May 6, 1969 TOSHIO ISHIKAWA ET AL 3,442,589

SENSITIZED PAPER DEVELOPMENT DEVICE

Filed May 16, 1967 Sheet 1 of 4

Fig 1

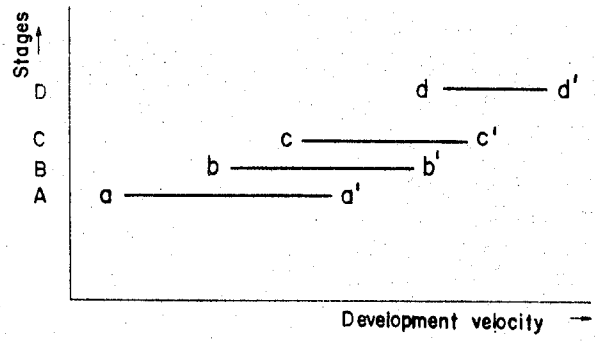


Fig 2

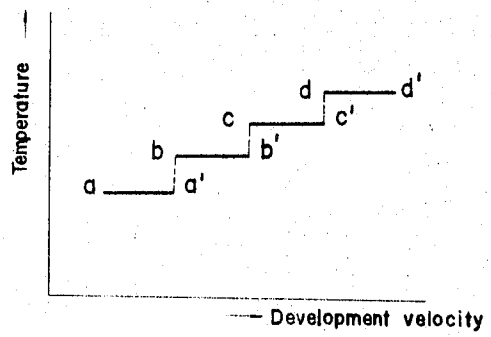


Fig 3

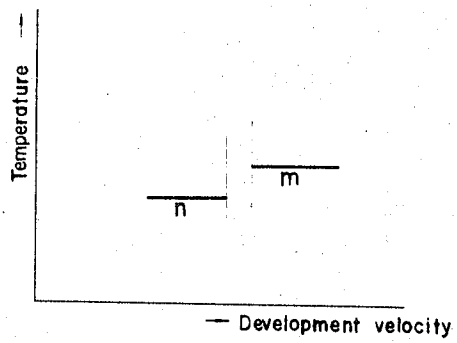


Fig 4

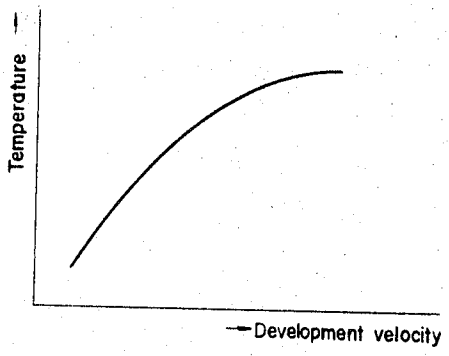
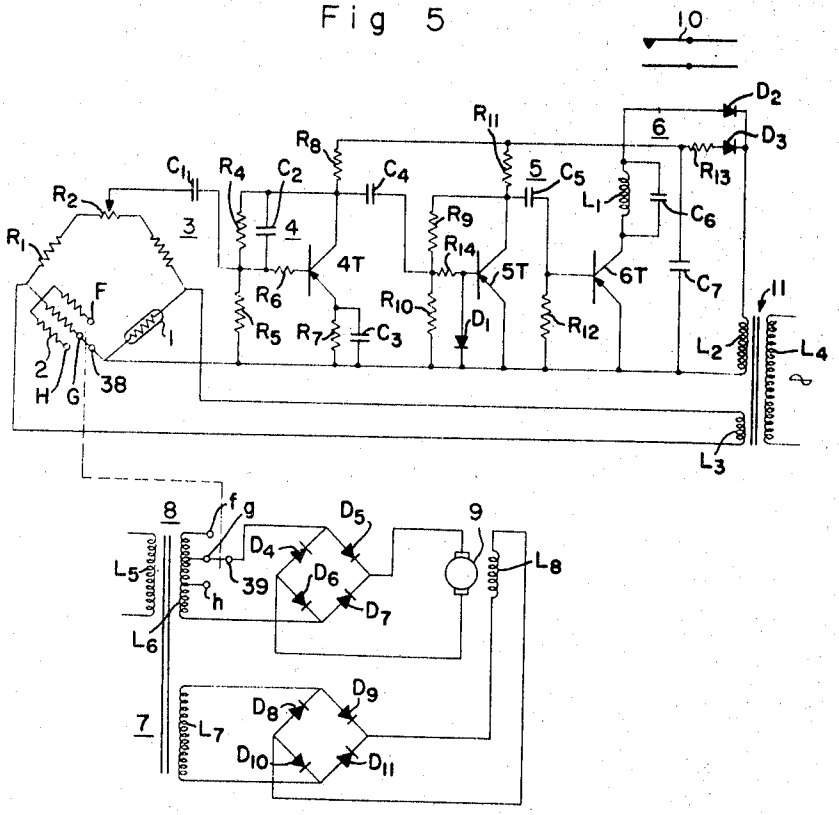

Temperature
Development velocity

Fig 5


10
D2
D3
R11
R8
6
R13
C1
R4
C2
C4
5
C5
L1
C6
R2
R1
3
4
R9
R14
4T
5T
6T
C7
11
F
R6
R10
D1
R12
R5
R7
C3
L2
L4
2
H
G
38
1
L3

8
f
g
D5
9
D4
D6
L8
L5
39
h
D7
L6
D9
D8
7
L7
D10
D11

FIG. 6

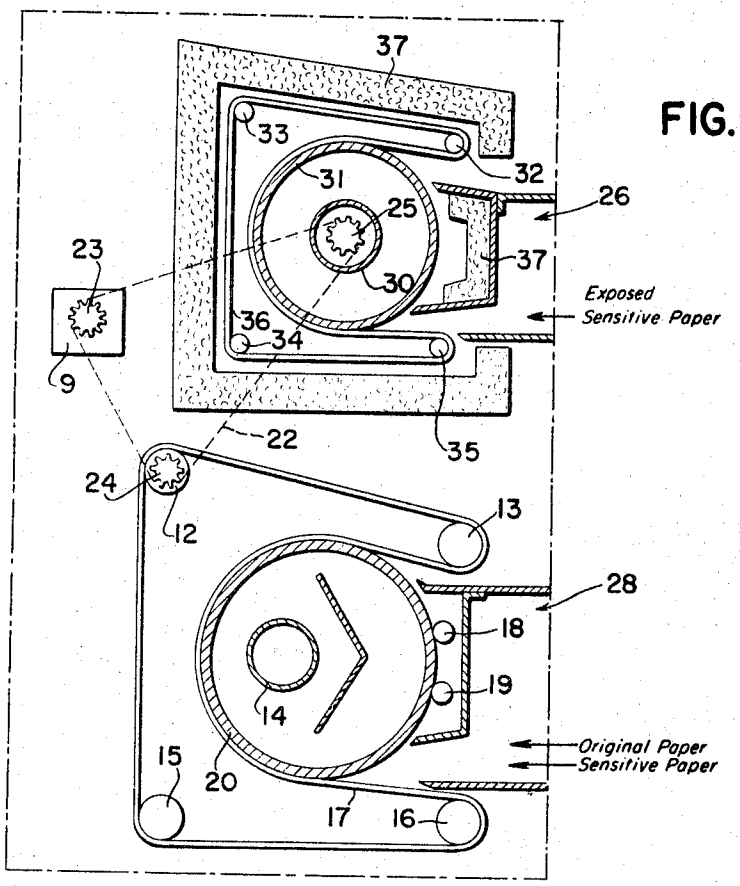

37
33
32
31
25
26
23
37
30
Exposed
Sensitive Paper
36
34
9
22
35
24
12
13
28
18
19
14
Original Paper
Sensitive Paper
15
20
17
16

FIG. 7

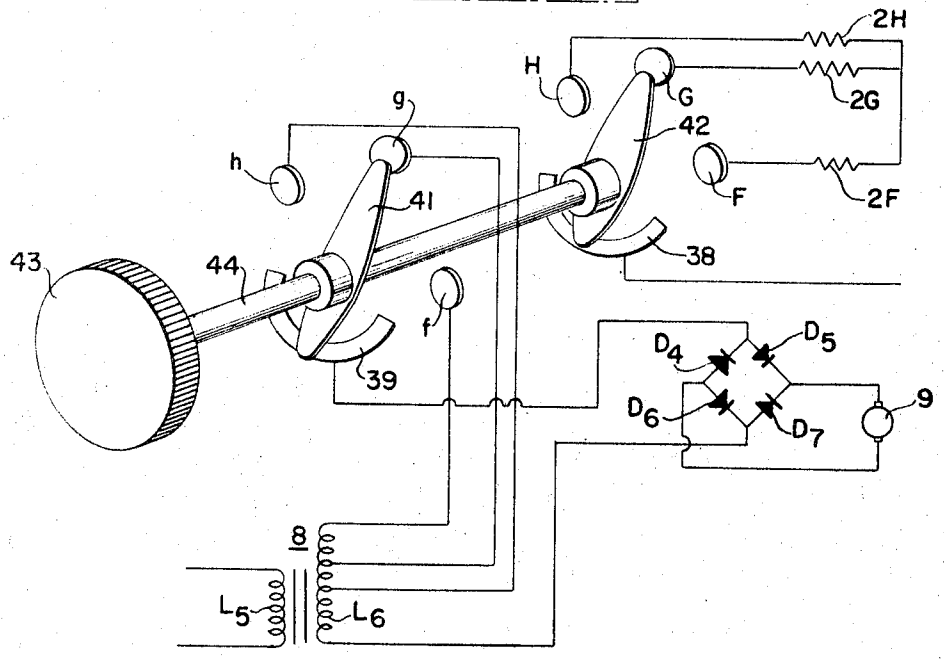

2H
H
G
2G
g
42
h
41
F
2F
43
44
38
f
39
D4
D5
D6
D7
9
8
L5
L6

FIG.8

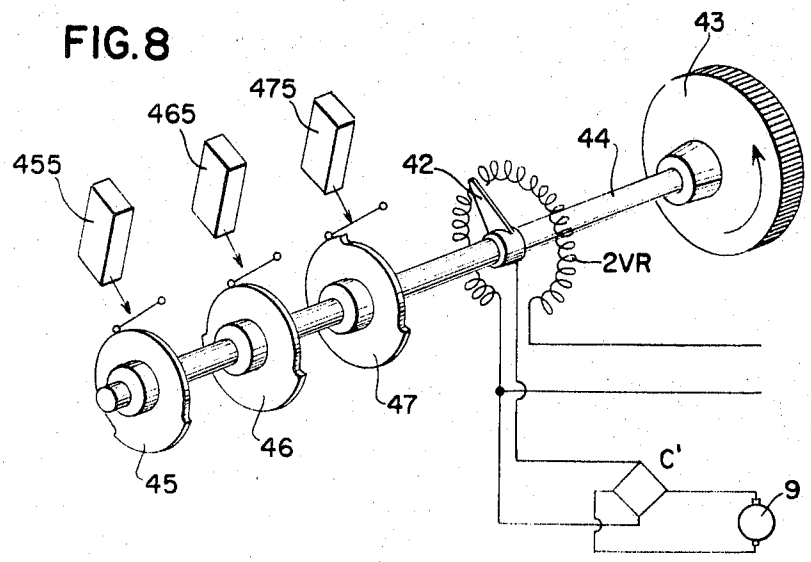
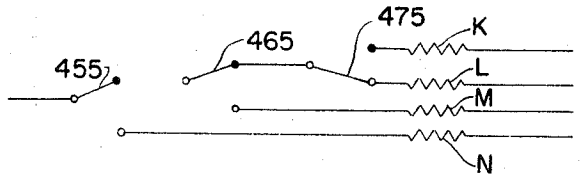


FIG.9



United States Patent Office 3,442,589 Patented May 6, 1969

3,442,589

SENSITIZED PAPER DEVELOPMENT DEVICE

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Continuation-in-part of application Ser. No. 399,784, Sept. 28, 1964. This application May 16, 1967, Ser. No. 638,898

Claims priority, application Japan, June 25, 1964, 39/35,973

Int. Cl. G03b 27/02

U.S. Cl. 355—106 5 Claims

ABSTRACT OF THE DISCLOSURE

An apparatus for heat development of positive sensitized paper which exposes sensitized paper first to a light source and then to a heat source. An electric curcuit in the device simultaneously controls both the velocity of the paper moving past both sources and the developing temperature.

Related applications

This application is a continuation-in-part of application Ser. No. 399,784, filed Sept. 28, 1964.

Background

The invention relates to copiers, and more specifically, to light exposure and heat developer copiers having velocity and temperature control circuitry.

In positive printing machines the relation between the transportation velocity of the paper during heat developmen and the development temperature is very important. Heat development in general is provided by imparting a certain quantity of heat from a heating source onto sensitized paper moving past the heating source. To create color, the development apparatus is first heated in advance to a predetermined temperature and then held at that temperature by compensating for any temperature changes due to heat absorbed by the sensitized paper during development. The velocity of the paper moving past the heat source is usually controlled by a motor driving a belt which carries the paper around the heating source. Both the temperature and the development velocity must be considered so that the heat quantity necessary for sensitized paper is radiated uniformly over the paper surface.

Since it is generally desirable that he quantity of heat generated on the paper surface be approximately constant during development the ratio of the development temperature and the paper velocity past the heat source, should also be approximately constant. If the operating temperature is changed to a higher level the velocity should be increased correspondingly, or if the temperature is lowered , the velocity should be lowered.

In addition to maintaining an optimum relation between the temperature and the velocity of paper movement in the development stage, it is desirable in positive printing machines to synchronize the velocity of the sheet of paper moving through the light exposure stage with that of the developing stage. When synchronization between the stages is not maintained, a portion of the paper inserted in both of the stages becomes either stretched or damaged; when the development stage velocity exceeds the light exposure stage or when the developing velocity falls below that of the light exposure stage, a back up of light sensitized paper occurs causing stagnation of the paper prior to the development stage. Finally, it is necessary to provide some flexibility in temperature range settings of the developer in order satisfactorily to develop prints from different shades of original paper.

In the past positive printing developers have not been entirely satisfactory in maintaining optimum heating characteristics when ether the velocity of the sheet or the developer temperature was changed to any degree. These devices also have failed to synchronize the paper sheet transportation rate through both the light exposure and heat developing stages and have experienced difficulties in compensating for heat losses in the development stage due to the removal of heat by the sensitized paper.

It is an object therefore to overcome the foregoing limitations and difficulties by providing a novel copier apparatus.

Summary

A novel copier for positive print developing is obtained by the provision of a novel developer temperature and sheet velocity control circuit in combination with a light exposure device and a heat developer device. With the copier of this invention, it is possible to adjust development velocity to varying temperature ranges in accordance with the shade of color of the original paper while the exposure velocity is maintained constantly synchronized with the developing velocity. Heat development efficiency is maximized with an automatic adjusting control circuit which varies both the heat source temperature and the sheet velocity simultaneously, thus providing a continuous temperature velocity relationship.

Brief description of the drawings

FIGS. 1–4 are graphs showing relationships between the temperature and velocity of development;

FIG. 5 is a circuit diagram illustrating a control circuit of the invention;

FIG. 6 illustartes light exposure and heat developing stages of a copier in accordance with the invention;

FIG. 7 is an electromechanical illustration of one embodiment of a temperature range selecting switch interconnecting temperature and velocity control circuitry in FIG. 5;

FIG. 8 is an illustartion of another interconnecting electromechanical switch circuit embodiment; and

FIG. 9 is a switching arrangement for the switches of FIG. 8.

Description of the preferred embodiments

Referring now to the drawings, the graphs of FIGS. 1–4 shows the manner in which the temperature and the developing velocity may be related. Normally when the velocity of movement of the developing portion of a copier becomes higher, the temperature should be higher and as it becomes lower the temperature should be lower. Sensitized paper becomes scorched below *a*, and the development is incomplete above *a'*. Each corresponding velocity may have some tolerance, such as *a–a'*, *b–b'*, etc. in FIG. 1, and may overlap to a certain degree as temperature is increased A, B, C, D.

If, as in FIG. 2, satisfactory developing velocities do not overlap with increases in temperature, a gap *n–m* in the developing section could result if optimum operating velocities lie somewhere between *a–a'*, *b–b'*, etc. Such gaps, however, are avoided with the present invention and a continuous temperature velocity relationship is developed as shown in FIG. 4.

FIG. 6 illustrates a copier with light exposure stage **28** and a heat developing stage **26**. In the exposing section a roller belt **17** engages rollers **12**, **13**, **15** and **16** and a transparent cylinder **20** which contains a light source **14**. The transparent cylinder **20** is sustained from slipping out by two stopping rollers **18** and **19**. Both the original paper and light sensitized paper are combined together and inserted in the direction of the arrow between the

belt, which is revolved by driving roller 12 and the periphery of cylinder 20.

The developing stage 26 has a heating roller 31 which rotates around a heating source 30. The heating source may be, for example, a heating wire such as a Nichrome wire, or an infrared ray lamp. A belt 36 is wound around rollers 32, 33, 34 and 35 for carrying light-sensitized paper around the heating roller. A heat insulating material 37 covers the rollers 32–35 and belt and shields the heating roller 31. When light-sensitized paper, which has been exposed in the light exposure stage, is inserted between the heating roller 31 and the belt 36, it is developed while the paper is revolved around the periphery of roller 31. The light exposure and developing stages are shown being driven by the same chain or belt linkage 22 from a gear 23 which may be connected to the drive shaft of a motor 9 (FIG. 5). The rotation of the linkage 22 rotates both gear 25 on the developing section and gear 24 in the exposure section.

As well known in the art, the phase relation between the input and output voltages of an AC bridge is reversed as one or more branch impedances of the bridge are varied from one side of the balance point of the bridge to the opposite side thereof. Accordingly, it is possible to form an AC bridge circuit consisting of an arm including a thermistor located at a desired temperature measuring point and the remaining three arms each including a resistor, so that for a given constant input voltage to the AC bridge, the polarity of the phase angle of the output voltage therefrom can be changed depending on whether the temperature of the thermistor is in excess of or is less than a certain preselected value, which value is determined as a function of the temperature-resistance characteristics of the thermistor and resistance values of resistors of the three arms of the bridge. With the provisions of a phase discriminator circuit to check the polarity of the phase angle of the output voltage from the bridge and an electric heater connected to the phase discriminator circuit, then it is possible to switch on and switch off the heater in response to each change-over of the polarity of the phase angle of the output voltage of the bridge and hence in response to the temperature variation of the thermistor passing a certain preselected value determined by the design of the bridge.

In FIG. 5, the circuit includes a thermistor 1 in a bridge leg, resistance leg 2 having a plurality of temperature setting contacts F, G, H being separately switched into a bridge circuit 3 that is connected to AC amplifiers 4 and 5 which are in turn connected to a phase discriminator 6 that controls operation of a relay 10; a power transformer 11 is the power source for the circuit and the temperature setting contacts F, G, H are interconnected with speed control means 7 and 8 for the motor 9.

In the particular embodiment of the AC bridge shown in FIG. 5, one arm consists of the thermistor 1 located at a desired temperature measuring point and another arm is adapted to be selectively connected to one of the resistors in resistance leg 2 for facilitating the temperature setting, while the remaining two arms consist of resistors R_1 and R_3 of identical resistance values connected by a variable resistance R_2 for adjustment. The AC amplifiers 4, 5 consist of PNP type transistors 4T and 5T, respectively, and the phase discriminator circuit 6 is also made of a PNP type transistor 6T. The coil L1 of relay 10 is connected to the transistor of the phase discriminator circuit 6 as a collector load thereof, so that the relay 10 is energized when the transistor is conductive, and the relay contact is closed. The relay contact is kept open as long as the transistor of the discriminator circuit 6 is nonconductive.

The power source transformer 11 is provided to apply a half-way rectified voltage across the collector and the emitter of the transistor 6T through suitable diodes. As far as direct voltage is concerned, the emitter and the base of the transistor of the circuit 6 are at the same potential.

A collector current flows through the relay 10 if the emitter is made positive with respect to the base of the transistor 6T during the period when the emitter is kept positive with respect to the collector, namely, during the positive half cycle of the power source voltage. If an AC voltage applied across the emitter and the base of the transistor 6T in the aforesaid phase relation with the power source voltage, then the collector current flows during each positive half cycle of the power source voltage. On the other hand, if the AC voltage across the emitter and the base of the transistor 6T is so phased as to keep the emitter negative with respect to the base during the positive half cycle of the power source voltage, then the transistor is kept nonconductive and the relay 10 is not actuated.

In FIG. 5, the temperature and velocity control circuit is used to continuously control sheet velocity and heat developer temperature in a copier such as that illustrated in FIG. 6. A predetermined temperature setting is first made at resistor 2 with one or more contacts F, G, H being switched into the bridge circuit. At the same time, the variable speed control transformer 8 has appropriate taps *f*, *g*, *h*, etc. connected to a full wave rectifier comprising diodes D_4, D_5, D_6 and D_7. Under optimum developing conditions bridge 3, comprising resistors R_1, R_2, R_3, thermistor 1 and variable selection resistors 2, is balanced. Thermistor 1 is located in the vicinity of the heat-development roller and detects any changes in temperature. If the bridge becomes unbalanced, a signal is picked up at variable resistor R_2 and is transmitted through capacitor C_1 to the amplifier 4. The signal passing through capacitor C_1 goes through a voltage divider and resistor R_6 connected to the base of transistor 4T. The voltage dividing circuit consisting of and RC network R_4C_2 and a resistor R_5 is connected between capacitor C_1 and resistor R_6. The amplifier transistor 4T has a resistor R_7 and capacitor C_3 connected in parallel between the emitter and junction A of the bridge network. The amplifier transistor 4T has a DC current path through resistor R_8, resistor R_{13} and diode D_3 to winding L_2 of transformer 11. An AC path exists through capacitor C_4, voltage divider network comprising resistors R_9, R_{10}, and resistor R_{14} to the base of transistor 5T. A current limiting diode D_1 is connected between the base and emitter electrodes of transistor 5T. An output signal from the collector of transistor 5T is coupled through RC network C_5 and R_{12} to the base of relay transistor 6T. When transistor 6T has a collector output signal through inductor L_1 and capacitor C_6, relay 10 is actuated in order to control the amount of heating current to be applied to the heating source. The output circuit of transistor 6T is completed through diode D_2 and winding L_2. A capacitor C_7 is connected in a conductor extending from a junction 38 between the bridge legs 1 and 2 and a junction between resistors R_{11} and R_{13}. Winding L_3 is connected between two junctions of the bridge circuit and the primary winding L_4 of transformer 11 is connected to a suitable power source.

The transformer 8 includes a primary winding L_5 connected to a suitable power source and a secondary winding L_6 providing variable speed control to motor 9 through the full wave rectifier consisting of diodes D_4, D_5, D_6 and D_7. A motor coil L_8 provides feedback signals through a full wave rectifier consisting of diodes D_8, D_9, D_{10} and D_{11} for a DC control signal through winding L_7 to insure synchronization of motor 9 at the desired speed. The three transformer taps *f*, *g* and *h* are separately switched to a junction 39 which is connected to the junction between diodes D_4 and D_5.

If it is assumed in FIG. 5 that the two secondary windings L_2 and L_3 of the power source transformer 11 are so connected that corresponding ends are simultaneously made positive with respect to the opposite ends thereof, and if it is further assumed that the variable resistor R_2 for adjustment is set at the center point thereof and the resistance of the thermistor 1 is higher than the particular resistance 2 selected at the particular moment,

which means that the temperature of the thermistor located at the desired measuring point is lower than a preselected temperature setting made on the resistor **2**, then the output voltage from the bridge **3** is applied to the transistor **4T** across the emitter and the base thereof in such polarity that the emitter is kept positive with respect to the base during the positive half cycle of the power source voltage applied to the transistor **6T**, namely, that half cycle when the emitter of the transistor **6T** is kept positive with respect to the collector of the same. Since the power source voltage to the amplifier circuits **4** and **5** is half-wave rectified by diodes and then applied thereto through filter circuits consisting of resistors and capacitors, the transistors **4T** and **5T** of the amplifier circuits are made conductive under such conditions throughout each cycle. Thus, the output voltage from the bridge circuit **3**, which is applied to the amplifier circuit **4**, is amplified by the AC amplifier circuits **4** and **5**, and then applied to the phase discriminator circuit **6**. Due to the fact that the output and input voltages are in phase in the case of a two-stage AC amplifier of resistor-capacitor coupling type as shown in FIG. 5, the output voltage of the bridge circuit **3** is amplified and applied to the transistor **6T** across the emitter and base thereof after being amplified without any phase-shifting. Thus, as described above, in the transistor **6T**, the emitter is made positive with respect to the collector in synchronism with the AC voltage making the emitter positive with respect to the base. Thereby, the transistor **6T** is made conductive to actuate the relay **10** and the relay contact is closed. Upon closure of the relay contact, an electric heater in the developing portion is energized or switched on to heat up the developing portion.

As the temperature of the developing portion is raised by such heating, the temperature of the thermistor **1** located in a suitable measuring area of the developing portion **26** is also increased, and accordingly, the resistance of the thermistor becomes lower. When the resistance of the thermistor is lowered to the same value as that of the resistor **2** preselected for temperature setting, the bridge circuit **3** is balanced, and the output voltage from the bridge becomes zero. Thus, no voltage is applied to the transistor **4T** as an input voltage thereto, and the transistor **6T** becomes nonconductive to deenergize the relay **10**. Consequently, the contact of the relay **10** is opened and the electric heater is switched off.

If there is a considerable time delay between the heating effect of the electric heater and the temperature of the thermistor **1** in the developing portion to cause temperature rise even after switching off the heater, the resistance of the thermistor is excessively lowered beyond the value for proper balance of the bridge circuit **3** to again unbalance the bridge. However, the output voltage from the bridge circuit **3** under these conditions is produced in exactly opposite phase relation to the power source voltage applied to the transistor **6T**; namely, when the collector of the transistor **6T** is made positive with respect to the emitter by the power source voltage from the bridge circuit **3**. Thus, the transistor **6T** is kept nonconductive.

With the electric heater switched off, the temperature of the developing portion **26** is gradually reduced to increase the resistance of the thermistor **1**, and when the resistance value of the thermistor is increased in excess of the aforesaid preselected resistor for setting, then the balance of the bridge circuit is again broken in the same manner as described above. Thus, the transistor **6T** of the discriminator circuit **6** is made conductive to energize the electric heater.

As a result of it, when the temperature of the thermistor is low and the resistance thereof is larger than that of a resistor **2** preselected for temperature setting, the heater is switched on. On the other hand, when the temperature of the thermistor is high and the resistance thereof is smaller than that of the resistor for temperature setting, the heater is switched off. By providing a plurality of different resistors having suitable resistance values for temperature settings, the temperature setting can be changed by selectively connecting one of such resistors to the bridge circuit **3**. By the operation of the variable resistor R_2 for adjustment, the temperature setting can be made with fine adjustment.

Two embodiments which may be used to interconnect the temperature control circuit with the motor speed control are shown in FIGS. 7 and 8. In FIG. 7 changeover contact members **41** and **42** are spacedly mounted on a spindle **44** attached to a dial **43**. The switching members **41** and **42** always make contact with junctions **38** and **39**, respectively, but are switchable between contacts F, G, H, and *f*, *g*, *h*, respectively, so that any change in temperature setting makes a corresponding velocity change and vice versa.

With the dial **43** positioned as illustrated in FIG. 7, the secondary tap *g* of the transformer **8** is connected to the rectifier bridge through the rotary member **41**, and a direct voltage from the rectifier bridge is applied to the armature of the DC motor **9**. The other rotary member **42** connects a temperature setting resistor G to the bridge circuit **3**. Thus, the revolving speed of the motor **9** is determined by the voltage appearing on the secondary tap *g* of the transformer **8** thus selected, and the temperature of the developing portion is regulated by the temperature setting resistor **2G** thus connected to the bridge **3**.

When the dial **43** is rotated in a counterclockwise direction from the position of FIG. 7, the revolving speed of the DC motor **9** is determined by a secondary tap *h* of the transformers **8**, while the temperature of the developing portion is regulated by the temperature setting resistor **2H**. Conversely, if the dial **43** is rotated in a clockwise direction from the position of FIG. 7, the revolving speed of the motor **9** is determined by the secondary tap *f* of the transformer **8**, while the temperature of the developing portion is regulated by the temperature setting resistor **2F**.

FIG. 8 shows another example of setting device of the revolving speed and developing speed by means of microswitches and a variable single winding transformer, in which three cams **45**, **46** and **47** are secured to the dial shaft **44** so as to cooperate with microswitches **455**, **465** and **475**, respectively. Also secured to the dial shaft is a rotary contact arm **42** of the variable single winding transformer **2VR**. With the setting dial positioned as shown in FIG. 8, only the microswitch **475** is actuated. As the setting dial **43** is rotated in a counterclockwise direction, the microswitches **465** and **475** are actuated successively, and finally all the microswitches **455**, **465** and **475** are actuated simultaneously. If the setting dial **43** is turned to the extreme end of the clockwise direction, all the microswitches **455**, **465** and **475** are switched off simultaneously. The rotation of the contact arm **42** of the variable single winding transformer **2VR** is so arranged that it is not possible to transfer from the condition of simultaneous actuation of the microswitches to the condition of the simultaneous switching-off of all microswitches and vice versa.

FIG. 9 illustrates four temperature range adjustments by means of four resistors K, L, M and N and with corresponding changes in development velocity. The temperature setting resistors to be connected to the bridge circuit **3** under each operative condition of the microswitches are shown in the following table.

TABLE

Microswitch No.	Conditions			
	I	II	III	IV
455	Off	Off	Off	On.
465	Off	Off	On	On.
475	Off	On	On	On.
Resistor to be connected	K	L	M	N.

In the particular example shown in FIG. 8, the combination of the cams and the microswitches can take only four positions designated by conditions I to IV in the table, and the microswitches are always in one of the four conditions selected by suitable combinations of the cams **45**, **46** and **47**. Thus, the revolving speed is regulated by the rotation of the contact arm of the variable single winding transformer **2VR**, and at the same time the temperature setting of the developing portion can be switched over in a very reliable manner.

What is claimed is:

1. In apparatus for heat development of positive sensitized sheets, the combination comprising, an exposure device having a light source and first means for moving an original copy and a sensitized sheet conjointly past said light source to expose said sensitized sheet; a heat development device having a heat source and second means for moving the exposed sensitized sheet past said heat source to develop said sheet; switch means selectively operable to connect said heat source to a source of potential; a thermistor operatively associated with said heat development device and subjected to the temperature therein; an electric control circuit including an A.C. bridge, amplifier means connected to the output of said bridge and a phase discriminator connected to the output of said amplifier means, said thermistor being connected in an arm of said bridge; means applying a first A.C. potential to the input of said bridge and a second A.C. potential to said phase discriminator, said first and second A.C. potential being in phase coincidence; the amplified output potential of said A.C. bridge constituting a third A.C. potential which is applied to said phase discriminator; said switch means being connected to said phase discriminator and closed thereby when said second and third A.C. potentials are in substantial phase coincidence; the phase of said third A.C. potential, relative to that of said first and second A.C. potentials, being dependent on the resistance value of said thermistor; said third A.C. potential being substantially in phase with said second A.C. potential when the resistance of said thermistor is above a selected value, and being in phase opposition with said second A.C. potential when the resistance of said thermistor is below said selected value.

2. In apparatus for heat development of positive sensitized sheets, the combination claimed in claim **1**, including an adjustable resistance in said bridge for setting said selected value; the output of said bridge being zero when the resistance of said thermistor is at said selected value.

3. In apparatus for heat development of positive sensitized sheets, the combination claimed in claim **1**, in which said amplifier means comprises an RC coupled two-stage amplifier.

4. In apparatus for heat development of positive sensitized sheets, the combination claimed in claim **3**, in which the stages of said amplifiers comprise transistors having said second A.C. potential applied to their outputs; said phase discriminator comprising a transistor having said second A.C. potential applied to its collector-emitter circuit; said switch means comprising a switch operating coil in the collector circuit of the transistor of said phase discriminator; the output of said bridge being applied to the input of the transistor of the first stage of said amplifier.

5. In apparatus for heat development of positive sensitized sheets, the combination claimed in claim **1**, including plural resistors of respective different resistance values included in an arm of said bridge and each having one terminal commonly connected to one input terminal of said bridge; first selector switch means selectively operable to connect the other terminal of a selected one of said resistors to an output terminal of said bridge; an electric motor commonly driving said first and second means; a source of potential having plural terminals at respective different potentials; and second selector switch means selectively operable to connect said motor to a selected one of the terminals of said last-named source of potential; said first and second selector switch means being interconnected for conjoint operation to control the speed of operation of said first and second means in accordance with the resistance setting of said A.C. bridge.

References Cited

UNITED STATES PATENTS

3,207,896	9/1965	Meaney	95—77.5 X
3,224,355	12/1965	Thomiszer	95—77.5

JOHN M. HORAN, *Primary Examiner.*

U.S. Cl. X.R.

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