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METHOD FOR DEVELOPING ELECTROSTATIC LATENT IMAGES

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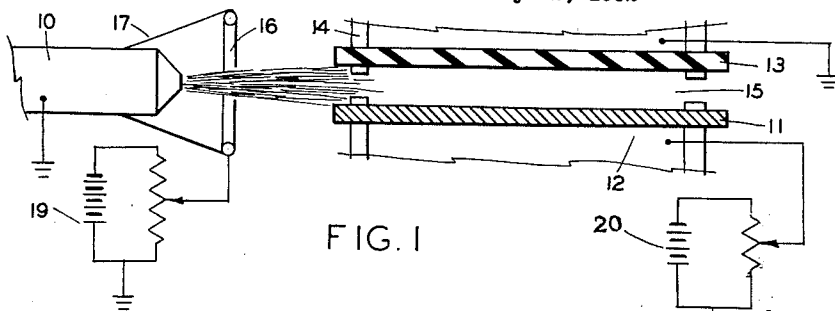


FIG. 1

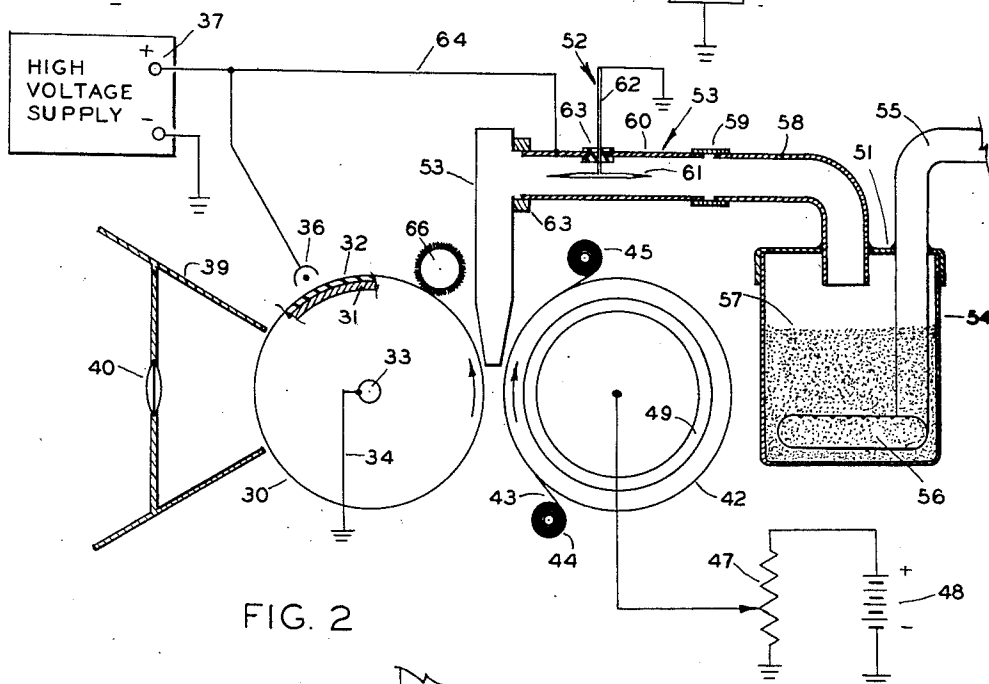


FIG. 2

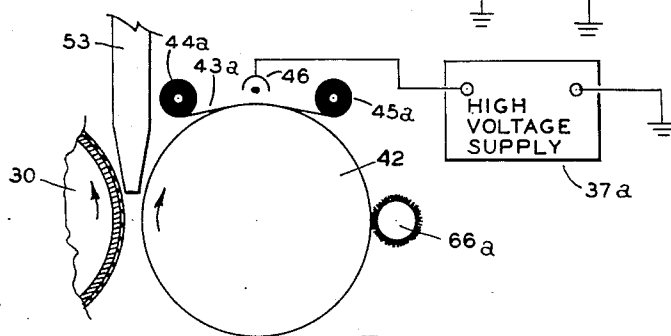


FIG. 4

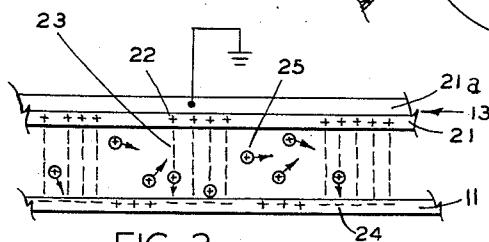


FIG. 3

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METHOD FOR DEVELOPING ELECTROSTATIC LATENT IMAGES

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Application May 12, 1952, Serial No. 287,275

1 Claim. (Cl. 117—17.5)

This invention relates in general to xerography and, in particular, to a new xerographic process.

According to the invention disclosed in Carlson U. S. Patent No. 2,297,691, an electrostatic latent image is produced on a photoconductive insulating surface in one of several ways such as by imposing a uniform electrostatic charge on the surface and exposing the charged surface to an energizing radiation pattern, whereupon the exposed areas become selectively discharged. It has been usual to transform this electrostatic latent image to a visible image by treating it with an electrostatically attractable material, such as a fine powder or mist, by which treatment the electrostatically attractable material is selectively deposited on the surface bearing the electrostatic latent image. The deposited image is then transferred to another surface or otherwise utilized to form a useful product, and the image surface is cleaned if necessary, recharged and again exposed to energizing radiation.

It has now been found that the Carlson process of electrophotography, since known as xerography, can be modified and improved by a step in which the electrostatic latent image induces an electrostatic image on another surface such as, for example, an adjacent conductive surface, and the induced image is developed or otherwise usefully employed.

It is an additional object of the invention to provide a new process for developing an electrostatic latent image from an insulating or photoconductive insulating surface.

It is a further object of the invention to provide a process including the step of developing an induced electrostatic latent image.

It is a still further object of the invention to provide a xerographic process comprising forming an electrostatic latent image, inducing a corresponding latent image on an adjacent conductive surface and developing said induced image on the conductive surface.

Other objects of the invention will in part be obvious and will in part be apparent from the specification and from the drawings in which:

Figure 1 is a diagrammatic view of apparatus according to one embodiment of the invention;

Figure 2 is a diagrammatic view of apparatus according to another embodiment of the invention;

Figure 3 is an enlarged fragmentary diagrammatic view of an image bearing member and an induced-image member, illustrating the behavior of electrostatically attractable particles therebetween; and

Figure 4 is a fragmentary diagrammatic view of a portion of a modified apparatus according to a modified embodiment of the apparatus of Figure 2.

Figure 1 is illustrated simple apparatus adaptable to an improved xerographic process according to this invention. Shown in the figure is an electroscopic material source 10 such as, for example, a liquid mist nozzle, a conductive electrode 11, optionally mounted on support means 12, and an image bearing member 13 also optionally mounted on support means 14. The electrode 11 and image bearing member are closely spaced across a development zone

or space 15, and the nozzle 10 is directed into and through the space, substantially parallel to members 11 and 13. A conductive charging ring 16 is mounted in front of nozzle 10 by insulating supports 17, being positioned so that the mist or spray emerging from the nozzle passes through the ring. The ring is conductively joined to a potential source 19, optionally at variable potential. Image member 13 is connected to a potential source, such as ground potential; or in the case of an image member consisting of a conductive backing and an insulating layer, the conductive backing is thus connected, optionally this connection being through support means 14. Similarly, electrode 11 is conductively connected to a potential source, for example, potential source 20, optionally a source of a variable potential.

The operation of this mechanism depends upon the nature of the image bearing member 13 and varies with the intended end purpose. This will be described with reference to a typical situation, it being understood that the specific instance is not a limiting one. The usual image member is a plate or other member having a conductive backing and an insulating or photoconductive insulating layer. In the case of a photoconductive insulating layer, the layer may be charged, for example, to a positive polarity of about 100 to 500 volts and exposed to a light image whereupon it becomes selectively conductive under the influence of the selective illumination. The electric charge thus is selectively dissipated, yielding a latent image having various charged areas having potentials ranging downward from the original or maximum potential. Such an image member is placed on support 14 and the conductive backing is electrically grounded.

In operation, ring 16 is connected to a potential of opposite polarity to the image on member 13, in this case a negative potential, and electrode 11 is connected to ground potential or a potential a few volts from ground potential. Spray nozzle 10 is then energized, producing a liquid spray that consists of fine droplets positively charged by induction from charging ring 16. These charged droplets are directed into development zone 15 where they are deposited on electrode 11 by the induced electrostatic image thereon.

In Figure 2, there is shown a copying mechanism employing the principles of this invention. In the mechanism shown in Figure 2, there is an image-bearing member or cylinder 30 which, along at least one segment of its area, has an image surface comprising a conductive backing member 31 and a photoconductive insulating layer 32 therein. The cylinder is rotatably mounted on an axle 33 and is electrically connected to a suitable potential source, such as ground, by means of a conductive connection 34.

Positioned around the cylinder are several stations at which may be carried out the process steps according to electrophotography or xerography. Illustrated diagrammatically is a charging station 36 which may, in a simple form, comprise a corona discharge electrode conductively connected to a high voltage source 37. At a subsequent position in the direction of rotation of the cylinder is an exposing station including, for example, a camera housing 39 and a lens 40. It will be understood that this exposing station may comprise appropriate contact exposing means or suitable lens or projection exposing means which may operate in any desired manner such as, for example, by means of slit projection or the like.

A second cylinder 42 is positioned closely adjacent to cylinder 30 at a subsequent position or station around cylinder 30 to define a developing zone in the form of a narrow gap between the two cylinders. This cylinder 42 is spaced from cylinder 30 as closely as is consistent with the process steps of xerography and preferably is maintained with a free space less than $\frac{1}{8}$ ", and usually in the

order of about $\frac{1}{40}$ " free space therebetween. It is to be noted that it is desirable to have as narrow a space as possible between these two members, the minimum of the width being set in part by the need to flow a suspension of finite sized particles therebetween and to avoid contact caused by vibration, etc., during movement of the members. The two cylinders preferably are rotatably mounted and driven from a single power source at synchronized speeds so that the surface of the cylinders across the developing zone are adapted to move in the same direction and at the same rate of speed.

An image receiving material such as, for example, a sheet or web 43 is mounted to be carried across the developing zone along the surface of cylinder 42, preferably being carried thereacross from a sheet feeding roll 44. If desired, the material may be collected on a sheet receiving roll 45 or optionally may be ejected from the apparatus in the form of a print-containing sheet which is, in effect, the finished print. It will be apparent that this sheet or web 43 is spaced from the printing cylinder 30 by a very narrow air gap which acts as the developing zone and is completely free from contact with the printing cylinder at all times.

Cylinder 42 is electrically connected to a potential source which, preferably, is maintained at variable or adjustable potential such as, for example, a potentiometer 47 which may operate between a battery 48 or other potential source and ground potential. In this manner, the cylinder 42 acts as a counter-electrode with reference to the printing cylinder 30 and is acted upon by a field of force determined by the electrical potential or potential pattern on the adjacent surface of cylinder 30. It is at once apparent that a corresponding potential pattern is induced on the surface of cylinder 42 at the development zone in the same manner as such pattern is induced on electrode 11 of Figure 1, and accordingly, this cylinder 42 is analogous in operation and function to that electrode.

As illustrated in Figure 2, a suitable heating coil 49 may desirably be positioned within cylinder 42 whereby the surface thereof may be heated for the purpose of fusing a thermoplastic material at the outer surface of the cylinder, or other means, as desired, may be employed to fix the image to sheet 43.

Positioned to operate into the developing zone between cylinders 30 and 42 is a source of a charged cloud or mist of finely divided particles such as, for example, a source of an electrostatically charged powder cloud. One form of such device is illustrated in Figure 2 and comprises, generally a cloud generating means 51, a cloud charging means 52 and a guide zone 53 which operates to direct the charge to the desired position. The cloud generating member comprises a container 54 having an inlet tube 55 connected to gas supply source such as an air source (not shown) and terminating within the chamber in a ring manifold 56. The manifold has a plurality of upwardly aimed openings through which air can be directed upwardly within the container. A mass of finely divided powder 57 is within the container, covering the manifold and preferably about half filling the volume of the container.

A guide tube 58 leads from the upper or free space of the cloud generating means to the cloud charging means. Optionally this guide tube 58 is connected to the cloud charging means by an insulating sleeve 59.

The cloud charging means 52 consists of a conductive casing or electrode 60 having mounted therein a corona electrode or needle 61 with a conductive support and lead 62 extending through casing 60 and being electrically connected to a suitable potential, such as ground. An insulating block 63 preferably is placed in the casing wall to receive support 62 and hold the corona needle in position within the casing. The casing or electrode 60 is mounted at its other end to the guide member 53 preferably by means of insulating washer 63. By means of insulating washer 63 and insulating sleeve 59 the casing

for electrode 60 is insulated from the rest of the mechanism and may be maintained at a desired potential independently of the potential or potentials of other and adjacent mechanism. A conductive lead 64 electrically connects the electrode 60 to a positive polarity high voltage source which may, for example, be the same high voltage source 37 as employed for corona electrode 36. The general arrangement of the powder cloud generating and charging means is disclosed and claimed in copending application Serial No. 244,556.

While there is substantially no deposition of the charged powder cloud on the image-bearing cylinder 30, it is preferred to have a cleaning station at one point along the cylinder which cleaning station may be a rotating brush 66 or other cleaning means adapted to remove developing material which from time to time will be deposited thereon in small quantities, or may, if desired, be a means for cascading thereacross a cleaning material such as for example, a granular material as shown in Copley U. S. 2,484,782.

In use and operation the mechanism of Figure 2 is employed as follows:

The two cylinders 30 and 42 are driven at a synchronized speed at such a rate as may be desired. The high voltage source 37 is activated whereby a positive corona discharge is energized at electrode 36 and a negative corona discharge is energized at electrode 61. A light pattern or image is focused on the surface of cylinder 30 through lens 40. In this manner the conventional functions of xerography are considered to occur on cylinder 30 wherein an electrostatic charge is imposed on photoconductive layer 32 by electrode 36 and the charge is selectively dissipated between action of the light pattern from lens 40. The resulting electrostatic charge pattern is carried around cylinder 30 to the development zone where it induces a corresponding pattern on the surface of cylinder 42. The charge patterns thus act to create a field of force across the developing zone which in turn deposits charged particles at the zone as disclosed in connection with Figure 1.

Along with the operation thus described, the powder cloud generating means is activated by means of a gas passed through tube 55 which carries a powder cloud through charging means 52 and then through guide means 53. This cloud of charged powder particles emerging from guide means 53 into the developing zone is thereby caused to deposit on the sheet or web 43 which has been interposed between the developing zone and the counter-electrode 42. This sheet then bearing the powder image is carried by cylinder or electrode 42 out of the developing zone to collecting roll 45. If desired, heating coils 49 are operated preferably with a warm up period whereby the powder image, if thermoplastic, is fused or fixed on the sheet immediately upon deposition thereof. In this manner, the sheet or web collected on roll 45 is the developed and fixed xerographic print.

It will be observed that the mechanism and apparatus shown in Figure 2 yields a positively charged image on cylinder 30 and a negatively charged powder. Since the induced image on cylinder 42 will be of polarity opposite to the image on cylinder 30, this will cause formation of a photographically negative or reversed image on the print receiving material. A direct positive image will be formed when the electrical connections to the charging means 52 are reversed to give positive polarity corona therein.

The operation of image member 13 and electrode 11 to induce an image on electrode 11 is best understood with relation to Figure 3, it being understood that essentially the same mode of operation applies to the mechanism of Figure 2. Image member 13 consisting of an insulating or photoconductive insulating layer 21 on backing member 21a has an electrostatic charge pattern or latent image as indicated by the plus (+) marks 22. Electrode 11, being spaced closely adjacent thereto acts

as a complementing condenser plate across the air gap or development zone, and lines of force 23 join the positive polarity image on member 13 to an induced negative polarity image on conductive electrode 11, the image being indicated by negative (—) mark 24. Positively charged particles 25 from nozzle 10 (Fig. 1) or nozzle 53 (Fig. 2) are propelled in the directions indicated by the arrows, these directions being toward electrode 11 where the induced charge exists and through the development zone parallel with electrode 11 by the spraying force of nozzle 10 where no induced image exists. It will be realized, of course, that in practical operation the deposition of particles on the induced image will seldom follow exactly the theoretical pattern of the induced image because of space charge and like factors, and for this reason it may be generally desirable to bias electrode 11 at a few volts potential, usually of the same polarity as the charge on the particles. In spite of the fact that an overall or average potential may be applied to electrode 11, it is to be noted that the induced electrostatic image is superposed on the average charge potential, so that the electrode, although conductive, may at points repel charged particles while at other points it nevertheless attracts these same particles.

This process of developing the induced image is continued until the charge on the deposited particles substantially neutralizes the induced image charge, at which time the deposited particles form a visible image which is a mirror reproduction of the original electrostatic latent image on member 13. The deposited visible image is then utilized, for example, by transfer to a transfer surface by adhesive transfer, electrostatic transfer or other method, and optionally is fixed thereon. Alternatively, the electrode 11 may be a consumable conductive material of color contrasting to the deposited image, and the image may be fixed directly thereon to form a xerographic print; or the image may be deposited on a sheet or web held against electrode 11, the image being self-fixing or subsequently fixed.

It is to be observed that the original electrostatic latent image on member 13 is substantially unaffected by the development process and is reusable to induce another image on the same or another electrode placed adjacent thereto. Thus, a single electrostatic image can be utilized for the deposition of several successive visible images, being re-used until it is erased by suitable methods such as re-charging or, in the case of a photoconductive member, also by exposure to light.

Within the scope of the invention various effects of photographic tone and quality can be achieved by varying the potential on electrode 11 or 42, either by variation from one print to another or by variation during the deposition of the particles on the induced image. Thus, by suitable biasing of the conductive member 11 or 42, particle deposition can be restricted to the intense portions of the induced image or can be caused to occur on background portions in addition to image portions of the area. Thus, for example, using the polarities shown in Figure 3, negative bias of the electrode 11 will cause overall deposition of particles even on back-

ground areas while substantial positive bias will cause blanking out of less intense areas.

It is to be understood that numerous variations and modifications may be made within the scope of the present invention, and that the invention is not to be limited to the specific embodiment described, but is to be restricted only to the scope of the appended claim.

What is claimed is:

The method of developing by making visible charge gradients induced on an equipotential conducting surface across a free space from an actual electrostatic latent image on an electrostatic latent image bearing member said method comprising, positioning an equipotential conducting surface closely adjacent to an actual electrostatic latent image bearing member with a small free space between said equipotential conducting surface and said image bearing member, positioning an image receiving web against said equipotential surface and between said equipotential surface and said image bearing member, said image bearing member carrying on its surface an actual electrostatic latent image comprising in image configuration electrostatic charges all of the same first polarity in respect to the equipotential surface, applying a potential to said equipotential conductive surface opposite in polarity with respect to the polarity of the electrostatic latent image and at a potential difference in respect to the highest potential of the electrostatic image substantially equal to the highest potential of the electrostatic image whereby charges opposite in polarity to the actual electrostatic image are induced on said equipotential surface in configuration conforming with the actual electrostatic latent image, directing a suspension of electrostatically charged particles into the space between said image bearing member and said image receiving material, said particles being electrostatically charged to the same polarity as the actual electrostatic latent image on the electrostatic latent image bearing member, and developing by making visible the charge gradients by deposition of the charged particles on the image receiving web through their attraction to said equipotential surface in configuration conforming with the actual electrostatic latent image.

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