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Gibson, Jr.

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[54] **CHARGE IMAGE STORAGE METHOD AND APPARATUS**

[75] Inventor: **Charles B. Gibson, Jr.**, Portland, Oreg.

[73] Assignee: **Tektronix, Inc.**, Beaverton, Oreg.

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Related U.S. Patent Documents

Reissue of:

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Filed: **Dec. 7, 1966**

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[52] **U.S. Cl.** .... **315/11;** 315/12 R

[51] **Int. Cl.²** **H01J 31/48**

[58] **Field of Search** 315/11, 12

[56] **References Cited**

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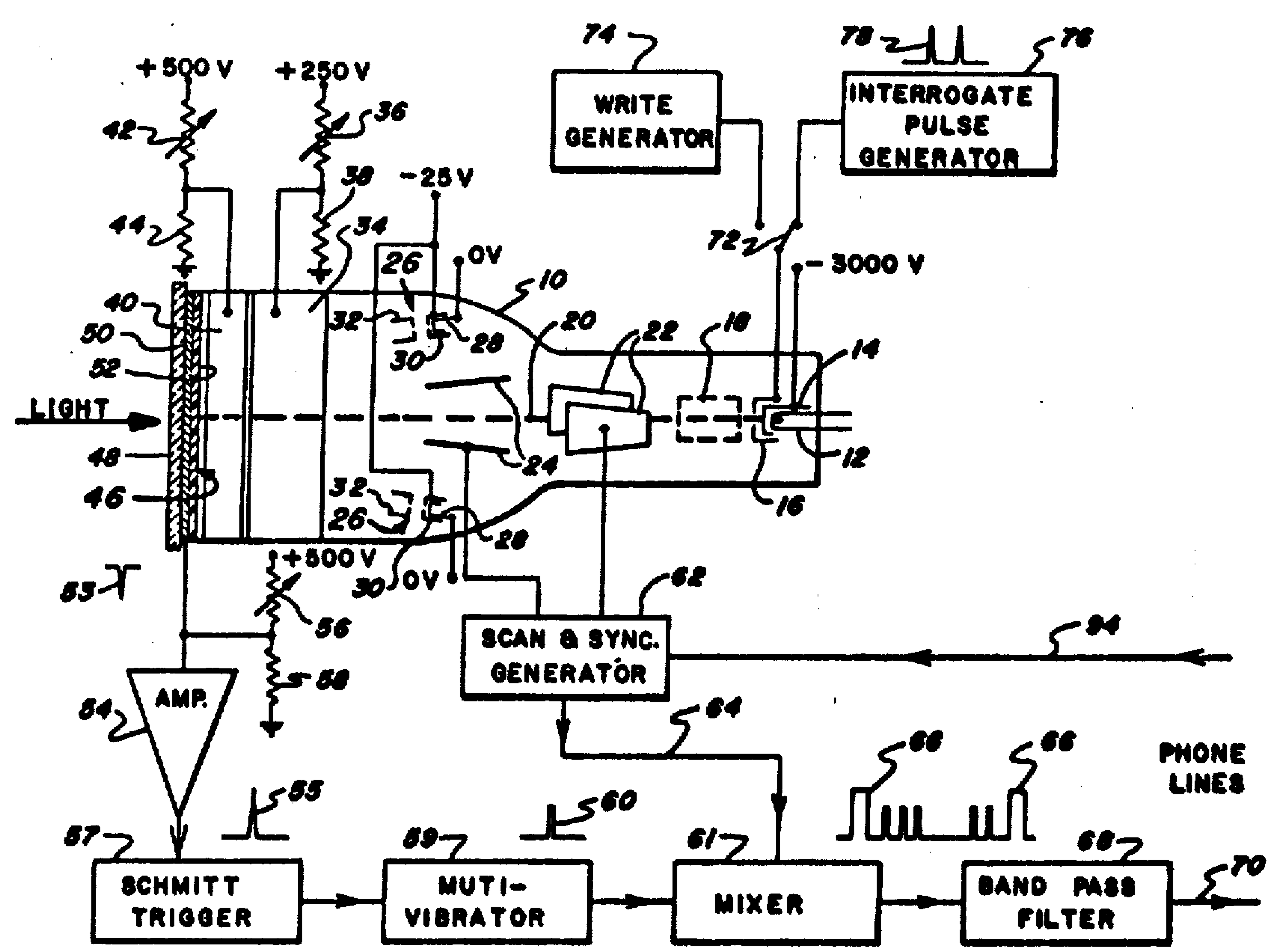
Primary Examiner—Benjamin R. Padgett
Assistant Examiner—P. A. Nelson
Attorney, Agent, or Firm—Klarquist, Sparkman, Campbell, Leigh, Hall & Whinston

[57] **ABSTRACT**

The information stored on the dielectric target of a bistable storage tube is read out nondestructively employing a pulsed electron beam. The electron beam is turned on for a period having a duration less than necessary to change a given area of the target from one stable stored potential to another, while the period between pulsations is long enough so the tube's flood beam can return a given area to its original stored potential.

27 Claims, 4 Drawing Figures



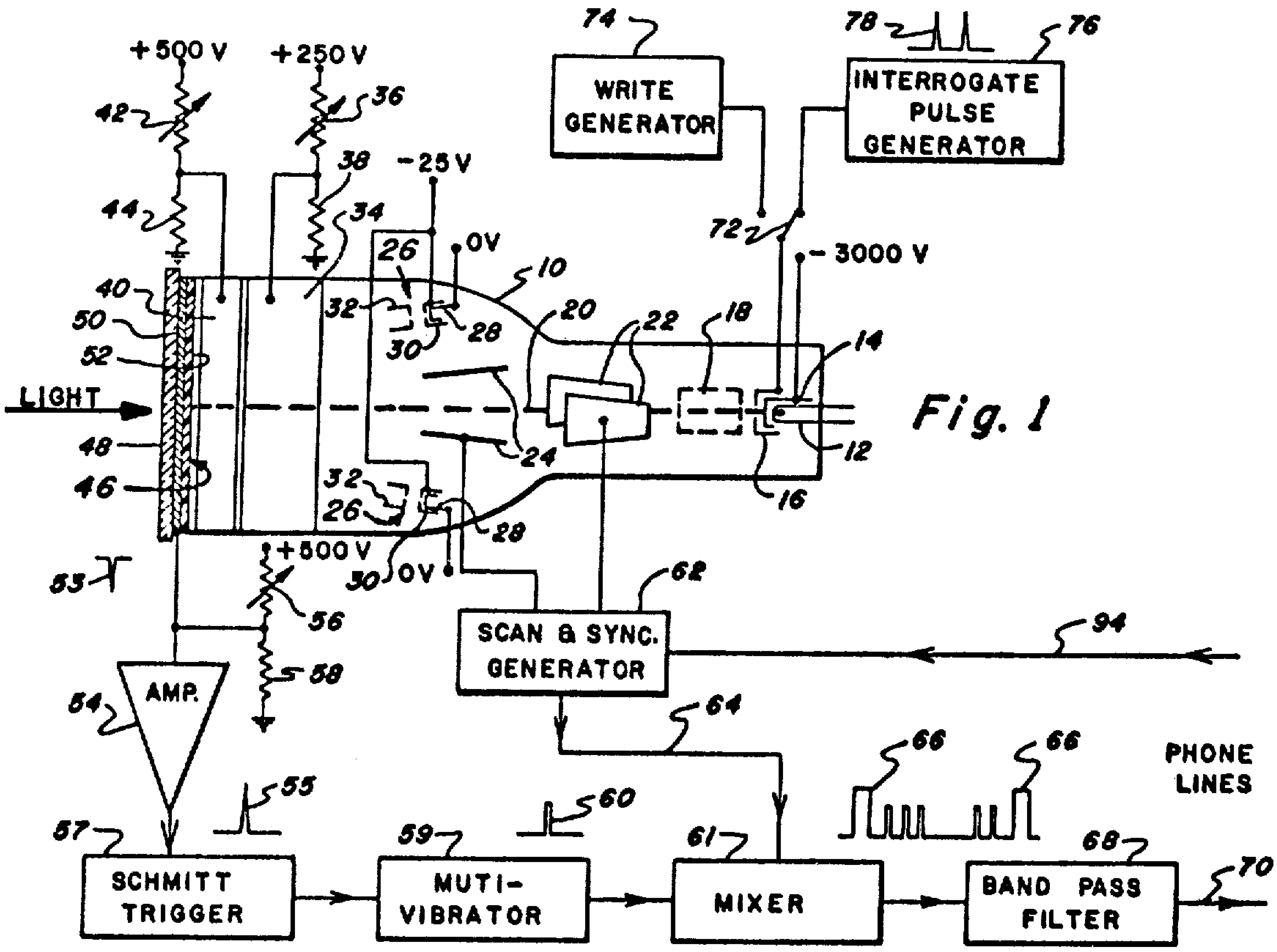


Fig. 1

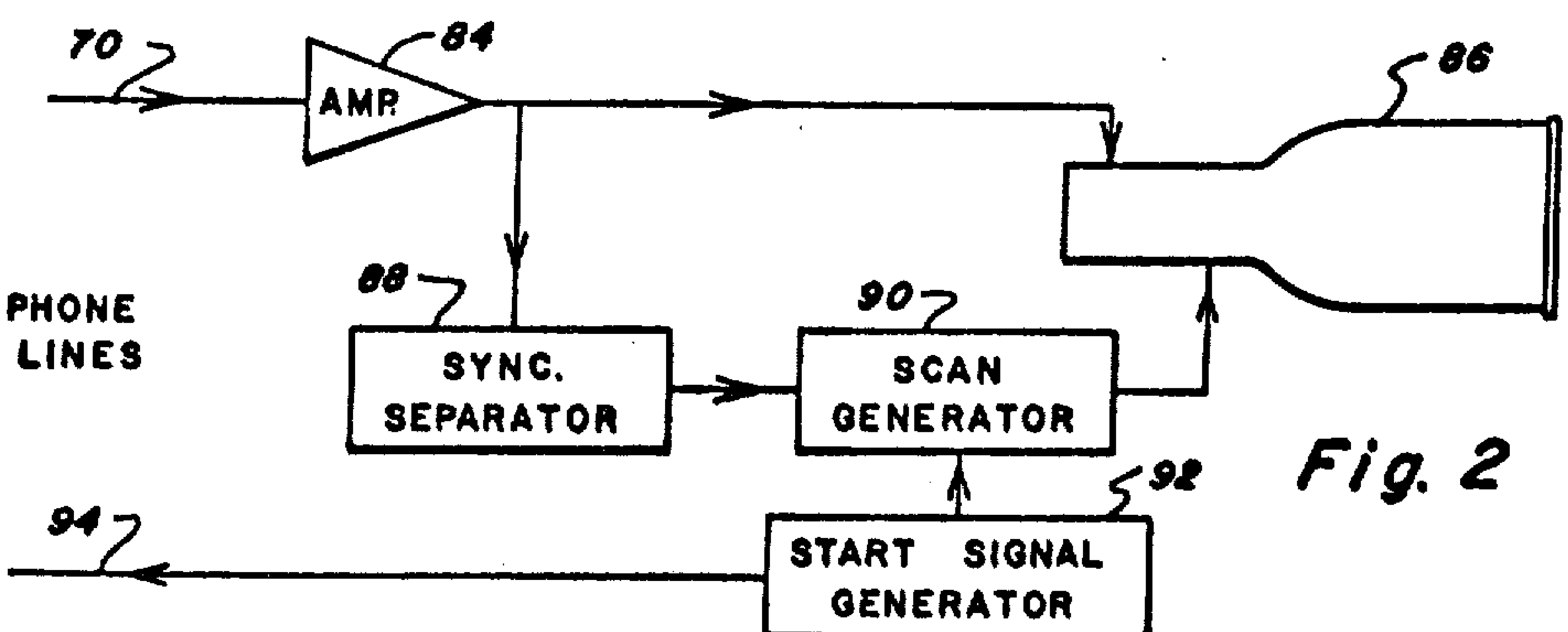


Fig. 2

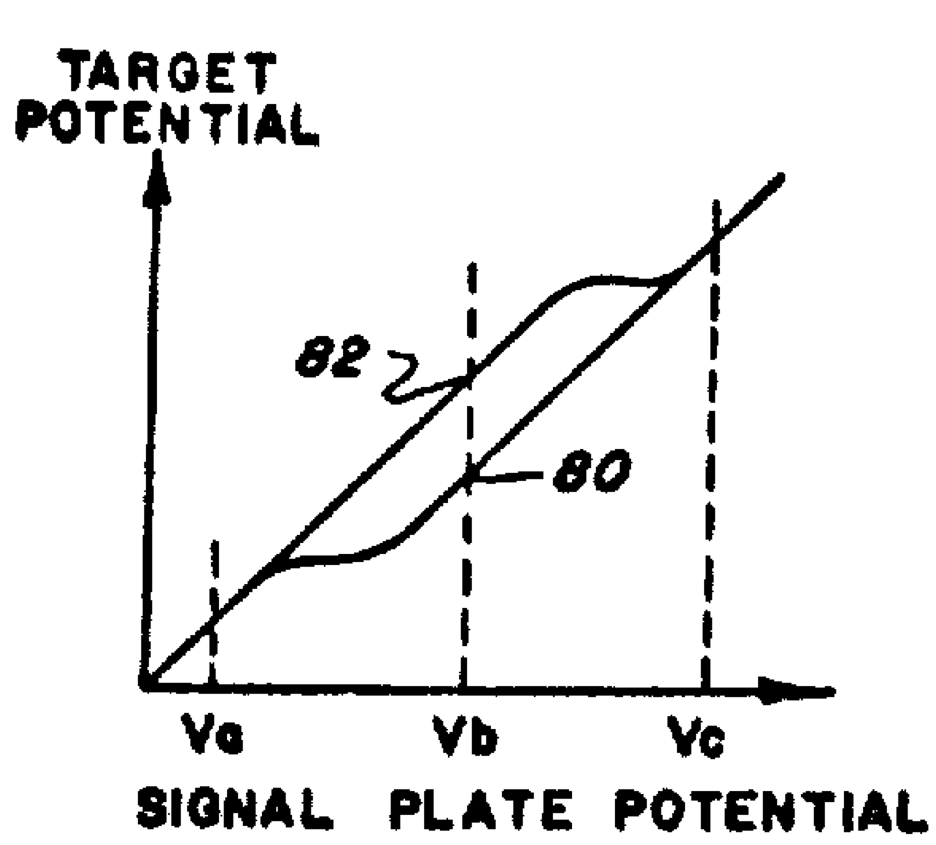


Fig. 3

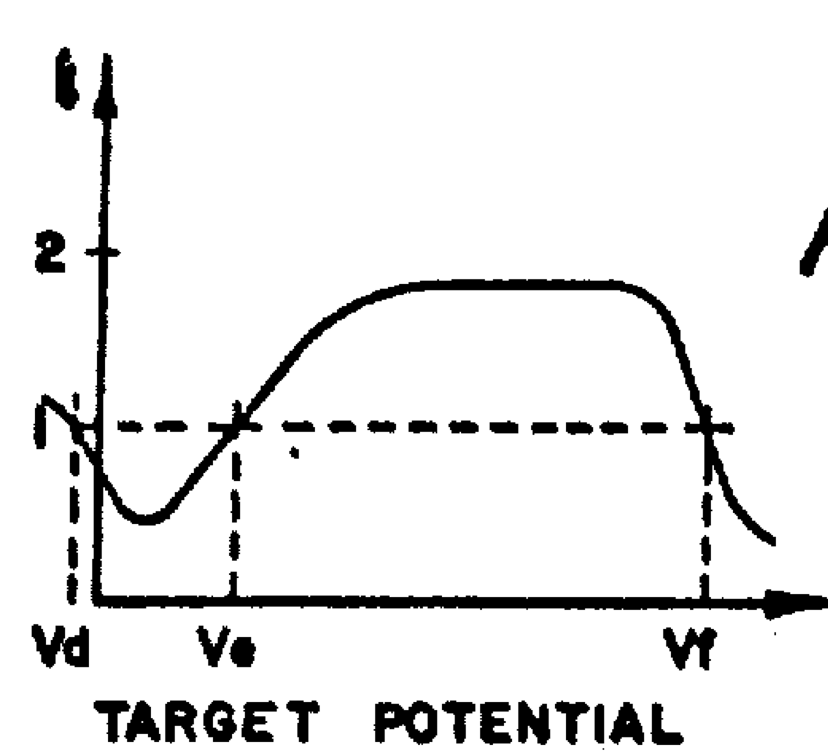


Fig. 4

CHARGE IMAGE STORAGE METHOD AND APPARATUS

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.

This is a continuation of application Ser. No. 106,613 filed Jan. 14, 1971, now abandoned which is a reissue of U.S. Pat. No. 3,426,238.

This invention relates to a charge image storage method and apparatus and particularly to such a method and apparatus providing high quality nondestructive read-out signals.

Information may be stored on the dielectric target of a cathode ray tube type device in the form of a plurality of electric charges. This information may be either digital, or pictorial as, for example, representing a curve or other visual information. Such a storage tube usually includes a high velocity electron gun for writing information on the dielectric target and one or more flood guns for retaining information on the target as a result of the secondary emission properties of the system. Information is then conventionally read out by means of a high velocity beam, either from the same gun or a gun similar to the one employed in writing the information. During read-out, charge is placed on a particular target area and causes an output signal on a signal plate associated with the target in accordance with the information previously stored. This method may destroy the information read out since information is read out in the same manner it is written.

A high velocity electron beam employed for reading information from a storage target may be deflected to scan over the surface of the storage target in a raster fashion in order to sequentially pass over the various storage locations and read out any or all of the stored information. If the beam scans rapidly and infrequently over areas of the target bearing charge information, destruction of the information stored will be avoided. However, when information is read out quite rapidly by means of a rapidly scanning electron beam, the information may encounter bandwidth problems when presented to ordinary communication circuitry for transmitting stored information from one location to another. The magnitude of the read-out current derived is also dependent upon the scanning rate. As the scanning rate and the beam current are decreased, the read-out current indicative of a particular element or area of target information is decreased. The read-out signal currents are then small and difficult to amplify, taxing the state of the art amplifier technology.

It is therefore an object of the present invention to provide an improved charge image storage method and apparatus wherein stored information is nondestructively read out.

Another object of the present invention is to provide an improved charge image storage method and apparatus wherein information may be nondestructively read out at a slow rate in order to accommodate low bandwidth transmission systems and wherein the scanning beam may be stopped during its scan without destroying the information stored at that location.

It is another object of the present invention to provide an improved charge image storage apparatus employing an electron beam for slowly scanning the stored information.

It is another object of the present invention to provide an improved charge image storage method and apparatus wherein beam scanning of the stored information is not necessary.

It is another object of the present invention to provide an improved charge image storage method and apparatus for nondestructively reading stored information in a manner providing higher amplitude read-out signals suitable for application to ordinary A.C. coupled amplification apparatus.

In accordance with the method and apparatus of the present invention, the information stored on a [dielectric] storage tube target is read out employing a [relatively high velocity] pulsating electron beam for interrogation. The interrogating electron beam may be either stationary or it may be scanned as desired in order to derive information from individual locations or the entire target. The electron beam is pulsed for periods having a duration less than [necessary to change a selected area of the storage tube target from one stable stored potential to another, that is, less than would be required to erase and write new information on the target. The] *will cause erasure of stored information. In a particular embodiment, the* period between pulsations is [then] arranged to be sufficient for [the] *a* flood beam associated with the storage tube to drive the area read back to its stable potential before another beam pulsation is received.

The subject matter which I regard as my invention is particularly pointed out and distinctly claimed in the concluding portion of this specification. The invention, however, both as to organization and method of operation, together with further advantages and objects thereof, may best be understood by reference to the following description taken in connection with the accompanying drawings wherein like reference characters refer to like elements and in which:

FIG. **1** is a schematic diagram of a charge image storage apparatus in accordance with the present invention,

FIG. **2** is a schematic diagram of charge image storage apparatus at a location remote from that illustrated in FIG. **1** which is connected to the FIG. **1** apparatus,

FIG. **3** is a plot of target potential versus signal plate potential in a charge image storage apparatus according to the present invention, and

FIG. **4** is a plot of target secondary emission ratio versus target potential for a charge image storage apparatus in accordance with the present invention.

Referring to FIG. **1**, a charge image storage apparatus according to the present invention includes a storage tube envelope **10** formed of insulating material housing a principal electron gun including a filament **12**, a cathode **14** connected to a high negative voltage source, a control grid **16**, and a focusing and accelerating structure **18**. The electron beam **20** produced by the principal electron gun is deflected horizontally by means of horizontal deflection plates **22** and vertically by means of vertical deflection plates **24**. The beam is directed towards a target **46** at the opposite end of the tube. The storage tube is additionally provided with one or more flood type electron guns **26** each having a cathode **28**, a control grid **30**, and an anode **32**, and which are supported inside the envelope **10** adjacent the end of the vertical deflection plates **24** closest the target. Cathodes **28** are conveniently maintained at the zero volt level while grids **30** are suitably connected to a −25 volts. Electrons emitted from the flood guns diverge into a wide beam which is substantially uniformly distributed towards the target **46**.

A plurality of electrodes are also provided on the inner surface of envelope **10** beyond the flood guns. A first electrode **34**, connected to midpoint of a voltage divider comprising resistors **36** and **38** coupled between a plus 250 volts and ground, acts to provide a more uniform electric field to collimate electrons. A collector electrode **40** near the target end of the tube is connected at a midpoint of a voltage divider including resistors **42** and **44** coupled between a plus 500 volts and ground. This electrode can perform the additional function of collecting secondary electrons as will hereinafter become more evident.

Storage target **46** is disposed on the inner side of glass end plate **48** and includes a transparent signal plate **50** over which is disposed a [photosensitive] dielectric **52** [, suitably] *which may be photosensitive, for example* an integral layer of P-1 type phosphor. Signal plate **50** is a thin transparent conductive coating such as tin oxide or the like and is connected to the midpoint of a voltage divider comprising resistors **56** and **58** disposed between a plus 500 volts and ground. The tube voltages are selected to result in the desired secondary emission characteristic of the tube as illustrated in FIG. **4** where secondary emission ratio is plotted against target potential.

An amplifier **54**, which may be of the alternating current coupled type, has its input coupled to signal plate **50**. Amplifier **54** drives a Schmitt trigger circuit **57**, the output of which is coupled to multivibrator **59**. The Schmitt trigger circuit **57** and multivibrator **59** operate as a shaping circuit or pulse stretcher to provide an output pulse **60** of uniform length and magnitude at a time when the input voltage threshold of Schmitt trigger circuit **57** is exceeded. Output pulse **60** of multivibrator **59** is applied to mixer **61** in common with an output of scan and synchronization generator **62**.

The scan and synchronization generator **62** principally provides horizontal and vertical scanning signals to horizontal and vertical plates **22** and **24** respectively of the storage tube. These scanning signals are suitably of the same general type employed in television practice and cause electron beam **20** to systematically and periodically scan target **46** in a scanning raster. The synchronizing signals corresponding to such scanning raster are applied to mixer **61** by way of lead **64**. The synchronization signals **66** are indicated at the output of mixer **61**, mixed with the output of multivibrator **59**. The output of mixer **61** is coupled to bandpass filter **68** and from there to a telephone line **70** employed for communication with a remote location.

Control grid **16** of the principal electron gun is connected via double throw switch **72** alternatively to write generator **74** or an interrogate pulse generator **76**. Write generator **74** applies the signal voltage to grid **16** for writing information charges by means of beam **20** on storage target **46** through the process of secondary emission. Write generator **74** provides its output at the same time beam **20** is directed towards or scans over a selected area or target element where information is to be written. With switch **72** thrown in the opposite position, interrogate pulse generator **76** provides a series of short duration negative voltage pulses **78** employed for reading information whereby an output is provided on signal plate **50**. The pulses are such that information is neither written nor destroyed on the storage target **46**, as hereinafter described. The repetition frequency of pulses **78** is adjusted to be high, for example, an order of magnitude higher than the repetition rate of information over which electron beam **20** scans during reading. This rate cannot, however, exceed the maximum bit rate of the output system unless this signal is later transformed to fall within the system's limits.

During operation, the tube polarities are arranged such that beam **20** has a relatively high velocity for writing and is capable of producing secondary electrons when it strikes storage dielectric **52**. Secondary electrons are then suitably collected by collector **40** in which case the potential of collector electrode **40** is suitably adjusted to be just slightly higher than the potential of signal plate **50**. The storage dielectric **52** may alternatively have a sufficiently porous structure to enable secondary electrons emitted from the bombarded surface of dielectric **52** to be transmitted therethrough and be collected.

The production of secondary electrons from an elemental area of dielectric **52** on target **46** causes such area to become relatively positive during operation of the present invention. Such area is retained at a relatively positive potential after beam **20** is scanned past such elemental area because of the action of flood guns **26**. Flood guns **26** produce relatively low velocity electrons which strike the target but which ordinarily have insufficient velocity for writing information thereon. When the electrons from flood guns **26** strike areas of the target upon which a positive charge has not been written, these flood electrons tend to maintain such areas at the relatively negative potential of the flood gun, e.g., zero volts. However, the flood gun electrons are attracted by positive elemental areas and obtain a high velocity with respect to these areas producing continued secondary emission therefrom such that these areas are maintained relatively positive or near the potential of signal plate **50** and collector electrode **40**. The target thus has bistable properties and is capable of retaining information written thereon, with the flood beam of electrons driving target areas toward one of two stable potentials depending upon the information written thereon with beam **20**.

[Since] *If* the phosphor storage dielectric **52** is photosensitive, a light image directed onto the storage dielectric, through end plate **48** and transparent signal plate **50**, produces a charge image on the storage dielectric corresponding to such light image. The light image produces charge carriers in the dielectric such that illuminated areas of the target dielectric become more conductive and tend towards the more positive potential of signal plate **50**. A light image of sufficient intensity directed towards target **46** will be maintained through the action of the flood guns in the same manner as an image written on the target by means of electron beam **20**. In order to enhance the photosensitive characteristics of the phosphor storage dielectric, photoconductive material such as cadmium sulphide or zinc oxide may be uniformly mixed throughout the phosphor layer.

As previously mentioned interrogate pulse generator **76** causes a pulsation of electron beam **20** wherein the pulses are of a predetermined duration and rate such that information is read out from signal plate **50** nondestructively, i.e., such that information is not read on to the target nor taken therefrom. During operation, when the electron beam **20** strikes an area of the target where information is written in the form of a positive charge, an output pulse as indicated at **53** for example will be produced corresponding to each such pulse **78.** The pulse is of relatively short duration and for this reason is applied to the pulse shaping or stretching circuitry including Schmitt trigger circuit **57** and multivibrator **59.** Schmitt trigger circuit **57** produces an output when pulse **55** exceeds a predetermined voltage level and continues to produce such an output until pulse **55** drops below a second predetermined voltage level. Multivibrator **59,** which is suitably a one-shot multivibrator, provides pulse **60** of uniform amplitude and duration for each such input pulse **55** applied to the Schmitt trigger circuit **57.** The output pulse **60** of multivibrator **59** is long enough so that it can be received by and communicated through ordinary communication equipment. Thus, a plurality of output pulses **60,** as mixed with synchronization signals **66,** is suitably applied to a telephone line **70** through bandpass filter **68.** Bandpass filter **68** suitably excludes 60-cycle and low frequency hum components. As will hereinafter become more evident, the scanning rate of electron beam **20** in the storage tube may be as slow as described without resulting in problems of destructive read-out. Since slow scan rates are possible, the video information may be transmitted through communications equipment of nearly any bandwidth.

The operation of the invention will be further described with reference to FIGS. **3** and **4.** A bistable storage device such as the present storage tube is in general characterized by hysteresis so that for one value of an independent variable, there are two values of a dependent variable. Such a hysteresis curve for a storage tube is illustrated in FIG. **3** where target dielectric potential is plotted against signal plate potential. The signal plate potential is the potential between the flood gun cathode **28** and signal plate **50.** The potential between flood gun cathode **28** and the scanned surface of dielectric **52** is the dependent variable. **[** it **]** *It* is noted the potential between the principal electron gun cathode **14** and signal plate **50** is always high enough to insure a secondary emission ratio greater than one for electrons from the principal electron gun. Now if the signal plate potential is first raised to V_c, in FIG. **3,** the target potential is single valued. If the signal plate potential is then lowered smoothly to the value V_a, the target potential is also single valued. However, moving the signal plate potential to V_b, therebetween, allows the target potential to be double valued, but since the target potential was at a uniform potential when the signal plate was at V_a, it is now still at a uniform potential at the lower value indicated at **80.** If we "write" a pattern on the target by preferentially raising selected areas to a higher potential level, e.g., by means of the principle of electron gun, we then store information and raise such areas to a potential indicated at **82,** because of secondary emission produced by beam **20.** Writing can also be accomplished, of course, by lowering the resistivity of a target area by photoconductivity. Now that information has been written on the target, it is maintained due to the action of the flood gun in retaining the negative polarity of unwritten areas and continuing secondary emission from positive areas.

Examining the secondary emission ratio versus target potential curve for the target acted on by the flood gun, which curve is illustrated in FIG. **4,** we see three points at which the secondary emission ratio is equal to one. At V_d, $\delta=1$, because the target, and specifically the inside surface of dielectric **52,** has collected sufficient electrons to charge a few tenths of a volt negative with respect to the flood gun cathode, thereby rejecting all electrons. At V_e, the accelerating potential is high enough for the material on the target dielectric surface to emit secondary electrons, and at V_f the target dielectric surface has charged a few volts higher than the collector and all secondary electrons in excess of primary electrons are returned to the target. V_d and V_f are stable potentials. If the target begins to rise above V_d, the target collects electrons, the secondary emission being less than one, and the target dielectric charges negatively restoring the target dielectric to V_d. If we bombard the target with a high energy electron beam **20,** and allow it to charge by secondary emission to any potential just under V_e, it will return under the action of the flood guns to V_d. However, if we allow it to charge more positively than V_e, due to the action of beam **20,** the secondary emission caused by the flood electrons will charge the target dielectric positively until it reaches V_f. If it passes V_f, the secondary emission ratio becomes less than one and any electrons arriving tend to charge the target negatively. V_e is described as the first crossover voltage of the secondary emission characteristic.

Now, if we wish to read out or interrogate information stored on the target, we may do so by means of the same electron beam **20** which has been employed to write information on the target, or, alternatively, we may use a separate but similar electron beam. As when writing information with such electron beam, secondary emission is produced at the target and information in the form of positive charge tends to be written. Thus information defined by the absence of a positive charge would tend to be destroyed.

In accordance with the present invention, however, short reading pulses **78** are applied to the grid **16** of the principal electron gun causing short duration pulsation of the electron beam **20.** The length of each pulsation is selected such that the area to which the beam is directed is not entirely changed from one potential to another. The negative area is not rendered positive because the pulsation is shorter than required to change the selected area from V_d to V_e as illustrated in the FIG. **4** curve. That is, the pulsation of the electron beam **20** is short enough so that the potential of the area being read out does not exceed the first crossover point, V_e of the secondary emission characteristic of the flood beam. Therefore, the flood beam drives such area back towards its original stable potential in order to retain the stored information. Mathematically t is less than:

$$\frac{V_e C}{[i_p(1-\delta_1)+i_f(1-\delta_2)]} \tag{1}$$

In this expression,

i_p=the high energy beam current, that is, the current of beam **20** during read-out;

i_f=the low energy flood beam current;

δ_1=secondary emission ratio for i_p (greater than 1);

δ_2=secondary emission for i_f (less than 1);

V_e=first secondary emission crossover;

C=target element capacitance at the area being read out;

t=time the high energy beam rests on the target element or area.

The time between pulsations of electron beam **20** is selected to be long enough for the target area read out to return to its original stable state, for example, from V_e to V_d. In general this time, T, should be more than:

$$\frac{V_e C}{i_f(1-\delta_2)} \qquad (2)$$

This is the time required for the target element to return from V_e to approximately zero (V_d being only slightly less than zero). However, if the pulsation time was materially less than required to take the target to the crossover point V_e, then the actual voltage to which the target area being read out was changed should be substituted for a V_e in the above expression.

In the above expressions it will be noted that δ_1, and δ_2 vary during the times t and T, so the inequalities (1) and (2) are usually satisfied empirically. In the case of an exemplary target employed, if a charge is delivered to the target area which is less than approximately 10 pico-couloumbs, it will be less than will write on such target. This value may be different for different targets.

The read-out obtained according to the present invention is in pulses which are uniform in amplitude, and width. The amplitude is dependent upon the current of beam **20,** which is fixed, and the potential of the target. If we pulse electron beam **20** with a train of pulses with an on-time less than expression (1) and off-time greater than expression (2), this allows a stationary beam to interrogate the target area without writing or destroying information.

According to the present invention, a scan may also be applied to horizontal deflection plates **22** and vertical deflection plates **24** so that the entire target area is suitably read out. When the beam is moving, the off-time may be shortened and the on-time may be lengthened, but the foregoing inequalities (1) and (2) must still be satisfied. Since we may interrogate with a stationary beam, it is seen that the scan rate is of virtually no consequence. Therefore, extremely slow scanning may be employed, for example, when it is desired to transmit information over a transmission system having low bandwidth capabilities. The output signal is a pulse signal, and therefore, A.C. coupled amplifiers may be used throughout the system. Since the pulse output also has a characteristic period, amplifiers of the bandpass type may be used as well as bandpass filter **68** so that interfering signals such as 60-cycle hum can be conveniently excluded. The read-out signals are also of reasonable amplitude and may be conveniently amplified with ordinary amplification circuitry.

FIG. **2** illustrates a circuit for storing information at a location remote from the FIG. **1** charge image storage apparatus. Referring to FIG. **2,** telephone line **70,** communicating with the FIG. **1** circuit, provides an input for amplifier **84** which drives the control grid or other control electrode of a storage tube **86.** Storage tube **86** is conveniently the same type of storage tube as employed in the FIG. **1** apparatus. The output of amplifier **84** is also applied to a sync separator **83** for deriving synchronization signals **66** (see FIG. **1**) from the input signal. These signals synchronize scan generator **90** coupled to drive the deflection apparatus of storage tube **86** in the same scanning pattern or raster executed by the FIG. **1** apparatus.

In order to start operation of the communications system including the circuits of FIGS. **1** and **2,** a start signal is initiated by means of start signal generator **92,** transmitting a start pulse to scan and synchronization generator **62** in FIG. **1** via telephone line **94.** The scan and synchronization generator **62** causes the electron beam **20** to execute a predetermined scan of information. At this time interrogate pulse generator **76** is coupled to control grid **16** by way of switch **72** and information is read out, the signal being derived from signal plate **50** and amplified in amplifier **54.** The resultant pulse information including a plurality of pulses **60** is transmitted over telephone line **70** to storage tube **86.** Pulses **60** are of sufficient duration and the constants of storage tube **86** are such that the information is written upon the target of storage tube **86.**

The telephone line transmission system herein employed may be of relatively narrow bandpass characteristics, and the scanning rate employed can be quite slow to accommodate such characteristics. For example, the scanning rate may be reduced to almost zero. It is noted the amplitude of pulses **60** are standard and the mixing of synchronization signals **66** therewith is therefore simplified.

While I have shown and described a preferred embodiment of my invention, it will be apparent to those skilled in the art that many changes and modifications may be made without departing from my invention in its broader aspects. I, therefore, intend the appended claims to cover all such changes and modifications as fall within the true spirit and scope of my invention.

I claim:

1. Charge image storage apparatus comprising:

a storage target having capacitance for storing a charge pattern,

first means for bombarding such storage target with a first beam of electrons capable of causing secondary emission from selected areas from said storage target upon which said beam is directed for changing the voltage at such selected areas to store information,

second means for bombarding the storage target with a lower velocity flood beam of electrons acting to drive areas of said target towards one of two stable potentials depending upon information stored thereon by said first means for the purpose of holding such information on the target,

means for modulating said first beam to read out stored potential information located at a selected area of said target at which the first beam is then directed including means for *independently* pulsing said first beam, wherein each pulsation thereof has a duration less than necessary to change such selected area from one said stable potential to another, the said flood beam driving said area back to its stable potential during the time between pulsations in order to retain such stable potential of such area, **[** and **]**

means for systematically scanning said first beam of electrons, during read-out, over areas of the target where information is stored, and

means coupled to said target for detecting a read-out signal.

2. A charge image storage apparatus comprising:

a storage target for storing a charge pattern, means for bombarding said storage target with an electron beam having a velocity capable of causing secondary emission from selected areas of said storage target upon which said beam is directed to change the voltage at such selected areas for storing information, and for bombarding sasid storage target with a beam of electrons for reading out stored information at a selected area of said target at which such beam is then directed, including means for *independently* pulsing said beam during read-out, [and]

means for systematically scanning said beam of electrons, during read-out, over areas of the target where information is stored, and

means for directing a flood beam of electrons at such target for driving areas of such target towards one of two stable potentials by continued secondary emission from areas where information has been previously stored by secondary emission and by driving such target negative in areas wherein information has not been previously stored by secondary emission,

wherein such pulsation during read-out has a duration less than necessary to change a selected area from one stable potential to another, the flood beam of electrons driving such area back towards its stable potential in order to retain such stable potential of such area.

[3. The apparatus according to claim 2 wherein such pulsation is periodic and the period between successive pulsations is sufficient for said flood beam to retain the area being read out at its stored potential by driving such area entirely back to its normally stored potential whereby the sequence of pulsations does not drive such area from one stable potential to another.]

4. The apparatus according to claim 2 wherein said storage target comprises a photosensitive storage dielectric such that information may be stored thereon by means of a light image.

[5. The apparatus according to claim 2 wherein areas of said target wherein information is stored are systematically scanned during read-out with a beam of electrons.]

[6. The apparatus according to claim 5 including detection means coupled to said target for providing a read-out signal corresponding to said pulsations and indicative of information stored on the systematically scanned areas of said target, and

including a second charge image storage apparatus comprising a storage tube disposed at a location remote from said first mentioned charge image storage apparatus, and

communication means between the first mentioned charge image storage apparatus and the charge image storage apparatus at the remote location including means for synchronizing the systematic scan at both such locations, such communication means coupling the output from the detection means of the first mentioned charge image storage apparatus to the second charge image storage apparatus for storing apparatus for storage at the latter location.]

[7. The apparatus according to claim 2 wherein the time duration, t, for a pulsation is less than the product of the voltage at the first crossover point in the secondary emission characteristic of the target and the capacitance of a target area read out, said product being divided by the sum of the reading beam current multiplied by (1 minus the secondary emission ratio for the reading beam) and the flood beam current multiplied by (1 minus the secondary emission ratio for the flood beam).]

8. The apparatus according to claim [7] *30* wherein said pulsation is repetitive and the period between pulsations is greater than the product of the voltage at the first crossover point in the secondary emission characteristic for the target and the capacitance of the target area being read out, said product being divided by the floor beam current multiplied by (1 minus the secondary emission ratio for the flood beam).

9. The apparatus according to claim [7] *30* wherein said pulsation is repetitive and the period between pulsations is greater than the product of a voltage, V, and the capacitance of the target area being read out, said product being divided by the flood beam current multiplied by (1 minus the secondary emission ratio for the flood beam), wherein the voltage, V, is the voltage actually reached by the target area being read out during the time, t.

10. Charge image storage apparatus comprising:

a storage target including a photosensitive storage dielectric of phosphor material,

a first electron gun for bombarding said storage dielectric and writing information thereon during a writing mode with a first beam of electrons capable of causing secondary emission from selected areas of said storage target upon which said beam is directed to change the voltage at such selected areas toward a more positive value for thereby storing information,

flood gun means for bombarding the storage dielectric with a flood beam of low velocity electrons to cause continued secondary emission from said storage dielectric in the region where said first beam has been directed in its writing mode while maintaining other regions negative for providing two stable dielectric potentials on said target,

said first electron gun including a control grid having read-out means coupled thereto for *independently* modulating said first beam in a reading mode such that said first beam emits regular pulsations of electrons, each pulsation having a duration less than necessary to change a selected area from one stable potential to another during read-out of stored information, said flood gun producing a flood beam driving the area read back towards its stable potential, and

signal plate means coupled to said target for providing a read-out signal,

said charge image storage apparatus being provided with deflection means and scanning signal generator means coupled to said deflection means to cause said first electron beam from said first electron gun to systematically and periodically scan during a reading mode the areas of said target where information is stored.

11. The apparatus according to claim 10 further including amplifier means coupled to said signal plate means for receiving the read-out signal,

pulse stretching means coupled to receive the output of said amplifier means for increasing the duration of pulsations received by said amplifier means indicative of information stored on said target,

mixing means for mixing said stretched pulsations with synchronization information from said scanning means,

a storage tube at a location remote from said charge image storage apparatus,

transmission means between said mixing means and said storage tube at said remote location,

scan synchronization means coupled to said transmission means at said remote location causing a systematically and periodic scan in said storage tube synchronized with the systematic and periodic scan in said charge image storage apparatus, and

means applying the pulsations from said transmission means to said storage tube as a writing input thereof so that information corresponding to the bistable images in said charge image storage apparatus is written in said storage tube.

12. The apparatus according to claim **11** further including a bandpass filter in cascade with said transmission means.

13. A method of reading information from charge image storage apparatus including a dielectric storage target, a high velocity electron beam means directing a high velocity beam at said storage target, a low velocity flood gun means directed at said storage target for retaining information thereon, and means coupled to said target for providing a read-out signal, said method comprising:

directing a high velocity beam from said first electron gun at a particular area of said storage target for reading information from the same,

independently pulsing said electron beam from said first electron gun with a pulse having a duration less than necessary to change an area being read out from one stable potential to another such stable potential,

repeating such pulse with a frequency such that the period between pulses is sufficient for said flood beam to retain such area at a stored potential value by driving such area back towards its stored potential, **[** and **]**

scanning said electron beam in a regular pattern across the areas of said target storing information at the same time such beam is pulsed, and

deriving from said means coupled to said target, read-out pulsations corresponding to pulses applied to said first electron gun and indicative of the polarity of stored information.

[14. The method according to claim **13** further including scanning said electron beam in a regular pattern across the areas of said target storing information at the same time such beam is pulsed. **]**

[15. The method according to claim **13** wherein the duration of a pulse is less than the product of the voltage at the first crossover point in the secondary emission characteristic of said target and the capacitance of the area of said target being read out, said product being divided by the sum of the first beam current multiplied by: (1 minus the secondary emission ratio for the beam from the first electron gun), and the flood beam current multiplied by (1 minus the secondary emission ratio for the flood beam) and wherein the period between pulses is greater than the product of the voltage at the first crossover in the secondary emission characteristic of the target and the capacitance at the area being read out, said product being divided by the flood beam current multiplied by (1 minus secondary emission ratio for the flood beam).**]**

16. The method of claim **[15]** *31* wherein said electron beam is scanned in a regular pattern and wherein the duration of pulsation of said beam is lengthened and the period between pulses is shortened as the beam scanning rate is increased.

17. Image storage apparatus comprising:

a tube adapted to store an image, said tube including a storage target and means for directing an electron beam toward said target for reading out stored information at selected areas of said target and including means for independently pulsing said beam during read-out, wherein the duration of a pulsation is less than would cause stored image information to be removed and new information written,

means for systematically scanning said electron beam, during read-out, over areas of the target where information is stored,

means coupled to said target for providing a read-out signal corresponding to said pulsations and indicative of information stored on the systematically scanned areas of said target,

utilization apparatus for providing a representation of information stored on the systematically scanned areas of said target, and

communication means between said means for providing a read-out signal and said utilization apparatus for coupling the output from the means for providing a read-out signal to said utilization apparatus.

18. The apparatus according to claim 17 further including means for synchronizing the systematic scan of the areas of said target where information is stored and the operation of said utilization apparatus for providing a representation of the information stored.

19. The apparatus according to claim 18 wherein said means for directing an electron beam at said target includes an electron gun and said means for pulsing said beam includes a control grid for said gun and means coupled to said control grid providing a control input for modulating said beam with regular pulsations.

20. Image storage apparatus comprising:

a tube having storage target, and an electron gun for bombarding said target with a narrow beam of electrons, said electron gun including a control grid provided with an input for independently modulating said beam such that said beam emits regular pulsations of electrons, each pulsation having a duration less than would cause removal of information stored on said storage target,

means coupled to said target for providing a read-out signal,

scanning means for causing said electron beam to systematically and periodically scan areas of the target where information is stored and is to be read out,

utilization means for providing a representative of information stored on systematically scanned areas of said target,

transmission means between said signal plate means and said utilization means,

and scan synchronization means coupled to said scanning means and to said utilization means for synchronizing operation of said utilization means with a systematic and periodic scan of the electron beam.

21. The apparatus according to claim 20 wherein said utilization means comprises a cathode ray tube having deflection means and adapted to have the electron beam thereof deflected under the control of said synchronization means substantially in step with the first mentioned beam of electrons from said electron gun.

22. Image storage apparatus comprising:

a storage target,

means for bombarding said storage target with an electron beam for reading out stored information at selected areas of said target at which such beam is then directed including means for independently pulsing said electron beam, wherein each pulsation thereof during normal read-out has a duration less than would remove the stored information, and

means coupled to said target for detecting a read-out signal in response to pulsation of said beam,

wherein said charge image storage apparatus is provided with deflection means for causing systematic scan of said electron beam over areas of the target where information is stored and which it is desired to read out.

23. The apparatus according to claim 22 including means for causing a beam of electrons to bombard said target for storing information on said target.

24. The apparatus according to claim 22 wherein said storage target comprises photosensitive material such that information may be stored thereon by means of a light image.

25. The apparatus according to claim 22 wherein said means for bombarding said storage target with an electron beam comprises an electron gun and wherein said means for pulsing said electron beam comprises a control grid for said electron gun having means coupled thereto for modulating said beam with regular voltage pulsations.

26. The method of reading information from an image storage apparatus including a target, means for directing a beam of electrons at said target, and means coupled to said target for providing a read-out signal, said method comprising:

directing a beam of electrons from the first mentioned means at a particular area of the target from which it is desired to read information,

independently pulsing said electron beam with a pulse duration less than would remove the stored information from the target,

scanning the electron beam in a regular pattern across areas of the target storing information at the same time the beam is pulsed, and

deriving, from said means coupled to said target, read-out pulsations corresponding to pulses applied to the beam.

27. The method according to claim 26 further including reproducing the stored information at a second location in response to the read-out pulsations derived from said means coupled to said target.

28. A charge image storage apparatus comprising:

a storage target for storing a charge pattern,

means for bombarding said storage target with an electron beam having a velocity capable of causing secondary emission from selected areas of said storage target upon which said beam is directed to change the voltage at such selected areas for storing information, and for bombarding said storage target with a beam of electrons for reading out stored information at a selected area of said target at which such beam is then directed, including means for pulsing said beam during read-out,

means for systematically scanning said beam of electrons, during read-out, over areas of the target where information is stored, and

means for directing a flood beam of electrons at such target for driving areas of such target towards one of two stable potentials by continued secondary emission from areas where information has been previously stored by secondary emission and by driving such target negative in areas where information has not been previously stored by secondary emission,

wherein such pulsation during read-out has a duration less than necessary to change a selected area from one stable potential to another, the flood beam of electrons driving such area back towards its stable potential in order to retain such stable potential of such area, and including means for causing said pulsation to be periodic and the period between successive pulses to be sufficient for said flood beam to retain the area being read out at its stored potential by driving such area entirely back to its normally stored potential whereby the sequence of pulsations does not drive such area from one stable potential to another.

29. A charge image storage apparatus comprising:

a storage target for storing a charge pattern,

means for bombarding said storage target with an electron beam having a velocity capable of causing secondary emission from selected areas of said storage target upon which said beam is directed to change the voltage at such selected areas for storing information, and for bombarding said storage target with a beam of electrons for reading out stored information at a selected area of said target at which such beam is then directed, including means for pulsing said beam during read-out,

means for systematically scanning said beam of electrons, during read-out, over areas of the target where information is stored,

means for directing a flood beam of electrons at such target for driving areas of such target towards one of two stable potentials by continued secondary emission from areas where information has been previously stored by secondary emission and by driving such target negative in areas where information has not been previously stored by secondary emission,

wherein such pulsation during read-out has a duration less than necessary to change a selected area from one stable potential to another, the flood beam of electrons driving such area back towards its stable potential in order to retain such stable potential of such area,

detection means coupled to said target for providing a read-out signal corresponding to said pulsations and indicative of information stored on the systematically scanned areas of said target, and

including a second charge image storage apparatus comprising a storage tube disposed at a location remote from said first mentioned charge image storage apparatus, and

communication means between the first mentioned charge image storage apparatus and the charge image storage apparatus at the remote location including means for synchronizing the systematic scan at both such locations, such communication means coupling the output from the detection means of the first mentioned charge image storage apparatus to the second charge image storage apparatus for storage at the latter location.

30. A charge image storage apparatus comprising:

a storage target for storing a charge pattern,

means for bombarding said storage target with an electron beam having a velocity capable of causing secondary emission from selected areas of said storage target upon which said beam is directed to change the voltage at such selected areas for storing *information, and for bombarding said storage target with a beam of electrons for reading out stored information at a selected area of said target at which such beam is then directed, including means for pulsing said beam during read-out,*

means for systematically scanning said beam of electrons, during read-out, over areas of the target where information is stored, and

means for directing a flood beam of electrons at such target for driving areas of such target towards one of two stable potentials by continued secondary emission from areas where information has been previously stored by secondary emission and by driving such target negative in areas where information has not been previously stored by secondary emission,

wherein such pulsation during read-out has a duration less than necessary to change a selected area from one stable potential to another, the flood beam of electrons driving such area back towards its stable potential in order to retain such stable potential of such area,

wherein the time duration, t, for a pulsation is less than the product of the voltage at the first crossover point in the secondary emission characteristic of the target and the capacitance of a target area read out, said product being divided by the sum of the reading beam current multiplied by (1 minus the secondary emission ratio for the reading beam), and the flood beam current multiplied by (1 minus the secondary emission ratio for the flood beam).

31. A method of reading information from charge image storage apparatus including a dielectric storage target, a high velocity electron beam means directing a high velocity beam at said storage target, a low velocity flood gun means directed at said storage target for retaining information thereon, and means coupled to said target for providing a read-out signal, said method comprising:

directing a high velocity beam from said first electron gun at a particular area of said storage target for reading information from the same,

pulsing said electron beam from said first electron gun with a pulse having a duration less than necessary to change an area being read out from one stable potential to another such stable potential, repeating such pulse with a frequency such that the period between pulses is sufficient for said flood beam to retain such area at a stored potential value by driving such area back towards its stored potential,

scanning said electron beam in a regular pattern across the areas of said target storing information at the same time such beam is pulsed, and

deriving from said means coupled to said target, read-out pulsations corresponding to pulses applied to said first electron gun and indicative of the polarity of stored information,

wherein the duration of a pulse is less than the product of the voltage at the first crossover point in the secondary emission characteristic of said target and the capacitance of the area of said target being read out, said product being divided by the sum of the first beam current multiplied by (1 minus the secondary emission ratio for the beam from the first electron gun), and the flood beam current multiplied by (1 minus the secondary emission ratio for the flood beam) and wherein the period between pulses is greater than the product of the voltage at the first crossover in the secondary emission characteristic of the target and the capacitance at the area being read out, said product being divided by the flood beam current multiplied by (1 minus the secondary emission ratio for the flood beam).

32. A charge image storage apparatus comprising:

a storage target for storing a charge pattern,

means for bombarding said storage target with an electron beam having a velocity capable of causing secondary emission from selected areas of said storage target upon which said beam is directed to change the voltage at such selected areas for storing information, and for bombarding said storage target with a beam of electrons for reading out stored information at a selected area of said target at which such beam is then directed, including means for pulsing said beam during read-out,

means for systematically scanning said beam of electrons, during read-out, over areas of the target where information is stored,

means for directing a flood beam of electrons at such target for driving areas of such target towards one of two stable potentials by continued secondary emission from areas where information has been previously stored by secondary emission and by driving such target negative in areas where information has not been previously stored by secondary emission,

wherein such pulsation during read-out has a duration less than necessary to change a selected area from one stable potential to another, the flood beam of electrons driving such area back towards its stable potential in order to retain such stable potential of such area,

detection means coupled to the charge image storage apparatus for providing a read-out signal corresponding to said pulsations and indicative of information stored on the systematically scanned areas of said target,

a cathode ray tube disposed at a location remote from said first mentioned charge image storage apparatus, and

communication means between the charge image storage apparatus and said cathode ray tube at said remote location including means for synchronizing the systematic scan at both such locations, said communication means coupling the output from the detection means of the charge image storage apparatus to the cathode ray tube at the latter location.

33. The apparatus according to claim 32 further including pulse stretching means for stretching the output of said detecting means.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : RE 28773

DATED : April 13, 1976

INVENTOR(S) : Charles B. Gibson, Jr.

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 5, line 24, "described" should be --desired--.

Column 6, line 65, between "emission and "for" insert --ratio--; "i_t" should be --i_f--.

Column 9, line 6, "sasid" should be --said--.

Column 10, line 11, "floor" should be --flood--.

Column 11, lines 7 and 8, claim 11, "systematically" should be --systematic--.

Column 11, line 67, "31" should be --33--.

Column 12, line 52, "representative" should be --representation--.

Column 16, last line, "detecting" should be --detection--.

Signed and Sealed this

Thirtieth Day of November 1976

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks