Patented July 22, 1952

2,604,606

UNITED STATES PATENT OFFICE

2,604,606

TARGET FOR STORAGE TUBES

Jan A. Rajchman, Princeton, N. J.,

assignor to Radio Corporation of America, a corporation of Delaware

Application October 15, 1949, Serial No.122,657

10 Claims (CL 215-12)

This invention relates to electron discharge devices of the type in which an elemental area of a target electrode is charged to one of two predetermined potentials and stores that potential whereby it constitutes a memory element. In particular, this invention relates to an improved target electrode construction and means for indicating the condition of the memory element of said target.

In my copending applications Ser. No. 665,031 filed April 26, 1946 for an "Electron Discharge Device," now Patent No. 2,494,670, issued January 17, 1950, and Ser. No.118,527, filed September 29, 1949 also for an "Electron Discharge Device," electron discharge devices of the area selection and storage or memory type have been described. Briefly, these consist of a source of electrons, a horizontal and a vertical selecting grid network for directing electrons from the source to a selected elemental area of a target electrode. Other well known types of storage tubes use electrostatic deflection plates or deflection coils for directing electrons from the source to a desired target area.

In my copending application for an "Electron Storage Device With Grid Control Action," Serial No. 722,194, filed January 15, 1947, now Patent No.2,513,743 issued July 4, 1950, I show various types of target constructions suitable for use In a memory type of tube. "Memory" tube targets in general have their surface areas divided into small areas each of which is capacitively coupled to a common signal plate. These small areas then comprise small condensers in which information is stored by the presence or absence of a charge. By conditioning successively selected ones of these small condensers to either have a charge or not, the device may be made to store intelligent information. The device finds its greatest utility in connection with computing systems utilizing the system of counting wherein one of two stable conditions represents a one and the other of the two stable conditions represents a zero, or any other system of counting in which the numbers are represented by coded combinations of the two conditions.

In my copending application for an "Electron Storage Device with Grid Control Action," I disclose a grid control type of memory target wherein a first target provides a "memory" and control function, and a second target provides for the reading or Indicating function. This is accomplished by providing holes in the dielectric surface which constitutes each memory element with corresponding holes in the signal plate through which electrons may pass to impinge upon a selected area of a second target to cause fluorescence. Alternatively the electrons which pass through the first target are passed into an area where three focussing electrodes are biased to cause the electrons to impinge on a wire. This sets up a current in the wire which constitutes a reading current.

Whether or not electrons may pass through the hole in the storage element of the first target depends upon the potential of that particular element.

The grid control type of targets shown in my above mentioned copending application all had storage elements which were in the form of a wire screen, a hollow truncated cone or a hollow cylindrical eyelet, all insulatingly mounted in a metal capacity plate, or writing plate. In view of the necessity for drilling the writing plate, then insulating the drilled holes, then fastening the various storage elements to the insulation, the manufacture of these targets proved difficult and expensive. Also, although these previous grid control types of targets operated satisfactorily, upon investigation it was found that they were not as efficient as they could be because the grid control effect interfered to a certain extent with the storage effect. In other words, it can be shown that at each of the eyelets or memory elements there is established a region which even though bombarded with primary electrons will not permit the escape of secondary electrons. The extent of this retarding field depends upon the potential at which the eyelet is established. It represents an area of wasted power as far as results from bombardment by electrons from the cathode are concerned.

In view of the insertion of the memory eyelets in the metal writing plate, as stated above, there Is some ohmic leakage between memory eyelets at a higher potential and those at a lower potential. Some "cross-talk" linkage also exists, that is, some secondary electrons which are emitted from the eyelets are collected by adjacent eyelets instead of by the collector plate.

It is an object of my present invention to provide an improved target electrode construction which is simpler to manufacture than heretofore. It is still another object of my present invention to provide an improved target electrode construction for an electron storage tube which is more efficient than heretofore. It is still another object of my present invention to provide an improved target electrode construction for an electron storage tube which can simultaneously provide a visual and electrical indication of the condition of the memory elements of the target.

These and other objects of my invention are achieved by making a target assembly consisting of a collector electrode which consists of two metal plates in intimate contact and having aligned perforations of different diameters, a plurality of storage eyelets insulatingly supported between two mica sheets, a perforated writing plate, both writing plate and collector electrode being capacitively associated with the plurality of eyelets and both having their perforations aligned with the plurality of storage eyelets. A reading plate, also with aligned perforations, is spaced from the writing plate. A Faraday cage is spaced from the reading plate and the two sides parallel to the reading plate have perforations aligned with those of the reading plate. A glass plate with a fluorescent and secondary electron emitting coating on one side has the coated side pressed against the perforated wall of the Faraday cage, which is further away from the reading plate inside the Faraday cage are 'reading' wires which are positioned between the perforations to be shielded from direct emission from the cathodes. Any electrons which are passed through the eyelets strike the fluorescent screen and cause fluorescence as well as secondary electron emission. This secondary emission is picked up by the reading wires as a reading current

The novel features of my invention as well as the invention itself both as to its organization and method of operation will best be understood from the following description when read in connection with the accompanying drawing in which:

Figure 1 is an axial sectional view of an election discharge storage tube which includes a target which is an embodiment of my present invention,

Figure 2. is an enlarged sectional view of the first target assembly which is a portion of an embodiment of my invention,

Figure 3 is a curve of the current voltage characteristic of a single storage eyelet element, and

Figure 4 is a schematic diagram illustrating the circuit connections for a tube of the type shown in Figure 1.

The electron discharge storage tube of which Figure 1 is an axial sectional view is described and claimed in my application Serial No. 118,758, for an "Electron Discharge Tube," filed September 30, 1949. Referring to Figure 1, an electron discharge storage device which includes the target which is an embodiment of my present invention, has an outer glass envelope **10**, a plurality of elongated cathodes **12** of rectangular cross section which are coextensive with a set of separately insulated vertical selecting wires **14** or bars of square cross section. The cathodes **12** are interposed between and are alternate with the vertical selecting bars **14**. A plurality of separately insulated vertical selecting wires **16** or bars are spaced on either side from and parallel with the plane formed by the cathodes and horizontal selecting bars.

It will be readily appreciated that when viewed in a plane perpendicular to the plane of the horizontal and vertical selecting bars, these bars define a plurality of windows. The bias applied to the selecting bars defining a window determines whether or not electrons flow through each of these windows. Although not shown herein, the individual wires of the horizontal and vertical selecting bar network are to be separately connected for individual excitation in accordance with the teaching of my copending applications for an "Electron Discharge Device" as identified above. Methods for effecting complete control of the electron stream utilizing a number of external leads which is less than the number of individual selecting bar wires have been described and claimed in my copending application Ser. No. 702,775, filed October 11, 1946, now Patent No. 2,558,460, issued June 26, 1951, and in the application of George W. Brown, Ser. No. 694,041, filed August 30, 1946, now Patent No. 2,519,172, issued August 15, 1950.

It is to be understood that the particular arrangement employed for generating and directing electrons toward a selected elemental area is not, as such, a part of my present invention. Any arrangement for this purpose may be employed.

On either outer side of the horizontal selecting bars is a first target electrode. Figure 2 is an enlarged cross sectional view of the first target electrode and also represents the electron path for two potential conditions of the storage area of the target.

The first target electrode consists of a collector electrode **18** having as many perforations as there are windows pr desired storage areas. These perforations are aligned with the windows. The collector electrode **18**, for ease of manufacture, consists of two adjacent metal plates, a collector mask **20** which has the smaller perforations and a. collector spacer **22** which has the larger perforations. Two perforated plates made of an insulating material **24**, such as mica, insulatingly support between them a plurality of storage eyelets **26**. The storage eyelets **26** are made from a metal having good secondary emission and not evaporating too easily. I prefer to use steel, with a plating of nickel, or beryllium. The storage eyelet is constructed with a collar **42** so that it may be easily dropped into one of the insulating plates and retained by placing the other insulating plate over the storage eyelet so that it bears on the collar. This assembly may then be easily fastened together at the four corners or any other convenient location. The perforations of the insulating plates are placed so that the eyelets **26** are retained in alignment with the collector electrode perforations and the windows formed by the selecting bars. The perforations in the collector spacer **22** are of such size as to permit it to be brought against the insulating plate which holds the storage eyelet without touching the eyelets. The thickness of the collector spacer is such as to support the collector mask **20** proximal to the storage eyelets **26**. Each perforation in the collector mask is slightly smaller than the conical opening **44** at the head of each of the storage eyelets. The collector electrode **18** thus effectively masks the insulating plates **26** from the contamination effects of the cathode or any other heated electrode and thus reduces any ohmic leakage which may occur along the surface of the insulating plates **24**.

A bias or writing plate **28** is the last part of the first target assembly. It is made of metal and also has perforations large enough so that it can fit over and proximal to the tails of the storage eyelets **26** and against the insulating sheet **24** between the storage eyelets. The thickness of the writing plate **28** is such as to cause it to extend slightly beyond the tail of the eyelet and to have a reasonably large capacity with all the eyelets since the writing technique with this type of target requires pulsing the bias plate to change the eyelet potential. Too small a capacity would require excessively high pulse amplitude.

The second target electrode structure consists of another metal plate spaced from and parallel to the writing plate. This is known as the reading plate **30** and also has perforations which are aligned with the storage eyelets.

Spaced from the reading plate is a Faraday screen **32** or cage. It is made in the form of a rectangular metal box having two sides parallel and substantially coextensive with the reading plate **30**. These two parallel sides have perforations which are aligned with the reading plate perforations and the storage eyelets. Extending through the Faraday cage and positioned between the rows of perforations are a number of reading wires **34**. These wires are connected together and a single shielded lead **36** is brought there from external to the tube. A translucent plate **38** having on one side a fluorescent and secondary emissive coating **40**, such as Willemite, is placed with its coated side against the outside of the perforated wall of the Faraday cage which is further from the reading plate **30**. Thus, any electrons which are passed by the eyelets into the Faraday cage **32**, strike the fluorescent coating **40** and the secondary electrons which are emitted therefrom are picked up by the reading wires **34** and detected externally as a reading current.

Leads connecting the various portions of the target external to the tube are shown connected to only one of the two target assemblies shown in Figure 1. Connections to the other target assembly will be understood although not shown. The collector electrode **18** is connected externally by means of the collector lead **23**, the writing plate **28** is connected externally by means of the writing plate lead **25**. The reading plate **30** is connected externally by means of its lead **31** and the reading wires are connected externally by means of the shielded lead **36**. Lead **15** Is representative of an externally connecting lead to a vertical selecting wire and lead **17** is representative of an externally connecting lead to a horizontal selecting wire.

The operation of this device including the selection of the individual storage elements, the release of secondary electrons by the storage elements and the method of conditioning the storage element to one or the other of two stable conditions is as described in my copending application for an "Electron Discharge Tube," Ser. No. 118,758, filed September 30, 1949, as well as the earlier applications referred to above and need not be described herein in greater detail.

The principle of operation of the storage eyelet is briefly set forth below for the purposes of a clearer exposition of one of the features of my invention. Referring to Figure 3 wherein is shown a curve of the electron current to the eyelet as a function of its potential, when the potential of the eyelet is more negative than the cathode (point Po) no electron current can reach it. When the eyelet is approximately at cathode potential electrons begin to strike it and some negative current gets to the eyelet (region P1 to P2 of the curve). As the eyelet potential becomes more positive, the secondary emission becomes greater than the primary emission and a positive current flows from the eyelet (region P2-P3 of the curve). As the eyelet reaches the potential of the collector electrode the secondary emission is suppressed because there is a lack of collecting field for the low energy secondary electrons so that the current again becomes zero at a point P3 (slightly more positive than the collector potential) in the absence of all leakage currents. For more positive values of the eyelet the secondary emission is suppressed completely and the current to the eyelet is negative again (points such as P4 on the curve).

If the eyelet is electrically floating, or connected to no lead, the electron current to it in a steady state must be zero, because the action of the electron current on the eyelet is such as to cause it to accumulate charges and thus to change in potential until it reaches the point at which no more electron current flows. The floating eyelet can therefore be at one of the three values P1, P2 or P3 for which the electron current is zero. In practice, however, only points P1 and P3 are stable ones. Any slight disturbances, such as a very slight ohmic current due to leakage on the surface of the mica, is sufficient to move the eyelet potential away from point P2. In order to place a storage eyelet into one or the other of the two stable potential conditions the electron current flow is directed only toward that single storage eyelet and none other. A similar procedure is followed for reading the potential condition of the eyelet. In order to assist the storage eyelet in properly repelling electrons, when it is near the cathode potential, so that none may get through the eyelet and cause a false reading during reading and quiescent periods of the tube, a negative bias potential is at all times placed on the writing plate **28** except when it is used for writing. The effect of this negative bias potential, in previous types of storage targets was to create an area in the storage eyelet where the field potential distribution was such as to prevent the emission of secondary electrons from a considerable portion of the storage eyelet under electron bombardment, regardless of its potential. The present eyelet is therefore made deep and to have a somewhat constricted neck portion so that no negative retarding field can reach that portion of the storage eyelet which is subjected to electron bombardment to diminish its efficiency. The diameter of the tail of the eyelet, however, must be chosen sufficiently large so that when the eyelet Is at Its most positive stable potential (or collector potential) it has enough influence to overcome the negative field region caused by the negative bias on the writing plate and thus permit the passage therethrough of electrons.

The eyelet head has a frusto-conical shape in order that the electron paths be as perpendicular to the surface at the opening **44** of the eyelet as possible for the negative condition of the storage eyelet. The electron paths for the positive and negative conditions of the eyelet may be seen in Figure 2. When the eyelet is positive the electrons pass through it substantially in the path shown. When the eyelet is negative most of the electrons are turned back to the collector. A few that get past the collar opening are repelled by the negative field from the writing plate. Electrons succeed best in overcoming a potential "hill" when they are moving straight in line with the steepest gradient because they are not deflected sideways. An angle of 25.5 degrees was found to be optimum for the geometry of the particular tube described here. Some strong side deflections are unavoidable at the edges of the done. These strongly diverging electrons must be stopped from going into adjacent storage eyelets (crosstalk). This is done by the walls of the holes of the collector spacer plate **22** as shown in Figure 2. The wall area of the hole in the collar of the eyelet must be small enough so that the percentage of electron current striking there without producing secondary electrons may be as small as possible. On the other hand it must be large enough to let through an appreciable electron reading current. A ratio of diameters of 3:1 of the collector mask hole to the eyelet collar hole was found to be satisfactory. The ratio of diameters of the eyelet head to the collector mask hole was established in the ratio of 5:3 in order to reduce the diverging electron effect mentioned above. The combination of eyelet head diameter and the proper cone angle brings about a reasonably large negative loop in the voltage current characteristic curve of the eyelet (Fig. 3). The smallness of the eyelet hole and the proximity to the collector plate brings about a good secondary emission collecting field insuring a reasonably large positive loop in the voltage-current characteristic curve (Fig. 3).

The electrical circuit connections for one half of the tube illustrated in Fig. 1 is shown schematically in Fig. 4. Since, as seen in Figure 1, the tube is symmetrical about its cathode plane, it will be understood that this system or connections is utilizable for both halves of the tube. The cathodes **12** are preferably connected to ground while the collector electrode **18**, the writing **28** and reading plates **30**, the Faraday shield **32** and the reading wires **34** are all connected to a suitable source of D.C. potential **48** the approximate values of which are indicated in Fig 4. This source may, for example, be provided by a battery and a resistance voltage divider. The control circuit for applying potentials for opening or closing the windows formed by the horizontal and vertical selecting bars is represented by the selection circuit device **48**. A pulse for conditioning the storage eyelet selected is applied to the terminal **50** which is capacitively coupled to the writing plate by means of a condenser. A pulse to permit reading is applied to the reading plate through the terminal **52** which is capacitively coupled to the reading plates by means of a condenser. Electrical output is taken from the output terminals **54** which are connected across the load impedance.

In operation, when the device is in the quiescent or standby condition all the windows are on and all the storage eyelets are subjected to electron bombardment. Any storage eyelets which are in the negative condition, with the aid of the negatively biased writing plate, prevent electrons from passing therethrough. Any storage eyelets, which are in the positive condition, pass electrons but these are all captured or repelled by the negatively biased reading plate **30**. When it is desired to write or condition a storage eyelet, all the windows are closed except the one to the storage eyelet selected and a conditioning pulse is applied to the writing plate **28**. When it is desired to read the condition of a particular eyelet **26**, all the windows are closed except the one to the eyelet desired and a positive pulse is applied to the reading plate **30**. This permits passage of electrons therethrough from the selected eyelet, if the eyelet is in a positive condition. These impinge on the fluorescent coating **40** through the perforation associated with that eyelet causing the coating to fluoresce at that position, thus giving a visible indication of a positive condition. Secondary electrons which are emitted by the fluorescent coating are captured by the high potential reading wires **34** and thus provide an electrical indication of a positive condition. The Faraday cage **32** provides efficient shielding for the reading wires **34** against any stray capacity influence.

From the foregoing description it will be readily apparent that I have provided an improved and efficient grid action storage target and reading target assembly for memory type electron tubes. Although the target has been described in connection with a dual channel type of target area selecting type of memory tube using two targets, it may be used with any type of tube which provides the structure required to direct electrons from a source to a specific desired area of the target. Although I have shown and described but a single embodiment of my present invention it should be apparent that many changes may be made in the particular embodiment herein disclosed, and that many other embodiments are possible, all within the spirit and scope of my invention. For example, the reading wires and Faraday cage may be omitted and the condition of the target elements may be read visually by observing the presence or absence of fluorescence when a single eyelet is selected. The Faraday cage and fluorescent screen may be omitted, and the reading plate may be made without apertures so that when a single eyelet is selected, depending upon its potential, electrons may or may not strike the reading plate. Thus, the presence or absence of reading plate current may be used to evidence the eyelet potential condition. Therefore, I desire that the foregoing description shall be taken as illustrative and not as limiting.

What is claimed is:

1. An electron discharge device having a source of electrons, a storage target, and means to direct said electrons from said source to selected areas of said storage target, said storage target including a secondary emissive storage eyelet at each of said selected areas, and insulating means supporting and spacing all of the storage eyelets.

2. An electron discharge device having a source of electrons, a storage target, and means to direct said electrons from said source to selected areas of said storage target, said storage target including a secondary emissive storage eyelet at each of said selected areas and a pair of perforated insulating plates supporting and spacing all of the storage eyelets.

3. An electron discharge device having a source of electrons, a storage target, and means to direct said electrons from said source to selected areas of said storage target, said storage target including a secondary emissive storage eyelet at each of said selected areas, a pair of perforated insulating plates supporting and spacing all of the storage eyelets and a collector electrode between said insulating plates and said source of electrons, said collector electrode shielding said insulating plates from said source of electrons and having perforations aligned with each of the eyelets.

4. An electron discharge device as recited in claim 3 wherein there is Included in addition a metal writing plate having perforations aligned with said eyelets, said writing plate being capacitatively disposed with reference to all said eyelets.

5. An electron discharge device as recited in claim 4 wherein said collector

electrode comprises two perforated metal plates in contact with each other, one of said plates having perforations of sufficient size to be interposed between each of said storage eyelets and having a sufficient thickness to space the other of said plates over each of said eyelets, both said plates serving to prevent the passage of electrons between said eyelets.

6. A grid action storage target for an electron memory tube comprising a plurality of secondary emissive storage eyelets each having head and tall ends, a pair of perforated insulating plates supporting and spacing each of the eyelets between said head and tail ends, a collector electrode having perforations aligned with each of said storage eyelets and having a portion interposed between each of the head ends of the eyelets, and a metal writing plate having perforations aligned with each of said eyelets said perforations being of a size to permit said metal writing plate to be interposed between the tail ends of said eyelets and to be capacitively associated with said eyelets.

7. A storage eyelet for a grid action storage target made of a secondary emissive metal and having a head portion, a tail portion and a collar portion by means of which said eyelet is supported, the opening of said head portion of said eyelet being of a frusto-conical shape, said tail portion opening being of a cylindrical shape and a narrow cylindrical shaped throat portion joining the head and tail portion openings.

8. An electron discharge device having a source of electrons, a first grid action target including a plurality of storage eyelets, means to direct said electrons from said source to selected ones of said eyelets, and a second reading target, said second reading target including a transparent dielectric base having a fluorescent and second electron emissive coating thereon and a plurality of interconnected reading wires biased to capture the emitted secondary electrons.

9. An electron discharge device having a source of electrons, a first grid action target having a plurality of perforated storage areas, means to direct said electrons from said source to selected ones of said perforated storage areas, and a second reading target, said reading target comprising a reading electrode consisting of a metal plate spaced from said grid action target and having a plurality of perforations aligned with said storage area perforations, a Faraday cage having two walls parallel to said reading

electrode, said walls having perforations aligned with said reading electrode perforations, a plurality of parallel reading wires positioned within said Faraday cage and between said perforations to be shielded from said grid action target, and a translucent dielectric plate having one side coated with a fluorescent and secondary emissive material, said dielectric plate being positioned with its coated side adjacent a perforated wall of said Faraday cage to be bombarded by electrons which pass through said cage from said grid action target to emit secondary electrons responsive thereto which are collected by said reading wires.

10. First and second targets for an electron memory tube, said first target comprising a plurality of secondary emissive storage eyelets each having head and tail ends, a pair of perforated insulating plates supporting and spacing each of the eyelets between said head and tail ends, a collector electrode having perforations aligned with each of said storage eyelets and having a portion interposed between each of the head ends of the eyelets, and a metal writing plate having perforations aligned with each of said eyelets, said perforations being of a size to permit said metal writing plate to be interposed between the tail ends of said eyelets and to be capacitively associated with said eyelets, said second target comprising a metal plate reading electrode spaced from said writing plate and having a plurality of perforations aligned with said eyelet, a Faraday cage having two walls parallel to said reading electrode, said walls having perforations aligned with said reading electrode perforations, a plurality of parallel reading wires positioned within said Faraday cage and between said perforations to be shielded from said grid action target, and a translucent dielectric plate having one side coated with a fluorescent and secondary emissive material, said dielectric plate being positioned with its coated side adjacent a perforated wall of said Faraday cage to be bombarded by electrons which pass through said cage from said grid action target and to emit secondary electrons responsive thereto which are collected by said reading wires.

JAN A. RAJCHMAN.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,172,738	Levin	Sept.12, 1939
2,291,577	Farnsworth	July 28, 1942
2,416,720	Teal	Mar. 4, 1947
2,423,124	Teal	July 1, 1947

FOREIGN PATENTS

Number	Country	Date
539,496	Great Britain	Apr. 1, 1940