United States Patent [19]

Anemaet

[11] **3,871,329**

[45] **Mar. 18, 1975**

[54] **DEVELOPMENT ELECTRODE**

[75] Inventor: **John M. Anemaet**, Millis, Mass.

[73] Assignee: **Dennison Manufacturing Co.**, Framingham, Mass.

[22] Filed: **Oct. 16, 1972**

[21] Appl. No.: **297,779**

[52] **U.S. Cl.**..... **118/637**, 117/37 LE, 118/DIG. 23

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

[58] **Field of Search**..... 118/DIG. 23, 637, 638, 118/419, 423, 424; 117/37 LE

[56] **References Cited**

UNITED STATES PATENTS

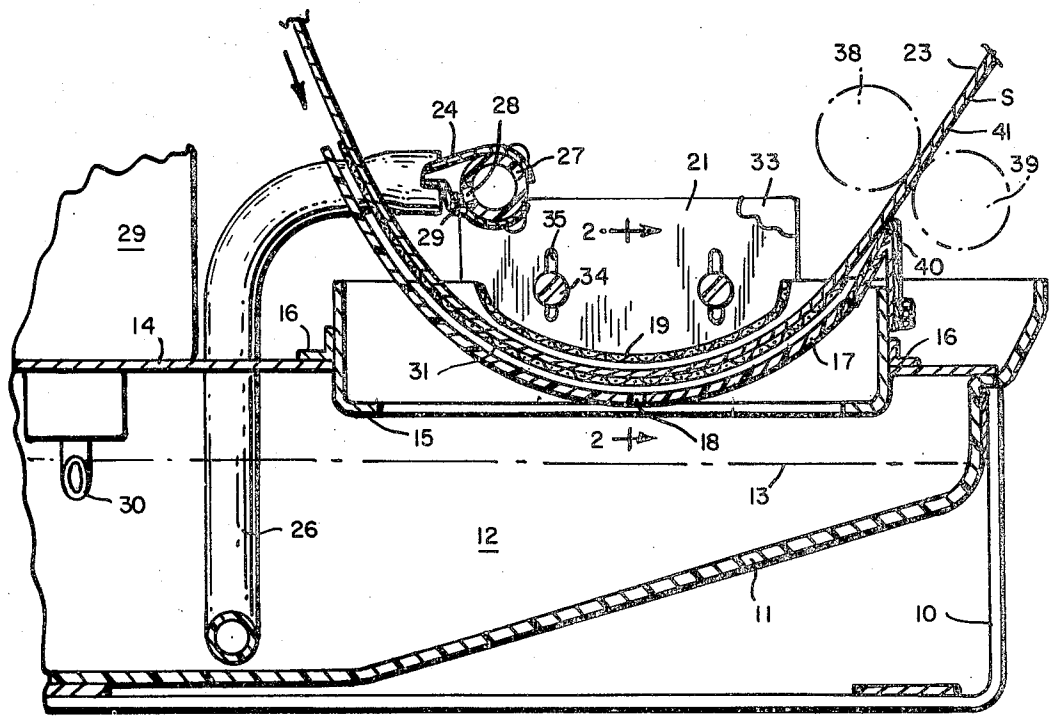
3,415,223	12/1968	Zweig	118/637
3,442,254	5/1969	Akiyama et al.	118/637
3,547,076	12/1970	Saklikar	118/DIG. 23
3,577,259	5/1971	Sato et al.	118/DIG. 23
3,598,086	8/1971	Kushima	118/612 X
3,605,693	9/1971	Zweig	118/637
3,682,542	8/1971	MacKenzie	118/637 X
3,753,393	8/1973	Niesen	118/428
3,799,791	3/1974	Kolibas	117/37 LE
R27,260	12/1971	MacKenzie	118/637

Primary Examiner—Mervin Stein
Assistant Examiner—Leo Millstein
Attorney, Agent, or Firm—George E. Kersey

[57] ABSTRACT

An electrostatic photocopy apparatus uses a liquid developer for developing the electrostatic image on an image bearing sheet. The structure of the developing means utilizes upper and lower electrode means connected to the same electric potential between which the sheet passes in a pool of developer liquid. Both electrodes in a preferred embodiment are in the form of metallic screens, the upper electrode having a mesh size within a range of about 30 mesh to 325 mesh and the lower electrode having a mesh size within a range of about 10 mesh to about 80 mesh. The spacing between the electrodes is in a range between about ¼ to about 1/16 inch, such close spacing providing improved image contrast without causing any jamming of the sheet as it passes therethrough.

14 Claims, 2 Drawing Figures



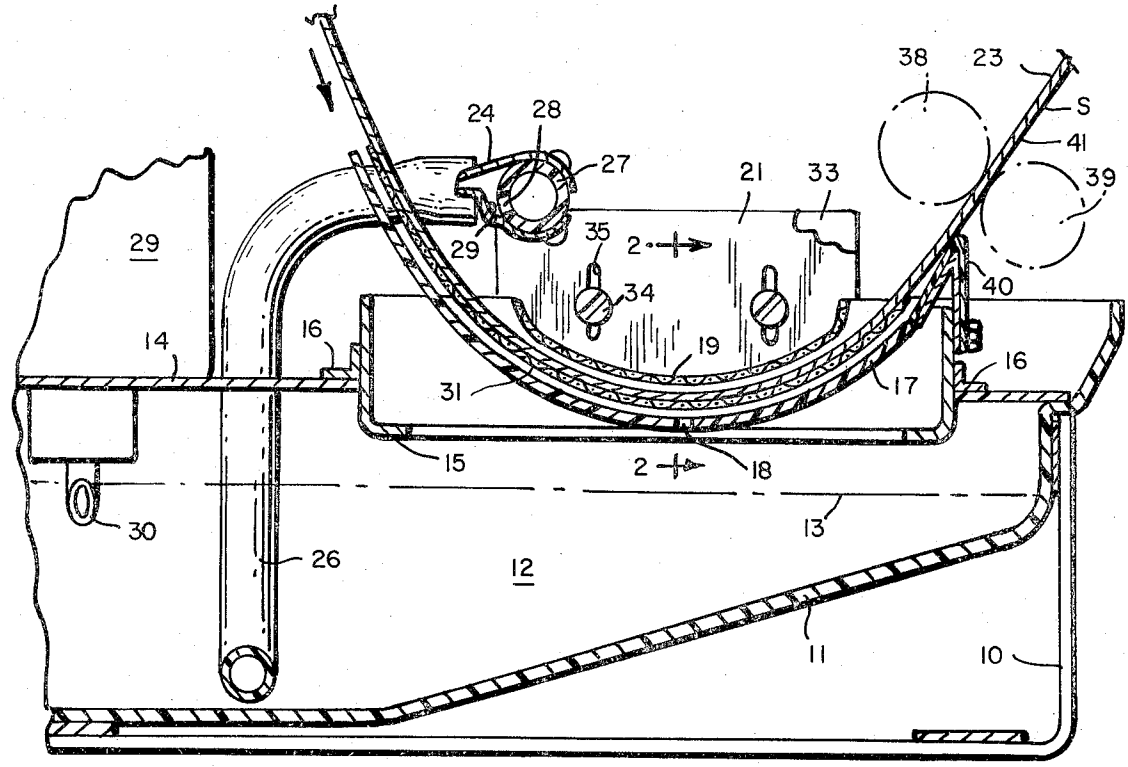

38
23
S
41
39
24
28
27
21
33
29
35
2
34
40
14
16
19
16
31
17
15
2
18
30
13
26
12
11
10

FIG. 1

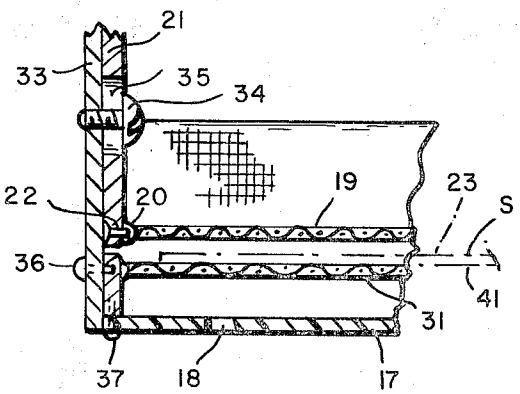

21
33
35
34
22
20
19
23
S
36
41
31
37
18
17

FIG. 2

DEVELOPMENT ELECTRODE

DISCLOSURE OF THE INVENTION

Introduction

This invention relates generally to electrostatic photocopying apparatus wherein electrically sensitized paper and liquid developer are utilized and, more particularly, to improved apparatus for developing an image bearing sheet as the sheet is conveyed through the developer station thereof.

1. Background of the Invention

In developing electrostatic images on paper or other sheet material it is desired to feed the material along a path which dips into a tray of developing liquid with the latent image on the upper side of the material. Difficulty has been experienced in obtaining prints having sufficient contrast, without either background cloudiness or the presence of streaks in the image, particularly in high speed photocopying apparatus or in applications where continuous tone copies are required.

2. Description of the Prior Art

In an effort to improve the developing characteristics of electrostatic photocopying apparatus, the prior art has found that images may be intensified (i.e., contrast may be improved) by providing upper and lower metallic electrode members in the developer pool above and below the sheet material as it is conveyed therethrough. Such a developer electrode structure is shown in Reissue U.S. Pat. No. Re. 27260, reissued on Dec. 28, 1971 to A. K. MacKenzie. As shown therein, the upper metallic member is perforated and the lower one is in the form of a solid plate having one or more drain holes, both such members being juxtaposed opposite the upper and lower surfaces of the sheet material during its travel therebetween throughout substantially the width of the sheet.

In such a structure a liquid developer is supplied through the perforations of the upper member so that a pool thereof is formed by the lower member. It has been found in utilizing such a structure that the sheet material tends to become jammed therein because the bottom, or non-image, surface thereof tends to adhere to the lower metallic electrode plate member. In order to overcome such problem the MacKenzie patent teaches the use of a plurality of dielectric guide or rib members placed on the upper surface of the lower metallic electrode, the sheet being permitted to ride over such guides so as not to come into contact with the lower electrode. Such structure permitted the sheet more readily to pass between the two electrodes without jamming.

However, even in such a structure it was found that the contrast in the developed image is not always as good as desired, particularly during high speed operation and/or where continuous tone images are being developed. Although a better image is obtained the closer the spacing between the electrodes, such prior art structure, requiring the presence of dielectric guides, prevents the electrodes from being capable of placement sufficiently close to each other to achieve the desired enhanced image effect.

While an increase in toner concentration in the developer pool in the MacKenzie structure may tend to improve the image intensification, the operation becomes more expensive and in some applications the increase in toner concentration tends to reach a practical limit wherein any further increase produces no better results.

DESCRIPTION OF THE INVENTION

In accordance with the invention described herein, the upper and lower electrodes in a developer station are formed in such a manner that they can be spaced much closer together than in prior art structures using stationary electrodes so that a relatively narrow passageway is available therebetween for the sheet as it is conveyed through the developer station. Such close spacing permits the utilization of lower toner concentrations than are required to obtain the same image contrast in presently known structures. In accordance with the invention the upper metallic electrode is in the form of a foraminous metallic material, such as a metallic screen, or other mesh-like structure, while the lower electrode is also in the form of a perforated or mesh-like structure, the shape of which is substantially the same as that of the upper electrode. It is found that, if both electrodes are of a mesh-like structure, such as in the form of metallic screens, they can be placed very close to each other without causing a jamming of the sheet during its passage through the developer station. In such structure a marked improvement in contrast in the developed image is achieved. Such a structure eliminates the need for any dielectric guides, or ribs, as are found in the structure of the above referenced prior art MacKenzie patent.

A more detailed description of the electrode of the invention is discussed with the aid of the accompanying drawing wherein

FIG. 1 shows a view in cross-section of the development electrode of the invention; and

FIG. 2 shows an enlarged view in cross-section of a portion of the structure in FIG. 1, taken along the line 2—2 of FIG. 1.

As can be seen in FIG. 1, for the purpose of describing the invention in a preferred embodiment thereof, there is shown a base 10, a tank 11 supported on the base, the tank containing a liquid developer 12 up to the level 13 and having a cover 14 provided with an opening in which a support 15 is mounted by means of brackets 16. In the support 15 is mounted a tray 17 the bottom of which has a plurality of drainage apertures 18. In the embodiment described, tray 17 can be made of a plastic material or a plastic coated metal, or the like, although it also could be made of metal, if desired. An upper electrode 19 is supported in a frame 20, as by being soldered thereto, which frame is in turn attached to a bracket 21 by end screws 22. The upper electrode 19 is a foraminous metal member, in the form, for example, of a metallic screen.

As a sheet material S having an electrostatic latent image on its upper surface 23 approaches the tray 17 it is sprayed with a developer through a nozzle 24 which may have a slot or a series of apertures extending across the width of the material, the developer being supplied to the nozzle from tank 11 by a suitable pump through conduit 26 and tube 27. The outlet 28 from the tube to the nozzle, which may comprise a slot or series of apertures, is directed toward a wall 29 in the nozzle for the purpose of producing turbulence, thereby causing the stream of developer delivered by the nozzle to be distributed uniformly across the sheet S. Alternatively, the nozzle may be reversed in direction so that

the liquid does not strike the paper directly but is generally directed toward the region of the upper electrode so as to form the liquid pool through which the sheet passes during its development stage. Developer is pumped into tray 17 faster than it can drain through the bottom apertures thereof so as to maintain the pool in the tray relatively full, the excess flowing over the ends of the tray.

The developer in tank 11 is maintained at the level 13 from an inverted bottle 29 having a neck extending through an opening in cover 14. The bottle is sealed with foil which, when the bottle is inserted, is punctured by a tube 30 appropriately mounted thereon, as described in the aforementioned MacKenzie patent.

A second lower electrode 31 is positioned below upper electrode 19 and, particularly with reference to its portion contiguous to upper electrode 19, electrode 31 has substantially the same concave shape and is parallel to the latter electrode. Lower electrode 31 has a large number of perforations and in a preferred embodiment it may be a foraminous, or mesh-like, metal member, such as a metallic screen, and is supported in a frame bracket 32 as by being soldered thereto at its ends, as shown in FIG. 2.

Bracket 21 is adjustably affixed to a frame member 33 via screws 34 and slots 35, frame member 33 being in turn appropriately attached to the support 15 in any suitable manner (not shown). Bracket 32 is fixedly attached to frame member 33 by screws 36 as shown in FIG. 2. Lower tray 17 is attached to the bottom of bracket 32 by screws 37, also as shown in FIG. 2.

After leaving the pool of liquid in the tray, the developed sheet S passes between squeegee rolls 38–39 which may also serve to draw the material through the tray. Between the exit end of the tray and the squeegee rolls is a V-shaped guide 40 which guides the material flatwise into the nip between the rolls so that the material does not tend to wrinkle.

In passing through the developer station between electrodes 19 and 31 the back, or non-image side, 41 of the sheet S comes into contact with the screen electrode 31 while the image side is generally removed from the upper electrode so as to avoid extended pressure contact therewith, although some relatively light contact may occur without adverse effect on the developed image. It has been found in accordance with the invention that the spacing between the upper electrode 19 and the lower electrode 31 should be within a range between about ¼ inch to about 1/16 inch to achieve the desired improved contrast in the developed image. In one satisfactorily used embodiment of the invention a spacing of about ⅛ inch has provided excellent results. Even at such closely spaced positions it has been found that there is little or no tendency for the image bearing sheet to jam therebetween during its passage through the developer station.

Thus, in accordance with the invention, the mesh-like character of the lower electrode 31 avoids the need for dielectric ribs or guides and the lower or non-image side 41 of the image bearing sheet effectively contacts the electrode 31 over a relatively large area during its passage without causing any streaking of either the back side or the image side thereof. When a metallic screen material is used for upper electrode 19 an effective compromise is made between the relatively coarse mesh size needed to provide sufficient mechanical strength for shaping the electrode to form the desired concave path with minimal support only along its ends through frame 20 and the relatively fine mesh size which is desired in order to achieve the intensified image during the developing process. Thus, screens having mesh sizes ranging from about 30 to about 325 have been found effective and in a preferred embodiment an 80 mesh screen size has been found preferable for many practical applications. If the mesh size is too fine it becomes more difficult mechanically to mount the upper screen electrode so as to provide a smooth concave path under which the sheet passes without the use of additional more elaborate and complicated support means therefor. On the other hand, if the mesh is too coarse the contrast in the developed image becomes less effective and the improvement over prior used electrodes is not nearly so noticeable.

The mesh size of the lower electrode is not as critical as that of the upper electrode and is selected so that, on the one hand, it is fine enough to produce the desired electrical characteristics and, on the other hand, not so coarse as to cause jamming of the sheet S in the openings thereof, particularly as the sheet enters the development structure. Generally, the mesh size should be no lower than about 10 mesh, depending on the shape of the development structure, the angle of entry thereto of the sheet S and the nature of the sheet material being used. Further, while a relatively fine mesh can be used for the lower electrode, the use of mesh sizes greater than about 80 mesh may make the fabrication and installation thereof more difficult than necessary in many practical applications, without producing any further improvement in the electrical characteristics that are desired. It has been found that a 30 mesh size has proved to produce satisfactory results for most applications.

The spacing between the upper and lower electrodes can lie within a range from about 1/16 inch up to about ¼ inch and it has been found that in one satisfactory embodiment of the invention good contrast can be maintained when such spacing is about ⅛ inch. In using the invention in any particular application, the specific structure thereof, as selected for use, will normally take into account the relationships between mesh size of the upper electrode, upper and lower electrode spacing, toner concentration, and speed of operation.

In one successfully used embodiment excellent contrast has been achieved using an upper screen electrode having an 80 mesh size, a lower screen electrode having a 30 mesh size, an electrode spacing of ⅛ inch, and paper speeds through the developer from about 1 to 10 inches per second.

When the metallic screen electrode 31 of the invention is utilized, the tray 17, as mentioned above, need not be made of metal as in the prior discussed structure of the MacKenzie patent wherein the tray itself is used as the lower electrode. Consequently, the tray may be made of a plastic or other non-metallic material, for example, since it is used merely to form and hold an appropriate pool of developer during operation.

Moreover, while both the upper and lower electrodes in the embodiment shown and discussed above are metallic, in order to enhance the smoothness of travel of a sheet therethrough, either one or both electrodes in some applications may be very thinly coated with a plastic material, such as an epoxy resin, the thickness of which should be no greater than about 1 mil, so that the desired electrical effect of the electrode on the

image will not be disturbed. In any event, both the upper and lower electrodes are maintained at the same potential and in the embodiment shown in the drawing they are, in effect, electrically connected together through brackets **21** and **32** which are commonly attached to frame member **33.** Frame member **33** is, in turn, connected to support **15,** the latter being at a suitable reference potential, such as ground potential, for example.

While one desirable embodiment of the invention has been disclosed by way of example, it should be understood that the invention is broadly inclusive of other modifications which may fall within the scope of the appended claims.

What is claimed is:

1. Apparatus for developing electrostatic images on sheet material comprising a developer station, means for moving said sheet material through said developer station, an upper electrode at said developer station, a lower electrode at said developer station positioned opposite said upper electrode, said sheet material being conveyed between the electrodes, said upper electrode and said lower electrode being of perforated material and being equipotential members, said lower electrode being in contact with said moving sheet material, and the spacing between the electrodes being less than about ¼ inch.

2. Apparatus in accordance with claim **1** wherein said upper electrode is made of metallic screen material having a mesh size in the range from about 30 mesh to about 325 mesh.

3. Apparatus in accordance with claim **2** wherein said electrode mesh size is about 80 mesh.

4. Apparatus in accordance with claim **1** wherein said lower electrode is a metallic screen.

5. Apparatus in accordance with claim **4** wherein the screen size is within a range from about 10 mesh to about 80 mesh.

6. Apparatus in accordance with claim **5** wherein said mesh size is about 30 mesh.

7. Apparatus in accordance with claim **1** wherein the spacing between said electrodes is in a range from about ¼ inch to about 1/16 inch.

8. Apparatus in accordance with claim **7** wherein said spacing is about ⅛ inch.

9. Apparatus in accordance with claim **1** wherein said electrodes are at the same electrical potential.

10. Apparatus in accordance with claim **7** wherein said electrical potential is ground potential.

11. Apparatus in accordance with claim **1** wherein at least one of said electrodes is coated with a dielectric material.

12. Apparatus in accordance with claim **11** wherein both said electrodes are coated with a dielectric material.

13. Apparatus in accordance with claim **11** wherein the coating is a dielectric material having a thickness of about **1** mil or less.

14. Apparatus in accordance with claim **13** wherein said dielectric material is an epoxy resin.

* * * * *