United States Patent [19]

Miller

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[45] **Aug. 14, 1973**

[54] **DEVELOPING UNIT**

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[73] Assignee: SCM Corporation, New York, N.Y.

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Related U.S. Application Data

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[52] **U.S. Cl.** ..... **355/10,** 95/89 R, 118/DIG. 23

[51] **Int. Cl.** **G03g 15/10**

[58] **Field of Search** ..... 95/89 R, 89 A, 89 L; 118/DIG. 23; 355/10, 16

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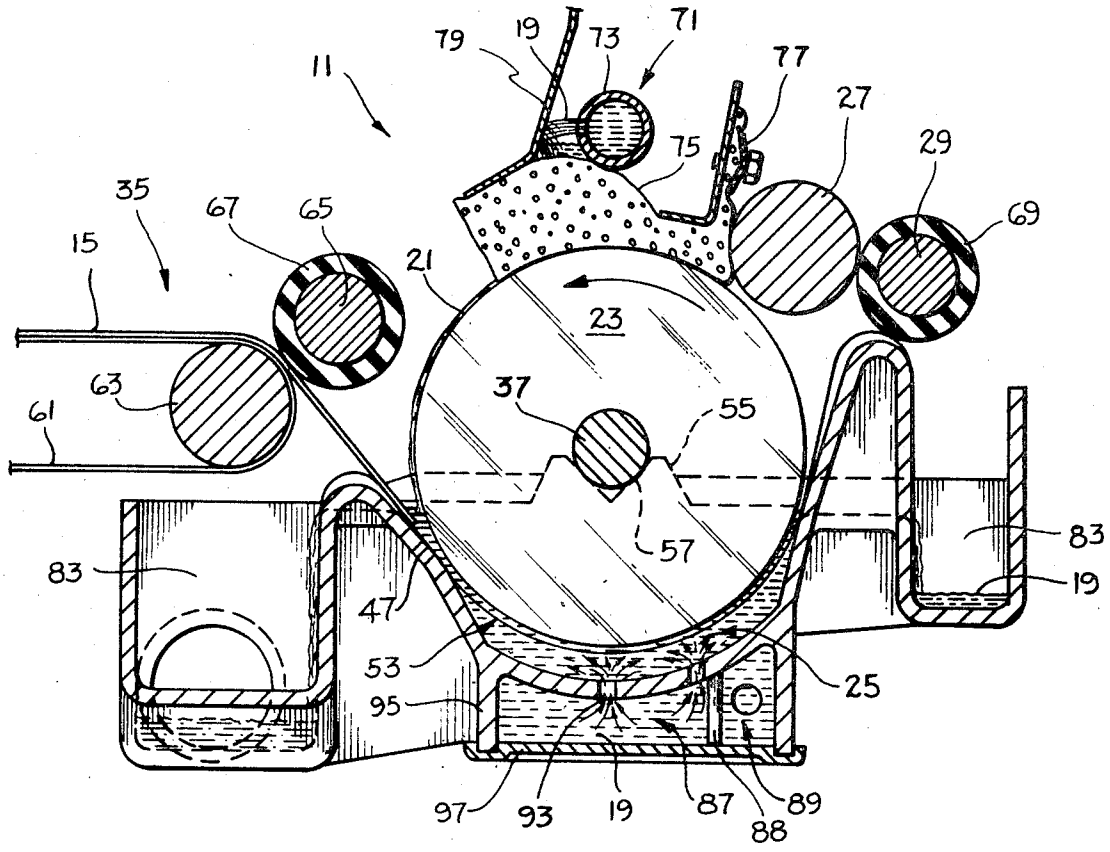
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Primary Examiner—Fred L. Braun
Attorney—Gerald S. Schur et al.

[57] **ABSTRACT**

A latent electrostatic image on a surface of a carrier is developed into a visible image by moving the carrier along a developing path with the image-bearing surface contacting a developing liquid in effective field control spacing with an electrically conductive surface of an image intensifier moving along the developing path. Developing liquid is supplied to the surface of the image intensifier by a porous wiper wetted with developing liquid, and an incoming image-bearing carrier is guided along the developing path in contact with the developing liquid by ridges extending along the developing path on an upwardly concave wall which forms a trough through which the image intensifier moves. As the carrier moves through the developing trough, the image-bearing surface is pressed into effective field control spacing with the image intensifier over an elongated distance of the developing path by developing liquid which is received into a chamber and directed against the back side of the carrier by orifices formed in the upwardly concave wall. After passing through the trough, the carrier is guided through a pair of cooperating squeegee rollers which remove excess developing liquid from the carrier.

10 Claims, 7 Drawing Figures



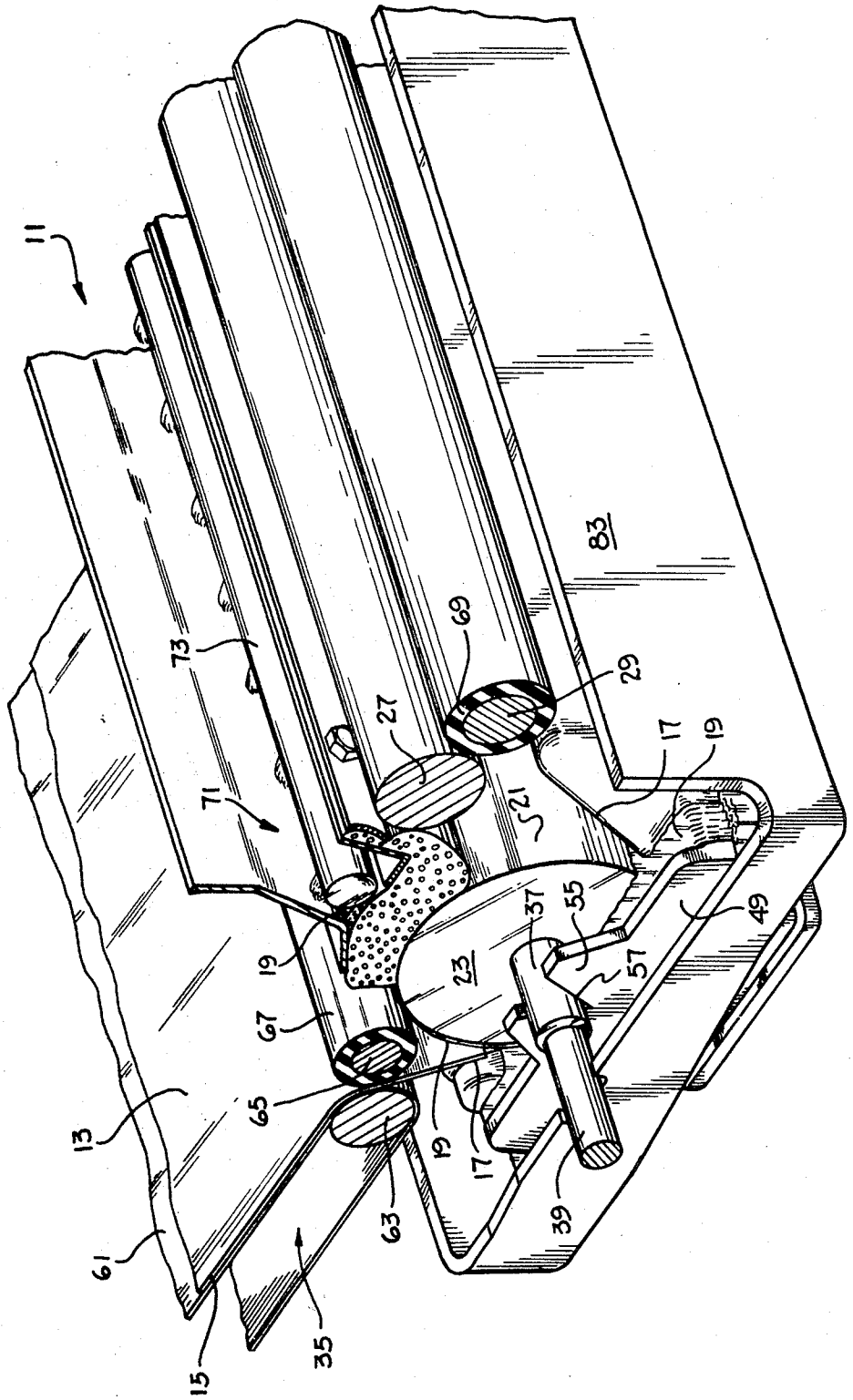

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Fig. 1

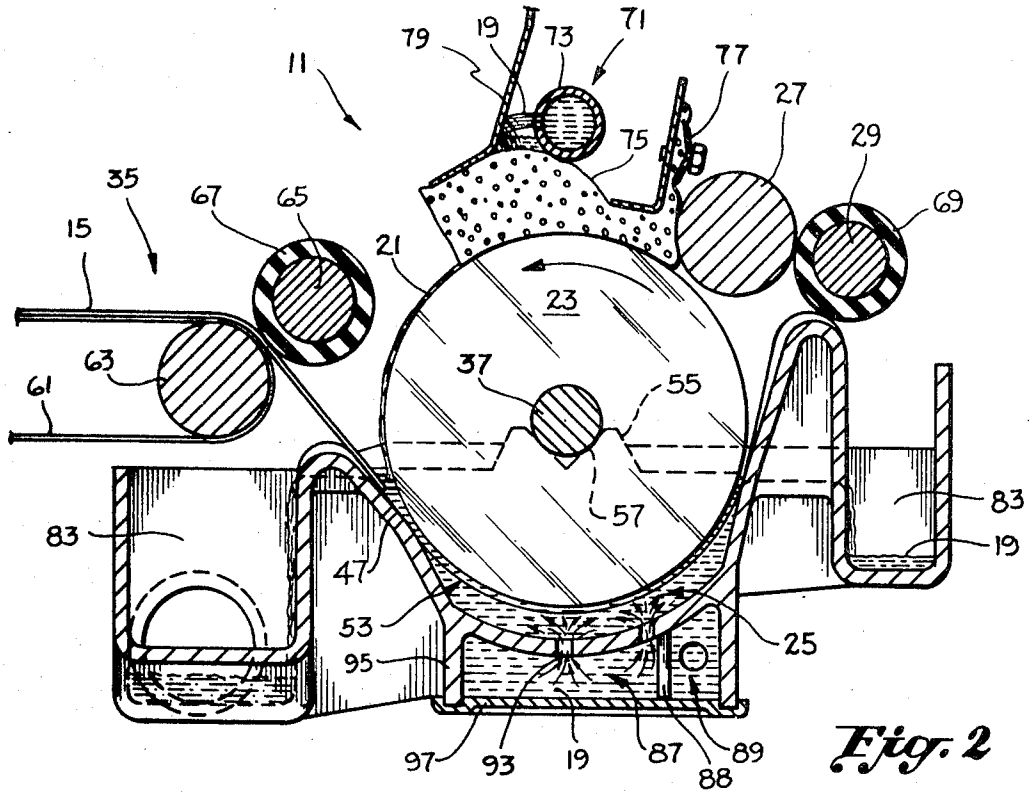

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Fig. 2

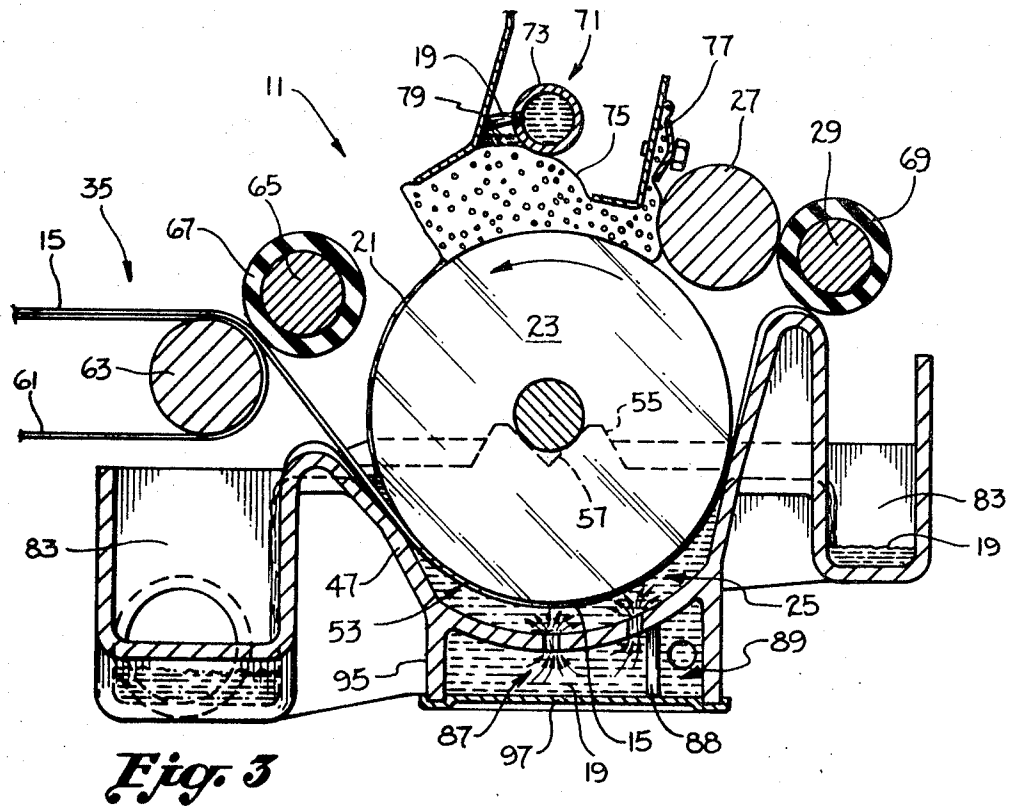

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Fig. 3

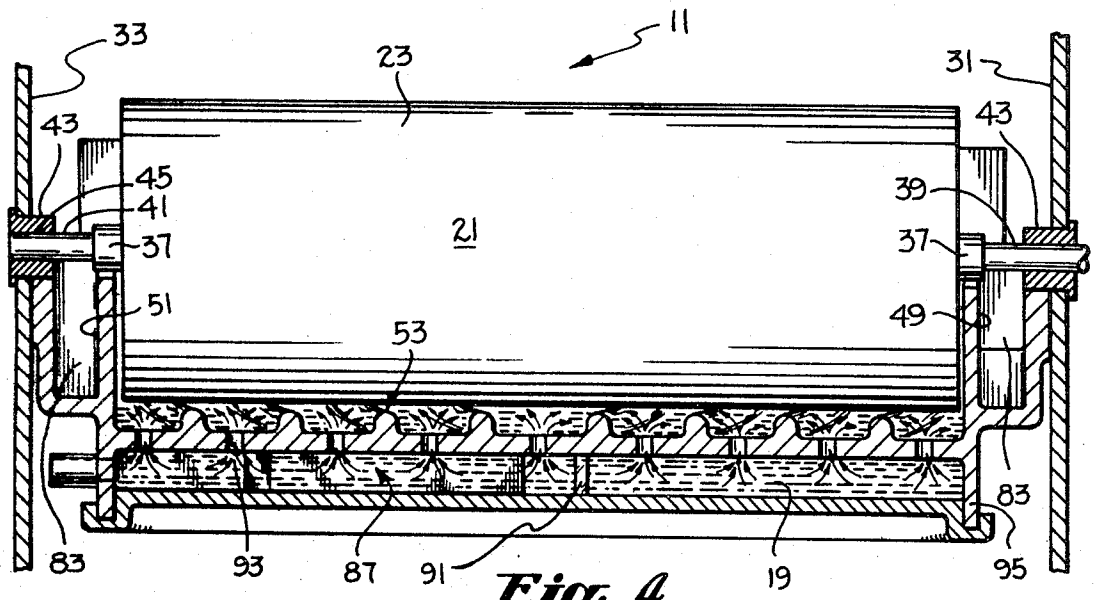

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Fig. 4

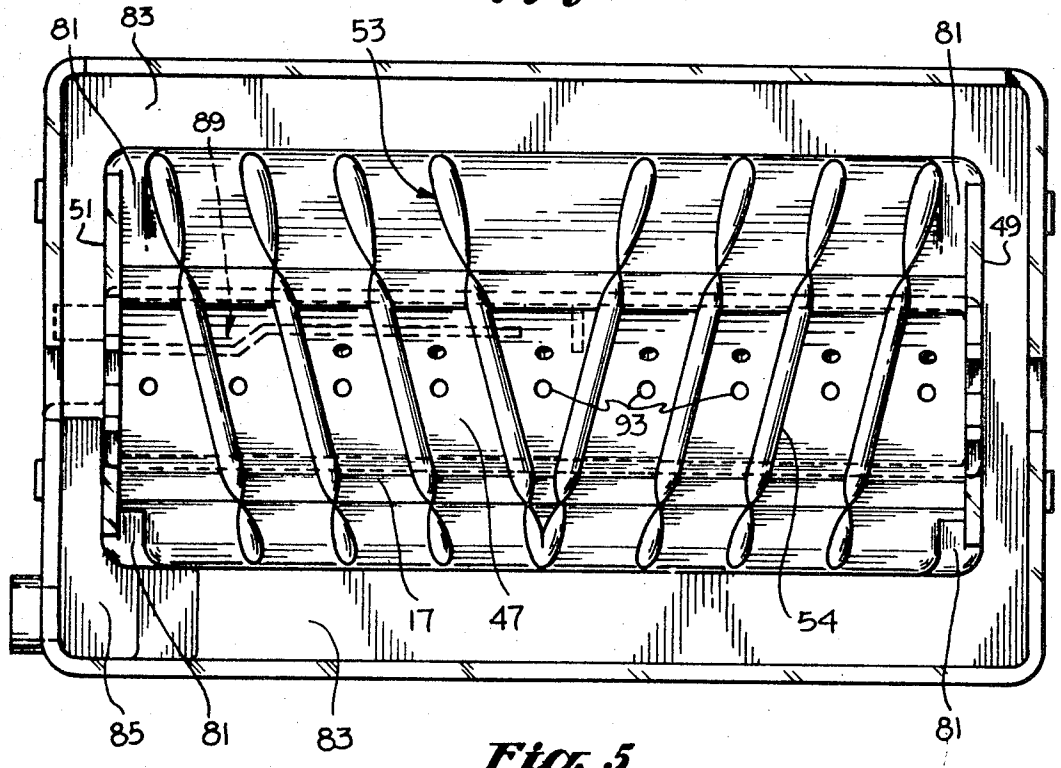

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Fig. 5

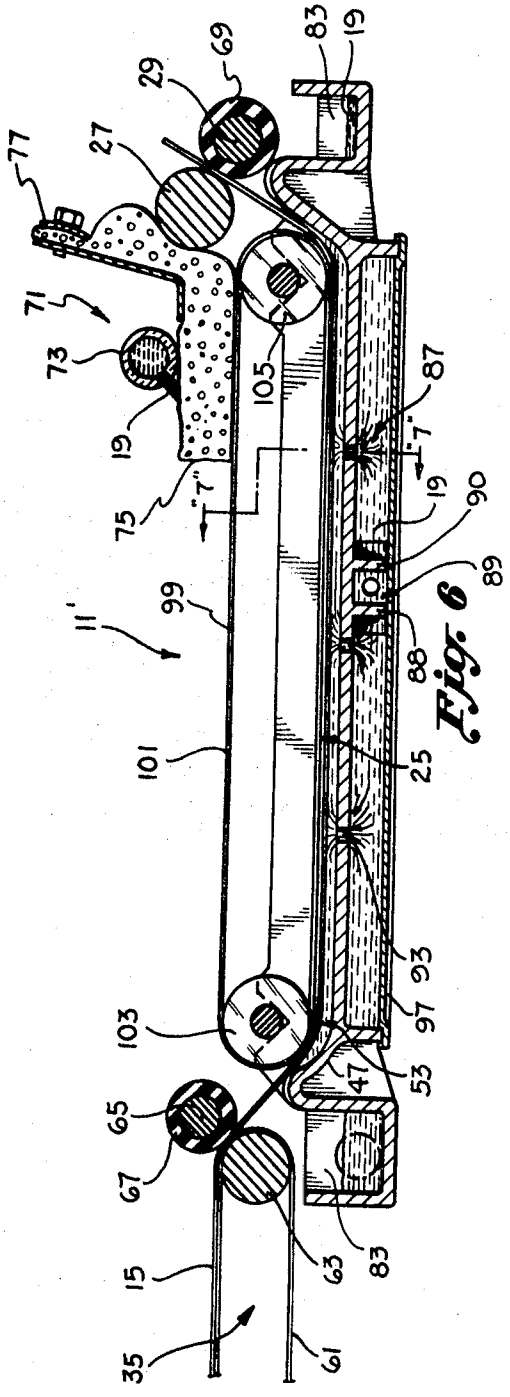

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Fig. 6

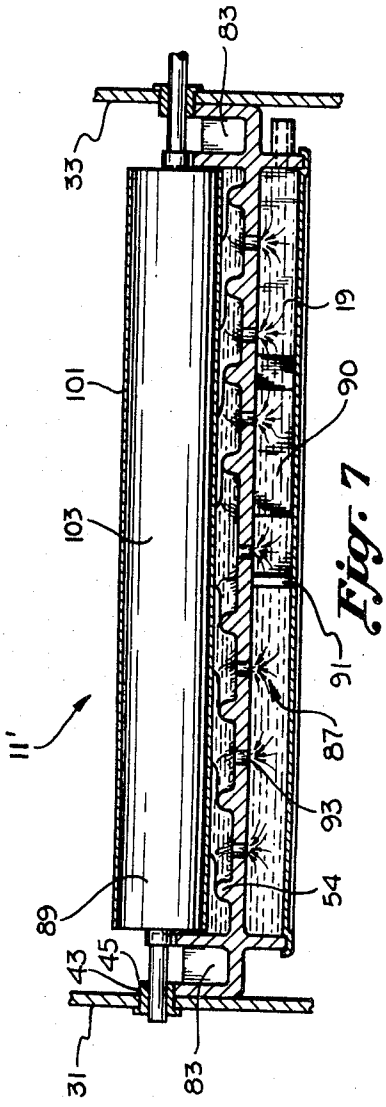

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Fig. 7

DEVELOPING UNIT

This is a division of application Ser. No. 884,393, filed Dec. 12, 1969, now U.S. Pat. No. 3,667,987.

This invention relates to a developing station for an electrostatic photocopying machine, and more particularly to a developing station wherein a latent electrostatic image on a surface of a carrier is developed into a visible image by bringing the image-bearing surface of the carrier into contact with a developing liquid in effective field control spacing with an electrically conductive surface.

In an electrostatic photocopying machine, a copy of a document is produced by forming a latent electrostatic image of the document on the surface of a suitable carrier, for example a sheet of copy paper, and then developing the latent image into a visible image. The latent image is developed into a visible image by bringing the image-bearing surface of the copy paper into contact with a developing liquid having visible particles which are electrically attractable to the electrostatic image. The visible developer particles are attracted by the portions of the image-bearing surface having an electrostatic charge and are deposited thereon to transform the latent image into a visible image. Subsequently, the image-bearing carrier is passed between a pair of squeegee rollers which remove excess liquid from the carrier and press the visible particles forming the developed image into the image-bearing surface.

During the development of a latent electrostatic image, the visible developer particles often tend to be deposited more densely along the fringe portions of the image as compared to the central portions thereof, and this effect is usually referred to as fringe development. When the visible developer particles are attracted to the latent electrostatic image, they move in an electrostatic field produced by the latent electrostatic image. The electrostatic field is theoretically composed of lines of force, and the phenomenon of fringe development is believed to result from the lines of force being more concentrated at the fringe portions of the image, thus causing the developed particles to be more strongly attracted thereto as compared with the central portion of the image.

It is known that the fringe effect may be alleviated to produce a more uniform development of the latent image by bringing the image-bearing surface of the carrier into close proximity with an electrically conductive surface so as to straighten out the lines of force and thus reduce the concentration of the lines of force at the fringe portion of the image. However, several problems are encountered in bringing the image-bearing surface of the carrier into close proximtiy with the electrically conductive surface of an image intensifier. If the image-bearing surface is brought too close to the surface of the image intensifier, then there may be insufficient visible particles in the intervening space to fully develop the latent image. On the other hand, if the intervening space is too great, then the image intensifier will not be effective in straightening out the lines of force and producing a more uniform development of the latent electrostatic image. Furthermore, to enhance the effect of the image intensifier, it is desirable to maximize the period of time that the image-bearing surface is in effective field control spacing with the image intensifier.

In the past, there have been developing stations which bring an image-bearing carrier into effective field control spacing with an image intensifier in the presence of a liquid developer. However, such developing stations usually have a mechanical apparatus which contacts the image-bearing carrier while bringing it into effective field control spacing with the image intensifier, and the use of such a mechanical apparatus generally increases the difficulty in assembling the developing station as well as increasing the cost of the photocopying machine. Furthermore, such an arrangement usually has stationary surfaces which are contacted by the image-bearing carrier as it is brought into effective field control spacing with the image intensifier, and this often results in scuff marks being placed on the carrier due to contact with visible particles which may have accumulated on the stationary surfaces.

Accordingly, an object of the present invention is to provide uniform development of a latent electrostatic image by bringing it into effective field control spacing with an image intensifier without the use of a mechanical apparaus for pressing the carrier into close proximity with the image intensifier.

Another object of the present invention is to provide a developing station for bringing an image-bearing surface of a carrier into effective field control spacing with an image intensifier without placing undesirable scuff marks on the back of the carrier as it moves through the developing station.

A further object of the present invention is to provide a developing station for uniform development of a latent electrostatic image, wherein the developing station may be easily assembled with a minimum number of parts, and particularly without the need of a mechanical apparatus for bringing the image-bearing surface of the carrier into effective field control spacing with an image intensifier.

Still other objects, features and advantages of the present invention will be apparent to those skilled in the art from a reading of the following detailed description of the various embodiment of the invention, taken in conjunction with the accompanying drawings, wherein:

FIG. 1 is a perspective view of a preferred embodiment of a developing station according to the present invention;

FIG. 2 is a partial cross-sectional view of the developing station shown in FIG. 1, and illustrating an incoming image-bearing carrier moving into the developing trough;

FIG. 3 is a partial cross-sectional view of the developing station shown in FIG. 1, and illustrating an image-bearing carrier moving into a pressurized area of the developing station;

FIG. 4 is a partial axial cross-sectional view of the developing station shown in FIG. 1, with the developing station being supported between two upright walls;

FIG. 5 is a plan view of the developing trough shown in FIG. 1;

FIG. 6 is a side view of an alternative developing station constructed in accordance with the present invention, and illustrating the movement of an image-bearing carrier therethrough;

FIG. 7 is a cross-sectional view of the embodiment shown in FIG. 6, taken along the lines 7—7.

Referring generally to FIGS. 1–5 in the drawings, there is shown a developing station, generally indicated at 11, for developing a latent electrostatic image on a surface 13 of a carrier 15 into a visible image as the carrier 15 moves past the developing station 11 along a developing path. The incoming image-bearing carrier 15 is guided into a trough 17 and brought into contact with developing liquid 19 on an electrically conductive surface 21 of a cylinder 23 rotating in the trough 17. As the carrier 15 moves through the trough 17, it enters a pressurized area, generally indicated 25, where additional developing liquid 19 is directed under pressure against the back side of the carrier 15 to press the image-bearing surface 13 into effective field control spacing with the electrically conductive surface 21 of the cylinder 23. The pressurized area 25 extends over an elongated distance of the developing path, and the cylinder 23 serves as an image intensifier to straighten out the lines of force produced by the electrostatic image to achieve a more uniform deposition of visible particles on areas of the image-bearing surface 13 having the same uniform electrostatic charge. From the trough 17, the image-bearing carrier 15 passes between the cooperating surfaces of a pair of rotating squeegee rollers 27, 29 respectively, which remove excess developing liquid from the carrier 15 and press the visible particles into the surface thereof to provide a permanent copy of an original document.

The developing station 11 is supported in the photocopying machine by two parallel upright walls 31, 33 and positioned to receive a carrier 15 being advanced by a suitable transport mechanism, generally indicated 35, and subsequently direct the carrier 15 into the nip of the cooperating squeegee rollers 27, 29 which remove the carrier 15 from the developing station 11 for further processing in the machine. As more particularly shown in FIG. 2, an incoming carrier 15 is received into the developing trough 17 beneath the image intensifying cylinder 23 which is rotatably supported for movement about an axial shaft 37 having reduced end portions 39, 41. As shown in FIG. 4, the reduced end portion 39 is received through a suitable bushing 43 which is secured in an opening 45 formed in the upright wall 31. The other reduced end portion 41 is rotatably supported in the same identical manner and accordingly identical reference numerals have been placed on identical portions.

The lower portion of the cylinder 23 extends into the trough 17 which is defined by a generally upwardly concave wall 47 formed integrally with spaced side walls 49, 51 respectively, which are located beside the opposite ends of the cylinder 23. An incoming carrier 15 is guided through the trough 17 and around the image intensifying cylinder 23 by guide means, generally indicated 53, which are provided on the bottom wall 47 of the trough 17. As more particularly shown in FIG. 5, the guide means 53 are in the form of ridges 54 extending along the developing path obliquely to the direction of movement of a carrier 15 along the path. The guide means 53 are easily positioned relative to the surface 21 of the cylinder 23 during the assembly of the developing station 11 by providing each of the side walls 49, 51 of the trough 17 with a raised portion 55 having a V-shaped groove 57 for engaging the axial shaft 37 of the cylinder 23. The trough 17 may be fixedly secured by suitable means between the upright walls 31, 33.

The image intensifying cylinder 23 may be constructed from a suitable electrically conductive material, such as steel or aluminum. Alternatively, the cylinder 23 may be formed from an electrically insulating material, and then coated with a suitable electrically conductive material. The trough 17 may be constructed from a suitable electrically insulating material which is not effected by the developing liquid 19, and which does not adversely affect the developing liquid 19. One such material is acrylomitrile-butadiene-styrene copolymer. The bushings 43 which receive the reduced end portions 39, 41 of the axial shaft 37 may be constructed from a suitable electrically conducting material, for example bronze.

As shown, the paper transport mechanism 35 may be a conventional endless belt 61 trained around a suitable roller 63 which may be rotatably supported between the two upright walls 31, 33 in the same manner as the cylinder 23. A carrier 15 transported along the endless belt 61 may be guided into the developing station 11 by another rotatably supported and cooperating idler roller 65 which engages the image-bearing surface 13 of the carrier 15 and is positioned relative to the roller 63 for directing the carrier 15 into the developing trough 17 beneath the cylinder 23. The endless belt 61 may be constructed from a suitable material, for example rubber, and the cooperating roller 65 is provided with an electrically insulating surface, by means of a rubber sleeve 67, to enable it to contact the image-bearing surface 13 of the carrier 15 without discharging the latent electrostatic image.

As previously mentioned, the cooperating squeegeeing rollers 27, 29 remove excess developing liquid from the carrier 15 and press the visible particles into the image-bearing surface 13. The cooperating squeegee rollers 27, 29 may be rotatably supported betwen the two upright walls 31, 33 in the same manner as the cylinder 23, with the roller 29 engaging the back side of the image-bearing carrier 15 while the roller 27 engages the image-bearing surface 13. The roller 29 is an idler roller having a sleeve 69 constructed from a resilient material, such as rubber, while the roller 27 is a drive roller which presses against the resilient sleeve 69 of the idler roller 29. The drive roller 27 is constructed from a suitable electrically conductive material, such as steel, and may desirably be pressed against the idler roller 29 by a conventional resilient biasing means, not shown.

The electrically conductive surface 21 of the image intensifying cylinder 23 and the electrically conductive squeegee roller 27 may both be electrically grounded by suitable means, for example through bushings or a brush contact, to the frame portions of the photocopying machine, for example the parallel upright walls 31, 33. In addition, the image intensifying cylinder 23, the roller 63 for the endless transport belt 51, and the squeegee roller 27 may all be separately driven by conventional drive means, not shown, or for that matter may be driven by a common drive means through a conventional chain and sprocket arrangement.

As the cylider 23 rotates in the developing trough 17, developing liquid, generally indicated at 19, is supplied from a suitable reservoir, not shown, onto the surface 21 of the cylinder 23 by fluid supply means, generally indicated at 71. As shown, the fluid supply means 71 is in the form of an apertured header tube 73 which extends across the length of the cylinder 23 above a wiper

75 engaging the upper surface portion of the rotating cylinder 23. The wiper 75 is constructed from a suitable porous material, such as an open-celled polyurethane foam. The wiper 75 is held against the surface of the cylinder by a suitable clamp 77 which may be supported between the two upright walls 31, 33 and a shield 79 which protects other portions of the photocopying machine, not shown, from becoming wetted with the developing liquid 19. To insure thorough saturation of the wiper 75 by the developing liquid 19, the header tube 73 directs the developing liquid 19 onto the shield 79 so as to form a pool of developing liquid between the shield 79 and the wiper 75. In addition, developing liquid is supplied under pressure to the bottom portion of the trough 17 in the pressurized area 25 in a manner which will be described hereinbelow.

The developing liquid 19 supplied to the developing station 11 fills the trough 17 and flows over recesses 81 formed in the bottom wall 47 beside the side walls 49, 51 and into a gutter, generally indicated 83. The gutter 83 surrounds the developing trough 17 and carries the developer liquid 19 to a sump 85 where it drains back to the reservoir. As shown, the gutter 83 may be formed integrally with the trough 17, or alternatively may be formed separately and secured in fluid-sealing relation to the trough 17. The means for circulating the developing liquid 19 between the reservoir and the developing station 11 have been omitted from the description, since it forms no part of the present invention.

When an incoming image-bearing carrier 15 is advanced into the developing station 11, by the transport mechanism 35, the leading edge of the carrier 15 is guided by the guide means 53 into the developing liquid 19 in the space between the upwardly concave wall 47 and the rotating cylinder 23. As the incoming carrier 15 moves further along the developing path, the ridges 54 guide the image-bearing surface 13 of the carrier 15 into substantially constant spaced relation with the surface 21 of the cylinder 23. As more particularly shown in FIG. 5, the ridges 54 are generally oblique to the direction of movement of the carrier 15, and it is believed that the movement of the back side of the carrier 15 across the oblique ridges 54 provides a wiping action which prevents an accumulation of visible developer particles on the ridges 54 and prevents backmarking of the carrier 15. In addition, the ridges 54 serve to reduce the friction the carrier 15 would otherwise encounter if it moved along a flat bottom wall.

Further advancement of the carrier 15 along the developing path brings the leading edge into the pressurized area 25 where developing liquid is directed under pressure toward the surface 21 of the rotating cylinder 23. As more particularly shown in FIGS. 2–4, developing liquid 19 is received into the pressure chamber, generally indicated 87, through a passageway, generally indicated 89. The passageway 89 opens into the chamber 87 adjacent a baffle wall 91 at the center thereof so as to enable the fluid to be evenly distributed throughout the chamber 87. From the fluid pressure chamber 87, the fluid flows into the bottom portion of the trough 17 through orifices, generally indicated 93, which are formed in the upwardly concave wall 47 so as to direct the developing liquid toward the surface 21 of the rotating cylinder 23. As shown, the pressure chamber 87 is formed by a generally box-shaped wall 95 depending integrally from the back side of the upwardly concave wall 47, and which is closed by a manifold cap 97 engaging the depending box-shaped wall 95 in fluid-sealing relation thereto. The passageway 87 is defined by a portion of the wall 95 and a wall 88 extending adjacent thereto. The wall 88 may be formed integrally with the upwardly concave wall 47.

The pressurized area 25 extends over an elongated distance of the developing path generally adjacent the orifices 93 in the bottom wall 47 of jthe developing trough 17. As more particularly shown in FIG. 5, the orifices 93 in the upwardly concave wall 47 are arranged in dual rows transverse to the direction of movement of the carrier 15. When the carrier 15 enters the pressurized area 25, the developing liquid 19 directed towards the cylinder 23 tends to press the leading edge of the carrier 15 away from the surface 21 of the cylinder 23. However, the ridges 54 maintain the image-bearing surface 13 in substantially constant spaced relation with the surface 21 of the cylinder 23 until a sufficient length of the incoming carrier 15 enters the pressurized area 25 to enable the force of the liquid 19 to lift the carrier 15 from the ridges 54 and press the image-bearing surface 13 into effective field control spacing with the image intensifying cylinder 23. Although the means for circulating the developing liquid from the reservoir to the pressurized area 25 are not shown, the effective field control spacing may be varied by controlling the pressure of the developing liquid directed against the back side of the carrier 15.

As the carrier 15 moves through the pressurized area 25, the image-bearing surface 13 is maintained in substantially constant spaced relation with the image intensifier roller 23. The length of the elongated distance of pressurized area 25 is extended along the developing path so as to maximize the period of time that the carrier 15 is in effective field control spacing and thus enhance the deposition of visible particles onto the image-bearing surface 13. It is believed that the electrically conductive surface 21 of the cylinder 23 serves to straighten out the lines of force of the electrostatic field produced by the latent electrostatic image. As a result, the visible particles in the developing liquid 19 confined in the effective field control spacing between the image-bearing surface 13 of the carrier 15 and the electrically conductive surface 25 of the image intensifying cylinder 23 are more uniformly deposited on areas of the latent image having the same uniform electrostatic charge. In addition, it is believed that the developing liquid 19 directed against the back side of the carrier 15 tends to wash the back side of the carrier 15 free from visible developer particles which may be placed there during the course of movement along the ridges 54.

From the pressurized area 25, the image-bearing carrier 15 is guided into the nip of the cooperating squeegee rollers 27, 29 which are rotatably driven so as to have a peripheral speed substantially equal to the linear speed of the image-bearing carrier 15. As the carrier 15 passes between the squeegee rollers 27, 29 the electrically conductive surface of the roller 27 presses the carrier against the rubber sleeve 69 on the roller 29 so as to produce a squeegeeing effect which removes excess developing liquid 19 from the carrier 15 and presses the visible particles of the developed image into the image-bearing surface 13. To prevent over-printing resulting from developer particles clinging to the electrically conductive surface of the roller 27, the wiper

75 is also held against the surface of the squeegee roller 27 so as to wipe the surface free from any visible developer particles.

Another embodiment of a developing station constructed in accordance with the present invention is shown diagramatically in FIGS. 6 and 7. With the exception of the image intensifier, the developing station, generally indicated 11', of this embodiment is generally identical to the developing station 11 described in the previous embodiment, and accordingly identical reference numerals have been placed on identical portions thereof. In this embodiment, the image intensifier is in the form of an endless belt 99 having an electrically conductive surface 101 which is movable along the developing path. The image intensifying belt 99 extends around two rotatable rollers 103, 105 which are spaced sufficiently apart to maintain the belt 99 in a taut condition. The lower portion of the image intensifying belt 99 moves through the developing trough 17 which is formed by a generally upwardly concave bottom wall 47 extending in a linear direction over an elongated distance of the developing path so as to increase the elongated length of the pressurized area 25 of the developing station 11'.

The rollers 103, 105 for the image intensifying belt 99 may be rotatably supported between the upright walls 31, 33 in the same manner as the image intensifying cylinder 23 of the previous embodiment, and either roller may be rotatably driven to move the belt 99 by means of frictional engagement through the developing trough 17. Due to the increased length of the pressurized area 25, the developing liquid 19 is received into the pressure chamber 87 through a passageway 89' which is located in a central portion of the chamber 87 so as to evenly distribute the fluid pressure. As shown, the passageway 89' is defined by two walls 88', 90' which may be formed integrally with the generally upwardly concave bottom wall 47. Also, since the fluid supply means is located further from the paper transport 35 than in the previous embodiment, it is unnecessary to provide a shield to prevent other components of the machine from being wetted by the developing liquid 19. Accordingly, the header tube 73 is turned so that the developing liquid 19 is directed onto the wiper 75 rather than against the shield, as in the previous embodiment.

In operation, an image-bearing carrier 15 is advanced by the paper transport apparatus 35 into the developing station 11' where the leading edge of the carrier 15 is guided by the guide means 53 into the developing trough 17 beneath the image intensifying belt 99. As the incoming carrier 15 moves along the developing path, the ridges 54 guide the image-bearing surface 13 of the carrier 15 into substantially constant spaced relation with the surface of the belt 99. Further advancement of the carrier 15 brings the leading edge into the pressurized area 25 where developing liquid 19 is directed under pressure towards the surface 101 of the endless belt 99. As in the previous embodiment, the image-bearing surface 13 of the carrier 15 is pressed into effective field control spacing with the electrically conductive surface of the image intensifying belt 99 so as to produce a more uniform deposition of visible developer particles on areas of the image-bearing surface 13 having the same uniform electrostatic charge. After moving through the pressurized area, the image-bearing carrier 15 is guided into the nip of the rotatably driven squeegee rollers 27, 29 which remove excess developing liquid 19 from the carrier 15 and press the visible particles of the developed image into the image-bearing surface 13 to provide a permanent copy of the original document.

While only a limited number of embodiments have been illustrated and described, it will be apparent to those skilled in the art that various modifications and improvements may be made without departing from the scope and spirit of the invention. Accordingly, it is to be understood that the invention is not to be limited by the illustrative embodiments, but only by the scope of the appended claims.

What is claimed is:

1. Apparatus for developing a latent electrostatic image on a surface of a carrier into a visible image, comprising an image intensifier having an electrically conductive surface movable along a developing path, fluid supply means for supplying fluid to the surface of said image intensifier, guide means for guiding an incoming image-bearing carrier along said developing path with the electrostatic image-bearing surface of the carrier facing the electrically conductive surface of the image intensifier, and fluid pressure means for applying fluid under pressure to said image-bearing carrier over an elongated distance of said developing path to press the image-bearing surface of the carrier into an effective field control spacing with the surface of said image intensifier over the elongated distance of said developing path.

2. Apparatus for developing a latent electrostatic image on a surface of a carrier into a visible image according to claim 1, wherein said fluid pressure means applies fluid under pressure to said image-bearing carrier over an elongated distance of said developing path to press the image-bearing surface of the carrier into a substantially constant spaced relation with the surface of said image intensifier over the elongated distance of said developing path.

3. Apparatus according to claim 1, wherein said electrically conductive surface of said image intensifier moves along said developing path in a substantially straight plane, and said guide means guides said image-bearing carrier substantially parallel to the surface of said image intensifying member over an elongated distance of said developing path.

4. Apparatus according to claim 3, wherein said image intensifier comprises an endless belt having an electrically conductive surface movable along said developing path, and said endless belt being mounted for movement in a substantially straight line along an elongated distance of said developing path.

5. Apparatus according to claim 1, wherein said electrically conductive surface of said image intensifier has an arcuate cross-sectional configuration movable along said developing path in an arcuate direction, and said guide means guides said image-bearing carrier along said developing path substantially parallel to the surface of said image intensifier over an elongated distance of said developing path.

6. Apparatus according to claim 5, wherein said image intensifier comprises a cylinder having an electrically conductive surface, said cylinder being rotatably mounted for moving the electrically conductive surface along said developing path, said guide means comprising arcuate-shaped ridges facing the electrically conductive surface of said cylinder and extending

in the direction of movement of said electrically conductive surface along said developing path for guiding the leading edge of an incoming image-bearing carrier along said developing path in substantially constant spaced relation to the electrically conductive surface of said image intensifying cylinder.

7. Apparatus according to claim **1**, wherein said fluid pressure means comprises means defining a chamber for receiving fluid under pressure, said chamber-defining means including a wall extending along said developing path with one side of the wall facing the electrically conductive surface of said image intensifier, and said wall having orifices formed therein for directing fluid from said chamger toward the electrically conductive surface of said image intensifier.

8. Apparatus according to claim **7**, wherein said guide means comprises ridges formed on said wall and extending along said developing path in substantially constant spaced relation from the surface of said image intensifier for guiding the leading edge of an incoming image-bearing carrier along said developing path in substantially constant spaced relation with the electrically conductive surface of said image intensifier.

9. Apparatus according to claim **7**, wherein said wall defines a trough through which the electrically conductive surface of said image intensifier moves and for containing a quantity of developing liquid when fluid is supplied under pressure to said pressure chamber and directed through the orifices formed in said wall toward the electrically conductive surface of said image intensifier.

10. Apparatus for developing a latent electrostatic image into a visible image, comprising a trough for containing developing liquid, an image intensifier having an electrically conductive surface and being movable through said trough, fluid supply means for supplying developing liquid to the surface of said image intensifier as it moves through said trough, guide means for guiding an image-bearing surface of an incoming carrier into engagement with the developing liquid on the surface of said image intensifier, means defining a chamber adjacent said trough for liquid under pressure, said chamber-defining means further defining orifices providing fluid communication between said chamber and said trough for directing liquid under pressure from said chamber toward said image intensifier moving through said trough to press the image-bearing surface of said carrier into an effective field control spacing with the electrically conductive surface of said image intensifier over an elongated distance of the movemnt of the carrier through said trough.

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