May 7, 1940. B. C. GARDNER 2,200,166

IMAGE ANALYZING AND DISSECTING TUBE

Filed Aug. 17, 1937

Fig. 1.

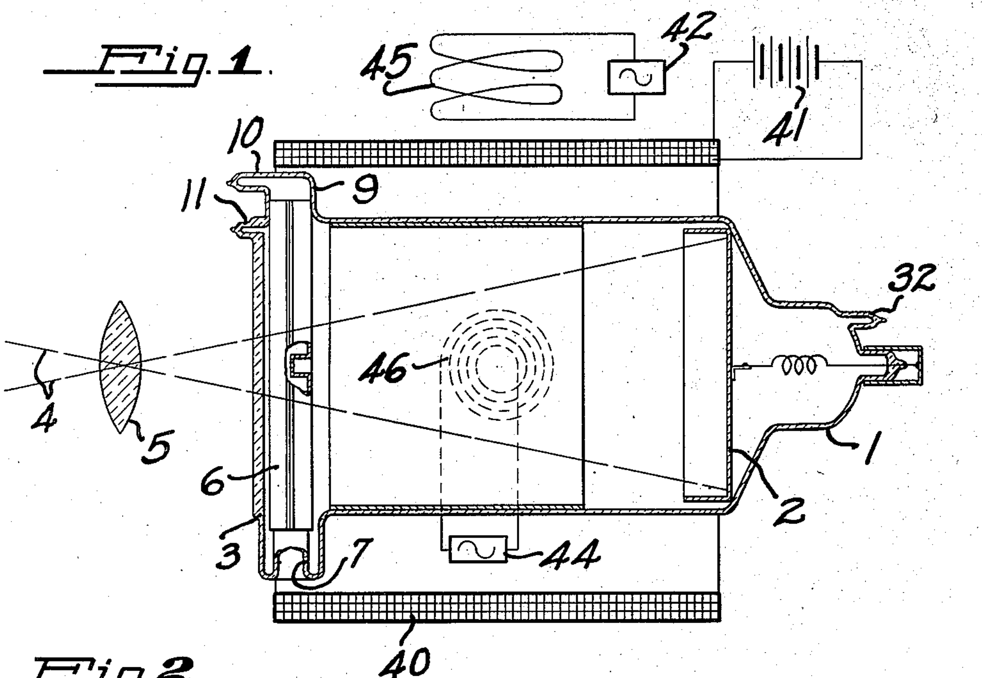


Fig. 2.

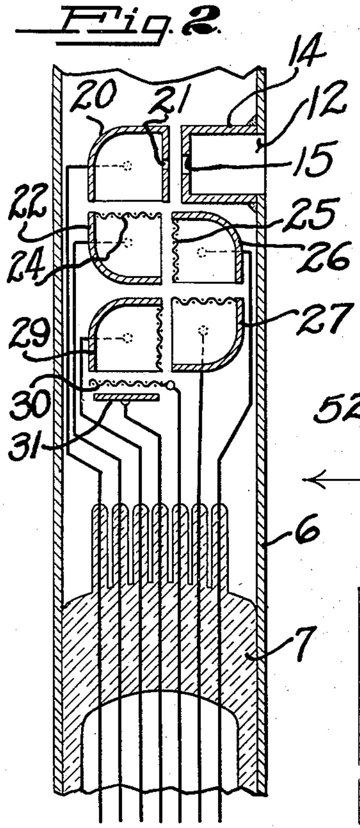


Fig. 3.

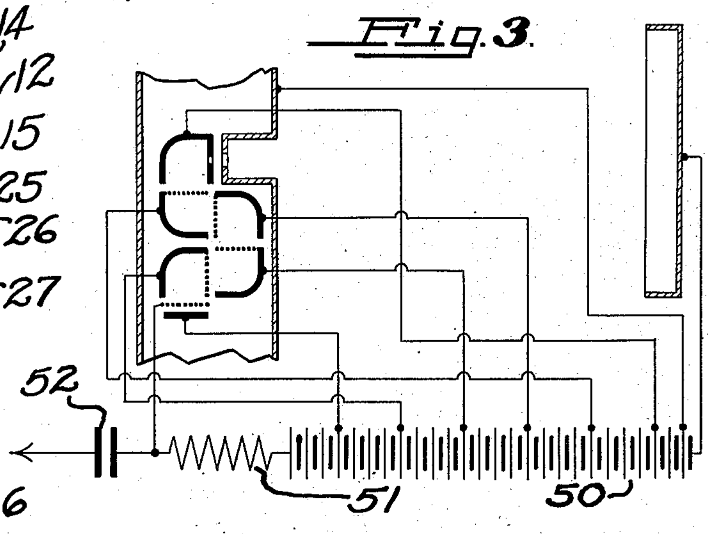
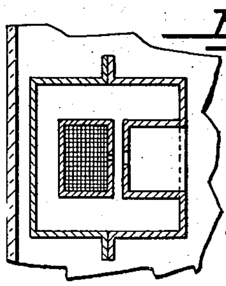


Fig. 4.



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ATTORNEYS.

Patented May 7, 1940

2,200,166

UNITED STATES PATENT OFFICE

2,200,166

IMAGE ANALYZING AND DISSECTING TUBE

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Application August 17, 1937, Serial No. 159,492

3 Claims. (Cl. 250—150)

My invention relates to image analyzing and dissecting tubes, and more particularly to such a device embodying an electron multiplier in order that the output from the device may be increased.

My invention embodies, with the exception of the multiplier, the general structure of the Farnsworth image analysis tube, as described by him in United States Patent No. 1,773,980, issued August 26, 1930, and also embodies the same general type of multiplier as described and claimed by Snyder in his application, Serial No. 149,654, filed June 22, 1937, for a Box element multiplier, now Patent No. 2,163,966, issued June 27, 1939.

Among the objects of my invention are: To provide an image analysis tube suitable for television or like purposes, wherein an electron image may be analyzed into elementary components and the components thereafter amplified within the tube by the use of an electron multiplier; to provide an image analysis tube having embodied therein an electron multiplier of small size; to provide an image analysis tube having a photoelectric cathode and an electron multiplier together with means whereby the cathode and the multiplier may be separately sensitized; to provide an image analysis tube embodying a direct-current electron multiplier of small size; to provide an image analysis tube wherein a direct-current multiplier is utilized, and wherein the direct-current multiplier is of such small size that it can be placed in the path of the optical image to be analyzed without obstructing sufficient light to destroy the efficient action of the device; to provide a target finger for a dissector tube containing an electron multiplier of small size; and to provide a highly efficient and high-gain image analysis tube.

Other objects of my invention will be apparent or will be specifically pointed out in the description forming a part of this specification, but I do not limit myself to the embodiment of the invention herein described, as various forms may be adopted within the scope of the claims.

In a type of dissector tube described by Farnsworth for the analysis of television images to form a train of television signals, an optical image is focused by proper lens system through a transparent envelope wall onto a solid photoelectric cathode. Electrons are emitted from the photoelectric surface of this cathode in proportion to the light intensity falling upon each elementary area thereof. A hollow tubular anode is provided to withdraw the emitted photoelectrons from the vicinity of the cathode as an electron image, and this anode is usually provided with an aperture through which only one elementary area of the electron image can pass through the anode. The electrons are maintained in electron image relationship by the use of a focusing solenoid producing lines of force parallel to the direction of travel of the electrons, and the electron image thus formed in the plane of the aperture is oscillated, preferably magnetically, in two directions and at different speeds across the aperture, so that each elementary area of the electron image enters the aperture during one complete scansion of the electron image. Inasmuch as the electron image represents the light intensity falling on the individual elementary emitting areas of the cathode, any collecting device placed back of the anode aperture will receive thereon electrons varying in number with respect to time, and representing, after a complete scansion, a train of television signals, each signal representing the light intensity of the area from whence they came.

It will be obvious, however, that even though the photoelectric cathode be covered with a material of high work function such as, for example, metallic caesium distilled upon silver oxide, the number of electrons per elementary area will be relatively few, and that unless precautions are taken to multiply the electrons, the signal current will be relatively weak as it emerges from the analysis tube envelope. If it is weak, then a sensitive and powerful external amplifier will be necessary to increase the strength of the train before it can be utilized for transmission and reception to a distant point.

I have found that I am able to make a dissector tube wherein the anode that accelerates the electrons as they leave the cathode is in tubular form, and of such small size that it may be placed directly in the path of the image thrown on the cathode; and I have further been able to define and position an electron multiplier of the direct-current type within the anode back of the scanning aperture and dispose the elements of this multiplier within the small tube, to the end that the electrons passing through the scanning aperture are multiplied by a factor of from five hundred to several thousand before leaving the tube.

Furthermore, while a general statement may be made that many photoelectric materials also act as good secondary emitters when impacted by a primary electron traveling at high velocity, it may also be stated that it is not by any means always satisfactory to process the photoemissive cathode in the same manner as the secondary electron emissive cathodes should be processed. Furthermore, the photoelectric cathode in the tube of my invention is open to the main chamber of the tube, whereas the electron multiplier is contained within the anode finger. I have therefore provided in the tube of my invention envelope tubulations so positioned with respect to the photoelectric cathode, and with respect to the interior of the anode finger, that sensitizing vapors may be directed at the respective cathodes in the most efficient manner, and to allow separate processing if desired.

One preferred form of my invention is shown in the drawing, wherein

Fig. 1 is a longitudinal sectional view of a tube of my invention, with certain auxiliary apparatus shown diagrammatically;

Fig. 2 is an enlarged longitudinal sectional view of the anode finger embodying a preferred electron multiplier;

Fig. 3 is a diagram showing how the various electrodes may be energized for operation; and

Fig. 4 is a cross-sectional view of the anode finger taken in the plane of the scanning aperture.

My invention may be more fully understood by direct reference to the drawing.

In Fig. 1, which represents schematically a television dissector tube, an envelope 1 is provided with a cathode 2 at one end thereof, the opposite end 3 being transparent and preferably in the form of a planar window so that an optical image, as represented by the optical path lines 4, may be projected on cathode 2 by an outside lens or equivalent optical system 5. Close to the window 3 is positioned an anode finger assembly comprising a hollow conductive tube 6, preferably having a square section. This tube is made sufficiently small in diameter so that it does not appreciably distort the optical image. Inasmuch as it is not in the focus of the lens system, its only action is to reduce the over-all light on cathode 2. The tube 6 is maintained in position by having one open end thereof slipped over a reentrant stem 7 carrying the multiplier leads, as will be explained later, and the other open end is fixed by entering an envelope side arm 9, this latter side arm being provided with a tubulation 10. Thus there is a clear path through the tubulation 10 and side arm 9 into the interior of tube 6. The main envelope 1 is provided with a second tubulation 11, this being positioned at one side of tube 10 and opening directly toward cathode 2 without obstruction.

The anode tube 6 is provided with a primary scanning aperture 12 facing cathode 2, and axially positioned with regard to the tube envelope and the cathode, as clearly shown in Fig. 2 of the drawing. Extending into the interior of the anode tube 6 from the edges of primary aperture 12 is a cylindrical cup 14, the bottom of which is provided with a secondary scanning aperture 15 also axially positioned with respect to envelope and cathode. Immediately back of aperture 15 is first multiplier element 20, in the form of a box having a flat side facing secondary aperture 15, and provided with a tertiary scanning aperture 21. The primary, secondary, and tertiary apertures are concentric and in alignment, and diminish in size, tertiary aperture 21 being the smallest of the three.

The back of the multiplier element 20 is curved, and the side at right angles to the one carrying aperture 21 is open, and second multiplier element 22 is positioned with a screened side 24 presented to the open side of element 20. The open side of second element 22 opens to the screened side 25 of multiplier element 26, and the same construction and position holds with the fourth multiplier element 27 and the fifth multiplier element 29. Parallel to the open side of the fifth multiplier element 29 is an output screen 30 backed by final multiplier element 31. The leads from each individual element are brought out separately through the press of stem 7, on which one end of the anode tube 6 is mounted.

After the tube has been assembled it is preferably exhausted through an exhaust tubulation 32, and inasmuch as it is advantageous in many instances to process the multiplier elements for maximum secondary emission, and the cathode 2 for maximum photoelectric emission, tubulations 10 and 11 are therefore connected to different sources of metallic vapor. Usually, the most sensitive photoelectric surfaces are produced by evaporating caesium vapor onto an oxidized silver surface. The cathode 2 is preferably made of silver; the surface facing the anode finger is etched and oxidized, and then caesium vapor is admitted through tubulation 11 so that the vapor may have an unrestricted path to settle and condense upon cathode 2.

It is obvious, however, that none, or at least a very small amount, of this vapor would normally penetrate to the multiplier elements enclosed within the anode finger, and therefore the cathode 2 may be processed, irrespective of the processing of the multiplier elements. When it is desirable to process the multiplier elements, they are supplied with metallic vapor, such as caesium, barium or beryllium, through tubulation 10, so that the metal vapors pass directly into the anode finger and thus may condense upon the multiplier elements directly. Likewise, this vapor cannot contaminate the surface of cathode 2 because the only outlet for the vapor from the anode tube would be the secondary scanning aperture 15. When the tube has been properly sensitized, both as to the cathode and as to multiplier elements, the final exhaust is given and the tubulation 32 is sealed off. Also, the remaining tubulations 10 and 11 are sealed from the source of vapors.

In operation, the optical image falling on cathode 2 produces an electron image which is drawn toward anode finger 6, and the electrons are maintained in electron image array by means of a longitudinal magnetic field provided by focusing coil 40. This focusing coil is energized, preferably, by a source of direct current 41. The electron image is moved in two directions across aperture 12, and, consequently, across apertures 15 and 21, by scanning generators 42 and 44 supplying magnetic deflection coils 45 and 46.

Thus it can be arranged, as is well known in the art, to successively scan each elementary area of the electron image corresponding to each elementary area of the optical image producing the electron image. The stream of electrons entering primary scanning aperture 12 is still further selected by passing through secondary scanning aperture 15 and tertiary aperture 21, and will finally, within the first multiplier element, give a stream of electrons representing the dissection or analysis of the image on cathode 2.

However, it is obvious that in dissecting such an image the number of electrons entering the first multiplier stage will be small. After passing through scanning aperture 21, however, in the first multiplier element, they impact the back surface of multiplier element 20 and there produce secondary electrons, because the multiplier elements, as shown in Fig. 3, are supplied with successively increasing positive potentials from anode source 50. The secondary electrons produced in the first multiplying element are drawn through the accelerating screen 24 on the second multiplier element 22, and there again produce secondaries. Electrons then pass successively through the following multiplier elements, creating secondaries at each impact, the stream finally passing out of the fifth multiplier element 29 to impact the final multiplying element 31. The secondaries produced by impacting the final multiplier element 31 are collected by collection screen 30, which is at the highest positive potential, and which is connected to source 50 through an output resistor 51, and the output may be then taken directly from the output electrode 30 through output condenser 52.

Multiplications of several thousand are readily obtained with this type of structure, and it is obvious that the multiplication taking place within the tube greatly enhances the sensitivity and the final output of the dissector tube itself, and thus allows a reduction in sensitivity of the outside amplifiers usually necessary in order to bring the train of television signals up to a usable amplitude.

As a guide to the actual dimensions of an operable dissector tube built to embody my invention the following measurements of one such tube are given below:

	Inches
Length of tube	10½
Diameter of tube	4½
Diameter of photo cathode	4¼
Diameter of anode finger	$1\frac{7}{32}$
Diameter of tertiary scanning aperture	0.01
Multiplier element size	¼ x $\frac{3}{16}$

I claim:

1. An image dissector tube having an envelope including a transparent window through which an optical image may be projected onto a photoelectric cathode positioned within said envelope image, and means for collecting and amplifying photo-electrons emitted from said cathode comprising a hollow conductive tube extending across the projection path of said optical image and positioned at a point between said window and said cathode, said tube having a recess therein facing said cathode and the bottom of said recess having an aperture therein, a hollow body positioned in said tube back of said aperture and having therein a second aperture registering with but apart from said first aperture, a surface capable of emitting secondary electrons upon electron impact therewith at a ratio greater than unity carried by said body and in line with said apertures, and a plurality of additional and similar surfaces within said tube and located to be serially impacted by electrons leaving said first surface and passing through said aperture, said conductive tube shielding said additional secondary electron emitting surfaces from all other electrons leaving said photoelectric cathode.

2. An image dissector tube having an envelope including a transparent window through which an optical image may be projected onto a photoelectric cathode positioned within said envelope, and means for collecting and amplifying photo electrons emitted from said cathode comprising a hollow conductive tube extending across the projection path of said optical image and positioned at a point between said window and said cathode, said tube having a recess therein facing said cathode and the bottom of said recess having an aperture therein, an electron multiplier within said tube having a plurality of surfaces located to be serially impacted by electrons passing through said aperture, an envelope tubulation positioned to direct vapor of a photoelectric material toward said cathode, and a second envelope tubulation opening into the interior of said tube.

3. In an image dissector tube of the type having an envelope including a transparent window through which an optical image may be projected onto a photoelectric cathode positioned within said envelope, said photoelectric cathode emitting electrons over each incremental area thereof in proportion to the intensity of light falling on each said incremental area and said dissector tube having means for attracting emitted electrons toward said window, the combination of a hollow conductive tube extending across the projection path of said optical image and positioned within said dissector tube at a point between said window and said cathode, said conductive tube having an aperture in a side wall thereof facing said cathode, and a plurality of elements having surfaces capable of emitting secondary electrons upon electron impact therewith, said elements being positioned within said conductive tube at different levels therein and so located as to be successively impacted by a secondary electron stream initiated by a first of said elements upon impact of such primary electrons as are emitted by said cathode and pass through said aperture.

BERNARD C. GARDNER.

Patent No. 2,200,166. CERTIFICATE OF CORRECTION. May 7, 1940.

BERNARD C. GARDNER.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 3, first column, line 48, claim 1, before the comma, strike out "image"; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 31st day of October, A. D. 1944.

Leslie Frazer

(Seal) Acting Commissioner of Patents.