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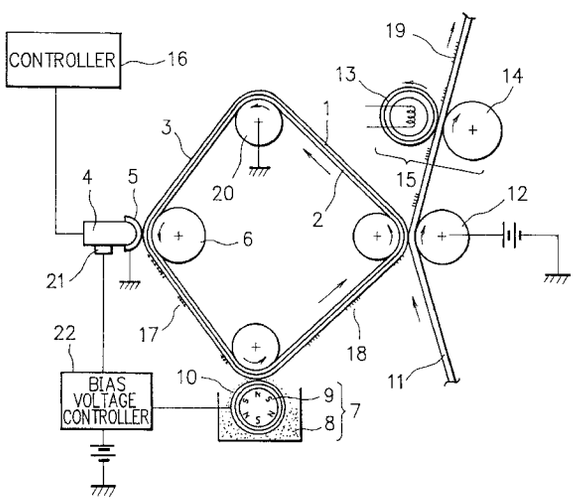
(54) Image recording apparatus

(57) A surface of a pyroelectric layer (1) of a latent image charge keeping medium (3) is selectively heated by a thermal head (4) according to a video signal. In a heated portion of the medium (3), there is collected electric charge to form an elecrtrostatic latent image (17) on the surface of the pyroelectric layer (1). When the latent image (17) is developed by a developer (7), a developing sleeve (10) is applied with an appropriate bias voltage obtained according to temperatures of the thermal head (4), the latent image charge keeping medium (3) and the apparatus sensed by temperature sensors (21, 21a, 21b). This keeps the potential contrast between the latent image (17) and the sleeve (10) to remain within a favorable range in any situation. Consequently, even when the charge density of the latent image becomes excessive due to, for example, heat accumulation of the thermal head (4), it is possible to prevent increase in the recording density so as to suppress the foggy portion in the picture.

FIG. 3



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BACKGROUND OF THE INVENTION

The present invention relates to an image recording apparatus applicable to a printer, facsimile equipment, a copying machine, and the like and, in particular, to an image recording apparatus in which an electrostatic latent image created according to pyroelectric effect is developed with an electrically charged coloring medium to be transferred and fixed onto a recording medium, thereby obtaining an image on the recording medium.

Description of the Related Art

Pyroelectric material has a characteristic in which when the materials are heated, electric charge is collected on surfaces thereof. There have been offered several proposals for applications of the characteristic to the recording of images. That is, a pyroelectric material is selectively heated according to information of an image to form an electrostatic latent image thereof such that the latent image is visualized by a toning or coloring medium so as to record the visual image on a recording medium.

J. G. Bergman et al have first disclosed a copying device using a pyroelectric substance. According to the U.S.P. No. 3,824,098 of J. G. Bergman et al and in page 497 to 499 of "Applied Physics Letters", Vol. 21 (10) published in 1972, there has been proposed a copying machine in which polymeric polyvinylidene fluoride (PVDF) is adopted as the pyroelectric material. In the facility, as shown in Fig. 1, a light beam illuminated from a lamp, namely, a light source 46 is passed through a sheet of manuscript 45 to be irradiated onto a laminated plate including a pyroelectric layer 43 and an electrically conductive layer 44 so as to heat the plate according to an image pattern produced by the light beam. Due to pyroelectric effect, electric charge of the latent image is collected on the surface of the pyroelectric layer 43 and then is developed with electrically charged particles of toner 47 into a toner image. The toner image is subsequently copied onto, for example, a sheet of recording paper to obtain a copied image of the manuscript.

Subsequent to the apparatuses above, there have been disclosed image recording devices employing various methods of heating pyroelectric materials. For example, methods in which a thermal head (an array of heating elements) is utilized as means of heating the pyroelectric material have described in the Japanese Patent Laid-Open Publication No. Sho-56-158350 of Yamazaki et al, the Japanese Patent Laid-Open Publication No. Sho-57-70677 of Matsushita, the Japanese Patent Laid-Open Publication No. Sho-60-104965 of Sakai et al, and the Japanese Patent Laid-Open Publication No. Hei-5-134506 and U.S.P. No. 5,185,619 of C. Snelling. Additionally, there has been described a method of heating the pyroelectric material by a laser light has been described in the Japanese Patent Laid-Open Publication No. Sho-56-158350 of Yamazaki et al and the Japanese Patent Laid-Open Publication No. Hei-1-161370 of Okuyama et al.

Referring now to Fig. 2, description will be given of the basic configuration of the conventional image recording device in which a heating element array is adopted as the heating means primarily according to the apparatus proposed by Snelling. The device includes a latent image charge keeping medium 31 for keeping thereon electric charge of a latent image. The medium 31 includes a pyroelectric film 32 and an electrically conductive film 33. The charge keeping medium 31 is heated by a heating element array (heating needle) 34 under supervision of a controller 36. In this connection, although the process of forming the latent image will be described later, in order to obtain a satisfactory charge density of the latent image when the charge keeping medium 31 is cooled, it is important to effectively cancel or neutralize the charge which appears on the surface of the pyroelectric film 32 during the pyroelectric material heating operation. For this purpose, according to the method of Snelling, there is provided on a surface of the heating needle 34 an electrically conductive layer 35 connected to a ground potential such that the charge collected in the heating stage is neutralized through the conductive layer 35. When the charge keeping medium 31 is cooled, a latent image 37 is generated on the surface of the pyroelectric layer 32. The image 37 is developed by a developing device 38 using a toner to be thereafter transferred onto a sheet of recording paper 40 by transferring means 41 so as to form an image 42 on the recording sheet 40. The transferred particles of toner are fixed onto the sheet 40 by a fixing apparatus (not shown).

However, the conventional image recording apparatuses are attended with difficulty in that variation in temperature of the heating means or chanae in the environmental temperature causes non-uniformity in the final recording density, leading to deterioration in quality of the recorded image. Specifically, in a sequential image recording operation, when the temperature of the heating means is increased (due to heat accumulation) or the environmental temperature becomes higher in the apparatus, there occurs a problem that an excessive recording density appears in the attained image or a foggy portion takes place due to toner particles attached onto non-image areas in the recorded picture.

To cope with the heat accumulation in the heating means and the variation in the environmental temperature, there has been generally known a correction method in which the amount of heat generated from the heating means is controlled. That is, the mean temperature and environmental temperature are obtained by temperature sensors to be fed back to the

circuit controlling the heating means so as to decrease the amount of heat created from the heating means, thereby suppressing the excessive heat. In the conventional thermal printing process, the method above has been usually employed as a method to correct or compensate for the heat accumulation in the thermal head.

However, according to the method of controlling the amount of heat created from the heating means, influences of the heat accumulation of the heating means and the variation in the environmental temperature cannot be completely removed in the image recording operation using the pyroelectric substance. Reasons therefor will be next described by reference to a specific example.

Assume that a thermal head is adopted as the heating means and the temperature thereof is generally increased by 10 °C due the heat accumulation and/or alteration in the environmental temperature. When the base temperature of the thermal head is increased, there appear two primary influences upon the recorded image.

First, there occurs an excessive increase in the temperature of the imaging section. Namely, even when the temperature increase of the section is beforehand set to 90°C, when the base temperature is increased by 10°C, there takes place a temperature increase of 100 °C in the imaging section. This results in problems of an excessive recording density and a thermal damage in the charge keeping medium.

Second, there appears a foggy portion in the non-image area of the recorded picture. Namely, although the non-image area of the charge keeping medium is not heated, the temperature of pyroelectric material of the non-image area is increased by 10 °C due to contact with the heated thermal head. Since the pyroelectric material collects latent image charge substantially in proportion to the heating temperature, there appears latent image charge also in the non-image area according to the 10°C temperature rise. This causes the foggy portion in the resultant picture.

When the amount of heat created from the heating means is controlled as described above, the first influence can be prevented. Namely, the excessive increase in temperature of the image area can be suppressed. However, it is almost impossible to prevent the foggy portion in the non-image area by controlling the amount of heat produced from the heating means for the following reason. Namely, the control operation of the amount of heat created from the heating means is nothing to do with the effect of the correction with respect to the temperature rise in the non-image area. In contrast thereto, the control operation is effective in the thermal recording operation. Namely, the thermal recording operation has a unique characteristic that the recording operation (transfer of ink) is carried out only when the temperature of ink is at its melting point or more. In short, since the foggy portion is missing in the thermal printing even when the themperature of the non-image area is increased by about 10 °C, considerations need not be given to the temperature rise in the non-image area. On the other hand, in an image recording operation using the pyroelectric substance, even a slight temperature rise in the non-image portion causes a foggy portion, which makes it necessary to prepare a sufficient contermeasure to overcome this problem.

As above, in an image recording facility employing a pyroelectric material, it is quite difficult to completely remove influences of the heat accumulation of the heating means and variation in the environmental temperature. In particular, the foggy portion cannot be suppressed in the picture generated according to the conventional methods.

SUMMARY OF THE INVENTION

It is therefore an object of the present invention to provide an image recording apparatus in which even when the mean temperature of the heating means is increased or the environmental temperature is changed in the apparatus, the recording density is kept at a sufficiently uniform level to attain a high picture quality, thereby solving the problems above

To achieve the object above in accordance with the present invention, there is provided an image recording apparatus comprising a latent image charge keeping medium including a pyroelectric layer, heating means for selectively heating the charge keeping medium according to a video signal and forming an electrostatic latent image, developing means for visualizing the electrostatic latent image on the medium with an electrically charged toning medium, thereby visualizing the latent image, means for sensing at least temperature of the heating means, temperature of the medium, and environment temperature, and means of controlling, according to data of the obtained temperature, an amount of the toning medium supplied from the developing means onto the charge keeping medium.

It is in particular preferred that the means for controlling the amount of the toning medium is a bias voltage controller supervising a developing bias voltage applied to the developing means.

The latent image charge keeping medium including the pyroelectric layer is locally heated by the heating means according to a video signal. In the heated portion of the charge keeping medium, the state of orientation of molecules is altered in the pyroelectric layer. This resultantly causes latent image charge to appear on the surfcace of the pyroelectric layer.

When the charge keeping medium in which the latent image is created is in the proximity of or is brought into contact with a charged toning medium, the toning medium is selectively attached onto the surface of the pyroelectric medium so as to visualize

or develop the latent image. In this operation, the amount of the toning medium supplied from the developing means is controlled to attain a favorable record image. That is, the amount of the toning medium is set to an optimal value according to data of at least either one of the heating temperature. temperature of the charge keeping medium, and the environmental temperature in the apparatus, the temperature data being obtained from temperature sense means.

The amount of the supplied toning medium is supervised, for example, by a bias voltage applied to the developing means. Namely, in case where the charge keeping medium is excessively heated due to heat accumulation of the heating means, the bias voltage applied to a developing electrode of the developing means is increased in the direction of the polarity of latent image charge to thereby minimize the potential difference between the latent image and the developing means. When the potential contrast is reduced in the developing step, the amount of the toning medium attached onto the charge keeping medium is minimized. This resultantly suppresses the excessive increase in the recording density and prevents the excessive amount of the coloring medium (causing the foggy portion) from being attached on the non-image area.

BRIEF DESCRIPTION OF THE DRAWINGS

The objects and features of the present invention will become more apparent from consideration of the following detailed description taken in conjunction with the accompanying drawings in which:

Fig. 1 is a diagram for explaining the fundamental configuration of an image recording apparatus using a lamp beam to heat a pyroelectric material in accordance with the prior art;

Fig. 2 is a diagram showing constitution of an image recording apparatus in accordance with the present invention;

Fig. 3 is a diagram useful to explain an embodiment of the image recording apparatus according to the present invention;

Fig. 4A to 4D are diagram for explaining processes of producing a latent image;

Fig. 5 is a diagram showing structure of a thermal head and an electrically conductive layer the apparatus of Fig. 3;

Fig. 6 is a cross-selectional view showing a cross section along direction VI of Fig. 5;

Fig. 7 is a diagram showing the configuration of a bias voltage controller of Fig. 3; and

Fig. 8 is a diagram for explaining another embodiment of the image recording apparatus in accordance with the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to the drawings, description will be given of embodiments in accordance with the present invention.

Fig. 3 shows constitution of a first embodiment of the image recording facility in accordance with the present invention. The image recording device of this embodiment includes a latent image charge keeping medium 3 in an endless belt shape, a thermal head 4, a conductive film 5, a temperature sensor 21, a bias voltage controller 22, a developing device 7 as developing means, a transfer roller 12, and a fixing device 15.

The charge keeping medium 3 includes two layers, namely, a pyroelectric layer 1 (about 30 micrometer (μm) thick) and an electrically conductive layer 2 (about 500 angstrom (A) thick), which are configured in an endless belt contour. The layers 1 and 2 are made of polyvinyldene fluoride (PVDF) and aluminum, respectively. The conductive layer 2 is kept at a grounding potential through a conductive roller 20.

The thermal head 4 employed as the heating means in this embodiment is a line-type thermal head generally utilized for the thermal recording operation. In the thermal head 4, fine heating elements to generate Joule heat are arranged with a pitch of about 83 μm (300 dots/inch) along lines in the direction of width of the charge keeping medium 3. These heating elements are selectively initiated by a controller 16 in response to video signals to heat the charge keeping medium 3.

On the surface of the thermal head 4, an electrically conductive layer 5 is formed to cover the heating section. The layer 5 neutralizes electric charge on the surface of the pyroelectric layer 1 in the heating state thereof. For easy understanding of the function of the layer 5, description will be given in detail of processes of generating a latent image in this embodiment by reference to Figs. 4A to 4D.

In these diagrams, a pyroelectric layer 51 of the charge keeping medium has electric charge on a surface thereof due to spontaneous polarization of molecules of the layer 51. In the initial state, the surface charge is in the neutral state (Fig. 4A). That is, floating charge existing in the air and charge 53 supplied from neutralizing means such as an electrically conductive brush fix onto the surface of the pyroelectric layer 51 to establish the electrically neutralized state. Assume that the polarized charge appearing on the surface of the pyroelectric layer 51 has the positive polarity and true effective charge attached onto the surface has the negative polarity.

When the charge keeping medium is heated, the state of orientation of molecules changes in the pyroelectric layer 51. This results in reduction in the amount of polarized charge appearing on the surface

of the pyroelectric layer 51. In consequence, the amount of negative charge fixed on the surface becomes excessive and hence the surface is negatively charged (Fig. 4B). In this situation, when charge neutralizing means 55 is brought into contact with or is in the neighborhood of the surface of the pyroelectric layer 51. the excessive charge on the surface is cancelled by the neutralizing means 55 and returns again to the neutral state (Fig. 4C).

After the heating stage is completed, when the charge keeping medium is cooled down to the initial temperature, the polarized state is also restored to the original state in the pyroelectric layer 51. In this situation, the surface of the pyroelectric layer 51 has already been separated from the charge neutralizing means. Consequently, the negative charge is insufficient on the pyroelectric layer surface. Virtually, the surface is positively charged as a result (Fig.4D). Namely, in the heated portion of the charge keeping medium, a positive-polarity latent image is created after the charge keeping medium is cooled down.

The latent image thus obtained is gradually vanished because floating charge existing in the air is collected onto the image. However, in general, the phenomenon takes a long period of time and hence the latent image is kept retained for several hours to several tens of hours in ordinary cases.

In Fig. 3, an electrically conductive layer 5 is formed as the charge neutralizing means. In this embodiment, a thin metallic film of aluminum or chrome having a thickness of about 1000 angstroms is fabricated on the thermal head surface by evaporation.

Figs. 5 and 6 shows constitution of the thermal head 4 and the conductive layer 5. Specifically. Fig. 6 shows a cross section of the construction along direction VI of Fig. 5. The thermal head 4 includes a ceramic substrate 401 and a resistive layer 402 formed thereon as a heating section. Disposed on the resistive layer 402 are electrodes 403 and 404 to oppose to each other with a predetermined interval therebetween. A portion of the resistive layer 402 between the electrodes 403 and 404 functions as the heat generating section. Namely, when an electric current flows between the electrodes 403 and 404, the heating section of the layer 402 generates heat.

On the electrodes 403 and 404 and resistive layer 402, there are fabricated an insulating protective layer 405 and an electrically conductive layer 5 thereon. As can be seen from Fig. 5, the resistive layer 402 provides a string of heating elements on the thermal head 4. The conductive layer 5 is formed along a longitudinal central line of the resistive layer 402 forming the heating element string. The conductive layer has a width of about four millimeters (mm) in the direction of width of the heating element string. However, the width may be four mm or less or four mm or more only if the conductive layer 5 covers the heat generating section.

Incidentally, the material and structure of the charge neutralizing means are not restricted by those of the embodiment above. Namely, there may be employed other substances and configurations thereof. For example, the means may include a thin film made of a conductive organic material and a configuration in which a conductive film is interposed between a thermal head and a pyroelectric layer.

After the heating step is finished, the heated medium 3 is naturally cooled down to the room temperature to produce a latent image 17. In addition to the natural cooling, there may be employed a forced cooling step or forced cooling means utilizing, for example, thermal conduction to a heat sink.

The latent image 17 created on the medium 3 is visualizedor developed by the developer 7. In this embodiment, the developer 7 carries out the so-called two-component magnetic brushing operation. Namely, there is employed a developing agent 8 containing insulating and non-magnetic toner particles mixed with magnetic carrier particles to electrically charge the toner particles by friction therebetween so that the toner particles are fixed onto carrier particle surfaces. The developing agent 8 is kept applied onto a sleeve 10 with a magnet roller 9 disposed therein. When the agent 8 is brought into contact with the charge keeping medium 3, the toner is selectively fixed onto the surface of the medium 3 according to the charge distribution thereon, thereby forming a visual image.

In the operation, the sleeve 10 is applied with a bias voltage from a bias voltage controller 22. To obtain an appropriate potential contrast between the latent image 17 and the sleeve 10, the bias voltage is controlled according to a representative temperature of the thermal head 4 obtained from a temperature sensor (thermistor) 21. That is, the bias voltage is selected to prevent the toner from fixing onto the non-image area even when latent image charge appears thereon.

Fig. 7 shows details of the bias voltage controller 22, which includes temperature sensors 21, 21a, and 21b to control the bias voltage to be applied to the sleeve 10. The sensor 21 senses temperature of the thermal head 4. The sensor 21a detects the environmental temperature, namely, the environmental temperature in the apparatus; whereas the sensor 21b measures temperature of the charge keeping medium 3.

Sensed data items are transmitted from the sensors 21, 21a, and 21b respectively to analog-to-digital (A/D) converters 201 to 203 to be converted into digital signals, which are then sent to a central processing unit (CPU) 204. The CPU 204 decides the largest value among the data items from the sensors 21, 21a, and 21b to produce a control signal according to the maximum temperature value. The control signal is then transformed into an analog signal by a digital-to-

analog converter 205 to be supplied to a direct-current (dc) power source 206. This signal controls the value of voltage outputted from the dc power source 206, namely, the bias voltage to the sleeve 10. To supervise the dc power circuit 206 when the mean value exceeds a present value, the CPU 204 may obtain a mean value of the outputs from the sensors 21, 21a, and 21b in place of the maximum temperature value. Moreover, the CPU 204 carries out such processes including a time control (delay) operation in the voltage control process of the dc power supply 206.

After the developing phase is completed, the medium 3 is fixed onto a sheet of recording paper 11 as a recording medium. Thereafter, to electrostatically transfer the toner onto the surface of the recording sheet 11, the recording sheet 11 is pushed by the transfer roller 12 on a rear surface thereof. In this embodiment, a voltage of about +1 kV is applied to the conducutive gum roller to effect the electrostatic transfer of the tone.

The recording sheet 11 onto which the toner has been transferred is passed through the fixing facility 15 including a heater roller 13 and a pressure roller 14 such that the toner is once fused on the sheet surface, thereby fixing the toner on the recording sheet 11.

In this connection, the method of developing the latent image, kind of the developing agent, method of transferring the toner agent onto the recording medium, and method of fixing the toner onto the recording medium are not limited to those used in the embodiment. That is, the similar advantageous effect can be obtained according to other conventional methods utilized in electrophotography.

After the toner is completely transferred onto the recording sheet 11, the charge keeping medium 3 is again returned to the latent image creating section (thermal head section) to generate a subsequent latent image. Prior to this operation, when the toner not transferred still remains on the medium 3, the toner is removed by a cleaner (not shown) when necessary.

In addition, when a portion of the latent image charge also remains after the transfer of toner onto the recording sheet 11, there may be employed charge removing means such as an electrically conductive brush (not shown) when necessary. The charge removing means is grounded in operation to be brought into contact with the surface of the pyroelectric layer 1 so as to easily neutralize the charge remaining on the surface of the pyroelectric layer 1, thereby restoring the charge keeping medium 3 to the initial state.

Results of recording experiments conducted in the image recording device structured as above lead to confirmation that favorable pictures free of the foggy portion can be attained through a continuous recording operation. Moreover, also in case where a gray-scale recording operation is conducted while controlling temperature of the heating elements of the thermal head, it has been confirmed that the recording operation is effected with a highly stable recording density to obtain a high-quality picture.

Fig. 8 shows constitution of an alternative embodiment of the image recording device in which the latent image generating and developing processes are simultaneously carried out in accordance with the present invention. The constituent elements of the apparatus are almost the same as those of the first embodiment of Fig. 3 and hence are assigned with the same reference numerals.

In this system, the charge keeping medium 3 is heated by the thermal head 4 pushed against the side of the conductive layer 2 of the medium 3. This embodiment includes the developing device 7 opposing to the thermal head 4 such that the developing of a latent image is simultaneously achieved while the medium 3 is being heated. In this case, the complicated process of creating a latent image as described in conjunction with the first embodiment is unnecessary. That is, in the heated portion of the medium 3, the state of orientation of the molecules alters in the pyroelectric layer, which consequently reduces the amount of polarized charge appearing on the surface of the pyroelectric layer. As result, the amount of true effective charge fixed on the surface becomes excessive (Fig. 4B). When a toning medium charged to a polarity opposite to that of the excessive charge is brought into contact with or is in the proximity of the excessive charge, the toning medium is attached onto the surface of the pyroelectric layer, thereby visualizing of the latent image. In this embodiment, a toner agent charged to the positive polarity is employed as the coloring agent. The structure of the developing facility is the same as that shown in first embodiment.

Also in this operation, the sleeve 10 of the developer 7 is applied with a bias voltage from the bias voltage controller 22. In order to obtain an appropriate potential discrepancy between the latent image 17 and sleeve 10, the bias voltage is supervised according to information of temperatures measured by the temperature sensor 21 to sense accumulated heat of the thermal head 4, the temperature sensor 21a to measure temperature in the apparatus, and the temperature sensor 21b to detect temperature of the charge keeping medium 3.

Conducting the recording processes thereafter including the developing, transferring, and fixing processes similar to those of the first embodiment, a desired image 19 can be recorded on the recording sheet 11.

Description has been given in detail of embodiments in accordance with the present invention. However, the present invention is not restricted only by the embodiments. For example, although a line-type thermal head is adopted as the heating means in the embodiments, there may be employed any kinds of

heating means including a serial-type thermal head, laser light, lamp light heating employing optical shutters, and flash heating element.

Additionally, the latent image charge keeping medium is in the form of a belt in the embodiments. However, the similar advantages can also be attained by use of the medium in any other form, for example, that of a drum or flat plate.

Furthermore, although a sheet of paper is used as the recording medium in the embodiments above, there may be naturally adopted various types of recording media in accordance with the present invention. In addition, the transfer and fixing steps of the toning medium onto the recording medium may be dispensed with. That is, the present invention, is also applicable to apparatuses such as an indication board in which the toning medium is temporarilly kept retained on the recording medium so as to display information thereon for a predetermined period of time.

Moreover, although the coloring particles (i.e., powdered toner particles) are utilized as the toning medium in the above embodiments, there may also be utilized any other coloring media such as a liquid toner and a liquid ink.

In addition, to control the amount of supply of the toning medium, a method of applying a bias voltage to the developing means is employed in the embodiments. However, other methods may also be used, for example, the number of rotation of the developing sleeve or the magnitude of charge of the toning medium may be supervised for the control of the amount of the coloring medium.

In accordance with the present invention, even when the temperature of the heating means is increased or the environmental temperature is varied in a continuous image recording operation, the recording density can be kept retained and the foggy portion is suppressed in the picture, thereby achiving a high-quality image recording operation.

While the present invention has been described with reference to the particular illustrative embodiments, it is not to be restricted by those embodiments but only by the appended claims. It is to be appreciated that those skilled in the art can change or modify the embodiments without departing from the scope and spirit of the present invention.

Claims

1. An image recording apparatus comprising a latent image charge keeping medium (3) including a pyroelectric layer (1); heating means (4) for selectively heating the charge keeping medium (3) according to a video signal; and developing means (7) for visualizing with a charged toning medium (8) an electrostatic latent image formed on the charge keeping medium (3);

   characterized in that the apparatus further comprises:

   means (21, 21a, 21b) for sensing temperature of at least one of the heating means (4), the charge keeping medium (3), and environment in the apparatus; and

   means (22) for controlling, according to data of the obtained temperature, an amount of the toning medium supplied from the developing means (7) to the charge keeping medium (3).

2. An image recording apparatus as claimed in claim 1, wherein the means (22) for controlling the amount of the toning medium is a bias voltage controller for controlling a bias voltage applied to the developing means (7).

3. An image recording apparatus as claimed in claim 1, wherein the latent image charge keeping medium (3) includes a conductive layer (2) and the conductive layer (2) is kept at a grounding potential.

4. An image recording apparatus as claimed in claim 3, wherein the latent image charge keeping medium (3) has an endless belt shape.

5. An image recording apparatus as claimed in claim 1. wherein the heating means (4) is a thermal head (4) and the thermal head (4) includes a substrate (401), a resistive layer (402) formed on the substrate (401), electrodes (403, 404) disposed on the resistive layer (402) and an insulating protective layer (405) formed on the electrodes (403, 404) and the resistive layer (402).

6. An image recording apparatus as claimed in claim 1, further comprising means (5) for neutralizing electric charge on the surface of the pyroelectric layer (1).

7. An image recording apparatus as claimed in claim 5, further comprising means (5) for neutralizing electric charge on the surface of the pyroelectric layer (1).

8. An image recording apparatus as claimed in claim 7, wherein the means (5) for neutralizing electric charge is electrically conductive layer (5) formed to cover the heating section of the thermal head (4).

9. An image recording apparatus as claimed in claim 1, wherein the developing means (7) includes a sleeve (10) with a magnet roller (9).

10. An image recording apparatus as claimed in claim 1, wherein the means (21, 21a, 21b) of

sensing temperature includes a sensor (21) for sensing temperature of the heating means (4), a sensor (21a) for sensing temperature of environment in the apparatus, and a sensor (21b) for sensing temperature of the charge keeping medium (3).

11. An image recording apparatus as claimed in claim 10, wherein the means (22) for controlling the amount of the toning medium controls the amount of the toning medium according to maximum temperature value of the sensors (21, 21a, 21b).

12. An image recording apparatus as claimed in claim 10, wherein the means (22) for controlling the amount of the toning medium controls the amount of the toning medium according to mean temperature value of the sensors (21, 21a, 21b).

13. An image recording apparatus as claimed in claim 10, wherein the means (22) for controlling the amount of the toning medium includes DC power circuit (206).

14. An image recording apparatus as claimed in claim 8, wherein the developing means (7) opposes to the thermal head (4).

FIG. 1
PRIOR ART

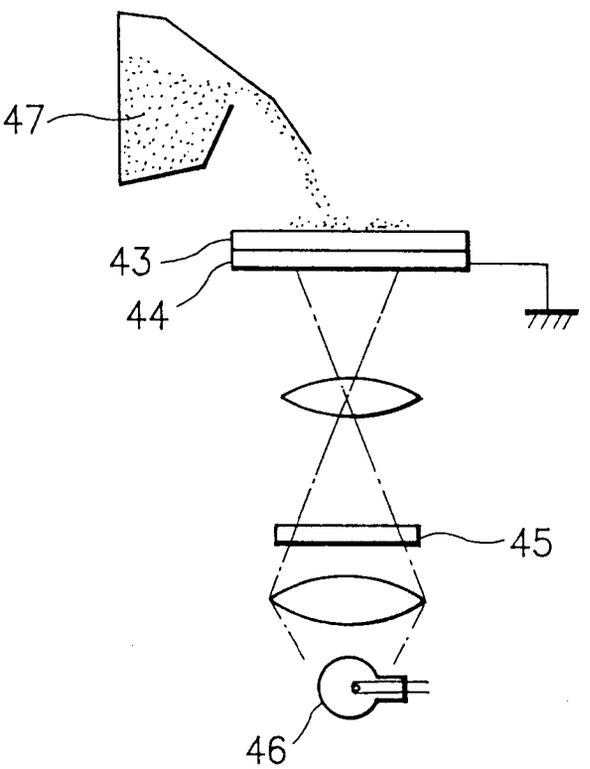

FIG. 2
PRIOR ART

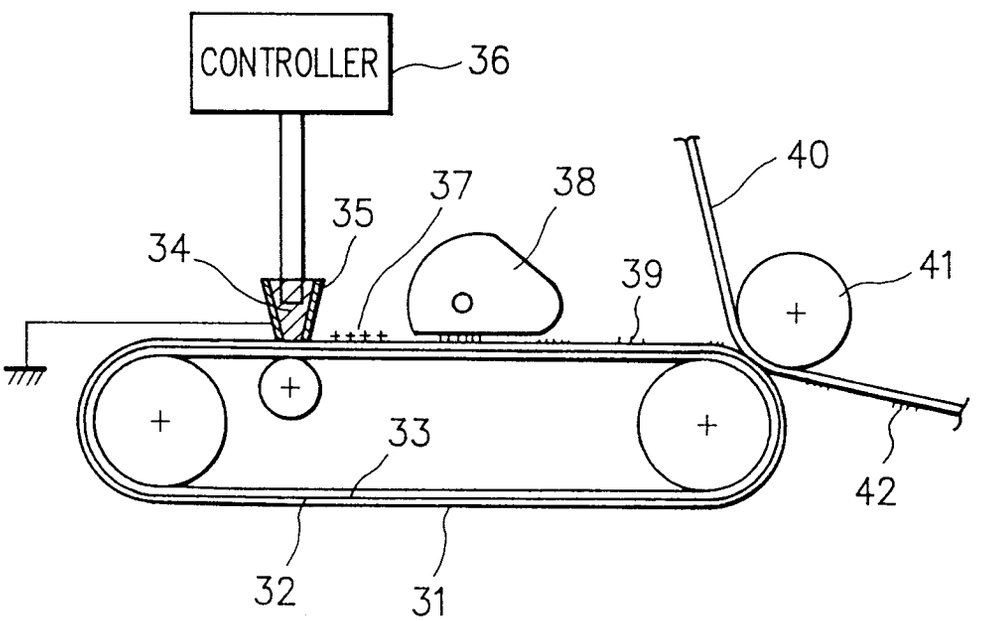

FIG. 3

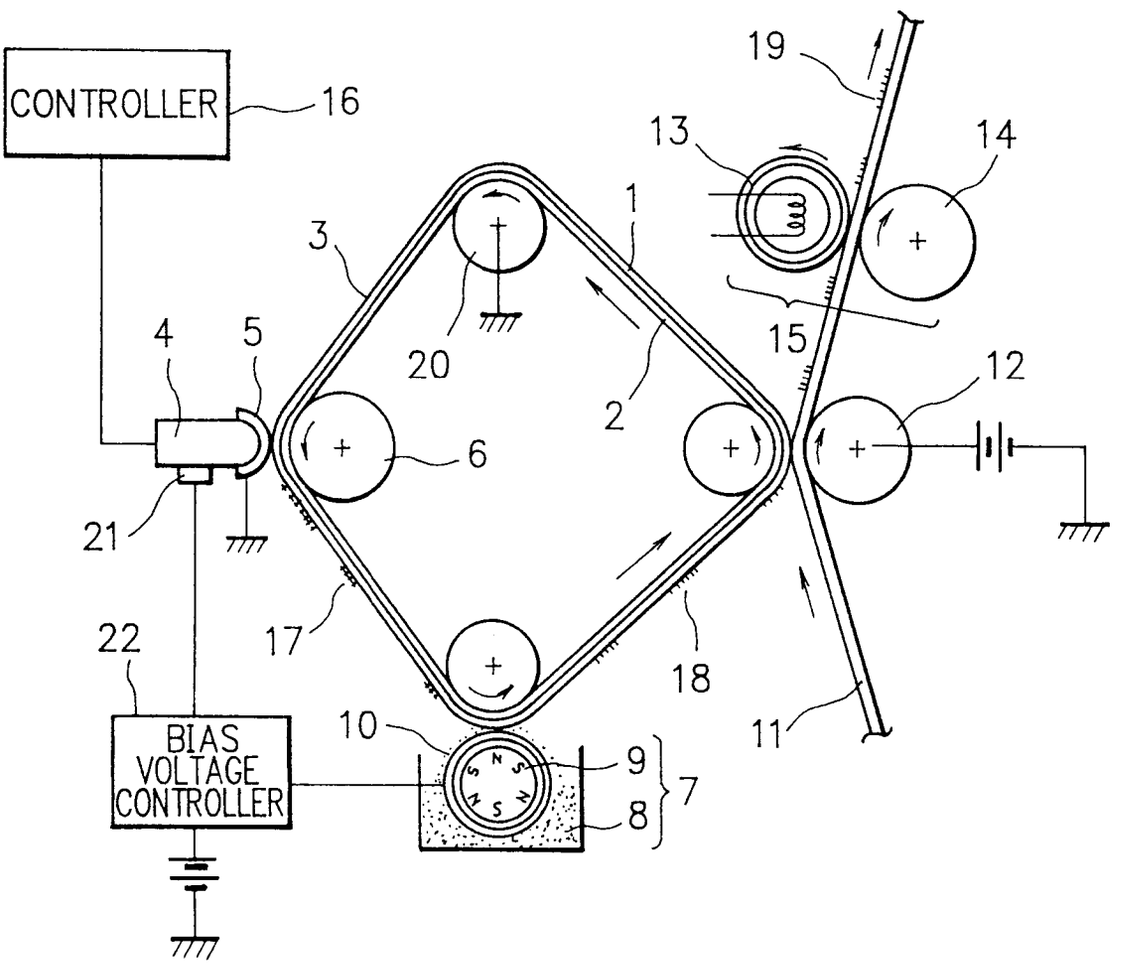
CONTROLLER
16
19
13
14
1
3
20
15
4
5
2
12
6
21
17
18
22
10
11
BIAS
VOLTAGE
CONTROLLER
9
8
7

FIG. 4A

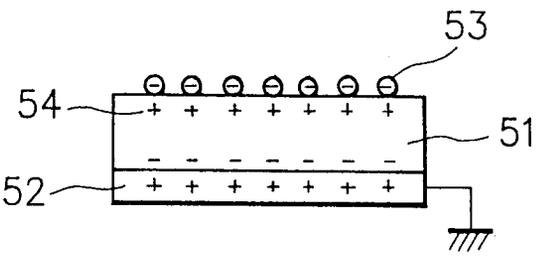

FIG. 4B

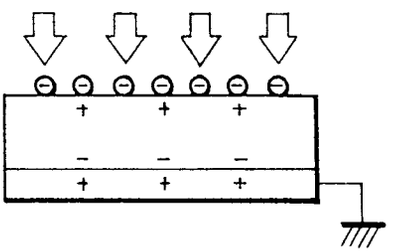

FIG. 4C

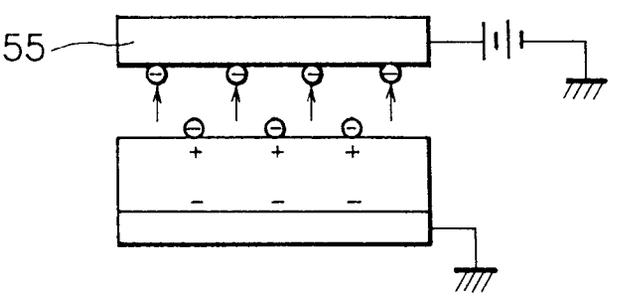

FIG. 4D

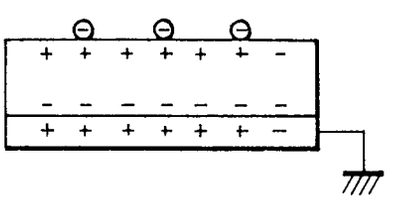

FIG. 5

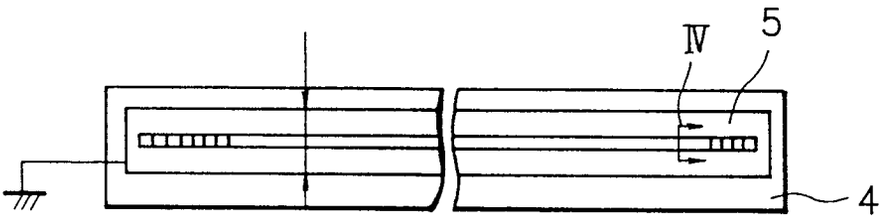

FIG. 6

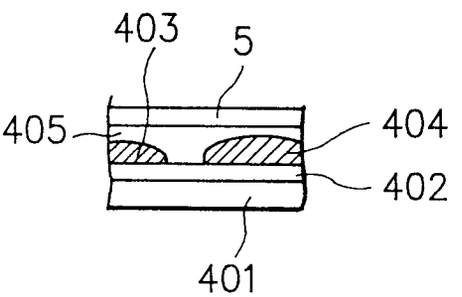

FIG. 7

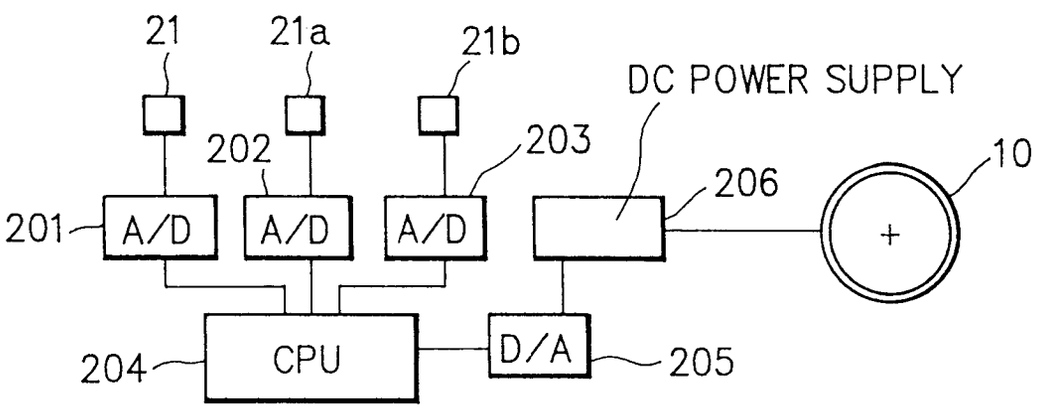

FIG. 8