

- [54] **HIGH SPEED ELECTROSTATIC PRINTING TUBE USING A MICROCHANNEL PLATE**
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- [52] U.S. Cl. **346/74 P, 250/49.5 E, 313/105, 346/74 EB, 346/74 ES**
- [51] Int. Cl. **G01d 15/06, G03g 15/04**
- [58] Field of Search **346/74 CR, 74 ES, 346/74 P, 74 EB, 74 R; 250/49 SE; 313/105**

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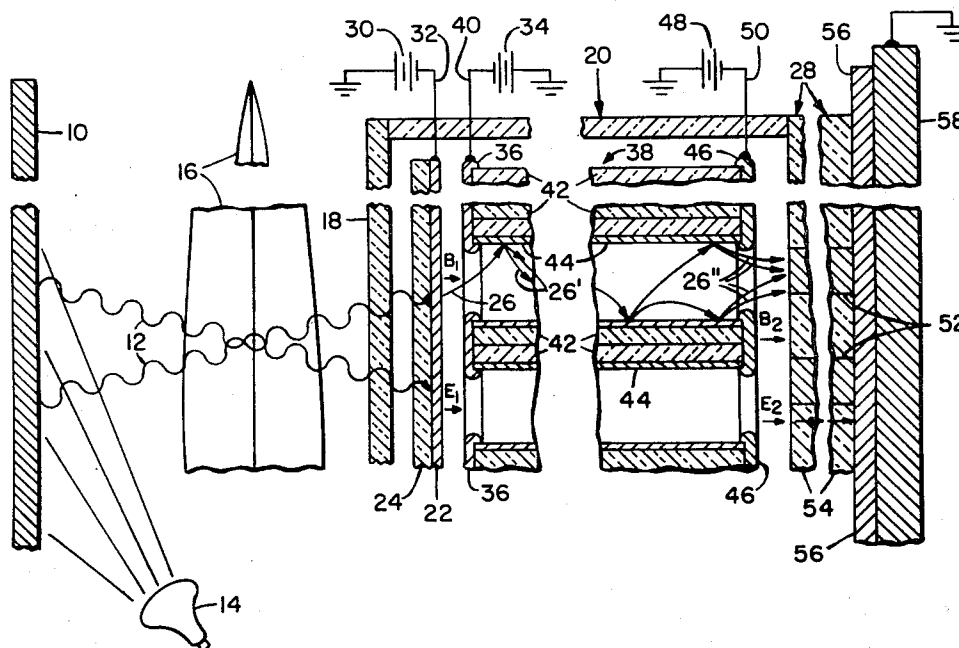
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[57]

ABSTRACT

Apparatus for converting a photon input image into an electron image, intensifying the electron image, and then depositing the electron image on a dielectric target medium as an electrostatic charge pattern which corresponds to the input image. The apparatus comprises means for providing a photon image, a photocathode to convert the photon image to an electron image, a microchannel plate which intercepts and provides electron multiplication of the electron image, and a multilead array which collects the multiplied electrons. The multiplied electrons are then transferred onto a dielectric target medium thereby disposing on the target an electrostatic charge pattern which corresponds to the input image and which may be developed and fixed by standard techniques.

22 Claims, 7 Drawing Figures



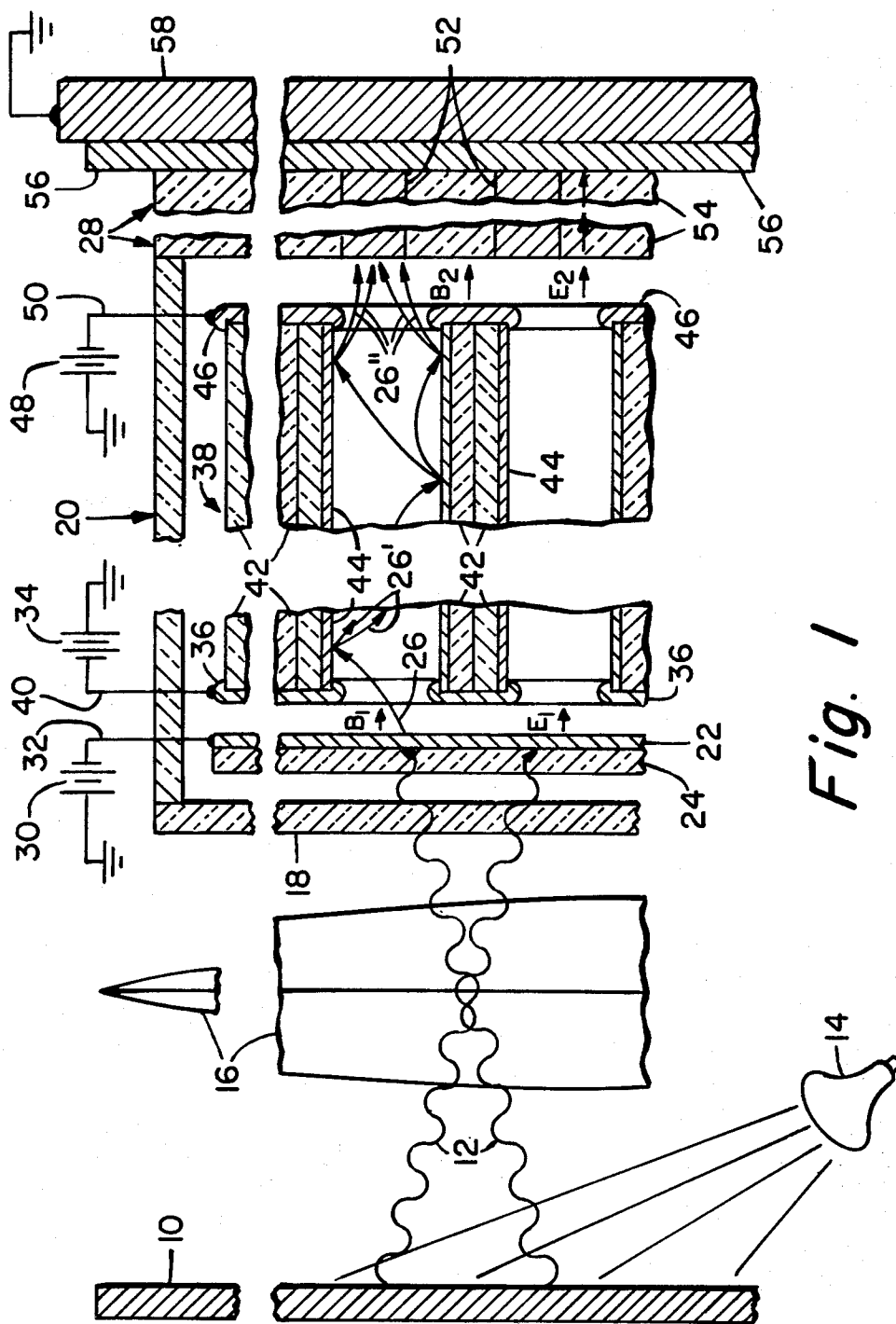


Fig. 1

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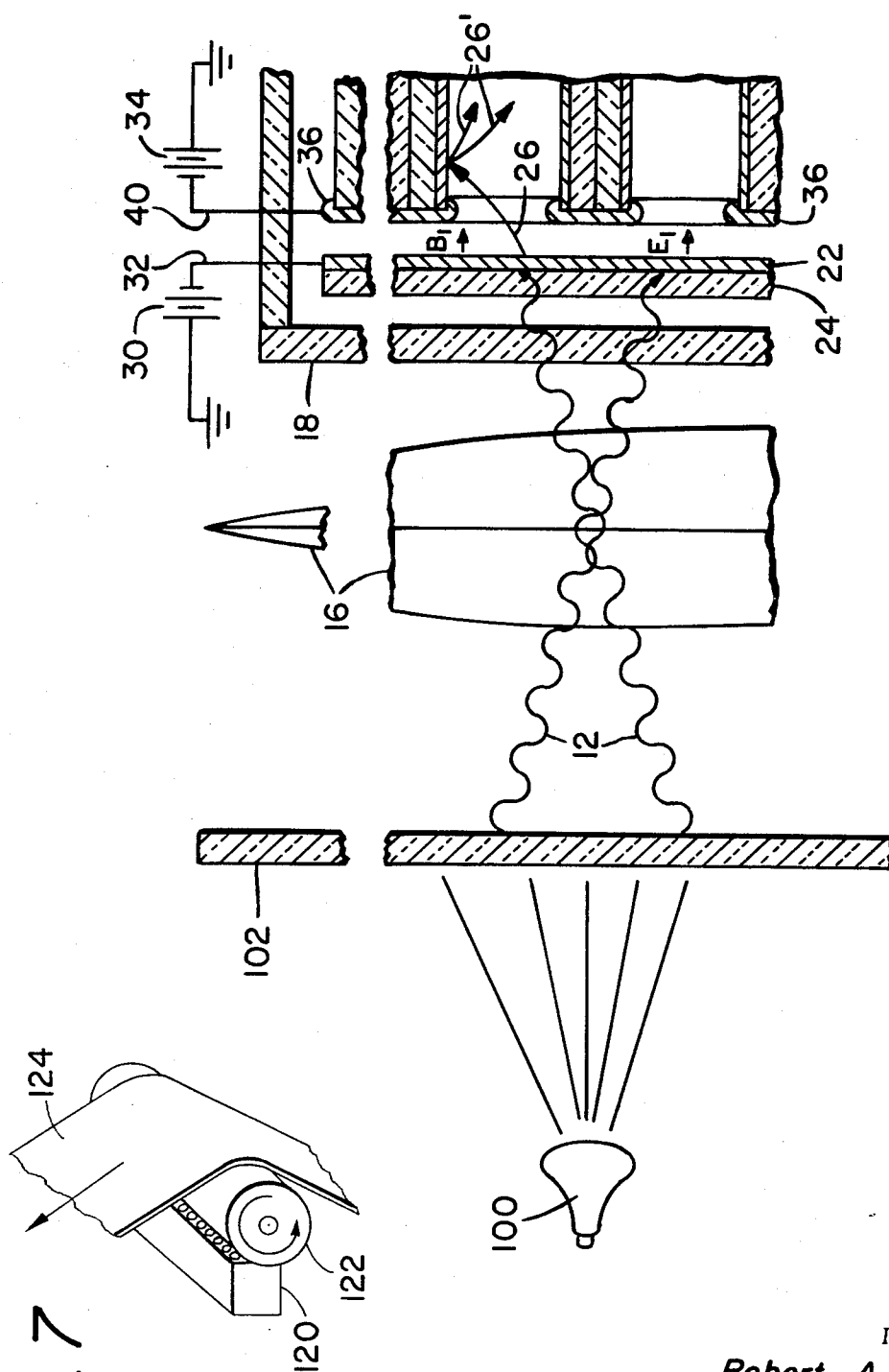


Fig. 7

Fig. 2

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Fig. 3

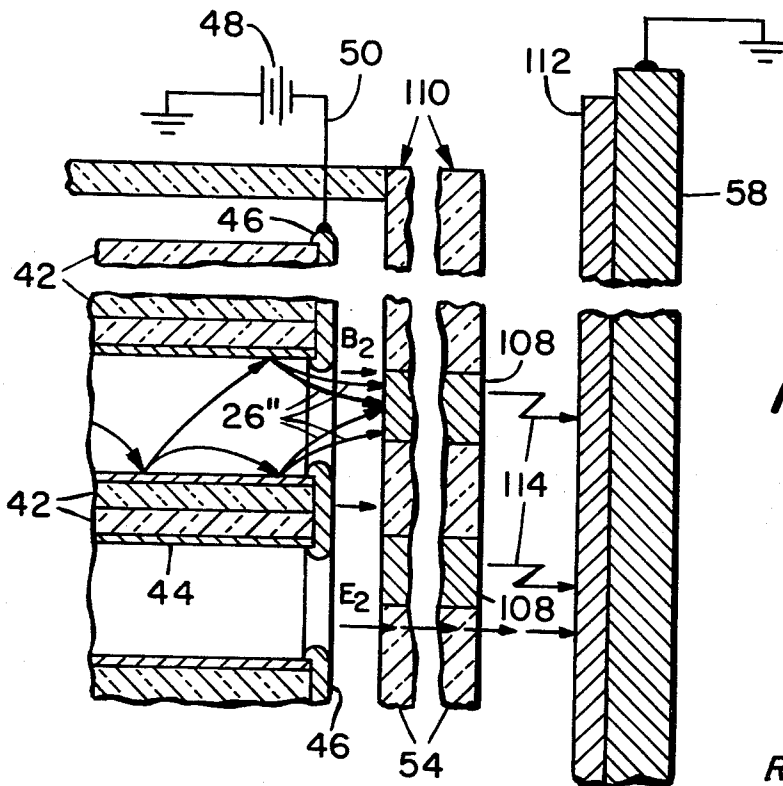
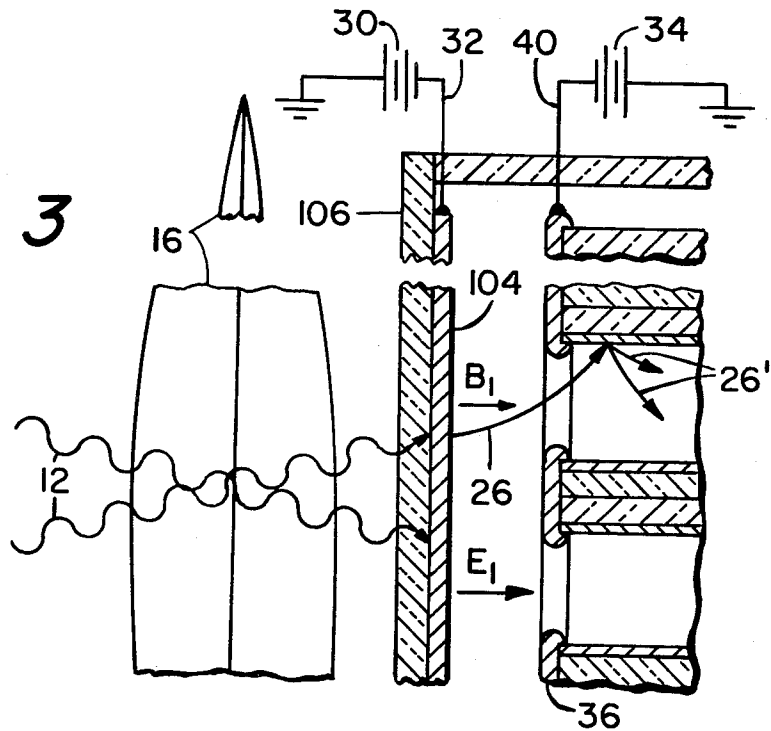


Fig. 4

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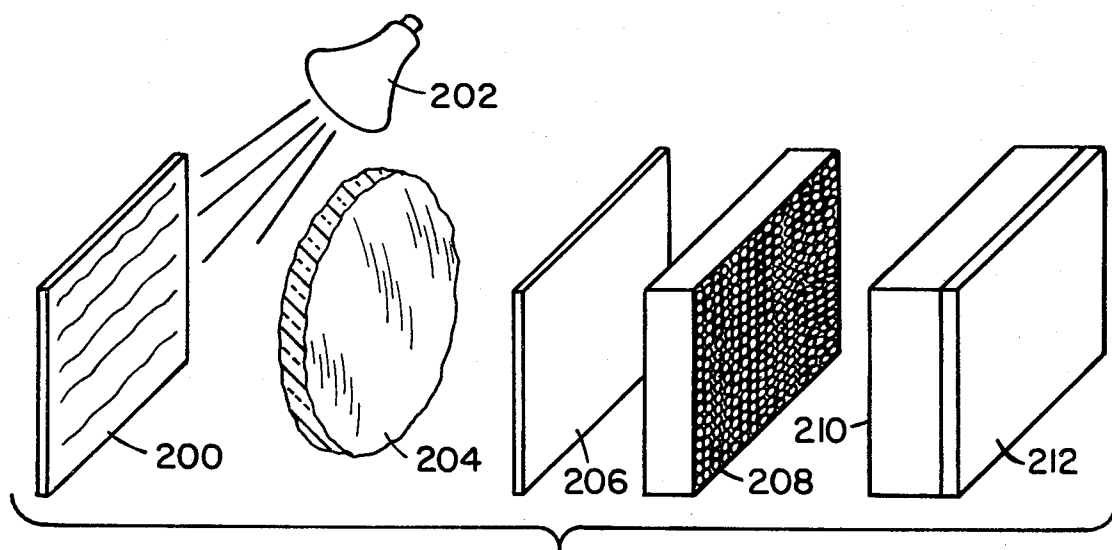


Fig. 5

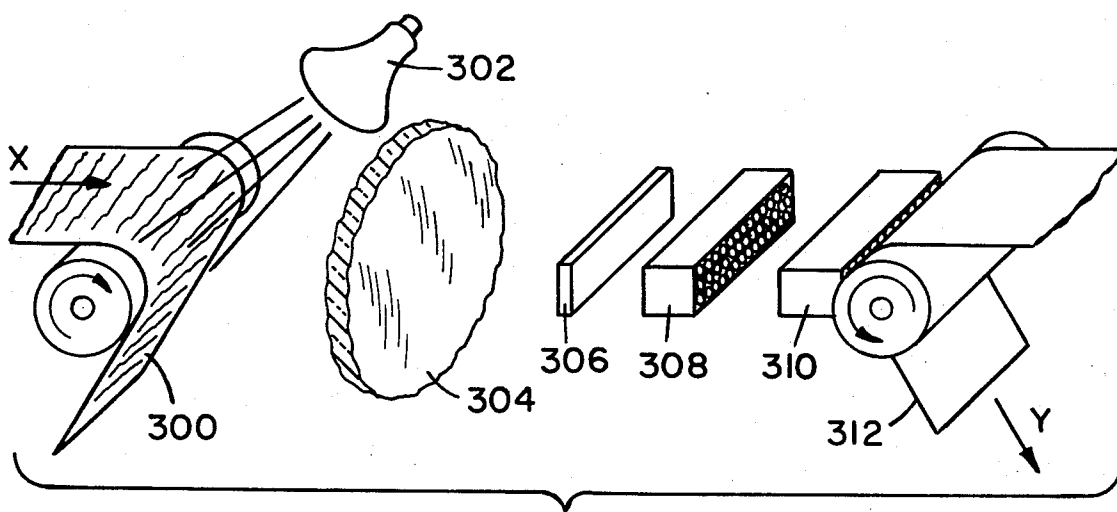


Fig. 6

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HIGH SPEED ELECTROSTATIC PRINTING TUBE USING A MICROCHANNEL PLATE

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to improved photon to electron or electrostatic image conversion devices and to electrostatic printing apparatus utilizing the same. More particularly, this invention relates to high speed apparatus which converts a photon image to an electron image, intensifies the electron image, and then deposits the electron or electrostatic image on a dielectric target. The dielectric target may be paper to which toner is added and fixed to develop the electrostatic image.

2. Description of the Prior Art

There are several well known methods for making a photon image to electrostatic image conversion which include "Xerox" and "Electrofax" processes. In such processes a charged photo conductive surface is exposed to the photon image to be reproduced. During exposure to said image, those areas of the photoconductive surface which are illuminated become conductive, dissipating the surface charge previously placed on the photoconductive surface. Those areas which were not illuminated remain charged and attract toner particles to develop a visible image which is then fixed. This process, although commercially successful is complex, costly and is generally incapable of reproducing half tones and heavy black areas with the desired quality.

Another known method uses a cathode ray tube, (CRT), having, instead of a normal screen, an array of conductive pins embedded in the CRT screen on which the electron beam impinges. In this method, a television type pick-up camera is used to convert the photo image to a video signal, and the resulting signal then controls the electron flow between the cathode and the conductive pin array of the CRT. Standard television scan speeds and methods of sweep and intensity control are used to direct the image modulated electron beam onto the pins. Electron flow from the conductive pin array onto a dielectric medium results in an electrostatic image which is then developed and fixed by a method such as that used by the "Xerox" process. The cost and complexity of the combination cathode ray tube, conductive pin array and auxiliary electronic components prevents widespread application of this system.

Another more recent system is described in U.S. Pat. No. 3,419,888 by R. M. Levy comprising a photo electric material which emits electrons in accordance with an optical image desired to be reproduced. These electrons are captured by a conductive pin or wire array similar to that used in the cathode ray tube and conductive pin array combination. One end of said pins being in very close proximity to the photo electron material. This electron image is then carried by the conductive pins or wires directly toward a dielectric material on which it impresses an electron or electrostatic image corresponding to the optical input image. The image may then be developed and fixed by a method such as the "Xerox" method. This system is presently unacceptable for commercial use because of the very low current density and the resulting slow writing speed. Current density determines both the writing speed and the photo cathode life span. If the current density is in-

creased to increase the writing speed, the life of the cathode is significantly decreased.

SUMMARY OF THE INVENTION

- 5 It is therefore an object of the present invention to provide simple, economical high speed apparatus for converting a photon image into an electron image, and transferring said electron image onto a dielectric target. The image may then be developed and fixed.
- 10 Briefly, the high speed photon to electrostatic printing device of this invention comprises means for providing a photon image of an item or document to be electrostatically reproduced. Also included is a photon image to electron image converter and intensifier comprising an evacuated container having a first wall portion through which said photon image may be projected, a photo cathode disposed within said container to intercept said photon image and give off electrons corresponding to said photon image, and a microchannel plate disposed within said container for intensifying said electron image. A multilead array comprises a second wall portion of said evacuated container, said multilead array being disposed such that one surface of said multilead array is within said evacuated container and the other surface is outside of said evacuated container whereby the intensifier electron image from said microchannel plate may be conducted out of said evacuated container. A dielectric target is disposed adjacent to said outside surface of said multilead array such that said intensified electron image may be transferred to said dielectric target.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an illustration, partly schematic and partly in cross-section, of an electrostatic printer incorporating this invention.

FIG. 2 is an illustration, partly schematic and partly in cross-section, of an alternate embodiment of the device illustrated in FIG. 1 showing a photon image input produced by transparent originals.

FIG. 3 is an illustration, partly schematic and partly in cross-section, of another alternate embodiment of the device in FIG. 1, showing the photo cathode applied to the wall portion of the evacuated container.

FIG. 4 is an illustration, partly schematic and partly in cross-section, of still another alternate embodiment of the device of FIG. 1, showing the dielectric target spaced at a distance from the multilead array.

FIGS. 5 and 6 are exploded oblique illustrations of two additional alternate embodiments of this invention.

FIG. 7 is a fragmentary illustration of still another embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

55 In the copier shown in FIG. 1, light modulated by the image of a document, original paper or other item 10 which is to be reproduced is represented by undulated arrows 12. The modulated light or photon image is produced by light from light source 14 being reflected off of the document 10 to be copied. FIG. 2 shows an alternate method of producing said photon image wherein light from light source 100 is projected through a document or other item 102 to be copied. The term photon image when used herein not only includes images being transmitted by visible light rays, but also includes images transmitted by invisible light rays such as infrared, ultraviolet and X-rays. Referring again to FIG. 1, lens

system 16 projects and focuses said photon image through a first wall portion 18 of evacuated container 20 onto photo cathode 22 supported by glass substrate 24 which converts said photon image into an electron image by emitting electrons represented by arrow 26 in a density pattern corresponding to variations in the photon image of the document being reproduced. Container 20 is a sealed structure evacuated to a vacuum level within the range commonly used by standard vacuum tubes such as approximately 10^{-7} torr. Said container 20 may be formed from any suitable material such as metal, glass or the like except for said first wall portion 18 which is formed of a material that will readily transmit said photon image, such as transparent glass, and a second wall portion comprising a multilead array 28 hereinafter described. Suitable photocathodes may readily be fabricated by one familiar with the art by depositing a layer of photo emissive material over one surface of a transparent glass substrate. Photo emissive layers consisting of the alkali metal cesium in combination with silver, bismuth or antimony will respond to wavelengths of light in the range from infrared through the visible and ultraviolet and up to and including X-rays. Photo emissive layers consisting of any of the alkali metals or combinations thereof will respond to wavelengths of light in the range from visible through ultraviolet and up to and including X-rays. Photo emissive layers of most other metals will respond to wavelengths of light in the range from ultraviolet and up to and including X-rays. The most suitable metals being aluminum, gold or nickel.

FIG. 3 shows an alternate embodiment of the present invention wherein the photo-cathode is fabricated by depositing a layer 104 of photo emissive material or transparent wall portion 106 of the evacuated container.

The negative side of potential source 30, which source is outside of evacuated container 20, is connected to photocathode 22 by conductive means 32 and the positive side of said potential source is connected to ground. The negative side of potential source 34, which source is also outside of evacuated container 20 and the potential of which is less than potential source 30, is connected to conductive layer 36 on the input surface of microchannel plate 38, hereinafter discussed, by conductive means 40. The positive side of potential source 34 is also connected to ground. As will be understood, the potential on conductive layer 36 will therefore be greater than the potential on photo cathode 22. Accordingly, a potential or electrical field E_1 will exist between photo-cathode 22 and conductive layer 36 which will focus and accelerate the electrons emitted by photo-cathode 22 toward microchannel plate 38. The electrons traveling between the photocathode and the microchannel plate may also be focused by applying a magnetic field which is represented by arrow B_1 . However, if an electrical field E_1 of between 10 volts/0.001 inch and 50 volts/0.001 inch exists between the photo-cathode and the input surface of the microchannel plate, said electrical field will be sufficient for focusing, and additional magnetic focusing of the electrons would ordinarily be unnecessary. For example, if the spacing between the two members is about 0.02 inch and a potential or electrical field of 300 volts exists between photo-cathode 22 and conductive layer 36 the electrical field will be about 15 volts/0.001 inch, and the electrons will travel in sub-

stantially parallel paths without magnetic focusing. Testing indicates that an electrical field of approximately 30 volts/0.001 inch and a spacing of between 0.010 inch and 0.1 inch will produce the most effective focusing.

The electrons emitted by photo-cathode layer 22 and illustrated by arrow 26 then enter the electron multiplying microchannel plate 38 which is also within evacuated container 20. It is to be noted that the drawings are illustrative only and are not to scale. The microchannel amplifier and the multilead array are greatly enlarged with respect to the other portions of the drawings so that the operation of these components may be more readily understood. The microchannel plate consists of a plurality of glass tubes or microchannels 42 each having a secondary emissive surface 44 formed on the inside wall surface of said tubes. The microchannel plate may be formed in accordance with the teachings of U.S. Pat. No. 3,341,730 to G. W. Goodrich et al. Microchannel plates for use as electron multipliers are normally formed of tubes with an inside diameter of about 50 microns, and the thickness of the plate or the length of the tubes are normally in the range of 25 to 100 times the tube diameter. The tube inside diameter range and the microchannel plate thickness range heretofore set out are not critical and in some instances it may be desirable to operate outside of these given ranges. The inside diameter range and the length range as given represent particularly suitable dimensions for microchannel amplifier plates produced to date. However, new developments in the field of microchannel amplifiers may result in other more favorable dimensions. Secondary emissive surface 44 comprises a metal oxide such as tin oxide, lead oxide, aluminum oxide and the like, or any other semi-conductive material having good secondary emissive characteristics such as strontium titanate or vanadium phosphate and the like. A particularly suitable microchannel plate with a secondary emissive surface 44 for use with this invention may be obtained by forming said microchannel plate from glass tubes containing lead oxide, and then reducing some of the lead oxide in the glass to a semiconductive lead oxide. The technique comprises subjecting the inside surfaces of the glass tubes, which form the channels, to a hydrogen reducing atmosphere at an elevated temperature which results in a semiconductive lead oxide being formed. This semiconductive lead oxide forms in minute globules which are randomly scattered in the inside surface glass of each tube. The input and output surfaces of the microchannel plate are provided with conductive layers 36 and 46 respectively. Each conductive layer being at least 1000A in thickness and may be deposited on the ends of microchannel plate 38 by such methods as including but not limited to sputtering and evaporation, said conductive layers may consist of such materials as aluminum, gold, silver, chrome filled alloys or the like. In addition to potential source 34 which is connected to conductive layer 36 of said microchannel plate, the negative side of potential source 48, is connected to conductive layer 46 on the output surface of microchannel plate 38 by conductive means 50 and the positive side of said potential source 48 being connected to ground. Source 48 is also outside of evacuated container 20 and has a potential less than potential source 34. As will be understood, the potential on conductive layer 46 will therefore be greater than the potential on conductive layer 36. Accordingly,

a potential will also exist between the input and output surfaces of said microchannel plate. During operation of the microchannel plate, electrons represented by arrow 26, which have entered said microchannel plate, impact with channel secondary emissive surface 44, and give rise to secondary electrons represented by arrows 26' which in turn impact said secondary emissive surface further down the channel giving rise to still additional secondary electrons represented by arrows 26''. This cascading process continues for the length of the channel thereby resulting in a large electron gain. In addition to intensifying the electron image by increasing the number of electrons available for depositing on multilead array 28, described hereinafter, microchannel plate 38 has a further advantage of requiring no focusing field in the region of the microchannel plate since it has parallel tubular holes therein within which the electrons are confined.

Microchannel plate 38 can provide extremely high current gains of around 10^4 to 10^6 , and the gain may be adjusted below such range to any appropriate value. Such adjustment may be accomplished by varying the potential that exists between the input and output surfaces of said microchannel plate. This potential is typically around 1000 volts and provides the operating potential for the microchannel plate. As a result of electrical field E_2 , to be further discussed hereinafter, which exists from the output surface of the microchannel plate, across multilead array 28, to dielectric target 56, the multiplied electrons will leave the end of the microchannel plate and impact on multilead array 28, thereby depositing an intensified electron image which corresponds to the input photon image on said multilead array. For the sake of clarity, only the secondary electrons represented by arrows 26'' in FIG. 1 are shown leaving said microchannel plate. If necessary or if otherwise desired, the electrons traveling between the output surface of said microchannel amplifier and the adjacent and parallel side of said multilead array may be focused by a magnetic field represented by arrow B_2 so that they travel in a path substantially perpendicular to the plane of the microchannel plate and the multilead array. However, if electrical field E_2 is at least 10 volts/0.001 inch there will normally be no need for magnetic focusing between these two members.

Multilead arrays of the type used in this invention are fabricated by embedding parallel, miniature diameter on cross-section conductors 52 perpendicular to the plane of an insulating plate 54 of a material such as glass, glass-ceramic or ceramic. The ends of conductors 52 are exposed on both faces of said insulating plate 54 thereby providing a plurality of individual conductive paths through said insulating sheet. A typical multilead array may contain conductive pins with a diameter of 0.001 inch on 0.004 inch centers. The diameter of the conductors in a suitable multilead array for this invention is not critical, and may vary greatly with different arrays. Some arrays may use conductors with a diameter no greater than 5 microinches, while other arrays may use conductive pins with a diameter as large as 0.010 inch. The diameter of the glass tubes used in the microchannel amplifier may also vary greatly as explained heretofore. Therefore, as an example, FIG. 1 shows the conductive pins of the multilead array as having a diameter slightly smaller than that of the inside diameter of the microchannel amplifier tubes. It is entirely feasible, however, to use a multilead array hav-

ing conductive pins with diameters many times greater than even the outside diameter of the microchannel amplifier tubes. If such a selection of components is chosen, the only change in operation from that illustrated by FIG. 1 is that a plurality of microchannel tubes will feed a single conductive pin. However, because of the extremely small size of even the largest diameter pin likely to be used in the multilead array, any decrease in the resolution of the electron image would be imperceptible to the unaided eye. The thickness of the multilead array may also vary according to the specific need.

The electrons on the multilead array which comprise the intensified electron image may then be transmitted outside of said evacuated container by the conductors of said multilead array and deposited on a dielectric target 56 such as paper, glass or the like as an electron or electrostatic image which corresponds to the photon input image. The electrostatic image may then be developed and permanently fixed by well known techniques such as those commonly used by "Xerox" or "Electrofax" copiers.

If dielectric target 56 is initially at any potential more positive, such as ground for example, than conductive layer 46 of microchannel plate 38, electrical field E_2 will exist. As a result of said electrical field E_2 , not only will the multiplied electrons from the microchannel plate be focused and accelerated such that they collect on said multilead array, but said multiplied electrons that have collected on said multilead array will be attracted towards said dielectric target where they may be deposited. Therefore, areas of said target where electrons are deposited will be charged by said deposited electrons such that the potential of said areas varies from the initial dielectric target potential to a level significantly below such potential. The electrostatic image created by the potential variation on the dielectric target corresponds to the intensified electron image on the multilead array which in turn corresponds to the input photon image. In the preferred embodiment illustrated in FIG. 1 one surface of dielectric target 56 is fully in contact with a conductive plate 58 which is connected to ground. Therefore, prior to any electron deposition by multilead array 28, dielectric target 56 is substantially at ground potential. Consequently, a potential will exist not only between dielectric target 56 and conductive layer 46 of said microchannel plate 38 but also between conductive plate 58 and conductive layer 46. As a result of grounded conductive plate 58 the potential on said dielectric target will not tend to vary. It will be readily understood by those skilled in the art that the toner used to develop electrostatic images such as those discussed above may be positively or negatively charged as necessary for proper image development.

Since the intensity of the electrostatic image on the dielectric target determines the quantity of toner attracted to any one portion of said image, a continuous gray scale between white and black can be reproduced if the intensity of different portions of the electrostatic image corresponds to the gray scale of the corresponding portions of the document or item being reproduced. The intensity of any portion of an electrostatic image is determined by how many electrons are deposited in that portion of the electrostatic image by the corresponding portion of the multilead array, and the amount of charge or the number of electrons deposited

by a particular conductive pin will vary proportionally with variation of the photon image input.

Methods of transferring an electrostatic image from the multilead array to a dielectric target include but are not limited to the three discussed below. The first and simplest method is to place the dielectric target directly against the multilead array, as is illustrated in FIG. 1, such that the electrons flow directly from the conductive pins on to the surface of the dielectric target.

Two other methods involve the use of an arc discharge between the conductive pins and the dielectric target which is at some predetermined distance from the conductive pins. Results satisfactory for most applications may be achieved as long as such distance is no greater than about 0.002 inch. As is illustrated in FIG. 4, in both arc discharge methods, when the electrical potential difference between conductive pins 108 of multilead array 110 and dielectric target 112 reaches the value necessary for electrical breakdown, the air therebetween ionizes and an arc discharge occurs as illustrated by arrows 114.

When said arc discharge occurs between all of the charged conductive pins and the dielectric target an electrostatic image is deposited on said dielectric target which corresponds to the photon input image received by the photo cathode. The amount of charge deposited on the target by each conductive pin will vary if either (1) the number of arc discharges between pin and target is different for each pin, or if (2) the duration and intensity of the arc discharge of each pin varies. For example, it is assumed that a document to be reproduced varies from very black through all shades of gray to very white.

In the first arc discharge method, the light reflected from the white portions of the document may stimulate the corresponding areas of the photo cathode to emit such a large number of electrons that when said electrons are multiplied by the microchannel plate, the corresponding conductive pins in the multilead array may charge up to the level necessary for electrical breakdown and arc discharge several hundred times as the original document is being exposed. In contrast, the stimulus to a corresponding area of the photo cathode from the very black portions of the document may be so slight and the emitted electrons so few that, even after multiplication by the microchannel amplifier, the corresponding pins in the multilead array may never reach the necessary potential for even a single arc discharge during the time the original document is being exposed. Between these extremes, an electrostatic image with varying charge intensity is produced which corresponds to the gray scale of the original document. That is, the number of arc discharges of different conductive pins will vary from zero up to the maximum possible as the portions of the document being reproduced vary from black through various shades of gray to white.

In the second arc discharge method, an electron image, which corresponds to the document being reproduced is generated on the multilead array by charging the individual pins in said multilead array to different levels during the period said document is exposed. Variations in the level of charge between any one conductive pin and another is determined by variations in the gray scale of the document being reproduced. After the electron image has been generated on the multilead array, the complete array is then discharged at one time

onto the dielectric target. The amount of charge deposited on any one portion of said target depends upon the amount of charge existing on the corresponding conductive pin or pins just prior to the arc discharge. The discharge of the multilead array may be initiated when desired by any suitable technique including but not limited to bringing the target closer to said array, thus reducing the potential difference necessary for an arc discharge; or by changing the target potential or the potential of the conductive back plate in a step change such that the electrical potential difference between each of the conductive pins and the dielectric target is sufficiently great to initiate an arc discharge.

In tests using an apparatus built in accordance with the present invention, excellent high quality electrostatic images have been produced by exposing the photo cathode to a photon image of a document to be reproduced for a period of time of not less than 2 milliseconds, and acceptable quality images have been produced by exposure periods of as low as 0.1 milliseconds. Therefore, apparatus built in accordance with the teachings of this invention has a theoretical copying speed or reproducing speed of at least 500 copies per second. It is to be further noted that this high copying speed is possible because of the high amplification available from the microchannel amplifier. The copying speed may be increased by increasing microchannel amplifier gain.

In addition to transferring the electrostatic image directly onto a target where it is developed and permanently fixed, the electrostatic image may be transferred from multilead array 120 onto a dielectric drum 122 or plate for temporary storage and then subsequently transferred onto another dielectric material such as paper 124 or glass on which the electrostatic image is developed and permanently fixed, as illustrated in FIG. 7.

FIG. 5 illustrates one embodiment of the present invention wherein an electrostatic image of the entire document to be copied is produced at once. For the sake of clarity the evacuated container is not shown in this illustration. The entire document 200 is illuminated by light source 202, and a photon image corresponding to the complete document is projected from said document through lens system 204 toward photo cathode 206. The photo cathode 206, microchannel amplifier 208, multilead array 210, and the dielectric target 212 are all at least of a size sufficient to produce a resulting electrostatic copy of the complete document. Accordingly, all portions of the photon image are converted to an electron image, intensified and then deposited on the dielectric target at substantially the same time.

FIG. 6 illustrates another embodiment of the present invention wherein the original document to be copied moves past the photo cathode. For the sake of clarity, the evacuated container is not shown in this illustration. Document 300 to be copied is illuminated by light source 302 such that a photon image of a portion of said document is projected through lens system 304 onto photo cathode 306. Document 300 moves in direction X such that said photon image of the top portion of the document is projected onto photo cathode 306, and as the document continues to move said photon image of said top portion passes out of range of said photo cathode and the photon image of a succeeding lower portion of the document moves into range. The

movement of the document past the photo cathode continues until said photo cathode has been exposed to photon images comprising the entire document. The electrons emitted by said photo cathode are multiplied by a microchannel amplifier 308 and impinge and are collected by multilead array 310 from which they are transmitted to a dielectric target precisely in the same manner as previously described. Dielectric target 312, of a material such as paper, moves in direction Y past the output end of the multilead array at a speed synchronized to the speed of the document moving past the photo cathode and illuminating light. Because of such synchronous motion an electrostatic image corresponding to the complete document is transferred to said dielectric target as said target moves past said multilead array 310. The electrostatic image may then be developed and permanently fixed by known methods. This embodiment, although more complex than the embodiment of FIG. 5 due to the requirement of synchronous movement of the document to be copied and the target paper, can use a photo cathode, microchannel amplifier, and multilead array of considerably smaller size than can be used in the embodiment of FIG. 5. This smaller size is possible because the complete electrostatic image of the document to be copied is not produced at one time. Although the embodiment of FIG. 6 is described in terms of the original document moving past the photo cathode, and the dielectric target moving past the multilead array, there are other possible methods of obtaining the necessary motion between the respective components still consistent with the teachings of this invention. For example, the document and the dielectric target may be stationary during the exposure period while the photo cathode, microchannel plate and multilead array combination move between or past said document and dielectric target. Further, there may be a combination of linear or arcuate movement of any or all of the document, target, and the combination of the photo cathode, microchannel plate and multilead array.

A specific example of working prototype of an electrostatic copying device of the type illustrated in FIG. 3 and built in accordance with the teachings of this invention follows. A multilead array of approximately 0.090 inch thick comprising a sheet of glass in which approximately 0.001 inch diameter conductive pins were embedded on approximately 0.004 inch centers. The ends of said conductors were exposed in the multilead array input and output surfaces. A cylindrically shaped hollow container was provided and the multilead array was used to cap off one end thereof comprising the output end of the device.

The photo cathode was fabricated by vacuum evaporating a film of aluminum having a thickness of 300A onto one surface of a 1/8 inch thick disk shaped glass substrate. Such a photo cathode is readily stimulated by ultraviolet light with a wavelength of approximately 2537A.

A disk shaped microchannel amplifier was aligned with said photo cathode and spaced approximately 0.020 inch away from the coated size of said photo cathode. Said amplifier comprised of a plurality of lead oxide containing glass tubes of approximately 0.1 inch in length with an inside diameter of about 50 microns. The secondary emissive layer on the inside surface of each of the microchannel glass tubes was produced by subjecting said surfaces to a hydrogen atmo-

sphere at approximately 425°C. A conductive aluminum film was deposited by vacuum evaporation on the input and output surfaces of said amplifier.

The above components were placed in said container and disposed so that the output surface of the microchannel amplifier was spaced approximately 0.01 inch away from the inner surface of the multilead array.

The negative side of an approximately 1600 volt DC source was connected to said photo cathode and the positive side of said 1600 volt source was connected to ground. The negative side of an approximately 1300 volt DC source was connected to said conductive layer on the input side of said microchannel plate, and the positive side of said 1300 volt source was connected to ground. Therefore, a potential of approximately 300 volts existed between said photo cathode and the input side of said microchannel plate. As a result of said 300 volt potential and the small spacing between the two components magnetic focusing was not required to direct the electrons emitted from the photo cathode onto the microchannel amplifier plate. The negative side of an approximately 300 volt DC source was connected to the conductive layer on the output side of said microchannel plate, and the positive side of said 300 volt source was connected to ground. Therefore, a potential of approximately 1000 volts existed between the input and output of said microchannel plate. A sheet of transparent glass sealed the remaining open end of the cylinder. The container was then evacuated to 10^{-7} torr.

The components contained inside the cylinder and the multilead array were all oriented such that the desired electron image flow was parallel to the axis of said cylinder. That is, the photon image entered the input end of the cylinder through the transparent sheet of glass, and an electrostatic image was generated on the multilead array at the output end.

During operation, a document was illuminated for at least 2 milliseconds by a mercury light source which emitted ultraviolet light waves of approximately 2537A, and the photon image reflected from said document was focused by a lens system through the transparent glass at the input end of the cylindrical container onto the photo cathode. A grounded backing plate supported a piece of common bond paper which was placed against the output end of the multilead array such that the electron image generated on said multilead array was transferred to said paper. The paper containing the electrostatic image was then developed and permanently fixed. Experiments showed that excellent copies could be obtained even if up to eight hours elapsed between the time the electrostatic image was impressed on the paper and the time the paper was developed. Relative humidity of the surrounding atmosphere was found to be one of the most critical factors affecting the life span of the underdeveloped electrostatic image on the paper.

Although the present invention has been described with respect to specific details of certain embodiments thereof, it is not intended that such details be limitations upon the scope of the invention except insofar as is set forth in the following claims.

I claim:

1. A high speed electrostatic printing apparatus comprising
 - means to provide a photon image;
 - a photon to electron image converter and intensifier comprising

an evacuated container having a first wall portion through which said photon image may be projected,

a photo cathode disposed within said evacuated container for intercepting said photon image and converting it to an electron image, 5

a microchannel plate having an input surface and an output surface disposed and aligned within said evacuated container such that said input surface is adjacent and parallel to said photo cathode for intensifying said electron image, 10

a multilead array comprising a second wall portion of said evacuated container having a plurality of conductors embedded in an insulating plate having two broad surfaces parallel to the plane of said plate, said conductors being oriented perpendicular to the plane of said insulating plate such that one end of insulating conductor is exposed at each broad surface of said insulating plate, said multilead array being disposed such that one broad surface is within said evacuated container and is adjacent and parallel to said output surface of said microchannel plate for collecting said intensified electron image and the other broad surface forms a portion of the outside surface of said evacuated container; and 25

a dielectric target for receiving said intensified electron image from said conductors of said multilead array, said dielectric target having one surface thereof disposed adjacent to said other broad surface of said multilead array. 30

2. The electrostatic printing apparatus of claim 1 further comprising means for applying an electrical potential between said photo cathode and said input surface of said microchannel plate for accelerating and focusing electrons leaving said photo cathode. 35

3. The electrostatic printing apparatus of claim 1 further comprising a magnetic field between said photo cathode and said microchannel plate to focus said electron image onto said microchannel plate. 40

4. The electrostatic printing apparatus of claim 1 further comprising means for applying an electrical potential between the input and output surfaces of said microchannel plate. 45

5. The electrostatic printing apparatus of claim 1 further comprising means for effecting an electrical potential between said output surface of said microchannel plate and said dielectric target. 50

6. The electrostatic printing apparatus of claim 1 further comprising a magnetic field between said microchannel plate and said multilead array to focus said electron image onto said multilead array. 55

7. The electrostatic printing apparatus of claim 1 further comprising an electrically conductive plate connected to ground disposed adjacent to and in contact with the surface of said dielectric target opposite said multilead array. 60

8. The electrostatic printing apparatus of claim 1 wherein said dielectric target is disposed in contact with said conductors of said multilead array. 65

9. The electrostatic printing apparatus of claim 1 further comprising

means for applying a potential between said photo cathode and said input surface of said microchannel plate such that said photo cathode is at a lower potential than said input surface of said microchannel plate,

means for applying a potential between said input and output surfaces of said microchannel plate such that said input surface is at a lower potential than said output surface,

a conductive plate connected to ground in contact with said dielectric target, and

means for applying a potential between said output surface of said microchannel plate and said conductive plate such that said output surface of said microchannel plate is at a lower potential than said conductive plate.

10. The electrostatic printing apparatus of claim 1 wherein said means to provide a photon image includes an item to be electrostatically copied further comprising a means to move said item and said dielectric target in synchronous motion.

11. The electrostatic printing apparatus of claim 1 wherein said means to provide a photon image includes an item to be electrostatically copied further comprising means to move said image converter and intensifier between said item and said dielectric target.

12. The electrostatic printing apparatus of claim 1 wherein said means to provide a photon image includes an item to be copied further comprising means to move said image converter and intensifier, said item, and said dielectric target in synchronous motion. 25

13. The electrostatic printing apparatus of claim 1 wherein said means comprises

an item to be electrostatically copied, a light source, the light of which is modulated by said item to be copied thereby producing a photon image, and

a lens system for projecting said photon image.

14. The electrostatic printing apparatus of claim 13 wherein said dielectric target is disposed in contact with said conductors of said multilead array and further comprising 35

means for applying a potential between said photo cathode and said input surface of said microchannel plate such that said photo cathode is at a lower potential than said input surface of said microchannel plate, 40

means for applying a potential between said input and output surfaces of said microchannel plate such that said input surface is at a lower potential than said output surface, 45

a conductive plate connected to ground in contact with said dielectric target, means for applying a potential between said output surface of said microchannel plate and said conductive plate such that said output surface of said microchannel plate is at a lower potential than said conductive plate, and means to move said item to be copied and said dielectric target in synchronous motion. 50

15. The electrostatic printing apparatus of claim 13 wherein said dielectric target is disposed in contact with said conductors of said multilead array and further comprising 55

means for applying a potential between said photo cathode and said input surface of said microchannel plate such that said photo cathode is at a lower potential than said input surface of said microchannel plate, 60

means for applying a potential between said input and output surfaces of said microchannel plate such that said input surface is at a lower potential than said output surface, 65

a conductive plate connected to ground in contact with said dielectric target,
 means for applying a potential between said output surface of said microchannel plate and said conductive plate such that said output surface of said microchannel plate is at a lower potential than said conductive plate, and
 means to move said image converter and intensifier between said item to be copied and said dielectric target.

16. The electrostatic printing apparatus of claim 13 wherein said photo cathode, microchannel plate, multilead array and dielectric target each have at least as much surface area as the resulting electrostatic copy of said item such that said item may be reproduced at one time, said dielectric target being in contact with said conductors of said multilead array and further comprising

means for applying a potential between said photo cathode and said input surface of said microchannel plate such that said photo cathode is at a lower potential than said input surface of said microchannel plate,

means for applying a potential between said input and output surfaces of said microchannel plate such that input surface is at a lower potential than said output surface,

a conductive plate connected to ground in contact with said dielectric target, and

means for applying a potential between said output surface of said microchannel plate and said conductive plate such that said output surface of said microchannel plate is at a lower potential than said conductive plate.

17. The electrostatic printing apparatus of claim 13 wherein said light from said light source is modulated by reflecting at least a portion of said light from said item to be copied.

18. The electrostatic printing apparatus of claim 13 wherein said light from said light source is modulated by transmitting at least a portion of said light through said item to be copied.

19. The electrostatic printing apparatus of claim 1 wherein said dielectric target is no further than 0.002 inch from said conductors, and said intensified electron image is transferred to said dielectric target by arc discharge.

20. The electrostatic printing apparatus of claim 1 wherein said microchannel plate embodies a plurality of channels, the inner surfaces of said channels con-

taining a resistive secondary-electron emissive layer, the openings at the ends of said channels being at said input and output surfaces of said microchannel plate.

21. The electrostatic printing apparatus of claim 22 wherein said microchannel plate comprises a plurality of tubular members, the ends of which form said input and output surfaces of said microchannel plate.

22. A high speed electrostatic printing apparatus comprising

means to provide a photon image;

a photon to electron image converter and intensifier comprising

an evacuated container having a first wall portion through which said photon image may be projected,

a photo cathode disposed within said evacuated container for intercepting said photon image and converting it to an electron image,

a microchannel plate having an input surface and an output surface disposed and aligned within said evacuated container such that said input surface is adjacent and parallel to said photo cathode for intensifying said electron image,

a multilead array comprising a second wall portion of said evacuated container having a plurality of conductors embedded in an insulating plate having two broad surfaces parallel to the plane of said plate, said conductors being oriented perpendicular to the plane of said insulating plate such that one end of each conductor is exposed at each broad surface of said insulating plate, said multilead array being disposed such that a first broad surface is, within said evacuated container and is adjacent and parallel to said output surface of said microchannel plate for collecting said intensified electron image, and the second broad surface forms a portion of the outside surface of said evacuated container;

a first dielectric target for receiving and temporarily storing said intensified electron image from said conductors of said multilead array, said first dielectric target having one surface thereof disposed adjacent to said second surface of said multilead array; and

a second dielectric target disposed in such manner as to receive said electron image from said first temporary storage target, said second target being the one on which the electrostatic image is permanently developed and fixed.

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