

Description

FIELD OF THE INVENTION AND RELATED ART

The present invention relate to a charging device for charging a member to be charged, more particularly to a contact charging device which charges a member to be charged by contacting a member supplied with a voltage to the member to be charged. The charging device of the present invention is suitably usable as a charging means for an image forming apparatus of an electrophotographic apparatus or an electrostatic recording apparatus.

The description will be made with respect to, as an example, charging a photosensitive member for an electrophotographic apparatus.

A well-known electrophotographic process includes the step of uniformly charging the surface of the photosensitive member. Almost all of the electrophotographic machines commercialized at present include a corona discharger mainly consisting of a wire electrode and a shield electrode. However, the charging system using the corona discharger involves the following problems:

(1) High voltage application:

In order to provide 500 - 700 V of the surface potential, a voltage as high as 4 - 8 KV is required to be applied to the wire electrode. The discharger is bulky in order to maintain a large distance between the wire electrode and shield electrode to prevent the leakage of the current to the shield electrode and the body, and also use of a highly insulative shielded cable is inevitable.

(2) Low charging efficiency:

Most of the discharging current from the wire electrode is flown to the shield electrode, and only several percent of the total discharging current is flown to the photosensitive member which is a member to be charged.

(3) Corona discharge product:

By corona discharge, ozone or the like is produced, so that the image is easily blurred due to oxidation of the parts and ozone deterioration of the photosensitive member surface (this is particularly remarkable under high humidity conditions). In consideration of the influence of the ozone to human body, an ozone absorbing and/or decomposition filter and a fan or the like to flow the air to the filter are necessitated.

(4) Wire contamination:

In order to enhance the discharge efficiency, a discharge wire having a large curvature (generally 60 - 100 microns in diameter) is used. The wire surface attracts fine dust in the apparatus by the strong electric field and is contaminated thereby. The wire contamination leads to non-uniform discharge, resulting in non-uniform image. Therefore, the wire or the inside of the discharger has to be cleaned.

Recently, consideration is made not to use the corona discharger involving the above described problems but to use a contact charging means as the charging means.

More particularly, a conductive member such as conductive wire brush or conductive elastic roller externally supplied with a DC voltage of approximately 1 KV or a superposed DC and AC voltage is contacted to the photosensitive member surface which is the member to be charged, so that the photosensitive surface is charged to a predetermined potential (for example, U.S. Patent No. 4,455,078 or Japanese Laid-Open Patent Application 104347/1981).

Actually, however, even if the photosensitive member surface to be charged is charged by the contact charging method, the photosensitive member cannot be uniformly charged, and spotty charge occurs. The reason is considered to be that the contact between the conductive member supplied with the voltage and the photosensitive member surface contacted thereto is not complete if seen microscopically, due to the non-smoothness of those contact surfaces, even if the image forming process including the image exposure is executed on the photosensitive member surface spotty non-uniform photosensitive member surface, the output contains the spotty image corresponding to the non-uniform charge, and no high quality image can be obtained.

From a first aspect of the present invention a charging apparatus comprises a moveable member to be charged, a charging member in contact with the moveable member over a first region extending transverse to the direction of movement of the moveable member, and a voltage source arranged to supply a vibratory voltage to the charging member, the charging member and the moveable member being shaped to provide a gap which increases in width in the direction of movement, and characterised in that the voltage source is arranged to supply to the charging member a vibratory voltage having a peak-to-peak magnitude not less than twice a threshold voltage (V_{TH}) which corresponds to the minimum DC voltage which would cause the moveable member to be charged if applied to said charging member.

From a second aspect the present invention comprises a method of operating an image forming apparatus comprising a member to be charged and a contacting charging member for charging the member to be charged, said charging member comprising a portion coextensive with the member to be charged and defining a progressively increasing gap therewith, said method comprising the steps of applying between the charging member and the member to be charged a vibratory voltage, and moving the member to be charged relative to the charging member, and characterised in that the voltage has a peak-to-peak magnitude which is not less than twice the value of a threshold voltage (V_{TH}) which corresponds to the minimum DC voltage which would cause the moveable member to be charged if applied to said charging member.

In order that the invention may be more readily understood, embodiments thereof will now be described by way of example and with reference to the accompanying drawings in which:

Figure 1 is a sectional view of part of a photosensitive drum as a member to be charged and a conductive roller, as a contacting member, contacted to the surface of the photosensitive member.

Figures 2A and 2B are sectional views of examples of the conductive rollers.

Figures 3 and 4 are graphs showing the relationship between applied voltage V_{p-p} and the charge potential V of the photosensitive member, for an OPC photosensitive drum and an amorphous silicon photosensitive drum.

Figure 5 is an example of a voltage applied to the conductive roller.

Figure 6 is a graph illustrating the vibration of the charge potential of the drum in the region where the conductive roller and the photosensitive drum are close.

Figures 7 and 10 are graphs showing relationships between an applied DC voltage V_{DC} and the charge potential V of the photosensitive drum.

Figure 8 shows a model of the gap between the photosensitive layer and the conductive roller.

Figure 9 is a graph showing the relationship between Paschen's curvature and the gap voltage.

Figures 11A and 11B are sectional views of another example of the contact member.

Figure 12 is a graph showing the relationship between the potentials of the photosensitive drum before and after charging.

Figure 13 shows an example of the charging device according to the present invention when used with an electrophotographic apparatus.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to Figure 1, reference numeral 1 designates a part of an electrophotographic photosensitive drum as an example of a member to be charged. The drum 1 comprises an electrically conductive drum base 1a and a photosensitive layer 1b (photoconductive semiconductor layer of an organic photoconductive, amorphous silicon, selenium or the like) and is rotated at a predetermined speed in the direction indicated by an arrow a. A conductive roller 2 is contacted to the surface of the photosensitive drum 1 under a predetermined pressure, and it rotates in the direction indicated by an arrow b following the rotation of the photosensitive drum 1. The conductive roller 2 is supplied with a voltage from the voltage source 3.

Figure 2A shows an example of a structure of a conductive roller 2, wherein a metal core rod 2a is coated with a two layer structure comprising an elastic rubber layer 2b made of EPDM or NPR, for example and a urethane rubber layer 2c, thereon, (resistance is approx. 10^5 ohm) containing carbon dispersed therein.

Figure 2B shows another example wherein a metal core rod 2a coated with a single layer structure comprising urethane foam layer 2d containing carbon dispersed therein.

In any case, the conductive roller usable with this embodiment includes a metal core coated with a material having resistivity of $10^2 - 10^{10}$ ohm.cm.

The contact member 2 may be a non-rotatable member, pad or belt member.

Now, the description will be made as to the charging of the photosensitive drum 1 using the conductive roller:

(1) When a DC voltage is applied to the conductive roller:

In this example, the photosensitive layer 1b of the photosensitive drum 1 includes a CGL (carrier generating layer) of azo pigment and CTL (carrier transfer layer) having a thickness of 19 microns and containing a mixture of hydrazone and resin. The photosensitive layer is an OPC (organic photoconductor) layer of a negative property. The OPC drum is rotationally driven, to the surface of which the conductive roller 2 is contacted. The conductive roller 2 is supplied with a DC voltage V_{DC} to effect the contact charging to the OPC photosensitive drum in the dark. The surface potential V of the OPC photosensitive drum 1 charged by the conductive roller 2 and the DC voltage V_{DC} applied to the conductive roller 2 were measured. Figure 7 shows the results of measurements. The charging action involves a threshold concerning the

DC voltage V_{DC} applied. The charging effect starts at approximately 560 V. The provided surface potential V by the applied voltage higher than the charge starting voltage is linear with respect to the applied voltage as shown in Figure 7. The property is substantially immune to ambient conditions, that is, generally the same results are confirmed under high humidity and high temperature conditions and under low humidity and low temperature conditions.

Namely,

$$V_c = V_a - V_{TH}$$

V_a : DC voltage applied to the conductive roller 2;

V_c : potential of the surface of the OPC photosensitive drum;

V_{TH} : charge starting voltage.

The equation derives from the Paschen's law.

Referring to Figure 8 showing a model of microscopic clearance between the surface of the photosensitive drum and the conductive roller 2, the voltage V_g across the microscopic gap Z between the OPC photosensitive layer 1b and the conductive roller 2 is expressed by the following equation:

$$V_g = [(V_a - V_c)Z] / (L_s / K_s + Z) \quad (1)$$

V_a : applied voltage

V_c : surface potential of the photosensitive layer

Z : gap

L_s : thickness of the photosensitive layer

K_s : dielectric constant of the photosensitive layer

On the other hand, the air gap break-down voltage V_b can be expressed by a linear expression on the basis of the Paschen's law where the gap Z is more than 8 microns, as follows.

$$V_b = 321 + 6.2 Z \quad (2)$$

The equations (1) and (2) are plotted on a graph in Figure 9 which shows air gap break-down voltage or gap voltage as a function of the gap Z . In the graph, reference numeral 1 designates a Paschen's curve which is convex-down, and reference numerals 2, 3 and 4 designate the gap voltage V_g curves which are convex-up with a parameter of $V_a - V_c$.

The electric discharging action occurs when the curves 2, 3 or 4 cross the Paschen's curve 1. At the point of the discharge start, a discriminant of a Quadratic of Z given by $V_g = V_b = 0$, that is,

$$(V_a - V_c - 312 - 6.2 \times L_s / K_s)^2 = 4 \times 6.2 \times 312 \times L_s / K_s$$

That is,

$$V_c = V_a - (\sqrt{7737.6 \times L_s / K_s} + 312 + 6.2 \times L_s / K_s) \quad (3)$$

When the dielectric constant 3 of the OPC photosensitive layer 1b and the thickness of 19 microns of the CTL layer are substituted into the right side of the equation (3), the following results:

$$V_c = V_a - 573$$

This is generally the same as the equation obtained from experiments.

Paschen's law related to a discharge in the gap. Even in the charging using the conductive roller 2, the production of a small amount of ozone is recognized at a position very close to the charging portion (1/100 - 1/1000 of the case of corona discharge), so that it is considered that the charging by the conductive roller involves a discharge phenomena in one way or another.

Figure 10 is a graph showing the results of measurements of the DC voltage applied to the conductive roller 2 and the surface potential of the photosensitive drum 1 after being charged by the conductive roller 2, when the photosensitive layer 1 of the photosensitive drum 1 is replaced by an amorphous silicon photosensitive drum.

To minimize the influence of the dark decay, the experiments were carried out without exposure to light prior to the charging step. The charging starts at V_{TH} = approx. 440 V, and with the higher voltage a linear relationship was confirmed like the OPC photosensitive drum case as shown in Figure 7.

When $K_s = 12$ and $L_s = 20$ microns of an amorphous silicon photosensitive drum are substituted for K_s and L_s of the equation (3), $V_{TH} = 432$ V, which is substantially the same as the results of experiments.

When a DC voltage is applied to a conductive roller 2, the surface of the photosensitive member is charged with the properties described above. When the electrostatic pattern resulted is visualized by a known developing method, a spotty pattern results due to the spotty charging.

For the purpose of eliminating the non-uniformness of the charging, the inventors applied a vibratory voltage provided by a DC voltage and an AC voltage superposed therewith is applied to the conductive roller. As a result, it has been found that it is effective for elimination of the non-uniformness to superpose to the DC voltage an AC voltage having a certain level of peak-to-peak voltage.

This will be explained in detail.

(2) When a vibratory voltage provided by superposed DC and AC voltage is applied to the conductive roller:

The OPC photosensitive drum and amorphous silicon photosensitive drum are the same as the ones used in paragraph (1).

A vibratory voltage ($V_{DC} + V_{AC}$) provided by superposing a DC voltage V_{DC} and an AC voltage V_{AC} having a peak-to-peak voltage V_{p-p} is applied to the conductive roller 2 to contact-charge the amorphous silicon photosensitive drum. The peak-to-peak voltage and the charged potential of the surface of the photosensitive drum were measured.

Figures 3 and 4 show the results.

In the area of small V_{p-p} , the potential increases substantially linearly proportionally with V_{p-p} . When it is beyond a certain level, the potential levels off substantially at the V_{DC} level of the DC component of the applied voltage and becomes substantially constant irrespective of increase of V_{p-p} .

The inflection point α with respect to V_{p-p} is approx. 1100 V as shown in Figure 3 in the case of OPC photosensitive drum, and approx. 900 V in the case of the amorphous silicon drum as shown in Figure 4. These are approximately twice the charge starting voltage V_{TH} when the DC voltage is applied (paragraph (1)).

Even if the frequency of the AC voltage and the voltage level V_{DC} of the DC component of the applied voltage are changed, the position of the inflection point α with respect to V_{p-p} is constant, although the level-off point of the charged potential changes with the variation of V_{DC} . Also, the inflection point is not dependent on the relative speed between the conductive roller 2 and the photosensitive member 1, including for example stopping, forward rotation and backward rotation.

The surface of the photosensitive drum is charged by the conductive roller supplied by the superposed DC component.

When the level of V_{p-p} is small, that is, when there is a linear relationship between $V_{p-p}/2$ and the charged potential (inclination is 1), a spotty charging results like when a DC voltage alone is applied to the conductive roller 2. However, when the peak-to-peak voltage higher than the inflection point α is applied, the charged potential level is constant, and the resultant visualized image is uniform, that is, the charging is uniform.

That is, in order to obtain uniform charging, it is necessary to apply between the photosensitive member and the conductive roller a vibratory voltage having a peak-to-peak voltage which is not less than the absolute value of the charge starting volt-

age V_{TH} when a DC voltage determined on the basis of the various properties or the like of the photosensitive member which is a member to be charged is applied. The surface potential of the photosensitive member provided is dependent on the DC component of the voltage applied.

The relationship among the uniformness of the charging, the peak-to-peak voltage V_{p-p} of the vibratory voltage and the charge starting voltage V_{TH} , more particularly, the uniform charging is provided when $V_{p-p} > 2 V_{TH}$ is exemplarily confirmed. This is theoretically supported as follows.

With respect to the relation between the charged potential and the V_{p-p} change, the inflection point α is considered to be a starting point where the electric charge starts to transfer back from the photosensitive member to the conductive roller under the vibratory field between the photosensitive member and the conductive roller, provided by the vibratory voltage application.

Figure 5 shows a waveform of the voltage applied to the conductive roller. For the sake of simplicity, it is assumed that the vibratory voltage waveform is a DC component V_{DC} and an AC component V_{p-p} of a sine wave, the V_{max} and V_{min} of the vibratory voltage are expressed as follows:

$$V_{max} = V_{DC} + V_{p-p}/2$$

$$V_{min} = V_{DC} - V_{p-p}/2$$

When the voltage of V_{max} is applied, the photosensitive member, by the equation $V_c = V_a - V_{TH}$, is charged to the following surface potential:

$$V = V_{DC} + V_{p-p}/2 - V_{TH}$$

In the process of the applied voltage to the conductive roller relative to the surface potential approaching the minimum V_{min} , when the potential difference becomes beyond the charge starting voltage V_{TH} , the excessive charge on the photosensitive member is transferred back to the conductive roller.

The fact that the transfer and the back transfer of the charge between the conductive roller and the photosensitive roller are carried out under the existence of the threshold V_{TH} , means that the transfer of the charge therebetween is determined on the basis of the gap voltage, and therefore, the charge transfer is directionally equivalent.

For this reason, in order that the back transfer occurs, the following is to be satisfied:

$$(V_{DC} + V_{p-p}/2 - V_{TH}) - (V_{DC} - V_{p-p}/2) \geq V_{TH}$$

That is,

$$V_{p-p} \geq 2V_{TH}$$

This agrees with the above described experimental equation.

In other words, even if excessive charge is deposited locally on the photosensitive member to provide a high potential, the back transition of the charge makes the potential uniform.

By the formation of the vibratory electric field by the vibratory voltage between the conductive roller and the photosensitive member, the charge transfers and transfers back therebetween, wherein the charge transfer is dependent on the threshold V_{TH} . If it is assumed that the charge movement occurs when a potential difference not less than the threshold V_{TH} in a certain determined distance, in the area where the conductive roller and the photosensitive drum are close to each other, the charge potential of the photosensitive drum vibrates in the manner shown in Figure 6 by broken line, which is similar to a pulse wave. As seen from the Figure, the amplitude is $V_{p-p}/2 - V_{TH}$.

In Figure 6, in the process of the conductive roller potential approaching V_{max} , the surface potential of the photosensitive drum increases by the charge transfer from the conductive roller to the photosensitive drum such that the potential difference becomes V_{TH} . On the contrary, in the process of the potential of the conductive roller decreasing from V_{max} to V_{min} , the charge transfer does not occur until the potential difference between the conductive roller and the charged potential of the photosensitive drum becomes the threshold V_{TH} , and therefore, the charged surface potential gained thereby when the voltage V_{max} is applied to the conductive roller is maintained, and thereafter, when the potential difference is going beyond V_{TH} , and at this time, the transfer (back transfer) of the charge occurs from the photosensitive drum to the conductive roller so that the potential difference becomes V_{TH} . Therefore, the charged potential of the photosensitive drum decreases until the voltage V_{min} is applied to the conductive roller. By the repetition of those processes, the potential of the charged photosensitive drum vibrates with the center of V_{DC} in the pulse-like waveform, as shown in Figure 6 by broken lines.

On the other hand, the voltage V_{TH} is a potential difference in the smallest distance that produces the charge transfer because of its definition, and therefore, it is dependent on the distance, more particularly, the threshold voltage V_{TH} required for transferring the charge has to be large if the gap between the conductive roller and the photosensitive drum is large. The Paschen's curve shown in Figure 9 exhibits increase of the air gap

break-down voltage in accordance with increase of the distance.

When, therefore, the structure is such that the distance between the conductive roller 2 and the photosensitive drum 1 gradually increases toward the downstream from the contact point with respect to movement of the periphery of the photosensitive drum 1, the potential of the charged photosensitive drum having been vibrating in the pulse waveform having an amplitude of $V_{p-p}/2 - V_{TH}$ as shown in Figure 6 becomes vibrating with smaller amplitude to zero with the increase of the threshold voltage V_{TH} . In the area where the charge does not transfer or transfer back where the distance is sufficiently large, the surface potential of the photosensitive member is not dependent on the peak-to-peak voltage V_{p-p} of the vibratory voltage applied to the conductive roller, but is stabilized at the level of V_{DC} .

From this standpoint, in order to stabilize the potential of the charged member, the shape of the contact member to be contacted to the member to be charged is not inevitably limited to a roller shape. Instead, as shown in Figures 11A and B, for example, the shape may be such that the contact member includes a portion A contacted to the member to be charged and a portion B continuous from the portion A to provide an increasing distance from the member 1 to be charged toward the downstream of the member to be charged with respect to its movement. Figures 11A and B show it as a pad contacted to the member to be charged 1.

As described hereinbefore, between the photosensitive drum as the member to be charged and the conductive roller as a contacting member, it is considered that the charge transfers and transfers back, so that a desired voltage can be provided after the charging with high precision independently of the potential of the member to be charged prior to the charging operation.

The charging device according to the present invention involves the effects similar to those of a grid used with conventional corona dischargers, and therefore, a stabilized charging process is enabled without the phenomena of varied image provided by varied electrostatic latent image in an electrophotographic process.

Figure 12 shows results when a vibratory voltage of $V_{DC} = -630$ V and frequency of $F = 1000$ Hz is applied to the conductive roller, and the photosensitive drum is of OPC (negative property).

In the foregoing embodiment, the waveform of the vibratory voltage is a sine wave as shown in Figure 5, but this is not limiting, and instead rectangular wave or pulse wave may be usable for the vibratory voltage.

Next, the example will be explained wherein the charging device according to the present invention is incorporated into an image forming apparatus.

Referring to Figure 13, the charging device according to the present invention is used in an electrophotographic apparatus which is in this example a laser beam printer.

The photosensitive drum 1 is uniformly charged to a predetermined potential by a conductive roller 2, and thereafter, is scanningly exposed to a laser beam L through a mirror 5, the laser beam L being modulated in accordance with image information from a known laser scanner unit 4. By this exposure, an electrostatic latent image is formed on the photosensitive drum 1 in accordance with the image information. Then, the electrostatic latent image is visualized by the developing device 6.

The visualized image formed on the photosensitive drum 1 is transferred onto a sheet P by a transfer roller 7 at a transfer station, the sheet P having been transferred by an unshown conveying means. In this embodiment, the transfer roller 7 is supplied with a DC voltage having a polarity opposite to that of the visualized image from the power source 8.

The sheet P on which the visualized image is transferred from the transfer roller 7 is conveyed to an image fixing means not shown, where the visualized image is fixed on the sheet P.

On the other hand, the developer remaining on the photosensitive drum 1 after the image transfer is removed by a cleaner 9, so that the surface of the photosensitive drum 1 is cleaned, and the photosensitive drum is prepared for the next image forming operation.

In such an image forming apparatus, the charging device according to the present invention can be employed with the result of good image without non-uniform charging can be provided. This is because of the above-described vibratory voltage applied to the conductive roller 2 from the power source 3.

In this embodiment, the description has been made with the primary charging means for charging the photosensitive drum. However, the present invention is applicable to the image transfer charging means.

In this embodiment, the scanning exposure means is of a laser beam type, but this is not limiting, and the present invention is applicable to an electrophotographic apparatus having a conventional analog type exposure optical system.

As described in foregoing, according to the present invention, a vibratory voltage having a peak-to-peak voltage which is not less than twice the absolute value of the charge starting voltage to

a member to be charged is applied between the member to be charged and a contacting member contacted thereto to form a vibratory electric field therebetween to charge the member to be charged, whereby spotty charging does not occur on the member to be charged, so that it can be uniformly charged to a predetermined potential always stably. According to the charging device of the present invention, a low voltage is usable for charging a member as compared with the voltage necessary in a corona discharging device.

While the invention has been described with reference to the structures disclosed herein, it is not confined to the details set forth and this application is intended to cover such modifications or changes as may come within the scope of the following claims.

Claims

1. A charging apparatus comprising:
 - a moveable member (1) to be charged,
 - a charging member (2) in contact with the moveable member (1) over a first region extending transverse to the direction of movement of the moveable member, and a voltage source (3) arranged to supply a vibratory voltage to the charging member,
 - the charging member and the moveable member being shaped to provide a gap which increases in width in the direction of movement, and
 - characterised in that the voltage source is arranged to supply to the charging member a vibratory voltage having a peak-to-peak magnitude not less than twice a threshold voltage (V_{TH}) which corresponds to the minimum DC voltage which would cause the moveable member (1) to be charged if applied to said charging member (2).
2. Apparatus according to claim 1, wherein the charging member is curved adjacent to the first region.
3. Apparatus according to either claim 1 or claim 2, wherein said charging member (2) is a pad.
4. Apparatus according to either claim 1 or claim 2, wherein said charging member (2) is a rotational member.
5. Apparatus according to claim 4, wherein said charging member (2) is a roller.
6. Apparatus according to any one of the preceding claims, wherein said vibratory voltage is in the form of a sine wave.



Next, the example will be explained wherein the charging device according to the present invention is incorporated into an image forming apparatus.

Referring to Figure 13, the charging device according to the present invention is used in an electrophotographic apparatus which is in this example a laser beam printer.

The photosensitive drum 1 is uniformly charged to a predetermined potential by a conductive roller 2, and thereafter, is scanningly exposed to a laser beam L through a mirror 5, the laser beam L being modulated in accordance with image information from a known laser scanner unit 4. By this exposure, an electrostatic latent image is formed on the photosensitive drum 1 in accordance with the image information. Then, the electrostatic latent image is visualized by the developing device 6.

The visualized image formed on the photosensitive drum 1 is transferred onto a sheet P by a transfer roller 7 at a transfer station, the sheet P having been transferred by an unshown conveying means. In this embodiment, the transfer roller 7 is supplied with a DC voltage having a polarity opposite to that of the visualized image from the power source 8.

The sheet P on which the visualized image is transferred from the transfer roller 7 is conveyed to an image fixing means not shown, where the visualized image is fixed on the sheet P.

On the other hand, the developer remaining on the photosensitive drum 1 after the image transfer is removed by a cleaner 9, so that the surface of the photosensitive drum 1 is cleaned, and the photosensitive drum is prepared for the next image forming operation.

In such an image forming apparatus, the charging device according to the present invention can be employed with the result of good image without non-uniform charging can be provided. This is because of the above-described vibratory voltage applied to the conductive roller 2 from the power source 3.

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In this embodiment, the scanning exposure means is of a laser beam type, but this is not limiting, and the present invention is applicable to an electrophotographic apparatus having a conventional analog type exposure optical system.

As described in foregoing, according to the present invention, a vibratory voltage having a peak-to-peak voltage which is not less than twice the absolute value of the charge starting voltage to

a member to be charged is applied between the member to be charged and a contacting member contacted thereto to form a vibratory electric field therebetween to charge the member to be charged, whereby spotty charging does not occur on the member to be charged, so that it can be uniformly charged to a predetermined potential always stably. According to the charging device of the present invention, a low voltage is usable for charging a member as compared with the voltage necessary in a corona discharging device.

While the invention has been described with reference to the structures disclosed herein, it is not confined to the details set forth and this application is intended to cover such modifications or changes as may come within the scope of the following claims.

Claims

1. A charging apparatus comprising:
 - a moveable member (1) to be charged,
 - a charging member (2) in contact with the moveable member (1) over a first region extending transverse to the direction of movement of the moveable member, and a voltage source (3) arranged to supply a vibratory voltage to the charging member,
 - the charging member and the moveable member being shaped to provide a gap which increases in width in the direction of movement, and
 - characterised in that the voltage source is arranged to supply to the charging member a vibratory voltage having a peak-to-peak magnitude not less than twice a threshold voltage (V_{TH}) which corresponds to the minimum DC voltage which would cause the moveable member (1) to be charged if applied to said charging member (2).
2. Apparatus according to claim 1, wherein the charging member is curved adjacent to the first region.
3. Apparatus according to either claim 1 or claim 2, wherein said charging member (2) is a pad.
4. Apparatus according to either claim 1 or claim 2, wherein said charging member (2) is a rotational member.
5. Apparatus according to claim 4, wherein said charging member (2) is a roller.
6. Apparatus according to any one of the preceding claims, wherein said vibratory voltage is in the form of a sine wave.



7. Apparatus according to any one of the preceding claims, wherein said voltage source (3) provides a vibratory voltage by superposing a DC voltage and an AC voltage.

8. Apparatus according to any one of the preceding claims, wherein said moveable member comprises a photosensitive member.

9. Apparatus according to claim 8, wherein said moveable member (1) has an organic photoconductor layer.

10. Apparatus according to claim 8, wherein said moveable member (1) has an amorphous silicon photoconductive layer.

11. Apparatus according to any one of the preceding claims, wherein said charging member comprises a core member (2a) surrounded by an inner layer (2b) in turn surrounded by an outer conductive layer (2c).

12. Apparatus according to claim 11 wherein the inner layer is an elastic rubber layer and the outer layer is of urethane containing carbon dispersed therein.

13. Apparatus according to any one of claims 1 to 10 wherein the charging member comprises a core member and a single surrounding layer of conductive material.

14. Apparatus according to claim 13 wherein the surrounding layer is a urethane foam layer containing carbon dispersed therein.

15. Apparatus according to claim 11, wherein the surface layer of the charging member has a volume resistivity of 10^2 - 10^{10} Ohm.cm.

16. Apparatus according to claim 4 or any one of claims 5 to 15 when dependant on claim 4, wherein the surface velocity of the charging member is the same as that of the moveable member.

17. Apparatus according to any of claims 11 to 16 arranged such that as the charging member (2) and a portion of the moveable member (1) move away from each other the strength of the electric field between the charging member (2) and that portion progressively reduces with time.

18. A method of operating an image forming apparatus comprising a member to be charged (1) and a contacting charging member (2) for

charging the member to be charged (1), said charging member (2) comprising a portion co-extensive with the member to be charged (1) and defining a progressively increasing gap therewith, said method comprising the steps of applying between the charging member (2) and the member to be charged (1) a vibratory voltage, and moving the member to be charged relative to the charging member (2), and characterised in that the voltage has a peak-to-peak magnitude which is not less than twice the value of a threshold voltage (V_{TH}) which corresponds to the minimum DC voltage which would cause the moveable member (1) to be charged if applied to said charging member (2).

19. A method according to claim 18, wherein the voltage comprises a DC-biased AC voltage.

20. A method according to either claim 18 or claim 19 in which the charging member (2) comprises a rotatable member in contact with the moveable member.

21. A method according to claim 20 wherein the charging member (2) comprises a roller.

22. A method according to either claim 20 or claim 21 in which the surface velocity of the charging member is the same as that of the moveable member.

23. A method according to either claim 18 or claim 19 wherein the charging member (2) comprises a pad.

24. A method according to any one of claims 18 to 23, wherein the potential to which the moveable member is charged is unrelated to its potential before charging.

25. A method according to any of claims 22 to 24 in which the strength of the electric field between a charged portion of the member to be charged (1) and the charging member (2) across the said gap progressively reduces over time.

Patentansprüche

1. Aufladevorrichtung mit:
einem zu ladenden, beweglichen Teil (1);
einem Ladeteil (2), das in einem sich transversal zur Bewegungsrichtung des beweglichen Teils (1) erstreckenden ersten Bereich das bewegliche Teil (1) berührt;
und einer Spannungsquelle (3) zum Zuführen



- einer Wechselspannung zum Ladeteil, wobei das Ladeteil und das bewegliche Teil derart geformt sind, daß ein sich in Bewegungsrichtung vergrößernder Spalt gebildet ist, dadurch gekennzeichnet, daß die Spannungsquelle dem Ladeteil eine Wechselspannung mit einem Spitze-Spitze-Wert von nicht weniger als dem zweifachen einer Schwellspannung (V_{TH}) zuführt, die dem minimalen Gleichspannungswert entspricht, der das bewegliche Teil (1) laden würde, wenn er an das Ladeteil (2) angelegt wäre.
2. Vorrichtung nach Anspruch 1 in der das Ladeteil an den ersten Bereich angrenzend gewölbt ist.
 3. Vorrichtung nach Anspruch 1 oder 2, in der das Ladeteil (2) ein Kissen ist.
 4. Vorrichtung nach Anspruch 1 oder 2, in der das Ladeteil (2) ein drehendes Teil ist.
 5. Vorrichtung nach Anspruch 4, in der das Ladeteil (2) eine Walze ist.
 6. Vorrichtung nach einem der vorstehenden Ansprüche, in der die Wechselspannung die Form einer Sinuswelle hat.
 7. Vorrichtung nach einem der vorstehenden Ansprüche, in der die Spannungsquelle (3) die Wechselspannung durch Überlagern einer Gleichspannung und einer Wechselspannung erzeugt.
 8. Vorrichtung nach einem der vorstehenden Ansprüche, in der das bewegliche Teil ein photoempfindliches Material enthält.
 9. Vorrichtung nach Anspruch 8, in der das bewegliche Teil eine Schicht aus einem organischen Photoleiter enthält.
 10. Vorrichtung nach Anspruch 8, in der das bewegliche Teil eine Schicht aus photoleitendem amorphem Silizium enthält.
 11. Vorrichtung nach einem der vorstehenden Ansprüche, in der das Ladeteil ein Kernteil (2a) enthält, das von einer inneren Schicht (2b) umhüllt ist, die wiederum von einer äußeren leitenden Schicht (2c) umhüllt ist.
 12. Vorrichtung nach Anspruch 11, in der die innere Schicht eine elastische Gummischicht und die äußere Schicht eine dispergierten Kohlenstoff enthaltende Urethanschicht ist.
 13. Vorrichtung nach einem der Ansprüche 1 bis 10, in der das Ladeteil ein Kernteil und eine einzelne umhüllende Schicht aus leitfähigem Material enthält.
 14. Vorrichtung nach Anspruch 13, in der die umhüllende Schicht eine dispergierten Kohlenstoff enthaltende Urethanschicht ist.
 15. Vorrichtung nach Anspruch 11, in der die Oberflächenschicht des Ladeteils einen spezifischen Widerstand von 10^2 bis 10^{10} Ohm $\cdot$ cm hat.
 16. Vorrichtung nach Anspruch 4 oder einem von Anspruch 4 abhängigen Anspruch der Ansprüche 5 bis 15, in der die Oberflächengeschwindigkeit des Ladeteils gleich der des beweglichen Teils ist.
 17. Vorrichtung nach einem der Ansprüche 11 bis 16, die derart beschaffen ist, daß dann, wenn sich das Ladeteil (2) und ein Teil des beweglichen Teils (1) voneinander entfernen, die elektrische Feldstärke zwischen dem Ladeteil (2) und diesem Teil mit der Zeit ständig geringer wird.
 18. Verfahren zum Betreiben eines Bilderzeugungsgeräts, das ein zu ladendes Teil (1) und ein das zu ladende Teil (1) berührendes Ladeteil (2) enthält, wobei das Ladeteil (2) einen Bereich enthält, der sich in die selbe Richtung wie das zu ladende Teil (1) erstreckt und einen sich fortschreitend vergrößernden Spalt dazwischen bestimmt, wobei das Verfahren die Schritte des Anlegens einer Wechselspannung zwischen dem Ladeteil (2) und dem zu ladenden Teil (1) und des Bewegens des zu ladenden Teils relativ zum Ladeteil (2) umfaßt, dadurch gekennzeichnet, daß die Spannung einen Spitze-Spitze-Wert hat, der nicht geringer ist als der zweifache Wert einer Schwellspannung (V_{TH}), die dem minimalen Gleichspannungswert entspricht, der das bewegliche Teil (1) laden würde, wenn er an das Ladeteil (2) angelegt wäre.
 19. Verfahren nach Anspruch 18, bei dem die Spannung eine Wechselspannung mit Gleichspannungsanteil enthält.
 20. Verfahren nach Anspruch 18 oder 19, bei dem das Ladeteil (2) ein in Kontakt mit dem beweglichen Teil befindliches drehbares Teil enthält.
 21. Verfahren nach Anspruch 20, bei dem das Ladeteil (2) eine Walze enthält.



22. Verfahren nach Anspruch 20 oder 21, bei dem die Oberflächengeschwindigkeit des Ladeteils gleich der des beweglichen Teils ist.

23. Verfahren nach Anspruch 18 oder 19, bei dem das Ladeteil (2) ein Kissen aufweist.

24. Verfahren nach einem der Ansprüche 18 bis 23, bei dem das Potential, auf das das bewegliche Teil geladen wird, in keinem Zusammenhang zu seinem Potential vor dem Laden steht.

25. Verfahren nach einem der Ansprüche 22 bis 24, bei dem die elektrische Feldstärke über dem Spalt zwischen einem geladenen Teilbereich des zu ladenden Teils (1) und dem Ladeteil (2) mit der Zeit ständig geringer wird.

Revendications

1. Appareil de charge comprenant:
un élément mobile (1) à charger,
un élément de charge (2) en contact avec l'élément mobile (1) dans une première région s'étendant transversalement à la direction de déplacement de l'élément mobile, et une source de tension (3) agencée pour alimenter l'élément de charge avec une tension oscillatoire, l'élément de charge et l'élément mobile étant conformés pour fournir un espace dont la largeur croît dans la direction de déplacement, et

caractérisé en ce que la source de tension est agencée pour alimenter l'élément de charge avec une tension oscillatoire ayant une amplitude crête-à-crête non inférieure au double d'une tension de seuil (V_{TH}) qui correspond à la tension continue minimum qui conduirait l'élément mobile (1) à être chargé si elle était appliquée audit élément de charge (2).

2. Appareil selon la revendication 1, dans lequel l'élément de charge est courbe dans un emplacement adjacent à la première région.

3. Appareil selon la revendication 1 ou la revendication 2, dans lequel ledit élément de charge (2) est un patin.

4. Appareil selon la revendication 1 ou la revendication 2, dans lequel ledit élément de charge (2) est un élément rotatif.

5. Appareil selon la revendication 4, dans lequel ledit élément de charge (2) est un rouleau.

6. Appareil selon l'une quelconque des revendications précédentes, dans lequel ladite tension

oscillatoire se présente sous la forme d'une onde sinusoïdale.

7. Appareil selon l'une quelconque des revendications précédentes, dans lequel ladite source de tension (3) fournit une tension oscillatoire en superposant une tension continue et une tension alternative.

8. Appareil selon l'une quelconque des revendications précédentes, dans lequel ledit élément mobile comporte un élément photosensible.

9. Appareil selon la revendication 8, dans lequel ledit élément mobile (1) comporte une couche photoconductrice organique.

10. Appareil selon la revendication 8, dans lequel ledit élément mobile (1) comporte une couche photoconductrice de silicium amorphe.

11. Appareil selon l'une quelconque des revendications précédentes, dans lequel ledit élément de charge comporte un élément central (2a) entouré par une couche interne (2b) à son tour entourée par une couche conductrice externe (2c).

12. Appareil selon la revendication 11, dans lequel la couche interne est une couche de caoutchouc élastique et la couche externe est constituée d'uréthane contenant du carbone dispersé dans celle-ci.

13. Appareil selon l'une quelconque des revendications 1 à 10, dans lequel l'élément de charge comporte un élément central et une seule couche d'entourage en matériau conducteur.

14. Appareil selon la revendication 13, dans lequel la couche d'entourage est une couche en mousse d'uréthane contenant du carbone dispersé dans celle-ci.

15. Appareil selon la revendication 11, dans lequel la couche de surface de l'élément de charge a une résistivité volumique de $10^2 - 10^{10}$ ohms.cm.

16. Appareil selon la revendication 4 ou selon l'une quelconque des revendications 5 à 15 lorsqu'elle dépend de la revendication 4, dans lequel la vitesse de surface de l'élément de charge est identique à celle de l'élément mobile.

17. Appareil selon l'une quelconque des revendications 11 à 16 agencé de telle sorte que



l'élément de charge (2) et une partie de l'élément mobile (1) s'éloignent l'un de l'autre, l'intensité du champ électrique entre l'élément de charge (2) et cette partie diminuant progressivement avec le temps.

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18. Procédé de fonctionnement d'un appareil de formation d'image comprenant un élément à charger (1) et un élément de charge (2) en contact pour charger l'élément à charger (1), ledit élément de charge (2) comprenant une partie s'étendant parallèlement à l'élément à charger (1) et définissant avec celui-ci un espace augmentant progressivement, ledit procédé comprenant les étapes d'application entre l'élément de charge (2) et l'élément à charger (1) d'une tension oscillatoire, et de déplacement de l'élément à charger par rapport à l'élément de charge (2), et caractérisé en ce que la tension a une amplitude crête-à-crête qui n'est pas inférieure au double de la valeur d'une tension de seuil (V_{TH}) qui correspond à la tension continue minimum qui conduirait l'élément mobile (1) à être chargé si elle était appliquée audit élément de charge (2).
19. Procédé selon la revendication 18, dans lequel la tension comporte une tension alternative polarisée en continu.
20. Procédé selon la revendication 18 ou la revendication 19, dans lequel l'élément de charge (2) comporte un élément rotatif en contact avec l'élément mobile.
21. Procédé selon la revendication 20, dans lequel l'élément de charge (2) comporte un rouleau.
22. Procédé selon la revendication 20 ou la revendication 21, dans lequel la vitesse de surface de l'élément de charge est identique à celle de l'élément mobile.
23. Procédé selon la revendication 18 ou la revendication 19, dans lequel l'élément de charge (2) comporte un patin.
24. Procédé selon l'une quelconque des revendications 18 à 23, dans lequel le potentiel auquel l'élément mobile est chargé est sans relation avec son potentiel avant la charge.
25. Procédé selon l'une quelconque des revendications 22 à 24 dans lequel l'intensité du champ électrique entre une partie chargée de l'élément à charger (1) et l'élément de charge (2) aux bornes dudit espace diminue progressivement avec le temps.