Feb. 4, 1958 M. D. HARSH 2,822,493

GRAPHECHON STORAGE TUBE

Filed April 24, 1953

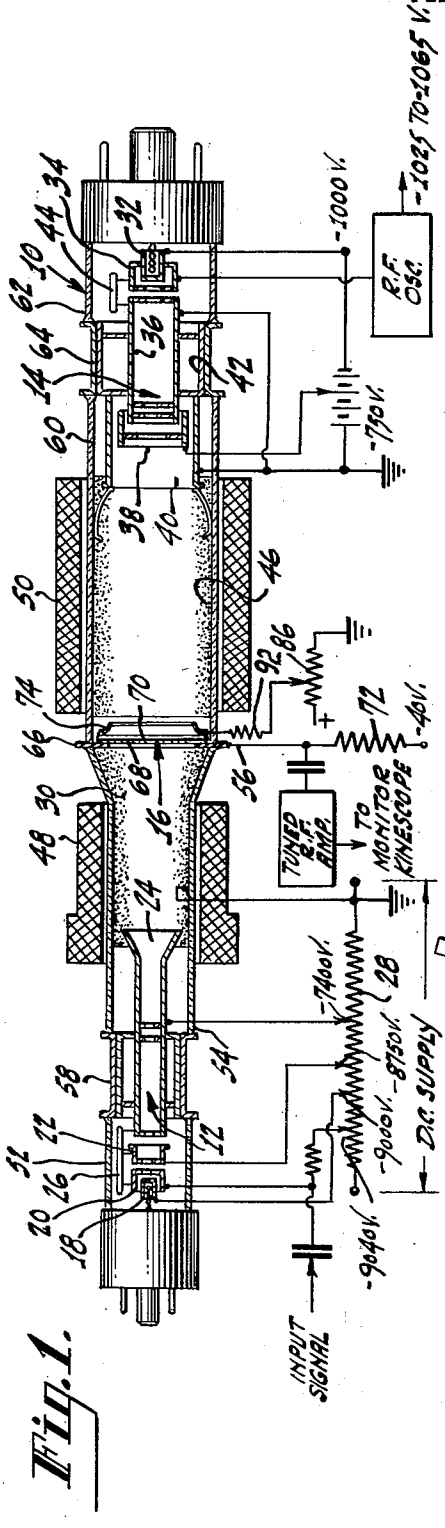


Fig. 1.

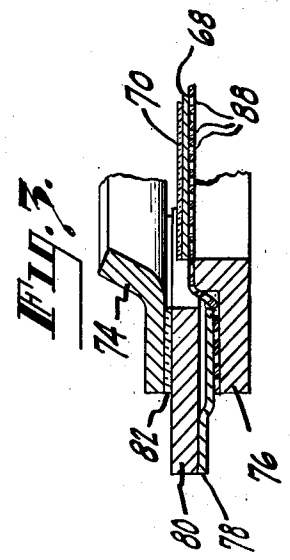


Fig. 3.

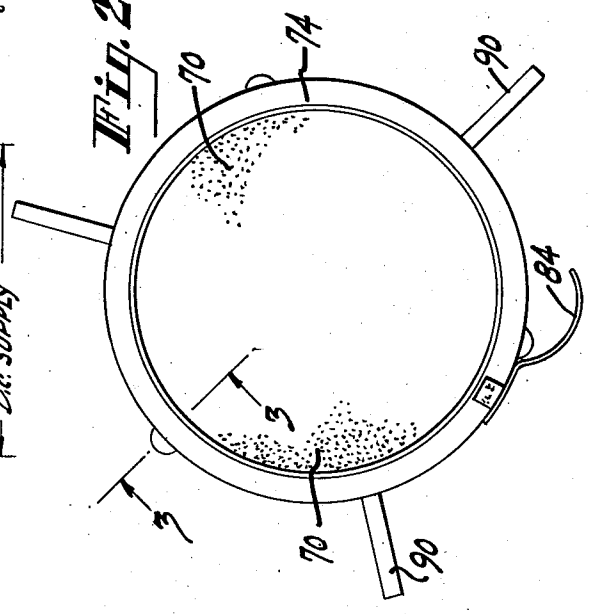


Fig. 2.

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GRAPHECHON STORAGE TUBE

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Application April 24, 1953, Serial No. 350,972

4 Claims. (Cl. 313—89)

This invention is directed to an electron discharge device and more particularly to a storage tube for the conversion of one type of electrical signal to another type of electrical signal.

The invention relates specifically to a storage tube having an insulating target upon which a signal charge pattern is established. The charge pattern is used to provide output signals from the tube corresponding to the charge pattern. The output signals are utilized to provide a visual picture of the pattern. One storage tube of this type is that which is fully disclosed in U. S. application Serial Number 29,746 of L. Pensak, filed May 28, 1948. One modification of this type of storage tube utilizes a target electrode having a thin film of insulating material. An electron beam is directed against one side of the target film to provide a charge pattern on the insulating film. A second electron beam is scanned over the charged surface of the target film to discharge the film and to provide output signals from the tube, which may be amplified and fed into a kinescope or viewing tube to provide a visual picture of the charge pattern on the storage tube target.

Such a storage tube consists essentially of a first electron gun, called a writing gun, directed at one side of the target electrode and a second electron gun, known as the reading gun, directed at the opposite side of the target. Both of the guns are substantially on the same axis and the target electrode is positioned intermediate the guns and substantially normal thereto. The target is formed with a supporting mesh screen coated on one side with an electron pervious aluminum film. A thin film of insulating material is supported on the exposed surface of the aluminum film.

The reading gun faces the insulating film surface and provides a relatively low velocity beam which is scanned over the insulating target film. Secondary electrons are knocked out of the insulating film surface when the reading beam impinges on the surface and are collected on a conductive coating on the wall of the tube, thus causing the target surface to become charged to an equilibrium potential which is positive with respect to the aluminum film. There is an output from the tube even though no signals are being "written" onto the target by the writing gun. This signal is referred to as the background signal and is due to the secondary electrons driven off the target surface by the electron beam of the reading gun. However, only as many secondaries can leave the surface as are replaced by the impinging electron beam of the reading gun.

The writing gun provides a high velocity beam which, when modulated, for instance, penetrates through the aluminum and insulating films and discharges the surface of the insulating film to the potential of the aluminum film at all points penetrated. Thus, when the writing gun beam is modulated by a signal applied to the gun, there is established on the target surface a charge pattern corresponding to the incoming signals applied to the writing gun. The reading gun then, upon scanning the

charged target surface, charges the surface from point to point back to the equilibrium potential and by an amount depending on the potential at each point set by the writing gun. This charging of the target surface provides successive signal pulses in the target circuit, which can be amplified and fed to the kinescope or viewing tube so that the charge pattern on the storage tube is visually represented. The collection of secondary electrons from portions of the target which are not discharged by the writing beam, provide the background signal or black level of the picture on the kinescope. This collection of secondaries from these areas should be uniform to provide a uniform black level of the kinescope picture.

However, the signal output from such a storage tube has a non-uniform black level or background which causes a shading or decrease in contrast of the picture. The background shading a signal is higher in the center of the picture than at the edge. This higher background signal in the central part of the target results from the fact that more secondary electrons are collected from portions of the target near the center which are not discharged by the writing beam than are collected from target portions near the edge which are not discharged by the writing beam. The metallic ring for supporting the target is normally operated at about 40 volts negative with respect to the collector electrode, and it has been determined that this neagtive potential sets up a retarding field between the target and the conductive coating or collector near the outer edges of the target so that secondaries generated near the edge of the target tend to be directed towards the central part of the target and collected by the positive areas there. This "rain" of secondaries charges the positive areas negatively below equilibrium, and therefore produces a non-uniformity in the background signal. Fringe fields from the deflecting yokes are present also. When the deflecting field is such that the beam is near the edge of the target, this field is in the direction to cause secondaries leaving the target to turn towards the center of the target. Thus, in two ways, secondary electrons are forced towards the middle of the target.

The maximum current from a written signal is fixed by the potential of the target and by the beam current in the writing gun, and is independent of shading. The usable output signal of the tube is equal to the difference between the signal resulting from the penetration of the writing beam through the target surface and the background signal.

A reduction of the background or shading signal, therefore, results in a more usable output signal having improved contrast and relatively higher amplitude.

A principal object of this invention is to provide an improved storage tube.

Another object of this invention is to provide a storage tube in which the background signal level is substantially uniform irrespective of the part of the target where said output signal is derived.

Still another object of this invention is to provide a storage tube in which the ratio between the modulation signal amplitude and the amplitude storage signal are more nearly constant over the entire surface of the target on which information is stored.

The above and related objects are achieved in accordance with the present invention by the addition of a shield ring to the target structure. The shield ring, insulated from the target and extending along the longitudinal axis of the tube in the direction of the conductive wall coating or collector on the "reading" end of the tube, is operated at a positive potential to overcome the previously mentioned repelling fields which tend to deflect secondary electrons towards the center of the insulating film. Thus,

the rate of collection of electrons on the conductive wall coating or collector electrode is substantially uniform regardless of which area of the target from whence the electrons were emitted.

The invention will best be understood by reference to the following description taken in connection with the accompanying drawing, in which:

Figure 1 is a cross sectional view of a storage tube utilizing this invention;

Figure 2 is an end view of the target assembly of the tube shown in Figure 1, and

Figure 3 is an enlarged partial sectional view taken along line 3—3 of Figure 2.

Figure 1 shows an electron discharge device consisting of a storage tube having a tubular envelope portion **10**. At one end of the envelope **10** there is mounted an electron gun **12** to be described as the "writing gun" of the tube. At the opposite end of the envelope there is mounted an electron gun **14** to be known as the "reading gun" of the tube. Intermediate the electron guns **12** and **14** there is positioned a target electrode **16**, positioned transversely to the axes of the electron guns **12** and **14**.

The storage tube **10** is a type which has been fully described in the copending application of Pensak cited above. The writing gun **12** consists principally of a cathode electrode **18** mounted within a cup like control grid electrode **20** and coaxially aligned with a first accelerating electrode **22** and the second accelerating electrode **24**. Electrodes **20**, **22** and **24** are mounted successively along a common axis by any well-known means such as glass support rods **26**, only one of which is shown for simplicity of illustration, sealed to metal studs projecting from each electrode, as shown. Cathode **18** consists primarily of a closed cylinder with the closed end facing target **16** and being coated with an electron emitting material. The electrodes **20**, **22** and **24** have apertures therethrough on the common axis of the gun to provide a passage for electrons emitted from the cathode coating. During tube operation, the cathode emitting surface is heated to provide a copious emission of electrons which are drawn by the positive field of the accelerating electrode **22** away from the cathode surface. These electrons pass through the apertures of electrodes **20**, **22** and **24**, while the fields between the electrodes form the electrons into a beam, which is brought to a minimum cross sectional area, or spot, on the surface of target **16**. The final focusing of the electron beam of gun **12** on target **16** is provided by the field established between the tubular electrode **24** and a conductive wall coating **30** applied to the inner surface of the tube envelope between gun **12** and the target **16**. The parts of the electron gun **12** are conventional and the electron optics of such a gun and its operation are well-known and are not further described as they do not constitute a part of this invention.

As shown in Figure 1, the several electrodes of the gun **12** are connected to a voltage divider **28** for providing operating voltages to the respective electrodes of the gun. A set of voltages is indicated in the drawing. These voltages represent values which have been used in the successful operation of a tube of the type described, but are not meant to be limiting.

Electron gun **14**, the reading gun, includes a cathode electrode **32** and a control grid electrode **34** similarly respectively to electrodes **18** and **20** of the writing gun **12**. Mounted successively along the common axis between the control grid **34** and the target electrode **16** are an accelerating electrode **36**, a focusing electrode **38** and a second accelerating electrode **40**. Accelerating electrodes **36** and **40** are connected directly to each other through a common supporting metal cup or gun holder **42**. The cathode-control grid assembly of gun **14** is rigidly mounted to the accelerating electrode **36** by means of glass support rods **44**, only one of which is shown for simplicity of illustration. A conductive coating **46** extends over the inner surface of the envelope **10** from the accelerating electrode **40** to a point adjacent to the screen target electrode **16**.

As indicated in Figure 1, the several parts of gun **14** are also connected to external sources of potential for providing operating potentials to the gun electrodes. During tube operation, the gun **14** forms an electron beam with the electron emission from the cathode **32**, which is directed onto the target **16** and focused to a fine spot at the point it strikes the target.

The beams emanating from guns **12** and **14** are respectively scanned over opposite surfaces of target **16** by deflecting yokes **48** and **50**. These deflection yokes are of conventional design, in that they consist of two pairs of deflecting coils mounted in the yoke with the coils of each pair on opposite sides of the tube envelope **10**. The coils of each pair are connected in series to a source, not shown, of saw toothed currents for providing a magnetic field in the path of the respective electron beam. The fields of each yoke **48** or **50** provide line and frame scansion of the respective electron beams over the surface of target **16**. Such deflection coils and their mode of operation is well-known in the prior art and since they do not constitute a part of this invention, they are not described in further detail.

The envelope **10** of the tube is formed from several tubular sections. The portion, for example, enclosing the gun **12** is formed from a pair of glass tubular members **52** and **54** which are connected together through a metal alignment cylinder **58** sealed thereto. In a similar manner the portion of envelope **10** enclosing gun **14** is formed from a pair of tubular glass members **60** and **62** which are joined together through an intermediate alignment cylinder **64**.

The tube may be enclosed in a housing of the type disclosed and claimed in co-pending application Serial No. 312,004, filed September 29, 1952, by Fadner, Dyall and Harsh.

Target electrode **16** is mounted on a flat ring **66**, to which the tubular envelope portions **54**, and **60** housing the respective guns **12** and **14** are both sealed to close the envelope. Target **16** consists primarily of a thin electron pervious metallic film, such as an aluminum film **68**, coated on its surface facing gun **14** with a thin film **70** of insulating material such as magnesium fluoride, for example.

The operation of the tube is substantially that in which input signals are applied to the control grid **20** of gun **12** to modulate the electron beam of the gun while it is scanned over the surface of target **16**. The aluminum target film **68** is maintained in the order of a —40 volts negative with respect to ground. The electron beam of gun **14** is unmodulated and is scanned over the surface of the magnesium fluoride film **70** in a substantially rectangular raster formed by a normal frame and line television scansion. The beam of electron gun **14** will strike the dielectric target film **70** at energies in the order of 1,000 volts. These energies are between the first and second crossover potentials for the magnesium fluoride screen so that at every point on target film **70** where the beam of gun **14** strikes, the ratio of the secondary electron emission current from the film to the incident electron current is greater than unity. The secondary electrons are drawn away and collected by the positive collecting coating **46**. The loss of secondary electrons from each point of film **70** under the scanning beam of gun **14** raises the potential of that point positively to a level close to the potential of coating **46** which is held at ground potential. In this manner then the target surface scanned by the beam of gun **14** is raised to an equilibrium potential which is that potential level at which the secondary electrons leaving the target surface are equal in number to the primary electrons of the beam of gun **14** striking the surface.

The modulated electron beam of gun **12** strikes the target with energies in the order of 9,000 volts, which is

sufficient to cause the electrons of the beam of gun **12** to penetrate through the target films **68** and **70** as described in the above cited copending application of L. Pensak. The magnesium fluoride film **70** is a material which is normally insulating, but which becomes conducting when struck by high velocity electrons at those points where the electrons penetrate substantially through the magnesium fluoride film. Thus, during tube operation, the modulated high velocity beam of gun **12** provides conductivity between the aluminum film **68** which is at a potential of, for example, —40 volts and the exposed scanned surface of the magnesium fluoride film **70** at equilibrium potential, i. e. close to that of ground potential of the collecting coating **46**. The conductivity induced at any one point through the magnesium fluoride film **70** is proportional to the strength of the beam of gun **12** inducing the conductivity. Thus, the beam of gun **12** will discharge the positive surface of film **70** toward the negative potential of the aluminum film **68** and in proportion to the strength of the beam inducing the conductivity at each point. The scanning of the high velocity modulated beam of gun **12** over the surface of target **16**, in this manner, establishes on the exposed surface of film **70** a negative charge distribution or pattern corresponding to the sequential input signals applied to the control grid **20** of gun **12**.

The beam of gun **14**, on scanning over the charged surface of the film **70**, will instantaneously charge the areas that have been discharged by the beam of gun **12** back to the equilibrium potential. When the beam of gun **14** strikes a negative area of film **70** the secondary emission from this point is instantaneously greater than from a positive area. This instantaneous charging of any one point of film **70** results in a corresponding pulse in the circuit **56** of aluminum film or plate **68** causing a change in the voltage across the high resistance **72** of the plate circuit. This voltage is detected and amplified in well-known manner to provide an output signal from the tube, which is fed to a monitor kinescope or other utilization means. Thus, as the beam of gun **14** scans the charged pattern established by the beam of gun **12** on film **70**, there is provided a succession of signal pulses which vary in amplitude as determined by the potential of the areas charged.

Bombardment of the target **16** by the writing beam produces a flow of current in the target circuit **56** which must be separated from the target current produced by the reading beam. The separation of the two components of target current may be accomplished by a time-sharing method, or, as illustrated in Fig. 1, by the use of radio-frequency modulation of the reading component in conjunction with a tuned output amplifier.

If the beam of gun **14** is scanned over the charged surface of target film **70** in a normal television scan, the output is a television signal which will produce on the monitor kinescope a scanning visual representation of the charge pattern written on film **70** of the storage tube. By controlling the beam current of gun **14**, it is possible to control the storage time of the charge pattern on film **70**. Thus, if the beam current of gun **14** is sufficiently small, the charge pattern on target film **70** may remain for a determinable length of time before it is entirely erased. In this manner then, the scanning rate of the beam of gun **12** may be different from that of the beam of gun **14**. Furthermore, the pattern or scanning raster established on film **70** may be written down differently than the reading raster of gun **14**. For example, the writing gun **12** may be operated to provide a radar raster of the charge pattern which is laid down on the target **70** in several seconds, while simultaneously the pattern may be continually read off by the reading gun **14** with a television scan frame time of $\frac{1}{30}$ of a second.

The storage tube and its operation, as thus described, are in accordance with prior art practice.

However, the metallic target ring is normally operated at, for example, 40 volts negative potential with respect to the conductive coating or collector electrode which is at ground potential. Thus, part of the secondary electron emission from near the edges of the insulating film which would normally be attracted to the collector electrode **46** is repelled by the negative field of the target ring and falls back on the positive center portions of the insulating film rather than be collected by the collector electrode **46**. This non-uniform collection of electrons, as mentioned before, causes a shading effect in the picture due to non-uniformity of the background signal. Also, amplitude of signals due to modulation of the writing beam and signal storage are reduced near the edge of the insulating film as a result of this non-uniform electron redistribution.

Fringe fields from the deflecting yokes also tend to cause secondary electrons leaving the edge of the target to turn towards the center of the target.

In accordance with the present invention, and as shown more clearly in Figures 2 and 3, the target **16** is provided with a ring-like shield **74** extending axially towards the reading gun **14**.

The target **16**, as previously mentioned, comprises a thin electron pervious metallic (aluminum, for example) film **68** on a fine mesh carrier **88**. The mesh **88** is secured to the mesh target supporting member or ring **76** by the target retaining mesh welding ring member **78**. The film of insulating material **70** is deposited on the surface of metallic film **68** which faces the reading gun **14**.

The ring-like shield **74**, which faces the reading gun **14**, is secured to a shield support ring or member **80** by means of a fused seal **82** which also provides insulation between the shield **74** and the ring **80**. The shield support ring **80** is welded or otherwise conductively secured to the mesh welding ring **78**, thus fixing the position of the shield ring **74** relative to the target **16**.

The target assembly is held in position within the tube by the welding strips or tabs **90** which are welded or otherwise conductively secured to the flat ring **66** previously mentioned. The inner diameter of the shield **74** encircles the target **16**. This method of mounting the target assembly in the tube offers several advantages over prior art target assembly mounting arrangements. First, the entire target assembly may be completed outside the tube where the alignment of parts may be accurately controlled. Formerly, target assemblies for tubes of the type described have been secured to the tube envelope by glass bead seals, and the heat required to effect these seals is so intense that damage to the thin target would almost certainly occur. Therefore, in the past, only a target holder member would be sealed to the envelope wall, and the remainder of the assembly was completed inside the tube envelope. Naturally under such circumstances it is very difficult to accurately mount the target perpendicular to the longitudinal axis of the tube.

In target assemblies in accordance with the present invention, sealing the target in a plane perpendicular to the longitudinal axis of the tube is a simple matter, as the three tabs **90** of the target assembly rest on, and are welded to, the flat ring **66** which has previously been accurately positioned with reference to the tube axes.

Electrical contact to the shield **74** is made by a spring wiper contact **84** which brushes against a conductive coating on the inner surface of the envelope wall. A pin (not shown) through the envelope wall may provide a means by which a potential may be applied to the shield **74**.

Since the negative potential of the target ring **76** and fringe fields from the deflecting coils repel some of the secondary electrons emitted from the coating of insulating material **70**, especially secondaries emitted from near the edges of the target **16**, and causes these electrons to fall back on the central portion of the target, a positive potential is applied to the shield **74** from a circuit **86**. The positive potential on the shield **74** is adjusted to overcome the effect of the deflecting fields due to both the negative ring **76** and the deflecting field of yoke **50**. The

result is substantially uniform over the entire target and shading is eliminated.

In a typical storage tube of the type under consideration herein, it was found that a positive potential of about 40 volts on the shield 74 produced excellent results when radio frequency modulation of the reading beam was used. A positive potential of about 5 volts on the shield 74 proved sufficient to provide uniform output when the reading beam was un-modulated.

Since the addition of the shield ring 74 adds to the capacitance of the target assembly, it is desirable if radio frequency signal separation is used to isolate the shield ring 74 from associated wiring capacitance. A resistor 92 of about one half megohm value has been found to be satisfactory for use as the isolating impedance.

Incorporation of the present invention in storage tubes of the type described has resulted in a shading-free target and in a 2-to-1 improvement in the signal-to-noise ratio.

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. A target assembly for a storage tube comprising a target structure and a shield structure, said target structure including an annular target supporting member, a sheet-like target, and an annular retaining member, said target being stretched across said target supporting member, a peripheral part of said target being secured between said target supporting member and said retaining member, said shield structure comprising a tubular shield and an annular shield supporting member, said shield being secured to but insulated from said shield supporting member, said retaining member of said target structure being secured to said shield supporting member of said shield structure.

2. A target assembly for a storage tube comprising a target structure and a shield structure, said target structure comprising an annular target supporting member, a target including a mesh carrier, and an annular retaining member, said mesh carrier being carried by said target supporting member, a peripheral part of said mesh carrier being secured between said target supporting member and said target retaining member, said shield structure comprising an annular shield and an annular shield supporting member, said shield being secured to said shield supporting member by an insulating fusion type seal, said

retaining member of said target structure being secured to said shield supporting member of said shield structure, and means for biasing said shield with respect to said target.

3. An assembly for a storage tube comprising a conductive mesh, a thin metallic film supported on said mesh, an insulating coating supported on said metallic film, an annular target supporting member, an annular retaining member, said mesh being stretched across said target supporting member, a peripheral part of said mesh being secured between said target supporting member and said retaining member, an annular shield supporting member secured to said retaining member, and a tubular flanged shield secured to but inuslated from said shield supporting member with said shield on the same side of said assembly as said insulating coating.

4. An electron discharge device for the storage of electrical signals comprising an elongated envelope, an electron beam-producing means in one end of said envelope, a disk-like target assembly within said envelope and in the path of the electron beam from said beam-producing means, means for scanning said target assembly with said electron beam, a target supporting member, a mesh carrier extending across said target supporting member, a target retaining member, a peripheral part of said mesh carrier being secured between said target supporting member and said target retaining member, a shield structure for providing a substantially uniform background signal level from all parts of said target when said target is struck by said beam, said shield structure comprising a shield and a shield supporting member, said shield being secured to said shield supporting member, said retaining member of said target structure being secured to said shield supporting member of said shield structure, and means for biasing said shield with respect to said target.

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