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3,359,945	12/1967	Hastings et al.....	118/637
3,369,918	2/1968	Young.....	117/37 L
3,392,707	7/1968	Marx.....	117/37 L X
3,407,786	10/1968	Beyer et al.....	118/637
3,435,802	4/1969	Nail.....	118/637

OTHER REFERENCES

Crawford, T. M., Developing Electrostatic Charge Patterns, IBM Technical Disclosure Bulletin; Vol. 8, No. 4, Sept., 1965, Page 527.

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[54] **APPARATUS FOR DEVELOPING LATENT ELECTROGRAPHIC IMAGES WITH LIQUID INK**
6 Claims, 4 Drawing Figs.
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[51] Int. Cl..... **G03g 13/00**
[50] Field of Search..... **118/602, 638, 637, 410, 637 LX; 117/37, 93.4, 93.4 A, 93.41**

[56] **References Cited**

UNITED STATES PATENTS			
1,928,235	9/1933	Taylor.....	118/637 L X
2,431,041	11/1947	Hassler.....	118/637 L X
3,202,072	8/1965	Limberger.....	118/637 L X
3,284,224	11/1966	Lehmann.....	118/637 L X
3,177,793	4/1965	Stewart.....	118/637 L
3,249,088	5/1966	Ostensen.....	118/637

ABSTRACT: An electrographic developer is disclosed which includes an ink pervious development electrode structure having a development surface over which an electrographic recording web bearing latent electric charge images to be developed is disposed. Liquid ink is forced through the ink pervious electrode structure against the image bearing surface of the recording web for developing the latent charge image pattern. The development electrode can take the form of a plate, a roller or a continuous belt. In the case of the continuous belt or roller, ink is forced through the ink pervious electrode structure from the inside and the recording web is pressed into engagement with the outer surface of the electrode structure.

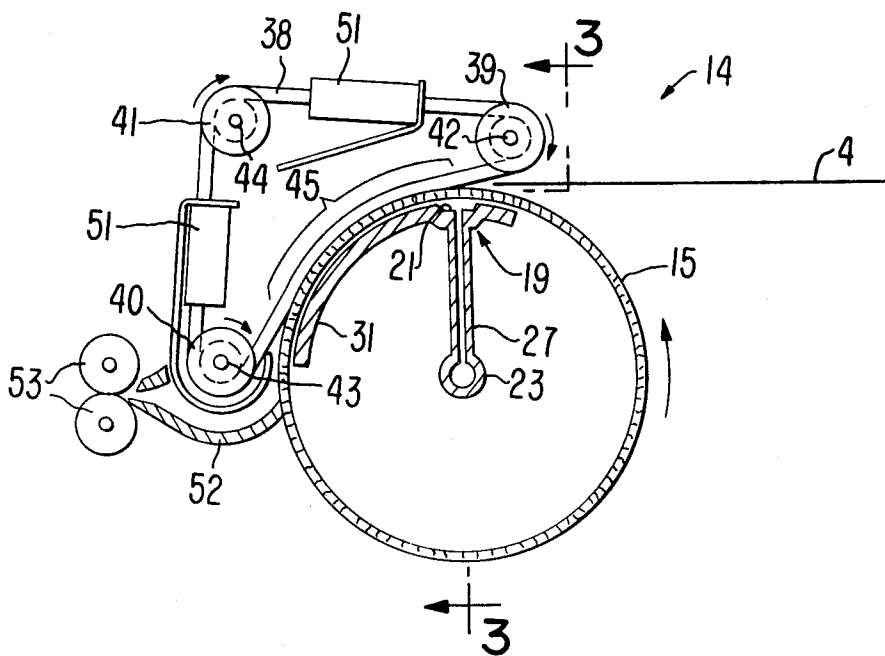


FIG. 1

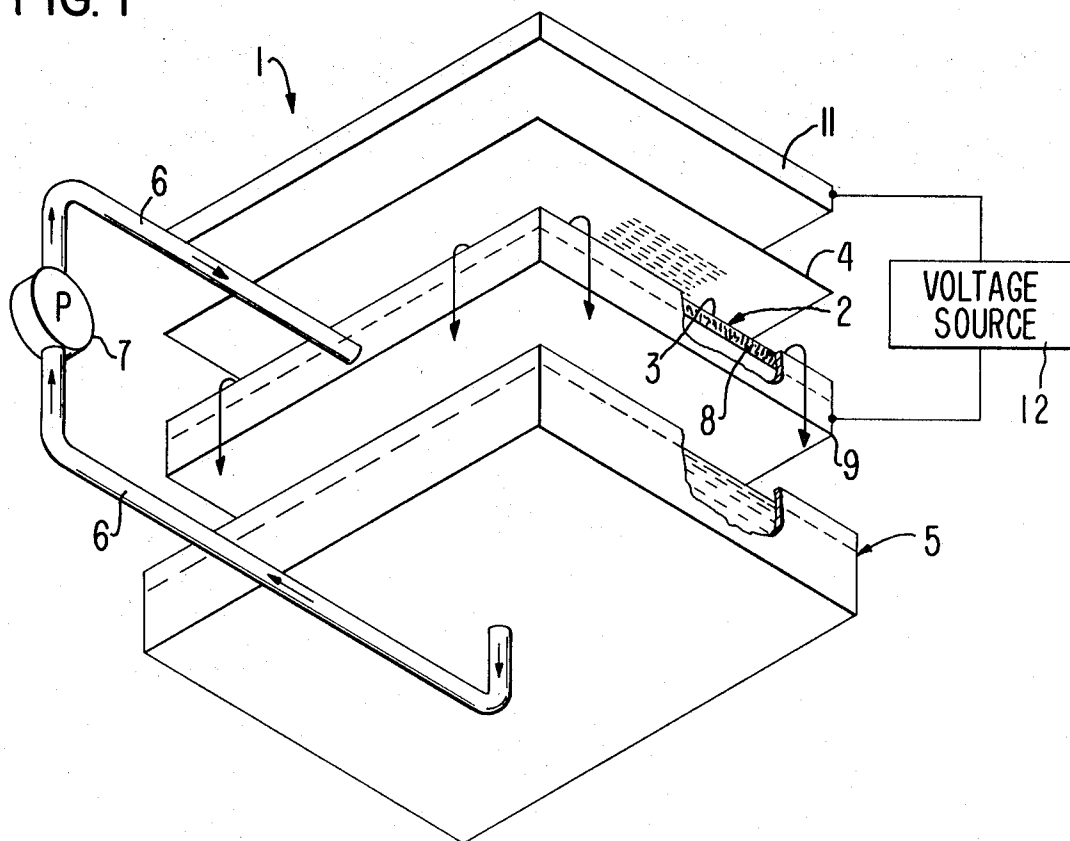
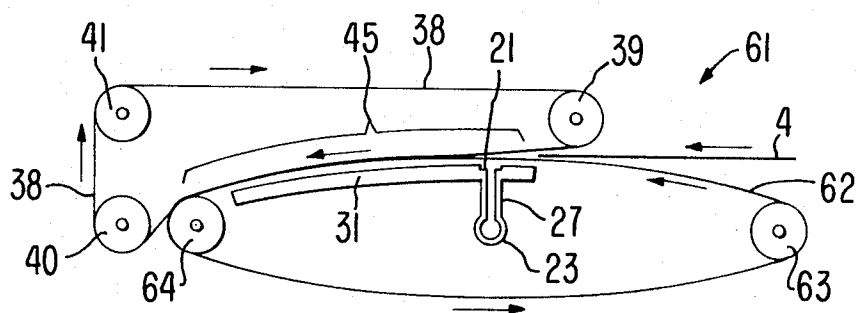


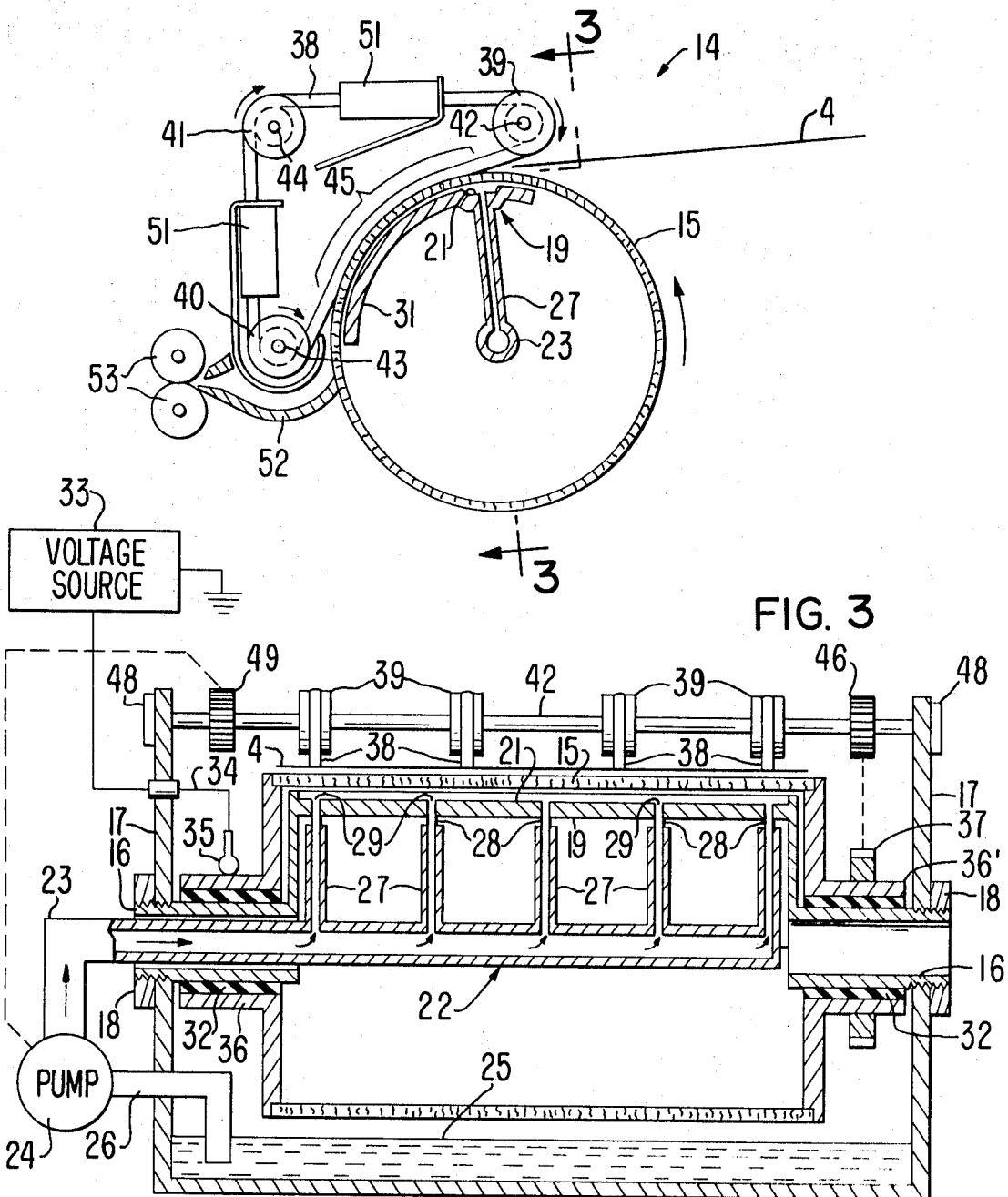
FIG. 4



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FIG. 2



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APPARATUS FOR DEVELOPING LATENT ELECTROGRAPHIC IMAGES WITH LIQUID INK

DESCRIPTION OF THE PRIOR ART

Heretofore, development electrodes for developing electrographic images with liquid ink have employed a porous development electrode to be saturated with electrographic ink for carrying the ink to the charge retentive surface of the recording web to be developed. In the case of a continuous printer, the porous development electrode took the form of a drum having a lower portion thereof immersed in a reservoir of electrographic ink such that as the drum rotated it picked up additional ink to supply the ink lost to the recording web. The problem with this prior art electrographic developing apparatus was that at relatively high printing and developing speeds, the rate of depletion of pigmented toner particles from the liquid carrier was greater than the normal replacement by particle migration in the fluid at the surface, such that the electrographic charge images were not sufficiently developed. An example of this prior art porous development electrode inker is disclosed in U.S. Pat. No. 3,096,198 issued July 2, 1963.

Others, have proposed electrographic inkers wherein an ink absorbent pad, as of cotton, felt or fiberglass, was impregnated or supplied with ink from a reservoir under pressure. The pad was caused to contact the charge image bearing surface of the recording web for developing same. In one such prior proposal the recording web to be developed was disposed between a roller and an absorbent pad, there being a gear arrangement connected to the roller for causing the supply of ink supplied to the absorbent pad to vary in accordance with the rotational speed of the roller. However, use of such a nonconductive absorbent pad is not suitable for development of a relatively large area electrographic images, such as encountered in electrophotography, since the proper development of such large area images requires the provision of a development electrode adjacent the charge image bearing surface of the recording web. Moreover, the use of the absorbent pad inker provided a relatively small contact area between the pad and the recording web which tends to substantially reduce the available development time and therefore substantially limits the speed at which electrographic images can be properly developed due to the relatively low mobility of the pigment particles in the ink.

SUMMARY OF THE PRESENT INVENTION

The principal object of the present invention is the provision of an improved developer for developing latent electrographic images with liquid electroscopic ink.

One feature of the present invention is the provision, in an electrographic inker, of an ink pervious conductive development electrode structure and means for forcing electroscopic ink through the ink pervious development electrode structure onto the image bearing surface of an electrographic recording web to be developed, whereby relatively large area development is possible at relatively high development speeds.

Another feature of the present invention is the same as the preceding feature wherein the ink pervious development electrode structure is formed into a closed path such as that provided by a continuous belt or drum and wherein an arcuate inking trough structure is disposed inside the continuous belt or drum for forcing the liquid electroscopic ink through the ink pervious development electrode structure to the recording web partially wrapped around the outside of the development electrode structure, whereby ink is supplied simultaneously to a relative large area of the recording web to be developed.

Another feature of the present invention is the same as the preceding feature wherein ink is fed to the inking trough by a hollow axle on which the ink pervious drum is rotatable.

Another feature of the present invention is the same as any one or more of the preceding features wherein an elastic belt is at least partially wrapped around and movable with a closed path ink pervious development electrode structure for

pressing the recording web into engagement with the movable development electrode structure.

Other features and advantages of the present invention will become apparent upon a perusal of the following specification taken in connection with the accompanying drawings wherein:

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an exploded schematic perspective view, partially broken away, depicting an electrographic inker incorporating an ink pervious conductive pad,

FIG. 2 is a side cross-sectional view of an electrographic inker incorporating an ink pervious conductive roller,

FIG. 3 is a sectional view of the structure of FIG. 2 taken along line 3—3 in the direction of the arrows, and

FIG. 4 is a schematic line diagram depicting an alternative electrographic inker incorporating an ink pervious conductive belt.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to FIG. 1, there is shown an electrographic inker 1 for developing relatively large area electrographic images, such as those obtained by electrophotography, and incorporating features of the present invention. Electrographic inker 1 includes an ink pervious development electrode structure 2 having a development surface 3 over which is disposed the charge retentive surface of an electrographic recording web 4 to be developed. Electroscopic ink is supplied to the development electrode structure 2 from a reservoir 5 disposed below the level of the development electrode 2 via an ink return line 6 and a pump 7. The ink pervious development electrode structure 2 includes an ink pervious plate 8, as of 0.046 inch thick porous stainless steel. A suitable porous stainless steel material is commercially available under the trade name Felt Metal FM-123-125 from Huyck Metals Company, 45 Woodmont Road, Milford, Connecticut. Such ink pervious stainless steel plate is porous with the average pore size falling within the range of 85 to 150 microns and is approximately 65 percent dense.

The ink pervious plate 8 closes off the top of a rectangular chamber 9 into which is fed the electroscopic ink via pump 7 and line 6 from the reservoir 5. The output pressure of the pump 7 is adjusted such that there is a continuous flow of ink through the ink pervious plate 8 against the charge-bearing surface of the recording web 4 for developing same. The excess ink flows over the side edges of the development electrode structure 2 and is caught by the reservoir 5 for recirculation. A backup plate electrode structure 11 is disposed adjacent the conductive side of the recording web 4 and a source of potential 12 is connected between the backup plate 11 and the development electrode structure 2 for applying a suitable development potential across the recording web 4 during development thereof.

In FIG. 1 the view is exploded for the sake of explanation. However, in use, the recording web 4 would be placed in nominal contact with the development surface 3 of the development electrode structure 2 and the backup plate 11 would be placed into nominal contact with the conductive surface of the electrographic recording web 4. In this manner, the electroscopic ink is applied only to the image-bearing surface of the recording web 4 and an adequate supply of electroscopic ink is continuously supplied to the image for developing same in a relatively short development time span. The use of the conductive development electrode structure 2 assures uniform development and proper gray scale tonal characteristics to the resultant print when relatively large area charge images are to be developed, such as those encountered in electrophotography.

Referring now to FIGS. 2 and 3, there is shown a relatively high speed continuous electrographic developer 14 incorporating features of the present invention. The developer 14 includes a drum-shaped development electrode structure 15. The cylindrical wall of the development electrode structure 15

is made of the ink pervious conductive material, such as that described above for plate 8 of the development electrodes 2 of FIG. 1. The drum 15 is carried upon a centrally disposed axle 16 which in turn is fixedly secured, at its ends, to a metallic housing 17 via lock nuts 18. The axle 16 includes an axially offset portion 19 disposed immediately adjacent the inside surface of the drum 15 and including an axially directed recessed portion 21 to define an inking trough.

An electroscopic ink distribution manifold 22 is disposed inside the drum 15 and includes a tubular portion 23 defining an ink inlet tube passing axially through the hollow axle 16 to the output of an ink pump 24 which in turn is connected to a reservoir 25, disposed below the inking drum 15, via pump inlet conduit 26. A plurality of feed conduits 27 branch off from the main conduit 23 and are connected to nipples 28 passing through the bottom of the inking trough 21 at a plurality of axially spaced positions 29 for feeding electroscopic ink from the pump via conduit 23 and feed lines 27 into the inking trough 21.

A curved skirt portion 31, of cylindrical section, is affixed to one side of the inking trough 21 and extends in the direction of rotation of the drum along the inside surface of the drum and conforming to the inside surface of the drum. The spacing between the skirt 31 and the inside surface of the drum 15 is made relatively small to trap electroscopic ink in the space between the skirt 31 and the drum 15 with substantial hydrostatic pressure derived from the inking trough 21. In this manner, ink is forced due to the hydrostatic pressure through the ink pervious drum over a substantial arcuate section of the drum, as of 90° of arc, to provide a relatively large development area, more fully described below.

The drum 15 is supported from axle 16 via electrically insulative bearings 32, as of Teflon. A development potential is applied to the drum 15 from a source of potential 33 via lead 34 and wiper blade 35 bearing in slidable engagement on a hub portion 36 of the drum 15. The drum 15 is rotatably driven around the axle 16 from a motor, not shown, via a chain driven sprocket 37 fixed to the opposite hub 36' of the drum 15.

A plurality of elastic bands or belts 38 are carried in "V" grooves in the periphery of wheels 39, 40, and 41 carried upon axles 42, 43, and 44 respectively. The elastic bands 38, as of neoprene rubber, are arranged to ride in elastic bearing engagement with a substantial arcuate section of the periphery of the drum 15, indicated at 45 in FIG. 2. Drive wheels 39 are rotationally driven via a chain driven sprocket 46 pinned to axle 42. The drive wheels 39 are driven at such a speed that the elastic bands 38 move at the same speed as the periphery of the rotating drum 15.

An electrographic recording web 4 to be developed is slipped into position between the elastic bands 38 and the periphery of the drum 15 with the charge image-bearing surface of the recording web 4 facing the drum 15. The recording web 4 is partially wrapped around the drum 15 via the provision of the elastic bands 38 and the rotation of the drum 15 such that the charge image on the recording web is exposed to electroscopic ink flowing through the drum 15 over substantially the entire arcuate extent of the skirt 31 and trough 21, roughly indicated by numeral 45.

Drive 42, and idler shafts 43 and 44 for the belt drive wheels 39, and idler wheels 40 and 41 are carried at their ends from the housing 17 via retaining rings 48. A second sprocket 49 is affixed to drive shaft 42 and a chain schematically indicated at 50, is fixed to sprocket 49 and connected to the pump 24 for causing the flow through the pump to vary in accordance with the rotational speed of the drum 15. In a typical example, 0.23 gallons per minute of electroscopic ink is fed through the pump 24 and inking trough 21 for developing electrographic recording webs carried around the drum 15.

Wipers 51 are disposed around each of the elastic belts 38 for wiping the ink off the bands and returning the ink to the reservoir 25.

A comb-shaped structure 52 is disposed with its fingers riding in slidable engagement with the surface of the rotating drum 15 opposite, or near to, the end of the skirt 31 for peeling the developed electrographic recording web from the drum 15 and feeding the developed web through a pair of squeegee rollers 53 for squeegeeing ink from the recording web. Thence, the developed web is fed through a drying section, not shown, wherein the web is dried by an airblower.

Referring now to FIG. 4, there is shown, in schematic line diagram form, an electrographic inker 61 incorporating alternative features of the present invention. Inker 61 is substantially the same as that described above with regard to FIGS. 2 and 3 with the exception that instead of using a cylindrical inking drum 15 a continuous sheet metal band 62 of porous metal, as of 0.010 inch thick stainless steel is employed. Band 62 is formed into an oblong path having a relatively large radius of curvature for the arcuate section 45 to be contacted with the recording web 4 for development thereof. In this manner, the volume of the inking apparatus that has to be devoted to the development electrode structure is substantially reduced compared to the use of a cylindrical or a drum shaped development electrode 15, as shown in FIGS. 2 and 3. The continuous belt electrode 62 is rotationally driven by a frictional drive roller 63 disposed at one end of the elongated closed loop of the belt and opposite from an idler roller 64 disposed at the opposite end of the oblong loop of the belt 62.

Since many changes could be made in the above construction and many apparently widely different embodiments of this invention could be made without departing from the scope thereof, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. An apparatus employing liquid ink having a suspension of toner particles therein for developing the charge image on the charge retentive surface of a moving recording medium, comprising the combination:

a rotatable drum developing electrode made of ink pervious conductive material the outside surface of which is adapted to engage the charge retentive surface of the moving recording medium as the drum rotates;

liquid ink feed trough positioned proximate the inside surface of the drum development electrode and displaced slightly from top dead center in the direction of rotation for preventing ink from flowing onto the back of the recording medium;

hollow axle means for supporting the rotatable drum and for distributing fresh liquid ink to the feed trough; and

hydrostatic pressure means for forcing the ink from the feed trough through the porous drum development electrode and onto the charge retentive surface of the recording medium to continuously replenish the toner particles as the development proceeds and toner particles are depleted from the ink.

2. The apparatus of claim 1, wherein the feed trough includes a skirt structure extending in an arc around the inside surface of the drum in the direction of rotation for establishing a hydrostatic pressure head on the liquid ink contained between the skirt and the drum.

3. An apparatus for developing the charge image on the charge retentive surface of a moving recording medium with liquid ink-containing particles of toners suspended therein, comprising the combination:

a development electrode which is pervious to the liquid ink and has an upper surface adapted to engage the charge retentive surface of the recording medium;

liquid ink feed trough positioned proximate the underside of the development electrode for supplying liquid ink against the undersurface of the development electrode;

a skirt extending from the feed trough along the underside of the development electrode and proximate to the development electrode defining a liquid ink distribution channel; and

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pump means for forcing the liquid ink from the feed trough into the ink distribution chamber between the skirt and the development electrode and through the development electrode and onto the charge retentive surface of the recording medium.

4. The apparatus of claim 3, wherein the development electrode is formed in a rotatable closed loop the outside surface of which engages the charge retentive surface of the recording medium and the inside surface of which is disposed toward the feed trough and the skirt.

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5. The apparatus of claim 4, wherein the feed trough is displaced slightly from top dead center of the loop development electrode in the direction of rotation for preventing liquid ink from flowing onto the back of the recording medium.

5 6. The apparatus of claim 4, wherein the area of engagement between the recording medium and the outside surface of the loop development electrode is at least partially coextensive with the area of the distribution channel along the inside surface of the loop development electrode.

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