Feb. 17, 1942. E. BRUCE 2,273,433

CATHODE RAY TUBE

Filed April 10, 1940

FIG. 1

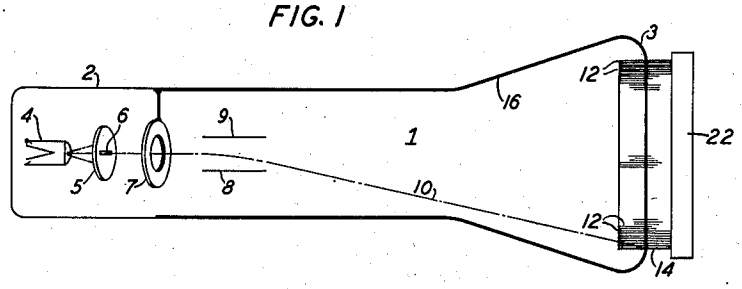


FIG. 2

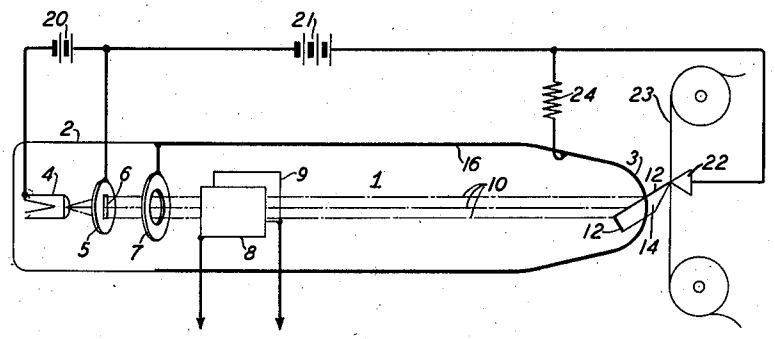


FIG. 3

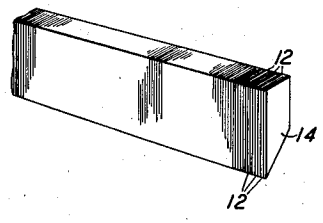
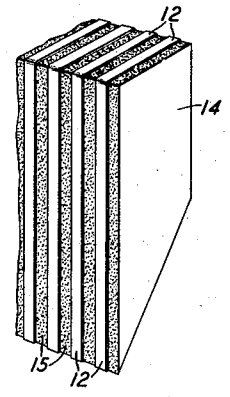


FIG. 4



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2,273,433

CATHODE RAY TUBE

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Application April 10, 1940, Serial No. 328,816

12 Claims. (Cl. 250—164)

This invention relates to cathode ray devices and particularly to a cathode ray tube having a so-called "current window" in the beam-receiving end thereof.

An object of the invention is to provide a cathode ray tube having a current window in the form of a single sharp line: an electron current "slit."

A further object is to provide a low resistance path for the beam current to the exterior of the tube.

Still another object is to provide means for concentrating a maximum of beam current energy into a single sharp line in the direction in which beam scanning takes place.

There are many connections in which it is desirable to draw current of an electron beam directly out through the beam-receiving end of a cathode ray tube. Electrostatic recording as described in U. S. Patent No. 2,200,741, May 14, 1940, to Frank Gray, provides an example. Another example is provided by a facsimile signal reproducing or printing system in which the beam current passes through a current window and through a tape of electrosensitive material to an external electrode, leaving impressions on the tape which are proportional to the intensity of the beam current and inversely proportional to the scanning speed. Such a system is described and claimed in application Serial No. 331,716, filed April 26, 1940, of E. Bruce and W. S. Gorton.

The well-known "Lenard" window of thin metal foil has long been used as a means of egress for the beam current from a cathode ray tube, but, aside from the structural difficulties which attend the supporting of thin metal foil against the force of atmospheric pressure over any considerable area, a window of this character suffers from the excessively high attenuation which it offers to the beam current and the consequent reduction in efficiency of the device as a whole.

It has already been proposed to substitute for the well-known Lenard window a mosaic of discrete conductors, each insulated from all the others, and passing through the wall of the beam-receiving end of the tube, perpendicular thereto and substantially parallel with the direction of the oncoming electron beam. Such a mosaic structure is illustrated in Sabbah et al. Patent 2,015,570, September 24, 1935. Aside from the serious difficulties which attend the construction of a current window of this form, it does not lend itself to the uses for which the tube of this invention was devised and which require a long narrow window in the form of a fine, sharp line and constituting in effect an electron current slit. Even if only a single row of the wires of this mosaic were scanned in one direction only in accordance with the scheme of the aforementioned application, Serial No. 331,716, filed April 26, 1940, thereby sacrificing the great majority of the conductors, it would still be necessary to focus the cathode beam with excessive sharpness into a minute spot; to focus it, in fact, on the inner end of a single one of the wires of the mosaic. When the cathode beam carries any considerable amount of energy this places an excessively heavy burden on the electron focusing means and presents a problem which, if possible, it is better to avoid than to meet.

The tube of this invention may comprise a current window of novel form, construction and arrangement which meets the objections to the Lenard window and the mosaic, and provides a narrow electron current slit of low electron resistance and through which greatly increased energy may be drawn. It is characterized in its preferred embodiment by a plurality of closely spaced discrete conductors arranged in a single row, extending through the end wall of the tube, each insulated from all the others. In a preferred modification the individual conductors are disposed in a plane oblique to the direction of the oncoming electron beam.

The invention in its various aspects will be more fully understood from the following description of preferred embodiments thereof taken in connection with the appended drawing in which:

Fig. 1 is a schematic plan view of a cathode ray tube according to the invention;

Fig. 2 is a schematic side elevation of the tube of Fig. 1 arranged to produce impressions on a sensitized tape, and showing, additionally, simple circuit connections for energizing the tube:

Fig. 3 shows a beam-receiving member of the tube of Figs. 1 and 2 to an enlarged scale before its incorporation in the tube wall; and

Fig. 4 shows one end of the member of Fig. 3 to a still more highly enlarged scale.

Referring now to the figures, Figs. 1 and 2 show a closed glass vessel 1 having a neck portion 2 and a beam-receiving portion 3 which is enlarged in one dimension and flattened out into the form of a blunt wedge in the other dimension. An electron gun including a cathode 4, an apertured screen anode 5, an accelerating elec-

trode 7, and a pair of beam-deflecting plates 8, 9 are mounted in the neck portion 2 of the tube, and the path of an electron beam 10 originating at the cathode 4, defined by the aperture 6 of the anode 5 and deflected by an electric field between the deflecting plates 8 and 9 is indicated by broken lines.

Mounted in the end wall of the beam-receiving end 3 of the tube are a plurality of closely spaced discrete conductors 12 of minute cross-section which protrude through the wall of the tube, from the inside to the outside, each conductor being insulated from its neighbors. As more clearly shown in Fig. 2, the discrete insulated conductors 12 are arranged in a single row to form a comb. Further, as shown in Fig. 2, they are mounted obliquely to the direction of the oncoming cathode beam 10 so that, despite the minute cross-section of each particular conductor 12, the cathode beam 10 will strike it at a greater or less distance from the point at which it passes through the tube wall, even though the focusing of the cathode beam 10 in a direction perpendicular to the scanning direction be more or less imperfect.

For use of the tube as a facsimile reproducer, the distance from the center line of each conductor to the center line of an adjacent conductor should preferably be not greater than the width of a single picture element to be reproduced; for example, the distance may be of the order of 0.01 inch.

The current window comb of this invention may be formed and incorporated in the beam-receiving end 3 of the tube in any desired manner. For example, it may be formed by plating a glass prism 14 having a bevelled edge with a film of some tough, highly conductive metal, such as platinum, and subsequently subdividing the resulting metal film into a plurality of discrete parallel strips, as by scribing closely spaced lines through the film. According to another method, the comb may be formed by first masking a plurality of closely spaced parallel strips of the prism surface, then covering the unmasked parts as by plating or sputtering, and finally removing the masking material.

After the plating operation has been completed, the resulting block, bearing its ribbon-like conductors 12, may be sealed into the wall of the beam-receiving end 3 of the tube, bevelled edge outward and with each conductor 12 extending through the tube wall and lying at an angle to the direction of the oncoming electron beam 10.

The plating is not limited to one side of the prism. By plating at least two adjacent sides an additional advantage is secured, namely, each conductor turns through an angle inside the tube so that even if the main portion extends through the wall in a direction parallel with that of the oncoming beam, the shorter portion of the same conductor still extends through a substantial distance in a direction perpendicular thereto, so that the beam need not be focused with perfect exactness in the plane of the main portion of the comb. This construction is shown in Fig. 4.

Indeed, all four sides of the prism may be plated, if desired, and the lines of separation continued all the way around the prism so that each conductor consists of a loop. This loop may be continuous, or, if desired, all of the loops may be severed at their outer ends by grinding, thus providing U-shaped conductors, the bend of the U being inside the tube. For certain purposes, for example the purposes fully described in the aforementioned copending application Serial No. 331,716, filed April 26, 1940, in which a sliding contactor bears against certain of the conductors of the comb, the return side of the loop may be of decided advantage. In any event, it may be used as a spare in case of injury to the main or working portion of the same conductor.

The inner surface of the beam-receiving end 3 of the tube is preferably coated with some conductive substance 16 such as that commonly known as "aquadag," and it is advantageous to spread some high resistance fluorescent material 15, such as zinc silicate, on the glass surfaces between and adjacent to the comb wires 12 inside the tube to enable focusing to be adjusted visually. This is indicated in Fig. 4 which shows one end of the glass prism with the discrete ribbon-like conductors 12 applied thereto and fluorescent material 15 between them.

Fig. 2 shows circuit connections for the tube of this invention when incorporated as a component part of a facsimile printer. The negative terminal of a battery 20 or other source of potential is connected to the cathode 4 and the positive terminal to the beam-defining anode 5. The negative terminal of another battery 21 is connected to the anode 5 and the positive terminal to a knife edge 22 which is placed in close parallel alignment with the outer ends of the comb wires 12 and also, through a resistance 24, to the accelerating anode 7. An appropriately sensitized low resistance paper tape 23 is arranged to be advanced between the comb wires 12 and the knife edge 22 by a suitable mechanism, not shown; and the cathode beam 10, originating at the cathode 4, may be swept along the row of comb wires by a scanning voltage of suitable wave form impressed on the deflecting elements 8, 9 in any desired manner. For example, the scanning may be either oscillatory or at constant speed with rapid fly-back or at variable speed in accordance with the so-called "velocity modulation" system.

The conductive lining 16 of the tube is connected through the resistor 24 to the positive terminal of the battery 21 to withdraw stray electrons, especially secondary electrons which may be driven out of the comb wires by impact of the primary electrons of the cathode beam and which might otherwise modify the motions of the primary electrons in an objectionable manner.

It will be understood by those skilled in the art that current flow may take place from the outer point of that particular conductor 12 of the comb which is instantaneously impinged by the cathode beam to the knife edge 22 which is placed close thereto on the far side of the sensitive paper tape 23, the magnitude of the current being governed mainly by the energy of the cathode beam, since the resistance of each individual comb wire 12 and of the sensitized paper tape 23 may be small in comparison with that of the beam.

With the current window of this invention, the current flowing from a particular comb wire 12 through the sensitized paper 23 to the knife edge 22 will be sensibly the same whether it originates in electrons which strike the inner portion of the particular comb wire 12 close to the point at which it passes through the tube wall, at the end of the wire toward the cathode 4, or anywhere in between. Thus the stringency of the electron beam-focusing requirements are greatly reduced, with consequent simplification of the apparatus and reduction in the cost.

A feature of the invention is the utilization of a very much larger part of the energy available in a cathode beam than has heretofore been possible. As is well known, there is a decided limit to the sharpness with which a cathode beam may be brought to a point focus due to the fact that the electrons when brought sufficiently close together tend to repel one another. However, if sufficiently spread apart in one direction, the electron beam may be focused with almost any desired degree of sharpness in the other direction. That is to say, a line focus may be obtained which is far sharper than a point focus, and far more electron current energy may be concentrated in a narrow rectangle than could be concentrated in a circular spot of the same width.

By the preferred construction in accordance with this invention advantage is taken of this fact and it is therefore preferred to employ an electron gun arrangement which is capable of focusing the electron beam into a narrow rectangle whose width is no greater than the width of a single one of the comb wires 12 but whose length may be as great as the projected length of the same comb wire on a plane perpendicular to the direction of motion of the oncoming electron beam. Thus all the electrons which are concentrated into the narrow rectangular spot strike some portion of a particular comb wire whether close to the point at which it passes through the tube wall or further back towards its end; and all of these electrons combine to form a substantial current from the comb wire 12 to the knife edge 22 and therefore make a heavy and durable impression on the sensitized tape 23. As is well known, the beam may be focused in a narrow rectangular spot by the use of a suitably shaped aperture in the electrode which defines the cross-section of the beam. This arrangement is shown in Figs. 1 and 2, where the electrode 5 is shown mounted in front of the cathode and provided with a narrow vertical slit 6. The same result may also be secured by other means, for example, the means described and claimed in Winans application Serial No. 307,255, filed December 2, 1939.

Various modifications of the arrangements above described which are within the spirit of the invention will occur to those skilled in the art. In particular, it is contemplated that the conducting comb of this invention may be constructed in a number of different ways and of a number of different materials. For example, an excellent construction is that described and claimed in Ekstrand application Serial No. 328,819 filed April 10, 1940.

What is claimed is:

1. A cathode ray device which comprises a vessel having a non-conductive wall, means within said vessel for projecting a cathode beam, and beam-receptive means sealed into said wall in position to be impinged by said beam, said beam-receptive means comprising a plurality of discrete conductors arranged in a single row and extending parallel to each other through said wall and disposed with one of their smaller dimensions lying in the direction of the row, the outer end of each conductor terminating in a sharp tip, the distance from each of said tips to an adjacent tip being of the order of 0.01 inch.

2. A cathode ray device which comprises a vessel having a non-conductive wall, means within said vessel for projecting a cathode beam, and beam-receptive means sealed into said wall in position to be impinged by said beam, said beam-receptive means comprising a plurality of closely spaced discrete conductors, insulated from each other, arranged in a single row and extending parallel to each other through said wall, at least the portion of each of said conductors lying within said vessel being disposed at an oblique angle to the direction of projection of said beam.

3. A cathode ray device which comprises a vessel having a non-conductive wall, means within said vessel for projecting a cathode beam, and beam-receptive means sealed into said wall in position to be impinged by said beam, said beam-receptive means comprising a plurality of discrete conductors, arranged in a single row, parallel to each other and spaced apart by distances of the order of less than 0.01 inch, and extending through said wall, at least the portion of each of said conductors lying within said vessel being disposed at an oblique angle to the direction of projection of said beam.

4. Apparatus for synthesizing an image, element by element, from signals related to the light and shade values of successive elements of an image, which comprises a vessel having a non-conductive wall, means within said vessel for projecting a cathode beam, and beam-receptive means sealed into said wall in position to be impinged by said beam, said beam-receptive means comprising a plurality of discrete conductors arranged in a single row and extending parallel to each other through said wall and disposed with one of their smaller dimensions lying in the direction of the row, the outer end of each conductor terminating in a sharp tip, the distance from the center line of each of said conductors to the center line of an adjacent conductor being of the order of the width of a single image element.

5. Apparatus for synthesizing an image, element by element, from signals related to the light and shade values of successive elements of an image, which comprises a vessel having a non-conductive wall, means within said vessel for projecting a cathode beam, and beam-receptive means sealed into said wall in position to be impinged by said beam, said beam-receptive means comprising a plurality of discrete bare conductors arranged in a single line and extending parallel to each other through said wall and disposed with one of their smaller dimensions lying in the direction of the row, the outer end of each conductor terminating in a sharp tip, adjacent sides of adjacent conductors being spaced apart by distances of the order of less than the width of a single image element.

6. A cathode ray device which comprises a vessel having a non-conductive wall, means within said vessel for projecting a cathode beam having a cross-section in the form of a narrow rectangle, and beam-receptive means sealed into said wall in position to be impinged by said beam, said beam-receptive means comprising a plurality of closely spaced discrete conductors arranged in a single row and extending parallel to each other through said wall, at least the portion of each of said conductors which lies within said vessel being disposed at an oblique angle to the direction of projection of said beam and lying in the plane defined by the longer axis of said narrow rectangle and said projection direction.

7. A cathode ray device which comprises a vessel having a non-conductive wall, means within said vessel for projecting a cathode beam, and

beam-receptive means sealed into said wall in position to be impinged by said beam, said beam-receptive means comprising a plate of insulating material and a plurality of discrete strips of conductive material attached to the surface of said plate, said strips being spaced from each other and extending parallel to each other through said wall, at least the portion of each of said strips which lies within said vessel being disposed at an oblique angle to the direction of projection of said beam.

8. Apparatus for synthesizing an image on a sheet of electricity-sensitive material disposed adjacent said apparatus in position to receive electric current therefrom, which comprise a vessel having a non-conductive wall, means within said vessel for projecting a cathode beam, a plurality of discrete elements for collecting beam current of relatively large cross-section inside of said vessel and concentrating it to a point outside of said vessel, each of said elements comprising a conductor extending through the wall of said vessel, terminating outside of said vessel in a comparatively small area and terminating inside of said vessel in a surface of comparatively large area, said surfaces being in position to be impinged by said cathode beam, said external ends lying in a row and having a center-to-center spacing of the order of the width of an elemental image area, and means for sweeping said cathode beam over said surfaces.

9. Apparatus for synthesizing an image on a sheet of electricity-sensitive material disposed adjacent said apparatus in position to receive electric current therefrom, which comprises a vessel having a non-conductive wall, means within said vessel for projecting a cathode beam, a plurality of closely spaced discrete elements for collecting beam current of relatively large cross-section inside of said vessel and concentrating it to a point outside of said vessel, each of said elements comprising a conductor extending through the wall of said vessel, terminating outside of said vessel in a point and terminating inside of said vessel in a surface of substantial extent, said surfaces being in position to be impinged by said cathode beam, said external end points lying in a row, and means for sweeping said cathode beam over said surfaces.

10. A cathode ray device which comprises a vessel having a non-conductive wall, means within said vessel for projecting a cathode beam, and beam-receptive means sealed into said wall in position to be impinged by said beam, said beam-receptive means comprising a plurality of discrete elongated non-overlapping conductors arranged in a single row and extending through said wall and disposed with one of their smaller dimensions lying in the direction of the row, the center-to-center spacing distance of the outer ends of said conductors being uniform and close, the cross-sectional area of the outer parts of each of said conductors being less than the square of said spacing distance, the inner part of each of said conductors presenting to said projected beam an area substantially in excess of the square of said spacing distance.

11. A cathode beam device having a wall of insulating material, a target member for the beam forming a part of said wall and consisting of an insulating element sealed therein and projecting therefrom within said vessel, said element having conducting material plated on one face thereof and extending through said seal to the outside of said vessel and within said vessel in a position to be impinged by said beam.

12. A cathode beam device comprising a vessel having a wall of vitreous insulating material, a target member for the beam forming a part of said wall and consisting of a vitreous insulating element sealed therein and projecting therefrom both within and without said vessel, said element having a face with narrow strips of conducting material plated thereon, which strips extend through said seal with their outer extremities lying close together in a row along an edge of said element in position to be aligned with and uniformly spaced from an external electrode, said strips having portions extending within the vessel for a distance many times greater than the width of a strip at said edge, and means for deflecting said beam to cause it to impinge in turn upon said strips, said beam being oblong in cross-section at said target with its short transverse dimension substantially perpendicular to the longest dimension of each of said strips.

EDMOND BRUCE.