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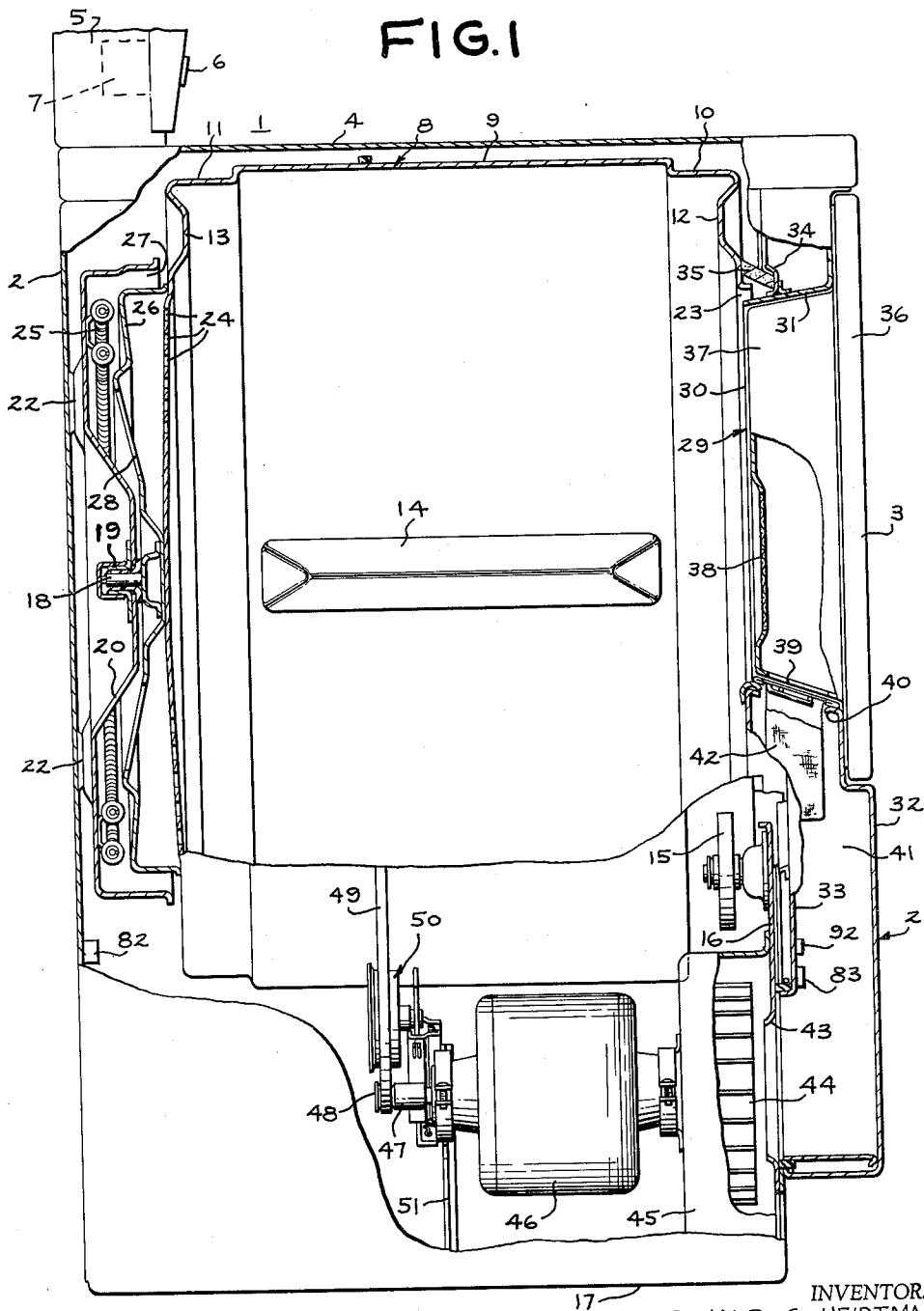
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3,229,379

CONTROL SYSTEM FOR FABRIC DRYER

Filed March 18, 1963

3 Sheets-Sheet 1



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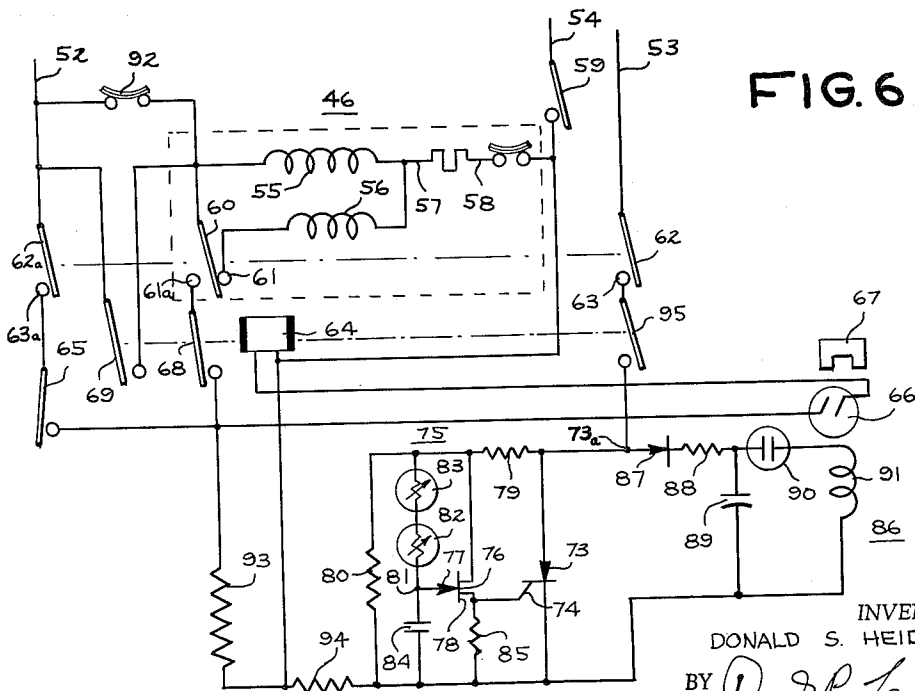
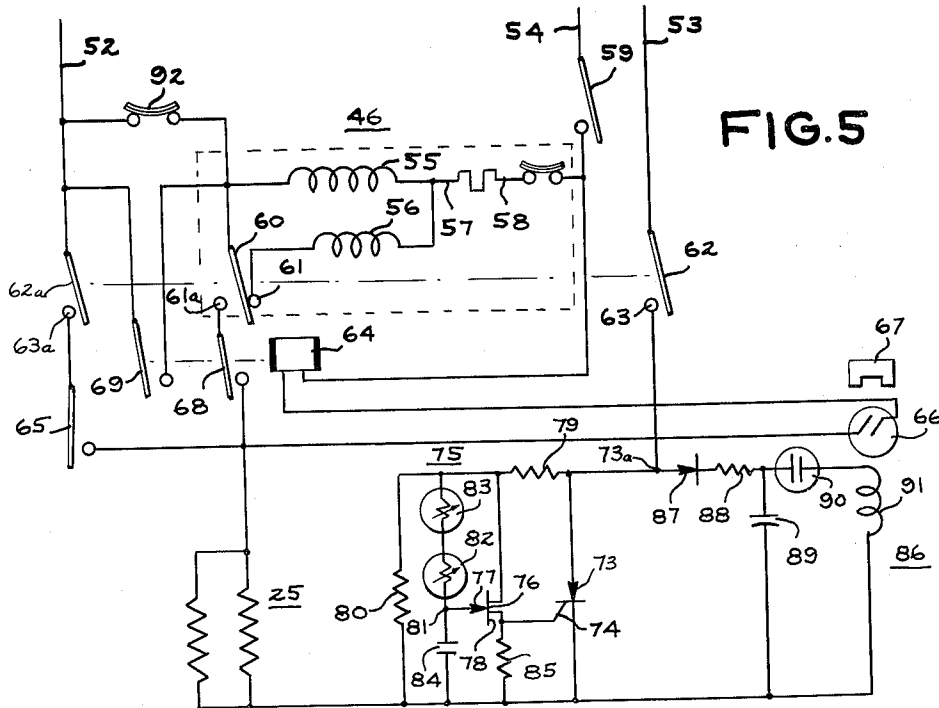
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CONTROL SYSTEM FOR FABRIC DRYER
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 Electric Company, a corporation of New York
 Filed Mar. 18, 1963, Ser. No. 265,656
 8 Claims. (Cl. 34-45)

This invention relates to fabric dryers, and more particularly to a fabric dryer of the type in which a control system decreases the energy input to the fabrics as they become increasingly dry.

It is a known fact that, in a fabric dryer, when fabrics are quite wet it is desirable to have a substantial energy input, but that as the fabrics become dryer the energy input should be decreased from the high level required initially.

In the light of the foregoing, it is an object of my invention to provide an improved control circuit for a dryer in which the energy input to the clothes is continuously decreased as the moisture content of the clothes decreases.

A further more specific object of my invention is the provision of such an effect by use of a controlled rectifier of the type which has recently come into common use.

It is also known that a time control circuit is readily and simply achieved by use of a resistor and capacitor: the length of time before the voltage across the capacitor reaches the predetermined rated level is dependent upon the characteristics of the capacitor and the resistor. The longer the desired length of time before the predetermined voltage is reached (called the RC time constant hereinafter), the larger the capacitance must be and the higher the resistance; unfortunately, both the capacitor and the resistor increase in difficulty of use and in expense as their values become higher.

Yet another object of my invention is the provision of an RC time control circuit wherein relatively economical resistance and capacitance components may be used and may be caused to provide a relatively long RC time constant by a novel interaction with the structure previously mentioned including the controlled rectifier.

In carrying out my invention in one form thereof, I provide a fabric dryer which in the usual way has a chamber for receiving fabrics to be dried, together with heating means arranged to heat fabrics in the chamber. The heating means is adapted to be connected across a source of alternating current. A controlled rectifier is provided in series with the heating means. It is a characteristic of a controlled rectifier that it becomes conductive for one direction or polarity of current when a predetermined voltage is applied to its gate; thus, when connected in series with the heating means, it may control the portion of half of each cycle of proper polarity of the alternating current that energizes the heating means.

In order to control the voltage on the controlled rectifier gate I provide a rapid-response controlling circuit, which includes means responsive to dryness of fabrics in the chamber. This circuit is arranged to cause an increase in the time for the voltage on the gate to reach the predetermined level each half cycle of proper polarity as the fabrics become dryer. As a result of this, a continually decreasing amount of electrical energy is provided to the heating means because of the decrease in the length of each half cycle of proper polarity that the rectifier is conductive.

In another aspect of my invention, I combine with the foregoing a timing circuit which includes a half wave rectifier, a resistor, and a capacitor connected in series with each other and in parallel with the controlled rectifier. The half wave rectifier in this circuit is arranged to permit passage of current during the same half cycle as the controlled rectifier. This has the result that the

capacitor charges only during that portion of each half cycle of proper polarity before the controlled rectifier becomes conductive, thereby substantially extending the charging time of the capacitor. Together with this, conventional means may be provided for terminating operation of the dryer in response to a predetermined voltage across the capacitor.

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 which may incorporate my invention, the view being partly broken away and partly sectionalized in order to illustrate details;

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

FIGURE 3 is a graph showing the shape of the alternating current wave energizing the dryer heater at one point in a drying operation;

FIGURE 4 is a graph similar to FIGURE 3 showing the form of the alternating current energizing the heater at a later point in a drying cycle;

FIGURE 5 is a schematic circuit diagram showing a first modification of my invention; and

FIGURE 6 is a schematic circuit diagram showing a second modification of my invention.

Referring now to FIGURE 1, there is shown herein a typical fabric drying machine 1 in which my improved control system may be used. Dryer 1 is provided with a cabinet 2 having a front door 3 to provide access to the interior of the cabinet for loading and unloading fabrics such as clothes. Provided on the top wall 4 of cabinet 2 is a control panel 5 which includes a suitable manual control 6. Within panel 5 there may be provided a suitable control system, schematically indicated at 7, whose operation and structure are fully described herebelow.

Within cabinet 2, there is provided a clothes tumbling container or drum 8 mounted for rotation on a substantially horizontal axis. Drum 8 is substantially cylindrical in shape, having a first central cylindrical outer wall portion 9, second and third outer wall portions 10 and 11 located respectively adjacent the ends 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 drum, or basket, is imperforate. On the interior surface of central portion 9 there may be provided a plurality of clothes tumbling ribs 14 so that clothes are lifted up when the basket rotates and then tumble back down to the bottom of the basket.

The front of drum 8 may be rotatably supported within outer casing 2 by two idler wheels, one of which is shown by the numeral 16. These wheels are rotatably secured to the top of a member 16 which extends up from base 17 of the machine. Wheels 15 are disposed beneath the drum in contact with portion 10 thereof so as to support portion 10 on each side to provide a stable support.

The rear end of the drum 8 receives its support by means of a stub shaft 18 extending from the center of wall 13. Shaft 18 is secured within a bearing 19 formed in a baffle 20 which in turn is rigidly secured to the back wall 21 of cabinet 2 by any suitable means such as, for instance, welding at a number of points 22. With the arrangement shown, the basket may rotate on a horizontal axis with rollers 15 providing the front support and the stub shaft 18 within bearing 19 providing the rear support.

In order to provide for the flow of a stream of drying air through the clothes drum, the drum is provided with a central aperture 23 in its front wall 12 and with an opening in the form of a plurality of perforations 24 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 20 is rigidly secured to rear wall 21 of cabinet 2. Baffle member 20 also serves to support heating means such as electric heating elements 25 appropriately insulated from the baffle member. Elements 25 may be annular in shape so as to be generally coextensive with the perforations 24 in drum 8. A baffle member 26 is rigidly secured to the back wall 13 of the drum outside the ring of perforations 24 and within the stationary baffle 20 so that an annular inlet 27 is, in effect, formed by baffles 20 and 26. In this manner a passage is formed for air to enter annular inlet 27 between the baffles, pass over the heating elements 25, and then pass through openings 28 formed in baffle 26 to the interior of drum 8.

The front opening of the drum is substantially closed by means of a stationary bulkhead generally indicated by the numeral 29. Bulkhead 29 is made up of a number of adjacent members including the inner surface 30 of access door 3, a stationary frame 31 for the door formed as a flange of the front wall 32 of the cabinet, the inner surface member 33 of an exhaust duct which is formed by the cooperation of member 33 with the front wall 32 of the cabinet, and an annular flange 34 mounted on frame 31 and on the duct wall. It will be noted that a suitable clearance is provided between the inner edge of the drum opening 23 and the edge of bulkhead 29 so that there is no rubbing between the drum 2 and the bulkhead during rotation of the drum. In order to prevent any substantial air leakage through opening 23 between the interior and the exterior of the drum, a suitable ring seal 35, preferably formed of belt-like material, is secured to flange 34 in sealing relationship with the exterior surface of drum wall 12.

Front opening 23, in addition to serving as part of the flow path 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 door frame 31. It will be noted that the door includes an outer flat imperforate section 36 and an inwardly extending hollow section 37 mounted on the flat outer section. Hollow section 37 extends into the door frame 31 when the door is closed, and the door surface 30 which comprises part of the combination bulkhead 29 is actually the inner wall of the hollow section.

The air outlet from the drum is provided by the perforated opening 38 formed in the inner wall 30 of hollow door section 37. The bottom wall section of door 3 and the adjacent wall of door frame 31 are provided with aligned openings 39 and 40 providing the entrance to the duct 41 formed by the cooperation of member 33 with front wall 32. As shown, a lint trap 42 which may comprise a fine mesh bag is preferably positioned in exhaust duct 41 at opening 40, the bag being supported by the door frame 31.

Duct 41 leads downwardly to an opening 43 formed in the member 16 which supports wheels 15. Opening 43 constitutes an inlet to a blower member 44 contained within a housing 45 and directly driven by an electric motor 46. Opening 43 connects duct 41 to blower 44 so that the blower may draw air in over the heaters 25, through the basket, and then through the door 3 and the duct 41, and into the blower. From the blower the air passes to any appropriate duct (not shown) out of cabinet 2 so as to be exhausted from the machine.

In addition to driving blower 44, motor 46 has a shaft 47 with a small pulley 48 formed thereon. A belt 49

extends around pulley 48 and also entirely around the cylindrical wall section 9 of drum 8. The relative circumferences of pulley 48 and wall section 9 cause the drum to be driven by the motor at a speed suitable to effect tumbling of fabrics therein. In order to provide proper tensioning of the belt 49, there may be provided a suitable idler assembly 50 secured on the same support 51 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 the air is heated by heating elements 25, the heated air passing through the drum causes vaporization of moisture from the clothes, and the vapor is carried off with the air as it passes out of the machine.

The operation of dryer 1 is controlled by a new and improved control system as shown in the circuit diagram of FIGURE 2. As shown, there the entire control system of the machine may be energized across a three-wire power supply system which includes supply conductors 52 and 53, and a neutral conductor 54. For domestic use the conductors 52 and 53 will normally be connected across a 220 volt power supply, with 110 volts appearing between the neutral line 54 and each of the conductors, and with the neutral line being at ground voltage.

Motor 46 is connected between conductors 52 and 54. The motor is generally an induction motor, including in the usual manner a main winding 55 and a start winding 56, both connected at a common end to a conductor 57 which, through a conventional motor protector 58 and a door switch 59, is connected to neutral conductor 54. In the usual way, door switch 59 is closed when door 3 is closed and is open when the door is open.

Start winding 56 is connected in parallel with main winding 55 through a speed responsive switch 60 which is in the position shown when the machine is at rest or operating at low speed, and which moves out of engagement with contact 61 and into engagement with a contact 61a as the machine comes up to speed. It can readily be seen that engagement with contact 61 connects the start winding 56 in parallel with the main winding 55, while movement of switch 60 away from the position opens the start winding. Thus, when the motor comes up to speed the start winding becomes de-energized and motor 46 then continues to run on main winding 55 alone. Additional switches 62 and 62a, which are normally in the open position shown, may be ganged to move with switch 60. Switches 62 and 62a move into closed position, in engagement with contacts 63 and 63a, when the motor comes up to speed.

A relay 64 is provided and is adapted to be energized across conductors 52 and 54 through a circuit which, starting at conductor 52, proceeds through a normally open, manually operated, switch 65, a reed switch 66, the relay coil 64, and back to conductor 54 through door switch 59. Reed switch 66 is normally closed by virtue of the proximity of a permanent magnet 67, so that the closing of switch 65 energizes relay coil 64 through the circuit described. Switch 65 may be closed, in the present structure, by depression of the manually operable button 6 shown in FIGURE 1, the switch remaining closed only as long as the button is depressed.

When relay coil 64 is not energized, a pair of switches 68 and 69 controlled by the relay are open. For as long as the relay coil 64 is energized, switches 68 and 69 are closed. Accordingly, when the relay coil 64 is energized by a manual closing of switch 65, switches 68 and 69 both close.

Closure of switch 69 provides a complete circuit from conductor 52 to motor 46 and back to conductor 54. Accordingly, provided the door is closed so that switch 59 is closed, motor 46 starts operation. As it comes up to speed, contacts 60, 62 and 62a move over into engagement with contacts 61a, 63 and 63a respectively. The new position of switch arm 60 causes the start winding to be disconnected and the motor continues to run

on winding 55 alone. Also, the engagement of switch arm 60 with contact 61a causes switch 65 to be bypassed through switch 69, switch arm 60, and switch 68. Consequently, relay 64 remains energized after switch 65 is opened by the release of button 6. Thus, motor 46 continues to run.

As previously mentioned, when the motor is operating, switches 62 and 62a are engaged with contacts 63 and 63a. This permits energization of the heaters 25 as follows: Starting at conductor 52, the heater energizing circuit extends through relay contact 69, switch arm 60, contact 61a, and relay switch 68 to the heaters 25. From the heaters, the circuit then extends through a normally closed safety thermostat 70 and a normally closed switch 71.

At this point, the energizing circuit becomes divided. For one half of each cycle of alternating current energization, the current is flowing so as to be passed by a half wave rectifier 72. For the other half of each cycle, the current is flowing in a direction to be passed by a controlled rectifier 73, to be further discussed herebelow. The other side of rectifiers 72 and 73 is joined at point 73a, and the heater energizing circuit is then completed through contact 63, switch 62, and conductor 53. The heaters may thus be energized across a full 220 volt potential.

The half wave rectifier 72 is of the conventional type, which conducts during a full half cycle. The controlled rectifier 73, however, is a PNP solid state device, of a type in substantial commercial use; this type of rectifier is non-conductive, even during the half cycle in which it normally conducts, until a predetermined voltage is applied to the gate 74 thereof. When this predetermined voltage is applied, then the rectifier 73 becomes conductive and remains so until the voltage across it reaches substantially zero. Thus, if the predetermined voltage at the gate occurs subsequent to the beginning of the half cycle in which the rectifier 73 may conduct, there will be conduction through the rectifier only during a portion of that half cycle.

In order to control the voltage at gate 74 of controlled rectifier 73, a rapid-response control circuit, generally indicated by the numeral 75, is provided. This circuit, in its general arrangement, is of a type well known in the art and involves the use of a unijunction transistor 76; such transistors are known to have the characteristic of acting as an electrical switch. Unijunction 76 is effective upon application of a predetermined voltage across its emitter 77 and its base portion 78 to permit the necessary voltage to exist at gate 74 of rectifier 73 so that the rectifier becomes conductive. Resistors 79 and 80 comprise a voltage dividing system so as to limit the maximum voltage on unijunction 76. While the voltage on the unijunction transistor need not be limited specifically to that required to trigger it, it should not be allowed to go above the value for which the transistor is designed.

The emitter 77 is connected at point 81 between a pair of resistors 82 and 83 on one side and a capacitor 84 on the other side. Until the predetermined voltage across emitter 77 is reached, the two resistors 82 and 83 and capacitor 84 are, in effect, in series to provide an RC timing circuit for the emitter. Resistor 82 may be positioned in the dryer 1 as shown in FIGURE 1, for instance, so as to sense ambient temperatures, and resistor 83 may be positioned in the exhaust duct 41, also as shown in FIGURE 1. Both resistors are of the type whose resistance varies with temperature. Resistor 82 is a negative temperature coefficient element whose resistance decreases as the temperature increases. Resistor 83 is a positive temperature coefficient element whose resistance increases with temperature increases.

Resistance element 82 is used to adjust the control system for different ambient temperatures, since air taken into the dryer may vary over a wide range of temperatures

and therefore be heated to different temperatures before it contacts the clothes. Resistor 83, with the compensation provided by resistor 82, then provides an increasing resistance as the temperature goes up. As is well known to those in the art, the exhaust temperature from a dryer increases as the clothes become dryer. What this means, in effect, is that the RC time constant provided by resistors 82 and 83 and capacitor 84 will increase as the clothes become dry because of the increased resistance of resistor 83, it being assumed that resistor 82 will stay approximately at the same level during any one drying operation.

The values of the elements are selected so that, with wet clothes in the dryer, resistor 83 permits almost instantaneous build up across capacitor 84 of the voltage required to trigger unijunction 76 into providing the required voltage at gate 74 of controlled rectifier 73. This condition is shown in FIGURE 3, where it can be seen that only a very small portion of each half cycle of current above the zero current line elapses before the controlled rectifier becomes conductive. However, as the drying operation continues and the resistance of element 83 increases, the RC time constant rises so that as the clothes are becoming dry the current input to the clothes decreases, at a point near dryness, to the configuration shown in FIGURE 4. It can be seen here that a substantial part of each current half cycle above the zero current line has elapsed before the controlled rectifier becomes conductive and that thus the power input to the heaters 25 has been decreased by almost half, compared to what it was when the condition shown in FIGURE 3 prevailed.

As an example of a suitable group of components for achieving this effect, unijunction transistor 76 may be of the type which, at about 30 volts at the emitter 77, becomes sufficiently conductive that gate 74 of controlled rectifier 73 causes the controlled rectifier to conduct. Capacitor 84 may have a value of 0.1 microfarad. Element 82 may be a thermistor of negative coefficient type (20,000 to 6,000 ohms at 50 to 100 degrees) while resistance 83 may be a positive temperature coefficient resistor of the type whose resistance increases from 5,000 to 60,000 ohms between 100 and 160 degrees. Resistors 79 and 80 may typically be on the order of 15,000 and 2,000 ohms. An additional resistor 85 is conventionally provided in order to preclude the premature triggering of the controlled rectifier 73. Resistor 85 is normally of a low value compared to the others, and may, for instance, be on the order of 50 ohms.

It will be seen that, with the arrangement described, for each half cycle of current below the line as seen in FIGURES 3 and 4 rectifier 72 will conduct for the full half wave, but that for the half cycle above the zero current line the controlled rectifier 73 will determine the amount of energy input to the heaters. This determination is in accordance with the dryness of the clothes as measured by the temperature of the exhaust air. Of course, any other means of making a resistance vary in accordance with the dryness of the clothes may be used; in this connection, it is obviously possible to make a humidity responsive element respond in substantially the same way that element 73 is made to respond in the present structure.

The arrangement shown in connection with controlled rectifier 73 is effective to vary the energy input to the heaters, and this energy input decreases as the clothes become dryer (a highly desirable result). Other related means are, however, needed in order to effect termination of the cycle in response to a dry condition of the clothes. This means is provided by the circuit generally shown at 70. It includes a half wave rectifier 87 connected to points 73a and arranged to permit passage of current during the same half cycle in which controlled rectifier 73 may conduct current. In series with rectifier 87 are a high resistance 88 and a capacitor 89. The other side of capacitor 89 is connected in series with the heaters.

Connected across capacitor 89 is a circuit including a device which is non-conductive until a predetermined voltage is built up across capacitor 89. In the present embodiment, this may be a relatively inexpensive item such as, for instance, the glow tube which is commercially marketed by the General Electric Company under the model No. NE-2. Included in series with glow tube 90 and in parallel with capacitor 89 is an induction coil 91. Coil 91 has a controlling relationship, when energized, to the reed switch 66, overcoming the effect of magnet 67 and opening reed switch 66 for as long as coil 91 is energized.

It will readily be seen that resistor 88 and capacitor 89 constitute a standard RC timing circuit for determining when glow tube 90 will become conductive and permit the capacitor to discharge through coil 91, thereby energizing the coil and opening switch 66.

It will be understood that the higher the values of the resistor 88 and the capacitor 89 the more expensive and difficult the control of the components, and that therefore reasonably low values are desirable. However, the lower the ratings of these components the lower the RC time constant of the circuit. As an important feature of my invention, I permit the use of relatively economical components for the RC timing circuit 86 by causing the charging of capacitor 89 through resistor 88 to occur for only a very small portion of each cycle when the fabrics are quite wet, and for an increasing portion of each cycle as the clothes become dryer.

This results from the fact that rectifier 87 permits passage of current through circuit 86 only during that portion of the half cycle prior to controlled rectifier 73 becoming conductive. When the controlled rectifier is conductive, it constitutes a shunt across circuit 86 and therefore there is no charging of capacitor 89 during conductivity of controlled rectifier 73. However, during the period prior to the unblocking of controlled rectifier 73, current does pass through circuit 86, and therefore during that portion of the circuit there is charging of capacitor 89.

Referring again to FIGURES 3 and 4, it will be seen that there is very little charging of capacitor 89 while the fabrics are still wet, but that the rate of charging of the capacitor increases as the clothes approach dryness; in fact, charging occurs for most of each half cycle when the condition of FIGURE 4 is reached. As a result, the capacitor charges more rapidly at the end of an operation when the clothes are dry, as sensed by element 83, than at the beginning, and comparatively economical elements may be used compared to what would be required if charging of the system for a full half cycle throughout an operation were permitted.

Returning to induction coil 91 and its effect on switch 66, the opening of switch 66 de-energizes main relay 64 and thereby opens switches 68 and 69. This opens the circuit to the heater, since switch 65 is open, and to the relay itself. However, motor 46 may readily be kept running by the well known expedient of providing a normally open thermostat 92 across switch 69; thermostat 92 closes early in a drying cycle, as it senses temperature increases, and when closed constitutes a shunt across the switch 69. Thermostat 92 may be positioned adjacent thermostat 83, for instance, so that it also senses the exhaust temperature of the air. When thermostat 92 is closed, the heater still cannot be energized because of the open condition of switch 68. However, an energizing circuit is still completed to motor winding 55, and therefore the motor continues to run, thereby tumbling drum 8 and operating blower 44. As a result the fabrics are tumbled and cooled until the point is reached where the temperature of the air passing through exhaust duct 41 is low enough that thermostat 92 no longer stays closed but returns to its normal open position. Then the energizing circuit for the motor is no longer complete, and the motor will terminate operation so that the entire machine is de-energized.

It will be seen from the foregoing that a control system has been described wherein, by the use of a controlled rectifier in series with the heater 25 the amount of energy provided for drying purposes is decreased as the fabrics become dryer. It will also be seen that the circuit arrangement permits the use of a timing circuit wherein the charging of a capacitor to end the heating operation is under the control of the controlled rectifier, the capacitor being permitted to charge only during the period in each half cycle of proper polarity prior to the controlled rectifier becoming conductive.

Completing the description of FIGURE 2, it will be noted that switch 71 prevents completion of the heater circuit when it is open. This switch is provided so as to permit provision of a "Fluff" cycle when the operator so desires, that is, the provision of tumbling without heat for a number of minutes so as to fluff clothes and other fabrics. The timing is effected in the same way as previously. That is, circuit 86 will effect a timing function, with capacitor 89 charging during a full half cycle. It has been found that a ten minute fluff operation may readily be provided by this expedient.

It will also be understood that circuit 75 (except for resistors 82 and 83), circuit 86, and relay 64 may be physically incorporated as part of the control system 7 secured within panel 5 (FIGURE 1).

Referring now to FIGURE 5, there is shown a second embodiment of my invention. The only difference between this arrangement and the first arrangement is that the half wave rectifier 72 is eliminated so that energization of the heaters can be provided only through the controlled rectifier 73. This permits a much greater variation in the amount of energy provided to the clothes at the beginning of the cycle and at the end of the cycle. With the structure of FIGURE 3 the maximum variation can only be from full power to half power, that is, the energy provided at the end may be about 50% of the energy at the beginning. However, with the structure of FIGURE 5, the energy at the end can be virtually down to zero percent of the energy provided at the beginning.

Referring now to FIGURE 6, there is shown a third embodiment of my invention wherein the heaters are divided into a pair of elements 93 and 94. Rather than having the two elements both connected across the conductors 52 and 53, element 93 is connected between conductors 52 and 54 while element 94 is connected between conductors 53 and 54. An added switch 95 is controlled by relay 64 in this case to provide for de-energization of heater 94 when relay 64 trips as explained in connection with the first embodiment.

Thus, each of the heating elements is energized by 110 volts, and only the element 94 is under the control of controlled rectifier 73. This gives a degree of control similar to that of the structure of FIGURE 2 since the heating element 93 is energized all the time, and the other heating element 94 may be energized anywhere from half the time down to virtually none of the time. This feature in the embodiment of FIGURE 6 permits the controlled rectifier 73 to be of the type which needs to be rated only for 110 volts operation, as opposed to the requirement for a 220 volt rating in the embodiments of FIGURES 2 and 5. The cost of controlled rectifiers increases with the voltage rating thereof, and thus the controlled rectifier in the control system of FIGURE 6 can be a more economically purchased item than those of FIGURES 2 and 5. However, it will be recognized that different control characteristics are achieved with the various embodiments, and that any of the different embodiments may be deemed suitable depending upon many factors such as the particular design of the dryer in which the control system is used, etc.

While in accordance with the patent statutes I have described what at present are considered to be the preferred embodiments of my invention, it will be obvious to those skilled in the art that various changes and modi-

fications may be made therein without departing from the invention. As an example of this, the particular rapid-response control circuit using a unijunction transistor to switch the controlled rectifier on and off may be varied. One variation of this would be to use a Shockley diode in the place of the unijunction transistor. Yet a further variation that readily comes to mind results from the fact that, on an experimental basis, controlled rectifiers have been provided which act merely as conductors for one direction of current but as controlled rectifiers for the reverse direction of current. In such a case a separate half wave rectifier would not be necessary since, in effect, the half wave rectifier and the controlled rectifier would be incorporated in the same structure. Also, where temperature-sensitive resistors are used, as in the illustrated embodiments, various circuit connections may be provided besides what is illustrated.

These examples are intended merely for purposes of illustration as to some modifications that can be provided, and are not intended to eliminate other obvious changes and modifications which may be made. 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. In a fabric dryer including a chamber for receiving fabrics to be dried, heating means arranged to heat fabrics in said chamber and adapted to be connected across a source of alternating current, and a forced air system with an exhaust duct leading from the chamber; means for controlling energization of the heating means, including:

(a) a controlled rectifier connected in series with the heating means to control passage of current through the heating means during current half cycles of a first polarity, said rectifier becoming conductive when a predetermined voltage is applied to its gate, and

(b) a rapid response controlling circuit controlling the voltage at said gate and including means responsive to dryness of fabrics in said chamber, said dryness responsive means causing said circuit to increase the time during each current half cycle of the first polarity for the voltage applied to said gate to reach said predetermined voltage as the fabrics become drier whereby a continuously decreasing amount of electrical energy is provided to the heating means.

2. In a fabric dryer including a chamber for receiving fabrics to be dried, heating means arranged to heat fabrics in said chamber and adapted to be connected across a source of alternating current, and a forced air system with an exhaust duct leading from the chamber; means for controlling energization of the heating means, including:

(a) a controlled rectifier connected in series with the heating means to control passage of current through the heating means during current half cycles of a first polarity, said rectifier becoming conductive when a predetermined voltage is applied to its gate,

(b) a rapid response controlling circuit controlling the voltage at said gate and including means responsive to dryness of fabrics in said chamber, said dryness responsive means causing said circuit to increase the time during each current half cycle of the first polarity for the voltage applied to said gate to reach said predetermined voltage as the fabrics become drier whereby a continuously decreasing amount of electrical energy is provided to the heating means,

(c) a timing circuit having a half wave rectifier, a resistor, and a capacitor connected in series, said half wave rectifier being arranged to conduct during current half cycles of the first polarity and said timing circuit being connected in parallel with said controlled rectifier so that said capacitor charges only during the portion of each current half cycle of the

first polarity before said controlled rectifier conducts to thereby extend the charging time of said capacitor, and

(d) means for terminating operation of the dryer in response to a charge of a predetermined value across said capacitor.

3. The apparatus defined in claim 1 wherein said dryness responsive means includes a temperature sensitive resistance member positioned in said duct so as to sense the temperature of the air being exhausted from said chamber.

4. The apparatus defined in claim 1 wherein said control means further includes a half wave rectifier is connected in series with said heating means and in parallel with said controlled rectifier thereby to permit energization of said heating means during the other half of each cycle of alternating current.

5. An apparatus as defined in claim 3 wherein said dryness responsive means further includes a second temperature sensitive resistance member positioned to sense ambient temperature.

6. The apparatus defined in claim 2 wherein said means for terminating operation of said dryer includes a glow tube, a relay coil and a switch opened by energization of said coil, said coil and said tube being connected in series with each other across said capacitor, said tube becoming conductive when the charge across said capacitor reaches said predetermined value.

7. In a fabric dryer including a chamber for receiving fabrics to be dried, heating means arranged to heat fabrics in said chamber and adapted to be connected across a source of electrical energy, and a forced air system with an exhaust duct leading from the chamber; means for controlling energization of the heating means, including:

(a) a controlled rectifier connected in series with the heating means to control passage of current through the heating means during current half cycles of a first polarity, said rectifier becoming conductive when a predetermined voltage is applied to its gate,

(b) a rapid response control circuit for controlling the voltage at said gate, said control circuit including a first temperature sensitive resistance member positioned in the exhaust duct to sense the temperature of air being exhausted from the chamber and a second temperature sensitive resistance member positioned to sense ambient temperature to cause said control circuit to increase the time during each current half cycle of the first polarity for the voltage applied to said gate to reach said predetermined voltage as the fabrics become drier whereby a continuously decreasing amount of electrical energy is provided to the heating means,

(c) a timing circuit having a half wave rectifier, a resistor, and a capacitor connected in series, said half wave rectifier being arranged to conduct during current half cycles of the first polarity and said timing circuit being connected in parallel with said controlled rectifier so that said capacitor charges only during the portion of each current half cycle of the first polarity before said controlled rectifier conducts to thereby extend the charging time of said capacitor, and

(d) means for terminating operation of the dryer in response to a charge of a predetermined value across said capacitor, said terminating means including a glow tube, a relay coil and a switch opened by energization of said coil, said coil and said tube being connected in series across said capacitor, said tube becoming conductive when the charge across said capacitor reaches said predetermined value.

8. In a fabric dryer including a chamber for receiving fabrics to be dried, heating means arranged to heat fabrics in said chamber and having two heaters adapted to be connected across a three wire single phase source

of electrical energy of the type including two supply lines and a neutral line with each heater connected across one supply line and the neutral line, and a forced air system with an exhaust duct leading from the chamber; means for controlling energization of the heating means including:

- (a) a controlled rectifier connected in series with one of the heaters to control passage of current through said one heater during current half cycles of a first polarity, said rectifier becoming conductive when a predetermined voltage is applied to its gate, 5
- (b) a rapid response control circuit for controlling the voltage applied to said gate, said control circuit including a first temperature sensitive resistance member positioned in the exhaust duct to sense the temperature of air being exhausted from the chamber and a second temperature sensitive resistance member positioned to sense ambient temperature to cause said control circuit to increase the time during each current half cycle of the first polarity for the voltage applied to said gate to reach said predetermined voltage as the fabrics become drier whereby a continuously decreasing amount of electrical energy is provided to the heating means, 10
- (c) a timing circuit having a half wave rectifier, a resistor, and a capacitor connected in series, said half wave rectifier being arranged to conduct during current half cycles of the first polarity and said timing circuit being connected in parallel with said controlled rectifier so that said capacitor charges only during the portion of each current half cycle of the first polarity before said controlled rectifier conducts 15
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to thereby extend the charging time of said capacitor, and

- (d) means for terminating operation of the dryer in response to a change of a predetermined value across said capacitor, said terminating means including a glow tube, a relay coil and a switch opened by energization of said coil, said coil and said tube being connected in series across said capacitor, said tube becoming conductive when the charge across said capacitor reaches said predetermined value.

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