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Rarey et al.

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[54] **FALLING DEVELOPER CURTAIN PRINTING AND COATING**

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[73] Assignee: **Continental Can Company, Inc.**, New York, N.Y.

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[21] Appl. No.: **111,233**

[52] **U.S. Cl.**..... **101/129,** 101/114, 101/DIG. 13

[51] **Int. Cl.**..... **B41m 1/12,** B41f 15/00

[58] **Field of Search**..... 101/DIG. 13, 114, 101/129, 35

[56] **References Cited**

UNITED STATES PATENTS

3,266,046	8/1966	Boyd	101/DIG. 13
3,320,879	5/1967	Edwards et al.	101/DIG. 13
2,930,351	3/1960	Giaimo	101/DIG. 13
3,081,698	3/1963	Childress et al.	101/DIG. 13
3,238,053	3/1966	Morgan	101/DIG. 13
3,302,561	2/1967	Edwards	101/114 X
3,302,579	2/1967	Edwards et al.	101/DIG. 13
3,306,193	2/1967	Rarey et al.	101/DIG. 13
3,340,802	9/1967	Pilon	101/DIG. 13
3,418,930	12/1968	Rarey et al.	101/114
3,473,467	10/1969	Johnson et al.	101/DIG. 13
3,487,775	1/1970	Chaney et al.	101/DIG. 13
3,521,558	7/1970	Fisher et al.	101/DIG. 13
3,529,546	9/1970	Kollar	101/426

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[57] **ABSTRACT**

Method and apparatus for creating a falling curtain of toner adjacent to a vertically disposed stencil screen for printing or coating a vertically disposed surface of a substrate. By creating the falling curtain between a pair of spaced stencil screens, two substrates can be simultaneously coated or printed. Non-planar objects can be printed or coated by providing a non-planar stencil screen.

4 Claims, 9 Drawing Figures

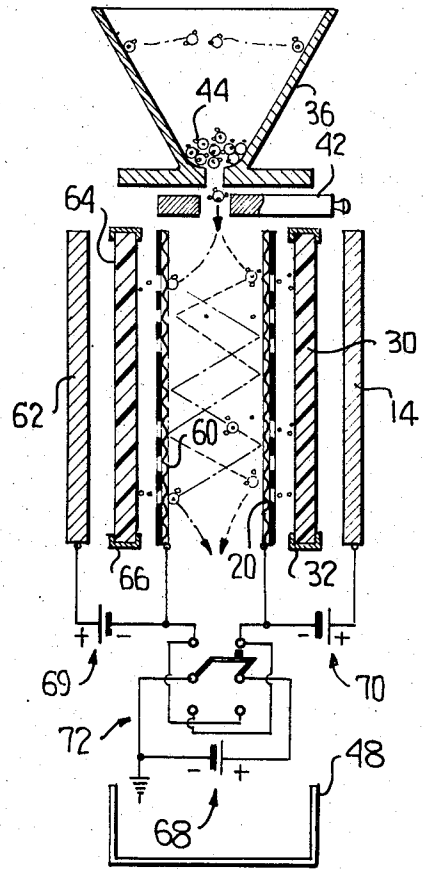


FIG. 2

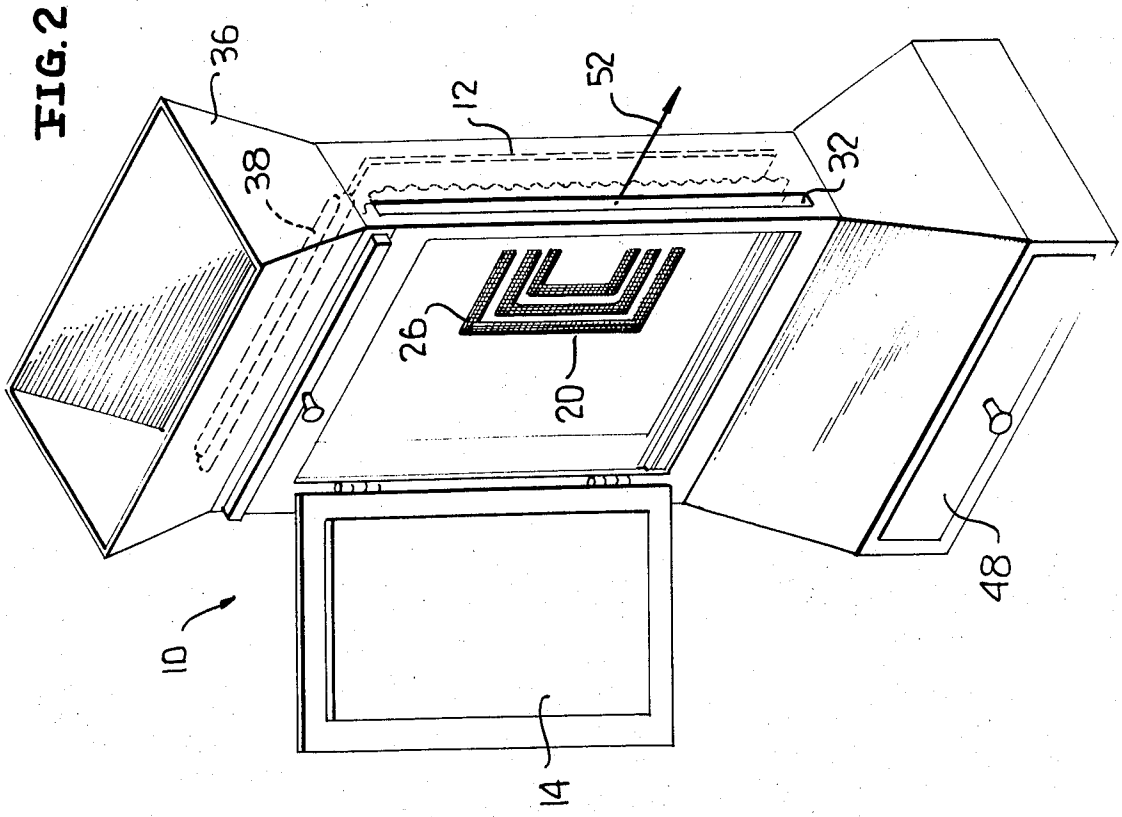
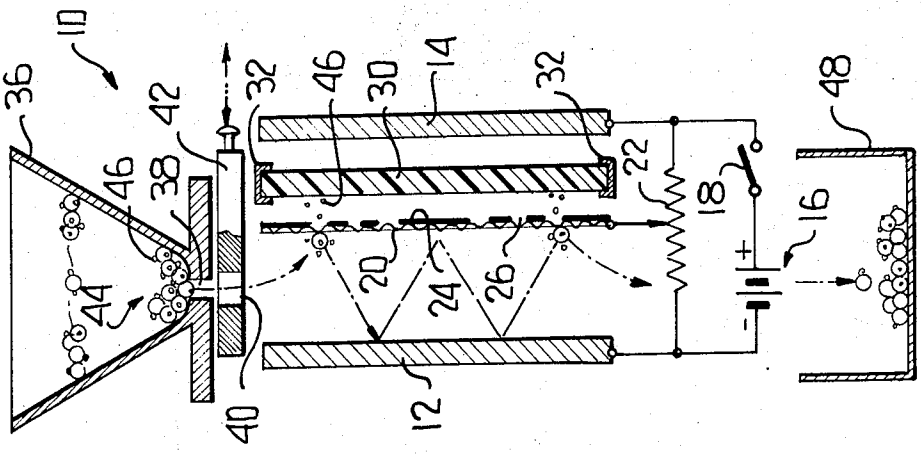


FIG. 1



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FIG. 4

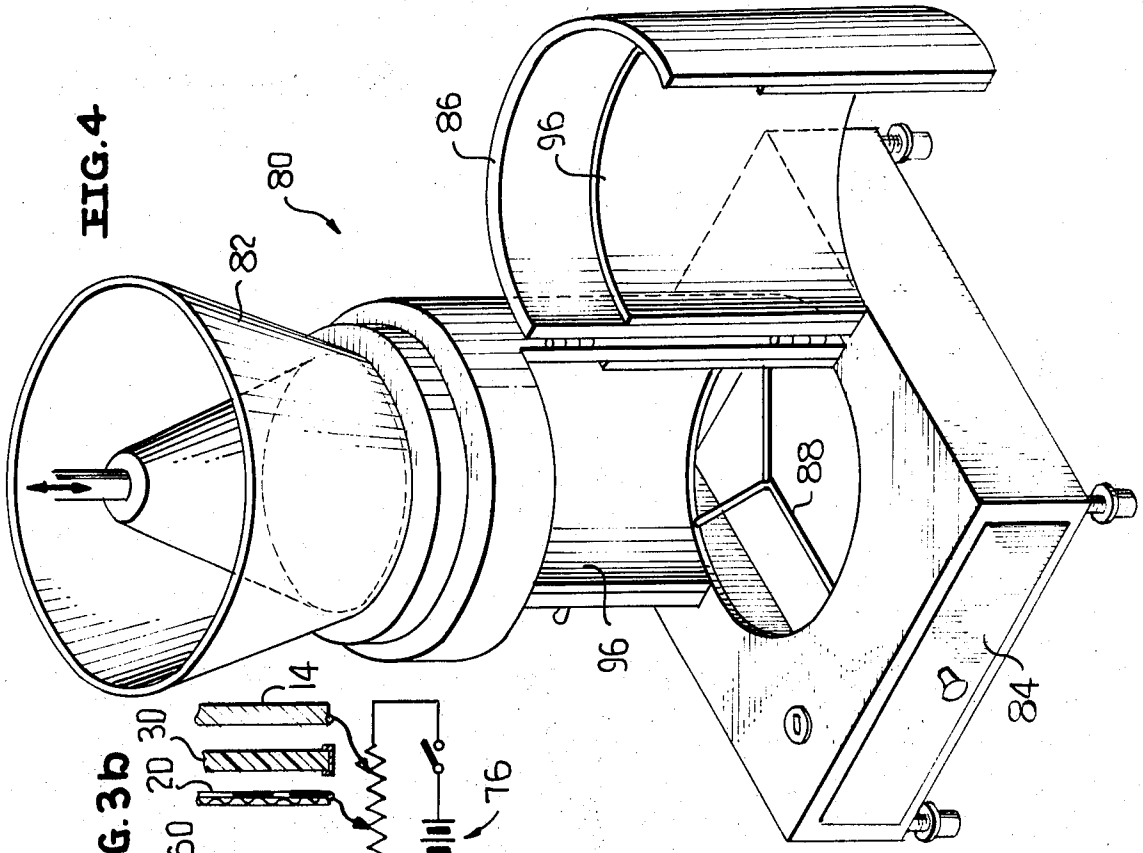


FIG. 3b

FIG. 3

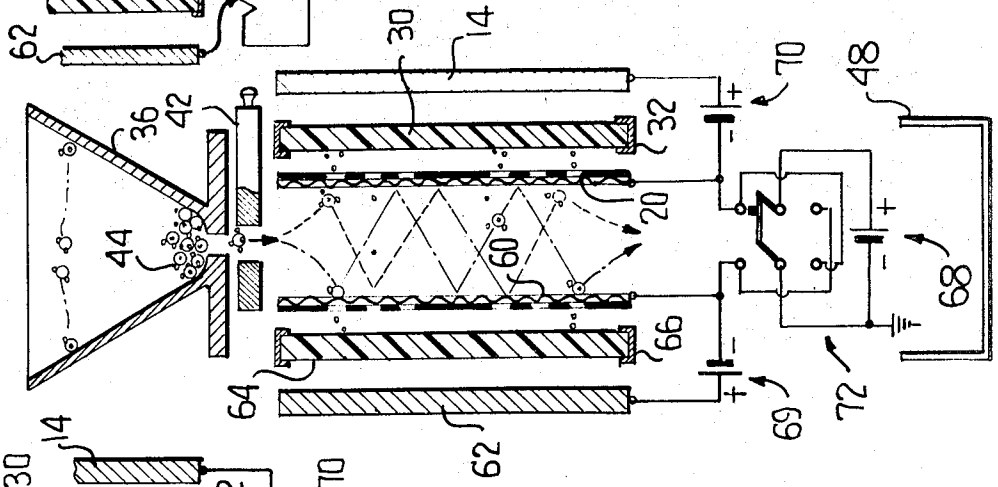
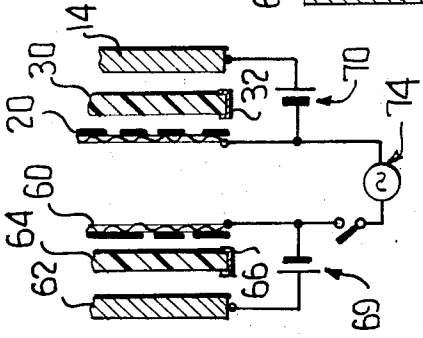


FIG. 3a



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FIG. 7

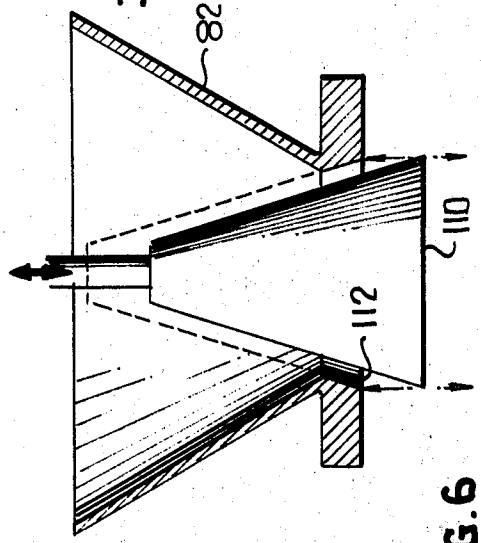


FIG. 6

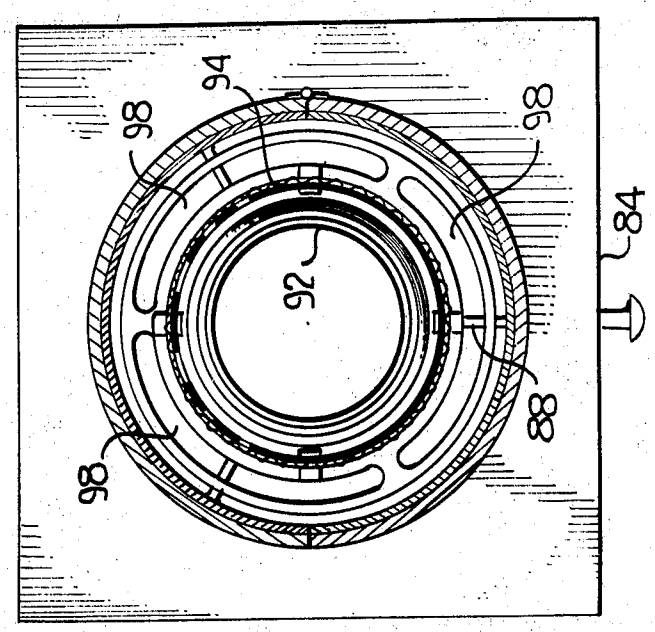
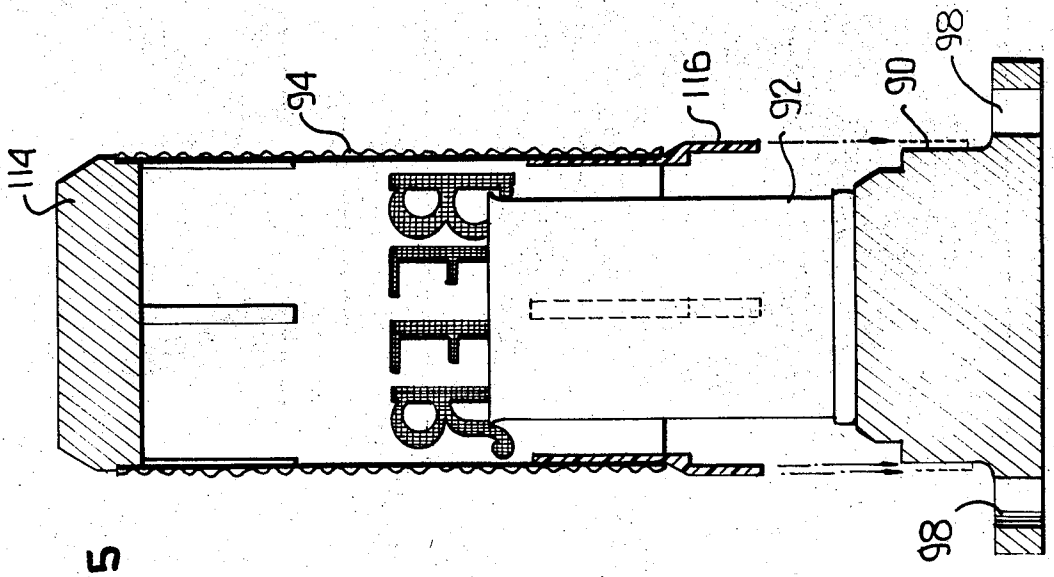


FIG. 5



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FALLING DEVELOPER CURTAIN PRINTING AND COATING

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to methods and apparatus for electrostatic stencil screen printing or coating of substrates by utilizing a falling curtain of toner. The substrates may be electrically conductive or non-conductive and, if the substrate is electrically non-conductive, the toner may be either electrically conductive or non-conductive.

2. Description of the Prior Art

Electrostatic stencil screen printing or coating has been previously accomplished by methods and apparatus disclosed in U. S. Pat. No. 3,306,193, issued in the names of the present inventors; in U. S. Pat. No. 3,081,698, issued in the names of Childress et al.; in U. S. application Ser. No. 386,182 filed on July 30, 1964 in the name of John B. Kennedy, Jr.; and in U. S. application Ser. No. 386,183, filed on July 30, 1964 in the name of Kenneth W. Rarey.

In the prior art printing apparatus wherein the stencil screens are horizontally disposed, toner or developer is introduced beneath the stencil screen. As a result, the toner or developer is acted upon by gravity thereby requiring relatively high voltages for causing upward movement of the toner or developer during the printing operation or, conversely, the spacing between the substrate and stencil screen must be reduced. Gravitational force impedes the oscillation of toner or developer between the base electrode and the stencil screen and, in addition, only the top few layers of toner or developer oscillate thereby limiting the rate of deposition of toner upon the substrate.

SUMMARY OF THE INVENTION

The present invention provides a falling curtain of toner or developer wherein gravitational force, rather than being an impediment, is advantageously utilized for moving the toner or developer through the printing zone. Greater toner deposition rates are available as compared to the prior art devices. If greater deposition rates are not needed the additional flexibility may be used in one or more ways. For example, printing or coating time may be reduced; or printing and cleaning voltages may be reduced; or developer concentration may be lowered. Decreasing both the printing time and printing voltage will reduce any tendency for arcing between the base electrode and the stencil screen; also, by decreasing the printing or coating time, the present invention increases the number of objects or substrates that can be printed in a given period of time. An ancillary benefit to decreasing the developer concentration is that the amount of toner dusting is decreased during normal handling.

The present invention also provides for printing of non-planar surfaces such as annular or cylindrical objects which can be printed all the way around. Since the substrate and stencil screen are at rest during the printing operation, any smearing due to relative motion between them is prevented.

Further, in one form of the invention, the number of objects printed in a given period of time is doubled because two objects can be printed at the same time by the single falling curtain of toner.

The present invention provides a falling curtain of toner or developer which oscillates in an electric field established between a vertically disposed stencil screen and base electrode or between a pair of vertically disposed stencil screens.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagrammatical, vertical section showing essential elements of one embodiment of the invention.

FIG. 2 is a perspective view of one form of printing or coating apparatus.

FIGS. 3, 3*a* and 3*b* are diagrammatical, vertical sections showing another embodiment of the invention and modifications thereof wherein a pair of stencil screens are used for printing or coating a pair of substrates using either direct or alternating current.

FIG. 4 is a perspective view of a third form of printing apparatus.

FIG. 5 is a vertical section of elements which are used with the apparatus shown in FIG. 4.

FIG. 6 is a horizontal section through a central portion of FIG. 4 after the elements of FIG. 5 have been positioned therein.

FIG. 7 is an enlarged vertical section of the top portion of the apparatus shown in FIG. 4.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

A basic embodiment of a falling curtain printing and coating apparatus, generally indicated by the numeral **10**, is shown in FIGS. **1** and **2**. A base electrode **12** and a back electrode **14** are shown as being comprised of a pair of conductive plates located in a substantially vertical plane and spaced from each other. A power source **16** is shown as being a source of direct current and is connected across electrodes **12** and **14** and including a switch **18** in the circuit. A substantially vertically arranged stencil screen **20** is disposed between electrodes **12** and **14** and is connected across power source **16** by a voltage divider **22**. Stencil screen **20** may be comprised of a fine wire-mesh screen, of approximately 325 mesh, having areas thereon blocked by suitable masking material **24** so as to provide openings **26** which define the desired pattern for printing or coating.

A substrate **30** is shown as being comprised of a vertically disposed sheet of non-conductive material slidably mounted upon a pair of guides **32** for movement into and out of apparatus **10**.

A reservoir **36** is disposed above apparatus **10** and is provided with an elongated slot **38** located above an elongated slot **40** in a slidably mounted adjustment plate **42**. As is shown in FIG. **1**, reservoir **36** may contain a developer mixture **44**, such mixture being comprised of electrically conductive carrier particles and electrically non-conductive toner particles; however, it is to be understood that reservoir **36** might also contain toner particles which are electrically conductive.

A printing operation is performed by suitably positioning substrate **30** between stencil screen **20** and back electrode **14**, and closing switch **18** to create a horizontally oriented electric field between base electrode **12** and stencil screen **20**. Plate **42** may be adjusted so as to align slots **38** and **40** so that carrier particles and/or toner particles fall from reservoir **34** in the form of a free falling curtain. The electric field between base electrode **12** and stencil screen **20** causes the de-

veloper mixture, or conductive toner, to oscillate back and forth therebetween in the same manner as disclosed in U. S. Pat. No. 3,306,193. Carrier particles are precluded from reaching substrate **30** by the size of the openings in the wire-mesh screen while toner particles **46** can freely pass through openings **26** and impinge upon substrate **30.** It will be apparent that a second horizontally oriented electric field exists between stencil screen **20** and back electrode **14** so as to aid toner particles **46** in reaching the substrate.

A receptacle **48** is located beneath apparatus **10** for receiving used developer and/or toner after it has passed through the electric field located between base electrode **12** and stencil screen **20.** This material can be recirculated up to reservoir **36** by hand or by other suitable means which may include apparatus for adding additional toner to the mixture.

After completion of the printing or coating operation, switch **18** may be opened and substrate **30** is removed from apparatus **10** in the direction of the arrow **52,** as is shown in FIG. **2.**

While substrate **30** is shown as being formed of electrically non-conductive material, conductive substrates may also be printed or coated by having such substrates perform the function of back electrode **14.**

Back electrode **14** may also be replaced by a suitable corona charging unit which will deposit ions of the proper polarity upon substrate **30** in order to attract toner particles onto the substrate.

The rate of developer flow is determined by the width of slot **38,** the angle at which the sides of reservoir **36** slope toward the slot **38,** the material and size of the carrier particles and toner particles, and the amount of toner in the developer mixture **44.** Achieving proper flowability of some developers from the reservoir **36** may require the use of flow-control means, vibrators, or the use of compressed air flowing through the developer mixture to relieve a slight vacuum created by the developer flow.

The electrically conductive carrier particles touch either the base electrode **12** or the stencil screen **20** and are charged, by conduction, to the potential of the element touched. Substantially all of the carrier in a falling curtain oscillates, whereas in a horizontal or inclined orientation only the top few layers oscillate. Because gravity does not impede carrier oscillation and because more carrier oscillates, more toner is available for printing, thus increasing the toner deposition rate. Increasing the toner deposition rate increases the flexibility of the apparatus in that more toner can be deposited in a given period of time, print and clean voltages can be lowered, and developer concentration can be reduced.

A second embodiment of the invention is shown in FIG. **3** which includes essentially the same elements except that a second stencil screen **60** replaces base electrode **12.** In addition, a second back electrode **62** is required to establish a third horizontally oriented electric field between the stencil screen **60** and back electrode **62.** A second substrate **64** can then be suported upon suitable support means **66.**

A power source **68,** which may be **10** kilovolts, is connected to stencil screens **20** and **60,** while other power sources **69** and **70,** which may be **5** kilovolts, are connected to electrodes **14** and **62,** so that the polarities of back electrodes **14** and **62** are always of the same polarity relative to stencil screens **20** and **60.** Switch means **72** is illustrated as being a double pole, double throw switch. The switch means may take other forms such as, for example, an electronic switch, possibly controlled by a multi-vibrator capable of limiting pulses to approximately one-tenth of a second. Switch means **72** is provided for alternately switching the polarities of stencil screens **20** and **60** relative to one another without changing the polarities of back electrodes **14** and **62** relative to their adjacent stencil screen.

A known type of developer mixture **44** includes electrically conductive carrier particles and electrically non-conductive toner particles which are so located in a triboelectric series that the non-conductive toner particles are negatively charged. When stencil screen **20** is positive relative to stencil screen **60,** a falling curtain of developer **44** will oscillate between the two stencil screens and cause toner to be deposited upon stencil screen **20** and upon substrate **30.** When switch means **72** is reversed, toner will be deposited on stencil screen **60** and on substrate **64;** simultaneously, an important feature of the invention is that previously deposited negative toner will be cleaned from the now negative stencil screen **20.**

A modification of the invention of FIG. **3** is shown in FIG. **3***a* wherein a power source **74** is comprised of a source of alternating current. When using a developer mixture of conductive carrier and non-conductive toner, negatively charged toner will be deposited upon stencil screen **20** and substrate **30** when stencil screen **60** is negative; at the same time, stencil screen **60** will be cleaned by bombardment of carrier particles which, in a broad sense, agitate screen **60** to overcome imaging forces and Van der Waal forces and allow negative toner to come free of and be repelled from the negatively charged screen **60.** Comparable results are obtained on the reverse portion of the alternating cycle with respect to stencil screen **20.**

When it is desired to use electrically conductive toner with the apparatus of FIG. **3,** it is unnecessary to provide switching means **72** because stencil screens **20** and **60** do not become dirty during a printing operation. As is shown in FIG. **3***b*, a power source **76** and voltage divider **78** are connected to the stencil screens and back electrodes. It is preferred that stencil screen **20** and back electrode **14** be held at one polarity with respect to the stencil screen **60,** and the potential on the back electrode **14** being somewhat greater than the potential on the stencil screen **20.** Similarly, the stencil screen **60** and the back electrode **62** are preferably held at an opposite polarity with respect to the polarity of the stencil screen **20,** the potential on the back electrode **62** being somewhat greater than the potential on the stencil screen **60.**

A third form of the invention is illustrated in FIGS. **4–7** as being a bench-top printer or coater **80** which includes a toner reservoir **82,** best shown in FIGS. **4** and **7,** which is used to create a tubular curtain which falls between reservoir **82** and a catch receptacle **84.**

Apparatus **80** includes a pivotally mounted door **86** for providing access into the interior. Support wires **88** are used for supporting thereon the apparatus shown in FIG. **5** which includes a pedestal **90** for supporting a non-planar substrate such as beverage container **92.** An annular stencil screen **94** is telescoped downwardly over container **92** prior to insertion of the elements within apparatus **80.** Base electrode means are pro-

vided by non-planar base electrodes **96** which are spaced from stencil screen **94** to provide an annular passageway for an annular falling curtain of developer or toner from reservoir **82**. The developer or toner will then oscillate between stencil screen **94** and base electrode **96** and cause toner to pass inwardly through stencil screen **94** and become deposited upon the container or substrate **92**. Excess developer or toner will then pass into catch receptacle **84** by passing through elongated openings **98** in pedestal **90**.

Reservoir **82** is provided with a conical member **110** which may be adjustably positioned upwardly or downwardly, by any suitable means, to vary the size of an opening **112** for controlling the amount of developer or toner which forms the falling curtain. As the toner or developer leaves reservoir **82** and passes between stencil screen **94** and base electrode **96** it is prevented from entering within annular stencil screen **94** by a suitable shield **114** positioned within the top of stencil screen **94**.

If the substrate or container **92** is electrically conductive, no back electrode is necessary since an electrical connection can be made directly to the substrate. If pedestal **90** is electrically conductive, an insulative sleeve **116** is used for mounting stencil screen **94** upon the pedestal **90**.

It is to be understood that the electrical connection for the embodiments shown in FIGS. **1** and **2**, and in FIGS. **4–7**, may also provide means for reversing the respective electric fields so that cleaning pulses may be generated between printing or coating operations so as to maintain the respective stencil screens in operating condition. Suitable connection means are shown in U.S. Pat. No. 3,306,193 wherein means are provided for reversing the respective polarities of the base electrode and stencil screen whenever desired.

While preferred forms and arrangements of parts have been shown in illustrating the invention, it is to be understood that various changes in detail and arrangement of parts may be made without departing from the spirit and scope of the invention, as defined in the appended claimed subject matter.

We claim:

1. A method of electrostatically printing or coating a substrate comprising the steps of providing a stencil screen and a substrate, said stencil screen being of the type having openings therein for defining a desired pattern, placing said stencil screen and said substrate in a substantially vertically disposed orientation adjacent to each other, creating a substantially vertical free falling curtain of toner in a space adjacent to said stencil screen on the side thereof remote from said substrate and along the full extent of said openings, creating a substantially horizontally directed electric field in said space for causing some of said toner to pass through said openings in said stencil screen and impinge upon said substrate, providing a second stencil screen and a second substrate, placing said second stencil screen in spaced relation to the first-mentioned stencil screen and placing said second substrate adjacent said second stencil screen on the side thereof remote from said first-mentioned stencil screen, and creating said falling curtain of toner so that it falls in the space between said first-mentioned stencil screen and said second stencil screen.

2. The method defined in claim **1** including the step of electrically charging said first-mentioned stencil screen and said second stencil screen to different potentials for creating an electric field in the space therebetween.

3. The method defined in claim **2** including the step of reversing the respective potentials of said first-mentioned stencil screen and said second stencil screen.

4. The method defined in claim **2** including the step of creating additional electric fields in the spaces between the respective stencil screens and adjacent substrates.

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