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Kishi et al.

[11] **3,712,203**

[45] **Jan. 23, 1973**

[54] **AUTOMATIC CONTROL DEVICE FOR THE TONER CONCENTRATION WITHIN A DEVELOPER IN AN ELECTROSTATIC COPY MACHINE**

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[30] **Foreign Application Priority Data**

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Nov. 15, 1969 Japan 44/91171

[52] **U.S. Cl.** ..... **95/89 R,** 117/37 LE, 118/7, 118/637, 137/93, 355/10, 250/218

[51] **Int. Cl.** **G03d 3/00**

[58] **Field of Search** ..... 355/10; 95/89; 118/637, 7, 118/8, 9; 250/218; 117/37 L; 137/91, 92, 93

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Assistant Examiner—Richard M. Sheer
Attorney—Robert E. Burns and Emmanuel J. Lobato

[57] **ABSTRACT**

In a successive development of the images on an electrostatic copy machine, toner concentration within the developer is continuously detected in an optical manner and the supply of the toner to the developer is automatically controlled in accordance with thusly detected time sequential deviation in the toner concentration so as to compensate for the deviation, thereby the toner concentration can be maintained constant even when the copying operation is repeated many times in succession.

10 Claims, 13 Drawing Figures

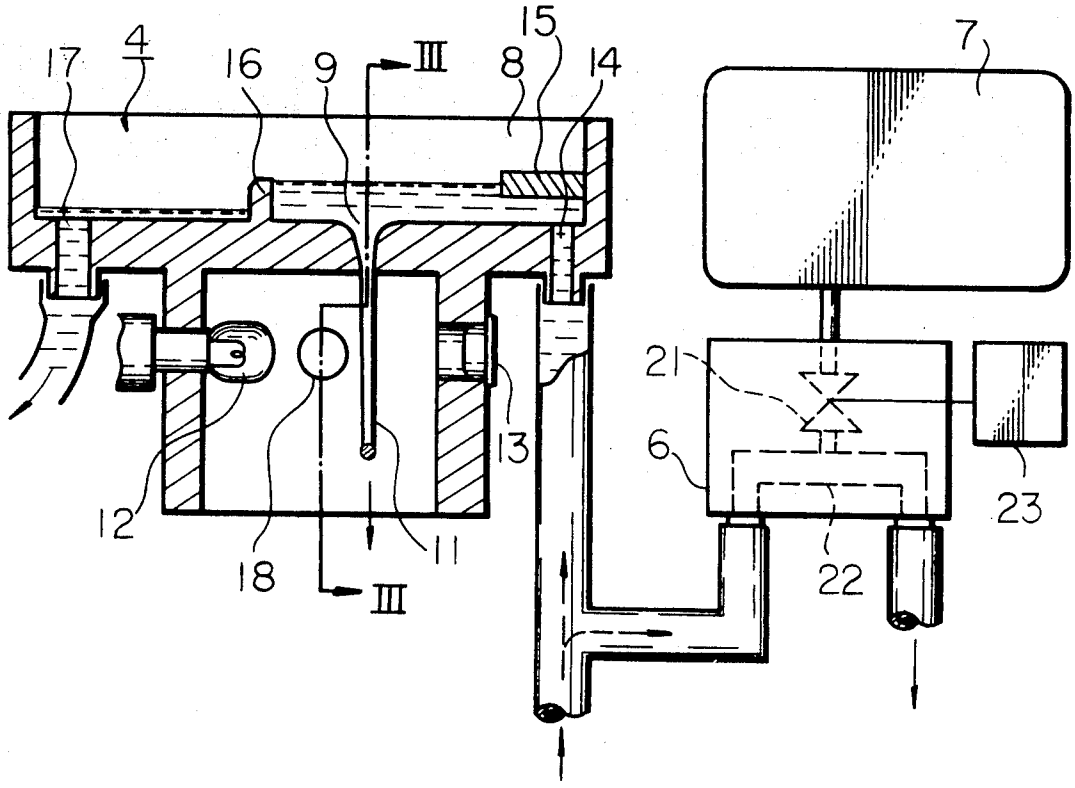


Fig. 1

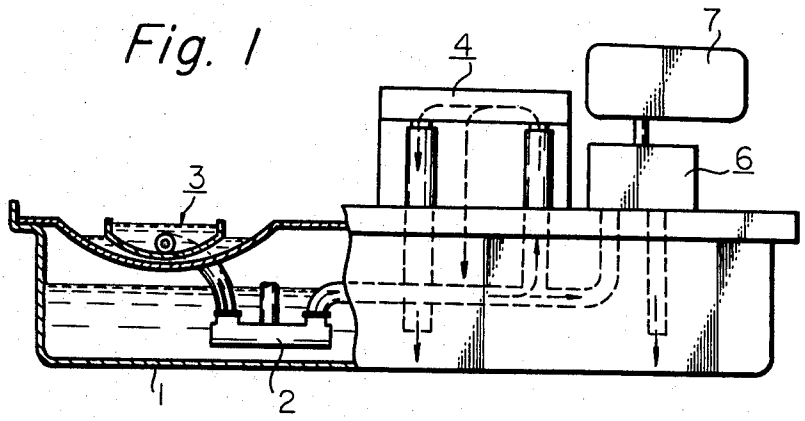


Fig. 2

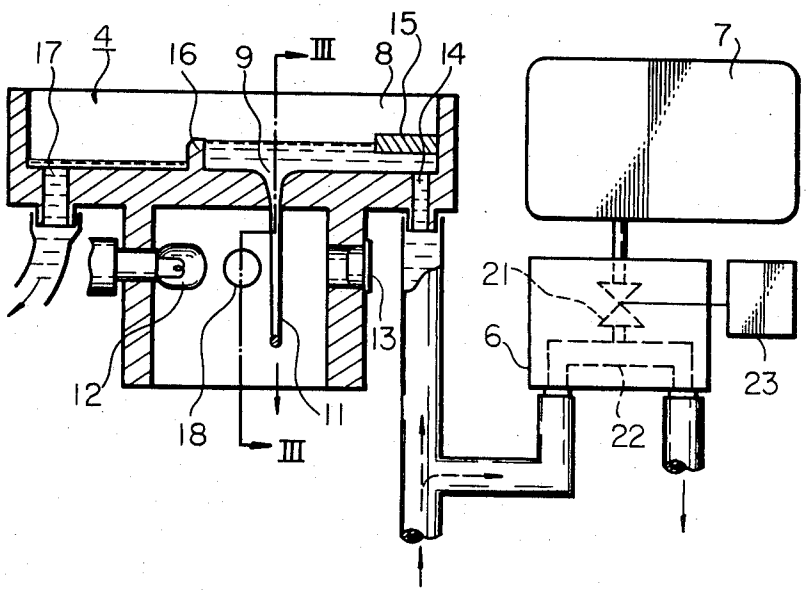


Fig. 3

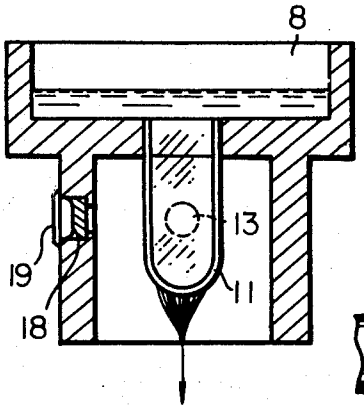


Fig. 4

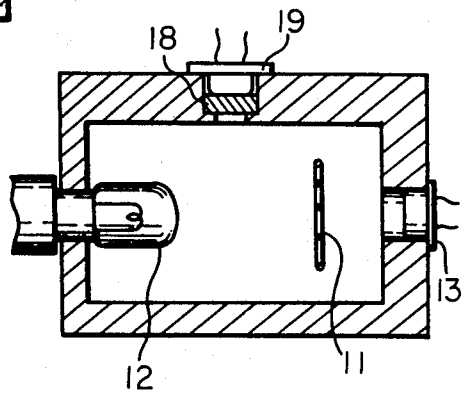


Fig. 5

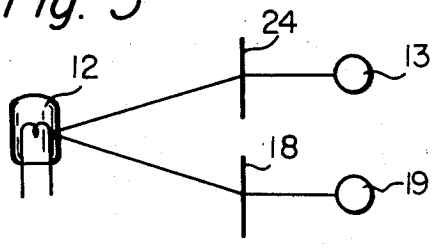


Fig. 6A

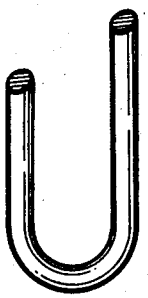


Fig. 6B

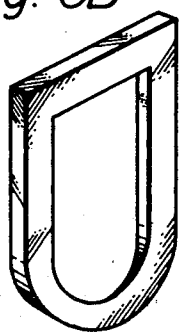


Fig. 7

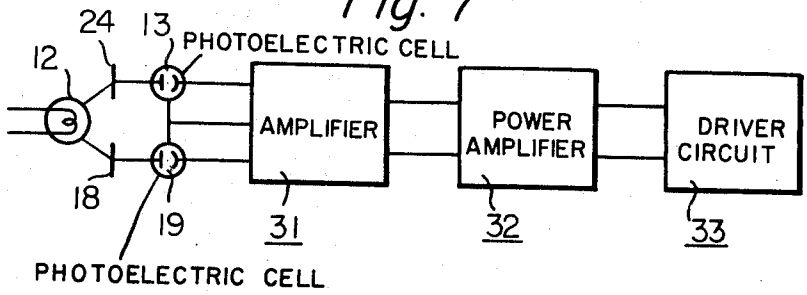


Fig. 8A

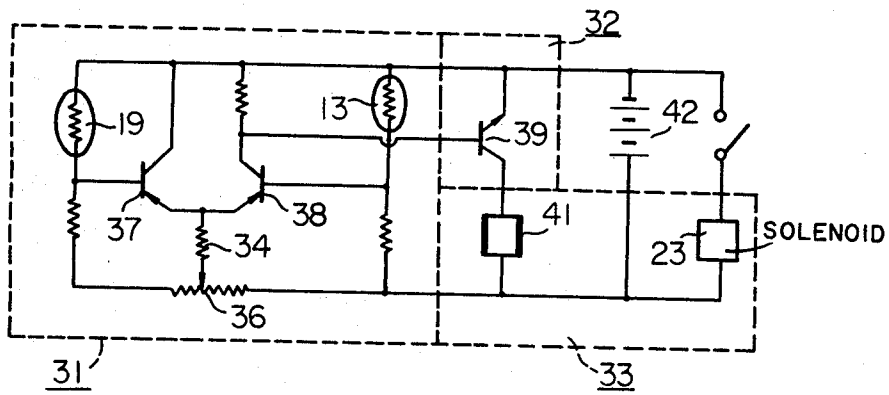
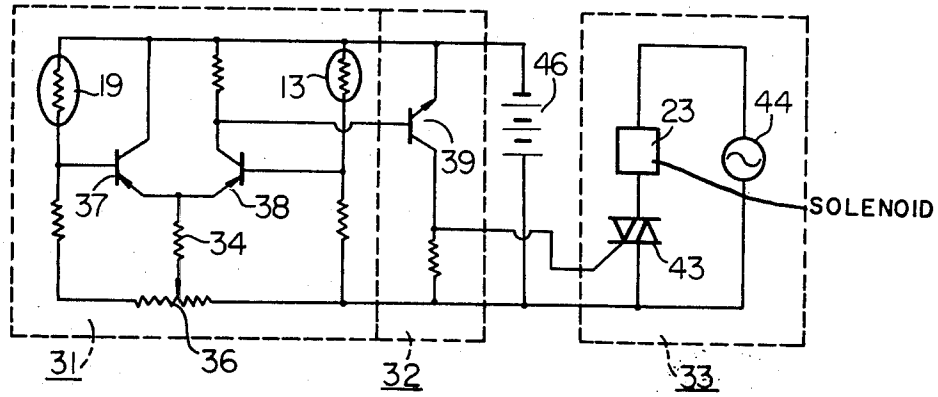


Fig. 8B



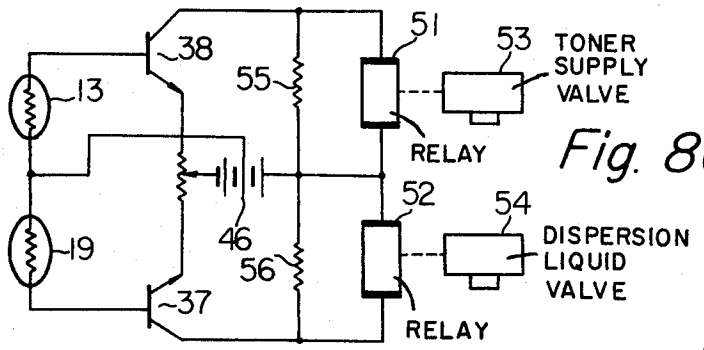


Fig. 8C

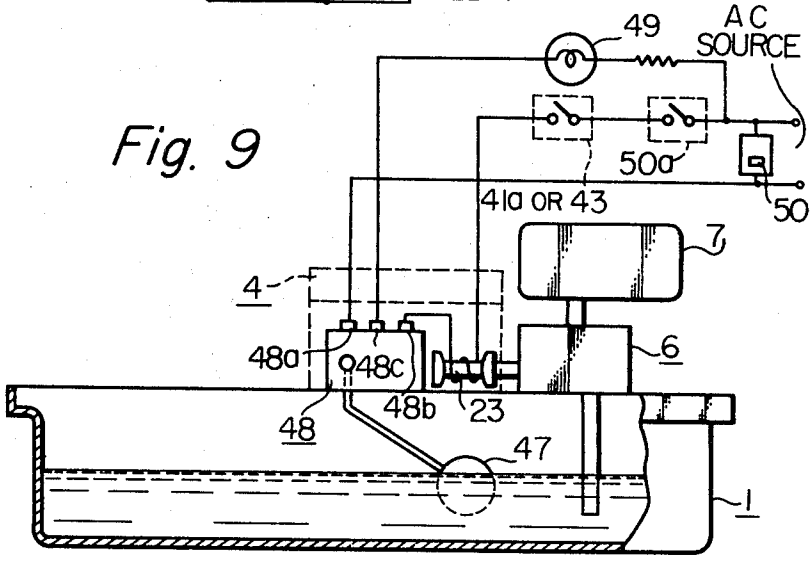


Fig. 9

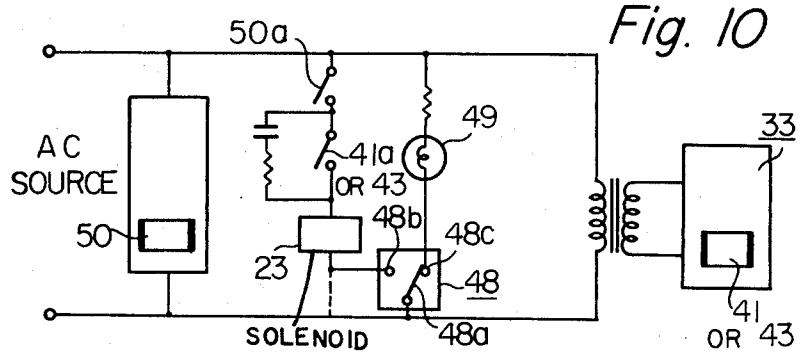


Fig. 10

AUTOMATIC CONTROL DEVICE FOR THE TONER CONCENTRATION WITHIN A DEVELOPER IN AN ELECTROSTATIC COPY MACHINE

The present invention relates to an automatic control device of the toner concentration within a developer on an electrostatic copy machine, more particularly relates to an automatic device for controlling the supply rate of the toner to the developer in accordance with the time sequential deviation of the relevant toner concentration within the developer from the preset command.

In order to repeat the copying operation many times in succession on a wet type electrostatic copy machine with uniform tone of images developed on the given photosensitive surfaces, it is necessary that the content ratio of the toner within the developer (hereinafter referred to as the toner concentration) should be maintained constant throughout the operation. Conventionally, this control work was performed through manual operation, wherein a certain quantity of toner was supplied to the developer basing upon the judgement by the operator. Because this compensation work was based upon the manual work and the judgement by the operator, it was actually difficult to maintain the toner concentration always exactly constant. Therefore, it was almost impossible to obtain images of uniformly clear tone on a plurality of photosensitive surfaces supplied in succession to the copy machine. Further, it was relatively troublesome work to manually control the quantity of the toner to be supplied to the developer throughout the copying operation, especially when the copying operation has to be repeated many times.

There is another method of maintaining the toner concentration constant, wherein a prescribed quantity of toner is added to the developer at selected cycle or cycles of the copying operation regardless of actual toner concentration of the relevant developer. This method is also accompanied with drawbacks the same with that above described.

In order to obviate the drawbacks encountered in the manual control of the toner concentration within the developer, there is proposed an automatic method of controlling the supplying rate of toner to the developer through detection of the actual toner concentration in the developer and the detection of the toner concentration is performed through a continuous optical measurement of the toner concentration of developer. Generally in this optical measurement, the developer is contained within a bath having a transparent window, the window is subjected to a light of a constant intensity emerging from a given luminous source and the change in the intensity of the light after permeating through the developer is measured, thereby the corresponding toner concentration within the measured developer being known. In the case of this method, since the material forming the transparent window is always in a direct contact with the developer in the bath and is contaminated considerably during a long time use thereof. Contamination of the window causes reduction in the intensity of the light permeated through the developer and the detected intensity of the light does not correspond to the actual toner concentration within that developer.

One of the solutions to this window contamination trouble is a provision of a wiper or wipers to the transparent window for the permeation of the light. In this connection, however, provision of such an additional mechanical part causes increase in the installation cost of the measuring arrangement. Further, great difficulty resides in the perfect sealing of the connection between the wiper mechanism and the driving source of the mechanism. Removal of the contamination is effective only within the area over which the wiper mechanism operates and a direct contact of the wiper with the window tends to accidentally damage the window material.

Another solution to this window contamination trouble is the use of resonator plate or plates for the part to be kept free from contamination. This solution may be substituted by the provision of supersonic vibration to the parts to be kept free from contamination. In these cases, the vibrating parts must be composed of a light permeable member such as made of crystal material and provision of suitable mechanism for effectuating such vibration is inevitably required, also, resulting in the complicated construction of the entire arrangement and increase in the cost thereof.

A principal object of the present invention is to provide an automatic control device of the toner concentration within a developer on an electrostatic copy machine, thereby the toner concentration within the developer being successfully maintained constant during a long time repeated copying operation.

Another object of the present invention is to provide a device for performing the automatic control of the toner concentration of the developer in an exact and stable manner without any time lag and direct contact of the detecting arrangement with the developer.

Still another object of the present invention is to provide a device for developing uniformly clear images on a plurality of photosensitive surfaces supplied in succession.

In order to attain the above-recited objects, in the device of the present invention, a filmy flow of the developer is temporarily formed in the circulation path of the developer through the developer bath and the image developing part of the copy machine and intensity of the light permeating across through the filmy flow is photoelectrically detected, the intensity of the light being dependent upon the toner concentration of the relevant developer. Supply of the toner to the developer is automatically controlled in its rate in accordance with the detected toner concentration within the developer, thereby time sequential deviation of the toner concentration within the developer being compensated.

Further features and advantages of the present invention will be more apparent from the ensuing description, reference being made to the accompanying drawings, wherein;

FIG. 1 is a partly-sectional side view of an embodiment of the automatic control device of the present invention,

FIG. 2 is a partly-sectional enlarged fragmentary view of the automatic control device shown in FIG. 1,

FIG. 3 is a section taken along the line III—III in the device shown in FIG. 2,

FIG. 4 is a plan-sectional view of the toner concentration detecting part of the device shown in FIG. 2,

FIG. 5 is a diagrammatic representation of the optical detecting mechanism used in the device shown in FIG. 2,

FIG. 6A is a fragmentary perspective view of an embodiment of the guide for the filmy flow formation,

FIG. 6B is a fragmentary perspective view of another embodiment of the guide for the filmy flow formation,

FIG. 7 is a diagrammatic representation of the electric circuit used in the device of the present invention,

FIGS. 8A, 8B and 8C are circuit diagrams of actual examples of the electric circuit shown in FIG. 7,

FIG. 9 is another example of an embodiment of the automatic control device of the present invention,

FIG. 10 is a circuit diagram used in the automatic control device shown in FIG. 9.

Referring to FIG. 1, there is shown an entire arrangement of an embodiment of the automatic control device of the present invention. In the shown arrangement, a developer bath 1 is internally provided with a circulation pump 2 for compulsorily circulating the developer. Being connected to this developer bath 1, an image developing part 3 is provided above the developer bath 1. The developer bath 1 is also connected to a bath toner concentration detector part 4 and a toner supply mechanism 6 for supplying prescribed amounts of toner from a toner supply source 7 to the developer when required. By the compulsory circulating effect by the circulation pump 2, the developer within the developer bath 1 is supplied to the image developing part 3, the toner concentration detector part 4 and the toner supply mechanism 6.

The detailed arrangement of the toner concentration detector part 4 is shown in FIG. 2, wherein an overflow tank 8 is internally provided with a dam wall 16 dividing the overflow tank 8 into two parts of different developer levels. The first part of the overflow tank 8 of higher developer level is provided with a developer inlet 14 connected to the toner supply mechanism 6 whereas the second part of the overflow tank 8 of lower developer level is provided with an overflown developer outlet 17. A horizontal member 15 is projected from an inside wall of the overflow tank 8 at an upper position facing the developer inlet 14 so that gushing of liquid from the inlet 14 into the overflow tank 8 is quelled. At the bottom of the first part of the overflow tank 8, which is provided with a developer outlet 9 which, as seen in FIGS. 2 and 3 is a narrow elongated slit having downwardly converging opposite side walls. The developer flowing through the slit 9 falls downwardly in the form of a thin unconfined sheet or film between opposite vertical legs of a U-shaped guide 11 formed integrally with the tank. At a disposition spacedly sandwiching thusly formed thin developer filmy flow, a light source 12 is stationarily located in a face to face relationship to a photoelectric cell 13 located stationarily, also. At a position aside from the developer filmy flow formation, another photoelectric cell 19 and a filter 18 are stationarily provided, which filter 18 has a light permeability the same with that possessed by a developer of a standard toner concentration (see FIG. 3). Now, referring back to the illustration shown in FIG. 2 again, the toner supply mechanism 6 is internally provided with a circulation pipe 22 connected to the developer inlet 14 of the overflow tank 8 and a supply valve 21 for governing the supply of the toner from the toner supply source 7 into the developer flowing through the circulation pipe 22. The supply valve 21 is connected to a solenoid 23 controlled by the toner concentration detector part 4 via suitable intermediate equipment hereinafter explained in detail.

In the above-described construction of the automatic control device of the present invention, the developer is introduced into the first part of higher developer level of the overflow tank 8 passing through the developer inlet 14 due to the compulsory circulation pump 2 and thusly introduced developer falls down through the developer outlet 9 due to its own weight. At this moment, owing to the presence of the guide 11, the developer falls in the form of a thin filmy flow whereas remainder of the developer flowing over the dam wall 16 is discharged out of the overflow tank 8 through the overflow developer outlet 17. In this filmy flow formation mechanism, the overflow tank 8 functions so as to provide the filmy flow with constantly uniform thickness, thereby the light permeability of the developer filmy flow is not affected to an appreciable extent by the time sequential deviation in the thickness thereof.

The locational relationship between the light source 12, the photoelectric cell 13, the other photoelectric cell 19, the filter 18 and the guide for filmy flow formation 11 will be better understood from the illustration shown in FIG. 4, wherein the light emitted form the common light source 12 is sensed by both photoelectric cells 13 and 19, the latter being through the filter 18. The difference in the intensities of the light thusly sensed is utilized for detecting the toner concentration of the corresponding developer.

The above-described optical detecting mechanism of the toner concentration within the developer is diagrammatically shown in FIG. 5 in a simplified illustration. A part of the light emitted from the common light source 12 is sensed by the photoelectric cell 13 via the formed developer filmy flow 24 whereas another part of the light is sensed by the other photoelectric cell 19 via the filter 18 which, as mentioned above, has the light permeability the same with that possessed by the developer of the standard toner concentration. In reference to the difference in the intensities of the light thusly sensed, the opening magnitude of the toner supply valve 21 (see FIG. 2) is controlled so as to maintain the toner concentration within the developer constant in an automatic manner via electric arrangement hereinafter explained.

The guide 11 used for the filmy flow formation can be given in the form of a downwardly U-shaped wire such as shown in FIG. 6A or a thin plate such as shown in FIG. 6B. In the case of the latter, the plate is provided with a suitably dimensioned central aperture for the passing of the light emitted from the light source.

A principal arrangement of the electric circuit advantageously usable in the device of the present invention is shown in FIG. 7, wherein the photoelectric cells 13 and 19 are connected to a differential amplifier circuit 31. Only when a difference in the magnitude of the light received is produced between the two photoelectric cells 13 and 19, the differential amplifier circuit 31 generates a corresponding output signal, which is brought into a driver circuit 33 via a power amplifier circuit 32. Upon reception of thusly amplified signals,

the driver circuit 33 produces operational signals so as to open the toner supply valve 21 (see FIG. 2) and the toner is supplied, due to its own weight, from the toner supply source 7 to the developer within the circulation pipe 22.

As is self-obvious from the foregoing description, the difference in the magnitude of the light received by the photoelectric cells 13 and 19 is caused by dilution of the actual toner concentration. So, with advancement of the new toner supply, the actual toner concentration gradually approaches the prescribed value. Upon revival of the prescribed toner concentration, an electric balance is established in the differential amplifier circuit 31 and no further output signals therefrom is produced. This absence of the output signals leads to the disappearance of the operational signals from the driver circuit 33 and the valve 21 is closed accordingly so as to stop the toner supply.

An actual example of the circuits 31, 32 and 33 is shown in FIG. 8A.

In the shown arrangement, the differential circuit includes the photoelectric cells 13 and 19, an emitter resistor 34, a variable resistor 36 and transistors 37 and 38; the power amplifier circuit 32 includes a transistor 39; and the driver circuit 33 includes a relay 41 and the solenoid 23. Further, an electric source 42 is provided for exciting a solenoid 23 and biasing purpose to the electric circuit.

Another actual example of the circuits 31, 32 and 33 is shown in FIG. 8B. In the shown arrangement, the driver circuit 33 includes the solenoid 23, a thyrister 43 and an AC electric source 44 for exciting a solenoid 23. Further, an electric source 46 for biasing purpose is provided also.

In case the toner concentration within the developer is required to change purposely for any particular reason, for example because of the difference in the clearness in the originals, the filter 18 should be changed accordingly. This is one of the very advantageous features of the art of the present invention. Only by changing the type or kind of the filter 18, the resulting toner concentration can be changed as desired.

This adjustment can be effected by application of adjustment to the variable resistor 36 used in the electric circuit also.

Further actual example of the circuits 31, 32 and 33 is shown in FIG. 8C. In the shown arrangement, when the toner concentration becomes weak, the light received by the photoelectric cell 13 increases thereby the differential amplifier composed of transistors 37 and 38 becomes an unbalanced condition. As a result of this, the relay 51 connected to a collector of the transistor 38 is actuated and then renders the valve of the toner supply source 53 open. On the other hand, when the toner concentration becomes thick by supplying the toner, the relay 52 connected to a collector of the transistor 37 is actuated and then the valve of the new dispersion liquid 54 opens. As a result of this, the concentration of the toner becomes a constant value. Further, by shorting the load resistor 55, the toner can be supplied manually thereby a thicker concentration than the predetermined value can be obtained.

An another embodiment of the control device of the present invention shown in FIG. 9 is further provided with a float 47 which actuates a commutating switch 48 also shown in FIG. 10. The electrical circuit used in the embodiment in FIG. 9 is shown in FIG. 10. Referring to FIG 10, a contact 50*a* is closed by actuating a relay 50 during a constant time, every time a photosensitive paper passes in the electrostatic copy machine. In the case of the control device which is not provided with a float, when the circulation of the developer is stopped due to the decreasing of the developer, the passage of the developer for the toner concentration detector part 4 decreases, thereby the light permeability becomes increased, that is, the same effect wherein the concentration of the toner decreases. Referring to FIG. 9, the same part of FIG. 1 such as the circulation pump 2, the image developing part 3 etc. are omitted for the convenience of explanation. The float 47 moves upwardly or downwardly in accordance with the level of the developer. When the level of the developer becomes inferior to the nominal level of the developer, a common terminal 48*a* of the commutation switch 48 is switched to a terminal 48*c* and the alarm lamp 49 is illuminated. At the same time, the circuit of the solenoid 23 is opened thereby an unuseful supply of the toner being prevented. By detecting an insufficiency of the developer by the illumination of the alarm lamp 49 and supplying a new dispersion liquid, the level of the developer rises. Then, the common terminal 48*a* of the commutation switch 48 returns to a terminal 48*b* thereby the automatic control device of the toner concentration being reoperated. In the actual case, it is preferable that consideration is taken concerning the time lag between the illumination of the alarm lamp 49 and the supply of the dispersion liquid.

While the invention has been described in conjunction with certain embodiments thereof it is to be understood that various modifications and changes may be without departing from the spirit and scope of the invention.

What is claimed is:

1. An automatic control device for controlling toner concentration in a liquid developer in an electrostatic copying machine comprising, means for supplying toner to such liquid developer, pumping means for circulating liquid developer along a flow path, a receptacle in said flow path having a plurality of walls, one of said walls having an inlet therein to receive liquid developer from said pumping means, one of said walls of said receptacle having a narrow elongate discharge orifice therein through which a portion of such liquid developer entering said receptacle is discharged in a vertically downward direction in the form of a thin free falling sheet along a vertical flow path; overflow means in said receptacle for discharging excess liquid developer from said receptacle and for maintaining a constant pressure head on said orifice and a constant flow rate along said vertical flow path, means in said vertical flow path for guiding such thin sheet of liquid developer along said vertical flow path in the form of a smooth thin laminar sheet opposite faces of which are unsupported; means for continuously optically detecting the light permability of such thin laminar sheet of liquid developer and for detecting toner concentration in such liquid developer, and means controlled by said detecting means for controlling the supply of toner from said toner supply means to such liquid developer

in accordance with detected time sequential deviation in toner concentration in such liquid developer.

2. An automatic control device as claimed in claim 1, wherein said overflow means comprises an overflow dam dividing said receptacle into a first portion into which liquid developer flows from said inlet and from which a portion of such liquid developer is discharged through said orifice and a second portion into which excess liquid developer flows over said dam and is discharged from said receptacle.

3. An automatic control device as claimed in claim 1, wherein said orifice comprises a narrow elongate slot in one of said wells of said receptacle, said slot having downwardly converging opposite side walls.

4. An automatic control device as claimed in claim 1, wherein said guiding means comprising a U-shaped wire with parallel legs extending vertically downwardly respectively at opposite ends of said elongate discharge orifice.

5. An automatic control device as claimed in claim 1, wherein said guiding means comprises a thin plate extending vertically down from said elongate discharge orifice and having an aperture for passage of light for operation of said optical detecting means.

6. An automatic control device as claimed in claim 1, wherein said optical detecting means comprises a light source and a photoelectric cell so disposed respectively on opposite sides of such thin sheet of liquid developer that light from such source passes only through said sheet in travelling from said source to said photoelectric cell.

7. An automatic control device as claimed in claim 6, wherein said optical detecting means further comprises a second photoelectric cell positioned to receive light from said light source, a filter of selected density between said second cell and said light source and electric circuit means for comparing signals received from said photoelectric cells.

8. An automatic control device as claimed in claim 7, wherein said circuit means comprises a differential amplifier circuit having two inputs and an output, means connecting said inputs respectively to said photoelectric cells, a power amplifier connected to the output of said differential amplifier circuit, and a driven circuit connected to said power amplifier circuit.

9. An automatic control device as claimed in claim 1, wherein said means for controlling the supply of toner comprises a second flow path for such liquid developer from said pumping means, a toner supply passage from said toner supply means to said second flow path, a solenoid valve controlling flow of toner through said passage and an electric circuit for actuating said solenoid valve in response to signals from said optical detecting means.

10. An automatic control device as claimed in claim 1 further comprising a float detecting the liquid level of liquid developer, an alarm, and circuit means comprising commutating switching means actuated by said float to deactivate said toner supply control means to prevent delivery of toner from such toner supply means to said liquid developer and to activate said alarm when the level of liquid developer falls below a predetermined level.

* * * * *