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(54) **Electrostatographic developing apparatus and method.**

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Description

This invention relates to an electrostatographic developing apparatus and process, and in particular to an electrostatographic developing apparatus including apparatus including a developer applicator for applying developer material to an electrostatic latent image on a flexible imaging surface, the developer material comprising magnetically attractable carrier particles and toner particles, means within the applicator for establishing a magnetic field around the applicator for bringing the developer material to the development zone, the magnetic field having a region of reduced strength in the development zone, as compared with its strength at the entrance and exit of said zone, and means for establishing an electric field between the applicator and the imaging surface in the development zone.

An electrostatographic developing apparatus of this kind is described in US Patent 3 900 001, which apparatus has an extended development zone, and includes relative movement between the imaging surface and the developer applicator. The reduced magnetic field in the development zone is said to allow the developer freedom of movement within this zone and to permit the carrier particles to roll more freely in contact with the imaging surface.

The development of images by electrostatographic means is well known, including the development of latent images employing toner particles, as described for example in US Patent 2 618 552, cascade development; US Patents 2 874 063, 3 251 706 and 3 357 402 magnetic brush development, and US 3 166 432 on touchdown development. In one magnetic brush system developer material comprised of toner and magnetic carrier particles, is transported by a magnet, which magnet is the source of a magnetic field that causes alignment of the magnetic carrier into a brush like configuration. The resulting magnetic brush is brought into close proximity to the electrostatic latent image bearing surface causing the toner particles to be attracted from the brush to the electrostatic latent image by electrostatic attraction.

While many processes are in existence for causing the development of images, difficulties continue to be encountered in the design of a simple, inexpensive and reliable two-component insulative developer system, which provides a high solid area development rate, low background deposition and long term stability. Thus for example, the present magnetic brush systems are sometimes inefficient since only a small fraction of the toner transported through the development zone is accessible for deposition onto the image bearing member. For insulative developer, the solid area deposition is limited by a layer of net-charged carrier particles resulting from toner deposition on a precharged imaging member. Since the developer entering the development zone has a neutral charge, deposition of charged toner onto the imaging member produces a layer of oppositely charged developer which opposes further toner deposition. The net electrostatic force due to the charged image member and the net-charged developer layer becomes zero for that toner between the developer and the electrostatic latent image of the imaging member. The collapse in the electrostatic force, or the electric field acting on the charged toner, occurs even though the toner charge deposited on the photoreceptor does not neutralize the image charge. Image field neutralization can occur, however, if there is a sufficiently high developer flow rate and multiple development rollers. Image field neutralization is herein defined to occur when the potential due to a layer of charged toner deposited on the imaging member is equal but opposite to the potential due to the charged imaging member. In the absence of a bias on the development roller, image neutralization produces a zero development electric field. Since a toner layer is of finite thickness, the charge density of the toner layer is less than the image charge density for the condition of image field neutralization. The difference in charge density depends on the relative thicknesses of the imaging member and toner layer. If the thickness of the charged toner layer is much less than the imaging member, image field neutralization occurs when the toner charge density neutralizes the image charge density.

When magnetic brush development is accomplished with conductive developer materials, the solid area deposition is not limited by a layer of net-charged developer near the imaging member, since this charge is dissipated by conduction to the development roller. The solid area deposition is, however, limited by image field neutralization, provided there is sufficient toner available at the ends of the developer brush, while the toner supply is limited to the ends or tips of the bristles, since tone cannot be extracted from the bulk of the developer where the high developer conductivity collapses the electric field within the developer, at any location, and confines it to the region between the latent image and the developer. For either insulative or conductive developer, the solid area deposition is limited by toner supply at low toner concentrations. The toner supply is limited to a layer of carrier material adjacent to the image bearing member since the magnetic field stiffens the developer and hinders developer mixing in the development zone.

Numerous improved types of toner materials, apparatus, and processes have been envisioned for the purpose of producing line copies of high resolution, however, difficulties continue to be encountered in producing consistently high quality copies of line and solid areas, in view of for example the breakdown in the triboelectric relationship between the carrier particles and the toner particles, inefficient and incomplete removal of sufficient toner from the carrier particles, the inability of the toner particles to transfer from one carrier bead to another carrier bead in the development zone, thereby depleting the amount of toner available at the surface of the image to be developed; and the like. While many of the electrophotographic machines now currently in use employ two-component developer mixtures of toner and carrier materials, solid area development is limited, particularly with magnetic brush systems, utilizing insulative developer materials, by for example, either electric field collapse or inadequate toner supply as explained hereinbefore.

IBM TDB Vol. 17 No. 9 of Feb. 1975 pages 2684—6, discloses a magnetic brush development system using a reduced field in part of the development zone and variations in magnetic field to cause turbulence and tumbling of the carrier to free toner and make it available for copy development.

There continues to be a need for apparatus and processes which will improve the quality of images produced, particularly in electrophotographic systems, such as xerographic imaging systems, which are simple and economical to operate; and which result in reproducible high quality images including both line copy quality and solid area image development. Additionally, it would be desirable to provide an apparatus and a process where background development is substantially eliminated, and where the life of the developer is increased. In the systems discussed hereinbefore, there continues to exist the problem of achieving uniform development for both the fine line image areas as well as the larger solid areas of the electrostatic latent image, while maintaining a minimum background density.

The present invention is intended to provide such an apparatus, and is characterised in that the flexible imaging member is a tensioned member which is deflected by a portion of the surface of the applicator so as to be spaced from the applicator in use by at least one layer of carrier particles, the arrangement being such that there is relative movement between the applicator and the imaging surface, whereby the carrier particles therebetween are caused to make rotational movements, such movements, together with the electric field, producing a migration of toner particles towards the imaging surface.

The invention also provides an electrostatographic development process comprising applying developer material by means of an applicator to an electrostatic latent image on a flexible imaging member, the developer material comprising magnetically attractable carrier particles and toner particles, establishing a magnetic field around the applicator for bringing the developer material to the development zone, the magnetic field having a reduced strength region in the development zone as compared with its strength at the entrance and exit of said zone, and applying an electric field between the applicator and the imaging member in the development zone, characterised by deflecting a tensioned, flexible imaging member around a portion of the surface of the applicator so that it is spaced from the applicator by at least one layer of carrier particles, and causing relative movement between the applicator and the imaging surface so that the carrier particles therebetween make rotational movements, such movements, together with the electric field, producing a migration of toner particles towards the imaging surface.

The toner migration rate depends generally on the amount of developer agitation, the magnitude of the electrical field applied to the development zone, and the length of the development zone, which depends on the amount or degree of deflection of the flexible imaging member. The magnitude of the electric field is inversely proportional to the developer thickness, and directly proportional to the difference in potential between the charged imaging member and the bias on the development roller. Thus for example, for a typical image potential of about 400 volts, a background potential of about 50 volts, and a roller bias of about 100 volts to suppress background deposition, the electric field potential is about 300 volts across the developer layer. For a preferred thickness of 0.5 mm (millimeters), the development electric field is 300 volts across 0.5 mm; i.e., 600 V/mm. Also the degree of developer agitation is proportional to the shear rate and development time. Thus for a particular imaging member speed and development roller speed, increased developer agitation is obtained when the developer layer is thin, for example, one layer of carrier particles and the development zone is long, which length ranges from 0.5 cm to 5 cm with a preferred length being between 1 cm and 2 cm. However, lengths outside these ranges may be used providing the objectives of the present invention are accomplished.

Improved developer agitation and hence solid area development is obtained with the apparatus, and process of the present invention when a low magnetic field is present in the development zone, since with such a field, the developer does not stiffen but is fluid-like under agitation and/or shearing. The magnetic field is generally less than 150 gauss and preferably less than 20 gauss. If desired, ferromagnetic material such as steel can be used to shape and reduce the magnetic field in the development zone.

A development system based on a self-agitated development zone has a number of advantages over conventional systems, for example, solid area and line development is at its maximum, since the toner charge neutralizes the fields from the image charge; and development, limited by image field neutralization enables the present system to develop in one embodiment low voltage images associated with thin image bearing members. For a particular image potential the amount of toner deposited on the imaging bearing member is substantially independent of the spacing between the development roll, and the image bearing member, within the range of 0.05 millimeters to 1.5 millimeters.

For a better understanding of the present invention, various preferred embodiments will now be described by way of example with reference to the accompanying drawings, wherein:

Figure 1 is a partially schematic cross-sectional view of the development zone in an apparatus according to the present invention. Figures 1A, 1B, and 1C illustrate the transfer of toner particles from carrier particles to the imaging member, and the transfer of toner particles from one carrier particle bead to another carrier bead; such transfer of toner particles occurring primarily as a result of agitation.

Figure 2 is a partially schematic cross-sectional view of a conventional development zone wherein two-component insulative developer material is employed.

Figure 3 is a partially schematic cross-sectional view of a conventional development zone wherein conductive developer is employed.

Figure 4 illustrates an electroded cell for measuring the electrical and development properties of developer.

Figure 5 illustrates a preferred embodiment of the development apparatus of the present invention that incorporates the features of a thin long and low magnetic field development zone, as well as a high magnetic field at the entrance and exit regions of the development zone.

Figure 6 illustrates a comparison between (1) the solid area development characteristic of the self-agitated development system of the present invention as illustrated in Figures 1 and 5; and (2) the development characteristics of a conventional magnetic brush development system as illustrated in Figure 2.

Figure 7 illustrates another preferred embodiment of a self-agitated development system that incorporates an idler roll.

Figure 8 illustrates the use of the process and apparatus of the present invention in an electrophotographic imaging system.

Illustrated in Figure 1 is the development zone of the apparatus of the present invention designated 10, which is comprised of a positively charged image bearing member 1, negatively charged toner particles 2, attached to positively charged carrier particles 3, a developer transporting member 4, which also serves as a development electrode, toner depleted layer D, which layer has carrier particles containing a positive charge, this layer having less tone on the carrier than the adjacent carrier layers, C, B, and A, a biased voltage source 6, and a toner developed layer 7. A, B, C, and D designate layers of developer comprised of carrier and toner particles. The image bearing member 1, and developer transporting member 4, in this embodiment are moving in the direction shown by the arrows 5 and 5a. In this illustration the transporting member 4 is moving at a greater speed than the image bearing member 1. It is this difference in speed between these two members which causes a shearing action in the development zone, thereby causing agitation of the carrier and toner particles whereby movement of the carrier particles causes toner particles to transfer from one layer of carrier particles, such as layer B, to another layer of carrier particles, such as layer A. It is not intended to be limited to the method of operation shown; thus other methods of operation are envisioned by this invention. For example the speed of the imaging member 1 can be greater than the speed of the transporting member 4, and movement can be in the opposite direction to that which is shown. Also although the carrier particles 3 are shown in ordered layers, in actual operation they can be distributed randomly in size and position. The shape of the carrier particles is not necessarily completely spherical as shown, that is, most carrier particles are non-spherical with surfaces that can be jagged or textured. Further, the toner particles 2 can be charged positively, and the carrier particles 3, can be charged negatively. Such a developer would be useful in systems where the image bearing member is charged negatively.

The arrows within the carrier particles 3, indicate that such particles are moving in both directions, first in one direction, for example, slightly to the right than in another direction, slightly to the left. While moving in one direction, then another, the particles are also rotating as more clearly illustrated in Figures 1A—1C. This movement or agitation which results in improved development of images, is caused primarily by the movement of the imaging member 1, and developer transporting member 4, as indicated herein.

In one method of operation, as indicated hereinbefore, the development electrode 4 is moving at a surface speed which is faster than the speed of the imaging member 1, both the development electrode and the imaging member moving in the same direction. This relative motion between the development electrode 4 and imaging member 1, causes the developer which is comprised of toner particles 2, and carrier particles 3, to be agitated by a shearing action. When the speed of the image bearing member 1, is less than the speed of the electrode 4, as shown in Figure 1, the shearing action causes movement of the carrier particles 3, that is, the carrier particles rotate in both a clockwise and counterclockwise direction, but on the average tend to rotate in a counterclockwise direction. The developer agitation the development electric field, and deflection of the flexible imaging member allow toner particles 2 adhering to the carrier particles 3 to migrate towards the imaging member 1. The toner particles closest to the imaging member 1 are deposited on the imaging surface, therefore the carrier particles adjacent the imaging surface lose some of the toner particles adhering thereto, which toner particles must be replaced in order to continue to achieve high quality development, and in particular, solid area development. In order for this to occur, toner particles must be transferred from adjacent carrier layers, and this transfer is caused on a continual and constant basis by the shearing action mentioned hereinbefore. Maximum agitation, which is preferred, is obtained when the magnetic field in development zone is low, and the developer layer is thin, that is, ranging in thickness from about 0.05 millimeters to about 1.5 millimeters and preferably from about 0.4 millimeters to 1.0 millimeters. by low magnetic field it is meant that the field strength is generally less than 150 gauss.

When the image bearing member is positively charged an electrostatic force directed towards the imaging member acts on all of the negatively charged toner particles 2, which are near the image-carrier interface, and the carrier-carrier interfaces. In the absence of developer agitation, the electrostatic force on the toner particles is not sufficient under normal conditions to overcome the toner adhesion, and thus the toner particles are retained on the carrier particles 3. However, when agitation is supplied to the developer, that is, toner particle plus carrier particles, the toner which remains between two carrier particles can easily transfer when the surfaces involved are separated by a rolling or a sliding action. The rate of electric field assisted toner migration towards the image bearing member is therefore increased in comparison to when agitation is not utilized. As illustrated in Figure 1, toner migration results in a toner depleted layer D and although the toner depleted carrier is positively charged, the effect of this charge layer on the toner motion in the bulk of the developer is small due to the proximity of the layer to the development electrode. However, both solid area and line development will cease when the charge on the imaging member is essentially neutralized with charged toner. Accordingly, the availability of toner for solid area development is enhanced for a self-agitated two-component insulative development system, and when the electrostatic force und development agitation are sufficient, nearly all of the toner in the developer bulk will deposit on the image bearing member.

The degree of developer agitation is defined by the product of the shear rate and development time. The average shear rate is equal to the absolute value of the difference in the devopment roller or electrode velocity, V_R, and imaging member velocity, V_I, divided by the developer thickness, L, i.e., the average shear rate equals

$$|V_R - V_1|/L.$$

The development time is equal to the development zone length, W, divided by the absolute value of the development roller speed, $|V_R|$; i.e. the develoment time equals $W/|V_R|$. Thus the degree of developer agitation is equal to

$$(|V_R - V_1|/L) \times (W/|V_R|)$$

or

$$[|1 - 1/V|]$$

where V is equal to V_R/V_I and is positive or negative when the development roller or electrode moves in the same or opposite direction to the image bearing member respectively. It is assumed that the quantity $|1-1/V|$, is typically near a value of 1 in which case the degree of developer agitation is approximated by W/L, i.e., the ratio of the developer zone length to the developer layer thickness. When the development zone length ranges from 0.5 cm to 5 cm (W) with a preferred length of 1 cm to 2 cm and the developer layer ranges in thickness of from about 0.05 mm to 1.5 mm (L) and preferably about 0.4 mm to 1.0 mm, the developer agitation ranges from 2 to 1000 units and preferably from 10 to 50 units.

There is shown in some detail in Figure 1A, 1B, and 1C, what is occurring at each of the different layers of developer, designated A, B, and C when employing the imaging process und apparatus of the present invention. In these figures the numerical and letter designations illustrate the identical components as described with reference to Figure 1, with the addition that Z represents an area or zone of the carrier particles which have been depleted of toner particles. In Figure 1A there is illustrated a carrier particle 3, of layer A, which is depleted of toner particles 2, in the area or zone Z; while Figure 1B, illustrates the transfer of toner particles 2, from carrier particle 3, of layer B, to carrier particle 3, of layer A, resulting in a toner depleted area or zone Z, on carrier particle 3, layer B. In this Figure 1B, 8 represents the interface area between carrier particles. Likewise toner particles 2 transfer from carrier particles 3 of layer C, to carrier particles 3, of layer B and there results a toner depleted layer or zone Z, on carrier particle 3, layer C. In essence thus the carrier particles of layers A, and B for example, reference Figure 1B, come into contact with each other, forcing the toner particles 2 between the carrier 3 of layers A and B, to in effect decide what carrier particles to remain with; those of layer A, or those of layer B. In view of the agitation system of the present invention the toner particles move from the carrier particles of layer B, to the carrier particles of layer A, thereby replacing the depleted toner particles on the carrier of layer A in order that such particles will be available to deposit on the imaging member and cause development. In zone Z no toner particles are present, since the electrical fields transferred the toner from the carrier beads, for example the carrier beads of layer A, to the imaging member 1. This is caused primarily because of the rocking motion of the carrier beads 3, which motion further causes a positive charge to be contained on the carrier particles.

More specifically, with reference to Figures 1A, 1B and 1C, as the carrier beads rotate as a result of agitation in accordance with the method of the present invention, some of the toner particles 2 on the carrier bead of layer A transfer to the image bearing member. The toner particles between the carrier particles of layer A, and the carrier particles of layer B, are being acted upon by two opposing forces; that from the carrier bead of layer A, and the imaging member, and that from the carrier bead of layer B. As the force from the carrier bead of layer A and the imaging member is greater than the force from the carrier bead of layer B, the toner particles become detached from the carrier particles of layer B and attach to the carrier particles of layer A during bead rotation, reference Figure 1B. This action replaces the toner particles on the carrier particles of layer A but leaves the carrier particles of layer B, with less toner particles. The carrier particle of layer A now has a net electrical charge of zero, whereas the carrier particle of layer B has a net positive electrical charge. The same transfer of toner particles and electrical forces is illustrated in Figure 1C, however, an additional layer of carrier particles is shown, namely layer C. Thus the carrier particles of layer B obtains toner particles from the carrier particles of layer C by the methods described herein. This transfer of toner particles across the different carrier interfaces actually occurs simultaneously throughout the development zone, and as a result toner particles are continually available on the carrier particles immediately adjacent the imaging member, while the carrier particles near the transporting member 4 contain thereon an excess of positive charges, in view of the loss of toner particles to the next layer of carrier particles. After a short period of time, the charge on the carrier particles near the member 4, become neutralized as a result of the high electrical field between the carrier particles and the imaging member. Subsequently, the carrier and toner particles contained thereon are allowed to pass through a development sump in order that neutral toner particles from a toner dispenser can replenish those toner particles that have been used for developing images, reference Figure 5. Developer mixing in the developer sump charges the added toner by triboelectric charging.

When the apparatus and process of the present invention are employed in an imaging system, there is provided increased line and increased solid area development even when the developers have a rather low toner concentration in comparison to the developers used in conventional systems. The minimum toner concentration for acceptable solid area development depends on several factors including the ratio of the development roller speed to photoreceptor speed and the degree of developer agitation which depends on the magnetic field strength, the development zone length and the spacing between the imaging member and the development roll. Thus for example for a developer containing 25 percent by weight of toner, mixed with about 75 percent by weight of 100 μm diameter steel carrier beads, the solid area development is 0.5 mg/cm^2 for a development voltage of 300 volts, a speed ratio of 3, a magnetic field less than 20 gauss, a development zone length of 3.3 cm and a developer layer thickness of 0.5 mm.

Illustrated in Figure 2 is a conventional magnetic brush development system, wherein two component insulative developer material is used, this illustration being provided in order to more clearly point out the advantages of the present invention in some respects over conventional magnetic brush systems. The imaging system of Figure 2 is comprised of an imaging member 1, negatively charged toner particles 2, positively charged carrier particles 3, development electrode 4, developed toner layer 7, image developer interface 9, and a biased voltage source 6. The developer, that is, toner plus carrier is a two-component insulative developer as described with reference to Figure 1.

The magnetic field causes the developer to form bead chains or bristles which are rigid or stiff. Thus developer agitation is limited to a region near the image developer interface 9, as no agitation is occurring with the other developer particles, transfer of toner from the carrier particles does not result, thereby in effect rendering these other developer particles substantially useless. The charge density on the developer layer A is equal to the negative of the toner charge density 7 on the image bearing member, divided by the ratio of the development roll speed to imaging member speed. The electric field from the layer of charged developer A is highly effective in reducing the net electric field at the image developer interface. This electric field becomes zero despite the fact that the image charge is not neutralized by toner charge. Solid area development with insulative developers is limited by field collapse even though a sufficient supply of toner might be contained within the first layer of developer A. Furthermore, the solid area development rate decreases when the toner concentration is low and the stiffening of developer by the magnetic field aids in limiting the supply of toner.

Illustrated in Figure 3 is an enlarged view of a development zone containing conductive developer. In this Figure, 1 represents the imaging member, 2 represents negatively charged toner particles, 3 represents positively charged carrier particles, 4 is a development electrode, 6 represents the voltage source, 7 represents the developed toner layer. As illustrated in this Figure, the charged image bearing member induces an opposite charge in the layer of developer adjacent to the image. Toner in the developer (within the layer of developer) is inaccessible since the electric field is zero because of the high developer conductivity, and the magnetic field stiffens the developer and reduces the migration of toner to the image bearing member, that is, toner particles are not transferred from one layer of carrier particles, such as B to another layer of carrier particles such as A, and thus no development will occur after a short period of time. Thus toner development onto the imaging member only occurs from the first bead layer 1. In both the systems as described in Figures 2 and 3, the amount of toner transferred from one layer of carrier particles to another layer of carrier particles is substantially zero, whereas with the system of the present invention, toner particles are being constantly replenished to the first layer of carrier particles, which replenishment is important for efficient solid area development, and efficient development of lines.

The conditions which make possible a self-agitated development zone for the improvement of solid area development efficiency is more clearly appreciated by describing measurements on a well defined system. This is illustrated in Figure 4, which represents an electroded cell for measuring the development properties of developer under controlled conditions. In this Figure, the developer is located in a conducting tray 11 that can be biased with a voltage supply. The upper electrode 12 is coated with an insulating material such as a polyester or photoreceptor layer 13, which is contacted with the developer 14, when a bias is applied to the developer tray 11. Movement of the electrode as indicated by the arrow causes agitation of the developer layer. The toner density developed onto layer 13 is measured by weighing the electrode assembly before and subjecting the assembly to an air jet for the purpose of removing loose toner particles. Using the device shown in Figure 4, in one embodiment, the toner weight per unit area was 0.23 mg/cm^2 which was deposited on an insulation overcoated electrode 12 under the following conditions; a developer bed thickness of 1.5 mm, an applied voltage of 600 volts and an electrode displacement of 1.9 cm. When a magnetic field of 450 gauss was applied perpendicular to the cell electrodes, the developed toner mass decreased to 0.09 mg/cm^2. The larger developed toner mass for magnetic field free conditions is attributed to increased developer agitation. In a situation where an operable development system is used the toner weight developed on the image bearing member is proportional to the ratio of the development roll speed to the imaging member speed. Thus when this ratio is 2, and under the conditions stated herein, the toner weight per unit area of 0.46 mg/cm^2 would be obtained on the image bearing member. This would result in an acceptable reflective optical density of (|).

When similar development data is obtained with a thinner developer layer of 0.5 mm the solid area development increases since the development electric field is higher. With a 450 gauss magnetic field applied across the developer, the developed toner density is 0.28 mg/cm^2 compared to the 0.09 mg/cm^2 obtained for a developer thickness of 1.5 millimeters. For magnetic field free conditions, the developed density increases to 0.80 mg/cm^2 compared to the 0.23 mg/cm^2 obtained when the developer thickness is 1.5 mm. The increase in solid area development for the magnetic field-free case is due to a high agitation of the thin developer layer. The agitation increases the toner supply and displaces the developer net-charge towards the development electrode. Increased solid area development is thus obtained by making the developer layer thin and the development zone magnetic field free.

Self-agitation of developer in the development zone requires relative motion between the developer transporting electrode member and the image bearing member. When the electrode is brought into contact with the developer without lateral movement, a small quantity of toner is transferred to the electrode when a voltage is applied and the electrode is removed. When the electrode is displaced while in contact with the developer, increased development occurs since the developer is agitated by the relative motion, the degree of agitation depending on the magnitude of the relative displacement which is the product of the relative speed and displacement time.

In a practical development system based on insulative developer a high solid area development rate is achieved when the development zone is thin, magnetic field free, and long, such development systems containing a means of flowing fresh developer through the development zone. Since the developer transporting roller is typically moving at a speed faster than the image bearing member, developer will tend to accumulate at the entrance to the magnetic field free zone. To ensure good developer flow, a strong magnetic field at the zone entrance helps to establish proper developer flow through the succeeding low magnetic field region. A strong magnetic field at the exit region of the developer zone reduces carrier adhesion to the image bearing member, and prevents scavenging of the toner in solid areas, since as the electrode spacing increases the fields in the solid areas decrease.

Illustrated in Figure 5 is a development system that incorporates the features of a thin and low magnetic field development zone, as well as a high magnetic field at the entrance and exit regions of the development zone. In this figure, there is represented a flexible image bearing member 1 and a development roller 15, containing magnets 16 therein, attached to a core or "keeper" 17. The roller 15 obtains developer 18 (toner and carrier) when it passes through the development sump 19. Metering blade 20 is used to control the thickness of the developer material. As the deflected flexible image bearing member 1 moves in the direction shown it comes into contact with the development roller 15, whereby toner particles are transferred to the imaging member 1. At this point there is a low magnetic field region 21. There are high magnetic field regions located at the entrance 22 and the exit 23 of the system. Region (21) allows developer to remain on the roller 15, while region 22 insures good developer flow and region 23 prevents developer from contacting the latent image surface as the electrode spacing increases.

In this embodiment developer agitation occurs in the region of low magnetic field, and the image bearing member can be a belt photoreceptor or an electroreceptor (charge patterns generated by electrical means; such as in electronic printers), both of which can be partially wrapped around the developer-covered development roller. The developer layer provides the spacing between the development roller and image bearing member. Steel shunting inside the development roller is used to reduce the magnetic field between the magnetic poles at the entrance and exit regions. Designating v as the ratio of the development roller velocity and imaging member velocity, good developer flow is obtained when the value of v is greater than zero and less than −1. If v is greater than −1, but less than zero inadequate developer flow results in the development zone.

A thin layer of developer is applied to the development roller with the aid of the metering blade 20, closely spaced from the development roller. The uniformity of the developer thickness is determined by the dimensional accuracy of the roller and the straightness of the metering blade. When the metering blade is positioned where the magnetic field is in a radial direction (perpendicular to the development roller), the developer layer thickness is approximately equal to the metering blade gap setting, while when the metering blade is located where the magnetic field is tangential to the roll, the developer layer thickness is approximately 0.4 of the metering gap setting. A reduced developer layer thickness is obtained because the developer bead chains tangential to the development roll are magnetically attracted to the mass of developer peeled away by the metering blade. Developer metering in a tangential magnetic field enables one to obtain a thin developer layer of approximately 0.5 mm when the metering gap is set at 1.2 millimeters.

Figure 6 is a graph of data displaying the solid area development characteristics of the self-agitated development system depicted in Figure 5. This figure also includes data obtained with a conventional single development roll magnetic brush development system. In Figure 6, the curve G represents data obtained for self-agitated development with a 0.4 mm gap, (distance between imaging member and transporting member) while curve H represents data obtained with a conventional magnetic brush system, 1.5 mm gap. The same developer with a toner concentration of 2.7 percent and fluoropolymer coated ferrite beads was used for both systems operating at a speed ratio v of 2. Increased development with the self-agitated system, curve G, is attributed to the thin developer layer (0.4 mm), low magnetic field (20 gauss) and long development zone (3 cm). For the conventional system, curve H, the gap between the photoreceptor and development roller is maintained at 1.5 mm. The magnetic field is 500 gauss over the development zone length of 0.5 cm. At a development potential of 200 volts, the reflection image density for the self-agitated system, curve G is greater than 1, while for conventional systems at 200 volts the reflection image density, curve H, is less than 0.2.

For the self-agitated development system described herein, the spacing between hhe development roller and image bearing member is determined by the developer layer thickness. As indicated this spacing typically ranges from about 0.05 millimeters to about 1.5 millimeters and preferably from about 0.4 millimeters to about 1.0 millimeters. The magnetic field within the central area of the development zone is generally less than 150 gauss and preferably less than 20 gauss, while the magnetic field at the entrance and exit regions of the development zone is radially directed and typically 300 to 800 gauss, with magnetic poles being of like polarity. The magnetic field profile is obtained by a suitable choice of permanent magnets. Thus steel shunting inside the development roll can provide magnetic field shaping at the surface of the development roll.

The length of the development zone depends on the configuration of the image bearing member and developer transport member. In a preferred embodiment, the image bearing member is a belt partially wrapped around a development roller with a diameter which is typically 3.8 cm to 6.4 cm. The length of contact between the developer and image bearing member ranges from 0.5 cm to 5 cm. The preferred length is 1 cm to 2 cm. Idler rolls positioned against the backside of the belt can be used to alter the belt path.

Figure 7 illustrates one example of a self-agitated development system design that incorporates the use of an idler roll. Although not shown more than one idler roll can be used. The purpose of the idler roll, or rolls, is to allow freedom in the position of the zones, such as the paper transport zone for example in an electrophotographic or similar apparatus. In this Figure the numerical designations 15, 16, 17, 19, 21, 22 and 23 represent the same components as described in Figure 5. In Figure 7 the idler roll in the region 22 is designated 24. It is understood that a second idler roll could be placed near the region 23 to alter the path of the imaging member without causing a change in the operation of the development system. The system shown in Figure 7 is operating in a mode in which the development roller and imaging member are moving in opposite directions.

The apparatus and process of the present invention is useful in many systems including electronic printers and electrophotographic copy machines, such as those employing xerographic apparatus well known in the art. In Figure 8 there is illustrated an electrophotographic printing machine employing an imaging member 1 having a photoconductive surface deposited on a conductive substrate, such as aluminized Mylar (Trademark), which is electrically grounded. The imaging member 1, or the photoconductive surface can be comprised of numerous suitable materials as described herein. For example, however, for this illustration the photoconductive material is comprised of a transport layer containing small molecules of N,N,N',N'-tetraphenyl-[1,1'-biphenyl] 4-4'-diamine, or similar diamines (m-TBD) dispersed in a polycarbonate and a generation layer of trigonal selenium. Imaging member 1 moves in the direction of arrow 27 to advance successive portions of the photoconductive surface sequentially through the various processing stations disposed about the path of movement thereof. The imaging member is entrained about a sheet-stripping roller 28, tensioning system 29, and drive roller 30. Tensioning system 29 includes a roller 31 having flanges on opposite sides thereof to define a path through which member 1 moves. Roller 31 is mounted between guides 22 attached to springs 32. Springs 32 are tensioned such that roller 31 presses against the imaging belt member 1. In this way, member 1 is placed under the desired tension. The level of tension is relatively low permitting member 1 to be relatively easily deformed. With continued reference to Figure 8, drive roller 30 is mounted rotatably and in engagement with member 1. Motor 33 rotates roller 30 to advance member 1 in the direction of arrow 27. Roller 30 is coupled to motor 33 by suitable means such as a belt drive. Sheet-stripping roller 28 is freely rotatable so as to readily permit member 1 to move in the direction of arrow 27 with a minimum of friction.

Initially, a portion of imaging member 1 passes through charging station H. At charging station H, a corona generating device, indicated generally by the reference numeral 34, charges the photoconductive surface of imaging member 1 to a relatively high, substantially uniform potential.

Next, the charged portion of the photoconductive surface is advanced through exposure station I. An original document 35 is positioned face down upon transparent platen 36. Lamps 37 flash light rays onto original document 35. The light rays reflected from original document 35 are transmitted through lens 38 forming a light image thereof. Lens 38 focuses the light image onto the charged portion of the photoconductive surface to selectively dissipate the charge thereon. This records an electrostatic latent image on the photoconductive surface which corresponds to the informational areas contained within original document 35.

Thereafter, imaging member 1 advances the electrostatic latent image recorded on the photoconductive surface to development station J. At development station J a self-agitated development system, indicated generally by the reference numeral 39, advances a developer material into contact with the electrostatic latent image. The self-agitated development system 39 includes a developer roller 40 which transports a layer of developer material comprising magnetic carrier particles and toner particles into contact with imaging member 1. As shown in Figure 5, developer roller 40 is positioned such that the brush of developer material deforms imaging member 1 in an arc such that member 1 conforms at least partially, to the configuration of the developer roller. The electrostatic latent image attracts the toner particles from the carrier granules forming a toner powder image on the photoconductive surface of member 1. The development roller 40 returns the developer material to the sump of development system 39 for subsequent re-use. The detailed structure of the development system 39 has been described herein, with reference to Figures 1, 1A, 1B, 1C, 5 and 7.

Imaging member 1 then advances the toner powder image to transfer station K. At transfer station K, a sheet of support material 44 is moved into contact with the toner powder image. The sheet of support material 44 is advanced to transfer station K by a sheet feeding apparatus (not shown). Preferably, the sheet feeding apparatus includes a feed roll contacting the uppermost sheet of a stack of sheets. The feed roll rotates so as to advance the uppermost sheet from the stack into a chute. The chute directs the advancing sheet of support material into contact with the photoconductive surface of member 1 in a timed sequence so that the toner powder image developed thereon contacts the advancing sheet of support material at transfer station K.

Transfer station K includes a corona generating device 46 which sprays ions onto the backside of sheet 44. This attracts the toner powder image from the photoconductive surface to sheet 44. After transfer, sheet 44 moves in the direction of arrow 48 onto a conveyor (not shown) which advances sheet 44 to fusing station L.

Fusing station L includes a fuser assembly, indicated generally by the reference numeral 50, which permanently affixes the transferred toner powder image to sheet 44. Preferably, fuser assembly 50 includes a heated fuser roller 52 and a back-up roller 54. Sheet 44 passes between fuser roller 52 and backup roller 54 with the toner powder image contacting fuser roller 52. In this manner, the toner powder image is permanently affixed to sheet 44. After fusing, a chute guides the advancing sheet 44 to a catch tray for subsequent removal from the printing machine by the operator.

Invariably, after the sheet of support material is separated from the photoconductive surface or imaging member 1 some residual particles remain adhering thereto. These residual particles are removed from the photoconductive surface at cleaning station M. Cleaning station M includes a rotatably mounted fibrous brush 56 in contact with the photoconductive surface. The particles are cleaned from the photoconductive surface by the rotation of brush 56 in contact therewith. Subsequent to cleaning, a discharge lamp (not shown) floods photoconductive surface 1 with light to dissipate any residual electrostatic charge remaining thereon prior to the charging thereof for the next successive imaging cycle.

It is believed that the foregoing description is sufficient for purposes of the present application to illustrate the general operation of an electrophotographic printing machine incorporating the features of the present invention therein.

Illustrative examples of the photoconductive surface of flexible image bearing member 1, include inorganic and organic photoreceptor materials such as for example amorphous selenium, selenium alloys, including alloys of selenium-tellurium, selenium arsenic, selenium antimony, selenium-tellurium-arsenic, cadmium sulfide, zinc oxide, polyvinylcarbazole, and layered organic photoreceptors, such as those containing an injecting contact, carbon dispersed in a polymer, overcoated with a transport layer, which in turn is overcoated with a generating layer, and finally an overcoating of an insulating organic resin, such as those described in U.S. Patent 4,251,612.

Other organic photoreceptor materials include, 4-dimethylaminobenzylidene, benzhydrazide; 2-benzylidene-amino-carbazole, 4-dimethylamino-benzylidene, polyvinyl carbazole; (2-nitro-benzylidene)-p-bromo-aniline; 2,4-diphenyl quinazoline, 1,2,4-triazone; 1,5-diphenyl-3-methyl pyrazoline 2-(4′-dimethyl-amino phenyl) benzoxazole; 3-amino-carbazole; polyvinylcarbazole-trinitrofluorenone charge transfer complex; phthalocyanines and mixtures thereof, and the like.

Illustrative examples of materials for the transporting member 4 include virtually any conducting material made for this purpose, such as stainless steel, aluminum and the like. Texture in the development roller provides traction necessary for good developer transport from the developer sump and through the development zone. The development roll texture is obtained by one of several methods involving flame-spray treating, etching, knurling, etc.

The developer material is comprised of a toner resin, colorant or pigment, and a suitable insulating magnetic carrier material. By insulating as used throughout the description, is meant sufficiently non-conducting for charge not to flow from the transport member to the ends of the carrier particles nearest the image bearing member within a time that is less than the development time. In one embodiment thus the range of development times is calculated as follows:

$$\text{Longest Time}\quad W=\frac{5\ \text{cm}}{5\ \text{cm/sec}}=1\ \text{second}$$

$$\text{Shortest Time}\quad W=\frac{0.5\ \text{cm}}{100\ \text{cm/sec}}=5.10^{-3}\ \text{seconds}$$

While any suitable material may be employed as the toner resin in the system of the present invention, typical of such resins are polyamides, epoxies, polyurethanes, vinyl resins and polymeric esterification products of a dicarboxylic acid and a diol comprising a diphenol. Any suitable vinyl resin may be employed in the toners of the present system including homopolymers or copolymers of two or more vinyl monomers. Typical of such vinyl monomeric units include: styrene, p-chloro-styrene vinyl naphthalene, ethylenically unsaturated mono olefins such as ethylene, propylene, butylene, isobutylene and the like; vinyl esters such as vinyl chloride, vinyl bromide, vinyl fluoride, vinyl acetate, vinyl propionate, vinyl benzoate, vinyl butyrate and the like; esters of alphamethylene aliphatic monocarboxylic acids such as methyl acrylate, ethyl acrylate, n-butylacrylate, isobutyl acrylate, dodecyl acrylate, n-octyl acrylate, 2-chloroethyl acrylate, phenyl acrylate, methyl alphachloroacrylate, methyl methacrylate, ethyl methacrylate, butyl methacrylate and the like; acrylonitrile, methacrylonitrile, acrylamide, vinyl ethers such as vinyl methyl ether, vinyl isobutyl ether, vinyl ethyl ether, and the like; vinyl ketones such as vinyl methyl ketone, vinyl hexyl ketone, methyl isopropenyl ketone and the like; vinylidene halides such as vinylidene chloride, vinylidene chlorofluoride and the like; and N-vinyl indole, N-vinyl pyrrolidene and the like; and mixtures thereof.

Generally toner resins containing a relatively high percentage of styrene are preferred since greater image definition and density is obtained with their use. The styrene resin employed may be a homopolymer of styrene or styrene homologs of copolymers of styrene with other monomeric groups containing a single methylene group attached to a carbon atom by a double bond. Any of the above typical monomeric units may be copolymerized with styrene by addition polymerization. Styrene resins may also be formed by the polymerization of mixtures of two or more unsaturated monomeric materials with a styrene monomer. The addition polymerization technique employed embraces known polymerization techniques such as free radical, anionic and cationic polymerization processes. Any of these vinyl resins may be blended with one or more resins if desired, preferably other vinyl resins which insure good triboelectric properties and uniform resistance against physical degradation. However, non-vinyl type thermoplastic resins may also be employed including resin modified phenolformaldehyde resins, oil modified epoxy resins, polyurethane resins, cellulosic resins, polyether resins and mixtures thereof.

Also esterification products of a dicarboxylic acid and a diol comprising a diphenol may be used as a preferred resin material for the toner composition of the present invention. These materials are illustrated in U.S. Patent No. 3,655,374, the diphenol reactant being of the formula as shown in column 4, beginning at line 5 of this patent and the dicarboxylic acid being of the formula as shown in column 6 of the above patent. When 5 percent by weight of the alkyl pyridinium compound is used and 10 percent by weight of pigment such as carbon black, about 85 percent by weight of resin material is used.

Optimum electrophotographic resins are achieved with styrene butylmethacrylate copolymers, styrene vinyl toluene copolymers, styrene acrylate copolymers, polyester resins, predominantly styrene or polystyrene based resins as generally described in U.S. Reissue 24,136 to Carlson and polystyrene blends as described in U.S. Patent No. 2,788,288 to Rheinfrank and Jones.

The toner resin particles can vary in diameter, but generally range from about 5 micronmeters to about 30 micronmeters in diameter, and preferably from about 10 micrometers to about 20 micrometers.

Any suitable pigment or dye may be employed as the colorant for the toner particles, such materials being well known and including for example, carbon black, nigrosine dye, aniline blue, calco oil blue, chrome yellow, ultramarine blue, DuPont oil red, methylene blue chloride, phthalocyanine blue and mixtures thereof. The pigment or dye should be present in sufficient quantity to render it highly colored so that it will form a clearly visible image on the recording member. For example, where conventional xerographic copies of documents are desired, the toner may comprise a black pigment such as carbon black or a black dye such as Amaplast black dye available from the National Aniline Products Inc. Preferably the pigment is employed in amounts from about 3 percent to about 20 percent by weight based on the total weight of toner, however, if the toner color employed is a dye, substantially smaller quantities of the color may be used.

Also there can be incorporated in the toner (resin plus colorant) various charge control agents primarily for the purpose of imparting a positive charge to the toner resin. Examples of charge control agents includes quaternary ammonium compounds as described in U.S. Patent 3,970,571, and alkyl pyridinium halides such as cetyl pyridinium chloride, as described in U.K. Patent Application No. 7916357, publication No. 2023298.

Any suitable insulating magnetic carrier material can be employed as long as such particles are capable of triboelectrically obtaining a charge of opposite polarity to that of the toner particles. In the present invention in one embodiment that would be negative polarity, opposite to that of the toner particles which are positively charged so that the toner particles will adhere to and surround the carrier particles. Thus, the carriers can be selected so that the toner particles acquire a charge of a positive polarity and include materials such as steel, nickel, iron, ferrites, magnetites and the like. The carriers can be used with or without a coating, examples of coatings including fluoropolymers such as polyvinylidene fluoride, methyl terpolymers and the like. Also nickel berry carriers as described in U.S. Patents 3,847,604 and 3,767,598 can be employed, provided they are rendered insulating in accordance with the process defined herein, these carriers being nodular carrier beads of nickel characterized by a surface of reoccurring recesses and protrusions providing particles with a relatively large external area. Preferably the carrier particles, or their cores are of materials that have a conductivity which is such as to dissipate net charge accumulation from the development process such as for example steel shot carriers. The diameter of the coated carrier particle ranges from about 50 to about 1000 micrometers, thus allowing the carrier particle to possess sufficient density and inertia to avoid adherence to the electrostatic images during the development process.

The carrier may be employed with the toner composition in any suitable combination, however, best results are obtained when about 1 part toner is used and about 10 to about 4000 parts by weight of carrier.

Claims

1. Electrostatographic developing apparatus including a developer applicator (15) for applying developer material (18) to an electrostatic latent image on a flexible imaging surface (1), the developer material comprising magnetically attractable carrier particles (3) and toner particles (2), means (16) within the applicator for establishing a magnetic field around the applicator for bringing the developer material to the development zone, the magnetic field having a region (21) of reduced strength in the development zone, as compared with its strength at the entrance and exit of said zone, and means for establishing an electric field between the applicator and the imaging surface in the development zone, characterised in that the flexible imaging member (1) is a tensioned member which is deflected by a portion of the surface of the applicator (15) so as to be spaced from the applicator in use by at least one layer of carrier particles, the arrangement being such that there is relative movement between the applicator and the imaging surface, whereby, the carrier particles therebetween are caused to make rotational movements, such movements, together with the electric field, producing a migration of toner particles towards the imaging surface (1).

2. The apparatus of claim 1 wherein the imaging member (1) is spaced from the applicator (15) in the development zone by a gap of from 0.05 to 1.5 mm.

3. The apparatus of claim 2 wherein the gap is from 0.4 to 1.0 mm.

4. The apparatus of any one of claims 1 to 3 wherein the applicator (15) is arranged for moving at a speed of from 6 cm/sec to 100 cm/sec and the imaging surface (1) is arranged for moving at a speed of from 5 cm/sec to 50 cm/sec.

5. The apparatus of any one of claims 1 to 4 wherein the magnetic field in the region of reduced strength is less than 150 gauss.

6. The apparatus of any one of claims 1 to 5 wherein the electric field in the development zone is about 600 v/mm.

7. The apparatus of any one of claims 1 to 6 wherein the development zone is from 0.5 to 5 cm long.

8. The apparatus of any one of claims 1 to 7 wherein the applicator (15) is a roller mounted for rotation about a fixed set of magnets (16) for establishing said magnetic field, and the imaging surface (1) is the surface of a flexible web arranged to be deflected by the roller so as to engage developer material on the surface of the roller in the development zone.

9. Electrostatographic development process comprising applying developer material (18) by means of an applicator (15) to an electrostatic latent image on a flexible imaging member (1), the developer material comprising magnetically attractable carrier particles and toner particles establishing a magnetic field around the applicator for bringing the developer material to the development zone, the magnetic field having a reduced strength region (21) in the development zone as compared with its strength at the entrance and exit of said zone, and applying an electric field between the applicator and the imaging member in the development zone characterised by deflecting a tensioned, flexible imaging member (1) around a portion of the surface of the applicator (15) so that it is spaced from the applicator by at least one layer of carrier particles, and causing relative movement between the applicator and the imaging surface so that the carrier particles therebetween make rotational movements, such movements, together with the electric field, producing a migration of toner particles towards the imaging surface (1).

Revendications

1. Appareil de développement électrostatographique comprenant un applicateur (15) de révélateur destiné à appliquer un matériau révélateur (18) à une image électrostatique latente sur une surface (1) flexible de formation d'image, le matériau révélateur comprenant des particules (3) de porteur et des particules de toner (2) attirables magnétiquement, un moyen (16) à l'intérieur de l'applicateur afin d'établir un champ magnétique autour de l'applicateur dans le but d'amener le matériau révélateur dans la zone de développement, le champ magnétique comportant une région (21) où règne une intensité réduite dans la zone de développement, par rapport à son intensité à l'entrée et à la sortie de ladite zone, et un moyen pour établir un champ électrique entre l'applicateur et la surface de formation d'image dans la zone de développement, caractérisé en ce que l'élément (1) flexible de formation d'image est un élément soumis à une tension qui est dévié par une partie de la surface de l'applicateur (15) de manière à être espacé de l'applicateur pendant l'utilisation suivant au moins une couche de particules de porteur, l'agencement étant tel qu'il y a un mouvement relatif entre l'applicateur et la surface de formation d'image, d'où il résulte que les particules de porteur situées entre sont amenées à faire des mouvements de rotation, de tels mouvements, en même temps que le champ électrique, produisant une migration des particules de toner vers la surface (1) de formation d'image.

2. Appareil selon la revendication 1, où l'élément (1) de formation d'image est espacé de l'applicateur (15) dans la zone de développement suivant un interstice compris entre 0,05 et 1,5 mm.

3. Applicateur selon la revendication 2, où l'interstice est compris entre 0,4 et 1,0 mm.

4. Appareil selon l'une quelcoque des revendications 1 à 3, où l'applicateur (15) est disposé de manière à se déplacer à une vitesse comprise entre 6 cm/s et 100 cm/s et la surface (1) de formation d'image est disposée de manière à se déplacer à une vitesse comprise entre 5 cm/s et 50 cm/s.

5. Appareil selon l'une quelconque des revendications 1 à 4, où le champ magnétique dans la région où règne une intensité réduite est inférieur à 150 gauss.

6. Appareil selon l'une quelconque des revendications 1 à 5, où le champ électrique dans la zone de développement est d'environ 600 V/mm.

7. Appareil selon l'une quelconque des revendications 1 à 6, où la zone de développement a une longueur comprise entre 0,5 et 5 cm.

8. Appareil selon l'une quelconque des revendications 1 à 7, où l'applicateur (15) est un rouleau monté en rotation autour d'un jeu fixe d'aimants (16) afin d'établir le champ magnétique, et la surface (1) de formation d'image est la surface d'un ruban flexible disposé de manière à être déviée par le rouleau pour venir en contact avec le matériau révélateur sur la surface du rouleau dans la zone de développement.

9. Procédé de développement électrostatographique comprenant l'application de matériau révélateur (18) au moyen d'un applicateur (15) sur une image électrostatique latente sur un élément (1) flexible de formation d'image, le matériau révélateur comprenant des particules de porteur et des particules de toner attirables magnétiquement, l'établissement d'un champ magnétique autour de l'applicateur pour amener le matériau révélateur dans la zone de développement, le champ magnétique ayant une region (21) d'intensité réduite dans la zone de développement par rapport à son intensité à l'entrée et à la sortie de ladite zone, et l'application d'un champ électrique entre l'applicateur et l'élément de formation d'image dans la zone de développement, caractérisé par la déviation d'un élément (1) flexible de formation d'image, soumis à une tension, autour d'une partie de la surface de l'applicateur (15) de sorte qu'il se trouve espacé de l'applicateur d'au moins une couche de particules de porteur, et la provocation d'un mouvement relatif entre l'applicateur et la surface de formation d'image de sorte que les particules de porteur se trouvant entre subissent des mouvement de rotation, de tels mouvements, avec le champ électrique, produisant une migration des particules de toner vers la surface (1) de formation d'image.

Patentansprüche

1. Elektrostatographische Entwicklungsvorrichtung mit einer Entwicklereinrichtung (15) um Entwicklermaterial (18) zu einem elektrostatischen, latenten Bild auf einer beweglichen Abbildungsoberfläche (1) aufzubringen, wobei das Entwicklermaterial magnetisch anziehbare Trägerpartikel (3) und Tonerpartikel (2) umfaßt, mit einer Einrichtung (16) innerhalb der Entwicklerauftragseinrichtung, um ein Magnetfeld um die Entwickleraufbringungseinrichtung (16) herum zu erzeugen, damit Entwicklermaterial auf den Entwicklungsbereich gebracht werden kann, wobei das Magnetfeld einen Bereich (21) einer verminderten Stärke in der Entwicklungszone hat, verglichen mit der Stärke am Anfang und am Ausgang dieser Zone und mit einer Einrichtung zur Erzeugung eines elektrischen Feldes zwischen der Entwickleraufbringungeinrichtung (16) und der Bildoberfläche in der Entwicklungszone, dadurch gekennzeichnet, daß das bewegliche Abbildungselement (1) ein gespanntes Element ist, welches von einem Abschnitt der Oberfläche der Entwickleraufbringungseinrichtung (15) abgelenkt wird, so daß es von der Entwicklungsaufbringungseinrichtung (15) durch mindestens eine Trägerpartikelschicht getrennt ist, wobei die Anordnung so getroffen ist, daß eine Relativbewegung zwischen der Aufbringungseinrichtung und der Abbildungsoberfläche stattfindet, wobei die Trägerpartikelchen dazwischen zu Rotationsbewegungen veranlaßt werden, wobei diese Bewegungen zusammen mit dem elektrischen Feld ein Hinwandern von Tonerpartikeln in der Richtung auf die Abbildungsfläche (1) hervorrufen.

2. Vorrichtung nach Anspruch 1, dadurch gekennzeichnet, daß das Abbildungselement (1) von der Aufbringungsvorrichtung (15) in dem Entwicklungsbereich durch einen 0,05—1,5 mm breiten Spalt getrennt ist.

3. Vorrichtung nach Anspruch 2, dadurch gekennzeichnet, daß der Spalt zwischen 0,4 und 1,0 mm breit ist.

4. Vorrichtung nach irgendeinem der Ansprüche 1—3, dadurch gekennzeichnet, daß die Aufbringungseinrichtung (15) so angeordnet ist, daß sie sich mit einer Geschwindigkeit zwischen 6 cm/sec. bis 100 cm/sec. bewegt und daß die Abbildungsoberfläche (1) so angeordnet ist, daß sie sich mit einer Geschwindigkeit zwischen 5 cm/sec. und 50 cm/sec. bewegt.

5. Vorrichtung nach irgendeinem der Ansprüche 1—4, dadurch gekennzeichnet, daß das Magnetfeld im Bereich der verminderten Stärke geringer als 150 Gauß beträgt.

6. Vorrichtung nach irgendeinem der Ansprüche 1—5, dadurch gekennzeichnet, daß das elektrische Feld in dem Entwicklungsbereich ungefähr 600 Volt/mm^2 beträgt.

7. Vorrichtung nach irgendeinem der Ansprüche 1—6, dadurch gekennzeichnet, daß der Entwicklungsbereich zwischen 0,5 bis 5 cm lang ist.

8. Vorrichtung nach irgendeinem der Ansprüche 1—7, dadurch gekennzeichnet, daß die Aufbringungseinrichtung (15) als Walze ausgebildet ist, die so angeordnet ist, daß sie

sich um einen feststehenden Satz von Magneten (16) zur Erzeugung des magnetischen Feldes dreht und daß die Abbildungsoberfläche (1) die Oberfläche ein flexibles Gewebe ist, welches so angeordnet ist, daß es von der Walze abgelenkt wird, und mit dem Entwicklermaterial auf der Oberfläche der Walze in der Entwicklungszone in Berührung kommt.

9. Elektrostatographisches Entwicklungsverfahren, bei dem ein Entwicklermaterial (18) mit Hilfe einer Aufbringungsvorrichtung (15) auf ein elektrostatisches latentes Bild auf einem flexiblen Abbildungselement (1) aufgebracht wird, wobei das Entwicklungsmaterial magnetisch anziehbare Trägerpartikel und Tonerpartikel umfaßt, und wobei ein magnetisches Feld um die Aufbringungsvorrichtung herum erzeugt wird, um das Entwicklermaterial in den Entwicklungsbereich zu bringen, wobei das Magnetfeld einen Bereich (21) verminderter Stärke in dem Entwicklungsbereich hat verglichen mit der Stärke am Anfang und am Ende dieser Zone, und wobei ein elektrisches Feld zwischen der Aufbringungsvorrichtung und dem Abbildungselement in der Entwicklungszone angewandt wird, dadurch gekennzeichnet, daß ein gespanntes, bewegliches Abbildungselement (1) um einen Teil der Oberfläche der Aufbringungsvorrichtung (15) so umgelenkt wird, daß es von der Aufbringungsvorrichtung durch mindestens eine Trägerpartikelschicht getrennt ist und daß eine relative Bewegung zwischen der Aufbringungsvorrichtung und der Abbildungsoberfläche erzeugt wird, so daß die Trägerpartikel dazwischen Drehbewegungen ausführen, wobei diese Bewegungen zusammen mit dem elektrischen Feld ein Hinwandern von Tonerpartikeln in Richtung auf die Abbildungsoberfläche (1) hervorrufen.

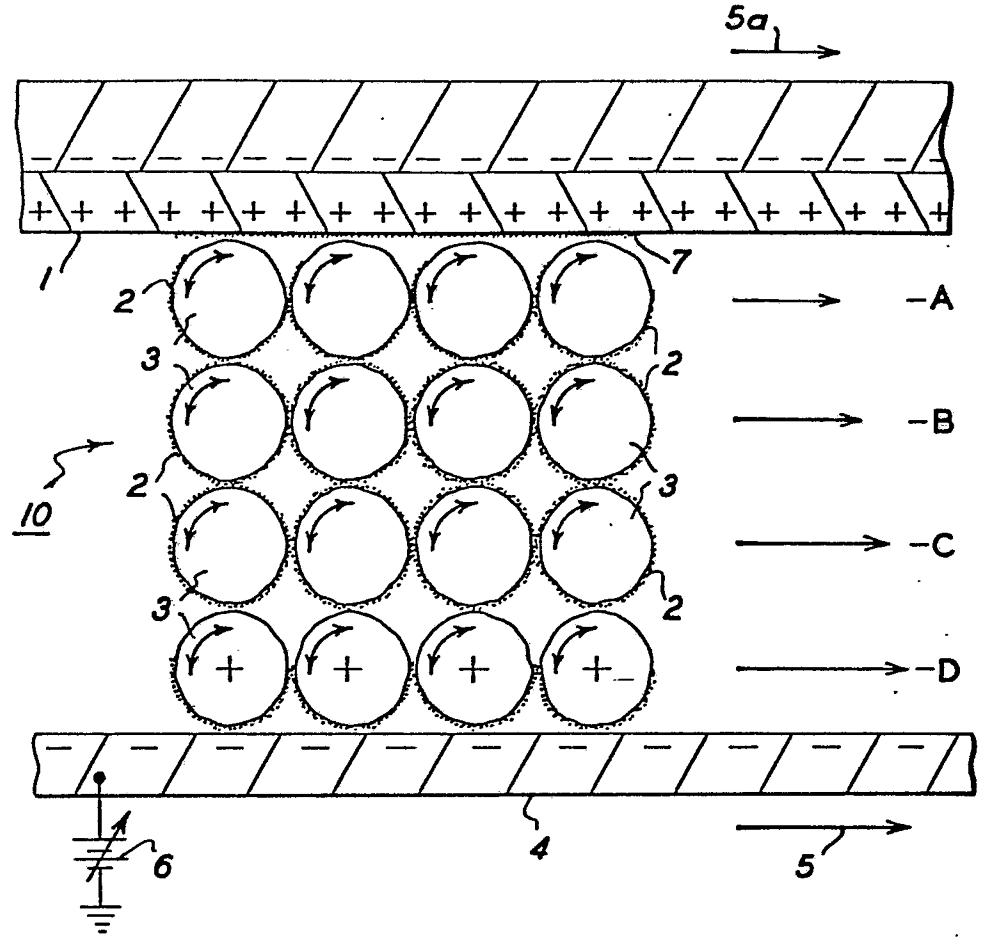
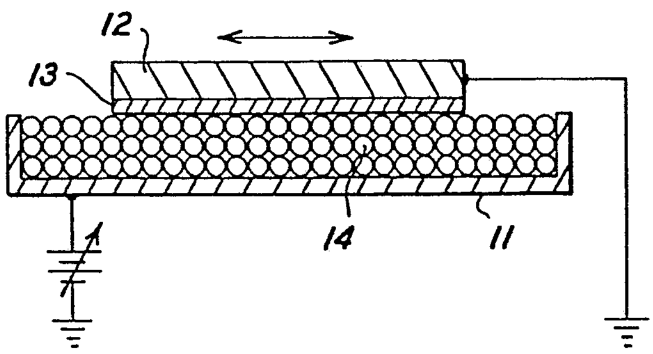


FIG. 1

FIG. 4



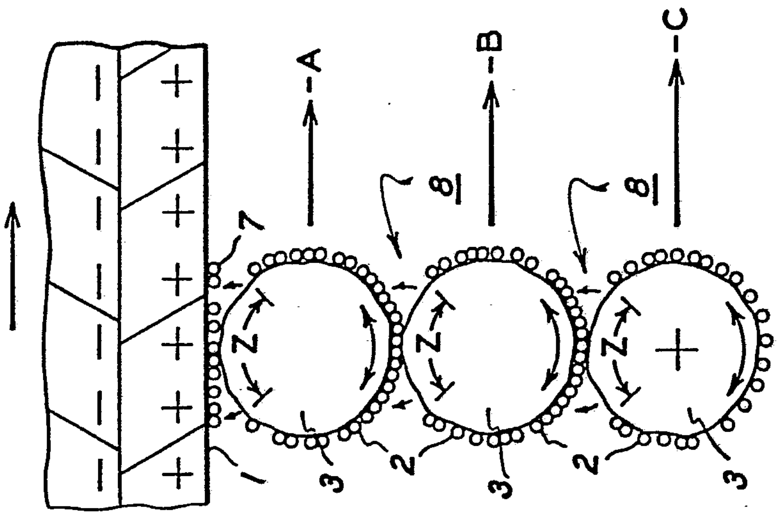


FIG. 1C

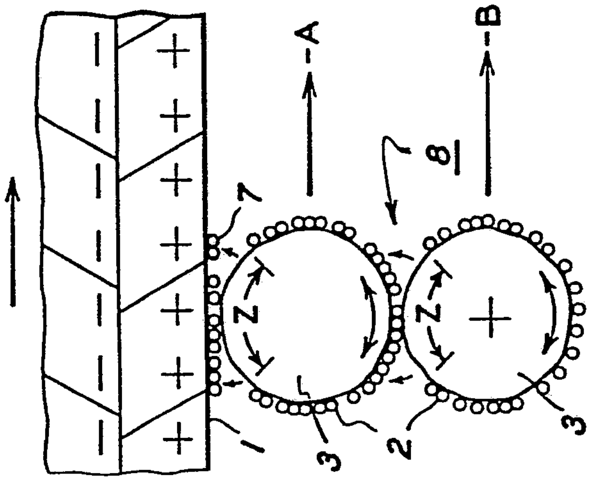


FIG. 1B

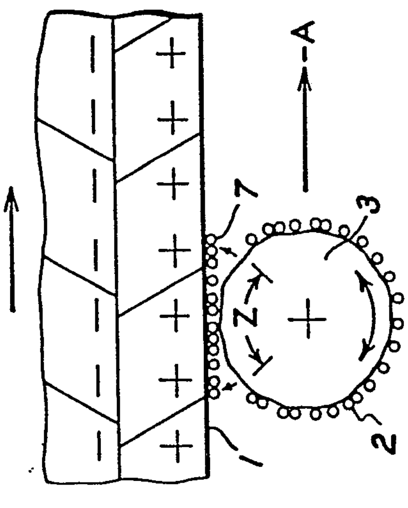


FIG. 1A

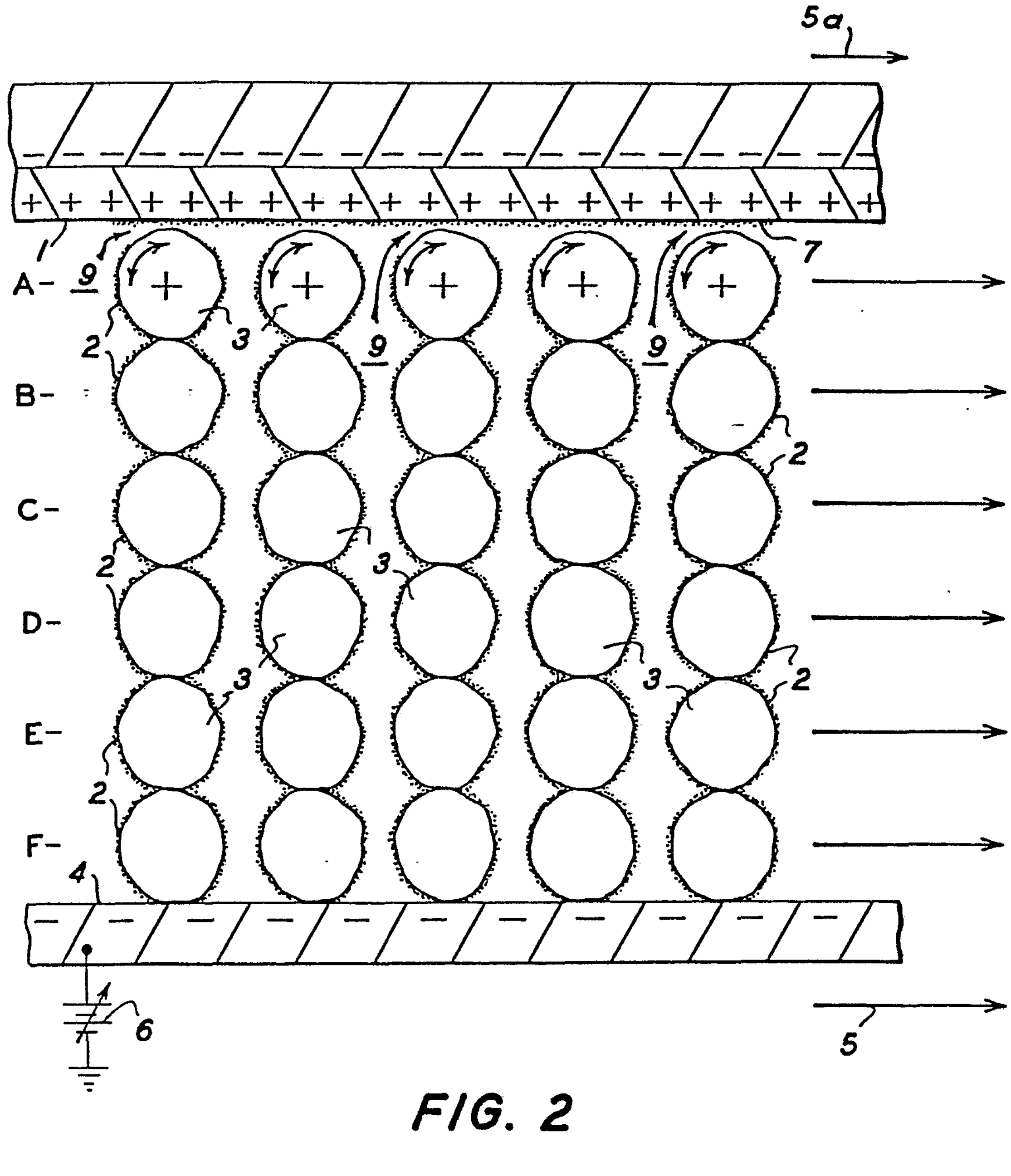


FIG. 2

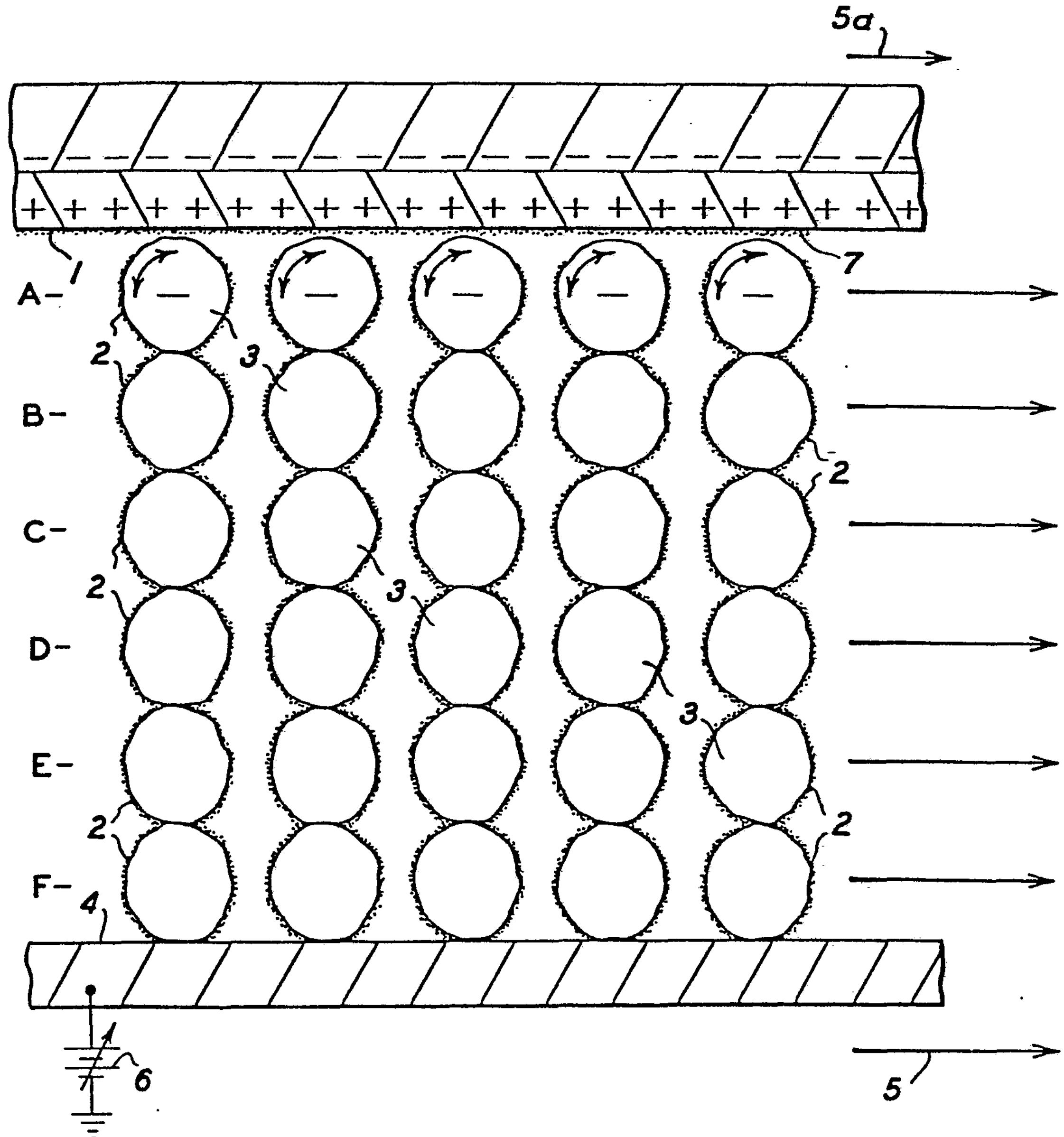


FIG. 3

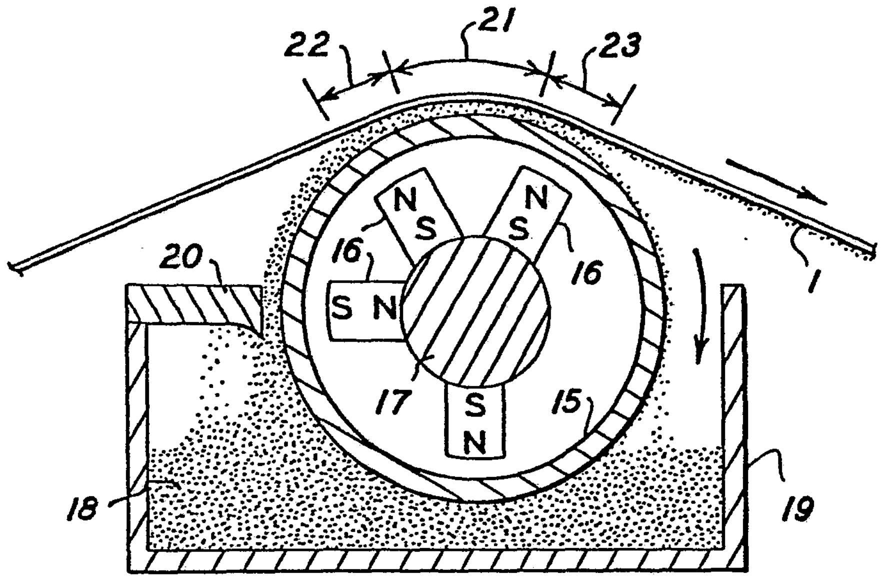

22
21
23
N
S
N
S
16
16
20
S N
17
S
N
15
18
19
1

FIG. 5

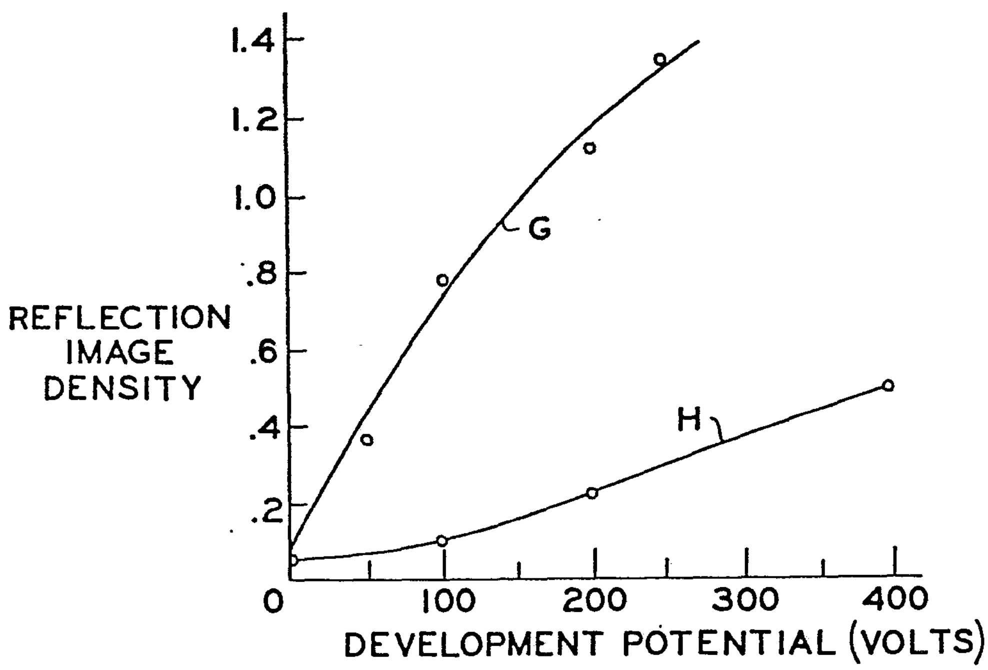

1.4
1.2
1.0
.8
.6
.4
.2
REFLECTION IMAGE DENSITY
G
H
0
100
200
300
400
DEVELOPMENT POTENTIAL (VOLTS)

FIG. 6

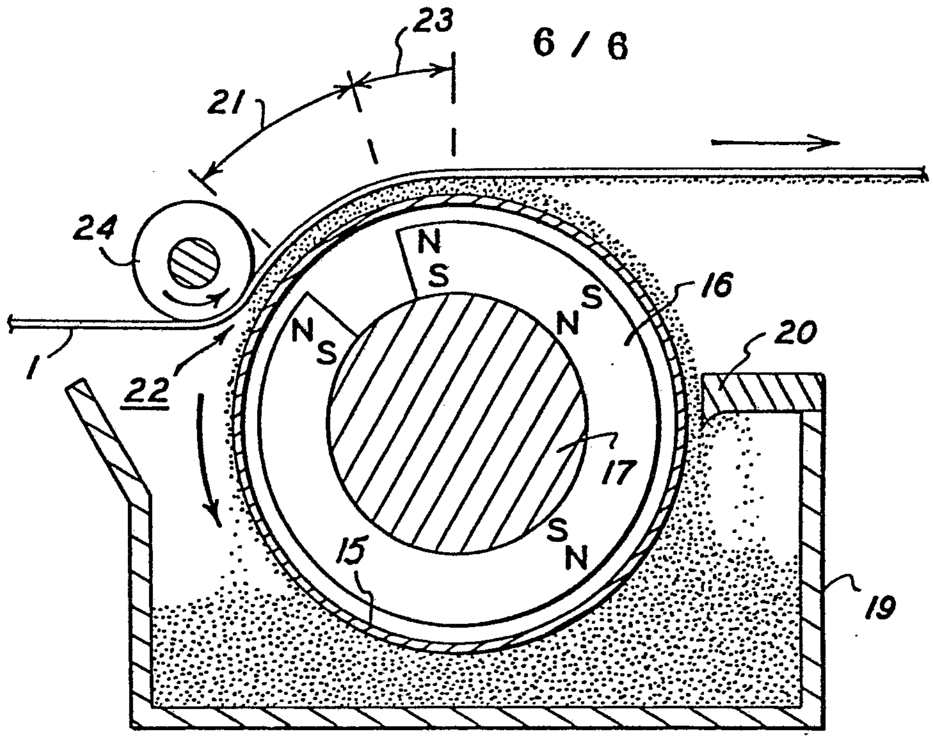

23
21
24
16
20
22
1
17
15
19
N
S
N
S
N
S
S
N

FIG. 7

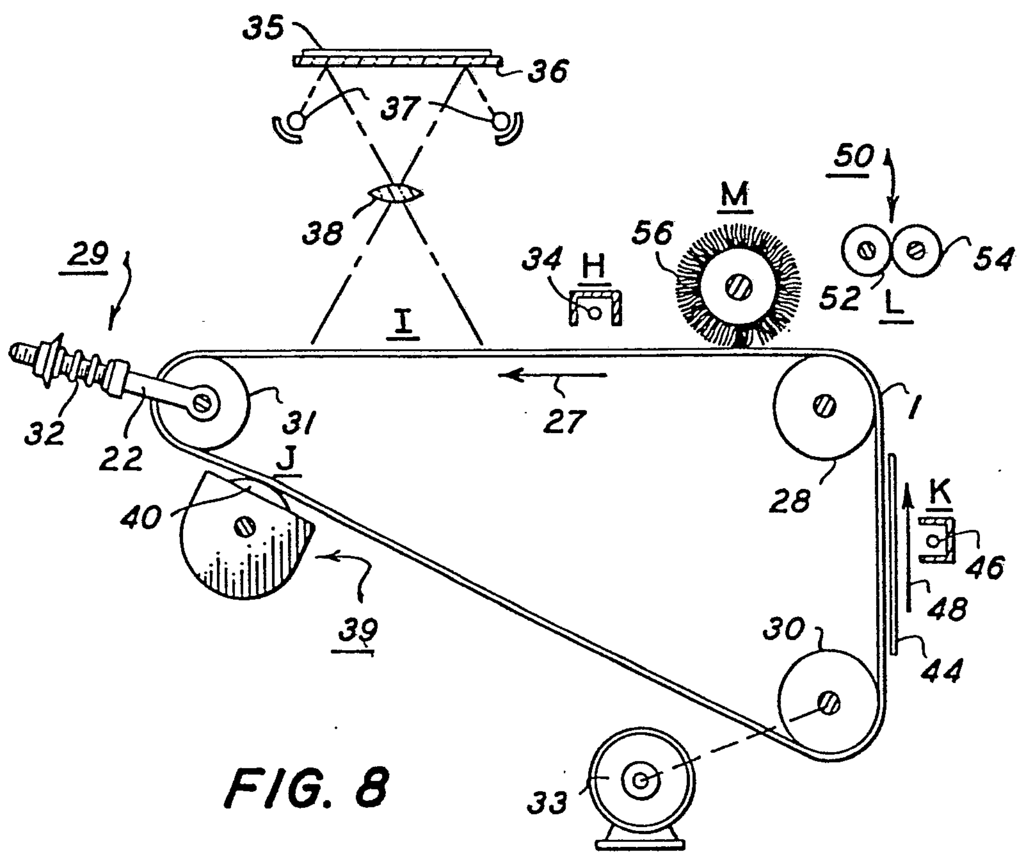

35
36
37
38
50
M
56
34
H
52
54
L
29
I
27
31
32
22
J
40
39
28
1
K
46
48
30
44
33

FIG. 8