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R. L. SNYDER, JR., ET AL
ELECTRON SIGNAL STORAGE TUBE

2,501,637

Filed April 12, 1946

Fig. 1.

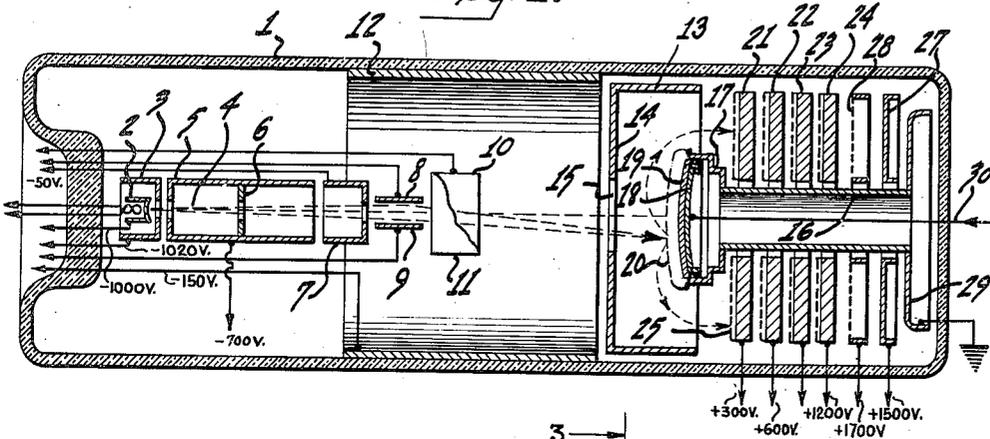


Fig. 2.

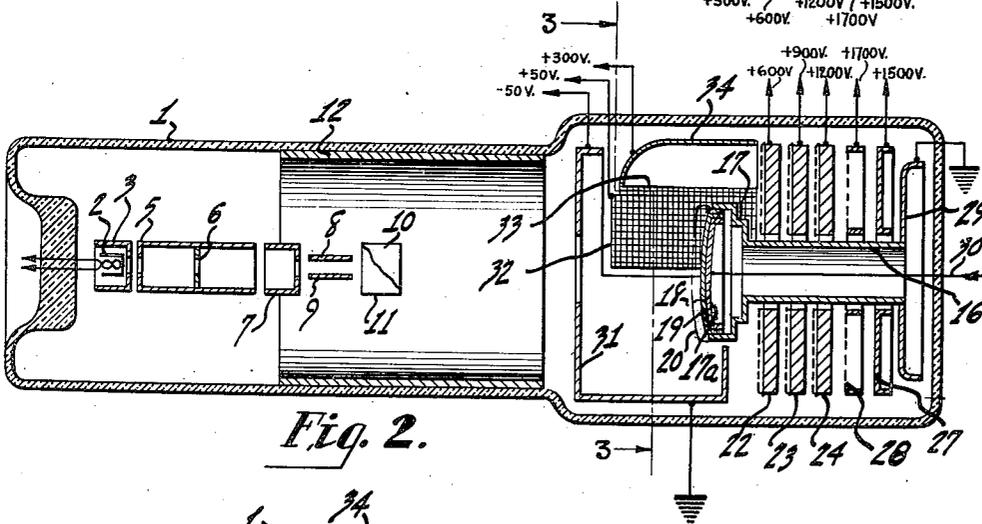
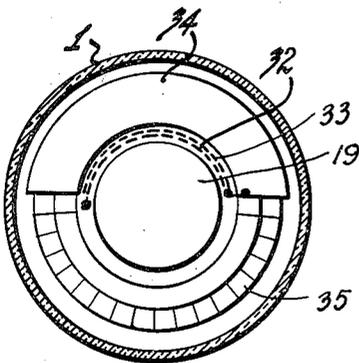


Fig. 3.



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ELECTRON SIGNAL STORAGE TUBE

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Application April 12, 1946, Serial No. 661,528

9 Claims. (Cl. 250-150)

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This invention relates to cathode ray tubes for storing signals for later use and is a modification of the storage tube in the sole application of co-applicant herein, Richard L. Snyder, Jr., filed July 24, 1945, Serial No. 606,812.

In the said application, electromagnetic focusing and deflecting fields were illustrated and secondary electrons bombarded from the target by the beam entered multiplier sections adjacent and around the gun. The construction shown in that application has operated very satisfactorily, but the weight of the tube unit and the power requirements are more than desired in certain uses.

In another sole application of said Richard L. Snyder, Jr., filed April 12, 1946, Serial No. 661,684, now issued as U. S. Patent No. 2,470,875, the same type of tube is disclosed in which electrostatic focusing and deflection means are disclosed to reduce the weight and power requirements of the tube.

It is an object of the present joint invention to provide a tube of similar storage type with electrostatic focusing and deflecting means in which the electrons leaving the target are attracted to multipliers arranged adjacent and around the target.

Another object of the invention is to arrange the electrodes and other parts so that a minimum number of secondary electrons return to the target from which they are emitted.

Another object of the invention is to direct electrons proportional to the released signals around the target into multiplier stages on the side of the target facing away from the gun.

Other objects will appear in the following specification, reference being had to the drawings, in which:

Fig. 1 is a longitudinal section of the essential parts of a tube involving my invention.

Fig. 2 is a modification.

Fig. 3 is a section taken on the line 3-3 of Fig. 2.

Referring to Fig. 1 of the drawing, the evacuated glass or other suitable envelope 1 encloses the gun and other tube elements. The gun consists of a cathode 2 with its heater coil, surrounded by the grid 3 having the usual small aperture for controlling the beam 4 projected therefrom by the first anode 5 having a similar aperture in the adjacent end. The mid-section of the first anode has a partition 6 with a defining aperture and the remote end of this anode is substantially open. The second anode 7 has an open end adjacent the open end of the first anode.

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Its other end is closed except for the defining aperture through which the beam passes. The deflecting plates 8 and 9 are positioned in front of the aperture in second anode 7 and the deflecting plates 10 and 11 are positioned in front of and at right angles to the plates 8 and 9. These deflecting plates are connected to deflecting voltage sources of any desired type to produce the desired type of scanning.

Surrounding the deflection plates, as well as the front part of the second anode, is the wall coating 12. A persuader electrode cylinder 13 is placed directly in front of the wall coating. This has an end 14 constituting a disc electrode with an opening 15 of sufficient size to permit the proper entry of the deflected beam as it is scanned over the target, as later referred to. The front end of this electrode is open and projecting slightly therethrough is a metal pedestal or shield tube 16 having a flanged end 17 in which is supported a flanged aluminum disc or signal plate 18 having a slightly convex surface facing the gun. This convex surface and the peripheral flange is anodized to form a thin coating 19 of aluminum oxide thereon. This coating constitutes the target. Over the convex oxide surface 19 is stretched a very fine woven mesh screen 20 preferably in contact therewith which is conductively joined to the pedestal 16. The oxide coating insulates the metal of disc 18 from the screen as well as from the pedestal.

Around the pedestal 16 are placed in proper spaced position the first, second, third and fourth "pinwheel" dynodes 21, 22, 23 and 24, respectively, of the multiplier. These have a plurality of slanting vanes somewhat resembling an electric fan with fine mesh screens 25 spaced from, but conductively attached to, the metal support of the blades, as disclosed for example, in the application of Paul K. Weimer, co-applicant herein, filed September 16, 1944, Serial No. 554,494, now issued as Patent 2,433,941. The fifth and last dynode 27 of the multiplier is a metal disc without an attached screen, and a collecting screen electrode 28 is placed between the fifth dynode 27 and the fourth dynode 24. A metal base of shield 29 may be slipped over and welded to the pedestal after the multipliers are assembled in place on the pedestal and mounted together for insertion in the tube envelope 1. A signal wire or lead 30 is connected to the inner unoxidized surface of disc 18.

The various elements of the tube are supported in proper relation by means not shown. Any desired form of support may be used, for example;

such as that disclosed in the applications of Stanley V. Forgue, filed February 7, 1946, Serial No. 646,075, and filed January 28, 1946, Serial No. 643,925 and now issued respectively as U. S. Patents 2,460,381 and 2,441,315.

The various elements would have appropriate voltages above and below ground potential, as understood by those skilled in the art, but suitable values have been indicated by way of example in the drawing. The electrode 13 and shield base 29 may have ground potential. The negative and positive potentials are given in relation to the ground potential.

Before describing the way in which storage of signals is secured, it will first be advisable to explain the effect of the scansion of the high velocity beam over the oxide target 19 with no signal being applied to the metal part 18 of the pedestal cup 17. The potential of the oxide target surface 19 may happen to be positive, negative, or equal to the potential of the screen 20 and ground. For the moment, let it be assumed that the oxide coating is positive with respect to the screen. As the high velocity beam is scanned over the oxide coating, secondary electrons will be bombarded therefrom at a greater than unity ratio. It is desirable to have the secondary emission be two or three times as great as the number of electrons landing from the beam. Whether these secondary electrons, however, eventually escape from the oxide surface depends upon the relative potential between the oxide surface and the screen 20. Since it has been assumed that the oxide surface is positive relative to the screen, the secondaries will not escape but will return to the oxide surface. This means that the target surface is collecting the negative electrons of the beam and losing none from secondary emission. Therefore, the surface, upon impact of the beam, will be reduced to the potential of the screen 20. At this point just as many electrons will leave the oxide surface as are added to it from the beam. Scansion of the beam over the oxide surface thus brings its potential to that of the screen through a net gain of electrons if it is positive to the screen, or through a net loss of electrons if it is negative thereto, and the elemental areas will stay at these relative potentials unless some extraneous potential is applied thereto.

While the improvement may be applied to various uses, the operation in a coherent pulse type of radar system will now be explained by way of example.

In the known coherent pulse radar system, the signal pulses are transmitted at the beginning of each line scansion at the peak of the sawtooth wave controlling this scansion. Echoes from both moving and stationary objects are received and impressed on the dielectric target in certain phases of the scansion, depending upon the distance of the objects from the transmitter-receiver. In most uses the reflections or echoes from stationary or fixed objects, such as mountains, are not only of no interest, but they also clutter up the desired record of echoes from moving objects, such as airplanes, and make it difficult to determine which of the signals represent a moving object. With fixed objects the successive echoes arrive at the signal plate 18 always in the same phase of the scansion, because their distance from the transmitter-receiver does not vary and the amplitude is constant. The echo signals from moving objects; however, vary rapidly in amplitude, due to the well-known

Doppler effect and slowly change in phase due to their varying distance from the transmitter-receiver. This means that if an echo signal from a fixed object is impressed on the signal plate 18 when the beam in one scansion is on a certain elemental area of the target, the same signals from that same fixed object will be impressed on that elemental area and will have the same amplitude as the signals in preceding scansions. On the other hand, successive trains of echoes from moving objects will produce signals of varying amplitude when the beam is on a particular elemental area, because of the Doppler effect.

Suppose trains of echo signals from a mountain peak are constantly arriving while the beam is on the n th elemental area of a scanned line. The signal potential will be impressed on the entire signal plate 18 and the potential of the entire dielectric target 19 will be proportionally altered, say raised above the potential of screen 20. The n th area will therefore receive electrons from the beam in excess of emitted secondaries sufficient to bring the surface down to the potential of the screen. As the beam leaves the elemental area n , the signal potential ceases to be impressed on signal plate 18 and the potential of the dielectric surface, except area n , drops down to screen potential. The elemental area n drops in potential as far below the potential of the screen 20 as it was raised above it by the signal. Absence of signals will be assumed until the beam reaches the m th area, when an echo signal of positive potential, say, from a moving object, is impressed on signal plate 18. The potential of all areas of the surface of the target, including area n , will again be altered by the signal. When the beam leaves the m th elemental area, the entire dielectric drops down to the potential of screen 20 except the elemental areas n and m , which drop as far below the screen in potential as they were raised above it by their respective signals when the beam was on those areas. The signal is thus recorded on the scansion described.

On the next scansion by the beam, it will find elemental area n just as far below the screen potential as the signal potential of the wave train can raise it above that potential, because the signal is identical with that previously impressed on this area. Thus, the signal from the fixed object raises the potential of elemental area n up to the potential of screen 20. Therefore, the electrons from the beam landing thereon release secondaries in a one-to-one ratio to the beam electrons, so that the electron stream passing to the multiplier is not modulated. When the beam reaches the m th area, the signal arriving from the moving object has a different amplitude, because of the Doppler effect. The beam finding the area m below the potential of screen 20 bombards a sufficient excess of secondary electrons from its surface to bring the potential back to that of screen 20. Thus, a signal is produced by an increase in the number of electrons going to the multiplier.

It will thus be seen that with our invention the use of radar systems in operations over or near land surfaces has been enormously increased in effectiveness, due to the substantial elimination of signals from stationary objects, leaving only those from moving objects which it is desired to identify and locate.

In radar systems the antenna is usually rotated to survey the entire horizon for echoes from objects. Since the radiation pattern of present di-

rectional antennas has material and variable breadth, signals from objects will vary with the field strength of this pattern. The received signals from fixed objects in one scansion may therefore have different amplitudes from those of the previous scansion. Echoes from fixed objects thus tend to increase in amplitude from scansion to scansion as the center of the radiation pattern approaches them and to decrease from scansion to scansion as the center of the radiation pattern moves away from them. Since this change in amplitude is unidirectional over a number of radar cycles, the differences passed by the storage tube are all in the same direction. The output of the storage tube will therefore have a very slowly changing pattern of the differences which can be removed by passing the signals through a second storage tube in cascade. That is, the output of one tube may be applied to the input signal plate of another tube. Since the small output pulses of the first tube will have substantially constant phase and amplitude for any two successive scansions for fixed objects, it will be apparent that the echoes from such objects will not produce signals. In the cascade arrangement, however, the echoes from moving objects will produce signals in the second tube, since they are of varying amplitude in the output of the first tube.

The improved storage tube may be used in various other ways where storage of information is desired. Signals may be impressed on the signal plate while the beam scans a predetermined pattern over the target. The signal and beam may then be shut off, leaving the information stored in the target. At any desired later time the beam may be turned on and, with no new signals impressed on the signal plate, scanned over the pattern so that the signal impressed during the first scansion will be taken off by the subsequent scansion. As is evident from the described method of operation, recorded signals may be combined with new signals, enabling one to use the tube for carrying out complex operations by suitable combinations of signals.

It will be apparent that when signals are recorded the beam is modulated to the same extent as when the signals are taken off in a subsequent scansion, but in the opposite sense and either or both modulations may be utilized when desired.

Since the secondary electrons leave the elemental areas of the target at a considerable range of potential with respect to the screen, some of the secondary electrons may return to the target or other elements of the tube instead of passing into the multiplier. To insure that there is substantially no return of secondary electrons to the target, the modification of Figs. 2 and 3 may be used. The construction is the same as in Fig. 1, except means are provided to create non-symmetrical fields in front of the target to pull the secondary electrons to one side and prevent "mirror" action by the persuader electrode from returning the secondary electrons in part to the target. Parts in this modification that are the same as those in Fig. 1 have been given the same reference characters and will not need detailed description. The asymmetrical field is produced by cutting out about one-half of the cylindrical persuader except at the end facing the gun. The disc electrode 31 with the central opening is the same as in Fig. 1. A semi-cylindrical fine mesh screen 32 is located where the persuader cylinder is cut out. Another semi-cylindrical screen 33 is located outside the first cylindrical screen and is the shield screen of the first dynode, which in

this embodiment consists of a semi-cylindrical cup 34. The inside surface of this cup, like the dynodes of the other multipliers, may have a surface of good secondary emission properties. The second, third, fourth and fifth dynodes and also the collector screen of this modification are shown as having the full circular form as in Fig. 1. However, one-half of these electrodes are inactive and could be omitted except they are not so conveniently made in that way. The slanting vanes 35 of the pin wheel multiplier previously referred to are indicated in Fig. 3, the screens 25 being omitted for clearness of illustration. The vanes are shown in detail and fully described in said Patent 2,433,941.

Suitable voltages for the persuader and the electrodes of the multiplier are given on the drawing, but these may be varied as desired.

The operation of this modification is the same as that of Fig. 1, except that the secondary electrons are attracted into the first multiplier stage by the asymmetrical field and bombard dynode 34. The secondaries emitted by the first dynode are then passed successively to the other dynodes and the collector screen, as in the embodiment of Fig. 1.

We claim:

1. A cathode ray beam tube comprising, an evacuated envelope containing beam forming electrodes, a signal plate, a dielectric target on said signal plate, a disc electrode in front of said target having an axial opening through which the beam bombards said target, said disc electrode having a semi-cylindrical portion extending toward said target whereby an unsymmetrical field is produced in front thereof, a semi-cylindrical fine mesh screen electrode coaxial with the semi-cylindrical portion of said disc electrode and opposite thereto, a semi-cylindrical multiplier dynode coaxial with said screen electrode having the end adjacent the disc electrode curved toward the fine mesh screen and the other end open, a fine mesh semi-cylindrical screen contacting the curved end of the dynode and an electrode for collecting electrons through the open end of the dynode.

2. A cathode ray beam tube comprising, an evacuated envelope containing beam forming electrodes, a metal pedestal, a signal plate contacting said pedestal, a dielectric target on said signal plate, a disc electrode in front of said target having an axial opening through which the beam bombards said target, said disc electrode having a semi-cylindrical portion extending toward said target whereby an unsymmetrical field is produced in front thereof, a semi-cylindrical fine mesh screen electrode coaxial with the semi-cylindrical portion of said disc electrode and opposite thereto, a semi-cylindrical multiplier dynode coaxial with said screen electrode having the end adjacent the disc electrode curved toward the fine mesh screen and the other end open, a fine mesh semi-cylindrical screen contacting the curved end of the dynode and an electrode for collecting electrons through the open end of the dynode.

3. A cathode ray beam tube comprising, an evacuated envelope containing beam forming electrodes, a signal plate, a dielectric target on said signal plate, a disc electrode in front of said target having an axial opening through which the beam bombards said target, said disc electrode having a semi-cylindrical portion extending toward said target whereby an unsymmetrical field is produced in front thereof, a semi-cylindrical fine mesh screen electrode coaxial with the semi-

cylindrical portion of said disc electrode and opposite thereto, a semi-cylindrical multiplier dynode coaxial with said screen electrode having the end adjacent the disc electrode curved toward the fine mesh screen and the other end open, a fine mesh semi-cylindrical screen contacting the curved end of the dynode, each having a shield screen facing toward the first-mentioned dynode and a collector electrode facing the last dynode of the series.

4. A cathode ray beam tube comprising, an evacuated envelope containing beam forming electrodes, a metal pedestal, a signal plate contacting said pedestal, a dielectric target on said signal plate, a disc electrode in front of said target having an axial opening through which the beam bombards said target, said disc electrode having a semi-cylindrical portion extending toward said target whereby an unsymmetrical field is produced in front thereof, a semi-cylindrical fine mesh screen electrode coaxial with the semi-cylindrical portion of said disc electrode and opposite thereto, a semi-cylindrical multiplier dynode coaxial with said screen electrode having the end adjacent the disc electrode curved toward the fine mesh screen and the other end open, a fine mesh semi-cylindrical screen contacting the curved end of the dynode, a series of multiplier dynodes successively positioned opposite the open end of the first-mentioned dynode each having a shield screen facing toward the first-mentioned dynode and a collector electrode facing the last dynode of the series.

5. A cathode ray beam tube comprising an evacuated envelope containing beam forming electrodes and a target spaced apart, electrostatic field producing means for focusing and deflecting the beam from said gun over said target to bombard secondary electrons therefrom, a screen at the front of said target adapted to control the escape of secondary electrons bombarded from said target by the cathode ray beam, a shield tube extending behind and coaxially with said target, electron multiplier stages extending around said tube and radially beyond said target and electrostatic field producing means for directing the electrons escaping from said target into said multipliers.

6. A cathode ray beam tube comprising an evacuated envelope containing beam forming electrodes, a signal plate spaced from said beam forming electrodes, a dielectric target on said signal plate, a lead for impressing successive signal potentials on said signal plate, means for focusing and deflecting the beam over the elemental areas of said target, a screen engaging the surface of said target adapted to control secondary electrons bombarded from said target by the cathode ray beam, electron multipliers behind said target and extending radially therebeyond and means for directing the electrons escaping from said target into said multipliers.

7. A cathode ray beam tube comprising an evacuated envelope containing beam forming electrodes, a signal plate spaced from said beam forming electrodes, a dielectric target on said signal plate, a lead wire for impressing successive signal potentials on said signal plate to charge simultaneously all the elementary areas of the target with each successive signal, electrodes for focusing and deflecting the beam over the elemental areas of said target, a screen at the front of said target adapted to control the escape of secondary electrons bombarded from said target by the cathode ray beam, an electron multiplier behind said target and extending radially therebeyond and an anode for directing the secondary electrons escaping from said target through said screen into said multiplier.

8. A cathode ray beam tube comprising an evacuated envelope containing beam forming electrodes, a signal plate spaced from said beam forming electrodes, a dielectric target on said signal plate, electrodes for focusing and deflecting the beam over the elemental areas of said target, a screen on the front of said target adapted to control the escape of secondary electrons bombarded from said target by the cathode ray beam, a shield tube extending behind said target coaxially thereof, an electron multiplier around said tube extending radially beyond the periphery of said target and electrostatic field producing means for directing the electrons escaping from said target into said multipliers.

9. A cathode ray beam tube comprising an evacuated envelope containing beam forming electrodes, a signal plate spaced from said beam forming electrodes, a dielectric target on said signal plate, a lead wire for impressing successive signal potentials on said signal plate to charge simultaneously all the elementary areas of the target with each successive signal, electrodes for focusing and deflecting the beam over the elemental areas of said target, a screen at the front of said target adapted to control the escape of secondary electrons bombarded from said target by the cathode ray beam, an electron multiplier behind said target and extending radially therebeyond and an anode for directing the secondary electrons escaping from said target through said screen into said multiplier and a lead wire extending through said tube and attached to said signal plate.

RICHARD L. SNYDER, JR.
PAUL K. WEIMER.

REFERENCES CITED

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

UNITED STATES PATENTS

Number	Name	Date
2,372,450	Rajchman et al.	Mar. 27, 1945