United States Patent

Solarek

[15] **3,692,402**

[45] **Sept. 19, 1972**

[54] **MATERIALS FOR FIBROUS DEVELOPMENT AND CLEANING MEMBER**

[72] Inventor: **Thomas W. Solarek,** Fairport, N.Y.

[73] Assignee: **Xerox Corporation,** Stamford, Conn.

[22] Filed: **April 26, 1971**

[21] Appl. No.: **137,379**

Related U.S. Application Data

[63] Continuation of Ser. No. 847,284, Aug. 4, 1969, abandoned, and a continuation of Ser. No. 889,282, Dec. 30, 1969, Pat. No. 3,610,693.

[52] **U.S. Cl.** **355/3,** 355/15

[51] **Int. Cl.** **G03g 15/08**

[58] **Field of Search** 355/15, 3; 15/1.5

[56] **References Cited**

UNITED STATES PATENTS

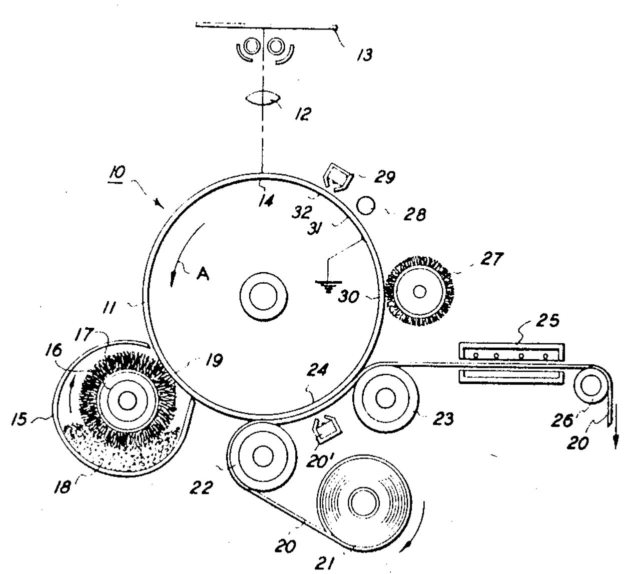
3,572,923	3/1971	Fisher et al. 355/15
2,959,153	11/1960	Hider........................355/15 X
2,894,744	7/1959	Schulze.....................15/1.5 X
2,832,977	5/1958	Walkup et al............355/15 X

Primary Examiner—John M. Horan
Assistant Examiner—Fred L. Braun
Attorney—James J. Ralabate, Albert A. Mahassel, John E. Beck and Irving Keschner

[57] **ABSTRACT**

A woven cut pile brush whose pile tufts are formed from glass fibers is particularly well suited for cleaning toner particles from reusable electrostatic imaging surfaces and for developing latent electrostatic charge patterns formed on an insulating surface.

1 Claim, 5 Drawing Figures



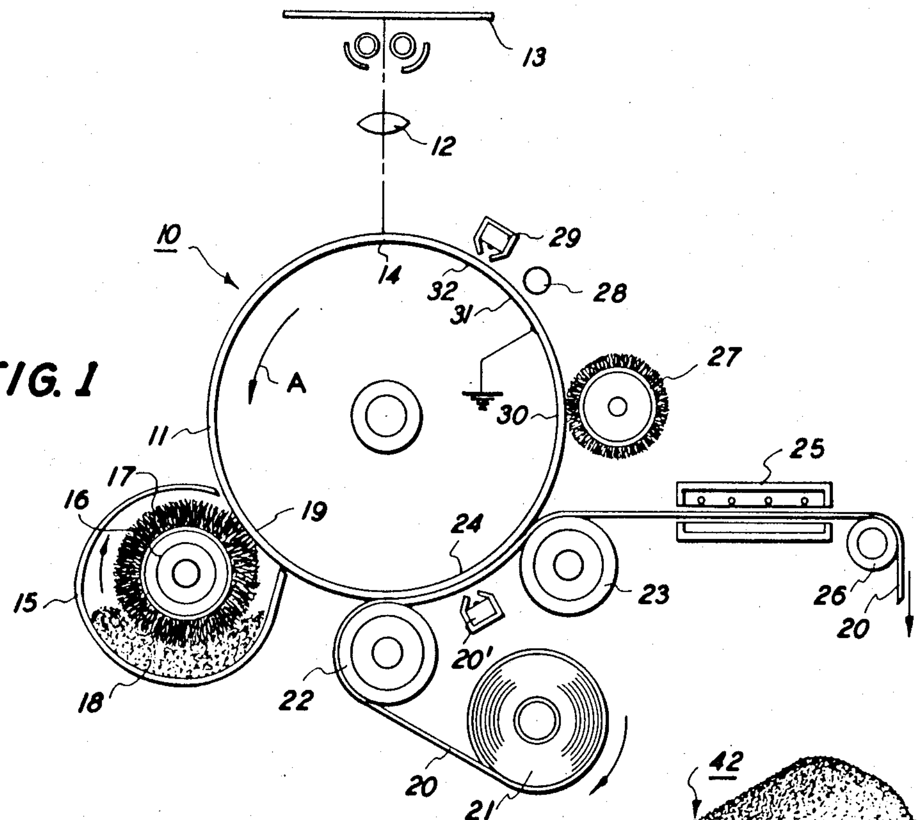


FIG. 1

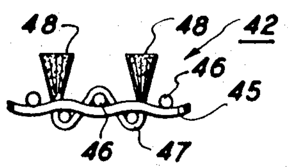


FIG. 3

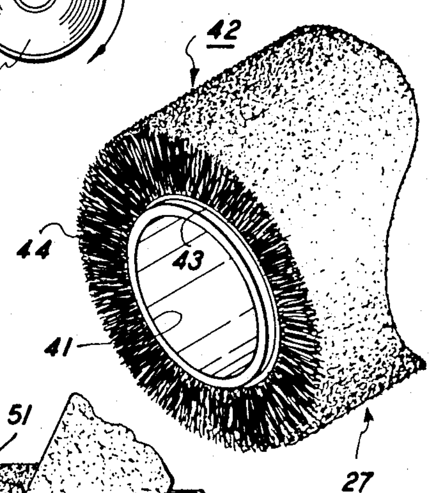


FIG. 2

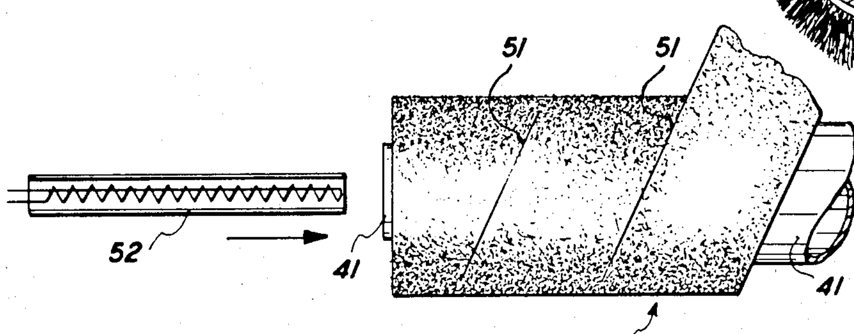


FIG. 4

INVENTOR.
THOMAS W. SOLAREK
BY Irving Keschner
ATTORNEY

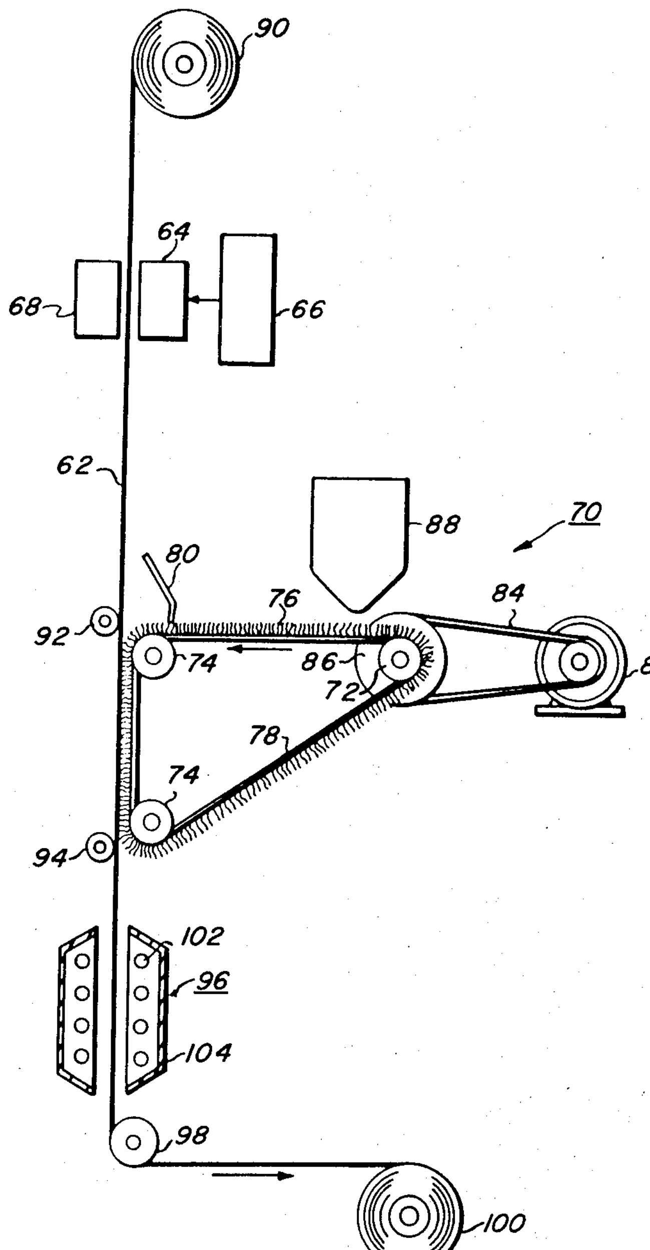


FIG. 5

MATERIALS FOR FIBROUS DEVELOPMENT AND CLEANING MEMBER

RELATED APPLICATIONS

This is a continuing application of applications Ser. No. 847,284, filed Aug. 4, 1969, now abandoned, and Ser. No. 889,282, filed Dec. 30, 1969 now U.S. Pat. No. 3,610,693.

BACKGROUND OF THE INVENTION

In xerography and related arts, it is usual to deposit an image such as a powder image on an electrostatic charge pattern conforming to a pattern of light and shadow which is to be recorded or reproduced. For example, an electrostatic charge pattern known to the art as a xerographic electrostatic latent image, corresponding to a document, picture, or other image, is formed on an image-bearing insulating surface. In the prior art electrographic processes, an electrostatic charge pattern corresponding to alphanumeric characters or symbols is deposited on a suitable recording medium. One means of utilizing the electrostatic latent charge pattern is by development with a finely divided powder material, or toner, which is caused to adhere to the surface in a configuration corresponding to the electrostatic charge pattern. One method for development of such latent charge patterns utilized in the art has been cascading across a charge bearing surface a two-component developer mixture such as is disclosed in U.S. Pat. No. 2,618,551. Another method for the deposition of powder pattern corresponding to an electrostatic charge pattern comprises depositing finely divided powder on the charge pattern from an elongated flexible carrier body such as, for example, a fibrous member, such as disclosed in U.S. Pat. No. 3,251,706. The adhered toner particles may then be transferred imagewise to an image receiving sheet. After transfer, the insulating surface may be cleaned of residual toner particles and the image charge pattern discharged, the insulating surface thereby being conditioned for use to produce another image.

It has been determined that natural fur materials when used as the fibrous development member described above provides satisfactory images. Natural furs, however, have proven to be expensive and, at times, unavailable. In addition, natural furs are undesirable primarily from the standpoint of the difficulties of meeting quality control standards. This is so because there are no "standard animals" — fur quality and the length of the fur fibers is a function of season, age and health of the animal, climate, etc. The synthetic brush materials developed in the prior art, to replace natural fur, such as nylon acrila and Dynel, have not performed as satisfactorily as natural fur to transfer toner to the electrostatic latent charge patterns.

Effective and efficient cleaning of the residual toner particles from the insulating surface is a critical operation if the insulating surface is to be reused since any residual toner will interfere with a subsequent image developed on the carrier. At the same time, it is important that the cleaning operation not damage the insulating, or image carrier, surface, and this is a particularly sensitive problem when the carrier is a reusable selenium photoconductor, as is often used to convert optical images to electrostatic images. Natural fur brushes have been utilized for cleaning, but as set forth hereinabove regarding development brushes, synthetics having the characteristics of fur have been sought for utilization as the cleaning brush material.

SUMMARY OF THE INVENTION

The present invention provides new brush materials for use in brush development of latent electrostatic charge patterns and/or cleaning residual toner material from reusable insulating surfaces, the brush comprising fibers of an insulating material such as glass. The fibers are woven to a backing member in accordance with a specified pile height and pile density.

It is therefore an object of this invention to provide new brush materials for use in the development of latent electrostatic charge patterns and for cleaning toner material from the surface of reusable insulating surfaces.

It is a further object of this invention to provide new brush materials utilized in brush development of latent electrostatic charge patterns, the developed charge pattern being of a quality at least equal to those developed with natural fur brushes.

It is still a further object of this invention to provide new brush materials for use in development of electrostatic latent charge patterns and for cleaning toner material from the surface of a reusable insulator, comprising fibers of an insulating material.

It is a further object of the present invention to provide woven pile brush materials for use in development of latent electrostatic charge patterns and for cleaning toner material from the surface of reusable insulators, the brush comprising an insulating material such as glass.

It is an object of the present invention to provide such a brush formed from a woven cut pile material.

DESCRIPTION OF THE DRAWINGS

For a better understanding of the invention as well as other objects and features thereof, reference is made to the following description which is to be read in conjunction with the accompanying drawings wherein:

FIG. **1** is a schematic illustration of a conventional xerographic photocopying apparatus;

FIG. **2** is a partial and enlarged perspective view of a brush used for cleaning residual toner particles from the electrostatic imaging surface of the apparatus of FIG. **1**;

FIG. **3** is an enlarged fragmentary cross-sectional view of the pile fabric used in making the brush of FIG. **2**;

FIG. **4** illustrates a stage in the manufacture of said brush; and

FIG. **5** illustrates the brush utilized for developing latent electrostatic charge patterns in another embodiment of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. **1** schematically illustrates a well-known xerographic process and apparatus for electrostatically photocopying documents. Drum **10** is provided with permanent photoconductive layer **11** over its cylindrical surface. The photoconductive layer **11** is commonly formed of selenium, and presents a relatively low electrical resistance when illuminated with light and a relatively high resistance when not illuminated. A plurality of operational stations are positioned about the periphery of the drum as follows: an optical station is provided at **14**, for focusing an optical image on the photoconductive layer **11**, a developing station is provided at **19**, an image transfer station is provided at **24**, a drum cleaning station is located at **30**, a general illuminating station is located at **31**, and it is followed by a general charging station at **32**.

Assuming that the drum **10** is rotating in the direction of arrow A, and assuming that the drum surface is clean and uniformly charged with an electrostatic surface charge as it approaches station **14**, an image of a portion of document **13** is focused by optical system **12** on the surface of photoconductive layer **11** at station **14**. As the drum advances in the direction of arrow A, successive portions of the document **13** are focused on successive portions of the photoconductive layer **11**. The portions of photoconductive layer **11** that are illuminated with light become conductive during the illumination period, causing a discharge to ground of the corresponding electrostatic charge portion on the surface of the photoconductive layer, and resulting in a latent electrostatic image of document **13** on the surface of drum **10**.

The electrostatic latent image is advanced to the developing station **19**, where a housing **15** contains a charge of electroscopic toner particles **18**, and a roll **16** having a pile brush **17** on its surface. As roll **16** rotates, the pile brush **17** passes through the toner particles and then across the surface of drum **10**, distributing the toner particles over the surface of the drum. The toner particles adhere to the drum in areas containing a residual charge, but not in the uncharged areas, resulting in development to visual form of the latent electrostatic image corresponding to document **13**.

At station **24**, this image is transferred to image receiving web **20**. Web **20** is drawn from supply roll **21** and is guided in contact with drum **10** for a short distance by guide rolls **22** an **23**. Transfer of the toner particles constituting the developed image may be aided by an appropriate electrical field or by charging of the web **20** by corona charging electrode **20'**, as is well understood in the art. After the image is transferred to the web **20**, the web may be passed through a heater **25** to fuse the toner particles to the web, and the web is guided by roll **26** to a delivery station.

Since in the embodiment illustrated in FIG. **1** the photoconductive layer **11** is to be reused for a subsequent imaging cycle, after the image transfer operation residual toner particles are removed from the surface of drum **10** by brush **27** at station **30**. Then the photoconductive layer **11** is exposed at **31** to uniform illumination by lamp **28**, to erase any residual electrostatic image. Before returning to the optical exposure station, the surface of the photoconductor is exposed to a general corona discharge by electrode **29** at station **32**, to provide a uniform electrostatic charge over the photoconductive layer **11** and thereby enable electrostatic optical recording of an image of the document **13**.

Brush **27**, for cleaning residual toner particles from the selenium surface **11** of drum **10**, is shown in the partial and enlarged perspective view of FIG. **2**. As there shown, the brush comprises a cylindrical structurally rigid core **41**, preferably formed of a suitable metal or other rigid material, such as a phenolic resin and glass fiber laminate. A woven cut pile fabric **42** is secured over the cylindrical surface of the core **41**, this fabric comprising a woven backing **43** carrying the pile fibers **44** interwoven therewith. As shown in FIG. **3**, the woven backing **43** comprises warp and woof yarns **45** and **46**, and woven into the backing is the pile yarn **47**. When the pile yarn is cut, the fibers at the cut ends of the yarn disperse to form the tufts **48**, with the fiber ends all at substantially the same height. In accordance with the preferred embodiment of the present invention, the pile yarn **47** is formed from very fine glass filaments, and backing yarns **45** and **46** are formed from thermoplastic resin filaments, such as polyethylene, polypropylene, nylon plastic, etc. The fibers do not abrade or otherwise mar the surface of insulating layer **11**.

Manufacture of brush **27** is illustrated by FIG. **4**. Using the brush core **41** as a mandrel, a strip of the cut woven pile fabric **42** is helically wound thereon with the adjacent ends of successive convolutions abutting, as shown at **51**, employing conventional and well known techniques and apparatus. The ends of the wound helix are, of course, squared by trimming, and these ends may be secured to the core mandrel **41** by an adhesive or by clamps to retain the helix on the mandrel. An electric heater **52** is then inserted in the hollow center of the core **41**, for the period of time and at the temperature required to effect partial fusing of the backing yarns **45** and **46** of the fabric **42**. As a result of this fusion, successive convolutions of the helically wound fabric **42** are united along the abutting edges **51**, and the entire backing surface may be bonded to the core **41**. Also, it is apparent that the partial fusion locks the cut pile yarn segments **47** in place in the backing of the fabric.

The brush thus formed corresponds to the cylindrical brush **27**, shown in perspective in FIG. **2** and in use in FIG. **1**. Obviously, the brush formed by this method may have various transverse shapes other than the circular shape shown, such as rectangular, semicircular or oval. All transverse shapes, regular or irregular, are contemplated as embraced by the term "cylindrical" as used herein.

To illustrate the brush more specifically, it is preferred that the glass fiber yarns **47** used to form the pile tufts **48**, be formed from glass filaments having a diameter between about 3 microns and about 10 microns, and preferably about 4 microns, with between about 150 and 450 filaments per yarn. Further, this pile fiber yarn should be woven into the fabric at a spacing that provides between 1 and 2 million, and preferable about 1½ million pile fiber ends per square inch of pile fabric. The pile height should be between about 0.4 and 0.8 inch, and preferably about 0.6 inch. A preferred backing yarn is polypropylene, but it will be apparent that the specific composition and diameter of the backing yarns are not at all critical to the practice of the present invention.

A brush development technique for developing latent electrostatic charge patterns deposited upon a medium is described in the above-mentioned U. S. Pat.

No. 3,251,706. The choice of the fibrous material to be used in the development structure is based upon certain mechanical and electrical characteristics. Mechanical properties which direct the choice include, for example, material softness and flexiblity so that while supported at one end it can be brushed against the charge pattern without undue abrasion of the medium supporting the charge pattern, a characteristic required also of the cleaning brush as set forth hereinabove. An electrical characteristic which is of vital significance for a development brush is the correct triboelectrical relationship with the development powder or toner. For this point it is noted that a very few select powder materials are suitable as developing powders and it is generally desired to charge these powders negatively by contact electrification with the brush for deposition on a positive polarity charge pattern. Other desirable properties of the brush-like member are absence of film forming or scum forming ingredients, suitable durability, chemical inertness and economical availability.

When using materials other then natural fur as the fiber material, an additional characteristic which may effect the choice of material is the weave pattern in which the fibers are woven to a backing member as the stiffness of the fibers is a function of the pile height and density of the woven pattern.

Previous attempts to use synthetics or materials other than natural animal fur for fur brush development have been relatively unsuccessful as the desired animal fur characteristics of proper toner triboelectrical relationship and soft and flexible fibers were not found in prior art materials. It has been discovered that a fibrous material comprising fibers of an insulating material, such as glass, provides the triboelectrical and softness characteristics which approaches that of natural fur. As set forth hereinabove, the configuration in which the fibrous materials are affixed to the backing member, i.e., pile height and pile density, controls the softness, or stiffness, of the fibrous material.

The glass fibers utilized in cleaning brush **27** have also been utilized successfully as the material for pile brush **17**. Other suitable insulators may be used as the fibrous material for pile brush **17**. Typical insulating materials include nylon, acrylic and methacrylic polymers, polyethylene, rayon, dacron, orlon, arnel, wool, polyacrylonitriles, polyethylene terephthalate and other polyesters, polyamides, vinylacetates, styrenes, polyurethanes, modified resin, polycarbonates, etc. It is to be noted that the fiber materials listed above may be coated with either organic or inorganic materials or combinations thereof to provide improved development characteristics.

The insulating fiber material described above is woven to a backing member in a pattern of predetermined pile height and pile density in accordance with the steps set forth hereinabove with reference to the manufacture of cleaning brush **27** to form development brush **17**.

As set forth hereinabove, fiber stiffness is related to pile height and pile density, as well as to the fiber material comprising the brush. Therefore, for a given fiber material, pile height and density may be controlled such that the surface on which the electrostatic charge pattern is deposited is not unduly abraded by the brush during development. The pile height also may be controlled so that a predetermined distance is maintained between the charge supporting surface and the member supporting the fibrous elements so, for example, one may observe the charge support surface as the charge patterns are being developed.

The preferred development brush comprises glass fibers, woven in a pattern of predetermined pile height and density onto a backing member. The pile density of the preferred brush may range from about 750,000 fibers per square inch to about 1,950,000 fibers per square inch, the pile height may range from about 0.30 inches to about 0.90 inches and the diameter of the fibers range from about 3.8 microns to about 15.3 microns. The advantage of using glass fibers as the brush material is that a high pile density may be obtained, increasing the surface area contacting the charge pattern to be developed. This in turn enables very high density development of the electrostatic latent images which enables smaller and more compact brushes to be used. The glass fibers are also soft and flexible, thereby enabling development to occur without undue abrasion of the surface supporting the charge pattern.

The general nature of the invention having been set forth, the following examples are given in further illustration thereof.

EXAMPLE I

A glass fiber development brush is formed by the method described in reference to FIG. **4**. The brush comprises 932,000 fibers per square inch. The fiber pile height is 0.48 inches and the fiber diameter is 3.8 microns.

EXAMPLE II

A glass fiber brush is formed by the method described with reference to FIG. **4**. The brush comprises 1 million fibers per square inch. The fiber pile height is 0.65 inches and the fiber diameter is 3.8 microns.

It should be noted that the procedure for identifying glass fibers having a nominal fiber diameter has been standarized in the textile industry. By specifying a particular glass fiber diameter, among other characteristics, the glass fibers as utilized in the present invention are readily available from the producers thereof.

It should be further noted that the ranges of pile heights, pile densities and fiber diameters set forth hereinabove will vary depending upon the brush material used.

Referring now to FIG. **5**, an electrographic process utilizing a non-reusable recording medium is illustrated.

As shown diagrammatically in the figure, a recording medium **62**, such as paper having a layer of thin insulating material coated on the working surface thereof, receives an electrostatic latent image at the recording station from the electrical discharge produced at recording head **64**. The electrical discharge is initiated by a controlled voltage pulse derived from a control unit **66**. Associated with the recording head **64** is a backing electrode **68**. In general, the recording head **64** is provided with a plurality of styli, electrically insulated from each other. The styli are energized by the control unit 66 to produce latent electrostatic charge patterns on the recording medium 62 corresponding to alphanumeric characters or symbols. Although the recording medium 62 is illustrated as moving relative to the recording head 64, the converse is equally applicable. The charge pattern may be formed by ionizing the air between the recording head 64 and the backing electrode 63 or by bringing the styli in contact with the recording medium 62. The deposition of charge on a recording medium in a pattern corresponding to alphanumeric characters or symbols may be provided in accordance with well-known conventional techniques, for example, such as disclosed in U. S. Pat. No. 3,289,209.

Next, subsequent to the recording station, is the development station 70. A developing belt 76 is passed around driver roller 72 and one or more guide rollers 74. Belt 76 is provided with elongated flexible carrier members supported at one end on a backing member 78 and free at the other end and positioned to brush against the charge bearing surface on recording medium 62, such carrier members, for example, being fibers of the brush or other fibrous material or similar elongated members adapted and disposed to hold on their surface by electrostatic action suitably charged powder particles, such as the powders disclosed in U. S. Pat. No. 2,659,670, which are appropriate for the deposition on and development of an electrostatic latent image. It should be noted that the developing member is not limited to the belt structure shown but may be, for example, a cylindrical member having the elongated carriers affixed to the outer surface thereof, exemplified by pile brush 16 shown in FIG. 1, a semicylindrical member having the elongated carriers affixed to the cylindrical portion thereof, a segmented brush, and various other geometrical configurations.

It is presently understood and believed that the mechanism of the development as shown is as follows. A powder-impregnated brush-like member is prepared by brushing the member into a supply of the appropriate powder whereupon the powder adheres to the elongated carrier body, apparently by electrical attraction from frictionally generated electricity. When the powder-impregnated brush is touched to the charge pattern on the recording medium, the charge preferentially attracts the charged powder from the brush fibers causing deposition of the powder on the pattern areas. A striking plate 80 is mounted to strike the brush fibers prior to their meeting the surface of the recording medium. The striking plate is generally metallic and is electrically grounded. It is thought that the powder-bearing brush striking against the metal plate causes uniform charging of the powder. The outer surface of the developing belt is brush-like in characteristics and is a multitude of elongated carrier members composed of the fiber materials described hereinabove extending outwardly from the surface of the belt. At least one of the rollers, such as for example roller 72, is desirably power driven as illustrated by member 82 and adapted to drive roller 72 through belt 84 operating pulley 86. Positioned adjacent to the path of motion of developing belt 76 is a powder dispensing hopper 88 containing a supply of developer powder and adapted to dispense this developer powder gradually to the developing member 76.

A recording medium supply roll 90 is adapted to feed the recording medium 62 past guide roller 92 and the development belt 76. After passing between these members, the recording medium 62 may pass around guide roller 94, desirably through a fixing station 96, and around a guide roller 98 to take-up roller 100. The fixing station 96 may be a suitable means to apply heat, solvent vapor of the like to the surface of the recording medium and as illustrated, may consist of a plurality of heating units 102 mounted within a casing 104 thereby adapted to heat the transfer web to melt onto its surface the plastic powder deposited thereon. The operation of the apparatus described hereinabove is as follows. The surface of the recording medium 62 is charged by passing it under recording head 64 and energizing control unit 66 to produce latent electrostatic charge patterns corresponding to alphanumeric characters of symbols thereon. The recording medium 62 then passes to the development station 70. At this point development belt 76, with its brush-like surface coming into contact with the recording medium 62, deposits a finely divided powder material on the surface thereof.

Leaving the development station is the recording medium 62 now bearing the powder pattern thereon which pattern corresponds to the electrostatic charge pattern on the recording medium 62. The recording medium 62 passes to a suitable fixing device 96 and then to take up roll or to some other means for utilizing the resulting print.

The invention described hereinabove provides a synthetic fibrous brush for high quality development of latent electrostatic charge patterns and/or for cleaning toner from the surface of reusable insulators. The synthetic materials utilized are generally available at an economical cost when compared to the natural fur brushes presently being used for development and cleaning. The characteristics and chemical composition of the synthetics are generally carefully controlled, thereby providing means for producing a "standard" brush when compared to the usual differences in composition and characteristics found between each natural fur brush.

While the invention has been described with reference to its preferred embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents substituted for elements thereof without departing from the true spirit and scope of the invention. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the invention without departing from its essential teachings.

What is claimed is:

1. Apparatus for developing a latent electrostatic charge pattern formed on a support surface comprising:

a brush element having a fibrous surface, said fibrous surface comprising glass fibers woven onto a backing member, said fibers having a pile height in the range from about 0.30 inches to about 0.90 inches and a pile density in the range from about 750,000 fibers per square inch to about 1,950,000 fibers per square inch, the diameter of said glass fibers being in the range from about 3.8 microns to about 15.3 microns, means for supporting said brush element adjacent to and in surface contact with said support surface,

means for impregnating the brush element with a powder developing material, said fibrous surface adapted to hold thereon by electrostatic attraction powder material during impregnation and adapted to release said powder material for development of an electrostatic latent image, and

means for causing relative motion between the brush element and the support surface, thereby depositing the developing material on said latent charge pattern.

* * * * *