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Gerber

[11] **3,724,347**

[45] **Apr. 3, 1973**

[54] APPARATUS FOR SELECTIVELY EXPOSING A PHOTOSENSITIVE SURFACE

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[21] Appl. No.: **136,909**

[52] **U.S. Cl.** .....**95/12,** 95/1 R

[51] **Int. Cl.** **G03b 29/00**

[58] **Field of Search** .....95/12, 1 R; 355/3

[56] **References Cited**

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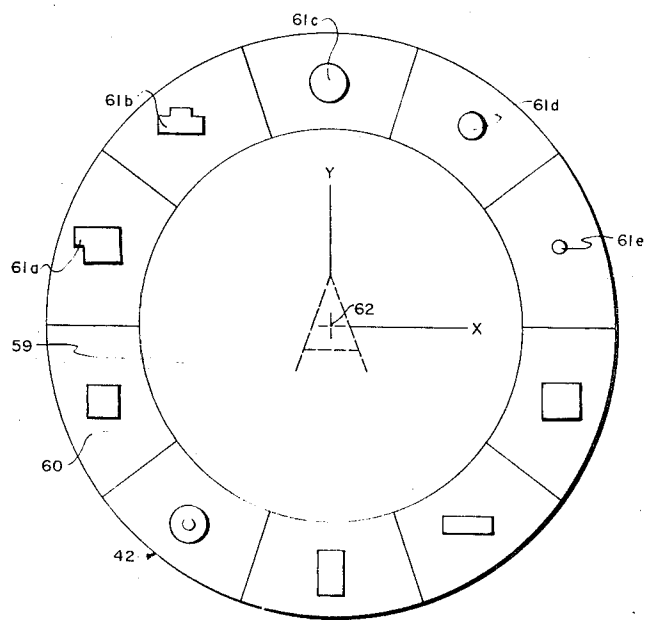
[57] **ABSTRACT**

A method and apparatus for selectively exposing the photosensitive surface of an article employs a cathode ray tube to generate radiant images which are projected onto the photosensitive surface. The cathode ray tube is connected to a computer which controls the deflection of its beam to generate the images, and the tube and the associated optical system are mounted on a carriage movable relative to the photosensitive surface to enable exposure of different regions of the photosensitive surface and the exposure of lines on the photosensitive surface by moving a projected spot of light. The radiant images are produced both by drawing images on the display screen with the beam and by causing the beam to substantially continuously energize different selected areas of the screen to illuminate predefined images, the shapes of which are determined by masks or similar means, each one of such selected areas having one of the predefined images associated with it.

11 Claims, 5 Drawing Figures



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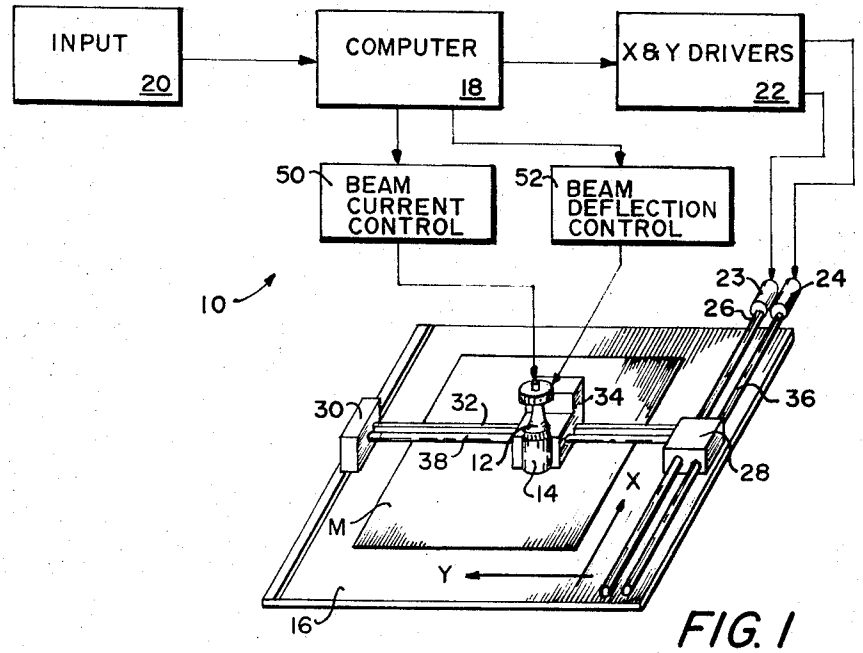

FIG. 1

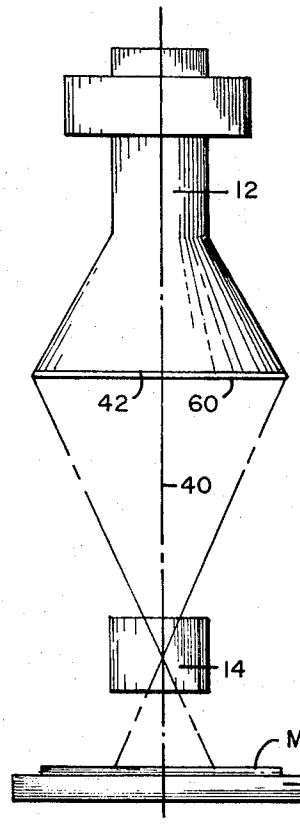

FIG. 2

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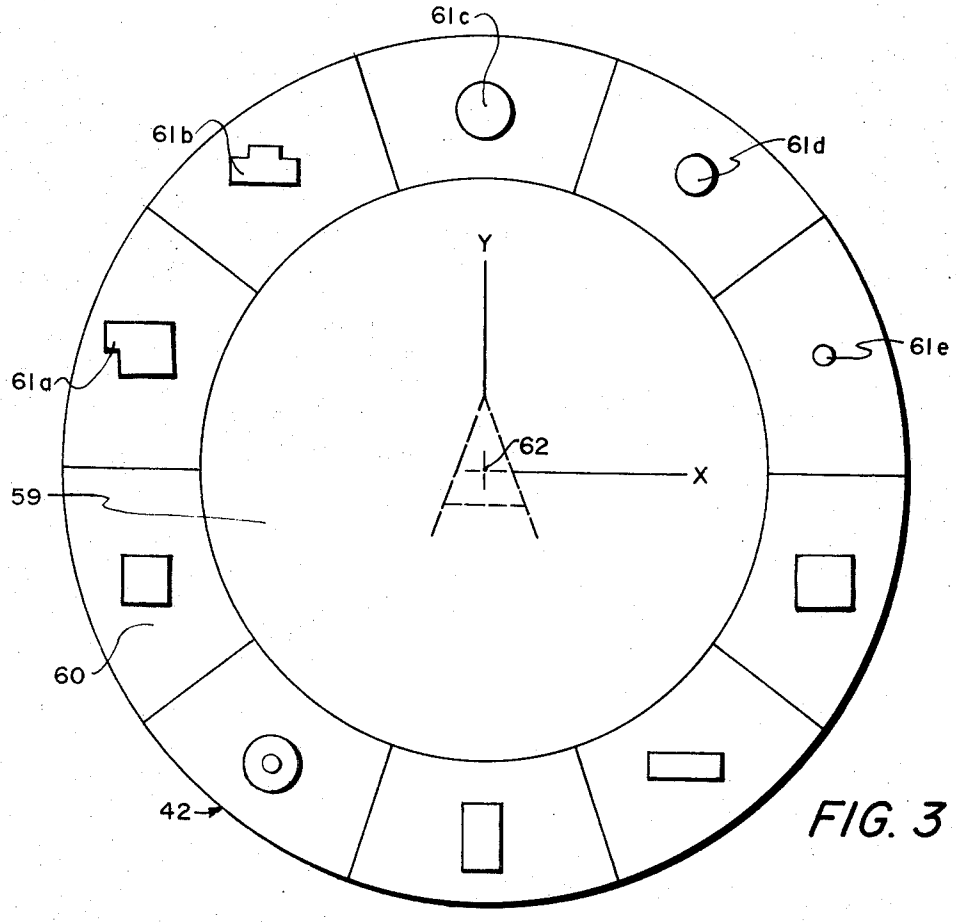

FIG. 3

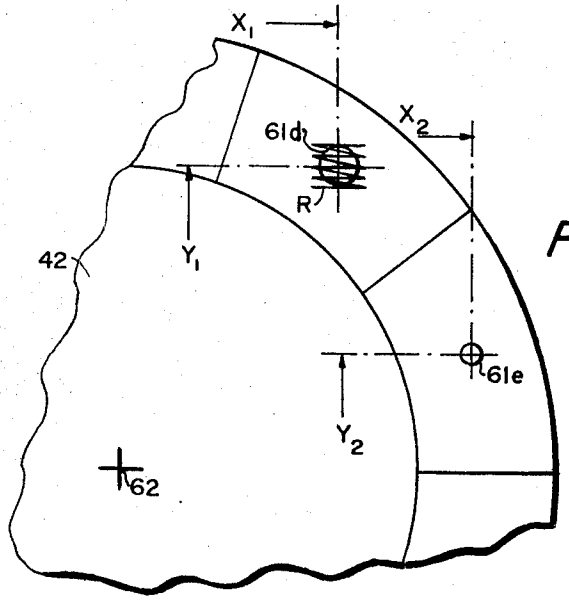

FIG. 5

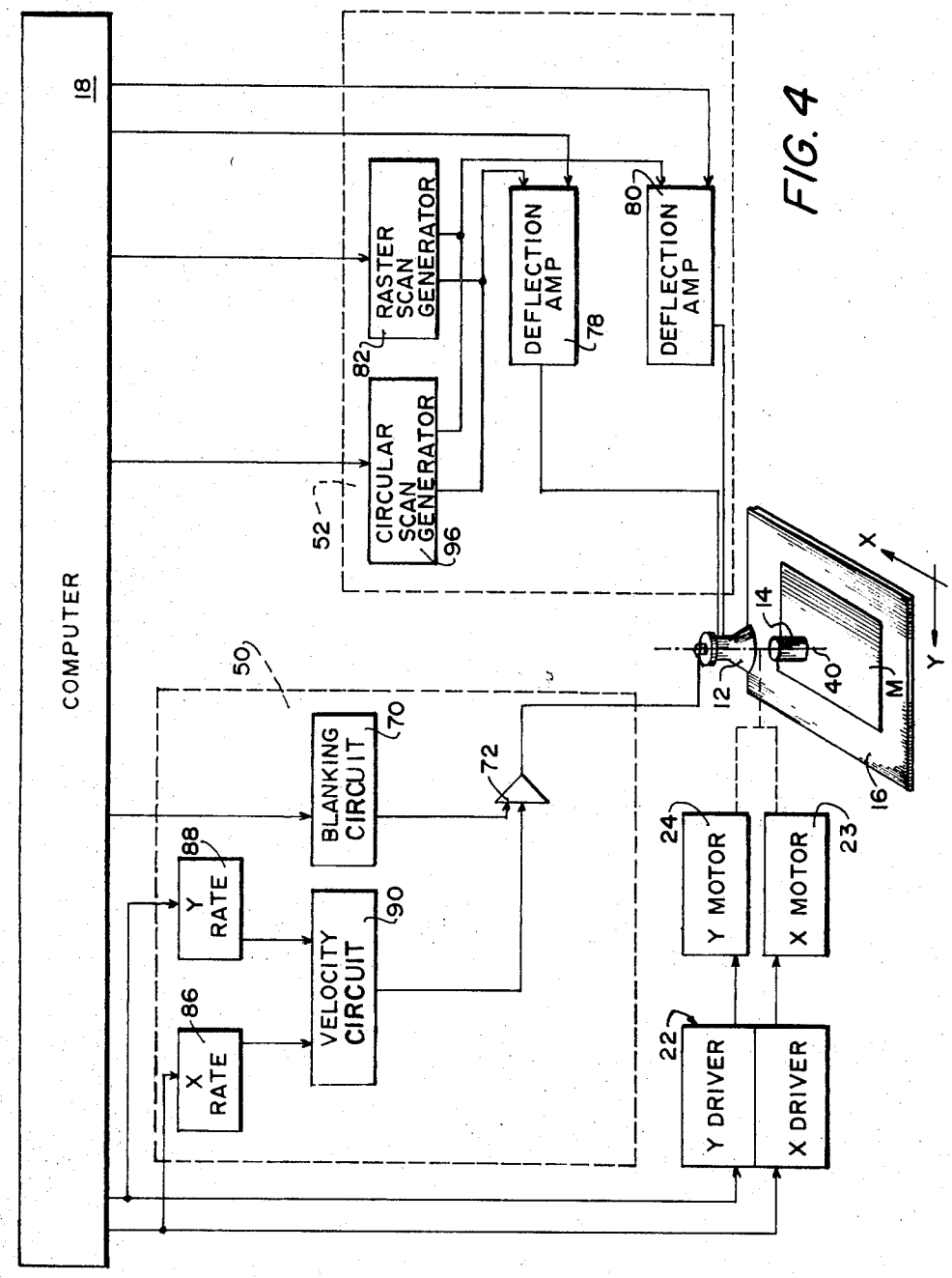
COMPUTER
18
RASTER SCAN GENERATOR
82
CIRCULAR SCAN GENERATOR
96
52
DEFLECTION AMP
78
80
DEFLECTION AMP
50
BLANKING CIRCUIT
70
72
Y RATE
88
VELOCITY CIRCUIT
90
X RATE
86
Y MOTOR
24
X MOTOR
23
Y DRIVER
22
X DRIVER
12
14
40
M
16
X
Y

FIG. 4

APPARATUS FOR SELECTIVELY EXPOSING A PHOTOSENSITIVE SURFACE

BACKGROUND OF THE INVENTION

This invention relates to an apparatus and method for selectively exposing the photosensitive surface of an article to produce a graphic art work and, more particularly, is concerned with an apparatus and the method carried out by the apparatus in which an energized beam is utilized to generate images to be projected onto the photosensitive surface.

Mechanization in the field of graphic arts has recently received increased interest, particularly in the production of photographic transparencies used as masters in making drawings for printed circuit boards or integrated circuit elements and other articles of a similar character. If prepared manually, drawings of this type involve a great deal of labor and skill and frequently are tedious due to the complexity of the drawings and the accuracy with which the masters must be prepared. Automatic drafting machines do not suffer from such emotional stresses and, once programmed, are capable of producing copies of complex drawings faster and more accurately than a draftsman.

One apparatus employed in the production of graphics is disclosed in U.S. Pat. No. 3,330,182 entitled "A Device for Exposing Discrete Portions of a Photosensitive Surface to a Variable Intensity Light Beam," issued July 11, 1967, to the assignee of the present invention. In the patented device, a light beam is projected from a moving carriage onto a light-sensitive material to expose the material in a particular pattern or graphic. A light beam generator is mounted on the carriage which translates above the sensitive material, and the projected light beam passes through several modulating elements to control the exposure pattern on the material. For a more detailed description of the prior art apparatus, reference may be had to the preferenced patent.

It is usually desirable to generate many different patterns on a photosensitive surface, and the development of computer technology has greatly facilitated the achievement of this end. For example, in the above-referenced patent, the motions of the light beam across the photosensitive material are controlled by a computer. For large scale graphic characters, physical displacement of the beam generating mechanism is possible; however, for versatility in generating small characters, such as letters or numerals, motions of the generator must be controlled accurately and can consume considerable periods of time where the graphic information produced on the sensitive material includes significant numbers of alphabetical or numeral characters. An apparatus which is capable of generating both large scale and small scale characters with accuracy, speed and efficiency is therefore desirable and has significant utility in the field of graphic arts.

SUMMARY OF THE INVENTION

The present invention resides in an apparatus and the method by which the apparatus operates to selectively expose a photosensitive surface of an article. The apparatus comprises a generator means, such as the electron gun of a cathode ray tube, for generating an energized beam along a beam axis, and a radiant energy emitting means, such as the screen of a cathode ray tube, located along the beam axis and sensitive to the beam for emitting radiant energy from emitting regions impinged upon by the beam. The emitting means includes two different areas which are used to generate radiant images in different ways. In the use of the first area, the beam is deflected by a deflector means, under the control of a first control means, to cause the beam to draw, within the first area, a character or other radiant image in the same manner as a pen, pencil or other writing instrument is conventionally used to draw characters on a piece of paper. In the use of the second area, the beam is deflected, by the deflector means under the control of a second control means, so as to substantially continuously impinge upon and energize the full extend of the second area to thereby produce radiant energy used to illuminate a character or other image associated with such second area, the shape of which image is defined by an associated mask or other means. Preferably, a plurality of such second areas are provided with each having a different predefined image associated therewith. Projection means are provided for projecting the radiant images produced by both the first and second areas of the emitting means onto the photosensitive surface of the article to be exposed. The two different control means and the two different areas of the emitting means permit radiant images of graphic characters to be prepared by both drawing the images with the beam and by causing predefined graphic characters or other images to become radiant. In each case, the images can be generated and projected onto the photosensitive surface without displacing the entire image generating apparatus. When it is desired to draw a very long line or generate a very large character, a spot of radiant energy may be produced, by using either area of the emitting means, and projected onto the photosensitive surface. This spot may then be moved relative to the photosensitive surface to produce the line or character by moving the entire image generating apparatus relative to such surface.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagram, partly in block form and partly schematic, showing the general configuration of an apparatus embodying the present invention.

FIG. 2 is an elevational view of the cathode ray tube and lens system utilized in the apparatus of FIG. 1.

FIG. 3 is a frontal view of the screen of the cathode ray tube of FIG. 2.

FIG. 4 is a diagram showing partly in block form and partly in schematic form the detailed construction of the apparatus in FIG. 1.

FIG. 5 is a fragmentary view of the screen of the cathode ray tube shown in FIG. 3.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 shows the general configuration of an apparatus for selectively exposing a photosensitive material according to the present invention. The apparatus, generally designated 10, utilizes a cathode ray tube 12 and a lens system 14 which are translated above a support table 16 in both of the illustrated X and Y coordinate directions by a numerical control computer 18. The computer 18 may be a general or special purpose computer which receives from an input

device 20 program information defining a particular graphic to be exposed on a photosensitive material M positioned in a spread condition on the support table 16. The program information is stored in the computer memory, which can be a magnetic or punched memory tape, as coded information which is read and understood by the computer. From the information, the computer generates a sequence of machine commands which cause the material M to be exposed by the cathode ray tube 12 and lens system 14 in the graphic pattern.

Motion commands generated by the computer 18 are transmitted through X and Y drivers 22 to an X drive motor 23 and a Y drive motor 24. The output shaft 26 of the X drive motor 23 is a lead screw which is threadably engaged by a guide block 28 at one edge of the support table 16. The guide block 28 is mounted on a rail or other guide mechanism (not shown) to be moved back and forth along the table 16 in the X direction by the X drive motor 23. A corresponding guide block 30 at the opposite side of the support table 18 is interconnected with the guide block 28 by a rail 32 so that the two blocks 28 and 30 move together back and forth over the table 16 in the X direction. The cathode ray tube 12 and lens system 14 are supported on the rail 32 by means of a carriage 34 which is translatable on the rail 32 relative to the support table 16 in the Y direction. The Y drive motor 24 has a splined drive shaft 36 connected through a gear mechanism (not shown) in the block 28 to a lead screw 38 which extends over the support table 16 between the blocks 28 and 30 and threadably engages the carriage 34 to move it, the cathode ray tube 12 and the lens system 14 in the Y direction. In this manner, a two-axis carriage system is formed in which the guide blocks 28 and 30 and rail 32 are the X carriage and the carriage 34 translatable on the rail 32 is the Y carriage. Composite movements in both the X and Y directions or individual movements along each direction are produced by the drive motors to move the tube 12 and the lens system 14 over the entire photosensitive surface of the material M.

As shown in FIGS. 1 and 2, the cathode ray tube 12 and the lens system 14 are fixedly mounted to the carriage 34 with the optical axis 40 of the lens system colinear with the central axis of the tube along which the cathode ray beam is generated, and, therefore, intersecting the display screen 42 at the center in perpendicular relationship with the screen. The lens system and the optical axis 40 are also oriented perpendicular to the work surface of table 16 and the photosensitive surface of the material M spread on the table 16. The lens system 14 has a field of view which fully encompasses the display screen 42 and is positioned above the work surface of table 16 at a distance which allows a sharply focussed image of the picture on the display screen 42 to be projected onto the photosensitive surface of the material M. It will be noted that the lens system 14 is located closer to the table 16 than the display screen 42 indicating that a reduced image of the screen 42 is actually projected onto the material M. Of course, a magnification or a one-to-one size relationship between the screen images and the projected images could be had if desired; however, since the present invention has particular utility in producing micro-miniaturized printed circuits, an image reducing lens system is indicated in the drawing.

In addition to the motion commands to move the cathode ray tube 12 and lens system 14 over the table 16, the computer 18 also produces commands to control the beam generated within the cathode ray tube 12. Computer commands are delivered to the beam current control 50 which is connected to the electron gun of the cathode ray tube to regulate the beam current or the intensity of the beam and the image produced by the beam at the impingement region on the display screen 42. The computer 18 also supplies deflection commands to the beam deflection control 52 which is connected to the deflection plates within the cathode ray tube 12 to deflect the beam away from the beam axis and across the display screen 42. By appropriate modulation of the beam through controls 50 and 52 and movement of the tube 12 and lens system 14 over the table 16, it is possible to selectively expose the photosensitive surface of the material M to produce a wide variety of graphic characters and lines.

In accordance with the present invention, the computer 18, the beam controls 50 and 52 and the cathode ray tube 12 are constructed to enable the generation of radiant images in either one of two different ways, the first of these involving the movement of the beam over one area of the screen to draw a character or other image in much the same fashion as characters are normally drawn by pen or pencil on a sheet of paper, and the second of these involving the use of the beam to energize another substantial area of the screen to produce radiation illuminating a character or other image defined by a mask or other means. The screen 42 on the tube 12 is a conventional cathode ray tube screen to the extent that it is covered with a phosphorescent material which produces radiant energy at the point of beam impingement.

For the purpose of generating characters by drawing with the beam, the portion of the display screen 42 surrounding the center 62 is used and forms a first area 59 which is capable of emitting radiant energy at every point thereof on which the beam impinges. Therefore, it is possible for the computer 18 (FIG. 1) to modulate and deflect the beam so that it draws characters in such area of the screen. For example, the image of the letter A, shown at the center of the screen in FIG. 3, is generated by appropriately blanking the beam and simultaneously deflecting the beam in the X and Y directions in accordance with an alphabetical sub-routine stored within the memory of the computer 18. That is, sub-routines for generating commonly used characters such as letters, numbers or other symbols are stored in the computer memory or inserted in the memory as an input at the beginning of an exposure operation. By indexing the tube 12 and lens system 14 an amount equal to the width of the letter after each letter is formed, it is possible to print out (expose) words and instructions from the sub-routines stored in the computer memory. The individual letters or numbers are drawn on the screen by blanking and deflecting the beam within the tube and without moving the two-axis carriage mechanism. This allows the exposure of each character to be carried out more rapidly than by a process involving movement of the carriages.

To enable the generation of characters or other images in the second mentioned way, the outer annular portion of the screen **42** is covered or partially obscured with an opaque mask **60** including a plurality of openings or apertures **61**, **61** each of which defines a unique character. Some of the illustrated characters, for example, have shapes such as used to generate exposures of conductors, terminal pads and similar shapes found on printed circuit boards. Of course, the illustrated characters are intended to be exemplary only and the style or shape of the characters may be varied widely without departing from the invention, and is desired some or all of the characters may be alphabetical or numerical characters.

Each opening **61** of the mask resides within the bounds of an associated second area of the screen **42** so that when the beam of the tube is caused to impinge on and energize such second area in a substantially continuous manner, the mask opening **61** is illuminated to produce a radiant image of the character defined by the opening. The radiant image of the character so produced is then projected onto the photosensitive surface of the material M (FIG. **1**) through the lens system **14**. As described hereinafter, the substantially continuous energization by the beam of the second area associated with each mask opening **61** is preferably achieved by focusing the beam to form a spot substantially smaller than the opening **61** and by deflecting it in a raster fashion over the second area so as to repeatedly and rapidly scan such area. However, if desired, in some cases the beam may also be defocused so as to form a spot larger than the mask opening **61** while the beam axis is held stationary at the center of such opening.

FIG. **4** shows the construction of the beam current control **50** and the beam deflection control **52** which permit printed characters such as the illustrated letter A to be drawn in the first area **59** of the display screen in response to commands from the control computer **18**. The beam current control **50** includes a blanking circuit **70** which is connected through a summing amplifier **72** to the control grid of the electron gun in the cathode ray tube **12**. In response to commands from the computer **18**, the blanking circuit **70** provides voltage signals which bias the grid and turn the beam on or off. At the same time, deflection commands are supplied from the computer **18** to the X deflection amplifier **78** and the Y deflection amplifier **80** which are connected to the corresponding deflection plates in the cathode ray tube **12** to cause the beam to be deflected in accordance with stored sub-routines defining the configuration of the letter, number or other figure to be drawn, the blanking commands and the deflection commands being synchronized to produce the radiant image of the character. When it is desired to generate words or a series of numbers composed of a plurality of adjacent characters, the computer **18** supplies commands through the X and Y drivers **22** to the X drive motor **23** and the Y drive motor **24** to index the carriages supporting the tube **12** and lens system **14** by the distance required between characters and words.

Considering the second mode of characters generation and referring again to the display screen **42** seen in FIG. **3**, the openings **61**, **61** in the mask **60** define graphic characters which have various configurations and dimensions which may be larger than the radiant spot produced at the impingement point of the beam. In order to produce a sharp and clear image of any one of the mask characters, it is necessary to deflect the beam to the particular mask opening defining the character, and, if the character does have a dimension larger than the radiant beam spot, to scan the beam in a raster over the second area of the screen within which the opening is located. For example, as indicated in FIG. **5**, to produce an image of the circular opening **61d** of the mask **60**, the beam must be deflected fundamentally from the origin or center **62** of the screen **42** to the coordinates X_1, Y_1 of the center of the opening **61d** and then scanned along a raster path R covering the sub-area of the screen within which the opening is located. If the radiant spot produced by the beam is larger than the mask opening to be illuminated, the beam need not necessarily be scanned. For example, if the illustrated opening **61e** is to be illuminated, and if the radiant spot produced on the screen by the beam is considerably larger than such opening, the beam may be fundamentally deflected from the center **62** to a position having the coordinates X_2, Y_2 of the center of the opening **61e** and then held stationary for as long a time as required to effect the desired exposure. If desired, the radiant spot produced by the beam may be purposely made larger than the opening to be illuminated by defocusing it.

The apparatus of FIG. **4** related to the production of radiant images through the use of the mask **60** includes the blanking circuit **70** in the beam current control **50** and the X and Y deflection amplifiers **78** and **80** and the raster scan generator **82** in the beam deflection control **52**. Upon command from the computer **18**, the blanking circuit **70** turns on the beam in he cathode ray tube and the deflection amplifiers **78** and **89** receive deflection signals which cause the beam to be deflected fundamentally toward the center of the mask opening to be illuminated. At the same time, if needed, a signal from the computer to the scan generator **82** superimposes scanning signals on the fundamental deflection signals and causes the beam to follow the small raster path R covering the surface of the screen containing the mask opening. A radiant image of the character so illuminated is projected through the lens system **14** onto the photosensitive material M.

Since the mask **60** lies along the periphery of the display screen **42**, as seen in FIG. **3**, each mask opening is spaced from the center **62** of the screen and from the optical axis **40** of the lens system **14**. The image of each opening as projected onto the photosensitive surface of the material M correspondingly is spaced from the intersection point of the optical axis **40** and the photosensitive surface. To adjust for such displacement, the computer utilizes the fundamental deflection information representing the location of the mask opening relative to its center of the display screen **42** and produces a compensating displacement of the tube **12** and the lens system **14** through signals transmitted to the X and Y drivers **22** and drive motors **23** and **24** to position the projected image at the desired location relative to the photosensitive surface.

If desired, and without departing from the broader aspects of this invention, various other means may be used in place of the illustrated mask **60** for defining the

shape of an image as the beam is caused to energize an associated subrarea of the screen. For example, one alternative is to eliminate the mask **60** and to construct the screen **42** of the cathode ray tube so that at each sub-area of the screen associated with a particular character, the phosphorescent material is applied to the screen in the shape of the character. Another alternative is to provide a movable mask containing a number of different openings each of which openings may be moved into registration with a given sub-area of the tube screen so that when such sub-area is energized by the beam any one of a number of different illuminated images may be produced by positioning any selected one of the mask openings over such sub-area.

In addition to the above-described device being used to expose characters or symbols while the cathode ray tube and other parts of the image generating apparatus are held stationary relative to the photosensitive surface, the device may also be used to draw lines by means of a spot of light movement of which is produced by moving the cathode ray tube and associated parts relative to the photosensitive material. With the illustrated device, one way of doing this is to produce a spot of light through the use of one of the mask openings **61**, **61**, and to then move the projected spot so produced relative to the photosensitive surface by moving the carriage **34** relative to the photosensitive material M. Since the photosensitive surface of the material M must receive substantially the same quantity of light per unit of time in order to be uniformly exposed at each point along an exposed line, and since the drive motors **23** and **24** are capable of moving a projected image at different rates over the photosensitive surface, the beam current control **50** is provided with compensating networks to increase the beam intensity as a function of the rate at which the projected image is moved over the photosensitive surface. The displacement commands along the X and Y axes are sensed by an X tachometer or rate sensor **86** and a Y rate sensor **88**, respectively. The rate signals from sensors **86** and **88** are supplied to a velocity circuit **90** which combines the two rate signals into a composite velocity representative of the rate at which the X and Y motors translate the tube **12** and the lens system **14** relative to the material M and, hence, the rate at which the image projected onto the material M moves over the photosensitive surface. The velocity signal is appropriately scaled by the circuit **90** and is added to the biasing signal from blanking circuit **70** at summing amplifier **72**. The blanking circuit **70** establishes a given control grid or beam intensity which is sufficient for drawing images in the first area **59** of the display screen **42** and for illuminating the openings **61**, **61** in the mask when there is no relative movement between the lens system **14** and the photosensitive material M. The velocity signal from circuit **90** adds an additional bias to the intensity signal from the blanking circuit **70** and the combined signals from summing amplifier **72** are applied to the control grid of the cathode ray tube **12** to adjust the beam intensity.

Another way of drawing lines with a moving light spot, the movement of which is produced by moving the cathode ray tube, is to deflect the beam of the tube so as to generate a circle in the first area **59** of the screen and to then translate the cathode ray tube **12** and lens system **14** over the photosensitive material while the circular image is projected onto the surface of such material. For this purpose, the beam deflection control **52** includes a circular scan or circular sweep generator **96** which, upon command from the computer **18**, causes the beam in the cathode ray tube to produce a circle at the center **62** of the screen **42**. The size of the circle can be adjusted by the sweep voltage so that the width of the exposed strip may be varied. Where very narrow exposed strips are desired, the image of the beam itself at the center **62** of the screen without circular sweep may be employed; however, due to the generally blurred image of a beam on the screen **42**, it is generally preferable when a small circular spot is required to employ an opening in the mask **60** to define such spot.

While the present invention has been described in a preferred embodiment, it should be understood that various modifications and substitutions to the structures and processes disclosed may be employed. Accordingly, the present invention has been described in a preferred embodiment by way of illustration rather than limitation.

I claim:

1. An apparatus for selectively exposing a photosensitive surface of an article, said apparatus comprising: generator means for generating an energized beam along a beam axis; radiant energy emitting means located along said beam axis and sensitive to said energized beam for emitting radiant energy from areas thereof impinged upon by said energized beam, said emitting means having discrete first and second areas; means fully uncovering the first area and having a substantially opaque portion overlying one part of the second area and uncovering another part of the second area for defining the shape of an image illuminated by radiant energy from substantially the full extent of the second area; deflector means for deflecting said energized beam from said beam axis over said first and second areas of said emitting means; first control means connected to said generator means and to said deflector means for causing said beam to draw radiant images in the uncovered first area of said emitting means; second control means connected to said generator means and to said deflector means for causing said beam to substantially continuously impinge on the full extent of said second area without impinging on said first area; and projection means for projecting radiant images from both said first and said second areas of said emitting means onto said photosensitive surface of said article.

2. An apparatus for selectively exposing a photosensitive surface of an article as defined in claim **1** further including carriage means for moving said projection means relative to said article whereby said radiant images may be projected onto different areas of said photosensitive surface.

3. An apparatus for selectively exposing a photosensitive surface of an article as defined in claim **2** including a support table for said article, said carriage means including a movable carriage translatable over said support table; and wherein said generating means, said radiant energy emitting means, and said projection means are mounted on said movable carriage.

4. An apparatus for selectively exposing a photosensitive surface of an article as defined in claim **1** wherein

said radiant energy emitting means comprises a radiant screen sensitive to impingement of the energized beam, and said means having a substantially opaque portion for defining the shape of an image illuminated by radiant energy from said second area comprises a mask between said second area and said projection means and including an opening which defined said shape of said image.

5. An apparatus for selectively exposing a photosensitive surface of an article as defined in claim 4 further characterized by said radiant screen including a plurality of second areas located along the peripheral margin thereof, and said mask overlying all of said second areas and including a plurality of shape defining openings each associated with a respective one of said second areas.

6. An apparatus for selectively exposing a photosensitive surface of an article as defined in claim 1 wherein said second control means includes a scan generating means for scanning said radiant energy beam over said second area of said radiant energy emitting means.

7. An apparatus for selectively exposing a photosensitive surface of an article as defined in claim 1 wherein said generator means comprises the electron gun of a cathode ray tube, said radiant energy means comprises the screen of said cathode ray tube, and said deflector means comprises the beam deflection means of said cathode ray tube.

8. An apparatus for exposing graphic characters on a photosensitive surface of an article comprising: a cathode ray tube having a display screen comprised of first and second radiating portions; a mask overlying said second radiating portion of said display screen of said cathode ray tube, said mask having a cutout uncovering a part of said second radiating portion and defining a graphic character; first control means connected to said cathode ray tube to cause the beam of said tube to draw radiant images of graphic characters in said first radiating portion of said display screen; second control means connected to said cathode ray tube to cause said tube to illuminate the part of said second radiating portion of said display screen uncovered by the cutout of said mask whereby a radiant image of said graphic character is produced from said second radiating portion of said display screen; and projection means for projecting the radiant images of the graphic characters from both the first and second areas onto the photosensitive surface of the article.

9. An apparatus as defined in claim 8 wherein said first control means includes beam deflection means connected to said cathode ray tube.

10. An apparatus as defined in claim 9 wherein aid second control means includes a raster scan generator connected to said beam deflection means.

11. An apparatus as defined in claim 8 wherein said first radiating portion of said display screen encompasses the central region of said display screen; said second radiating portion of said display extends along the entire peripheral region of said screen; and said mask overlies said second portion along the entire peripheral region of said screen and has a plurality of cutouts defining a plurality of characters.

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