

[54] **COPYING MACHINE**

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[58] **Field of Search**.....355/3, 4, 16, 17;
96/1, 1.2

[56] **References Cited**

UNITED STATES PATENTS

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FOREIGN PATENTS OR APPLICATIONS

1,152,308 5/1969 Great Britain.....355/3 UX

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[57]

ABSTRACT

An improved electrostatic copying machine which utilizes a novel, biased double screen arrangement to form latent electrostatic image on a dielectric receiving layer, such as paper or the like, is disclosed. The double screen arrangement includes a first wire mesh screen having a photoconductive coating thereon and a second wire mesh screen having either a photoconductive coating or an insulator coating thereon. These screens are positioned, one above the other, between a conventional corona device and the receiving layer, with the first screen being positioned adjacent to the corona device and the second screen being positioned adjacent to the receiving layer. The first screen is biased with respect to the receiving layer and with respect to the second screen and the second screen is biased with respect to the receiving layer. A latent electrostatic image is formed on the receiving layer by projecting an optical image of the original to be copied onto the first screen while simultaneously raising the corona device to a corona discharge potential. The latent electrostatic image thus formed on the receiving layer is then made visible by suitable developing techniques known to the art.

12 Claims, 2 Drawing Figures

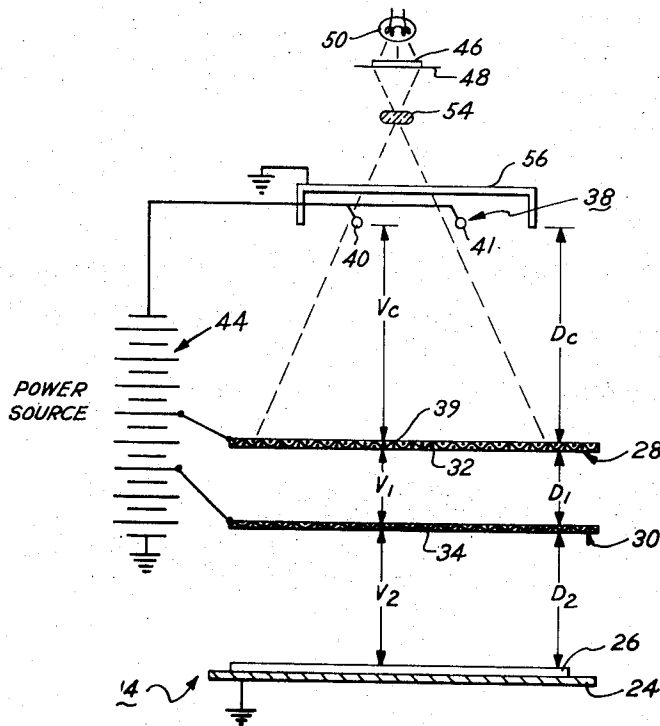


Fig. 1

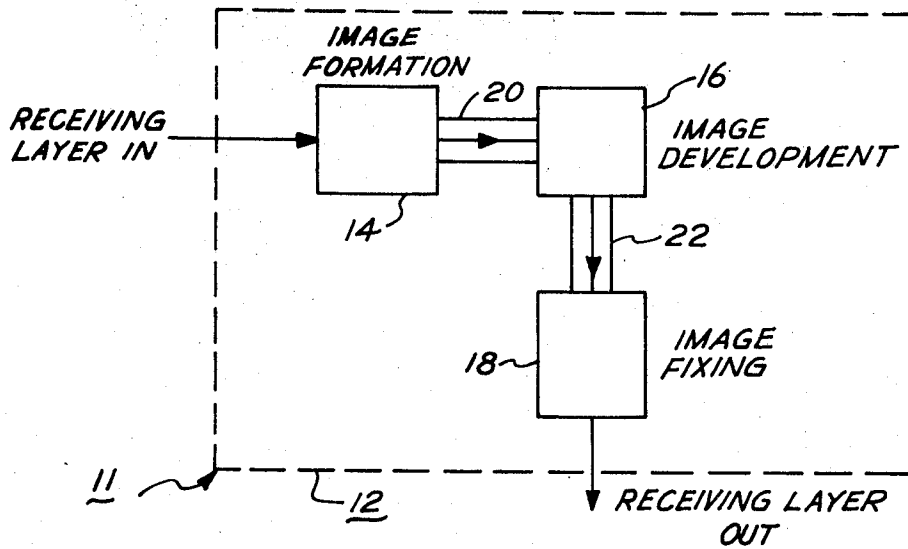
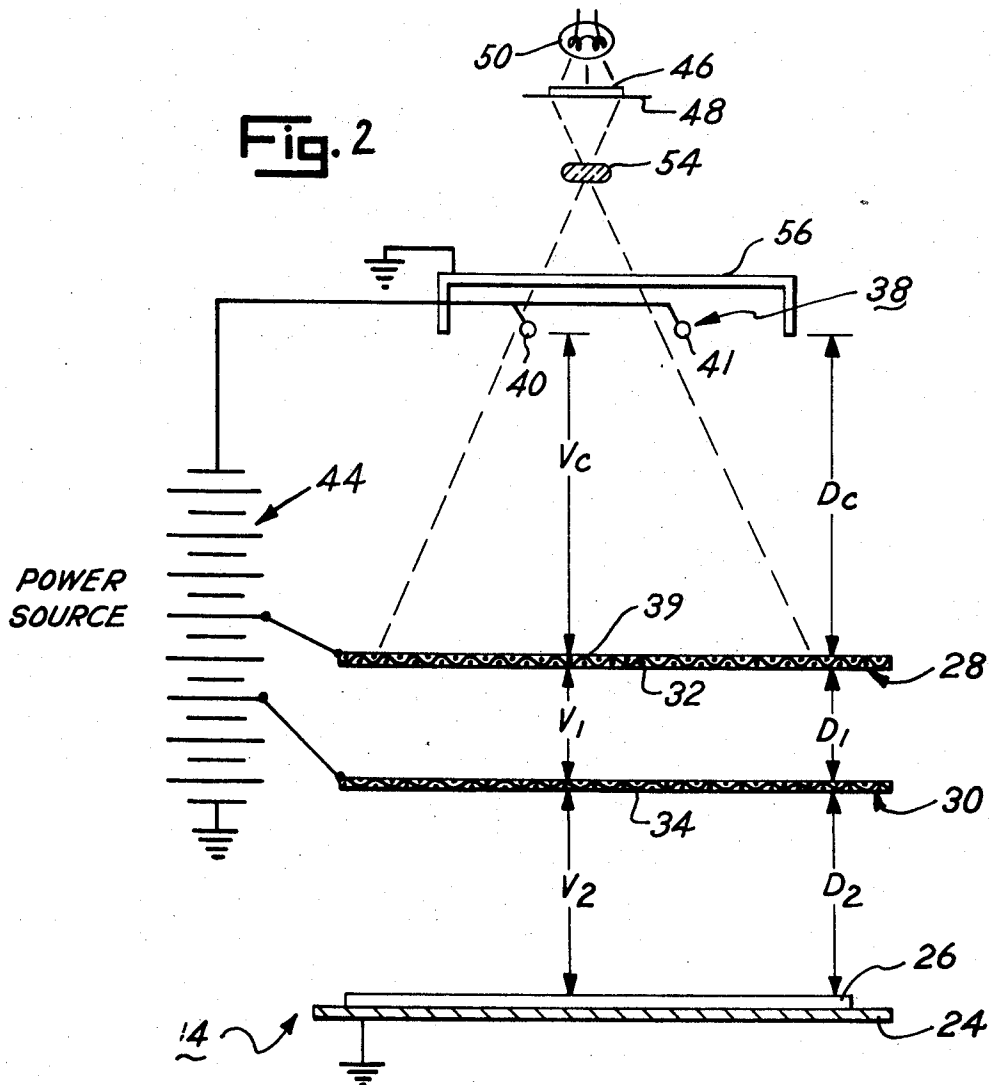


Fig. 2



COPYING MACHINE

BACKGROUND AND SUMMARY OF THE INVENTION

This invention relates to an improved electrostatic image copying machine for reproducing, on a dielectric receiving layer, an optical image conforming to the original to be copied, and more particularly, to an improved copying machine which utilizes a novel, biased, double screen arrangement to initially form a latent electrostatic image, conforming to the original to be copied, on a dielectric receiving layer and which then causes this latent electrostatic image to be made visible in accordance with conventional developing techniques.

In the past, electrostatic principles have been applied in connection with various different types of imaging machines and processes. For instance, it has been proposed to utilize electrostatic principles, in combination with the principles of silk screen printing, for printing on odd shapes and rough textures. According to this proposal, a wire mesh screen (with holes cut out of the screen conforming to the images to be copied) is positioned between a grounded plate which supports a receiving layer and a cloud of charged electrostatic toner particles. A field is created between the wire mesh and the grounded plate, and this field pulls the charged toner particles through the holes in the screen and onto the receiving layer so as to form an image on the receiving layer. Heat is applied to the image thus formed to make the image permanent. Since the receiving layer does not come into physical contact with the receiving layer, odd shaped and rough textured objects can be used as the receiving layer.

In a modification a wire mesh screen with a photoconductive coating thereon is utilized instead of the screen with cut out holes. The photoconductive coated screen is charged in the dark and a light, optical image is projected onto the screen. The charge on the screen is leaked off where the light image strikes the screen thereby forming an invisible, electrostatic image on the screen, corresponding to the projected optical image. The charged toner particles are drawn through the portions of the screen where the charge has been leaked off, i.e., in the light exposed portions, while the still charged portions of the screen prevent toner particles from passing through the screen. While the aforementioned screen processes have certain advantages over prior silk screen processes, they also have the disadvantage that the practical limits of screen mesh size and toner particle size restrict image density and resolution and cause the screens to become clogged thereby requiring cleaning after limited usage.

Electrostatic principles have also been utilized in two general types of commercially available machines for copying documents and the like. One of these types of copying machines utilizes a reusable plate or drum which has a photoconductive layer overlying a conductive backing member. The plate or drum is uniformly charged and is then exposed to an optical image conforming to an original document or the like to be copied. The charge on the area of the plate or drum upon which the light strikes is discharged; whereas, the charge is retained on the non-light struck areas of the plate or drum. This latent image is then made visible by an application of an electrically attachable toner to the

plate or drum in a conventional manner. This visible image is transferred from the plate or drum to a receiving layer, such as a sheet of paper, and is thereafter fixed on the receiving layer, usually by an application of heat. In the other general type of copying machines, the manner by which the latent image is formed and made visible is substantially similar to that utilized by the first type of copying machines, except that a disposable plate, such as paper coated with a photoconductive layer, is used. Thus in the other general type, the plate also serves as the receiving layer so that the transfer step is eliminated.

While machines of both types have met with commercial success, the presently commercially available machines do have certain disadvantages which may be overcome by machines embodying the present invention. More specifically and with respect to machines of the first type, the cost per copy is relatively expensive for low volume users; the machines require considerable maintenance because of their relative complexity; the coating on the plate or drum is relatively expensive, fragile and is subject to wear so that it must be replaced periodically; the machines do not make particularly good copies of photographs or other documents containing large solid areas; the operation of the machines require, as noted above, a separate image transfer step; and the speed of operation of the machine is limited because a charge and exposure step is required for each copy made by the machine. With respect to machines of other general type, special paper, which is more expensive and heavier than regular paper, is required and copies can be marred by scratches on the paper. Furthermore, the speed of the operation of the machine is limited because of the fact that for each copy, the charging and exposure steps must be done in sequence.

Others have proposed machines for overcoming the disadvantages of the aforementioned two general types of copying machines. In the British Pat. No. 1,152,308 (complete specification published May 14, 1969) a machine is described wherein a latent electrostatic image is formed directly on a dielectric receiving layer, such as ordinary paper, without the necessity of using uniformly charged plate or drum, such as utilized in the above described, commercially available machines. This machine utilizes a screen having a photoconductive coating thereon. The receiving layer is positioned adjacent to one side of the screen and a conventional corona device is positioned adjacent to other side of the screen, i.e., the side opposite to the receiving layer. To make a copy, an optical image of the document or the like to be copied is projected onto the other side of the screen, and the corona device is raised to its discharge potential. The photoconductive coated screen becomes selectively more conductive in those areas of the screen upon which light strikes in response to the projection of the optical image, and as a result, the disposition of electrical charge on the receiving layer is regulated such that the receiving layer has a latent electrostatic image formed thereon which conforms to the projected optical image.

It has also been proposed, in the British Pat. No. 1,152,308, that a second, all metal, conductive screen or grid be utilized in the copying machine just described. This second screen or grid is positioned between the first, photoconductive screen and the receiving layer and forms an electrostatic shield which does not absorb a majority of the ion flow. The use of this

second screen decouples the voltage across the photoconductive screen from the voltage across the receiving layer. Thus, a relatively large potential can be established between the second screen and the receiving layer so that, it is said, diffusion of the ions will be minimized between the second screen and the receiving layer while permitting the thickness of the photoconductive layer on the first screen to be minimized relative to the thickness of the photoconductive coating that would be required for a comparable single screen machine. Since, it is said, the thickness of the photoconductive layer is a limiting factor of the machine, the use of the second screen, according to the disclosure in the British Pat. No. 1,152,308, permits a theoretical increase in the resolution of obtainable copies as compared to a single screen machine.

The present invention represents an important improvement to the two-screen copying machines disclosed in the British Pat. No. 1,152,308. Experimentation has shown that a copying machine embodying the present invention has the same advantages with respect to the two types of commercially available electrostatic copying machines and machines utilizing silk screen principles as do the two-screen machines disclosed in the British patent, while in addition, having the commercially significant advantages of having faster printing speeds, with a smaller corona power supply and much higher contrast ratios than can be obtained by the use of the two-screen machines disclosed in the British patent.

Machines embodying the principles of the present invention are structurally and functionally similar to the two-screen machine disclosed in the British patent except for a significant and critical difference which affords the advantageous and unexpected results provided by the invention. In the machines disclosed in the British patent, the second screen, i.e. the screen disposed between the first screen and the receiving layer, is a conductive metal grid or screen. In contrast, it has been found, through experimentation, that if the second screen has an insulator coating thereon, improved and unexpected results can be achieved relative to the results that would be obtainable by the two screen machines disclosed in the British patent.

Preferably, the second screen is a wire mesh screen having a photoconductive coating thereon. It has been found, again through experimentation, that by using such a photoconductive coated screen, a commercially significant increase in contrast can be obtained in the copies made, as compared to the contrast of copies made by a machine embodying the principle of the present invention but using a non-photoconductive insulator coating on its second screen. (In this regard it should be noted that experimentation has also shown that the contrast obtainable by the use of the latter machine, i.e. a machine having its second screen coated with a non-photoconductive insulator material, is far superior to the contrast obtainable by the use of the machine disclosed in the British patent. Moreover, it has been found that the contrast obtainable in the copies can be varied by varying the bias existing between the two screens so that this, together with the increase in contrast obtainable, permits the user of a machine embodying the present invention to be able to selectively match the contrast of the copies to be made with the contrast of the document to be copied.

Therefore, it is a primary object of the present invention to provide an improved electrostatic copying machine.

Another object of the present invention is to provide an improved electrostatic copying machine which includes: a grounded support for an image receiving layer; a corona discharge device; first and second screens disposed between the receiving layer and the corona discharge device wherein the first screen, i.e., the screen adjacent to the corona discharge device having a photoconductive coating thereon and wherein the second screen i.e., the screen adjacent to the receiving layer having an insulator coating thereon; means for projecting an optical image onto the surface of the first screen adjacent to the corona discharge device; means for biasing the first screen with respect to the second screen and with respect to the receiving layer; and a means for biasing the second screen with respect to the receiving layer.

A still further object of the present invention is to provide an improved copying machine of the type described wherein the second screen has a photoconductive coating thereon and wherein the improved machine includes a means for varying the bias between the first and second screens.

These and other objects and advantages of the present invention will become apparent from the following description of the preferred embodiment of the invention.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagrammatic illustration of an improved copying machine embodying the principles of the present invention; and

FIG. 2 is a schematic illustration of the image formation section of the improved machine shown in FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to FIG. 1, a copying machine embodying the principles of the present invention is shown diagrammatically at 11. The machine 12 includes an electrostatic image formation section 14, an image development section 16, and an image fixing section 18.

As more specifically described hereinbelow, the function of the image formation section 14 is to form an invisible, latent electrostatic image, corresponding to the optical image to be copied by the machine 12, on a receiving layer positioned in the section 14. This receiving layer could be conventional paper, either in sheet or web form, but may also be a wide variety of other materials and objects such as, for example, rugs, cloth clothing, and other textile fabrics; dishes, glassware, lighting fixtures, and other ceramic materials; oranges, candy, pills, and other odd-shaped articles; and bottles, plastic containers, cans, and other packaging materials. The only requirement for the receiving layer is that an electrostatic image can be formed or accepted on its surface and can be retained there for a finite period of time sufficient to enable the receiving layer to be conveyed to the image development section 16 and there made visible as hereinafter described.

After an invisible electrostatic image has been formed on the receiving layer, a mechanical drive means 20 is utilized to convey the receiving layer from the image formation section 14 to the image development section 16. This drive means 20 has a conven-

tional structure and mode of operation, with the specific structure and mode of operation of the means 20 depending on the receiving layer being used with the machine 12.

In the image development section 16, the invisible electrostatic image on the receiving layer may be made visible by any of the developing processes known in the art. For example, a developer of finely divided resinous toner particles may be cascaded across the surface of the receiving layer in the manner described in U.S. Pat. No. 2,638,416. Such toner particles adhere to the portions of the receiving layer on which the electrostatic image has been formed as a result of electrical attachment between the toner particles and those portions of the receiving layer. Thus, this adherence of the toner particles causes the formation of a visible image on the receiving layer corresponding to the electrostatic image which had been formed thereon in the image formation section 14.

The visible image thereby formed on the receiving layer may be made more permanent in the image fixing section 18. The receiving layer is conveyed from the image development section 16 to the image fixing section 18 by mechanical drive means 22. Like drive means 20, the drive means 22 has a conventional construction and mode of operation, with the specific construction and mode of operation of the means 22 depending on the particular receiving layer being utilized with the machine 12.

In the image fixing section 18, the visible image, formed by the toner particles, may be fixed more permanently onto the surface of the receiving layer by any process known in the art. For example, the image fixing process may be accomplished by the application of a heat fusing process or by exposing the toner image to vapors which are a solvent for the toner particles and which cause the particles to soften and coalesce together. Thereafter, the fused toner particles rehardens and cling to the receiving layer.

Subsequent to the image being fixed, the receiving layer is removed from the machine 12 by any conventional means known to the art.

Referring now to FIG. 2, the image formation section 14 of the machine 12 includes a support plate 24 which is electrically grounded and which is adapted to support an image receiving layer, such as a conventional dielectric paper sheet 26, during the image formation process. The plate 24 is constructed so that the plane of the paper sheet 26 is substantially horizontally disposed during the image formation process in section 14.

A first screen 28 and a second screen 30 are disposed above the upper surface of the sheet 26, as shown in FIG. 2. The screens 28 and 30 are made of conventional conductive, interwoven metal wire mesh. The second screen 30 is disposed adjacent to the upper surface of the paper sheet 26, and the first screen 28 is disposed above and adjacent to the second screen 30 with the screens 28 and 30 both being arranged so that they are both substantially horizontal.

The first screen 28 has a coating of a photoconductive material, such as zinc oxide or selenium, applied thereto. The second screen 30 has an insulator coating 34 such as polystyrene or an epoxy resin, applied thereto and functions as a biasing control grid. Preferably, this coating 34 is also a photoconductive material, such as zinc oxide or selenium, and in fact, the same

material may be utilized to coat both screens 28 and 30. The photoconductive insulating coatings may be incorporated onto the screen, for example, by oxidizing at least one side of the conductive screens and applying the photoconductive coating thereto. However, as noted above, the coating 34 of screen 30 does not have to be a photoconductive material so long as it is an insulator. As explained above and hereinafter, the application of the coating 34 to the second screen or biasing control grid 30 is the critical feature of the present invention since it is this coating 34 which causes the improved and unexpected results obtainable through the use of machine 12.

A conventional corona discharge device 38 is disposed above and adjacent to the upper surface 39 of the first screen 28. The corona device 38 includes a pair of electrodes 40 and 42 which are connected to a conventional power supply 44. The power supply 44 is also utilized to bias the first screen 28 with respect to the paper sheet 26 and with respect to the second screen 30 and to bias the second screen 30 with respect to the sheet 26. Preferably, the power supply 44 includes a conventional means for varying the bias of the first screen 28 with respect to the second screen or biasing control grid 30.

A document to be copied in the machine 12 is shown generally at 46 and may be, for example, a microfilm transparency. A horizontally disposed, transparent document support 48 is arranged to support the document 46 directly above the first screen 28. Light is projected through the document 46 by a conventional light 50 and is focused onto the upper surface 39 of the first screen 28 by a lens system 54 such that an optical image, corresponding to the document 46, strikes the surface 39 when the lamp 50 is energized. As shown, an electrically grounded, transparent shield 56 is disposed between the electrodes 40 and 41 and the lens system 54.

During operation of the image formation section 14, a document 46 to be copied is placed on the support 48 and the lamp 50 is energized. Simultaneously with the projection of an optical image on the surface 39 of the screen 28, the corona electrodes 40 and 41 are raised to a corona discharge potential by means of the power supply 44. In practice, it has been found that preferably the corona 38 should be operated at a potential somewhat above its threshold potential. Moreover it has been found that for multiple copies, the lamp 50 can remain illuminated while the corona device 38 is pulsed for each copy.

In response to the optical image, the photoconductive coating 32 on the screen 28 become selectively more conductive in the illuminated areas. As a result, disposition of electrical charge on the paper sheet 26 occurs such that a latent electrostatic image, conforming to the document 46, is formed on the paper sheet 26. The screen 30 functions as a means focusing, i.e., preventing diffusion, of the ions passing through the screens. Moreover, by varying the bias the first screen with respect to the second screen, the contrast of the latent image (more accurately, the image developed from this latent image) can be matched to the contrast of the document 46. After the latent electrostatic image has been formed on the sheet 26, the corona device 38 and the lamp 50 are turned off. As best seen in FIG. 1, the sheet 26 is conveyed to the image development section 16 and then to the image fixing section 18

by the mechanical means 20 and 22, respectively, wherein the latent image is made visible and is fixed relatively permanently onto the sheet 26. The sheet 26 is thereafter removed from the machine.

As shown in FIG. 2, the screens 28 and 30 are spaced vertically a distance D_1 while the second screen 30 is spaced vertically above the sheet 26 a distance D_2 and the first screen 28 is spaced vertically below the horizontal plane of the electrodes 40 and 41 a distance D_c . It has been found that in machines, such as the machine 12, satisfactory results can be obtained if the separate distance, D_1 , is between 1 millimeter and 1 centimeter; and the separation distance D_2 is between 1 millimeter and 1 centimeter; and if the power supply 44 is selected so that V_1 (i.e., the electric field between the screens 28 and 30) is between 500 volts per centimeter and 10,000 volts per centimeter and V_2 (i.e., the electrical field between the screen 30 and the sheet 26) is between 1,000 volts per centimeter and 20,000 volts per centimeter, with the distance D_c and corona device 38 being selected so that an electric field, resulting from the corona discharge, of between 3,000 volts per centimeter exists in the region of the upper surface 39 of the screen 28. Preferably, it has been found that for the best results, the distance D_1 should be less than 1 centimeter, with a photoconductive coated 40 mesh aluminum screen being used for the screens 28 and 30.

As noted above, unexpected and commercially significant results are obtainable through use of the machine 12, as compared to the two-screen machines disclosed in the British Pat. No. 1,152,308. More specifically, it has been found, through experimentation, that there is approximately 100 times current density in a machine utilizing the present invention (whether the coating 34 on screen 30 is photoconductive or not) as in machines constructed in accordance with the disclosure of the British patent. Thus, the time required to form a satisfactory latent electrostatic image on the paper sheet 26 is considerably shorter than the time required to form a comparable latent image by use of the machines disclosed in the British patent. Likewise, the optimum contrast ratio obtainable from the machines, as disclosed in the British patent, is about 3:1 (dark to light); whereas, the optimum contrast ratio obtainable with a machine embodying the principles of the present invention can be up to 10:1 (when the coating 34 on the second screen 30 is not photoconductive) and is up to 200:1 (when the coating 34 is photoconductive and with optimum tuning).

Thus, these significantly higher contrast ratios, in addition to the increase in current density, afford copying machines embodying the present invention, commercially important advantages as compared to copying machines in the prior art.

Lastly, it should be noted that while a preferred embodiment of the present invention has been described above, obvious modifications to machine 12 could be made. For example, the document 46 and support 48 could be arranged such that an optical image of the document 46 would be reflected from the document and this reflected optical image could be projected onto the first screen 28 by means of mirrors and a different lens system. Likewise, while the screens 28 and 30 have been described as being an interwoven mesh, they could have other forms and constructions. Further, the described vertical orientation of the machine 12 is not essential. Therefore, the specific embodi-

ments described above are to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than the foregoing descriptions, and all changes that come within the meaning and range of equivalency of the claims are, therefore, intended to be embraced therein.

We claim:

1. An improved copying machine for reproducing, on a dielectric receiving layer, an optical image conforming to an original to be copied, the improved machine comprising:

a. means adapted for forming latent electrostatic image on a surface of a dielectric receiving layer comprising:

means adapted to support the receiving layer while an electrostatic image is being formed thereon; ion generating source positioned at one side of and spaced from said surface of the receiving layer as it is supported by the supporting means; relatively high voltage power supply means which, when connected to the ion generating source, maintains the ion generating source at an ion discharge potential; first electrically conductive, electrostatic and electrophotographic grid means spaced from and positioned between the ion generating source and the receiving layer as it is supported by the supporting means; biasing control grid means spaced from and positioned between the first grid means and the receiving layer as it is supported by the supporting means, the biasing control grid means having an electrically insulating outer coating thereon;

first means for electrically biasing the first grid means with respect to the biasing control grid means and with respect to the receiving layer as it is supported by the supporting means;

second means for electrically biasing the biasing control grid means with respect to the receiving layer as it is supported by the supporting means; means for projecting an optical image, conforming to the original to be copied, onto one surface of the first grid means; and

means for connecting the power supply means to the ion generating source, and thus causing ion discharge, simultaneously while said optical image is being projected onto the first grid means, while the first biasing means biases the first grid means with respect to the biasing control grid means and with respect to the receiving layer, and while the second biasing means biases the biasing control grid means with respect to the receiving layer;

b. means for applying toner to the electrostatic image formed on the receiving layer;

c. means for fixing the toner on the receiving layer; and

d. means for transporting the receiving layer from the supporting means to the toner applying means and then to the toner fixing means.

2. The improved machine described in claim 1 wherein the first grid means is a wire mesh screen having a photoconductive coating thereon; and wherein the first biasing means is connected the wire mesh.

3. The improved machine described in claim 2 wherein the biasing control grid means is a wire mesh screen having an electrical insulating coating thereon;

and wherein the second biasing means is connected to the wire mesh.

4. The improved machine described in claim 2 wherein the biasing control grid means is a wire mesh screen having a photoconductive coating thereon; and wherein the second biasing means is connected to the wire mesh.

5. The improved machine described in claim 2 which includes means for varying strength of the electric field between the biasing control grid means and the first grid means so as to vary the contrast of the electrostatic image formed on the receiving layer.

6. For use in a copying machine, an improved apparatus for reproducing, on a surface of a dielectric receiving layer, an electrostatic image conforming to an optical image to be copied, the improved apparatus comprising:

means adapted to support the receiving layer while an electrostatic image is being formed thereon; an ion generating source positioned at one side of and spaced from the surface of the receiving layer as it is supported on the supporting means; relatively high voltage power supply means which, when connected to the ion generating source, maintains the ion generating source at an ion discharge potential; first conductive, electrostatic and electrophotographic grid means spaced from and positioned between the corona generating means and the receiving layer as it is supported by the supporting means; biasing control grid means spaced from and positioned between the first grid means and the receiving layer as it is supported by the supporting means, the biasing control grid means having an electrically insulating outer coating thereon; first means for electrically biasing the first grid means with respect to the biasing control grid means and with respect to the receiving layer as it is supported by the supporting means; second means for electrically biasing the biasing control grid means with respect to the receiving layer as it is supported by the supporting means; means for projecting an optical image, conforming to the original to be copied, onto the first grid means; and means for connecting the power supply means to the ion generating source, and thus causing ion discharge, simultaneously while the optical image is being projected onto the first grid means, while the first biasing means biases the first grid means with respect to the biasing control

trol grid means and with respect to the receiving layer, and while the second biasing means biases the biasing control grid means with respect to the receiving layer.

7. The improved apparatus described in claim 6 wherein the first grid means is a wire mesh screen having a photoconductive coating thereon; and wherein the first biasing means is connected to the wire mesh.

8. The improved apparatus described in claim 7 wherein the biasing control grid means is a wire mesh screen having an insulating coating thereon; and wherein the second biasing means is connected to the wire mesh.

9. The improved apparatus described in claim 7 wherein the biasing control grid means is a wire mesh screen having a photoconductive coating thereon; and wherein the second biasing means is connected to the wire mesh.

10. The improved apparatus described in claim 8 wherein an electric field of between approximately 1,000 volts per centimeter to 20,000 volts per centimeter exists between the biasing control grid means and the receiving layer as it is supported by the support means, with the separation distance between the biasing control grid means and the receiving layer being between approximately 1 millimeter and 3 centimeters; wherein an electric field of between approximately 500 volts per centimeter to 10,000 volts per centimeter exists between the first grid means and the biasing control grid means, with a separation distance between the first grid means and the biasing control grid means being between approximately 1 millimeter and 1 centimeter; and wherein an electric field, resulting from the corona discharge, of between approximately 3,000 volts per centimeter to 10,000 volts per centimeter exists in the region of the first grid means.

11. The improved apparatus in claim 10 which includes means for varying strength of the electric field between biasing control grid means and the first grid means so as to vary the contrast of the developed electrostatic image formed on the receiving layer.

12. The improved apparatus described in claim 10 wherein the separation distance between the first grid means and the biasing control grid means is less than 1 centimeter and wherein the coating on wire mesh screen of the biasing control grid means is photoconductive.

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