# United States Patent [19]

**Bock**

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[54] **METHOD OF MEASURING THE TONER CONCENTRATION OF A DEVELOPER CIRCULATING IN AN ELECTROPHOTOGRAPHIC REPRODUCTION MACHINE**


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[52] **U.S. Cl.** ..... **73/150 R;** 96/1 SD; 118/637; 355/3 DD; 356/212; 96/1 R; 346/74 ES

[51] **Int. Cl.²** ..... **G03G 15/08**

[58] **Field of Search** ..... 96/1 SD, 1 R; 118/637; 356/209, 212; 355/3 DD; 117/17, 17.5



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[57] **ABSTRACT**

A method of measuring or measuring and controlling the toner concentration of a developer circulating in an electrophotographic reproduction machine wherein a test charge pattern based on toner concentration is formed independent of the photoconductor, the test charge pattern is developed together with the photoconductor exposed to produce an image, optical properties of the developed test charge pattern are measured and toner is added to the developer based upon the measurement. An apparatus including electrodes for producing a test charge pattern which are so arranged in the electrophotographic reproduction machine that together with the photoconductor they can be moved past the operative devices in the electrophotographic cycle, sliding contact rings and/or wiper contacts for applying potential to the electrodes from a voltage source and comparative light beams from the same source for carrying out the measurement of a developed test charge pattern. One of the beams is affected by the developed test charge pattern while the other is an unaffected reference beam. The apparatus also may include a controlling device for the addition of toner to the developer which is responsive to the optical property of the test charge pattern.


**4 Claims, 6 Drawing Figures**

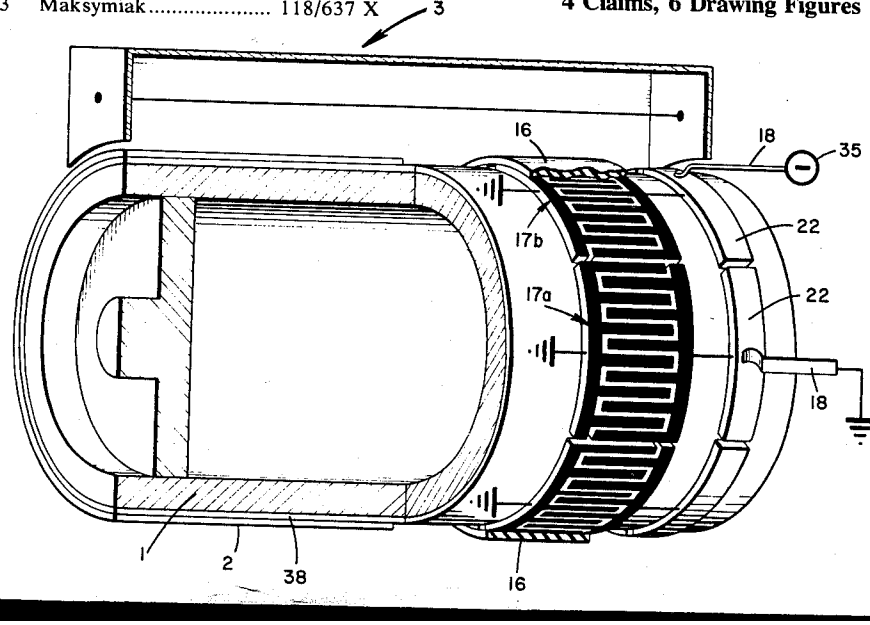
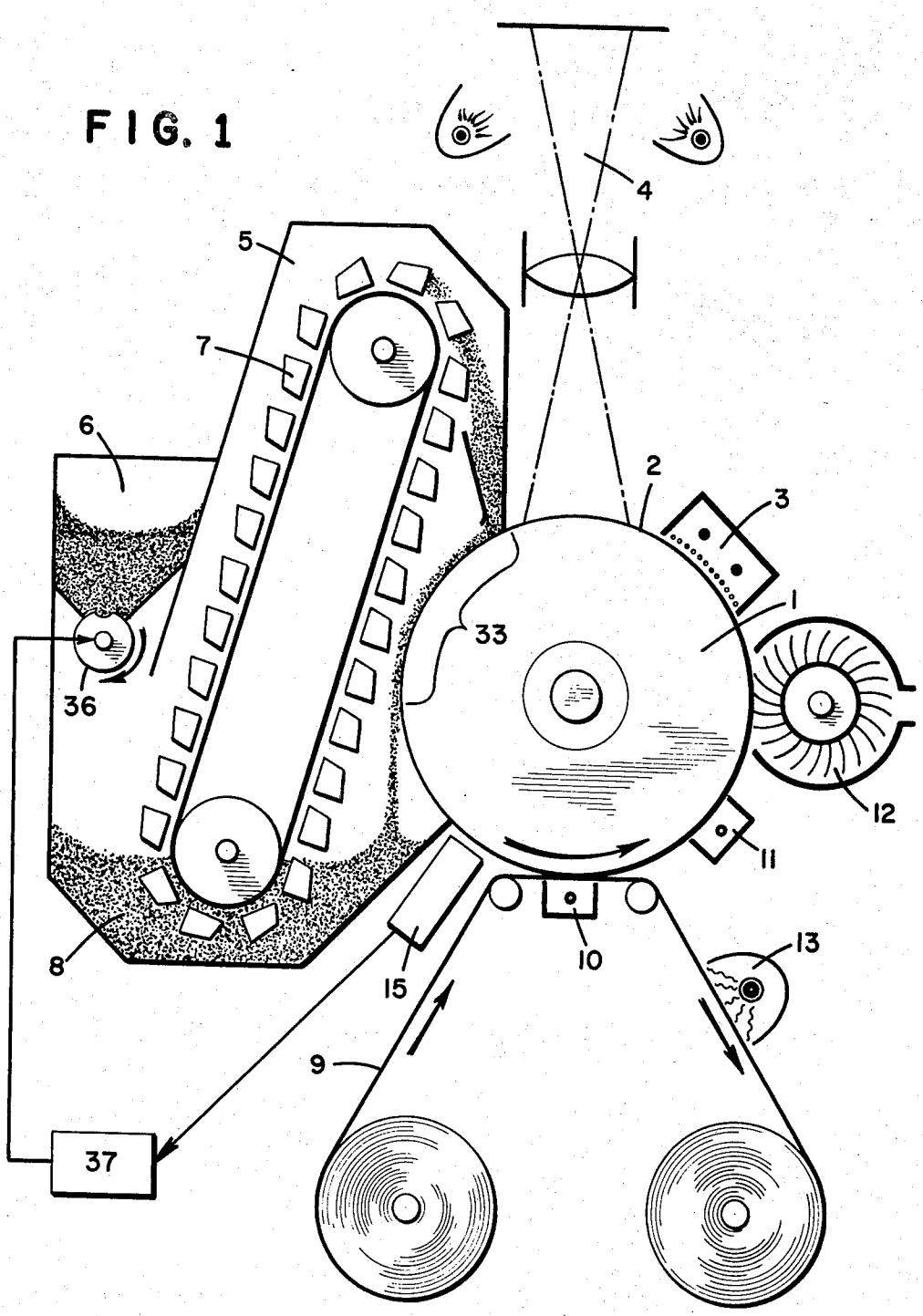


FIG. 1



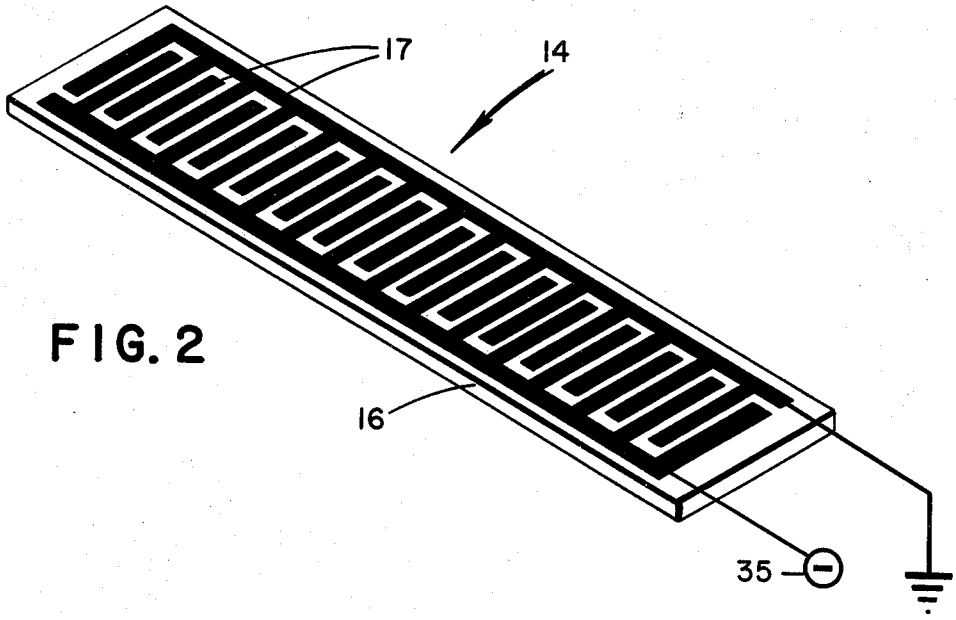



FIG. 2

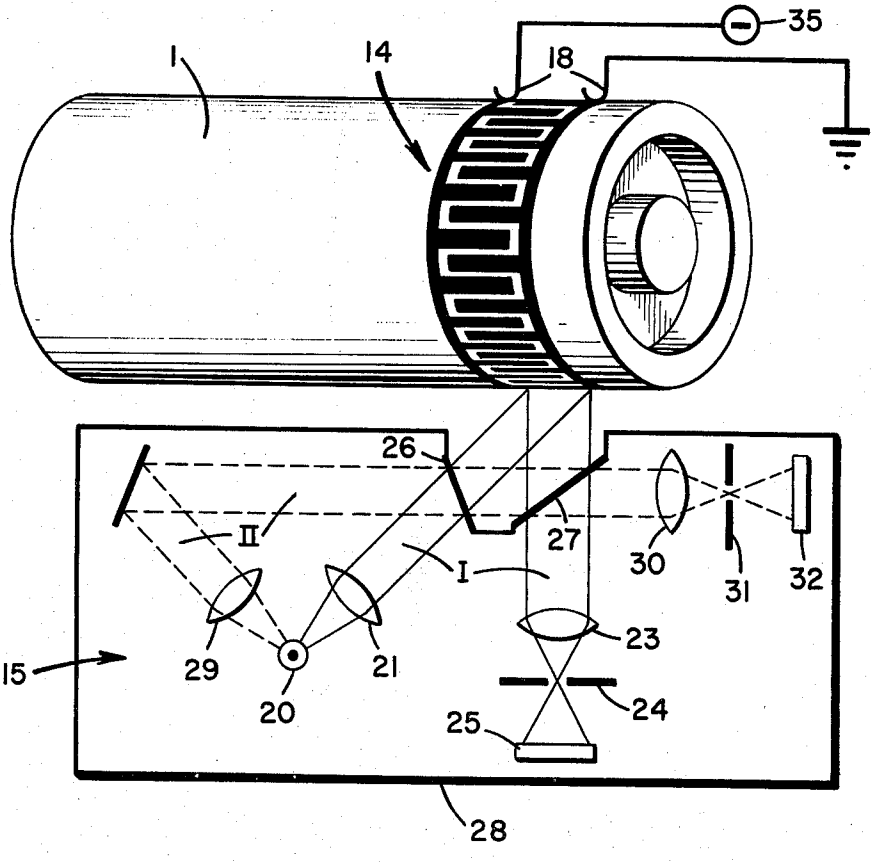



FIG. 3

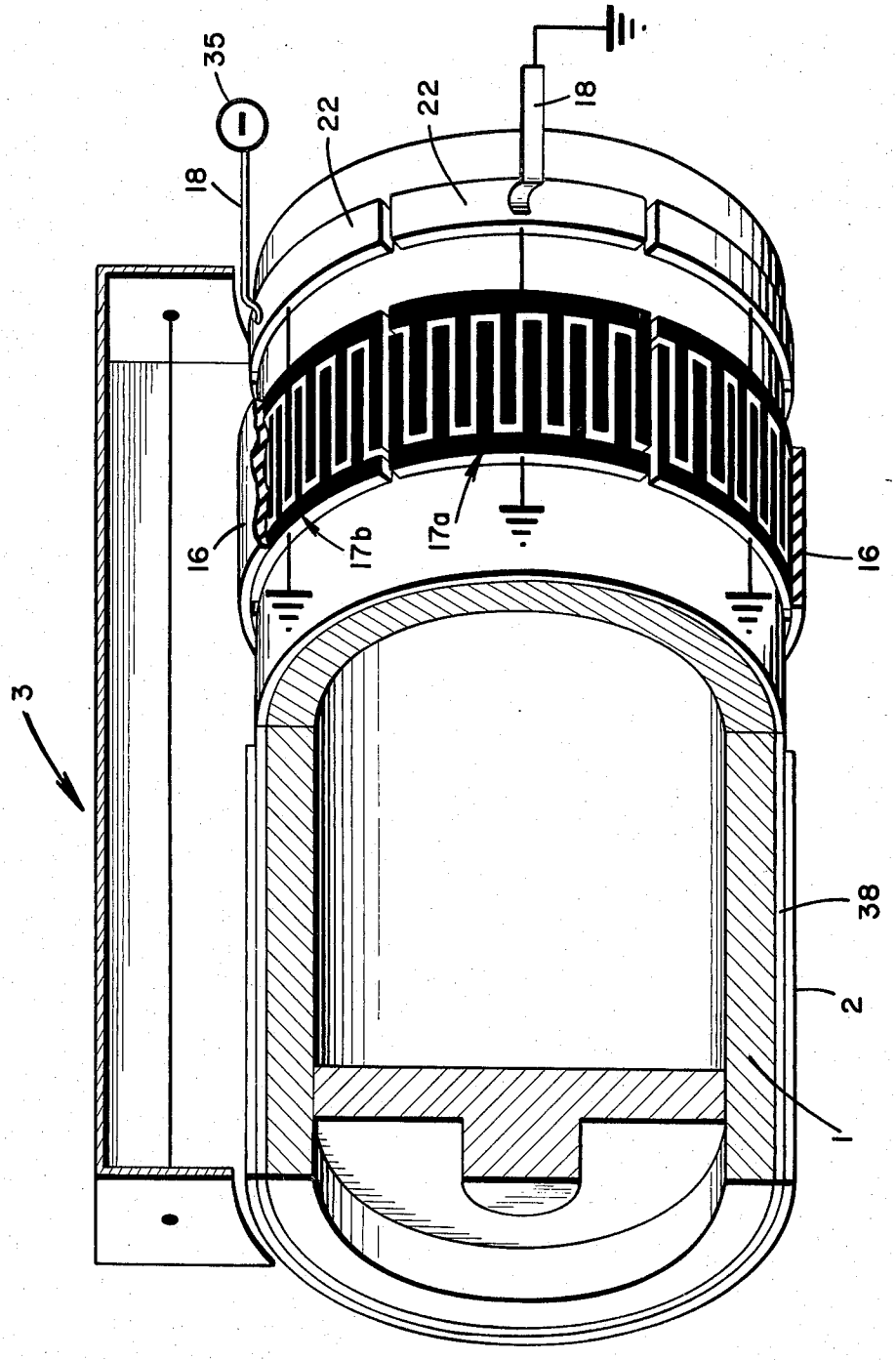



FIG. 4

FIG. 5

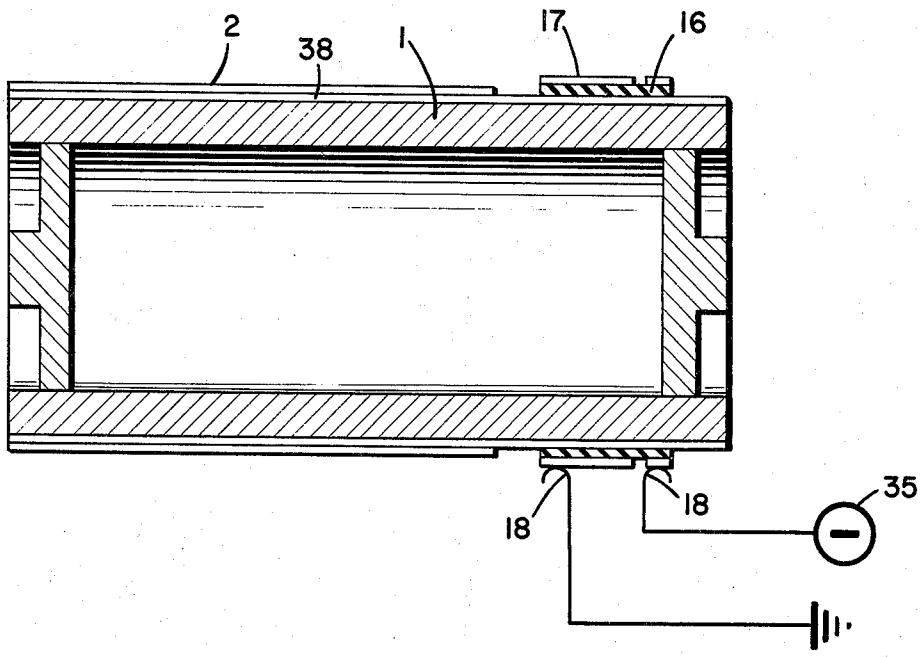
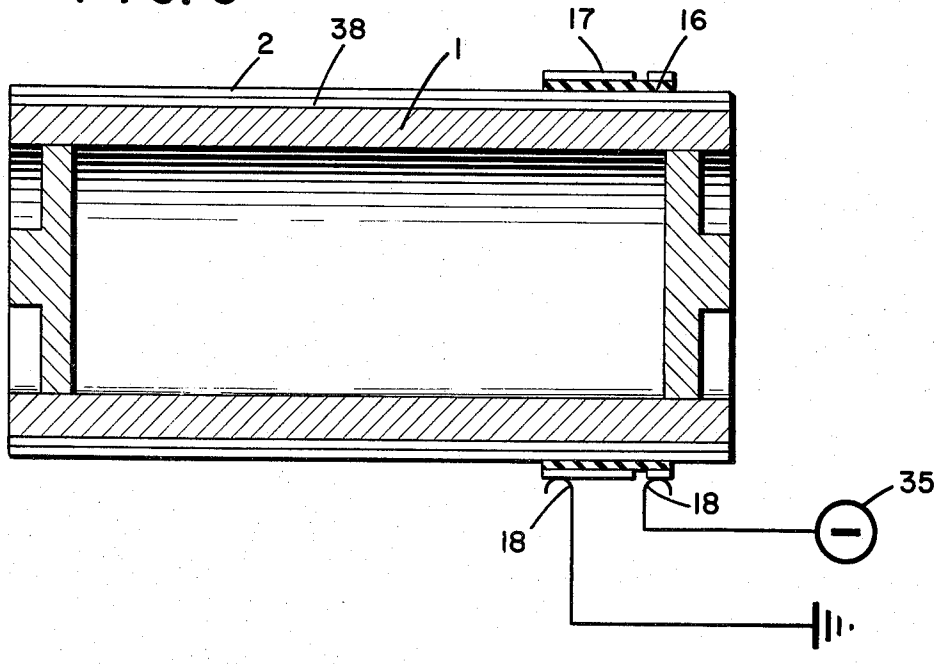



FIG. 6



# METHOD OF MEASURING THE TONER CONCENTRATION OF A DEVELOPER CIRCULATING IN AN ELECTROPHOTOGRAPHIC REPRODUCTION MACHINE

This invention concerns a method of and apparatus for measuring or measuring and controlling the toner concentration in electrophotographic reproduction machines.

In electrophotographic reproduction machines the images are now usually developed with developers which generally consist of two components: the toner and the carrier. The toner may be a colored synthetic resin powder and the carrier a granular material consisting of glass, or iron coated with synthetic resin. The carrier is used for carrying the toner and in charging it triboelectrically. In the case of liquid developers, the toner is finely distributed in a liquid having a high specific resistance. The toner is used for inking up the copies. The toner is used up at a varying rate during developing, depending upon the nature and number of the copies. Further amounts of toner must be added in order to keep the inking up effect as constant as possible. For the purpose of controlling the toner concentration in the toner-carrier mixture, it is necessary to measure the change in toner concentration and to regulate a further supply of toner in accordance with the measured values obtained.

Various optical methods of measuring toner concentration are known. One of these methods consists in measuring the reflection from the developed, i.e., toner-covered photoconductor. In accordance with another known method, this measurement can be carried out with the aid of a test image which is located at the edge of the photoconductor and on to which light is directed. In a second group of measuring methods, the reflection is measured from a toner-covered electrode, not participating in the actual electrophotographic cycle.

The first-mentioned known methods have the disadvantage that the measurements are dependent upon the properties of the photoconductor and upon the charge and the type of exposure. Restandardization may become necessary when the photoconductor, the corona voltage and/or the lamps are changed. The methods of the second group have the disadvantage that the application of the toner does not occur under the same conditions as in the actual development of the photoconductor. There thus exists the danger of the measurement indicating a proportion of toner that is different from that present in the developer.

The object of the present invention is therefore to provide a method of and apparatus for measuring or measuring and controlling the toner concentration, in which the measurements can be carried out in the reproduction machine in a manner which is to a far reaching extent independent of the parameters of the photoconductor, of the exposure and, if necessary, of the characteristics of the charging means.

The invention accordingly provides in the first place a method of measuring or measuring and controlling the toner concentration of a developer circulating in an electrophotographic reproduction machine, in which method

a. a test charge pattern based on the said toner concentration is formed, which pattern is one that is independent of the photoconductor of the machine,
b. this test charge pattern is developed together with the photoconductor exposed to produce an image,
c. one or more optical properties of this developed test charge pattern are measured and
d. in any subsequent controlling step, based on the said measurement a quantity of further toner is added to the developer to raise the measured toner content to the required value.



The invention further provides an apparatus for use in the method of the invention, said apparatus including at least one electrode for producing the said test charge pattern, said electrode or electrodes being so formed and arranged in an electrophotographic reproduction machine containing a photoconductor, that together with the photoconductor it or they can be moved past the various operative devices in an electrophotographic cycle, and further including means for applying potential to the electrode or electrodes and means for determining an optical property of a test charge pattern after development thereof.

The method of the invention offers the particular advantage that the toner concentration is measured, on the one hand, by reference to a toner treatment that is identical to that used for developing the image, and on the other hand independently of the other parameters of the electrophotographic reproduction cycle. Furthermore, the method of the invention is not complicated, and the apparatus of the invention can be incorporated without any great difficulty in electrophotographic equipment of the kind now manufactured on a mass-production scale. The apparatus and the method of the invention are suitable for developing the charge image on the photoconductor by means of a liquid.

That form of the method of the invention in which charged metal electrodes themselves are used as the test charge pattern and are developed together with the photoconductor exposed in the manner to produce an image, carries the advantage that it is also completely independent of the corona charge. Etching and vaporization processes for producing the electrodes on insulating carrier material have reached a relatively advanced stage of development, and it is possible to produce appropriate electrodes which are able to withstand the mechanical stresses occurring in the electrophotographic method for at least as long as the photoconductor.

However, the method of the invention can also be used when the electrodes are coated with a layer of insulating material. In this case the layer of insulating material is charged, and the voltage conditions on the underlying electrodes are so varied in a prescribed manner that a test charge pattern corresponding to the electrodes is formed on the layer of insulating material.

The invention is illustrated by way of example in the accompanying drawings, in which:

FIG. 1 is a diagrammatic section of an electrophotophotographic reproduction machine with the measuring and controlling apparatus of the invention,

FIG. 2 is a perspective view of a measuring strip,

FIG. 3 is a part perspective, part diagrammatic illustration of the measuring apparatus,

FIG. 4 is a perspective view on a larger scale, partly in section, of part of the measuring apparatus,

FIG. 5 is a diagrammatic section of part of the measuring apparatus with a measuring strip disposed alongside a photoconductor, and

FIG. 6 is a similar view of a different embodiment.

Referring to the drawings, a photoconductor 2 which may be insulated from drum 1 by carrier 38 is electrically charged by a charging device 3, is exposed to the light from an exposure means 4 and is developed with the aid of developer 8 in a developing zone 33 in a developing device 5 consisting of a toner supply container 6 and a conveyor system 7. The developer device 5 may instead be of the kind designed to develop the charge image with the aid of a liquid. The toner image is transferred from the photoconductor 2 to paper 9 at a transfer device 10, and is fixed on the paper 9 at a fixing device 13. The photoconductor 2 is then discharged at a discharging unit 11 and is cleansed from toner by a cleaning device 12.

As shown in FIG. 3, a measuring strip 14 is located on the drum 1. This strip 4 is shown in the developed state in FIG. 2. It consists of a carrier strip 16, made for example of the material "HOSTAPHAN," on which two spaced, meshing electrodes 17 are provided. These electrodes can be formed, for example, by etching a metal coating applied to the insulating material, or by a metal-vaporization deposition technique. A charge pattern is produced with the aid of the measuring strip 14 in a manner to be hereinafter described, which pattern and the photoconductor are together subjected to precisely the same treatment in the electrophotographic reproduction machine. The degree of darkening by inking up of the developed charge pattern is measured in a measuring device 15. A controlling device 37 may be provided which, by means of a feed roller 36, supplies toner to the developer 8 whenever the darkening of the measuring strip 14 falls below a certain level.

The measuring strip 14 with the electrodes 17 can be used in different ways for producing the test charge pattern.

In a first procedure, as applied with the aid of the apparatus illustrated in FIG. 4, the electrodes 17 are nearer to the drum 1 than the carrier strip 16 and are insulated from the developing zone 33 of the drum. In this arrangement, a plurality of pairs of electrodes 17*a*, 17*b*, etc. are distributed over the periphery of the drum 1. The voltage from a voltage source 35 is applied to that pair of electrodes 17*b* that is for the time being located below the charging device 3 (e.g., a corona discharge device). The pair of electrodes 17*a* that has just moved into the developing zone 33, however, is electrically connected as indicated by the grounding of one of two wiper contacts 18. In this way a test charge pattern corresponding to the electrode pattern is produced in the developing zone 33 on that side of the strip 14 facing the developing device 5. It is here assumed that the creation of the test charge pattern is based on the following effect: a charge of the same potential is applied to the upper face of the carrier strip 16 with the aid of the charging device 3, whereas a differing potential is applied to the insulated underlying electrodes, so that a potential difference occurs between the electrodes. Each electrode and the associated charged zone of the carrier strip 16 form a "capacitor." The electrical fields or the electrical energies in the two geometrically identical "capacitors" are different because of the potential difference. When the electrodes are connected in the developing zone, a small displacement current flows. The potential difference at the individual "capacitor", or the electrical energy stored therein, remains constant. Thus the voltage difference that previously existed between the electrodes must now exist between the different zones of the charge, i.e., a charge pattern (a voltage pattern) has been created. This explanation is only tenative and may not be the correct one.

When the electrodes are connected, such a potential is suitably applied thereto that the resultant potentials of the charged zones on the carrier strip do not become excessively high, since otherwise spray-discharge losses, among other phenomena, will lead to errors in the measurements. It is advantageous if each common electrode potential is so selected that the level of the potential of the applied charges does not rise, but either falls in one of the zones opposite the electrodes and remains constant in the other, or falls in both zones.

Although in the procedure described, the test charge pattern is no longer influenced by the properties of the photoconductor, it is still dependent upon the characteristics of the charging device 3. This dependence is avoided by a second procedure. In this case the two electrodes 17 face outwards (FIGS. 3, 5 and 6). Voltage is continuously applied to the electrodes 17. The electrodes connected to the voltage source 35 constitute the charge pattern which is developed in the developing zone 33. Charging with a corona discharge device is no longer necessary, and the charge pattern is independent of the charging device 3. However, a corona charge is not inconvenient since it has no effect upon the test charge pattern and the degree of darkening. The test charge pattern produced is developed in a cascade unit 5, for example. The density resulting from the application of toner is a measure of the toner concentration. This density is measured by optical reflection with the aid of the measuring apparatus 15.

A light source 20 and a lens 21 produce a parallel light beam I which is directed on to the toner-carrying electrodes 17. With the aid of a second lens 23, a diaphragm 24 and a photosensitive element 25 (e.g., a photo cell or a photoresistor) the reflected light is measured at a suitable angle dependent upon the type of toner and the type of test strip. Two windows 26 and 27 and a housing 28 protect the measuring apparatus against dust. A second light beam II emanates from the same light source 20 and passes through the same windows 26 and 27 as the first light beam. Two lenses 29 and 30, a diaphragm 31 and a further photosensitive element 32 are used for carrying out the measurements. The cross-sections of the light beams I and II are the angle of the windows 26 and 27 with respect to the light beams are so selected that both beams penetrate the same window surfaces. Thus any contamination of the windows weakens the light beams to the same extent. Comparison (e.g., in a bridge circuit) of the amounts of light striking the two photosensitive elements (25 and 32) thus eliminates the effects of contamination of the windows by dust and of fluctuation in the intensity of the light source.

When uncovered, the electrodes 17 can be connected directly to voltage sources 35 through wiper contacts 18 as illustrated in FIGS. 3, 5 and 6, in a simplified manner. In cases where the electrodes are not uncovered, as for example in the arrangement illustrated in FIG. 4, and also for the purpose of avoiding any likelihood of breakdown, it is expedient to provide separate sliding contact rings or segments 22 of such rings, and to connect these electrically to the electrodes. These sliding contact rings can also be fitted at the ends of the drum.

What I claim is:

1. A method of measuring the toner concentration of a developer circulating in an electrophotographic reproduction machine comprising applying different voltages to spaced meshing electrodes on a drum carrying the photoconductor whereby the electrodes are arranged besides the exposure zone of the photoconductor, charging an insulating layer formed on the electrodes simultaneously with the photoconductor, connecting the electrodes just moved into the developing zone by grounding each after the charging step, applying a common electrical potential to the electrodes, a test charge pattern being thereby formed on the insulating layer, developing the test charge pattern based on a treatment identical to that used for developing the latent charge image, said test charge pattern being independent of the photoconductor's properties and treatment and of the other parameters of the electrophotographic reproduction cycle, and measuring the darkness of the test charge pattern which is a measure of the toner density by optical reflection carried out by light beams from the same light source, one of the beams being affected by the developed test charge pattern and the other being an unaffected reference beam.

2. The method of claim 1 wherein said common electrical potential is so applied to the electrodes that the electrical potential set up in the various zones on the insulating layer either remains the same or decreases in absolute value.



3. A method of measuring the toner concentration of a developer circulating in an electrophotographic reproduction machine comprising forming

a. a test charge pattern with the aid of spaced meshing electrodes placed under a voltage on a measuring strip which is located on a drum carrying the photoconductor, whereby the measuring strip is arranged besides the exposure zone of the photoconductor,

b. developing the test charge pattern based on a treatment identical to that used for developing the latent charge image, said test charge pattern being independent of the photoconductor's properties and treatment and of the other parameters of the electrophotographic reproduction cycle, and

c. measuring the darkness of the test charge pattern which is a measure of the toner density by optical reflection carried out by light beams from the same light source, one of the beams being affected by the developed test charge pattern and the other being an unaffected reference beam.

4. The method of claim 3, including connecting for the purpose of effecting brief recharging the oppositely disposed electrodes to a capacitor arranged to rotate with them and to make contact with an external fixed voltage source after each revolution of the drum carrier for the photoconductor.

* * * * *