Nov. 4, 1969 K. A. METCALFE ET AL 3,476,935

CONTROL OF XEROGRAPHIC IMAGES BY CHARGING THE PHOTOCONDUCTOR WITH ONLY AN OUTER BAND OF A CORONA DISCHARGE

Filed Aug. 30, 1966 2 Sheets-Sheet 1

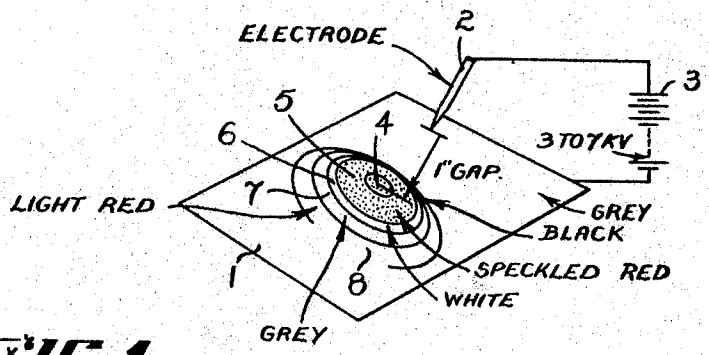

FIG 1

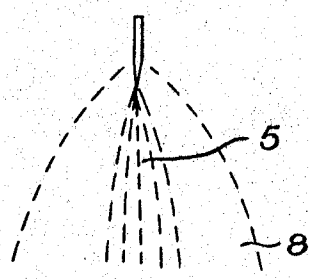

FIG 2

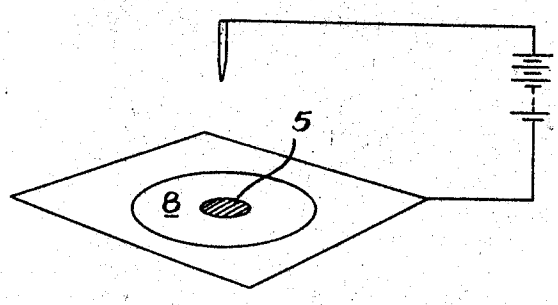

FIG 3

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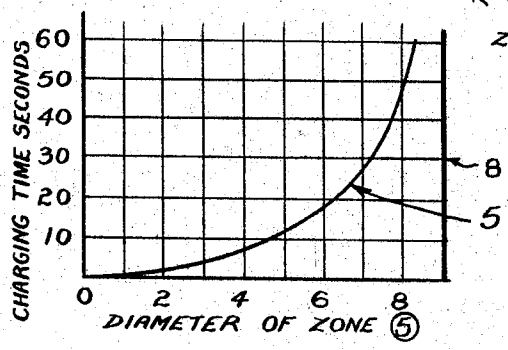
FIG 4



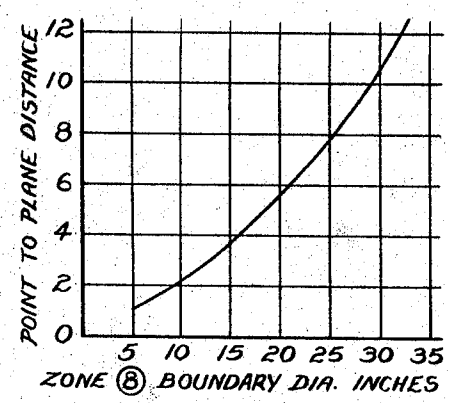


FIG 5

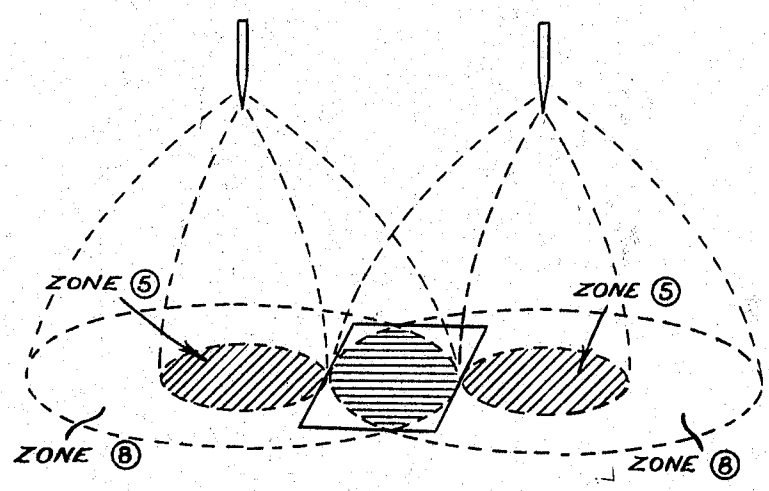


FIG 6

United States Patent Office 3,476,935
Patented Nov. 4, 1969

3,476,935

CONTROL OF XEROGRAPHIC IMAGES BY CHARGING THE PHOTOCONDUCTOR WITH ONLY AN OUTER BAND OF A CORONA DISCHARGE

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Filed Aug. 30, 1966, Ser. No. 576,091
Claims priority, application Australia, Aug. 30, 1965, 63,375/65
Int. Cl. H01j 37/26
U.S. Cl. 250—49.5 4 Claims

ABSTRACT OF THE DISCLOSURE

Provision is made to utilize the outer band of a corona discharge while avoiding the central zone thereof to obtain improved charging for electrostatic processes.

This invention relates to an improved control of xerographic images and in particular it relates to a method of and means whereby firstly a better image can be produced and secondly wherein the tone or hue of the image comes under closer control.

It is already well known that when producing xerographic images a surface which may be a photoconductor surface or may be an insulating surface has an image produced thereon by means of an electrical field, many ways of producing this image being known, such for instance as to use a sheet bearing a photoconductive layer on it which is first charged and is then light-modified by exposure through a negative or the like and the resultant image is then developed by subjecting same to toner particles either in a dry or wet process, whereupon the toner particles are deposited according to the configuration of the latent electrostatic image, or according to a more recent method charging is not resorted to but the surface is simply exposed to electro-magnetic waves in accordance with an image to produce the required latent image and this image is then developed in the same way as in the charge process first described.

In some cases it has even been proposed to first image-modify the surface and to then apply a charge to same, which charge will be held according to the modification of the surface which has taken place.

In all of the known processes there are certain problems in preventing discolouring of the background and the deposition of unwanted toner particles or impurities from the developer so that the cleanness of the image and then contrast are impaired due to this imperfect deposition of toner materials, and various processes have been proposed with a view to preventing this type of unwanted deposition, one of which consists in treating the surface with a material which will leave a slight bias on the surface to repel particles of developer in those areas where normally no attracting field would exist, and another method of achieving this is to use an electrical bias at the time of development which is so disposed that a field is introduced which tends to drive the developer particles away from the background areas where normally no electrostatic field exists.

The method of applying a bias however has always been one of the problems in xerographic development processes because photoconductors as such tend to have artifacts or imperfections and the surfaces are therefore not as uniform and clean as is desirable and also in those methods where charging of the surface is involved problems have been found through the introduction of imperfections due to the charge.

For a considerable time we have suspected that there is an imperfect understanding of the mechanism whereby a corona discharge is applied particularly to a photoconductor surface, and the present invention relates to those processes where charging forms a part during some stage of the process, be it for the purpose of achieving intensification of an image due to the charging of the surface and the bleeding away of unwanted charge in an image-wise manner or whether the charging is merely for the purposes of producing a bias on the surface which will then control deposition of developer in accordance with this bias, the latter part of the process probably being the more important one in that it has been found that by its use very exact control of charge levels is possible without the introduction of artifacts so that in, for instance, colour reproduction, it is possible to vary the hues which are being applied by means of a succession of developers by controlling the charge characteristic on the surface rather than the colour value of the toners themselves.

It will readily be realised that in three-colour work or other colour processing it will be a great step forward to be able to use a series of standard coloured developers corresponding to the basic hues which are to be applied to give the final colour image and to control the densities of each of these developments by regulating the charge existing on the image, it obviously being much simpler to vary the charge by simply varying time or potential than to have to resort to colour mixing to produce certain hues.

While therefore, the invention can be applied to practically all cases where xerographic images are being produced and developed the present invention will be described more in reference to tone control with any of the processes known heretofore, such as the usual process in which the photoconductor is first charged and then image-modified by light or the like or where a chargeless process is used in which the surface is itself simply modified by light or other electro-magnetic waves and independently of whether dry or wet development processes are used.

The principle of our invention is to utilise a corona discharge to apply a bias on a surface which is to have a latent electrostatic image developed thereon or on which a latent electrostatic image has already been produced, the corona being however so controlled that only a certain portion of the corona acts on the surface, which portion of the corona is selected by an appropriate positioning of the corona discharge means and the control of the field generally at such discharge means.

Thus a charging electrode and a base electrode are so spaced and directioned, one in relation to the other, that a series of bands are produced outwardly of a core which is substantially medial to the discharge direction from the electrode, and utilising only an outer band for charging purposes.

To understand the invention it will be necessary to look first at the effects which result when a corona is produced between a pair of electrodes, and for the purpose of studying this we carried out a series of experiments utilising various surfaces such as zinc oxide sheets, aluminum, selenium, brass, titanium dioxide and the like, and we then produced a corona from a single point set at various angles and distances to the sheet and developed the resulting fields produced on the surface by means of different developers.

From this we found that basically there were two significant zones, the first being an inner zone not suitable for charging purposes, the other being an outer zone which

produces greatly improved results. This invention utilises the outer zone.

The invention will be better understood in relation to the effects achieved, by considering the accompanying drawings in which:

FIG. 1 is a perspective view showing the experiment carried out to demonstrate the effects of a corona discharge on a photoconductive surface, using a combination of red and black developers of opposite polarity in an insulating liquid,

FIG. 2 shows an inner core or zone and an outer band or zone, is simplified form, the inner zone having been found to produce interior results, but the outer zone giving improved results,

FIG. 3 is a simplified version of the inner and outer zone which can be deduced from the experiments undertaken,

FIGS. 4 and 5 respectively show graphs of charging time against the diameter of the inner zone, and point to plane distance in relation to the outer zone, and

FIG. 6 shows a form of device which can conveniently be used to charge xerographic papers, the points being used succesively.

Referring first to FIG. 1 it is to be noted that the photoconductive sheet **1** formed the lower electrode of a corona discharge system by placing this sheet on to a metal backing to which the voltage was applied, the electrode **2** being positioned approximately one inch above the sheet **1** and at an angle of about sixty degrees to the vertical, numerous experiments of course having been carried out with different angles and different spacings.

The potential was applied from a suitable generator **3** which produced approximately three to seven kv.

By the application of the corona to a dark-rested sheet for a short period of time it was found that a number of zones were produced which, when developed in the two-colour developer previously referred to, showed the charges at different distances from the electrode **2** and in this way it was found for instance that a typical picture was one in which there was a central ellipse **4** which, when a negative potential was applied to the electrode, developed with a spatter effect, but immediately surrounding this is a primary area **5**, the area however being speckled and containing a percentage of black pigment particles showing that some amount of spatter by relatively positive particles (from air or gas) takes place.

Surrounding this area **5** is an area **6** which is colourless, that is, on white zinc oxide paper the area remains white in that neither the positively charged nor negatively charged developer particles are attracted to this area, while the area **7** which surrounds this red area develops in grey, showing that here relatively positive charges have been impressed on the photoconductive paper to attract the black negatively charged developer, the white marginal ring **6** between these two areas obviously being one where fringe effects between the two areas caused the presence of both positive and negative fields which countered to produce no signficant colouration by either developer in this area.

Surrounding the area **7** of positive charge is a secondary area **8**, or an "outer" zone, which takes a very light hue of red, showing that here there is a negative charge of much lesser intensity, which negative charge in the experiments carried out invariably had a soft and uniform nature and obviously thus was free of the streaming or similar effects which gave mottling in the other areas, so that this particular area produced a relatively weak but uniform charge which we have found is ideal for applying a biasing voltage of negative characteristic to a surface which is subsequently to be developed.

Referring now to FIG. 2 it will be realised that an inner zone **5** is formed which is of inferior characteristic for charging purposes, and it can be assumed that in all the previous work utilising coronas to charge photoconductors it is this area which has been effective in applying a charge being readily available and of fast charging characteristics.

The outer zone **8** is however of highly desirable characteristic and it is this zone which is used according to our invention.

By utilising this for a sufficient time it could be used to charge the photoconductor sheet, but because of the relatively lesser intensity of this charge, longer charging times will be necessary and no effective result would have been obtained had the corona been sufficiently far removed from the photoconductor with the times and voltages previously used. Thus with methods used heretofore no signficant charging effect which would have resulted using normal xerographic processes because from the charging times and intensities it is clear that the prior art charging did not recognise or use this secondary negative charging.

Thus the charge pattern produced by a single point corona comprises a number of zones which may however be divided into two main concentric zones, the central zone **5** and the larger outer zone **8**. The boundary of zone **8** is established early in the charging cycle and remains fixed in diameter regardless of charging time. The diameter of zone **8** increases with increasing point to plane distance as shown in FIG. 1. The diameter of zone **5** increases with charging time as shown in FIG. 4.

The charge zone **8** is characterised by superior electrophotographic speed and exceptional continuous-tone image quality as compared with the zone **5**, the developed density varying radially across zone **8** being of greatest value in the vicinity of zone **5**. The portion of the charge pattern giving optimum speed and contrast is in the form of a ring surrounding zone **5** in the case of a point corona and comprises a parallel band displaced on each side of the wire electrode for a wire corona charging device. The width of this zone may be increased by increasing the inter-electrode distance, this arrangement requires increased charging periods. For example the width of the optimum zone is not greater than 8" for a point to plane distance of 12" at 15 kv. requiring a charging time of 1½ minutes.

The graph of FIG. 4 shows charging time in seconds against the diameters of zones **5** and **8** produced and this suggests that shorter times reduce the central zone **5**.

The graph of FIG. 5 shows how the distance from the point varies the diameter of the zone **8**.

One method of producing a large area of the optimum charge consists of using a plurality of corona points as shown in FIG. 6 arranged so that the outer charge zone **8** produced independently by each corona overlaps adjacent patterns, resulting in a charge area which produces uniform developed density. Unlike conventional multi-corona charging devices this new method is dependent on each corona point acting consecutively. This allows each charge pattern to be superimposed on the other. Simultaneous multiple-corona action does not produce charge overlap due to mutual repulsion of adjacent plasma envelopes which also reduce the size of the outer charge zone **8** without effecting zone **5**.

To uniformly charge a definite area by consecutive multi-corona charging the charging time, point to plane distance and horizontal spacing of the corona points are adjusted to suit the required area. FIG. 6 shows a typical arrangement using two point electrodes. A greater charge uniformity is achieved by using a greater number of points. A convenient method of supplying consecutive high voltage pulses to the points is the use of a system similar to the automotive high tension ignition system. Another method of achieving the optimum charge is to use the overlapping charges from two spaced parallel wire corona discharges each supplied by consecutive voltage pulses.

What we claim is:

1. The method of charging a surface to produce a latent charge thereon, which consists in applying a direct-current corona-producing voltage between at least a

charging electrode and a base electrode, spacing and directing the charging electrode to produce a central zone with an outer band surrounding the same and inserting a work-piece into the outer band of the corona whereby the surface of the work-piece is charged only by the said outer band and is not subjected to the central zone.

2. The method of claim 1 characterized by a multiplicity of spaced apart points energised successively to produce outer bands which overlap to form the charging areas.

3. Apparatus for charging a surface comprising a charging electrode shaped to emit a corona, a base electrode spaced from the charging electrode, direct current voltage supply means connected between the charging electrode and the base electrode to produce a corona discharge having a central zone and an outer band surrounding said central zone and a work-piece holder positioned to allow the surface of the work-piece to be positioned in the outer band only of the corona.

4. Apparatus according to claim 3 wherein the corona is emitted in a direction angularly to the work-piece holder but above the work-piece holder, at a distance and voltage such that the surface of the work-piece is disposed outside of the central zone of the corona to be influenced only by the outer band.

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U.S. Cl. X.R.

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