United States Patent [19]

Inoue et al.

[11] **3,761,951**

[45] **Sept. 25, 1973**

[54] **ELECTROSTATIC IMAGE FORMING APPARATUS**

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[73] Assignee: **Canon Kabushiki Kaisha,** Toyko, Japan

[22] Filed: **Dec. 16, 1971**

[21] Appl. No.: **208,785**

Related U.S. Application Data

[62] Division of Ser. No. 800,962, Feb. 20, 1969, Pat. No. 3,653,064.

[30] **Foreign Application Priority Data**

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Feb. 27, 1968 Japan 43/12739
Feb. 27, 1968 Japan 43/12740

[52] **U.S. Cl.** ..... **346/74 ES,** 96/1 PC, 346/74 EB, 346/74 P, 355/16

[51] **Int. Cl.** ... **G03g 5/02,** G03g 13/00, G03g 15/00

[58] **Field of Search** ..... 346/74 ES, 74 EB, 346/74 P; 355/16; 96/1 PC

[56] **References Cited**

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Primary Examiner—Terrell W. Fears
Assistant Examiner—Stuart Hecker
Attorney—Elmer R. Helferich et al.

[57] **ABSTRACT**

Image-forming apparatus includes an electron beam generator responsive to image-defining excitation signals to apply a pattern of electron beams to a plate. The plate thereupon emits radiation in pattern according with the electron beam pattern.

9 Claims, 37 Drawing Figures

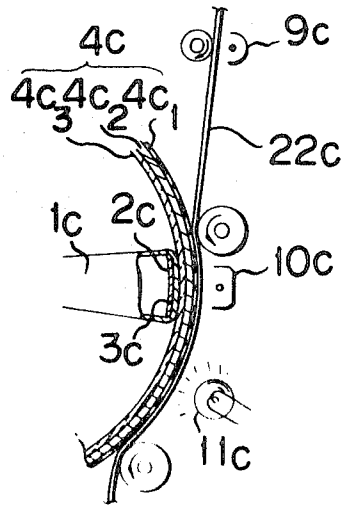


FIG. 1

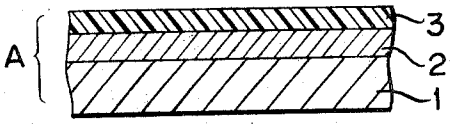


FIG. 1a

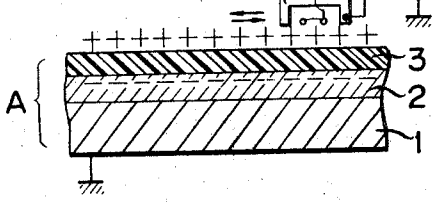


FIG. 3a

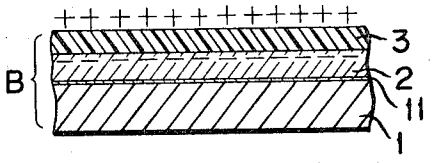


FIG. 1b

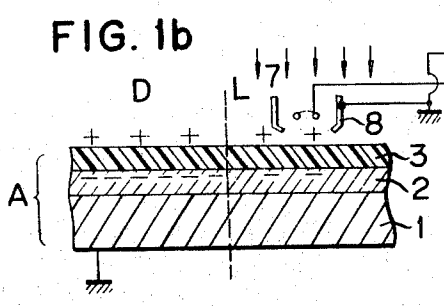


FIG. 3b

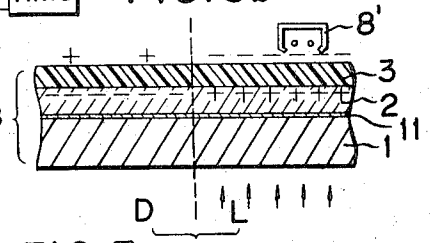


FIG. 1c

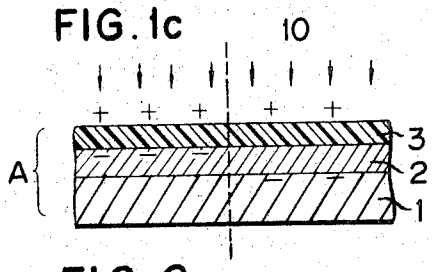


FIG. 3c

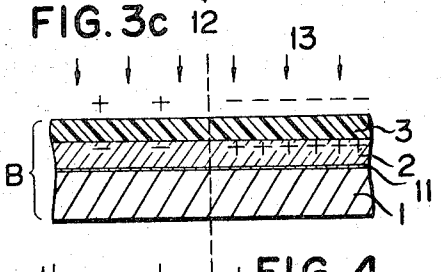


FIG. 2

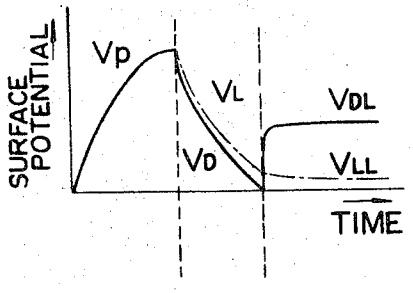


FIG. 4

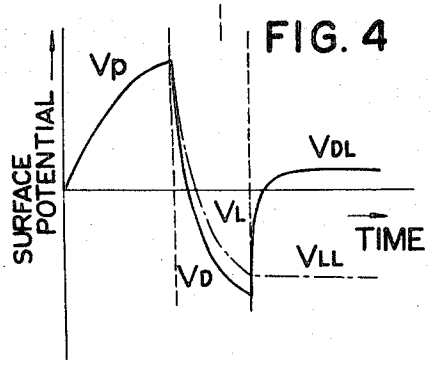


FIG. 5a

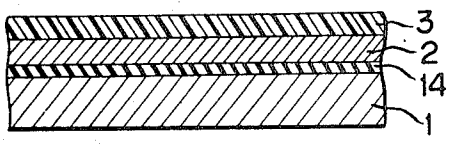


FIG. 5b

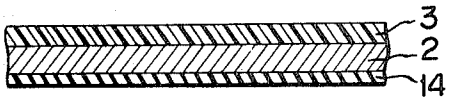


FIG. 5c



FIG. 5d

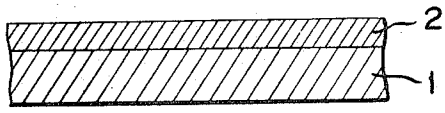


FIG. 5e

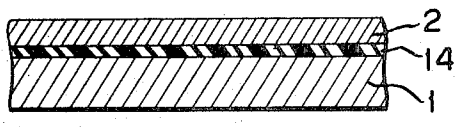


FIG. 5f



FIG. 6a



FIG. 6b

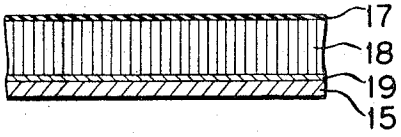


FIG. 6c

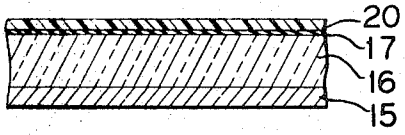


FIG. 6d

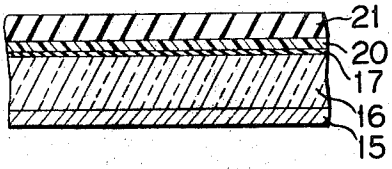


FIG. 6f

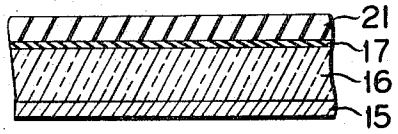


FIG. 6e

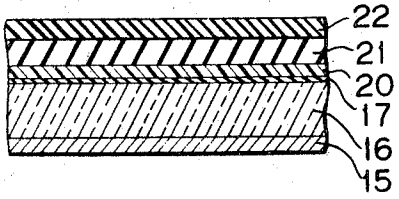


FIG. 6g

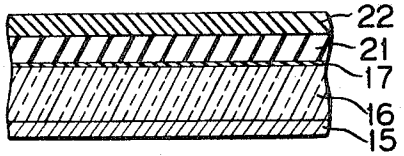


FIG. 7

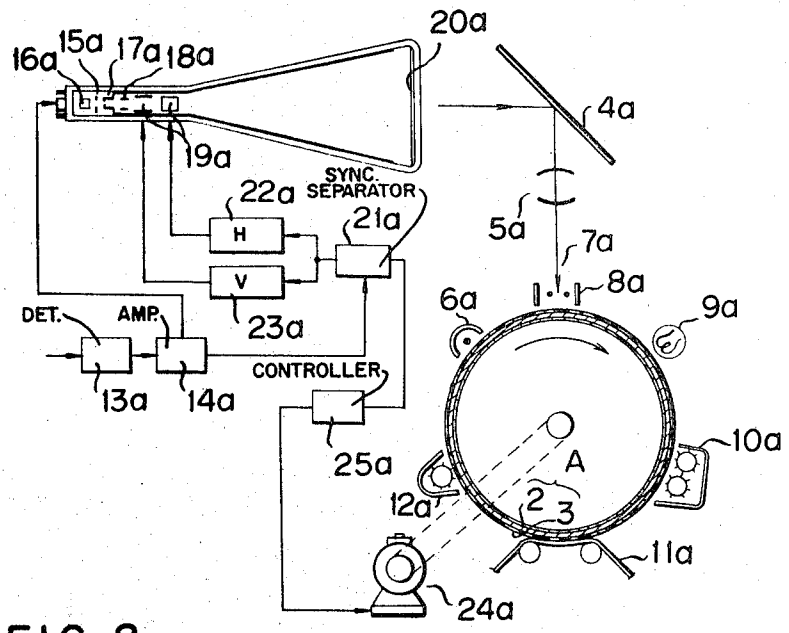

16a
15a
17a
18a
19a
20a
4a
22a
SYNC. SEPARATOR
21a
H
V
23a
5a
7a
8a
6a
9a
DET.
AMP.
13a
14a
CONTROLLER
25a
10a
A
12a
2
3
11a
24a

FIG. 8

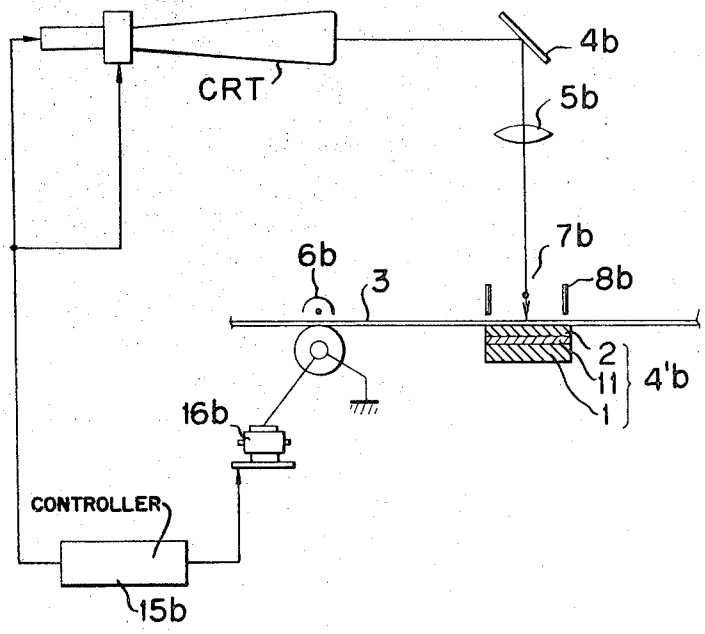

CRT
4b
5b
7b
6b
3
8b
2
11
1
4'b
16b
CONTROLLER
15b

FIG. 9

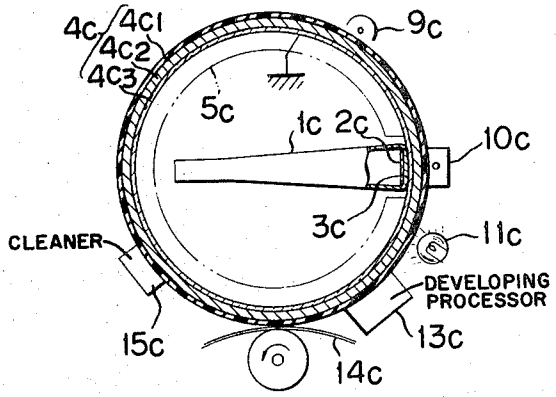

4c
4c1
4c2
4c3
9c
5c
1c
2c
10c
3c
11c
CLEANER
DEVELOPING PROCESSOR
15c
13c
14c

FIG. 10

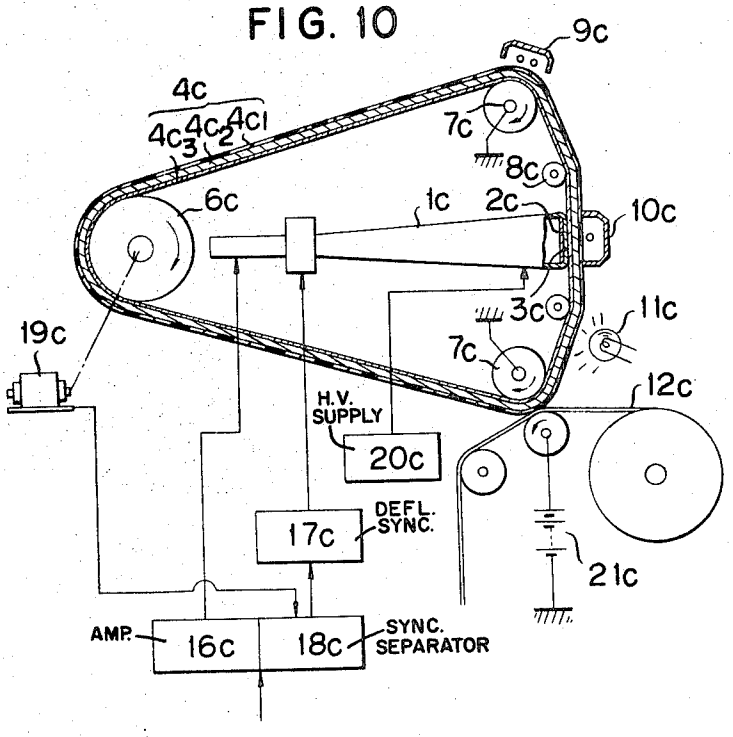

9c
4c
4c3
4c2
4c1
7c
8c
6c
1c
2c
10c
3c
11c
19c
7c
12c
H.V. SUPPLY
20c
17c
DEFL. SYNC.
21c
AMP.
16c
18c
SYNC. SEPARATOR

FIG. 11

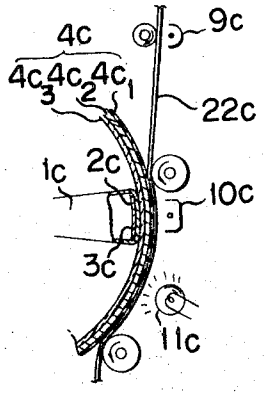


FIG. 12

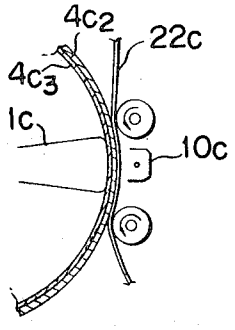


FIG. 13

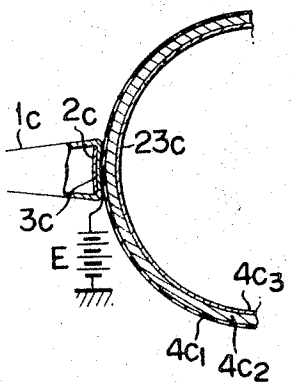


FIG. 14

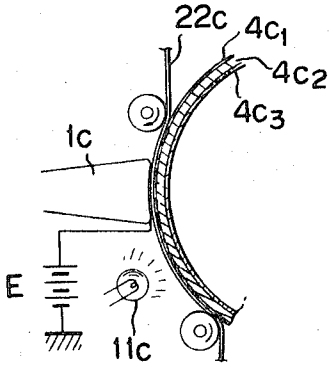


FIG. 15

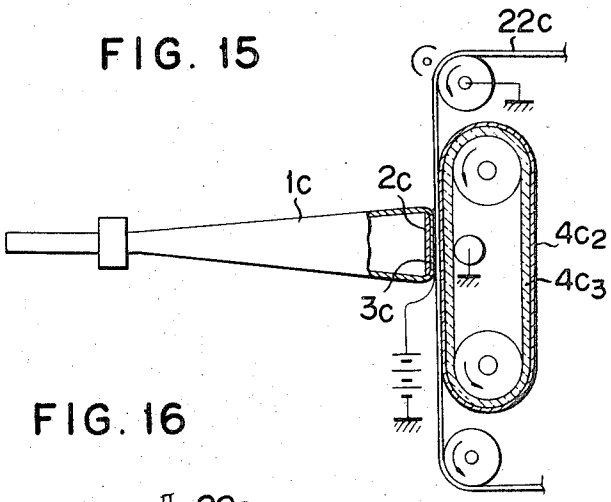


FIG. 16

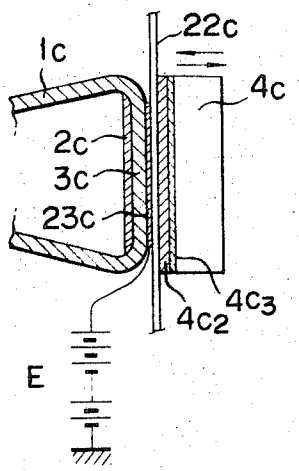


FIG. 17

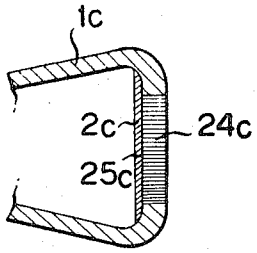


FIG. 18

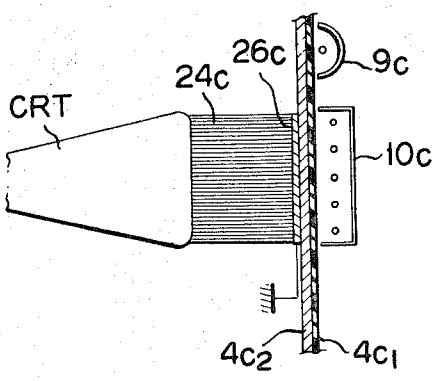


FIG. 19

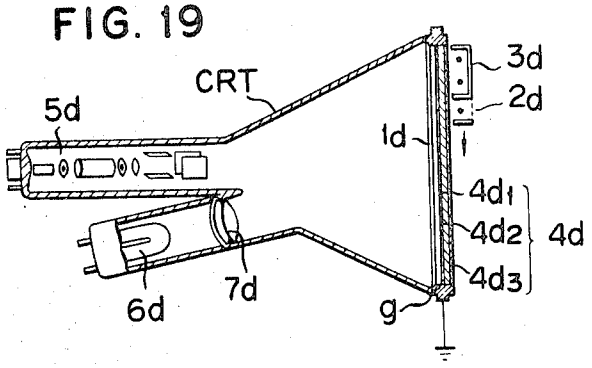


FIG. 20

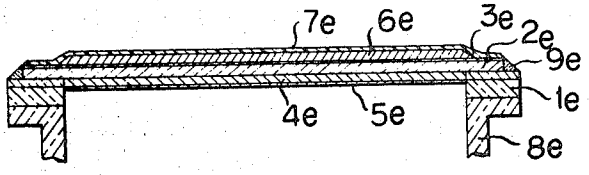
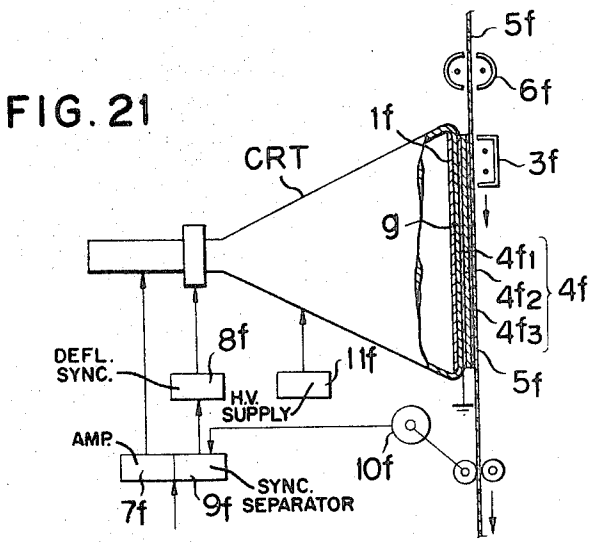


FIG. 21



ELECTROSTATIC IMAGE FORMING APPARATUS

This is a division of application Ser. No. 800,962, filed on Feb. 20, 1969, now U.S. Pat. No. 3,653,064.

The present invention relates to electrostatic recording methods, and to recording tubes with multilayer face plates responsive to information signals for use in electrostatic image-forming processes.

One known method for electrostatically recording information signals is disclosed in U.S. Pat. No. 2,879,422, issued to H. C. Borden et al. This method employs a cathode ray tube having a face plate comprising an insulative layer in which conductive pins electrically isolated from one another are embedded in a matrix. Information signals are converted into electron beams by the cathode ray tube and the electron beams are passed through these pin-shaped conductors so as to cause atmospheric discharge in a recording material, thereby recording electrostatic patterns in accordance with the information signals. In this method, the resolution of said patterns is significantly influenced by the density of the conductive pins in the matrix. However, from the standpoint of function and structure, it is extremely difficult to arrange and dispose conductor pins in a high density matrix in the face plate. Furthermore according to this method, the electrostatic pattern formation is affected by atmospheric discharge, so that as such discharge tends to become unstable under environmental conditions, the images are distorted. Thus, it is difficult to form high contrast electrostatic patterns.

Another method is disclosed in U.S. Pat. No. 3,132,206 issued to P. F. King. According to this method, the information signals are converted into images by the cathode ray tube and are displayed on the phosphor screen thereof. Such displayed images are used as light images for the electrophotographic image-forming in accordance with the Carlson process, i.e., by projecting the light images upon a xerographic plate, thereby forming electrostatic patterns on the photoconductive layer of the plate. In this process, in order to retain charge on the photoconductive layer, the photoconductor material must have a relatively high resistance and use of the relatively low resistance, highly sensitive photoconductor material is impractical. Therefore, in this process, formation of high contrast and highly sensitive electrostatic patterns is not expected. Furthermore, in this process the signals are first converted into an image displayed on the screen which in turn is projected upon a photosensitized plate so as to electrostatically record the signals. Therefore, the efficiency and the speed of this process are rather inferior in practice.

The present invention contemplates recording processes by which such defects encountered in conventional methods or processes are completely eliminated.

In brief, according to the present invention, in formation signals are first converted into electron beam signals, thereby representing the signals as radiation images, more specifically images displayed by a luminous body. These images are converted further into electrostatic images upon a photosensitive member composed fundamentally of an electric charge-retaining insulative layer, a photoconductive layer and a substrate; and these electrostatic images are transferred directly to a photosensitive material or to other recording materials. The fundamental process for forming electrostatic images herein is based upon the inventions disclosed in U.S. applications Ser. Nos. 563,899/1966, now abandoned and 571,538/1966 now abandoned. The fundamental process herein includes the use of a photoconductor member in which a photoconductive layer and charge-retaining insulative layer are overlaid in order upon a conductive or insulating substrate or lamination thereof and the process herein is characterized by the first step of applying to said insulative layer a first voltage (DC voltage) so as to mainain said insulative layer at a predetermined potential level, thereby generating a strongly bound charge layer at the interface between the photoconductive and insulative layers, or the portion adjacent thereto, by utilizing the electrical field provided by said potential, by the second step of applying a second voltage having a polarity opposite to that of said first voltage, or AC voltage, to said insulative layer and simultaneously projecting light images so as to vary the state of the charge due to the first voltage application by said second voltage, and by the third step of applying uniform radiation to which said photoconductive layer is sensitive, thereby forming an electrostatic image upon said insulative layer. While the present invention is based upon such fundamental process, the invention includes other improved processes providing the same results, advantages and features as said fundamental process.

Briefly, according to the present invention, the process includes the first step of applying a first voltage to a photoconductive member composed fundamentally of a substrate, a photoconductive layer and a charge-retaining insulative layer, the second step of applying a second voltage thereto and simultaneously projecting thereupon a radiation image corresponding to the electron beam signals of a cathode ray tube or projecting said radiation image onto a photosensitive body disposed in contact with said photoconductive member, and the third step of applying uniform radiation thereto.

Alternatively, another process of the present invention includes the first step of applying a first voltage to the face plate of a cathode ray tube incorporating the above-described photoconductive member, the second step of applying a second voltage to this face plate and simultaneously projecting thereupon a radiation image corresponding to the electron beam signals, and the third step of uniformly illuminating the face plate with radiation interiorly or exteriorly of the cathode ray tube, thereby forming an electrostatic image directly upon the face plate, or transferring said electrostatic image to copying material. A further alternative process of the present invention includes the first step of applying a first voltage to the face plate of a cathode ray tube incorporating said photoconductive member in contact with the charge-retaining member or applying said first voltage either to said face plate or member before they are placed in close contact, the second step of applying a second voltage to said face plate in contact with said member and simultaneously projecting a radiation image corresponding to the electron beams thereon, and the third step of applying uniform radiation to the face plate from the interior or exterior of the cathode ray tube, thereby forming an electrostatic image upon said charge-retaining member.

These processes of the present invention are characterized by the fact that the first voltage is applied directly or indirectly to the charge-retaining recording

member so as to maintain said recording member at a predetermined potential and when the second voltage is applied to the recording member with simultaneous application of the radiation image corresponding to the electron beams thereto, the substrate, the photoconductive layer and the charge-retaining insulative layer, with or without the charge-retaining recording member, are maintained in the form of a lamination.

According to the process of the present invention, high contrast electrostatic patterns can be obtained. For example, in the case of the Carlson process disclosed in U.S. Pat. No. 3,041,167 when the insulative layer has a thickness substantially equal to or slightly greater than the photoconductive layer, electrostatic contrast as high as 1,000 to 1,500 V can be attained. According to the processes of the present invention, electrostatic charges are maintained in the charge-retaining insulative layer of the photoconductive member and it is not necessary to maintain these charges in the photoconductive layer so that a highly sensitive photoconductive material having a relatively low resistance may be used, thereby providing a highly sensitive photoconductive member.

According to the present invention, images displayed on the phosphor screen by the electron beams of a cathode ray tube are projected on a photoconductive member of the type described above either in contact with or remote from the cathode ray tube or on a photoconductive member or a recording member placed over a multilayer face plate of a cathode ray tube, thereby forming an electrostatic image in the charge-retaining member. Therefore, light image loss is less, and generation of electron beams and radiation and the formation of electrostatic images can be effected with high efficiency.

As described above, in the processes of the present invention, the electrostatic images are formed in the charge-retaining insulative layer of the photoconductive member so that application of the first voltage and processing following formation of the electrostatic image can be effected even in ambient light.

Furthermore, when said insulative layer is made of a material which is non-transmissive to radiation applied with the second voltage and to which the photoconductive layer is sensitive, the entire process can be carried out in ambient light.

The electrostatic charge images formed by the processes of the present invention can be rendered permanently visible by applying toner to color the image, by the frost method or by any suitable method for recording. Alternatively, the electrostatic image can be transferred to a copying or recording material.

One of the objects of the present invention is to provide a novel electrostatic recording process.

Another object of the present invention is to provide a cathode ray tube incorporating a multilayer face plate adapted to convert electron beam signals into radiation images or patterns.

A further object of the present invention is to provide an improved recording tube adapted to provide electrostatic patterns upon the face plate thereof.

Another object of the present invention is to provide an improved recording tube having means for uniformly illuminating the face plate thereof with radiation.

A still further object of the present invention is to provide recording processes for recording electrostatic patterns by conversion of electron beam signals controlled by information signals.

A further object of the present invention is to provide a recording process comprising the step of applying voltage to a face plate incorporating a photoconductive layer and simultaneously applying electron beams thereto, thereby efficiency recording the electron beam signals as electrostatic patterns upon a charge-retaining member.

A still further object of the present invention is to provide a recording process for forming high contrast electrostatic images upon a photoconductive member having a charge-retaining insulative layer.

A still further object of the present invention is to provide an electrostatic recording process which permits the use of highly sensitive photoconductive materials.

Another object of the present invention is to provide a recording process for forming high contrast electrostatic images even in ambient light.

Another object of the present invention is to provide an improved process for permanently recording electrostatic images corresponding to electron beam signals.

The above and other objects, advantages and features of the present invention will become more apparent from the following description taken in conjunction with the accompanying drawings.

FIG. **1** illustrates the structure of a photoconductive member used in the present invention.

FIGS. **1***a* – **1***c* illustrate a process for forming electrostatic images using the photoconductive member shown in FIG. **1**.

FIG. **2** is a diagram of surface potential attained in the process of FIGS. **1***a* – **1***c*.

FIG. **3***a* illustrates another photosensitive member structure according to the present invention and FIGS. **3***a* – **3***c* illustrate a process for forming an electrostatic image using the photoconductive member shown in FIG. **3***a*.

FIG. **4** is a diagram of surface potential attained in the process of FIGS. **3***a* – **3***c*.

FIGS. **5***a* – **5***f* illustrate structures of photoconductive members for use in processes of the present invention.

FIGS. **6***a* – **6***g* illustrate structures of face plates for cathode ray tubes according to the present invention.

FIGS. **7** – **16, 18, 19** and **21** illustrate further processes of the present invention.

FIGS. **17** and **20** illustrate other embodiments of face plates for cathode ray tubes according to the present invention.

Referring now particularly to FIG. **1**, which illustrates the fundamental structure of a photoconductive member used in the process of the present invention for converting radiation into an electrostatic image, photoconductive layer **2** is formed upon substrate **1** by a coater, wheeler, etc. or by sputtering, vacuum deposition, etc. and, if required, a small quantity of a binder such as resin or the like may be added to the material forming photoconductive layer **2**. Insulative layer **3** is formed upon photoconductive layer **2**. The photoconductive member must have essentially these three layers, i.e., substrate **1**, photoconductive layer **2** and insulative layer **3** for electrostatic image-forming.

Substrate **1** may be made of an insulative or electrically conductive material or a lamination composed of photoconductive and insulative layers. Such conduc-

tive materials include metal conductors such as aluminum, copper and the like, humid paper, Nesa coating, glass and so on. Suitable insulative materials are selected from the same materials used for insulative layer 3 which will be described in more detail hereinafter, but are limited thereto and may be selected from a wide range of insulative materials known in the art.

Materials for photoconductive layer 2 include cadmium sulfide, cadmium selenide, crystal and amorphous selenium, zinc oxide, zinc sulfide, titanium dioxide, selenium telluride, lead oxide, sulfur and other chalcogenide compounds, inorganic photoconductors and organic photoconductors such as anthracenes, carbazoles and so on. The material may be coated upon the substrate, or a mixture of the above materials with or without a binding agent may be used or they may be formed into laminations consisting of more than two layers. Among the above-described photoconductive materials, the materials best suited for use in the present invention are CdS, CdSe, SeTe, and so on, and with use thereof sensitivity can be elevated to higher than ASA 100. The present invention can employ photoconductive materials having relatively low resistance values, which materials have not been used in conventional processes in which electric charges must be maintained in the photoconductive layer. Such materials can be used in the present invention since charge maintaining capability is imparted to the photoconductive layer by the insulative layer superposed thereupon.

The characteristics required for insulative materials are (a) sufficiently high resistivity to retain electrostatic charge and (b) resistance to abrasion, and any material satisfying these conditions may be used as the insulative layer in the present invention. When the radiation image is applied to photoconductive layer 2 through the insulative layer, the insulative material must be transparent to activating radiation. On the other hand, when the substrate is made of a material, for example, Nesa glass or the like which permits the transmission of the activating radiation therethrough and when the radiation image is applied to the photoconductive layer through this substrate, the insulative layer need not be transparent. For example, a film or coating of fluorine resin, polycarbonate resin, polyethylene resin, cellulose acetate resin, polyester resin and so on may be used. Furthermore, glass made of Al_2O_3, SiO_2, etc., ceramic, inorganic compound thin layers and so on, which are or are not transparent, may be used.

The processes for forming electrostatic images upon insulative layer 3 of the photoconductive member will now be described. First a process will be described wherein substrate 1 is made of conductive material and wherein application of a second voltage by AC corona discharge is performed simultaneously with emission of radiation. As shown in FIG. 1*a*, the surface of insulative layer 3 of photoconductive plate A is electrically charged, for example in positive polarity, by corona device 5 connected to high voltage DC source 4. In this case, it is presumed that negative charges are injected from the conductive substrate side and are bound at the interface between photoconductive layer 2 and insulative layer 3 or within photoconductive layer 2 adjacent to insulative layer 3. In this process, the surface potential of insulative layer 3 increases as charging time elapses as illustrated in FIG. 2 by curve V_P. It is of course possible to effect the above-described charging by using an electrode instead of corona discharge. It should be noted that this charging step can be performed in ambient light.

When photoconductive layer 2 has n-type semiconductivity the insulative layer is preferably charged positively. When photoconductive layer 2 has p-type semiconductivity, the insulative layer is preferably charged negatively.

Then as shown in FIG. 1*b*, a radiation image (a light image will be used herein for the sake of convenience of description) is projected upon insulative layer 3 while simultaneously AC corona discharge is applied thereto from charging device 8 connected to high voltage AC source 9. When the light image is projected through insulative layer 3 as shown in FIG. 1*b*, the upper end of charging device 8 must be optically open. After projection of the light image and charging by AC corona discharge, the positive charges provided by the first charging are all or almost all discharged by the AC corona discharge where these positive charges are located at portions of the surface of insulative layer 3 which were illuminated by the light image. Such discharge is dependent upon AC corona discharge time and intensity. In this case, the resistance of photoconductive layer 2 is reduced where illuminated by the light image so that layer 2 becomes conductive. Consequently, the negative charges bound at the interface between photoconductive layer 2 and insulative layer 3 or within photoconductive layer 2 adjacent to insulative layer 3 become free and are discharged as the surface charges upon insulative layer 3 are discharged. Almost all of these negative charges are discharged into conductive substrate 1. Therefore, the surface potential of the image-illuminated portions of insulative layer 3 is reduced as AC corona discharge time elapses as shown in FIG. 2 by curve V_L.

The positive charges at portions of insulative layer not illuminated by the light image are also discharged by the AC corona discharge, but such discharge is less than that described above for charges at illuminated portions. The negative charges bound in image-unilluminated portions of the photoconductive member are not discharged by AC corona discharge because of the high resistance of such image-unilluminated portions of photoconductive layer 2. Therefore, the positive charges in the corresponding portions of insulative layer 3 are maintained or remain almost unchanged. In image-unilluminated portions of insulative layer 3 many more positive charges are retained than in image-illuminated portions thereof. However, a large number of negative charges still remain bound in photoconductive layer 2, so that the electrical field due to the surface potential of insulative layer 3 is influenced rather strongly by the negative charges bound in photoconductive layer 2, whereby the external field due to the surface potential is extremely slight or negligible. The surface potential in the image-unilluminated portions is less than the surface potential in the image-illuminated portions as illustrated in FIG. 2 by a curve V_D.

Thus, surface potential differences ($V_L - V_D$) are provided upon the surface of insulative layer 3 in accordance with the light image pattern, thereby forming an electrostatic image of the light image. These surface potential differences ($V_L - V_D$) vary as shown in FIG. 2 when the light image is projected while simultaneously applying AC corona discharge, so that the

image projection and AC corona discharge time must be selected suitably depending upon the sensitivity of the photoconductive plate, AC discharge conditions and so on in order to obtain large surface potential differences.

Thereafter, the surface of insulative layer 3 upon which such electrostatic image has been formed is exposed to radiation 10 as shown in FIG. 1*c*. In this case, the image-illuminated portions of photoconductive layer 2 remain substantially unchanged, so that the positive charges upon the surface of insulative layer 3 also remain substantially unchanged, thereby maintaining the surface potential as shown in FIG. 2 by the curve V_{LL}. On the other hand, the image-unilluminated portions of photoconductor layer 2 which have maintained high resistance since they have not been exposed are now exposed to activating radiation in this step and the resistance thereof is rapidly reduced and they become conductive. Consequently, the negative charges bound therein are almost all discharged into electrically conductive substrate 1 and only a very small portion of the charges are bound by the field of the positive charges upon the surface of insulative layer 3. Thus, positive surface charges, that is, charges having the same polarity as the first or initial charges provided upon the surface of insulative layer 3, which charges provide a field acting strongly upon negative charges bound in photoconductive layer 2 in the previous step, now act to provide an external field. The surface potential of insulative layer 3 is thereby rapidly increased upon exposure of the whole surface of the insulative layer 3 to activating radiation as illustrated in FIG. 2 by curve V_{DL}. As described above, when the whole surface of insulative layer 3 is exposed to activating radiation, the surface potentials V_L and V_D become V_{LL} and V_{DL} respectively, so that the surface potential of the image-unilluminated portions becomes higher than that of the image-illuminated portions. That is, the respective surface potentials are reversed, and the difference therebetween increases.

According to one process of the present invention, the surface of the insulative layer is charged in maintaining equilibrium with charges induced in the photoconductive layer underlying the insulative layer, and a surface differential is provided upon the surface of the insulative layer by interaction of the charges upon the insulative layer and those in the photoconductive layer, thereby forming an electrostatic image in accordance with the light-dark pattern of the original image. Therefore, as compared with conventional electrophotographic methods in which electrostatic images are formed upon the surface of the photoconductive layer, the electrostatic image formed by the present invention has a stronger external field and a large surface potential, thus increasing sensitivity.

In the present invention, a fluorescent image formed upon the face plate of a cathode ray tube is used as the radiation image and use of the process of the present invention is very advantageous in forming electrostatic patterns from such low intensity fluorescent images, in providing rapid development and in providing high sensitivity.

In FIG. 3, another embodiment of the present invention is shown wherein the voltage application which is performed simultaneously with the projection of the light image is provided by DC corona discharge having the same polarity with that of the first charging. Substrate 1 of photoconductive plate B is made of a radiation transmissive material such as Nesa glass or the like having a Nesa coating 11 thereon and the light image is projected upon the photoconductive layer thereof through the substrate. Such process is substantially similar to the process described above with reference to FIG. 1.

The first step is, as in the case of FIG. 1*a*, to positively charge the surface of insulative layer 3 (FIG. 3*a*). In the second step, as shown in FIG. 3*b*, light image 12 is projected through substrate 12 while discharging device 8' supplied with a high negative potential is simultaneously moved across the surface of insulative layer 3. When insulative layer 3 is made of a material which is transmissive to the light image, the upper end of the shield plate of discharging device 8 is optically closed so as to prevent radiation, except that from the substrate side, from impinging upon the surface of insulative layer 3. On the other hand, when the insulative layer 3. On the other hand, when the insulative material is non-transmissive to the light image, the provision is not necessary and furthermore this process may be carried out in ambient light.

Portion L of photoconductive layer 2 is illuminated by the light image in the second step and reduces its resistance to the charges bound therein in the first charging step. Furthermore, the positive charges upon the corresponding image-illuminated portion of the surface of insulative layer 3 are discharged by the negative corona discharge applied thereto simultaneously with the projection of the light image and such portion is then negatively charged. Concurrently, positive charges are induced at the interface between the insulative and photoconductive layers or within the photoconductive layer adjacent thereto.

On the other hand, in image-unilluminated portion D, the positive charges applied to the surface of insulative layer 3 by the first charging step are partially or completely neutralized by the negative charges applied thereto in the second step. In this case, the degree to which such portion of the insulative layer surface is negatively charged is less than in the case of portion L as described above. This means that the external field due to the persistently bound carriers has a strong influence.

Next, the whole surface of insulative layer 3 upon which an electrostatic charge pattern was formed in the second step is exposed to activating radiation 13. In this case, in portion L the condition of photosensitive plate A remains substantially unchanged so that the surface potential of insulative layer 3 remains substantially unchanged. On the other hand, at portion D which has a high resistance, the resistance is rapidly reduced as this portion is exposed to activating radiation in this third step and portion D becomes electrically conductive. Therefore, the charges bound internally in the previous step are discharged into the electrically conductive substrate. Concurrently, positive charges are induced in photoconductive layer 2 by the negative charges upon the surface of insulative layer 3. Consequently, the surface potential of the surface of insulative layer 3 is rapidly reduced so that the field due to the negative charges on insulative layer 3 acts strongly upon the positive charges induced in photoconductive layer 2 while the external field due to the surface charges becomes negligible.

On the other hand, when the external field due to the internally bound charges is very strong, the charges imparted in the first step may not be completely neutralized even after the second step. In this case, the external fields are superposed and provide a net field of zero, and since the bound charge field is released upon illumination of activating radiation over the whole surface of the insulative layer, the electrostatic contrast of positive and negative charge combination is obtained with resultant high contrast. The surface potentials of the electrostatic pattern formed upon photoconductive plate B after the third step are shown in FIG. 4, the reference characters of which have the same meaning as in FIG. 2.

So far the process of the present invention has been described with particular reference to FIGS. 1 through 3 with use of the above-discussed fundamental photoconductive plates. The photoconductive plates whose structures are shown in FIG. 5 may be used in applications of processes of the present invention based upon the same concepts discussed heretofore.

The photoconductive plate shown in FIG. 5*a* is similar to that shown in FIG. 1 with the exception that between photoconductive layer 2 and electrically conductive substrate 1 is interposed insulative layer 14. In other words, the substrate is composed of electrically conductive layer 1 and insulative layer 14 laminated thereupon. Insulative layer 14 serves as a blocking layer upon charging to block injection of charges from the electrode. During the electrostatic image-forming process, charges active in photoconductive layer 2 of the photoconductive plate shown in FIG. 5*a* are free carriers existing in photoconductive layer 2 and photocarriers induced upon illumination thereof by radiation. Therefore, when the first charging step is conducted with accompanying uniform illuminating radiation, sufficient binding of charges is provided adjacent both of photoconductive layer 2 and insulative layer 3.

The photoconductive plate shown in FIG. 5*b* is similar to that shown in FIG. 5*a* with the exception that the electrically conductive substrate 1 is removed therefrom so that insulative layer 14 constitutes the only substrate of this photoconductive plate. When this photoconductive plate is used, chargings and illuminating radiation are carried out in conjunction with an additional electrode, which will be described in more detailed hereinafter. The photoconductive plate shown in FIG. 5*c* is similar to that shown in FIG. 1 with the exception that substrate 1 is removed therefrom. This plate may be used in a similar process as in the case of the plate shown in FIG. 5*b*. The photoconductive plate shown in FIG. 5*d* is similar to that shown in FIG. 1 with the exception that insulative layer 3 is removed therefrom. This plate may be used in a process wherein, after the first charging of the photoconductive plate, an insulative layer (not shown) is overlaid thereupon or an insulative film (not shown), which has been previously charged, is overlaid thereupon. The photoconductive plate shown in FIG. 5*e* is also similar to that shown in FIG. 5*a* with the exception that insulative layer 3 is removed therefrom. This plate may be used in the same manner as in the case of the photoconductive plate shown in FIG. 5*d*. The photoconductive plate shown in FIG. 5*f* is similar to that shown in FIG. 5*e* with the exception that substrate 1 is removed therefrom. This plate may be used in a process wherein the first charging step is carried out as in the case of the photoconductive plate shown in FIG. 5*d* and then the second step is carried out as in the case of the photoconductive plate shown in FIG. 5*b*.

A special face plate for a cathode ray tube will now be described with reference to FIG. 6. The face plate, as shown in FIG. 6*a*, comprises at least phosphor layer 15 adapted to illuminate upon bombardment thereof by electron beams, vacuum envelope 16 transmissive to light and made of glass or the like, and light-transmissive thin layer electrode 17. This face plate may be suitably utilized in combination with one of the photoconductive plates shown in FIG. 5 in one of the processes which will be described in more detail hereinafter. In the face plate shown in FIG. 6*b* fiber optics are applied to the face plate of the cathode ray tube envelope instead of glass layer 16 of the face plate shown in FIG. 6*a*. This arrangement prevents diffraction within the glass of the image formed at phosphor screen or layer 15. As shown in FIG. 6*b*, thin conductive layer 19 may be interposed between phosphor screen or layer 15 and glass envelope 18 to constitute the anode of the cathode ray tube. Alternatively, a metal backing (not shown) formed from thin layer aluminum may be coated upon the inner surface of phosphor screen 15 if needs demand.

The above-described fiber optics, anode and metal backing will not be discussed specifically in the following description of the face plates shown in FIGS. 6*c* through 6*g*, but it should be understood that same may be incorporated in these face plates as needs demand.

In the face plate shown in FIG. 6*c* thin insulative layer 20 similar to layer 14 in FIG. 5*a* is disposed upon transparent electrode 17 of the face plate of FIG. 6*a*. In this case, this thin insulating layer must be transmissive to the radiation employed. This face plate cooperates with one of the photoconductive plates shown in FIG. 5*b*, FIG. 5*c* and FIG. 5*f* in the second step of the process.

In the face plate shown in FIG. 6*d* photoconductive layer 21 is disposed upon insulative layer 20 of the face plate shown in FIG. 6*c*. This plate may be used in forming electrostatic patterns upon a recording insulative film overlaid upon this face plate.

In the face plate shown in FIG. 6*e* insulative layer 22 is disposed upon the face plate shown in FIG. 6*d*. Such additional insulative layer 22 itself can serve as a medium for generating a phosphor or luminescent image and for converting this image into an electrostatic image as will be described in more detail hereinafter.

Face plates shown in FIG. 6*f* and FIG. 6*g* are respectively similar to those shown in FIG. 6*d* and FIG. 6*e* with the exception that blocking insulative layers 20 are removed therefrom.

The photoconductive materials and phosphors used in the above-described photoconductive plates and face plates will be described in more detail in examples hereinafter, but preferable combinations of these materials are set forth in Table I.

TABLE I

Phosphors	Photoconductive materials
$BaSO_4$:Pb	ZnO (without sensitizer) (+ binder)
ZnO:Zn	ZnO (chromatically sensitized) (+ binder)
(Zn,Cd)S:Ag (Zn:Cd=58:42)	CdS (+ binder)
$(Zn,Be)_2SiO_4$:Mn (Zn:Be=9:1)	CdSe (+ binder)

$CaWo_4$	SeTe
ZnS:Ag	(Te=15%)
(Zn,Cd)S:Cu	As_2S_3:As_2Se_3

All of the materials in Table I are sensitive to electron beams, ultraviolet rays, X-rays and to illumination.

So far the structures of the photoconductive plates employable in the present invention have been described with reference to FIGS. **1**, **3***a* and **5***a* through **5***f*. The structures of face plates adapted to be applied to the cathode ray tubes according to the present invention have been described with reference to FIGS. **6***a* through **6***g*. The results, advantages and features of the invention are accomplished by combination of such photoconductive plates and cathode ray tubes having such face plates.

As described hereinabove, it is imperative in the present invention that at least a substrate, a photoconductive layer and a charge-retaining insulative layer are maintained in the form of a lamination in the first charging step of charging and in the second charging step performed simultaneously with image irradiation by electron beams in the electrostatic image-forming process of the electrostatic recording process of the present invention. This imperative condition can be met by arrangements of the photoconductive plates or face plates having the foregoing structures or by combination of photoconductive plates having some of the required layers and face plates having the other layers, whereby arrangements or combinations are provided to which the above-described steps of the process of the present invention are applicable.

When the plates shown in FIGS. **1**, **3***a*, **5***a* and **6***b* which have all of the required fundamental layers are used in forming electrostatic patterns, in the second step of the process of the present invention, the radiation image is either projected upon the photoconductive plate as shown in FIG. **7** or the photoconductive plate is disposed in close contact with the face plate as shown in FIGS. **9** and **10** so as to directly receive the radiation image therefrom. In both cases, the second voltage is applied to the plate insulative layer simultaneously with emission of the electron beams and the electrostatic image is formed directly upon the photoconductive plate or upon a charge-retaining recording member interposed between the face plate and the photoconductive plate as shown in FIG. **11**.

When such recording member is used, the process includes the step of charging the recording member and then overlaying same upon the photoconductive plate or the step of charging the photoconductive plate and then overlaying the recording member thereupon.

It is to be understood that, in the processes or examples which will be described hereinafter, when the recording member is overlaid upon the photoconductive plate or upon the face plate of a cathode ray tube, either of said two steps is practiced.

The photoconductive plate shown in FIG. **5***c* is used in combination with one of the face plates shown in FIGS. **6***a*, **6***b* and **6***c* with the photoconductive layer being maintained in contact with the face plate as shown in FIG. **18**, thereby forming an electrostatic image upon insulative layer **3**.

The photoconductive plates shown in FIGS. **5***d*, **5***e* and **5***f* are used in combination with a conventional cathode ray tube and are maintained in contact therewith as shown in FIG. **12**. Alternatively, these photoconductive plates may be used in the manner as shown in FIG. **8** wherein the radiation image is projected thereupon. In both cases, the insulative layer is maintained in close contact with the photoconductive layer when the radiation image is projected thereupon and a second voltage is simultaneously applied thereto. These photoconductive plates may be also utilized in combination with one of the face plates shown in FIGS. **6***a*, **6***b* and **6***c*. In this case, a charge-retaining recording member is interposed between the photoconductive layer of the photoconductive plate and the face plate while the radiation image is projected and a second voltage is simultaneously applied thereto, thereby forming an electrostatic image upon the recording member.

The face plates shown in FIGS. **6***a* through **6***g* can be used with or without the above-described photoconductive plates to form an electrostatic image. Thus, the face plates shown in FIGS. **6***a*, **6***b* and **6***c* may be used in combination with the photoconductive plates shown in FIGS. **5***c*, **5***d*, **5***e* and **5***f* or in combination with the photoconductive plates shown in FIGS. **1**, **3***a*, **5***a* and **5***b* in such an arrangement shown in FIG. **13** or **14**. In this arrangement, a high voltage is applied to the face plate as the second voltage while simultaneously projecting the radiation image corresponding to the electron beam signals, thereby forming an electrostatic image upon the photoconductive plate, or a charge-retaining recording member is interposed between the face plate and the photoconductive plate.

The face plates shown in FIGS. **6***e* and **6***g* are adapted to form electrostatic images upon the face plates themselves. As shown in FIG. **19**, electrostatic images can be formed directly or, as shown in FIG. **12**, electrostatic images can be formed upon charge-retaining recording members overlaid upon the face plates.

The face plates shown in FIGS. **6***d* and **6***f* are used in such a manner that the charge-retaining insulative layer is overlaid upon each of these face plates when the secondary voltage is applied thereto while simultaneously projecting thereupon the radiation image corresponding to the electron beam signals, thereby forming the electrostatic image upon the insulative layer. In this case, the first charging may be applied either to the photoconductive layer of the face plate or to the charge-retaining insulative layer. Alternatively, the first and second voltages may be applied after the insulative layer has been overlaid on the face plate.

So far the processes for forming electrostatic images by use of the combinations of the photoconductive plates and face plates according to the present invention have been described. But it will be understood that the present invention is not limited thereto and that the present invention covers variations and modifications made in the following examples and in the processes defined in the appended claims without departing from the true spirit of the present invention.

One embodiment of a process for forming an electrostatic image corresponding to electron beam signals according to the present invention will now be described with reference to FIG. **7** which illustrates a process in which facsimile signals are converted into radiation images which in turn are recorded as electrostatic images. The image provided on a cathode ray tube is projected upon photoconductive plate A through an optical system including reflecting mirror **4***a*, lens **5***a*, etc.

The facsimile or input signals are detected by detector **13***a* and separated into video signals and synchro-

nizing signals. The former are amplified by amplifier 14*a* and applied to control grid 15*a* of a CRT for controlling the electron beams emitted by cathode 16*a*. The electron beams are accelerated by acceleration grid 17*a* and focused by focusing grid 18*a* so as to produce a small electron beam cross-sectional area. Then, by deflection electrodes 19*a*, the beams scan phosphor screen 20*a*. The synchronizing signals are separated by synchronizing separation circuit 21*a* into vertical and horizontal sync. signals which are in turn applied to deflection circuits 22*a* and 23*a* respectively and finally to the deflection coils. These synchronizing signals also control motor 24*a*, which rotates a drum carrying thereupon photoconductive plate A, through control circuit 25*a* so as to synchronize the rotation of the drum with the original transmission speed at the transmitting terminal.

First, photoconductive plate A is charged by charging device 6*a* and is then displaced to phosphor image exposure station 7*a* where DC or AC secondary charging, having opposite polarity relative to that of the first charging is applied to photoconductive plate A, whereby an electrostatic image is formed upon insulative layer 3. Thereafter, photoconductive plate A is completely exposed by a lamp 9*a*, thereby increasing the contrast of the electrostatic image, whereby an electrostatic image having a strong external field and large surface potential difference is formed.

Such electrostatic image may be electrostatically transferred to copying paper, or as shown in FIG. 7, the image may be developed by toner in processor 10*a* and then transferred to copying paper 11*a*. Thereafter, photoconductive plate A is cleaned by cleaner 12*a* for repetitive use.

In this embodiment, P 11 (ZnS activated by Ag) was used as the phosphor screen of the cathode ray tube. As the photoconductive plate A, amorphous SeTe (Te: 15 mol %) was vacuum deposited upon the drum to a thickness of about 40 μ and upon this SeTe layer was applied a polyester film 25 μ in thickness by using an adhesive of epoxy resin. The first charging was made by corona discharging device 6*a* supplied with a negative voltage of −8KV so to negatively charge the polyester film to about −2,000V. Next, simultaneously with the projection of the image, the second charging was made by discharging device 8*a* having an optically open upper end and being supplied with +7KV. Thereafter, by illumination lamp 9*a*, such as a tungsten lamp, the whole surface of photoconductive plate A was uniformly illuminated, whereby an electrostatic image having about +600V was obtained.

In the above embodiment, the photoconductive plate shown in FIG. 1 was used, but the photoconductive plate shown in FIG. 5*a* may also be used in this process. It will be understood that such plate interchangeability is also possible in the embodiments or examples which will be described hereinafter.

FIG. 8 illustrates one variation of the embodiment described hereinabove with reference to FIG. 7. In this variation, transparent insulative layer 3 of the photoconductive plate is separated therefrom and is subjected to previous first charging by device 6*a*. Thereafter the insulative layer is advanced so as to be placed in close contact with the photoconductive plate secured opposite charging means 7*b*. The electrostatic image can be formed in the manner described above and then insulative layer 3 is removed from the photoconductive plate for processing or transferring of the formed image.

Since the photoconductive plate is made of material having a quick response, the photoconductive plate 4'*b* may be used in stationary position. In this case, the scanning of the face plate by the information signals and the advance of the recording film 3 are controlled by synchronizing device 15*b* and motor 16*b*. Reference numerals 4*b*, 5*b* and 8*b* designate respectively a mirror, a lens and a charging device shield.

In FIGS. 9 and 10, another embodiment of the present invention is shown wherein a photoconductive plate of the type shown in FIG. 1 and 5*a* is placed in contact with a face plate of a cathode ray tube thereby forming an electrostatic image. Like reference numerals are used to designate like parts in FIGS. 9 and 10.

Cathode ray tube 1*c* has a face plate comprising phosphor screen 2*c* and glass plate 3*c*. Photoconductive plate 4*c* is composed of a lamination of insulative layer 4*c*1, made of a material having high resistivity and resistance to abrasion such as fluoroplastics, polycarbonate resin, polyethylene resin, polyester resin or the like, photoconductive layer 4*c*2 and transparent, conductive thin layer electrode 4*c*3 formed by vacuum deposition of a metal.

Photoconductive plate 4*c* is adapted to be placed in contact with the face plate of the CRT. For this purpose, photoconductive plate 4*c* is an endless belt advanced by annular frame 5*c* encircling the CRT as shown in FIG. 9 or by guide rollers 6*c*, 7*c* and 8*c* disposed about the cathode ray tube as shown in FIG. 10.

Insulative layer 4*c*1 of photoconductive plate 4*c* is first charged by charging device 9*c* and then the charged photoconductive plate is advanced toward the face plate of the CRT where phosphor screen 2*c* of CRT is illuminated in accordance with signal information converted into electron beams whereby photoconductive plate 4*c* is exposed. At the same time, the photoconductive plate is subjected to DC or AC corona discharge from discharging device 10*c* supplied with a voltage having a polarity opposite to that of the first charge, whereby an electrostatic image in accordance with the CRT presentation is recorded upon insulative layer 4*c*1. Thereafter, photoconductive plate 4*c* is further advanced and is illuminated completely by ambient light or by illumination lamp 11*c*, thereby imparting high contrast to the electrostatic image.

Thereafter, the electrostatic image is transferred to copying paper 12*c* (See FIG. 10) and developed and fixed according to well-known methods of electrophotography. Alternatively, as shown in FIG. 9, the electrostatic image thus formed upon photoconductive plate 4*c* can be developed by toner in processor 13*c* and then transferred to copying paper 14*c*. Thereafter, photoconductive plate 4*c* is cleaned by cleaner 15*c* for repetitive use.

In this embodiment, in order to synchronize the CRT presentation with the second charging and also with the stopping of photoconductive plate 4*c* during this second charging, both motor 19*c* which advances photoconductive plate 4*c* and discharging device 10*c* are controlled through sync. separation circuit 18*c* and the CRT is actuated by input information applied through signal amplifier 16*c* to deflection synchronizing circuit 17*c*. High voltage source 20*c* and transfer bias voltage source 21*c* provided for the CRT. When a photocon-

ductive material having a quick response is used, electrostatic images can be formed even if drum 6c or belt 4c are moved continuously. This effect was attained by the use of CdS.

In FIG. 11, insulative film 22c is overlaid upon photoconductive plate 4 when this plate is placed upon the face plate of CRT. Insulative film 22c may be made of the same material as insulative layer 4c1, such as Mylar (polyethylene terephthalate). Insulative film 22c is charged prior to being overlaid upon photoconductive plate 4c by charging device 9c. After formation of the electrostatic image, the insulative film is removed from photoconductive plate 4c. The use of insulative film 22c much facilitates processing following image-forming, such as development, fixing, etc.

In this case, discharge occurs between insulative layer 4c1 and insulative film 22c when the film is removed from plate 4c and means for preventing this discharge must be provided such as is shown in FIG. 12. Therein, insulative layer 4c1 of photoconductive plate 4c is removed therefrom and insulative film 22 is overlaid directly upon photoconductive layer 4c2. The whole surface of the insulative film is illuminated completely after being removed from photosensitive plate 4c so that the electrostatic image may have a strong external field and hence improved constrast. Therefore, illumination lamp 11c for illuminating the whole surface of photoconductive plate 4c is not necessary in this embodiment.

Face plates of the type shown in FIGS. 6a, 6b and 6c may be used in the manner shown in FIG. 13. That is, exterior of the glass plate of the face plate of the CRT is formed thin layer electrode 23c upon which is overlaid photoconductive plate 4c composed of insulative layer 4c1, photoconductive layer 4c2 and electrically conductive substrate 4c3. A voltage E is applied to electrode 23c for secondary charging simultaneously with the exposure. Alternative usages of insulative film 22c are shown in FIGS. 14 and 15.

In FIG. 16, photoconductive plate 4c is reciprocated upon the face plate of CRT while insulative film 22c which has been previously charged is advanced in only one direction.

When a separating agent such as silicon oil, Teflon (polytetrafluoroethylene) oil, or the like is applied between insulative film 22c, electrode 23c and insulative layer 4c1, their service lines can be lengthened. This application of a separating agent provided a remarkably better effect when the electrostatic image was transferred because the latent image was transferred through the separating agent in liquid form.

As shown in FIG. 17, when fiber optics 24c, each fiber of which has a diameter of from 10 to 25 μ, is used as the glass plate of the face plate of the CRT in order to reduce loss due to diffraction of light passing therethrough, resolution can be improved to about 20 lines/mm. For maintaining a high degree of vacuum in the envelope of the CRT, mica 25c or the like may be interposed between phosphor screen 2c and the fiber optics.

FIG. 18 shows a still further variation of the present invention. Fiber optics 24c, each fiber of which has a diameter of from 10 to 25 μ, is secured to the face plate of the CRT. At the end of optics 24c, thin layer electrode 26c is provided by vacuum deposition of metal or the like, and the photoconductive plate composed of a lamination of photoconductive layer 4c2 and insulative layer 4c1 are moved across the surface of electrode 26. Electrode 26c is grounded and insulative layer 4c1 is charged by charging device 9c. Upon exposure of the photoconductive plate to the phosphor image of the CRT, the photoconductive plate is charged with a polarity opposite to that of the first charging by means of second charging device 10c, thereby forming an electrostatic image upon insulative layer 4c1.

In this case, it is necessary to slide the insulative layer in close contact with electrode 26c so that it is preferable to use a material having a low coefficient of friction, such as polyester resin, fluoroplastics and so on, as the insulative layer.

Furthermore, as described above, where a separating agent such as silicon oil, Teflon oil or the like is applied between electrode 26c and photoconductive layer 4c2, their service lines can be lengthened. When the elctrostatic image is transferred, remarkably better results are obtained because the electrostatic image is transferred through such oil.

The use of a face plate of the type as shown in FIGS. 6e and 6g in combination with a cathode ray tube will now be described.

Referring particularly to FIG. 19, the CRT includes phosphor screen 1d adapted to be illuminated by bombardment of electron beams. Transparent electrode layer 4d1 is applied to the exterior of the CRT face plate, for example, by vacuum deposition of a metal. Photoconductive plate 4d composed of a lamination of photoconductive layer 4d2 and high resistance transparent insulative layer 4d3, made for example, of Mylar or the like, is overlaid upon electrode layer 4d1.

Insulative layer 4d3 of photoconductive plate 4d is charged by first discharging device 2d and, at the instant when photoconductive plate 4d is exposed to illumination from phosphor screen 1d in response to information signals, the photoconductive plate is discharged by DC secondary charging, or AC corona discharge, having a polarity opposite to that of the first charge provided by second charging device 3d, whereby an electrostatic image is formed upon insulative layer 4d3 of photoconductive plate 4d. Thereafter, the whole surface of the photoconductive plate is illuminated whereby contrast of the electrostatic image is further improved.

Then, the electrostatic image is toner-developed upon the surface of photoconductive plate 4d and transferred to a copying paper. The surface of the photoconductive plate is cleaned and the remaining charges are removed therefrom for repetitive use. Repetitive recordings of luminescent CRT images are thus effected.

In one method for illuminating the whole surface of the photoconductive plate insulative layer 4d3 is made of a material which is transparent to the radiation to which photoconductive layer 4d3 of the photoconductive plate is sensitive and such radiation is directly uniformly from outside of the face plate of CRT. In an alternative method, such radiation is directed uniformly upon the face plate from inside the cathode ray tube as shown in FIG. 19 by electron gun 5d which is adapted to emit such radiation or by ultraviolet ray generating means 6d and lens 7d. Alternatively, an electron gun to whose grid is applied a constant negative potential may be used for bombardment of the face plate with electron beams.

One example of the structure of a face plate of the type described in the above embodiment is shown in FIG. 20. Upon one side of chromium iron frame 1e was fixedly attached by molten glass 9e, glass layer 2e having a Nesa coating with Nesa film 3e being directed outwardly. Next a mixture, in which CdS powder was uniformly dispersed in epoxy resin with a weight ratio of 96 : 4, was applied to a thickness of about 30 μ use of a squeegee upon Nesa film 3e, thereby forming photoconductive layer 6e. Polyester film 7e about 25 μ in thickness was secured to layer 6e by resin adhesive. After the resin adhesive has been sufficiently cured, a mixture consisting of ZnS activated by Ag, CdS (ratio = 58 : 42) and a synthetic resin was applied to the surface of the Nesa glass opposite the Nesa film, thereby forming phosphor screen 4e. A coating 5e of aluminum of about 500 A thickness was applied to the phosphor screen by vacuum deposition, thereby providing a metal backing. Frame 1e of the thus-obtained face plate was secured to metallic tube 8e, and then electron gun 5d and an ultraviolet ray emission means, e.g. hydrogen discharge lamp 6d and lens 7d in FIG. 19, were incorporated in the tube. Thereafter, the lamp was evacuated and sealed.

In FIG. 19, first charging device 2d having an optically open front end (it is not necessarily open) and second charging device 3d having a light shield plate are moved over the surface of photoconductive plate 4 upon the face plate of the CRT. In practice the process of FIG. 19 takes substantial time, thus causing a slow speed operation. This defect is eliminated by the arrangement shown in FIG. 21. Over the surface of photoconductive plate 4f is moved a transparent or nontransparent insulative film 5f made of the same material as insulative layer 4f3 of photoconductive plate 4f such as fluoroplastics, polycarbonate resin, polyethylene resin, polyester resin or the like having sufficiently high resistance to retain electrostatic charge and high resistance to abrasion. Insulative film 5f is charged before it is placed in contact with photoconductive plate 4f. The other steps of forming electrostatic images are similar to those described in the above embodiment. The electrostatic image may be recorded by either developing and fixing or by developing and transferring. Thus, this arrangement facilitates high speed recording operations. In this case, the second charging device may be replaced with electrode charging means. Furthermore, insulative layer 4f3 may be eliminated.

When phosphor screen 1f of the CRT is illuminated for display of an information image, the second charging of photoconductive plate 4f must be performed. In order to synchronize these two opeations, motor 10f for driving photoconductive plate 4f and second discharging device 3f are controlled through sync. separation circuit 9f, when the information inputs are applied to the CRT, through signal amplifier 7f and deflection synchronization circuit 8f. Reference numeral 11f designates a high voltage source. Furthermore, as described above, the use of fiber optics, each fiber of which has a diameter of from 10 to 25 μ, for eliminating the loss due to light scattering, provides a resolution of about 20 lines/mm. For maintaining a high degree of vacuum in the CRT, mica or the like may be interposed between the phosphor screen and the ends of fiber optics.

The face plate of the CRT of the present invention described hereinabove includes at least a luminous body adapted to be illuminated upon bombardment thereof by electron beams, a transparent electrode layer, a photoconductive layer and an insulative layer. For example, in the case of the face plate shown in FIGS. 19 and 21, the face plate is one of a conventional CRT and includes luminous body 1d or 1f illuminated upon bombardment thereof by electron beams and a tubular glass surface g. A photoconductive plate on surface g comprises transparent electrode layer 4d1 or 4f1, photoconductive layer 4d2 or 4f2 and insulative layer 4d3 or 4f3 made of Mylar or the like. In one variation a transparent electrode layer, a luminous body layer, a photoconductive layer and an insulative layer may be attached to the front face plate of a cathode ray tube. In another variation an insulative layer is interposed between the luminous body layer and the photoconductive layer. In a further variation a luminous body layer, fiber optics, a transparent electrode layer, an insulative layer (this may be eliminated), a photoconductive layer, and an insulative layer may be used. In a still further variation another electrostatic image-forming insulative film is used instead of insulative layer $4f_3$ as shown in FIG. 21.

What is claimed is:

1. Image-forming apparatus comprising means operably responsive to information signals for emitting electron beams defining said image along an axis and plate means including in succession along said axis a radiation image-generating layer comprising a material emitting radiation upon electron beam bombardment thereof and an electrode transmissive to said radiation and coextensive with said radiation image-generating layer.

2. The apparatus claimed in claim 1 wherein said electrode is metallic film.

3. The apparatus claimed in claim 1 wherein said plate means further includes a layer of optical fibers interposed between said radiation image-generating layer and said electrode.

4. The apparatus claimed in claim 1 further including means for applying blanket radiation to said plate means.

5. The apparatus claimed in claim 1 wherein said plate means further includes a photoconductive layer sensitive to said radiation and disposed successively along said axis from said electrode.

6. The apparatus claimed in claim 5 wherein said plate means further includes an insulative layer disposed successively along said axis from said photoconductive layer.

7. The apparatus claimed in claim 1 wherein said plate means further includes an insulative layer transmissive to said radiation and disposed successively along said axis from said electrode.

8. The apparatus claimed in claim 7 wherein said plate means further includes a photoconductive layer sensitive to said radiation and disposed successively along said axis from said insulative layer.

9. The apparatus claimed in claim 8 wherein said plate means further includes a second insulative layer disposed successively along said axis from said photoconductive layer.

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