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M. B. CULHANE ET AL
CHARGING SYSTEM FOR PLACING A UNIFORM CHARGE
ON A PHOTOCONDUCTIVE SURFACE

3,527,941

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2 Sheets-Sheet 1

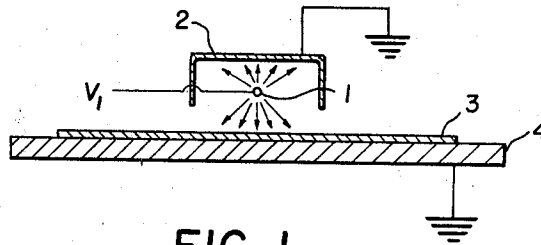


FIG. 1
(PRIOR ART)

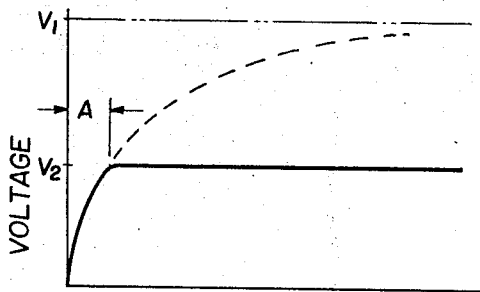


FIG. 2
(PRIOR ART)

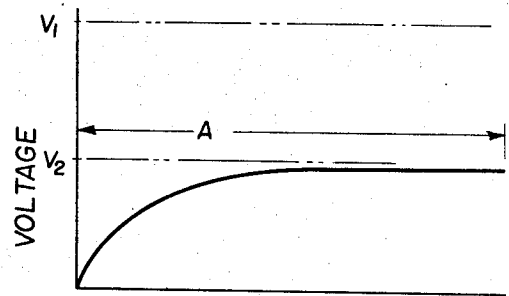


FIG. 4
(PRIOR ART)

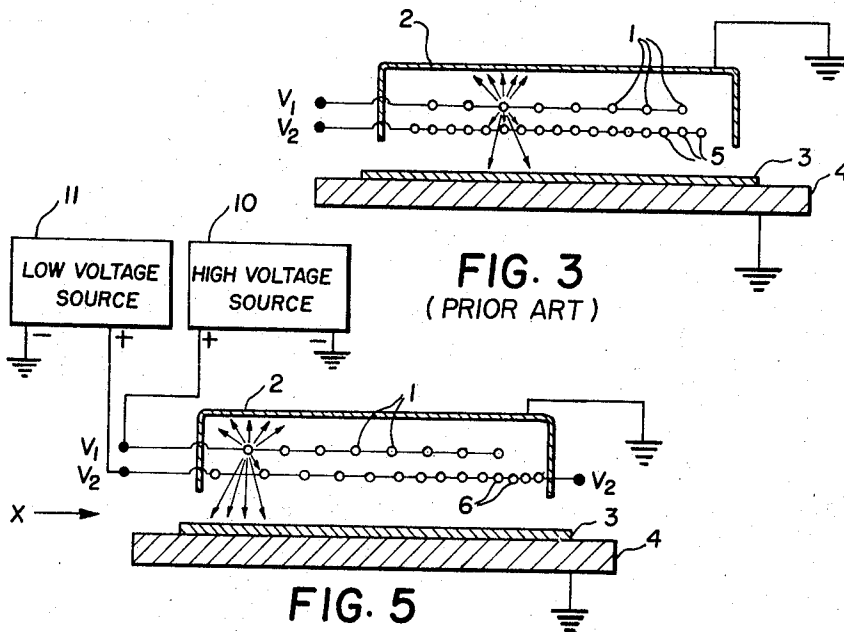


FIG. 3
(PRIOR ART)

FIG. 5

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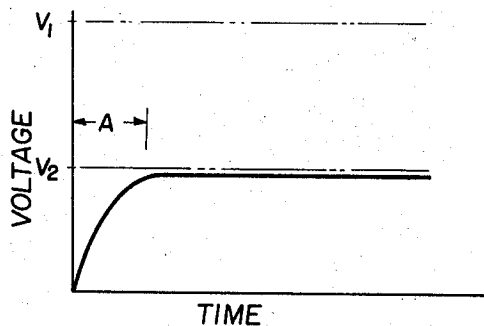


FIG. 6

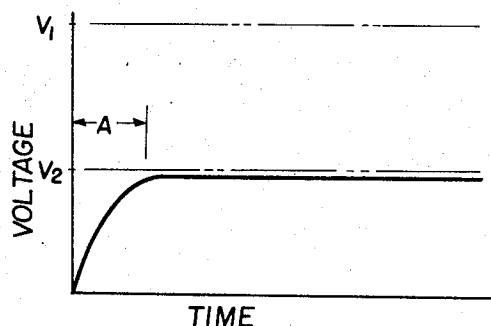


FIG. 8

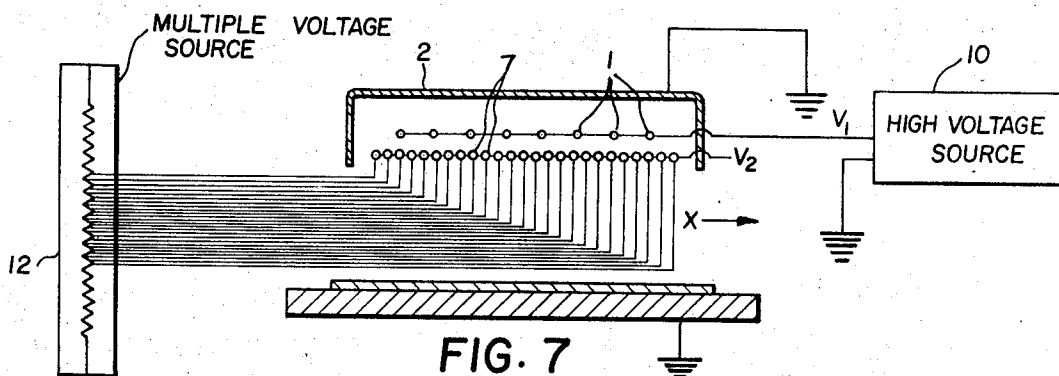


FIG. 7

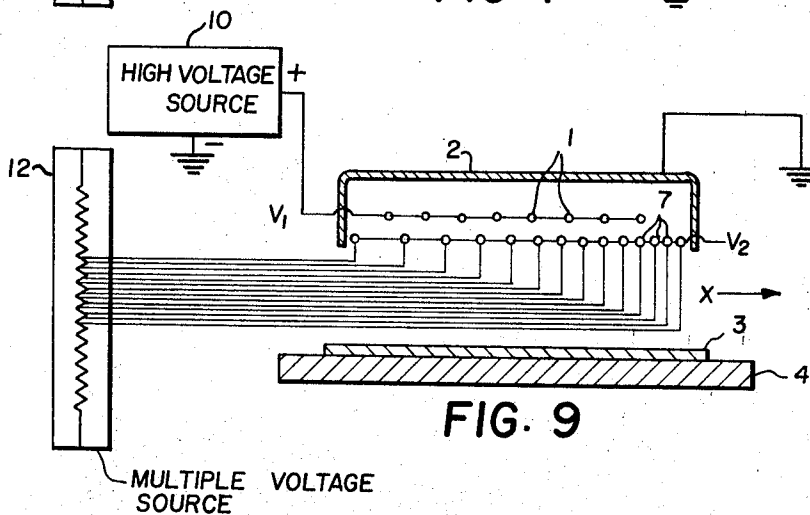


FIG. 9

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CHARGING SYSTEM FOR PLACING A UNIFORM CHARGE ON A PHOTOCONDUCTIVE SURFACE

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U.S. Cl. 250—49.5

7 Claims

ABSTRACT OF THE DISCLOSURE

A single charging station places a uniform charge of a predetermined magnitude upon an insulator by graduating the amount of control that a grid exerts upon an ion source, preferably a corona discharge. The size of the grid mesh may be varied or the potential of the grid may be varied, or a combination of the two may be used to provide the desired control.

BACKGROUND OF THE INVENTION

Field of the invention

This invention relates to apparatus for placing a uniform predetermined charge on a photoconductive surface for use in electrophotography.

Description of the prior art

In one form of electrophotographic apparatus, an electrostatic charge of predetermined magnitude is deposited upon a photoconductor which is exposed simultaneously or subsequently to radiation in a pattern which is to be reproduced. The photoconductor becomes conductive in those areas where it has been exposed. Thus, the remaining electrostatic charge assumes a pattern corresponding to the dark areas of the radiation pattern to which the photoconductor was exposed. A toning medium is then applied to the photoconductor but is attracted thereto only in those places where the electrostatic charge remains to form a toner image. The toner image may be utilized on the photoconductor or transferred to a copy medium or receiver.

In photographic apparatus it is desirable to charge the photoconductor to a specific voltage which does not vary appreciably over the surface of the photoconductor, so that the reproduced image will be a true likeness of the original, particularly when reproducing patterns having a number of density variations. In commercial electrophotographic copiers, high uniformity of charge has been obtained by shielding a corona discharge with a grid to which has applied thereto a potential equal to that to which the photoconductor is to be charged. An example of this system is shown in U.S. Pat. No. 2,777,957 granted Jan. 15, 1967, to Walkup. Although this system produces a uniform charge, it does so at the expense of speed compared to a corona discharge without a grid, since the potential difference between the grid and the photoconductor is lower than the potential difference between the corona discharge device and the photoconductor.

One solution to this problem is shown in U.S. Pat. No. 2,701,764 issued Feb. 8, 1955, to Carlson. Here the photoconductor is successively charged at two different charging stations. The first charging station gives a rapid nonuniform charge to the approximate potential desired, whereas the second charging station more slowly brings the charge to the proper potential. This system has the disadvantage that two charging stations are required.

Another solution is shown in U.S. Pat. No. 2,778,946, Mayo, where two charging stations are combined in one

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structure. However, the rapid deposition of a uniform charge is still not attained, since the photoconductor is effectively being subjected to two successively different fields.

SUMMARY OF THE INVENTION

It is, therefore, an object of the invention to provide an electrostatic charging device which requires only one charging station but which applies a uniform charge at a relatively high rate of speed.

This and other objects of the invention are accomplished by providing a corona discharge which is separated from the photoconductor by a grid which produces a nonuniform field so that as the photoconductor is moved past the charging station it is subjected to a progressively lower potential which finally becomes the potential to which the photoconductor is to be charged. Thus, the photoconductor is uniformly and rapidly charged to the desired potential. In specific embodiments of the invention, the electrostatic field produced by the grid is made nonuniform by (1) applying graduated voltages to the individual elements of the grid, (2) by graduating the spacing between the grid elements themselves, or (3) by a combination of the above two methods.

BRIEF DESCRIPTION OF THE DRAWING

The invention will be better understood when reference is made to the following specification and the accompanying drawing wherein:

FIG. 1 shows a prior art corona discharge charging device;

FIG. 2 shows the charging curve of the photoconductor when using a device such as in FIG. 1;

FIG. 3 shows a prior art corona discharge charging device with a control grid;

FIG. 4 shows a charging curve of the charging device such as shown in FIG. 3;

FIG. 5 shows a corona discharge charging device according to the invention in which the elements of the controlled grid are variably spaced;

FIG. 6 shows a charging curve for the device such as shown in FIG. 5;

FIG. 7 shows a charging device in which the grid elements are evenly spaced but have applied thereto decreasing potentials;

FIG. 8 shows a charging curve for a device such as shown in FIG. 7; and

FIG. 9 shows a charging device in which the elements of the control grid are variably spaced and have applied thereto decreasing potentials.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIG. 1 there is shown a prior art high speed charging device which comprises a corona wire 1 which is held at a high potential V_1 . The upper part of corona wire 1 is enclosed by a shield 2 which is grounded. Below shield 2 is a photoconductor 3 which is to be charged. Photoconductor 3 rests upon a grounded conductor 4.

FIG. 2 shows how the charge accumulates on photoconductor 3 of FIG. 1 as time progresses after a potential is applied to corona wire 1. It is apparent from the curve that the photoconductor tends to charge exponentially to the potential on the corona wire V_1 . However, after time length A charging is stopped either by disconnecting the potential V_1 or by moving the photoconductor away from the charging station. The photoconductor is therefore left with an uneven charge of a value somewhere in the vicinity of V_2 .

Although the system shown in FIGS. 1 and 2 has the ability to rapidly charge the photoconductor, it does not do so with the uniformity necessary for some applica-

tions. In order to achieve uniformity, the device shown in FIGS. 3 and 4 has been used. This device is similar to that shown in FIG. 1; however, a matrix 5 of grid wires has been placed between the corona wire or wires 1 and the photoconductor 3. This device behaves as though the ions originate at the grid wires 5. As shown in FIG. 4, the photoconductor again charges exponentially. However, it takes a much longer time to charge to voltage V_2 than it does in the system shown in FIG. 2 but the charge is very uniform. Unfortunately, as can be seen from FIG. 4, the time to charge to the required potential is much longer.

In order to provide a rapid charge but at the same time provide a uniform charge, the present invention has been developed. Referring to FIGS. 5 and 6, there is shown a system which uses a corona wire or wires 1 and shield 2 similar to that shown in FIG. 1. This shield and corona wire arrangement is positioned above a photoconductor 3 and grounded conductive layer 4, also similar to that shown in FIG. 1. Positioned between the corona wires 1 and the photoconductor 3 is a grid matrix 6. This matrix is arranged as a series of wires or as a mesh. The wires are arranged so that the spacing is very great at the left and decreases toward the right. Where the spacing is very great, there is a large amount of leakage through the grid matrix. Where the spacing of the wires is very close, there is little or no leakage. Where there is a high leakage, the photoconductor will tend to be charged to the potential on the corona wires. Where there is little leakage, the photoconductor will tend to be charged to the voltage applied to the grid. Since the photoconductor is moved in the direction of arrow X, the photoconductor will first be subjected to a very high potential from source 10 and then to an increasingly lower potential until it is subjected only to the potential from source 11, to which it is intended to be charged.

Referring to FIG. 6, there is shown a graph of the charging curve of the apparatus of FIG. 5. As can be seen, during the initial part of time length A, the photoconductor exponentially charges to voltage V_1 . However, since the photoconductor is moving toward a lower charging potential, the curve is flattened somewhat but reaches voltage V_2 in a much shorter length of time than it does in FIG. 4.

FIGS. 7 and 8 show another embodiment of the invention. Here the usual shield 2 and corona wires 1 are provided to charge photoconductor 3 which is positioned on grounded conductor 4. In FIG. 7, however, individual grid elements 7 are provided which are insulated from each other. The grid elements toward the left are energized from source 12 by a high voltage approximating voltage V_1 whereas the grid elements toward the right are energized by a multiple voltage source so that a voltage gradient is produced along the grid. Source 12 is connected so that the gradient decreases in direction of relative movement of the photoconductor to the grid. Where the potential on the grid is high, the grid exerts very little influence on the ions emanating from the corona wires. Where the potential on the grid is low, the grid exerts control over the ions so as to charge the photoconductor to the potential on the grid. Since the photoconductor is moving in the direction shown by arrow X, the photoconductor is initially exposed to a high potential and is subsequently exposed to a lower potential so as to initially give it a high charge which is then smoothed out by the lower potential. The charging curve is shown in FIG. 8 where it can be seen that the photoconductor is charged in time length A to potential V_2 .

It is, of course, understood that a combination of the methods shown in FIGS. 5 and 7 could be used, i.e., the grid wires could be variably spaced and at the same time be insulated from each other so that they could have applied thereto differing potentials. FIG. 9 shows such a device which has a variably spaced grid 7 as well as a voltage gradient along the grid produced by multiple

voltage source 12. In any case, there should be a voltage gradient across that portion of the insulator which is at the charging station.

It is also to be understood that instead of moving the photoconductor past a stationary charging station, the charging station could be moved past a stationary photoconductor. All that is required is relative motion between the two.

Although the invention has been described in considerable detail with reference to certain preferred embodiments thereof, it will be understood that variations and modifications can be effected without departing from the spirit and scope of the invention as described hereinabove and as defined in the appended claims.

We claim:

1. Apparatus for placing a substantially uniform electrostatic charge upon an insulative surface, said apparatus comprising:

- (a) a source of ions movable relative to said surface;
- (b) a source of electrical potential; and
- (c) grid means positioned between said ion source and said surface and connected to said potential source for producing a decreasing voltage gradient along said surface in the direction of relative movement of said surface.

2. Apparatus as defined by claim 1 in which said grid means comprises:

- (a) a plurality of conductors; said conductors being directed at approximate right angles to said direction; and
- (b) means applying a different potential to each of said plurality of conductors, the potentials on said conductors being arranged to decrease in said direction.

3. Apparatus as defined by claim 1 in which said grid means comprises at least first, second, and third consecutive conductors numbered in the direction of relative movement, the spacing between said first and second conductors being greater than the spacing between said second and third conductors.

4. Apparatus as defined by claim 3 in which said potential source comprises means for simultaneously applying different potentials to said conductors.

5. Apparatus for placing a substantially uniform electrostatic charge upon a movable photoconductive surface, said apparatus comprising:

- (a) a corona wire adapted to produce ions and being positioned adjacent said surface;
- (b) a source of potential; and
- (c) grid means positioned between said corona wire and said photoconductor and connected to said potential source for producing a decreasing voltage gradient along said photoconductive surface in the direction of relative movement of said surface.

6. Apparatus for placing a substantially uniform electrostatic charge upon a movable photoconductive surface, said apparatus comprising:

- (a) a stationary corona wire adapted to produce ions;
- (b) a source of potential; and
- (c) grid means positioned between said source of ions and said surface and connected to said potential source for producing a decreasing voltage gradient along said surface in the direction of relative movement of said surface, said grid means comprising at least first, second, and third consecutive conductors numbered in the direction of relative movement, the spacing between first and second conductors being greater than the spacing between said second and third conductors.

7. Apparatus for placing a substantially uniform electrostatic charge upon a relatively movable photoconductive surface, said apparatus comprising:

- (a) a corona wire adapted to produce ions, said wire being positioned adjacent said surface;
- (b) a source of multiple potentials,

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- (c) grid means positioned between said corona wire and said surface, said grid means comprising a plurality of conductors positioned approximately perpendicular to the direction of relative movement of said surface;
- (d) means connecting said multiple potentials to individual conductors, the potential on said conductors decreasing in the direction of relative movement of said surface; and
- (e) the spacing between said conductors decreasing in the direction of relative movement of said surface.

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A. L. BIRCH, Assistant Examiner
U.S. Cl. X.R.
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