

March 22, 1966

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3,242,367

STORAGE TARGET ELECTRODE

Filed March 29, 1962

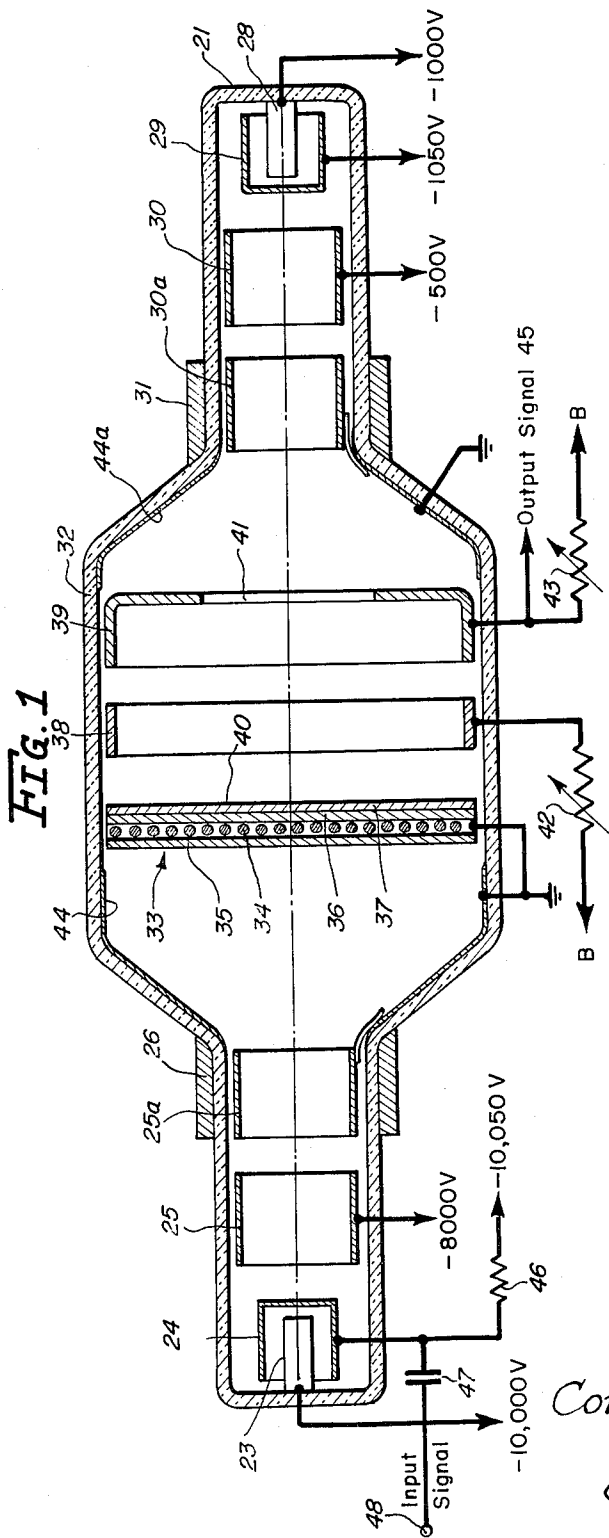


FIG. 6

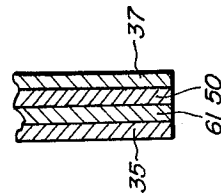


FIG. 5

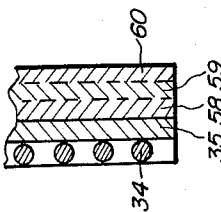


FIG. 4

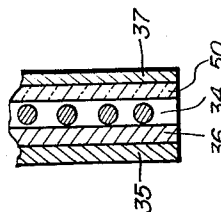


FIG. 3

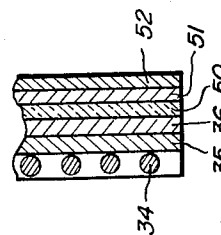
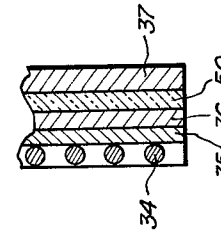


FIG. 2



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3,242,367

STORAGE TARGET ELECTRODE

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Filed Mar. 29, 1962, Ser. No. 183,606
11 Claims. (Cl. 313-89)

The present invention is directed to storage devices of the type which employ the phenomenon of electron-bombardment-induced conductivity. This phenomenon is experienced with certain materials that may be classified as insulators but which, when subjected to electron bombardment, exhibit enhanced conductivity. Control of such factors as the velocity and intensity of the impinging electrons facilitates controlled modification of the conductivity in elemental transverse sections of the insulating material.

A device of the general type under consideration has already been proposed and is known as a storage tube. It comprises a glass envelope within which is centrally positioned a target usually made of a thin sheet of insulating material, preferably evaporated on one side of a thin aluminum foil. The aluminum foil is supported on a fine metallic mesh having a high transmissivity for electrons. This target structure is disposed transversely of the tube axis. A writing gun faces the aluminum coated side of the target assembly and is located at one end of the tube envelope while a reading gun is positioned at the opposite end of the envelope to face the obverse side of the target assembly. The operating potentials of the writing gun are high in order that electrons emitted therefrom may have sufficient energy to pass through the aluminum foil and through the layer of insulating material to effect induced conductivity. A signal may be employed to modulate the writing beam which is scanned across the target assembly to establish a charge condition representing the signal modulation. An output signal is obtained from a load impedance connected in series with a collector electrode positioned adjacent the target assembly on the side facing the reading gun.

In operation, a reference charge condition is established on the target assembly at the outset and the target is then scanned by the writing beam modulated with an input signal. The electron induced conductivity varies the charge condition of the target assembly and establishes a charge pattern corresponding or representing the input signal. The stored intelligence may be recovered by scanning the target assembly by the reading beam which is unmodulated. The reading beam is of low velocity so that it does not induce conductivity in the target. Its effect is to restore the reference charge condition in the target assembly by effecting secondary electron emission from the face of the target which it scans. This emission, resulting in the collection of electrons by the collector electrode, is manifest in collector electrode current which develops the signal potential across an impedance. Obviously, the developed signal potential may be obtained from that impedance.

Although tubes of this construction are known and have been operated successfully, they are subject to certain limitations. For example, the signal output has been undesirably low and the response is sufficiently slow that intelligence may not be adequately stored in a single fast trace of the writing beam.

Accordingly, it is an object of the invention to provide a storage tube which avoids one or more of the aforementioned limitations of prior devices.

It is a specific object of the invention to provide a storage tube having a materially increased output.

A further object of the invention is to provide a storage tube which exhibits improved response, especially for signals of high frequency.

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A particular object of the invention is the construction of an improved target assembly for a storage device of the type under consideration which substantially amplifies signals translated therethrough.

Another particular object of the invention is to provide a signal storage tube having improved time-storage properties.

A storage tube constructed in accordance with the invention comprises an evacuated envelope which contains a target electrode including a phosphor screen deposited on a support member. A photo-conductive layer of a material having the property of bombardment-induced conductivity is placed in juxtaposition with the phosphor screen. Means are provided for projecting a beam of electrons through the phosphor screen onto the photo-conductive layer to establish conductivity in the latter by two phenomena, (a) by photo-conductivity in response to light developed in the phosphor screen due to the passage of electrons therethrough, and (b) by bombardment-induced conductivity in response to the impingement of the electron beam on the photo-conductive layer.

The target electrode assembly to which the invention is specifically directed comprises a first portion constructed of a material which emits radiation in response to impinging electrons. This first portion may be a separate fluorescent layer secured to a support or it may constitute a support member formed of a material such that the support emits radiation in response to impinging electrons. The target assembly further includes a second portion, in juxtaposed relation to the first portion, and constructed to be photo-conductive, that is to say, it conducts in response to the radiation of the first mentioned portion. The second portion is also constructed to have the property of electron-bombardment-induced conductivity. This second portion may be a single layer of a photo-conductive material which also has the property of bombardment-induced conductivity. Alternatively, the second portion may comprise two layers; a first layer which is a photoconductor and a second layer which has the bombardment-induced conductivity property.

The features of the present invention which are believed to be novel are set forth with particularity in the appended claims. The invention, together with further objects and advantages thereof, may best be understood by reference to the following description taken in connection with the accompanying drawing, in the several figures of which like reference numerals identify like elements, and in which:

FIGURE 1 is a schematic representation of a storage tube embodying the present invention; and

FIGURES 2 through 6 represent various forms that the target assembly of that tube may take.

Referring now more specifically to FIGURE 1, the storage tube there represented has an enclosing envelope 21 usually made of glass with a central portion of large diameter from which extend a pair of reduced-diameter neck sections. A target electrode assembly 33, constructed in accordance with the invention, is disposed transversely of the tube axis essentially in the center of the enlarged diameter section. The target assembly comprises an electron-permeable conductive support member 34 shown as a thin conductive wire mesh having a high transmissivity for electrons. A thin layer 36 of fluorescent material is deposited on the side of mesh 34 which faces a reading electron gun to be described hereinafter. The fluorescent layer is preferably deposited by evaporation in order that it may be sufficiently thin to be readily penetrated by the electrons of a writing electron beam which is also to be described hereafter. Zinc sulfide, cad-

mium sulfide, cadmium selenide, aluminum oxide self-activated by aluminum, and other similar phosphors activated by manganese or silver may be employed for layer 36.

A photo-conductive layer 37, constructed of a material exhibiting the property of bombardment-induced conductivity, is placed in juxtaposition with the fluorescent or phosphor layer 36. Layer 37 may be formed of an insulating material such as barium fluoride, magnesium fluoride and the like but it has been found that antimony trisulfide is particularly advantageous for this purpose. The target electrode assembly 33 is completed by a conductive layer 35 which is preferably a thin aluminum foil positioned on one side of wire mesh 34. It is not particularly significant on which side of mesh 34 the aluminum layer is located; as shown it is on the side opposite phosphor screen layer 36.

The described target assembly may be charged, so to speak, with intelligence or an input signal in response to its being scanned by a high velocity writing beam and to that end the arrangement includes means for projecting a beam of electrons through phosphor screen 36 onto photo-conductive layer 37 in order to concurrently establish a conductivity pattern in response to the conjoint effect of photo-conductivity and bombardment-induced conductivity as will be explained hereinafter. This means is the writing gun which comprises a cathode 23, a first grid or control electrode 24, a focusing electrode 25 and an anode 25a. The electron gun structure may be entirely conventional and therefore has been represented schematically.

Scanning of target assembly 33 with the writing beam is accomplished by a deflection yoke 26 positioned in customary fashion at a center of deflection close to the juncture of the neck section of the tube housing the writing gun and the enlarged diameter section containing the target electrode. Any suitable generating system (not shown) may be employed to energize the deflection yoke with line and field frequency signals to accomplish scanning of the target assembly by the writing electron beam in a series of fields of spaced parallel lines. In order that the scanning may result in the storing of intelligence in the target assembly, the writing beam is modulated with an input signal representing that intelligence. For that purpose, an input terminal 48 which may be coupled to any suitable source of input signal is connected with control grid 24 through a coupling capacitor 47. Control electrode 24 has a grid resistor 46 and is operated to be slightly negative relative to cathode 23. The cathode, on the other hand, is at a high potential difference with respect to target assembly 33 in order to establish a high velocity writing beam focused on the target.

Stored information to be extracted from the target assembly is read out by means of a reading electron beam originating at an electron gun contained in the opposite neck section of the tube envelope. As shown, this gun comprises a cathode 28, a control electrode 29, a focusing electrode 30 and an anode 30a. This is likewise a conventional electron gun structure and has an associated deflection yoke 31. It will of course be understood that yoke 31 is likewise to be energized by line and field scanning signals in order that it may trace a series of fields of parallel lines on the target assembly at selected scanning frequencies.

A collector electrode 39 is positioned between anode 30a of the reading electrode system and the target assembly to collect electrons emitted from that assembly. An impedance 43 is coupled in series with the collector and serves to develop a signal potential that may be obtained from the output terminal as designated by the arrow 45. Interposed between collector 39 and the target assembly is an annular shading electrode 38 which serves to provide a more uniform distribution of the charge on the surface of the storage electrode. Both electrodes 38 and 39 are coupled through resistors 42 and 43 to a source

of operating potential as are the other electrodes of the reading gun system. The electrode potentials of the reading gun establish an electron beam of much lower velocity than the writing beam, of sufficiently low velocity that it does not effect bombardment-induced conductivity in the target assembly. The conductive mesh 34 of the target may be operated at ground potential as indicated.

In describing the operation of the storage tube, it will be assumed initially that target assembly 33 has been primed by scanning with the reading beam. The reading beam is unmodulated and its effect is to drive off secondary electrons from the surface 40 of the target assembly upon which that beam is focused. Scansion of the target by the beam to accomplish the emission of secondary electrons tends to bring the potential of surface 40 to that of collector 39. Since conductive mesh 34 and conductive layer 35 are established at ground potential, there is a uniform or reference charge condition established across the target assembly and it is the establishment of this reference charge condition that is referred to as priming the target assembly.

Having primed the target, the writing beam modulated by an input signal applied to terminal 48 is scanned across the surface of the target assembly facing cathode 23. Scansion by the writing beam changes the charge condition of the target assembly so that it manifests a charge pattern representing the intelligence of the input signal. The change in charge condition results from elemental areas of the target assembly being rendered conductive in response to bombardment-induced conductivity and also in response to photo-conductivity both of which may be produced by the impinging writing beam.

It will be apparent that if during the scansion of one elemental area of the target the input signal shall bias the writing beam substantially to cut off, that area of the target will not experience a change in its charge condition. At the other extreme, where an elemental area of the target is subjected to the full intensity of the writing beam, it experiences full conductivity which brings it and the corresponding elemental area of surface 40 of the target assembly to a common potential, specifically to ground. More particularly, the writing beam for this assumed condition penetrates aluminum layer 35, mesh 34, and fluorescent layer 36 to impinge upon the near surface of insulating layer 37. Since the material of this layer is selected as one which exhibits the property of induced bombardment conductivity and since the velocity of the writing beam is sufficiently high to take advantage of that property, the result is that this elemental area of surface 34 is rendered conductive. Its conduction tends to bring both elemental areas of the opposed faces of insulating layer 37 to the same potential and its effect is augmented by fluorescent layer 36.

Layer 36 is excited by the writing beam and emits radiation which produces an additional response in the local area of layer 37 since the material of this layer has the additional property of photo-conductivity. The two conductivity effects, that attributable to bombardment and that attributable to its photo response, cooperate in changing the charge of the elemental target area.

Scanning of the target assembly by the writing beam as it is modulated by the input signal results in changing the charge condition of the target assembly so that it represents the input signal. The target may now be considered as charged with intelligence in contra-distinction to its initial condition in which it was primed to have a uniform charge throughout its surfaces.

The stored information may be extracted by scanning surface 40 of the target assembly with the reading beam. If the reading beam is incident at one elemental area of target 40 which exhibits its reference charge, no secondary electrons are emitted and there is no contribution from this element to the output signal. On the other hand, at any instant when the reading beam impinges upon an elementary portion of surface 40 which has

been completely discharged under the influence of the writing beam secondary electrons are driven off to restore that elemental area of surface 40 to its initial reference charge. The electrons emitted are collected by collector 39, developing a signal component across impedance 43. As a consequence, scanning of target surface 40 by the reading beam develops a signal voltage across impedance 43 which represents the stored information, that is to say, represents the signal applied at input terminal 48 to modulate the writing beam. This may be supplied to a load as indicated by the arrow 45 with as much amplification as desired.

It may be shown that the writing beam may develop a signal component in the circuit of collector electrode 39 and this may be discriminated against, if desired. For example, one may modulate the reading beam with a high frequency signal of constant amplitude. Where that is done, the stored signal information developed in the circuit of collector 39 may be derived through a filter tuned to the frequency of the modulating signal but then the output is first detected before application to a load.

One embodiment of the arrangement of FIGURE 1 which has been constructed and operated successfully utilized the following parameters which are given by way of illustration and in no sense by way of limitation.

Writing gun potentials:

Cathode 23	-----	-10,000 volts.
Control grid 24	-----	50 volts negative relative to cathode 23.
Focus electrode 25	-----	-8,000 volts.
Anode 25a	-----	Ground potential.

Reading gun potentials:

Cathode 28	-----	-1,000 volts.
Control grid 29	-----	50 volts negative relative to cathode 28.
Focus electrode 30	-----	-500 volts.
Shading electrode 38	-----	+20 to 30 volts.
Collector electrode 39	-----	+10 to 20 volts.
Anode 44a	-----	Ground potential.

The target modification of FIGURE 2 includes a thin conductive transparent layer 50 of gold bismuth oxide positioned between fluorescent layer 36 and insulating layer 37 to maintain the potential on the backside of the insulating layer.

The modification of FIGURE 3 is similar to that of FIGURE 2 except that in this instance there are discrete and separate layers of material for photo-conductivity and bombardment-induced conductivity. In particular, layer 51 is a photo-conductive material but layer 52 is a material chosen primarily for the property of bombardment-induced conductivity. By contrast with the embodiment of FIGURE 1, it is clear that a single layer may exhibit properties of photo-conductivity and bombardment-induced conductivity or, alternatively, two separate layers may be used each selected for one or the other of these properties. In FIGURE 3 the photo-conductive layer 51 is adjacent fluorescent layer 36 and it must be electron permeable so that the beam may reach layer 52 to excite it. The order of these layers is not critical so long as the inner layer has the properties necessary to permit the excitation of the other layer.

A further modification is shown in FIGURE 4. Here, conductive mesh 34 is in the center of the assembly with aluminum layer 35 and phosphor layer 36 on the side thereof facing the writing gun. A gold bismuth oxide layer 50 and the insulating layer 37 are on the side which faces the reading gun.

Another target assembly is shown in FIGURE 5 and features a composite semi-conductor element. A first zone 58 of the composite element is doped to exhibit fluorescent properties having a long after-glow. The next zone 59 of the semi-conductor exhibits photo-conductive properties in response to radiation from zone 58.

The final zone 60 exhibits the property of bombardment-induced conductivity.

The semi-conductor element may be made of zinc sulfide, cadmium sulfide or zinc-cadmium sulfide. To fabricate this element, a layer 58 of zinc sulfide is evaporated onto aluminum foil 35 to an approximate depth of one micron. The zinc sulfide layer is doped by evaporation of copper and gallium or indium to be fluorescent and have the desired long after-glow property. Next a zinc sulfide layer 59 is evaporated onto layer 58 and is doped with copper and thermally treated to diffuse the copper throughout the layer. This is carried out in a vacuum or in a gas atmosphere to the end that layer 59 contains from 0.1 to 1.0% of copper contrasted with a copper content of only 10^{-3} to 10^{-4} percent for zone 58. Zone 59 accordingly is doped to be a photoconductor. Finally, a third layer 60 of zinc sulfide having the inherent property of bombardment-induced conductivity is evaporated onto layer 59.

The conductive wire mesh 34 of the afore-described target assembly may be omitted and in its place a layer 61 of aluminum oxide, self-activated by aluminum, may be used as a support as indicated in FIGURE 6. Since the activated aluminum oxide layer 61 emits ultra-violet radiation in response to excitation by electrons, this same layer provides the further function of fluorescent layer 36 in the illustrative embodiment of FIGURE 1. Of course, if layer 61 is not activated and is thus unable to energize photo-conductive layer 37, a fluorescent layer is to be added between layers 61 and 59.

The described arrangements, taking advantage of photo-conductivity and induced bombardment conductivity, permit an increased output from storage devices of the type under consideration. The target assembly has an improved high frequency response and may be quick acting so that a significant amount of information may be stored in a single pass of the writing beam. As illustrated, one material may be utilized to impart the desired photo-conductivity and induced bombardment conductivity to the target assembly or, alternatively, separate layers individually having one of these conductivity properties may be used. Of course, the relative position of the two such layers is of no critical importance and they may be inter-changed from what is represented in the drawing, assuming of course that the layers are transparent as required to make full use of both types of conductivity.

While particular embodiments of the invention have been shown and described, it will be obvious to those skilled in the art that changes and modifications may be made without departing from the invention in its broader aspects, and, therefore, the aim in the appended claims is to cover all such changes and modifications as fall within the true spirit and scope of the invention.

I claim:

1. A target electrode assembly for an electronic storage device of the type having at least one electron source comprising:

a first portion constructed of an electron permeable material which emits a radiation in response to impinging electrons from said source; and a second portion in juxtaposed relation to said first portion constructed to be photo-conductive in that it conducts in response to said radiation of said first portion and which also exhibits the property of electron-bombardment-induced conductivity in response to impinging electrons from said source.

2. A target electrode assembly for an electronic storage device of the type having at least one electron source comprising:

a first portion constructed of an electron permeable material which emits a radiation in response to impinging electrons from said source;

- and a second portion in juxtaposed relation to said first portion including a photo-conductive layer responsive to said radiation of said first portion and a layer which exhibits the property of electron-bombardment-induced conductivity in response to impinging electrons from said source.
3. A target electrode assembly for an electronic storage device of the type having at least one electron source comprising:
- a first layer of an electron permeable material which emits a radiation in response to impinging electrons from said source;
 - and a second layer in juxtaposed relation to said first layer constructed to be photo-conductive in that it conducts in response to said radiation of said first layer and which also exhibits the property of electron-bombardment-induced conductivity in response to impinging electrons from said source.
4. A target electrode assembly for an electronic storage device of the type having at least one electron source comprising:
- a first portion constructed of an electron permeable material which emits a radiation in response to impinging electrons from said source;
 - and a second portion in juxtaposed relation to said first portion including a photo-conductive layer adjacent said first portion, having a high transmissivity for electrons and being responsive to said radiation of said first portion and further including a layer which is remote from said first portion and exhibits the property of electron-bombardment-induced conductivity in response to impinging electrons from said source.
5. A target electrode assembly for an electronic storage device of the type having at least one electron source comprising:
- a support member;
 - a first portion carried by said support member and constructed of an electron permeable material which emits a radiation in response to impinging electrons from said source;
 - and a second portion carried by said support member in juxtaposed relation to said first portion, constructed to be photo-conductive in response to said radiation of said first portion and also exhibiting the property of electron-bombardment-induced conductivity in response to impinging electrons from said source.
6. A target electrode assembly for an electronic storage device of the type having at least one electron source comprising:
- a support member constructed of a material which emits radiation in response to impinging electrons and having a high transmissivity to electrons from said source;
 - and a second member carried by said support member, constructed to be photo-conductive in that it

- conducts in response to said radiation of said support member and which also exhibits the property of electron-bombardment-induced conductivity in response to impinging electrons from said source.
7. A target electrode assembly for an electronic storage device of the type having an electron source comprising:
- an electron permeable support member;
 - an electron permeable fluorescent layer carried by said support member;
 - an electron permeable photo-conductive layer superposed on said fluorescent layer;
 - and a layer superposed on said photo-conductive layer exhibiting the property of electron-bombardment-induced conductivity in response to the impingement of electrons from said source.
8. A target electrode assembly in accordance with claim 1 in which said first portion is a layer composed of one of the groups of compounds consisting of aluminum oxide and magnesium oxide.
9. A target electrode assembly in accordance with claim 1 in which said second portion is a layer composed of one of the groups of compounds including barium fluoride, magnesium fluoride, arsenic tri-sulfide, and antimony tri-sulfide.
10. A target electrode assembly in accordance with claim 1 comprising a semi-conductor which has a first zone doped to exhibit fluorescent properties, has a second zone doped to exhibit photo-conductive properties and further has a third zone doped to exhibit the properties of electron-bombardment-induced conductivity.
11. A storage tube comprising in an evacuated envelope:
- a target electrode comprising a phosphor screen;
 - a photo-conductive layer of a material having the property of bombardment-induced conductivity in juxtaposition with said phosphor screen; and
 - means for projecting a beam of electrons through said phosphor screen onto said photo-conductive layer to concurrently establish a conductivity pattern in the latter:
 - (a) by photo-conductivity in response to light developed at said phosphor screen by the passage of said electron beam therethrough and
 - (b) by bombardment-induced conductivity in response to impingement of said electron beam on said photo-conductive layer.

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