

Aug. 28, 1962

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3,050,865

CONTROL SYSTEM FOR CLOTHES DRYERS

Filed July 9, 1959

3 Sheets-Sheet 2

FIG. 2

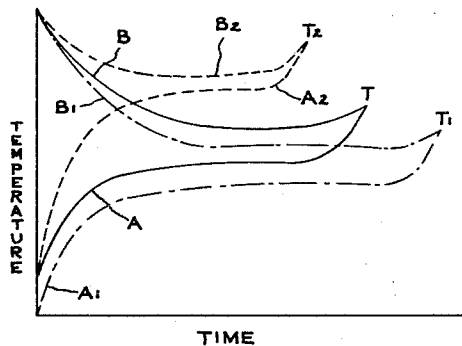
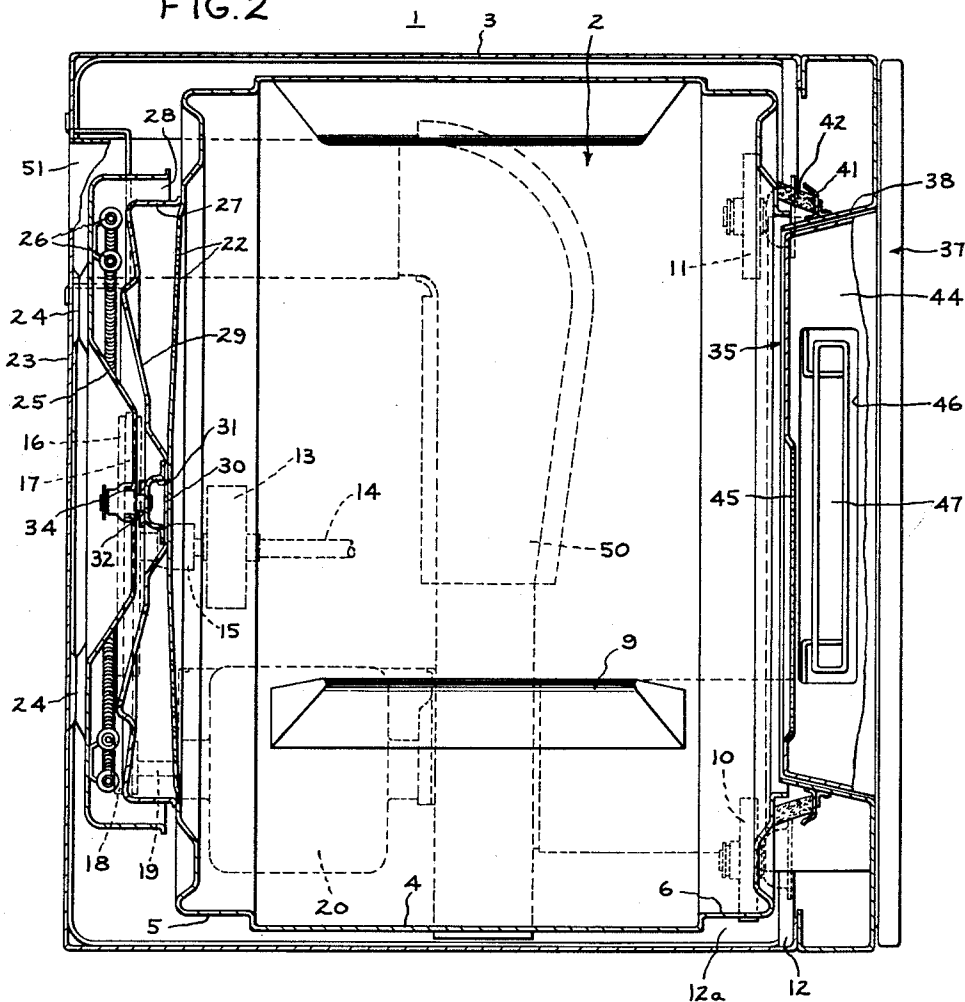


FIG. 5

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3 Sheets-Sheet 3

FIG. 3

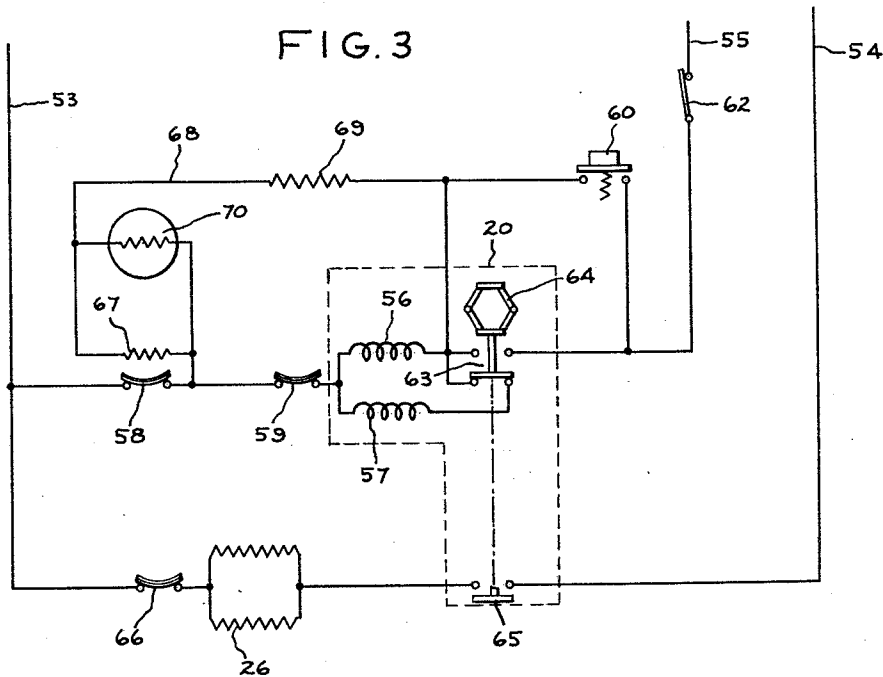
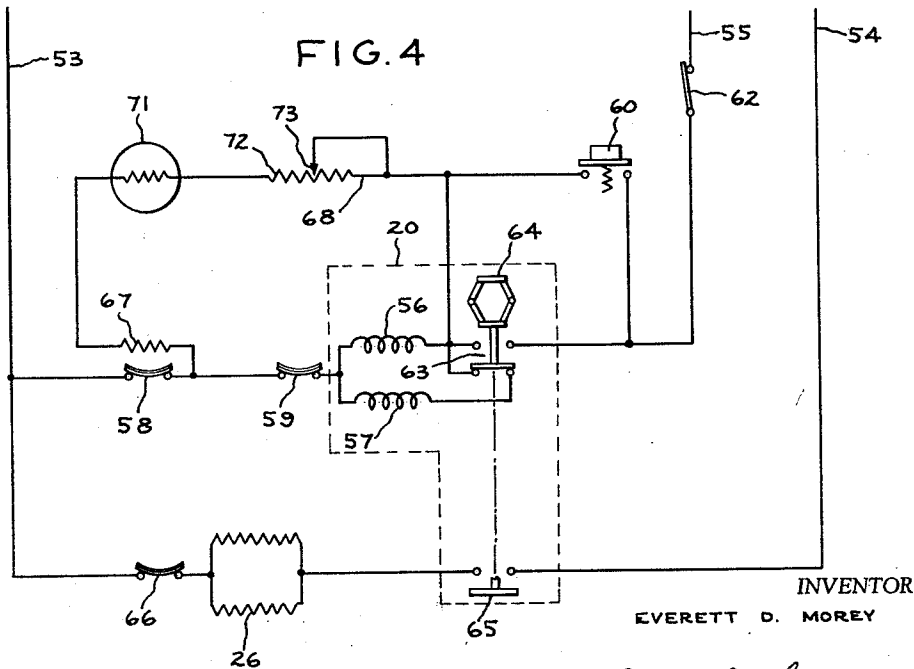


FIG. 4



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1

3,050,865

CONTROL SYSTEM FOR CLOTHES DRYERS

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Filed July 9, 1959, Ser. No. 825,934
10 Claims. (Cl. 34-45)

My invention relates to clothes drying machines, and more particularly to automatic control systems for use in such machines for controlling the drying operation.

It is well known that the length of time required to dry clothes in a domestic clothes drying machine may be controlled by the dryness of the clothes, with the machine finishing its operation when the clothes are dry, rather than by presetting a fixed length of time of operation. This is generally effected by using a thermostatic control which measures indirectly the dryness of the clothes. The use of temperature changes to measure dryness is possible by virtue of the fact that when the clothes are quite wet and the clothes temperature is at a level where almost all the energy input to the machine is being used to vaporize the moisture from the clothes, very little energy is available to raise the temperature of the clothes and there is therefore a temperature plateau, so to speak, as the cycle progresses. When, however, a substantial part of the moisture in the clothes has been vaporized and removed, the energy input is then free to raise the temperature of the clothes.

For this reason, thermostatic controls measure the dryness of the clothes on the basis that a sharpened rise in the clothes temperature indicates that the clothes are substantially dry. Conventionally, such thermostatic controls shut off the means heating the clothes when a predetermined high temperature or trip point is reached. Depending upon other structural features of various drying machines, a single such occurrence may be provided or several such occurrences may be provided in a single drying sequence. In either event, it is important for optimum operation of machines having thermostatically controlled drying cycles that suitable changes be made to the clothes temperature causing the thermostat to trip (hereinafter called the "effective trip temperature") in order to compensate for variations in such factors as size of clothes load, type of clothes load, ambient temperature, and power supply variations. All of these factors are capable of varying the temperature at which the plateau will be reached. Thus, for instance, for a relatively small load of clothes, a relatively high temperature plateau must be reached before a balance is obtained between the energy input and the rate of moisture vaporization, whereas with a larger clothes load, the energy input will be balanced by the moisture vaporization at a lower temperature. By the same token, if the ambient temperature rises, then the temperature of the air as it comes into contact with the clothes rises. This change in the temperature at which the air contacts the clothes represents a change in the energy input to the clothes, and therefore will cause a similar variation in the temperature plateau. It can readily be seen that if a single predetermined trip temperature is provided, the operation of the machine will be impaired because for some conditions the trip temperature may be very close to the plateau temperature—or even below it—while under other opposite conditions the trip temperature may be very substantially above the plateau temperature. These variations in the plateau temperature, if the trip temperature is a constant one, may cause overdrying, underdrying, and, in the extreme case where the trip temperature is so far above the plateau temperature that it cannot be reached, continuous operation of the machine until it is shut off manually. This latter condition may occur when the power input is low and a very

2

low ambient prevails as may be the case, for instance, where the machine is used in the northern latitudes in winter time and is located in a cold basement, garage, porch or the like. In such a case it can readily be seen that a low heating effect due to the low power input together with the low temperature of the entering air may prevent the heater from ever being able to raise the air to the trip temperature even though the clothes may have long been dry.

Because of this situation, it has been found to be of high importance to provide suitable compensating means responsive to the various factors affecting the plateau level, which compensating means will correct the effective trip temperature accordingly.

It is therefore an object of the invention to provide an improved economical means of compensating for various factors such as, for instance, ambient temperature, power supply variations, size of load, and type of load, so that the effective trip temperature is maintained at a relatively even level above the plateau regardless of the level of the plateau.

It is further an object of this invention to achieve this compensation by suitable variation of the heating effect of a biasing heater positioned in heating relation to the main thermostat, so that although the thermostat senses the same real trip temperature all the time, the temperature of the clothes required to trip the thermostat (i.e., the effective trip temperature) is varied inversely with the heating effect provided by the biasing heater.

A further object of the invention is to achieve this variation of the heating effect of the biasing heater by connecting in a circuit with the biasing heater means which varies its resistance with variations in its temperature, the connection being such as to cause a decrease in the effectiveness in the biasing heater with increases in the sensed temperature.

In carrying out my invention in one form thereof, I provide a clothes drying machine which has a conventional clothes container with a main heater positioned to heat the clothes in the container. Thermostatic means are positioned to be responsive to the temperature of the clothes in the container and also are acted on by an electric resistance type biasing heater which is positioned in suitable heating relation to the thermostatic means. When the thermostatic means senses a predetermined high temperature, due to the combination of the clothes temperature and the biasing heater, it causes a switch to open to stop operation of the main heater. As thus far described, it is clear that the more effective the biasing heater, the lower the clothes temperature which will trip the thermostatic means.

In circuit with the biasing heater, I provide conductive means of a type which varies its resistance with changes in the temperature it senses. The circuit connections are such that the changes in the resistance of the conductive means cause a decrease in the effectiveness of the biasing heater when the temperature increases. By positioning the conductive means so that it senses temperature changes which are significant to the operation of the clothes drying machine, any rise in that temperature will also cause a rise in the clothes temperature required to trip the thermostatic means with the general effect that the differential between the plateau temperature mentioned above and the effective trip temperature is maintained at a substantially constant value.

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 de-

3

scription 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;

FIGURE 2 is a horizontal sectional view of the dryer, with certain surfaces broken away and partly sectionalized to illustrate further details;

FIGURE 3 is a schematic illustration of a first embodiment of my improved control circuit as used in the control of drying machines such as the machine of FIGURES 1 and 2;

FIGURE 4 is a schematic illustration of a second embodiment of my improved control circuit which may be embodied in the machine of FIGURES 1 and 2; and

FIGURE 5 is a graph indicating time-temperature relationships obtained under varying circumstances by use of the control circuits of FIGURES 3 and 4.

Referring now to FIGURES 1 and 2 of the drawings, I have shown therein a domestic clothes dryer 1 including a clothes tumbling container or drum 2 provided with a suitable outer casing or cabinet 3 which completely encloses the drum on all sides. The drum is mounted for rotation within cabinet 3 on a substantially horizontal axis, and is generally cylindrical in shape, having a first outer wall portion 4, second and third outer wall portions 5 and 6 located respectively adjacent the ends of the drum, a back wall 7, and a front wall 8. Outer wall portions 4, 5, and 6 are imperforate over their entire length, so that the entire outer shell of the basket is imperforate; on the interior surface of central portion 4 there is provided a plurality of clothes tumbling ribs 9.

The front of drum 2 is rotatably supported within the outer casing 3 by means of a pair of idler roller wheels 10 and 11 which are rotatably secured to the top of an upwardly extending member 12 secured at its bottom to the base 12a of the machine (FIGURE 1). Rollers 10 and 11 are disposed beneath the drum in contact with portion 6 thereof. The rear end of the drum receives its support from a roller wheel 13 which is positioned beneath portion 5 of the drum in supporting and frictionally driving engagement therewith.

Roller 13 is secured on a shaft 14 supported in bearings 15. Shaft 14 is secured to a pulley 16 which is driven from a belt 17 in turn powered by a pulley 18 mounted on an end of the shaft 19 of an electric motor 20. The motor, pulleys, and roller 13 are so proportioned to drum 2 and to each other that drum 2 is rotated by roller 13 at an appropriate speed to provide tumbling action for articles of clothing placed therein.

In order that a stream of drying air may be introduced into and passed through the clothes drum, the drum is provided with a central aperture 21 in its front wall 8 and with a plurality of perforations 22 extending in an annulus around back wall 7. Rigidly secured to the rear wall 23 of casing 3 by any desired means such as, for instance, welding at suitable points 24, is a baffle member 25 which has secured thereto heating means such as an electric heater 26 appropriately insulated from the baffle member. Heating elements 26 may be annular in shape so as to be generally coextensive with the perforations 22 in drum 2. A baffle member 27 is rigidly secured to the back wall 7 of the drum outside the ring of perforations 22 and within the stationary baffle 25 so that an annular air inlet 28 is, in effect, formed by the two baffles 25 and 27. Baffle 27 is further provided with an annular series of openings 29; in this manner a passage is provided for air to enter annular opening 28 between the baffles, pass over the heating elements 26, through opening 29 and perforations 22 into the interior of drum member 2.

In addition to the air guiding function, the baffles 25 and 27 help the rollers 10, 11 and 13 support the drum

4

2. Secured to the central portion 30 of baffle 27 is a bracket 31 to which in turn is secured a stub shaft member 32 substantially coaxially positioned relative to drum 2. The central portion of baffle 25 has a slot-like opening 34 formed therein. The slot is suitably formed (as more fully described in application S.N. 789,869 filed January 29, 1959, by William F. Simpson and assigned to the same assignee as this invention) so as to permit stub shaft 32 a limited amount of movement in the vertical direction but virtually no movement in horizontal directions. Thus, the slight vertical motions of the drum which result from the tumbling of the clothes can be accommodated while at the same time undesirable horizontal motion is affirmatively prevented by engagement of stub shaft 32 in slot 34.

The front opening 21 of the drum is substantially closed by means of a stationary bulkhead generally indicated by the numeral 35. Bulkhead 35 is made up of a number of adjacent members including the inner surface 36 of an access door 37 mounted on the dryer cabinet, a stationary frame 38 for the door, the inner surface 39 of an exhaust duct 40, and an annular flange 41 mounted on the frame 38 and on the duct wall. It will be noted that a suitable clearance is provided between the inner edge of the drum opening 21 and the edge of bulkhead 35 so that there is no rubbing between the drum and the bulkhead during rotation of the drum. In order to prevent any substantial air leakage through opening 21 between the interior and the exterior of the drum a suitable ring seal 42, preferably formed of felt-like material, is secured to flange 41 in sealing relationship with the exterior surface of drum wall 8.

Front opening 21, in addition to serving as part of the air flow path through the drum, also serves as a means whereby clothes may be loaded into and unloaded from the drum. The door 37, whose inner surface forms part of the bulkhead closing the opening, is mounted on cabinet 3 and when the door is opened clothes may be inserted into or removed from the drum through the door frame 38. It will be noted that the door includes an outer flat imperforate section 43 and an inwardly extending hollow section 44 mounted on the flat outer section. Hollow section 44 extends into the door frame 38 when the door is closed and the door surface 36 which comprises part of the combination bulkhead 35 is actually the inner wall of the hollow section.

The air outlet from the basket is provided by a perforated opening 45 formed in the inner wall 36 of hollow door section 44. The bottom wall section of door 34 and the adjacent wall of door frame 38 are provided with aligned openings 46 and 47, opening 47 providing the entrance to duct 40. As shown, a lint trap 48, which may comprise a fine mesh bag, is preferably positioned in exhaust duct 40 at opening 47, the bag being supported by the door frame 38. Duct 40 leads to suitable air moving means which may, as shown, comprise a centrifugal blower 49 mounted on the motor shaft and thus driven by motor 20. The outlet of blower 49 communicates with an outlet duct 50 (FIGURE 2) which extends to an opening 51 in the back 23 of cabinet 3. During operation of motor 20, the rotation of blower 49 causes air to be drawn into cabinet 3 through a suitable opening 52 (FIGURE 1) provided at the front of the machine, through annular opening 28, over heaters 26, through openings 29 and perforations 22 into drum 2, across the drum, through perforated opening 45 and aligned openings 46 and 47 into duct 40, and then through the blower 49, the outlet duct 50, and opening 51 to atmosphere.

The operation of dryer 1 is controlled by a new and improved control system, one embodiment of which is shown in the circuit diagram of FIGURE 3. As shown there, the entire control system of the machine is energized across a three-wire power supply system including supply conductors 53 and 54 and a neutral conductor

55. For domestic use, the conductors 53 and 54 will normally be connected across a 220 volt power supply, with 110 volts appearing between the neutral line 55 and each of the conductors.

The drive motor 20 includes a main winding 56 and a start winding 57 which are connected in parallel with each other between supply conductor 53 and neutral conductor 55. Specifically, the circuit, starting at supply conductor 53, passes through a disc-type bimetallic thermostatic device 58, a conventional motor protector 59, then through the windings 56 and 57 in parallel with each other, a start switch 60 (which may be positioned, as shown in FIGURE 1, on a control panel 61 mounted on top of cabinet 3), a door switch 62 (which may be provided, as shown in FIGURE 1 to be closed by the closing of door 37), and neutral conductor 55. Included in the parallel branch circuit of start winding 57 is a switch 63 controlled by a centrifugal mechanism 64 rotatable with the motor; when the motor comes up to a certain speed upon energization of the windings 56 and 57, the device 64 causes switch 63 to open the winding 57 and permit the motor to continue running on winding 56 alone. Centrifugal device 64 also controls a switch 65, closing it at the same time that it opens switch 63. Switch 65 is in series with the main heater elements 26, which are connected, together with a standard safety thermostat 66, across the two conductors 53 and 54. By this arrangement it will readily be seen that the heaters 26 are operative only when motor 20 comes up to speed thereby insuring that they will not operate if the motor is not running.

It will be observed in FIGURE 1 that the thermostatic device 58 is positioned at the front of the dryer on the bulkhead 35 directly below the air outlet 45 from the drum. The thermostat 58 is thus effective to sense the temperature of the exhaust air leaving the drum, which temperature is very close to the actual clothes temperature. In addition to the clothes temperature as a factor affecting the operation of thermostat 58, a biasing heater 67 is provided in close physical relationship with element 58 so as to be in heating relation thereto. The heater 67 is of relatively high resistance compared to heater 26 (for example, approximately 1100 ohms for heater 67 and 10 ohms for heater 26 may be provided), so that its power consumption compared to the main heater is exceedingly small. In fact, the small size of heater 67 and the desirability of having it close to the thermostatic element 58 generally causes the preferred construction, in practice, to provide for a unitary assembly within a single casing, which assembly includes both the biasing heater and the thermostatic disc element.

The biasing heater 67 is energized through a circuit which is in parallel with the motor but in series with the disc thermostat element. Specifically, the circuit for the biasing heater, after proceeding through the thermostat 58, passes through the biasing heater, through a conductor 68 which includes a resistor 69, and then passes through start switch 60 and door switch 62 to neutral conductor 55.

In the biasing heater circuit, in series with resistor 69 but in parallel with the biasing heater 67, I provide conducting means 70 which, as an important feature of my invention, is of the type whose resistance changes when its temperature changes. In the specific embodiment of FIGURE 3, the conductive device 70 is of a type having a negative thermal coefficient, that is, as the temperature increases its resistance decreases. Several such temperature-variable resistances with a negative thermal coefficient are commercial in use at the present time. For instance, one group of such materials derived from mixtures of iron, nickel, and cobalt is known as "thermistors."

It will readily be observed that the more effective the biasing heater 67 the lower the clothes temperature required to trip the thermostat 58 (i.e., the lower the ef-

fective trip temperature) inasmuch as the tripping of the thermostat is effected by a combination of the clothes temperature and of the heat from the biasing heater 67. It will further be clear that the heat produced by resistor 67 is a direct function of the power impressed on the resistor; therefore, any decrease either in the voltage across the resistor or in the current through the resistor decreases its heating effect. Since heater 67 and conducting means 70 form together one resistance, in effect, and resistor 69 forms another resistance in series therewith, it will readily be seen that if a voltage of 110 volts is impressed between conductor 53 and neutral line 55, and assuming no voltage losses elsewhere in the circuit in series with the bias heater circuit, the potential of 110 volts will be divided between resistance 69 on the one hand and conducting means 70 and heater 67 on the other hand. It will further be seen that, since the net resistance of conductors in parallel is determined by the formula

$$\frac{1}{R_{\text{net}}} = \frac{1}{R_1} + \frac{1}{R_2} \dots$$

variations in the resistance of conducting means 70 will cause the net resistance of the conducting means 70 and the heater 67 in parallel with each other to vary also. Inasmuch as the voltage drop across each serially connected resistance is generally proportional to the resistance, and since the total voltage drop across the entire circuit is a constant (110 volts), variations in the resistance of heater 67 and conducting means 70 as a group will cause the division of the voltage between resistor 69 on the one hand and the conducting means and biasing heater on the other hand to be modified.

To give a specific example, assuming all pure resistances in the circuit, let it be assumed that resistor 69 equals 500 ohms, conducting means 70 equals 1,000 ohms, and heater 67 equals 1,000 ohms at a given temperature. The conducting means and the biasing heater together present a resistance of 500 ohms by application of the formula

$$\frac{1}{R_{\text{net}}} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{1000} + \frac{1}{1000} = \frac{1}{500}$$

With this arrangement, the 110 volts of electric potential will be divided so that there is a 55 volt drop across resistor 69 and a 55 volt drop across the group consisting of conducting means 70 and heater 67. If now, for the sake of simplicity, it is assumed that a temperature rise sufficient to decrease the resistance of conducting means 70 to 500 ohms is provided, the resistance of the conducting means and heater group is determined by the same formula i.e.,

$$\frac{1}{R_{\text{net}}} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{1000} + \frac{1}{500} = \frac{1}{333.3}$$

Thus, the net resistance is 333 ohms. This means that the 110 volts of potential will be split in the ratio of 500 to 333 between the group of resistance and resistor 69; the group resistance will have a voltage of 44 volts across it and the resistor 69 will have a voltage of 66 volts across it. Inasmuch as the resistance of the biasing heater is a constant, a decrease in the voltage across it causes a decrease in the current passing through the heater, and the power causing the heating operation is decreased, that is, the heater is less effective.

It will thus be seen that with a rise in temperature the change of resistance of conducting means 70 decreases the effectiveness of the biasing heater. Conversely, with decreases in temperature the effectiveness of the biasing heater is increased by the change in resistance of the conducting means 70.

Referring to FIGURE 1, it can be seen that a preferred location for the conducting means 70 is within the hollow door portion 44 so that it is in the direct path of the exhaust air after it has been in contact with the clothes.

In this position conducting means 70 is sensitive to four separate factors: First, it is sensitive to the temperature changes resulting from the size of the clothes load. Second, it is sensitive to temperature changes resulting from the type of clothes load (for instance, slow drying items such as cottons as opposed to faster drying loads of synthetic materials). Third, changes in the voltage of the power supply cause different heating effects from main heater 26, and this, while tempered by passage through the clothes, nonetheless creates temperature changes when it is exhausted from the basket. And fourth, conducting means 70 is sensitive to temperature changes resulting from the temperature of the ambient air brought in for heating: the higher the temperature of the ambient air the higher will be the temperature of the air passed into the basket after passage over heaters 26, and the higher the temperature of the air passing into the basket the higher will be the temperature of the air exhausting from the basket.

As stated, conducting means 70 is connected so that when its temperature is increased it decreases the effectiveness of the biasing heater thereby increasing the clothes temperature required to effect tripping of thermostat 58. Referring to FIGURE 5, there is shown a graph of elapsed time of drying against temperature. Curve A represents the temperature of the clothes in the drum for a particular type of load introduced at a particular ambient temperature with a particular voltage supply. For instance, curve A might well represent the curve for an 8-pound load of ordinary cottons to be dried on a steady 220 volt power supply at an ambient temperature of 70 degrees Fahrenheit. It will be observed that at first the temperature of the clothes rises steeply during the period when the temperature is not high enough for the rate of evaporation of moisture from the clothes to absorb substantially all the energy (in the form of heat) being supplied to the clothes. Then, after a certain temperature is reached, the evaporation of the moisture from the clothes does absorb substantially all the energy and the temperature rise becomes very small so that, in effect, a temperature plateau is reached with respect to time. This continues until there is little enough moisture remaining to be evaporated that the energy being supplied to the clothes again tends to cause a temperature rise rather than being absorbed by evaporation of the moisture. This part of the curve can be seen over at the right hand end in the form of a steep temperature rise with respect to time.

Referring now to curve B it shows the effective trip temperature, at any given instant during the drying cycle of the clothes load which provided curve A. When the cycle starts, the biasing heater has been supplying no heat and therefore at that instant the clothes temperature required to trip the thermostat is at a maximum. However, as the biasing heater becomes operative, it supplies a good deal of the heat required for the trip temperature to be reached and thereby decreases the "effective trip temperature." For this reason, the initial part of curve B is represented by a relatively steep decrease in the effective trip temperature. After this initial substantial decrease, which occurs at the same time that the temperature of the clothes is rising steeply, the effective trip temperature becomes a function of the effect of the conducting means 70 on biasing heater 67. During the period when the clothes temperature is passing through its plateau, the conducting means, sensing that there is relatively little temperature change, will also maintain the effective trip temperature relatively constant. The calibration of the different parts is such that the effective trip temperature is maintained at approximately six to ten degrees Fahrenheit above the plateau temperature in order to obtain normal dryness.

When the relatively steep temperature rise of curve A commences at the end of the plateau, signifying that there is relatively little moisture left in the clothes, the conducting means 70 senses this temperature rise and as a result

its resistance decreases. This decrease causes the biasing heater to become less effective, and the effective trip temperature is increased. However, the thermal mass of the parts, such as the conducting means 70 itself, causes the temperature rise of curve B to lag the temperature rise of curve A so that they cross at point T, that is, at point T the clothes temperature equals the effective trip temperature, and the thermostat 58 opens. When the thermostat opens the motor 20 is de-energized and de-energization of the motor causes centrifugal device 64 to open switch 65 to de-energize the heater thereby ending the operation.

Let it now be assumed that for the same type of clothes load and the same voltage supply the machine is being operated in an ambient temperature of 50° F. instead of 70°. The fact that the entering air is at a temperature 20 degrees less than previously means that the heaters 26 can no longer raise the temperature of the air entering drum 2 to the previous high level. As a result, as shown by curve A₁, under such circumstances the initial temperature rise will be slower and the balance between the energy input and the rate of vaporization is reached at a somewhat lower temperature so that the plateau occurs, as shown, below the plateau of curve A. Inasmuch as the rate of vaporization is slower, the plateau is longer and the steep rise showing that the clothes are becoming dry occurs at a later point in time.

Under the low ambient temperature circumstances just described, and as shown by curve B₁ the effective trip temperature is initially, as before, the actual trip temperature of the disc thermostat 58. Thereafter the trip temperature decreases substantially as the biasing heater 67 heats up. However, due to the lower temperature sensed by conducting means 70, the resistance of the conducting means is higher at each given instant and consequently a higher voltage is impressed across the biasing heater 67. Because of this, the rate of decrease of the effective trip temperature and the point to which it is decreased are greater than in the case of curve B, and the effective trip temperature decreases more than before, so that the difference between the flat parts of curves A and B is substantially the same as the difference between the flat parts of curves A₁ and B₁. The effect at the end is also substantially similar in that when the clothes temperature represented by curve A₁ rises steeply curve B₁ follows as a result of the action of conducting means 70 as influenced by the thermal mass of the parts involved. However, since the steep rise occurs at a later point in time for curve A₁, this is also true of curve B₁. Accordingly, curves A₁ and B₁ cross at point T₁, at which point the disc thermostat opens to end the cycle.

Now let it be assumed that for the same ambient and voltage supply as in the case of curve A, a small four pound mixed loaf of light cottons and synthetics is to be dried. The fact that there is a relatively small amount of moisture in the clothes accessible to the heat compared to the larger load represented by curve A means that a higher temperature will be reached before the plateau occurs and that the temperature will increase to the plateau more rapidly. As a result, the curve shown by A₂ represents the changes in temperature of the clothes with respect to time. In this case the effective trip temperature (represented by curve B₂) again decreases from the top trip temperature, but at a relatively slow rate and to a relatively small extent because conducting means 70 has a lower resistance due to the high plateau temperature, and therefore less power is being supplied to biasing heater 67. The action at the end, when the clothes temperature again starts to rise steeply because there is relatively little moisture left to be evaporated, is substantially the same as before. The steep rise in the clothes temperature causes the conducting means resistance to decrease thereby causing the effective trip temperature to rise. Curve A₂ crosses curve B₂ at point T₂, and the thermostat opens to end the heating cycle.

It will be observed, as to curves A₂ and B₂, that the action of conducting means 70 causes approximately the

same temperature differential to be preserved between the clothes temperature plateau and the effective trip temperature, even though in this case the plateau temperature is actually occurring above the trip temperature of the other two curves.

Thus, for all the factors such as size of clothes load, type of clothes load, ambient temperature, and supply voltage, which may cause variations in the level, length, and position of the temperature plateau, the conducting means 70 causes the effective trip temperature to be modified accordingly so that the cycle is always ended after a substantially constant temperature rise at the end of the plateau.

Referring now to FIGURE 4, there is shown a second embodiment of the improved control arrangement of my invention, wherein components which are the same as those described in connection with the embodiment of FIGURE 3 are represented by like numerals. A major difference between the embodiments of FIGURES 3 and 4 is that instead of a resistance having a negative thermal coefficient of resistance, a positive coefficient conducting means 71 is provided and is connected in series with the biasing heater 67 instead of in the parallel connection of FIGURE 3. Further, as shown, an additional resistor 72 may be provided in cooperation with a movable contact 73 whose position in turn is controlled by appropriate manually operable means located on control panel 61.

With heater 67, conducting means 71, and conductor 72 in series with each other, the potential is divided between them in accordance with their resistances. An increase in the resistance of conducting means 71 will cause a greater voltage drop thereacross, with accordingly a smaller voltage drop across heater 67 thereby making the heater less effective and raising the effective trip temperature of the clothes. Thus, with increases in temperature the resistance of conducting means 71 increases thereby causing an increased effective trip temperature, and with decreases in temperature there is a decrease in the effective trip temperature. It will readily be observed that when conducting means 71 is placed in a position to sense the air temperature after it has contacted the clothes being dried, such as the position shown for conducting means 70 in FIGURE 1, it will perform the same function in substantially the same manner, giving curves similar to those in FIGURE 5 under the same circumstances.

Movable contact 73 may be provided with suitable indicia in cooperation with the control panel, such as "bone dry" and "damp dry." It will readily be seen that the position of contact 73 on resistor 72 controls to a limited extent the differential between the clothes temperature plateau and the effective trip temperature plateau. Thus, it is possible to have the intersection point of the clothes temperature and the effective trip temperature varied from a point very close to the plateau temperature to a point substantially above the plateau temperature. In this manner the dryness of the clothes, which is dependent upon how far up the steep portion of the curve at the end of the plateau the temperature is allowed to travel before the heat is shut off, may be controlled by the contact 73 and the resistor 72; an intersection point relatively low on the steep part of the curve will give generally damp-dry clothes and an intersection on the relatively high part of the curve will give substantially bone-dry clothes.

It will be understood that while the resistor 69 of FIGURE 3 is an essential part of the invention when conducting means 70 is in parallel with heater 67, such an additional resistance in the circuit when the temperature sensitive conducting means and the biasing heater are in series is an optional feature. This results from the fact that without an additional resistor such as 69 in the circuit of FIGURE 3, 110 volts would be impressed across the group consisting of the conducting means and the biasing heater regardless of variations in the conducting means resistance; only when another resistor is put in series therewith, and the voltage across the conducting

means and biasing heater group is made variable in accordance with the changes in the conducting means resistance can the voltage across the biasing heater be varied. In the circuit of FIGURE 4, on the other hand, with conducting means 71 in series with the biasing heater, variations in the resistance of conducting means 71 will cause changes in the voltage across the biasing heater 67 without any need for additional resistance. Thus, while for design purposes or for dryness selection purposes a resistor may be provided as shown, it is to be understood that in the more basic aspects of the circuit of FIGURE 4 it is not essential.

It will be seen from the foregoing that my invention provides a relatively simple system where all possible variations in the time and temperature required for the drying of any given clothes load under any particular circumstances are compensated for by a simple and effective circuit. In addition, devices such as thermistors are readily available commercially at an economical figure, and therefore the variable control which is effected by use of the temperature variable conducting means is achieved at relatively little expense. It will readily be understood that the particular switch arrangement shown for controlling the heater, motor, etc. is not necessarily required to be incorporated together with the invention. For instance, the thermostat 58 may very well be provided directly in circuit with the heater in order to shut the heater off directly rather than through the motor. A further point is that while a control arrangement purely dependent upon the temperature is shown, it is conceivable that my invention may be advantageously used where the trip temperature of the heater biased thermostat controls the machine in combination with timing means; for instance, two or more drying periods may be provided separated by a timed period initiated by the tripping of the thermostat.

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 modifications may be made therein without departing from the 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 the invention.

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

1. A clothes drying machine comprising a clothes container, a main heater positioned to heat clothes in said container, thermostatic means positioned to be responsive to the temperature of clothes in said container, an electric resistance-type biasing heater positioned in heating relation to said thermostatic means, means controlling operation of said main heater, said thermostatic means causing said controlling means to shut off said main heater in response to a predetermined high temperature, conductive means having an internal resistance variable to a substantial extent with changes in the temperature of said conductive means, a circuit including both said conductive means and said biasing heater connected to cause a decrease in the heating effectiveness of said biasing heater with increases in the temperature of said conductive means, and said conductive means being positioned to sense temperature changes significant to the operation of said machine to dry clothes.

2. A clothes drying machine comprising a clothes container, a main heater positioned to heat clothes in said container, thermostatic means positioned to be responsive to the temperature of clothes in said container, an electric resistance-type biasing heater positioned in heating relation to said thermostatic means, switch means controlling operation of said main heater, said thermostatic means causing said switch means to open in response to a predetermined high temperature, conductive means having an internal resistance inversely variable to a substantial extent to changes in temperature, a circuit including said

11

biasing heater and said conductive means in parallel with each other, said circuit further including a resistance in series with both said biasing heater and said conductive means, the resistance of said conductive means decreasing with increases in the temperature of said conductive means thereby to decrease the voltage across said biasing heater and cause a decrease in the heating effectiveness of said biasing heater, and said conductive means being positioned to sense temperature changes significant to the operation of said machine to dry clothes.

3. A clothes drying machine comprising a clothes container, a main heater positioned to heat clothes in said container, thermostatic means positioned to be responsive to the temperature of clothes in said container, an electric resistance-type biasing heater positioned in heating relation to said thermostatic means, switch means controlling operation of said main heater, said thermostatic means causing said switch means to open in response to a predetermined high temperature, conductive means having an internal resistance directly variable to a substantial extent with changes in the temperature of said conductive means, a circuit including said conductive means and said biasing heater connected in series with each other whereby increases in the resistance of said conductive means cause a decrease in the heating effectiveness of said biasing heater, and said conductive means being positioned to sense temperature changes significant to the operation of said machine to dry clothes.

4. A clothes drying machine comprising a clothes container, means for circulating air through said container, a main heater positioned to heat the air prior to its entry into said container, thermostatic means positioned to be responsive to the temperature of the air after it has contacted the clothes in said container, an electric resistance-type biasing heater positioned in heating relation to said thermostatic means, switch means controlling operation of said main heater, said thermostatic means causing said switch means to open in response to a predetermined high temperature, conductive means having an internal resistance variable to a substantial extent with change in the temperature of said conductive means, a circuit including both said conductive means and said biasing heater connected to cause a decrease in the heating effectiveness of said biasing heater with increases in the temperature of said conductive means, and said conductive means being positioned to sense significant changes in the temperature of the circulated air.

5. A clothes drying machine comprising a clothes container, a main heater positioned to heat clothes in said container, thermostatic means positioned to be responsive to the temperature of clothes in said container, an electric resistance-type biasing heater positioned in heating relation to said thermostatic means, means controlling operation of said main heater, said thermostatic means causing said controlling means to shut off said main heater in response to a predetermined high temperature, conductive means having an internal resistance variable to a substantial extent with changes in the temperature of said conductive means, a circuit including both said conductive means and said biasing heater connected to cause a decrease in the heating effectiveness of said biasing heater with increases in the temperature sensed by said conductive means, and said conductive means being positioned to sense changes in the temperature of clothes in said container, whereby increases in the clothes temperature increase the clothes temperature required to shut off said main heater.

6. A clothes drying machine comprising a clothes container, a main heater positioned to heat clothes in said container, thermostatic means positioned to be responsive to the temperature of clothes in said container, an electric resistance-type biasing heater positioned in heating relation to said thermostatic means, means controlling operation of said main heater, said thermostatic means causing said controlling means to shut off said

12

main heater in response to a predetermined high temperature, conductive means having an internal resistance inversely variable to a substantial extent with changes in the temperature of said conductive means, a circuit including said conductive means and said biasing heater connected in parallel with each other, said circuit further including a resistance in series with both said conductive means and said biasing heater, whereby there is a decrease in the heating effectiveness of said biasing heater with increases in the temperature of said conductive means, and said conductive means being positioned to sense changes in the temperature of the clothes whereby increases in the clothes temperature increase the clothes temperature required to shut off said main heater.

7. A clothes drying machine comprising a clothes container, a main heater positioned to heat clothes in said container, thermostatic means positioned to be responsive to the temperature of clothes in said container, an electric resistance-type biasing heater positioned in heating relation to said thermostatic means, means controlling operation of said main heater, said thermostatic means causing said controlling means to shut off said main heater in response to a predetermined high temperature, conductive means having an internal resistance directly variable to a substantial extent with changes in the temperature of said conductive means, a circuit including said conductive means and said biasing heater connected in series with each other thereby to cause a decrease in the heating effectiveness of said biasing heater with increases in the temperature of said conductive means, and said conductive means being positioned to sense changes in the clothes temperature whereby increases in the clothes temperature increase the clothes temperature required to shut off said main heater.

8. A clothes drying machine comprising a rotatable clothes container, air circulating means for circulating air through said container, a main heater positioned to heat the air prior to its entry into said container, thermostatic means positioned to be responsive to the temperature of the air after it has passed through said container, an electric resistance-type biasing heater positioned in heating relation to said thermostatic means, means controlling operation of said main heater, said thermostatic means causing said controlling means to shut off said main heater in response to a predetermined high temperature, conductive means having an internal resistance variable to a substantial extent with changes in the temperature of said conductive means, a circuit including both said conductive means and said biasing heater connected to cause a decrease in the heating effectiveness of said biasing heater with an increase in the temperature of said conductive means, and said conductive means being positioned to sense the temperature of the air after it has passed through said container and contacted the clothes whereby increases in the clothes temperature increase the clothes temperature required to shut off said main heater.

9. A clothes drying machine comprising a clothes container, a main heater positioned to heat clothes in said container, thermostatic means positioned to be responsive to the temperature of clothes in said container, an electric resistance-type biasing heater positioned in heating relation to said thermostatic means, means controlling operation of said main heater, said thermostatic means causing said controlling means to shut off said main heater in response to a predetermined high temperature, conductive means having an internal resistance variable to a substantial extent with changes in the temperature of said conductive means, a circuit including both said conductive means and said biasing heater connected to cause a decrease in the heating effectiveness of said biasing heater with increases in the temperature of said conductive means, said conductive means being positioned to sense changes in the clothes temperature whereby increases in the clothes temperature increase the

13

clothes temperature required to shut off said main heater, a variable resistance in said circuit in series with both said conductive means and said biasing heater, and manually operable means for varying said variable resistance.

10. A clothes drying machine comprising a rotatable clothes container, means for circulating air through said container, motor means for rotating said container and operating said air circulating means, a main heater positioned to heat the air prior to its entry into said container, a first circuit for energizing said main heater, first switch means in said first circuit responsive to the speed of said motor, said first switch means being closed when said motor operates above a predetermined speed and being open when said motor is at a standstill, thermostatic means positioned to be responsive to the temperature of the air after it has passed through said container and contacted the clothes, an electric resistance-type biasing heater positioned in heating relation to said thermostatic means, second switch means controlled by said thermostatic means, said thermostatic means causing said second switch means to open in response to a predetermined high temperature,

14

a second circuit for energizing said motor, said second switch means being connected in said second circuit in series with said motor, conductive means having an internal resistance variable to a substantial extent with changes in the temperature of said conductive means, a third circuit including both said conductive means and said biasing heater connected to cause a decrease in the heating effectiveness of said biasing heater with increases in the temperature sensed by said conductive means, and said conductive means being positioned to sense the temperature of the air after it has passed through said container and contacted the clothes whereby said second switch means is opened at a temperature which increases as the temperature of the air which has passed through said container increases.

References Cited in the file of this patent

UNITED STATES PATENTS

2,851,790	Worst	Sept. 16, 1958
2,878,579	Fuchs	Mar. 24, 1959