United States Patent [19]

Pressman

[11] **3,839,027**

[45] **Oct. 1, 1974**

[54] **APERTURE CONTROLLED ELECTROSTATIC PRINTING SYSTEM AND METHOD**

[75] Inventor: **Gerald L. Pressman,** San Jose, Calif.

[73] Assignee: **Electroprint, Inc.,** Palo Alto, Calif.

[22] Filed: **July 28, 1971**

[21] Appl. No.: **166,984**

Related U.S. Application Data

[62] Division of Ser. No. 673,499, Oct. 6, 1967, Pat. No. 3,256,604.

[52] **U.S. Cl.** ..... **96/1 R,** 117/37 LE, 101/128.4, 101/DIG. 12

[51] **Int. Cl.** **G03g 15/22,** G03g 5/02

[58] **Field of Search** ..... 101/128.2, 128.4, 129, 101/DIG. 12; 117/37 LE; 355/16, 3; 96/1

[56] **References Cited**

UNITED STATES PATENTS

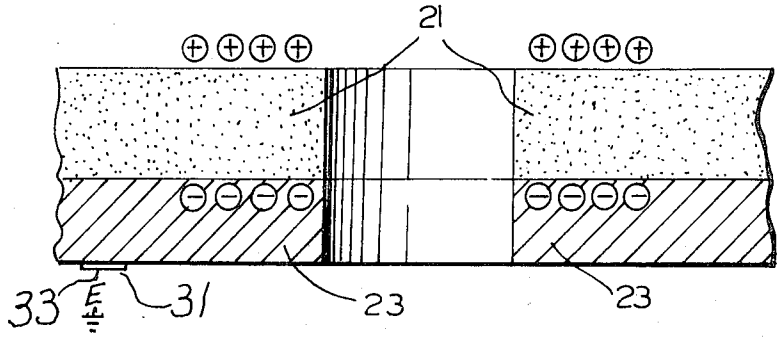
3,081,698	3/1963	Childress et al.	101/129
3,339,469	9/1967	McFarlane	355/16
3,372,675	3/1968	Tressel	101/DIG. 13
3,625,604	12/1971	Pressman	355/3

Primary Examiner—Ronald H. Smith
Assistant Examiner—John L. Goodrow
Attorney, Agent, or Firm—Wilfred G. Caldwell

[57] **ABSTRACT**

This invention relates to an aperture controlled electrostatic printing process and method which employs a multi-layer screen comprising at least a conductive layer and a superimposed insulative layer to enable the deployment of opposite electrostatic charges on the screen relative to the insulative layer. The double layer charges are modified in accordance with an image to produce blocking and non blocking fields controlling the apertures in accordance with the image to be reproduced. The conductive screen layer is maintained at a potential usually during charging and printing, and a propulsion field is provided for directing charged printing particles toward the screen. The charged particles pass through the screen where the apertures are not blocked by the fringing fields and also pass through apertures which are partially blocked, but in fewer numbers. This process uses a charge pattern which modulates the flow of toner particles through the screen to a print receiving medium, via preferably an air gap, for subsequent fixing thereon, if necessary.

7 Claims, 12 Drawing Figures



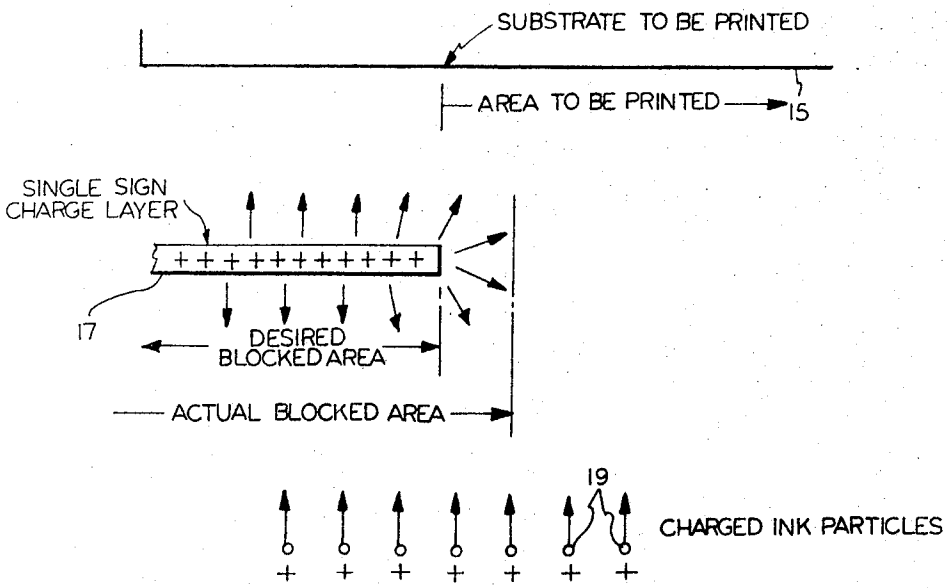

SUBSTRATE TO BE PRINTED
AREA TO BE PRINTED
15
SINGLE SIGN CHARGE LAYER
17
DESIRED BLOCKED AREA
ACTUAL BLOCKED AREA
19
CHARGED INK PARTICLES

FIG. 1

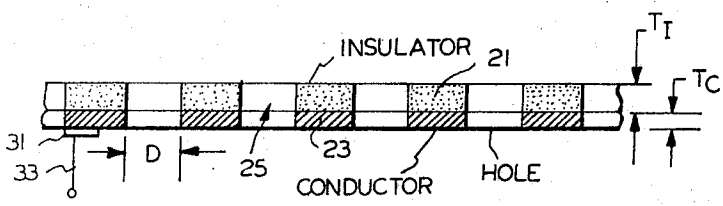

INSULATOR
21
T_I
T_C
31
33
D
25
23
CONDUCTOR
HOLE

FIG. 2

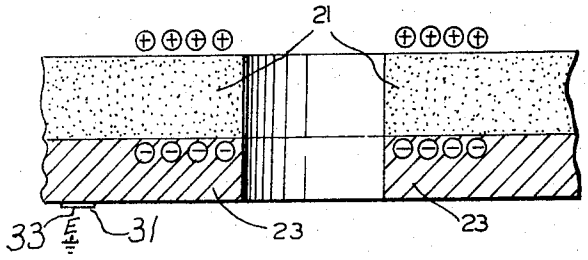


FIG.3

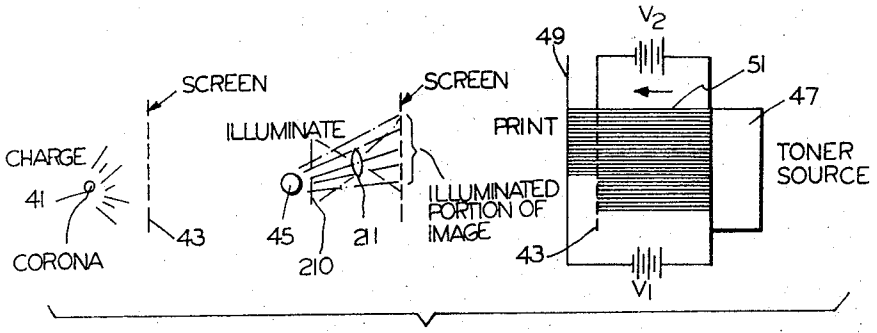


FIG.6

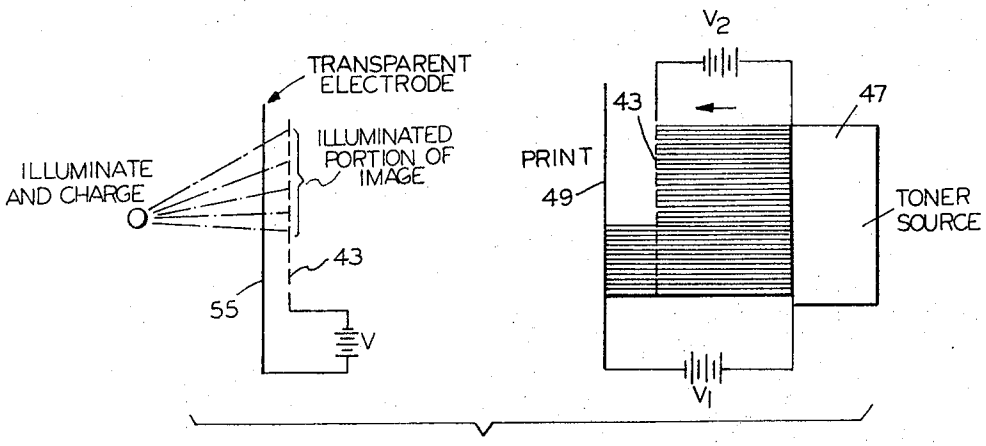


FIG.7

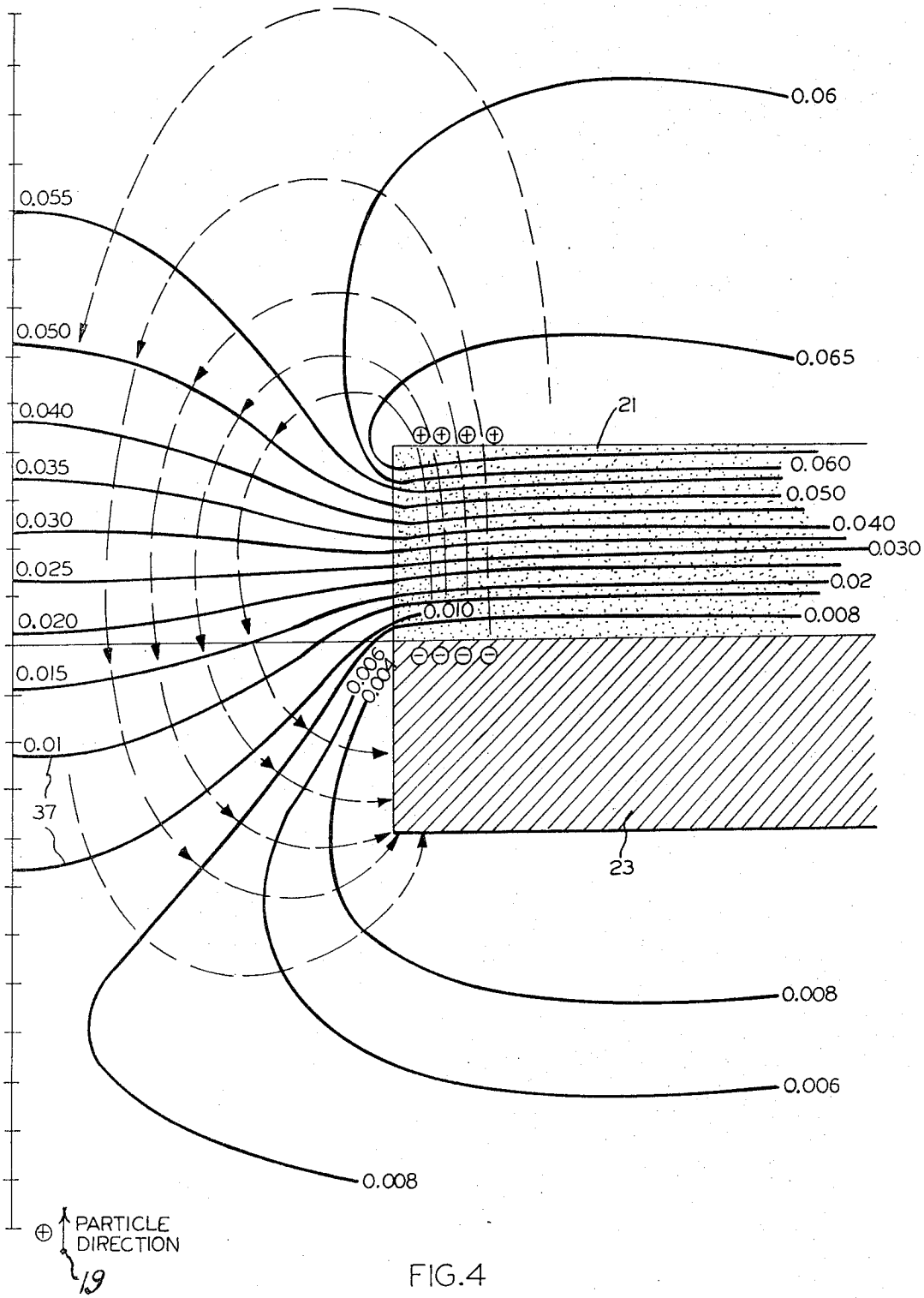

0.06
0.055
0.050
0.065
0.040
21
0.035
0.060
0.050
0.030
0.040
0.025
0.030
0.02
0.020
0.010
0.008
0.015
0.006
0.004
0.01
37
23
0.008
0.006
0.008
PARTICLE DIRECTION
19

FIG.4

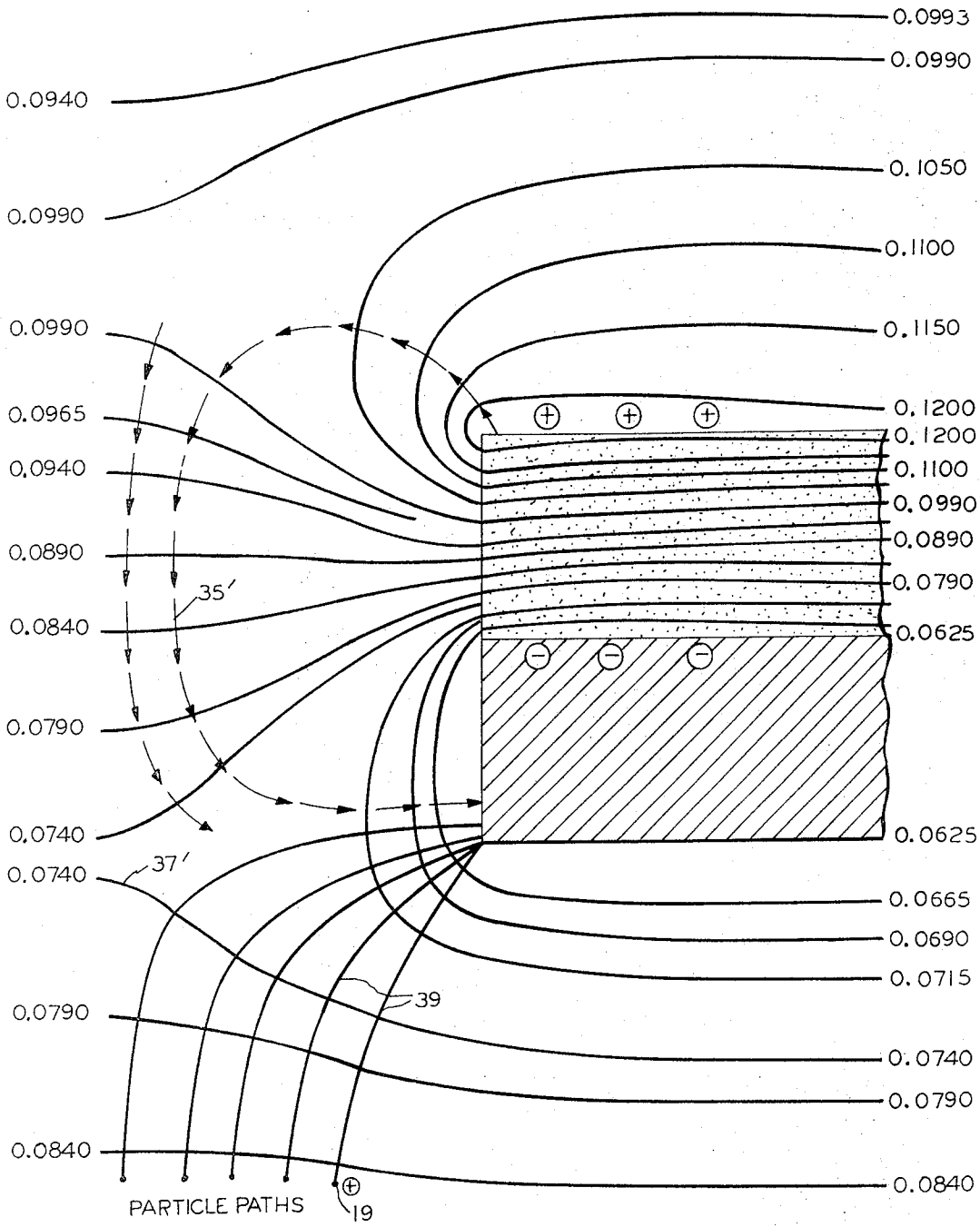

0.0993
0.0990
0.0940
0.1050
0.0990
0.1100
0.0990
0.1150
0.0965
0.1200
0.0940
0.1200
0.1100
0.0890
0.0990
0.0890
35'
0.0790
0.0840
0.0625
0.0790
0.0740
0.0625
37'
0.0740
0.0665
0.0690
0.0715
39
0.0790
0.0740
0.0790
0.0840
0.0840
PARTICLE PATHS
19

FIG. 5

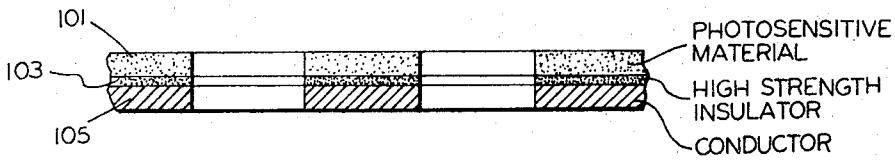


FIG. 8a

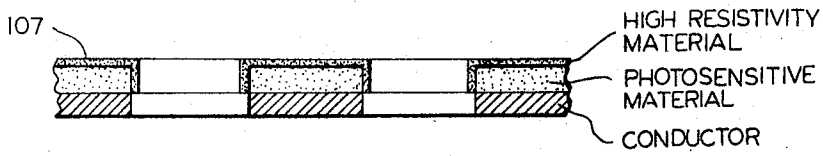


FIG. 8b

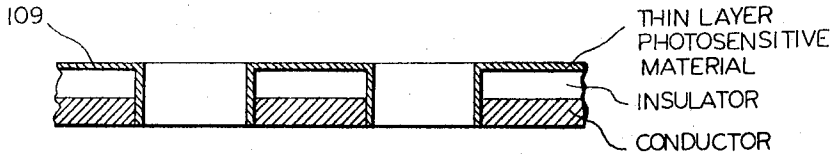


FIG. 8c

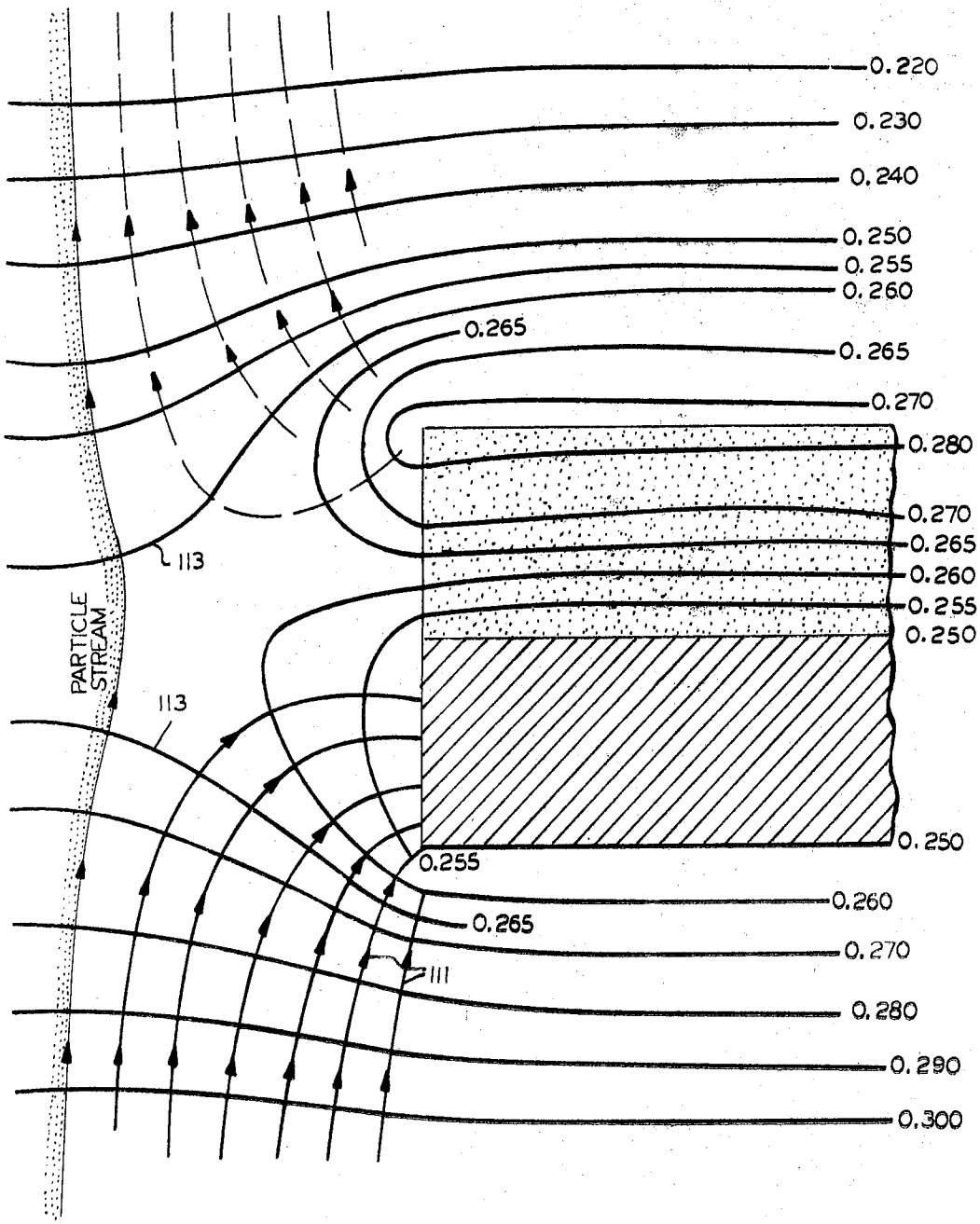

0.220
0.230
0.240
0.250
0.255
0.260
0.265
0.265
0.270
0.280
0.270
0.265
0.260
0.255
0.250
0.250
0.255
0.260
0.265
0.270
0.280
0.290
0.300
113
113
111
PARTICLE STREAM

FIG.9

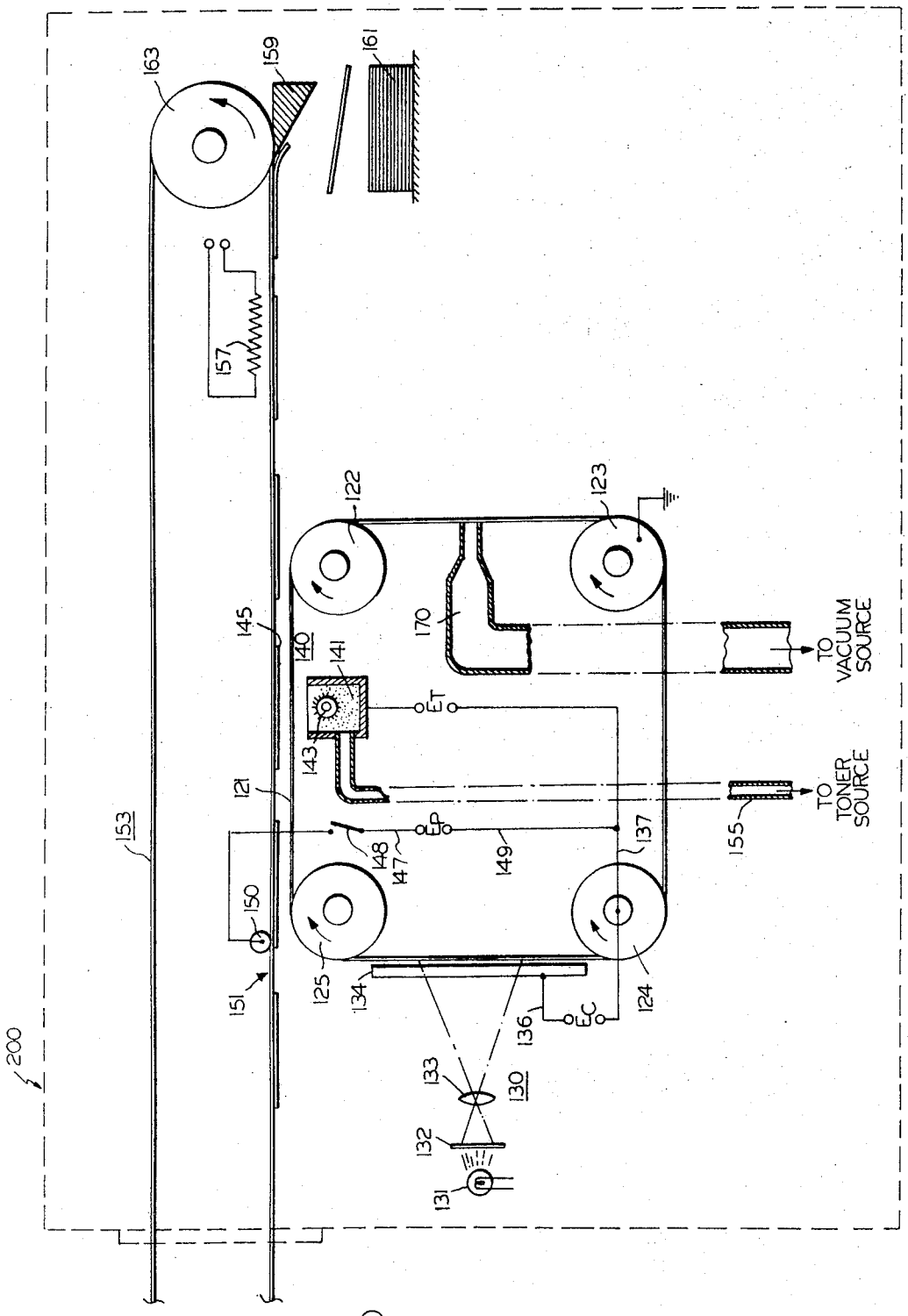

200
153
163
159
161
157
122
123
145
140
141
170
TO VACUUM SOURCE
ET
143
121
TO TONER SOURCE
155
148
147
EP
149
137
150
151
125
134
136
EC
124
133
130
132
131

FIG. 10

APERTURE CONTROLLED ELECTROSTATIC PRINTING SYSTEM AND METHOD

This is a division of application Ser. No. 673,499 filed Oct. 6, 1967 now U.S. Pat. No. 3,256,604.

The insulator layer of the screen may comprise a photoconductor which is merely charged or discharged in accordance with a light pattern or it may comprise an insulator other than of the photoconductive type which may be electrically charged. Alternatively, if the selected insulator screen has a low dielectric strength, a thin undercoating of a high dielectric material, not necessarily photoconductive, is employed between the photoconductive layer and the conductive layer. Similarly, a thin overcoating of high resistivity material may be employed to provide a charged carrier for photoconductors with poor surface resistivity. When employing photoelectric materials that cannot be deposited in heavy layers, the insulating layer may be comprised of any good insulating material which will accept the sensitive material as a thin deposit. Thus, a thin layer photosensitive material may be coated over the screen comprised of an insulator and conductive layer.

Other materials which may be used as the insulator layers are photoemissive material, polyester films, epoxy, photoresists, fused quartz, or combinations thereof. In addition, the conductor backing itself may be deposited on the insulator, or a separate insulator layer, not taking part directly in the electrostatic process, may be used to support both the conductor and insulator layers.

The present invention improves over the known stencil type inventions, such as disclosed in U.S. Pat. No. 3,061,068 to C. O. Childress, et al, issued Mar. 16, 1963 and entitled Electrostatic Printing System for the reason that the screen employed in this patent must be in the form of a permanent stencil having openings where printing is desired and through which the particles pass to the print receiving material. However, these stencils are not useful for producing more than one shape of image without resorting to stencil forming processes to change the image. Such stencil forming processes may be similar to the production of a silk-screen image. In the present invention, the screen is instantly reuseable and there is no physical stencil required.

The present invention differs from the McFarlane inventions disclosed in U.S. Pat. No. 3,220,831 to S. McFarlane issued Nov. 30, 1965 and entitled Electrostatic Printing Method and Apparatus Using Developer Powder Projection Means and, also U.S. Pat. No. 3,220,833 to Samuel McFarlane issued Nov. 30, 1965 entitled Electrostatic Printing Method in that the McFarlane inventions employ electrostatic latent images which are powdered and the powder is projected across an air gap from a photoconductive needle tip carrier in the former patent or from a photoconductive coated screen carrier in the latter patent. The present invention actually electrostatically modulates the apertures of the screen, through the provision of the double layer charge, which is modified in accordance with the image to control the flow of charged toner particles through the screen to the print receiving material.

In the composite screen structure of the present invention, the conductive layer, at fixed potential performs two novel functions. In the first place, it enables the insulative layer to be charged oppositely, thereby

developing the fringing or blocking fields within the apertures of the screen, which fields are subsequently modulated in accordance with the image pattern. It also enables the maintenance of the blocking fields during projection of the charged marking material, and the charges of the particles which do not pass through the grid are simply dissipated due to the electrical potential maintained at the conductive layer.

The conductor layer may also be used to establish a uniform field between the screen and receiving material, if this is desired. Depending on the charge level of the toner particles, the conductor layer does not have to face the toner supply.

Thus, the invention may comprise a composite screen mounted for endless movement and having at least an insulative and a conductive layer with coinciding mesh. An imaging station is provided which may enable positive or negative printing. When a photoconductor is employed as the insulator of the screen, such a material is an insulator in the dark and becomes conductive in the light. It can be charged by ions or an electrode and a light image is then used to discharge those areas to be printed. The light image is reproduced in negative form because printing occurs where the image light impinges on the screen and the discharge has been diminished or reduced to zero. For positive printing, the screen may be charged by an applied field during exposure to the light image. Illuminated areas of the screen photoconductive layer becomes conductive and under the influence of the applied charge field cause a charge separation similar to the double charge previously mentioned. After the charge separation is formed, the illumination is removed, causing all parts of the screen photosensitive layer to become insulative. Then, the charging field is removed and the portions of the field which were illuminated remain charged, and thus block the passage of the toner particles during the printing step.

In either event, the modulated apertures of the screen, depicting the image area, move into a propulsion field where charged toner particles are projected toward the conductive side of the screen and pass through the screen in accordance with the modulation to continue across an air gap due to the propulsion field to ordinary print receiving paper. A heat fixing station fixes the ink, where necessary, because this process may employ powdered inks, as well as aerosol sprays, or liquid droplets. The conductor may not face the toner source in all embodiments.

With the foregoing in mind, it is among the objects of the invention to provide an aperture controlled electrostatic printing process and method which enables printing through a modulated screen onto ordinary paper, across an air gap.

It is a further object of the invention to provide such reproduction simulating half-tone printing with varying degrees of gray to black printing or sequential color reproduction.

A further object of the invention is the provision of a novel multi-layer screen susceptible to image modulation for controlling the passage of charged toner material therethrough.

It is a further object of the invention to provide a method wherein a double layer charging of a screen may be employed for subsequent modulation to provide blocking fields in the apertures of areas of the image being reproduced.

Yet another object is the provision of positive or negative printing free of holidays and with good edge effects.

The invention will be better understood from a reading of the following detailed description thereof when taken in conjunction with the drawing wherein:

FIG. **1** is an arrangement to depict single charge stencil type blocking of charged toner particles with fringe effects;

FIG. **2** is a view in section of a preferred embodiment of the screen of the present invention;

FIG. **3** is an enlarged view of a portion of FIG. **2**;

FIG. **4** depicts a computer analysis of the fringing or blocking field in association with a single aperture or screen;

FIG. **5** depicts a computer analysis of a combined propulsion and fringe field for a single aperture of the screen;

FIG. **6** is a schematic illustration of the processing steps for reproducing the light image in negative form;

FIG. **7** is a schematic illustration of the processing steps for reproducing the light image in positive form;

FIG. **8***a* is a view, in cross section, of a portion of a screen showing the use of low dielectric strength photosensitive material in conjunction with high dielectric strength insulative material intermediate the photosensitive layer and the conductive layer;

FIG. **8***b* is a similar view showing the use of high resistivity material as the charge carrier overlying photosensitive material with poor surface resistivity;

FIG. **8***c* is another view employing a conductive layer, a good insulative layer and a thin layer of photosensitive material deposited over the insulator and within the apertures;

FIG. **9** depicts a computer analysis of the electrical fields within an aperture which is only partially charged as it has insufficient charge for full blocking; and

FIG. **10** is a schematic arrangement showing suitable apparatus for carrying out the method.

In FIG. **1** there is shown an arrangement for stencil blocking utilizing a single sign charge layer only, to show the limitations of this approach. The substrate **15** to be printed is positioned behind the stencil **17** which is positively charged, and the charged ink particles or toner material **19** are similarly charged and projected toward the substrate.

Electrostatic printing is normally achieved by the propulsion of the charged ink particles **19** through the fixed stencil **17** by means of an electric field. The blocked portions of the stencil **17** prevent passage of certain of the ink particles **19,** thus forming the image that is printed. This use of mechanical blocking requires that the stencils be prepared by mechanical or photochemical means; these are slow processes, requiring several hours for the completion of a screen stencil.

Greater usefulness of the electrostatic printing process would be achieved if the stencils could be substituted for and the substitute prepared within seconds, and if the image could be erased and the screen reused.

As is well known, the presence of a concentration of charges will create surrounding fields such that the charges of like sign are repelled from the charged area. It is clear that if an image is formed of coplanar uniformly charged layers, and the sign of the charges used to form the image is the same as the charge on the toner particles, the toner will be repelled from the charged areas, thus producing the blocking required to use the image as a stencil. Since this blocking of the passage of the charged toner or equivalent is accomplished by the field surrounding the charge layer, these fields are called "blocking fields."

However, a one sign charge layer will not satisfy the requirements of a blocking field since the fields of such a system extend in all directions from the charges. Thus, toner particles will be repelled not only from the surface of the charge layer (the desired blocking effect) but also from the edges of the charge layer, which exist at the image boundaries (FIG. **1**). For printing to occur, particles must pass through the uncharged areas (indicated in FIG. **1** as "AREA TO BE PRINTED"). The lateral repulsion field existing at the edge of the layer increases the blocking area, diffuses the edges of the printed image, and prevents passage of ink through small gaps in the charge layer.

The present invention overcomes the problems described above while permitting the desired charge layer blocking in the nonprinting areas of the image.

The screen used to carry the charges, and the disposition of charges on the screen so as to perform the blocking action on the toner, thus forming a printed image, is illustrated in FIG. **2.** The screen is constructed of conventional insulator material **21,** layered with a conductor **23,** the holes **25,** through which the ink particles pass, extend in coincidence through both layers of the screen.

Electrical connection is made to the conductor layer **23** of the screen by tab **31** and lead **33** so that the potential of the backing members can be maintained during printing and charging.

The insulator portion is charged so as to acquire a "double layer" of charge (as indicated in FIG. **3**) in which one face of the insulator **21** contains charges of one polarity, while the other surface contains an equal amount of charge of opposite polarity. (The charge layer which is formed on the insulator surface, in contact with the conductor, appears on the surface of the conductor **23,** as shown in FIG. **3.**) Thus, the net charge on the screen is zero; therefore no field exists from these charges at a distance of more than a few screen thicknesses away from the charged double layer. The motion of toner particles which have passed through the screen at uncharged areas is therefore not affected by the charged areas of the screen.

Charging of the form indicated in FIG. **3,** is made possible by the presence of the conductor layer. A charge source (such as a corona wand or radioactive strip) is used to spray ions on the surface of the insulator; the conductor portion of the screen is maintained at a fixed potential during this process so that any charge which deposits on the insulator surface will attract an equal and opposite charge to the junction between the insulator and the conductor, thus creating the required double layer.

Blocking of ink particles in the charged areas is performed by the fringing field which exists within the holes of the screen. The fringing field is oriented so as to prevent charged ink particles from passing through the hole. The field structure of such a charge layer, as solved by computer analysis, is given in FIG. **4** is association with one-half of an aperture. In FIG. **4,** the elec-

trical force of field lines are depicted at **35,** and the equi-potential lines at **37,** their magnitude being plotted along the ordinate axis, through the center of the hole or aperture. Thusly, it will be apparent that the positively charged particle(s) **19** will be deflected to one or the other sides of the aperture and collected and the charge disseminated by the conductor **23.**

If the ink particles are positive, then the double layer charges are arranged so that the particles approach the screen's negatively charged side; conversely, negative particles must be directed toward the positively charged surface. The weakest fringing field exists along the center of the hole, and the magnitude of this field depends on both the charge magnitude (strength of the field inside the insulator) and the thickness-to-diameter ratio (T_I/D) for the screen to aperture. Since the fringing field increases in strength as the insulator thickness increases, it is clear that for effective blocking, a large ratio of T_I/D, as well as high charge level is desirable. The amount of fringing field required to block the charged particles depends on the strength of the field used to propel the particles from the source to the printing substrate. If the particles had no inertia, blocking would occur if the combination of fringing field and the propulsion field (which act in opposition) produce a net zero field or repulsive field at any point along the centerline of the hole. However, particle inertia effects (which increase with particle diameter) will carry the particle through the hole unless the combined fields within the hole exert a net repelling force.

Prototype designs have indicated that the internal field in the insulator should be at least 8 to 10 times the propulsion field if the T_I/D ratio is 0.25. Thus, for a screen with 0.008 inch diameter holes, an insulator thickness of 0.002 inch, and a propulsion field of 5,000 V/in., the screen should be charged to a potential of 100 volts.

The field structure for a blocking effect (combined propulsion and fringing fields) is shown in FIG. **5.** FIG. **5** indicates a second major function of the conductive layer. Particles which are blocked, deposit on the conductor portion; if the conductor were not present, these charged particles would soon neutralize the charge on the screen and blocking action would cease. The conductor, when maintained at constant potential during printing, will shield the charge on the insulator from the effects of the accumulated ink particle charges.

In FIG. **5** the combined effects of the propulsion and fringing fields is plotted and field force lines **35'** and equipotential lines **37'**, as well as, the particle paths **39** indicate how the aperture is blocked.

To obtain printing, the charge image on the screen in one embodiment must be negative of the desired print; i.e., printing will occur where no charge exists. A number of techniques may be used to create the charge image.

The preferred technique is the utilization of a photoconductive material as the insulator layer of the screen. Such a material, which is an insulator in the dark and becomes conductive in the light, can be charged as described above (e.g., with a corona wand) and a light image used to discharge those areas to be printed (FIG. **6**). Thus, the light image would be reproduced in negative form. The corona wand **41** is used to uniformly charge the composite screen **43.** Thereafter, the screen is illuminated from a light source **45** in accordance with the image **210** as projected by lens system **211.** Next, the toner source **47** contains particles which are charged in conventional manner and ordinary paper serves as the print receiving medium, generally designated at **49.** The propulsion field for the particles is represented by V_1 and the screen **43** has its conductive layer maintained at V_2. The blocking effect of a portion of the screen is illustrated by the particle paths **51,** some of which penetrate the screen to deposit particles on the paper **49.**

By way of example, for suitable conventional materials, the screen may be charged by an applied field during exposure to the light image, as in FIG. **7.** The illuminated areas of the screen photosensitive layer become conductive, and under the influence of the applied charging field, via transparent electrode **55,** acquire a charge separation similar to that shown in FIG. **3.** After the charge separation is formed, the illumination is removed, causing all parts of the screen photosensitive layer to become insulator. At this point the charging field may be removed and the portions of the screen which were illuminated would remain charged and thus block the passage of toner particles during the printing process. This technique produces positive reproductions of the light image.

Effective field blocking of toner particles requires a combination of high charge level and large insulator thickness. The range of photosensitve materials which may be used for the insulator layer can be extended by special screen configurations. If the desired insulator material **101** (FIG. **8***a*) has a low dielectric strength (thus limiting the amount of charge separation it can support) a thin undercoating **103** of a high dielectric strength (but not necessarily photoconductive) material can be used to separate the photosensitive layer from high field regions near the edge of the holes. The conductor **105** is affixed to the undercoating **103.**

Similarly, a thin overcoating **107** (FIG. **8***b*) of high resistivity material can be used to provide a charge carrier for photoconductors with poor surface resistivity.

For photoelectric materials that cannot be deposited in the heavy layers required for this process, the insulating layer may be formed of any good insulating material which will accept the sensitive material as thin deposit **109** (FIG. **8***c*). The entire screen, including portions of the conductive layer, may be coated.

It is computed that the form of the field within the hole is such that, if a hole is only partially charged (i.e., has not developed sufficient charge to block) the effect of the charge is to limit the aperture of the hole (FIG. **9**). Partially charged holes are created by reduced exposure during discharge, as would occur in gray areas of the image. Thus, gray areas reproduce with reduced apparent aperture, forming a half-tone reproduction of a continuous-tone source. The field lines are shown at **111** and the equi-potential lines at **113.**

In FIG. **10** the composite screen is shown at **121** supported by the four motor-driven drums **122** through **125.** This screen **121** may take the form of any of the screens of FIG. **2,** FIGS. **8***a*, **8***b*, and **8***c*.

An image station **130** includes a light source **131,** image **132,** and lens system **133,** which directs the light through transparent electrode **134** and onto the screen **121.** The transparent electrode **134** may be comprised of mylar with a conductive coating or of conductive glass. Thus, the charging voltage E_C is connected by lead **136** to electrode **134** and extends to common lead

or ground **137.** The conductive layer of screen **121** is grounded by drum **123** at fixed potential to complete the charging field and to fulfill its two functions, previously described.

The modulated image is moved to the printing station, generally designated at **140,** where a toner supply of charged particles **141** is maintained at a toner potential E_T.

A revolving brush **143** is provided to agitate the toner material, facilitating its movement toward screen **121** under control of propulsion field E_P, and the apertures of the screen **121** control passage thereof onto the paper **145** to be printed. The propulsion field is provided by leads **147** and **149,** the former of which extends to a roller **150** which is in contact with a continuous backing **151** of paper carrying belt **153.** Toner is supplied in powdered or atomized form over conduit **155** from a suitable source (not shown).

The charged particles which pass through screen **121** are deposited on the paper **145** in the form of a positive or negative image as hereinfore explained and the paper passes under resistance heater **157,** which fixes the image thereto, if necessary, and wedge **159** drops the printed paper into stack **161.** The paper drive is taken from motor driven drum **163** which is synchronized with conveyor screen **121,** preferably for intermittent motion to permit printing at station **140.**

A vacuum scavenger is shown as conduit **170** provided to remove the marking particles or droplets from the conductor side of screen **140.**

Propulsion field switch **148** is closed upon arrested motion of conveyor screen **140** and paper belt **153** to cause transfer across an air gap or in direct contact, if desired. Of course, if paper belt **153** and screen **140** are synchronized, provisions for interrupted motion are unnecessary.

The schematic arrangement of FIG. **10** may be built using components selected from the apparatus and control circuitry of U.S. Ser. No. 565,284 in the name of Samuel B. McFarlane, Jr. filed July 14, 1966 and entitled Method and Apparatus of Electrostatic Color Reproduction, assigned to the same assignee as the subject invention; with the exceptions, as depicted in FIG. **10,** i.e., the screen **140,** transparent electrode **134** and the various electrical fields herein described. Exposure and printing are preferably carried out with the conveyor intermittently stopped although exposure may be accomplished in line by line fashion on a continuous basis and printing done as above described. Similarly, sequential color reproduction may be achieved with the present invention, in accordance with the apparatus disclosed herein identified and as in the McFarlane application.

Also, the apparatus of FIG. **10** is useful as shown for positive or negative reproductions. Moreover, if only negative reproductions are contemplated, a conventional corona discharge source may replace transparent electrode **134.** All fields depicted are preferably direct (D.C.) potential fields.

With the foregoing in mind, it will be appreciated that the invention is preferably characterized by an insulating screen of sufficient thickness compared to hole diameter to produce a repulsive field within the holes when a double layer charge is modified in accordance with the image. The conductive layer, directly or indirectly connected to the insulator layer, provides charging of the insulator in this double form. The conductor layer, when maintained at a constant potential during printing, limits the discharging effect of the ink or toner particles by shielding the insulator screen and absorbing the charges of the particles. The propulsion field of sufficient magnitude propels the particles to the substrate or conductor, but has insufficient force to cause the particles to pass through charged areas of the screen. The holes which have less than sufficient charge to completely block the printing material act as holes of reduced aperture thereby permitting the reproduction of continuous tone gray scale, as in half-tone printing. Also, the use of multiple layer configurations has been described to protect photosensitive layers from excessive fields, as is the case when insulator layers are used to form the base for thin film photosensitive materials to obtain the charge separation distance.

Alternately, if charge neutralization is not a problem, the conductor layer may be used to establish a uniform field between the screen and receiving surface for accurate reproduction of the charge image, in which case the conductor layer faces the receiving surface.

By way of example, screens having from 80 to 1,000 lines per inch are effective for good reproduction. A screen with 200 lines per inch will reproduce as faithfully as present-day office machines and exhibits the characteristic that the edges of the reproduction are clearly and strongly outlined with little or no holidays, thereby enhancing the resolution available from this system.

It is, of course, desired that a maximum charge be carried by the insulator of the multi-layer grid so that good and strong control can be had at the individual apertures. It is for this reason that several modifications of the screen are presented to encompass the conventional materials available today. The T_I/D ratio is just as important as total charge in determining the blocking effectiveness. This ratio, of course, is limited by construction difficulties.

When using photosensitive materials in connection with the apparatus of FIG. **10** a light-tight box, indicated by the dotted line **200,** is employed with suitable ingress and egress openings being provided.

It has also been determined that highly viscous mediums are desirable for the supply of toner material, and one example is a suspension in fluoride gas. The preferred gap for marking material transfer between screen and paper is of the order of 1/16 to ¼ inch, but it should be noted that contact printing may also be achieved with the process of this invention. Toner particles of the order of 4 to 8 microns have been found to be operative within the teaching of this invention to provide the good edge effects which are readily achieved. Contact printing on any medium can be achieved if the conductor layer faces the printed surface--otherwise only insulators may be printed in contact.

Since further modifications of the invention within the principles herein taught may readily occur to those skilled in the art, it is intended that the invention be limited only by the appended claims wherein:

What is claimed is:

1. The method of electrostatic printing comprising the steps of applying an electric field to a combination screen having an electrically photosensitive apertured insulative layer and a conductive apertured layer while exposing the insulative layer to a light image to produce

a charge separation across the insulative layer in accordance with said image; removing the light image and then removing the electric field; charging printing material; projecting the printing material toward the screen from the conductive layer side to permit the material to pass through the screen in accordance with the image; and intercepting the printing material which passes through the screen on a print receiving medium.

2. The method of electrostatic printing comprising the steps of producing a uniform double layer of charges on an insulating screen having a conductive layer affixed thereto with the screen and conductive layer having coinciding apertures; modifying the double layer charge in accordance with an image to electrically unblock selected apertures thereof while maintaining the conductive layer at a fixed potential; directing charged printing material, charged to a sign opposite to that of the charge adjacent to the conductive layer, toward the conductive layer and intercepting the charged printing material which is permitted to pass through the unblocked apertures of said screen on print receiving material.

3. The method of electrostatic printing comprising the steps of electrostatically charging a combination screen having at least an apertured conductive screen layer and an apertured insulative layer, affixed together, with a double layer of charges across the insulative layer; modifying the double layer charge of the so-charged insulative layer in accordance with an image to be reproduced; projecting charged marking material toward the image charged screen; and receiving the marking material which is permitted to pass through the screen on paper as printed reproductions of the image.

4. The method of electrostatic printing comprising the steps of charging an apertured insulating screen having a corresponding apertured conductive layer with a uniform double layer of charges; modifying the double layer of charges in accordance with an image to electrically unblock selected apertures thereof while maintaining the conductive layer at a fixed potential; directing charged printing material toward the insulative layer; and intercepting the charged printing material, which is permitted to pass through the screen and conductive layer, on print receiving material.

5. The method of electrostatic printing using screen means comprising an array of apertures, comprising the steps of: establishing electric fringing fields effective within the apertures of various magnetudes in accordance with an image to be reproduced; and directing charged particles through the screen means in accordance with the magnetudes of the fringing fields of the apertures to a receiving medium.

6. The method of electrostatic printing comprising the steps of: creating charge patterns on apertured composite screen means which charge patterns establish lines of force extending into the apertures to electrically close apertures in varying degrees from complete closure to open to charged particle passage in accordance with an image; and directing charged particles through the screen means to a receiving means in accordance with the charge pattern on the screen means.

7. The method of electrostatic printing using screen means comprising an electrically photosensitive insulative layer and a conductive layer having an array of coinciding apertures, comprising the steps of: maintaining the conductive layer at a fixed potential; establishing electric fringing fields effective within the apertures and having magnetudes in accordance with an image pattern; and directing charged particles through the screen means by an applied propulsion field encompassing the screen means in accordance with the magnetudes of the fields therein relative to the propulsion field to a receiving medium.

* * * * *