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STORAGE TUBE CIRCUIT EMPLOYING AMPLITUDE AND PHASE COMPARISON

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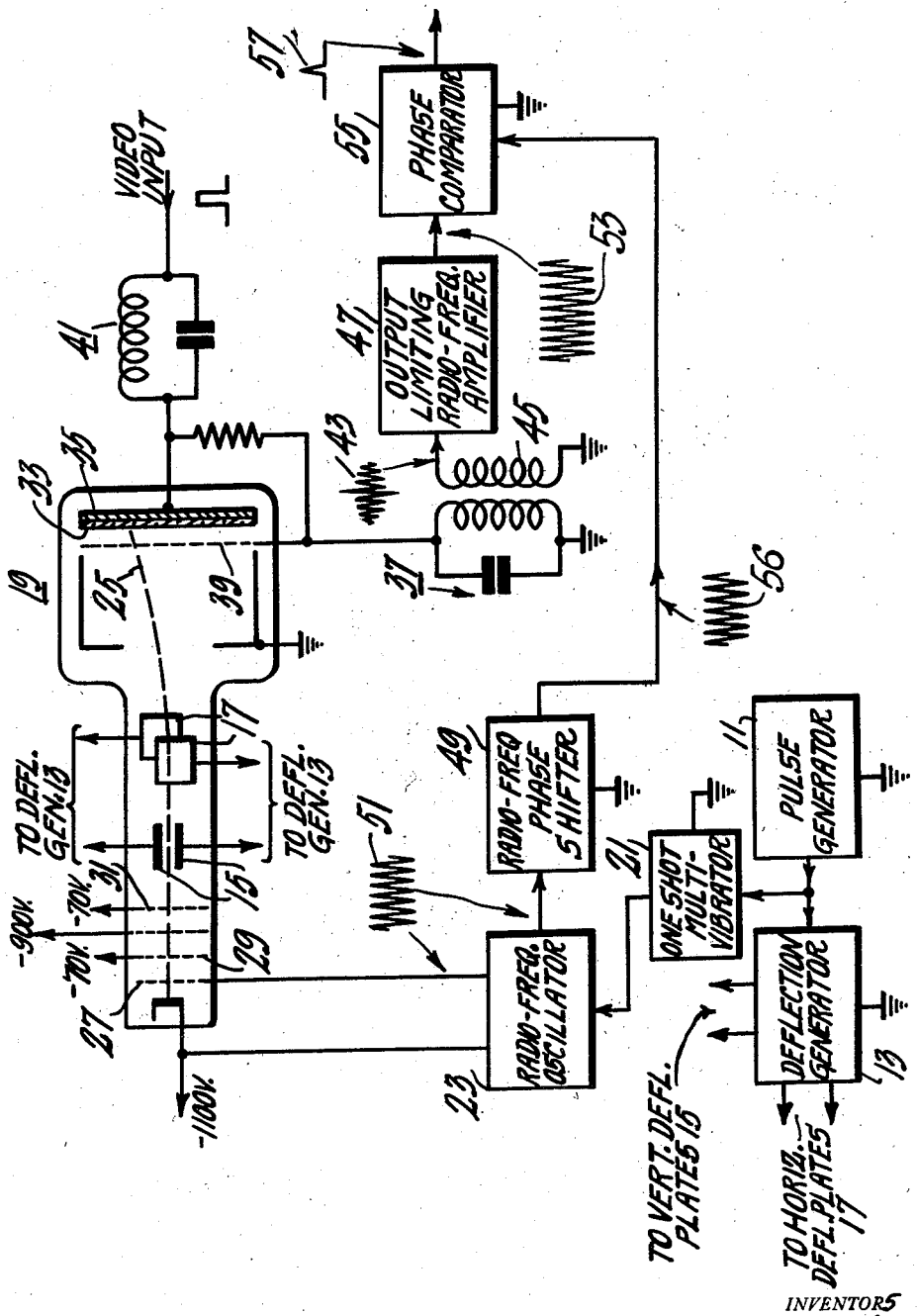

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STORAGE TUBE CIRCUIT EMPLOYING AMPLITUDE AND PHASE COMPARISON

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5 Claims. (Cl. 250—27)

This invention relates generally to electrical signal storage and more particularly to a circuit for use with the barrier grid storage tube employing amplitude limiting and phase comparison in conjunction with radio-frequency signal separation. The present application is related to our copending application Serial No. 399,051 filed concurrently herewith, now abandoned.

When a charge storage member is bombarded by an electron beam and the beam impinges thereon with an energy between the first and second cross-over points for the secondary emission ratio curve of the storage member, the secondary emission ratio of the member for most materials is greater than unity. Under bombardment the potential of the storage member changes with respect to the electrode which collects the secondary electrons, until the net number of secondary electrons leaving the charge storage member equals the number of arriving primary electrons. The surface potential at which this action takes place is known as the equilibrium potential. The remaining secondary electrons collect in the form of a space charge and rain back on the storage surface undesirably charging unbombarded parts of the storage member and partially neutralizing desired charges stored on other portions of the storage member.

To obviate this effect of "redistribution" of secondary electrons the barrier grid storage tube employs a fine mesh screen located within a few mils of the front surface of the storage member. The barrier grid or screen functions as a virtual collector so that the equilibrium potential is established with respect to the barrier grid and not with respect to the actual collector electrode. At this potential a number of secondary electrons just equal to the number of arriving primaries are sufficiently energetic to penetrate the screen. These secondaries cannot return to the storage member since appropriate fields urge them toward the actual collector electrode as a secondary or return beam. Meanwhile, the excess secondary electrons are not sufficiently energetic to reach the screen and are restricted in their motion by the proximity of the screen to the storage surface. Thus, their redistribution to portions of the storage member not directly under the beam is considerably reduced.

When the barrier-grid tube is operated in a system such, for example, as a radar moving target indication system, input video information is applied to a conductive signal plate in contact with the back surface of the charge storage member. The tube electron beam is "on" substantially continuously and is not time-shared for writing and reading. Output information is developed across a circuit connected to the barrier grid.

Because of the fact that the charge storage member is spaced quite close to the barrier grid there is a tendency for input video data applied to the signal plate to capacitively couple immediately to the output circuit. To prevent this undesired coupling a technique known as radio-frequency signal separation is employed. The electron beam is gated on for each deflection interval and is modulated at a radio-frequency rate. The storage surface

meanwhile is modulated at a video rate. The video modulation gives rise to charging or discharging currents in the output circuit which is tuned to the radio-frequency modulation frequency. Thus video instantaneously applied to the signal plate does not immediately feed through. Video information is coupled from the tube only as a result of scanning the stored charges with the radio-frequency modulated electron beam.

It has been found that interception of a portion of the incident electron beam by the barrier grid and interception of some of the secondary electrons liberated from the charge storage member result in the generation of a pedestal signal which appears across the output tuned circuit. The desired video information is superimposed on or "rides" on top of the pedestal signal. The amplitude and phase of the pedestal signal, referenced with respect to the radio-frequency beam gate signal, has been found to vary as a function of the position of the electron beam on the storage surface. The amplitude and phase variation is attributable primarily to non-parallel landing of the incident electron beam on the storage surface and a non-uniform collector field at the barrier grid. Where an implitude detector is used as an output signal measuring device, the pedestal signal amplitude variation may be as much as three times the amplitude of the desired video signals. In many applications this is highly undesirable due to the wide dynamic range required of output amplifiers and the difficulty encountered in separating the useful video signals from the unwanted pedestal signal.

An object of the present invention is to provide an improved circuit for operating the barrier-grid storage tube.

Another object of the invention is to provide improved circuit means for use in connection with the barrier-grid storage tube for permitting simultaneous reading and writing of pulsed information.

Another object of the invention is to obviate the effects of phase and amplitude variation of the heretofore discussed pedestal signal.

A further object of the invention is to reduce the dynamic range of the pedestal signal.

A still further object of the invention is to utilize amplitude limiting and phase comparison for reducing the dynamic range of the pedestal signal.

Briefly, in accordance with the invention the pedestal signal is amplitude-limited and applied to one input circuit of a phase comparator. A constant-amplitude constant-phase signal of the same frequency as the pedestal signal is applied to the second input circuit of the phase comparator. The phase of the constant-amplitude signal is carefully adjusted until the ouput of the phase detector yields the video data having no pedestal or zero D.-C. level. The need for filtering, D.-C. restoration, or amplifiers having wide dynamic ranges thus is overcome.

The invention will be described in greater detail with reference to the accompanying drawing in which the single figure is a schematic circuit diagram, partially in block form, of apparatus employing amplitude limiting and phase detection in accordance with the invention.

Referring to the drawing, a pulse generator 11 produces two sets of pulses. One set of pulses occurs at the horizontal or line rate at which the barrier-grid tube is to be operated while the second set of pulses occurs at the vertical or frame rate. The two sets of signals trigger a deflection generator 13 having circuits which produce separate deflection wave trains. These wave trains are applied to the vertical and horizontal pairs of deflection plates 15 and 17, respectively, of the barrier-grid tube 19.

The set of pulses occurring at line rate also is coupled to a circuit such as one-shot multivibrator 21 which performs the function of providing in response to each pulse at line rate a substantially square wave output signal having a pulse duration which is equal to the line deflec-

tion interval. The square wave signal produced by the multivibrator **21** is coupled to a normally turned-off radio-frequency oscillator **23** as a gate signal thereby turning the oscillator "on" and permitting it to oscillate during each line deflection interval at some selected radio-frequency, for example, thirty megacycles.

While the barrier-grid tube electron beam **25** is thus gated on, accelerated and decelerated by electrodes **27**, **29**, and **31**, and deflected across the front surface of the charge storage member **33**, video data may be applied to the conductive signal plate **35** in contact with the back surface of the member **33** thereby establishing an electrical charge pattern on the member. A detailed description of the manner in which a charge pattern is established under these conditions may be had with reference to either Patent Number 2,548,405 issued April 10, 1951, to R. L. Snyder, Jr. or Patent Number 2,563,488 issued August 7, 1951, to Albert Rose. However, in the present instance, the tube output signal is developed across a parallel-resonant radio-frequency tuned circuit **37** connected to the barrier-grid **39**. The circuit **37** is tuned to resonate at the radio-frequency modulation frequency. A second parallel resonant circuit **41**, also tuned to resonate at the radio-frequency modulation frequency, is connected between the signal plate **35** and a video driver circuit (not shown) to provide radio-frequency isolation therebetween. The impedance of the circuit **41** is low at the video frequencies involved.

As mentioned heretofore, the signal developed across the tuned circuit **37** (the pedestal signal) varies in amplitude and phase with respect to the amplitude and phase of the radio-frequency oscillator signal. The desired video information is superimposed on this pedestal. The composite signal **43** comprising these two signals is inductively coupled by a winding **45** to the input circuit of an output limiting tuned radio-frequency amplifier **47**. The output of the amplifier **47** thus comprises a constant-amplitude varying-phase signal **53** which is applied to one input circuit of a linear phase comparator **55**. The phase comparator **55** may be a phase detector of the type described by F. S. Holman, Jr. in the August 1953 edition of Electronics, pages 180–181. The second input circuit of the phase comparator **55** is coupled via a radio-frequency phase shifter **49** to receive a portion **56** of the constant-amplitude constant-phase signal from the oscillator 23. The phase shifter **49** is carefully adjusted until at the output of the comparator **55** the undesired pedestal signal has substantially zero D.-C. level and the detector has maximum sensitivity for the desired video information. The video information **57** may then be utilized as desired. Since the variable amplitude pedestal signal has been removed, neither filtering nor D.-C. restoration nor amplifiers having wide dynamic ranges are required.

What is claimed is:

1. Electrical apparatus comprising, an electrical storage tube having a charge storage member and a normally biased-off electron beam, means for gating-on said normally biased-off electron beam at a radio-frequency rate, means for simultaneously applying video information to said tube to establish an electrical charge pattern on said charge storage member, means for deriving an output signal from said storage tube comprising video information superimposed on a radio-frequency pedestal signal, said pedestal signal having an amplitude and phase which vary in accordance with the position of said beam on the surface of said storage member, means for amplitude limiting said superimposed video information and pedestal signal to provide a constant-amplitude varying-phase signal, and means for phase comparing said constant-amplitude varying-phase signal and said radio-frequency gating signal to provide video signals having substantially zero D.-C. level.

2. Electrical apparatus comprising, an electrical storage tube having a charge storage member and a normally biased-off electron beam, means for gating-on said normally biased-off electron beam at a radio-frequency rate, means for simultaneously applying video information to said tube to establish an electrical charge pattern on said charge storage member, means for deriving an output signal from said storage tube comprising video information superimposed on a radio-frequency pedestal signal, said pedestal signal having an amplitude and phase which vary in accordance with the position of said beam on the surface of said storage member, means for amplitude limiting said superimposed video information and pedestal signal to provide a constant-amplitude varying-phase signal, a phase comparator, means for applying said constant-amplitude varying-phase signal to one input circuit of said phase comparator, and means for applying a portion of said radio-frequency beam gating signal energy to a second input circuit of said phase comparator to provide at the output of said phase comparator video information having a substantially zero D.-C. level.

3. Electrical apparatus comprising, an electrical storage tube having a charge storage member and a normally biased-off electron beam, deflection means for deflecting said beam against said charge storage member during predetermined deflection intervals, means for gating-on said normally biased-off electron beam at a radio-frequency rate during said deflection intervals, means for applying video information to said tube during said deflection intervals to establish an electrical charge pattern on said charge storage member, means for deriving an output signal from said storage tube comprising video information superimposed on a pedestal signal, said pedestal signal having an amplitude and phase which vary in accordance with the position of said electron beam on the surface of said storage member, means for amplitude limiting said superimposed video information and pedestal signal to provide a constant-amplitude varying-phase signal, means for applying said constant-amplitude varying-phase signal to one input circuit of a phase comparator, a phase shifter coupled to said radio-frequency beam gating means, and means for coupling said phase shifter to a second input circuit of said phase comparator to provide at the output of said phase comparator video information having a substantially zero D.-C. level.

4. Apparatus as claimed in claim 3 wherein said phase shifter is adjustable.

5. Apparatus as claimed in claim 3 wherein said output signal deriving means comprises a parallel-resonant circuit tuned to said radio-frequency.

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