(9)

PATENT SPECIFICATION (11) 1259588

1259588

DRAWINGS ATTACHED

(21) Application No. 4541/70 (22) Filed 30 Jan. 1970

(31) Convention Application No. 796456 (32) Filed 4 Feb. 1969 in

(33) United States of America (US)

(45) Complete Specification published 5 Jan. 1972

(51) International Classification H 04 n 1/24//G 02 b 5/12

(52) Index at acceptance

G4H 13D 14D 1C 1D 3X 4A 5D 6B 7R 9B2
G2J 11C B7C13 B7G B7M B7X19 B7X21
H4F S27A1 S27A2 S27M6 S27M7 S27R1 S27R2 S27R9 S27S S27T1 S27T2 S42M S42P S49S9 S53M

(72) Inventors DONALD RICHARD HERRIOTT, KENNETH MAXWELL POOLE and ALFRED ZACHARIAS

(54) IMPROVEMENTS IN OR RELATING TO PATTERN, CHARACTER OR IMAGE GENERATION APPARATUS

(71) We, WESTERN ELECTRIC COMPANY, INCORPORATED, of 195 Broadway, New York City, New York State, United States of America, a Corporation organised and existing under the laws of the State of New York, United States of America, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to pattern, character or image generation apparatus, and whilst in no way limited thereto finds application in the generation of mask patterns involved in the manufacture of electronic circuit devices such as semiconductor integrated circuits.

The fabrication of semiconductor integrated circuits requires the repeated projection of light through different masks onto a semiconductor wafer coated with a photosensitive layer. After each exposure and appropriate development the layer itself constitutes a mask for permitting selective processing of the wafer, such as etching and diffusion.

The photolithographic mask pattern may be prepared by a draughtsman and then photographically reduced to a size more appropriate for production of the actual mask. As mask patterns become increasingly complex and dimension tolerances more exacting however, more skillful pattern design and more expensive photographic reduction equipment is required to make the desired mask.

Because photolithographic masks comprise only transparent and opaque regions, it has been proposed that the mask pattern be described by digital information, that is, by a train of stored electrical pulses or "bits" each representing successive areas on a mask pattern that are either transparent or opaque. For example, a positive pulse or a "1" bit may represent a transparent area, while the absence of a pulse, or a "0" bit, may represent an opaque area. The stored information may then be used to drive any of various kinds of facsimile recorders to reproduce the desired mask pattern. Another advantage of this approach is that, with new computer techniques, a computer may actually design the desired mask pattern as well as store the information representative of it.

According to this invention apparatus for the generation of a pattern, character or image includes means for producing a writing beam of radiant energy; means responsive to modulation signals representative of a pattern, character or image to be generated for intensity modulating said beam; scanning means arranged to cause said beam to scan, said scanning means including a plurality of reflective surfaces arranged for rotation about a central axis, and means for rotating said plurality of reflective surfaces about said axis at a substantially constant angular velocity; and a lens positioned in the path of the scanning beam, said lens having a focal length which varies in accordance with $K\theta/\tan\theta$ where K is a constant, and θ is the angle between the scanning beam and the focal axis of said lens. The purpose of the said lens is to make the linear scan velocity of the writing beam across a flat radiant energy-sensitive medium as uniform as reasonably possible.

Each of said plurality of reflective surfaces may comprise a roof-shaped reflector prism having two reflective surfaces at a right angle to each other.

There may be providtd support means for supporting a radiant energy-sensitive medium, and means for advancing said support means

in a direction transverse to the direction of each scan of said writing beam.

There may be provided means for deriving a correction signal representative of the difference between actual advancement and a predetermined desired advancement of said support means, and means adapted to deflect said writing beam in response to said correction signal in such a direction as to compensate for said difference.

There may be provided means for producing a coding beam of radiant energy, said scanning means being arranged to cause said writing beam and said coding beam to scan in synchronism, means for deriving a synchronising signal from the coding beam scan, and control means responsive to said synchronising signal for controlling the application to said intensity modulating means of said modulation signals. The means for deriving a synchronising signal may include coding means comprising a plurality of alternate opaque and transmissive regions and arranged to be scanned by said coding beam, and detector means arranged to detect coding beam energy transmitted through said coding means thereby to produce said synchronising signal.

Preferably means are provided for causing said coding beam to be ribbon-shaped in cross section, said alternate opaque and transmissive regions being strip-shaped and having their longer dimensions arranged parallel to the longer cross-sectional dimension of said coding means.

The said means for producing a writing beam and said means for producing a coding beam may include a laser source, and means for splitting the output beam from said laser into said writing beam and said coding beam.

The invention will now be described by way of example with reference to the accompanying drawings in which:

FIG. 1 is a schematic illustration of one embodiment of the invention;

FIG. 2A is a graph of the intensity of light impinging on the photodetector of FIG. 1 versus time;

FIG. 2B is a graph of a typical portion of the digital output of the storage apparatus of FIG. 1;

FIG. 3 is a schematic illustration of the scanning beam lens of FIG. 1;

FIG. 4 is a schematic illustration of part of a code plate that may be used in the apparatus of FIG. 1;

FIG. 5 is a schematic illustration of an interferometer servomechanism that may be used in the apparatus of FIG. 1; and

FIGS. 6 and 7 are schematic illustrations of a roof-shaped reflector prism structure that may be substituted for the planar mirror facet structure in the apparatus of FIG. 1.

Referring now to FIG. 1 the pattern generator shown includes a storage apparatus 11 which, as the pattern to be generated consists only of transparent and opaque regions, stores information in the form of digital data; for example, a positive voltage pulse of a "1" bit represents a transparent area to be reproduced, while a "0" bit, or the absence of a pulse, represents an opaque area. The information is eventually reproduced on a photographic plate 12 which is exposed to light generated by a laser 13. A beam splitter 15 divides light from the laser into a writing beam 16 and a coding beam 17 which are both directed through a lens 18 onto a rotating polygonal structure 19 comprising a plurality of mirror facets 20.

A control circuit 22 periodically causes electronic data from storage apparatus 11 to be transmitted to an optical modulator 23 where it intensity modulates the writing beam 16. Since the modulating information is digital, it may be used simply to switch the beam off and on; for example, a "1" bit may cause the writing beam to be obstructed while a "0" bit permits the writing beam to be transmitted through the modulator 23 without obstruction.

The rotating mirror structure 19 is driven by an electrical motor 25, and as it rotates, successive mirror facets 20 are presented to the writing and coding means. Since each mirror facet revolves about an axis of rotation, the angle of reflection of the coding and writing beams constantly changes, causing the reflected beams to scan or sweep through a prescribed angle until a successive mirror facet is presented to the light beams. The writing beam 16 is directed through a slit 26 in a mask 27 onto the photographic plate 12, and thus periodically scans the photographic plate. The coding beam 17, on the other hand, is intercepted by a mirror 29 which directs it towards a photodetector 30.

A stepping motor 31 periodically moves the photographic plate 12 with respect to the scanning writing beam 16. The motor 31 is preferably actuated by a signal from control circuit 22, that is, after the quantity of information required for modulating the light beam during a single scan has been transmitted by the control circuit to the optical modulator 23, the scan is completed, and a signal is sent to the motor 31 which causes a lead screw 32 to be rotated so as to advance a table 33 supporting the photographic plate 12 to a suitable position for receiving the next scan of the writing beam. Appropriate apparatus maintains mask 27 in a stationary position so that writing slit 26 is always exposed to the scanning beam.

In operation, serially stored data representative of one scan of the photographic medium is directed to the optical modulator 23 as the writing beam 16 commences a single scan. After completion of this scan, motor 31 is actuated to advance the photo-

graphic plate, and a new train of information is transmitted to the modulator as the writing beam commences its successive scan. It is, of course, desirable that the input modulation information be synchronised with the scanning of the writing beam, not only to ensure that modulation begins at the commence of each scan, but also to ensure that each quantum of information, or bit, modulates the writing beam during the correct part of its scan, among other reasons, spurious velocity variations of the rotating mirror structure 19 may be intolerably large in a high resolution system.

The purpose of the coding beam is to maintain proper synchronism between the writing beam modulation and writing beam scan so that each information bit modulates the writing beam at precisely the correct instant in its scan. The coding beam 17 and the writing beam 16 are projected towards the rotating mirror 19 in a plane which is parallel to the axis of rotation of the mirror so that at any instant they are reflected at a common angle from a mirror facet and therefore scan in synchronism. As the writing beam scans the photographic plate, the coding beam is reffected from mirror 29 to scan a code plate 34 comprising a succession of alternately opaque and transparent regions or strips. The coding beam is then focussed by a lens 35, which may be a Fresnel lens, onto the photodetector 30.

Because of the variable transmission through the code plate, the light intensity impinging on photodetector 30 varies with time as shown by curve 37 of FIG. 2A, and the photodetector releases an electrical synchronising or coding signal to the control circuit 22 having substantially the same waveform as that shown by curve 37. The widths of the opaque and transparent strips of code plate 34 are arranged so that they each correspond to a location at which a single bit of writing beam information is transferred to the photographic plate by the scanning writing beam. Accordingly, the control circuit 22 is designed so as to release a single bit of information to the optical modulator 23 in response to one voltage pulse from the photodetector.

This is illustrated by the graph of FIG. 2B. For example, the first positive pulse of the synchronising signal (corresponding to the first positive pulse of curve 37) releases a "0" bit (curve 38) to the optical modulator, while the successive negatively extending pulse releases a "1" bit to the modulator. Thus, if there is some variation in the scanning velocity of the writing beam, the coding beam scanning velocity will be similarly varied, curve 37 in FIG. 2A will be varied, and the information transmitted to the writing beam modulator will be maintained in synchronism with the writing beam scan.

The design of the control circuit 22 to accomplish the functions described is well within the ordinary skill of a worker in the art and will not therefore be described in detail. The circuit may typically comprise a shift register containing a train of information pulses which is gated by each pulse of the synchronising or coding signal to release an information bit to the modulator. Appropriate counters and a "buffer store" device may be used for controlling transmission of the information from the storage apparatus 11 to the shift register. The stored information may contain an appropriate signal indicating the termination of each line of scan which may be used to actuate the stepping motor 31; alternatively, appropriate counters may be used for generating an actuatnig signal after the completion of each scan. A general purpose computer may be programmed, in a manner which would be apparent to one skilled in the art, to accomplishe the above functions, as well as other functions such as error detection and correction and providing a visual display from which the pattern generation can be monitored.

Even though the coding beam synchronises modulation and scanning, it is necessary to make the linear scan velocity of the writing beam across the photosensitive medium as uniform as reasonably possible. In the absence of lens 18, the scanning velocity of the writing beam on the photographic plate 12 would be substantially constant only if the plate were a curved surface having its centre of curvature at the axis of rotation of the mirror. However, with a suitable lens 18, the linear velocity of the writing beam on the photographic plate may be made substantially constant even though the plate is flat.

Referring to FIG. 3, θ designates the angle between the reflected writing beam 16 and the lens optic axis, OA. With the polygonal mirror structure 19 rotating in a direction shown by the curved arrow, the writing beam will scan the photographic plate 12 in a direction shown by the straight arrow. It can be shown that, at a constant angular velocity of rotation of the polygonal mirror, the linear velocity of scan of the writing beam will be constant if the lens 18 has a focal length F.L. that varies with θ in accordance with the relationship:

$$F.L. = k\theta/\tan\theta \qquad (1)$$

where k is a constant. Many alternative lens structure designs, all within the ordinary skill of a worker in the art, may be used to satisfy equation (1).

Lens 18 should either be a lens system or an optically thick lens. In either case, as is known, the focal length of the lens is defined as the distance between the lens focal plane and the lens rear nodal point. Uniform

focussing can be ensured by designing the optical system such that writing beam light impinging on the polygonal mirror is collimated and that the local plane of lens 18 is coincident with the surface of photosensitive medium 12. Under these conditions, writing beam light will be uniformly focussed on the flat surface of the photosensitive medium in spite of variations in distance between the reflecting mirror facet 20 and the photosensitive medium as the mirror rotates. Equation (1) implies that the location of the nodal point of the lens, not the focal surface, varies as a function of θ.

Collimation of the writing beam light can conveniently be accomplished by directing the writing beam through the lens prior to reflection, as shown, and focussing the writing beam to a "waist" at a plane coincident with the focal plane of the lens. The light emerging from lens 18 and directed towards the rotating mirror is then collimated and the precise vertical location of the reflecting mirror facet is relatively unimportant. This feature can also be used for properly imaging characters on the photosensitive medium. For example, if the writing beam is formed to image the letter "A" at a plane coincident with the focal plane of the lens and a plane extending through the photosensitive medium surface, that letter will be imaged, after reflection, on the photosensitive medium at a point determined only by the orientation of the mirror facet and independent of the vertical position of the rotating mirror facet.

Referring again to FIG. 1, the writing and coding beams are most conveniently of circular cross-section, but where really high resolution is required it is preferable to include a cylindrical lens 39 beam in the path of coding beam 17 for reforming the coding beam so as to make it ribbon-shaped. As will be appreciated, the higher the required resolution, the smaller the widths of the code plate strips become, and any structural defect in the code plate is more likely to give an incorrect coding signal output from the photodetector. The effect of the reformed beam is shown in FIG. 4 which shows a portion of code plate 34 comprising alternate transparent regions 40 and opaque regions 41. With an appropriate lens included in the code beam path, the coding beam 17 (indicated by the dashed line) is ribbon-shaped, has an elongated cross-section as shown, and scans the code plate as shown by the arrow. This beam shape increases the area of impingement on the code plate and minimises the effects of small-area defects. For example, a typical defect 42 may interfere with the desired light transmission through the code plate, but it will not result in an incorrect code signal output because its area is small with respect to the area of impingement of the coding beam; if, on the other hand, the coding beam were of circular cross-section, the defect might result in an incorrect output. The appropriate design of lens 39 to produce a ribbon-shaped coding beam is within the ordinary skill of the worker in the art.

FIG. 5 illustrates how a refracting plate 45 can be incorporated in the apparatus of FIG. 1 to compensate for spurious deviations in the advancement of the photographic plate 12 by the motor 31. The periodic advancement of the table 33 supporting photographic plate 12 is detected by an interferometer 46 which reflects, in a known manner, a light beam 47 from the moving table. The interferometer generates a signal indicative of the distance the table has moved, which is transmitted to a control circuit 48 that generates a voltage in response to any deviations. If the table has overshot its desired location, a voltage of one polarity is generated, while if it has not moved sufficiently far, a voltage of the opposite polarity is generated, the voltage amplitude in either case being a function of the extent of deviation. The control voltage actuates a galvanometer 49 which rotates refracting plate 45 in one direction or another depending upon the polarity of the voltage received. If there has been no deviation, no control signal is generated, the refracting plate is not rotated, and the writing beam 16 is unaffected. When a control signal is generated, the rotated refracting plate 45 deflects the writing beam 16 in one direction or the other to compensate for the mislocation of the photographic plate 12.

Interferometers capable of performing the functions described are commercially available and will therefore not be described in detail. Basically, the reflected beam 47 interferes with a reference beam to produce an interference fringe each time the path length of beam 47 changes by a half wave-length. By inducing a phase shift between the two beams, and comparing phase differences, the interferometer is also capable of detecting and indicating whether the path length of beam 47 has become shorter or longer. For example, if it is desired that the table moves to the left by seven microns, the path length of beam 47 would be reduced by approximately 14 wavelengths. As such, if all went well, the interferometer would detect or count 28 successive fringes, which, in turn, would be detected by the control circuit 48 as being the correct number, and no control signal would be transmitted to the galvanometer. If, on the other hand, 30 fringes were counted, a control signal would be generated and the writing beam would be deflected accordingly. If the table oscillates temporarily about its desired position, the control voltage will likewise oscillate to give compensatory deflection of the writing beam.

An interferometer arrangement of the type described is especially suitable for controlling continuous movement of the photographic plate if so desired. The motor 31 may be a narrow band slow speed servo motor which is controlled by the output of control circuit 48. In addition to driving the refracting plate 45, the control signal then also controls the speed of the motor 31 to give a uniform continuous advancement of the table. The continuous, rather than stepped, advancement of the photographic plate results in a writing beam scan that is more akin to raster scanning of conventional television and facsimile.

It is, of course, important that the polygonal mirror structure be made with precision and that eccentricities of rotation or "wobble" be avoided so that the writing beam 16 is precisely projected through writing slit 26 during each scan. Experience has shown that this structure is preferably made by forming all of the mirror facets 20 on a single piece of fused silica. Any such technique has the disadvantage, however, that if only one of the mirror facets is imperfect, the entire structure may be unusable.

FIGS. 6 and 7 show an alternative polygonal mirror structure 50 comprising a plurality of roof-shaped reflector prisms 51. Each prism comprises reflecting surfaces 52 arranged at right angles such that incoming light 16 is reflected from both surfaces as indicated schematically. The polygonal mirror structure 50 performs the same function as the mirror structure 19 of FIG. 1; that is, as it rotates, it reflects both writing and coding beams such that they scan linearly.

The structure of FIGS. 6 and 7, however, has the advantage that each prism 51 may be fabricated independently, and if any intolerable defects occur only a single prism need be discarded rather than the entire polygonal mirror structure. The various prisms may then be mounted on a common substrate 53, and it can be shown that the tolerance of the prisms to misalignment is larger than that of planar mirror facets. It can also be shown that the prism structure is capable of tolerating larger rotational deviations or "wobble" in certain directions than the multifaceted planar mirror structure of FIG. 1. The criterion of equation (1) is valid when roof-shaped reflectors are used.

The embodiment described is of course by way of example and is not intended to be limiting. Variations will occur to those skilled in the art. The apparatus could be made responsive to stored analog signals of the type normally used in facsimile reproduction instead of digital signals. The control circuit 22 of FIG. 1 would then be designed such that each coding beam pulse of curve 37, shown in FIG. 2A, would release an increthan a single information pulse. Although the coding beam is shown as being reflected from the same mirror facet as the writing beam, it could in a differently arranged apparatus be reflected from a different part of the mirror structure. A rotatable mirror could, of course, be substituted for the refracting plate 45 or FIG. 5.

WHAT WE CLAIM IS:—

1. Apparatus for the generation of a pattern, character or image including means for producing a writing beam of radiant energy; means responsive to modulation signals representative of a pattern, character or image to be generated for intensity modulating said beam; scanning means arranged to cause said beam to scan, said scanning means including a plurality of reflective surfaces arranged for rotation about a central axis, and means for rotating said plurality of reflective surfaces about said axis at a substantially constant angular velocity; and a lens positioned in the path of the scanning beam, said lens having a focal length which varies in accordance with $K\theta/\tan\theta$ where K is a constant, and θ is the angle between the scanning beam and the focal axis of said lens.

2. Apparatus as claimed in claim 1 wherein each of said plurality of reflective surfaces comprises a roof-shaped reflector prsim having two reflective surfaces at a right angle to each other.

3. Apparatus as claimed in claim 1 or 2 including support means for supporting a radiant energy-sensitive medium, and means for advancing said support means in a direction transverse to the direction of each scan of said writing beam.

4. Apparatus as claimed in claim 3 including means for deriving a correction signal representative of the difference between actual advancement and a predetermined desired advancement of said support means, and means adapted to deflect said writing beam in response to said correction signal in such a direction as to compensate for said difference.

5. Apparatus as claimed in claim 4 wherein said means for deriving a correction signal includes an interferometer.

6. Apparatus as claimed in any one preceding claim including means for producing a coding beam of radiant energy, said scanning means being arranged to cause said writing beam and said coding beam to scan in synchronism, means for deriving a synchronising signal from the coding beam scan, and control means responsive to said synchronising signal for controlling the application to said intensity modulating means of said modulation signals.

7. Apparatus as claimed in claim 6 wherein said means for deriving a synchronising signal includes coding means comprising a plurality of alternate opaque and transmissive regions and arranged to be scanned by said coding beam, and detector means arranged

An interferometer arrangement of the type described is especially suitable for controlling continuous movement of the photographic plate if so desired. The motor 31 may be a narrow band slow speed servo motor which is controlled by the output of control circuit 48. In addition to driving the refracting plate 45, the control signal then also controls the speed of the motor 31 to give a uniform continuous advancement of the table. The continuous, rather than stepped, advancement of the photographic plate results in a writing beam scan that is more akin to raster scanning of conventional television and facsimile.

It is, of course, important that the polygonal mirror structure be made with precision and that eccentricities of rotation or "wobble" be avoided so that the writing beam 16 is precisely projected through writing slit 26 during each scan. Experience has shown that this structure is preferably made by forming all of the mirror facets 20 on a single piece of fused silica. Any such technique has the disadvantage, however, that if only one of the mirror facets is imperfect, the entire structure may be unusable.

FIGS. 6 and 7 show an alternative polygonal mirror structure 50 comprising a plurality of roof-shaped reflector prisms 51. Each prism comprises reflecting surfaces 52 arranged at right angles such that incoming light 16 is reflected from both surfaces as indicated schematically. The polygonal mirror structure 50 performs the same function as the mirror structure 19 of FIG. 1; that is, as it rotates, it reflects both writing and coding beams such that they scan linearly.

The structure of FIGS. 6 and 7, however, has the advantage that each prism 51 may be fabricated independently, and if any intolerable defects occur only a single prism need be discarded rather than the entire polygonal mirror structure. The various prisms may then be mounted on a common substrate 53, and it can be shown that the tolerance of the prisms to misalignment is larger than that of planar mirror facets. It can also be shown that the prism structure is capable of tolerating larger rotational deviations or "wobble" in certain directions than the multifaceted planar mirror structure of FIG. 1. The criterion of equation (1) is valid when roof-shaped reflectors are used.

The embodiment described is of course by way of example and is not intended to be limiting. Variations will occur to those skilled in the art. The apparatus could be made responsive to stored analog signals of the type normally used in facsimile reproduction instead of digital signals. The control circuit 22 of FIG. 1 would then be designed such that each coding beam pulse of curve 37, shown in FIG. 2A, would release an increthan a single information pulse. Although the coding beam is shown as being reflected from the same mirror facet as the writing beam, it could in a differently arranged apparatus be reflected from a different part of the mirror structure. A rotatable mirror could, of course, be substituted for the refracting plate 45 or FIG. 5.

WHAT WE CLAIM IS:—

1. Apparatus for the generation of a pattern, character or image including means for producing a writing beam of radiant energy; means responsive to modulation signals representative of a pattern, character or image to be generated for intensity modulating said beam; scanning means arranged to cause said beam to scan, said scanning means including a plurality of reflective surfaces arranged for rotation about a central axis, and means for rotating said plurality of reflective surfaces about said axis at a substantially constant angular velocity; and a lens positioned in the path of the scanning beam, said lens having a focal length which varies in accordance with $K\theta/\tan\theta$ where K is a constant, and θ is the angle between the scanning beam and the focal axis of said lens.

2. Apparatus as claimed in claim 1 wherein each of said plurality of reflective surfaces comprises a roof-shaped reflector prsim having two reflective surfaces at a right angle to each other.

3. Apparatus as claimed in claim 1 or 2 including support means for supporting a radiant energy-sensitive medium, and means for advancing said support means in a direction transverse to the direction of each scan of said writing beam.

4. Apparatus as claimed in claim 3 including means for deriving a correction signal representative of the difference between actual advancement and a predetermined desired advancement of said support means, and means adapted to deflect said writing beam in response to said correction signal in such a direction as to compensate for said difference.

5. Apparatus as claimed in claim 4 wherein said means for deriving a correction signal includes an interferometer.

6. Apparatus as claimed in any one preceding claim including means for producing a coding beam of radiant energy, said scanning means being arranged to cause said writing beam and said coding beam to scan in synchronism, means for deriving a synchronising signal from the coding beam scan, and control means responsive to said synchronising signal for controlling the application to said intensity modulating means of said modulation signals.

7. Apparatus as claimed in claim 6 wherein said means for deriving a synchronising signal includes coding means comprising a plurality of alternate opaque and transmissive regions and arranged to be scanned by said coding beam, and detector means arranged

* C L M S *

to detect coding beam energy transmitted through said coding means thereby to produce said synchronising signal.

8. Apparatus as claimed in claim 7 including means for causing said coding beam to be ribbon-shaped in cross-section, and wherein said alternate opaque and transmissive regions are strip-shaped and have their longer dimensions arranged parallel to the longer cross-sectional dimension of said coding beam.

9. Apparatus as claimed in any one of claims 6 to 8 wherein said means for producing a writing beam and said means for producing a coding beam include a laser source, and means for splitting the output beam from said laser into said writing beam and said coding beam.

10. Apparatus as claimed in any one preceding claim wherein said intensity modulating means is positioned in the beam path between said means for producing a writing beam and said means arranged to cause said beam to scan.

11. Apparatus as claimed in any one preceding claim including means for collimating said writing beam prior to scanning thereof.

12. Apparatus as claimed in claim 11 wherein said means for collimating said writing beam includes said lens.

13. Apparatus as claimed in any one preceding claim including storage apparatus for storing said modulation signals.

14. Apparatus for the generation of a pattern, character or image substantially as herein described with reference to the accompanying drawings.

15. An electronic circuit device made with the aid of apparatus as claimed in any one preceding claim.

C. S. T. BUCKLEY
Chartered Patent Agent
5, Mornington Road,
Woodford Green, Essex.
Agent for the Applicants.

Printed for Her Majesty's Stationery Office, by the Courier Press, Leamington Spa, 1972.
Published by The Patent Office, 25 Southam pton Buildings, London, WC2A 1AY, from which copies m ay be obtained.

