Oct. 7, 1958 E. C. GIAIMO, JR 2,854,947

ELECTROSTATIC PRINTING

Filed July 1, 1953 2 Sheets-Sheet 1

Fig. 1.

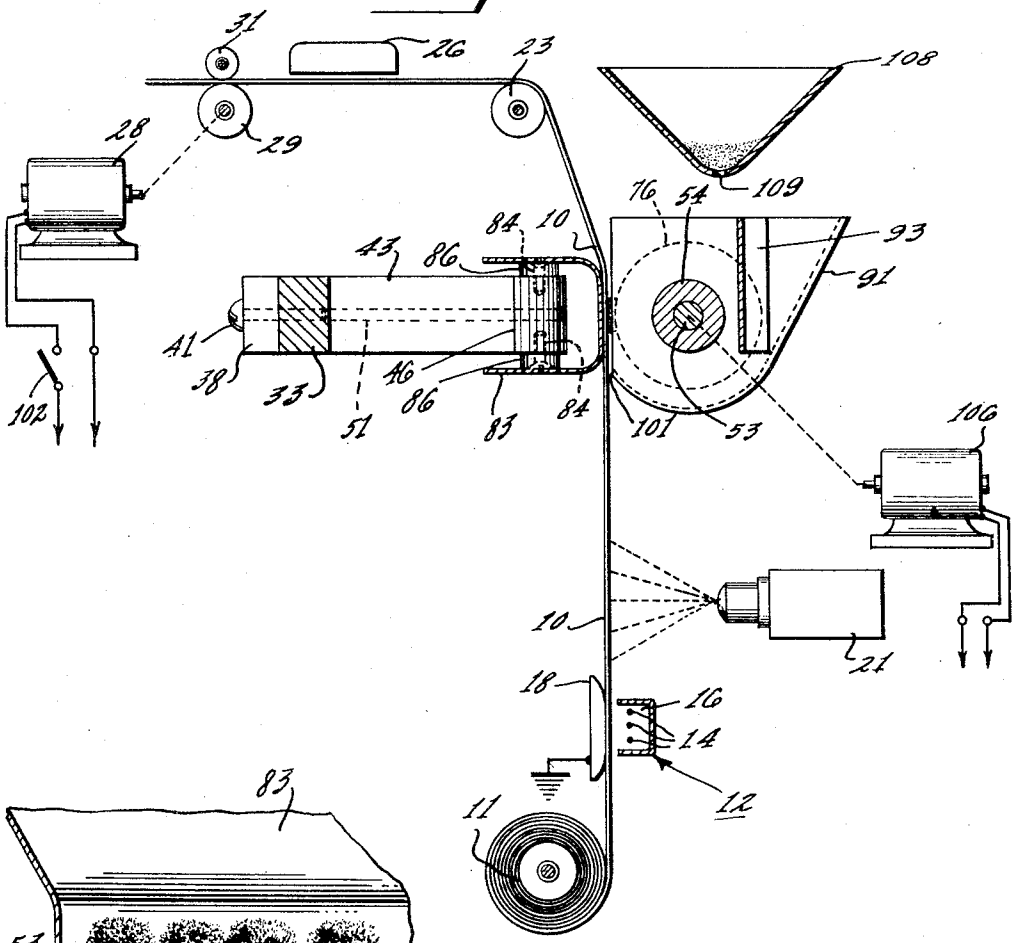
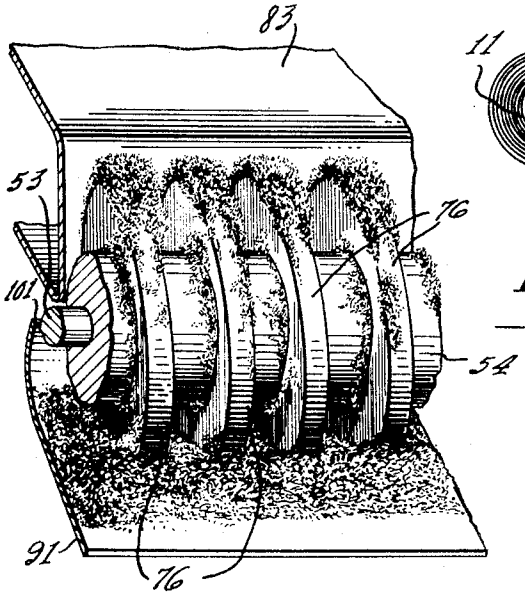


Fig. 3.



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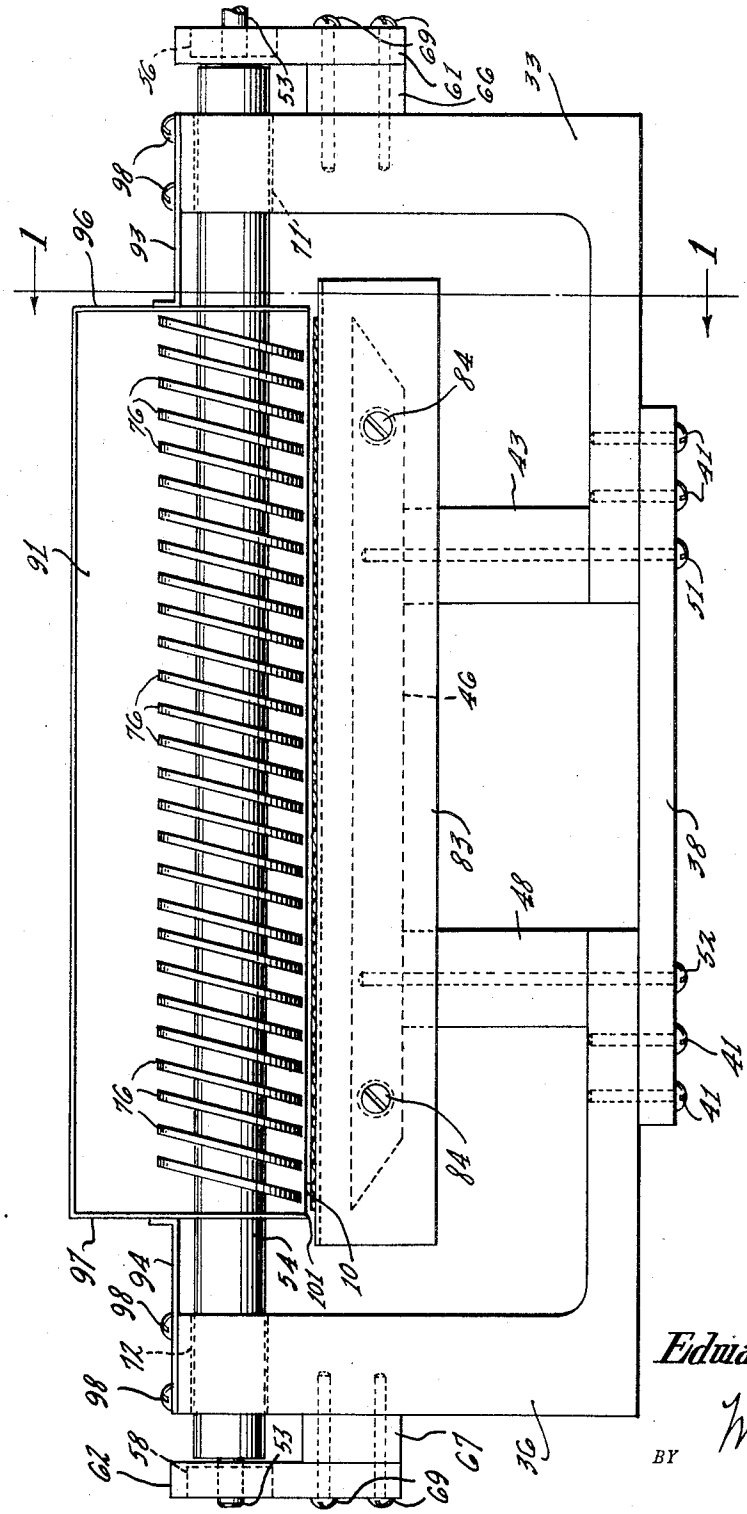


Fig. 2.

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ELECTROSTATIC PRINTING

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Application July 1, 1953, Serial No. 365,431

8 Claims. (Cl. 118—637)

The present invention relates to electrostatic printing, and, more particularly, although not necessarily exclusively, to novel means for applying developer material or developer mix having magnetic properties onto a surface bearing a latent electrostatic image.

In accordance with the present invention, a developer mix comprising a developer powder and a ferromagnetic carrier material is applied to a surface bearing a charge image in the presence of a moving magnetic field. A magnetic field is preferably continuously applied and a member, such as a paper sheet bearing the charge image, is passed through the magnetic field. A quantity of developer mix comprising developer powder and a ferromagnetic carrier material is introduced in the field so that streamers are formed and movement is imparted to these streamers by moving the field in a novel manner whereby the streamers brush the surface bearing the charge image and thus deposit the developer powder upon the charge image. In the illustrative apparatus to be described herein the field is established between a fixed pole and a magnetic pole having inclined members thereon the outlines of which define or lie within a cylindrical surface of revolution. The inclined members agitate and mix a quantity of developer mix which is released and picked up successively by each inclined member so that the streamers which form a plurality of oscillating brushes exist continuously and are continuously being renewed.

The principal object of the present invention is to provide novel means for continuously maintaining a plurality of streamers and imparting movement to the streamers to provide a brush action for depositing the developer powder upon a surface bearing a charge image.

Another object of the invention is to provide novel means for continuously maintaining while continuously renewing a plurality of clusters of brush-like streamers in contact with a charge image bearing surface and maintaining oscillatory movement of the clusters over the charge image.

A further object of the present invention is to provide a novel magnetic structure having a rotatable pole piece composed of a plurality of spaced inclined discs the peripheries of said discs defining a cylinder.

Other objects and advantages of the present invention will, of course, become apparent and immediately suggest themselves to those skilled in the art to which the invention is directed from a reading of the following specification in connection with the accompanying drawings in which:

Fig. 1 is a view in side elevation, partly diagrammatic, of electrophotographic apparatus embodying the present invention;

Fig. 2 is a view in plan of the magnetic structure of the apparatus of Fig. 1 showing the physical and magnetic relationship of the parts for applying developer mix to the record receiving sheet included in the showing of Fig. 1; and

Fig. 3 is a fragmentary view in perspective of the rotary portion of the magnetic structure of Fig. 2 pictorially disclosing the formation of the clusters or brushes composed of streamers of developer mix.

The apparatus to be described, embodying the invention in illustrative form, may be operated with a developer mix comprising a developer powder and a carrier material consisting of "alcoholized iron," that is, iron particles free from grease and other impurities soluble in alcohol. These iron particles are preferably of a relatively small size, being in their greatest dimension about .002" to .008". Generally, any of the large number of developer powders known in the art is suitable for mixing with iron particles to form a developer mix to be employed in operating the present invention. A developer powder above iron in the triboelectric series is generally suitable for developing a direct image upon a negatively charged surface or a reversed image upon a positively charged surface, and conversely a developer powder below iron in the triboelectric series is suitable for developing a reversed image upon a like negatively charged surface or a direct image upon a positively charged surface. Examples of developer powders of the first named class are powdered shellac and rosin, each pigmented with a suitable coloring material such as carbon black. An example of the second class is Vinsol resin (an extract from long leaf yellow pine stumps composed principally of an oxidized form of abietic acid and manufactured by Hercules Powder Company, 908 Market Street, Wilmington, Delaware) colored with a suitable dye such as azo oil black. For purposes of illustration there is described herein by way of example the development of a direct image upon a negatively charged surface. However, it should be understood that by substituting a suitable different developer powder as described above there may be developed a reversed image upon such a surface.

Developer mixes of the type described above for the sake of completeness of illustration and methods of employing such mixes are disclosed and claimed in a copending application of Harold G. Greig, Serial No. 344,123, filed March 23, 1953, and entitled "Electrostatic Printing." In disclosing the invention, reference will be had to a record receiving member in the form of a paper sheet or web **10** (Fig. 1) which is fully disclosed and claimed in a copending application of Harold G. Greig, Serial No. 248,937, filed September 29, 1951, now abandoned, and entitled "Electrostatic Printing." The mode of operation employing the paper **10** will be sufficiently set forth herein for the sake of completeness of description. The paper web **10** may have its surface coated with zinc oxide suspended in a vehicle such as a resin.

Referring more in detail to Fig. 1 of the drawing, the coated paper **10** is provided with a distributed electrostatic charge over one of its surfaces exposed to the influence of an electrostatic charging device **12**. The charging device may comprise a plurality of fine wires **14** carried by a pair of spaced insulating members **16** only one of the latter appearing in Fig. 1 of the drawing. It will be understood that the insulating members are spaced in such a manner that the wires **14** span the width of the

paper sheet 10. It will be understood that light is preferably excluded during the charging step. A source of high voltage D. C. (not shown) is connected to the wires 14 so as to give them a negative charge with respect to a ground plate or platen 18. The charged paper is exposed to a light image from a luminous image projector 21 of any known kind. The paper bearing the charge image or latent image in the form of an electrostatic charge then passes through the magnetic field of the developer powder applying apparatus to be described hereinafter more in detail. An idler roller 23 guides the paper web 10 so that it is drawn past a heater or fuser 26 where the developer powder is melted and fused to the paper surface to form a permanent image.

Reference character 28 indicates an electric motor of any suitable kind or type which drives a feed roller 29. A pressure roller 31 serves to press the paper against the roller 29 so that it may be drawn through the several recording stages or stations described above.

The aforementioned developer powder applying apparatus in accordance with the invention will now be described in detail. Two similar frame members 33 and 36 of magnetic material, such, for example, as cold rolled steel are joined by a nonmagnetic member 38 of brass or dural. The member 38 is secured to the frame members 33 and 36 by suitable fastening means such as machine screws 41. A permanent magnet 43 is seated against the frame member 33 and supports an elongated pole piece 46 adjacent one of its ends. A permanent magnet 48 similar to the magnet 43 supports the elongated pole piece 46 near its remaining end. The magnets are clamped in position on their respective frame members and to the elongated pole piece by suitable means such as screws 51 and 52 which have threaded engagement with the taped holes in the elongated pole piece 46. The magnets are similarly poled. For example, the north poles of the magnets 43 and 48 are in contact with the respective frame members 33 and 36. A shaft 54 of magnetic material, such as iron, is supported by suitable antifriction bearings 56 and 58 recessed in nonmagnetic brackets 61 and 62 respectively of brass or dural. A shaft 53 telescoping into and secured to the shaft 54 is received by the bearings 56 and 58. It will be understood that the shaft 54 may have reduced ends for this purpose. The brackets 61 and 62 are placed from their respective frame members by filler pieces 66 and 67 of brass or dural. Suitable fastening means such as screws 69 serve to secure the brackets to their respective frame members. The shaft 54 extends through holes 71 and 72 in the frame members. These holes are slightly larger than the diameter of the shaft to provide clearance without introducing an excessive amount of reluctance into the magnetic circuit of which the shaft 54 is an important part.

A plurality of elliptical members 76 are secured to the shaft 54. These members 76 are aligned in parallel relationship and are so spaced that as the shaft rotates a point on the periphery of one of the members 76 will be adjacent a part of the length of the pole piece 46 swept over by an adjacent member. As will hereinafter appear, the developer mix, one component of which has magnetic properties will be moved or brushed over the surface of the paper 10 in the region between the pole piece 46 and the pole piece composed of the shaft 54 in combination with the members 76.

A channel-shaped paper guide member 83 of nonmagnetic material is secured to the pole piece 46 by suitable fastening means such as screws 84. Filler members 86 are employed whereby the face of the paper guide member may be of sufficient width to contact the paper throughout a portion of its length greater than the width of the pole piece 46.

A trough 91 to contain the developer mix partially encircles the rotating pole piece composed of the shaft 54 and the members 76. Brackets 93 and 94 are connected to the end members 96 and 97 of the trough 91. These brackets are secured to the ends of the frame members 33 and 36 by suitable fastening means such as screws 98. The trough and the brackets are preferably of nonmagnetic material such as brass or the like. The front of the trough 91 facing the paper guide member 83 is open, the bottom of the trough ending in a lip 101. In operation of the recording apparatus described herein, the recording paper which may be of the electrosensitive or light-sensitive type described above by way of example is fed from the supply roll 11 past the charging device 12 and the projector 21 where it receives a latent charge image. It will be understood that each film or the like (not shown) is fed through the projector 21 a frame at a time. The web 10 may be moved intermittently by operation of a switch 102 in the supply circuit of the motor 28. If this type of operation is to be used then the spacing between the projector and the paper guide member 83 should be such as to provide for application of developer to the paper web during movement of the paper web to locate a fresh area of the paper 10 before the projector 21. It is also to be understood the projector 21 may be in the form of a light image projection device such as a cathode ray tube, for example, in which the cathode ray beam is scanned along a single coordinate of deflection. In this instance the paper 10 may be moved continuously. Continuous movement of the paper web 10 may be employed if the projector 21 flashes the image for a short time on the web 10 either by projection from a film or by projection of a light image produced by operation of a raster deflected cathode ray beam.

To effect development of the charge image on the paper web 10 a quantity of developer mix comprising powdered iron and a pigmented resin described above by way of example is placed in the trough 91. A motor 106 is mechanically coupled to drive the shaft 54. It will be understood that a single motor, for example the motor 28, may be used for driving both the roll 29 and the shaft 54 through suitable and well known mechanical transmission devices. It will be understood that the rotational speed of the shaft 54 exceeds somewhat the rotational speed of the roller 29 although no definite ratio of speed is required. Referring to the pictorial showing of Fig. 3, it will be seen that the iron in the developer mix causes streamers to extend from the members 76 in relatively thick brush-like clusters and that these brush-like clusters have a maximum number of streamers in the region of the paper guide member 83 where the magnetic field is strongest. The field strength at the point on the rotating pole piece directly opposite the paper guide member 83 is the weakest and consequently the developer mix will fall to the bottom of the trough to again be picked up as the pole piece rotates. It is assumed that rotation of the pole piece is clockwise as viewed in Fig. 1 of the drawing. As the shaft 54 rotates the brush-like clusters or brushes of developer mix will be oscillated transversely of the paper web 10 whereby to transfer the developer powder component of the paper mix onto the charged areas of the paper thereby to develop the latent charge image. It is to be noted that the developer mix is agitated and stirred by the oscillation of the periphery of the members 76 as the shaft 54 rotates. In operation of the developing apparatus substantially only the developer powder component of the mix is used up by the developing process. The amount of the powedered iron in the trough 91 remains substantially constant. For this reason it is only necessary to add the developer powder component which, as stated above by way of example, may be pigmented resin. A quantity of pigmented resin is maintained in a hopper 108 which is positioned above and extends longitudinally of the trough 91. A slot 109 is provided in the bottom of the hopper to permit developer powder to drop into the trough 91.

It is to be noted that the inclination of the members **76** on the rotating shaft **54** performs three functions. First, the inclined discs provide a transverse brushing action of the developer mix over the exposed face of the paper web **10** or other surface in the developing position. Secondly, these members **76** causes thorough mixing of iron powder with the developer powder. Third, the members **76** provide for a uniform distribution of the mixture in the trough and on the brushing surface.

What is claimed is:

1. Electrostatic printing apparatus comprising means for supporting a member presenting a record receiving surface bearing a charge image, a magnetic structure comprising a magnetized polar member extending laterally of said surface, a second magnetized polar member oppositely disposed with respect to said first named polar member and on the opposite side of a member presenting a record receiving surface supported by said first named means, means to produce relative movement between said surface and said magnetized polar members, means to support said first named polar member for rotation, means to rotate said first named polar member, means to maintain a quantity of developer mix having magnetic properties in contact with said first named polar member whereby to provide brush-like streamers of said mix, said first named polar member being located with respect to the record receiving surface of a member presenting a record receiving surface supported by said first named means so that said streamers contact said record receiving surface, and said first named polar member having means to provide oscillatory motion of said streamers.

2. Electrostatic printing apparatus comprising means for supporting a member presenting a record receiving surface bearing a charge image, a magnetic structure comprising a magnetized polar member extending laterally of said surface, a second magnetized polar member oppositely disposed with respect to said first named polar member and on the opposite side of a member presenting a record receiving surface supported by said first named means, means to produce relative movement between said surface and said magnetized polar members, means to support said first named polar member for rotation, means to rotate said first named polar member, means to maintain a quantity of developer mix composed of a developer powder component and a component having magnetic properties in contact with said first named polar member whereby to provide brush-like streamers of said mix, said first named polar member being located with respect to the record receiving surface of a member presenting a record receiving surface supported by said first named means so that said streamers contact said record receiving surface, said first named polar member having means to provide oscillatory motion of said streamers, and means to supply developer powder component to said quantity of developer mix.

3. Electrostatic printing apparatus comprising means for supporting and moving a member bearing a charge image, a magnetic structure having a magnetized polar member extending laterally of a member supported by said first named means, said polar member being positioned whereby a member supported by said first named means moves past said polar member, means to support said polar member for rotation, means to rotate said polar member, said polar member having a plurality of parallel projections thereon inclined to the axis of said polar member, and means to maintain a quantity of developer mix having magnetic properties in contact with said projections whereby said projections are provided with brush-like streamers of said mix, said polar member being located with respect to a member supported by said first named means so that said streamers contact a member supported by said first named means as said polar member rotates.

4. Electrostatic printing apparatus comprising means

for supporting and moving a member bearing a charge image, a magnetic structure comprising a magnetized polar member extending laterally of a member supported by said first named means, said polar member being positioned whereby a member supported by said first named means moves past said polar member, means to support said polar member for rotation, means to rotate said polar member, said polar member having a plurality of parallel projections thereon inclined to the axis of said polar member, and means to supply a quantity of developer mix having magnetic properties to said projections whereby said projections are provided with brush-like streamers of said mix, said polar member being located with respect to a member supported by said first named means so that said streamers contact a member supported by said first named means as said polar member rotates.

5. Electrostatic printing apparatus comprising means for supporting and moving a paper web treated in a manner to present a record receiving charge image bearing surface, a magnetic structure comprising a magnetized polar member extending laterally of a moving paper web supported by said first named means and positioned to be passed by the charge image bearing surface thereof, means to support said polar member for rotation, means to rotate said polar member, said polar member having a plurality of parallel projections thereon inclined to the axis of said polar member, and means to maintain a quantity of developer mix having magnetic properties in contact with said projections whereby said projections are provided with brush-like streamers of said mix, said polar member being located with respect to a treated paper web supported by said first named means so that said streamers contact said charge image bearing surface as said polar member rotates.

6. Electrostatic printing apparatus comprising means for supporting a member bearing a charge image, a magnetic structure including a magnetized polar member extending laterally of a member supported by said first named means, means to produce relative movement between a member supported by said first named means and said magnetized polar member, means to support said polar member for rotation, means to rotate said polar member, said polar member comprising a shaft of magnetizable material, a plurality of elliptical members, each elliptical member having a centrally located elliptical aperture receiving said shaft, said elliptical members being spaced along and secured to said shaft in inclined relationship with respect to said shaft, and means to maintain a quantity of developer mix having magnetic properties in contact with said elliptical members whereby said members are provided with brush-like streamers of said mix, said shaft being located with respect to a member supported by said first named means so that said streamers contact a member supported by said first named means as said shaft rotates.

7. In combination, means for supporting a member bearing an electrostatic charge image, means for applying a quantity of developer mix having magnetic properties to an image bearing member supported by said first named means comprising a magnetic structure having a rotatable polar member, means for rotating said polar member, and a plurality of spaced inclined magnetic members on said polar member.

8. In combination, means for supporting a member bearing an electrostatic charge image, means for applying a quantity of developer mix having magnetic properties to an image bearing member supported by said first named means comprising a magnetic structure having a rotatable polar member, means for rotating said polar member, a plurality of spaced inclined magnetic members on said polar member, a second polar member oppositely disposed with respect to said first named polar member, and means partially surrounding said first

named polar member for holding a quantity of developer mix.

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