

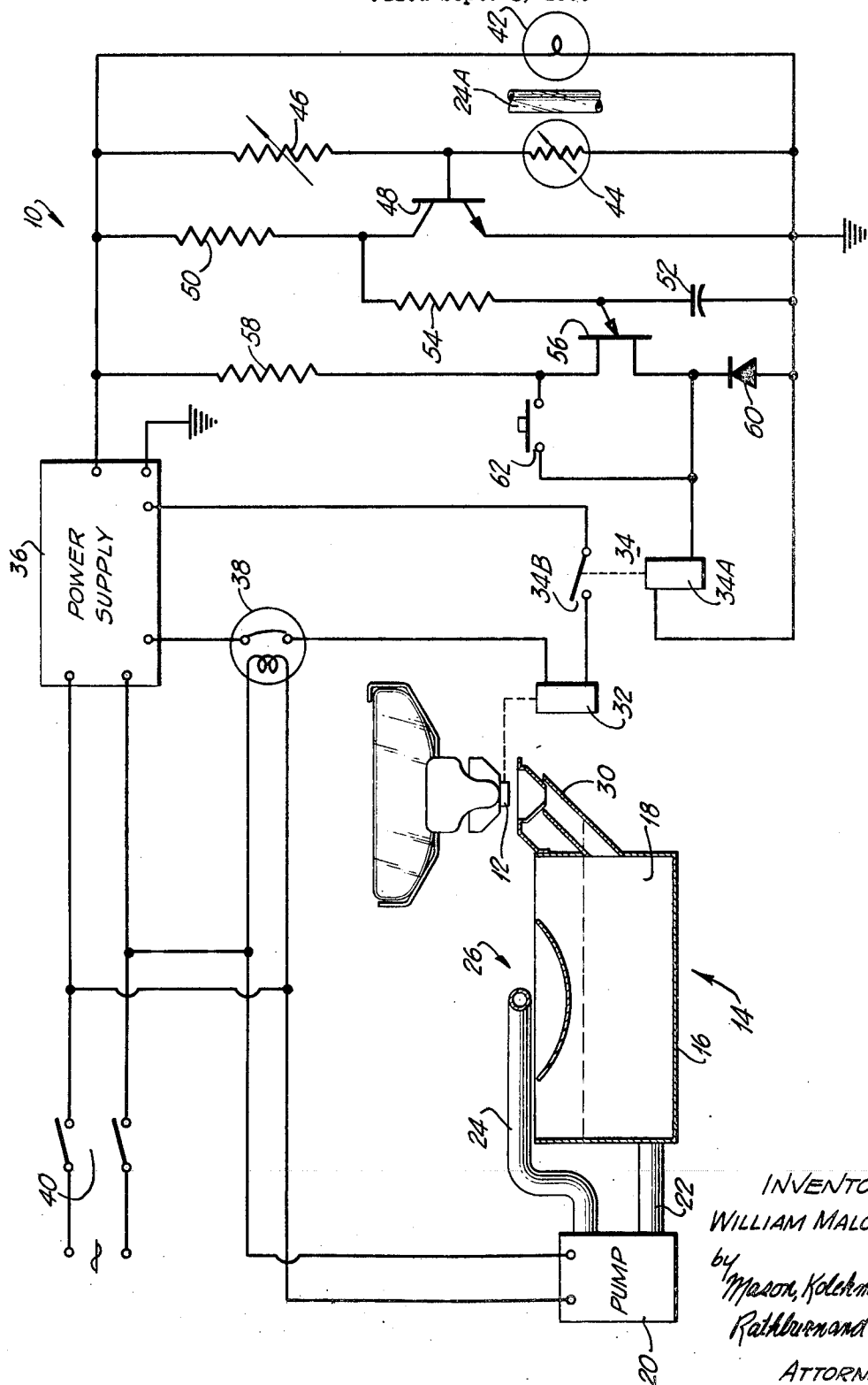
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W. MALONEY

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LIQUID PHOTOELECTROSTATIC DEVELOPER UNIT

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INVENTOR
WILLIAM MALONEY
by *Mason, Kolehmainen,
Rathburn and Wyas*
ATTORNEYS.

1

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LIQUID PHOTOELECTROSTATIC DEVELOPER UNIT

William Maloney, Lake Forest, Ill., assignor to Addressograph-Multigraph Corporation, Mount Prospect, Ill., a corporation of Illinois

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ABSTRACT OF THE DISCLOSURE

A toner level control for a liquid photoelectrostatic developer unit includes a lamp and a photocell disposed opposite a light transmitting portion of a pump conduit coupled to a developer tank. Changes in the toner level control the photocell to actuate a pulse generator which periodically operates a toner dispenser to repeatedly add measured increments of toner to the developer liquid until the proper toner level is reached. A time delay circuit prevents operation of the toner dispenser until the pump has been operating for a period of time.

This invention relates to a liquid developer unit for photoelectrostatic copying machines and, more particularly, to such a unit including means for automatically maintaining the liquid developer at a desired composition.

Photoelectrostatic copiers using liquid developer units are generally of the type in which the developer liquid is pumped from a reservoir to an applicator structure, such as a tank having sheet or web guiding means, in which the developer liquid is placed in contact with the surface of the web or sheet material bearing a latent electrostatic image to be developed. The liquid generally comprises a liquid carrier containing electroscopic developer or toner powder that is deposited on the sheet or web material in accordance with the charge image. These developer units frequently include agitating means to insure uniform developer liquid composition or uniform distribution of the powder or toner in the liquid carrier.

Because of the removal of the developer powder by the sheet or web material, it is necessary to replace or replenish the developer powder from time to time depending on the extent of use of the copier and other factors. The amount of powder in the developer liquid can be maintained at the desired level by periodically adding either the developer powder or a developer concentrate including a rich mixture of powder and liquid carrier. The developer liquid can also be maintained at the desired composition by periodically changing the supply of developer liquid. These arrangements are not satisfactory because of the expense of replacing the developer liquid, the time required, and the danger that a low powder or toner level frequently cannot be observed before copy quality starts to deteriorate. Arrangements have been made to provide means for automatically adding developer liquid or concentrate at periodic intervals or on demand, but these arrangements frequently are not capable of adding carefully controlled quantities or are such that the added liquid is not of uniform consistency. One improved arrangement for dispensing toner or developer concentrate is shown and described in detail in the contemporaneously filed application of Robert F. Zawiski, Ser. No. 576,613, which application is assigned to the same assignee as the present invention.

Although this application provides means for metering controlled quantities of developer concentrate of

2

uniform consistency, it is necessary to provide means for adequately measuring the ratio of powder or toner to carrier or the quantity of toner available in the carrier for deposition on the sheets to be developed. In addition, the arrangement for measuring toner concentration must be such as to avoid a spurious reading resulting from measuring improperly mixed developer liquid or developer liquid from which the toner has been permitted to settle out due to inactivity of the copying apparatus.

Accordingly, one object of the present invention is to provide a new and improved liquid developer unit.

Another object is to provide a liquid developer unit including new and improved means for measuring or detecting the quantity of developer material or powder in a liquid developer.

Another object is to provide means for automatically adding developer material to a developer liquid in accordance with the amount of developer material in the developer liquid.

A further object is to provide an arrangement for measuring the amount of developer material in the developer liquid that avoids spurious readings resulting from inadequate mixing of the developer liquid or settling of the developer material from the liquid carrier.

In accordance with these and many other objects, an embodiment of the invention comprises a liquid developer unit including a developer applicator structure for receiving material to be developed, a reservoir containing a quantity of developer liquid, and a pumping means for circulating the developer liquid between the reservoir and the applicator structure and for also circulating the developer liquid to insure consistency of the mixture or a uniform composition thereof. A developer concentrate dispensing assembly is also provided for adding controlled quantities of liquid developer rich in developer material to the developer liquid in the unit to replace the developer material lost in the image developing process.

The developer concentrate dispensing assembly is actuated by an electric solenoid which, in accordance with the present invention, is connected to a first control or bistable circuit which when placed in operation alternately operates and releases the solenoid. Each cyclic operation and release of the solenoid dispenses a predetermined amount of developer concentrate into a reservoir of liquid developer.

To provide means for controlling the operability of the bistable circuit for operating the solenoid and dispensing assembly, a further control circuit or assembly is provided including an electric lamp or illuminating source and a light responsive means or photocell. These two elements are spaced apart from each other to permit a portion of the developer liquid to be disposed therebetween. These two elements thus can be immersed in the reservoir or can be disposed adjacent a light transmitting portion of a fluid conveying means in the liquid developer unit, for example, a discharge line from the pump. The developer material or toner powder is substantially opaque and thus the concentration of developer material changes the light reflecting and transmitting characteristic of the developer liquid so that the light responsive means provides an output signal varying in accordance with variations in the concentration of the developer material in the developer liquid.

The light responsive means is connected to a switching means, such as a transistor, which selectively controls the application of potential to the circuit for periodically operating the dispensing solenoid. Therefore, when the level of developer material in the developer liquid falls below

a desired level, the change in the illumination of the light responsive means renders the bistable circuit effective to intermittently operate and release the solenoid in the concentrate dispensing assembly. This assembly adds increments of developer material or concentrate to the reservoir until the desired ratio of developer material to carrier liquid is reached. At this time, the light responsive means renders the control circuit for the solenoid ineffective.

The pumping means in the liquid developer unit not only serves to convey the developer liquid to the point of application to the sheet or web material but also serves to agitate the developer liquid in the developer unit to maintain uniform consistency. This pumping means is operated only during the intervals at which the copying machine is in use. Thus, during periods of inactivity, the developer material tends to settle out of the carrier liquid. Accordingly, there is a tendency for the detecting unit including the light responsive means to indicate the need for developer material when the machine is first placed in operation and before the pumping means has operated a sufficient time to obtain a uniform dispersion of developer material in the carrier liquid. Accordingly, the control circuit of the present invention includes means, such as a time delay means, for inhibiting the operation of the dispensing unit until the developer liquid has been sufficiently agitated by the pumping means to attain readings accurately reflecting the ratio of developer material to the carrier liquid.

Many other objects and advantages of the present invention will become apparent from considering the following detailed description in conjunction with the drawing which comprises a schematic illustration of a liquid developer shown in conjunction with a schematic circuit diagram of a control means therefor embodying the present invention.

Referring now more specifically to the drawing, therein is illustrated a control circuit 10 for automatically monitoring the amount of developer material in a developer liquid and for controlling the automatic addition of developer material by a dispensing assembly 12 to a liquid developer indicated generally as 14. The control circuit 10 accurately measures the ratio of developer material to the carrier liquid or the quantity of developer material available for deposition on the copies to be reproduced and controls the dispensing assembly 12 to supply only the quantity of developer material to the developer unit 14 that is required to provide copies that are neither undertoned nor overtoned.

Although the construction of the liquid developer unit 14 can be of any of the well-known constructions, it preferably comprises a liquid developer unit of the type shown in the above-identified application of Robert F. Zawiski. In general, this developer unit includes a tank or reservoir 16 adapted to contain a body of developer liquid 18. The reservoir 16 is placed in communication with an inlet to a pumping means or pump 20 through an inlet line 22, and an outlet line 24 from the pump 20 is connected to an applicator structure indicated generally as 26 which includes sheet or web guiding means and means for distributing developer liquid over the surface of the sheet or web material bearing a latent electrostatic image to be developed. When the pump 20 is placed in operation, developer liquid from the reservoir 16 is drawn through the inlet line 22 and is discharged through the outlet line 24 to be applied to the sheet material by the applicator structure 26, the surplus of the liquid falling back into the reservoir 16. This circulation of the developer liquid 18 thoroughly mixes and agitates the fluid so that it is of uniform consistency in which the developer material or toner is thoroughly dispersed in the carrier liquid.

The automatic dispensing or metering assembly 12 is provided for adding toner or developer material to the developer liquid 18 in the reservoir 16 to replace the toner removed from the developer liquid during the de-

veloping operation. This assembly 12 can comprise any suitable construction, but preferably comprises the construction shown and described in detail in the contemporaneously filed application of Robert F. Zawiski, identified above. In general, the dispensing assembly 12 includes a bottle or receptacle containing a quantity of developer concentrate in which the ratio of developer material or toner to the liquid carrier is relatively high. This supply receptacle, which is continuously oscillated during the operation of the machine to maintain uniform dispersion of the toner and the carrier, is mounted at an elevation above the reservoir on tank 16 and includes a metering assembly for discharging a known quantity of the concentrate through a conveying means 30 to the body of the developer liquid 18 in the reservoir 16. In one assembly 12 constructed in accordance with the invention disclosed and claimed in the Zawiski application, each actuation of the metering assembly discharges one milliliter of developer concentrate to the reservoir 16. This metering assembly in the assembly 12 is actuated by a solenoid 32.

The metering or dispensing assembly 12 discharges the fixed quantity of toner concentrate through the conveying means 30 to the reservoir 16 each time that the solenoid 32 is energized and released, as described in detail in the above-identified Zawiski application. The energization of the solenoid 32 is controlled by a relay 34 having a winding 34A and a pair of normally open contacts 34B. When the relay 34 is operated to close the contacts 34B, the winding of the solenoid 32 is connected across one input of a power supply circuit 36 in series with a time delay device 38. The time delay device 38 provides a control for insuring that the dispensing assembly 12 cannot be operated when the liquid developer unit is started until the developer liquid 18 has been thoroughly mixed and agitated to provide a representative sample for evaluation by the control circuit 10.

More specifically, when the copying machine of which the liquid developer unit 14 forms a part is placed in operation, suitable control means, such as a normally open switch 40, is closed to energize the power supply circuit 36 and to start operation of the pump 20. The operation of the pump circulates the developer liquid 18 through the unit 14 and agitates and mixes the developer liquid 18 so that it attains uniform consistency. When the switch 40 is closed, a filament in the delay device 38 is energized to initiate the timing period of the device 38. After a suitable delay, such as ninety seconds the solenoid 32 can be operated and released under the control of the relay 34.

The control circuit 10 includes means for alternately operating and releasing the relay 34 so long as the developer liquid 18 contains an insufficient quantity of toner or developer material. The circuit 10 exercises this control by examining the light transmitting or reflecting characteristic of a representative sample of the developer liquid 18. To accomplish this, the control circuit 10 includes a light source or illuminating lamp 42 which is energized by the power supply circuit 36 and a light sensitive means or photosensitive cell 44 which are mounted in the developer unit 14 spaced from each other so that the light from the source 36 impinges on the light responsive means 44 by transmission through or reflection from the developer liquid 18. In one construction, the elements 42 and 44 are immersed in the body of developer liquid 18 in the tank 16. In another embodiment, the elements 42 and 44 are disposed in proximity to a transparent or light transmitting portion or section 24A of the outlet line 24 through which developer fluid is discharged from the pump 20 to the applicator structure 26. Since the light reflecting and transmitting characteristics of the developer liquid 18 vary in dependence on the quantity of toner or developer powder in the liquid carrier, the incident light striking the light responsive means 44 varies

5

in accordance therewith. The light responsive means 44 can be such that the resistance of this element decreases with increasing illumination.

The light responsive element 44 is connected in series with a variable resistance element 46 across the output of the power supply circuit 36 to provide a voltage divider connected to the base of a transistor 48, the collector of which is connected to the power supply circuit 36 through a resistance element 50. The emitter electrode of the transistor 48 is returned to a reference potential, and the collector electrode is also coupled to a timing capacitor 52 through a series connected resistance element 54. The point of common connection of the capacitor 52 and resistance element 54 is connected to the emitter of a unijunction transistor 56. The power supply circuit 36 is of a conventional design and provides a well regulated constant voltage output to avoid the introduction of erroneous readings resulting from voltage fluctuations.

The value of the variable resistance 46 is so adjusted that when the light responsive means 44 receives a quantity of illumination corresponding to a correct level of toner material in the developer liquid, the bias applied to the base of the transistor 48 by the network including the elements 44 and 46 maintains the transistor 48 in a conductive condition. By adjusting the value of the resistance 46, the control circuit 10 can be adjusted for operation with developer liquids having different ratios of developer material to carrier liquid.

The transistor 48 provides, in function, a switch for controlling the effectiveness of a unijunction relaxation oscillator including the unijunction transistor 56. One base of the transistor 56 is connected to the power supply circuit 36 through a resistance element 58, and the other base of the transistor 56 is connected to a source of reference potential through the winding 34A of the relay 34, the winding being shunted by an oppositely poled diode 60 to provide transient suppression. In the normal condition of the control circuit 10, the transistor 56 is in a nonconductive condition.

However, when the level of toner or developer material in the developer liquid 18 drops below a given level, the light responsive means 44 receives greater illumination so that the effective resistance of this element drops. This reduces the positive bias applied to the base of the transistor 48 so that this transistor is placed in a nonconductive condition. The capacitor 52 then charges in series with the resistance elements 50 and 54 until the point is reached at which a sufficiently positive bias is applied to the connected base of the unijunction transistor 56. At this time, the unijunction transistor 56 is placed in a conductive condition to energize the winding 34A of the relay 34 so that the contacts 34B are closed. If the delay interval of the timing device 38 has been completed, the solenoid 32 is energized.

When the unijunction transistor 56 is placed in a conductive condition, the very low impedance of the emitter-lower base path permits the capacitor 52 to discharge through the winding 34A so that the bias applied to the emitter of the transistor 56 is reduced. When this bias is reduced to a given level, the unijunction transistor 56 is placed in a nonconductive condition to terminate the energization of the winding 34A of the relay so that this relay releases to open the contacts 34B and thus release the solenoid 32. The operation and release of the solenoid 32 discharges a predetermined quantity of developer concentrate into the body of developer liquid 18 contained in the reservoir or tank 16 and thus terminates the first dispensing operation.

The termination of conduction through the transistor 56 also permits the capacitor 52 to again be charged over the series circuit including the resistance elements 50 and 54. When the capacitor 52 is again charged to the point at which the emitter is biased sufficiently positive, the transistor 56 is placed in operation to again

6

operate the solenoid and to discharge the capacitor 52. This periodic operation and release of the solenoid 32 under the control of the relay 34 and the transistor 56 continues so long as the transistor 48 is maintained in a nonconductive condition. The value of the resistance element 54 can be varied to adjust the time interval between successive operations of the solenoid 32.

When the level of toner material in the developer liquid 18 reaches the desired level, the illumination of the cell 44 is reduced, and the voltage dividing network including the elements 44 and 46 again biases the base of the transistor 48 sufficiently positive with respect to its emitter so that this transistor is placed in a conductive condition. When the transistor 48 is placed in a conductive condition, a low impedance shunt is provided across the network including the capacitor 52 and resistance element 54 and further charging of this capacitor and operation of the relaxation oscillator including the transistor 56 is terminated. In this manner, the quantity of toner or ratio of toner to carrier liquid in the developer unit 14 directly and automatically controls the dispensing of developer material. A switch 62 provides manually operated means for controlling the operation and release of the relay 34 and the solenoid 32.

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

1. In a liquid developer unit of the type in which photoelectrostatic copy material is contacted with a developer liquid containing particulate developer material,

a detecting means for examining the developer liquid and providing an output signal varying in dependence on the composition of the developer liquid,

a dispensing unit for dispensing developer material to the liquid developer unit and operable to dispense a predetermined amount of developer material in response to each operation of the dispensing unit, and

a control circuit connected between the dispensing unit and the detecting means and controlled by the output signal, said control circuit including means for repetitively operating the dispensing unit at fixed time intervals to automatically add a series of said predetermined amounts of developer material to the liquid developer unit for so long as the composition of the developer liquid is not at a predetermined level, the control circuit being placed in operation when the composition of the developer liquid changes and remaining continuously operative to provide repetitive operation of the dispensing unit at said fixed time intervals until the developer liquid returns to the predetermined level.

2. The liquid developer unit set forth in claim 1 in which

the control circuit includes a time delay means for inhibiting operation of the dispensing unit under the control of the output signal for a predetermined time interval.

3. The liquid developer unit set forth in claim 1 in which

the control circuit includes means for adjusting the fixed time interval between operations of the dispensing means.

4. In a liquid developer unit of the type in which photoelectrostatic copy material is contacted with a developer liquid containing particulate developer material, a light source,

a light responsive means spaced from the light source to permit a portion of the developer liquid to be disposed therebetween, the light responsive means receiving a varying amount of light from the light source in dependence on the composition of the developer liquid and providing a corresponding output,

7

a developer dispensing unit for dispensing developer material to the liquid developer unit,
 a control circuit connected between the developer dispensing unit and the light responsive means and controlled by the output of the light responsive means for operating the developer dispensing unit to automatically add developer material to the liquid developer unit whenever the composition of the developer liquid changes from a predetermined level, pumping means for circulating the developer liquid in the developer unit,
 means for starting operation of the pumping means, and
 means for preventing operation of the dispensing unit for a period of time following the starting of the pumping means and for thereafter automatically rendering the dispensing unit responsive to control by the light responsive means.

5. In a liquid developer unit of the type in which an electrostatic image is developed by contact with the developer liquid containing particulate developer material, the light transmitting characteristic of the developer liquid varying as the quantity of developer material changes,
 a light source for illuminating the developer liquid, light responsive means receiving light from the developer liquid resulting from illumination of the developer liquid by the light source, the quantity of light varying in accordance with the developer material in the developer liquid,
 a developer dispensing unit for dispensing a predetermined quantity of developer material to the liquid developer unit in response to each operation of the dispensing unit,
 a first control means connected to the dispensing unit for repetitively operating the dispensing unit at fixed time intervals to supply a series of increments of said predetermined quantity of developer material to the liquid developer unit, and
 a second control means connected to the first control means and the light responsive means for placing the first control means in and out of operation in dependence on the light received from the developer liquid.

6. In a liquid developer unit of the type in which an electrostatic image is developed by contact with a developer liquid containing particulate developer material, the light transmitting characteristic of the developer liquid varying as the quantity of developer material changes,
 a light source for illuminating the developer liquid, light responsive means receiving light from the developer liquid resulting from illumination of the developer liquid by the light source, the quantity of

8

light varying in accordance with the developer material in the developer liquid,
 a developer dispensing unit for dispensing developer material to the liquid developer unit,
 a first control circuit connected to the dispensing unit and operable when rendered effective to intermittently operate the dispensing unit to supply developer material to the liquid developer unit and operable when rendered ineffective to inhibit operation of the dispensing unit, and
 a second control circuit connected to the first control circuit and including the light responsive means for rendering the first control circuit effective and ineffective to operate the dispensing unit in dependence on the light received by the light responsive means from the developer liquid.

7. The liquid developer unit set forth in claim 6 including
 means for starting operation of the liquid developer unit, and
 delay means for preventing operation of the dispensing unit by the first control circuit for a predetermined period of time following the starting of the liquid developer unit.

8. The liquid developer unit set forth in claim 6 in which
 the first control circuit includes a controlled conduction device alternately operable to conductive and nonconductive states under the control of a capacitive means.

9. The liquid developer unit set forth in claim 8 including
 a potential source, and in which
 the second control circuit includes means controlled by the light responsive means for controlling the connection of the potential source to the capacitive means.

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