July 6, 1965 C. J. YOUNG 3,192,897

ELECTROSTATIC PRINTING APPARATUS

Original Filed Dec. 28, 1960 2 Sheets-Sheet 1

Fig. 1.

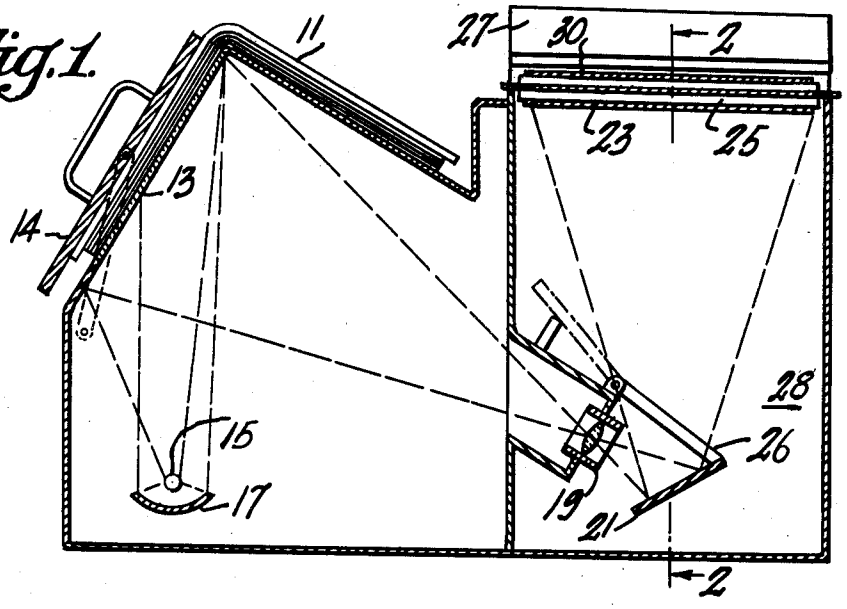
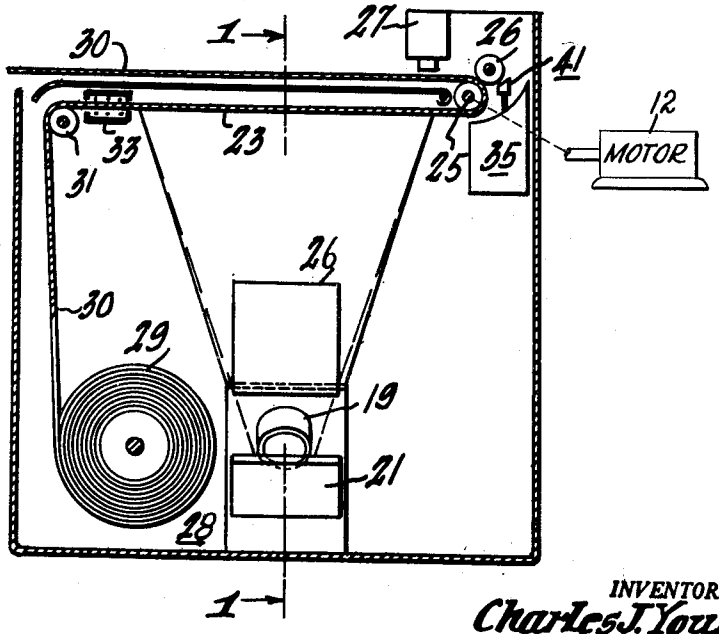


Fig. 2.



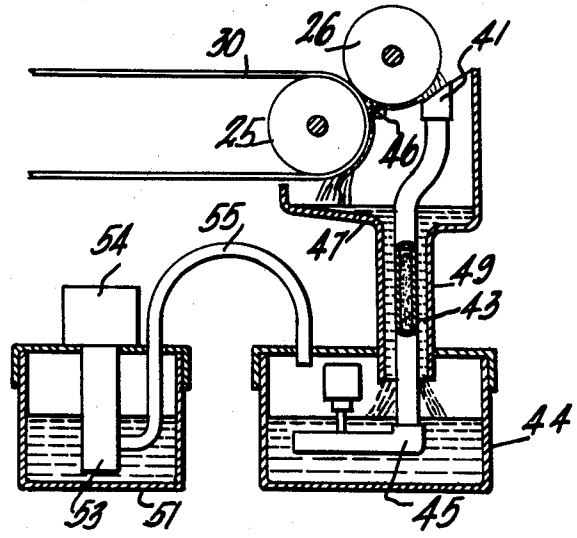
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ELECTROSTATIC PRINTING APPARATUS

Original Filed Dec. 28, 1960 2 Sheets-Sheet 2

Fig. 3.



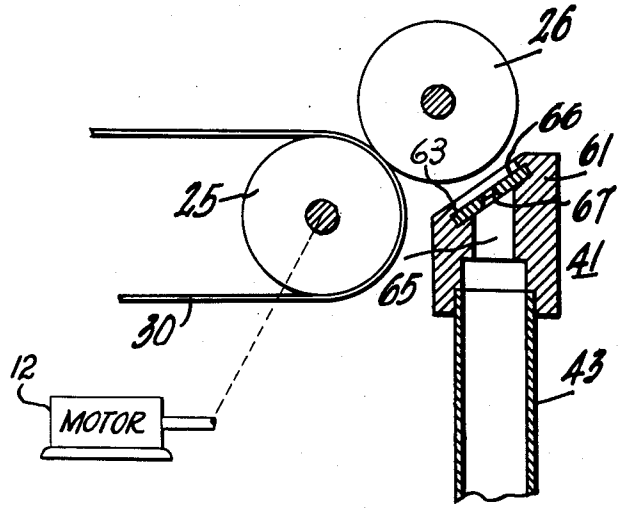


Fig. 4.

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ELECTROSTATIC PRINTING APPARATUS

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Original application Dec. 28, 1960, Ser. No. 78,930. Divided and this application Dec. 29, 1961, Ser. No. 163,313

5 Claims. (Cl. 118—637)

This invention relates generally to improved electrostatic printing apparatus and more particularly to such apparatus including improved means for applying liquid developer compositions to electrostatic images. This is a division of my copending application Serial No. 78,930, filed December 28, 1960.

In the art of electrostatic printing, electrostatic images are produced on the surface of an insulating material. Such images comprise a pattern of electrostatic charges on the surface. Visible images are commonly produced therefrom by applying across the surface a dry mixture of finely-divided developer particles and substantially larger carrier particles. The developer particles deposit in charged areas to produce a visible image in substantial configuration with the pattern of charges. Several methods of producing visible images are described in "Electrofax" Direct Electrophotographic Printing on Paper, by C. J. Young and H. G. Greig, RCA Review, December 1954, vol. XV, No. 4.

The recording element may comprise almost any insulating surface but, preferably, the recording surface is also photoconductive to enable the recording of light images. Recording elements comprising photoconductive selenium coated plates are described in U.S. Patent 2,297,691, issued October 6, 1942, to C. F. Carlson. Recording elements comprising photoconductive coatings on paper are described in the aforementioned Young and Greig publication.

A so-called liquid process for developing electrostatic images has been proposed in which the solid developer particles are suspended in an insulating carrier liquid. Liquid development methods provide many distinct advantages over the use of dry developer mixtures and other methods of developing electrostatic images for some applications. Basically, the liquid developer consists of finely-divided developer particles dispersed in an insulating liquid. This developer can be flowed over a surface bearing an electrostatic image or the surface can be immersed in a tray of liquid developer. It can also be sprayed or rolled onto the surface. A liquid developer process for charge images is described in greater detail by K. A. Metcalf and R. J. Wright in a paper entitled "Xerography," published in the Journal of the Oil and Colour Chemists' Association, November 1956, vol. 39, No. 11, London, England and in another paper entitled "Liquid Developers for Xerography," published in the Journal of Scientific Instruments, February 1955, vol. 32.

Although the above-mentioned liquid development processes are suitable for many purposes, it has been found that they have at least one serious deficiency. When producing a visible image by deposition of developer particles from a liquid onto a charged surface, particles adhere in the background areas as well as in the image areas on the surface. Background areas are those areas on the surface bearing little or no electrostatic charge and hence, are those areas in which deposition of developer particles is unwanted. Such spurious deposit in non-image areas results in a spotted or mottled background on the finished print which, in many applications, is unsatisfactory. This effect is even more pronounced when attempting to reproduce fine detail. The more finely-divided the developer particles are, the greater the spurious deposition in background areas.

In addition to the foregoing, it has been found that when images are developed with a liquid composition carried on a roller, second and subsequent rotational cycles of the roller cause ghost images to be offset printed on a recording medium by the roller.

It is a general object of this invention to provide improved electrostatic printing apparatus.

A further object of this invention is to provide improved apparatus for applying liquid developer compositions to electrostatic images.

A still further object is to provide improved roller apparatus for developing electrostatic images on recording members with substantial reduction or elimination of undesirable offset printing of ghost images thereon.

These and other objects are accomplished in accordance with this invention which provides electrophotographic apparatus including means for charging the surface of an electrophotographic member, means for transporting the member through an exposure region, and a developer mechanism adjacent the exposure region comprising a developer roller adapted to have the electrophotographic member contact therewith and means for washing said roller with liquid developer composition in a manner to substantially reduce or eliminate offset printing or ghost images deriving from the previous development of the preceding electrostatic images.

Other objects and advantages will be apparent from the following detailed description to be read with reference to the accompanying drawings wherein:

FIG. 1 is a side elevational, cross-sectional view of the interior of an electrostatic printing apparatus made in accordance with this invention;

FIG. 2 is a rear elevational, cross-sectional view of the interior of the apparatus of FIG. 1 taken along the line 2—2 thereof;

FIG. 3 is a side elevational view, partly in section, of the developer mechanism of FIG. 2;

FIG. 4 is an enlarged side view partially in cross section of a portion of the developer mechanism of FIG. 3.

Similar reference characters are applied to similar elements throughout the drawings.

A compact photocopy apparatus in accordance with this invention is illustrated in FIG. 1. The apparatus is designed with a portion of the top of the housing thereof forming an inverted V-shaped roof. This V-shaped structure is adapted, as shown, to support a book **11** so that a page thereof which is to be copied is in contact with a transparent plate **13**. A hinged plate **14** is provided to insure that the page to be copied is firmly held against the transparent plate **13**. A single sheet, such as a letter, could be equally well held in place by the hinged plate **14**. The page of the book is illuminated through the transparent plate **13** by means of a light source **15** and a reflector **17**.

The light source **15** may comprise one or more pencil shaped horizontal lamps. Well suited for the purpose are lamps such as 500 watt tungsten filament quartz tubes which contain traces of iodine. The iodine in the lamp functions to catch tungsten particles which evaporate during operation and to return those particles to the filament. Such a lamp is produced by the General Electric Corporation, catalogue No. 500T3Q/CL. The reflector **17** conveniently comprises a ¼" segment of a 6" hollow cylinder, the inside of which is polished to a high degree. Since the distance from the light source **15** to the bottom edge of the plate **13** is much less than the distance of the light source **15** to the top edge of the plate **13**, the reflector **17** is positioned to concentrate reflected light toward the upper portion of the transparent plate **13** so that the entire area under the plate is uniformly illuminated.

Light reflected from the page of the book 11 is concentrated through a lens 19 to impinge upon the mirror 21. The light is then reflected from the mirror 21 upwardly and focused on an exposure plane 23. A shutter 25 is provided in the light path between the mirror 21 and the exposure plane 23 in order to prevent any light from entering the right hand compartment 27 of the copier apparatus except when exposure is desired.

Further details of the internal structure of the compartment 27 are illustrated in FIGURE 2. A supply roll of photosensitive webbing is mounted in the lower portion of the compartment 27. The webbing 30 on the supply roll may comprise, for example, electrophotographic paper such as is described in the aforementioned Young and Greig publication. The paper 30 is fed from the supply roll 29 over an idler roller 31 through a double corona charging apparatus 33 and into the exposure plane 23. The paper is then carried partly around one roller 25 of a pair of pressure rollers in a manner so that it reverses its direction and is then brought out from the copier apparatus under a heat fusing mechanism 27.

In the apparatus as shown in FIGURE 2, the double corona charging unit 33 may comprise 2 opposed structures of very fine parallel wires as described in U.S. Patent 2,922,883, issued to E. C. Giaimo, Jr. and the heat fuser 27 one such as is described in U.S. Patent 2,857,-682 to R. G. Olden et al.

From the charging apparatus 33 the paper 30 is transported into the exposure plane 23 with its photosensitive surface facing downward. While the paper is maintained stationary in the exposure plane 23, the light image reflected upward from the mirror 21 will substantially reduce or eradicate the charges placed on the paper by the corona unit 33 in those areas on which light impinges. As the paper 30 passes over one of the pressure rollers 25, liquid developer composition from liquid developer unit 35 is applied to the other pressure roller 26, which in turn applies the liquid developer composition to the paper 30 to produce, in those areas thereon which were not struck by light, a visible image of developer material. This visible image is then fixed to the surface of the paper as it passes under the fuser 27.

In FIGURE 3, the developing unit 35 of FIG. 2 is illustrated in greater detail. This developer unit includes the two pressure rollers 25 and 26 which engage the paper and which are driven by a motor 12 which is connected to roller 25, to pull the paper from the supply roller 29 (FIG. 2) through the projection plane 23 shown in FIGURE 2. Liquid developer composition is applied to the upper pressure roller 26 by means of an applicator 41. The developer composition is supplied to the applicator 41 through a pipe 43 (FIG. 3) connected to a centrifugal pump 45. As liquid developer composition is carried by the upper pressure roller 26 into contact with the paper, a turbulent nip 46 of the developer composition is formed where the roller 26 contacts the paper. This turbulent nip 46 of developing composition substantially enhances development of images on the paper and also enhances clean up of developer material which may adhere in unwanted areas on the paper 30. The liquid developer composition not only forms the nip 46 but also flows down the surface of the paper 30 as it is carried over the pressure roller 25. The developer composition is thereby caused to be in contact with a substantial portion of the paper 30 as it is transported over the roller 25.

Developer composition in excess of that used to develop an image on the paper drops therefrom into a tray or sump 47 positioned below the two pressure rollers 25 and 26. The developer composition collected in the sump 47 is returned to the developer container 44 through a pipe 49 which surrounds the feed pipe 43.

An important feature of the developer unit shown in FIG. 3 is that it comprises a substantially closed system for developing images on the paper 30. Such a closed system makes it possible to use developer compositions

which include a highly volatile liquid without resulting in excessive evaporation of that liquid. Excessive evaporation would ultimately result in wide variations in the concentration of the developer material in the developer composition.

An example of a suitable, highly volatile developer composition is one wherein finely-divided electroscopic developer particles are dispersed in a liquid carrier of trichlorotrifluoroethane.

EXAMPLE

A black pigment is prepared by making two solutions:

Solution one comprises—
6 grams Iosol Black (C. I. Solvent Black 13)
400 grams methanol

Solution two comprises—
9 grams Spirit Nigrosine (C. I. 50415)
400 to 600 grams methanol

Solution one is poured into solution two with continuous stirring. Once the solutions have been thoroughly mixed and a black, relatively insoluble pigment is precipitated, the mixture is filtered and the filter cake allowed to dry. The dried filter cake is broken up and dispersed in dimethyl polysiloxane liquid having a viscosity of about 2 centistokes. The proportions in this dispersion are about 1 to 10 parts black pigment to about 20 parts of liquid. It is preferred that the liquid content be kept as low as possible but sufficient to provide a uniform dispersion. After ball milling the black pigment is classified as to particle size. Particles having a diameter of 74 microns or less are preferred.

Also prepared is a solution consisting of:

200 grams dimethyl polysiloxane
200 grams trichlorotrifluoroethane

About one part by weight pigment dispersion per 10 parts solution is added to provide a final developer composition.

As images are developed on the paper with the apparatus, the concentration of developer particles in the container 44 will become depleted at a greater rate than will the liquid carrier portion thereof. In order to maintain the proportions of components in the liquid developer at a substantially constant level, means are provided for injecting into the container 44, metered amounts of a concentrated developer composition. The developer concentrate is contained in a jar 51. A reciprocating pump 53 is inserted in the jar 51 and is powered by a solenoid 54. At each stroke of the pump 53 in the jar 51 a small quantity of developer concentrate is forced through the pipe 56 and injected into the container 44. It is desirable that the reciprocating pump 53 be provided with an adjustable stroke whereby the quantity of developer concentrate injected each time into the container 44 can be regulated. It is also desirable that the solenoid be energized, if desired, each exposure cycle or if desired once each two cycles or once each five cycles or so.

A suitable developer concentrate may be prepared by dispersing developer material such as that described heretofore in a dimethyl polysiloxane in a proportion of about 20 parts by weight of developer material to 80 parts by weight of a dimethyl polysiloxane having a viscosity from 0.6 to about 3 centistokes.

In FIG. 4 further details are provided of a suitable construction for the applicator member 41 of FIG. 3. The applicator member is here shown as comprising a metal head 61 which will have a length equal to the length of the paper to be developed. One face 63 of the applicator member is bevelled so that it can be positioned in close proximity to the pressure roller 26. An elongated U-shaped slot 65 is provided in the head 61 and into this slot developer cmoposition is supplied under pressure through the pipe 43. Near the top of the slot there is provided an elongated slide 66 having a multiplicity of apertures 67 therethrough. These apertures being, for

example, holes .040 inch in diameter, counter sunk on one side, and spaced about ¼ inch apart along the length of the slide **66**. By using such a slide, a convenient means is provided whereby, upon removal of the slide **66** from the head **61**, both the slide **66** and the U-shaped slot **65** can be easily cleaned.

It has been found that, in normal operation, development of the image on the paper **30** as it is carried over the lower pressure roller **25** will cause a ghost image to be off-set printed on the upper pressure roller **26** as the periphery thereof moves away from the paper **30**. Unless some means are provided for removing this ghost image from the upper pressure roller **26**, it would again contact the paper and off-set print thereon a ghost image which under most circumstances would be undesirable in a finished print. In the embodiment illustrated herein, developer composition is forced through the apertures **67** in the slide **66** under pressure so that the composition strikes the roller **26** with sufficient force to substantially obliterate any offset images previously formed on the surface thereof.

What is claimed is:

1. Apparatus for applying liquid developer composition to a continuous web bearing a latent electrostatic image, said apparatus comprising a pair of pressure rollers adapted to contact opposite surfaces of said web, one of said rollers being adapted to have said web contact a substantial portion of the periphery thereof, the other of said rollers being positioned in a plane above said one roller so as to make substantially line contact with said web, drive means for rotating said rollers to move said web therebetween, means for washing said other roller with said liquid developer composition to substantially obliterate offset images formed on said other roller as a result of previous development of electrostatic images on said web with said other roller, rotation of said other roller providing means for carrying developer composition into contact with said image bearing web and forming a turbulent nip of developer composition between said image bearing web and said other roller, and sump means for collecting developer composition flowing down over the surface of said image bearing web on said portion of said one roller.

2. Apparatus for applying liquid developer composition to a continuous web bearing a latent electrostatic image, said apparatus comprising a pair of pressure rollers adapted to contact opposite surfaces of said web, one of said rollers being adapted to have said web contact a substantial portion of the periphery thereof, the other of said rollers being positioned in a plane above said one roller so as to make substantially line contact with said web, drive means for rotating said rollers to move said web therebetween, container means for a supply of said liquid developer composition and means for drawing said composition from said container means and squirting it onto said other roller with sufficient force to substantially

obliterate offset images formed on said other roller as a result of previous development of electrostatic images on said web with said other roller, rotation of said other roller providing means for carrying developer composition into contact with said image bearing web and forming a turbulent nip of developer composition between said image bearing web and said other roller, and sump means for collecting developer composition flowing down over the surface of said image bearing web on said portion of said one roller.

3. The apparatus of claim **2** including means for replenishing said container means with metered amounts of developer composition.

4. Apparatus for applying liquid developer composition to a continuous web of electrophotographic material bearing a latent electrostatic image, said apparatus comprising a pair of pressure rollers adapted to contact opposite surfaces of said web, one of said rollers being adapted to have said web contact a substantial portion of the periphery thereof, the other of said rollers being positioned in a plane above said one roller so as to make substantially line contact with said web, drive means for rotating said rollers to move said web therebetween, applicator means for applying liquid developer composition to said other roller in a multiplicity of fine liquid jets with sufficient force to substantially obliterate offset images formed on said other roller as a result of previous development of electrostatic images on said web with said other roller, rotation of said other roller providing means for bringing developer composition into contact with said web and forming a turbulent nip of developer composition between said web and said other roller, container means for a supply of said liquid developer composition, pump means for drawing liquid developer composition from said container means and supplying it to said applicator means under pressure, and sump means positioned below said rollers for collecting excess developer composition flowing down over the surface of said web on said portion of said one roller and returning it to said container means.

5. The apparatus of claim **4** including additional container means for a supply of concentrated liquid developer composition and means for supplying metered amounts of said concentrated composition to said first mentioned container means.

References Cited by the Examiner

UNITED STATES PATENTS

2,161,795	6/39	Benello	118—259 X
2,649,758	8/53	Cowgill	118—259 X
2,991,754	7/61	Johnson.	
3,003,404	10/61	Metcalfe et al.	118—637 X
3,005,388	10/61	Limberger	118—637 X
3,052,213	9/62	Schaffert	118—637

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