

June 9, 1936.

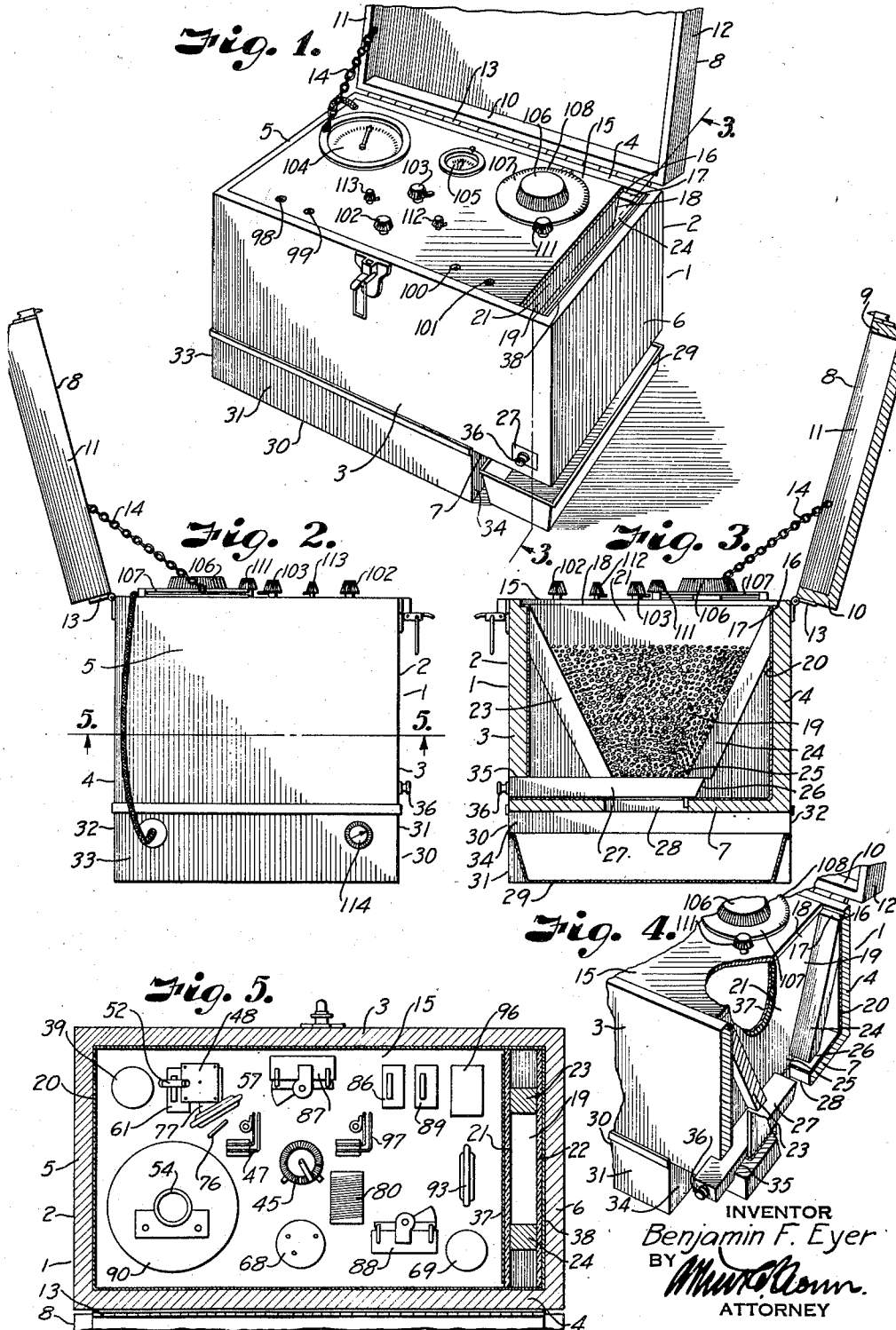
B. F. EYER

2,043,241

APPARATUS FOR DETERMINING THE MOISTURE CONTENT OF A MATERIAL

Filed Dec. 9, 1932

3 Sheets-Sheet 1



June 9, 1936.

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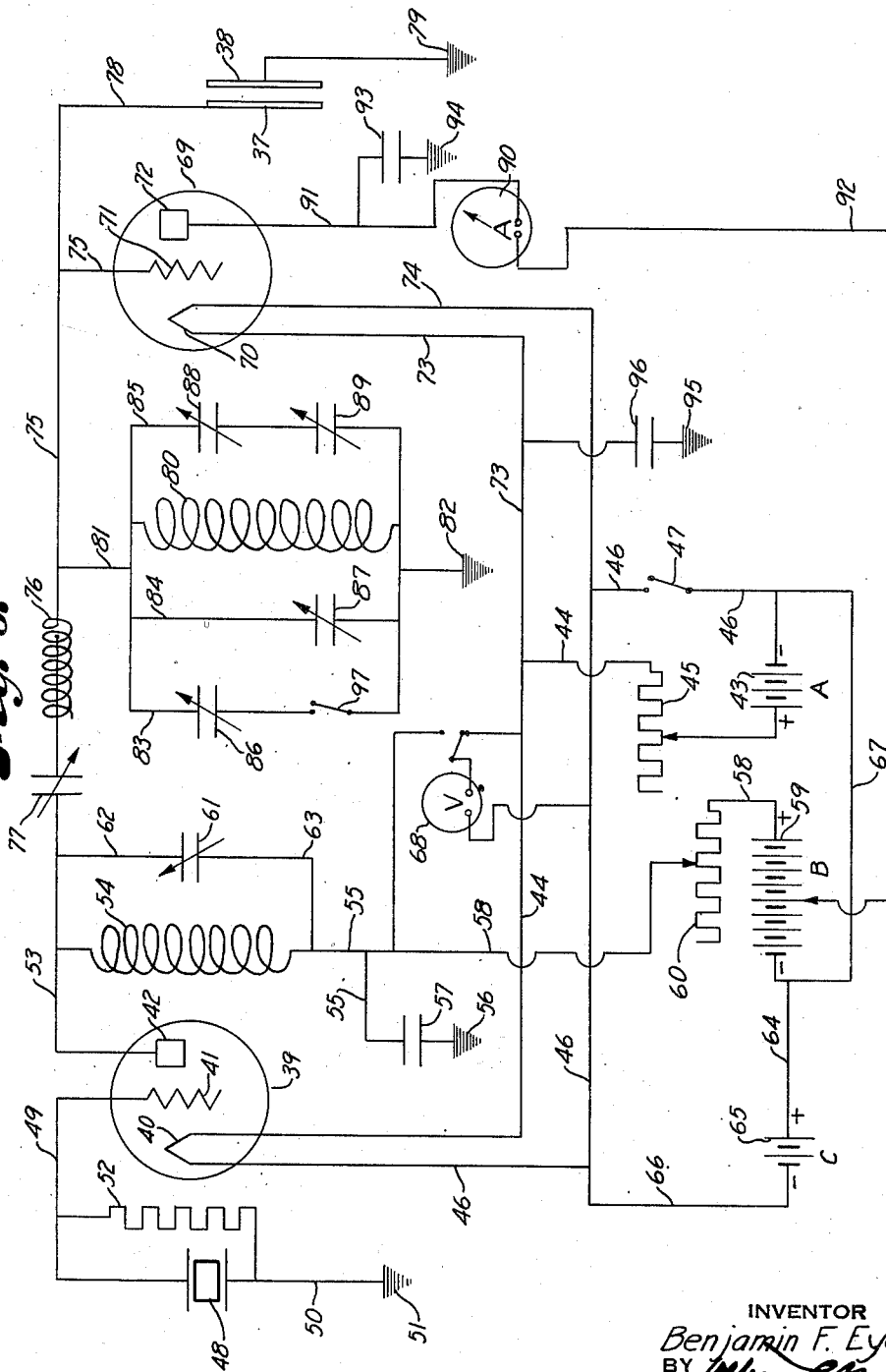
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Fig. 6.



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Fig. 7.

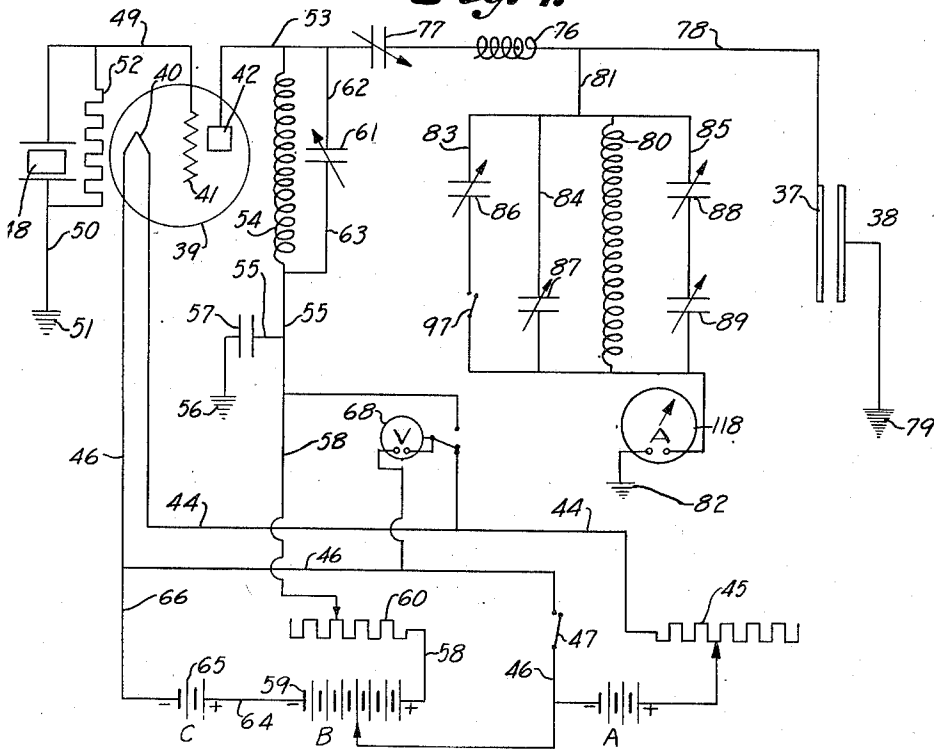
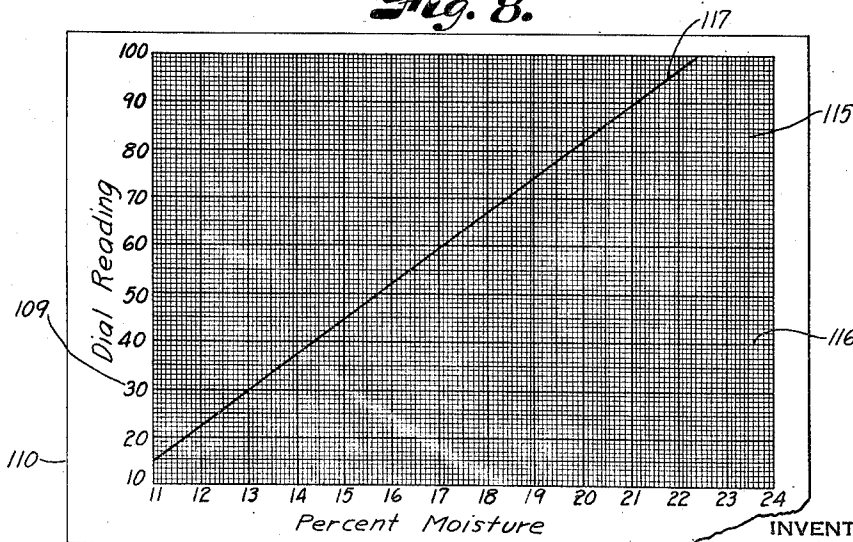


Fig. 8.



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APPARATUS FOR DETERMINING THE MOISTURE CONTENT OF A MATERIAL

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12 Claims. (Cl. 175—183)

This invention relates to an apparatus for determining the moisture content of grain, forage, grain products, dairy products and the like, and has for its principal object to provide a simple apparatus for quickly and accurately determining the moisture content of materials of this character.

It is known that changes in the di-electric constant of such materials is principally a function of their moisture content and, therefore, bears direct relation to the amount of moisture in the material. In carrying out my invention, I utilize this change in di-electric constant and employ an improved apparatus for determining the di-electric properties of the materials as illustrated in the accompanying drawings, wherein:

Fig. 1 is a perspective view of the apparatus particularly designed for measuring the moisture content of grains.

Fig. 2 is an end view of the apparatus.

Fig. 3 is a cross sectional view on the line 3—3, Fig. 1, particularly illustrating the hopper in which the material is placed to determine its moisture content.

Fig. 4 is a detail perspective sectional view of the hopper particularly illustrating the slide for discharging the grain after its moisture content has been determined.

Fig. 5 is a horizontal sectional view through the housing enclosing the apparatus, on the line 5—5, Fig. 2, particularly illustrating the various condensers and instruments employed in the electric circuit.

Fig. 6 is a schematic wiring diagram illustrating the electric circuit.

Fig. 7 is a schematic wiring diagram of a modified form of circuit.

Fig. 8 is a plan view of a chart for comparing the dial readings with the percentages of moisture in a given quantity of wheat.

Referring more in detail to the drawings:—

1 designates a preferably rectangular housing including a body portion 2 comprising front and rear side walls 3 and 4, end walls 5 and 6, and a bottom 7. The top of the body portion 2 is closed by a lid 8 having side flanges 9—10 and end flanges 11—12 cooperating with the walls 3, 4, 5 and 6 to enclose portions of the instruments projecting above the body portion of the housing when the apparatus is not in use.

The lid 8 is preferably hinged to the body portion of the box by a hinge member 13 fixed to the flange 10 of the lid and to the rear wall 4 of the housing, respectively. When the lid is opened, it is retained from falling back against the rear wall of the box by a flexible member 14 having one end fixed to the flange 11 of the lid and its opposite end fixed to a preferably metallic instrument panel 15 extending horizontally of the housing adjacent the upper edges of its side walls.

In order to conveniently mount the instrument panel, the upper edges of the front and rear walls 3—4 and the side wall 5 are rabbeted, as at 16, to form shoulder portion 17 to support the edges of the panel, as illustrated in Fig. 3. The instrument panel is shorter in length than the width of the box to provide an elongated rectangular-shaped opening 18 adjacent the side wall 6 through which the material to be gauged is poured into a hopper 19 later described.

In order to shield the instruments and wiring from effects of exterior influences, the inner walls and bottom of the box are covered with a metallic lining 20. The upper edges of the lining are preferably flanged outwardly to seat against the shoulder 17 and to contact with the metallic instrument panel 15 so that the instruments and electric circuits are entirely shielded by the metal which forms a ground for the electrical circuits later described.

The hopper 19 includes spaced rectangular-shaped plates 21 and 22 conforming in size to the inner dimensions of the end wall 6, and are formed of insulating material such as "Bakelite". The plates 21 and 22 constitute the side walls of the hopper and are spaced apart by downwardly converging strips 23 and 24 having their upper ends aligning with the ends of the opening 18 and their lower ends spaced apart to form the hopper chamber and provide an outlet 25. The strips terminate short of the bottom wall 7 to form a horizontal passageway 26 for a sliding gate member 27 arranged to open or close the outlet 25.

Formed in the bottom 7 in substantial alignment with the opening 25 is an opening 28 to allow the material discharged from the hopper to flow from the housing into a receptacle 29 positioned under the housing.

In order to provide space under the housing for the receptacle 29 and to provide a compartment for the "A", "B" and "C" batteries necessary to supply current to the electrical circuits, the housing is provided with a base portion 30 having front and rear walls 31—32 aligning with the front and rear walls of the housing, an end wall 33 aligning with the side wall 5, and an end wall 34 spaced from the end wall 6 to permit placing the receptacle 29 under the opening of the hopper to receive discharge therefrom when the slide 27 is moved outwardly through an opening 35 in the front wall 3 of the box. The slide 27 is preferably provided with a suitable knob 36 by which it may be readily moved to and from closing position relatively to the openings 25 and 28.

The outer face of the plate 21, constituting the inner wall of the hopper, carries a metallic plate 37 insulated from the lining 20 but cooperating with the portion 38 of the lining adjacent the side

wall 6 to form the plates of a condenser having its capacity governed by the di-electric constant of the air or other material which is contained in the hopper. It is, therefore, apparent that the capacity of the condenser will have its effect upon an electric circuit with which it is connected proportionate to the di-electric constant of the material in the hopper and that various materials will affect an electric circuit proportionate to the percentage of moisture in the materials.

In order to determine the inductive capacity of the di-electric in the hopper, I provide for connecting the plates in a high frequency circuit and bringing the circuit into resonance with an oscillatory electric circuit having a constant or fixed frequency now to be described.

The fixed frequency or oscillatory circuit includes a three-element vacuum tube 39 of ordinary construction including a filament 40, grid 41 and plate 42. The positive side of the filament is connected to the positive terminal of an "A" battery 43 by a conductor 44 in which is interposed a rheostat or filament adjuster 45. The negative filament terminal of the tube is connected by a conductor 46 with the negative terminal of the "A" battery 43. Interposed in the conductor 46 is a switch 47 controlling flow of "A" battery current to the filament.

The grid element 41 of the tube 39 is connected with one side of a crystal 48 by a conductor 49, while the other side of the crystal is connected by a conductor 50 with the shielding, as indicated by the ground 51. The crystal 48 is connected in the grid circuit to maintain an invariable frequency in the oscillatory circuit. The crystal is by-passed with a bias resistor 52.

The plate element 42 of the tube 39 is connected by a conductor 53 with one end of an oscillator coil 54. The opposite end of the oscillator coil is connected by a conductor 55 with the shielding, as indicated by the ground 56, through a fixed by-pass condenser 57 in order to complete the plate and grid circuits.

To supply a high tension current to the plate 42, the conductor 55 is connected by a conductor 58 with the positive terminal of a "B" battery 59, a variable rheostat 60 being inserted in the conductor to control the voltage to the plate.

In order to tune the oscillatory circuit, the oscillator coil is by-passed by a variable tuning condenser 61 connected to the conductor 53 and the conductor 55 by conductors 62 and 63, respectively.

The negative terminal of the "B" battery is connected by a conductor 64 to the positive terminal of a "C" battery 65 having its negative terminal connected with the negative filament lead 46 by a conductor 66 to supply the negative bias to the tube grid. The minus terminals of the "A" and "B" batteries are also interconnected by a conductor 67.

If desired, a voltmeter 68 may be inserted in the filament and plate circuits to indicate their respective voltages.

The high frequency circuit of which the plates 37 and 38 are a part includes a three-element vacuum tube 69 similar to the tube 39 previously described and which has a filament 70, grid 71 and plate 72. The filament 70 is connected to the lead 44 by a conductor 73 and the conductor 46 by a conductor 74 to supply current from the "A" battery. The grid 71 is connected in inductive relation to the oscillatory circuit by a conductor 75 through a fixed coupling condenser 76 and a variable coupling condenser 77 so that the high

frequency output from the oscillatory circuit is supplied to the grid of the tube 69. The grid 71 is also connected to the plate 37 of the hopper by a conductor 78 which is connected with the lead 75. The opposite plate 38, being grounded, as indicated at 79, thus forms a condenser which affects the circuit by regulating the number of electrons passing to the plate and, consequently, the amperage of the plate circuit. The grid circuit of the tube 69 also includes a tuning coil 80 having one end connected to the grid circuit by a conductor 81 and its opposite end grounded to the shield, as indicated at 82. Also connected with the conductor 81 and with the ground 82 and parallel with the coil 80 by conductors 83, 84 and 85 are condensers 86, 87, 88 and 89.

The condenser 86 is inserted in the conductor 83 and is to compensate for the inductive capacity of the hopper 19 (Fig. 3), while the condenser 87 is the zero adjustment condenser for permitting adjustment of the condenser 88 to zero position when the indicating hand of the ammeter 90 is reading somewhere in the middle of its scale.

The condensers 88 and 89 are inserted in series in the conductor 85. The condenser 88 is for bringing the circuit into resonance with the oscillatory circuit when the material is poured into the hopper and from which a reading may be obtained for calculating the moisture content of the material. The condenser 89 is of such capacity that it affects the capacity of the condenser 88 to spread its reading, as later described.

The plate 72 of the vacuum tube 69 is connected by a conductor 91 to one of the terminals of the ammeter 90, and the other terminal of the ammeter is connected by a conductor 92 to an intermediate tap of the "B" battery 59 to supply the positive "B" current to the plate. The conductor 91 is connected by a by-pass condenser 93 grounded to the shielding, as indicated at 94. The conductors 73 and 44 are also grounded to the shielding, as at 95, through a by-pass condenser 96.

The various instruments just described are supported upon the instrument panel 15 and are housed within the body portion of the box.

The conductor 83 connecting the condenser 86 into the circuit is provided with a switch 97 to remove the condenser 86 from the circuit when the moisture content of the material is being measured by the condenser 88, as later described.

The condensers 61 and 77 are adjusted by manipulating screws 98 and 99 projecting through openings in the panel 15, and the condensers 86 and 89 are similarly adjusted by screws 100 and 101 also projecting through openings in the plate 15.

The plates of the condenser 87 are operated by a knob 102 rotatably mounted on the upper face of the plate 15. The filament control rheostat 45 is also controlled by a similar knob 103 projecting above the instrument panel. The ammeter 90 and the voltmeter 68 are mounted in the instrument panel so that their indicators 104 and 105 are visible to the operator.

The condenser 88 is operable by a knob 106 having a dial 107 provided with a series of graduations 108 corresponding to the vertical row of numbers 109 on the chart 110 illustrated in Fig. 8. The dial 107 may be provided with a vernier 111 in order to provide minute adjustment of the condenser 88 when measuring the moisture content of the grain, as later described.

The switch 97 is operable by a knob 112 and the switch 47 controlling the filament circuit 75

is operated by a knob 113. The rheostat controlling the "B" voltage is controlled by a knob 114 extending from the base portion of the housing, as illustrated in Fig. 2.

The chart illustrated in Fig. 8 includes vertical lines 115 representing the percentage of moisture and horizontal lines 116 representing readings on the dial 107. The diagonal line 117 represents the graph for the percentages of moisture at the various dial readings. Various charts similar to the chart illustrated in Fig. 8 may be provided for the various materials which are tested in the machine.

In Fig. 7 is illustrated a modified form of wiring diagram wherein the rectifying tube 69 has been omitted. Otherwise the diagram is substantially identical. In this circuit, the indicating ammeter indicated at 118, complementary to the ammeter 90, is of the rectifying type and may be employed in place of the vacuum tube to rectify the high frequency current.

In an apparatus constructed as described and employing the circuit as illustrated in Fig. 6, the permanent factory adjustments of the parts are as follows:

The switch 47 is closed. The voltages of the "A" and "B" batteries are ascertained from the voltmeter 68 to make sure that the proper voltages are supplied to the filaments and plates of the vacuum tubes. The oscillation tuner condenser 61 and the variable coupling condenser 77 are then adjusted to obtain the maximum output from the oscillatory circuit which is supplied to the input or grid of the high frequency circuit including the hopper plates 37 and 38. The adjustments to these condensers are made through the openings 98 and 99 in the instrument panel 15.

The condenser 88 is then adjusted by the knob 106 so that it is at its maximum capacity and the zero graduation of the dial 107 aligns with the marking on the instrument panel. The condenser 89 is then adjusted through the opening 101 in the instrument panel so that the condenser 88 requires a relatively large adjustment in order that there is a wide variation in the graduations on the dial for each degree or percentage of moisture variation in the material to be tested. In other words, the condenser 89 tends to magnify the reading and adjustment of the condenser 88 so that relatively small differences in moisture percentage may be accurately and quickly ascertained from the reading on the dial of the condenser 88. When the proper positions for the plates of the condenser 89 are determined, the condenser 88 is set to zero position, that is, all of the plates of the condenser 88 are in so that it has its maximum capacity.

The condenser 86 is then adjusted through the opening 100 in the panel 15 so that the desired reading is obtained on the dial for a given load.

After the condensers 61, 77, 86 and 89 have been adjusted, the openings in the panel are closed by a sealing material and the apparatus is then ready for use.

Assuming that the moisture content of a sample of grain is desired, the switch 97 is closed to bring the condenser 86 into circuit. The indicator of the ammeter 90 should then record a reading approximately halfway of the scale due to the capacity of the condenser 86 being in the circuit. It is thus apparent that the output of current from the oscillatory circuit is delivered to the input of the high frequency or measuring circuit and the alternating current is being rectified by the tube 69 so that a positive current

is flowing through the ammeter 90 to actuate its indicator. Due to the fact that the high frequency circuit is not necessarily in resonance with the fixed frequency circuit, the indicator of the ammeter will not be at its highest point which it will attain when the circuits are in resonance, and, in order to tune the measuring circuit, the condenser 87 is adjusted to bring the measuring circuit into resonance with the oscillatory circuit. When this occurs, the indicator for the ammeter 90 will reach its highest point on the scale, thereby visibly indicating that the respective circuits are in resonance.

A fixed amount of the grain, by weight, for which the chart 110 was prepared, is poured into the hopper 19. The di-electric constant of the grain will, of course, increase the effective capacity of the condenser which includes the plates 37 and 38. When this occurs, the high frequency circuit is again thrown out of balance with the oscillatory circuit, and, before the circuit can again be brought into resonance, an equivalent inductive capacity must be removed from the circuit. The switch 97 is then opened to remove the condenser 86 from the measuring circuit. The knob 106 of the condenser 88 is then rotated to reduce the capacity of this condenser to bring the circuits into substantial resonance, which will be indicated visibly by the indicator 90 again reaching its maximum position on the scale. Vernier adjustment of the condenser 88 may then be obtained by operating the knob 111 until the indicator assumes a stationary position indicating that the respective circuits are in perfect resonance. The amount of inductive capacity removed by the condenser 88 is, therefore, proportional and/or equal to the inductive capacity or the di-electric constant of the grain. The reading on the dial 107 is then observed and is compared with the dial reading as indicated on the chart in Fig. 8. For example, assuming that the dial reading is 70, the amount of moisture content will be the point at which the line 70 crosses the diagonal line 117 on the chart, which may be observed by noting the point of crossing of the vertical line 70 and diagonal line 117, which is shown on the diagram as 18.4% moisture.

An apparatus employing the circuit as illustrated in Fig. 7 is adjusted identically the same as an instrument employing the circuit illustrated in Fig. 6, as the point of resonance between the respective circuits is indicated on the rectifying ammeter 118 exactly in the same manner as indicated by the ammeter 90 just described.

From the foregoing it is apparent that I have provided an apparatus whereby the moisture content of a material may be accurately ascertained, as I employ a fixed frequency oscillating circuit and bring the high frequency or measuring circuit into resonance with the fixed circuit regardless of the changes in atmospheric conditions and the change in the air di-electric in the hopper. The circuits are, therefore, first balanced to take care of all variables so that when circuits are rebalanced to obtain the di-electric constant of the material an accurate reading results under all conditions.

What I claim and desire to secure by Letters Patent is:

1. In a device for measuring moisture content of material, a housing, an opened bottom hopper in the housing formed of insulating material, a valve member controlling the open bottom of the hopper, condenser plates fixed in spaced relation at opposite outer sides of the hopper, a measuring

circuit including said condenser plates, an oscillatory circuit intercoupled with the measuring circuit, means in the oscillatory circuit to maintain a fixed frequency in said oscillatory circuit, and means in the measuring circuit for bringing said circuits into resonance to determine the relative di-electric capacity of a material placed in said hopper.

2. In a device for measuring moisture content of material including a housing, an opened bottom hopper in the housing, a valve member controlling the open bottom of the hopper, condenser plates at opposite sides of the hopper, electric means connected with said plates for determining di-electric capacity of a material placed in the hopper, and shielding means in the housing common to one of the plates and to said electric means.

3. In a device of the character described, a housing, a shield lining the housing, a pair of insulating partitions mounted in the housing to form a material receiving hopper therebetween, a plate supported in the housing adjacent one of the insulating partitions and cooperating with the shield to form a condenser, a valve slidably mounted in the housing adjacent the bottom of the hopper for discharging material from the hopper, and means in the housing including a fixed frequency circuit and a measuring circuit connected with said condenser for measuring the di-electric capacity of the material in the hopper.

4. In a device of the character described, a housing having a battery compartment and an instrument compartment supported above the battery compartment and projecting therefrom at one side thereof, a shield lining the instrument compartment, spaced insulating partitions extending across the instrument compartment at the projecting side thereof to form a material receiving hopper therebetween, a valve slidable in the housing and cooperating with the partitions to retain the material in the hopper, a plate cooperating with the shield to form condenser elements at opposite sides of the hopper, and means in the instrument compartment and connected with said condenser elements for measuring the di-electric capacity of the material in the hopper.

5. In a device of the character described, a housing having off-set portions spaced from the bottom thereof, spaced insulating partitions extending across the housing in said off-set portions, condensed elements supported in juxtaposition with said partitions, a valve member movable in the housing and cooperating with the partitions to retain a material therein, and means in the housing including a fixed frequency circuit and a measuring circuit connected with said condenser elements for measuring di-electric capacity of the material.

6. In a device of the character described, a housing, a shield lining the housing, a hopper formed of insulating material and positioned in the housing in juxtaposed relation with said shield, a plate supported in the housing in juxtaposed relation with the hopper and cooperating with said portion of the shield to form a condenser, and means in the housing including a fixed frequency circuit and a measuring circuit connected with said plate and with the shield for measuring di-electric capacity of material in the hopper.

7. In a device of the character described, a housing, a shield lining the housing, a hopper

formed of insulating material and positioned in the housing in juxtaposed relation with a portion of said shield, a metallic plate supported in the housing on the opposite side of the hopper from said portion of the shield to cooperate therewith in forming a condenser, means in the housing including a fixed frequency circuit and a measuring circuit connected with said plate, and means grounding said circuits to the shield for completing circuit through the condenser.

8. In a device of the character described, a housing having a battery compartment and an instrument compartment, a shield lining the instrument compartment, spaced insulating partitions extending across the instrument compartment to form a material receiving hopper therebetween, a plate cooperating with the shield to form condenser elements at opposite sides of the hopper, and means in the instrument compartment and connected with said condenser elements for measuring the di-electric capacity of material in the hopper.

9. In a device of the character described, a housing, a shield lining the housing, spaced insulating partitions mounted in the housing to form a material receiving hopper therebetween, a plate supported in the housing adjacent one of the insulating partitions and cooperating with the shield to form a condenser, and means in the housing including a fixed frequency circuit and a measuring circuit connected with the condenser plate and with the shield for measuring the di-electric capacity of material in the hopper.

10. In a device for measuring moisture content of material, including an insulated receptacle for containing the material, a condenser element separated from electrical contact with the material by the receptacle, a second condenser element cooperating with the first condenser element, electrical means connected with the condenser elements for determining di-electric capacity of the material in the receptacle, and shielding means for said electrical means having connection with one of said condenser elements and with said electrical means.

11. In a device for measuring moisture content of material, including an insulated receptacle for containing the material, a condenser element separated from electrical contact with the material by the receptacle, a second condenser element cooperating with the first condenser element, a measuring circuit including said condenser elements, an oscillatory circuit intercoupled with the measuring circuit, and means in the measuring circuit for bringing said circuits into resonance to determine the relative di-electric capacity of the material in said receptacle.

12. In a device for measuring moisture content of material, including an insulated receptacle for containing the material, a condenser element separated from electrical contact with the material by the receptacle, a second condenser element cooperating with the first condenser element, a measuring circuit including said condenser elements, an oscillatory circuit inter-coupled with the measuring circuit, means in the measuring circuit for bringing said circuits into resonance to determine the relative di-electric capacity of the material in said receptacle and shielding means for said electrical circuits having connection with said circuits and with one of the condenser elements.

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