The present invention relates to a developing apparatus for electro-photographic copying materials, the apparatus comprising a tank containing a liquid developer which consists of a carrier liquid and a picture toner dispersed therein, and which is consumed during the developing by depositing the toner on the copy-receiving sheet.

The electro-photographic method and materials and devices for the same are already known, for example from U.S. Patents Nos. 2,965,481, 2,297,691, 3,013,678. Electro-photographic copying materials contain layers which are charged prior to their exposure by means of a corona discharge of a charging device and a latent electrostatic image is then formed in these layers by exposing the charged layer via a pattern or master. This latent image is then developed by using particles which adhere to the charged surface in consequence of the electrostatic forces. Fixing may be effected, for example, by heating, thereby causing the toner particles to be baked in. This step may also be combined with image transfer. In one technique, the latent picture is transferred and the development is effected in a sheet of material other than that which has been exposed; in another system the latent picture may be developed on the exposed electro-photographic sheet of copying material and a so-called powder picture is transferred to another receptor sheet on which it is fixed.

Whilst the electro-photographic copying material is equipped with a special layer, the receiving sheet can be ordinary paper.

The present invention relates to both systems. The known dispersion of the particles of the toner for example, carbon black, in a liquid, such as kerosene, represents an improvement compared with the spraying of developer particles. Also here, the actual particles of the toner or pigment may be provided and these particles are retained detachably on the latent picture by the electrostatic forces. The above-mentioned term "picture-toner" comprises both pigment particles in conjunction with carriers and pigment particles which are subject to the electrostatic attraction.

Where a fluid medium—as a liquid in the case of the present invention—is used for receiving the picture toner, an important problem arises from the fact that the same conditions must be observed in order to ensure the uniform developing of successively produced latent pictures. Where liquid containing a dispersed toner is used, the toner, or at least the pigment particles of the toner, are consumed during the processing of the electro-photographic material, so that the intensity of successive developed pictures gradually lessens.

It might therefore appear advantageous to add picture toner manually at regular intervals of time. However, developing devices involving such handling have certain disadvantages. On the one hand, it requires observation by the operator and this observation is always uncertain. On the other hand, the manual "topping up" with picture toner can produce a balance only after a certain considerable consumption of toner. Here, it must be accepted that the picture become gradually weaker until picture toner is added when a lower limit value has been reached. The results obtained in this manner differ to such an extent that they can no longer be regarded as uniform copying, quite apart from the fact that the checking requires an additional operator.

It is therefore an object of the present invention to provide an apparatus using a liquid developer and producing a substantially uniform picture.

It is another object of the present invention to provide an apparatus which produces copies according to the electro-photographic method, using a liquid developer, wherein the pictures are substantially uniform and in which additional labor or observation is no longer necessary.

It is a further object of the present invention to provide an apparatus of the kind hereinbefore mentioned which is of simple construction and which may be adapted to certain requirements or tints.

According to the invention, these objects may be realized in that there is arranged in the liquid a monitoring device for the cloudiness of the liquid, wherein the said monitoring device is connected to apply the device indicating the change in the cloudiness of the liquid.

The term "cloudiness" used in this specification indicates the enrichment of the liquid with particles of the picture toner and expresses simultaneously an optical effect.

In a preferred embodiment of the invention, this monitoring device for the cloudiness of the liquid operates optically. However, in additional to the permeability of light of the liquid, also its electrical resistance, for example, its frequency resistance or its dielectric properties may be used for controlling the indicating system as a function of the cloudiness.

The term "indicating system" includes a moving system, the movements of which may be used for producing or initiating further control movements.

According to the invention, an optical monitoring system is preferred, because it produces advantageous results in conjunction with the cloudiness in a particularly economical manner.

Naturally, it is also possible to use the changes in the electric conductivity of the liquid in conjunction with its enrichment of picture toner for control purposes.

The term "developing" includes, according to the invention, the preferred embodiment, in which the electro-photographic copying material is passed through the developer fluid.

However, the present invention is not restricted thereto. The use of a liquid according to the invention makes it also possible to carry out the developing by spraying the liquid by spraying an electro-photographic copying material, or by using a surface developing device, known per se, such as a roller. Naturally, the liquid with the dispersed picture toner may be so agitated by stirring and/or beating mechanisms as that vapor forms above the liquid which supplies the toner particles to be deposited on the electro-photographic copying layer of the material. However, in any case, there is a supply of liquid developing substance,
the composition of which is controlled by means of the monitoring device according to the invention so as to ensure the uniform developing.

According to a preferred embodiment of the invention, the indicating device is connected with a locking member controlling the supply of picture toner particles so as to add picture toner particles or concentrated picture toner with decreasing cloudiness of the suspension. According to this preferred embodiment of the invention, the said monitoring device consists of a photoresistor and an associated light source.

Preferably, the liquid is located in a transparent tank of synthetic resin, having transparent recesses adapted to receive the said light source and photoresistor.

According to a convenient embodiment of the invention, there is arranged, above the liquid tank a storage tank for the picture toner or a picture toner concentrate, in which this storage tank communicates with the interior of the liquid tank by means of a conduit. This conduit is equipped with a closing member controlled by the indicating device.

In conjunction with the said storage tank, according to the invention the cover is equipped with a trough or trough-shaped profile into which the developing fluid enriched with picture toner is pumped, and which contains a curved guide element, preferably equipped with orifices, for passing throught the electro-photographic or other material. This provides a particularly simple construction with does not require any complicated measures.

The invention will be further described and its advantages and features explained, with reference to the accompanying drawings, in which:

FIG. 1 is a side elevation of the developing device according to the invention, shown in cross section;

FIG. 2a, 2b and 2c show the control circuits necessary for operating a preferred embodiment of the device of FIG. 1;

FIG. 3 is a side elevation corresponding to that of FIG. 1 but showing only a part of the monitoring device.

Although the invention will be described in the following with reference to an optical monitoring device, it should again be stressed that this monitoring may also be effected by using the changes in the conductivity of the liquid, and that also the dielectric properties of the liquid in conjunction with the enrichment in picture toner material can be used in a capacitor-like arrangement. The present description relates merely to a particularly preferred embodiment.

A tank 1 of transparent synthetic resin, glass or another equivalent material contains a carrier liquid 2 which is enriched with picture tone or picture toner particles. The top of the tank is closed with a cover 3 of a sliding material. This cover 3 has recesses or wells 4, 5 for the monitoring device. The recess 4, which may be tubular, for example, holds an electric light source 6 having leads 7.

The recess 5 contains a photoresistor 9 whose light-responsive surface is arranged to face the light source 6. Conveniently, the recesses 4 and 5 have confronting parallel wall sections. The electrical connections of the photoresistor are shown at 10. As may be seen, the light source 6 irradiates the photoresistor 9, while between these two elements there is a path 11 along which the light beam must pass through the liquid.

According to FIG. 1 which shows a particularly preferred embodiment, a storage tank 12 for concentrated picture toner, e.g. pigment particles, is arranged on the cover 3; this tank contains a supply of picture toner 33. This storage tank 12 may be supported on the cover 3 either directly or, as shown, through a support 34. The top of this storage tank has an orifice 35 which is closed by a screwed plug 36. The storage tank communicates through a conduit 13 with the interior of the tank 1. The conduit 13 has a vertical section 14.

The conduit 13, 14 is equipped with a closing member 15 which is connected by a linkage 16 with an actuating device 8, for example, a lifting magnet which may be supported by a frame 37 on the cover 3. This frame is shown in a higher construction at 38 in FIG. 3. As described further below, the magnet is energized as a function of the condition of the liquid along the path 11 so as to allow picture toner to flow through the conduit 13, 14 when the liquid is insufficient, or to block this supply when the concentration is correct. Naturally, the whole conduit 13, 14 may be arranged substantially vertically.

The closing members may, for example, a tape or valve, blocking the passage in one position and opening it in the other. Conveniently, the conduit has at least one downwardly directed section, containing the closing member, and assuring the uniform flow.

According to a preferred embodiment of the invention, the closing member is actuated by an operating magnet which is energized as a function of the response of the monitoring device. Although this presents a particularly simple and convenient solution, the invention is not so limited.

This embodiment has the further special advantage that the inserts are provided in the dovewhich has simultaneously a recess forming the trough profile containing the guide element and a pump, the actuating motor of which may also be mounted on the cover which carries at the same time the storage tank for the picture toner and preferably also the actuating magnet controlled by the monitoring device.

Conventionally, the photoresistor and the light source are immersed in transparent inserts into the liquid. This solution takes into account the optical method, based on the permeability to light of the developer liquid. The inserts may be of glass or of plastic. Naturally, it is also possible to use the resistance of the liquid for control purposes, in which case electrodes will be used as measuring devices.

The linkage 16 moves as a function of the monitoring device comprising the elements 6 and 9. This linkage may serve therefore as indicating device, wherein a lever arm 39 for the closing member 15 has a pointer, formed by a projection extending at right angles to its pivot axis.

FIG. 2 shows the circuits for the arrangement of FIG. 1. These relate to the connecting means between the monitoring device on the one hand and the indicating system or the closing member on the other hand.

A circuit with the voltage terminal 17 has a series circuit comprising a rectifier 18, corresponding to the photoresistor 9 in FIG. 1, and a relay 20. The light source 6 in FIG. 1 is mounted in a circuit 21, controlled by a potentiometer 22 and connected to a voltage source 23, forming the operating source.

A further circuit 24 which may be connected to one of the said voltage sources, e.g. to the voltage source 23, contains the operating magnet 8 for the closing member 15. The working contact 25 of the relay 20 is located in this circuit 24.

The operation is as follows:

If the photoresistor 19 is energized by a sufficient incidence of light from the light source 6, i.e. the cloudiness of the liquid has dropped below a certain value, the working contact 25 closes and the magnet 8 is energized. This causes the indicating system 16 to move and the closing member 15 to open so that picture toner is supplied to the liquid.

It may be seen that the perfect production of copies according to the invention is no longer dependent on an estimate but on a definite value. The picture toner which may, for example, be of highly viscous consistency, is applied in drops into the thin developer fluid.

As shown in FIG. 1, the cover 3 is formed to provide a trough 26; developer fluid is pumped into this trough by means of a pump 27 driven by a motor 28. This trough which may be arched at 29 contains a substantially semi-circular guide element 30 which is adapted to guide
electro-photographic copying material downwardly into the liquid as shown by the arrows 31, deflects it there and guides it finally upwardly as indicated by the arrow 32. This guide element 30 is mounted on the trough.

According to a preferred embodiment of the invention, a pump 27 is used which serves simultaneously as agitator. This object is achieved by means of a conical member forming the pump 27, the outer wall of which revolves in the liquid. In addition, the outer wall may be provided with profiles which increase the agitating effect.

This pump has been described, for example, in the commonly assigned copending U.S. application Ser. No. 447,430, now abandoned.

An essential feature of a preferred embodiment of the invention is that the extent of the tank 2 is larger than that of the trough 26. This enables the pump 27 to be arranged in spaced relationship from the point at which the picture toner is supplied so that the same is uniformly distributed in the liquid, owing to the stirring action of the pump, before it reaches the operating zone of the pump. Also, according to the preferred embodiment, the subsequently applied picture toner or picture toner concentrate is supplied directly into the measuring path, i.e., for example, between the light source 6 and the photosensor 9. This results in high response values. However, excess supply is avoided in consequence of the said gap between the 9 nor for the toner and the pump, because the supplied picture toner or picture toner concentrate is supplied directly into the measuring path, i.e., for example, between the light source 6 and the photosensor 9. This results in high response values. However, excess supply is avoided in consequence of the said gap between the

In a preferred embodiment, the guide element 30 has only the shape of a quarter cylinder, and the rising section is formed by the guide 29. This section has an overflow orifice 33 at a level corresponding to the liquid level. Naturally, the orifice 33 may be replaced by a horizontal row of holes.

Above the guide element, there may be provided guide means for holding down the sheet of material passing therethrough.

As already mentioned, the recesses 4, 5 need not be provided rigidly in the cover. According to a particularly preferred embodiment of the invention, the gap between the inserts, formed by the recesses 4 and 5 is variable. In this way, the ratio between carrier liquid and picture toner may be easily adjusted, and lighter or darker pictures may be produced at choice.

A similar choice may be made by varying the resistance 22 in FIG. 2.

FIG. 3 shows a part of FIG. 1 with certain modifications, wherein the same or equivalent elements are marked with the same reference numerals. However, in this embodiment, the insert 40 with the photosensor 9 is mounted movably in the cover 3. This cover 3 may be equipped, for example, with an oblong orifice 41, located parallel to the plane of the drawing. The insert 41 is pushed therethrough and rests with an outer rim 42 on the edges of the oblong hole 41. This enables it to be displaced in the direction of the arrow 43, whereby to change the gap between the parts 6 and 9. In order to make possible this displacement, the tank 12 and the actuating element 8 are arranged on raised supports or frames 38.

Having thus fully disclosed my invention, what is claimed and desired to be secured by Letters Patent is:

1. In a device for developing electro-photographic copy materials having a layer formed with an electrostatic latent image and including a container for a bath of a developing liquid comprising a liquid vehicle and toner particles dispersed in said vehicle, means for applying the liquid from said bath to said layer for development of said image, dispensing means for supplying toner particles to said container, valve means between said dispensing means and said container selectively operable to admit said toner particles thereto or block passage of the toner particles into said container, sensing means responsive to the concentration of dispersed toner particles in said vehicle, and control means responsive to said sensing means for operating said valve to supply toner particles from said dispensing means to said container upon depletion of the toner particles in the bath therein, the improvement wherein said sensing means comprises a pair of cooperating elements optically responsive to the opacity of the bath between them, said container having a pair of wells extending into said bath therein and spaced apart with liquid of said bath between them, each of said wells having at least a translucent portion confronting the other of said wells and receiving a respective one of said elements.

2. The improvement defined in claim 1 wherein said wells are composed of transparent material and said elements include a photosensor connected in circuit with said control means and a light source transmitting illumination to said photosensor.

3. The improvement defined in claim 2 wherein said wells are composed of a synthetic resin.

4. The improvement defined in claim 1, further comprising means enabling relative displacement of said wells toward and away from one another to adjust the separation of said elements.

5. The improvement defined in claim 4 wherein said container is formed with a cover and said wells are set into said cover, said cover being provided with a slot stretching from a location relatively close to the nonmovable well to a location relatively remote therefrom, the movable well having a shank portion slidably received in said slot and a head overhanging said slot for supporting the movable well on said cover.

6. The improvement defined in claim 1 wherein said control means includes an electric circuit establishing a threshold value of the concentration of said particles in said dispersion, said elements having an electrical output applicable to said circuit for operating said valve means when the concentration of particles in said bath falls below said threshold.

7. The improvement defined in claim 1 wherein said dispensing means has an outlet opening into said container between said wells.

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