Jan. 16, 1968 R. A. FEHLBERG ETAL 3,364,020

PHOTO-ELECTRET MULTIPLE COPY PROCESS

Filed April 1, 1964

FIG. 1

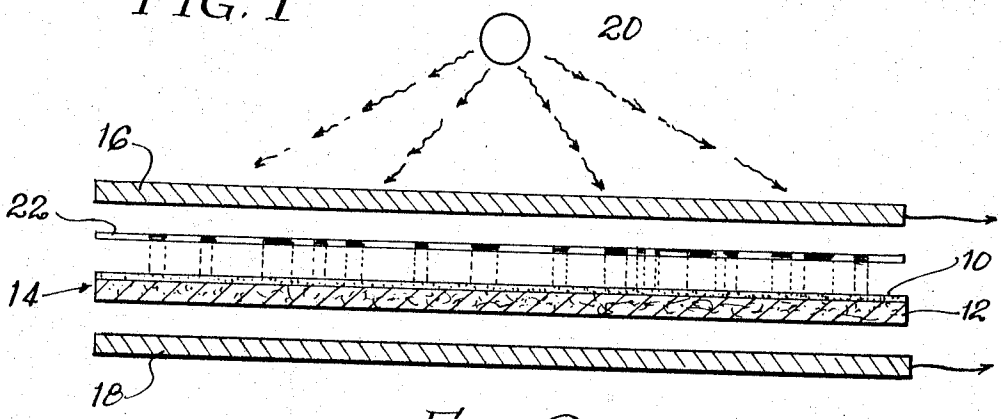


FIG. 2

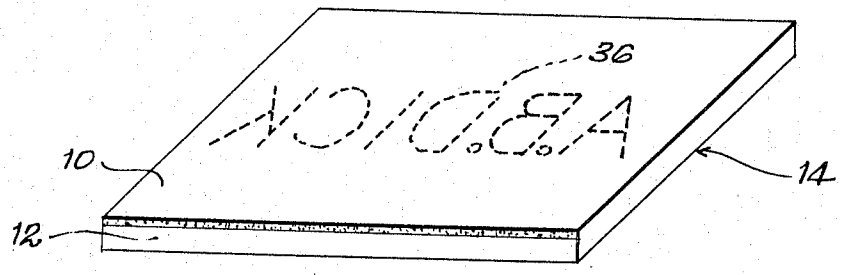
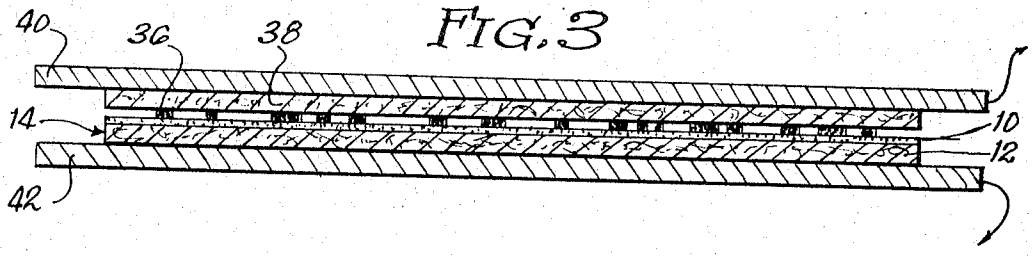


FIG. 3



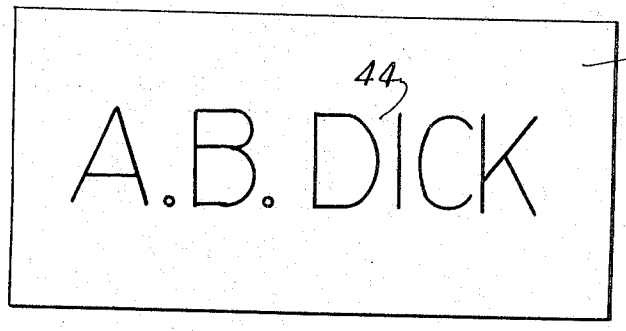


FIG. 4

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PHOTO-ELECTRET MULTIPLE COPY PROCESS

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10 Claims. (Cl. 96—1)

ABSTRACT OF THE DISCLOSURE

An electrostatic copy process for producing more than one copy from an imaged electret in the form of a phosphor which includes positioning the electret layer between electrodes and passing a D-C potential of 50–500 volts between the electrodes and simultaneously exposing the electret layer to radiations either in the form of an overall pattern to polarize the phosphor layer or in the form of a light pattern corresponding to the image to effect internal polarization of the exposed portions. In the event that the phosphor layer is formed with overall internal polarization, it is exposed to a light pattern in the absence of the external electrical field to dissipate the internal polarization from the exposed portions. The electret layer having the latent polarized image is developed with a toner, a copy sheet is positioned in surface contact with the toned side of the electret and the assembly is positioned between electrodes for the passage of a potential therebetween for effecting transfer of the toner from the electret to the adjacent surface of the copy sheet without destroying the internally polarized image in the electret layer. The copy sheet is separated from the electret and the image is set thereon while the steps from the development of the internally polarized image are repeated any number of times for the production of additional copy without the need for resensitization or exposure of the electret layer.

This invention relates to a copy process and it relates more particularly to an electrostatic dry copy process from which more than one copy can be produced from a single exposure.

In the electrostatic copy process developed by Dr. Carlson, U.S. Patent No. 2,297,691, a photo-conductive layer on an electrically conductive base is charged in an overall pattern by corona discharge from an electrostatic source. Thereafter the charge is destroyed from portions exposed to light through an original to leave a latent electrostatic image which can be developed by a suitable pigment powder or toner. The toner can be set on the dielectric coating to produce a single copy or the toner on the developed image can be transferred to a copy sheet brought into surface contact with the developed image by reversal of the electrostatic charge. In either event, the latent electrostatic image is destroyed upon the development of the copy with the result that only one copy can be secured per exposure.

Formation of the charge by corona discharge in the process of Dr. Carlson represents a surface phenomenon wherein it is difficult to retain the latent electrostatic image on the surface over an extended period of time. More recently, a technique has been developing wherein a latent electrostatic image is formed in depth through a phosphor layer, hereinafter referred to as an electret, whereby a more stable electrostatic image is formed in the electret to offer the possibilities of image retention for a time sufficient to produce one or more copies from a single exposure.

In an article entitled, "Data Storage and Display with Polarized Phosphors," by H. P. Kallmann and J. Rennert, Electronics, Aug. 28, 1959 (pages 39–41), description is made of a photo-electret in which the latent electrostatic image is formed by exposure of the phosphor simultaneously to a D-C field and to radiations to cause internal polarization of the phosphor. In the arrangement described in the aforementioned article, the phosphor is imaged by selective radiation, in the dark, of portions of the phosphor to be imaged while an overall D-C field on the order of 50–500 volts is applied. This causes internal polarization in the portions radiated to produce a latent electrostatic image. The image is retained over an extended period of time if the phosphor is confined to the dark. The image can be wiped out by exposure to radiations such as light, infrared, ultra violet and the like. Instead of exposing the phosphor simultaneously to the D-C field and the selective radiations, an overall polarization can be effected by simultaneous exposure of the electret to the D-C field and to light in an overall pattern after which exposure of the charged electret to light through a transparent original or the like will effect removal of the charge in the non-imaged portions, leaving the electret with the latent electrostatic image for subsequent development.

It has been suggested that, by reason of the volumetric characteristic of the latent electrostatic image developed in the electret, as compared to the surface charge characteristic of the process of Dr. Carlson, the latent electrostatic image might be capable of being retained in the electret for a time sufficient to develop more than one copy per exposure. However, the systems that have been suggested tend to destroy the latent electrostatic image during development or transfer with the result that the imaged electret is suitable only for the production of but one good copy per each exposure.

It is an object of this invention to provide a method and means whereby an electret having a latent electrostatic image formed therein can be used to produce one or multiple copies of good quality from a single exposure and it is a related object to provide a method and means of the type described which is simple in construction and easy in operation, which does not require additional expense or complicated equipment, and which is capable of reduction to a commercially desirable copy process for the production of multiple copies from a single exposure.

These and other objects and advantages of this invention will hereinafter appear and for purposes of illustration, but not of limitation, an embodiment of the invention is shown in the accompanying drawing, in which:

FIG. 1 is a schematic sectional elevation view of the arrangement of elements for use in the production of a charged electret in accordance with the teachings of the aforementioned article of Kallmann et al.;

FIG. 2 is a perspective view of the developed latent electrostatic image on the electret;

FIG. 3 is a schematic sectional elevational view of the arrangement of elements for transfer of the developed image from the imaged electret to a copy sheet in accordance with the practice of this invention; and

FIG. 4 is a top plan view of the copy that is produced.

The concept of this invention resides in the processing of the electret, independent of the manner in which the latent electrostatic image is formed, to produce one or more copies of good quality from the imaged electret without destruction of the latent electrostatic image. The invention is applicable to a photo-electret imaged as by the process described in the aforementioned article of Kallmann et al., or by other processes heretofore or hereafter developed for producing a latent electrostatic image by polarization or by volumetric orientation of charges in a phosphor coating.

For purposes of illustration, brief description will hereinafter be made of the process for preparing an imaged electret in accordance with the teachings of Kallmann et al.

Example 1.—Preparation of charged electret

Referring to FIG. 1 of the drawing, a phosphor layer **10** of zinc cadmium sulfide doped with about 0.5% by weight of silver and bonded with an organo silicon resin is provided on a paper base sheet **12** to form an electret **14**. A voltage of 50 volts D-C is applied to external electrodes **16** and **18** positioned on opposite sides of the electret **14** for 10 seconds. During this period, the phosphor layer is excited by a 2 microsecond light flash from an xenon flash tube **20** through a transparent original **22** to impress a polarized light signal into the electret which functions as the latent electrostatic image.

Example 2.—Image development

The latent electrostatic image can be developed on the electret by dusting with a suitable pigment powder in a thermoplastic resinous base wherein the pigment powder is attracted to the charged areas of the electret in amounts proportional to the density of charge thereby to provide a corresponding density of color in the developed image **36**, as described in U.S. Patent No. 3,060,051, or the copending application of Averbach, Ser. No. 97,162.

Example 3.—Preparation of copy

In accordance with the practice of this invention, the preparation of copy from the developed latent electrostatic image, without destruction of the latent electrostatic image so that additional copies can be produced from the imaged electret, is accomplished by arrangement of the electret with the toned electrostatic image in surface contact with a sheet of copy paper **38** and with the assembly positioned between electrically conductive plates **40** and **42** to which a potential can be applied. In this arrangement, the plates **40** and **42**, when charged, function as a capacitor while the assembly of the electret **14** and copy sheet **38** functions therebetween as the dielectric. In response to the application of a potential onto the plates **40** and **42**, it will be found that when the sheets are removed from between the plates and when the copy sheet **38** is stripped from the electret **14**, the toner will be retained on the copy sheet to form the developed image **44** thereon, while the electret will still retain the latent electrostatic image in sufficient intensity and in sufficient detail to enable re-development of the latent electrostatic image by re-application of the pigment powder or toner.

The toner in the image developed on the copy sheet **38** can be set by conventional means, such as by heat, solvent, adhesive or the like, to produce permanent copy. By the same token, the latent electrostatic image **36** in the electret can be again toned by the developing composition to develop the image which can again be transferred to another copy sheet for the production of an additional copy. It has been found that this can be repeated a number of times before the latent electrostatic image becomes weakened or else spreads to the extent that copy of good quality can no longer be produced. When this occurs, the latent electrostatic image can be wiped from the electret by exposure to radiation, such as light, infrared or ultra violet, and the electret can thereafter be recharged and exposed to form another latent electrostatic image from which one or more copies can be produced in accordance with the manner described.

The described transfer of the toned image from the electret is best performed with a potential between the plates that is greater than the potential employed to charge the electret in the preparation of the latent electrostatic image but not so great as to spray corona over the surfaces of the electret or to induce its own overall charge on the plate to wipe out the image. Thus for imaging the plate in accordance with the process of the aforementioned article of Kallmann et al., wherein the electret is exposed to a D-C field of 50–500 volts with simultaneous exposure, a potential of 2 kv. is sufficient. Thus, in general, it is desirable to make use of a potential for transfer which is greater than 50 volts but less than 5 kv. for an imaged electret developed in accordance with the teachings of the aforementioned article and it is preferred to make use of a potential within the range of 50 volts to 3.5 kv.

As the plates **40** and **42**, between which the copy sheet and electret are disposed for image transfer, it is desirable to make use of a thin but highly conductive material, such as sheets of copper, aluminum or steel, or use can be made of such materials as Nesa glass and the like. It is preferred to dimension the plates to extend beyond the portions of the electret and copy sheets from which transfer is to be effected. Best results are secured when the copy sheet and the adjacent plate are displaced together from the surface of the toned electret, but good results will be secured by removal of the plate prior to the removal of the copy sheet.

Example 4

When employing the process of selective depolarization for development of the latent electrostatic image on the phosphor layer, a D-C potential of 50–500 volts is applied, as in Example 1, across the entire layer with simultaneous radiation of the entire surface by light to provide an overall polarization in charging the layer. The image is thereafter written into the layer by selective radiation in the absence of an external field to destroy the internal polarization in the exposed portions. This leaves the layer with polarization in the unexposed portions to provide the latent electrostatic image which can be developed and transferred as in the previous Examples 3 and 4.

It will be apparent from the foregoing that we have provided a means whereby use can be made of a latent electrostatic image in an imaged electret to produce multiple copies from a single exposure thereby to introduce great flexibility in this new form of dry copy process.

It will be understood that changes may be made in the details of construction, arrangement and operation, without departing from the spirit of the invention, especially as defined in the following claims.

We claim:

1. In an electrostatic copy process, the method of producing more than one copy from an imaged electret comprising the steps of:

(a) positioning the electret layer between electrodes and passing a D-C potential between the electrodes, simultaneously exposing the electret layer to radiations over its entire surface internally to polarize the electret layer, exposing the polarized electret layer to a light pattern in the absence of the electrical field to eliminate the internal polarization from the exposed areas, developing the latent electrostatic image in the electret with a toner;

(b) positioning a copy sheet in surface contact with the toned side of the electret;

(c) positioning the copy sheet and electret between electrodes;

(d) passing a potential between the electrodes whereby toner transfers from the imaged electret to the adjacent surface of the copy sheet to form an image thereon without destroying the latent electrostatic image in the electret;

(e) separating the copy sheet and the electret from between the electrodes;

(f) separating the copy sheet from the electret; and

(g) setting the toned image on the copy sheet.

2. The copy process as claimed in claim **1** in which the potential passed between the electrodes is greater than the potential used for imaging the electret.

3. The copy process as claimed in claim **1** in which the potential passed between the electrodes is more than 50 volts but less than 5 kv.

4. The copy process as claimed in claim **1** in which the copy paper and electrode adjacent to the copy paper are removed together from the surface of the electret.

5. The copy process as claimed in claim **1** which includes the step of redeveloping the latent electrostatic

image in the electret subsequent to separation from the copy sheet to retone the latent electrostatic image and repeating steps (b) to (g).

6. In an electrostatic copy process, the method of producing more than one copy from an imaged electret in the form of a phosphor layer comprising the steps of:

(a) positioning the electret between electrodes and passing a D-C potential between the electrodes, simultaneously exposing the electret layer to radiations in the form of a light pattern to effect internal polarization in the exposed portions, developing the latent polarized image in the electret with the toner;

(b) positioning a copy sheet in surface contact with the toned side of the electret;

(c) positioning the copy sheet and electret between electrodes;

(d) passing a potential between the electrodes whereby toner transfers from the imaged electret to the adjacent surfaces of the copy sheet to form an image thereon without destroying the latent electrostatic image in the electret;

(e) separating the copy sheet and the electret from between the electrodes;

(f) separating the copy sheet from the electret; and

(g) setting the toned image on the copy sheet.

7. The copy process as claimed in claim **6** in which the potential passed between the electrodes is greater than the potential used for imaging the electret.

8. The copy process as claimed in claim **6** in which the potential passed between the electrodes is more than 50 volts but less than 5 kv.

9. The copy process as claimed in claim **6** in which the copy paper and electrode adjacent to the copy paper are removed together from the surface of the electret.

10. The copy process as claimed in claim **6** which includes the step of redeveloping the latent electrostatic image in the electret subsequent to separation from the copy sheet to retone the latent electrostatic image and repeating steps (b) to (g).

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