Aug. 23, 1955 W. J. SEN ET AL 2,716,203

ELECTRONIC IMAGE STORAGE TUBE AND SYSTEM

Filed June 23, 1947 3 Sheets-Sheet 1

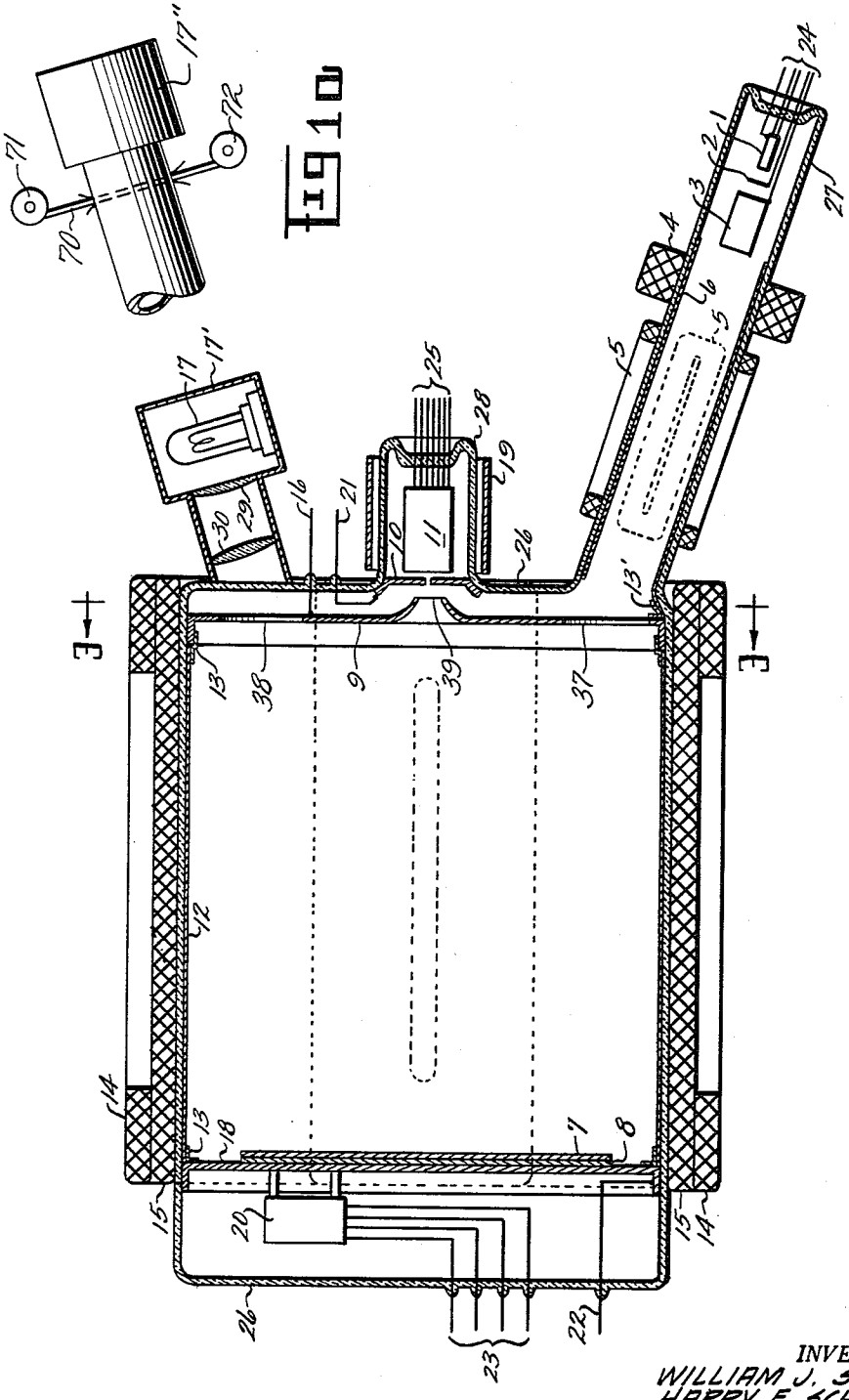


Fig 1

Fig 1a

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Fig 2

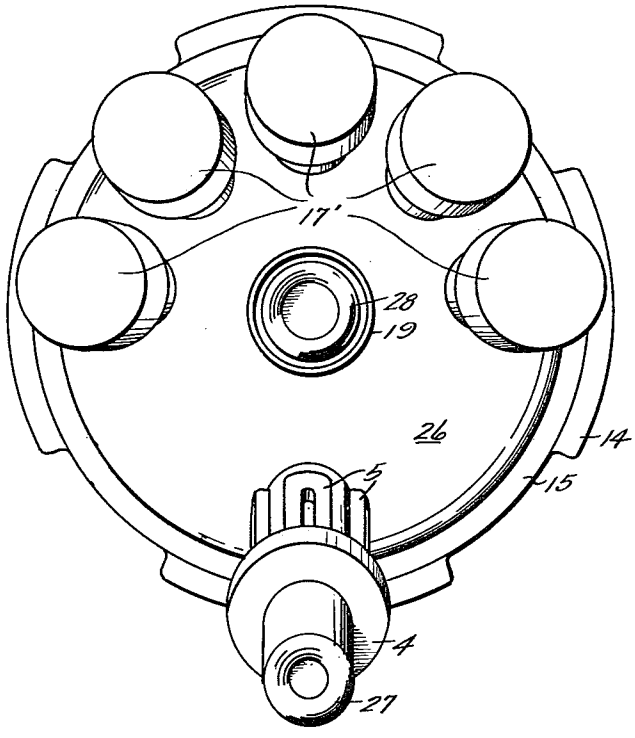
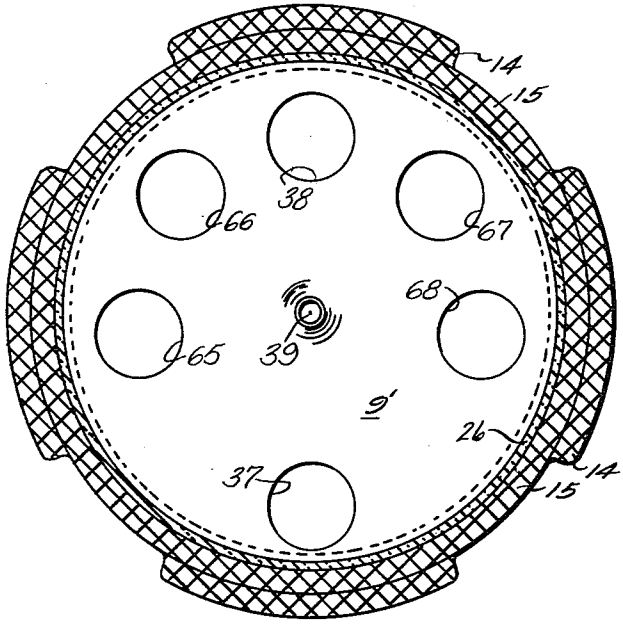


Fig 3



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ELECTRONIC IMAGE STORAGE TUBE AND SYSTEM

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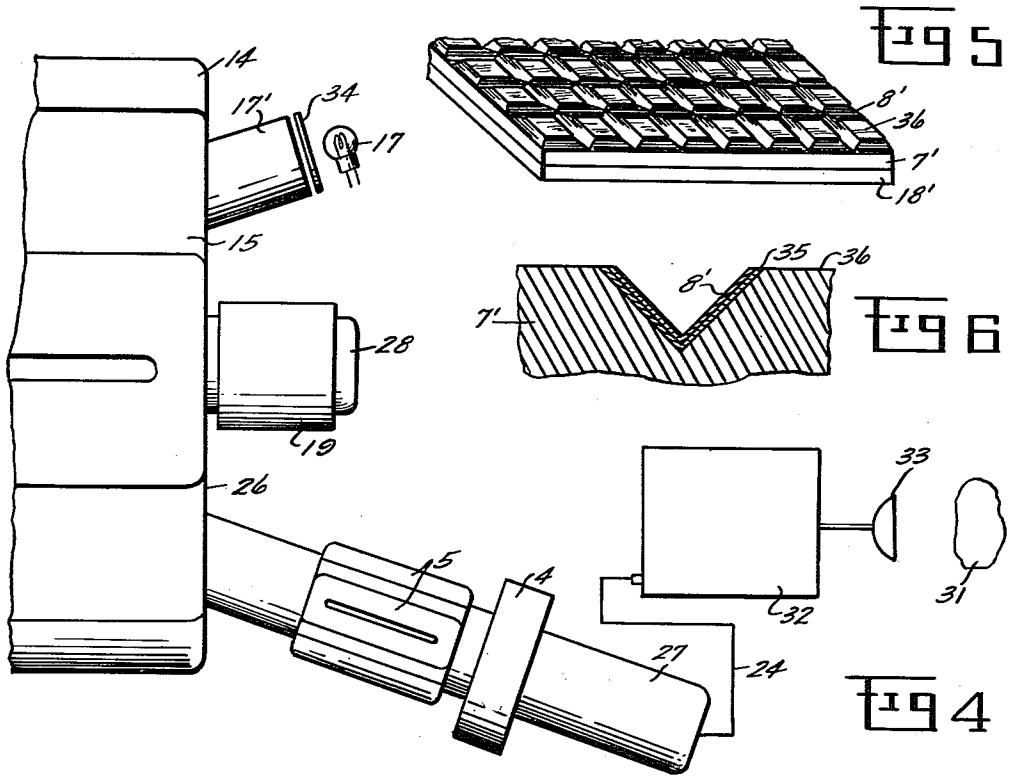


Fig 4

Fig 5

Fig 6

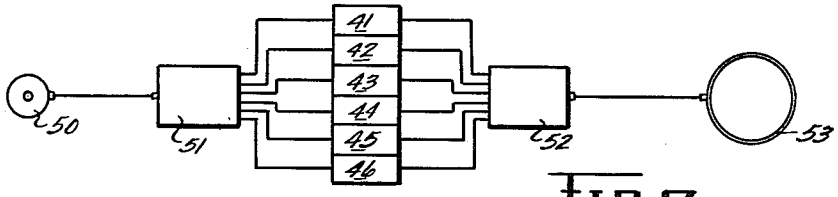


Fig 7

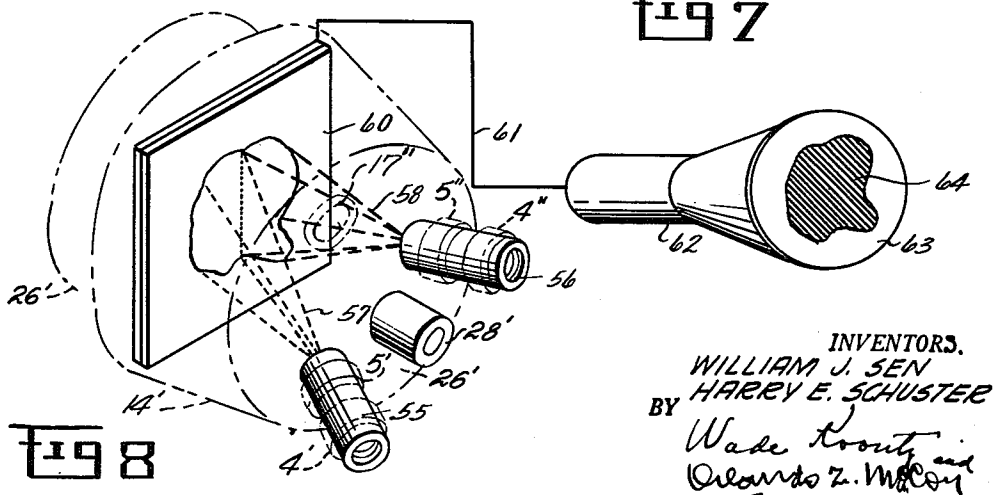


Fig 8

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2,716,203

ELECTRONIC IMAGE STORAGE TUBE AND SYSTEM

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Application June 23, 1947, Serial No. 756,534

11 Claims. (Cl. 315—11)

(Granted under Title 35, U. S. Code (1952), sec. 266)

The invention described herein may be manufactured and used by or for the Government for governmental purposes without the payment of any royalty thereon.

This invention relates to electronic tubes and particularly to a tube and a method for the optional mixing, storing and reproducing of electronic and optical information.

Storage tubes that have been available heretofore are characterized by relatively short available storage time during which storage information may be removed usually but once without deterioration of the original stored information. The storage tube that is disclosed herein provides improved performance in this particular, over previously known tubes.

Objects of the present invention comprise the provisions of an improved storage tube adapted for combining electronic and optical information, storing the information for periods of up to three minute duration and making the information available in the form of video signals for repeated withdrawals with minimized information deterioration with increase in storage time.

Another object of the invention is to provide an electronic storage tube adapted for supplying a video signal output that is the resultant of combining electronic and optical information inserted into the tube and that is useable directly from the tube in external circuits.

A further object is to provide an electronic tube containing a mosaic to which an optical image may be applied selectively or simultaneously with the application thereto of an electronic signal.

Another object is to provide an electronic tube containing a mosaic scanned by an electron beam of predetermined time rate and style of scan during the insertion of electronic information into the tube or its withdrawal therefrom and wherein the input and output time rates and styles of scan are substantially unrelated and independent.

Another object is to provide an electronic tube to which a plurality of inputs may be applied subsequently or simultaneously for mixing, storing and subsequently copying and recopying, as a single video signal, tube output with substantially persistent fidelity for use directly in external circuits.

A further object is to provide an electronic tube device adapted for the composite reception and presentation of related radar or television pictures for exampie, and fitting adjacent or overlapping presentations to produce radar and television panoramic views of greater magnitude and scope than in previously known devices of its kind. This information is supplied in video signal form.

Another object peculiar to radar practice is to provide an electronic device that is capable of simultaneously plotting a plurality of radar targets from information received from different airplanes by sorting each radar picture as it is received by the single device and by supplying a series of such stored pictures in sufficiently rapid succession and precision to follow the path and direction of progress of the targets during the time interval covered

by a predetermined number of the most recently acquired pictures.

In addition to the tube and the tube arrangements that are illustrated in the accompanying drawings and described hereinafter, the present invention includes a method for storing and reproducing an electrical image. In the practice of the invention, a picture is stored upon a mosaic within the tube in the form of isolated negative electrical charges imparted to the mosaic by its being scanned by one or more electron beams with or without the presence of an optical image simultaneously impressed upon the mosaic.

As a step in practicing the present method, there is provided within the tube a source of electrons having a uniform density emission rate per unit area applied from a photo cathode part of the mosaic to emit electrons that pass through the storage surface of the mosaic to the front thereof, and that appear in various densities due to the influence of the charges that make up the picture stored on the mosaic. The storage surface of the mosaic that is contemplated hereby has a low electrical leakage factor and is positioned within a highly evacuated envelope. With these provisons the stored picture will not lose its definition by developing faded or blurred portions for a period of several minutes. A picture so stored upon the mosaic is thereafter reproduceable from the mosaic in the form of video signals without its destruction.

In taking the video signals from the mosaic the electrons are brought to focus within a plane of an aperture in an apertured anode in front of the mosaic by means of magnetic lens preferably posted outwardly of the envelope. The focussing and deflection coils when energized, form and deflect an aura of electrons provided by the mosaic in an electron stream containing the image to be converted into video signals in the form of various electron densities sufficiently so that it may be scanned across an electron multiplier or a probe in a predetermined manner. Electrical currents produced in an external circuit attached to the electron multiplier or probe are transformed into video voltage for transmissible signals which may then be applied to an external circuit for related use such as being broadcasted in the usual manner of radio transmission. In practising the described method of transmission of intelligence, numerous copyings of an image so stored may be reproduced and presented as desired without the destruction of the original stored pictures within the storage time of the mosaic.

For clarity of understanding of the following description of an illustrative electron tube and the method of its use in the practice of the present invention, the term "electronic information" includes an image placed upon a storage mosaic by the action of an electron gun similar to that used in a cathode ray tube. The term "input scanning" is applied to a predetermined method of raster or scan that is used to apply an electronic image to the storage mosaic. The term "optical information" is applied to the information imparted to the mosaic by optical means. The term "output scanning" is applied to the method of unscanning the total information carried by the storage mosaic within the tube. The term "resultant information" is applied to the output of the hereinafter described tube and may be electronic information alone or may be electronic information together with optical information.

With the above and other objects in view which will appear from the following description, an illustrative embodiment of the tube and its associated circuit that embody parts of the present invention are shown in the accompanying drawings wherein:

Fig. 1 is partly diagrammatical and is partly a sectional view taken along the longitudinal axis of a tube envelope embodying the present invention;

Fig. 1a is a fragmentary elevational view of a moving film light source for the tube shown in Fig. 1;

Fig. 2 is a view of the tube shown in Fig. 1 taken from the right hand end and with a plurality of light sources;

Fig. 3 is an elevational view of a modified dissector anode for substitution within the tube shown in Fig. 1, as modified in Fig. 2, with the dissector deflection and dissector coils shown in section;

Fig. 4 is a fragmentary side elevation of the tube shown in Figure 1 with its gun connected with and receiving as input the output from a radar set scanning an object;

Fig. 5 is a fragmentary perspective view of a preferred mosaic for use in the tube shown in Fig. 1;

Fig. 6 is a fragmentary enlarged elevational view of the mosaic shown in Fig. 5;

Fig. 7 is a block diagram showing a plurality of storage tubes that embody the present invention connected in parallel between a switching device to which video input is applied and an output rapid switching device applying its output to a display device; and

Fig. 8 is a diagrammatic view of a plurality of electron guns and a mosaic as parts of a modified tube for use in panoramic work, together with a radio signal transmitting lead connecting the mosaic with a cathode ray tube to provide upon its screen a single presentation from a plurality of signal sources separately applied to the electron guns.

A device that embodies the present invention is shown in longitudinal section in Fig. 1 of the accompanying drawings. The device there shown comprises an evacuated and sealed envelope **26** continuous with an electron gun stem **27** and an electron multiplier stem **28**. Within the electron gun stem **27** is disposed a cathode **1** at which an electron beam originates. A grid **2** is disposed forwardly of the cathode **1** and is interposed between the cathode **1** and a first anode **3**, electrical connections to each of which is provided by a necessary number of electron gun leads **24**. An electron beam focusing coil **4** is disposed forwardly of the first anode **3** and outwardly of the substantially cylindrical electron gun stem **27** part of the envelope **26**. As is usual practice in cathode ray tubes, the focusing coil **4** maintains a magnetic field that exerts a focusing effect upon the electron beam from the cathode **1** after it has passed through the grid **2** and first anode **3**.

Forwardly of the beam focusing coil **4** and externally of the envelope electron gun stem **27** a desired plurality of electron beam deflection coils **5**, preferably four in number, are disposed. A second anode **6** is disposed inwardly of and extends longitudinally over a greater portion of the length of the envelope stem **27** from its junction with the major portion of envelope **26** axially of the stem **27** to beyond the beam focusing coil **4**.

An electron beam, not shown, originates at the cathode **1**, passes through the grid **2** and is accelerated by the anode **3** and focused to a small beam by the focusing coil **4**. The electron beam so indicated is caused in usual manner, by deflection coils **5**, or the like, to sweep a quartz mosaic **7** supported within the envelope **26** at the end remote from the envelope stem **27**. A caesium-silver oxide photo-cathode **8** is disposed upon a mosaic support **18** with quartz particles making up the mosaic **7** distributed over the photo-cathode **8** to provide the structure of the mosaic. The quartz particles or mosaic **7** and photo-cathode **8** are positioned upon the side of the mosaic support **18**, which faces the envelope gun stem **27**. The mosaic support **18** is firmly mounted within the tube envelope **26** in a fixed relation therewith. The caesium silver oxide photo-cathode **8**, with the quartz particles of the mosaic **7** distributed thereupon, is firmly mounted upon and supported immovably with respect to the gun cathode **1** by the mosaic support **18**.

Another type of special mosaic is shown vastly enlarged in Figs. 5 and 6 of the drawings and comprises a mosaic or solid quartz sheet **7'** mounted upon a support **18'**. The quartz sheet **7'** is of the desired useful mosiac cross sectional area and has an approximate thickness of ¼ inch. The useful face of the mosaic is optically flat and is engraved with two separate sets of parallel lines disposed in a single plane and intersecting each other at a preferred angle, such as at a right angle, for example. A preferred line mesh approximately 500 lines per inch and of a depth from peak to valley of approximately $\frac{1}{1000}$ of an inch is engraved into the face of the quartz sheet **7'**. The engraved face of the quartz plate is then silver plated as at **35** to a suitable depth of for example .0005". The face of the quartz plate is then reground to remove all silver from the peaks **36** of the engraved surface, thus leaving a conducting mesh of silver **35** disposed in the valleys. A material providing a caesium, silver oxide photo-cathode **8'** is then evaporated under vacuum conditions upon the quartz sheet **7'**, in such a manner as to form individual promontories, bosses, quartz islands or peaks **36** in a sea of photo-cathode material **8'**. The mosaics contemplated hereby may comprise a grillwork structure of crossed rows of upwardly projecting bosses. The mosaic parts designated by the numerals **7'**, **8'** and **18'** are comparable electronically with parts bearing corresponding numerals unprimed in Fig. 1 of the drawings.

A dissector anode **9** is firmly mounted within the tube envelope **26** substantially parallel to the quartz mosaic **7** and remote therefrom. The dissector anode **9** is apertured at **37** for the unrestricted passage of an electron beam from the cathode **1** in its scanning operation over the quartz mosaic **7**. The dissector anode **9** is also apertured at **38** for the passage of rays such as infrared from a source **17** that is disposed within a light source housing **17'** that is supported by the housing for the tube envelope **26**.

The light source **17** is disposed with respect to the envelope **26** so that substantially that portion of the envelope between the dissector anode **9** and the mosaic **7** may be substantially flooded with infrared light or light of other desired wave length. The dissector anode **9** substantially conforms in shape with that of the mosaic and is apertured centrally at **39** for purposes of scanning the electron aura within the envelope **26**. A modified dissector anode **9'** is shown in plan view in Fig. 3 wherein a plurality of openings **38**, **65**, **66**, **67**, and **68** for light rays such as those from the source **17** are provided where it is desired that a plurality of additional light sources may open into the interior of the tube envelope **26**.

A dissector anode lead **16** connects electrically the dissector anode **9** to the exterior of the tube envelope **26** so that a strong positive electrical charge may be maintained thereupon. The aperture centrally of the dissector anode **9** is in registration with a smaller aperture disposed centrally of an apertured anode **10** that is supported by the tube envelope **26** at its junction with a second cylindrical electron multiplier stem **28** that projects from the tube envelope **26** and that houses an electron multiplier **11**. A plurality of electron multiplier leads **25** connect the electron multiplier **11** with the exterior of the envelope **26** through the end wall of the second or electron multiplier stem **28** so that the interior of the second stem **28** is in continuous evacuated relationship with the interior of the tube envelope **26**. A magnetic shield **19** is disposed externally of and substantially coaxially with the second stem **28** for minimizing the effects of extraneous circuits upon the functioning of the electron multiplier **11**.

The inner wall of that portion of the tube envelope **26** which is disposed between the mosaic support **18** and the dissector anode **9** has a thin nickel film **12** disposed thereupon. The nickel film **12** is in electrical connection with both the dissector anode **9** and the mosaic support **18**, as by means of the bonding material indicated by the nu-

meral 13 or the like disposed at the junctions of the parts of the device. The mosaic support 18 is connected externally of the tube envelope 26 in a desired manner, as by the photo-cathode lead 22 or the like that passes through the wall of the envelope 26.

A dissector focusing coil 15 is placed externally of the tube envelope 26 and continues axially thereof for a sufficient distance to overlie the apertured anode or disc 10 at one end and at the opposite end the mosaic support 18 so that the electron aura within the tube envelope 26 is subjected at all times to the action of the dissector focusing coil 15. A plurality of dissector deflection coils 14, preferably four in number, are disposed in quadrant positions outwardly of both the tube envelope 26 and the dissector focusing coil 15. Each of these dissector deflection coils 14 preferably is an elongated loop with its longer axis substantially parallel to the longer axis of the tube envelope 26. Electrical connection to the apertured anode 10 from outside of the envelope 26 is provided, as by the lead 21 or the like.

The mosaic support 18 also carries a dynamic getter 20 within the tube envelope 26 upon the side of the mosaic support 18 that is remote from the dissector anode 9. Dynamic getter leads 23 connect the getter 20 externally of the tube envelope 26.

The described tube comprises broadly an electron gun within the envelope gun stem 27 adapted for sweeping the quartz particles 7 in the mosaic underlaid by the caesium, silver oxide photo-cathode 8 which serves as a source of an electron field of normally uniform density and large cross sectional area positioned inwardly of the thin nickel film 12 and axially of the tube envelope 26 between the mosaic and the dissector anode 9. Signals are taken from the tube through the aperture in the apertured anode 10 by the electron multiplier 11.

The device so constructed comprises a storage tube adapted for storing video signals such as those used in television, radar and the like, for periods of several minutes. These periods are of sufficient length to permit the reproduction of those signals, such as for display at either local or remote positions, for several hundred times without objectionable loss of detail. It will be apparent that the above mentioned elements comprising the present storage tube may assume physical forms other than that shown in Fig. 2 of the accompanying drawing within the scope of the present invention, so that the resulting device operates and functions substantially in the manner described herein.

In the electron gun element the second anode 6 may be of conductive material such as graphitic carbon in a dispersing medium, or the like. The second anode 6 is bonded, as at 13', electrically to the dissector anode 9 so that a strong positive charge applied through the lead 16 to the dissector anode 9 is simultaneously maintained upon the second anode 6. The mosaic support 18 shown in Fig. 1 is a silver disc upon which a uniform photocathode 8 of caesium and silver oxide has been disposed. The quartz mosaic 7 shown in Fig. 1 comprises a uniform layer of quartz particles preferably of an average diameter of approximately 50 microns bonded to the photocathode 8. The quartz particles preferably are disposed in a layer of one particle thickness and of a density such that approximately one half of the surface area of the photo-cathode 8 is uniformly covered.

The dissector anode 9 preferably is a silver disc that is dished frustoconically adjacent its central aperture, as shown in Figs. 1 and 3 of the drawings. The central portion defining the aperture, extends axially of the envelope 26 almost to the apertured anode 10. The aperture disposed centrally of the apertured anode 10 preferably is a round hole of approximately 50 microns diameter and located at substantially the center of the disc. The central aperture of the dissector anode 9 permits electrons from the mosaic to pass through the dissector anode 9 and through the aperture in the apertured anode 10 to the electron multiplier 11.

The thin nickel film 12 preferably is evaporated upon the inside surface of the envelope 26 between the mosaic and the dissector anode 9 and is bonded electrically as indicated by bonding material 13, to both of these structural elements of the tube. The nickel film 12 preferably is of uniform thickness and is of such density as to provide an electrical resistance of approximately 1 megohm between the mosaic support 18 and the dissector anode 9.

The apertured anode 10 preferably is of silver or may be of nickel, and is supported by the tube envelope 26 at its junction with the second or electron multiplier stem 28 portion thereof in a desired manner as by being bonded thereto or shaped to fit into the opening of the second stem 28, or otherwise as preferred.

The electron multiplier 11 is positioned within the second tube stem 28 upon the side of the apertured anode 10 that is remote from the dissector anode 9 and is oriented so that its input opening is aligned with the aperture in the center of the apertured anode 10. The magnetic shield 19 disposed outwardly of the second stem 28 protects the electron multiplier 11 from spurious stray electrical fields and electrical energy in general that would tend to affect the accuracy of the signals supplied by the electron multiplier 11 to the multiplier leads 25.

The dissector focusing coil 15 comprises a solenoid mounted outwardly of the tube envelope 26 and extending axially thereof beyond the mosaic at one end and beyond the apertured anode 10 at the opposite end. The deflection coils 14 preferably are pancake coils shaped to fit the contour of the outer surface of the focusing coil 15 and are spaced equally from each other outwardly of the tube envelope 26.

The source 17 of infrared light may comprise an incandescent lamp together with a lens system which projects the light uniformly over the surface of the photocathode 8. As previously stated, additional sources of infrared light may be provided if preferred, by providing additional apertures through the dissector anode 9 for the admission of the infrared light within the interior of the tube envelope 26.

Where preferred, a lens system such as that indicated by the lenses 30 may be positioned between the infrared light source 17 and the interior of the tube envelope 26 for the purpose of projecting the infrared light uniformly over the surface of the photo-cathode 8. Light rays other than infrared may be used if preferred, consistent with the type of photo electric material that is used upon the photo-cathode 8. The caesium, silver oxide material previously indicated for the photo-cathode 8 is illustrative and provides optimum performance in the presence of light rays within the red portion of the spectrum.

It is within the further concept of the present invention that the light rays from the light source 17 may be projected upon the photo-cathode 8 by means of a film strip projector of a common type indicated in Fig. 1 by a film 70 passing between spools 71 and 72 with a projection housing 17'' so that light projection may be that of a definite pattern if preferred. It is within the further concept of the present invention that the light rays from the light source 17 may be varied in intensity in their application to the photo-cathode 8, if preferred.

A dynamic getter 20 may, if preferred, comprise a triode assembly with a coating of getter material upon the plate element of the assembly. Voltages are applied through the getter leads 23 to the tube elements so that a steady stream of electrons bombards and hence maintains the getter material in its activated state. The various leads extending into the interior of the tube envelope 26 through the ends of the tube stems 27 and 28 are sealed through the walls thereof to maintain a high degree of evacuation inwardly of the tube envelope 26.

In the general operation of the present device incoming video signals are applied through a grid lead 24 to

the grid 2 of the electron gun to thereby modulate the electron beam emitted from the cathode 1. The electron beam from the cathode 1, after passing the grid 2, is shaped and accelerated by the first anode 3 and is then focused axially of the gun stem 27 by the focusing coil 4. The modulated electron beam is deflected by the deflection coils 5 in such a manner to scan the mosaic along a predetermined pattern as required by a particular application, such as for example a plan position indicator scan, a parallel line or television scan or the like.

The voltages that are applied over the leads 24 to the elements of the electron gun in the tube stem 27 may be adjusted for two modes of operation. In the first mode of operation, it is assumed that the voltage of the second anode 6, with respect to the cathode 1 is below a critical value. The electrons arrive at the mosaic at small velocities, so that more incident electrons remain upon the quartz portion of the mosaic than there are secondary electrons emitted from the quartz. As a result the quartz has negative charges distributed over its area in densities that vary corresponding to the densities of signals applied to the grid 2 of the electron gun.

In the event the voltage on the second anode 6 is greater than a critical value, electrons from the scanning beam emitted from the cathode 1 strike the mosaic with sufficient velocities to cause more secondary electrons to be emitted from the quartz than there are incident electrons lodging upon the quartz. This leaves the quartz with positive charges distributed over its area in varying densities that correspond to the densities in the signals arriving over the grid lead 24 and impressed upon the grid 2 of the tube. Because of the high resistivity of quartz the charges thus disposed will remain in their respective positions for usable periods of time during which the charge on a particular quartz particle or cluster thereof may be caused to provide a distinctive electrical signal. As a consequence the incoming video signals are recorded upon the mosaic in the form of a charge density pattern. During the recording process the lead 16 connected to the dissector anode 9 and the lead 22 connected with the mosaic support 18 are connected together so that the two silver discs 9 and 18, together with the nickel film 12, form a second anode for the tube when operating as a recording scanner.

The reproduction of a picture so applied and stored upon the mosaic of the described tube is accomplished by initially discontinuing the energization of the leads 24, other than the filament leads, connected with the electron gun portion of the tube. A direct current potential of, for example, 1000 volts, is applied across the dissector anode 9 and mosaic support 18 through their respective conductors 16 and 22 with the mosaic maintained negative with respect to the dissector anode 9. As previously stated the thin nickel film 12 has a preferred resistance of approximately 1 megohm so that the voltage drop across this resistance provides a uniform potential gradient between the mosaic and the dissector anode 9. The photo-cathode 8 is flooded uniformly with light from the light source 17, thereby causing the emission of photo electrons from the photo-cathode 8. These electrons are propelled between the quartz particles of the mosaic toward the dissector anode 9 by the strength of the electrostatic field that is maintained by the potential applied between the mosaic support 18 and dissector anode 9. The quantity of electrons emitted from any elemental area of the mosaic is determined by the magnitude of the charge that is stored upon that particular element. The less negative the stored charge upon an element of the mosaic, the greater will be the number of photo-electrons leaving that element. Where in the recording operation the second anode voltage is less than the critical value, the electron density pattern formed by the photo electrons is reversed from that of the original scanning beam. In the event the second anode voltage exceeds the critical value, the two density patterns are the same.

The current in the dissector focusing coil 15 is adjusted to the lowest value which will bring the electron image generated at the mosaic to focus in the plane of the aperture in the center of the apertured anode 10. The magnetic field produced by the dissector deflection coils 14 deflects the entire field of electrons between the mosaic and the apertured anode 10 in a manner which is equivalent to the aperture scanning the electron image. Electrons which pass through the aperture in the apertured anode 10 are multiplied by the electron multiplier 11. The output of the electron multiplier 11 is connected by leads 25 to an external circuit which is to utilize the reproduced video signals. The apertured anode 10 is maintained at a negative potential of approximately 50 volts with respect to the dissector anode 9 so that the dissector anode acts as a collector of secondary electrons emitted by the apertured anode 10.

The reproduction as a video signal of the image on the mosaic can be repeated as long as the photo-cathode 8 is illuminated by the light source 17, within the storage time of the mosaic.

A picture stored upon the mosaic is removed therefrom and the mosaic prepared for the reception of a new picture in the following manner. The connection of the photo-cathode lead 22 bearing a high negative voltage to the mosaic support 18 is interrupted, and the lead 22 is connected to the dissector anode lead 16 and is thereby grounded. The application of electrical current to the deflection coil 14, focusing coils 15, and light source 17 is interrupted.

The gun leads 24 supplying current to the electron gun portion of the device are energized and in the absence of current to the deflection coils 5 the electron gun is defocused so that it bombards the mosaic with electrons of substantially uniform density throughout its area. The voltages supplied to the electron gun over the leads 24 are then shifted to bring the electron beam emitted by the cathode 1 into focus by the energization of the focusing coil 4. The tube is now ready for the storage of a new picture. These operations in the order stated may be performed manually or may be performed entirely by automatic means in the interest of speed of performance, as preferred.

It is within the concept of the present invention to introduce a plate or a film running continuously from a projector interposed between the light source 17 and the interior of the evacuated envelope 26 for the purpose of introducing additional predetermined fixed information or patterns tending to reproduce pictures. In this type of operation the additional information is supplied in the desired manner for its projection upon the mosaic through the use of either moving or still plates or film. Portions of the photo-cathode 8 upon which the film casts a shadow will emit fewer electrons than will other portions of the photo-cathode, the actual amounts of electron emission depending upon the density of the film. In this manner portions of the picture stored on the mosaic may be blocked out by making portions of the film opaque.

Information may be added to the stored picture by making a portion of the film bearing the information less dense than the remainder of the film and the remainder of the film of a uniform density which will allow light to pass through it. Varied operation of the light source 17 or the pattern of the moving or still film would permit the introduction of other special types of information. The use of these adjuncts to the tube that is shown in Fig. 1 is of particular value in the protection of transmitted information, particularly in times of war since the preconceived conditions of transmission would of necessity have to be duplicated in the receiver in order that transmitted information might be accurately interpreted.

The line of sight limitation of transmission of video signals, such as is the case in most television and radar

transmission at their present states of development, is avoided in the present device by converting the radar picture into narrow band transmissible electrical signals. The image is applied to the mosaic at any desired scan rate and unscanned at a slow scan rate, thus making the image information available at the output terminals of the device in narrow band form for suitable application as modulation to a low frequency carrier capable of beyond line-of-sight transmission.

In Fig. 4 of the drawings an object **31** is scanned in the usual manner by radar equipment **32** with radar antenna **33**. Signals in the radar equipment **32** are applied over one of the leads **24** to the grid **2** of the electron gun in the gun stem **27**. The signal image is applied to the mosaic within the tube envelope **26** where it is stored and then unscanned at a low scan rate. Thus, the image information is available at the output terminals of the device in narrow band form suitable for beyond line-of-sight transmission.

The apparatus shown in Fig. 4 also may be used for television applications by removing the light source **17**, the filter **34** and the lens assembly inside of the light source housing **17'** and replacing these parts with a projection system suitable for focusing an image of the object **31** being televised upon the storage mosaic where it is utilized as previously described for producing a video output signal at the electron multiplier in the stem **28**.

The mosaic shown in Figs. 5 and 6 comprises a sheet **7'** of low conductivity material such as quartz with a surface providing a multiplicity of electronically capacitive promontories, bosses, islands or peaks **36** in a sea of photocathode **8**.

Further modification of Figs. 5 and 6 may be provided by etching the face of the quartz sheet **7'** to provide a multiplicity of peaks and valleys without resort to a definite geometric pattern if desired.

Since the described device supplies an electronic memory with a time duration of from microseconds to several minutes, it is believed this constitutes a new building block for electronic circuits and consequently is believed to be adapted for numerous applications that are not foreseen at the present time.

An adaptation for which the tube was originally designed is shown as a block diagram in Fig. 7 of the drawings. In the adaptation shown a bank of six tubes **41** to **46** inclusive, are used to provide a memory element for semi-automatic radar plotting equipment. In Fig. 7 video signal from a radar is applied constantly to the video input **50** and is separated by a first switching device **51** to be applied with each rotation of the radar antenna consecutively and selectively to the plurality of tubes **41** to **46** inclusive. The individual outputs from the tubes **41** to **46** inclusive, are applied in consecutive order through a rapid second switching device **52** to a display device **53** that may present a visual display or that may be recorded photographically or otherwise, as desired. Each of the tubes selectively receives and stores video signals from a radar set during one complete rotation only of the antenna and retains the stored picture during the following five rotations. The tubes **41** to **46** inclusive, receive the video signals in succession so that upon the seventh rotation of the antenna a new picture is applied to the first tube of the series, or the tube **41** for example. The sequence then repeats itself. The old picture is removed in consecutive order from each of the tubes **41** to **46** inclusive, during a plan position indicator sweep for example, immediately preceding the application of a new picture upon a particular tube. The output from this use or adaptation of the disclosed tube is obtained by copying the stored pictures in the same sequence in which they were stored but at a more rapid rate.

When the output video signals from the tubes **41** to **46** inclusive, are passed through the rapid second switching device **52** and are applied to the display device **53**, the radar pictures appear upon the screen of the display device in rapid succession. The presentation of a single moving target appears as a series of five dots, or one dot for each picture being copied, since the picture is not copied from the tube currently receiving the picture for storage. This series of dots represents consecutive positions of the target at the time of the last five scans by the antenna and consequently forms a plotted track of the target. The rate at which the copying process is conducted is maintained constant so that the distance between dots in the track of a target is an indication of the speed of the target.

A modified tube for panoramic work is indicated diagrammatically in Fig. 8 of the drawings. This tube embodies the replacement of the single gun stem **27** as shown in Fig. 1 with a desired plurality of such gun stems and illustratively the two gun stems **55** and **56** indicated in Fig. 8. In this adaptation video signals from two different radar equipments such as from two aeroplanes or the like, may be applied simultaneously and selectively to the grids of the guns in the gun stems **55** and **56**. The two guns cause their respective electron beams **57** and **58** to scan adjacent parts of a common mosaic **60**.

The tube stems **55** and **56** extend from a tube envelope **26'** shown in phantom for clarity of presentation. Tube parts in Fig. 8 other than the gun tubes **55** and **56** and the mosaic **60** are indicated by primed reference numerals that correspond to those in the tube **26** shown in Fig. 1.

The conversion of the electronic charge distribution upon the mosaic **60** into a corresponding pictorial presentation by its being converted into video signals is substantially the same as that described for the tube shown in Fig. 1. In the diagrammatical showing in Fig. 8, the means of conversion is indicated by the line **61**. The line **61** is a symbolic representation that the information resulting from unscanning a composite image on the mosaic **60** is passed to the viewing device **62** with which the mosaic **60** has no direct connection. The viewing device **62** that is shown for example as a cathode ray tube, comprises a screen **63** upon which a presentation **64** is caused to appear as a replica of the charge distribution applied to the mosaic **60** from the plurality of guns **55** and **56**.

The disclosed device provides a plurality of types of scan and rates of scan, such as plan position indicator, B-scan etc., at both the input and output terminals, the performance of which is comparable with that of normal cathode ray tubes and the like.

It is to be understood that the particular tube construction, the arrangement of the tube elements, types of mosaic, adaptations to radar and television practices, radar plotting equipment and panoramic adaptation that have been shown and described herein are submitted for the purposes of illustrating and describing a representative embodiment of the present invention, together with suggested adaptations to which it is peculiarly fitted in the radio and radar field and that modifications in its construction, parts, submitted arrangements and adaptations may be made without departing from the scope of the present invention where comparable results are obtained thereby.

What we claim is:

1. A storage mosaic, comprising a sheet of material having a substantially high electrical resistivity, an electrically conductive mosaic support upon which said highly resistive sheet of material is mounted, an optically flat working face upon the material of high resistivity, a multiplicity of diminutive peaks of the optically flat working face of the material of high resistivity, and a substantially continuous mesh of photo-cathode material around the peaks on the working face of the material of high resistivity.

2. A mosaic, comprising a quartz plate having a working side from which a multiplicity of promontory quartz islands project, and a sea of photo-cathode material distributed upon the promontory bearing side of said quartz plate and above which said quartz islands project.

3. A mosaic, comprising a quartz plate having a substantially flat working face adapted for being bombarded by the electrons of a cathode ray beam in a scanning operation, a plurality of narrow faces substantially below the plane of the working face of said quartz plate, thin metallic silver electrically conductive means disposed upon said narrow faces, a plurality of caesium particles distributed over said metallic silver plate, and a plurality of silver oxide particles distributed over said metallic silver plate to provide a grill work having photo-cathode properties extending over said quartz plate working face and substantially beneath the plane thereof.

4. A photo-sensitive storage mosaic, comprising a quartz sheet having a substantially optically flat signal output face engraved with two separate sets of parallel lines intersecting each other at an angle to provide a line mesh, a silver plate defining the lines and substantially interrupted by exposed quartz peaks on the signal output face of said quartz sheet to provide a substantially continuous silver mesh interrupted by the isolated quartz peaks, and a multiplicity of caesium silver oxide particles splattered upon said silver mesh and individual quartz peaks on the signal output face of said quartz sheet.

5. A storage tube for converting optical and electrical input signal into electrical output signal carrying both optical and electrical effects as modulation thereon, comprising an evacuated envelope having a plurality of stems projecting from a first end thereof, an electron beam emitting electron gun disposed in one of the stems projecting from said envelope and including a cathode for emitting the electron beam and a grid on which electrical signal is impressed for modulating the electron beam, a storage mosaic positioned within a second end of said envelope for permitting the electron beam from the electron gun to impact the storage mosaic for imparting grid carried electric signal modulation thereto, a light source of modifiable pattern and intensity for application to said mosaic for modifying electrical characteristics thereof, a dissector focusing coil outwardly of and continuously axially of the envelope between the first end thereof and the mosaic for focusing electron flow from the mosaic to the first end of said envelope, dissector deflection coils outwardly of said dissector focusing coil and extending axially of the envelope between the first end thereof and the mosaic for deflecting electron flow from the mosaic to the first end of said tube, and means at the first end of said envelope for withdrawing electrical signal modulated both optically and electrically from said mosaic.

6. A cathode ray tube, comprising an evacuated glass envelope from a first end of which a plurality of evacuated stems project, a mosaic from which modulated signal is derived adjacent the second end of said envelope, an electrically conductive mosaic support mounted in said envelope, a first envelope stem housed electron gun directing an electrically modulated cathode ray toward said mosaic, a light source directing an intensity modulated light beam toward said mosaic from the first end of said envelope, a second envelope stem housing externally shielded electron multiplier disposed substantially centrally of the first end of said envelope, a centrally apertured dissector first anode within said envelope adjacent the first end thereof and apertured eccentrically for the passage of the cathode ray and the light beam therethrough, a nickel film deposited on the inner side of said envelope and connecting said mosaic support with said dissector first anode continuously axially of said envelope, a centrally apertured second anode interposed between and coaxial with said dissector first anode and said electron multiplier, a dissector focusing coil outwardly of said envelope and continuous axially thereof from the first end of said envelope to said mosaic support, and dissector deflection coil means outwardly of and extending axially of said dissector focusing coil for substantially the axial length thereof, and means at the first end of said tube for withdrawing electrical signal modulated both optically and electrically from said mosaic.

7. A cathode ray tube having a mosaic providing a panoramic presentation signal that is a composite of separate signals from a plurality of tracking operations fed into a plurality of electron guns in the tube at separately scanned predetermined fractional portions of said mosaic, the cathode ray tube comprising an evacuated envelope continuing in a plurality of evacuated stems projecting from a first end thereof, a plurality of cathode ray emitting guns disposed separately in the evacuated stems in the first end of said envelope, an externally shielded electron multiplier in an evacuated stem disposed substantially centrally in the first end of said envelope, a mosaic mounted within said envelope remote from the first end thereof and bombarded in fractional portions by separate cathode ray emitting guns in the gun housing stems of said envelope to provide a composite signal from said mosaic, a mosaic support within said envelope, a light source directing an intensity modulated light beam toward said mosaic, a centrally apertured dissector first anode adjacent the first end of said envelope and apertured for the passage of cathode rays and the light beam therethrough, a nickel film connecting said mosaic support with said dissector first anode and continuous axially of said envelope, a centrally apertured second anode interposed between said dissector first anode and said electron multiplier, a dissector focusing coil outwardly of said envelope and continuous axially thereof from the first end of said envelope to said mosaic, a dissector deflection coil means outwardly of and extending axially of said dissector focusing coil for the axial length thereof, and means for withdrawing electrical signal modulated both optically and electrically from said mosaic.

8. A storage tube for converting optical and electrical input signals into electrical output signal carrying both optical and electrical effects as modulation thereon, comprising an evacuated envelope having a plurality of evacuated stems projecting from a first end thereof, an electron gun housed in a first stem projecting from said envelope, and electron multiplier housed in a second stem projecting from said envelope, a light source in a third stem projecting from said envelope, a mosaic inside of and spaced from the first end of said envelope and receiving the discharge from the electron gun and light from the light source simultaneously upon one side of said mosaic, a dissector first anode substantially parallel to said mosaic within and adjacent the first end of said envelope and apertured eccentrically for the passage of an electron beam from said electron gun to said mosaic in the impressing of an electrical modulation thereupon and apertured eccentrically for the passage of a light beam to said mosaic in the impressing of an optical image thereupon and apertured centrally for signal conduction from said mosaic to said electron multiplier, a positively chargeable second anode substantially parallel to said mosaic within and adjacent the first end of said envelope and apertured centrally for signal conduction from said mosaic to said electron multiplier, and electron multiplier leads extending to outside of said envelope and providing radio transmission output signals bearing correlated electrical and optical modulations as applied simultaneously to said mosaic.

9. An electronic storage tube, comprising the combination of a highly evacuated envelope having a first end to which signal input is applied and from which a signal output is derived and from which a plurality of stems project, a long storage mosaic of a plurality of quartz peaks in a grid of caesium and silver oxide adjacent a second end of and within said envelope, a cathode ray gun means within a first stem of said envelope for applying a cathode ray of electrons in a controlled and predetermined sweep over the grid bearing working face of said mosaic, an optical system mounted on the first end of said envelope and adapted for applying light rays

to the grid bearing working face of said mosaic simultaneously with the application of the cathode ray thereto, and signal withdrawal means extending outside of said envelope and deriving a composite electrical signal from said tube.

10. A storage modulation tube, comprising the combination of an evacuated envelope continuing at a first end thereof into a gun stem portion, a cathode in the gun stem portion of said envelope and adapted for providing a beam of electrons, a grid within the gun stem portion of said envelope and to which signals may be applied for modulating the electron beam emitted by said cathode, a first anode means within the gun stem of said envelope for accelerating the flow of electrons from said cathode as modulated by said grid, a storage mosaic within said envelope and a target for the electron beam from said cathode, a dissector anode within said envelope and chargeable to maintain an electrostatic field for attracting electrons returning through an aperture in the center of the dissector anode, a plurality of dissector deflection coils mounted outwardly of and in quadrant positions with respect to said envelope and extending substantially the length thereof for the deflection of electron flow inwardly thereof with respect to the aperture disposed centrally of said dissector anode, a dissector focusing coil disposed outwardly of said envelope and extending substantially the length thereof for the focusing of the electron flow inwardly thereof to the central aperture of said dissector anode, and an electron multiplier aligned with the aperture in said dissector anode at the first end of said envelope and converting electron density differences within the envelope into tube output signals upon the controlled energization of said dissector coils.

11. An electronic storage tube, comprising a highly evacuated envelope having a first end to which signal input is applied and signal output is derived and from which a plurality of evacuated stems project, a cathode ray gun means to which input signal is applied as modulation impressed upon a cathode ray controlled and directed by said gun in a first one of said stem, a long storage mosaic within said envelope as a target for the cathode ray from said gun, dissector anode means apertured eccentrically for the passage therethrough of the cathode ray from said gun and apertured centrally for the passage therethrough of signal from said mosaic as output from said tube, and coil means on said envelope for centering the signal from said mosaic for passage through the central aperture in said dissector anode.

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