

May 9, 1961

W. VEITH ET AL

2,983,841

SIGNAL-STORING ELECTRON BEAM TUBE

Filed April 30, 1958

3 Sheets-Sheet 1



Fig. 1

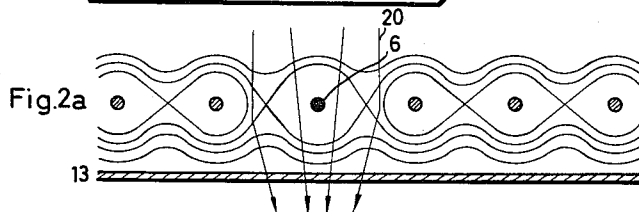
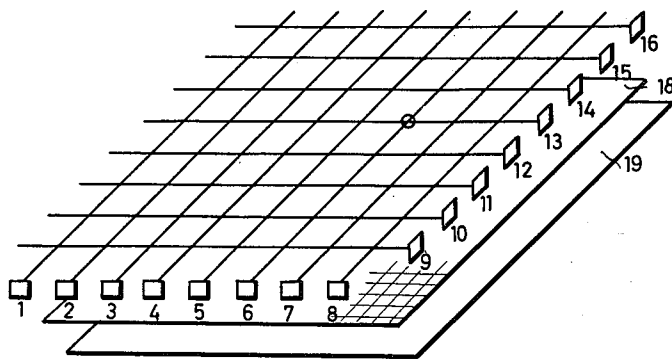
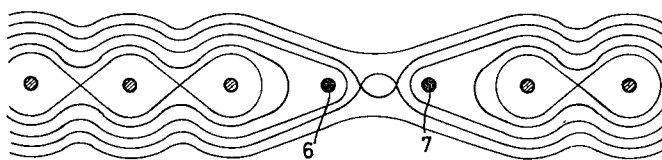


Fig. 2a

Fig. 2b



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Fig. 3a

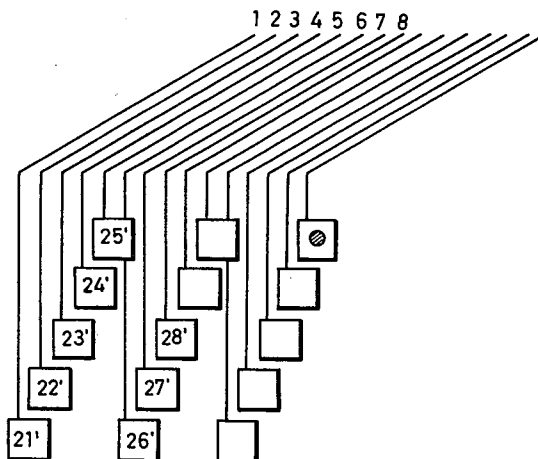
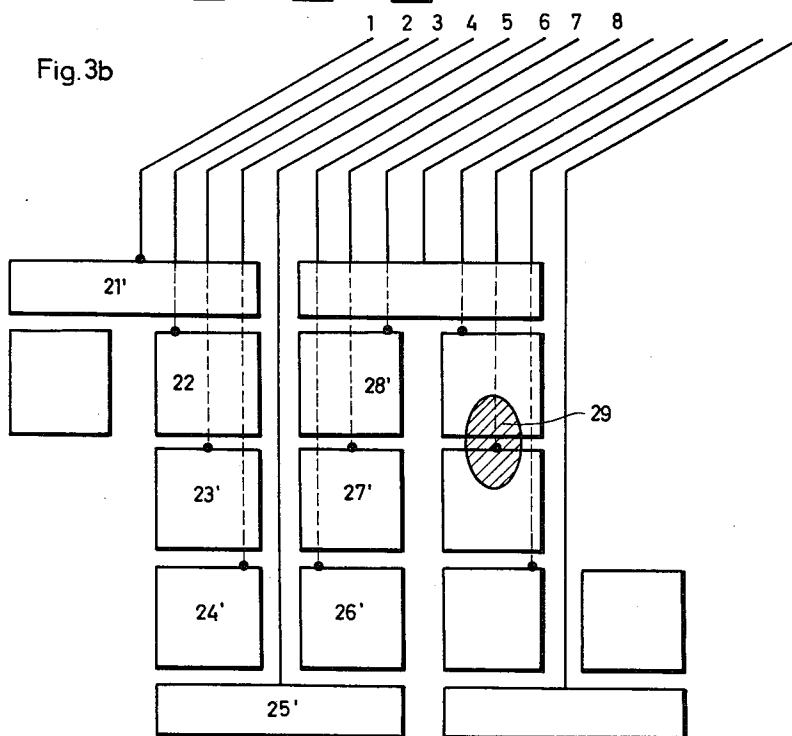


Fig. 3b



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Fig. 4

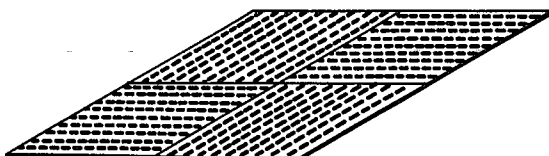


Fig. 5

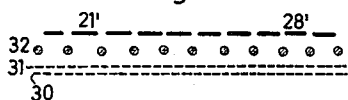


Fig. 6

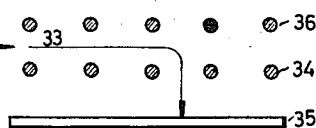


Fig. 8

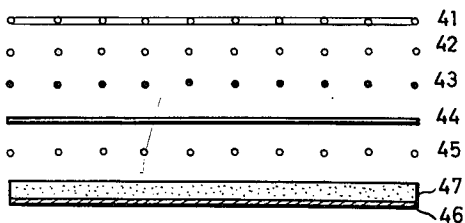


Fig. 9

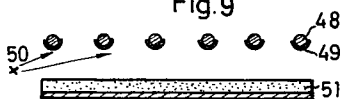


Fig. 10

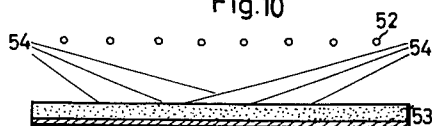
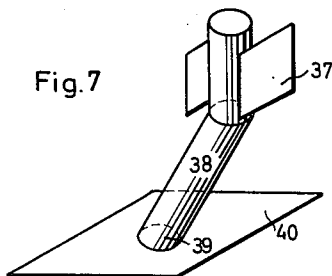


Fig. 7



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2,983,841

SIGNAL-STORING ELECTRON BEAM TUBE

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Claims priority, application Germany June 28, 1957

9 Claims. (Cl. 315-12)

This invention is concerned with an electron beam tube for storing electrical signals in the manner of a planar storage tube, comprising a storage electrode made of a metal-backed homogeneous insulating plate which is scanned by an electron beam, producing charges, due to release of secondary electrons, which correspond to the stored signals. The tube according to the invention is particularly useful for storing electrical signals, for example, in electronic computers and in communication systems and the like.

In known planar storage tubes, the storage electrode is scanned by an electron beam which is moved thereover line-by-line, under control of a suitable deflection system operating, for example, in a similar manner as a deflection system in a television tube and thereby exciting the bit points to be selected. Tubes constructed in this manner produce the same resolutions as picture tubes with, for example, 600 lines; however, the requirements in the case of storage tubes for the above indicated purposes with, for example, 400 times 400=160,000 bits, are incomparably higher. In case of a television tube, the total picture produced will not be particularly disturbed if an individual line is not accurately hit or, for example, if the n th line is recorded upon the $(n+1)$ line. As compared with this situation, in a storage tube, for example, for computing operations, the accurate position of each individual point is of interest; each individual point must be definitely secured. A further requirement must be put on such a storage tube, namely, in the course of an extended computing operation, a stored signal must be maintained at a given bit point, without renewal thereof, even in the presence of repeated charging and extinguishing of bit points surrounding such given points on all sides thereof. It will readily be realized that this problem cannot be solved even nearly satisfactorily in the case of a known planar storage tube in which the beam is deflected in a manner as in a cathode beam tube.

The object of the present invention is to provide an electron beam storage tube in which the selection of an individual point is not effected by badly controllable electrical or magnetic deflection as in a television tube, but by a particular control and selection system, making it possible to definitely determine upon the storage electrode the position of each individual bit point so that each bit may after the lapse of a desired time interval again be definitely ascertained in practically unchanged condition thereof. The sensitivity of the tube according to the invention is, therefore, appreciably greater than that of prior tubes.

This object is according to the invention realized by arranging ahead of the storage electrode two serially related control grids (selection grids) which are as compared with the respectively associated cathode negatively differently biased, each grid being made by wires extending in a layer exclusively in parallel and at right angle to the wires of the other grid. Upon simultaneously changing the potential to positive values, electrons from a beam flowing uniformly in the direction of the storage

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plate in the manner of an electron shower or from a regionally effective beam periodically showering the first control grid, will permeate through the control grids only in the immediate vicinity of the grid wires (crossing points), impacting in focused manner a point (bit) of the storage plate, which corresponds to the wires, and effecting at such point due to release of secondary electrons a corresponding positive charge (storage). This charge may be extinguished after a desired time interval in the same manner by the same electron shower responsive to increasing the positive potential of the storage plate to a value at which secondary electrons cannot be absorbed, thereby producing a signal at the signal plate.

The invention will now be explained more in detail with reference to the accompanying drawings, assuming, to give a numerical example, a storage tube provided for 160,000 bits. The representation in the drawings is purely schematic, showing and particularly identifying only the parts which are essential for the invention and which contribute to the understanding thereof.

Fig. 1 shows an arrangement of the wires of the control grids;

Figs. 2a and 2b are sectional views of the first control grid which is close to the cathode producing the electron shower, indicating the potential conditions obtaining at certain grid wires;

Figs. 3a and 3b illustrate the use of elements forming contact surfaces in connection with the grid wires;

Fig. 4 indicates the grouping of the contact surfaces to extend in a common plane;

Fig. 5 shows the use of current amplifying means in connection with contact surfaces of the grid wires;

Fig. 6 illustrates the use of a planar electron beam which is deflected in the direction of a control grid;

Fig. 7 indicates a modified arrangement in which a relatively undefined electron beam is guided to an area upon a control grid which encloses the desired bit point to be selected; and

Figs. 8, 9 and 10 show in schematic manner embodiments of devices for producing holding beams for the purpose of augmenting charges so as to obtain signals with full values.

It will be apparent from previous explanations that a planar storage tube for 160,000 bits must be provided with control grids each having respectively 400 or 401 wires depending upon whether the selection is effected by one or by two neighboring wires, and that the grids must be disposed so that the wires of one grid extend at right angle to the wires of the other grid.

Such an arrangement is represented in Fig. 1, showing for the sake of simplicity only eight wires for each grid. The wires marked 1 to 8 form the first grid and the wires marked 9 to 16 form the second grid. All grid wires are normally negative with respect to the cathode of the electron shower system (not shown in detail) or biased to cathode potential, so that the electrons of an electron beam producing an electron shower 17, are due to the negative potential of the first control grid slowed down to slow electrons and reflected. Potential conditions permitting passage of slow electrons will occur, for example, only when one wire of each grid receives positive potential. If it is, for example, desired to use the crossing point of the wires 6 and 13 for the fixation of the bit point associated therewith, the potential 0 will be placed on the wire 6 of the first control grid and a positive potential of about 50 to 200 volt will be connected to the wire 13 of the second grid. Part of the slow electrons will now permeate the two grids. Suitable spacing between the two grids and spacing thereof from the collector grid 18 will effect focusing of the electrons permeating the grids so that they impact the storage electrode 19 in a fine bit point, producing by the release of second-

ary electrons a positive charge corresponding to a stored signal. The potential conditions thereby occurring in the vicinity of the wires 6 and 13 are indicated in Figs. 2a and 2b, showing the first control grid which faces the cathode producing the electron shower in sectional view.

It will be seen that a field distribution permitting the passage of slow electrons will be produced only in the immediate vicinity of the wire 6, carrying 0-volt, and only at an instant when the wire of the second grid, for example, the wire 13 carries positive potential. It will also be seen that the electron paths 20 are deflected toward the control wire; accordingly, suitable spacing of the parts and use of proper potentials will make it possible to produce a finely focused bit point in alignment with the crossing point of the two selected wires.

If it is desired to use, for the determination of the bit point, the space between two neighboring wires of a grid instead of the crossing point between two wires, other potentials must be placed upon such wires, so as to obtain a potential distribution as indicated in Fig. 2b. The corresponding neighboring wires of the first grid are indicated at 6 and 7, the two wires of the second grid being omitted in the figure. It will be seen from the indicated course of the potential field that the slow electrons can in similar manner pass focused through the space between the wires.

The potential increase required on the respective wires for the fixation of the crossing point may be conducted thereto, so far as the principle is concerned, by way of suitable contacts carried through the tube envelope. However, such a structure would become very complicated and its technical realization would cause considerable difficulties. In order to avoid these difficulties, the contacting is in accordance with another feature of the invention effected by utilizing a customary electron beam adapted to impact the surfaces of small contact members arranged in a row and respectively associated with the individual grid wires as indicated in Fig. 1. The accuracy in the spotting of individual points will be increased by making the elements forming the contact surfaces of considerably increased size and arranging them within a contact area or field, as schematically shown in Fig. 3a for one control grid. As will be seen from Fig. 3a, the wires 1 to 8 are bent along on edge, extending for different lengths at an angle to the grid plane, and the ends thereof are respectively provided with approximately square metallic members 21' to 28'. The contact members need not be disposed staggered, as indicated, but may be arranged in chessboard fashion providing for relatively large contact members. The contact surfaces for the second grid may be similarly formed and disposed in a plane extending perpendicular to the plane of the contact members for the first grid. The electron beam systems for the corresponding planes of the contact members will likewise be oriented one extending perpendicular to the other.

In case two wires of each control grid are utilized for the selection of a bit point, instead of one wire from each grid, the elements forming the metallic contact surfaces and the contact beams therefor must be arranged so that the electrons always hit two neighboring contact members in common. The contact surfaces are in such a case advantageously disposed, for example, in the fashion of a meandering curve, as indicated in Fig. 3b, reference in accordance with Fig. 3a, and the beam 29 is cross-sectionally elliptical. Reliability of operation is in no manner affected. The grouping of the contact members may be different, for example, such that the last contact member in a row appears again at the start of the next successive row.

In accordance with the assumed numerical example, such a contact area must for each control grid accommodate 400 contact members, that is, 20 contact members for each row (line). With such small number of 20 contact members in a row, an individual contact member can be hit by a scanning beam with very great

certainty. As the example shows, the selection from the 400 wires of a grid will take place with an accuracy corresponding to 20:1. Since the same conditions also apply for the second grid, each individual one of the 160,000 bits is activated with 400-fold accuracy, as compared with direct activation over 800 contact members, thereby extraordinarily increasing reliability of operation.

The described arrangement of the two groups of contact members in two mutually perpendicularly extending large planes or fields, together with the storage system and the electron shower system, would form a cubelike structure, with the two contact beam systems disposed perpendicular to each other and, moreover, perpendicular to the system axis. A much more favorable arrangement will be obtained by bending the individual contact members for each grid, together with the corresponding wire extensions, over an edge so as to extend in two groups in opposite directions in a plane extending in parallel with the plane of the storage plate, as is schematically indicated in Fig. 4. The result is a square area which is uniformly subdivided into four square fields, each two diametrically extending fields containing only the contact members belonging to one and the same control grid. The scanning of the contact members of each partial field is effected separately by means of a contact beam system respectively associated therewith. It is, however, also possible to scan the diametrically disposed partial fields belonging to one grid, by means of a single beam system. The required contact beam systems can at any rate be disposed approximately along the system axis or directly adjacent thereto, resulting in an approximately cylindrical discharge vessel with coaxially disposed beam systems.

As mentioned before, the increase of the potentials at the selected grid wires is effected by a charge produced by a contact beam of fast electrons, resulting in a positive charge produced by a sufficient number of secondary electrons released at the contact surface. The original potential which is negative with respect to the electron shower cathode may be imparted to each individual wire, for example, from a common voltage source by way of a sufficiently high resistance associated with each wire. However, it is in very advantageous manner possible to produce this negative potential without any galvanic connection with a voltage source, by utilizing another contact beam, simply by increasing the potential of the corresponding contact beam cathode to such an extent that the contact beam hits the individual contact members only in the manner of slow electrons, that is, with a velocity such that the secondary emission factor remains on the average always smaller than 1.

The currents of the contact beam must be sufficiently high so as to obtain satisfactory activation of each individual contact member and the wire respectively associated therewith. This may be effected in particularly simple manner by the use of correspondingly dimensioned secondary emission paths. For example, a 10-fold amplification may be provided to produce the required potential increases at the wires, amounting from 50 to 100 volt. A booster network amplifier may be most advantageously used for this purpose, simply by arranging ahead of the entire contact surface field and the gridlike collector electrode associated therewith, a corresponding number of booster networks common to all contact members, as indicated in Fig. 5, the individual contact members thereby serving as booster plate and being correspondingly activated. The individual metal sheets forming the contact surface and serving as booster plates are in such a secondary electron multiplier positively charged in accordance with a secondary electron stream produced thereon.

Fig. 5 shows the use of two such common booster networks indicated at 30 and 31. The collector 32 which also serves as a common electrode is disposed between the last booster network and the individual contact members indicated by numerals 21' to 28'.

Instead of the beam producing the electron shower,

shown in Fig. 1, which may come from a common large-surface cathode—with a current strength on the order of magnitude of 2–10 amperes—or which may be produced by a plurality of incandescent parallel wires, there may be employed a planar electron beam moving through the system in parallel to the planes of the control grids and the parallel wires of a further deflection grid. The individual wires of this deflection grid, which also extends in parallel with the remaining electrodes, may be negatively biased in periodic intervals or selectively individually, causing deflection of the electron shower beam perpendicular in the direction of the first control grid. Fig. 6 shows in schematic manner an arrangement of this kind.

It will be seen from Fig. 6 that the planar beam 33 which flows between the first control grid 34 and the deflection grid 36 with an energy of 100 to 1000 volt, is deflected from its direction of flow due to reflection caused by the potential field forming on a control wire responsive to making such wire negative, hitting the second control grid 35 practically perpendicular thereto.

Fig. 7 shows in schematic manner a mode of electron showering differing somewhat from the arrangements wherein the showering beam hits the control grid perpendicular thereto. In this case, the entire surface of the control grid is not simultaneously or regularly showered with electrons, effecting instead a kind of selection with respect to the desired area. There is provided a deflection system 37 which guides a relatively undefined electron beam 38 merely to an area 39 embracing on the first control grid 40 the vicinity of the desired bit point, instead of guiding it accurately to such point, the accurate selection of the desired point being left to the operation of the two control grids which is effected in the manner already described.

Since some operations in which the storage tube according to the invention may be used, for example, some computer operations, may consume considerable time, it will be necessary to pose the requirement according to which a stored signal is to be maintained as long as may be desired. Therefore, although the signal is essentially maintained with its assigned value, a kind of augmenting may be effected incident to the charging of the associated bit point by refreshing the charge by means of a so-called "holding beam" so as to obtain upon extinguishing a signal with its desired full value. Holding beam devices shown schematically in Figs. 8, 9 and 10 may also be advantageously employed in connection with the storage tube according to the invention.

In Fig. 8, numeral 41 indicates the electron shower cathode, 42 is an acceleration grid, 43 and 44 are the two control grids, 45 is the collector grid, and 46 is the signal plate with its storage coating 47. A typical potential distribution for the recording operation is, for example, as follows: cathode 41 is on ± 0 volt; acceleration grid 42 on +50 volt; first control grid 43 on -50 volt; second control grid 44 on ± 0 volt; collector grid 45 on +300 volt; and signal plate on +200 volt. The electrons accordingly impact the signal plate with a velocity of +200 volt and produce secondary electrons which flow to the collector 45, thereby again positively charging the signal plate at the corresponding point. For the reading or pickup, the signal plate 46 is placed on +300 volt, that is, on the same potential as the collector grid 45, thus preventing flow of secondary electrons and thereby extinguishing the positive charge, and in this manner producing at the signal plate a corresponding signal.

An auxiliary (not illustrated) cathode may be used for the holding beam device, such cathode being disposed beyond the electron shower cathode 41. The holding beam may be switched in during pauses between the recording and reading operations, whereby the special cathode and the signal plate are simultaneously placed on a more negative potential than that of the first control grid, namely, at a potential of about -200

volt. The electrons of the holding beam, passing through the control grids, should hit the storage plate with a velocity such that the previously positively charged points are charged further to the collector voltage, at a secondary emission factor ≥ 1 , while the previously uncharged points remain, at a secondary emission factor ≤ 1 , at the potential of the storage plate. However, the electron shower cathode itself may be employed for this purpose, provided that care is taken, in addition to having the storage plate at cathode potential, to make the control grids sufficiently positive with respect to the electron shower cathode, so as to make the flooding of the electrons possible.

Another mode of a holding beam arrangement is schematically indicated in Fig. 9. The collector grid 48 is in this case coated with an electron emitting photo layer 49, at the side thereof which faces the storage plate, causing it to emit electrons responsive to illumination by a light source 50, the electrons emitted functioning as a holding beam on the storage plate 51.

Fig. 10 shows a further arrangement in which a holding beam 54 hits the surface of the storage plate continuously at an oblique angle of incidence from all sides between the collector grid 52 and the storage plate 53.

Changes may be made within the scope and spirit of the appended claims.

We claim:

1. An electron beam tube for planar type storage of electrical bit signals, comprising a metal-backed homogeneous insulating plate constituting a storage electrode, a cathode for producing an electron shower directed toward said storage electrode, the cross-sectional area covered by said electron shower corresponding to an area occupied by at least a portion of said storage electrode, a first control grid comprising a plurality of electrically insulated wires uniformly spaced from said storage electrode and each uniformly spaced from the adjacent wire of such grid, a second similarly constructed control grid disposed farther away from said storage electrode with the wires of said second grid uniformly spaced therefrom and uniformly spaced from said first control grid, the direction of the wires on the second grid extending at right angles to the direction of the wires of the first control grid, means for biasing said control grids negatively with respect to the cathode which supplies said electron shower, further electron beam means for activating selected wires of the respective control grids to alter the initial potentials on such wires, whereby the potential on one of said wires belonging to said second control grid is altered in the positive direction by the action of said electron beam means while the potential on one of the wires of said first control grid which is in crossing relationship with such activated wire of the second control grid is simultaneously altered by the action of said electron beam means in the positive direction to place a positive potential thereon, the altered potentials on said wires causing electrons of said electron shower to pass through said control grids only in the immediate vicinity corresponding to the crossing point of such crossing wires, said passage of electrodes being effective to define an impact point on said storage electrode which corresponds to said crossing point, said impacting electrons releasing at said point secondary electrons to place at such point a positive charge constituting a stored bit signal.

2. An electron beam tube according to claim 1, comprising means for accelerating the electrons of said electron shower in the direction towards said control grids and said storage electrode, electrons of said shower which move in the immediate vicinity of the crossing point of the wires having altered potentials passing through as slow electrons and reaching said storage electrode in focused manner.

3. An electron beam tube according to claim 1, comprising a plurality of wires extending in parallel in a common plane ahead of said control grids and constitut-

ing a deflection grid, said electron shower being produced by a uniformly moving planar beam, said planar electron beam entering between one of said control grids and said deflection grid and flowing parallel to the plane of the latter, a predetermined wire of said deflection grid being negatively biased with respect to said cathode for deflecting said planar electron beam in its vicinity so as to flow approximately perpendicularly in the direction of said control grid, means for accelerating the electrons in the direction towards said control grids and said storage electrode, electrons of said planar electron beam which move in the immediate vicinity of the crossing point of said wires having altered potentials passing through as slow electrons and reaching said storage electrode in focused manner.

4. An electron beam tube according to claim 1, comprising a freely disposed contact member for each wire of each of said control grids, each contact member forming a generally rectangular contact surface and being free of galvanic connection with a voltage source, a collector grid common to said contact members and disposed ahead thereof, said contact members and said collector grid being assembled in an approximately rectangular field, the contact surfaces of said contact members being scanned by an intensity-modulated electron beam of said further electron beam means which is deflectable in two mutually perpendicular directions, whereby secondary electrons are released by the action of electrons of said electron beam for altering the bias potential of the wires respectively associated with activated contact members in a positive direction, the normal negative bias potential being produced between said cathode and said collector by slow electrons.

5. A structure and cooperation of parts according to claim 4, wherein the wires of the respective control grids with their respective contact members extend in two groups in opposite directions, said wires being bent to dispose said contact members in a contact field of generally square configuration and extending in a common plane containing four partial generally square fields, each pair of diametrically disposed partial fields belonging to the wires and contact members of one of said grids, the

contact members disposed in said field being scanned by said further electron beam means.

6. A structure and cooperation of parts according to claim 1, comprising means for causing said electron shower to impact said control grids in preselecting manner along an area containing the crossing point of activated wires defining the bit point which is to be selected for storing a signal.

7. A structure and cooperation of parts according to claim 4, comprising a device for maintaining stored bit signals containing at least one further electron beam producing system, wherein the cathode and the storage electrode are placed at a potential such that electrons directed to the storage electrode can only reach positively charged bit points thereon, secondary electrons being released for repeatedly augmenting the charge on said bit points to a desired value.

8. A structure and cooperation of parts according to claim 7, comprising a plurality of further electron beam producing systems disposed laterally of said storage electrode for showering said storage electrode with electrons at oblique angles of incidence.

9. A structure and cooperation of parts according to claim 4, containing a device for maintaining stored bit signals, said device comprising photo sensitive layers carried by the wires of the collector grid upon the side thereof which faces the storage electrode, photons produced thereby responsive to illumination from laterally disposed light sources continuously showering said storage electrode due to the presence of the predominant electrical field.

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