

Feb. 24, 1959

R. W. KETCHLEDGE

2,875,373

STORAGE TUBE AND CIRCUIT

Filed Nov. 21, 1956

FIG. 1

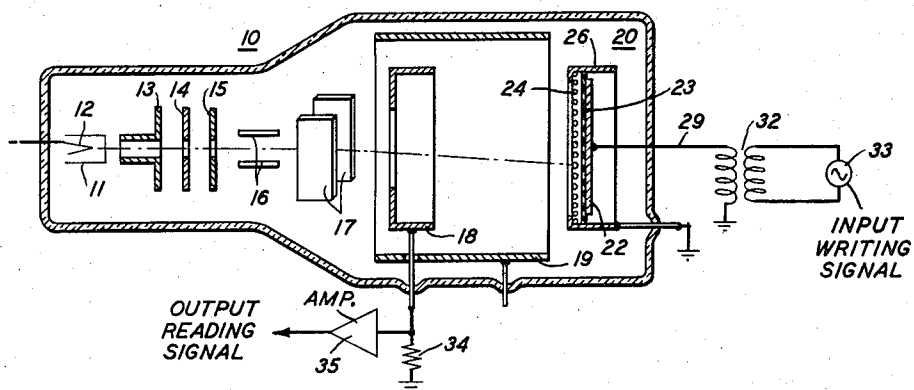


FIG. 2

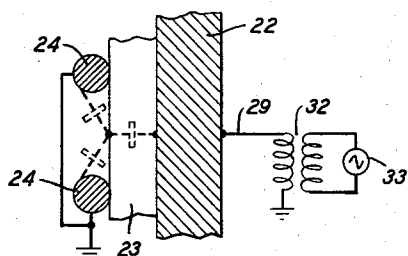
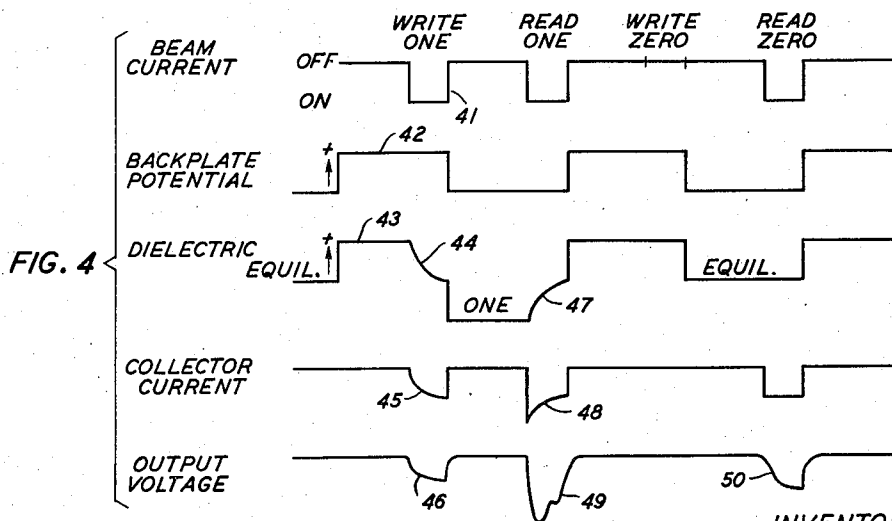
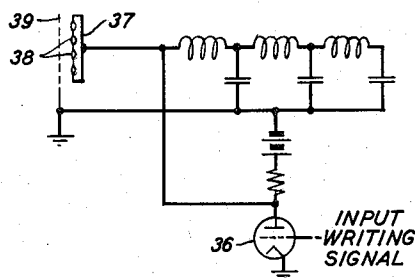


FIG. 3



INVENTOR
R. W. KETCHLEDGE

BY *James J. Falk*
ATTORNEY

1

2,875,373

STORAGE TUBE AND CIRCUIT

Raymond W. Ketchledge, Whippany, N. J., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Application November 21, 1956, Serial No. 623,624

15 Claims. (Cl. 315—12)

This invention relates to electron discharge devices of the beam storage type and more particularly to the writing of information in such devices.

One type of fast access, short storage memory device that has been employed in recent memory and storage systems utilizes electron discharge devices of the beam storage type and particularly of the type known as the barrier grid storage tube. Such tubes are well known in the art, being described, for example, in an article "Digital Memory in Barrier Grid Storage Tubes" by M. E. Hines, M. Chrunev and J. A. McCarthy, Bell System Technical Journal, vol. 34, pages 1241-1264, November 1955, and in R. W. Sears Patent 2,675,499, April 13, 1954.

In a barrier grid storage tube a target such as a dielectric sheet has a conductive electrode or backplate secured to one face thereof, an electron gun projects a concentrated electron stream against the other face of the dielectric through a barrier grid which is positioned immediately adjacent the other face of the dielectric. In the operation of such a tube the electron beam advantageously is deflected in two coordinate directions; for example, it may be rapidly swept in one coordinate and selectively deflected in the opposite coordinate, or it may be turned on and deflected to a discrete area of the dielectric surface if completely random access is desired. The operation of the device involves basically two cycles; one Store or Write and the other Remove or Read. During the writing cycle the potential or charge present at discrete areas of the dielectric surface impinged by the electron beam is varied in accordance with an input signal, the variation in charge being dependent on the signal present at the time the beam impinges on the discrete area. During the reading cycle the charges upon these areas are removed by action of the electron beam.

Fundamentally the charging and discharging of discrete areas of the dielectric noted above result from the emission of secondary electrons. The flow of secondary electron current may be detected in several ways including variations in current received at a collector electrode or variations due to secondary electron current at the target structure itself.

A degree of control over the charge present on the dielectric is obtained by varying the potential of the target structure. This may be accomplished in a preferred manner by varying the potential of the backplate behind the dielectric with the barrier grid grounded. The capacitance existing between the backplate and the barrier grid is appreciable. Thus in obtaining variations in voltage on the dielectric by the application of input signals at the backplate, a considerable charging current may be required. With a large target surface having a correspondingly large capacity between backplate and barrier grid, the power requirement to charge this capacity is excessive when the charging current is obtained from standard vacuum tube sources.

It is an object of this invention to provide an improved beam storage tube.

It is another object of this invention to improve the operation of beam storage tubes and particularly to improve the means for applying input signals to the tube.

2

These and other objects of this invention are attained in one specific embodiment thereof wherein the writing signal is applied to the target assembly through a resonant circuit, including as an element in the resonant circuit the capacitance existing between the backplate and barrier grid. In this specific embodiment the barrier grid advantageously is grounded and a resonant tank is formed by the capacitance of the target assembly and an inductance. An alternating current signal at the tank circuit resonant frequency is applied through an inductive coupling including the inductance of the tank circuit.

The above structure takes cognizance of the fact that normal operation of a barrier grid tube is programmed such that reading cycles almost invariably are followed by writing cycles. Consequently, normal operation requires that input signals to the target follow an alternating read-write pattern and consequently an alternating signal input is acceptable.

The storage tube may be of the barrier grid type, as described hereinbefore, or may be of the dielectric island type disclosed in Patent 2,726,328 issued to A. M. Clogston on December 6, 1955. In a dielectric island tube a plurality of dielectric regions or islands are mounted on a backplate. A barrier grid is not employed, but a field equalizing grid may be located in front of the dielectric islands. In embodiments of this invention utilizing such devices the charging currents are the same as discussed above. However, in the dielectric island tube the capacitance being discharged on reading of the stored information is solely between the dielectric and the backplate. This capacitance is nevertheless appreciable so that a tuned writing circuit in accordance with this invention is applicable.

It is preferable to charge the target capacitance with an input signal having a rectangular rather than sinusoidal waveform. This may be achieved in accordance with an aspect of this invention by substituting a pulse forming line for the simple inductive coupling circuit arrangement described hereinbefore. In this instance the target structure capacity is absorbed in the resonant line to form a tuned circuit whose normal mode of oscillation includes a semirectangular waveform. This resonant line can be driven from a separate rectangular wave oscillator or from oscillations of the line itself. Variations of the pulse forming line can be utilized to create any particular wave shape desired for any given application.

It is a feature of this invention that the input alternating signal be applied directly to the backplate of the target assembly through a resonant circuit including the capacitance existing in the target structure.

It is another feature of this invention that the writing signal input circuit include an inductance element which balances the capacitance of the target structure, forming a tuned circuit.

It is a further feature of this invention that the inductance element receive the input alternating signal through inductive coupling action.

It is a feature in accordance with one aspect of this invention that the input signal circuit include a pulse forming line including as an element thereof the capacitance of the target structure so as to form a square or rectangular wave resonant input circuit.

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 diagrammatic representation of one specific illustrative embodiment of this invention;

Fig. 2 is a simplified circuit schematic for the writing circuit of the embodiment of Fig. 1;

Fig. 3 is a schematic representation of a writing circuit

3

in accordance with another specific illustrative embodiment of this invention utilizing a dielectric island storage tube, only the target portion of the tube being shown; and

Fig. 4 is a chart of currents and voltages for various conditions during the operation of the embodiment of Fig. 1.

Referring now to the drawing, Fig. 1 depicts an illustrative embodiment of this invention utilizing a barrier grid storage tube 10. As is known in the art, the tube 10 may comprise within an evacuated envelope, such as glass, an electron gun including a cathode 11, heater 12, accelerating and focusing electrodes 13, 14 and 15 defining an electron lens, deflection plates 16 and 17, a collector electrode 18, a shield 19, and a target assembly 20. The target assembly 20 includes a backplate 22, a dielectric sheet 23, and a barrier grid 24, the barrier grid 24 being positioned directly in front of the dielectric sheet 23. A shielding member 26 advantageously encloses the target assembly and is connected to the barrier grid 24 providing it with a path to ground.

In storage tubes of this kind information is stored by an electrostatic charge on a discrete area of the surface of dielectric 23. To place such a charge on the surface the electron beam is turned on while the backplate 22 is raised to a positive potential. This temporarily increases the potential on the front face of the dielectric sheet through capacitor action. The electron beam then charges the front face of the dielectric by deposit of electrons sufficient to drop the potential then existing at the front face to that of the barrier grid, which is the equilibrium potential. During the charging operation, secondary electrons emitted from the dielectric return to it, due to its relatively positive potential state. When the beam is moved elsewhere, or turned off, and the backplate potential returned to normal the charge deposited at the discrete area remains, thus presenting a negative potential at this portion of the dielectric surface. During the reading operation the beam is again focused on this discrete area. Secondary electrons now escape through the barrier grid to the collector electrode, since the potential at the dielectric is insufficient in relation to the potential of the barrier grid to return the secondary electrons to its surface. Thus, dependent upon the state of charge at the discrete area of the dielectric when the beam is applied thereto during the reading operation, the current from the collector electrode will determine the information stored at the discrete area of the dielectric. A degree of control over the potential of the dielectric is obtained by varying the potential of the backplate 22. The equivalent circuit of the target assembly, as best shown in Fig. 2, may be visualized. Here the capacitance distributed between the barrier grid 24, the dielectric 23, and the backplate 22 is shown. Measurements indicate that approximately 60 percent of the backplate voltage change appears at the face of the dielectric with the barrier grid at ground potential, as shown. In storing binary information the backplate potential advantageously is switched between two voltages, for example, 50 volts apart.

Returning again to the operation as described hereinbefore and visualizing a discrete area of the dielectric which has been bombarded by the electron beam until the equilibrium potential has been reached, a positive step function voltage is now applied at the backplate 22, as depicted at 42 in the "write one" interval of Fig. 4. The target capacitance is charged, the front face of the dielectric rises to a new value 43 and negative charge begins to accumulate thereon under the action of electron beam current 41. This causes the potential at the dielectric surface to fall rapidly 44 and approach the equilibrium condition. When equilibrium is reached the beam is removed from the discrete area and the backplate potential returned to its previous low value. The potential at the dielectric consequently drops below the

4

equilibrium value, for example, to the "one" value shown in Fig. 4. When the beam is again returned to this discrete area of the dielectric surface, as in the "read one" interval of Fig. 4, positive charge will accumulate thereon, 47, tending to drive the dielectric surface potential up again toward the equilibrium value.

During the time that negative charge is accumulating, 44, the number of secondary electrons which escape from the target to the collector electrode 18 is less than the number when the dielectric has reached its equilibrium condition, as evidenced by the slope of pulse 45, Fig. 4. Conversely, when positive charge is accumulating, 47, there is a temporary excess in secondary electrons escaping from the target, as shown by pulse 48.

Collecting the total secondary electron current at electrode 18 forms a voltage in the output circuit which may be amplified in amplifier 35 to form the output reading signals 36 and 39. This output differs from the equilibrium value only during intervals of positive or negative charging of the dielectric. The output voltage signal 49, formed during reading of a "one" from a discrete area when the dielectric is accumulating positive charge, is readily distinguished from the voltage signal 46 formed during writing of a "one" charge on a discrete area when the dielectric is accumulating negative charge, and from the voltage signal 50 formed during reading of a "zero" charge from a discrete area.

It is essential for rapid reading and writing operation in the barrier grid store that rapid and abrupt changes in backplate potential occur. Input circuitry supplying a charging current directly to the backplate 22 must supply considerable power in order to realize the abrupt charging operation required. In accordance with this invention and as further shown in Fig. 1, an inductance 32 is connected to the backplate input lead 29 and to ground. With the barrier grid 24 grounded as shown, a tank circuit is formed including the inductance 32 and the capacitance of the dielectric as shown in Fig. 2. An input writing signal from a source 33 at the resonant frequency of this tank circuit advantageously is applied through transformer action with the inductance 32 acting as the transformer secondary. Thus the target capacitance is absorbed in the tank circuit and the power requirement is reduced to a minimum. The backplate potential under these conditions is alternately raised and lowered so that alternate reading and writing operations may be effected.

In Fig. 4 the input signals for effecting the various reading and writing operations are shown. Thus, with the potential at a discrete area of the dielectric at the equilibrium value, the beam is turned on for a short time to perform the "write one" and reading operations and is off during the "write zero" operation. The backplate potential is switched to one maximum value to write information on the dielectric and during the next interval moves to its other maximum value to read the desired information. The information stored at any discrete area during one time interval need not be read out during the next time interval, but rather, the beam may be deflected to another discrete area to read out information stored thereat, the only requirement being that during consecutive time intervals a reading operation is followed by a writing operation and, conversely, a writing operation is always followed by a reading operation. The output signal then is detected during alternate time intervals.

Fig. 3 depicts an alternative scheme for applying the input writing signal to the backplate, utilizing a pulse forming line, again including the target capacitance as an element in a resonant tank circuit. Such a pulse forming line may include a ladder arrangement of serial inductance and shunt capacitance, as shown, to form a rectangular or square wave input pulse. Such a pulse is desired to provide the abrupt charging of the target capacitance. The drive for the input circuit of Fig. 3

may be provided from a separate oscillator through tube 36 to provide a rectangular waveform, or the line itself may be utilized to provide the rectangular waveform from a sine wave input to the grid of tube 36.

The storage tube shown in the embodiment of Fig. 3 comprises a dielectric island tube of the type disclosed in Patent 2,726,328 issued to A. M. Clogston on December 6, 1955. The target array comprises a backplate 37 on the front surface of which are located small spots or islands 38 of dielectric material. A field equalizing grid 39 is positioned in front of the dielectric islands 38 and between it and the remainder of the tube, which may be as depicted in Fig. 1; grid 39 is supported by the shield member 26 encompassing the target array.

The effectiveness of the signal input circuitry in accordance with this invention in reducing the power required to charge the storage tube target capacitance is evidenced by the following example. In a storage tube with a large target, the capacity to be charged may reach 1500 micromicrofarads. Typical operation may require that this capacity be charged by 50 volts in 0.1 microsecond, which in turn requires more than $\frac{1}{2}$ an ampere of charging current. Thus the power requirement in this instance, utilizing direct drive from vacuum tubes, is 25 watts. With the capacitance absorbed in a tuned circuit in accordance with this invention, the resonant frequency may be set at 0.5 megacycle to satisfy the 0.1 microsecond charging time. For a coil Q of 100 the reactive impedance is 20,000 ohms, and the 50 volt charge can be achieved with less than 125 milliwatts of power. This is a power saving of more than 99 percent over direct drive methods.

It is to be understood that the above-described arrangements are 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 device comprising a conducting member, dielectric target means mounted on said conducting member defining a capacitance, and means for applying signals to said conducting member to store information on said dielectric means, said last-mentioned means comprising a source of alternating voltage, a circuit including said capacitance, said conducting member and inductive means to tune said circuit to the frequency of the alternating voltage, and means coupling said circuit to said source of alternating voltage, said capacitance providing at least a portion of the capacitive reactance of said tuned circuit.

2. An electron discharge device comprising a backplate, dielectric target means mounted on said backplate, electron gun means for projecting a stream of electrons against said dielectric target means, and means for storing information on said dielectric target means and for removing information from said dielectric target means, said last-mentioned means comprising said electron gun means, a source of alternating voltage, a tank circuit comprising the capacitance across said dielectric target means as a capacitively reactive element of said tank circuit, and means coupling said source of alternating voltage to said tank circuit, said tank circuit being resonant at the frequency of the alternating voltage.

3. An electron discharge device in accordance with claim 2 wherein said dielectric target means comprises a plurality of distinct dielectric islands mounted on said backplate.

4. An electron discharge device in accordance with claim 2 further comprising a shielding member encompassing said backplate and said dielectric means, said shielding member being electrically connected in said tank circuit.

5. An electron discharge device in accordance with claim 4 further comprising a grid positioned to the other side of said dielectric means than said backplate so as to

define said capacitance between said backplate and said grid.

6. An electron discharge device in accordance with claim 5 wherein said dielectric target means comprises a dielectric sheet and said grid is a barrier grid positioned closely adjacent said dielectric sheet.

7. An electron discharge device in accordance with claim 5 wherein said grid is mounted by said shielding member.

8. An electron discharge device in accordance with claim 2 wherein said tank circuit further comprises inductance means to balance said tank circuit capacitance.

9. An electron discharge device in accordance with claim 8 wherein said means coupling said tank circuit and said alternating voltage source comprises said tank circuit inductance means and a coil connected to said alternating voltage source and in inductive coupling relation with said tank circuit inductance means.

10. An electron discharge device comprising a backplate and a grid electrode spaced apart by dielectric target means so as to define interelectrode capacitance between said backplate and said grid electrode and means for varying the potential on said backplate to store information on and erase information from said dielectric target means, said means comprising a source of alternating voltage, a tank circuit including said interelectrode capacitance as a capacitively reactive element and means coupling said tank circuit and said alternating voltage source, said tank circuit being resonant at the frequency of the alternating voltage.

11. An electron discharge device comprising a backplate, dielectric means in contact with said backplate, electron gun means for projecting a stream of electrons against said dielectric means, and means for storing information on said dielectric means and for removing stored information from said dielectric means comprising a source of alternating voltage, a circuit comprising the capacitance defined by said dielectric means and inductance means sufficient to permit resonance at the frequency of the alternating voltage, and means for coupling said source of alternating voltage to said circuit, said capacitance providing a capacitive reactance for said resonant circuit.

12. An electron discharge device in accordance with claim 11 and further comprising a pulse forming line including series inductance and shunt capacitance connected to said circuit.

13. An electron discharge device comprising a backplate, dielectric target means in contact with said backplate, electron gun means for projecting a stream of electrons against said dielectric target means, and means for storing information on said dielectric target means and for removing information from said dielectric target means comprising said electron gun means, a source of alternating voltage and a resonant circuit comprising the capacitance defined by said dielectric target means and a first conductor connected to said backplate, a second conductor coupled to said first conductor and connected to said source of alternating voltage, said circuit being resonant at the frequency of the alternating voltage.

14. An electron discharge device in accordance with claim 13 wherein said first conductor further comprises a coiled portion forming an inductance, said second conductor being coupled to said coiled portion.

15. An electron discharge device in accordance with claim 13 and further comprising a pulse forming line including series inductance and shunt capacitance connected to said resonant circuit.

References Cited in the file of this patent

UNITED STATES PATENTS

2,503,949	Jensen et al.	Apr. 11, 1950
2,675,499	Sears	Apr. 13, 1954
2,689,301	Skellett	Sept. 14, 1954