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Szostak et al.

[11] **3,866,573**

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[54] **ELECTROSTATIC COPYING APPARATUS**

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[52] **U.S. Cl.** **118/637,** 117/17.5

[51] **Int. Cl.** **G03g 13/00**

[58] **Field of Search** 118/637; 117/17.5

[56] **References Cited**

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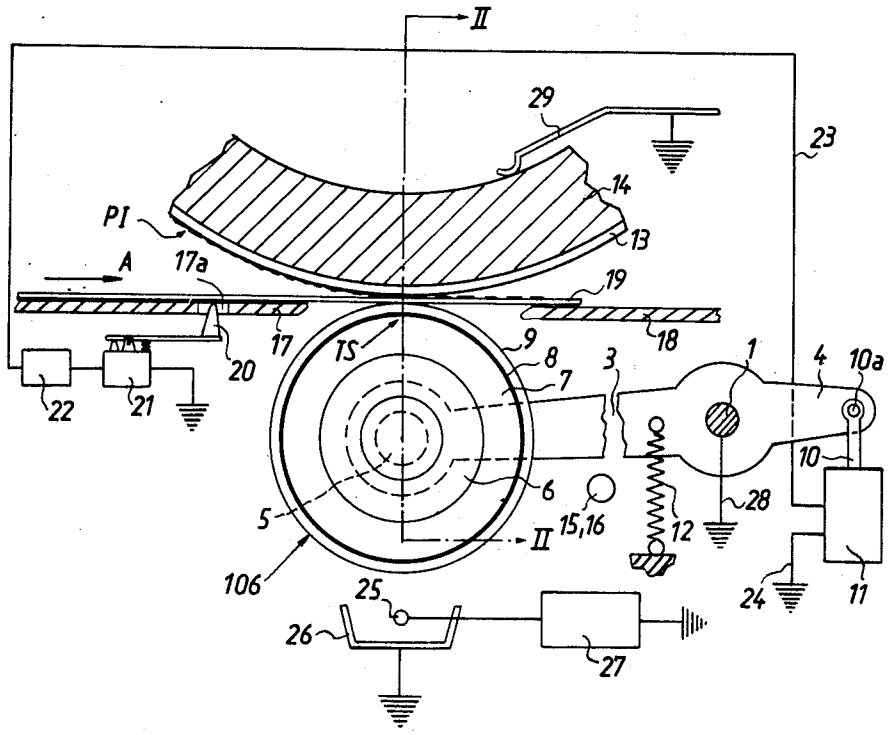
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Assistant Examiner—Leo Millstein
Attorney, Agent, or Firm—Michael S. Striker

[57] **ABSTRACT**

An electrostatic copying apparatus wherein the rear sides of transfer sheets are biased by a roller during transfer of powder images from an electrostatically charged xerographic surface onto the front sides of transfer sheets. The roller has a dielectric elastic outer cylindrical layer having a thickness of 0.02–0.5 millimeter, a hardness of 30–60 Shore and consisting of a polyolefine; an inner elastic cylindrical layer having a thickness of 2–10 millimeters and consisting of a polyurethane; a deformable third cylindrical layer galvanized onto the inner elastic layer, surrounded by the outer elastic layer, consisting of gold, copper, cadmium or tin and having a thickness of 0.02–2 microns; and a hollow metallic core which is surrounded by the inner elastic layer and is elastically connected with the third layer. The outer elastic layer is charged by the positive electrode of a corona discharge device which is in circuit with a source of high-voltage current. One pole of the current source is connected with the third layer by way of the core.

19 Claims, 4 Drawing Figures



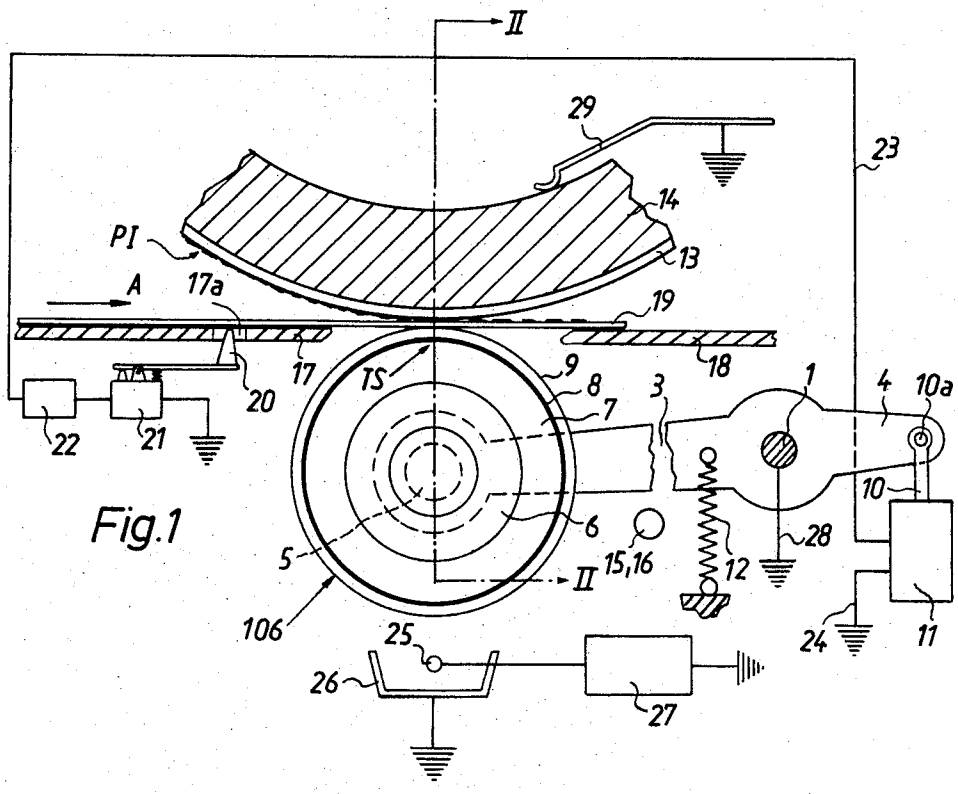

II
29
23
14
PI
13
A
17a
19
17
18
TS
9
8
7
3
1
4
10a
20
22
21
10
6
28
5
15,16
12
II
106
25
24
11
26
27

Fig.1

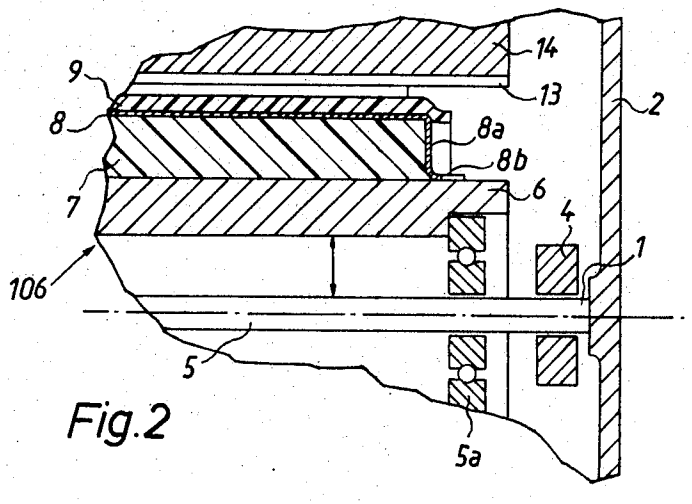

14
9
13
2
8
8a
8b
7
6
4
1
106
5
5a

Fig.2

Fig.3

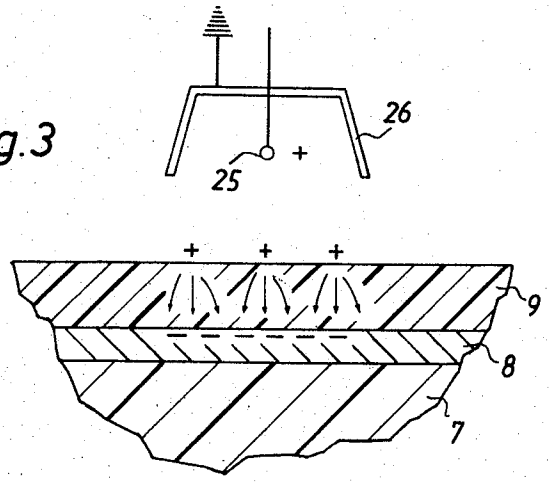
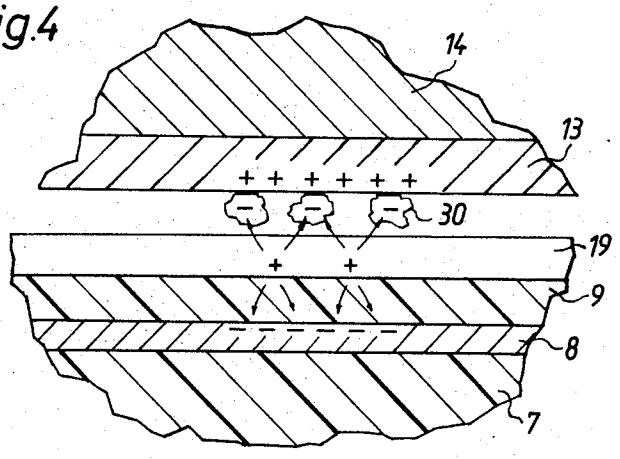


Fig.4



ELECTROSTATIC COPYING APPARATUS

CROSS-REFERENCE TO RELATED APPLICATION

Certain features of the electrostatic copying apparatus of the present invention are disclosed and claimed in the commonly owned copending application Ser. No. 300,376 filed by Szostak and Kruger on Oct. 24, 1972 and entitled "Electrostatic copying apparatus with means for preventing contamination of transfer material."

BACKGROUND OF THE INVENTION

The present invention relates to electrostatic copying apparatus in general, and more particularly to improvements in electrostatic copying apparatus of the type wherein the rear side of a sheet consisting of transfer material is biased by a preferably roller-shaped countersurface in order to maintain the front side of the sheet in contact with a mobile xerographic surface during transfer of powder images. The countersurface comprises a dielectric outer layer to effect the transfer of pulverulent material from the electrostatically charged xerographic surface during engagement of the xerographic surface with the adjacent surface of a sheet which is biased by the countersurface. The charging of dielectric layer of the countersurface is effected by a corona discharge device.

A drawback of presently known electrostatic copying apparatus of the just outlined character is that the material of the countersurface is too rigid so that the dielectric layer of the countersurface cannot insure a satisfactory transfer of powder images. This is due to the fact that the dielectric layer surrounds a metallic electrode of the countersurface and is incapable of yielding so as to closely follow the outline of that portion of a sheet which is in the process of receiving a powder image or to closely follow the outline of that portion of the xerographic surface which is in the process of being relieved of the powder image. It was already proposed to provide the dielectric layer of the countersurface with an inhomogeneous charge so as to enhance its effect upon the particles of the powder image. However, such inhomogeneous charging of the dielectric layer is likely to result in nonuniform transfer of powder images. Furthermore, the dielectric layer of such apparatus must be provided with a substantial charge because at least some portions of the charge are often located at a considerable distance from the powder image.

SUMMARY OF THE INVENTION

An object of the invention is to provide an electrostatic copying apparatus with a novel and improved countersurface which can insure satisfactory transfer of powder images onto sheets of transfer material and which can insure a satisfactory image transfer even if the configuration of the xerographic surface deviates from an optimum configuration.

Another object of the invention is to provide an electrostatic copying apparatus which embodies the improved countersurface.

A further object of the invention is to provide a countersurface whose dielectric layer need not be charged to the extent which is necessary in certain presently known electrostatic copying apparatus.

An additional object of the invention is to provide novel and improved means for charging the dielectric layer of the countersurface in an electrostatic copying apparatus.

Still another object of the invention is to provide a deformable countersurface.

An ancillary object of the invention is to provide a countersurface which can be used in existing electrostatic copying apparatus and whose mounting in existing apparatus necessitates relatively minor changes in the design of such apparatus.

The improved electrostatic copying apparatus comprises transporting means which serves to advance a series of discrete sheets of transfer material along a predetermined path toward, through and beyond a transfer station, an electrostatically charged xerographic surface located at one side of the path and arranged to transport powder images toward the transfer station, and a countersurface which is located at the other side of the path and serves to maintain the xerographic surface in contact with sheets advancing through the transfer station. In accordance with a feature of the invention, the countersurface comprises a preferably cylindrical sheet-contacting outer layer which consists of elastomeric material and may have a thickness of 0.02–0.5 millimeter and a hardness of 30–60 Shore, a relatively thin preferably cylindrical currentconducting second layer which may consist of gold, copper, cadmium or tin and may have a thickness of 0.02–2 microns, and a relatively thick preferably cylindrical third layer consisting of elastomeric material and preferably having a thickness of 2–10 millimeters. The second layer surrounds the third layer and is surrounded by the first layer, and the countersurface preferably further comprises a tubular metallic core which is surrounded by the third layer and is electrically connected with the second layer by way of an extension of the second layer which preferably overlies one or both axial ends of the third layer. The first layer can be charged by the positive electrode of a corona discharge device which is in circuit with a source of high-voltage current. One pole of the current source is connected with the second layer by way of the metallic core.

The novel features which are considered as characteristic of the invention are set forth in particular in the appended claims. The improved electrostatic copying apparatus itself, however, both as to its construction and its mode of operation, together with additional features and advantages thereof, will be best understood upon perusal of the following detailed description of certain specific embodiments with reference to the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a fragmentary vertical sectional view of an electrostatic copying apparatus employing a countersurface which embodies tthe invention;

FIG. 2 is a sectional view as seen in the direction of arrows from the line II-II of FIG. 1;

FIG. 3 is a fragmentary axial sectional view of the countersurface, illustrating the charging of the dielectric layer; and

FIG. 4 is a fragmentary diagrammatic sectional view of the xerographic surface and the countersurface, showing the transfer of a powder image onto a sheet of transfer material.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIGS. **1** and **2**, there is shown a portion of an electrostatic copying apparatus which comprises a frame **2** supporting a horizontal shaft **1** for a carrier structure including a pair of two-armed levers **3** and **4**. The longer arms of the levers **3, 4** support a second horizontal shaft **5** which in turn supports a freely rotatable countersurface here shown as an idler roller **106**. The roller **106** comprises a tubular metallic core **6** which is rotatable with the outer races of antifriction bearings **5***a* (only one shown in FIG. 2) provided on the shaft **5** between the carrier levers **3** and **4**. The peripheral surface of the core **6** is surrounded by a cylindrical portion or layer **7** which consists of elastomeric material and is somewhat shorter than the core **6**. The layer **7** may consist of a polyurethane with a hardness of 30–60 Shore.

The elastomeric layer **7** is surrounded by a much thinner metallic cylindrical portion or layer **8** which is preferably galvanized onto the peripheral surface of the layer **7** and is in turn surrounded by a dielectric outer elastomeric cylindrical portion or layer **9**. As shown in FIG. **2** the right-hand axial end of the current-conducting layer **8** is provided with an inwardly extending portion or extension **8**a which overlies the respective axial end of the elastomeric layer **7** and has a smaller diameter neck portion **8***b* which is electrically connected with the metallic core **6**. A similar extension can be provided at the other axial end of the layer **8** to overlie the left hand exial end of the layer **7** and to contact the core **6**.

In galvanizing the metallic layer **8** onto the elastomeric layer **7**, the latter is preferably coated with a binder or bonding agent, such as Silane. Once the Silane layer has dried, a coat of reduction silver is sprayed over it to form a conductive layer which is sufficient for subsequent galvanic deposition of a ductile metal, such as gold, copper, cadmium or tin, which is to form the current-conducting layer **8**. The above are a few of presently preferred metals which can be used to form the layer **8**, i.e., other metals or alloys can be used as well as long as they are sufficiently flexible to insure satisfactory transfer of powder images. The minimum thickness of the layer **8** is preferably not less than **0.02** micron in order to insure that this layer forms an uninterrupted coat around the entire elastic layer **7**. The maximum thickness of the layer **8** preferably does not exceed **2** microns so as not to overly stiffen the elastomeric inner layer **7**. The dielectric layer **9** can constitute an elastic pipe or hose which is shrunk onto the metallic layer **8** and has a dielectric constant = 2–6.

The shorter arms of the levers **3, 4** are connected to each other by a rod **10***a* which is articulately coupled to the reciprocable armature **10** of an electromagnet **11**. When the electromagnet **11** is energized, the armature **10** pivots the levers **3, 4** against the opposition of one or more helical springs **12** which tend to maintain the levers **3, 4** in abutment with fixed stops **15, 16**. The roller **106** then assumes the operative position of FIG. **1** in which its outermost layer **9** bears against the underside of a sheet **19** of transfer material. The region of contact between the sheet **19** and the layer **9** is located at a transfer station TS where the upper side of the sheet **19** receives a powder image PI from (the) selenium layer **13** on a drum-shaped xerographic surface **14**. The path for transport of successive sheets **19** toward, through and beyond the transfer station TS is defined by two guides **17, 18**. It will be noted that such path extends between the roller **106** and the xerographic surface **14**.

The guides **17, 18** can be said to form part of a transporting mechanism which advances a series of sheets **19** in the direction indicated by arrow A and may include, for example, a roller which removes successive sheets from a stack located to the left of the guide **17**, as viewed in FIG. **1**. Reference may be had to the commonly owned copending application Ser. No. 181,374 filed Sept. 17, 1971 by SZOSTAK et al. and entitled "Electrostatic Copying Apparatus."

The guide **17** is formed with an opening **17**a for a portion of a scanning device **20** arranged to close a microswitch **21** in response to detection of the leading portion of a sheet **19** and to open the switch **21** when the trailing portion of a sheet **19** on the guide **17** advances beyond the opening **17***a*. The switch **21** controls a time-delay device **22** which energizes the electromagnet **11** when the leading portion of a sheet **19** reaches the transfer station TS and deenergizes the electromagnet **11** when the trailing portion of a sheet **19** reaches or moves only slightly beyond the transfer station. The details of the time-delay device **22** and its mode of operation are described in the aforementioned copending application Ser. No. 300,376 filed Oct. 24, 1972 by SZOSTAK et al. and entitled "Electrostatic copying apparatus with means for preventing contamination of transfer material." The timedelay device **22** is connected in the circuit **23, 24** of the electromagnet **11**.

The means for charging the dielectric layer **9** of the roller **106** comprises a corona discharge device having a wirelike positive electrode **25** and a grounded housing **26**. The electrode **25** is connected with a source **27** of high-voltage energy. The charging circuit is completed by connecting the metallic layer **8** with a grounded conductor **28** (i.e., with one pole of the energy source **27**) by way of the shaft **1**, levers **3, 4** core **6** and extension **8***a*, **8***b*. In order to allow for transfer of powder images PI from the selenium layer **13** onto the upper side of a sheet **19** which is being transported through the transfer station TS, the xerographic surface **14** is connected to the ground by way of an elastic contact **29** or the like.

FIGS. **3** and **4** respectively illustrate the field lines during charging of the dielectric layer **9** on the roller **106** and during transfer of a powder image PI onto a sheet **19**. As shown in FIG. **3**, the field lines of charge particles which are sprayed by the positive electrode **25** onto the dielectric layer **9** are tied primarily to negative charge particles in the metallic layer **8**. Consequently, such lines cannot interfere with further spraying of charge particles and cannot adversely influence each other. This insures that, even at low charging voltages, the dielectric layer **9** is provided with a dense and uniform charge.

When the positively charged sheet **19** is located between the thus charged dielectric layer **9** and the positively charged selenium layer **13** (FIG. **4**), a substantial number of field lines of the positive charge particles on the layer **9** will be attracted to the negative charges of the toner particles **30**. This generates the electrostatic attracting force which is necessary for the transfer of toner particles **30** onto the sheet **19**. If the charges of the dielectric layer **9** are sufficiently large, they over-

come the attraction between the selenium layer **13** and the toner particles **30.**

It is equally within the purview of the invention to extend the metallic layer **8** beyond one or both axial ends of the dielectric layer **9** and to engage the projecting portion of the layer **8** by a sliding contact which is connected with one pole of the energy source **27.** However, this would be likely to cause excessive wear upon the projecting portion of the layer **8.** An advantage of the roller construction shown in FIG. **2** is that the core **6** is electrically connected with the extension **8***a*, **8***b* of the layer **8** and with one pole of the energy source **27** so that the layer **8** is not subjected to any wear.

The elasticity of the layers **7, 9** and the flexibility or deformability of the layer **8** insures that the layer **9** can closely follow the outline of the selenium layer **13** at the transfer station TS. This guarantees an optimum utilization of the charge of the dielectric layer **9.** Moreover, the elasticity of the roller **106** reduces the likelihood of damage to the sensitive surface of the selenium layer **13.**

The layer **9** can exhibit a relatively low elasticity, i.e., its thickness can be minimal (0.02 –0.5 millimeter). Consequently, the exposed surface of the layer **9** is closely adjacent to the metallic layer **8** so that the layer **9** can store a substantial charge of great uniformity by the application of relatively low charging voltages. This can be explained as follows: The fields of the charge particles at the exposed surface of the thin dielectric layer **9** are strongly attracted to the metallic layer **8** and thus cannot interfere with further charging and/or with the fields of the adjacent charge particles. It was further found that the metallic layer **8** can be made so thin that it does not interfere with elastic deformation of the layers **7, 9** and is not damaged during deformation of such elastomeric layers.

The hollow core **6** contributes to lower weight and lower inertia of the roller **106.** This is desirable in order to insure that the powder image to be transferred is not blurred during initial contact of the layer **9** with a sheet **19** at the transfer station. The provision of bearings **5***a* also contributes to a reduction of friction between the roller **106** and its carrier structure. However, it is also possible to utilize a roller **106** which is driven at the exact speed of movement of sheets **19** along the path defined by the guides **17** and **18.**

The thickness of the elastomeric layer **7** may be in the range of 2–10 millimeters. The material of the layer **9** may be a polyolefine, preferably polyethylene, or a halogenated polyolefine, preferably polyvinyl chloride.

The material of the dielectric layer **9** preferably exhibits a high zone resistance and a smooth external surface with a high surface resistance preferably exceeding 10^{14} Ω. Moreover, the layer **9** should exhibit a high resistance to puncturing and should be sufficiently stiff, in spite of its minimal wall thickness, to avoid a distortion of the transferred image even though the elasticity of the layer **7** is preferably high.

The aforementioned metals (gold, copper, cadmium and tin) were found to be particularly suited for galvanic deposition of the layer **8.** They are good conductors of electric current even when the thickness of the layer **8** is only a small fraction of 1 micron and are resistant to ozone. Moreover, such materials are pliable so that they can readily follow the outline of the elastically deformed layer **7** and/or **9** without undergoing permanent deformation.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can, by applying current knowledge, readily adapt it for various applications without omitting features which fairly constitute essential characteristics of the generic and specific aspects of our contribution to the art and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the claims.

What is claimed as new and desired to be protected by Letters Patent is set forth in the appended

We claim:

1. In an electrostatic copying apparatus, the combination of transporting means arranged to advance a series of sheets of transfer material along a predetermined path toward, through and beyond a transfer station; an electrostatically charged xerographic surface located at one side of said path and arranged to transport powder images toward said transfer station; and a countersurface located at the opposite side of said path and arranged to maintain said xerographic surface in image-receiving contact with sheets advancing through said transfer station, said countersurface including a relatively thin sheet-contacting dielectric layer consisting of elastomeric material, a relatively thin current-conducting flexible second layer, and a relatively thick third layer consisting of elastomeric material, said second layer being disposed between said dielectric layer and said third layer.

2. The combination of claim **1,** further comprising corona discharge means for electrostatically charging said dielectric layer and an energy source connected in circuit with said corona discharge means and having first and second poles, said second layer being electrically connected with one of said poles.

3. The combination of claim **1,** wherein said countersurface comprises a roller having a first cylindrical portion constituting said dielectric layer, a second cylindrical portion constituting said second layer, and a third cylindrical portion constituting said third layer, said first and second cylindrical portions respectively surrounding said second and third cylindrical portions.

4. The combination of claim **3,** wherein said roller further comprises a core consisting at least in part of current-conducting material and surrounded by said third cylindrical portion.

5. The combination of claim **4,** wherein said core is a tube.

6. The combination of claim **1,** wherein said third layer has a hardness of 30–60 Shore.

7. The combination of claim **1,** wherein the thickness of said third layer is 2–10 millimeters.

8. The combination of claim **1,** wherein the thickness of said dielectric layer is 0.02–0.5 millimeter.

9. The combination of claim **1,** wherein the thickness of said second layer is 0.02–2 microns.

10. The combination of claim **1,** wherein said third layer consists of polyurethane.

11. The combination of claim **1,** wherein the material of said dielectric layer is a polyolefine.

12. The combination of claim **11,** wherein said polyolefine is polyethylene.

13. The combination of claim **11,** wherein said polyolefine is a halogenated polyolefine.

14. The combination of claim **13,** wherein said halogenated polyolefine is polyvinyl chloride.

15. The combination of claim 1, wherein said dielectric layer is a hose which is shrunk onto said second layer.

16. The combination of claim 1, wherein the dielectric constant ϵ of the material of said dielectric layer is between 2 and 6.

17. The combination of claim 1, wherein said second layer is a metal selected from the group consisting of gold, copper, cadmium and tin.

18. The combination of claim 17, wherein said metal is galvanized onto said third layer.

19. In an electrostatic copying apparatus, the combination of transporting means arranged to advance a series of sheets of transfer material along a predetermined path toward, through and beyond a transfer station; an electrostatically charged xerographic surface located at one side of said path and arranged to transport powder images toward said transfer station; and a countersurface comprising a roller located at the opostie side of said path and arranged to maintain said xerographic surface in contact with sheets advancing through said transfer station, said roller having a relatively thin sheet-contacting first cylindrical portion constituting a dielectric layer and consisting of elastomeric material, a relatively thin flexible second cylindrical portion constituting a current-conducting second layer, and a relatively thick third cylindrical portion constituting a third layer and consisting of elastomeric material, said first and second cylindrical portions respectively surrounding said second and third cylindrical portions, and said roller further comprising a core consisting at least in part of current-conducting material and being surrounded by said third cylindrical portion, said third cylindrical portion having an axial end and said second cylindrical portion including an extension overlying said axial end of said third cylindrical portion and electrically connected with said core.

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