

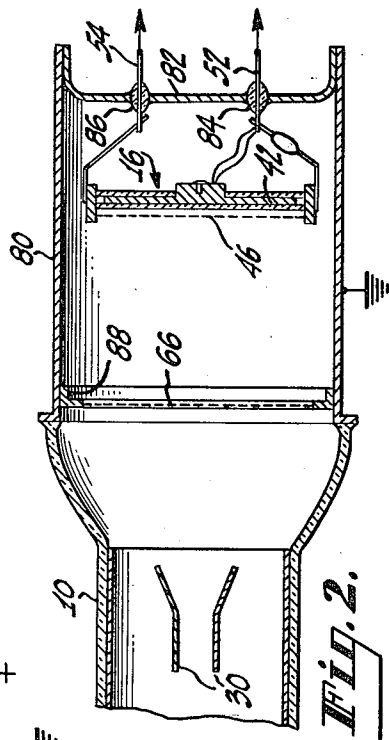
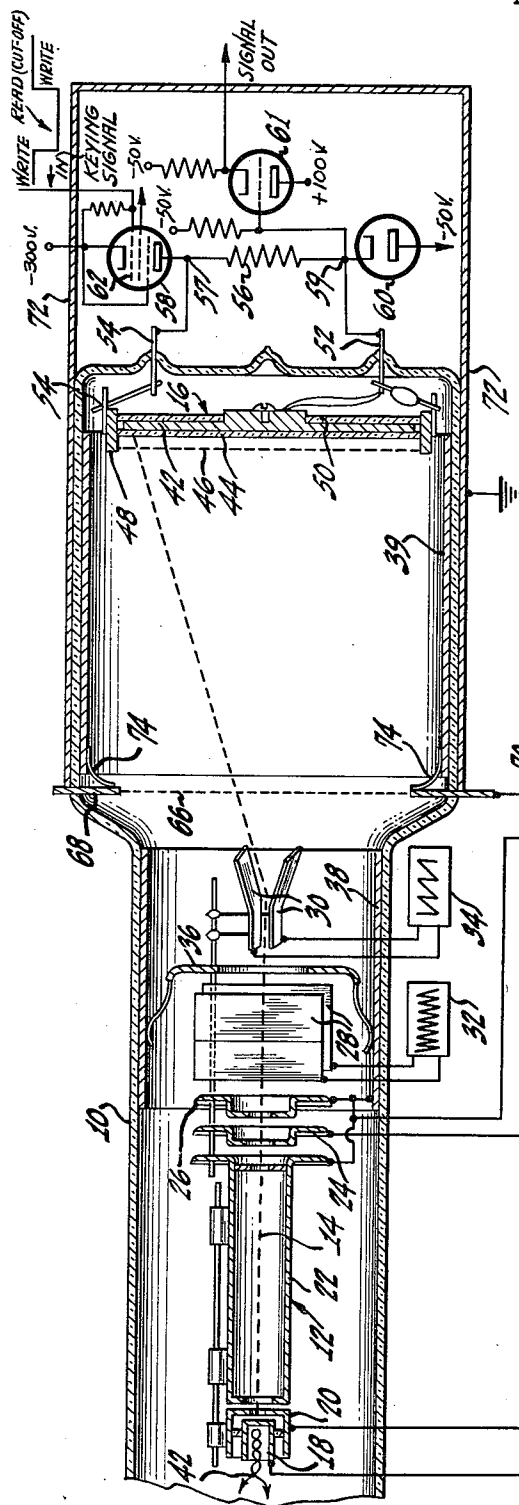
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STORAGE TUBE

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STORAGE TUBE

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This invention is directed to an electron discharge tube, and more specifically to a storage tube having a dielectric target upon which a charge pattern may be established and used to provide output signals from the tube.

One type of storage tube is that similar to the tube disclosed in U. S. Patent 2,548,405 to R. L. Snyder, Jr. Such a storage tube consists of an electron gun for producing an electron beam along a path. Mounted transversely to the beam path is a target electrode consisting of an insulating film having a dielectric surface facing the electron gun and a conductive coating or signal plate spanning the other surface of the insulating film. Mounted closely adjacent to and overlying the dielectric surface is a fine mesh screen. During tube operation the fine mesh screen is maintained negatively to the potential of the conductive target coating or signal plate. The electron beam is scanned over the dielectric surface of the target electrode and simultaneously incoming signal pulses are applied to the signal plate of the target. These incoming signals swing the potential of the target signal plate relative to the negative potential of the fine mesh screen. The secondary emission initiated by the electron beam from the dielectric surface is thus varied in accordance with the incoming signals. The negative screen drives the secondary emission back to each elemental area of the dielectric target surface and thus each elemental area becomes negatively charged to an amount corresponding to the signal applied to the signal plate at that moment. This produces on the dielectric target surface a charge pattern corresponding to both the beam scansion and the incoming signals applied to the target signal plate. Upon further scansion of the dielectric surface by the electron beam, the secondary electron emission initiated by the beam is directed to a collector electrode within the tube to provide the video or output signal of the tube.

Such storage tubes, as described above, have many applications. It is particularly desirable to use such tubes in high frequency work, in which high frequency signals are fed to the tube. For example, such applications may be those involving computers or signal amplitude analysis. In such applications, it is possible to apply the high frequency signals to the control grid of the electron gun. Also, it is desirable to use electrostatic deflection provided by two pairs of deflection plates mounted between the electron gun and the target. With electrostatic deflection of this type, it is possible to use higher deflection frequencies.

For high frequency applications, however, storage tubes of the type described, have several disadvantages. For example, the signal provided by the collection of the secondary electrons from the target electrode is relatively small. Furthermore, the deflection frequencies applied to the electrostatic deflection plates can not be satisfactorily shielded from the collector or output signal electrode which is mounted between the deflection plates and the target. Even when the barrier grid is grounded, or by-passed to ground to provide shielding between the deflection frequencies and the target signal plate, there

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is too much capacitance between the signal plate and the barrier grid of the target for the simple design of an output video amplifier, for example. Another disadvantage of using such a tube with high frequency signals is that when the high frequency input signal is applied to the control grid of the gun of the tube, the signals used are radiated to the other tube electrodes including the output or collector electrode between the gun and the target. For high frequency work it is desirable, if not necessary, that the input and output sections of the tube be entirely separated so that there will be no interaction between these electrodes.

It is, therefore, an object of my invention to provide a storage tube in which the output electrode of the tube is not affected by the input signal or the deflection frequencies of the tube.

It is a further object of my invention to provide an electron storage tube in which the output and input electrodes are electrically separated from each other.

It is another object of my invention to provide an electron storage tube for high frequency operation in which the output portion of the tube is completely shielded electrically from the input portion of the tube.

Specifically, the invention is directed to a storage tube having a dielectric target and a barrier grid immediately adjacent the target surface. A charge pattern is established on the surface of the target by scanning the target with a modulated electron beam. The output signals of the tube are provided by changing the modulated electron beam to an unmodulated beam and scanning the charged surface of the target. The target signal plate which is capacitively coupled to the dielectric surface provides means for inducing output signals from the tube. Between the target and the electron gun there is provided shielding means to electrically separate the input signals fed to the gun from the output signals induced by scanning the dielectric target surface with the unmodulated electron beam.

Figure 1 discloses a sectional view of a storage tube in accordance with the invention.

Figure 2 is a partial sectional view of a modification of the invention.

Figure 1 shows an electron storage tube having a vitreous envelope 10 including an electron gun 12 mounted at one end of the envelope. The electron gun is to provide an electron beam along a path 14 extending substantially coaxially with the tubular envelope. Mounted at the other end of the tubular envelope 10 is a target electrode 16 arranged transversely to the beam path 14. The electron gun consists somewhat of conventional parts and comprises a cathode electrode 18, which may be a short tubular member having a closed end facing the target electrode 16. Enclosing cathode electrode 18 is a tubular control grid electrode 20 coaxially mounted with respect to cathode 18. Arranged substantially along the tube axis and spaced from each other are successively a first accelerating electrode 22, a decelerating plate electrode 24 and a second accelerating plate electrode 26. Each of the electrodes 20, 22, 24 and 26 have apertured openings therethrough substantially on the tube axis to provide passage therethrough of electrons from cathode 18. These electrons are formed into a beam by the several gun electrodes and directed and focussed by gun 12 to a fine point on the surface of target 16.

The electron beam passes between a pair of horizontal deflecting plates 28 and a second pair of vertical deflecting plates 30, to which appropriate potentials are applied to cause the electron beam to be scanned in a raster over the surface of target 16. The pairs of deflecting plates 28 and 30 are respectively connected to sources 32 and 34, of saw-tooth voltages of any desired type and providing any arbitrary scan such as line and frame scansion of

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the electron beam over the target surface. For computer work scanning is better done by pulses of measured amplitude, since each bit of information is placed at a single dot on the target and one deflects the beam from one dot to another in a quite arbitrary order. The scanning of the beam is well-known and is of a conventional type that is not further described.

Between the pairs of deflecting plates 28 and 30 there is mounted a shield electrode 36. Also, a conductive electrode coating 38 is deposited on the inner surface of envelope 10 to form substantially a tubular electrode enclosing the second accelerating plate electrode 26 and the pairs of deflecting plates 28 and 30. A second tubular wall coating electrode 39 is spaced from coating 38 and extends to and partially encloses target 16. The conductive coatings 38 and 39 may be of any appropriate type such as a colloidal suspension of carbon in a binder, which may be painted on the glass wall surface; or a metallic coating such as silver or aluminum, which can be put down on the glass wall surface by metallic evaporation. Also, electrodes 38 and 39 may constitute metal tubes mounted in the same relative positions. Wall coating 38 is tied conductively to the second accelerating electrode 26 which is in turn electrically tied to the first accelerating electrode 22. Electrode 39 is connected to ground, as shown, by a lead 68 sealed through the envelope wall.

The several gun electrodes shown are respectively tied to an appropriate source of potential which may, for example, be a voltage divider 40. Voltage values are given as representative of potentials which have been used successfully in a tube of the type described during tube operation. However, these values need not be limiting but only illustrative.

The target 16 consists essentially of a heavy metal signal plate 42. A thin dielectric sheet 44 such as mica or an equivalent is mounted on the surface of signal plate 42 facing the electron gun 12. Spaced closely to the surface of the dielectric sheet 44 or mounted in contact thereto is a fine mesh metal barrier grid screen 46. Screen 46 is mounted across a support ring 48 in which the target assembly 16 is arranged. An insulating disk 50 spaces signal plate 42 from the support ring 48. Signal plate 42 is connected to an external circuit through lead means 52, while the barrier grid screen 46 is connected to the exterior of the tube by lead means 54 connected directly to the support ring 48.

In operation of the tube, barrier grid 46 and signal plate 42 of the target assembly 16 are connected to a circuit such as that schematically shown in the figure. Barrier grid 46 is connected by lead 54 to a point 57 in the circuit between a high resistance 56 and a pentode tube 58, while signal plate 42, as shown is connected by lead 52 to a point 59 between the high resistance 56 and a diode 60, such as a crystal diode, for example. Point 59 of the circuit is connected directly to the control grid of a triode 61. As shown, the several terminals to which the circuit parts are connected are maintained at appropriate potentials, the values of which are shown in the figure.

During tube operation, the control grid 20 of the electron gun 12 is pulsed above cutoff by the application of a square wave signal 63 through a conductor 64. The time of the negative pulse 65 of the square wave signal is referred to as the "writing time," while the time of the positive pulse 67 of the square wave signal is referred to as the "reading time." Any signal 69 which is to be stored on the target 16 is superimposed upon the square wave signal during the "writing time." Such signals are of high frequency and pulse the control grid potential above cutoff so that the electron beam directed at target 16 is a modulated beam in accordance with the signals applied during the writing time. The modulated beam during this writing time is scanned over the surface of the dielectric sheet 44. Since the cathode 18 of the gun is operated at about -1200 volts, and the barrier grid 46 is operated in the neighborhood of a negative 300 volts,

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the electron beam will strike the surface of the dielectric sheet 44 with sufficient energy to drive off more secondary electrons than the number of primary beam electrons striking each point. In synchronism with the square wave signal applied to control grid 20 there is simultaneously applied to the control grid 62 of the pentode 58, a square wave signal of opposite phase. Thus, during the writing time, control grid 62 is pulsed positively. Likewise, during the reading time, control grid 62 is pulsed negatively below cutoff. Thus, during the writing time pentode 58 conducts and there is a flow of current through pentode 58 resistor 56, and diode 60. During this time, the barrier grid 46 assumes a negative potential in the order of 20 volts below that of the signal plate 42. During the reading time, current flow through pentode 58 is cut-off, and with no flow of current across resistance 56, barrier grid screen 46 and signal plate 42 assume the same potential.

During the reading time of tube operation, with signal plate 42 and barrier grid 46 at the same potential, the electron beam is scanned over the surface of the dielectric sheet 44 in a complete raster. The secondary emission from the dielectric sheet passes out through the barrier grid 46 and is collected by the wall coating 39 which is at a more positive potential. Due to the secondary emission leaving the dielectric surface of sheet 44, this surface will be driven positively until it reaches an equilibrium potential which is substantially that of the adjacent grid electrode 46. At this potential sufficient secondaries are driven back to the dielectric surface to maintain it at equilibrium potential. During the writing cycle of tube operation, the incoming signal 69 is superimposed upon the square wave signal fed to the control grid 20, as described above. The electron beam is thus modulated as it is scanned over the surface of the dielectric sheet 44. During this writing time, however, since the barrier grid 46 is now some 20 volts or more negative to its previous value, the secondary electrons initiated under beam bombardment are repelled back to the dielectric surface, which is thus driven negatively at each elemental area in proportion to the strength of the beam current striking that element. In this manner then, as the beam is scanned over the target surface during the writing cycle there is established on the dielectric surface of film 44 a succession of charges corresponding to the successive modulations of the electron beam. In this manner, there is established a charge pattern on the dielectric surface of sheet 44 corresponding from point to point successively to the signal pulses superimposed on the square wave applied to the control grid 20 during the writing time. During the next pulse or reading time the full beam scanning over the surface of sheet 44 again drives this surface positively to the equilibrium potential equal to that of the barrier grid 46. However, the secondary emission from each point of the target surface is now determined by the charge at that point, which was established by the modulated beam during the writing time. As each elementary area of the target is thus discharged by the full beam, a signal pulse occurs in the circuit of the target signal plate 42. These signal pulses are each proportional to the charge which the beam erases from point to point. These signal pulses are established on the control grid of the triode 61 to provide modulations to the current flow through tube 61. This modulated current becomes the output signal of the tube.

It is desirable that such a tube be operated in high frequency work such as that with computers or signal amplitude analysis. In such applications the signals fed into the control grid 20 of the gun 12 during the writing time are of extremely high frequency. These high frequency incoming signals are picked up and appear in the circuits of the target output electrodes. This results in spurious signals in the output circuit of the tube. It is desirable that such spurious signals do not

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occur and that there is no electrical coupling between the input and output sections of the tube.

In accordance with the invention the tube is designed to provide electric shielding of the input and output portions. The invention is carried out by mounting a conductive screen electrode 66 adjacent the deflecting system of the tube and between gun 12 and the target electrode 16. Screen 66 is a large mesh screen of approximately 10 mesh per inch. The screen is mounted on a conductive ring 68 sealed through the envelope wall 10. As shown in the drawing, ring 68 and screen 66 are connected directly to ground by a lead 70. Also, in accordance with the invention, the portion of the tube envelope extending from the ring 68 and beyond the target electrode 16 is enclosed in a tubular metal canister or container 72. This canister 72 may be either connected directly to ground or through ring 68 to ground. This provides a grounded external shield for target electrode 16. Furthermore, container 72 is extended beyond the target end of the tube envelope 10. This provides a shielded mounting for the output circuit of the tube which is placed within container 72, so that it is effectively shielded from the input signals applied to the control electrode 20 of gun 12. The internal accelerating electrode coating 39 provides further shielding between the input and output portion of the tube by grounding the coating through spring fingers 74 mounted on ring 68. Coating 39 extends beyond and substantially encloses the target electrode 16. In lieu of this coating and the ring seal, this entire end of the tube may be made of metal with insulating beads through which the barrier grid 54 and plate 52 leads emerge in well-known fashion.

Such a modification is shown in Figure 2. The gun end of the glass envelope 10 is sealed directly to a metal cylinder 80, which forms the target end of the tube envelope, as shown. Target 16 is mounted by means of its leads 52 and 54 on a metal header 82 which is fitted into the open end of cylinder 80 and sealed thereto. Leads 52 and 54 are brought out through apertures in header 80 and are insulated from the header 82 by glass beads 84 and 86 sealed into the apertures. Cylinder 80 may be extended farther beyond header 82 to serve as a screening container for output circuits in the manner described above for Figure 1. Or an additional metal cylinder may be slipped over the end of cylinder 80 to serve this purpose and in the manner described above for canister 72. Screen 66 may be fixed across a mounting ring 88 which in turn is welded to the metal cylinder 80. In this manner the input and output portions of the tube are shielded. Cylinder 80 also serves as a collector electrode for secondary electrons from target 16 in the manner of electrode 39, described above.

The use of the support ring 68 sealed through the envelope wall provides for shielding elements 39, 66 and 72, a short lead passing out of the tube envelope. Ring 68 has little capacitive coupling to the input and output portions of the tube.

The screen 66, together with the ring 68, and shields 39 and 72, completely separate the input and output portions of the tube. With this shielding arrangement, the input signals have little or no effect on the output circuit portions of the tube. Furthermore, the high frequency deflection voltages applied to plates 28 and 30 will in no way effect the reading and writing functions at target 16. Again, by utilizing such a shielding arrangement, it is unnecessary to depend upon the barrier grid 46 as a shield between the input portion of the tube and the signal plate 42. This has proved an advantage since use of barrier grid 46 as an electrostatic shield necessitates tying it to ground potential and unduly increasing the capacity between grid 46 and signal plate 42. The output capacitance of the tube, as modified by the invention, is now only between the target electrodes 42 and 46 and the shielding electrodes 66, 39 and 72, which because of their design and nature provide a capacitance

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considerably less than is possible without their use. The tube, shown in the figure, has been described above as being operative in connection with a particular form of output circuit. The operation of the tube, however, is not limited to this particular circuit. It has been recognized that certain circuit requirements are necessary for optimum operation of the tube. If the tube is operated with the video input signal applied to the control grid 20 of gun 12, it is desirable for optimum operation that, during writing, screen 46 should be well by-passed to ground and that the keying signals should be applied to the signal plate 42, so that it is driven positively during writing, and is returned to its normal potential during reading. For this type of operation during the reading time, both the plate 42 and the screen 46 must be separated from ground by a high impedance, and the output reading signal is taken off the barrier grid.

The tube may also be operated by applying the incoming video signals to the plate 42 and simultaneously scanning the target with an unmodulated beam from the gun 12. The video input signals should be kept to about 20 volts maximum for linear operation. During this time the screen 46 is kept at a constant potential negative to that potential to which the plate 42 is driven by the input signals. In this manner, a charge pattern is established on the dielectric sheet 44 by secondary electrons driven back to the dielectric surface by the negative grid 46. During reading both the plate 42 and screen 46 are kept at a common potential while the unmodulated beam is scanned across the target to erase the charge pattern established thereon. Again the output signal may be taken off the barrier grid while both barrier grid and plate are separated from ground by a high impedance. This last method of operation is similar to that described in U. S. Patent 2,548,405 of Snyder.

The tube described above is one which does not require a collector electrode to provide the output signal of the tube. Since reading and writing are sequential and not simultaneous, a collector electrode between the gun 12 and the target 16 is unnecessary. The use of such a collector electrode requires excessive shielding electrodes surrounding the collector which in turn necessitates longer gun-to-target spacing. With the design described above and as shown in the drawing, it is possible to mount the gun 12 closer to the target 16 and thus provide a smaller spot size of the beam on the target surface and thus better resolution.

The secondary electrons passing from target sheet 44 through the mesh screen 46 are now enabled to be collected by any more positive electrode. There is thus no necessity for directing them specifically to an output collector electrode with a resulting shading of the output signal because of non-uniform collection from all portions of the target surface. Since the electrode coating 39, as well as the shielding grid 66, are maintained more positive than the target surface during tube operation, the secondary electrons may pass to these electrodes without any attempt to control their collection.

The output signal of the tube described, is produced by the electrons leaving the target and not by their collection. Thus, merely the provision of a large off-target positive gradient between the target and electrodes 39 and 66 is sufficient to provide a good signal. In this manner then, the complications of former storage tubes have been eliminated and both the structure and operation of the tube has been greatly simplified with the above described advantages.

While certain specific embodiments have been illustrated and described, it will be understood that various changes and modifications may be made therein without departing from the spirit and scope of the invention.

What is claimed is:

1. An electron discharge device comprising, an electron gun for producing an electron beam along a path,

a target electrode spaced from said gun and mounted transversely to said path, means shielding said target electrode from said gun, said shielding means including a conductive screen mounted across said beam path adjacent to said gun and between said gun and said target electrode and providing a larger space between said conductive screen and said target electrode than between said conductive screen and said gun, and a tubular electrode electrically connected to and extending from said screen to said target and enclosing said larger space between said conductive screen and said target electrode and means electrically insulating said shielding means from said target and said electron gun.

2. An electron discharge tube comprising, an envelope, an electron gun within said envelope for producing an electron beam along a path, a target electrode spaced from said gun and mounted within said envelope transversely to said beam path, means between said gun and said target for deflecting said beam over said target, means shielding said target electrode from said deflecting means, said shielding means including a conductive screen mounted adjacent to said gun and within said envelope between said deflecting means and said target electrode and providing a larger space between said conductive screen and said target electrode than between said conductive screen and said gun, and a tubular conductive member electrically connected to and extending from said screen to said target and enclosing said larger space between said conductive screen and said target electrode and, means electrically insulating said shielding means from said target and said deflecting means.

3. An electron discharge tube comprising, an envelope, an electron gun within said envelope for producing an electron beam along a path, a target electrode mounted within said envelope transversely to said beam path, and means shielding said target electrode from said gun, said means including a conductive screen mounted within said envelope between said gun and said target electrode, a tubular electrode within said envelope electrically connected to said screen and extending from said screen to and partially enclosing said target electrode and a conductor member electrically connected to said screen and extending over the outer surface of said envelope and enclosing said target electrode, and means electrically insulating said shielding means from said target and said electron gun.

4. An electron discharge tube comprising, an envelope, an electron gun within said envelope for producing an electron beam along a path, a target electrode mounted within said envelope transversely to said beam path, means shielding said target electrode from said gun, said means including a metal ring sealed through the envelope wall between said gun and said target electrode, a conductive screen mounted within said envelope across said ring, a tubular electrode within said envelope extending from said ring to and partially enclosing said target electrode and a tubular conductor mounted on the outer surface of said envelope between said screen and said target electrode and enclosing said target electrode, and means electrically connecting together said screen, tubular electrode and tubular conductor.

5. A storage tube comprising, an envelope, an electron gun within said envelope for producing an electron beam along a path, a target electrode mounted within said envelope transversely to said beam path, means between said gun and said target for deflecting said beam over said target, and means shielding said target electrode from said gun and said beam deflecting means, said shielding means including a conductive screen mounted within said envelope between said gun and said target electrode and a tubular electrode extending from said screen to and enclosing said target electrode, said tubular electrode comprising a portion of said envelope and having a wall portion closing the end thereof away from said conductive screen, and means electrically in-

ulating said shielding means from said target said deflecting means and said gun.

6. An electron discharge device comprising, an envelope, an electron gun within said envelope for producing an electron beam along a path, a target electrode mounted within said envelope transversely to said beam path, said target electrode including a dielectric sheet and a screen electrode closely spaced from the surface of said dielectric sheet facing said gun, means shielding said target electrode from said gun, said shielding means including a tubular conductive member mounted around said envelope and enclosing said target and a second screen mounted across one end of said tubular member and in said beam path between said gun and said target electrode, said tubular conductive member having a conductive wall portion closing the other end thereof, and a tubular electrode within said envelope extending from said second screen and enclosing said dielectric target sheet, said second screen being of a conductive material.

7. A storage tube comprising, an envelope, an electron gun within said envelope for producing an electron beam along a path, a target electrode mounted within said envelope transversely to said beam path, said target electrode including a dielectric sheet and a screen electrode closely spaced from the surface of said dielectric sheet facing said gun, means shielding said target electrode from said gun, said shielding means including a second conductive screen mounted across said beam path between said gun and said target electrode and a tubular electrode extending from said second screen and enclosing said dielectric target sheet, means including a conductor sealed through said envelope and electrically connecting said second screen to said tubular electrode, and means electrically insulating said shielding means from said target and said gun.

8. A storage tube comprising, an envelope, an electron gun within said envelope for producing an electron beam along a path, a target electrode mounted within said envelope transversely to said beam path, said target electrode including a dielectric sheet and a screen electrode closely spaced from the surface of said dielectric sheet facing said gun, means shielding said target electrode from said gun, said means including a metal ring sealed through the envelope between said gun and said target electrode, a conductive second screen mounted within said envelope across said ring, a tubular electrode within said envelope electrically joined to said second screen and extending from said ring to and partially enclosing said target electrode and a tubular conductor mounted on the outer surface of said envelope between said screen and said target electrode and enclosing said target electrode, means connecting together said second screen, tubular electrode and tubular conductor, and means electrically insulating said shielding means from said target and said electron gun.

9. A storage tube comprising, an envelope, an electron gun within said envelope for producing an electron beam along a path, a target electrode mounted within said envelope transversely to said beam path, said target electrode including a dielectric sheet and a screen electrode closely spaced from the surface of said dielectric sheet facing said gun, means shielding said gun from said target electrode, said means including a second conductive screen mounted across said beam path between said gun and said target electrode and a tubular conductive member electrically joined to said second screen and extending from said second screen and enclosing said target electrode, said tubular electrode comprising a portion of said envelope, and means electrically insulating said shielding means from said target and said electron gun.

10. An electron discharge tube comprising, an envelope having a tubular metal portion, an electron gun within said envelope for producing an electron beam directed along a path into said tubular metal envelope portion, a target electrode mounted within said metal en-

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velope portion transversely to said beam path, a conductive wall portion closing the end of said tubular metal envelope portion away from said gun, means within said envelope between said gun and said target for deflecting said beam over said target, means shielding said target electrode from said gun and said deflecting means, said shielding means including a conductive screen mounted across the other end of said metal tubular envelope portion between said target and said beam deflecting means, and means electrically insulating said shielding means from said target said gun and said deflecting means.

11. An electron discharge device comprising, an electron gun for producing an electron beam along a path, a target electrode spaced from said gun and mounted transversely to said beam path, means shielding said target electrode from said gun, said shielding means including a conductive apertured electrode mounted across said beam path adjacent to said gun and between said gun and said target electrode and providing a larger space between said conductive apertured electrode and said target electrode than between said conductive apertured electrode and said gun, and a tubular electrode electrically connected to and extending from said apertured electrode to said target and enclosing said larger space between said conductive apertured electrode and said target electrode, and means electrically insulating said shielding means from said target and said electron gun.

12. An electron discharge tube comprising, an envelope,

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an electron gun within said envelope for producing an electron beam along a path, a target electrode mounted within said envelope transversely to said beam path, and means shielding said target electrode from said gun, said means including a conductive apertured electrode mounted within said envelope between said gun and said target electrode, a tubular electrode within said envelope electrically connected to said apertured electrode and extending from said apertured electrode to and partially enclosing said target electrode, and a conductor member electrically connected to said apertured electrode and extending over the outer surface of said envelope and enclosing said target electrode, and means electrically insulating said shielding means from said target and said electron gun.

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