

[54] **LIQUID DEVELOPER SYSTEM FOR ELECTROSTATIC COPIER**

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[51] Int. Cl. **G03d 3/12**

[58] Field of Search **95/89, 94; 355/10, 355/100, 106; 118/637, DIG. 23, 602, 603, 428, 429**

[56]

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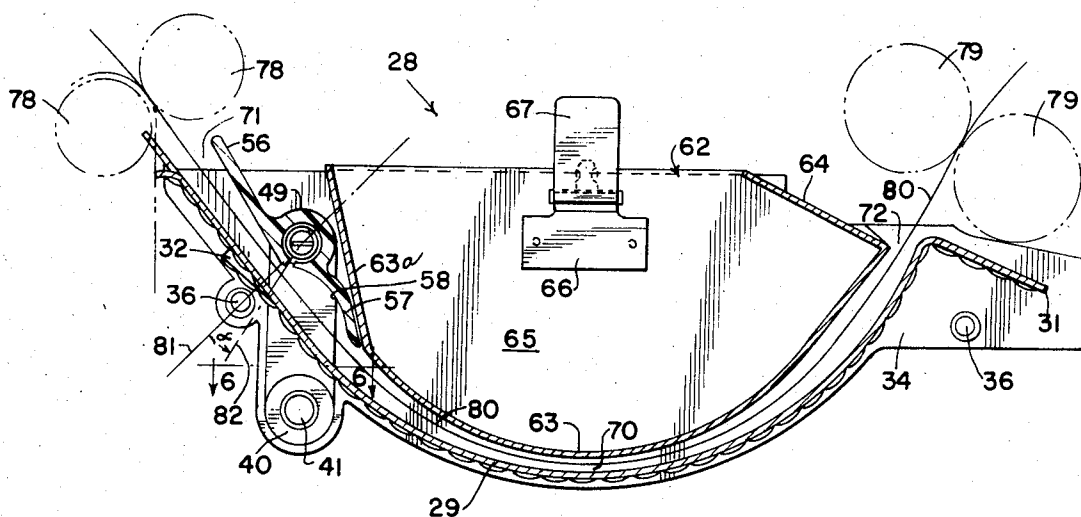
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[57]

ABSTRACT

Upper and lower guides are curved in the direction of the path of movement of the copy material to be developed and extend transversely of such path for a distance greater than the width of the copy material. Opposed walls are connected with the ends of these guides to define a confined arcuate space with an inlet slot and an outlet slot. A liquid developer distribution outlet opens into such arcuate space adjacent to and inwardly of the inlet slot for distributing a flow of developer fluid in a pattern extending transversely of said path for a distance substantially the same as the width of the copy material. The liquid developer is forced through said outlet under pressure resulting in a turbulent flow of the developer liquid throughout the arcuate space thereby causing a substantial quantity of fresh, active, charged toner particles to come into contact with the latent electrostatic image on the copy material.

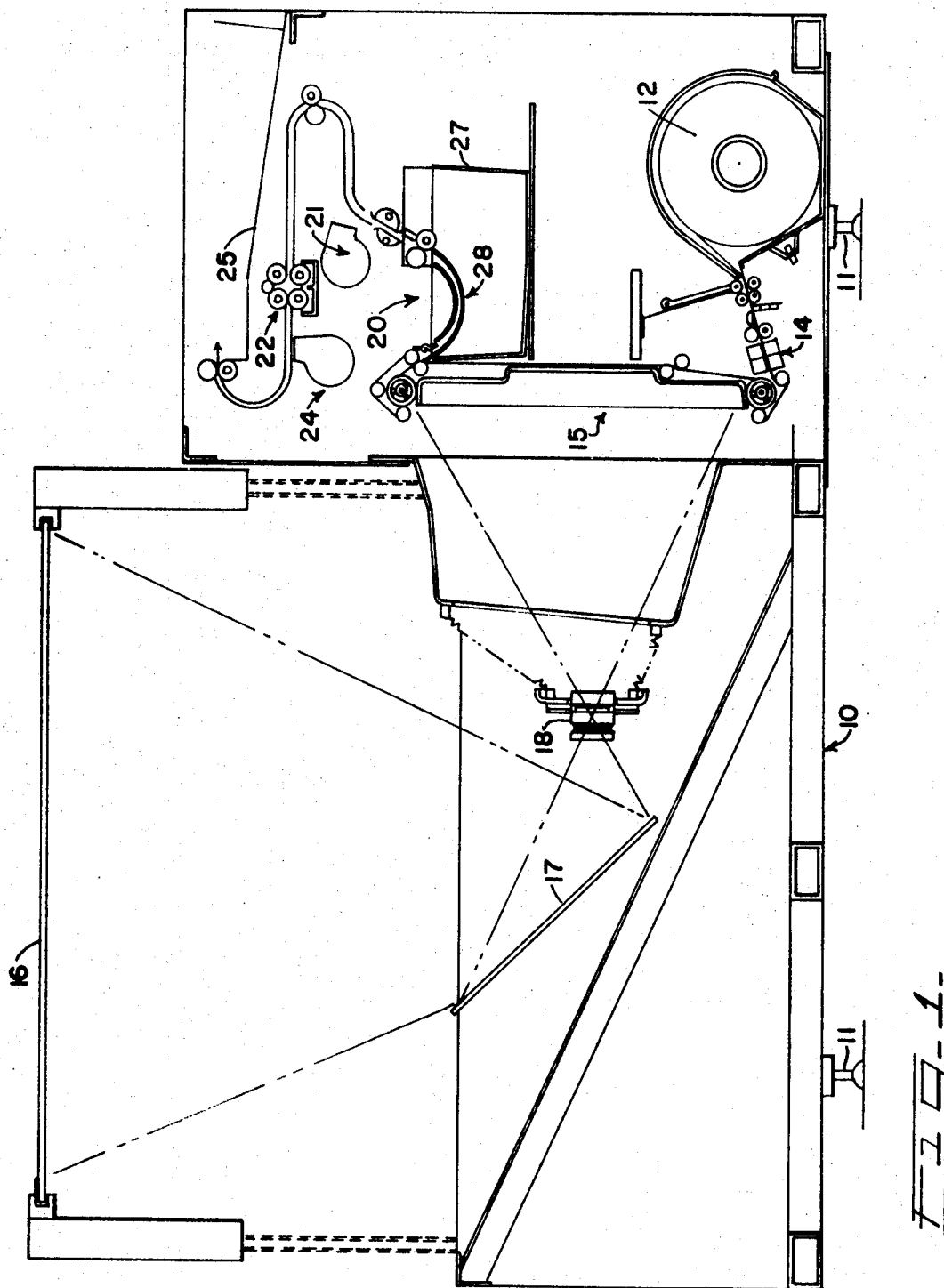
12 Claims, 6 Drawing Figures



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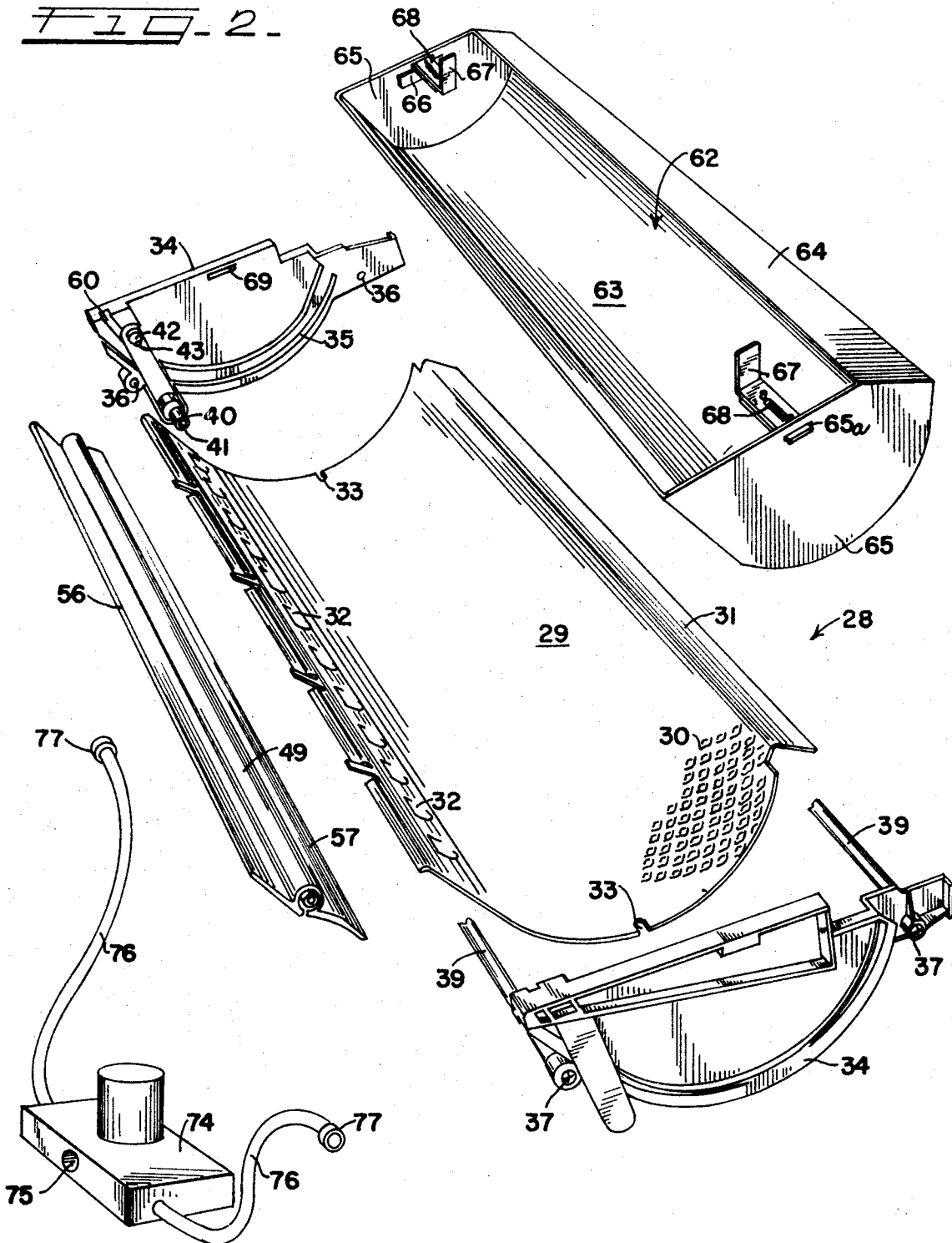
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FIG. 2.

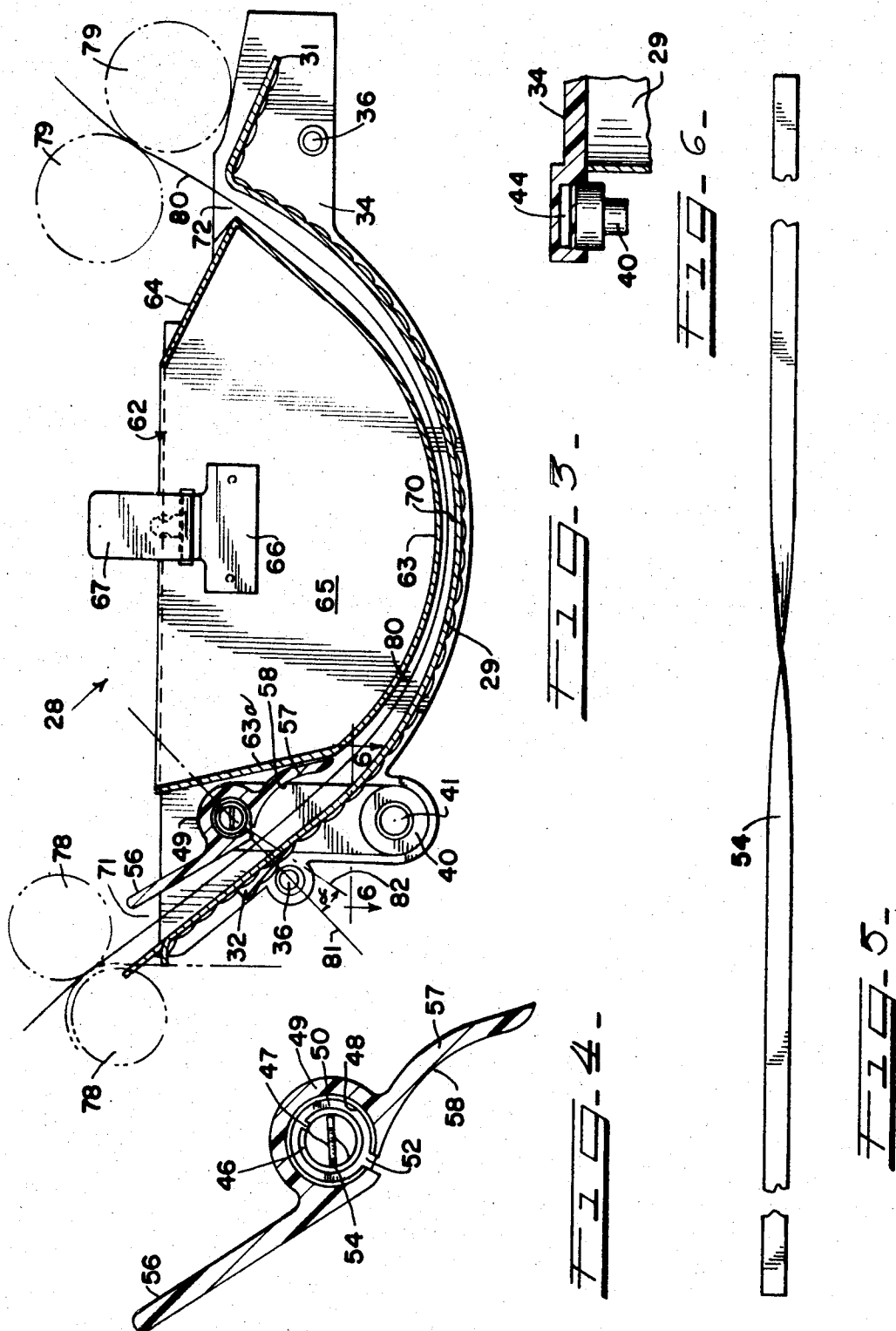


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LIQUID DEVELOPER SYSTEM FOR ELECTROSTATIC COPIER

BACKGROUND OF THE INVENTION

1. Field of the Invention

The field of the present invention pertains to electrostatic copying machines in which a sheet of material having a photoconductive coating thereon receives an electrostatic charge and then is exposed to an image of an original to produce a latent electrostatic image of the original on the copy material. The copy material carrying the latent electrostatic image is passed through a developing zone in which it is brought into contact with particles of toner material which adhere to the copy material over the charged areas of the latent image. After passing through the developing zone, the copy material is advanced through a drying station where the developed image is fixed. More particularly, the field of the present invention relates to copying machines of the type described wherein a liquid toner or developer is used to bring the toner particles into contact with the latent electrostatic image on the copy material.

2. Prior Art

In one system according to the prior art, the copy material is passed through a still pool of developer fluid. In another prior art system, the developer fluid is caused to flow uniformly and non-turbulently through an arcuate confined space in a direction opposite to the path of movement of the copy material. Representative prior art liquid developer systems are shown in U.S. Pat. Nos. 3,359,945, 3,361,113 and German Offenlegungsschrift No. 1,572,389, laid open to public inspection on Feb. 26, 1970.

These prior art systems, although generally satisfactory, are nevertheless often deficient in supplying adequate quantities of charged or active toner particles throughout the entire area of the latent electrostatic image so as to bring about optimum development of the image. The present invention is directed to a novel liquid developer system which does not have that deficiency and which possesses other advantages over the prior art.

SUMMARY AND OBJECTS OF THE INVENTION

The present invention may be summarized as relating to means defining a confined arcuate space through which the copy material is passed in the developing zone, and to a specially arranged and adapted liquid developer distribution outlet in said space which forces the liquid developer thereinto in a turbulent manner so that a substantial quantity of fresh, active toner particles are brought into contact with the latent electrostatic image.

A primary object of the present invention is the provision of a new and improved liquid developer system for an electrostatic copier.

Another object of the present invention is the provision of a liquid developer system of the type described wherein the developer fluid is caused to flow in a turbulent manner in a confined arcuate space through which the copy material is passed.

These and other objects and advantages of the invention will become apparent from the following specification disclosing a preferred embodiment shown in the accompanying drawings.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a vertical section, largely diagrammatic, of an electrostatic copying machine in which the present invention is embodied;

FIG. 2 is an exploded perspective view showing the principal components constituting the present invention;

FIG. 3 is an enlarged vertical section through the components shown in FIG. 2;

FIG. 4 is an enlarged section taken through the liquid developer distribution channel;

FIG. 5 is an elevational view of a twisted element received within the distribution channel; and

FIG. 6 is a section taken along the line 6—6 of FIG. 3.

DESCRIPTION OF A PREFERRED EMBODIMENT

Referring to FIG. 1, an electrostatic copying machine in which the present invention is embodied is seen to include a housing or frame 10 supported by a plurality of feet 11. The housing 10 contains a rotatably mounted roll 12 of copy material having a coating of photoconductive material thereon, such as zinc oxide, for example. The copy material is advanced by suitable rollers to a corona or charging station 14 for subjecting the copy material to a potential between a corona discharge wire and a ground roller (not shown), all in a manner well known to those skilled in the art.

The copy material, having received a charge, is advanced by suitable rollers and belts to the exposure station, generally designated 15. An original to be copied is placed face down on the glass platen 16. An image of the original to be copied is focused on the copy material at the exposure station by means of a mirror 17 and a lens assembly 18, whereupon a latent electrostatic copy of the original is formed on the copy material.

The copy material is then passed through a developer zone, generally designated 20, in which the present invention is embodied. In this zone, as will be explained more fully below, the copy material with the latent electrostatic image thereon is brought into contact with the developer fluid carrying particles of a suitable toner which adhere to the copy material over the charged areas thereof for forming a visible copy of the original. After leaving the developer zone 20, the copy material is passed under a drying blower 21 for affixing the image on the copy material. Next, the copy material is passed through a conversion station 22 for coating its image side with a suitable conversion solution to change the surface property of the copy material from hydrophobic to hydrophilic thereby making the copy capable for use as a master in an offset duplicating apparatus. After passing through the conversion station, the copy material is advanced past another drying blower 24 and is then advanced into a tray or receptacle 25 for removal from the copying machine.

It is believed that the foregoing description of the electrostatic copying machine, which of itself forms no part of the present invention, is adequate for an understanding of the invention to be described hereinbelow. The present invention is not to be limited for use with the particular copying machine just described; the invention has applicability in other forms of electrostatic copying machines which utilize a wet or liquid developer. For further background information as concerns

electrostatic copying machines in which the present invention may be utilized, reference may be had to U.S. Pat. No. 3,361,113.

The developer zone 20, which embodies the present invention, primarily includes a developer tank 27 and a trough assembly, generally designated 28, which assembly is suitably mounted in the developer tank. The trough assembly includes a lower guide plate 29 which is curved in the direction of the path of movement of the copy material and which extends transversely of such path for a distance greater than the width of the copy material. The guide plate 29 preferably has its upper surface defined by dimpled formations 30 to minimize the area of contact between such plate and the underside of the copy material. The plate 29 is bent along one longitudinal edge thereof to form a drainage lip 31. The lower guide plate 29 includes a plurality of openings 32 struck therefrom to provide an overflow for the liquid developer as will be explained hereinbelow. The lower guide plate also contains a pair of drainage openings 33.

The trough assembly 38 includes a pair of end wall members 34, which members are of identical but opposite-hand construction. Each end wall member contains an arcuate slot 35 for receiving an end of the plate 29. A pair of apertures 26 is formed in each end wall for receiving fasteners 37, which fasteners are threadingly received within the ends of connecting rods 39. It will be apparent that the connecting rods and fasteners serve to secure the end wall members 34 to the lower guide plate 29.

Each end wall includes an integral formation 40 defining an inlet port 41; such end wall member also includes another cylindrical formation 42 having a tapered end and defining an outlet port 43. These ports are in communication with each other by means of a passageway 44 (FIG. 6) formed in each end wall 34.

The tapered cylindrical formations 42 are received within opposite ends of a distribution pipe 46, which pipe includes a slot 47 extending along the length thereof. This pipe is mounted within the bore 48 of a distribution channel 49. Suitable spacers (not shown) mount the pipe 46 in spaced relation within the bore 48 so as to define an annular chamber 50. The channel 49 includes an outlet slit 52 extending the length thereof, which slit communicates with the annular space 50. The aforementioned spacers mount the pipe 46 such that its slot 47 is in diametrically oppositely disposed relationship with the slit 52. A strip 54, which is twisted such that its planar end portions are at right angles to each other, is mounted within the pipe 46 to improve the flow pattern of the liquid developer as will be explained herein.

The distribution channel includes an integral, generally planar flange portion 56. This channel member also includes an integral, arcuate flange 57 defining a generally downwardly facing recess 58.

It will be apparent that upon assembly of the trough 28, the strip member 54 is inserted within the pipe 46 and the latter mounted within the bore 48 by the aforementioned spacers. The tapered cylindrical formations 42 are inserted within opposite ends of the pipe 46 during the process of assembling the end walls 34 to the lower guide plate 29. Each end wall 34 is preferably provided with a slot 60 to receive an end portion of the distribution channel 49 to aid in mounting the same in place.

The trough assembly 28 further includes an upper guide structure, generally designated 62, which contains an upper guide plate 63 curved in the direction of the path of movement of the copy material and which extends transversely thereof for a distance greater than the width of the copy material. The upper guide plate is bent to define a generally upstanding planar portion 63a. This upper guide plate is joined with a splash plate 64. A pair of end plates 65 is suitably connected to the plates 63, 64.

Each plate 65 has a bent bracket 66 connected thereto, which bracket slidably mounts another bracket 67 having an upstanding portion so as to be grasped by a person's fingers. Springs 68 urge respective brackets 67 outwardly with end portions thereof extending through apertures 65a in the plate 65. These projecting end portions of the brackets 67 are adapted to be received within recesses 69 formed in respective end plates 34. The subassembly 62 is mounted in place by grasping the upstanding portions of the brackets 67 and withdrawing the projecting end portions so that the same are flush with the plate 65. After positioning of the subassembly 62 in place, the brackets 67 are released allowing the end portions thereof to snap into place within the recesses 69.

Referring to FIG. 3, the upper guide plate 63 cooperates with the flanges 56, 57 of the distribution channel to define an upper guide surface, which surface is generally complementary in shape with the lower guide plate 29, is closely spaced thereto, and defines, along with end walls 34, a confined, arcuate space 70. The longitudinally extending edge of the flange 56 cooperates with the adjacent longitudinally extending edge of the plate 29 to define an inlet slot 71 for the space 70, which slot of course extends transversely of the path of movement of the copy material for a distance greater than the width thereof. The longitudinally extending edge of the plate 63, which joins with the splash plate 64, cooperates with the adjacent longitudinally extending rounded portion of the plate 29 at its juncture with the drainage lip 31 to define an outlet slot 72 for the space 70, which outlet slot extends transversely of the path of movement of the copy material for a distance greater than the width of the latter.

Referring to FIG. 2, a pump 74, of the flooded sump type, is mounted at the bottom of the developer tank 27. This pump has an inlet opening 75 and a pair of outlet pipes or conduits 76, each of which conduits includes a fitting 77 for engagement with the cylindrical formation 40 thereby to place the conduits 74 into communication with the inlet ports 41 in the end walls 34.

Suitable rollers and/or belts, shown in phantom lines in FIG. 3 and designated 78, are provided for feeding the copy material into the confined arcuate space 70 through its inlet slot 71. Similar rollers and/or belts 79, again shown in phantom lines in FIG. 3, receive the copy material from the outlet slot 72 and advance the copy material to other stations or zones in the electrostatic copying machine as explained above.

In operation, a sheet or length of copy material 80 with the latent electrostatic image thereon is grasped by the nip of the roller 78 and fed through the inlet slot 71 into the confined arcuate space 70 with the latent image facing upwardly. The pump 74 is placed into operation prior to arrival of the copy material for forcing a suitable developer or toner solution through the con-

duits 76. Such fluid is admitted into opposite ends of the pipe 46. The twisted member 54 assures that the developer fluid is distributed uniformly throughout the length of the pipe 46. The fluid passes through the slot 47 and enters the annular chamber 50. The fluid is discharged through the slit 52 in a pattern extending along the length of such slit.

As noted in FIG. 3, the slit 52 is angularly disposed with respect to the longitudinal central axis of the distribution channel such that the fluid is discharged through the slit 52 at an angle with respect to the plane of the copy material. An imaginary plane perpendicular to the plane of the copy material 80 adjacent the slit 52 is designated 81. The pattern of developer fluid leaving the slit 52 may be considered as defining another imaginary plane 82. In a preferred embodiment of the invention, the planes 81, 82 define an angle α , in the order of 15°.

The developer fluid entering the arcuate space 70 through the slit 52 flows in a turbulent manner throughout substantially all areas of this arcuate space. The developer fluid is discharged from the space 70 by flowing over the drainage lip 31, and also by flowing through the outlet openings 32. A small amount of the developer fluid is discharged through the openings 33 in the lower guide plate 29. Because of the splash plate 64 and the cooperating effect of the lower guide plate portion 63a and the distribution channel flange 56, the developer fluid is not permitted to flow or to be splashed into the opening at the top of the subassembly 62. It is noted that the outlet slit 52 is disposed at an elevation lower than the outlet openings 32 such that the outlet slit will be immersed in the liquid developer at all times during operation of the developer system according to the present invention.

All of the liquid developer discharged from the arcuate space 70 of the trough assembly 28 flows into the developer tank 27. Suitable means (not shown) automatically operated by sensors, add toner concentrate to the developer fluid in the tank 27 such that the same always contains a sufficient amount of active toner particles to develop the latent electrostatic image properly.

It has been found that because of the aforementioned turbulent flow of the developer fluid throughout substantially all of the confined arcuate space 70, optimum development of the latent electrostatic image is achieved. Because of this turbulent flow, all of the charged areas of the copy material have an opportunity to attract active toner particles. In other words, the latent image of the copy material is flooded with the fast moving turbulent fluid so as to allow a large quantity of fresh, active, charged toner particles to come into contact with the copy material. Therefore, the weakly charged areas as well as the strongly charged areas of the latent electrostatic image will be presented with charged toner particles such that the solid image areas are well filled and an excellent electrostatic copy will be made.

The aforementioned turbulent flow action of the developer fluid is aided by the provision of the recess 58. This recess, which faces generally downwardly into the space 70, may be characterized as defined by upstream and downstream longitudinal edges which extend transversely of the path of movement of the copy material, such upstream edge being defined by the adjoining edge of the outlet slit 52. It is believed that the recess

58 provides a suitable space above the image face of the copy material to allow creation or generation of the turbulent flow pattern which continues, although in somewhat diminished form, throughout the confined arcuate space 70 as the fluid flows toward the outlet slot 72.

The aforescribed angular disposition of the outlet slit 52 is of importance in generating this turbulent flow of the developer liquid. If the pattern of liquid developer exiting through the slit 52 were to define a plane perpendicular to the plane of the copy material, an undesired splash would result. If the aforescribed angle α were to be increased substantially beyond the preferred extent, i.e., in the order of 15°, the developer fluid would simply flow more or less uniformly through the space 70 and would not provide the desired turbulent flow according to the present invention. The angular disposition of the outlet slit 52 with respect to the plane of the copy material is such that the fluid force of the exiting developer fluid acting on the copy material may be considered as having one component thereof acting perpendicularly against the copy material and the other component thereof extending along the path of movement of the copy material.

One embodiment of the present invention, which produced an electrostatic copy of excellent quality, was constructed according to the following dimensions. The outlet slit was approximately 12 inches in length and had a width of approximately 0.040 inches (this slit width should be in the order of 0.030 to 0.050 inches to cause adequate jet action to generate the turbulent flow). The thickness of the arcuate space 70 adjacent the outlet slit 52 was approximately 0.187 inches; the thickness of the space 70 at its lowermost portion, which is its area of minimum thickness, was approximately 0.125 inches. The preferred range of thicknesses of the space 70 at its lowermost portion is between 0.093 inches and 0.125 inches. The thickness of the space 70 adjacent its outlet slot was approximately 0.312 inches. The pump 74, which was used with this embodiment just described, had a capacity of 2.5 gallons per minute. The developer solution contained 4 cc's of toner concentrate per quart of solution. It was found that the minimum flow rate which produced copies of high quality was 2.0 gallons per minute — at this rate the developer solution contained 6 cc's of toner concentrate per quart of solution.

We claim:

1. In a liquid developer system for subjecting a length of copy material to the action of a liquid developer in a developing zone through which said length passes along a path, the improvement comprising:

- substantially imperforate lower guide means curved in the direction of said path and extending transversely thereof for a distance greater than the width of such copy material;
- substantially imperforate upper guide means curved generally complementarily with said lower guide means and extending transversely of said path for a distance greater than the width of such copy material;
- substantially imperforate end wall means connected with respective opposite ends of said lower and upper guide means for holding the same in closely spaced relation and thereby defining a confined, arcuate space with an inlet slot and an outlet slot constituted by longitudinal edges of said upper

- and lower guide means extending transversely of said path, the lowermost portion of said arcuate space being disposed between said slots;
- d. liquid developer distribution outlet means within said arcuate space adjacent said inlet slot, said outlet means including first elongated wall means defining an elongated chamber having aperture means therealong which open into said arcuate space adjacent to and inwardly of said inlet slot and second elongated wall means adjacent to and inwardly of said first elongated wall means defining a recess, which recess extends transversely of said path in substantial parallel relation with said aperture means for distributing a flow of developer fluid in a pattern extending transversely of said path for a distance substantially the same as the width of such copy material, said first elongated wall means having an inlet communicating with said chamber;
- e. pump means and conduit means connected to said inlet for forcing developer fluid under pressure through said aperture means and into said arcuate space thereby causing in cooperation with said recess a turbulent flow of developer fluid throughout substantially all of said arcuate space; and
- f. advancing means for advancing a length of copy material along said path through said arcuate space from the inlet slot to the outlet slot thereof.
2. The improvement according to claim 1 wherein said outlet means means is adjacent said upper guide means.
3. The improvement according to claim 2 wherein such copy material has a latent electrostatic image thereon and wherein said advancing means advances such copy material through said arcuate space with such image facing upwardly.
4. The improvement according to claim 3 wherein said lower guide means includes an overflow opening to maintain the level of developer fluid in said arcuate space above said distribution outlet means.
5. The improvement according to claim 3 wherein said distribution outlet means is arranged to discharge developer fluid to produce a fluid force acting on such copy material, which force has one component thereof acting against such copy material perpendicular thereto and has the other component thereof extending along said path.
6. The improvement according to claim 3 wherein said second elongated wall means comprises an arcuate wall defining a downwardly facing recess.
7. The improvement according to claim 6 further de-

finied by:

- a. said recess being defined by upstream and downstream edges which extend transversely of said path; and
- b. said aperture means being defined by a slit extending transversely of said path, said upstream edge being defined by a longitudinal edge of said slit.
8. The improvement according to claim 4 wherein said distribution outlet means is arranged to discharge developer fluid to produce a fluid force acting on such copy material, which force has one component thereof acting against such copy material perpendicular thereto and has the other component thereof extending along said path.
9. The improvement according to claim 4 wherein said second wall means comprises an arcuate wall defining a downwardly facing recess.
10. The improvement according to claim 9 further defined by:
- a. said recess being defined by upstream and downstream edges which extend transversely of said path; and
- b. said aperture means being defined by a slit extending transversely of said path, said upstream edge being defined by a longitudinal edge of said slit.
11. The improvement according to claim 3 wherein:
- a. the dimension of said arcuate space as measured transversely of said path is approximately 12 inches;
- b. the minimum thickness of said arcuate space is in the range of 0.093 to 0.125 inches;
- c. said aperture means is a slit having a length of approximately 12 inches and a width in the order of 0.040 inches; and
- d. said pump means and conduit means are capable of forcing developer fluid through said aperture means at the rate of at least 2 gallons per minute.
12. The improvement according to claim 5 wherein:
- a. the dimension of said arcuate space as measured transversely of said path is approximately 12 inches;
- b. the minimum thickness of said arcuate space is in the range of 0.093 to 0.125 inches;
- c. said aperture means is a slit having a length of approximately 12 inches and a width in the order of 0.040 inches; and
- d. said pump means and conduit means are capable of forcing developer fluid through said aperture means at the rate of at least 2 gallons per minute.
- * * * * *

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3753393 Dated August 21, 1973

Inventor(s) George P. Niesen and Edward Domeco

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

In column 8, lines 36 and 37, after "said" delete "aperture means" and insert -- slit --.

In column 8, lines 48 and 49, after "said" delete "aperture means" and insert -- slit --.

Signed and sealed this 27th day of November 1973.

(SEAL)
Attest:

EDWARD M. FLETCHER, JR.
Attesting Officer

RENE D. TEGTMEYER
Acting Commissioner of Patents

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