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Cotton

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[54] **MOISTURE SENSING CONTROL FOR DRYER**

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[51] **Int. Cl.** **F26b 19/00**

[58] **Field of Search** ..... 34/45, 46, 48, 53, 55; 328/4, 293; 318/483; 324/65 R

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[57] **ABSTRACT**

In a material moisture sensing control, an integrating switch, in series circuit with a pair of moisture sensing electrodes in a fabric drying apparatus, is operable to a conductive posture for a time delay period as a function of the dryness condition of the fabrics being dried. In one embodiment an integrating switch comprises an electrolytic cell operable to the conductive posture by current flow through the wet fabrics and operable for returning to the nonconductive condition upon the fabrics achieving a predetermined dryness condition. A transistor is operable for initiating a control function responsive to the high voltage developed across the electrolytic cell in the nonconductive condition.

21 Claims, 2 Drawing Figures

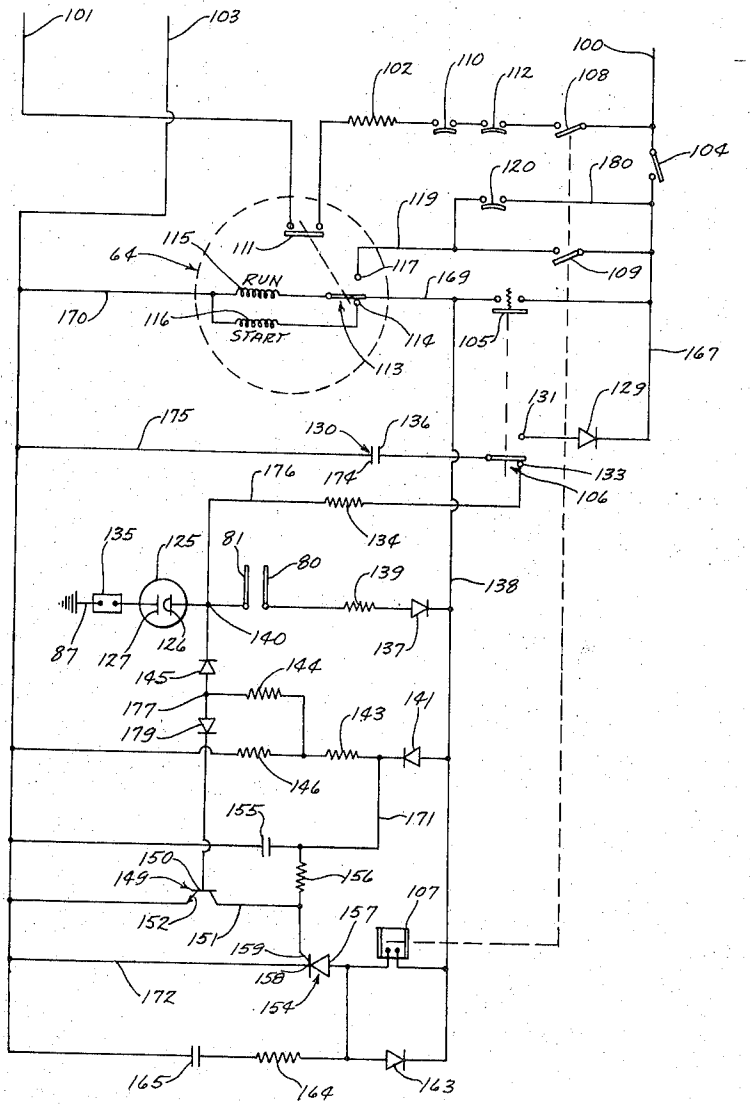


Fig. 1

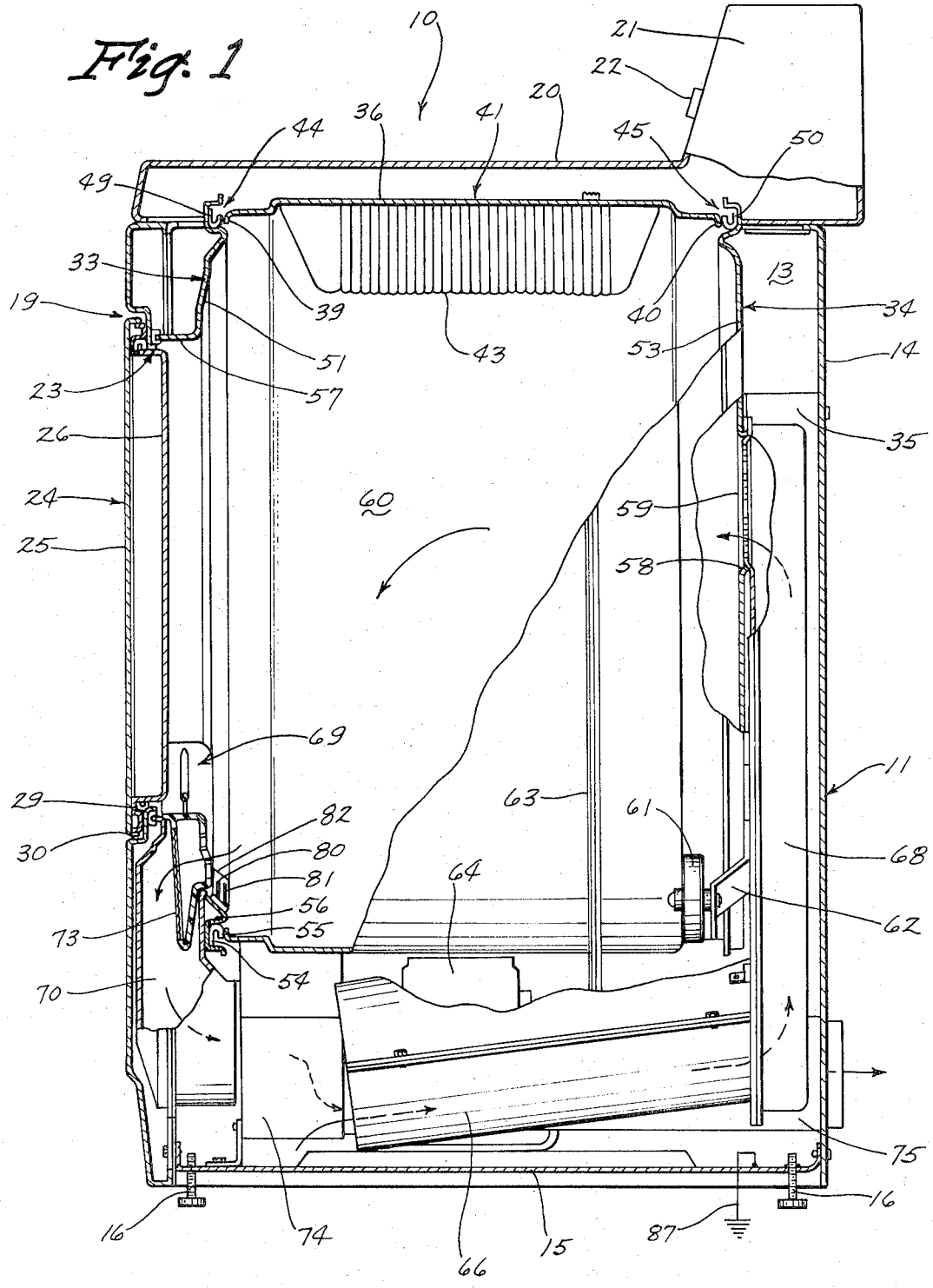
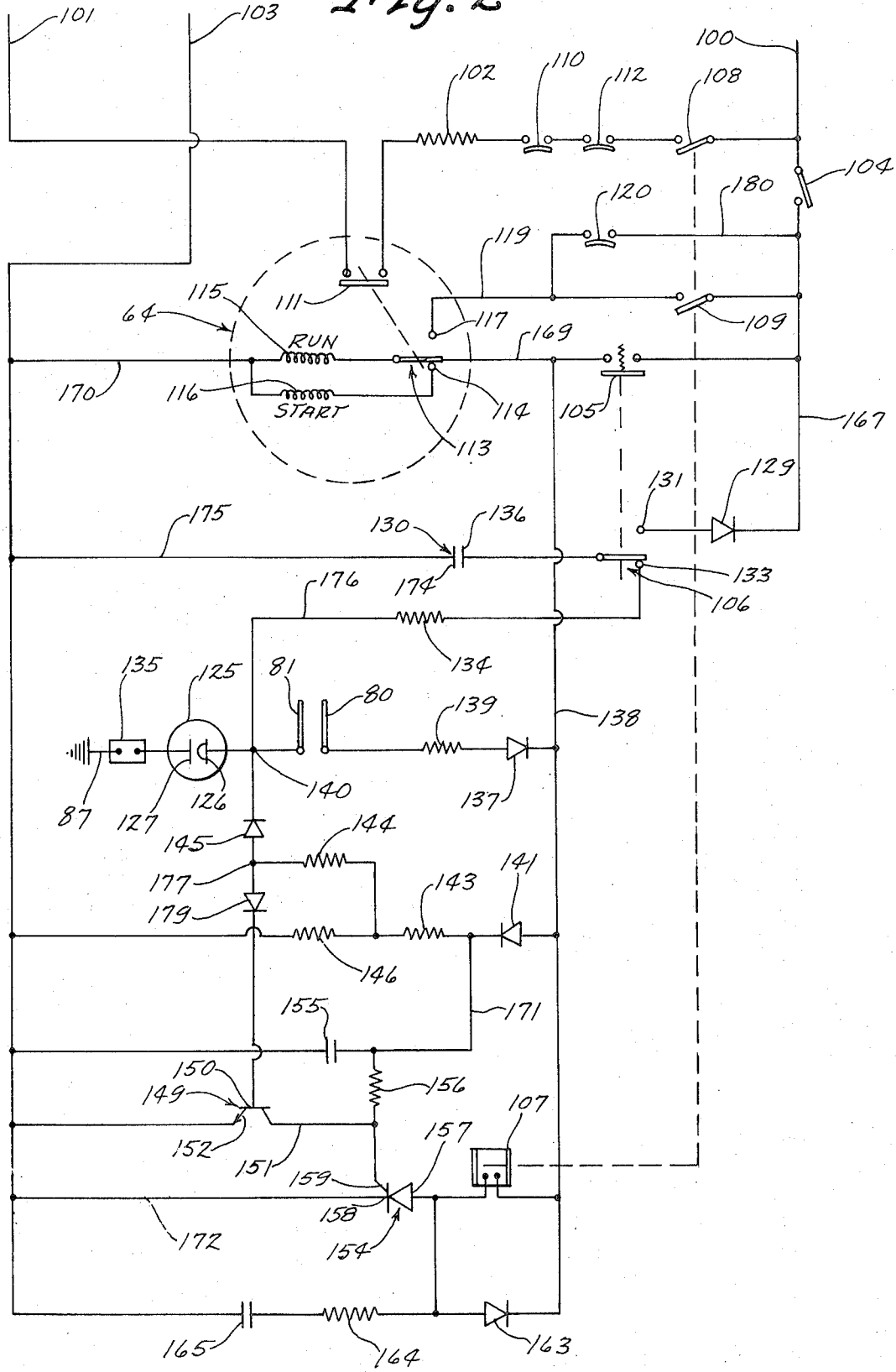

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Fig. 2


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MOISTURE SENSING CONTROL FOR DRYER

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a dryer control system and more particularly to a control circuit for automatically initiating termination of operation of a dryer apparatus when fabrics being dried therein attain a predetermined dryness condition.

2. Description of the Prior Art

One type of dryer control frequently used for effecting automatic termination of the drying operation of a fabric drying apparatus includes a pair of electrodes or conductors for sensing the electrical conductivity of the fabrics in the fabric tumbling chamber. The prior art patents show a number of specific control circuits for measuring fabric dryness by means of a sensing circuit including a resistance-capacitance circuit portion responsive to the resistance of the fabrics across the electrodes and operable for terminating the drying operation at a preselected dryness condition as indicated by a predetermined charge on a capacitor. The capacitor, in at least a portion of these dryness sensing controls, has been operable for providing a time delay to insure proper drying and thus has been of relatively large capacitive value and accordingly of relatively high cost. In other systems, a timer mechanism has additionally been used to achieve all or part of the long time delay. Both of these systems have commonly included means responsive to the voltage on the capacitor, such as a neon tube, for initiating a control function.

There is, however, a continuing search for improved control systems having greater reliability and accuracy as well as being more compact and of lower cost.

SUMMARY OF THE INVENTION

It is an object of the instant invention to provide an improved fabric dryness sensing circuit operable for terminating the dryness sensing operation at a desired fabric dryness condition.

It is a further object of the instant invention to provide an improved fabric dryness sensing circuit for directly integrating current flow through the wet fabrics bridging a pair of conductors.

It is a further object of the instant invention to provide an improved fabric dryness sensing circuit including an integrating switch in series connection to the fabric sensing electrodes.

It is still a further object of the instant invention to provide an improved dryness sensing circuit wherein the long time delay capacitor may be eliminated from the circuit.

It is yet a further object of the instant invention to provide an improved dryer control circuit including output means responsive to a voltage drop across an electrochemical device which is in series connection with the moisture sensing electrodes whereby an intermediate signal emitting device may be eliminated.

These objects are achieved in a fabric drying apparatus having a dryness sensing circuit comprising an integrating switch in circuit with the moisture sensing electrodes for directly integrating the current flow through the wet fabrics and further comprising accumulating circuit means and dissipating circuit means for maintaining the integrating switch means in a predetermined electrical condition during the drying operation and for

operating to a second electrical condition upon the fabrics reaching a predetermined moisture condition to terminate the dryness sensing operation and to initiate termination of operation of the apparatus.

Operation of the device and further objects and advantages thereof will become evident as the description proceeds and from an examination of the accompanying two pages of drawings.

DESCRIPTION OF THE DRAWINGS

The drawings illustrate a preferred embodiment of the invention with similar numerals referring to similar parts throughout the several views, wherein:

FIG. 1 is a view of a fabric drying apparatus partially broken away and sectioned and incorporating the control system of the instant invention; and

FIG. 2 is an electrical schematic diagram of a preferred circuit embodying the dryness sensing control of the instant invention.

DESCRIPTION OF A PREFERRED EMBODIMENT

Referring to FIG. 1 there is shown the overall construction for a clothes dryer 10 including a cabinet assembly comprising a sidewall wrapper 11 having generally vertical opposite side panels 13 and a rear panel 14. The sidewall wrapper 11 is supported on a base 15 which in turn is supported on a horizontal surface through a plurality of adjustable feet 16. The cabinet assembly further comprises a front panel 19 and top cover 20 supported on the sidewall wrapper 11. The top cover 20 includes an upwardly extending housing 21 for accommodating selected controls for the dryer such as a push-to-start mechanism operated by button 22.

The front panel 19 defines a generally central access opening 23 and includes a door 24 hinged on the front panel 19 and operable between open and closed positions relative to the access opening 23. The door 24 includes an outer panel 25 substantially flush with the front panel 19 and an inner panel 26 having a portion that extends rearwardly into the access opening 23. A seal 29 supported by the inner panel 26 extends endlessly around the rearwardly extending portion of the inner panel 26 for engagement with a recessed portion 30 of the front panel 19 to effectively provide an air seal at the access opening 23.

Disposed within the cabinet assembly is a pair of spaced apart generally vertical bulkheads 33 and 34. The rear bulkhead 34 is fixed to the sidewall wrapper 11 by a pair of brackets such as the bracket 35 that includes a front flange connected to the bulkhead 34 and a rear flange connected with the rear panel 14. The front bulkhead is similarly connected to the front flanges of wrapper 11 with a pair of brackets.

A generally cylindrical peripheral sidewall 36 is disposed between the stationary bulkheads 33 and 34. At the front and at the rear of the peripheral sidewall 36 there are inwardly turned flanges comprising relatively short end walls 39 and 40 juxtaposed the front and rear bulkheads 33 and 34 and cooperable with the sidewall 36 to effectively define a fabric tumbler 41. A plurality of baffle members 43 are fixed to the peripheral sidewall 36 and extend into the tumbling chamber for assisting in the movement of fabrics therewithin during rotation of the fabric tumbler 41.

The front and rear bulkheads **33** and **34** include radially outwardly disposed recess portions **44** and **45** extending axially toward the front and toward the rear, respectively, of the dryer **10.** Seals **49** and **50** are fixed to the bulkheads **33** and **34** in the recesses **44** and **45** and are engageable with the tumbler end walls **39** and **40** to provide an air seal at the ends of the tumbler **41.** The bulkheads **33** and **34** also include generally annular portions **51** and **53** inwardly disposed from the recesses **44** and **45** that effectively provide extensions of the end walls **39** and **40** of the fabric tumbler **41.**

The seal member **49,** for example, disposed between the stationary bulkhead **33** and the rotatable tumbler **41** is shown as a U-shaped or channel-shaped felt member having a pair of generally outwardly extending legs **54** and **55** connected by an intermediate arcuate portion. The leg **54** is fixed, as with adhesive, to the stationary bulkhead **33** in the recess **44** so that the intermediate arcuate portion conforms generally to the corner radius **56** and effectively biases the other leg **55** into engagement with the front wall **39** of the tumbler **41.** The felt may be coated on one side with an antifriction layer such as polytetrafluoroethylene to provide a smooth, more durable, and lower friction running surface for engagement with the tumbler end wall **39.**

The front bulkhead **33** defines an access **57** into the tumbling chamber that is substantially aligned with the access opening **23** in the front panel **19.** The rear bulkhead **34** defines an opening **58** to receive a perforate panel **59** through which airflow is directed into the tumbling chamber **60** from a duct system as will be shown.

The tumbler **41** is supported on a generally horizontal axis by a system including a pair of rollers **61** supported on brackets **62** fixed to the rear bulkhead **34** and by a pair of slide bearings (not shown) supported by similar brackets fixed to the front bulkhead **33.** The tumbler **41** could be supported entirely on rollers or entirely on slides as conditions permit.

The fabric tumbler **41** is rotated by a belt **63** encompassing the periphery of the tumbler sidewall **36** and driven by a motor **64** mounted on the base **15.**

The airflow system for the clothes dryer **10** includes a heater assembly **66** supported adjacent the base **15** and into which air is drawn from the atmosphere for heating prior to movement into the fabric tumbling chamber **60.** The heater assembly **66** accommodates an electric heating coil as will be considered in greater detail as related to the control circuitry of FIG. **2.** The heater assembly **66** is connected to a generally upwardly extending rear air duct **68** which conducts heated air from the heater assembly **66** through the rear perforate panel **59** and into the tumbling chamber **60.**

The air then flows from the chamber **60** through a filter assembly **69** into the front air duct **70.** The filter assembly **69** includes a filter screen **73** supported within the air duct **70** for removing lint particles from the air flowing out of the tumbling chamber **60** into the front air duct **70.**

The air is drawn from the front air duct **70** into a blower assembly **74** from which it is forced through a rearwardly extending lower air duct **75** to atmosphere. The blower **74** includes an impeller (not shown) that is driven by the motor **64** mounted adjacent to the blower **74** on the base **15.** The general airflow pattern within the drying apparatus **10** is shown by the broken and solid line arrows in FIG. **1.**

In order to measure the electrical conductivity or resistance of the fabrics within the chamber **60,** as a measure of the condition of dryness of the fabrics, electrodes or conductors **80** and **81** are mounted within the chamber **60.** In a preferred embodiment, the electrodes are in the form of a pair of spaced-apart elongated conductor members mounted on an insulating member **82** and in turn fixed to a lower portion of bulkhead **33** to provide a pair of electrically insulated contacting surfaces engageable by the fabrics tumbling within the tumbling chamber. It will be realized that different forms of electrodes or conductors may be used although the type disclosed herein is a preferred construction.

The electrical circuitry connected to the electrodes will be explained in greater detail in the discussion of FIG. **2** hereinbelow. It is noted, however, that the cabinet and other conductive portions of the apparatus are electrically connected to each other and are in turn connected to earth ground by conductor **87.**

Referring now to FIG. **2** the control circuitry includes three conductors that are connectable with a conventional three-wire 240 volt, alternating current supply. For the explanation of the circuitry of FIG. **2,** it will be assumed that conductors **100** and **101** are connected with the power lines and that the conductor **103** is connected to the earth-grounded neutral line.

The energizing circuit for the appliance includes a door switch **104** connected to conductor **100** and also includes a manually actuatable momentary push-to-start switch mechanism operated by button **22** and which includes a first single-pole single-throw momentary switch **105** and a second single-pole double-throw momentary switch **106** to be described further herein. The closing of the contacts in the push-to-start switch **105** effects energization of a control relay including a coil **107** and a pair of single-pole single-throw switches **108** and **109.** The relay switch **108** is in the heater circuit while the relay switch **109** serves as a holding switch during operation of the apparatus. The relay operation in the control of the machine will be described in greater detail herein.

The electric heating coil **102** is connected between the first and second power conductors **100** and **101** by a circuit portion including the relay switch **108,** a high limit thermostat **112,** a cycling thermostat **110,** and a centrifugal switch **111** in the motor **64.** The centrifugal switch **111** is normally open but is operable to the closed position upon energization of the motor **64.**

The drive motor **64** is initially energized by a circuit extending from the first power conductor **100** through the door switch **104,** push-to-start switch **105,** and through centrifugal switch **113** made to contact **114** within the motor **64.** Until the motor **64** rotates at a predetermined speed, the run and start windings **115** and **116** are both energized through centrifugal switch **113** made to contact **114,** but upon operation of the centrifugal switch **113** to the normally open contact **117** the start winding **116** is disconnected from the circuit. After initial energization of the motor **64** and operation of the centrifugal switch **113** to the normally open contact **117** and release of the push-to-start switch **105,** the circuit for energizing the motor **64** and maintaining energization thereof will be completed from the first power conductor **100** through the door

switch **104**, the relay holding switch **109** and a conductor **119** to the normally open contact **117** of the centrifugal switch **113**.

A cool-down thermostat **120** is provided in the circuit to the motor **64** and is operable to a closed position at a predetermined temperature within the tumbling chamber **60** of, for example, 135° F. After the dryer apparatus has operated for a period of time with heat, the cool-down thermostat **120** will close and maintain the motor **64** energized until the temperature within the tumbling chamber **60** is reduced to 135° F. This cool-down thermostat **120** therefore provides a fabric cool-down operation following a heat "On" drying operation.

The lower portion of the circuit diagram of FIG. **2** comprises primarily the moisture sensing and automatic termination circuit for the fabric drying apparatus. It is the general function of this sensing circuit to measure the moisture content of the tumbling fabrics during the drying operation and to initiate termination of operation at a particular fabric dryness condition. The circuit is operable for utilizing the resistance of momentary electrical paths completed through random samples of tumbling fabrics within the drying chamber. Generally speaking, these values of resistance are integrated and after a time delay period the control indicates the presence of fabrics having a generally predetermined or preselected condition of dryness. A predetermined electrical condition within the circuit initiates termination of operation through an output circuit portion.

An integrating switch provides the integration of the random momentary resistance values. An electrochemical device, such as an electrolytic cell **125**, is used as the integrating switch in the preferred embodiment of FIG. **2** and is operable as a timer or as an integrator. Operationally, the electrolytic cell **125** functions as a switch having a conductive posture in which the resistance through the electrolytic cell is relatively low and a nonconductive posture in which the resistance through the electrolytic cell is relatively high. The electrolytic cell **125** is operable as a bidirectional electron or current flow integrator as will become clear from the following explanation.

More specifically, the electrolytic cell **125** is a reversible micro-coulometer device designed in accordance with Faraday's law of electroplating. The device operates by means of the physical transfer of atoms of metallic silver across an electrolyte. The device has a central gold electrode, as shown schematically and designated by numeral **126** in FIG. **2** and a silver electrode shown as numeral **127**, which also serves as the outer case. When current flows in one direction, namely, from the silver electrode **127** to the gold electrode **126**, the positive silver ions in the electrolyte are deposited on the gold electrode **126**. The effective resistance of electrolytic cell **125** and the corresponding voltage drop across the cell are low. When current is applied in the opposite direction, namely, from gold electrode **126** to the silver electrode **127**, the silver is deplated from the gold electrode **126** but the device still exhibits a low resistance as long as there is silver remaining on the working or gold electrode **126**. As soon as the silver has been depleted from this gold electrode **126**, the electrolytic device **125** changes to a nonconductive or high resistance state, usually of the order of several megohms, with a corresponding voltage rise to over 800 millivolts.

In this specification, the convention that electrons flow by the same path as current and in the opposite direction thereto will be used. Therefore, electron flow through the electrolytic cell **125** from the gold electrode **126** to the silver electrode **127** will effect a plating of the gold electrode **126**.

Since the flow of current through the electrolytic cell **125** is accompanied by a transfer of silver from one electrode to the other in a direct proportionality to the level and time of current flow, including periodic or random inputs of any time-current integral, the device is a true integrator of the current input over a time period. At any instant, the quantity of silver on the working or gold electrode **126** represents a true value of the integral of the current that has passed through the electrolytic cell **125** during the integrating function.

As a simple timing device the electrolytic cell **125** may be given an initial charge comprising a predetermined plating current flow, or current flow from the silver electrode **127** to the gold electrode **126**, for a specific time to "set" or charge the device to a given level of plating. The electrolytic cell **125** may then be used to provide a time delay by connecting the electrolytic cell **125** to a circuit effecting an opposite current flow through the device for a deplating of the silver from the gold electrode **126**.

A combination of both timing and integration is utilized in the circuit of FIG. **2** as will be shown by the following detailed explanation of the circuit and operation thereof.

To set the electrolytic cell **125** for a guaranteed minimum timing function, a preplating circuit portion is connected between the first and second power lines **100** and **101** for effecting a plating current flow through the electrolytic cell **125** to condition the device to the conductive posture. The preplating circuit portion includes a rectifier **129** connected to the first power line **100** through door switch **104** which permits negative charging of a capacitor **130** through the momentary start switch **106** made to the normally open contact **131**. Upon the release of the momentary switch **106** for operation to its normally closed contact **133**, the accumulated negative charge on capacitor **130** is discharged through resistor **134** and through the electrolytic cell **125** and chassis **135** to ground. It is noted that the capacitor **130** is negatively charged with an accumulation of electrons on the right-hand plate **136** of the capacitor **130** so that the flow of electrons is through the electrolytic cell **125** from the gold electrode **126** to the silver electrode **127**. This flow of electrons from the gold electrode **126** to the silver electrode **127** corresponds by common practice, to the flow of current from the silver electrode to the gold electrode so that silver ions are deposited on the gold electrode **126** as previously explained, to operate the electrolytic cell **125** to the conductive posture.

It is also noted at this time that the silver electrode **127** of the electrolytic cell **125** is connected to earth ground through the conductive chassis **135** of the apparatus. In the specific embodiment of FIG. **2**, the chassis **135** is maintained disconnected from or electrically isolated from the neutral line **103** within the control circuit as shown in FIG. **2** but is effectively connected to the earth-grounded neutral line **103** by an external ground path including the earth-grounded neutral line

of a normal household supply. Such a circuit provision requires that the apparatus chassis be connected to the earth ground for operability of the circuit and apparatus. Further details and explanation of operation of such a control circuit are fully shown and claimed in copending application Ser. No. 405,203 filed Oct. 10, 1973 by the instant inventor and assigned to the assignee of the instant application.

The control circuit also includes a plating circuit portion extending from conductor **138** and comprising rectifier **137**, resistor **139** and the pair of conductive electrodes **80** and **81** connected in series with rectifier **137**, resistor **139**, and junction **140**. As wet fabrics contact and bridge the electrodes **80, 81**, the resistance between the electrodes will be relatively low and thus current flow therethrough will be at a high level. This current flow through the fabrics effects further plating of the electrolytic cell **125** but at a decreasing rate as the fabrics become dry and thus of higher resistance. The rectifier **137** limits the plating to half cycle operation and the variable resistance of the fabrics across the electrodes **80, 81** as a measure of the moisture content of the fabrics provides a variable plating signal to the electrolytic cell **125**.

The preplating circuit including capacitor **130** and the plating circuit including the electrodes **80, 81** may thus be considered as accumulating circuit means operable for effecting a plating of the electrolytic cell **125**.

A dissipating circuit is connected between the conductor **138** and the electrolytic cell **125** to effectively provide a deplating of the electrolytic cell **125** at a predetermined constant rate while the device remains in the conductive posture. The deplating path includes rectifier **141**, resistor **143**, resistor **144**, and rectifier **145**. It is noted that the relative positioning of rectifiers **129** and **137** relative to **141** provides that electrons flowing through the electrolytic cell **125** from the conductor **100** to the chassis **135** effect plating of the electrolytic cell **125** whereas electrons flowing from ground and through the chassis **135**, the electrolytic cell **125**, and the deplating circuit including rectifiers **145** and **141**, effect a deplating of the electrolytic cell **125**. Resistance **146** functions with resistance **143** as a voltage divider for effecting the current flow required for the shutdown device as will be shown.

Also included in the circuit of FIG. **2** is an output circuit portion including a transistor **149** having a base **150**, a collector **151**, and an emitter **152**. The base-emitter junction **150, 152** is responsive to the voltage drop across the electrolytic cell **125** as will be shown.

The output circuit further includes a silicon-controlled rectifier, or SCR **154**, in circuit with the transistor **149**. A capacitor **155** and resistor **156** are connected to the conductor **138** through the rectifier **141** and function as an auxiliary power supply for gating the SCR **154** to a conductive condition. The SCR **154** includes a path from the anode **157** to cathode **158** connected in series to the relay coil **107** and triggered to the conductive condition by the auxiliary power supply at gate **159** for maintaining the relay coil **107** energized while the drying operation proceeds. A diode **163** is shown in parallel connection to the relay coil **107** for conducting the self-induced current that is produced by the collapsing magnetic field of the inductive relay coil **107** during the half cycle of normal deenergization. A snubber circuit including series-connected resistor **164** and capacitor **165** is in parallel connection to the SCR anode-cathode path to protect the SCR **154** against electrical transients.

The operation of the circuit of FIG. **2** for controlling operation of the dryer apparatus will now be described. With the door switch **104** in its closed position as by the closing of the door **24**, manual operation of the push-to-start button **22** will close momentary switches **105** and **106** for energizing the drive motor **64** and effectively energizing the control circuit to initiate operation of the apparatus. Initially, the circuit for energizing the motor **64** extends from the first power line **100**, through door switch **104**, conductor **167**, switch **105**, and conductor **169** to the centrifugal switch **113**. The circuit continues through the run and start windings **115** and **116** connected in parallel and through a conductor **170** to the neutral line **103**.

At the same time, a circuit will be completed to the relay coil **107** and extending from the first power line **100**, through door switch **104**, conductor **167**, the momentary switch **105**, and conductor **138** to one side of the coil **107**. A circuit is also completed from the conductor **138** through diode **141** and conductor **171** to one side of the capacitor **155** for positive charging thereof. The capacitor **155** with resistor **156** effectively provides a positive power supply for triggering the SCR **157** to the conductive position. This effects energization of the relay coil **107** by a circuit extending from conductor **138** and through the anode-cathode path of the SCR **157** and conductor **172** to the neutral line **103**. Energization of the relay coil **107** closes relay switches **108** and **109**.

Upon the motor **64** reaching a predetermined speed, the centrifugal switch **113** operates from the normally closed contact **114** to the normally open contact **117** for deenergizing the start winding **116** and maintaining the run winding **115** energized by a circuit which extends from the first power line **100** through the closed door switch **104** and relay switch **109** and conductor **119** to the normally open contact **117** of the centrifugal switch **113**. The closing of the relay switch **108** also energizes the heater **102** by a circuit that extends from the first power line **100** through the relay switch **108**, the high limit thermostat **112**, the cycling thermostat **110**, the heater **102**, and the centrifugal switch **111** to the second power line **101**.

For charging capacitor **130**, closing of the momentary switch **133** to its normally open contact **131** completes a circuit between the first power line **100** and the neutral line **103**. Capacitor **130** is negatively charged by the circuit that extends from the conductor **167** through rectifier **129** and through the momentary switch **106** closed to its normally open contact **131** to the negative plate **136** of the capacitor **130**. The positive plate **174** of the capacitor **130** is connected to the neutral line **103** through conductor **175**.

At this stage of energization, the apparatus is operating with the motor **64** energized for tumbling fabrics in chamber **60** and the heater **102** energized to provide heat for drying the fabrics in the apparatus.

Upon manual release of the push-to-start button **22**, the momentary switch **106** operates to contact **133** and completes an electrical path from the negatively charged capacitor **130** through resistance **134** and conductor **176** to the electrolytic cell **125**. The electrons from the negative or right-hand plate **136** of the capaci-

tor 130 flow through the electrolytic cell 125 to ground. This flow of electrons corresponds to the flow of current through the electrolytic cell 125 for causing a plating action to occur within the electrolytic cell and the cell 125 becomes conductive to provide a very low impedance path to ground. The charge provided by capacitor 130 provides a one-shot predetermined plating of the electrolytic cell 125 to condition it to the conductive posture and establish a minimum period of conductive operation thereof.

With the motor 64 operating, the wet fabrics within the chamber 60 are tumbling therein for random engagement with the electrodes 80, 81. The bridging of wet fabrics between the pair of electrodes 80 and 81 completes the plating circuit between the conductor 138 and the neutral line 103 for flow of electrons, as controlled by rectifier 137, through the electrolytic cell 125 to effect a further plating thereof. The circuit extends from the conductor 138 through rectifier 137, resistor 139, the electrodes 80, 81 as bridged by the wet fabrics, and through the junction 140, the electrolytic cell 125, and the chassis grounding path 135 to the earth ground potential. This current flow continues during each negative half cycle at a rate depending upon the moisture content of the fabrics and will thus decrease in rate as the fabrics become more dry. The rate of plating is directly proportional to the current flow through the electrolytic cell 125 from the silver electrode 127 to the gold electrode 126 and will thus also decrease as the fabrics become dry.

The voltage divider formed by resistances 143 and 146 establishes a resistance network to effect a predetermined current flow through the electrolytic cell 125 for deplating the electrolytic cell 125 at a generally constant rate. The deplating current flow extends through the conductive chassis grounding path 135 and the electrolytic cell 125 to the junction 140. The deplating circuit then extends from the junction 140 through rectifier 145, resistor 144, resistor 143, and rectifier 141 to the conductor 138. The rate of deplating effected by the current flow is substantially constant as determined by the impedance of the deplating path.

The relative rates of charging or plating of the electrolytic cell 125 through the electrodes 80, 81 and bridging fabrics as compared to the deplating of the electrolytic cell 125 through the dissipating or deplating circuit are thus dependent upon the fabrics attaining a predetermined dryness. It is noted that while the fabrics are relatively wet at the initial portion of the cycle the rate of plating of the electrolytic cell 125 by a circuit extending through the electrodes 80, 81 and wet fabrics exceeds the the deplating rate through the dissipating circuit. As the dryness of the fabrics approach a preselected desired dryness, the constant rate of deplating exceeds the plating achieved through the electrodes 80, 81 and fabrics so that the remaining quantity of plated material on the gold electrode 126 decreases. Eventually the electrolytic cell 125 becomes deplated, assumes a nonconductive posture, and exhibits a high voltage drop thereacross. This plating and deplating operation of the electrolytic cell 125 provides direct integration of the current flow through the electrodes 80, 81 as dependent upon the moisture content of the fabrics and in addition provides the time delay period deemed necessary for proper drying.

It is desirable to provide to the operator a selection of drying cycles or of degrees of dryness. To achieve this selectivity, the built-in time delay may be made variable as by providing a variable component for capacitor 130. Alternatively, one or more of the resistors 139, 143, 144 and 146 could be made variable. For convenience of explanation in this specification, however, the components are considered fixed.

When the electrolytic cell 125 is plated, the voltage at the junction 177 is essentially the voltage drop across rectifier 145 since the electrolytic cell 125 has a conductive posture. This same voltage is impressed across rectifier 179 and the base-emitter junction 150, 152 of transistor 149. This voltage level, however, at the base-emitter junction 150, 152 of transistor 149 is insufficient to cause transistor 149 to conduct across the collector-emitter junction 151, 152. As the clothes become dry, however, the the electrolytic cell 125 becomes deplated and changes to a relatively high impedance posture as previously shown. The electrolytic cell 125 thus becomes nonconductive in comparison to the path through rectifier 179 and base-emitter junction 150, 152 of transistor 149. Further, the increased voltage drop across the electrolytic cell 125 is effectively impressed on the base-emitter junction 150, 152 of transistor 149 and with the resulting increased current flow through the base-emitter junction 150, 152 causing the transistor 149 to become significantly more conductive across the collector-emitter junction 151,152. The current path to the base-emitter junction 150, 152 extends from conductor 138, through rectifier 141, resistor 143, resistor 144, and rectifier 179 to the transistor base 150.

The conductive path through the transistor 149 shunts the SCR gate signal which is provided to the SCR 154 through resistor 156. The SCR 154 then ceases conduction to deenergize the relay coil 107 and thereby open relay switches 108 and 109. Opening of switch 108 deenergizes the heater circuit while opening of switch 109 deenergizes the motor circuit unless the cool-down thermostat 120 has been operated to the closed position. If the cool-down thermostat 120 has closed, the motor 64 will remain energized until the thermostat reset temperature is reached. During this time, the motor 64 remains energized by a circuit extending between the first power line 100 through the door switch 104, the conductor 180, the cool-down thermostat 120, conductor 119, and the centrifugal switch 113 made to the normally open contact 117.

During the cool-down period, a circuit will also be completed from the first power line 100 through the cool-down thermostat 120, conductor 119, the centrifugal switch 113 made to the normally open contact 117, through conductor 169 and conductor 138 to one side of rectifier 141. A power supply thus remains to the capacitor 155 and permits current flow through resistor 143, resistor 144, rectifier 179 and the base-emitter junction 150,152 of transistor 149 to maintain the transistor 149 conductive and the SCR 154 nonconductive so that the relay coil 107 remains deenergized during the cool-down operation.

Upon the temperature decreasing to the established temperature for opening the cool-down thermostat 120, the motor 64 will be deenergized and the control circuit deenergized for effectively terminating operation of the apparatus.

As previously shown, the electrolytic cell **125** is connected to an earth ground path through the chassis grounding path **135** and requires the presence of an earth grounding of the apparatus for operability of the apparatus. If such a ground is not present the initial preplating charge provided by the capacitor **130** will find no path to ground through the electrolytic cell **125.** Upon release of the push-to-start button **22,** the transistor **149** will sense the high voltage condition and will terminate operation of the apparatus even though the fabrics remain wet within the tumbling chamber **60.** The wet fabrics in the chamber **60** will also be unable to provide a plating of the electrolytic cell **125** because of the absence of a complete circuit to ground.

Note also in FIG. **2** that rectifiers **145** and **179** are placed in a back-to-back relationship to prevent damage to the circuit components in case a two-wire connector is utilized, such as in a 120-volt gas appliance, where the user could inadvertently interchange the neutral and hot power lines at the appliance input connections. In the circuit of FIG. **2,** the neutral line **103** is connected to the emitter terminal **152** of the transistor **149** and a ground line is connected to the electrolytic cell **125.** Should a two-wire connection be used and should the plug be reversed, the line to the emitter **152** of transistor **149** would become the hot line and there would be 120-volt differential between the emitter of transistor **149** and ground. This differential could cause damaging current to flow both through the transistor **149** and the electrolytic cell **125** were it not blocked by the back-to-back relationship of rectifiers **145** and **179.**

The circuit for preplating the electrolytic cell **125** is provided to insure proper operation of the device and in particular to provide the ability to dry small loads. This preplating provides a guaranteed heat time so that regardless of the amount of plating or deplating the time delay provides an insured drying operation.

For the purposes of a particular reduction to practice of this circuit the following values of components were utilized:

capacitor **130**	30 MFD
capacitors **155,165**	0.1 MFD
resistor **134**	200 K ohms
resistor **139**	variable from 360 K ohms to 1.45 megohms
resistor **143**	820 K ohms
resistor **146**	33 K ohms
resistor **144**	285 K ohms
transistor **149**	transistor 2N 4123
SCR **154**	G.E. C103B

electrolytic cell 125 Bisset Berman "E Cell" 560-0002

It is clear that the circuit described hereinabove achieves a novel combination of components comprising a fabric dryness sensing circuit for controlling operation of a drying apparatus. The circuit eliminates the large and expensive time delay capacitor and also eliminates the neon tube previously used in dryness sensing circuits. These accomplishments permit an improved circuit having more compact features and which may potentially be provided at a lower cost.

In the drawings and specification there has been set forth a preferred embodiment of the invention and although specific terms are employed these are used in a generic and descriptive sense only and not for purposes of limitation. Changes in form and the proportion of parts as well as the substitution of equivalents are contemplated as circumstances may suggest or render expedient without departing from the spirit or scope of the invention as further defined in the following claims.

I claim:

1. A moisture sensing control for use with a drying apparatus and operative to control said apparatus in accordance with the moisture content of material being dried therein, the combination comprising: electrode means including a pair of spaced conductors engageable with the material being dried for completing a current path through said pair of conductors and wet material therebetween; electrical supply means for applying power across said pair of conductors; integrating switch means in series with said pair of conductors and operable for effectively integrating the current flow through the material bridging said pair of conductors as a measure of the moisture content thereof; accumulating circuit means operable for initially conditioning said integrating switch means to a conductive posture and establishing a time delay period of conductive operation thereof and also operable for effectively extending said time delay period at a rate dependent upon the moisture content of said material; dissipating circuit means connected to said integrating switch means for decreasing the time delay period of conductive operation thereof at a rate less than the extending rate of said accumulating circuit means when said materials are relatively wet and at a rate greater than the extending rate of said accumulating circuit means when said materials are relatively dry, said integrating switch means being thereby operated to a nonconductive posture after a period of conductive operation which is a function of said material attaining a predetermined degree of dryness; and output means responsive to the nonconductive posture of said integrating switch means indicative of the material attaining said predetermined degree of dryness for initiating a control function.

2. A moisture sensing control as defined in claim **1** wherein said integrating switch means includes an electrochemical integrating device responsive to current flow therethrough in a first direction for operation to said conductive posture and responsive to current flow therethrough in the opposite direction over a time delay period for operating to said nonconductive posture from said conductive posture.

3. A moisture sensing control as defined by claim **1** wherein said accumulating circuit means includes a first circuit portion for initially conditioning said integrating switch means to said conductive posture and establishing a minimum time delay period of conductive operation thereof and further includes a second circuit portion for extending the effective time period of conductive operation thereof at a rate dependent upon the moisture content of said material.

4. A moisture sensing control as defined in claim **1** wherein said integrating switch means includes an electrolytic cell operable to said nonconductive posture for exhibiting a substantially increased voltage concurrent with the material attaining a predetermined degree of dryness and wherein said output means includes a transistor responsive to said substantially increased voltage for initiating said control function.

5. A moisture sensing control for use with a drying apparatus and operative to control said apparatus in accordance with the moisture content of material being dried therein, the combination comprising: electrode means including a pair of spaced conductors engage-

able with the material being dried for completing a current path through said pair of conductors and wet material therebetween; electrical supply means for applying power across said pair of conductors; integrating switch means in series circuit with said pair of conductors and operable for effectively integrating the current flow through the material bridging said pair of conductors as a measure of the moisture content thereof; first means for initially conditioning said integrating switch means to a conductive posture and establishing a minimum time delay period of conductive operation thereof; second means including the current path through said pair of conductors and wet material therebetween and operable for effectively maintaining said integrating switch means in said conductive posture by extending the effective time delay period at a rate dependent upon the moisture content of said material; third means connected to said integrating switch means for decreasing the time delay period of conductive operation thereof at a rate less than the extending rate of said second means when said materials are relatively wet and at a rate greater than the extending rate of said second means when said materials are relatively dry whereby said integrating switch means is operated to said nonconductive posture after a time period of conductive operation which is a function of said material attaining a predetermined degree of dryness; and output means responsive to the nonconductive posture of said integrating switch means indicative of the material attaining said predetermined degree of dryness for initiating a control function.

6. A moisture sensing control as defined in claim **5** wherein said first means includes a resistance-capacitance circuit and a momentary switch for supplying a one-time pulse of current to said integrating switch means to effect the initial conditioning of said integrating switch means to said conductive posture.

7. A moisture sensing control as defined in claim **5** wherein said integrating switch means includes an electrolytic cell and wherein said first means is operable for effecting a predetermined quantity of charging thereof, said second means is operable for effecting an additional quantity of charging dependent upon the moisture content of the material bridging said electrodes and wherein said third means is operable for clearing the electrolytic cell at a generally constant rate.

8. A moisture sensing control as defined in claim **7** wherein said output means includes a transistor responsive to a substantial increase in voltage drop across said electrolytic cell.

9. A moisture sensing control for use with a drying apparatus and operative to control said apparatus in accordance with the moisture content of material being dried therein, the combination comprising: electrode means including a pair of spaced conductors engageable with the material being dried for completing a current path through said pair of conductors and wet material therebetween; electrical supply means for applying power across said pair of conductors; integrating switch means in series circuit with said pair of conductors and operable for effectively integrating the current flow through the material bridging said pair of conductors as a measure of the moisture content thereof; accumulating circuit means for initially conditioning said integrating switch means to a conductive posture and also operable for effectively extending a time delay period of conductive operation thereof at a rate dependent upon the moisture content of said material; dissipating circuit means connected to said integrating switch means for decreasing the time delay period of conductive operation thereof at a rate less than the extending rate of said accumulating circuit means when said materials are relatively wet and at a rate greater than the extending rate of said accumulating circuit means when said materials are relatively dry whereby said integrating switch means is operated to said nonconductive posture after a period of conductive operation which is a function of said material attaining a predetermined degree of dryness; output circuit means including a transistor having a base-emitter junction in parallel connection to said integrating switch means; and voltage divider circuit means connected to said integrating switch means and said base-emitter junction, said transistor being responsive to the substantially increased voltage drop across said integrating switch means in the nonconductive condition upon the material attaining said predetermined degree of dryness for becoming conductive to initiate a control function.

10. A moisture sensing control as defined in claim **9** wherein said accumulating circuit means and said dissipating circuit means are in parallel connection to each other and wherein said accumulating circuit means establishes a minimum time delay period and extends the time delay period dependent upon the moisture content of said material and wherein said dissipating circuit means decreases the effective time delay period at a generally constant rate.

11. A moisture sensing control as defined in claim **9** wherein said integrating switch means includes a bidirectional current integrating device responsive to current flow in one direction therethrough for operation to said conductive posture and responsive to current flow in the opposite direction therethrough for operation to said nonconductive posture after a time period controlled by the amount of current in the first direction.

12. A moisture sensing control as defined in claim **9** wherein said integrating switch means includes an electrolytic cell responsive to current flow in one direction through said accumulating circuit means for operation to said conductive posture and responsive to a generally equal quantity of current flow in the opposite direction through said dissipating circuit means for operation to said nonconductive posture.

13. A moisture sensing control for use with a drying apparatus and operative to control said apparatus in accordance with the moisture content of material being dried therein, the combination comprising: electrode means including a pair of spaced conductors engageable with the material being dried for completing an electrical path through said pair of conductors and wet material therebetween; electrical supply means for applying power across said pair of conductors; a bidirectional current integrating device in circuit with said pair of conductors and operable between a conductive posture and a nonconductive posture for effectively integrating the current flow through the material bridging said pair of conductors as a measure of the moisture content thereof; first circuit means for effecting current flow through said integrating device in a first direction to condition said integrating device to said conductive posture and establish a minimum time delay period of conductive operation thereof; second circuit means including the electrical path through said pair of conduc-

tors and wet material therebetween and operable for effecting current flow through said integrating device in said first direction to extend the effective time delay period of conductive operation at a rate dependent upon the moisture content of said material; third circuit means connected to said integrating device for effecting current flow through said integrating device in a second direction to decrease the time delay period at a rate less than the extending rate of said second circuit means when said materials are relatively wet and at a rate greater than the extending rate of said second circuit means when said materials are relatively dry and thus return said integrating device to said nonconductive posture after a period of conductive operation which is a function of said material attaining a predetermined degree of dryness; and output means responsive to the nonconductive posture of said integrating device indicative of the material attaining said predetermined degree of dryness for initiating a control function.

14. A moisture sensing control as defined in claim **13** wherein said bidirectional current integrating device includes an electrolytic cell responsive to current flow in said first direction for becoming plated to assume said conductive posture and responsive to current flow in said second direction for becoming deplated over a period of time controlled by the relative rates of plating and deplating to return to said nonconductive posture.

15. A moisture sensing control as defined in claim **14** wherein said second circuit means is operable for effecting a plating of said electrolytic cell at a rate dependent upon the moisture content of the material between said electrodes and wherein said third circuit means is operable for effecting a generally constant deplating of said electrolytic cell.

16. A moisture sensing control for use with a drying apparatus and operative to control said apparatus in accordance with the moisture content of material being dried therein, the combination comprising: electrode means including a pair of spaced conductors engageable with the material being dried for completing an electrical path through said pair of conductors and wet material therebetween; electrical supply means for applying power across said pair of conductors; an electrolytic device in circuit with said pair of conductors and operable between a nonconductive deplated condition and a conductive plated condition; first circuit means for effecting an initial plating of said electrolytic device; second circuit means including the electrical path through said pair of conductors and wet material therebetween and operable for effecting additional plating of said electrolytic device at a rate comprising a function of the conductivity condition of the material between said conductors; third circuit means connected to said electrolytic device for effecting a deplating thereof at a rate less than the plating rate effected by said second circuit means when said material is relatively wet and at rate exceeding the plating rate of said second circuit means when said material is relatively dry whereby said electrolytic device effectively integrates the conductivity condition of said material as a measure of the moisture content thereof during a drying operation of said apparatus and is operated to the nonconductive condition upon the material attaining a predetermined degree of dryness; and output circuit means responsive to the nonconductive deplated condition of said electrolytic device for initiating a control function.

17. A moisture sensing control as defined in claim **16** wherein said first circuit means is operable for effecting an initial predetermined quantity of plating of said electrolytic device, wherein said second circuit means is operable for effecting a plating of said electrolytic device at a rate proportional to the moisture content of the material between said conductors and wherein said third circuit means is operable for effecting a deplating of said electrolytic device at a generally constant rate.

18. A moisture sensing control as defined in claim **16** wherein said output circuit means includes a transistor having a base-emitter junction responsive to an increased voltage drop across the electrolytic device in said nonconductive condition for initiating said control function.

19. A moisture sensing control as defined in claim **16** wherein said first circuit means includes a resistance-capacitance circuit and a manually operable momentary switch for effecting a predetermined plating of said electrolytic device to initiate conductive operation of said electrolytic device for a predetermined period of time.

20. A moisture sensing control as defined in claim **16** wherein said second circuit means provides a variable half cycle current for plating said electrolytic device at a rate dependent upon the moisture of the material bridging said conductors.

21. A moisture sensing control as defined in claim **20** wherein said third circuit means includes a resistive network for providing a predetermined deplating current flow through said electrolytic device to achieve a deplating thereof at a generally constant rate.

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