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ELECTROSTATIC CHARGING METHOD AND DEVICE

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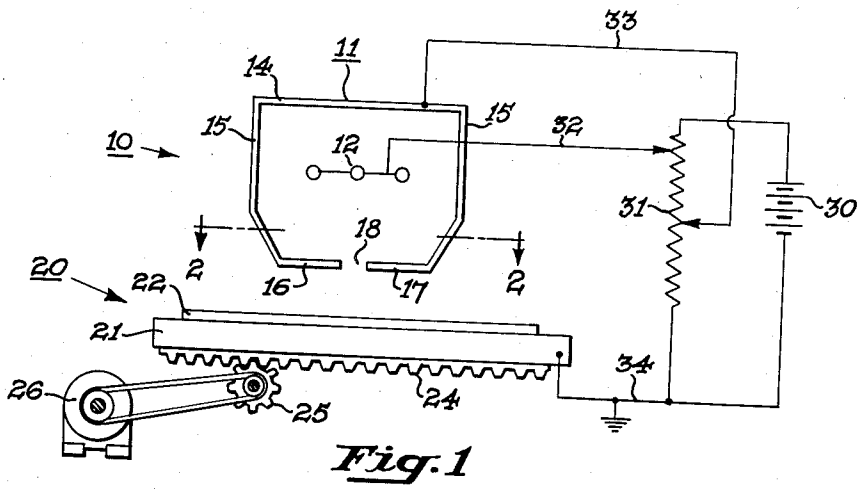


Fig. 1

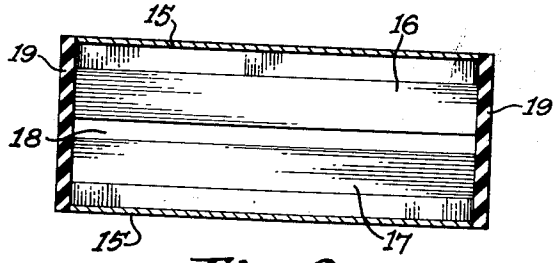


Fig. 2

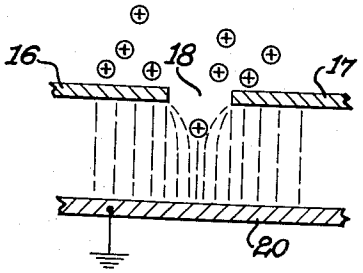


Fig. 3

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ELECTROSTATIC CHARGING METHOD AND DEVICE

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5 Claims. (Cl. 250—49.5)

This invention relates in general to electrostatic images and in particular to electrostatic images such as are encountered in the art of xerography.

In the art of electrostatics a relatively recent advance disclosed in Carlson 2,297,691 usefully employs a pattern of electrostatic charge on an insulating surface, for example, for the formation of pictures for reproduction of documents or the like. Prior to this time the commercial art of electrostatics had generally been a negative art devoted principally to the elimination of the detrimental effects of electrostatic charge. Thus, for example, the most typical prior applications of electrostatic art had been applications such as disclosed in Chapman U. S. Patents 824,339, and 940,430, in which there had been disclosed methods and apparatus for the neutralization of electrostatic charge or potential so that rolls of paper, textile materials and the like could be safely and easily handled without adverse electrical effects. With the advent of the Carlson invention, and the recent advent of other useful applications of electrostatic charge patterns, it has now become necessary to devise prior electrostatic art in order to accomplish new and opposite functions. Thus the earlier prior art had been primarily concerned with elimination of electrostatic charge and charge patterns, and the present state of the art is now concerned with the utilization and control of electrostatic charge patterns.

For example, in the art of xerography as typified by the Carlson patent, it is usual to form an electrostatic charge pattern on an insulating or photoconductive insulating surface, and to employ this charge pattern usefully for the making of pictures or other reproductions. In normal operation the photosensitive xerographic member may comprise a photoconductive insulating coating on a conductive support surface. This member is sensitized to light by charging it to an electrostatic potential that is as nearly uniform as can be achieved. In the art of xerography the quality of the results have depended as much as anything on the degree of uniformity of this potential, and uniformity of potential has in itself been one method of overcoming other nonuniform conditions. In line with this path of improvement, in one advance in the art of xerography more uniform sensitization of the xerographic photosensitive member has been accomplished by ion discharge or corona discharge elements in which the measure of uniformity has been a high degree of uniformity of charge potential. In such operation the xerographic plate has been charged to a predetermined voltage by corona discharge, usually to positive polarity, and has been selectively discharged by exposure to a pattern of activating radiation such as a light image. This results in an electrostatic latent image on a xerographic plate which image can be developed and made visible by the deposition of charged particles in accordance with the charge potential remaining on the xerographic plate.

Further in accordance with the present state of the art of xerography, it has been possible to achieve either direct

or reversal photographic reproduction by employing developer material which is charged, respectively, to either opposite polarity for direct development or to the same polarity as the electrostatic latent image for reversal development. In addition, certain special effects can be achieved and certain improved process characteristics can be obtained by varying the apparent potential of the xerographic latent image. Thus, for example, if an electrically conductive or equi-potential surface or electrode is placed closely adjacent to the xerographic image bearing surface, a potential placed on this electrode can bring about conditions for photographic reversal if desired, or for appropriate photographic tone control and similar photographic effects in the developed image. In effect, this variation is accomplished by placing the adjacent electrode at a known potential with respect to the xerographic latent image and adjusting this potential so that the xerographic latent image may take on a new relative potential with respect to the applied control potential. If, for example, it is desired to develop only certain tones of the electrostatic image, the control potential may be so adjusted as to cause the other tones to be neutral or repellant with respect to the charge of the xerographic developing material. Highlights can thus be brightened or more dense image portions made more dense. The contrast may be decreased or increased as desired.

It is unfortunately, but not unexpectedly, true that these advantages and flexibilities can be achieved only with accompanying difficulties. One of the problems in such a system is the gradual variation in charge potential, particularly in the most highly charged areas of the xerographic latent image, due to a small degree of conductivity in the photoconductive insulating layer of the xerographic plate. This effect is unfortunately most seriously detrimental in xerographic plates or members having the greatest sensitivity to light. Thus, tone control operations are difficult with such plates since it is generally necessary to control the potential on the adjacent electrode very exactly with reference to the actual potential of a certain portion of the xerographic latent image which usually is the most highly charged, and, therefore, most rapidly charging image potential. It is apparent, therefore, that one most valuable improvement in the art of dealing with electrostatic charge patterns would be a means of altering the average charge on an image bearing surface while retaining, substantially without alteration, the image configuration and potential differentials of the original charge pattern.

It is, therefore, an object of the present invention to provide new methods and apparatus for varying the charge potential on an electrostatic latent image bearing surface while retaining the image configuration on such surface.

It is another object of the invention to provide a new corona discharge apparatus for varying the electrostatic potential on an electrostatic image bearing surface while retaining the image configuration of such electrostatic image bearing surface.

It is a further object of the invention to provide a new constant current corona discharge electrode adapted in current flow to be substantially completely independent of electrostatic charge potential on a surface or electrode being charged.

It is still a further object of the invention to provide a new and improved corona discharge electrode particularly adaptable to reverse the polarity of an electrostatic latent image on an image bearing surface.

Additional objects of the invention will in part be obvious and will in part become apparent in the following specification and drawings in which:

Fig. 1 is a partly diagrammatic view of a corona dis-

charge element according to one embodiment of the present invention.

Fig. 2 is a cross sectional view of the electrode according to Fig. 1, taken along line 2—2.

Fig. 3 is a fragmentary enlarged diagrammatic view of one portion of the apparatus of Fig. 1, illustrating a possible mechanism of performance.

In Fig. 1 there is illustrated a corona discharge electrode generally designated **10** comprising an electrode shield **11** partly surrounding one or more corona discharge wires **12**. The shield **11** may, if desired, have an upper or backing wall **14**, side walls **15**, and, along the bottom or face of the shield, a pair of lips **16** and **17** defining a corona ion slit **18**. Desirably the ion slit extends substantially completely along the length of the electrode across its bottom face and may be fixed or adjustable as desired. Mounted more or less centrally within the shield **11** are one or more fine conductive strands or corona discharge wires **12** electrically insulated from the shield for example by insulating end walls **19** and spaced from each of the walls at a sufficient distance so as to eliminate sparking or electrical avalanche between the wires and the shield.

The corona electrode **10** is illustrated as being positioned above and closely adjacent to the surface to be charged such as, for example, a xerographic plate generally designated **20** comprising a conductive support base **21** having on its surface an insulating or photoconductive insulating layer **22**. Preferably, suitable drive means are provided such as for example a rack and pinion **24** and **25** operated by a power source such as for example an electric motor **26**. The drive means, either mechanical or manual, is adapted to cause relative motion between the surface being charged and the charging electrode, this motion being across the direction of the ion slit **18** and optionally at right angles thereto.

A suitable electric potential source **30** is operably connected to the shield, the corona discharge wires, and the backing plate, so as to provide a series of inter-related potentials on these members as will be described hereinafter. Thus, for example, the power supply **30** may be operably joined to a potentiometer **31** which has fixed or variable conductive leads **32** to the corona discharge wires, leads **33** to the shield, and a grounded lead to the backing plate **34**.

In accordance with this general description an illustrative corona discharge electrode was constructed according to the following specifications. A single corona discharge wire consisting of a 0.0035 inch stainless steel strand was mounted on a polystyrene insulating block within a conductive shield substantially square in cross-section and having a cross-sectional area of about 1 inch square. On the lower face of the corona discharge electrode directly adjacent to the surface being charged was a slit about 1/32-inch wide extending substantially along the length of the electrode or, in this case, about 9 inches along the lower face of the electrode. This ion slit was positioned and disposed 3/8 inch from the surface of the xerographic plate being charged. A drive motor was adapted to move the electrode across the plate surface at a rate of travel of 2.5 inches per second while maintaining the 3/8-inch distance between the ion slit and the plate. In this manner the ion slit covered a path equivalent to the entire area of the xerographic plate at a distance therefrom of 3/8 inch.

The electric potentials on the various members are adjusted and adapted to provide a corona generating potential between the corona discharge wires **12** and the walls of the shield **11** and to provide a strong field potential between the lips **16** and **17** of the electrode on the one hand and the backing plate **21** of the xerographic plate on the other hand. Thus, desirably, the potential difference between the corona generating wires **12** and the shield **11** will be maintained well above the threshold of corona current and preferably well over 1,000 volts above such

threshold. This means that there will be a potential difference between the wires and the shield of at least one or more thousand volts depending upon the fineness of the wire and generally in the order of several thousand volts such as for example between about four and ten thousand volts. When the shield is of about 1-inch square cross-section it has been found that a potential in the order of about four to five thousand volts between the corona wires and the shield is a very acceptable corona generating potential.

The external field potential or potential between the shield **11** and the backing plate **21** is so adjusted and adapted as to provide a strong potential gradient from the shield to the plate. Thus for example the potential difference maintained between lips **16** and **17** of the shield on the one hand and backing plate **21** on the other hand will generally be in the order of at least 1000 volts and may be as high as just barely below the threshold of breakdown of the air or gas layer between the shield and the plate. This potential, therefore, may be as high as a good many thousand volts if there are no irregularities or sharp radii on the sharp surface but generally will be between about 1000 and about 3000 volts. The exact potential difference between the shield and the backing plate will be varied in relation to the image forces involved. Thus, for a spacing of about 3/8-inch between the shield and the image surface it is desirable that the potential difference between the shield and the surface be roughly at least four times the difference in potential between highest charge and lowest charged image areas and preferably about ten to twenty times the image potential difference.

In the example illustrated wherein a single corona discharge wire is mounted within the 1-inch square cross-section shield at a spacing 3/8-inch from the image plate, optimum operating potentials were about 4800 volts potential difference between the wire and the shield and about 2400 volts potential difference between the shield and the plate. In operation in this manner and at potentials in this order, it was found that a xerographic plate could be charged to uniform charge density at an average potential of about 150 volts. It was further found that an image surface bearing an electrostatic latent image of maximum charge potential of about 150 volts could be effectively reversed at the same operating distances, speeds and potentials.

In accomplishing reversal of the electrostatic latent image the corona discharge electrode is operated at a polarity opposite to the polarity of the image and functions to reduce the maximum image areas to substantially zero potential while raising the originally discharged image areas to potential of opposite polarity. The reversal of such image is further described in concurrently filed, co-pending application Serial Number 556,869, filed January 3, 1956.

Considerable variation may be made in the scope of the invention with reference to the shape of the electrode and shield and with particular reference to spacings, electric potentials, and the like. In general the effects of these variations can be separated into two types of result. In the first type of effect a change may be made in the ionization conditions within the electrode shield and in the second type of effect a change may be made in the ionization transport conditions externally from the shield.

It is known in the art that the flow of current from a fine radius conductor at an elevated potential, or in other words the corona current, is critically dependent on both the potential and the radius of conductor. The criticality with respect to radius is so narrow that even extremely uniform wires show major variation of current flow from end to end, especially for negative corona discharge. This is particularly significant after use, since corrosion of the wire under corona discharge conditions tends to change the surface shape of a wire. To a large extent,

however, this criticality can be reduced in proportion by maintaining an extremely high rate of current flow. Thus, as a fine radius conductor is gradually raised in potential it first approaches, then reaches and then passes a potential threshold at which corona discharge starts. At the threshold potential, discharge principally centers at irregularities in the conductor. As the potential is raised, and this threshold is far exceeded, a continuing difference is noted between the current flow at a fine radius and the current flow at a somewhat greater radius, but this difference becomes proportionately less as the current flow increases. Thus, by maintaining the corona generating potential at a voltage far in excess of the corona threshold, relative or proportional uniformity is approached. In addition, uniformity of the ion discharge reaching the ion slit **18** may be improved by motion within the shield. For example, the corona wire may be longitudinally moved or vibrated or may be axially rotated. Similarly, the air or gas itself within the shield may be moved or vibrated so as to effectively scatter the flow of ions from a particular conductor area. Similarly, known or systematic non-uniformities of current flow can be corrected by compensating systematic variations in the width of the ion slit **18**.

The external ion flow control which controls the direction and rate of flow of ions from the slit **18** to the surface being charged is particularly highly critical in achieving the effect of constant current charging as distinguished from constant potential charging of the prior art. The essential effect involved in this concept of constant and highly directional ion flow is illustrated in Fig. 3. As shown in the figure, lips **16** and **17** defining the ion slit **18** are positioned closely adjacent to a surface **20** to which uniform and directionalized current is being passed. A relatively high potential is applied to the shield with respect to the charging surface which may for example be grounded. There is, therefore, an intense electric potential gradient between the shield and the image surface as illustrated by the dotted lines in Fig. 3 which represent electrostatic lines of force. Inside the shield as illustrated above, lips **16** and **17** there is a relatively high population density of ions indicated in the figure by plus signs representing positive ions. Most of this high population density of ions is being directed from the corona wire to the conductive shield but a small proportion of them are carried through the ion slit **18** where they come under the influence of the external electric field. At this point the ions receive an additional, intensified and highly directional impetus directly toward the image surface **20** whereby they are shot directly against the image surface and deposited thereon. It is apparent that in the course of travel from the ion slit to the image surface the ions pick up a significant quantity of momentum whereby their deposition on the image surface is substantially independent of relatively localized image forces residing on the image surface. From an analysis of this situation it was apparent that the directional effect and uniformity of charge as a result of overcoming image forces is achieved by causing this external electric field to be intense and either substantially perpendicular to the image surface or substantially focused along a line of this surface. Thus, in the situation illustrated, the field is substantially perpendicular to the image surface except in the vicinity of the ion slit where there is some inward fringing of the field resulting in a focusing action.

In order to achieve the function of directionalization it is important that the shield be spaced at a finite distance from the image surface and, nevertheless, that it be spaced relatively close to this surface. Thus, the shield must be close enough so that ion progress in a nearly straight path toward the image surface has little length of travel in which to wander from the perpendicular. Similarly, the distance must be great enough so that the directionalized field does impart direction as well as momentum to the ion on its passage through the shield to the plate.

Closely coordinated with the distance is the potential difference between the shield and the plate which is to be sufficiently intense as to minimize the field distortion caused by image forces on the image surface **20**. It has been found in practice that this potential from the shield **15** to the plate **20** should be at least about four times the maximum image potential variation and preferably about 10 to 20 times such variation. At the upper end of the scale it is necessary that the potential be insufficient to cause dielectric breakdown of the air or other gas or to cause substantial localized corona discharge from fine radii on lips **16** and **17**.

In the absence of an intense and substantially parallel or focused field as illustrated in Fig. 3, the corona discharge electrode serves to charge an adjacent surface to a substantially uniform electric potential rather than to a substantially uniform charge density or increment of charge density. Thus, in the absence of this field the electrode becomes a constant potential device rather than a constant current device.

The apparatus illustrated in Figs. 1 to 3 is useful for depositing a constant current ion flow on a desired surface or on suitable articles or objects. Such a device is useful in conjunction with uniform surface coating as for example with paint spraying or the like. It has a particular advantage or utility in the exerographic art for the variation of average potential on an image bearing surface while maintaining existing electric image configuration. More specifically, it is useful in electric image reversal wherein image configuration is retained while image polarity is reversed, as disclosed in the above identified copending application.

It is apparent that the advantages of the invention can be realized through numerous variations and modifications of method and structure so long as the principles inllustrated in the figures are retained. Particular reference is made to the illustration of a directionalized field of force according to Fig. 3 with the understanding that modifications of structure may be made in accordance with principles illustrated in this figure.

What is claimed is:

1. Xerographic charging apparatus to deposit uniform increments of charge on a charge pattern bearing surface comprising support means for the layer to be charged and means to support a field generating electrode behind the layer, an electrode structure comprising a corona discharge wire electrode and a shield electrode spaced from the layer to be charged and movable relative to said support means at a substantially uniform rate in a direction transverse to said corona electrode and parallel to the surface, means to apply a corona generating field between said corona discharge wire electrode and said shield electrode, and means to apply between said shield electrode and said field generating electrode a potential equal to at least four times the maximum image potential variation of the charge pattern on the surface being charged to cause charge deposition on the surface being charged substantially independent of charge variations thereon.

2. Xerographic charging apparatus to deposit uniform increments of charge on a charge pattern bearing surface comprising suppport means for the layer to be charged and means to support a field generating electrode behind the layer, an electrode structure comprising a corona discharge wire electrode and a shield electrode substantially surrounding said discharge wire electrode and having a narrow slit opening positioned between the discharge wire electrode and said support means, said electrode structure being spaced from the layer to be charged and movable relative to said support means at a substantially uniform rate in a direction transverse to said corona discharge wire electrode and parallel to the surface, means to apply a corona generating field of a first polarity between said corona discharge wire electrode and said

shield electrode, and means to apply between said shield electrode and said field generating electrode a potential of said same first polarity and equal to at least four times the maximum image potential variation of the charge pattern on the surface being charged to cause charge deposition on the surface being charged substantially independent of charge variations thereon.

3. Xerographic charging apparatus to deposit uniform increments of charge on a charge pattern bearing surface comprising support means for the layer to be charged and means to support a field generating electrode behind the layer, an electrode structure comprising a corona discharge wire electrode and a shield electrode substantially surrounding said discharge wire electrode and having a narrow slit opening positioned between the discharge wire electrode and said support means, said electrode structure being spaced from the layer to be charged and movable relative to said support means at a substantially uniform rate in a direction transverse to said corona electrode and parallel to the surface, means to apply a corona generating field of a first polarity between said corona discharge wire electrode and said shield electrode, and means to apply between said shield electrode and said field generating electrode a potential of said same first polarity and equal to ten to twenty times the maximum image potential variation of the charge pattern on the surface being charged to cause charge deposition on the surface being charged independent of charge variations thereon.

4. A method of depositing uniform charge density increments on a surface comprising creating ions in air adjacent to a surface to be charged, and applying an intense directionalized electric field between said created ions and said surface to be charged to cause ion impingement at the surface along perpendiculars to the surface and charge deposition on the surface substantially independent of charge variations existing at the surface.

5. A method of depositing uniform charge density increments on an image bearing surface comprising generating ions adjacent to said surface, and applying an electric potential at least equal to about ten to twenty times the maximum image potential variation of the image on the surface being charged to create an electric field between said ions and said surface to cause impingement of the ions at the surface and charge deposition on the surface substantially independent of charge variations existing on the surface.

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