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2,859,376

ELECTRON DISCHARGE STORAGE DEVICE

Filed May 19, 1955

3 Sheets-Sheet 1

FIG. 1

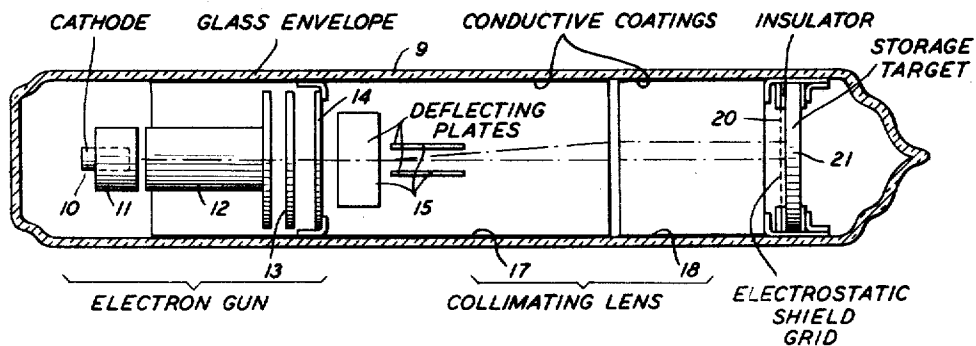


FIG. 2A

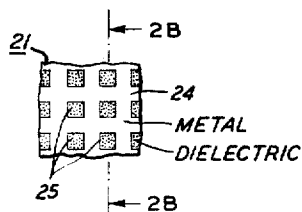


FIG. 2B

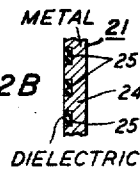
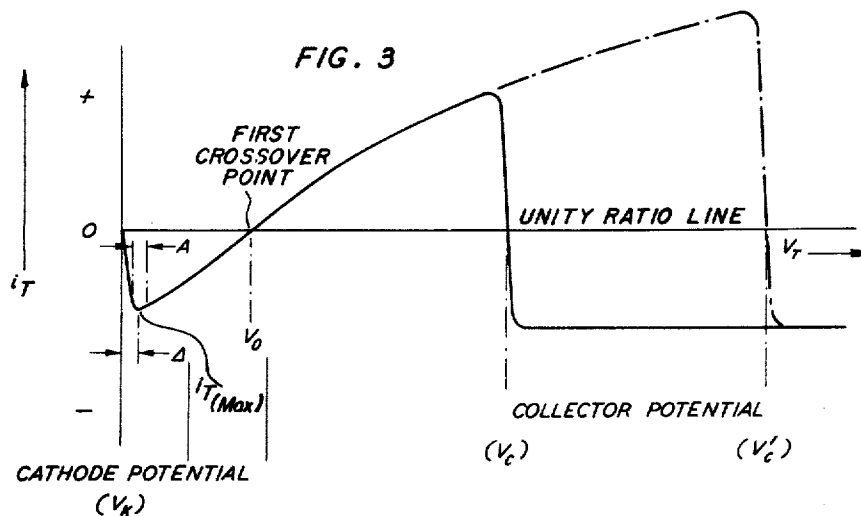


FIG. 3

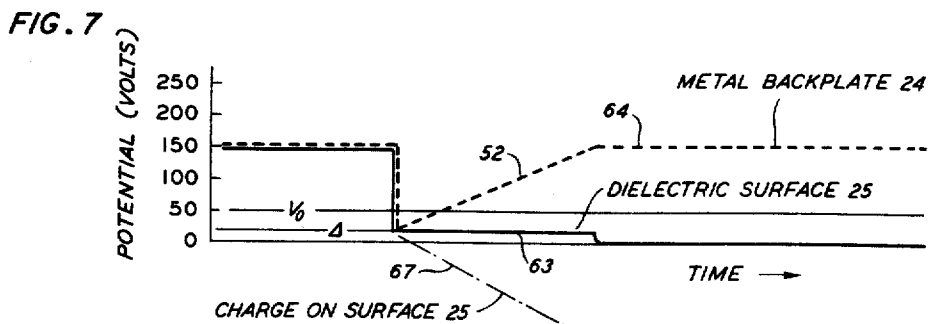
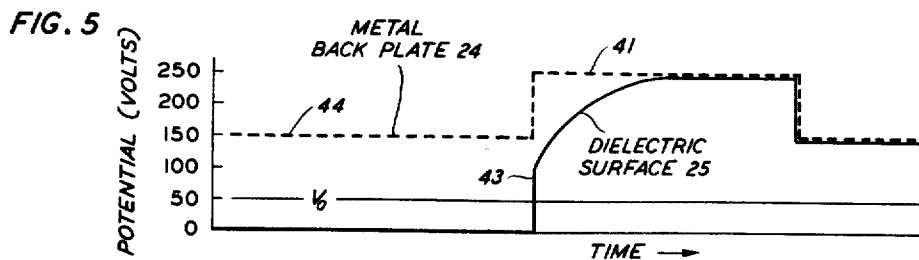
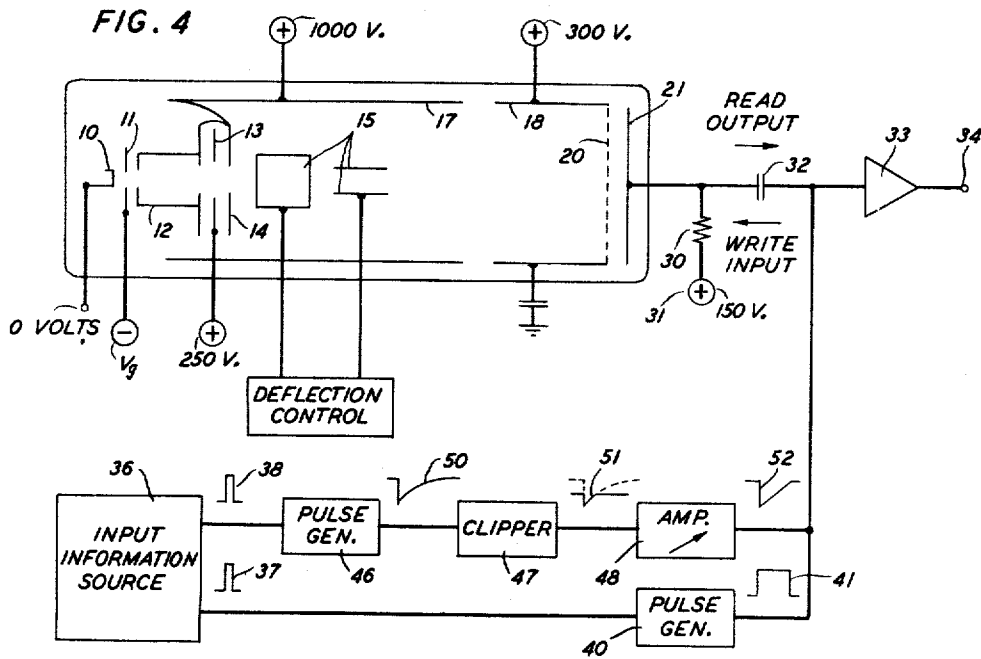


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3 Sheets-Sheet 2



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FIG. 6

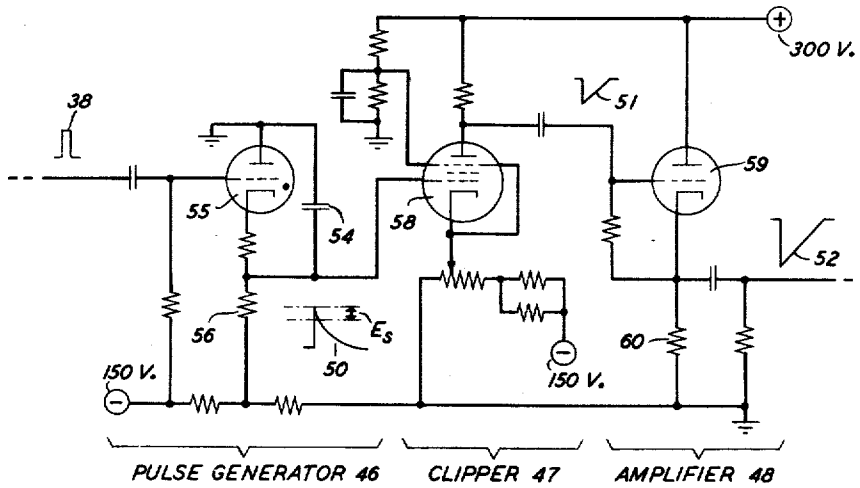


FIG. 8

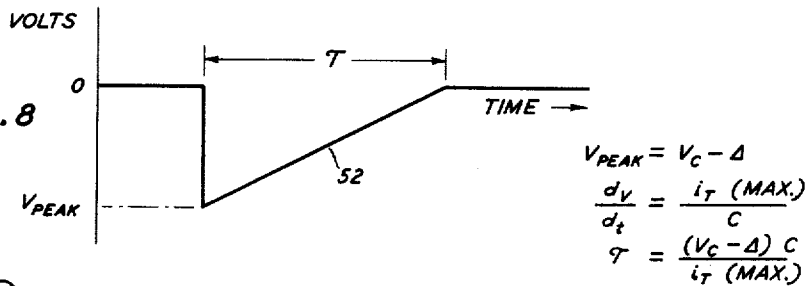


FIG. 9A

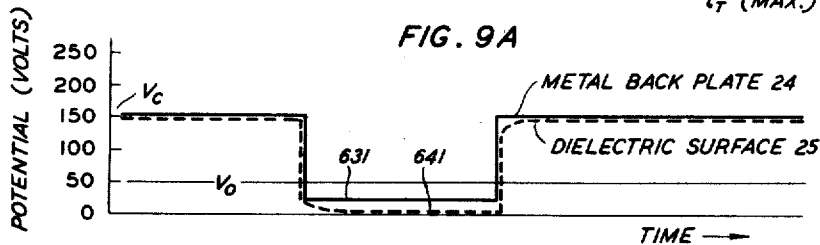
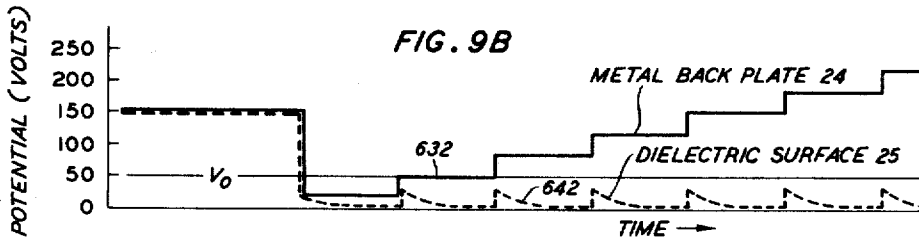


FIG. 9B



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ELECTRON DISCHARGE STORAGE DEVICE

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12 Claims. (Cl. 315—8.5)

This invention relates to electron discharge storage devices and more particularly to such devices having two stable potential states.

There are a number of storage tubes known which utilize the equilibrium potentials acquired on insulating surfaces under electron bombardment to store binary information. Certain of these devices and their general characteristics are set forth in "Storage Tubes and Their Basic Principles" by M. Knoll and B. Kazan, John Wiley and Sons, N. Y., 1952. Another type of storage device is that known as the dielectric island storage tube described in Patent 2,726,328, issued December 6, 1955, of A. M. Clogston and in French Patent 1,055,818, October 21, 1953.

One characteristic of a dielectric island storage tube is that information is stored on discrete dielectric spots mounted on a metallic back plate by placing the spots at either of two stable equilibrium conditions, either at the cathode or zero potential V_k or the collector potential V_c , these two stable equilibrium points being on opposite sides of the so-called cross-over potential so that, under bombardment by an electron stream, the dielectric will charge to one or the other of these two potentials.

The writing of information in the storage thus comprises pulsing the target while applying an electron beam and allowing the change in charge on the surface of the dielectric to place the dielectric at one or the other of these stable potentials. However, a change in charge involves a finite time. This time will be dependent on the rate at which the charge is changed and more specifically on the magnitude of the current, or electrons, either flowing towards or away from the dielectric surface, depending on whether the secondary emission factor is less than unity, as when writing down to V_k , or greater than unity, as when writing up to V_c .

Further, the collector voltage V_c may be set at substantially any desired value by biasing the target assembly. The cross-over voltage V_0 , however, is a factor of the dielectric surface itself and cannot be varied. If the back plate voltage V_c is of the order of twice or more the cross-over voltage V_0 , the charging of the dielectric surface down to the cathode or zero potential V_k has priorly been attained in a large number of charging steps. Even in cases where the collector voltage is less than twice the cross-over voltage, as in the above-mentioned application and patent, two charging steps have been required.

It is, however, of great importance to be able to write or alter information in the tube storage as rapidly as possible. Prior techniques of writing up to the collector potential V_c have been generally adequate but prior techniques for writing down to cathode or zero potential V_k have been very time consuming, requiring as much as several times the period of time for the other writing operation. This has accordingly slowed down the whole cycle of information storage to a great and undesirable degree.

It is an object of this invention to provide an improved electron discharge storage device capable of storing in-

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formation in either of two stable potential states on a dielectric surface.

It is another object of this invention to decrease the time for writing information in an electron discharge storage device and specifically in a dielectric island tube.

It is a further object of this invention to reduce to a minimum the time requisite for erasing one value of stored information or writing down to the other value of stored information represented by cathode potential V_k .

It is a still further object of this invention to provide an improved writing circuit for an electron discharge storage device.

It is still another object of this invention to provide an improved method for altering the potential state of a dielectric element in an electron discharge storage device.

These and other objects of this invention are attained in a specific embodiment thereof wherein the writing circuit comprises a pulse generator, a clipper, and an amplifier arranged to provide a pulse of specified initial amplitude, subsequent slope and duration to the target of a dielectric island storage tube. The current or secondary emission characteristic of all materials under electron bombardment is basically the same and includes a portion, below the so-called cross-over voltage V_0 , at which the secondary emission factor is less than unity. In this portion the target current i_T , which represents electrons emitted by the dielectric, or circuit current toward the dielectric from the cathode side, increases to a maximum absolute value $|i_{T(max)}|$ from the potential V_0 and then very quickly drops to zero at the potential V_k ; this is clearly seen in the attached drawing and is further described below.

The rate of change of charge on the surface of the dielectric element will of course be dependent on the magnitude of the current i_T at the target. Thus the maximum charging rate, and the minimum time requisite for the change in charge, would occur if the current during the charging process could be maintained at the maximum target current during substantially the whole charging time.

In accordance with an aspect of this invention, this is attained by applying to the target assembly and specifically to the metallic back plate thereof a triangular shaped pulse to write the surface of the dielectric element to the cathode or zero potential V_k . This pulse has a sharp initial drop of a magnitude such that the potential of the dielectric element is immediately placed in the region of substantially maximum target current. The pulse then rises in value at the rate requisite to keep the potential of the surface of the dielectric element so that the current to the element is always the maximum target current. Specifically the time rate of charging the element is given by the expression:

$$\frac{dv}{dt} = -\frac{|i_{T(max)}|}{C} \quad (1)$$

where v is the potential difference between the surface of the dielectric element and the metal backplate, $|i_{T(max)}|$ is the maximum absolute value of target current, and C is the capacitance to be charged which is largely that between the surface of the dielectric element and the back plate of the target.

Therefore the slope of the applied writing pulse, in accordance with this invention, is arranged to have the value

$$+\frac{|i_{T(max)}|}{C} \quad (2)$$

by appropriate correlation of circuit parameters in the writing circuit. Further the duration of the pulse is made such that the pulse is present only until the potential of the metallic back plate has been returned to its initial or stable value V_c ; at that time the pulse is effectively turned

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off and the dielectric element charges the remainder of the way down to V_k under the influence of the electron beam alone.

In one specific illustrative embodiment of a writing circuit, the desired writing pulse is attained by first rapidly discharging a condenser through a gas tube and then charging the condenser through a resistor, the values of resistor and condenser being such that the charging time constant affords the desired slope of the writing pulse. The pulse is then clipped and amplified, the amplifier being arranged so that the pulse has the required initial amplitude to reduce the voltage on the dielectric element to the region of maximum target current.

It is a feature of this invention that a writing pulse be applied to an electron discharge storage tube to place a dielectric element at the potential V_k , the writing pulse being shaped to maintain the surface of the dielectric element at a potential for maximum current whereby a minimum time is required to change the charge on the dielectric element and thus write the desired information thereon.

It is another feature of this invention that the writing pulse for writing down to cathode potential V_k on a dielectric element in an electron discharge storage device have an initial steep portion and a rising portion, the slope of which corresponds to the rate of change of charge on the dielectric element. Specifically, it is a feature of this invention that the slope of the rising portion of the writing pulse be given by the expression

$$+\frac{|i_{T(max)}|}{C} \quad (3)$$

where $|i_{T(max)}|$ is the maximum absolute value of the target or charging current and C is the capacitance between the surface of the dielectric element and the metallic back plate of the target.

It is still another feature of this invention that the initial amplitude of the writing pulse be such as substantially immediately to change the potential of the dielectric element from collector potential V_c to the potential at which the target current is a maximum, the slope of the rising portion of the pulse be as given above, and the duration of the pulse be just sufficient to raise the back plate potential back to V_c .

It is a further feature of this invention that the writing circuit for a dielectric island storage tube comprise a pulse generator, a clipper, and an amplifier, the pulse generator generating a pulse having an initially sharp front and a rising portion having a slope as given above, the clipper and amplifier determining the amplitude of the initially sharp front portion to be such as immediately to drop the potential of the dielectric element to the desired value.

It is still a further feature of this invention that the writing circuit for a dielectric island storage tube comprise a pulse generator having a condenser, a gaseous discharge device, and a resistor, the condenser discharging through the gaseous discharge device to give an initial steep front to the generated pulse and charging back through the resistor, the time constant of the charging circuit being such that the slope of the generated pulse maintains the surface of the dielectric element at the target of the tube at the potential for maximum target current during the charging and writing process.

A complete understanding of this invention and of these and various other features thereof may be gained from consideration of the following detailed description and the accompanying drawing, in which:

Fig. 1 is a representation of electron discharge storage tube of the dielectric island type with which this invention may be employed;

Figs. 2A and 2B are partial plan and section views, respectively, of the target assembly of the tube of Fig. 1 showing the dielectric islands and metallic back plate of the target assembly of the tube;

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Fig. 3 is the characteristic curve for target current i_T against target potential V_T on bombardment of the target by an electron beam;

Fig. 4 is a schematic representation of the tube of Fig. 1 and a block diagram representation of the writing circuits therefor in accordance with one specific illustrative embodiment of this invention;

Fig. 5 is a plot of potential against time for storing information by writing up to the collector potential V_c ;

Fig. 6 is a schematic representation of one specific illustrative erasing circuit in accordance with the embodiment of this invention depicted in Fig. 4;

Fig. 7 is a plot of potential against time for storing information by writing down to the cathode potential V_k in accordance with this invention;

Fig. 8 is a voltage-time plot indicating the characteristics of the writing down or erasing pulse applied to the target of the storage tube in accordance with this invention; and

Figs. 9A and 9B are plots of potential against time for storing information by writing down to cathode potential in accordance with prior art processes.

Turning now to the drawing, Fig. 1 is a representation of a storage tube with which this invention may be employed. The tube is of the type known as a dielectric island storage tube, as described in Patent 2,726,328, issued December 6, 1955, of A. M. Clogston and French Patent 1,055,818, October 21, 1953, and comprises an elongated glass envelope 9 in which are positioned, in succession, an electron gun comprising a cathode 10, a control grid 11, a first accelerating electrode 12, a focusing electrode 13, and a second accelerating electrode 14, two pairs of deflection plates 15, a collimating lens comprising a first conductive coating 17 on the inner wall of the envelope 9 and electrically connecting to the accelerating electrodes 12 and 14 and a second conductive coating 18, and a target assembly comprising an electrostatic shield grid 20 and a storage target 21. The shield grid 20 is a fine mesh or wound grid of high electron transparency spaced, as of the order of 0.010 inch, from the storage target 21; the grid is advantageously electrically connected to the second conductive coating 18 and serves to prevent pulses from the target region affecting the action of the collimating lens.

The storage target 21 in a dielectric island storage tube of the type described in the above-mentioned United States and French patents comprises, as seen in Figs. 2A and 2B, a metallic back plate 24, such as of copper Inconel, an alloy of nickel, chromium and iron, or other materials, on which are positioned a plurality of small dielectric or insulating elements or islands 25. In one specific illustrative embodiment the target back plate 24 was provided with an array of 250 dielectric spots per linear inch. Thus the islands 25 may be of the order of .002 inch in diameter and may be positioned on centers spaced .004 inch apart. The target 21 may advantageously be prepared by photo-etching the metallic back plate 24 using a dot negative of the required mesh size and subsequently filling the etched holes with a silica sol suspension of Vycor glass powder, Vycor itself being nearly pure silica. However, other insulating elements may be used for the islands 25, as is known in the art.

In Fig. 3 is shown the curve characteristic of target current i_T as a function of bombarding potential V_T when the target is bombarded by an electron beam. This curve is basically characteristic of all materials, both insulators and conductors, with a secondary emission ratio δ greater than unity for some range of bombarding potential V_T . As can be seen, the characteristic crosses the current axis at three distinct points, namely, when the bombarding potential is at the cathode potential V_k , at the collector potential V_c , and at some intermediate potential V_0 . In the specific embodiment of this invention described herein, the portions of the metallic plate 24 between adjacent dielectric islands 25 serve as the collector

electrode and thus the target potential is also the collector potential V_c . Accordingly, as further discussed below, whenever the target potential is changed the collector potential V_c is also changed. It should be noted that in this embodiment the grid 20 is sufficiently removed from the surface of the target 21 to have substantially no effect as a collector.

As can be seen, the secondary emission ratio is less than unity for bombarding potentials less than V_0 and is greater than unity for bombarding potentials greater than V_0 . V_0 is commonly called the first cross-over and is the bombarding potential value at which $\delta=1$. The value of V_0 , as is known, is entirely a property of the bombarded material and is very susceptible to surface conditions; it cannot, however, be changed by varying potentials in the storage tube circuit. The target current curve, however, again crosses the axis at the collector potential V_c . The exact shape of the curve at this potential depends on a number of factors, among them being the initial velocity of the secondary emission of the material being bombarded and the geometrical configuration of the target-collector arrangement. If the collector potential is changed, as to V'_c , the overall curve shifts to the dotted one, as shown.

As is known in the art, the points $V_T=V_k$ and $V_T=V_c$ are stable equilibrium points to one or the other of which an insulator or unconnected metal target will go and remain at under the influence of a continuously bombarding electron beam. The point V_0 , however, is a point of unstable equilibrium and small departures from the potential V_0 in either direction will cause the target to seek that one of the two stable points towards which the departure is. In some prior types of storage tubes, such as that known as the barrier grid storage tube, storage is attained only in the neighborhood of the collector potential V_c , which may be of the order of twenty times the voltage of the cross-over or equilibrium point V_0 . In such tubes the target is a continuous plate of a dielectric material positioned on a metallic backplate and the potential of the dielectric or storage surface is always more positive than V_0 . Information is stored by applying a signal to the back plate while the beam is impinging on the target so as to leave a charge on the dielectric surface when the beam and signal are removed. In the process of reading out the information, the stored signal is destroyed.

However, in a dielectric island storage tube both stable equilibrium points V_k and V_c are employed for binary storage of information, V_c being of the order of only a few times the magnitude of V_0 . In dielectric island tubes the process of reading does not destroy the information stored but in fact the impinging beam revivifies the potential of the dielectric spot from any change which may have occurred for any reason whatever. Thus in the dielectric island type of storage tube one value of binary information, which may be defined as binary "1," is written or stored when the dielectric island is at the potential V_c and the other value of binary information, which may be defined as binary "0," is written or stored when the dielectric island is at the potential V_k . These are sometimes referred to as writing "up" to V_c and erasing or writing "down" to V_k .

While the above and following descriptions are concerned with the characteristics of a single dielectric island 25, considered exemplary of the action of the target 21, it is to be understood that in actual practice the electron beam will normally impinge on a number of such islands 25 simultaneously, the dielectric island diameter and the separation of the islands being small in comparison to the electron beam diameter. In practice, it has been found that if the beam diameter covers about ten to twelve dielectric islands, the target appears substantially as a homogeneous surface to the electron beam. In this manner the acute problem of registration

that would occur were it necessary to focus an electron beam cyclically on but a single dielectric island is avoided.

In Fig. 4 there is depicted, in schematic form, a dielectric island storage tube as described above with reference to Figs. 1 and 2, together with the writing circuits therefore in accordance with one illustrative embodiment of this invention. As there depicted the target 21 is connected through a resistor 30 to a source 31 of positive potential, which in one specific illustrative embodiment was +150 volts. The target 21 is also connected through a condenser 32 to the output and writing circuits. The output circuit comprises merely an output terminal 34 connected to the capacitor 32 through an output amplifier 33, the read output pulse being transmitted from the target 21 through the capacitor 32 to the amplifier 33 and thence, amplified, to the output terminal 34. The reading operation is described further below.

The writing circuit comprises an input information source 36 which, in accordance with the dictates of associated circuitry, initiates either a write "1" pulse 37 or a write "0" or erase pulse 38. Let us consider the operation of writing a "1" or writing up to the potential V_c . The pulse 37 is applied to a pulse generator circuit 40 which generates a square pulse 41. Pulse 41 is applied through the capacitor 32 to the backplate 24 of the target 21.

To appreciate best the operation of a dielectric island storage tube in writing up to V_c or in changing a stored "0" to a stored "1" let us again consider the characteristic of Fig. 3 together with the voltage-time plot of Fig. 5 and let us assume, for purposes of this explanation, a few exemplary values. Thus we shall assume a cross-over voltage V_0 of 50 volts, a collector voltage V_c of 150 volts and a writing pulse 41 of 100 volts amplitude; the duration of the pulse is not critical provided that it is of a minimum length, as will be apparent.

Initially with a zero stored in the target 21 the potential of the dielectric island 25 is V_k or zero and the potential of the metal backplate 24 is V_c or +150 volts. These conditions are indicated at the left of Fig. 5 wherein the continuous line 43 indicates the potential of the dielectric island 43 and the dashed line 44 the potential of the metal backplate 24. As these two potentials are stable equilibrium conditions, they will not change even under electron bombardment of the target 21.

When it is desired to write "1" the pulse 41 is applied to the backplate 24 and the potential of the backplate is raised from $V_c=150$ volts to $V'_c=250$ volts. As the surface of the dielectric island 25 is capacitively coupled to the back plate 24 it also must rise in potential 100 volts from the potential $V_k=0$ to a potential of 100 volts. However, as is readily seen on both Figs. 3 and 5, the potential of the dielectric island is now above or to the right of V_0 and therefore in an unstable region where it will tend to go to V'_c under bombardment by an electron beam. Accordingly under bombardment by an electron beam the potential of the dielectric island will rise to $V'_c=250$ volts. Then when the pulse 41 is terminated, any time after sufficient charge has accumulated on the dielectric island 25 to raise its potential to 250 volts, the potential of both the backplate 24 and the surface of the dielectric island 25 fall back to $V_c=150$ volts, which is the stable equilibrium voltage for storage of a "1" in this specific embodiment.

In order to increase the capacity and usefulness of the storage tube it is desirable to reduce the time requisite for writing and erasing stored information. It is therefore desirable to have the surface of the dielectric island, on writing a "1," charge under the bombardment of the electron beam at a fast rate, i. e., with a large value of target current i_T . This is readily attained by employing a square shaped pulse 41 which rapidly causes the potential on the dielectric island surface to

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increase to values which, as seen in Fig. 3, correspond to large values of target current i_T .

When it is desired to write "0" or to erase a "1," the write "0" pulse 38 is applied from the input information source 36 to the erase circuit which comprises a pulse generator 46, a clipper circuit 47, and an amplifier 48. The pulse generator 46 is triggered by the input pulse 38 and produces a pulse 50 having an initial steep front followed by a slower rising portion. This pulse is applied to the clipper circuit 47 which removes all but the lower section of the wave shape 50, producing the pulse 51. Pulse 51 is then applied to the amplifier 48 the constants of which have been predetermined so that the output pulse 52 therefrom is of the same shape as pulse 51 but of an amplitude suitable for use in erasing the information on the target 21, as discussed further below.

The pulse generator 46 may advantageously include a condenser 54, as seen in Fig. 6 which is a detailed schematic diagram of one specific illustrative embodiment of the erase circuit in accordance with Fig. 4. The wave form 50 may thus be attained by a rapid discharge of the condenser 54, as through a gaseous discharge device 55, followed by a charging of the condenser 54 through a resistor 56, the values of capacitance and resistance of the condenser 54 and resistor 56 being chosen so that the pulse 50 has a predetermined wave form in accordance with an aspect of this invention, as discussed further below.

In the specific embodiment of the erase circuit depicted in Fig. 6 a positive going pulse 50 is applied to the clipper circuit 47, which advantageously comprises a pentode 58 which both clips and inverts the pulse, only the portion E_s of pulse 50 being employed. The pulse 51 from the pentode plate is applied to the grid of a triode 59 of the amplifier circuit 48, the desired erase pulse 52 being taken from the cathode resistance 60 of the triode.

In order best to understand the erase operation in accordance with aspects of this invention, let us again consider the characteristic curve of Fig. 3 together with the voltage-time plot of Fig. 7, assuming the same exemplary values as in the writing operation described above with reference to Fig. 5. When it is desired to erase a stored bit, i. e., to write down from a stored "1," at V_c to a stored "0," at V_k , both the metal backplate and the surface of the dielectric island are initially at the potential V_c , which we have assumed to be 150 volts; in Fig. 7 the continuous line 63 indicates the potential of the dielectric island surface and the dashed line 64 the potential of the metal backplate 24.

When the erase pulse 52 is initially applied from the erase circuit, and specifically from the amplifier 48 thereof, to the backplate 24, the potential of both the backplate 24 and the dielectric island 25 drop to some value below the cross-over potential V_0 . Accordingly, when an electron beam is applied to the dielectric island, the surface of the dielectric will tend to charge towards the stable equilibrium point $V_k=0$. In this process of erasing the surface from V_c to V_k a finite time is required to make this change in potential due to change of charge on the dielectric island. In accordance with an aspect of this invention, this charging time is reduced to a minimum.

Let us turn back to Fig. 3; in this curve it will be observed that there is a region "A" close to the cathode potential V_k at which the current leaving the target, or the electrons arriving at it, is a maximum. This is the region then at which charge accumulates most rapidly in lowering the potential of an element towards cathode potential. In accordance with an aspect of this invention, a dielectric island at potential V_c may be most rapidly reduced to V_k by first pulsing the spot to the "A" region and then allowing the pulse to decay at the rate the spot charges negatively while it is in the "A"

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region. Accordingly the parameters of the pulse 52 are chosen, by the capacitor 54 and resistor 56 of the pulse generator circuit 46 and the amplifier 48, so that the initial amplitude of the pulse will drop the voltage of both the backplate 24 and the dielectric island 25 to the voltage Δ at this "A" region and then keep the dielectric island surface at that potential while the backplate potential rises again to the potential V_c .

This action is depicted in Fig. 7. The dielectric island 25 and the target backplate 24 are initially at the potential $V_c=150$ volts, which is of course above the cross-over V_0 . When the pulse 52 is applied, the voltage of both the backplate 24 and the dielectric island surface, which are capacitively coupled together, drop to the potential Δ of region "A." In this region the time rate of charging, in the negative direction, is:

$$\frac{dv}{dt} = -\frac{|i_{T(\max)}|}{C} \quad (4)$$

where $i_{T(\max)}$ is the absolute value of the target current i_T in the "A" region and C is the capacitance of the spot whose potential it is desired to change.

In accordance with an aspect of this invention the backplate pulse 52 is shaped to rise at the same slope, that is, the pulse slope is made equal to

$$+\frac{|i_{T(\max)}|}{C} \quad (5)$$

Accordingly the potential at the surface of the dielectric island 25, as indicated by the line 63, remains at the potential Δ . When the potential of the backplate 24 has been raised, by the pulse 52, to V_c , the pulse is removed and the dielectric island surface will then charge the rest of the way to the potential $V_k=0$, as indicated in Fig. 7.

The pulse generator 46 in the erasing circuit generates a pulse, as by charging of a condenser, whose rising slope is given by the expression

$$+\frac{|i_{T(\max)}|}{C} \quad (6)$$

for the particular target 21 of the storage tube. In this manner the target dielectric island surface remains at the potential at which maximum current leaves the surface during substantially the entire erasing operation, thereby attaining the fastest erasing process. In general the potential will be of the order of 5 or 10 volts, depending on the material of the dielectric.

The action of the target 21 during the erasing process can also be considered by looking more carefully at the potential of the surface of the dielectric island 25, which is given by the line 63 in Fig. 7. At any instant the potential at the surface of the dielectric 25, in terms of the cathode potential, will be determined by the potential on the backplate 24, to which the surface 25 is capacitively coupled, and the charge that has built up on the surface. Accordingly we can consider the line 67 as being the potential of the charge on the surface 25 due to the charging action of the beam. The rate of charging, and thus the slope of this line, are given by Equation 4. Further in accordance with this invention line 67 is of maximum slope as the charging action occurs throughout substantially its entire duration with maximum current. At any instant the sum of the charge voltage, as given by line 67, and the backplate voltage, as given by line 64, is the potential of the dielectric surface, as given by line 63, and specifically is the potential Δ .

The characteristics of the pulse 52 in accordance with this invention are indicated in Fig. 8 and are as follows:

(1) The initial amplitude of the pulse is $V_c-\Delta$;

(2) The slope of the pulse is

$$\frac{|i_{T(\max)}|}{C}$$

(3) The duration of the pulse is

$$\frac{(V_c-\Delta)C}{|i_{T(\max)}|}$$

A further appreciation of the advantages of this invention can be gained from consideration of Figs. 9A and 9B together with the current characteristic of Fig. 3. Fig. 9A is a voltage-time plot showing the effect of attempting to erase with a single square erase pulse when the target potential V_c is more than twice the cross-over potential V_0 . In this case the backplate 24 and dielectric island surface are initially at V_c . When the target is pulsed both the backplate potential 631 and the dielectric island surface potentials 641 drop, because of the pulse, to some value below V_0 . At this potential, under the influence of an impinging electron beam, the potential of the dielectric island surface will charge down to $V_k=0$. When the pulse is removed, the potentials of both the backplate and the dielectric island will increase by the magnitude of the pulse. As $V_c-V_0=100$ volts and $V_0=50$ volts, in this exemplary embodiment, the dielectric potential must return above V_0 by some value, after which it will charge back to V_c and thus no erasing is possible by this process. This process however can be utilized if V_c is chosen so that $V_c-V_0 < V_0$, as is disclosed in the above-mentioned patents.

For the exemplary embodiment depicted a stepped erase pulse could be employed, as depicted in Fig. 9B wherein line 632 indicates the potential of the backplate 24 and dashed line 642 the potential of the surface of the dielectric island. By arranging each increment or step of the rise in backplate potential less than V_0 the potential of the dielectric island surface 25 is never raised above V_0 and thus always charges back to the potential V_k . In this manner erasure of information is attained in successive steps. It is apparent however that such is a very time-consuming process.

In accordance with this invention erasure of information or the changing of the dielectric island surface potential from V_c corresponding to a stored binary "1," to V_k , corresponding to a stored binary "0," is attained in a single step in the minimum time by proper choice of the shape of the erase pulse applied to the backplate in terms of the physical constants of the target itself.

When it is desired to read the stored information the electron beam is returned to the dielectric islands. If a zero is stored in the dielectric island, the dielectric surface will be at the potential $V_k=0$ and will tend to restrain the emission of secondary electrons from the metal backplate portions immediately surrounding the dielectric island; if a binary "1" has been stored, the dielectric surface is at the potential V_c , which is the same as that of the backplate, and this action will not occur. Thus while from all dielectric spots, either at $V_k=0$ or at V_c , a current equal to the impinging beam current is returned (see Fig. 3), the secondary current from the metal area around the dielectric spots that escapes and is not returned to the target varies from a high value from the regions around spots at V_c , where the secondaries are uninhibited in their flow, to a low value from the metal areas around the spots at V_k , where secondaries tend to be suppressed. This variation in effective secondary emission of the metal target plate is a useful form of signal separation which reveals itself as an amplitude variation in the output pulse appearing at output terminal 34 during the reading process.

It is to be understood that the above-described arrangements are merely illustrative of the application of the principles of the invention. Numerous other arrangements may be devised by those skilled in the art without departing from the spirit and scope of the invention.

What is claimed is:

1. An electron discharge storage device comprising a target having a dielectric element and a metallic backplate, said dielectric having a current voltage characteristic under bombardment by an electron stream having a maximum absolute value of target current adjacent zero potential, means for projecting a stream of electrons against the surface of said dielectric element, and means for maintaining the target current at said maximum ab-

solute value during charging of said surface by said electron stream, said last mentioned means including means for applying a pulse to said backplate having an initially steep front portion and a slowly rising portion, the slope of said rising portion corresponding to the rate of change of charge on said surface of said dielectric element during charging of said surface by said electron stream.

2. An electron discharge storage device comprising a target having a dielectric element and a metallic backplate, there being a capacitance C between the surface of said dielectric element and said backplate, means for projecting a stream of electrons against said target, said dielectric having a current voltage characteristic under bombardment by an electron stream having a maximum absolute value of target current $|i_{T(max)}|$ adjacent zero potential, and means for maintaining the potential on said dielectric surface during charging of said surface by said electron stream at a value that the target current at said surface is $|i_{T(max)}|$, said last mentioned means including means for applying a pulse to said backplate having an initially steep falling portion to drop the potential of the surface of said dielectric element to said value and having a slowly rising portion having a slope $|i_{T(max)}|/C$.

3. An electron discharge storage device wherein information is stored on the surface of a dielectric element by placing said surface at one of two stable potentials comprising a target having a dielectric element and a metallic backplate, there being a capacitance C between the surface of said dielectric element and said backplate, means for projecting a stream of electrons at said dielectric element, means for biasing said backplate at one of said stable values of potential V_c , said dielectric having a current-voltage characteristic under bombardment by said electron stream having a maximum value of target current $i_{T(max)}$ at a voltage Δ adjacent the other stable value of potential on said dielectric surface during charging of said surface by said electron beam at said voltage Δ to attain minimum time for changing the potential of said surface from said stable value V_c to said stable value V_k , said last mentioned means including means for applying a pulse to said backplate having an initially steep falling portion of an amplitude $(V_c-\Delta)$, a slowly rising portion having a slope $i_{T(max)}/C$, and a duration $(V_c-\Delta)C/i_{T(max)}$.

4. An electron discharge storage device in accordance with claim 3 wherein said last mentioned means further comprises pulse generator means for generating a pulse having said slope and amplified means for determining said amplitude of said initially steep falling portion.

5. An electron discharge storage device in accordance with claim 4 wherein said pulse generator means includes a condenser, means including a gaseous discharge device for rapidly discharging said condenser, and means including a resistor for slowly charging said condenser at a rate equal to said slope.

6. An electron discharge storage device wherein information is stored on the surface of a dielectric element by placing said surface at one of two stable potentials comprising a target having a dielectric element and a metallic backplate, means for projecting an electron stream against the surface of said dielectric element, and circuit means for applying a pulse to said backplate to maintain the current at said target constant under bombardment by said electron stream, said circuit means including a pulse generator and amplifier means for generating a pulse having an initially falling portion and a slowly rising portion having a slope equal to the rate of change of charge on said dielectric element under said bombardment by said electron stream.

7. The method of altering the potential state of a dielectric element in an electron discharge storage device comprising projecting an electron stream against said element, applying an initial voltage to a metallic backplate adjacent to said element to establish the potential of the surface of said element at a value for maximum

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electron collection by said element, and maintaining the potential of said surface constant during charging of said element by said electron beam, whereby the rate of change of charge on said surface is maximum during the period of said charging.

8. The method of altering the potential state of a dielectric element in an electron discharge storage device comprising projecting an electron stream against said element, applying an initial voltage to said element so that the magnitude of the current at said element is maximum, and causing said voltage applied to said element to change at a rate equal to the rate of change of charge on the surface of said element, whereby the potential of the surface of said element remains constant.

9. The method of altering the potential state of a dielectric element in an electron discharge storage device, said dielectric element being supported on a target backplate having an original value of potential applied thereto, comprising the steps of projecting an electron stream against said element, applying a voltage pulse to said backplate of a magnitude to determine the potential of the surface of said element at an initial value for maximum target current under bombardment by said electron stream, causing the magnitude of said voltage pulse to vary at a rate equal to the rate of change of charge on said dielectric element surface whereby the potential at said surface remains substantially constant, and terminating said voltage pulse when the potential of said backplate has returned to its original value.

10. The method of changing the potential state of a dielectric element in an electron discharge storage device initially at a collector potential V_c to cathode potential V_k comprising the steps of bombarding the element with an electron stream, applying a pulse to said element to change the potential of the surface of said element from V_c to a potential adjacent V_k at which the electron collection of the element is a maximum, and maintaining the potential at said surface constant during charging of said surface by said electron stream, whereby the rate of change of charge on said surface is maximum over the period of said charging.

11. The method of changing the potential of a dielec-

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tric element in an electron discharge storage device initially at a collector potential V_c to cathode potential V_k , said dielectric element being mounted on a metallic backplate, comprising the steps of bombarding the element with an electron stream, applying a pulse to said backplate initially to change the potential of the surface of said element from V_c to a potential adjacent V_k at which the electron collection of the element is a maximum, causing the magnitude of the pulse applied to said backplate to decrease at a rate equal to the rate of change of charge on the surface of said element due to said electron stream, whereby the potential of said surface remains constant, and terminating said pulse when the potential of said backplate has been raised back to V_c .

12. The method of changing the potential of a dielectric element in an electron discharge storage device initially at a collector potential V_c to cathode potential V_k , said dielectric element being mounted on a metallic backplate, comprising the steps of bombarding the element with an electron stream, applying a pulse to said backplate initially to change the potential of the surface of said element and the potential of said backplate from V_c to a potential adjacent V_k at which the electron collection of the element is a maximum, causing the amplitude of said pulse applied to said backplate to decrease at a rate equal to the rate of change of charge on the surface of said element due to said electron stream whereby the potential of said surface remains constant and the rate of change of charge on said surface is maximum during the period of said charging, discontinuing said pulse when the potential of said backplate has returned to V_c , and causing the potential of said surface to change from said constant potential adjacent V_k to V_k under bombardment by said electron stream alone.

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