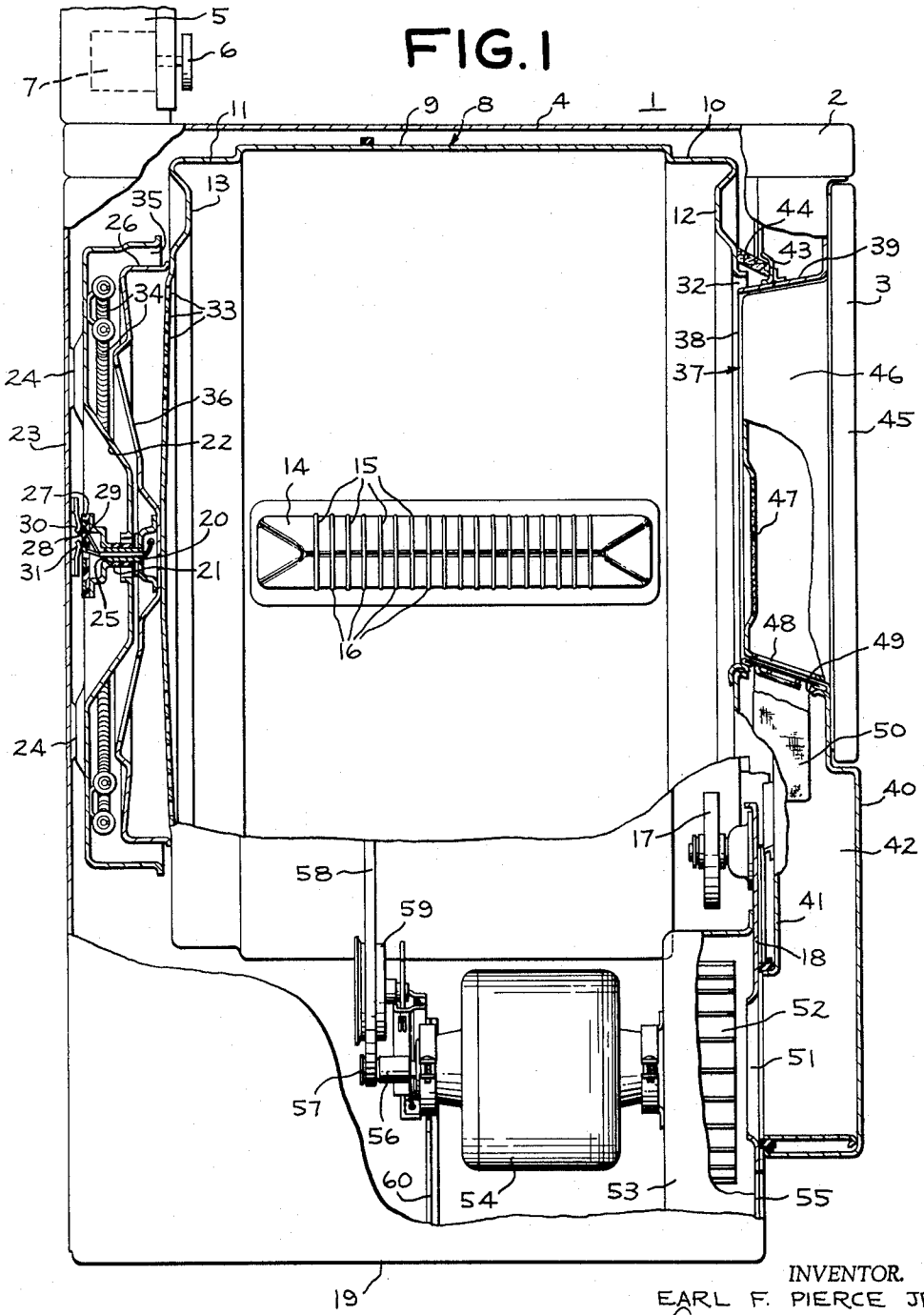
May 3, 1966 E. F. PIERCE, JR 3,248,800

AUTOMATIC DRYER CONTROL CIRCUIT

Filed March 25, 1964 2 Sheets-Sheet 1

FIG. 1



INVENTOR.
EARL F. PIERCE JR.
BY Derek P Lawrence
HIS ATTORNEY

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Filed March 25, 1964 2 Sheets-Sheet 2

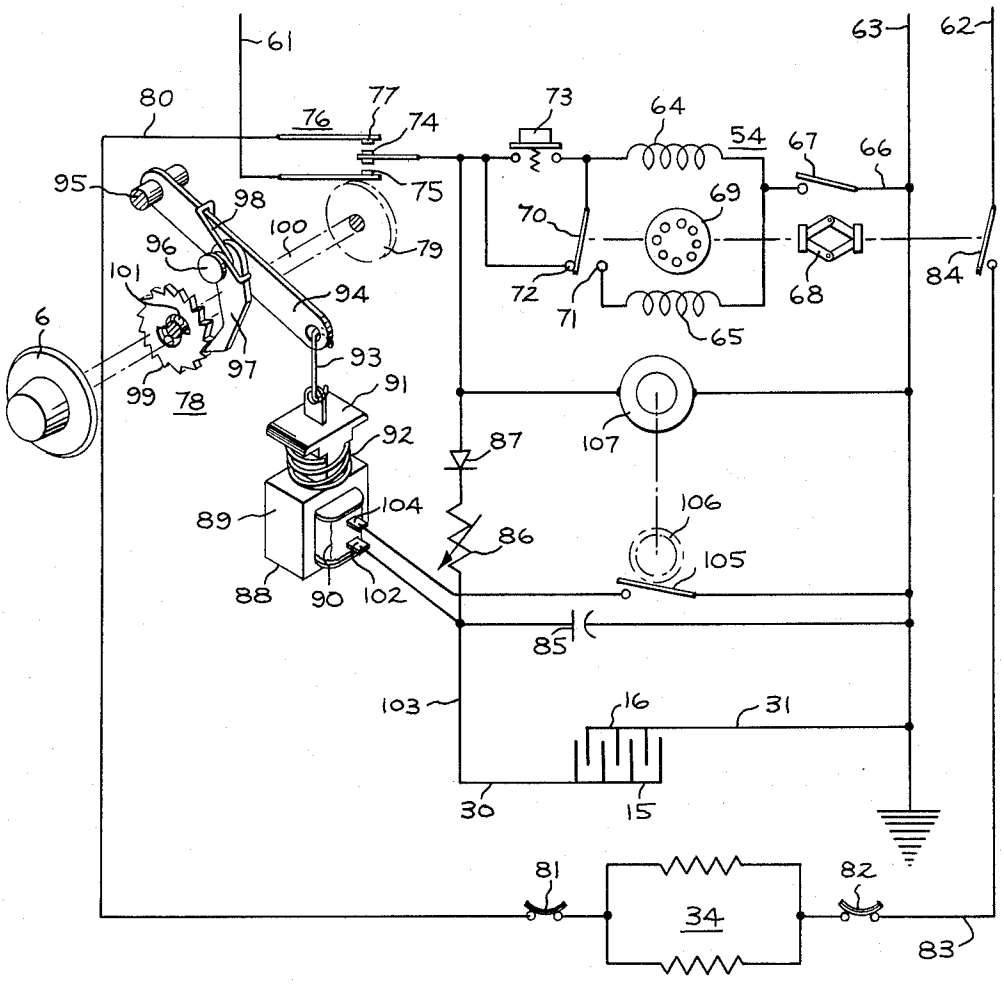


FIG.2

INVENTOR.
EARL F. PIERCE JR.
BY Derek P Lawrence
HIS ATTORNEY

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3,248,800

AUTOMATIC DRYER CONTROL CIRCUIT

Earl F. Pierce, Jr., Clarksville, Ind., assignor to General Electric Company, a corporation of New York

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8 Claims. (Cl. 34—45)

This invention relates to domestic fabric drying machines, and more particularly to an electrical control system for use in such machines.

There are many types of dryer control circuits which provide for terminating operation of the dryer when it is sensed that the fabrics within the dryer have achieved a predetermined degree of dryness. There are a variety of such circuits; the basis for determining dryness may be made to be a temperature function, or an air humidity function, for instance. Another approach with substantial reliability is to actually sense to what extent the fabrics themselves are electrically conductive, since fabrics normally present a high electrical resistance, and it is only when they have a substantial amount of moisture in them that their resistance decreases appreciably.

Accordingly, there are on the market some domestic fabric dryers in which this approach is taken, that is, the conductivity of the fabrics is used to determine when the drying operation will be ended, or when steps will be taken to initiate ending of the operation. Heretofore, the approach has been taken that when the sensing means determines dryness of the clothes, the operation is ended or a predetermined period of time then tolls before the operation ends. Because of this, it has been necessary to integrate the sensing over an appreciable period of time. This was important, because, in domestic fabric dryers, the fabrics are tumbled during drying and at any given instant they may be out of contact with the sensing element. Thus, it has been deemed important to preclude the machine from determining that dryness has been achieved simply because there is a brief period when a high resistance appears across the sensing elements. This limitation on such machines has required the incorporation of relatively expensive components.

It is an object of my invention to provide a dryer control circuit wherein decreased conductivity of the fabrics causes termination of the operation to approach, but any renewed sensing of a high conductivity, that is, of a greater amount of moisture, stops the approach of the end of the operation until such time as the conductivity decreases again.

More specifically, it is an object of my invention to achieve this goal by causing the sensing elements to control the operation of a timer mechanism so that the timer will be caused to run when the sensing elements determine that there is a high resistance, and the timer stops running when the sensing elements determine that there is a low resistance, regardless of the points at which these events occur in the cycle, or their sequence.

More specifically in my preferred embodiment, it is an object of my invention to achieve this goal by causing the sensing elements to control the charging of a capacitor which is cyclically connected in operative relation to an impulse type timer, so that whenever there is a sufficient charge on the capacitor at the time of connection it will advance the timer one impulse toward the point at where it ends the sequence of the operation.

In carrying out my invention in one form thereof, I provide a fabric drying machine which has a conventional chamber for receiving fabrics to be dried, together with drying means arranged to cause evaporation of moisture from fabrics placed in the chamber. Together with this there is provided means for tumbling fabrics in the chamber. Spaced conductors are positioned so as

to be bridged by the tumbling fabrics, so that the conductors are provided with a relatively low resistance electrical bridge when there is substantial moisture in the fabrics which bridge the conductors. Together with this structure, I provide sequence control means. It has been found that, by so relating the sequence control means to the bridging of the spaced conductors, proper drying is readily achieved. This is done by providing a predetermined amount of time of operation of a sequence control mechanism before it shuts the machine off. The sequence control mechanism advances towards the termination of operation when there is high resistance across the spaced conductors; this advance ceases when there is low resistance across the spaced conductors, regardless of when these events occur during the drying operation.

In my preferred embodiment, I achieve this goal by providing a capacitor connected in series with the conductors, and an impulse type sequence control means which is effective after a predetermined number of impulses to terminate operation of the drying means. The control means is connected across the capacitor under the control of cyclic means which cyclically opens and closes the connection. When the capacitor is charged to a predetermined value it is effective, when connected across the control means, to provide an impulse to the control means. However, the spaced conductors prevent charging of the capacitor to the predetermined value whenever they are provided with a low resistance electrical bridge by clothes with substantial moisture in them.

The subject matter which I regard as my invention is particularly pointed out and distinctly claimed in the concluding portion of this specification. My invention, however, both as to organization and method of operation together with further objects and advantages thereof, may best be understood by reference to the following description taken in conjunction with the accompanying drawings.

In the drawings,

FIGURE 1 is a side elevational view of a clothes dryer incorporating my improved dryer control arrangement, the view being partly broken away and partly sectionalized in order to illustrate details; and

FIGURE 2 is a schematic illustration of my improved control system, as used in the control of the drying machine of FIGURE 1.

Referring now to FIGURE 1, the machine illustrated is a domestic clothes dryer generally indicated by the numeral **1**. Dryer **1** is provided in the usual way with a cabinet **2** having a front door **3** to provide access to the interior of the cabinet for loading or unloading clothes. Provided on the top wall **4** of cabinet **2** is a control panel **5** which may include a suitable manual control **6** connected to a sequence control assembly **7**. By manual setting of control **6**, the machine may be caused to start and, as will be explained below, automatically proceed through a cycle of operation.

Within cabinet **2** there is provided a clothes tumbling container or drum **8** which constitutes a chamber for receiving fabrics to be dried, and which is mounted for rotation on a substantially horizontal axis. Drum **8** is substantially cylindrical in shape, having a first cylindrical outer wall portion **9**, second and third cylindrical outer wall portions **10** and **11** located respectively adjacent the front and back of the drum, a front wall **12**, and a back wall **13**. Outer wall portions **9**, **10** and **11** are imperforate over their entire length so that the entire outer shell of the basket is imperforate. On the interior surface of central portion **9** there is provided a plurality of clothes tumbling ribs **14** formed of a suitable heat resistant insulating material. Over each rib extend a number of conductors or wires **15** and **16** spaced from

each other and which alternate with each other along the length of the rib. The purpose of these wires and the structure to which they are related will be more fully discussed herebelow.

The front of drum 8 may be rotatably supported within outer casing 2 by suitable idler wheels, one of which is shown by the numeral 17. These wheels are rotatably secured to the top of a member 18 which extends up from the base 19 of the machine. Wheels 17 are disposed beneath the drum in contact with portion 10 on each side to provide a stable support.

The rear end of drum 8 receives its support by means of a stub shaft 20 extending from the center of wall 13. Shaft 20 is secured within a bearing 21 formed in a baffle 22. Baffle 22, in turn, is rigidly secured to the back wall 23 of cabinet 2 by any suitable means such as, for instance, welding at a number of points 24. With the arrangement shown the basket may rotate on a horizontal axis, with wheels 17 providing the front support and stub shaft 20 within bearing 21 providing the rear support.

It is to be noted at this point that stub shaft 20 is provided with a central opening 25. The wires 15 and 16 all extend from ribs 14 around the back of drum 8 and through suitable openings in a baffle member 26; the wires then extend through the opening 25 formed through shaft 20. At the outer end of shaft 20, a disk 27 may be formed, as shown, with the conductors 15 being secured to a conductive outer ring portion 28 and the conductors 16 being secured to a conductive inner portion 29. Portions 28 and 29 are electrically insulated from each other; this may readily be done by making disk 27 of an insulating material, with the conductive ring portions embedded therein. A contact member 30 is continually in contact with conductor portion 28 while, similarly, conductor portion 31 is continuously in contact with conductor portion 29 of the disk. Thus all of the conductors 15 are connected to stationary conductor 30 and all of the conductors 16 are similarly connected through similar means to stationary conductor 31.

In order to provide for the flow of the stream of drying air through the clothes drum the drum is provided with a central aperture 32 in its front wall 12 and with an opening in the form of a plurality of perforations 33 in its rear wall 13, the perforations in the present case being formed to extend around the rear wall in an annulus.

As has been stated, baffle member 22 is rigidly secured to rear wall 23 of cabinet 2. Baffle member 22 also serves to support suitable heat drying means such as electrical heating elements 34 appropriately insulated from baffle member 22. Elements 34 may be annular in shape so as to be generally coextensive with perforations 33 in drum 8. The other baffle member 26 is rigidly secured to the back wall 13 of the drum, outside the ring of perforations 33 and within stationary baffle 22, so that an annular air inlet 35 is in effect formed by baffles 22 and 26. In this manner, a passage is formed for air to enter annular inlet opening 35 between the baffles, pass over the heater 34, and then pass through openings 36 formed in baffle 26 to the interior of drum 8.

The front opening 32 of the drum is substantially closed by means of a stationary bulkhead, generally indicated by the numeral 37. Bulkhead 37 is made up of a number of adjacent members including the inner surface 38 of access door 3, a stationary frame 39 for the door formed as a flange of the front wall 40 of the cabinet, the inner surface member 41 of an exhaust duct 42 which is formed by the cooperation of member 41 with the front wall 40 of the cabinet, and an annular flange 43 mounted on frame 39 and on the duct wall. It will be noted that a suitable clearance is provided between the inner edge of the drum opening 32 and the edge of bulkhead 37 so that there is no rubbing between the drum and bulkhead during rotation of the drum. In order to prevent any substantial air leakage through opening 32 between the interior and exterior of the drum, a suitable ring seal 44, preferably formed of felt-like material, is secured to flange 43 in sealing relationship with the exterior surface of drum wall 12.

Front opening 32, in addition to serving as part of the air flow passage through the drum, also serves as a means whereby clothes may be loaded into and unloaded from the drum. Door 3, whose inner surface forms part of the bulkhead closing the opening, is mounted on cabinet 2 so that when the door is opened clothes may be inserted into or removed from the drum through the door frame 39. It will be noted that the door includes an outer flat imperforate section 45 and an inwardly extending hollow section 46 mounted on the flat outer section. Hollow section 46 extends into the door frame 39 when the door is closed and the door surface 38 which comprises part of the combination bulkhead 37 is actually the inner wall of the hollow section.

The air outlet from the drum is provided by a perforated opening 47 formed in the inner wall 38 of hollow door section 46. The bottom wall section of door 3 and the adjacent wall of door frame 39 are provided with aligned openings 48 and 49, opening 49 providing the entrance to duct 42. As shown, a lint trap 50 which may comprise a fine mesh bag is preferably positioned across duct 42 at opening 49, the bag being supported by the door frame 39. Duct 42 leads downwardly to an opening 51 formed in the member 18 which supports wheels 17. Opening 51 constitutes the inlet to a blower member 52 contained within a housing 53 and directly driven by an electric motor 54. The blower draws ambient air in through any appropriate opening in the cabinet such as, for instance, through opening 55. From opening 55 the air is drawn over heaters 34, through the basket, through door 3 and duct 42, and into blower 52. Form the blower, the air passes through any appropriate duct (not shown) out of cabinet 2 so as to be exhausted from the machine.

In addition to driving blower 52, motor 54 constitutes the means for effecting rotation of drum 8. In order to effect this, motor 54 is provided with a shaft 56 having a small pulley 57 formed at the end thereof. A belt 58 extends around pulley 57 and also entirely around the cylindrical wall section 9 of drum 8. The relative circumferences of pulley 57 and wall section 9 cause the drum to be driven by the motor at a speed suitable to effect tumbling of the clothes therein. In order to effect proper tensioning of belt 58 there may be provided a suitable idler assembly 59 secured on the same support 60 which secures one end of the motor.

Thus, the air is pulled through the drum, and at the same time the fabrics in the drum are tumbled. When air is heated by heating elements 34, it passes through the drum and causes vaporization of moisture from the clothes. The vapor is carried off with the air as it passes out of the machine.

The operation of dryer 1 is controlled by the new and improved control system shown in the circuit diagram of FIGURE 2. As shown therein, the entire control system of the machine may be energized across a three-wire power supply system which includes supply conductors 61 and 62 and a neutral conductor 63. For domestic use the conductors 61 and 62 will normally be connected across a 220 volt power supply, with 110 volts appearing between the neutral line 63, which may be grounded as shown, and either of the supply conductors. Motor 54, connected between conductors 61 and 63, is a single-phase induction-type motor having a main winding 64 and a start winding 65, both connected at their common ends to a conductor 66 through a conventional door switch 67 (which is closed when door 3 is closed and is opened when the door is opened). Conductor 66 is connected to conductor 63.

Start winding 65 is connected in parallel with main winding 64 under control of a speed responsive device,

such as that shown at 68, which is schematically shown as connected to the rotor 69 of the motor. Speed responsive device 68 controls a switch 70 which is engageable with either a contact 71 or a contact 72, being engaged with contact 71 when the motor is at rest and moving into engagement with contact 72 as the motor comes up to speed. It can readily be seen that engagement with contact 71 connects the start winding 65 in parallel with main winding 64 while movement of switch 70 away from this position opens the start winding. Thus, as rotor 69 comes up to speed the start winding becomes de-energized and the motor then continues to run on main winding 64 alone.

The starting of the motor is provided by a manually operable switch 73 which may, for instance, in the structure of FIGURE 1, be moved to its closed position by pulling out on member 6. Switch 73 connects the motor to supply conductor 61 through contacts 74 and 75 of a switch 76 which also includes a third contact 77. Switch 73 is normally biased to the open position shown. However, when member 6 is pulled out manually, and provided switch 76 is closed, energization of the motor is provided. Within less than a second then, under normal circumstances, the motor comes up to speed so that switch 70 engages contact 72. As a result of this movement of switch 70 the main winding 64 of motor 54 continues to be energized by the bypass around switch 73 when member 6 is released and switch 73 opens.

An impulse-type sequence control assembly, generally indicated by the numeral 78, is provided with a cam 79 which controls switch 76. It will be understood that cam 79 is movable by rotation of member 6 in the usual way, so that when operation of the machine is desired member 6 may be rotated until cam 79 causes switch 76 to close all three of its contacts. The machine operation is terminated, as will be seen herebelow, when cam 79 has been rotated sufficiently to open the contacts of switch 76.

An energizing circuit is also completed for heater 34 through the following circuit: starting at conductor 61, the circuit proceeds through contacts 75 and 77 of switch 76, and then through a conductor 80 to a conventional temperature-controlling thermostat 81 of the type which is frequently provided is connected with fabric drying machines of the type shown. From thermostat 81, the circuit proceeds through heater 34 and the conventional safety thermostat 82 to a conductor 83 leading back to conductor 62 through a switch 84. Switch 84 is controlled by centrifugal member 68, being closed only when the motor has come up to speed so that there can be no energization of heater 34 except when motor 54 is operating properly.

The spaced conductors 15 and 16 are connected in parallel with a capacitor 85 which may have a relatively low capacitance, for instance on the order of 1.0 microfarad. Capacitor 85 is connected across the source of power in series with a relatively high resistance 86 (for instance, about 15 megohms) and a rectifier 87. As shown, resistor 86 may be variable for calibration purposes; its main function is to provide an appropriate RC time constant in cooperation with capacitor 85. However, this time constant need not be a large one, and therefore resistor 86, while of large value, need not be of the extremely high order of magnitude heretofore believed necessary.

As stated above, timer 78 is of the impulse type. It is shown for purposes of illustration as including a solenoid member 88 having a core 89, a coil 90, and a movable armature 91. Energization of coil 90 pulls armature 91 down into core 89, and spring 92 tends to return the armature member 91 to the position shown. Armature 91 is connected through a link 93 to an arm 94 pivoted on a pin 95. Pin 95, it will be understood, it secured within a rigid housing.

Mounted on arm 94 by a pin 96 is a pawl member 97 which is biased by a spring 98 into engagement with a ratchet 99. Ratchet 99 is mounted on the same shaft 100 which connects member 6 to cam 79. Member 6 may be connected to shaft 100 by a conventionl one-way clutch (not shown), so as to permit rotation of shaft 100 in a clockwise direction only by means of member 6.

It will be seen that with this assembly of parts, each time armature 91 is pulled down pawl 97 will cause ratchet 99 to move around, so that one impulse is provided to timer assembly 78. When the armature is returned by spring 92 to the position shown, pawl 97 slides over the top of a tooth into the position where it engages the next tooth and will move it upon the next downward movement of armature 91. Thus, each time coil 90 is energized so as to pull armature 91 down into core 89, an impulse is provided to impulse timer 78. It will be understood that the arrangement shown is schematic in nature, and is merely intended to provide a simple and clear picture of an impulse-type timer.

One terminal 102 of coil 90 is connected to conductor 103 on one side of capacitor 85, and the other terminal 104 of the coil is connected through a switch 105 to conductor 63, and therefore to the other side of capacitor 85. Thus, coil 90 is connected across capacitor 85 when switch 105 is closed. Switch 105 is operated by a cam 106, so that it is cyclically opened and closed, by any suitable mechanism such as that shown at 107. For instance, switch 105 may open and close each 120 seconds, being open for 115 seconds and then closed for 5 seconds.

It will be clear that, when the fabrics in the drum are quite wet, since they will bridge conductors 15 and 16 virtually all of the time they will bleed off any charge from the capacitor 85. Therefore little or no charge will be provided on the capaictor. As a result, when switch 105 is closed there is insufficient voltage potential stored in the capacitor to cause energization of coil 90 and therefore no impulse is provided to assembly 78. The high resistance 86 precludes any impulse being provided to the timer as a result of its connection across the source of supply since virtually all of the voltage drop occurs across resistor 86 rather than across coil 90.

As the clothes start to dry, there will be more and more of a tendency for the resistance across conductors 15 and 16 to rise; therefore, capacitor 85 will be better able to store potential since less of the charge is being bled off across the conductors 15 and 16. As a result, when switch 105 closes, more and more often there will be a sufficient charge across capacitor 85 to energize coil 90 sufficiently to pull down armature 91.

As explained earlier, many types of clothes loads, as they tumble, may have one or more garments in contact with the spaced conductors, for several minutes, and then out of contact with the conductors for several minutes. Thus, for example, let it be assumed there is an almost-dry load, but with a couple of heavy towels which are still quite moist. While these towels are toward the center of the load, i.e., not touching conductors 15 and 16 for a period of time, then each time switch 105 closes there will be an impulse provided to sequence control 78, and cam 79 will advance toward its switch-opening position. However, when these relatively moist towels again come to the outside of the tumbling load, and engage conductors 15 and 16 frequently for a period of several minutes, they will again bleed off the charge across capacitor 85, and timer 78 will stop advancing, or will advance cam 79 less often.

Thus, rather than providing an arrangement which determines once and for all that the clothes are dry, i.e., where the decision is an irrevocable one as in structures presently on the market, my arrangement permits the operation of the heater to continue—and the timer to stop advancing—if it is "rediscovered" that there are wet clothes being tumbled in the drum. In this way, my invention provides more effective and more certain drying of the clothes, yet still without undesirable overdrying.

Of course, toward the end of an operation, when all of the clothes are dry, the timer will advance each time switch **105** is closed, and will quickly toll out the cycle, rotating cam **79** to the point at which switch **76** opens.

It will be understood that while a particular form of my invention has been illustrated, many others will occur to those skilled in the art once the basic aspect of the invention is understood. For instance, rather than providing a cyclically opening and closing switch and an impulse timer, the broad scope of my invention would include the concept of a continuous relationship between the sensing spaced conductors and the sequence control means; in such a case, rather on a step-by-step basis the advance of the sequence control means would occur whenever the resistance was high and would stop whenever the resistance was low. Also, it will be apparent that various ways of causing the advance of the sequence control means as a result of high resistance will occur to those skilled in the art. For instance, a neon tube could be lit whenever there was a high resistance, and by its light trigger a circuit-completing device for a timer.

While in accordance with the patent statutes I have described what at present is considered to be the preferred embodiment of my invention, it will be obvious to those skilled in the art that various changes and modifications (including, but not limited to, that described immediately hereabove) may be made therein without departing from this invention, and it is therefore aimed in the appended claims to cover all such equivalent variations as fall within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A fabric dryer comprising:
(a) a chamber for receiving fabrics to be dried;
(b) drying means arranged to cause evaporation of moisture from the fabrics;
(c) means for tumbling fabrics in said chamber;
(d) spaced conductors positioned so as to be bridged by fabrics tumbling in said chamber whereby said conductors are provided with a relatively low resistance electrical bridge when there is substantial moisture in fabrics bridging said conductors;
(e) sequence control means effective after a predetermined length of operation to terminate operation of said drying means;
(f) and a circuit providing control of said sequence control means by said conductors, said circuit precluding operation of said sequence control means when said conductors are provided with a relatively low resistance electrical bridge and causing operation of said sequence control means at other times.

2. The apparatus defined in claim **1** wherein said sequence control means is electrically operated.

3. The apparatus defined in claim **2** wherein said sequence control means is an impulse type electrically operated sequence control means, and means are provided for completing said circuit cyclically, said circuit providing an impulse to said sequence control means each time it is completed if said low resistance electrical bridge is not provided across said conductor.

4. A fabric dryer comprising:
(a) a chamber for receiving fabrics to be dried;
(b) drying means arranged to cause evaporation of moisture from the fabrics;
(c) means for tumbling fabrics in said chamber;
(d) spaced conductors positioned so as to be bridged by fabrics tumbling in said chamber whereby said conductors are provided with a relatively low-resistance electrical bridge when there is substantial moisture in fabrics bridging said conductors;
(e) a capacitor connected in parallel with said conductors and connected so as to be charged from a source of electrical energy;
(f) impulse-type sequence control means, effective after a predetermined number of impulses to terminate operation of said drying means, connected across said capacitor;
(g) and cyclic means cyclically opening and closing the connection of said control means across said capacitor;
(h) said capacitor being effective when charged to a predetermined value to provide an impulse to said control means when said cyclic means closes its connection, said spaced conductors preventing charging of said capacitor to said predetermined value when they are provided with said low-resistance electrical bridge.

5. The apparatus defined in claim **4** wherein a relatively high resistance is connected in series with both said control means and said capacitor.

6. The apparatus defined in claim **4** wherein said cyclic means includes a switch connected in series with said control means, and electrically operated means continuously opening and closing said switch during operation of said fabric dryer.

7. A fabric dryer comprising:
(a) a chamber for receiving fabrics to be dried;
(b) drying means arranged to cause evaporation of moisture from the fabrics;
(c) means for tumbling fabrics in said chamber;
(d) spaced conductors positioned so as to be bridged by fabrics tumbling in said chamber whereby said conductors are provided with a relatively low-resistance electrical bridge when there is substantial moisture in fabrics bridging said conductors;
(e) a capacitor connected in parallel with said conductors and connected so as to be charged from a source of electrical energy;
(f) impulse-type sequence control means including a switch effective when open to terminate operation of said drying means, a cam controlling the opening of said switch, movable means movable one impulse at a time and effective after a predetermined number of impulses to move said cam to a position where it opens said switch, and electrical means responsive to a predetermined voltage to cause an advance of one impulse of said movable means, said electrical means being connected across said capacitor;
(g) and cyclic means cyclically opening and closing the connection of said control means across said capacitor;
(h) said capacitor being effective when charged to a predetermined value to provide an impulse to said control means when said cyclic means closes its connection, said spaced conductors preventing charging of said capacitor to said predetermined value when they are provided with said low-resistance electrical bridge.

8. The apparatus defined in claim **4** wherein said electrical means includes an armature member movable in response to energization by predetermined voltage, and said movable means includes a pawl and ratchet system, said pawl being positioned to engage said ratchet and move it a predetermined distance each time said electrical means is energized.

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WILLIAM F. O'DEA, *Primary Examiner.*

J. J. CAMBY, *Assistant Examiner.*