

Sept. 23, 1969

K. H. PETERSEN ET AL

3,469,077

HEATING DEVICE

Filed Sept. 3, 1963

2 Sheets-Sheet 1

FIG. 1

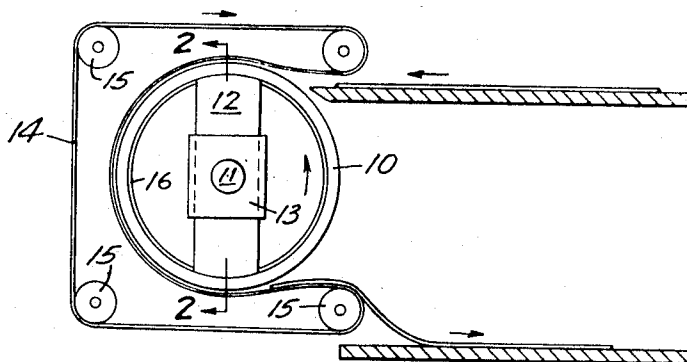


FIG. 2

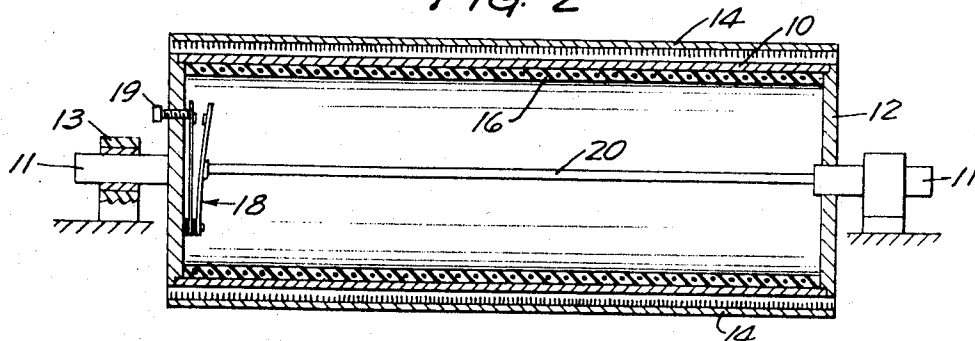


FIG. 3

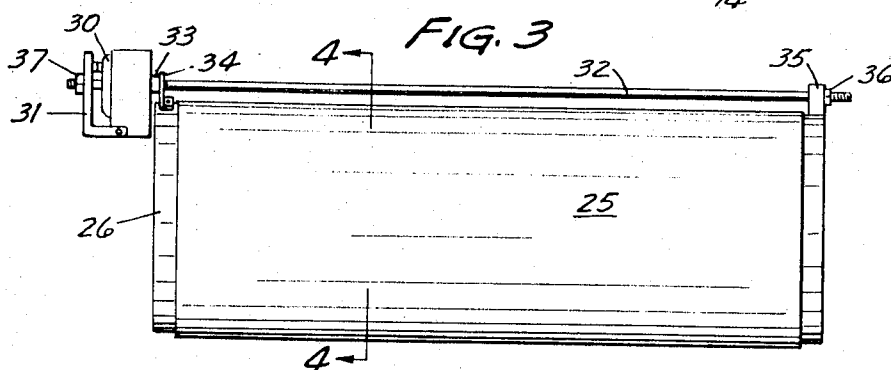
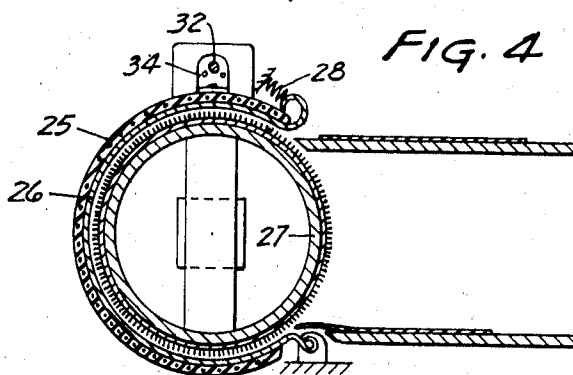


FIG. 4



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FIG. 5

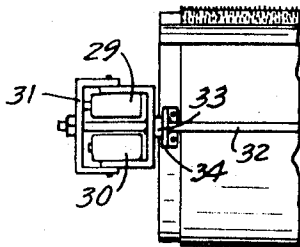


FIG. 6

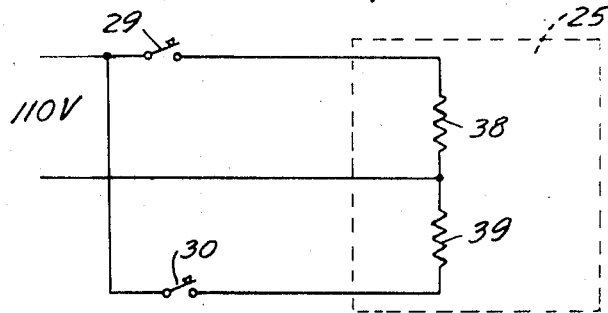


FIG. 7

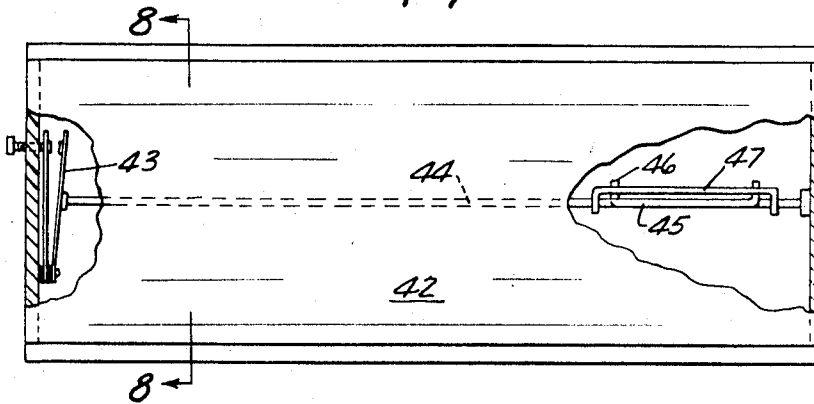
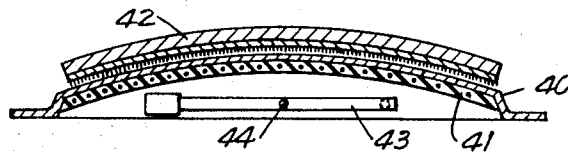


FIG. 8



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3,469,077

HEATING DEVICE

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U.S. Cl. 219—469

8 Claims

This invention relates to heating devices, more particularly to self-temperature-regulating, heating platens. While useful in many other situations, the invention will be here described for convenience in terms of its application as a heat source in copying machines.

A well-known commercial copying process involves the transfer at an elevated temperature of image-forming material from a source sheet to a copy-sheet. The process is particularly adapted for copying office correspondence and the like. As described in Workman U.S. Patent No. 3,094,417, a reactant material is transferred at image areas in vapor form to a receptor sheet containing a co-reactant, the two then reacting at the temperature provided to form a visible image. In other systems a fusible or waxy image is transferred from an intermediate sheet to a paper copy-sheet. In both instances there is required a source of heat which for reasons of economy and safety is not activated during periods of non-use, but which when activated reaches operating temperature with minimal lapse of time and preferably within a few seconds, and then closely maintains its assigned elevated temperature irrespective of changing rates of heat loss occasioned by periodic contact with the relatively cool copy-paper during use of the machine.

Previous copiers utilizing heat have included thermostats near the heating platen to control heating surface temperature. But since they are spaced from the platen, and measure temperature at that spaced point rather than over the whole area of the platen, thermostats do not provide a completely satisfactory control. When using thermostats, for example, even under normal or steady operating conditions, the platen surface temperature fluctuates through a wider range than desirable because of "overshooting," or excessively long periods of heating and cooling. Further a thermostat may not have an early enough response to increased demands on the heating device due to high rates of feeding copy-sheets. Other disadvantages of thermostats are their susceptibility to variations in ambient temperature unassociated with the heating surface temperature and their possible insufficient response to local variations of temperature on the platen surface.

The novel control system of the present invention provides for immediate response to changes in heating surface temperature. The apparatus permits use of high wattage heaters while still maintaining heating surface temperature within a narrow range. Further, the new apparatus is simple and inexpensive.

These advantageous results are achieved by employing the heating platen itself as the temperature sensing element. Heat is supplied directly to one surface of the platen and is conducted to the copy-sheet in contact with the opposite surface. The platen has a relatively high thermal coefficient of linear expansion and its length therefore changes significantly with changes in temperature. A gauge member having a relatively low coefficient of expansion serves as a standard and carries an adjustable switch member which controls the source of heat.

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The novel heating device will be more explicitly described in terms of illustrative but non-limitative examples and in connection with the appended schematic drawings, in which:

FIGURE 1 is a side elevation of a heating device of the invention;

FIGURE 2 is a section along the lines 2—2 of FIGURE 1;

FIGURE 3 is a back elevation of another embodiment of the invention;

FIGURE 4 is a section along the lines 4—4 of FIGURE 3;

FIGURE 5 is a partial top view of the embodiment of FIGURE 3;

FIGURE 6 is a wiring diagram for the embodiment of FIGURE 3;

FIGURE 7 is a top view of another embodiment of the invention; and

FIGURE 8 is a section along the lines 8—8 of FIGURE 7.

FIGURES 1 and 2 illustrate schematically the essential apparatus of a copying device of the invention. In the construction shown, a metal cylinder 10 having a high thermal coefficient of linear expansion rotates about an axis formed by short axles 11 extending from narrow plates 12 fixed in the ends of the cylinder, one of the axles 11 being supported in a bearing 13 in which it is free to axially slide. A belt 14, moved in the direction shown, is supported by rollers 15 against the cylinder 10 and drives the cylinder at the same surface speed. Copy-sheets are fed between the belt and cylinder from an upper table and are discharged at a lower table as illustrated in FIGURE 1. The metal cylinder 10 serves as a heating platen and is heated by a thin blanket 16 covering the inner cylindrical surface and formed by high resistance wires sheathed between glass fiber reinforced silicone rubber layers. The cylinder's outer surface is preferably roughened to improve its frictional properties, while the belt surface against the roller is insulated with fabrics or rubber foams to isolate other parts of the device from heat and prevent dissipation of heat.

The blanket 16 is connected in series with an electrical power source through a point contact, leaf spring switch 18 mounted on one narrow plate 12. One arm of the switch 18 is attached to the plate 12 except that it may be adjusted toward and away from the other arm by a screw 19. The other arm pivots about its mounting on the plate 12, and the free end is attached to the end of a low thermal coefficient of linear expansion rod or gauge member 20 which extends lengthwise through the cylinder 10 and is fixed to the second narrow plate 12 at the other end of the cylinder. When the heating circuit is completed by closing the switch 18, the resistor wires in the blanket 16 increase in temperature over a period of time, preferably heating rapidly to a high temperature to quickly prepare the device for use.

As will be seen, the described arrangement maintains the cylinder 10 at a set temperature selected by adjusting the screw 19. The metal cylinder 10 increases in length as its temperature rises, moving the plates 12 further apart and sliding the free axle 11 in its bearing 13. Since the rod expands very little, or substantially not at all, the points of the switch separate after the desired temperature is reached, to open the heating circuit. The control provided is directly responsive to changes in the cylinder's heating surface temperature without undesirable

ble time lag or influence of environmental conditions. A time delay relay may be provided in the circuit between the switch and power source if desired, e.g. for lengthening somewhat the time periods of heating and cooling by delaying the action of the switch to prevent the switch from "chattering" on and off.

FIGURES 3-6 illustrate a preferred embodiment of the invention. In this embodiment a resistor wire heating blanket 25 is adhered to the back or outer surface of a curved metal shoe 26 which fits against and partially covers a rotatably driven cylinder 27 to form a path for sheets being treated. The shoe is pivoted at one lip and biased resiliently against the insulated cylinder surface by springs 28 acting on the other lip to provide uniform pressure on sheets between the shoe and cylinder. Since the springs act on the sheet entrance lip, as shown in the drawing, if sheets bind between the cylinder and shoe, the shoe will be pushed away from the cylinder. The inner surface of the shoe is polished or otherwise treated to have a low coefficient of friction with respect to the copy-sheets, while the cylinder surface has a high coefficient so that sheets are drawn between the cylinder and shoe and held in even close contact with the stationary shoe surface.

The heating element 25 is comprised of two resistance windings 38 and 39 which are separately controlled by differential travel switches 29 and 30 respectively as indicated in FIGURE 6. The frame supporting the switches is rigidly attached to an end of the metal shoe 26 by being riveted to a support 34 mounted on the shoe. An insulating bushing 33 between the support 34 and switch frame prevents heat loss from the shoe. The switches are operated by a lever 31 which is connected to the opposite end of the shoe 26 by a gauge rod 32 having a low thermal coefficient of linear expansion, the rod being fixedly supported by bushing 35 and nut 36, and loosely supported by support 34. Rod 32 is adjustably fastened to lever 31 as indicated by nut 37.

When the shoe 26 expands upon heating, the plungers carried in the switch bodies are moved toward the lever 31. The plunger of the switch 29 has a longer length of travel between the switch open and switch closed positions than the plunger of the switch 30, so a longer expansion is required to operate the switch 29. In the illustrated embodiment the plungers are depressed to open and released to close the switches, and by properly adjusting the original positions of the plungers, preferably so that the two switches open at the same time, the quicker acting switch 30 will close before the slower acting switch 29. The difference in the lengths of travel is utilized to provide a rapidly heated machine as well as one which maintains a heating surface temperature within a narrow range by connecting the high wattage winding 38 through the switch 29, and the low wattage winding 39 through the switch 30. Ideally the low wattage winding is sufficient, once the machine has been heated to its operating temperature by both sources, to maintain the machine at that temperature. The operating temperature of the copier can be varied by adjusting the fastener 37 on the rod 31.

Since differential travel switches are used, providing periods of heating or cooling during the plunger's travel, a time delay relay is not needed. The switches used work well in their unconfined environment, in contrast to the problems which might result inside the heated cylinder shown in FIGURES 1 and 2. The use of a curved heated shoe also has the advantage that only one moving part, the cylinder 27, is needed as compared to the several moving parts shown in FIGURES 1 and 2. Further the moving belt shown there has a tendency to dissipate some heat when away from the cylinder.

In a different design illustrated in FIGURES 7 and 8 and particularly adapted for use in a portable copier, an arcuately curved metal plate 40 provides the heating surface and sensing member of the thermostatic control.

A heating blanket 41 covers the bottom of the plate, and sheets to be treated are laid on the top surface. A lid 42 with an insulating layer on its inner surface is used to conform the sheets to the hot surface. Since the top surface of the plate 40 is often exposed to the touch when hot, a short flocked fiber (not illustrated) is preferably coated over it as a safety measure. A leaf spring electric switch 43 is attached between a low thermal coefficient of expansion member 44 and a depending wall of the plate 40 similarly to the arrangement shown in FIGURES 1 and 2.

For reasons of economy the rods 20, 31, and 44 may be Invar (a nickel-steel alloy), though a material such as fused quartz having a thermal coefficient of expansion of substantially zero gives better results. A construction illustrated by the member 44 in FIGURE 7 also may be used to minimize the expansion of the low thermal coefficient of linear expansion member with increase in temperature. The member 44 is formed by two low coefficient rods 45 and 46 which overlap over a minor part of their length and which are linked by a thin, narrow, high coefficient plate 47. The rods slidingly pass through turned down ends of the plate and are turned up at their ends and fixed in holes in the plate. With temperature increases, the plate 47 lengthens to shorten the over-all length of the gauge member and thereby to compensate for the slight lengthening of the rods 45 and 46.

Aluminum, which has a relatively high thermal coefficient of linear expansion of approximately 13×10^{-6} inches per inch per degree Fahrenheit and performs well in the temperature conditions of the copier, is preferably used to make the heated platen. Other metals, or other materials which have high thermal coefficients of linear expansion may be used where their heat conductivity and other properties are suitable. It will be noted that the platen responds to local temperature variations as well as those over the entire surface, and averages the local effect into the whole effect.

In a specific example for the embodiment illustrated in FIGURES 3-5, the shoe, made of 0.030" sheet aluminum, is 11¼" long and the rod 31, made of Invar, 13" long. A phenolic resin insulator stable at high temperatures is used at 33. The cylinder is externally covered with a dense mohair fabric, and the shoe carries a heating blanket in which the Nichrome resistance wire is spaced approximately 0.010" from the shoe by the intermediate layer of silicone rubber insulation. The two switches have differential lengths of travel of 0.003-0.005" and 0.0005-0.0008" and are connected to 900 watt and 300 watt windings respectively. The machine heats to its desired operating temperature of 270° F. within 30 seconds and holds within a range of 2-4° F. for both high and low rates of feeding paper-like copy-sheets through the machine.

What is claimed is as follows:

1. A heating device suitable for supplying heat to paper-like sheet materials in the copying of graphic originals by procedures set forth in the foregoing description, said device being capable of rapidly attaining and accurately maintaining a prescribed surface temperature, said device comprising: a thin metal plate having a high thermal coefficient of linear expansion, having an outer surface for contacting of said sheet materials, and having over the inner surface an electrically actuated source of heat; two differential travel electric switch means, each having a first contact member attached to an end of said plate and a second contact member movable along the length of said plate, the movable contact members having different lengths of travel to complete a circuit; an elongate gauge member having a relatively low thermal coefficient of linear expansion, lying generally parallel to the length of said plate and attached at one end to the other end of said plate, the gauge member's other end being attached to means providing a stop in the path of, and adjacent to, the movable contact members for moving the movable

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contact members when the plate changes length to maintain the plate at a prescribed temperature; and means for connecting the heat source to a low wattage power source through the switch of least travel and to a high wattage power source through the switch of greatest travel.

2. A heating device suitable for supplying heat to paper-like sheet materials in the copying of graphic originals by procedures set forth in the foregoing description, said device being capable of rapidly attaining and accurately maintaining a prescribed surface temperature, said device comprising: a rotatably supported cylinder covered with a relatively soft surfaced, high friction, thermal insulating layer; a curved aluminum plate about 30 mils in thickness having a high thermal coefficient of linear expansion, having a cylindrical concave surface conforming to the cylinder surface for contacting of said sheet materials, and having a thin stretchable heating element sheathed in an electrically insulative elastomeric material bonded in heat conductive relation over a large portion of the convex surface of the aluminum plate, said plate being resiliently biased against the cylinder, electric switch means attached to an end of said plate; an elongate gauge member having a relatively low thermal coefficient of linear expansion, lying generally parallel and adjacent to the convex surface of said plate and attached at one end to the other end of said plate, the gauge member's other end being attached to said switch means; and means for connecting said switch means and said heat source in series with a source of electric power.

3. A heating device suitable for supplying heat to paper-like sheet materials in the copying of graphic originals by procedures set forth in the foregoing description, said device being capable of rapidly attaining and accurately maintaining a prescribed surface temperature, said device comprising: a thin metal plate having a high thermal coefficient of linear expansion and having an extensive heating surface for contacting of said sheet materials, a thin stretchable heating element sheathed in an electrically insulative elastomeric material and bonded in heat conductive a large portion of the opposing surface of said metal plate; electric switch means attached to an end of said plate; an elongate gauge member having a relatively low thermal coefficient of linear expansion, lying generally parallel to the length of said plate and attached at one end to the other end of said plate, the gauge member's other end being connected to said switch means to actuate the switch in response to changes in the length of the plate; and means for connecting said switch means and said heating element in series with a source of electric power.

4. A heating device suitable for supplying heat to paper-like sheet materials in the copying of graphic originals by procedures set forth in the foregoing description, said device being capable of rapidly attaining and accurately maintaining a prescribed surface temperature, said device comprising: a thin metal plate having a high thermal coefficient of linear expansion and having an extensive heating surface for contacting of said sheet materials, and having over its opposing surface an electrically actuated source of heat; two differential travel electric switch means, each having a first contact member and a second contact member movable with respect to the first contact member along the length of said plate, a stop in the path of, and adjacent, the movable contact members, one of the stop or the switches being mounted on the plate and movable as the plate changes dimension, and the other of the stop or the switches being substantially fixed in a constant position so that the stop abuts and moves the movable contact members when the plate changes length to maintain the plate at a prescribed temperature; and means for connecting the heating element to a low wattage power source through the switch of least travel and to a high wattage power source through the switch of greatest travel.

5. A heating device suitable for supplying heat to paper-like sheet materials in the copying of graphic originals by procedures set forth in the foregoing description, said device being capable of rapidly attaining and accurately maintaining a prescribed surface temperature, said device comprising: a thin metal plate having a high thermal coefficient of linear expansion and having an extensive heating surface for contacting of said sheet materials, a thin stretchable heating element sheathed in an electrically insulative elastomeric material and bonded in heat conductive relation over a large portion of the opposing surface of said plate; two differential travel electric switch means, each having a first contact member and a second contact member movable with respect to the first contact member along the length of said plate, a stop in the path of, and adjacent, the movable contact members, one of the stop or the switches being mounted on the plate and movable as the plate changes dimension, and the other of the stop or the switches being substantially fixed in a constant position so that the stop abuts and moves the movable contact members when the plate changes length to maintain the plate at a prescribed temperature; and means for connecting the heating element to a low wattage power source through the switch of least travel and to a high wattage power source through the switch of greatest travel.

6. A heating device suitable for supplying heat to paper-like sheet materials in the copying of graphic originals by procedures set forth in the foregoing description, said device being capable of rapidly attaining and accurately maintaining a prescribed surface temperature, said device comprising: a rotatably supported cylindrical tube formed from thin metal plate having a high thermal coefficient of linear expansion, said tube having an outer surface for contacting of said sheet materials and having over the inner surface an electrically actuated source of heat; electric switch means attached to an end of said tube; an elongate gauge member having a relatively low thermal coefficient of linear expansion axially disposed inside the cylindrical tube and attached at one end to the other end of said tube, the gauge member's other end being attached to said switch means to actuate the switch in response to changes in the length of the tube; and means for connecting said switch means and said heat source in series with a source of electrical power.

7. The heating device of claim 6 further characterized in that the cylindrical tube is rotatively supported by axles at each end journaled in bearings, at least one of the axles being axially slidable in its bearing.

8. A device for the development or printing of photographic material, comprising: a hollow cylindrical contact member having an outer surface of extended area for contacting material to be developed or printed; means for mounting said contact member so as to permit rotation of said member about the axis thereof upon the passage of photographic material over said member; an electric heater element which extends over and is in good thermal contact with the inner surface of said contact member so that, upon supply of current to said element, heat is supplied to the extended outer surface of said contact member at a rate suitable for printing or developing contacted material; control means; including, an elongated control member having a co-efficient of thermal expansion different from that of the said contact member, said control member extending through the interior of said contact member, parallel with the axis thereof, and having one end fixedly secured relative to one end of said contact member so that relative movement takes place between the other ends of the respective contact and control members upon a change in temperature of said contact member; and switch means electrically connected to said heater element and mounted on the said other end of said contact member, said switch means being arranged to be actuated by a relative movement of the said other ends of said respective contact and control members cor-

responding to a predetermined rise in temperature of said contact member and, upon actuation, to control the supply of current to said heating element.

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