

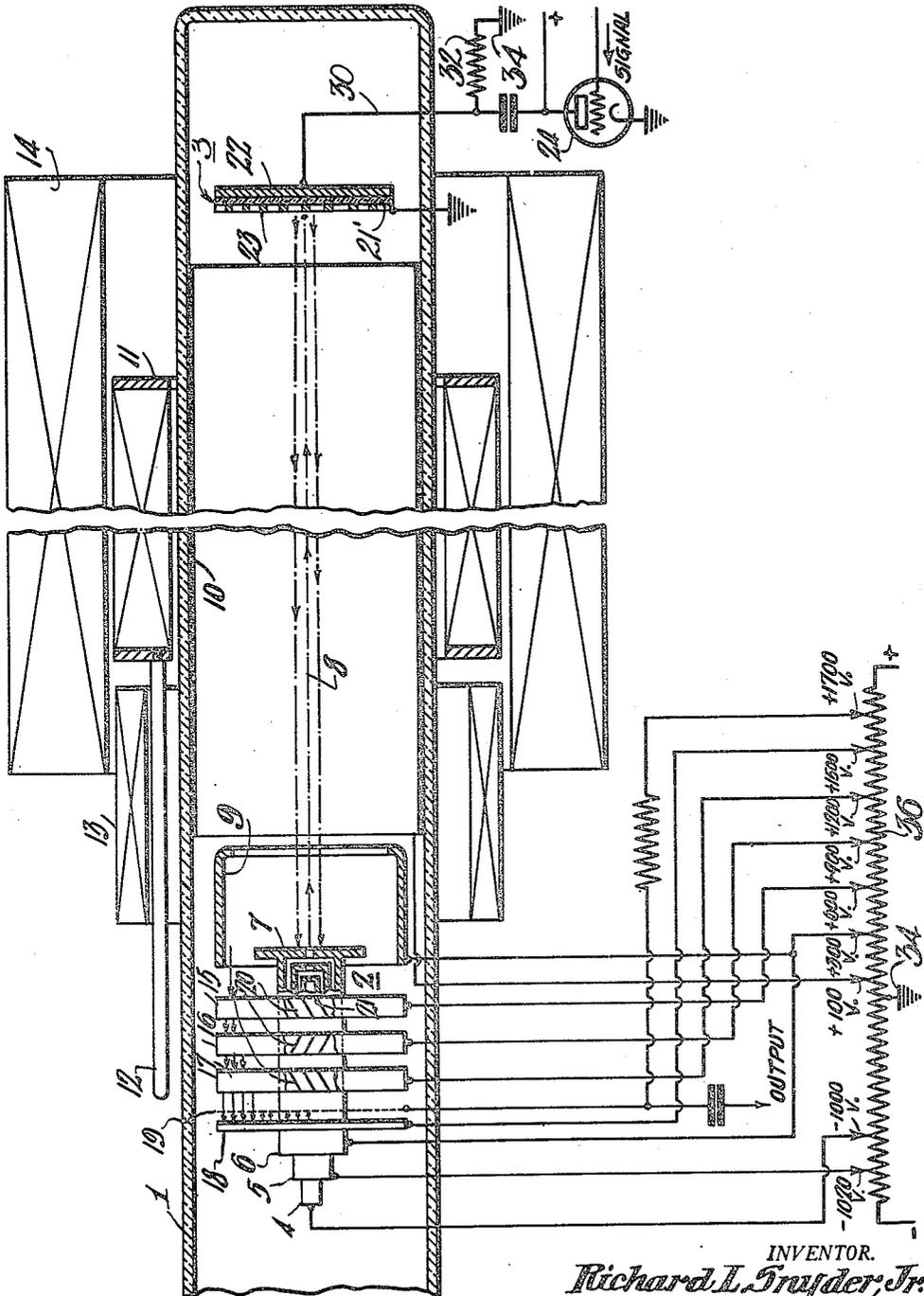
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ELECTRON TUBE

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## ELECTRON TUBE

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This invention relates to storage tubes of the cathode beam type. Storage tubes have heretofore been made in which a charge pattern has been built up on the mosaic surface of the target of a cathode beam tube by a signal-modulated beam impinging on such surface under one set of conditions and discharged by an unmodulated beam impinging thereon at a later time under a different set of conditions.

It is an object of this invention to build up an electrical potential image on the scanned surface of a dielectric target of a cathode beam storage tube by signals applied to the signal plate at one side of the dielectric target as the beam is scanned over the other side.

Another object of the invention is to devise a cathode beam tube in which the electron stream is not modulated by signals repeated at the same phase of line scansion and is modulated by those repeated at changing phase.

Another object is to devise a cathode beam tube for use in a radar system in which only changes between successive wave trains of echoes are passed to the output circuit.

Another object is to devise a tube in which the echoes from fixed or stationary objects are suppressed and those from moving objects are passed to the output circuit.

Other objects of the invention will appear in the following description, reference being had to the drawing, in which the single figure is an illustration of a tube embodying the invention.

My invention may be applied to cathode beam tubes of various types, but by way of example it has been illustrated in connection with a multiplier tube such as disclosed in the Patent 2,433,941 of Paul K. Weimer, filed September 16, 1944. The tube consists of an evacuated envelope 1 containing a gun 2 at one end of the tube and a target 3 at the other end. The gun consists of the usual indirectly heated cathode 4 (the heater not being shown), surrounded by the control electrode or grid 5. Around the grid is the anode 6, the end 7 of which constitutes the first dynode of the multiplier. In the drawing the cathode, grid and first anode are partially sectioned to illustrate the tubular construction. The grid and first anode have minute orifices, as shown, through which the beam 8 is projected in the usual way. Tubular electrode 9 is axially placed around the front part of the gun. This electrode is often referred to as the "persuader," because of its action in directing the secondary electrons into succeeding multiplier dynodes, as will be later referred to.

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Wall coating 10 is applied to the inner wall of envelope 1, as usual.

Outside the envelope of the tube is placed the deflecting unit 11, consisting of two coils having their field axes perpendicular to each other and to the longitudinal axis of the tube. One of these coils deflects the beam in a vertical direction in the drawing and the other deflects it at right angles. These coils are of well-known construction and hence have not been individually shown. It will be understood that these coils will have varying voltages applied, say by a saw-tooth generator, to produce line and page scansion, or voltages may be applied thereto for producing spiral scansion of the target or line scansion only, as may be desired. In the latter case, a direct current voltage would be applied to the vertical deflector coil. The means for producing the different types of scansion of the target are well known in the art and need not be further described.

The deflecting unit 11 may be adjusted by any suitable means, such as by rod 12. Outside of the envelope 1 an adjustable coil 13 may be used having a field perpendicular to the axis of the tube. By adjusting this coil around the axis of the tube, any slight miscentering of the beam due to mechanical imperfections can be compensated for. This also is a known arrangement and need not be further described.

Outside the coils 11 and 13 is placed solenoid 14, which produces a strong magnetic focusing field parallel to the axis of the tube.

Around the gun is placed a plurality of multiplier dynodes 15, 16, 17 and 18 and a collecting electrode 19, which is illustrated as a screen. The multiplier dynodes 15, 16 and 17 are fully described in the said Weimer application and it will be sufficient to say that each has a sufficiently large axial opening to fit in spaced relation over the tubular anode 6 and consists of slanting radial blades 20, somewhat like an electrical fan, held in a suitable annular frame. In front of the blades is a screen 21 secured to the annular frame so as to be in electrical contact with the multiplier blades 20, from which it is suitably spaced. The multiplier dynodes 15, 16 and 17 are partially broken away to show the blades 20 and screen 21. The multiplier dynode 18 is the final multiplier stage and consists of a flat annulus. The multiplier dynodes 15, 16, 17 and 18 may have any desired coating of active material to produce suitable emission of secondary electrons upon bombardment. Various voltages may be applied to the electrodes of the tube, by connect-

ing each electrode respectively to an appropriate source of potential as for example, a voltage divider 36 connected, as is shown in the drawing, across the terminals of a direct current source. By way of example I have illustrated in the drawing suitable voltages. All of the tube thus far disclosed is the same as disclosed in the said Weimer application.

The target 3 of my invention consists preferably of a dielectric plate 21', such as mica or aluminum oxide, for example, which may be rectangular or circular, as desired. The signal plate 22 may be formed on the non-scanned side of the dielectric plate by depositing a metallic coating thereon, or may be produced in various other ways. If aluminum oxide is used for the target 3, one side of an aluminum plate may be anodized to produce the insulating material of the target and the other side may be left unoxidized for the signal plate.

A metal screen 23, which may be like that disclosed in the application of Harold B. Law, filed March 31, 1945, Serial No. 585,925, which application is now abandoned, is in intimate contact with the target 3 on the gun side.

The signal plate 22 is connected through a resistance to a suitable voltage source indicated as ground 34, and to the output of the receiving apparatus, which is typified by a single triode 24, having its plate-anode connected by a lead 30 to the signal plate 22 and to a suitable voltage supply, the cathode being grounded. The received signals are applied to the grid of this tube 24.

Before describing the detail operation of my invention, the general theory of the action of the beam will be explained. The beam from the gun passes through the screen 23 and hits the dielectric surface of target 3 at high velocity. Secondary electrons are bombarded from the dielectric surface and, if the bombarded area is negative relative to the screen, pass through the screen towards the first dynode 7. This causes the bombarded area of the target to become more positive, until the potential of the target area reaches that of screen 23. If the bombarded area of the dielectric target is positive relative to the screen, the secondary emission from the area is suppressed by the negative field caused by the screen and the target element becomes more negative until it reaches screen potential. When an element under bombardment is at screen potential its voltage is in equilibrium, because if it goes negative, the number of secondaries leaving exceeds the number of primaries landing and the element becomes positive; whereas if the element goes positive, secondary emission is suppressed and the element goes negative. When the bombarded elemental area is at screen potential, there are therefore as many electrons leaving the target as land from the beam. Thus, scansion of the beam across the target brings the scanned areas to the potential of the screen. The beam will be made to have sufficient intensity to substantially instantly bring the potential of an elemental area to the screen potential. The emitted secondaries are drawn back to and bombard the first multiplier dynode 7, from which new secondaries are emitted. These secondaries, guided by the persuader 9, are drawn outward by the field from the second dynode 15 through screen 21, which has the same potential as this dynode. This passage of electrons from dynode 7 to the first multiplier stage proceeds throughout the whole annular space around the gun and not merely in

the one path indicated in the drawing. Secondary electrons are bombarded from the inclined blades 20 and, shielded from the potential of the previous electrodes by screen 21, are attracted into the dynode 16 through its screen, where the process is repeated. The additional secondary electrons, after being emitted from stage 17 in the same way, pass through the collector screen 19 and produce by bombardment more secondary electrons from the final dynode 18 and these are collected by screen 19 and pass to the output terminal.

The electrons in the beam which strike the wires of the screen 23 also release secondary electrons, which enter the multiplier in the same way as other secondaries. Since the beam current is constant, the effect produced by these secondaries is essentially constant and has little influence on the output signal.

Thus, the beam, modulated by the signal as later described, is passed successively to the five multiplier stages and the signal strength is greatly increased.

The operation of my storage tube in a coherent pulse type of radar system will now be explained for single line scansion.

The previous scansion of the beam over target 3 has brought the dielectric surface to the potential of screen 23. In the known coherent pulse radar system, the signal pulses are transmitted at the beginning of each line scansion at the peak of the saw-tooth wave controlling this scansion and echoes from both moving and stationary objects are received and impressed on the dielectric target in certain phases of the line scansion, depending upon the distance of the objects from the transmitter-receiver. In certain 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 22 always in the same phase of the line scansion, because their distance from the transmitter-receiver does not vary and their amplitude is constant. The echo signals from moving objects, however, vary rapidly in amplitude, due to the well-known Doppler effect in the coherent pulse system 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 signal plate 22 when the beam in one scansion is on a certain elemental area of the target, all successive signals from that same fixed object will arrive while the beam is on that elemental area and will have the same amplitude as the preceding signal. 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 22 and the potential of the entire dielectric target 3 will be proportionally raised, say, above the potential of screen 23. 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

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plate 22 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 23 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 22. The potential of all areas of the surface of the target, including area  $n$ , will again be raised by the signal. When the beam leaves the  $m$ th elemental area, the entire dielectric drops down to the potential of screen 23 except the elemental areas  $n$  and  $m$ , which drop as far below the screen in potential as they were raised above it by the signal when the beam was on area  $m$ .

On the next scansion of this same line by the beam, it will find elemental area  $n$  just as far below the screen potential as the signal potential of the second wave train can raise it above that potential, because the signal is identical with that previously impressed on this area. Thus, the second wave train from the fixed object raises the potential of elemental area  $n$  up to the exact potential of screen 23 and no higher. 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 23 bombards a sufficient excess of secondary electrons from its surface to bring the potential back to that of screen 23. Thus, a signal is produced by an increase in the number of returning electrons in this case. With fixed objects, in all scansions except the first one, which may be disregarded, the beam is not modulated. With moving objects, the beam is modulated during each scansion and the multiplier output from the tube contains substantially only signals from such moving objects.

It will thus be seen that with my invention the use of radar systems in operations over or near land surfaces has been enormously increased in effectiveness, due to the elimination of all 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 directional 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

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substantially constant phase and amplitude for any two successive line 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 rapidly varying amplitude in the output of the first tube.

I have described the operation of my storage tube in connection with a radar system, but this is by way of example only. 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 operation will be reproduced. The signals need not be recorded in one scansion and utilized in the next scansion. Signals can be stored at one time and reproduced at any later time merely by shutting off and turning on the beam at the desired times. As will be 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 combination of signals.

Having described my invention, what I claim is:

1. A cathode ray beam storage tube system comprising a cathode ray beam gun adapted to produce a beam of electrons along a path, a target having a surface positioned transversely to said beam, a screen at said surface of said target, means for scanning the beam of said gun over elemental areas of said target surface, a signal receiver including an output terminal, means capacitively connecting said output terminal to said target surface to apply each of successive signal potentials simultaneously to all of the scanned elemental areas, and means connected to said screen for applying an electrostatic potential thereto to control the secondary emission from said target surface.

2. A cathode ray beam storage tube system comprising a cathode ray beam gun adapted to produce a beam of electrons along a path, a dielectric target having a surface facing said gun and positioned transversely to said beam path, a screen at said dielectric target surface, means for scanning the beam of said gun over elemental areas of said dielectric surface through said screen, a signal receiver including an output terminal, means capacitively connecting said output terminal to said dielectric surface to apply each of successive signal potentials simultaneously to all of the scanned elemental areas.

3. A cathode ray beam storage tube system comprising a cathode ray beam gun adapted to produce a beam of electrons, a target, a screen at the surface of the side of said target facing said gun, and an input signal electrode at the opposite surface of the target, means for scanning the beam of said gun over elemental areas of the first mentioned surface of the target, and a signal receiver having its output terminal connected to said signal electrode for applying signal potentials simultaneously to all said elemental areas.

4. A cathode ray beam tube system compris-

ing a cathode ray beam gun adapted to provide a beam of electrons, a dielectric target, a screen at the surface of the side of said dielectric target facing said gun, means for scanning the beam of said gun over elemental areas of said surface, an input signal electrode at the opposite surface of the target and a signal receiver having its output terminal connected to said input signal electrode for applying signal potentials simultaneously to all said elemental areas.

5. A storage cathode ray beam tube system comprising a cathode ray beam gun adapted to produce a beam of electrons, a dielectric target, a screen on the surface of the side of said dielectric target facing said gun, and an input signal plate on the opposite surface thereof, means for scanning the beam of electrons over elemental areas of the first mentioned surface through said screen at high electron velocity, and a signal receiver having its output terminal connected to said plate for applying signal potentials simultaneously to all said elemental areas.

6. A cathode ray beam storage tube system comprising a cathode, a grid, an anode having a beam aperture, a multiplier dynode at the side of the aperture, a target having one surface facing said aperture, a screen at said target surface, an input signal electrode at the opposite surface of the target, a direct current potential source having negative potential terminals connected to said grid and cathode, positive potential terminals connected to said anode and said screen and a terminal of still higher positive potential connected to said dynode, whereby a beam of electrons issues from said aperture, means for producing a focusing field for said beam, means for scanning said beam over a line of said target, and a signal receiver having its output terminal connected to said input signal electrode for applying signal potentials simultaneously to all elemental areas of said line.

7. A storage cathode ray beam tube system comprising a cathode, a grid and an anode having a beam aperture and an electron multiplier surface therearound, a dielectric target having one surface facing said aperture, a screen at said surface, an input signal electrode at the opposite surface of the target, means for producing a magnetic focusing field in the tube, a direct current potential source having negative potential terminals connected to said grid and cathode, positive potential terminals connected to said anode and said screen and terminal of still higher positive potential connected to said multiplier dynode, whereby a beam of electrons issues from said aperture, means for scanning said beam of electrons over a line of said target, and a signal receiver having its output terminal connected to said signal electrode for applying signal potentials simultaneously to all elemental areas of said line.

8. A storage cathode ray beam tube system comprising a cathode, a grid, an apertured anode, a dielectric target, a screen at one surface of said target, an input signal electrode at the opposite surface of the target, a direct current source adapted to apply voltages to said cathode, grid, anode, and screen to produce a beam of electrons through said apertured anode of sufficient velocity to bombard secondary electrons from said target at greater than unity ratio and to produce a voltage between said screen and said anode to bombard

secondary electrons from said anode at greater than unity ratio, means for producing a magnetic focusing field in said tube, means for scanning said beam of electrons over a line of said target and a signal receiver having its output terminal connected to said input signal electrode for applying signals simultaneously to all the elemental areas of said line.

9. A cathode beam storage tube comprising a cathode ray beam gun adapted to produce a beam of electrons along a path, a target having a dielectric surface positioned transverse of said beam path, a screen at said dielectric target facing said gun, means for scanning the beam of said gun over elemental areas of said target, a conducting plate on the other face of said target and a conductor connected to said plate for applying each of successive signal potentials simultaneously to all of the scanned elemental areas of the target.

10. A signal storage device comprising, an electron gun adapted to produce a beam of electrons along a path, said beam being of sufficient energy to initiate secondary electron emission from a dielectric surface, a target electrode mounted transversely to said beam path, said target electrode including a surface of dielectric material facing said electron gun and an input signal electrode capacitively connected to said dielectric surface, means for scanning said electron beam over said dielectric surface to produce a secondary emission therefrom, an electrode spaced from said dielectric surface for collecting the secondary emission therefrom, a screen electrode adjacent said dielectric target surface between said electron gun and target, a signal receiver including an output terminal, means connecting said output terminal to said signal electrode, and means connected to said screen and said signal electrode for applying a common potential thereto to control the secondary emission from said dielectric target surface.

11. A signal storage device comprising an envelope, an electron gun within said envelope adapted to produce a beam of electrons along a path and of sufficient energy to initiate secondary electron emission from a dielectric surface, a target electrode mounted transversely to said beam path, said target electrode including a surface of dielectric material facing said electron gun and an input signal electrode capacitively connected to said dielectric surface, a screen electrode in contact with said dielectric target surface and positioned between said electron gun and said target, a lead connected to said input electrode for connecting said input signal electrode to a signal source, and lead means connected to said screen electrode and said signal electrode for applying a common potential thereto to control the secondary emission from said dielectric target surface.

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