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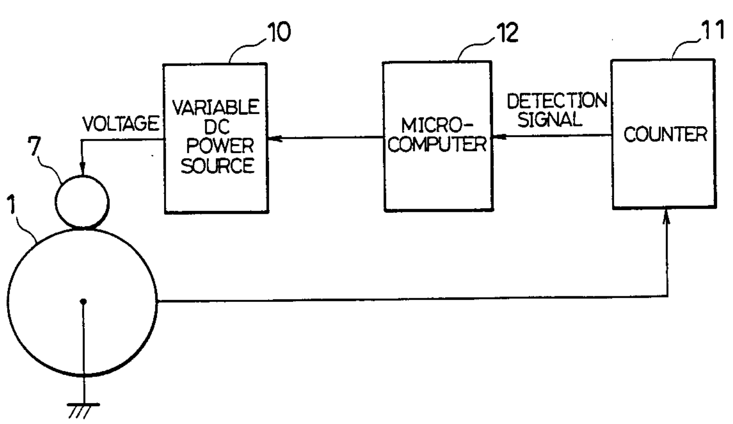
(54) **Charging device.**

(57) A charging device having a counter (11) for outputting an information signal indicating the number of copies produced as a detection signal indicating a change in the thicknes (T_3) of a photosensitive layer (1c), and a microcomputer (12) for correcting the voltage to be applied to a charging roller (7) by a variable DC power source (10). When a detection signal from the counter (11) is input into the microcomputer (12), it corrects the voltage so as to approximate the surface potential of a photoreceptor drum to a set value. With this arrangement, the surface potential (V_c) of the photoreceptor drum (1) is kept uniform, and therefore it is possible to produce copies of good quality constantly.

FIG. 8



EP 0 525 616 A2

FIELD OF THE INVENTION

The present invention relates to a charging device which charges a photosensitive layer covering the surface of a photoreceptor by applying a voltage to a charging member disposed in contact with the photosensitive layer.

BACKGROUND OF THE INVENTION

In a conventional copying machine, generally, a developing unit 22, a transfer charger 23, a cleaner unit 24, an erase lamp 25, and a corona discharge device 26 are disposed around a photoreceptor drum 21 as illustrated in Fig. 10. The following will discuss a series of copying processes performed in such a machine. Firstly, the surface (photosensitive layer) of the photoreceptor drum 21 is charged uniformly by the corona discharge device 26. Secondly, the surface of the photoreceptor drum 21 is exposed to reflected light R from a document at the exposure point B, whereby an electrostatic latent image corresponding to the image on the document is formed on the photosensitive layer of the photoreceptor drum 21. Next, the electrostatic latent image is developed into a toner image by the developing unit 22. Finally, the toner image is transferred to a sheet P by the transfer charger 23, whereby a copy of the document is produced.

After the transfer of the image, any toner remaining on the surface of the photoreceptor drum 21 is collected by the cleaning unit 24, and any remaining electrostatic charges are erased by the erase lamp 25.

However, in the case where charging of the surface of the photoreceptor drum 21 is performed by using the corona discharge device 26 as is in the above-mentioned machine, a high voltage, 4 kV to 8 kV, is required in order to set the surface potential of the photoreceptor drum 21 between 500 V and 700 V. Moreover, since corona discharge generates ozone which corrodes components of the machine and causes the surface of the photoreceptor drum 21 to be worn away, unclear copied images are more likely produced This occurs particularly under the condition of high temperatures.

In order to overcome such problems, as is disclosed in the Japanese Publication for an Unexamined Patent Application No. 149668/1988 (Tokukaisho 63-149668), in recent years, a charging device of a different type has been proposed. In this charging device, a charging roller is disposed in contact with the surface of a photoreceptor drum and the drum surface is charged by applying a voltage to the photoreceptor drum through the charging roller. However, when a photosensitive layer on the photoreceptor drum is worn away due to abrasion, the surface potential of the photoreceptor drum increases. As a result, the condition of the photoreceptor drum, components placed around the photoreceptor drum and developer deteriorates. Therefore copied images of good quality can not be produced constantly.

SUMMARY OF THE INVENTION

One object of the present invention is to provide a charging device which always keeps the surface potential of a photoreceptor sustained at a set value irrespective of wear of the photosensitive layer coating the surface of a photoreceptor.

In order to achieve the above object, a charging device of the present invention at least includes the following means, shown in Fig. 1.

a) a charging member disposed in contact with the photosensitive layer on the surface of a photoreceptor drum;

b) detection signal outputting means for outputting a signal indicating a change in the thickness of the photosensitive layer; and

c) voltage control means which controls the voltage to be applied to the charging member upon a detection signal from the detection signal outputting means so as to approximate the surface potential of the photoreceptor drum to a set value.

With this configuration, the voltage control means approximates the surface potential of the photoreceptor drum to a set value by controlling the voltage to be applied to the charging member according to a detection signal indicating a change in the thickness of the photosensitive layer, transmitted from the detection signal outputting means to the voltage control means.

Consequently, the surface potential of the photoreceptor drum is always maintained at a uniform value irrespective of wear of the photosensitive layer. This prevents the photoreceptor drum and components located around the photoreceptor drum from deteriorating. It is therefore possible to produce copies of good quality continuously.

For a fuller understanding of the nature and advantages of the invention, reference should be made to the following detailed description taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a block diagram illustrating the structure of a charging device of the present invention.

Fig. 2 is a front view illustrating essential parts of a copying machine according to one embodiment of the present invention.

Fig. 3 is an explanatory view illustrating a photoreceptor drum constituting the copying machine.

Fig. 4 is a graph illustrating the relation between the number of copies produced and the thickness of the CTL on the photoreceptor drum.

Fig. 5 is a graph illustrating the relation between the thickness of the CTL and the surface potential of the photoreceptor drum.

Fig. 6 is an explanatory view illustrating a voltage applied to the minute clearance between the photoreceptor drum and a charging roller.

Fig. 7 is a graph illustrating the Paschen's discharge characteristics.

Fig. 8 is a block diagram illustrating a charging device having a variable DC power source.

Fig. 9 is a block diagram illustrating a charging device according to another embodiment of the present invention.

Fig. 10 is a front view illustrating essential parts of a conventional copying machine.

DESCRIPTION OF THE EMBODIMENTS

One embodiment of the present invention is described below with reference to Figs. 2 through 8. This embodiment shows a charging device which is used with a copying machine.

The copying machine of this embodiment has a photoreceptor drum 1, shown in Fig. 3, as photoreceptor The photoreceptor drum 1 includes a cylindrical drum base 1a which is made of aluminum having a thickness T_1 of 1 mm. The external surface of the drum base 1a is covered with a CGL (carrier generation layer) 1b of a thickness T_2 of 1 μm and then with a CTL (carrier transmission layer) 1c of a thickness T_3 of 20 μm. The CGL 1b and CTL 1c form a photosensitive layer.

In the device, as illustrated in Fig. 2, the photoreceptor drum 1 is driven to rotate in the A direction and, when an original document is scanned, the external surface of the photoreceptor drum 1 is exposed to reflected light R from the document at exposure point B. A developing unit 2 with a magnet roller 2a, a sheet transporting path 3, a transfer roller 4, a cleaning unit 5 with a blade 5a, an erase lamp 6, and a charging roller 7 are disposed around the photoreceptor drum 1 serially from the exposure point B in the A direction. The transfer roller 4 and the charging roller 7 as charging means are respectively disposed in contact with the external surface of the photoreceptor drum 1.

The charging roller 7 is made of a rubber roller with a diameter of 12 mm, and charges the surface (photosensitive layer) of the photoreceptor drum 1 to a set potential. The developing unit 2 develops an electrostatic latent image, which is formed by exposure at the exposure point B, into a toner image with developer. The transfer roller 4 is made of a sponge roller with a diameter of 14 mm, and transfers the toner image to a sheet P supplied from the sheet transport path 3. The cleaning unit 5 collects any toner remaining on the surface of the photoreceptor drum 1. The erase lamp 6 removes any remaining charges on the surface of the photoreceptor drum 1.

The following explains the relation between a reduction in the thickness T_3 of the CTL 1c of the photoreceptor drum 1 and the copying operation in the copying machine.

The main factor in the reduction in the thickness T_3 is abrasion of the photoreceptor drum 1 which is caused by an antistatic agent included in the developer in the developing unit 2 and the blade 5a of the cleaning unit 5. Such abrasion occurs because the magnetic particles of magnetite forming the antistatic agent function as abrasive powder when they are removed from the surface of the photoreceptor drum 1 with the blade 5a. Reductions in the thickness T_3 of the CTL 1c were measured with respect to the copying operation, i.e., with respect to the number of copies produced, and the results are shown in Table 1 and the graph of Fig. 4.

Table 1

number of copies produced (sheet)	thickness of CTL (μm)
start 0	20.0
17 k	18.0
45 k	14.9
55 k	13.5
72 k	12.2
(k: × 10^3)	

It can be seen from Table 1 and Fig. 4 that the thickness of the CTL decreases about 1 μm every 10000 copies. However, the rate of decrease varies depending on the type of a binding resin used for forming the CTL of a photoreceptor drum. For example, Table 2 shows the wear rate (the relative amount of decrease in the thickness) of two types of CTLs, types A and B, with respect to the wear rate of the CTL 1c of the present invention denoted as type C. The CTLs of types A, B and C are formed by a styrene acrylic binder resin, a polycarbonate binder resin, and a modified polycarbonate resin, respectively.

Table 2

type	binder	wear rate
type A	styrene acrylic resin	2.0
type B	polycarbonate resin	1.5
type C	modified polycarbonate resin	1.0

Changes in the surface potential of the photoreceptor drum 1 were measured with respect to the decrease in the thickness T_3 of the CTL 1c under a condition where the current flowing into the charging roller 7 was set at -5 μA by setting the resistance of the charging roller 7 at $10^7\,\Omega$ and the applied voltage from the DC power source to the charging roller 7 at -1.2 kV. The results are shown in Table 3 and the graph of Fig. 5.

Table 3

thickness (μm)	measured value of the surface potential of photoreceptor drum (-V)
20.0	650
18.0	670
14.9	702
13.5	716
12.2	730

Table 3 and Fig. 5 show that the surface potential rises around 10 V per μm reduction in thickness.

According to Paschen's law,

$$V_c = V_a - V_{TH} \qquad (1)$$

where V_a is the voltage applied to the charging roller 7, V_c is the surface potential of the photoreceptor drum 1, and V_{TH} is the starting voltage for charging the photoreceptor drum 1.

A voltage V_g which is applied to a minute clearance S between the charging roller 7 and the photoreceptor drum 1, shown in Fig. 6, is given by:

$V_g = (V_a - V_c)Z / (T_3 / K + Z)$ (2)

where Z is the width of the clearance S, and K is the dielectric constant of the CTL 1c. According to Paschen's discharge characteristic curve shown in Fig. 7, when the clearance S is substantially in the range of 8 µm to 100 µm, a breakdown voltage V_b at the clearance S is given by an approximation

$V_b = 312 + 6.2Z$ (3)

The charged portion is estimated from the intersections of equations (2) and (3). Then, if $V_g = V_b$, a value of the starting voltage V_{TH} for charging the photoreceptor drum 1 is given theoretically by finding equal roots. In the calculation for obtaining the starting voltage V_{TH}, the dielectric constant K of the CTL 1c is 3.

From the equations (2) and (3), an equation is expressed

$(V_a - V_c)Z / (T_3 / 3 + Z) = 312 + 6.2Z$ (4)

Then, quadratic equation (5) is written.

$6.2Z^2 - (V_a - V_c - 312 - 2.07T_3)Z + 104T_3 = 0$ (5)

And, Z is given by using the formula:

$Z = \{- b \pm (b^2 - 4ac)^{1/2}\} / 2a$ (6)

If a equals 6.2, b equals $-(V_a - V_c - 312 - 2.07T_3)$ and c equals $104T_3$, there are two roots. These values correspond to two clearances where a charge shift and a breakdown of an air insulation start, respectively. The smaller value is excluded according to the Paschen's equation, $Z \geqq 8$ µm. Thus, the greater value becomes a single root.

Since $b^2 = 4ac$ is a condition for the charge shift, equation (7) is expressed.

$(V_a - V_c - 312 - 2.07T_3)^2 = 4 \times 6.2 \times 104T_3$ (7)

From equations (1) and (7), a value of the starting voltage V_{TH} is given theoretically by:

$$V_{TH} = V_a - V_c$$
$$= 50.8(T_3)^{1/2} + 2.07T_3 + 312 \quad \ldots (8)$$

Then equation (8) is modified into theoretical equation (9) for obtaining the surface potential V_c of the photoreceptor drum 1.

$V_c = V_a - 50.8(T_3)^{1/2} -2.07T_3 - 312$ (9)

The relation between the thickness T_3 of the CTL 1c and the number of copies produced is written with an empirical equation:

$T_3 = \beta - \alpha X$ (10)

where X is the number of copies produced, β is the initial thickness (µm) of the CTL1c, α is a constant determined by the photoreceptor drum 1 or other factor, and $\alpha X < \beta$. From equations (8) and (10), a value of the starting voltage V_{TH} for charging the photoreceptor drum 1 is given theoretically in relation to a reduction in the thickness T_3 of the CTL 1c. And, the surface potential V_c of the photoreceptor drum 1 with respect to reductions in the thickness T_3 of the CTL 1c was theoretically calculated by substituting 1.2 k (-V) for the applied voltage V_a in equation (9) and equation (10). 1.2 k (-V) is the voltage applied to the charging roller 7 in the above-mentioned experiment. The results are shown in Table 4.

Table 4

thickness T_3 (μm)	theoretical value of surface potential V_c (-V)	theoretical value of starting voltage V_{TH} (-V)
20.0	650	580
18.0	666	564
14.9	691	539
13.5	704	526
12.2	716	514

From Table 4, it is theoretically proved that the starting voltage V_{TH} decreases around 8 V and the surface potential increases around 8 V, respectively, per μm reduction in the thickness T_3. Moreover, it can be seen that the theoretical values of the surface potential are substantially equal to the surface potential measured, shown in Table 3.

Therefore, in the copying machine of this embodiment, as illustrated in Fig. 8, a charging device of the present invention is constituted by the counter 11 as detection signal outputting means, the charging roller 7, and the variable DC power source 10 and a microcomputer 12 as voltage control means for controlling the voltage to be applied to the charging roller 7.

The counter 11 counts the number of copies which have been produced, and transmits to the microcomputer 12 an information signal indicating the number of copies produced as a detection signal indicating a change in the thickness T_3.

When the detection signal is input into the microcomputer 12, it calculates a voltage to be applied to the charging roller 7 by equations (9) and (10) for correction so that the surface potential V_c of the photoreceptor drum 1 is maintained at a set value. It also controls the variable DC power source 10 so that the calculated voltage is applied to the charging roller 7. The set value is equal to the surface potential of the photoreceptor drum 1 at the starting time where any copy has not yet been made.

As described above, the charging device of this embodiment has the charging roller 7 installed in contact with the surface of the photoreceptor drum 1, the variable DC power source 10 for applying a variable voltage to the charging roller 7, the counter 11 for outputting an information signal indicating the number of copies produced as a detection signal indicating a change in the thickness T_3, and the microcomputer 12 which controls the voltage to be applied to the charging roller 7 by the variable DC power source 10 upon the detection signal from the counter 11.

In the charging device, the voltage to be applied to the the charging roller 7 is lowered according the wear of the CTL 1c of the photoreceptor drum 1 which increases as the number of copies produced increases. This enables the surface potential of the photoreceptor drum 1 to be maintained at a uniform value. Consequently it is possible to produce copies of good quality continuously.

Since the present invention is not restricted to the above-mentioned embodiment, various changes may be made within the scope of the invention. For example, in this embodiment, the counter 11 is provided as detection signal outputting means for outputting a detection signal indicating a change in the thickness of the photosensitive layer. However, this is merely one instance, and therefore any other detecting means may be provided if they can detect a change in the thickness of the photosensitive layer directly and output it as a detection signal.

Another embodiment of the present invention is described below. Except for the erase lamp 6, variable DC power source 10 and microcomputer 12, the structure of the charging device of this embodiment is the same as that of the above mentioned embodiment, and therefore omitting explanations of the members which are employed in both the above-mentioned embodiment and this embodiment. Equations (9) and (10) are also used in this embodiment.

As illustrated in Fig. 9, the charging device of this embodiment is constituted by the charging roller 7 installed in contact with the surface of the photoreceptor drum 1, an erase lamp 6' as erase means, a DC power source 10', the counter 11 as detection signal outputting means for outputting a detection signal indicating a change in the thickness of a photosensitive layer, and a microcomputer 12' as erasing control means.

The DC power source 10' constantly applies a uniform voltage to the charging roller 7 during a copying operation.

The erase lamp 6' removes any charges remaining on the surface of the photoreceptor drum 1 by illuminating erase light D to the photosensitive layer of the photoreceptor drum 1, while the microcomputer 12' varies the luminance of the erase light D.

When a detection signal indicating a change in the thickness of the photosensitive layer is output from the counter 11 and input into the microcomputer 12', the luminance of the erase light D is increased according to the equations (9) and (10) for correction so as to approximate the surface potential V_c of the photoreceptor drum 1 to a set value. The erase lamp 6' lowers the potential for charging the photoreceptor drum 1 by increasing the luminance of the erase light D. As a result, the surface potential of the photoreceptor drum 1, which tends to rise as the thickness of the CTL 1c of the photoreceptor drum 1c decreases, is kept uniform.

As described above, the charging device of this embodiment has the charging roller 7 installed in contact with the surface of the photoreceptor drum 1, the erase lamp 6' for illuminating the erase light D of variable luminance, the DC power source 10' for applying a uniform voltage to the charging roller 7, the counter 11 for outputting an information signal indicating the number of copies produced as a detection signal indicating a change in the thickness of the photosensitive layer, and a microcomputer 12' which controls the luminance of the erase light D upon the detection signal from the counter 11.

In the charging device, the luminance of the erase light D is increased according to wear of the CTL 1c of the photoreceptor drum 1 which increases as the number of copies produced increases. This arrangement enables the surface potential of the photoreceptor drum 1 to be kept uniform. Consequently, it is possible to produce copies of good quality continuously.

In this embodiment, the surface potential of the photoreceptor drum 1 is kept uniform by increasing the luminance of the erase light D while lowering the potential for charging the photoreceptor drum 1. However, it is also possible to lower the potential by changing the wavelength of the erase light D. In this case, the erase lamp 6' may be replaced with a member which can maintain the surface potential of the photoreceptor drum 1 uniform by controlling the wavelength of the erase light D with the microcomputer 12'.

Since the present invention is not restricted to the above-mentioned embodiment, various changes may be made within the scope of the invention. For example, in the embodiment, the erase lamp 6 for erasing any remaining charges on the surface of the photoreceptor drum 1 functions as erase means. However, this is merely one instance, and therefore an erase lamp and erase means may be provided separately.

The invention being thus described, it will be obvious that the same may be varied in many ways. Such variations are not to be regarded as a departure from the spirit and scope of the invention, and all such modifications as would be obvious to one skilled in the art are intended to be included within the scope of the following claims.

Claims

1. A charging device comprising:

charging means, disposed in contact with a photosensitive layer on a photoreceptor, for charging said photosensitive layer;

detection signal outputting means for outputting a detection signal indicating a change in the thickness of said photosensitive layer; and

voltage control means for controlling a voltage to be applied to said charging means for charging said photosensitive layer according to the detection signal from said detection signal outputting means so as to approximate the surface potential of said photoreceptor to a set value.

2. The charging device according to claim 1, wherein said voltage control means controls the voltage to be applied to said charging member based on correction formulas which are established so as to lower the voltage according to a reduction in the thickness of said photosensitive layer indicated by the detection signal.

3. The charging device according to claim 1, wherein said photoreceptor is a rotary photoreceptor drum, and said charging means is a charging roller which rotates when said photoreceptor drum rotates.

4. The charging device according to claim 1, wherein said detection signal outputting means includes a counter for outputting an information signal indicating the number of copies produced as a detection signal indicating a change in the thickness of said photosensitive layer.

5. The charging device according to claim 1, wherein said detection signal outputting means includes detecting means for directly detecting a reduction in the thickness of said photosensitive layer and for outputting a detection signal indicating the reduction.

6. The charging device according to claim 1, wherein said voltage control means includes:
a power source for applying a voltage to said charging means; and
a microcomputer for controlling the voltage to be applied to said charging means by said power source according to a detection signal input thereto from said detection signal outputting means.

7. The charging device according to claim 6, wherein said power source is a variable DC power source.

8. A charging device comprising:
charging means disposed in contact with a photosensitive layer on the surface of a photoreceptor;
detection signal outputting means for outputting a detection signal indicating a change in the thickness of said photosensitive layer;
erase means capable of changing the luminance or the wavelength of erase light; and
erasing control means for controlling the erase light according to the detection signal from said detection signal outputting means so as to approximate the surface potential of said photoreceptor to a set value

9. The charging device according to claim 8, wherein said erasing control means controls said erase means based on correction formulas which are established so as to raise the luminance of the erase light according to a reduction in the thickness of said photosensitive layer indicated by the detection signal.

10. The charging device according to claim 8, wherein said erase means is an erase lamp for erasing any remaining charges on the surface of said photoreceptor.

FIG. 1

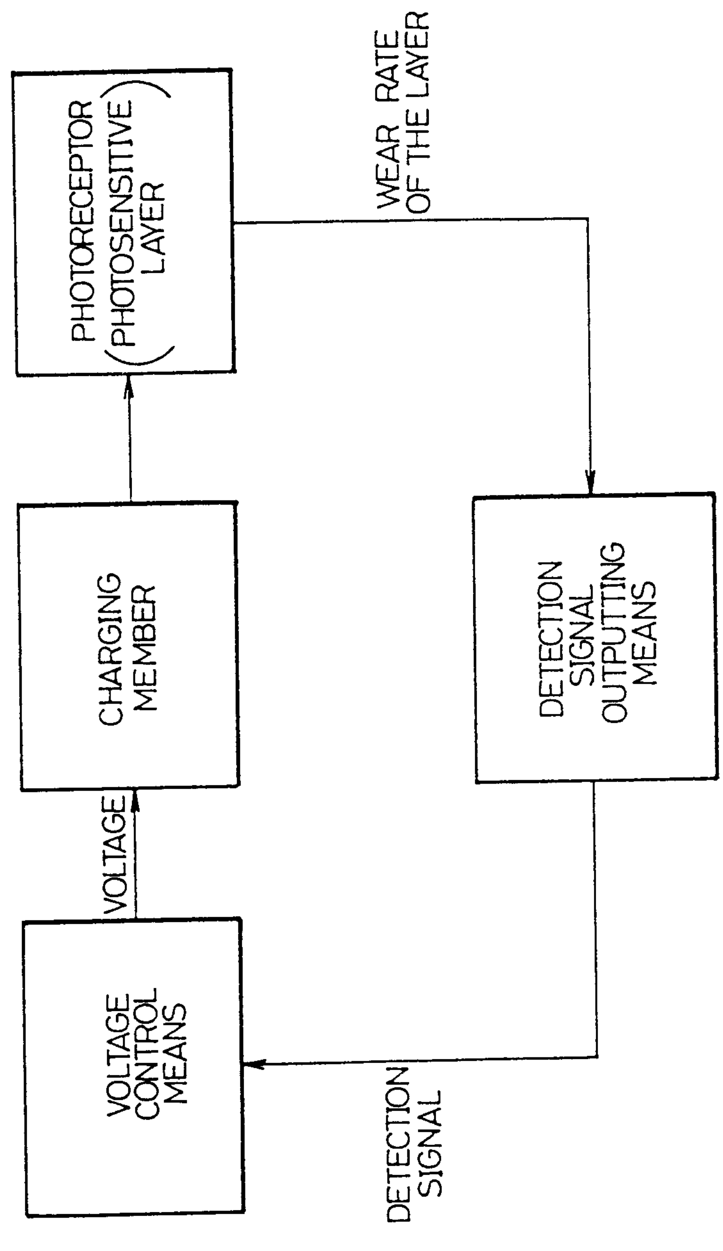

PHOTORECEPTOR (PHOTOSENSITIVE LAYER)
CHARGING MEMBER
VOLTAGE
VOLTAGE CONTROL MEANS
WEAR RATE OF THE LAYER
DETECTION SIGNAL OUTPUTTING MEANS
DETECTION SIGNAL

FIG. 2

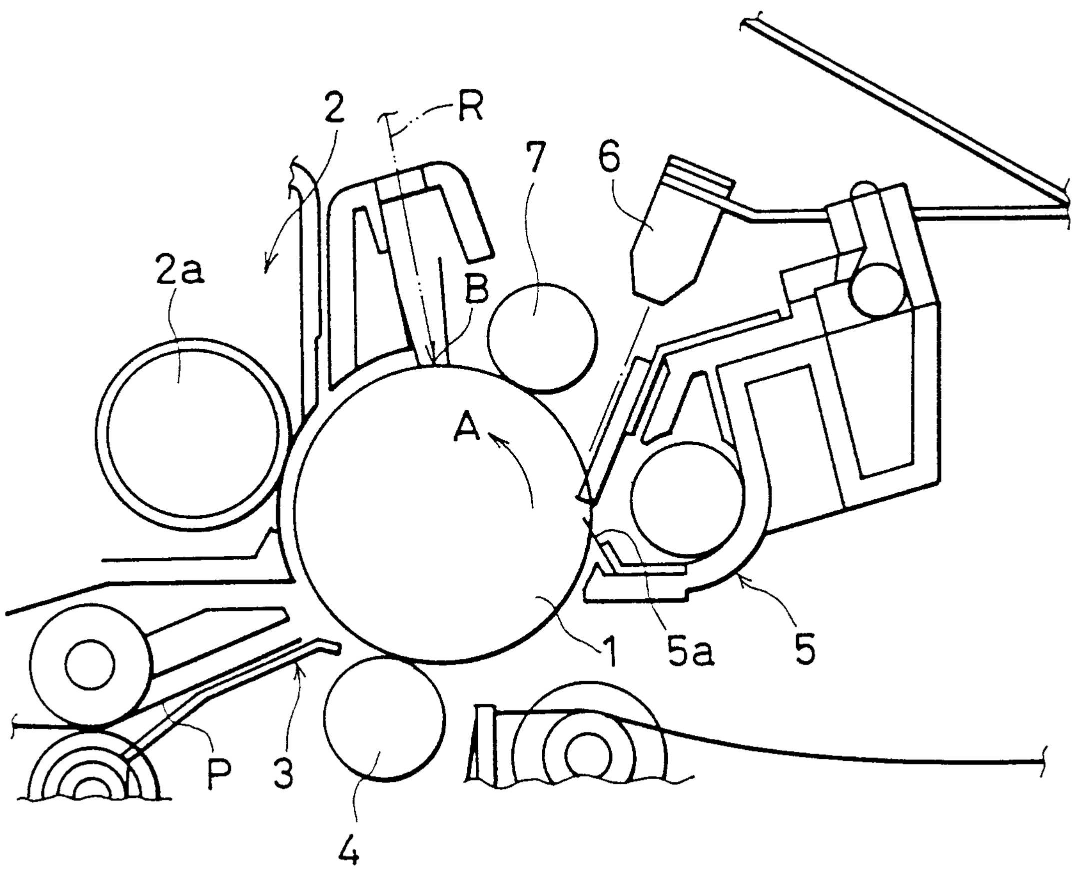


FIG. 3

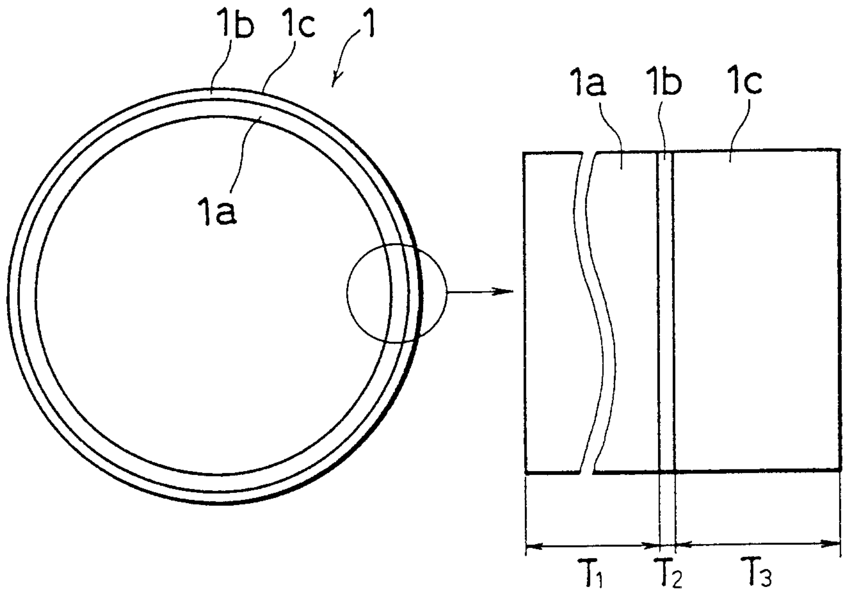

1b
1c
1
1a
1a
1b
1c
T_1
T_2
T_3

FIG. 4

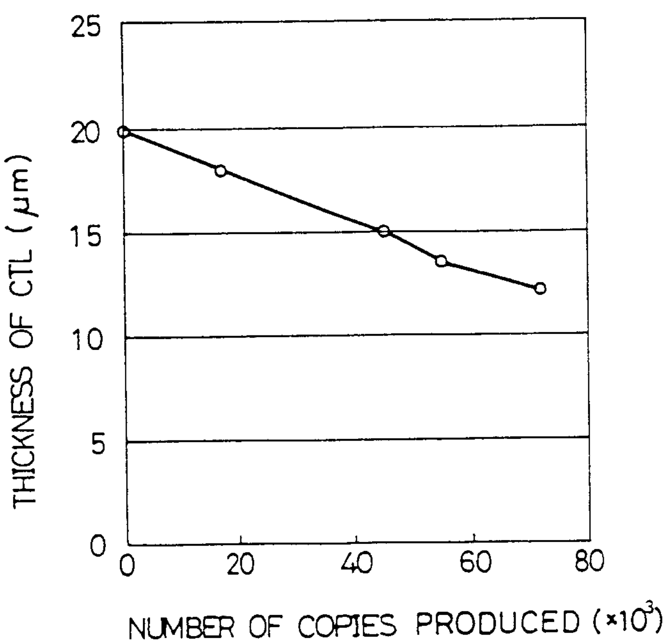

THICKNESS OF CTL (μm)
25
20
15
10
5
0
0
20
40
60
80
NUMBER OF COPIES PRODUCED (×10³)

FIG. 5

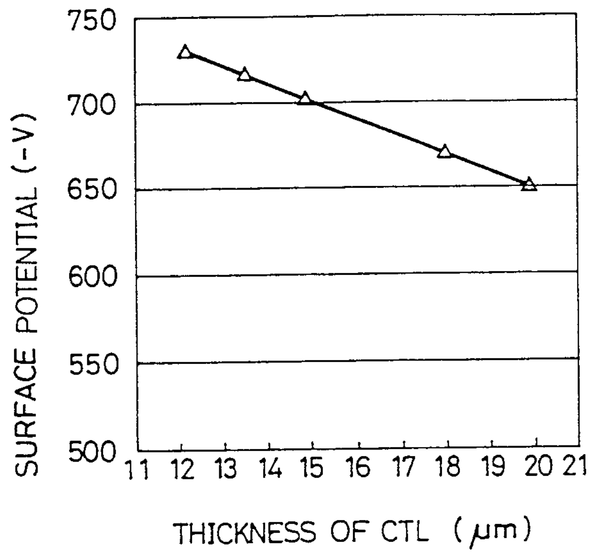

SURFACE POTENTIAL (-V)
750
700
650
600
550
500
11 12 13 14 15 16 17 18 19 20 21
THICKNESS OF CTL (μm)

FIG. 6

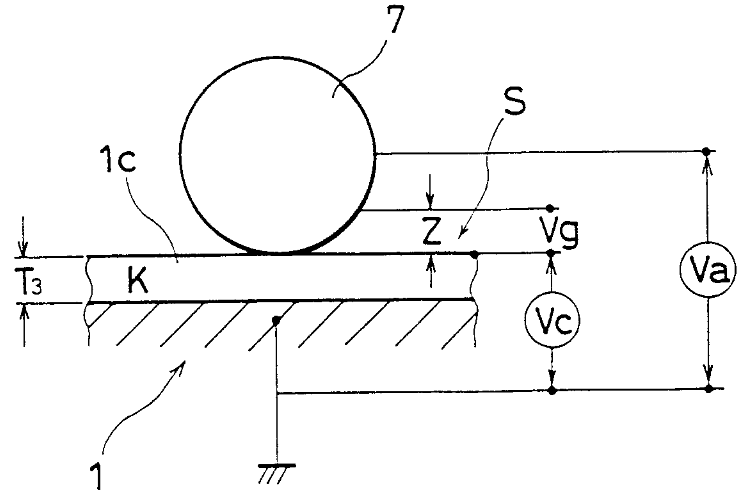

7
S
1c
Z
Vg
Va
T3
K
Vc
1

FIG. 7

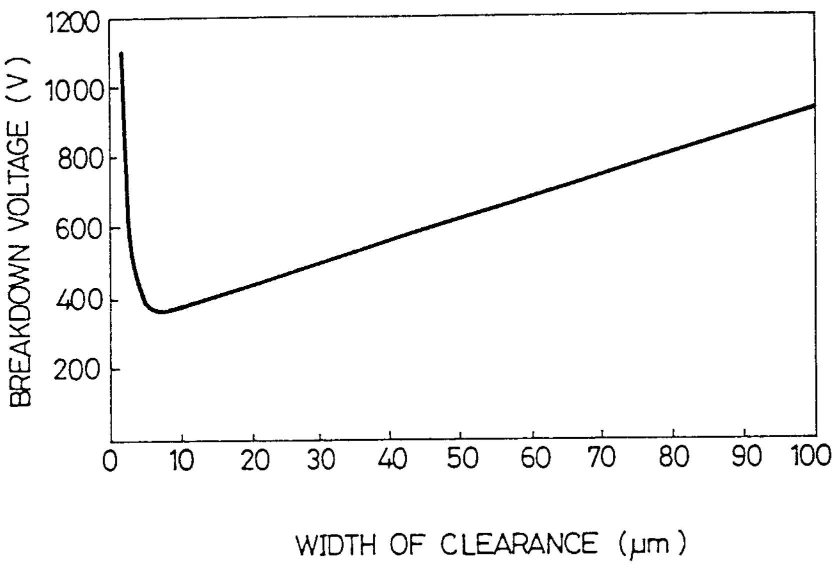

1200
1000
800
600
400
200
BREAKDOWN VOLTAGE (V)
0
10
20
30
40
50
60
70
80
90
100
WIDTH OF CLEARANCE (μm)

FIG. 8

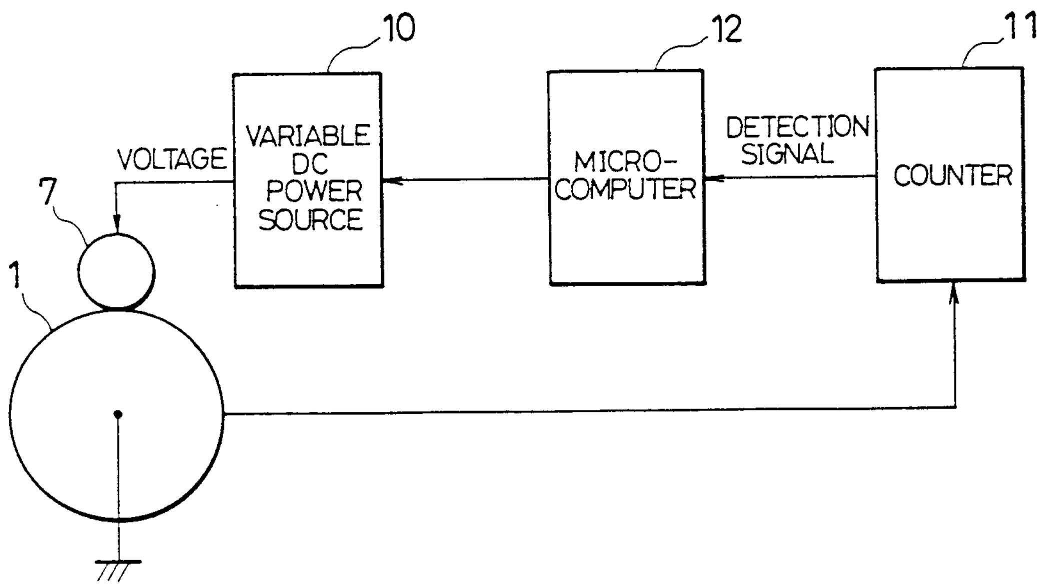

10
12
11
VOLTAGE
VARIABLE DC POWER SOURCE
MICRO-COMPUTER
DETECTION SIGNAL
COUNTER
7
1

FIG. 9

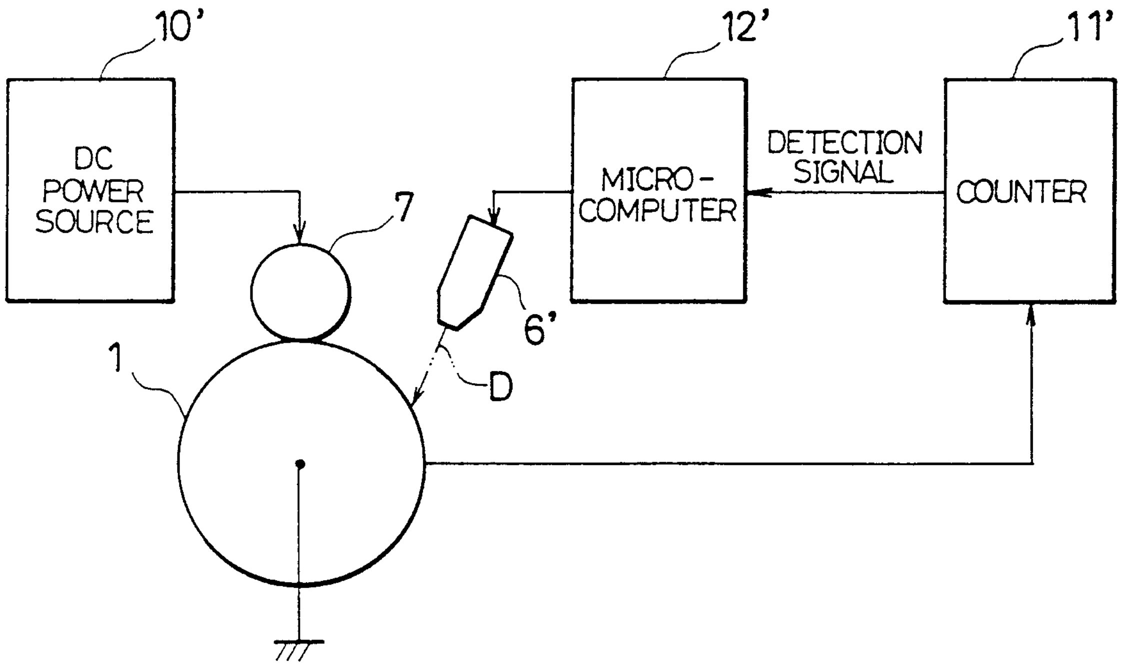

10'
DC
POWER
SOURCE
12'
MICRO-
COMPUTER
DETECTION
SIGNAL
11'
COUNTER
7
6'
1
D

FIG. 10