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Fraser

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[54] **LINE CHARGE TONER CLEANING**

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[52] **U.S. Cl.**..... **355/15,** 15/1.5, 15/256.52

[51] **Int. Cl.**..... **G03g 15/00**

[58] **Field of Search**..... 15/1.5, 256.51, 256.52; 355/3 R, 3 DD, 15

[56] **References Cited**

UNITED STATES PATENTS

3,523,319 8/1970 Stoever 15/1.5

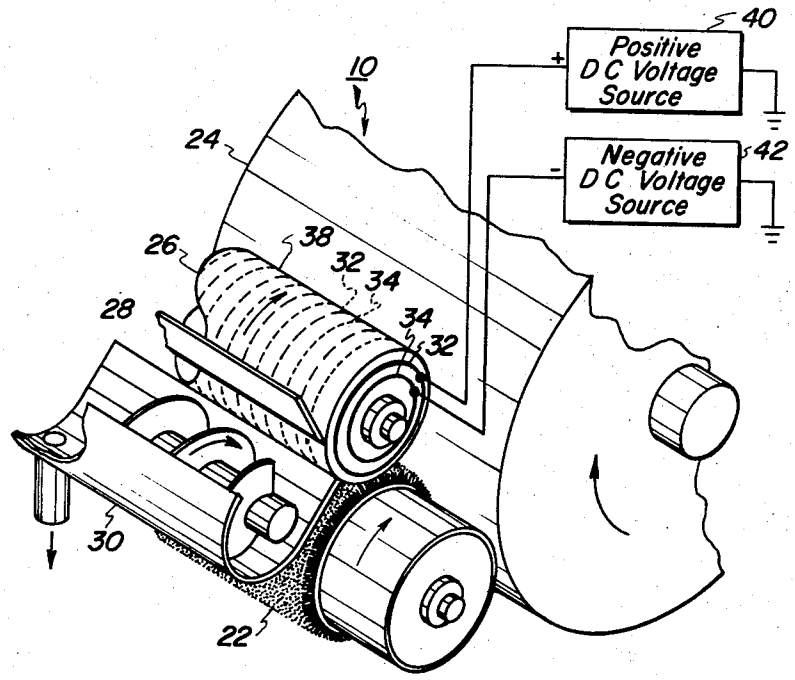
3,780,391 12/1973 Leenhouts 15/1.5

Primary Examiner—Edward L. Roberts

[57] **ABSTRACT**

An electrostatographic system in which dry imaging material (toner) is cleaned from a photoreceptor surface by a soft cleaning member, and the cleaning member in turn is electrostatically cleaned by a secondary or pickoff roller having a multiplicity of closely adjacent and differently charged conductors, which attract toner particles of either polarity and also uncharged toner. This electrical charge pattern may be provided by differentially biasing a bifilar helical conductive winding on an insulative surface of the secondary roller.

9 Claims, 3 Drawing Figures



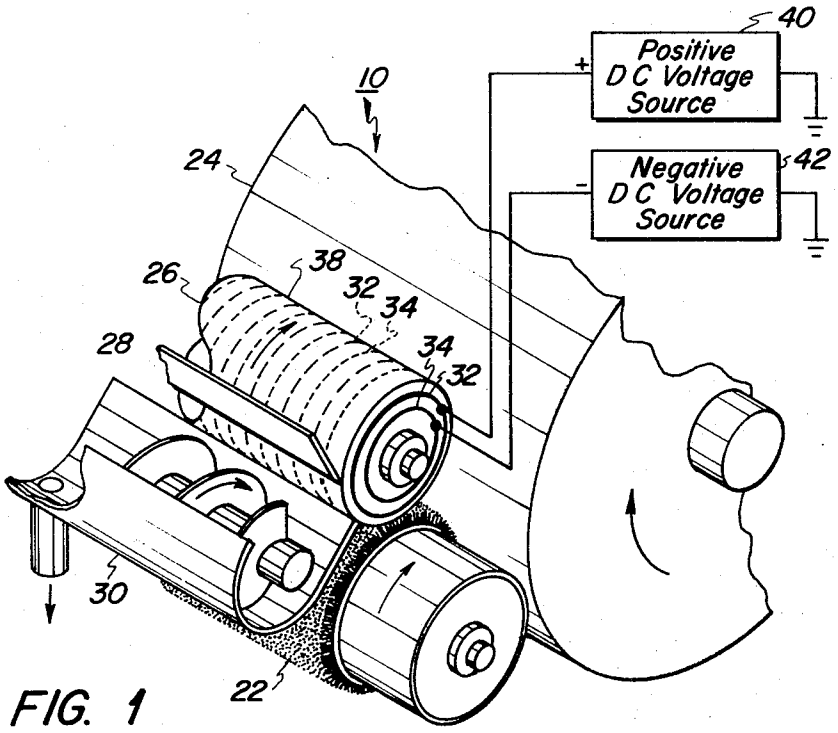


FIG. 1

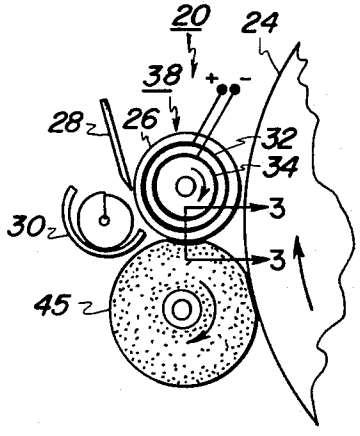


FIG. 2

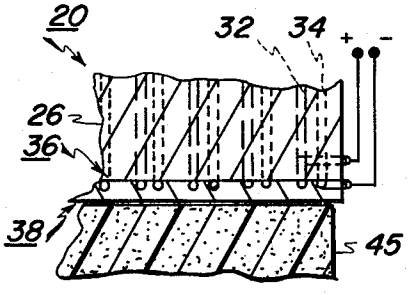


FIG. 3

LINE CHARGE TONER CLEANING

This invention relates to electrostatographic imaging systems and, more particularly, to an improved cleaning apparatus for cleaning electrostatographic image developer material from an imaging surface.

The general development and cleaning of imaging materials on a re-usable imaging surface in electrostatography is well-known. In xerography, for example, a latent electrostatic image is optically formed on a photoconductive imaging surface and developed by depositing on the latent image a charged finely divided dry electroscopic visible image developer material known in the art as toner. This toner image may then be electrostatically transferred and permanently fixed to a support surface such as paper. However, after such transfer, residual toner remains on the photoreceptor, which for re-use thereof must be removed by a cleaning operation at a cleaning station. This cleaning of residual toner from the photoreceptor must be accomplished rapidly and thoroughly yet without damage to the delicate photoreceptor, and the removed toner must be appropriately disposed of. The residual toner is tightly retained on the photoconductive surface and is difficult to remove. This retention is believed to be caused both by electrical charge attractions and by Van der Waals forces that prevent complete transfer of the toner to the support surface. Also, a small percentage of the toner can be wrongly charged, or uncharged, either initially or by virtue of the cleaning operation. Thus, cleaning of the imaging surface is one of the more difficult technical problems in practical xerography.

Conventional photoreceptor cleaning devices are brush type cleaning apparatus, web type cleaning apparatus, or blade type cleaning apparatus. A brush type cleaning system is usually comprised of one or more rotating brushes which frictionally brush toner from the photoconductive surface by a mechanical brushing or wiping action into a brush hood from which the removed toner is exhausted through a filtering system. Exemplary brush cleaning apparatus is disclosed in U.S. Pat. Nos. 2,357,809 to Carlson, 2,832,977 to L. E. Walkup et al., and 2,911,330 to H. E. Clark. Such brush cleaning systems have been commercially successful.

One problem in long term cleaning system usage has been the tendency of the brush (or other cleaning member) to itself become contaminated with toner. This can result in both decreased cleaning efficiency and also undesired smearing of the toner particles on the photoreceptor or other contacting member. Various structures have been employed to continuously remove the toner from the cleaning member. One such structure, for cleaning the electrostatographic cleaning brush or fabric belt, is a flicker bar deformably engaging the fiber to mechanically remove toner. The flicker bar may be made of a material such that triboelectric charges are produced thereon for assisting in the attraction of toner from the cleaning brush, as taught in West German application Ser. No. P 2,201,784.1, filed Jan. 14, 1972 and published Aug. 3, 1972 by Robert L. Foster. It is known that the flicker bar surface and/or the cleaning brush housing may be conductive and electrically biased or grounded for assisting in toner removal. However, flicker bars systems have disadvantages in terms of generation of a powder cloud of the toner, and buildup of toner on the flicker bar. It is also known that the cleaning brush or other cleaning member may be corona charged by an adjacent corona emitter. However, such corona emitters are subject to toner contamination problems in this particular embodiment.

Of particular relevance to the present invention is U.S. Pat. No. 3,572,923 by Donald J. Fisher issued Mar. 30, 1971, and its divisional U.S. Pat. No. 3,655,373. These patents disclose a fiber cleaning roller which may have an electrically biased segmented substrate for applying a toner attractive electrical field between the base of the cleaning fibers and a photoreceptor. This cleaning member in turn is cleaned by engagement with a uniformly electrically biased secondary roller which removes the accumulated toner from the cleaning member. This toner may then be removed from the secondary roller surface by a cleaning blade and auger removal system. In this prior patent structure, however, the secondary roll is fully conductive and is uniformly charged to a single electrical bias polarity. This provides removal of most of the toner, since most of the toner particles will be charged to one polarity which is opposite from the secondary roller bias. However, there will be a small percentage of toner particles which will be biased to the opposite polarity or will be uncharged (neutral). These latter toner particles will not be removed by the uniform charge and uniform field on the secondary roller.

The present invention overcomes these and other problems by providing a cleaning system in which the secondary roller has a plurality of non-uniform electrical fringe fields, which attract toner of either polarity and also uncharged toner. A pattern of closely spacing spaced alternate differing charges over the surface of the secondary roller has been found to achieve stronger toner attraction by means of the electrostatic contrast and the highly non-uniform electrical fields which can be provided thereby. These electrical fields attract toner strongly in a manner similar to the "line charge" attraction or "edge effect" known in the xerographic development of images on the photoreceptor. The discrete adjacent charged areas provide greater fields and field gradients for a given bias potential level than a uniformly biased secondary roller.

The disclosed imaging surface cleaning member may comprise a brush, fabric, or other fibrous member, or a foraminous material such as open cell porous foam rubber or plastic. The use of foam rollers in photoreceptor cleaning is taught for example in pending U.S. Pat. application Ser. No. 279,156 filed Aug. 9, 1972 by Frederick W. Hudson and entitled "Cleaning Apparatus". Other examples of foam roller imaging surface cleaning systems may be found, for example, in U.S. Pat. No. 3,438,706 to Tanaka et al. at column **23** and FIGS. **38, 40** and **45.** Foam roller cleaning is also disclosed in the different environment of liquid developer removal in U.S. Pat. Nos. 3,656,200 to B. J. Riley, Jr. and 3,654,654 to C. O. Abreu et al. An electrically biased foam wiper pad cleaning system in which the pad is mechanically scraped by ridges on the photoreceptor drum is disclosed in U.S. Pat. No. 3,728,016, to Harbour et al.

The above-cited and other references in the xerographic art teach suitable exemplary structures, components, materials, and xerographic systems for the exemplary embodiments of the present invention dis-

closed herein. Accordingly, the following description is directed only to the specific features of the invention which represent a departure from the above cited art. All of the references cited herein are hereby specifically incorporated by reference in the present specification.

Further objects, features and advantages of the present invention pertain to the particular apparatus and details whereby the above-mentioned aspects of the invention are obtained. Accordingly, the invention will be better understood by reference to the following description and to the drawings forming a part thereof, which are substantially to scale wherein:

FIG. 1 is a perspective view of an exemplary electrostatographic imaging material cleaning system in accordance with the present invention;

FIG. 2 is an end view of a second embodiment which differs from the embodiment of FIG. 1 only in that the cleaning member is a foraminous roller rather than a brush; and

FIG. 3 is a partial cross-sectional view taken along the line 3—3 of FIG. 2.

Referring now to the drawings, there is illustrated in FIG. 1 an exemplary toner cleaning apparatus **10** for a xerographic photoreceptor. FIGS. 2 and 3 illustrate a second apparatus **20** differing only in the substitution of a foam rubber cleaning roller for the cleaning brush of the apparatus **10.** Accordingly, the following description is applicable to all of the figures, and the exemplary components thereof are otherwise identical, and identically positioned. As previously noted, U.S. Pat. Nos. 3,572,923 or 3,655,373, and the other cited references, may be referred to for further appropriate details.

Referring first to FIG. **1,** a rotatably driven cylindrical cleaning brush **22** is shown in cleaning engagement with a photoreceptor imaging surface **24** for removing the toner imaging material therefrom. The cleaning brush **22** here is cylindrical, and rotated so that its surface moves relative to the imaging surface **24.** It will be appreciated that a web or belt could be utilized in certain applications in place of a cylinder.

A substantial portion of the removed toner will be normally retained in the fibers of the cleaning brush **22** and must be removed therefrom. This is accomplished hereby a rotating cylindrical pickoff member or secondary roller **26** which continuously deformably engages the cleaning brush **22** at an area of the cleaning brush different from its engagement area with the imaging surface **24.** The pickoff roller **26** is also rotatably driven so as to present a continuously moving outer surface **38** relative to the cleaning brush **22.** Thus, the pickoff roller **26** makes a cleaning engagement with the cleaning brush **22** for removing the toner from the cleaning brush onto the surface **38** of the pickoff roller **26.** This toner removal from the cleaning brush **22** is accomplished by the electrostatic field producing means described herein which produces a plurality of non-uniform toner attractive electrical fields between the pickoff roller and the cleaning brush.

As in the cited U.S. Pat. No. 3,572,923, additional toner removal means can be provided for removing the toner from the surface of the pickoff roller **26.** Here this comprises a cleaning blade **28** scraping the toner from the smooth, rigid, surface **38** of the pickoff roller **26** into an underlying adjacent auger and trough toner transport mechanism **30.**

The structure and electrical connections of the exemplary pickoff roller **26** may be seen particularly in FIGS. **1** and **3.** The pickoff roller **26** preferably has an outer surface **38** of a material which is electrically insulative and which is adapted to triboelectrically generate electrostatic charges by frictional engagement with the cleaning brush **22** or other cleaning member. Such materials are, of course, well known in the xerographic art, examples being commercially available epoxies, or fluorinated hydrocarbon materials such as Teflon.

The pickoff roller **26** illustrated here has a smooth surface, which would tend to generate relatively uniform surface charges triboelectrically in operation by the frictional engagement of its surface **38** relative to the surfaces of the cleaning brush **22.** However, it will be appreciated that the outer surface of the pickoff roller **26** may be grooved or otherwise made irregular so as to irregularly generate or irregularly retain electrostatic charges thereon, thereby creating a multiplicity of uneven electrostatic fringe fields in a pattern over the roller surface. Of course, the smooth cylindrical surface illustrated here is desirable from the standpoint of uniform surface cleaning by a cleaning blade **28.**

Preferably, the principal source here of the electrostatic fields for attracting toner onto the pickoff roller **26** is a plurality of closely spaced conductive elements on the surface of the pickoff roller **26** which are differently electrically biased so as to create a plurality of non-uniform electrostatic fields between adjacent conductive elements, which fringe fields are electrostatically attractive to all of the toner particles regardless of their charge.

This plurality of discrete conductive elements here comprises a bifilar (two conductor) helical winding circumferentially around the surface of the pickup roller **26.** This may be particularly seen in FIG. **3.** This known winding arrangement provides a closely spaced pattern of conductive elements across the entire surface of the pickoff roller **26,** yet it consists of only two discrete continuous conductors **32** and **34.** By virtue of the bifilar helical winding pattern these two conductors **32** and **34** are closely adjacent one another across the entire pickoff roller surface.

One possible method of construction of the bifilar winding is illustrated in FIG. **3.** There the conductors **32** and **34** are conventional electrical wires, e.g. of 0.02 inch diameter, which are conventionally helically wound on a first insulative surface **36** which may be grooved to receive them if desired. A spacing of 1/16 inch between line turns is satisfactory. These conductors are then covered with a thin outer layer of insulative material to form the final outer surface **38,** in which the conductors are imbedded and insulated from one another. This outer surface may be ground down to smooth it to a uniform thickness of, for example, 15 mils.

The ends of the conductors **32** and **34** may conventionally be brought out to slip rings or other conventional rotary electrical connectors on the ends of the pickoff roller **26** for connection to the electrical biasing source. As shown in FIG. **1,** this may comprise a positive DC voltage source **40** connected to the conductor **32** and a negative DC voltage source connected to the conductor **34.** It will be appreciated, of course, that these voltages may be generated in a single conventional power supply circuit. The particular appropriate voltage will depend, of course, on the construction and

spacing of the conductors, the materials, the nature of the cleaning member, etc. Voltages of approximately +1,000 and −1,000 volts are appropriate for the voltage sources **40** and **42,** respectively, for the exemplary dimensions noted above.

Although with the disclosed construction here the conductors **32** and **34** are covered by, and just slightly below, the insulative outer surface **38** of the pickoff roller **26,** this is not required and in fact it may be desirable to have the conductors exposed at the surface of the pickoff roller **26,** providing an appropriate cleaning blade **28** or other toner removal means can be provided which will not damage the conductors. Exposure of the conductors at the otherwise insulative surface will have the effect of breaking up the outer surface **38** into discrete areas of different triboelectric properties, for differential charging.

Although a conventional wire winding is shown here for providing the conductors **32** and **34,** printed circuit techniques may be utilized instead, such as the forming of a desired pattern of conductors on a flexible printed circuit sheet, which sheet may then be bonded to the pickoff roller surface. With printed circuit techniques any desired pattern of conductors may be utilized. Thus, for example, the conductors may extend in a linear pattern along the axis of the pickoff roller **26** rather than circumferentially around it as disclosed here.

If the cleaning brush **22** or its substrate is also electrically biased, it will be appreciated that the conductors **32** and **34** should preferably be respectively biased above and below the bias level of the cleaning brush so that in all cases both positive, negative and neutral toner particles can be pulled from the cleaning member onto the pickoff roller by the electrostatic fields. In any case, the electrical biasing source preferably applies opposite polarity electrical potentials between closely adjacent conductive elements so as to create a plurality of strong electrostatic fringe fields between all of these adjacent conductive elements across the surface of the pickoff roller **26,** which electrostatic fields are attractive to all of the imaging material. Appropriate fringe fields can also be generated by the adjacent application of substantially different potentials of the same polarity.

Turning now to the apparatus **20** of FIGS. **2** and **3,** the above description is equally applicable thereto. The difference is only that the cleaning brush **22** is replaced here by a foraminous cleaning roller **45.** This cleaning roller **45** preferably has an open pore or open cell moving cleaning surface which deformably engages both the imaging surface **24** and the pickoff roller **26.** This material can be a conventional polyurethane foam or any other suitable foranimous material. The references on this subject previously cited are noted in this regard.

In conclusion, it may be seen that there is disclosed herein an improved cleaning apparatus providing improved dry developer material removal from electrostatographic imaging surfaces. The exemplary embodiments described herein are presently considered to be preferred; however, it is contemplated that numerous further variations and modifications within the purview of those skilled in the art can be made herein. The following claims are intended to cover all such variations and modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. In electrostatographic apparatus in which electrostatically attractable imaging material is cleaned from an imaging surface, the improvement comprising:

a moving surface cleaning member making a cleaning engagement with said imaging surface for removing said imaging material from said imaging surface;

a moving surface pick-off member making a cleaning engagement with said cleaning member for removing said imaging material from said surface of said cleaning member to said surface of said pick-off member;

electrostatic field means for generating a multiplicity of closely adjacent differently charged areas on said pick-off member in said engagement with said cleaning member for producing a plurality of non-uniform imaging material attractive electrical fringe fields between said pick-off member and said cleaning member;

and imaging material removal means for removing said imaging material from said pick-off member.

2. The apparatus of claim **1** wherein said cleaning member is a cylindrical rotating cleaning brush and said pickoff member is a rigid cylindrical roller.

3. The apparatus of claim **1** wherein said cleaning member comprises a foraminous surfaced cylindrical roller deformably engaging both said imaging surface and said pickoff member.

4. The apparatus of claim **3** wherein said pickoff member is a rigid cylindrical roller having an substantially electrically insulative surface.

5. The apparatus of claim **4** wherein said electrostatic field means comprises a plurality of closely spaced conductive elements on said insulative surface of said pick-off member and electrical biasing means for differently electrically biasing said conductive elements.

6. The apparatus of claim **5** wherein said electrical biasing means applies substantially different electrical potentials to adjacent said conductive elements to create a plurality of non-uniform electrostatic fields between said plurality of adjacent conductive elements attractive to all of said imaging material including electrically uncharged imaging material.

7. The apparatus of claim **5** wherein said conductive elements are thinly covered by said insulative surface.

8. The apparatus of claim **5** wherein said conductive elements comprise a two conductor bifilar helical winding pattern on said pickoff member.

9. The apparatus of claim **8** wherein said electrical biasing means comprises a positive voltage source connected to one conductor of said bifilar winding and a negative voltage source connected to the other conductor of said bifilar winding.

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