March 29, 1955 H. E. CLARK 2,705,199

METHOD OF DEVELOPING AN ELECTROSTATIC LATENT IMAGE

Filed Sept. 12, 1951

3 Sheets-Sheet 1

FIG. 1

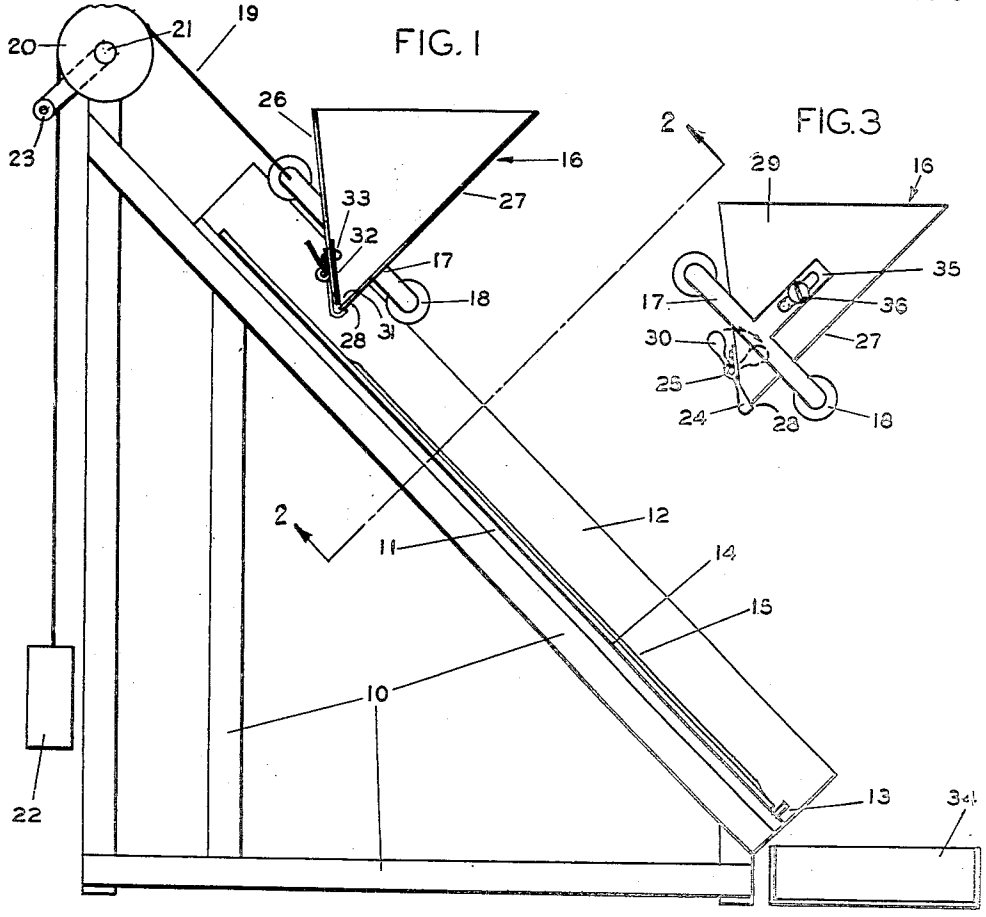
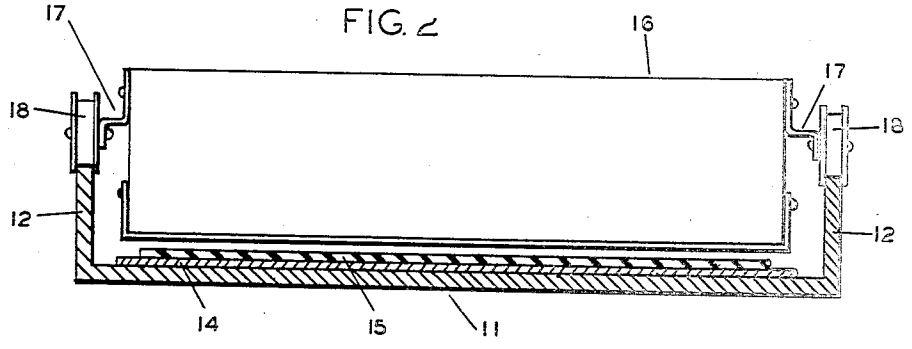


FIG. 3

FIG. 2



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FIG. 4

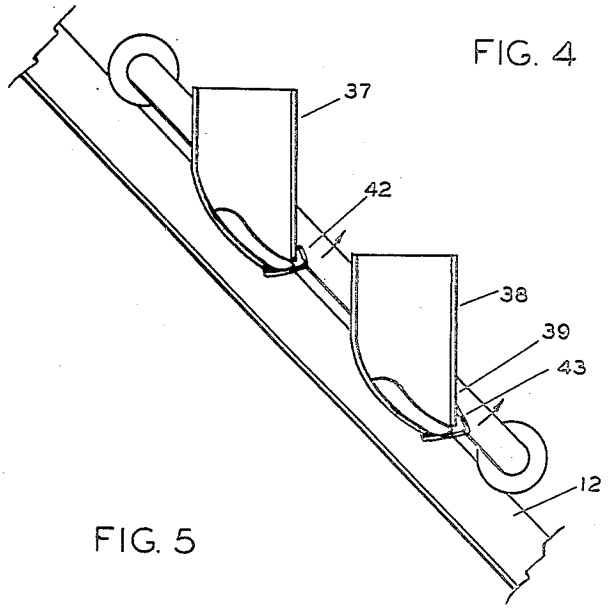
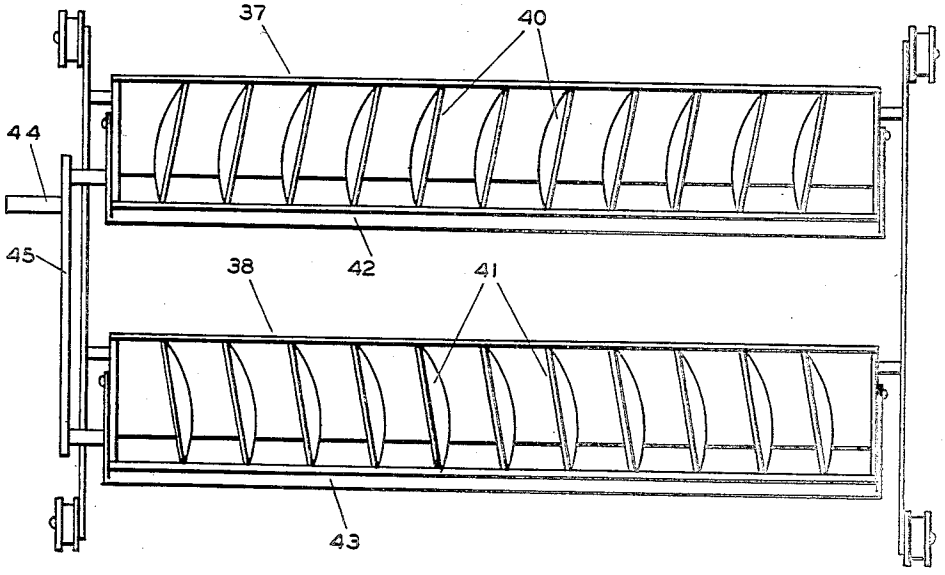


FIG. 5



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FIG. 6

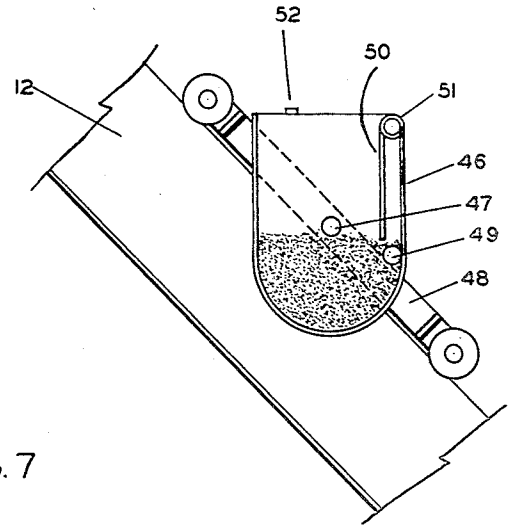


FIG. 7

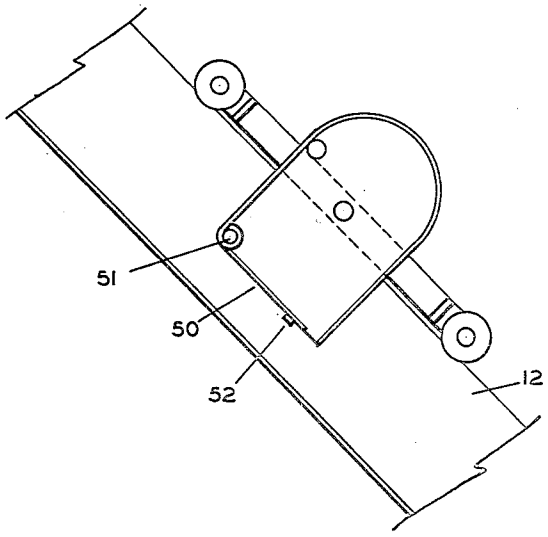
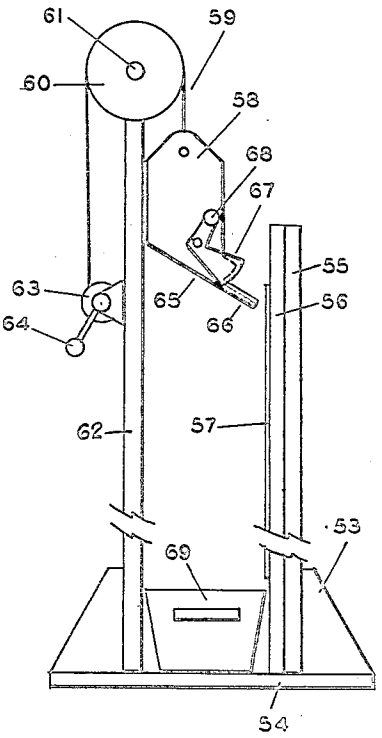


FIG. 8



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METHOD OF DEVELOPING AN ELECTROSTATIC LATENT IMAGE

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Application September 12, 1951, Serial No. 246,223

2 Claims. (Cl. 95—1.9)

This invention relates to xerographic devices and particularly to xerographic processing machines having means for developing the electrostatic images on xerographic plates.

A feature of the invention resides in means for developing flat, xerographic plates by discharging a developing material thereon from a travelling hopper.

In the process of xerography, or electrophotography, a xerographic plate consisting of a metal base plate coated with a layer of photoconductive insulating material is electrically charged to provide an electrostatic charge over the surface of the coating, after which the plate is exposed in a camera, contact printing frame, or by projection from a microfilm enlarger or other image projector. Exposure discharges the electrostatic charge from the areas which are struck by light and the resulting electrostatic latent image can then be developed with a fine powder, after which the powder image may be transferred to a sheet of paper and affixed on the paper to form a permanent image.

The developing material commonly used in xerography may consist of a finely-pulverized, pigmented resin powder or a mixture of such a powder with a coarser granular material to which the powder loosely adheres by the electrostatic charges generated by contact between the powder and the granular material. When the developer mixture is tumbled over the exposed xerographic plate, the powder particles are attracted to the image from the granular material and produce a powder image. Heretofore, with plates of moderate size, the developing step has frequently been performed by placing the xerographic plate face upward in a tray having a reservoir of powder at one end and tilting the tray back and forth to pass the developer over the plate. There has not, however, been any convenient means heretofore for developing large xerographic plates, such as plates having a length of several feet. The tilting tray arrangement becomes extremely unwieldy with such plates and, more seriously, it has been found that large plates cannot be developed with satisfactory uniformity with tilting tray apparatus. While the reason for the deficiency in operation of such device is not entirely understood at present, it is thought that the powder carrier mixture accelerates as it cascades across the plate so that it reaches a speed which is not conducive to proper deposition of the powder at the ends of the plate.

The present invention, accordingly, contemplates an apparatus which is adapted to the development of images on plates of any size but is particularly useful for large plates, such as those which have a length of several feet.

Other features and objects will be apparent from the following detailed description, together with the figures of the accompanying drawing illustrating certain embodiments of the invention.

In the drawings:

Figure 1 is a vertical section through a xerographic apparatus arranged for developing xerographic plates;

Figure 2 is a section on the line 2—2 of Figure 1;

Figure 3 is an end view of the travelling hopper for the apparatus of Figure 1;

Figure 4 is a sectional view showing a modified hopper arrangement;

Figure 5 is a top view of the hopper arrangement of Figure 4;

Figures 6 and 7 are two views showing a further modified hopper arrangement in two of its operating positions; and

Figure 8 is an elevation of a modified xerographic apparatus.

The developing device shown in Figures 1, 2 and 3 comprises a frame 10 adapted to rest on a floor or other horizontal surface and a flat bed plate 11 supported by the frame 10 in a sloping plane making an angle preferably of 45° with the floor. Plate 11 is provided with a pair of side walls 12 along its sloping edges, and two or more stop pins 13 project from its face in a horizontal row near the lower end of the plate. Pins 13 provide means for locating and supporting the lower end of a xerographic plate 14 having a coating 15 of photoconductive insulating material which is to be developed with powder. When the xerographic plate is placed in position against stop pins 13, as shown, it rests against the flat upper surface of bed plate 11 and covers substantially the entire surface of the bed plate.

A moving hopper 16 is mounted on carriage elements 17 carrying flanged wheels 18 which ride on the top edges of side walls 12 so that the hopper can be moved up and down over the surface of the plate on the tracks provided by the side walls. The hopper is supported by a cable 19 which passes over a pulley 20 mounted on horizontal rotary shaft 21 supported in bearings mounted along the top of frame 10 and above the upper end of bed plate 11. Cable 19 terminates in a counterweight 22 which hangs at the back of the frame and substantially counterbalances the weight of hopper 16. A hand crank 23 is secured to one end of shaft 21 to permit the operator to raise and lower hopper 16 along its tracks over bed plate 11 and any xerographic plate supported thereon.

The hopper 16 comprises a V-shaped trough extending across the width of the xerographic plate and preferably slightly beyond the edges of coating 15. A powder discharge gate 24 is hinged at 25 to the hopper wall 26, which is a vertical wall forming the side of the V-shaped trough which is nearest the upper end of the plate. When gate 24 is in closed position, as shown, its lower end is in abutment with the lower end of the sloping wall 27 comprising the other wall of the hopper. The gate is provided with a pair of flanges 28 at its ends which overlap a portion of the end walls 29 of the hopper. A manual handle 30 is provided at one end of the gate to rotate it into open position. The hinges 25 have high friction bearings to hold the gate in open or closed position as manually set, the handle 30 also acting as a counterweight to bias the gate toward either its open or its closed position when it has been set to one of those positions.

Wall 26 terminates short of wall 27 to leave powder exit slot 31 which is closed by gate 24. The height of slot 31 may be preset by varying the position of adjustable slide 32 which is secured by setscrews 33 against the inside wall of hopper wall 26. The height of the discharge slot above the plate 14 to be developed may be adjusted by loosening setscrews 36 and sliding the hopper in or out in slotted portions 35 of carriage elements 17. A catching hopper 34 is set at the bottom of plate 11 to collect the powder which has cascaded over the plate.

In operation of the device, hopper 16 is filled with developing material, such as a powder-carrier mixture, and with gate 24 closed is moved to the upper end of plate 14 by hand crank 23. Gate 24 is then opened and the developing material begins to discharge onto the upper end of the plate and to cascade down the surface of the plate where it is caught in catching hopper 34. In order to insure adequate development of the upper end of the coating 15 the discharge may be begun at a point several inches above the upper end of the coating and the hopper may immediately be started down the incline by turning crank 23. In this way the hopper has several inches of travel during all of which time developer is cascading over the top end of the coating so that the coating is adequately developed along its top edges by the time the hopper passes further down the plate. According to another procedure the gate 24 may be opened with the hopper in stationary position just

above the upper end of coating **15** and the hopper allowed to stand still until the first few inches of the coating are developed, after which it is lowered down the surface of the plate at a constant rate of speed until it reaches the bottom.

During development it appears that most of the developing action takes place in the first six to eight inches after the developing material has left the hopper. The material apparently accelerates in speed as it passes down the plate and this reduces its effectiveness in depositing powder on the image. However, the unexpected discovery has been made that this cacacading developer does not materially affect the quality of the image and a large mass of developer can pass over the plate without interfering with the electrical image, and, hence, it is possible for the image to be developed as the slower moving portion of the developer stream reaches successively lower areas of the coating. By providing exit slot **31** in the wall **26**, which faces the upper end of the plate, the developer is discharged without any initial downstream velocity. The velocity of the developer is thereby kept low for the first few inches of travel after the stream leaves the hopper, thus contributing to the complete development of the image.

The hopper having passed over the plate from top to bottom, gate **24** is closed and the developing material caught in hopper **34** is poured back into hopper **16**. The moving hopper can then be returned to the upper part of the plate for future use and developed plate **14** may be removed from the apparatus with its powder image for transfer of the image to paper in another piece of equipment. It is, however, contemplated that other steps of the xerographic process may be performed with the plate in sloping position in the development apparatus. For example, a charged plate can be exposed to a microfilm-projected image and then immediately developed in the same position.

Figures 4 and 5 illustrate a modified hopper arrangement which can be substituted for hopper **16** in the apparatus of Figures 1 and 2. This arrangement comprises a pair of hoppers **37** and **38** arranged in tandem along moving carriage elements **39** arranged to run on side tracks **12**. The discharge openings of hoppers **37** and **38** are directed so as to discharge the developing material substantially parallel to the plate in a downward direction. Hoppers **37** and **38** are each provided with a series of baffles **40** and **41**, respectively, which are mounted in spaced parallel relation in the bottom of the hoppers and set at a slight angle to the direction of travel of the hoppers to guide the discharging developer onto the plate at a slight angle to the direction of travel. Baffiles **40** direct the developing material toward one side and baffles **41** toward the opposite side of the plate so that the image carriers are developed successively by powder streams passing in slightly different directions. Swinging gates **42** and **43** are provided on hoppers **37** and **38** to control the powder flow, these being operated by a manual handle **44** and link **45**.

The cross current flow provided by this hopper arrangement contributes to improve development of the image in certain cases, particularly where lines are present in the image parallel to the direction of travel of the hopper.

Figures 6 and 7 illustrate a further hopper arrangement comprising a tilting hopper **46** which is pivoted along its central axis on pintles **47** which are arranged to turn in suitable bearings in moving carriage frame **48** which is arranged to run on side walls **12** as in the modifications previously described. A stop pin **49** projects from the end of the hopper and is brought into abutment with the top edge of carriage frame **48** when the hopper is in upright position as shown in Figure 6. The hopper is also provided with a swinging cover **50** hinged at **51** along an upper edge of the hopper so that it normally hangs down inside the hopper wall when the hopper is in upright position. When it is desired to discharge the hopper onto the plate the entire hopper is swung about its pivot **47** until stop pin **49** is brought into abutment with the top carriage frame **48** as shown in Figure 7. At the same time cover **50** swings outward to a position parallel with the top of the hopper where it is stopped by ears **52** bent in from the end walls of the hopper. Cover **50** is narrower than the mouth of the hopper so that when it is in this position it provides a discharge slot through which the developer can discharge from the hopper down onto the plate to be developed. This arrangement is advantageous in that it is practically impossible for the gate to become clogged with powder.

As has been previously mentioned, the preferred developing angle for the xerographic plate is 45° with respect to the horizontal. However, it is permissible to develop the plate while it is mounted at other angles within the range between 30 and 90° with the horizontal. Below 30° the tendency of the developer and carrier particles to become lodged on the plate, due to insufficient slope, becomes evident. This blocking of developer on the plate takes place at low angles independently of the electrostatic image and, hence, tends to obscure the image as well as to permit the granular carrier particles to remain on the plate and interfere with subsequent transfer of the powder image to paper. While higher angles than 45° makes less efficient use of the developer due to the excessive velocity it acquires shortly after it leaves the discharge hopper, it has been found that development can be carried on successfully at angles up to 90° with the horizontal end, where there are other reasons for using steeper angles, such may be resorted to. For instance, if it is desirable to project an image onto the plate while it is in developing positon, and it is most convenient to mount the projector in a horizontal position, the plate may be mounted vertically, for instance, as shown in Figure 8. This arrangement is particularly useful in the case of extremely large plates where a large image is to be projected onto the plate from a projector mounted several feet away and, hence, where horizontal projection is the only feasible method.

Referring to Figure 8, development apparatus here illustrated comprises a frame **53** comprising a flat base **54** on which is mounted a vertical backing plate on which are mounted vertical uprights **55** which support vertical backing plate **56** against which xerographic plate **57** is clamped. The travelling hopper **58** is suspended at its ends on a pair of cables **59** which pass over pulleys **60** pivoted on a shaft **61** which runs in horizontal bearings secured to the top of an upright frame **62** mounted a few inches in front of backing plate **56**. Cables **59** wind onto a rail **63** which may be turned by a hand crank **64** to raise and lower hopper **58** along the face of the xerographic plate to be developed. The hopper **58** is provided with a discharge chute **65** which makes an angle of 30° or greater with the horizontal and terminates in a lip portion **66** one-quarter inch or less from the face of xerographic plate **57**. A swinging gate **67** is pivoted to the hopper and may be swung into open or closed position by manual handle **68**. A catching hopper **69** is placed at the bottom of plate **56** to catch the developer as it falls down the front of the plate. The developing operation is substantially the same as previously described, the hopper gate being opened and the hopper slowly lowered from the top to the bottom of the area to be developed, with developer discharges from chute **65** against the plate. Frame member **62** may be spaced apart to provide an opening or a window directly in front of the sensitized area of the plate to permit an image to be projected onto the plate while it is mounted in developing position.

With this modification, as with the others, the rate of travel of the hopper may be varied depending on the type of developer used and on other variables. In general, there is no minimum speed below which it is undesirable for the hopper to travel. For most purposes a speed of hopper travel of four or five inches per second produces satisfactory development in the minimum of time. It will be apparent that a novel developing apparatus has been disclosed which is useful for the development of xerographic plates of any size and is particularly successful in the development of large flat plates.

While the present invention, as to its objects and advantages, has been described herein as carried out in specific embodiments thereof, it is not desired to be limited thereby but it is intended to cover the inventon broadly within the spirit and scope of the appended claims.

What is claimed is:

1. A method of developing an electrostatic latent image on a long plane image bearing surface comprising positioning the image bearing surface lengthwise on an

incline of at least 30 degrees and continuously feeding additional increments of a developer from a source of supply moving relatively along the image-bearing surface to the surface in a travelling location, beginning at the top of the incline and ending at the bottom of the incline, said developer consisting of granular carrier particles and oppositely charged electroscopic powder particles wherein the powder particles are charged to a polarity opposite to the polarity of the electrostatic latent image, whereby the electroscopic particles are deposited on the image bearing surface in conformity with the electrostatic latent image to yield a developed image substantially free from end to end non-uniformity.

2. A method of developing an electrostatic latent image on a long plane image bearing surface comprising positioning the image bearing surface lengthwise on an incline of at least 30 degrees and continuously feeding additional increments of a developer from a source of supply moving relatively along the image-bearing surface to the surface first for a delay period at the top of the incline and subsequently in a traveling location, beginning at the top of the incline and ending at the bottom of the incline, said developer consisting of granular carrier particles and oppositely charged electroscopic powder particles wherein the powder particles are charged to a polarity opposite to the polarity of the electrostatic latent image, whereby the electroscopic particles are deposited on the image bearing surface in conformity with the electrostatic latent image to yield a developed image substantially free from end to end nonuniformity.

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