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[54] **FUSER CONTROL CIRCUIT FOR COPYING APPARATUS**

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[52] **U.S. Cl.** **219/501,** 219/216, 219/505

[51] **Int. Cl.**.....**H05b 1/02**

[58] **Field of Search**.....219/494, 501, 505, 219/216

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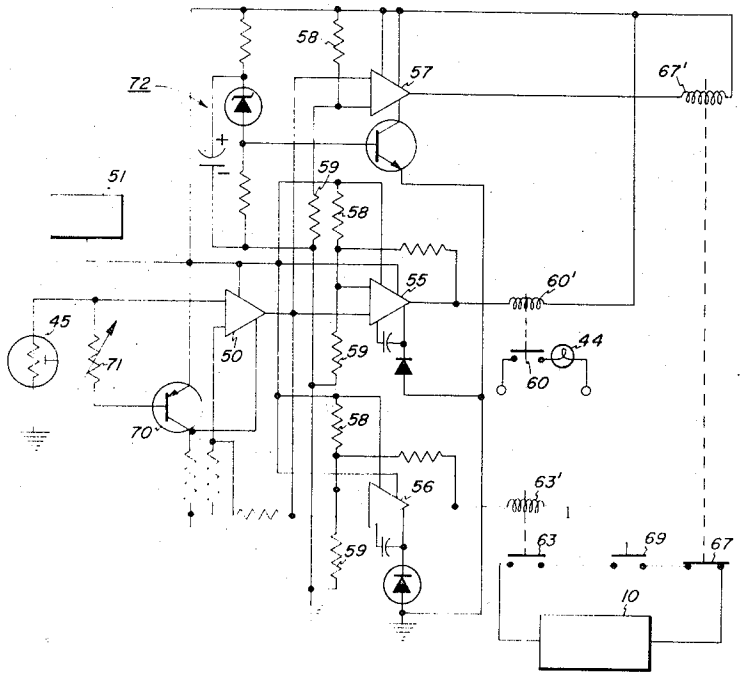
[57] **ABSTRACT**

An arrangement for controlling the fuser heat source in an electrostatic type reproduction machine to maintain fuser temperatures within a desired operating range and protect the reproduction machine in the event fuser temperatures become too high. The arrangement includes a thermistor to sense temperature conditions within the fuser, an amplifier to amplify the thermistor signal output to a level permitting relatively inexpensive switching devices to be used directly as fuser and reproduction machine controls without the need for relatively sensitive and correspondingly expensive intermediate comparator circuitry, and switching devices for operating the fuser heat source and controlling the reproduction machine in response to predetermined fuser temperature conditions.

6 Claims, 5 Drawing Figures



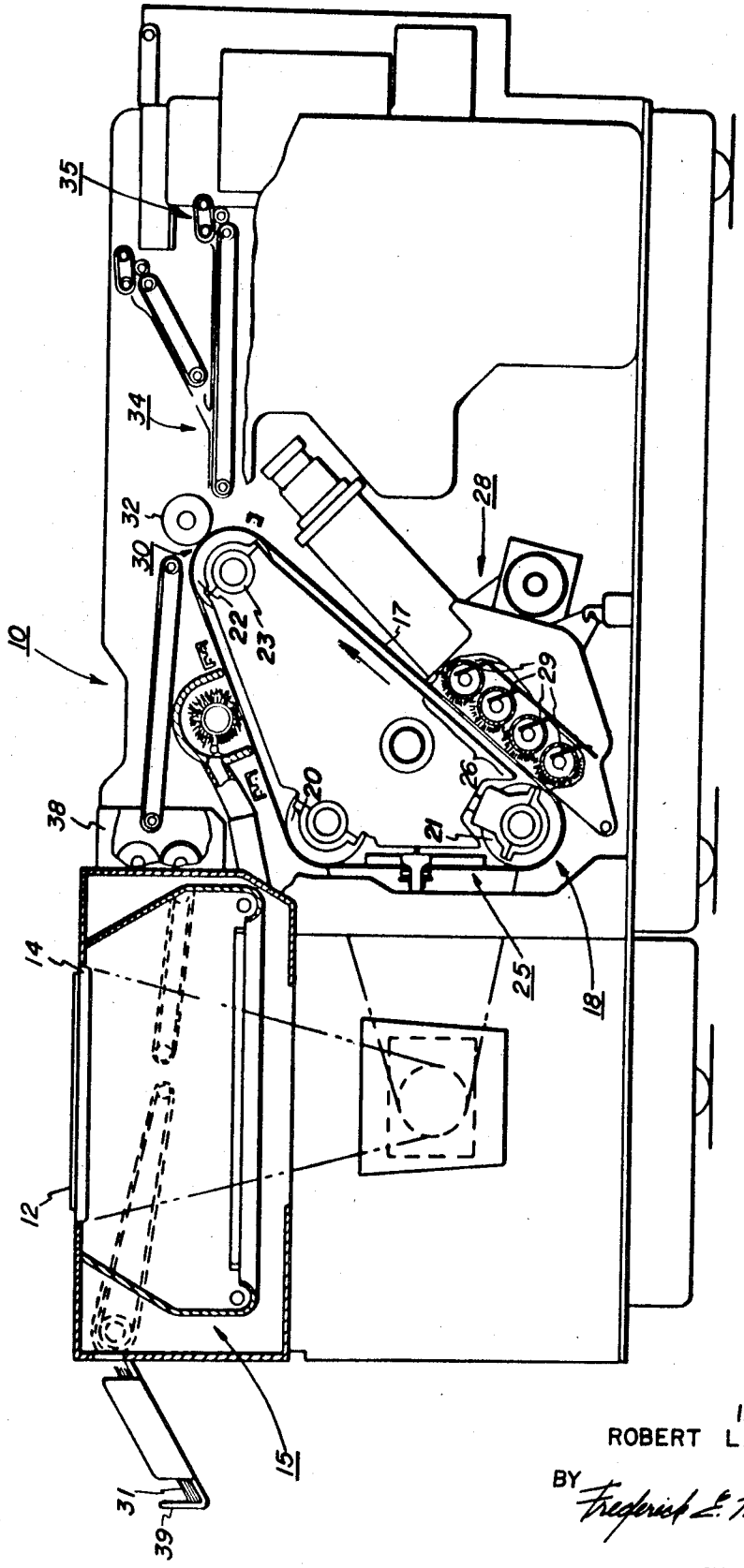


FIG. 1

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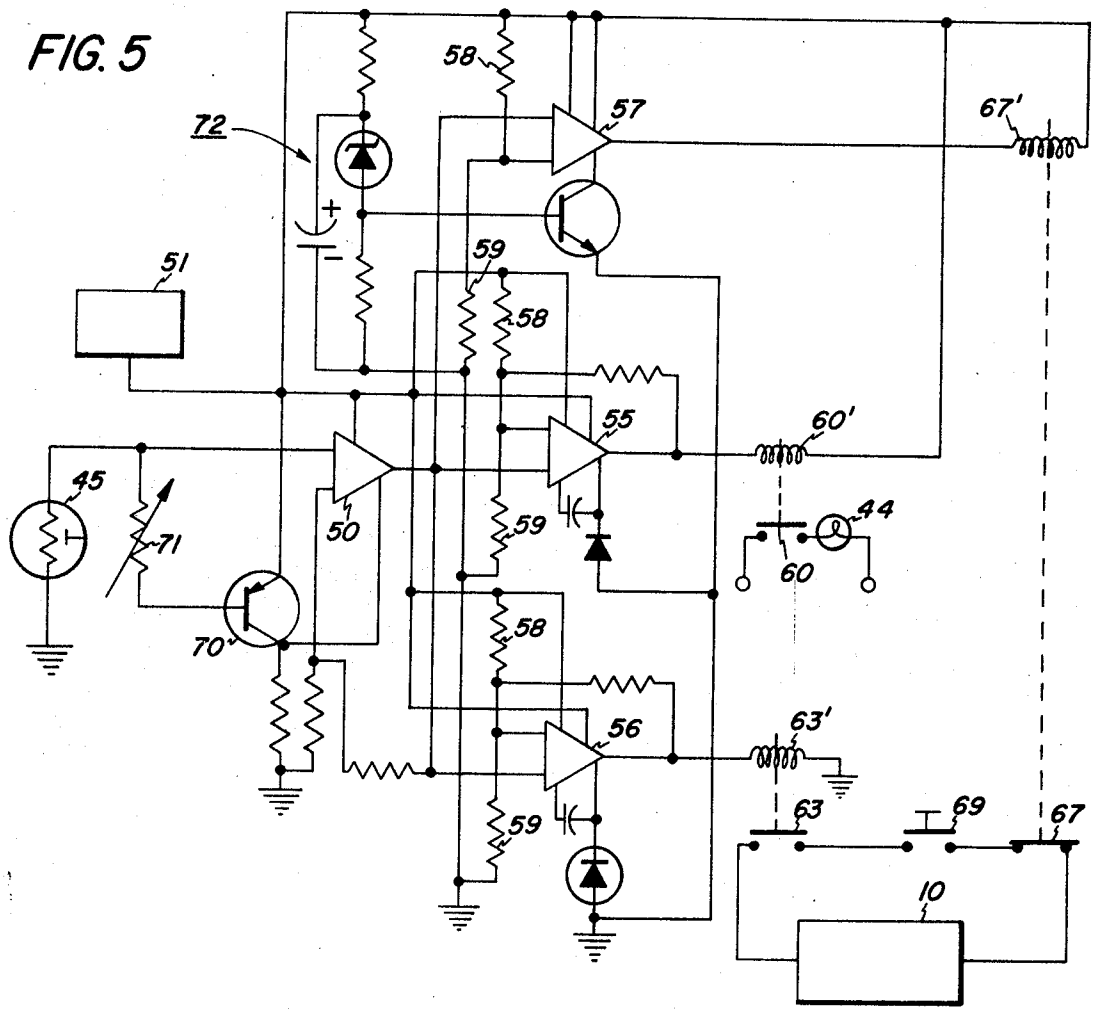
FIG. 5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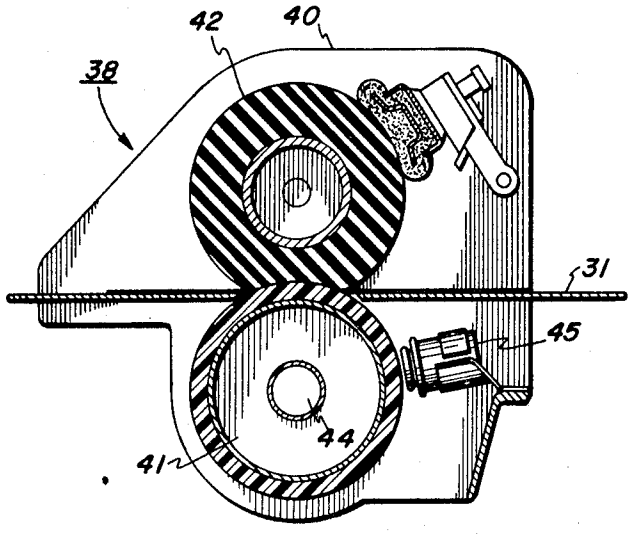
42
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44
41

FIG. 2

FIG. 3

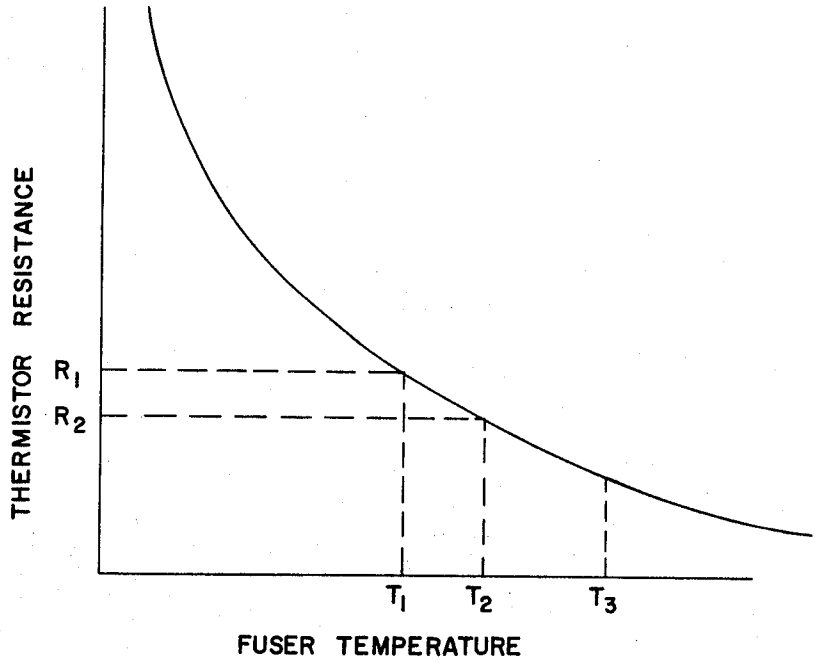
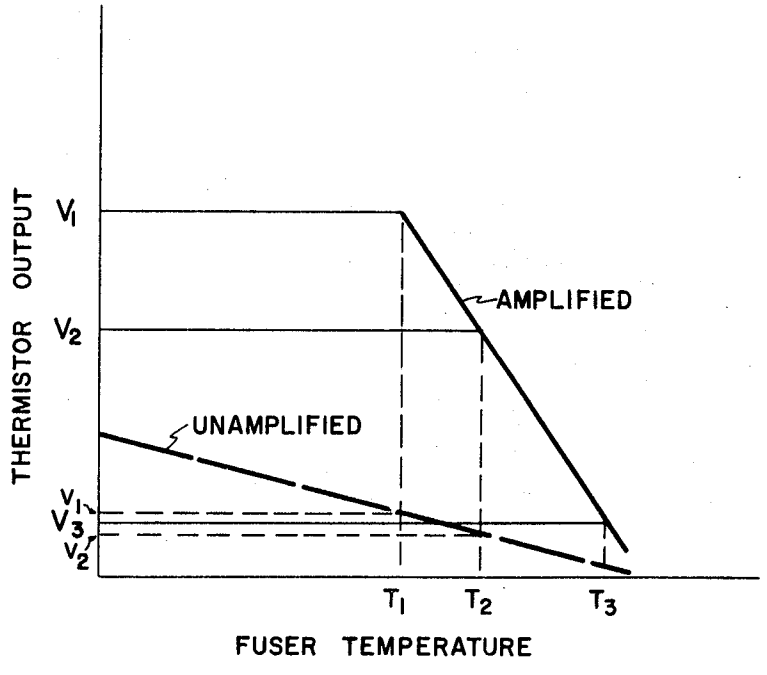

THERMISTOR RESISTANCE
R1
R2
T1
T2
T3
FUSER TEMPERATURE

FIG. 4


THERMISTOR OUTPUT
V1
V2
AMPLIFIED
UNAMPLIFIED
V1'
V3
V2'
T1
T2
T3
FUSER TEMPERATURE

FUSER CONTROL CIRCUIT FOR COPYING APPARATUS

This invention relates to a fuser for electrostatic type reproduction machines, and more particularly, to a fuser for electrostatic type reproduction machines incorporating improved fuser temperature controlling means.

In electrostatic type reproduction machines, a toner delineated image of the original document being copied is electrostatically formed on the copy material. In order to render the image permanent, the image is fused by passing copy material through a heated oven, conventionally called a fuser. There, a combination of heat and pressure melts, i.e. fuses, the toner onto the copy material to form a permanent image.

In machines of this type, correct fuser temperatures are critical. If the fuser temperature is too low, fusing may be incomplete. This is most often evidenced by smearing or loss of image, particularly when the copy material is handled. If the fuser temperature is too high, there is danger that the copy material may burn or char.

In controlling fuser temperatures, a resistive type transducer, normally a thermistor, is usually used. The thermistor, which is disposed in heat exchange relationship with the fuser, is circuited to provide a signal change in response to changes in fuser temperatures, this signal being relied upon to start and stop the fuser heat source as required to maintain desired fuser temperatures. However, thermistor type devices suffer from the fact that their response or sensitivity to temperature change ordinarily decreases with increasing temperature. In the relatively high operating temperature range of modern fusers, thermistor sensitivity is very low. Hence, the thermistor signal output band over the fuser operating temperature range is quite small. This, in turn, has required that relatively sensitive comparator circuits be provided if accurate control over fuser temperatures are to be obtained, particularly where other machine control functions such as over-temperature shutdown protection are provided.

It is a principle object of the present invention to provide a new and improved fuser for an electrostatic type reproduction machine.

It is an object of the present invention to provide a control for copy machine fusers having means to amplify the output of the fuser temperature responsive transducer across the fuser operating temperature range.

It is a further object of the present invention to provide an improved control for maintaining operating temperatures in the fuser of an electrostatic copying machine.

It is an object of the present invention to provide an improved temperature controller for the fuser of a copy machine employing a resistive type transducer to sense fuser temperature conditions, with means to amplify the transducer signal output over at least the fuser operating temperature range to enhance control accuracy and avoid the need for relatively complex and expensive comparison circuitry.

It is an object of the present invention to provide a fuser control for accurately maintaining critical fuser operating temperatures employing relatively simple and inexpensive switching devices.

It is a further object of the present invention to provide, in an electrostatic type copying apparatus having a fuser temperature sensor with means to amplify the signal output thereof, control means effective on failure of the temperature sensor to prevent signal amplification and shut down the copying apparatus.

It is an object of the present invention to provide a fuser control designed to hold fuser temperatures in a copying machine within a prescribed operating limit while preventing operation of the copy machine whenever fuser temperatures are too low.

It is an object of the present invention to provide a copy machine control effective to shut down the machine on a fuser over-temperature condition.

This invention relates to a copying apparatus having a fuser for fixing the toner developed images of the copying apparatus, comprising, in combination: circuit means adapted to generate a control signal proportional to temperature conditions in the apparatus fuser, the circuit means including a temperature variable resistor in heat exchange relation with the fuser, the resistive change of the resistor in response to changes in temperature in the fuser normally being relatively small within the operating temperature range of the fuser with the result that the sensitivity of the circuit means is relatively low in the fuser operating temperature range; means for amplifying the signal output of the circuit means at least in the fuser operating temperature range whereby to avoid the need for relatively sensitive output comparator circuitry and instead permit use of relatively simple switching means; means for heating the fuser; and switching means for controlling the fuser heating means, the switching means being adapted to render the fuser heating means inoperative in response to a first amplifier means signal reflecting attainment of normal operating temperature in the fuser.

Other objects and advantages will be apparent from the following description and drawings in which:

FIG. 1 is a schematic sectional view of an electrostatic type reproduction machine embodying the principles of the present invention;

FIG. 2 is an enlarged cross sectional view showing the fusing apparatus of the reproduction machine shown in FIG. 1;

FIG. 3 is a plot of the temperature versus resistance relationship for a typical thermistor;

FIG. 4 is a plot of the temperature versus output signal relationship for the thermistor of FIG. 3 with unamplified thermistor signal output shown in dotted lines and amplified thermistor signal output shown in solid lines; and

FIG. 5 is a schematic circuit representation of the fuser control arrangement of the present invention.

Referring particularly to FIGS. 1 and 2 of the drawings, an exemplary copier/reproduction machine, designated generally by the numeral 10 and incorporating the fuser control arrangement of the present invention, is there shown. As in all electrostatic systems such as the xerographic type machine illustrated, a light image of a document to be reproduced is projected onto the sensitized surface of a xerographic plate to form an electrostatic latent image thereon. Thereafter, the latent image is developed with an oppositely charged developing material to form a xerographic powder or toner image, corresponding to the latent image on the plate surface. The toner image is then electrostatically transferred to a support surface where it is fused by a

fusing device so that the toner image is permanently adhered to the support surface.

In machine **10**, an original document **12** to be copied is placed upon a transparent support platen **14** fixedly arranged in an illumination assembly generally indicated by the reference numeral **15** and disposed at the left end of the machine. While upon the platen, the document **12** is illuminated, thereby producing image rays corresponding to the informational areas on the original. The image rays are projected by means of an optical system onto the photosensitive surface of a xerographic plate. In the exemplary copier/reproduction machine **10**, the xerographic plate is in the form of a flexible photoconductive belt **17** supported in a belt assembly **18**.

The support assembly **18** for photoconductive belt **17** includes three rollers **20, 21** and **22** located with parallel axes at approximately the apices of a triangle. The upper roller **22** is rotatably supported on shaft **23** which in turn is rotatably driven by a suitable motor and drive means (not shown) to drive belt **17** in the direction shown by the arrow in FIG. **1**. During this movement of the belt, the reflected light image of the original document **12** on platen **14** is flashed upon the photoreceptor surface of belt **17** at an exposure station **25** to produce an electrostatic latent image thereon.

The continued movement of photoconductive belt **17** carries the electrostatic image through a developing station **26** in which there is positioned a developer assembly generally indicated by the reference numeral **28**. There the latent electrostatic image is developed by means of toner through the use of a multiple magnetic brush system **29**.

The developed electrostatic image is carried by belt **17** to the transfer station **30** where the developed image is transferred to a support surface, normally a sheet of copy paper **31**, brought forward between transfer roller **32** and belt **17**. In order to accomplish transfer of the developed image solely by means of the electrical bias on transfer roller **32**, the copy sheet **31** is moved at substantially the same speed as belt **17**. A sheet transport mechanism generally indicated at **34** is provided to advance copy sheets **31** from a paper handling mechanism generally indicated by the reference numeral **35** to transfer station **30**.

Following transfer, the copy sheet **31** is stripped from belt **17** and conveyed through fuser **38** wherein the toner image is permanently fused or affixed thereto. Following fusing, the finished copy is discharged into output tray **39**.

Photoconductive belt **17** comprises a photoconductive layer of selenium, which is the light receiving surface and imaging medium for the apparatus, on a conductive backing. Further details regarding the structure of the belt assembly **12** and its relationship with the machine and support therefor may be found in the copending application Ser. No. 102,312, filed Dec. 29, 1970, and assigned to the same assignee.

Referring now to FIG. **2**, fuser **38** includes a suitable housing **40** within which is disposed a lower heated fuser roll **41** and an upper pressure roll **42**, rolls **41, 42** cooperating to form a nip through which the copy sheets **31** pass. Rolls **41, 42** are suitably supported for rotation and driven in unison by a suitable drive means (not shown). Pressure roll **42** is comprised of a relatively soft material such as Teflon, Neoprene, and the like with the result that pressure contact between the rolls **41, 42** deforms the surface of pressure roll **42**. In this way, an increased contact arc between the copy sheet and the heated fuser roll **41** is obtained.

In the exemplary arrangement illustrated, fuser roll **41** is hollow, the roll **41** being formed from a suitable heat conductive material. A source of heat such as lamp **44** is disposed therewithin. A suitable temperature variable resistor, i.e. thermistor **45** is supported on a fuser housing **40** in heat exchange relation therewith to sense temperature conditions within the fuser housing **40**.

Referring to FIGS. **3** and **4**, where resistance vs. temperature and output voltage vs. temperature relationships for a typical thermistor are plotted, the latter for both unamplified and amplified voltage outputs of thermistor **45**, it will be seen that the change in thermistor resistance becomes progressively less and less with increasing temperatures. In the relatively high operating temperature range of fuser **38**, which typically extends from a minimum operating temperature of 350° F (T_1) to a normal operating temperature of 430° F (T_2), the change in thermistor resistance, R_1 to R_2 is relatively small. The unamplified signal output of thermistor **45** in this temperature range, v_1 to v_2, is correspondingly small, a signal output of approximately two volts being typical. This relatively small change in signal output, which covers the operating temperature range of fuser **38**, renders accurate control of fuser temperatures difficult to obtain. Where, as in the case of electrostatic copying machines, fuser temperatures are critical if legible and permanent copy is to be obtained, accurate control of fuser temperatures is essential, and relatively expensive and sophisticated comparator circuits would normally be required to obtain the necessary control accuracy.

To avoid the need for expensive and complex comparator type circuits, the signal output of thermistor **45** across the operating temperature range of fuser **38** is amplified. This in turn enables relatively simple and inexpensive switches **55, 56, 57** to be used as control devices instead.

Referring to the circuit diagram of FIG. **5**, the signal output of thermistor **45** is fed to a suitable operational amplifier **50**. Amplifier **50** is gated to amplify thermistor signals equal to or less than v_1 by means of a suitable source **51** of d.c. voltage. The signal amplification accordingly takes place at fuser temperatures equal to or above minimum fuser operating temperature T_1. The amplified signal from amplifier **50** is impressed on the control gate of switching amplifiers **55, 56, 57**. As will appear, switching amplifiers **55, 56, 57** control fuser heating and operation of copying machine **10**. The switching amplifiers **55, 56, 57** are each biased to a suitable control level by voltage source **51**, various resistor combinations **58, 59** being provided to obtain the different individual switching responses from each of the switching amplifiers **55, 56, 57** as required to provide the requisite copying machine control.

Switching amplifier **55** controls operation of fuser heating lamp **44**. For purposes of illustration, the fuser lamp control consists of switch **60** in the power line to lamp **44** with the switch operating coil **60'** in series with the output gate of amplifier **55**. On triggering of switching amplifier **55** to a conducting state, coil **60** is energized to close switch **60** and complete the energizing circuit to fuser heat lamp **44**.

Switching amplifiers **56, 57** control operation of copying machine **10,** amplifier **56** serving to prevent operation of copying machine **10** on start-up until temperatures of fuser **38** reach a predetermined level. Schematically, a switch **63** is provided in the copying machine operating circuit, the operating coil **63'** therefor being in series relationship with the output gate of amplifier **56.** Switch **63** prevents or inhibits operation of the copying machine **10** until closed by coil **63'** upon energization thereof through triggering of amplifier **56** to a conducting state.

Switching amplifier **57** serves to shut down copy machine **10** should fuser temperatures become too high as represented by temperature T_3 of FIGS. 3 and 4. Schematically, the output gate of amplifier **57** is series connected with the operating coil **67'** for normally closed switch **67** in the operating circuit of copying machine **10.** On triggering of amplifier **57** to a conducting state, coil **67'** opens switch **67** to shut down copying machine **10.**

On start-up of copying machine **10,** which is effected by operator closure of a suitable start or PRINT control, schematically represented by switch **69,** the temperature of fuser **38** may be below minimum fuser operating temperature T_1. This normally occurs when copying machine **10** is unused for a relatively long period or on first start-up following an overnight shutdown. In this circumstance, resistance of thermistor **45** is relatively high so that the signal output of thermistor **45** to amplifier **50** is relatively high. Since the thermistor signal output is greater than v_1, the voltage for which amplifier **50** is gated to conduct, amplifier **50** is held in a non-conducting condition. Since switching amplifiers **55, 56, 57** are set to respond to predetermined signal inputs from amplifier **50,** amplifiers **55, 56, 57** remain in their quiescent state. In this situation, switching amplifier **55** is in a conducting state while amplifiers **56, 57** are in a blocking state. The signal from amplifier **55** energizes coil **60'** to close switch **60** and energize fuser heating lamp **44.** Lamp **44,** in turn, heats fuser roll **41.**

Switch **63,** which is closed only on triggering of switching amplifier **56,** is open thereby preventing operation of copying machine **10.** With amplifier **57** in a blocking condition, switch **67** is closed.

With operation of heating lamp **44,** temperatures within fuser **38** rise. This results in a decrease in resistance of thermistor **45.** On fuser **38** reaching the temperature range of interest, which is normally the minimum operating temperature T_1, the unamplified signal output of thermistor **45** equals v_1 and amplifier **50** is switched to a conducting state. The signal V_1, which appears at the output gate of amplifier **50** and which represents an amplified version of the output signal generated by thermistor **45** in response to temperatures of fuser **38,** is impressed on the control gates of switching amplifiers **55, 56, 57.** The bias level on amplifiers **55, 57** as determined by the values of their individual resistor combinations **58, 59** hold amplifiers **55, 57** in their quiescent state. However, the resistor combination **58, 59** for switching amplifier **56** is chosen so that the amplified signal V_1 from amplifier **50,** representing attainment of the minimum operating temperature T_1 in fuser **38,** switches amplifier **56** to a conducting state. With switching of amplifier to a conducting state, relay coil **63'** is energized to close switch **63** and enable operation of copying machine **10.**

Fuser lamp **44** continues to heat fuser **38,** the rise in fuser temperature being accompanied by a continued decrease in resistance of thermistor **45** and hence a decrease in the amplified signal output from amplifier **50.** On fuser **38** reaching normal fuser operating temperature T_2, the signal output V_2 from amplifier **50** switches switching amplifier **55** to a non-conducting state. The resultant deenergization of relay coil **60'** opens switch **60** to interrupt power to fuser lamp **44** and terminate heating of fuser **38.**

It is understood that with fuser lamp **44** off, temperatures in fuser **38** decrease. Following a small temperature decrease, as sensed by thermistor **45,** the signal from amplifier **50** switches switching amplifier **55** to a conducting state to actuate fuser lamp **44** and heat fuser **38.** Thus, while copying machine **10** is operational, amplifier switches between a conducting and non-conducting state in response to changes in fuser temperatures as sensed by thermistor **45** to maintain fuser **38** at approximately temperature T_2. It is understood that if fuser temperatures fall below the minimum operative temperature T_1, switching amplifier **56** switches to a non-conducting state to open switch **63** and prevent further operation of copying machine **10.**

Should temperatures of fuser **38** rise above the normal fuser operating temperature, T_2, to the maximum safe temperature T_3, the amplified signal output V_3 of thermistor **45** switches amplifier **57,** to a conducting state. The signal from amplifier **57** energizes coil **67'** to open switch **67** and shut down copying machine **10.**

In order to protect fuser **38** from over-heating in the event thermistor **45** fails, in which event resistance thereof would become extremely high and switching amplifier **55** would normally be held in a conducting state with fuser heating lamp **44** energized, a second control gate circuit to amplifier **50** incorporating transistor **70** is provided. The base of transistor **70** is connected through adjustable resistor **71** to the output side of thermistor **45** while the emitter of transistor **70** is connected with a control gate of amplifier **70.**

During normal operation of thermistor **45,** transistor **70** is conductive to provide a gate signal to amplifier **70.** In the event that the resistance of thermistor **45** exceeds a predetermined value indicating a failure or malfunction of thermistor **45,** transistor **70** is switched to a non-conducting state. This in turn causes the output voltage of amplifier **50** to drop to a low level. The low level output from amplifier **50** on such failure or malfunction of thermistor **45,** which is below the triggering signal V_3 of switching amplifier **57,** triggers amplifier **57** to a conducting state thereby energizing relay coil **67'** and opening switch **67.** Opening of switch **67** shuts down the copying machine **10** as described heretofore. A suitable delay circuit **72** is provided to prevent premature triggering of switching amplifier **57** when fuser **38** is first warmed up.

If desired, switch **67** may comprise a manually resettable type switch requiring, once opened, manual reclosing before operation of copying machine **10** can be resumed. In addition, triggering of switching amplifier **57** may also serve to actuate an alarm or signal to alert the operator to the fuser over-temperature condition.

While the invention has been described with reference to the structure disclosed, it is not confined to the details set forth, but is intended to cover such modifications or changes as may come within the scope of the following claims.

What is claimed is:

1. In a copying apparatus having a fuser for fixing toner developed images on the copy output of said apparatus, the combination comprising

circuit means for generating a control signal proportional to temperature conditions in said fuser, said circuit means including a temperature variable resistor in heat exchange relation with said fuser, the resistive change of said resistor in response to changes in temperature in said fuser normally being relatively small within the operating temperature range of said fuser whereby the sensitivity of said circuit means is relatively low in said fuser operating temperature range;

means for amplifying the signal output of said circuit means at least in said fuser operating temperature range whereby to avoid the need for relatively sensitive output comparator circuitry and instead permit use of relatively simple switching means;

means for heating said fuser;

means for operating said fuser heating means in response to signals from said amplifier means whereby to maintain said fuser in a predetermined operating temperature range; and

control means for said copying apparatus, said control means including switching means operative to prevent actuation of said copying apparatus while temperature of said fuser is below a predetermined minimum, said switching means being operative on a preset signal from said amplifier means reflecting attainment of said predetermined minimum fuser temperature to enable operation of said copying apparatus.

2. The copying apparatus according to claim 1 in which said copying apparatus control means includes second switching means operative to shut down said copying apparatus in response to a second preset signal from said amplifier means reflecting a predetermined overtemperature in said fuser.

3. The copying apparatus according to claim 1 including means for monitoring operation of said temperature variable resistor operative on failure of said resistor to abort said amplifying means to generate said second preset signal whereby said second switching means shuts down said copying apparatus.

4. In a copying apparatus having a fuser for fixing toner developed images on the copy output of said apparatus, the combination comprising

circuit means for generating a control signal proportional to temperature conditions in said fuser, said circuit means including a temperature variable resistor in heat exchange relation with said fuser, the resistive change of said resistor in response to changes in temperature in said fuser normally being relatively small within the operating temperature range of said fuser whereby the sensitivity of said circuit means is relatively low in said fuser operating temperature range;

means for amplifying the signal output of said circuit means at least in said fuser operating temperature range whereby to avoid the need for relatively sensitive output comparator circuitry and instead permit use of relatively simple switching means;

means for heating said fuser; and

switching means for controlling said fuser heating means, said switching means rendering said fuser heating means inoperative in response to a first amplifier means signal reflecting attainment of normal operating temperature in said fuser;

said amplifying means comprising a variable voltage amplifier gated to operate in response to a preset unamplified control signal from said circuit means reflecting attainment of minimum operating temperature in said fuser so that at fuser temperatures below said minimum operating temperature, said amplifier assumes a signal blocking condition.

5. In a copying apparatus having a fuser for fixing toner developed images on the copy output of said apparatus, the combination comprising:

circuit means for generating a control signal proportional to temperature conditions of said fuser, said circuit means including a temperature variable resistor in heat exchange relation with said fuser;

means for heating said fuser;

switching means for operating said fuser heating means in response to said circuit means control signals whereby to maintain said fuser in a predetermined temperature range during operation of said copying apparatus, and

means monitoring said temperature variable resistor operative on failure of said resistor to terminate operation of said fuser heating means.

6. The copying apparatus according to claim 5 including means to delay response of said resistor monitoring means whereby to avoid premature response of said resistor monitoring means and shut down of said fuser heating means.

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