STORED SIGNAL ENHANCEMENT ELECTRON DISCHARGE DEVICE

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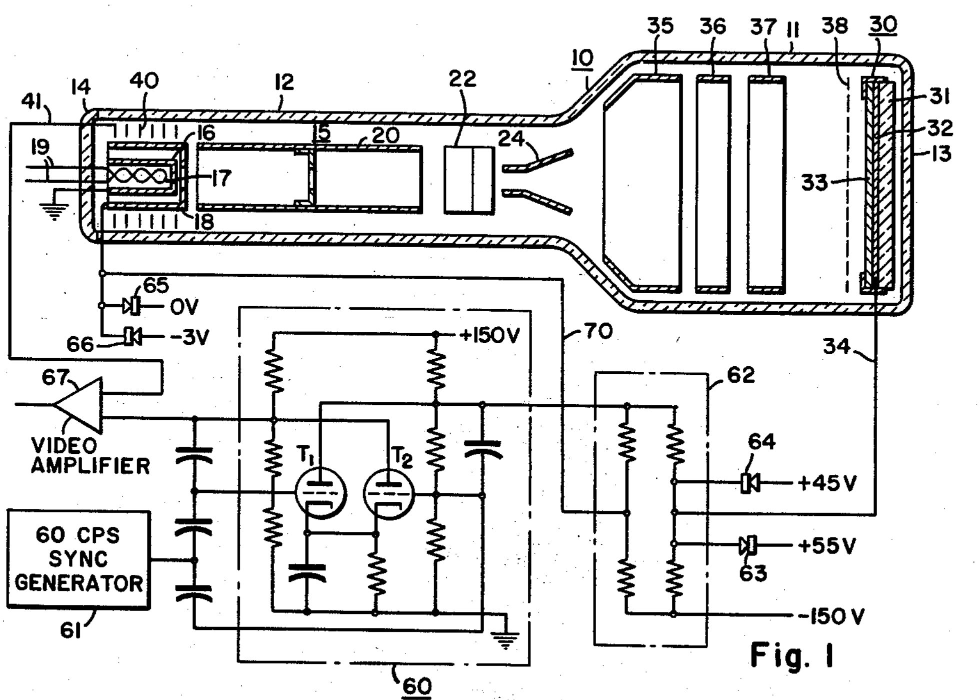

Fig. 1

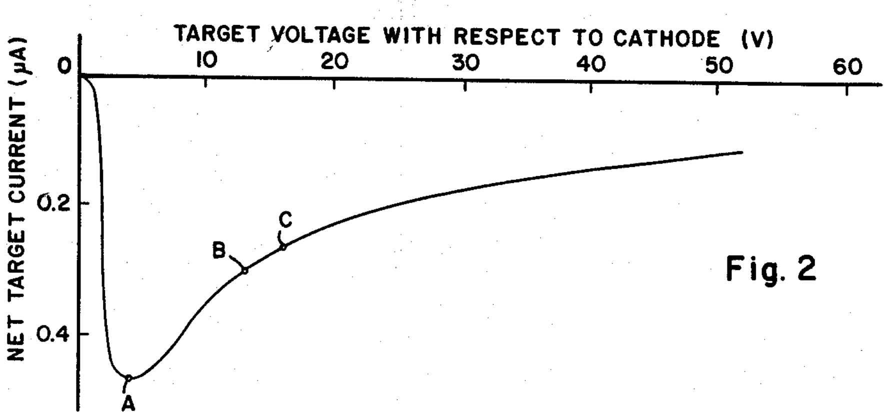

Fig. 2

WITNESSES

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This invention relates to electron discharge devices and, more particularly, to storage and imaging type tubes which utilize a target member which is excitable to provide a distributed charge pattern thereon.

Several types of devices, including some image pickup tubes and several varieties of storage tubes, have target or retina structures which are capable of storing information thereon in the form of a charge pattern. This charge pattern in turn gives rise to a corresponding potential field pattern which acts to control or modulate an electron reading beam. The modulated reading beam current is proportional to the strength of the stored potential pattern. To maintain independence in the charge pattern, each resolvable elemental target area must have a capacitance to ground greater than the inter-element capacitance.

Irrespective of the manner in which the charge pattern is established on the target member, it is often desirable to enhance or develop a low contrast charge pattern to one in which the resolvable elements are more fully separated in their relative potential values.

It is, therefore, an object of this invention to provide an improved electron discharge device.

A further object is to provide an improved electron discharge device having target means capable of providing a potential charge pattern.

Another object is to provide means for enhancing the stored signal on the target member of an electron discharge device.

A further object is to provide a pickup tube capable of half tone reproduction.

A still further object is to provide means for the differential rate of change in the charge on resolvable target areas of an electron discharge device.

A still further object is to provide an electron discharge device in which a single electron beam source is utilized sequentially, on a time shared basis, first to enhance the target charge pattern and then, by the use of the same beam, to read out the information of the enhanced charge pattern.

Basically, the present invention provides an electron discharge device provided with a target structure which is capable of providing an information pattern thereon in the form of electrical charges on elemental areas of the target. The discharge device also includes a single focused electron beam source or electron gun which is sequentially utilized first to enhance the charge pattern on the target structure and then to read out the enhanced charge pattern. The enhancement is achieved through the careful selection of the voltage at which the electron beam is incident upon the target surface so as to produce a differential rate of secondary emission therefrom in accordance with the charge initially on the target. This differential rate of secondary emission provides that with the electron gun cathode maintained at a constant potential, the secondary emission from more positively charged target portions is greater than the secondary emission from those portions of the target less positively charged. From this, it is evident that if the electrons from the gun are incident upon the target with uniform current density, the net effect resulting from secondary emission will be that the potential difference between two initially charged areas will increase. The sequential operation of the device is achieved by commutating the target supply voltage between two values, one for development or enhancement and one for reading.

Further objects and advantages of the invention will become apparent as the following description proceeds and features of novelty which characterize the invention will be pointed out in particularity in the claims annexed to and forming a part of this specification.

For a better understanding of the invention, reference may be had to the accompanying drawings, in which:

FIG. 1 is an elevational view in section of an electron discharge device embodying the present invention connected to a schematic representation showing one form of circuitry which may be used to commutate the potential applied to the target structure; and,

FIG. 2 is a typical secondary emission curve for materials such as those which would be employed as target material in the device of FIG. 1.

Referring in detail to FIG. 1, there is shown an evacuated vacuum tight envelope 10 of suitable material such as glass having an enlarged tubular portion 11 and a smaller tubular portion 12. The enlarged portion 11 may be closed off by means of a face plate 13 of a suitably wideband transmitting material such as sapphire, calcium fluoride, or barium fluoride which may be integrally formed with the envelope 10 while the portion 12 is sealed off by a button stem header 14 in a manner well known in the art.

A suitable electron beam producing source 15 is disposed near one end of the envelope 10 within the portion 12. The beam source 15 comprises generally an electron emissive cathode 16, a control electrode 18, and a focusing and accelerating assembly 20. The construction and operation of the beam producing source 15 is that which is well known in the art. The cathode 16 is of the thermionic emission type and is provided with a heater 17 which is connected to a suitable source of potential by a pair of leads 19 which extend through the header 14. The cathode 16 is operated at ground potential while the control electrode 18 is commutated between 0 and 3 volts negative as will be more fully explained later. The focusing and accelerating assembly 20 may be operated at approximately 0.5 kilovolt positive with respect to the cathode.

Also disposed within the portion 12 is a set of deflection plates 22 and 24 which are connected to suitable sources of varying voltage to provide, respectively, the horizontal and vertical deflection of the electron beam produced by the assembly 15. This deflection is utilized to cause the beam to scan over a signal storage target 30 which is located at the opposite end of the envelope 10 near the face plate 13.

In the present embodiment, the signal storage target 30 is shown to be one which is sensitive to visible radiation and includes a support member 31 which is of suitably radiation transmissive material such as glass. A layer 32, disposed upon the surface of the support member 31, which faces the beam source 15 is of a suitably electrically conductive material transmissive of the input radiation, for example a very thin gold or tin oxide film. Disposed upon the layer 32 is a layer 33 of suitable radiation responsive material such as antimony trisulphide, arsenic trisulphide, or arsenic triselenide. The conducting layer 32 is connected to a commutated source of potential by means of a lead 34 extending through the envelope 10.

Interposed between the deflecting plates 24 and the signal storage target 30 are a plurality of cylindrically shaped conducting electrodes 35, 36 and 37 which collectively form a collimating electron lens system. The electrodes 35, 36 and 37 are provided with suitable sources of potential which may be approximately 0.5 kilovolt, 1 kilovolt and 1 kilovolt, respectively. A decelerator grid assembly 38, which may be at the same potential as the electrode 37, is provided in close proximity to the input screen 30. The decelerator grid 38 serves to collect at least a portion of any secondaries emitted from the layer 33 as well as providing a uniform electric field within which the electrons of the electron beam slow down without divergence to be incident upon the layer 33 orthogonally and at a low energy.

The present device, which is of the return beam type, the operation of which is well known in the art, also includes an electron multiplier assembmly 40. The assembly 40 is positioned within the envelope portion 12 surrounding the control electrode 18 and serves to produce an output signal in response to the magnitude of the return read out beam. During the read out operation, the signal collected on the assembly 40 is applied to a video amplifier 67 by a suitable lead 41.

The layer 33 is responsive to radiation incident thereon through the face plate 13 and, as such, changes its conductivity in accordance with the intensity of the radiation. This change in conductivity, because there is a voltage impressed across the layer 33, results in a current flow within the layer 33 which serves to establish a charge pattern on the free surface thereof. If the layer 33 is viewed to be in the nature of a very large number of very small discrete elements, it is seen that the free surface of each of these elements will take on an individual charge in accordance with the intensity of the radiation information incident upon that particular element. It is essential in this type of device that the free surface of each of the discrete elements has a capacitance to ground (the thin conductive layer 32) which is greater than the capacitance between the elements. A charge pattern thus produced, particularly by low intensity radiation, is often one of low contrast and it is, therefore, often desirable to develop or enhance the contrast of such a pattern, thus increasing the sensitivity of the device. This development may be accomplished by increasing the potential difference between resolvable areas of the target.

In the present invention, the development of this latent type of charge pattern is achieved through the use of the electron beam from the source 15, which is also used in sequential operation on a subsequent scan period to read out the enhanced charge pattern on the layer 33. The manner in which the beam serves to enhance the charge image on the layer 33 may best be explained with reference to FIG. 2. In FIG. 2 there is shown as the abscissa the target voltage with respect to the cathode and as the ordinate the net target current. This curve is a typical secondary electron emission curve for resistive type targets such as are used in devices of the above described nature. It is readily apparent from this curve that at point A, which accurs at about 4 volts for the particular curve shown, the secondary emission curve makes an abrupt change in its direction. As the voltage is increased from point A, it is noted that the net target current decreases with an increase in voltage thus showing a negative resistance characteristic to the material in this voltage range. This negative resistance characteristic is the result of the secondary emission ratio which in this region increases as the voltage increases and it is within this region that the development of the charge pattern takes place in the present invention.

If two points B and C, on the negative resistance portion of curve, are selected to represent the conditions of two elemental areas B and C of the surface of the target layer 33 having different potentials thereon due to the incident radiation, the manner in which the enhancement of the charge pattern on the surface of layer 33 occurs is as follows. In the case of both areas B and C, the secondary emission ratio is less than unity so that

with the incidence of the beam on the layer 33 there is a net deposition of electrons on that area. The amount of this net deposition is determined by the point's position on the curve. While the incident beam will cause both elemental areas B and C to charge negatively, as point B is lower on the curve than point C, the rate of secondary emission from area B is less than that from area C. Therefore, with the same amount of beam current, area B will charge negatively a greater amount than will area C. The amount of charging of an area by this enhancement method is proportional to the charge already on the area. It is this differential rate of charging which provides the desired pattern enhancement. For a more complete description of this manner at pattern enhancement, reference is made to copending application 198,932 entitled "Electron Discharge Device" filed May 31, 1962, and which is assigned to the assignee of the present invention.

After the layer 33 has been scanned and the latent pattern thereon developed to provide one of greater contrast, the layer 33 is again scanned by the beam from the source 15 to provide for reading out the information on that layer. However, the cathode to target voltage which is desirable for the development period is not the desirable voltage for the read out period. Therefore, in order to utilize the beam from the same source 15 for the two distinct operations sequentially, the voltage between the cathode and the target is commutated between two separate values.

The commutation or switching of the target supply voltage is achieved, in the present example, by means of a multivibrator 60 (see FIG. 1). As the operation of multivibrators is well known in the art, no detailed explanation will be given here. A sixty cycle per second synchronous generator 61 is utilized to trigger the multivibrator 60. Multivibrator 60 is of a bistable nature and is one in which the alternate tubes are conductive at a rate one-half that of the triggering impulse. The output of T_1 of the multivibrator 60 is fed into a voltage divider circuit 62. Two diodes 63 and 64, connected in opposite polarity, are utilized to connect respectively voltages of values 55 and 45 volts to a common point of the voltage divider 62.

Similarly, two additional diodes 65 and 66 serve to connect the control electrode 18 through lead 70, alternately to voltages of 0 volt and 3 volts negative. The changing of the control electrode potential is for the purpose of controlling the density of the electron beam. During the development portion of the cycle, T_2 of the multivibrator 60 is in the conducting state while T_1 is in the non-conducting state. With T_1 non-conducting, the circuitry is such that the 55 volts positive is impressed upon the layer 32 of the target 30 and the 0 volt potential is applied to the control electrode 18. At the same time the output from the plate of T_2, which is a 30 cycle per second square wave, is applied to a video amplifier 67 as a blanking pulse to block out the signal from the tube output assembly 40. During the alternate portion of the cycle, which is the reading portion, T_1 is conducting while T_2 is in the non-conducting state. Under these circumstances the 45 volt positive potential is applied to the layer 32 of the target structure 30 while the 3 volts negative potential is applied through the diode 66 to the control electrode 18. Thus it is seen that a single electron beam is time shared in its capacity to perform two functions. The first of these functions is that of enhancing the charge image on the layer 33 and the second function is that of providing a read out beam.

In the present device, the read out beam also causes the erasure of the charge pattern. As has been stated, the voltage on the conducting layer 32 is commutated between two values, the lesser of these values (45 volts in the example given) being utilized during the read out period. This lower voltage is selected to provide that during read out, the device operates on the positive resistance slope part of the secondary emission curve so that all target areas are returned substantially to ground potential and hence the charge pattern is erased.

In order to operate a device in the above described manner, three basic qualities must exist in the device utilized. These three qualities are: (1) a negative resistance region in the retina transfer characteristic of sufficient slope to give gain through a differential rate of charging, (2) a retina time constant of sufficient duration to allow the charges at the surface to remain until read off by the reading beam, and (3) enough beam current to permit development of the latent image. It has been found that these qualities exist in several types of devices including many vidicons, thin film image orthicons and many storage tubes.

An additional advantage derived in the above described sharing of time of the electron beam in a sequential manner is the reduction of reading beam noise. As targets utilized in devices of this nature are of a resistive type, due to the potential difference across the surfaces of the resistive layer there is a current within this layer even in the absence of a signal on the target. This current is known as the dark current and is often of a relatively large magnitude. When this current is supplied by the reading beam, small variations in the dark current may act to add erroneous signals in the return beam and hence produce errors in the output signal. In the present invention, where the beam is time shared to provide sequential functions, the bulk of the dark current may be supplied during the development period. Therefore, during the reading period, the beam need be only of sufficient magniture to read the charged pattern. This represents a considerably smaller beam than that required for the conventional operation of these tubes.

It is thus seen, by the present invention utilizing the time sharing of the electron beam, that a conventional type of pickup or storage tube may be utilized to provide an enhanced image. This permits the use of the tube at lower radiation input levels.

While there has been shown and described what is at present considered to be the preferred embodiment of the invention, modifications thereto will readily occur to those skilled in the art. It is not desired, therefore, that the invention be limited to the specific arangement shown and described and it is intended to cover in the appended claims all such modifications as fall within the true spirit and scope of the invention.

We claim as our invention:

1. An electron discharge device comprising an envelope, target means within said envelope excitable to produce a charge pattern on one surface thereof, electron beam producing means, means for scanning said beam over said charge pattern, said beam producing means operable at a first electrical potential with respect to said target to provide enhancement of said charge pattern through differential charging by secondary electron emission therefrom, said beam producing means sequentially operable at a second electrical potential with respect to said target to permit read out of said charge pattern.

2. An electron discharge device comprising an envelope, a radiation sensitive target within said envelope to produce a charge pattern corresponding to a radiation pattern, directed thereon, electron beam producing means within said envelope for the projection of an electron beam onto said charge pattern, means for deflecting said electron beam to provide that said electron beam scans said charge pattern, means for applying a first electrical potential between said beam producing means and said target during a first of successive scan periods and means for applying a second electrical potential between said beam producing means and said target during a second of successive scan periods, said first potential being of a value to provide enhancement of said charge pattern through differential secondary emission from said target and said second potential being of a value to provide read out of said target charge pattern.

3. An electron discharge device comprising an envelope, target means within said envelope excitable to produce a charge pattern on one surface thereof, electron beam producing means including a cathode and a control electrode, means for causing said electron beam to be scanned over said charge pattern, said target operable at a potential of approximately 55 volts positive and said control electrode about 3 volts negative with respect to said cathode during a first of successive scans to provide enhancement of said charge pattern through differential secondary electron emission from said charged surface and said target operable at a potential of approximately 45 volts positive and said control electrode near cathode potential during a second of successive scans to provide an output signal corresponding to said charge pattern.

4. An electron discharge device comprising an envelope, target means within said envelope for the production of a charge pattern on one surface thereof in response to excitation, electron beam producing means, means to cause said electron beam to be scanned over said charge pattern, said target operable at a first potential positive with respect to said beam producing means during a first of successive scan periods to provide enhancement of said pattern through secondary emission from said surface, said target means operable at a second potential less positive than said first potential, with respect to said beam producing means during the second of successive scan periods to provide an output signal corresponding to the enhanced charge pattern on said target surface.

5. An electron discharge device comprising an evacuated envelope, target means within said envelope, said target means excitable to produce a charge pattern on one surface thereof, and being of a material whose secondary emission curve exhibits a negative resistance characteristic, electron beam producing means, means to effect the scanning of said beam over said charge pattern, said target operable at a first positive potential with respect to said beam producing means during a first of successive scan periods, said first positive potential being of a value to provide that said beam electrons are incident upon said target surface at a voltage corresponding to a negative resistance portion of the target material's secondary emission curve whereby enhancement of said charge pattern is achieved, said target operable at a second positive potential with respect to said beam producing means during a second of successive scan periods, said second positive potential being of a value that said beam electrons are incident upon said target surface at a voltage corresponding to a positive resistance portion of the target material's secondary emission curve whereby said electron beam provides an output signal corresponding to said charge pattern while simultaneously effecting an erasure of said charge pattern.

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