

[54] **ELECTROSTATIC PRINTING APPARATUS
USING CHARGE INDUCED TONING**

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Related U.S. Application Data

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118/DIG. 23, 355/16

[51] Int. Cl. **G03g 9/04, G03g 13/10**

[58] Field of Search..... 355/10, 16, 17; 96/1 LY;
117/37 LE; 118/DIG. 23

[56] **References Cited**

UNITED STATES PATENTS

3,281,241	10/1966	Mihajlov	96/1
3,556,784	1/1971	Robinson et al.	96/1.4

3,705,768 12/1972 Moraw et al. 355/8

FOREIGN PATENTS OR APPLICATIONS

27,558 0/1969 Japan 355/10

Primary Examiner—Richard L. Moses

[57] **ABSTRACT**

A source of electrostatic charges comprising a latent electrostatic image is brought into close proximity to a record member having one face of the said record member wetted by a liquid toner. The toner is in contact with both the electrostatic charge source and the record member for an interval during which a latent charge of opposite sign is induced in the record member and the toner particles in the liquid toner are driven by the field lines established between the electrostatic charge source and the induced charge on the record member to form a visible image on the record member.

16 Claims, 4 Drawing Figures

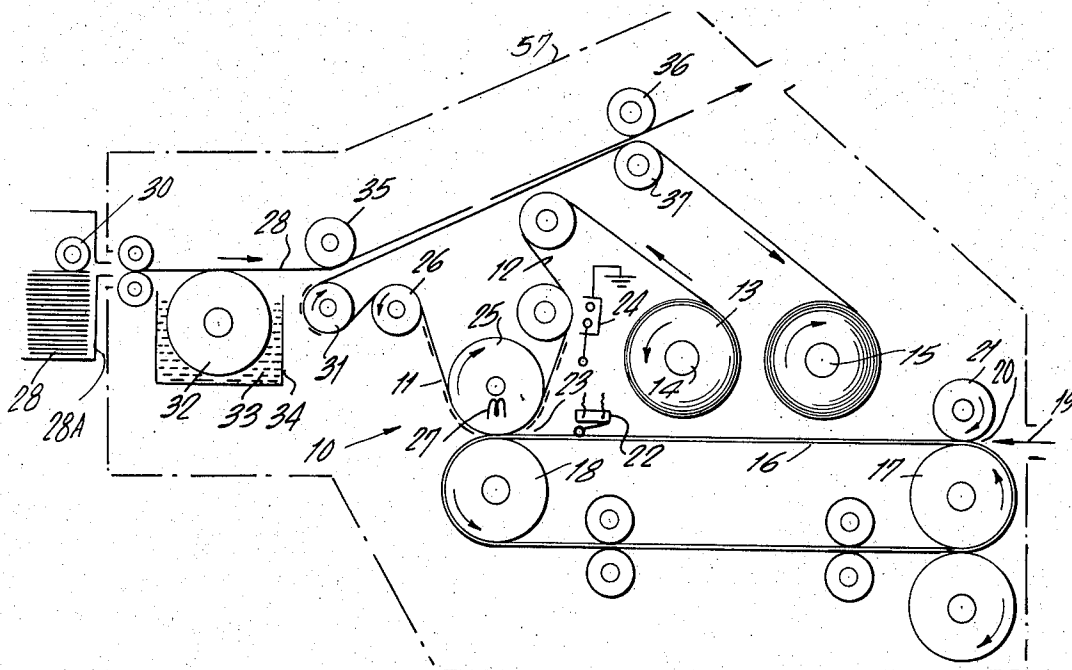


FIG. 1

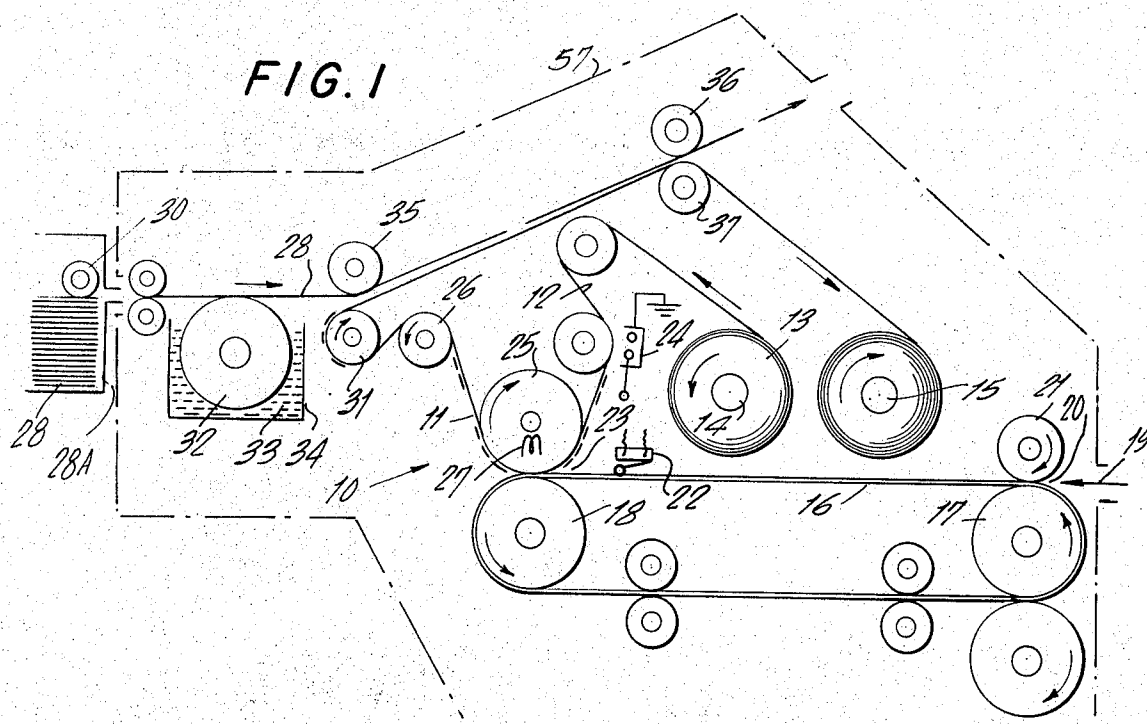
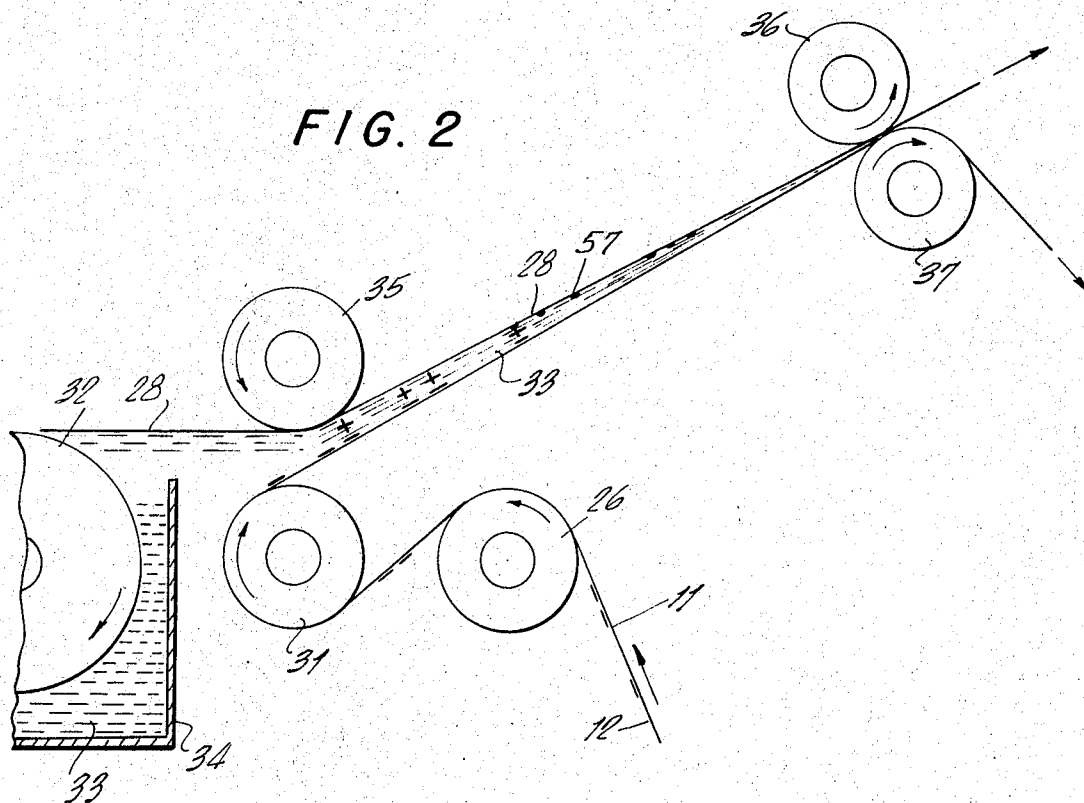


FIG. 2



SHEET 2 OF 2

FIG. 4

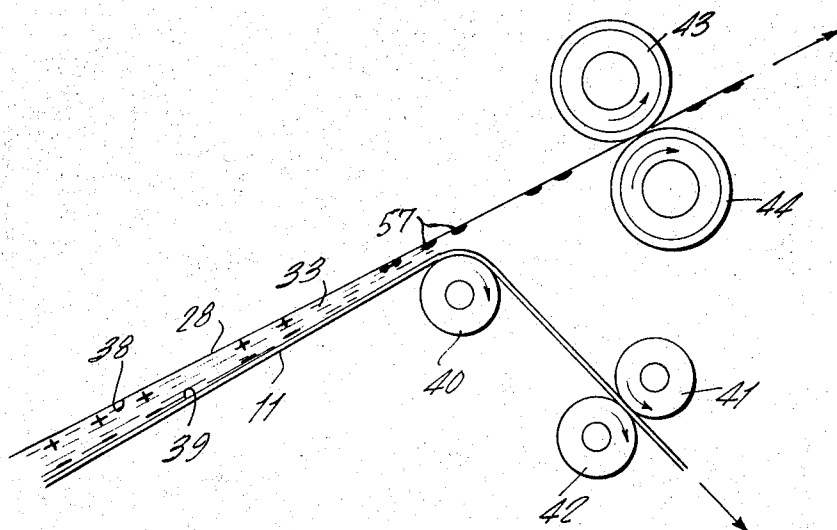
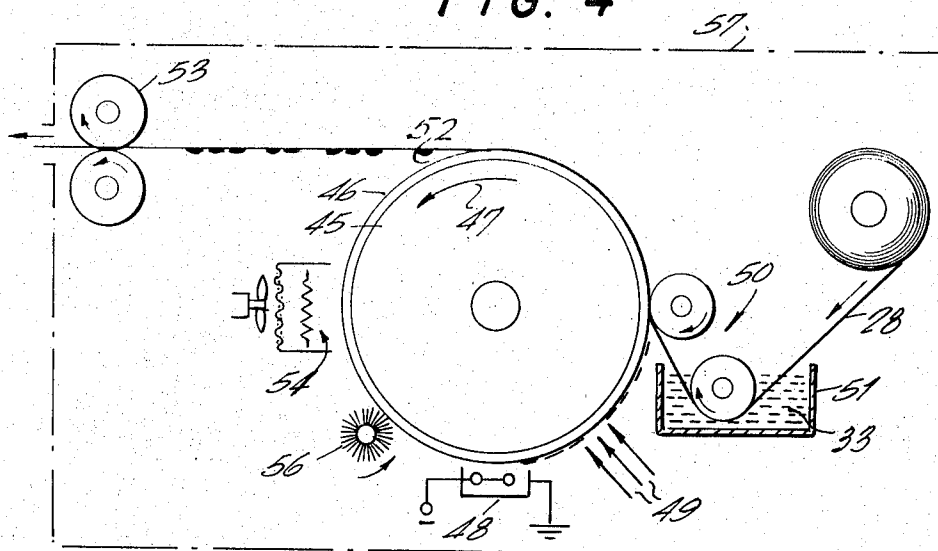


FIG. 3

ELECTROSTATIC PRINTING APPARATUS USING CHARGE INDUCED TONING

This is a continuation, of application Ser. No. 221,646, filed Jan. 28, 1972.

BACKGROUND OF THE INVENTION

Electrostatic printing apparatus in which a latent charge image is formed upon a surface such as photoconductive insulating layer, toned by the application of dry toner particles thereto and the toner thereafter transferred to a record medium to produce a copy of the original are well-known, (the Xerographic process). Such apparatus, in the use of dry toner require fusing steps to permanently affix the toner to the record member, expensive mechanisms to clean the photoconductive surfaces following each cycle and high voltages for their successful operation.

Toning an electrostatic latent image in the nip of two rollers or between a roller and a flat plate or two flat plates pressed together has been disclosed in U.S. Pat. No. 3,556,784 issued to Robinson et al. This patent, however, requires that toning be effected simultaneously with the application of the pressure applied to the two sheets and that no toner other than that necessary to form a visible image get past the line of pressure. These requirements place great limitations upon the nature of the equipment and supplies which can be employed in the practice of the invention.

Accordingly, it is an object of the present invention to provide electrostatic printing devices free of many of the limitations of prior art devices.

Another object of the present invention is to provide an electrostatic printing device in which an inexpensive record member is employed.

A further object of the present invention is to provide a relatively simple and less-expensive electrostatic printing device.

Still another object of the present invention is to provide an electrostatic printing device in which the toning step is carried out between the source of electrostatic charges and the record member in the presence of an image inducing field.

SUMMARY OF THE INVENTION

In the present invention a latent electrostatic image is produced upon a sheet, plate or drum by any of the well-known means such as charging and selectively exposing a web, plate or drum having a zinc-oxide in resin xerographic coating or a selenium xerographic coating; or by selectively charging an insulative sheet. A sheet or web of record material such as a suitable paper is uniformly pre-wetted to provide a layer of toning liquid thereon. The wetted record material is brought into close proximity with the latent image bearing member so that the gap between the record member and the latent image bearing member is filled by the liquid toner. The record material and the latent image bearing member with the toner between them are kept in this position for an interval of time sufficient for the field lines emanating from the latent image to induce a mirror image of opposite sign in the record member. During this interval the field lines repel the toner particles in the toner liquid (which are of opposite sign from the latent image charge) thereby driving them on to the record member, the induced image of which attracts them thereby forming a visible image on the record

member. The toning of the record member during the induction charging of the record member is herein referred to as "induction toning."

The toned record member is next separated from the latent image bearing member following which it may be dried in air or squeegeed dry between suitable rollers.

DESCRIPTION OF THE DRAWINGS.

In the accompanying drawings forming part hereof, similar parts have been given identical reference numerals, in which drawings:

FIG. 1 is a somewhat diagrammatic side view of one complete embodiment of the present invention.

FIG. 2 is a diagrammatic side view on an elongated scale showing the induction charging station of the embodiment of FIG. 1.

FIG. 3 is a view similar to FIG. 2 showing an alternate structure for drying the record member and latent image bearing member following induction toning.

FIG. 4 is a somewhat diagrammatic side view of a second embodiment of the present invention employing a drum as the latent image bearing member.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the drawings and particularly to FIGS. 1 and 2; 10 indicates, somewhat diagrammatically, a side view of an electrostatic printing apparatus according to the present invention. It will be understood that the apparatus is enclosed in a light tight housing 57 in accordance with well-known electrostatic printing machine principles. For the purpose of illustration the electrostatic image bearing member 11 is shown as an elongated web such as a strip of paper, plastic or the like having a coating 12 on one face thereof consisting of a layer of conductive material such as a conductive salt or resin upon which there is deposited a photoconductor. The photoconductor may be a zinc-oxide in resin xerographic coating, a selenium xerographic or an organic photoconductive coating or any of the other photoconductive materials well-known in the electrostatic printing art. Alternately, a highly insulative material may be employed for the electrostatic image bearing member 11 in which case an electrostatic latent image may be placed thereon by means well-known in the art, such as an array of charge emitter pins or the like.

The web 11 is carried as a roll 13 upon a shaft 14. After passing through the apparatus the web 11 is wound upon a second shaft 15.

A continuous feed belt 16 is carried upon pulleys 17, 18 which are driven by a source of rotary power (not shown). The indicia bearing sheet, indicated by the arrow 19 is fed into the nip 20 between a roller 21 and the belt 16 with the side to be copied facing up. Other sheet advancing means such as rollers may also be employed.

As the indicia sheet moves into the apparatus 10 it trips a switch 22 which sets the copying mechanism in motion. The web 11 is advanced in front of a corona charger 24 or other source of ions so that a uniform electrostatic charge is placed upon the photoconductive surface 12 of the web. The web 11 is further advanced into the nip 23 formed by the feed belt 16 upon the pulley 18 and a transparent or translucent drum 25. The indicia bearing sheet mates with the web 11 in

the nip 23 and light from the source 27 passing through a slit (not shown) reflex exposes the photoconductive material 12 in the manner well-known in the electrostatic printing art, to produce an incorrect left-right reading latent image on the photoconductor.

The web 11 with the latent electrostatic image formed by the reflex exposure next passes over idler roller 26 and under idler roller 31 whereupon the selectively charged photoconductive surface 12 is positioned as the upper surface of the web. It has also been found desirable to incline the web upward slightly as shown in FIGS. 1 and 2.

A supply of record members 28 in sheet or roll form is contained within a storage chamber 28A. The record member material is selected from among ordinary papers having some barrier to liquid toner penetration as for example: clay coated, starch coated or resin coated papers. Dense sheets which have been fibrillated and calendered during manufacture such as glassine sheets can be used in the practice of the present invention.

Using paper as the record member having a moisture content equilibrated to relative ambient humidities of from 10 percent to 90 percent or other suitable materials having resistivities of from that of conductive metals up to 1×10^{16} ohm cms. Satisfactory copy can be achieved with machine speeds of from less than 1 to about 30 inches per second.

The record member 28 passes across a reservoir 34 having a roller 32 which is rotated within a quantity of liquid toner 33. The toner contains particles having a charge of the same electrical sign as the latent charge image. This device, known as a kiss roller, applies a thin, uniform film of liquid toner to the bottom surface of the record member. It is important in securing good toning and therefore satisfactory imaging that the toner liquid be first applied to the record member and not to the electrostatically charged surface. As the two faces are brought together, as shown in FIGS. 1 and 2, the toner particles will then be repelled by the like sign charges of the latent image and the toner particles driven toward the induced charge image on the record member.

It will be apparent that other liquid toner applicators such as dipping trays, wicks, reverse rollers and the like may be substituted for the kiss roller, shown in FIGS. 1 and 2.

It will be seen from an examination of the enlarged drawing of the toning portion of the apparatus shown in FIG. 2, that the record member sheet 28 and the web 11 are brought close together by reason of the relative spacing of the rollers 31 and 35. A separation of between one-sixteenth to one-eighth inch at the rollers 31, 35 between the record member sheet 28 and the web 11 has been found suitable. The slight incline of the record member sheet material 28 and the web 11 as they synchronously move together toward the squeeze rollers 36, 37 causes the toner to flow across the opposed faces and improves the uniformity of the toner liquid layer between the web and record member. As shown in FIG. 2, an induced charge of opposite sign (positive) builds up upon the record member caused by the proximity of the latent charge on the photoconductive layer 12. The field lines coming from the photoconductor 12 pass through the toner, normal to the surface of the record member 28, thereby providing great field strength. A high contrast system result may thus

be achieved in a low charge system with excellent solid area fill in.

In conventional liquid toning of a zinc oxide latent image bearing surface, a typical charge of 400 volts on a coating of 20 lbs. per 3,000 square feet is required to produce image densities between 0.5 to 0.7. With the present invention, it is possible to achieve similar densities on the record member with zinc oxide latent image charges of 125 volts and only 9 lbs per 3,000 square feet of zinc oxide and resin coating. As a result substantial economies can be achieved. Since the zinc oxide bearing web is not the final copy, less expensive base material can be used and dying of the zinc oxide resin coating to achieve desired appearance may be eliminated.

The time interval required for induction toning (of the order of from 0.1 sec. to 10 sec.) serves to permit the build up of the induced charge on the record member and also allows toner particles to migrate laterally within the liquid and thereby increase the density of the image produced on the record member. Excellent uniform solid area image fill is thus produced on the record member.

The use of the induction time charge build up eliminates any need for contacting the rear of either the record member or web with conductive elements, voltages or ground loop, (which devices may cause random field effects detrimental to good imaging), or connecting rollers to each other by biasing.

The distance between rollers 31, 35 and the squeeze rollers 36, 37 provides for a charge build up interval during which induction toning occurs. The induced charge on the record member 28 increases during this interval and the toner particles in the liquid which are of opposite sign to the induced charge (e.g., negative in the example illustrated) are both repelled by the latent image charge and attracted to the said induced charge.

In order to produce good imaging resolution it is important to keep the record member and latent image bearing member moving synchronously (that is without relative longitudinal or lateral displacement).

In the above there has been described the production of a positive image (black on white) on the record member. It will be apparent to those skilled in the art that a negative image (white on black) can be produced on the record member by employing a toner having particles of the opposite sign to that of the latent image charge.

By the time the record member 28 and the photoconductive web 11 reach the squeeze rollers 36, 37 the toning is complete and the visible image produced on the record material. The squeeze rollers 36, 37 merely serve to dry the record member 28 and the web 11 as they pass therethrough. In some toner formulations employing highly volatile solvents the squeeze step may be eliminated. As the record member leaves the squeeze rollers 36, 37, it is ejected from the apparatus as a finished copy. The web 11 is wound up upon the take up shaft 15 as shown in FIG. 1.

In FIG. 3 there is shown another arrangement for drying the toned record member 28 and the photoconductive web 11. In this embodiment the opposed faces 38, 39 are not brought together but are always separated by a distance at least as great as the film of toner material 33 therebetween. Following the induction imaging step, at which time the visible image has been

produced upon the record member 28, the web 11 is lead away from the record member 28 by directing it over guide roller 40 and, if desired, through squeegee rollers 41, 42 from which it is taken up on shaft 15 (see FIG. 1).

The record member 28 in the embodiment of FIG. 3 continues through blotter rollers 43, 44 which dry and synchronously move the toned record member and direct it out of the apparatus. Additional air or heat can be applied to assist drying.

Referring to FIG. 4 there is shown another embodiment of the present invention in which the photoconductive layer support is a cylindrical drum 45. If the drum 45 is made of conductive material a photoconductive material 46 such as zinc oxide in a resin binder, selenium, anthracene etc. may be coated on the surface thereof. If the drum 45 is not conductive, a thin layer of a suitable conductive material such as metal may be interposed between the drum 45 and the photoconductive material 46. In the diagrammatic illustration of FIG. 4, the drum 45 rotates in a counter clockwise direction indicated by the arrow 47.

A source of electrons such as the corona charger 48 applies a uniform charge to the photoconductive material 46 as the drum 45 is rotated in front of the corona charger. It will be understood that the apparatus of FIG. 4 is enclosed in a light tight housing 57 and that the charging of the photoconductive material is carried out while it is in the dark adapted state.

The charged photoconductive surface is next selectively discharged in accordance with well-known electrostatic printing techniques by either reflex exposing, as described in connection with FIG. 1 or by projecting a wrong reading left to right aerial image of the indicia to be reproduced upon the surface of the photoconductor 46 as indicated by the arrows 49.

As the drum 45 continues to rotate it reaches the toning station 50 where the record material 28 which has been pre-wetted by passing it through a tray 51 containing liquid toner 33 is brought against the selectively charged surface of the drum. The drum 45 and record material 28 with the liquid toner therebetween rotate together synchronously, that is without lateral or horizontal displacement with respect to each other, for an interval of time sufficient to enable the induction toning of the record member to take place as the latent charge image placed on the photoconductive material 46 induces a charge image of opposite sign into the record member 28. It will be understood that if a positive image is desired the toner particles 57 will be of the same charge as the latent image charge and if a negative image is desired the toner particles will be of the opposite charge as hereinabove set forth in connection with FIG. 1.

The record member 28 is separated from the drum 45 following the induction toning interval as indicated at 52. As the record material 28 leaves the drum 45 a right reading image of the indicia desired to be printed will be on the bottom surface of the record member. The record member 28 can then be air dried, heat dried or squeegeed dry by the rollers 53 as desired.

Following separation of the record material at 52, the drum 45 is rotated past a heater 54 where a blast of warm air dried the surface of the drum of any toner liquid which may remain on the drum. A soft rotating brush 56 may next be used to brush off any toner particles which may remain on the photoconductor.

The drum 45 then moves past the cleaning station brush 56 into the charging station in front of the corona charger 48.

From the foregoing it will be seen that there have been provided electrostatic printing devices employing induction toning in which the visible image is produced on plain (not electrostatically coated) paper and which are not subject to the limitations of prior art devices such as humidity restriction complexity, size, etc.

Having thus fully described the invention, what is claimed as new and desired to be secured by Letters Patent of the United States, is:

1. An electrostatic printing apparatus comprising a housing, a latent charge image receiving member within said housing, means to create a latent charge image upon the latent charge image receiving member, a source of sheet-like record material, a source of liquid toner, means to (wet) apply a thin film of said toner to at least one major surface of the record material (with the liquid toner), feed means to bring the latent image bearing member and record member together in an initially gapped relationship with one wetted surface of the record member facing a surface of the latent image bearing member, means to transport the said wetted record member and latent image bearing member synchronously and along a converging path with the liquid toner on the record member in contact with the surface of the latent image bearing member until an image is induced in the record member and a visible image is formed upon the record member by the said toner and means adjacent the end of said converging path for separating the toned record member from the latent image bearing member.

2. An electrostatic printing apparatus according to claim 1 in which the latent charge image receiving member is an elongated support having a photoconductive insulative layer thereon.

3. An electrostatic printing apparatus according to claim 2 in which the support is a continuous strip of flexible material having an electrically conductive surface and a layer of a photoconductive material carried on said conductive surface.

4. An electrostatic printing apparatus according to claim 3 in which the photoconductive material is a zinc oxide in resin layer.

5. An electrostatic printing apparatus according to claim 1 in which the latent image bearing member is a highly insulative strip on a conductive backing.

6. An electrostatic printing apparatus according to claim 1 in which the latent image bearing member is a cylindrical drum.

7. An electrostatic printing apparatus according to claim 6 in which the surface of the drum is formed of electrically conductive material upon which there is carried a layer of photoconductive material.

8. An electrostatic printing apparatus according to claim 7 in which the photoconductive material is selenium.

9. An electrostatic printing apparatus according to claim 6 in which the latent charge image creating means comprises means to uniformly charge the charge image receiving surface of the drum and means to direct an aerial image upon said uniform charge.

10. An electrostatic printing apparatus according to claim 1 in which the feed means to bring the latent image bearing member and the record member to-

gether includes at least one roller closely adjacent the latent image bearing member and disposed so as to direct the record member toward the latent image bearing member.

11. An electrostatic printing apparatus according to claim 10 in which the roller is separated from the latent image bearing surface a distance of the order of one-sixteenth to one-eighth inch.

12. An electrostatic printing apparatus according to claim 10 in which the feed means includes a pair of squeegee rollers disposed at the end of the synchronous travel path of the latent image bearing member and record member and before the separating means.

13. An electrostatic printing apparatus according to

claim 12 in which the squeegee rollers are disposed on either side of the record member following the separating means.

14. An electrostatic printing apparatus according to claim 1 in which the transport means directs the wetted record member and the latent image bearing member upwardly and along a non-vertical path whereby the liquid toner flows, between the record member and the facing surface of the latent image bearing member.

15. An electrostatic printing apparatus according to claim 14 in which the non-vertical path is sloping.

16. An electrostatic printing apparatus according to claim 14 in which the non-vertical path is curvilinear.

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