United States Patent [19]

Hudson

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[45] **Feb. 20, 1973**

[54] **MAGNETIC GATE**

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[52] **U.S. Cl.** **118/636,** 117/17.5, 118/637, 118/DIG. 24, 222/DIG. 1

[51] **Int. Cl.**.....**B05b 5/02,** G03g 13/06

[58] **Field of Search**.....118/637, DIG. 24, 638, 639, 118/640; 117/17.5; 222/DIG. 1, DIG. 2; 346/74 ES

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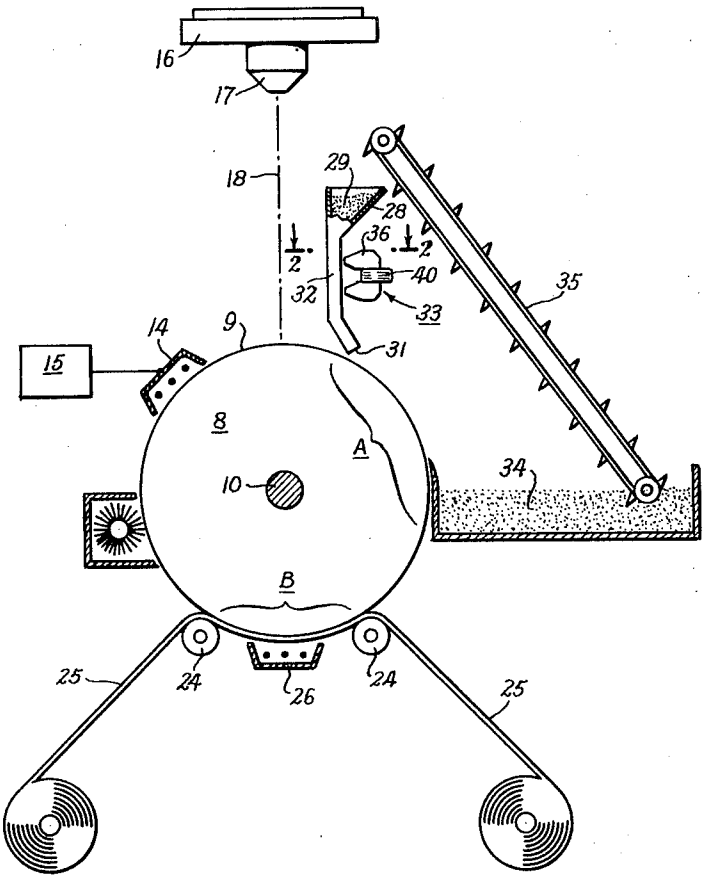
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[57] **ABSTRACT**

In an electrostatic copying apparatus, a flow control for a cascade developer material having ferromagnetic carrier particles comprising a means for selectively establishing a magnetic field in he flow path of the developer material. The developer material does not contact moving elements in the described control and malfunctions resulting from the particulate characteristic of the material are eliminated.

6 Claims, 5 Drawing Figures

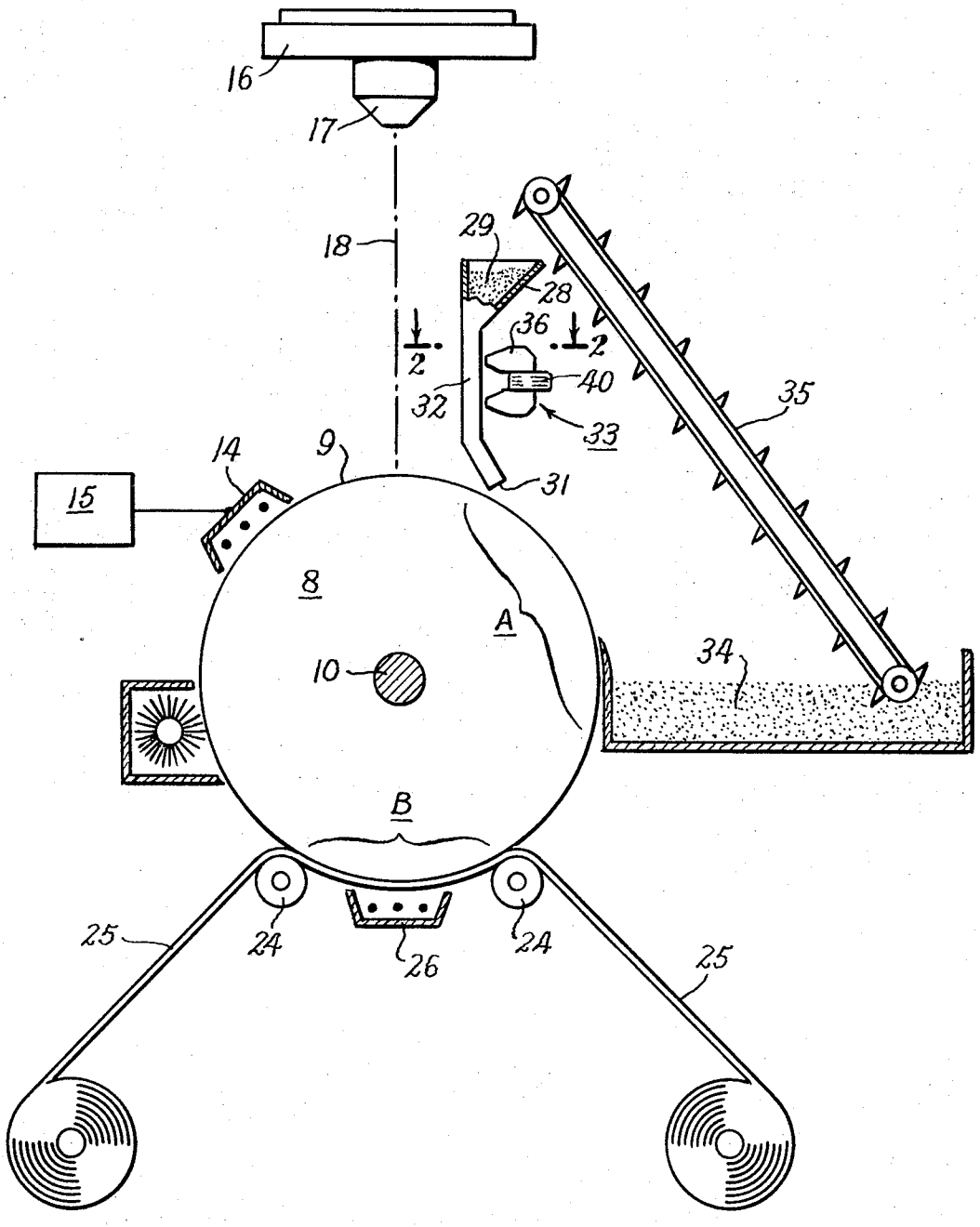


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SHEET 1 OF 2

Fig 1



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FIG 2

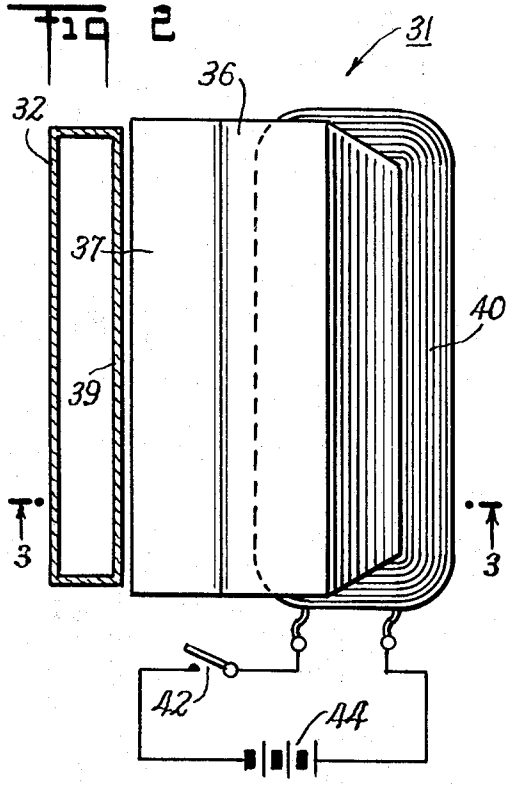


FIG 3

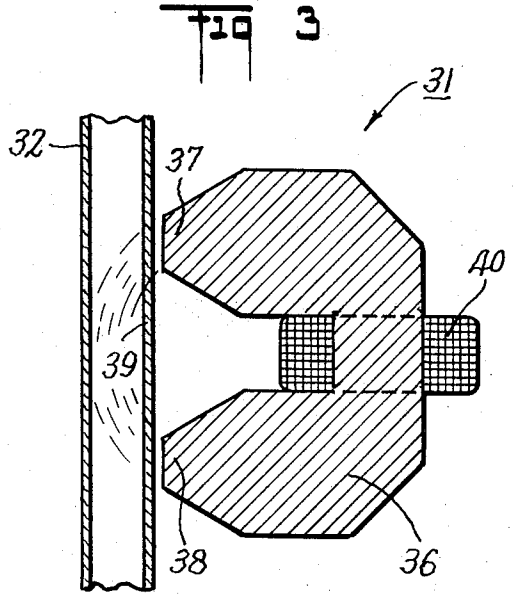


FIG 4

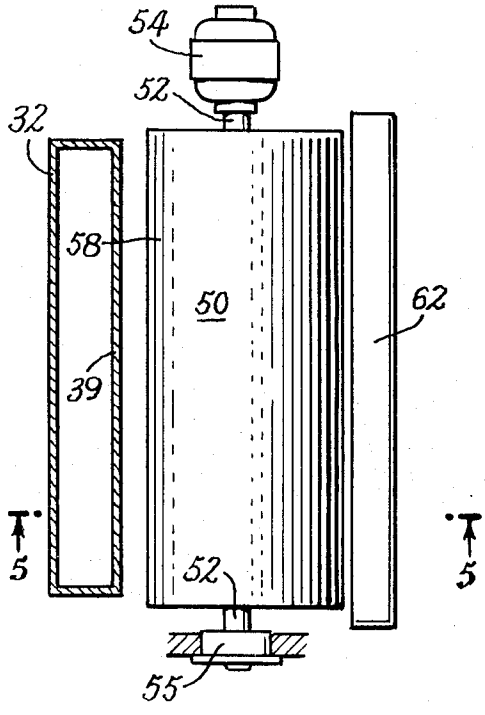
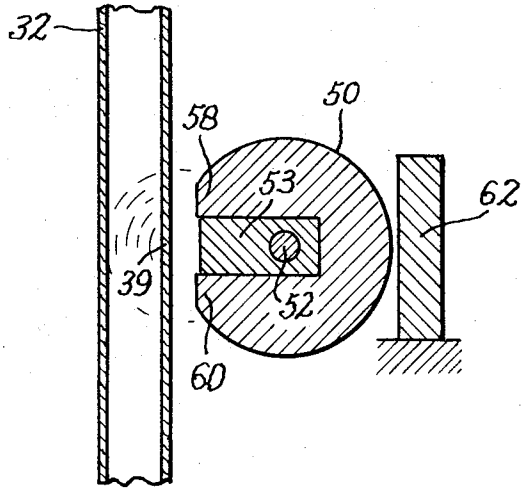


FIG 5



MAGNETIC GATE

This invention relates to copying apparatus. The invention relates more particularly to improvements in a developer flow control for electrostatic copying apparatus.

In a known form of electrostatic copying apparatus, a latent image is established electrostatically on a photoconductive surface and is developed by passing a toner material over the surface. Electrostatic forces cause the toner material to adhere to the surface and to conform to the image. The image is then transferred to a record medium for recording.

In one type of image development, referred to as cascade development, a developing material is flowed across the photoconductive surface. A typical cascade developer material comprises glass carrier particles which are generally spherically shaped and toner particles of much smaller relative dimensions which adhere to the carrier particles. The toner particles comprise a mixture of very finely divided pigmented particles generally having a diameter in the range of a few microns. This developer material is contained in a hopper and is supplied to the photoconductive surface by gravity feed through a conduit extending from the hopper. After flowing across the photoconductive surface, the developer material is collected in a sump and conveyed to the hopper for reuse.

Various automatic copying apparatus of this general type operate in a cyclic manner to sequentially establish a latent image, develop the image, and form a permanent record of the image. This cyclic operation necessitates an interruption of the flow of the developer material from the hopper as well as the delivery of predetermined quantities at a particular interval during a cycle. Heretofore, the flow of developer material from the hopper has been controlled by various mechanical gates or valves which have demonstrated a tendency to frequently jam or malfunction due to the particulate character of the cascade developer material. This, of course, is disadvantageous since it necessitates repeated servicing of the apparatus and reduces its useful operating time.

During the cyclic operation of the apparatus, it is desirable as indicated to discharge a quantity of material within a predetermined range of quantities from the supply hopper for development of the latent image. The quantity of material discharged has a pronounced affect on the quality of the image being developed. For example, a discharge of material outside the predetermined range results in the development of either a low contrast image having a washed out appearance or alternatively a high contrast image having high background development. In a gravity flow cascade developer supply, the quantity of developer material discharged is dependent in part on the amount of material remaining in the hopper at the termination of the prior discharge. Although the establishment of a head of material for providing rapid acceleration of the particles and instantaneous flow thereof is desirable, it can result in the jamming and malfunction of the flow valve. The quantity of material remaining in the hopper has, therefore, generally been restricted to relatively small quantities and a conveyor has been employed for transporting the material from the sump to the reservoir in accordance with demand requirements.

This prior arrangement leads to two disadvantageous results. The flow valve is automatically opened for a fixed interval of time during the cycle and the quantity of material discharged will then be subject to variation. Both the quality and the reproducibility of the image will then be subject to variation. The second disadvantage is the over accumulation of developer material in the sump area and a consequent overload of the conveyor system.

Accordingly, it is an object of this invention to provide an improved flow control arrangement for developer material in an electrostatic copying apparatus.

Another object of the invention is to provide an improved flow control for a cascade developer material in an electrostatic copying apparatus.

A further object of the invention is to provide a flow control arrangement for a cascade developer material wherein moveable elements of a flow control valve are positioned out of contact with the material and therefore avoid the jamming and malfunctions attributable to the particulate characteristic of the material.

It is another object of this invention to provide a flow control valve arrangement for a cascade developer which is adapted to operate in the presence of a head of cascade developer material.

A further object of the invention is to provide an electrostatic copying apparatus having a cascade developer which provides a relatively large head of developer material.

Another object of the invention is the provision of a developer material supply for enhancing initiation of the discharge of the material from the supply hopper.

In accordance with the general features of this invention, a cascade developer material for an electrostatic copying apparatus includes carrier particles formed of a ferromagnetic material. Magnetic flow control means are provided in an electrostatic copying apparatus for selectively establishing a flow restraining magnetic field at a location along the flow path of the particles. A flow restraining force is thereby established on the developer material by a magnetic field and the malfunctions of prior art mechanisms in contact with this particulate material are advantageously avoided. In addition, the magnetic gate advantageously operates under a head of developer material thus providing for a relatively rapid initiation of discharge upon removal of the field. In a particular embodiment of the invention, the flow restraining magnetic field is established by an electromagnet at a location in a conduit extending from the supply hopper.

These and other objects and features of the invention will become apparent with reference to the following specification and to the drawings wherein:

FIG. 1 is a schematic view of an electrostatic copying apparatus constructed in accordance with features of the invention;

FIG. 2 is an enlarged view of a magnetic valve portion of the apparatus taken along line 2—2 of FIG. 1;

FIG. 3 is a view taken along line 3—3 of FIG. 2;

FIG. 4 is an alternative embodiment of the flow valve arrangement of this invention; and,

FIG. 5 is a view taken along line 5—5 of FIG. 4.

Referring now to FIG. 1, an electrostatic copying apparatus is shown to include a drum 8 having a

photoconductive material 9 coated on the outer surface of the drum. The drum includes a cylindrical member 10 mounted in suitable bearings of the machine and is driven by a motor (not shown). A corona charging device 14 is positioned near an upper sector of the drum. This charging device is connected to a source of high potential 15 and spray a charge on the proximate photoconductive surface. An imaging means 16 scans the data to be reproduced and projects this data through a suitable lens and focusing assembly 17 along an optical path 18 onto the uniformly charged surface of the drum. The uniformly charged photoconductive material is thereby exposed in imagewise configuration. Continuous rotation of the drum transports the photoconductive surface bearing the latent image to an image development station A. A reservoir or hopper 28 containing cascade developing material 29 of a type referred to hereinbefore and including ferromagnetic carrier particles is positioned with respect to the surface of the drum for discharging the developer material across the surface 9 of the drum. The developer material will flow from an outlet aperture 31 of a chute 32 when a magnetic flow valve 33 constructed in accordance with features of the invention and described in detail hereinafter is selectively operated. The material 29 which flows across the latent image flows toward a sump 34 where the residue is collected and conveyed by a conveyor means 35 to the hopper 28. After development of the latent image, the drum 8 advances to an image transfer station B where the image is transferred to a recording medium for permanent record. Paper 25, for example, is transferred by rollers 24 over the drum 8 and a corona charging device 26 establishes a charge at the rear of the paper thereby transferring a developed powder image from the drum 8 to the paper 25. While the present invention is being described with respect to well known Xerographic electrostatic copying apparatus, it will be appreciated that the present invention is equally applicable to other forms of electrostatic copy apparatus.

In accordance with more particular features of this invention, the developer material 29 includes carrier bodies formed of a ferromagnetic material and magnetic valve means 33 are provided for selectively establishing a magnetic field in the flow path of the particles for restricting their passage. The carrier particles may comprise, for example, any ferrous material such as a stainless steel alloy exhibiting ferromagnetic characteristics. FIG. 2 illustrates an electromagnetic means for establishing a magnetic field and a resulting restraining force within the chute 32. A generally U-shaped electromagnet 36 having pole tips 37 and 38 is positioned adjacent a longitudinally extending wall 39 of the chute. That segment of the chute 32 which is located in the vicinity of the pole pieces is constructed of a material not exhibiting ferromagnetic characteristics such as aluminum or plastic materials. A coil 40 is positioned about a segment of the U-shaped core and is energized from a source of D.C. potential 44 via a switch 42. The switch 42 can be operated manually if desired or alternatively and preferably, it is operated automatically by a cam in accordance with a predetermined cyclic operation of the apparatus. When the switch 42 is closed, then current will flow in the coil 40 and establish a strong magnetic field between the pole tips 37 and 38. This field will exert a force on ferromagnetic objects in its vicinity and will accordingly exert a force on the ferromagnetic carrier particles of the developer material. The force thus established on the particles will restrain the motion of these particles at a cross section of the chute 32 and will therefore function as a magnetic gate or valve. Particles will be released and flow through the chute when the switch 42 is opened and the coil 40 de-energized. The electromagnet is positioned for establishing a magnetic field which extends in the direction of the particle flow path as illustrated in FIGS. 3 and 5. An advantageous magnet physical size and form factor is thus provided.

A feature of this arrangement is the elimination of moving parts of the valve from contact with the particulate developer material and for this reason the probability of malfunction because of the character of the material being controlled is eliminated. A further advantage of the arrangement is the establishment of a head of material from the flow valve to the top of the hopper 28. This head assures instantaneous flow of the developer material upon the opening of the magnetic gate.

In another embodiment of the invention illustrated in FIGS. 4 and 5, the magnetic field is shown to be established by a permanent magnet 50. The magnet is rotated about its axis 52 by a motor 54. The magnet 50 may be imbedded in a plastic cylinder having a drive axis or rod extending through its length and coupled to the motor 54 at one end and supported by a bearing 55 at an opposite end. Alternatively, and as shown in FIGS. 4 and 5, the magnet may be generally cylinderically shaped and include an insert 53 which receives the drive rod 52. When the valve is actuated, the motor 54 rotates the magnet and the field will be established by rotating the pole tips 58 and 60 towards the wall 39 of the chute 32. The particles will then be restrained by the field forces established by the magnet in this position. This magnetic valve is "opened" by rotating the magnet about its shaft 180° at which point the pole tips 58 and 60 are aligned with a magnet keeper 62.

Thus, there has been described an improved magnetic gate for flow control of particulate cascade developer material in an electrostatic developer apparatus which avoids the malfunction and jamming problems created by particulate developer material of the prior art devices and which advantageously provides the instantaneous flow of material due to the establishment of a head of developer material.

While I have illustrated and described particular embodiments of my invention, it will be understood that various modifications may be made therein without departing from the spirit of the invention and the scope of the appended claims.

What is claimed is:

1. An electrostatic copying apparatus having an image retaining surface, means for establishing an electrostatic latent image on said surface, a hopper for receiving cascade developer material, said hopper positioned relative to said surface for discharging said material onto said surface by gravity flow, said developer material including solid state carrier particles exhibiting ferromagnetic characteristics and a toner developer material adhering thereto, a flow control gate valve for alternatively enabling and interrupt-

ing the discharge of said solid state developer material onto said surface, said valve comprising means for establishing and for intermittently interrupting a particle flow restraining magnetic field in the flow path of said material which interacts with said solid state particles to thereby establish and intermittently remove a restraining magnetic force on said carrier particles during operation of said electrostatic copying apparatus.

2. The apparatus of claim 1 including a conduit extending from said hopper for directing the flow of said particles onto said surface, and said field establishing means is positioned outside said conduit and is arranged for establishing the magnetic field within said conduit.

3. The apparatus of claim 2 wherein said field establishing means comprises an electromagnet.

4. The apparatus of claim 2 wherein said field establishing means comprises a permanent magnet.

5. The apparatus of claim 2 wherein said field establishing means establishes a field having lines of flux extending through said conduit in the general direction of particle flow within the conduit.

6. An electrostatic copying apparatus having an image retaining surface, means for establishing an electrostatic latent image on said surface, a hopper for receiving cascade developer material, said hopper positioned relative to said surface for discharging said material onto said surface by gravity flow, said developer material including carrier particles formed of a ferromagnetic substance and a toner developer material adhering thereto, a conduit extending from said hopper for directing the flow of said particles onto said surface, a flow control valve for controlling the discharge of developer material onto said surface, said flow control valve being positioned outside said conduit and arranged for selectively establishing a magnetic field which extends in the direction of the flow path of said material to thereby establish a restraining magnetic force on said carrier particles; said flow control valve including a permanent magnet rotably mounted on an axis extending generally normal to the direction of particle flow within the conduit, said magnet having pole pieces defining an air gap therebetween and adapted for rotating said pieces adjacent to a wall of said conduit for restricting flow and away from said wall of said conduit for discharging said material.

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