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STORAGE TUBE TARGET
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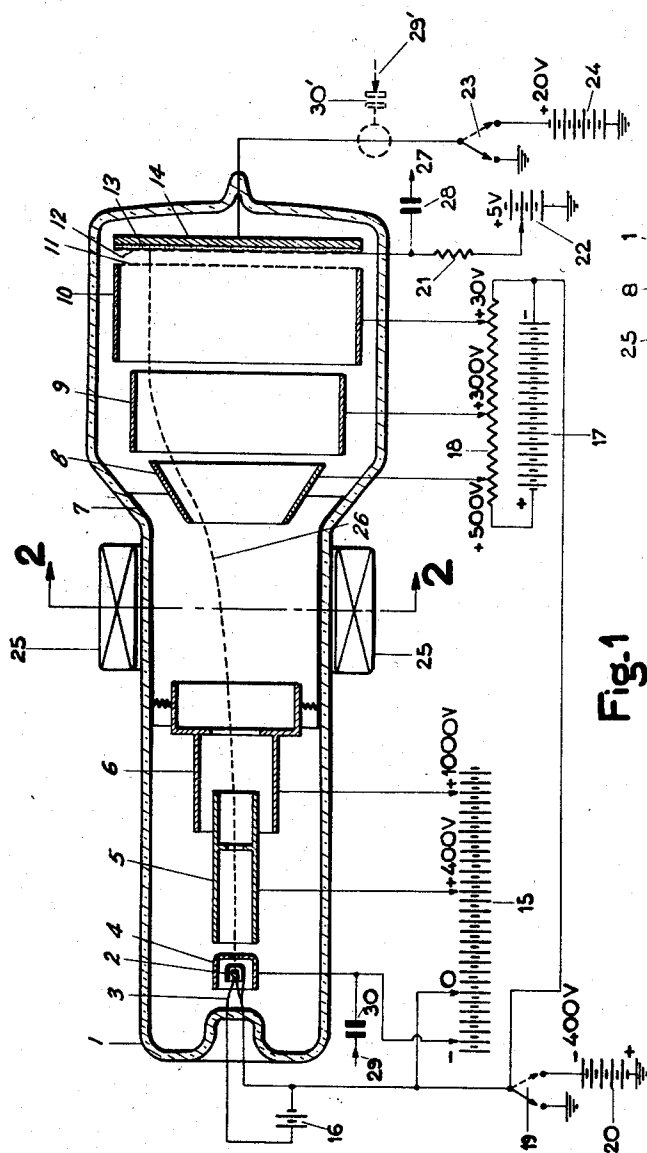


Fig. 1

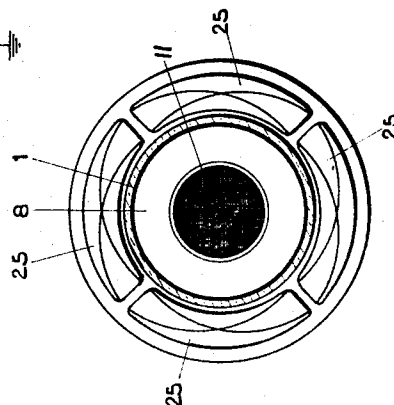


Fig. 2

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1

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STORAGE TUBE TARGET

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The present invention relates to storage tubes operating by accumulation of charges and having a single electron gun which directs an electron beam toward a storage target. The electron beam sweeps periodically the target surface and the consecutive sweeping periods may be respectively dedicated to writing of an electric signal on the target, to one or several readings and to one or several erasings of said signal. These periods may succeed each other without interruptions or be separated by time intervals.

For practical technical application purposes these tubes must present the following characteristics:

(1) The signals which have been stored between the moments O and T of a writing period must be reproduced without distortion of the curve of stored signals as a function of time and without relative shift relatively to the initial instant of each period, in one or several reading periods comprised between moments nT and $(n+1)T$, n designating an integer.

(2) This previous requirement is necessary for the accurate reproduction of each signal being read in accordance with the written signal as well as for the accurate comparison of several signals read consecutively with or without time intervals between the reading periods. Consequently, each preceding reading must not modify the value of the charges written on the target during the writing period, the stored charges only controlling the reading without being removed except during a period of intended erasing.

(3) The transfer characteristic must allow the correct rendering of half-tones for a speed of inscription corresponding to a sweeping period of the order of a $\frac{1}{60}$ of a second.

It is an object of this invention to provide an improved storage tube of the above type satisfying the aforementioned requirements.

It is also an object of this invention to provide an improved combination of storage tube and circuitry therefor providing high writing signal retentivity for prolonged periods of time and means for reading the written signal without changing the stored value thereof.

Another object of this invention is to provide improved circuitry for a tube operating as described above.

Still another object of the present invention is to provide an improved combination of a specific storage tube structure with a control circuit combined therewith in a novel manner.

The tube according to the invention comprises a single electron gun in combination with a target, part of which is constituted by a metallic layer or back plate to which different potentials are applied during the writing and reading periods. During the same periods the potentials applied to the gun electrodes remain the same. The gun also comprises an electrostatic system of electron optics such that the electrons emitted by the gun during writing and reading periods are slow with secondary emission ratio less than unity and impinging the target at

2

a direction substantially perpendicular to the target surface whatever the location of the impact is.

According to the invention, such tube is also characterized by the construction of the target comprising a metallic layer or back plate mentioned above on which an insulating layer is deposited, which insulating layer supports a metallic grid oriented toward the gun and serving to deliver the output signal.

In one embodiment of the invention the input signal is supplied to the Wehnelt or control electrode of the gun in a manner known in the art.

In another embodiment of the invention, the input signal is supplied to the metallic back plate of the target.

These and other objects, features and advantages of the present invention will become more obvious from the following description when taken in connection with the accompanying drawing, which shows, for purposes of illustration only, two embodiments in accordance with the present invention, and wherein:

Figure 1 is a longitudinal section of tube according to the invention with the circuitry therefor schematically illustrated; and

Figure 2 is a transversal section along line 2—2 of Figure 1.

The tube of Figure 1 comprises an evacuated cylindrical glass envelope 1 enclosing an electron gun, electron beam guiding means and a target.

The electron gun comprises a cathode 2, a heating filament 3, a Wehnelt or control electrode 4, a first accelerating anode 5, and a second accelerating anode 6 connected to the metallic layer 7 covering part of the inside of the wall of enclosure 1.

To guide the target impinging electrons in parallel paths the tube includes a plurality of electrodes of collimation 8, 9, 10 either cylindrical or conical, electrode 10 being provided with a transversal grid 11 parallel to and co-extensive with the target.

The target is composed of a very thin fine mesh grid 12 displayed on an electrically insulating back plate 13 mounted on a metallic layer 14, grid 12 facing grid 11, i.e., grid 12 is oriented toward the gun.

Vacuum-tight connections are provided in the enclosure 1 for the purpose of connecting electrodes 2, 3, 4, 5, 6, 8, 9, 10, 11, 12 and 14 to the outside circuits.

A direct current source 15 provides the potentials applied to the gun elements. As an example, considering the cathode potential as a reference voltage, a negative potential of 70 volts is applied to the Wehnelt electrode 4, a positive potential of about 400 volts is applied to anode 5, a positive potential of about 1000 volts is applied to anode 6.

The heating filament 3 is fed by source 16.

A direct current source 17 feeds potentiometer 18 which supplies collimating electrodes 8, 9, 10 with successively decreasing and adjustable positive potentials. Said potentials can be, for instance, 500 volts to electrode 8, 300 volts to electrode 9, 30 volts to electrode 10, the cathode potential still being considered as the reference voltage. The negative pole of source 17 is connected to the cathode 2, thus assuming the same potential.

The terminal of source 15 which is at the potential of the cathode is connected to switch 19 which, in the solid line position, connects the cathode to a potential at or near ground and in the dotted position, connects the cathode at a high negative potential relatively to the ground, a potential of -400 volts for instance. This potential is supplied by direct current source 20.

It is understood that the representation of switch 19 as shown in the drawings is only symbolic and that, in practice, it may correspond to any suitable switching means.

The target grid 12 is connected through a resistor 21 to

a terminal of a direct current source having a positive potential of a few volts, 5 volts for instance, relative to ground.

Metallic layer 14 of the target is connected to switch 23. The previous remarks relative to switch 19 also apply to switch 23. In the solid line position switch 23 connects layer 14 to ground, or a potential very close thereto, and in the dotted position layer 14 is connected to direct current source 24 a positive potential of, for instance, 20 volts relative to the ground.

Two pairs of deflecting coils 25, energized by suitable sweeping sources (not shown), are mounted around the neck of enclosure 1 to provide respectively the magnetic deflection, horizontal and vertical, of electron beam 26 produced by the gun.

An output circuit 27 for the read signal is connected through condenser 28 to grid 12 at a point between grid 12 and resistor 21.

The input circuit 29 of the signal to be recorded is connected, in the example shown, to the Wehnelt electrode 4 through a condenser 30. Instead of being linked to the Wehnelt electrode, the input circuit could also be connected to the line joining metallic layer 14 to switch 23 as shown in dotted lines at 29' and 30' with an appropriate change in the direct current potential of Wehnelt electrode 4 as discussed hereinafter.

Operation

Initially, the target is fully erased, i.e., all the points of the surface of insulating layer 13 adjacent to grid 12 are at the same potential supplied to grid 12 by source 22, namely, 5 volts in the present example.

At the beginning of the writing period, switch 19 is so oriented that the cathode is grounded and switch 23 is so positioned that a positive potential of 20 volts is applied to layer 14. The writing signal source is connected at 29 to the Wehnelt electrode 4 which is so biased that the electron beam is cut off in the absence of a signal. Said signal modulates beam 26 which sweeps the surface of grid 12 and insulating layer 13 under the action of deflective coils 25.

The beam paths 26 are first angularly displaced during their passage through the gun, but are curved under the action of the collimating electrodes 8, 9, 10 and become parallel to the axis of the tube in their last portion of travel.

The design of the electron-optical system is such that the beam parallelism is constantly maintained through the entire sweeping period. Consequently the electrons pass through grid 11 in a perpendicular direction and are impinging grid 12 in a direction perpendicular to the target whatever the location of the impact may be.

The electrons of beam 26 are emitted by the cathode at a zero potential and are partly collected by grid 12 at a potential of +5 volts and directed to resistor 21. Due to this small potential difference, they are slow electrons. The other beam electrons pass through the meshes of grid 12 and are intercepted by the surface of the insulating layer 13 which is at a greater potential than grid 12 since a 20 volt positive potential has been applied to the metal supporting layer 14.

The impact of the slow electrons on the insulating layer causes a secondary emission of electrons from said layer with an emission coefficient lower than unity. Consequently, at a given point of impact, the amount of electrons emitted is smaller than the amount received, the point of impact being charged negatively, its potential decreasing (or becoming less positive) proportionally to the amount of electrons received, proportionally that is to the modulating signal applied at 29. The circuit potentials will be preferably chosen so that the maximum amplitude of the modulating input signal will bring the potential of the point of impact to zero.

The sweeping of the surface of layer 13 by beam 26 during the writing period thus produces on this surface

an impression of potential corresponding to the variations of the input signal within the limits of said period.

At the end of the writing period, switch 23 is moved to the position connecting the metal layer 14 to ground. The potentials of all the points of surface 13 then decrease an amount corresponding to the 20 volt reduction in potential of plate 14. The points at which the potential did not change during the inscription because the signal was null are again at a zero potential; the points brought to a zero potential by action of the maximum signal are now at a negative potential equal to the uniform potential decrease of plate 14.

The relative values of potential at the charged points on surface 13 are not disturbed by this operation, the signal being thus retained until a reading period is reached. Said period may or may not follow immediately the inscription period. For reading, the target is swept with a beam of constant intensity, provided, for example, by applying a signal of fixed amplitude applied at 29 during the sweeping, the potentials of all the electrodes being kept at the values they had at the end of the writing period.

At any time of the reading period the path of the beam is exactly the same as at the corresponding time of the writing period provided the tube supplying sources are stable enough. As previously the reading beam arriving at grid 12 is composed of slow electrons and again impinges the target perpendicularly regardless of the location of the impact.

However, as opposed to the situation in the writing period, the electrons now find behind the grid an insulating surface having points which are either at a zero potential in the areas corresponding to a null signal or at a negative potential relatively to the ground, each negatively charged point having a potential value corresponding to the amplitude of a time related part of the signal. In the areas of zero potential all electrons are collected by grid 12. In the negatively charged areas the points of the insulating surface which are negatively charged act like Wehnelt electrodes and repel the electrons, the rejected electrons being divided into two portions, the one of which being collected by the grid 12, and, the other portion moving backward and being collected first by the grid 11 and then by electrodes 10, 9, 8. The ratio in which the rejected electrons are thus divided depends upon the potential value of the negative charge at each point, that is to say upon the amplitude of the recorded signal at the corresponding point. At no time are the electrons collected by the insulating surface; as a consequence the reading does not alter the value of the potential recorded on the surface. Such reading can in theory be repeated an infinite number of times, and in practice it is only limited by the erosion or leakage of the stored potential occurring with time and due to the non-infinite resistivity of the insulating layer, such resistivity being obviously kept as high as possible.

The electrons collected by grid 12 move through resistor 21; the current in this resistor is thus maximum and the current diverted by electrodes 11, 10, 9, 8 is a minimum when the recorded signal is null and the former current gradually decreases while the latter increases when the amplitude of said signal increases. For a certain value of the amplitude the current in resistor 21 will become null; the system will be so designed that said value of the amplitude will correspond to the crest of the amplitudes of the signal susceptible to be brought to the tube input. In this manner, the crest is brought to coincide with an absolute level of current in the load resistor.

Considering that, with a null current in resistor 21, the voltage between the connecting point of condenser 28 and the ground is equal to the bias of grid 12, and considering also that said voltage gradually decreases when the current in resistor 21 increases, it is noticed that the voltage transmitted through condenser 28 to

the output circuit reproduces exactly the signal which was brought to the input during the writing period, the crest of this voltage being given by the bias of grid 12 determined by source 22.

When, after any desired number of readings, it is desired to erase the target to have it ready for a new inscription, the control handle of switch 19 is moved toward the right or dotted position; the control handle of switch 23 being kept in the left or solid line position as it previously was. All potentials of the gun electrodes and of the collimating electrodes are then decreased of the same amount corresponding to the voltage of battery 20 which, according to the described example places the cathode at a potential of -400 volts relative ground. The Wehnelt electrode receives from input 29 a constant signal which allows passage of the beam and the electrons reaching grid 12 at potential +5 v. are fast electrons. They pass through the grid and hit the insulating layer 13 and sweep it under the action of the deflective coils 25. A secondary emission then occurs, originating from layer 13 with an emission coefficient greater than unity. Consequently, at a given point of impact, the amount of electrons emitted is greater than the amount received, the point is positively charged which destroys the negative charge if previously recorded and brings the potential to a value near the potential of grid 12 which stays at +5 volts. Finally, all the points of the insulating layer reach the same potential as the grid and the erasing is completed.

If after one sweeping operation the erasing is not sufficient, it can be repeated several times, a new writing period then follows and the same cycle as previously described occurs.

When, according to the modified embodiment of the invention, the signal to be recorded is not applied to the Wehnelt electrode 4, but modulates the potential of plate 14 through the circuit indicated at 29'-30', nothing changes in the operations of reading and of erasing as previously described. The mechanism of writing is the only one to be affected by the modification, however, the result is the same. In such a modification the control handle of switch 23 stays in the left position and plate 14 stays at a zero potential while the Wehnelt electrode receives such a bias that the electron beam is emitted from the gun. The constant intensity of the beam sweeping the target is adjusted by a suitable choice of Wehnelt bias such that the secondary emission will not alter the storage of charges on the insulating layer 13 so that the potential of each point of the surface will be brought to a zero value when impinged by the constant intensity beam. If the signal applied at 29' causes the potential of plate 14 to vary, the fluctuation is transmitted to all the points of layer 13, but at the point corresponding to the impact of the beam the potential is maintained at a zero value by the beam. Consequently, a stored potential appears on surface 13 and, at the end of the writing period, when the plate 14 is again at a zero potential, the potentials of the points under impact when the plate was receiving the signal become negative according to the corresponding instantaneous amplitude of the input signal when the respective points were under beam impact. The result is the same as the one obtained by modulation of the beam by the Wehnelt electrode.

It has been noticed that during writing and reading periods the gun and the collimating electrodes were operated under the same supplied voltages. As a consequence, the reproduction of the recorded information is not affected by the geometrical defects of the tube and of the sweeping. The perfection of the time basis and the stabilization of the supply sources only intervene. It is seen that, as described, the apparatus answers the first requirements outlined at the beginning of the specification.

Since, also, the relief of the charges deposited during the inscription appears not to be disturbed by the reading operation the second requirements are also fulfilled.

Finally, since it is possible to have the maximum signal coincide with the threshold of cancellation of the current in the resistance 21, it is also possible to establish a univocal relationship between each intermediate value of the amplitude and a given current in the resistance, that is to say to correctly reproduce the half-tones as mentioned in the third requisite.

While we have shown and described two embodiments in accordance with the present invention, it is understood that the same is not limited thereto but is susceptible of many changes and modifications within the scope and spirit of the present invention and we, therefore, intend to cover all such changes and modifications as are encompassed by the scope of the appended claims.

We claim:

1. A storage tube apparatus for operation successively in input signal writing, reading and erasing conditions, comprising in combination a single electron gun having a plurality of electrodes including a control electrode and at least one collimating electrode, a target having a metal layer, an insulating layer on said metal layer and a metal grid on said insulating layer, said grid facing said gun, means for applying to said gun electrodes substantially the same constant direct current potentials during both writing and reading time intervals, said potentials being selected so that the electrons issued from said gun impinge said target substantially perpendicular thereto and provide a secondary emission ratio less than unity, deflecting means for said electrons for sweeping said target surface, means for applying to said metal layer the same direct current potential during both said reading and writing intervals, and input means connected to said metal layer for producing stored charges at points on said insulating layer corresponding to the value of an input signal as at the moments the respective points are swept by the beam, and signal output means operatively coupled to said target grid.

2. A storage tube apparatus as claimed in claim 1, further comprising means for varying said direct current potentials applied to said gun electrodes to raise said electron velocity thereby erasing said input signal recorded on said target.

3. A storage tube apparatus for operation successively in input signal writing, reading and erasing conditions, comprising in combination a single electron gun having a plurality of electrodes including a control electrode and at least one collimating electrode, a target having a metal layer, an insulating layer on said metal layer and a metal grid on said insulating layer, said grid facing said gun, means for applying to said gun electrodes substantially the same constant direct current potentials during both writing and reading time intervals, said potentials being selected so that the electrons issued from said gun impinge said target substantially perpendicular thereto and provide a secondary emission ratio less than unity, deflecting means for said electrons for sweeping said target surface, means for applying to said target metal layer different direct current potentials respectively in said writing and reading time intervals, signal input means coupled to said control electrode, and signal output means operatively coupled to said target grid.

4. Storage tube apparatus as claimed in claim 3, further comprising means for biasing said control electrode to prevent electrons from impinging said target except upon application of an input signal exceeding a predetermined value.

5. A storage tube apparatus as claimed in claim 3, further comprising means for varying the direct current potentials applied to said gun electrodes to raise said electron velocity thereby providing a secondary emission ratio greater than unity at said target for erasing signals recorded thereon.

6. An electronic storage tube apparatus for operation successively in signal writing, reading and erasing conditions, comprising in combination a target electrode com-

posed of a metal back plate, an insulating layer disposed on said back plate and a fine mesh metal grid on said insulating layer, an electron gun including a cathode, a control electrode, accelerating electrodes and collimating electrodes for forming a concentrated electron beam directed toward said target grid, deflecting means intermediate said accelerating electrodes and said collimating electrodes for deflecting said beam to sweep the whole surface of said target, means for bringing said gun electrodes to predetermined fixed potentials relative to said cathode for increasing the electron velocity along said accelerating electrodes and decreasing that velocity along said collimating electrodes, a resistor connected to said fine mesh grid by one of its terminals, a low voltage direct current source connected between the other terminal of said resistor and ground so that said grid is at a low positive potential relative to ground, means for selectively bringing said cathode to substantially ground potential for both writing and reading operation and to a highly negative potential relative to ground for erasing operation thereby impinging said target by slow and fast electrons, respectively, means for selectively bringing said back plate to a potential higher than said grid potential for writing operation and to substantially ground potential for both reading and erasing operation, input means connected to said control electrode and output means connected across said resistor.

7. An electronic storage tube apparatus for operation successively in signal writing, reading and erasing conditions, comprising in combination a target electrode composed of a metal back plate, an insulating layer disposed on said back plate and a fine mesh metal grid on said insulating layer, an electron gun including a cathode, a control electrode, accelerating electrodes and collimating electrodes for forming a concentrated electron beam directed toward said target grid, deflecting means intermediate said accelerating electrodes and said collimating electrodes for deflecting said beam to sweep the whole surface of said target, means for bringing said gun electrodes to predetermined fixed potentials relative to said cathode for increasing the electron velocity along said accelerating electrodes and decreasing that velocity along said collimating electrodes, a resistor connected to said fine mesh grid by one of its terminals, a low voltage direct current source connected between the other terminal of said resistor and ground so that said grid is at a low positive potential relative to ground, means for selectively bringing said cathode to substantially ground potential for both writing and reading operation and to a highly negative potential relative to ground for erasing operation thereby impinging said target by slow and fast electrons, respectively, means for bringing said back plate to substantially ground potential, input means connected to said back plate and output means connected across said resistor.

8. An electronic storage tube apparatus for operation successively in signal writing, reading and erasing conditions, comprising in combination a target electrode composed of a metal back plate, an insulating layer disposed on said back plate and a fine mesh metal grid on said

insulating layer, an electron gun including a cathode, a control electrode, accelerating electrodes and collimating electrodes for forming a concentrated beam directed toward said target grid, deflecting means intermediate said accelerating electrodes and said collimating electrodes for deflecting said beam to sweep the whole surface of said target, means for bringing said gun electrodes to predetermined fixed potentials relative to said cathode for increasing the electron velocity along said accelerating electrodes and decreasing that velocity along said collimating electrodes, a resistor connected to said fine mesh grid by one of its terminals, a direct current source connected between the other terminal of said resistor and ground, means for selectively bringing said cathode to a first potential with respect to ground for both writing and reading operation and to a second potential for erasing operation, said first and second potentials being so chosen that said target is struck by slow and fast electrons, respectively, and the secondary electron emission ratio of said insulating layer is smaller and greater than unity, respectively.

9. An electronic storage tube apparatus for operation successively in signal writing, reading and erasing conditions, comprising in combination a target electrode composed of a metal back plate, an insulating layer disposed on said back plate and a fine mesh metal grid on said insulating layer, an electron gun including a cathode, a control electrode, accelerating electrodes and collimating electrodes for forming a concentrated beam directed toward said target grid, deflecting means intermediate said accelerating electrodes and said collimating electrodes for deflecting said beam to sweep the whole surface of said target, means for bringing said gun electrodes to predetermined fixed potentials relative to said cathode for increasing the electron velocity along said accelerating electrodes and decreasing that velocity along said collimating electrodes, a resistor connected to said fine mesh grid by one of its terminals, a direct current source connected between the other terminal of said resistor and ground, means for selectively bringing said cathode to a first potential with respect to ground for both writing and reading operation and to a second potential for erasing operation, said first and second potentials being so chosen that said target is struck by slow and fast electrons, respectively, and the secondary electron emission ratio of said insulating layer is smaller and greater than unity, respectively, means for applying an input signal to said apparatus during said writing operation for producing, by means of said slow electrons, stored charges at points on said insulating layer corresponding to the value of the input signal at the moments the respective points are impinged by the beam, and means for abstracting an output signal from said grid during said reading operation.

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