May 6, 1969 R. G. OLDEN 3,442,645

ELECTROPHOTOGRAPHIC METHOD

Filed June 12, 1964

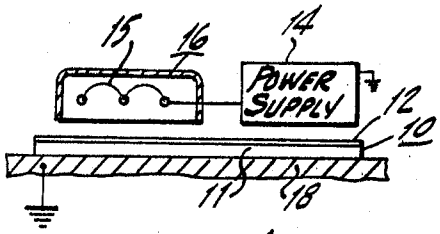


Fig. 1.

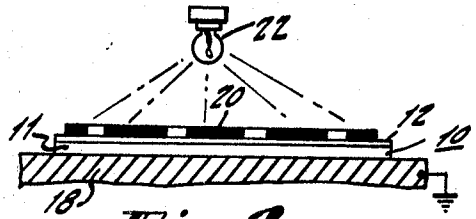


Fig. 2.

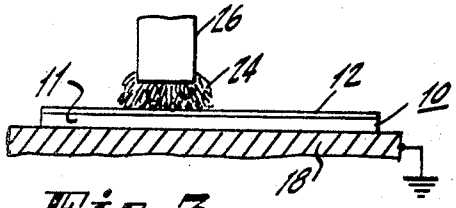


Fig. 3.

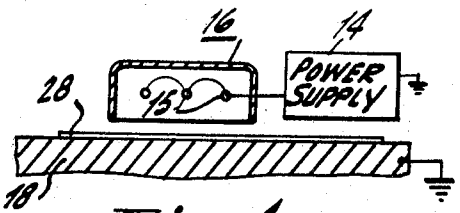


Fig. 4.

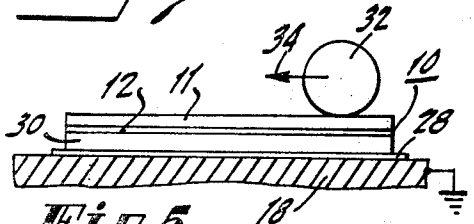


Fig. 5.

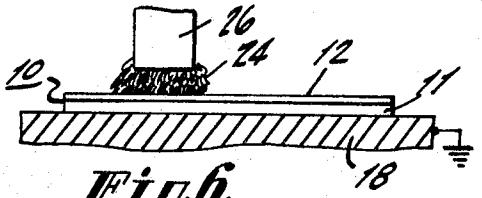


Fig. 6.

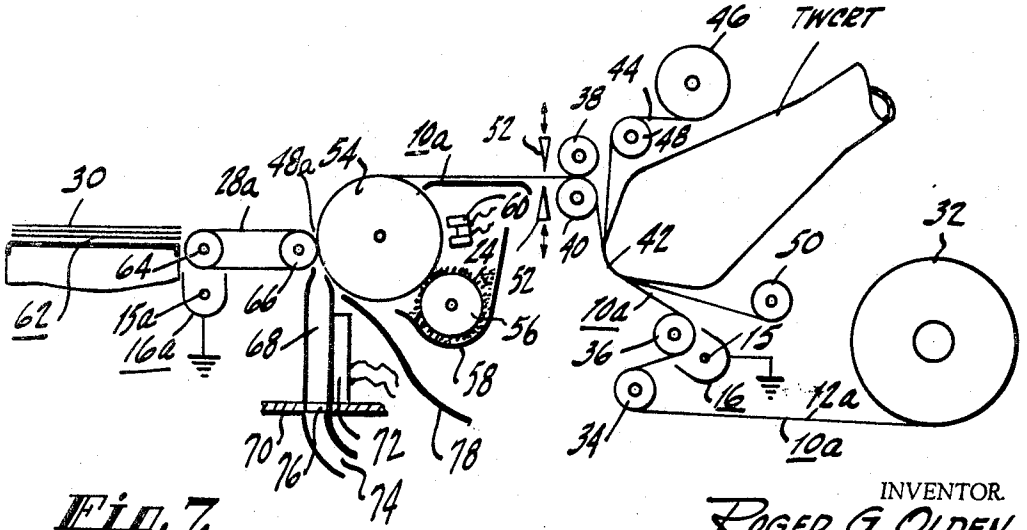


Fig. 7.

INVENTOR.
ROGER G. OLDEN
BY
W.S. Hill
AGENT

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ELECTROPHOTOGRAPHIC METHOD

Roger G. Olden, Trenton, N.J., assignor to Radio Corporation of America, a corporation of Delaware

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U.S. Cl. 96—1.4 6 Claims

ABSTRACT OF THE DISCLOSURE

A method of transferring an unfused, visible image of electroscopic toner particles from a record to a transfer sheet comprises the steps of (a) charging a dielectric sheet with a uniform electrostatic charge, (b) disposing the record in contact with the transfer sheet with the visible image against the transfer sheet, (c) disposing both the record and the transfer sheet on the charged dielectric sheet, and (d) applying pressure between the record and the transfer sheet. The charge on the dielectric sheet should be of a polarity to effect a transfer of the electroscopic toner particles from the record to the transfer sheet. The apparatus comprises a rotatable dielectric belt disposed between charging means and developing means for conveying both transfer sheets and a charge to the developing means.

This invention relates generally to the field of electrophotography, and more particularly to an improved method of and apparatus for transferring an image on a master electrophotographic record to one or more transfer sheets. The method and apparatus of the present invention are particularly useful for making copies of information from electrophotographic records produced by an electrophotographic output printer of the type proposed for electronic data processing apparatus.

It has been proposed to transfer the unfused visible image of electroscopic particles on an electrophotographic record to a transfer sheet by placing one side of the transfer sheet against the visible image and exposing the opposite side of the transfer sheet to a corona discharge of a polarity that attracts the electroscopic particles to the transfer sheet. Where the unfused visible image is on a rotatable drum and the transfer sheet is moved against the drum to transfer the image to the transfer sheet, the corona discharge must be applied at substantially the points of contact between the drum and the transfer sheet. The method and apparatus of the invention for the charging and moving of the transfer sheet are even simpler than the prior methods and apparatus.

It is an object of the present invention to provide an improved method of making one or more copies of an image which is on a master electrophotographic record.

Another object of the present invention is to provide an improved method of and apparatus for making a plurality of copies of an image which is on a master electrophotographic record at a relatively higher speed and at a relatively lower cost per copy than has heretofore been possible.

A further object of the present invention is to provide improved apparatus by means of which many prior art electrophotographic machines may be converted to apparatus for producing one or more copies of an image which is on a master electrophotographic record.

Still a further object of the present invention is to provide an improved method of copying on transfer sheets of any selected one of many different types an image which is on a master electrophotographic record.

Another object of the present invention is to provide an improved method of transferring an image to a transfer sheet from a master electrophotographic record that

is relatively easy to carry out, and improved apparatus by means of which the improved method may be performed efficiently.

These and other objects are attained, in accordance with the improved method of the present invention, in conjunction with an electrophotographic process wherein an unfused image of electroscopic toner particles on a master electrophotographic record is first produced. A sheet of dielectric material is provided with an electrostatic charge of a polarity that will cause the electroscopic particles that form the image to leave the master record. A transfer sheet and the master record are placed in contact with each other with the image against the transfer sheet, and both transfer sheet and master record are stacked on the charged dielectric sheet. Pressure is applied between the master record and the transfer sheet. The electroscopic powder of the image is attracted to the transfer sheet by the charge on the dielectric sheet. The master record is separated from the transfer sheet and the visible images on both the master record and the transfer sheet may be fixed by heat. If more than one copy of the image on the master record is desired, the master record may be redeveloped by applying additional electroscopic toner thereto and the aforementioned method can be repeated.

The improved apparatus of the present invention comprises the combination of a dielectric belt with record supporting means, such as a drum, for developing a master record. The dielectric belt is charged at a point remote from the point of transfer of the image from the master record to the transfer sheet. The dielectric belt serves two functions: First, the dielectric belt, when charged, provides efficient conveying means for holding the transfer sheet firmly to it by electrostatic attraction and for moving it into contact with the image on the master record, and, second, the charge on the dielectric belt provides an electrostatic force, other than the corona discharge device, for attracting the electroscopic particles on the master record to the transfer sheet.

The novel features of the present invention, both as to its organization and method of operation, as well as additional objects and advantages thereof, will be more readily understood from the following description, when read in connection with the accompanying drawing in which similar reference characters refer to similar parts throughout, and in which:

FIGS. 1, 2, and 3 are schematic sectional views of apparatus for carrying out the steps of charging, exposing and developing a master electrophotographic record in accordance with the improved method of the present invention;

FIG. 4 is a schematic sectional view of apparatus for charging a dielectric sheet in a step of the improved method of the present invention;

FIG. 5 is a schematic sectional view of apparatus for transferring a visible image from a master electrophotographic record to a transfer sheet in a step in the improved method of the present invention;

FIG. 6 is a schematic sectional view of apparatus for redeveloping the master electrophotographic record after a copy has been made in a step in the improved method of the present invention; and

FIG. 7 is a schematic sectional view of one embodiment of improved apparatus for making a plurality of copies from a master electrophotographic record in accordance with the improved method of the present invention.

Referring, now, particularly to FIG. 1 of the drawing, there is shown an electrophotographic record **10**, hereinafter called the master record **10** primarily for purposes of identification. The master record **10** may comprise a flexible substrate **11**, such as paper, and a photoconductive layer **12**, such as photoconductive zinc oxide dispersed in a resin binder.

To produce a visible image on the master record **10**, a uniform electrostatic charge is applied to the photoconductive layer **12**, in the dark, by a corona discharge device, as shown in FIG. 1. A relatively high voltage, about 6,000 volts, is applied from a power supply **14** between one or more thin wires **15** of a shielded corona discharge device **16** and a grounded plate **18**. The master record **10** is placed on the grounded plate **18**. One terminal of the power supply **14** is grounded and the other terminal is connected to at least one wire **15**. Depending upon the polarity of the terminal of the power supply **14** that is connected to the wire **15**, the master record **10** may be charged either positively or negatively, in a manner known in the art.

The uniformly charged master record **10** is exposed to a light image, as by placing a photographic negative **20** against the master record **10** and exposing the photoconductive layer **12** to a source **22** of light through the photographic negative **20**, as shown in FIG. 2. The portions of the photoconductive layer **12** that are exposed to light become conductive and decrease the electrostatic charge in these portions in proportion to the intensity of the light impinging on them. Thus, an electrostatic latent image is formed on the photoconductive layer **12**.

The electrostatic latent image can be converted to a visible image by applying electroscopic toner particles thereto, by any suitable means known in the art. Referring to FIG. 3 of the drawing, there is shown an electroscopic developing mixture **24**, such as a mixture of toner particles of pigmented shellac, for example, and iron filings applied to the photoconductive layer **12** by means of a magnet **26** to develop the aforementioned latent image thereon. This method of "magnetic brush" development is described in U.S. Patent 2,786,439, issued to C. J. Young, on Mar. 26, 1957, for Electrophotographic Developing Apparatus, and assigned to the assignee of the present invention.

Before transferring the unfused visible image on the photoconductive layer **12**, an electrostatic charge is applied to a dielectric sheet **28**, such as a sheet of insulating plastic material of the polyethylene terephthalate type, of which "Mylar" is an example. The charge on the dielectric sheet **28** should be of such a polarity that the toner particles are repelled from the master record **10** and driven or drawn towards the transfer sheet. In the arrangement shown in FIG. 5, this means, that for a direct image on the master record **10**, the charge on the dielectric sheet **28** should be negative, and, for a reverse image on the master record **10**, the charge on the insulating plastic material **28** should be positive. A direct image may be defined as one in which the opaque areas in the photographic negative **20** are duplicated as black areas on the master record **10**. A reverse image is one in which the transparent areas on the photographic negative **20** are printed black on the master record **10**. Regardless of which method is used, the image on the transfer sheet **30** is always a true facsimile of the image on the master record **10**. The electrostatic charge can be applied to the dielectric sheet **28** by means of the corona discharge device **16**, energized by the power supply **14**, as shown in FIG. 4.

The unfused visible image of electroscopic particles on the photoconductive layer **12** of the master record **10** can be transferred to a transfer sheet **30**, such as a sheet of paper, for example, by placing the transfer sheet **30** on the previously charged dielectric sheet **28**, and by placing the master record **10** on the transfer sheet **30** with the visible image in contact with the transfer sheet **30**. Pressure is then applied between the master record **10** and the transfer sheet **30** by any suitable means, as by a roller **32** adapted to be pushed manually across the top of the master record **10** in the direction of the arrow **34**, as shown in FIG. 5. The amount of pressure used is not critical, but there should be enough pressure applied to provide good contact between the master record **10** and the transfer sheet **30**. The charged dielectric sheet **28** attracts the electroscopic toner particles of the visible image on the photoconductive layer **12** of the master record **10** and transfers them to the transfer sheet **30**, thereby effecting a transfer of the visible image. More than one copy of the visible image on the master record **10** is possible by redeveloping the master record **10**, as shown in FIG. 6, as long as the electrostatic latent image is present on the photoconductive layer **12**. The redevelopment of the master record **10** shown in FIG. 6 is substantially similar to the original development of the master record **10**, as shown in FIG. 3. The number of times the master record **10** may be redeveloped may depend upon the ambient temperature and humidity, the moisture content of the transfer sheet, and the time of each cycle of development.

Referring, now, to FIG. 7 of the drawing, there is shown an embodiment of the improved apparatus for making one or more copies of a visible image on a master electrophotographic record **10*a***, a portion of a web of electrophotographic record material. The master record **10*a*** may be similar in composition to the master record **10**. The master record **10*a*** is a continuous web of material from which sheets of desired lengths may be cut. The web of the master record **10*a*** is unwound from a supply roll **32**, passed over idler rollers **34** and **36**, and pulled between a pressure roller **38** and a driven roller **40**. The web of the master record **10*a*** is moved over a window **42** of a thin window cathode ray tube TWCRT for exposing the photoconductive surface **12*a*** of the master record **10*a*** in a manner described by the instant inventor in RCA Review, September 1961, vol. XXII, No. 3. The photoconductive surface **12*a*** of the master record **10*a*** is disposed preferably against the window **42**. Where the master record **10*a*** is translucent, its photoconductive surface **12*a*** may be exposed from either surface of the master record. While the thin window cathode ray tube is illustrated herein as means for exposing the master record **10*a***, any suitable means of electromagnetic radiation known in the art for exposing the master record may be employed.

In order to prevent excessive frictional wear of the thin window **42** by the web of the master record **10*a***, a web of transparent plastic material **44**, having a relatively low coefficient of friction, such as "Mylar," is disposed between the master record **10*a*** and the thin window **42** of the cathode ray tube TWCRT. The web of plastic material **44** is unwound from a supply roll **46**, passed over an idler roller **48**, and pulled by a driven wind-up roller **50**. Thus, the master record **10*a*** can be exposed to light from the cathode ray tube through the window **42** and the transparent plastic material **44**.

The photoconductive surface **12*a*** of the master record **10*a***, before being exposed to light, is provided with a uniform electrostatic charge by a corona discharge device **16** disposed adjacent to the master record **10*a***. The corona discharge device **16** is provided with the usual power supply, not shown for the sake of simplicity. Thus, upon exposure to light from the electron beam at the window **42**, an electrostatic latent image is produced on the photoconductive surface **12*a*** of the master record **10*a***.

After exposure, a suitable length of the web of master record **10*a*** is cut, as by shears **52**, and fastened to the cylindrical surface of a rotatable drum **54** by any suitable means, such as by adhesive tape or by suction means (not shown) of the type used in the printing arts. The drum **54** is disposed for rotation about its axis and is rotated by any suitable means, such as a motor (not shown).

The electrostatic latent image on the photoconductive surface **12*a*** of the master record **10*a*** is developed by moving it over a cylindrical brush **56** disposed to rotate about its axis in a trough **58** of electroscopic developing mixture **24**. Any iron filings from the developing mixture **24** remaining on the master record **10*a*** after development can be cleaned up by an electromagnet **60** disposed adjacent to the developed master record **10*a*** on the drum

54. The master record 10*a* rotates with the drum 54 through any number of desired revolutions, depending upon the number of copies of the unfused electroscopic image thereon to be made.

Means are provided to transport transfer sheets 30 from a stack 62 of transfer sheets to the drum 54 for contact with the image of unfused electroscopic toner particles on the developed (toned) master record 10*a*. To this end, there is provided a belt 28*a* of dielectric material, similar to the aforementioned dielectric sheet 28, such as "Mylar," for example. The belt 28*a* is disposed around an idler roller 64 and a driven roller 66 for rotation thereabout. The roller 66 presses the belt 28*a* against the master record 10*a* on the drum 54. When an electrostatic charge is applied to the belt 28*a*, as by a corona discharge device 16*a*, the belt 28*a* becomes an efficient conveyor for a transfer sheet 30 because the latter adheres to the belt 28*a* by electrostatic attraction. The corona discharge device 16*a* is disposed at a point remote from the points of contact 48*a* between a transfer sheet 30 on the belt 28*a* and the master record 10*a* on the drum 54.

To transfer the visible image on the master record 10*a* to a transfer sheet 30, an electrostatic charge from the corona discharge device 16*a* is applied to the dielectric belt 28*a*, and a sheet 30 is placed on the belt 28*a*. The sheet 30 adheres electrostatically to the belt 28*a* and is moved thereby into contact with the master record 10*a* on the drum 54. The drum 54 and the roller 66 are moved synchronously, by any means known in the art. The charge applied to the dielectric belt 28*a* should be of a polarity opposite to that of the electroscopic toner particles in the developing mixture 24 if a positive image is desired. Thus, when the transfer sheet 30 is brought into contact with the image of electroscopic toner particles on the master record 10*a*, as at points 48*a*, the charged belt 28*a* functions to attract the charged electroscopic particles from the visible image on the master record 10*a* to the transfer sheet 30. Thus, in addition to serving as a conveyor belt, holding the transfer sheet 30 thereto by electrostatic attraction, the belt 28*a* also functions as an electrostatic force means to attract electroscopic toner particles whereby to effect a transfer of the image from the master record 10*a* to the transfer sheet 30.

The radius of curvature of the roller 66 is small enough so that the transfer sheet 30 can not follow the belt around the roller 66. For example, when the diameter of the roller 66 is smaller than 1 and ½ inches, ordinary paper will not follow a "Mylar" belt 28*a* around the roller. Thus, the transfer sheet 30 leaves the roller 66 and falls into a chute 68. A slide 70 at the bottom of the chute 68 is adapted to retain the transfer sheet 30 therein so that it may be exposed to heat from a fuser 72 disposed on one side of the chute 68 and adapted to radiate sufficient heat to fuse the transferred image on the transfer sheet 30. The sheet 30 is allowed to fall into an exit chute 74 through a slot 76 in the slide 70 after the transferred image has been fused on the transfer sheet 30.

Additional copies may be made of the image on the master record 10*a* by redeveloping the master record 10*a* and pressing another transfer sheet 30 into contact with the image of electroscopic toner particles by means of the charged dielectric belt 28*a*. Thus, by redeveloping the same latent electrostatic image on the master record 10*a* for each additional copy on the transfer sheet 30 desired, a plurality of copies of an image on the master record 10*a* may be made. Four copies of good quality have been obtained by transfer from a master record 10*a*, redeveloping the master record 10*a* after each transfer and using a master record and a developing mixture of the type described in the aforementioned patent. When the master record 10*a* is no longer needed, it may be stripped from the drum 54 and allowed to fall onto an exit guide 78. The image on the master record 10*a* may be fused and kept as a reference, if desired.

It is apparent from the aforementioned description of the method and apparatus of the present invention that the image transferred to the transfer sheet is a mirror image of that on the master record. If the image on the transfer sheet is to be an exact representation of the object that the image portrays, the image on the master record should be a mirror image of the true object. The latter results are easily obtained by using the proper number of lenses and/or mirrors in a manner well known in the electrophotographic and photographic arts for making a mirror image of a true object on a master record.

From the foregoing description, it will be apparent that there has been provided an improved method of and apparatus for transferring an image on a master record to one or more transfer sheets. Since the transfer sheet can be almost any kind of sheet mateial, the cost per copy is relatively low. Although the embodiment of the apparatus for carrying out the method is one that is particularly applicable for making copies from master records produced by an electrophotographic output printer of the type proposed for electronic data processing equipment, the improved arrangement of the dielectric belt and the corona discharge device for charging the belt with respect to the means for carrying and developing the master record may be applied to many prior art electrophotographic processing apparatuses. Thus, while only one embodiment of the invention has been described and shown in diagrammatic form, variations in its structure coming within the spirit of this invention will, no doubt, readily suggest themselves to those skilled in the art. Hence, it is desired that the foregoing shall be considered as illustrative and not in a limiting sense.

What is claimed is:

1. In an electrophotographic method wherein an electrostatic latent image on an electrophotographic master record is developed with an electroscopic toner of one polarity to produce an unfixed visible image which is then transferred to a transfer sheet, the improvement of making a copy of said visible image on said transfer sheet, with the aid of a dielectric sheet, comprising the steps of

charging said dielectric sheet with an overall electrostatic charge of a polarity opposite to said one polarity,

disposing said transfer sheet against said charged dielectric sheet,

disposing said master record against said transfer sheet with said visible image facing said transfer sheet, and

applying pressure between said master record and said sheets.

2. In an electrophotographic method wherein an electrostatic latent image on an electrophotographic master record is developed with an electroscopic toner to produce a visible image of said latent image, the improvement of making copies of said visible image on transfer sheets, with the aid of a dielectric sheet, comprising the steps of

charging said dielectric sheet with an overall electrostatic charge,

disposing one of said transfer sheets against said charged dielectric sheet,

disposing said master record against said one transfer sheet with said visible image facing said one transfer sheet,

applying pressure between said master record and said sheets,

separating said master record, said one transfer sheet, and said dielectric sheet from each other,

redeveloping said master record with said toner,

disposing another of said transfer sheets against said charged dielectric sheet and said master record on said other transfer sheet with the redeveloped image against said other transfer sheet, and

applying pressure between said redeveloped master record and said other transfer sheet.

3. A method of electrostatic recording comprising the steps of

applying an electrostatic charge separately to a master record and to a dielectric sheet,

exposing said master record with a light image to produce a latent electrostatic image thereon,

applying an electroscopic toner to said latent image to produce a visible image on said master record,

placing said transfer sheet on said charged dielectric sheet,

placing said master record on said transfer sheet with said visible image against said transfer sheet, and

applying pressure between said master record and said sheets whereby to transfer some of said toner of said visible image to said transfer sheet, the polarities of said electrostatic charge and said electroscopic toner being such as to apply a force to said electroscopic toner to effect the transfer of said visible image from said master record to said transfer sheet.

4. A method of electrostatic recording comprising the steps of

applying an electrostatic charge of one polarity separately to a master record and to a dielectric sheet,

exposing said master record with a light image to produce a latent electrostatic image thereon,

applying an electroscopic toner having a polarity opposite to said one polarity to said latent image to produce a visible image on said master record,

superimposing said transfer sheet on said charged dielectric sheet and said master record on said transfer sheet with said visible image against said transfer sheet,

applying pressure between said master record and said sheets, whereby to transfer some of said toner of said visible image to said transfer sheet, and

heating the transferred image on said transfer sheet to fuse said transferred image thereon.

5. An electrostatic duplicating method comprising the steps of

applying an electrostatic charge to a master record which includes a photoconductive layer, in the dark,

exposing said master record photoconductive layer with an image of electromagnetic radiation to product a latent electrostatic image thereon,

applying an electroscopic toner to said latent image to produce a visible image on said layer,

applying an electrostatic charge to a dielectric sheet,

disposing a first transfer sheet against said charged dielectric sheet,

disposing said master record against said first transfer sheet with said toned image against said transfer sheet,

applying pressure between said master record and said sheets, whereby to transfer some of said toner of said visible image to said transfer sheet,

separating said master record, said first sheet and said dielectric sheet from each other,

applying said electroscopic toner again to said latent image remaining on said photoconductive layer to redevelop said master record,

disposing another of said transfer sheets against said charged dielectric sheet and said redeveloped master record against said other transfer sheet with said layer against said transfer sheet, and

applying pressure between said redeveloped master record and said other transfer sheet.

6. In an electrophotographic method wherein an electrostatic latent image on an electrophotographic master record is developed with an electroscopic toner to produce a visible image of said latent image, the improvement of transferring said visible image to a transfer sheet, with the aid of a dielectric material, comprising the steps of,

applying an electrostatic charge to said dielectric material,

superimposing said transfer sheet against said master record with said visible image of electroscopic toner facing said transfer sheet,

disposing said superimposed transfer sheet and master record on said dielectric material, and

applying pressure between said dielectric material, said master record, and said transfer sheet, the polarity of said electrostatic charge applied to said dielectric material being such as to apply a force on said electroscopic toner to effect the transfer of said visible image from said master record to said transfer sheet.

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J. TRAVIS BROWN, *Primary Examiner.*

C. E. VAN HORN, *Assistant Examiner.*

U.S. Cl. X.R.

96—1; 117—17.5