June 2, 1959 J. J. WALKER 2,889,234
XEROGRAPHIC DEVELOPMENT PROCESS
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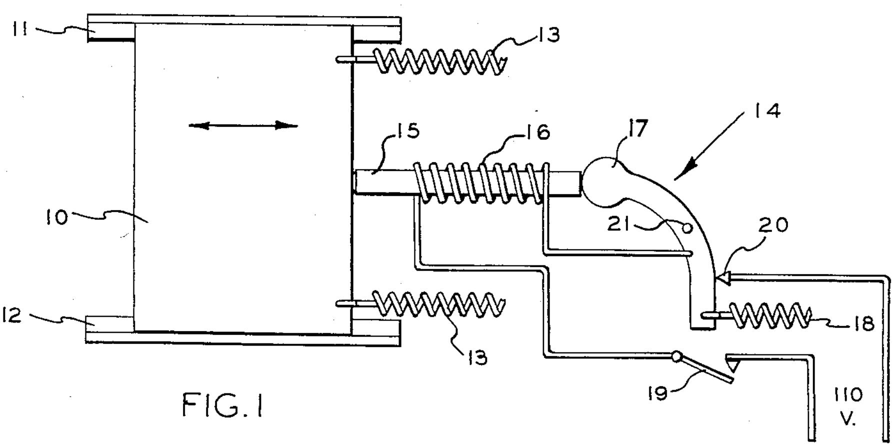

FIG. 1

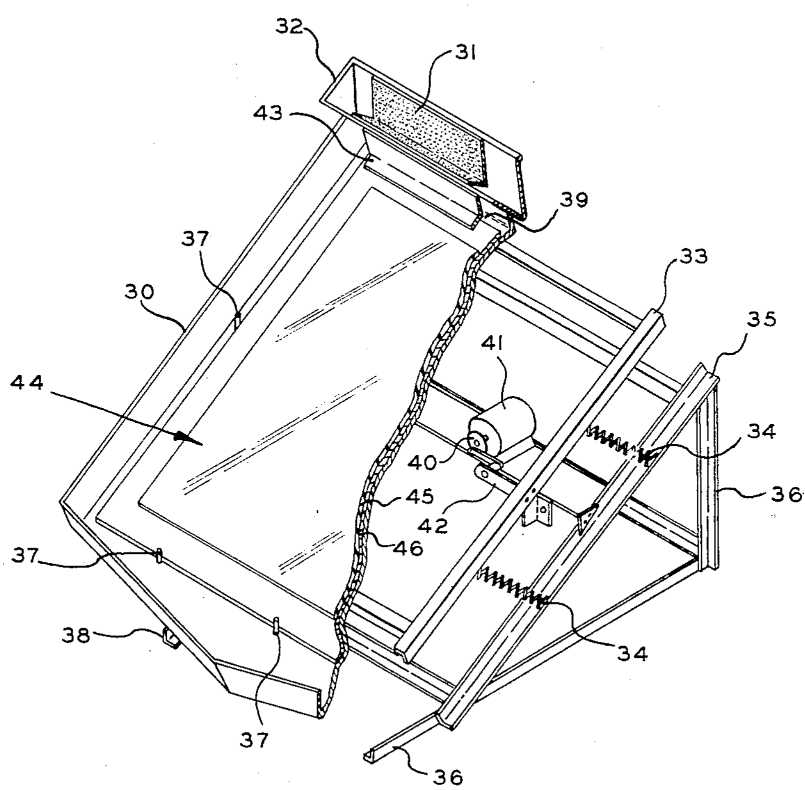

FIG. 2

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XEROGRAPHIC DEVELOPMENT PROCESS

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Application July 13, 1955, Serial No. 521,668
1 Claim. (Cl. 117—17.5)

This invention relates to a method and apparatus for the development of electrostatic latent images.

In xerography it is usual to form an electrostatic latent image on a surface. One method of doing this is to charge a photoconductive insulating surface and then dissipate the charge selectively by exposures to a pattern of activating radiation. Other means of forming electrostatic latent images are set forth in U.S. 2,647,464 to James P. Ebert and U.S. 2,576,047 to Roland M. Schaffert. Whether formed by these means or any other, the resulting electrostatic charge pattern is conventionally utilized by the deposition of an electroscopic material thereon through electrostatic attraction whereby there is formed a visible image of electroscopic particles corresponding to the electrostatic latent image. Alternatively, the electrostatic charge pattern may be transferred to an insulating film and the electroscopic particles deposited thereon to form the visible image. In any case, this visible image in turn may be transferred to a second surface to form a xerographic print.

It is at once evident that this process has exceptional flexibility and lends itself to a limitless number of end uses. On such application, which is particularly challenging in the strictness of its requirements, is the transfer of the visible image formed by the electroscopic particles to a conductive plate and fixing the particles to the plate to form thereby a lithographic plate. Such plates vary in size from the dimensions of a postage stamp up to those used in making maps, which plates are generally 2'x3' in size. Furthermore, irrespective of the size of the image developed, an extremely high quality of resolution is required throughout, often as high as 150 lines per inch or better.

One particularly troublesome defect accompanying the transfer of the visible image formed by the electroscopic particles to the conductive plate is termed "hollow lines." A line segment appearing on the original as a solid line, on transfer to the conductive plate, appears as two very narrow parallel lines with a white or unprinted area in between. Because of this appearance the defect has been given the name of "hollow lines." A most unusual feature of this defect is that the visible image formed on the photoconductive insulating surface by the deposited electroscopic particles reproduces the solid lines of the original as solid lines, i.e. not as hollow line segments. The "hollowness" only appears on the image transferred to the conductive plate. While this would appear to be a fault of the transfer operation, applicant has found, surprisingly enough, that an improved development process eliminates this difficulty.

The developing material commonly used in xerography consists of a finely pulverized pigmented resin powder called a "toner" mixed with a coarser granular material called a "carrier" to which the powder loosely adheres by the electrostatic charges generated by contact between the powder and the granular carrier. When the developer mixture has tumbled over the exposed xerographic plate, as by tilting the plate to different angles while in contact with the developer mixture, the powder particles are attracted to the image from the granular material to produce a visible powder image. This method of development is known as "cascade development" and is set forth in U.S. 2,618,552. Applicant has now found that if, in this basic process of cascade development, the developing material—rather than being permitted to flow in uniform parallel lines across the surface of the xerographic plate—is made to follow a zig-zag course while cascading over the surface carrying the electrostatic latent image, the resulting image formed by deposition of the toner on the electrostatic latent image conforms faithfully to the original to be reproduced without loss of detail and, furthermore, an image developed in this way, on transfer to a conductive plate, is free from hollow lines.

By the term "xerographic plate" as used herein is meant, of course, a conductive backing member having a coating or layer of a photoconductive insulating material on at least one side. If desired, the photoconductive insulator may be protected by a thin film of an insulating resin such as polystyrene, a cellulose ester, a polyvinyl acetal, etc. The backing member may be of any conductive material having the desired structural properties for the use intended such as, for example, a metallic member, plate or the like as of brass, aluminum, zinc, etc. or, optionally a nonconductive member of desired structural properties, such as glass or plastic having a conductive coating as of tin oxide, silver, etc., or a fibrous material, such as paper, having therein conductive material, such as water, particles of carbon, metal or the like, to render the material conductive. Representative photoconductive insulators include vitreous selenium, sulphur, anthracene, mixtures of selenium and sulphur, various photoconductive phosphors such as zinc oxide, cadmium sulfide and the like. These may be applied to the conductive backing member either as a continuous layer or as discreet particles in a resinous binder.

The general nature of the invention having been set forth, there will now be presented a more detailed description, in illustration but not limitation, of the invention in the following specification and drawings in which:

Fig. 1 is a semi-diagrammatic representation of apparatus according to one embodiment of the invention, and

Fig. 2 is a diagrammatic view of development mechanism according to another embodiment of the invention.

The present invention is particularly intended and adapted for the development of electrostatic latent images on relatively large xerographic plates such as are commonly used in the reproduction of full-size maps. Images of this sort require an unusually high degree of fidelity and resolution in their reproduction.

Illustrated in Fig. 1 is a development system presented semidiagrammatically comprising a developer tray **10** movably positioned on slides **11** and **12** wherein it is yieldably secured by means **13**, as springs or the like. Means **14** to vibrate the tray are also provided in this case, consisting of an armature **15** and a solenoid **16** with a contact lever **17** which is loaded by spring **18**. The slide and tray assembly is free to rotate about axis made by the two slide means **11** and **12**.

In operation, a surface bearing an electrostatic latent image to be developed is placed face up in the tray **10**. When the image is on a photoconductive insulating layer, as is the case when a xerographic plate is used, the entire unit must be handled in a darkroom to prevent dissipation of the charge in the image areas. The image-bearing member is secured to suitable means, as pins, to the developer tray **10**. The tray is then positioned at a slight angle to the horizontal with a supply of developer, such as disclosed in 2,618,552, distributed along that end which is raised from the horizontal. The spring **18** is then adjusted to obtain the desired rate of vibration and the vibrating means **14** actuated by closing switch **19**. Current flows through solenoid **16** forcing armature **15** back against contact lever **17**. This causes contact lever **17** to rotate on pin **21** breaking the circuit at contact point **20**. With the force exerted by the armature **15** on the upper arm of contact lever **17** removed by the breaking of the circuit at contact point **20**, spring **18** rotates contact lever **17** around pin **21** striking armature **15**. The upper arm of contact lever **17** drives armature **15** against tray **10** causing it to vibrate while simultaneously the lower arm of contact lever **17** restores current to coil **16** by making contact with contact point **20**. The cycle repeats until switch **19** is opened. The time for completing one cycle may be adjusted either by varying the tension on spring **18** or by varying the point of contact between contact lever **17** and contact point **20**. The developer then cascades across the image-bearing surface in a zigzag path and collects on the lower side of the developer tray **10**. In this manner the image is developed.

Example 1

The apparatus of Fig. 1 was used. The image to be developed was on a xerographic plate consisting of a layer of vitreous selenium on an aluminum backing and measuring 11" x 14" in size. The plate was secured to the developer tray **10** by pins and the tray tilted about ten degrees to the horizontal. A two-component developer prepared in accordance with U.S. 2,618,551 and available commercially from The Haloid Company under the name "XeroX Toner and Developer" was distributed at the far end of the upper side of the tray. The armature **15** weighed two ounces and was moved by a hundred-watt electromagnet. The armature **15** traveled about one-quarter inch. The spring **18** was adjusted to produce a frequency of about ten cycles per second. The amplitude of vibration of the tray **10** was approximately 0.01". After the two-component developer was distributed, the switch **19** was closed. Development was complete in about one minute.

The image was then electrostatically transferred to a zinc plate using the apparatus of U.S. patent application Serial No. 491,344, filed March 1, 1955, by Matthews and Walker, with a potential of about 500 volts, and fused to the zinc plate in the same apparatus using trichloroethylene vapor. The image on the zinc plate was then examined and found to be characterized by exceptionally good quality, having good resolution, density, and relative absence of hollow lines.

In Fig. 2 the tray **30** contains a perforated screen **31** positioned in a slotted trough **32** at the upper end of the tray. The trough **32** connects to the surface of tray **30** by means of slot **39**. The tray **30** is fastened to a tray support **33** which is fastened by yielding means as springs **34** to stand **35**. Stand **35**, in turn, is positioned by rack **36** so that the tray **30** is inclined at an angle to the horizontal. A spout **38** is at the bottom of the tray **30**. An eccentric **40** driven by motor **41** is connected to tray support **33** by suitable means as a rod **42**.

In operation, an image bearing member **44** having a photoconductive insulating layer **45** on a conductive back **46** is placed with the insulating layer **45** up in the tray **30** where it is secured by suitable means, as pins **37** and flange **43**. Alternatively, the tray **30** may be so constructed as to firmly hold the image-bearing members to be developed therein. A supply of two-component developer prepared in accordance with U.S. 2,618,551 and available commercially from The Haloid Company under the name "XeroX Toner and Developer" is distributed along the perforated screen in the slot developer trough. The motor driving the eccentric is then actuated causing the tray to oscillate in the plane of the tray **30** and in a direction approximately at a right angle to the direction of motion of the powder particles over the image-bearing member. The result is to impart a zigzag pattern to the developer particles. These particles passing over the image-bearing member pass through the hole **38** and are collected in suitable means as a jar, trough, or other container. The developer so collected may then be redistributed over the perforated screen for the development of another image-bearing member.

Example 2

The apparatus of Fig. 2 was used. The electrostatic latent image to be developed was on a xerographic plate consisting of a layer of vitreous selenium on an aluminum backing and measuring 11" x 14". Accordingly, development was carried out in the dark to prevent dissipation of the electrostatic image. The plate **44** was placed in the tray **30** image side (i.e., the side bearing the photoconductive insulating layer **45**) up. The stand **36** holding the tray **30** was so constructed that the tray was inclined at five degrees to the horizontal. A supply of two-component developer prepared in accordance with U.S. 2,618,551 and available commerically from The Haloid Company under the name "XeroX Toner and Developer" was distributed along the length of the perforated screen **31** in the slot developer trough **32**. The eccentric **40** was adjusted to displace the tray **30** about one-eighth inch while the motor **41** was adjusted to provide about thirty such oscillations per second. The motor **41** was then actuated. The two-component developer cascaded over the image-bearing member **44** collecting at the bottom of the tray **30** where it passed through hole **38** to be collected in a jar. Development took about two minutes.

The image was then electrostatically transferred to a zinc plate using the apparatus of U.S. patent application Serial No. 491,344, filed March 1, 1955, by Matthews and Walker, with a potential of about 500 volts, and fused to the zinc plate in the same apparatus using trichloroethylene vapor. The resulting image was characterized by good resolution, density, and by freedom from hollow lines.

Example 3

Example **2** was duplicated except that the stand **36** was constructed to incline the tray **30** at an angle of ten degrees to the horizontal. In this case complete development of the 11" x 14" xerographic plate was obtained in one-half minute. Again, the image on the zinc plate was characterized by good resolution, density, and freedom from hollow lines.

While the present invention 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 invention broadly within the spirit and scope of the appended claim.

I claim:

In the process wherein an electrostatic latent image on a smooth, planar, electrically insulating surface is developed to yield an image of electrostatically attractable material electrostatically adhering on said surface by cascading across the electrostatic latent image a dry mixture of loose, movable finely divided particles of electrostatically attractable powder and separate granular carrier material, the individual granules of said carrier material being substantially larger than the individual particles of said attractable powder, the powder and carrier having a triboelectric relationship of opposite polarity whereby the powder removably adheres electrostatically to the surface of the carrier granules the improvement comprising flowing the dry mixture over the said image bearing surface in a zigzag course.

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