

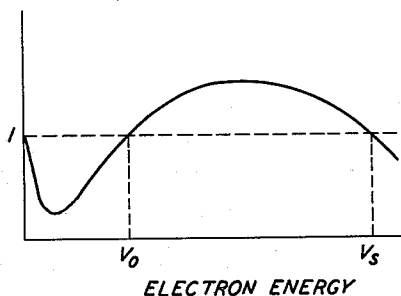
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BINARY STORAGE SYSTEM
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2,726,328

SECONDARY EMISSION RATIO

FIG. 1



NET TARGET CURRENT

FIG. 2

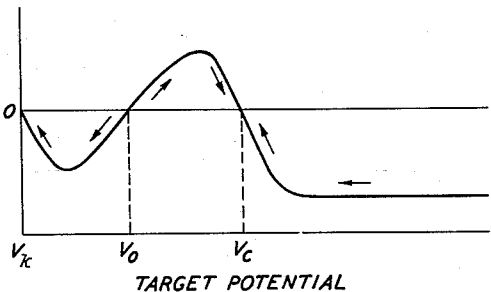


FIG. 3

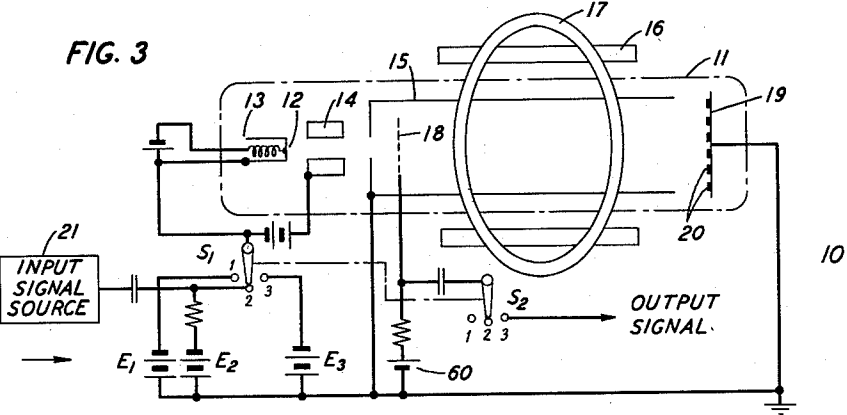


FIG. 4

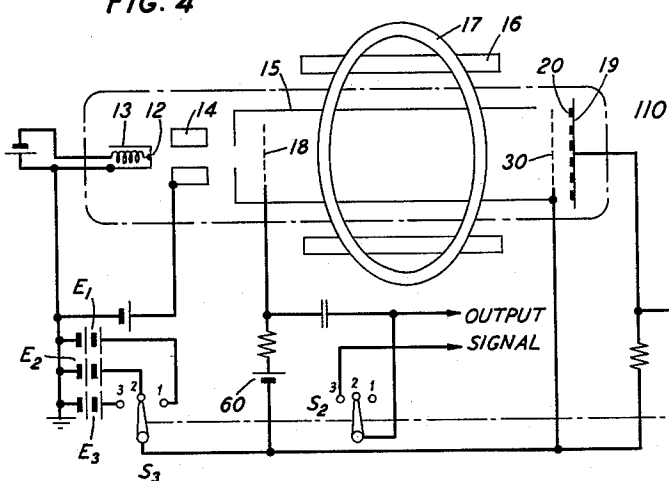
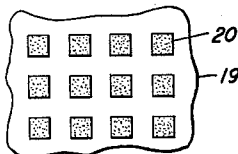


FIG. 5



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BINARY STORAGE SYSTEM

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4 Claims. (Cl. 250—27)

This invention relates to cathode-ray apparatus and, more particularly, to storage devices for electrostatic storage, wherein an input signal is stored in the form of a charge distribution for a period of time and converted subsequently into an output signal which is a facsimile of the stored signal.

Storage devices of this type generally make use of the fact that a pattern of electrostatic charges deposited on the surface of a good insulator can be retained for an appreciable period of time. In the operation of such a device, a cathode-ray beam is deflected to scan elemental areas of the face of a dielectric storing surface, and the potential or charge stored upon each of the elemental areas of the bombarded face is selectively varied in accordance with input signals. Thereafter, by a subsequent scanning, the charges stored upon these areas are resolved into respective potential changes in an output circuit.

This storing capacity has been utilized in several ways. In particular, it is characteristic that if an electron beam is directed from a source at a dielectric surface through a grid which is adjacent to the surface and is at a potential V_0 , there exist two stable potentials which the dielectric surface will assume as the electron energy of the beam is varied. For values of electron energy below a critical value V_0 which is a function of the dielectric surface, the stable position is the potential of the electron source V_k . For values of electron energy in excess of the value V_0 , the stable position is the potential of the grid V_0 . This characteristic is described in greater detail hereinbelow. It can be seen that an elemental area of an insulator can be made to provide in this way for the storage of one binary digit of information. For example, zero can be represented by storage at the source potential V_k and unity by storage at the grid potential V_0 . By use of an extended insulating surface to provide a plurality of elemental storage areas, a plurality of binary digits can be stored. This technique will hereinafter be referred to as binary electrostatic storage. Coding methods for converting signal information into binary pulse codes can be utilized herewith for the storage of more complex information.

One of the earliest developed devices for use in a system for taking advantage of this storing property of a dielectric surface comprises a source for providing an electron stream, a dielectric surface in target relationship with the source, and a mesh grid interposed between the source and the dielectric surface. In this arrangement, the grid wires act to establish a uniform second stable position over the whole surface and shield elemental areas from one another for permitting resolution of the surface into a plurality of elemental areas. In this way, an extended dielectric surface can be used for the storage of many binary digits if the various elemental storage areas can be prevented from coalescing or otherwise interfering with one another. However, it is found that for continued stability without coalescence, certain critical conditions must be satisfied.

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In particular, it has been found that for storage stability of elemental areas during the charging cycle, the grid potential V_0 must satisfy quite precisely certain relationships which are functions of the characteristic of the storage surface V_0 . However, it is undesirable to have storage stability depend upon the precise value of some voltage, as is the case here for the grid potential V_0 . Moreover, in practice, the surface characteristic V_0 will vary from point to point in a manner to make it extremely difficult to meet the condition for stability over the whole surface.

One solution that has been attempted in previously developed devices is the utilization for storage of a mosaic surface prepared by evaporating areas of conducting metal on a dielectric surface. However, in such devices, it is still important to have a mesh grid adjacent the storage surface to serve as the equipotential surface fixing the stable potential V_0 and reducing the mutual interaction between elemental areas. This grid must normally be spaced uniformly from the storage surface a distance comparable to the closest points it is desired to resolve and also should be of a corresponding fineness. The structural problem of satisfying these conditions imposes serious physical limitations in applications where it is desired to obtain maximum detail on a minimum storage surface. In addition, other considerations limit the utility of such a device. For satisfactory stability, it is necessary that the insulating regions surrounding the metallic islands have a high surface resistivity. This demands the most exacting care in preparing and processing the mosaic surface. As a consequence, it has been difficult and expensive to obtain satisfactory storage with devices of this kind.

Therefore, it is a broad object of this invention to improve devices for electrostatic storage.

Other objects related thereto are to simplify the construction of storage devices for binary storage and to increase the stability of storage surfaces for use therewith.

A principal feature of the present invention is a storage surface formed by depositing islands of dielectric material on a conducting member, for example, a sheet of metal. It has been found that with such a storage surface, the function served by the grid for fixing the stable potential V_0 and thereby providing binary electrostatic storage in the arrangement previously described can be readily performed by the conducting sheet with the consequent elimination of the grid. In operation, therefore, the conducting sheet is maintained at some voltage V_0 with respect to the electron source. The insulating islands thereafter can be charged either to cathode potential V_k or the potential of the conducting sheet V_0 . If the voltage V_0 is related to the storage element characteristic voltage V_0 in such a manner that the areas negatively charged to the potential V_k tend to grow in size, these charged areas can only expand until they approach the boundary between the dielectric islands and the metal. Negatively charged portions of the storage surface, therefore, can maintain stable configurations. Positively charged elements of dielectric, being surrounded by metal of the same potential, are also stable. Therefore, such a mosaic surface is adaptable for binary electrostatic storage.

A storage device wherein the storage surface comprises a mosaic formed of insulating islands on a conducting member, for example, islands of quartz on a metal plate, in accordance with the present invention, presents several important advantages over the mosaic surfaces of metallic islands on an insulating sheet known to the prior art. As mentioned hereinbefore, since the metallic sheet serves the function of the interposed grid, there is no requirement for a separate grid in front of the mosaic

surface. This permits structural simplification of a storage device embodying such a mosaic. In addition, it is usually easier to obtain high secondary emission from an insulating material than from a conducting surface. In applications where it is necessary to store and read information at a rapid rate, high secondary emission ratios are very important. Moreover, such a mosaic provides a high signal contrast between the two digits of the binary code. In a preferred embodiment of the invention, the output signal is derived during a scanning of the charge pattern on the storage mosaic by distinguishing between the rapidly moving electrons returned from the elemental areas charged to the negative potential V_k , which forms one of the code, and the slowly moving electrons returned from the elemental areas charged to the more positive potential V_c , which forms the second unit of the code.

The invention will be better understood by reference to the following more detailed description taken in connection with the accompanying drawings forming a part thereof, in which:

Figs. 1 and 2 are graphs useful in explaining the principles of binary electrostatic storage;

Fig. 3 is in part a diagram of a storage tube and in part a circuit schematic illustrating one embodiment of the invention in which the input signal is applied to the tube cathode;

Fig. 4 is in part a diagram of a storage tube and in part a circuit schematic illustrating an alternative embodiment of the invention wherein the input signal is applied to the tube anode; and

Fig. 5 shows in more detail a portion of the target assembly of a tube according to the invention.

Referring more particularly to the drawings, Fig. 1 illustrates a typical characteristic of a dielectric surface under bombardment by electrons. At low primary energies, the secondary emission ratio is less than unity, indicating that the net current is negative (i. e., the surface is assuming a negative charge resulting from the acquisition of electrons). As a result, a target element bombarded by low velocity electrons tends to assume a more negative potential. When the electron energy is increased to a critical voltage V_0 , the secondary emission ratio becomes equal to unity, and the net current to the target is zero. At higher energies, the secondary emission ratio exceeds unity, and the net current to the target is positive. At a very high voltage V_s , a saturation point is reached, after which the secondary emission ratio becomes less than unity again.

These characteristics are reflected in the graph of Fig. 2, wherein the net current to the dielectric target is plotted as a function of the target potential for the case in which a collector electrode is positioned adjacent the target, as, for example, a target surface according to the invention comprising dielectric storage elements deposited on a back plate conducting sheet of metal which is at a potential V_c , greater than the dielectric surface characteristic voltage V_0 and less than the saturation potential V_s . When a stream of electrons is directed towards the target surface from a cathode source at a potential V_k , then any storage element of the target surface which has a potential below the critical value V_0 will tend to accumulate a negative charge and will finally reach the cathode potential V_k . On the other hand, any element charged to a potential more positive than the critical value V_0 will become more positive and tend to approach the potential of the back plate. Thus, the cathode potential V_k and the back plate potential V_c are two stable points at which the target elements may maintain themselves under continuous bombardment by a stream of electrons. This characteristic of such a storage surface is utilized in a system for binary electrostatic storage, wherein the two stable points V_k and V_c serve as the two digits.

A preferred and exemplary form of a binary electrostatic storage system in accordance with the invention is shown in Fig. 3 and will be described with reference to that figure. The storage device 10 comprises an evacuated enclosing envelope 11 having at one end thereof an electron gun, which includes a cathode 12, a heating coil 13, the collimating electrodes 14, and the accelerating electrodes 15. The electron gun produces a concentrated electron beam which is projected centrally between two sets of deflecting means 16 and 17 mounted in space quadrature. In this preferred embodiment, a strong axial magnetic field is provided by magnetic coils (not shown) exterior to the tube to collimate the electron beam and aid in insuring a closely confined electron beam during its passage through the tube. In such a case, the deflecting means 16 and 17 are also preferably magnetic deflecting coils, although electrostatic means are practicable.

The electron beam is projected against a target mounted at the opposite end in the envelope 11, the target comprising a back plate 19 of conducting material, for example, copper, having evaporated, or deposited in other ways known in the art, on its front surface facing the gun a plurality of small insulating elemental areas 20, for example, .005-inch diameter islands of quartz. In Fig. 5, a portion of the storage surface is shown in greater detail. The elemental areas need not be regular in shape nor need the distribution be exactly uniform, since each elemental area is small in comparison with the scanning spot. Interposed between the electron gun and the target is a collector electrode 18. The collector electrode 18 preferably should be positioned to minimize interference therewith from the electron beam to limit spurious noise. One expedient for minimizing interference is to locate the collector electrode 18 near the electron gun at a point where the electron beam is in a well-concentrated stream under the influence of the accelerating electrode 15 and is not yet within the deflecting field of the coils 16 and 17. Then the collector electrode can conveniently be apertured to permit passage therethrough of the concentrated electron beam with a minimum of interference. The collector electrode is preferably a mesh grid of high transparency for reasons to be described in more detail hereinafter. The magnetic deflecting coils 16 and 17 are energized, in a manner well known in the art, by deflecting circuits (not shown) to sweep the electron beam cyclically in a predetermined scanning pattern across the target surface.

In reading, the switch S_1 is on position 3 so that the S_1 for successively changing the potential of the cathode in synchronism with the deflecting circuits so that after each complete scan of the storage surface, there is one advance in the position of the switch S_1 . The three positions 1, 2, 3 control sequentially the erasing, writing, and reading intervals of a complete storage cycle. In the erasing position, the cathode is negative with respect to the back plate 19 by a voltage which is fixed by the voltage supply E_1 . In the writing position, the quiescent cathode potential is fixed by the voltage supply E_2 . In addition, for writing, input signals are applied to the cathode 12 from an input source 21. The input source 21 is of a type to supply the off-on binary pulse code to be stored. In the reading position, the cathode 12 is at a potential fixed by the voltage supply E_3 . The collector electrode 18 also is connected to an electronic switch S_2 , operated in synchronism with the switch S_1 . An output signal is derived on the third position thereof in synchronism with the reading interval of the storage cycle. To facilitate collection, the collector electrode 18 is maintained at a slightly positive potential with respect to the back plate 19 by means of the voltage supply 60.

In describing the operation of the device, it will be helpful to assign, by way of example, typical values for the various cathode potentials to which the three positions of the switch S_1 correspond. In the erasing posi-

tion, the potential difference between the back plate 19 and the cathode 12 is adjusted to be less than the characteristic voltage V_0 of the storage elements 20. If, for example, it is assumed that for this particular surface, the characteristic V_0 is equal to 50 volts, then a typical value for the voltage supply E_1 can be 45 volts, so that during the erasing interval, the cathode is maintained at a voltage of -45 volts with respect to the back plate 19 whose potential is assumed to be at zero or ground. For the writing interval, the voltage between the cathode and the back plate is preferably adjusted to be between the voltage V_0 and $2V_0$; for example, the voltage E_2 can be 75 volts, so that the quiescent voltage of the cathode is -75 volts with respect to the back plate during this writing interval. In addition, the signal E_s , which is supplied by the input source 21, is made sufficient so that the sum of the voltages E_s and E_2 is greater than the sum of the voltages E_1 and V_0 . For values already designated for E_1 , E_2 , and V_0 , a signal voltage E_s of 25 volts is sufficient for the successful operation of the device. During the reading portion, the voltage difference between the back plate and the cathode is preferably maintained at a voltage equal to the voltage E_2 of the writing interval. Therefore, the supply E_3 is also made 75 volts. Now, for purposes of simple analysis, consider that cyclical sweep voltages are supplied to the deflecting means for sweeping the electron beam emitted by the cathode 12 in a scanning pattern over the whole of the target surface and that, in synchronism with each complete scan, the electron switch S_1 varies the cathode potential sequentially in accordance with the three intervals of the storage cycle. It will be important throughout that the intensity of the scanning beam be sufficiently high and the capacitance of the storage elements sufficiently low to insure full charging during the short intervals the elements are being swept.

During the erasing interval, each storage element is scanned by a beam whose energy is less than the characteristic voltage V_0 assumed for each element, so that as each element is swept by the beam, it assumes the first of the two stable positions, the cathode potential V_k described in connection with Figs. 1 and 2. Therefore, in this case, at the completion of this erasing scan, each element is left charged to -45 volts with respect to the grounded back plate. At the start of the writing interval, the cathode potential is fixed by the supply E_2 so that the cathode becomes -75 volts with respect to the back plate. Thereafter, if at the time a particular element is being scanned, the cathode is being supplied with an "on" signal, the amplitude of which in this case has been set at -25 volts, the cathode voltage will be decreased to -100 volts so that the voltage difference between the particular storage element and the cathode is 55 volts, which is in excess of the critical voltage V_0 , so that the element is charged to the second stable position V_0 , which is the voltage of the back plate. Therefore, after the beam has swept past the element, the stored element is left with a positive potential difference of 75 volts with respect to the cathode. However, for an element corresponding to an "off" signal, the voltage difference between the cathode and the element is only $75 - 45 = 30$ volts, which is less than the critical voltage V_0 , so that the element is charged to the first stable position V_k . Therefore, after the beam has swept past, this element is left at the potential of the cathode. In this manner, the storage surface obtains a charge distribution comprising areas charged positively with respect to the cathode voltage and areas charged to the voltage of the cathode. The nature of the charge on each of these areas is determined by the potential difference between the cathode and the storage element at the time the scanning beam impinged thereon during the writing interval. Since each of the storage elements 20 has a very high resistivity, the charge pattern thereon will remain stable for some time, thus constituting storage.

In reading, the switch S_1 is on position 3 so that the

cathode is maintained at the constant voltage E_3 with respect to the back plate during the whole of scanning interval. The output or reading signal is derived by collecting electrons returned from the storage surface during this reading scan. This return current is composed essentially of two kinds of electrons. When electrons are directed at an elemental area which has been charged to the cathode potential V_k , the element bombarded first accumulates a slight negative charge. Thereafter, electrons directed at this element are repelled by the negative field thereon and reflected back towards the electron gun at velocities comparable to those with which they approach the surface. These rapidly moving electrons constitute the first and undesirable part of the return current. By making the collector electrode of transparent mesh, the majority of these electrons can be permitted to pass undisturbed through the comparatively weak field surrounding the collector electrode without interception by the collector grid wires. The second kind of electrons constituting the return current comprises slow-moving electrons which are the result of secondary emission from the more positive portions of the target surface under bombardment by the electron beam. These slow-moving electrons are easily intercepted by the collector electrode and constitute the output current. Moreover, where elemental areas of the target surface are charged negatively, the resulting fields serve to suppress secondary emission from the surrounding metallic boundaries, and only fast electrons are returned from the surface. As a result, by distinguishing between the rapidly-moving electrons returned from negative areas and the slowly-moving electrons returned from positive areas, there is derived during the reading interval an output signal which is a reproduction of the stored binary signals.

Fig. 4 illustrates an alternative embodiment 110 of the invention, more particularly adapted for applying the input signal to the back plate. Optionally, there is interposed in front of the storage surface a neutralizing electrode 30 for minimizing the disturbance of the accelerating field in the region of deflection during the pulsing of the back plate 19. This electrode 30 is preferably a coarse mesh grid to minimize interference with the electron beam and is to be distinguished from the fine mesh grid utilized in devices in the prior art to serve the function served here by the back plate for securing the uniform second stable position over the whole storage surface, important for binary storage. In this device, the cathode is kept at a fixed potential, while the back plate potential is changed with respect thereto for each of the three scanning intervals of a complete storage cycle. The back plate 19 is connected to an electronic switch S_3 for successively changing the back plate potential in synchronism with the deflecting circuits so that after each complete scan, there is one advance in the position of the switch S_3 . The three positions sequentially control the erasing, writing, and reading intervals of a complete storage cycle in the manner already described, wherein the voltages E_1 , E_2 , and E_3 cooperate to secure binary storage. The input signal is supplied from the binary source 21 to the back plate by way of the electronic switch S_4 , operated in synchronism with the switch S_3 , to permit the input signal to pulse the back plate during the writing interval. The output signal is derived as before by collection of the return current during the reading interval.

It is to be understood that the above-described arrangements and modes of operation are merely illustrative of the principles of the invention. Numerous others may be devised by one skilled in the art without departing from the scope of the invention. In particular, it is possible to employ electrostatic focusing of the electron beam, in which case it may be preferable to position the collector electrode adjacent the storage surface and to apply the input signals to the back plate in the manner hereinbefore described.

Moreover, numerous applications for such a device will be evident to one skilled in the art. Devices of this sort can be connected in parallel with appropriate switching for storage of continuous signals. In addition, by varying the length of the reading interval with respect to the writing, band-width increase or reduction can be effected. What is claimed is:

1. In a binary electrostatic storage system, a cathode ray device comprising an electron beam source, means for controlling the velocity of the electron beam formed by said source, a storage electrode in target relationship with said beam source including a conducting member having thereon a plurality of discrete islands of insulating material having good secondary electron-emissive properties, a collecting electrode in secondary electron emission collecting relation with the storage electrode, and means for cyclically scanning the storage electrode with the electron beam for storing and reading signals thereon, a signal source, an output circuit, means including voltage supply means providing a plurality of different D.-C. biasing voltage levels, and switching means for applying different D.-C. biasing levels on the beam velocity control means on the storing and reading scans of the storage electrode surface and connecting electrically the signal source to the velocity control means on a storing scan and the output circuit to the collecting electrode on a reading scan.

2. In a binary electrostatic storage system, a cathode ray device comprising an electron beam source, means for controlling the velocity of the beam from said source, a storage electrode in target relation with said beam source including a conducting member having thereon a plurality of discrete islands of insulating material, and means for cyclically sweeping the electron beam over the storage electrode for storing and reading charge distributions on successive scans, a signal source, an output circuit, means including voltage supply means providing a plurality of different D.-C. biasing voltage levels, and switching means for applying different D.-C. biasing levels on the beam velocity control means during the storing and reading scans of the storage electrode surface, connecting the signal source electrically to the velocity control means on a storing scan for superimposing input signals on one biasing level whereby a binary signal pattern is stored on the storage electrode, and connecting electrically the output circuit to the cathode ray device on the reading scan.

3. In a binary electrostatic storage system, a cathode ray device comprising an electron beam source, a storage electrode in target relationship with said beam source including a conducting member having thereon a plu-

rality of discrete islands of insulating material having good secondary electron-emissive properties, means for cyclically scanning the storage electrode with the electron beam, and means for controlling the velocity of the beam impinging on the storage electrode, a signal source, an output circuit, means including voltage supply means providing a plurality of different D.-C. voltage levels, and switching means for applying different D.-C. biasing potentials on the beam velocity control means during the storing and reading cycles and connecting electrically the signal source and output circuit alternately to the cathode ray device during storing and reading scans.

4. In a binary electrostatic storage system, a cathode ray device comprising an electron beam source, a storage electrode in target relationship with said beam source including a conducting member having thereon a plurality of discrete islands of insulating material, means for cyclically scanning the storage electrode with the electron beam, and means for controlling the velocity of the beam impinging on the storage electrode including a control electrode and means for establishing a D.-C. bias between said control electrode and storage electrode, a signal source, an output circuit, and means including voltage supply means for providing a plurality of different D.-C. biasing levels, and switching means for applying a different D.-C. biasing level between the control electrode and the storage electrode and electrically connecting alternately on storing and reading scans the input source and the output circuit to the cathode ray device.

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