

July 22, 1958

M. E. HINES
ELECTRON DISCHARGE DEVICES

2,844,722

Filed Feb. 4, 1955

2 Sheets-Sheet 1

FIG. 1

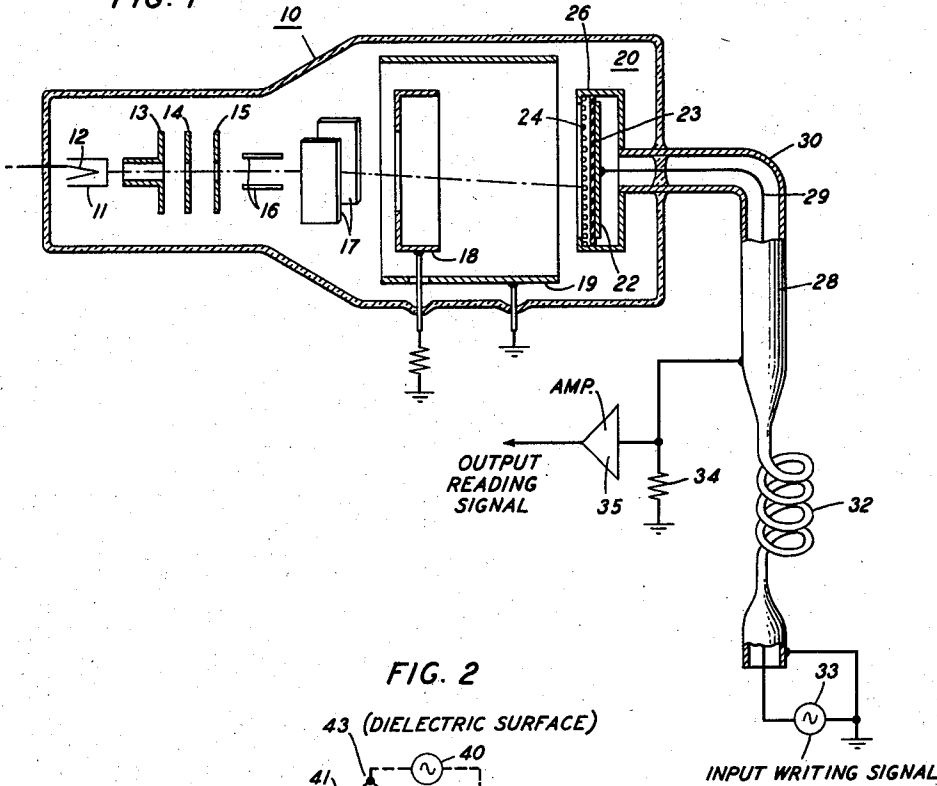
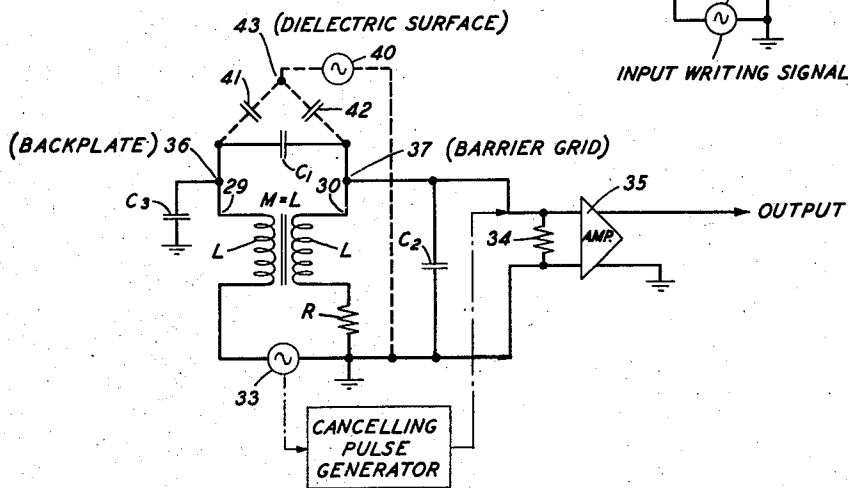


FIG. 2



INVENTOR
M. E. HINES
BY *James W. Folk*
ATTORNEY

July 22, 1958

M. E. HINES

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2 Sheets-Sheet 2

FIG. 3

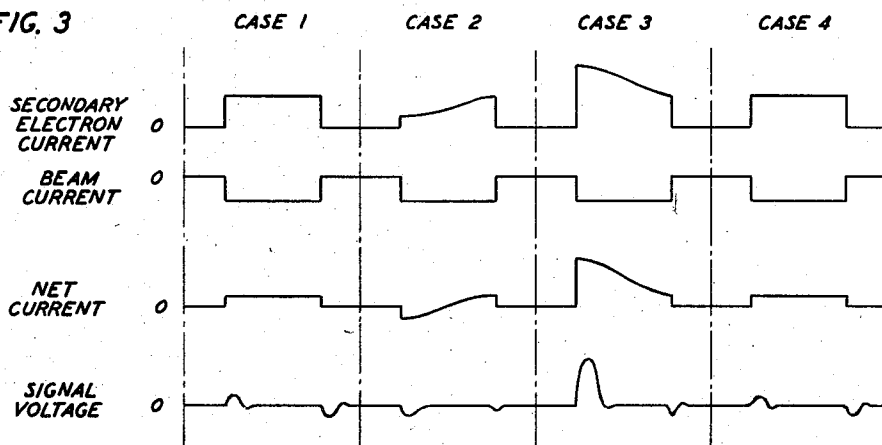
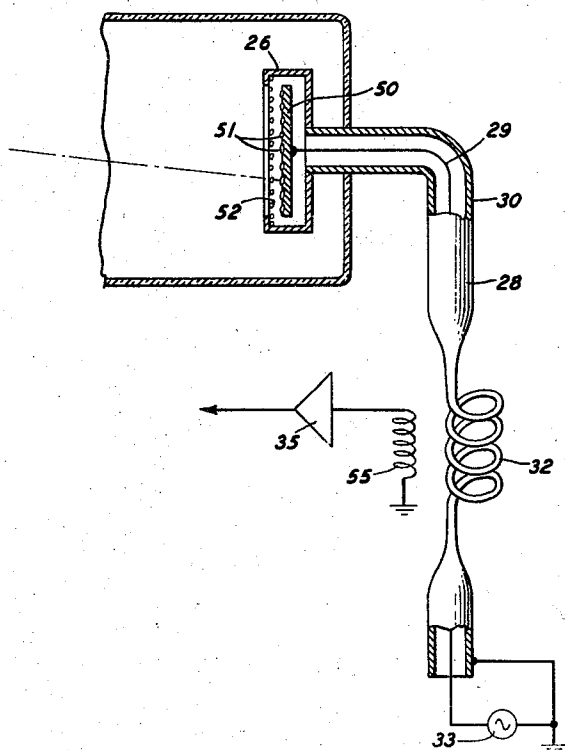


FIG. 4



INVENTOR
M. E. HINES
BY *James W. Fack*
ATTORNEY

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2,844,722

ELECTRON DISCHARGE DEVICES

Marion E. Hines, Summit, N. J., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Application February 4, 1955, Serial No. 486,221

19 Claims. (Cl. 250—27)

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

One type of fast access short storage memory that has been employed in recent memory or storage systems utilizes electron discharge devices of the beam storage type and particularly of the type known as a barrier-grid storage tube. Such tubes are well known in the art, being described, for example, in an article "Barrier-grid storage tube and its operation," by A. S. Jensen, J. P. Smith, M. H. Mesner, and L. E. Flory, R. C. A. Review IX, pp. 112-135, March 1948, 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 back plate 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 directly adjacent this other face of the dielectric. In the operation of such a tube, the beam is deflected in two coordinate directions; for example, it may be repeatedly swept in one direction and selectively deflected in the other direction or it may be turned on and deflected to a particular spot on 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 of elemental areas of the bombarded dielectric surface is varied in accordance with an input signal, the charge change being dependent on the signal at the time the beam impinges on the area. During the reading cycle, the charges upon these areas are removed by action of the electron beam.

Fundamentally the charging and discharging of the elemental areas above noted result from the emission of secondary electrons. The flow of secondary electron current can be detected in several ways and provides an output indication of the stored information during the reading cycle. Generally the method of operation of the barrier grid storage tube has been to read the signals stored on the target by detecting variations in the current to a large collector electrode placed in front of the barrier grid and dielectric surface, the current to the collector electrode being due to secondary electrons released from the dielectric surface and passing through the barrier grid.

Several major problems arise in this type of operation, however. First, the signal received at the collector is very small, not all of the emitted secondaries being collected at the collector electrode. Secondly, and more serious, the fractional amount of such collection is dependent on the position of origin in the storage array. Thus there are variations in the size of the signal at the collector as a function of spot position on the dielectric surface independent of the stored information. This effect is called "shading." Shading appears as a decrease in magnitude of the reading signal as the spot approaches the edge of the target and is caused mostly by decrease in col-

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lector efficiency. A third disadvantage in this type of operation is that a number of secondary electrons are emitted whenever the beam is striking the array, though temporarily greater or lesser amounts of secondaries may appear during writing or reading operations. The equilibrium value of secondary electron current at the collector forms a "pedestal" upon which the reading information is superimposed. Variations in the fractional collection of such secondary electrons affect the "pedestal" also and consequently positive identification of the type of information stored becomes more difficult.

By reading the stored information directly at the target structure, that is, by reading the signal caused by the secondary electrons leaving the target instead of those arriving at the collector, the problem of collector efficiency and the variations in fractional amounts of secondary electrons collected are obviated. Further, this not only eliminates shading almost entirely but increases the magnitude of the output signal as well. However, it is also most desirable to apply the writing signal directly to the target assembly and thus in considering obtaining the reading signal from the target assembly directly, it must be remembered that there are two signals that differ by at least three orders of magnitude. This means that an amplifier connected to the target assembly for the purpose of amplifying reading signals must not be badly jammed by the considerably larger writing signals.

It has been proposed to apply the input signal to the barrier grid directly and take the output signal from the back plate of the target assembly, but with such an arrangement the writing and reading, i. e., the input and output circuits, are not effectively isolated.

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 recognition and detection of output signals read from the tube.

It is a further object of this invention to enable the reading and writing circuits both to be connected directly to the target assembly and yet to be effectively and substantially completely isolated, electrically, from each other.

These and other objects of this invention are attained in one specific embodiment thereof wherein the writing signal is applied directly to the back plate portion of the target assembly, as is preferred, and the reading signal is taken directly from the target assembly as a whole. In this specific embodiment, a coaxial line is connected through the envelope of the tube so that its inner conductor is connected to the back plate and its outer conductor is connected to a shielding member encompassing the target assembly, the barrier grid being supported by the shielding member so that the outer conductor is in effect connected to the barrier grid.

The coaxial line has a portion wound as an inductor with the two conductors having essentially equal inductances and a mutual inductance between the two conductors equal to the self inductance of either. The input or writing signal is then applied between these two conductors. The charging current requisite for the capacitance between the barrier grid and the back plate flows to the target along the inner conductor and returns along the outer conductor so that the two currents flowing in the two conductors effectively cancel each other out in the coiled portion and induce no voltage across this inductance. However, when the information is being read, the surface of the dielectric is being charged or discharged through capacitances to both the barrier grid and back plate simultaneously so that current flows in both conductors of the line in the same direction. This current produces an output signal voltage across the

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coiled portion of the coaxial line which can be detected and utilized by an output circuit.

The storage tube may be of the barrier-grid type, described above, or may be of the dielectric-island type, disclosed in application Serial No. 169,140, filed June 20, 1950, now U. S. Patent No. 2,726,328, issued December 6, 1955, of A. M. Clogston. In a dielectric-island tube a plurality of distinct small dielectric regions or islands are mounted on a back plate. A barrier grid is not employed but a field equalizing grid may be advantageously 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, here the condenser being discharged on reading of the stored information is substantially solely between the dielectric and the back plate so that the current flows almost solely in the inner conductor of the coaxial line.

The reading signal may be detected directly across the coiled portion of the coaxial line, as by an amplifier connected thereto, or may be detected by an amplifier connected to a transformer winding inductively coupled to the coiled portion. Further the writing signal is substantially prevented from appearing across the coiled portion of the output line by completely shielding the back plate and dielectric members of the target assembly, as by having the target assembly effectively encompassed by the outer conductor of the coaxial line and specifically by a shielding member connected to the outer conductor and to which the barrier grid or field equalizing grid is attached. In this manner, extraneous capacitances between target elements and ground or collector, which may be at ground potential, are reduced or inhibited thereby eliminating the charging current to these capacitances, which current would not be equally balanced in the two conductors of the coaxial line.

It is a feature of this invention that the writing signal be applied directly to the back plate of the target assembly and the reading signal be taken from the target assembly as a whole. More specifically, it is a feature of this invention that the writing and reading signals utilize the same connectors to the target assembly.

It is another feature of this invention that a coaxial line be connected to the target assembly of a beam storage tube, the coaxial line having a coiled portion across which the reading signal is detected.

It is a further feature of this invention that the inner conductor of the coaxial line be connected to the back plate of the target assembly and the outer conductor to a barrier or field-equalizing grid.

It is a still further feature of this invention that the back plate be substantially entirely shielded from the other elements of the tube and from ground. More specifically it is a feature of this invention that a shielding member connected to the outer conductor of the coaxial line encompass the back plate. Further in accordance with this feature of the invention, the barrier or field equalizing grid may be supported by the encompassing shielding member.

It is a feature of one specific embodiment of this invention that the reading signal be detected by an amplifier connected directly to the coiled portion of the coaxial line. It is a feature of another specific illustrative embodiment of this invention that the reading signal be detected by an amplifier inductively coupled to the coiled portion of the coaxial line.

It is still another feature of one specific embodiment of this invention that the coaxial line comprise a hollow metallic tube having a wire positioned therein, the metallic tube advantageously having adequately thick walls to reduce the resistance of the outer conductor of the line. Further it is a feature of this invention that the coiled portion of a copper tube be wound on a magnetic core.

A complete understanding of this invention and of these and various other features thereof may be gained

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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 reading and writing circuits of the embodiment of Fig. 1;

Fig. 3 is a chart of currents and voltages for various conditions during the operation of the embodiment of Fig. 1; and

Fig. 4 is a diagrammatic representation of another specific illustrative embodiment of this invention utilizing a dielectric island storage tube, only the target portion of the tube being shown.

Referring now to the drawing, Fig. 1 depicts an illustrative embodiment of this invention utilizing a barrier grid storage tube 10. As known in the art, the tube 10 may advantageously comprise within an evacuated envelope, such as glass, an electron gun including a cathode 11, heater 12, and 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 back plate 22, a dielectric sheet 23, and a barrier grid 24, positioned directly in front of the dielectric sheet 23. In accordance with an aspect of this invention, the back plate 22 and dielectric sheet 23 are enclosed within a shielding member 26 to which the barrier grid is attached.

In storage tubes of this kind, information is stored by an electrostatic charge on a discrete zone or area of the surface of the dielectric 23. To place such a negative charge on the surface, the electron beam is turned on while the back plate is temporarily raised to a positive potential. This temporarily raises the potential of the front face of the dielectric through capacitive action. The electron beam then charges this surface with negative electrons sufficiently to drop its potential to that of the barrier grid which is the equilibrium potential. During the charging operation, the secondary emission electrons from the dielectric return to it and cannot escape. When the beam is turned elsewhere and the back plate potential returned to normal, the charge remains, leaving the dielectric surface at a negative potential.

In this embodiment of the invention the writing circuit, which applies the positive writing potential to the back plate during the storage operation just described, comprises a coaxial line 28 having its inner conductor 29 connected to the back plate 22 and its outer conductor 30 connected to the shielding member 26 and thus to the barrier grid 24. The coaxial line 28 has a portion 32 wound as an inductor with the two conductors 29 and 30 having equal inductances at this portion and a mutual inductance between them equal to the self-inductance of either one. A source 33 of input writing signals is connected between the inner and outer conductors 29 and 30 of the coaxial line 28.

When a writing signal is applied by the source 33, the current flows along the inner conductor 29 to charge the internal capacitance and returns via the outer conductor. The coiled portion of the coaxial line acts as a noninductive winding, and, ideally, in the absence of beam current no voltage should appear between the barrier grid 24 and ground.

The information thus stored in this spot or zone on the surface of the dielectric 23 is subsequently read by returning the electron beam to this spot. The beam in striking the dielectric releases more secondary electrons than there are primary electrons striking it, and these are repelled from the surface, causing the potential to rise to that of the barrier grid. The potential will not become more positive than the barrier grid through this type of action because the secondary electrons in that case would return to the surface and fail to escape. At

equilibrium, the dielectric surface releases as many electrons as arrive and remains at the barrier grid potential.

It is thus apparent that when the information is being read out, the surface of the dielectric is being discharged through capacitances both to the barrier grid and the back plate simultaneously. Accordingly, current will flow in both the inner conductor 29 and the outer conductor 30 in the same direction. These currents produce a signal voltage across the coiled portion 32 of the coaxial line 28 which can be read by an output circuit. In this specific embodiment, a resistance 34 is connected in shunt across the coiled portion 32 and an output amplifier 35 is connected across the resistance 34 and the coiled portion 32.

Thus, application of the writing signal alone to the back plate ideally will induce no signal into the reading amplifier. However, the electron beam will affect the reading amplifier by applying current to the storage target as a whole. The net current to the target will be the difference between the impinging beam current and the escaping secondary electron current. Any change in this net current will cause a signal to appear and be amplified. Whenever the dielectric surface is being charged or discharged, whether in reading or writing, there will be a deficiency or excess of secondary electron current escaping from the target; the detection and interpretation of these current changes constitutes the reading operation. It is an aspect of this invention to eliminate from the reading circuit spurious signals induced from other sources than the electron beam current.

A schematic diagram of the reading and writing circuits of the embodiment of Fig. 1 is shown in Fig. 2. In this schematic diagram each conductor of the coiled portion 32 has an inductance L and a mutual inductance M , advantageously equal to L . Inner conductor 29 connects one inductance to the back plate, which is represented by the point 36, and outer conductor 30 connects the other inductance to the barrier grid, which is represented by the point 37. Capacitance C_1 , which is the barrier grid to back plate capacitance, is connected between points 36 and 37. C_2 is the barrier grid to ground capacitance, which is relatively large, and C_3 is the back plate to ground capacitance, which is very small due to the shielding action of the shielding member 26 and the construction of the target assembly. R is the equivalent resistance of the outer conductor of the coaxial line 28 and is also very small.

Connected between the two inductors is the writing signal source 33. The output amplifier 35 is connected across the load resistor 34 between the barrier grid and ground. During the charging of the capacitor C_1 ideally current flows from the source 33 through the input inductor L to the capacitor and then all the current returns to the source 33 through the output inductor L ; as mentioned below, not all the current does return and there is a slight unbalance of current in the two inductors.

When the beam returns to the charged spot on the dielectric to read out the information stored at that spot, the charge on the dielectric is removed and current flows to ground through both the input and output conductors of the coaxial line. We can therefore consider that there is a current generator 40 connected to a point 43 representing the dielectric surface which is connected by a first capacitance 41, representing the dielectric surface to back plate capacitance, to the back plate and by a second capacitance 42, representing the dielectric surface to barrier grid capacitance, to the barrier grid. The reading signal source is thus an assumed source of current that is actually the difference between the primary and secondary electron currents at the dielectric surface. As this source and its current path are not actually present, but only assumed, the source has been indicated as connected in the circuit by dotted lines.

The coiled portion 32 may advantageously be attained by coiling a coaxial cable, using the outer and inner conductors as the two self inductances of an air core coil.

However, as depicted in Fig. 2, a magnetic core may also be employed. Thus in one specific embodiment the coiled portion 32 comprises a wire positioned within a copper tubing wound on a ferrite ferromagnetic core.

From the above discussion it is apparent that, when the beam is turned on suddenly at a particular spot on the dielectric 23, there are four possible conditions to consider. These conditions are:

Case 1: No charge previously stored and no writing voltage applied;

Case 2: No charge previously stored and writing voltage applied;

Case 3: Negative charge previously stored and no writing voltage applied; and

Case 4: Negative charge previously stored and writing voltage applied.

In Fig. 3 the character of the current to and from the storage array for each of these cases is shown as a function of time for a pulse of sufficient duration to achieve equilibrium. Also shown are the forms of the voltage pulses generated in the reading circuit. In Case 1 only the equilibrium number of secondary electrons leave the surface. In Case 2 writing of information on the spot is to occur and there is a temporary deficiency in the number of secondary electrons while the charging operation takes place with a gradual return to the equilibrium value. In Case 3 reading of the information priorly stored is to occur and an excess number of secondary electrons is produced while the surface is discharged, followed by a gradual return to normal. There is also a net current which, as described above, flows inductively in the coiled portion 32 thereby inducing the output signal voltage. In Case 4 the current is at an equilibrium value as in Case 1 because the positive writing pulse alone should return the negatively charged surface to the potential of the barrier grid.

The writing signals applied to the target array are of the order of several tens of volts while the reading signals received by the amplifier 35 are of the order of a few millivolts; the reading signals may then of course be amplified to any desired level. In accordance with my invention the application of the very large writing signals does not interfere with the operation of the sensitive amplifier connected to the reading circuit. Ideally, as discussed above, there should be no signal at all across the coiled portion 32 on application of the writing signal. However, in effect a very small signal is induced due to unbalance in the currents flowing in the inner and outer conductors. This unbalance is, in part, caused by other capacitances within the tube. It is therefore desirable that the back plate and dielectric be substantially entirely shielded from the rest of the tube. Accordingly in the embodiment of the invention depicted in Fig. 1, the shield member 26, which is an extension of the outer conductor 30, completely encompasses these elements.

However, there is a very small direct capacitance between the back plate and the other elements in the tube, specifically the shield 19 and collector 18, through the holes in the barrier grid. The shield 19 is advantageously grounded and the collector 18 may be connected directly to ground, as by being connected to the shield 19, or be connected to ground through a resistance, as shown in Fig. 1. This capacitance can be considered, therefore, as a back plate-to-ground capacitance, and is the capacitance 63 in Fig. 2. Accordingly, not quite all the charging current due to a writing signal in the inner conductor 29 returns through the outer conductor 30; some very small fraction appears as displacement current through the holes in the barrier grid to ground. A second effect which prevents the perfect current balance desired is caused by the finite resistance of the outer conductor of the line. The charging current will therefore induce a slight voltage between the barrier grid and ground. This voltage, however, can be kept quite small, well below the

magnitude of the reading output signals, so that discrimination between the two types of induced signals is not difficult.

The resistance of the outer conductor 30 is shown as resistor R in the schematic diagram of Fig. 2. To reduce the value of this resistance, it may be desirable to employ a hollow copper tubing, having a relatively thick wall, as the outer conductor 30.

If it is desired further to eliminate the small residual error signal due to the writing signal applied to the target assembly, various types of cancellation schemes can be utilized. One such scheme is indicated in Fig. 2 wherein a canceling pulse generator 45 is operated by the writing pulse source 33 to apply a canceling pulse of proper sign and magnitude directly to the reading amplifier 35, as directly across the load resistor 34 to cancel out the residual error signal appearing at that resistor due to the unbalance of current flow in the two conductors of the coaxial line.

In Fig. 4 there is shown another specific illustrative embodiment of this invention wherein the storage tube comprises a dielectric island tube of the type disclosed in application Serial No. 169,140, filed June 20, 1950, now U. S. Patent No. 2,726,328, issued December 6, 1955, of A. M. Clogston. In the embodiment of Fig. 4, the target array comprises a back plate 50 on the front surface of which are located small spots or islands 51 of dielectric material. A field equalizing grid 52 is positioned in front of the dielectric islands 51 and between it and the remainder of the tube, which may be as depicted in Fig. 1; grid 52 is supported by the shield member 26 encompassing the target array.

In this specific embodiment the output amplifier 35 is not directly connected across the coiled portion 32 but is coupled thereto by an inductive winding 55, whereby transformer coupling is attained with an increase in signal strength over the direct coupling method of Fig. 1.

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 back plate, dielectric target means in contact with said back plate, an electrode positioned to the other side of said dielectric means than said back plate, electron gun means for projecting a beam of electrons through said electrode and against said dielectric means, and means comprising said gun means, said back plate and said electrode for storing information on said dielectric means and for receiving stored information from said dielectric means, said last-mentioned means further comprising an intermittent voltage source and a coaxial line connected to said source and having its inner and outer conductors individually connected to said back plate and said electrode.

2. An electron discharge device comprising a back plate, dielectric target means mounted on said back plate, a grid positioned in front of said dielectric means, electron gun means for projecting a beam of electrons through said grid and against said dielectric means, and means including said electron gun means for applying signals to said back plate to store information on said dielectric means and for receiving output information from said dielectric means, said last-mentioned means including a coaxial line having its inner conductor connected to said back plate and its outer conductor connected to said grid, said coaxial line having a coiled portion, a source of intermittent input signals connected between said inner and outer conductors, and means coupled to said coiled portion for receiving output signal voltages developed thereacross.

3. An electron discharge device in accordance with claim 2 further comprising a shielding member encom-

passing said back plate and said dielectric means, said shielding member being connected to said outer conductor of said coaxial line.

4. An electron discharge device in accordance with claim 3 wherein said grid is mounted by said shielding member.

5. An electron discharge device in accordance with claim 2 wherein said coiled portion of said coaxial line defines a pair of inductances having substantially equal self-inductances and a mutual inductance equal to said self-inductances.

6. An electron discharge device in accordance with claim 2 wherein said coaxial line comprises a conducting wire positioned within a hollow conducting tube.

7. An electron discharge device in accordance with claim 6 wherein said coiled portion encompasses a magnetic core.

8. An electron discharge device in accordance with claim 2 wherein said dielectric target means comprises a dielectric sheet and said grid is a barrier grid positioned closely adjacent said dielectric sheet.

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

10. An electron discharge device in accordance with claim 2 wherein said means coupled to said coiled portion for receiving output signal voltages comprises an amplifier connected directly to said coiled portion.

11. An electron discharge device in accordance with claim 2 wherein said means coupled to said coiled portion for receiving output signal voltages comprises an amplifier inductively coupled to said coiled portion.

12. An electron discharge device comprising a back plate, dielectric target means mounted on said back plate, an electrode positioned to the other side of said dielectric means than said back plate, a shielding member encompassing said back plate and dielectric means and connected to said electrode, electron gun means for projecting a stream of electrons against said dielectric means, and means including said electron gun means for applying signals to said back plate to store information on said dielectric means and for receiving information from said dielectric means, said last-mentioned means including a first conductor connected to said back plate and a second conductor connected to said shielding member, said conductors together defining a coiled portion, and a source of intermittent input signals connected between said first and second conductors.

13. An electron discharge device in accordance with claim 12 further comprising means coupled to said coiled portion for receiving output signal voltages developed thereacross.

14. An electron discharge device comprising a back plate, a dielectric target means mounted on said back plate, a grid positioned in front of said dielectric means, a shielding member encompassing said back plate and dielectric means and mounting said grid, electron gun means for projecting a stream of electrons through said grid against said dielectric means, and means including said electron gun means for applying signals to said back plate to store information on said dielectric means and for receiving information from said dielectric means, said last-mentioned means including a coaxial line having its inner conductor connected to said back plate and its outer conductor to said shielding member, said coaxial line comprising a wire within a hollow metallic tubing and having a coiled portion, input signal means connected between said inner and outer conductors, and means coupled to said coiled portion for receiving output signal voltages developed thereacross.

15. An electron discharge device comprising a back plate, a dielectric target means in contact with said back plate, a grid positioned in front of said dielectric means, electron gun means for projecting a stream of electrons

through said grid and against said dielectric means, and means including said electron gun means, said back plate and said grid for storing information on said dielectric means and for receiving stored information from said dielectric means, said last-mentioned means including a coaxial line having its inner and outer conductors individually connected to said back plate and said grid and output means coupled to said coaxial line for receiving an output signal on flow of current in only one direction in said coaxial line but no output signal on flow of current in opposite directions in said inner and outer conductors of said coaxial line.

16. An electron discharge device comprising a back plate, dielectric target means in contact with said back plate, a grid positioned in front of said dielectric means, a shielding member encompassing said plate and dielectric means and supporting said grid, electron gun means for projecting a stream of electrons against said dielectric means, and means comprising said electron gun means, said back plate, and said grid for storing information on said dielectric means and for receiving information from said dielectric means, said last-mentioned means further comprising a coaxial line having its inner conductor connected to said back plate and its outer conductor to said shielding member, a source of writing signals connected between said inner and outer conductors, an output circuit, and means preventing an output signal being applied to said output circuit on application of said writing signals to said coaxial line.

17. An electron discharge device in accordance with claim 16 wherein said output circuit is electrically connected to said preventing means, the output signals being across said preventing means on the reading of information stored on said dielectric means.

18. An electron discharge device comprising a back plate, dielectric target means in contact with said back plate, an electrode positioned to the other side of said dielectric means than said back plate, electron gun means for projecting a stream of electrons through said electrode and against said dielectric means and means including said electron gun means, said back plate and said electrode for storing information on said dielectric means and for receiving stored information from said dielectric

means, said last-mentioned means including a first conductor connected to said back plate, a second conductor adjacent said first conductor so as to be electromagnetically coupled thereto and connected to said electrode, a source of intermittent writing signals connected between said first and second conductors, and output means coupled to said conductors for receiving an output signal on flow of current in only one direction in said conductors but no output signal on flow of current in opposite directions in said conductors.

19. An electron discharge device comprising a back plate, dielectric target means in contact with said back plate, a grid positioned in front of said dielectric means, a shielding member encompassing said plate and said dielectric means and connected to said grid, electron gun means for projecting a stream of electrons against said dielectric means, and means including said electron gun means, said back plate, and said grid for storing information on said dielectric means and for receiving information from said dielectric means, said last-mentioned means including a first conductor connected to said back plate, a second conductor electromagnetically coupled to said first conductor and connected to said shielding member, a source of intermittent writing signals connected between said conductors, an output circuit, and means preventing an output signal being applied to said output circuit on flow of writing current in both said conductors.

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