

[54] **DEVELOPER BLADE CLEANING**

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

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

[58] Field of Search **15/1.5, 256.51, 256.5; 101/425; 68/270; 100/174, 126; 118/637, DIG. 23, 24; 117/17.5, 37 LE; 355/15, 34/85;120**

[56]

References Cited

UNITED STATES PATENTS

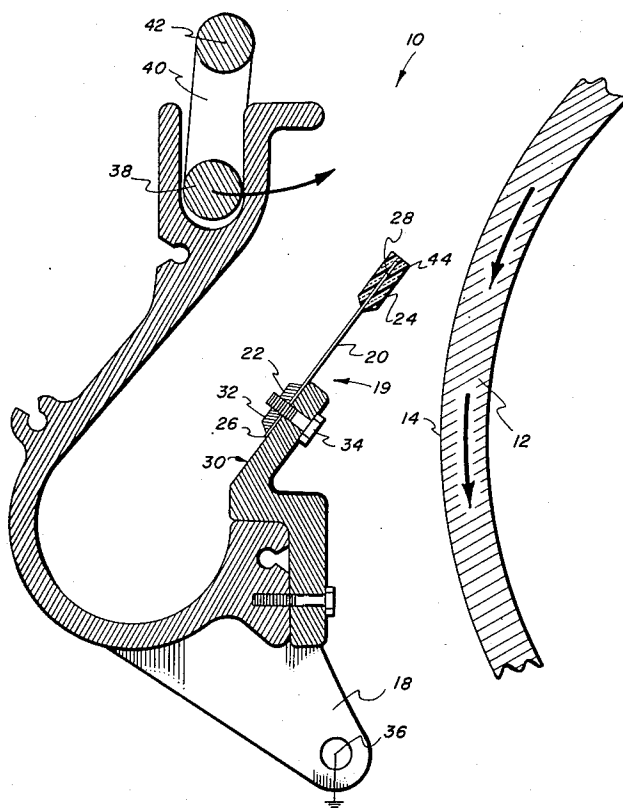
3,651,784	3/1972	Hewitt	118/637 X
3,655,373	4/1972	Fisher et al.	118/637 X
3,660,863	5/1972	Gerbasi	15/256.51

Primary Examiner—Edward L. Roberts

[57] **ABSTRACT**

An electrostatographic cleaning system for cleaning dry toner from a photoreceptor surface without lubrication other than the toner itself, comprising a sharp-edged elastomer cleaning tip held in chiseling engagement against the photoreceptor, which tip is integrally mounted on a main blade portion of a much more rigid but thin material, such as thin steel shimstock, which extends out to closely adjacent the cleaning edge of the tip to fully support it and render the blade substantially rigid except perpendicular the photoreceptor surface. This main blade portion is cantilever mounted generally parallel to, and into the direction of movement of the photoreceptor surface. The blade is mounted by the main portion rather than to the elastomer material.

12 Claims, 4 Drawing Figures



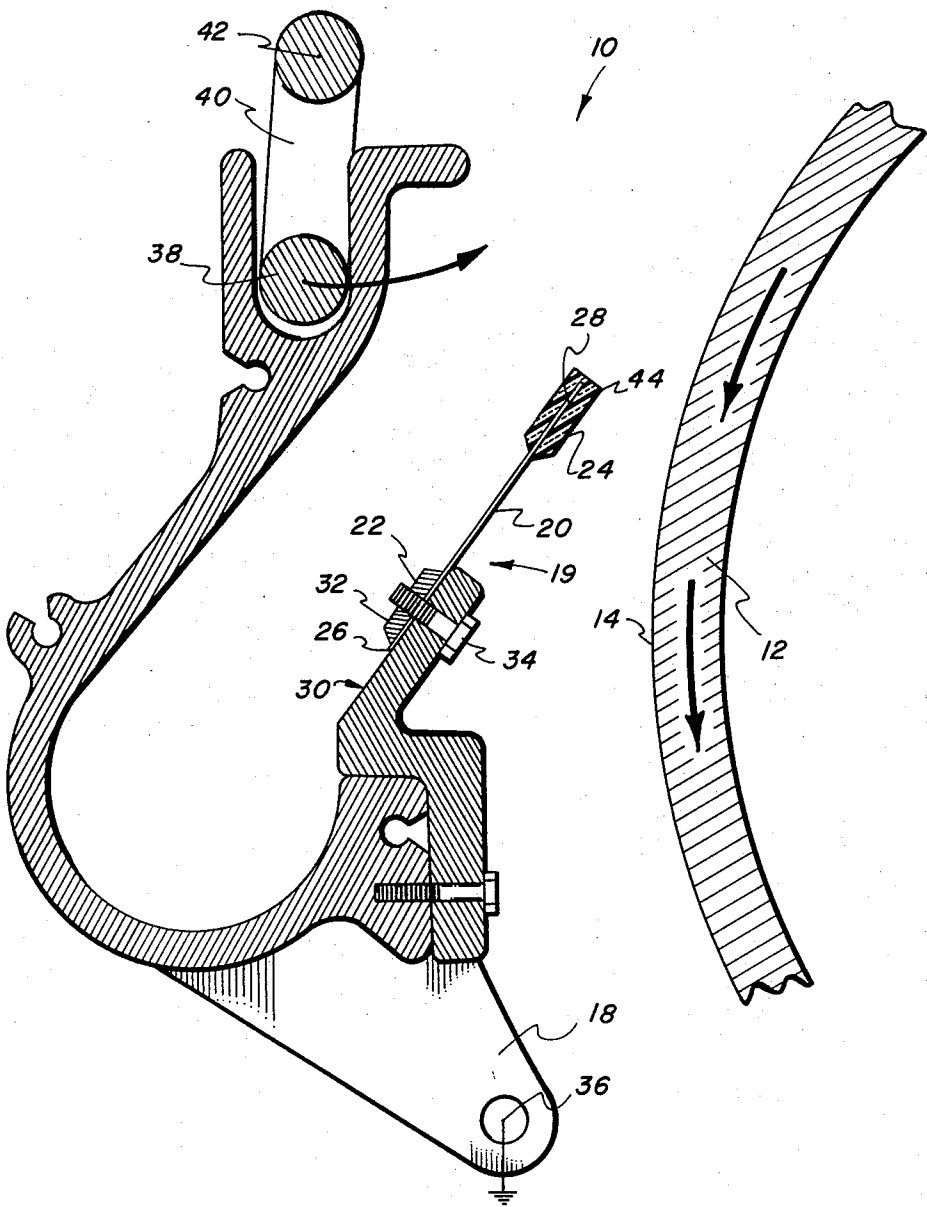


FIG. 1

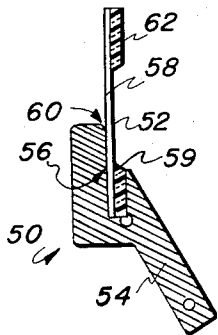


FIG. 4

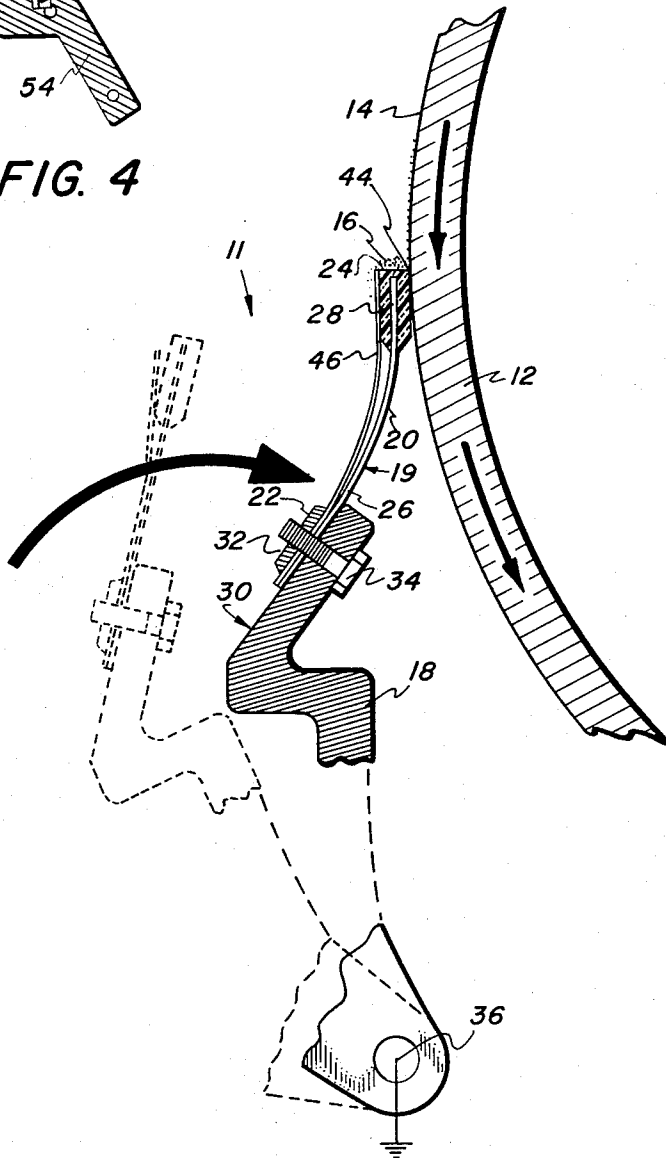


FIG. 2

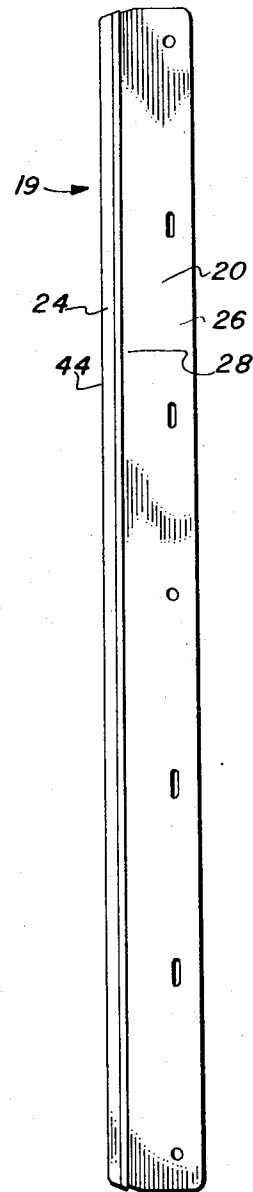


FIG. 3

DEVELOPER BLADE CLEANING

A related application of the same filing date and assignee is Ser. No. 356,986 by C. S. Hasiotis, entitled Supported Developer Blade Cleaning.

This invention relates to electrostatographic imaging systems and, more particularly, to an improved blade cleaning apparatus for cleaning developer from electrostatographic imaging surfaces.

The formation and development of images on the surface of recording materials by electrostatographic means is well known. One basic process, xerography, as taught for example in U.S. Pat. No. 2,297,691, by C. F. Carlson; U.S. Pat. No. 3,062,536, by J. Rutkus, Jr., et al., and other patents cited herein, involves placing a uniform electrostatic charge on an imaging surface such as a photoconductive insulating layer, exposing the layer to a light-and-shadow image to selectively dissipate the charge, and developing the resulting electrostatic latent image by depositing on the image a finely-divided dry electroscopic developer material known in the art as toner. The toner is normally attracted to those areas of the latent image which retain a charge, thereby forming a visible (toner) image corresponding to the electrostatic latent image. This toner image may then be transferred and permanently affixed to a support surface such as paper. After such transfer, the residual toner remaining on the photoreceptor imaging surface is removed by a thorough cleaning operation at a cleaning station so that the imaging surface may be reemployed for another imaging cycle.

In modern commercial automatic copier/reproduction machines, the electrostatographic imaging surface, which may be in the form of a drum or belt, is preferably designed to move at high rates of speed relative to a plurality of processing stations. Such rapid movement of the imaging surface requires greater amounts of toner to be used during development, and requires more rapid and efficient toner removal at the cleaning station. Further, as reproduction and copying devices become both smaller and more sophisticated, spacing of components around the imaging surface becomes more critical. It is, therefore, desirable to reduce the spacing occupied by the individual stations along the surface as much as possible.

Fully removing the residual toner image remaining on a photoreceptor imaging surface after transfer without damage to the photoreceptor has been one of the more difficult technical problems in xerography. The residual image is tightly retained on the photoconductive layer and difficult to remove. This is believed to be caused by both electrical charge attractions and by Van der Waals forces that prevent complete transfer of the toner to the support surface, particularly in the image area.

The residual toner image is normally removed by photoreceptor cleaning devices such as brush type cleaning apparatus, web type cleaning apparatus, or, more recently, by blade type cleaning apparatus. Blade cleaning provides advantages of compactness, quietness, reduced machine toner contamination and allows simpler continuous toner capture (and reuse) in the same machine.

A typical brush cleaning apparatus is disclosed in U.S. Pat. No. 2,832,977 to L. E. Walkup, et al., and in U.S. Pat. No. 2,911,330 to H. E. Clark. The brush type cleaning means usually comprises one or more rotating

brushes which brush toner from the photoconductive surface into a stream of air which is exhausted through a filtering system. A typical web cleaning device, which wipes the surface and usually retains the toner in the web, is disclosed in U.S. Pat. No. 3,186,838 to W. P. Graff, Jr., et al.

Xerographic blade type dry toner cleaning apparatus, to which the present invention relates, are disclosed in U.S. Pat. Nos. 3,552,850 issued Jan. 5, 1970, to S. F. Royka, et al.; 3,634,077 issued Jan. 11, 1972, to W. A. Sullivan; 3,438,706 issued Apr. 15, 1969, to H. Tanaka et al.; 3,724,019 issued Apr. 3, 1973 to Alan L. Shanly; 3,724,020 issued Apr. 3, 1973 to Henry R. Till; German Application DOS 2,111,509 by Cannon filed Mar. 10, 1971, and laid open Sept. 23, 1971; and U.S. Pat. No. 3,660,863 issued May 9, 1972, to D. P. Gerbasi, successfully commercially embodied in the Xerox Corporation "4000" xerographic copier, which has a cut tip polyurethane cleaning blade. The present invention is an improvement thereon, and accordingly this Gerbasi patent, and the others cited herein, are hereby incorporated by reference, and the present specification is specifically directed to the present improvement.

While ordinarily capable of cleaning electrostatographic imaging surfaces, conventional cleaning devices have not been entirely satisfactory. Most of the known cleaning devices usually become less efficient as they become contaminated with toner and require fairly frequent replacement or servicing of the cleaning device. Even a partial failure of the cleaning element at any point can cause a background of undesired toner deposition to appear in streaks or spots on the copy sheets.

In toner blade cleaning, the toner is not being doctored, rather the toner is preferably totally stopped by the cleaning blade or blades in a single rotation of the photoreceptor drum or surface, and simultaneously or subsequently removed from the surface. The entire surface must be cleaned thousands of times without damage. The cleaning loads on the blade are very uneven, both short term and long term, because the location, density and tenacity of the residual toner varies widely over the surface, depending on the images, the exposures, the surface charges, the toner development, the image border areas, etc. Furthermore, the frictional forces of the cleaning operation, unless carefully controlled, can easily result in the generation of excessive pressure or heat, resulting in physical and chemical changes in the toner, smearing of toner materials onto the photoreceptor, or blade, excessive photoreceptor wear, or other problems, especially in higher speed machines. Thus, cleaning dry toner from a photoreceptor presents extremely critical requirements not normally found in other cleaning fields, and blade cleaning systems suitable for other fields and applications, e.g., cleaning or doctoring systems for metal gravure rollers or inking rollers or paper mill rollers or adhesive applicators, are not normally appropriate.

There are, of course, literally thousands of patents teaching various cleaning blades in numerous such non-analogous applications, including both doctor and wiper blades. A hindsight search of this extensive art will naturally uncover blade structures which are similar in general appearance to the present blade. However, almost all blades from non-analogous arts would be completely unsuitable for photoreceptor toner cleaning, and it will be appreciated that the sheer vol-

ume of such teachings would make the selection of the structure of the invention therefrom virtually impossible without the teachings of the present invention. Examples of patents subsequently found in such non-analogous arts disclosing blades structures similar to the present structure are U.S. Pat. Nos. 2,052,679 to J. Wainwright, et al., issued Sept. 1, 1936; 2,313,830 to A. E. Lundbye, issued Mar. 16, 1943; 1,803,927 to J. W. Vedder, issued May 5, 1931; 2,287,350 to F. W. Lodding issued June 23, 1942, and numerous others.

Almost all such non-analogous blade cleaning systems are designed for, and teach operation in, totally different environments wherein a liquid or semi-liquid is partially or wholly removed from a roller of metal or other material far less susceptible of damage than a re-useable photoreceptor surface. Obviously the cleaning of liquid materials is inherently non-analogous since such materials are selflubricating and can provide much lower cleaning frictions as well as surface protective filming.

The interdependent frictional cleaning force requirements for dry toner blade cleaning have heretofore necessitated in practical xerographic cleaning systems the use of a lubricant material added in some manner to reduce the friction between the cleaning blade edge and the photoreceptor surface. Examples of such lubricants and methods of applying them are disclosed, for example, in the incorporated Royka, et al., U.S. Pat. No. 3,552,850.

The peculiar problems of dry toner removal are further aggravated by the fact that accumulated dry toner, plus the added lubricants, builds up at the cleaning edge against the photoreceptor surface. This provides a particulate seal assisting in trapping further toner particles approaching the blade edge. However, along with other contaminants such as paper fibers, it adds to the frictional loads on the blade.

All of the above-noted toner blade cleaning problems are highly aggravated by low relative humidity environments. With low humidity the toner becomes more tenacious and difficult to remove. It retains electrical charges longer, and triboelectric charges may be generated from the cleaning action itself. The coefficient of friction increases substantially, and gross blade failures, such as blade tuckunder are more likely to occur. By tuck-under is meant the blade failure mode wherein the frictional force on the blade tip by the photoreceptor becomes so high as to deform the blade tip substantially out of its normal cleaning position into a non-cleaning position.

A chiseling type blade cleaning system, such as that of the incorporated Gerbasi U.S. Pat. No. 3,660,863, is particularly susceptible to this type of blade failure mode because the blade resiliently engages the photoreceptor surface extending toward the direction of surface motion and is subjected to increased compression forces rather than tension forces as friction increases between the blade and photoreceptor. Yet a blade material which is sufficiently rigid to withstand blade tuckunder or other deformation forces does not provide the other needed blade properties of sufficient deformability to continuously conform to the photoreceptor surface and provide good cleaning engagement therewith without damaging the surface.

The improved xerographic toner removal system disclosed herein provides all of the advantages of the prior blade cleaning systems yet overcomes many of the

above-described disadvantages and cleaning blade failures modes. In particular, the cleaning blade system of the invention can be utilized without any required lubricants other than the xerographic toner being removed, yet without blade tuck-under or photoreceptor damage.

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 attained.

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 except as otherwise noted herein, wherein;

FIG. 1 is a cross-sectional view of an exemplary blade cleaning system in accordance with the present invention;

FIG. 2 is a corresponding cross-sectional view of a second embodiment similar to the embodiment of FIG. 1, illustrating movement of the cleaning blade into its operative cleaning position;

FIG. 3 is a planar view of the exemplary cleaning blade itself of the cleaning systems of FIGS. 1 and 2; and

FIG. 4 is a cross-sectional view of an alternative embodiment of the photoreceptor cleaning systems of FIGS. 1-3.

Referring now to the drawings, there is illustrated in FIGS. 1 and 3 and electrophotographic developer material cleaning system 10 in accordance with the present invention. FIGS. 2 and 4 illustrate alternative cleaning systems 11 and 50 for which the same description will apply, except for the specific differences subsequently noted herein. The cleaning systems 10 and 11 differ in the provision in the cleaning system 11 (FIG. 2) of a backup support blade in addition to the main blade. This system 11 is more specifically claimed in an application Ser. No. 356,986 by Christ S. Hasiotis of the same filing date and assignee. The disclosed exemplary cleaning systems 10 and 11 are shown with a relevant portion of a xerographic system photoreceptor drum 12 with an outer surface 14 on which toner 16 has been developed, and from which the toner 16 is removed during cleaning of the photoreceptor 12 by the cleaning blade.

As was previously noted, the other components of conventional or suitable xerographic or other electrostatographic systems are fully disclosed in the above-cited and other references, and details thereof need not be disclosed herein. It is contemplated that the presently disclosed cleaning systems are applicable to cleaning and removing almost any type of developer material, including, but not limited to, the well-known two-component types. Exemplary patents disclosing developer compositions include U.S. Pat. No. 2,618,551 to Walkup, No. 2,618,552 to Wise; No. 2,633,415 to Walkup and Wise; No. 2,659,670 to Copley; No. 2,788,288 to Rheinfrank and Jones; and U.S. Pat. No. Re. 25,136 to Carlson. Generally such toners comprise triboelectrically chargeable and thermally or vapor fusible pigmented resins, having a particle diameter of between about 1 and 30 microns.

The cleaning systems 10, 11 and 50 do not require a separate lubricant or additive material in the toner 16 or on the photoreceptor surface 14 before or during the cleaning operation. This simplification and materials

saving is accomplished by the disclosed structure, which is sufficiently rigid to resist blade tuck-under even under low humidity conditions and yet has an elastomer cleaning edge of known or suitable materials which is sufficiently soft to provide a cleaning seal and protect the surface 14 from abrasion or damage, even where the surface 14 is bare selenium metal, selenium alloy, or an organic photoconductor.

The exemplary cleaning systems 10 and 11 disclosed here consist basically of a pivoted blade support arm 18 and a blade unit 19 mounted on the support arm 18 by a blade clamping arrangement 22, where the blade unit 19 comprises an elastomer cleaning tip portion 24 mounted to the outer edge of a main blade portion 20 for resiliently engaging and cleaning the photoreceptor surface 14. Additional associated means may be provided for removal and/or recirculation of the blade cleaned toner, as taught in several of the above-cited toner blade cleaning patents and applications.

The main blade portion 20 is a continuous sheet of substantially inelastic thin planar material, preferably sheet metal. As may be seen in FIG. 3, it is in the form of a continuous generally rectangular blade extending in length sufficiently to clean the entire axial width of the photoreceptor surface 14. It has opposing parallel spaced edges 26 and 28. The mounting edge 26 is adapted to mount to the support arm 18 at the clamping arrangement 22. Preferably the support arm 18 and the clamping arrangement 22, illustrated in cross-section in FIGS. 1 and 2, extend uniformly and continuously along the mounting edge 26 of the main blade portion 20. The opposing spaced free edge 28 of the main portion 20 continuously supports the much smaller elastomer cleaning tip portion 24, which extends evenly therealong.

An appropriate exemplary main blade portion 20 has been found to be an elongated generally rectangular strip of thin stainless steel shimstock, with a thickness and unsupported width appropriate to provide the desired beam strength yet suitable normal direction resilience. The thickness is preferably only a few mils for a blade having an unsupported width of one-half to one inch. By unsupported width is meant the cantilever distance which the main portion 20 extends beyond the clamping arrangement 22 to the edge of the cleaning tip.

The entire blade unit 19 is cantilever mounted from the support arm 18 at the clamping arrangement 22. It will be noted that only the main portion 20 of the blade unit 19 is secured, and there is no clamping engagement whatsoever with any of the elastomer cleaning tip material. The elastomer cleaning tip 24 is spaced from the clamping arrangement 22 by the entire unsupported width of the main portion 20. This has been found to be important for preventing distortion of the orientation and shape of the cleaning tip 24.

Considering the clamping arrangement 22 in greater detail, it will be appreciated that various other suitable clamping arrangements may be provided which will achieve the desired objectives. For example, a quite different clamping arrangement 56 is illustrated in the system 50 of FIG. 4. The clamping arrangement 22 of FIGS. 1 and 2 is intended to rigidly and planarly clamp only the mounting edge 26 of the main blade portion 20 continuously therealong. This is provided here by a continuous flat mounting surface 30 on the support arm 18 against which the main blade portion 20 is

clamped by an opposing planar solid keeper plate 32 which continuously overlies the mounting surface 30. The mounting edge 28 of the main blade portion 20 is compressively sandwiched between the surface 30 and the keeper 32 by means of a plurality of mounting bolts 34 extending through all three components from the support arm 18. For this purpose suitable mounting apertures may be etched in the main blade portion 20 as illustrated in FIG. 3. The clamping arrangement 22 is intended to keep the entire blade unit 19 as flat as possible as well as properly aligned and oriented with respect to the photoreceptor surface 14.

Since the main blade portion 20 is of a very rigid and inelastic material, and since it extends over substantially the entire area of the blade unit 19, the blade unit 19 is effectively rigid and inelastic in both planar axes. Thus, for example the entire blade unit 19 may be translated in the direction of its elongate dimension, i.e., laterally of the photoreceptor, without significant distortion of the blade. The resilient flexibility of the main portion 20 is provided only perpendicular its planar dimensions. This flexibility is allowed by thinness of the shimstock material which allows it to be flexed out of its normal planar configuration. The normal unflexed planar configuration of the blade unit 19 is shown in FIG. 1 and in the dashed outline alternate position of FIG. 2, in contrast to the flexed cleaning position of FIG. 2.

It may be seen that the main blade portion 20 is mounted so as to extend generally parallel to the photoreceptor surface 14. This allows the resiliency of the main portion 20 to be utilized for loading the blade unit 19 against the photoreceptor surface uniformly. With this arrangement the main blade portion has substantial resilience only in a direction toward or away from the photoreceptor surface, thereby maintaining the desired cleaning position and orientation of the cleaning tip 24 yet resiliently urging it against the surface 14 in the cleaning position, as shown in FIG. 2, by the flexural beam characteristics of the main portion 20 as the support arm 18 is moved toward the surface 14.

As illustrated in FIGS. 1 and 2 the support arm 18 is pivotally mounted about a pivot axis 36 parallel the axis of the drum 12 and spaced below the clamping arrangement 22. Suitable means are provided for pressing the tip portion of the blade unit 19 into substantially uniform cleaning engagement with the photoreceptor surface 14 by rotating the support arm 18 about the pivot axis 36 toward the surface 14. In the exemplary structure of FIG. 1 this is provided by a cam 38 swung on an arm 40 about a pivot 42. The cam 38 operatively engages a corresponding camming notch in the upper portion of the support arm 18.

The pressure with which the cleaning tip 24 engages the surface 14 is a function of the beam strength or flexural resistance of the main portion 20, which is related to its thickness and unsupported width, and its deflection, although the unsupported width has been found to be relatively uncritical. The blade deflection, shown in FIG. 2, is controlled by the distance which the support arm 18 is moved toward the surface 14 after engagement is made by the cleaning tip 24. It may also be seen from FIG. 2 that this deflection or angular deformation of the main blade portion 20 is controlled and designed so that the free edge 28 and its cleaning tip 24 are deflected into a position almost parallel the surface 14 to be cleaned at the contact line. That is, the

beam deformation of the main portion 20 orients the attached cleaning tip 24 substantially tangential the surface 14 and projecting directly toward the direction of motion of the photoreceptor surface 14 when the top 14 is in cleaning engagement therewith. This allows the main portion 20 to extend along and through substantially the entire cleaning area closely adjacent the surface 14 and also causes the frictional forces exerted on the blade unit 19 to be substantially purely compressive forces as seen by the main portion 20. This also provides the desired orientation for a chiseling cleaning engagement of the cleaning tip 24 against the surface 14, described in greater detail in the previously cited Gerbasi U.S. Pat. No. 3,660,863.

A suitable angle of approach of the blade unit 19 to the photoreceptor surface tangent at the point of contact is approximately 36°, within the range of 24° to 48°. The angle of approach is the included angle formed by the main blade portion 20 with the tangent of the surface 14 at the initial point of contact with the cleaning tip 24 before any cleaning force is applied, i.e., the angle formed with the cleaning blade still planar and undeflected but touching the surface 14.

A suitable cleaning force with which the cleaning tip may be urged against the surface 14, expressed in pounds per inch of blade length across the photoreceptor, is preferably in the length of 0.17 to 0.36 pounds per inch, with 0.30 pounds per inch preferred. This can be achieved with a blade deflection in the range of 0.125 to 0.275 inches, with approximately 0.22 inches preferred. The blade deflection is the distance by which the blade is deflected at the end of the cleaning tip 24 from its normal unsprung position (FIG. 1 and FIG. 2 dashed) into its normal cleaning position (FIG. 2). It will be appreciated that these ranges are merely exemplary of suitable operative structures.

The main blade portion 20 is sufficiently stiff to prevent blade tuck-under from the high frictional forces between the cleaning tip 24 and the photoreceptor surface even in the absence of lubricating materials therebetween. This is achievable because the main blade portion 20 of rigid material extends, for all practical structural purposes, completely out to the free end of the entire blade unit 19. Further, as discussed above, the forces on the main blade portion 20 are compression forces acting primarily in the plane of the main portion 20 material, and therefore, acting on the blade primarily on an axis in which it is inelastic.

Considering now in further detail the cleaning tip 24, as previously noted this is a body of elastomer material extending along only the free edge 28 of the main blade portion 20 and firmly secured thereto. The elastomer tip material protects the photoreceptor from contact by the main blade portion 20 by always separating the two, and that portion of the elastomer material providing this separation also provides the necessary close cleaning seal with the surface 14. This seal should be generally maintained to near the particle diameter range of the toner in order to provide complete removal of toner. The toner itself, and other particular materials which may accumulate on the cleaning tip, can provide additional cleaning and sealing effects. However, for effective cleaning the cleaning tip 24 itself should have a sharp tip corner 44 which provides a line engagement across the photoreceptor surface. This sharp tip corner 44 may be formed by first molding or bonding the elastomer material evenly along the

free edge 28 of the main blade portion, extending slightly beyond the free edge 28, and then sharply squarely cutting the end of the elastomer material off the free edge 28 (e.g., 0.015 inches) so as to form a sharp tip corner or edge 44 of an approximately 90° included angle. It may be seen that this structure and manufacturing method, in addition to forming the sharp tip corner 44 insures that the main blade portion 20 extends to closely adjacent the tip corner 44, preferably to within approximately 0.03 inches, and also to closely adjacent the end of the cleaning tip 24. Thus, the portion of the cleaning tip contacting the surface 14 is fully supported and backed continuously by a rigid backing consisting of the main blade portion 20.

A suitable exemplary elastomer cleaning tip 24 may be provided by molding the suitable elastomer material evenly around the free edge 28 of the main blade portion so as to provide a generally uniform thickness layer of the elastomer material over the free edge 28. For example, an approximately 50 mil thick strip of polyurethane material has been found to be appropriate when molded concentrically onto the free edge 28 as illustrated in FIGS. 1 and 2. This elastomer body is thus substantially thicker than the main blade portion 20 which it encompasses, since it may be seen that this provides an approximately 0.030 inch thick layer of elastomer between an approximately 0.004 inch thick main blade portion 20 and the surface 14. This thickness of the elastomer tip material allows its elastomeric properties to be effectively utilized for sealing, even for areas of minor irregularities in the surface 14 or the main blade portion 20.

The elastomer material of the cleaning tip 24 may be of any suitable material, such as polyurethane, including those selected from the disclosure of the above-cited Gerbasi U.S. Pat. No. 3,660,863 and the Royka et al. U.S. Pat. No. 3,552,850. Preferably it is elastomeric in the range of 50–80 Shore A durometer durometer and has suitable abrasion resistance.

It will be appreciated that while the cleaning tip 24 here is shown flat ended, that the rear edge thereof, opposite from the tip corner 44, may be beveled off or rounded to reduce the flat area available at the end of the tip for toner accumulation. Where the beveling is confined to the rear portion of the tip behind the main blade portion 20, it will have little structural effect on the blade unit.

It has been noted that in a lubricantless cleaning blade system in accordance with the present invention that some toner which carries an electrical charge opposite from that of the main body of toner may escape from under the cleaning tip 24 rather than be removed from the surface 14 by the blade. However, since such oppositely charged toner will not normally be transferred in the transfer station it will not appear in the final copy sheet. Further, such toner can be recovered or scavenged from the surface 14 in the developer station as noted in the above-cited Royka et al. patent, particularly where magnetic brush development is utilized.

The differences between the cleaning systems 10 and 11 of FIGS. 1 and 2 respectively relate to a backup or reinforcing shim blade 46 in the cleaning system 11, and a corresponding small difference in the preferred thickness of the main blade portion 20. In the system 10 the blade unit 19 is completely unsupported and de-

pendents entirely on the resiliency of the main blade portion 20 (its deformation from its normal planar configuration) for transmitting all of the cleaning engagement force of the cleaning tip 24 against the surface 14. In the cleaning system 11 this force is supplemented by a separate and independent continuous backup blade 46. The backup blade 46 may be mounted by the same clamping arrangement 22 in the same manner as the main blade portion 20, as shown in FIG. 2, or independently mounted to the support arm 18. A suitable thickness for an unreinforced main blade portion 20 as in FIG. 1 has been found to be 4 mils. In the reinforced system 11 approximately the same cleaning forces can be provided by a main blade portion 20 of approximately 3 mils thickness together with a backup blade 46 of this same 3 mil thickness and the same general width. The backup blade 46 is preferably made of the same width. The backup blade 46 is preferably made of the same smooth stainless or spring steel shimstock material. However, sufficiently rigid, resilient and conductive plastic blade materials could also be utilized.

The primary function of the backup blade 46 is not to provide increased cleaning force, since the resilient beam strength of the main blade portion 20 can be made quite adequate in itself for this. Rather, its function is primarily to make the cleaning force sealing engagement of the cleaning tip 24 more uniform along its length across the photoreceptor surface. Waves or ripples can occur in the main blade portion 20 which can impose corresponding unevenness along the cleaning tip 24. Such unevenness can occur as a result of the bonding of the cleaning tip 24, by other manufacturing operations, by localized distortions caused by the clamping arrangement 22, and by unevenness in the blade material. Since the backup blade 46 is an independent structure and is independently cantilevered, it will not be subjected to the same distortions as the main blade portion 20. Further, any uneven spots in the backup blade 46 are statistically unlikely to occur at the same points as those in the main blade unit 19. By the disclosed arrangement the backup blade 46 independently exerts its own cleaning force directly against the cleaning tip 24 and therefore can compensate for uneven loading and sealing by the main blade portion 20, providing a composite force, as well as providing increased structural rigidity. Independent expansion of the blade unit 19 is not restricted by the backup blade 46, since its free end simply slideably abuts the rear surface of the cleaning tip 24.

It is important to note that the backup blade 46 does not contact the main blade portion 20 at any point beyond the clamping arrangement 22. It contacts the blade unit 19 only at the tip 24. It may be seen that this abutment extends over almost the entire area of the planar rear surface of the cleaning tip 24, so that the elastomer material is not subjected to any appreciable non-uniform pressures. Like the main blade portion 20, the backup blade 46 extends out to closely adjacent to, or even slightly beyond, the outer end of the cleaning tip 24. Thus, it may be seen that the backup blade 46 (since it is also of a rigid material) provides additional structural rigidity to the position of the elastomer cleaning tip 24 for greater blade tip control at the point of contact with the photoreceptor surface. That is, it assists the main blade portion 20 in helping to resist any twisting, tuck-under or other misalignment of the cleaning tip 24 at the top corner 44.

The above-discussed advantages are increased where, as in FIG. 2, the rear surface of the cleaning tip provides a uniform layer of elastomer material separating, and providing an elastomer contact pressure pad between, the two metal blade members, rather than metal-to-metal contact. This increases the effective blade thickness and rigidity at the tip and helps even out uneven forces due to minor blade irregularities.

It may be seen that the backup blade 46 also provides a smooth continuous surface for the removal of toner 16 away from the end of the cleaning tip 24, as does the main blade portion 20. Since both backup blade 46 and the main blade portion 20 are metal and are directly mounted to the metal support arm 18, which in turn is mounted to the machine frame, all of these components may be readily electrically grounded. This further assists in toner removal since both the backup blade 46 and the main blade portion 20 extend to either direct contact with, or are closely adjacent from, the toner accumulation at the end of the cleaning tip 24. Thus, they will provide sharp edged grounding rods for grounding electrical charges which tend to buildup as charged toner accumulates at the cleaning tip.

This same current path through one or both metal blades is also available for the improved application of electrical charges to the cleaning tip rather than grounding. The main blade portion 20 and/or the backup blade 46 (if present) provide a low resistance uniform electrical path by which an electrical bias voltage may be applied uniformly to directly adjacent the cleaning tip corner 44 for a high electrical field intensity between it and the surface 14. Yet the applied voltage will be spaced, and at least partially insulated from direct electrical shorting to the surface 14, by the elastomer tip material (which may be selected for a desired level of electrical resistivity). While the application of electrical bias voltages to cleaning blades has been previously suggested, as may be seen from the previously cited references, the present structure allows the charge (bias voltage) to be brought directly to the seal position at which the electrical field is desired, without being as affected by the resistivity variations (with humidity, etc.), of many appropriate elastomer cleaning blade materials, since the current does not have to be conducted through the elastomer material to the cleaning tip. Electrical charges applied to the present blade through the main blade portion 20 can be utilized to improve either or both the cleaning attraction or electrical discharge of charged toner particles at the blade tip and also to improve the ability of the tip corner 44 to form a toner trapping seal against the surface 14 by assisting in the retention there of toner particles (and lubricant materials, if any).

Considering now the cleaning system 50 of FIG. 4, this system differs structurally from the systems 10 and 11 of FIGS. 1-3. However, it functions to clean toner from a photoreceptor surface in the same advantageous manner. The differences relate primarily to the structure of the blade unit 52 and the manner in which it is mounted to its pivotable support arm 54.

Considering the mounting of the blade unit 52, a clamping arrangement 56 where comprises a single channel or recess into which the mounting edge of the blade unit 52 is mounted. It may be seen that the main blade portion 58, corresponding to the main blade portion 20 of FIGS. 1 and 2, is held by an integral molded elastomer tip 59 along its mounting edge. This elastomer

mer tip 59 corresponds generally in material and shape to the cleaning tip 24 of the blade unit 19. The elastomer tip 59, containing the blade mounting edge, is inserted firmly into the close-fitting channel of the clamping arrangement 56 and thereby frictionally retains the mounting edge of the blade portion 58 (to which it is bonded) therein. The main force on the blade unit 52 during operation is a compressive cleaning force acting downwardly on the main blade portion 58, and this force helps retain the blade unit 52 in the clamping arrangement 56 during operation. The blade unit 52 is restrained against downward movement by a flat transverse support surface at the base of the recess of the clamping arrangement 56. In view of these force components, it may be seen that the elastomer material 59 bonded to the blade mounting edge is not essential, and that an inserted metal keeper bar or spring or other clamping arrangement may be readily provided in its place.

In the cleaning system 50 the linearity or wave suppression along the clamping edge of the main blade portion 58 at the clamping arrangement 56 is not as critical because there is provided an additional means for uniformly urging the blade unit 52 into its cleaning contact with the surface 14. This is provided by a rounded linear solid surface 60 on the support arm 54 spaced substantially above the clamping arrangement 56. The surface 60 makes a uniform line contact directly against the main blade portion 58 separately from the clamping arrangement 56. The surface 60 passes firmly against, and resiliently deflects, the outside of the main blade portion 58 when the blade unit 52 is in its cleaning position. Preferably, as shown, this contact point on the surface 60 is substantially greater from the cleaning tip 62 than from the clamping arrangement 56, since that portion of the blade unit 52 extending beyond the surface 60 is the principal unsupported or cantilevered portion of the blade unit 52 which is deformed to provide the photoreceptor cleaning contact force by its beam action. While the surface 60 here is provided on a rigid extension of the support arm 54, it will be appreciated that the same function can also be provided by a flexible spring steel leaf shim or other component mounted to the support arm 54 at the clamping arrangement 56 or elsewhere.

The cleaning tip 62 shown here of the cleaning system 50 illustrates a slightly different tip arrangement in which the elastomer material is glued or otherwise bonded to only the one side of the main blade portion 58 facing the surface 14. Otherwise, it may be the same as the cleaning tip 24. This arrangement allows the full extent of the metal main blade portion 58 to be exposed, all the way out to the end of the cleaning tip 62, where that is desired.

In conclusion, it may be seen that there has been disclosed herein a novel and improved blade cleaning apparatus for providing improved dry developer material removal from electrophotographic 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. A photoreceptor blade cleaning system for cleaning dry developer material from a moving photoreceptor surface in electrophotographic apparatus comprising:

5 a cleaning blade having a main portion of thin planar material with a mounting edge and an opposing free edge substantially spaced from said mounting edge,

said cleaning blade further having a cleaning tip portion comprising a body of elastomer material mounted to said free edge of said main portion, extending over only said free edge and substantially spaced from said mounting edge,

said main portion being resiliently flexible only perpendicular said planar dimensions thereof, and being cantilever mounted by blade mounting means at said mounting edge of only said main portion, extending generally parallel to said photoreceptor surface for substantial resilience only in a direction toward or away from said photoreceptor surface,

said blade being mounted to project toward the direction of motion of said photoreceptor surface when in cleaning engagement therewith to provide a chiseling cleaning engagement of said cleaning tip against said surface,

and means for pressing said tip portion of said blade into substantially uniform cleaning engagement with said photoreceptor surface,

said main portion of said blade being sufficiently stiff to prevent blade tuck-under from high frictional forces between said tip and said photoreceptor surface.

2. The cleaning system of claim 1 wherein said tip portion is an elastomer body substantially thicker than said main portion of said blade.

3. The cleaning system of claim 2 wherein said main portion of said blade is steel and said tip portion is an elastomer material in the range of 50-80 Shore A durometer.

4. The cleaning system of claim 1 wherein said tip portion has a sharp tip corner cleaning edge which engages the photoreceptor surface and said main portion of said blade extends to closely adjacent said tip corner and reinforces said tip portion.

5. The cleaning system of claim 4 wherein said main portion of said blade extends to within approximately 0.03 inches of said tip corner.

6. The cleaning system of claim 4 in which said elastomer cleaning blade tip is cut-off substantially perpendicularly to and closely adjacent to said free edge of said main portion of said blade to form said sharp tip corner edge.

7. The cleaning system of claim 3 wherein said main portion of said blade is approximately 0.004 inches thick.

8. The cleaning system of claim 1 wherein said free edge of said main portion of said blade at said cleaning up position is deformed into an orientation substantially parallel said photoreceptor surface by said cleaning engagement of said cleaning tip with said photoreceptor.

9. The cleaning system of claim 1 wherein said means for pressing said tip portion of said blade further includes means for engaging only one side of said blade at one minor area substantially spaced from said mounting edge.

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10. The cleaning system of claim 1 wherein said cleaning blade provides an electrically conductive path from said tip portion to said blade mounting means for controlling electrical charges directly at said tip portion.

11. The cleaning system of claim 10 wherein said

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main portion of said blade is electrically grounded and provides a path to ground from said tip portion.

12. The cleaning system of claim 10 wherein said tip portion is at least partially electrically conductive.

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