Aug. 12, 1969 J. L. LORENZ 3,460,267

DRYER CONTROL

Filed April 20, 1967 2 Sheets-Sheet 1

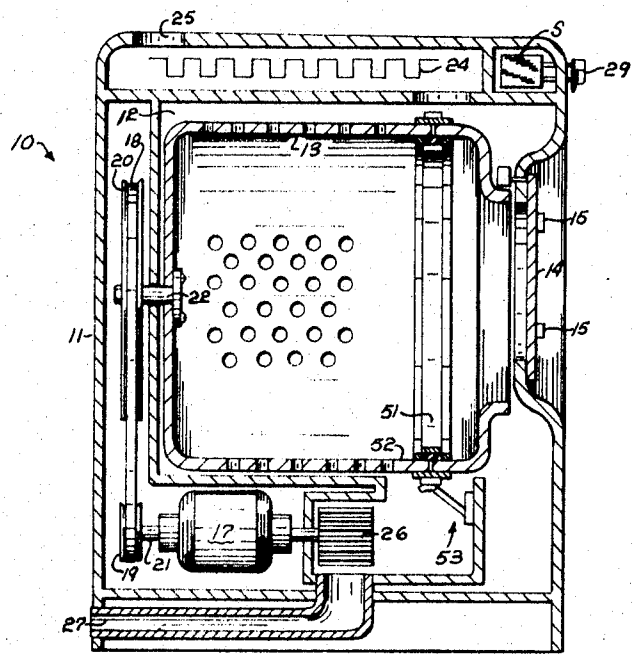

FIG. 1

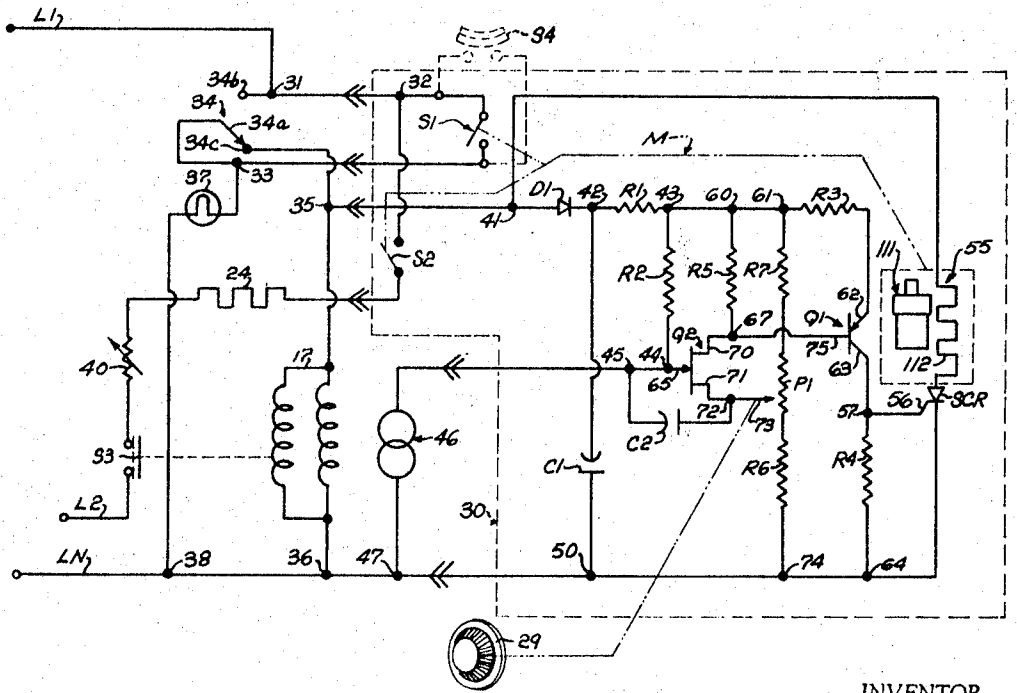

FIG. 2

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DRYER CONTROL

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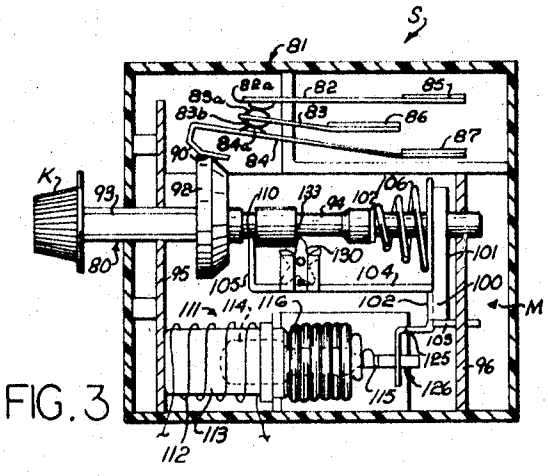

FIG. 3

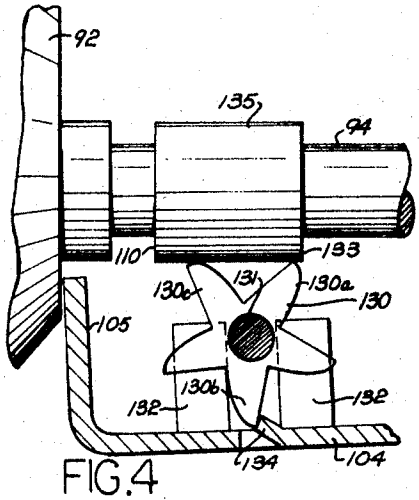

FIG. 4

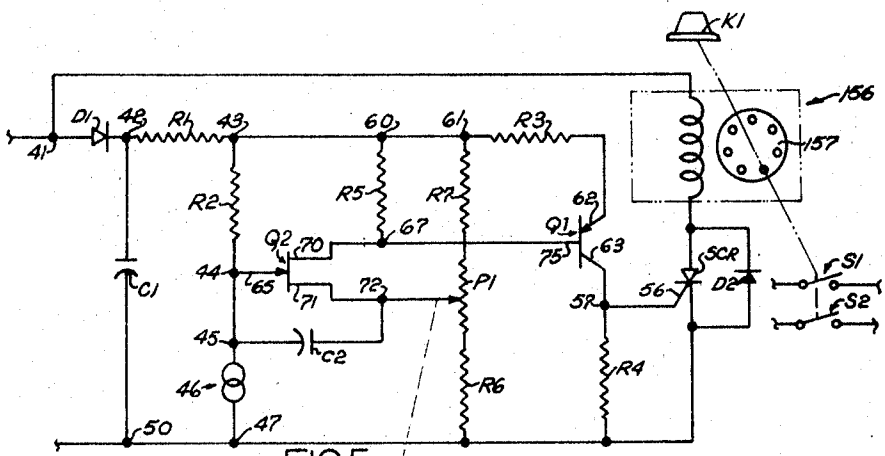

FIG. 5

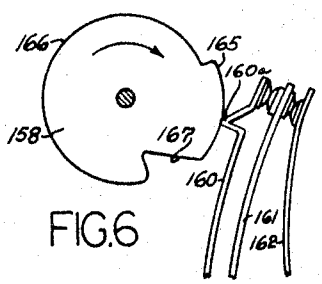

FIG. 6

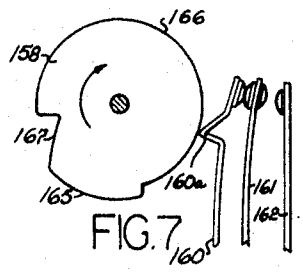

FIG. 7

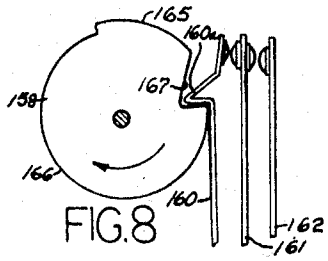

FIG. 8

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3,460,267

DRYER CONTROL

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Int. Cl. F26b 3/02, 11/04, 21/10
U.S. Cl. 34—45 8 Claims

ABSTRACT OF THE DISCLOSURE

Drying apparatus having a control for terminating a drying cycle of the apparatus includes electrodes for engaging fabrics in the dryer to establish a conductive path therethrough and actuates a triggering circuit which energizes actuating means for terminating the drying cycle in response to a predetermined low moisture content of the articles and in response to an accumulation of electrical energy applied to the actuating means which is preferably in the form of an electric heat motor.

The present invention relates to drying apparatus, and more particularly relates to drying apparatus including control means for terminating operation of the apparatus in response to moisture content of articles being dried thereby.

Previously known controls in drying apparatus for fabric articles such as domestic clothes dryers, have often employed spaced electrodes located within a drum of the dryer which are positioned to be bridged by articles within the drum as the articles are tumbled, so that a conductive path is established through the articles between the electrodes. The conductivity of the path depends upon the moisture content of the articles being dried so that operation of the apparatus can be controlled accordingly. Generally, when the articles have reached a predetermined moisture content, a relay, or similar actuating device, is operated to perform a switching function which terminates the drying cycle.

In previously known control circuits utilized to control operation of such dryers, tumbling of the articles in the apparatus interrupts the conductive path as the articles being dried move out of engagement with the electrodes in the dryer, and the resulting low conductivity of the air gaps between the electrodes produces false indications that the fabric within the dryer is dry. Such false indications tend to render the control circuit operative to energize the relay and terminate the drying cycle. False indications of dryness, of the type referred to, occur at random times during the drying cycle depending upon the manner of movement of the fabrics within the drum, the amount and type of fabric being dried, and construction and positioning of the electrodes, and as a result of these false signals, it has been necessary in the past to connect a relatively large capacitor in parallel with the electrodes in the dryer to absorb the energy of the false signals by being charged thereby to prevent termination of the drying cycle by the false dryness signals. The use of such capacitors has materially added to the cost of controls of the type mentioned.

Prior art dryness controls have also included numerous resistors associated with relatively complex switching devices for switching the resistors into and out of the control circuitry to provide for termination of the drying cycle depending on moisture content desired, as well as to compensate for differences in types of fabrics. Such circuit components have also added to the cost of the dryer control while providing only a limited selectivity to the user of the apparatus.

A principal object of the invention is the provision of

a new and improved fabric article dryness control apparatus wherein electrically energized actuating means for controlling a drying cycle of the apparatus is energized according to conductivity of fabric randomly tumbled into engagement with two spaced electrodes, and wherein the actuating means is effective to perform its control function only in response to an accumulation of electric energy applied thereto so that the drying cycle is not terminated when fabric therein is randomly disengaged from the electrodes, and wherein the length of the drying cycle is time independent.

Another object of the present invention is the provision of a new and improved dryer control having electrically energized actuating means to effect performance of control functions of the dryer apparatus, and which is energized at randomly when articles being dried are randomly disengaged from electrodes in the dryer, and with the actuating means being energized continuously when the articles in the dryer have reached a predetermined moisture content, regardless of whether or not such articles are in contact with the electrodes, the actuating means being characterized by the fact that it performs its control function when a predetermined cumulative amount of electrical energy is applied thereto, so that continuous energization of the actuating means occurs over a relatively brief period depending on the number of random energizations of the actuating means during the cycle.

Another object of the present invention is the provision of a new and improved dryer control as set forth in the next preceeding paragraph wherein the actuating means comprises an electrically operated heat motor having an expansible chamber containing thermally expansible material adapted to be heated by an electric heater and which when continuously energized, causes expansion of the material and the chamber to effect a control function of the dryer.

A further object of the invention is the provision of a new and improved control of the type referred to wherein the actuating means includes an A.C. induction timer motor drivingly linked to contacts of control switches of the drying apparatus, the motor being operated randomly when the circuit through the articles is interrupted and continuously when the articles have reached a preselected dryness, and in which the driving connection includes cam means having a first lobe portion operative to maintain the control switches closed during random operation of the motor and briefly after constant operation of the motor is initiated, the cam means thereafter permitting of at least one set of contacts of the control switches.

Another object of the present invention is the provision of a new and improved dryer control including electrically energized actuating means and a triggering circuit for effecting energization of the actuating means in response to a predetermined voltage across electrodes positioned in the dryer and connected in a signal circuit, and which triggering circuit includes an input circuit connected to the signal circuit, having an input impedance at least as large as the impedance of dry particles bridging the electrodes, and wherein the voltage across the electrodes at which the trigger circuit is rendered conductive is infinitely variable between fixed limits to provide a wide range of selectivity of the moisture content of articles at which the drying cycle is terminated.

A further object of the present invention is the provision of a new and improved dryer control circuit including a switch actuating member which is movable manually in a first direction to initiate operation of the drying apparatus, a linkage means for maintaining said switch operating member in such position, electrically energized actuating means for unlocking the linkage means from the switch operating member when fabric articles

being dried have reached a predetermined moisture content to permit the switch operating member to return to its original position and terminate operation of the drying apparatus, and wherein the linkage means cooperates with the switch operating member to permit termination of operation of the drying apparatus when the switch operating member is moved manually in the first mentioned direction and released so that operation of the drying apparatus may be terminated by a user of the apparatus independently of operation of the actuating means.

Other objects and advantages of the present invention will become apparent from consideration of the following detailed description thereof made with reference to the accompanying drawings, which form a part of the specification and wherein;

FIG. 1 is a sectional of a drying apparatus embodying the present invention;

FIG. 2 is a schematic illustration of the portion of the dryer apparatus of FIG. 1;

FIG. 3 is a sectional view of a portion of the apparatus of FIG. 1;

FIG. 4 is a fragmentary view of a portion of the apparatus of FIG. 3;

FIG. 5 is a schematic illustration of a modified control circuit embodying the present invention; and

FIGS. 6–8 are portions of the control of FIG. 5 shown in various operative positions.

FIG. 1 illustrates an example of a conventional domestic clothes dryer **10** of a type with which the invention may be used to advantage. The dryer **10** comprises a cabinet **11** having an inner chamber **12** in which a perforated drum **13** is rotatably supported. The drum **13** may be loaded with clothes or fabrics to be dried through an access door **14** which is connected to the cabinet by hinges **15**.

Rotation of the drum **13** is effected by a drive motor **17** which is operatively connected to the drum through suitable transmission means, such as a belt **18** and pulleys **19** and **20**, which are secured on the motor and drum shafts **21**, **22**, respectively. Heating means, such as an electrical resistance type heater **24**, or its equivalent, is provided to heat air drawn through an intake opening **25**, over the heater **24**, through the drum **13**, and an exhaust duct **27**, by a suitable blower or fan **26** which is driven by the motor **17**.

Energization of the motor **17** and heater **24** is controlled by a control circuit **30** (see FIG. 2) including a function control switch assembly generally indicated at S in FIGS. 1 and 3. The function control switch S is provided with a control knob K which is manually operable by a user of the apparatus to initiate and terminate drying of the articles placed in the drying apparatus, and the precise mode of operation of the switch S is described presently.

The desired moisture content of articles in the drum at the end of a drying cycle of the apparatus is selected by rotation of a knob **29** (see FIG. 2) which is associated with suitable indica (not illustrated) for indicating when a desired dryness of particular articles to be dried has been selected. When the knob **29** has been positioned as desired, the control knob K is pushed in to start operation of the dryer **10**.

Pushing in the control knob K closes the contacts of switches S1, S2 (see FIG. 2) which permits completion of energization circuits from a two phase three wire alternating current power supply, such as a 220 volt alternating current power supply available for household use, through the motor **17** and heater **24**, respectively. The motor **17** is energized from the line L1 through junctions **31**, **32**, the closed contacts of the switch S1, a junction **33**, through a door switch **34**, which is described presently, a junction **35**, the windings of the motor **17**, and a junction **36**, the neutral line LN. Completion of the motor circuit just described is effective to energize the motor **17** by single phase alternating current of approximately 110 volts across the line L1, LN. A light **37** is connected in parallel with the motor **17** between the junction and a junction **38** at the line LN, so that when the door **14** is closed and the motor **17** is operating, the light **37** is operative to illuminate the interior of the drum **13**. The light **37** may be of a germicidal type if desired.

When the motor **17** has accelerated the drum **13** to a predetermined rotational speed, a centrifugal switch S3, associated with the motor **17**, is closed to complete an energization circuit for the heater **24** from the line L1 through the junction **31**, the junction **32**, contacts of the switch S2, the heater **24**, a variable load resistor **40** operable to control the temperature of the heater **24**, contacts of the centrifugal switch S3, and to the line L2. Connection of the heater **24** between the lines L1, L2 provides for energization thereof by 220 volt AC current from the power supply.

It is apparent from the above description that operation of the motor **17** controls energization of the heater **24**, and that the energization circuit for the motor **17** is connected between the lines L1, LN through the door switch **34**. The door switch **34** includes a moving contact **34***a* and stationary contacts **34***b*, **34***c*, with which the moving contact **34***a* is alternately engageable. When the door **14** is closed, the door switch **34** is in its position illustrated in FIG. 2 whereby the motor energizing circuit for the motor **17** may be completed. If for some reason, the user of the dryer **10** should desire to open the door **14** while the motor **17** and heater **24** are energized, the moving contact **34***a* of the door switch **34** moves out of engagement with the fixed contact **34***c* and into engagement with the contact **34***b*. Actuation of the door switch **34** by opening of the door **14**, thus interrupts the energizing circuit for the motor **17**, which in turn interrupts the energizing circuit for the heater **24** so that neither the motor **17**, nor heater **24** are energized when the door **14** is opened. With the moving contact **34***a* closed upon the fixed contact **34***b*, the light **37** is connected between the junction **31** at the line L1, through the door switch **34**, the junction **33**, and to the junction **38** at the line LN so that the light **37** maintains the interior of the drum **13** illuminated when the door **14** is opened even through the motor **17** is de-energized.

Assuming that the door **14** is closed and the switches S1, S2 are closed so that the motor **17** is revolving the drum **13**, and the heater **24** is energized, articles such as clothing, in the drum **13** are tumbled within the drum and the flow of heated air is circulated through the drum into contact with the articles to effect a drying thereof in a manner which is well known. During such operation of the dryer **10**, the control circuit **30** is effective to govern operation of the dryer in response to sensed moisture content of the articles being dried. In the illustrated embodiment, the control circuit **30** is connected in parallel with the motor **17**, between the junction **35** in the motor energizing circuit, and the line LN.

The control circuit **30** includes a moisture sensing signal circuit which may be traced from the junction **35**, through a junction **41**, a diode D1, a junction **42**, a resistor R1, a junction **43**, a resistor R2, junctions **44**, **45**, through spaced electrodes forming a sensing means generally indicated at **46** located in the drum **13**, and to the junction **47** at the line LN. The diode D1 cooperates with a capacitor C1 connected between the junction **42**, and a junction **50** at the line LN to provide a filtered half wave power supply for energizing the signal circuit just described, and the remaining elements of the control circuit **30**.

The drum sensor unit **46** includes spaced electrodes **51**, **52** which, in the illustrated embodiment, comprise a band of conductive material extending around the inner periphery of the drum **13**, as viewed in FIG. 1, and the conductive material of the drum **13** adjacent the band **51**. For this purpose, the drum **13** is formed of conductive material and suitably grounded. The electrode **51** is in-

sulated from the drum 13 so that conduction between the electrode 51 and the drum 13 occurs only when damp fabrics being tumbled in the drum simultaneously engage the drum and the electrode 51, so that the damp fabrics form part of the conductive path of the signal circuit. The electrode 51 is connected into the signal circuit by a suitable slip ring assembly generally indicated at 53 in FIG. 1 and since such slip ring assemblies are conventional in the art, further description thereof is not necessary. It should be understood that the present invention may be used in conjunction with any suitably constructed drum sensor unit and that the drum sensor 46 illustrated and described herein is merely exemplary of one type of construction which might be used.

It should be appreciated by those skilled in the art that the resistor R2 and the drum sensor 46, in conjunction with damp fabrics in bridging engagement with the electrodes of the drum sensor, combine to form a voltage divider which produces what may be termed a signal voltage at the junction 44, and which signal voltage varies inversely with the moisture content of the articles contacting the drum sensor 46. When the operation of the dryer 10 is first initiated with wet articles in the drum 13, the voltage at the junction 44 is relatively low due to the relatively high conductivity of the fabric articles bridging the sensors. As the moisture content of the articles in the drum 13 is continually reduced, the voltage level at the junction 44 increases since the resistance of the articles in the drum 13 has been increased because of the decrease in moisture content thereof. As the drum is rotated as described, the articles therein are tumbled and may, at random intervals, be thrown out of engagement with the electrodes 51, 52, thus causing interruption of the signal circuit, at such intervals. When the articles do not bridge the electrodes, the resistance between the electrodes increases to that of the air gap therebetween so that the voltage at the junction 44 is approximately at half supply voltage.

The control circuit 30 includes an electrically energized actuating means 55 which is connected between the junction 41 and the line LN, through the anode and cathode electrodes of a silicon controlled rectifier or SCR. The SCR is rendered conductive by triggering circuitry connected between the gate electrode 56 of the SCR and the junction 44 in the signal circuit, which triggering circuitry is described presently, so that an energizing circuit for the actuating means 55 is established from the line L1, through the junction 31, junction 32, contacts of the switch S1, junction 33, contacts 34*a*, 34*c* of the door switch 34, junction 35, junction 41, the actuating means 55, anode and cathode electrodes of the SCR, and to the line LN.

The actuating means 55 is constructed in such a manner that when the articles in the drum 13 have reached a predetermined moisture content, the actuating means effects opening of the switches S1, S2 in the motor and heater circuits of the dryer 10 through a link or latching mechanism M (illustrated schematically in FIG. 2). Operation of the mechanism M by the actuating means 55 effects termination of operation of the dryer 10 when the fabrics therein have been dried to a desired low moisture content. As previously noted, the SCR controls energization of the actuating means 55 and is rendered conductive during positive half cycles of the power supply by the aforementioned triggering circuitry whenever the instantaneous voltage at the junction 44 is above a predetermined level, so that the actuating means is energized at the random intervals during which the fabrics in the drum do not bridge the electrodes of the drum sensor 46, and is also energized constantly when the fabrics in the drum 13 have been dried to a predetermined relatively low moisture content which moisture content results in voltages at or above the predetermined level at the junction 44.

As noted previously, the SCR is rendered conductive by the triggering circuit which in the embodiment of FIG. 2 includes an amplifier comprised of transistors Q1, Q2. The gate electrode 56 of the SCR is connected into the output circuit of the PNP transistor Q1 at a junction 57, and which output circuit may be traced from the line L1 to the junction 35, through the junction 41, the diode D1, junction 42, resistor R1, junction 43, junctions 60, 61, a resistor R3, the emitter 62, and collector 63 of the transistor Q1, the junction 57, the gate electrode 56 of the SCR and to the line LN. A resistor R4 is connected between the junction 57 and a junction 64 at the line LN to establish a positive voltage between the gate 56 of the SCR and the cathode electrode thereof, in a manner which is well known. Thus, when the transistor Q1 is conductive, the SCR is rendered conductive during positive half cycles of the power supply to establish an energizing circuit through the actuating means 55, and when the transistor Q1 is in a nonconductive state, the SCR is also nonconductive thereby preventing energization of the actuating means.

The transistor Q1 is rendered conductive in response to conduction of a field effect transistor Q2 which has its input electrode 65 connected to the junction 44 in the signal circuit. The input impedance of the input circuit of the transistor Q2 is orders of magnitude greater than the impedance afforded by dry fabrics across the electrodes of the drum sensor 46, and thus the input electrode 65 of the field effect transistor Q2 can be connected directly to the point 44. When the voltage at the point 44 is sufficient to render the transistor Q2 conductive, an output circuit for the transistor Q2 is established from the line L1 to the junction 35, through junction 41, diode D1, junction 42, resistor R1, junctions 43, 60, a resistor R5, the junction 67, electrodes 70, 71 of the transistor Q2, a junction 72, a wiper 73 of a potentiometer P1, a resistor R6, and a junction 74 at the Line LN. The wiper 73 of the potentiometer P1 is linked to the knob 29, and is movable relative to the potentiometer P1 to control the voltage at the electrode 71 of the transistor Q2 relative to the voltage at the input electrode 65 thereof. In this regard, it will be apparent that the potentiometer P1 and resistor R6 combine with a resistor R7 to form a voltage dividing circuit between the junction 61 and the junction 74, and since the resistors R6, R7 are fixed resistors, movement of the wiper 73, by rotation of the knob 29, controls the voltage across the electrodes 65, 71 of the transistor Q2 at which that transistor is rendered conductive.

The base electrode 75 of the transistor Q1 is connected to the electrode 70 of the field effect transistor Q2 at the junction 67, so that when the transistor Q2 becomes conductive as described, the voltage at the junction 67 is reduced, which in turn reduces the voltage at the base 75 of the transistor Q1 relative to the voltage at its emitter 62. With the base 75 of the transistor Q1 being negative to the voltage at the emitter 62 thereof, an emitter base circuit is established for the transistor Q1, from the emitter 62, through the base 75, junction 67, electrodes 70, 71 of the transistor Q2, the junction 72, potentiometer P1, resistor R6, and the junction 74 at the line LN. Establishment of the base emitter circuit, as described, produces transistor action in the transistor Q1 to render the emitter collector circuit thereof conductive to trigger the SCR into a conductive state and energize the actuating means 55 as described above.

Operation of the triggering circuitry for the SCR should be apparent from the foregoing description. When extremely damp fabrics are contained within the drum 13 and the dryer 10 is operating, as described, the resistance through the fabrics between the electrodes of the drum sensor 46 is relatively low, resulting in a relatively low voltage in the junction 44 of the signal circuit. As the articles are dried and the moisture content thereof is reduced, the resistance of the fabric

across the electrodes of the drum sensor **46** increases causing an increase in the voltage at the junction **44**. Similarly, when the electrodes of the drum sensor are not bridged by fabrics, the resistance between the electrodes is extremely high, and the voltage at the junction **44** increases accordingly to effect triggering of the SCR. When the fabrics in the drum **13** have reached a preselected moisture content, as determined by the setting of the wiper **73** of the potentiometer P1, the voltage at the junction **44** produced by articles of the preselected moisture content across the electrodes of the drum sensor **46** renders the transistor Q2 conductive, turning on the transistor Q1 and triggering the SCR. It is apparent that the transistor Q1 conducts continuously when the articles are dried as desired due to the filtered rectified power applied across its emitter-collector circuit, however, the SCR conducts only during the positive half cycles as is well known.

A capacitor C2 is connected between the junction **45, 72** in parallel with the input electrode **65** of the transistor Q2 and its output electrode **71** for the purpose of bypassing electrical noise around the transistor Q2. It is apparent from the foregoing that the SCR is rendered conductive when the fabric articles in the drum **13** have reached a preselected moisture content, and at random times during the drying process during which the fabrics are not in bridging engagement with the electrodes of the drum sensor **46**.

A preferred construction of the switch assembly S including the switches S1, S2, knob K, and switch operating member **80**, the actuating means **55**, and the mechanism M linking the actuating means to the switch operating member **80** is shown in FIG. 3, wherein these elements are contained within a suitably constructed box-like container **81**. The container **81** supports leaf contact members **82, 83, 84** therein, which are preferably molded into the container **81** to provide terminals **85, 86, 87**, the ends of which extend outwardly from the container. The contact members **82–84** include contacts **82***a*, **83***a*, which provide the contacts for the switch S2 and contacts **83***b*, **84***a* providing the contacts for the switch S1. The contact member **82** is connected through the heater energizing circuit to the line L2 while the terminal **87** of the contact member **84** is connected through the motor energizing circuit to the line LN. The terminal **86** of the contact member **83** is connected to the power line L1 so that power is supplied thereby to the motor and heater circuits respectively.

The contact members **82–84** are operated to open and close the contacts thereof by the switch operating member **80** which is a shaft-like member having a knob receiving shank **93** to which the knob K is connected and a generally cylindrical shaft portion **94** formed integrally with the shank **93**, and which is supported adjacent its ends for axial movement within the container **81**. The shank portion **93** is supported by a support plate **95** which is suitably fixed in the container **81**, and includes an opening therein shaped to correspond to the cross section shape of the shank **93**. The shaft portion **94** is supported by a support plate **96** having an opening therein shaped to receive the right end shaft portion. The openings in the support plates **95, 96** are slightly larger than the shank portion **93** and shaft portion **94** of the switch operating member, so that the switch operating member is freely movable longitudinally relative to the plates.

When the drying apparatus **10** is to be rendered operative, the knob K is pushed in (to the right in FIG. 3) to move the switch operating member **80** to the right so that such movement of the switch operating member effects closing of the switches S1, S2. More specifically, the shaft portion **94** of the member **80** carries a cam member **92**, formed integrally therewith, and which cooperates with the contact member **84** to close the contacts of the switches S1, S2 when the member **80** moves toward the right and permits opening of the contacts when the member moves left. The contact members **82–84** are positioned so that they are closely spaced but separated from each other when in a relaxed condition. The contact member **84** carries a reversely bent portion at its end which forms cam following surfaces **90** thereon cooperable with the cam member **92** to effect movement of the contact member **84** into engagement with the contact member **83** when the member **80** is pushed in, and the contact member **83** is deflected into engagement with the contact member **82**, closing the switches.

When the switch operating member **80** has been moved to the right a sufficient distance to close contacts of the switches S1, S2, the mechanism M is effective to latch the member **80** in its position, illustrated in FIG. 3. The mechanism M includes a supporting or base member **100** which is preferably constructed of parallel extending arms **101** (only one of which is shown in FIG. 3) which are interconnected by a web member **102**. The base member **100** also includes a flange portion **103** extending to the right from the web member **102** and which includes a part extending through a suitably formed opening in the support plate **96**, so that the base member **100** is pivotally movable about the point of engagement of the part of the flange portion **103** and the support plate **96**.

An arm **104** is formed integrally with the base member **100** and extends from the web member **102** substantially parallel to the axis of the shaft member **94**. The free end of the arm **104** includes a finger-like member **105** which extends into engagement with the shaft portion **94** of the switch actuating member **80**. The arm **104** and finger **105** are urged into engagement with the shaft portion **94** by a compression spring **106** which is held between a shoulder **107** on the shaft **94**, and the arms **101** of the support **100**. The compression spring **106** urges the support member **100** of the mechanism M in a clockwise direction, as viewed in FIG. 3, to bias the finger **105** of the arm **104** into engagement with the shaft portion **94**.

When the switch operating member **80** is in its position illustrated in FIG. 3, the finger **105** of the arm **104** is in engagement with a shoulder **110** formed on the shaft portion **94** of the switch operating member so that movement of the switch operating member to the left from the biasing force of the spring **106** is prevented.

During normal operation of the drying apparatus **10**, the switch operating member **80** is locked in its position shown in FIG. 3 to maintain the switches S1, S2 closed until the articles in the drum **13** have reached a predetermined moisture content, at which time the actuating means **55** is rendered effective to unlatch the finger **105** of the arm **104** from the shoulder **110** on the shaft **94** so that the switch operating member **80** is moved to the left by the action of the compression spring **106**.

The actuating means **55** is constructed to absorb the energizing current passing therethrough when the SCR is rendered conductive in response to random disengagement of articles in the drum from the electrodes of the drum sensor **46**. In the embodiment illustrated in FIGS. 2–4, the actuating means **55** is a heat motor which includes a power element **111**, and a heater **112** for the power element. The power element **111** is of conventional construction, and preferably includes a body member **113** having a cavity portion therein partially filled with a thermally expansible wax, or similar substance, which is suitably contained within the cavity, and a piston **114** in the cavity which is moved axially relative to the body member in response to increases in volume of the substance in the cavity caused by temperture increases. The piston **114** includes a rod portion **115** which is connected to the body **113** by a tension spring **116**, which urges the piston **114** into the cavity in the body member. The heater **112** encircles the body **113** in close heat exchange relationship therewith so that when the SCR is rendered conductive, the heater **112** is energized and transfers heat to the thermally responsive substance in the body **113**.

It should be apparent that when the SCR is rendered conductive at random times during the drying cycle, the heat from the momentarily energized heater **112** is absorbed by the thermally responsive substance without moving the piston **114** appreciably. However, when the articles in the dryer have reached their preselected low moisture content and the SCR is continuously conductive during alternate half cycles of the power supply, heat is provided to the heat motor at a relatively high rate so that after a brief interval, the substance in the cavity of the power element expands sufficiently to move the piston through the remainder of its travel. It should be apparent that the amount of travel of the piston due to random energization of the heater varies depending on the construction of the electrodes, the number and character of articles being dried, and the amount of heat dissipated from the power element. For this reason, a thermally responsive substance is selected which has a time constant of expansion slightly greater than the time during which the heater is randomly energized throughout a drying cycle under the most unfavorable conditions. While the heater **112** has been shown in the form of a coil surrounding the body **113** of the heat motor, it should be appreciated that other forms of heaters could be utilized, such as a film heater surrounding the body member of the heat motor.

The rod **115** of the piston **114** is connected to an arm member **125** of the mechanism M by a suitable lost motion connection, generally indicated at **126**, so that after a predetermined amount of expansion of the substance within the body **113** of the power element, the piston rod engages the arm **125** of the mechanism M and urges the arm toward the right as viewed in FIG. 3, resulting in counter-clockwise movement of the base member **100** and arm **104** of the mechanism M, about the point of engagement between the flange **103** and the support plate **96**. It is apparent that as the mechanism M is rotated counter-clockwise, as viewed in FIG. 3, the finger **105** is moved out of engagement with the shoulder **110** of the switch operating member **80**, resulting in movement thereof to the left as viewed in FIG. 3, by the action of the compression spring **106**. As the switch actuating member **80** moves to the left, the contacts of the switches S1, S2 are opened by the camming action between the surfaces **90** of the contact member **84** and the cam member **92**.

The mechanism further includes ratchet means for permitting termination of operation of the apparatus **10** independently of operation of the actuating means **55** when it is desirable to manually terminate operation of the apparatus during the drying cycle. The manual terminating ratchet means is best illustrated in FIG. 4 and includes a star wheel **130** having a supporting shaft **131** extending from opposite sides thereof, and which shaft is supported at each of its ends by a pair of parallel projecting members **132**, formed integrally with the arm **104** of the mechanism M. The members **132** extend toward the shaft **94** and provide a slot therebetween in which the shaft **131** of the star wheel **130** is supported for rotation with respect to the arm **104** and for lateral shifting movement in the slot.

When the switch operating member **80** is in its position illustrated in FIG. 3, a tooth **130***a* of the star wheel **130** is engaged by a shoulder **133** of the shaft member **94**, so that when knob K is pushed in to manually terminate operation of the drying apparatus, the shoulder **133** effects a clockwise rotation of the star wheel **130**. As the star wheel rotates, a tooth **130***b* of the star wheel is moved into engagement with the arm **104** to cam the arm **104** away from the shaft **94**, thereby moving the finger **105** out of engagement with the shoulder **110**. The arm **104** is provided with a spur-like projection **134** against which the tooth **130***b* of the star wheel is moved upon clockwise rotation thereof, and the projection **134** and tooth **130***b* of the star wheel cooperate to prevent counterclockwise rotation of the star wheel **130** from its position shown in FIG. 4. It is apparent from the drawings that the teeth **130***a*, **130***c* of the star wheel are slidably engaged on the cylindrical surface **135** between the shoulders **110**, **133** on the shaft and maintain the finger **105** spaced from the shaft when the shaft is pushed in. When the knob K is released, the compression spring **106** urges the switch actuating member **80** to the left, as viewed in FIG. 4, to its limit position wherein the contacts of the switches S1, S2 are opened, and operation of the drying apparatus **10** is terminated. The tooth **130***c* of the star wheel remains engaged with the surface **135** as the member **80** moves toward the left and thus prevents the finger **105** from reengaging the shoulder **110** as the member **80** moves toward the left.

In certain dryers of the type referred to, it is desirable to provide a cool-down cycle after termination of the drying cycle during which the motor **17** remains energized to tumble the articles in the drum **13**, and provide a forced flow of air through the drum into contact with the articles, but with the heater **24** being de-energized so that the articles are cooled by the forced flow of ambient temperature air. After the fabrics in the drum **13** have been exposed to the atmospheric temperature air for a relatively short period of time, the motor **17** is de-energized and the articles may be removed from the drum **13** without discomfort to the user. Such a cool-down cycle for the illustrated drying apparatus **10** may be provided by connection of a thermostatic switch S4 in parallel with the motor energizing switch S1. The switch S4 is illustrated schematically in FIG. 2 as a bimetallic switch, although other types of thermostatic switches could be employed.

The switch S4 is exposed to the flow of air through the drum **13** so that when the heater **24** is energized, the high temperature air causes the contacts of the switch S4 to be close. Thus, the switch S4 and the switch S1 are both closed during the drying cycle of the apparatus. After the actuating means **55** has opened the switches S1, S2 at the end of the drying cycle, the heater is de-energized but the motor **17** remains energized through the closed contacts of the switch S4. After a predetermined time, the switch S4, which is exposed to atmospheric temperature air passing through the dryer, opens to de-energize the motor **17**.

FIGS. 5–8 illustrate a modified control circuit embodying the present invention. It is apparent from FIG. 5 that the signal circuit, including the resistor R2 and the drum sensing unit **46**, are the same as described above in reference to FIG. 2, and that the triggering circuit connected between the signal circuit and the SCR are also the same as described in FIG. 2, and reference should be made to the descripiton of FIG. 2 for the operation of the circuit of FIG. 5.

The actuating means **155** of FIG. 5 includes an AC induction timer motor **156** having its field winding connected in series with the SCR, so that during a positive half-cycle of the power supply, the windings of the motor **156** are energized when the SCR is rendered conductive. A diode D2 is connected in parallel with the SCR so that during negative half cycles of the power supply, the field windings ofthe motor **156** are energized regardless of the condition of articles in the drum **13**. When the voltage level at the junction **44** is sufficiently high to render the transistors Q1, Q2 conductive to trigger the SCR; that is to say, when the articles in the drum are out of contact with the electrodes of the drum sensor **46**, or when the articles in the drum are of sufficiently low moisture content to develop the requisite voltage at the junction **44**, the field windings of the timer motor **156** are rendered conductive during positive half cycles of the power supply due to conduction of the SCR, so that the armature **157** of the motor **156** is rotated.

The construction of the motor **156** is such that the armature **157** thereof is not rotated when the field windings are energized only during alternate half cycles, for example, negative half cycles of the power supply in the illustrated embodiment, and only rotates after the field

windings have been energized during several successive full cycles of the power supply. The motor **156** is such that the armature **157** thereof abruptly ceases to rotate when not energized by successive positive and negative half cycles of the power supply. When articles in the drum **13** have not reached their preselected dryness, but are moved out of engagement with the electrodes of the drum sensor **46**, the timer motor **156** may be briefly energized to effect rotation of the armature. When the articles in the drum **13** have reached their preselected dryness, the triggering circuit is continually energized to maintain the SCR in a conductive state during successive positive half cycles of the power supply, and the armature of the timer motor **156** is continually rotated.

The armature **157** of the timer motor **156** is drivingly connected to the switch contacts of the switches S1, S2 through a suitable mechanism such as the cam **158** illustrated in FIGS. 6–8, which controls the positioning of contact members **160, 161, 162** forming the switches S1, S2. The cam **158** may also be manually rotated by a control knob K1 (see FIG. 5) which is associated therewith, and which control knob is operated by the user of the apparatus to manually control the operation performed by the drying apparatus.

When operation of the drying apparatus is to be initiated, the control knob K1 is suitably actuated by the user of the machine to rotate the cam **158** to a position wherein the contact member **160** is moved into the engagement with the contact member **161**, and urges the contact member **161** into engagement with the contact of the member **162**. As illustrated in FIG. 6, the contact member **160** includes a cam following portion **160***a* which rides upon a lobe **165** of the cam **158** to close the switch contacts when operation of the drying apparatus is initiated.

When articles in the drum are momentarily out of contact with the electrodes of the drum sensor unit **46**, the motor **156** steps the cam **158** in a clockwise direction, as viewed in FIG. 6, with the lobe **165** of the cam **158** maintaining the contacts of the switches S1, S2 in engagement. The length of the cam lobe **165** is such that the cam following portion **160***a* of the contact member **160** continues to ride upon the surface **165** to maintain the contacts of the switches S1, S2 closed, in spite of the stepping action of the cam as the motor **156** is randomly energized. When the articles in the drum **13** have reached their preselected moisture content, the motor **156** is operated continuously driving the cam in a clockwise direction to step the cam following portion **160***a* of the contact member **160** onto the cam lobe portion **166**.

When the contact member **160** is in engagement with the lobe **166** of the cam **158**, the contact members **161, 162** are moved out of engagement to de-energize the heater **24**. The contact members **160, 161**, however, are still urged into engagement so that the motor **17** continues to drive the drum and circulate air therethrough; however, since the heater is de-energized, the air circulating through the drum **13** is at atmospheric temperature. Due to the low moisture content of the articles in the drum, the motor **156** is continuously driven and thus provides a cool-down cycle for apparatus **10** for the purpose described above. It is apparent that the cam lobe portion **166** is designed to be of such length that an adequate cool-down period for widely varying types of articles in the drum is provided.

It should be understood that the length of the lobe portion **165** need only be sufficient to accommodate random energization of the motor **156** so that when the articles in the dryer are of sufficiently low moisture content, the cool-down cycle is initiated a brief interval subsequent to continuous operation of the timer motor. Those skilled in the art will recognize that the length of the cam lobe **165** may be varied depending upon the construction of the electrodes of the drum sensor, as such constructions affect the probability of articles being out of contact with the electrodes at times during the drying cycle.

A notch **167** is formed in the cam **158** at the end of the lobe portion **166** so that at the end of the cool-down cycle, the contact member **160** is moved out of engagement with the contact member **161** (as shown in FIG. 8) to terminate operation of the motor **17**. Opening of the switch S1 additionally de-energizes the timer motor **156** so that operation of the drying apparatus **10** is terminated. It will be apparent from the construction of the cam **158** illustrated in FIGS. 6–8, that the apparatus can be re-energized by rotation of the knob K1 to move the contact members **160–162** into engagement as illustrated in FIG. 6.

Although it is apparent that many modifications could be made, the following values or characteristics have been found satisfactory in the construction of the circuitry of FIG. 2.

Transistors:

Q1	2N3638
Q2	2N4220
Diode D1	1N488
SCR	C106B

Resistors:

R1	ohms	180K
R2	do	22M
R3	do	2.2K
R4	do	2.2K
R5	do	10K
R6	do	10K
R7	do	10K
Potentiometer P1	do	20K

Capacitors:

C1	μf	.22
C2	μf	.02

It can now be seen that the objects heretofore enumerated and others have been accomplished, and that there has been provided a new and improved control for drying apparatus. While two preferred embodiments of the present invention have been illustrated herein and described in considerable detail, the present invention is not to be considered to be limited to the precise construction shown.

Having described my invention, I claim:

1. A control for a fabric article drying apparatus which is operative to terminate a drying cycle of said apparatus when the conductivity of articles therein reaches a predetermined value due to the articles being dried to a desired moisture content, said control comprising control switch means for said drying apparatus, electrically energized actuating means for operating said control switch means in response to a predetermined cumulative amount of energizing power being applied thereto, said electrically energized actuating means includes a thermally responsive power element and electric heating means in heat exchange relationship with said power element, said power element including a member movable to actuate said control switch means in response to a predetermined cumulative amount of heat transfer from said heating means to said power element and circuitry for controlling energization of said heating means including a signal circuit having electrodes in said apparatus for establishing an electric current through articles bridging said electrodes with the voltage level at a point in said circuit increasing as the moisture content of the articles bridging said electrodes decreases and increasing when said articles are randomly separated from said electrodes, and voltage responsive switching means for effecting energization of said heating means when the voltage at said point reaches a predetermined level, said heating means energized randomly during said drying cycle when said articles are separated from said electrodes and accumulating the heat resulting from said random energizations over the length of said drying cycle, said heating means being continuously energized for a brief interval when said articles reach a predetermined low moisture content to apply the remainder of said pre-

determined amount of energizing power to said heating means whereby said control switch means is operated to terminate the drying cycle.

2. A control as defined in claim 1 wherein said member of said power element is operatively associated with a switch operating member and latching mechanism, said power element member operative to effect operation of said switch operating member through a lost motion.

3. A control as defined in claim 2 wherein said latch mechanism is operable by a user of the dryer to effect termination of said drying cycle independently of operation of said actuating means.

4. A control for a fabric drying apparatus comprising electrically energized actuating means energized to effect a control function of said apparatus in response to a predetermined low moisture content of fabric being dried, switching circuit means connected in circuit to said actuating means and operable between conductive and nonconductive conditions to control energization of said actuating means, and sensing means including a signal circuit and electrodes in said circuit positioned for bridging engagement with articles being dried, said electrodes and articles cooperating to produce a signal voltage at a point in said circuit with the magnitude of said voltage increasing as moisture content of the articles decreases and with the voltage at said point increasing in magnitude randomly during drying of said articles when said electrodes are not bridged by articles, said switching circuit means including a field effect transistor having an input electrode connected to said point in said signal circuit and characterized by having an input impedance at least of the order of magnitude of the impedance of dry articles across said electrodes, said transistor being rendered operative to effect energization of said actuating means at said random times and when said articles have reached a predetermined moisture content.

5. A control for drying apparatus as defined in claim 4 wherein said semiconductor element includes output electrodes connected in circuit with the base and emitter electrodes of a transistor, said transistor changing its conductive state in response to a change in the conductive state of said semiconductor element to effect energization of said actuating means.

6. A control for drying apparatus as defined in claim 5 wherein the collector and emitter circuit of said transistor is connected to a gate electrode of an SCR and with said SCR operative to control energization of said actuating means.

7. A control as defined in claim 4 wherein an output electrode of said semiconductor element is connected to a circuit element for providing an adjustably variable voltage at said output electrode, said semiconductor element rendered conductive at a predetermined voltage across its input electrode and said output electrode, and said circuit element being adjustable to variably control the voltage level at said input electrode which renders said semiconductor element conductive.

8. A control as defined in claim 7 wherein said circuit element is a manually adjustable potentiometer.

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