

United States Patent

Miles

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[54] ILLUMINATION CONTROL FOR PHOTOCOPYING MACHINE

[72] Inventor: William B. Miles, Arlington Heights, Ill.
[73] Assignee: Addressograph-Multigraph, Mt. Prospect, Ill.
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[51] Int. Cl. G03b 27/72
[58] Field of Search 355/68, 69

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Primary Examiner—Samuel S. Matthews
Assistant Examiner—Monroe H. Hayes
Attorney—Mason, Kolemmainen, Rathburn & Wyss

[57] ABSTRACT

A photocopying machine has a photosensitive surface which receives a light image of an original to be copied. To obtain consistent uniform density copies, the light source or the light imaging system is automatically controlled to provide uniform illumination by an SCR controlled relay. The gate of the SCR is coupled to a capacitor having two charging and/or discharging circuits, one of which includes a light responsive cell subjected to illumination from the light source. These circuits are sequentially rendered effective by a copy sheet actuated responsive

6 Claims, 2 Drawing Figures

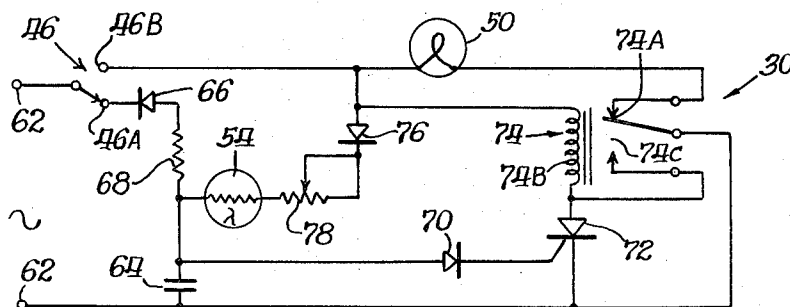


Fig. 1.

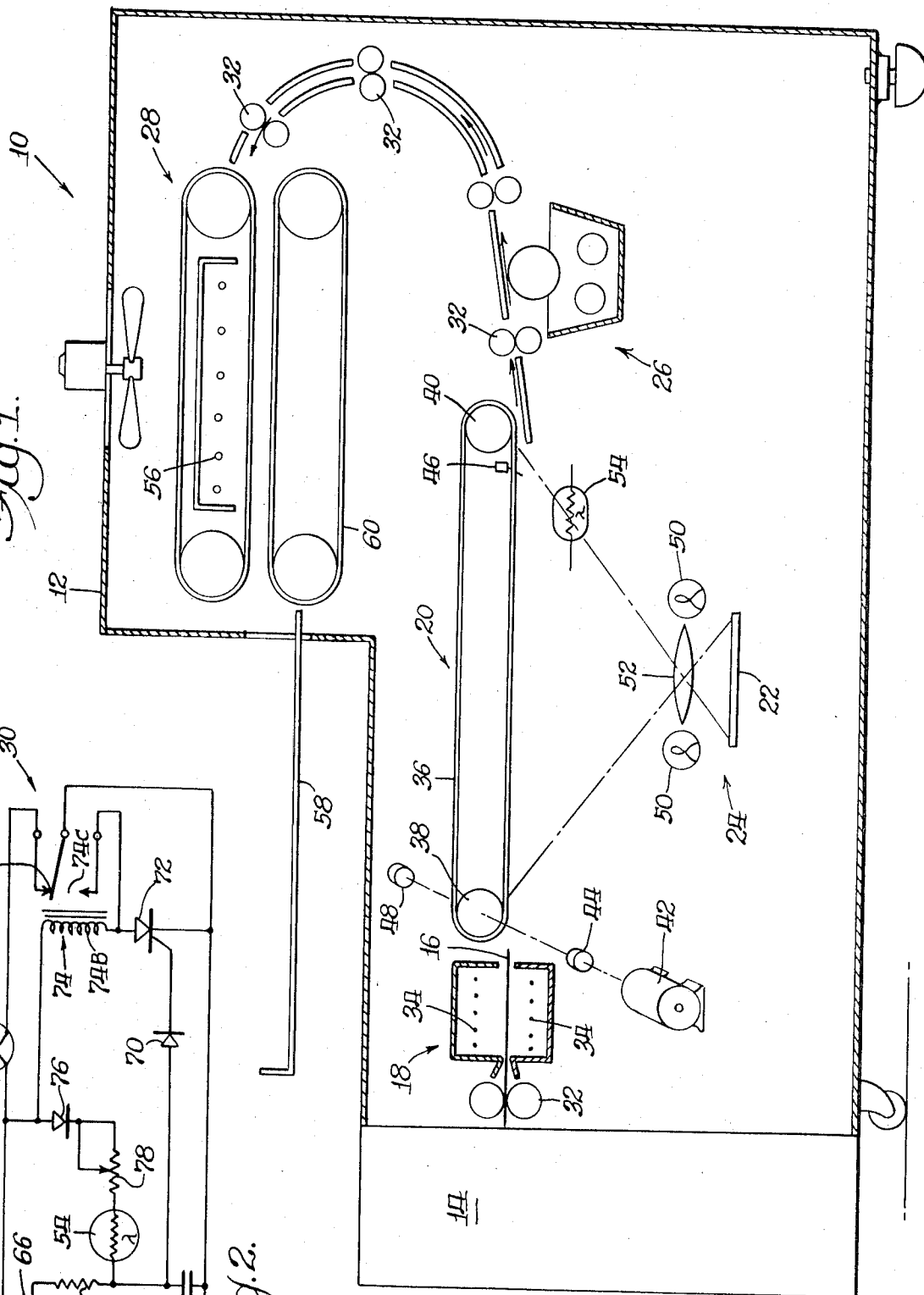
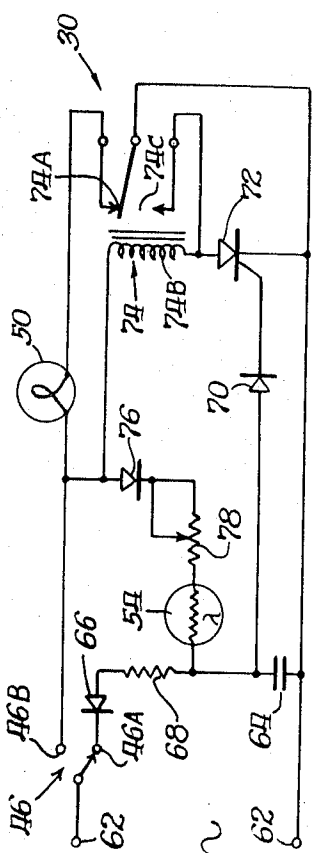


Fig. 2.



Inventor
 William B. Miles
 By: Mason, Kolehmainen, Rathburn & Wyss
 Attorneys

ILLUMINATION CONTROL FOR PHOTOCOPYING MACHINE

BACKGROUND OF THE INVENTION

This invention relates to a photocopying apparatus and, more particularly, to a new and improved illuminating control for such a copying apparatus.

Electrophotographic copying machines using uniformly charged photoconductive surfaces on either a printing master or a drum or individual copy sheets direct the light image on the charged surface to provide a latent electrostatic image which is developed by the application of a developer or toner material. To obtain uniform copy density with the developer or toner material, it has been found necessary to control the intensity of the light energy provided in the light image impinging on the charged surface. This can be done by a manual adjustment, but this is not generally feasible in commercial machines. Further attempts to do this automatically and in synchronism with the production of successive copy sheets has frequently led to the use of very expensive and elaborate systems, such as the one shown in U.S. Pat. No. 3,298,296.

SUMMARY OF THE INVENTION

One object of the present invention is to provide a photocopying machine with a new and improved light source control for obtaining uniform density copies.

Another object is to provide a simple and reliable control for the light source in a copying machine.

A further object is to provide a light source control using two capacitor charging or discharging circuits, one of which includes a cell responsive to the illumination directed on the photoconductive surface, and both of which are operated in a synchronized relation by copy sheet movement.

In accordance with these and many other objects, an embodiment of the invention comprises a photocopying apparatus using a photoconductive member whose uniformly charged surface is exposed by a light image of an original to be copied. A light source in the light imaging system is energized when the member is moved to an exposure station by a switch actuated by movement of the member. Operation of this switch also opens a first capacitor charging circuit which establishes a reference level potential on a capacitor and closes a second capacitor charging or discharging circuit including a light responsive device subjected to the light image or light from the source. This light responsive element varies the rate at which the potential on the capacitor is changed by the second circuit in accordance with light intensity so that when a given intensity is reached, an SCR responsive to the charge on the capacitor operates a relay to terminate the light source energization until the member has moved beyond the exposure station.

BRIEF DESCRIPTION OF THE DRAWINGS

Many other objects and advantages of the present invention will become apparent from considering the following detailed description in conjunction with the drawings in which:

FIG. 1 is a schematic view in section of a photocopying apparatus embodying the present invention; and

FIG. 2 is a schematic circuit diagram of a light source control circuit used in the copying apparatus shown in FIG. 1.

DESCRIPTION OF THE ILLUSTRATED EMBODIMENT

Referring now more specifically to FIG. 1 of the drawings, therein is illustrated a photocopying machine which embodies the present invention and which is indicated generally as 10. The photocopying apparatus 10 includes a housing 12 having an assembly or station 14 for supplying web or sheet copy material with a photoconductive surface such as a copy sheet 16 having a downwardly facing photoconductive surface. The copy sheet 16 is moved through a charging station 18 at which the photoconductive surface receives a uniform electrostatic

charge to an exposure station indicated generally as 20 at which the sheet 16 is stopped momentarily to receive a light image of an original 22 to be copied from the light imaging system indicated generally as 24. The latent electrostatic image produced at the exposure station 20 is then developed by moving the copy sheet 16 through a developing station indicated generally as 26 and a fixing or fusing station 28. In accordance with the present invention, a light or lamp control circuit indicated generally as 30 (FIG. 2) controls the intensity of the illumination received by the copy sheet 16 at the exposure station 20 so that copies of uniform print density are produced when the copy sheet 16 is moved to the developer station 26.

Referring now more specifically to the operation of the photocopying apparatus 10, this apparatus includes components and is constructed in a manner well known in the art. The assembly 10 can supply discrete copy sheets 16 or can comprise an assembly of the type shown in U.S. Pat. No. 3,418,047 for severing discrete lengths from a roll of copy material. The leading edge of the copy sheet 16 from the assembly 14 which is advanced in response to a demand for a copy is fed from the assembly 14 by one of a plurality of pairs of drive rollers 32, which rollers can be intermittently or continuously driven in accordance with the construction of the machine. As the copy sheet 16 passes through the charging station 18, a plurality of corona wires 34 deposit uniform layers or blankets of charge of opposite polarity on the opposite surfaces of the copy sheet 16, the lower surface of which is provided with a photoconductive surface.

As the leading edge of the copy sheet 16 leaves the charging station 18 and enters the exposure station 20, a plurality of flexible conveying belts 36 driven by a pulley 38 and passing around an idler pulley 40 pick up the leading edge of the sheet 16 and convey the sheet into the exposure station 20. The lower lengths of the flexible conveying belts 36 can be connected to a vacuum chest in the manner well known in the art to detachably mount the copy sheet 16 on these belts. The pulley 38 is driven by a drive motor 42 which is coupled to the pulley 38 through an electrically controlled clutch 44.

When the leading edge of the copy sheet 16 reaches a point at which the copy sheet is properly disposed in the exposing station, the leading edge of the sheet 16 actuates a suitable control device such as an electric switch 46. The actuation of the electric switch 46 releases the clutch 44 and applies an electrically controlled brake 48 so that the copy sheet 16 is stopped in an exposing position. The actuation of the switch 46 can also be used to initiate the operation of the imaging system 24 so that uniform electrostatic charge on the photoconductive lower surface of the copy sheet 16 is selectively discharged in accordance with a light image representing the original 22 to be copied.

The light imaging system 24 is of conventional construction and includes, for example, one or a plurality of electric lamps 50 which uniformly illuminate the original 22 to be copied and provide a reflected light pattern or image which is applied by a lens 52 on the charged surface of the copy sheet 16. This illumination selectively discharges the photoconductive surface of the sheet 16 to provide a latent or electrostatic image. In order to insure uniform density of the copy produced, it is desirable that the copy sheet 16 receive uniform illumination. Accordingly, a light responsive means or cell 54, such as a cell whose resistivity varies in accordance with illumination, is disposed to receive light reflected from the original 22 in such a position as not to obscure the material to be copied. The cell 54 can be of conventional construction and, for example, can be a cell in which increasing incident light energy reduces the resistivity.

When the copy sheet 16 has been suitably exposed, illumination of the lamps 50 is terminated, and the control exercised by the switch 46 is overridden to release the brake 48 and apply the clutch 44 so that the copy sheet 16 is advanced from the exposure station 20 to the developer station 26. The developer station 26 is of conventional construction and may

comprise, for example, a magnetic brush or a liquid toner unit, and effects the selective deposition of toner material on the adjacent surface of the copy sheet 16 to provide a developed copy. The copy sheet 16 is advanced to the developer station 26 by additional pairs of rollers 32, and these rollers then advance the copy sheet into the fuser station 28. This station is of conventional construction and serves to fix or place in permanent form the developer image on the copy sheet 16. The fuser or fixing station 28 can include, for example, a number of resistance heating elements 56. When the copy on the sheet 16 has been placed in permanent form, it is discharged from the machine into a receiving tray 58 by a flexible belt conveyor 60 forming a part of the fusing station 28.

As set forth above, the lamp control circuit 30 provides means for automatically insuring uniform intensity of illumination of the photoconductive surface of the copy sheet 16 at the exposure station 20. The control circuit 30 (FIG. 2) is energized by a conventional source of alternating current potential connected across a pair of input terminals 62. In the normal condition of the circuit 30 when the light imaging system 24 is not in use, a switch actuated in synchronism with movement of the copy sheet 16 through the station 20, such as the switch 46, closes a pair of contacts indicated as 46A to complete a circuit for charging a capacitor 64 to a more negative potential through a series connected circuit including a diode or unidirectional conducting device 66 and a resistance element 68. The more negative potential applied across the capacitor 64 reverse biases a diode 70 connected to the gate of a silicon controlled rectifier or SCR 72.

When the copying sheet 16 moves to a proper position at the exposure station 20 and the switch 46 is operated to produce the functions described above, actuation of the switch 46 opens the contacts 46A to disable the first circuit for charging the capacitor 64 to a reference level potential and closes a pair of contacts indicated at 46B to illuminate the lamp or lamps 50 providing the light source. This circuit extends through the closed contacts 46B, the filament of the lamp or lamps 50, and a pair of normally closed contacts 74A on a relay which is indicated generally as 74 and which includes an operating winding 74B and a pair of normally open contacts 74C. Thus, upon actuation of the switch 46, the lamp 50 is illuminated to render the light imaging system 24 effective.

The closure of the contacts 46B also renders a second capacitor charging or discharging circuit effective to vary the reference level potential now applied across the capacitor 64. More specifically, this circuit includes a diode or unidirectional conducting device 76, a potentiometer 78, and the light responsive means 54. Because of the opposite polarity of the diode 76, the capacitor 64 charges in an opposite direction or discharges through the potentiometer 78 and the light responsive means 54. The rate at which the potential level on the capacitor 64 changes varies in accordance with the intensity of the illumination received by the light responsive means 54. The closure of the contacts 46B also applies an energizing potential across the cathode-anode gap of the rectifier 72. The rectifier 72 cannot, however, be placed in a conductive condition because the diode 70 in the gate electrode circuit of this rectifier is reverse biased by the charge across the capacitor 64.

When a quantity of light energy sufficient to provide the density of copy desired has been reached, the reduction in the resistance of the light responsive element 54 reduces the impedance of the second charging or discharging circuit to the point at which the charge across the capacitor 64 is dropped to a point at which the diode 70 is forward biased. At this time the rectifier 72 draws a gate current and is placed in a conductive condition to energize the winding 74B of the relay 74. Energization of the winding 74B opens the contacts 74A and closes the normally open contacts 74C. The closure of the contacts 74C completes a holding circuit for the winding 74B of the relay 74 independent of the rectifier 72 and thus insures that the relay 74 remains operated regardless of the conduc-

tive or nonconductive state of the rectifier 72. The opening of the contacts 74A terminates the energization of the lamps 50 and thus renders ineffective the light source in the light imaging system 24. Accordingly, the light imaging system 24 is rendered ineffective in direct dependence on the receipt of an adequate level of illumination on the photoconductive surface of the copy sheet 16 necessary to provide the desired copy density.

As described above, the control exercised by the actuated switch 46 is overridden to render the drive for the conveying belts 36 effective and the exposed copy sheet 16 is transported from the exposure station 20 to the developing station 26. When the trailing edge of the sheet 16 passes by the switch 46, the contacts 46B are opened and the contacts 46A are closed. The opening of the contacts 46B interrupts at an additional point the energizing circuit for the lamp 50 and interrupts the holding circuit for the winding 74B of the relay 74. Thus, this relay releases to close the contacts 74A and to open the contacts 74C. The opening of the contacts 74C interrupts the holding circuit for the relay 74 at an additional point, and the closure of the contacts 74A reestablishes one point in the operating or energizing circuit for the lamp 50. The opening of the contacts 46B also interrupts the second capacitor charging or discharging circuit.

The closure of the contacts 46A reestablishes the first capacitor charging or discharging circuit so that the capacitor 64 is charged in an opposite sense or direction to a reference level of potential. As this reference level is approached, the diode 70 is again reverse biased to insure the absence of gate current for the rectifier 72. The control circuit 30 remains in this condition until the next time that a copy sheet is advanced to a proper position at the exposure station 20, at which time the reactuation of the switch 46 causes an additional cycle of operation in the manner described above.

Thus, the lamp or light source control circuit 30 is positively synchronized with the movement of the copy sheet 16 through the exposure station 20 and provides a simple, economical, and reliable circuit for providing uniform copy density by insuring uniform intensity of illumination of the photoconductive surface of the copy sheet 16 in the exposure station 20.

What is claimed and desired to be secured by Letters Patent of the United States is:

1. An apparatus for copying an original using a light imaging system comprising
 - a light source included in the imaging system,
 - a light responsive means subjected to illumination from the light source,
 - a controlled conduction device for controlling the energization of the light source, said device having a control electrode,
 - capacitive means coupled to the control electrode to control the conductivity of the device,
 - a potential source,
 - first circuit means coupling the potential source and the capacitive means for establishing a reference potential level on the capacitive means,
 - a normally incomplete second circuit means including the light responsive means for coupling the potential source and the capacitive means to change the potential level on the capacitive means to a level different from said reference level,
 - and a switching means included in the first and second circuit means for normally completing the first circuit means and operable when the light source is to be energized for interrupting the first circuit means, completing the second circuit means, and initiating the energization of the light source.
2. The apparatus set forth in claim 1 in which the first circuit means includes a unidirectional conducting device connected between the capacitive means and the potential source and poled to charge the capacitive means with a potential of a given polarity.
3. The apparatus set forth in claim 1 in which

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the second circuit means includes a unidirectional conducting device connected in series with the light responsive means and between the capacitive means and the potential source.

4. An apparatus for copying an original on copy material using an imaging system comprising
- a light source included in the imaging system,
 - a light responsive means disposed to receive illumination from the light source,
 - a potential source,
 - a control relay having an operating winding, a first pair of normally closed contacts and a second pair of normally open contacts,
 - a first circuit for coupling the light source to the potential source to illuminate the light source, said first circuit including said first pair of contacts,
 - capacitive means,
 - second and third circuit means coupled to the capacitive means for charging and discharging the capacitive means, respectively, said second circuit means coupling the capacitive means to the potential source, one of said second and third circuit means including the light responsive means,
 - a controlled conduction device coupled to the capacitive means and the winding of the control relay for controlling the operation of the control relay in accordance with the charging and discharging of the capacitive means by the second and third circuit means,
 - a fourth circuit means for connecting the winding to the potential source through the second pair of contacts,
 - and a control means operable from a normal setting to an operated setting when a copy is to be made, the control means in its operated setting controlling the completion of one and the interruption of the other of the second and third circuit means and the completion of the first circuit means, the operation of the control relay under the control of the capacitive means operating the contacts to interrupt the first circuit means and to close the fourth circuit means when a given level of light is detected by the

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light responsive means.

5. The apparatus set forth in claim 4 in which the controlled conduction device includes a controlled rectifier with a cathode-anode path connected between the potential source and the winding and a control electrode coupled to the capacitive means.
6. An apparatus for copying an original using a light imaging system comprising
- a light source included in the imaging system,
 - a light responsive means subjected to illumination from the light source,
 - a relay having a winding and contact means operable between normal and actuated states,
 - first circuit means including the contact means in their normal state for energizing the light source,
 - a controlled conduction device for controlling the energization of the relay winding, said device having a control electrode,
 - capacitive means coupled to the control electrode to control the conductivity of the device,
 - a potential source,
 - second circuit means coupling the potential source and the capacitive means for establishing a reference potential level on the capacitive means,
 - third circuit means including the light responsive means for coupling the potential source and the capacitive means to change the potential level on the capacitive means to a level different from said reference level,
 - a switching means normally completing the second circuit means and operable when the light source is to be energized for interrupting the second circuit means, completing the third circuit means, and completing said first circuit means to energize the light source,
 - and fourth circuit means including the contact means and completed by operation of the contact means to their actuated state for maintaining the energization of the relay winding independent of the controlled conduction device.

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