Toner System for an Electro-Photographic Copying Machine and a Copying Machine Utilizing This Toner System

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Filed: Apr. 9, 1974
Appl. No.: 459,374

U.S. Cl. ......... 355/10; 117/37 LE; 118/DIG. 23; 354/324; 354/336
Int. Cl.² ................. G03G 15/10
Field of Search....... 355/10, 3 R; 118/DIG. 23; 117/37 LE; 96/1 LY; 354/324, 326, 320, 336

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Primary Examiner—Richard L. Moses

ABSTRACT
A toner system for an electro-photographic copying machine comprising a developing trough and a separate store receptacle for toner liquid which can be detachably connected with the trough by connecting means defining separate forward and return flow passages for circulating toner liquid from the receptacle through the trough and back into the receptacle, said connecting means extending downwardly from the trough to be positioned in the store receptacle through a single opening in the top wall thereof and incorporating a pump for pumping toner liquid through said forward flow passage. The toner system can be utilized in a copying machine in which the original to be reproduced and a copy sheet traverse the machine downwardly in synchronism from spaced substantially vertical initial positions in which they are held by gravity along substantially vertical travelling paths, the toner system being arranged below the exposing means in the copy sheet travelling path in the lower portion of the machine casing in which a supporting member is provided for positioning the separate store receptacle in an operative communication with the trough by simple manipulations conducted outside the machine casing.

6 Claims, 7 Drawing Figures
TONER SYSTEM FOR AN
ELECTROPHOTOGRAPHIC COPYING MACHINE
AND A COPYING MACHINE UTILIZING THIS
TONER SYSTEM

The present invention relates to an improved toner system for use in electrophotographic copying machines and to a vertical copying machine of the kind described in my patent application Ser. No. 358,325 filed on May 8, 1973 as a continuation of my application Ser. No. 112,565 filed on Feb. 4, 1971, in which such a toner system is utilized.

BACKGROUND OF THE INVENTION

The development of electrophotographic copying machines has resulted in two main types of such machines, i.e. table-size and floor-type machine. Almost all floor-type machines are suitable for the reproduction from books, bulkier equipment and increasing dimensions, weight and costs resulting therefrom.

As a result of consumers' demands on the one hand and reasons of competition on the other hand, electrophotographic copying machines are becoming increasingly more complicated. If printing material in the form of sheets is used, the machine may be provided with magazines for several sheet sizes. In case of printing material in the form of a roll of paper, the machine may be provided with means for cutting off sheets of paper of different lengths. To avoid the necessity of the user having to press a button each time a copy is to be produced of a certain original, the machine may be provided with an automatic repeating device adjustable to the reproduction of a predetermined number of copies.

In the development that has taken place, attention has not been drawn to the fact that a need exists for a simple and cheap electrophotographic copying machine usable in places where sufficient space is not available neither for known table-size machines nor for floor-type machines.

The present invention relates to an electrophotographic copying machine, in which copying sheets having a photo-sensitive surface are charged, exposed and developed, each sheet traversing the machine in synchronism with an original which is scanned by an optical system, by means of which an image of the original is formed directly on the copying sheet.

Traversing machines of the above-mentioned type are known, in the operation of which a copy sheet is taken by hand from a sheet supply, e.g. an external magazine or a drawer, and is placed on an original document to be copied, said copy sheet and original being then introduced into the machine in a horizontal direction on each side of a separating bar arranged in an insertion opening. The purpose of putting the original and the copy sheet together and introducing them into the machine at the same time is to bring about the synchronism necessary for reproducing the original correctly on the copy sheet. However, in practice it often happens that in order to introduce the original and the copying sheet on each side of the separating bar in the insertion opening, said sheets, being put together, are edged forward so that the introduction thereof begins at a corner, the result being that the copy sheet and the original are drawn obliquely into the machine.

In known traversing machines, in which the original disappears into the machine and is ejected again therefrom after exposure, it might happen that the original jams in the machine, for example, in case it is curled and, at the worst, it might be ruined. In such cases, it will be necessary to open the machine and release the jammed original from the feeding rollers for said original. If reversal of the original inside the machine is to be avoided in order to eject it through an opening in the end wall of the machine parallel to the insertion opening, the original moving right through the machine, said machine has to be accessible from the front side as well as from the rear side thereof, which might be inexpedient for reasons of operation and demands on space.

The invention described in my copending application Ser. No. 358,325 solves the problem of providing an electrophotographic copying machine which is simple and cheap, and the operation of which offers considerable advantages.

The toner system of a copying apparatus comprises a trough containing the toner bath through which the copy sheet is advanced by guide means securing that each and every point of the surface coating on the copy sheet is brought into contact with the toner fluid for a period sufficient to obtain a reproduction of a good quality. The toner fluid is circulated by means of a pump through the trough from a supply of mixed toner fluid contained in an open tank arranged directly below the toner trough, from which toner returns to the tank through a number of openings in the bottom of the trough.

Variations in the concentration of active toner particles in the toner fluid is avoided by controlling separate supplies of carrier liquid and active toner particles to the mixed toner fluid in the tank. This makes the toner system complicated and, moreover, it is difficult for the user to time the replenishment of carrier liquid or addition of fresh particles. Replenishment may be obtained automatically by means of a valve controlled by an optical device for detecting the blackness of the toner fluid.

In large copying machines the increased complication of the automatic toner system can be tolerated because the weight of say 75 kilos and the already large volume is not increased substantially. However, in small portable machines reduction of weight and size is of importance, and new problems arise. The upper weight limit for portable machines is officially recognized as 25 kilos. Reduction of size may be obtained by diminishing the length of the path of the copy paper. The result is, however, that the requirements to the efficiency of the toner system increase because the time between start of the machine and feeding of the copy paper into the toner trough is decreased. A certain time is necessary for the pump to feed a sufficient quantity of toner liquid into the trough to enable development to commence immediately whenever a sheet of copy paper arrives.

The portability of the machine raises another problem, namely how to avoid spilling the toner when the machine is moved. Large size machines are demonstrated at the seller's place. The new small size machine, however, invite to demonstrations at the customers' place, but a tank filled with toner and open to receive toner returning along the whole length of the trough excludes this possibility in practice. It is a complicated and dirty job to empty the tank before and refill it after the machine has been moved to the prospective customers' place.
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It is an object of the present invention to devise an improved toner system and a copying machine in which these drawbacks are avoided.

SUMMARY OF THE INVENTION

According to the invention, the main problem outlines above is solved by means of a toner system for developing a latent electrostatic image on a copy sheet in an electrophotographic copying machine, comprising:

a separate closed store receptacle for toner liquid and having bottom and side walls as well as a top wall, in which a single opening is formed for outlet and inlet of toner liquid;

a developing trough adapted to be secured in a horizontal position in the copying machine to receive copy sheets to be developed, said trough having downwardly extending connecting means to reach into the interior of the store receptacle through said single opening when the store receptacle is positioned below the trough so as to detachably connect the store receptacle with the trough, said connecting means including separate forward and return flow passages for feeding toner liquid from the store receptacle to the trough and returning toner liquid by gravity from the trough into the container, said forward and return flow passage communicating with the interior of said store receptacle through inlet and outlet openings, respectively, arranged with mutual separation in the lower part of said connecting means to secure an effective mixing of toner liquid returned to the store receptacle before re-entering said forward flow passage; and

a pump mechanism arranged at the lower part of said connecting means in an operative relationship to the inlet opening of said forward flow passage for pumping toner liquid from the store receptacle up therethrough to the developing trough.

The single opening in the top wall of the disconnected receptacle may be closed by a cap, whereby any risk of spilling toner during transport is avoided. As shall be explained later in detail, the trough is arranged to be quickly filled sufficiently to obtain completely developed copies, and quickly emptied to avoid spilling, when the receptacle is disconnected shortly after use of the machine. This occurs if the user wants to insert a new receptacle with fresh toner liquid.

The fact that all toner liquid a few seconds after the machine has been switched off is returned to the store receptacle, the single opening in which is mainly blocked by the connecting means extending downwardly from the trough reduces the risk of spilling liquid by normal cautious transport of the machine.

Circulation of toner liquid not only in order to fill the trough, but continuously during every copying process avoids the sedimentation which may occur in toner systems with an open tank below the trough, which tank is intermittently, manually or automatically supplemented with toner and carrier liquid. The controlled circulation of the whole quantity of the toner results in a homogeneous toner liquid throughout the life time of the toner. The compact, low volume developing system permits the use of a small quantity of toner liquid. Thus, it is possible without undue waste to use a disposable toner liquid receptacle containing sufficient toner liquid to make a suitable number of copies, say 500, but not so great a quantity that the ratio between toner and carrier liquid exceeds the acceptable limits within which satisfactory copies are made. Consequently, the tedious, time consuming and dirty job of cleaning an open tank is avoided.

The improved toner system according to the invention is well suitable for use in a vertical copying machine of the kind mentioned hereinbefore, said machine comprising a vertically extending casing; means in the upper portion of said casing for receiving a stack of copy sheets; means for electrostatically charging a copy sheet having a photosensitive surface; means for exposing said copy sheet to an image of an original to be reproduced; means for feeding a copy sheet from said stack and said original from spaced, substantially vertical initial positions in the upper portion of the casing in synchronism through the machine to respective ejection openings in the lower portion of said casing; an optical system for scanning said original during the movement thereof and subjecting said copy sheet to exposure to form a latent electrostatic image thereon; guide means for said original forming a substantially vertical, downwardly directed original travelling path to its ejection opening, said charging means and said exposing means being likewise arranged along a mainly vertical, downwardly directed copy sheet travelling path; at least one retractable stop member in the path of said original, and at least one retractable stop member in the path of said copy sheet to define said initial positions, in which said original and copy sheet are positioned by gravity; means for retracting said stop members from the paths of said original and copy sheet, respectively, in a mutually timed relationship to ensure correct synchronization; and the above mentioned toner system which is arranged below the exposing means in the copy sheet travelling path.

In this machine a support member may be provided in the lower portion of the casing to receive an oblong store receptacle and position said receptacle in an operative communication with the trough by simple manipulations conducted outside the machine casing, said manipulations including an upwards movement of the store receptacle, whereby the connecting means extending downwardly from the trough is positioned in the interior of the receptacle, whereafter the receptacle is turned through an angle of approximately 90°, whereby it is brought to rest on the support member.

BRIEF DESCRIPTION OF THE DRAWINGS

In the following the invention is explained in greater detail with reference to the accompanying drawings, in which:

FIG. 1 is a sectional view from one side of a vertical copying machine utilizing the improved toner system according to the invention;

FIG. 2 is a sectional view from the other side of the copying machine in FIG. 1;

FIG. 3 is a perspective view of the improved toner system, showing a separate store receptacle for toner liquid and a developing trough separated from each other;

FIG. 4 is a sectional view along a longitudinal plane of the toner system in FIG. 3, showing the operational relation between the developing trough and the store receptacle, wherein some parts have been omitted;

FIG. 5 is a top plan view of the developing trough in the toner system shown in FIGS. 3 and 4; and

FIGS. 6 and 7 are sectional views along the lines VI—VI and VII—VII, respectively, in FIG. 5.
DETAILED DESCRIPTION

The vertical copying machine shown in the sectional views in FIGS. 1 and 2 is a somewhat modified version of the general vertical machine construction disclosed in my copending patent application Ser. No. 358,325 mentioned hereinbefore and corresponds to the copying machine disclosed in my other copending application Ser. No. 405,907 filed on Oct. 12, 1973.

In this machine copy sheets are taken individually from a vertical sheet supply 101 by means of a turntable frictional catch mechanism 102 which on actuation performs a single complete revolution during part of which it catches the nearest copy sheet in sheet supply 101, said copy sheet being thereby advanced towards an initial position for the copy sheet movement, in which it is held vertically by its own weight, the lowest limit of said initial position being defined by stop members 103 which in the rest condition of the apparatus are inserted in the copy sheet travelling path immediately below the uppermost pair of advancing rollers in said path, the rollers 104 and 105 of said roller pair being kept in a mutually spaced relation in said initial position.

When reproduction has to take place stop members 103 are retracted from the copy sheet conveying path and simultaneously rollers 104 and 105 are coupled together such as explained in the following. The copy sheet is thereafter in a manner known per se advanced through a corona charging unit 106 in which the photosensitive surface of the sheet is electrostatically charged, an exposure station 107 at which the sheet is exposed to the image of an original, a toner system 108 and a drying device 109 in order of succession, the copy sheet finally leaving the apparatus through an ejection opening 110 at the lower portion of the machine casing. The copy sheet movement is performed by means of a roller pair 111, 112 between exposure station 107 and toner system 108, a roller pair 113, 114 between toner system 108 and drying device 109, said roller pair also serving to sweep off excess developer liquid from the copy sheet, and a roller pair 115, 116 arranged at ejection opening 110.

An original to be reproduced is inserted from above behind a cover 117, which is pivotally mounted at the front of the apparatus in a manner not shown, until it assumes an initial position, in which it is held vertically by its own weight just like the copy sheet in its initial position, the lower limit of which initial position of the original is defined by stop members 118 which in the rest condition of the apparatus are inserted in the original travelling path immediately below the uppermost pair of advancing rollers in said path, the rollers 119 and 120 of said pair being kept in a mutually spaced relation in said initial position. When the copy sheet has started to move from its initial position through the corona charging unit 106 towards the exposure station 107, stop members 118 are retracted from the original travelling path and simultaneously rollers 119 and 120 are coupled together, whereby the original will be advanced in synchronism with the advancement of the copy sheet past an exposure window 121 through which it is imaged onto the copy sheet through an exposure window 130 at exposure station 107 by means of an optical system incorporating in a manner known per se an exposure lamp 122, two inclined mirrors 123 and 124, a lens system 125 having a reflecting mirror 126 and a light screen member 127 for adjusting the light intensity. After having passed the exposure window 121, the original is ejected from the machine casing below the cover 117 by means of a roller pair 128, 129.

The optical system is of the same general configuration as ordinarily used in known copying machines of the traversing type, wherein the original and the copy sheet are advanced along separate travelling paths which at least on the part of their length, at which exposure of the copy sheet takes place, extend in mutual parallel relationship. However, I have found that the arrangement of the object plane and the image plane at exposure windows 121 and 130, respectively, to form an acute angle with each other, the magnitude of which may be 10° to 15°, such as shown in FIG. 1, makes a valuable contribution to the achievement of a reduced size of the machine casing, which is a major aim in the construction of vertical copying machines for use on a table. As a matter of fact, it is known in the art that light rays coming to and going from the objective lens in an optical system of this kind must form a small angle of 10° to 15° in order to allow the necessary optical separation. The arrangement of the object plane and the image plane to form an angle of approximately the same size permits reduction of the size of the casing in the vicinity of the upwards pointing apex of the angle between the light rays without any crossing of the light rays being needed, such as in many prior realizations of optical systems of this kind.

It will appear that in the copying machine in FIG. 1 the arrangement of the object plane and the image plane of the optical system to form an acute angle with each other has been utilized to permit a somewhat tilting position of the front of the casing. This facilitates insertion of the original and creates a design suitable to be mounted on a wall as well as to be placed on top of a writing desk resting on a support means as shown at 131.

In order to obtain synchronism between the movements of the original and the copy sheet in the copying machine, it will be necessary that all pairs of feeding rollers are driven at the same circumferential speed. It is not illustrated in the drawings how this is achieved. However, the said condition may be fulfilled in a known manner by driving continuously one roller of each pair of rollers by means of the motor of the machine through a common, endless drive belt which may be provided, in order to reduce play and friction with teeth and may mesh with gears mounted on the roller shafts.

In the machine configuration shown in FIG. 1 synchronism between the advancement of the original and the advancement of the copy sheet is obtained by retracting stop members 118 in the original travelling path with a time delay after retracting stop members 103 in the copy sheet travelling path. As explained in greater detail in the above-mentioned application Ser. No. 405,907, the retraction of stop members 103 and 118 may be actuated in a correctly timed sequence with the actuation of catch mechanism 102 to forward a copy sheet from sheet supply 101 and the operation of electrical switches controlling the corona charging unit 106 and the exposure lamp 122 by simple mechanical means incorporating a rotary actuation disc governing all said control functions in the course of a single revolution, which is initiated by depressing a start button 133.
After having left the exposure station 107, the copy sheet proceeds along its travelling path to the toner system 108, which comprises as its main parts a developing trough 201 for a bath of toner liquid, which in a manner known per se consists of a dispersion of electro-active toner particles in a carrier liquid and a closed removable store receptacle 202 for said toner liquid, which is formed to be detachably connected with trough 201. The detailed structure of the toner system 108 will be apparent from the views shown in FIGS. 3 to 7.

Thus, referring to the perspective view in FIG. 3, it is seen that the store receptacle 202, which as shown in FIGS. 1 and 2 is to be positioned below the trough 201, consists of a closed, generally box-shaped and oblong casing which may be made of plastics and in one end of the top wall of which a single opening 203 is formed for communication with the trough, which opening may be closed by a screw cap 205.

Trough 201 for the bath of toner liquid is defined by two end walls 206 and 207 and a curved bottom wall 208. In order to reduce the amount of toner liquid necessary for development and secure that each and every point of the photosensitive surface coating on the copy sheet is brought into contact with the toner fluid during passage through the trough, a displacement body in the form of a metallic guide plate 209 having a curvature corresponding to that of bottom wall 208 is arranged in the trough a small distance above the bottom wall to define together therewith a narrow passageway for copy sheets to be developed. The copy sheet to be developed is advanced through this passageway by the rollers 111 and 112 shown in FIG. 1, the copy sheet entering the passageway through an inlet slit 210 and leaving the passageway through an outlet slit 211. In addition to its function as a displacement body the metallic guide plate which may be electrically grounded also serves to obtain a uniform distribution of the electrostatic field which is achieved in the toner liquid.

Outside end wall 206 of trough 201 a pipe stub 212 is formed integrally with the trough, said pipe stub constituting the connecting means to be positioned in the interior of receptacle 202 through the single opening in the top wall thereof. In order to position receptacle 202 correctly for communication with trough 201, the copying machine is provided as shown in FIG. 4 with a shelf-like support member 132 which supports the bottom wall of receptacle 202. Thus, as already explained the store receptacle 202 may be correctly positioned relative to trough 201 by a simple manipulation conducted outside the machine casing and including an upwards movement, by which pipe stub 212 is positioned in receptacle 202 through opening 203, wherein the receptacle is turned through an angle of approximately 90° and brought to rest on support member 132.

In order to obtain a continuous circulation of toner liquid through trough 201 the toner liquid contained in receptacle 202 has to be pumped up into the trough, and distributed over the entire length thereof, after which the toner liquid should be collected and returned to receptacle 202.

With this object in mind, a hollow tubular member 214 is fitted with its upper rim in pipe stub 212 and extends downwards therefrom to be positioned in the interior of receptacle 202 when connected with trough 201. As explained in the following, a pump tube which is not seen in FIG. 3 extends inside the tubular member 214 from one end thereof to the other and is bent through an angle of 90° to extend throughout the length of trough 201 between end walls 206 and 207 thereof. The internal space of tubular member 214 surrounding the pump tube communicates with a flow duct 216 which is formed integrally with trough 201 below the outlet slit 211 to collect toner liquid which has circulated through the trough, said flow duct communicating with the bottom of the trough through a restricted flow passage 217.

The operational relationship between trough 201 and receptacle 202 when connected with each other is illustrated in FIGS. 4 and 6 showing sectional views taken along vertical planes in the longitudinal direction of the trough and transversely to that direction through the pump mechanism, respectively.

In the embodiment shown pipe stub 212 is formed as a downwardly hanging part of trough 201. Inside the stub a horizontal support plate 218 is formed integrally with the end wall 206 of trough 201. The hollow tubular member 214 is fitted in the lower part of stub 212 by screws 219 and 220 extending through holes formed in the horizontal support plate 218 and screwed into tapped bores formed in the walls of tubular member 214 at the edge thereof. The internal space of tubular member 214 communicates with flow duct 216 through an opening 221 formed in the upper part of stub 212 between the horizontal support plate 218 and the bottom wall of flow duct 216 and communicates with the interior of receptacle 202 through an opening 222 in the side wall of the tubular member. The lower end of tubular member 214 positioned in the interior of receptacle 202 is closed by an end wall 223 which together with a cap 224 forms a casing for a pump impeller 225, said casing communicating with the interior of the receptacle 202 through intake openings 224a formed in cap 224. Inside tubular member 214 the above-mentioned pump tube, which is designated by 226, extends throughout the length of the tubular member and the stub 212 between end wall 223 and horizontal support plate 218, said pump tube communicating with the interior of the casing between end wall 223 and cap 224. The pump impeller 225 is rigidly secured on the lower end of a drive shaft 227, which is journaled in a longitudinal bearing 228 formed coaxially inside tubular member 214 and integrally with end wall 223 thereof, a catch member 227a being rigidly secured on the upper end of said drive shaft, so that the pump impeller 225 can be rotated in a manner known per se by means of an electric motor 227b, as shown in FIG. 2.

When this electric motor is operating, pump impeller 225 will be rotated so as to pump the toner liquid from the interior of receptacle 202 through the intake openings 224a formed in cap 224 and pump tube 226 to the developing trough 201.

Referring now to FIGS. 3, 4 and 7, it is seen that guide plate 209 forming the upper wall of the trough is formed at the side adjoining the inlet slit 210 with a backwaredly inclined flange portion 209a, above which pump tube 226 extends throughout the length of the trough between end walls 206 and 207 thereof. In the underside of pump tube 226 facing the upper surface of flange portion 209a of guide plate 209 a number of discharge apertures 226a for toner liquid are formed, so that toner liquid pumped up into the pump tube will be cascaded through said apertures against the flange.
portion 209a and down into the trough, whereby a continuous flow of toner liquid will be directed against the photosensitive surface coating on a copy sheet throughout the width of the copy sheet already when entering the inlet slit 210.

Referring now to FIGS. 4, 5 and 7, it is seen that the curved bottom wall 208 of the trough is formed in its lower part with a meandering drain groove 229 communicating with the restricted flow passage 217 mentioned in the foregoing, said groove sloping downwardly from each end of the trough towards the central portion thereof at which the flow passage 217 is formed. Thereby, the toner liquid supplied to the trough throughout the length thereof will be collected in drain groove 229 and will be caused to flow through the restricted flow passage 217 to the flow duct 216, which is inclined from end wall 207 towards end wall 206, at which flow duct 216 communicates through tubular member 214 with the interior of receptacle 202.

Furthermore, it is seen that the upper surface of the curved bottom wall 208 of the trough is formed between the inlet slit 210 and the drain groove 229 with a number of ribs 230 and between the drain groove and the outlet slit 211 with a number of ribs 231, said ribs serving to keep a copy sheet entering the trough in a spaced relation to the surface of the bottom wall so as to prevent the copy sheet from adhering to the bottom wall.

In the copying apparatus shown in FIGS. 1 and 2, the electric pump motor 227b is actuated by depressing the start button 133, whereby the advancement of an original to be reproduced and a copy sheet through the machine is initiated. Upon actuation of the electric motor 227b, the pump impeller 225 will start to force toner liquid from the interior of receptacle 202 up into pump tube 226. From pump tube 226 the toner liquid will be discharged through apertures 226a against the flange portion 209a of guide plate 209 so as to be cascaded against the photosensitive surface coating on a copy sheet entering the toner trough 201 throughout the width of said copy sheet. In this connection, the electric motor 227b is proportioned so as to impart a rotational speed on the pump impeller 225 of a magnitude sufficient to secure that a satisfactory amount of toner liquid is present in the bath enclosure as soon as a copy sheet arrives with its leading edge to the inlet passage 210. The copy sheet is now advanced from the inlet passage 210 through the narrow passageway defined by end walls 206 and 207, curved bottom wall 208 and guide plate 209 of the trough 201 to the outlet slit 211. From the trough toner liquid is drained through drain groove 229, flow passage 217 and flow duct 216 back into the interior of receptacle 202. In this connection, the cross-sectional area of the restricted flow passage 217 and the inclination thereof from the lowest part of drain groove 229 towards flow duct 216 are chosen of such magnitudes relative to the amount of toner liquid supplied through pump tube 226 so that a toner bath is formed which fills out the passageway between bottom wall 208 and guide plate 209, such as indicated in FIG. 7.

Upon deactuation of the electric motor 227b, toner liquid will no longer be forced up into pump tube 226 by pump impeller 225 and supplied into the trough, whereas the toner liquid remaining in the trough will be drained through flow duct 216 to receptacle 202 within a prescribed time interval of about 5 to 6 seconds. As soon as all the toner liquid has been drained, receptacle 202 can be removed from the copying machine.

The presence of the restricted flow passage 217 in the central portion of the trough necessitates that a greater amount of toner liquid is supplied into that portion. Therefore, discharge apertures 226a in pump tube 226 lie closer to each other in the central part of the tube positioned opposite flow passage 217 than at the ends of the pump tube on each side of said central portion.

The structure of tubular member 214 incorporating the pump mechanism with the relative offset positions of the outlet opening 222, through which toner liquid is discharged from the internal space of tubular member 214 surrounding pump tube 226 and the intake openings in cap 224, said openings being positioned vertically below pump impeller 225, secures that toner liquid drained from trough 201 into receptacle 202 is effectively mixed with the content of toner liquid present in the receptacle before reentering the intake openings.

It will appear from the foregoing that by means of the present invention a vertical electrophotographic copying machine has been provided, which is of a very compact construction and requires a minimum of space, the copying machine being suitable for suspension directly on a wall as well as for positioning directly on a writing desk in the immediate nearness of a user having the need of making a great number of copies.

In addition, the operation of the machine is very simple. The only manipulations required by the actual user is the loading of a supply of copy sheets, the positioning of a store receptacle of premixed toner liquid to cooperate with the development trough, the insertion of an original to be copied and the depression of the start button. Copy sheets can be supplied in a box-shaped magazine, part of the outer wall of which should be torn off when loading the magazine into the machine through a cover in the top wall of the casing. The store receptacle for toner liquid, which may have a volume of 1 litre to contain an amount of toner liquid sufficient for producing for example 500 copies of an excellent quality, is positioned in correct cooperation with the development trough by a simple and easy operation, such as described with reference to FIGS. 1 and 3, and may just as easily be removed to be replaced by a new receptacle.

In the preferred embodiment shown in FIG. 1, all what the user has to do when a copy is to be made, is to insert the original behind the cover of the front wall of the casing and depress the start button. The original will assume, by its own weight, a correct initial position defined by the stop members inserted in the original travelling path. When the start button is depressed, the electric motor 227b driving the pump impeller of the development means is energized, and the rotary actuating disc governing all the control functions is started. Thereby, a copy sheet will be forwarded from the sheet supply towards the initial position of the copy sheet travelling path defined by the stop members inserted in said path. When the copy sheet has assumed this initial position, the stop members are retracted from the copy sheet travelling path, and the rollers of the roller pair associated with said stop members are coupled together. After a predetermined time delay, the stop members are retracted from the original travelling path, and the rollers of the roller pair associated there-
with are coupled together. The original and copy sheet will now traverse the machine in mutual synchronism and finally leave the casing through the ejection openings in the front wall thereof.

It will readily be appreciated that the improved toner system according to my invention is not limited to be used in a vertical copying machine of the kind described hereinbefore, but may without difficulties also be applied to other types of copying machines having a horizontally extending casing, in which the copy sheet is conveyed along a main horizontal travelling path. The advantages obtained by utilizing the toner system in such a machine are the same as those mentioned hereinbefore.

Furthermore, various modifications and alterations relative to the preferred embodiment of the toner system described hereinbefore and shown in the drawings will be readily apparent to anyone skilled in the art. Therefore, the attached claims are contemplated to cover all such modifications and alterations falling within the spirit and scope of my invention.

What is claimed is:

1. A toner system for developing a latent electrostatic image on a copy sheet in an electrophotographic copying machine, comprising:
   a separate closed store receptacle for toner liquid and having bottom and side walls as well as a top wall, in which a single opening is formed for outlet and inlet of toner liquid;
   a developing trough adapted to be secured in a horizontal position in the copying machine to receive copy sheets to be developed, said trough having downwardly extending connecting means incorporating a single pipe stub formed integrally with the trough outside one end wall thereof and a tubular member fitted in said pipe stub and extending downwardly therefrom to reach into the interior of the store receptacle through said single opening when the store receptacle is positioned below the trough so as to detachably connect the store receptacle with the trough, separate forward and return flow passages extending inside said pipe stub and tubular member and communicating with the interior of said store receptacle and with said trough for feeding toner liquid from the store receptacle to the trough and returning toner liquid by gravity from the bottom of the trough into the container, said forward flow passage being defined by a pump tube extending right through the tubular member and throughout the length of the trough at the top thereof for distributing toner liquid across the width of a copy sheet entering the trough and having an inlet opening positioned at the lower end of the tubular member, said return flow passage being formed by the interior of the tubular member surrounding said pump tube and having an outlet opening positioned in the lower part of the side wall of the tubular member separate from the inlet opening of said pump tube to secure an effective mixing of toner liquid returned to the store receptacle before reentering the pump tube; and
   a pump mechanism including a drive shaft extending vertically through said pipe stub and tubular member to have its lower end positioned outside the inlet opening of the pump tube and an impeller secured on the lower end of said drive shaft for pumping toner liquid from the store receptacle up through the pump tube to the developing trough.

2. A toner system as claimed in claim 1, wherein the drive shaft of said pump mechanism extends coaxially with said pipe stub and said tubular member to have the impeller on its lower end positioned in an operative relationship to the inlet opening of the pump tube, a housing for said impeller being formed by a cap secured to the lower end of the tubular member and having intake openings separate from the outlet opening in the side wall of said tubular member.

3. A toner system as claimed in claim 1, wherein the developing trough has a curved bottom wall, the lower part of which inclines downwardly in the longitudinal direction of the trough from both end walls toward the central portion thereof, a metallic plate shaped displacement body having a curvature corresponding to that of the bottom wall being arranged in the trough a small distance above the bottom wall to define a narrow curved passageway for copy sheets to be developed, said passageway extending between inlet and outlet slits formed between opposite sides of the displacement body and opposite upper edges of the bottom wall, an inclined return flow duct being formed integral with the trough below said outlet slit, said flow duct communicating in its lower end with said tubular member and in the upper portion of said casing for receiving a stack of copy sheets, means for electostatically charging a copy sheet having a photosensitive surface, means for exposing said copy sheet to an image of an original to be reproduced, means for feeding a copy sheet from said stack and said original from spaced, substantially vertical initial positions in the upper portion of the casing in synchronism through the machine to respective ejection openings in the lower portion of said casing; an optical system for scanning said original during the movement thereof and subjecting said original to exposure to form a latent electrostatic image thereon; guide means for said original forming a substantially vertical, downwardly directed original travelling path to its ejection opening, said charging means and said exposing means being likewise arranged along a main vertically, downwardly directed copy sheet travelling path; at least one retractable stop member in the path of said original, and at least one retractable stop member in the path of said copy sheet to define said initial position, in which said original and copy sheet are positioned by gravity; means for retracting said stop members from the paths of said original and copy sheet, respectively, in a mutually timed relationship to ensure correct synchronization; a toner system arranged below said exposing means to develop said latent electrostatic image, said toner system comprising a separate closed store receptacle for toner liquid and having bottom and side walls as well as a top wall, in which a single opening is formed for outlet and inlet of toner liquid; a developing ditch arranged in a horizontal position to receive copy sheets to be developed, said trough having downwardly extending connecting means to reach into
the interior of the store receptacle through said single opening when the store receptacle is positioned below the trough so as to detachably connect the store receptacle with the trough, said connecting means including separate forward and return flow passages for feeding toner liquid from the store receptacle to the trough and returning toner liquid by gravity from the trough into the container, said forward and return flow passage communicating with the interior of said store receptacle through inlet and outlet openings, respectively, arranged with mutual separation in the lower part of said connecting means to secure an effective mixing of toner liquid returned to the store receptacle before re-entering said forward flow passage; a pump mechanism arranged at the lower part of said connecting means in an operative relationship to the inlet opening of said forward flow passage for pumping toner liquid from the store receptacle up therethrough to the developing trough; and driving means for continuously driving said pump mechanism during operation of the copying machine.

5. An electrophotographic copying machine as claimed in claim 4, wherein said pump mechanism comprises a drive shaft extending vertically through said connection means to reach into the store receptacle when positioned below the trough and an impeller secured on the lower end of said drive shaft in an operative relationship to the inlet opening of the forward flow passage, said driving means comprising an electric motor which is operatively connected with the upper end of said drive shaft.

6. An electrophotographic copying machine as claimed in claim 4, further comprising a supporting member for said store receptacle in the lower portion of said casing below said trough, said portion of the casing being formed so as to permit said store receptacle to be positioned below said trough by manipulations conducted outside the machine and including an upwards movement of the store receptacle, by which said connecting means is positioned in the interior of the store receptacle and a subsequent turning movement of the store receptacle around said connecting means to be brought to rest on said supporting member.

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