

[54] **CLOTHES DRIER HAVING MOISTURE
SENSING CONTROL**

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patent subsequent to Mar. 28, 1989,
has been disclaimed.

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3,651,579, which is a continuation-in-part of Ser. No.
329,155, Dec. 9, 1963, Pat. No. 3,613,254, which is a
continuation of Ser. No. 22,323, April 14, 1960,
abandoned.

[52] U.S. Cl. **34/45**

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

[58] Field of Search 34/45, 48, 5

[56] **References Cited**

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[57] **ABSTRACT**

A control for a drying apparatus uses an electrical
breakdown device, for example, a neon bulb, to
generate a signal that actuates a relay when the arti-
cles sensed by electrodes attain a predetermined
moisture content as determined by their electrical re-
sistance. A timer motor is energized upon actuation of
the relay to control the drying apparatus in one em-
bodiment.

13 Claims, 8 Drawing Figures

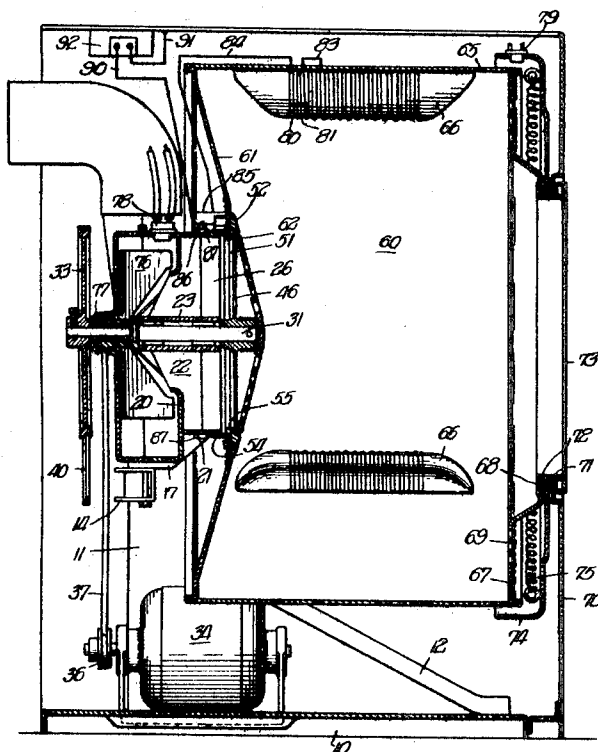


Fig. 1.

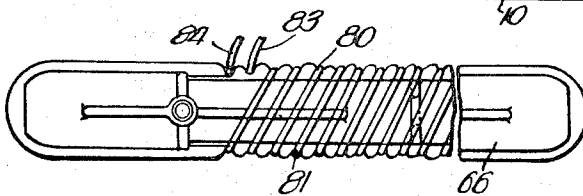
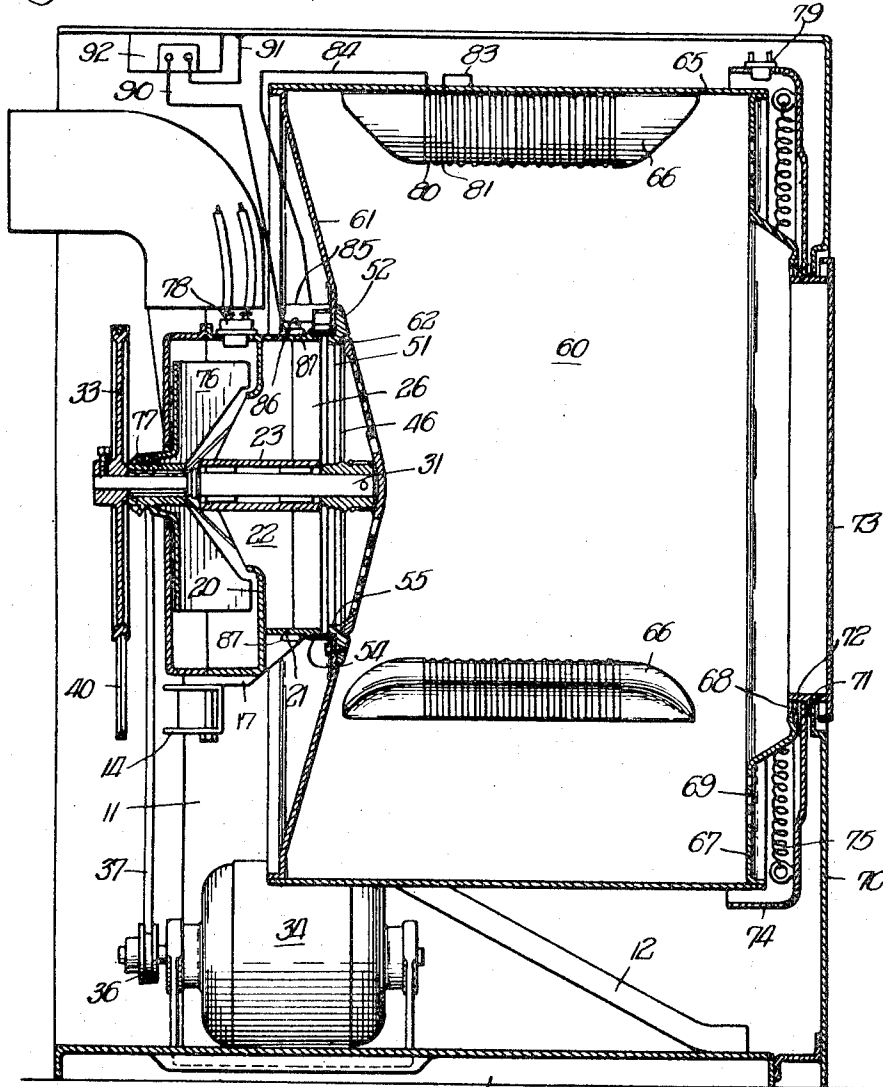


Fig. 2.

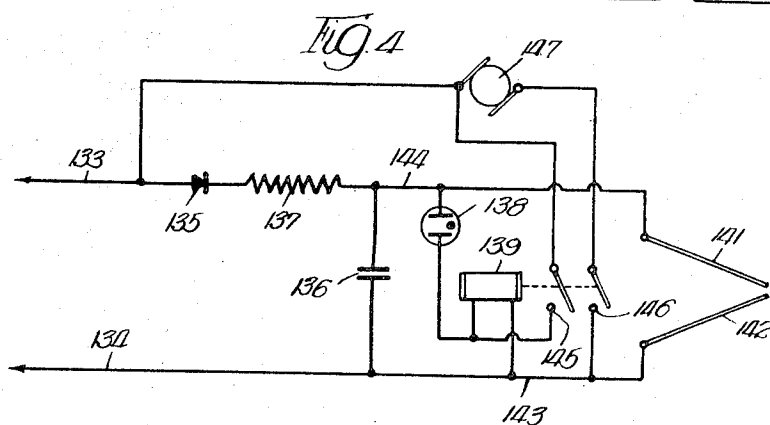
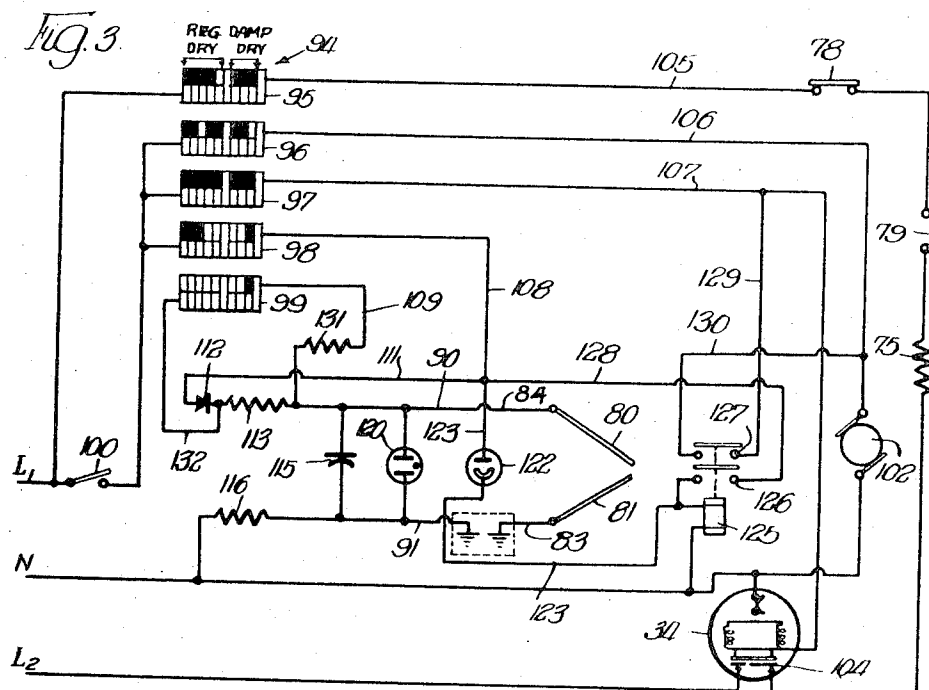


Fig. 5

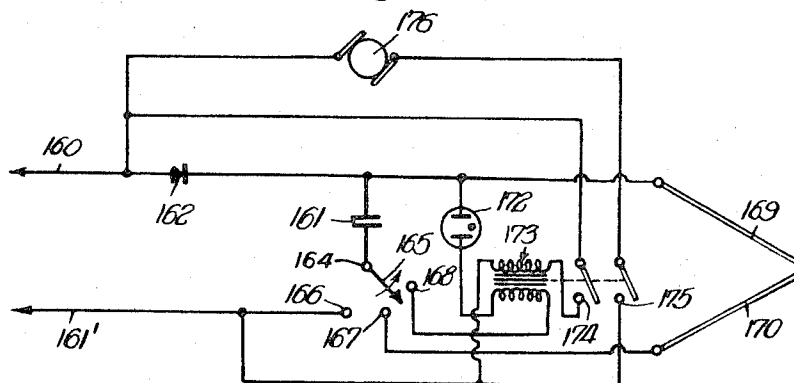
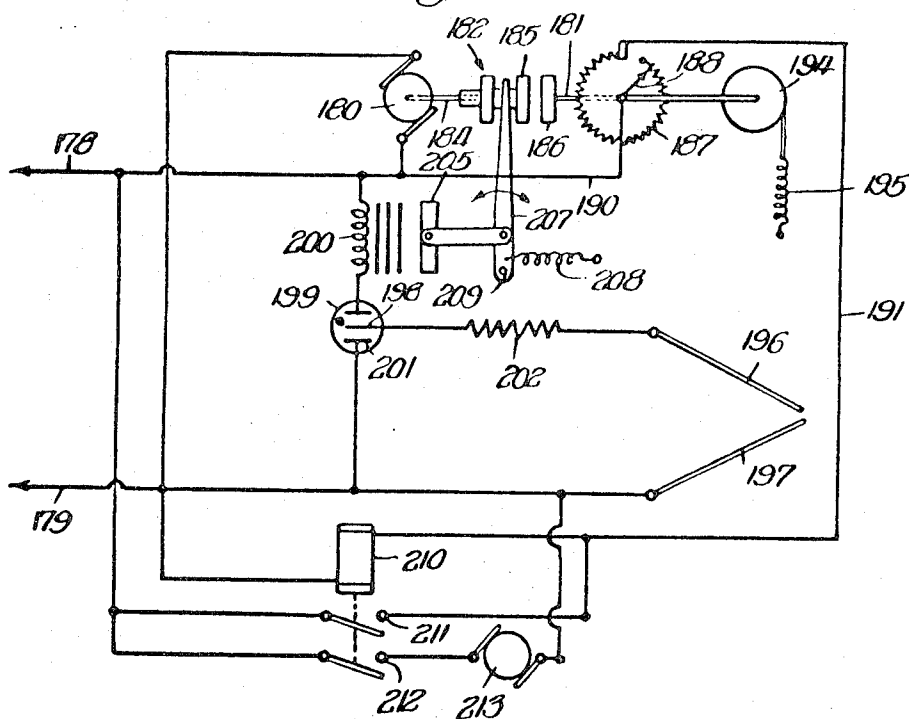


Fig. 6



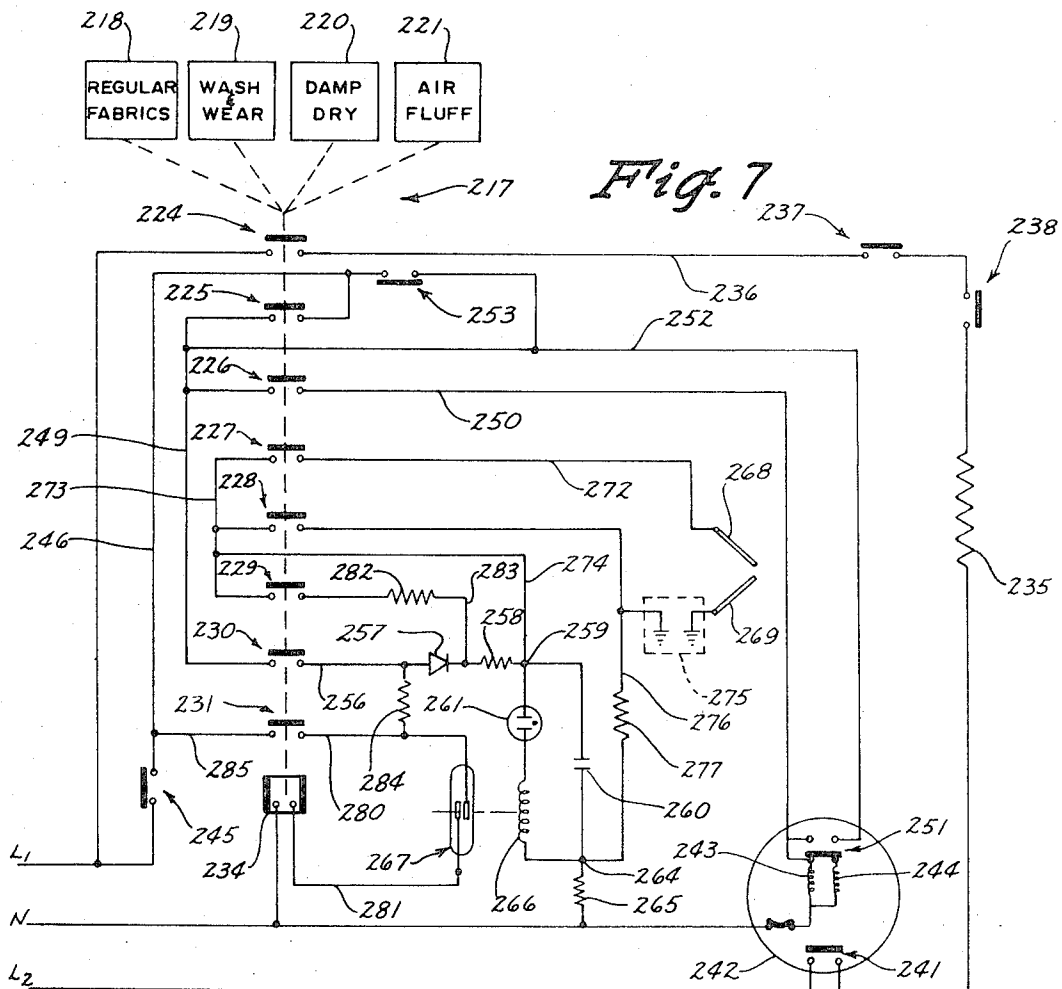


Fig. 8

PUSH BUTTON SWITCH	224	225	226	227	228	229	230	231
REGULAR	X	X	□	X	○	○	X	X
WASH & WEAR	X	X	□	X	○	○	○	X
DAMP DRY	X	X	□	X	○	X	X	X
AIR FLUFF	○	X	□	○	○	○	X	X
SOLENOID ACTUATED	○	○	○	⊗	X	⊗	○	○

X SWITCH
CLOSED

○ SWITCH
OPEN

□ SWITCH
MOMENTARILY
CLOSED

⊗ OPTIONAL

CLOTHES DRIER HAVING MOISTURE SENSING CONTROL

This application is a division of copending application Ser. No. 604,757 filed 12/27/66 now U.S. Pat. No. 3,651,579 the latter of which was filed as a continuation-in-part of application Ser. No. 329,155, filed Dec. 9, 1963, now U.S. Pat. No. 3,613,254, issued Oct. 19, 1971, which in turn is a continuation of application Ser. No. 22,323, filed Apr. 14, 1960, now abandoned.

This invention relates to a control system in a machine for drying fabrics, and more particularly, to a system for automatically controlling termination of the drying operation after the fabrics have reached a predetermined degree of dryness.

Most of the conventional driers, especially of the home laundry type, regulate the drying period by a manually adjustable timer which is preset by the operator. The duration of the drying operation depends upon the judgment, or guess, of the operator as to the proper period for the desired degree of dryness. The results are inconsistent overdrying, underdrying, or, in the case of some fabrics, incomplete drying of particular pieces.

Heretofore, numerous control systems for domestic clothes driers have been attempted in an effort to obtain automatic termination of the drying operation in a domestic clothes drier after the fabrics have reached the desired dryness. One of the major problems facing any automatic control system is the difficulty in obtaining consistently completely dried loads of mixed fabrics as found in the home laundry, since different fabrics vary in their moisture retentivity. In addition, some fabrics have both light and heavy, thin and thick sections, to further complicate the problem.

One previous system has used the change in conductivity of the fabrics as the moisture is removed in order to discontinue operation of a drying machine at the moment electrical conductivity of the fabrics, as sensed directly between conductors in the drum, attains a predetermined value. This type of control causes premature shut-off of the machine before the clothes are completely dry, especially with mixed loads, which frequently occur in the home, because some of the pieces dry long before others and the wet pieces when enclosed in, or shielded by, drier pieces causes instantaneous premature shut-off of the machine. In this type of control, since the drier operates only if a damp fabric is continuously contacting the electrodes, if at any moment none of the electrodes, or probes, within the drier drum contact a damp piece, the control will operate immediately to institute termination of drying. For this reason the control is unreliable, and unsatisfactory.

In other control systems, the humidity of the air within the drier is measured to determine when the drying operation should be terminated, instead of direct measurements of the electrical conductivity of the fabrics. Humidity determinations are an unreliable index of the condition of the fabrics, and control systems dependent thereon contain an inherent deficiency.

In still other systems attempts have been made to control the termination of the drying period by thermostats in the drier. In these systems the thermostats operate to shut-off the heaters when the temperature within the drying cabinet rises above a set value which occurs when most of the clothes have been dried. Again, the control does not insure that all of the fabrics have been dried.

It is an object of the present invention to provide a control system for a clothes drier responsive to the dry condition of the fabrics being treated. It is a further object of the invention to provide a system for controlling termination of a drying operation that is responsive to the isolated fabrics in a load, so as to obtain reliable shut-off of the drying operation. It is a still further object of the invention to provide a system whereby direct response of the control to the dryness or conductivity of fabrics is made practical or feasible for home laundry clothes driers. It is another object of the invention to provide a control system having a manually operable preselection adjustment which initiates termination of the drying operation when the clothes have reached the manually preselected condition of dryness, for example, when the fabrics are in damp dry condition suitable for ironing. Further objects and advantages of this invention will become evident as the description proceeds and from an examination of the accompanying drawings which illustrate several embodiments of the invention and in which similar numerals refer to similar parts throughout the several views.

IN THE DRAWINGS

FIG. 1 is a view in vertical section, partly broken away, illustrating a drier which incorporates the control system of the invention;

FIG. 2 is a bottom view of one of the baffles shown in the drum of the drier in FIG. 1, illustrating the location of the electrodes;

Fig. 3 is a schematic diagram of a preferred circuit employing the principles of the control system of the present invention;

Fig. 4 is a schematic diagram of a modified form of circuit which may be used as a control employing the principles of the invention;

FIG. 5 is a schematic diagram of a modified form of circuit which may be used as a control employing the principles of the invention;

FIG. 6 is a schematic diagram of a modified form of circuit which may be used as a control employing the principles of the invention;

FIG. 7 is an electrical schematic diagram of a modified form of circuit which may be used as a control including the principles of the basic invention; and

FIG. 8 is a chart showing the selective operation of the switches of the electrical diagram of FIG. 7.

Briefly described, the invention relates to a control system in which conductors, electrodes, or probes, directly contact fabrics being dried, and control termination of the drying operation after their electrical resistance, or conductivity, dependent upon their condition of dryness, exceeds a predetermined value for a predetermined time.

In FIG. 1 of the accompanying drawings is shown a clothes drier having a base frame 10 which serves as a support for upstanding channel base members 11 and 12 which together with cross piece 14 support the hollow blower housing casting 17. Housing 17 includes a tubular portion 21, a divider wall 20 having a rearwardly flared inner portion defining an intake into an impeller chamber, and radially directed longitudinal webs 22 which converge toward each other to provide a retainer member 23. A passageway 26 is located between the tubular portion 21 and the bearing retainer member 23 which transverses the supporting webs 22.

Journalled within member 23 is a revolvable drum drive shaft 31 which projects from both ends of the housing 17. Affixed to drum drive shaft 31 at the rear of the cabinet is a large pulley 33 which is driven by motor 34 through motor pulley 36, main drive belt 37, a speed reduction system (not shown) and belt 40.

The opposite or forward end of the drum drive shaft 31 is rigidly connected to the drum spider member 46 which has radiating spokes 51 that support rim 52. A heat resistant sealing member 54 encircles the front periphery of blower housing 17 and the circular shoulder 55 located on the rear portion of drum spider 46.

A horizontally mounted tumbling drum 60 has a rear wall 61 which is secured to rim 52 for support and rotation by shaft 31. Rear drum wall 61 is imperforate except for a central exhaust opening 62.

The periphery of rear wall 61 is flanged to form a supporting shoulder for the imperforate cylindrical side wall 65 which carries the clothes elevating vanes 66 for tumbling clothing within drum 60 during rotation of the latter member. Cylindrical side wall 65 is connected to the front drum wall 67.

Front wall 67 has a centrally located access opening 68 and a circular perforate portion 69 located concentrically to access opening 68. This perforate portion 69, formed by several concentric rows of holes, serves as the air intake into drum 60.

The cabinet 70 which is fastened to base frame 10 and which encloses the entire drying mechanism has an access opening 71 aligned to drum access opening 68 thereby allowing both of openings 68 and 71 to receive the door gasket 72. The door 73 is hinged and forms an airtight seal with gasket 72.

Fastened to cabinet 70 is the shroud or cowling member 74. Located between shroud 74 and the front drum wall 67 is an open coil electric heating element 75 which extends completely around the inside of cowling member 74 to raise the temperature of air passing through perforate portion 69 in the front drum wall 67. It will be understood that a gas heater may be used in place of the electrical element.

Air flow into drum 60 through the perforate area 69 and into the blower housing 17 is produced by rotation of the revolvable impeller member 76 located in blower housing 17. Fan pulley 77 is connected to the driving motor 34 by main drive belt 37. The blower housing casting 17 supports a cycling thermostat 78 which is connected in series with the heating element 75 in order to maintain the interior of drum 60 at the proper selected drying temperature. In practice, this switch is set to open at approximately 135°.

Also connected in series with the heating element 75 is the high limit switch 79 which is mounted on an upper part of shroud member 74 so as to disconnect heating element 75 from its source of power in case the temperature near the front of the drum should rise above a predetermined selected temperature during the operation of the clothes drier, for instance, in the event of reduced air flow through drum 60.

In order to measure the electrical conductivity or resistance for determining the condition of dryness of the fabrics, electrodes or probes 80, 81 are mounted within the drum 60. In the form shown, the electrodes are spirally wound about each of the drum baffles 66 to provide a maximum amount of contacting or probing surfaces exposed to the fabrics placed within the drum. As best illustrated in FIG. 2, the electrodes are preferably

set in recesses or grooves in the baffles to prevent shorting therebetween by metallic objects sometimes attached to the fabrics, for example, metal buttons, clips, buckles, and the like. It will be realized that different forms of electrodes, or probes, may be used, although the type disclosed herein is preferred.

Electrical energy is supplied to electrode 80 by lead 84 that is connected to brush 85 which engages the stationary slip ring 86 while the drum 60 is rotating. The slip ring 86 may be supported on an electrically insulative band 87 mounted on housing 17. Slip ring 86 is in turn connected to a lead 90 which runs to the control unit 92. Electrode 81 may also be supplied with electrical energy of the opposite polarity to electrode 80 by lead 83 that may be connected to a similar arrangement of brushes and slip rings. It is preferred, however, to ground electrode 81 to the rotatable drum 60, so that it is supplied by current from lead 91 which is also grounded to the frame work of the drier.

The automatic control unit 92 may be secured to the upper portion of the cabinet. Leads 90, 91 enter the control unit and are connected to the control circuit to be described hereinafter.

It will be noted that the baffles 66 are formed of electrically non-conductive material in order to insulate the electrodes. However, the electrodes are electrically shorted by contacting the wet fabrics during tumbling. Ordinarily, a plurality of baffles 66 are mounted within the drum 60, each of which is provided with electrodes 80, 81, and the respective electrodes of all the baffles connected in parallel.

Referring now to FIG. 3 which illustrates the automatic control circuitry, there is shown diagrammatically a timing cam stack 94 for controlling the drying operation. The cam stack has five cam switches 95 to 99 in which cam switch 95 controls the heater, cam switch 96 the timer motor, cam switch 97 the drive motor, cam switch 98 the sensing circuit, and cam switch 99 the damp dry setting.

It will be noted that the cam stack has "regular dry" and "damp dry" settings, either of which may be preselected through manual operation of a knob (not shown) by the operator. It should be clear that the cam stack may include other selections, for example, for wash and wear fabrics, air fluff, and special loads.

The cam stack 94 is advanced by a timer motor mechanism 102 in three minute intervals, each of which three minute interval is represented by the vertical lines in the cam stack 94 in the drawing. The shaded areas in the drawing indicate that the circuit is completed, while the blank portions means that the circuit is open at the time interval and for the cam switch specified.

The drier is energized by a conventional three wire system represented by power lines L₁, L₂ and N. The heater is connected between L₁ and L₂ for 220 volts a.c. by a circuit from L₁ through cam switch 95, line 105, thermostat switch 78, high limit switch 79 to one side of the heater 75. The other side of the heater is connected to power line L₂ through centrifugal switch 104 in motor 34. Centrifugal switch 104 is normally open. When motor 34 is rotated, switch 104 is centrifugally closed to energize heater 75.

The timer motor 102 is energized by a circuit from power line L₁, on-off switch 100, cam switch 96, line 106 to one side of the timer motor 102. The other side of the timer motor is connected to power line N.

The sensing circuit is energized by a circuit from power line L_1 , on-off switch 100, can switch 98, line 108.

The sensing circuit has a selenium half-wave rectifier 112 connected on one side to line 108 through line 111. The other side of the rectifier 112 is connected to capacitor 115 through a series resistor 113. The other side of the capacitor 115 is connected to power line N through series resistor 116. It will be noted that the electrodes 80, 81 within the drum are connected across the capacitor 115 by lines 90, 91. When the capacitor is charged by the d.c. circuit from the rectifier 112, it may be discharged by any conducting material placed across, and shorting, the electrodes 80, 81.

A gaseous discharge tube, such as a neon lamp 120 is connected across capacitor 115. Neon lamp 120 normally has an infinite resistance, however, when the charge on the capacitor 115 reaches a predetermined value, the gas is ionized and the circuit is conducted therethrough to produce visible discharge.

A light sensitive cell 122 is positioned to detect the discharge of the neon lamp 120. One side of the light sensitive cell 122 is connected by line 124 to line 108, and the other side of the light sensitive cell is connected to relay 125 through line 123. The other side of the relay 125 is fastened to power line N. Normally, when dark, the light sensitive cell 122 has a very high resistance. However, when it detects light, its resistance is greatly reduced and completes the circuit to energize relay 125.

Relay 125 operates switches 126 and 127. Switch 116 completes a holding circuit in order to maintain the relay 125 energized after the photo-electric cell 122 has been excited through the discharge of neon lamp 120. The holding circuit is from line 108 to line 128 through switch 126 to one side of the relay 125. The other side of the relay is connected to power line N.

Switch 127 controls the timer motor 102. When switch 127 is closed the timer motor is energized by a circuit from line 107, line 129, switch 127, line 130 to one side of timer motor 102. The other side of the timer motor 102 is connected to power line N.

It will be seen that the capacitor 115 is charged by a d.c. circuit through the rectifier 112 and series resistance 113, 116 to power line N. The rate at which the capacitor 115 is charged depends, among other factors, upon the value of resistors 113, 116. It has been found that if the power between L_1 and N is 110 volts 60 cycle alternating current, the capacitor 115 may be a 6 microfarads paper condenser and the total resistance of 113 and 116 is 31 megohms, or 30 and 1 megohms, respectively. The neon lamp in this arrangement may be designed to fire at 68 to 76 volts.

As the capacitor 115 is slowly charged through resistors 113, 116, it is also discharged through electrodes 80, 81 when the clothes are wet. However, as the clothes are dried, the average rate of discharge diminishes to a point at which the charge on the condenser reaches an amount which will fire the neon lamp 120. This operates the relay 125 through the photoelectric cell 122.

It will be apparent that resistors 113, 116 may be connected on the same side of capacitor 115. However, for safety reasons, it is better to divide the total resistance between the two sides of the capacitor.

From the foregoing, it is believed that the operation of the device is apparent. The operator opens the door 73 of the drier and inserts the fabrics in the drum 60. Next the cam timer is manually set to "regular dry" position and the on-off switch 100 closed. When the timer is set to the beginning of the "regular dry" position, the heater line 105 is connected to power line L_1 through cam switch 95. Also timer motor line 106, drive motor line 107 and sensing circuit line 108 are all connected to power line L_1 , if the on-off switch 100 is closed through cam switches 96 to 98, as indicated by the shaded areas in the cam stack 94. The drive motor 34 rotates the drum 60 to tumble the clothes therein by baffles 66. After a certain rotational speed is achieved by the drive motor 34, switch 104 is centrifugally operated to close the circuit to the heater 75.

The timer drive mechanism 102 when energized advances the cam stack 94 every three minutes. It will be noted that the timer drive mechanism 102 is maintained in energized position for a total of 6 minutes after which it is de-energized by the cam switch 96, as indicated by the blank area in the third 3 minute interval. When the timer drive mechanism is de-energized, continued operation of the drier is under control of the sensing circuit. The timer drive mechanism remains de-energized and the drier continues to operate until the timer drive mechanism is again energized to terminate the drying operation through actuation of the sensing circuit. With the timer drive mechanism de-energized, the drier operation continues with the heater energized and the drive motor rotating to tumble the fabrics within the drum 60.

As long as the clothes remain wet, or sufficiently damp to effectively discharge the capacitor 115, the drying operation is maintained. Although the capacitor 115 is charged by the rectifier and through resistors 113, 116 is continues to be discharged by the fabrics shorting electrodes 80, 81. However, when the moisture is removed, the fabrics achieve increased electrical resistance and the charge on the capacitor 115 begins to accumulate. The build up of the charge on capacitor 115 reaches a predetermined amount over a predetermined period of time of sufficient duration for all of the clothes within the drum to contact the electrodes during tumbling. Thus, if a damp fabric has been entrapped in dry fabrics, as the drum continues to rotate, the damp piece will eventually contact the electrodes 80, 81 and discharge the capacitor 115 to prevent termination of the drying operation. On the other hand, if the pieces are all dry, termination of the drying operation will be initiated.

One of the important features of the present invention is the time integration of the effective average resistance of the fabrics which fall across the probes with a predetermined average value necessary for initiating termination of the drying period. This reduces the occasion for premature termination of the drying operation.

After all of the fabrics have achieved a predetermined resistance for a predetermined period of time, the neon lamp 120 discharges. This excites light sensitive cell 122 to complete the circuit to the relay 125. When relay 125 is energized, it is maintained energized through the circuit completed through switch 126. The relay also completes a circuit through switch 127 to again energize the timer drive mechanism 102. The timer drive mechanism then begins to run through the

remainder of the open interval in the timer cam switch 96 and for 2 additional 3 minute periods making a total of approximately 6 minutes. It should be noted that at the end of the first additional 3 minute interval the heater circuit is de-energized at the end of the second 3 minute interval all remaining circuits are de-energized by the timer cam stack 94 and the drying cycle discontinued.

The additional 3 minute heating period insures that the clothes will be completely dry, even in the folds or thick portions which are often found in fabrics of the home laundry. The last 3 minute period of operation without heat obtains a cooling period to bring the temperature of the clothes down to a comfortable handling temperature.

In the event the operator desires the clothes to be damp dry, a condition suitable for ironing, the timer can stack 94 is manually positioned to "damp dry". In this position, operation of the device is similar to "regular dry" with two exceptions. The cam switch 99 connects resistor 131 in parallel to resistor 113. The circuit is completed by a line 132, cam switch 99, and line 109 to one side of resistor 131. The other side of resistor 131 is connected in parallel to resistor 113. Resistor 131, has, for example, a value of 330,000 ohms. This means that the total resistance in series with the capacitor 115 is substantially reduced. Thus, the capacitor 115 is charged at a greater rate. The increased rate at which the capacitor 115 is charged results in the neon lamp 120 being fired at a time when the resistance through the clothes as sensed by the electrodes 80, 81 indicates the clothes are still damp. The charge on the capacitor 115 accumulates more rapidly through the reduced value of the total resistance and overtakes the discharge through the electrodes at an earlier fabric resistance, so that the clothes are partially damp when the neon tube is discharged.

As in the instance of the "regular dry" position, in the "damp dry" position the relay 125 also completes a circuit through switch 127 to again energize the timer drive mechanism 102. The timer drive mechanism 102 then begins to run through the remainder of the open interval in the timer cam switch 96 at which time all circuits are de-energized. In this way, the clothes in the damp dry position are subjected to less heat before the drive motor is stopped, so that they contain the desired amount of moisture.

FIG. 4 shows a modified form of sensing circuit which may be employed in the control of FIG. 3. A rectifier 135 is connected on one side to a power line 133. The other side of the rectifier 135 is connected to the capacitor 136 through a series resistor 137. The other side of the capacitor 136 is connected to the power line 134.

The electrodes 141, 142, located within the drum of the drier, are connected across the capacitor 136 by lines 143, 144. When the capacitor 136 is charged by the d.c. circuit from the rectifier 135, it will be discharged by any conducting material placed across the electrodes, such as wet fabrics.

A gaseous discharge tube 138 and a relay 139 are connected between lines 143, 144 across the capacitor 136. The relay contacts 145, 146, normally open, are closed when the relay 139 is energized when the gaseous tube 138 becomes conductive. Contact 145 is in series with a holding circuit to maintain the relay 139 closed after the gaseous tube 138 has fired. Contact

146 connects the timer motor 147 of the control circuit to the power line 134. The other side of the timer motor is connected to the power line 133.

In operation, the sensing circuit of FIG. 4 operates to fire the gaseous tube 138 when the resistance of the clothes, as determined by the electrodes 141, 142, reaches a predetermined value. During the time the clothes are tumbled, the capacitor 136 is gradually charged by a d.c. circuit through the rectifier 135 and through the series resistance 137 at a rate which is less than the discharge from the capacitor through the electrodes 141, 142 when the clothes are wet, however, when the clothes reach a predetermined dryness the capacitor 136 is charged faster than it is discharged through the electrodes. When the capacitor charge accumulates to a predetermined value, the discharge tube fires to energize relay 139. The relay is kept energized by holding circuit through relay switch 145. Relay switch 146 completes the circuit to the timing motor 147 which initiates the termination of the drying operation.

An alternative form of sensing circuit is shown in FIG. 5 in which a half-wave rectifier 162 is connected on one side to power line 160. The other side of the rectifier 162 is connected to a capacitor 161. The opposite side of the capacitor 161 is connected to a rotor switch 164. Rotor switch 164 has a switch blade 165 rotated by a drive mechanism (not shown). The switch blade 165 successively and alternately engages contacts 166, 167 and 168.

Switch contact 166 is connected to the other side of the power line 161' so that when the switch blade engages contact 166, capacitor 161 is charged through the rectifier 162. The switch blade, as it continues to rotate, opens the circuit to the power line 161' and contacts the contact 167 which connects the capacitor 161 across electrodes 169, 170, located within the drum of the clothes drier, in order to contact the tumbling clothes. If the clothes are wet the capacitor will be discharged through the electrodes 169, 170, when switch blade 165 engages contact 167. Delay time of switch blade 165 on contact 167 may be varied to obtain the desired dampness of the clothing. On the other hand, if the clothes are dry, the capacitor will retain its charge.

The switch blade 165 next touches contact 168 which places the capacitor 161 across the circuit which has in series a gaseous tube 172 and relay 173. If the charge on the capacitor 161 is nil, or only of small value, because it has been discharged through the clothes, the gaseous tube is undisturbed. However, if the capacitor 161 has built up a certain charge, as determined by the value of the gaseous tube 172, the tube 172 will fire and energize relay 173. When the relay 173 is energized, contacts 174, 175 are closed. Contact 174 completes a holding circuit to maintain the relay energized, while contact 175 energizes the timing motor 176 to initiate termination of the drying operation.

The sensing circuit of FIG. 5 is the subject matter of Ser. No. 334,086, filed Dec. 30, 1963, issued as U.S. Pat. No. 3,221,417, Dec. 7, 1965 assigned to the same assignee.

Yet another form of the sensing circuit is shown in FIG. 6 of the drawing. In the sensing circuit of FIG. 6, a motor 180 is connected to power lines 178 and 179. Motor shaft 184 of motor 180 drives a shaft 181

through a slip clutch 182. The slip clutch has a movable clutch face 185 splined on motor shaft 184 for longitudinal movements along its axis. An opposite clutch face 186 is non-rotatably secured to the shaft 181.

A variable resistance 187 has a movable arm 188 driven by shaft 181. The variable resistance is connected at one end to line 191. The movable arm 188 is connected to power line 178 through line 190, so that the resistance in line 191 is changed from a high value to nil as the arm is rotated clockwise.

When the shaft 181 is rotated it moves against the bias of spring 195, which may be accomplished by winding a cable secured to wheel 194 and spring 195. When the shaft 181 is released, it is rotated counter-clockwise and returned to starting position by the spring 195.

A three element gaseous tube 199 is connected in series with a solenoid 200 between the power lines 178, 179. The gaseous tube normally is not conducting, however, when its grid 198 receives a positive potential it becomes conducting. A pair of electrodes 196 and 197 are connected between the grid 198 and the cathode 201 of the three element gaseous tube. A grid resistor 202 is in series with the grid and electrode 196. As long as the clothes are wet and electrically conducting, a current flows between the electrodes 196, 197 to apply a positive potential to the grid 198 which permits the gaseous tube 199 to conduct current between the power lines 178, 179 to energize the solenoid 200. However, when the clothes are dry and non-conducting, the grid receives a negative potential which does not permit the tube to fire, so that the solenoid 200 remains de-energized.

The lever 207 is normally urged clockwise about pivot pin 209 by a spring 208, so that the friction face 185 splined on the motor shaft 184 contacts friction face 186 on shaft 181. However, when the armature 205 is moved by the solenoid 200 through energization of the solenoid 200, the friction face 185 is disengaged from friction face 186 by movement of the lever 207 in a counter-clockwise direction.

A relay 210 is mounted in the line 191 having contacts 211, 212. Contact 211 completes a holding circuit, and contact 212 connects timer 213 to the power line.

Operation of the sensing circuit shown in FIG. 6 is as follows. The relay 210 remains de-energized since it has in series therewith resistance 187. Motor 180 is constantly rotating and when the clutch 182 is engaged, the arm 188 is turned to decrease the resistance in series with the relay 210 to nil. However, as long as the clothes are wet, the gaseous tube 199 will fire to energize solenoid 200 and disengage the clutch 182 through operation of the solenoid armature 205. Lever 207 then moves against the bias of spring 208 to disengage clutch 182 and spring 195. If isolated clothes come into contact with the electrodes before the arm 188 of resistance 187 has swung completely around to short out the resistance 187, the clutch is disengaged to permit the spring 195 to move the resistance arm to full value. It is evident that the resistance 187 can also be eliminated and the time of movement of the arm 188 from a "O" position to a contact with line 191 used to provide the time delay. When the clothes become completely dry, the clutch is engaged for a period of time sufficient for the arm 188 to swing in to contact line 191, thereby effectively eliminating the resistance 187.

The relay 210 is then energized to close contacts 211, 212. Contact 211 maintains the relay energized, while contact 212 energizes a timing motor 213 which initiates the termination of the drying operation.

FIGS. 7 and 8 show a modification of the circuit of FIG. 4 and represents an improved system for controlling a drier apparatus to terminate heating and tumbling operations following determination of the desired dryness of the fabrics. This control system is operable for initiating and terminating drier operation without a mechanical timing mechanism and includes further improvements and advantages over previously used systems as will become apparent from the discussion hereinafter.

The drier apparatus is energized by a conventional three-wire system represented by power lines L_1 , L_2 and N as shown in FIG. 7. A circuit may be completed between L_1 and L_2 to obtain an incoming a.c. voltage level of approximately 220 volts. A circuit between L_1 and N is at approximately 110 volts.

The automatic control circuitry includes a cycle selection switch 217 shown diagrammatically in FIG. 7, including a plurality of manually operable push buttons 218 through 221 for actuating a plurality of switch members 224 through 231. It will be shown that the eight switch members 224 through 231 are operable for controlling operation of the dryer apparatus through a complete cycle of operations. The four push buttons 218 through 221 are designed as "regular dry", "wash and wear", "damp dry", and "air fluff", respectively. Manual operation of one of these push buttons will actuate the switch members to either an open or closed position to effect completion of preselected circuits according to the operation desired during each of the available cycles.

The cycle selection switch 217 is also linked to a selectively energizable solenoid 234 operable for repositioning the switches to a condition for terminating the selected drying operation. The specific condition of each of the switches 224 through 231 upon selection of one of the available cycles of operation and upon actuation of the solenoid 234 is shown in FIG. 8. Operation of the individual switch members to the closed or conductive position establishes circuits for energizing various operating and control components as will be shown hereinafter.

A heater 235 is connected between lines L_1 and L_2 and may be energized by a circuit from L_1 through switch member 224, conductor 236, high-limit thermostatic switch 237, and regulating thermostatic switch 238, to one side of the heater 235. The other side of the heater 235 is connected to power line L_2 through a centrifugally operated switch 241 located within the drive motor 242. The centrifugal switch 241 is normally open and centrifugally operable to the closed position for energizing the heater 235 upon rotation of motor 242 at speeds above a predetermined minimum.

The drive motor 242 is connected between lines L_1 and N and includes a run winding 243 and a start winding 244. The run and start windings 243, 244 of the drive motor 242 are initially energized by a circuit including the momentarily closed switch member 226. This energizing circuit extends from power line L_1 through the door switch 245, conductor 246, switch member 225, conductor 249, switch member 226, and conductor 250 to one side of the run and start windings 243, 244. The other side of the run and start windings

243, 244 is connected to power line N. Upon opening of the momentarily closed switch member 226 and operation of the centrifugally actuated start switch 251, energization of the motor 242 is continued by a circuit extending from power line L₁ through the door switch 245, the conductor 246, switch member 225, and conductor 252 to the run winding 243 through the centrifugally actuated start switch 251. A cool-down thermostat 253, as will be more fully described hereinafter, is connected between conductor 246 and 252, in parallel to the switch member 225, for bypassing switch member 225 subsequent to actuation of solenoid 234 and the return of switch member 225 to the open position. The cool-down thermostat 253 is operable to a closed position at a temperature of approximately 135°F. within the fabric container and operable from a closed to an open position at a temperature of 120°.

A sensing and termination circuit is included in the circuit of FIG. 7 for directly sensing the electrical resistance of the fabrics to effectively measure the moisture content thereof. Upon sensing a predetermined resistance, or relative dryness, the sensing and termination circuit is operable for initiating termination of the heating operation and the tumbling operation. The sensing and termination circuit may be energized by a circuit including switch member 230. The circuit from line L₁ includes the door switch 245, conductor 246, switch member 225, conductor 249, switch member 230, and conductor 256 connected to one side of rectifier 257. The rectifier 257 is connected to a "regular dry" resistor 258 that is in turn connected to junction point 259 to which is connected one side of capacitor 260 and neon tube 261 connected in parallel to each other.

The other side of the capacitor 260 is connected to a junction point 264 and then through a "safe" or current limiting resistor 265 to line N. The other side of the neon lamp 261 is connected to a reed switch coil 266 which has its opposite end connected to the junction point 264. The reed switch coil 266 is juxtaposed to a reed switch 267 for actuating the reed switch 267 to a closed position upon completion of a circuit through the neon lamp 261 and upon energization of the switch coil 267 as will be more fully explained hereinafter.

It will be noted that a pair of electrodes 268, 269 have a parallel relationship with the capacitor 260 and neon tube 261. One electrode 268 is connected to junction point 259 through conductor 272, switch member 227 and conductors 273 and 274. The other electrode 269 is connected to junction point 264 through the drum ground 275, conductor 276, and discharge resistor 277.

A gaseous discharge tube, such as the neon lamp 261, has a normal condition of very high or effectively infinite resistance; however, when a voltage or charge on the discharge tube reaches a predetermined value the gas is ionized and a conductive circuit is completed therethrough. The capacitor 260 in parallel with the neon lamp 261 is charged by a d.c. circuit extending from the rectifier 257 through the "regular dry" resistor 258 to provide the firing voltage. The rate at which the capacitor 260 is charged depends, among other factors, upon the value of the resistors in series therewith. It has been found in the instant embodiment that the "regular dry" resistor 258 may have a value of 30 megohms and the safe resistor 265 a value of 1 megohm. The capacitor 260 has a value of approximately 7 to

10.9 microfarads and the neon lamp 261 fires at approximately 72 volts.

As the capacitor 260 is charged through the resistors 258 and 265, it is also discharged through a discharging circuit including conductive material such as wet fabrics contacting and shorting across the electrodes 268, 269 thus making the firing of the neon tube 261 dependent upon the moisture content of the fabrics. As the fabrics become dried, the rate of discharge across the electrodes 268, 269 diminishes to a point at which the charge on the condenser or capacitor 260 increases to a value corresponding to the firing voltage to the neon lamp 261.

Energization of the neon lamp 261 completes a circuit through the reed switch coil 266 for operating the reed switch 267 to a closed position. The circuit for energizing the coil 266 extends from one side of the capacitor 260 at junction point 264 through coil 266 and neon tube 261 to the other side of the capacitor at junction point 259. Closing of the reed switch 267 completes a circuit from line L₁ to one side of the selection switch solenoid 234 through door switch 245, conductor 285, switch member 231, and conductors 280 and 281. The other side of the solenoid 234 is connected to power line N. Upon energization of the solenoid 234, which is maintained for a period of approximately 12 milliseconds, selection switch 217 is returned to a deactuated condition for terminating, or initiating termination of the dry operation through operation of the switch members 224 through 231 to the positions indicated in FIG. 8. As will be shown more fully hereinafter, operation of the solenoid 234 de-energizes the heater 235 while operation of the drive motor 242 is maintained through a termination operation by the cool-down thermostat 253.

Upon actuation of the solenoid 234, the switch member 228 is operated to a closed position for establishing a discharging path for the capacitor 260. This discharging path extends from one side of the capacitor 260 to the opposite side of the capacitor and includes junction point 259, conductor 274, switch member 228, conductor 276, discharge resistor 277, and junction point 264.

If instead of "regular dry", the operator selects "damp dry", an additional or "damp dry" resistor 282 is connected in parallel with the "regular dry" resistor 258 to decrease the charging time of the capacitor. The circuit for connecting the "damp dry" resistor 282 in parallel extends from one side of the "regular dry" resistor 258, through conductor 283, "damp dry" resistor 282, switch member 229, and conductor 274 to the other side of the "regular dry" resistor 258 at junction point 259.

A "wash and wear" resistor 284 may be connected in series with the "regular dry" resistor upon selection of the "Wash and Wear" cycle which causes switch member 230 to remain open. Closed switch 231 thereby completes a circuit to the rectifier 257 from line L₁ through door switch 245, conductor 285, switch member 231, conductor 280, and "wash and wear" resistor 284. The charging time is increased with this circuit.

It is believed that operation of the above described control circuit as shown in FIG. 7 becomes more clear by reviewing a complete cycle of operation. After the fabrics are inserted into the drum, the operator closes the door to actuate the door switch 245 to conductive

condition. The operator then manually depresses a selection push button to select the desired cycle of operation. Assuming selection of a "regular dry" cycle, switch members 224, 225, 227, 230, and 231 are operated to the closed or conductive condition while switch members 228 and 229 remain open or non-conductive. Switch member 226 is momentarily closed to initiate operation of the drive motor 242 after which energization is maintained through switch member 225. The drive motor 242 rotates the drum to tumble the clothes therein and after a certain rotational speed is achieved by the drive motor 242, the centrifugally operated switch 241 is closed to complete a circuit to the heater 235. The sensing and termination circuit is also energized through the closed switch members 225 and 230.

During the initial portion of the drying operation, parallel circuits are completed to the capacitor 260 and to the electrodes 268, 269. The capacitor 260, while being charged by a circuit extending from switch member 230, through the rectifier 257 and "regular dry" resistor 258, is at the same time being discharged through the wet fabrics contacting the electrodes 268, 269. As long as the clothes remain wet, or sufficiently damp to effectively maintain the discharge path, the drying operation is maintained. However, as the moisture is removed, the fabrics achieve increased electrical resistance and the rate of discharge decreases and the net charge on the capacitor 260 begins to accumulate. The buildup of the charge on the capacitor 260 reaches a predetermined amount over a predetermined period of time of sufficient duration for at least a sampling of all of the clothes in the drum to contact the electrodes 268, 269 during tumbling. After the fabrics reach a predetermined condition of resistance, or dryness, the capacitor 260 will reach a predetermined voltage for energizing the neon lamp 261. Completion of the circuit through the neon lamp 261 energizes the reed switch coil 266 for actuating the reed switch 267 and completing a circuit to the selection switch solenoid 234. Completion of the circuit to the solenoid 234 is maintained for a period of sufficient duration to actuate the solenoid 234 and to return the selection switches 224 through 231 to their normal position. The heater 235 is de-energized by the opening of switch member 224. The sensing and termination means is de-energized by the opening of switch member 230. Switch member 225, controlling energization of the drive motor 242 during the major portion of the cycle, is also operated to the open position; however, energization of the drive motor 242 is maintained through the cool-down thermostat 253 which is connected in parallel to the switch member 225. Energization of the drive motor 242 is maintained through a period of time for permitting the temperature within the fabric container to drop to a level of approximately 120°. Upon the decrease to this temperature, the cool-down thermostat 253 is opened and the drive motor 242 is de-energized to terminate the operation.

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 this invention as further defined in the following claims.

I claim:

1. In a drying machine operable through a cycle including a drying operation, a moisture sensing control operable for controlling said drying machine in accordance with the moisture content of the material dried therein comprising, means including spaced electrodes adapted to engage random portions of said material and further including means for applying a potential across said electrodes, said electrodes ranged to be bridged by said material so that the potential between said electrodes varies as a function of the moisture content of the material bridging the electrodes, circuit means including electrical breakdown means connected in circuit with said electrodes and responsive to a predetermined potential across said electrical breakdown means which is a function of the potential across said electrodes to operate from a first electrical condition to a second electrical condition, and means including an inductive coil in series with said electrical breakdown means for controlling termination of the drying operation.

2. In a drying machine operable through a cycle having a drying operation and a termination operation, the combination of a chamber for articles to be dried, heating means for drying said articles in said chamber during said drying operation, electrodes for contacting and completing an electrical circuit through said articles, said electrodes being spaced apart and adapted to receive therebetween said articles being dried so that the electrical resistance between said electrodes varies with the electrical resistance condition of the articles therebetween, motive means in association with said chamber for causing relative movements and random contact between said electrodes and said articles to obtain representative sampling of the electrical resistance condition of the articles, means including electrical charging circuit means and discharging circuit means communicating with said charging circuit means for discharge of said charging circuit means, said discharging circuit means including electrical breakdown means having a normally effectively infinite resistance and through which a predetermined charge is discharged, said charging circuit means providing a time delay in the accumulation of said predetermined charge which is a function of the electrical resistance between said electrodes, and means including an inductive coil in series with said electrical breakdown means for controlling termination of the drying operation and initiation of the termination operation.

3. In a drying machine operable through a cycle having a drying operation and a termination operation and having manually operable means to initiate said drying operation, the combination of a chamber for articles to be dried, heating means for drying said articles in said chamber during said drying operation, electrodes for contacting and completing an electrical circuit through said articles, said electrodes being spaced apart and adapted to receive therebetween said articles being dried so that the electrical resistance between said electrodes varies with the electrical resistance condition of the articles therebetween, motive means in association with said chamber for causing relative movements and random contact between said electrodes and said articles to obtain representative sampling of the electrical resistance condition of the articles, means including electrical charging circuit means and discharging circuit means communicating with said charging circuit

means for discharge of said charging circuit means, said discharging circuit means including electrical breakdown means having a normally effectively infinite resistance and through which a predetermined charge is discharged, said charging circuit means providing a time delay in the accumulation of said predetermined charge which is a function of the electrical resistance between said electrodes, and means including an inductive coil in series with said electrical breakdown means for controlling said manually operable means to effect termination of the drying operation and initiation of the termination operation.

4. In a drying machine as defined in claim 3 and further including means operable after said charge is discharged through said electrical discharging circuit means for effecting a termination operation to reduce the temperature within said chamber and to terminate said cycle.

5. In a drying machine as defined in claim 3 wherein said last named means includes a switch member operated by said inductive coil and further includes means for terminating said drying operation and wherein said switch member is operable for actuating said means for terminating the drying operation upon discharge of said predetermined charge through said electrical discharging circuit means.

6. In a drying machine as defined in claim 5 wherein said switch member is in the form of a reed switch and said means for terminating the drying operation includes a solenoid energizable for a short period of time.

7. In a drying machine operable through a cycle including one of a plurality of selectable drying operations and a termination operation, the combination of a chamber for articles to be dried, means manually operable from a first condition to a second condition for selecting and initiating one of said drying operations, heating means for drying said articles in said chamber during said drying operation, electrodes for contacting and completing an electrical circuit through said articles, said electrodes being spaced apart a fixed distance and adapted to receive therebetween said articles being dried so that the electrical resistance between said electrodes varies with the electrical resistance condition of the articles therebetween, motive means in association with said chamber for causing relative movement and random contact between said electrodes and said articles to obtain representative sampling of the electrical resistance condition of the articles, means including an electrical charging circuit means and discharging circuit means communicating with said charging circuit means for discharge of said charging circuit means, said discharging circuit means including electrical breakdown means having a normally effectively infinite resistance and through which a predetermined charge is discharged, said charging circuit means providing a time delay in the accumulation of said predetermined charge which is a function of the electrical resistance between said electrodes, and control means for actuating said manually operable means to said first condition

for ending the selected drying operation and initiating the termination operation when said predetermined charge is discharged through said electrical discharge circuit means, said control means including a relay coil in series circuit with said electrical breakdown means.

8. In a drying machine operable through a cycle including one of a plurality of selectable drying operations and a termination operation as defined in claim 7 and further including means responsive to a predetermined temperature within said chamber for ending said termination operation to thereby terminate said cycle.

9. In a drying machine operable through a cycle including one of a plurality of selectable drying operations and a termination operation as defined in claim 7 wherein said control means further includes a reed switch responsive to energization of said relay coil.

10. In a drying machine operable through a cycle including one of a plurality of selectable drying operations and a termination operation as defined in claim 7 wherein said control means includes solenoid means mechanically linked to said manually operable means and energizable for mechanically actuating said manually operable means to said first condition when said predetermined charge is discharged through said electrical discharging circuit means.

11. In a drying machine operable through a cycle including one of a plurality of selectable drying operations and a termination operation as defined in claim 10 wherein said control means further includes reed switch means responsive to energization of said relay coil for energizing said solenoid means for a short period of time of sufficient duration to actuate said manually operable means to said first condition.

12. A clothes drier having a moisture sensing control for controlling said clothes drier in accordance with the moisture content of the material in the clothes being dried, the combination comprising, drum means for tumbling the clothes as they are dried, heating means for drying the clothes in said drum means, spaced electrodes arranged in said drum means to be bridged by said clothes as they are tumbled so that the resistance between said electrodes varies as the moisture content of the clothes bridging said electrodes, means connected in circuit with said electrodes for applying a DC potential across the electrodes that increases as said resistance of the material increases, a neon bulb breakdown device connected in circuit with said electrodes and responsive to a predetermined potential across the electrodes to produce a signal, solenoid means connected in circuit with said neon bulb breakdown device and responsive to said signal for operation from a first condition to a second condition, and switch means operated by said solenoid means to perform a control function in said clothes drier.

13. The clothes drier of claim 12 which further includes timer means for controlling said clothes drier, said timer means controlled by said switch means.

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