

REPLACED SHEETS SG

☐ Description : paged to paged
☒ Claim(s) : paged 32 to paged 35
☒ Drawing(s) : paged FIG 1 to paged FIG 4
☒ Abstract : paged 36 to paged

-1-

CHARGING MEMBER, PROCESS CARTRIDGE USING THE SAME
AND ELECTROPHOTOGRAPHIC APPARATUS

FIELD OF THE INVENTION AND RELATED ART

5 The present invention relates to a charging member for image formation. Particularly, the present invention relates to a charging member for uniformly charging a charge-receiving member (a member to be charged) by applying a voltage to the charging member
10 disposed in contact with the charge-receiving member, a process cartridge including the charging member, and an electrophotographic apparatus including the charging member.

 In an image forming apparatus including an
15 electrophotographic apparatus, a discharge device using a non-contact charging scheme such as corona charging has generally been used heretofore, as means for charging the surface of a charge-receiving member such as an electrophotographic photosensitive member,
20 a dielectric material, etc. Such a corona charging is effective in uniform chargeability but requires a high applied voltage, thus being accompanied with a problem such as occurrence of ozone.

 In contrast to such a corona charging, a
25 contact charging wherein a drive voltage composed of a DC voltage or a DC voltage superposed with an AC voltage is applied to a charging member disposed in

contact with a charge-receiving member to charge the charge-receiving member, has been adopted to realize less occurrence of ozone, low voltage charging and cost reduction.

5 Figure 2 is a schematic sectional view of an embodiment of a charging roller as a charging member for performing contact charging. Referring to Figure 2, a charging roller 6 includes an electroconductive support 7 as a supporting member (core metal), an
10 electroconductive elastic layer 8 having an elasticity required to form a uniform nip portion together with the charge-receiving member surface, and a medium-resistive coating layer 9 for controlling a resistivity (electrical resistance) of the charging
15 roller 6.

 More specifically, the electroconductive elastic layer 8 may be formed by dispersing an electroconductive substance, such as a metal compound or carbon black, in a solid rubber, such as ethylene-
20 propylene-dien terpolymer (EPDM), nitrile-butadiene rubber (NBR), butyl rubber, acrylic rubber, or urethane rubber. When a drive voltage is applied to the charging roller 6, a charging current (electrification current) passes through the
25 electroconductive elastic layer 8. An elastic foam (foamed elastic material) may be used instead of the solid rubber in order to prevent a charging noise and

provide a lightweight charging roller.

The coating layer 9 is a medium-resistive layer which may be formed by dispersing an electroconductive substance as mentioned above in a resin or rubber, such as nylon, polyester or urethane rubber, and is constituted so as not to cause charging failure in an image region even when defects, such as pinholes are caused to occur on the surface of a charge-receiving member (not shown). The coating layer 9 may be controlled to have a desired (electric) resistance value by changing an amount of the electroconductive substance dispersed therein.

As described above, an elastic layer of the charging member may include a solid rubber or elastic foam and has a function of imparting an appropriate nip portion to the charge-receiving member so as to allow a uniform or even contact of the charging member with the charge-receiving member.

On the other hand, many coating layers have been proposed in order to allow a ununiform charging based on a uniformity of electric resistance distribution in the coating layers. Examples of such coating layers may include one wherein a dispersibility of an electroconductive substance in a resin is enhanced, one using an electroconductive resin or polymer (e.g., methoxymethylated nylon), one which is physically adjusted to have a uniform

thickness, and one which is formed to have a small surface roughness by using a leveling agent or by polishing to improve a contact characteristic thereof with a photosensitive member as the charge-receiving member.

However, even when these coating layers have been used, image defects (e.g., fogs) which may be attributable to ununiform electric resistance have been liable to occur. This phenomenon is noticeable in case where the coating layer is leftstanding for several ten hours to several days while keeping a constant nip portion with the photosensitive member and thereafter is subjected to image formation. As a result, inferior images (fog images) are formed in the nip shape in some cases.

As a countermeasure thereto, it is possible to apply a method wherein the coating layer is improved in its electroconductivity. In this instance, however, the coating layer is accompanied with a problem of a lowered anti-leakage characteristic in a high-humidity environment. Further, a method wherein a nip pressure is lowered by decreasing a pressing (abutting) force between the charging member and the photosensitive member may be adopted. In this case, however, a slip phenomenon is liable to occur between the charging member and the photosensitive member, thus causing difficulties, such

as toner sticking and ununiform charging in some cases. Accordingly, these methods are insufficient to provide excellent images.

5 SUMMARY OF THE INVENTION

An object of the present invention is to provide a charging member capable of preventing a change in electric resistance in the vicinity of a nip portion to perform uniform charging for a long period
10 of time thereby to provide excellent images.

Another object of the present invention is to provide a process cartridge and an electrophotographic apparatus each including such a charging member.

According to the present invention, there is
15 provided a charging member, which is disposed in contact with a charge-receiving member and is supplied with a voltage to charge the charge-receiving member, comprising:

an electroconductive support, an elastic
20 layer disposed on the electroconductive support, and a coating layer disposed on the elastic layer,

the coating layer having a tensile modulus of above 2000 kgf/cm² to at most 30000 kgf/cm².

According to the present invention, there is
25 also provided a process cartridge, comprising:

an electrophotographic photosensitive member, a charging member disposed in contact with

the photosensitive member and supplied with a voltage to charge the photosensitive member, and at least one means of developing means and cleaning means,

the charging member comprising an
5 electroconductive support, an elastic layer disposed on the electroconductive support, and a coating layer disposed on the elastic layer,

the coating layer having a tensile modulus of above 2000 kgf/cm² to at most 30000 kgf/cm², and

10 the photosensitive member, the charging member, and the above-mentioned at least one means of developing means and cleaning means being integrally supported to form a cartridge which is detachably mountable to an electrophotographic apparatus main
15 body.

The present invention provides an electrophotographic apparatus, comprising:

an electrophotographic photosensitive member, a charging member disposed in contact with the
20 photosensitive member and supplied with a voltage to charge the photosensitive member, exposure means, developing means and transfer means,

the charging member comprising an electroconductive support, an elastic layer disposed
25 on the electroconductive support, and a coating layer disposed on the elastic layer, and

the coating layer having a tensile modulus of

above 2000 kgf/cm² to at most 30000 kgf/cm².

These and other objects, features and advantages of the present invention will become more apparent upon a consideration of the following
5 description of the preferred embodiments of the present invention taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

10 Figure 1 is a schematic sectional illustration of an embodiment of a roller-shaped charging member according to the present invention.

 Figure 2 is a schematic sectional illustration of an embodiment of a roller-shaped
15 charging member.

 Figure 3 is a schematic sectional view of an embodiment of an electrophotographic apparatus including a process cartridge using a charging member according to the invention.

20 Figure 4 is a schematic illustration of an embodiment of a stress-strain measuring apparatus.

DETAILED DESCRIPTION OF THE INVENTION

 The charging member according to the present
25 invention is disposed in contact with a charge-receiving member and is supplied with a voltage to charge the charge-receiving member.

The charging member includes an electroconductive support, an elastic layer, and a coating layer disposed in this order.

In the present invention, the coating layer
5 of the charging member has a tensile modulus (modulus in tension) in the range of above 2000 kgf/cm² to at most 30000 kgf/cm². Such a charging member is effective in preventing charge irregularity after being left standing for a long time in such a state
10 that the charging member is pressed or abutted against a charge-receiving member, such as a photosensitive member. As a result, a high-quality image free from image defects, such as fogs is provided.

This may be attributable to a proper
15 elasticity of the coating layer. More specifically, when a charging member having an elastic layer and a coating layer is pressed or abutted against a photosensitive member, the coating layer is irreversibly deformed at a resultant nip portion
20 and/or the surrounding portion in some cases. In this instance, if the coating layer has a tensile modulus in the range of above 2000 kgf/cm² to at most 30000 kgf/cm², the above irreversible deformation of the coating layer is not readily caused, thus not changing
25 a resistance distribution of the coating layer. As a result, the charging member retains a uniform charge-imparting performance.

If the coating layer has a tensile modulus of 2000 kgf/cm² or below, an electroconductive filler dispersed in a polymeric substance constituting the coating layer is liable to change its dispersion state
5 due to the abutment or pressing, thus changing a resistance value of the coating layer to cause image irregularity. On the other hand, if the coating layer has a tensile modulus of above 30000 kgf/cm², the coating layer is liable to be cracked when the
10 charging member is repetitively used. As a result, the charging member is remarkably decreased in its anti-leakage characteristic, thus failing to provide excellent images in some cases.

In the present invention, the tensile modulus
15 is determined, e.g., in the following manner.

A tensile modulus of a test piece prepared by cutting a coating layer of the charging member is determined based on a relationship between a change in stress and a change in strain per unit area under
20 application of load. More specifically, Figure 4 shows an embodiment of a schematic structural illustration of a measuring apparatus 26 for measuring stress and strain.

Referring to Figure 4, a test piece 23 which
25 is accurately cut for performing precise measurement of sectional area thereof is held at both terminal ends by grips or clamps 22 and 24. One grip 22 is

fixed at a fixed end 21 and the other grip 24 is connected to a loading device 25. The test piece 23 is pulled or stretched in the direction of an arrow, so that a stress-strain (deformation) curve is recorded by a recorder 27 including a load indicator and an extensometer. A tensile modulus of the test piece 23 is calculated according to the equation shown below based on a relationship between a change in stress and a change in strain in a linear elastic region in the vicinity of an inflection point of a resultant stress-strain curve.

Tensile modulus (kg/cm^2) = Δf (kgf/cm^2)/ Δh , wherein Δf denotes a change in stress between two points per unit area and Δh denotes a change in strain between the above two points. More specifically, Δh is equal to a value of $(L-L_0)/L_0$ wherein L_0 denotes a length before extension and L denotes a length after extension.

The coating layer having a tensile modulus in the above-mentioned range may be formed by various methods.

Examples of such methods may include: a method wherein an electroconductive filler is blended with a polymeric substance; a method wherein a degree of crosslinking of a polymeric substance is adjusted by adding a crosslinking agent; a method wherein an additive, such as a thickener, coupling agent or

pigment is blended with a polymeric substance; and a method wherein a mixing ratio of two or more polymeric substances is controlled. Among these methods, the method of blending the polymeric substance with the
5 electroconductive filler may preferably be used because the tensile modulus is readily adjusted while controlling a resistance or resistivity of a resultant coating layer.

Examples of the polymeric substance may
10 include resins, such as acrylic resin, polyethylene, polyester resin, polyurethane resin, polysulfone resin, epoxy resin, phenolic resin, styrene resin, nylon resin, polyvinyl chloride, alkyd resin, silicone resin, urea resin, melamine resin and fluorine-
15 containing resin; and synthetic rubbers, such as polybutadiene, butadiene-styrene rubber, butadiene-acrylonitrile rubber, polychloroprene, polyisoprene, chlorosulfonated polyethylene, polyisobutylene, isobutylene-isoprene rubber, acrylic rubber, urethane
20 rubber, polysulfide synthetic rubber, fluorine-containing rubber, and silicone rubber. These resins and rubbers may be used singly or in combination of two or more species.

The polymeric substance may preferably have a
25 tensile modulus of 60 - 10000 kfg/cm².

Among the above polymeric resins and rubbers, an acrylic polymer-modified urethane resin may

preferably used as the polymeric substance because the acrylic polymer-modified polyurethane is excellent in mechanical strength and durability to suppress abrasion or wear of the surface of the photosensitive member caused by contact of the charging member with the photosensitive member.

The acrylic polymer-modified urethane resin referred to herein means a polymer wherein a polyol component and a polyacrylate component are connected by a urethane bond (linkage). The polyol component may preferably be polyester polyols. The polyacrylate component may preferably be acrylate-styrene copolymers.

Examples of the electroconductive filler may include powder of metals, such as aluminum, nickel, stainless steel, palladium, zinc, iron, copper, or silver; composite metallic powder comprising fiber, zinc oxide, tin oxide, titanium oxide, copper sulfide and/or zinc sulfide; and carbon powder, such as acetylene black, ketjen black, PAN-based carbon or pitch-based carbon. These powders may be used singly or in combination of two or more species.

The electroconductive filler may be used in any amount as long as a resultant coating layer shows a tensile modulus of above 2000 kgf/cm² to at most 30000 kgf/cm² and an appropriate resistance. The electroconductive filler may preferably be mixed in an

amount of 1 - 100 wt. parts with 100 wt. parts (as solid matter) of the polymeric substance.

Examples of the crosslinking agent for adjusting a degree of crosslinking may include
5 melamine and melamine compounds in which amino group is substituted with hydrogen atom, aliphatic hydrocarbon group, aromatic hydrocarbon group or derivatives of these groups. Among these compounds, methylol melamine or its derivatives may preferably be
10 used.

Examples of the thickener may include sodium polyacrylate, polymethacrylate acid, ammonium polymethacrylate, and polyethylene oxide.

Examples of the coupling agent may include
15 silane coupling agent, such as γ -(2-aminoethyl)-aminopropyltrimethoxysilane, γ -(2-aminoethyl)-aminopropyldimethoxysilane, γ -glycidoxypropyltrimethoxysilane, vinyl triacetoxysilane and vinyl trimethoxysilane.

20 Examples of the pigment may include carbon black, colcothar (red oxide), nigrosine, triphenylmethanes, imidazole metal oxides, metal oxides and chromium compounds of salicylic acid derivatives.

25 For instance, the coating layer may be formed in the following manner.

To a liquid polymeric substance (e.g.,

dispersion or solution of acrylic polymer-modified urethane resin), the electroconductive filler is added together with the crosslinking agent, thickener coupling agent and/or pigment, as desired, thus
5 preparing a coating liquid. The coating liquid is applied onto the surface of the elastic layer by, e.g., dipping, spray coating or transfer coating and air-dried, followed by pre-drying at 30 - 90 °C and heating at about 90 - 140 °C to form a coating layer
10 on the elastic layer.

In the present invention, the coating layer may preferably have a volume resistivity of 1×10^5 - 1×10^{13} ohm.cm, more preferably 1×10^6 - 1×10^{11} ohm.cm. If the volume resistivity is below 1×10^5 ohm.cm,
15 dielectric breakdown of the charge-receiving (photosensitive) member is liable to occur under a high-humidity environmental condition. If the volume resistivity exceeds 1×10^{13} ohm.cm, image fog is liable to occur under a low-humidity environmental condition.

20 The coating layer may preferably have a thickness of 10 - 1000 μm , particularly 30 - 300 μm . If the coating layer has a thickness of below 10 μm , dielectric breakdown of the charge-receiving member is liable to occur. If the coating layer has a thickness
25 of above 1000 μm , a resultant charging member fails to sufficiently charge the charge-receiving member in some cases.

The coating layer may be a surface layer or may be covered with another coating layer. Such another coating layer may be prepared in the same manner as in the above-mentioned coating layer by
5 using the materials as mentioned above. Another coating layer may further contain a filler to be dispersed therein as desired. Examples of such a filler may include the above-described electroconductive filler, silica, metal oxides (e.g.,
10 alumina), and glass fiber.

The elastic layer of the charging member according to the present invention may preferably have a hardness (ASKER-C hardness) of 20 - 60 degrees, particularly 30 - 45 degrees. Below 20 degrees, it
15 becomes impossible to form a uniform layer. Above 60 degrees, a sufficient nip portion between the charging member and the charge-receiving member is not readily formed.

The ASKER-C hardness is determined based on
20 values measured by using a spring-type hardness meter ("ASKER-C Model", mfd. by Kobunshi Keiki K.K.). A test sample for measurement may be prepared by cutting the elastic layer so as to have a thickness of 5 mm by using one or two or more sheets of the elastic layer.
25 The thus prepared test sample is subjected to measurement of ASKER-C hardness by using the above hardness meter under application of a load of 500 g.

Materials for the elastic layer may be any elastic material. Examples of such elastic material may include synthetic rubber, such as EPDM, NBR, butyl rubber, acrylic rubber, urethane rubber,

5 polybutadiene, butadiene-styrene rubber, butadiene-acrylonitrile rubber, polychloroprene, polyisoprene, chlorosulfonated polyethylene, polyisobutylene, isobutylene-isoprene rubber, fluorine-containing rubber, and silicone rubber; and natural rubbers.

10 The elastic material may be solid or in the form of a foam. In the present invention, a foamed elastic material may preferably be used because the foamed elastic material is readily controlled to have an appropriate elasticity.

15 In the present invention, the elastic layer may contain the above-mentioned electroconductive filler to be used in the coating layer in order to impart an appropriate electroconductivity to the elastic layer.

20 The elastic layer may preferably have a resistance (electric resistance) of 1×10^2 - 1×10^9 ohm, particularly 1×10^3 - 1×10^8 ohm.

If the resistance is below 1×10^2 ohm, dielectric breakdown of the charge-receiving member is
25 liable to occur. If the resistance exceeds 1×10^9 ohm, it becomes difficult to sufficiently charge the charge-receiving member in some cases.

The elastic layer may preferably have a thickness of 0.5 - 30 mm, particularly 1 - 15 mm.

If the elastic layer has a thickness of below 0.5 mm, it becomes difficult to form a sufficient nip portion
5 with the charge-receiving member in some cases.

If the elastic layer has a thickness of above 30 mm, an amount of permanent set (permanent strain) is liable to become large, thus resulting in ununiform charging.

10 A method of forming the elastic layer may be molding wherein a mold is filled with elastic material to form a molded product or extrusion wherein an elastic material is extruded from an extruder to form an extruded product.

15 In the present invention, it is possible to form an intermediate (or adhesion) layer between the coating layer and the elastic layer in order to enhance adhesive properties and/or electroconductivity.

20 The electroconductive support of the charging member according to the present invention may be formed by using a metallic material, such as iron, copper, stainless steel, aluminum and nickel. The surface of the metallic material may be subjected to
25 plating, as desired, in order to prevent rust and mar at the metallic material surface. In this instance, however, such a plating-treated metallic material is

required to show electroconductivity at its surface.

The charging member may be formed in the shape of, e.g., a roller or a blade. In view of uniform charging properties, the charging member may
5 preferably be formed in a roller shape.

Figure 1 is a schematic sectional view of a charging roller as a preferred embodiment of the charging member of the present invention.

Referring to Figure 1, a charging roller 1
10 includes an electroconductive support 2, an elastic layer 3, an intermediate (adhesive) layer 4, and a coating layer 5 disposed in this order.

In the present invention, the electrophotographic photosensitive member as the
15 charge-receiving member, exposure means, developing means, cleaning means and transfer means are not restricted particularly.

Figure 3 is a schematic sectional view of an embodiment of an electrophotographic apparatus
20 including a process cartridge using the charging member according to the present invention.

Referring to Figure 3, a photosensitive drum (i.e., electrophotographic photosensitive member) 10 is rotated about an axis 11 at a prescribed peripheral
25 speed in the direction of the arrow shown inside of the photosensitive member 10. The surface of the photosensitive member 10 is uniformly charged by means

of a charging member 13 according to the present invention while being rotated to have a prescribed positive or negative potential. The photosensitive member 10 is exposed to light-image 12 (an exposure
5 light beam) as by laser beam-scanning exposure by using an imagewise exposure means (not shown), whereby an electrostatic latent image corresponding to an exposure image is successively formed on the surface of the photosensitive member 10. The thus formed
10 electrostatic latent image is developed by a developing means 13 to form a toner image on the photosensitive member surface. The toner image is successively transferred to a transfer-receiving material 15 which is supplied from a paper-supply part
15 (not shown) to a position between the photosensitive member 10 and a transfer means 14 in synchronism with the rotating speed of the photosensitive member 10, by means of the transfer means 14.

The transfer-receiving material 15 with the
20 toner image thereon is separated from the photosensitive member surface to be conveyed to an image-fixing device 16, followed by image fixing to be printed out as a copy out of the image forming apparatus. Residual toner particles on the surface of
25 the photosensitive member 10 after the transfer are removed by means of a cleaning means 17 to provide a cleaned surface, and residual charge on the surface of

the photosensitive member 10 is erased by a pre-exposure light 18 emitted from a pre-exposure means (not shown) to prepare for the next cycle. In case where a contact charging means is used as the charging member 13, the pre-exposure step may be omitted.

In the present invention, a plurality of the above-mentioned structural elements inclusive of the photosensitive member 10, the charging member 13, the developing means 13 and the cleaning means 17 can be integrally supported and assembled into a single unit as a process cartridge 19 which is detachably mountable to a main body of the electrophotographic apparatus, such as a copying machine or a laser beam printer, by using a guide means such as a rail 20 of the apparatus body.

For example, at least one of the developing means 13 and cleaning means 17 may be integrally assembled together with the photosensitive member 10 and the charging member 3 of the invention into a process cartridge 19.

In case where the electrophotographic apparatus is used as a copying machine or printer, image exposure 12 may be effected by using reflection light or transmitted light from an original or by reading data on the original, converting the data into a signal and then effecting a laser beam scanning, a drive of LED array or a drive of a liquid crystal

shutter array in accordance with the signal.

Hereinbelow, the present invention will be more specifically described with reference to Examples.

5 Example 1

A charging roller (charging member) 1 as shown in Figure 1 was prepared in the following manner.

10 A 6 mm dia.-core metal 2 of stainless steel (as electroconductive support) in a length of 251 mm was covered with an urethane foam (average cell diameter = 100 - 150 μ m) prepared by extrusion containing electroconductive acetylene black. Thereafter, the surface of the urethane foam was
15 polished or abraded to form a 13 mm dia.-cylindrical roller having a 3.5 mm-thick elastic layer 3. The elastic layer 3 showed an ASKER-C hardness of 36 degrees and a resistance of 2×10^5 ohm.

20 2 wt. parts of aminopropyltrimethoxysilane and 8 wt. parts of polyacrylate were dissolved in a mixture solvent (acetone-isopropyl alcohol) to prepare a solution. The solution was applied onto the elastic layer 3 by dipping and dried under heating at 100 °C to form an adhesive (intermediate) layer 4.

25 Then, 29 wt. parts of an electroconductive tin oxide doped with antimony slurry (solid content = 51 %) and 10 wt. parts of 2 wt. %- γ -(2-aminoethyl)-

aminopropylmethyldimethoxysilane aqueous solution (hereinafter referred to as "aminosilane aqueous solution") were dispersed in 58 wt. parts of an acrylic polymer-modified urethane resin aqueous emulsion (solid content = 40 %). To the dispersion, 2 wt. parts of a 12 wt. %-ammonium polymethacrylate aqueous solution (as thickener) was added, thus preparing a coating dispersion (viscosity = $240 \text{ cp} \pm 5$ % (at 23°C)). The dispersion was applied onto the adhesive layer by dipping and air-dried under an environment of 23°C and 50 %RH, followed by predrying at 50°C . Thereafter, the coating dispersion was applied onto the resultant surface again, air-dried, predried, and further dried for 45 minutes at 120°C to form a 120 μm -thick coating layer 5.

The coating layer showed a tensile modulus of 4200 kfg/cm^2 and a volume resistivity of $8 \times 10^8 \text{ ohm.cm}$. In this instance, the tensile modulus was measured by using an apparatus ("Tensilon RTM-250", mfd. by Orientec Corp.) and a test piece in a sheet form (width = 5.0 mm, thickness = 0.5 mm (accurately measured) under conditions including a pulling speed of 5 mm/min., a temperature of 23°C , and a relative humidity of 50 %.

The thus prepared charging roller was incorporated in a laser beam printer ("Laser Jet-IV, mfd. by Hewlett-Packard Co.) and subjected to 8000

sheets of image formation (durability test) after left standing for 10 hours, 50 hours and 250 hours (standing time), respectively, under normal temperature-normal humidity (23 °C, 60 %RH)

5 environmental condition while retaining a pressing (abutting) state against a photosensitive member under application of two loads each of 500 g (total 1 kg) for providing a nip width of about 2 mm on both lateral ends of the core metal.

10 A formed image and evaluation method thereof were as follows.

Image: 2 dot-width lines extending in longitudinal direction at a space of 3 dots were formed.

15 Evaluation: Image defects resulting from charge irregularity were observed by eyes with respect to resultant images at an initial stage and at after the durability test each after a lapse of a prescribed standing time (Image evaluation 1) and
20 image defects resulting from abrasion or wear of the photosensitive member were observed by eyes with respect to resultant images after the durability test after a lapse of a standing time of 10 hours (Image evaluation 2).

25 Evaluation results are shown in Table 3 appearing hereinafter according to the following evaluation standards.

○: Very excellent.

o: Excellent (but (practically acceptable)
slight image defects were observed).

x: Image defects were observed.

5 xx: Noticeable image defects were observed.

Examples 2 - 4

Charging rollers were prepared and evaluated
in the same manner as in Example 1 except that the
coating layer was changed to those shown in Table 1
10 below and that the preparation conditions for the
coating layer were changed as follows.

(Example 3)

A 3 wt. %-vinyl triacetoxysilane aqueous
solution was used instead of the aminosilane aqueous
15 solution used in Example 1.

(Example 4)

The electroconductive tin oxide doped with
antimony was changed to an electroconductive titanium
oxide and the addition amount (10 wt. parts) of the
20 aminosilane aqueous solution used in Example 1 was
changed to 15 wt. parts.

Table 1

Ex. No.	Polymeric substance	Tensile modulus (kgf/cm ²)	Resistivity (ohm.cm)	Thickness (μm)
2	Polyester urethane	2200	1x10 ⁹	100
3	Styrene-acrylate copolymer	22300	1x10 ⁸	150
4	Acrylic polymer-modified urethane resin	8100	8x10 ⁸	100

The results are shown in Table 3.

Examples 5 - 7 and Comparative Example 1

Charging rollers were prepared and evaluated in the same manner as in Example 1 except that respective coating layers having physical properties shown in Table 2 below were prepared by adding an appropriate amount of melamine (as crosslinking agent) and that the preparation conditions for the coating layer were changed as follows.

(Example 5)

The electroconductive tin oxide doped with antimony was changed to ketjen black.

(Example 7)

The aminosilane aqueous solution was changed to a 2 wt. %-γ-(2-aminoethyl)aminopropyltrimethoxysilane aqueous solution.

Table 2

Ex.No.	Tensile modulus (kgf/cm ²)	Resistivity (ohm.cm)	Thickness (μm)
5	8500	8x10 ⁸	100
6	18400	1x10 ⁹	150
7	27900	1x10 ⁹	200
Comp. Ex. 1	32000	3x10 ⁹	250

The results are shown in Table 3.

Example 8

A charging roller was prepared and evaluated in the same manner as in Example 1 except that the addition amount of the ammonium polymethacrylate aqueous solution was changed so as to provide a coating dispersion for the coating layer with a viscosity of 670 cp ± 5 %.

The resultant coating layer had a thickness of 150 μm and showed a tensile modulus of 18500 kgf/cm² and a volume resistivity of 2x10⁹ ohm.cm.

The results are shown in Table 3.

Comparative Example 2

A charging roller was prepared and evaluated in the same manner as in Example 1 except that the addition amount of the ammonium polymethacrylate aqueous solution was changed so as to provide a

coating dispersion for the coating layer with a viscosity of 920 cp $\pm$ 5 %.

The resultant coating layer had a thickness of 280 μ m and showed a tensile modulus of 37000
5 kgf/cm² and a volume resistivity of 6×10^9 ohm.cm.

The results are shown in Table 3.

Example 9

A charging roller was prepared and evaluated in the same manner as in Example 1 except that the
10 electroconductive tin oxide doped with antimony was changed to a prescribed amount of electroconductive carbon so as to provide the resultant coating layer with a tensile modulus of 6800 kgf/cm².

The resultant coating layer had a thickness
15 of 90 μ m and showed a volume resistivity of 5×10^6 ohm.cm.

The results are shown in Table 3.

Comparative Examples 3 and 4

Charging rollers were prepared and evaluated
20 in the same manner as in Example 1 except that the aminosilane aqueous solution was not used and that the electroconductive tin oxide doped with antimony was changed to a prescribed amount (e.g., 15 wt. parts in Comp. Ex. 3) of electroconductive carbon so as to
25 provide the resultant coating layer with tensile moduli of 800 kgf/cm² (Comp. Ex. 3) and 1900 kgf/cm² (Comp. Ex. 4), respectively.

The resultant coating layer (Comp. Ex. 3) had a thickness of 180 μm and showed a volume resistivity of 6×10^8 ohm.cm, and the resultant coating layer (Comp. Ex. 4) had a thickness of 180 μm and showed a
5 volume resistivity of 2×10^7 ohm.cm.

The results are shown in Table 3.

Example 10 and Comparative Example 5

Charging rollers were prepared and evaluated in the same manner as in Example 1 and Comparative
10 Example 3, respectively, except that respective elastic layers were prepared in the following manner.

A 3.5 mm-thick foamed elastic layer was prepared by causing a silicone rubber containing electroconductive ketjen black and azodicarbonamide
15 (as foaming agent) dispersed therein to foam in a 13 mm-dia. cylindrical mold.

The thus prepared foamed elastic layer showed an ASKER-C hardness of 42 degrees and a resistance of 1×10^6 ohm.

20 The respective coating layers showed tensile moduli of 4150 kgf/cm² (Example 10) and 810 kgf/cm² (Comparative Example 5).

The results are shown in the following Table
3.

Table 3

Ex. No	Tensile modulus (kgf/cm ²)							Image evaluation 2
		Initial			After durability test			
		10 hr.	50 hr.	250 hr.	10 hr.	50 hr.	250 hr.	
Ex. 1	4,200	⊙	⊙	⊙	⊙	⊙	⊙	⊙
2	2,200	⊙	⊙	⊙	⊙	⊙	⊙	○
3	22,300	⊙	⊙	⊙	⊙	⊙	⊙	○
4	8,100	⊙	⊙	⊙	⊙	⊙	⊙	⊙
5	8,500	⊙	⊙	⊙	⊙	⊙	⊙	⊙
6	18,400	⊙	⊙	⊙	⊙	⊙	⊙	⊙
7	27,900	⊙	⊙	⊙	⊙	⊙	⊙	⊙
8	18,500	⊙	⊙	⊙	⊙	⊙	⊙	⊙
9	6,800	⊙	⊙	⊙	⊙	⊙	⊙	⊙
10	4,150	⊙	⊙	⊙	⊙	⊙	⊙	⊙
Comp. Ex. 1	32,000	x	xx	xx	x	Leakage*	Leakage*	x
2	37,000	xx	xx	xx	Leakage*	Leakage*	Leakage*	xx
3	800	xx	xx	xx	xx	xx	xx	○
4	1,900	x	x	xx	x	x	xx	○
5	810	xx	xx	xx	xx	xx	xx	○

* Charge leakage occurred.

As apparent from the above results, the charging member (rollers) including a coating layer showing a tensile modulus in the range of above 2000 kgf/cm² to at most 30000 kgf/cm² according to the present invention did not cause charge irregularity or ununiform charge and abrasion of a photosensitive member even after left standing for a long period of time, thus providing high quality images free from image defects (e.g., fogs). Particularly, the charging member including a coating layer using an acrylic polymer-modified urethane resin showed a remarkable abrasion-preventing effect to provide high quality images after the durability test similar to those at the initial stage.

On the other hand, the charging members including a coating layer showing a tensile modulus of at most 2000 kfg/cm² caused deformation of a nip portion by being left standing in a pressing (abutting) state with the photosensitive member, thus resulting in charge irregularity corresponding to the deformation of the nip portion. In this case, however, no image defects resulting from abrasion of the photosensitive member were observed.

The charging members including a coating layer showing a tensile modulus of above 30000 kgf/cm² caused a crack in the coating layer at the nip portion or in the vicinity thereof, thus resulting in inferior

images with poor image quality. Such charging rollers
also caused a charge leakage phenomenon due to
accelerated abrasion of the photosensitive member
resulting from an expanded crack in the coating layer
5 during the durability test.

10

15

20

25



WHAT IS CLAIMED IS:

1. A charging member, which is disposed in contact with a charge-receiving member and is supplied with a voltage to charge said charge-receiving member,
5 comprising:

an electroconductive support, an elastic layer disposed on said electroconductive support, and a coating layer disposed on said elastic layer,
said coating layer having a tensile modulus
10 of above 2000 kgf/cm^2 to at most 30000 kgf/cm^2 .

2. A member according to Claim 1, wherein said coating layer comprises a polymeric substance and an electroconductive filler.
15

3. A member according to Claim 2, wherein said polymeric substance comprises an acrylic polymer-modified urethane resin.

- 20 4. A member according to Claim 1 or 2, wherein said elastic layer has a hardness of 20 - 60 degrees.

5. A member according to Claim 4, wherein said elastic layer has a hardness of 30 - 45 degrees.
25

6. A member according to Claim 1 or 2, wherein said elastic layer comprises a foamed material.



7. A member according to Claim 1 or 2, wherein said charge-receiving member comprises an electrophotographic photosensitive member.

- 5 8. A process cartridge, comprising:
 an electrophotographic photosensitive member, a charging member disposed in contact with said photosensitive member and supplied with a voltage to charge said photosensitive member, and at least one
10 means of developing means and cleaning means,
 said charging member comprising an electroconductive support, an elastic layer disposed on said electroconductive support, and a coating layer disposed on said elastic layer,
15 said coating layer having a tensile modulus of above 2000 kgf/cm² to at most 30000 kgf/cm², and
 said photosensitive member, said charging member, and said at least one means of developing means and cleaning means being integrally supported to
20 form a cartridge which is detachably mountable to an electrophotographic apparatus main body.

9. A cartridge according to Claim 8, wherein said coating layer comprises a polymeric substance and an
25 electroconductive filler.

10. A cartridge according to Claim 9, wherein said



polymeric substance comprises an acrylic polymer-modified urethane resin.

11. A cartridge according to Claim 8 or 9, wherein
5 said elastic layer has a hardness of 20 - 60 degrees.

12. A cartridge according to Claim 11, wherein said elastic layer has a hardness of 30 - 45 degrees.

10 13. A cartridge according to Claim 8 or 9, wherein said elastic layer comprises a foamed material.

14. An electrophotographic apparatus, comprising:
an electrophotographic photosensitive
15 member, a charging member disposed in contact with said photosensitive member and supplied with a voltage to charge said photosensitive member, exposure means, developing means and transfer means,

said charging member comprising an
20 electroconductive support, an elastic layer disposed on said electroconductive support, and a coating layer disposed on said elastic layer, and

said coating layer having a tensile modulus of above 2000 kgf/cm² to at most 30000 kgf/cm².

25

15. An apparatus according to Claim 14, wherein said coating layer comprises a polymeric substance and



an electroconductive filler.

16. An apparatus according to Claim 15, wherein
said polymeric substance comprises an acrylic polymer-
5 modified urethane resin.

17. An apparatus according to Claim 14 or 15,
wherein said elastic layer has a hardness of 20 - 60
degrees.

10

18. An apparatus according to Claim 17, wherein
said elastic layer has a hardness of 30 - 45 degrees.

19. An apparatus according to Claim 14 or 15,
15 wherein said elastic layer comprises a foamed
material.

This Sheet Has Been Replaced



20

25