

July 14, 1953

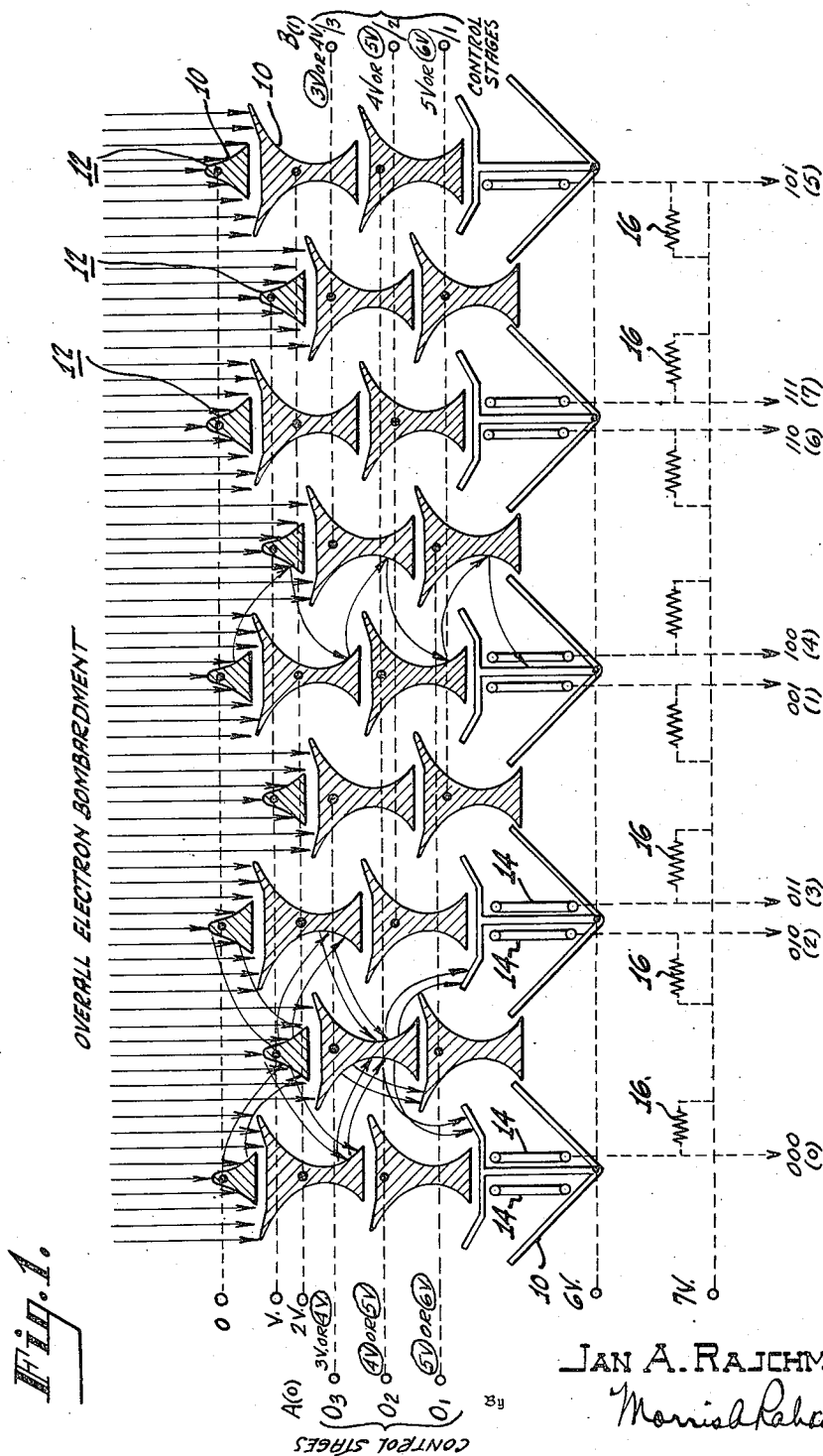
J. A. RAJCHMAN

2,645,734

STORAGE TUBE WITH ELECTRON MULTIPLYING AND SELECTING ELECTRODES

Filed Sept. 29, 1949

4 Sheets-Sheet 1



July 14, 1953

J. A. RAJCHMAN

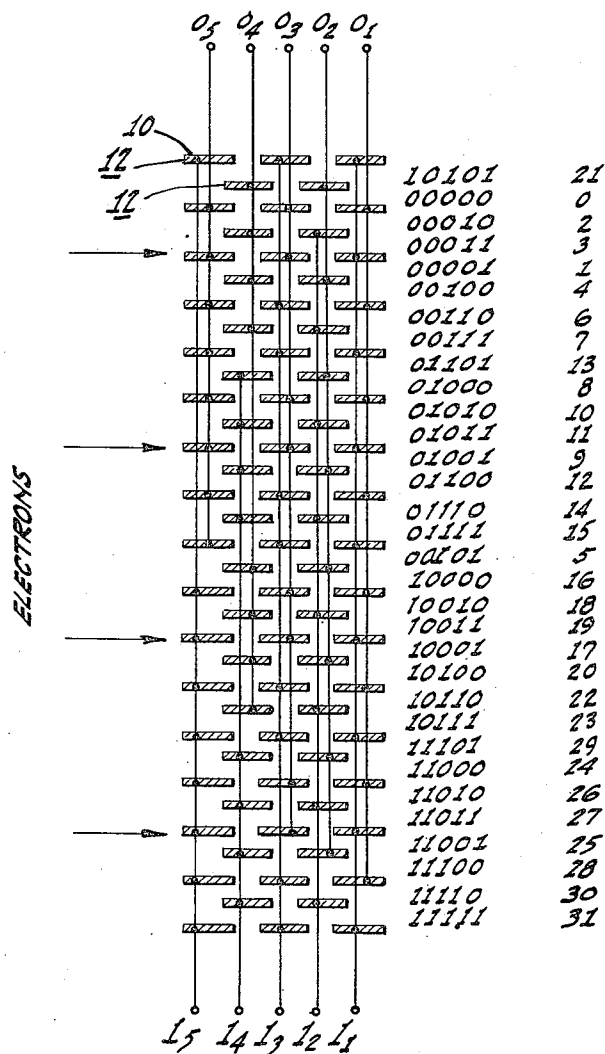
2,645,734

STORAGE TUBE WITH ELECTRON MULTIPLYING AND SELECTING ELECTRODES

Filed Sept. 29, 1949

4 Sheets-Sheet 2

Fig. 2.



Inventor

JAN A. RAJCHMAN

Marion K. Kline

Attorney

July 14, 1953

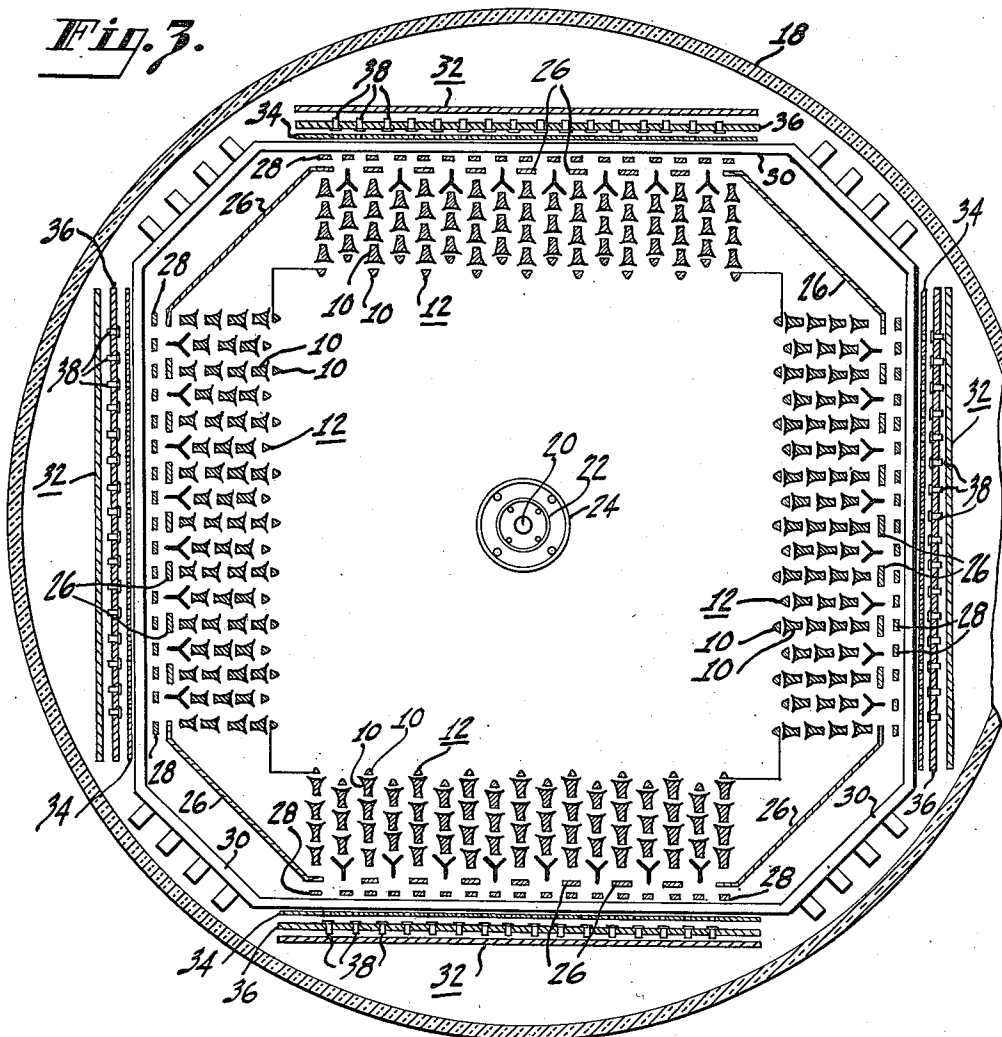
J. A. RAJCHMAN

2,645,734

STORAGE TUBE WITH ELECTRON MULTIPLYING AND SELECTING ELECTRODES

Filed Sept. 29, 1949

4 Sheets-Sheet 3



Inventor
JAN. A. RAJCHMAN

Morris H. Kahn

Attorney

July 14, 1953

J. A. RAJCHMAN

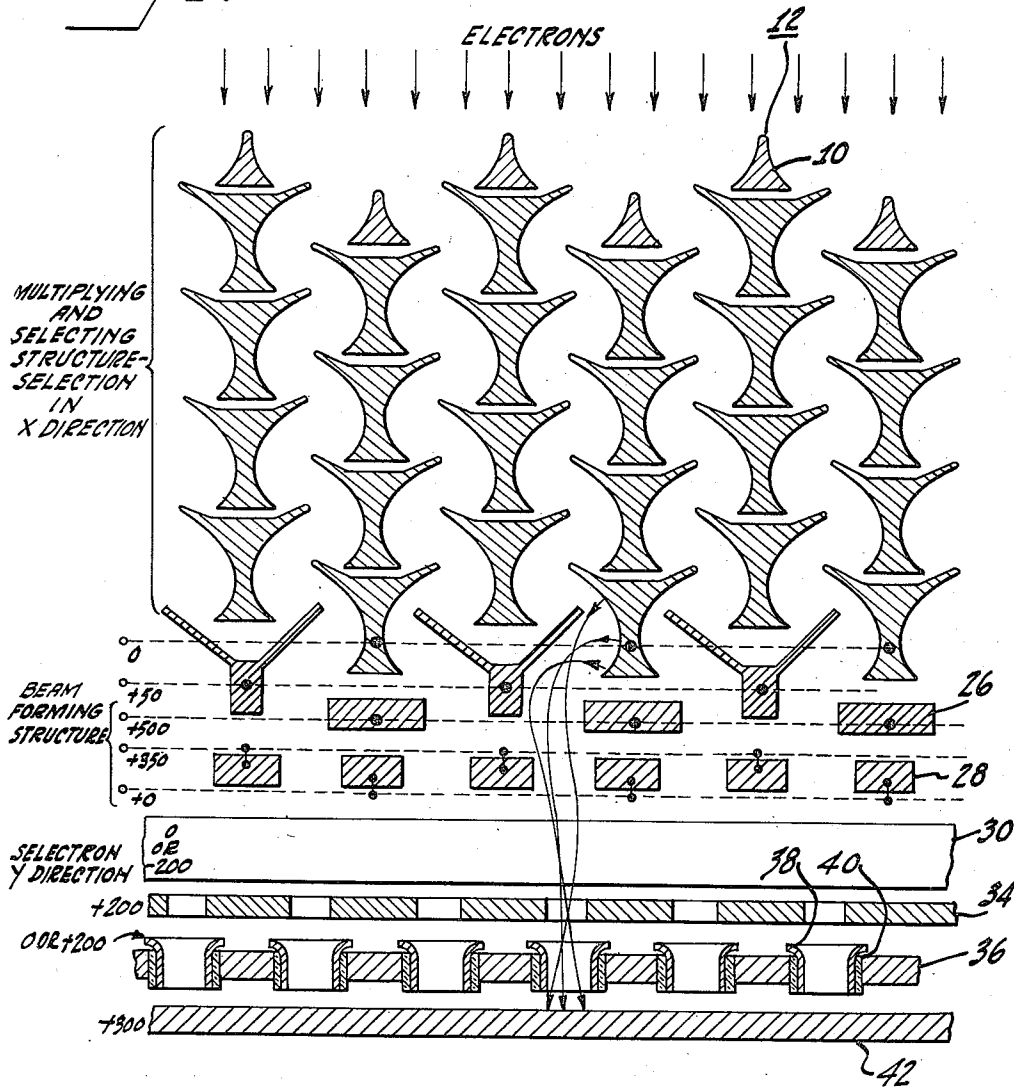
2,645,734

STORAGE TUBE WITH ELECTRON MULTIPLYING AND SELECTING ELECTRODES

Filed Sept. 29, 1949

4 Sheets-Sheet 4

Fig. 4.



Inventor

JAN A. RAJCHMAN

Morris Rabin

Attorney

UNITED STATES PATENT OFFICE

2,645,734

STORAGE TUBE WITH ELECTRON MULTIPLYING AND SELECTING ELECTRODES

Jan A. Rajchman, Princeton, N. J., assignor to
Radio Corporation of America, a corporation
of Delaware

Application September 29, 1949, Serial No. 118,527

9 Claims. (Cl. 313—68)

1

This invention relates to electron discharge devices of the type in which elemental areas of a target electrode are selectively bombarded. More particularly this invention is an improved grid structure for selecting and bombarding an elemental target area.

The problem of obtaining bombardment by electrons in one definite location amongst many possible locations is always present in devices such as, cathode ray tubes, kinescopes, beam electron switches, storage tubes and area selection tubes of the type known as the selectron. The use of a focussed beam in obtaining selective local bombardment, which is electrostatically or magnetically deflected, provides a method which is efficient with respect to the amount of current required. The drawback in this method, however, is the fact that the location of a spot which is to be bombarded is determined by the amplitude of the energy applied to the deflecting system and is therefore difficult to obtain with a high degree of precision and reproducibility. Furthermore, the amount of current available for a given accelerating voltage is limited.

Another system of selective local electron bombardment consists of an overall electron bombardment which is intercepted, as desired, by applying a bias to a system of selective grids. This system is explained in my application for an "Electronic Discharge Device," Serial No. 665,031, filed April 26, 1946, now Patent No. 2,494,670, issued July 4, 1950, and in an application by G. W. Brown, Serial No. 694,041, filed August 30, 1946, for "Control of Electron Discharge Device of Area Selection Type," now Patent No. 2,519,172, issued August 15, 1950. These systems provide a definite and very rapid means for selecting any chosen area positively. However, the results, in the cases of these above mentioned area selecting type tubes, are obtained at the expense of current intensity since almost all electrons emitted from the central electron source are either wasted or suppressed and only a very few are utilized.

It is therefore an object of my present invention to provide an improved grid structure providing a more accurate target area selection and a greater current intensity flowing to the selected target area for a given exciting voltage than heretofore.

It is a further object of my present invention to provide an improved grid structure which, while providing more accurate target area selection and a greater current intensity to said target area for a given exciting voltage than heretofore, is very efficient.

2

These and other objects of my invention are achieved in one embodiment of my invention by using a grid structure made of a plurality of dynodes or secondary electron producing electrodes which are arranged to form channels through which secondary electrons travel on their way to the target. Primary electrons, from a cathode, bombard dynodes at the beginning of these channels thereby releasing secondary electrons which travel from dynode to dynode along each of the channels thus releasing an increasing number of secondary electrons. Whether or not there is any output from a channel is determined by the bias applied to the dynodes defining that channel. At the output of each channel, in one embodiment of my invention, there is provided a target consisting of a separate collector electrode and load resistor for each channel for providing an external electric indication of the output from a channel which is open.

In another embodiment of my invention, at the output end of each of the channels formed by the dynodes are provided electron beam forming means which serve to focus the electrons into narrow horizontal beams. A network of spaced parallel vertical selecting wires is at right angles to the horizontal electron beams and the electrons pass between adjacent wires of the network. A collector electrode and target structure may be provided such as any of the ones which are described and claimed in my applications 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, and "Target for Storage Type Tubes," Serial No. 122,657, filed October 15, 1949, now Patent No. 2,604,606, issued July 22, 1952.

By applying a proper bias to selected dynodes, all channels except a single channel are closed. By applying a proper bias to selected vertical selecting wires, electrons in the horizontal beam output from the open channel will pass only between the two adjacent selecting wires which are not biased. A desired target storage area to be bombarded by electrons may thus be selected by merely applying a bias to proper ones of the dynodes and the vertical selecting wires.

The novel features of the 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 drawings in which similar reference numerals are applied to similar functioning parts and in which,

Figure 1 is a schematic view of one embodiment of my invention, and

Figure 2 is a schematic diagram of a system of interconnecting individual dynodes in combinatorial fashion which dynodes are arranged to comprise an embodiment of my invention.

Figure 3 is a cross section of an area selecting type of tube using the electron multiplying and selecting grid structure comprising another embodiment of my invention.

Figure 4 is an enlargement of a section of the electron multiplying and selecting grid and target structure of the area selection type of tube shown in Figure 3.

Secondary emission electron multipliers are well-known in the art. Also well-known is the system of building up ladders of dynodes which are shaped and biased so that an electron striking the first dynode of the ladder releases secondary electrons which are guided to strike the second dynode of an adjacent ladder releasing more secondary electrons. These secondary electrons are then guided to strike the third dynode of the first ladder releasing still more secondary electrons. This system of electron multiplication has proved itself very efficient. Besides the shape of the dynodes being necessarily made in a form to guide the released secondary electrons the ability of the secondary electrons to release more secondary electrons is also dependent upon the potential of a dynode which is next in the ladder chain. The potential of any one of the dynodes along a ladder must be sufficiently higher so that not only are the secondary electrons, released by the previous dynode, drawn to it but they must be so drawn with a sufficient velocity to release more secondary electrons. The required difference in potential depends upon the nature of the secondary electron emanating material with which the dynode is coated. When the potential of a dynode is different from its required value the electron trajectory is altered. By varying the value of the voltage applied to a dynode in a ladder this electron trajectory can be so altered as to diminish the gain considerably or to reduce it to zero for a particular channel. See Electron Multiplier, Patent No. 2,231,682 by J. A. Rajchman et al.

Referring to Figure 1, a plurality of dynodes 10 are shown which are positioned to form nine dynode ladders 12. The first dynodes in these ladders are all bombarded from a source of electrons by electrons whose paths are represented by the arrows. The space between the ladders 12 are channels of multiplication through which the secondary electrons may pass from the dynodes 10 of one ladder to the dynodes of the adjacent ladder. There are eight channels of multiplication shown. A collector electrode 14 is associated with each channel and is proximal to the last dynode 10 in each ladder 12 to collect any electrons released therefrom. Each collector electrode is connected to an associated external load resistor 16, the connection being represented by a dotted line.

For the purposes of explanation let V represent a required increment in voltage between two dynodes in order that electrons may be guided from one dynode to the next dynode with a sufficient velocity to release more secondary electrons. Then, in order for any one of the eight channels shown in Figure 1 to be open for the passage of secondary electrons therethrough, the successive dynodes 10 in one ladder 12 must be biased at voltages 0, $2V$, $4V$ and $6V$ and the successive dynodes in the adjacent ladder de-

fining the one channel must be biased at voltages V , $3V$ and $5V$. Expressed in general terms where the n th dynode of a ladder is either at the potential of the $(n-1)$ th dynode or the $(n+1)$ th dynode, a channel is closed and the gain is zero. This occurs because, in the case where the n th dynode is at $(n-1)$ dynode potential, any secondary electrons emitted by the $(n-1)$ dynode strike the n th dynode with practically no energy, if they strike at all, so that no secondary electrons are produced at the n th dynode. Similarly, if the n th dynode is at the potential of the $(n+1)$ th dynode, no secondary electrons will emanate from the $(n+1)$ th dynode for the same reason. When the n th dynode is at $(n-1)$ th dynode potential it may also happen that many electrons may go from the $(n-1)$ th dynode to the $(n+1)$ th dynode directly. However, due to the dynode shapes these electrons strike such portions of the $(n+1)$ th dynode that no secondary electrons can escape from this dynode.

It may therefore be seen that the effective gain, or output from any channel may be controlled by controlling the potential of the dynodes defining that channel. Since all the dynode ladders 12, except the outside two, separate two channels, the potential or bias applied to any one dynode 10 actually affords a means of controlling the two adjacent channels which it separates. Therefore, altho a separate lead for biasing may be connected to each dynode, a combinatorial scheme of interconnecting the dynodes may also be utilized to reduce the number of external leads required to control the channel outputs in the same manner that a combinatorial system is used to interconnect the selecting wires forming the grid structure of an area selecting type of tube as is described and claimed in the aforementioned applications. The bias on a selecting wire of the grid structure of an area selecting type of tube controls the electron flow through two adjacent windows which are separated by the selecting wire in similar fashion to the manner in which the bias on a dynode may control the electron flow through the two adjacent channels which it separates.

In Figure 1, the dotted lines show one system for interconnecting the dynodes (a binary system) so that only six external leads are required to which a bias may be applied to open or close any one of the eight channels. In the system shown in Figure 1 only one dynode 10 in each ladder 12 is used as a control. More than one control dynode may be used per ladder if desired. There are three stages of straight multiplication in each ladder which also serve as a means of collecting the overall primary electron bombardment. These are followed by three multiplication and control stages. Finally there is a stage of straight multiplication which surrounds the collector. This arrangement of collector and last stage provide a pentode type of output characteristic because the collector is essentially in a Faraday cage. The approximate electron trajectories are shown by arrows in Figure 1 for one open channel and for two closed channels. Also shown are the potentials required to open all the channels. The potentials which are encircled are the alternative potentials which are applied to the control dynodes to close all the channels but the one shown open. This dynode grid system therefore represents a selecting, as well as a multiplying grid structure.

For the purposes of explanation of the binary

5

control system available with the dynode connections shown in Figure 1, the three leads from the dynode control stages brought out to the left of Figure 1 are called A_0 leads and designated $0_1, 0_2, 0_3$, where the subscript denoted the "zero" position in the binary number and the three leads from the dynode control stages brought out to the right of Figure 1 are called " B_1 " leads, and designated $1_1, 1_2, 1_3$, where the subscript denotes the "one" position in the binary number. The outputs from each of the eight channels are labeled with both their binary and equivalent decimal numbers. Thus, if it is desired to open the number 4 or binary 100 channel, proper dynode bias voltages $3v, 4v$ and $5v$ are respectively applied to " B_1 " lead 1_3 and to A_0 leads 0_2 and 0_1 . Improper dynode voltages are applied to the other leads and all the other channels are thus closed.

Figure 2 is a schematic of a combinatorial system for interconnecting an array of 83 control stage dynodes 10 arranged to form dynode ladders 12 and spaced to form 32 channels. The dynodes are represented by the horizontal blocks and the connections from the dynodes are brought out to either side. The connections shown are for a "binary" system. In the first controlling stages the dynodes are connected into two halves, the division being in the center. The second controlling stage has interlacing quarters, the third stage has interlacing eighths and the fourth and fifth controlling stages simply have every other dynode connected together and these two stages interlace one with respect to the other. A "group of two" system of connection with octal, decimal or other groupings is also possible. The " A " leads (shown at the top of Figure 2) from the dynodes, correspond to the "zeros" of a binary number and the " B " leads (shown at the bottom of Figure 2) correspond to the "ones" of a binary number. To open any given channel the required bias is applied to the A and B leads and thus to the dynodes defining the given channel. For example, if a channel corresponding to binary number 01100, which is twelve in the decimal system, is to be selected, a bias of $v, 2v, 3v, 4v$ and $5v$ are respectively applied to the " A " lead designated as 0_5 , the " B " lead designated as 1_4 , the " B " lead designated as 1_3 , the " A " lead designated as 0_2 and the " A " lead designated as 0_1 . All the remaining leads are given a bias to close the other channels as explained above. The 01100 or No. 12 channel is thus opened and all the others are closed. Both the binary and decimal number equivalents for the respective channels are shown in Figure 2. As another example, if the 10111=23 channel is desired to be opened, then the $v, 2v, 3v, 4v$ and $5v$ biases are respectively applied to " B " lead 1_5 , " A " lead 0_4 , and " B " leads $1_3, 1_2$ and 1_1 , the remaining " A " and " B " leads having a "channel closing" bias applied to them.

It should be understood that as many straight multiplying stages as may be desired may be placed before and after the multiplying and control stages shown in Figure 2.

Figure 3 is a cross section of a target area selecting tube which includes the dynode grid structure which characterizes my invention. The tube structure is enclosed in an evacuated envelope of glass 18. The target area selection type of tube of the class intended is described and claimed in my copending applications for an "Electronic Discharge Device," Serial No. 665,031, filed April 26, 1946, now Patent No. 2,494,670, issued January 17, 1950, and an "Electronic Discharge Device," Serial No. 118,758, filed September 30, 1949.

6

In this type of area selecting tube, a grid structure is formed of horizontal and vertical networks of parallel, separately insulated wires. These wires define a plurality of windows through which electrons pass from the source of electrons to the target. By properly biasing all but selected ones of these wires all windows but a desired one may be closed to the passage of electrons. All four selecting wires defining a window (two horizontal and two vertical) must have the proper bias voltage applied in order to keep that window open. If any one of the four window defining selecting wires is not at the proper voltage the window is closed.

In Figure 3, in place of a horizontal network of selecting wires there is substituted a dynode grid array such as has been heretofore described. An elongated cylindrical cathode 20 is centrally located along the axis of the tube which is enclosed in an evacuated envelope of glass 18. Surrounding the cathode 20 is a control grid 22 which is pervious to electrons from the cathode and whose function is later described herein. This control grid 22 may consist of a spiral of fine wire and may be mounted on four supporting rods suitably anchored in the base of the tube. Spaced from and surrounding the control grid is an accelerating electrode 24 which may also consist of a spiral of fine wire and may also be mounted on four supporting rods suitably anchored in the base of the tube.

Spaced from the accelerating grid and around it are a plurality of dynodes 10 arranged as a selecting and multiplying grid, as heretofore described, to define a plurality of multiplication channels. The dynodes are also anchored in the tube base in well known manner. There are four of these selecting and multiplying grids around the accelerating grid and cathode in rectangular array. Electron beam forming means 26, 28 are positioned at the output of each channel in order to focus the beam into a vertical ribbon of electrons. A network of separately insulated parallel selecting wires 30 is positioned outside of the beam forming means. The selecting wires are at right angles to the vertical ribbon of electrons and are coextensive with the dynode grid array. Electrons on their way to the target 32 from the channels pass between adjacent selecting wires of the network. There are four targets, one for each of the four dynode arrays. Each target includes a collector electrode 34 which is essentially a metal plate having perforations which are aligned with the electron apertures defined by the intersection of two adjacent selecting wires and the focussed output from each channel. A metal capacity plate 36 is spaced close to the collector plate. The capacity plate 36 has apertures aligned with the collector apertures. These apertures have small metallic sleeves 38 inserted in them which are suitably insulated from the capacity plate by means of glass or ceramic sleeves 40. These metal sleeves are generally funnel shaped, having their large diameter towards the electron stream. These sleeves are secondary electron emissive and therefore can serve as storage elements. A second target electrode 42 is also provided which consists of a metal plate. This second target electrode is also known as the reading plate.

Figure 4 shows in greater detail a section of the dynode (x direction selection) and selection wire (y direction selection) grid structure and the target structure shown in Figure 3. Similarly functioning parts have similar reference

characters. Also shown are the approximate bias values which may be applied to the focussing electrodes, selecting wires and the target. As many dynode control stages may be selected as is desired and required for the combinatorial system of dynode interconnection selected.

A target assembly such as is briefly described above is described in detail and claimed in my copending application Serial No. 722,194, filed January 15, 1947, now Patent No. 2,513,743, issued July 4, 1950. The operation of the target briefly is as follows: To condition any one of the metallic sleeves 33 to be at one of two stable potentials (either that of the cathode 20 or that of the collector 34) the electron stream is closed by a suitable means to all other sleeves but the desired one. A voltage pulse, known as a writing pulse, having an amplitude of about twice the collector voltage is applied to the capacity plate 36. If it is desired to write positively, that is to leave the sleeve 38 at collector potential, the pulse is allowed to decay gradually and the selected sleeve stabilizes at collector potential. The electron stream is then reopened to all the other sleeves which are then found to be at substantially the same potential as they were prior to the electron stream being cut off from them.

If it is desired to write negatively upon a sleeve, that is to place the sleeve at cathode potential, the electron stream to all sleeves but the desired one is again cut off and a voltage pulse similar to the one used for positive writing is applied to the capacitive plate. But this time, shortly before the writing pulse begins to decay, the electron stream to the desired sleeve is also cut off for the duration of the writing pulse. The electron stream is then again opened to all the sleeves and the desired sleeve will be found to be at cathode potential and all other sleeves are at the same potential as they had prior to the electron stream being cut off from them.

Reading of the target may be accomplished one eyelet at a time by cutting off the electron stream to all but the eyelet desired to be read. The reading plate 42 is then biased positively. If the storage sleeve is at collector potential, electrons will pass through it and strike the reading plate 42. This electron current can be detected and its presence evidences the fact that the storage sleeve is positive. If the selected storage sleeve is at the cathode potential electrons will not pass through it and the absence of a current on the reading plate evidences the fact that the selected eyelet is negative.

When the capacity plate is not being used to condition the storage sleeves it is biased slightly negative in order to shield the reading plate and to aid the storage sleeves, when they are at cathode potential, in turning back to the collector electrons which otherwise would strike the sleeve and alter its potential. This negative field set up by the capacity plate, however, it still not sufficiently negative to prevent the passage of electrons through the sleeves when they are at collector potential.

Any type of storage target may be used with the selecting and multiplying grid described herein. The above target is merely described by way of example.

For the purposes of channel selection by the dynodes and selection of a portion of the electron stream from the channel selected, individual lead wires may be brought external to the tube from both the individual dynodes and the individual vertical selecting wires for the pur-

pose of applying a bias to selected ones of the dynodes and selecting wires. As shown above, for the purposes of channel selection, the dynodes may be interconnected in a combinatorial fashion to reduce the number of external leads required to control the channel outputs. The selecting wires may likewise be interconnected in a combinatorial fashion in order to have complete control of the electron stream utilizing a number of external leads which is less than the number of individual selecting wire leads. As shown above, the dynodes, for interconnection in combinatorial fashion, may be regarded as similar to individual selecting wires and may then be treated in the manner taught for selecting wires in my copending application, Serial No. 702,775, filed October 11, 1946, now Patent No. 2,558,460, issued June 28, 1951, and the application of George W. Brown, Serial No. 694,041, filed August 30, 1946, now Patent No. 2,519,172, issued August 15, 1950 which were also previously mentioned.

The multiplier channels shown in Figure 3 and in greater detail in Figure 4 are used for selection in one direction, while a straight, area selecting type of grid is used for selection in the other direction. In principle, it is conceivable that, selective multiplier channels may be used in both x and y directions by positioning another dynode array in place of the selecting wires shown in Figures 3 and 4. However, with presently known electron multipliers, the current spreads along the dynodes in the linear direction. This would effectively broaden the 2nd channel output and thus lose the selection obtained in going through the first channel.

Another important advantage of the multiplier grid structure shown in Figures 3 and 4 is that it permits faster and clearer "reading" and "writing" by pulse operation of the tube. The reason for opening all the multiplier channels to permit electron bombardment of all the target storage sleeves 38 after a "reading" or "writing" operation is to overcome any ohmic leakage currents which tend to alter the sleeves' potential and to thus maintain the sleeves at the desired storage potential.

This replenishing current must be available to all the target storage elements and therefore, the limit to its intensity is determined by the power dissipation capabilities of the tube. In the process of writing, a charging current is supplied to only a single storage sleeve 38 and the writing time is the time required to charge up the capacitor formed by the storage sleeve 38 and the capacitor plate 36 to a given voltage. This charging current can advantageously be made much greater than the quiescent current, thus shortening the charging or writing time. Since it is present on only one element and needs to last only a very short time, it is not restricted by any essential power dissipation limit. A similar observation may be made for the reading current. A stronger reading current is desirable since the required reading time is diminished and the ratio of reading signal to spurious capacity and pickup signals is increased.

It is therefore advantageous to use a pulse type of operation whereby the intensity of the overall target bombardment is as high as power dissipation will permit in the quiescent state, while the electron bombardment is increased suddenly for reading and writing. Oxide coated cathodes when operated in a pulsed condition provide about five to ten times more current for a fraction of a microsecond than when operated in

the steady state stage. However, a much higher factor of current multiplication, between approximately 100 to 1000 can be gained when a pulsed electron source is followed by a selective multiplication grid.

Thus, referring to Figure 3, during the intervals between reading and writing or during the quiescent periods, the control grid 22 is biased to maintain the emission from the cathode 20 at a value so that the dissipation capabilities of the tube are not exceeded. For reading or writing, after a single eyelet 38 is selected, the bias on the control grid 22 can be momentarily removed to obtain very high pulses of reading or writing current.

It is to be noted that the selecting and multiplying grid system described herein is very efficient in terms of free electrons delivered to a definite target location for a given expenditure of power. Despite the fact that only a portion of the electrons from the cathode are used to produce secondary electrons, when a single channel is selected and the remaining channels are closed, by the use of a sufficient number of stages of multiplication the number of secondary electrons finally obtained for each bombarding primary electron can be much greater than the total number of primary electrons emitted by the cathode. The efficiency in power expended per free electron obtained comes about from the fact that electrons are obtained "en route" in the one open channel, whereas they are stopped at various degrees of progress in all the others.

If R is the secondary emission ratio (assumed to be the same on all stages and all channels), the final current obtained after n stages will be:

$$I_n = \left(\frac{R}{2}\right)^n I_0$$

where I_0 is the initial bombarding current. The total wasted current I_w at all stages is given by:

$$\begin{aligned} I_w &= \frac{I}{2} \left(\frac{R}{2}\right)^0 + \left(\frac{R}{2}\right)^1 + \left(\frac{R}{2}\right)^2 + \dots + \left(\frac{R}{2}\right)^n \\ &= I_0 \frac{1}{2} \frac{\left(\frac{R}{2}\right)^{n+1} - 1}{\frac{R}{2} - 1} \quad \text{when } R \neq 2 \\ &= I_0 \frac{n+1}{2} \quad \text{when } R = 2 \end{aligned}$$

The power expended to obtain the current in the useful channel, assuming a constant voltage difference V between channels is:

$$W_s = I_0 V 2^{-n} (1 + R + R^2 + \dots + R^n)$$

While the total expended power is:

$$W_t = I_0 V \left(1 + \frac{R}{2} + \left(\frac{R}{2}\right)^2 + \dots + \left(\frac{R}{2}\right)^n\right)$$

The power efficiency η is therefore:

$$\eta = \frac{W_s}{W_t} = 2^{-n} \frac{R^{n+1} - 1}{R - 1} \cdot \frac{\frac{R}{2} - 1}{\left(\frac{R}{2}\right)^{n+1} - 1} \quad R \neq 2$$

For $R=2$, this expression becomes:

$$\eta = \frac{W_s}{W_t} = \left(\frac{2-2^{-n}}{n+1}\right) \cdot \frac{2}{n+1} \quad (R=2)$$

or for 3 stages, ($n=3$) the efficiency is 50 percent and for 6 stages the efficiency is about 29 percent. However, as R increases, the efficiency increases also. Where R equals infinity the efficiency is 100 percent.

From the foregoing description it will be readily

apparent that I have provided a grid structure for electron tubes which both selects an electron path and multiplies the electrons along the path selected. Although several embodiments of my invention have been shown, it should be apparent that many other embodiments are possible, all within the spirit and scope of my invention. I therefore desire that the foregoing description shall be taken as illustrative and not as limiting.

What is claimed is:

1. In an electron discharge device having a cathode, a target and a grid structure comprising a plurality of electron multiplying means arranged to form a plurality of ladders, said ladders being spaced parallel to each other to provide a plurality of electron multiplying channels, means to bias selected ones of said plurality of electron multiplying means to close all but a desired electron multiplying channel to the passage of electrons, a network of parallel separately insulated selecting wires positioned at the output end of said plurality of electron multiplying channels and at an angle thereto whereby electrons from any one of said electron multiplying channels pass between all the selecting wires, and means to bias all but selected ones of said selecting wires to prevent the passage of electrons between all but an adjacent two of said selecting wires.

2. In an electron discharge device having a cathode, a target and a grid structure between said cathode and said target, said grid structure consisting of a plurality of dynodes arranged to form dynode ladders, said ladders being positioned adjacent each other to form electron multiplication channels, leads interconnecting said plurality of dynodes in combinatorial fashion, and a plurality of bias leads connected to said interconnecting leads for electron multiplication channel control, the number of said bias leads required being less than the number required without said combinatorial interconnecting leads.

3. An electron discharge tube comprising a source of primary electrons, a storage target, a plurality of electron multiplying means interposed between said source of primary electrons and said target to produce secondary electrons responsive to electrons from said source, each of said plurality of electron multiplying means being positioned in said tube to provide electrons to a different area of said target, and bias means connected to each of said electron multiplying means to control the flow of said secondary electrons to selected areas of said storage target.

4. An electron discharge device comprising a source of electrons, a selecting and multiplying grid structure including a plurality of dynodes arranged to form a plurality of electron multiplication channels, each of said plurality of electron multiplication channels having an input end and an output end, the dynodes at the input end to each of said channels being bombarded by electrons from said source, means to bias selected ones of said dynodes to close all but selected ones of said electron multiplication channels, and target means positioned at the output end of each of said electron multiplication channels to receive an output therefrom.

5. An electron discharge tube comprising a source of primary electrons, a storage target, secondary electron generating means interposed between said source of primary electrons and said storage target and defining a plurality of secondary electron multiplying channels, a network of spaced, parallel, separately insulated wires interposed between said secondary electron gener-

ating means and said storage target, the parallel separately insulated wires of said network being positioned at right angles to the path of said secondary electrons in their passage from said channels to said target, said secondary electrons passing between said wires, and means to bias selected ones of said secondary electron generating means and said parallel wires to permit passage of secondary electrons to only selected areas of said storage target.

6. An electron discharge tube comprising a cathode, a storage target and a grid structure between said cathode and said storage target, said grid structure comprising a plurality of dynodes arranged to form a plurality of electron multiplying channels through which successively emitted secondary electrons may travel to said storage target, a network of parallel separately insulated wires between said dynodes and said storage target, the parallel separately insulated wires of said network being positioned at right angles to the path of the secondary electrons in their passage to said storage target, said secondary electrons passing between said wires, and means to bias selected ones of said dynodes and said parallel wires to permit passage of secondary electrons to only selected areas of said target.

7. An electron discharge tube comprising a central cathode, an accelerating grid surrounding said cathode, a plurality of dynodes around said accelerating grid, said plurality of dynodes being arranged to form a plurality of electron multiplying channels, means to bias selected ones of said dynodes to close all but a desired one of said channels, electron beam focussing means at the output of each of said channels to focus the electron output from each channel, a network of spaced parallel separately insulated wires positioned at right angles to said beam focussing means, the output from said focussing means passing between all said spaced parallel separately insulated wires, means to bias selected

ones of said parallel separately insulated wires to prevent passage of electrons between all but an adjacent two wires of said network, a collector electrode surrounding said network of parallel separately insulated wires and said plurality of dynodes, said collector electrode having perforations therethrough aligned with the focussed output from each of said electron multiplying channels and the spacing between said parallel separately insulated wires, and a storage target having storage areas aligned with the perforations of said collector electrode.

8. The electron discharge tube as recited in claim 7 wherein said dynodes are interconnected in a combinatorial combination and said spaced parallel separately insulated wires are interconnected in a combinatorial combination whereby the number of leads required for applying a bias to all but selected ones of said dynodes and said spaced parallel separately insulated wires is reduced.

9. The electron discharge tube as recited in claim 7 wherein there is provided in addition a control grid between said cathode and said accelerating grid to provide for pulsed operation of said cathode.

JAN A. RAJCHMAN.

References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
2,205,207	Krenzien	June 18, 1940
2,230,134	Colberg et al.	Jan. 28, 1941
2,254,617	McGee	Sept. 2, 1941
2,305,179	Lubszynski	Dec. 15, 1942
2,407,906	Rose	Sept. 17, 1946
2,431,510	Salinger	Nov. 25, 1947
2,494,670	Rajchman	Jan. 17, 1950
2,548,789	Hergenrother	Apr. 10, 1951
2,555,423	Sheldon	June 5, 1951