

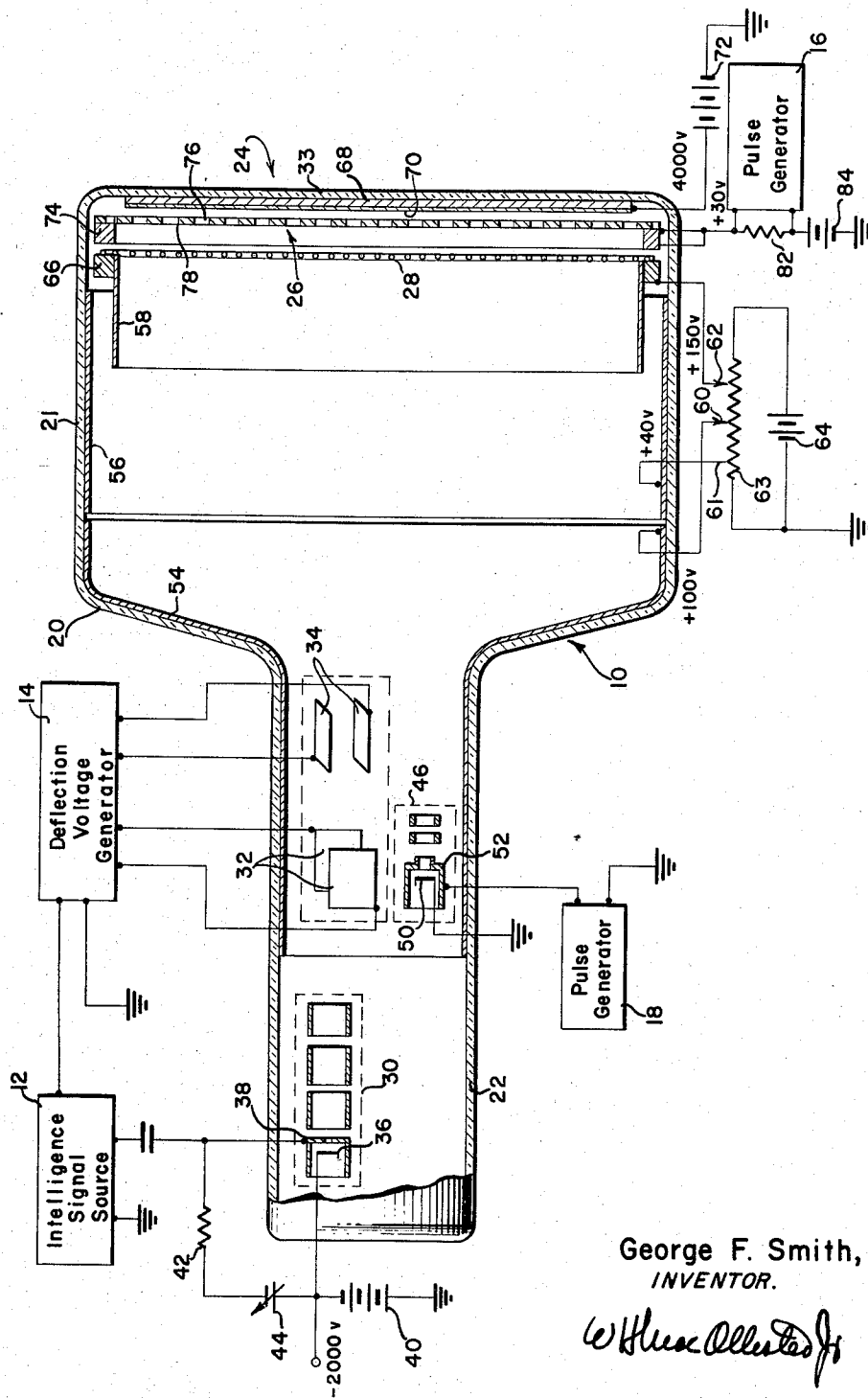
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DIRECT-VIEWING STORAGE TUBE

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DIRECT-VIEWING STORAGE TUBE

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This invention relates to electronic storage devices and more particularly to a direct-viewing storage tube capable of half-tone presentation of given information for an extended period of time.

The direct-viewing half-tone storage tube to which the present invention relates is of the type described in U.S. Patent 2,790,929 to E. E. Herman and G. F. Smith, and assigned to the instant assignee. This storage tube comprises a target assembly which includes a storage target and a viewing screen. Two electron guns are provided; one gun (hereinafter called the "writing" gun) causes the formation of a charge pattern on the storage target corresponding to the information to be presented, and the other gun (hereinafter called the flood or viewing gun) renders the charge pattern visible on the viewing screen. Information-representative signals are employed to modulate the intensity of the electron beam produced by the writing gun. The storage target is initially uniformly charged negatively. When the writing beam strikes the storage target, a less negative potential is produced at the point of impingement by the phenomenon of secondary emission. It should be understood that as used herein in describing the storage or charge pattern on the storage target, the term "positive" designates those portions which are less negatively charged than other portions of the target. The potentials on the storage target are always negative with respect to the potential of the flood gun cathode except when erasing. Thus by scanning the storage target an overall charge pattern corresponding to the information to be presented is obtained. Thereafter this charge pattern controls the passage of flood electrons from the viewing gun to the viewing screen; flood electrons, properly collimated over the entire area of the storage target, are only passed through areas of the storage target which are less negatively charged. It should be understood that the potentials capable of being stored range from a uniformly negative "black" value to a uniformly positive "white" value; at intermediate potentials only a portion of the flood electrons passes through the storage element to the viewing screen thereby producing intermediate or half-tone shades.

In general such direct-viewing half-tone storage tubes are capable of retaining a charge pattern and visually presenting an acceptable reproduction thereof for periods up to about one minute. While for many purposes such retention times are entirely satisfactory, there are occasions when much longer periods are desirable. The limits on the retention time are set by ion currents produced in the tube by collisions between the flood electrons and residual, unremovable gasses and the like. These ions which are positively charged, are attracted to the negatively charged portions of the storage element and slowly drive these portions positive.

It is therefore an object of the instant invention to provide an improved direct-viewing half-tone storage tube having means to substantially increase the retention time of information presented.

Another object of the invention is to provide an im-

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proved direct-viewing half-tone storage tube having means to decrease or retard the effects of ionization upon the charge pattern stored on the storage element therein.

These and other objects and advantages of the invention are achieved by periodically instead of continuously producing flood electrons at a frequency at least as high as the "flicker" frequency so that the visual presentation appears to be continuous. The periodic production of flood electrons is accomplished according to the invention, by pulsing the grid of the flood electron gun.

The invention will be described in greater detail with reference to the drawings wherein the sole figure is a schematic diagram of the direct-viewing half-tone storage device according to the present invention.

Referring now to the drawings, a direct-viewing half-tone storage tube 10 is shown cooperatively associated with a signal source 12, a deflection voltage generator 14, and two pulse generators 16 and 18. The tube 10 comprises an evacuated envelope 20 having an enlarged cylindrical portion 21 and a neck portion 22. The end portion 33 of the cylindrical portion 21 is generally flat and transparent. Disposed adjacent the flat end portion 33 is the target assembly comprising a viewing screen 24, a storage screen 26, and a collector grid 28. An electron gun 30, hereinafter called the "writing" gun, is disposed in the neck portion 22 of the envelope 20 as well as the horizontal and vertical deflecting plates 32 and 34, respectively, for directing the electron beam produced by the writing gun 30 towards selected elemental areas on the storage screen 26. The electron beam produced by the writing gun is of elemental cross-sectional area.

More particularly, the writing electron gun 30 includes a cathode 36 and a grid 38 which controls the intensity of the writing electron beam in accordance with signals supplied thereto by a connection from the signal source 12. Illustratively, the cathode 36 is maintained at a potential of about 2000 volts negative with respect to ground by means of a connection to the negative terminal of a battery 40 whose positive terminal is connected to ground. An adjustable quiescent potential of about 50 volts negative, for example, with respect to the cathode potential is maintained on the intensity grid 38 by means of a connection from the grid 38 through a resistor 42 to the negative terminal of a variable potential source 44 and a connection to the cathode 36 from the positive terminal of this potential source.

By means of appropriate connections, horizontal and vertical deflection voltages are applied, respectively, on the horizontal and vertical deflection plates 32 and 34. These deflection voltages are developed by the deflection voltage generator 14 in synchronism with signals through a connection to the signal source 12.

Likewise disposed in the neck portion 22 of the tube envelope is a flood or viewing electron gun 46 for producing a broad beam of electrons. The flood electron gun 46 comprises a cathode 50 which is grounded and a grid 52. By means of a connection to the pulse generator 18, the grid 52 is pulsed so as to periodically turn the electron gun 46 "on" to produce flood electrons. This operation will be described in greater detail hereinafter.

In the operation of the tube, it is desirable that the flood electrons arrive at the storage screen 26 at approximately normal incidence. Collimation of flood electrons is effected by means of a collimating lens produced by lens cylinders 54, 56, and 58. The lens cylinders 54 and 56 are coaxially disposed about the inner surface of the envelope 20 from the flood electron gun 46 to the collector grid 28. These cylinders may comprise conductive coatings provided, for example, by painting a colloidal suspension of graphite, commonly known as "Aquadag," on the glass. The lens cylinders

54 and 56 are maintained at potentials of the order of about 100 and 40 volts, respectively, by connections to taps 60 and 61 of a potentiometer 63 which in turn is connected across a battery 64, the negative terminal of which is connected to ground.

The other collimating lens cylinder 58 is attached to the inner periphery of a ring 66 which also serves to support the collector grid 28. This lens cylinder 58 extends from the ring 66 towards the flood gun 46 and overlaps the right extremity of the cylinder 56, as viewed in the drawings. Both the cylinder 58 and the collector grid 28 are maintained at a potential of the order of 150 volts positive with respect to ground by means of a connection to a tap 62 of the potentiometer 63.

The viewing screen 24 of the target assembly comprises a transparent conductive coating 68 and a phosphor coating 70 disposed in the order named on the inner surface of the flat transparent end portion 33 of the envelope 20. The transparent conductive coating 68 may be provided, for example, by a thin layer of stannous oxide on the glass envelope. This conductive coating 68 is maintained at a potential of about 4000 volts positive with respect to ground by a connection to the positive terminal of a battery 72 whose negative terminal is connected to ground.

The storage screen 26 is supported by a ring 74 between the collector grid 28 and the viewing screen 24 and is coextensive therewith and includes an electroformed nickel screen 76, having, for example, about 250 meshes per inch and a thickness of the order of about 0.001 inch. The outer periphery of the screen is welded to the ring 74. A thin layer 78 of secondary electron emissive dielectric material provided on the side of the screen 76 facing the neck portion 22 of the tube constitutes the storage surface. It should be noted that this thin secondary emissive layer 78 does not overhang or extend over the interstices of the nickel screen 76. The thickness of this layer (78) is preferably about 20,000 Angstroms but may be as thick as 50,000 Angstroms. Such a layer may be provided by evaporating magnesium fluoride, for example, onto the nickel screen 76.

In operation the nickel screen 76 is maintained at a quiescent potential of about 5 volts positive with respect to ground by means of a connection through a resistor 82 to the positive terminal of a battery 84 whose negative terminal is connected ground. The quiescent potential on the storage surface 78 hence is about 5 volts negative with respect to ground. The storage screen 26 may be periodically pulsed by a pulse generator 16 connected across the resistor 82 in order to "erase" stored charges from the storage surface; that is, to restore the quiescent potential on the storage surface of 5 volts negative with respect to ground. The magnitude of these pulses is approximately equal to the range of potentials over which half-tone operation takes place, for example, 5 volts. Since the instant invention is seeking to increase the retention time of stored charges on the storage screen, the pulse generator 16 is adapted to generate "erase" pulses at time intervals corresponding to the desired time of observation. For example, in some instances, it may be desired to hold a particular type of presentation for as long as 15 minutes and other types of presentation for as long as 20 minutes. In either case, the pulse generator 16 is set to produce an "erase" pulse every 15 minutes or every 20 minutes, as the case may be.

It is also possible to achieve erasure of an image by a fade-out technique which has certain advantages. A "single pulse" type of erasure is accompanied by an objectionable bright flash which is not produced when the presentation is slowly faded-out. Such fading-out may be accomplished, for example, by utilizing a low duty cycle pulse train from the pulse generator 16.

In operation, the dielectric storage surface is charged negatively with respect to the flood gun cathode potential by application of an erase pulse from the pulse gen-

erator 16. Thus flood electrons cannot penetrate the storage screen and are returned to the collector grid 28. Upon the application of intelligence signals to the writing electron gun 30 and its associated deflection system,

the writing electron beam is intensity modulated and strikes the storage surface with such energy that the secondary emission from this surface is very high; i.e., many secondary electrons are emitted for each incident primary electron. These secondary electrons are attracted away from the storage surface to the collector grid 28, thus causing the formation of a charge pattern on the storage surface in accordance with the applied intelligence signals. Potentials ranging from a uniformly positive "white" value to a uniformly negative "black" value are capable of being stored. A more detailed explanation of the half-tone storage and presentation operation of direct-viewing half-tone storage tubes is found in the previously mentioned patent to E. E. Herman and G. F. Smith. As shown in this patent, the brightness of the viewing screen ranges from 0 to 100% brightness as a function of storage surface potentials ranging from about -5.5 volts to about -2 volts. The whole range from black through grey to white is thus achieved in an increment of about 3½ volts on the storage surface. Potentials in this range are established according to the current of the writing electron beam, which in turn, as noted previously, is intensity modulated according to the applied intelligence signals.

Thus those areas of the storage surface which are charged positive in this manner permit the flood electrons to pass through the storage screen assembly to strike the viewing screen producing a visual presentation in accordance with the number of impinging flood electrons which in turn depends upon the storage surface potentials. As mentioned heretofore, the storage surface can hold its charge pattern until ionization within the tube, produced by the flood electrons, begins to cause the negatively charged portions of the storage pattern to go positive. In general, such ionization is effective to limit the retention time of the storage pattern and hence the presentation to about one minute.

According to the instant invention this retention time can be greatly extended to obtain periods of retention for up to 30 minutes by retarding the ionizing action of the flood electrons. This may be accomplished by periodically rather than continuously producing the flood electrons at a frequency just high enough to inhibit "flicker" in the brightness of the presentation. Thus the flood electron gun can be "off" for longer periods than it need be "on" in order to maintain continuity of presentation. In this manner the ionization currents produced by the flood electrons do not reach a value high enough to positively charge the storage surface until after a substantial period of time. In practice retention times of about 30 minutes have been achieved by the instant invention.

Referring again to the drawings, a convenient method for periodically producing the flood electrons is shown wherein pulses are applied to the grid 52 of the flood electron gun 46 by means of a connection therefrom to a pulse generator 18. This generator provides a pulse train whereby the grid 52 is normally biased to cut-off by a negative potential of about 75 volts for example and periodically biased positively by pulses of about 5 volts negative or less, the pulses occurring at intervals at least higher than the "flicker" frequency. It should be understood that the "flicker" frequency is determined by the ability of the observer's eye to see an apparently continuous presentation of an optical image whose brightness is actually changing. In general, the human eye exhibits such persistency if the frequency of brightness change of the image being viewed is at least faster than 16 to 18 times per second. With a pulse of about 10 microseconds occurring about 6000 times per second, for example, the retention time of a direct-viewing half-

tone storage tube was increased from about 40 seconds to about 10 minutes.

The pulses of the train utilized to bias the flood gun grid should be substantially square so as to avoid a concentration of brightness toward the center of the presentation. Such a concentration results if the flood gun grid potential is slowly, rather than abruptly, reduced from the operating level to cut-off because the size of the presentation shrinks from full coverage to a small spot in the center of the viewing screen.

While it may be thought that the ionization current could be lowered by merely lowering the voltage on the grid 52 of the flood gun 46, this is not the case. Reducing the grid voltage merely diminishes the size of the flood beam and hence the presentation while the current density remains substantially the same. Hence the present invention may be utilized in presently-existing storage tubes without impairing the presentation thereof and without requiring extensive re-design and modification.

There thus has been described a direct-viewing half-tone storage device having means for substantially increasing the retention time of a stored charge pattern and the visual presentation thereof. It should be appreciated that the incorporation of the instant invention into storage tubes of the type described is a relatively inexpensive and easily accomplished operation, and, as mentioned previously, does not require extensive alteration or re-design of such tubes.

What is claimed is:

1. In a direct-viewing half-tone storage tube of the type wherein a charge pattern corresponding to information to be presented is formed upon a storage-target by modulating an electron beam produced by a first electron gun in accordance with information-representative signals and wherein said charge pattern is rendered visible by means of a flood of electrons produced by a second electron gun, the combination with said second electron gun of means to periodically produce said flood of electrons at a frequency at least high enough so that the visual presentation of said information appears to be continuous.

2. In a direct-viewing half-tone storage tube of the type wherein a charge pattern corresponding to information to be presented is formed on a storage-target by modulating an electron beam produced by a writing electron gun in accordance with information-representative signals and wherein said charge pattern is rendered visible by means of flood electrons produced by a flood electron gun, the combination with said flood electron gun of means to pulse said flood of electrons at a frequency at least high enough so that the visual presentation of said information appears to be continuous.

3. In a direct-viewing half tone storage tube of the type wherein a charge pattern corresponding to information to be presented is formed on a storage-target by an electron beam produced by a writing electron gun and intensity-modulated in accordance with information-rep-

resentative signals and wherein said charge pattern is rendered visible by means of a flood of electrons produced by a flood electron gun having a grid associated therewith, the combination with said grid of means to periodically bias said flood of electrons from said flood gun to cut-off at a frequency at least high enough so that the visual presentation of said information appears to be continuous.

4. In a direct-viewing half-tone storage tube of the type wherein a charge pattern corresponding to information to be presented is formed on a storage-target by an electron beam produced by a writing electron gun and intensity-modulated in accordance with information-representative signals and wherein said charge pattern is rendered visible by means of a flood of electrons produced by a flood electron gun having a grid associated therewith, the combination with said grid of pulse-generating means to periodically bias said flood of electrons from said flood gun to cut-off at a frequency at least high enough so that the visual presentation of said information appears to be continuous.

5. A direct-viewing half-tone storage device comprising a storage-target, means to produce a charge pattern on said storage target corresponding to information to be presented, said means including a first electron gun for producing a writing electron beam modulated in accordance with information-representative signals, a viewing screen, means including a second electron gun for producing a flood of electrons for rendering said charge pattern visible on said viewing screen, and means cooperating with said second electron gun for periodically producing said flood of electrons at a frequency at least high enough so that the visual presentation of said information appears to be continuous.

6. A direct-viewing half-tone storage device comprising a storage-target, means to produce a charge pattern on said storage-target corresponding to information to be presented, said means including a first electron gun for producing a writing electron beam modulated in accordance with information-representative signals, a viewing screen, means including a second electron gun for producing a flood of electrons for rendering said charge pattern visible on said viewing screen, and means including a pulse generator cooperatively associated with said second electron gun for periodically producing said flood of electrons at a frequency at least high enough so that the visual presentation of said information appears to be continuous.

References Cited in the file of this patent

UNITED STATES PATENTS

2,532,339 Schlesinger ----- Dec. 5, 1950

OTHER REFERENCES

Knoll et al.: "Characteristics of a Transmission Control Viewing Storage Tube with Halftone Display," Proc. of the Inst. of Radio Eng., vol. 41, October 1954, pages 1496 to 1504.