Feb. 6, 1968 L. F. W. LAWES ETAL 3,367,306

CASCADE DEVELOPING APPARATUS

Filed Nov. 29, 1965 3 Sheets-Sheet 1

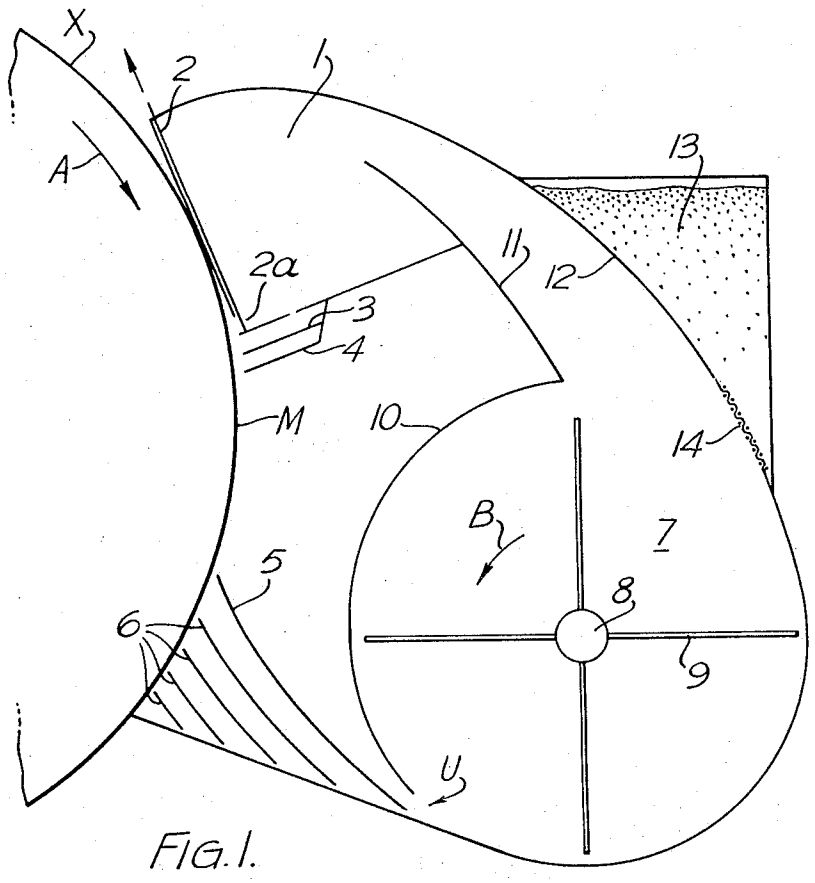

FIG. 1.

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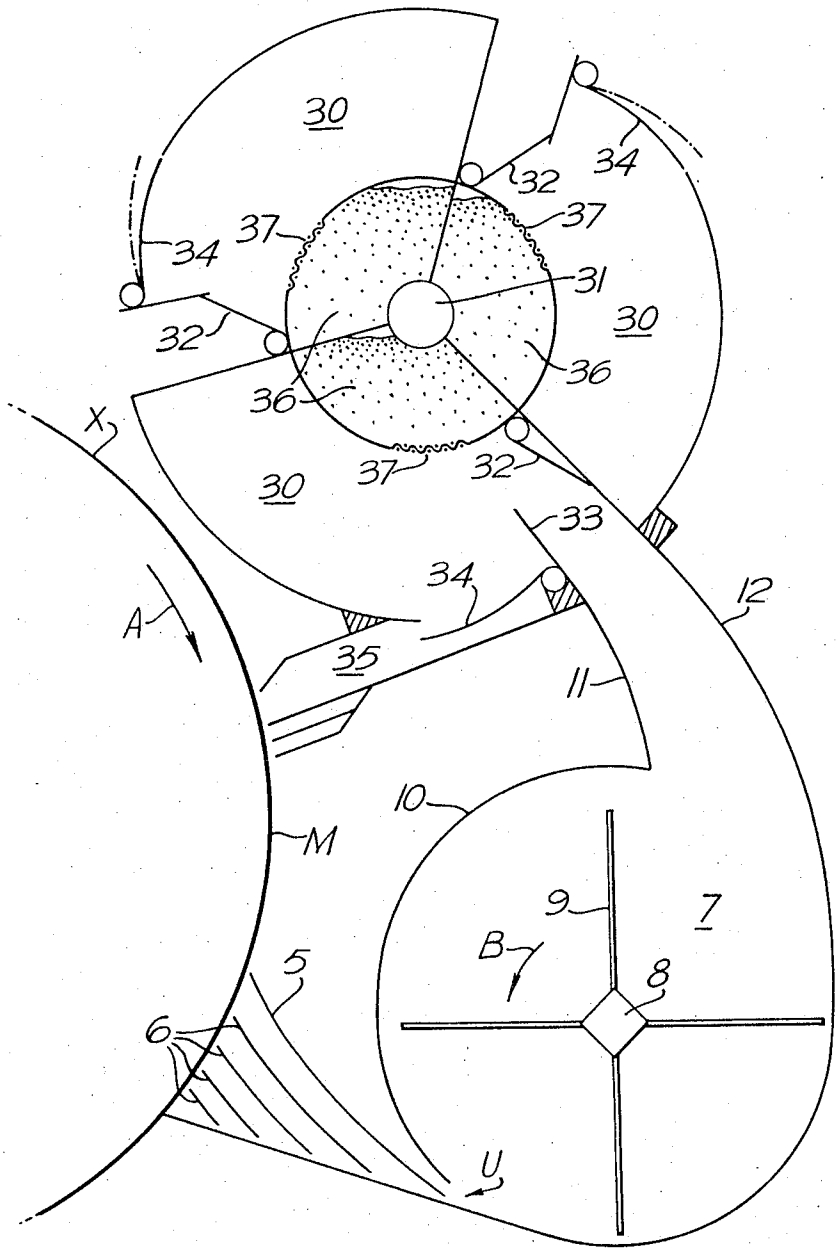

FIG. 2.

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CASCADE DEVELOPING APPARATUS

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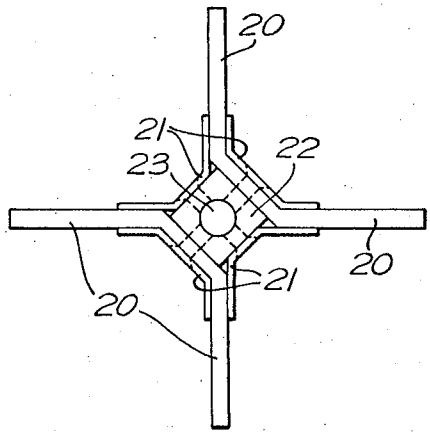

FIG. 3.

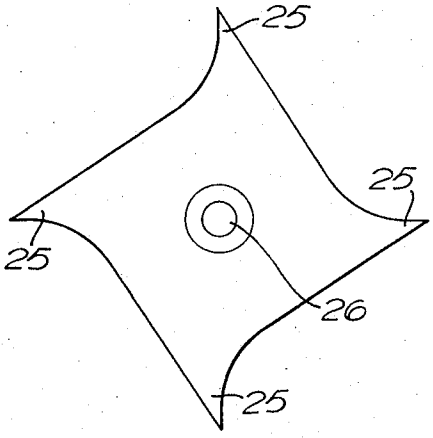

FIG. 4.

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CASCADE DEVELOPING APPARATUS

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Claims priority, application Great Britain, Dec. 3, 1964, 49,193
13 Claims. (Cl. 118—637)

ABSTRACT OF THE DISCLOSURE

Cascade developing apparatus for developing electrostatographic images on an electrostatographic surface which is other than horizontal including a storage hopper for developer composition having means for discharging the developer composition by gravity onto said image-bearing electrostatographic surface, means for varying, over a range, the rate of discharge of said composition from said hopper, a chamber for collecting all the developer composition falling from the developed electrostatographic surface, and scavenging means within said chamber for sweeping up all the developer composition falling into the chamber and throwing it all back up to the storage hopper. The scavenging means is constructed so that it retains no developer composition.

This invention relates to an apparatus for applying developer to an elestrostatographic surface so that electrostatographic latent images thereon may be developed.

In an electrostatographic process, a latent image formed on an electrostatographic surface is developed by the application of a suitable developer, so that the latent image is rendered effective, but not necessarily visible. Among methods by which this may be done is that generally known as cascade development. In cascade development, carrier particles coated with developer powder are flowed over the latent image bearing surface in such a manner that the powder is removed from the carrier particles by the latent image, but not by the background area of the surface, nor by any small residual forces remaining on said surface, resulting in a print of good clarity and line. It has previously been proposed to effect cascade development by means of tipping powder from drawers or trays, or by lifting the carrier and developer by buckets or similar means from a reservoir, and allowing them to cascade down the electrostatographic surface back to the reservoir. It has also been proposed to throw carrier and developer by fan blades directly on to the latent image bearing surface.

According to the present invention apparatus for developing electrostatographic images comprising a storage hopper from which developer composition may be discharged by gravity on to an image-bearing electrostatographic surface, means for regulating the rate of discharge of developer composition from the hopper, a chamber for collecting developer composition falling from the electrostatographic surface and an elevator means adapted to return the developer composition falling into said chamber to the storage hopper.

The elevator means may comprise a rotatable member including a hub member rotatably mounted with its axis horizontal and provided at circumferentially spaced locations with a plurality of radial members adapted to lift developer from the receiving chamber and to deliver it to the storage hopper.

Preferably means are provided for feeding additional developer powder into the hopper or adjacent the rotatable member as and when required.

The storage hopper may be divided into a plurality of interchangeable compartments, each of which is provided with means for regulating the rate of discharge of developer. Each of the interchangeable compartments may be provided with means for supplying developer powder as and when required so that developer powder of different colours may be supplied to the various compartments.

The means for regulating the rate of discharge of developer composition from the hopper may comprise a shutter adjustable to control an aperture at the base of the storage hopper through which aperture developer is discharged on to the electrostatographic surface.

The developer composition may comprise simply conventional developer powder or may comprise developer powder mixed with a carrier material such as glass beads. The precise form of the developer composition is not essential to the present invention provided that it is in a free flowing particulate form.

Embodiments of the present invention are now described with reference to the accompanying drawings, in which:

FIGURE 1 shows an apparatus with a single hopper,

FIGURE 2 shows an apparatus with a multi-chamber hopper,

FIGURE 3 and FIGURE 4 show two alternative constructions of the scavenger blades.

Referring to FIGURE 1, a drum X with an electrostatographic latent-image bearing surface, rotates in the direction indicated by arrow A. The apparatus according to this invention may fit the drum as shown; the drum may have slots at the outer edges in which the sides of the said apparatus fit, to prevent any lateral loss of materials, as well as to locate the unit. It will be appreciated, however, that the apparatus works equally well with the electrostatographic surface presented by a flexible belt, or fixed plate as it does in the embodiment herein described. A storage hopper **1** contains developer composition consisting, for example, of glass or synthetic resin beads, or other alternative suitable material and developer powder. A slide **2** in the form of a movable door controls an opening **2***a* in the hopper **1** and by using a suitable preadjustable stop, the distance that the slide **2** can open can be set to a predetermined extent, so that the opening **2***a* and hence the feed rate of developer composition can be carefully regulated. The slide **2** is operated by means of a solenoid suitably activated by the copying apparatus, of which the present developing apparatus forms a part, so that the developer composition is caused to cascade down the surface of the drum X just as an image bearing area of the surface approaches the developing station, and in the same way the flow of developer composition is stopped when the image bearing area has passed through the developing station.

As the developer composition cascades down the surface of drum X, some of it rebounds from the surface and this is returned to the surface by deflector plates **3** and **4**. As can be seen in FIGURE 1, the developer composition is cascaded onto the drum X above the point M where the tangent is vertical.

A guide **5** is provided below the point M to recover the greater part of the developer composition, which by this stage is falling freely as a result of gravity, centrifugal force throwing the surplus or excess composition on the drum surface.

Beneath the guide **5** are provided further recovery guides **6** to ensure that no carrier particles leave the developing station and thees are so arranged that their distance from surface X is more than the mean diameter of the composition particles.

The guides **5** and **6** conduct the developer composition into a receiving chamber **7** in which is mounted a rotating member **8** around which are arranged a series of scaveng-

ing blades **9**. The scavenging blades are arranged in the receiving chamber **7** somewhat like a fan, being enclosed by the outer container wall of the chamber and an inner partition **10**, and rotating in the direction shown by arrow B. The rotating member **8** turns at a suitable speed, so that cascaded particles are not only conducted by gravity along the guides **5** and **6** into the chamber but are also sucked into the chamber through a lower aperture U, swept around and thrown up through a throat formed between two walls **11** and **12** and thence fall into storage-hopper **1**. The walls **11** and **12** are shaped so that the developer composition is delivered directly into the storage hopper, it being found that if the developer composition is thrown against the wall **11** at the wrong angle, much of it may fall back into the scavenging system. The walls **10** and **11** meet in such a fashion as to allow clearance for the blades of the scavenger unit, which is thus able to suck down and redeliver any developer composition that has not been discharged between the walls **11** and **12** without risk of catching the carrier-developer between the edge of the scavenger blades and the walls of the unit.

Replenisher developer powder is stored in a compartment **13** and suitable means are provided to allow powder to be fed from the compartment **13** into scavenger chamber through a mesh **14** as and when required.

It will be appreciated that the design of the scavenger unit is of importance, since it must operate at such a rate as to keep the storage hopper at least partly charged at all times. This is achieved by suitable design of the scavenger blades and of the receiving chamber **7**. In FIGURES 3 and 4 are shown two examples of construction, both of which are capable of completely returning all carrier-developer within seconds of the cascade ending, leaving the chamber **7** completely free of carrier-developer, and at the same time of ensuring that the rate of replenishment of the hopper is not less than the rate of cascade discharge.

FIGURE 3 shows a construction using resiliently flexible blades **20** of natural or synthetic rubber held in position by metal formers **21** which are fastened by suitable screws or bolts into a square rod **22** with a spindle **23**. This construction is simple and has the advantage of silence in movement because of the flexibility of the blades. It will be appreciated that, by ensuring that the blades do not go to the centre of the member, no inertial mass of developer can be held between the blades, since each carrier-particle unit is at all times subject to centrifugal force.

FIGURE 4 shows a modified form of scavenger blade, which may be made in one piece or constructed from a number of components. Four blades **25** are circumferentially spaced around a hub **26** and they are shaped to take the greatest advantage of centrifugal force, so that the developer composition is delivered most efficiently into the storage hopper.

Because of the efficiency of the scavenging unit, it is not essential for the rotating member to move except during development and for a few seconds after development has been completed, so that provision may be made for bringing it into and out of operation by a suitable device such as, for instance, an electromagnetic clutch.

Referring to FIGURE 2, the storage hopper is formed with two or more identical compartments: in the embodiment of FIGURE 2 three compartments are shown, and it will be clear that a hopper with any number of compartments may be constructed in a similar way. The compartments **30** each contain developer composition which may be of different colours in the different compartments. The compartments **30** form segments of a cylinder mounted on a shaft **31**, which cylinder can be rotated to bring which ever of the compartments is required into an operative position. Each compartment has an inlet shutter **32** and a conduit **33**, and the shutter **32** can be opened when the conduit **33** is in register with the passage between the walls **11** and **12**. An outlet shutter **34** provided with each compartment opens into a passage **35** and when in register therewith can be opened to the extent required for the desired flow of developer composition to take place.

Chambers **36** which are provided around the shaft **31** contain a supply of developer powder which is used to replenish the compartments **30** by passing through meshed apertures **37**, which are controlled by shutters (not shown).

The apparatus is designed so that it is not possible to turn the colour selector, which rotates shaft **31** and, therefore, the different segments of the storage hopper, until the scavenger fan has completed a cycle after development and returned all the carrier-developer back to the appropriate compartment of the storage hopper. It is then possible to rotate the selector, so that the compartment containing the colour selected is in the operative position. For colour printing, provision is made for repeat printing onto the same copy sheet in register by a combination of colours and filters, the whole synchronised automatically.

The apparatus of the present invention has other advantages. It is found that not only does the scavenging system impart tribo-electrical charges to the developer composition when comprising carrier beads and developer powder but that these charges depend to some extent on the materials from which the apparatus is constructed and on the particular carrier beads and developer powder used. It is further found that the scavenging system results in a complete and even coating of developer powder on the carrier beads with a resultant beneficial effect upon image development.

What we claim is:

1. Apparatus for developing electrostatographic images on an electrostatographic surface, the surface being other than horizontal when being developed, the apparatus comprising support means for supporting said apparatus adjacent said surface; a storage hopper for developer composition, said storage hopper comprising means for discharging said developer composition by gravity on said image-bearing electrostatographic surface; means for varying, over a range, the rate of discharge of said developer composition from said hopper; a chamber for collecting all the developer composition falling from the developed electrostatographic surface, said collecting chamber being located below said storage hopper; and scavenger means within said chamber arranged to sweep up all the developer composition falling into said chamber and throw it all up to said storage hopper.

2. Apparatus as claimed in claim **1** wherein said scavenger means comprises a rotatable hub member of rectangular section; means for supporting said rotatable hub member with its axis horizontal; drive means for said hub member; and a plurality of radial members extending from the corners of said hub member and arranged and adapted to sweep up all developer in said receiving chamber and to throw it all up to said storage hopper.

3. Apparatus as claimed in claim **2** including means for feeding additional developer composition into said collecting chamber, as and when required.

4. Apparatus as claimed in claim **1** including means for feeding additional developer composition into said hopper, as and when required.

5. Apparatus for developing electrostatographic images on an electrostatographic surface, said surface being other than horizontal when being developed, said apparatus comprising support means for supporting the apparatus adjacent said surface; a storage hopper for developer composition divided into a plurality of interchangeable compartments, each of which is provided with means for varying, over a range, the rate of discharge of developer therefrom by gravity on said image-bearing electrostatographic surface; means for selecting one of said compartments for discharging developer composition on said electrostatographic surface; a chamber for collecting all the developer composition falling from the developed electrostato-

graphic surface; and scavenging means arranged within said chamber to sweep up all the developer composition falling into said chamber and to throw up all said composition into the selected compartment in said storage hopper.

6. Apparatus as claimed in claim 5 wherein said scavenging means comprises a member rotatable about an axis and including a hub member; means for supporting the rotatable member with its axis horizontal; and a plurality of radial members provided at circumferentially spaced locations around the hub member and arranged and adapted to lift developer from the receiving chamber and to deliver it to the storage hopper.

7. Apparatus as claimed in claim 6 wherein each of said interchangeable compartments is provided with means for supplying developer composition thereto as and when required.

8. Apparatus as claimed in claim 1 wherein said means for varying, over a range, said rate of discharge of developer composition from said hopper comprises an aperture at the base of the storage hopper through which aperture developer can be discharged on said electrostatographic surface; and a shutter variably adjustable to control the size of said aperture.

9. Apparatus for developing electrostatographic images on an electrostatographic surface, said surface being other than horizontal when being developed, said apparatus comprising support means for supporting the apparatus adjacent said surface; a storage hopper for developer composition having an aperture in the base of said hopper through which aperture developer composition can be discharged by gravity on the electrostatographic surface; a shutter adjustable to vary, over a range, the size of said aperture; a chamber for collecting all developer composition falling from the developed electrostatographic surface, said collecting chamber being located below said storage hopper; and scavenging and elevator means comprising a member rotatable about an axis, and means for supporting the rotatable member with its axis horizontal, said scavenging and elevator means being operative to sweep up all developer composition falling into said chamber and to lift all said developer composition from the chamber and to deliver it to the storage hopper, thereby leaving said chamber completely free of said composition.

10. Apparatus for developing electrostatographic images on an electrostatographic surface, said surface being other than horizontal when being developed, said apparatus comprising support means for supporting said apparatus adjacent the said surface; a storage hopper for developer composition divided into a plurality of interchangeable compartments, each of which is provided with an aperture through which aperture developer can be discharged; a shutter adjustable to control the size of said aperture, said storage hopper also comprising means for discharging the developer composition by gravity on the image-bearing electrostatographic surface; means for varying, over a range, the rate of discharge of the developer composition from the hopper; a chamber for collecting all the developer composition falling from the developed electrostatographic surface; and scavenging and elevator means comprising a member rotatable about an axis, and including a hub member of rectangular section, means for supporting the rotatable member with its axis horizontal, and a plurality of members extending from the corners of said hub member and arranged and adapted to sweep up all developer within said receiving chamber and to deliver it all to said storage hopper.

11. Apparatus for developing electrostatographic images on an electrostatographic surface, said surface being other than horizontal when being developed, said apparatus comprising support means for supporting the apparatus adjacent the said surface; a storage hopper for developer composition divided into a plurality of interchangeable compartments, each of which is provided with means for supplying developer composition thereto as and when required, with an aperture through which developer can be discharged and with a shutter adjustable to control the size of the aperture, and hence the rate of discharge of developer, the storage hopper also comprising means for discharging the developer composition by gravity on the image-bearing electrostatographic surface; means for varying, over a range, the rate of discharge of the developer composition from the hopper; a chamber below said storage hopper for collecting developer composition falling from the developed electrostatographic surface; and scavenging and elevator means rotatable about a horizontal axis, said scavenging and elevator means being capable of collecting all developer composition within said chamber and delivering it all to said storage hopper.

12. Apparatus according to claim 11 in which said scavenging and elevator means includes a hub member of square section and a resiliently flexible blade extending from each corner of said hub member, the arrangement being that no developer composition can be held between the blades, whereby it is at all times subject to centrifugal force.

13. Apparatus for developing electrostatographic images on an electrostatographic surface around a cylinder disposed with its axis horizontal, said apparatus comprising support means for supporting said apparatus at one side of said cylinder; a storage hopper for developer composition, said storage hopper comprising means for discharging said developer composition by gravity onto a substantially vertical zone of said image-bearing electrostatographic surface; means for regulating, over a range, the rate of discharge of said developer composition from said hopper; a chamber located below said storage hopper for collecting developer composition falling from the developed electrostatographic surface, said chamber having a base curved about an axis parallel to that of said cylinder; scavenger means located in said collecting chamber and arranged to sweep up all the developer composition falling into said chamber and throw it all up to said storage hopper; and at least one curved guide plate extending from said cylinder, below said substantially vertical zone, to said base of said collecting chamber.

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