ABSTRACT: Various methods and apparatus are disclosed for the treatment of poorly conducting substrates with ions so that the substrate is more receptive to printing materials and the printing material is more adherent to the substrate prior to being fused thereon.
PRECHARGING OF SUBSTRATE FOR ELECTROSTATIC PRINTING

CROSS-REFERENCE TO RELATED APPLICATIONS
This is a continuation-in-part of application Ser. No. 396,060, filed on Sept. 14, 1964; and now U.S. Pat. No. 3,306,193 a continuation-in-part of application Ser. No. 599,822, filed on Dec. 7, 1966 as a division of application Ser. No. 396,060; a continuation-in-part of application Ser. No. 409,213, filed on Nov. 5, 1964, now abandoned; and a continuation-in-part of application Ser. No. 609,275 filed Jan. 10, 1967 as a continuation of application Ser. No. 409,213.

BACKGROUND OF THE INVENTION

The invention relates to the field of corona phenomena and particularly to the application of such phenomena to the field of electrostatic printing.

Prior art electrostatic printing methods and apparatus utilize toner for producing the desired image upon a substrate. The toner is generally provided with an electrostatic charge of a single polarity and, by electrical means, is deposited upon a substrate. Consequently, initially deposited toner creates an electric field which tends to repel deposition of additional toner having the same polarity. Additional toner can be deposited if an electric field is utilized to effect the deposition; however, during transfer of the printed substrate to a fixing or fusing station, the substrate is removed from the influence of the electric field and part of the deposited toner is repelled from the substrate prior to the fixing or fusing operation. As a result, top-quality printing cannot be achieved by prior art devices.

SUMMARY OF THE INVENTION

The present invention provides improved methods and apparatus for depositing toner upon a substrate and for holding the toner upon the substrate until it is fixed or fused thereon.

In addition, the invention provides improved apparatus for creating and maintaining corona discharges and control means for governing the quantitative and qualitative distribution of ions upon an article to be charged.

Printing rates for poorly conducting materials such as paper, cardboard, paperboard and the like have heretofore been relatively slow, as compared to the printing rates of the present invention and have been considerably lower under conditions of low relative humidity. With the ambient atmosphere having a relative humidity of 20 percent, or less, printing rates greater than 100 impressions per minute could not be attained; the present invention provides for improved printing rates, and rates in excess of 100 impressions per minute have been attained.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagrammatic elevational view illustrating one embodiment of the present invention;

FIG. 2 is a diagrammatic elevational view, partly in section, showing one operative embodiment of a printing machine embodying the present invention;

FIG. 3 is a diagrammatic elevational view illustrating a second embodiment of the invention wherein the substrate is precharged at a precharging location outside of the printing zone;

FIG. 4 is a diagrammatic elevational view illustrating another embodiment of the invention wherein the substrate is precharged outside of the printing zone but on the side of the substrate upon which printing will occur;

FIG. 5 is a diagrammatic view of a second form of printing machine embodying the present invention;

FIG. 6 is a diagrammatic perspective view illustrating one form of the invention wherein a flow of air is used to move ions into contact with a substrate to be charged;

FIG. 7 is a diagrammatic elevational view, similar to FIG. 6, but showing the substrate as being charged on the surface upon which printing is to be performed;

FIG. 8 is a graphical representation qualitatively illustrating the potential of a card, or substrate, with respect to time before printing, during printing, after printing and after removal of the card from the printing location during a process which includes charging of the card, or substrate, both prior to and during printing;

FIG. 8-A is a graphical representation qualitatively illustrating the net charge on a card, with respect to time, during a printing process performed as in FIG. 8;

FIG. 9 is a graphical representation, similar to FIG. 8, but for a printing process wherein the cards, or substrates, are charged only prior to printing;

FIG. 9-A is a graphical representation similar to FIG. 8-A but for a process as in FIG. 9 wherein charging occurs only prior to printing;

FIG. 10 is a graphical representation similar to FIGS. 8 and 9 except that the card, or substrate, is simply interposed between a stencil and backing electrode and only toner deposition during the printing process adds charge to the card;

FIG. 10-A is a graphical representation similar to FIGS. 8-A and 9-A except that the printing process is as described with respect to FIG. 10.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 illustrates one embodiment of apparatus for practicing the present invention. A corona source, generally indicated by the numeral 10, is comprised of a conductive plate member 11 having a plurality of corona needles 12 secured thereto. A conductive base electrode 14 is disposed in spaced parallel relation to the conductive plate member 11. Interposed between the conductive plate member 11 and the conductive base electrode 14 are a stencil screen 16, a substrate 18 which is to be printed upon and a conductive control grid 20.

The material with which printing is to be accomplished is illustrated as being toner 22 which is initially deposited upon the base electrode 14. The toner 22 may be fine granulated particles of conductive material, such as charcoal, or may be comprised of conductive carrier particles 23 and nonconductive toner 24 (FIG. 2) which triboelectrically adheres to the conductive carrier particles 23.

The stencil screen 16 is illustrated as being comprised of a conductive, fine wire-mesh screen 26 which has appropriate portions thereof blocked out by coating material 28 so as to provide openings 30 which permit passage of toner 22, or 24, so that the toner can impinge upon substrate 18 to print the desired pattern or image thereon. The substrate 18 is comprised of relatively nonconductive material, e.g., as compared to metal, and is generally comprised of paper, cardboard, paperboard, plastics, or similar materials.

The conductive control grid 20 is illustrated as being a perforated electrode which can be generally described as a woven screen made up of conductive wires such as might be used in conventional copper screen.

A power source 32 of direct current is provided and has connection means 33 and 34 for connecting the power source 32 across the conductive plate member 11 and the conductive base electrode 14. Switch means 36 is provided between the power source 32 and the conductive plate member 11, while switch means 38 is provided between the power source 32 and the base electrode 14. Connection means 34 may also contain a secondary power source 40 which can be connected in series with the power source 32 by the switch means 38. A voltage divider 42 is connected across the power source 32 and has an adjustable tap 44 which provides an electrical connection to the conductive control grid 20.

OPERATION OF FIRST EMBODIMENT

A substantially nonconductive card or substrate 18 is placed into the printing location in spaced relation with the stencil screen 16 and the conductive control grid 20. When switch means 36 is closed an electric field is established between the corona source 10 and the conductive stencil screen 16. An
The electric field is also established between the conductive control grid 20 and the corona source 10, as well as an electric field being established between the conductive control grid 20 and the conductive stencil screen 16. The electric field between the corona source 10 and the perforated control grid 20 produces a corona discharge at the corona needles 12. If the needles 12 are positive, they collect the negative ions while the perforated control grid 20 collects some positive ions. The electric field between the conductive grid 20 and the conductive stencil screen 16 causes positive ions to be deposited upon the substrate 18 and such deposition of positive ions occurs until the potential of the substrate 18 reaches that of the control grid 20. After the substrate 18 is uniformly charged, closing of the switch means 38 will cause toner 22 to be charged negatively and be repelled by the base electrode 14. Some of the toner 22 passes through openings 30 in the stencil screen 16 and is deposited upon the substrate 18. As the buildup of toner 22 on the substrate 18 continues, the accumulation of negatively charged toner tends to repel deposition of additional toner; however, the original positive charge on the substrate 18 is reduced because of the neutralizing effect of the negatively charged toner and, since the potential of the substrate 18 is no longer the same as the potential of the control grid 20, additional positive ions are deposited upon the substrate 18 from the corona source 10.

As a result, the repelling effect of the negatively charged toner on the substrate 18 is diminished and additional toner 22 passes through the opening 30 and becomes deposited upon the substrate 18. A printing operation as just described can be carried out in something on the order of one-twentieth of a second. After the toner 22 is deposited upon the substrate 18, the substrate 18 is removed from the printing location and the toner is fused thereto by conventional processes using heat or solvent vapor. It should be noted that as the substrate 18 is removed from the electric field at the printing station, the toner 22 will remain on the substrate 18 because the accumulation of negative charges resulting from deposition of charged toner 22 has been effectively neutralized by the addition of positive ions under control of the conductive control grid or perforated electrode 20.

THE EMBODIMENT OF FIG. 2

FIG. 2 is a diagrammatic illustration of a printing machine which utilizes the present invention. A more complete disclosure of this mechanism is set out in application Ser. No. 396,060, filed on Sept. 14, 1964, and now U.S. Pat. No. 3,306,193. A corona source, generally indicated by the numeral 48, is similar to the corona source 10 but may be comprised of corona wires 50 instead of corona needles 12. A conductive control grid or perforated electrode 52 is interposed in spaced relation between the corona source 48 and a substrate 54. A conductive stencil screen 56, which is the same as stencil screen 16, is disposed in spaced relation between the substrate 54 and a conductive base electrode 58. The conductive particles 23 are preferably comprised of magnetic material and may be uniformly deposited upon the base electrode 58 by a magnetic drum 60 and a magnetic roller 62. A conductive doctor blade 64 uniformly spreads the carrier particles 23, and nonconductive toner 24 above the base electrode 58 and also provides for an electrical connection for establishing an electric field between the base electrode 58, the stencil screen 56, the control grid 52 and the corona source 48. Suitable switch means 66, 67, 68 and 69 are utilized for connecting the various elements to suitable power sources 70, 71, 72 and 73. If desired, a mechanical connection, indicated by the broken line 74, can couple the switch means 66, 67 and 68 for simultaneous operation. The just described circuitry is more particularly disclosed in the aforementioned application Ser. No. 396,060.

OPERATION OF THE EMBODIMENT OF FIG. 2

At the beginning of the printing operation, it is preferable that a corona discharge occur above the substrate 54. Corona wires 50 are provided for producing the desired corona discharge and an electric field is established between the stencil screen 56 and control grid 52 to cause positive ions formed by the corona discharge to be carried to the substrate 54. This establishes a high intensity electric field between the substrate 54 and the stencil screen 56. In addition, the charge deposited upon the substrate 54 tends to neutralize the field associated with a charged toner image which is caused by accumulation of negatively charged toner 24 upon the substrate 54. Thus, accumulation of toner 24 on the substrate 54 has little influence on subsequently arriving toner 24.

During this printing operation, the carrier particles 23 are charged by contact with the base electrode 58 and are repelled therefrom toward the stencil screen 56. The mesh size of the stencil screen 56 is such that carrier particles 23 cannot pass therethrough but toner 24 passes through the openings in the stencil screen 56 and become deposited upon the substrate 54. The carrier particles which are stopped by contact with the stencil screen 56 become reversely charged and are repelled back toward base electrode 58 so that the carrier particles oscillate between the base electrode 58 and the stencil screen 56 throughout the printing operation.

After an image of the desired optical density is deposited upon substrate 54, the substrate 54 is moved from the printing zone to a conventional fixing station where heat or solvent vapors fuse the toner image to the substrate 54. During this transfer between the printing station and the fixing station, the toner image is maintained because the negative charges on the toner are effectively neutralized by positive ions which have been deposited upon the substrate 54 from the corona source 48 under control of the control grid or perforated electrode 52.

EMBDIMENT OF FIG. 3

A potentially adverse characteristic of the apparatus and processes of FIGS. 1 and 2 has to do with the time required for charge to attain a properly uniform distribution on the surfaces of the substrates 18 and 54 which are to be printed. If the substrate to be printed is sufficiently conductive so that the required time for this uniform distribution to occur is very small, as compared to the times required to position the substrate, perform the printing operation and transfer the substrate out of the printing zone, then there is no problem. However, if a relatively long time is required, it imposes a severe limit on the printing rate. It has been found that under conditions of low relative humidity, such as up to 20 percent, printing rates greater than 100 impressions per minute could not be attained.

This time problem can be solved by the apparatus and method illustrated diagrammatically in FIG. 3. This method has been practiced by simply using two of the units previously disclosed and connecting the units electrically as shown in FIG. 3. A first corona source 80 is provided at the precharging location and is electrically connected by wire 81 to a second corona source 82 which is located at the printing location. A first control grid 84 is situated at the precharging location and is connected by wire 85 to a second control grid 86 disposed at the printing location. A stencil screen 88 may conveniently extend between the precharging location and the printing location; of course, the portion of the stencil screen 88 at the printing location is provided with openings 90 in the form of the desired image. The corona sources 80 and 82 are connected to the opposite side of a power source 92 from the conductive stencil screen 88. Control grids 84 and 86 are connected across the power source 92 by a voltage divider 94 and an adjustable tap 96. Suitable switch means 98 is provided for closing the circuit.
OPERATION OF THE EMBODIMENT OF FIG. 3

A first substrate 100 is shown as being disposed at the printing location above that portion of the stencil 88 which contains an opening 90 for defining the desired image to be printed. Of course, it is understood that a base electrode, such as 14 or 58, is located beneath the stencil 88 in the same manner as previously described with respect to FIGS. 1 and 2. A second substrate 102 is located at a precharging location prior to entry into the printing location. The substrates 100 and 102 are shown as being comprised of cardboard stock having spaced sheets of paper material 104 and 105 separated by an intermediate sheet of fluted paper material 106. The first substrate 100 has been previously charged so that, for example, positive ions are uniformly distributed on the side of substrate 100 adjacent to the stencil screen 88. Upon closing the switch 98, toner will pass through the image-defining opening 90, from the base electrode (not shown), and become deposited upon the lowesterm surface of substrate 100. Simultaneously, ions will be emitted from the corona source 82 such that control grid 86 will allow additional ions to be deposited upon the substrate 100 in order to neutralize the charge buildup due to the negatively charged toner being deposited upon the substrate. Also simultaneously, positive ions will be emitted from the corona source 80 and, under the influence of control grid 84, will become deposited upon the uppermost surface of substrate 102. After the printing of substrate 100 has been completed, it is moved out of the printing location to a fixing station (not shown) and the substrate 102 is moved into the printing location. The time required for the first printing operation and the time required for movement of the substrates 100 and 102 provide sufficient time for the ions on sheet 105 to become uniformly distributed upon sheet 104. As the time lag is too small, the printed image will have a striped effect along those portions of the flutes 106 which engage the sheet 104. With a proper time sequence, it is possible to improve the printing rate and obtain in excess of 100 impressions per minute. It has been found that charging the substrate at the precharging location is sufficient for some toners. With this arrangement, the only function the corona source 82 has is to maintain the substrate at the potential of the perforated electrode 86 while toner is being deposited. For some toners, the total amount of charge borne by the toner is sufficiently small that the potential of the substrate is not significantly altered. An example of such toner is that known as IPI 9431; for other toners, such as Xerox 914, the corona source 82 is desirable when extended solid areas are printed to a high optical density. In this case, a considerable change in potential of the substrate can occur because of the relatively large amount of charge associated with the toner.

DESCRIPTION OF THE EMBODIMENT OF FIG. 4

The method and apparatus illustrated in FIG. 3 has been demonstrated as being superior to that shown in FIGS. 1 and 2. However, the situation still exists where charges are not being deposited directly onto the surface that is to receive the toner. Thus, it is still required that the charge flow through a material that can have a low electrical conductivity. It is possible to acquire independence of conductivity by a direct application of ions onto the surface to be printed. Such a method would work on material of any conductivity and at a rate limited only by the speed with which the substrates can be handled and printed. The time required for charge already deposited on the surface to flow to, and become uniformly distributed on, the printing surface can be eliminated as a rate-limiting factor. Such a method and apparatus has been successfully tested and illustrated in FIG. 4.

Charging of the substrate is done by the same basic method as described in the previously discussed approaches. A power source 110 and switch means 112 are connected across a back electrode 114 and a corona source 116. A voltage divider 118 is connected by an adjustable tap 120 to a perforated electrode or control grid 122. A substrate 124 is disposed in spaced relation between the control grid 122 and the back electrode 114. Closing the switch 112 will cause positive ions to be emitted from corona source 116 and be deposited upon the lowermost surface of substrate 124 under the influence of control grid 122. The substrate 124 and the back electrode 114 combine to form a parallel-plate capacitor. The capacitance of this system is much greater than that of an isolated substrate. Thus, for any given quantity of charge required on the substrate, the voltage to which it must be charged is less when used with a back electrode than it is without one. If the capacitance of the substrate-back electrode system is C, and the potential to which it is charged is V, then these are related to the quantity of charge Q stored in the capacitor by the expression Q = CV. If the capacitance of the isolated substrate is Cc, and the potential to which it must be charged to store the same quantity of charge as that given above is Vc, then these variables are related to those of the substrate-back electrode system by the expression VC = CVCc.

Now, since Cc is much smaller than C, Vc must be much greater than V. As a practical matter, higher voltages are more difficult to attain and maintain. Attainment requires a power supply of higher voltage; maintenance may require a power supply of higher current capability. This latter point may not be immediately obvious. The upper limit on the potential to which an object can be maintained in air depends to a large extent on the rate of leakage of charge from the object due to breakdown of the air. Now this breakdown of nearby surfaces, such as bush electrodes or charging sources. Thus, the electrical field about a given point is a function of only its radius and electrical potential. It is not a function of the separation of such flows from nearby objects. These flows can produce discharges which may be continuous and may be maintained sometimes by a power supply with an adequate current capability. But any attempt to raise the voltage beyond this range can result in a catastrophic discharge to a nearby object. Thus, the highest charging of an object can generally be accomplished by use of a high-capacitance system and a relatively low voltage. Voltages such as 3–5 kilovolts are common.

OPERATION OF THE EMBODIMENT OF FIG. 4

Positive ions are deposited upon the lowermost surface of substrate 124 upon closing the switch means 112. The substrate 124 can then immediately be transferred by known conveyance means to a printing location above stencil 130 while the previously printed substrate 132 is being removed. With the apparatus located as disclosed, improved printing rates can be attained, as compared with those of FIGS. 1, 2 and 3.

EMBODIMENT OF FIG. 5

The printing machine, generally indicated by the numeral 140, is described in detail in application Ser. No. 409,213, filed on Nov. 5, 1964. Essentially, toner is charged by corona means 142 and expelled from tubes 144 so as to pass through openings 146 in a continuous belt-type stencil screen 148 so as to be deposited on substrate 150 to produce the desired image. Substrate 150 is carried by a conductive conveyor means 152 which is electrically connected to a corona source 154 by a power source 156 and switch means 158. The electrical contacts 160 cause the conveyor means 162 to function as a back electrode in a manner similar to that of back electrode 114 in FIG. 4. Positive ions are emitted from corona source 154 and become deposited upon that surface of substrate 150 upon which toner will be deposited by the printing machine 140. It will be apparent that a voltage divider means and per-
forated electrode or control grid may also be utilized in the same manner as described with respect to FIG. 4.

DESCRIPTION OF THE EMBODIMENT OF FIG. 6

The previously discussed charging methods have all involved electrostatic deposition of ions generated in a corona discharge. The electric field between the control grid of the charge source and either the back electrode or conductive stencil screen deposits charge generated in the corona discharge onto the substrate to be printed. However, the deposition need not be accomplished by electrostatic means. Charge can be conveyed from a corona discharge to an object to be printed by a moving airstream. The method illustrated in FIG. 6 is quite similar to the first method described; the substrate is charged in the printing location; it is fully charged prior to printing; charge should flow to and become uniform on the surface to be printed, prior to printing; ions are deposited on the substrate during printing to compensate for the toner-borne charge and maintain the card at a constant potential; after printing, the card retains a net charging that maintains the toner image in location until the toner is permanently fixed to the substrate. This form of deposition can be substituted for electrostatic deposition in each of the previously discussed charging methods.

Corona chambers, generally indicated by the numeral 170, are constructed of first conductive end members 172 and have at least one opening 174 herein. The second conductive end members 176 are spaced from the end members 172 and an insulative sleeve 178 is connected between each of the end members 172 and 176 for defining a hollow chamber 180. A power source 182 and switch means 184 are connected between the first and second conductive end members 172 and 176. A corona discharge means, such as needles 186, are provided upon the end members 176 for providing a source of ions. It is to be understood that end members 176 and needles 186 could be replaced by other types of corona discharge means such as fine wires. A flow of air is introduced into hollow chambers 180 through hollow tube means 190 which is connected to a source of pressurized air or other means for producing a flow of air such as fans, or the like.

OPERATION OF THE EMBODIMENT OF FIG. 6

A substrate 192 is located above a conductive stencil screen 194 which has openings 196 for producing the desired image. Upon closing switch 184, ions are emitted by the corona needle 186 and air flowing through the switch means 184 are connected between the first and second conductive end members 172 and 176. A corona discharge means, such as needles 186, are provided upon the end members 176 for providing a source of ions. It is to be understood that end members 176 and needles 186 could be replaced by other types of corona discharge means such as fine wires. A flow of air is introduced into hollow chambers 180 through hollow tube means 190 which is connected to a source of pressurized air or other means for producing a flow of air such as fans, or the like.

DESCRIPTION OF THE EMBODIMENT OF FIG. 7

The embodiment of FIG. 7 is somewhat similar to that in FIG. 3 in that a substrate 200 is charged at a precharging location 206, removed into the printing location and sheeted on the stencil screen 202. Likewise, charges are deposited upon that surface of substrate 200 upon which the toner image is to be deposited. Accordingly, faster printing rates are attained because there is no need to hesitate in order to permit the charges to become uniformly distributed on the substrate. Also, low conductivity of the substrate is no longer a factor.

A corona chamber, generally indicated by the numeral 204, is comprised of conductive members 206 and 208 which are separated by an insulative sleeve 210 in order to provide a hollow chamber 212. Corona means 214 are carried by end member 208 for emitting ions within the hollow chamber 212. Power source 216 and switch means 218 are connected across end members 206 and 208 such that, upon closing switch 218, a corona discharge is caused within the hollow chamber 212. Air flowing through tube 220 then carries the ions outwardly from the hollow chamber 212 through an opening 224 in the end member 206.

With this embodiment, it is preferable to provide a back electrode 230 which may be ground as at 232. The function of the back electrode 230 is to reduce the repulsive field that charges already accumulated on the substrate 200 exhibit to subsequently arriving ions. In FIG. 6, the conductive stencil screen 194 satisfies this same function.

During the time that a toner image is being deposited upon a substrate 232, the substrate 200 is being charged. Subsequently, the substrate 232 is moved out of the printing location to a fixing station where substrate 200 is being moved into position adjacent the stencil screen 202. The potential of the substrate in the printing zone, relative to the conductive electrode without the addition of a corona screen 202, is the same as that of the substrate relative to the back electrode 230 if the substrate is separated from each of these the same amount at the appropriate location.

EXPLANATION OF FIGS. 8—10

FIG. 8 is a graphical, qualitative representation of the potential on the substrate, or card, during the intervals of (1) before printing, (2) during printing, (3) after printing and (4) after removal of the substrate, or card, from the printing location. The potential in FIG. 8 occurs during that printing method where the card, or substrate, is charged from a corona source both prior to and during printing. It will be seen that once a substrate is charged to a given potential (illustrated as being positive) the potential does not vary because during the actual printing, i.e., while toner is being deposited upon the substrate, negative charges associated with the toner are balanced out by the addition of positive charges from the corona discharge. After printing, and after removal of the substrate from the printing location, the potential remains the same because of the balance maintained between the positive charges from the corona discharge and the negative charges associated with the toner.

FIG. 8-A graphically illustrates the net charge on the card, or substrate, for the same printing process as in FIG. 8. Before printing, the positive charges from the corona discharge and the negative charges associated with the toner are balanced out by the addition of positive charges from the corona discharge. After printing, and after removal of the substrate from the printing location, the potential remains the same because of the balance maintained between the positive charges from the corona discharge and the negative charges associated with the toner.

FIGS. 9 and 9-A graphically illustrate the potential and net charge on a substrate during the same time intervals as in FIGS. 8 and 8-A except that the substrate, or card, are charged only prior to printing and charge is not added during the printing process by the charged toner. It will be apparent that the potential and the net charge becomes less positive during the printing but then remains constant upon completion of the printing and after removal of the substrate from the printing location. The charge associated with IPI 9431 toner is less negative than that associated with Xerox 914 toner, but the potential and net charge are both sensitive to toner characteristics.

FIGS. 10 and 10-A graphically illustrate that method in which the substrate, or card, is simply interposed between a stencil screen and a back electrode without the addition of any charge being applied to the substrate from a corona discharge. The substrate is held at a potential determined by the electrostatic field associated with the printing machines. As charged toner is applied during the printing, the potential of the substrate and the net charge on the substrate decrease. The potential and net charge remain constant after printing but the potential immediately decreases upon removal of the
substrate from the associated electric fields while the net charge remains constant at its lowermost values. It is readily apparent that the substrate, desirably, should be fully charged prior to printing. In addition, during printing, additional charge is to be deposited on the substrate. Part of this charge is that borne by the toner while the rest is that delivered by the corona to maintain the card at the same potential as the perforated electrode or control grid in spite of the toner deposits. If there is no leakage of charge from the card, the net charge addition during printing is zero; after printing, the substrate is removed from the printing location and, without leakage, the accumulated charge should remain constant. This charge aids in maintaining the toner image on the substrate until permanent adhesion is produced by a fusing operation. After fusing, this charge can be neutralized by known means if desired. The electrical potential of the substrate before, during and after printing should be the same as that of the perforated electrode if leakage is avoided.

We have preferred forms and arrangement of parts have been shown in illustrating the invention, and preferred methods have been described, it is to be clearly understood that various changes in details and arrangement of parts and method steps 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 electrostatic printing comprising the steps of providing a substantially electrically nonconductive substrate to be printed upon, a first step of treating an area of said substrate with electrical charges having a first polarity for providing said substrate with an electrical potential, said area being greater than the area to be printed, applying-electrically charged toner having a different polarity to less than the treated area of said substrate, maintaining said substrate at substantially said electrical potential by a second step of treating said substrate for providing additional electrical charges to compensate for the charge of the applied toner, and fusing said toner to said substrate.

2. A method as defined in claim 1, wherein said first step is comprised of treating said substrate with ions on the side thereof which is opposite to the side upon which toner is to be applied.

3. A method as defined in claim 1 wherein said first step is comprised of treating said substrate with ions on the side thereof upon which toner is to be applied.

4. A method as defined in claim 1, wherein said first step of treating and said toner applying step are performed with the substrate at the same location.

5. A method as defined in claim 1, wherein said first step of treating is performed while said substrate is at a precharging location, and said toner applying step is performed while said substrate is at a printing location.

6. A method as defined in claim 1, wherein said first step of treating is performed prior to the step of applying toner to said substrate.

7. A method as defined in claim 6 wherein said second step of treating said substrate with electrical charges is performed simultaneously with the step of applying toner to said substrate.

8. In an electrostatic printing apparatus for printing upon a substrate, electric field means for selectively depositing electrically charged toner on a substrate to form an image upon said substrate, said toner tending to migrate on said substrate in the absence of said electric field prior to fixing said toner to said substrate, means for preventing said migration of said toner prior to fixing including separate means for depositing an electrical charge upon said substrate for neutralizing the electric field associated with the charged toner which defines said image.

9. In an electrostatic printing apparatus as defined in claim 8, said separate means for depositing an electric charge being comprised of corona electrode means disposed in spaced relation to said substrate, and a control grid disposed in spaced relation from and between said corona electrode means and said substrate for controlling the flow of ions from said corona electrode means to said substrate.

10. In an electrostatic printing apparatus as defined in claim 8, said means for selectively depositing charged toner being comprised of a base electrode, a conductive stencil screen disposed in spaced relation between said substrate and said base electrode, and means for establishing an electric field between said stencil screen and said base electrode.

11. In an electrostatic printing apparatus as defined in claim 10, said separate means for depositing an electric charge being comprised of corona electrode means disposed in spaced relation to said substrate on a side directly opposite from said stencil screen, and a control grid disposed in spaced relation from and between said corona electrode means and said substrate to control the flow of ions from said corona electrode means to said substrate.

12. In an electrostatic printing apparatus as defined in claim 10, said means for selectively depositing charged toner being comprised of a stencil screen having a pattern of openings formed therein, means for positioning said substrate adjacent to said stencil screen, and means for causing toner particles to pass through said openings and be deposited upon said substrate in a pattern determined by said pattern of openings; said separate means being comprised of means for substantially uniformly coating said substrate with ions prior to printing upon said substrate.

13. In an electrostatic printing apparatus as defined in claim 12, said means for substantially uniformly coating said substrate including a corona discharge means for coating said substrate with ions on a side of said substrate upon which said charged toner is to be deposited.

14. In an electrostatic printing apparatus as defined in claim 13, said separate means being comprised of corona means for emitting ions, electrode means disposed in spaced relation from said corona means, and means for connecting a source of potential between said electrode means and said corona means.

15. In an electrostatic printing apparatus as defined in claim 14, grid means located in spaced relation from and between said electrode means and said corona means, and means for applying a potential to said grid means.

16. In an electrostatic printing apparatus as defined in claim 15, wherein said electrode means comprises a conductive stencil screen having openings therein defining an image to be printed upon said substrate.

17. In an electrostatic printing apparatus as defined in claim 16, wherein said separate means comprises a corona chamber including a first conductive end member having at least one opening therein, a second conductive end member spaced from said first conductive end member, an insulative sleeve connected between said first and second end members, corona discharge means on said second conductive member for providing a source of ions, and means for providing a flow of air through said hollow chamber whereby ions can be caused to flow through said opening in said first conductive end member.

18. In an electrostatic printing apparatus as defined in claim 17, an electrode spaced from said corona chamber a distance just large enough for allowing a substrate to be interposed in slightly spaced relation therebetween, and means for creating a potential difference between said electrode and said corona discharge means.

19. In an electrostatic printing apparatus as defined in claim 18, said printing apparatus including a printing station and a precharging station, said separate means being located at said precharging station, and being comprised of corona electrode means, a back electrode located at said precharging station and spaced from said corona electrode means, means for connecting a source of potential between said back electrode and said corona electrode means, and means for moving a sub-
strate through said precharging station and into said printing station, said corona electrode means being located so that ions can be deposited on the side of said substrate upon which toner is to be deposited at said printing station.

20. In an electrostatic printing apparatus as defined in claim 8, said separate means comprising a first conductive member and a second conductive member disposed in spaced relation from each other, an insulative sleeve connected between said first and second conductive members for defining a hollow chamber, means for connecting a source of potential between said first and second conductive members, said first conductive member having at least one opening therein, said second conductive member comprising a source of corona discharge, and means for providing a flow of air through said hollow chamber whereby ions can be caused to flow through said opening in said first conductive member.

21. In an electrostatic printing apparatus as defined in claim 8, said separate means comprising a first conductive member and a second conductive member disposed in spaced relation from each other, means for connecting a source of potential between said first and second conductive members, needle means connected to one of said conductive members, control means disposed in spaced relation from and located between said first and second conductive members, and means for applying a potential to said control means.

22. Apparatus as defined in claim 21, wherein said control means comprises a conductive mesh screen.

23. Apparatus as defined in claim 21, wherein said means for applying a potential to said control means comprises a voltage divider means connected across said means for connecting a source of potential between said first and second conductive members.

24. Apparatus as defined in claim 23, wherein said control means comprises a conductive mesh screen, and adjustable tap means connected between said conductive mesh screen and said voltage divider means.

25. In an electrostatic printing apparatus for printing upon a substrate, electric field means for selectively depositing electrically charged toner on a substrate to form an image upon said substrate, said toner tending to migrate on said substrate in the absence of said electric field prior to fixing said toner to said substrate, means for preventing said migration of said toner prior to fixing including means for neutralizing the electric field associated with the charged toner which defines said image, said means for neutralizing including separate means for depositing an electrical charge upon said substrate prior to and simultaneously with the depositing of charged toner upon said substrate.