

Nov. 15, 1966

C. O. CHILDRESS
POWDER IMAGE TRANSFER SYSTEM

3,285,168

Filed May 7, 1963

3 Sheets-Sheet 1

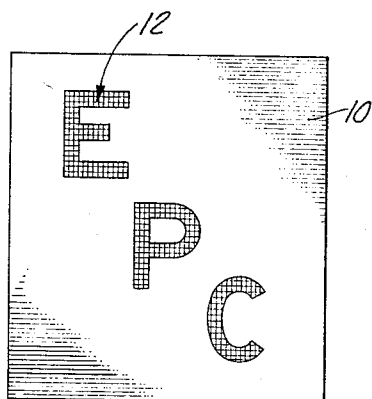


FIG. 1.

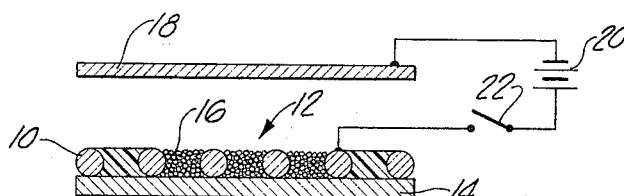


FIG. 2.

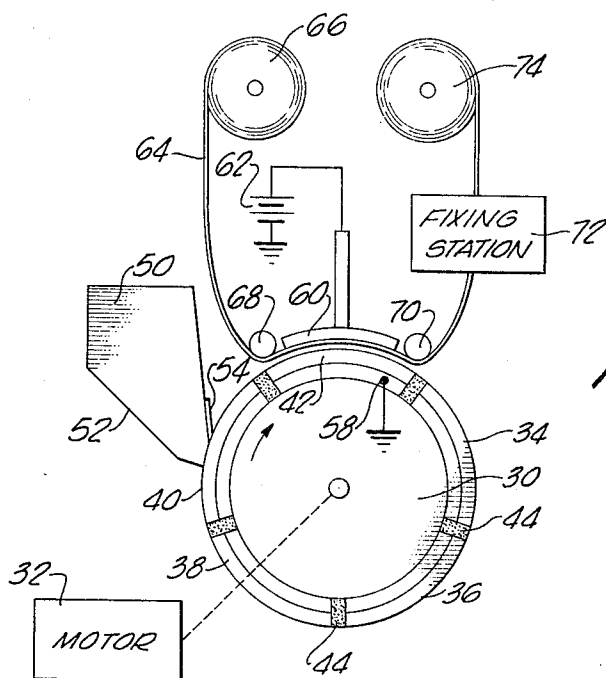


FIG. 3.

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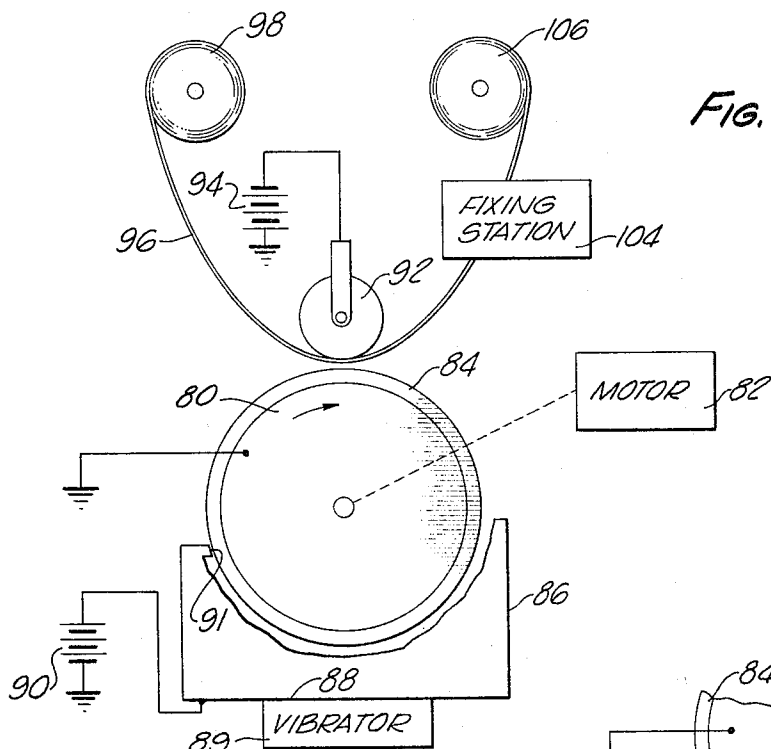


FIG. 5.

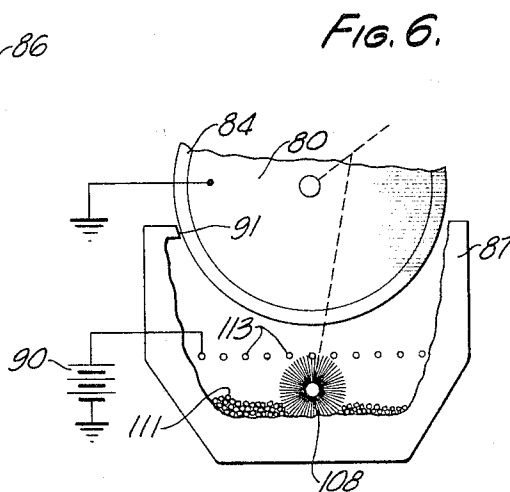


FIG. 6.

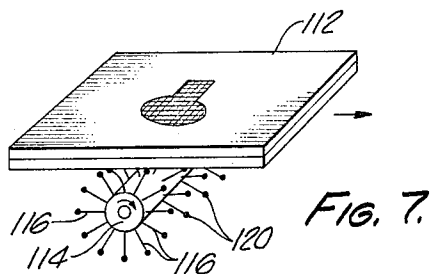


FIG. 7.

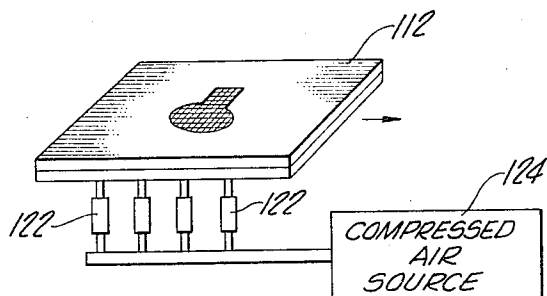


FIG. 8.

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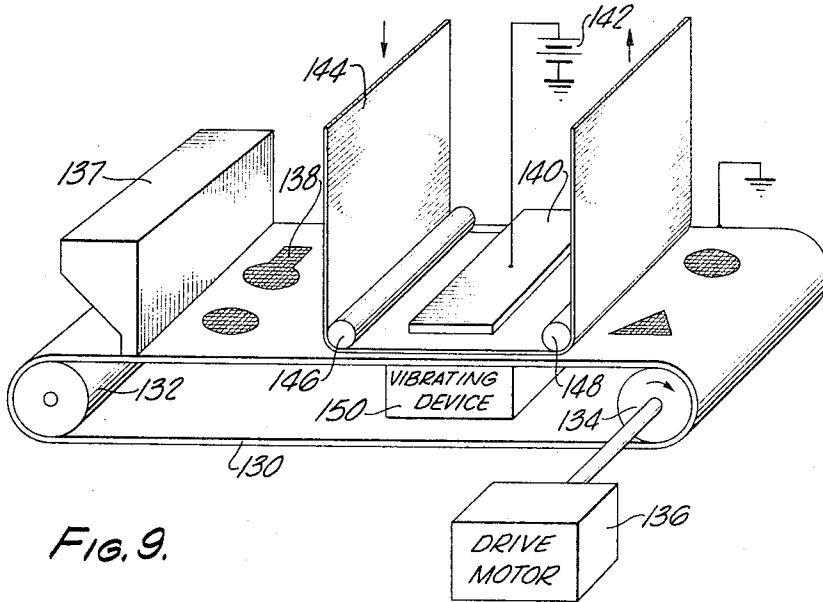


FIG. 9.

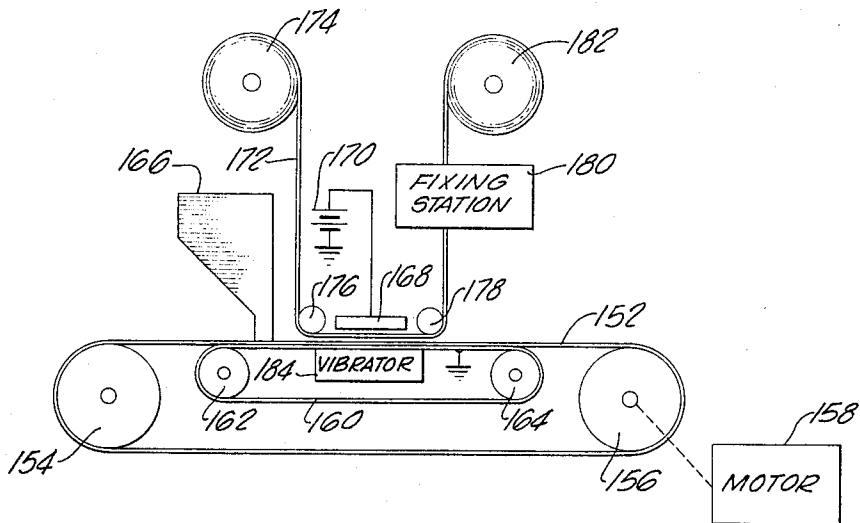


FIG. 10.

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3,285,168

POWDER IMAGE TRANSFER SYSTEM

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Filed May 7, 1963, Ser. No. 278,549

6 Claims. (Cl. 101-150)

This invention relates to electrostatic printing and more particularly to improvements therein.

In a patent, No. 3,081,698, issued to this inventor, there is described and claimed a system for electrostatic printing in which an electric field is established between two spaced electrodes, one of which is an image forming electrode. The image forming electrode comprises a screen having all of its apertures masked except those which define the image desired to be printed. Electroscopic powder particles, which are sized smaller than the apertures of the image, are applied to the side of the screen which is outside of the electric field. These powder particles pass through the apertures of the screen into the electric field, and are carried by the electric field toward the opposite electrode. They are deposited on the electrode to form the image which the open apertures of the screen establish. If it is not desired to deposit the image on the opposite electrode, but rather on some other image receiving member, then such other image receiving member may be interposed in the field established between the two electrodes.

The system described operates satisfactorily. However, if it were possible to provide an arrangement whereby instead of pushing powder particles by means of a brush through the image defining apertures of the screen while the electric field is applied, the whole powder image is formed by preloading the image forming electrode, then it is possible to increase the speed of the powder image transfer by transferring a much larger portion, if not all of the image at once. Furthermore, when preloading of powder is performed, independently of the electric field being present, one can more easily meter the amount of powder and thus obtain a more uniform powder image.

Accordingly, an object of this invention is the provision of an electrostatic printing system in which the electroscopic powder is preloaded on the image defining member before it is brought into the electric field.

Another object of this invention is the provision of an image forming member for an electrostatic printing system wherein electroscopic powder particles are deposited and removed from the same side.

Still another object of the present invention is the provision of an improved arrangement for an electrostatic printing system.

These and other objects of this invention may be achieved in an arrangement wherein an image forming member for an electrostatic printing system has a plurality of electroscopic powder receiving openings which are arranged in a pattern which defines the desired image. Provision is made for loading these openings with electroscopic powder particles prior to establishing an electric field between the image forming member and an opposite electrode. Upon establishing said electric field, then the powder particles are transferred from said image forming member by means of said electric field toward said opposite electrode.

The novel features that are considered characteristic of this invention are set forth with particularity in the appended claims. The invention itself both as to its organization and method of operation, as well as additional objects and advantages thereof, will best be understood from the following description when read in connection with the accompanying drawings, in which:

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FIGURE 1 is a plan view of an image defining member in accordance with this invention.

FIGURE 2 is an enlarged fragmentary view of a cross section of the image defining member shown in FIGURE 1 as well as illustrating how it is used for electrostatic printing.

FIGURE 3 is a system illustrating how the image defining member shown in FIGURE 1 may be employed on a continuous basis.

FIGURE 4 shows how an additional feature may be added to the system of FIGURE 3 to improve its operation.

FIGURE 5 is another arrangement in accordance with this invention for preloading the image defining member.

FIGURE 6 illustrates an additional loading feature for the system shown in FIGURE 5.

FIGURE 7 and FIGURE 8 illustrate arrangements whereby the transfer of the powder image in an electrostatic printing system in accordance with this invention may be improved.

FIGURE 9 illustrates an electrostatic printing system in accordance with this invention using the features shown in FIGURES 7 and 8; and

FIGURE 10 illustrates an electrostatic printing system in accordance with this invention.

Referring now to FIGURES 1 and 2, there may be seen an image forming member, in plan view and in an enlarged section, in accordance with this invention. This image forming member comprises a conductive screen 10 which has all of the apertures therein masked except those 12, which are in an area defining a desired image pattern. In accordance with this invention, a backing 14 is provided for the screen which may either be co-extensive therewith or if desired may only cover the region of the screen which has apertures extending therethrough. The backing may be made integral with the screen or may be brought in juxtaposition therewith and held by pressure or any other means.

The screen openings are filled with electroscopic powder particles 16, by any suitable mechanism such as spreading powder over the surface and then using a doctor blade to sweep the excess away from the surface and leave the openings filled with these powder particles 16, in the manner shown in FIGURE 2. In order to transfer these powder particles either to an opposite electrode 18, which may comprise a flat plate, or to any other image receiving member, which may be inserted between the electrodes established by the screen 10 and the flat plate 18, a source of potential 20 may be connected as by a switch 22, between the two electrodes. If the relative polarity of the screen electrode 10 is made the same as the polarity of the charge carried by the electroscopic powder particles, 16, then these will be repelled from the screen electrode 10 toward the electrode 18 which tends to attract them and hold them. They can then be fixed upon the image receiving electrode, or other image receiving member, either by heat, or by a suitable spray comprising a suitable adhesive, or in any other manner which is well known in this particular art.

By way of illustration, a pigment powder which may be transferred in the manner described, from a preloaded screen, by the application of an electric field between the screen and an opposite electrode is a mixture of 65% by weight of a resin powder sold by the Union Carbide Company, and designated as Ayac, with 35% by weight of Union Carbide's pigment ultra marine blue. These are mixed and then melted and thereafter ground in a microatomizer to a suitable particle size for passing through the screen apertures.

The reason for using a backing for the screen image forming electrode is to assure some degree of uniformity

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in the amount of powder in the apertures of the screen. When powder is applied to a screen, as by a brush, the apertures retain some powder, not all of it passes through even though the powder particles are sufficiently smaller than the screen apertures to freely pass therethrough. The reason for this is not too clear, it may possibly be due to triboelectric forces or possibly due to the actual mechanical locking of the powder particles with one another due to their surface irregularities. However, by employing a backing one is assured that the amount of powder in each one of the screen apertures is uniformly the same. Without the backing some of the apertures will retain more powder than the ones through which the powder passes.

FIGURE 3 shows an arrangement wherein an image screen of the type shown in FIGURE 1 may be preloaded and used in a continuous fashion. A rotatably mounted cylinder 30 is driven by a motor 32 to rotate in the direction shown by the arrow. Mounted about the periphery of the cylinder are a plurality of powder image forming members respectively 34, 36, 38, 40, 42. Each one of these has apertures therein which define the image pattern and which are backed at one side. The region between adjacent screens may be filled by insulating material 44.

Mounted at one side of the rotating cylinder is a container 50. Electroscopic powder having the desired triboelectric properties may be loaded into the containers. The bottom 52, of the container is at an angle to the sides in order to use gravity to direct the powder toward a slot at the lower end opening onto the screen surface which is rotated past that slot. A doctor blade 54 removes powder from the top surface of the screen. Any excess of powder is pushed back into the container 50 to be directed again by gravity against the screen surface.

The preloaded screen is then carried by the cylinder to the printing position at which an electric field is established. The screen 42 is shown at the printing position. The electric field potential is applied to the screen by means of a roller electrode 58, which is connected to ground and which contacts the screen when it attains the proper printing position. An oppositely placed plate electrode 60 which is spaced from the screen electrode is connected to a potential source 62, which is also connected to ground. For the purpose of illustrating the image receiving member, a web 64, of paper for example, is represented as being fed off of a payout reel 66, over to guide rollers 68, 70, then through a fixing station 72 onto a take-up reel 74. The rollers 68, 70, together with the plate electrode 60 may be used to properly dispose the paper relative to the screen in its passage through the electric field. An alternative arrangement may be to have suitable spacers on the screen against which the rollers 68, 70, depress the paper so that it is properly aligned relative to the screen. The fixing station 72 fixes the powder on the paper by heat or spray, or any other of the means well known in this art.

FIGURE 4 illustrates another way in which the image screen may be front loaded prior to its transportation into the electric field. The same type of container 50 as is shown in FIGURE 3 may be used for carrying triboelectric powder toward the surface of the screen. However, if the gravity feed is insufficient to insure a uniform loading of the openings in the screen, then a rotatable brush 76 may be employed. This brush is positioned at the bottom slot opening of the container and rotates against the direction of rotation of the drum. The powder particles are guided onto the brush which then deposits them uniformly in the screen apertures. The doctor blade 54 is provided for the purpose of removing the unwanted powder excess.

FIGURE 5 illustrates another mechanism for preloading the screen in accordance with this invention. In this embodiment of the invention advantage is taken of the

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fact that the electric field may be used not only for transferring electroscopic powder particles from a screen to an image receiving member, but the screen itself may be loaded by means of an electric field. A rotatably supported drum 80, is rotatably driven by a motor 82. The surface of the drum and/or the screen, is conductive and the drum surface is connected to ground. An image screen 84 is wrapped around the surface of the drum so that the drum surface serves as a backing for the image defining apertures in said screen 84. As the drum is rotated its surface passes through a powder loading container 86. A powder cloud is established in the region adjacent the drum surface which passes through the container. Such powder cloud is established in any number of well known ways such as by vibrating the container using a vibrator 89, or making the base 88 of the container a fluidized bed using low air pressure. The bottom 88 of the container is made conductive and is connected to a source of positive potential 90. The container is loaded with electroscopic powder having triboelectric properties such that the positive bottom of the container 86 repels the powder particles and they are attracted to the relatively negative surface of the drum 80. As a result, the screen 84 on the drum surface is loaded with powder particles. A doctor blade 91, at the trailing side of the container 86 removes the powder from the regions of the screen which do not have apertures therein.

The drum rotates the loaded screen into the region of the electric field where the powder image transfer occurs. The field is established between the screen and an opposite electrode roller 92, which is connected to a source of negative potential 94. Accordingly, since the drum surface is now relatively positive with respect to the roller 92, the powder particles are now repelled from the drum surface and are moved toward the relatively negative roller 92. The powder image is intercepted by an image receiving web 96, which is taken off a payoff reel 98 at a speed matching the drum surface, guided through the nip or region between the roller 92 and the screen 84 then through a fixing station 104 and thereafter on to a take-up reel 106.

The blue electroscopic powder previously described can operate with the system just described. Another powder which will perform in the manner described, is a powder manufactured by Switzer Brothers, Inc., of 9314 East Fern Street, South El Monte, California. This powder is known commercially as Dayglo-Rocket Red-A13. A powder which can serve with the system described in FIGURES 2 and 3, is a powder known as DK Red Overglaze No. 61176, which is made by the Drakenfeld Company. Some powders can be used as they are received from the manufacturer. Others however, maybe require precharging. This can easily be determined by a trial use. Precharging is done in any manner known in the art, such as by using a corona arc for example.

Another method for loading a screen using potentials is shown in FIGURE 6. The same drum 80 with a screen 84 wrapped around the periphery is used. The same arrangement for electrostatic printing as is shown in FIGURE 5, may be used. Here, however, a brush 108 is mounted in the container 87 and is made to rotate. In rotating, the brush dips into the electroscopic powder 111 and carries it up to be rubbed off as the brush rubs against a plurality of parallel wires, 113. The wires are connected to a positive supply source. The rubbed off powder particles pass through the openings between wires into the electric field which is established between the wires 113 and the drum 80 and are moved to the surface of the drum by the field, thereby loading the screen 84 which is wrapped around the drum 80. The doctor blade 91 removes excess powder particles. Electrostatic writing occurs thereafter in the manner described in FIGURE 5.

It can happen that the preloaded powder particles, with certain types of powders, may "stick" in the apertures of a preloaded screen when it is brought into the printing electric field. This phenomenon is not too well understood, but it is thought that it may be either because of triboelectric properties of the particular powder, or because of compaction which, due to the irregular shapes of the powder particles provides a locking action which opposes the electric forces attempting the transfer of the powder particles. It has been found however, that this can be overcome and indeed some improvement in uniformity can be noted in practically all of the preloaded powder image transfers when the image screen is tapped or vibrated when it is brought into the electric field. This has the effect of breaking up the compaction of the powder particles so that they can be more easily transferred by the electric field.

FIGURES 7 and 8 illustrate two simple mechanical methods for effectuating the tapping or vibration for breaking up the powder particle compaction. In FIGURE 7 a screen image electrode 112, of the type described, is gently tapped as well as vibrated by means of a device comprising a rotatably driven hub 114 which has extending from the surface thereof, a plurality of flexible wires 116, each of which terminates in a small metal pellet 120. The hub 114, as it is rotatably driven, causes the pellets 120, to tap the powder image forming member 112, rapidly and in succession whereby the compaction of the preloaded powder may be broken up.

In the arrangement shown in FIGURE 8, a plurality of air driven hammers 122 which are distributed over the region of the image pattern, are driven from a compressed air source 124. These air driven hammers may be of the type for example, employed by dentists for compacting fillings.

The foregoing arrangements for tapping and vibrating the image screen when it is brought into the electric image transfer field are shown merely by way of illustration, and not as exclusive. A vast range of other types of vibration causing apparatus may be employed such as piezoelectric crystals, magnetostrictive devices, solenoids, etc. These are apparent to those skilled in the art and are intended to be included in the term "vibratory device."

FIGURE 9 illustrates an arrangement whereby the embodiment of the invention may be used in a belt arrangement for effectuating electrostatic printing. The image screen of the type described is formed into a belt 130 which is supported over two rotatably supported and spaced-apart cylinders, respectively 132, 134. A drive motor 136 is employed to move the belt successively past a powder loading location, then through the powder image transfer location, and then around back under the powder image loading location. At the powder image loading location there is positioned a container 137, which may be of the type 50, described in either FIGURE 3 or FIGURE 4. Triboelectric powder particles are loaded therefrom into the open screen apertures 138, in the screen image belt 130. The loaded screen apertures are then carried into the electric field which is established between the belt and a conductive back plate 140. The belt 130 is connected to ground. The conductive back plate 140 is connected to a source of potential 142 which is also connected to ground, whereby an electric field is established between the two electrodes comprising the conductive plate 140 and the portion of the belt 130 which is positioned opposite this plate. A powder image receiving member 144 is directed at a matching speed between the belt 130 and the electrode 140 by means of two guide rollers 146, 148. The image receiving member 144, as was shown previously, passes on to a powder image fixing station and thereafter to a take-up reel. Positioned beneath the belt 130 at the powder image transferring region and in operative contact therewith is a vibrating device 150 which may be any one of the types described or mentioned hereinabove. The powder images

on the image forming web 130 are transferred to the image receiving web 144 as it passes through the electric field.

An advantage of using an image forming member of the type described herein, is that the screen need not be made of conductive material. The backing may be made of conductive material instead, with substantially the same results being achieved upon image transfer. Not only may cheaper screen materials be employed, but also materials may be employed which are more easily workable, which permit smaller apertures to be obtained than with conductive mask material and thereby permit the obtaining of finer detailed images.

In the description of the operation of the invention herein, an opposite electrode is shown being employed. In the event that the image receiving member is sufficiently conductive to be able to establish an electric field for transferring powder when a potential is applied thereto, then the indicated plate electrode may be omitted and a source of potential may be connected instead to the print receiving material. This can be the case for many types of paper, wood, cloth, etc., depending upon the composition thereof and/or the moisture content. Further, as previously pointed out, the backing for the screen need not be integral therewith or permanently attached thereto. Such backing need be brought into co-operative contact with the image screen only during the interval of loading the image screen and the subsequent image transfer. FIGURE 10 shows an arrangement in accordance with this invention, illustrating this. An image screen 152 is supported to be rotatably driven by two rollers 154, 156. A motor 158, rotates the cylinder 156. A conductive backing member 160 is supported to be rotatably movable by two cylinders 162, 164. The two cylinders are positioned to bring the conductive backing member 160 in contact with the screen web 152 as it passes under a powder loading station and thereafter through the image transfer station. The powder loading station is defined as the location at which powder particles are distributed onto the image forming member, which is the screen 152, from the powder container 166. The distribution is made in a manner so that only the apertures receive powder. The backing member 160 prevents the powder particles from passing through these apertures.

The image transfer region is defined by a plate electrode 168 which is positioned opposite the screen 152 and which is connected to a source of operating potential 170. The conductive backing member 160 is connected to ground so that an electric field will exist between the conductive plate 170 and the backing member. The powder particles which are in the screen apertures are directed toward the electrode 168 and are intercepted by an image receiving web 172. This web is fed from a take-off reel 174, and guided through the image transfer region by means of two rollers 176, 178, thereafter through a fixing station 180, and thereafter onto a take-up reel 182. If desired, or required, a vibrating device 184 may be employed, positioned at the backing member 160, and in the region where the powder image transfer occurs.

There has accordingly been shown and described herein a novel, useful, electrostatic printing arrangement wherein the electroscopic powder particles are loaded into suitable receiving apertures therefor in an image forming member with apertures open on the side of the region of the electric field. The preloaded image forming member is then moved into the electric field wherein the powder particles are transferred to the image receiving member by said field.

I claim:

1. In an electrostatic powder image transfer system wherein an electric field is established between two spaced apart members, one of which is an image forming member for electroscopic powder particles which are transferred therefrom in the desired image pattern toward said other

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of said two members, the improvement comprising a continuously movable conductive image forming member having a plurality of apertures which are open to only one surface thereof, said plurality of apertures being arranged to provide the desired image, means for loading said apertures with electroscopic powder particles at a first position, an image receiving member located at a second position means for moving said conductive image forming member with its apertures loaded with said electroscopic powder particles from said first position to another position which is opposite and spaced apart from said image receiving member and thereafter back to said first position, means for moving said conductive image forming member for establishing an electric field between said image forming and image receiving member to transfer the electroscopic powder particles to said image receiving member while said image forming member is at said another position.

2. The improvement recited in claim 1 wherein said means for loading said apertures with electroscopic powder particles at said first position comprises a container for said electroscopic powder particles, said container having an opening in the base thereof which is co-extensive with the region of said image forming member having said plurality of apertures, means positioning said container with said opening adjacent said image forming member to permit powder particles to fall upon said conductive image forming member as it is moved past said container, and a doctor blade positioned at the trailing edge of said container relative to the motion of said conductive image forming member for removing excess powder particles from said conductive image forming member.

3. In an electrostatic powder image transfer system as recited in claim 1 wherein said means for loading said apertures with electroscopic powder particles comprises a container for electroscopic powder particles positioned adjacent said conductive image forming member, and means for transferring powder particles from said container to said image forming member including means for establishing an electric field between said container and said conductive image forming member.

4. In an electrostatic printing system of the type wherein an electric field is established between two spaced members for transferring electroscopic powder particles in a desired pattern from the one of said two spaced members which is the image member to the other of said two spaced members, the improvement comprising an image forming member having one surface on which said desired image is formed as a pattern of openings each of which is blocked on the opposite surface, a powder loading location including means for depositing electroscopic powder particles in the openings of said image forming member, an image receiving member positioned at a powder image transfer location, means for moving said image forming member from said powder loading location to said powder image transfer location opposite said image receiving member, means for establishing an electric field between said image forming member and said image receiving

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member at said powder image transfer location, and vibratory means in operative contact with the blocked surface of said image forming member adapted to receive said vibratory means at said powder image transfer location for vibrating said image forming member.

5. A powder image transfer system comprising a movable web having a plurality of apertures therethrough disposed to form a desired image, a backing member for said web, means for moving said backing member into contact with one surface of said movable web to block one side of the apertures therethrough, means in the path of said web and backing member for filling the apertures in said web with electroscopic powder particles, an image receiving member positioned adjacent said unblocked side of said web after it passes said means for loading said web apertures with said electroscopic powder particles, and means for establishing an electric field between said web and backing member and said image receiving member for transferring said electroscopic powder particles out of the apertures in said web to said image receiving member in the form of said desired image.

6. A powder image transfer system comprising a rotatable cylinder, a conductive image forming member on the periphery of said cylinder, said image forming member having a plurality of apertures therein disposed in a pattern which forms said desired image, means for loading said image forming member apertures with electroscopic powder particles at one location comprising a powder particle container having powder particles whose particle size is smaller than the apertures in said image forming member means establishing an electric field between said container and said image forming member for transferring powder particles across intervening space from said container to said image forming member, a powder image transfer location including an electrode positioned opposite and spaced apart from the surface of said cylinder, and means for establishing an electric potential between said electrode and said image forming member for transferring the powder particles in the apertures of said image forming member to said electrode.

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