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(54) IMPROVEMENTS IN AND RELATING TO ELECTROPHOTOGRAPHIC APPARATUS

(71) We, RICOH COMPANY, LTD., a Japanese Body Corporate of 3-6 1-Chome, Naka Magome, Ohta-ku, Tokyo, Japan, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:-

The present invention relates to electrophotographic development apparatus.

According to the invention, there is provided electrophotographic development apparatus comprising a developer roller arranged for rotation adjacent a path along which a latent electrostatic image is arranged to pass, a hopper for supplying toner to the developer roller, and a developer regulating member for controlling the thickness of the toner on the developer roller, as it rotates from the hopper towards the path, the developer regulating member being blade-like and having an end portion tapering to an edge which lies spaced from the roller to define with the roller an elongate gap through which developer carried by the roller from the hopper can pass, the angle θ_1 between the upstream and downstream faces of the end portion lying in the range between 0 to 90°, the upstream face making an angle θ with a tangent to the roller at a point adjacent the said edge, the angle θ lying in the range between 90° to 180°, and the combined values of the angles θ and θ_1 lying in the range between 90° to 180°.

According to the invention, there is further provided electrophotographic development apparatus comprising a developer reservoir, a developer roller for drawing a toner developer from the reservoir and carrying it through a location along an electrostatic image carrying path for transferring toner from the roller to the image at said point, and a blade positioned adjacent the roller to control the thickness of the developer on the roller as it passes from the reservoir to said point, the upstream and downstream faces of the blade immediately adjacent the edge of the blade closest to the roller making an angle θ_1 lying in the range of between 0° to 90° and the upstream face making an angle θ_2 with the tangent to the roller at a point immediately adjacent the said edge, the angle θ_2 lying in the range of between 90° to 180° and the combined values of the angles $(\theta_1+\theta_2)$ being less than 180°.

Electrophotographic development apparatus, embodying the invention will now be described, by way of example, with reference to the accompanying diagrammatic drawings, in which:

Figure 1 is a side elevation of an electrophotographic copying machine, incorporating the apparatus;

Figure 2 is a side elevation of part of the development apparatus to an enlarged scale;

Figure 3 is a graph of replenishment quantity versus replenishment time;

Figure 4 is a side elevation of another form of the apparatus;

Figure 5 is a fragmentary view to an enlarged scale of the apparatus of Figure 4;

Figure 6 is a side elevation of a previously proposed development apparatus;

Figure 7 is a fragmentary view to an enlarged scale of the apparatus of Figure 6;

Figure 8 is a side elevation of another form of the development apparatus embodying the invention;

Figure 9 is a fragmentary view to an enlarged scale of the apparatus of Figure 8; and

Figure 10 is a graph of charge carried by toner versus time.

The electrophotographic copier shown in Figure 1 includes a rotary photoconductive drum 8, a corona discharger 9, an exposure station in which a light 10 from a light source (not shown) exposes the surface of the photoconductive drum to an image of an

original, a development apparatus 11 and a guide path 12 for carrying a transfer sheet to the drum. The copier also includes a corona transfer charger 13 for effecting image transfer from the drum to the sheet, a corona discharger 14 having a polarity opposite to that provided by the transfer charger 13 or instread having an alternating polarity, a lamp 15 for illuminating the surface of the photoconductive drum after image transfer and a brush cleaning roller 16 which acts to remove any toner remaining on the photoconductive drum 8. The copier further includes a roller 17 for recovering the toner particles sticking to the brush cleaning roller through electrostatic or magnetic attraction and a cleaning blade 18 for removing the toner particles from the roller 17 by pressure contact with the roller 17. The toner particles, after being scraped off from the cleaning blade 18, are recovered in a container 19.

The development apparatus 11 includes hopper 21 filled with a toner developer 20 and a rotary development roller 22 which is positioned in the outlet of the hopper 21 to carry the developer from the hopper 21 into contact with electrostatic latent images carried by the photoconductive drum 8. A developer regulating member 21*a* is mounted at the outlet of the hopper 21, to limit the developer carried by the roller 22 to a layer having a predetermined thickness. The developer layer is then electrically charged by a corona discharger 23 to have a polarity opposite to that of the electrostatic image. Unused developer after development is returned to the hopper 21.

Figure 2 shows the developing roller 22 of Figure 1 and the blade 21*a* in more detail with the roller 22 being referenced 5 and the blade being referenced 6. The blade or developer regulating member 6 has its end portion profiled to form a tip having an acute angle. One (upstream) face 6*a* of the tip, which face is coplanar with the face of the blade lying inside the hopper, forms an angle of θ_1 in the range of $0° < 0_1 \leqslant 90°$ with the other (downstream) face 6b of the tip.

The inside face of the blade makes an angle θ_2 with the plane passing through both the axis of the development roller 5 and the adjacent end of the inside surface of the blade. The angle θ_2 lies in the range of $0° \leqslant 0_2 < 90°$. When the angles θ_1 and θ_2 lie in the above mentioned range the developer regulating member 6 is brought into almost line contact with the development roller 5. Thus, no excessive force is applied to the toner particles which pass through the gap between the member 6 and roller 5 and so coagulation of toner particles by the member rarely occurs.

Additionally the combined values of the angles θ_1 and θ_2 must satisfy the condition $0° < \theta_1 + \theta_2 \leqslant 90°$.

Thus, it is required that the inside face 6*a* of the developer regulating member 6 makes an obtuse angle with a tangent to the development roller at point of intersection of a line passing both the centre of the roller and the tip of the developer regulating member 6 and the outer surface of the roller. Also, the tangent must make an acute angle with the outer or downstream face 6*b* of the regulating member 6.

If the gap between the hopper 21 and the development roller 22 through which developer is returned to the hopper is too small, some of the toner particles will be scattered at the inlet. In order to prevent such scattering of the toner particles, a roller 24 is slidably supported in the gap between the hopper and roller 22 for movement towards or away from the roller 22. The roller 24 is lightly biased into engagement with the development roller 22 and is displaced away from the roller 24 in accordance with the thickness of the returned layer of developer. In this way the scattering of developer when it is returned to the hopper 21 is substantially prevented.

The roller 24 can be made of metal or of rubber. It is preferable for the roller 24 to be rotated in the opposite sense to the development roller 22 and at a speed so that at adjacent surfaces, the roller 24 has the same or a greater speed than that of the development roller22.

A flexible blade 25 is mounted on the hopper to make contact with the roller 24 and thus scrape off any developer sticking to the roller 24 to prevent the developer scattering outside of the hopper 21.

The development roller 22 can be made of conductive rubber such as silicone rubber.

In order to increase the efficiency with which the developer is carried, the coefficient of friction of the development roller with respect to the developer is preferably at least 0.5 Also it is preferable for the surface roughness of the development roller to be smaller than the particle size of the developer, for instance, when the particle size is 10 μ, the surface roughness is preferably in the range of from 3 to 10μ. In order to improve the development condition, it is preferable for the hardness of the rubber to be in the range of from 30° to 40°.

The surface speed of the development roller is at least the same as, but not exceeding, twice that of the photoconductive drum 8 in order to effect a development having a sufficiently high density substantially without any background. A development bias from outer bias power source 26 is applied to the roller 22 so that adhesion of the developer to the background portions on the photosensitive drum is prevented. The charger 23 is preferably a scoroton charger having a charging control grid so that the developer can be

subjected to a charging control.

When the developer is in the form of a one-component insulating toner, a triboelectric charging member which is different in triboelectric series can be used instead of the corona discharger 23 in order to charge the toner triboelectrically.

When the developer is in the form of a one-component magnetic toner, a magnet, which magnetically attracts the magnetic toner to the surface of the development roller 22, is mounted inside the development roller 22.

When the gap between the developer regulating plate 21*a* and the development roller 22 was set in the range of 0.03 to 0.06 mm, a uniform layer of the developer could be formed on the development roller 22.

It has been found that an uneven development occurs when the thickness of the developer layer is not even. Thus when a developer layer is formed evenly on the development roller 22 and applied to the drum, the developer in the portions corresponding to the electrostatic image on the drum 8 are removed electrostatically thus leaving an uneven layer of developer on the development roller 22. Upon further rotation of the development roller 22, it passes through the inside of the hopper 21, where the reduced thickness portions of the layer are replenished.

When the peripheral speed of the developer roller 22 was 50 mm/sec and the replensihment width of the hopper 21 was 10 mm, it was found that the reduced thickness portions could not be fully replenished upon a single rotation of the roller but multiple rotations were needed.

Figure 3 illustrates the time taken to bring the layer of the developer to a uniform level when the speed of the development roller and the replenishment width of the hopper are held constant.

When the replenishment width is 10 mm, the replenishment time of the developer is 0.2 seconds. At this time, only the half of the developer is replenished in the reduced thickness portions of the layer. When the replenishment time is lengthened to 1.0 second or longer, the developer is replenished completely in the reduced thickness portions and accordingly the replenishment amount is saturated.

Therefore, in order to set the replenishment time of the developer to at least 1.0 second, the development apparatus must be modified either by reducing the peripheral speed of the development roller or increasing the replenishment width of the developer of the hopper to 50 mm, that is, to five times the width of 10 mm.

Thus in order to make a uniform layer of the developer on the developer roller 22 using the developer regulating member 21*a*, a uniform layer of the developer must already exist on the development roller 22 before the developer comes into contact with the development regulating member 22. Further, the scattering of the developer from the hopper 21 can be prevented by the developer regulating member 21*a* and the roller 24, which are respectively mounted at the outlet and the inlet of the hopper 21. The mounting of the outlet and inlet of the hopper need not be above the developer roller 22 as shown in Figure 1, but instead it can be below the horizontal plane passing through the axis of the developer roller 22. In this way, it is possible to increase the area of contact between the developer in the hopper 21 and the developer roller 22 so that a uniform layer of the developer can be formed on the development roller.

While, the developer regulating member 21*a* is mounted to form the outlet of the hopper 31, it can instead be mounted separately immediately behind the outlet of the hopper.

As already stated the developer on the development roller 22 can be electrically charged by use of the corona charger 23.

This charger can be dispensed with when the developer regulating member 21*a* is made of a material or materials different in the triboelectric series from the toner to provide a simple and inexpensive development apparatus.

The development apparatus shown in Figure 4 includes a development roller 31 made of conductive rubber, and a direct current source which supplies the development roller 31 with a predetermined bias potential.

The development roller 31 is mounted in an opening in the bottom of a toner tank 34 holding toner 3. At one side of the opening in the toner tank 34 is a triboelectric charging blade 35 which extends towards the roller 31 to make an obtuse angle with a tangent to the development roller 31 at a point adjacent the top of the blade 35. The lowermost portion of the development roller 31 lies adjacent a path along which a latent electrostatic image bearing photoconductor 36 is arranged to pass. In operation the toner 3 in the toner tank 34 is scraped out of the tank by the rotation of the development roller 31, thereafter it is charged by the triboelectric charging blade 35 and brought into close contact with the photoconductor 36. The triboelectric charging blade 35 extends to make an obtuse angle with a tangent to the development roller 31 in a manner similar to that shown in Figure 2.

When the toner level in the toner tank drops too low so that insufficient toner is supplied to the roller, a uniform and thin layer of the toner will not be formed on the development roller 31. This is because (as illustrated in Fig.5) the driving force f_2

imparted to the toner 3 is directed along a tangent to the surface of the development roller 31, and the reaction f_1 from the triboelectric charging blade is normal to the surface of the triboelectric charging blade 35. Accordingly, the resultant force F applied to the toner is directed nearly along the surface of the triboelectric blade 5. Therefore, the resultant force F is not directed towards the development roller 31 and so the uniform layer cannot be ensured.

In the development apparatus shown in Figure 6 to 8, parts similar to those in Figure 4 are similarly referenced.

As shown in Figure 6 a triboelectric charging blade 44 has an arc-shaped tip 43. This effectively means that top surface of the triboelectric charging blade forms an acute angle with the tangent α to a development roller 49 and acts to effect good replenishment of the toner 3 even when the toner level in the tank is low in amount. This is because the reaction f_1 from the tribolectric charging blade is directed downward, due to driving force f_2 and so the resultant force F acts on the toner in a direction towards the development roller 49. However, when the toner level in the tank is high the resultant toner layer will be thick and so cause background or deteriorate the tone grades or sharpness of the image when developed. Accordingly, downstream of the charging blade 44 there is provided a developing regulating member blade 45.

The development roller 49 is mounted in the opening in the bottom of the toner tank 42. The triboelectric charging blade 44 having the arc-shaped portion 43 is positioned to be spaced a distance d_1 from the development roller 49. The blade 45 having a sharp knife edge is positioned to be spaced a distance d_2 from the development roller; the distance d_2 being smaller than the distance d_1.

The angles θ_1 and θ_2 formed by these two triboelectric charging blades 44 and 45 (see Fig.9) and the respective tangents α_1 and α_2 to the roller 45 are respectively in the ranges $0° < \theta_1 < 90°$ and $90° < \theta_2 < 180°$. The numeral 46 is a photoconductor.

In operation, a layer of the toner drawn from the toner tank 42 is formed with a predetermined thickness on the surface of the development roller 49 while the toner is being triboelectrically charged by the triboelectric charging blade 44. In this portion, as indicated in Fig.7, replenishment of the toner 3 is good and a rather thick but uniform layer of the toner is formed. Subsequently, the toner layer is made thinner by the balde 45 which also acts to triboelectric charge the toner. At this stage, as a sufficient amount of the toner 3 has already been supplied, a thin but uniform layer of the toner is formed.

With the apparatus of Figures 7 to 9, charging saturation is reached in a shorter time than in the case of a development apparatus having but a single triboelecgric charging blade. This is illustrated in the graph shown in Figure 10. Therefore, when copying is started at time A and the charging potential of the toner is lowered, the period of time before the toner recovers its charging potential is rather short. This in the final copy serves to improve image qualities, make solid areas uniform with the sufficient density and also makes background less while improving the tone grades.

It will be appreciated that instread of two triboelectric charging blades more blades can be used. Also, instead of employing a plurality of triboelectric charging blades, an integrated triboelectric charger having a plurality of blades can be used.

WHAT WE CLAIM IS:

1. Electrophotographic development apparatus comprising a developer roller arranged for rotation adjacent a path along which a latent electrostatic image is arranged to pass, a hopper for supplying toner to the developer roller, and a developer regulating member for controlling the thickness of the toner on the developer roller, as it rotates from the hopper towards the path, the developer regulating member being blade-like and having an end portion tapering to an edge which lies spaced from the roller to define with the roller an elongate gap through which developer carried by the roller from the hopper can pass, the angle θ_1 between the upstream and downstream faces of the end portion lying in the range between 0 to 90°, the upstream face making an angle θ with a tangent to the roller at the point adjacent the said edge, the angle θ lying in the range between 90° to 180°, and the combined values of the angles θ and θ_1 lying in the range between 90° to 180°.

2. Apparatus according to claim 1, wherein the hopper is arranged to hold an electrically insulating toner and including biasing means for imparting to the toner an electrostatic charge.

3. Apparatus according to claim 1, wherein the hopper is arranged to hold an electrically insulating toner which can be triboelectrically charged, and wherein the developer regulating member is made of a material or materials different from said toner in the triboelectric series, whereby to electrostatically charge any toner passing through said elongate gap.

4. Apparatus according to any preceding claim, including at least one further developer regulating member located adjacent the developer roller at a point just upstream of the first mentioned developer regulating member, the upstream face of a portion of the said further member which lies

immediately adjacent the roller making an acute angle with the tangent to the roller at the point on the roller adjacent the said portion of the said further member, the spacing between the further member and the roller being greater than the width of said elongate gap.

5. Apparatus according to claim 4, wherein the further developer regulating member is a triboelectric charging member.

6. Electrophotographic development apparatus comprising a developer reservoir, a developer roller for drawing a toner developer from the reservoir and carrying it through a location along an electrostatic image conveying path, for transferring toner from the roller to the image at said point, and a blade positioned adjacent the roller to control the thickness of the developer on the roller as it passes from the reservoir to said point, the upstream and downstream faces of the blade immediately adjacent the edge of the blade closest to the roller making an angle θ_1 lying in the range of between 0° to 90° and the upstream face making an angle θ_2 with the tangent to the roller at a point immediately adjacent the said edge, the angle θ_2 lying in the range of between 90° to 180° and the combined values of the angles $(\theta_1+\theta_2)$ being less than 180°.

7. Electrophotographic development apparatus substantially as hereinbefore described, with reference to Figures 1 to 3 of the accompanying drawings.

8. Electrophotographic development apparatus substantially as hereinbefore described, with reference to Figures 4 and 5 of the accompanying drawings.

9. Electrophotographic development apparatus substantially as hereinbefore described, with reference to Figures 8 to 10 of the accompanying drawings.

10. An electrophotographic copier including developing apparatus according to any preceding claim.

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1583472 COMPLETE SPECIFICATION

3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

FIG. 1

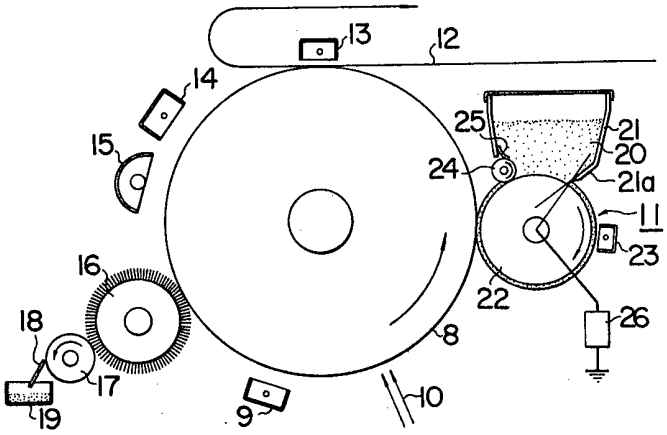


FIG. 3

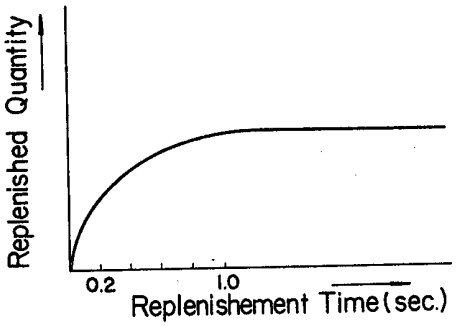


FIG. 4

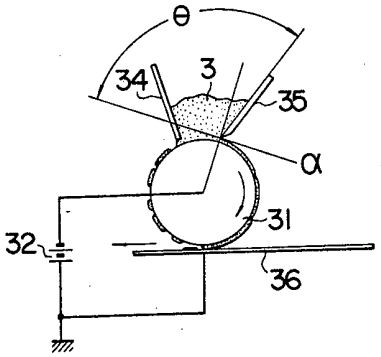


FIG. 5

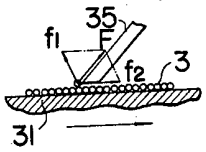
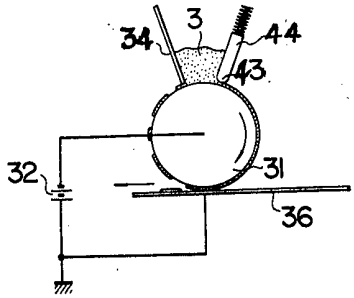


FIG. 6



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3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheet 3

FIG. 7

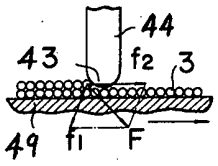

FIG. 8

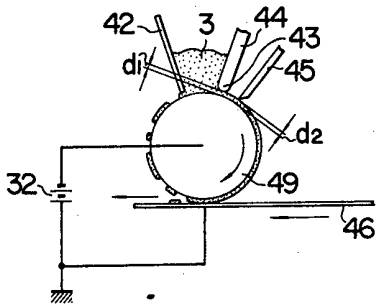

FIG. 9

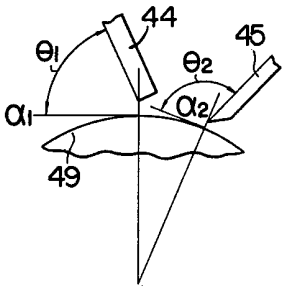

FIG. 10

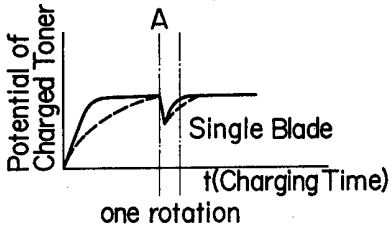

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FIG. 2

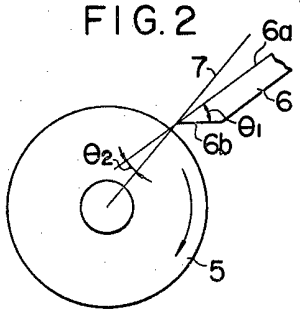

FIG. 1