United States Patent

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[54] **APPARATUS FOR DEVELOPING ELECTROSTATIC IMAGES**
18 Claims, 8 Drawing Figs.

[52] **U.S. Cl.** **355/3,** 118/624, 118/637
[51] **Int. Cl.** **G03g 15/00**
[50] **Field of Search** 355/3; 118/624, 637

[56] **References Cited**
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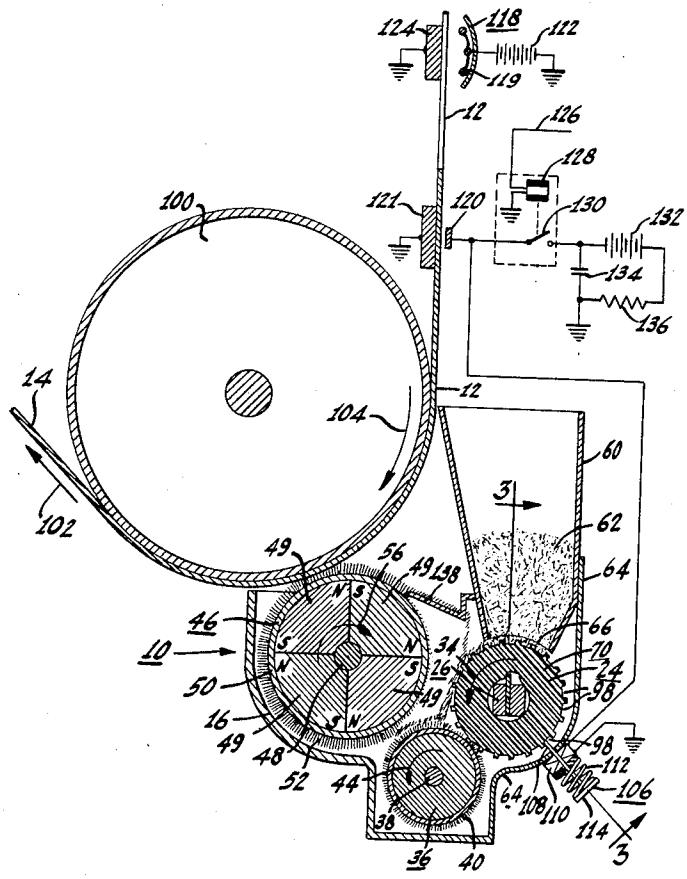
ABSTRACT: Developing apparatus for an electrostatic printer comprises a roller formed by a plurality of peripherally-slotted wheels frictionally mounted on a shaft for rotation therewith. The roller is in contact with a source of toner particles. Either manually or electrically operated means are provided to overcome the driving forces selectively between one or more of the wheels and the rotating shaft to stop them from rotating with the shaft. Thus, selected portions of the toner particles, in the peripheral slots of the rotating wheels, can be conveyed to electrostatic images on a recording medium according to the charge patterns thereon.



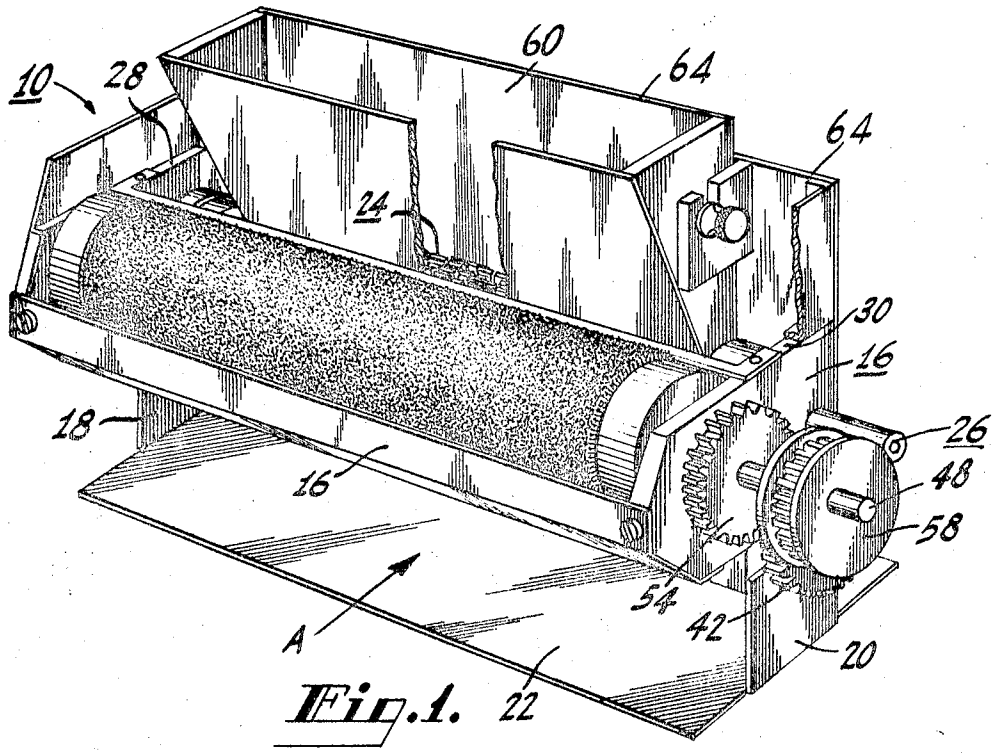


Fig. 1.

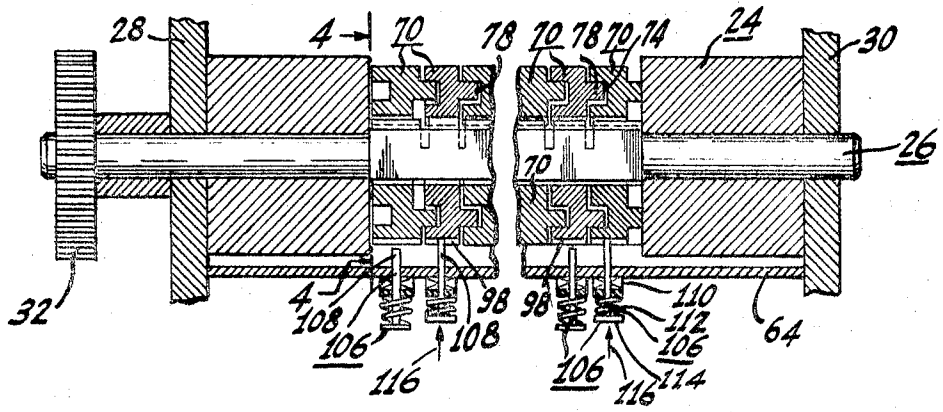


Fig. 3.

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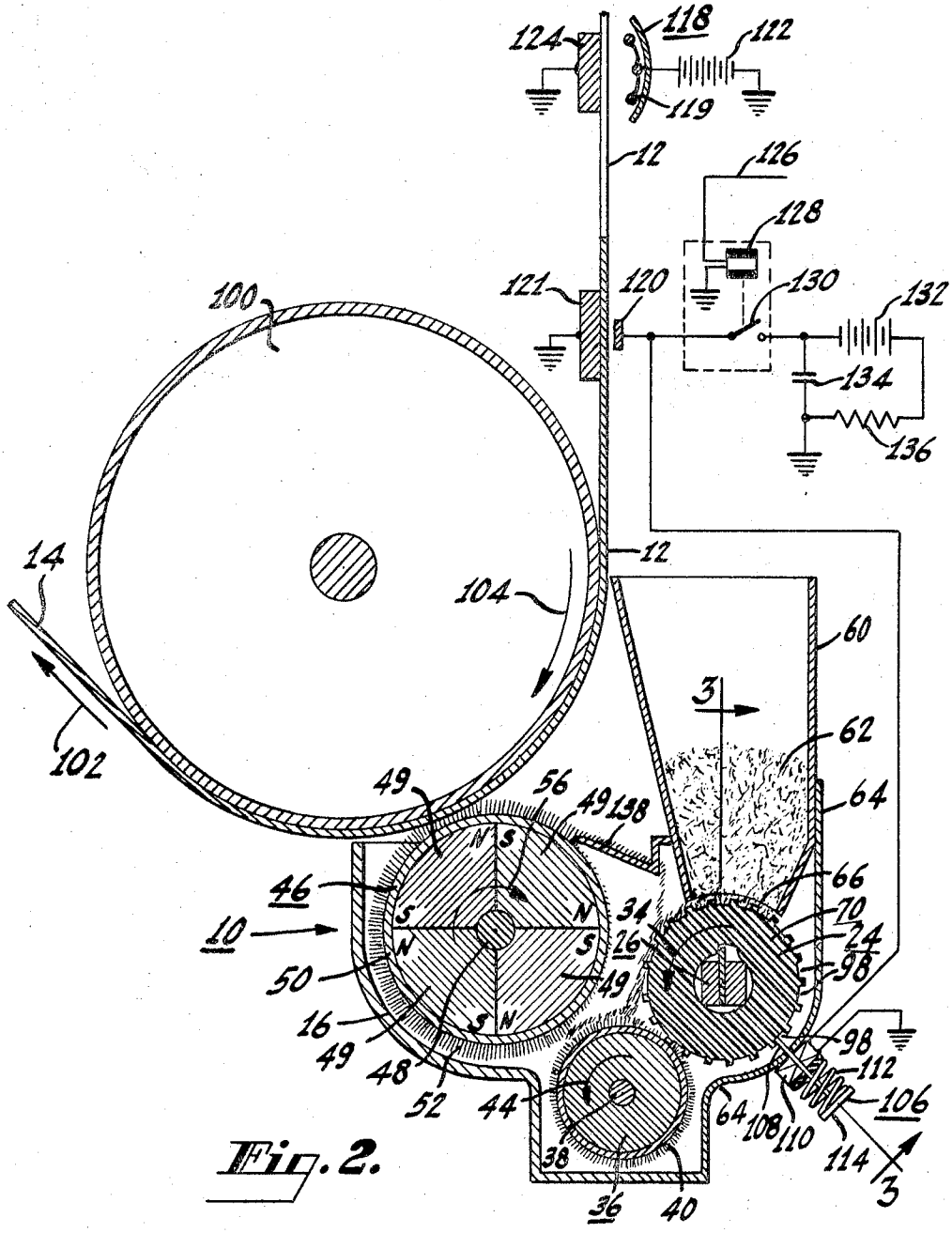

Fig. 2.

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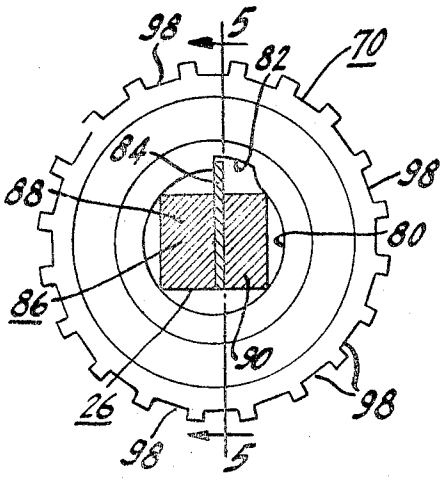

Fig. 4.

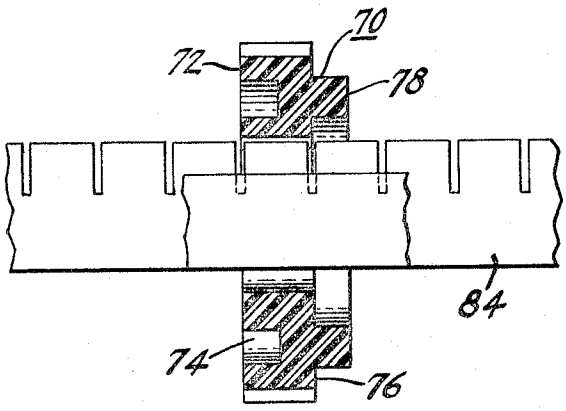

Fig. 5.

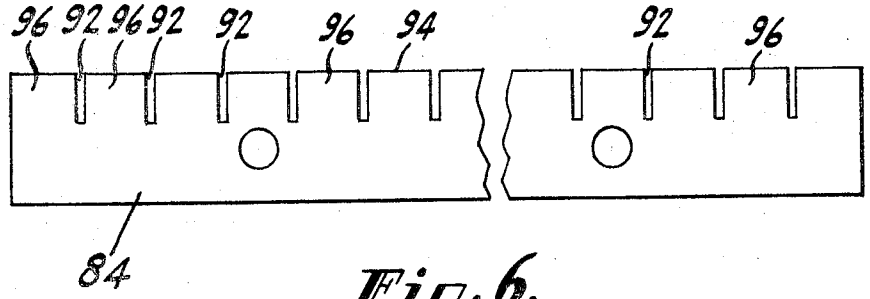

Fig. 6.

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Fig. 7.

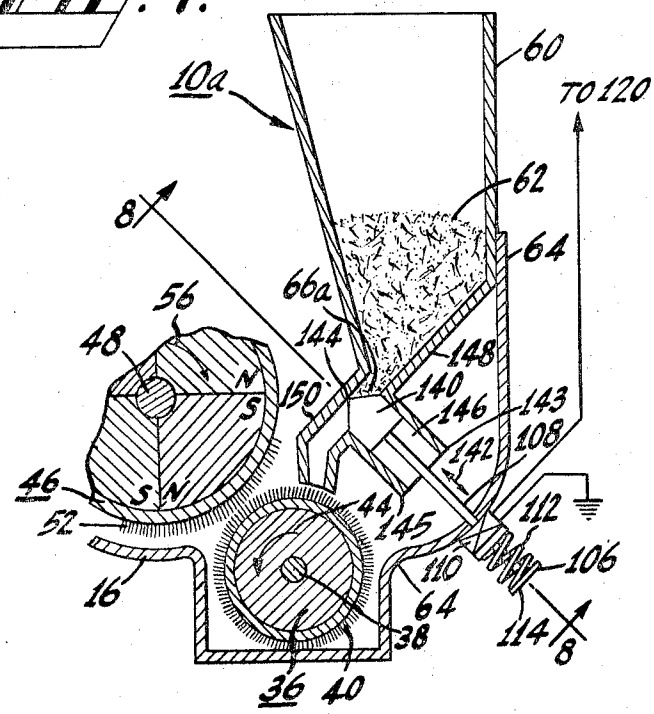
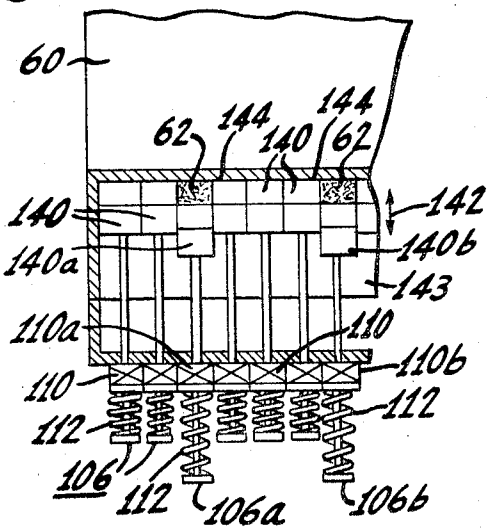


Fig. 8.



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APPARATUS FOR DEVELOPING ELECTROSTATIC IMAGES

BACKGROUND OF INVENTION

This invention relates generally to apparatus for developing electrostatic images, and more particularly to improved apparatus for electrostatic images with toner particles distributed in spaced relationships corresponding substantially to the distribution of the electrostatic charges on an insulating surface. The improved apparatus is particularly useful for developing the output of a computer of the type whose output system comprises electrostatic images on a recording medium.

It has been proposed to develop electrostatic images on an insulating surface of a recording medium by applying electroscopic toner particles substantially uniformly over the entire insulating surface of the recording medium. Under ideal conditions, only the electrostatic images are developed and the background, that is, the nonimage area of the insulating surface, is free of toner particles. In practice, however, it has been found that some unwanted toner particles may sometimes stick to the nonimage areas, giving the background a "dirty" appearance. This usually happens when an electrostatic image occupies only a small portion of the surface of the recording medium, and/or the surface of the recording medium is relatively rough. The improved apparatus for developing electrostatic images provides cleaner prints and prevents overdeveloping by conveying the toner particles to the recording medium in distribution patterns corresponding substantially to the distribution of the electrostatic images on the surface of the recording medium.

SUMMARY OF THE INVENTION

The improved developing apparatus comprises a source of toner particles and conveyor means disposed to convey the toner particles from the source toward a recording medium to develop electrostatic charge patterns thereon. The conveyor means comprise a plurality of substantially similar and aligned conveyor devices. Means are provided to selectively actuate one or more of the conveyor devices so as to convey the toner particles toward the recording medium in a pattern corresponding to the distribution of the electrostatic charge patterns on the recording medium to be developed.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of one embodiment of the improved developing apparatus, parts being broken away to reveal details;

FIG. 2 is a cross-sectional view of the improved developing apparatus shown in FIG. 1, taken in the general direction of the arrow A in FIG. 1, including additional apparatus for conveying a recording medium, and showing a schematic diagram of circuitry for operating the developing apparatus in cooperation with a computer;

FIG. 3 is a fragmentary longitudinal sectional view of a roller of the developing apparatus, taken along the line 3–3 of FIG. 2;

FIG. 4 is an enlarged side view of a wheel on the roller taken along the line 4–4 of FIG. 3 showing the roller shaft in cross section;

FIG. 5 is a cross-sectional view of the wheel, taken along the line 5–5 of FIG. 4, showing a fragmentary portion of the roller shaft;

FIG. 6 is a fragmentary view of a resilient spine fixed to the shaft of the roller;

FIG. 7 is a fragmentary cross-sectional view, similar to that of FIG. 2, of another embodiment of the improved developing apparatus; and

FIG. 8 is a fragmentary cross-sectional view, taken along the line 8–8, of the developing apparatus shown in FIG. 7.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now particularly to FIGS. 1 and 2, there is shown improved apparatus 10 for developing electrostatic images on an electrically insulating surface 12 of a recording medium 14. The apparatus 10 comprises a trough 16 supported by any suitable means, such as vertical walls 18 and 20 extending upwardly from a base 22. The recording medium 14 may be a sheet of plastic material, such as Mylar or a sheet of paper coated with a layer of photoconductive zinc oxide to provide the insulating surface 12.

Three parallelly disposed rollers are mounted for rotation with the trough 16. Thus, a roller 24 has a shaft 26 whose ends are journaled in side walls 28 and 30 (FIG. 3) of the trough 16 for rotation therein. A gear 32 is fixed to one end of the shaft 26 for coupling to a suitable source of energy for rotating the roller 24 in the direction indicated by the arrow 34, shown in FIG. 2. The roller 24 comprises means to convey toner particles towards the recording medium 14, as will hereinafter by explained.

A toner transfer roller 36 has a shaft 38 whose ends are also journaled in the sidewalls 28 and 30 of the trough 16 for rotation therein. The toner transfer roller 36 is disposed adjacent to, and below, the roller 24, as shown in FIG. 2. The peripheral surface of the toner transfer roller 36 has a brushlike surface 40, such as of fur or velour, for example, for the purpose thereinafter appearing. A gear 42 is fixed to one end of the shaft 38 for coupling to a suitable source of energy for rotating the toner transfer roller 36 in the direction indicated by the arrow 44, shown in FIG. 2.

A toner applicator roller 46 has shaft 48 whose ends are also journaled in the sidewalls 28 and 30 of the trough 16 for rotation therein. The toner applicator roller 46 comprises a plurality of permanent magnets 49 within a cylindrical tube 50 of a nonmagnetic material, such as aluminum, for example. A brushlike surface 52 comprising magnetic particles, a component of some powder developers used in the electrostatic printing art, is disposed on the peripheral surface of the tube 50 to provide the toner applicator roller 46 with a suitable surface for applying toner particles to the surface 12 of the recording medium 14, in a manner hereinafter to be explained.

A gear 54 is fixed to one end of the shaft 48 of the toner applicator roller 46 for coupling to a suitable source of energy to rotate the toner applicator roller 46 in the direction indicated by the arrow 56 shown in FIG. 2. The gear 54 may be meshed with the gear 42 so that the toner transfer roller 36 can be rotated simultaneously with the toner applicator roller 46 from energy applied to a gear 58 also coupled to the shaft 48 of the toner applicator roller 46, as shown in FIG. 1. The toner applicator roller 46 may also have the magnetic structure for providing a magnetic brush taught in U.S. Pat. No. 3,040,704 for Apparatus for Developing Electrostatic Printing.

A source of developer comprises container 60 for toner particles 62. The 60 is supported above the roller 24 by any suitable means. For example, the container 60 is removably fixed to rear wall 64 of the trough 16 by any suitable means. The container 60 is formed with a lower elongated opening 66 and is disposed so as to prevent the toner particles 62 from spilling out of the opening 66 when roller 24 is stationary, the opening 66 being spaced very slightly from the periphery of the roller 24. The toner particles 62 may be any suitable electroscopic developer powder well known in the electrostatic printing art.

Conveyor means are provided in the improved apparatus 10 to convey the toner particles 62 to the insulating surface 12 of a recording medium 14 in distribution patterns corresponding substantially to the distribution of electrostatic images, or charges, on the surface 12. To this end, the roller 24 is provided with conveyor devices, such as a plurality of wheels 70 disposed side by side and frictionally mounted on the shaft 26 for rotation therewith. Each of the wheels 70 is adapted to slip on the rotating shaft 26 when stopped by a force of sufficient magnitude to overcome the driving force between the wheel 70 and the rotating shaft 26.

Each of the wheels 70 has sides that are formed with annular grooves and ridges so that adjacent wheels 70 on the roller 24 have complementary tongue and groove mating surfaces. This structure prevents the toner particles 62 from falling onto, and reaching, the shaft 26, thereby preventing the toner particles 62 from interfering with the unique cooperation of the wheels 70 with the shaft 26, as hereinafter to be explained. Thus, as shown in FIGS. 4 and 5, one side 72 of each of the wheels 70 is formed with an annular groove 74, and the opposite side 76 is formed with an annular tongue 78. With this arrangement, as shown in FIG. 3, the annular tongue 78 on one wheel 70 mates with the complementary groove 74 in an adjacent wheel 70 so that adjacent wheels 70 have complementary mating surfaces that are slidable in a tongue and groove relationship to each other. The wheels 70 are preferably of a plastic material having a low coefficient of friction, such as Teflon, for example.

Each of the wheels 70 has a central opening 80 for receiving the shaft 26 therein. Each wheel 70 is also formed with a keyway 82 that communicates with the central opening 80 for receiving a resilient spline 84 therein. The shaft 26 has end portions of circular cross section, as shown in FIG. 3, and an intermediate portion 86 of rectangular cross section, as shown in FIG. 4. The portion 86 of the shaft 26 comprises two rectangular portions 88 and 90 fixed by any suitable means, as by screws, for example, to opposite sides of the spline 84.

The spline 84 comprises a sheet of resilient metal formed with a plurality of equally spaced slots 92 adjacent one edge 94 thereof, providing a plurality of spring members 96 for rotating the wheels 70 with the rotating shaft 26. Each spring member 96 is adapted to project into the keyway 82 of each wheel, respectively, as shown in FIG. 4, so that it will rotate the wheel 70 when the shaft 26 is rotated. Each of the spring members 96, however, is resilient enough to bend when any wheel 70 has exerted upon it a force of sufficient magnitude to overcome the driving force pro provided by the rotating shaft 26. Under these latter conditions, the shaft 26 can be rotated and one or more of the wheels 70 can be stopped selectively from rotating with the rotating shaft 26.

Means are provided to convey the toner particles 62 to the surface 12 of the recording medium 14 for developing any electrostatic image that may be produced thereon. To this end, each of the wheels 70 is formed with a plurality of regularly spaced circumferential depressions 98, such as slots, for example. As shown in FIG. 2, the toner particles 62 fall into the depressions 98 of the wheels 70 by gravity. The toner particles 62 are conveyed from the container 60 to the outside thereof in the depressions 98 of the wheels 70. The toner particles 62 thus conveyed are then deposited onto the toner transfer roller 36, which is in contact with the roller 24. The toner particles 62 are next transferred from the toner transfer roller 36 to the toner applicator roller 46, with which it is in contact. The toner particles 62 can now be brushed onto the surface 12 of the recording medium 14 by the brushlike surface 52 of the magnetic particles on the toner applicator roller 46.

The recording medium 14 is moved adjacent to the toner applicator roller 46 by a rotating drum 100 disposed for rotation about an axis parallel to the toner applicator roller 46, as shown in FIG. 2. The recording medium 14 is moved in the direction indicated by the arrow 102 by a rotation of the drum 100 in the direction indicated by the arrow 104.

Means are provided to apply the toner particles 62 selectively to the surface 12 of the recording medium 14 in spaced relationships corresponding substantially to the distribution of electrostatic charges on the surface 12. To this end, there are provided stop means, such as plungers 106, for the conveyor devices, the wheels 70. A separate plunger 106 is provided for each of the wheels 70, and each of the plungers 106, when actuated, either manually or automatically, is adapted to stop the rotation of its associated wheel 70 with respect to the rotating shaft 26.

Referring now particularly to FIG. 3, there is shown a plurality of plungers 106 associated with their respective wheels 70. Each of the plungers 106 comprises a pin 108 which extends through a separate opening in the rear wall 64 of the trough 16. A solenoid coil 110 and a spring 112 are disposed around the forces, 108 and between the wall 64 and a head 114 of the plunger 106. With this arrangement, one or more of the plungers 106 may be moved, either manually or electrically, against the tension of the spring 112 so that its pin 108 lodges in a depression 98 in its associated wheel 70. When so actuated, the plunger 106 stops its associated wheel 70 from rotating with the rotating shaft 26. Those wheels 70 that are not engaged by their respective plungers 106 continue to rotate with the rotating shaft 26. Thus, as shown in FIG. 3, FORCES, indicated by arrows 116, are shown acting upon two of the plungers 106 so that their associated wheels 70 will remain stationary while the remaining wheels 70, not acted upon by their respective plungers 106, will continue to rotate with the rotating shaft 26. These forces can be applied either manually or electrically by energizing the solenoid coils 110, as needed.

Control means are provided to actuate the plungers 106 selectively from the output system of a computer so that the toner particles 62 that are conveyed to the surface 12 of the recording medium 14 are distributed in a desired spaced relationship that corresponds substantially to the distribution of the electrostatic charges on the surface 12. Means for e such operation are shown in FIG. 2.

Referring now to FIG. 2, there is shown a corona discharge device 118 disposed adjacent to the surface 12 of the recording element 14 for producing an electrostatic charge thereon. Corona discharge wires 119 are connected to one terminal of a source 122 of suitable voltage for producing a corona discharge from the wires 119. The other terminal of the voltage source 122 is grounded. A grounded metallic plate 124 is disposed opposite the wires 119 and on the opposite surface to the surface 12 of the recording medium 14. The corona discharge device 118 provides a uniform electrostatic charge on the surface 12 in a manner well known in the art. This electrostatic charge is preferably somewhat below a critical stress value. The transfer of a configuration of a symbol or character, that is, an electrostatic image of particular configuration, from a configured electrode 120 to the surface 12 of the recording medium 14 is effected by the use of a relatively low potential triggering pulse which raises the electrostatic charge, already on the surface 12, above the critical stress value to produce a certain discharge in the space between the surface 12 and the electrode 120. This discharge action gives rise to the formation of an electrostatic image of the planar configured surface, or pattern, of the electrode 120 on the insulating surface 12.

Electronic switching circuits are associated with the electrostatic apparatus to supply triggering pulses to the electrode 120 in accordance with information signals received electrically from a computer or other signal source. A suitable computer system for the electrostatic recording of information on the recording element 14 of the type described herein is described in detail in U.S. PAT. No. 3,060,432 for "Electrostatic Recording of Information," issued on Oct. 23, 1962. Only a portion of the circuitry associated with the improved developing apparatus 10 will be described since the origin of information pulses and the production of electrostatic images on a recording element forms no part of the present invention. A relatively large electrostatic image may be considered, within the scope of the instant invention, as comprising a plurality of smaller discrete electrostatic charges.

A plurality of configured electrodes 120, only one of which is shown in FIG. 2 for the sake of clarity, are disposed along the width of the recording medium 14, transverse to the direction of motion of the recording medium 14, and slightly spaced from the insulating surface 12 thereof. Electrical pulses, such as information and timing pulses from the output system of a computer, are applied to a lead 126, connected to ground through a solenoid coil 128 of a normally open relay switch 130. One terminal of the relay switch 130 is connected

to the electrode 120, and the other terminal is connected to a terminal of a suitable source 132 of triggering voltage and to ground through a capacitor 134. The other terminal of the triggering voltage source 132 is connected to ground through a resistor 136. The electrode 120 is also connected to ground through the solenoid coil 110 disposed about one of the plungers 106, as shown in FIG. 2. The circuitry described thus far is for applying triggering pulses to one of the electrodes 120, but a plurality of such circuits are used, a separate circuit for each electrode, for a plurality of electrodes 120.

The operation of the improved apparatus 10 for developing electrostatic images with toner particles 62 distributed in patterns corresponding substantially to the distribution of the electrostatic charges on the surface 12 of the recording medium 14, will now be described. The rollers 24, 36, and 46 and the drum 100 are rotated in the direction of the arrows 34, 44, and 56 and 104 by any suitable means of motive power. A uniform precharge to a point below the critical stress value is applied uniformly to the surface 12 of the recording medium 14 by the corona discharge device 118. The charged surface 12 is moved by the drum 100 past the electrode 120 which may have any particular plane planar configuration, as for example the letter O. An information pulse applied to the lead 126 closes the normally open relay switch 130 and produces a triggering pulse, by the condenser 16 charge through the resistor 17, from the relatively low voltage source 132. An electrostatic latent image corresponding to the shape (O) of the electrode 120 is thereby formed on the surface 12 of the recording medium 14, which electrostatic image may thereafter be developed in the manner hereinafter described.

Electrostatic images may also be produced on the surface 12 of the recording medium 14 by exposing the uniformly charged surface with light images in a manner well known in the electrostatic printing art. In the latter case, the recording medium 14 has an insulating surface 12 of the photoconductive material, such as zinc oxide.

Control means are provided to actuate the plunger. Thus, when a triggering pulse is applied to the electrode 120, the triggering pulse is also applied through the solenoid coil 110 disposed around a plunger 106. In the absence of a pulse, the plunger 106, in the instant embodiment, is disposed in one of the depressions 98 to prevent its associated wheel 70 from rotating with the rotating shaft 26. When the triggering pulse energizes the solenoid coil 110, the plunger 106 is moved out of the depression 98, against the tension of the spring 112, so that the wheel 70 rotates with the rotating shaft 26.

Let it be assumed that the recording medium 14 is a continuous web and that it is moved continuously over the brushlike surface 52 of the toner applicator roller 46 for the development of electrostatic images thereon. In the absence of any information signals from the computer, no electrostatic images are formed on the surface 12 and, consequently, no toner particles 62 are needed on the toner applicator roller 46. Under these conditions (of no information pulses), no pulses are transmitted to the solenoid coils 110 and the plungers 106 remain in the depressions 98 of the wheels 70. Hence, the wheels 70 do not rotate with the continuously rotating shaft 26, and no toner particles 62 are conveyed from the container 60 to the surface 12 of the recording medium 14.

Let it now be assumed that a plurality of information signals are applied to the electrodes 120 via the relay switches 130. Triggering pulses are then applied to the solenoid coils 110 and the plungers 106 are moved out of the depressions of the wheels 70, allowing the wheels 70 to rotate with the rotating shaft 26 and to convey the toner particles 62 to the outside of the container 60. The toner particles 62 that fall into the depressions 98 are the toner particles that are conveyed from the container 60. Thereafter, the toner particles 62 fall onto the toner transfer roller 36 and from there are transferred to the brushlike surface 52 of the toner applicator roller 46. By the time the electrostatic images reach the toner applicator roller 46 to be developed, the toner particles 62 from the container 60 have been transferred to the brushlike surface 52 of the tone toner applicator roller 46, via the roller 24 on the toner transfer roller 36, in a desired spaced relationship corresponding to the distribution of the electrostatic charges on the surface 12.

Let it now be assumed, for example, that pursuant to information pulses from the computer, electrostatic images in the form of a long vertical column on the surface 12 are to be formed by only five adjacent electrodes 120. Under these conditions, only five adjacent solenoid coils 110 are energized from the five associated electrodes 120 that received triggering pulses, so that only five adjacent wheels 70, associated with five actuated plungers 106, rotate with the rotating shaft 26 and convey toner particles 62 in a desired distribution pattern for the development of only the column of information. Under these conditions, no fresh toner particles 62 are conveyed to nonimage areas on the surface 12.

The apparatus 10 has been described herein as having the brushlike surface 52 of the toner applicator roller 46 comprising magnetic particles to provide a magnetic-brush effect. A magnetic brush, however, is not necessary for the operation of the instant invention, and any other suitable brushlike means, such as fur or velour, for example, can be substituted for the brushlike surface 52.

When the brushlike surface 52 of the toner applicator roller 46 includes magnetic particles, these particles can be scraped from the surface of the tube 50 by means of a doctor blade 138, as shown in FIG. 2. The doctor blade 138 may be fixed to a wall of the container 60 so that one edge is disposed against the surface of the tube 50 of the toner applicator roller 46 to scrape the magnetic particles off the toner applicator roller 46. The magnetic particles so removed from the toner applicator roller 46 are allowed to fall onto the roller 42 and the toner transfer roller 36, as shown in FIG. 2, whereby these magnetic particles are mixed with the toner particles 62 to form a triboelectric toner mixture of the type well known in the electrophotographic printing art.

It is within the contemplation of the invention to provide controlled conveyor devices of types other than the wheels 70. For example, rotary means, such as rubber rings, may be frictionally mounted on the shaft 26, and the rubber rings may be formed with dimpled depressions in their circumferential peripheries to retain toner particles therein. Other rotary means may comprise a plurality of aligned endless belts that may be substituted for the wheels 70.

Referring now to FIGS. 7 and 8, there is shown another embodiment 10*a* of the improved developing apparatus wherein the conveyor means for conveying the toner particles toward the recording element are other than rotary. Similar components in the developing apparatus 10 and 10*a* are designated by similar reference characters. The conveyor means of the developing apparatus 10*a* comprise a plurality of substantially similar aligned pistons 140 disposed side-by-side beneath a narrow opening 66*a* of the container 60. Each of the pistons 140 is connected to the pin 108 of the plunger 106, as shown in FIGS. 7 and 8, and may be moved reciprocally, in the directions of the double-headed arrows 142, by means of the solenoids 110.

The pistons 140 may be of rectangular cross section and formed with a sharp edge 144 at its e upper end. The aligned pistons 140 are disposed between upper and lower walls 143 and 145, respectively, of a chute 146. The chute 146 extends from a lower wall 148 of the container 60 and communicates with the interior of the container 60. The sharp edge 144 of the piston 140 extends to a wall 150 opposite to the wall 148. The pistons 144 function, in the positions shown in FIG. 7, to maintain the toner particles 62 within the container 60.

Means are provided to actuate one or more of the plungers 106 in accordance with signals applied to one or more of the solenoids 110 respectively. Thus, each of the solenoids 110 is connected to a source of electrical signals, as, for example, the electrode 120 shown in FIG. 2. While only one of the solenoids 110 in FIG. 7 is indicated as being connected to the electrode 120, all of the other solenoids 110 (FIG. 8) are con-

nected to corresponding electrodes so that they may be actuated when their respective electrodes are actuated. The solenoids **110** in FIG. **8** are not shown as being connected to a source of electrical signals for the sake of clarity, but each solenoid **110** is connected as described and indicated in FIGS. **2** and **7**.

The operation of the developing apparatus **10***a* will now be explained. In the absence of any signals whereby electrostatic charges are applied to the recording medium **14**, no signals are applied to any of the solenoids **110**, and all of the pistons **140** are biased upwardly against the wall **150**, preventing any toner particles **62** from being conveyed onto the toner transfer roller **36**. When a signal is applied to one of the electrodes **120** to place a charge pattern on the surface **12** of the recording medium **14**, the signal is also simultaneously applied to a respective solenoid **110**. Under these latter conditions, the respective piston **140** is moved away from the wall **150** and toner particles **62** are conveyed, by gravity, from the container **60**, through the opening **66***a*, and onto the toner transfer roller **36**. From the transfer roller **36**, the toner particles **62** are transferred to the toner applicator roller **46**, and from the latter roller they are applied to the surface **12** of the recording medium **14** to develop the charge pattern thereon, as described for the developing apparatus **10**.

Referring now to FIG. **8**, there are shown pistons **140***a* and **140***b* in their positions when their respective solenoids **110***a* and **110***b* are electrically energized by signals. As shown, the pistons **140***a* and **140***b* are displaced from the wall **150** and the toner particles **62** can be conveyed through the opening **66***a* and onto the surface of the toner transfer roller **36**. When the solenoids **110***a* and **110***b* are deenergized, the pistons **140***a* and **140***b* are moved against the wall **150**, by the springs **112** of the solenoids, and no toner particles **62** are conveyed toward the recording medium **14**. It is also within the contemplation of the instant invention to substitute other individually controlled conveyor devices, such as aligned screw means and sleeve valves means, for example, for those shown and described.

I claim:

1. Developing apparatus for use in an electrostatic printer for conveying toner particles to electrostatic charge patterns on a recording medium, said apparatus comprising:

a source of said toner particles;

conveyor means disposed to receive said toner particles from said source and to convey them toward said recording medium, said conveyor means comprising a plurality of substantially similar and aligned conveyor devices;

means for selectively actuating one or more of said conveyor devices to convey said toner particles to said recording medium according to the distribution of said charge patterns thereon;

said electrostatic printer comprising means for applying said electrostatic charge patterns on said recording medium; and

control means coupled between said electrostatic printer and said means for selectively actuating one or more of said conveyor devices to convey said toner particles toward said recording medium in a distributed pattern determined by the said means for applying said electrostatic charge patterns on said recording medium.

2. Developing apparatus as described in claim **1** wherein:

said conveyor means comprises a rotatable shaft;

said conveyor devices comprise rotary means frictionally mounted on said shaft for rotation therewith; and

said means for selectively actuating one or more of said conveyor devices comprise means to apply a force to said one or more of said rotary means selectively to overcome the driving forces thereon by said shaft and to stop said one or more rotary means from rotation with said shaft.

3. Apparatus for developing electrostatic images on a surface with toner particles, said apparatus comprising:

a roller having a shaft and a plurality of wheels frictionally mounted thereon for rotation therewith;

means to dispose said roller adjacent a source of said toner particles;

each of said wheels being formed with a plurality of depressions in its circumferential periphery adapted to convey portions of said toner particles from said source when said wheels are rotated by said shaft;

means to apply a force to one or more of said wheels selectively to overcome the driving force thereon by said shaft and to stop said one or more of said wheels selectively from rotation with said shaft; and

means to apply said toner particles conveyed by said wheels to said surface.

4. Apparatus for developing electrostatic images as described in claim wherein:

said source of said toner particles comprises a container formed with an elongated opening adjacent the bottom thereof; and

said roller is disposed adjacent to said opening to contact said toner particles.

5. Apparatus for developing electrostatic images as described in claim **3**, wherein;

said wheels have sides that are formed with annular grooves and ridges so that adjacent grooves and ridges of adjacent wheels have mating tongue and groove complimentary surfaces, whereby said toner particles are substantially prevented from reaching said shaft.

6. Apparatus for developing electrostatic images as described in claim **3**, wherein;

each of said wheels is formed with a central hole through which said shaft extends;

a keyway communicates with each of said holes in each of said wheels; and

resilient spline means are fixed to said shaft and extend into said keyways for rotating said wheels with said shaft, said spline means being adapted to move out of said keyways and to permit said wheels to slip on said shaft when said shaft is rotated and a force of sufficient magnitude is applied to said wheels to hold them stationary.

7. Apparatus for developing electrostatic images as described in claim **3**, wherein:

said means to apply a force to one or more of said wheels selectively comprises a separate plunger having a pin disposed adjacent to each of said wheels; and

means to selectively move said pin into or out of one of said depressions in its adjacent wheel, whereby to selectively stop the wheel from rotating with said shaft or to permit the wheel to rotate with said shaft.

8. Apparatus for developing electrostatic images as described in claim **7**, wherein:

said means to selectively move said pin comprises electromagnetic means.

9. Apparatus for developing electrostatic images as described in claim **8**, wherein:

said electromagnetic means are connected to means for forming said electrostatic images for energization thereby.

10. In apparatus of the type wherein an electrostatic image on a surface is developed with toner particles applied thereto, the improvement comprising:

a roller comprising a shaft and a plurality of wheels frictionally mounted thereon for rotation therewith;

means disposing said roller adjacent a source of said toner particles;

means coupled to said shaft to rotate it, whereby to rotate said roller;

each of said wheels being formed with a plurality of depressions in its circumferential periphery, whereby to convey portions of said toner particles therein away from said source of toner particles when said wheels are rotated by said shaft;

means to selectively stop the rotation of one or more of said wheels while said shaft is rotated, whereby to prevent certain portions of said toner particles from being conveyed

from said source, while allowing other portions of said toner particles to be conveyed from said source; and

means to convey said portions of said toner particles from said wheels, when rotating, to said surface to develop said electrostatic image.

11. In apparatus of the type described in claim 10, wherein:

said source comprises a container for said toner particles, said container being formed with an opening adjacent the bottom thereof; and

means disposing said container above said wheels of said roller, whereby said toner particles can fall through said opening and into said depressions of said wheels.

12. In apparatus of the type described in claim 10, wherein:

a portion of said shaft on which said wheels are mounted has a noncircular cross section,

resilient means are disposed between said portion of said shaft and each of said wheels for rotating each of said wheels with said shaft with a predetermined driving force; and

said means to selectively stop the rotation of one or more of said wheels comprising means to apply a force to said one or more of said wheels to overcome said driving forces thereon by said shaft.

13. In apparatus of the type described in claim 10, wherein:

each of said wheels has a groove on one side and a ridge on the other side, so that adjacent wheels on said roller have complementary tongue and groove mating surfaces, that are slidable with respect to each other, whereby said toner particles are prevented from reaching said shaft.

14. In apparatus of the type described in claim 10, wherein:

said means to convey said portions of said toner particles from said wheels comprises at least another roller having a brushlike surface in contact with said wheels.

15. In apparatus of the type described in claim 10, wherein:

said means to convey said portions of said toner particles from said wheels comprises a toner transfer roller in contact with said wheels, and a toner applicator roller in contact with said toner transfer roller and adapted to contact said surface for applying said toner particles thereto.

16. Apparatus for conveying toner particles from a source thereof in discrete portions in selected distribution patterns, said apparatus comprising:

a roller comprising a shaft and a plurality of wheels frictionally mounted, side-by-side, on said shaft for rotation therewith, each of said wheels being adapted to slip on said shaft when a force is applied thereto to overcome the driving force between it and said shaft;

means to dispose said roller in contact with said source of toner particles;

each of said wheels having a plurality of depressions in its circumferential periphery, whereby to convey, in said depressions, discrete portions of said toner particles away from said source when said wheels are rotated by said shaft; and

means to overcome the driving force selectively between one or more of said wheels and said shaft, whereby to prevent certain ones of said wheels from rotating with said shaft and allowing the other of said wheels to rotate with said shaft and to convey said toner particles from said source.

17. Apparatus for conveying toner particles from a source thereof as described in claim 16, wherein:

said means to overcome the driving force between one or more of said wheels and said shaft comprises a separate plunger disposed adjacent each of said wheels, each of said plungers comprising a pin adapted to engage a depression in its adjacent wheel; and

electrically actuated means to move each of said pins selectively into and out of a depression in an adjacent wheel.

18. Apparatus for conveying toner particles from a source thereof as described in claim 17, wherein:

said electrically actuated means comprises means electrically coupled to the output of a computer for receiving electrical pulses therefrom.