Nov. 3, 1959 R. HERMAN 2,910,963

APPARATUS FOR DEVELOPING AN ELECTROSTATIC IMAGE

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Fig. 1.

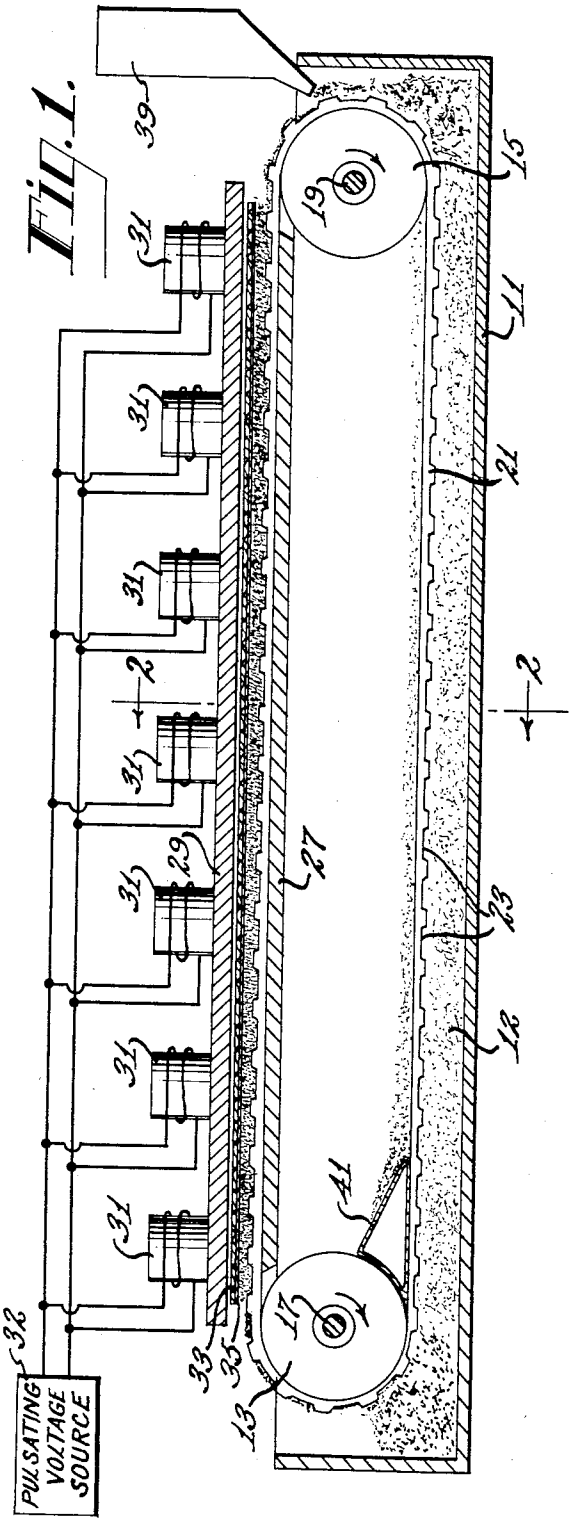
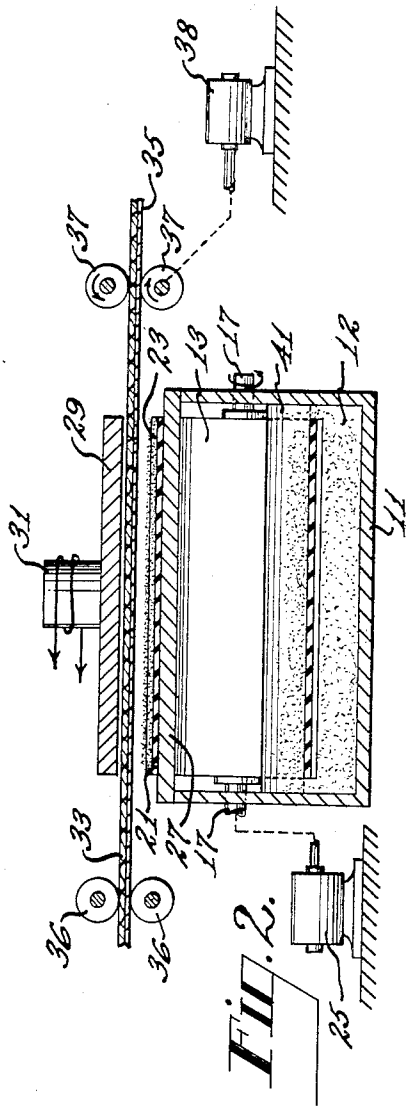


Fig. 2.



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APPARATUS FOR DEVELOPING AN ELECTROSTATIC IMAGE

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4 Claims. (Cl. 118—623)

This invention relates to elctrostatic printing, and more particularly to novel methods of and means for developing a surface bearing an electrostatic charge image.

In a typical electrostatic printing process, a member, such as a sheet or web, on which a print is to be made, is provided with a coating of a photoconductive insulating material on one surface. An electrostatic charge is applied uniformly to the photoconductive surface and the charged surface is then exposed through a transparency, the charge bleeding off the surface where it is exposed to light. There remains, then, a latent charge image corresponding to the transparency.

The latent charge image is developed by contacting the surface with an electroscopic developer powder having a charge opposite to that of the surface, the powder adhering to the surface in conformity with the latent charge image. The developed image is then fixed by heating, for example.

A means for transporting the developer powder comprises mixing the developer powder with magnetic particles to form a magnetic developer mix and carrying the mix under the influence of a magnetic field which forms a brush of the mix. The brush is engaged with the image bearing surface and the developer powder particles are withdrawn from the brush to the surface due to electrostatic attraction.

In carrying the developer mix to the surface in the manner above described, a magnetic system providing a permanent magnetic field has been employed. When a magnetic brush, formed under the influence of a permanent magnetic field, is contacted with a surface to be developed, developer powder particles are released only from the tip portions of the brush which contact the surface and a substantial amount of the developer powder contained in the brush, if the brush structure is maintained, does not participate in the development of the surface. In accordance with the present invention, the brush structure is dropped and renewed at spaced intervals at its web contacting position. This is accomplished by arranging for the magnetic field, which forms and directs the brush, to be effectively diminished to zero at spaced time intervals.

An object of this invention is to provide improved and novel methods of and means for depositing electroscopic developer powder on a charge image bearing surface.

Another object of this invention is to provide improved and novel methods of and means for non-magnetically carrying developer mix adjacent the surface to be developed and for magnetically contacting the mix with the surface.

A further object of this invention is to provide novel methods of and means for carrying a mixture of developer powder and magnetic particles adjacent a surface to be developed and for presenting a substantial portion of the developer powder particles within the mixture to the surface.

A still further object of this invention is to provide a

novel method of and means for dropping and reforming, at spaced intervals, a brush of developer mix.

In accordance with the present invention, a path is provided for a member having a downward facing charged image bearing surface. Means are provided for presenting developer mix comprising magnetic carrier particles and developer powder particles adjacent the charged surface. A magnetic field, which decays to zero at spaced time intervals, is provided having flux lines passing through the member for intermittently attracting the developer mix in the form of a brush toward the surface to be developed. The pulsating field causes the brush to be alternately built up and partially or wholly dropped to effect mixing of the developer mix and to present a substantial portion of the developer powder particles in the mix to the surface.

The novel features of the invention, as well as additional objects and advantages thereof, will be understood more fully from the following description when read in connection with the accompanying drawing, in which:

Figure 1 is a diagrammatic sectional view in front elevation of an apparatus embodying the present invention; and

Figure 2 is a sectional view in elevation taken on the lines 2—2 of Figure 1 looking in the direction of the appended arrows.

Referring now to the drawing, an illustrative embodiment of apparatus in accordance with the present invention is shown. The essential parts of the apparatus are shown without supporting structure for the sake of convenience of illustration. A mixing chamber 11 consists of an elongated rectangular trough. A pair of pulleys 13 and 15, mounted on shafts 17 and 19, respectively, are rotatably supported in the chamber 11 adjacent each end. An endless belt 21 is supported on the pulleys. The outer surface of the belt is provided with grooves or pockets 23 lying transverse to the longitudinal dimension of the belt. The pulleys are disposed so that a lower run of the belt moves adjacent the bottom of the chamber 11 and an upper run of the belt moves in a plane above the top of the chamber 11.

A quantity of developer mix 12 is provided in the reservoir. The developer mix is made up of electroscopic developer powder particles and magnetic carrier particles. The magnetic carrier material consists of soft iron or other magnetic material having lower or negligible residual magnetism. The developer powder and the magnetic carrier are chosen, with reference to the triboelectric series, so that when they are mixed together the electroscopic developer powder particles will take on an electrostatic charge of predetermined polarity. The carrier particles will, necessarily, take on an opposite charge.

The pulleys and belt are driven in the direction indicated by the arrows, by a motor 25 which is coupled to the shaft 17. When the belt is driven, the lower run of the belt effects a mixing of the developer powder and carrier to provide the desired charges on these particles. As the belt moves out of the chamber 11, at the pulley 13, the developer mix is carried out of the chamber in the belt grooves 23 and is carried along the upper run of the belt. A supporting platen 27, mounted at the top of the chamber 11, prevents the belt from sagging between the pulleys 13 and 15 and hence maintains the upper run in a single plane.

A magnetic pole piece 29 is disposed above the chamber 11 and lies in a plane parallel to the plane of the upper run of the belt 21 and spaced above the belt. The material of the pole piece 29 is a soft iron or a magnetic grade iron having the property of low residual magnetism. As viewed from the top, the pole piece 29 is substantially the same width as the belt 21 and its length

is substantially equivalent to the distance between the shafts **17** and **19**. A plurality of electromagnets **31** are mounted on the pole piece **29** in abutting relation to the pole piece. The number of these electromagnets may be few or many depending upon the length of the pole piece **29** and other factors which effect the uniformity of the magnetic field produced by the pole piece. It is desired to produce a magnetic field emanating from the lower face which is substantially uniform across the entire length of the pole piece. A source of pulsating voltage **32** is electrically connected to the electromagnets **31** to produce a pulsating magnetic field in the pole piece **29**. Alternatively, the voltage source **32** may be an alternating voltage source so that an alternating magnetic field is produced. With an alternating magnetic field, the developing action is similar to the action of a pulsating field. The expression "pulsating field" in the accompanying claims will be understood to include an alternating field.

The member upon which the print is to be made is a continuous web or strip of paper **33** having an insulating, photoconductive layer or coating **35** on one surface. The web **33** is drawn through the apparatus in a path provided between the pole piece **29** and the upper run of the belt **21**. The web, supported on idler rollers **36** and drive rollers **37**, passes immediately adjacent the pole piece **29** and is spaced from the upper surface of the belt **23**. This space is sufficient to permit the developer mix **12** to the carried on the belt without contacting the coating **35**. The web is moved, through the drive rollers **37** by a motor **38**, in a direction transverse to the direction of movement of the belt **21**, as indicated by the arrow in the drawing.

In operation, the chamber **11** is supplied with a quantity of developer mix **12** as above described and the paper **33** is fed through the apparatus. Prior to its being fed to the apparatus, the photoconductive layer **35** is charged uniformly and exposed to provide the latent charge image. The polarity of the surface charge is opposite to the charge provided in the developer powder. As the developer mix is carried by the belt adjacent the charged surface of the paper **33**, a pulsating voltage at a frequency of the order of 200 to 300 cycles per minute is applied to the electromagnets **31**. This causes the magnetic developer mix to be intermittently attracted upwardly from the belt **21** in the form of a brush and to be intermittently dropped to the belt. The frequency of the field is relatively low to permit the mix particles to drop back to the belt when the field is reduced to zero whereby a definite "making" and "breaking" of the magnetic brush is provided. As the developer mix is attracted upwardly, both the developer powder particles and the carrier particles contact the charged surface of the paper **33**. The developer powder particles adhere to the charged portions of the surface, since they have a charge opposite to that of the surface, and the carrier particles do not adhere to the surface. The latent charge image on the surface is therefore developed by the developer powder particles. In Figure 1 the developer mix is shown contacting the charged surface at an instant when the electromagnets are energized. Figure 2 illustrates the condition when the electromagnets are deenergized and the developer mix has dropped to the surface of the belt.

In order to insure continuous developement of the charged surface, the speed of travel of the paper **33** and the width of the pole piece **29** are considered in relation to the frequency of the field. These factors are controlled so that all portions of the surface are contacted by the developer mix.

As the developer mix **12** is carried across the path of the paper **33**, the mix becomes depleted of the developer powder particles which are deposited on the paper so that, when the mix is returned to the chamber **11** at the pulley **15**, it is comprised largely of the magnetic carrier particles. In order to provide for a continuously operating printing apparatus, a hopper **39** is provided at the end of the reservoir **11**, where the carrier is returned to the reservoir, for supplying additional amounts of developer powder to the mix. The hopper **39**, preferably including a metering device (not shown), is provided for supplying developer powder at a rate substantially equivalent to the rate of its application to the paper **33**. As the developer powder and the magnetic carrier are carried from the hopper end of the chamber **11** to the discharge end, the particles are mixed together as previously described by the lower run of the belt **21** to produce the desired charge on the developer particles. A shield **41** mounted between the reservoir walls adjacent the pulley **13** and the lower run of the belt **21** prevents the developer mix from being carried between the pulley and belt.

The above-described method and apparatus provide a number of advantages in the developement of latent electrostatic charge images. The pulsating magnetic field produces a constant agitation of the developer mix resulting in a more complete mixing of the particles. If the prior mixing of the particles has not been sufficient to impart the desired charge to all of the developer powder particles, those particles may obtain the desired charge due to this agitation and hence be made available to participale in the development of the image. A further advantage of this agitation is that a substantial portion of the developer particles are presented to the surface and hence a more efficient use of the developer mix is obtained. Where a magnetic brush of the developer mix is provided in a stationary fiield, only the developer particles at the tip portions of the brush participate in the development of the surface. This inefficiency is eliminated in the above described aparatus. A further advantage is that the pressure of the developer mix on the surface of the paper is uniform over the entire surface. Uniform pressure is not readily obtainable with a brush of developer mix of maintained structure. The uniform pressure of the developer mix coupled with the presentation of a substantial portion of the developer particles in the mix to the paper necessarily results in a more uniform development of paper over its entire surface. A particular advantage of the pulsating magnetic system described is that the development can be very easily controlled either by varying the intensity of the magnetic field produced or by varying the frequency of the pulsating field in order to obtain optimum results.

What is claimed is:

1. Apparatus for applying electroscopic developer powder to a surface bearing a latent electrostatic charge image, said apparatus comprising means defining a horizontal path for a member having said charged surface on its under side, means for mixing a magnetic developer mix including developer powder particles and magnetic carrier particles, means for transporting said magnetic developer mix transverse to said horizontal path in a plane parallel to and spaced beneath said path, a magnetic system disposed above said path and including at least one electromagnet opposing said transporting means, and a source of pulsating voltage connected to said electromagnet to provide a pulsating magnetic field directed toward said transporting means, said pulsating field acting to produce intermittent vertical movement of said magnetic developer mix between said transporting means and said path whereby said developer mix is agitated to present a substantial number of said developer particles to said member.

2. In apparatus for developing a latent electrostatic charge image, in combination, an elongated pole piece, a plurality of electromagnets mounted on said pole piece, means for applying a pulsating voltage to said electromagnets whereby said pole piece is intermittently magnetized to one polarity, means for presenting a magnetic developer mix in a plane beneath and spaced from said

pole piece, means for moving said developer mix presenting means in said plane relative to said pole piece, and means for feeding a member bearing said latent charge image between said pole piece and said mix presenting means in a path spaced from said mix presenting means, said latent charge image on said member facing said mix presenting means, said pulsating voltage being of a frequency to provide agitation of said magnetic developer mix and to intermittently attract said mix from said mix presenting means to said member bearing said latent charge image.

3. Apparatus for applying electroscopic developer powder to a surface bearing a latent electrostatic charge image, said apparatus comprising means defining a horizontal path for a member having said charged surface on its under side, a mixing chamber disposed beneath said path for mixing developer powder particles and magnetic carrier particles to form a magnetic developer mix, an endless belt disposed in said chamber and having upper and lower horizontal runs, means for driving said belt, said upper run of said belt moving in a plane adjacent to said path, said belt being provided with transverse pockets in its outer surface to effect mixing of said developer mix particles in said chamber and to carry said mix from said chamber over the upper run of said belt, a magnetic pole piece disposed horizontally only above said path and opposing the upper run of said belt, a plurality of electromagnets mounted on said pole piece, and a source of pulsating voltage connected to said electromagnets whereby a pulsating magnetic field is directed from said pole piece to produce intermittent vertical movement of said magnetic developer mix between said belt and said path, said pulsating field being produced at a frequency to provide agitation of said developer mix whereby a substantial number of said developer particles in said developer mix are presented in said path.

4. Apparatus for applying electroscopic developer powder to a surface bearing a latent electrostatic charge image, said apparatus comprising means defining a horizontal path for a member having said charged surface on its under side, a mixing chamber disposed beneath said path, an endless belt disposed in said chamber and having an upper horizontal run lying in a plane adjacent to said path and a lower horizontal run lying in a plane adjacent to the bottom of said chamber, means for driving said belt, a quantity of magnetic carrier particles disposed in said chamber, means for introducing to said chamber a continuous supply of developer powder particles, said belt being provided with transverse pockets in its outer surface to effect mixing of said developer powder particles and said carrier particles in said chamber and to carry said mixed particles over the upper run of said belt, a magnetic pole piece disposed horizontally only above said path and opposing the upper run of said belt, a plurality of electromagnets mounted on said pole piece, and a source of pulsating voltage connected to said electromagnets whereby a pulsating magnetic field is directed from said pole piece to produce intermittent vertical movement of said mix between said belt and said path, said pulsating field being produced at a frequency to provide agitation of said developer mix whereby a substantial number of said developer particles in said developer mix are contacted with a member having said charged surface.

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