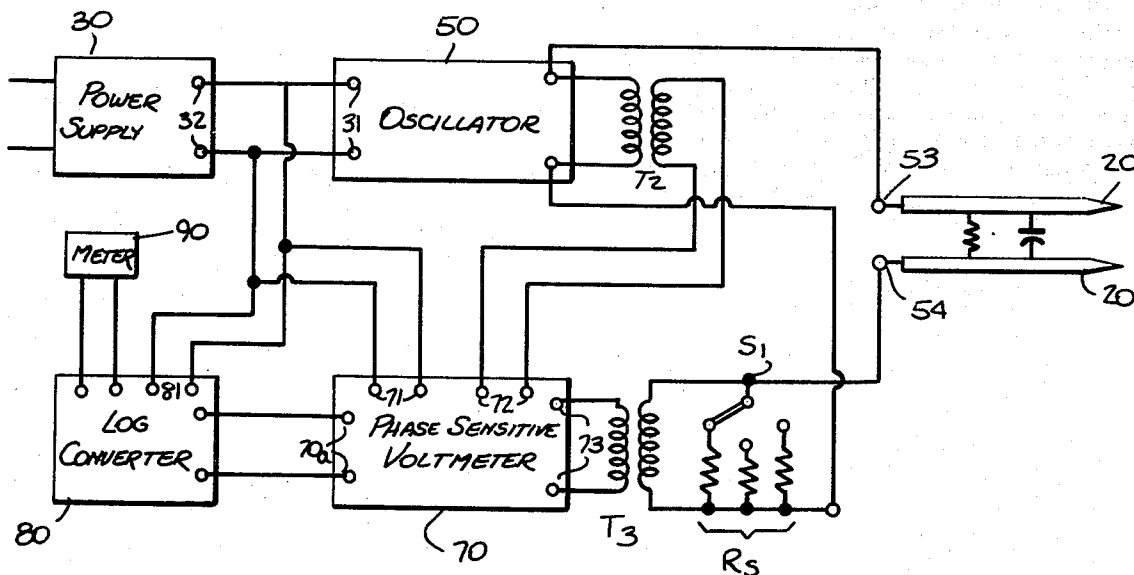
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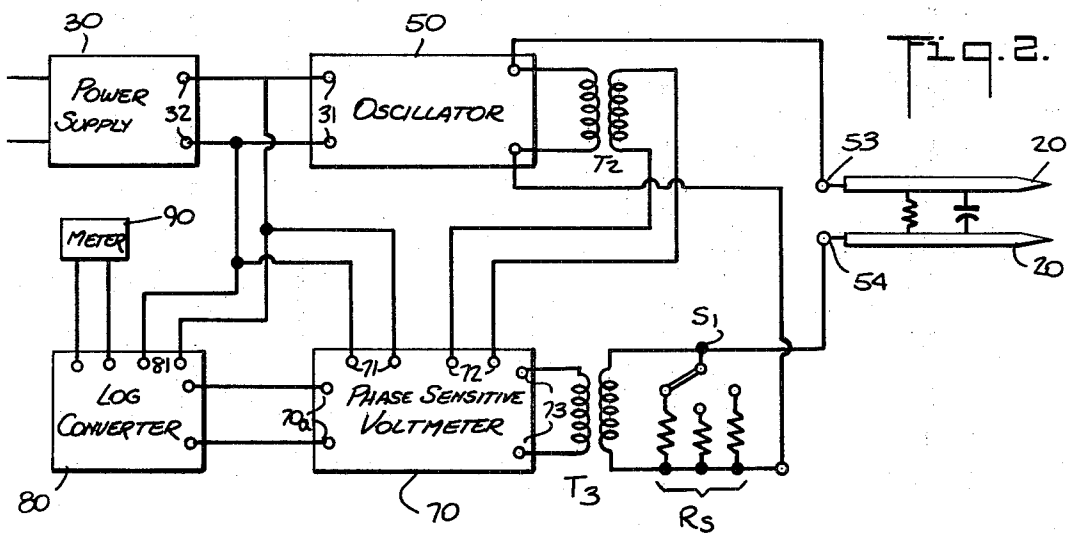
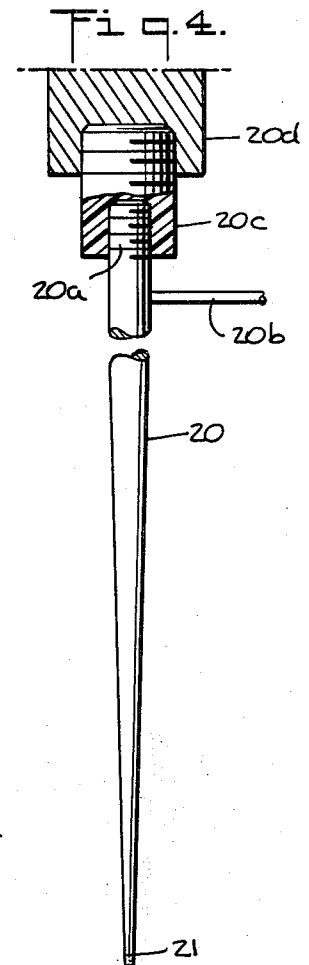
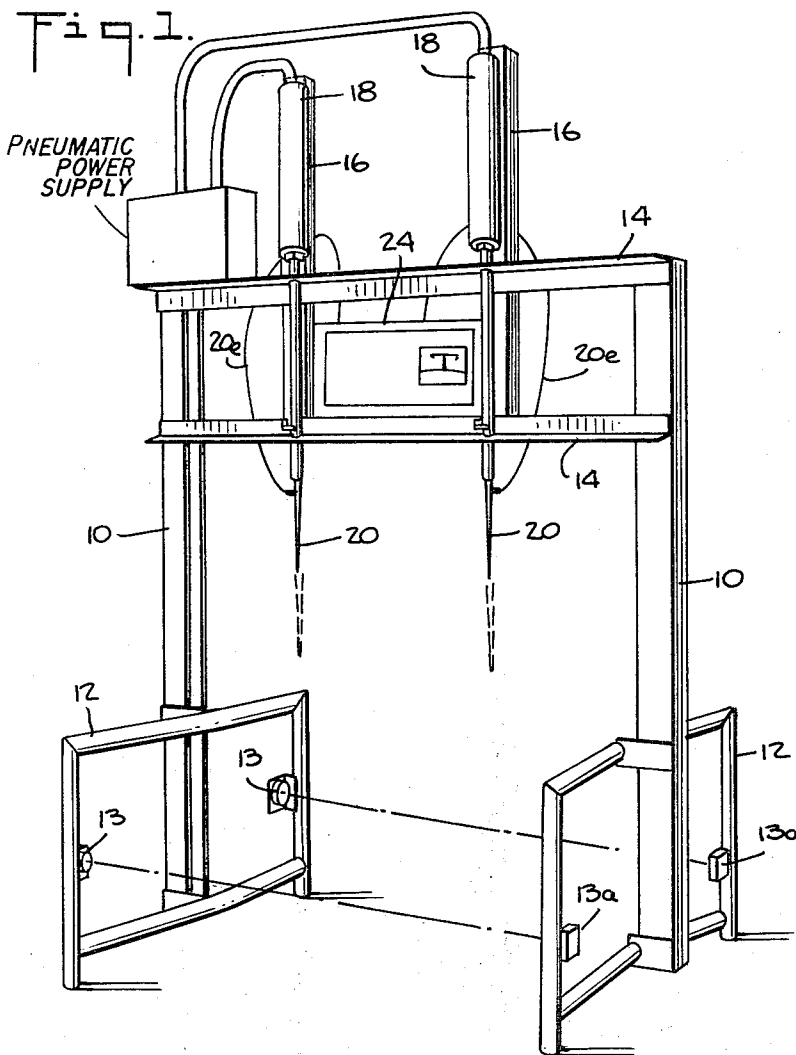
Primary Examiner—Stanley T. Krawczewicz
Attorney—Edward W. Greason et al.

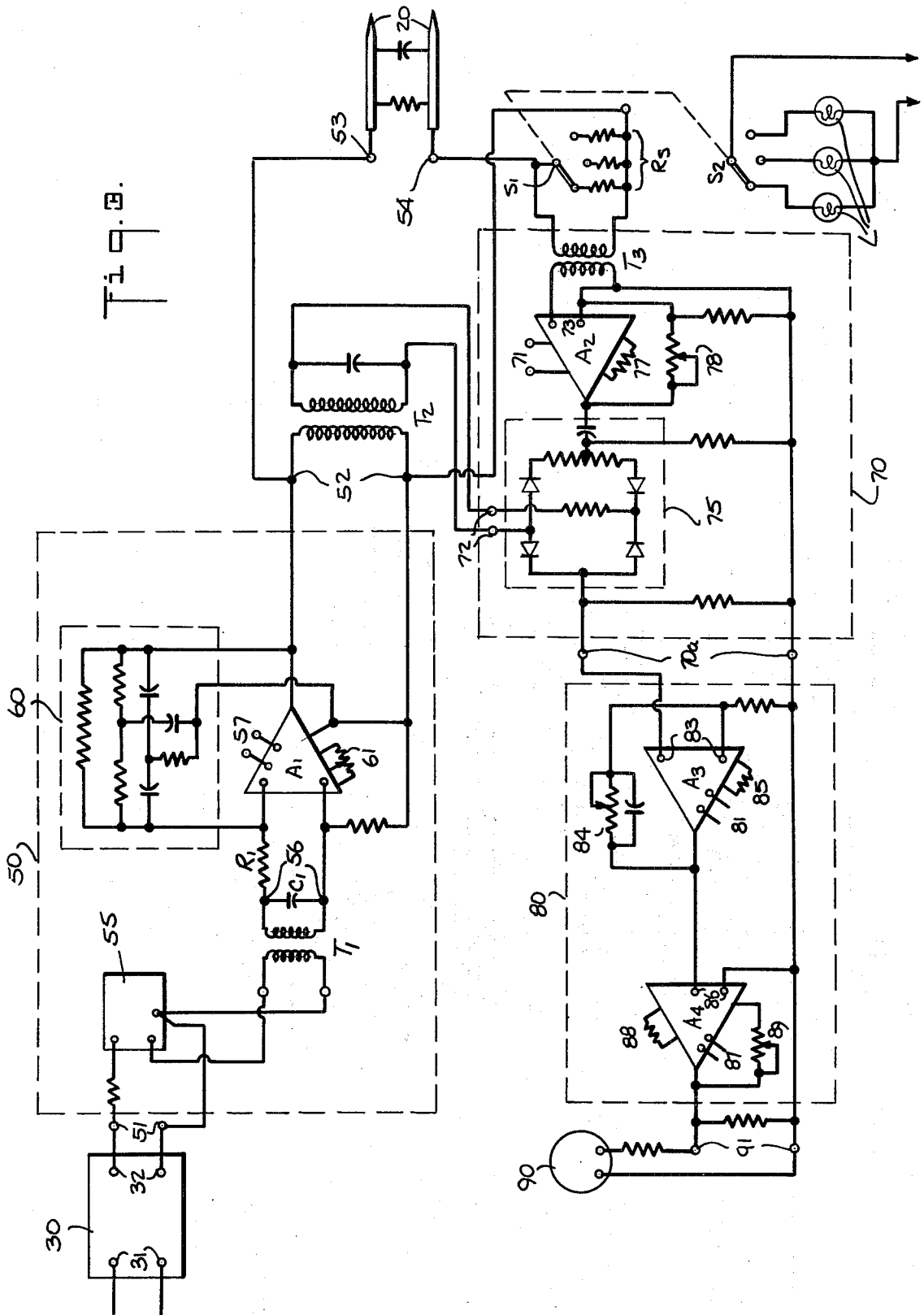
[57] **ABSTRACT**

A method and apparatus for determining the moisture content of freshly prized remoistened tobacco compressed into hogs-heads. An alternating voltage is applied to a pair of electrodes connected in a circuit and thrust into the hog'shead. A phase sensitive voltmeter connected to the electrode circuit measures the component of the current in that circuit which is in phase with the alternating voltage, and hence the resistive component of the impedance between the electrodes. A logarithmic converter transforms this resistive component into a signal varying linearly with moisture content.

15 Claims, 4 Drawing Figures







METHOD AND APPARATUS FOR DETERMINING MOISTURE CONTENT OF TOBACCO

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to methods and apparatus for determining the moisture content of tobacco in hogsheads, particularly the moisture content of freshly prized tobacco which has been recently remoistened.

2. Description of the Prior Art

In the process of curing tobacco, an important step includes a procedure known as "remoistening." Tobacco having a moisture content of approximately 20 percent is dried to a moisture level of about 4 to 7 percent and subsequently moisture, in the form of steam or water, is added, in order to bring the moisture content up to approximately 10 to 12 percent. This remoistened tobacco is then compressed and sealed into wooden containers known as "hogsheads." The tobacco in the hogsheads is then removed to a storage area, for aging, during which time curing effects take place.

It is important that the moisture increase in the tobacco resultant on remoistening be accurately known and controlled. If the moisture content of the tobacco is insufficient after remoistening, the subsequent aging process takes much longer than it would if the moisture level were in the prescribed 10 to 12 percent range. On the other hand, if too much moisture is injected into the tobacco immediately prior to aging, the tobacco can spoil and become useless.

Many different methods and devices have been used in the past to accurately measure the moisture level of tobacco in hogsheads. One such method is moisture testing by hand, which is done by a trained and experienced sampler who, within limits, can gauge the moisture of the tobacco simply by its "feel." Besides requiring an individual with long experience in this art, this method has not been completely satisfactory, because even the most skilled sampler cannot always detect the moisture level of tobacco with sufficient accuracy.

Another method of testing moisture content is by removing a sample of tobacco from the hogshead, weighing it, and subsequently drying and reweighing the sample. This method can be quite accurate, but requires approximately 20 minutes for each test. Because tobacco is remoistened on a continuous basis, the time required for this type of testing is excessive. It is necessary to maintain an almost continuous sampling of the moisture content of tobacco hogsheads, in order that the information thereby obtained may be fed back to the remoistening machines, so that continual adjustment in the amount of moisture injected into the tobacco can be made as needed.

This need has led to the use of various electronic instruments which can make relatively fast moisture determinations, without the need for a highly skilled and experienced operator. One of these electronic techniques involves passing microwave energy through samples of the tobacco, and measuring the microwave energy loss occurring as the waves pass through the tobacco.

Another method has been to place samples of the tobacco between the plates of a capacitor, and to subsequently measure the dielectric constant of the tobacco.

Both of these two latter techniques have proved to be unsatisfactory in measuring moisture content of freshly

prized tobacco. (The tobacco, immediately after remoistening, and compressing into a hogshead, is referred to as "freshly prized"). The reason for this is related to a problem which is uniquely associated with measuring the moisture content of remoistened tobacco shortly after the remoistening process.

This problem is accountable to two factors. First, the freshly prized tobacco is not, at first, uniformly moistened. It takes a certain amount of time, for "equilibration" of the moisture throughout the tobacco to take place. Secondly, and more importantly, it is known that, when moisture is added to tobacco, it remains in a free state for a period of time, and subsequently gradually becomes "bonded" i.e., molecularly bound, to the tobacco itself.

It is further known that, as this binding takes place, the dielectric constant of the tobacco decreases, and so does the ability of the tobacco to attenuate microwaves passing through it. Therefore, it can be seen that moisture readings taken by instruments which measure dielectric constant or microwave loss in the tobacco will vary according to the amount of time elapsed since the remoistening process and according to the relative fraction of the total moisture which is freshly applied. This phenomenon will take place notwithstanding the fact that the moisture content remains relatively stable throughout the "bonding" period. It can thus be seen that the electronic techniques discussed here, while they might be quite satisfactory for use with "equilibrated" tobacco, are not suitable for freshly prized tobacco, due to the bonding process, and the variations it induces in moisture measurements made with the instruments.

It is also noteworthy that the hand sampling and oven drying methods and apparatus for measuring moisture in freshly prized tobacco involve the necessity for removing a sample of the tobacco from the hogsheads and placing it in some sort of test cell for the actual measurement. This requires more effort and time than would be the case if a measurement could be made of the entire tobacco sample within a hogshead, without the necessity for removing any of the tobacco therefrom.

Another type of moisture detector is disclosed in the May, 1946, issue of "Electronics" magazine, on page 180, by John H. Jupe. This detector includes a test cell into which a sample of material to be evaluated is placed, the cell having electrodes attached to an AC voltage source. An alternating voltage is applied across the test cell, and a voltmeter is provided to measure the alternating current in the electrode circuit which bears a predetermined phase relationship to the main supply. This apparatus, however, when adjusted to the manner recommended in the article, is unsuitable for measuring the moisture content of freshly prized tobacco in a hogshead, and the article reveals no appreciation of the problems of such measurement.

Moisture has also been measured by simply testing DC resistivity. This method is subject to substantial inaccuracies, due to effects of electrolytic polarization and other factors.

It is therefore an important purpose of this invention to provide a moisture detector for freshly prized tobacco which is responsive to the total moisture content of the tobacco, without regard to the fraction of that moisture which may be bonded to the tobacco.

It is a further purpose of this invention to provide a moisture detector for freshly prized tobacco which is operable by an individual not having the benefit of extensive experience in determination of tobacco moisture content.

It is another purpose of this invention to provide a moisture detector for freshly prized tobacco which enables very rapid determination of moisture content of the tobacco.

It is a still further purpose of this invention to provide a moisture detector for freshly prized tobacco which is capable of making moisture measurement on entire hogsheads of tobacco without the necessity for removing samples of the tobacco from the hogsheads.

BRIEF SUMMARY OF THE INVENTION

This invention includes driving a pair of electrodes through a wall of a tobacco hogshead, and applying a 1 KHz alternating voltage across the electrodes. The alternating current thus impressed between the electrodes is input to a phase-sensitive voltmeter which compares the current in the electrode circuit with a reference voltage which is taken from the AC voltage source. The phase-sensitive voltmeter is designed to provide an output which is proportional to the magnitude of the component of the alternating current in the electrode circuit which is in phase with the alternating voltage. This output is fed into a logarithmic converter which produces a signal in proportion to the log of the input from the voltmeter, which signal varies in magnitude in linear proportion to the moisture content of the tobacco between the electrodes.

It is noteworthy that the electrodes are constructed in the form of elongated probes, and are made of a relatively tough material, so that they are susceptible of being forced through the walls of the tobacco hogshead. A pneumatic system is provided in order to selectively force the probes through the hogshead.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of the moisture determining apparatus of this invention, showing the electrode probes in phantom lines in their extended positions.

FIG. 2 is a block diagram of the moisture detector of this invention.

FIG. 3 is a detailed schematic drawing of the electronic circuitry of the moisture detector of this invention.

FIG. 4 is an elevation view of the electrode probes comprising the moisture detector of this invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. 1, the basic mechanical structure of the apparatus of this invention includes upright support columns 10, to the base of which are attached guardrails 12. Crossbars 14 extend between the upper ends of support columns members 10. Attached to crossbars 14 are vertical cylinder supports 16. Pneumatic cylinders 18 are fastened in a vertical fashion to cylinder supports 16, and electrodes 20 are attached to the pistons of cylinders 18. The electronic components of this apparatus are contained within box 24, which is fixed to crossbars 14.

Photocells 13 and light sources 13a are mounted on guardrails 12 and function to direct a light beam across the assembly, the interruption of which indicates when

a hogshead of tobacco is properly positioned for insertion of the electrode probes 20 into the hogshead.

Pneumatic cylinders having pistons 18 are driven by a pneumatic pressure system of a known type, which is not shown. Upon actuation of the pneumatic system, the pneumatic cylinders drive electrodes 20 through the wooden walls of the hogshead and into the tobacco.

Notwithstanding that this specification is directed primarily to piercing the walls of a wooden hogshead with the probes, it is contemplated that this device has analogous utility when employed to detect the moisture level of freshly re-moistened tobacco in open containers, such as bins, not requiring any piercing of the container walls in order to reach the tobacco with the probes.

Referring to FIG. 4, it can be seen that the electrode probes 20 have a generally elongated rod-like configuration, tapering toward the lower ends thereof, at 21. Electrodes 20 are secured to the pistons of pneumatic cylinders 18 in such a way that contact 20b, which is electrically attached to probe 20, is insulated, along with probe 20 from the pneumatic system itself, to wit, the pneumatic cylinders. This is accomplished by means of nylon threaded bushing 20c, the threads of which engage and are screwed onto threads 20a at the top of each of probes 20. Threaded bushing 20c is then in turn screwed into member 20d which is fixed with respect to the pistons of pneumatic cylinder 18. In this way, the electrical contact 20b is fully insulated from all other portions of the apparatus except the probe 20 to which it is attached. Probes 20 are connected electrically to the electrical box 24 by means of flexible cables 20e.

Electrodes 20 are suitably made from a tough material, such as stainless steel. They are approximately 1 foot in length. Pneumatic cylinders 18, however, have a path of travel which is somewhat longer than 1 foot in order to insure that the entire length of the electrodes can be driven into the hogshead in which the tobacco to be evaluated is contained.

Referring now to FIG. 2, there is illustrated a block diagram of the electronic circuitry involved in the apparatus of this invention. Electrode probes 20 are shown having resistor R and capacitor C in parallel between them, these two elements representing schematically the complex impedance between the probes which is presented by the re-moistened tobacco located between them.

An alternating reference voltage is applied between electrode probes 20 by oscillator 50. This voltage is applied from terminals 52 located on oscillator 50 to terminals 53 and 54, as indicated in FIG. 2. The current generated by application of this reference voltage flows between electrode probe 20 and through one of the sampling resistors R_s, the particular one of the R_s resistors in the circuit being dictated by the position of switch S₁.

Also included in the circuitry is phase sensitive voltmeter 70, having first input 72 and second input 73. Phase sensitive voltmeter 70 produces at its output 70a a signal which is proportional to that component of the voltage presented to second input 73 which is in phase with the reference voltage input at first input 72. The reference voltage is input at 72 from terminals 52 by means of the voltage thereby generated across the secondary at transformer T₂. A voltage drop proportional to the current in the electrode probe circuit is im-

pressed on second input 73 by means of the voltage drop across the resistor R_e which is in the electrode probe circuit, which generates a voltage across the secondary of transformer T_3 . It can be seen that, if R_e is not excessively large, with respect to the value of R , the presence of R_e will not appreciably distort the current in the electrode probe circuit. It can also be seen that the voltage appearing at second input 73 will be approximately in phase with the alternating current in the electrode probe circuit.

Therefore, the output 70a of phase sensitive voltmeter 70 will have a magnitude which is directly proportional to that component of the alternating current in the electrode probe circuit which is in phase with the reference voltage applied at first input 72 from oscillator 50. This means, in effect, that the output from voltmeter 70 will be in approximate inverse proportion to the resistive component R of the complex impedance between electrodes 20, which resistive impedance indicates, by a logarithmic relation, the moisture content of the tobacco.

The resistive component R of the impedance in moisturized tobacco varies in approximate inverse logarithmic relation with respect to actual moisture content M of the tobacco, such that $M \propto 1/R$. Therefore, it is contemplated that logarithmic converter 80 can be employed to receive the output of voltmeter 70, and to itself produce an output which is proportional to the value of the logarithm of the magnitude of the said output of voltmeter 70.

The addition of logarithmic converter 80 thereby enables the obtaining of an output signal, which may be measured as at meter 90, which signal is linearly proportional to the actual moisture content of the tobacco.

Power for oscillator 50, voltmeter 70 and logarithmic converter 80 is provided, as is shown in FIG. 2, by power supply 30, which, by way of its output 32, supplies power to the aforementioned elements at terminals 51, 71, and 81, respectively. Power source 30 also supplies power to various internal components of these elements in a manner described below.

A better understanding of the electronic functioning of the apparatus of this invention may be had by referring to FIG. 3, which shows a detailed schematic drawing of the circuitry therein.

Power supply 30 is supplied with conventional 115 volt ac at its input 31, and produces its output at terminals 32. Applicant has found that a suitable power supply for this apparatus is a Burr Brown Dual Power Supply Model 501.

The oscillator circuitry is designated generally by the dotted line defining zone 50, and consists primarily of square wave oscillator 55, and a square to sine wave converter including amplifier A_1 and its attendant conversion and stabilization circuitry, designated within box 60, and as C_1 and R_1 . Square wave oscillator 55 is supplied with power at terminals 51 from output terminals 32 of power supply 30. Suitable hardware for the square wave oscillator may be a Fork oscillator, type G, manufactured by Fork Standards, Inc. The output from square wave generator 55 is input to the primary winding of transformer T_1 .

The secondary windings of transformer T_1 are connected to input terminals 56 of convertor amplifier A_1 . Square wave conversion and stabilization circuitry, indicated within box 60 and as capacitor C_1 and resistor R_1 , operate in conjunction with amplifier A_1 to produce

an output at terminals 52 which is approximately a sinusoid having the same frequency as square wave oscillator 55. This frequency, as noted hereinabove may satisfactorily be 1,000 Hz. Amplifier A_1 is provided with power from output terminal 32 of power supply 30 at terminals 57. For simplicity, the connection between terminals 32 and 57 is not shown. Also, amplifier A_1 is provided with balance circuitry indicated at 61. Amplifier A_1 may suitably be a Burr Brown Model 3241.

It is understood that oscillator 50 need not have the specific circuitry described herein, but can be any constant voltage oscillator capable of producing a sine wave of any frequency appropriate for the measurement contemplated, at a suitable energy level.

The output of oscillator circuitry 50 is input at terminals 52 to the primary windings of transformer T_2 . The output of the secondary windings of transformer T_2 is connected to terminals 72, the first input of phase sensitive voltmeter 70, which first input is connected to phase detector circuitry 75, as indicated in the box bearing that designation. The voltage at oscillator output 52 is also connected to electrode probes 20 to form the electrode circuit. Connection is made to one of the probes between the uppermost of terminals 52 and terminal 53. The other probe is connected to the lower terminal 52 through the one of resistors R_e which is connected in series with the electrode probe circuit, by way of terminal point 54.

The operator of this apparatus may select which of resistors R_e he desires to insert into the electrode probe circuit by appropriate positioning of switch S_1 . The particular one of resistors R_e which is in the circuit is indicated by the illumination of one of the lamps L which are connected to an independently supplied AC circuit. Switch S_2 being ganged with switch S_1 , determines which of lamps L is lighted, in accordance with which resistor is in the electrode circuit.

The reason for provision of a choice of resistors R_e of varying value is to permit measurement of a wide range of moisture levels and testing of different tobaccos, which may vary in impedance from one type to another, although moisture content is the same. Applicant has found that suitable values of resistors R_e are 10, 100, and 1,000 ohms, respectively, enabling measurement of impedance in the respective ranges of 10^2 - 10^3 , 10^3 - 10^4 , and 10^4 - 10^5 ohms.

The voltage drop across the one of the resistors R_e which is in the electrode probe circuit, which voltage drop is of course, generated by the alternating current flowing in that circuit, is impressed on the primary windings of transformer T_3 . Transformer T_3 , amplifier A_2 and phase detector circuitry 75 are the principle components of phase sensitive voltmeter 70, indicated within the dotted lines in FIG. 3.

Detector amplifier A_2 is provided with power from output 32 of power supply 30 through terminals 71, the actual connections being omitted here for simplicity. The output of the secondary windings of transformer T_3 is input at terminals 73 of amplifier A_2 . Amplifier A_2 , which has been found to be suitably provided by a Burr Brown Model 3308 amplifier, is provided with associated balance circuitry 77 and gain control circuitry 78. The output of amplifier A_2 is input to phase detector circuitry 75.

The output of phase sensitive voltmeter 70, which appears at terminal 70a, is proportional to that component of current flowing in the electrode circuit (as

sensed by the voltage drop across R_s) which is in phase with the reference voltage output of transformer T_2 which is input to voltmeter 70 by way of first input terminals 72.

Thus, the output of voltmeter 70 will be inversely proportional to the value of the resistive component of the complex impedance between electrode probes 20.

The resistive component of the complex impedance of freshly re-moistened tobacco is related to the moisture content of the tobacco by an approximate inverse logarithmic function. Therefore, it can be seen that if the output of voltmeter 70 is converted such that an output is obtained which is proportional to the value of the logarithm of the output of voltmeter 70, then a signal is obtained which is linearly related to the actual moisture content of the tobacco.

This function is provided by the inclusion of logarithmic converter 80, indicated within the dotted lines on FIG. 3. Converter 80 consists primarily of drive amplifier A_3 and linear-to-log-amplifier A_4 , which are connected in series, as shown in FIG. 3. Amplifiers A_3 and A_4 are supplied with power from output terminals 32 of power supply 30 via terminals 81 and 87, respectively. Gain control is provided for amplifiers A_3 and A_4 by means of gain control elements 84 and 89, respectively, and balance resistors 85 and 88.

Applicant has found that suitable amplifiers for supplying drive amplifier A_3 and linear-to-log-amplifier A_4 are Burr Brown Models 3241 and 4007, respectively.

Functionally speaking, output 70a is applied to input terminal 83 of drive amplifier A_3 . The signal is amplified and passed in series to inputs 86 of linear-to-log-amplifier A_4 , where it is converted to a logarithmic function of the signal at output 70a of voltmeter 70. The output of the log converter ranges in logarithmic fashion relative to the input thereto, from a relatively large positive output when the input from the phase sensitive voltmeter is near zero, to a relatively large negative output when the input has a relatively high positive value.

The output of converter 80, appearing at terminals 91, is thus a linear function of the moisture content of the tobacco sampled between electrode probes 20. Because resistance R of the complex impedance of the tobacco is reduced as the moisture content thereof increases, the co-efficient of linearity between the signal at output 91 and the actual moisture content will be negative. An ammeter 90 may be provided to receive the signal at terminal 91 in order to indicate its value. Ammeter 90 is of a type which yields left-hand deflections for negative voltages and right-hand deflections for positive voltages. Ideally, the ammeter can be caused to show upward (right-hand) deflections corresponding to high moisture content (negative outputs of the log converter) by connecting it "backward" to the log converter, so that maximum positive voltage (low moisture) gives a full left deflection.

This apparatus can be calibrated for varying moisture levels of tobacco, by simply taking measurements of a number of tobacco samples, noting the meter deflections which are obtained in those measurements, and determining the precise moisture content of each of the samples by means of conventional, analytical methods, such as the oven drying process described hereinabove. Applicant believes that the method and apparatus taught in this application has solved a longstanding problem in the measurement of moisture levels on

freshly re-moistened tobacco, which problem has been peculiar to measurement of such levels in the past.

For a very long time, tobacco processors have had difficulty in determining moisture content of freshly re-moistened tobacco. To Applicant's knowledge, and based on his extensive tests, no previous attempts to test moisture levels in such tobacco have been able to avoid the deceptive influence of moisture progressively bonding to the tobacco. Only this invention has been able to accomplish this purpose. The apparatus and method of this invention avoid almost entirely the influence of the degree of such bonding on moisture readings.

It is to be understood that these disclosures are illustrative only, and that one of ordinary skill in this art could modify, alter, or depart from the specific embodiments taught without deviating from the spirit of this invention.

What is claimed is:

1. A method for determining the moisture content of freshly re-moisturized tobacco, comprising the steps of:
 - a. placing a quantity of said tobacco in a container,
 - b. inserting a pair of separated electrodes connected in a circuit into the tobacco, said circuit partially comprising said tobacco,
 - c. applying a reference alternating voltage to said electrodes through said circuit to thereby generate an alternating current in said circuit, said alternating current passing through said tobacco,
 - d. measuring the relative magnitude of that component of said alternating current which is in phase with said reference alternating voltage by means of a phase-sensitive voltmeter,
 - e. placing other quantities of tobacco separately into said container, each of said other quantities being equal to said quantity, each of said other quantities having a known moisture content, each of said moisture contents being different,
 - f. repeating steps (b) through (d) on each of said other quantities of tobacco, and
 - g. determining from the measurements of steps (e) and (f) the relation between the magnitude of in-phase alternating current measured in said quantity of tobacco and the moisture content thereof, and
 - h. determining from said relation of step (g) the moisture content of said quantity of tobacco.
2. The method of claim 1, in which the tobacco is compressed in a hogshead and said electrodes have an elongated rod configuration, in which:
 - the step of inserting the electrodes into the tobacco comprises forcing the electrodes through the walls of the hogshead.
3. The method of claim 1, in which the step of applying an alternating voltage comprises:
 - applying an alternating voltage having a frequency of 1 KHz.
4. The method of claim 1, in which step (d) comprises:
 - a. passing said alternating current through a resistor
 - b. applying the voltage drop across said resistor to a second input of a phase sensitive voltmeter, said voltmeter having first and second voltage inputs and being capable of producing an output proportional to the magnitude of the component of the voltage across said second input which is in phase with the voltage across said first input,

- c. applying said alternating reference voltage to said first input of said phase sensitive voltmeter, and
- d. measuring at the output of said phase sensitive voltmeter the magnitude of the component of said voltage drop which is in phase with said reference alternating voltage. 5
- 5. The method of claim 1, in which step (d) comprises:
 - a. passing said alternating current through a resistor
 - b. applying the voltage drop across said resistor to a second input of a phase sensitive voltmeter, said voltmeter having first and second voltage inputs and being capable of producing an output proportional to the magnitude of the component of the voltage across said second input which is in phase with the voltage across said first input 10 15
 - c. applying said alternating reference voltage to said first input of said phase sensitive voltmeter, and
 - d. measuring at the output of said phase sensitive voltmeter the magnitude of the component of said voltage drop which is in phase with said reference alternative voltage 20
 - e. applying said output of said voltmeter to a logarithmic converter which produces an output proportional to the logarithm of the output of said voltmeter, so that the output of said converter is proportional to the moisture content of the tobacco. 25
- 6. The method of claim 1, in which step (a) comprises:
 - placing the tobacco in a hogshead and positioning the hogshead beneath said electrodes, for insertion of said electrodes into said tobacco. 30
- 7. Apparatus for measuring the moisture content of freshly prized tobacco comprising:
 - a. a frame 35
 - b. a pair of electrodes connected in a circuit and movably mounted to said frame for selective insertion into the tobacco,
 - c. power means connected to said circuit for applying an alternating voltage between said electrodes to generate an alternating current in said circuit, 40
 - d. means connected to said power means to said circuit for measuring the magnitude of said alternating current which is in phase with said alternating voltage 45

whereby the relative magnitude of the resistive component of the impedance between said electrodes may be measured, and the moisture content of said tobacco may be determined by comparing the relative magnitude of said resistive component with the relative magnitude of the resistive component of the impedance between said electrodes when said electrodes are inserted into tobacco having a known moisture content. 50
- 8. The apparatus of claim 7, in which said measuring means comprises: 55
 - a. a resistor serially connected in said circuit, and
 - b. a phase sensitive voltmeter having
 - i. a first input connected to said power means to receive said alternating voltage,
 - ii. a second input connected across said resistor to apply the voltage drop of said alternating current across said resistor to said second input, and 60
 - iii. means for producing an output signal whose magnitude is proportional to the magnitude of the component of said voltage drop which is in phase with said alternating voltage. 65
- 9. The apparatus of claim 8, further comprising:

- a logarithmic converter having an input connected to the output of said phase-sensitive voltmeter for producing an output which is proportional to the logarithm of said output signal of said phase-sensitive voltmeter,
- whereby the output of said logarithmic converter is proportional to the moisture content of the tobacco.
- 10. The apparatus of claim 7, in which said electrodes have an elongated rod configuration.
- 11. The apparatus of claim 10, further comprising: means connected to said electrodes for forcing said electrodes into said tobacco, whereby said electrodes may be forced through the walls of a container into which the tobacco is placed.
- 12. The apparatus of claim 11, in which said forcing means comprises:
 - a. a pneumatic cylinder connected between said frame and said electrodes, and
 - b. pneumatic power means for actuating said pneumatic cylinder.
- 13. The apparatus of claim 7, in which: said power means comprises:
 - a. a square wave generator having its output connected to the input of a selective amplifier to convert said square waves to sine waves.
- 14. A method for determining the moisture content of freshly re-moisturized tobacco, comprising the steps of:
 - a. inserting a pair of electrodes connected in a circuit into the tobacco,
 - b. applying a reference alternating voltage to said electrodes through said circuit to generate an alternating current in said circuit,
 - c. determining the relative magnitude of the component of said alternating current which is in phase with said reference alternating voltage, said determination further comprising the steps of:
 - i. passing said alternating current through a resistor,
 - ii. applying the voltage drop across said resistor to a second input of a phase sensitive voltmeter, said voltmeter having first and second voltage inputs and being capable of producing an output proportional to the magnitude of the component of the voltage across said second input which is in phase with the voltage across said first input,
 - iii. applying said alternating reference voltage to said first input of said phase sensitive voltmeter, and
 - iv. measuring at the output of said phase sensitive voltmeter the magnitude of the component of said voltage drop which is in phase with said reference alternating voltage, and
 - d. comparing said relative magnitude of said in-phase component of said alternating current with the in-phase magnitude of said alternating current when said electrodes are inserted into tobacco having a known moisture content.
- 15. A method for determining the moisture content of freshly re-moisturized tobacco, comprising the steps of:
 - a. inserting a pair of electrodes connected in a circuit into the tobacco,
 - b. applying a reference alternating voltage to said electrodes through said circuit to generate an alternating current in said circuit,

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- c. determining the relative magnitude of the component of said alternating current which is in phase with said reference alternating voltage, said determination further comprising the steps of:
 - i. passing said alternating current through a resistor, 5
 - ii. applying the voltage drop across said resistor to a second input of a phase sensitive voltmeter, said voltmeter having first and second voltage inputs and being capable of producing an output proportional to the magnitude of the component of the voltage across said second input which is in phase with the voltage across said first input, 10
 - iii. applying said alternating reference voltage to said first input of said sensitive voltmeter, 15
 - iv. measuring at the output of said phase sensitive

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- voltmeter the magnitude of the component of said voltage drop which is in phase with said reference alternative voltage, and
- v. applying said output of said voltmeter to a logarithmic converter which produces an output proportional to the logarithm of the output of said voltmeter, so that the output of said converter is proportional to the moisture content of the tobacco, and
- d. comparing said relative magnitude of said in-phase component of said alternating current with the in-phase magnitude of said alternating current when said electrodes are inserted into tobacco having a known moisture content.

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